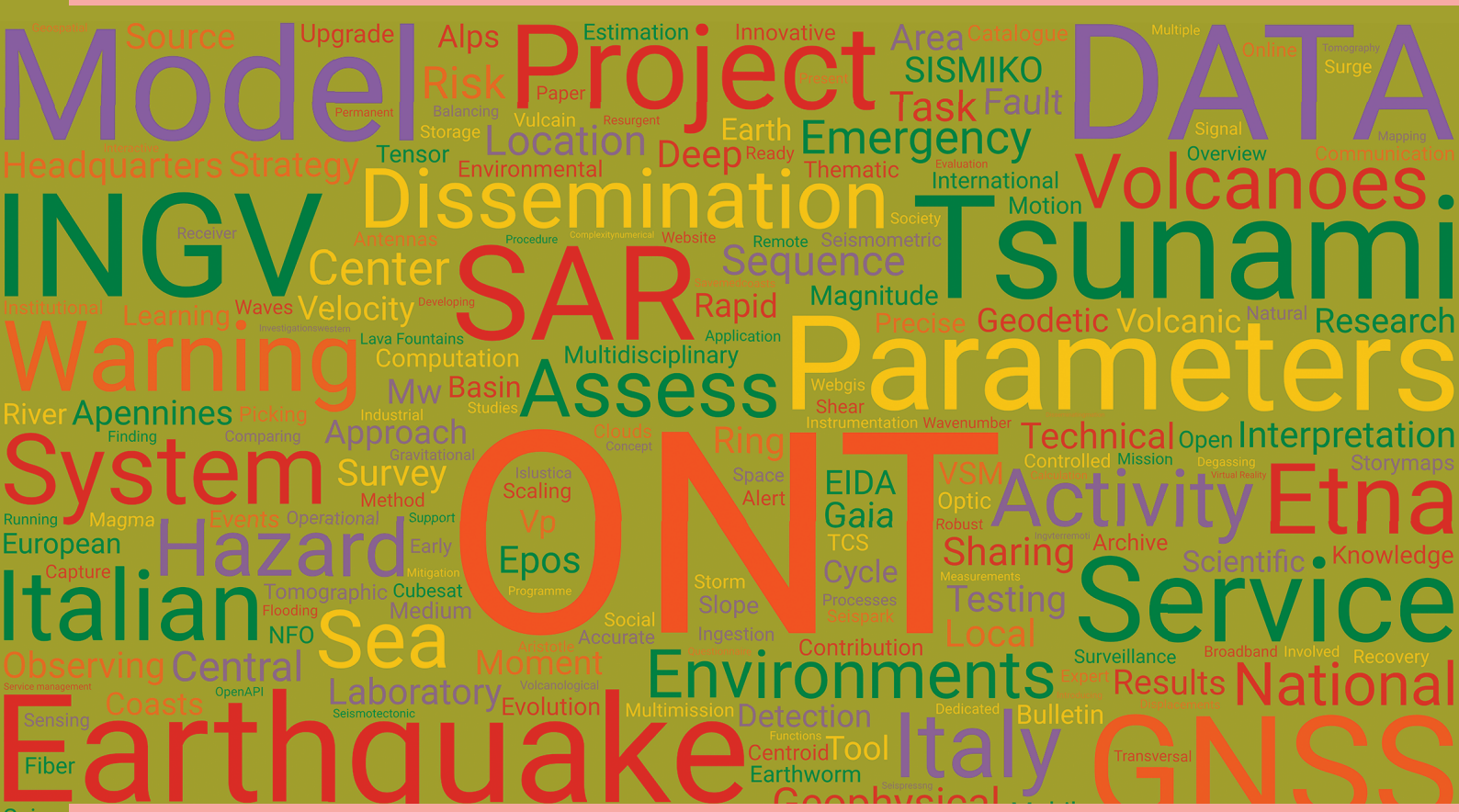
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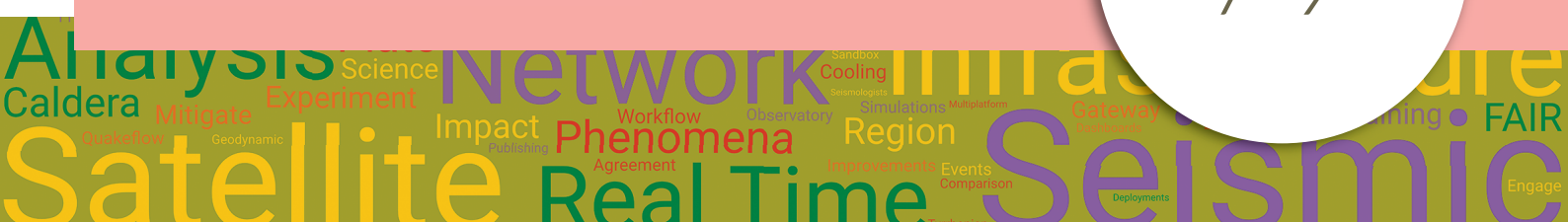


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79

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INDEX

PREFACE 15
Carlo Doglioni - President of INGV

INTRODUCTION 16
Salvatore Stramondo - Director of ONT (2017-2023)

INFRASTRUCTURES, DATA-SHARING AND LABORATORIES 19

Evolution and improvements of the National Seismic Network 20
Sandro Rao, Catello Acerra, Augusto Bucci, Carlo Calamita, Antonio Costanzo, Fabio Criscuoli, Antonino D'Alessandro, Roberto D'Anna, Sergio Del Mese, Gaetano De Luca, Pierdomenico Del Gaudio, Sergio Falcone, Stefano Farroni, Anna Gervasi, Edoardo Giandomenico, Lucian Giovani, Chiara Ladina, Simone Marzorati, Matteo Migliari, Milena Moretti, Debora Pantaleo, Massimo Pascolini, Giuseppe Passafiume, Massimo Perfetti, Ulderico Piccolini, Leonardo Salvaterra, Salvatore Scudero, Andrea Serratore, Stefano Speciale, Paolo Strappaveccia, Giovanni Vitale

Seismic monitoring of central-eastern Italy 22
Carlo Calamita, Debora Pantaleo, Simone Marzorati, Chiara Ladina, Milena Moretti

The technical management of the Central-Eastern Italy seismic monitoring, Ancona headquarters 24
Debora Pantaleo, Carlo Calamita, Simone Marzorati, Chiara Ladina, Milena Moretti

Upgrade of the National Seismic Network in Sicily as part of the PON GRINT Infrastructure project 26
Antonino D'Alessandro, Roberto D'Anna, Salvatore Scudero, Stefano Speciale, Giovanni Vitale, Sandro Rao, Salvatore Stramondo

The ONT Mobile Seismic Network for temporary experiments: where are we headed? 28
Mario Anselmi, Diana Latorre, Stefano Farroni, Sandro Rao, Luisa Valoroso, Fabio Villani

Thematic Core Service TSUNAMI (TCS TSU) in the pan-European research infrastructure EPOS (European Plate Observing System) 30
Silvia Filosa, Stefano Lorito, Roberto Basili, Beatriz Brizuela, Sergio Bruni, Fabrizio Romano, Roberto Vallone, Manuela Volpe and TCS Tsunami

GNSS Survey Networks managed by ONT 32
Alessandro Galvani, Mirko Iannarelli, Marco Anzidei, Roberto Devoti, Alessandra Esposito, Grazia Pietrantonio, Federica Riguzzi, Vincenzo Sepe, Andrea Terribili

NFO Federated Specific Data Gateway: an innovative portal for advancing multidisciplinary Earthquakes Science 34
Ivano Matiddi, Luca Elia, Ivano Carluccio, Ovidiu Jianu, Lauro Chiaraluce, Gaetano Festa

ONT IT infrastructure and services 36
Emiliano Della Bina, Peter Danecek, Stefano Pintore, Massimo Fares, Ivano Carluccio, Diego Franceschi, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello

SeiSpark: a computational archive for seismology 38
Peter Danecek, Stefano Pintore, Massimo Fares, Ivano Carluccio, Diego Franceschi, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello

Data dissemination: real time sharing and EIDA italian node 40
Ivano Carluccio, Massimo Fares, Emiliano Della Bina, Peter Danecek, Stefano Pintore, Diego Franceschi, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello

Italian Seismic Bulletin working group: new web site and data dissemination strategies 42
Barbara Castello, Patrizia Battelli, Michele Maniscalco, Ivano Carluccio, Emiliano Della Bina, Valentino Lauciani, Raffaele Di Stefano, Anna Nardi, Alessandro Marchetti, Diana Latorre, Maria Grazia Ciaccio and BSI working group

SISMIKO: Emergency Seismic Data Dissemination and Recovery 44
Ezio D'Alema, Simone Marzorati, Milena Moretti, Alfonso Giovanni Mandiello, Ivano Carluccio, Mario Locati and SISMIKO Working Group

An overview of the different responses from the National Seismic Network 46
Flavia Tavani, Massimo Fares, Emiliano Della Bina, Ivano Carluccio, Diego Franceschi, Michele Maniscalco, Peter Danecek, Stefano Pintore, Alfonso Giovanni Mandiello

Data Ingestion: acquisition system at ONT 48
Diego Franceschi, Ivano Carluccio, Emiliano Della Bina, Peter Danecek, Stefano Pintore, Massimo Fares, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello

Seismic Data Life Cycle 50
Massimo Fares, Ivano Carluccio, Emiliano Della Bina, Peter Danecek, Stefano Pintore, Diego Franceschi, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello

Data Curation: toward FAIR data 52
Massimo Fares, Diego Franceschi, Ivano Carluccio, Emiliano Della Bina, Peter Danecek, Stefano Pintore, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello

GAIA-IV: the new version of the INGV seismic data logger 54
Leonardo Salvaterra, Sandro Rao, Catello Acerra, Massimiliano Vallocchia, Massimo Perfetti, William Thorossian, Ulderico Piccolini, Fabio Criscuoli, Augusto Bucci, Paolo Strappaveccia, Edoardo Giandomenico, Carlo Salvaterra

Laboratory of Geophysical and Seismometric Instrumentation 56
Paolo Strappaveccia, Sandro Rao

Analysis of full-GNSS observations by comparing different choke-ring antennas: LEIAT vs TRM 58
Roberto Devoti, Mirko Iannarelli, Grazia Pietrantonio, Andrea Terribili

MAST satellite Multimission Acquisition System for Earth Observation at INGV Rome headquarters 60
Dario Stelitano, Luca Merucci, Stefano Corradini, Pietro Ficeli, Francesco Zanolin, Lorenzo Guerrieri

Institutional activities and research projects of the INGV-Rende headquarters 62
Antonio Costanzo, Pierdomenico Del Gaudio, Sergio Falcone, Daniela Fucilla, Anna Gervasi, Raffaele Giordano

ANALYSIS, MODELLING, INTERPRETATION OF GEOPHYSICAL PHENOMENA - SEISMOLOGICAL 65

CARS - Catalog of Relative Seismic Locations of 1981-2018 Italian Seismicity 66
Maddalena Michele, Raffaele Di Stefano, Lauro Chiaraluce, Diana Latorre, Barbara Castello

A 10-year-long earthquake catalogue of area monitored by The Altotiberina Near Fault Observatory (Northern Apennines, Italy) 68
Samer Bagh, Raffaele Di Stefano, Adriano Gualandi, Marco Cattaneo, Debora Pantaleo, Carlo Calamita, Chiara Ladina, Simone Marzorati, Lauro Chiaraluce

The September 18th, 2023, Mw 4.9, earthquake in the northern Apennines (Marradi, FI): the work of the BSI on the early days of the seismic sequence 70
Arianna Lisi, Luca Arcoraci, Patrizia Battelli, Michele Berardi, Barbara Castello, Maria Grazia Ciaccio, Diana Latorre, Alessandro Marchetti, Maddalena Michele, Valeria Misiti, Anna Nardi, Davide Piccinini, Antonio Rossi and BSI working group

Moment vs local magnitude scaling of small-to-medium earthquakes from seismic moment estimation of 10 years (2009-2018) of Italian seismicity 72
Mariano Supino, Lauro Chiaraluce, Raffaele Di Stefano, Maddalena Michele

ML-based workflow for earthquake detection and location. Preliminary results from the northern Apennines 74
Giulio Poggiali, Samer Bagh, Lauro Chiaraluce, Chris Marone, Zachary E. Ross, Weiqiang Zhu

Vp and Vp/Vs tomographic model of the Fucino fault-controlled basin obtained through a very dense temporary seismic network 76
Pasquale De Gori, Luigi Improta, Maurizio Vassallo, Fabrizio Cara, Gaetano De Luca, Alberto Frepoli, Samer Bagh, Luisa Valoroso, Mario Anselmi, Francesco Pio Lucente

Technical-scientific activities and products relating to the agreement between INGV-Ancona and the Marche Region 78
Chiara Ladina, Simone Marzorati, Milena Moretti, Debora Pantaleo, Carlo Calamita, Viviana Castelli

Broadband Ground Motion Simulations of M⩾6.0 earthquakes in Central Italy using a Frequency-Wavenumber Approach 80
Pietro Artale Harris, Arben Pitarka, Aybige Akinci

Centroid Moment Tensor computation: inversion based on a 3D velocity model 82
Pietro Artale Harris, Laura Scognamiglio, Federica Magnoni, Emanuele Casarotti, Elisa Tinti

Earthquake Detection and Phase Picking using Deep Learning method: a case study on local events (Groningen Region, Netherlands) 84
Andrea Di Benedetto, Luca Trani, Andrea Pagani, Giosuè Lo Bosco, Antonino D'Alessandro

Preliminary results of QuakeFlow application: the case of L'Aquila 2009 seismic sequence 86
Rossella Fonzetti, Luisa Valoroso, Matteo Bagagli, Pasquale De Gori, Aladino Govoni, Claudio Chiarabba

Automatic seismic source modeling of InSAR displacements 88
Simone Atzori, Andrea Antonioli, Nikos Svigkas, Fernando Monterroso, Claudio De Luca, Francesco Casu, Michele Manunta, Matteo Quintiliani, Riccardo Lanari

Geodetic modelling of recent earthquakes in Turkiye: from the 2020 Mw 6.8 Elazig earthquake to the 2023 Mw 7.8 Kahramanmaras seismic sequence 90
Daniele Cheloni, Aybige Akinci, Nicola Angelo Famiglietti, Annamaria Vicari

Balancing physical complexity and accuracy in numerical models for tsunami forecasting 92
Alice Abbate, Stefano Lorito, José Manuel González-Vida, Manuela Volpe, Fabrizio Romano, Hafize Basak Bayraktar, Manuel Castro Diaz, Roberto Basili

A multidisciplinary approach to assess the kinematics of the Pisciotta Deep-Seated Gravitational Slope Deformation (Southern Italy) 94
Matteo Albano, Michele Saroli, Lisa Beccaro, Fawzi Doumaz, Marco Moro, Marco Emanuele Discenza, Luca Del Rio, Matteo Rompato

ANALYSIS, MODELLING, INTERPRETATION OF GEOPHYSICAL PHENOMENA - VOLCANOLOGICAL 97

Volcanic and Seismic source Modeling (VSM). An open tool for geodetic data modeling 98
Elisa Trasatti

Volcanic clouds characterization of the 2020-2022 sequence of Mt. Etna lava fountains using MSG-SEVIRI and comparison with other products 100
Lorenzo Guerrieri, Stefano Corradini, Nicolas Theys, Dario Stelitano, Luca Merucci

20 years of geodetic measurements reveal the degassing magma cooling processes under the Ischia resurgent caldera 102
Alessandro Galvani, Mirko Iannarelli, Giuseppe Pezzo, Vincenzo Sepe, Guido Ventura

ANALYSIS, MODELLING, INTERPRETATION OF GEOPHYSICAL PHENOMENA ENVIRONMENTAL 105

Monitoring of the River Po drought using SAR data 106
Emanuele Ferrentino, Marco Polcari, Francesca Silverii, Christian Bignami, Ferdinando Nunziata, Maurizio Migliaccio, Salvatore Stramondo

CO_2 capture and storage: a current transversal issue that involved ONT 108
Mario Anselmi, Mauro Buttinelli, Barbara Cantucci, Sabina Bigi, Claudio Chiarabba

NATIONAL AND INTERNATIONAL PROJECTS 111

Monitoring of different hazards and environmental impact due to heavy industrial activity and natural phenomena through Remote Sensing Data 112
Cristiano Tolomei, Lianhuan Wei, Fang Wang, Shanjun Liu, Christian Bignami, Bing Li, Donglin Lv, Elisa Trasatti, Yuan Cui, Guido Ventura, Meng Ao, Stefano Salvi, Shiliu Wang, Xingyu Pan

The VULCAIN project: a CubeSat space mission dedicated to volcanoes 114
Vito Romaniello, Maria Fabrizia Buongiorno, Malvina Silvestri

Shear waves velocity model of the crust and uppermost mantle in the eastern Alps from Receiver Functions Pseudo-Tomography 116
Francesco Pio Lucente, Irene Bianchi, Massimo Di Bona, Carlo Doglioni, Aladino Govoni, Simone Salimbeni and AlpArray Working Group

Recent results from geodynamic and seismotectonic investigations in the western Alps 118
Elena Eva, Marco G. Malusà, Stefano Solarino

The temporary seismic network "FXLand": contribution to the project "Fiber Optic Cable Use For Seafloor Studies Of Earthquake - FOCUS" 120
Lucia Margheriti, Milena Moretti, Chastity Aiken, Salvatore Claudio Alparone, Ornella Cocina, Danilo Contrafatto, Antonio Costanzo, Pierdomenico Del Gaudio, Sergio Di Prima, Sergio Falcone, Rocco Lorenzo Festa, Anna Gervasi, Aladino Govoni, Marc-Andre Gutscher, Graziano Larocca, Mario La Rocca, Diana Latorre, Alfonso Giovanni Mandiello, Alessandro Marchetti, Shane Murphy, Anna Nardi, Marina Pastori, Davide Piccinini, Stefano Pintore, Michela Ponte, Salvatore Rapisarda, Luciano Scuderi, Salvatore Stramondo

Finding a seismic signature of the Morrone Fault: the Majella-Morrone experiment 122
Mario Anselmi, Samer Bagh, Claudio Chiarabba, Pasquale De Gori, Rossella Fonzetti, Irene Menichelli, Giuseppe Pezzo, Gilberto Saccorotti, Francesca Silverii

Deformation of Mefite d'Ansanto area (AV). FURTHER Project 124
Alessandra Esposito, Fawzi Doumaz, Alessandro Galvani, Mirko Iannarelli, Mimmo Palano, Grazia Pietrantonio, Federica Riguzzi, Vincenzo Sepe, Federica Sparacino, Daniele Trippanera

ARISTOTLE: A multi hazard scientific expert assessment service for the EC Emergency Response Coordination Center 126
Adriano Azzarone, Stefano Carlino, Spina Cianetti, Stefano Corradini, Claudia D'Oriano, Gianfilippo De Astis, Paola Del Carlo, Alessio Di Roberto, Mauro Antonio Di Vito, Licia Faenza, Giovanna Forlenza, Carlo Giunchi, Roberto Isaia, Enrica Marotta, Luca Merucci, Alberto Michelini, Rosella Nave, Ilaria Oliveti, Marco Olivieri, Lucia Pappalardo, Mario Paratore, Massimo Pompilio, Dmitri Rouwet, Emiliano Russo, Giuseppe Salerno, Simona Scollo, Jacopo Selva, Giulia Sgattoni, Letizia Spampinato, Claudia Spinetti

INGV-MASE (Ministero dell'Ambiente della Sicurezza Energetica) Research Agreement - Subsidence Project 128
Francesca Silverii, Matteo Albano, Letizia Anderlini, Giulia Areggi, Roberto Devoti, Dung Thi Vu, Mimmo Palano, Francesco Pintori, Marco Polcari, Michele Proietto, Enrico Serpelloni, Federica Sparacino, Nikos Svigkas, Elisa Trasatti, Giuseppe Pezzo

Sea level rise projections up to 2150 in the northern Mediterranean coasts 130
Antonio Vecchio, Marco Anzidei, Enrico Serpelloni

A new webGIS for the interactive sea level rise and storm surge scenarios up to 2100 for the Mediterranean costs 132
Antonio Falciano, Marco Anzidei, Michele Greco, Maria Lucia Trivigno, Antonio Vecchio, Charalampos Georgiadis, Petros Patias, Michele Crosetto, Josè Navarro, Enrico Serpelloni, Cristiano Tolomei, Giovanni Martino, Giuseppe Mancino, Francesco Arbia, Christian Bignami, Fawzi Doumaz

Relative Sea Level Rise projections and flooding scenarios for 2150 A.D. for the Island of Ustica (Southern Tyrrhenian Sea, Italy) 134
Daniele Trippanera, Marco Anzidei, Alessandro Bosman, Franco Foresta Martin, Fawzi Doumaz, Antonio Vecchio, Enrico Serpelloni, Tommaso Alberti, Sante Francesco Rende, Michele Greco

SOCIETY - COMMUNICATION, DISSEMINATION, EMERGENCY MANAGEMENT 137

Real-time seismicity dashboards 138
Maurizio Pignone, Sergio Falcone, Raffaele Moschillo

Earthquake and Tsunami Stories 140
Maurizio Pignone, Anna Nardi, Maria Di Nezza, Carlo Meletti, Raffaele Moschillo, Alessandro Amato, Silvia Filosa, Laura Graziani, Lorenzo Cugliari

The Earthquake Calendar 142
Maurizio Pignone, Sergio Falcone, Anna Nardi

Tsunami Ready in Italy. A programme to mitigate tsunami risk 144
Alessandro Amato, Lorenzo Cugliari, Silvia Filosa, Laura Graziani, Fabrizio Romano, Cecilia Valbonesi, Maurizio Pignone

The social impact of Earthquake Early Warning systems. Testing the survey questionnaire 146
Lorenzo Cugliari, Giuseppe Ruzza, Alessandro Amato, Chiara Ladina, Simone Marzorati, Luigi Zarrilli

Longitudinal assessment of tsunami knowledge in an Italian school 148
Lorenzo Cugliari, Alessandro Amato, Massimo Crescimbene

A website concept for navigating into the earthquakes parameters 150
Giorgio Maria De Santis

Disseminating knowledge and best practice in low seismicity areas 152
Elena Eva, Stefano Solarino

The ONT's contribution to the Collane Editoriali INGV 154
Milena Moretti, Christian Bignami, Lorenzo Cugliari, Anna Nardi and Collane Editoriali INGV Team

International Training Schools. Past and future activities at ONT and Roma 2 156
Stefano Corradini, Massimo Musacchio, Claudio Cesaroni

Paper Volcanoes: laboratory a seven years' journey to engage (pre)scholar children on the wonderment of volcanoes 158
Stefania Amici, Barbara Castello, Pasqualino Cappuccio, Concetta Felli, Chiara Ladina, Stefania Lepidi, Vincenza Maiolino, Chiara Montagna, Loredana Napoli, Giovanna Lucia Piangiamore, Donatella Pietrangeli, Diego Sorrentino, Sabina Spadoni, Francesca Di Laura, Daniela Riposati

4 years of virtual reality at the ONT 160
Valerio Lombardo

The INGVterremoti Rapid Mapping Service 162
Maurizio Pignone, Sergio Falcone

Seismic emergencies and INGV operational task force 164
Raffaele Azzaro, Fabrizio Cara, Ezio D'Alema, Paolo Marco De Martini, Giuseppe Di Giulio, Emanuela Ercolani, Laura Graziani, Milena Moretti, Concetta Nostro, Davide Piccinini, Stefano Pucci

SISMIKO: INGV operational task force for seismic network rapid deployments 166
Davide Piccinini, Ezio D'Alema, Milena Moretti, Marina Pastori, Adriano Cavaliere, Antonio Costanzo, Danilo Galluzzo, Salvatore Claudio Alparone, Luciano Zuccarello, Angelo Castagnozzi, Stefano Speciale, Lucia Margheriti, Paolo Augliera, Simone Marzorati

SEISMIC SURVEILLANCE AND TSUNAMI WARNING 169

Italian 24/7 real-time earthquakes and tsunamis monitoring system 170
Salvatore Stramondo, Lucia Margheriti, Laura Scognamiglio, Alessio Piatanesi, Concetta Nostro, Alessandro Amato and Reperibili ADS

CaravelDB: a specific relational database model for seismic parametric data, geospatial information and communication services 172
Matteo Quintiliani

Dante: A robust Web Service for seismic data evaluation and accessibility through a microservices approach 174
Valentino Lauciani

Apollo: An OpenAPI-based Web Service for Seismic Localization and Magnitude Calculation 176
Valentino Lauciani

Introducing PFX: A new multiplatform tool for interactive seismic signal analysis 178
Andrea Bono

SeisPressNG: a system for publishing and disseminating information relating to seismic events in near real time 180
Matteo Quintiliani

Earthworm-Docker-Sandbox: a Docker tool for learning, testing, running and developing Earthworm System within single or multiple enclosed environments 182
Matteo Quintiliani

PRECISE: PRobabilistic Earthquake location Catalog of the Italian SEismicity in 3D tomographic models and 1D regional velocity models 184
Diana Latorre, Raffaele Di Stefano

PRECISE: Probabilistic 1D and 3D real-time automatic location of the Italian seismicity with INGV monitoring room data: the "NLL@INGV" procedure 186
Raffaele Di Stefano, Diana Latorre

Testing the Probabilistic Tsunami Forecasting 188
Valeria Cascone, Stefano Lorito, Alice Abbate, Hafize Basak Bayraktar, Fabrizio Bernardi, Sergio Bruni, Louise Cordrie, Andrea Di Benedetto, Marco Pagani, Alessio Piatanesi, Fabrizio Romano, Jacopo Selva, Matteo Taroni, Roberto Tonini, Manuela Volpe

Sea-level data acquisition 190
Sergio Bruni, Fabrizio Bernardi

Ten Years of Tsunami Risk Mitigation in the Mediterranean: Hazard Assessment, Warning and Mitigation Strategy of the INGV Tsunami Alert Center **192**
Alessandro Amato and CAT Team

The activities carried out by the Support Service in the management of Seismic Surveillance and Tsunami Warning Services from 2015 to the present **194**
Concetta Nostro, Anna Nardi, Eleonora Ruotolo, Lucia Margheriti, Alessio Piatanesi, Laura Graziani, Vincenzo Pirro, Alfonso Giovanni Mandiello, Sandro Rao, Laura Scognamiglio, Pietro Ficeli and Servizio di Supporto nella Gestione dei Servizi di Sorveglianza Sismica e di Allerta Tsunami

The Permanent Training of Seismologists and CAT Shift Workers and Officers, Technical Shift Workers, and On-Call Personnel of the ONT-Rome Center **196**
Concetta Nostro, Anna Nardi, Lucia Margheriti, Luca Pizzino, Alessio Piatanesi, Laura Graziani, Alfonso Giovanni Mandiello, Sandro Rao, Laura Scognamiglio and Servizio di Supporto nella Gestione dei Servizi di Sorveglianza Sismica e di Allerta Tsunami

TABLE OF AUTHORS **198**

Preface

The Istituto Nazionale di Geofisica e Vulcanologia (INGV) is a public research institution and the most important European scientific survey dealing with the study of the Earth. It has three Observatories: the Osservatorio Etneo, which monitors above all the Sicilian volcanoes; the Osservatorio Vesuviano, which deals in particular with the volcanoes in Campania; the Osservatorio Nazionale Terremoti, which monitors the seismicity all over the entire Italian territory and the surrounding areas, including Mediterranean tsunami. Every 30 minutes an earthquake is recorded in Italy and in the seismic surveillance room of the National Earthquake Observatory, where 24-hour duty workers monitor the seismicity of Italy in order to give the timeliest communication, either to citizens or to all the civil protection authorities. The ONT provides a fundamental aid to the research in the earthquake studies framework. We are still far from being able to predict them, but we have some important indications that can empower prevention activities, also linked to tsunami warnings.
In conclusion, the Osservatorio Nazionale Terremoti is truly a backbone of the INGV because it contributes not only to basic research, but also to its fundamental applications for society.

Carlo Doglioni - President of INGV



The INGV President, Carlo Doglioni, interview.

Introduction

The *"Giornata ONT 2023"* arises from the will to let know within INGV how many activities do people from the Osservatorio Nazionale Terremoti (ONT), and how strong is their contribution to the INGV missions: Research, Services, Education, Communication.
In the nearly seven years of the current management the ONT has experienced a continuous evolutionary, sometimes complex, path. But it is always a straight path to pursue the objective of a continuous growth of the ONT.
During these years the ONT has changed its name (from Centro Nazionale Terremoti – CNT, to ONT); it has experienced the coming out of some employees that moved to create the Irpinia new Section; it has lived the novelty of incoming people (example from the Centro Allerta Tsunami). It has also faced the need to overcome the limitations due to the worldwide pandemic emergency COVID19, either for the h24 services or for the research activities. Therefore in 2020 and 2021 we have only remotely attended the ONT days. The drive to be "in presenza" comes from this latter issue. We strongly want to meet, to talk face to face, to "Welcome" the young colleagues who are the injection of new ideas and perspectives, that are the necessary fuel to evolve the knowledge.
As a matter of fact it emerges from the DNA of the ONT, i.e. the inclusiveness and the multidisciplinarity. This latter is widely testified by the ONT activities that are shared among the three Departments and their strategic objectives.
The agenda of the *"Giornata ONT 2023"* has specifically emphasized the variety of the technical and scientific contents, that for sake of simplicity have been collected in the following themes:

- Infrastructures, Data-Sharing and Laboratories
- Analysis, Modelling, Interpretation of Geophysical Phenomena
- National and International Projects (Research Results and Products from Completed Projects; Ongoing Projects)
- Society - Communication, Dissemination, Emergency Management
- Seismic Surveillance And Tsunami Warning

Overall, the contributions have been 100, most of which are posters (77) and the remaining (23) in different exhibit formats. The wide interest about the proposed contents and the positive feedback from the attendance, pushed the decision to collect and publish the contributions in a Miscellanea INGV, where the documents can be easily found.
And we are finally ready to make the Miscellanea available to the reader.
I would warmly thank the Authors for their enthusiastic acceptance to contribute, the Conveners of the *"Giornata ONT 2023"* Sessions for their availability to organise and manage the submitted poster/exhibits, the Editorial Board members for their hidden work that led to this Miscellanea.
In conclusion, let me spend a few words about my personal journey as Director of the ONT.
After 2504 days it has come to an end and the *"Giornata ONT 2023"* and the Miscellanea are, somehow, the cherry on top.
It is really difficult to say "Thanks" one by one to the people who helped me along this complex and long path.
So, please, let me simply say

Grazie a tutti voi!

Salvatore Stramondo - Director ONT (2017-2023)

Don' t judge each day by the harvest you reap

but by the seeds that you plant.

[Robert Louis Stevenson]



The Giornata dell'Osservatorio Nazionale Terremoti 2023's video.

A Special Thank to: Patrizia Battelli for the very appreciated graphic design, Sergio Falcone for the clear and useful webpage, Marco Cirilli for his esteemed work, to stare at the special moments of the day, Nicole Silvestri, Giorgia Magalotti, Giulio Lozzi, Luca Raimondi, Massimiliano Ascani e Stefano Silvestri for their kindness and the irreplaceable technical support



The ONT staff.

Keywords Osservatorio Nazionale Terremoti; GIORNATA ONT 2023; Research scientific and service

INFRASTRUCTURES DATA-SHARING LABORATORIES

Evolution and improvements of the National Seismic Network

Sandro Rao*, Catello Acerra, Augusto Bucci, Carlo Calamita, Antonio Costanzo, Fabio Criscuoli, Antonino D'Alessandro, Roberto D'Anna, Sergio Del Mese, Gaetano De Luca, Pierdomenico Del Gaudio, Sergio Falcone, Stefano Farroni, Anna Gervasi, Edoardo Giandomenico, Lucian Giovani, Chiara Ladina, Simone Marzorati, Matteo Migliari, Milena Moretti, Debora Pantaleo, Massimo Pascolini, Giuseppe Passafiume, Massimo Perfetti, Ulderico Piccolini, Leonardo Salvaterra, Salvatore Scudero, Andrea Serratore, Stefano Speciale, Paolo Strappaveccia, Giovanni Vitale

INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy

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The ONT is the leader in the management, development, and maintenance of the Italian National Seismic Network (Rete Sismica Nazionale, RSN), the nationwide permanent seismological network managed by the INGV. This important goal is shared with the other INGV sections of Milano, Pisa, Bologna, Irpinia, Naples and Catania, and with the help of many external collaborators, like other institutions and observatories with which INGV has framework agreements or conventions. We remember, among the most important: DISTAV [University of Genoa, 1967], Seismological Research Center [OGS, 2016], "A. Bina" Seismic Observatory [*https://www.binapg.it/*], Prato Ricerche *Foundation* [*http://www.pratoricerche.it/*], Universities of Naples, Bari and Calabria [Università Della Calabria, 1981], Enel GreenPower. Due to this "federal" aspect, the network is increasingly referred to today as the integrated RSN [INGV, 2005]. The INGV monitoring network was born in the early 80s, following the Irpinia earthquake of November 23, 1980. Today, RSN is composed of about 450 stations mainly broadband, about 110 stations have also co-located strong motion instruments, and about 180 have GPS receivers and belong to the National GPS network [INGV RING Working Group, 2016]. Technological advancements and obsolescence of instrumentation used in the sites of the RSN has led to inevitable changes and improvements to the network itself. Several projects have made this possible, such as the FISR or the PON projects. The "escape from Nanometrics" was concluded with new connectivity techniques, leading, for certain stations, to redundant transmission of seismic data, with the use of Viprinet equipment. Additionally, power systems have been improved and many sites equipped with an accelerometer or other geophysical instrumentation. New stations have been added to improve the network geometry, to compensate for any malfunctions of strategic ones or due to decommissioning in some monitoring sites.

References

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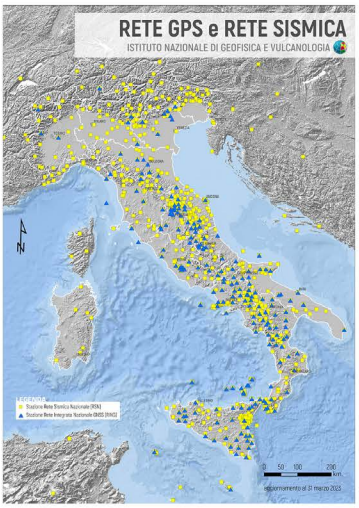
Acknowledgments

The authors would like to thank all the colleagues who have contributed, over the last 20 years, in different roles, to making the RSN an important research infrastructure.

GIORNATA ONT martedì 14 novembre 2023

Sandro Rao, Catello Acerra, Augusto Bucci, Carlo Calamita, Antonio Costanzo, Fabio Criscuoli, Antonino D'Alessandro, Roberto D'Anna, Sergio Del Mese, Gaetano De Luca, Pierdomenico Del Gaudio Sergio Falcone, Stefano Farroni, Anna Gervasi, Edoardo Giandomenico, Lucian Giovani, Chiara Ladina, Simone Marzorati, Matteo Migliari, Milena Moretti, Debora Pantaleo, Massimo Pascolini, Giuseppe Passafiume, Massimo Perfetti, Ulderico Piccolini, Leonardo Salvaterra, Salvatore Scudero, Andrea Serratore, Stefano Speciale, Paolo Strappaveccia, Giovanni Vitale

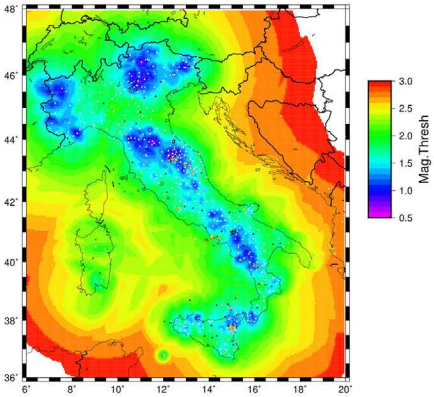
EVOLUZIONE E MIGLIORAMENTI DELLA RETE SISMICA NAZIONALE



L'Osservatorio Nazionale Terremoti (ONT) è *leader* nella gestione, nello sviluppo e nella manutenzione della Rete Sismica Nazionale, la rete di monitoraggio sismologico permanente a scala nazionale gestita dall'Istituto Nazionale di Geofisica e Vulcanologia (INGV).

Tale importante compito è condiviso con le altre sezioni INGV di Milano, Pisa, Bologna, Irpinia, OV-Napoli e OE-Catania, e possibile grazie al fondamentale contributo di numerosi *partners* nazionali e stranieri come enti di ricerca, Università e Osservatori con i quali l'INGV ha accordi quadri o convenzioni. Ricordiamo, tra i più importanti: il DISTAV dell'Università di Genova, il Centro Ricerche Sismologiche dell'OGS (Udine-Trieste), l'Osservatorio sismico "A. Bina" (Perugia, la Fonsazione "Prato Ricerche", le Università di Napoli, Bari e Calabria (Unical), Enel GreenPower.
Per questo aspetto "federale", sempre più spesso, la rete viene oggi indicata come Rete Sismica Nazionale Integrata (RSNI, codice di rete IV).

La rete di monitoraggio sismico dell'INGV nasce in seguito al terremoto dell'Irpinia del 23 novembre 1980. Oggi la RSNI, conteggiando tutti i flussi di dati acquisiti presso il centro di acquisizione INGV di Roma, è costitita da oltre 500 stazioni ubicate su tutto il territorio nazionale e all'estero. Circa 380 stazioni sono di proprietà INGV, mentre circa 90 sono gestite da altri enti di ricerca italiani: 38 stazioni estere, 26 stazioni della rete MedNet, ubicate in Italia, Europa, e Nord Africa ed altri di reti installate per esperimenti temporanei. Circa il 60% delle stazioni INGV installate sul territorio nazionale presenta accoppiamento dei canali velocimetrici ed accelerometrici.
Circa180 siti sono condivise con la rete Rete Integrata Nazionale GPS (RING).



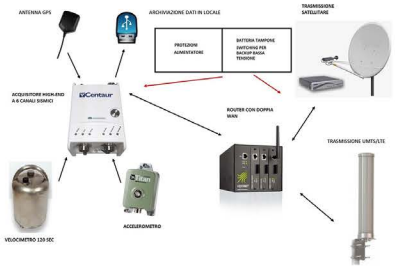
Mappa di detection della RSNI al 09/11/2023: rappresenta la minima magnitudo rilevabile dalla rete, basandosi sul rapporto segnale/disturbo ricavato dalla rumorosità delle stazioni rispetto alla stima dell'ampiezza del segnale per un evento di data magnitudo. Il calcolo simula la configurazione del detector automatico della Sala Operativa ONT come numero di stazioni alle quali viene superata la soglia di trigger, le stazioni realmente in picking e quelle attualmente funzionanti.

Nel 2017 la rete si basava principalmente su due tecnologie: Nanometrics e GAIA.
La prima prevedeva l'utilizzo sia di strumentazione geofisica (velocimetri, accelerometri, acquisitori) che di apparati per la connettività, forniti esclusivamente dalla ditta canadese Nanometrics, mentre la seconda si riferiva solo all'acquisitore interamente progettato e prodotto nei laboratori INGV, quindi scelta in parte più economica. La connettività delle stazioni Nanometrics si basava su sistemi satellitari TDMA, che con il passare degli anni richiedevano degli aggiornamenti all'hardware di trasmissione, imponendo il passaggio da sistemi Lybra1 a Lybra2 e considerando l'alto numero di stazioni da aggiornare, si decise di uscire gradualmente da questo tipo di connettività ("fuga da Nanometrics") orientandosi su altre tecnologie che in quegli anni incominciavano ad affermarsi, quali i collegamenti UMTS, WiFi regionali o satellitari KASAT.



Sito di TERO (Teramo), esempio di tipica stazione della RSNI in tecnologia Nanometrics. A sinistra è visibile l'intera stazione, con il pozzetto per la strumentazione tecnico-scientifica, il sistema di pannelli solari e la parabola di trasmissione satellitare TDMA, A destra si può osservare l'interno del pozzetto, con la schermatura del velocimetro e l'acquisitore Trident, che digitalizza il dato e tramite il protocollo proprietario Nanometrics, NMX, associa al pacchetto dati la marca oraria prodotta dal GPS e lo invia al sistema di trasmissione Lybra1, ubicato dietro la parabola.

La rete negli anni successivi, grazie a fondi DPC e/o di altri progetti, la RSNI ha subito notevoli aggiornamenti, con sostituzione di strumentazione scientifica più performante e l'aggiunta di nuove variabili geofisiche, orientandosi verso la multiparametricità del dato prodotto.
Per la parte di connettività negli ultimi tempi si è puntato su sistemi di rete a doppia connessione WAN, sfruttando apparati high-end della Viprinet, che hanno permesso delle connessioni simultanee dei siti remoti verso la sede centrale di acquisizione, tramite VPN. Questa scelta, che si sta adottando su un numero sempre crescente di siti, ha mostrato la sua efficacia recentemente, quando abbiamo assistito ad un black-out generale di tutti i siti KASAT, molti dei quali hanno continuato a trasmettere dati, grazie alla connessione a doppia WAN.
Sono state aggiunte nuove stazioni per migliorare la geometria di rete ed apportate delle migliorie ai sistemi di alimentazione.



Schema ed esempio di allestimento di un sito moderno ed aggiornato. Sono presenti sia velocimetro che accelerometro, acquisitore 24 bit high-end, doppia connettività (satellitare+LTE), vari sistemi di beck-up dell'alimentazione a partire dagli switching di bassa tensione, evitando gli UPS sulla tensione di rete che sono più dispendiosi dal punto di vista energetico.



INFRASTRUTTURE, BANCHE DATI E LABORATORI

Seismic monitoring of central-eastern Italy

Carlo Calamita*, Debora Pantaleo, Simone Marzorati, Chiara Ladina, Milena Moretti

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In the Ancona headquarters of the INGV, an acquisition system has been implemented to integrate the seismic data of central-eastern Italy.
The Ancona office is equipped with a Data Processing Center (CED) directly connected to the Rome office (LAN INGV) and a local monitoring room focused on the seismicity of central-eastern Italy.
The data exchange between the Ancona and Rome offices is redundant through 2 acquisition servers. The staff of the Ancona office is involved in shifts to ensure the continuity of the acquisition system. Currently, data are acquired from 117 sites where seismic stations are installed, equipped with velocimeters and/or accelerometers.
In Ancona, the 92 sites under the responsibility of the headquarters are acquired directly, but 45 are also called by the Rome headquarter. The remaining 25 are acquired by the Italian National Seismic Network (Rete Sismica Nazionale, RSN [Istituto Nazionale di Geofisica e Vulcanologia, 2005]) to be integrated into the regional monitoring system.
Through the Agreement with the Marche Region, INGV has a transmission band for the passage of Seismic Data through the MarcheWay telecommunications backbone and 19 SIMs for transmission by LTE routers. MarcheWay is a broadband wireless network (WIFI) based on a backbone of radio links owned by the Marche Region. 35 seismic stations currently pass along MarcheWay: 20 installed in the Marche region, 15 belonging to the infrastructure of the Near Fault Observatory EPOS-TABOO [Chiaraluce et al., 2014]. Furthermore, data is acquired from the local LAN networks of public structures (municipalities, universities, schools).

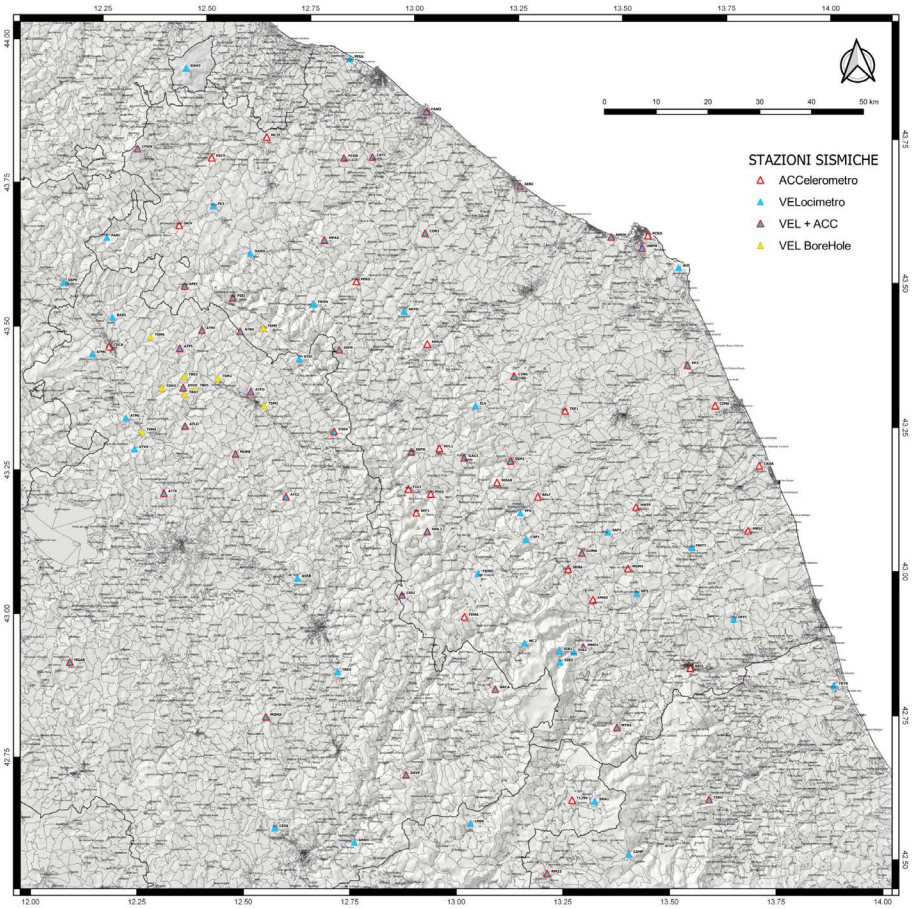
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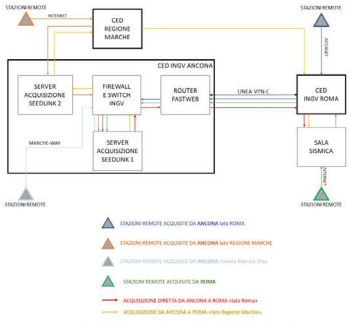
GIORNATA ONT martedì 14 novembre 2023

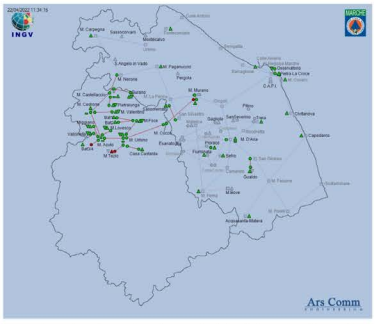
Calamita C., Pantaleo D., Marzorati S., Ladina C., Moretti M.
Osservatorio Nazionale Terremoti

Seismic monitoring of central-eastern Italy









In the Ancona headquarters of the INGV, hosted at the Functional Center of the Civil Protection Service of the Marche Region, an acquisition system has been implemented to integrate the seismic data of central-eastern Italy.
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INFRASTRUTTURE, BANCHE DATI E LABORATORI

Poster presented at the "Giornata ONT 2023". The work presents the infrastructure organization, network geometry and main transmission vectors.

The technical management of the Central-Eastern Italy seismic monitoring, Ancona headquarters

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**Corresponding author: debora.pantaleo@ingv.it*

The Ancona office manages, hosted at the Functional Center of the Civil Protection Service of the Marche Region, the operation and functioning of the geophysical monitoring stations and the acquisition system for the area of central-eastern Italy, in particular in the territory of Marche, Umbria and surrounding areas.
In particular, the Ancona office deals with the management of the stations of the Italian National Seismic Network (Rete Sismica Nazionale, RSN [Istituto Nazionale di Geofisica e Vulcanologia, 2005]) and the permanent and temporary local networks, the development of control systems for the operation of the seismic network (for example electrical voltage monitoring, transmission systems), signals quality, implementation of new technologies for the improvement and diffusion of accelerometer monitoring in open fields and in urban environments, also in collaboration with Universities and local Authorities. Operation tests of power systems, sensors and data acquisition systems are carried out in the laboratory. The Headquarters manages part of the instruments of the SISMIKO operational task force and participates actively in the installation of emergency networks [Moretti et al., 2023].
The Headquarters manages the infrastructure "*The Altotiberina Near Fault Observatory - TABOO-NFO*" [Chiaraluce et al., 2014] with regards to the installation and maintenance of the stations, the control of sensors, the transmission and power systems, the raw data acquisition.
Furthermore, support activities are carried out for the maintenance of multi-parametric sites where geodetic and geochemical instrumentation is present.

References

Chiaraluce, L., Amato, A., Carannante, S., Castelli, V., Cattaneo, M., Cocco, M., et al., (2014). *The Alto Tiberina Near Fault Observatory (northern apennines, Italy)*. Ann. Geophys. 57 (3). https://doi.org/10.4401/ag-6426

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GIORNATA ONT martedì 14 novembre 2023

Pantaleo D., Calamita C., Marzorati S., Ladina C., Moretti M.
Osservatorio Nazionale Terremoti

The technical management of the Central-Eastern Italy seismic monitoring, Ancona headquarters

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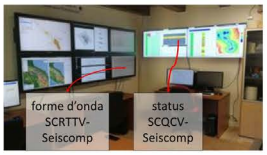
MANUTENZIONE

Gestione del funzionamento delle stazioni di monitoraggio geofisico della Rete Sismica Nazionale e delle Reti locali permanenti e temporanee per l'area dell'Italia centro orientale.



Strumentazione
sostituzione apparati elettronici, accumulatori, pannelli solari, regolatori di carica, celle metanolo, alimentatori, antenne, strutture di supporto, box.

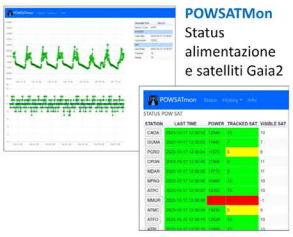
SISTEMI DI CONTROLLO



La sede di Ancona è dotata di una **Sala di Monitoraggio Locale** che permette il controllo dei sistemi di monitoraggio e trasmissione INGV-Regione Marche e attività tecnico-scientifiche per analisi di sismicità e rischio sismico del territorio regionale.



TELEGRAM
Status delle stazioni non acquisite e alert in caso di perdita stazioni, status riempimento dischi dei server di acquisizione

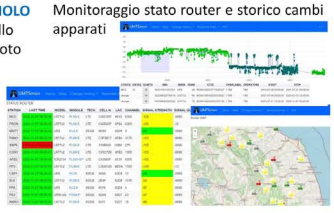


POWSATMon
Status alimentazione e satelliti Gaia2



CELLE METANOLO
Controllo da remoto

UMTSmon
Monitoraggio stato router e storico cambi apparati

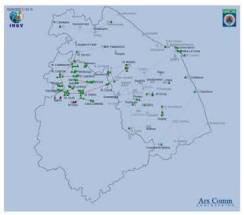


REPERIBILITA'



Diagnosi da remoto per controllo connettività e funzionamento applicativi; controllo forme d'onda e funzionamento sensori; mantenimento sistema acquisizione dati; assistenza interventi in campagna; collaborazione con Sala Sismica di Roma.

TRASMISSIONE DATI



Monitoraggio stato connettività **Dorsale Marche-Way**, rete wireless (WIFI) a larga banda basata su ponti radio di proprietà della Regione Marche gestita dalla ditta ArsComm. Rete chiusa di solo accesso dalla sede di Ancona.

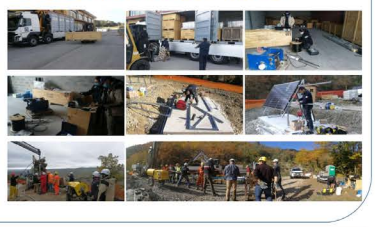
Il **NFO-TABOO** è dotato di una dorsale proprietaria INGV che si allaccia a Marche-Way per la centralizzazione dei dati nella sede di Ancona.

La trasmissione dati viene gestita anche attraverso reti internet, wifi, router telefonia mobile, sistemi satellitari





INSTALLAZIONI e MANUTENZIONE PROGETTO STAR - TABOO

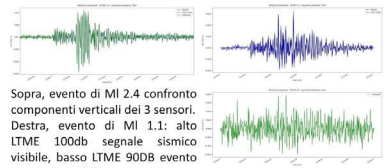


IMPLEMENTAZIONE NUOVE TECNOLOGIE

Miglioramento e diffusione del monitoraggio accelerometrico in campo aperto e in ambiente urbano in collaborazione con Università ed Enti Locali.



Posizione della stazione SIB1 (Tellus 5s – Gaia2) e MEMS LTME 100 dB a fianco di un 90dB collegati ad un Atlas.



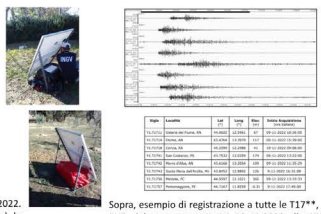
Sopra, evento di Ml 2.4 confronto componenti verticali dei 3 sensori. Destra, evento di Ml 1.1: alto LTME 100db segnale sismico visibile, basso LTME 90DB evento non riconoscibile.

SISMIKO

La sede di Ancona gestisce parte del parco strumentale del GO SISMIKO e a seguito dell'evento di magnitudo M_W 5.5 del 9 Novembre 2022 ore 06:07:24 UTC, localizzato in mare a circa 30 km dalla Costa Marchigiana Pesarese la sede di Ancona ha installato le stazioni T1741, T1742 e T1743.



Mappa delle stazioni sismiche e sismicità dal 08 al 10 Novembre 2022. Nella mappa è riportato l'epicentro (stella arancio su sfondo nero), le stazioni della RSN (quadrati colorati) e quelle della rete temporanea di SISMIKO installate (triangoli arancioni) (https://sismiko.ingv.it/).



Sopra, esempio di registrazione a tutte le T17**, canali EHZ, del terremoto ML 4.1 10-11-2022 alle 17:54:11 (UTC). Sotto, stazioni installate da SISMIKO, rete Y1. (SISMIKO working group 2022).

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INFRASTRUTTURE, BANCHE DATI E LABORATORI

Poster presented at the "Giornata ONT 2023". The work presents the technical management of the Central-Eastern Italy seismic monitoring, carried out by INGV staff at the Ancona headquarters.

Upgrade of the National Seismic Network in Sicily as part of the PON GRINT Infrastructure project

Antonino D'Alessandro*, Roberto D'Anna, Salvatore Scudero, Stefano Speciale, Giovanni Vitale, Sandro Rao, Salvatore Stramondo

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GRINT (Italian Research Infrastructure for Geosciences, [*https://progetti.ingv.it/it/pongrint*]) is a project in the framework of "*Programma Operativo Nazionale*". It envisages the upgrade of monitoring systems in the already existing nodes, and the integration of new nodes.
The main objective is to build a multiparametric network which integrates the seismic network, with the monitoring of other geophysical signals. Sicily is one of the target areas of the GRINT project.
The technological activities are targeted on the enhancement and upgrade of existing systems. The sensing part is upgraded with sensors covering the entire bandwidth of the seismic signal (velocimeters and accelerometers). Power-supply systems, data loggers, data transfer systems are also updated to optimize the performances, reduce the maintenance and the costs, and ensure the full operational services also during a possible crisis.
The laboratory and field activities were carried out by the INGV-ONT group which operates in Sicily. The most challenging task was the installation of 35 post-hole sensors. They were installed in already existing wells or in apposite drilled perforations. Post-hole installations sharply reduce the level of noise and make stable temperature, pressure, and humidity. In most cases, site-specific technical solutions were developed to cope with the peculiar conditions at each location (e.g. deployment and anchoring systems, extension cables, wiring). Moreover, a devoted software for the evaluation of the angular correction for the azimuthal position of the downhole sensor was developed.
Such a general upgrade of the seismic network in Sicily will provide the improvement of both seismic surveillance and scientific research.

GIORNATA ONT martedì 14 novembre 2023

Upgrade of the National Seismic Network in Sicily as part of the PON GRINT Infrastructure project

D'Alessandro A., D'Anna R., Scudero S., Speciale S., Vitale G., Rao S., Stramondo S.

1. Introduction

GRINT "**Italian Research Infrastructure for Geosciences**" is a project in the framework of the "Programma Operativo Nazionale" (PON). This plan envisages both the upgrade of monitoring systems in the already existing nodes, and the integration of new nodes. The main objective is to build a multiparametric network which integrates the main seismic network, with the monitoring of other geophysical signals (**Figure 1**). Such upgrade will provide the improvement of a series of seismological products: waveforms, seismological studies, bulletins for the seismic surveillance. Sicily is one among the target areas of the GRINT project. The main technological activities consist of the enhancement and upgrade of existing systems, an upgrade of seismic stations with installation of sensors covering the entire bandwidth of the seismic signal, both velocimeters and accelerometers. The new seismic sensors are posthole broad-band velocimeters. They are installed in apposite perforations that intercept the bedrock. Such solution reduces the level of seismic noise whose sources are almost always superficial (**Figure 3**). Together with sensors, power-supply systems, data loggers, real-time data transfer systems will be updated to optimize the performances, reduce the costs and the maintenance, and ensure the full operational services also during possible crisis. In detail, this contribution introduces the experiences gained by the ONT group which operates in Sicily and concerns the installation of post-hole broad-band sensors. This activity included the installation of **35 sensors**. We introduce the adopted procedures and the technical challenges faced for the optimal



Fig. 1 – Sites of the Italian seismic network managed by ONT-Sicilia group.

Each installation involved the following steps:

- Site selection
- Visual inspection
- Site characterization
- Administrative procedures for site acquisition
- Choice of the opportune deployment and anchoring solutions
- Design of power and acquisition box
- Installation of the reference sensor
- Data quality check
- Sensor rotation
- Accelerometer installation
- Period of test
- Signal sent to the "sala sismica"



Fig. 2 – Installation operation at various sites. a: visual inspection by means of a borehole camera; b: the lowering of the sensor inside a drilled perforation; c: details of the pulley aligned on the top of a pre-existing well; d: final set-up of the earthquake monitoring site: note the posthole sensor placed at surface next to the well and the accelerometer for its later replacement; e: lab testing for the anchoring system.

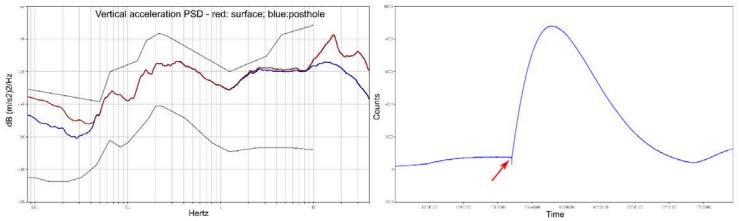


Fig 3 – Left: a comparison between the acceleration power spectral densities (24 hours signal) for the vertical components at FAVA site (62.5 m deep); red line: surface sensor; blue line: posthole sensor. Right: a micro-crack (red arrow) triggers a low-frequency asymmetric oscillation at LIBRI site (27 m deep).

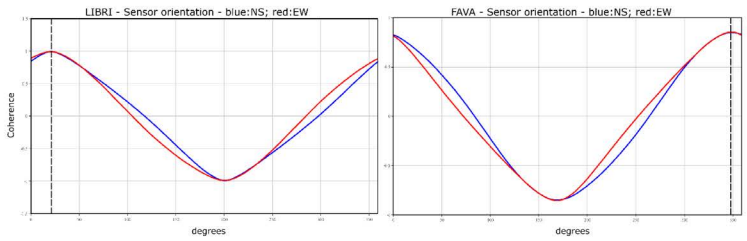


Fig. 4 – Estimation of the angular deviation of the pairs of horizontal components of the two sensors (i.e. surface and down-well). The vertical dashed lines correspond to the maximum values of the coherence and indicate the angular correction (21° for LIBRI and 349° for FAVA).

2. Field activities

The new seismic sensors are posthole broad-band velocimeters installed in apposite perforations or wells. Such solution reduces the level of seismic noise and makes stable temperature, pressure and humidity, The employed posthole sensor is the model **Trillium Compact** PH from Nanometrics. It is a compact (3.2 kg, 97x160 mm) sensor with bandwidth up to 120 s. When connected with **Nanometrics Centaur** digital recorder. The installations have been carried out either in already existing wells and specifically drilled perforation. Of course, in both cases, some characteristics should be preliminarily evaluated. Devoted geophysical investigation (seismic tomography, MASW, ambient noise characterization) have been carried out to fully characterize the sites. Before the installation, the well is inspected by means of a borehole camera to verify the integrity of the casing and of the bottom (**Figure 2**).

3. Lab activities

The laboratory activities to support the GRINT project consisted into the check of all the sensors and the data logger, the preparation of site-specific extension cables, wiring, and plugs ,the development of software for the evaluation of the rotation (**Figure 4**). Moreover, also an anchoring system has been successfully developed, tested, and installed (**Figure 2e**).

4. Conclusions

The upgrade of the earthquake monitoring network in Sicily thanks to the GRINT project represents a main advancement that makes the infrastructure more efficient, reliable, and sustainable for the next decade. In particular, the integration of the posthole seismometers will provide better quality data which will enhance a variety of high-quality seismological studies and will better support the INGV in the seismic surveillance of this region characterized by high seismic hazard,

Poster presented at the "Giornata ONT 2023".

The ONT Mobile Seismic Network for temporary experiments: where are we headed?

Mario Anselmi, Diana Latorre, Stefano Farroni, Sandro Rao, Luisa Valoroso*, Fabio Villani

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The ONT in Rome operates and maintains a temporary seismic network (Rete Mobile network, Re.Mo. [*https://www.ont.ingv.it/monitoraggio-e-sorveglianza/le-reti-temporanee-e-in-emergenza/rete-sismica-mobile-dell-ont-rsm*]) composed by about 30 continuously recording seismic stations (Reftek 130) equipped with velocimeters (broadband Trillium 120 sec; short-period Lennartz 1 or 5 sec instruments) and accelerometers (Episensor Kinemetrics), set up also for real-time data transmission (UTMS).
Since 2007, the COREMO group (Commissione Rete Mobile) group stations from this INGV infrastructure have been landed to INGV researchers to conduct more than 30 temporary experiments to study areas of particular scientific interest (see the geographical distribution of the experiments in the map). Furthermore, temporary stations were used during the last large seismic sequences that happened in Italy (Potenza 1990, Umbria Marche 1997-98, Molise 2002, Aquila 2009, Emilia 2012, Centro Italia 2016-17), helping following the spatio-temporal evolution of the the seismic sequences and furnishing fundamental seismological data to develop understanding on the earthquake generation processes.
Data acquired with the Re.Mo. network are stored in the European Integrated Data Archive database [*https://eida.ingv.it/it/*] after the end of the temporary experiment. Thus, data recorded during seismic sequences as well as during temporary experiments are made open-access to the scientific community.
Nowadays, the Re.Mo. infrastructure requires a technological renovation spurring for an updated and modern research infrastructure (e.g., integrated transmitting protocols, higher resolution, lighter instruments, high efficiency with low-power consumption), along with the need for a dedicated technical staff, able to guarantee the sustainable maintenance of this important infrastructure.
Then, the COREMO invites all the Re.Mo. collaborators and friends to meet up to share ideas about the Re.Mo. near-term and long-term future.

Acknowledgment
We acknowledge the work of all the technicians and researchers that in the past 30 years contributed to the development and maintenance of this research and monitoring infrastructure.

Presently, Mario Anselmi, Diana Latorre, Stefano Farroni, Sandro Rao, Luisa Valoroso, and Fabio Villani constitute the core members of COREMO.

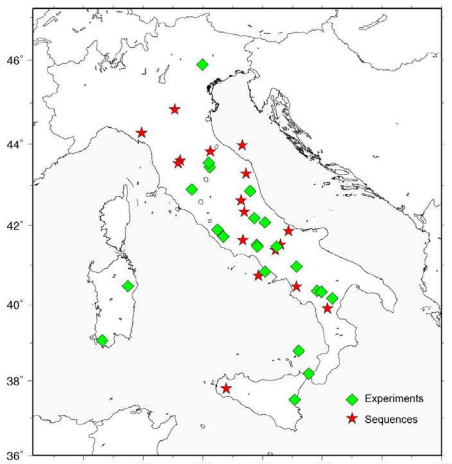
GIORNATA ONT martedì 14 novembre 2023

The ONT Mobile Seismic Network for temporary experiments: where are we headed?

The COREMO (Commissione Rete Mobile) working group:
M. Anselmi, D. Latorre, S. Farroni, S. Rao, L. Valoroso, F. Villani
together with the technicians of UF1-ONT

Con il ricordo affettuoso di ♥
Lucian Giovani e Andrea Serratore

Abstract: The ONT in Rome operates and maintains a temporary seismic network (Rete Mobile network) composed of about 30 continuously recording seismic stations (Reftek 130) equipped with velocimeters (broadband Trillium 120 sec; short-period Lennartz 1 or 5 sec instruments) and accelerometers (Episensor Kinemetrics), set up also for real-time data transmission (UTMS).
During the past 30 years, stations from this ONT infrastructure were landed to INGV researchers to conduct more than 30 temporary experiments to study areas of particular scientific interest.
Furthermore, temporary stations were used during the last large seismic sequences that occurred in Italy (Mw5.7 Potenza 1990, M6 Umbria Marche 1997-98, Mw5.9 Molise 2002, Mw6.1 Aquila 2009, Mw6 Emilia 2012, Mw6.5 Centro Italia 2016-17), helping following the spatio-temporal evolution of the the seismic sequences and furnishing fundamental seismological data to develop understanding on the earthquake generation processes.
Nowadays, the Rete Mobile infrastructure needs to be renovated. Then, the COREMO invites all the Rete Mobile friends to meet up to share ideas about its near-term and long-term future development and sustainability.



Temporary Experiments
2010 | Progetto AIRPLANE
2010 | Progetto OMBRA
2008 - 2010 | Progetto Messina 1908-2008
2012 | Puglia (Sismica attiva)
2012 - 2013 | Monte Amiata
2014 | Progetto DIONYSUS (Sismica attiva)
2014 - 2015 | ENI Val D'agri
2014 - 2016 | TOTAL Val D'Agri
2014 - 2015 | Progetto EASI
2015 - 2016 | Sardinia Passive Array
2015 - 2019 | Progetto AlpArray
2016 | Selve Di Nirano
2016 - 2017 | Caira
2016 | Sulcis
2021 - 2023 | Mefite d'Ansanto - FURTHER
2021 | Sardegna - SOS ENATTOS
2021 - In corso | Ascoli Piceno - OPENFIBER
2021 | Roma - ANTomography Rome
2021 - 2022 | Monte Cotugno
2021 - 2023 | Sicilia - FOCUS
2023 - 2025 | Matese - PD-MOSAICMO
2023 - 2024 | Majella - GEMME
2024 - 2025 | Cassino - AMICA

Seismic crisis (with the SISMIKO GO)
2009-2010 | L'Aquila
2009-2010 | Frusinate
2010 | Fermano
2011 | Montefeltro
2011-2013 | Pollino
2012-2013 | Emilia
2013 | Lunigiana
2013-2014 | Matese
2014 | Chianti
2014 | Roccadaspide
2016-2017 | Campobasso
2016 -2018 | Italia Centrale (AVN)
2017-2018 | Isola di Ischia
2018 | Molise
2020 | Salemi (Provincia di Trapani)
2022 | Chianti Fiorentino
2022-2023 | Costa marchigiana - pesarese

Now?

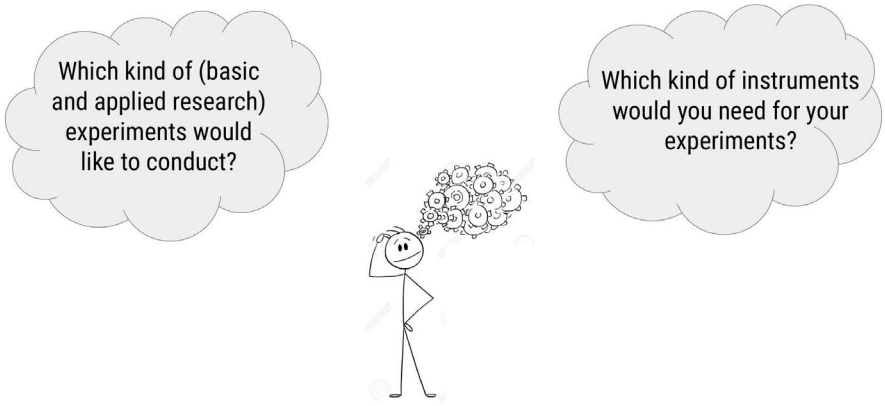
Two main criticalities:

- **Technological update of the instruments:** Most of the digitalizers dates back to 2003-2006 and are old. Only 4 new Reftek130 digitizers have been acquired in 2016-2018. This has a strong influence on the affidability of the present-day instruments. Furthermore, the technology can be upgraded in order to conduct (e.g., integrated transmitting protocols, higher resolution, lighter instruments, high efficiency with low-power consumption).
- **Need to hire additional and dedicated technical staff** to ensure the improvement and sustainable maintenance of this important infrastructure.

What in the short-term and long-term future of the Rete Mobile ONT?

The recent development of the *SISMIKO Gruppo Operativo*, which coordinates all the INGV seismic mobile networks to be installed during seismic crisis (including the 8 seismic stations in the "Zona Rossa" in Rome), gives us the possibility to rethink the Rete Mobile of ONT as a research infrastructure optimally designed for temporary experiments of research projects.
Taking into account the recent advances in instruments technology for field acquisition equipment (lighter, battery included, portable technology) we encourage all the *Rete Mobile friends* to share ideas on the short-term and long-term future of this important research infrastructure, to conduct basic and applied research projects.

Thinking about the short-term and long-term future of the ONT Rete Mobile Seismic Network, we share with you two questions:



Poster presented at the "Giornata ONT 2023". Map showing the past temporary experiments and seismic sequences conducted by using stations of the Re.Mo. seismic network.

Thematic Core Service TSUNAMI (TCS TSU) in the pan-European research infrastructure EPOS (European Plate Observing System)

Silvia Filosa*, Stefano Lorito, Roberto Basili, Beatriz Brizuela, Sergio Bruni, Fabrizio Romano, Roberto Vallone, Manuela Volpe and TCS Tsunami

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The strong earthquakes and subsequent giant tsunamis in recent decades have stimulated the study of the complex mechanisms of tsunami generation, propagation and inundation. Various scientists from all over the world have founded the GTM network to coordinate actions for tsunami hazard and risk assessment, and to develop shared methods and guidelines. In Europe in particular, they identified EPOS as the research infrastructure that facilitates the integrated use of data, data products, and facilities from the solid Earth science community.
The Tsunami Thematic Core Service (TCS TSU) joined EPOS in July 2021 with Candidate status and will become fully operational at the end of 2023. It currently counts 30 institutions from 14 European countries. Noteworthy, the TCS TSU includes the Tsunami Service Providers (TSP), in charge of Tsunami Early Warning within the framework of NEAMTWS, coordinated by IOC-UNESCO.
The TCS TSU provides sustainable and harmonized services based on four thematic pillars: support to TSPs, tsunami data, numerical models, and hazard and risk products to support research and risk reduction at national, European and international levels.
In Italy, the TCS TSU participates in the EPOS-Italy Joint Research Unit (JRU), signed by Public Research Organizations, Universities and Consortia to support the Italian scientific community in its data and services integration into EPOS, and to promote the development of further national infrastructures. It involves INGV, UNINA, ISPRA, CINECA, and UNIBO.
It currently participates with EPOS in various European projects such as DT-GEO, and GEO-Inquire.
Further information in EPOS web site [*www.epos-eu.org/tcs/tsunami*] and TCS Tsunami Portal [*https://tsunamidata.org*].

GIORNATA ONT martedì 14 novembre 2023

Thematic Core Service TSUNAMI in EPOS

the pan-European research infrastructure for solid Earth science

Authors: Filosa S., Lorito S., Basili R., Brizuela B., Bruni S., Romano F., Vallone R., Volpe M. e il TCS Tsunami

About TCS TSUNAMI www.epos-eu.org/tcs/tsunami

The **Tsunami Thematic Core Service (TCS TSU)** joined EPOS in July 2021 with Candidate status and will become fully operational at the end of 2023.
Tsunamis triggered by earthquakes, landslides or volcanic eruptions belong to multihazard cascades and Its interdisciplinarity fosters a natural interaction with other EPOS TCSs, such as Seismology, NearFault Observatories, Volcano Observations, or GNSS Data and Products contributing to reinforce the multihazard and multirisk characteristics of EPOS ERIC itself.

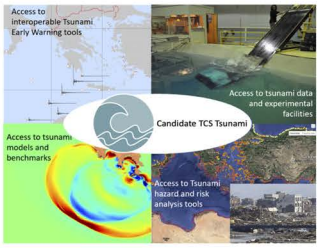
Partnership

Currently the **TCS TSU** counts **30 institutions from 14 Europe countries.** It includes the Tsunami Service Providers (TSP), charge of **Tsunami Early Warning** within the framework NEAMTWS, coordinated by IOC-UNESCO.



CENTRO ALLERTA TSUNAMI ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA https://cat.ingv.it/it/

Portfolio of Data, Data products, Services and Software (DDSS)



The **TCS TSU** provides sustainable, standardized and harmonized services based on four thematic pillars, each representing a specific family of DDSS elements:

- support to TSPs,
- tsunami data,
- numerical models,
- hazard and risk products.

Several services (DDSS) are already available on the EPOS ICS-C portal.

TCS Tsunami Portal https://tsunamidata.org/

Goals

The **TCS TSU** aims to:

- support the research and risk reduction at national, European and international levels.
- coordinate the provision of access to - and interaction with - data, products, software, workflows, and other services on a European level and beyond.
- contribute with new research to mitigate tsunami risk increasing risk awareness in governments and society.

TCS TSUNAMI in EPOS ITALIA Joint Research Unit (JRU) www.epos-italia.it

In Italy, the **TCS TSU** participates in the **EPOS Italia Joint Research Unit (JRU)**, an Agreement signed by Public Research Organizations, Universities and Consortia in June 2016 with the main goals: - to support the Italian scientific community in its data and services integration into EPOS; - to promote the development of further national infrastructures.
JRU EPOS IT has been recognised by the Ministry of Universities and Research (MUR) as a research infrastructure of international importance.

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TCS TSU partners in EPOS IT

Currently in the TCS TSU: **INGV**, **UNINA**, **ISPRA**, **CINECA**; **UNIBO** is about to join.

How EPOS IT works

EPOS-IT organises its activities through a four-year Activity Plan and annual Executive Plans. Activities are proposed by partners, approved by the General Assembly and co-financed by the MUR.

About EPOS www.epos-eu.org

EPOS, the European Plate Observing System, a multidisciplinary, distributed research infrastructure that facilitates the integrated use of data, data products, and facilities from the solid Earth science community in Europe. From April 2023 EPOS entered the Operational phase with the opening of the Data portal ICS-C to communities.
www.ics-c.epos-eu.org

EPOS ERIC legal framework

On October 30th, 2018, the European Commission granted to **EPOS** the legal status of ERIC (European Research Infrastructure Consortium), currently joined by 17 countries: Austria, Belgium, Denmark, France, Greece, Iceland, Italy, the Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Sweden and the United Kingdom, and Germany and Switzerland participating as Observers.
Its headquarters is hosted in Rome, at INGV.

How EPOS works

Four Elements represents the scientific and technical backbone of the whole infrastructure: **National Research Infrastructures** (NRI), **EPOS ERIC**; **Thematic Core Services** (TCS); **Integrated Core Services** (ICS). The ICS is the new e-infrastructure developed by EPOS and its key element is a **data portal (ICS-C).** www.ics-c.epos-eu.org/

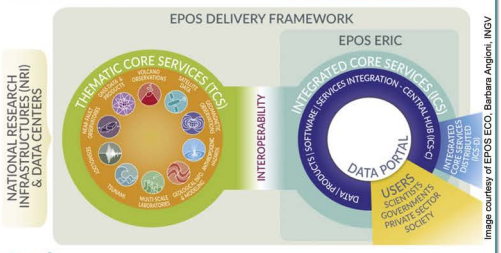


Image courtesy of EPOS ECO, Barbara Angioni, INGV

Goals

Providing a Central Data Access Point promoting FAIR (Findable, Accessible, Interoperable, and Reusable) data management; Helping Scientists to Drive Science; Helping Governments Plan for Natural Disasters and Geo-hazards; Inspiring the Next Generation.

TCS TSUNAMI in EU Projects

The **TCS TSU** currently participates with EPOS in various European projects such as:

Digital Twin for GEOPhysical extremes
Project funded by Horizon Europe, GA N. 101058129 https://dtgeo.eu/
September 1st 2022 | August 31st 2025

Geosphere INfrastructures for QUestions into Integrated Research
Project funded by EC, GA N. 101058518 within HORIZON-INFRA-2021-SERV-01 call.
www.geo-inquire.eu
October 1st 2022| September 30th 2026

INFRASTRUTTURE, BANCHE DATI E LABORATORI

GNSS Survey Networks managed by ONT

Alessandro Galvani*, Mirko Iannarelli, Marco Anzidei, Roberto Devoti, Alessandra Esposito, Grazia Pietrantonio, Federica Riguzzi, Vincenzo Sepe, Andrea Terribili

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The activities of the ONT includes the management, development and collection of GNSS data on survey-style networks. In particular, some dense mesh networks with interdistance between vertices ranging from 3 to 5 km have been designed for the near field study of the main seismogenic structures of the central and southern Apennine with the aim to provide new insights into the present-day deformation of this seismically active area, and information on seismic hazard assessment and evaluation of the seismogenic sources. The CAGEONET and SAGNET networks [Anzidei et al., 2005; Galvani et al., 2012; Esposito et al., 2020] are located in the main structures of central and southern Apennines. The MefiteNET is located around the degassing area of Mefite d'Ansanto (AV). The POLLINO network, established in the framework of a scientific collaboration between ONT, Università di Milano and the Politecnico di Milano, is located in the northern side of Calabria region [Cambiotti et al. 2020]. ONT also manages discontinuous networks in volcano areas: the COLLI ALBANI network established for monitoring the Alban Hills [Anzidei et al., 1998, Riguzzi et.al, 2009] later upgraded to CGPS stations; the ISCHIA network installed in cooperation with Osservatorio Vesuviano (OV) [Galvani et al., 2021]; PANAREA and SALINA Networks located in the Eolian Islands [Esposito et al., 2015; *https://progetti.ingv.it/it/pian-din*].
We also describe the design and implementation of portable, self-sustaining cases containing GNSS instrumentation and the associated power supply system of non-permanent geodetic networks.

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GIORNATA ONT martedì 14 novembre 2023

GNSS Survey Networks managed by ONT

Galvani A., Iannarelli M., Anzidei M., Devoti R., Esposito A., Pietrantonio G., Riguzzi F., Sepe V., Terribili A.



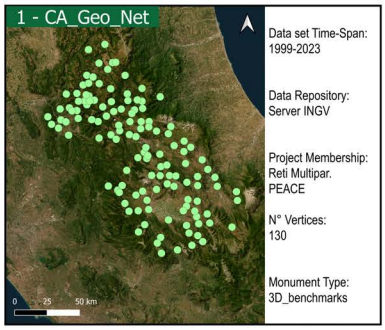
ABSTRACT

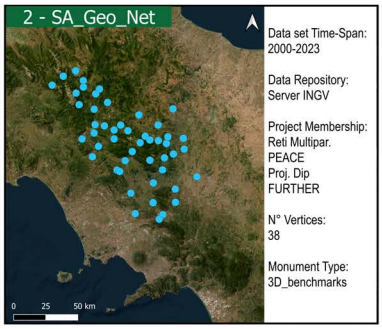
The activities of the ONT includes the management, development and collection of GNSS data on survey-style networks. In particular, some dense mesh networks with interdistance between vertices ranging from 3 to 5 km have been designed for the near field study of the main seismogenic structures of the central and southern Apennine with the aim to provide new insights into the present-day deformation of this seismically active area, and information on seismic hazard assessment and evaluation of the seismogenic sources.

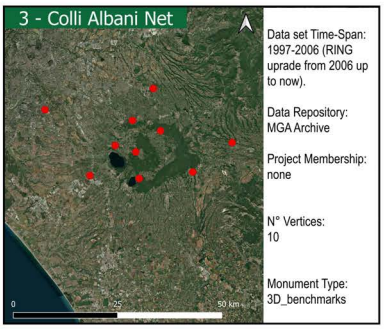
The CA_Geo_Net and SA_Geo_Net networks are located in the main structures of Central and southern Apennines. The POLLINO network, established in the framework of a scientific collaboration between ONT, "Università di Milano" and the "Politecnico di Milano" the POLLINO NETWORK is located in the northern side of Calabria region. The MEFITE network located in the Mefite D'Ansanto area. The vertices were installed as part of the further project.

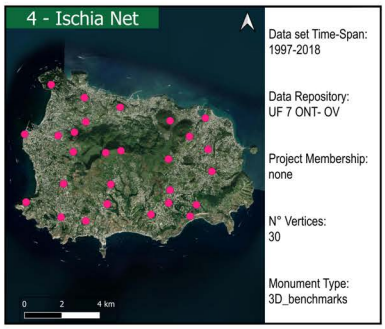
ONT also manages discontinuous networks in volcano areas: the COLLI ALBANI network established for monitoring the Alban Hills later upgraded to CGPS stations; the ISCHIA network installed in cooperation with OV; PANAREA and SALINA Networks and vertices belonging to the CAVEAT project in the Eolian Islands.

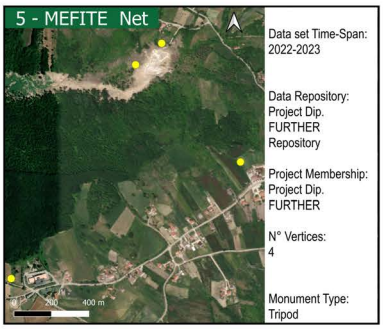
We also describes the design and implementation of portable, self-sustaining cases containing GNSS instrumentation and the associated power supply system of non-permanent geodetic networks.

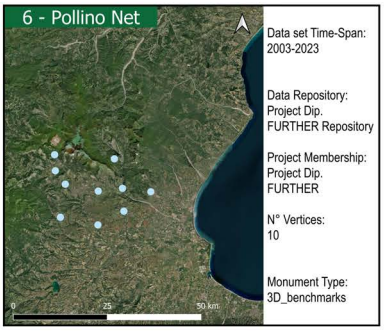


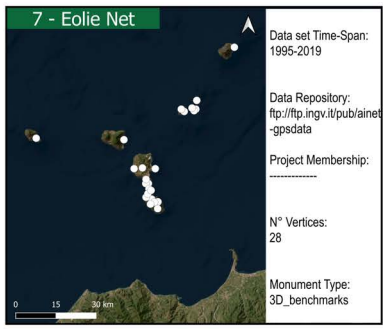


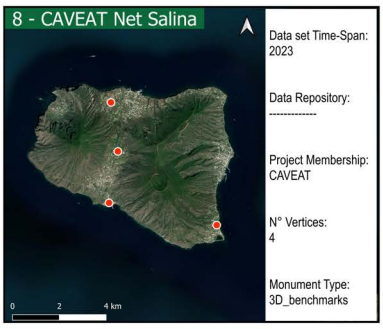




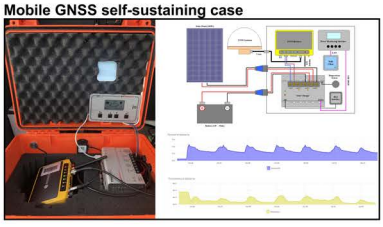








Mobile GNSS self-sustaining case

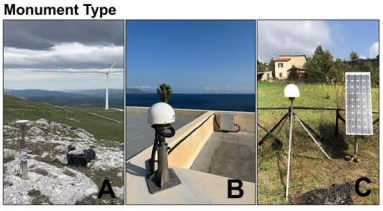


Mobile GNSS self-sustaining case and connection diagram with battery, solar panel antenna, and remote telemetry system monitoring battery voltage, system temperature and solar panel efficiency.

Monument Type

A - Selfcentering 3D INGV type A Monument
B - Selfcentering 3D INGV type B Monument
C - Tripod
(Anzidei & Esposito, 2003; Anzidei et Al., 2006)

Monument Type



References: Anzidei M. & Esposito A. (2003) - Linee guida per la identificazione di siti idonei alla realizzazione di stazioni GPS permanenti e non permanenti - Rapporti Tecnici dell'Istituto Nazionale di Geofisica e Vulcanologia, n.18.
Anzidei M., Casula G., Galvani A., Riguzzi F., Pietrantonio G., Nassucci A., Del Mese S. - (2006) - Le prime stazioni GPS permanenti INGV-CNT per il monitoraggio delle deformazioni crostali dell'area italiana - Quaderni di Geofisica n° 39.

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INFRASTRUTTURE, BANCHE DATI E LABORATORI

NFO Federated Specific Data Gateway: an innovative portal for advancing multidisciplinary Earthquakes Science

Ivano Matiddi[1,*], Luca Elia[2], Ivano Carluccio[1], Ovidiu Jianu[3], Lauro Chiaraluce[1], Gaetano Festa[2]

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[2]*UNINA | Dipartimento di Fisica Università di Napoli Federico II, Napoli, Italy*
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Federated Specific Data Gateway (FRIDGE) is an innovative resource that grants access to data and scientific products sourced from the European Near Fault Observatories (NFO) community [Chiaraluce et al., 2014; 2022]. The NFO community is coordinated within the framework of the European Plate Observing System (EPOS).
NFO are a vital part of EPOS Thematic Core Services, consisting of six observatories located in various tectonic regions throughout Europe. Equipped with advanced multi-parametric sensors, providing dense networks of seismic, geodetic, geochemical, and other geophysical sensors located near active faults. Anticipating moderate to large earthquakes along pivotal plate boundary systems like MARMARA, CORINTH, TABOO, IRPINIA, VALAIS, and VRANCEA.
The resources are categorized into Seismology, Geochemistry, and Geodesy. In addition to displaying seismic station distributions, FRIDGE provides access to both raw and curated instrumental earthquake data. It also directs users to other platforms established by Solid Earth communities that offer complementary seismological and geodetic data. The platform provides visualization tools that allow users to access GNSS data, station information, and Radon Meteo Co2 Vp/Vs [Poggiali et al., 2019] data in time series. Each data category includes specific instructions for selection, adjusting the time range, visualization, and download in standard formats like text, QuakeML, and JSON.The FRIDGE workflow starts with the FEDERATOR server granting access to data web services from NFO. Users choose the NFO observatory and service, then specify a temporary range to obtain data in standard formats and generate time series graphs.

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GIORNATA ONT martedì 14 novembre 2023

NEAR-FAULT OBSERVATORIES

NFO Federated Specific Data Gateway: *an innovative portal for advancing multidisciplinary Earthquakes Science*

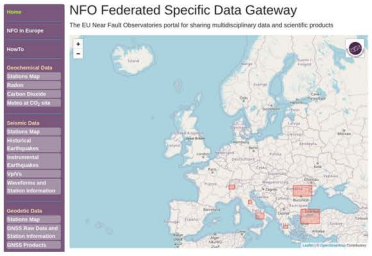
Matiddi I.[1],*Elia L.*[1,2],*Carluccio I.*[1], *Jianu O.*[3], *Chiaraluce L*[1], *Festa G.*[2]

[1]*Istituto Nazionale di Geofisica e Vulcanologia, Italy* - [2]*Dipartimento di Fisica Università di Napoli Federico II, Italy* - [3]*Institutul Național de Cercetare Dezvoltare pentru Fizica Pământului, Romania*

FRIDGE – NFO Federated Specific Data Gateway (**FRIDGE**) is an innovative resource for accessing data and scientific products provided by European Near Fault Observatories (**NFO**) community coordinated in the framework of the European Plate Observing System (**EPOS**).

NFO play a key role in providing open access multidisciplinary data helping the scientific community in better understanding earthquake science. FRIDGE portal provides users with the tools and information necessary to explore updated knowledge and effectively use state of art resources.

NFO services provided by the FRIDGE portal are intended to both broaden the vision and implications of using multidisciplinary data in Earth Science and to highlight their potential for advancing research in this area.





NFO: Monitoring Europe's Tectonic Pulse

Near Fault Observatories is one of the EPOS Thematic Core Services (TCS). The community organised in a (non-legally binding) consortium comprises six observatories settled in different tectonic regimes in Europe (see Figure on the left).

These monitoring infrastructures are composed by advanced networks of multi-parametric sensors that continuously monitor Earth instability processes over an extended period. In addition to complementing regional networks, NFO provide higher density distributions of seismic, geodetic, geochemical, and other geophysical sensors in the near-source domain of active faults, anticipating moderate to large earthquakes. The NFO areas cover plate boundary systems such as the Marmara Sea (MARMARA) and Corinth rift (CORINTH). In mountainous settings, NFO observe faults like Alto Tiberina (TABOO) and Irpinia (IRPINIA) in the Apenninic range, Valais (VALAIS) in the Alps, and Vrancea (VRANCEA) in the Carpathian Mountains. These observatories monitor various faulting mechanisms, including high to very low angle faults, shallow and deep faults, and regions with fast (cm/yr) and slow (mm/yr) strain rate accumulation. The members of NFO, including MARMARA, CORINTH, TABOO, IRPINIA, VALAIS, and VRANCEA, are in constant update to ensure the latest and most accurate monitoring of Earth's tectonic activities.

Exploring FRIDGE:

A Guide to Navigating the NFO Federated Specific Data Gateway

FRIDGE is the NFO Federated Specific Data and Products Gateway, where you can discover all the data and scientific products available for the European NFO. It provides NFO specific data, while other raw and non-specific data seismological and geodetic are available on other platforms developed by other Solid Earth communities.

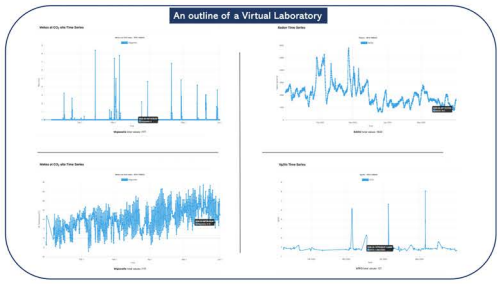
In addition to data discovery and access, Fridge also provides a virtual environment for simple visualization tools describing multidisciplinary data and product.

Example cases Include:

Seismology: View the distribution of seismic stations on a map, and select instrumental earthquakes and view their distribution on a map.

Geochemistry: Viewing radon data (time series).

Geodesy: Downloading GNSS data and station information



For each case, detailed steps are provided on how to select the NFO, change the time range, and visualize or download the data.

Note: You have two choices for downloads

Text and QuakeML for **Seismology**

Text and Json for **Geochemistry**.

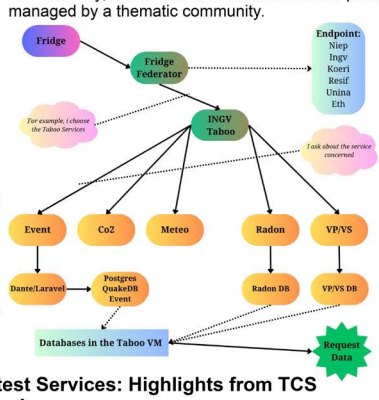
For Geodesy, the user is redirected to another portal managed by a thematic community.



Example of QuakeML output in FRIDGE

Workflow (DBs→ FEDERATOR→FRIDGE)

The DIAGRAM in Figure (on the right side) describe and example of FRIDGE workflow. The FEDERATOR server provides an access point to Near Fault Observatories specific data web services. The user interested in a specific data, first select the NFO observatory providing the data and then the specific service (from Event, Meteo, Co2, Radon, and VP/VS). Then, the temporary range is selected. The requested data is be provided in various STANDARD formats, including text, QuakeML(xml), and Json. Additionally, a TIME SERIES graph may be generated for display (see examples in Figure above). We are continuously implementing new services, so be sure to follow us for updates.



Thematic working groups will assess the existence of standards for individual datasets/products within the reference community. The groups will create roadmaps for implementation, including time evaluation and funding considerations.



The last NFO Workshop at "The National Institute for Earth Physics" in Romania

Showcasing the Latest Services: Highlights from TCS Workshops in Romania

The discussion focused on implementing new services, drawn from the original NFO wish-list (DDSS-Master Table), potentially integrated with DDSS developed in recent EU projects (e.g., Geo-Inquire, DT-Geo). The community aims to integrate these services into EPOS.

Seismology:	Geodesy:	Geology:
Focal mechanisms	Velocity field	Geological maps
Velocity/attenuation models	Strain rate maps	Fault maps
Arrival times	New routine analysis for satellite data on NFO areas	Velocity models
Static catalogues		
DAS		
Source parameters		

Scan the QR code to enter in "FRIDGE"

As a future vision, FRIDGE plans to improve the visualization tools (3D, space-time, different time series together), the inclusion of new time series (number of events per day), a more specific introduction to each NFO, with an extension of the multidisciplinary offer.

INFRASTRUTTURE, BANCHE DATI E LABORATORI

Poster presented at the "Giornata ONT 2023". We show the management of the FRIDGE portal and the operation of the backend part of the federator web services, how it connects to other NFO's.

ONT IT infrastructure and services

Emiliano Della Bina*, Peter Danecek, Stefano Pintore, Massimo Fares, Ivano Carluccio, Diego Franceschi, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello

INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy

**Corresponding author: emiliano.dellabina@ingv.it*

The current IT infrastructure available to the ONT department is designed to supply IT resources to some essential services like national monitoring room, tsunami warning centre [Margheriti et al., 2021], EIDA Italian node [*https://eida.ingv.it/en/*; Danecek et al., 2021], and various strategic projects that are actually the core business of the department. This infrastructure consists of both physical and virtual servers, located in two data centres at Rome INGV headquarters displaced in two different floors. To implement infrastructure redundancy, VMware clusters are utilized, distributed across 2 data centres. This infrastructure provides, also, a backup facility in order to assure VMs availability in any case: periodic snapshots of virtual machines are taken using Veeam software on a dedicated hardware to ensure immediate restore of each VM. Furthermore, on all data acquired a specific policy is applied.
Our policy for long-term-preservation is to have 3 copies: in local storage, then make a replication at a new storage archive in Naples and a backup in a tape library, compliant to 3-2-1 backup policy coined by P.K. Test suite on data backuped is performed on a regular basis. As an IT infrastructure it is also provided a ticket system in order to allow the users to request a VM for their purpose (European project, specific experiment, and so on).
Currently, both the OpenStack infrastructures in the Rome and Naples offices have been certified by Canonical, the company that managed the design and deployment.
Soon, tests will be started to clone applications for data and product exchange in both infrastructures.

References

Danecek, D., Pintore, S., Mazza, S., Mandiello, A., Fares, M., Carluccio, I., et al., (2021). *The Italian Node of the European Integrated Data Archive*. Seismological Research Letters 92 (3): 1726–1737. https://doi.org/10.1785/0220200409

Margheriti, L., Nostro, C., Cocina, O., Castellano, M., Moretti, M., Lauciani, V., et al., (2021). *Seismic Surveillance and Earthquake Monitoring in Italy*. Seismological Research Letters. 2021; 92 (3): 1659–1671. https://doi.org/10.1785/0220200380

GIORNATA ONT martedì 14 novembre 2023

ONT IT infrastructure and services

Della Bina E., Danecek P., Pintore S., Fares M., Carluccio I., Franceschi D., Maniscalco M.,Tavani F., Mandiello A.

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Compute and storage

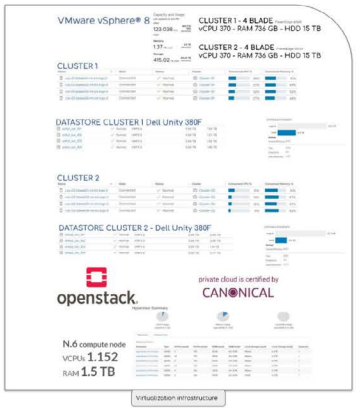
CED SALA SISMICA
5 RACK
24 SERVER BARE METAL
CLUSTER 1 - VMWARE (142 VM)
CLUSTER OPENSTACK
2 STORAGE ISILON
1 TAPE LIBRARY (over 300 TB)

CED CORDIS
CLUSTER 2 - VMWARE (117 VM)
VM BACKUP SERVER

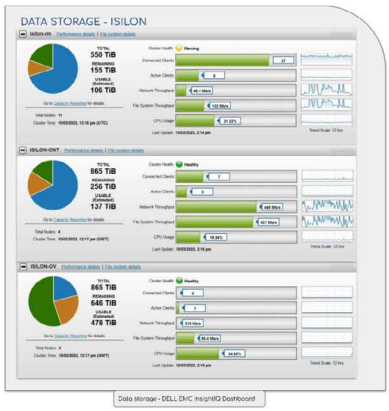
CED CENTRO DI CALCOLO
CLUSTER SEISPARK

CED OSSERVATORIO VESUVIANO
STORAGE ISILON EIDA (replica RM)

Hardware infrastructure



Virtualization infrastructure

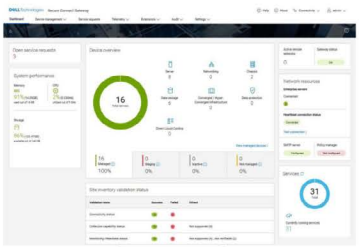


Data storage - DELL EMC insightIQ Dashboard

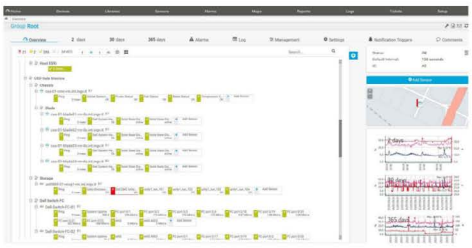
Real-time monitoring (dashboard, notifications, alerts)







DELL Secure Connect Gateway



Paessler PRTG Network Monitor - Sensors overview





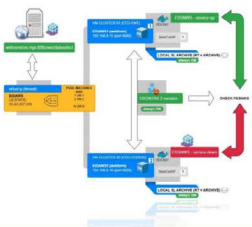


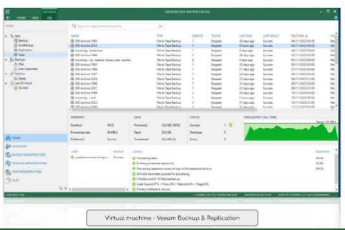
Grafana - VMware vSphere Dashboard

Integrated Service Solution (ticketing, HA design, vm/data backup)



Ticket system - Tuleap





Virtual machine - Veeam Backup & Replication

INFRASTRUTTURE, BANCHE DATI E LABORATORI

Poster presented at the “Giornata ONT 2023”.

SeiSpark: a computational archive for seismology

Peter Danecek, Stefano Pintore, Massimo Fares, Ivano Carluccio, Diego Franceschi, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello*

INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy

**Corresponding author: alfonso.mandiello@ingv.it*

The seismology data archive at INGV, a node of the EIDA federation [Danecek et al., 2021], currently holds more than 100 TB of seismological waveform data. However, it is getting increasingly more challenging to make good use of all these data assets, because the currently established workflows require users to download the dataset of interest (usually a rather small portion of the archive), and to process them on local resources. This approach gets at its limits when a more significant portion of the data holdings should be processed, both for the user and for the data centre. The user would need to ensure adequate local resources for storage, I/O and computation, while the data centre gets challenged by the immense amount of data requests for which the provided services and infrastructure were not designed. We have implemented the concept of a "computational archive" for seismological waveform data where storage resources and computational resources converge. The platform provides significant computational resources in combination with an adequate processing and analysis framework. This concept follows the paradigm of data locality, thereby avoiding unnecessary data transfers on every level. The processing framework leverages existing solutions from the BigData ecosystem, notably Apache Spark [*https://spark.apache.org/*; Zaharia et al., 2012], and combines them with the popular open source Scientific Python framework [*https://numpy.org*, *https://scipy.org*, *https://matplotlib.org*, *https://jupyter.org/*) which is well established in seismological research. ObsPy [*https://obspy.org*; Krischer et al., 2015], the well-known Python framework for processing seismological data, provides the domain-specific functionality.

References

Danecek, D., Pintore, S., Mazza, S., Mandiello, A., Fares, M., Carluccio, I., et al., (2021). *The Italian Node of the European Integrated Data Archive*. Seismological Research Letters 92 (3): 1726–1737. https://doi.org/10.1785/0220200409

Krischer, L., Megies, T., Barsch, R., Beyreuther, M., Lecocq, T., Caudron, C., et al., (2015). *ObsPy: a bridge for seismology into the scientific Python ecosystem*. Computational Science & Discovery, 8(1), 014003. https://doi.org/10.1088/1749-4699/8/1/014003

Zaharia, M., Chowdhury, M., Das. T., Dave A., Ma J., McCauley M., et al., (2012). *Resilient Distributed Datasets: A Fault-Tolerant Abstraction for In-Memory Cluster Computing*. NSDI 2012, April 2012.

GIORNATA ONT martedì 14 novembre 2023

SeiSpark: A computational archive for seismology

Danecek P., Pintore S., Fares M., Della Bina E., Carluccio I., Franceschi D., Maniscalco M., Tavani F., Mandiello A.

Introduction

The scope of the project is to add significant computational resources and an adequate processing framework to our seismological data archive. In contrast to currently adopted workflows, the *Computational Archive* employs the paradigm of data locality, avoiding unnecessary data transfers on every level, in order to ensure scalability and real parallelism. We leverage on an existing solutions from the BigData ecosystem: Apache Spark provides an execution engine which utilizes the Resilient Distributed Datasets (RDD) memory abstraction and a transformations-based programming model well suited for the usual data processing needs. PySpark, the Python API, offers the opportunity to combine the parallel processing engine with the open source scientific Python ecosystem which is popular with users from seismological research. In particular, ObsPy provides the necessary interface and domain-specific functionality for processing seismological datasets.

Design goals

The processing platform and its components have been selected and evaluated against a set of key design goals:

- Cluster setup with converged worker nodes, which provides both storage and computation resources;
- Leveraging on existing open-source solutions to limit maintenance effort and facilitate long-term sustainability;
- Well-known, modern seismological framework for processing, analysis and visualization -> Scientific Python and ObsPy;
- Immediate access to very large seismological waveform datasets, ideally the whole data holdings of our seismological archive;
- Possible scale-out strategy, e.g. to scientific computing centres or to public cloud providers;

Implementation

General concept of the system was first developed and tested on a sandbox infrastructure based on repurposed hardware. This helped to understand how the Spark processing framework, domain-specific data and software can interoperate. The specifications for the target hardware were derived from these experiments, as well as general recommendations and supplier dialogue.

For the production platform, we opted to implement the Kubernetes orchestration system for resource management, which should provide us with increased flexibility and better maintainability of the system, and it allows for the implementation of alternative processing frameworks. The processing framework (Apache Spark) and the block storage for persistent volumes (Longhorn) are implemented as Kubernetes applications. Only the distributed Object storage (Apache HDFS) and related access control (Apache Ranger) are installed on bare metal. The Object storage holds the data repository of archived seismological waveforms in their original format and layout, so data conversion on ingestion does not generate any new bottleneck.

Access to the platform is provided via JupyterHub which is connected to the institute's LDAP server and ensures authentication of users. Authorised users obtain access to dedicated resources of the cluster via JupyterLab, a web-based interactive development environment for notebooks. On first access, an individual user volume is created which holds the user's workspace with environment settings and user files, Jupyter notebooks or libraries and scripts. JupyterLab provides a series of pre-configured kernels, which are based on public images. One customized kernel (SeiSpark) provides Apache Spark together with the most relevant modules for seismological processing, analysis and visualization, notably modules ObsPy, Cartopy, matplotlib, mpld3. Apache Spark kernels establish a ad-hoc virtual cluster for worker processes.

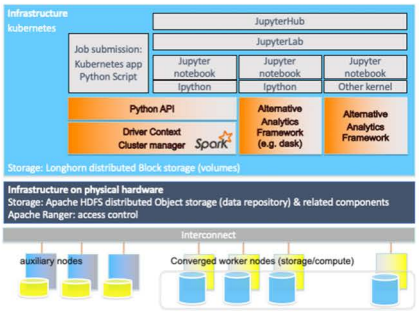


Figure 1: Schematic representation of the processing cluster and the software stack. Both storage and processing are distributed across the cluster. Apache Spark provides the parallel execution engine, which is controlled through the PySpark API, either by a python job script, or interactively by the user's Jupyter notebook and the respective kernel.



Server: Dell EMC PowerEdge R7525

Auxiliary Master Nodes:
- Management Role
  - CPU: 2x 16 core; AMD Epyc 7302, 3.0 GHz base clock
  - RAM: 256 GB; DDR4
  - Mem bandwidth: 204.8 GB/s /CPU
  - System disc: 2 x 960 GB SATA SSD, 6 Gbit/s

Networking:
- High-performance interconnect: InfiniBand 200 Gb/s
- Service network (redundant): Ethernet 25 Gb/s
- Management network: Ethernet 1 Gb/s

Converged Worker Nodes:
- Worker Role
  - CPU: 2x 24 core; AMD Epyc 7352, 2.3 GHz base clock
  - RAM: 1024 GB; DDR4
  - Mem bandwidth: 204.8 GB/s /CPU
  - System disc: 2 x 960 GB SATA SSD, 6 Gbit/s
- Storage Role
  - SAS SSD: 2x 3,840 GB
  - SAS HDD: 10x 18,000 GB
  - Transfer rate: 12 Gbit/s

Figure 2: The installed cluster, master nodes (upper position), the various types of interconnect switches (centre), worker nodes (lower position); summary of hardware characteristic;

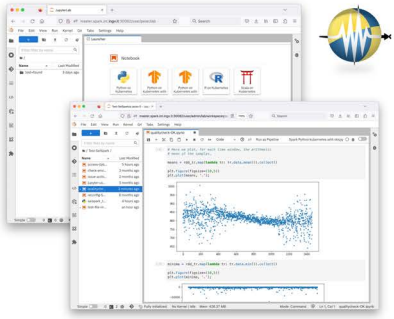


Figure 3: Interactive usage of Apache Spark (PySpark) for the exploration of seismological waveform data. In the example a year of recordings was explored and visualized on-the-fly.

Framework usage

Spark utilizes the RDD abstraction to represent datasets which are distributed across worker nodes, and where possible elements are mapped into memory. The dataset entity can consist of key and value of any type. Various operations are executed collectively on the whole RDD, they can be transformed, filtered, joined or grouped in order to generate new RDDs. These operations define the lineage of the workflow and are scheduled for execution in a lazy way when results are requested. Spark also provides an API similar to pandas DataFrames for table-style datasets.

The files (objects) from the data repository are accessed in parallel from storage nodes through the Apache Spark and become available to the workers as a collection in raw format, are then interpreted and further processed.

We expect most usage of the platform would consist in interactive and guided data exploration, using the JupyterLab environment for interactive data processing, computation and visualization. This approach is also rather convenient for the development of new ideas, methods and algorithms which might further evolve in standard procedures. These developments are consolidated into libraries and procedures, either Notebook documents, common modules or stand-alone scripts for job submission and batch processing. We also plan to turn some standard workflows into services and develop APIs on top of the platform.

Status & Conclusion

We have deploying the new production SeiSpark system as a Kubernetes cluster. Apache Spark and JupyterLab have been installed as Kubernetes application. Persistent volumes are provided by Longhorn block storage. We provide a HDFS Object storage with the EIDA seismological archive for immediate parallel access. Authentication through a centralized LDAP instance enables user access for interactive usage. Access control to the data repository is not yet fully supported. Submission of Spark jobs is currently not available to users, but should become available in future.

We are working on a tighter integration of SeiSpark platform with the EIDA datacentre infrastructure and data management procedures, in order to make the cluster an integral part of the data management system of the datacentre. Data management and scientific applications are being ported on the SeiSpark platform.

Preliminary test yielded satisfying parallel scaling and significant reduction of overall runtimes when accessing and processing large datasets in the order of tens of TB. Based on the preliminary experience and ongoing work, we expect this infrastructure to become an increasingly valuable asset of the EIDA node, addressing both datacentre operations and needs of the scientific users. The Kubernetes-based implementation will portability of the setup and configuration, and should facilitate an eventual scale-out strategy.

Poster presented at the "Giornata ONT 2023".

Data dissemination: real time sharing and EIDA italian node

Ivano Carluccio, Massimo Fares, Emiliano Della Bina, Peter Danecek, Stefano Pintore, Diego Franceschi, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello*

INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy

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ONT is a data aggregator centre for both the Italian National Seismic Network (Rete Sismica Nazionale, RSN [Istituto Nazionale di Geofisica e Vulcanologia, 2005]) and data from other Italian and foreign institutions. This responsibility includes making these data as accessible as possible, including all those archived over the years. The primary user of real-time data is the monitoring system in Rome. ONT is responsible for distributing real-time data to all INGV sections, other Italian data exchange centres, and, finally, to foreign institutional partners, following INGV's data policy rules. We distribute data and metadata via web services compliant with the FDSN standard, namely the Dataselect service for waveforms in mseed format, the WFCatalog service for waveform metadata regarding availability and metrics and the StationXML service for station metadata mainly in xml format. These web services are also integrated within the EIDA Italia web portal [*https://eida.ingv.it*]. The European Integrated Data Archive is an initiative within ORFEUS, constituting a distributed federation of data centres established to securely archive seismic waveform data and metadata gathered by European research infrastructures, and provide transparent access to data for the geosciences research communities. INGV constitutes one of the EIDA founding nodes since 2013 and represents an important building block of the European Plate Observing System (EPOS), being one of the main EPOS services for seismology. The EIDA Italia node node [*https://eida.ingv.it/*; Danecek et al., 2021] is the INGV managed datacenter that stores and distributes seismic waveforms collected by the INGV seismic networks and other Italian and foreign data providers; Data from other countries in the Euro Mediterranean area are collected directly by INGV and partners by the MedNet network [MedNet Project Partner Institutions, 1990].

References

Danecek, D., Pintore, S., Mazza, S., Mandiello, A., Fares, M., Carluccio, I., et al., (2021). *The Italian Node of the European Integrated Data Archive*. Seismological Research Letters 92 (3): 1726–1737. https://doi.org/10.1785/0220200409

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MedNet Project Partner Institutions, (1990). *Mediterranean Very Broadband Seismographic Network (MedNet)*. Istituto Nazionale di Geofisica e Vulcanologia (INGV). https://doi.org/10.13127/SD/FBBBTDTD6Q

GIORNATA ONT martedì 14 novembre 2023

Data dissemination: Real time sharing and EIDA italian node

Carluccio I., Fares M., Della Bina E., Danecek P., Pintore S., Franceschi D., Maniscalco M., Tavani F., Mandiello A.

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REAL-TIME DATA DISSEMINATION

Discovery is a dedicated seedlink server for real-time dissemination created to avoid overload on the HSL acquisition servers.

- INGV sections: Ancona, Catania, Grottaminarda, Milano, Bologna, Napoli, Pisa
- Italian data exchange centers: OGS, UNIGE, UNICAL, BINA, DPC FVG
- Foreign institutional partners: IRIS and NOAA (US), ETH (Ch), CEA (Fr), GFZ (De), NOA (Gr), CAS (Cz)



DATA AND METADATA DISSEMINATION

FDSN Dataselect
SeisComP based service for download waveforms data in mseed format

FDSN StationXML
nosql xml based system (eXist-db)

FDSN Availability
data availability (based on MongoDB)

EIDA WF-Catalog
- data availability
- data metrics
- data quality

EIDA Routing
find correct url to download across EIDA federation

WEB SERVICES PROXY

EIDA Italia Web Portal - *eida.ingv.it*

- Networks/Stations Map
- Networks list
  - Permanent
  - Temporary
  - Virtual networks
- Stations Information
- Landing pages [1]
- Datasets download [2]
- StationXML download
- Data Quality
  - Availability
  - Metrics
- Waveforms plot [3]

EIDA Italia — European Integrated Data Archive

Web Services and Software

INGV WEBSERVICES GUI - https://webservices.ingv.it

National Earthquake Observatory provides data by Web Services based on FDSN specification.

- Data about seismic events are provided by a Web Service based on QuakeML
- Data about instrumental station parameters are provides by a Web Service based on StationXML
- Data about seismic signals are provided by a Web Services based on DataSelect

Follow references to Web Services and other software.

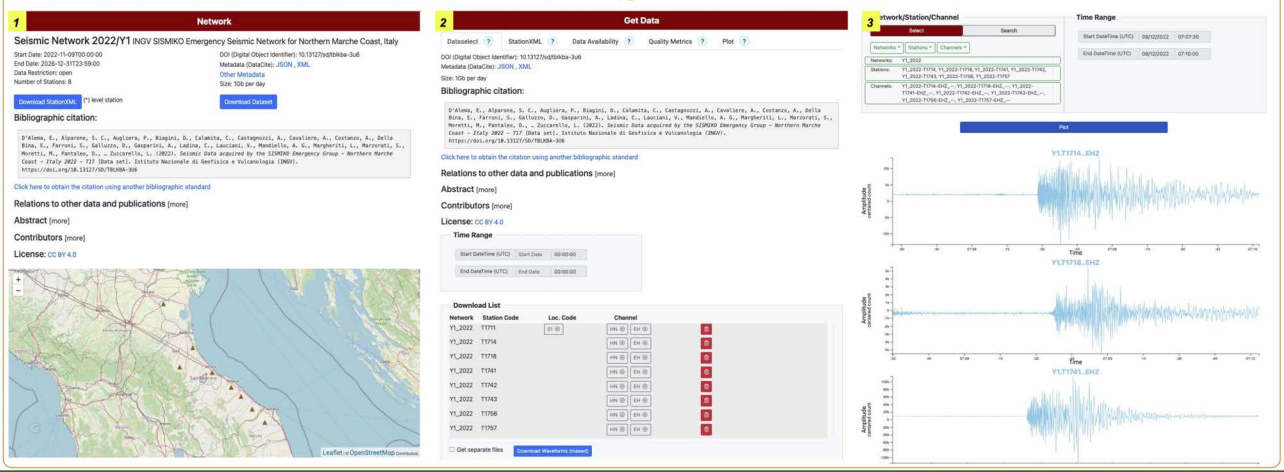
FDSNWS - Federation of Digital Seismograph Networks Web Services

Services	Summary
station	Station metadata and instrument specifics in FDSN StationXML an text format
event	Event (earthquake) information in QuakeML and text format
dataselect	Waveform data for requested channels and time windows in MSEED format

EIDAWS - EIDA Web Services

EPOS DATA PORTAL - https://www.ics-c.epos-eu.org/





INFRASTRUTTURE, BANCHE DATI E LABORATORI

Italian Seismic Bulletin working group: new web site and data dissemination strategies

Barbara Castello*, Patrizia Battelli, Michele Maniscalco, Ivano Carluccio, Emiliano Della Bina, Valentino Lauciani, Raffaele Di Stefano, Anna Nardi, Alessandro Marchetti, Diana Latorre, Maria Grazia Ciaccio and BSI working group**

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**Corresponding author: barbara.castello@ingv.it*

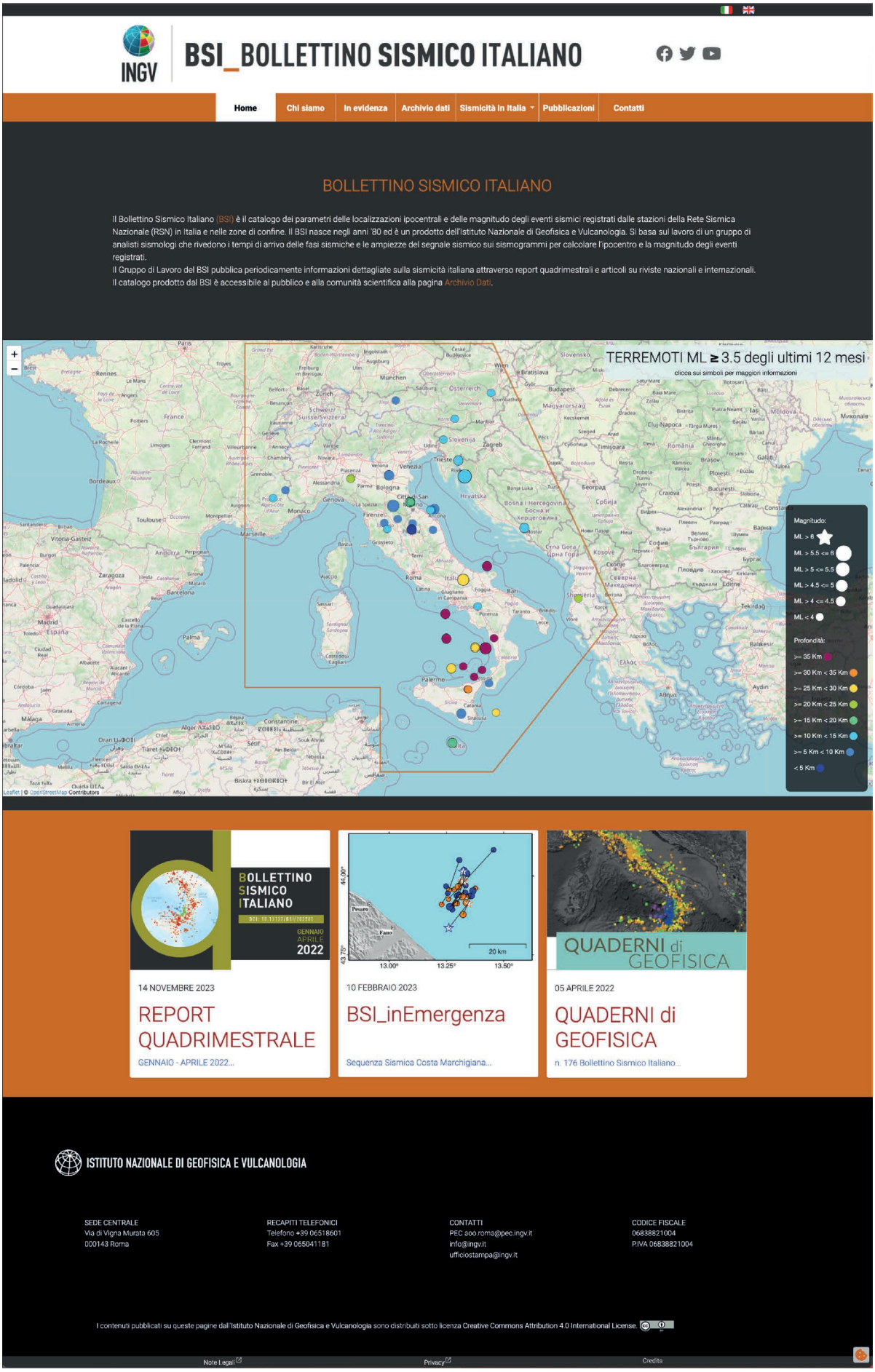
***BSI working group: L. Arcoraci, A. Battelli, M. Berardi, B. Cantucci, C. Castellano, D. Cheloni, L. Colini, M. De Caro, A. Frepoli, L. Improta, A. Lisi, A.M. Lombardi, A. Malagnini, L. Margheriti, M.T. Mariucci, G. Mele, C. Melorio, M. Michele, L. Miconi, V. Misiti, G. Modica, C. Montuori, N. Pagliuca, M. Pastori, S. Pinzi, L. Pizzino, A. Rossi, A. Sciarra, T. Sgroi, S. Spadoni, R. Tardini, C. Thermes, A. Bono, M. Fares, D. Franceschi, A.G. Mandiello, M. Moretti, S. Pintore, M. Quintiliani, L. Scognamiglio*

The analysts of the Italian Seismic Bulletin (Bollettino Sismico Italiano-BSI) routinely review the data recorded by the Italian National Seismic Network (managed by INGV) and other networks run by other institutions [Margheriti et al., 2021]. Arrival times readings of P and S waves and ground motion amplitudes are manually revised allowing to compute earthquake hypocenter locations and the associated magnitude. The obtained information flows into the INGV database and is delivered to the community. The data publication frequency is four months since 2015 and the format is QuakeML 1.2; this format contains the earthquake locations with the estimate of the errors, the magnitudes, the arrival times of the P- and S- phases. From 2020 the BSI faced a new update in terms of working group organisation strategies thanks to the experience of the emergency during the 2016-2018 seismic sequence in Central Italy. This has allowed the group to set new goals to achieve nowadays and for the future. Indeed, the BSI analysts group recently started early revision of first motion polarities for ML≥3.5 occurring in Italy and surrounding areas in order to update the catalogue of focal mechanisms from polarities [Ciaccio et al., 2021] in quasi-real time. Furthermore, the BSI informatics staff implemented tools to convert QuakeML format in text files useful for scientific community (NonLinLoc Observations input file, Hypo71 phases input file, location and magnitude parameters file) and finally it designed a new website to better disseminate the BSI datasets and publications. First version of the new BSI website will be soon available; forward steps are scheduled to improve in terms of a complete release of the entire BSI catalogue from the beginning, with interactive downloads tools and multiple data formats.

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New BSI website homepage with interactive map of last 12 months ML≥3.5 revised earthquakes.

SISMIKO: Emergency Seismic Data Dissemination and Recovery

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***SISMIKO Working Group: https://sismiko.ingv.it/chi-siamo*

Since 2008, a INGV team of people that become SISMIKO Operational Group in the 2015, manage systems finalised to collect seismological data during seismic sequence [Moretti et al., 2023]. The most important were the emergencies of 2009 (L'Aquila [Margheriti et al., 2011]), 2012 (Po Plain, [*https://sismiko.ingv.it/*; Moretti et al., 2012]) and 2016 (Central Italy [Moretti et al., 2016]) during which more than 20 temporary stations were installed.
Actually, thanks to codified procedures, the metadata parameters are preconfigured to allow the centralization of all emergency seismic stations into a dedicated INGV seismic data acquisition system. This guarantees rapid response after an earthquake and rapid integration of the data in the INGV Rome headquarters and if necessary, for use in the room INGV 24/7 seismic surveillance system. All data acquired by the SISMIKO, are made available to the scientific community, without any restrictions, via italian node of the EIDA portal which assures a high level of data quality [Danecek et al., 2021]. To uniform the dataset of the seismic sequence before the new codified acquisition system, the recovery of the continuous digital waveforms, the station metadata was performed. For each recovered emergency dataset, a new network code is requested to the International Federation of Digital Seismograph Network (FDSN) that in some case substitute the "IV" code with the aim to extract the temporary stations from the Italian National Seismic Network of the INGV (Rete Sismica Nazionale, RSN [Istituto Nazionale di Geofisica e Vulcanologia, 2005]).

References

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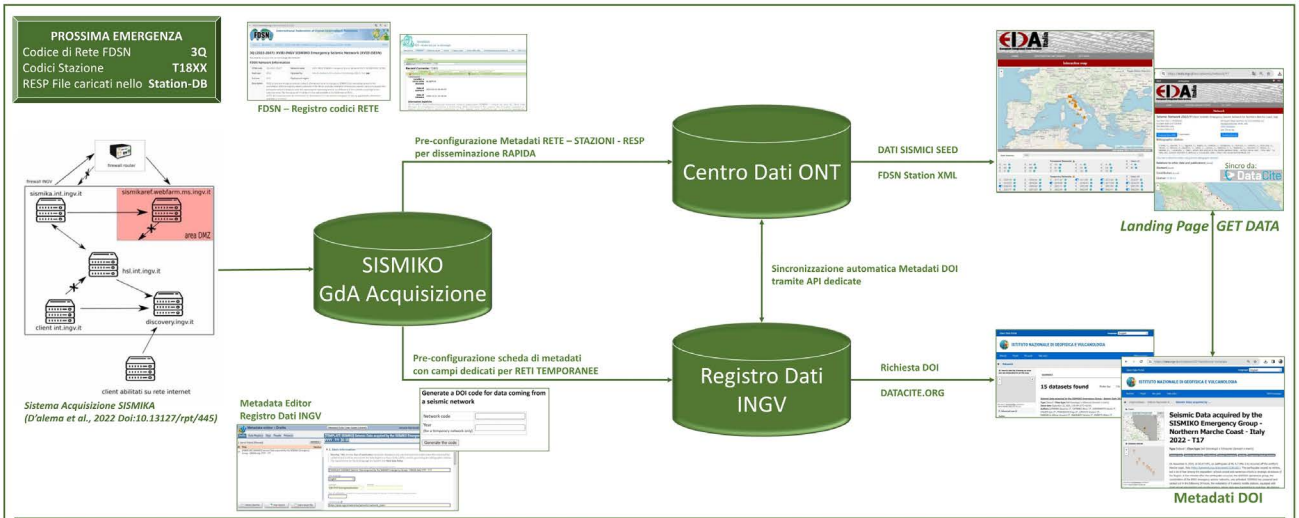
GIORNATA ONT martedì 14 novembre 2023

D'Alema E.(1), Marzorati S.(2), Moretti M.(2), Mandiello A.(2), Carluccio I.(2), Locati M.(1,4) and SISMIKO Working Group (3)

1 Sezione di Milano | 2 Osservatorio Nazionale Terremoti | 3 https://sismiko.ingv.it/chi-siamo | 4 Ufficio Gestione Dati

SISMIKO: Emergency Seismic Data Dissemination and Recovery

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To uniform the dataset of the seismic sequence before the new codified acquisition system, the recovery of the continuos digital waveforms, the station metadata was performed. For each recovered emergency dataset, a new network code is requested to the International Federation of Digital Seismograph Network (FDSN) that in some case substitute the "IV" code with the aim to extract the temporary stations from the National Seismic Network of the INGV.



DISSEMINAZIONE DATI
La **pre-configurazione** delle stazioni e del sistema di acquisizione garantisce la **risposta rapida** dopo un terremoto, permettendo l'integrazione dei dati sismici **in tempo reale** nel sistema di acquisizione nazionale INGV, e la capacità di rendere disponibili i dati alla comunità scientifica seguendo gli **standard internazionali** (*FDSN.org e Datacite.org*). I dati acquisiti da SISMIKO sono disponibili senza nessun vincolo (***open access data***) attraverso il nodo italiano di **EIDA (*European Integrated Data Archive*)** dopo procedure di controllo per garantire un **alto livello di qualità** dei dati in tempi rapidi. Oltre che con il **Centro Dati dell'Osservatorio Nazionale Terremoti**, SISMIKO collabora strettamente con l'**Ufficio Gestione Dati** per migliorare la compilazione dei metadati dei *dataset* prodotti dalle reti sismiche temporanee e per la sincronizzazione delle informazioni tra il **Registro Dati INGV**, le *landing page* di EIDA e il registro internazionale delle reti sismiche **FDSN (*International Federation of Digital Seismograph Networks*)**. Ad ogni *dataset*, prodotto in occasione degli interventi di SISMIKO, viene associato un **DOI (*Digital Object Identifier*)** che garantisce l'identificazione univoca dei dati, la citazione bibliografica, la valorizzazione delle attività tecniche e tecnologiche e l'inserimento di questi prodotti nelle Valutazioni della Qualità della Ricerca (VQR).

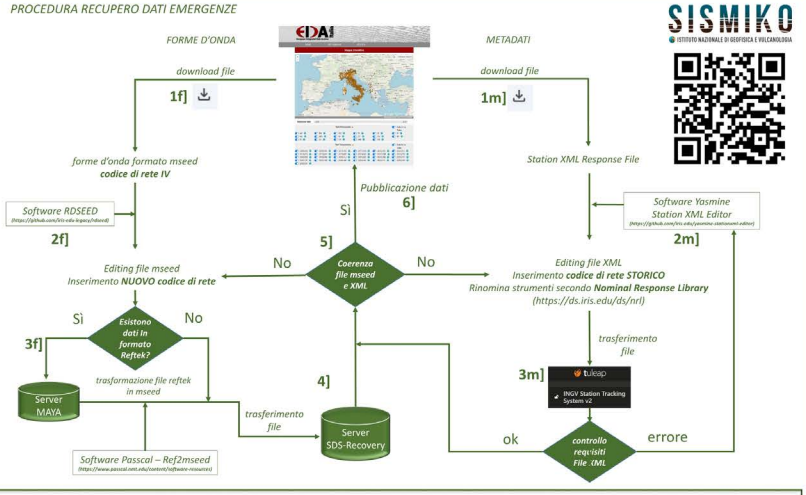
DATI EMERGENZE ARCHIVIATI



No. Emergency	No. Stations	Acquisition Period	Network Code (FDSN)	Station Code	Landing Page
SISMIKO TASK FORCE					
1	8	2020-11-09 2022-03-07	Y1	T17	https://eida.ingv.it/it/networks/network/Y1
2	5	2022-06-04 2022-09-07	ZH	T16	https://eida.ingv.it/it/networks/network/ZH
3	4	2020-09-22 2020-11-25	X3	T15	https://eida.ingv.it/it/networks/network/X3
4	5	2016/08/14 2016/10/26	YD	T14	https://eida.ingv.it/it/networks/network/YD
5	6	2017-08-26 2020-10-25	ZW	T13	https://eida.ingv.it/it/networks/network/ZW
6	24	2016-08-24 2016-07-05	IV—> 6P	T12	https://eida.ingv.it/it/networks/network/6P
7	1	2016-01-18 2016-03-31	IV	T11	https://eida.ingv.it/it/networks/network/IV

EMERGENCY MOBILE SEISMIC NETWORK					
8	3	2013-10-30 2014-03-07	IV	T19	https://eida.ingv.it/it/networks/network/IV
9	6	2012-05-21 2012-11-12	IV	T09	https://eida.ingv.it/it/networks/network/IV
10	22	2012-06-20 2013-04-06	IV—>NI	T08	https://eida.ingv.it/it/networks/network/IV
11	13	2011-11-06 2016-07-13	NI—> IV	T07	https://eida.ingv.it/it/networks/network/NI
12	4	2011-05-26 2011-06-30	IV	T05	https://eida.ingv.it/it/networks/network/IV
13	2	2010-01-13 2010-03-11	IV	T04	https://eida.ingv.it/it/networks/network/IV
14	4	2009-10-05 2010-01-22	IV	T02	https://eida.ingv.it/it/networks/network/IV
15	27	2009-04-06 2011-07-26	IV—> IM	T08	https://eida.ingv.it/it/networks/network/IV
16	8	2009-12-24 2009-12-31	IV	T01	https://eida.ingv.it/it/networks/network/IV

PROCEDURA RECUPERO DATI EMERGENZE



STORICO E RECUPERO DATI
SISMIKO. Formalmente costituito nel 2015, contribuisce all'**archiviazione omogenea e standardizzata** di dati sismici e ha attivato una procedura di recupero e uniformazione di *dataset* passati in collaborazione con il Centro Dati dell'ONT e l'Ufficio Gestione Dati INGV. Dal 2008 sono state installate 16 reti sismiche temporanee in occasione di emergenze sismiche o di eventi rilevanti., tra cui L'Aquila 2009, Pianura Padana 2012, Centro Italia 2016, con l'installazione di più di 20 stazioni.
Dall'intervento di Ischia del 2017, i dati sono stati archiviati ed identificati con un **codice di rete dedicato** e un **Digital Object Identifier (DOI) specifico**.
Per rendere omogenei i dataset precedenti al 2017, SISMIKO ha implementato una serie di operazioni e di controlli per modificare l'archivio di forme d'onda e i metadati delle stazioni, compiendo il trasferimento e la separazione dei dati delle stazioni delle reti **temporanee con codice IV** in nuovi dataset con l'assegnazione di un codice di rete e di un DOI. La procedura è riproducibile per tutti i dati delle reti temporanee non ancora inserite nell'**archivio EIDA**.

INFRASTRUTTURE, BANCHE DATI E LABORATORI

An overview of the different responses from the National Seismic Network

Flavia Tavani, Massimo Fares, Emiliano Della Bina, Ivano Carluccio, Diego Franceschi, Michele Maniscalco, Peter Danecek, Stefano Pintore, Alfonso Giovanni Mandiello*

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The INGV seismic network makes use of different models of seismic sensors (VBB, BB or SP) and different digitizers (Quanterra, Nanometrics, home made GAIA and many others). We have any possible installation's typology (inside tunnel, borehole, next to city or open) and geology. We show an overall analysis of seismic background noise in order to obtain some models that could establish the station functionality as fast as possible. We have used probabilistic power spectral densities (PPSDs) to characterize the seismic ambient noise with the methodology proposed by McNamara and Boaz [2005]. We have established to make use of SQLX software which has analysed continuous streams of more than 500 INGV seismic stations. We have extracted one or more of the stored statistics as mode, median etc. We have found that noise levels are homogeneous enough across the network in the microseismic band (3–20 s) but it varies outside this range due to different instruments at low frequency and to geology and human activity. In the poster we carried on an analysis based on the instruments used in the IV [Istituto Nazionale di Geofisica e Vulcanologia, 2005] and MN networks [MedNet Project Partner Institutions, 1990] during the year 2022. All the computations can be easily applied also for other years, by changing parameters of our procedure. For 2022, we distinguished 79 different pairs of sensors and data loggers in use and we tried to check the average behaviour of the stations. We focused our attention to the low frequencies, where we can more easily see the contribution of the instrument to the signal. This can help us to retrieve a mean trend of the signal for the stations with the same instruments and to compare them, quickly showing the possible anomalies.

References

Istituto Nazionale di Geofisica e Vulcanologia (INGV), (2005). *Rete Sismica Nazionale (RSN)*. Istituto Nazionale di Geofisica e Vulcanologia (INGV). https://doi.org/10.13127/SD/X0FXNH7QFY

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McNamara, D.E., Boaz, R.I., (2005). *Seismic Noise Analysis System, Power Spectral Density Probability Density Function: Stand-Alone Software Package*. Open-File Report 2005-1438. https://doi.org/10.3133/ofr20051438

GIORNATA ONT martedì 14 novembre 2023

An overview of the different responses from the RSN

Tavani F., Fares M., Della Bina E., Carluccio I., Franceschi D., Maniscalco M., Danecek P., Pintore S., Mandiello A.

We show an overall analysis of seismic background noise to obtain some models that could establish the station functionality as fast as possible. We base the study on the combination of sensors (VBB, BB, or SP) and digitizers (Quanterra, Nanometrics, homemade GAIA, and many others) installed on the stations of the network.

We use ObsPy (open source project in Python, providing useful tools for seismology) and the available APIs to interact with SQLX software, which converts time-domain data into **P**ower **S**pectral **D**ensity (PSD) equivalents in the frequency domain.

We prepare a complete analysis for 2022, and we recover all the stations that are still open on 31-12-2022 (in particular, this dataset includes the stations opened after 01-01-2022, and not the ones closed before 31-12-2022) but the final scope is to apply the procedure for every year.

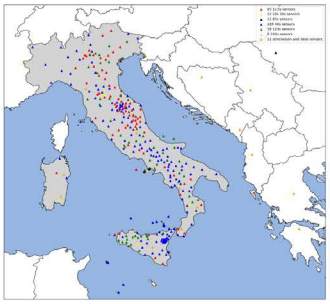


In 2022, we have **371** stations in the IV network, and **24** stations in the MN network (map on the left) with at least one open vertical component of the velocity channel (*HZ).
We grouped the sensor into **7** categories (map on the right).

We get the average behavior of a station considering the installed instruments. We focus our attention on the low frequencies (lower than 0.1Hz), where we can easily see the contribution of the sensors and data logger to the signal.

This can help us to retrieve a mean trend of the signal for the stations with the same instruments and to compare them, quickly showing the possible anomalies.

We carry on the quality analysis on **2176** overall couples of stations - velocity channels.



Steps:

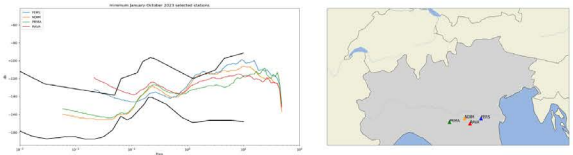
START :
Given the seismic stations in IV and MN, we extract all the different combinations of instruments installed.

P10 extraction:
Loop over pairs sensor/datalogger.
For each couple, we call SQLX to obtain the p10 statistics of the stations with those instruments during a year.

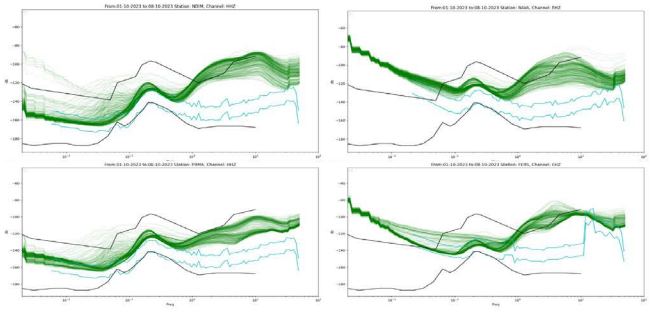
Data binning:
For each frequency in the spectrum up to 0.1Hz, we verify how the PSDs of the stations are distributed.
We divide their data values into bins, and we extract the bin where most values concentrate.

Quality assignment:
We check all the stations to indicate if they fall into the chosen bin.

END:
We get information about the quality of the signal for every station.



Here we propose an example where we use our procedure to understand the trend of the p10 statistics for four stations (FERS, NDIM, PRMA, and RAVA, located in Pianura Padana) during the first week of October 2023. We compare their behavior (figure above) and we show the quality of their signal (on the right).



This analysis is useful to retrieve a reference band to show the signal of the stations having the same kind of sensor (short period, VBB etc.)

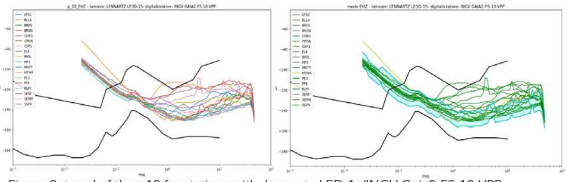


Figure 2: trend of the p10 for stations with Lennartz-LED-1s/INGV Gaia2-FS-10-VPP.

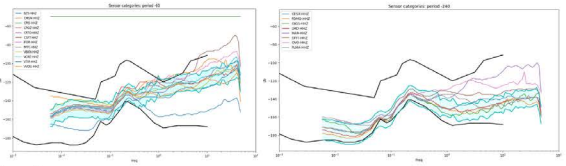


Figure 3:
Bands computed considering only the installed type of sensor (60 sec on the left, 240 sec on the right). This permits us to focus our attention on how much the sensor affects the signal.

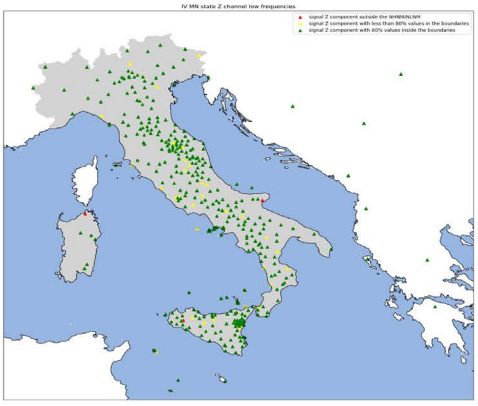


Figure 4: Map of the quality of the signal for all the stations in IV and MN, classified considering the couple sensor/digitizer. The considered frequencies are lower than 0.1Hz; in green, the stations with signal inside the band fixed for their instrument. In yellow are the ones with some values outside the band; in red are the ones with signal outside NHNM and NLNM values.

INFRASTRUTTURE, BANCHE DATI E LABORATORI

Data Ingestion: acquisition system at ONT

Diego Franceschi, Ivano Carluccio, Emiliano Della Bina, Peter Danecek, Stefano Pintore, Massimo Fares, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello*

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The core of the ONT acquisition system is based on the SeedLink protocol, a de-facto standard originally created as a transport layer for SeisComP [*https://www.seiscomp.de*]. It includes tools to collect, distribute and archive waveform data, and it has proven to be a reliable and robust product. For redundancy, a dual data flow is implemented, preferably at least one directly from the stations and the other, if not possible directly, from a server located at the peripheral sections. When a seismic emergency occurs, the acquisition system has been designed to provide immediate access to stations installed, making them available to the monitoring and INGV products. Furthermore, the SeisComP acquisition software is implemented within Linux containers (Docker) in order to have rapid configuration and installation to be ready for operation in a short time. The system configuration is fully integrated with the FDSN StationXML web service and the station management system. To ensure the reliability of the Real-Time data acquisition, regardless of the quality of the transmission system, we have made the servers resilient by placing them in high-availability (HA) configurations. Therefore, automatic procedures are implemented for data recovery from both the stations and peripheral servers.
We are implementing a new concept of data ingestion that provides a data validation system and quality assessment before allowing its preservation, following well-defined rules thanks to our data policy. The same policy and rules are applied also to all data sets from experiments and research projects that need to be ingested, preserved and disseminated by our systems.

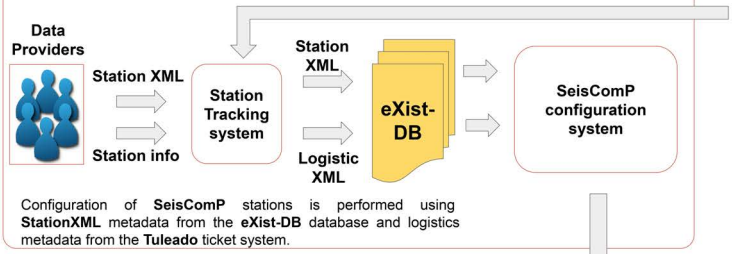
GIORNATA ONT martedì 14 novembre 2023

Data Ingestion: acquisition system at ONT

Franceschi D., Carluccio I., Della Bina E., Danecek P., Pintore S., Fares M., Maniscalco M., Tavani F., Mandiello A.

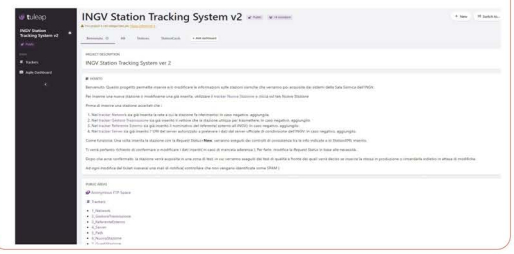
The core of the ONT acquisition system is based on the SeedLink protocol, a de-facto standard originally created as a transport layer for SeisComP (https://www.seiscomp.de). It includes tools to collect, distribute and archive waveform data, and it has proven to be a reliable and robust product. For redundancy, a dual data flow is implemented, preferably at least one directly from the stations and the other, if not possible directly, from a server located at the peripheral sections. When a seismic emergency occurs, the acquisition system has been designed to provide immediate access to stations installed, making them available for the monitoring and INGV products. Furthermore, the SeisComP acquisition software is implemented within Linux containers (Docker) in order to have rapid configuration and installation to be ready for operation in a short time. The system configuration is fully integrated with the FDSN StationXML web service and the station management system. To ensure the reliability of the Real-Time data acquisition, regardless of the quality of the transmission system, we have made the servers resilient by placing them in high-availability (HA) configurations. Therefore, automatic procedures are implemented for data recovery from both the stations and peripheral servers.
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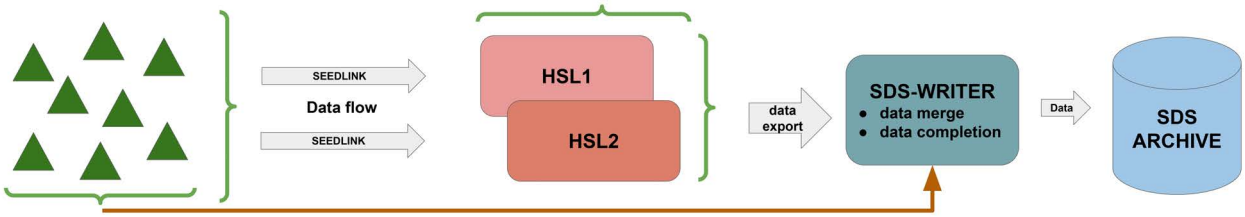
Metadata flow



Configuration of **SeisComP** stations is performed using **StationXML** metadata from the **eXist-DB** database and logistics metadata from the **Tuleado** ticket system.

Ingv Station Tracking system





Acquisition system explained

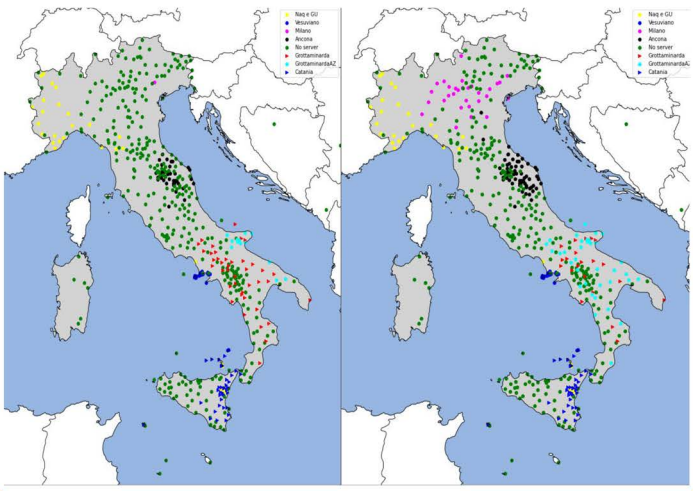
- The acquisition is performed by two redundant *SeisComP-based* systems.
- Each system acquires the same stations through different paths.
- A merge procedure is implemented to provide a single data stream for each channel to archive
- Daily completion process allows you to fill gaps with data not transmitted in real time.
- More than 30 data providers involved
- Permanent and Temporary Networks accepted

Data recovery for no-real-time data (projects and emergencies)

Data collected *on-site* during an emergency period or relating to a research project can be uploaded to the archive with an ad-hoc iter:

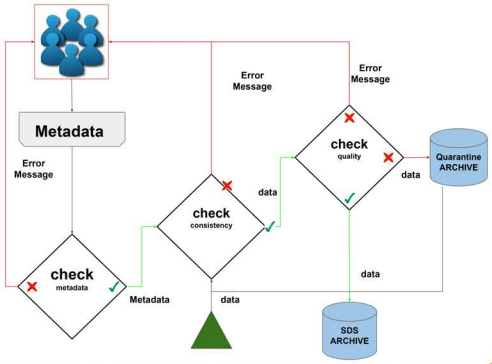
- Create a ticket in *tuleado tracking system* for network and station
- Create an issue on internal *Gitlab*
- Copy the data to a specific location on the *sds-recovery* server
- Data processing using *RUM Rule Manager*

RSN +GU +MN Station sources for HSL1 and HSL2



Eida Italian node data policy

- In order to share a *FAIR* archive with the scientific community, we have published guidelines for insert/modify stations and check data quality.
- Of particular interest is the one whereby, if a station does not comply with the imposed quality standards, it is moved to a quarantine archive.



INFRASTRUTTURE, BANCHE DATI E LABORATORI

Seismic Data Life Cycle

Massimo Fares, Ivano Carluccio, Emiliano Della Bina, Peter Danecek, Stefano Pintore, Diego Franceschi, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello*

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The EIDA Italian node data archive [*https://eida.ingv.it/en/*; Danecek et al., 2021] currently totals 130 TBytes of waveform data available for download, originating from 40 networks and 1156 stations, provided by INGV, MedNet, or contributed by various partner institutions. Geographically, it covers mainly Italy and some stations from the Mediterranean region. The archive is currently growing at a rate of approximately 15 TB/yr. INGV recently strengthened its data management capabilities, resources, and infrastructure to effectively respond to the growing scale of station inventory, Archive, and volumes of delivered data, and to acknowledge increasing attention toward open data sharing, appropriate attribution, and FAIR principles (Findability, Accessibility, Interoperability, and Reuse), as well as higher demands on data quality and expectations of the scientific user community. To this end, it established a dedicated internal unit in charge of all relevant activities related to the Italian EIDA node: the EIDA-Italia-Team. In these last years the Team is doing a brand new Data Management (thanks to a new Data Management Plan) exploiting new technologies and a modern approach; this is a long term work in progress but some new features are already in place and the others are coming soon in production.

References

Danecek, D., Pintore, S., Mazza, S., Mandiello, A., Fares, M., Carluccio, I., et al., (2021). *The Italian Node of the European Integrated Data Archive*. Seismological Research Letters 92 (3): 1726–1737. https://doi.org/10.1785/0220200409

GIORNATA ONT martedì 14 novembre 2023

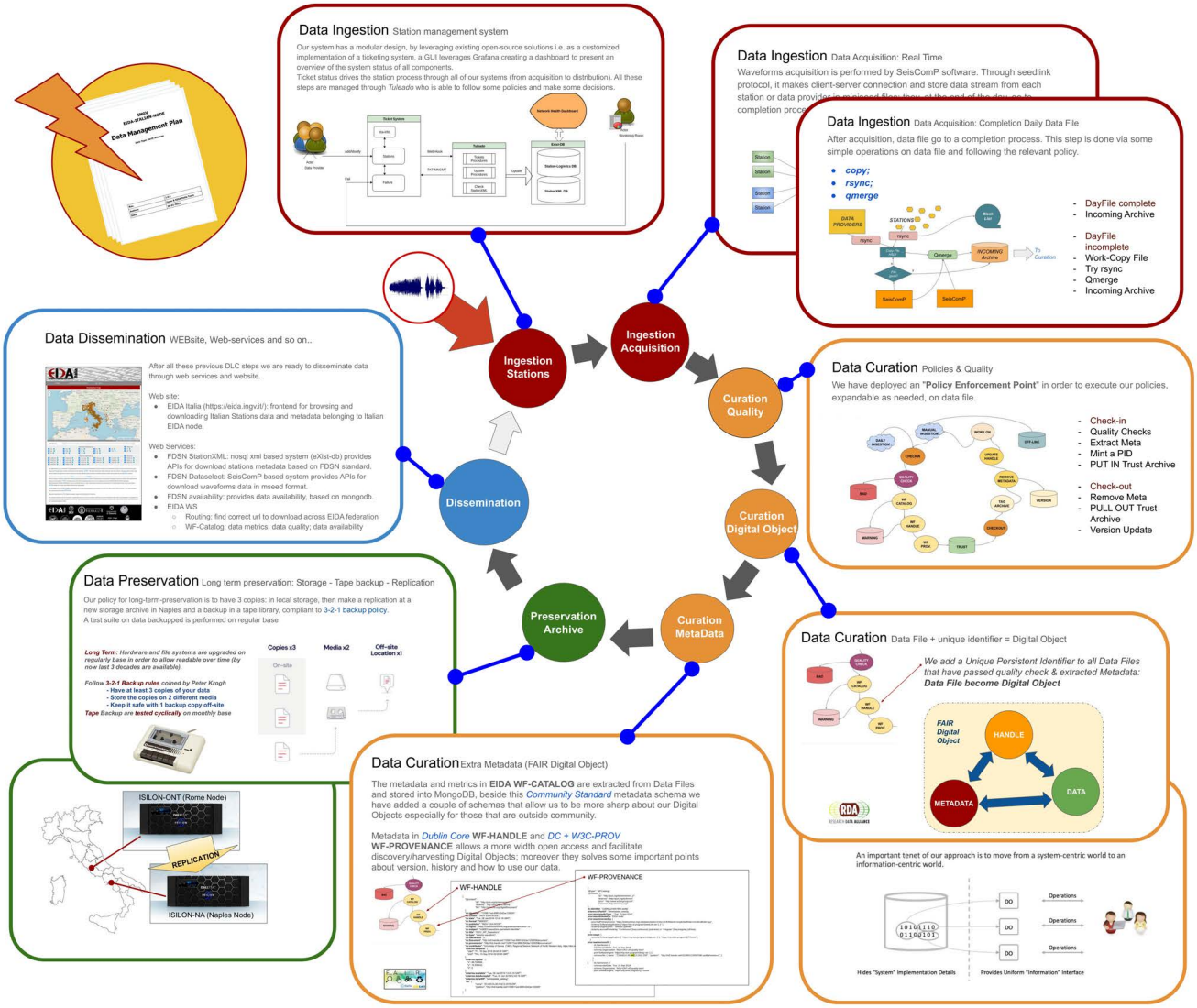
INGV-EIDA Italian node:
Seismic Data Life Cycle

Fares M., Carluccio I., Daneck P., Della Bina E., Franceschi D., Mandiello A., Maniscalco M., Pintore S., Tavani F.

The **Orfeus** European Integrated Data Archive (**EIDA**) provides a federated approach to the dissemination of seismological waveform data and ensures access to 12 regional seismological data centers: the EIDA nodes. The Istituto Nazionale di Geofisica e Vulcanologia (**INGV**) is one of the founding partners of this EIDA federation and manages the EIDA data distribution node in Italy. **INGV** has actively managed the smaller MedNet archive **since 1990** and adopted a more comprehensive and systematic approach to seismological data archiving since 2007.

The **Italian EIDA node** data archive currently totals **130 TBytes** of waveform data available for download, originating from 40 networks and **1156 stations**, provided by INGV, MedNet, or contributed by various partner institutions. Geographically, it covers mainly Italy and some stations from the Mediterranean region. The archive is currently growing at a rate of approximately **15 TB/yr**. INGV recently strengthened its data management capabilities, resources, and infrastructure to effectively respond to the **growing** scale of **station** inventory, **Archive**, and **volumes** of delivered **data**, and to acknowledge increasing attention toward open data sharing, appropriate attribution, and **FAIR** principles (Findability, Accessibility, Interoperability, and Reuse), as well as higher demands on **data quality** and expectations of the scientific user community. To this end, it established a dedicated internal unit in charge of all relevant activities related to the Italian EIDA node: the ***EIDA-Italia-Team***.

In these last years the *Team* doing a brand new Data Management (thanks to a new **Data Management Plan**) exploiting **new technologies** and a **modern approach**; this is a long term working in progress but some new features are already in place and the others are coming soon in production.



INFRASTRUTTURE, BANCHE DATI E LABORATORI

Data Curation: toward FAIR data

Massimo Fares, Diego Franceschi, Ivano Carluccio, Emiliano Della Bina, Peter Danecek, Stefano Pintore, Michele Maniscalco, Flavia Tavani, Alfonso Giovanni Mandiello*

INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy

**Corresponding author: alfonso.mandiello@ingv.it*

In 2014, a set of fundamental principles were developed to enhance the reusability of research data. They represent a set of guidelines and best practices designed to ensure that data or any digital object is "*Findable*, *Accessible*, *Interoperable*, *and Reusable*", known as the FAIR data principles [Wilkinson et al., 2016; De Smedt et al. 2020]. So, ideally, open research data can be reused or redistributed without restrictions, but open data sharing increases their exposure, thereby necessitating continuous control and ongoing checks to ensure research reproducibility and facilitate broader collaborative efforts. For these reasons, a virtuous path has been initiated and is well underway to enhance the qualification of seismic data stored at ONT. This involves developing tools for data control, qualification, and the calculation of various metrics useful for quality control of both data and metadata. Finally, a long-term goal is to achieve CoreTrustSeal certification for the seismic data repository. In detail, we have embarked on the two necessary paths: the first is to make the input, control, and distribution of metadata, more efficient; the second point is to establish a data policy that enables checks, as automated as possible, consistency and their coherence with the metadata. To achieve this, we have implemented a Policy Enforcement Point (PEP) called RUM, which is a rule manager developed in-house, using YML files, it describes the policies to be applied to our data files. Additionally, we have developed two new metadata schemes, WF-Handle and WF-Provenance, which assist in accurately describing our data. These schemes enable users to interact with our data more effectively and with greater awareness.

References

De Smedt, K., Koureas, D., Wittenburg, P. (2020). *FAIR Digital Objects for Science: From Data Pieces to Actionable Knowledge Units*. Publications 2020, 8, 21. https://doi.org/10.3390/publications8020021

Wilkinson, M., Dumontier, M., Aalbersberg, I. *et al.* (2016). *The FAIR Guiding Principles for scientific data management and stewardship*. *Sci Data* 3, 160018. https://doi.org/10.1038/sdata.2016.18

GIORNATA ONT martedì 14 novembre 2023

INGV-EIDA Italian node:
Data Curation: toward FAIR data

Fares M., Carluccio I., Daneck P., Della Bina E., Franceschi D., Mandiello A., Maniscalco M., Pintore S., Tavani F.

RUM in a nutshell

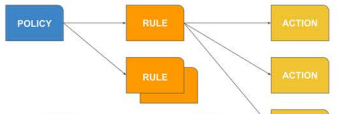
*INGV **RU**le **M**anager*

Rum is a framework that implement a Policy Enforcement Point (PEP) in order to apply some policies on a INGV-EIDA-Italia datafile.

Rum give the capability to choose a sequence of processings to be applied to a given file and can execute this task ***on-demand*** *(terminal mode)* or react an ***event*** *(daemon mode)*.This task is performed by **Policy**, **Rules** and **Action**.

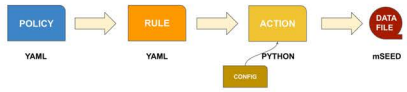
Rum is written in Python 3.8 and use Docker.

Policy, Rules and Actions: Rum model



We have a **Policy** that contains one or more **Rules** ordered in sequence which, in turn, have within one or more **Actions** that are executed in a specified order.
Actions are atomic-idempotent process.

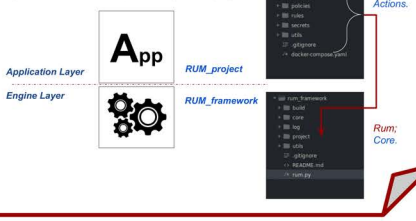
Policy, Rules and Actions: Rum implementation



Policies and **Rules** are yaml file that declare sequences, orders and behavior;
Actions are actually a python classes that are executed on a datafile with own configuration.

Rum Stack

We have the **Engine Layer** that contains a **Project**; these component are in two separate containers. This configuration allow us to decouple the engine from projects.



In 2014, a set of fundamental principles, known as the **FAIR data principles**, were developed to enhance the reusability of research data. They represent a set of guidelines and best practices designed to ensure that data or any digital object is **Findable, Accessible, Interoperable,** and **Reusable**

So, ideally, **open research data** can be reused or redistributed without restrictions, but open data sharing increases their exposure, thereby necessitating continuous control and ongoing checks to ensure research reproducibility and facilitate broader collaborative efforts.

For these reasons, a virtuous path has been initiated and is well underway to enhance the qualification of seismic data stored at **ONT** (INGV National Earthquake Observatory). This involves developing tools for data control, qualification, and the calculation of various metrics useful for quality control of both data and metadata. Finally, a long-term goal is to achieve **CoreTrust Seal certification** for the seismic data repository. In detail, we have embarked on the two necessary paths: the first is to make the input, control, and distribution of metadata, more efficient; the second point is to establish a **data policy** that enables checks, as automated as possible, consistency and their coherence with the metadata.To achieve this, we have implemented a **Policy Enforcement Point** (PEP) called **RUM**, which is a rule manager developed in-house, using Python and YAML files, it describes the policies to be applied to our data files. Additionally, we have developed two **new metadata schemes**, **WF-Handle** and **WF-Provenance**, which assist in accurately describing our data. These schemes enable users to interact with our data more effectively and with greater awareness.

The purpose of persistent identifiers (PID)

"In all areas of science the amount of stored data grows rapidly and more and more relations between these data and other resources become essential for science as for instance references to scientific publications. It turns out that scientific institutions need to develop a strategy for the long term preservation of their scientific resources, in order to ensure its long-lasting accessibility.

In the scientific community it is therefore increasingly necessary that the resources are registered in well-kept repositories with a content, that is never changing and which can be referenced and cited this way. Furthermore these references themselves have to be stable whereas the underlying repositories are more like "living organisms" with an often migration on various levels like changes in hardware, software, physical place or format. Because of these alterations the currently often used URLs with their physical paths and semantical contents, which are frequently outdated after a couple of years, are not suitable any more.

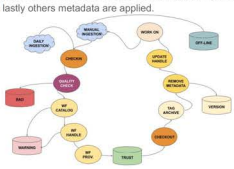
Science needs new methods to reference the primary and secondary scientific data in order to name these data in a unique and timeless way like the ISBN numbers for books, which are permanent and citable references to the related books. For the resolution of such unique and persistent identifiers (PID) one needs a commonly agreed process and due to the importance of the resolution of the references to actual URLs for a lot of transactions, the needed global resolution service has to have a high degree of robustness and reliability in the long-term."

FAIR Digital Object

- **Digital Object**: "A digital object is a data structure whose principal components are digital material, or data, plus a unique identifier for this material, called a handle"
  - *Kahn and Wilensky, 1995 (http://www.cnri.reston.va.us/k-w.html).*
- **FAIR:** (Findable, Accessible, Interoperable, Reusable) - *Wilkinson et al. 2016.* "Digital Objects have the built-in capability to implement FAIR data"
  - *George Strawn, 2019.*
- **FAIR Digital Object:** "..is a stable actionable unit that bundles sufficient information to allow the reliable interpretation and processing of the data contained in it"
  - *De Smedt, K., Koureas, D. and Wittenburg, P., 2020.*
- **More info**: https://www.go-fair.org/today/fair-digital-framework/

Policies & Quality

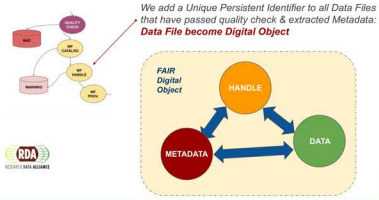
E.g. our 'checkin' policy do this: after pass sanity check and quality assessment, data file is directed to extract community metadata and metrics, then is turned from data file into digital object, lastly others metadata are applied.



- Check-in
- Quality Checks
- Extract Meta
- Mint a PID
- PUT IN Trust Archive

- Check-out
- Remove Meta
- PULL OUT Trust Archive
- Version Update

Data File + unique identifier = Digital Object



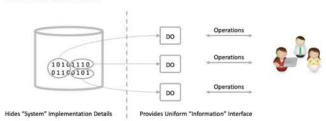
Extra Metadata (FAIR Digital Object)

The metadata and metrics in EIDA WF-CATALOG are extracted from Data Files and stored into MongoDB, beside this Community Standard metadata schema we have added a couple of schemas that allow us to be more sharp about our Digital Objects especially for those that are outside community.
Metadata in Dublin Core WF-HANDLE and DC + W3C-PROV WF-PROVENANCE allows a more width open access and facilitate discovery/harvesting Digital Objects; moreover they solves some important points about version, history and how to use our data.



From system-centric To information-centric

An important tenet of our approach is to move from a system-centric world to an information-centric world.



Handle resolver: a Digital Object approach

- *Provides uniform 'information' interface*
- *Easy to use*
- *DO Citation (ePIC-PID)*
- *Availability ensured to decades*
- *Hides system details*



https://www.doi.org/11099/11ed-996f-0242ac120005	:: latest version
http://www.handle.net/11099/11ed-996f-0242ac120005	:: latest version
11099/11ed-996f-0242ac120005**#version=1**	:: specific version
11099/11ed-996f-0242ac120005**#metadata**	:: DC metadata (WF-HANDLE)
11099/11ed-996f-0242ac120005**#provenance**	:: provenance (WF-PROV)
11099/11ed-996f-0242ac120005**#document**	:: doc of file (Human readable)
11099/wf-search/**flat; lon; rad; dstart; dend;**	:: list of PID in that area at given time-window

INFRASTRUTTURE, BANCHE DATI E LABORATORI

GAIA-IV: the new version of the INGV seismic data logger

Leonardo Salvaterra*, Sandro Rao, Catello Acerra, Massimiliano Vallocchia, Massimo Perfetti, William Thorossian, Ulderico Piccolini, Fabio Criscuoli, Augusto Bucci, Paolo Strappaveccia, Edoardo Giandomenico, Carlo Salvaterra

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GAIA-IV is the new data logger, designed and built in INGV - Rome laboratories, with improved features compared to the old model GAIA2 [Salvaterra e Rao, 2013], widely used in the National Seismic Network [Salvaterra et al., 2008].
To anticipate the obsolescence of the GAIA2 system components, the development project of the new GAIA-IV started in 2014. Several prototypes have been built over the years, culminating in the current design. The aim was to include next-generation, energy-efficient components that are easy to procure over time. The project was completed in 2020, while production of the first 100 systems was delayed due to pandemic and the resulting electronic chip crisis.
The technical features include 6 channels (3 independent - 9 optional), up to 2000 sps (one channel), temporal precision ±20 µsec TVCXO GPS synchronized and manual date setting, 2 USB port, FTP server, SSH server, WEB server, mass centering, information of temperature, input voltage and current, GPS status, sensor mass position (6 channels), current consumption of sensors, ABS case (IP66), LCD display, LED and membrane switches and finally wall or DIN rail fixing.
Finally, to proceed with the configuration and status control of GAIA-IV, communication via WEB interface was chosen without any additional software to be installed. The new interface, developed in PHP, is structured with tabbed graphics and has been designed so that it can be viewed correctly not only from a PC - Tablet, but also with a Smartphone, regardless of the S.O.

References

Salvaterra, L., e Rao, S., (2013). *Nuova interfaccia WEB della stazione sismica digitale GAIA2*. Rapp. Tec. INGV, 251: 1:42. https://doi.org/10.13127/rpt/251

Salvaterra, L., Pintore, S., Badiali, L., (2008). *Rete sismologica basata su stazioni GAIA*. Rapp. Tec. INGV, 68: 1:28. https://editoria.ingv.it/archivio_pdf/rapporti/67/pdf/rapporti_68.pdf

GIORNATA ONT martedì 14 novembre 2023

GAIA IV

THE NEW VERSION OF THE INGV SEISMIC DATA LOGGER

Salvaterra L., Rao S., Acerra C., Vallocchia M., Perfetti M., Thorossian W., Piccolini U., Criscuoli F, Bucci A., Strappaveccia P., Salvaterra C.

Storia

GAIA IV è il nuovo acquisitore sismico, progettato e realizzato nei laboratori di Ricerca e Sviluppo dell'INGV - Roma, con caratteristiche migliorate rispetto al vecchio modello GAIA2, ampiamente utilizzato nella Rete Sismica Nazionale. Per anticipare l'obsolescenza dei componenti del sistema GAIA2, nel 2014 è partito il progetto di sviluppo del nuovo acquisitore GAIA IV. Nel corso degli anni sono stati realizzati diversi prototipi che hanno consentito di raggiungere il progetto attuale. Lo scopo era inserire componenti di nuova generazione, a basso consumo energetico e di facile reperibilità nel tempo. Il progetto è stato ultimato nel 2020, mentre la produzione dei primi 100 sistemi si è prolungata nel tempo causa pandemia e la conseguenza crisi dei chip elettronici.

Attualmente sono installate 5 stazioni GAIAIV nella RSN ed in particolare a Rocca di Papa, Santa Maria delle Mole e sede INGV di Roma (RM), a Giuliano di Roma e Guarcino (FR).

Progetto

Sviluppate 4 schede con oltre 10 pagine di progetti Orcad, scritte oltre 5 mila righe di codice in linguaggio C, sia a basso livello (microprocessore) sia ad alto livello (ambiente Linux):

1. Scheda GAP (GAIA Acquisition Processing):

Basata su processore Cortex M3 a 32 bit della Energymicro

Gestisce e controlla 2-3 Moduli GADU per un totale di 6-9 canali sismici a 24 bit

Dispone di Clock autonomo su RTC con PLL

Si interfaccia con il GPS SIRF IV a doppia antenna

Gestisce la sincronizzazione del RTC con il GPS per time UTC

Memorizza i dati su SD in contemporanea alla telemetria RT

Ospita il modulo ARM 32bit Engicam con sistema operativo Linux

2. GADU (GAIA Analog to Digital Unit)

Stadio a 3 canali a 24 bit alta dinamica e basso rumore

Riferimenti di tensione ultra precisi

Stadio di alimentazione innovativo low power

Comunica con Modulo GAP tramite interfaccia SPI

3. PANIT (Panel Interface)

Gestione display, LED Ethernet-WIFI e pulsanti a membrana

Interfacce Bluetooth e WIFI e modulo GPS—L80 interno con eventuale antenna amplificata e due connettori USB per collegare le memorie di massa.

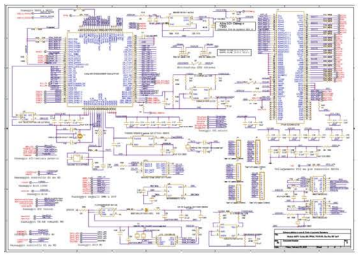
4. GPS4 (modulo GPS esterno)

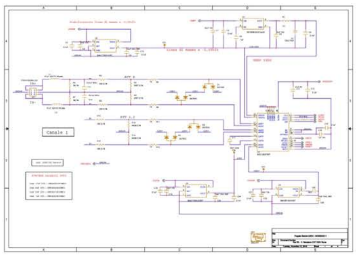
Telemetria RS485 per raggiungere distanze superiori ai 100m

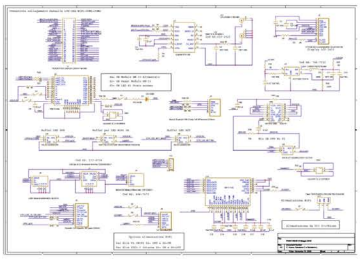


Caratteristiche tecniche

Canali	6 di cui 3 completamente indipendenti, opzionali 9
Risoluzione ADC	24 bit
Dinamica	~130dB
Data Format	MiniSEED—SeisComp ver 3.2 (2014.071)
Fondo scala ingresso sensori	2, 2.5, 4, 5, 8, 10, 16, 20, 40 Vp-p
Campionamenti	2000 (un canale), 1600, 1000, 800, 500, 250, 200, 125, 100, 50, 40, 20, 10, 1.
Precisione temporale e sincronizzazione	±20 µsec* TVCXO sincronizzato GPS, impostazione manuale data
Sistema Operativo	Linux kernel 4.1.36
Temperature	Fully specified -20 to +50C Operative -40 to +70C
Interfacce	2 prese USB, FTP, SSH e WEB server.
Controllo sensori	Centraggio masse su comando
Altre informazioni	Temperatura, tensione e corrente in ingresso, status GPS, misura posizione masse (6 canali), corrente assorbita sensori
Memoria	128MB o 256 MB RAM, 256MB NAND Flash
Network	Ethernet (10/100BT) WIFI, Bluetooth
Connessione seriale	1 porta console 115200 baud rate tramite USB
Media	Secure digital da 16GB (espandibile fino a 64GB). Possibilità di utilizzo di due penne USB fino a 64GB
Alimentazione	Ingresso 9-36 VDC ~1,2 W 3-canali ~1,6 W 6-canali
Box	Materiale ABS, grado di protezione IP66, dimensioni 227 x 237 x 84 mm, display, LED indicatori e pulsanti a membrana, fissaggio a parete o su guida DIN







Interfaccia WEB

Sviluppata completamente in PHP, la nuova interfaccia WEB della GAIA IV è strutturata con una grafica a schede selezionabili con i rispettivi TAB posti in alto. Attraverso quest'interfaccia è possibile procedere sia alla configurazione sia alla verifica dello status dell'intera stazione sismica (tutte le informazioni riportate sono in inglese) senza ulteriori software da installare. La struttura grafica è stata progettata in modo da potersi visualizzare correttamente, oltre che da PC - Tablet, anche con uno Smartphone, indipendentemente dal S.O.



INFRASTRUTTURE, BANCHE DATI E LABORATORI

Laboratory of Geophysical and Seismometric Instrumentation

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In seismological research, and in scientific fields in general, the choice of the necessary devices to equip an experiment depends on an assessment of the parameters stated by the manufacturer in the technical datasheets of the devices themselves. The problem is that these parameters are almost always only indicative. In the ONT's Geophysical Instrumentation and Seismometry Laboratory, which is in operation at the Rome office, acquisition devices and sensors are characterized through the design and development of specific measuring benches for each physical magnitude, in order to achieve accurate measurements in compliance with the reference standards for determining measurement uncertainty. In our poster presented at the "Giornata ONT 2023" we illustrated the measurement of electrical power absorption by different seismic stations under different operating conditions, to verify both the accuracy of the values reported in the datasheets, and to compare the different devices being used at our Institute [Strappaveccia e Rao, 2023]. Knowledge of this parameter facilitates appropriate sizing of the photovoltaic panel-based power system, in order to ensure continuous operation of remote seismic stations regardless of weather conditions.
We also introduced the measurement of the resolution of seismic digitizers by showing the instrumentation required to make a measurement bench with a specific communication bus and dedicated software for control using a PC. During the event we also showed our visitors our laboratory.

References

Strappaveccia, P., Rao, S., (2023). *Misura della potenza elettrica assorbita da diverse stazioni sismiche.* Rapp. Tec. INGV, 460: 1-28, https://doi.org/10.13127/rpt/460

GIORNATA ONT martedì 14 novembre 2023

Il Laboratorio di Strumentazione Geofisica e Sismometria

P. Strappaveccia, S. Rao

Abstract

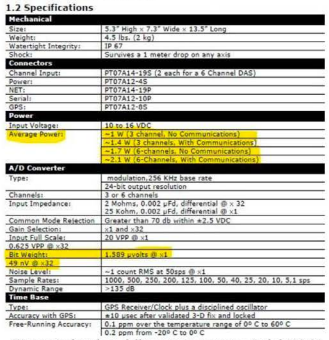
In seismometric research, and in scientific fields in general, the choice of the necessary devices to equip an experiment depends on an assessment of the parameters stated by the manufacturer in the technical datasheets of the devices themselves. The problem is that these parameters are almost always only indicative. At our Laboratory of Geophysical and Seismometric Instrumentation, acquisition devices and sensors are characterized through the design and development of specific measuring benches for each physical magnitude, in order to achieve accurate measurements in compliance with the reference standards for determining measurement uncertainty.

CARATTERIZZAZIONE DEGLI ACQUISITORI SISMICI

Nel nostro laboratorio intendiamo misurare, per tutti gli acquisitori in uso presso la RSNI, i seguenti parametri con i canali settati a diversi guadagni e a diverse velocità di campionamento:

1. Power Consumption
2. Input Impedance
3. Bit Weight
4. AC Full Scale
5. Input Shorted Offset
6. Self-Noise
7. Dynamic Range
8. Analog Bandwidth
9. Crosstalk
10. Time Tag Accuracy

Alcuni dei parametri sopra elencati sono inseriti nel datasheet dell'acquisitore Reftek130-01 mostrato in fig.1. Quelli evidenziati in giallo sono di seguito trattati.



1.2 Specifications

Mechanical	
Size:	5.3" High x 7.3" Wide x 13.5" Long
Weight:	4.5 lbs. (2 kg)
Watertight Integrity:	IP 67
Shock:	Survives a 1 meter drop on any axis
Connectors	
Channel Inputs:	PT07A14-19S (2 each for a 6 Channel DAS)
Power:	PT07A12-4S
NET:	PT07A14-19P
Serial:	PT07A12-10P
GPS:	PT07A12-8S
Power	
Input Voltage:	10 to 16 VDC
Average Power:	~1 W (3 channel, No Communications)
	~1.4 W (3 channels, With Communications)
	~1.7 W (6-channels, No Communications)
	~2.1 W (6-Channels, With Communications)
A/D Converter	
Type:	modulation, 256 KHz base rate
	24-bit output resolution
Channels:	3 or 6 channels
Input Impedance:	2 Mohms, 0.002 µFd, differential @ x 32
	25 Kohm, 0.002 µFd, differential @ x1
Common Mode Rejection:	Greate: than 70 db within ±2.5 VDC
Gain Selection:	x1 and x32
Input Full Scale:	20 VPP @ x1
	0.625 VPP @ x32
Bit Weight:	1.589 µvolts @ x1
	49 nV @ x32
Noise Level:	~1 count RMS at 50sps @ x1
Sample Rates:	1000, 500, 250, 200, 125, 100, 50, 40, 25, 20, 10, 5,1 sps
Dynamic Range	>135 dB
Time Base	
Type:	GPS Receiver/Clock plus a disciplined oscillator
Accuracy with GPS:	±10 usec after validated 3-D fix and locked
Free-Running Accuracy:	0.1 ppm over the temperature range of 0° C to 60° C
	0.2 ppm from -20° C to 0° C

Figura 1: datasheet dell'acquisitore sismico Reftek130-01

MISURA DELLA POTENZA ELETTRICA ASSORBITA DA DIVERSE STAZIONI SISMICHE

Le misurazioni di potenza elettrica assorbita dagli acquisitori sismici sotto diverse condizioni di utilizzo sono state effettuate utilizzando un wattmetro Yokogawa WT310E dotato di interfaccia ethernet. Gli acquisitori studiati sono stati i seguenti [Strappaveccia P., Rao S.]:

- Lunitek AtlasC
- INGV GAIA2
- INGV GAIAIV (prototipo)
- Nanometrics Centaur CTR46S
- Quanterra Q3306CH
- Reftek 130-01
- Nanometrics Pegasus

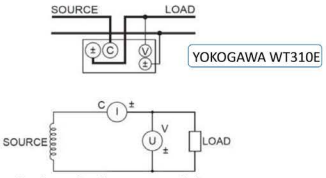


Figura 2: schema di collegamento tra l'alimentatore (source), il wattmetro (C,V) e l'acquisitore (load).



Figura 3: banco di misura per la potenza elettrica assorbita con acquisitore Quanterra Q330

Serie	Acquisitore - Condizioni sperimentali	Potenza dichiarata (W)	Potenza misurata (W)
1	Lunitek Atlas-C - canali attivi, registrazione, sensori non collegati, batteria full	< 2	1,990 ± 0,005
2	Lunitek Atlas-C - canali attivi, registrazione e trasmissione dei dati (4G), sensori collegati, batteria full	n.d.	4,40 ± 0,01
3	Lunitek Atlas-C - canali attivi, registrazione e trasmissione dei dati (4G), sensori collegati, batteria in ricarica	n.d.	17,39 ± 0,04
1	INGV GAIA2 - canali attivi, registrazione, sensori non collegati	4,8	4,78 ± 0,01
2	INGV GAIA2 - canali attivi, registrazione e trasmissione dei dati (ethernet), sensori collegati	n.d.	5,32 ± 0,01
1	INGV GAIAIV - canali attivi, registrazione, sensori non collegati	1,8	1.801 ± 0,005
2	INGV GAIAIV - canali attivi, registrazione e trasmissione dei dati (ethernet), sensori collegati	n.d.	2,491 ± 0,005
1	Nanometrics Centaur - canali attivi, registrazione, sensori non collegati	1,2	1,260 ± 0,005
2	Nanometrics Centaur - canali attivi, registrazione e trasmissione dei dati (ethernet), sensori collegati	n.d.	1,996 ± 0,005
1	Quanterra Q330 - canali attivi, registrazione, sensori non collegati, nessun SEEDlink server	< 0,8	1,068 ± 0,004
2	Quanterra Q330 - canali attivi, registrazione, e trasmissione dei dati (seriale), sensori collegati, no SEEDlink server	n.d.	2,142 ± 0,005
1	Reftek 130 - canali attivi, registrazione, sensori non collegati, nessun SEEDlink server	~ 1,7	1,88 ± 0,01
2	Reftek 130 - canali attivi, registrazione e trasmissione dati (wifi), si sensori, no SEEDlink server	n.d.	2,69 ± 0,01
1	Pegasus - canali attivi (3), registrazione, sensore non collegato	< 0,2	0,179 ± 0,001
2	Pegasus - canali attivi (3), registrazione, sensore collegato (Lennartz 3Dlite), no streaming dati	n.d.	0,244 ± 0,001

Tabella 1: riepilogo delle misure ottenute per ogni acquisitore nelle diverse condizioni di utilizzo

LA NORMATIVA UNI CEI 70098-3:2016 SULL'INCERTEZZA DI MISURA

Le incertezze di misura sono suddivise in due categorie:

Categoria A - *ricavabili attraverso l'elaborazione statistica di un campione di n osservazioni ripetute nelle stesse condizioni sperimentali;*

Categoria B - *ricavabili attraverso informazioni disponibili a priori e indipendenti dalle osservazioni sperimentali.*

Nel caso di un misurando y funzione di N grandezze variabili tra di loro indipendenti, ciascuna con una incertezza tipo $u(x)$ di categoria A o di categoria B, cioè $y = f(x_1, x_2, \ldots, x_n)$, la varianza composta $u^2(y)$ è data da [CEI UNI 70098-3]:

$$u_c^2(y) = \sum_{i=1}^{N} \left(\frac{\partial f}{\partial x_i}\right)^2 u^2(x_i) \qquad 1)$$

dove le derivate parziali sono calcolate nei valori medi delle grandezze medesime. L'incertezza tipo composta sarà allora la radice quadrata della varianza composta calcolata mediante la 1).

MISURA DELLA RISOLUZIONE DI DIVERSE STAZIONI SISMICHE

La risoluzione di un registratore sismico, espressa in *V/count*, (bit weight), è la minima tensione che può essere risolta dallo strumento e dipende dalla qualità del suo convertitore analogico-digitale (ADC). Lo schema dei collegamenti tra i diversi dispositivi è mostrato in fig.4:

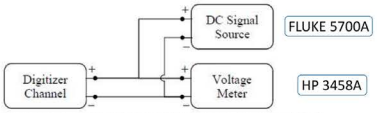


Figura 4: schema di collegamento tra l'acquisitore, il generatore di segnale e il multimetro digitale.

La risoluzione è espressa dalla seguente formula [SAND2018-11442]:

$$Ris = \frac{V_{pos} - V_{neg}}{C_{pos} - C_{neg}}$$

e l'incertezza composta:

$$u_c(y) = \sqrt{\frac{u^2(x_1)}{(\bar{x}_3 - \bar{x}_4)^2} + \frac{u^2(x_2)}{(\bar{x}_3 - \bar{x}_4)^2} + \frac{(\bar{x}_1 - \bar{x}_2)^2}{(\bar{x}_3 - \bar{x}_4)^4} u^2(x_3) + \frac{(\bar{x}_1 - \bar{x}_2)^2}{(\bar{x}_3 - \bar{x}_4)^4} u^2(x_4)} \quad \text{con} \quad \begin{cases} V_{pos} = x_1 \\ V_{neg} = x_2 \\ C_{pos} = x_3 \\ C_{neg} = x_4 \end{cases}$$

Per trasferire e salvare su un PC le misure di tensione acquisite mediante il multimetro digitale connesso tramite interfaccia GPIB, abbiamo sviluppato un'applicazione in ambiente LabVIEW, mostrata in fig.5.

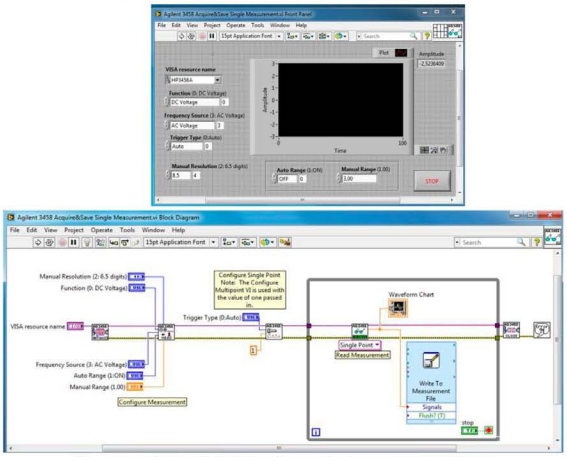


Figura 5: applicazione LabVIEW per la comunicazione con il DMM HP3458A

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Analysis of full-GNSS observations by comparing different choke-ring antennas: LEIAT vs TRM

Roberto Devoti, Mirko Iannarelli*, Grazia Pietrantonio, Andrea Terribili

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Permanent GNSS stations are often equipped with choke-ring antennas (of type Dorne-Margoline) that are especially designed to drastically reduce the multipath noise. The national RING (Rete Integrata Nazionale GNSS [INGV RING Working Group, 2016]) infrastructure is now going to carry out a major upgrade of the GNSS equipment, mainly to include full GNSS capabilities. Therefore it is interesting to screen the working, almost 20-year old, technology with the most up-to-date electronic devices in order to establish the pros and cons of those upgrades. We tested two LEIAT choke-ring antennas (LEIAT504 and LEIAT504GG), designed originally for tracking only GPS and GPS/GLONASS satellites, by scoring the acquired observations from the full-GNSS constellation. We perform a complete quality check comparing the observations of the LEIAT antennas with those of an up-to-date TRM choke ring antenna used as reference. The test sessions are carried out using the same receiver type (Trimble Alloy). Both LEIAT antennas do acquire full-GNSS observations, although the LEIAT504GG only partially, at a few percent lower rate with respect to the TRM (Trimble) antenna. The LEIAT504GG antenna apparently is unable to track the L5 band observations of both GPS and GALILEO satellites.

References

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GIORNATA ONT martedì 14 novembre 2023

Analysis of full-GNSS observations by comparing different choke-ring antennas: LEIAT vs TRM

R. Devoti, M. Iannarelli, G. Pietrantonio, A. Terribili

Abstract

Permanent GNSS stations are often equiped with choke-ring antennas (of type Dorne-Margoline) that are especially designed to drastically reduce the multipath noise. The national RING (Rete Integrata Nazionale GNSS) infrastructure is now going to carry out a major upgrade of the GNSS equipment, mainly to include full GNSS capabilities. Therefore it is interesting to screen the working, almost 20-years old, technology with the most up-to-date electronic devices in order to establish the pros and cons of those upgrades. We tested two LEIAT choke-ring antennas (LEIAT504 and LEIAT504GG), designed originally for tracking only GPS and GPS/GLONASS satellites, by scoring the acquired observations from the full-GNSS constellation. We perform a complete quality check comparing the observations of the LEIAT antennas with those of an up-to-date TRM choke ring antenna used as reference. The test sessions are carried out using the same receiver type (Trimble Alloy). Both LEIAT antennas do acquire full-GNSS observations, although the LEIAT504GG only partially, at a few percent lower rate with respect to the TRM antenna. The LEIAT504GG antenna apparently is unable to track the L5 band observations of both GPS and GALILEO satellites.



Figure 1. Test setup. Choke ring LEIAT504 (on the right) and the TRM (on the left) on the tripods.

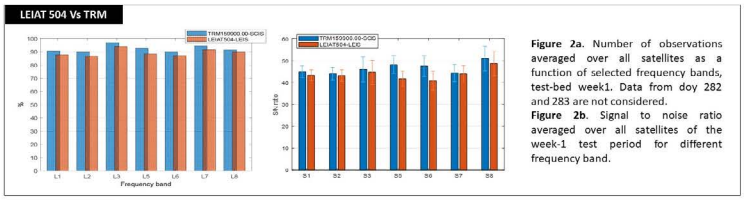


Figure 2a. Number of observations averaged over all satellites as a function of selected frequency bands, test-bed week1. Data from doy 282 and 283 are not considered.
Figure 2b. Signal to noise ratio averaged over all satellites of the week-1 test period for different frequency band.

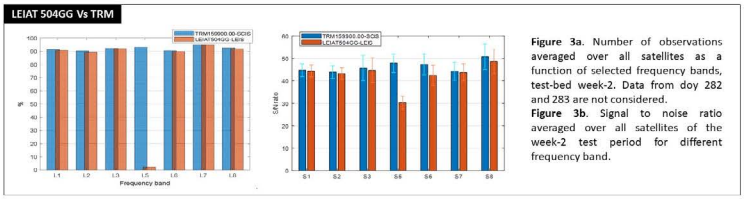


Figure 3a. Number of observations averaged over all satellites as a function of selected frequency bands, test-bed week-2. Data from doy 282 and 283 are not considered.
Figure 3b. Signal to noise ratio averaged over all satellites of the week-2 test period for different frequency band.

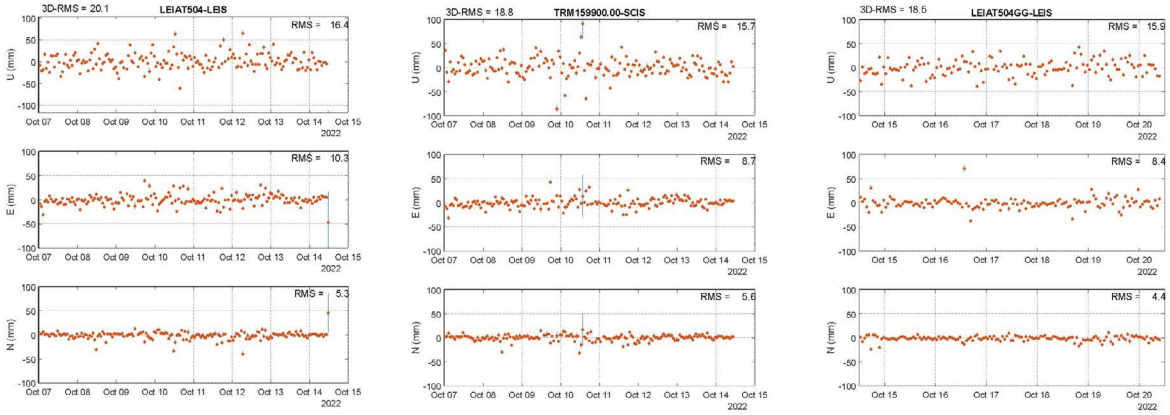


Figure 4. Hourly positions estimated using double difference L1-L2 phase observations of GPS and GLONASS satellites. Positions are given in the local vertical (up) and horizontal (east, north) reference frame. Upper two panels referee to the first week comparing LEIAT504-LEIS and TRM159900.00-SCIS antennas, the lower two panels referee to the second week where LEIAT504GG-LEIS and TRM159900.00-SCIS antennas were tested.

The experiment was conducted placed the antennas at 120 centimeters height, on the tripods and connected to the receivers using 10 meters of identical coaxial cable (**Figure 1**). The receivers were configured to acquire hourly files at 1Hz sampling rate for all satellites setting a 10° elevation cut-off. These antennas was design to reduce the indirect radiation to limit the "multipath noise".

Inspection of the data, reveals that LEIAT504 antenna looses a few percent of observations uniformly over all frequencies. The LEIAT504GG records almost all observations but missed almost completely the L5 band observations, that is, GPS third frequency and GALILEO second open frequency (**figure 3a**). Since all receiver configuration parameters are the same for the two antennas, and the choke rings are geometrically identical (**Figure 5**), we infer that LEIAT504GG suppress to some degree the low frequency L5 (1176.45 MHz), most likely in the electronic LNA or filtering unit.

The comparison of the two antennas reveal a systematic lower SNR (on average 6%) for the LEIAT504 with respect to the reference TRM antenna (**Figure 2b**). This is generally true also for the LEIAT504GG antenna, with the exception of the L5 band in which the SNR reduces to a modest value (30 dB) (**Figure 3b**). Thus both the LEIAT antennas acquire a lower signal strength on average, that could be explained by an improved gain in the amplifier chain for the up-to-date TRM antenna, but the LEIAT504GG seems designed to reject the L5 frequency and is unable to acquire the GPS and GALILEO L5 observations.

The time series of the two test antennas versus the reference TRM antenna, the coordinates and the root mean squares (RMS) are given in the Up, East and North directions (**Figure 4**). We see a worsening of 1.2 mm (in 3D) of the LEIAT504 antenna with respect to the reference TRM, whereas the LEIAT504GG show only half of that worsening (0.7 mm). This result suggest that LEIAT504GG antenna is performing better than LEIAT504, which is not surprising since the GG antenna model represents an upgrade to the previous choke ring antenna. The cons is that model GGis band-limited and does not acquire L5 observations at all.

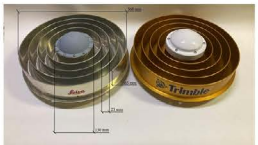


Figure 5. Comparison between the two types of antennas. Leica LEIAT504/504GG and Trimble TRM (without Radome enclosures).

INFRASTRUTTURE, BANCHE DATI E LABORATORI

MAST satellite Multimission Acquisition System for Earth Observation at INGV Rome headquarters

Dario Stelitano*, Luca Merucci, Stefano Corradini, Pietro Ficeli, Francesco Zanolin, Lorenzo Guerrieri

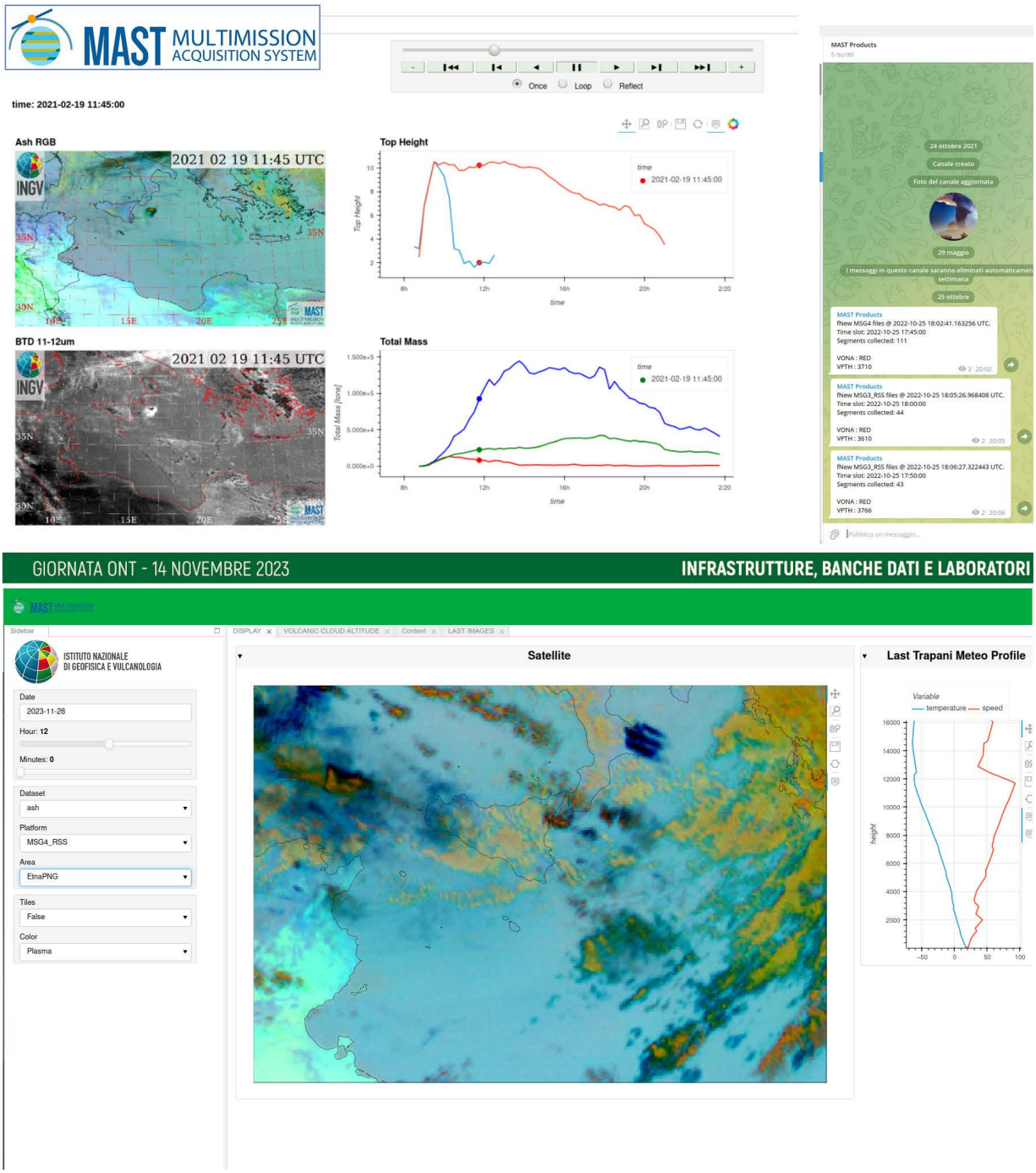
INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy

**Corresponding author: dario.stelitano@ingv.it*

This exhibit shows and describes the MAST satellite acquisition system (Multimission Acquisition SysTem [Stelitano et al., 2023]) operating at the INGV headquarters in Rome since 2019 and part of the main instrumentation of the ADEO laboratory (Earth Observation Data Acquisition) established in May 2021 by the Remote Sensing Functional Unit of the ONT section.
The EUMETSAT Consortium through the EUMETCast system distributes more than 120 Earth observation data and products (EO) in near real time acquired from instruments on board satellites in geostationary and polar orbit operated by major international space agencies.
MAST receives and processes environmental satellite data and products transmitted by EUMETCast services. The system responds to the need to provide the INGV with information on major volcanic, environmental and seismic events. It also provides the necessary infrastructure to develop and implement new monitoring and research products generated using Earth Observation data.
The MAST system has also been designed with the redundancy of its hardware and software components to increase the overall reliability of the system. Modular hardware components and open-source capture software based on Python were used in the GNU-Linux Os-based environment. These choices allow easier management of the MAST system completely controlled by INGV personnel without additional maintenance and licensing costs. All the software components are encapsulated inside Docker containers and in turn managed via Portainer GUI. This presentation describes both the hardware and software structure related to the acquisition and organization of satellite data used as the basis of the generated products.

References

Stelitano, D., Merucci, L., Ficeli, P., Zanolin, F., (2023). *Satellite Acquisition System at INGV Rome headquarters*. Rapp. Tec. INGV, 470: 134. https://doi.org/10.13127/rpt/470



The products (ash RGB, Brightness Temperature Difference, Top cloud height and Total Ash Mass) created during an eruption (top, left). The Telegram platform automatic messages (top, right). The MAST frontend dashboard and meteorological WMO profiles (bottom).

Institutional activities and research projects of the INGV-Rende headquarters

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The module presents a compendium of the institutional activities and participation in research/technical projects of the staff belonging at the INGV headquarters in Calabria.
The staff is employed in the following activities:

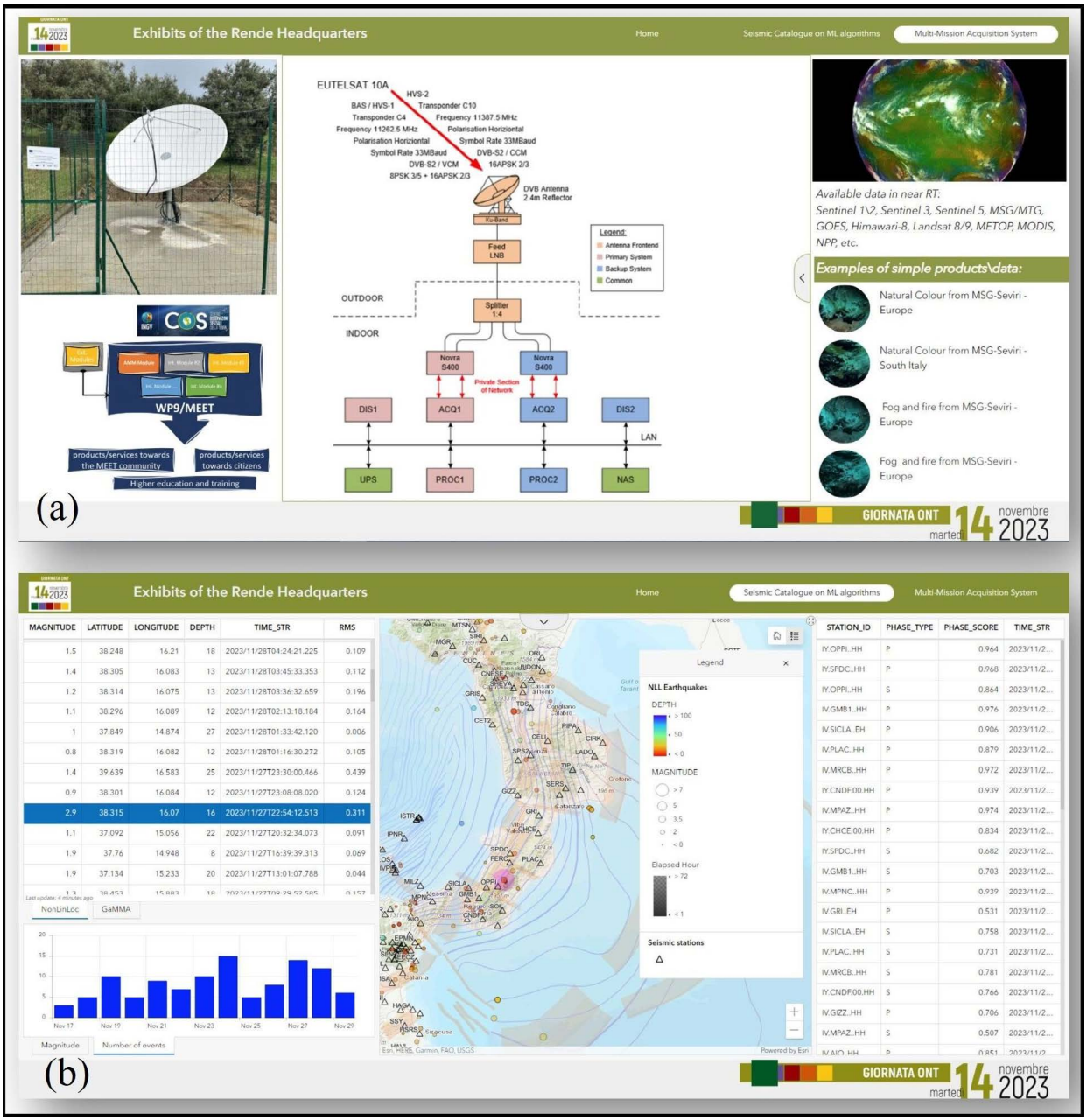
- deployment and management of the stations of seismic networks (e.g. in urban environment, historic centres and campaign) (e.g. [Caserta et al., 2016]);
- investigation activities for new sites useful for hosting new RSN stations to integrate existing ones;
- training\information activities at schools, dissemination to the public and management of relationships with public bodies in the region (Regional Civil Protection Department, Departments of the University of Calabria, municipal administrations, etc.);
- research and technical activities through participation in national and international projects: PON-MASSIMO, H2020-ARCH, PON-RAFAEL, PON-GRINT, PNRR-MEET, PD-CHIOMA, PD-GEMME;
- management of IT system, monitoring of critical infrastructures, cultural heritage and databases (e.g. [Costanzo et al., 2021]);
- support in the management of the research projects and the purchasing procedures.

Furthermore, specific exhibits will be presented on two new recent systems:
the multi-mission satellite data reception system through EUMETCast multicast service (Figure a), that was installed as part of the PON GRINT;
the first results of the implementation of a prototype seismic monitoring system (delayed by a few hours) by machine-learning-based processing (Phasenet code) of the waveforms recorded by seismic networks (Figure b).

References

Caserta, A., Doumaz, F., Costanzo, A., Gervasi, A., Thorossian, W., Falcone, S., et al., (2016). *Assessing soil-structure interaction during the 2016 central Italy seismic sequence (Italy): preliminary results*. Ann. Geophys., 59. https://doi.org/10.4401/ag-7250

Costanzo, A., Falcone, S., D'Alessandro, A., Vitale, G., Giovinazzi, S., Morici, M., et al., (2021). *Technological System for Post-Earthquake Damage Scenarios Based on the Monitoring by Means of an Urban Seismic Network*. *Sensors*, 21, 7887. https://doi.org/10.3390/s21237887



Web pages of the exhibits created for the “Giornata ONT 2023”. (a) Diagram of the satellite data reception infrastructure based on the EUMETSAT multicast service installed within the PON-GRINT project. (b) Dashboard implemented in ArcGIS Online with the list of earthquakes detected by the process based on machine learning algorithms, with indications of the phases associated with the single event.

ANALYSIS
MODELLING
INTERPRETATION OF
GEOPHYSICAL PHENOMENA

SEISMOLOGICAL

CARS - Catalog of Relative Seismic Locations of 1981-2018 Italian Seismicity

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We used the Catalog of Absolute Earthquake Locations (CLASS [Latorre et al., 2023]) as the initial dataset for generating relative locations of the same 310K events recorded by the Italian National Seismic Network (Rete Sismica Nazionale, RSN) plus permanent regional networks (PRN) occurred in Italy during 1981-2018. In detail, P- and S- waves arrival times dataset consists of data by RSN plus PRN for the period 1981-2008 and only by RSN for 2009-2018. For 2009-2018, absolute travel times data were integrated with ~17 million P- and ~23 million S-wave delay times, retrieved through a waveforms cross-correlation analysis. For the location, we used 1D velocity models pertaining to 18 different but geologically, seismically and tectonically homogeneous sub-regions of the Italian territory (after Pastori et al. in the framework of the DPC-B2 project 2019-2021, personal communication). Then, to both preserve the steady operational mode of HypoDD and to repeat hypocentral locations to be merged, we additionally discretized each area in 100x100km2 cells, spatially overlapped by the 80%. Final relative location errors estimated on the computed final weighted mean locations, were assessed by bootstrapping with replacement the final double-difference residual vector. Error ellipsoids were obtained at the 90% confidence level for 100 samples. With the new relative locations (CARS), seismicity distribution better defines local fault structures and regional alignments, testifying an improved resolution of the new catalog.

References

Latorre D., Di Stefano R., Castello B., Michele M., Chiaraluce L. (2023). *An updated view of the Italian seismicity from probabilistic location in 3D velocity models: The 1981–2018 Italian catalog of absolute earthquake locations (CLASS).* Tectonophysics, 846, 229664. https://doi.org/10.1016/j.tecto.2022.229664

GIORNATA ONT martedì 14 novembre 2023

Michele M., Di Stefano R., Chiaraluce L., Latorre D. and Castello B.

CARS - Catalog of Relative Seismic Locations of 1981-2018 Italian Seismicity

Abstract

We used the CLASS (Catalog of Absolute earthquake LocationS) catalog of the Italian seismicity (Latorre et al., 2023), as starting one for generating relative locations of the same 310K events recorded by the Rete Sismica Nazionale Integrata (RSN) plus PRN (permanent regional networks) occurred in Italy during 1981-2018. In detail, P- and S- waves arrival times dataset consists of data by RSN plus PRN for the period 1981-2008 and only by RSN for 2009-2018. For 2009-2018, absolute travel times data were integrated with ~17 million P- and ~23 million S-wave delay times, retrieved through a waveforms cross-correlation analysis. For the location, we used 1D velocity models pertaining to 18 different but geologically, seismically and tectonically homogeneous sub-regions of the Italian territory (after Pastori et al. B2-2019-2021). Then, to both preserve the steady operational mode of HypoDD and to repeat hypocentral locations to be merged, we additionally discretized each area in 100x100km2 cells, spatially overlapped by the 80%. Final relative location errors estimated on the computed final weighted mean locations, were assessed by bootstrapping with replacement the final double-difference residual vector. Error ellipsoids were obtained at the 90% confidence level for 100 samples. With the new relative locations (CARS), seismicity distribution better defines local fault structures and regional alignments, testifying an improved resolution of the new catalog.

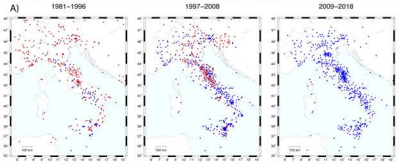
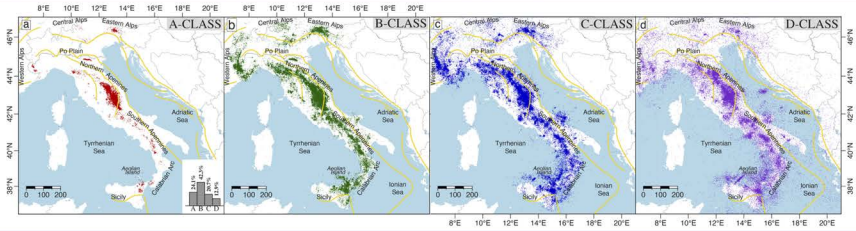


Fig 1. **Left**: Map view of seismic stations operating in Italy from 1981 to 2018, divided into three different periods (red and blue are No-INGV and INGV stations respectively). **Right**: CLASS catalog divided in different quality classes: from left to right, A, B, C and D quality respectively, where A is the best locations class while D is the worst one.



Filtering range	1-15 Hz
Maximum separation distance	10 km
Length of P-waves window	1 s
Length of S-waves window	1 s
CC coefficient threshold	0.7

Table 1. Setting used for applying the cross-correlation procedure.

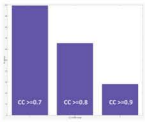
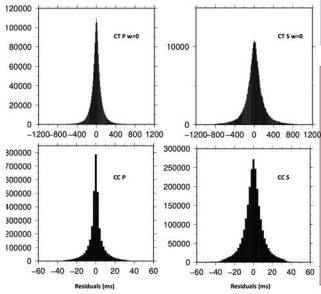


Fig 2. Histogram of events that correlate at the indicated threshold.

Fig 3. Histograms of residuals pertaining to cross-correlation (bottom) measurements and picks data with 0 weight (top).



1. Starting catalog and dataset

The CLASS catalog (Latorre et al., 2023), was obtained through the inversion of P and S wave arrival times from two different datasets: the CSI "Catalogo della Sismicità Italiana" 2.0 (Castello and Di Stefano, 2022) for the period 1981-2008 and the BSI (Italian Seismic Bulletin, http://terremoti.ingv.it/en/bsi and http://terremoti.ingv.it/en/iside) for the period 2009-2018, in order to ensure the proper data density coverage over time (Fig 1). We used the hypocenter location program NLL (NonLinLoc, Lomax et al., 2000), based on a probabilistic approach and a nonlinear, direct search inversion, method. We employed the last version of the Italian 3D Tomographic Model of Di Stefano and Ciaccio (2014) for locating the events and we added the station corrections. CLASS was quality classified via the empirical formula proposed by Michele et al. (2019) (see Fig. 1). A-class contains 25% of locations, B-class 43%, C-class 20% and D-class 11%.

From all the P and S pickings readings of CLASS, we derived the relative travel times, while limited to the period 2009-2018, we applied, in addition, the time domain cross-correlation method proposed by Schaff et al. (2004) and Schaff & Waldhauser (2005) (see selected settings in Table 1), producing additional 40 millions of P and S delay times (Fig. 2), whose cross-correlation coefficients distribution is reported in Fig. 2. The goodness of cross-correlation outputs is demonstrated by representing the residuals distribution, after the relocation, in terms of cross-correlation data, compared to catalog data (see Fig. 3).

2. CARS catalog

The previously described dataset was inverted applying the double-difference technique. We used HypoDD (Waldhauser and Ellsworth, 2000), that is steady operational in managing about 15,000 events considering the average number of available readings. For this reason, and for specifying the 1D velocity models of different areas, we first divided the Italian peninsula in 18 macro-areas, following Pastori et al., B2-2019-2021 (Wp1-task4) (see Fig. 4), and then we further discretized the area in 100kmx100km cells, overlapped for the 80% in longitude and latitude (see Fig. 4). We produced, for each area, multiple relocations of the same events, that we then merged by computing the weighted mean location. Fig. 5 reports CARS map view and different cross sections, reporting the comparison between CLASS and CARS locations. Hypocenters' uncertainties were derived from a bootstrap analysis of 100 random samples, starting from the final double-difference residual vector in each box (see Waldhauser & Ellsworth, 2000). We report in Fig. 6 the merged horizontal and vertical errors and the multiple results obtained for different regions.

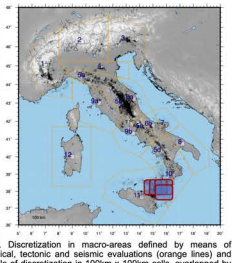
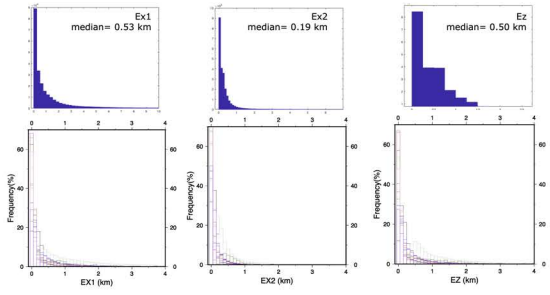


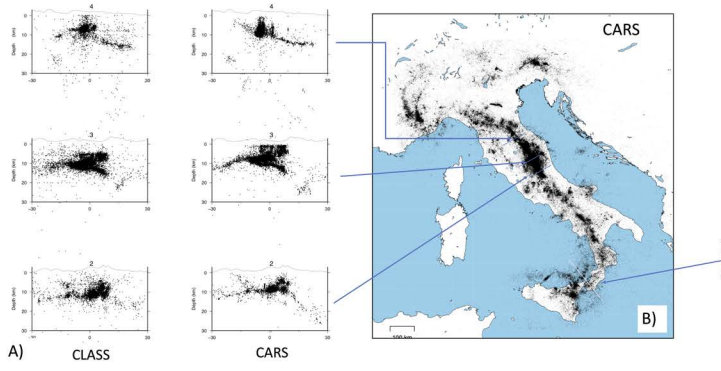
Fig 4. Discretization in macro-areas defined by means of geological, tectonic and seismic evaluations (orange lines) and example of discretization in 100km x 100km cells, overlapped by the 80% in longitude and latitude (blue squares).

3. Results

CARS, together with CLASS, is the largest (300k events) and longest (1981-2018) earthquake catalogs of the Italian seismicity with the most complete and homogeneous collections of hypocenter locations and exhaustive uncertainties positions description. It is suitable for specific applications, such as reference framework for Operational Earthquakes Forecast tests and better definitions of geological structures at local and regional scale. It can be used in monitoring systems as reference catalog to relatively improve the hypocentral resolution of new real-time events (DDRT). In addition, CARS is endowed with associated local and moment magnitude values for the 2009-2018 range.

Fig 6. Histograms reporting the distribution CARS location merged errors (i.e., the horizontal (Ex1 and Ex2) and vertical (Ez) projections of the 95% confidence ellipses) from a bootstrap analysis (top); different horizontal and vertical errors distributions for different regions.





References can be visualized here

Fig 5. A) Cross-section containing +/-2.5 km of CLASS and CARS locations projected on the traces represented in map-views, in the area of the 2016-2017 Central Italy seismic sequence. B) Map view of CARS hypocenters. C) Cross-section containing +/-100 km of CLASS and CARS locations projected on the traces represented in map-views, in the area between Sicily and Calabria.

Poster presented at the "Giornata ONT 2023".

A 10-year-long earthquake catalogue of area monitored by The Altotiberina Near Fault Observatory (Northern Apennines, Italy)

Samer Bagh[1,*], Raffaele Di Stefano[1], Adriano Gualandi[2], Marco Cattaneo[1], Debora Pantaleo[1], Carlo Calamita[1], Chiara Ladina[1], Simone Marzorati[1], Lauro Chiaraluce[1]

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We present a new earthquake catalogue 10-year-long (2010–2020) related to the activity of the Altotiberina (ATF) low-angle normal fault system (Northern Apennines of Italy). The analyzed seismicity has been recorded by the seismic network of The Altotiberina Near Fault Observatory (TABOO [Chiaraluce et al., 2014]). TABOO seismic network is a dense array of broadband and short period seismographs covering an area of 120×120 km^2. Such a network configuration allows a very low detection threshold of seismic events, resulting in a catalogue composed by high-resolution locations of almost 100,000 events with a completeness magnitude ≈ 0.1 M_L. Up to May 2013, the earthquakes composing the revised catalogue were manually treated, and since June 2013 an automatic procedure was adopted to detect phase arrival times, where pick identification is checked and refined iteratively, based on the computation of earthquake locations using the Hypoellipse code [Lahr, 1999]. Arrival times were manually revised whenever the automatic procedure fails to reach a satisfying result. As of November 2016, an updated version of the automatic detection-location system has been adopted, Including an enhanced picking scheme and NonLinLoc earthquake location code [Lomax et al., 2001]. Based on these starting locations and arrival times, we have been firstly working on the construction of a consistent MySQL-database. Then we worked on the improvement and homogenization of earthquake locations and magnitudes calculation for the new locations. Earthquake locations have been computed with the NonLinLoc, including newly estimated static station corrections.

References

Chiaraluce et al., (2014). *The Alto Tiberina Near Fault Observatory (northern Apennines, Italy)*. Ann. Geophys., 57, 3, 2014, S0327. https://doi.org/10.4401/ag-64

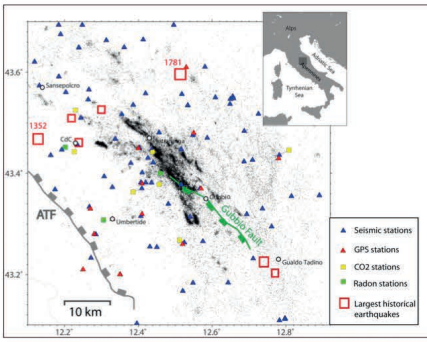
Lahr, J. C., (1999, revised 2012). *HYPOELLIPSE: a computer program for determining local earthquake hypocentral parameters, magnitude, and first-motion pattern. U.S.* Geological Survey Open-File Report, 99-23, version 1.1, 119 and software, available at http://pubs.usgs.gov/of/1999/ofr-99-0023

Lomax, A., Zollo, A., Capuano, P., and Virieux, J., (2001). *Precise, absolute earthquake location under Somma-Vesuvius volcano using a new 3D velocity model*. Geophysical Journal International, 146, 313–331.

GIORNATA ONT martedì 14 novembre 2023

A 10-year-long earthquake catalogue of area monitored by The Altotiberina Near Fault Observatory (Northern Apennines, Italy)

Samer Bagh, Raffaele Di Stefano, Adriano Gualandi, Marco Cattaneo, Debora Pantaleo, Carlo Calamita, Chiara Ladina, Simone Marzorati, Lauro Chiaraluce

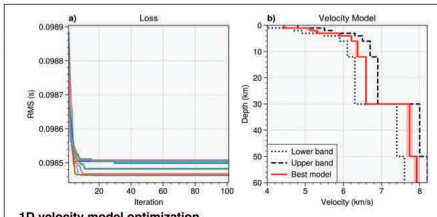


Introduction

The Alto Tiberina Near Fault Observatory (TABOO) is a multidisciplinary research infrastructure devoted to studying the Alto Tiberina Fault system (ATF) located in the Northern Apennines in central Italy.

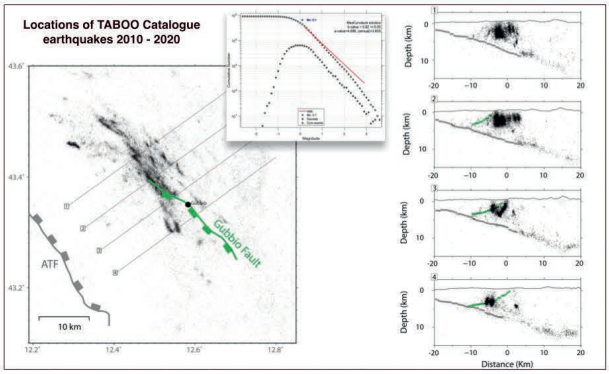
TABOO consists of seismic and geodetic networks as well as geochemical and electromagnetic stations. The seismic network is a dense array of broad band and short period seismographs covering an area of 120 x 120 km2.

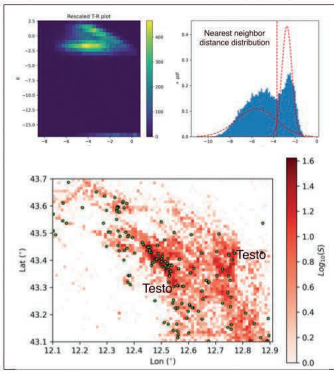
Such a seismic network configuration allowed us to obtain a catalogue composed of high-resolution locations of almost 100,000 events with magnitudes lower than 4 in the period 2010-2020 with a completeness magnitude 0.1 ML.



1D velocity model optimization

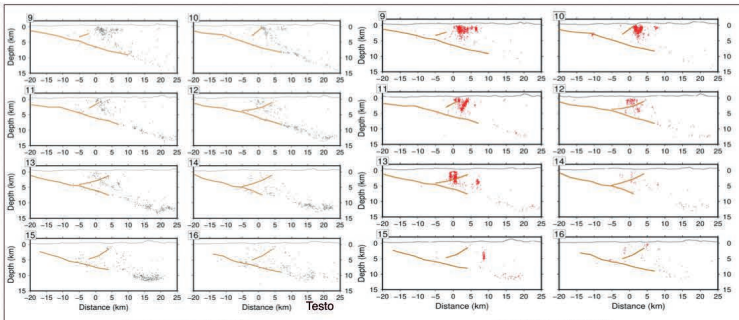
We computed the best-fit 1D Vp and Vp/Vs models by inverting P- and S-wave travel-times of a selected sub-dataset of earthquakes by a non-linear technique based on Fuzzy Self-tuning Particle Swarm Optimization (FST-PSO) (Nobile et al., 2018). In the final step we used the selected sub-dataset and the computed best-fit minimum 1D Vp and Vp/Vs velocity model to estimate static station corrections through four consecutive runs of NonLinLoc earthquake location code updating station corrections after each run.

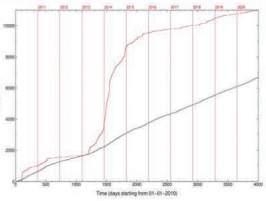




Clustering analysis

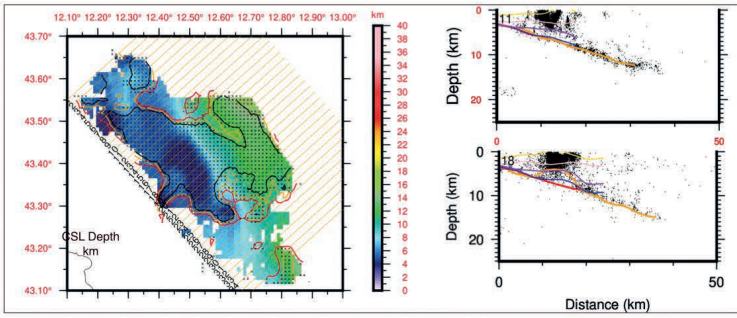
We use the clustering approach described in Zaliapin and Ben-Zion (2013). This method consists in finding the distribution of the nearest neighbor events in the space-time-magnitude space. Each event is characterized by 5 parameters describing its spatial location, its time and its magnitude.
We can thus plot the statistics of nearest neighbor distances. These histograms are typically bi-modal and can be used to separate between events that do or do not have a close nearest neighbor. Events with a close nearest neighbor are classified as clustered events, while events with the nearest neighbor farther than an empirical threshold estimated from the bi-modal distribution are considered as background events.





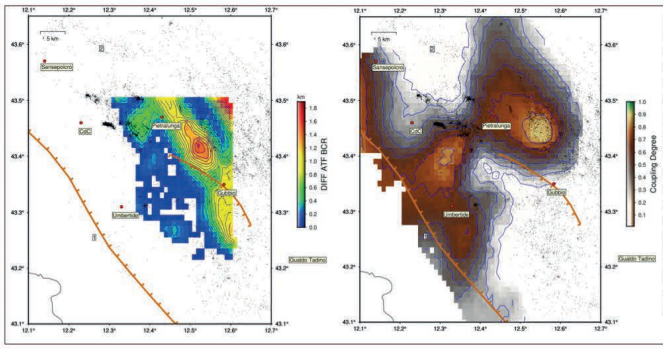
High-quality catalogs like the one here presented can help discriminating between clustered and non-clustered events, and we argue that a 3-dim analysis is preferrable if the depths of the events is well constrained. This becomes particularly crucial when studying tectonic scenarios populated by non-vertical faults.

We notice that the distribution of the clustered events in the TR plot is almost horizontal in the 2-dim analysis, while it is almost 135° inclined and parallel to the non-clustered distribution in the 3-dim analysis. Distributions with such orientation are produced by time-stationary space-homogeneous Poisson processes (Zaliapin and Ben-Zion, 2013). Our results suggest that also the clustered events might be generated by a Poisson process. This is quite different from what typically observed for mainshock-aftershock clustering and might be due to the swarm-like nature of the activity in the region.



ATF Topography

We imaged the ATF topography also in deeper volumes not covered by the active seismic survey. Due to the specificity of the ATF in this region, being the sub-horizontal limit of the crustal seismicity, we applied the robust procedure used in Latorre et al., (2023) to build the crustal seismogenic layer (CSL). Finally, we ran a bootstrap procedure with 1000 iterations, randomly sampling the dataset per cell to assess the quality of each depth estimate by the standard deviation in km. The figure shows the obtained CSL topography. The standard deviation of 1.5 km (orange solid line) is chosen to encompass the well constrained topography.
Finally we merged the ASS ATF and our interpolated one producing a new grid, where the ASS ATF surface is taken as primary and our estimated ATF surface is used only when the former is not present, thus extending the ATF geometry at depth.
It is worth noting that the ATF segment beneath the CSL uplift crosses the CB and releases very low seismicity with respect to the deeper portion of the fault, located within or along the base of the AB.



Lithology control on ATF activity?

We investigate the relationship between the ATF seismicity and the ATF vs the CB-top depth. For this purpose we performed a point to point comparison between the top of the CB and the ATF and we plot the results in terms of ATF depth minus CB-top depth, along with the ATF seismicity (earthquakes located within 1 km from the fault plane). In the map we only show the positive ATF minus CB-top differences. This map highlights that the seismicity release along the ATF is reduced where the fault surface lies below the CB top (orange, yellow and green zones). The orange spot in the figure represents the ATF surface portion located at the maximum distance in depth from the CB top. The seismic release is very low in this portion of the ATF compared to the deeper segments of the fault zone to northeast, where the fault crosses the AB or passes near the contact between the AB and the CB.

The comparison between the distribution of the ATF seismicity and the Interseismic Coupling model of Underline et al. (2016) highlights that the shallow locked area of the fault is almost devoid of seismic activity, while the deeper locked feature is characterized by a clear concentration of seismicity, although the asperity model in this portion of the fault does not predict release of seismicity, as is the case or the deeper creeping portions of the fault. Accordingly, the deeper high coupling feature might be located in correspondence with the orange spot and surrounding area shown in the previous figure where the ATF is located beneath the CB top.

ANALISI, MODELLAZIONE, INTERPRETAZIONE DI FENOMENI GEOFISICI - VULCANOLOGICI I ANALYSIS, MODELLING, INTERPRETATION OF GEOPHYSICAL PHENOMENA - VOLCANOLOGICAL

The September 18th, 2023, Mw 4.9, earthquake in the northern Apennines (Marradi, FI): the work of the BSI on the early days of the seismic sequence

Arianna Lisi*, Luca Arcoraci, Patrizia Battelli, Michele Berardi, Barbara Castello, Maria Grazia Ciaccio, Diana Latorre, Alessandro Marchetti, Maddalena Michele, Valeria Misiti, Anna Nardi, Davide Piccinini, Antonio Rossi and BSI working group**

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On September 18th, 2023, an earthquake with a magnitude of M_L 4.8 (M_W 4.9) occurred 4 km SW of Marradi (near Firenze) at a depth of ~8 kilometers. The earthquake, preceded by a foreshock with a magnitude of M_L 3.3 (M_W 3.4), triggered a seismic sequence that, in the first week, provided about 500 aftershocks localized by the staff on duty in the Seismic Monitoring Room of the INGV in Rome, including 5 earthquakes with a magnitude of $M_L \geq 3.0$.
The analysts of the BSI (Italian Seismic Bulletin [Marchetti et al., 2016]) focused on reviewing the first three days of the sequence, with particular attention to the hours immediately following the mainshock. This analysis allowed for the identification of an earthquake of M_L 3.4, occurring approximately one minute after the mainshock and missed during the surveillance service. Therefore, a thorough effort to recover smaller seismic events not analyzed in the Seismic Monitoring Room led to the localization of nearly 30% more events in the first three days.
The BSI working group revised picking of P and S phases and their proper weighting, the recovery of undetected P- and S-wave arrival times, as well as the verification of the maximum amplitudes to be used for M_L computation. Earthquakes detected in the first 3 days of the sequence were localized using a double differences location code and a regional velocity model. Simultaneously, an analysis based on the *template matching* technique was used to extract those events that the Earthworm system operating in the Seismic Monitoring Room had not identified. In this case, the number of detections increases by ~60%, highlighting the usefulness of incorporating this type of analysis as a support to the work of the BSI.

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GIORNATA ONT martedì 14 novembre 2023

Lisi A., L. Arcoraci, P. Battelli, M. Berardi, B. Castello, M.G. Ciaccio, D. Latorre, A. Marchetti, M. Michele, V. Misiti, A. Nardi, D. Piccinini, A. Rossi and BSI working group

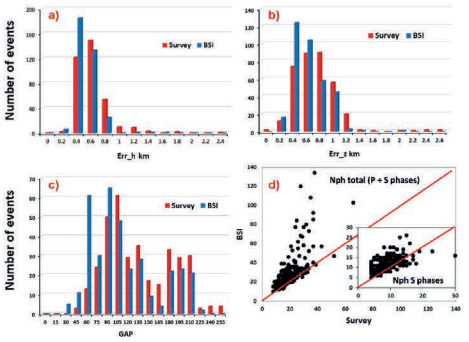
The September 18th 2023, Mw 4.9, earthquake in the northern Apennines (Marradi, FI): the work of the BSI on the early days of the seismic sequence

Abstract On September 18, 2023, an earthquake with a magnitude of Ml=4.8 (Mw=4.9) occurred 4 km SW of Marradi (FI) at a depth of ~8 kilometers. The earthquake, preceded by a foreshock with a magnitude of ML=3.3 (Mw=3.4), triggered a seismic sequence that, in the first week, provided about 500 aftershocks localized by the staff on duty in the Seismic Monitoring Room of the INGV in Rome, including 5 events with a magnitude of ML ≥ 3.0.

The analysts of the BSI (Italian Seismic Bulletin) focused on reviewing the first three days of the sequence, with particular attention to the hours immediately following the mainshock. This analysis allowed for the identification of an earthquake of ML=3.4, occurring approximately one minute after the mainshock and missed during the surveillance service. Therefore, a thorough effort to recover smaller seismic events not analyzed in the Seismic Monitoring Room led to the localization of nearly 30% more events in the first three days. The BSI work involved revised picking of P and S phases and their proper weighting, the recovery of unused phases, as well as the verification of the maximum amplitudes to be used for ML computation. Earthquakes detected in the first 3 days of the sequence were localized using a double differences location code and a regional velocity model.

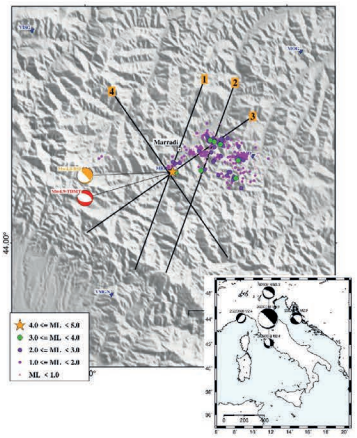
Simultaneously, an analysis based on the template matching technique was used to extract those events that the Earthworm system operating in the Seismic Monitoring Room had not identified. In this case, the number of detections increases by ~60%, highlighting the usefulness of incorporating this type of analysis as a support to the work of the Italian Seismic Bulletin (BSI).

1 Comparison between *seismic monitoring room*'s detection and revised events by BSI

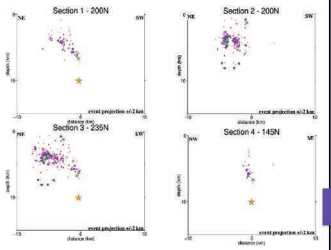


Comparison between hypocentral parameters (figures a, b c) and used time readings (figure d) of the two datasets. Comparison refers to the 352 earthquakes common to both datasets.

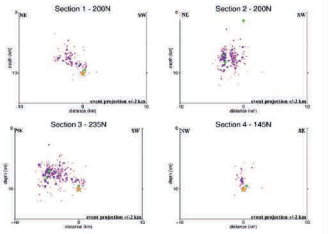
2



Probabilistic hypocenter location of the 498 events occurred in the first 3 days of the sequence and revised by the BSI working group. We apply the NonLinLoc code (Lomax et al., 2009) with a 1D regional velocity model and computed station corrections (Latorre & Di Stefano, **contribution IDL-17**). Beach balls represent the two focal mechanisms available for the main shock (in red the TDMT solution from Scognamiglio et al., 2006; in orange the BSI solution, Ciaccio et al., 2021). The black lines and relative numbers indicate the vertical cross sections shown in panel 2 and 3. The inset map shows the focal mechanisms of some aftershocks with ML>2 calculated using the polarity of P-phase.

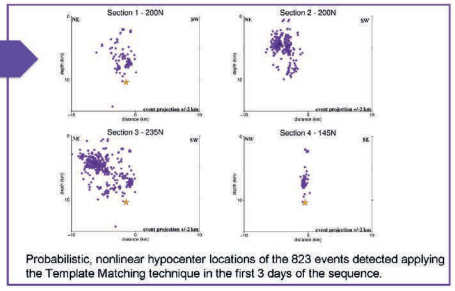


Probabilistic, nonlinear hypocenter locations of 498 events revised by the BSI in the first 3 days.

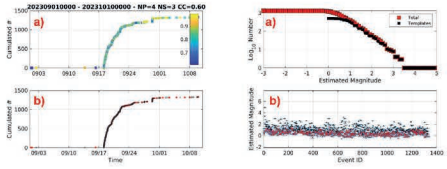


Relative hypocenter relocations calculated with double difference technique.

3 Results from Template Matching technique applied to the Marradi seismic sequence



Probabilistic, nonlinear hypocenter locations of the 823 events detected applying the Template Matching technique in the first 3 days of the sequence.



Cumulative number of events over time: in figure a) the color represents the average cross-correlation (CC) of each detected event. In figure b) new detected events are highlighted in red, while the templates are shown in gray.

Magnitude trends: in figure a) the log of the cumulative sum (Gutenberg-Richter). In figure b) the magnitudes of matched events (in red with their respective error bars) and that of the templates (in black).

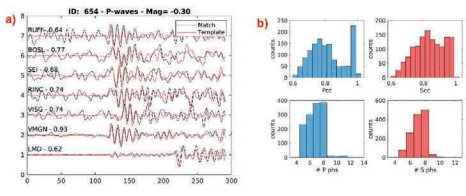


Figure a) example of match. Figure b) Distribution of the cross correlations with P/S waveforms (top, blue/red colors) and the number of P/S phases detected for each event (bottom, blue/red colors). The total number of identified events for the entire period is 1331, with 514 events corresponding to templates and 817 as newly identified events.

Possible future workflow of BSI procedures during a seismic sequence

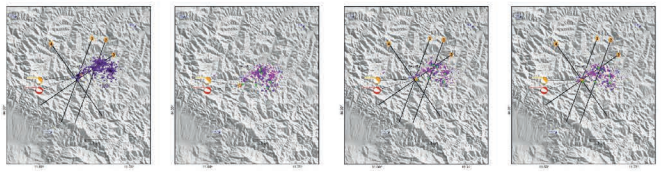
4

Template matching analysis using data from the seismic monitoring room or revised by the BSI working group

Visual revision and validation of matched events. Standard linearized hypocenter location

Probabilistic, nonlinear hypocenter locations of revised events

Relative hypocenter locations with double difference technique



ANALISI, MODELLAZIONE, INTERPRETAZIONE DI FENOMENI GEOFISICI

Moment vs local magnitude scaling of small-to-medium earthquakes from seismic moment estimation of 10 years (2009-2018) of Italian seismicity

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We computed the moment magnitude (M_W) for about 250,000 earthquakes occurred in Italy from 2009 to 2018 and recorded at seismic stations of the Italian National Network managed by INGV. We use raw velocity waveforms and invert the displacement spectra of more than 2,000,000 S-waves manually picked. We use the probabilistic method SPAR by Supino et al. [2019; 2020] to estimate the a-posteriori joint probability density function of seismic moment M0 and corner frequency fc. M_W is converted from M0 using the Kanamori equation. We observe a self-similar scaling between fc and M0 for M_W larger than 2.5. For smaller magnitudes, S-wave spectra show an almost constant fc (~10 Hz). We interpret this as the constant cut-off frequency of the anelastic attenuation, which produces an apparent corner frequency lower than source fc and corresponds to an apparent larger source duration. Because of the conservation of total displacement integral after a low-pass filtering, signals must exhibit an apparent lower maximum amplitude to "compensate" the apparent larger source duration. Local magnitude (M_L) values are therefore expected to be underestimated while M_W, by definition, are not affected by this as they are proportional to the displacement integral. Coherently, the comparison of our M_W and M_L estimates shows the systematic underestimation of M_L with respect to M_W for small magnitude events. The deviation from a 1:1 scaling between M_L and M_W overlaps the magnitude range where the constant apparent fc arises in the M0 - fc scaling (M_L < 2.5). Our results suggest that a robust analysis of the statistical features of earthquake catalogs with a completeness magnitude << 2.5 should use M_W instead of M_L.

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Moment vs local magnitude scaling of small-to-medium earthquakes from seismic moment estimation of 10 years (2009-2018) of Italian seismicity

We computed moment magnitude (Mw) of about 250,000 earthquakes occurred in Italy from 2009 to 2018 and recorded at seismic stations of the Italian National Network managed by INGV.

We use raw velocity waveforms and invert the displacement spectra of more than 2,000,000 S-waves manually picked. We use the probabilistic method SPAR by Supino et al. [2019] to estimate the a-posteriori joint probability density function of seismic moment M0 and corner frequency fc. Mw is converted from M0 using the Kanamori [1977] equation.

We observe a self-similar scaling between fc and M0 for Mw larger than 2.5. For smaller magnitudes, S-wave spectra show an almost constant fc (10 Hz). We interpret this as the constant cut-off frequency of the anelastic attenuation, which produces an apparent corner frequency lower than source fc and corresponds to an apparent larger source duration.

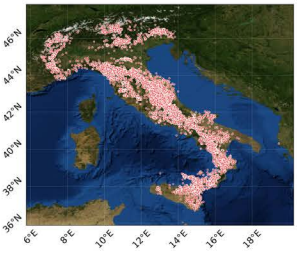
Because of the conservation of total displacement integral after a low-pass filtering, signals must exhibit an apparent lower maximum amplitude to "compensate" the apparent larger source duration. ML values are therefore expected to be underestimated while Mw, by definition, are not affected by this as they are proportional to the displacement integral.

Coherently, the comparison of our Mw and ML estimates shows the systematic underestimation of ML with respect to Mw for small magnitude events. The deviation from a 1:1 scaling between ML and Mw overlaps the magnitude range where the constant apparent fc arises in the M0 - fc scaling (ML < 2.5).

Our results suggest that a robust analysis of the statistical features of earthquake catalogs with a completeness magnitude << 2.5 should use Mw instead of ML.

Mariano Supino[1] , Lauro Chiaraluce[1], Raffaele Di Stefano[1], Maddalena Michele[1]

A DATA AND MODEL



We computed moment magnitude of ~ 250,000 earthquakes occurred in Italy from 2009 to 2018.

Earthquakes have been detected and located by INGV.

We use more than 2,400,000 raw velocity records and manually revised S-wave arrival times.

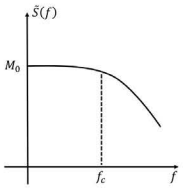
We invert the S-wave displacement amplitude spectra to characterize the source of the events. The model predictions are given by the forward operator g:

$$g(\boldsymbol{m}; f) = g(M_0, f_c, \gamma; f) = \tilde{S}(M_0, f_c, \gamma; f) \cdot \tilde{G}(Q; f)$$

where $\tilde{S}$ is the source spectrum expected from a generalized Brune's spectral model :

$$\tilde{S}(M_0, f_c, \gamma; f) = \frac{M_0}{1 + \left(\frac{f}{f_c}\right)^{\gamma}}$$

SOURCE PARAMETERS	
M_0	seismic moment
f_c	corner frequency
γ	high-frequency decay exponent

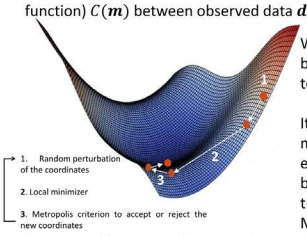


and $\tilde{G}$ is the Fourier transform of the Green propagator.
We use a theoretical Green's function and a frequency-independent anelastic attenuation factor Q.

B INVERSE METHOD

We use the probabilistic method SPAR by Supino et at. [1,2] to invert single-station displacement spectra and evaluate the joint PDF $\sigma(\boldsymbol{m})$ of the source parameters $\boldsymbol{m} = (M_0, f_c, \gamma)$.

We seek for the best-fit solution $\boldsymbol{m}^*$ by minimizing the squared L_2-norm (cost function) $C(\boldsymbol{m})$ between observed data $\boldsymbol{d}_{obs}$ and model predictions $\boldsymbol{g}(\boldsymbol{m})$.



We obtain $\boldsymbol{m}^*$ by applying the basin-hopping global optimization technique.

It combines a local (deterministic) minimization with a random exploration of the model space, by building a Markov chain with a transition probability given by the Metropolis criterion.

To assess the uncertainty associated with the best-fit solution $\boldsymbol{m}^*$, we estimate the *a-posteriori* joint probability density function (PDF) over the model space, $\sigma(\boldsymbol{m})$.

Under the hypothesis of an uniform *a-priori* PDF over the model space, and of modelization and data uncertainties normally distributed, it follows $\sigma(\boldsymbol{m}) = K' \cdot \exp\left(-\frac{1}{2} C(\boldsymbol{m}) \cdot MSE^{-1}\right)$, with K' normalization constant and MSE mean squared error between $\boldsymbol{d}_{obs}$ and $\boldsymbol{g}(\boldsymbol{m}^*)$ [1,3].

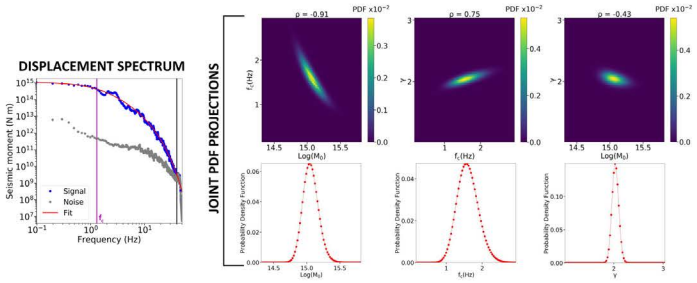
We evaluate $\sigma(\boldsymbol{m})$ around $\boldsymbol{m}^*$, in a model space sub-domain which spans on average more than three standard deviations.

C SOURCE PARAMETERS JOINT PDF

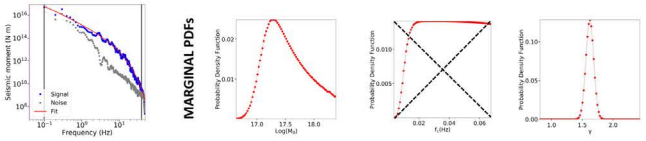
We integrate the joint PDF to obtain the marginal PDF of each parameter. The single-station solution and uncertainty are the mean and standard deviation of the parameter marginal PDF.
The final event solution and uncertainty are respectively the weighted average and weighted uncertainty of single-station estimates.

Using marginal PDFs has three major advantages when it comes to uncertainty estimation:

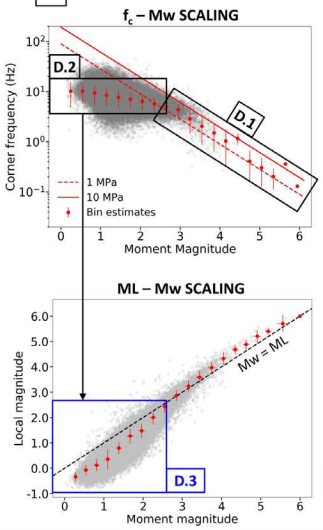
(1) It accounts for between-parameter correlation, as it results from the integration of the joint PDF;
(2) It also accounts for the quantity of information available in the frequency domain (frequency bandwidth), as larger uncertainty are associated to narrower frequency band [1].



(3) It allows to automatically reject bad quality spectra, which results in unconstrained PDF solution(s):



D SOURCE PARAMETERS SCALING



D.1 Almost constant stress drop scaling (1-10 Mpa) **Mw 2.5 - 6**

D.2 Almost constant corner frequency f_c ~ 10 Hz **Mw <~ 2.5**

Apparent lower f_c (higher duration) due to anelastic attenuation low-pass filtering
f_c is the cut-off frequency of the low-pass filter and does not scale with the source [5,6]

Total displacement integral (∝ ampl. x duration) **is conserved after a low-pass filtering**

Q OPERATOR $\quad M_0 \propto \int_0^{\infty} u(t)dt \propto \lim_{f \to 0} \tilde{u}(f)$

Observed signals must exhibit apparent (lower) maximum amplitude to "compensate" apparent higher duration

D.3 **ML** ∝ max. amplitude **underestimated [4]**

Seismic moment (Mw) ∝ displacement integral **not affected**

ANALISI, MODELLAZIONE, INTERPRETAZIONE DI FENOMENI GEOFISICI

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RISE
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ML-based workflow for earthquake detection and location. Preliminary results from the northern Apennines

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Recent advances in machine-learning (ML) based analysis have dramatically increased the quantity of low-magnitude earthquakes detected and properly located leading to a new generation of earthquakes catalogs. TABOO-NFO seismic network is an ideal site to better understand earthquakes driving processes in a shallow crust surrounded by deep fluid circulation. To build an earthquake catalog for this area from 2010 to present, we created a tailored ML-based workflow starting from an updated version of the deep learning picker PhaseNet [Zhu and Beroza, 2018] including polarity estimation and better detection of close-in-time events. We trained PN on TABOO waveforms manually labeled by analysts with P, S phases and polarities [Cattaneo et al., 2017]. Training the model with local data results in a significant improvement in S-phases accuracy and polarities. The result is a massive dataset composed of tens of millions of P and S arrival times making the events association a challenge. For this task we used the GAMMA [Zhu et al., 2022] algorithm, which treats the association as an unsupervised clustering problem in a probabilistic framework estimating rough locations, origin times and magnitudes. We end up with 1.4M earthquakes. Then, to estimate the absolute hypocentral locations we used an updated version of HypoSVI [Smith et al., 2022], a probabilistic location method in which the forward model is based on a physics informed neural network trained to solve the Eikonal equation. This location procedure makes use of source-specific station terms that can vary as a function of source position, allowing better correction for the unmodeled velocity structure.

References

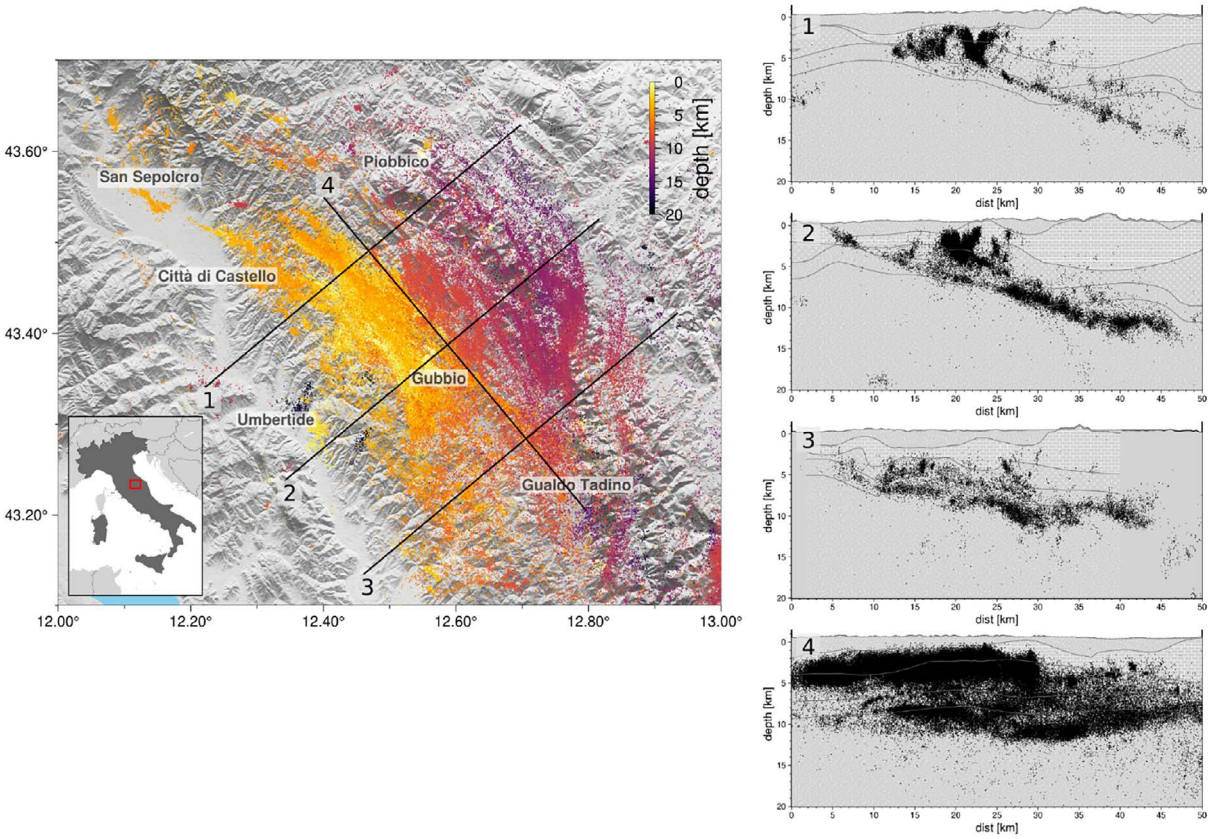
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Map, cross sections (1-3, width=5km) and longitudinal section (4, width=20km). Cross sections 1 and 2 clearly depict the Altotibernia Fault at depth and the shallower seismicity pertaining to the Pietralunga (1) and Gubbio (2) sequences. The lithological model on the background is from Latorre et al. [2016].

Vp and Vp/Vs tomographic model of the Fucino fault-controlled basin obtained through a very dense temporary seismic network

Pasquale De Gori*, Luigi Improta, Maurizio Vassallo, Fabrizio Cara, Gaetano De Luca, Alberto Frepoli, Samer Bagh, Luisa Valoroso, Mario Anselmi, Francesco Pio Lucente

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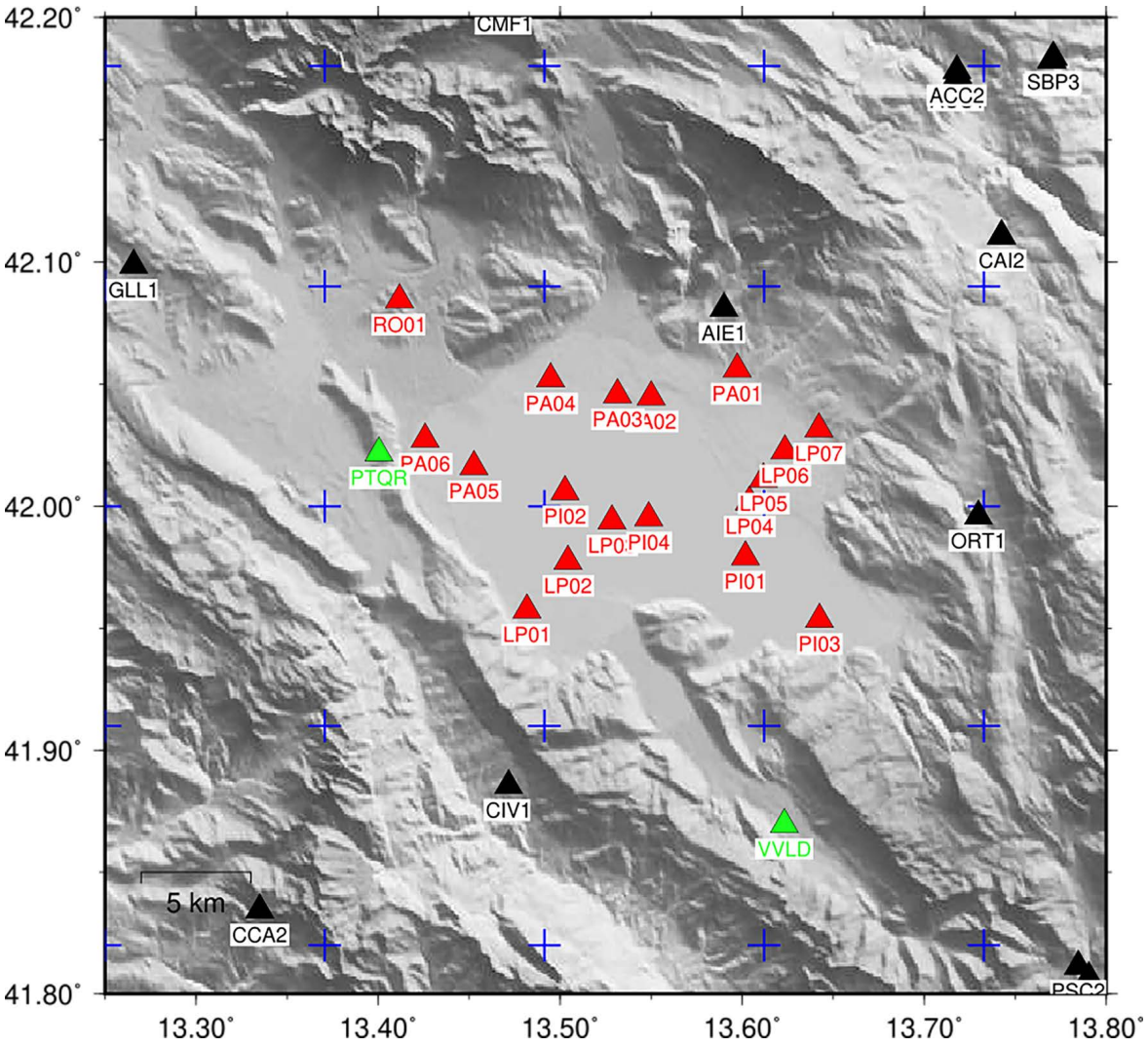
In this study we present a new local earthquake tomography model of the Fucino basin and surrounding regions aimed to reveal the crustal structure of this sector of Apennines characterized by a complex system of normal-faults responsible of the main historical earthquake (M_W 7.0, 1915 January 13) occurred in central Italy. The tomographic inversion benefits of seismic data recorded by a dense passive seismic survey that was carried out, in 2008-2009, in the Fucino area to investigate the basin seismic response and local site effects [Cara et al., 2011]. The temporary network consisted of 18 stations, with an average spacing of 2-3 km, operating in continuous mode with a sampling rate of 125 Hz and equipped with 5 second seismometers. In order to detect the maximum number of local earthquakes, we applied a trigger algorithm on the continuously recorded dataset of the Fucino temporary array integrated by the permanent stations of the Italian seismic network installed on the surrounding ridges.

The extracted events were manually analyzed for the determination of the P and S waves arrival times. For the more energetic earthquakes, we included the seismic phases of the regional Abruzzo network operating in trigger mode.

We realized a new earthquake catalog to perform a local-scale passive tomographic survey. The tomographic model, presented in terms of Vp and Vp/Vs, allow to image the crustal structure with a spatial resolution finer with respect to previous tomographic surveys of central Apennines. The 3D distribution of Vp and Vp/Vs and of relocated events helped us to identify the velocity contrasts related to the main faults and to improve our knowledge on their geometry at depth.

References

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Map of the Fucino temporary array.

Technical-scientific activities and products relating to the agreement between INGV-Ancona and the Marche Region

Chiara Ladina*, Simone Marzorati, Milena Moretti, Debora Pantaleo, Carlo Calamita, Viviana Castelli

INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy

**Corresponding author: chiara.ladina@ingv.it*

The collaboration between INGV and the Marche Region has continued for over twenty years, starting from the 2002 Framework Agreement, with the aim of improving seismic monitoring, obtaining timely information on the seismicity of the territory and promoting activities related to seismic risk.
The Marche Region provides resources for the transmission and centralization of data and a headquarters; while INGV integrates regional monitoring networks into its national system and provides technical-scientific support during seismic sequences.
The regional seismic activity (e.g. tectonic events, quarry explosions, blasting of war devices, snow avalanches) is monitored through permanent seismic networks and temporary measurement campaigns, allowing us to compile regional earthquake catalogues.
The impact of earthquakes on regional infrastructures is estimated in near real time to prepare automatic reports. Furthermore, we conduct temporary experiments for strategic and relevant public buildings.
In addition, initiatives are promoted in the context of Rapid Response to earthquakes and Earthquake Early Warning, through feasibility studies of warning systems and studies on risk perception [Ladina et al., 2021].
In coordination with the Civil Protection Service of the Marche Region, products and dissemination initiatives relating to the "Third Mission" and Services for Society of the INGV are developed, the staff participates in prevention and safety days in the regional territory, events for the anniversary of historic earthquakes, educational workshops with schools.

References

Ladina, C., Marzorati, S., Amato, A. and Cattaneo, M., (2021). *Feasibility Study of an Earthquake Early Warning System in Eastern Central Italy*. Front. Earth Sci. 9:685751. https://doi.org/10.3389/feart.2021.685751

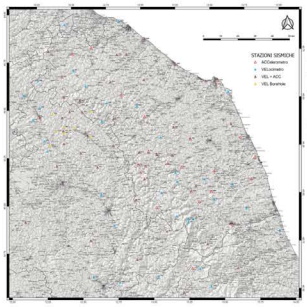
GIORNATA ONT martedì 14 novembre 2023

Ladina C. [1], Marzorati S. [1], Moretti M. [1], Pantaleo D. [1], Calamita C. [1], Castelli V. [2]
[1]Osservatorio Nazionale Terremoti, [2]Sezione di Bologna

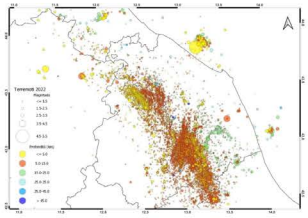
Technical-scientific activities and products relating to the agreement between INGV - Ancona and the Marche Region

The collaboration between INGV and the Marche Region has continued for over twenty years, starting from the 2002 Framework Agreement, with the aim of improving seismic monitoring, rapidly obtaining timely information relating to the seismicity of the territory and promoting activities relating to seismic risk. The Marche Region provides resources for the transmission and centralization of data and a headquarters; while INGV works to integrate regional monitoring networks into its national system and provide technical-scientific support during seismic events.
The interpretation of regional seismic activity (tectonic events, quarry explosions, blasting of war devices, avalanche monitoring...) is monitored through permanent seismic networks and temporary measurement campaigns, drawing up catalogs with regional parameters.
The impact of events on regional infrastructures is estimated in near real time to prepare automatic reports. Experiments with monitoring techniques for strategic and relevant public buildings are added to the other activities.
Furthermore, initiatives are promoted in the context of Rapid Response to earthquakes and Earthquake Early Warning, through feasibility studies of warning systems and studies on risk perception.
In coordination with the Civil Protection Service of the Marche Region, products and dissemination initiatives relating to the "Third Mission" and Services for Society of the INGV are developed, the staff participates in prevention and safety days in the regional territory, events for the anniversary of historic earthquakes, educational workshops with schools.

❖ Gestione, interpretazione routinaria e diffusione dei dati rilevati dalla Rete Sismica Integrata dell'Italia Centro Orientale (ReSIICO)

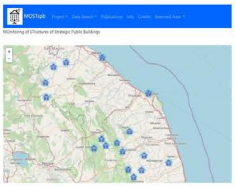


Le stazioni, acquisite direttamente presso il Centro Funzionale SPC, compongono la rete sismica virtuale **ReSIICO** che sfruttano l'integrazione dei dati acquisiti direttamente dai siti regionali, dalla **RSN** e dalla rete sismica del NFO TABOO per l'analisi della sismicità.
A queste si aggiungono 6 stazioni nell'ambito del progetto internazionale *Strainmeter Array Along the Alto Tiberina Fault System (STAR)*, pozzi con sensori sismici, di deformazione e geodetici.

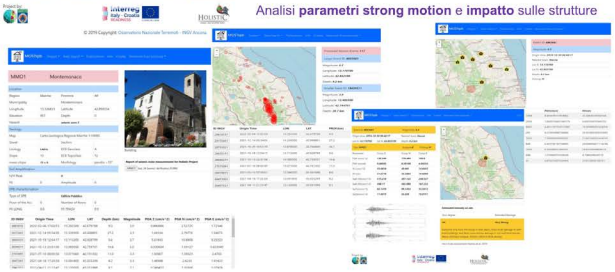


Dx eventi del 2022 elaborati dai sistemi della sede di Ancona con i dati automatici della rete ReSIICO.

❖ Monitoraggio sismico di edifici strategici www.an.ingv.it/MOST



L'infrastruttura comprende 19 punti di misura, monitoraggio continuo degli edifici strategici. La maggior parte degli edifici è in muratura e solo uno in cemento armato. La strumentazione è posizionata alla base degli edifici e comprende 4 accelerometri del tipo Episensor, 11 accelerometri del tipo Colibrys, 4 accelerometri Lunitek. Due edifici tra quelli già monitorati alla base hanno un accelerometro low-cost al piano più alto dell'edificio. Le aree interessate sono la zona a nord (Pesarese), la comunità montana di San Severino Marche (sud). I segnali delle stazioni vengono acquisiti in tempo reale presso la sede di Ancona.

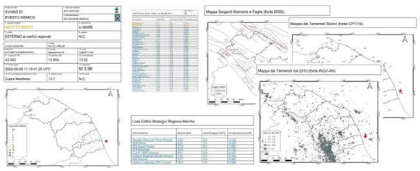


Analisi **parametri strong motion** e **impatto** sulle strutture

❖ Comunicazione tra INGV-Sede Ancona e SPC Regione Marche in caso di eventi a carattere regionale

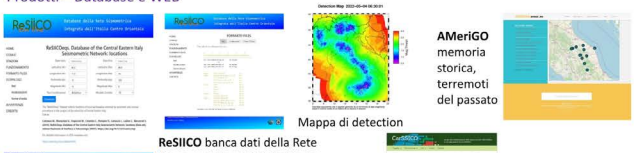
www.an.ingv.it (alias di ingvan.**protezionecivile.marche**.it)

Report automatici di evento – risposta rapida per SPC



La sede di Ancona svolge attività di supporto tecnico-scientifico al SPC in caso di eventi sismici risentiti dalla popolazione presente sul territorio della Regione Marche.
Tali attività hanno portato allo sviluppo di una procedura *software* automatica in grado di generare relazioni automatiche di dettaglio per la Regione Marche, per eventi di magnitudo M >=3 sfruttando anche le banche dati prodotte in ambito convenzionale.

Prodotti – Database e WEB



AMeriGO memoria storica, terremoti del passato

Mappa di detection

ReSIICO banca dati della Rete Sismometrica dell'Italia Centro-Orientale (dal 2009)
Fasi P e S: https://doi.org/10.13127/resiico/phs
Localizzazioni: https://doi.org/10.13127/resiico/eqs

CarSSICO caratterizzazione siti



NTSEq catalogo scoppi di cava
https://doi.org/10.13127/ntseqs2.0

BeachBall meccanismi Focali
https://doi.org/10.13127/bb2021

ESPO '14 Scenari di danno

Cico 1d Catalogo parametrico Italia centrale

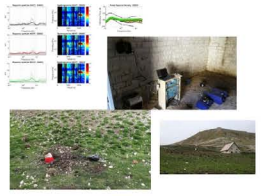
❖ Eventi divulgativi

La sede di Ancona partecipa ad attività di divulgazione sia a carattere regionale che istituzionale, come **'Giornata Prevenzione e Sicurezza'** organizzata dal Gruppo Volontari di Protezione Civile con il supporto dei colleghi della Sede di Roma, **Commemorazione dei 50 anni dal terremoto di Ancona del 1972**, organizzato **Open Day** della Sede per accogliere cittadini e ragazzi, **attività locali con le scuole** primarie e adulti. Ogni attività viene pubblicata attraverso post sul **Blog INGVTerremoti**.



❖ Gestione di Stazioni Sismiche Mobili per interventi temporanei

La sede di Ancona gestisce nel Laboratorio stazioni sismiche che permettono di svolgere misurazioni speditive di rumore sismico ambientale, sia per indagare le caratteristiche principali della risposta di edifici pubblici strategici e/o rilevanti sia per verificare la presenza di amplificazioni dei terreni per l'installazione di stazioni sismiche o per la registrazione di sismicità naturale e/o antropica.



Earthquake Early Warning

Promosse iniziative tramite studi di fattibilità dei sistemi di allerta e studi sulla percezione del rischio.
Utilizzo del software Presto in tempo reale presso la sede di Ancona (http://www.prestoews.org/).



Terremoto di magnitudo **Mw 4.5** del 09-03-2023 ore 19:08:06 (UTC) zona: **6 km E Umbertide (PG)**
https://terremoti.ingv.it/

ANALISI, MODELLAZIONE, INTERPRETAZIONE DI FENOMENI GEOFISICI

Poster presented at the "Giornata ONT 2023". The work presents the technical-scientific activities and products of the collaboration between INGV-Ancona and the Marche Region.

Broadband Ground Motion Simulations of M≥6.0 earthquakes in Central Italy using a Frequency-Wavenumber Approach

Pietro Artale Harris[1,*], Arben Pitarka[2], Aybige Akinci[1]

[1]*INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy*
[2]*Lawrence Livermore National Laboratory, Livermore, USA*

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The seismic activity known as the Amatrice-Visso-Norcia seismic sequence began on August 24th, 2016, with the M6.2 earthquake in Amatrice, Italy. This sequence included eight additional earthquakes with magnitudes above 5.0. The most significant event occurred on October 30th, 2016, with a magnitude of 6.5 in Norcia.
Here we perform physics-based simulations and investigate the ground motion variability for Norcia and Amatrice earthquakes using the Pitarka et al. [2021] and Akinci et al. [2023] simulation approaches, respectively. We generate broad-band ground motion acceleration time histories (0-10 Hz) for these two earthquakes using frequency-wavenumber Green's functions (FK approach) and kinematic rupture models generated with the Graves and Pitarka technique [Graves and Pitarka, 2016]. The FK Green's functions were computed using the propagator matrix method of Zhu and Rivera [2002] and a 1D velocity model of Central Italy. The FK-based broad-band simulation method allows for fast and realistic generation of synthetic seismograms, provided that an appropriate GF storage and source rupture models are available. Finally, we compare and test the performance of our synthetic 1D FK simulations with those from 3D simulations and recordings by analyzing the goodness of fit (GoF) between recorded and simulated ground motion. We find that the FK-based simulation approach and the 1D CIA velocity model produce ground motion that compares well with recorded data throughout the region in the modeled frequency range of 0-10 Hz. Because this simulation technique is very fast and reliable, it can be used to produce seismic hazard assessment for scenario earthquakes in Central Italy. In figure we show the spatial variability of the simulated ground motion for Amatrice and Norcia, as well as the GoF analysis indicating a good agreement between the recorded and simulated data.

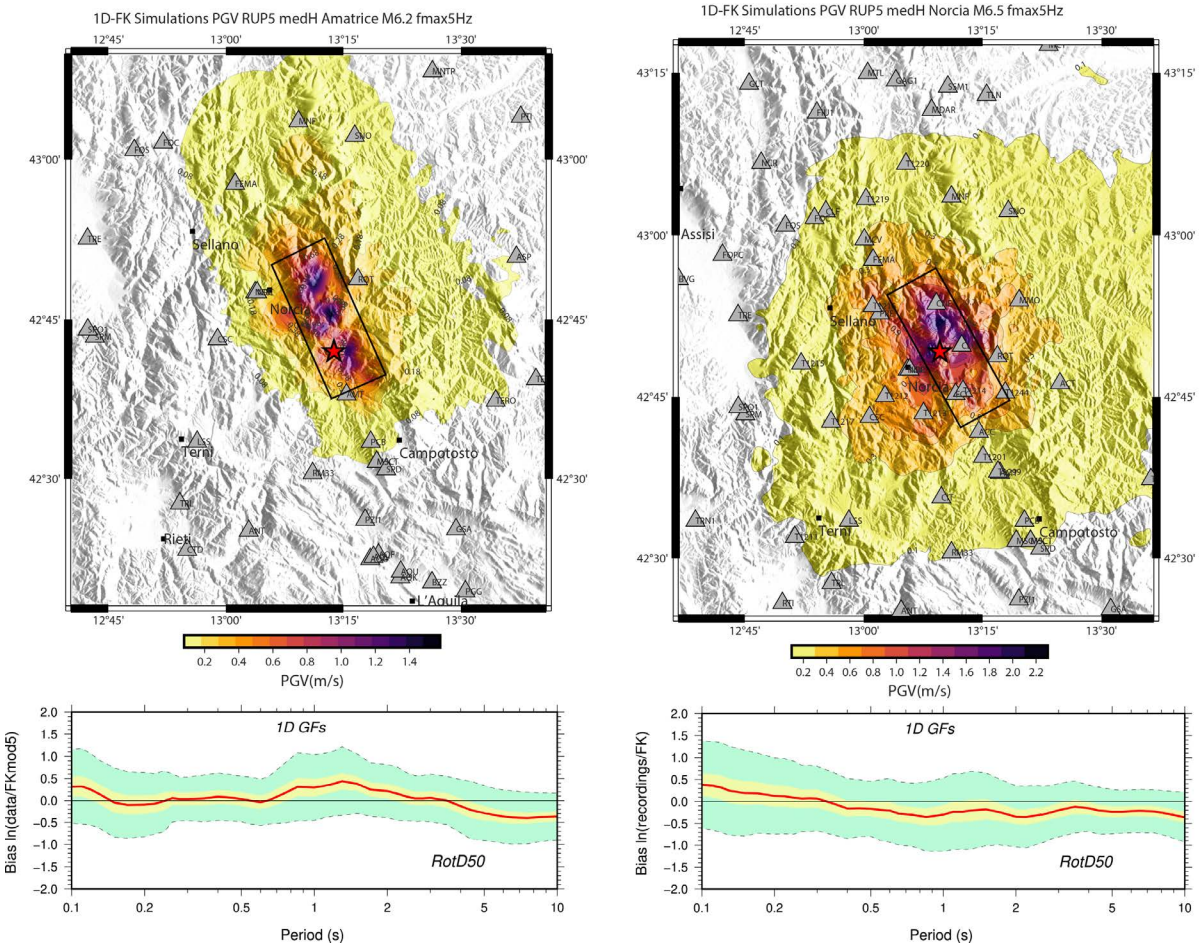
References

Akinci, A., Pitarka A., Artale Harris P., De Gori P., Buttinelli M., (2023). *Impact of the Earthquake Rupture on Ground Motion Variability of the August 24, 2016 Mw 6.2 Amatrice Earthquake, Italy*. Submitted to Bull. Seismol. Soc. Am.

Graves, R., and Pitarka, A., (2016). *Kinematic ground motion simulations on rough faults including effects of 3D Stochastic velocity perturbations*. Bull Seis. Soc Am. 106, 2136–2153. https://doi.org/10.1785/0120160088

Pitarka, A., Akinci, A., De Gori, P., and Buttinelli, M., (2021). *Deterministic 3D Ground-Motion Simulations (0–5 Hz) and Surface Topography Effects of the 30 October 2016 Mw 6.5 Norcia, Italy, Earthquake*. Bull. Seismol. Soc. Am. XX, 1–25, https://doi.org/10.1785/0120210133

Zhu, L., and Rivera, L.A., (2002). *A note on the dynamic and static displacements from a point source in multi-layered media*. Geophys. J. Int., 148, 619–627.



The upper left and right figures depict the spatial distribution of ground motion intensities, specifically the mean horizontal components of PGV (maximum frequency at 5 Hz) at 8633 (Amatrice) and 8712 (Norcia) virtual stations. These stations are arranged in a regular grid with 1 km × 1 km spacing. The simulation model covers an area of 102 km by 88 km and extends to a depth of 31 km. The black rectangles indicate the free-surface fault projection of the two earthquakes, while the red stars denote the location of the rupture initiation point. Triangles represent the station locations. In the bottom left and right figures, the goodness of fit (GoF) between recorded and simulated ground motion is presented, illustrating the model bias (solid line) and standard deviation (dashed lines) of the residuals for RotD50 SA values in the 0.1–10 s period range. These values are averaged over 41 and 37 stations for the Norcia and Amatrice earthquakes, respectively.

Centroid Moment Tensor computation: inversion based on a 3D velocity model

Pietro Artale Harris[1,*], Laura Scognamiglio[1], Federica Magnoni[1], Emanuele Casarotti[1], Elisa Tinti[2]

[1]*INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy*
[2]*Dipartimento di Scienze della Terra, La Sapienza Università di Roma, Italy*

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Moment tensor (MT) is a mathematical representation of the movement on a fault during an earthquake, and of the size, or magnitude, of the event. Such a tensor is often described through "beachballs", a graphic representation symbol that indicates the fault orientation and the type of slip that occurs during an earthquake. Usually, seismologists use source inversion procedures based on 1D wave speed models in order to routinely compute MTs (e.g. TDMT [Scognamiglio et al., 2009]. In recent years, due to the incredible progress of computer science, also 3D models, which can describe lateral velocity variations of the medium, have been successfully adopted to compute MTs. Here we present source solutions for a few Italian earthquakes obtained by using a source inversion method based on 3D wave speed models [Liu et al., 2004; Scognamiglio et al., 2016; Artale Harris et al., 2022]. To obtain the new Centroid Moment Tensor in 3D (CMT3D) solutions we consider the 3D Italian lithospheric velocity model "IMAGINE_IT" [Magnoni et al., 2022]. The computation needs a reliable starting MT and allows for a variability estimate of the source parameters, due to a bootstrap procedure. In our analysis, the starting focal mechanisms for CMT-3D inversions are the TDMT solutions. Nonetheless, if an accurate initial MT is not available, our procedure has been generalized to use several starting solutions, such as the focal mechanism obtained by first p-waves arrivals.
In the figure we show an example of fit used by pycmt3d to compute the solution and a comparison of TDMT and CMT-3D solutions for the M_W 3.8 12/31/2020-21:54:38 Sicily Earthquake.

References

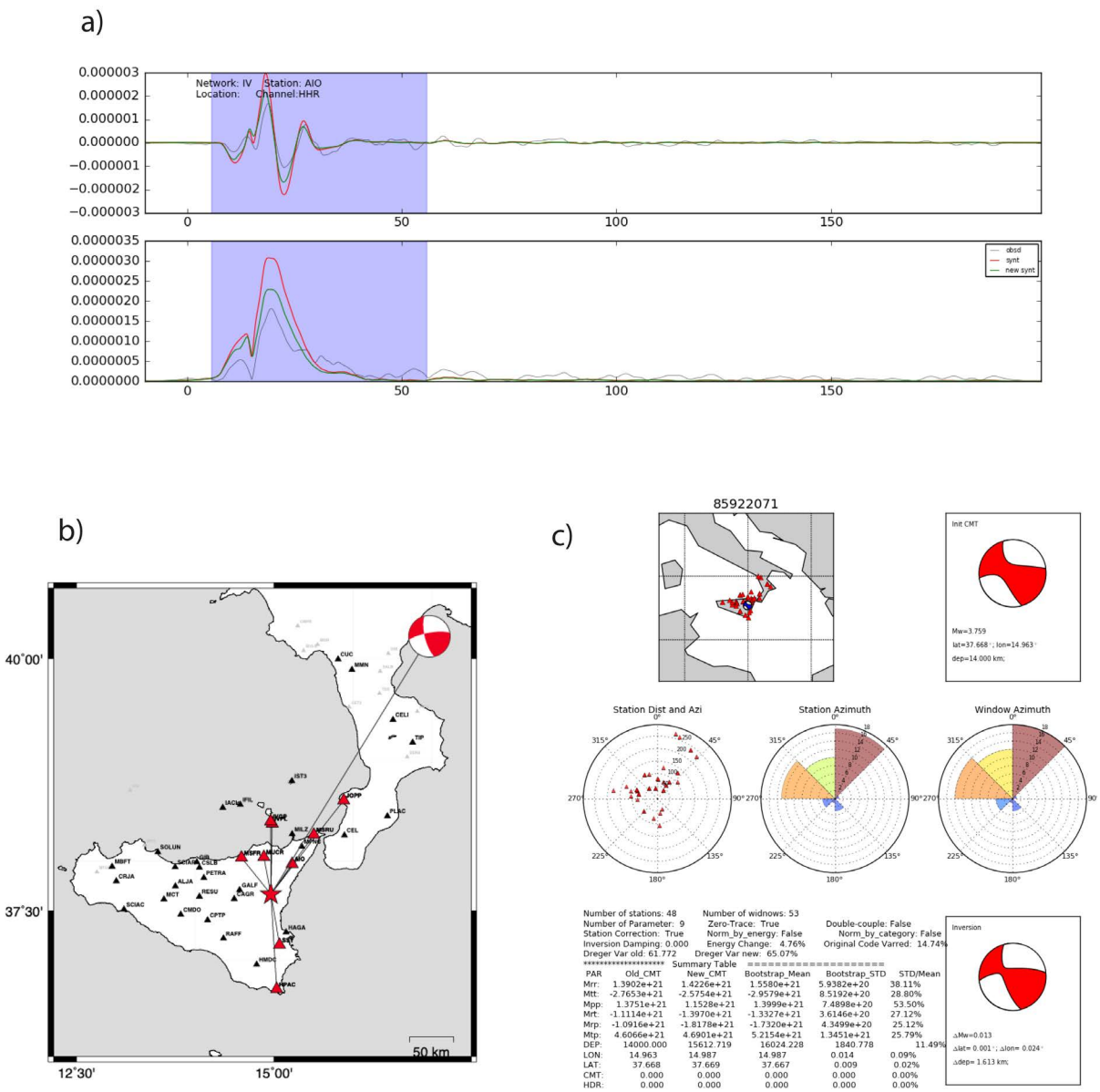
Artale Harris, P., Scognamiglio, L., Magnoni, F., Casarotti, E., and Tinti, E., (2022). *Centroid moment tensor catalog with 3D lithospheric wave speed model: The 2016–2017 Central Apennines sequence*. Journal of Geophysical Research: Solid Earth, 127, e2021JB023068. https://doi. org/10.1029/2021JB023068

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Liu, Qinya et al., (2004). Spectral-element moment tensor inversions for earthquakes in Southern California." *Bulletin of the Seismological Society of America* 94 (2004): 1748-1761. https://doi.org/10.1785/012004038

Scognamiglio, L., Magnoni, F., Tinti, E., Casarotti, E., (2016). *Uncertainty estimations for moment tensor inversions: the issue of the 2012 May 20 Emilia earthquake*. Geophysical Journal International, Volume 206, Issue 2, August 2016, Pages 792–806, https://doi.org/10.1093/gji/ggw173

Scognamiglio, L., Tinti, E., and Michelini, A., (2009). *Real-time determination of seismic moment tensor for Italian Region*. Bulletin of the Seismological Society of America, 99(4), 2223–2242. https://doi.org/10.1785/0120080104



a) Example of fit (top) and envelope (bottom) used by pycmt3d to compute the solution. The red seismogram is the one computed by SPECFEM3D from TDMT+3Dmodel, the black one is the data, and the green one is the inverted solution by pycmt3d. Bottom: comparison of b) TDMT and c) CMT-3D solutions. We observe a noteworthy increase of used stations and an increase of Double Couple as well.

Earthquake Detection and Phase Picking using Deep Learning method: a case study on local events (Groningen Region, Netherlands)

Andrea Di Benedetto[1,2,*], Luca Trani[3], Andrea Pagani[3], Giosuè Lo Bosco[2], Antonino D'Alessandro[1]

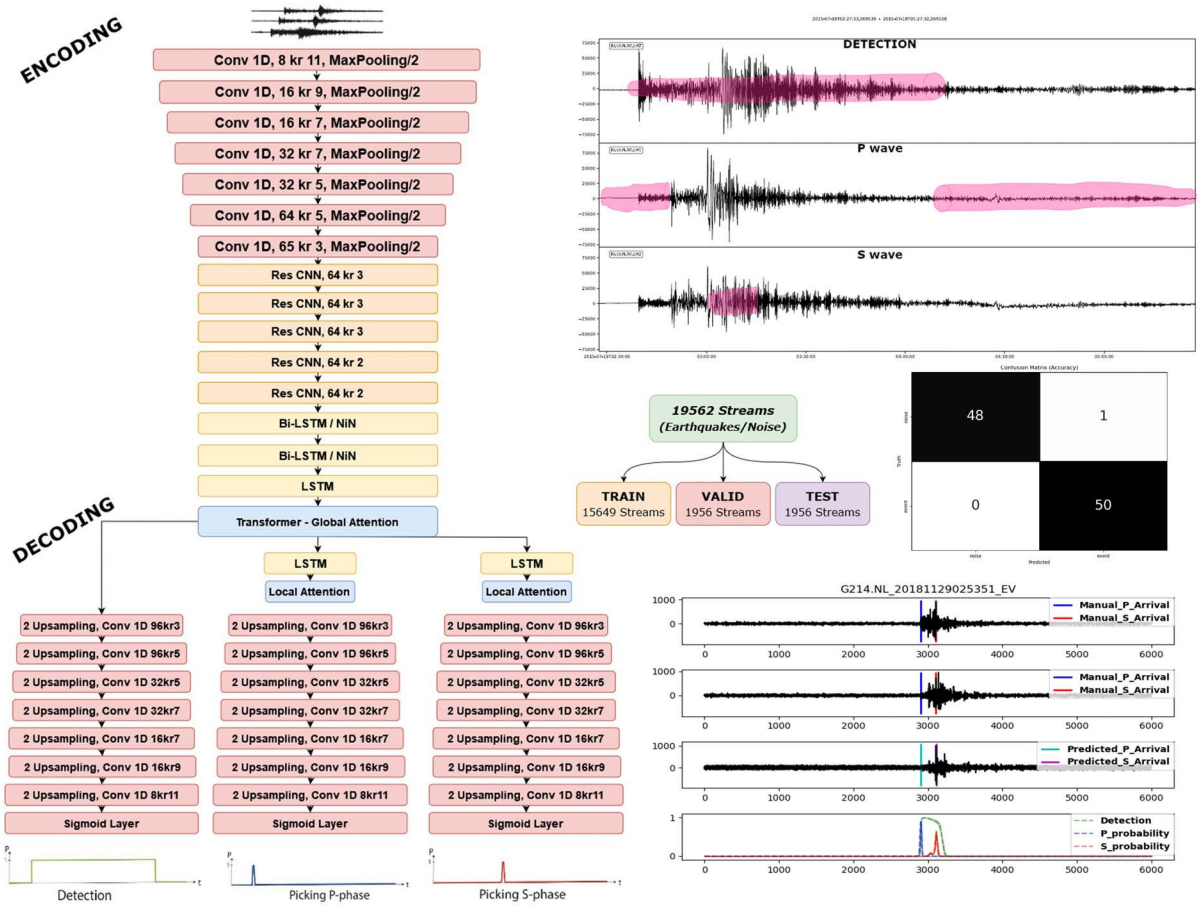
[1]*INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy*
[2]*Department of Mathematics and Computer Science, University of Palermo, Palermo, Italy*
[3]*Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands*

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The continuous expansion of the seismic network produces a large amount of data that can be used for tuning an algorithm for Earthquake Detection and Phase Picking purposes. In this work, we tested a Transformer model that uses an Attention Mechanism, called EQTransformer (Earthquake Transformer [Mousavi, et. al., 2020]) in order to detect earthquakes and seismic phases arrival time. Transformer models, by their nature, are suitable for the analysis of time-series data, such as seismic signals generated by earthquakes. We applied it on 467 manually reviewed low-magnitude (0.1 to 3.4) local events catalogued in Groningen Region (Netherlands) from 2016 to 2020. The 80% was used for training and the remaining 20% for validation/testing. Preliminary results for testing show 98% Accuracy for Event Detection. As a future improvement, we are working on tuning picking P and S phases, reviewing the data and making new experiments on the euro-mediterranean area.

References

Mousavi, S.M., Ellsworth, W.L., Zhu, W. et al., (2020). *Earthquake transformer—an attentive deep-learning model for simultaneous earthquake detection and phase picking*. Nat Commun 11, 3952. https://doi.org/10.1038/s41467-020-17591-w



The Transformer model called EQTransformer [Mousavi, et. al., 2020] to detect earthquakes and seismic phases arrival time. Preliminary results for testing show 98% Accuracy for Event Detection.

Preliminary results of QuakeFlow application: the case of L'Aquila 2009 seismic sequence

Rossella Fonzetti[1,2,*], Luisa Valoroso[1], Matteo Bagagli[3], Pasquale De Gori[1], Aladino Govoni[1], Claudio Chiarabba[1]

[1]*INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy*
[2]*Università degli Studi Roma Tre, Dipartimento di Scienze, Italy*
[3]*Università di Pisa, Dipartimento di Scienze della Terra, Pisa, Italy*

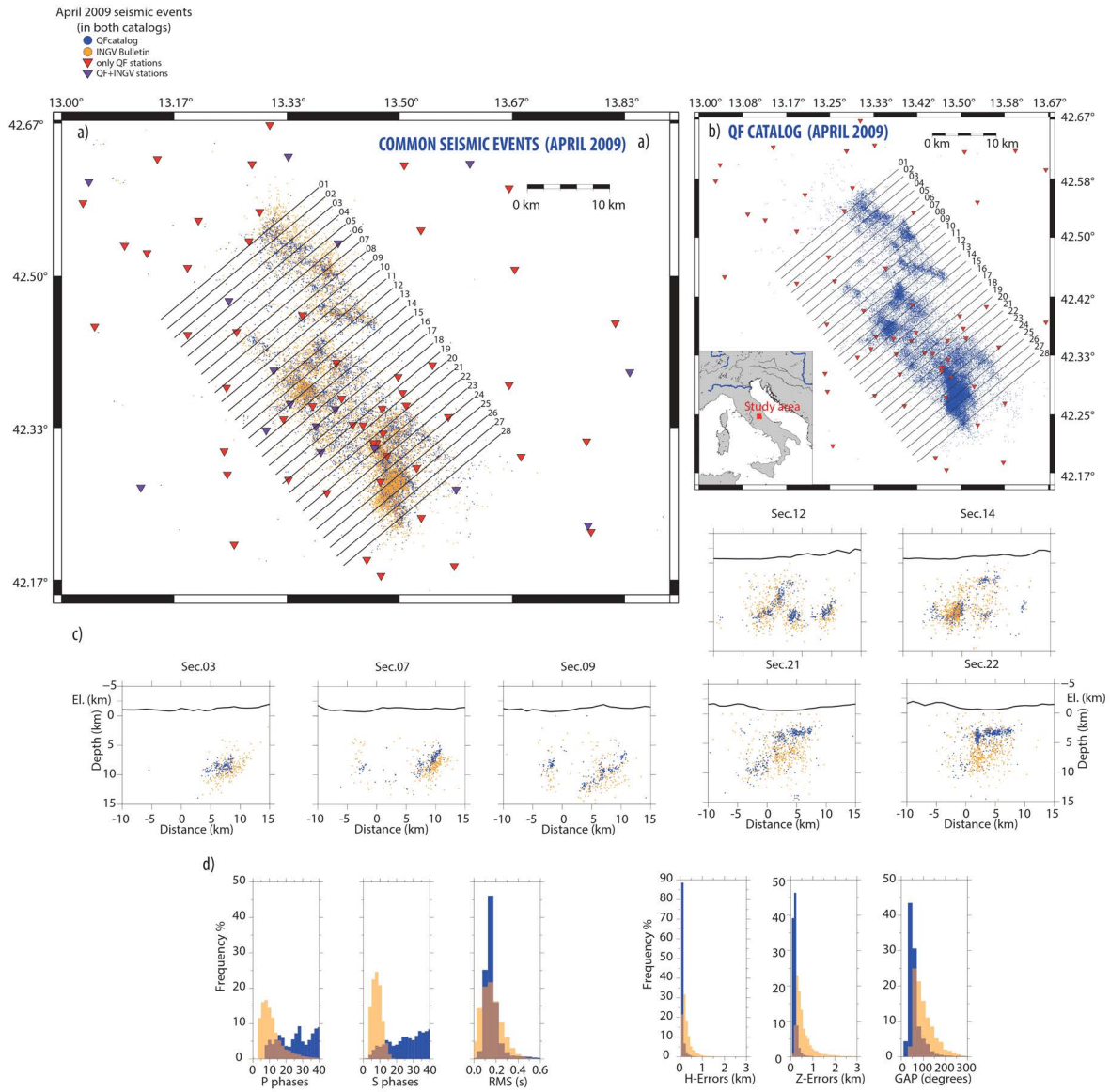
**Corresponding author: rossella.fonzetti@ingv.it*

Nowadays the use of artificial intelligence (AI) in seismology has become very common, allowing the creation of complete seismic catalogs including very small magnitude events that remained undetected by human analysts and standard monitoring room procedures. Here, we apply the QuakeFlow (QF [Zhu et al., 2023]) workflow, which combines two machine learning algorithms called PhaseNet and GaMMA to pick P- and S-waves, to associate picks and estimate approximate earthquake locations and magnitudes, to the 2009/04 of the L'Aquila 2009 seismic sequence. We compared our new catalog with the INGV bulletin in order to analyse the detection capabilities of QF with respect to manual picking performed by the INGV analysts. We used data coming from 66 seismic stations (46 from ING and 20 from RESIF station networks), identifying about 128,000 seismic events (best locations in Figure b).
We filtered the QF catalog considering only those events with 6 P- and 4 S- waves arrival times, obtaining 95,992 seismic events, and we relocated them by means of Hypoellipse using an ad-hoc 1D velocity model. Therefore, we compared the INGV bulletin with the QF catalog, by selecting common events (i.e., events having P- and S-waves arrival times at common stations within 2 seconds). All bulletin events (i.e. 8,542) are within the QF catalog (Figure b-d).
Our results show that AI detection and association methods yield a significant increase in the number of events, 10 times more than the data within the INGV bulletin.
In the next steps, we will apply QF to the entire seismic sequence, in order to test its performance as compared with the high-resolution catalog developed by Valoroso et al. [2013].

References

Valoroso, L., Chiaraluce, L., Piccinini, D., Di Stefano, R., Schaff, D., Waldhauser, F., (2013). *Radiography of a normal fault system by 64,000 high-precision earthquake locations: The 2009 L'Aquila (central Italy) case study*. Journal of Geophysical Research: Solid Earth, *118*(3), 1156-1176. https://doi.org/10.1002/jgrb.50130

Zhu, W., Hou, A. B., Yang, R., Datta, A., Mousavi, S. M., Ellsworth, W. L., et al., (2023). *QuakeFlow: a scalable machine-learning-based earthquake monitoring workflow with cloud computing*. Geophysical Journal International, 232(1), 684-693. https://doi.org/10.1093/gji/ggac355



Comparison between the same seismic events that occurred in April 2009 of QF (blue dots) and INGV seismic catalog (orange dots). a) map view of the common seismicity distribution. All the stations (red and purple triangles) are used by QF (including the LG French network, 4A temporary and IV permanent INGV networks); while the purple triangles are the seismic stations used by INGV. The black lines are traces of vertical cross sections; b) all the seismicity extracted by QF with ERH < 0.1 km and ERZ < 0.2 km (i.e. 39, 616 seismic events); c) some of the most interesting vertical sections (strike of N50°E) which show the depth distribution of seismic events occurring within ±0.8 km distance from the section; c) Distribution histograms of number of P- and S-waves, RMS (s), ERH (km), ERZ (km) GAP (°).

Automatic seismic source modeling of InSAR displacements

Simone Atzori[1,*], Andrea Antonioli[1], Nikos Svigkas[1], Fernando Monterroso[2], Claudio De Luca[2], Francesco Casu[2], Michele Manunta[2], Matteo Quintiliani[1], Riccardo Lanari[2]

[1]*INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy*
[2]*CNR | Istituto per il Rilevamento Elettromagnetico dell'Ambiente, IREA Naple, Italy*

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In this work we describe the implementation of a processing chain for a fully automatic modeling of the seismic source parameters and its slip distribution through the inversion of the InSAR displacements generated from the EPOSAR service. This processing chain consists of a suite of procedures and algorithms handling a sequence of steps: selection of the highest quality InSAR datasets, definition of the area of interest, image sampling, non-linear and linear inversions to get, respectively, the source geometry and its slip distribution [Atzori et al., 2019]. A set of side procedures and interfaces also allows an interactive refinement and the publication of results, consisting of scientific data and graphical outputs. The whole procedure has been developed, tested and validated by considering 100 events with magnitudes between 5.5 and 8.2, worldwide distributed and covering an exhaustive range of mechanisms and tectonic contexts. Main aim of this work is describing the implementation of the automatic modeling procedures, used to produce solutions in real time, already during the emergency phase. These sources, validated by experts before their publication, can be a reference for operational purposes and for the first scientific analyses. The creation of this repository also sets the framework to store, out of the emergency time, more sophisticated solutions, manually revised and with peer-review quality.

References

Atzori, S., Antonioli, A., Tolomei, C., De Novellis, V., De Luca, C., Monterroso, F., (2019). *InSAR full-resolution analysis of the 2017–2018 M>6 earthquakes in Mexico*. Rem. Sens. Env. 234, 111461. https://doi.org/10.1016/j.rse.2019.111461

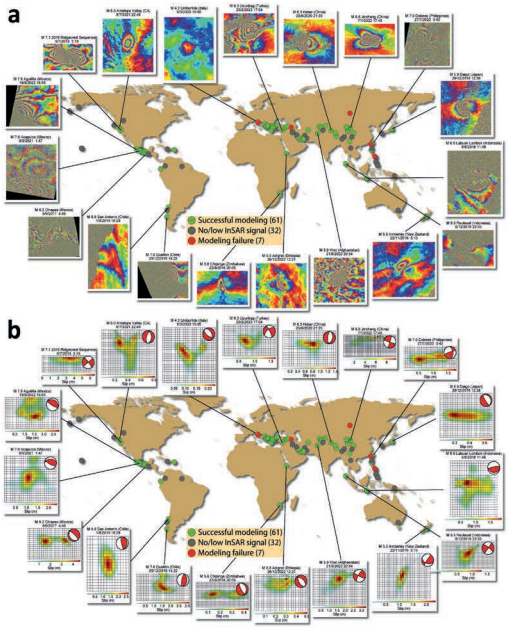
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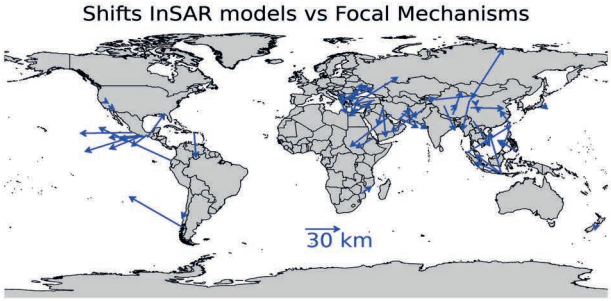
Automatic seismic source modelling of InSAR displacements

Simone Atzori, A. Antonioli, N. Svikgas, F. Monterroso, C. DeLuca, F. Casu, M. Manunta, M. Quintiliani, R. Lanari

In this work we describe the implementation of a processing chain for a fully automatic modeling of the seismic source parameters and its slip distribution through the inversion of the InSAR displacements generated from the EPOSAR service. This processing chain consists of a suite of procedures and algorithms handling a sequence of steps: selection of the highest quality InSAR datasets, definition of the area of interest, image sampling, non-linear and linear inversions to get, respectively, the source geometry and its slip distribution. A set of side procedures and interfaces also allows an interactive refinement and the publication of results, consisting of scientific data and graphical outputs. The whole procedure has been developed, tested and validated by considering 100 events with magnitudes between 5.5 and 8.2, worldwide distributed and covering an exhaustive range of mechanisms and tectonic contexts. Main aim of this work is describing the implementation of the automatic modeling procedures, used to produce solutions in real time, already during the emergency phase. These sources, validated by experts before their publication, can be a reference for operational purposes and for the first scientific analyses. The creation of this repository sets also the framework to store, out of the emergency time, more sophisticated solutions, manually revised and with peer-review quality.



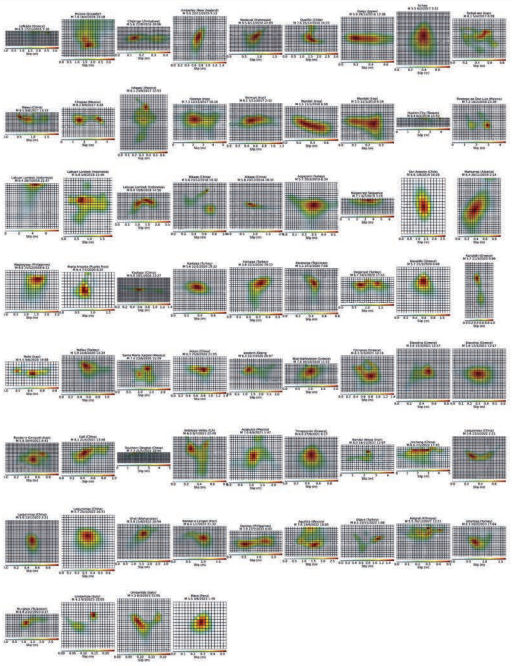
Map of the 100 events processed in this work, with some examples of interferograms (a) and slip distributions (b) obtained through automatic modeling. In the page *http://terremoti.ingv.it/finitesource* the complete database of finite sources derived



An InSAR peculiarity, compared to seismological data, is the ability of showing the actual planimetric location of the event. Weston et al. (2011 and 2012) investigated this problem showing systematic shifts, in some regions, between the InSAR and the USGS locations. These results can be replicated and possibly deepened using this new catalog (Fig 11). Morevorer, we exploit systematic shifts to correct the scenarios based on the focal mechanisms, thus better centering the area of interest already for the coarse non-linear inversion.

- an algorithm for earthquake automatic modeling with InSAR displacements is designed
- InSAR data are automatically provided through EPOSAR service with Sentinel-1 images
- a dataset of a hundred worldwide earthquakes from 2015 to 2023 and M 5.5+ is used
- the whole processing chain provides reliable results in 70% of the cases
- a complete database of sources is ongoing and already publicly accessible

SLIP DISTRIBUTION FOR SUCESSFULL OUTCOME



FUTURE DEVELOPEMENTS

From an algorithmic point of view, the results of these two years of development are a starting point for a more complex automation of InSAR displacements analysis and modeling. Steps forward, easy to implement in a close future, are the inclusion of GNSS data and the rake unlocking for the retrieval of variable rake, slip distributions, especially for large earthquakes. A more challenging improvement will be the ability to include multi-segment sources, for which the adoption of AI-based procedures will be considered to face the exponential growth of complexity in the investigation of the parameter space.

ANALISI, MODELLAZIONE, INTERPRETAZIONE DI FENOMENI GEOFISICI

Geodetic modelling of recent earthquakes in Turkiye: from the 2020 Mw 6.8 Elazig earthquake to the 2023 Mw 7.8 Kahramanmaras seismic sequence

Daniele Cheloni*, Aybige Akinci, Nicola Angelo Famiglietti, Annamaria Vicari

INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy

**Corresponding author: daniele.cheloni@ingv.it*

In this work, we propose geodetic models for several strong earthquakes that occurred in Turkiye between 2020 and 2023. We used Global Navigation Satellite System (GNSS) and Interferometric Synthetic Aperture Radar (InSAR) measurements to investigate the ground displacement field caused by the 2020 M_W 6.8 Elazig earthquake, by the major events of the 2023 M_W 7.8 Turkiye seismic sequence, and by other smaller earthquakes occurred in nearby regions, and to infer, by using elastic dislocation modeling, the fault geometry.

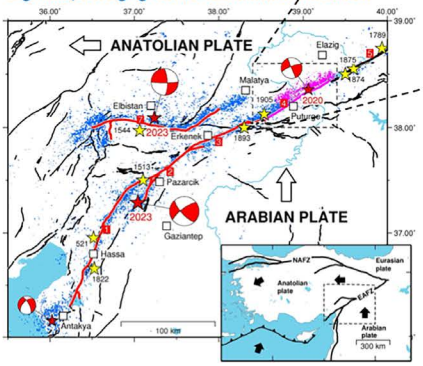
GIORNATA ONT martedì 14 novembre 2023

Geodetic Modelling of the Recent Earthquakes in Turkiye: from the 2020 M_W 6.8 Elazig Earthquake to the 2023 M_W 7.8 Kahramanmaras Seismic Sequence

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1 Osservatorio Nazionale Terremoti, Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy.
2 Roma1, Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy.
3 Sezione Irpina, Istituto Nazionale di Geofisica e Vulcanologia, Grottaminarda, Italy.

Abstract

In this work, we propose geodetic models for several strong earthquakes that occurred in Turkiye between 2020 and 2023. We used Global Navigation Satellite System (GNSS) and Interferometric Synthetic Aperture Radar (InSAR) measurements to investigate the ground displacement field caused by the 2020 M_W 6.8 Elazig, by the major events of the 2023 M_W 7.8-7.6 Turkiye seismic sequence, and by other smaller earthquakes occurred in nearby regions, and to infer, by using elastic dislocation modelling, the geometry and slip distribution of the causative fault segments, belonging to the East Anatolian Fault Zone.



Seismotectonic framework of the study area. The solid lines represent the main fault segments of the East Anatolian Fault Zone (EAFZ) with labeled name: (1) Amanos, (2) Pazarcik, (3) Erkenek, (4) Puturge, (5) Palu And (7) Surgu-Cardak-Savrun segments, respectively (after *Duman and Emre* 2013). Seismicity: blue circles are the relocated aftershocks of the 2023 sequence (*Lomax* 2023), while the pink ones are related to the previous 2020 Elazig seismic sequence; the red stars represent the location of the main events and their moment tensor solution; the yellow stars are the major historical earthquakes (e.g. *Ambraseys* 1989).

The 2020 M_W 6.8 Elazig earthquake

The 24 January 2020 M_W 6.8 mainshock nucleated on a segment of the East Anatolian Fault Zone (EAFZ).

Following the mainshock an intense aftershock sequence occurred both NE and SW on the EAFZ.

The 4 August 2020 M_W 5.6 earthquake nucleated at the western end of the Elazig seismic sequence.

The 9 April 2022 M_W 5.4 earthquake occurred further to the SW respect to the 2020 seismic sequence.

The 2023 M_W 7.8-7.6 Kahramanmaras earthquakes

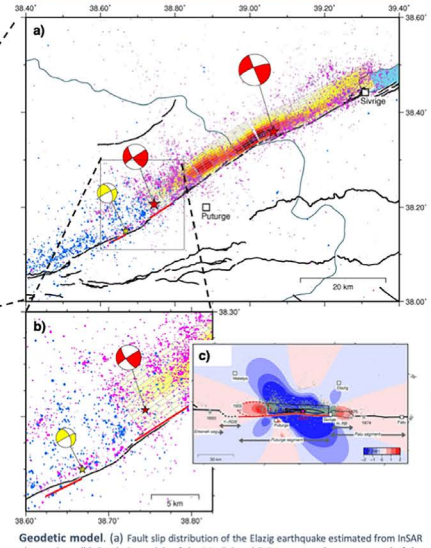
On 6 February 2023 a M_W 7.8 earthquake occurred in south-eastern Turkey, near the Pazarcik district.

This event was followed 9 hours later by a M_W 7.6 earthquake approximately 90 km to the north.

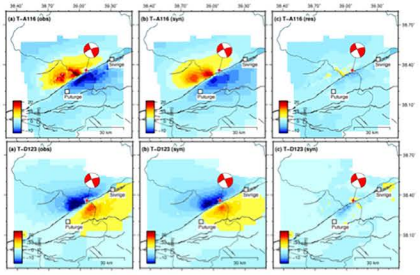
The largest aftershocks occurred on 6 February and 20 February (M_W 6.7 and 6.4).

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Duman T.Y. & Emre O. (2013). The East Anatolian Fault: geometry, segmentation and jog characteristics. *Geol. Soc. Lond. Spec. Publ., 372, 495-529.*
Lomax A. (2023). Precise, NLL-SSST-coherence hypocenter catalog for the 2023 Mw 7.8 and Mw 7.6 Turkey earthquake sequence, March 2023. *doi:10.5281/zeonodo.7699882.*

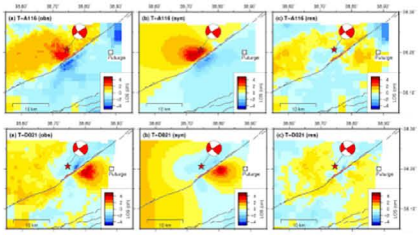
Geodetic Model: 2020-22 earthquakes



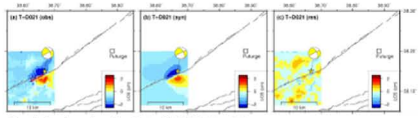
Geodetic model. (a) Fault slip distribution of the Elazig earthquake estimated from InSAR observations. (b) Geodetic models of the M_W 5.6 and 5.4 events on the western end of the Puturge segment. (c) Change of Coulomb stress computed at a reference depth of 10 km.



Geodetic data for 24 January 2020 Elazig M_W 6.8 earthquake. Data, model, and residuals sampled points from the unwrapped Sentinel-1interferograms.

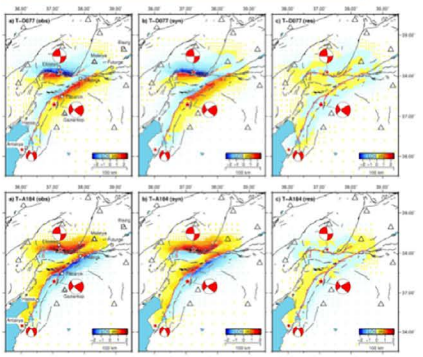


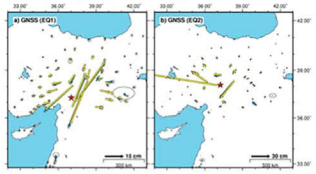
Geodetic data for the 4 August 2020 M_W 5.6 event. Data, model, and residuals sampled points from the unwrapped Sentinel-1 interferograms.



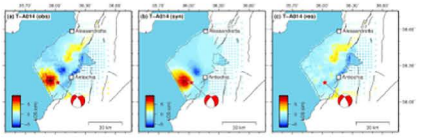
Geodetic data for the 9 April 2022 M_W 5.4 event. Data, model, and residuals sampled points from the unwrapped Sentinel-1 interferograms.

Geodetic Model: 2023 earthquakes

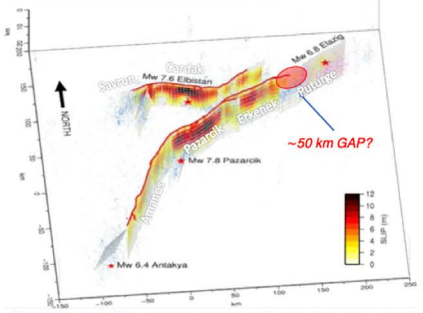




Geodetic data for the 6 February 2023 M_W 7.8-7.6 earthquakes. Data, model, and residuals sampled points from the unwrapped ALOS-2 interferograms, observed (blue) and predicted (yellow) GNSS horizontal displacements.



Geodetic data for the 20 February 2023 M_W 6.4 event. Data, model, and residuals sampled points from the unwrapped Sentinel-1interferograms.



Perspective view of the geodetic model. Three-dimensional view of the estimated rupture geometries and coseismic slip distributions of the 2020 and 2023 earthquakes.

Conclusions

Modelling of geodetic data shows:

The M_W 6.8 Elazig earthquake ruptured a portion of the Puturge segment of the left-lateral EAFZ (~40 km);

The M_W 7.8 mainshock ruptured the Amanos, Pazarcik and Erkenek segments of the left-lateral EAFZ (~300 km);

The M_W 7.6 earthquake ruptured the Cardak-Savrun segments of the northern strand of the EAFZ (~150 km).

Gap between the 2020 and 2023 seismic sequences?

ANALISI, MODELLAZIONE, INTERPRETAZIONE DI FENOMENI GEOFISICI

Balancing physical complexity and accuracy in numerical models for tsunami forecasting

Alice Abbate[1,2,*], Stefano Lorito[1], José Manuel González-Vida[3], Manuela Volpe[1], Fabrizio Romano[1], Hafize Basak Bayraktar[1], Manuel Castro Diaz[3], Roberto Basili[1]

[1]*INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy*
[2]*Department of Mathematics, Informatics and Geosciences, Università di Trieste, Trieste, Italy*
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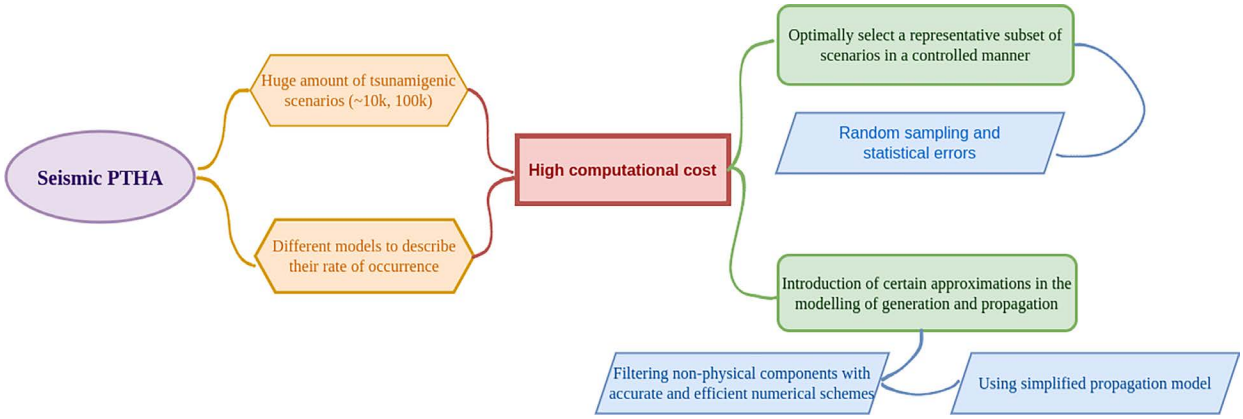
**Corresponding author: alice.abbate@ingv.it*

Computational-based probabilistic forecasting for earthquake-generated tsunamis typically deals with large numbers of scenarios to be numerically simulated over large domains. For accurate inundation forecasting, the resolution required is typically on the order of meters. To contain the associated high computational cost, one can try to reduce the size of the ensemble and the resolution of individual simulations. Additionally, some approximations are often adopted in terms of both the generation and propagation of the tsunami itself. For instance, one common approach is to impose a static and instantaneous initial condition in a purely shallow water hydrodynamic modeling framework. This work, part of a PhD research project, is developed along two complementary research lines: on the one hand, to select a subset of the ensemble that can optimally describe a given problem; on the other hand, to improve the physical approximation in the tsunami initial condition depending on the hazard sensitivity to it and the desired level of accuracy. Regarding the first line, we propose a possible approach for reducing the number of simulations to be conducted while quantifying the epistemic uncertainties associated with the inundation modeling. We developed a workflow based on the methodology proposed by Davies et al. [2022], which has been adapted for both site-specific S-PTHA and real-time PTF. For the latter case, we propose a new methodology to solve the model for calculating optimal tsunami initial conditions for a static displacement [Nosov and Kolesov, 2011], depending on the local bathymetry. Both methodologies are thought to be parallelized on either CPU or GPU based HPC clusters.

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Davies, G., Weber, R., Wilson, K., Cummins, P., (2022). *From offshore to onshore probabilistic tsunami hazard assessment via efficient Monte Carlo sampling*. Geophysical Journal International, 230 (3), 1630–1651. https://doi.org/10.1093/gji/ggac140

Nosov, M.A., Kolesov, S.V., (2011). *Optimal Initial Conditions for Simulation of Seismotectonic Tsunamis*. Pure Appl. Geophys. 168, 1223–1237. https://doi.org/10.1007/s00024-010-0226-6



The diagram summarises the practical limitations associated with seismic PTHA. The objective is to accurately and efficiently describe the tsunami hazard with as few scenarios as possible and avoiding overestimates in numerical simulations.

A multidisciplinary approach to assess the kinematics of the Pisciotta Deep-Seated Gravitational Slope Deformation (Southern Italy)

Matteo Albano[1,*], Michele Saroli[1,2], Lisa Beccaro[1], Fawzi Doumaz[1], Marco Moro[1], Marco Emanuele Discenza[3], Luca Del Rio[4], Matteo Rompato[2]

[1]*INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy*
[2]*Università degli Studi di Cassino e del Lazio Meridionale, Cassino, Italy*
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Deep-Seated Gravitational Slope Deformations (DSGSDs) are extensively documented, yet their evolution and kinematics remain elusive, demanding a multidisciplinary approach. This study delves into the complex geometry and kinematics of the Pisciotta DSGSD, a roto-translational sliding mass involving turbiditic rocks and impacting man-made structures [De Vita et al., 2013; Albano et al., 2023].
Mapping DSGSD landforms involved in-situ surveys, stereoscopic analysis of historical aerial images, and high-resolution drone mapping. Structural data and ground surveys unveiled a weathered and folded turbiditic sequence with sandstone and calcarenite units alternating with disrupted argillite and mudrock layers.
Remote sensing, including optical imagery and Synthetic Aperture Radar data, allowed to assess its past and current kinematics. Distinct stages emerged: a prefailure period with accelerating displacement rates, a failure period with maximum displacement rates, and a post-failure period with decelerating rates.
Analytical modeling established the DSGSD's deep reach (up to 85 m), estimating its bottom surface and volume, validated by boreholes and inclinometric measurements.
Numerical modeling emphasized the progressive weakening of DSGSD materials, coupled with alterations and changes in groundwater dynamics, as primary mechanisms driving observed kinematics.
In summary, this study unravels poorly understood aspects of DSGSDs, focusing on the Pisciotta case. Integrating diverse methodologies contributes to a nuanced understanding of the complex interplay between geological factors and human infrastructure in deep-seated gravitational slope deformations.

References

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Albano, M., Saroli, M., Beccaro, L., et al., (2023). *Multi-source data analysis to assess the past and present kinematics of the Pisciotta Deep-Seated Gravitational Slope Deformation (southern Italy).* Remote Sensing of Environment 296:113751. https://doi.org/10.1016/j.rse.2023.113751

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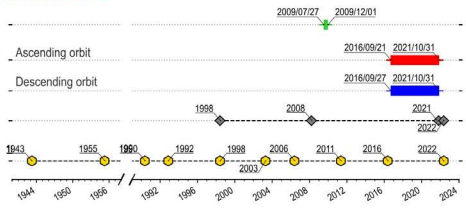
A MULTIDISCIPLINARY APPROACH TO ASSESS THE KINEMATICS OF THE *PISCIOTTA* DEEP-SEATED GRAVITATIONAL SLOPE DEFORMATION (DSGSD) (SOUTHERN ITALY)

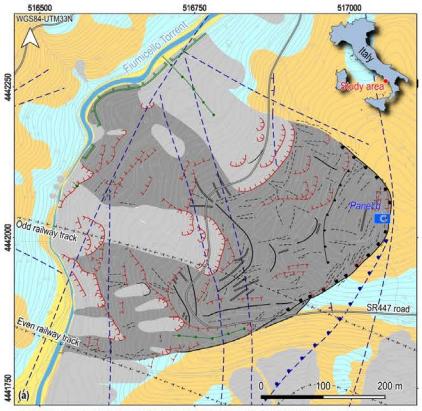
Matteo Albano (*matteo.albano@ingv.it*), **Michele Saroli, Lisa Beccaro, Fawzi Doumaz, Marco Moro, Marco Emanuele Discenza, Luca del Rio, Matteo Rompato**

CONTEXT

- The DSGSD extends approximately 0.2 km^2 and moves at a rate of about 100 cm/y towards the *Fiumicello* riverbed.
- The DSGSD body is made of alternating sandstones, calcarenites and argillites.
- The DSGSD movements affect the SR447 road and the odd and even tracks of the national railway.
- Currently, the **assessment of the present-day activity and kinematics of the *Pisciotta* DSGSD** has not been provided yet.

DATA & METHODS

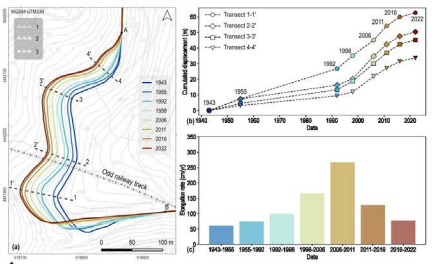




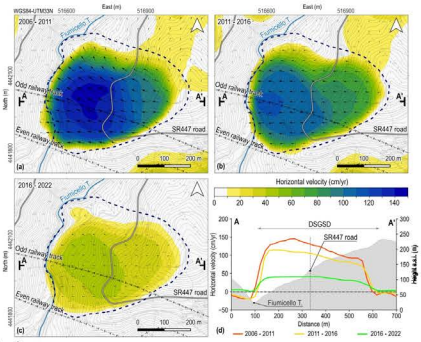
▲ (a) Geomorphological map of the Pisciotta DSGSD, with the indication of the main infrastructures. (b) DSGSD main scarp.

- Assessment of **long-wavelength DSGSD kinematics** with optical data analysis of the SR447 road shift and **Elongation rate** from 1943 to 2022.
- Assessment of the **horizontal velocity field** by means of **Digital Image Correlation (DIC)** of aerial and satellite images from 2006 to 2022.
- Assessment of the **elevation change rate** by Digital Terrain Model (DTM) difference (available from aerial images, Lidar data and Drone survey) from 1998 to 2022.
- Assessment of the **short-wavelength DSGSD displacements** by means of multitemporal **InSAR analysis** of Sentinel-1 data from 2016 to 2021.
- Estimation of the **DSGSD geometry** with the Sloping Local Base Level (SLBL) method (Jaboyedoff et al., 2019) and **3D numerical analysis** of its kinematics with FLAC3D code.

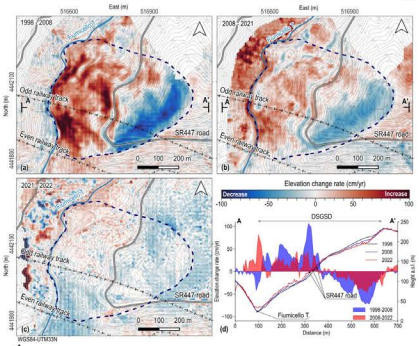
RESULTS



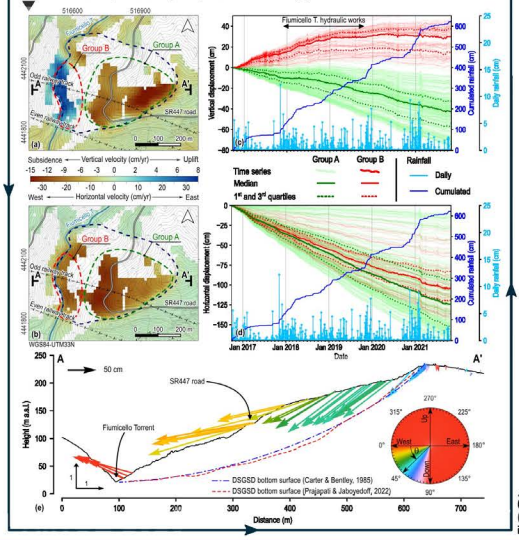
Assessment of the long-wavelength DSGSD displacements with optical data from 1943 to 2022. (a) Quantitative estimation of the SR447 road shift towards the *Fiumicello* Torrent. (b) Cumulated road displacements along the Transects in panel a. (c) Elongation rate of the SR447 road estimated between points A and B in panel a.



Results of the DIC analysis performed on the available digital orthophotos in the period 2006-2011 (a), 2011-2016 (b), and 2016-2022 (c), expressed as mean horizontal velocities. The black arrows indicate the direction and orientation of the horizontal movements, while the dashed blue curve identifies the inferred DSGSD boundary. (d) Horizontal velocity profiles along the A-A' cross-section in panels a, b, and c for the three investigated periods.

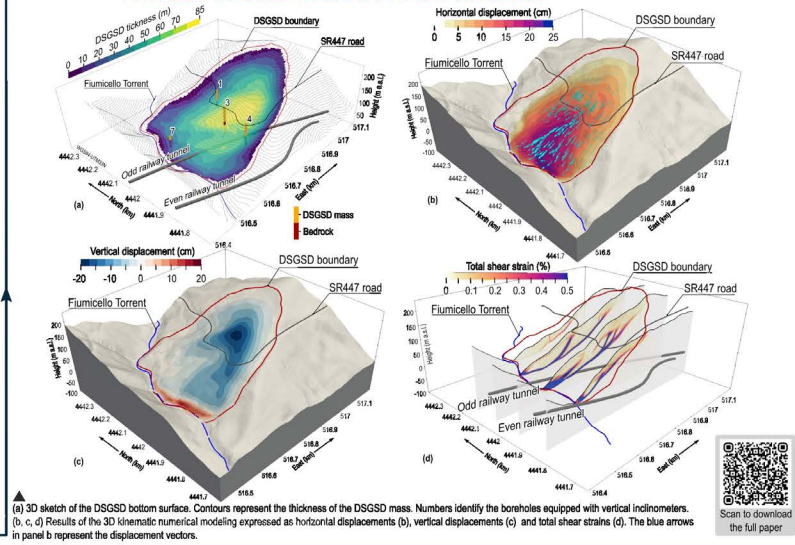


Results of the DEM difference, expressed as mean elevation change rate in the period 1998-2008 (a), 2008-2021 (b), and 2021-2022 (c). (d) Elevation change rate profiles along the A-A' cross-section (panels a and b) for the 1998-2008 and 2008-2021 periods, with topographic profiles in 1998, 2008, and 2022.



Decomposition of the ascending and descending S-1 InSAR displacements between September 2016, October 2021. (a) Vertical and (b) E-W mean displacement rates. (c) Vertical and (d) horizontal displacement time series of the distributed scatterers inside the DSGSD boundary (the dashed blue curve in panels a and b). Group A comprises points at the top of the DSGSD, while Group B is at its toe (see panels a and b). The red and green bolded curves identify the median trend. The dotted curves correspond to the 1st and 3rd quartiles for each investigated period for Groups A and B. (e) Cumulated resultant displacement vector field on October 31, 2021, along the A-A' cross-section in panels a and b. The vector length indicates the displacement amplitude, the color the inclination (θ).

DSGSD GEOMETRY AND KINEMATICS



▲ (a) 3D sketch of the DSGSD bottom surface. Contours represent the thickness of the DSGSD mass. Numbers identify the boreholes equipped with vertical inclinometers. (b, c, d) Results of the 3D kinematic numerical modeling expressed as horizontal displacements (b), vertical displacements (c) and total shear strains (d). The blue arrows in panel b represent the displacement vectors.

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ANALISI, MODELLAZIONE, INTERPRETAZIONE DI FENOMENI GEOFISICI

ANALYSIS MODELLING INTERPRETATION OF GEOPHYSICAL PHENOMENA

VOLCANOLOGICAL

Volcanic and Seismic source Modeling (VSM). An open tool for geodetic data modeling

Elisa Trasatti

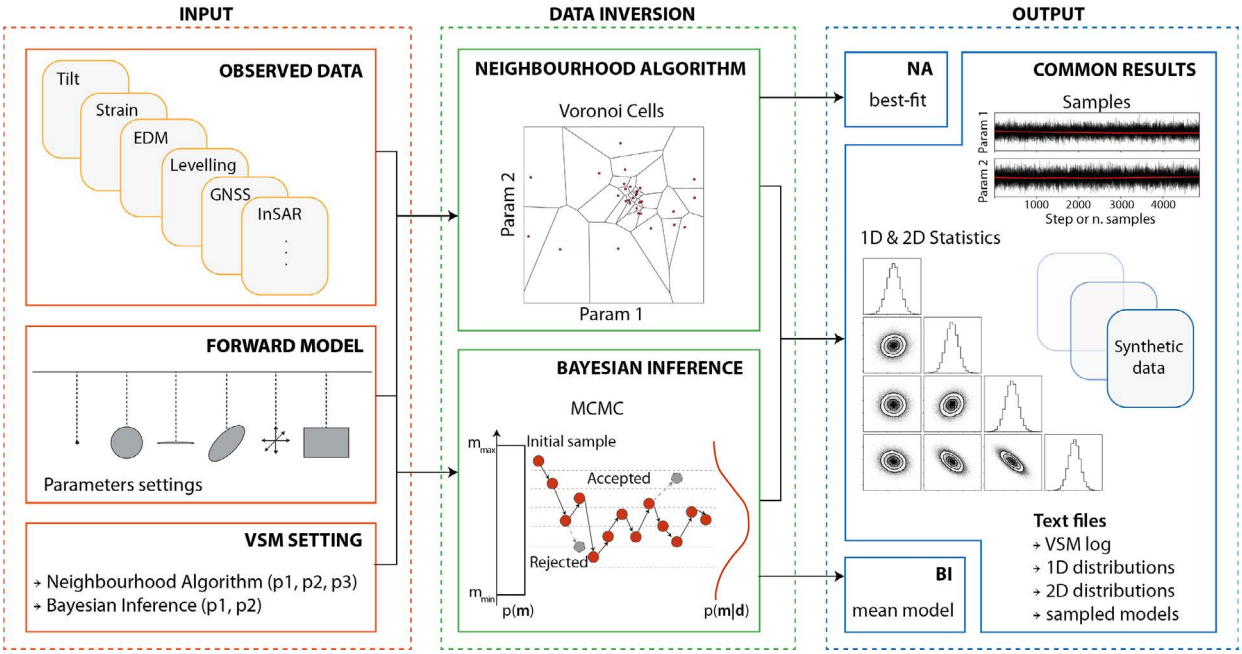
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Volcanic and Seismic source Modeling (VSM) is an open-source Python tool to model ground deformation [Trasatti, 2022]. VSM allows the user to choose one or more deformation sources of various shapes as a forward model among sphere, spheroid, ellipsoid, rectangular dislocation, and sill. It supports multiple datasets from most satellite and terrestrial geodetic techniques: Interferometric SAR, GNSS, levelling, Electronic Distance Measurements, tiltmeters, and strainmeters. Two sampling algorithms are available: one is a global optimization algorithm based on the Voronoi cells and yields the best fitting solution, while the second follows a probabilistic approach to parameters estimation based on the Bayes theorem and the Markov chain Monte Carlo method. VSM can be executed as a Python script, in Jupyter Notebook environments, or by its Graphical User Interface. Its broad applications range from high-level research to teaching, from single studies to near real-time hazard estimates. Potential users range from early-career scientists to experts. It is freely available on GitHub [*https://github.com/EliTras/VSM*] and is accompanied by step-by-step documentation in Jupyter Notebooks. This study presents the functionalities of VSM and test cases to describe its use and comparisons among possible settings.

References

Trasatti, E., (2022). *Volcanic and Seismic Source Modeling: An Open Tool for Geodetic Data Modeling*. Front. Earth Sci. 10:917222. https://doi.org/10.3389/feart.2022.917222



Scheme of the VSM. The input of VSM consists of at least one dataset. The forward model is one or more deformation sources. One of the two available sampling algorithms can be selected. Several products are generated as output. Redrawn from Trasatti [2022].

Volcanic clouds characterization of the 2020-2022 sequence of Mt. Etna lava fountains using MSG-SEVIRI and comparison with other products

Lorenzo Guerrieri[1,*], Stefano Corradini[1], Nicolas Theys[2], Dario Stelitano[1], Luca Merucci[1]

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In this work, the characterization of the 66 paroxysmal explosive episodes that occurred at Etna volcano in the period 2020-2022 is presented. This analysis was performed by processing the satellite images collected from the SEVIRI sensor on board MSG-4 geostationary satellite every 15 minutes. The Volcanic Cloud Top Height (VCTH) was computed by exploiting three different algorithms ("*Darkest Pixel*", "*Cloud Tracking*" and "*HYSPLIT*"). The discrimination between ash and ice in the volcanic cloud has been realized by exploiting the Brightness Temperature Difference (BTD) procedure. More than two thousand SEVIRI images were processed and, for each of these, the corresponding ash/ice effective radius, aerosol optical depth, columnar abundance and SO_2 columnar abundance maps were obtained. Results indicate a VCTH variation between 4 and 13 km asl, while the cumulative ash, ice, and SO_2 emitted from all the 2020–2022 lava fountains in the atmosphere are about 750, 2300, and 670 Gg, respectively. The retrieval products obtained from Volcanic Plume Retrieval (VPR) algorithm have been compared with those computed from Look Up Table (LUTp) procedure and other satellite sensor data (S5P-TROPOMI). The use of geostationary satellites is essential to characterize explosive volcanic events and provide a quantitative estimation of particles and gases emitted into the atmosphere, thus contributing to mitigate the risks that these phenomena induce on population, environment and airspace security. The results of this work have already been published in "Remote Sensing (MDPI)" international, peer-reviewed, open access journal, in April 2023 [Guerrieri et al., 2023].

References

Guerrieri, L., Corradini, S., Theys, N., Stelitano, D., Merucci, L., (2023). *Volcanic Clouds Characterization* of the 2020–2022 Sequence of Mt. Etna Lava *Fountains Using MSG-SEVIRI and Products' Cross-Comparison*. Remote Sens. 2023, 15, 2055. https://doi.org/10.3390/rs15082055

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Volcanic clouds characterization of the 2020-2022 sequence of Mt. Etna lava fountains using MSG-SEVIRI and comparison with other products

Lorenzo Guerrieri [1], Stefano Corradini [1], Nicolas Theys [2], Dario Stelitano [1], Luca Merucci [1]

Abstract: In this work, the characterization of the **66 paroxysmal explosive** episodes that occurred at **Etna volcano in the period 2020-2022** is presented. This analysis was performed by processing the satellite images collected from the **SEVIRI** sensor on board **MSG-4 geostationary satellite** every 15 minutes.
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The retrieval products obtained from **Volcanic Plume Retrieval (VPR)** algorithm have been compared with those computed from **Look Up Table (LUTp)** procedure and other satellite sensors data (**S5P-TROPOMI**).
The use of satellites is essential to characterize explosive volcanic events and provide quantitative estimation of particles and gases emitted into the atmosphere, thus contributing to **mitigate the risks** that these phenomena induce on population, environment and airspace security.

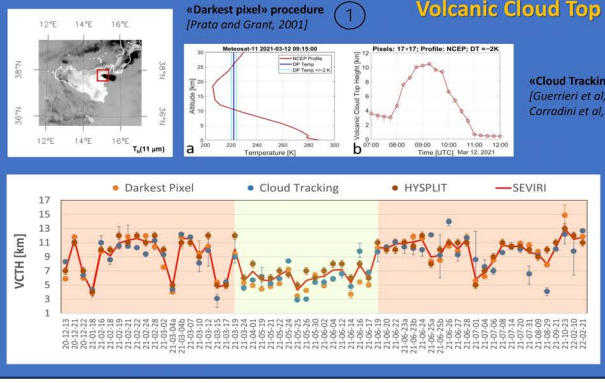


Volcanic Cloud Top Height (VCTH)

1 «Darkest pixel» procedure *[Prata and Grant, 2001]*

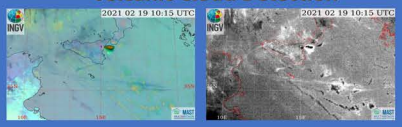
2 «Cloud Tracking» procedure *[Guerrieri et al, 2015; Corradini et al, 2018]*

3 «HYSPLIT» procedure *[Pardini et al., 2017]*



- Three different methods were compared
- Each procedure has strengths and weaknesses
- A weighted average has been used to obtain the "best" value
- The VCTH values obtained vary between 4 and 13 km, and the entire period can be approximately divided into 3 main time ranges of activity: high (December 2020 to March 2021), low (March to June 2021), and medium/high (June 2021 to February 2022)

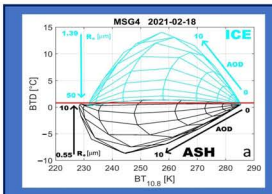
Volcanic Cloud Detection



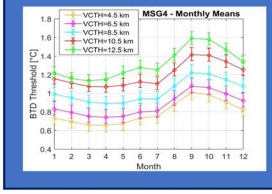
RGB combination:
R: T_b(12 μm) - T_b(10.8 μm)
G: T_b(10.8 μm) - T_b(8.7 μm)
B: T_b(10.8 μm)

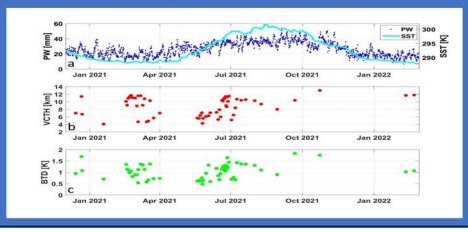
Brightness Temperature Difference: *[Prata et al., 1989]*
BTD: T_b(10.8 μm) - T_b(12 μm)

Ash/Ice Discrimination



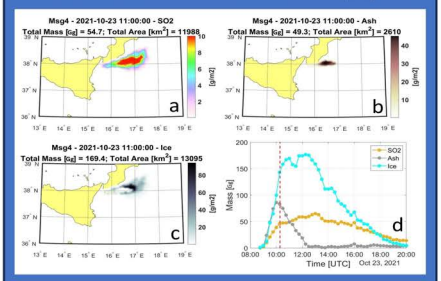
- Using MODTRAN Radiative Transfer Model it is possible to obtain for each eruption a specific BTD threshold to distinguish between Ash and Ice particles
- There is an overlap area in which ash and ice are indistinguishable
- The BTD threshold depends mainly on atmospheric water vapour content, VCTH and view zenith angle
- For Etna 2020-2022 these values range from 0.48 to 1.83, with a mean value of 1.04, that can be used as first approximation to avoid RTM computations.

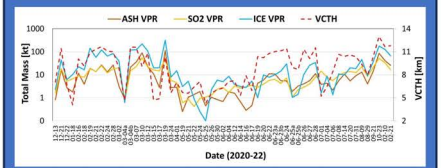




Ash/Ice/SO_2 Retrievals

Volcanic Plume Retrieval (VPR) *[Pugnaghi et al., 2013; 2016; Guerrieri et al., 2015]*

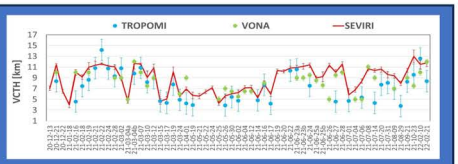


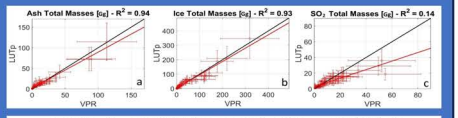


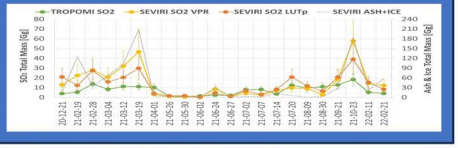
- Time series of ash/ice/SO2 total masses are in good correlation with VCTH and in most cases the ice content is greater than ash.
- The cumulative ash, ice, and SO2 emitted from all the 2020–2022 LFs in the atmosphere are about 750, 2300, and 670 Gg, respectively
- For a single episode, the ash, ice, and SO2 total masses reach maximum values of about 100, 300, and 50 Gg, respectively.

Products Cross-Comparison

- S5P-TROPOMI data (UV) are analyzed using COBRA algorithm [Theys et al., 2022]
- VONA: Volcano Observatory Notices for Aviation, a bulletin emanated from INGV-OE during the Etna activity
- The SEVIRI and VONA VCTHs are related to aerosols emissions near the volcano, while TROPOMI height refers to SO2 plume at quite some distance from Etna.
- The Look-Up Tables procedure (*LUTp*) is a well-known particles and gases retrieval method [Prata, 1989; Wen and Rose, 1994; Corradini et al., 2008; 2009; 2010]
- *VPR* and *LUTp* appear in good agreement for ash and ice retrievals, while SO2 *LUTp* results are generally lower than *VPR*, especially for the bigger activities (R^2=0.79 neglecting the nine LFs with ice total mass greater than 100 Gg)
- Generally, SEVIRI and TROPOMI SO2 are in quite good agreement for weak eruptions while for bigger eruptions SEVIRI > TROPOMI. The presence of large amounts of ash and ice produces an underestimation of TROPOMI retrievals (UV absorption)







This work was published in:
Guerrieri, L.; Corradini, S.; Theys, N.; Stelitano, D.; Merucci, L. *Volcanic Clouds Characterization of the 2020–2022 Sequence of Mt. Etna Lava Fountains Using MSG-SEVIRI and Products' Cross-Comparison*. Remote Sens. 2023, 15, 2055. https://doi.org/10.3390/rs15082055

ANALISI, MODELLAZIONE, INTERPRETAZIONE DI FENOMENI GEOFISICI

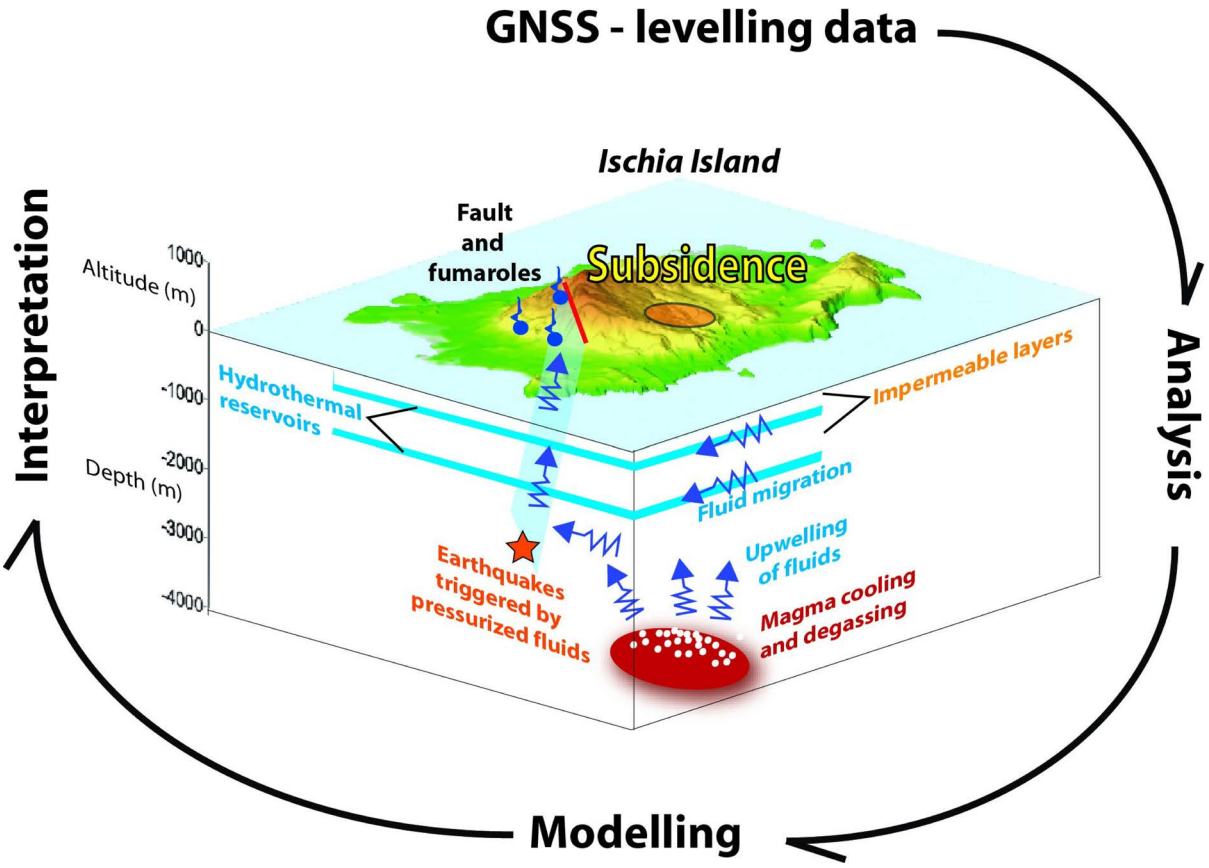
20 years of geodetic measurements reveal the degassing magma cooling processes under the Ischia resurgent caldera

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The knowledge of the processes that drive volcanoes deformation is of primary importance to decipher the dynamics of magmatic systems. We present twenty years (1997–2018) of geodetic GNSS and leveling data collected on survey-style Ischia Island network (Italy), which include a caldera affected by resurgence, hydrothermal manifestations, and shallow seismicity. The data from the GNSS Network and the leveling surveys reveal a continuous subsidence of the resurgent block with values up to −15 ± 2.0 mm/yr and centripetal, horizontal displacements with the largest values concentrated on the southern flank of the volcano. The modeling of GNSS and leveling data suggests a 4 km deep source deflating by degassing and/or magma cooling and it agrees with independent geophysical data. Degassing and magma cooling of reservoirs below the southern flank of Monte Epomeo are responsible for the Ischia deformation pattern that is not linked to gravity or volcano-tectonic processes. The Ischia shallow seismicity, located on active gas and hot water discharge areas, is due to the activities of the shallow hydrothermal system being neither temporally nor spatially related to the deflation.



Sketch of Ischia Island model.

ANALYSIS
MODELLING
INTERPRETATION OF
GEOPHYSICAL PHENOMENA

ENVIRONMENTAL

Monitoring of the River Po drought using SAR data

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One of the significant challenges faced by society and the environment in this century is climate change, which has led to various impacts, such as the severe drought in the Po River basin. Increasing temperatures and a shortage of rainfall have primarily caused this condition. The Po River District Basin Authority announced in June 2022 that this is the worst water crisis experienced in the last 70 years. Monitoring the river basins continuously can be crucial for understanding the issue's evolution and aiding in formulating regional or national water resource management strategies. Decision-makers can rely on cost-effective and dependable data on the river basins through the analysis of time-series satellite-based measurements. Within this context, remote sensing plays an important role and the Synthetic Aperture Radar (SAR) can be particularly advantageous for monitoring river basins due to its high-resolution imaging capabilities. The main goals of this study are to develop multi-temporal methods to effectively monitor the change of surface water area of the Po River, which is the longest river in Italy. The selected test site was strongly affected by drought in the Summer of 2022. Hence, monitoring it can be fundamental to understanding his emplacement evolution as well as the effects of climate change. Results are obtained by processing a set of 88 dual polarimetric (DP) SAR data collected at C-band from the Sentinel-1 and show that the SAR sensor can effectively monitor the water body changes that occurred over the river Po basin in an effective way.

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MONITORING OF THE RIVER PO DROUGHT USING SAR DATA

E. Ferrentino, M. Polcari, F. Silverii, C. Bignami, F. Nunziata, M. Migliaccio, S. Stramondo

INTRODUCTION

One of the major challenges faced by society and the environment in this century is climate change, which has led to various impacts, such as the severe drought in the Po River basin. This condition has been primarily caused by increasing temperatures and a shortage of rainfall. The Po River District Basin Authority announced in June 2022 that this is the worst water crisis experienced in the last 70 years. Within this context, radar sensors ensure all-day and almost all-weather observations, together with a wide area coverage and the Synthetic Aperture Radar (SAR), due to its almost all-weather and all-day fine spatial resolution imaging capabilities, can be a very useful tool for monitoring the change of surface water area of the Po River.

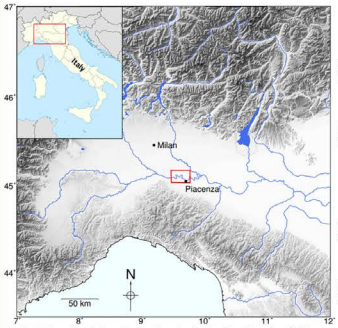


Fig. 1 - Map of the study area location. The red rectangle outlines the section of Po River analyzed in this study.

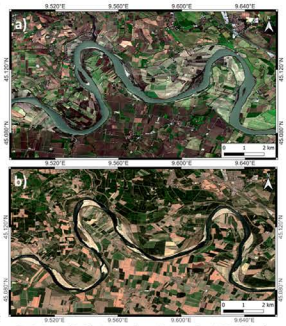


Fig. 2 – Sentinel-2 of the Po River observed on November 18, 2018 (a) and July 18, 2022 (b).

The main goals of this study are to develop polarimetric and temporal methods to effectively monitor the change of surface water area of the Po River, which is the longest river in Italy. The selected test site was strongly affected by drought in the Summer of 2022. Hence, monitoring it can be fundamental to understanding his emplacement evolution as well as the effects of climate change.

STUDY AREA AND DATASET

The study area is depicted in Fig. 1 and includes the Po River area close to the town of Piacenza. The Po is the longest Italian river, stretching over 650 km from its source in the Alps to the Adriatic Sea. The basin experienced several droughts in recent years, leading to significant water scarcity and economic losses. In June 2022, the Po River District Basin Authority declared that this was the most severe water crisis of the last 70 years.

The SAR dataset consists of a time series of **88 (one per month)** C-band Sentinel-1 collected from June 27, 2015, to September 18, 2022.

Dataset	Acquisition dates	Band	AoI	Acquisition pass	Pixel spacing (azimuth x range)
Sentinel-1	From 27/06/2015 to 18/09/2022	C-band	39°	Ascending	2.3x13.9

An excerpt of the speckle-filtered VV SAR scenes that include the Po River is shown in Figures Fig. 3 (a) and (b) before (November 14, 2018) and after (July 20, 2022) the major drought occurred in 2022.

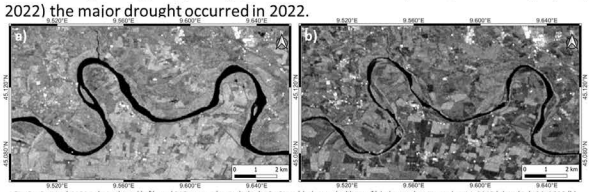


Fig. 3 – Sentinel-1 VV-polarized speckle filtered SAR scenes that include the Po River (darker snake-like profile) observed on November 14, 2018 (a) and July 20, 2022 (b).

PROPOSED METHODOLOGY

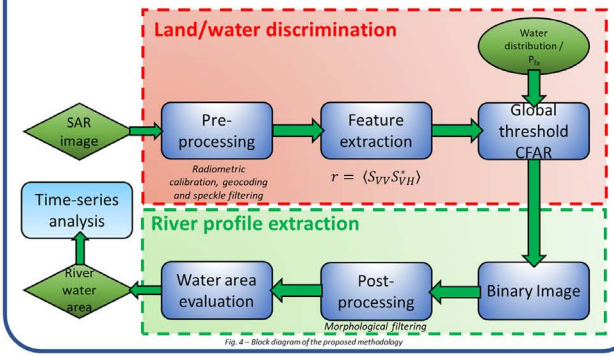


Fig. 4 – Block diagram of the proposed methodology

RESULTS

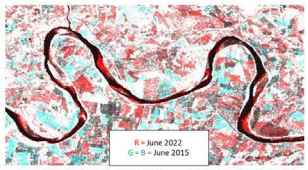


Fig. 5 – False color composite image of a section of the Po River close to the town of Piacenza, where R = G = June 2022 and B = June 2015. The area affected by the drought are visible in red.

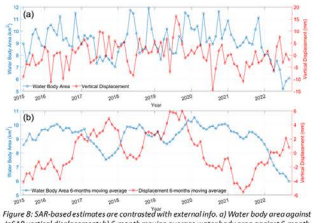


Figure 8: SAR-based estimates are contrasted with external info. a) Water body area against InSAR vertical displacement; b) 6-month moving average water body area against 6-month moving average vertical displacement.

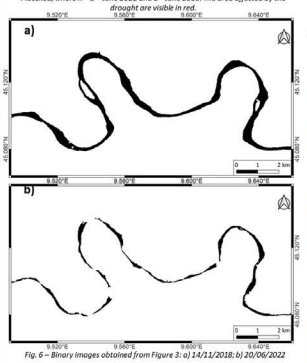


Fig. 6 – Binary images obtained from Figure 3: a) 14/11/2018; b) 20/06/2022

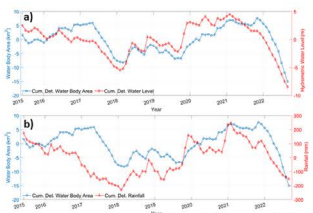


Figure 9: SAR-based estimates are contrasted with external information. a) cumulated and detrended water body area against cumulated and detrended water level; b) cumulated and detrended water body area against cumulated and detrended Rainfall.

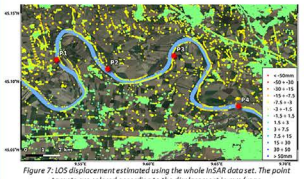


Figure 7: LOS displacement estimated using the whole InSAR dataset. The point targets are colored according to the displacement in mm/year.

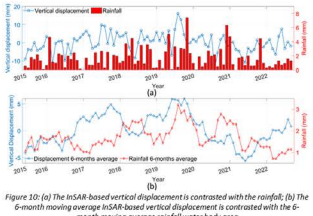


Figure 10: (a) The InSAR-based vertical displacement is contrasted with the rainfall; (b) The 6-month moving average InSAR-based vertical displacement is contrasted with the 6-month moving average rainfall water body area

SUMMARY

- Sentinel-1 SAR imagery can be successfully exploited to observe the time evolution of the water body area;
- Under reference conditions co- and cross-polarized SAR imagery provide similar performance in estimating the water-body area that agrees fairly well with information extracted by Sentinel-2 optical imagery. Under drought conditions, the cross-polarized channel provides odd results since it is not able to discriminate sandy areas from the surrounding environment;
- The time evolution of the water body area extracted from the time series of co-polarized Sentinel-1 imagery agrees fairly well with the independent hydrometric rainfall and SPEI information, suggesting including SAR-based analysis to help decision-makers.
- The ground deformation seems to be mainly linked to the elastic behavior of the banks of the river to the water load due to the increasing of the water level during the rainfall season and the significant uplift corresponding to the recent drought episode.
- The time evolution of the ground deformation clearly points out an anomalous behavior in 2022 confirming the severity of the drought event.

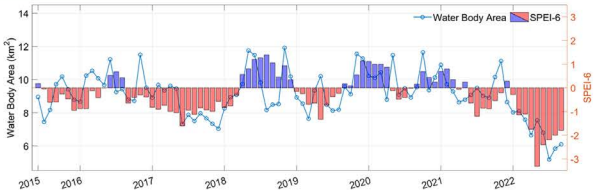


Figure 11: (a) SAR-based estimates (blue line) are contrasted with the SPEI-6 time series. Note that the red (blue) bars indicate negative (positive) SPEI values.

ANALISI, MODELLAZIONE, INTERPRETAZIONE DI FENOMENI GEOFISICI

CO_2 capture and storage: a current transversal issue that involved ONT

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CO_2 capture and storage (CCS) is an industrial technology that reduces greenhouse gas emissions in the atmosphere. It consists of a sequestration of the CO_2 produced by industrial activities, the transportation from the industrial plants to the storage sites, and the geological storage in oil/gas-depleted reservoirs. Since 2014, under a joint research agreement with a private research institute, a research team of ONT and Roma1 was involved in a project of a "*fault lab*" a test site for the development and testing of CO_2 monitoring technologies (microseismicity, leakage, deformation, flux dynamic, etc.). For the INGV task, our team carried out a passive seismic experiment to assess the seismic baseline in an area in the South-Western Sardinia (Sulcis). In addition to this activity, since 2016, our team has participated every year at the annual meeting of CO_2 Geonet (the significant European association promotes studies and technologies in CCS) and built a European research network with private companies and public research institutes engaged in CCS issues and emission reduction. The current need to achieve CO_2 emission neutrality worldwide in 2050 could address the growing involvement of ONT and the whole INGV in the future in terms of seismic and environmental themes.

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CO2 capture and storage: a current transversal issue that involved ONT

Anselmi M. ,Buttinelli M., Cantucci B., Bigi S., Chiarabba C.

CO2 capture and storage (CCS) is an industrial technology that reduces greenhouse gas emissions in the atmosphere. It consists of a sequestration of the CO2 produced by industrial activities, the transportation from the industrial plants to the storage sites, and the geological storage in oil/gas-depleted reservoirs.
Since 2014, under a joint research agreement with a private research institute, a research team of ONT and Roma1 was involved in a project of a "fault lab" a test site for the development and testing of CO2 monitoring technologies (microseismicity, leakage, deformation, flux dynamic, etc.). For the INGV task, our team carried out a passive seismic experiment to assess the seismic baseline in an area in the South-Western Sardinia (Sulcis).
In addition to this activity, since 2016, our team participated every year at the annual meeting of CO2 Geonet (the significant European association promotes studies and technologies in CCS) and built a european research network with private companies and public research institutes engaged in CCS issues and emission reduction.
The current need to achieve CO2 emission neutrality worldwide in 2050 could address the growing involvement of ONT and the whole INGV in the future in terms of seismic and environmental themes.

PILOT PROJECTS AND LABS



Sulcis - Italy (Sotacarbo)



Svelvik- Norway (Sintef)



Murcia- Spain (Carboncause)

INDUSTRIAL CO2 INJ. PROJECTS



Northern Lights -Norway (Equinor)



Ravenna PCMW - Italy (ENI-SNAM)

CCS European Alliances

EERA European Energy Research Alliance CCS - Carbon Capture and Storage

GeoNet

INJECTION NUMBERS

Norway
43Mtonn/y (2018)
Vestland-Sleipner Inj. Potential
20 Mt/y (2030)

Italy
430 Mtonns/y (2018)
Ravenna Injection potential
4Mt/y (2024) - 10 (2030)- 35(2040)

ANALISI, MODELLAZIONE, INTERPRETAZIONE DI FENOMENI GEOFISICI

Poster presented at the “Giornata ONT 2023”.

NATIONAL AND INTERNATIONAL PROJECTS

Monitoring of different hazards and environmental impact due to heavy industrial activity and natural phenomena through Remote Sensing Data

Cristiano Tolomei[1,*], Lianhuan Wei[2], Fang Wang[2], Shanjun Liu[2], Christian Bignami[1], Bing Li[3], Donglin Lv[4], Elisa Trasatti[1], Yuan Cui[3], Guido Ventura[1], Meng Ao[2], Stefano Salvi[1], Shiliu Wang[2], Xingyu Pan[2]

[1]*INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy*
[2]*School of Resources and Civil Engineering, Northeastern University, Shenyang, China*
[3]*Department of Geological Environment Monitoring, Liaoning 10th Geological Brigade, Fushun, China*
[4]*Energy Geology Institute, Liaoning Geology and Mineral Resources Group, Shenyang, China*

**Corresponding author: cristiano.tolomei@ingv.it*

In the framework of the ESA-MOST Dragon-5 project, the INGV from Italy, Northeastern University (NEU) and Jilin Earthquake Agency from China conduct collaborative research on the multiple mining-induced geohazards in Northeast China and the Changbaishan active volcano (Jilin Province, ~300 km east from Shenyang) using time Series SAR images. The Fushun west Opencast coal mine (FWOCM), located in the southwest of Fushun city, China, is the largest opencast mine in Asia. Since the 1920s, more than 90 landslides have been reported in FWOCM, especially the huge landslide on the south slope. In order to analyze the spatial pattern and temporal evolution of different periods of the landslides and subsidences, MT-InSAR techniques have been performed considering Sentinel-1 and Cosmo SkyMed SAR images collected during 2017 to 2022 to monitor the ground displacement [Wei et al., 2023]. Moreover, analysis on the multi-hazards of Changbaishan is very important because a population of ~135000 in China and 31000 in North Korea lives within 50 km far from the volcano. We analyzed the deformation of Changbaishan volcano during 2018–2022 processing by means of the Permanent Scatterers technique [Ferretti et al., 2001] a dataset consisting of 23 ALOS-2 images (L-Band, StripMap mode), acquired along the ascending orbit and revealing a low-level unrest occurred during 2020.12-2021.6. Modeling results suggest that three active sources are responsible for the observed ground velocities: a deep tabular deflating source, a shallower inflating NW-SE elongated spheroid source, and a NW-SE striking dip-slip fault.

References

Ferretti, A., Prati, C., and Rocca, F., (2001). *Permanent scatterers in SAR interferometry*. IEEE Trans. Geosci. Remote Sens., 39(1), 8– 20. https://doi.org/10.1109/36.898661

Wei, L., Wang, F., Tolomei, C., Liu, S., Bignami, C., Li B., Lv D., et al., (2023). *Displacements of Fushun west opencast coal mine revealed by multi-temporal InSAR technology*. Geo-spatial Information Science. https://doi.org/10.1080/10095020.2023.2239285

GIORNATA ONT martedì 14 2023

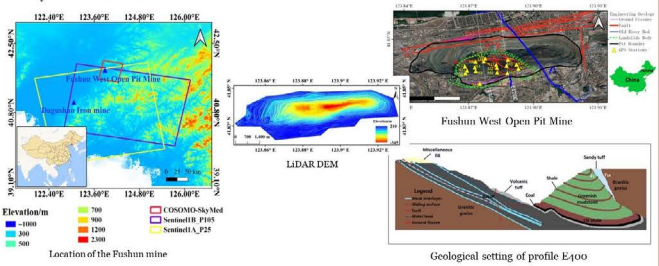
Monitoring of different hazards and environmental impact due to heavy industrial activity and natural phenomena through Remote Sensing Data

Cristiano Tolomei(1)*, Lianhuan Wei(2), Fang Wang, Shanjun Liu(2), Christian Bignami(1), Bing Li(3), Donglin Lv(4), Elisa Trasatti(1), Yuan Cui(3), Guido Ventura(1), Meng Ao(2), Stefano Salvi(1), Shiliu Wang(2) & Xingyu Pan(2).

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The Fushun west Opencast coal mine (FWOCM), located in the southwest of Fushun city, China, is the largest opencast mine in Asia. Since the 1920s, more than 90 landslides have been reported in FWOCM, especially the huge landslide on the south slope. In order to analyze the spatial pattern and temporal evolution of different periods of the landslides and subsidences, MT-InSAR techniques have been performed considering Sentinel-1 and Cosmo SkyMed SAR images collected during 2017 to 2022 to monitor the ground displacement.
Moreover, analysis on the multi-hazards of Changbaishan is very important because a population of ~135000 in China and 31000 in North Korea lives within 50 km far from the volcano. We analyzed the deformation of Changbaishan volcano during 2018–2022 processing, by means of the PS technique, a dataset consisting of 23 ALOS-2 images (L-Band, StripMap mode), acquired along the ascending orbit, revealing a low-level unrest occurred during 2020.12-2021.6.
Modeling results suggest that three active sources are responsible for the observed ground velocities: a deep tabular deflating source, a shallower inflating NW-SE elongated spheroid source, and a NW-SE striking dip-slip fault.

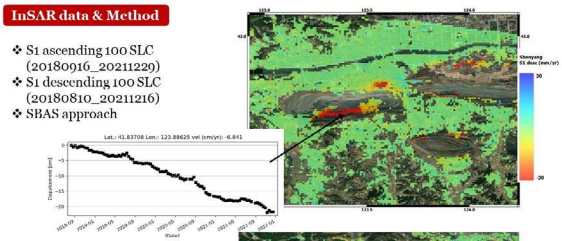
Landslide Monitoring in Fushun West Open Pit Mine

Study area and datasets

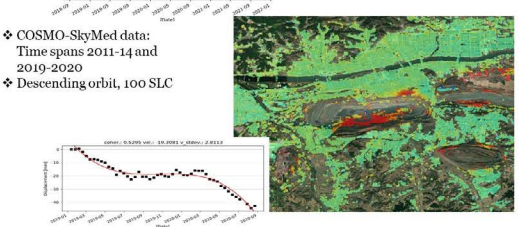


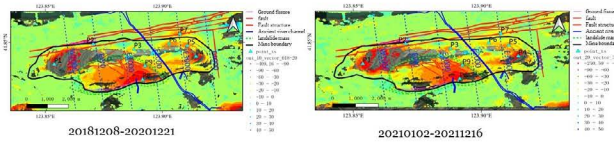
InSAR data & Method

- S1 ascending 100 SLC (20180916_20211229)
- S1 descending 100 SLC (20180810_20211216)
- SBAS approach



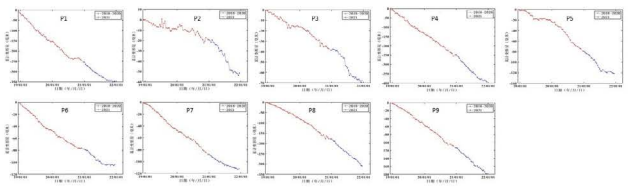
- COSMO-SkyMed data: Time spans 2011-14 and 2019-2020
- Descending orbit, 100 SLC





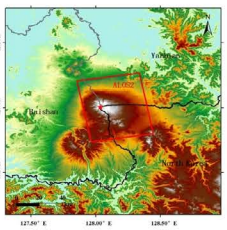
Areas under deformation

1. Qiantai Mountain Landslide on the south slope : the western part has decelerated in 2021 compared to 2018~2020, whereas the eastern part remains unstable, with maximum deformation near the ancient Liushan river channel (near P8).
2. City near the northeastern slope: elliptical subsidence area (centered on the intersection of E3000 and F1 Fault (near P7), has decelerated in 2021 compared to 2018~2020.
3. Western part of the north slope: historical landslide area, was stable during 2018~2020, whereas some local deformation occurred in 2021 (near P2).
4. Central part of the north slope (E1000~E1400,near P3): accelerates in 2021 compared to 2018~2020.
5. Western slope: reclaimed, with gentle slope angles, consolidation settlement of the backfill continuously occurs (near P1).
6. Eastern slope: steep slope, large deformation, vehicles passing by frequently, should be continuously monitored (near P4).

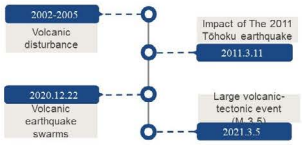


Recent activity of Changbaishan Tianchi Volcano

Study area



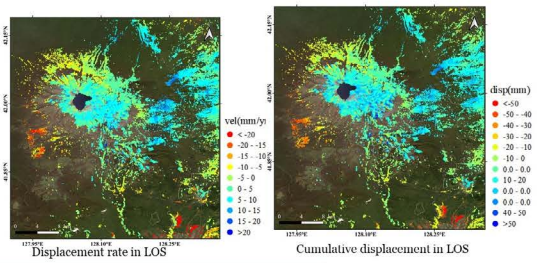
Changbaishan Tianchi volcano is the most complete Cenozoic composite volcano preserved in China. There is an annual uplift of about 4 mm close to the crater.



From 2002 to 2005, the Tianchi volcano has obvious magma disturbance events. On December 22, 2020, a volcanic earthquake swarms suddenly appeared on Tianchi Volcano. An earthquake of magnitude M3.1 occurred on March 5, 2021, which was the largest structural volcanic earthquake event after the end of the volcanic disturbance period. There are 135000 Chinese and 31000 North Korean residents living within 50km of the volcano, and about 2 million tourists visit Changbaishan Volcano National Nature Reserve every year. Therefore, the dynamic monitoring of Tianchi volcano is very important to ensure the safety of these people's lives and properties.

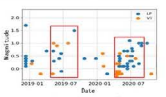
InSAR data & Method

19 L-band ALOS-2 images (ascending orbit) covering the study area (right) from November 2018 to October 2020 were processed using PSI technique.

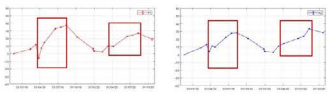


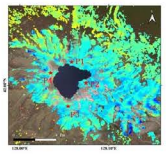
Displacement rate in LOS — Cumulative displacement in LOS

Recent activity of Changbaishan Tianchi Volcano

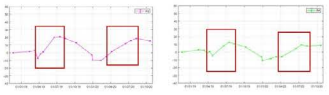


Seismic records



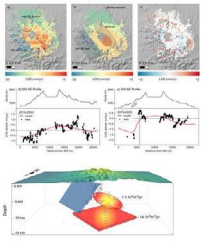


Cumulative displacement in LOS



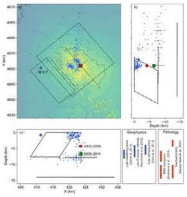
Displacement time series of P1-P4 sites in LOS

Geophysical Modeling



Three sources:
- a deflating deep tabular source
- an inflating spheroid
- a dip-slip fault

✓ **Changbaishan plumbing system is in a recharging phase with magma transfer from 14 to 7 km depth.**



Sources of the 2002-2005 uplift and 2009-2011 subsidence from levelling data

PROGETTI NAZIONALI E INTERNAZIONALI

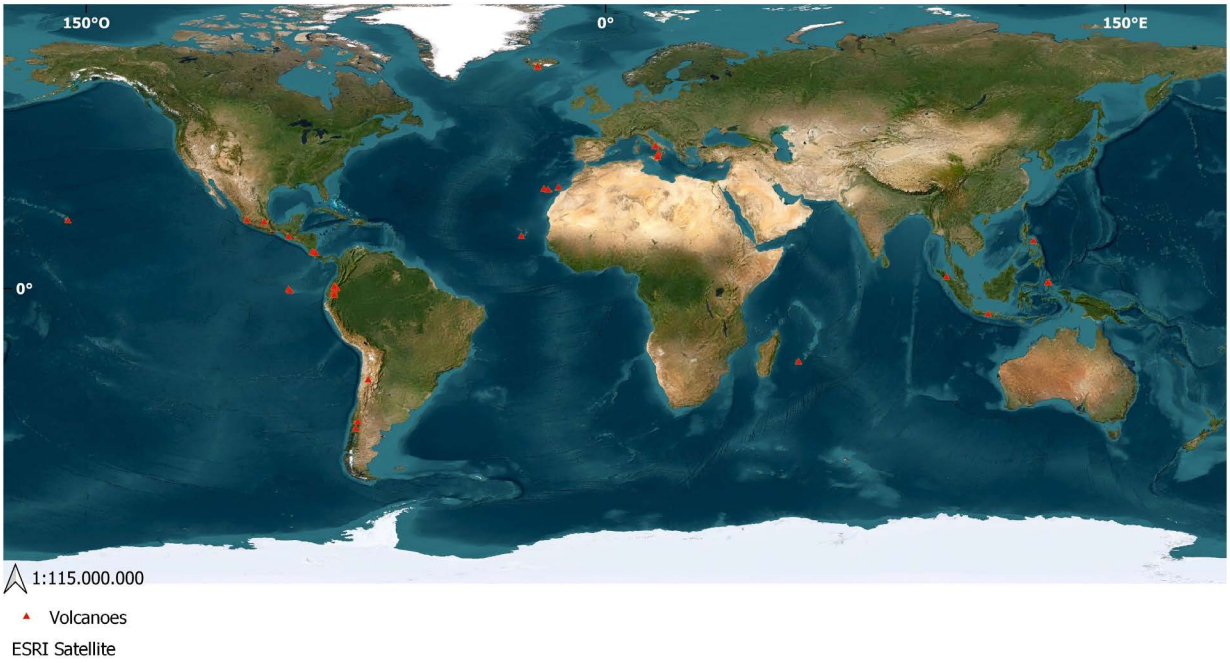
The VULCAIN project: a CubeSat space mission dedicated to volcanoes

Vito Romaniello*, Maria Fabrizia Buongiorno, Malvina Silvestri

INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy

**Corresponding author: vito.romaniello@ingv.it*

This work aims to present the VULCAIN mission study to design new CubeSat satellites for the observation of volcanoes. The project, funded by the Italian Space Agency (ASI) and supervised by the European Space Agency (ESA), includes six Italian partners. The project involves the construction of two 12U nanosatellites flying in formation in order to obtain stereoscopic images. Each satellite embarks two instruments on-board: a Commercial Off-The-Shelf (COTS) visible camera and a multispectral thermal camera with four channels in the 8-12 µm spectral range. The expected spatial resolution is <40 m and <100 m for visible and thermal cameras, respectively. The combination of VIS-TIR data allows to reduce the geolocation error and enhance the spatial resolution of thermal measurements. The main scientific objectives are to measure the Land Surface Temperature (LST), as well as the SO2 content in degassing plumes and to detect ash emissions from active volcanoes. Moreover, the use of two nanosatellites in formation allows us to obtain 3D images of volcanoes to support the morphological analysis. A total of 34 worldwide volcanic sites have been selected as primary targets for the VULCAIN space mission.



Location of volcanic targets.

Shear waves velocity model of the crust and uppermost mantle in the eastern Alps from Receiver Functions Pseudo-Tomography

Francesco Pio Lucente*, Irene Bianchi, Massimo Di Bona, Carlo Doglioni, Aladino Govoni, Simone Salimbeni and AlpArray Working Group**

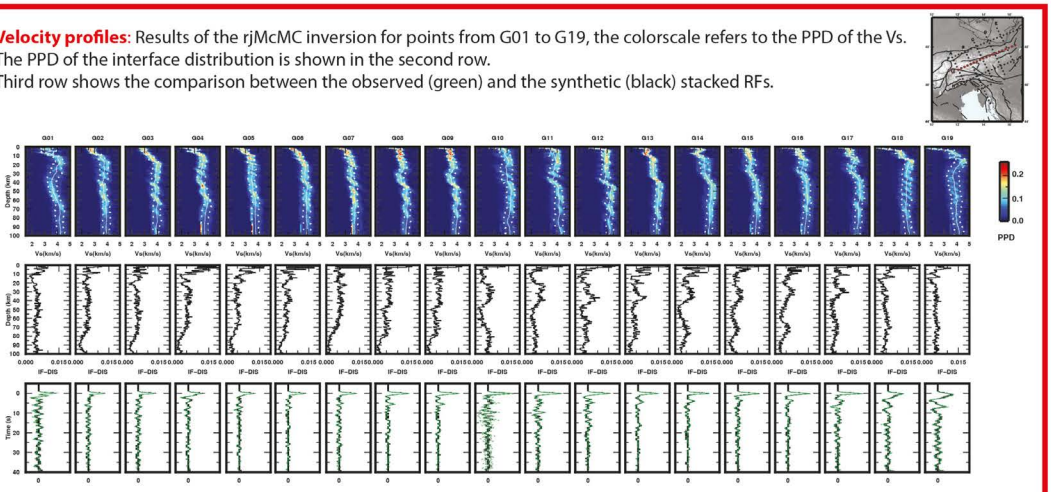
INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy

**Corresponding author: pio.lucente@ingv.it*

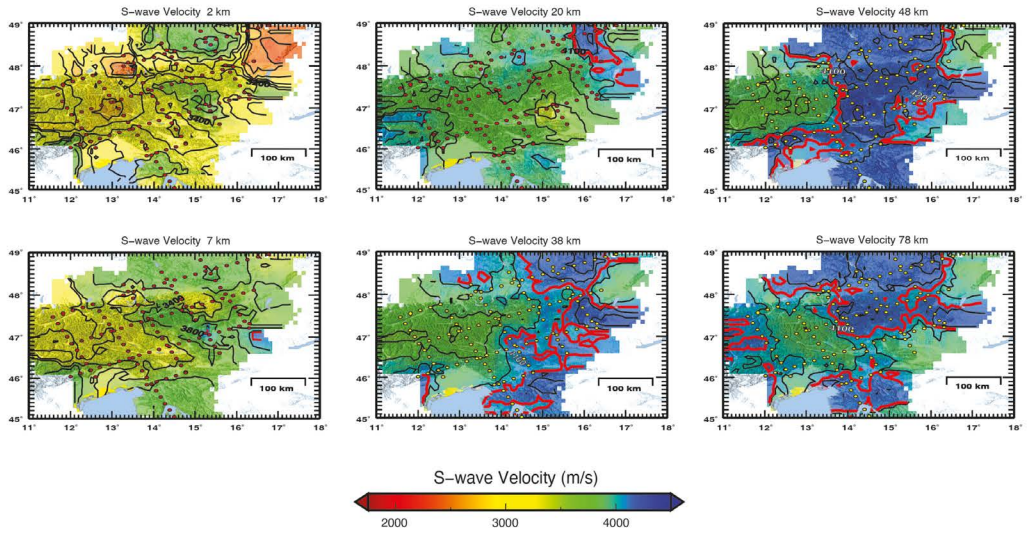
***AlpArray Working Group: http://www.alparray.ethz.ch/en/seismic_network/backbone/data-policy-and-citation/*

In the receiver function technique, the P-to-S seismic waves conversions at the Earth's internal discontinuities provide information about the depth of such discontinuities beneath the recording seismometer and about the seismic waves' velocity between the discontinuities and the receiver. The combination of receiver function (RF) data from multiple seismic stations is routinely used to map the main discontinuities in the Earth's crust and mantle. In this study, we took advantage of the RFs computed at the dense network of temporary and permanent seismic stations deployed in the framework of the AlpArray Project [*www.alparray.ethz.ch*] to construct a 3D continuous shear waves velocity model of the Earth's crust and uppermost mantle in the eastern Alp region, down to 100 km depth. Through this pseudo-tomographic model, we reconstruct the lateral and vertical distribution of the S-waves velocities: the result is a very heterogeneous structure, far away from a simple layered crust model. Among the main findings we highlight the very low velocity structure of the Alpine roots and beneath the Molasse basin, the presence of shallow high velocity bodies beneath the Pannonian basin, and the lack of continuities of a Moho-like seismic velocity horizon in the central-western part of the study region.

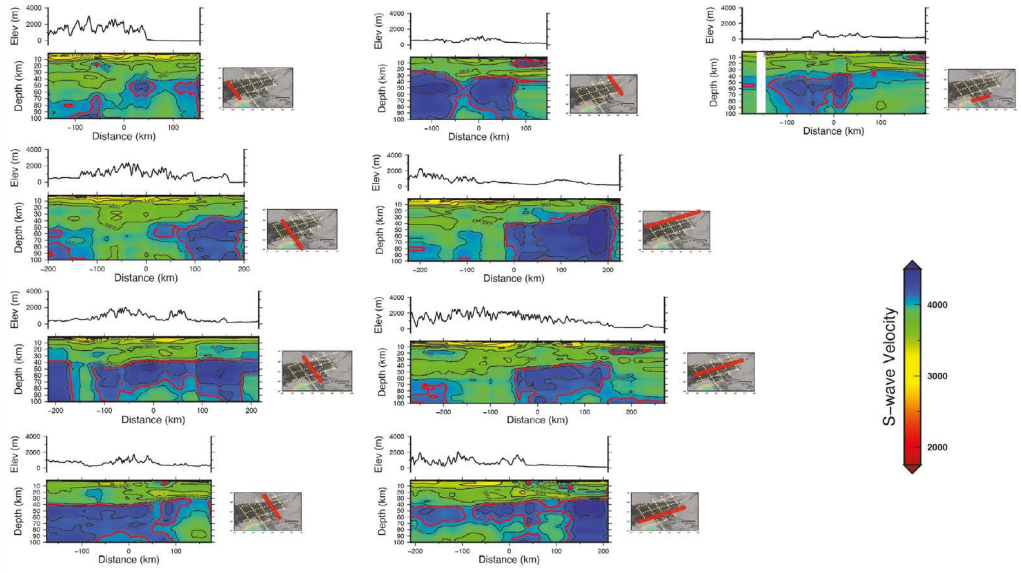
Velocity profiles: Results of the rjMcMC inversion for points from G01 to G19, the colorscale refers to the PPD of the Vs.
The PPD of the interface distribution is shown in the second row.
Third row shows the comparison between the observed (green) and the synthetic (black) stacked RFs.



Velocity maps: significant layers of the shear velocity model obtained by the interpolations at each depth of the values along the velocity profiles (see above panel) calculated in the points shown on each map.



Cross sections: significant cross sections through the interpolated shear velocity model. For each section the corresponding trace on the map is shown on its right.
Sections are drawn from West to East and from North to South. In each section the isoline at Vs = 4.1 km/s is highlighted (red line), as a first-order estimate of the Moho.



Shear waves velocity model of the Earth's crust and uppermost mantle in the eastern Alps from Receiver Functions analysis.

Recent results from geodynamic and seismotectonic investigations in the western Alps

Elena Eva[1], Marco G. Malusà[2], Stefano Solarino[1,*]

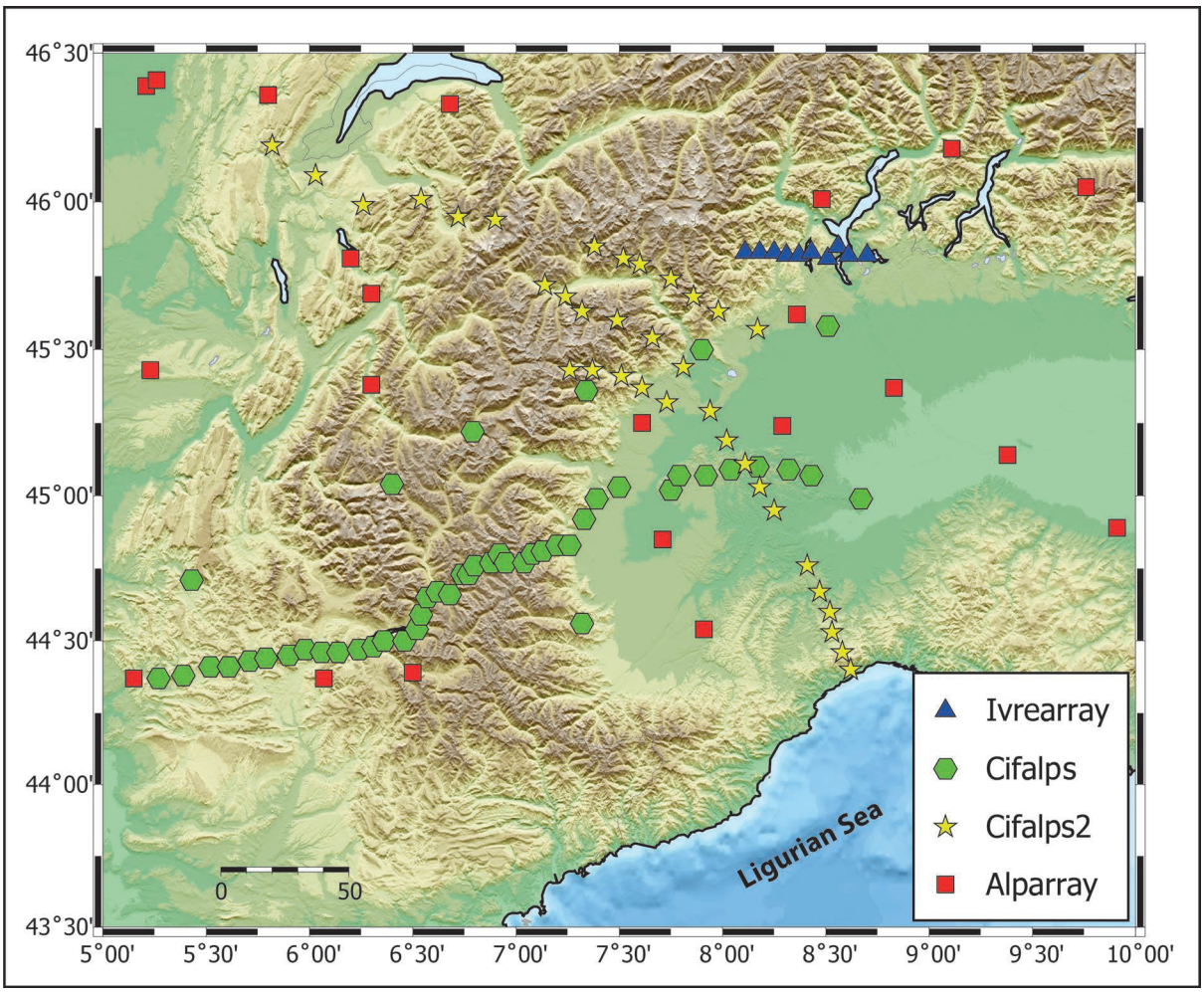
[1]*INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy*
[2]*Department of Earth and Environmental Sciences, University of Milano-Bicocca, Milano, Italy*

**Corresponding author: stefano.solarino@ingv.it*

The European Alps are the result of the oblique subduction of the Alpine Tethys under the Adriatic microplate since the Late Cretaceous, followed by continental collision between the Adriatic and European paleomargins in the Cenozoic. Despite the role of this chain in the geodynamic evolution, its deep tectonic structure has long been poorly constrained by independent geophysical evidence. However, in the last years, many seismological projects provided new data both on transects (Cifalps, Cifalps2 [*https://www.isterre.fr/english/research-observation/research-projects/other-projects/completed-projects/article/projets-cifalps-cifalps-2-china-italy-france-alps-seismic-survey.html*], Ivrea complementary array [*http://www.alparray.ethz.ch/en/research/complementary-experiments/ivrea/overview/*]) or on a grid geometry (Alparray [*http://www.alparray.ethz.ch/en/*]), from local to a regional scale.
The INGV-ONT group based in Genova joined all projects and cooperated with research groups of INGV (Bologna section for CIfalps e Cifalps2) and several Countries to exploit this unprecedented amount of data making use of local earthquake seismicity, high precision location methods, receiver function, full inversion of teleseismic waveforms, ambient noise tomography, seismic anisotropy among the others. The main results [Malusà et al., 2021] can be summarized as follows: - first seismic evidence of European crust subducted into the Adriatic upper mantle - evidence of the major involvement of the mantle wedge during crucial steps of (U)HP rock exhumation - high-resolution image of a fossil subduction channel providing evidence of a serpentinized plate interface that favors continental subduction - evidence of a continuous slab beneath the Western and Central Alps, ruling out the classic hypothesis of slab breakoff magmatism - evidence of a polyphase development of anisotropic mantle fabrics, either representing active mantle flows inducing localized weakening of the overlying lithosphere, or fossil fabrics inherited from previous rifting stages.
Data availability: Cifalps and Cifalps2 [*https://www.fdsn.org/networks/detail/XT_2018/*]; Alparray [*https://www.fdsn.org/networks/detail/Z3_2015/*]; Ivrea complementary array [*https://www.fdsn.org/networks/detail/XK_2017/*].

References

Malusà, M. G., Guillot, S., Zhao, L., Paul, A., Solarino, S., Dumont, T., et al., (2021). *The deep structure of the Alps based on the CIFALPS seismic experiment: A synthesis*. Geochemistry, Geophysics, Geosystems, 22, e2020GC009466. https://doi.org/10.1029/2020GC009466



Station map of the recent passive seismic experiments in the Northwestern Alps.

The temporary seismic network "FXLand": contribution to the project "Fiber Optic Cable Use For Seafloor Studies Of Earthquake - FOCUS"

Lucia Margheriti[1,*], Milena Moretti[1], Chastity Aiken[2], Salvatore Claudio Alparone[1], Ornella Cocina[1], Danilo Contrafatto[1], Antonio Costanzo[1], Pierdomenico Del Gaudio[1], Sergio Di Prima[1], Sergio Falcone[1], Rocco Lorenzo Festa[3], Anna Gervasi[1], Aladino Govoni[1], Marc-Andre Gutscher[2], Graziano Larocca[1], Mario La Rocca[3], Diana Latorre[1], Alfonso Giovanni Mandiello[1], Alessandro Marchetti[1], Shane Murphy[2], Anna Nardi[1], Marina Pastori[1], Davide Piccinini[1], Stefano Pintore[1], Michela Ponte[3], Salvatore Rapisarda[1], Luciano Scuderi[1], Salvatore Stramondo[1]

[1]*INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy*
[2]*Geo-Ocean | Unité Mixte de Recherche 6538 CNRS - Ifremer - UBO - UBS*
[3]*UniCal | Università della Calabria, Laboratorio di Sismologia, Cosenza, Italy*

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In the context of the Fiber Optic Cable Use for Seafloor (FOCUS) project [Gutcher et al., 2023], a temporary seismic network – called FXland (1J, Figure A [Moretti et al. 2021; Margheriti et al., 2024]) - was set up on land to monitor seismic activity in the Ionian Sea. This experiment aims to improve the detection of seismicity, the accuracy of earthquake localizations and define the crustal structure of the region in greater detail, with particular attention to the seismogenic structures present.
FXland was deployed on land to integrate in real time the permanent networks of the INGV for surveillance purposes and it was archived in the EIDA archive. Moreover, the FXOBS (XH) network was deployed at sea in stand-alone mode, the data will be released in EIDA in the next few years. The institutions involved in the project are collaborating on the acquisition and processing of data, the imaging of the Earth's interior and its modeling with advanced techniques. During the operation period (December 23, 2021 - February 2, 2023), 1186 regional earthquakes and 153 magnitude 6+ teleseisms were recorded [terremoti.ingv.it]. The Bollettino Sismico Italiano (BSI) analysts reviewed local events, including seismic sequences near Catania, in the Strait of Messina, and in the Ionian Sea from February to April 2022. A template match technique was applied, we obtained good results in the first two cases doubling the number of detected events, while for the seismicity in the Ionian Sea, there was no improvement; we plan to use the data of the XH network.

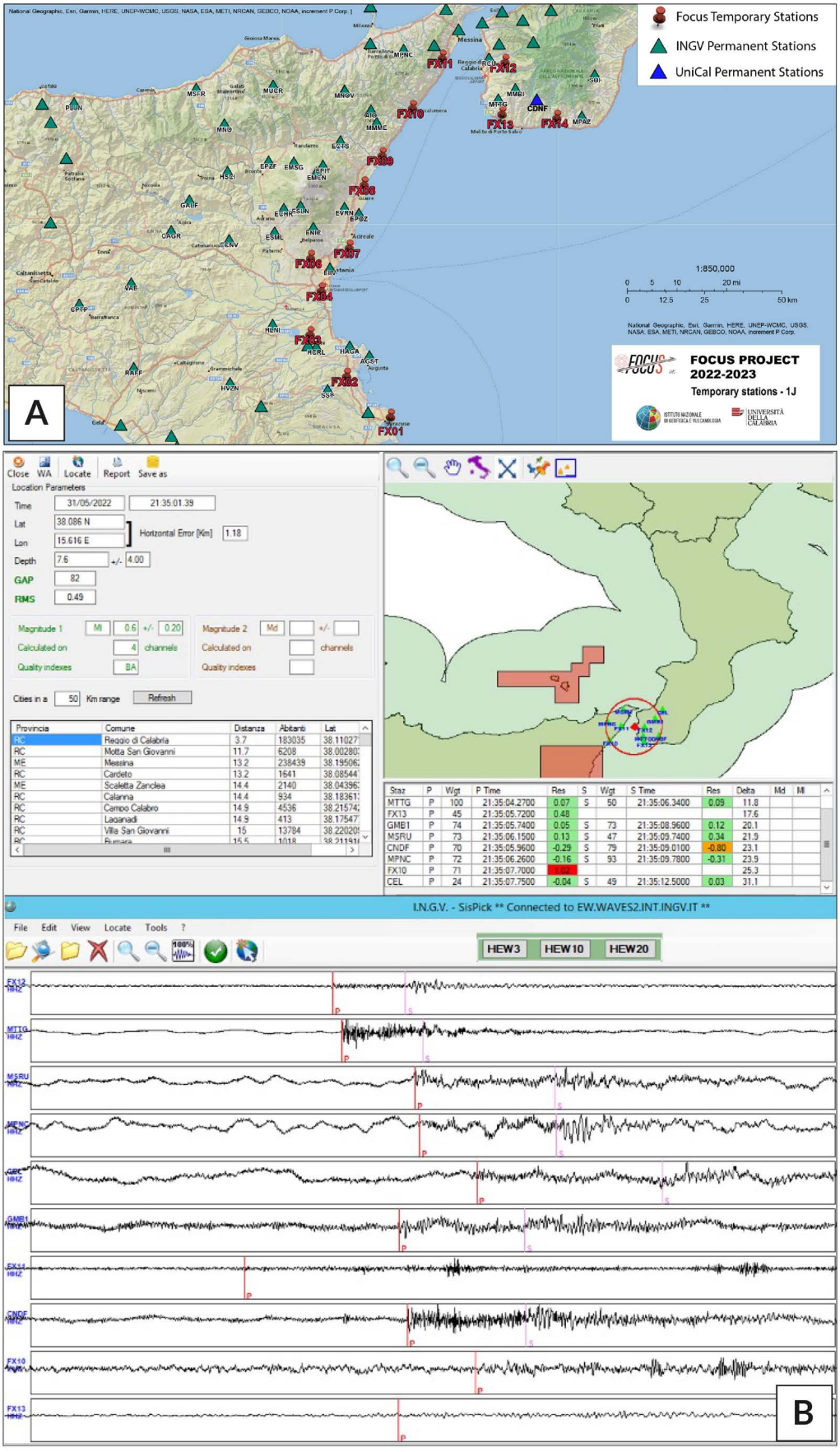
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Gutscher, M., et al., (2023). *Detecting strain with a fiber optic cable on the seafloor offshore Mount Etna, Southern Italy.* Earth and Planetary Science Letters, 616, 118230. https://doi.org/10.1016/j.epsl.2023.118230

Marchetti A., et al., (2016). *The Italian Seismic Bulletin: strategies, revised pickings and locations of the Amatrice seismic sequence,* Ann. Geophysics, this issue. https://doi.org/10.4401/ag-7169

Margheriti L., et al., (2024). *La rete sismica temporanea "FXLand": contribuito al Progetto "Fiber Optic Cable Use For Seafloor Studies Of Earthquake - FOCUS".* Rapp. Tec. INGV, 479: 1-26, https://doi.org/10.13127/rpt/479

Moretti, M., et al., (2021). *Seismic Data acquired by FocusX temporary land-network (FXland), Southern Italy* [Data set]. Istituto Nazionale di Geofisica e Vulcanologia (INGV). https://doi.org/10.13127/sd/o5qwm6wjcd



A) Map of the stations of the FXLand network in the frame of the permanent INGV network. B) Event M_L 0.6 of May 31st in the Messina Strait. Analysis done using the software of the Italian Seismic Bulletin.

Finding a seismic signature of the Morrone Fault: the Majella-Morrone experiment

Mario Anselmi*, Samer Bagh, Claudio Chiarabba, Pasquale De Gori, Rossella Fonzetti, Irene Menichelli, Giuseppe Pezzo, Gilberto Saccorotti, Francesca Silverii

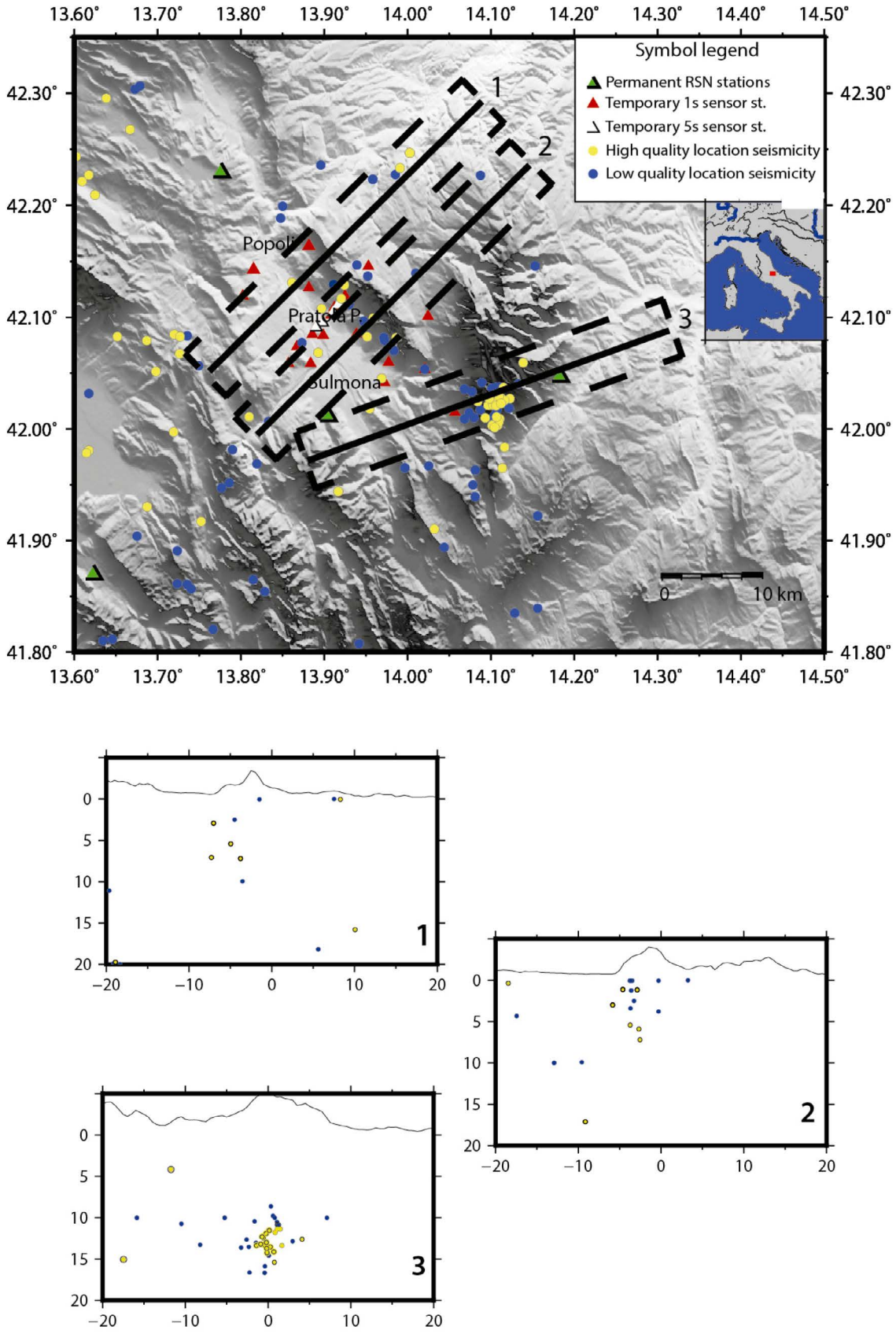
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In the PON-GRINT project framework, an ONT working group, some Ph.D. students, and researchers of other INGV venues designed and carried out a passive seismic experiment. The field activities began in May 2022 and are still ongoing in the Abruzzi region (Central Italy). Between May and October 2022, an amount of 23 temporary seismic stations were deployed in a ~ 250 km^2 area extending from the Sulmona-Pratola Peligna basin to the eastern side of Mount Morrone.

The location of the study area is in the Central Apennines, southeast of the area struck by the 2009 L'Aquila seismic sequence. Although the last 20 years have been characterized by a low-magnitude seismicity, the presence of the Morrone Fault (a debated active fault at the south-western front of the Monte Morrone) motivated the realization of our experiment with the goal of detecting the microseismicity that occurred in the whole area and also the possible release from the Morrone Fault.

The field activity results in the building of a temporary network, integrated with regional and national seismic networks, with an average station inter-distance of about 7-8 Km. We deployed a subset of network seismic stations to make a transect across the Monte-Morrone to define the fault structure using ambient noise seismological techniques.



Map of the temporary seismic network of the experiment and a preliminary location of the seismicity recorded between October and December 2022.

Deformation of Mefite d'Ansanto area (AV). FURTHER Project

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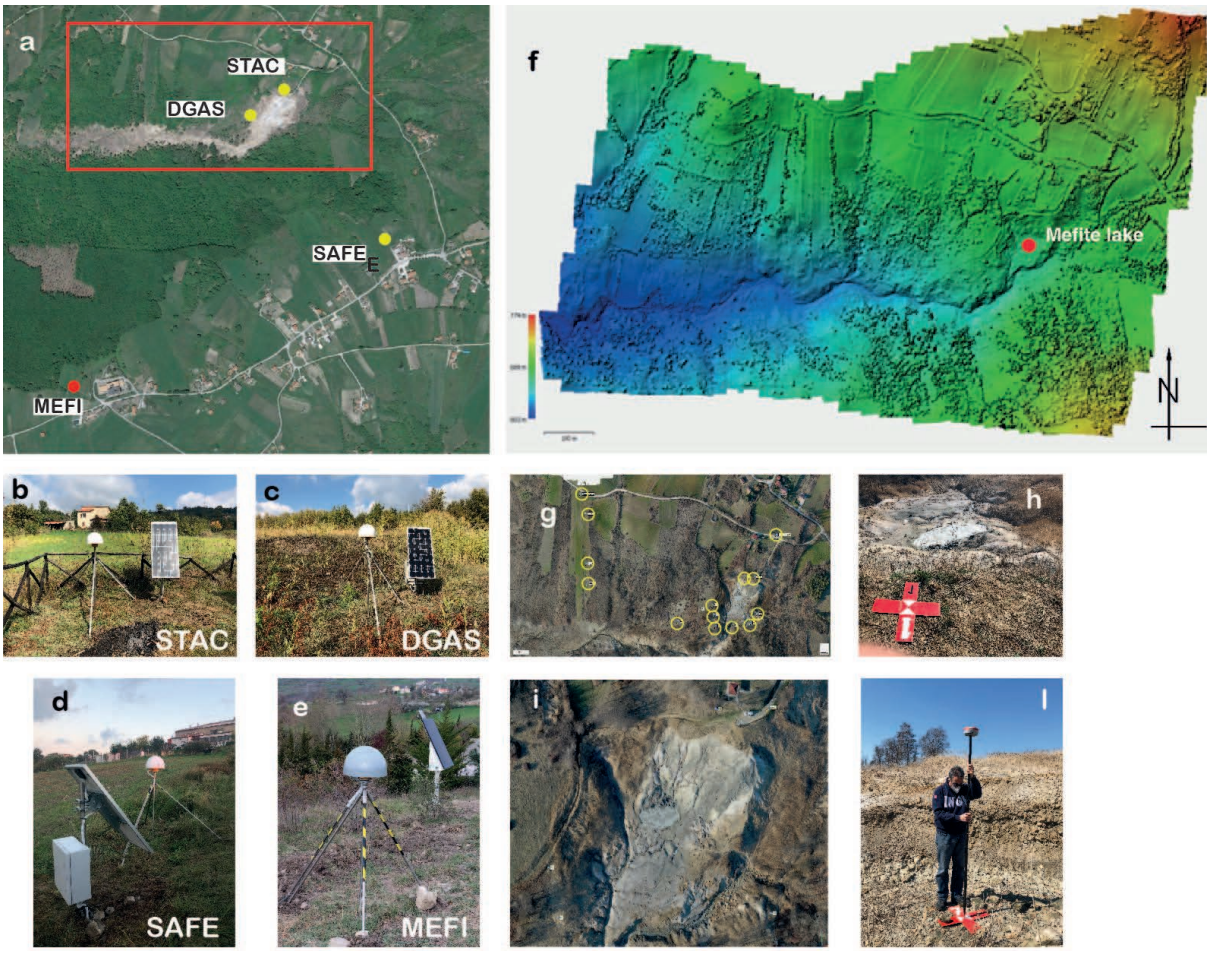
In the frame of the Departmental FURTHER project (The role of FlUids in the pReparaTory pHase of EaRthquakes in Southern Apennines [*https://progetti.ingv.it/en/further*]), we focus on the geodetic monitoring of the Mefite d'Ansanto deep CO_2 degassing area (AV, Italy) to provide an improved picture of the regional crustal deformation pattern. We analyzed all available continuous GNSS observations with the new data collected at episodic benchmarks. The area represents the largest low-temperature non-volcanic CO_2 emission of the Earth [Chiodini et al., 2010]. The main degassing vent is a wide horse-shoe shaped erosion hosting the lake Mefite, about 20 $m^{2.}$ We implemented a new local GNSS network (Figure), and we carried out a survey with flew over the area with a quadcopter drone to obtain a high-resolution Digital Elevation Model (DEM) (Figure); that also aim is also ed to estimate the amount and the variations of the Mefite lake level in space and time. The new local GNSS network, MefiteNet, consists of one permanent and three episodic stations. The permanent MEFI station was installed on 14th April 2022, in the Serro del Bosco location. Since 21th April 2022 MEFI is part of the RING network [Selvaggi et al., 2006; INGV RING Working Group, 2016]. On 14th October 2022 three GNSS stations, named SAFE, DGAS and STAC respectively were installed.
To create the DEM, an aerial photogrammetric survey was conducted using a DJI Mavic 2 Pro drone. We chose to perform a Terrain Follow Flight to ensure a constant pixel size and avoid issues with ground coverage. To increase the accuracy of the products and achieve the most precise georeferencing possible, we conducted a ground-based GPS measurement (RTK) using a STONEX S900A Rover receiver. This allowed us to measure 16 Ground Control Points, resulting in a ground resolution of 4.5 cm.

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GNSS MefiteNet and high-resolution Digital Elevation Model (DEM). a - location of benchmarks. Red square area of Digital Elevation Model. b, c, d, e - monumentation of the network at different benchmarks. f - first DEM of the degassing area. g - orthophoto with the Ground Control Points (yellow dots) position used during the UAVsurveys. h - detail of GCP. i - degassing area view, geological setting. l - detail of survey.

ARISTOTLE: A multi hazard scientific expert assessment service for the EC Emergency Response Coordination Center

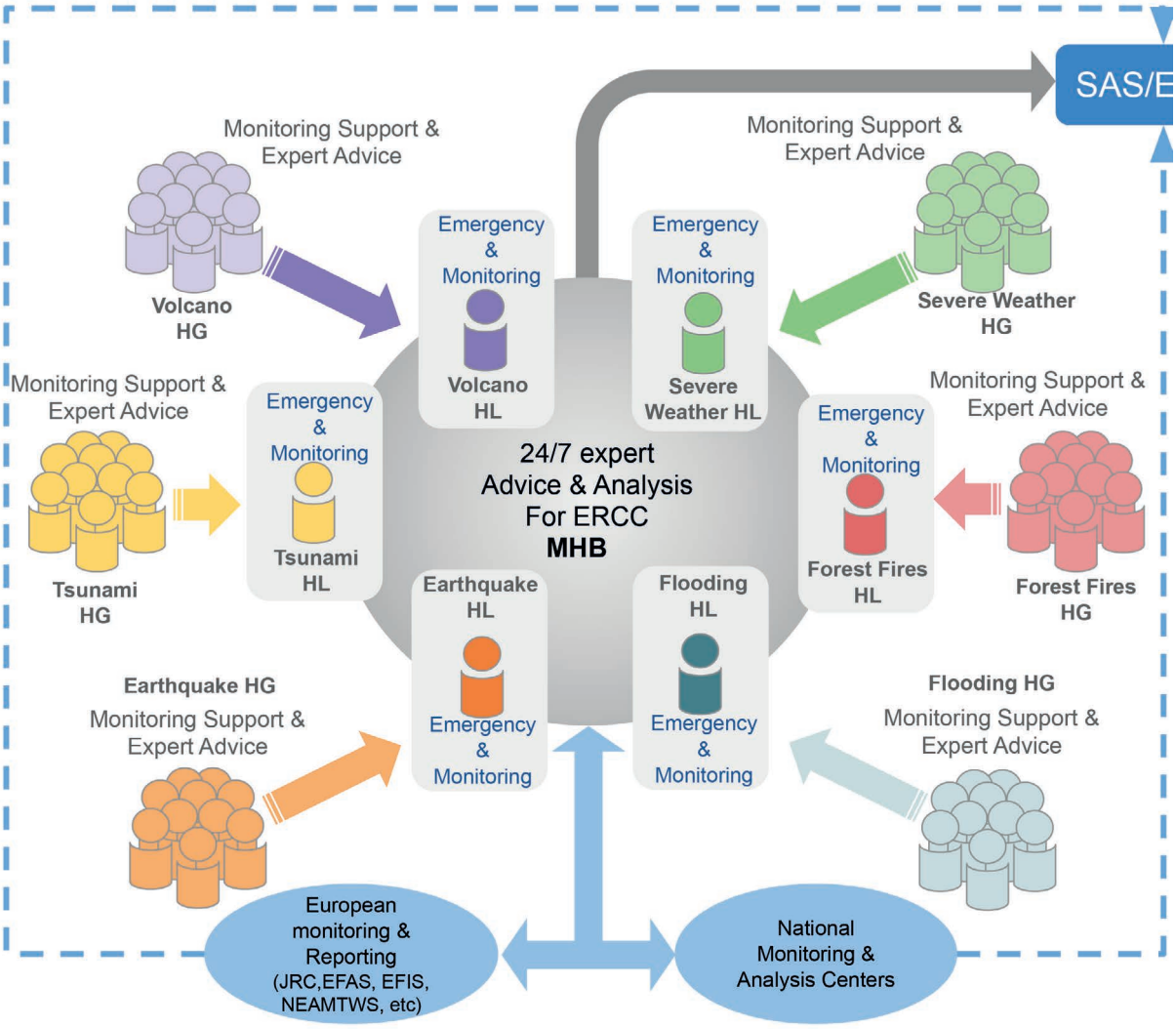
Adriano Azzarone, Stefano Carlino, Spina Cianetti, Stefano Corradini, Claudia D'Oriano, Gianfilippo De Astis, Paola Del Carlo, Alessio Di Roberto, Mauro Antonio Di Vito, Licia Faenza, Giovanna Forlenza*, Carlo Giunchi, Roberto Isaia, Enrica Marotta, Luca Merucci, Alberto Michelini, Rosella Nave, Ilaria Oliveti, Marco Olivieri, Lucia Pappalardo, Mario Paratore, Massimo Pompilio, Dmitri Rouwet, Emiliano Russo, Giuseppe Salerno, Simona Scollo, Jacopo Selva, Giulia Sgattoni, Letizia Spampinato, Claudia Spinetti

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This presentation describes the activities provided by the All Risk Integrated System TOwards Transboundary hoListic Early warning (ARISTOTLE [*http://aristotle.ingv.it*]) consortium to the Emergency Response Coordination Centre (ERCC) of the European Civil Protection and Humanitarian Aid Operations Directorate (DG-ECHO) for the realization of the European Natural Hazards Scientific Partnership (ENHSP). The ARISTOTLE partnership includes (currently) 24 institutions from EU and non-EU Countries and from European international organizations operating in the Meteorological and Geophysical domains. The service provided by the ARISTOTLE consortium responds to the needs of the ERCC to coordinate very rapidly the delivery of assistance to disaster-stricken countries within the EU Civil Protection Mechanism both within and outside the Union. It features a 7/24H operational system providing multi-hazard expert advice on six hazards: volcanoes, earthquakes, tsunami, severe weather, flooding and forest fires. Core to the service is the multi-hazard board (MHB) that is composed by one representative per hazard on duty call 7/24H for a total of six (i.e., the number of hazards currently active) people. They constitute the European Natural Hazards Scientific Partnership, ENHSP.

ARISTOTLE provides ERCC with three different operational services: emergency (ERM), routine (ROM) and the Scientific Technical Assistance Facility (STAF); the latter subdivided in fast track and operational preparedness. The ERM and ROM reports are assembled and created through the Scientific Products Archiving and Document Assembly (SPADA) platform. It consists of back-end software developed in the Python script language [*https://www.python.org/*], and of a front-end web browser application developed using the Tiki-Wiki [*https://tiki.org/*] and the PHP [*https://www.php.net/*] softwares. The activities carried out by the ARISTOTLE Consortium rely on a well consolidated, flexible and scalable governance structure that has allowed integrating new service components and additional hazard types into it and will continue progressing toward new technological development for further multi-hazard operational services.



The operational 24/7 multi-hazard advisory structure with the central core (the Multi-Hazard Board - MHB).

INGV-MASE (Ministero dell'Ambiente della Sicurezza Energetica) Research Agreement - Subsidence Project

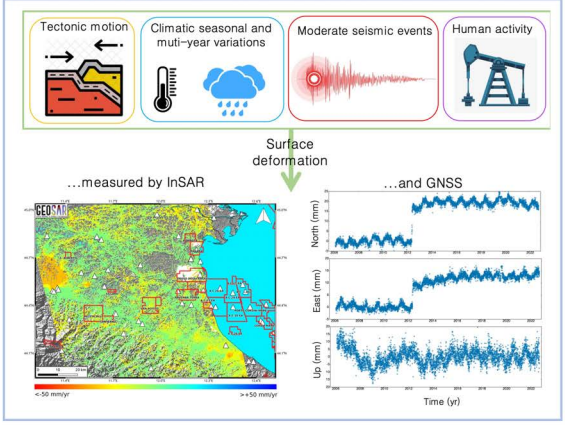
Francesca Silverii, Matteo Albano, Letizia Anderlini, Giulia Areggi, Roberto Devoti, Dung Thi Vu, Mimmo Palano, Francesco Pintori, Marco Polcari, Michele Proietto, Enrico Serpelloni, Federica Sparacino, Nikos Svigkas, Elisa Trasatti, Giuseppe Pezzo*

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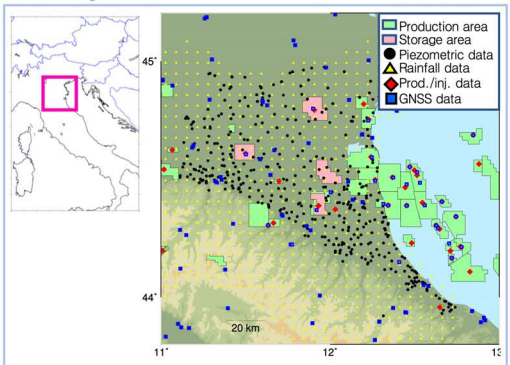
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We describe the activities carried out in the framework of the Research Agreement 2020 between INGV and the Ministry of Environment and Energy Security (MASE). Aim of the project is to develop a monitoring workflow to detect and quantify the different factors contributing to ground deformation, and, in particular, the hydrocarbon production and storage.
The pilot area is the eastern sector of Po Valley where ground deformation can be attributed to different processes, both natural and anthropogenic, characterized by different temporal trends and spatial distributions.
We tested an approach based on a workflow of 4 operational levels that start from deformation data processing and progressively extract information from these to provide an interpretation in a systematic and standardized manner, conceptually tracing the different steps of a ground deformation monitoring system.
In Level 1 we used GNSS and InSAR data, processed by INGV and Hydrocarbon Companies, obtaining integrated and validated displacement fields. Afterwards (Level 2), i) we collected and standardized deformation and ancillary (gas extraction/injection, hydrological and rain data) datasets; ii) based on time series frequency analysis and spatial/temporal signal decomposition, we defined parametric indices characterizing different ground deformation effects; iii) we compared (correlation analysis) displacement and ancillary data. Analytical modeling (Level 3) provided a first quantitative estimation of the anthropogenic contribution to the ground deformation. The final interpretation (Level 4) returns a successful workflow in which all data, analysis and modeling contributed to multiscale monitoring systems.

Study goal

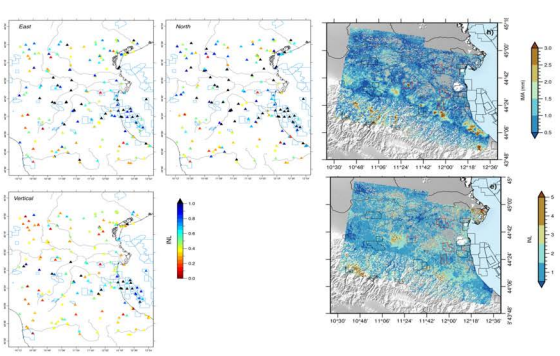


Study area and data

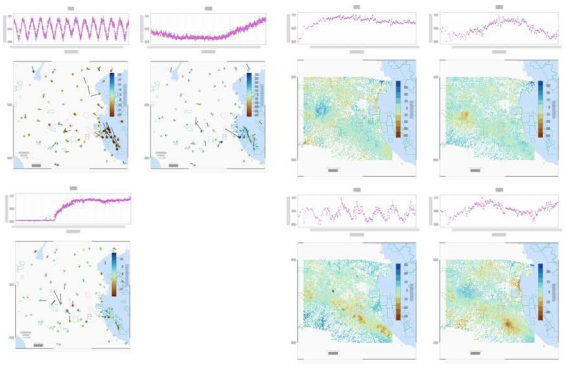


Study area with location of production areas/storage sites, of GNSS stations, and of ancillary datasets.

Examples of applied techniques and results



Index analysis results at regional scale on the GNSS (left) and InSAR Sentinel-1 descending (right) time series.



vbICA decomposition results at regional scale on GNSS (left) and InSAR Sentinel-1 desc (right) time series. Each panel represents a single component.

Study goal, involved study area and datasets used. Two examples of the techniques applied in Level 2 are presented. These show the results obtained respectively through the parametric indices computation and the data-driven decomposition, both applied on GNSS and InSAR data.

Sea level rise projections up to 2150 in the northern Mediterranean coasts

Antonio Vecchio[1,2], Marco Anzidei[3,*], Enrico Serpelloni[3]

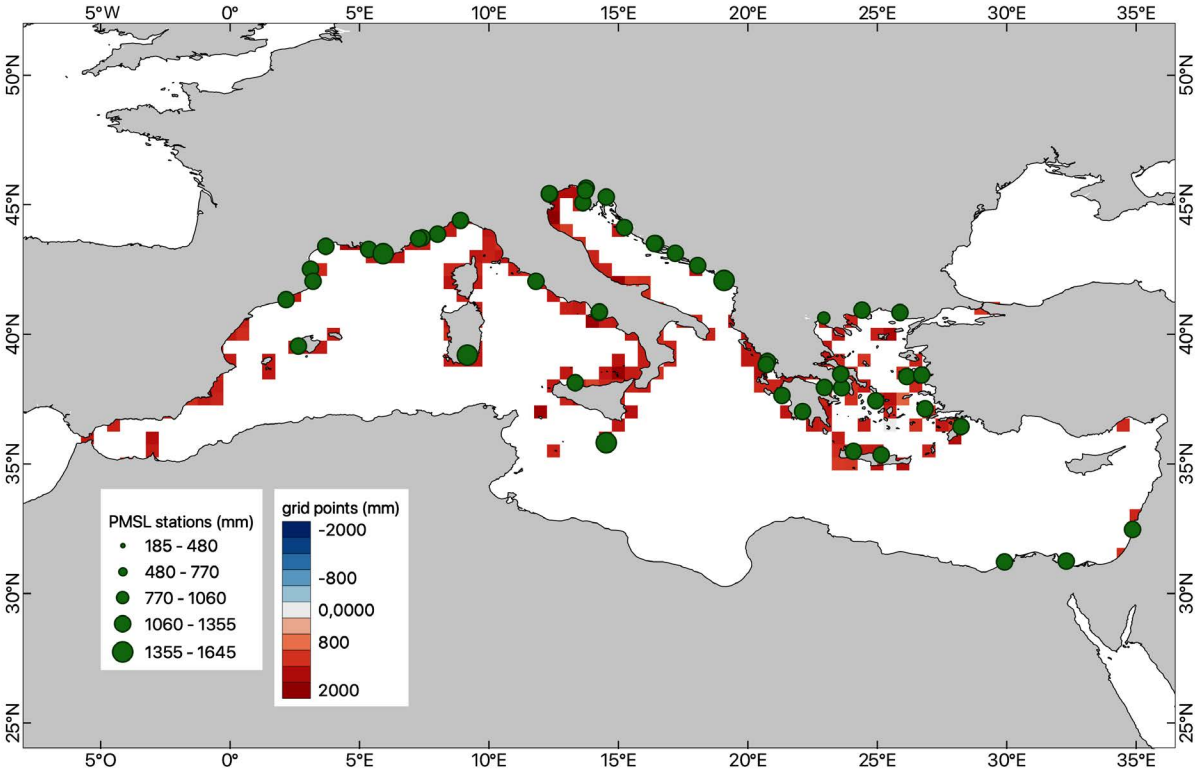
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Vertical land movements (VLM) play a crucial role in affecting the sea level rise along the coasts. They need to be estimated and included in the analysis for more accurate Sea Level (SL) projections. Here we focus on the Mediterranean basin characterized by spatially variable rates of VLM that affect the future SL along the coasts. To estimate the VLM rates we used geodetic data from continuous GNSS stations with time series longer than 4.5 years in the 1996-2023 interval, belonging to Euro-Mediterranean networks and located within 5 km from the coast. Revised SL projections up to the year 2150 are provided at 265 grid points and at the locations of 51 tide gauges of the Permanent Service for Mean Sea Level, by including the estimated VLM in the SL projections released by the Intergovernmental Panel on Climate Change (IPCC) in the AR6 Report [Vecchio et al., 2014]. Results show that the IPCC projections underestimate future SL along the coasts of the Mediterranean Sea since the effects of tectonics, volcanism and other local factors were not properly considered. Here we show that revised SL projections at 2100, when compared to the IPCC, show a maximum and minimum differences of 1094 ±103 mm and -773±106 mm, respectively, with an average value that exceeds by about 80 mm that of the IPCC in the reference Shared Socio-economic Pathways and different global warming levels. Finally, the projections indicate that about 19.000 km2 of the considered Mediterranean coasts will be more exposed to inundation for the next decades, leading to enhanced impacts on the environment, human activities and infrastructures, thus suggesting the need for concrete actions to support vulnerable populations to adapt.

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Vecchio, A., Anzidei, A., Serpelloni, E., (2024*). Sea level rise projections up to 2150 in the northern Mediterranean coasts*. Environ. Res. Lett., 19 014050. https://doi.org/10.1088/1748-9326/ad127e



Relative sea level rise projections at 2150 relative to 2020, for the coasts of the Mediterranean basin for SSP8.5 scenarios at the PSMSL tide gauges (green dots) and on a geographical grid of 0.5°× 0.5° (color scale). The map results from the combination of the IPCC AR6 projections at regional scales with the VLM derived from GNSS data (only grid points that include GNSS stations are represented). The VLM value in each cell is obtained by calculating the median of all the GNSS measurements contained in the given cell.

A new webGIS for the interactive sea level rise and storm surge scenarios up to 2100 for the Mediterranean costs

Antonio Falciano[1], Marco Anzidei[2,*], Michele Greco[3,4], Maria Lucia Trivigno[1], Antonio Vecchio[5,6], Charalampos Georgiadis[7], Petros Patias[7], Michele Crosetto[8], Josè Navarro[8], Enrico Serpelloni[2], Cristiano Tolomei[2], Giovanni Martino[3], Giuseppe Mancino[1], Francesco Arbia[4], Christian Bignami[2], Fawzi Doumaz[2]

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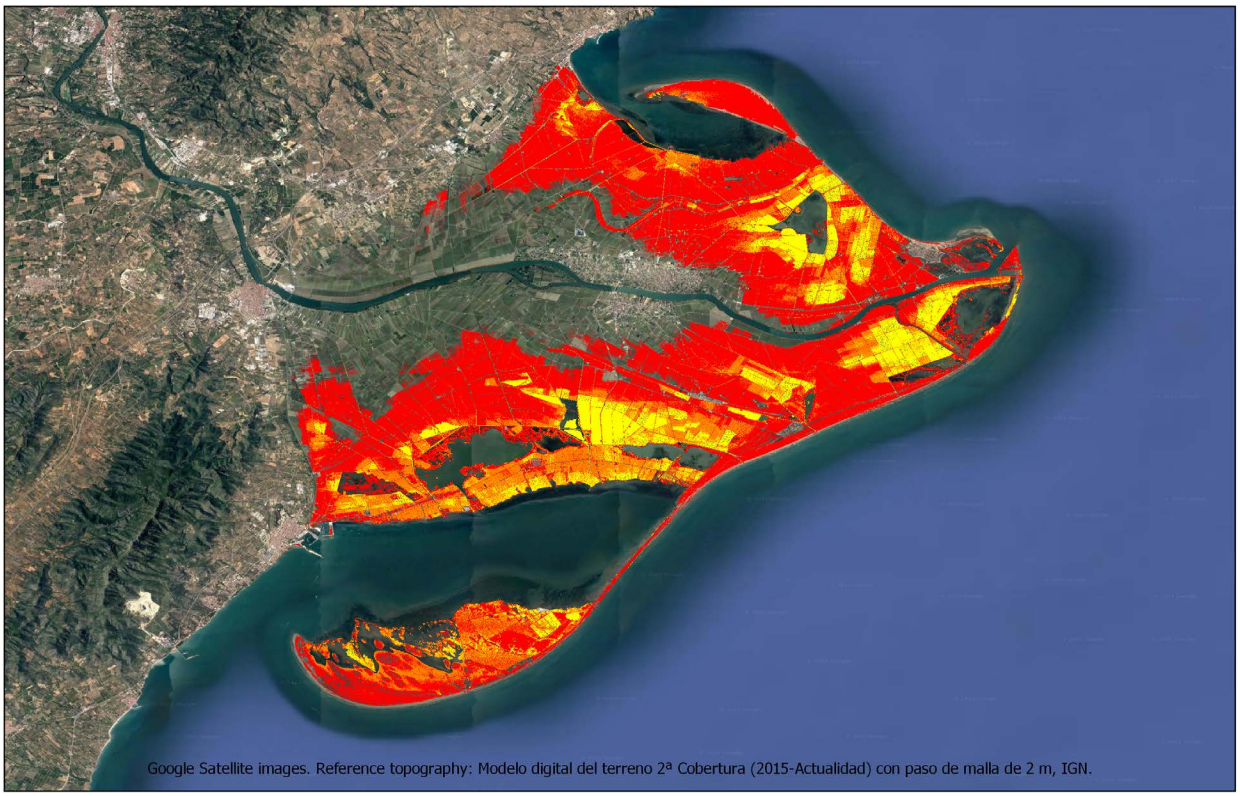
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Here we show a new thematic webGIS released in the frame of the SAVEMEDCOASTS-2 project. The aim is to provide a new tool to support land planners and decision-makers against the expected effects of Relative Sea Level Rise (RSLR) along the Mediterranean coasts. The webGIS has been developed according the formulation and prioritisation of climate-resilient adaptive pathways and realised under the umbrella of the European Union (DG-ECHO), to respond to the need for people and assets prevention from natural disasters of coastal communities in areas prone to the combined effect of Sea Level Rise (SLR) and vertical land movements (VLM). The geospatial data are based on high-resolution Digital Terrain Models (DTM) from available LiDAR data or specifically realised by UAVs, bathymetric data, rates of VLM, and multi-temporal coastal flooding scenarios for 2030, 2050, and 2100 with respect to 2021, as a consequence of RSLR. The latter are realised according to the 5th Assessment Report (AR5) released by the Intergovernmental Panel on Climate Change (IPCC, www.ipcc.ch) for two different Representative Concentration Pathways of climate projections (namely, RCP2.6 and RCP8.5 corresponding to low and high greenhouse gases emission scenarios). The high resolution maps of RSLR scenarios included in the webGIS, also take into account the contribution of the highest astronomical tides (HAT) and storm surges (SS) that exacerbate the RSLR effects on coastal infrastructures, environment and threatening human activities and safety.

References

Falciano, A., Anzidei, M., Greco, M., Trivigno, M.L., Vecchio, A., Georgiadis, C., et al., (2023*). The SAVEMEDCOASTS-2 webGIS: The Online Platform for Relative Sea Level Rise and Storm Surge Scenarios up to 2100 for the Mediterranean Coasts.* J. Mar. Sci. Eng., 11, 2071. https://doi.org/10.3390/jmse11112071

Vecchio A., Anzidei M., Serpelloni E. (2023.) *Sea level rise projections up to 2150 in the northern Mediterranean coasts*. Environ Res Lett. https://doi.org/10.1088/1748-9326/ad127e



The Ebro delta (Spain). Multitemporal RSLR scenarios in 2030 (yellow), 2050 (orange), and 2100 (red) for the RCP8.5 climate projections from the regional IPCC AR5 Report, integrated with the contribution of the mean VLM rate derived from the combined InSAR-GNSS analysis.

Relative Sea Level Rise projections and flooding scenarios for 2150 A.D. for the Island of Ustica (Southern Tyrrhenian Sea, Italy)

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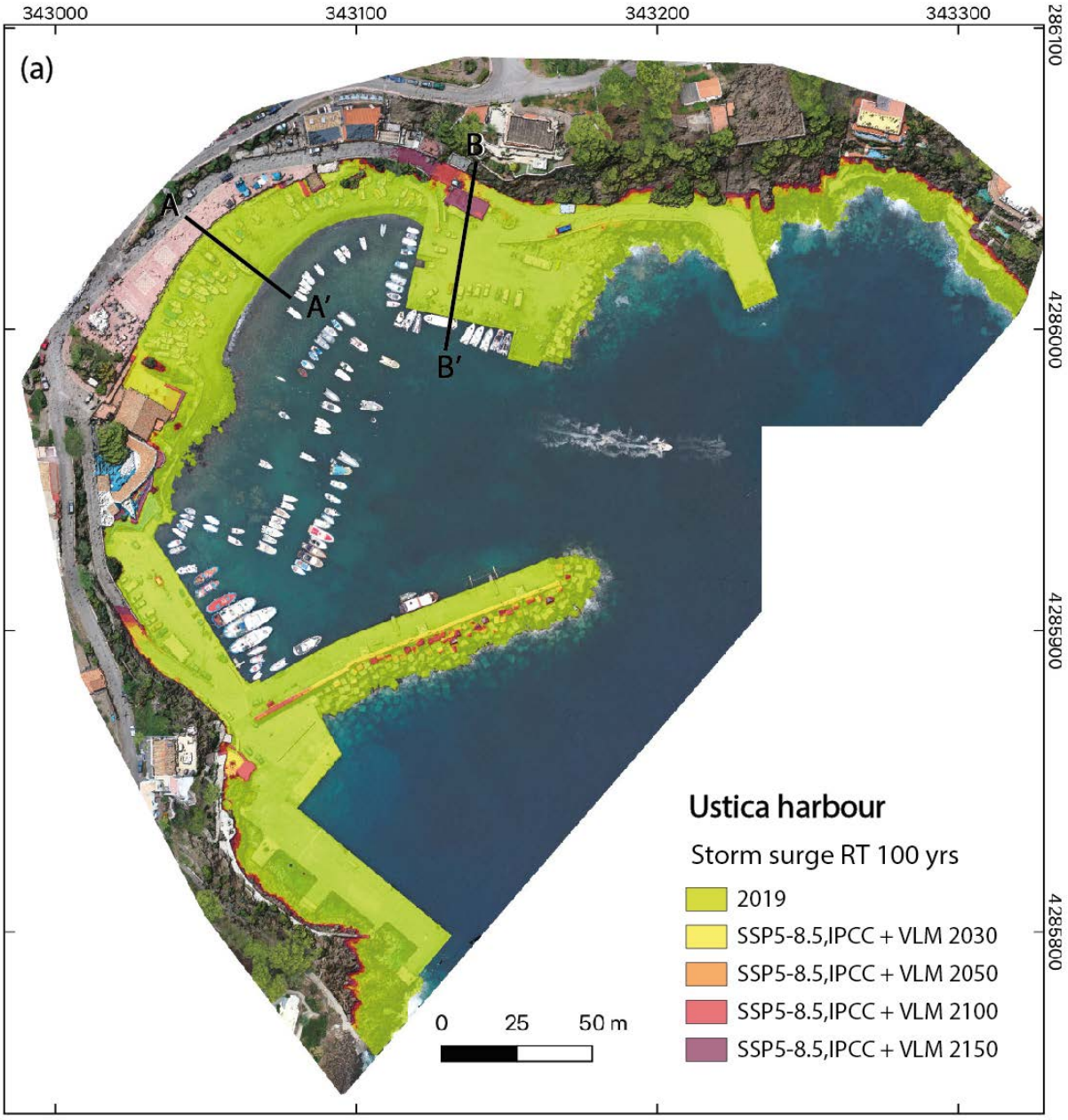
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The island of Ustica is exposed to the effects of sea level rise that is threatening its coastal zone. With the aim to assess the expected sea levels by 2150 under the climatic projections shown in the AR6 Report of the IPCC, a detailed evaluation of the potential coastal flooding under different climatic scenarios and the ongoing vertical land movements has been carried out for three coastal zones [Anzidei et al., 2023]. Scenarios are based on the determination of the current rates of land subsidence from GNSS data, coastline position, high-resolution Digital Terrain and Marine Model and the SSP1-2.6, SSP3-7.0 and SSP5-8.5 climatic projections. Relative sea level rise projections allowed to map the potential inundated surfaces for 2030, 2050, 2100 and 2150. Results show rising sea levels for 2150 ranging from a minimum of 66±40 cm (IPCC AR6 SSP2.6) to a maximum of 128±52 cm (IPCC AR6 SSP8.5). In such conditions, considering the SSP8.5 scenario, during storm surges with return time (RT) of 1 and 100 years the expected maximum wave run up along the island may vary from 3 m (RT=1) up to 14 m (RT=100), according to the coastal morphology. Our results show that adaptation and mitigation actions are required to protect the touristic and harbor installations of the island.

References

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The potential submersion areas for Ustica Harbor in storm surge conditions for a return time (RT) of 100 years, based on the 2019 sea level and the RSLR conditions in 2150 for the SSP5-8.5 climatic scenario.

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Real-time seismicity dashboards

Maurizio Pignone*, Sergio Falcone, Raffaele Moschillo

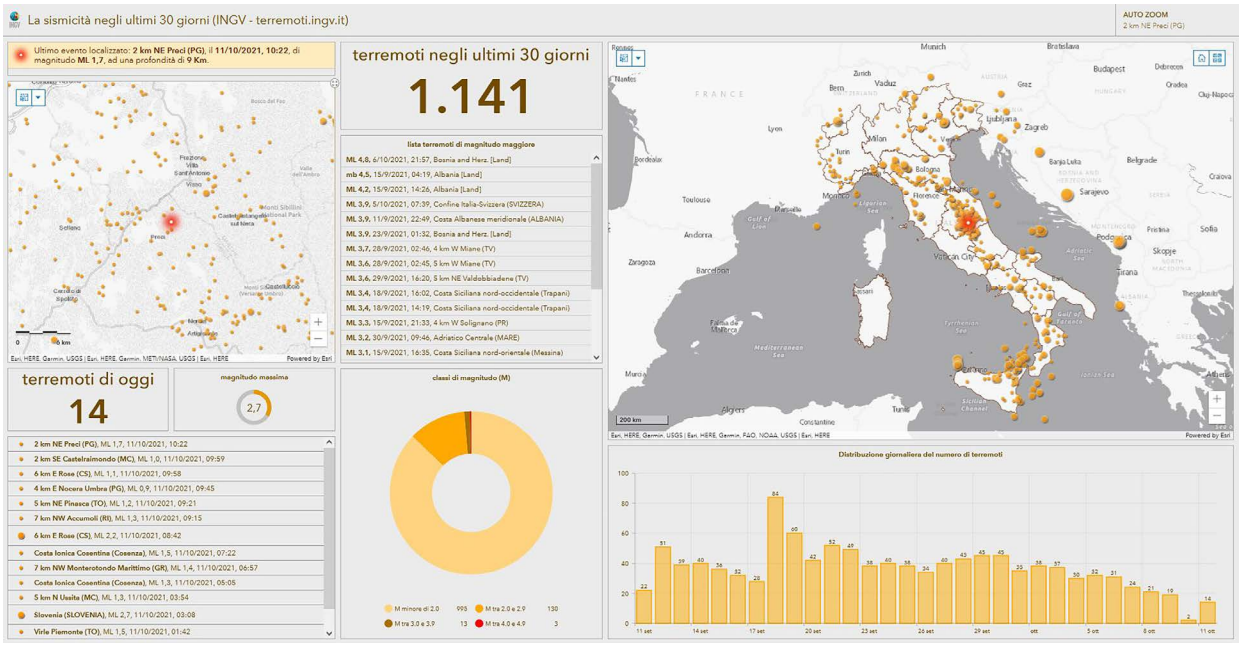
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Cloud-GIS applications of the "*dashboard*" type allow the creation of visualization tools for datasets and their associated information through simple, and even dynamic, infographics, which are highly effective for communicating with non-expert users. The use of dashboards is becoming increasingly common in seismology as well, to display the spatio-temporal evolution of seismicity or seismic sequences. Since 2021, thanks to the evolution of ArcGIS Online [*https://www.arcgis.com/*], it has been considered to use this tool for real-time visualization and interaction with real-time seismicity recorded by the Italian National Seismic Network's stations (Rete Sismica Nazionale, RSN).

By querying the web services of the terremoti.ingv.it portal, a service has been developed to continuously read seismic events within a certain spatial, temporal, or magnitude range and store them within a Geodatabase on SQL Server. All events are classified, filtered, and organized for the creation and publication of services, enabling the creation of numerous dashboards to interact with seismicity localized in Italy over the last 7, 30, and 90 days [*https://storymaps.arcgis.com/collections/e667de03a68f4a788cb786cc6ef6d771*].

The dashboard interface (Figure) presents various information in the form of dynamic maps, lists, and infographics that update automatically or with a browser refresh. Dashboards are a very valid tool also during the dissemination events and information days that the INGV promotes through the use of touch screens that allow the creation of real exhibits to interact with the public, demonstrating the potential of GIS in risk communication. Furthermore, real-time seismicity dashboards are used during a seismic emergency as they allow you to follow the trend of seismicity or a sequence and view the related information contained in the infographics.



Graphic interface of one of the dashboards with real-time seismicity over the last 30 days.

Earthquake and Tsunami Stories

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In recent years, INGVterremoti [*https://ingvterremoti.com/]* has published numerous story maps to narrate various aspects of earthquakes and tsunamis that have affected the Italian territory and the Mediterranean basin in the past and more recent times. These story maps integrate descriptive, photographic, and multimedia information with georeferenced data from INGV's seismological and seismotectonic databases. You can access the entire collection of story maps created by INGVterremoti on their page at *https://ingvterremoti.com/storymaps/*.
In particular, between 2022 and 2023, four story maps have been published that recount events and sequences, some more recent than others, which are associated with interesting and often impactful stories. The first two relate to two significant seismic sequences that affected the Italian territory in the decade from 2002 to 2012. The third tells the story and memory of an earthquake that struck Irpinia and Sannio in the early 1960s, and the fourth narrates the unimaginable stories of wrecks linked to the 2011 Japanese tsunami (Figure).

In Figure, from the top to bottom:
"I terremoti in Pianura Padana del 2012 - Un viaggio in 10 tappe nella sequenza sismica iniziata nel mese di maggio di dieci anni fa"
[https://storymaps.arcgis.com/stories/2dd75b9a57c54466b19b1dc48053f148];

"21 agosto 1962: un terremoto dimenticato - Il racconto e la memoria del terremoto che colpì l'Irpinia e il Sannio agli inizi degli anni '60"
[https://storymaps.arcgis.com/stories/f351489b8da7483b978c2e52e6dc9f75];

"I terremoti in Molise del 2002"
[https://storymaps.arcgis.com/stories/4da97a5cf09e4398b850223dba8d21e4];

"Maremoti e relitti - Storie straordinarie di oggetti dispersi dal maremoto giapponese dell'11 marzo 2011"
[https://storymaps.arcgis.com/stories/50a616d2d6bf4eb8adc3b98d81948d89].









The four-story maps published by INGVterremoti between 2022 and 2023.

The Earthquake Calendar

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You can consult day by day the occurrences of the strongest earthquakes that have struck the Italian territory in the past and more recently on the INGVterremoti channels [*https://ingvterremoti.com/*] and ONT website [*https://www.ont.ingv.it/*], using data, information, and testimonies contained in the historical seismicity databases curated by INGV and in-depth articles published on INGVterremoti.

The Earthquake Calendar allows access to the data and information contained in the catalogues and studies of historical seismology collected in the Italian Historical Macroseismic Archive (ASMI). It also presents the estimated magnitude (Mw) and maximum perceived intensity (Imax) parameters proposed by the Catalogo Parametrico dei Terremoti Italiani (CPTI15 [*https://emidius.mi.ingv.it/CPTI15-DBMI15/*]). From the Calendar, you can directly access the informative pages of ASMI [*https://emidius.mi.ingv.it/ASMI/*] for each event through the respective link. If the earthquake is also listed in the Catalogo dei Forti Terremoti (CFTI5Med [*https://storing.ingv.it/cfti/cfti5/*]), a link to the relevant page is available. Finally, a link to the articles published on INGVterremoti.com in the categories "*Earthquakes in History*" and "*Earthquakes in Italy*" is provided or to the relevant story map if it has been created.

To date, the calendar has included approximately 115 earthquakes, selected based on estimated magnitude and their effects on the territory; in the future events with effects related to the tsunami will also be included. The Earthquake Calendar is available as a story map [*https://arcg.is/1rmLnH*] on the ONT website (Figure [*https://www.ont.ingv.it/informazione-e-divulgazione/alla-scoperta-dei-terremoti/calendario-terremoti*]) in a dedicated page and is also shared as a post on the INGVterremoti Facebook page.



Earthquake Calendar graphical interface on the ONT website. For each event, the pop-up can be displayed with the relevant information and available links.

Tsunami Ready in Italy. A programme to mitigate tsunami risk

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Tsunami Ready aims to foster tsunami risk awareness and effective tsunami risk management by coastal communities, who are encouraged to take an active role in defining and implementing life-saving measures. Tsunami Ready is a voluntary, performance-based recognition programme that promotes prevention and preparedness through the active collaboration of national and local civil protection agencies, land-use authorities, scientists and citizens [Amato et al., 2020; 2023]. In taking the programme as one of its objectives, the IOC/UNESCO developed international guidelines as a guide for accrediting individual municipalities to be declared Tsunami Ready. INGV's Tsunami Alert Centre is working on the objectives of the Ocean Decade, particularly on the "Safe Ocean". Among the challenges in this area is to increase the resilience of communities towards the risks of the oceans and seas, and Tsunami Ready is one of the main tools to achieve this [UNESCO-IOC, 2023]. In 2020, the INGV and the Civil Protection Department launched the first initiatives in some pilot coastal municipalities that decided to join the programme with enthusiasm: the Municipality of Minturno in Lazio, the Municipality of Palmi in Calabria, and the Municipality of Pachino in Sicily; in 2023, the Municipality of Otranto in Puglia also joined the programme. We are currently waiting for the municipal resolution of the municipality of Lipari (ME), which will join the programme with Stromboli Island. Meanwhile, the first joining municipalities have taken important steps (Figure).

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Map with the location and some information of the 5 pilot sites that have joined the UNESCO Tsunami Ready program. Three of them started in 2021 (Minturno, Palmi, Pachino-Marzamemi), whereas the other two (Otranto and Stromboli volcano) joined in 2023.

The social impact of Earthquake Early Warning systems. Testing the survey questionnaire

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Earthquakes pose a particular risk to human lives. They are in fact unpredictable, temporally and spatially variable as well as occurring sequentially or in series. Depending on the territorial context, even small magnitude earthquakes can cause damage. Most of the Italian peninsula has a high seismic hazard. Earthquake Early Warning (EEW) is one of the most effective tools to protect human lives. The EEW allows the public to be alerted or to activate automatic protection mechanisms from a few seconds to a to a few tens of seconds (depending on the distance of the hypocentre from the person receiving the alert) before the earthquake-induced vibration is felt. In some regions, EEW systems have been operational for several years. In New Zealand, the system has not yet been implemented, so a team of sociologists surveyed the opinions of a sample of citizens on the degree of acceptance and what they thought of such a system [Becker et al., 2020]. In Italy, an operational earthquake early warning system does not yet exist [Satriano et al., 2011]. Based on New Zealand's experience, we translated the questionnaire they implemented and then administered it to a sample of Italian students visiting the INGV headquarters in Grottaminarda (Figure) to assess the acceptability and social impact of an EEW system in Italy. This administration is also essential to pre-test the survey instrument and to understand whether it works. To date, 212 questionnaires have been collected. This initiative is part of the: "*Ricostruzione Centro Italia DL50 - Monitoraggio e analisi fenomeni sismici / WP Earthquake Early Warning* project" (coord. Simone Marzorati and Claudio Martino).

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Earthquake Early Warning Questionnaire administration.

Longitudinal assessment of tsunami knowledge in an Italian school

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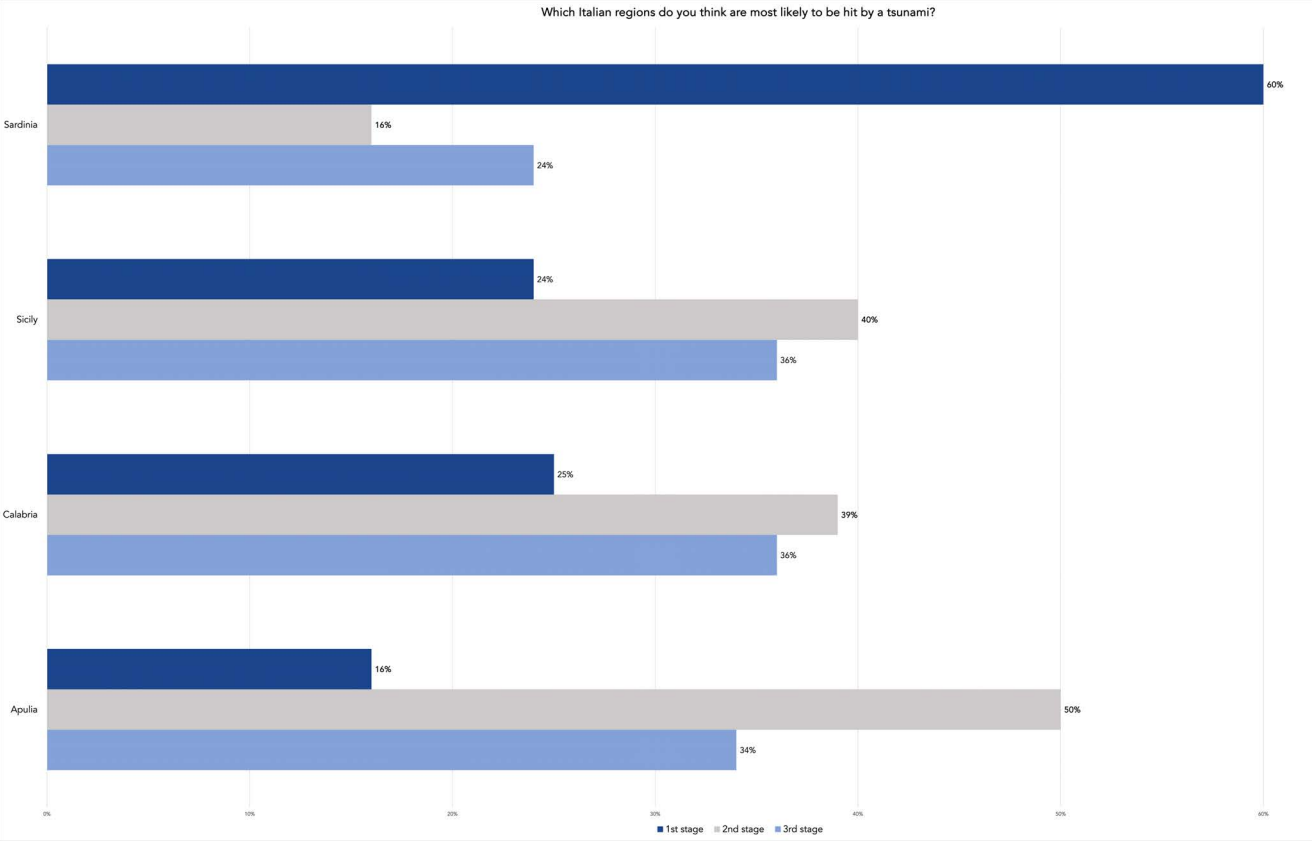
Italy is at tsunami risk, a phenomenon characterized by low frequency of occurrence that can cause widespread and destructive impact on coastlines. The activities carried out by the INGV's Tsunami Alert Center (CAT-INGV), in concert with Italian Department of Civil Protection, include tsunami risk mitigation through: i) the study of tsunami risk perception, ii) the Tsunami Ready program, and iii) educational and dissemination activities with different methodologies. In this work we analyze the effectiveness and durability of learning about knowledge and tsunami risk with Lazzaro Spallanzani Scientific High School students, in Tivoli (Rome province). The assessment involved the administration of an online questionnaire composed of selected items from the tsunami risk perception survey carried out by CAT for the tsunami risk perception study [Cerase et al., 2019; Cugliari et al., 2022]. The survey sample consists of 90 students identified by age group (16-19 y.o.) and study address (high school scientific address). Data analysis shows an evident increase in tsunami risk knowledge (e.g. Figure). Student educational needs also emerge that can be used as leverage to structure targeted and effective interventions and increase young people's awareness of tsunami risk in other areas. There is also evidence that fieldwork, with the aid of multimedia and possibly interactive or assisted media, provides successful maintenance of attention and facilitates assimilation.
The survey's preliminary outputs were presented at the 2023 EGU [Cugliari et al., 2023].

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Response percentages to the question “Which Italian regions do you think are most likely to be hit by a tsunami?” by stage.

A website concept for navigating into the earthquakes parameters

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A well designed, simple and immediate user experience makes the use of a software more enjoyable, usable, immediate and more accessible to a wider audience of users.
In recent years the development of web GIS, web scripting and geospatial data storage technologies has made possible the creation of high performance web sites with interactive maps. Our project aspires, using the aforementioned technologies, to realize a web interface that allows the consultation of seismic events using both a canonical tabular representation and an interactive and dynamic map. Furthermore, the introduction of the map as an additional tool to represent seismic events, allows less experienced users to make specific geographic queries and researches with more ease and with the possibility of combining it with more canonical instruments.



Screenshot extracted from the website presented at the “ONT Giornata 2023”.

Disseminating knowledge and best practice in low seismicity areas

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In Liguria, Valle d'Aosta and Piedmont, earthquakes are not the main threat. Seismicity is of low to moderate magnitude and rarely exceeds 5.0. Large earthquakes date back more than a hundred years and are perceived as impossible or at least uncommon events. However, there is a demand for educational activities from teachers and the public. These are valuable opportunities not only to inform about earthquakes, but also to promote best practices.
Educating people about natural hazards is a hard task that needs to overcome a certain public reluctance and must be addressed using proper and appealing language, often using alternative means like videos, serious games, and apps. As expected, the attention of the public and especially of the press is strictly dependent on the occurrence of earthquakes and, in the case of schools, often concentrated in peculiar periods dependent on school planning. We have designed tools to be implemented in happenings or as standalone as described, for example, in Musacchio and Solarino [2019] or Solarino et al. [2021].
The activities have been carried out in the form of conferences, frontal classes, laboratories, quizzes in public meetings or online. We discuss the pros and cons of each group of initiatives, keeping in mind that the hardest task is to check how much of the education message is transferred to the interlocutors and converted to best practices. Overall, risk communication is a great opportunity to transform scientific knowledge into preventive actions.

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Some shots from the recent ONT Genova branch education/dissemination activities.

The ONT's contribution to the Collane Editoriali INGV

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The ONT is a distinctive section within the INGV, characterized by strong technical and technological capabilities. Its core activities encompass technological development, infrastructure management—including monitoring networks and databases—and associated IT services. Disseminating acquired knowledge and showcasing implemented innovations, technical and scientific results, as well as highlighting significant accomplishments from national and international collaborations, stand as primary objectives of our institute.

The Collane Editoriali INGV [*https://editoria.ingv.it/*] serves as an ideal platform for fulfilling these objectives. Comprising technical-scientific journals subjected to a single-blind peer-review process, the Collane Editoriali INGV includes the scientific journal Quaderni di Geofisica, alongside the technical-scientific journals Rapporti Tecnici INGV and Miscellanea INGV. These publications cover a broad spectrum of Earth sciences, focusing on environmental issues, seismology, and volcanology—representing the key research areas of the three INGV departments: Environment, Earthquakes, and Volcanoes.

The inaugural publication of the Collane Editoriali INGV was Quaderni di Geofisica in 1998, with 189 volumes published as of October 1, 2023. Subsequently, Rapporti Tecnici INGV debuted in 2002, accumulating 476 issues by October 1. The last addition to the Collane Editoriali INGV, Miscellanea INGV, commenced in 2008 and presently boasts 76 issues.

Each of the three Collane Editoriali INGV holds an International Standard Serial Number (ISSN), and since 2015, every publication is assigned a DOI, with ongoing efforts to retroactively provide DOIs for earlier releases. A qualified Editorial Board, in collaboration with the Editorial Office, plays a pivotal role in selecting and managing high-quality papers.

We take pride in showcasing ONT's significant contributions to the Collane Editoriali INGV throughout its 25 years of active engagement.

GIORNATA ONT martedì 14 novembre 2023

*Milena Moretti1, Christian Bignami1, Lorenzo Cugliari1, Anna Nardi1 e Collane Editoriali INGV Team**

Il Contributo dell'ONT alle Collane Editoriali INGV

*1 INGV | Osservatorio Nazionale Terremoti - * INGV | Tutte le altre sezioni INGV*

*

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Dal **2010**, la pubblicazione delle Collane Editoriali INGV rientra "secondo lo Statuto" nella *mission* dell'INGV e negli obiettivi di **Terza Missione** che si svolge nell'ambito del **Centro Servizi Coordinamento delle Attività a Supporto per la Ricerca** (Responsabile Piergiorgio Scarlato).

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1 novembre 2023: **189** volumi

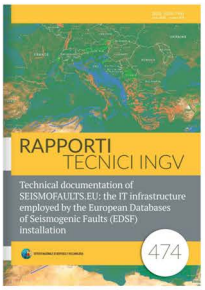


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MISCELLANEA INGV

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1 novembre 2023: **75** volumi



Favorisce la pubblicazione di articoli riguardanti attività che non troverebbero agevole spazio nelle riviste scientifiche tradizionali. In particolare, accoglie reports di progetti scientifici, proceedings di convegni, manuali, monografie di rilevante interesse, raccolte di articoli, ecc.

Ciascuna delle Collane Editoriali INGV è dotata di un ISSN (*International Standard Serial Number*)

Dal 2014, ogni pubblicazione è dotata di un *Digital Object Identifier* (DOI), ovvero di uno "standard" digitale che identifica il documento in maniera univoca e duratura. È in corso l'assegnazione del DOI anche alle precedenti pubblicazioni.

Ringraziamento speciale a Mario Locati e all'Ufficio Gestione Dati INGV.

I **temi di interesse** delle Collane Editoriali INGV riguardano studi nel **campo delle geoscienze** con riguardo alle problematiche **ambientali**, alla **sismologia** e alla **vulcanologia**, ovvero alle macroaree che caratterizzano le attività di ricerca scientifica e tecnologica dei tre Dipartimenti dell'INGV Ambiente, Terremoti e Vulcani.

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È possibile scaricare la monografia anche in formato **pdf**. Un'apposita ***image gallery*** permette che tutte le immagini siano rese visibili al massimo della loro dimensione e corredate dalla relativa didascalia.

Le Collane Editoriali INGV sono ***not-for- profit*** consentendo uno spazio di partecipazione inclusivo, senza alcun costo di pubblicazione a carico sia degli autori che dei fruitori.

Il Contributo dell'ONT

Lo sviluppo tecnologico, la gestione delle infrastrutture, quali le reti di monitoraggio e le banche dati, ed i servizi informatici connessi, sono tra le attività che maggiormente identificano l'ONT.

Dal 2008, più di 130 monografie (su 600 pubblicate), hanno **primo autore ONT**.



SOCIETÀ - COMUNICAZIONE, DIVULGAZIONE, GESTIONE DELLE EMERGENZE

Poster presented at the "Giornata ONT 2023". We show the current configuration of the Collane: the members of the Editorial Board and the Editorial Office. We also show the contribution made by the ONT.

International Training Schools. Past and future activities at ONT and Roma 2

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Training activities are essential for the dissemination of the most advanced knowledge in the different fields of science. For several years, at ONT and Roma 2, training schools have been organized in the field of monitoring convective and volcanic clouds (Convective and Volcanic Cloud Training School-CVC), calibration and validation (International Remote Sensing Summer School-IRSSS) and the study of ionospheric processes (East African Capacity Building Workshop on GNSS and the Low Latitude Ionosphere). The aim of the schools is to train new generations of researchers who are able to use innovative instruments and the most advanced techniques to understand natural phenomena and their effects on the environment and society. Schools promote an ideal environment capable of facilitating students' interaction with each other and with experts in different research fields as much as possible, in order to encourage the exchange of experiences and future collaborations. The poster in Figure describes the main activities of the three international training schools organized at ONT and Roma 2. As the poster shows, among the frontal theoretical lectures, great importance is given to field measurements and hands-on sessions using different instrumentations in order to allow students to understand advantages and drawbacks of these kinds of crucial activities. Exploiting the great success of the past editions, in 2024 other training schools will be organized.

In particular, the 9th edition of the CVC will be held in October in Nicolosi [*CVCtrainingschool.org*], at the slopes of Etna. The participants will also have the possibility to make ground based remote sensing measurements of the volcano emission and to process the data in near real time.

As part of the NORISK project [*norisk.rm.ingv.it*], INGV will organize the second Eastern Africa Capacity Building Workshop in October 2024 to be hosted at ICTP in Trieste, mainly dedicated to students coming from Africa.

In 2024 the IRSS Summer School will be dedicated to remote sensing in mountain areas. During the 5 days school, the student will be deeply involved in the estimation of superficial parameters suitable for the healthy status definition of a glacier area.

GIORNATA ONT martedì 14 novembre 2023

International Training Schools
Past and future activities at ONT and Roma2

Stefano Corradini (ONT),
Massimo Musacchio (ONT),
Claudio Cesaroni (Roma2)

Training activities are essential for the dissemination of the most advanced knowledge in the different fields of science. For several years, at ONT and Roma2, training schools have been organized in the field of monitoring convective and volcanic clouds (***Convective and Volcanic Cloud Training School-CVC***), calibration and validation (***International remote sensing summer school***) and the study of ionospheric processes (***East African Capacity Building Workshop on GNSS and the Low Latitude Ionosphere***). The aim of the schools is to train new generations of researchers who are able to use innovative instruments and the most advanced techniques to understand natural phenomena and their effects on the environment and society. Schools promote an ideal environment capable of facilitating students' interaction with each other and with experts in different research fields as much as possible, in order to encourage the exchange of experiences and future collaborations.

From 2015, 8 years of CVC

★ Students from all around the world



★ National and international lecturers
★ Frontal lessons (from 7 to 10 days, 8h/day)
★ Laboratories
★ Field measurements campaign and data analysis
★ Field Trip
★ Funded (partially) by
★ With the patronage of
★ Recognized as international interest by

The purpose of the School is to train students with primary research interest in:
- *Techniques to Detect, Monitor and Model Convective and Volcanic Clouds*
- *State-of-the-art Instruments and Satellite Missions*
- *Early Warning Systems and Aviation Safety in support of policymakers.*



CVC CONVECTIVE AND VOLCANIC CLOUDS TRAINING SCHOOL





Frontal Lessons



Field Campaign



Field Trip





http://www.CVCtrainingschool.org

Capacity Building Workshops on Space Weather and Ionosphere

In the realm of Space Weather and Ionospheric Physics, the INGV, together with International Center for Theoretical Physics, United Nation Office Outer Space Affairs, Boston College, Pwani University, Agenzia Spaziale Italiana and Kenyan Space Agency, has been actively engaged since 2019 in organizing an annual workshop tailored for young scientists hailing from developing countries. These workshops serve as a unique platform, offering an opportunity for over 30 students each year to partake in immersive experiences mentored by the main Space Weather experts from all over the World. Participants engage in both frontal lessons and hands-on activities, delving into the theoretical and experimental facets of ionospheric research. This initiative underscores our commitment to nurturing the talents of emerging researchers, fostering their growth, and enhancing global scientific collaboration.
In 2023 and 2024, these workshops are actively supported by the New Observatory for Real-time Ionospheric Soundings over Kenya (NORISK) project funded in the framework agreement between ASI and INGV.









NORISK NEW OBSERVATORY FOR REAL-TIME IONOSPHERIC SOUNDING OVER KENYA

ICTP The Abdus Salam International Centre for Theoretical Physics

UNITED NATIONS Office for Outer Space Affairs

BOSTON COLLEGE

Pwani UNIVERSITY

ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

Agenzia Spaziale Italiana

First International Remote Sensing Summer School-IRSSS-CAL/VAL



Provenience	#
Italy	16
Tanzania	3
Egypt	2
Morocco	1
Spain	1
China	1
Argentina	1

Date of Birth	
1978	1997



Education	#
Geology	11
Engineering	10
Agronomy	1
Archeology	1
Mathematic	1
Physics	1

Affiliation	#
University	17
Space Agencies	2
Private Sector	6

The School was organised in 5 days of activities. During each day, the morning was dedicated to the ground measures with sensors (e.g. on-board of UAVs and field spectral instrumentation), and in the afternoon the students have beed guided on the processing and interpretation of the data collected. Lectures completed the hands-on data processing practical exercises. The school was open to **early career scientists or employers, such as Ph.D. students, young post-doctoral scientists, technicians** with base knowledge in Earth Sciences and Remote Sensing disciplines, wishing to expand and improve their skills in EO and to improve the networking actions





Planned event

Remote Sensing Summer School for **Alpine/Mountain** Areas (June **2024**)
Second Edition of IRS-SS (September **2024**)
Remote Sensing Sumer School for **Coastal areas (sea and inland)** (Sardinia - Piscinas, July **2025**)
Third Edition of IRS-SS (September 2025)
Remote Sensing Summer School for **Arid areas** (candidate host: Nelson Mandela University-Morogoro Tanzania **2026**)
Fourth Edition of IRS-SS (September **2026**)

SOCIETÀ - COMUNICAZIONE, DIVULGAZIONE, GESTIONE DELLE EMERGENZE

Poster presented at the "Giornata ONT 2023".

Paper Volcanoes: laboratory a seven years' journey to engage (pre)scholar children on the wonderment of volcanoes

Stefania Amici*, Barbara Castello, Pasqualino Cappuccio, Concetta Felli, Chiara Ladina, Stefania Lepidi, Vincenza Maiolino, Chiara Montagna, Loredana Napoli, Giovanna Lucia Piangiamore, Donatella Pietrangeli, Diego Sorrentino, Sabina Spadoni, Francesca Di Laura, Daniela Riposati

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Natural disasters are relevant topics in the frame of Geoscience education; volcanic eruptions, wildfires, flooding, tornados, are few examples of natural disasters which are regularly in the news and grab kids' attention. The idea of the Paper Volcanoes Laboratory was born in 2016 when, exploring educational resources for pre-scholar kids, limited material was found compared to the educational activities to communicate natural hazards for scholar age children. To contribute in filling this gap Amici and Castello [2018] have been exploring playful approaches to be used to let kids familiarize themselves with volcanoes. Paper Volcanoes Laboratory uses an experience based and "object play" approach to create an engaging and easy-to-perform learning experience. The activities have been field tested in both open days and schools perfected and subsequently structured in a toolkit enriched with pedagogical elements [Amici and Castello, 2021].

Since 2016, it has involved more than 390 children in Italy, New Zealand [Singh et al., 2019], Australia and Africa [Amici et al., 2022] and aroused the interest of educators who, during the pandemic 2020, have requested the activity to meet the needs of children in the primary school as well. The concept of the paper volcanoes laboratory Junior edition was initiated and after three years work and monthly meetings led to the creation of the Italian Volcanoes Identity cards. With the growth of interest, the team of the Paper Volcanoes Laboratory has also grown from 2 to 47 INGV staff units from the INGV base quarter in Rome and from INGV branches in Palermo, Catania, Pisa, Grottaminarda, L'Aquila, Ancona, Napoli, Lerici.

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Acknowledgments

We thank the INGV colleagues who attended the training and helped during the activities and the colleagues who contributed to the Identity cards and some of the volcano scene and photos (the complete list of names can be seen on the poster). A special thanks to Dir. S. Stramondo who has been supportive of the project and G. D'Addezio for her initial help.

Thanks to IUGG funding body and the colleagues, R. Sulpizio, Bertoli A., J.T. Ng'asike, M. Tesar, S. Eleman, P. Emase.

GIORNATA ONT martedì 14 novembre 2023

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Paper Volcanoes: laboratory a seven years' journey to engage (pre)scholar children on the wonderment of volcanoes

Stefania Amici, Barbara Castello, Pasqualino Cappuccio, Concetta Felli, Chiara Ladina, Stefania Lepidi
Vincenza Maiolino, Chiara Montagna, Loredana Napoli, Giovanna Lucia Piangiamore, Donatella Pietrangeli
Diego Sorrentino, Sabina Spadoni, Francesca di Laura, Daniela Riposati

Motivation

Natural disasters are relevant topics in the frame of Geoscience education; volcanic eruptions, wildfires, flooding, tornados, are few examples of natural disasters which are regularly in the news and grab kids' attention. The idea of the ***Paper Volcanoes Laboratory*** **was born in 2016** when, exploring educational resources for pre-scholar kids, limited material was found compared to the educational activities to communicate natural hazards for scholar age children. To contribute in filling this gap Amici S. and Castello B. (2018) have been exploring playful approaches to be used to let kids familiarize with volcanoes.

Method

Paper Volcanoes Laboratory uses an experience based and "*object play*" approach to create an engaging and easy-to-perform learning experience. The activities have been field tested in both open days and schools perfected and subsequently structured in a toolkit enriched with pedagogical elements (Amici S. and Castello B. 2020).





Toolkit front page and Stromboli and Vesuvio colouring scene specifically created for the Paper Volcanoes Laboratory. S. Amici and B. Castello 2021, n 60.



2016 — **Rocca di Papa** Museum Sept. 2016
- Positive feedback
- Children engaged

2017 — **Francesco Crispi school - Rome**
- Teachers engaged
- Children engaged
- Feedback from parents

2019 — **Giornata alfabetizzazione** 1° INGV Rome staff training 20 Jan. 2019 –INGV and toolkit launch

2019 — **2nd staff training** INGV Palermo 3 Nov. 2019 2nd

2019 — **Open day** INGV Rome - May 2019

2019 — **3rd NGV staff training** INGV Catania 5 Nov. 2019



2019 — **Chrisalis Pre-scolar** 3 centres Nov. 2019 in New Zealand

2020 — **AGU 100 grant** awarded 2020

2020 — **4th and 5th INGV staff training ONLINE**, May-June 2020 - Pisa - Grottaminarda - L' Aquila - Lerici

2020 — **IUGG Grant** awarded for Africa

2020 — **Summer School-** L'Aquila 2020

2022 — **6th training hybrid** 29 Nov. 2022 Ancona

Moving forward from pre-scholar to primary school

The concept of the ***paper volcanoes laboratory Junior edition*** was initiated during the pandemic and after three years work and monthly meetings lead to the creation a complete series of coloring Italian volcanoes scenes drawn by the team and 14 Italian Volcanoes Identity cards which depict the major Italian volcanoes like characters. The cards have been realized with the contribution of INGV colleagues expert of the specific volcanoes. The development of a structure of the *Paper Volcanoes Laboratory Junior Edition* has been recently developed and tested at the Nuzzo school in Rome on 26-27 April 2023.

The Paper volcanoes laboratory on 2024 aims to reach more children by involving more INGV colleagues and teachers actively committed to bring forward the vison of the program.



Example identity card (volcano Etna) and of the new series of colouring scenes (Volcano) developed within the paper volcanoes lab junior edition.



IUGG grant- onsite attendees and trainers September 2022 Turkana, Kenya.



First Paper Volcanoes lab. Junior Edition pilot carried out on 26-27 April 2023 at Nuzzo school-Rome S. Amici, C. Ladina and D. Sorrentino pictured while carrying out the activity.

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The colleagues who contributed to the Identity cards and some of the volcano scene and photos: Paolo Madonia, Luca Pizzino, Daniele Andronico, Benedetta Calusi, Boris Behncke Rosella Nave, Cinzia Giuseppina Caruso, Sabina Morici, Luca Cocchi, and Danilo Cavallaro
A special thanks to Dir. Salvatore Stramondo who has been supportive along the project and Giuliana D'Addezio for her initial help.

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S. Amici and B. Castello, Laboratorio Vulcani di Carta. Guida allo svolgimento del laboratorio nell'ambito di eventi rivolti al pubblico per il "Settore Comunicazione e Divulgazione Scientifica dell'INGV", ISSN 2039-6651 anno 2021 numero 60.
Paper Volcanoes Lab. A Way To Engage Early Childhood And Primary School Children On Earth Science In Africa
S. Amici, M. Tesar, J. Teria Ng'asike. A. Bertoli COV 11 12-17 June 2022
Paper Volcanoes Lab: engaging young children with earth science, S. Amici, M. Tesar: 13th annual International Conference of Education, Research and Innovation, Dates: 9-11 November, 2020, ISBN: 978-84-09-24232-0, ISSN: 2340-1095, doi:10.21125/iceri.2020.1507.

SOCIETÀ - COMUNICAZIONE, DIVULGAZIONE, GESTIONE DELLE EMERGENZE

Poster presented at the "Giornata ONT 2023". Poster presented shows the method, the material and the flow of the activities carried out by the Paper Volcanoes laboratory in the last 7 years. A QRCode allows the reader to access extended information in relation to pre-scholar, primary and the IUGG project in Kenya.

4 years of virtual reality at the ONT

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Scientific divulgation can be defined as discourse activity, whose main objective is to communicate some knowledge previously produced in scientific contexts to a non-expert massive audience. One of the difficulties science divulgators need to overcome is to explain specific concepts from a given discipline in a language simple and understandable for their interlocutors.
Digital games today play a large role in young people's lives. Games are directly connected to the life of today's adolescents. Therefore, digital games should be included and broached as a subject in the classroom. Experiences in cyberspace or environments allow a complete immersion through the extension of systems of representation, three-dimensional modelling, virtual reality (VR) and simulation systems extending their imagination. Inquiry learning offers authentic experience to engage in a process of knowledge construction. Considering that the childhood stage is indispensable in the education of human beings and especially critical to children's scientific aspects, I realized didactic video games to teach geophysics and Earth sciences to high and low-school students.
Different VR scenarios were developed in the past four years aiming to teach thematic topics such as volcanoes, ocean environments and the solar system.



The exhibition poster presented at the “Giornata ONT 2023”.

The INGVterremoti Rapid Mapping Service

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Thanks to a research operational agreement with the Digital Earth LabGIS at the University of Rome3, a RAPID MAPPING service has been developed to enhance the communication of data from the seismic surveillance service by integrating seismic, seismotectonic, and geological databases from INGV and other organizations. The research project undertaken has led to the creation of a GIS application on the ArcGIS platform by ESRI, involving the development of various Python scripts using ArcPy, a Python library package provided by ESRI within the ArcGIS Desktop environment. Multiple thematic projects were established to create individual maps by integrating real-time seismic data through web service queries from the terremoti.ingv.it portal and other European and global portals (e.g., CSEM and USGS). The seismicity data was overlaid on datasets extracted from the INGV and other institutions' databases (e.g., ISPRA for geological data). The result is the automatic and near real-time production of a series of thematic maps with clear and easily understandable symbology. These maps are stored on a server and then sent via a dedicated service to a list of email addresses. Approximately three minutes after the definitive location of a seismic event with a magnitude greater than 3.0 in Italy, 7 maps in A4 format are produced and sent via email which contain and integrate information on instrumental seismicity from 1985 to today, historical seismicity, seismic hazard, seismotectonics and geology. Furthermore, weekly, fortnightly and monthly maps of seismicity in Italy are produced and made available.
For earthquakes with a magnitude of M ≥ 4.0 in the EURO-MEDITERRANEAN region, 4 maps are produced and sent via email, and for earthquakes with a magnitude of M ≥ 6.0 in the GLOBAL region, an additional 3 maps are created and sent (Figure).

Acknowledgment
The authors thank the Digital Earth LabGIS of the University of Rome 3 with which an operational research agreement is active - Università degli Studi Roma3, Dipartimento di Scienze, Rome, Italy.

GIORNATA ONT martedì 14 novembre 2023

Il Servizio di Rapid Mapping di INGVterremoti

INGV terremoti

M. Pignone, S. Falcone in collaborazione con LabGIS Digital Earth dell'Università degli Studi Roma3

Il progetto

Grazie ad una convenzione operativa di ricerca con il **Digital Earth LabGIS dell'Università degli Studi Roma3, tra il 2018 e il 2021** è stato realizzato un **servizio di RAPID MAPPING** al fine di **migliorare la comunicazione dei dati provenienti dal servizio di sorveglianza sismica** integrando le banche dati sismologiche, sismotettoniche e geologiche dell'INGV e di altri Enti.

L'applicazione

Il progetto di ricerca sviluppato ha portato alla realizzazione di **una applicazione GIS su piattaforma ArcGIS** della ESRI con la creazione di alcuni **script in Python**, utilizzando ArcPy, un pacchetto di librerie Python messo a disposizione da ESRI in ambiente ArcGIS Desktop. Sono stati creati diversi progetti tematici per realizzare le singole mappe **integrando i dati di sismicità in tempo reale** grazie all'interrogazione dei webservices del portale terremoti.ingv.it ma anche di altri portali europei e del resto del mondo (ad esempio CSEM e USGS). I dati di sismicità sono stati sovrapposti ai **dataset estratti dalle banche dati dell'INGV e di altri Enti** (ad esempio ISPRA per i dati geologici). Il risultato è la **produzione in automatico** e in ***near real time*** di una **serie di mappe tematiche** con simbologie chiare e di semplice lettura. Le mappe vengono immagazzinate su un server e quindi inviate attraverso un apposito servizio a una serie di indirizzi mail.

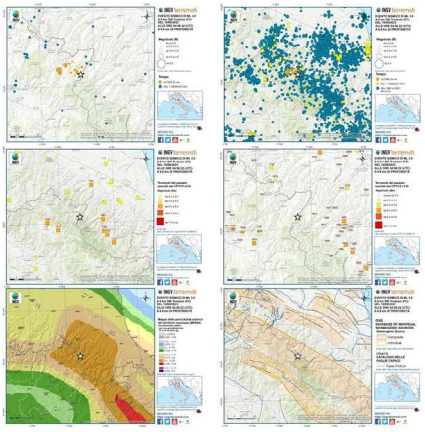


Il servizio

Dopo circa **tre minuti dalla localizzazioni definitiva** di un evento sismico di magnitudo **maggiore o uguale a 3.0 in ITALIA** vengono prodotte e inviate tramite mail **7 mappe in formato A4:**

- **Strumentale 1** (epicentro, sismicità ultime 24 ore, sismicità da inizio anno)
- **Strumentale 2** (epicentro, sismicità ultime 24 ore, sismicità da inizio anno, sismicità dal 1985)
- **Storica 1** (epicentro, terremoti storici CPTI15 con magnitudo stimata maggiore di 5.0)
- **Storica 2** (epicentro, terremoti storici CPTI15 di tutte le magnitudo)
- **Pericolosità** (epicentro, mappa di pericolosità MPS04)
- **Sismotettonica** (epicentro, sorgenti sismogenetiche DISS, database faglie ITHACA)
- **Geologica** (epicentro, carta geologica ISPRA alla scala 1:1.000.000)

Mappe Italia



Inoltre vengono prodotte e rese disponibili le **mappe settimanali, quindicinali e mensili** della **sismicità in Italia**.



Il **servizio di Rapid Mapping** produce **due set di mappe** entro circa **60 minuti** dalla localizzazione definitiva dell'INGV per terremoti in area **EURO-MEDITERRANEA** e nel **MONDO**. Per la realizzazione di queste mappe sono stati integrati dati dell'INGV con i dataset statici e dinamici di altri ENTI (GEM, CSEM, USGS).

Per i terremoti di magnitudo **M ≥ 4.0** in area **EURO-MEDITERRANEA** vengono prodotte e inviate tramite mail **4 mappe in formato A4**:

- **Strumentale** (epicentro INGV, sismicità dal 2007 dati CSEM)
- **Storica** (epicentro INGV, Catalogo SHARE e SHEEC)
- **Sismotettonica** (epicentro INGV, EDSF13 European Database of Seismogenic Faults)
- **Pericolosità sismica** (epicentro INGV, modello di pericolosità in valori di PGA - Global Earthquake Map GEM)

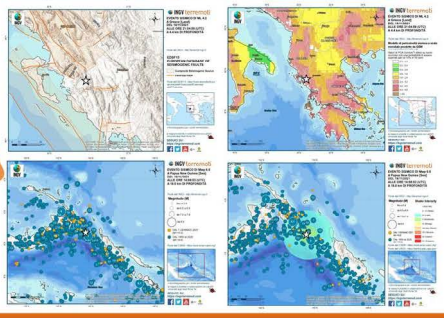
Mappe euro-med



Per i terremoti di magnitudo **M ≥ 6.0** in area **GLOBALE** vengono prodotte e inviate tramite mail **3 mappe in formato A4**:

- **Pericolosità sismica** (epicentro INGV, modello di pericolosità in valori di PGA - Global Earthquake Map GEM)
- **Strumentale** (epicentro INGV, sismicità dal 1900 al 2020 USGS e dal 2021 CSEM)
- **Shakemap** (epicentro INGV, sismicità dal 1900 al 2020 USGS e dal 2021 CSEM, shakemap USGS in valori di intensità)

Mappe world



Tutte le mappe prodotte dal servizio sono utilizzate per le **attività di comunicazione** dei canali web e social **INGVterremoti**.
In particolare nel blog-magazine **www.ingvterremoti.com** le mappe sono inserite negli articoli che descrivono la sismicità sul territorio nazionale e nel resto del mondo.



SOCIETÀ - COMUNICAZIONE, DIVULGAZIONE, GESTIONE DELLE EMERGENZE

Seismic emergencies and INGV operational task force

Raffaele Azzaro, Fabrizio Cara, Ezio D'Alema, Paolo Marco De Martini, Giuseppe Di Giulio, Emanuela Ercolani, Laura Graziani, Milena Moretti*, Concetta Nostro, Davide Piccinini, Stefano Pucci

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INGV has six task forces which are activated immediately in case of significant earthquakes (generally for a local magnitude ML equal to or greater than 5.0) or prolonged seismic sequences on the national territory or tsunami [Pondrelli et al., 2016].
These are the main objectives of the INGV-OG:

- COES (Seismic Emergency Operational Coordination): provides support to INGV personnel involved in emergency activities in the countryside but also to rescue operators involved in emergencies, local administrations and the population affected by the event [Pondrelli et al., 2019].
- EMERGEO: deals with the survey of the effects of earthquakes and tsunamis on the environment, in Italy and in the Mediterranean area [*https://emergeo.ingv.it/*].
- EMERSITO: deals with the study of site effects and microzonation activities [*http://emersitoweb.rm.ingv.it*].
- IES (Information in Seismic Emergency): aimed at information activities for schools and the population involved.
- QUEST (QUick Earthquake Survey Team): which carries out the macroseismic survey [*https://quest.ingv.it*].
- SISMIKO represents the coordination of the INGV Mobile Seismic Networks in an emergency. Installing a temporary seismic network allows you to significantly improve monitoring by optimizing the ability to detect seismic events and the quality of their locations [*https://sismiko.ingv.it/*; Moretti et al., 2023]).

Each task force has codified the main actions to be carried out in case of emergency through operational protocols.
Many researchers and technicians from the ONT are part of the task forces and participate in the activities inherent to seismic emergencies.

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GIORNATA ONT martedì 14 novembre 2023

Raffaele Azzaro(1), Fabrizio Cara(2), Ezio D'Alema(3), Paolo Marco De Martini(2), Giuseppe Di Giulio(2), Emanuela Ercolani(4), Laura Graziani(5), Milena Moretti(5), Concetta Nostro(5), Davide Piccinini(6), Stefano Pucci(2)

Le emergenze sismiche e i Gruppi Operativi INGV

1 Osservatorio Etneo | 2 Sezione Roma1 | 3 Sezione di Milano | 4 Sezione di Bologna | 5 Osservatorio Nazionale Terremoti | 6 Sezione di Pisa

L'Istituto Nazionale di Geofisica e Vulcanologia (INGV) dispone di **sei Gruppi Operativi** (GO) che si attivano immediatamente in caso di terremoti significativi (generalmente per magnitudo ML pari o superiore a 5.0) o sequenze sismiche prolungate sul territorio nazionale o tsunami: **COES, IES, EMERGEO, EMERSITO, QUEST** e **SISMIKO**.

Obiettivo dei GO EMERGEO, EMERSITO, QUEST e SISMIKO è la raccolta di nuovi dati per un supporto immediato alla Unità diCrisi dell'INGV, per svolgere analisi tecnico-scientifiche da inviare al Dipartimento di Protezione Civile nazionale, a supporto degli interventi di Protezione Civile, e per effettuare successive attività di ricerca.

I GO IES e COES svolgono essenzialmente attività di supporto (verso i colleghi INGV, gli operatori del soccorso e la popolazione colpita dall'emergenza).

Ogni GO ha codificate le principali azioni da compiere in caso di emergenza attraverso Protocolli Operativi.

EMERGEO

Coordinatori: Paolo Marco De Martini e Stefano Pucci



Effettua il rilievo degli effetti geologici cosismici superficiali prodotti da terremoti (fagliazione superficiale, fratturazione, liquefazione, frane e crolli) e maremoti (trasporto e deposizione di sedimenti nelle aree costiere e modellazione/modificazione di forme geomorfologiche) sull'ambiente naturale in Italia e nell'area mediterranea per la comunità scientifica e la Protezione Civile.

L'operazione riveste un carattere di urgenza, in quanto gli effetti cosismici superficiali possono interessare oltre che i centri abitati anche le infrastrutture del territorio (strade, acquedotti, dighe, porti, centrali elettriche, etc.) e la loro identificazione e caratterizzazione contribuisce alla definizione delle misure utili alla messa in sicurezza. Si avvale del contributo dei cittadini coinvolti nell'emergenza attraverso la compilazione di un questionario online.

Per maggiori informazioni: https://emergeo.ingv.it/

EMERSITO

Coordinatori: Fabrizio Cara e Giuseppe di Giulio



Si occupa di coordinare e svolgere campagne di monitoraggio per studi di risposta sismica locale a seguito di eventi sismici di forte magnitudo, o che comunque abbiano dato luogo a un danneggiamento imputabile anche all'amplificazione del moto sismico in superfici.

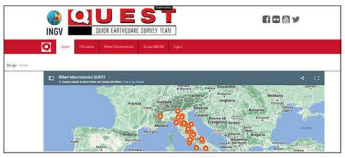
Svolge inoltre attività propedeutiche alla microzonazione sismica in fase di emergenza.

Fornisce quindi un contributo alla comunità scientifica, alla Protezione Civile e alle Autorità locali.

Per maggiori informazioni: http://emersitoweb.rm.ingv.it/

QUick Earthquake Survey Team - QUEST

Coordinatori: Laura Graziani e Raffaele Azzaro



Effettua il rilievo macrosismico con lo scopo di fornire, rapidamente ed univocamente, il quadro degli effetti nell'area colpita da un evento sismico, per la Protezione Civile e la comunità scientifica. L'operazione riveste un carattere di urgenza, in quanto eventi sismici successivi e gli interventi di messa in sicurezza (per es. demolizioni di edifici pericolanti e sgombero delle macerie) influenzano la raccolta omogenea del dato e la sua interpretazione.

Per maggiori informazioni: https://quest.ingv.it/

SISMIKO

Coordinatori: Davide Piccinini e Ezio D'Alema



Rappresenta il coordinamento delle Reti Sismiche Mobili INGV in emergenza. L'installazione di stazioni temporanee, ad integrazione di una rete sismica permanente presente nell'area interessata, consente di migliorare notevolmente il monitoraggio ottimizzando la capacità di detezione degli eventi sismici e la qualità delle loro localizzazioni, dando un immediato il contributo al servizio di sorveglianza sismica e, a posteriori, alle conoscenze scientifiche dell'area interessata.

Per maggiori informazioni: https://sismiko.ingv.it/

Informazione in Emergenza Sismica - IES

Coordinatori: Concetta Nostro e Emanuela Ercolani



Fornisce un supporto informativo alla popolazione coinvolta nella sequenza sismica, con particolare attenzione al mondo della scuola, fornendo agli insegnanti le conoscenze, e gli strumenti per gestire la ripresa delle attività didattiche. Un bisogno di conoscenza del fenomeno in atto da parte della popolazione coinvolta, che si è manifestato in modo rilevante a partire dalla sequenza in Abruzzo (2009) e che IES realizza principalmente attraverso l'incontro diretto sul campo.

Per maggiori informazioni: https://www.ingv.it/monitoraggio-e-infrastrutture/emergenze/-

Coordinamento Operativo Emergenza Sismica - COES

Coordinatrici: Milena Moretti e Concetta Nostro



Rappresenta il presidio dell'INGV in area epicentrale, generalmente inserito all'interno della Di.Co.Mac del DPC.

Funge da riferimento per i colleghi INGV impegnati nelle attività di emergenza in campagna e un supporto scientifico-informativo per gli operatori di soccorso impegnati nell'emergenza, le Amministrazioni Locali, gli Uffici Pubblici e la popolazione colpita dall'evento.

Per maggiori informazioni: https://sismiko.ingv.it/informazione-divulgazione/divulgazione/id-04

ESERCITAZIONI, EMERGENZE, PROGETTI DI RICERCA

Esercitazioni 2015-2022



Nelle esercitazione i GO testano le procedure di intervento e le attività tecnico scientifiche previste a seguito di una emergenza sismica: processi di comunicazione interna ed esterna ai GO (ad es. verso l'Unità di Crisi INGV e il DPC), organizzazione delle attività, l'acquisizione di nuovi dati, redazione di report di attività, ecc.

Progetti di ricerca

Convenzione INGV-DPC/Allegato Tecnico

"WP9 Preparazione e gestione dell'attività tecnico-scientifica in emergenza sismica /**sWP 9.2 Gruppi Operativi**" & "WP 12. Formazione, comunicazione e divulgazione/**sWP 12.3 Informazione in Emergenza Sismica**"

DL50 - RICOSTRUZIONE/Sotto-progetto: GRUPPI OPERATIVI/**OR: Strumentazione a supporto dei Gruppi Operativi**

Emergenze comuni dal 2009 al 2023



Importanti sono state le collaborazioni tra i GO durante le esercitazioni maggiori degli ultimi 15 anni.

IL CONTRIBUTO DELL'ONT AI GO-INGV

Molti ricercatori e tecnici dell'ON fanno parte dei GO e partecipano attivamente alle attività inerenti alle emergenze sismiche:

EMERGEO: 9 unità di personale/85, che contribuiscono a tutte le attività previste in emergenza.

EMERSITO: 7 unità di personale/50, in generale per attività di campagna (installazione delle stazioni) e analisi dei dati

QUEST: 7 unità di personale tra cui uno dei due coordinatori nazionali/48 per attività di campagna e analisi dati.

SISMIKO: 35 unità di personale/110, per i suoi obiettivi è il GO che probabilemnte contribuisce maggiormenente alle attività dell'ONT. Al suo interno, è previsto il servizio di reperibilità della Rete Sismica Mobile attivo presso la sede di Roma, di competenza ONT.

IES: 3 unità di personale tra cui uno dei due coordinatori nazionali/**9.**

COES: attualmente **2 unità di personale, entrambi** i coordinatori nazionali. Il GO è in fase di riorganizzazione. In passato molti colleghi ONT hanno collaborato alle attività del

INOLTRE... l'ONT fornisce

- **Comunicazioni degli eventi (SMS, MAIL) con il quale vengono attivate le procedure previste nei Protocolli Operativi dei GO - Servizio di sorveglianza sismica ONT**
- **Acquisizione dati in tempo reale di SISMIKO e EMERSITO, archiviazione e distribuzione dati tramite EIDA-nodo Italia - UF "ARCHIVIO E CONDIVISIONE DATI"**
- **Piattaforma condivisione dati**
- **Supporto amministrativo per acquisti e missioni - Segreteria amministrativa**

SOCIETÀ - COMUNICAZIONE, DIVULGAZIONE, GESTIONE DELLE EMERGENZE

Poster presented at the "Giornata ONT 2023".

SISMIKO: INGV operational task force for seismic network rapid deployments

Davide Piccinini*, Ezio D'Alema, Milena Moretti, Marina Pastori, Adriano Cavaliere, Antonio Costanzo, Danilo Galluzzo, Salvatore Claudio Alparone, Luciano Zuccarello, Angelo Castagnozzi, Stefano Speciale, Lucia Margheriti, Paolo Augliera, Simone Marzorati

INGV | Istituto Nazionale di Geofisica e Vulcanologia, Italy

**Corresponding author: davide.piccinini@ingv.it*

SISMIKO coordinates all working groups of the INGV for the rapid deployment of temporary seismic stations in the area hit by a significant earthquake or a seismic sequence causing concern and interest with impact on people [*https://sismiko.ingv.it/*; Moretti et al., 2023]. Decreasing the average distance between the seismic stations improves detection, accuracy of the earthquake locations, shakemaps and strong motion parameters.
SISMIKO was established formally in 2015. In these years, notable improvements have been made in the organisation of interventions and in the management of the data acquired. Today, over 100 INGV personnel join the task force: technicians, technologists and researchers from many of the offices distributed across the national territory. Furthermore, consolidated relationships with European research institutions and universities guarantee coordinated deployment in the event of strong earthquakes. The new configuration in Activity Groups allows to coordinate the distributed personnel and to cover all the aspects in the preparation of the emergency. The type of activities included in the new organisation refer to: - technical management of the instrumentation - field operations - relations with the INGV Crisis Unit and the other Operational Groups - development of the automatic procedures to analyse seismic data From the evaluation of the best choices of the equipment up to publication of the continuous digital raw data with associated DOI, reports and papers, the SISMIKO team contributes to create new knowledge about seismic sequence through high quality scientific data.

References

Moretti, M., Margheriti L., D'Alema, E., and Piccinini, D., (2023). *SISMIKO: INGV operational task force for rapid deployment of seismic network during earthquake emergencies*. Front. Earth Sci. 11:1146579. https://doi.org/10.3389/feart.2023.1146579

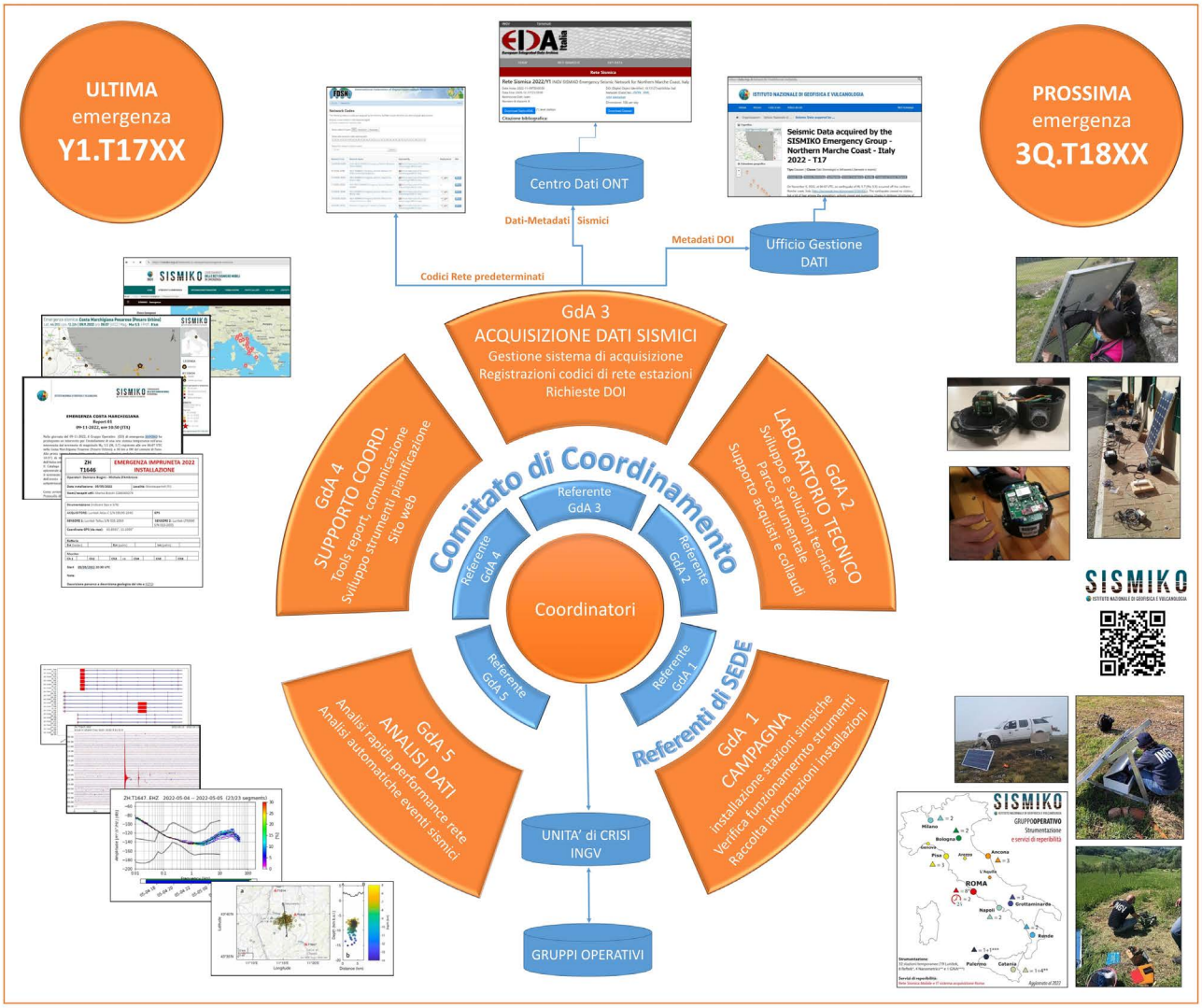
GIORNATA ONT martedì 14 novembre 2023

Piccinini D.(1), D'Alema E.(2), Moretti M.(3), Pastori M.(3), Cavaliere A.(4), Costanzo A.(3), Galluzzo D.(4), Alparone S.(5), Zuccarello L.(1), Castagnozzi A.(6), Speciale S.(3), Margheriti L.(3), Augliera P.(2), Marzorati S.(3)

1 Sezione di Pisa | 2 Sezione di Milano | 3 Osservatorio Nazionale Terremoti | 4 Sezione di Bologna | 5 Osservatorio Vesuviano | 6 Osservatorio Etneo | 7 Sezione Irpinia

SISMIKO: INGV operational task force for seismic network rapid deployments

SISMIKO coordinates all working groups of the Istituto Nazionale di Geofisica e Vulcanologia (INGV) for the rapid deployment of temporary seismic stations in the area hit by a significant earthquake or a seismic sequence causing concern and interest with impact on people. Decreasing the average distance between the seismic stations improves detection, accuracy of the earthquake locations, shakemaps and strong motion parameters. SISMIKO was established formally in 2015. In these years, notable improvements have been made in the organisation of interventions and in the management of the data acquired. Today, over 100 INGV personnel join the task force: technicians, technologists and researchers from many of the offices distributed across the national territory. Furthermore, consolidated relationships with European research institutions and universities guarantee coordinated deployment in the event of strong earthquakes. The new configuration in Activity Groups allows to coordinate the distributed personnel and to cover all the aspects in the preparation of the emergency.
The type of activities included in the new organisation refer to: technical management of the instrumentation, field operations, relations with the INGV Crisis Unit and the other Operational Groups, development of the automatic procedures to analyse seismic data. From the evaluation of the best choices of the equipment up to publication of the continuous digital raw data with associated DOI, reports and papers, the SISMIKO team contributes to create new knowledge about seismic sequence through high quality scientific data.



SISMIKO nasce nel 2015 ma la necessità di strutturarsi in modo organico per coordinare gli interventi delle reti sismiche temporanee in caso di emergenza, risale a qualche anno prima, in occasione della lunga sequenza sismica che colpì la città de L'Aquila e le zone limitrofe nella primavera del 2009, consolidando poi il progetto con il terremoto in Pianura Padana del 2012. L'**evoluzione del GO** si è focalizzata su due fronti: - **creare un gruppo coeso e strutturato** per sfruttare la copertura del territorio data dalla diffusione geografica dei gruppi di intervento presso le diverse sedi e sezioni dell'INGV e per interfacciarsi durante la fase di emergenza con le altre infrastrutture di monitoraggio dell'ente (come ad esempio la RSN, il centro acquisizione dati dell'INGV e la Sala Operativa) – **sviluppare e implementare strumenti tecnologici** con lo scopo di una generale omogeneizzazione della strumentazione sismologica, delle procedure di installazione, delle soluzioni tecniche per la trasmissione, l'acquisizione e la distribuzione dei dati.
Al fine di porre in essere azioni preventive e poi di gestione delle emergenze sismiche, SISMIKO si è innanzitutto dotato di un **protocollo operativo d'intervento** che stabilisse i ruoli di coordinamento, le attività e le modalità necessarie per essere preparati alle diverse situazioni straordinarie che si possono presentare a seguito di un forte terremoto o di una prolungata sequenza sismica.
Il GO si è quindi **strutturato attraverso un organo di coordinamento nazionale** composto dai referenti di ogni sezione e sede INGV e un team operativo organizzato in **Gruppi di Attività (GdA)**, pronto per affrontare con rapidità e tempismo gli interventi in campagna.

SOCIETÀ - COMUNICAZIONE, DIVULGAZIONE, GESTIONE DELLE EMERGENZE

SEISMIC SURVEILLANCE
TSUNAMI WARNING

Italian 24/7 real-time earthquakes and tsunamis monitoring system

Salvatore Stramondo*, Lucia Margheriti, Laura Scognamiglio, Alessio Piatanesi, Concetta Nostro, Alessandro Amato and Reperibili ADS**

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***Reperibili ADS: Fabrizio Bernardi, Andrea Bono, Sergio Bruni, Ivano Carluccio, Emiliano Della Bina, Massimo Fares, Valentino Lauciani, Matteo Quintiliani*

The INGV carries out the seismic surveillance service in the Italian territory and the tsunami warning in the Mediterranean Sea.
In the monitoring room, at the headquarters of the INGV in Rome, there are two seismologists, a tsunami specialist and a technician/engineer who work on three daily shifts to provide the services on a 24/7 basis [Margheriti et al., 2021]. They calculate, as quickly and accurately as possible, the location and magnitude of all Italian M2.5+ earthquakes and quickly disseminate the information to emergency authorities, government agencies, to the public and the media through various platforms (email, SMS and via Facebook and Twitter). Hypocentral and magnitude parameters together with moment tensors, historical seismicity maps and shakemaps are published in quasi- real time.
The Tsunami alert center CAT-INGV is one of the Tsunami service providers operating in the North-East Atlantic, Mediterranean and related seas (NEAM) region of the Intergovernmental Oceanographic Commission (IOC)/UNESCO and is responsible for monitoring the seismicity of the Mediterranean Sea and disseminating promptly the tsunami warning messages to Member States and EU agencies that subscribe to its services [Amato et al., 2021].
The operation and performance of the INGV monitoring system is ensured and developed by a dedicated research and IT staff that facilitates the acquisition and distribution of waveforms and develops real-time seismic processing systems.

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Margheriti, L., Nostro, C., Cocina, O., Castellano, M., Moretti, M. Lauciani, L., et al. (2021). *Earthquake Monitoring in Italy*. Seismol. Res. Lett. XX, 1–13. https://doi.org/10.1785/ 0220200380

GIORNATA ONT martedì 14 novembre 2023

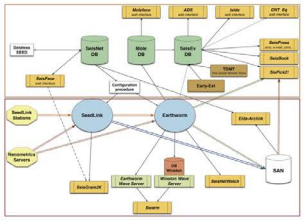
Stramondo S., L. Margheriti, L. Scognamiglio,
A. Piatanesi, C. Nostro, A. Amato and Sala Operativa Working group

Italian 24/7 real-time earthquakes and tsunamis monitoring system

Introduction

The Istituto Nazionale di Geofisica e Vulcanologia (INGV) has the primary responsibility for the seismic surveillance service of the Italian territory and the tsunami alert in the Mediterranean Sea.The activities in the monitoring room at the INGV National Earthquake Observatory headquarters in Rome (hereafter INGV-Rome), are carried on by two seismologists, one tsunami specialist and one technician/engineer who work in three shifts a day to provide monitoring service on a 24/7 basis. They calculate, as rapidly and accurately as possible, the location and size of all Italian earthquakes with M2.5+ and swiftly disseminate such information to emergency authorities, to government agencies, to the public and the media by different platforms (email, text message, and via Facebook and Twitter). Starting with hypocentral and magnitude parameters, the moment tensors, the historical seismicity map and the shakemaps are also published in (near) real time.



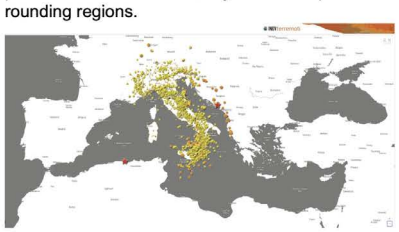


Logic Schema

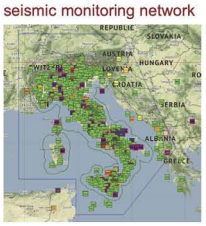
The surveillance system is designed to accomplish, in near real time, automatic earthquake detection and hypocenter and magnitude determination. It is composed of standard seismological protocols and software as well as software specifically designed for seismic surveillance.
The real-time earthquake analysis is based on the **Earthworm** location system, various seismological relational databases for parametric data and tools, as the **Mole database** (Quintiliani and Pintore, 2013), and a full set of webservices application programming interface. The earthquakes location revision is carried out with the **SisPick** software (Bono, 2008).
The acquisition system is based on the SeedLink protocol, it includes the tools to collect, distribute and archive waveform data. Stations are connected through many different links, but with only two protocols: SeedLink and the Nanometrics.

Located earthquakes (2022)

Earthquake parameters for the Italian region, including volcanoes as well as for the Mediterranean M ≥ 5:0) and for the entire world (M ≥ 6:0) are published in real time on a dedicated the web-portal. For the 2022, the earthquake list reports **16744** events located by the INGV specialists on duty 24/7 in Italy and surrounding regions.



seismic monitoring network

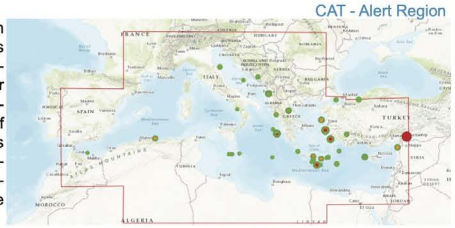


CAT released tsunami alerts (2017-2023)

Contrary to seismic shifts, the CAT shifts include Early Warning messages in the case of major earthquakes at sea or in coastal regions based on magnitude and hypocenter parameters. To obtain these parameters, the CAT uses the software **Early-Est** (Anthony Lomax and Alberto Michelini 2011).

Early-Est receives data from hundreds of seismic stations around the world and analyses them in real time in order to recognise any signals related to earthquakes. In case of a seismic event, it calculates a series of progressive localisations, determining the hypocentre coordinates and the magnitude.

CAT - Alert Region



Products

As soon as the verified origin and magnitude are evaluated by seismologists on duty, the events parameters are published through email, SMS and web-pages



Starting form the revised earthquake locations, a set of automatic procedures are triggered to generate a bunch of products decribing the event characteristics as: **ShakeMaps** (Michelini et al., 2020), time domain moment tensor solutions,**TDMT**, (Scognamiglio et al., 2009), geodetic **finite fault** models (Atztori et al., 2023),**Did you feel it** - Maps (Tosi et al., 2007) and other important information, such as historical data, seismotectonic context, references to the hazard.

http://terremoti.ingv.it

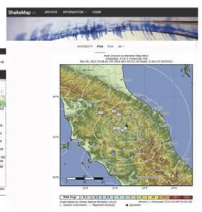




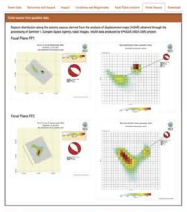
http://terremoti.ingv.it/tdmt/



https://www.hsit.it/



http://shakemap.ingv.it/shake4/



http://terremoti.ingv.it/finitesource/

Dissemination



References:
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Tosi, P. et al. (2007). Hai Sentito Il Terremoto (HSIT) https://doi.org/10.13127/HSIT

SERVIZI DI SORVEGLIANZA SISMICA E ALLERTA TSUNAMI

Poster presented at the "Giornata ONT 2023". Figure summarizes the activities carried out in the Italian 24/7 real-time earthquakes and tsunamis monitoring system.

CaravelDB: a specific relational database model for seismic parametric data, geospatial information and communication services

Matteo Quintiliani

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CaravelDB [Bono et al, 2021] is a relational database model designed to represent information related to seismic events and their associated parameters. It consists of three different logical schemas: "*quaked*", "*boundaries*" and "*seispress*". "*quaked*" is an evolution of the "*seisev*" MySQL database. It extends and optimizes the logical model, extends representation capacity, and offers new features, along with enhanced performance through the PostgreSQL/PostGIS DBMS. A complex migration procedure allows the restructuring and copying of all information from "*seisev*" into "*quaked*" at a specific point in time, preserving the entire history into the new model. "*quaked*" can manage information from multiple earthquake location systems while preserving their local entity IDs. It is also designed to represent all parameters encoded in the QuakeML XML interchange schema [Quintiliani and Pintore, 2013]. For each seismic event generated by a single instance, it is possible to configure an automatic selection of the preferred origin, magnitude, and focal mechanism entities, which can then be manually adjusted. Furthermore, it is possible to group seismic events generated by different instances that refer to the same real seismic event and establish an order of representativeness based on the quality and reliability of the results. "*boundaries*" is a relational model for storing geospatial information related to administrative and geographic boundaries. "*Seispress*" is the relational model used by SeisPressNG, the seismic event reporting system. CaravelDB is a component of the new Caravel System infrastructure based on microservices for 24/7 Italian Seismic Surveillance and can be deployed using Docker Containerization.

References

Bono, A., Lauciani, V., Margheriti L., and Quintiliani, M., (2021). *Caravel: A New Earthworm-Based Open-Source Development for the Italian Seismic Monitoring System*. Seismological Research Letters 92.3, pp. 1738–1746. issn: 0895-0695. https://doi.org/10.1785/0220200355

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GIORNATA ONT martedì 14 novembre 2023

CaravelDB: a specific relational database model for seismic parametric data, geospatial information and communication services

Matteo Quintiliani

Osservatorio Nazionale Terremoti - Istituto Nazionale di Geofisica e Vulcanologia

Caravel System

CaravelDB together with Dante, PFX and SeisPressNG are the main components of the Caravel system [Bono et al. 2021].

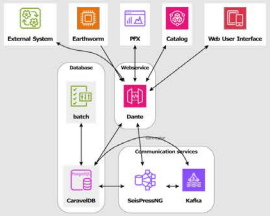


Figure 1. Caravel System is the new microservices-based infrastructure to support the 24/7 Italian Seismic Surveillance Service.

From seisev schema to quake schema

quake schema is an evolution of the **seisev schema** originally based on MySQL DBMS. It optimizes the logical model, extends representation capacity, and offers new features, along with enhanced performance through the PostgreSQL/PostGIS DBMS.

Preserving all historical data

A complex migration procedure allows the restructuring and copying of all information at a specific point-in-time from **seisev schema** MySQL into **quake schema** PostgreSQL/PostGIS DBMS.
In this way it preserves all the history into the new model and makes it available through the new Caravel System.



QuakeML interchange

quake schema is capable of representing everything that can be exchanged via the QuakeML format schema [Euchner et al. 2010].

Earthquake catalogs

Inside **quake schema** it is possible to create and save all the information relating to earthquake catalogs and seismic bulletins. To do this, simply define *localspace* entities by specifying the *'catalog'* value for the *environment* attribute.

Docker Containerization

CaravelDB can be deployed using Docker Containerization.

CaravelDB

CaravelDB is a relational database model designed to represent information relating to seismic events and their associated parameters. Furthermore, it has the ability to contain geospatial information relating to geographical and administrative boundaries and, as a support for SeisPressNG's communications services, all the references of the products and solutions generated for seismic events and the actions undertaken for their dissemination.
It is composed of three logical schemas:

- **quake schema** (fig. 2)
- **boundaries schema**
- **seispress schema**

It is designed to work both in near real time and as a database for reviewing events or creating earthquake catalogs and seismic bulletins.
It is mainly populated and updated via the Dante REST service OpenAPIs used by automatic systems (e.g. Earthworm [Johnson et al. 1995] or EarlyEst) and/or seismic event review systems (e.g. PFX). Although applications that directly access the database can be developed, such as the seismic event grouping procedure.
quake schema, unlike the **mole schema** [Quintiliani and Pintore 2013], is completely general and independent of Earthworm message structures.

quake schema

quake schema is the logical data model for storing seismic events and their associated parameters.

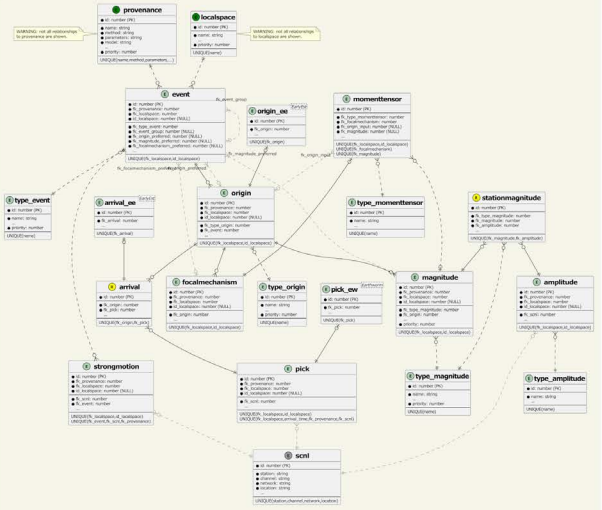


Figure 2. The figure shows a summary E-R diagram of the **quake schema**. The main entities are: *seismic events, origins, picks, arrivals, magnitudes, amplitudes, durations, moment tensors, focal mechanisms and strong motion parameters.* It is possible to associate confidence levels and uncertainty values, which can also be non symmetric, to particular parameters such as *picks, arrivals, origins and magnitudes.*

boundaries schema

boundaries schema is the logical data model for storing geospatial information about administrative and geographic boundaries.

seispress schema

seispress schema is the logical data model used by SeisPressNG, the seismic event reporting system.

References

Bono, A., V. Lauciani, L. Margheriti, and M. Quintiliani (Mar. 2021). "Caravel: A New Earthworm-Based Open-Source Development for the Italian Seismic Monitoring System". In: *Seismological Research Letters* 92.3, pp. 1738–1746. ISSN: 0895-0695. DOI: 10.1785/0220200355.

Quintiliani, M. and S. Pintore (July 2013). "Mole: An Open Near Real-Time Database-Centric Earthworm Subsystem". In: *Seismological Research Letters* 84.4, pp. 695–701. ISSN: 0895-0695. DOI: 10.1785/0220120066.

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Johnson, C. E., A. Bittenbinder, B. Bogaert, L. Dietz, and W. Kohler (1995). "Earthworm: A flexible approach to seismic network processing". In: *Incorporated Research Institutions for Seismology (IRIS) Newsletter* 14, pp. 1–4.

Provenance and Localspace

CaravelDB is capable of managing information coming from multiple different earthquake location instances while also preserving the IDs of their local resources.
An instance is described and identified by the *provenance* and *localspace* attributes through which it is possible to specify which and what type of system, and from where and with which software the associated values were produced.
Each instance is associated with a unique *localspace* name in which it can generate and manage the IDs of its local results, such as those relating to events, origins and magnitudes.

The Preferred Ones

For each new seismic event declared by a single instance, **CaravelDB** offers an automatic selection functionality of the preferred origin, magnitude and focal mechanism (fig. 3).
The automatic selection is based on quality criteria and priority values previously assigned to the corresponding *localspaces* and types of event, origin and magnitude.
The preferred values can then be subsequently manually adjusted, taking into account the various steps in the revision process of the events.

Example of Event Group and Preferred Selection

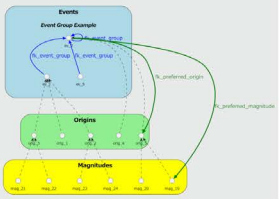


Figure 3. Graphical example of the preferred selection and event group representativeness. The real seismic event will be mostly represented by the tuple *(fk_event_group, fk_preferred_origin, fk_preferred_magnitude).*

Event Groups

The events located by the different instances converge within the database, therefore there may be multiple event IDs which however refer to the same real seismic event. **CaravelDB** offers an automatic clustering functionality in order to group similar seismic preferred event locations (fig. 3). Once a grouping is generated, the events within it are sorted based on the quality and priority criteria of their localspace. This ordering specifies the relative degree of representativeness of the real seismic event.

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SEISMIC SURVEILLANCE AND TSUNAMI WARNING

Dante: A robust Web Service for seismic data evaluation and accessibility through a microservices approach

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Real-time earthquake assessment includes the evaluation of seismic data, including picks, preliminary and automatic hypocenters, local magnitudes, and ground-motion parameters. In response to this demand, Dante emerges as a robust Web Service developed using the PHP Laravel framework. Dante offers a suite of Micro RESTful APIs, enabling seamless interaction with QuakeDB, our dedicated earthquake database, to access seismic data.
The adoption of OpenAPI specifications enhances accessibility and simplifies the generation of client development classes in multiple programming languages. Dedicated software tools, such as 'openapi-generator-cli,' further expedite this process. The utilization of the JSON format ensures efficient and interoperable communication between the Web Service and client applications.
Notably, Dante leverages containerization and employs a microservices architecture, facilitating deployment on Docker Swarm. This architectural approach fosters the scalability of individual components, while Dante's compatibility with Kubernetes broadens deployment possibilities.
In summary, Dante stands as a significant advancement for interacting with earthquake parameters, offering a comprehensive and versatile solution that is accessible, efficient, and seamlessly integrates with modern containerization technologies.

GIORNATA ONT martedì 14 novembre 2023

Author: Valentino Lauciani

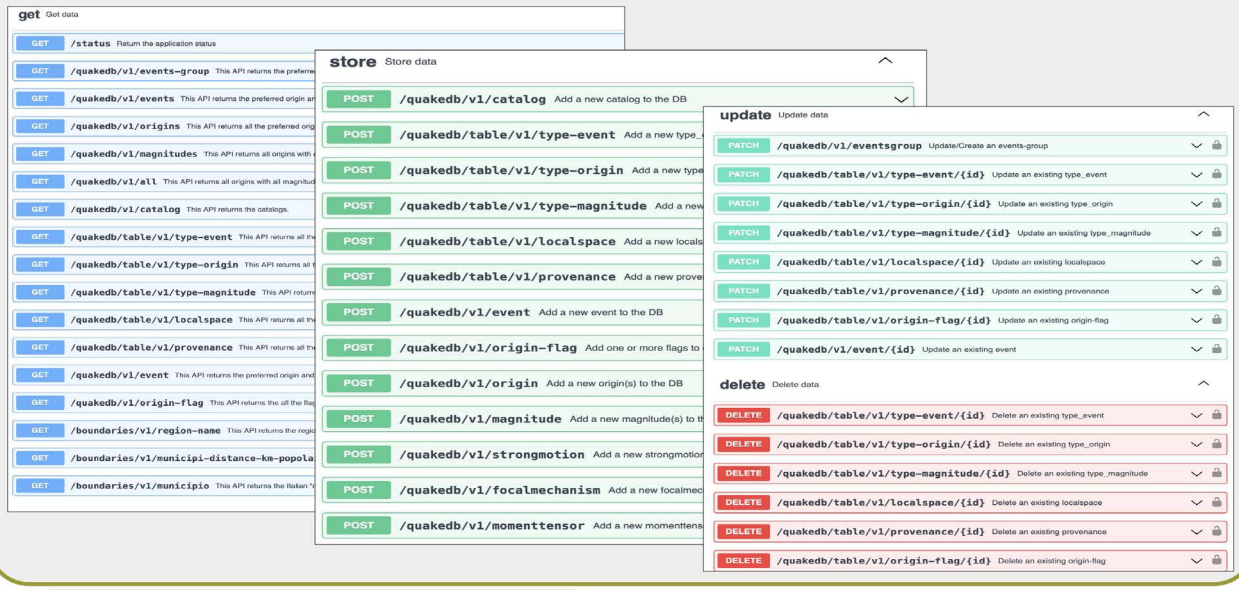
Thanks to: Andrea Bono, Raffaele Distefano, Lucia Margheriti, Laura Scognamiglio, Matteo Quintiliani

Dante: A robust Web Service for seismic data evaluation and accessibility through a microservices approach

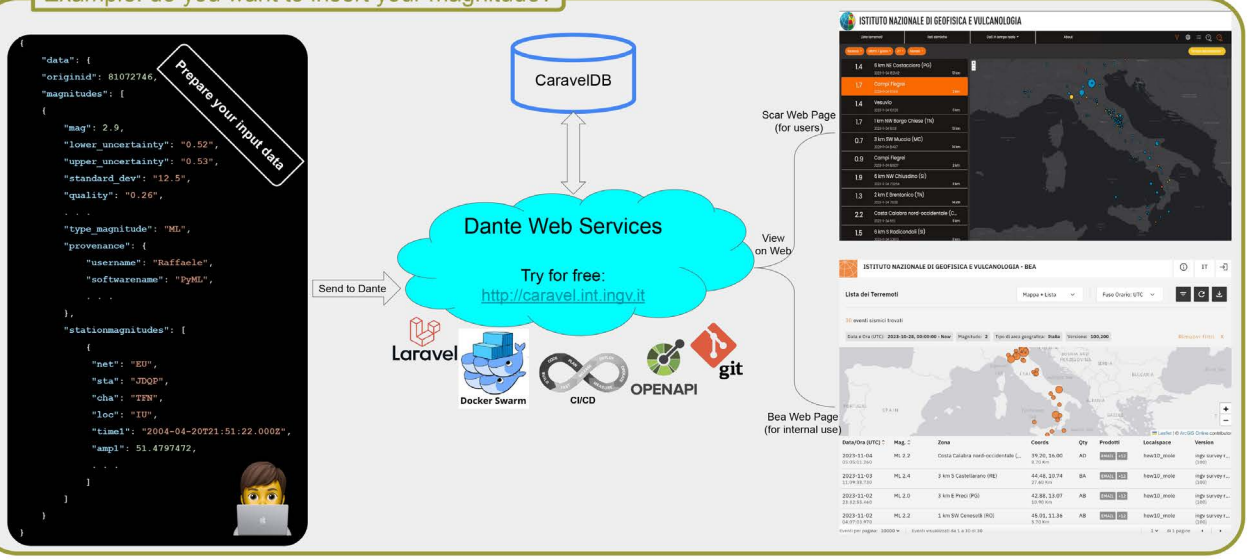
What is Dante?

Dante is a Web Services developed using Laravel that exposes new Micro-Web-Services API to interact with the DataBase (CaravelDB) to read, write, update and delete informations and provide data at the application level. This work highlights the key features of Dante, including its OpenAPI-based development, JSON communication, containerization, and open- source nature.

OpenAPI Spec



Example: do you want to insert your magnitude?



Who is using Dante?

Dante is the new interface to the CaravelDB database using RESTful API. It has been in testing since 2020 and currently receives all Early-Est and Earthworm (hew10, hew20, hew3, etc.) locations in real-time. It is also used by OV and OE to record their locations, as well as by various experimental setups like: "NLL@INGV" (for "1d" che "3d"), "CLASS", "NFO-TABOO", "Oss. Vesuviano", "Oss. Etneo", ecc...

SERVIZI DI SORVEGLIANZA SISMICA E ALLERTA TSUNAMI

Apollo: An OpenAPI-based Web Service for Seismic Localization and Magnitude Calculation

Valentino Lauciani

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Apollo is a Web Service developed using Laravel, specifically designed to expose seismic localization software "*hyp2000*" and magnitude calculation software "*PyML*" through APIs. This work highlights the key features of Apollo, including its OpenAPI-based development, JSON communication, containerization, and open-source nature. The adoption of OpenAPI specifications enhances accessibility and facilitates the generation of client development classes in various programming languages using dedicated software tools (ie: "*openapi-generator-cli*"). JSON format ensures efficient and interoperable communication between the Web Service and client applications. Apollo integrates dockerized versions of "*hyp2000*" [Klein, 2002] and "*PyML*" [Di Stefano et al., 2023] for precise and rapid earthquake localization. Furthermore, Apollo's presence on GitHub fosters a collaborative environment, encouraging researchers and developers to contribute, improve, and utilize the system for advancements in seismic research. Its versatility enables potential integration with other software, such as evaluating the possibility of making the NonLinLoc software a web service. Apollo leverages containerization and employs a microservices architecture, enabling seamless deployment on Docker Swarm for the scalability of individual components. In conclusion, Apollo presents a robust Web Service for seismic localization and magnitude calculation, adhering to OpenAPI standards, ensuring efficient communication, and offering versatility for potential integrations.

References

Di Stefano, R., Castello, B., Chiaraluce, L., Michele, M., Latorre, D., (2023). *Local magnitude estimation for 10 years of italian seismicity (2009-2018) based on new peak-to-peak amplitudes calculation on digital waveforms, and class catalog probabilistic locations*. GNGTS - Atti del 41° Convegno Nazionale, p.76-83. https://gngts.ogs.it/atti/GNGTS2023/HTML/76/

Klein, Fred W., (2002). *User's Guide to HYPOINVERSE–2000, a Fortran Program to Solve for EarthquakeLocations and Magnitudes*. U.S. Geological Survey Open-File Report 02-171, 123 pp. https://pubs.usgs.gov/of/2002/0171/

GIORNATA ONT martedì 14 novembre 2023

Author: Valentino Lauciani

Thanks to: Andrea Bono, Raffaele Distefano, Lucia Margheriti, Laura Scognamiglio, Matteo Quintiliani

Apollo: An OpenAPI-based Web Service for Seismic *Localization* and *Magnitude* Calculation

What is Apollo?

Apollo is a Web Service developed using Laravel, specifically designed to expose seismic localization software "hyp2000" and magnitude calculation software "PyML" through APIs. This work highlights the key features of Apollo, including its OpenAPI-based development, JSON communication, containerization, and open- source nature.

input pyml example


```
{
    "data": {
        "output": "json",
        "pyml_conf": {
            "preconditions": {
                . . .
            },
            "station_magnitude": {
                . . .
            },
            "event_magnitude": {
                . . .
            }
        },
        "origin": {
            "lat": 41.56380081176758,
            "lon": 13.792200008500977,
            "depth": 8.4
        },
        "amplitudes": [
            {
                "net": "IV",
                "sta": "MCI",
                "cha": "EHE",
                "loc": null,
                "ampl": -251.785,
                "time1": "2021-10-28T10:43:45.417Z",
                "amp2": 154.701,
                "time2": "2021-10-28T10:43:45.286Z"
            },
            . . .
        ]
    }
}
```


input hyp2000 example


```
{
    "data": {
        "hyp2000_conf": [
            "200 T 2000 0",
            "LET 5 2 3 2 2",
            "H71 1 1 3",
            . . .
            "APP F T F",
            "CON 25 0.04 0.001",
            "PHS './input.arc'",
            "LOC"
        ],
        "model": [
            "Italy",
            "5.00 00",
            "6.50 11.10",
            "8.05 26.90"
        ],
        "output": "json",
        "phases": [
            {
                "net": "IV",
                "sta": "CASA",
                "cha": "HNZ",
                "loc": null,
                "arrival_time": "2021-10-06T06:33:24.080Z",
                "isc_code": "P",
                "firstmotion": "U",
                "emersio": null,
                "weight": 2,
                "amplitude": null,
                "ampType": "1"
            },
            . . .
        ]
    }
}
```


Versatility



Apollo's presence on GitHub fosters a collaborative environment, encouraging researchers and developers to contribute, improve, and utilize the system for advancements in seismic research. Its versatility enables potential integration with other software, such as evaluating the possibility of making the NonLinLoc software a web service.

Apollo leverages containerization and employs a microservices architecture, enabling seamless deployment on Docker Swarm for the scalability of individual components.

IN

Apollo Web Services

Try for free:
http://caravel.int.ingv.it:8780

OUT

Laravel Docker Swarm CI/CD OPENAPI git Grafana Loki

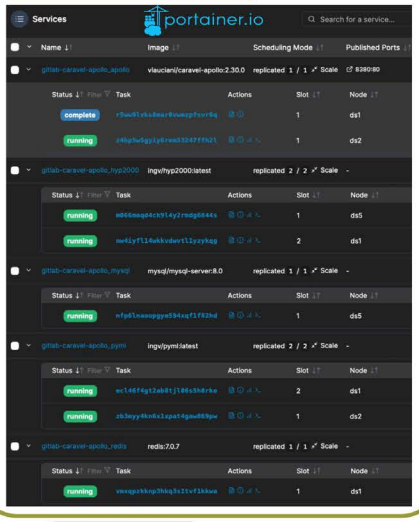
output pyml example


```
{
    "data": {
        "magnitudes": {
            "hb": {
                "ml": 3.120873817,
                "std": 0.20402174,
                "totsta": 56,
                "quality": "AB"
            },
            "db": {
                "ml": 3.126232557,
                "std": 0.17047259,
                "totsta": 56,
                "quality": "AA"
            },
            . . .
        },
        "stationmagnitudes": [
            {
                "net": "IV",
                "sta": "MCI",
                "cha": "EHE",
                "loc": null,
                "amp1": -251.785,
                "time1": "2021-10-28T10:43:45.417Z",
                "amp2": 154.701,
                "time2": "2021-10-28T10:43:45.286Z",
                "ep_distance_km": 8.26604792876969,
                "ep_distance_delta": 0.07439027866838683,
                "orig_distance": 12.141375431174087,
                "hb": {
                    "ml": 4.125500162461592,
                    "w": 0.33415894436780297
                },
                "db": {
                    "ml": 3.628967594491855,
                    "w": 0.7781721366856867
                },
                "lat": 41.491036,
                "lon": 13.813008,
                "elev": 493
            }
        ]
    }
}
```

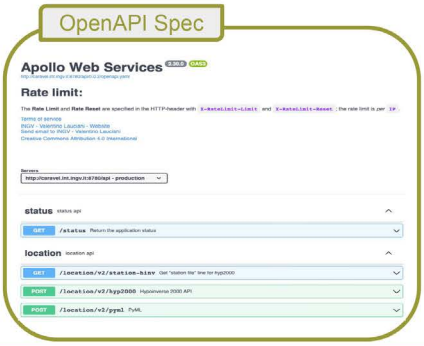

output hyp2000 example


```
{
    "ewLogo": {
        "type": "TYPE_HYP2000ARC",
        "module": "MOD_EW2OPENAPI",
        "installation": "INST_WILDCARD",
        "instance": "ew2openapi_convtool",
        "user": "ew2openapi",
        "hostname": "36b0b8f66e72"
    },
    "ewMessage": {
        "version": "ew rapid",
        "originId": 1,
        "originTime": "2022-05-31T00:36:17.020Z",
        "latitude": 42.469833,
        "longitude": 13.160666,
        "depth": 13.04,
        "nph": 8,
        "nphS": 3,
        "nphtot": 8,
        "nPfm": 0,
        "gap": 263,
        "dmin": 6,
        "rms": 0.13,
        "e0az": 201,
        "e0dp": 33,
        "e0": 1.11,
        "e1az": 28,
        "e1dp": 56,
        "e1": 0.75,
        "e2": 0.6,
        "exh": 0.92,
        "exz": 0.62,
        "Md": 0,
        . . .
        "ingvQuality": "AD",
        "phases": [
            {
                "sta": "RM33",
                "comp": "EHE",
                "net": "IV",
                "loc": "--",
                "Plabel": " ",
                "Slabel": " ",
                "Ponset": "P",
                "Pat": "2022-05-31T00:36:19.860Z",
                "Pres": 0.05,
                . . .
            }
        ]
    }
}
```


Deploy - *Docker Swarm*



OpenAPI Spec



Conclusion

Apollo presents a robust Web Service for seismic localization and magnitude calculation, adhering to OpenAPI standards, ensuring efficient communication, and offering versatility for potential integrations.

SERVIZI DI SORVEGLIANZA SISMICA E ALLERTA TSUNAMI

Introducing PFX: A new multiplatform tool for interactive seismic signal analysis

Andrea Bono

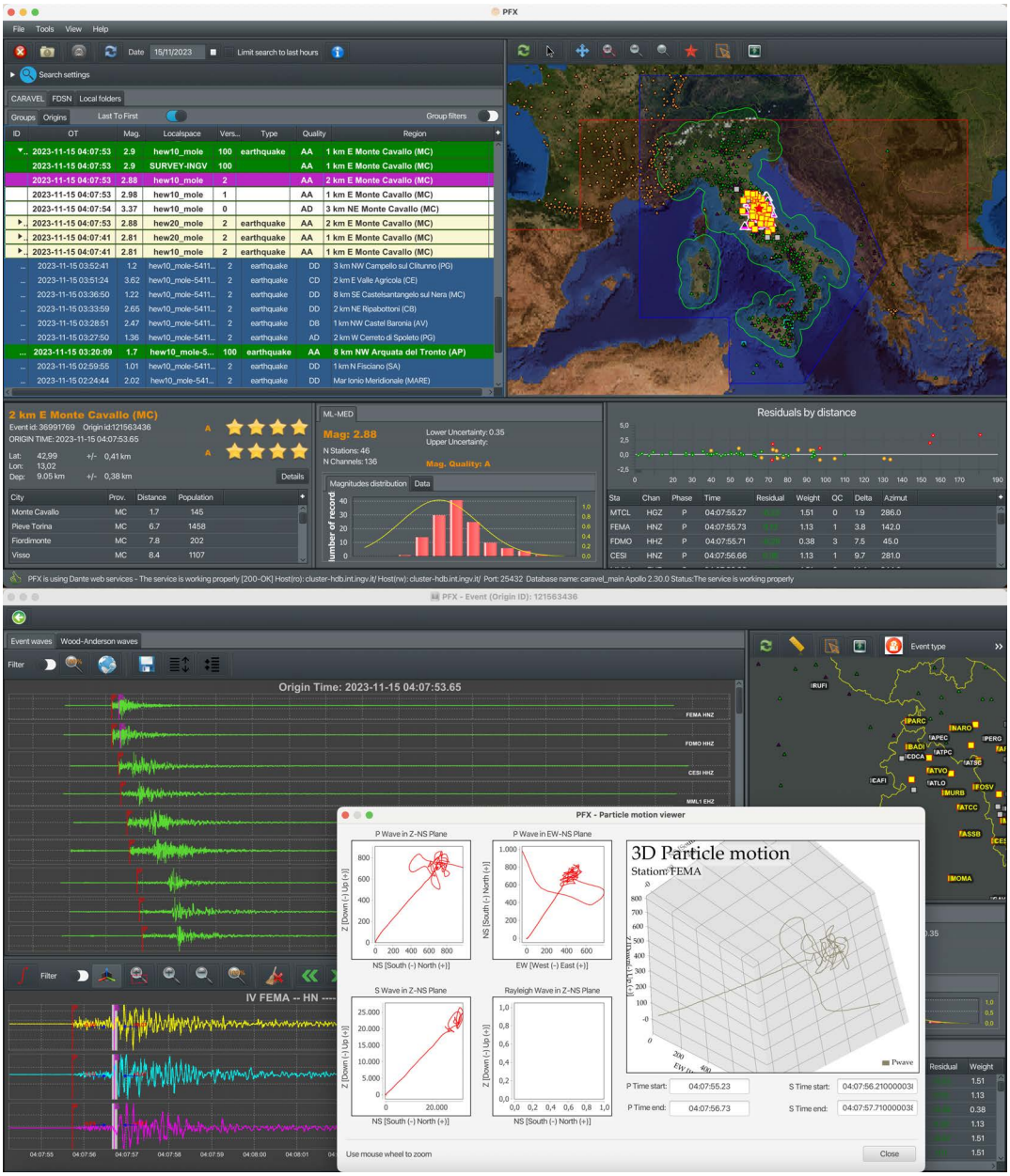
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Corresponding author: andrea.bono@ingv.it

PFX is a new cutting-edge software designed for interactive seismic signal analysis. After nearly three years of dedicated research and development, as a part of the upcoming Caravel system [Bono et al., 2021], PFX is ready to replace the old revision tool, SisPick, and improve the earthquake analysis at the INGV seismic control room in Rome. PFX represents a significant leap forward in seismic data analysis. It has been meticulously crafted to meet the evolving needs of the seismological community, offering a comprehensive set of features embedded in a user-friendly interface. PFX is designed to seamlessly integrate the existing systems and data sources and it can easily access and analyse data from multiple sources, providing a unified platform for seismic monitoring. It boasts the state-of-the-art of signal recovering and processing algorithms, ensuring that users can easily access all the available data in near-real-time. It offers intuitive graphical representations, allowing the users to effortlessly explore and interpret seismic signals. PFX is designed with simplicity in mind, ensuring that both seasoned seismologists and newcomers can navigate the software. With the introduction of PFX, we can expect: improved accuracy and speed in revising events, enhanced situational awareness through interactive dashboard, streamlined operations, a smoother transition from the legacy software and increased efficiency in safeguarding lives and infrastructure. The development of PFX represents my personal commitment to innovation and my dedication to providing the best tools for seismic monitoring.
I invite you to explore PFX and experience the future of interactive seismic signal analysis.

References

Bono, A., Margheriti, L., Quintiliani, M., Lauciani, V., (2021). *Caravel: A New Earthworm-Based Open-Source Development for the Italian Seismic Monitoring System*. Seismological Research Letters, 92 (3): 1738–1746. https://doi.org/10.1785/0220200355



The PFX main interface.

SeisPressNG: a system for publishing and disseminating information relating to seismic events in near real time

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SeisPressNG is a seismic event reporting system capable of sending SMS and email notifications, printing reports, publishing on Twitter, activating external services via Webhooks, and triggering internal service mechanisms such as generating hazard maps and historical seismicity ShakeMaps. It represents a complete redesign of the current SeisPress system which is based on the "*seisev*" MySQL database.
SeisPressNG (NG stands for "*next generation*") is designed as a microservices and event-driven architecture. Information exchange occurs through an Apache Kafka/ZooKeeper architecture. The primary data source is CaravelDB [Bono et al., 2021] which is based on the PostgreSQL/PostGIS DBMS.
"*connectors*" monitor the insertion and modification of specific database tables, generating real-time messages on Kafka topics. The "*scheduler*" component listens to messages from topics and schedules requests based on SeisPressNG configurations and received messages. The requests are then fulfilled by the "*agent*" components, responsible for executing the requested services. The "*supervisor*" component monitors the successful completion of all processes. To optimize response times and prevent redundant operations, certain information is stored and shared among different microservices via the REDIS system.
Interface "*seispressui*" allows you to configure, monitor operations, and consult logs.
SeisPressNG is a component of the new Caravel System infrastructure based on microservices for 24/7 Italian Seismic Surveillance and can be deployed using Docker Containerization.

References

Bono, A., Lauciani, V., Margheriti L., and Quintiliani, M., (2021). *Caravel: A New Earthworm-Based Open-Source Development for the Italian Seismic Monitoring System*. Seismological Research Letters 92.3, pp. 1738–1746. issn: 0895-0695. https://doi.org/10.1785/0220200355

GIORNATA ONT martedì 14 novembre 2023

SeisPressNG: a system for publishing and disseminating information relating to seismic events in near real time

Matteo Quintiliani

Osservatorio Nazionale Terremoti - Istituto Nazionale di Geofisica e Vulcanologia

Caravel System

SeisPressNG together with CaravelDB, Dante and PFX are the main components of the Caravel system [Bono et al. 2021].

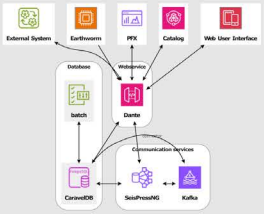


Figure 1. Caravel System is the new microservices-based infrastructure to support the 24/7 Italian Seismic Surveillance Service.

From SeisPress to SeisPressNG

It represents a complete redesign of the current SeisPress system which is based on the **seisev schema** MySQL database.
SeisPressNG (NG stands for *next generation*) is designed as a microservices and event-driven architecture. Information exchange occurs through an **Apache Kafka**/ZooKeeper architecture.

SeispressUI

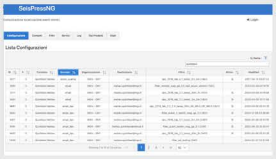


Figure 2. The figure shows a screenshot of the web interface through which you can configure **SeisPressNG**, define filters, types of services and products, and also view the logs of operations carried out by the agents including the return codes.

Docker Containerization

SeisPressNG can be deployed using Docker Containerization. Below are the services launched via the `docker-compose.yml` file. (Refer to fig. 3)

- redis
- zookeeper
- kafka
- connectors
- scheduler
- agents
- supervisor (in progress)
- seispressui
- redis-ui
- debezium-connectors-ui
- kafka-ui
- ksqldb-server, ksqldb-cli (experimental)

SeisPressNG

SeisPressNG is a seismic event reporting system capable of sending SMS and email notifications, printing reports, publishing on Twitter, activating external services via Webhooks, and triggering internal service mechanisms such as generating hazard maps and historical seismicity ShakeMaps. The primary data source is **CaravelDB** (fig. 1, 4) which is based on the PostgreSQL/PostGIS DBMS.

SeisPressNG Components

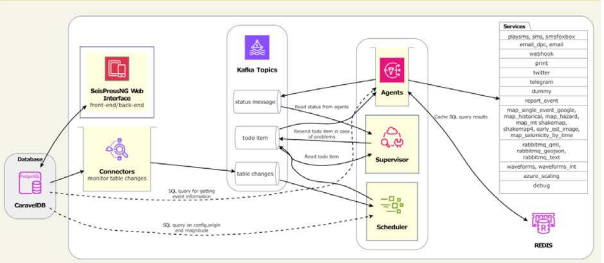


Figure 3. **SeisPressNG** Components.

Specific **Connectors** monitor the insertion and modification of the *origin* and *magnitude* database tables, generating real-time messages on corresponding Kafka topics.
The **Scheduler** component listens to these topics, generating and scheduling requests based on SeisPressNG configurations and the seismological parameters contained in the pair (*origin*, *magnitude*).
The requests are then fulfilled by the **Agent** components, responsible for executing the requested services, such as SMS, email, Webhooks, etc.
The **Supervisor** component monitors the successful completion of all processes.
To optimize response times and prevent redundant operations, certain information is shared among different microservices via the **Redis System**.
An interface, known as **SeispressUI** (fig. 2) has been developed to configure users and services, monitor operations, and consult logs.

seispress schema within CaravelDB

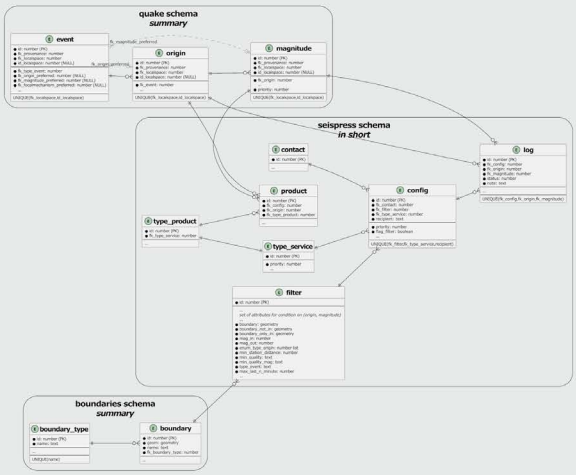


Figure 4. The main entities of the **seispress schema** are *config*, *filter*, *type_service*, *log* and *product*. *filter* can refer to a predefined geometry in *boundary* so that it can be used through PostGIS geospatial function. The execution states of the services triggered by the configuration for the pair (*origin*, *magnitude*) are saved inside *log*. Within *product*, the content or reference of a product that refers to (*origin*, *magnitude*) can be saved.

Services

SeisPressNG is mainly capable of:

- sending SMS via playSMS API Restful. 2 servers with 2 dedicated SIMs are installed on the intranet of the Rome office.
- sending email messages with 2 different formats.
- triggerin external services via the *webhook* mechanism. It can automatically make http calls to remote URLs passing the seismic event information via GET or POST.
- publishing tweets on Twitter.
- sending messages to RabbitMQ system in the following formats: QuakeML, geoJSON, Text.
- triggering for report/map/image generation: *map_single_event_google*, *map_historical*, *map_hazard*, *map_mt*, *map_seismicity_by_time*, *early_est_image*, *shakemap*
- trigger for event waveforms package generation: *waveforms*, *waveforms_int*
- printing.

Configuration

SeisPressNG configuration is defined by a triple:

1. the type of service, for example, SMS, email, Webhooks, etc.
2. a filter comprising a set of conditions for which the pair ('origin', 'magnitude') returns a Boolean value of 'true,'
3. a recipient, whose meaning varies based on the type of service, such as an email address, a telephone number, a *Webhook* URL, etc.

Filters

A filter includes a set of attributes used to construct an SQL query to evaluate whether a pair (*origin*, *magnitude*) satisfies the conditions with respect to the values contained in them.
The execution of this query is up to the **Scheduler** after having received a message from the **Connectors** via the *Kafka Topics*.
If the query is satisfied, the **Scheduler** will send a message in the *Kafka Topics* of the "todo items" with the pair *origin*, *magnitude*), the type of service and the recipient.
The **Agents** will then be taken in charge of carrying out the requested service.

References

Bono, A., V. Lauciani, L. Margheriti, and M. Quintiliani (Mar. 2021). "Caravel: A New Earthworm-Based Open-Source Development for the Italian Seismic Monitoring System". In: *Seismological Research Letters* 92.3, pp. 1738–1746. ISSN: 0895-0695. DOI: 10.1785/0220200355.

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SEISMIC SURVEILLANCE AND TSUNAMI WARNING

Earthworm-Docker-Sandbox: a Docker tool for learning, testing, running and developing Earthworm System within single or multiple enclosed environments

Matteo Quintiliani

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Earthworm is the most widely used open-source seismic data acquisition and automatic earthquake detection processing system for regional seismic networks [Johnson et al., 1995]. It is a modular system composed of numerous software components developed by various authors. Maintaining and developing core library and modules code to ensure functionality across different platforms Linux, Windows and Mac OS X is very challenging. For a single module developer, this task can often exceed their skills and become overly burdensome in terms of the cost-benefit ratio. Time that could otherwise be more profitably invested in improving the logic of their software. Moreover, successfully compiling every individual part does not guarantee that the software will behave perfectly identically on different platforms. Docker Containerization offers the possibility to easily create isolated environments in which to compile and run Earthworm, develop modules, test features and configurations, customize the compilation of specific software components, facilitate versioning of different binary compilations, ensure reproducibility and uniformity in software behavior, and launch native binaries on Linux. Earthworm-Docker-Sandbox is a command-line tool that primarily allows you to: 1) easily build custom Docker images of Earthworm and other desired software; 2) create different Earthworm configuration environments with ease; 3) launch various Docker images in separate containers using different configuration environments. Earthworm instances used in production for the Italian National Seismic Surveillance Service are launched via Earthworm-Docker-Sandbox.

References

Johnson, C. E., Bittenbinder, A., Bogaert, B., Dietz, L., Kohler, W., (1995). *Earthworm: A flexible approach to seismic network processing*. Incorporated Research Institutions for Seismology (IRIS) Newsletter 14, pp 1-4.

GIORNATA ONT martedì 14 novembre 2023

Earthworm Docker Sandbox: a Docker tool for learning, testing, running and developing Earthworm System within single or multiple enclosed environments

Matteo Quintiliani

Osservatorio Nazionale Terremoti - Istituto Nazionale di Geofisica e Vulcanologia

Earthworm System

Earthworm [Johnson et al. 1995] is the most widely used open-source seismic data acquisition and automatic earthquake detection processing system for regional seismic networks. It is a modular system composed of numerous software components developed by various authors. It is the official automatic system to support the 24/7 Italian Seismic Surveillance Service.

Earthworm Docker Sandbox

Earthworm Docker Sandbox is a command-line tool that primarily allows you to:

1. easily build custom Docker images of Earthworm and other desired software;
2. create different Earthworm Configuration Environments with ease;
3. launch various Docker images in separate containers using different configuration environments.

Earthworm instances used in production for the 24/7 Italian National Seismic Surveillance Service are launched via **Earthworm Docker Sandbox**.
This tool is entirely based on **docker**, **make**, **bash** and other utilities like **sed**, **grep**, **find**, **wget**, etc.

Docker Containerization

Docker Containerization offers the possibility to easily create isolated environments in which to compile and run Earthworm, develop modules, test features and configurations, customize the compilation of specific software components, facilitate versioning of different binary compilations, ensure reproducibility and uniformity in software behavior, and launch native binaries on Linux.

Quick Start and First Test

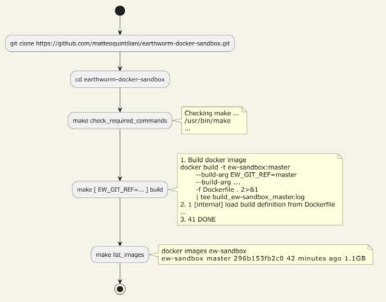


Figure 1. Clone project and build the Docker Image from branch *master* of the official Earthworm Git repository.

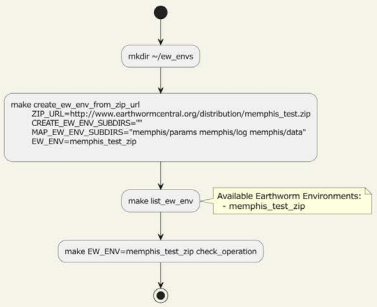


Figure 2. Create the Earthworm Configuration Environment called "memphis_test_zip", downloading the file URL `http://www.earthwormcentral.org/distribution/memphis_test.zip`.

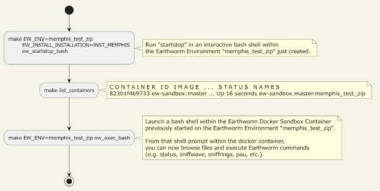


Figure 3. Running Earthworm Docker Sandbox Container in *detached mode* and then connect by *docker exec*.

Earthworm Challenge

One of the main challenges in maintaining and developing its code is to ensure the proper functioning of all its software components, including the core library and modules, across all major Linux distributions and versions of Windows and macOS.
For a single module developer, this task can often exceed their skills and become overly burdensome in terms of the cost-benefit ratio. Time that could otherwise be more profitably invested in improving the logic of their software.
Moreover, successfully compiling every individual part does not guarantee that the software will behave perfectly identically on different platforms.

Docker Compose

A `docker-compose.yml` example:

```
services:
  hew:
    container_name: hew
    image: ew-sandbox:a7e23e8e
    command: /opt/scripts/ew_startstop_trap_pau.sh
    ports:
    # export wave server ports
      - 16021-16044:16021-16044
    # import/export generic ports
      - 19001-19010:19001-19010
    # export winston scnl ports
      - 16001-16006:16001-16006
    environment:
      - EW_HOSTNAME=hew
    volumes:
      - ${EW_RUN_DIR}:/opt/ew_env:consistent
      - ${EW_PARAMS}:/opt/ew_env/params:consistent
      - ${EW_LOG}:/opt/ew_env/log:consistent
```

Earthworm Configuration Environment

An Earthworm Configuration Environment is a directory that must contain the following subdirectories:

- **params**: contains Earthworm configuration files (`EW_PARAMS` variable)
- **log**: where Earthworm log files are written (`EW_LOG` variable)
- **data**: where additional files are read and written by Earthworm modules (`EW_DATA_DIR` variable)

The directory structure is the same used in Earthworm Memphis Test bundled zip file.
This tool allows you to easily create environments from scratch, copying them from another environment or through a URL or a git repository

Running Container on Earthworm Configuration Environment

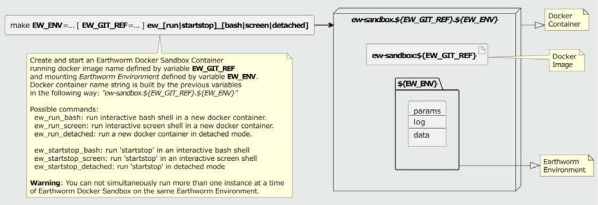


Figure 4. Running Earthworm Docker Sandbox Container Example. This tool prevents launching multiple Earthworm Docker Sandbox Container on the same Earthworm Environment. All commands will be executed within the container for the Earthworm Environment declared by the variable `EW_ENV` which is usually passed to command line on run-time.

Building Docker Image

Building the Earthworm Docker Sandbox images is based on:

- Local files Dockerfile, Makefile and Makefile.env
- Online official Earthworm Git Repository `https://gitlab.com/seismic-software/earthworm.git`

Default settings get the latest Earthworm commit from the *master* branch of the official Earthworm Git Repository and compile all Earthworm sources. You can compile specific Earthworm versions using variables `EW_GIT_REP` and `EW_GIT_REF`.

Software Download

Earthworm Docker Sandbox is Open-Source and publicly available from GitLab or GitHub.

- `https://gitlab.com/matteoquintiliani/earthworm-docker-sandbox`,
- `https://github.com/matteoquintiliani/earthworm-docker-sandbox`

Check the documentation for a detailed description of all features.

References

Johnson, C. E., A. Bittenbinder, B. Bogaert, L. Dietz, and W. Kohler (1995). "Earthworm: A flexible approach to seismic network processing". In: *Incorporated Research Institutions for Seismology (IRIS) Newsletter* 14, pp. 1–4.

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SEISMIC SURVEILLANCE AND TSUNAMI WARNING

PRECISE: PRobabilistic Earthquake location Catalog of the Italian SEismicity in 3D tomographic models and 1D regional velocity models

Diana Latorre*, Raffaele Di Stefano

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**Corresponding author: diana.latorre@ingv.it*

In recent years, two catalogs of absolute earthquake hypocenter locations of the Italian seismicity have been created through the application of the NonLinLoc code within the scope of the DPC-B2 projects. These catalogs consist of:
The CLASS catalog [*https://ingv.github.io/class/locations;* Latorre et al., 2023], which encompasses earthquakes occurring between 1981 and 2018 whose hypocenters were localized within the 3D tomographic model of Di Stefano and Ciaccio [2020].
The B2_2012-2020 NLL1D catalog, which includes earthquakes recorded between 2012 and 2020, and localized in the regional 1D velocity models defined by Pastori et al. in the framework of the DPC-B2 project 2019-2021 (personal communication).
Both the catalogs are based on P and S arrival time readings revised by the Italian Seismic Bulletin (BSI [*https://terremoti.ingv.it/bsi*]) for the period beyond 2009. Additionally, the CLASS catalog incorporates the CSI 2.0 integrated phases [*https://ingv.github.io/class/phases*] for the period spanning from 1981 to 2008.
Employing (1) identical model parameterization, (2) NonLinLoc control file settings, and (3) computed station corrections, we have extended the earthquake hypocenter locations within both catalogs to more recent times. This extension (the PRECISE-1D and -3D catalogs) allows us to establish a temporal link between them and the real-time automatic locations computed by the NLL@INGV machine [Di Stefano & Latorre, 2024], in order to produce maps and vertical sections for visualization of the more recent real-time automatic locations compared to the previously located instrumental seismicity. The PRECISE-1D and -3D catalogs will be stored in the QuakeDB database developed by the informatic crew of the ONT UF2 "*Sala Operativa*" [*https://www.ont.ingv.it/sezione/organizzazione-descrizione-uf/unita-funzionali?view=article&id=58&catid=2*].

References

Di Stefano, R., Ciaccio, M. G., (2020). *Seismic Velocity Model of P- and S-waves for the Italian Lithosphere (Version 1.0) [Data set]*. Zenodo. https://doi.org/10.13127/tomorama.1

Di Stefano, R., Latorre, D., (2024). *PRECISE: Probabilistic 1D and 3D real-time automatic location of the Italian seismicity with INGV monitoring room data: the "NLL@INGV" procedure*. In this Volume.

Latorre, D., Di Stefano, R., Castello, B., Michele, M., Chiaraluce, L., (2023). *An updated view of the Italian seismicity from probabilistic location in 3D velocity models: The 1981–2018 Italian catalog of absolute earthquake locations (CLASS),* 846, Tectonophysics. https://doi.org/10.1016/j.tecto.2022.229664

GIORNATA ONT martedì 14 novembre 2023

PRECISE: PRobabilistic Earthquake location Catalog of the Italian SEismicity in 3D tomographic models and 1D regional velocity models.

Diana Latorre and Raffaele Di Stefano

Abstract: In recent years, two catalogs of absolute earthquake hypocenter locations of the Italian seismicity have been created through the application of the NonLinLoc code within the scope of the DPC-B2 projects:

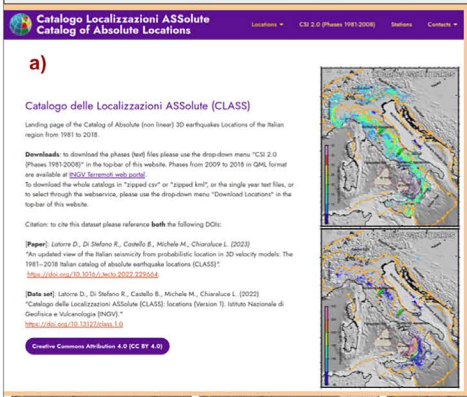
1. **The CLASS catalog** (Latorre et al., 2023; https://ingv.github.io/class/locations), which encompasses earthquakes occurring between 1981 and 2018 whose hypocenters were localized within the 3D tomographic model of Di Stefano & Ciaccio (2014).
2. **The B2_2012-2020 NLL1D catalog**, which includes earthquakes recorded between 2012 and 2020, and localized in the regional 1D velocity models defined by Pastori & Latorre (2021).

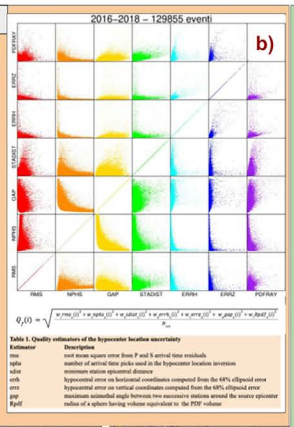
Both the catalogs are based on P and S arrival time readings revised by the Italian Seismic Bulletin (BSI, https://terremoti.ingv.it/bsi) for the period beyond 2008. Additionally, the CLASS catalog incorporates the CSI 2.0 integrated phases for the period spanning from 1981 to 2008 (https://ingv.github.io/class/phases).

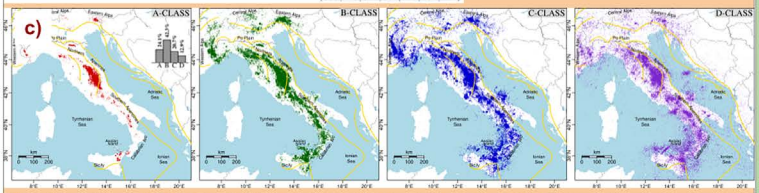
Employing (1) identical model parameterization, (2) the same NonLinLoc control file settings, and (3) the computed station corrections, we have extended the earthquake hypocenter locations within both catalogs to more recent times. This extension (**the PRECISE-1D and -3D catalogs**) allows us to establish a temporal link between them and the real-time automatic locations computed by the NLL@INGV machine (**Di Stefano & Latorre, contribution 1-18**), in order to produce maps and vertical sections for visualization of the more recent real-time automatic locations compared to the previously located instrumental seismicity.

PRECISE-1D and -3D catalogs will be stored in the Caravel Database (contribution 5-2) and will be available for the scientific community through the Web Services (contribution 5-11) developed by the informatic crew of the UF2 Sala Sismica.

1. The CLASS 1.0 catalog: 1981 - 2018

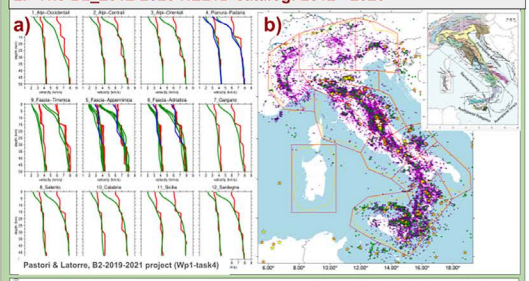


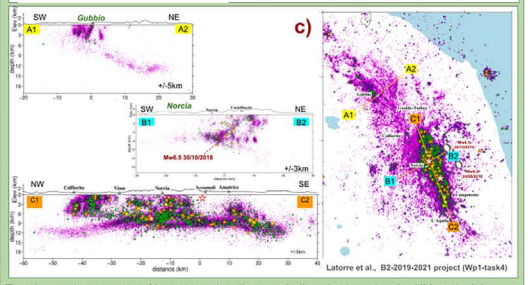




Through the web page of the CLASS catalog (Figure a), it is possible to download more than 420,000 earthquake hypocenter parameters obtained by applying the NonLinLoc code (Lomax et al., 2000) in the 3D velocity model of Italy from Di Stefano & Ciaccio (2014). A procedure was followed for the quality assessment of hypocenter locations (Figure b) using the Empirical formula from Michele, Latorre & Emolo (2019). This formula considers the relationships among all the estimators that contributes to the robustness of a hypocenter solution (Figure b, top panel). Hypocenter solutions are therefore grouped into four classes (Figure c) ranging from A (best solutions) to D (worst solutions) in order to allow a correct interpretation of the located seismicity.

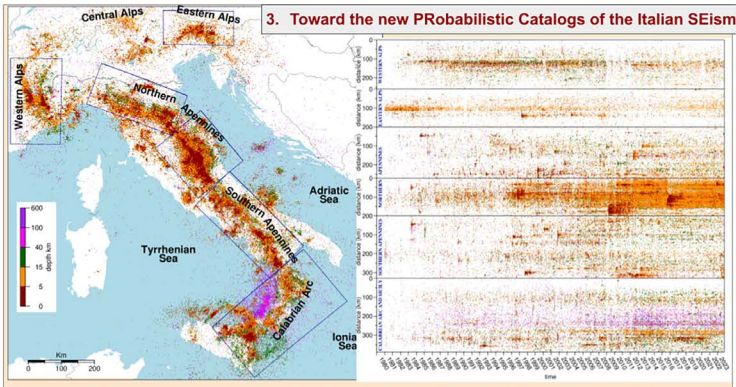
2. The B2_2012-2020 NLL1D catalog: 2012 - 2020





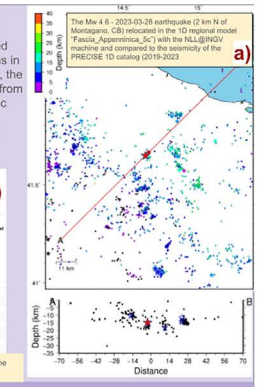
To enhance the accuracy of hypocenter locations at shallow depths using the NLL code, it is crucial to significantly increase the density of the inversion grid within the first tens of kilometers. Currently, this proves unfeasible with the Italian 3D velocity model due to the large dimensions of the computational grid. As part of the DPC-B2 project (2019-2021), a new catalog of probabilistic hypocenter locations within the first 100 km depth has been generated, using local 1D velocity models (Figure a) based on a regional characterization of the Italian peninsula in 18 macro areas (Figure b). **P and S phases pickings for hypocenter location are data revised by the BSI working group (contribution 1-22)** from 2012 to 2020. In Figure C, we present an example of results in the Central Apennines area.

3. Toward the new PRobabilistic Catalogs of the Italian SEismicity: PRECISE-3D and PRECISE-1D



In the context of the new real-time automatic locations computed by the NLL@INGV machine (Di Stefano & Latorre, contribution 1-17), we have compiled the PRECISE-3D catalog to generate more comprehensive maps and vertical sections for visualizing the most recent real-time locations in comparison to the previously located instrumental seismicity. PRECISE-3D incorporates the CLASS catalog (1981-2018) and extends it up to 2023. The seismicity for the years 2019-2023, revised by the BSI (Bollettino Sismico Italiano) working group, has been relocated using the same NLL@INGV machine created for real-time locations. This process involves the utilization of the same (1) 3D tomographic model, (2) station corrections, and (3) parameter tuning applied to the CLASS catalog. Consequently, PRECISE-3D represents the most comprehensive and homogeneous catalog of Italian seismicity, with periodic updates coinciding with the availability of BSI quarterly reports (BSI working group, contribution 1-22).

Similar to the PRECISE-3D catalog, we have employed the same procedure to extend the earthquake locations in 1D regional velocity models up to 2023. Consequently, the PRECISE-1D catalog encompasses Italian seismicity from 2012 to 2023 and can be utilized to generate automatic maps and vertical sections of seismic activity in Italy (Figure a). This facilitates the visualization of the most recent real-time locations in comparison to previously identified instrumental seismic events (Figure b)





Internal web page of automatic real-time probabilistic earthquake locations with the NLL@ingv machine (**see contribution 1-18 for more details**)

4. Work in progress

- Automate the periodic updates of the PRECISE-3D and 1D catalogs to coincide with the availability of BSI quarterly reports (BSI working group, contribution 1-22).
- Automate periodic updates of stations corrections.
- Introduce a new Empirical Formula for the quality assessment of dynamic seismic catalogs.
- Beyond regional 1D velocity models: PRECISE-3D from national to local scale 3D models

SERVIZI DI SORVEGLIANZA SISMICA E ALLERTA TSUNAMI

PRECISE: Probabilistic 1D and 3D real-time automatic location of the Italian seismicity with INGV monitoring room data: the "NLL@INGV" procedure

Raffaele Di Stefano*, Diana Latorre

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**Corresponding author: raffaele.distefano@ingv.it*

In the framework of the new INGV monitoring room, a renewal from the database to the dissemination, we have treasured our experience in producing high quality images of the Amatrice-Visso-Norcia seismic sequence from real-time revised picks, and in building the CLASS 1981-2018 NLL absolute 3D locations catalog, and the B2 2012-2020 NLL absolute 1D locations catalog. Based on this know-how, we have setup and configured a fully automatic procedure (NLL@INGV) that uses the real-time revised data (P- and S- arrival times by the analysts-seismologists on duty in the INGV monitoring room) to locate the detected earthquakes in quasi-real-time with a nonlinear probabilistic approach (NonLinLoc [Lomax et al., 2000]), with stations' corrections, and in both a national 3D velocity model and regionalized 1D velocity models. The whole procedure and the output data are hosted on a virtual machine supplied and supported by the ONT UF 3. The results are first stored in a local MySQL database and then exposed on a website originally intended for development only. The website allows users to query the DB, to visualize the new locations versus the official one, to access the parameters of each nonlinear location and to produce maps and vertical sections (beta version) of the NLL 1D and 3D seismicity from 2019 to present. Finally, by using the API's developed by the informatic crew of ONT UF2 "*Sala Operativa*" [*https://www.ont.ingv.it/sezione/organizzazione-descrizione-uf/unita-funzionali?view=article&id=58&catid=2*], the NLL@INGV earthquakes' locations are now posted to the QuakeDB, to be part of the new Monitoring Room Real-Time dataset. The next step is to implement the procedure itself as an API, able to get picks and restitute a location through a web route, for full compatibility and flexibility.

References

Lomax, A., Virieux, J., Volant, P., Berge, C., (2000). *Probabilistic earthquake location in 3D and layered models: Introduction of a Metropolis-Gibbs method and comparison with linear locations*. Advances in Seismic Event Location Thurber, C.H., and N. Rabinowitz (eds.), Kluwer, Amsterdam, 101-134.

GIORNATA ONT 1-18 martedì 14 novembre 2023

PRECISE: Probabilistic 1D and 3D real-time automatic location of the Italian seismicity with INGV monitoring room data:the “NLL@INGV” procedure.

Raffaele Di Stefano and Diana Latorre

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Finally, by using the API’s developed by the informatic crew of our UF 2 (Sala Operativa), the **NLL@INGV** earthquakes’ locations are now posted to the QuakeDB, to be part of the new Monitoring Room Real-Time dataset. The next step is to implement the procedure itself as an API, able to get picks and restitute a location through a web route, for full compatibility and flexibility.

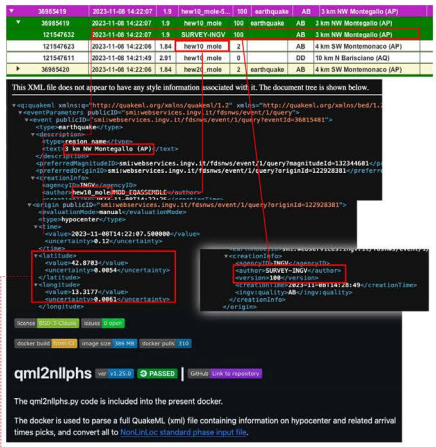
http://nll.int.ingv.it

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ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

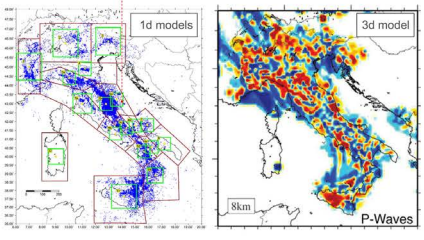
Experimental Automatic NLL 1D earthquakes locations (Di Stefano and Latorre)
based on regional (Pastori and Latorre) 1d models (Latorre feat Di Stefano) and stations corrections (Latorre)
with INGV real time seismologists and BSI seismologists picks

1 Source Data (P- and S- arrival times)



An automated procedure, hosted on nll.int.ingv.it VM, 1) checks the FDSN/event web service, in real-time for new SURVEY-INGV event (version 100 from the monitoring room), 2) downloads them in full quakeML format, 3) extracts the location parameters and converts P- and S- arrivals into NonLinLoc observation file input format by using qml2nllphs.py (a tool out of the set built for BSI and hosted on github/INGV https://github.com/INGV/qml2nllphs).

2 Velocity Model(s) and location

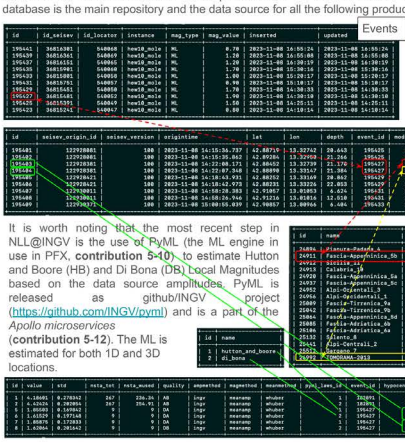


Each new event is **real-time located in both 1D and 3D velocity models**.
The NonLinLoc setups and the **stations corrections** are the same used for the 1D and 3D PRECISE catalogs reported on in **contribution 1-17**.
The 1D model specific for a new event is chosen according to the INGV-Survey location based on the **zoning scheme** used for the 1D PRECISE catalog.
The 3D graded tomographic velocity model is the same used for the CLASS catalog (https://ingv.github.io/class/locations/).
For both 1Ds and 3D velocity model, as soon a new seismic station appears among the picked stations, the procedure calculates the new travel-times before locating.

3 Local Database

The payload of each step of the procedure is sent to a local relational database (MySQL), organized into five main tables: events, hypocenters, quality, models, and pyml_magnitudes.
The table ***events*** stores the SURVEY-INGV key information (event id, locator id, and the earthworm instance that generated the event); the table ***hypocenters*** stores the 1D and 3D locations; the table ***quality*** stores all the NLL statistics also including the PDF; the table ***models*** stores the available and used velocity models; the table ***pyml_magnitudes*** stores the estimation of **local magnitude** based on the NLL locations and the amplitudes from the SURVEY-INGV. This database is the main repository and the data source for all the following products.

Events



It is worth noting that the most recent step in NLL@INGV is the use of PyML (the ML engine in use in PFX, **contribution 5-10**) to estimate Hutton and Boore (HB) and Di Bona (DB) local Magnitudes based on the data source amplitudes. PyML is released as github/INGV project (https://github.com/INGV/pyml) and is a part of the *Apollo microservices* (**contribution 5-12**). The ML is estimated for both 1D and 3D locations.

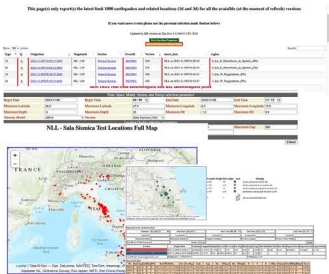
4 Toward the new monitoring room integrated system.



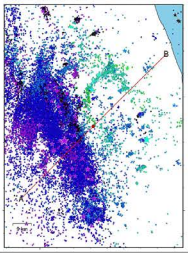
Keeping the reference to the source data (arrivals and amplitudes), all the results, hypocenters (1d, 3d) and magnitudes (HB, DB) are sent to the *CaravelDB* (**contribution 5-2**) through the *Dante Web Service* (**contribution 5-11**) and thus accessible as products of the “new monitoring room” products through the related *BEA portal*.

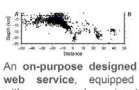
5 State of the art

The NLL@INGV is up and running since 2020-02-27. Several updates and upgrades have been applied, including the 3D implementation, the “zoning” setup, the ML estimation, the local web-page development tools implementation (see below), and finally the posting of results to the CaravelDB. The latest version is thus continuously and homogeneously operative only since 2023-06-06.
Nevertheless, to both collect statistics and close the gap with the PRECISE catalogs we back-rescued locations to 2019-01-01.
The local DB now hosts about 156k origins for ~78,000 earthquakes.
To best monitor and visualize the results we progressively built a set of **web tools** for development purposes that might be considered as **experimental beta-version tools for rapid scientific response**, enlightening and valorising the quality and importance of the work done by the seismologists on duty in the monitoring room e by the BSI workgroup.



The base route of the NLL@INGV web server reports the last 1000 origins. Ordering and paging are user-configurable. Links to the results details page (location and stations on openstreetmap, parameters, phase-residuals), to the official INGV page, and to a scientific oriented plot are available along with a map reporting the last 1000 events.





An **on-purpose designed web service**, equipped with several input parameters allowing to personalize the output, is the source of the map and vertical section reporting all the available origins around the selected event.
The link “Vertical section” available on the main page (and personal mask selection output) is a pre-parameterized query.

Work in progress

- periodic auto-update of stations corrections
- NLL@INGV as a web-service to be called by PFX
- produce exhaustive statistics
- upgrade the vertical sections web service
- 3d model zoning

SERVIZI DI SORVEGLIANZA SISMICA E ALLERTA TSUNAMI

Testing the Probabilistic Tsunami Forecasting

Valeria Cascone[1,*], Stefano Lorito[1], Alice Abbate[1], Hafize Basak Bayraktar[1], Fabrizio Bernardi[1], Sergio Bruni[1], Louise Cordrie[1], Andrea Di Benedetto[1], Marco Pagani[3], Alessio Piatanesi[1], Fabrizio Romano[1], Jacopo Selva[2], Matteo Taroni[1], Roberto Tonini[1], Manuela Volpe[1]

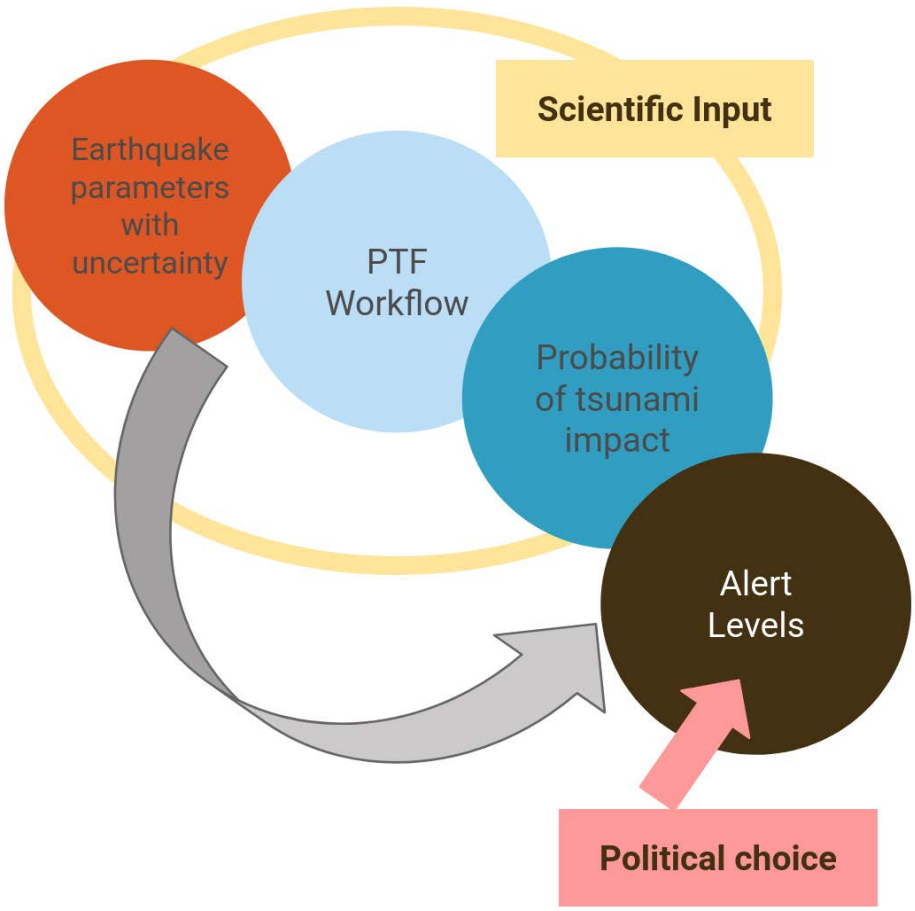
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[2]*Department of Physics -Ettore Pancini-, University of Naples Federico II, Naples, Italy*
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Probabilistic Tsunami Forecasting (PTF) is an innovative approach for real time forecast of tsunamis (Figure). It provides the probability of exceedance as a function of the tsunami intensity at given coastal points soon after a potentially tsunamigenic earthquake, once its location and magnitude are available [Selva et al., 2021]. Presently, in the NEAMTWS, Tsunami Early Warning Systems use a conservative, false-alarm prone, Decision Matrix to provide deterministic tsunami alert levels (ALs) without any uncertainty quantification. On the contrary, PTF enables uncertainty-informed AL definition. The PTF has been tested against available data from recent past events in the Mediterranean Sea and the Pacific Ocean. Given the relatively limited number of recent tsunamigenic events instrumentally recorded in the Mediterranean, more extensive tests are necessary for a thorough benchmarking and calibration, before adopting the PTF within an operational context, as also requested by the INGV Scientific Committee. We perform a large number of synthetic tests of the PTF with~ 3.5M of seismic events belonging to a Monte Carlo catalog in the Mediterranean, spanning ~200kyrs, based on the GEM hazard model. We present some preliminary results by comparing the PTF results for a large set of scenarios, over a wide range of magnitudes and fault mechanisms, against the numerical tsunami simulations performed for the same set of scenarios.

References

Selva, J., Lorito, S., Volpe, M., et al., (2021). *Probabilistic tsunami forecasting for early warning*. Nature Communication 12, 5677 (2021). https://doi.org/10.1038/s41467-021-25815-w



Display of the PTF concept. On the basis of the earthquake parameters and their uncertainties, the PTF allows for an estimate of probability of tsunami impact. Using rules set in advance by the decision-makers, it is possible to convert the PTF results into ALs.

Sea-level data acquisition

Sergio Bruni*, Fabrizio Bernardi

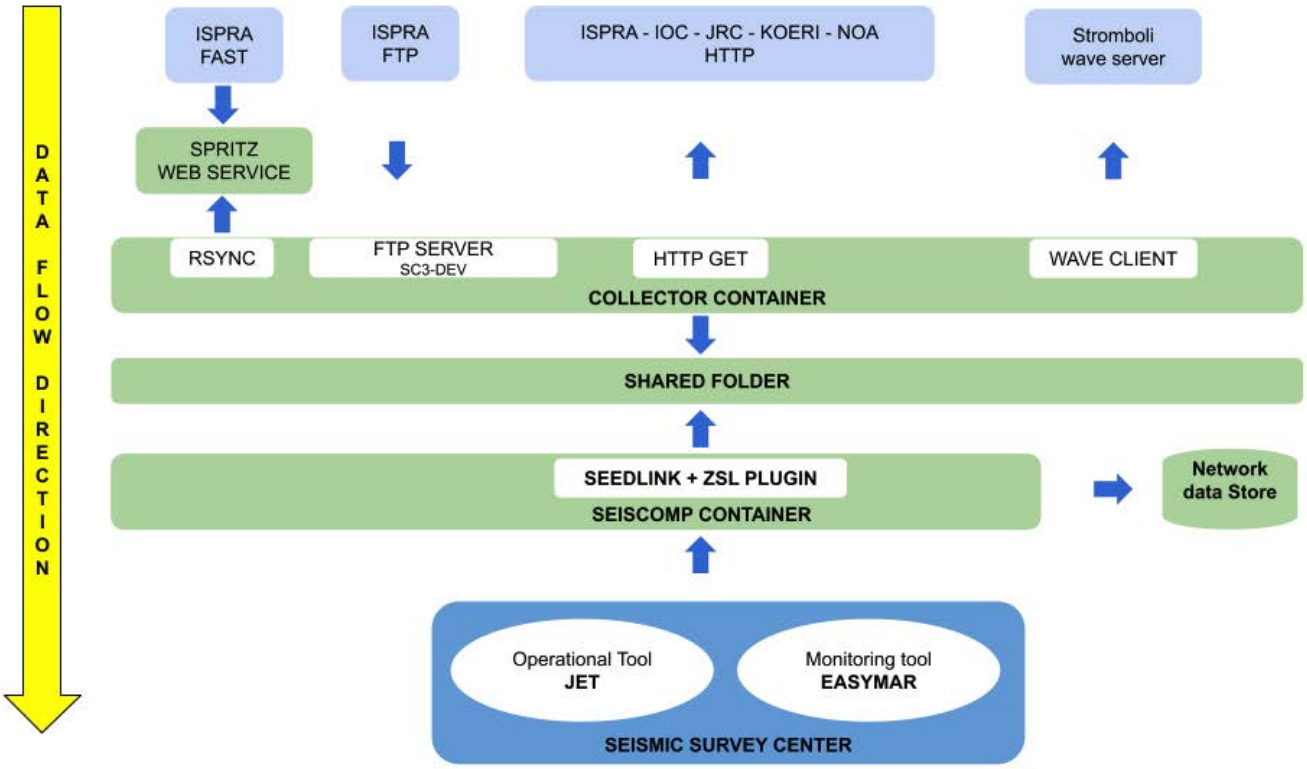
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The aim of INGV sea level data acquisition system is to collect mareographics data, distributed worldwide by many providers, in heterogeneous formats and protocols, and make them available from a single standard server provider, that is seedlink.
The main application that runs in INGV survey center, JET [Bono et al., 2019], acquires mareographics data from seedlink. Moreover, JET gets from the database, named "tsunami", the tsunami alert messages automatically generated by the PTF (Probabilistic tsunami forecasting system) from a potentially tsunamigenic event located by Early-est [*http://early-est.rm.ingv.it/warning.html*].
When a tsunamigenic earthquake occurs, and the related alert message is shown by the JET panel, the operator of CAT (Centro Allerta Tsunami [*https://cat.ingv.it/en/]*) examines the map with all the tide gauge stations around the earthquake, then She/He examines the tide gauges of those stations, and makes decisions about the weight of the situation, alerting the Italian Civil Protection for any action to take to protect the population.
The message sent to the Civil Protection is compiled in a CAP standard format (Common Alert Protocol) and may also contain some tide measures taken by CAT operators from the tide gauges.

References

Bono A., Pintore S., Lauciani V., (2019). *JET Java Estimate Tsunami. Sistema di analisi interattiva di mareogrammi per il Centro Allerta Tsunami*. Rapp. Tec. INGV, 408:1-20. https://doi.org/10.13127/rpt/408



The figure shows the tide gauge data flow, from the providers to the seedlink server.

Ten Years of Tsunami Risk Mitigation in the Mediterranean: Hazard Assessment, Warning and Mitigation Strategy of the INGV Tsunami Alert Center

Alessandro Amato* and CAT Team

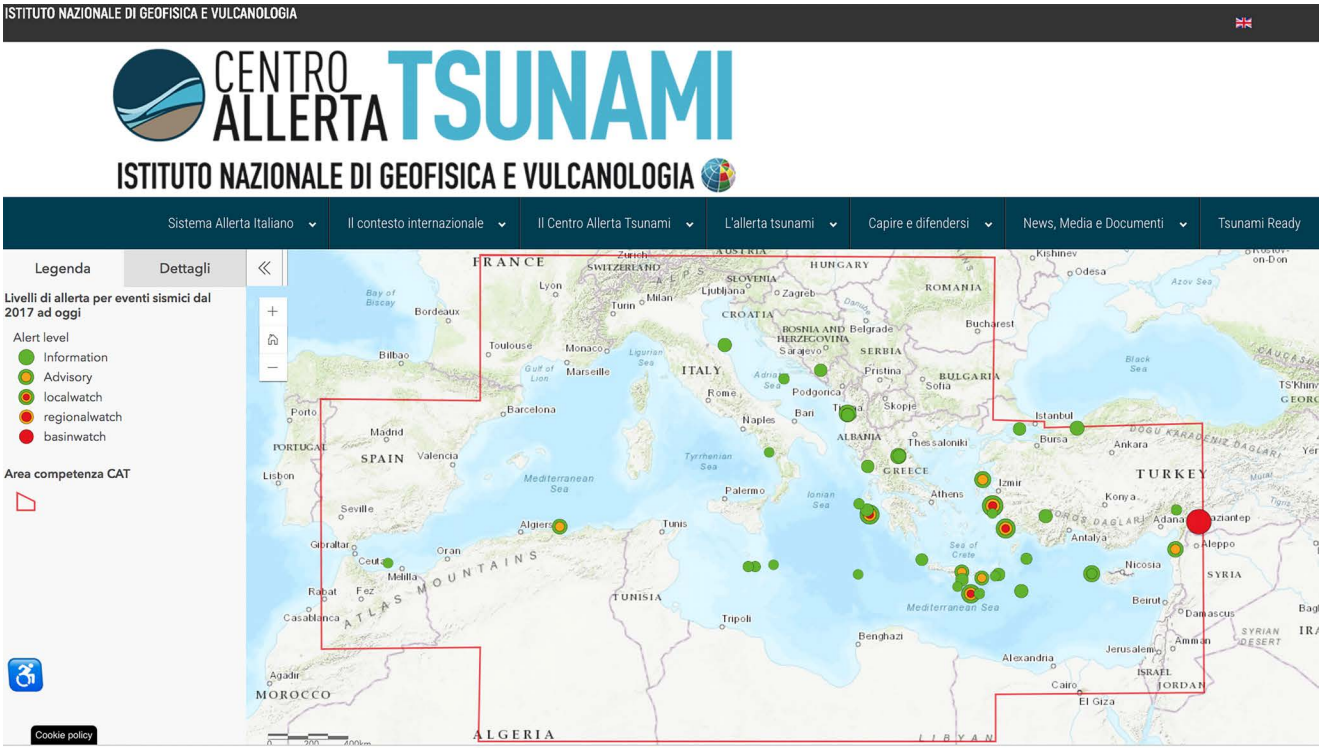
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In 2014 the INGV established an experimental service of tsunami warning for the Mediterranean basin, in the framework of the ICG/NEAMTWS (Intergovernmental Coordination Group for the North East Atlantic, Mediterranean and connected seas Tsunami Warning System). After acting 3 years as a NEAM candidate Tsunami Service Provider, the Italian Centro di Allerta Tsunami (CAT [*https://cat.ingv.it/en/*]) became operational in 2016, monitoring tsunamis of seismic origin worldwide, with a special attention to the Mediterranean coasts. From January 2017 to November 2023, CAT has released more than 40 tsunami Information and Alert messages to the Italian authorities and to the NEAM National Tsunami Warning Centers of several Euro-Mediterranean countries, for earthquakes in the magnitude range 5.5 - 7.8.
In the same period, in cooperation with DPC and ISPRA, the inundation areas for the entire coastal belt of Italy have been mapped based on the PTHA results of the TSUMAPS-NEAM project. In the past 3 years, the CAT has also been involved in several activities aimed at increasing people's awareness, such as the analysis of tsunami risk perception in Italy, the development of a website (in Italian and English), the participation in campaigns and drills, and rolling out the Tsunami Ready project in some pilot municipalities.
Ongoing activities include:

- the adoption of Probabilistic Tsunami Forecast for real time warning;
- an improved PTHA model for the Italian coasts;
- hazard modeling and inundation mapping across scales, from global to local;
- sea level instrumental improvements, including the deployment of two deep sea pressure sensors in the Ionian Sea;
- connection of the regional NEAM system with the local one operating in Stromboli island for volcanic tsunamis.

All this is done with a continuous update of the legal and procedural frameworks to remain aligned with the scientific and technological developments and best practices worldwide.



Home page of the CAT website [https://cat.ingv.it/en/]. The red line indicates the area of competence, within which information and warning messages are issued (for earthquakes of M≥5.5 at sea or near the coasts). The green, orange and red symbols represent the epicenters of the earthquakes that triggered the CAT from January 2017 to November 2023 (legend on the left).



Click the image and watch the video.

The activities carried out by the Support Service in the management of Seismic Surveillance and Tsunami Warning Services from 2015 to the present

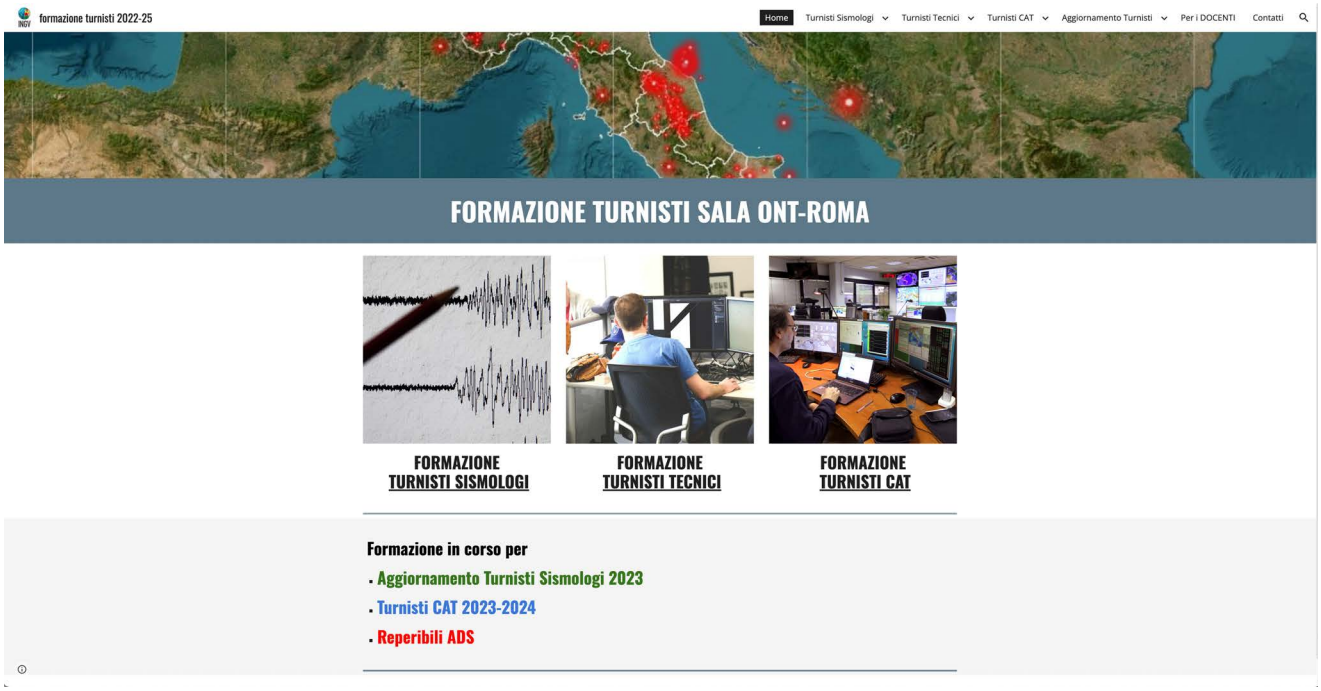
Concetta Nostro*, Anna Nardi, Eleonora Ruotolo, Lucia Margheriti, Alessio Piatanesi, Laura Graziani, Vincenzo Pirro, Alfonso Giovanni Mandiello, Sandro Rao, Laura Scognamiglio, Pietro Ficeli and Servizio di Supporto nella Gestione dei Servizi di Sorveglianza Sismica e di Allerta Tsunami**

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***Servizio di Supporto nella Gestione dei Servizi di Sorveglianza Sismica e di Allerta Tsunami: https://www.ont.ingv.it/sezione/organizzazione-descrizione-uf/servizi-e-gruppi*

The Seismic Surveillance and Tsunami Warning Services are complex activities that are carried out in the ONT-Rome Monitoring Room with the involvement of 12 figures on shift in presence (Seismologists, Technicians and CAT Shift Workers) and 12 on call.
Since 2015, the ONT Director has created a Support Service in the Management of Seismic Surveillance and Tsunami Warning Services (hereinafter *Servizio Sala*) to carry out the activities connected to the two Services. Specifically, the *Servizio Sala* processes the shift and ensures all the logistical aspects necessary for the smooth functioning of the Monitoring Room - with particular attention during the health emergency. It also plans new arrivals on shift and on-call; identifies training needs and draws up guidelines for training and refresher activities; organises the courses and manages the evaluation process of new trained personnel and their placement in the role, making use of the Permanent Training Group.
The *Servizio Sala* is also the context that activates the collaboration between the ONT UFs involved in the two Services, in order to harmonise the contributions aimed at improving the Services themselves; collaborates with the representatives of the other INGV Operating Rooms to improve communications between monitoring rooms and with DPC.
The Servizio Sala collaborates with the CAT CD for the management of the Tsunami Warning Service, pre-operational since 2015; takes care of the drafting and updating of the regulations, protocols, guidelines and job descriptions relating to the two Services, made official in 2021 by the INGV Board of Directors, and collaborates with the ONT Information, Communication and Web Service for dissemination activities and in general for visits to the Seismic Surveillance and Tsunami Monitoring Room.



The ONT-Rome Monitoring Room where the 24-hour Seismic Surveillance and Tsunami Warning Services take place.

The Permanent Training of Seismologists and CAT Shift Workers and Officers, Technical Shift Workers, and On-Call Personnel of the ONT-Rome Center

Concetta Nostro*, Anna Nardi, Lucia Margheriti, Luca Pizzino, Alessio Piatanesi, Laura Graziani, Alfonso Giovanni Mandiello, Sandro Rao, Laura Scognamiglio and Servizio di Supporto nella Gestione dei Servizi di Sorveglianza Sismica e di Allerta Tsunami**

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***Servizio di Supporto nella Gestione dei Servizi di Sorveglianza Sismica e di Allerta Tsunami: https://www.ont.ingv.it/sezione/organizzazione-descrizione-uf/servizi-e-gruppi*

Since 2015, the ONT Director has been assisted by the Group for the Permanent Training of Seismologists and CAT Shift Workers and Officers, Technical Shift Workers, and On-Call staff (Permanent Training Group) in carrying out activities related to the training of personnel involved in the Seismic Surveillance and Tsunami Alert Services. This Group plans and organises training and refresher courses for shift workers, on-call staff and officers, with the collaboration of the Support Service in the Management of Seismic Surveillance and Tsunami Warning Services and the ONT - Information, Communication and Web Service.

The training and refresher activities carried out continuously from 2015 to today by the Permanent Training Group have guaranteed the entry of new staff on shift to replace those who left the service due to personal details or work commitments incompatible with a 24-hour service and to make the Services themselves more and more efficient. Furthermore, the teaching experience gained over the years has made it possible to identify for each role carried out within the Seismic Surveillance and Tsunami Warning Services a specific and necessary training path for the correct carrying out of the same (frontal lessons, exercises, coaching in the monitoring room).

In recent years, 5 training courses have been held for new Seismologist shift workers and the same number for new CAT shift workers, 4 refresher courses for Seismologist shift workers and 2 for CAT shift workers. Training and refresher courses were also held for Seismology Officers, CAT Officers and ADS on-call personnel. All the educational material produced to date for the various training and refresher courses (course programmes, presentations and video recordings, guidelines for the various phases of the training process, etc.) has been organised within a Google Site and is available at the following link: *https://sites.google.com/ingv.it/formazione-turnisti-sala-ont/home.*







Website for the training of shift workers and officers.

Table of authors

A

Alice Abbate 92, 188
Catello Acerra 20, 54
Chastity Aiken 120
Aybige Akinci 80, 90
Matteo Albano 94, 128
Tommaso Alberti 134
Laura Alfonsi 154
Salvatore Claudio Alparone 120, 166
AlpArray Working Group 116
Alessandro Amato 140, 144, 146, 148, 170, 192
Stefania Amici 158
Letizia Anderlini 128
Barbara Angioni 154
Mario Anselmi 28, 76, 108, 122
Andrea Antonioli 88
Marco Anzidei 32, 130, 132, 134
Meng Ao 112
Francesco Arbia 132
Luca Arcoraci 42, 70
Giulia Areggi 128
Pietro Artale Harris 80, 82
Simone Atzori 88
Paolo Augliera 166
Raffaele Azzaro 154, 164
Adriano Azzarone 126

B

Matteo Bagagli 86
Samer Bagh 68, 74, 76, 122
Roberto Basili 30, 92
Patrizia Battelli 42, 70
Hafize Basak Bayraktar 92, 188
Lisa Beccaro 94
Michele Berardi 42, 70
Fabrizio Bernardi 170, 188, 190
Irene Bianchi 116
Sabina Bigi 108
Christian Bignami 106, 112, 132, 154
Andrea Bono 42, 70, 170, 178
Alessandro Bosman 134
Beatriz Brizuela 30
Sergio Bruni 30, 170, 188, 190
BSI working group 42, 70
Augusto Bucci 20, 54
Maria Fabrizia Buongiorno 114
Mauro Buttinelli 108

C

Carlo Calamita 20, 22, 24, 68, 78
Barbara Cantucci 42, 70, 108
Pasqualino Cappuccio 158
Fabrizio Cara 76, 164
Simona Carannante 154
Stefano Carlino 126
Ivano Carluccio 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 70, 170
Emanuele Casarotti 82
Massimiliano Cascone 154
Valeria Cascone 188
Angelo Castagnozzi 166
Corrado Castellano 42, 70
Viviana Castelli 78, 154
Barbara Castello 42, 66, 70, 158
Manuel Castro Diaz 92
Francesco Casu 88
CAT Team 192
Marco Cattaneo 68
Adriano Cavaliere 166
Rossella Celi 154
Claudio Cesaroni 156
Daniele Cheloni 42, 70, 90
Claudio Chiarabba 86, 108, 122
Lauro Chiaraluce 34, 66, 68, 72, 74
Maria Grazia Ciaccio 42, 70
Spina Cianetti 126
Luca Cocchi 154
Ornella Cocina 120
Laura Colini 42, 70
Collane Editoriali INGV Team 154
Danilo Contrafatto 120
Louise Cordrie 188
Stefano Corradini 60, 100, 126, 156
Rosa Anna Corsaro 154
Antonio Costanzo 20, 62, 120, 166
Massimo Crescimbene 148
Fabio Criscuoli 20, 54
Michele Crosetto 132
Luigi Cucci 154
Lorenzo Cugliari 140, 144, 146, 148, 154
Yuan Cui 112

D

Ezio D'Alema 44, 164, 166
Antonino D'Alessandro 20, 26, 84
Roberto D'Anna 20, 26
Claudia D'Oriano 126

Peter Danecek 36, 38, 40, 46, 48, 50, 52
Gianfilippo De Astis 126
Mariagrazia De Caro 42, 70
Pasquale De Gori 76, 86, 122
Claudio De Luca 88
Gaetano De Luca 20, 76
Paolo Marco De Martini 164
Giorgio Maria De Santis 150
Paola Del Carlo 126
Pierdomenico Del Gaudio 20, 62, 120
Sergio Del Mese 20
Luca Del Rio 94
Emiliano Della Bina 36, 40, 42, 46, 48, 50, 52, 70, 170
Roberto Devoti 32, 58, 128
Maria De Caro 42, 70
Andrea Di Benedetto 84, 188
Massimo Di Bona 116
Alessia Di Caprio 154
Giuseppe Di Giulio 164
Francesca Di Laura 158
Roberto Di Martino 154
Domenico Di Mauro 154
Maria Di Nezza 140
Sergio Di Prima 120
Alessio Di Roberto 126
Francesca Di Stefano 154
Raffaele Di Stefano 42, 66, 68, 70, 72, 184, 186
Mauro Antonio Di Vito 126
Marco Emanuele Discenza 94
Carlo Doglioni 15, 116
Domenico Doronzo 154
Fawzi Doumaz 94, 124, 132, 134

E

Luca Elia 34
Emanuela Ercolani 164
Alessandra Esposito 32, 124
Elena Eva 118, 152

F

Licia Faenza 126
Antonio Falciano 132
Sergio Falcone 20, 62, 120, 138, 142, 162
Nicola Angelo Famiglietti 90
Massimo Fares 36, 38, 40, 42, 46, 48, 50, 52, 70, 170
Stefano Farroni 20, 28
Concetta Felli 158
Emanuele Ferrentino 106
Gaetano Festa 34
Rocco Lorenzo Festa 120
Pietro Ficeli 60, 194
Silvia Filosa 30, 140, 144
Rossella Fonzetti 86, 122
Franco Foresta Martin 134
Giovanna Forlenza 126
Diego Franceschi 36, 38, 40, 42, 46, 48, 50, 52, 70
Alberto Frepoli 42, 70, 76
Daniela Fucilla 62

G

Danilo Galluzzo 166
Alessandro Galvani 32, 102, 124
Charalampos Georgiadis 132
Anna Gervasi 20, 62, 120
Edoardo Giandomenico 20, 54
Raffaele Giordano 62
Lucian Giovani 20
Carlo Giunchi 126
José Manuel González-Vida 92
Aladino Govoni 86, 116, 120
Laura Graziani 140, 144, 164, 194, 196
Filippo Greco 154
Michele Greco 132, 134
Adriano Gualandi 68
Lorenzo Guerrieri 60, 100
Marc-Andre Gutscher 120

I

Mirko Iannarelli 32, 58, 102, 124
Alessandro Iarocci 154
Luigi Improta, 42, 70, 76
Roberto Isaia 126

J

Ovidiu Jianu 34

L

Mario La Rocca 120
Chiara Ladina 20, 22, 24, 68, 78, 146, 158
Riccardo Lanari 88
Graziano Larocca 120
Diana Latorre 28, 42, 66, 70, 120, 184, 186
Valentino Lauciani 42, 70, 170, 174, 176
Stefania Lepidi 158

Bing Li 112
Marcello Liotta 154
Arianna Lisi 42, 70
Shanjun Liu 112
Giosuè Lo Bosco 84
Mario Locati 44
Valerio Lombardo 160
Anna Maria Lombardi 42, 70
Stefano Lorito 30, 92, 188
Francesco Pio Lucente 76, 116
Donglin Lv 112

M

Federica Magnoni 82
Vincenza Maiolino 158
Andrea Malagnini 42, 70
Marco G. Malusà 118
Giuseppe Mancino 132
Alfonso Giovanni Mandiello 36, 38, 40, 42, 44, 46, 48, 50, 52, 70, 120, 194, 196
Michele Maniscalco 36, 38, 40, 42, 46, 48, 50, 52, 70
Michele Manunta 88
Alessandro Marchetti 42, 70, 120
Lucia Margheriti 42, 70, 120, 166, 170, 194, 196
Maria Teresa Mariucci 42, 70
Chris Marone 74
Enrica Marotta 126
Giovanni Martino 132
Simone Marzorati 20, 22, 24, 44, 68, 78, 146, 166
Ivano Matiddi 34
Mario Mattia 154
Giuliana Mele 42, 70
Carlo Meletti 140
Daniele Melini 154
Cinzia Melorio 42, 70
Irene Menichelli 122
Luca Merucci 60, 100, 126
Maddalena Michele 42, 66, 70, 72
Alberto Michelini 126
Luca Miconi 42, 70
Maurizio Migliaccio 106
Matteo Migliari 20
Valeria Misiti 42, 70
Giorgio Modica 42, 70
Chiara Montagna 158
Fernando Monterroso 88
Caterina Montuori 42, 70
Milena Moretti 20, 22, 24, 42, 44, 70, 78, 120, 154, 164, 166
Marco Moro 94
Raffaele Moschillo 138, 140
Shane Murphy 120
Massimo Musacchio 156

N

Loredana Napoli 158
Anna Nardi 42, 70, 120, 140, 142, 154, 194, 196
Lucia Nardone 154
Josè Navarro 132
Rosella Nave 126
Concetta Nostro 164, 170, 194, 196
Ferdinando Nunziata 106

O

Ilaria Oliveti 126
Marco Olivieri 126, 154

P

Andrea Pagani 84
Marco Pagani 188
Nicola Pagliuca 42, 70, 154
Mimmo Palano 124, 128
Xingyu Pan 112
Debora Pantaleo 20, 22, 24, 68, 78
Patrizia Pantani 154
Lucia Pappalardo 126
Mario Paratore 126
Massimo Pascolini 20
Giuseppe Passafiume 20
Marina Pastori 42, 70, 120, 166
Petros Patias 132
Massimo Perfetti 20, 54
Giuseppe Pezzo 102, 122, 128
Giovanna Lucia Piangiamore 158
Alessio Piatanesi 170, 188, 194, 196
Davide Piccinini 70, 120, 164, 166
Ulderico Piccolini 20, 54
Donatella Pietrangeli 158
Grazia Pietrantonio 32, 58, 124
Maurizio Pignone 138, 140, 142, 144, 162
Stefano Pintore 36, 38, 40, 42, 46, 48, 50, 52, 70, 120
Francesco Pintori 128
Stefania Pinzi 42, 70
Vincenzo Pirro 194

Arben Pitarka 80
Luca Pizzino 42, 70, 196
Giulio Poggiali 74
Marco Polcari 106, 128
Massimo Pompilio 126
Michela Ponte 120
Michele Proietto 128
Stefano Pucci 164

Q

Matteo Quintiliani 42, 70, 88, 170, 172, 180, 182

R

Sandro Rao 20, 26, 28, 54, 56, 194, 196
Salvatore Rapisarda 120
Sante Francesco Rende 134
Reperibili ADS 170
Federica Riguzzi 32, 124
Daniela Riposati 158
Vito Romaniello 114
Fabrizio Romano 30, 92, 144, 188
Pierangelo Romano 154
Matteo Rompato 94
Zachary E. Ross 74
Antonio Rossi 42, 70
Dmitri Rouwet 126
Eleonora Ruotolo 194
Emiliano Russo 126
Giuseppe Ruzza 146

S

Gilberto Saccorotti 122
Giuseppe Salerno 126
Simone Salimbeni 116
Carlo Salvaterra 54
Leonardo Salvaterra 20, 54
Stefano Salvi 112
Michele Saroli 94
Alessandra Sciarra 42, 70
Laura Scognamiglio 42, 70, 82, 170, 194, 196
Simona Scollo 126
Luciano Scuderi 120
Salvatore Scudero 20, 26
Jacopo Selva 126, 188
Vincenzo Sepe 32, 102, 124
Enrico Serpelloni 128, 130, 132, 134
Andrea Serratore 20
Giulia Sgattoni 126
Tiziana Sgroi 42, 70
Francesca Silverii 106, 122, 128
Malvina Silvestri 114
SISMIKO Working Group 44
Stefano Solarino 118, 152
Maurizio Soldani 154
Diego Sorrentino 158
Sabina Spadoni 42, 70, 158
Letizia Spampinato 126
Federica Sparacino 124, 128
Stefano Speciale 20, 26, 166
Claudia Spinetti 126
Dario Stelitano 60, 100
Sara Stopponi 154
Salvatore Stramondo 16, 26, 106, 120, 170
Paolo Strappaveccia 20, 54, 56
Mariano Supino 72
Supporto nella Gestione dei Servizi di Sorveglianza Sismica e di Allerta Tsunami 194, 196
Nikos Svigkas 88, 128

T

Umberto Tammaro 154
Roberto Tardini 42, 70
Matteo Taroni 188
Flavia Tavani 36, 38, 40, 46, 48, 50, 52
TCS Tsunami 30
Andrea Terribili 32, 58
Andrea Tertulliani 154
Nicolas Theys 100
Corrado Thermes 42, 70
William Thorossian 54
Elisa Tinti 82
Cristiano Tolomei 112, 132
Roberto Tonini 188
Luca Trani 84
Elisa Trasatti 98, 112, 128
Daniele Trippanera 124, 134
Maria Lucia Trivigno 132

U

Stefano Urbini 154

V

Cecilia Valbonesi 144
Massimiliano Vallocchia 54
Roberto Vallone 30
Luisa Valoroso 28, 76, 86
Maurizio Vassallo 76

Antonio Vecchio 130, 132, 134
Guido Ventura 102, 112
Annamaria Vicari 90
Fabio Villani 28
Giovanni Vitale 20, 26
Manuela Volpe 30, 92, 188
Dung Thi Vu 128

W

Fang Wang 112
Shiliu Wang 112
Lianhuan Wei 112

Z

Francesco Zanolin 60
Luigi Zarrilli 146
Weiqiang Zhu 74
Luciano Zuccarello 166

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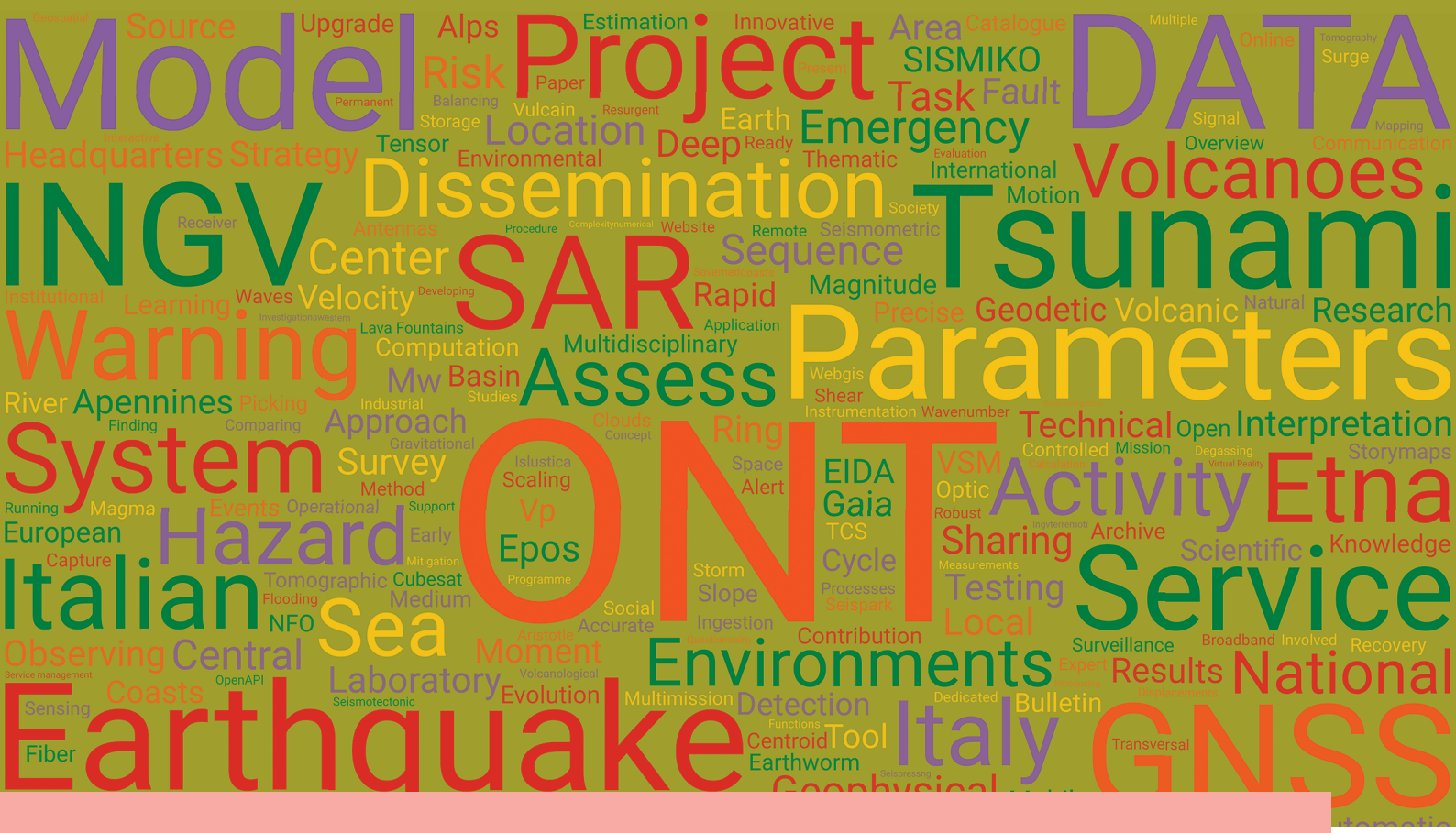
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