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IRON-DB: A DATABASE FOR THE ITALIAN RADON MONITORING NETWORK

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1. Introduction

The IRON-DB was developed in 2016 in order to support operation of IRON, the Italian Radon mOnitoring Network. IRON is a network of permanent, continuously operating, real-time radon monitoring stations, developed and implemented in Italy in the past 7 years [Cannelli et al., submitted]. The network represents, at present, the first Italian regional-scale infrastructure for a systematic and continuous monitoring of radon emissions (see for example [Piersanti et al., 2015; Cannelli et al., 2016; Piersanti et al., 2016]). IRON presently consists of 19 stations, mainly located in the Central-Southern Apennines, but marginally covering the whole Italian peninsula (Figure 1). Owing to the evolution of IRON network since 2009, in terms of instrumentations, different type of installation and overall of a large number of continuous measurements, it was necessary to implement a database allowing access to all the collected data and to keep track of the evolution of the network.

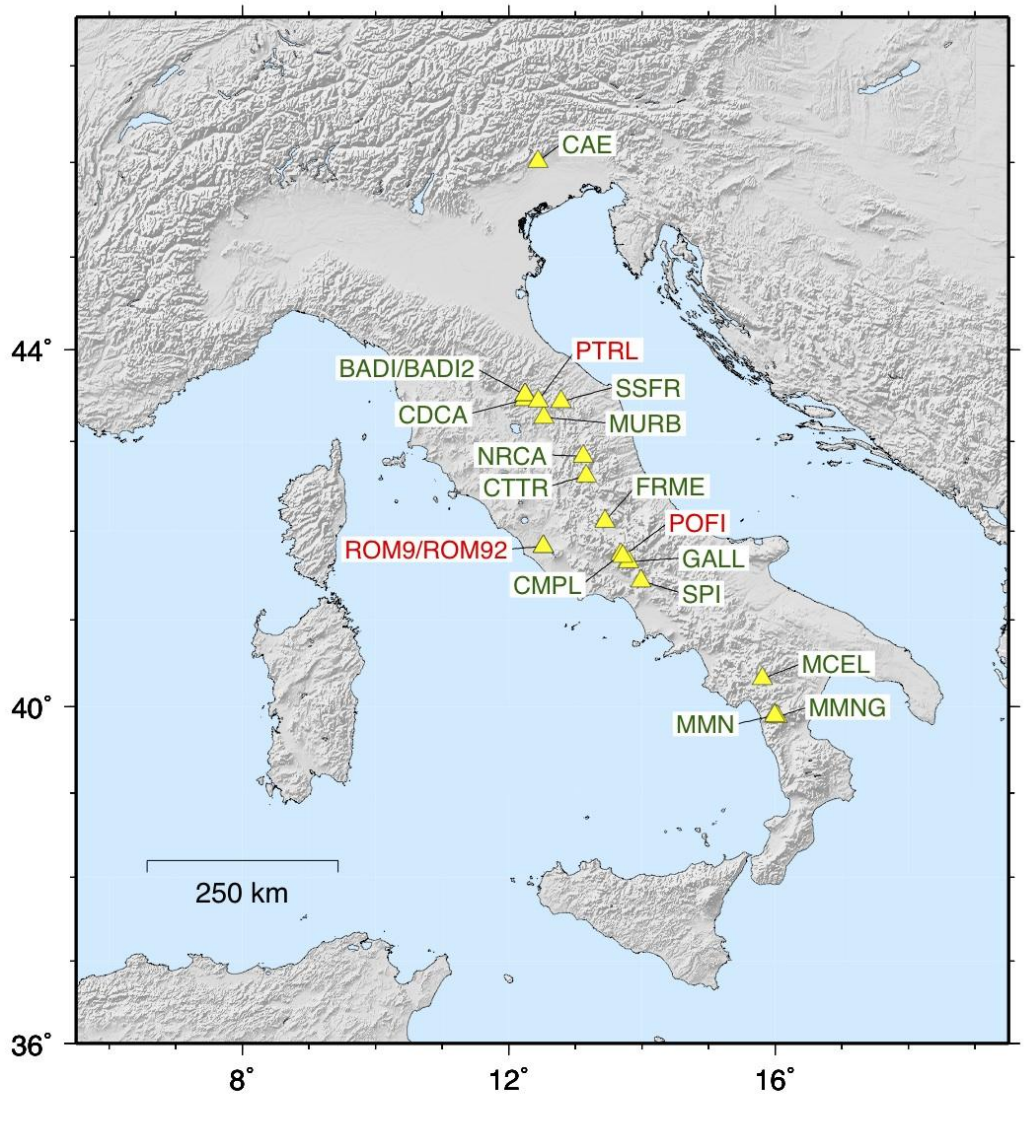

Figure 1. Geographical distribution of IRON stations, as of February 2017. The green labels correspond to presently operating stations, while the red ones represent discontinued stations. The figure has been drawn using the Generic Mapping Tools (GMT) of [Wessel and Smith, 1998].

2. Layout of IRON-DB

The IRON-DB is a specifically designed relational database hosted by INGV, Istituto Nazionale di Geofisica e Vulcanologia. It was developed on the MySQL platform [Axmark, D., & Widenius, M., 2015] according to the scheme shown in Figure 2.

All data are organized in structured, related tables and satisfy the referential integrity, i.e. each declared foreign key (ID_XXX fields marked by a red symbol in Figure 2) contains only values from a parent table's primary key (IDs marked by a yellow key in Figure 2). This is a guarantee that prevents users or applications from entering inconsistent data or updating/deleting referenced data.

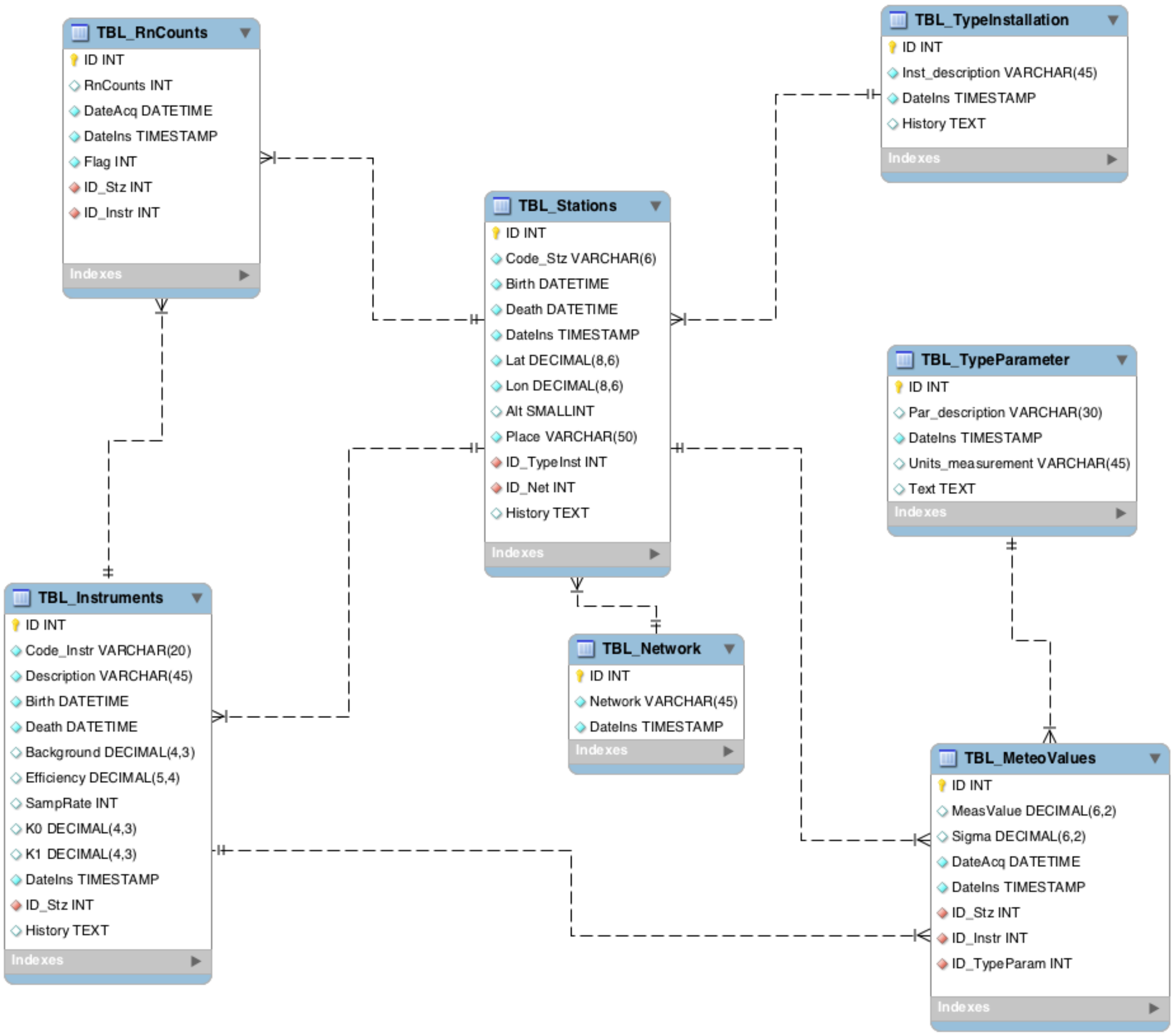

Figure 2. Scheme of IRON-DB designed with MySQL Workbench (version 6.1.7).

3. Tables description

The core of IRON-DB is represented by `TBL_Stations`, which contains all the fields necessary for a complete description of the station.

Field	Type	Null	Key	Default	Extra
ID	int(11)	NO	PRI	NULL	auto_increment
Code_Stz	varchar(6)	NO	MUL	NULL	
Birth	datetime	NO		NULL	
Death	datetime	NO		2064-01-01 00:00:00	
DateIns	timestamp	NO		CURRENT_TIMESTAMP	
Lat	decimal(8,6)	NO		NULL	
Lon	decimal(8,6)	NO		NULL	
Alt	smallint(6)	YES		NULL	
Place	varchar(50)	NO		NULL	
ID_TypeInst	int(11)	NO	MUL	NULL	
ID_Net	int(11)	NO	MUL	NULL	
History	text	YES		NULL	

Each radon station is univocally determined by:

- `ID`: a unique identity (primary key) for each station, automatically assigned;
- `Code_Stz`: an alphanumeric code of 3-4 characters identifying station (see Figure 1);
- `Birth, Death`: the dates of start and end acquisition of the station;
- `DateIns`: the date in which row is inserted into the table (automatically initialised to the current date and time);
- `Lat,Lon,Alt`: the geographic coordinates and the altitude of the station;
- `Place`: a short description of the place in which the station is installed in administrative terms (i.e. for `NRCA` is `PieLaRocca(PG,Umbria)`);
- `ID_TypeInst`: a foreign key that refers to the primary key `ID` of `TBL_TypeInstallation` and specifies what type of installation characterizes the station;
- `ID_Net`: a foreign key that refers to the primary key of `TBL_Network` and specifies what network the station belongs to;
- `History`: a text field with notes and/or additional information about the station.

The different installation typologies of radon instrument are described in the secondary table

`TBL_TypeInstallation`

Field	Type	Null	Key	Default	Extra
ID	int(11)	NO	PRI	NULL	auto_increment
Inst_description	varchar(45)	NO		NULL	
DateIns	timestamp	NO		CURRENT_TIMESTAMP	
History	text	YES		NULL	

containing the following fields:

- `ID`: a unique identity (primary key) for each installation typology, automatically assigned;
- `DateIns`: the date in which row is inserted into the table (automatically initialised to the current date and time);
- `Inst_description`: a short description of radon instrument installation typology (i.e. indoor, soil etc.);
- `History`: a text field with notes and/or additional information about the installation typology.

The list of different networks stations is stored in `TBL_Network`

Field	Type	Null	Key	Default	Extra
ID	int(11)	NO	PRI	NULL	auto_increment
Network	varchar(45)	NO		NULL	
DateIns	timestamp	NO		CURRENT_TIMESTAMP	

in which the fields are:

- `ID`: a unique identity (primary key) for each network, automatically assigned;
- `Network`: an acronym identifying the network, if it exists (i.e. INSN, OGS);
- `DateIns`: the date in which row is inserted into the table (automatically initialised to the current date and time).

Each station is equipped with an open instrument developed to monitor radon concentration. Some of the employed radon monitors record also meteorological parameters (temperature and atmospheric pressure). In other cases, the station is equipped with a secondary sensor, co-located with the radon detector that acquires locally. All instruments measure at one point in space and at equal intervals of time. Regardless of the physical measured quantity (e.g. radon concentration or temperature), they are listed and described in `TBL_Instruments`.

Field	Type	Null	Key	Default	Extra
ID	int(11)	NO	PRI	NULL	auto_increment
Code_Instr	varchar(20)	NO	MUL	NULL	
Description	varchar(45)	NO		NULL	
Birth	datetime	NO		NULL	
Death	datetime	NO		2064-01-01 00:00:00	
Background	decimal(4,3)	YES		NULL	
Efficiency	decimal(5,4)	YES		NULL	
SampRate	int(11)	YES		NULL	
K0	decimal(5,1)	YES		NULL	
K1	decimal(6,5)	YES		NULL	
DateIns	timestamp	NO		CURRENT_TIMESTAMP	
ID_Stz	int(11)	NO	MUL	NULL	
Last_Download	datetime	NO		NULL	
History	text	YES		NULL	

Each instruments is univocally determined by:

- `ID`: a unique identity (primary key) for each instrument, automatically assigned;
- `Code_Instr`: an alphanumeric code identifying univocally the instrument;
- `Description`: a short description of what the instrument measures (radon counts or meteorological parameters values);
- `Birth,Death`: the dates of start and end of acquisition for the instrument;
- `Background`: background of the instrument expressed in [cpm], if applicable;
- `Efficiency`: efficiency of the instrument expressed in [cpm Bq^{-1} m^3], if applicable;
- `SampRate`: sampling rate of the instrument expressed in [min];
- `K0,K1`: calibration parameters of the instrument, if applicable;
- `DateIns`: the date in which row is inserted into the table (automatically initialised to the current date and time);
- `ID_Stz`: a foreign key that refers to the primary key `ID` of `TBL_Stations` and specifies in which station the instrument is installed;
- `Last_Download`: the date of last download of data;
- `History`: a text field containing notes and/or additional information about the instrument.

Some fields in TBL_Stations are meaningful only for a certain class of instruments (e.g. the background and efficiency are stored only for radon detectors, while they have no meaning for temperature sensors).

All measured data, i.e. radon counts and meteorological parameters values, are stored in TBL_RnCounts and TBL_MeteoValues, respectively. Even though the structure of these two tables is very similar, they have been maintained separate in order to guarantee a distinct access to measurements made with different instruments (and consequently with different methods). TBL_RnCounts contains raw radon data, i.e. counts of radon decay signals as output by the detector front-end; these data need to be corrected taking into account efficiency, background and calibration parameters (stored in TBL_Instruments) in order to obtain radon concentrations.

Field	Type	Null	Key	Default	Extra
ID	int(11)	NO	PRI	NULL	auto_increment
RnCounts	int(11)	YES		NULL	
DateAcq	datetime	NO		NULL	
DateIns	timestamp	NO		CURRENT_TIMESTAMP	
Flag	int(11)	NO		0	
ID_Stz	int(11)	NO	MUL	NULL	
ID_Instr	int(11)	NO	MUL	NULL	

Each entry is univocally characterized by:

- ID: a unique identity (primary key) for each measurement, automatically assigned;
- RnCounts: an integer representing the number of radon counts at the time specified by DateAcq field;
- DateAcq: the date of acquisition in the instrument date format (yyyy-mm-dd hh:mm:ss);
- DateIns: the date in which row is inserted into the table (automatically initialised to the current date and time);
- Flag: an integer flag used to record if some special condition occurred for that measurement;
- ID_Stz: a foreign key that refers to the primary key ID of TBL_Stations and specifies in which station the measurement has been acquired;
- ID_Instr: a foreign key that refers to the primary key ID of TBL_Instruments and specifies which instrument has made the measurement.

The Flag field is presently used only for Barasol probes, which signal if a shock occurred during the acquisition window, because that could affect the reliability of the measurement. However, this field could be used to take into account other special conditions that may arise with future instrumental developments of the network.

TBL_MeteoValues contains measured meteorological values (presently temperature and atmospheric pressure).

Field	Type	Null	Key	Default	Extra
ID	int(11)	NO	PRI	NULL	auto_increment
MeasValue	decimal(6,2)	YES		NULL	
Sigma	decimal(6,2)	YES		NULL	
DateAcq	datetime	NO		NULL	
DateIns	timestamp	NO		CURRENT_TIMESTAMP	
ID_Stz	int(11)	NO	MUL	NULL	
ID_Instr	int(11)	NO	MUL	NULL	
ID_TypeParam	int(11)	NO	MUL	NULL	

Each entry is univocally characterized by:

- `ID`: a unique identity (primary key) for each measurement, automatically assigned;
- `MeasValue`: a decimal representing the measured meteorological value at the time specified by `DateAcq` field;
- `Sigma`: a decimal representing the systematic error associated to the instrument that has made the measurement;
- `DateAcq`: the date of acquisition in the instrument date format (`yyyy-mm-dd hh:mm:ss`);
- `DateIns`: the date in which row is inserted into the table (automatically initialised to the current date and time);
- `ID_Stz`: a foreign key that refers to the primary key `ID` of `TBL_Stations` and specifies in which station the measurement has been acquired;
- `ID_Instr`: a foreign key that refers to the primary key `ID` of `TBL_Instruments` and specifies which instrument has made the measurement;
- `ID_TypeParam`: a foreign key that refers to the primary key `ID` of `TBL_TypeParameter` and specifies which type of meteorological parameter the instrument has measured.

The list of different meteorological parameters is stored in the secondary `TBL_TypeParameter` table

Field	Type	Null	Key	Default	Extra
ID	int(11)	NO	PRI	NULL	auto_increment
Par_description	varchar(30)	YES		NULL	
DateIns	timestamp	NO		CURRENT_TIMESTAMP	
Units_measurements	varchar(45)	NO		NULL	
Text	text	NO		NULL	

containing the following fields:

- `ID`: a unique identity (primary key) for each meteorological parameter type, automatically assigned;
- `Par_description`: a short description of meteorological parameter (i.e. internal temperature, atmospheric pressure, etc.);
- `DateIns`: the date in which row is inserted into the table (automatically initialised to the current date and time);
- `Units_measurements`: a short description of the units of measurement associated to that meteorological parameter;
- `Text`: a text field for notes and/or additional information.

4. Some considerations on the design choices of IRON-DB

IRON-DB has been designed for working with continuous, station-oriented and event-oriented time series data from a permanent network. As a consequence, the present structure of the network does not imply a particular data complexity, because the main data types are essentially limited to radon concentration and meteorological parameters.

At the present data is initially stored in a local memory in the front-end electronics of the instruments. It is then downloaded through a serial interface, requiring an on-site operation at the station, and finally loaded into IRON-DB, after a conversion in ASCII formatted text file. A new multiparametric acquisition system, based on the open-source Arduino platform, is being developed. This platform will provide both local storage on a flash memory and real-time data transmission via the GSM network, which will allow automatic loading of data into IRON-DB, with minimal changes to actual DB structure, as well as remote diagnosis of the stations.

The database is flexible enough for including extensible auxiliary information with the time series data (i.e. to append new data field in tables as new parameters characterizing the station or new instruments).

Even though the data record size is bound to increase (the database size is 29.1 in MB, with 421,732 entries, actually), a system of indices (cross references) to logical records ensure efficient access (i.e. `ID_Xxx's` foreign keys refers to `ID's` primary keys). Also the use of few string data types with respect to numeric and date/time data types helps the database efficiency.

The choice of storing raw data from field station instruments (i.e. counts rather that concentration data for radon) allows the user/ researcher to know the zero-level correction data, even if auxiliary information (i.e. instrument background and efficiency) is needed for deeper analyses.

5. Conclusions

The relational database IRON-DB was specifically designed in order to support the the first national-scale permanent network for real time measurements of soil radon emissions in Italy (Italian Radon mOnitoring Network - IRON). At present, most IRON network stations have recorded radon concentration time-series longer than 4-5 years; since the sampling rate is about two hours, the whole IRON dataset consists of almost 400,000 radon concentration measurements. The relational database described in this report allows to easily manage this amount of data; at the same time, the design choices of the database allow to simply handle the future growth and/or evolution of the network.

IRON-DB is hosted on a virtual server platform operated by the INGV IT services. It is currently reachable only from the internal computer network of INGV, however in future it may be linked to a public web interface to allow data dissemination.

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References

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

Cannelli V., Piersanti A., Galli G. and Melini D. *Italian Radon mOnitoring Network (IRON): A permanent network for the measurement of soil radon emanations associated to earthquake preparation processes*, submitted to Journal of Environmental Radioactivity.

Cannelli V., Piersanti A., Spagnuolo E., Galli G., (2016). *Preliminary analysis of radon time series before the Ml=6 Amatrice earthquake: possible implications for fluid migration*. Annals of Geophysics, [S.l.] (2016), http://dx.doi.org/10.4401/ag-7166.

Piersanti A., Cannelli V. and Galli G., (2015). *Long term continuous radon monitoring in a seismically active area*. Ann. Geophys., 58 (2015), S0437, doi:10.4401/ag- 6735.

Piersanti A., Cannelli V. and Galli G., (2016). *The Pollino 2012 seismic sequence: clues from continuous radon monitoring, Solid Earth*, 7 (2016), 1303-1316, doi:10.5194/se-7- 1303-2016.

Wessel P. and Smith W.H.F., (1998). *New, improved version of Generic Mapping Tools released*, Eos T. Am. Geophys. Un., 79 (47), 579, doi:10.1029/98EO00426.

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