Hydrometeorological data acquisition, management and analysis for the Athens water supply system

Nikos Mamassis, Antonis Christofides and Demetris Koutsoyiannis
Department of Water Resources, School of Civil Engineering, National Technical University of Athens, Heroon Polytechneiou 5, Zographou, Greece

Abstract: A hydrolometeorological telemetric network has been installed, in the framework of a decision support system (DSS) for the management of the Athens water resource system, that extends over an area of 5000 km^2. In this paper the telemetric network and data management and analysis are described. The information collected includes meteorological data, reservoir water levels and stream flow data. The data acquisition procedure is executed periodically, by a computer at the data centre and all data is stored in the database for immediate use by other subsystems of the DSS. Some data by conventional instruments are also stored for comparison and tests. A software application (Hydrognomon) is used for management and analysis of the various types of raw data and for producing a large number of derivative time series. The whole procedure has been standardised for easy implementation in other similar networks.

Key words: Telemetric network, decision support system, hydrometeorological stations, Athens water recourse system

1. INTRODUCTION

The Athens water supply system is extensive and complicated, and includes (among others), four reservoirs, 100 boreholes, three major water transfer works (with total length about 290 km) and four water treatment plants. In order to manipulate this system, the Athens Water Supply and Sewage Company (EYDAP) proceeded to the development of a modern decision support system (DSS) to control that system. The DSS uses simulation and optimisation techniques combined with data base and geographical information systems (GIS). The DSS explores alternative management practices and locates optimal solutions for the operation of the water resource system (*Koutsoyiannis et. al.,* 2003). In the development of the DSS an automated telemetric system has been included, in order to provide data of high reliability, without delay, and less costly than conventionally measured data. The telemetric stations are located near the main reservoirs and transmit automatically or semi-automatically hydrological data to the DSS.

Recently, special emphasis has been given to the installation of telemetric networks in order to provide real time and high reliability data. Several researchers have presented their experiences about the function of such telemetric networks (e.g. *Slaughter et. al.,* 2001; *Benschop,* 2003). In Greece the hydrometeorological variables are measured from various agencies, using mostly conventional instruments (gauges and recorders). The operational utilisation of these measurements has serious disadvantages, such as the low reliability and accuracy, the inappropriate temporal scale, the delay in the availability and in the detection of instrument malfunctions, the incongruity in data measurement and processing between different agencies and finally the high installation and operation costs.

The telemetric data is transmitted from the stations via telephone network and stored automatically to the data base of the system. The transmission is made at predefined time periods (for example every 24 hours). A specific software application (Hydrognomon) is used for management and analysis of the various raw data in the data base and for producing a large number of derivative time series.

2. TELEMETRIC SYSTEM PRESENTATION

In Figure 1 the water resource system of Athens is presented. The system includes four reservoirs located in different rivers and in each of the four basins three telemetric stations are installed, in order to collect meteorological data, water level data from the reservoirs and stage data from the main stream of each river basin. The river discharge is measured using conventional methods, in order to convert the river stage time series to discharge.

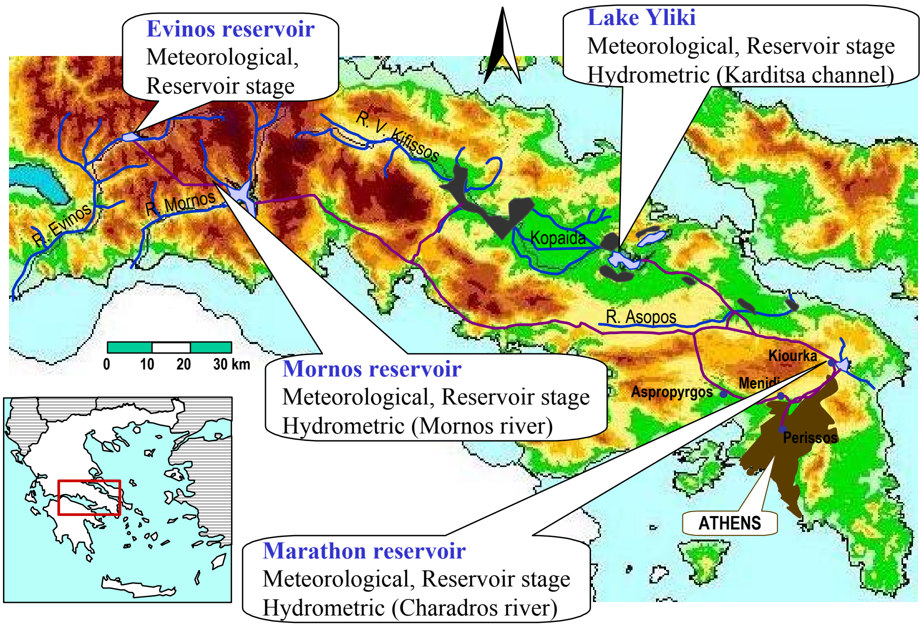

Figure 1: Athens water supply system and sites of hydrometeorological stations.

The telemetric system has four main purposes:

1. the quantitative inspection of the water resources of water basins that contribute to the water supply of Athens and the improvement of the estimation of the parameters involved to the water budget of the reservoirs;
2. the exploration of the hydrological and climatic characteristics of these basins with the gradual collection of reliable hydrometeorological data;
3. the supply of hydrometerological and water availability information in real time on the Internet for public awareness;
4. the feeding of the DSS with reliable data.

The selection of the appropriate technologies for data measurement, transmission and storage is based on local experience that originated from the operation of a telemetric meteorological station located at the National Technical University of Athens campus since 1993. During this period several types of sensors and devices for energy supply, as well as techniques for data acquisition, logging and transmission were tested (Koutsoyiannis et. al., 2000). Also, turned into account the recent international experience (e.g. Herschy, 1999, pp. 245-264).
The positioning of the sites of telemetric stations was initially based on specifications of the World Meteorological Organisation (WMO, 1983; WMO, 1996). Several visits were made to candidate sites and the characteristics of each site were evaluated (hydrological suitability, security, availability of electricity and telephony, ease of installation) and compared in order to select the location of each station. The hydrologically appropriateness according to WMO specifications and the neighbourhood to the EYDAP facilities (dams or water pumping stations) were the main criteria. For the specific types of stations additional criteria were examined. Meteorological stations had to be close to the maximum reservoir elevation in

order to be as representative as possible for the variables that take part to the reservoir water budget. The reservoir stage stations had to be installed at the deepest point of the reservoir (but above the dead storage). Finally the flow measuring stations had to be as close to the dams as possible (above maximum reservoir elevation) in order to measure the maximum portion of inflow to the reservoir.

The main components of the system are the telemetric stations and the Data Administration Centre (DAC) in Athens. The telemetric station consists of the sensors, sensor reading unit, data logger, modem and power supply unit (main and backup). The DAC, composed of a computer and a modem, manages the whole network and all data. The Regional Data Control Points (RDCP) near each reservoir are responsible for the supervision of the three telemetric stations of one basin. There are three different data transmission modes: normal, optional and emergency. During normal transmission the data is transported from the data loggers to DAC via telephone network at predefined time periods (for example every 24 hours). Optional transmission is achieved through telephone network but at unscheduled moments from the stations to elsewhere (DAC, RDCP or other external licensed users). Emergency transmission occurs when there is a communication problem between modems. In this case, there is an on site access and the data is entered from the data logger to a laptop computer (part of the local RDCP). Finally the data is transmitted to DAC using several alternative ways.

3. DATA ACQUISITION AND ANALYSIS

In Figure 2 the general scheme of telemetric data acquisition is presented. According to this scheme the ASCII files from the data loggers are transmitted every 24 hours to DAC via telephonic network and stored to a hard disk of a computer. A subprogram (LogToDB) transfers the data from the ASCII files to a relational data base. The subprogram takes into account the correspondence between ASCII files columns and time series identification numbers.

The data stored for a measuring station includes general information (name, location, co-ordinates, type, functioning period), multimedia (photographs, videos), instruments, events (an electronic logbook) and remarks (any information that does not fit into the rest of the fields, from short notes to reports of unlimited length). Each station, several instruments and for each instrument there are several time series. So for each station, the time series for all its instruments, and time series that are not tied to specific instruments (for example, evapotranspiration derived by a method such as Penman, or reservoir surface), are included. For each time series, general information is stored (variable name, time series name, time step, remarks and events). The main temporal resolutions (supported from all applications) are 10-minute, hourly, daily, monthly and yearly. It is also possible to store time series that refer to other geographical entities besides stations (for example areal rainfall refers to a water basin). Time series records have flags in order to signal error conditions or other circumstances, such as range errors, suspect values, snow, values that were originally missing but were calculated, and so on. A software application (Hydrognomon) is used for management and analysis of the various raw data and for producing a large number of derivative time series. The data processing module includes applications that provide a range check facility, time stamp correction (determination and elimination of irregularities), filling of missing values, time series aggregation, construction of stage-discharge curves, calculating discharge time series, statistical analysis and fitting of several probability functions. Several forms have been designed for the easy and effective viewing and management of time series data.

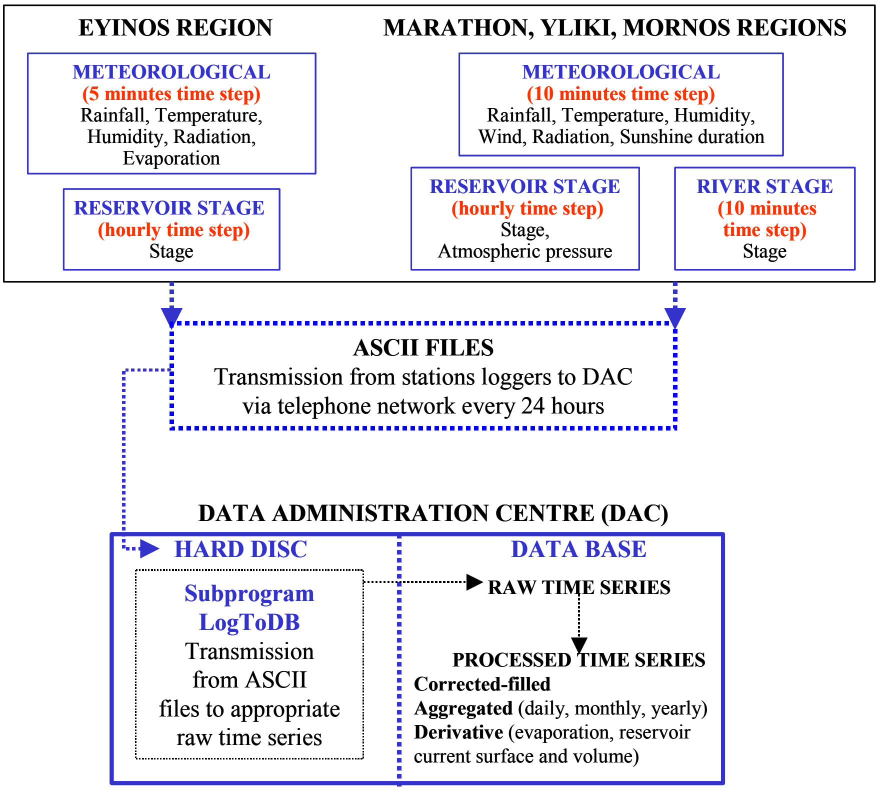

Figure 2 General scheme of telemetric data acquisition

4. DISCUSSION

Efficient hydrometeorological data acquisition is essential for a large number of applications. In this specific project the telemetric data is used for operational, research and public awareness purposes.

The operational needs include the real time quantitative inspection of the evolution of water resources of Athens, the improvement of the estimation of the parameters involved to the water budget of the reservoirs and the feeding of the DSS with reliable hydrometeorological data. The experience of the DSS operation shows that data collection is a harder task than the simulation and optimisation processes or the final results elaboration. The whole decision making procedure has been significantly accelerated, since the telemetric network functions operationally.

The research needs include the exploration of the hydrological and climatic characteristics of the different areas of the water resource system. They also include the comparison of several instruments (conventional, telemetric) in order to standardize the error inspection procedure.

The measuring system also contributes to the public awareness by supplying hydrometerological data and water availability information on the Internet. This information includes real time data, daily report of water availability and consumption and other information such as technical reports.

Finally, the whole procedure for station installation and data acquisition and management has been standardised for easy implementation in other similar networks.

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