A METEOROLOGICAL TELEMETRIC NETWORK FOR MONITORING OF THE ATHENS WIDER AREA (METEONET). A REAL TIME APPROACH FROM POINT TO AREAL MEASUREMENTS

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EXTENDED ABSTRACT

This paper is focused on the description of a meteorological telemetric network (METEONET) that is being installed for the integrated analysis and management of the meteorological information concerning the wider area of Athens.

The need for the development of such a network originated from the absence of a modern, fully automated hydrometeorological network in the wider area of Athens, which could provide processed hydrometeorological information in real time through the Internet.

This network, in full operation, will consist of 10 automatic meteorological stations around Athens. For the proper sitting of the stations, hydrological, topographical and security factors were taken under consideration. The network stations provide information of high reliability and easy acquisition for several variables such as precipitation, humidity, temperature, solar radiation, sunshine duration and wind velocity and direction. Mobile telephony is used for the data transmission to a central repository. The system was founded on an open source project and includes automated loading of data files to a central database. The database schema has been developed and implemented within National Technical University of Athens (NTUA), and is optimized for the efficient storage and easy management of the time series. It incorporates facilities for storing raw, as well as, processed time series and functions for the automated or semi-automated error checking and data elaboration.

This information is provided in real time on the Internet and apart from point raw measurements (charts, tables etc) in predefined time-scales, the system users will gain access to processed areal information of the mentioned variables, depicting the evolution of weather conditions in time and space. Also, via Internet will be provided other derivative hydrometeorological information, such as evaporation estimations, statistical elaboration of extreme events, bioclimatic factors and climatological estimates.

Emphasis will be put in the growth of a system for the best understanding and evolution of the weather conditions in Athens and for public awareness related to extreme rainfall events (estimated from areal precipitation data), resulting in the optimum management and the prevention of their consequences.

Key words METEONET, telemetric network, hydrometeorological stations, Athens

1. INTRODUCTION

The function of a well-organized hydrometeorological stations network in combination with further discharge measurements is a basic infrastructure for the best management of extreme rainfall events and consequently for the flood-related events, especially in the greater Athens area, where intense flood-producing rainstorms often occur, resulting in the loss of human lives and properties [5]. The effectiveness of the rainfall measuring stations depends on the quality and kind of the instruments, but moreover on the correct placement, which is based on certain criteria such as the placement on land, the accessibility and the closeness to special interest points (settlements, surface waters etc).

Unfortunately, there is still no hydrometeorological stations network organized under a main administration that works through a unified scientific and technical medium [1]. Various State Services have established sectional networks of specific coverage (Public Power Corporation, National Meteorological Service, National Observatory of Athens, Ministry for the Environment, Physical Planning and Public Works, Ministry of Agriculture etc), so the standardization of the equipment used or the procedures followed for all services is not achieved yet.

The operational utilisation of these measurements has serious disadvantages, such as the low reliability and accuracy, the delay in the availability and in the detection of instrument malfunctions, and finally the incongruity in data measurement and processing between different agencies. Thus, the existing conventional measuring systems cannot support efficiently the need for the development of modern water resource management systems [4].

The design of the telemetric system includes two main issues, the selection of the appropriate technologies for data measurement, transmission and storage, and the positioning on the appropriate sites. For the first issue both international and local experience is very important for the effective system design [2],[3],[4]. Two pilot telemetric stations located at the NTUA campus operating for 10 and 5 years correspondingly, were the bases for the network set up, concerning the types of sensors, the devices for energy supply, as well as the techniques for data acquisition logging and transmission.

2. NETWORK OVERVIEW

As shown in Figure 1, the METEONET network consists of 10 automatic telemetric hydrometeorological stations, installed in such a way, for the optimum recording of the weather conditions in Athens. The sitting of the stations was based on the following criteria:

- Meteorological, as the low barometric systems arrive from west, south-west and north-west direction [6].
- Elevation, in order to record the increased amounts of precipitation in high-land areas.
- Security, accessibility and infrastructure facilities, so the placement should be near public buildings
- Topographical, so according to World Meteorological Organization (WMO) regulations, for the meteorological station's installation [8],[9] and among other restrictions, the stations should be placed on land with even slopes, should not be close to trees or buildings and should be relieved from local atmospherical turbulences.

Each one of the stations is equipped with sensors that perform the measurements, the data logger for the data recording, the transmission system, and finally the energy supply unit. The station's measuring characteristics are presented in Table 1. It must be noticed, that for the ensuring of the continuity of the most important variable, the idea of installing two rainfall sensors was promoted, as it provides the system with maximum possible reliability.

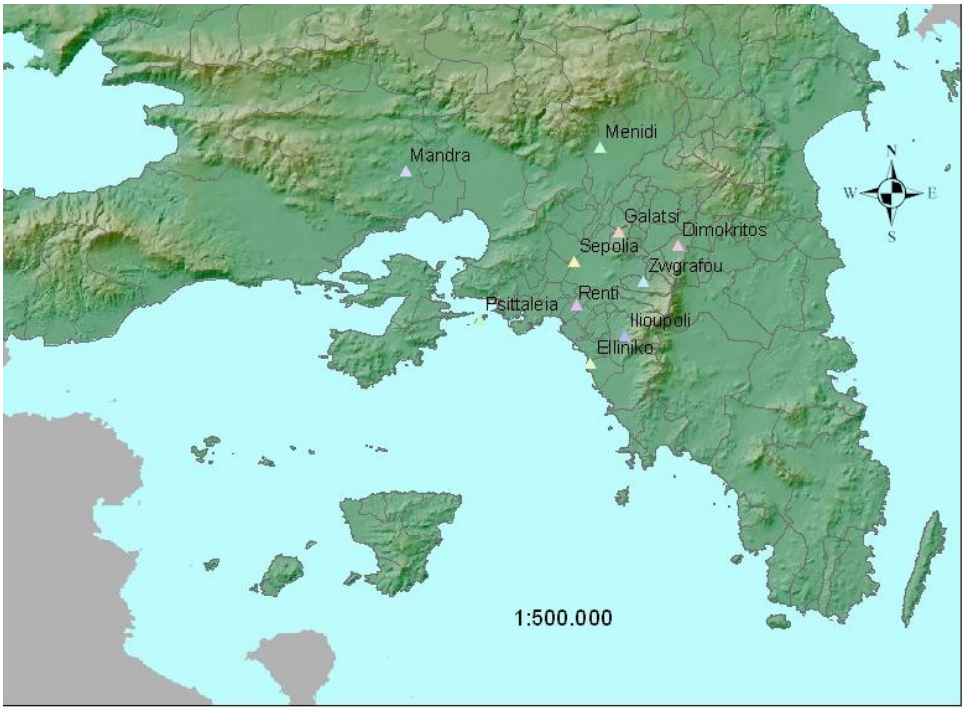

Figure 1: Disposition of METEONET network.

Table 1: Network's measuring characteristics.

Variable	Sensor	Manufacturer
Rainfall_1	ARG100 Tipping Bucket Raingauge	Cambel Scientific
Ranfall_2	52202 Tipping Bucket Raingauge	R. M. Young Co
Wind speed	Switching Anemometer A100R	Winspeed Ltd
Wind direction	Potentiometer Windvane W200P/L	Winspeed Ltd
Temperature	MP101A	Rotronic Ag
Humidity	MP101A	Rotronic Ag
Solar radiation	SP-LITE Pyranometer	Kipp and Zonen
Net radiation	NR-LITE Net Radiometer	Kipp and Zonen
Sunshine duration	CSD-1 sunshine duration meter	Kipp and Zonen

The main reasons that led to the development of such a network include the need for a real time monitoring of the hydrometeorological conditions of the greater Athens area and the dissemination of this information through the Internet for public awareness, the inspection of the temporal and spatial evolution of the meteorological phainomena, in relation with the hydrological and climatic characteristics of Athens and the creation of a reliable data bank as a support tool for the optimum decision making.

3. DATA PROCESSING AND MANAGEMENT

In Figure 2, the general scheme of telemetric data acquisition and processing is presented. According to this, the ASCII files from the data loggers are transmitted every hour to the main server, located at the NTUA campus via mobile telephonic network, where they are stored. A subprogram transfers the data from the ASCII files to a relational data base, taking into account the correspondence between ASCII files columns and time series identification numbers.
Afterwards, the raw time series are directly available through the Internet, in the form of point measurements and charts, while the time series are automatically processed within the data base. The processing includes the following procedures [7]:

- range check,
- time consistency check,
- time series conversion from irregulars to strictly regulars by the use of a strict time step,
- filling in the missing values,
- Aggregation of the regular time series for the generation of derivative time series (hourly, daily, monthly etc)

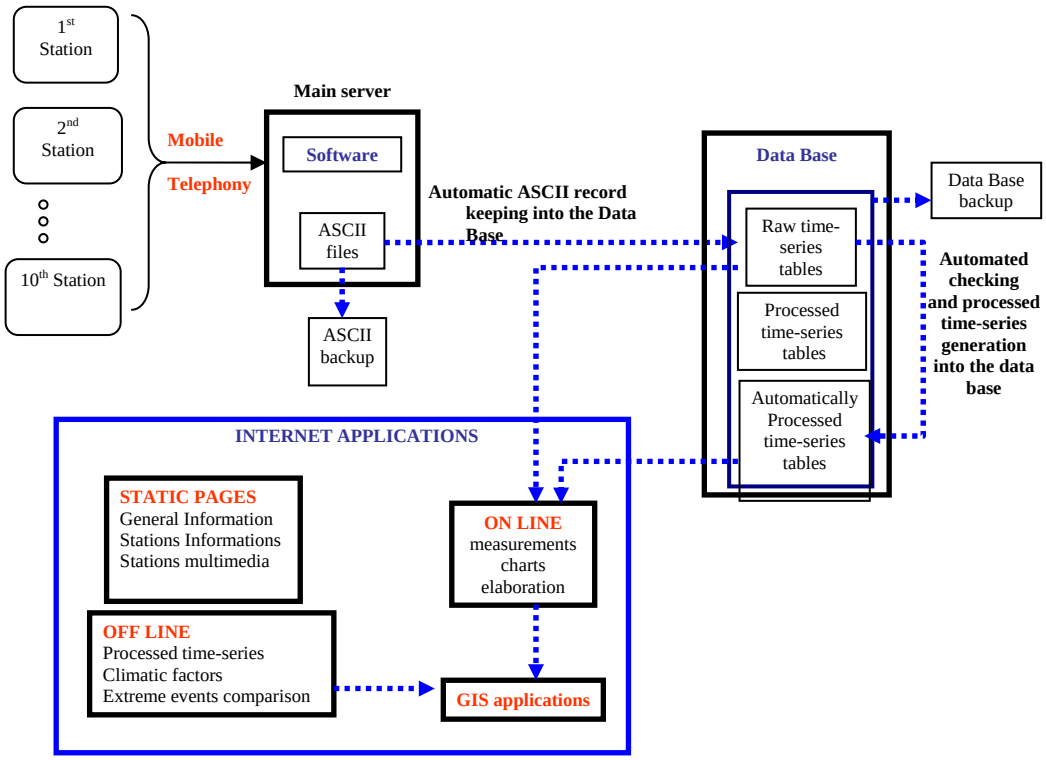

Figure 2: General scheme of telemetric data acquisition and processing.

The data base contains tables, triggers, functions, views, rules constraints and sequences. The time series records are stored in the timeseries_records table, in three parts: top, middle and bottom. “Top” and “Bottom” are plain text, whereas “middle” is plain text compressed in gzip format. The advantages of this paradoxical system of storage are:

- Large time series are uncompressed to the user, thus easing network and server load
- Very little disk space is used (20 times less than storing time series with conventional methods)

- If “top” and “bottom” are kept small, it is very fast to perform the frequently needed operations of retrieving the first and last records and appending a record. All other operations must practically retrieve/update the entire time series.

4. APPLICATIONS - PRELIMINARY RESULTS

The METEONET project implementation on the Internet consists of two basic components: the information provided on point measurements and the areal variables estimation. The user that is interested in specified areas or stations has access to point time series in different time steps (10-min, 1 hour, 1 day, 1 month and 1 year) for all the measured variables in the form of tables or charts. The data stored for each station includes general information (name, location, coordinates, functioning period), multimedia (photographs, videos), instruments and remarks.

Using techniques of areal integration (Thiessen polygons, Krigging etc), the system estimates the spatial representation of the weather conditions at the wider area of Athens. It must be pointed out that this option is available only if there is sufficient data from a minimum number of stations, working properly at a specified period.

The areal estimations provide information for the meteorological conditions of Athens, with data retrieved not only from the most recent update of the system, but also from other time periods.

From the data processing and the statistical elaboration, other derivative information are provided, as follows:

- Estimation of the return period for the rainfall events that occurred, based on the idf curves (intensity-duration-frequency) for Athens

- Peak values of the measured variables in daily, monthly and user-defined basis

- Proportional deviations of the measured variables (temperature, precipitation, humidity etc) from the mean monthly values of the existing statistical sample.

- Comparison of different time series periods for different stations and variables, for predefined or user defined temporal scales

- Drought index, which is related only to precipitation measurements. This index is equivalent to SPI index (Standardized Precipitation Index) in a monthly basis, taking into account the range of the measured precipitation from the 30-year mean value.

- Discomfort index, provided in a common chart with mean values of temperature and humidity, from all METEONET stations in an hourly, daily and monthly temporal scale base.

The system will be supported by a glossary, where users will be referred for the explanation of hydrological, meteorological and climatic terms that are used as well as for the clarification of the procedures followed with references to other sites or international bibliography.

The first four operating stations of the network were preliminary tested during the rainfall event of the 23/02/2005 that last 2 hours (between 18:00 – 20:00). The total rainfall was

recorded and apart from the temporal evolution, it has also been possible to investigate the spatial rainfall distribution and the peak event evolution, as shown in Figure 3.

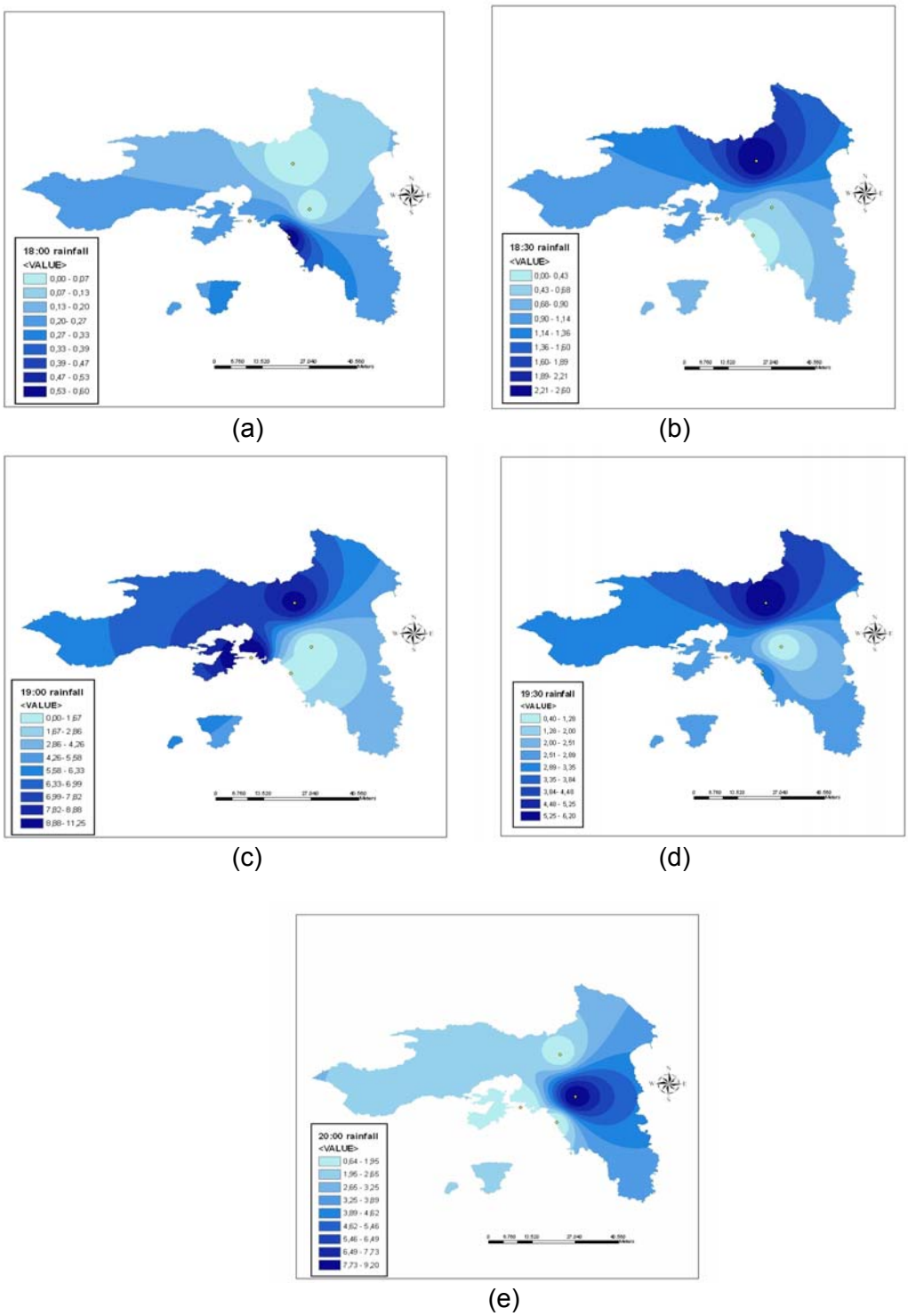

Figure 3: Temporal and spatial evolution of the rainfall event of the 23/02/2005.

5. CONCLUSIONS

The retrieval of reliable processed hydrometeorological data, which will be used as a tool for the integrated hydrological planning, is considered to be one of the most difficult tasks in water resources applications. Experience has shown that problems that arise have to

do not only with the quantity and quality of the available data but also with the ways of easy and quick acquisition. The METEONET network is the first attempt for the collection, storage, elaboration and dissemination of the hydrometeorological information in real time on the Internet, contributing to the public awareness.

With this system in full operation, the definition and the mapping of areas that are most likely for extreme events to occur, in relation to a better understanding of the evolution of the meteorological events over Athens, can lead to specification of measures and actions that need to be implemented for the optimum management and the prevention of human loss and property.

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