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Osimin - A meteorological data platform for processing SIMIN data built on open source software

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Abstract. In 2003, the Romanian National Institute of Meteorology and Hydrology inaugurated National Integrated Meteorological System (SIMIN), consisting of a network of stations and instruments for measurement and detection of hydro and meteorological data, a specialized communication network, a forecasting network, and a dissemination network. With a setup cost of $55 million and a national priority role, SIMIN (implemented by Lockheed Martin) is relatively black boxed even today, using proprietary technology and software. Few institutions have direct access to the data it provides. In this paper, we present the design of a web-based software application built on open source software that allows easy access to and processing of data available in SIMIN.

1. Introduction

Meteorological and hydrological information play vital roles in planning any modern human activity, from agriculture to space launches. Hydro-meteorological measurements using scientific instruments have a long history dating back to 15th century [1], while weather forecasting using these data and scientific methods is a much more recent endeavor [2]. Although algorithmic and numerical forecast methods were discussed in early 20th century [3] [4], up until World War II, weather forecasting was an art mastered only by trained specialists, highly dependent on their experience. The advent of electronic computers and computer networks, leading up to the Internet and World Wide Web, opened up new possibilities for hydro-meteorological data collection, data exchange and data analysis using numerical simulations for global atmospheric circulation. With the increase of data storage, transfer speeds and computer processing power, weather forecasting models and processing algorithms also grew in complexity [5] [6] [7] [8] [9] [10].

Algorithms and models are one of the two key ingredients for accurate weather forecasting, with the data being the other key ingredient. As with all other algorithms, the output of weather forecasting models depends on the quality and quantity of input hydro-meteorological data. Even if we focus on weather data recording, ignoring the forecasting feature, collecting complete and accurate data is an important issue in meteorology. Furthermore, sharing weather data sets is of major importance for research activities, too, as they allow researchers to build and validate new models.

In this paper, we review the characteristics of the Romanian National Integrated Meteorological System (SIMIN) and introduce Osimin, a web-based software application built on open source software that allows easy publication and basic processing of data collected by SIMIN. It should be noted that SIMIN data is intellectual property of the Romanian National Meteorology Administration

(ANM), but Osimin is agnostic to the data source and can be easily integrated with other information providers. The following section presents the architecture of SIMIN and the data formats available in it. The third section presents the architecture of Osimin, the open-source platform for importing and publishing meteorological data from SIMIN. Last section presents conclusions and further work.

2. SIMIN architecture and data

In 2003, the Romanian National Institute of Meteorology and Hydrology (INMH), the predecessor of ANM, inaugurated the National Integrated Meteorological System or SIMIN for short. As its name suggests, SIMIN is an integrated system designed for hydrological and meteorological data measurements, exchange and forecast. It consists of a network of stations and instruments for measurement and detection of hydro-meteorological data, a forecasting network, a specialized communication network, and a dissemination network.

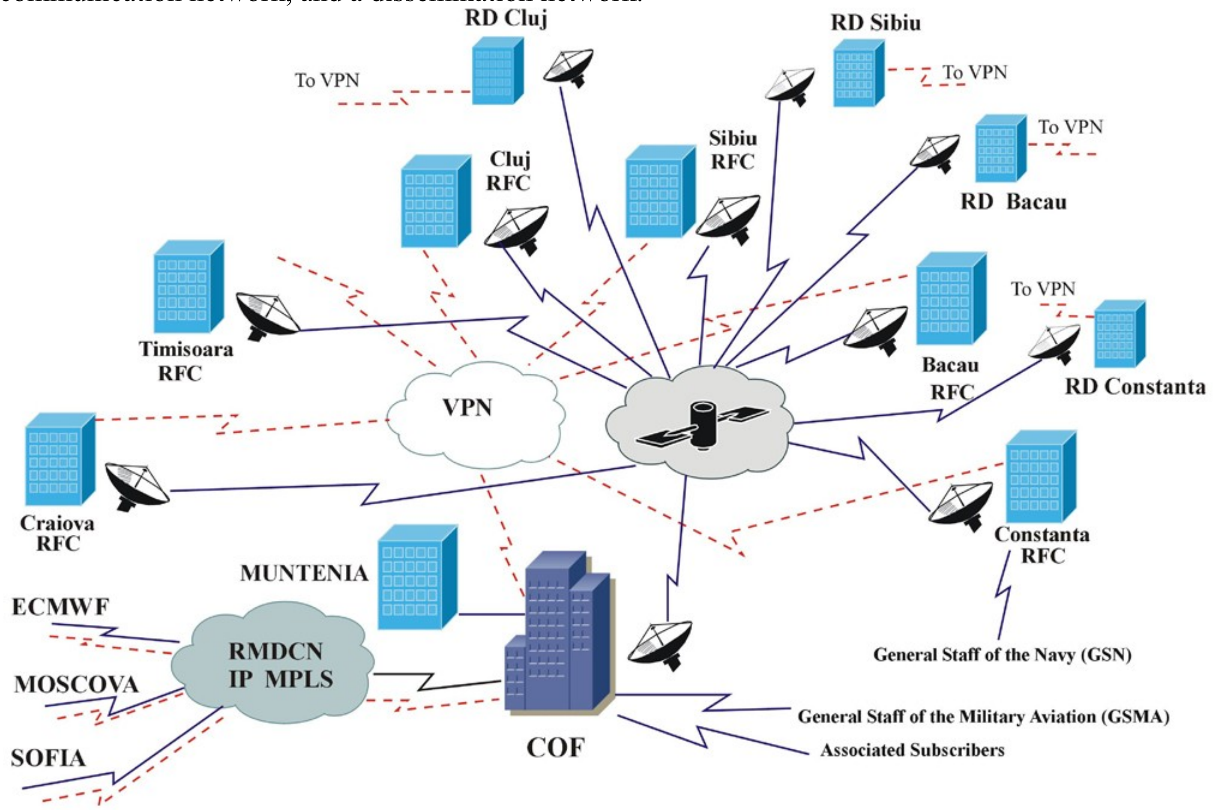


Figure 1 The general structure of the SIMIN network.

The network of stations and instruments for measurement and detection (called sensor sites) includes a reception system for MSG satellite observations, 8 Doppler radar systems, over 260 meteorological stations (including over 160 fully automated stations and 23 stations which are part of the meteorological network of the World Meteorological Organization), and around 2200 pluviometric locations [11]. Over 20 stations have daily measurements logs spanning over 100 years. Over 160 stations have daily measurements logs spanning over 50 years.

All sensor sites send their raw data to the regional forecasting center (RFC) they belong to. Currently, RFCs exist in Cluj, Timișoara, Bacău, Craiova, Constanța and Sibiu. They collect raw data from sensor sites, validate it, process it, create forecasts and forward all this information to the center for operational forecasting (COF) in Bucharest, which sends it to the European and world partner networks (e.g. EUMETSAT, ECMWF, EUMETNET, etc).

The Constanta RFC is also responsible from integration of data received via the Romanian Maritime Hydrographic Direction (DHM) from the 11 fully automated meteorological stations of the

Romanian Navy, located in Navy bases (Sulina, Sfântu Gheorghe, Gura Portiței, Midia, Constanța, Tuzla, and Mangalia), and on-board Navy ships ("Cpt. Cdor Alexandru Cătuneanu" Hydrographic Ship, "Mircea" Training Ship, "Maria" Frigate, and "Ferdinand" Frigate).

The communication network for SIMIN (called SIMIN WAN), presented in Figure 1 [11] provides bidirectional data transfers (including radar and satellite imagery and VoIP) between sensor sites, RFCs, the COF and international partners. RFCs send data to COF using IP unicast, while COF sends data to RFCs using IP Multicast. The main communication channel is VSAT link and the backup channel is a VPN setup.

Contracted in 1999 for a setup cost of $55 million, SIMIN (implemented by Lockheed Martin) is relatively black boxed even today, using proprietary technology and software. Few institutions have direct access to the data it provides. Some particular (high-resolution) data series managed by ANM are classified information and is subject to Romanian laws on protection of classified information.

All the data collected by SIMIN is intellectual property of ANM, which provides limited free access to its data via its online website [11], and paid access to more general primary and processed data. The data transferred and processed by ANM via SIMIN is encoded in various formats, ranging from alphanumeric formats (SYNOP, TEMP, CLIMAT and AMDAR) and binary formats (GRIB, BUFR) for hydro-meteorological parameters to maps and satellites imagery [11]. The SYNOP (surface synoptic observations) format [12], also known as FM-12 by World Meteorological Organization, is a widely used alphanumerical code which allows manned and automated weather stations to report weather observations. The Osimin web platform, presented in the following section, is capable of parsing, SYNOP codes, store the data, process it for basic reporting, and export it for additional analysis using specialized tools.

3. Osimin – an open platform for SIMIN data

Osimin is an meteorological platform developed within the scope of the Projects no. 164 of the 2017 Research and Development Plan of the Romanian Ministry of National Defense, using open-source technologies. The scope of Osimin is to provide an ready to use web platform capable of importing data from SIMIN (and other compatible systems) and publish them online for easy access and research use. It allows data from different timeframes and locations to be queried, based on different meteorological parameters and it also performs basic statistical processing, like average, minimum, and maximum, in real-time for the retrieved data.

Osimin uses a relational database for storing information on weather stations, monitored meteorological parameters, and configuration of the entire system. In our prototype, the relational database is managed by a MySQL relational database management system (RDBMS). Although we did not test other types of database management systems, the system uses a database access abstraction layer that offers the ability to be used with other RDBMSs (e.g. PostgreSQL, SQLite).

In terms of database structure, Osimin uses a high level of normalization to enable an expandable and dynamic structure, and at the same time to make the most of the caching system provided by modern RDBMSs. For weather stations, the system stores the station name, the address of the station, station identification code (unique identifier assigned by ANM and/or DHM), station RFC code, geographical coordinates and altitude of the station, station type (e.g. manual or automatic), other information. These fields represent a minimum of information and can be easily extended with other information about the station, such as the contact details of the service staff, the type of equipment used, etc. Figure 2 presents a part of the web form for adding and editing weather station metadata. Figure 3 presents a part of the web page displaying information about one particular meteorological station. Figure 4 presents the interactive online map with all the meteorological web stations registered in our prototype setup of Osimin.

The meteorological data stored into Osimin comes from parsing SYNOP data from SIMIN. Depending on the technical characteristics of the equipment available in the weather stations, a number of parameters are recorded for each of the stations registered in Osimin. For each parameter measurement Osimin records the date where the data entry was added and/or modified, the code of the station that recorded the information, the measured value for the parameter, date of the measurement and up to 5 parameter specific additional information.

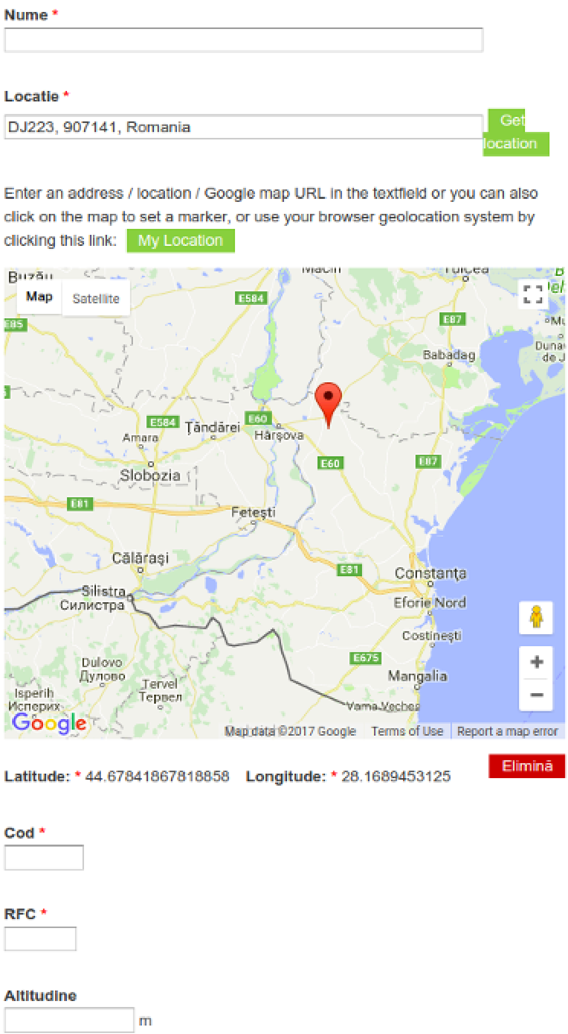


Figure 2 Web form for registering a new station.

Figure 3 Display for a meteorological station.

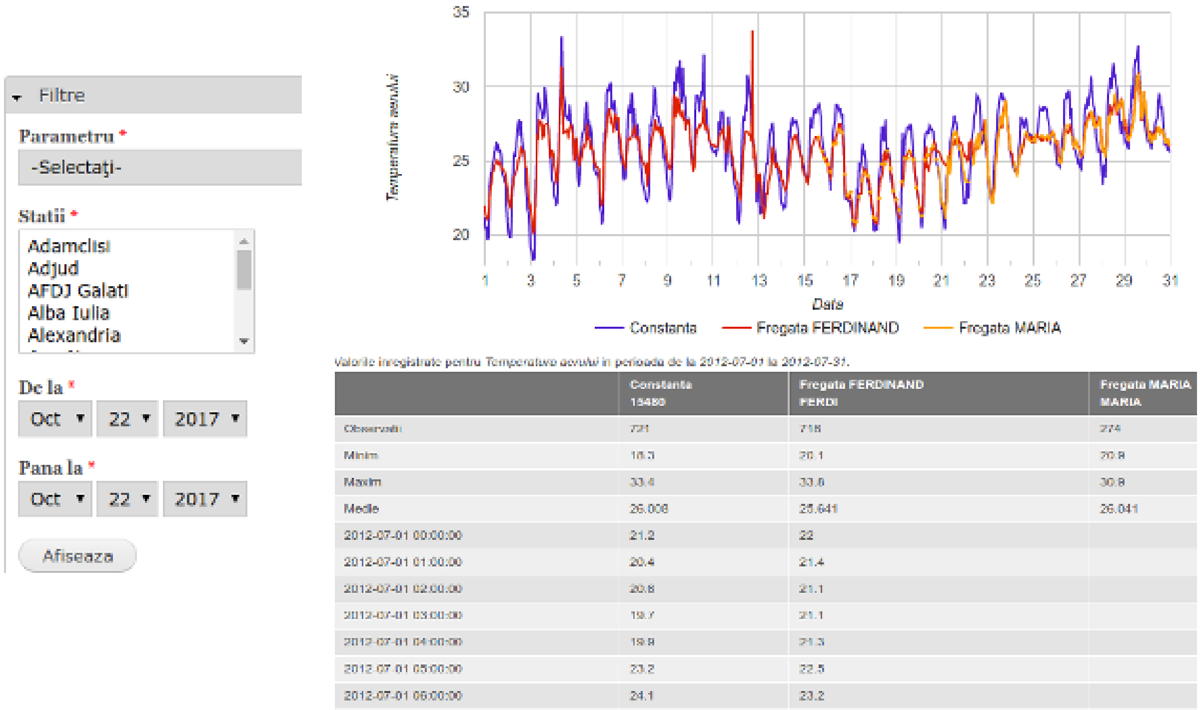
Figure 4 Meteorological stations registered in Osimin.

Osimin implements a business-logic abstraction layer which isolates the database structure from the definition of specific parameters. Due to this layer, the system can handle currently more than 140 meteorological parameters and new parameters can be added in a matter of minutes. Given the large volume of data and trying to avoid human errors, manual adding and editing of measurement data is not allowed to regular users (only to system administrators). Therefore, regular users can only add meteorological data through the import tool. The data import interface allows the user to choose the source of the data and which parameters will be imported (see Figure 5 – left). After entering the desired options, pressing the Import button will start the import process. The time required to complete the import depends on the volume of imported data, but the user will be informed via the interface displayed on the current actions and overall progress (see Figure 5 - right).

Researchers can use Osimin to view imported data, while applying various filters based on time, station/location, and meteorological parameters. For the resulted data, basic statistic analysis (average, minimum, maximum, etc) are available, as well as exporting the data. The filtering form used to view the data is shown in the left side of Figure 6.

Figure 5 Import of meteorological data into Osimin (left - setup stage; right – processing stage).

An example of data view is presented in right side of Figure 6, showing a report for the air temperature parameter, as measured in Constanta and onboard the Ferdinand and Maria Frigates in July 2012. As can be noticed, data from the Maria Frigate is partially available, as the ship was undergoing a mission before July 15th.



	Constanta 15480	Fregata FERDINAND FERDI	Fregata MARIA MARIA
Observatii	721	718	274
Minim	18.3	20.1	20.8
Maxim	33.4	33.8	30.8
Medie	26.008	25.641	26.041
2012-07-01 00:00:00	21.2	22	
2012-07-01 01:00:00	20.4	21.4	
2012-07-01 02:00:00	20.8	21.1	
2012-07-01 03:00:00	19.7	21.1	
2012-07-01 04:00:00	19.8	21.3	
2012-07-01 05:00:00	23.2	22.5	
2012-07-01 06:00:00	24.1	23.2	

Figure 6 Query of meteorological data from Osimin (left - filtering stage; right – view/export stage).

4. Conclusions

Access to data is a key component for successful research. While SIMIN provides the proper national infrastructure and international connectivity for gathering hydro-meteorological data, it is a closed system, with limited options for sharing data. In this paper, we presented Osimin, a web-based platform built using open-source software that can be used to publish and analyze meteorological data.

Although we used SIMIN as the main data source, Osimin is agnostic in this respect and it can be integrated with other systems or can be used as a standalone meteorological archive for personal or institution use.

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