ISSN 2039-7941
anno 2024 numero 481

RAPPORTI TECNICI INGV

A New RDBMS and Structure for the IRON Database

ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

481

REGISTRAZIONE AL TRIBUNALE DI ROMA N.174 | 2014, 23 LUGLIO

Sede: Via di Vigna Murata, 605 | Roma

ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

ISSN 2039-7941
anno **2024** numero **481**

RAPPORTI TECNICI INGV

A New RDBMS and Structure for the IRON Database

Veronica Vignoli*, Alessandro Pignatelli

INGV | Istituto Nazionale di Geofisica e Vulcanologia, Sezione Roma 2

**Corresponding author*

Accepted 7 February 2024 | *Accettato 7 febbraio 2024*

Come citare | *How to cite* Vignoli V. and Pignatelli A., (2024). A New RDBMS and Structure for the IRON Database. Rapp. Tec. INGV, 481: 1-18, https://doi.org/10.13127/rpt/481

Cover Image by Adobe Stock, https://stock.adobe.com/it/search?k=radon&search_type=autosuggest&asset_id=109491431 (standard licence)
In copertina Immagine presa da Adobe Stock, https://stock.adobe.com/it/search?k=radon&search_type=autosuggest&asset_id=109491431 (licenza standard)

481

INDEX

Abstract

In the last decade, radon monitoring advanced with active techniques and a regional high-frequency network. The Italian Radon mOnitoring Network (IRON) started in 2010, growing from 19 to 136 stations. To handle the increasing data, a MySQL database was implemented in 2016, followed by advanced tools in 2019. This included a refined database, SQL procedures for automatic creation (preferring PostgreSQL), and MATLAB® procedures for data standardization. In this paper, the database' structure and the procedures are described.

Keywords Relational database; Automatic procedures; IRON

Introduction

During the last decade the radon investigation and monitoring field has seen the emergence of active monitoring techniques and the implementation of the first regional scale high frequency monitoring network [Cannelli et al., 2018] [Toader et al., 2021]. Such infrastructures produce a large amount of data (with respect to previous same-discipline approaches) requiring new specific storage and post processing facilities. IRON (Italian Radon mOnitoring Network) is a network of permanent stations continuously collecting real-time radon soil emanation data. It has been conceived as the first Italian national scale infrastructure for systematic radon monitoring. The network implementation started in 2010 and, since then, it has continuously and significantly grown both in terms of instrument number and data volume availability. To get an idea about the increasing rate, it is worth considering that in 2017 the recording stations were 19 against the 136 of today and the single radon measurements have increased well above order 106 heading towards 107.
In order to guarantee data collection usage in terms of data retrieving, in 2016 a MySQL relational database was implemented [Cannelli, 2017] but, due to the mentioned increasing rate, more advanced tools in terms of data storage capability and automatic procedure implementation were needed. In 2019 we started the implementation of a set of procedures designed to build, populate, and update a relational database.
More specifically, the implemented work includes:

1. A new relational database, refined in terms of architecture and capable of handling additional information and significant larger data amount.
2. The implementation of SQL procedures for the automatic creation of the database from scratch, with a preference for PostgreSQL over MySQL.
3. The implementation of MATLAB® procedures to populate the created tables starting from the raw data (as produced by instruments without any modification).
4. The implementation of MATLAB® procedures to standardize data and make it uniform, such as aligning instruments that measure radon counts and others that measure concentrations. The procedures have been designed to store only concentration data: radon counts data are converted to radon concentrations.

In the next sections we will recall a general description of the relational database structure and a quick overview of the implemented procedures.
While 3-4 are basically new implementations of (important) potentialities, 2 implies a change in the already adopted relational database management system (RDBMS). MySQL and PostgreSQL

are both widely used in a variety of applications, from small websites to large enterprise systems. However, there are some important differences between the two systems. MySQL is a purely relational database, while PostgreSQL is an object-relational database. This means that PostgreSQL offers more sophisticated data types and overall database features. On the flip side, it also makes it more complex to work with PostgreSQL. MySQL is generally known to be faster with read-only commands at the cost of concurrency, while PostgreSQL works better with read-write operations, massive datasets, and complicated queries. Finally, MySQL is licensed under the GPLv2, while PostgreSQL is licensed under the PostgreSQL License which is more permissive [Drake et al., 2002] [Stones et al., 2006] [Truskowski et al., 2020].

1. PostgreSQL Database Architecture Description

The database structure, shown in Figure 1, is not significantly different from the one described in [Cannelli, 2017], so we will refer to that article for the general table explanation and we will focus on the additional tables and fields.

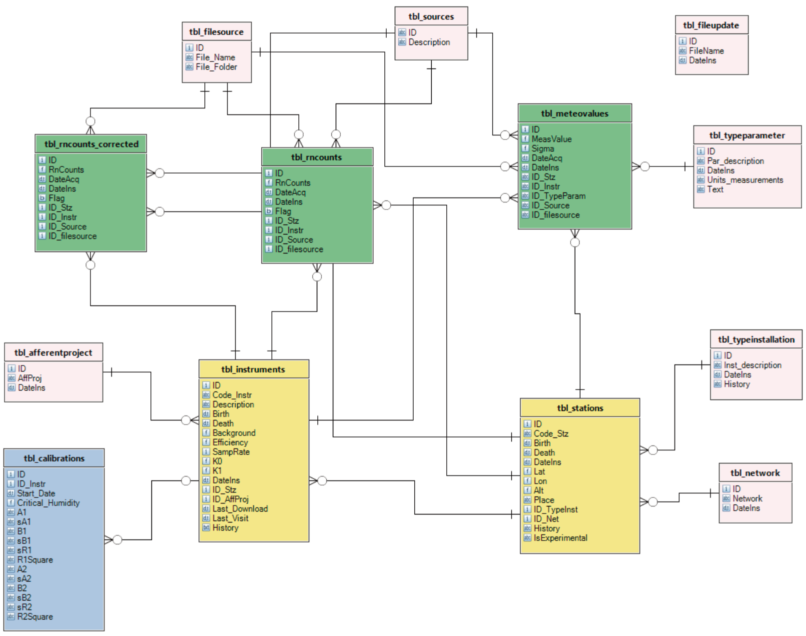

Figure 1 The new IRON database structure.

With respect to Figure 1, the green tables contain the data (radon data and meteorological values), the yellow tables provide a description of the IRON network and its history in terms of instrumentation and stations, the blue table presents data used for the processing of radon data, and the pink tables encompass all supporting tables to ensure that the database is a well-structured relational database.

2. Tables Description

As in 2017's version, the database core table is **tbl_stations**. The table's fields are shown in Figure 2. As mentioned in the previous section, for this and the already existing tables, we will not describe all fields, but we will refer to [Cannelli, 2017].

table_name name	column_name name	data_type character varying
tbl_stations	IsExperimental	boolean
tbl_stations	ID_TypeInst	integer
tbl_stations	ID_Net	integer
tbl_stations	ID	integer
tbl_stations	Birth	date
tbl_stations	Death	date
tbl_stations	DateIns	timestamp without time zone
tbl_stations	Lat	double precision
tbl_stations	Lon	double precision
tbl_stations	Alt	double precision
tbl_stations	Code_Stz	character
tbl_stations	Place	character
tbl_stations	History	text

Figure 2 tbl_stations.

In the new database it has been added just one new column to this table, which is

- **IsExperimental**: Over the years, certain indoor stations have been set up. We have chosen to classify these stations as "experimental" due to their high reliance on human activities within the building and because they are more designed to investigate the anthropic effect on radon data than the general purposes of the IRON database. This field indicates whether a station falls under this classification or not.

The list of the different installation typologies for stations and the list of the networks are stored respectively in **tbl_typeinstallation** (Figure 3) and **tbl_network** (Figure 4). These two tables have not been modified since [Cannelli, 2017], so following we will only list their fields for the sake of completeness.

table_name name	column_name name	data_type character varying
tbl_typeinstallation	ID	integer
tbl_typeinstallation	DateIns	timestamp without time zone
tbl_typeinstallation	Inst_description	character
tbl_typeinstallation	History	text

Figure 3 tbl_typeinstallation.

table_name name	column_name name	data_type character varying
tbl_network	ID	integer
tbl_network	DateIns	timestamp without time zone
tbl_network	Network	character

Figure 4 tbl_network.

As detailed in [Cannelli, 2017], every station is equipped with a radon concentration (or counts) recording instrument, and in certain instances, it may also include meteorological parameter measurements. The installation of a new instrument is occasionally associated with a particular research project. For example, a study might be concentrated on a specific region of Italy, requiring additional radon concentration data from that area. Hence, to be thorough, we have decided to add a new table, called **tbl_afferentproject** (Figure 5), to store the roster of projects.

Figure 5 tbl_afferentproject.

table_name name	column_name name	data_type character varying
tbl_afferentproject	ID	integer
tbl_afferentproject	DateIns	timestamp without time zone
tbl_afferentproject	AffProj	character varying

- **ID**: it is the unique identifier (primary key) for each afferent project, automatically assigned.
- **DateIns**: as in all the other tables, it is the date in which the row is inserted into the table. It is automatically initialized to the current date and time. As new data inserted are never updated, the name of this field as been preferred to the usual "DateUpdate".
- **AffProj**: it is an acronym identifying the project. The information about which project an instrument is part of is stored in the field ID_Proj of **tbl_instruments** (Figure 6). A row of this table univocally describes an instrument of IRON. With respect to the instruments' table described by Cannelli, now tbl_instruments records two new pieces of information.

Figure 6 tbl_instruments.

table_name name	column_name name	data_type character varying
tbl_instruments	ID	integer
tbl_instruments	ID_AffProj	integer
tbl_instruments	Last_Download	date
tbl_instruments	Last_Visit	date
tbl_instruments	Birth	date
tbl_instruments	Death	date
tbl_instruments	Background	double precision
tbl_instruments	Efficiency	double precision
tbl_instruments	SampRate	integer
tbl_instruments	K0	double precision
tbl_instruments	K1	double precision
tbl_instruments	DateIns	timestamp without time zone
tbl_instruments	ID_Stz	integer
tbl_instruments	Code_Instr	character
tbl_instruments	Description	character
tbl_instruments	History	text

- **ID_Proj**: it is a foreign key that refers to the primary key ID of tbl_afferentproject and specifies the type of research project. As each instrument insert is performed at procedural level, in order to avoid project reference missing we have set this field as "not nullable". For all instruments not linked with any project, we insert the connection to the row "IND" (indeterminate) of tbl_afferentproject.
- **Last_Visit**: data downloading can be performed in two ways: physically, by visiting the station where the instrument is installed, or remotely, by connecting to a website. It became evident that a data download does not always entail a physical mission, which is a visit to the installation site. To account for this distinction, we decided to introduce a field to record the date of the last mission conducted. Furthermore, there are instances when a site visit is solely for maintenance purposes. As a result, when a mission also involves data downloading, Last_Visit corresponds to the Last_Download field described in [Cannelli, 2017]; otherwise, they capture two separate dates.

All recorded data, including radon concentration values and meteorological parameter values, are stored in **tbl_rncounts** (Figure 9) and **tbl_meteovalues** (Figure 10), respectively. These data originate from different sources. Some of the installed instruments are online, capable of not only acquiring data but also transmitting it in real-time to the instrument producer's website, where radon and meteorological parameter data are stored. Even if theoretically website data should be identical to the instrument one, there are occasional issues related to the instruments' clocks, causing some data to lack the correct time reference. The online data, on the other hand, undergo correction during their publication through cross-checking with the server's time, ensuring their accuracy. To address this, we have implemented a procedure for verifying the date and time of instrument-downloaded data and, when necessary, automatically correcting them using the data from the website. Unfortunately, data publication is not continuous, and not all stored data is sent to the website. Therefore, we cannot solely rely on website data; instead, we need to merge data from both sources. As a result of this merging need, some data can be duplicated in the database. For this reason, have added a new table, **tbl_sources**, where the information about the sources is stored.

table_name name	column_name name	data_type character varying
tbl_sources	ID	integer
tbl_sources	Description	character

Figure 7 tbl_sources.

- **ID**: it is the unique identifier (primary key) for each source, automatically assigned.
- **Description**: it displays the list of all the sources, distinguishing those from the website based on the different producers.

The database population is carried out at a procedural level, automating the reading of raw files, as they are downloaded from the instruments or online, and processing them to correct and standardize the data. Naturally, this has required numerous technical tests on the code and output to ensure the quality of the data ultimately stored in the database, especially during the development step. For this reason, we found it appropriate and convenient to also save the names of the raw files that the procedure actually reads, so that we can trace each piece of data back to its source.

table_name name	column_name name	data_type character varying
tbl_filesource	ID	integer
tbl_filesource	File_Name	character
tbl_filesource	File_Folder	character

Figure 8 tbl_filesource.

In **tbl_filesource** we have saved the raw files' relative paths, divided in File_Folder and File_Name, with respect to the paths in our repository.

- **ID**: it is the unique identifier (primary key) for each source, automatically assigned.
- **File_Name**: it is the name of the raw file as saved in the repository. Its name is designed to be parsed when the procedures run to provide the necessary information for inputting data into the file in a format agreed upon with the research group. An illustrative example of a data file is titled "tool__AER__ISAR__AERC-102151-C__AERC-102151-C-T-H__20231025.csv." Here, the term "tool" aligns with the Description value found in the tbl_source table. While "AER" denotes the instrument type (not explicitly stored in the database, yet crucial for the correct file reading format), "ISAR" refers to the station

(equivalent to the Code_Staz field in tbl_station). The segments "AERC-102151-C" and "AERC-102151-C-T-H" correspond to entries within the Code_Instr field of tbl_instrument, representing the instruments utilized for radon measurement and meteorological data, respectively. The "20231025" component indicates the deployment date of the instrument data, formatted as yyyymmdd. Notably, the parsing of this file, executed by the designated procedures, seamlessly facilitates data insertion into tbl_rncounts and tbl_meteovalues, complete with all the requisite relational ID fields.

- **File_Folder**: it is the name of the path of our repository where the relative raw file is saved.

The information regarding the source and specific file within the repository from which a recorded data originated is stored in ID_Sources and ID_filesource fields of the abovementioned tables **tbl_rncounts** and **tbl_meteovalues**, respectively.

Figure 9 tbl_rncounts.

table_name name	column_name name	data_type character varying
tbl_rncounts	ID	integer
tbl_rncounts	RnCounts	integer
tbl_rncounts	DateAcq	timestamp without time zone
tbl_rncounts	DateIns	timestamp without time zone
tbl_rncounts	Flag	boolean
tbl_rncounts	ID_Stz	integer
tbl_rncounts	ID_Instr	integer
tbl_rncounts	ID_Source	integer
tbl_rncounts	ID_filesource	integer

Figure 10 tbl_meteovalues.

table_name name	column_name name	data_type character varying
tbl_meteovalues	ID	integer
tbl_meteovalues	MeasValue	double precision
tbl_meteovalues	Sigma	double precision
tbl_meteovalues	DateAcq	timestamp without time zone
tbl_meteovalues	DateIns	timestamp without time zone
tbl_meteovalues	ID_Stz	integer
tbl_meteovalues	ID_Instr	integer
tbl_meteovalues	ID_TypeParam	integer
tbl_meteovalues	ID_Source	integer
tbl_meteovalues	ID_filesource	integer

In both tables:

- **ID_Source**: it is a foreign key that refers to the primary key ID of tbl_sources and specifies where the data has been downloaded from.
- **ID_filesource**: it is a foreign key that refers to the primary key ID of tbl_filesource and specifies the raw file where the data has been taken from.

An important point to emphasize regarding tbl_rncounts is that, in comparison to the previous database, the field RnCounts now exclusively contains radon concentration data. Some instruments measure counts while others measure concentrations. The procedure manages these differences and automatically converts counts into concentrations.

The field ID_TypeParam in tbl_meteovalues is the foreign key that refers to the primary key of **tbl_typeparameter**, a table which has not been modified since [Cannelli, 2017] that contains the list of meteorological parameters.

table_name name	column_name name	data_type character varying
tbl_typeparameter	ID	integer
tbl_typeparameter	DateIns	timestamp without time zone
tbl_typeparameter	Par_description	character
tbl_typeparameter	Units_measurements	character
tbl_typeparameter	Text	text

Figure 11 tbl_typeparameter.

One of the most significant changes in the database structure involves the introduction of new tables designed to accommodate calibration parameters and calibrated data. Instruments that record radon emission data are highly sensitive to specific climatic conditions that can potentially compromise the acquisition of accurate data. In particular, the recorded radon data are influenced by the humidity levels registered by the same instrument. Therefore, in order to obtain more accurate data, it is necessary to make corrections based on humidity levels. The most suitable correction model for each instrument is not universal; it depends on the specific instrument and is also influenced by a critical humidity threshold, before and after which the correction model may vary. Typically, before an instrument is deployed at a new IRON station, it undergoes calibration in a laboratory setting. This calibration process involves determining the critical humidity threshold. For data corresponding to humidity levels above or below this critical threshold, the most appropriate correction models, along with their associated coefficients, are established [Galli et al., 2019]. As the effort required for the calibration process is very time demanding and not all instruments have undergone calibration, we have devised a strategy to store both raw and corrected data in the database, using separate tables. In pursuit of more advanced data storage capabilities, in addition to the tables already in place as of 2017, we have opted to create a new table called **tbl_calibrations** to store the calibration data.

table_name name	column_name name	data_type character varying
tbl_calibrations	ID	integer
tbl_calibrations	ID_Instr	integer
tbl_calibrations	Start_Date	timestamp without time zone
tbl_calibrations	Critical_Humidity	double precision
tbl_calibrations	A1	double precision
tbl_calibrations	sA1	double precision
tbl_calibrations	B1	double precision
tbl_calibrations	sB1	double precision
tbl_calibrations	sR1	double precision
tbl_calibrations	R1Square	double precision
tbl_calibrations	A2	double precision
tbl_calibrations	sA2	double precision
tbl_calibrations	B2	double precision
tbl_calibrations	sB2	double precision
tbl_calibrations	sR2	double precision
tbl_calibrations	R2Square	double precision

Figure 12 tbl_calibrations.

- **ID**: it is the unique identifier (primary key) for each calibration data, automatically assigned.
- **ID_Instr**: it is a foreign key that refers to the primary key ID of tbl_instrumets and specifies the instrument the calibration data refers to.

- **Start_Date**: it is the date from which that calibration holds true. It is possible for there to be two or more rows associated with the same ID_Instr, each having a different Start_Date. This indicates that the instrument has undergone calibration multiple times. The database population procedure is designed to effectively manage this scenario and determines which calibration should be applied based on the corresponding date when correcting data.
- **Critical_Humidity**: it is the critical value of the humidity before and after which the correction model changes.
- **A1, B1**: they are the coefficients of the correction model for data corresponding to humidity values smaller than the Critical_Humidity.
- **sA1, sB1**: they are the errors associated with the coefficients A1 and B1 respectively.
- **sR1**: it is the interpolation error of the first correction model.
- **R1Square**: it is the coefficient of determination (R2) associated with the interpolation of the first correction model.
- **A2, B2, sA2, sB2, sR2, R2Square**: they are analogous to the previous fields, but they refer to the correction model for data corresponding to humidity values greater than the Critical_Humidity.

The radon data corrected by the calibration procedure are stored in **tbl_rncounts_corrected**, whose fields are the same as tbl_rncounts ones with the only difference of the records in RnCounts, that contains the corresponding calibrated data.

Figure 13 tbl_rncounts_corrected.

table_name name	column_name name	data_type character varying
tbl_rncounts_corrected	ID	integer
tbl_rncounts_corrected	RnCounts	integer
tbl_rncounts_corrected	DateAcq	timestamp without time zone
tbl_rncounts_corrected	DateIns	timestamp without time zone
tbl_rncounts_corrected	Flag	boolean
tbl_rncounts_corrected	ID_Stz	integer
tbl_rncounts_corrected	ID_Instr	integer
tbl_rncounts_corrected	ID_Source	integer
tbl_rncounts_corrected	ID_filesource	integer

As previously highlighted, the most significant enhancement over the previous database lies in its transformation from a static repository to a dynamic system of generalised procedures, meticulously organised into distinct functions, responsible for:

1. Establishing the database structure.
2. Automatically importing all data contained in the row files collected before 2020.
3. Automatically updating the database population as new data is acquired.

About the point 3, when a new data file is downloaded it is saved in a repository folder, and an update procedure is initiated to read the folder and insert the data. To avoid multiple updating process for the same file, we have introduced a new table, **tbl_fileupdate**, that records the names of the update files when they are read by the procedure and processed.

Figure 14 tbl_fileupdate.

table_name name	column_name name	data_type character varying
tbl_fileupdate	ID	integer
tbl_fileupdate	DateIns	timestamp without time zone
tbl_fileupdate	FileName	character

- **ID**: it is the unique identifier (primary key) for each file name, automatically assigned.
- **DateIns**: it is the date in which the row is inserted into the table. It is automatically initialised to the current date and time. As new data inserted are never updated, the name of this field has been preferred to the usual "DateUpdate".
- **FileName**: it is the update files' relative path in our repository.

3. Conclusions

The expansion of IRON in recent years has required a new approach to data storage. This paper outlines such an innovative approach including an improved database architecture and the implementation of automated procedures for database creation, population, and ensuring data consistency.
Currently, the database is accessible only within the INGV internal network. Nevertheless, we are actively working towards making a portion or the entirety of the data available on a public website.

Bibliography

Axmark D., Widenius M., (2015). *MySQL 5.7 reference manual. Redwood Shores, CA:Oracle*. Available online at https://dev.mysql.com/doc/refman/5.7/en/index.html

Cannelli V., (2017). *IRON-DB: a database for the Italian Radon mOnitoring Network*. Rapp. Tec. INGV 371. https://editoria.ingv.it/rapporti/2017/rapporto371/

Cannelli V., Piersanti A., Galli G., Melini D., (2018). *Italian Radon mOnitoring Network (IRON): A permanent network for near real-time monitoring of soil radon emission in Italy*. Ann. Geophys., 61, 4, SE444. https://www.annalsofgeophysics.eu/index.php/annals/article/view/7604

Drake J. D. and Worsley J. C., (2002). *Practical PostgreSQL. O'Reilly Media, Inc.Galli G., Cannelli V., Nardi A., Piersanti A., (2019). Implementing soil radon detectors for long term continuous monitoring*. Appl. Radiat. Isot. 153, 108813, https://pubmed.ncbi.nlm.nih.gov/31349111/

Stones R. and Matthew N., (2006). *Beginning databases with postgreSQL: From novice to professional*. Apress. https://link.springer.com/book/10.1007/978-1-4302-0018-5

Toader V.E., Mihai A., Moldovan I.-A., Ionescu C., Marmureanu A., Lingvay I., (2021). *Implementation of a radon monitoring network in a seismic area*. Atmosphere, 12, 8, 1041. https://www.mdpi.com/2073-4433/12/8/1041

Truskowski W., Klewek R., and Skublewska-Paszkowska M., (2020). *Comparison of MySQL, MSSQL, PostgreSQL, Oracle databases performance, including virtualization*. Journal of Computer Sciences Institute, 16, 279–284. https://doi.org/10.35784/jcsi.2026

QUADERNI di GEOFISICA

ISSN 1590-2595 https://istituto.ingv.it/it/le-collane-editoriali-ingv/quaderni-di-geofisica.html/

I QUADERNI DI GEOFISICA (QUAD. GEOFIS.) accolgono lavori, sia in italiano che in inglese, che diano particolare risalto alla pubblicazione di dati, misure, osservazioni e loro elaborazioni anche preliminari che necessitano di rapida diffusione nella comunità scientifica nazionale ed internazionale. Per questo scopo la pubblicazione on-line è particolarmente utile e fornisce accesso immediato a tutti i possibili utenti. Un Editorial Board multidisciplinare ed un accurato processo di peer-review garantiscono i requisiti di qualità per la pubblicazione dei contributi. I QUADERNI DI GEOFISICA sono presenti in "Emerging Sources Citation Index" di Clarivate Analytics, e in "Open Access Journals" di Scopus.

QUADERNI DI GEOFISICA (QUAD. GEOFIS.) welcome contributions, in Italian and/or in English, with special emphasis on preliminary elaborations of data, measures, and observations that need rapid and widespread diffusion in the scientific community. The on-line publication is particularly useful for this purpose, and a multidisciplinary Editorial Board with an accurate peer-review process provides the quality standard for the publication of the manuscripts. QUADERNI DI GEOFISICA are present in "Emerging Sources Citation Index" of Clarivate Analytics, and in "Open Access Journals" of Scopus.

RAPPORTI TECNICI INGV

ISSN 2039-7941 https://istituto.ingv.it/it/le-collane-editoriali-ingv/rapporti-tecnici-ingv.html/

I RAPPORTI TECNICI INGV (RAPP. TEC. INGV) pubblicano contributi, sia in italiano che in inglese, di tipo tecnologico come manuali, software, applicazioni ed innovazioni di strumentazioni, tecniche di raccolta dati di rilevante interesse tecnico-scientifico. I RAPPORTI TECNICI INGV sono pubblicati esclusivamente on-line per garantire agli autori rapidità di diffusione e agli utenti accesso immediato ai dati pubblicati. Un Editorial Board multidisciplinare ed un accurato processo di peer-review garantiscono i requisiti di qualità per la pubblicazione dei contributi.

RAPPORTI TECNICI INGV (RAPP. TEC. INGV) publish technological contributions (in Italian and/or in English) such as manuals, software, applications and implementations of instruments, and techniques of data collection. RAPPORTI TECNICI INGV are published online to guarantee celerity of diffusion and a prompt access to published data. A multidisciplinary Editorial Board and an accurate peer-review process provide the quality standard for the publication of the contributions.

MISCELLANEA INGV

ISSN 2039-6651 https://istituto.ingv.it/it/le-collane-editoriali-ingv/miscellanea-ingv.html

MISCELLANEA INGV (MISC. INGV) favorisce la pubblicazione di contributi scientifici riguardanti le attività svolte dall'INGV. In particolare, MISCELLANEA INGV raccoglie reports di progetti scientifici, proceedings di convegni, manuali, monografie di rilevante interesse, raccolte di articoli, ecc. La pubblicazione è esclusivamente on-line, completamente gratuita e garantisce tempi rapidi e grande diffusione sul web. L'Editorial Board INGV, grazie al suo carattere multidisciplinare, assicura i requisiti di qualità per la pubblicazione dei contributi sottomessi.

MISCELLANEA INGV (MISC. INGV) favours the publication of scientific contributions regarding the main activities carried out at INGV. In particular, MISCELLANEA INGV gathers reports of scientific projects, proceedings of meetings, manuals, relevant monographs, collections of articles etc. The journal is published online to guarantee celerity of diffusion on the internet. A multidisciplinary Editorial Board and an accurate peer-review process provide the quality standard for the publication of the contributions.

Coordinamento editoriale
Francesca DI STEFANO
Istituto Nazionale di Geofisica e Vulcanologia

Progetto grafico
Barbara ANGIONI
Istituto Nazionale di Geofisica e Vulcanologia

Impaginazione
Barbara ANGIONI
Patrizia PANTANI
Massimiliano CASCONE
Istituto Nazionale di Geofisica e Vulcanologia

Istituto Nazionale di Geofisica e Vulcanologia
Via di Vigna Murata, 605
00143 Roma
tel. +39 06518601

www.ingv.it

ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA