Using open source software for the supervision and management of the water resource system of Athens

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1. Abstract

The water supply of Athens, Greece, is implemented through a complex water resource system, extending over an area of around 4 000 km^2 and including surface water and groundwater resources. It incorporates four reservoirs, 350 km of main aqueducts, 15 pumping stations, more than 100 boreholes and 5 small hydropower plants. The system is run by the Athens Water Supply and Sewerage Company (EYDAP)

Over more than 10 years we have developed, information technology tools such as GIS, database and decision support systems, to assist the management of the system. Among the software components, “Enhydris”, a web application for the visualization and management of geographical and hydrometeorological data, and “Hydrognomon”, a data analysis and processing tool, are now free software. Enhydris is entirely based on free software technologies such as Python, Django, PostgreSQL, and jQuery. We also created http://openmeteo.org/, a web site hosting our free software products as well as a free database system devoted to the dissemination of free data.

In particular, “Enhydris” is used for the management of the hydrometeorological stations and the major hydraulic structures (aqueducts, reservoirs, boreholes, etc.), as well as for the retrieval of time series, online graphs etc. For the specific needs of EYDAP, additional GIS functionality was introduced for the display and monitoring of the water supply network. This functionality is also implemented as free software and can be reused in similar projects.

Except for “Hydrognomon” and “Enhydris”, we have developed a number of advanced modeling applications, which are also generic-purpose tools that have been used for a long time to provide decision support for the water resource system of Athens. These are “Hydronomeas”, which optimizes the operation of complex water resource systems, based on a stochastic simulation framework, “Castalia”, which implements the generation of synthetic time series, and “Hydrogeios”, which employs conjunctive hydrological and hydrogeological simulation, with emphasis on human-modified river basins. These tools are currently available as executable files that are free for download though the ITIA web site (http://itia.ntua.gr/). Currently, we are working towards releasing their source code as well, through making them free software, after some licensing issues are resolved.

2. Free software technologies

Our systems are based on well-known, open, robust and widely tested free software technologies. The back-end of our web-based applications such as **Enhydris**, is based on the **PostgreSQL** RDBMS. Geospatial (GIS) functions are provided by the **PostGIS** extension for the PostgreSQL. Server applications are written mainly in **Python**, however some computationally intensive operations such as time series handling are implemented in **C**. Python calls C functions with the help of the **ctypes** interface. Web server applications are based on the **Django** framework while web-GIS is based on **GeoDjango** (django.contrib.gis) with the cooperation of **jQuery** and **OpenLayers** javascript library on the client side. Our server applications are mostly tested on **GNU/Linux**, but they can also run on Microsoft Windows. The server for the Athens Water Supply System Management runs on **Debian GNU/Linux**, with **apache** and **mod_wsgi**.

Our standalone applications (free and non-free) are currently based on proprietary software technologies, mainly on the Delphi computer language, however we are trying to adopt free software technologies such as **Qt** and **PyQt** for our future releases of standalone programs.

3. Source code – Documentation - License

The source code for our free applications such as **Enhydris** and **Hydrognomon**, is hosted under the **openmeteo.org** website; **openmeteo.org** is a project devoted to the development of free hydrological and meteorological software and to the collection and distribution of free hydrological and meteorological data. The developer site, made with **trac**, is at:

http://openmeteo.org/code/

The whole source code repository can be downloaded with a **Mercurial** command:

hg clone http://openmeteo.org/openmeteo/

The documentation of **Enhydris**, with installation instructions is built with **Sphinx** and can be found at:

http://openmeteo.org/doc/

Our free software is licensed under **GPL licenses**. More specifically, **Enhydris** is available under the **GNU Affero General Public License version 3** or any later version; the rest of the software (**Hydrognomon** and some libraries of **Enhydris**) is available under the **GNU General Public License version 3** or any later version.

4. Enhydris

The core of the information system for the management of the water resources system of Athens is the **Enhydris** server software application. *Enhydris* is a database system for the storage and management of hydrological and meteorological data. It allows the storage and retrieval of raw data, processed time series, model parameters, curves and meta-information such as measurement stations overseers, instruments, events etc. The database is accessible through a web interface, which includes several data representation features such as tables, graphs and mapping capabilities. Data access is configurable to allow or to restrict user groups and/or privileged users to contribute or to download data. With these capabilities, *Enhydris* can be used either as a public repository of free data or as a secured – restricted system for data storage. Time series can be downloaded in plain text format that can be directly loaded to *Hydrognomon*. More information on *Enhydris* can be found on its own web site:

http://openmeteo.org/enhydris/

as well as to the 2011 EGU poster presentation about *Enhydris*:

http://itia.ntua.gr/1120

5. The information system

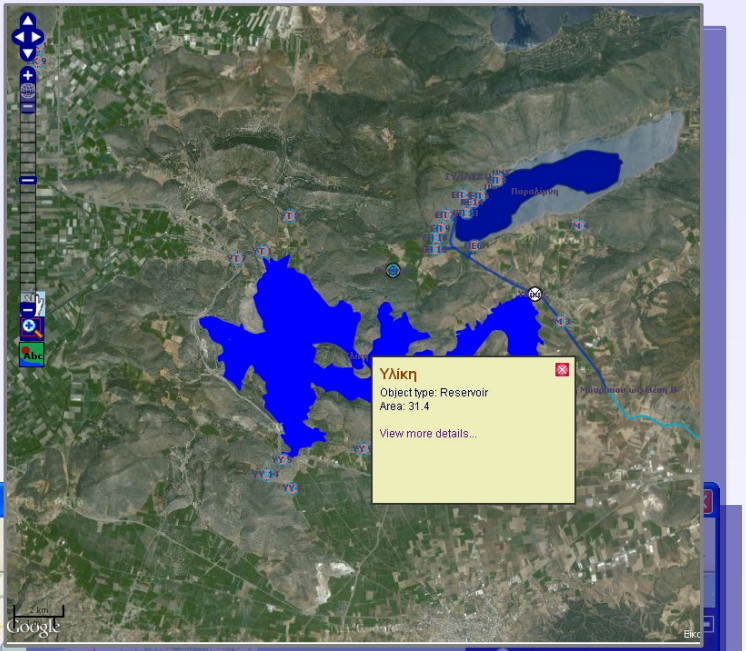
We made a special setup of *Enhydris* and customized the system for the needs of the Athens Water Supply and Sewerage Company (EYDAP). The information system contains data and time series of the components of the water resource system comprising reservoirs, boreholes, aqueducts, pumping stations, small hydropower plants, water treatment plants (WTP), as well as measurement equipment, such as meteorological stations etc. The web address to access the information system is:

http://itia.ntua.gr/eydap/db/

The style-sheet of *Enhydris* as well as the web templates are configured to match the EYDAP main web page design (see image on the right). The *Enhydris* multilingual environment allows the web pages to be available in Greek for EYDAP employees and customers as well as in English for the international public. Data availability to the public is configured by the administrators of the system. Only privileged users can add new content to the service and edit data. The main web page of the service (right) has the appropriate links to browse the components of the hydrosystem, to download data and to draw dynamic maps. Some static links are also included to access important documents, software downloads (e.g. *Hydrognomon*) etc.

6. The Geographical Information System (GIS)

An integrated GIS in the *Enhydris* system based on the PostGIS and OpenLayers visualizes the network components such as aqueducts, reservoirs, pumps and boreholes as well as the meteorological station positions. The user can produce customized – dynamic maps and easily browse the entities.



Structures list

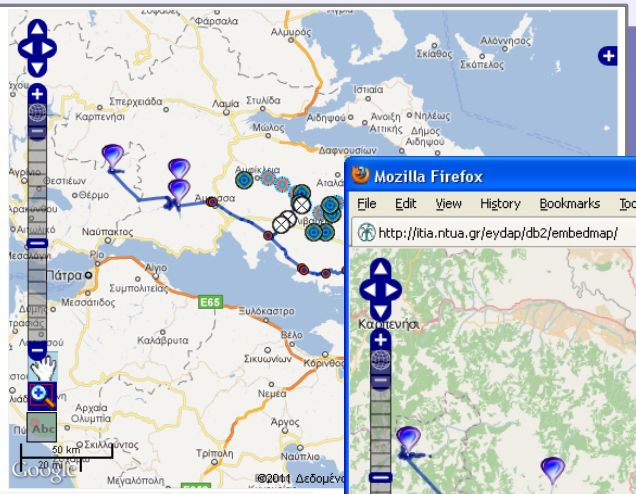
Entity type: Αντλιοστάσιο

Display entities with time series only

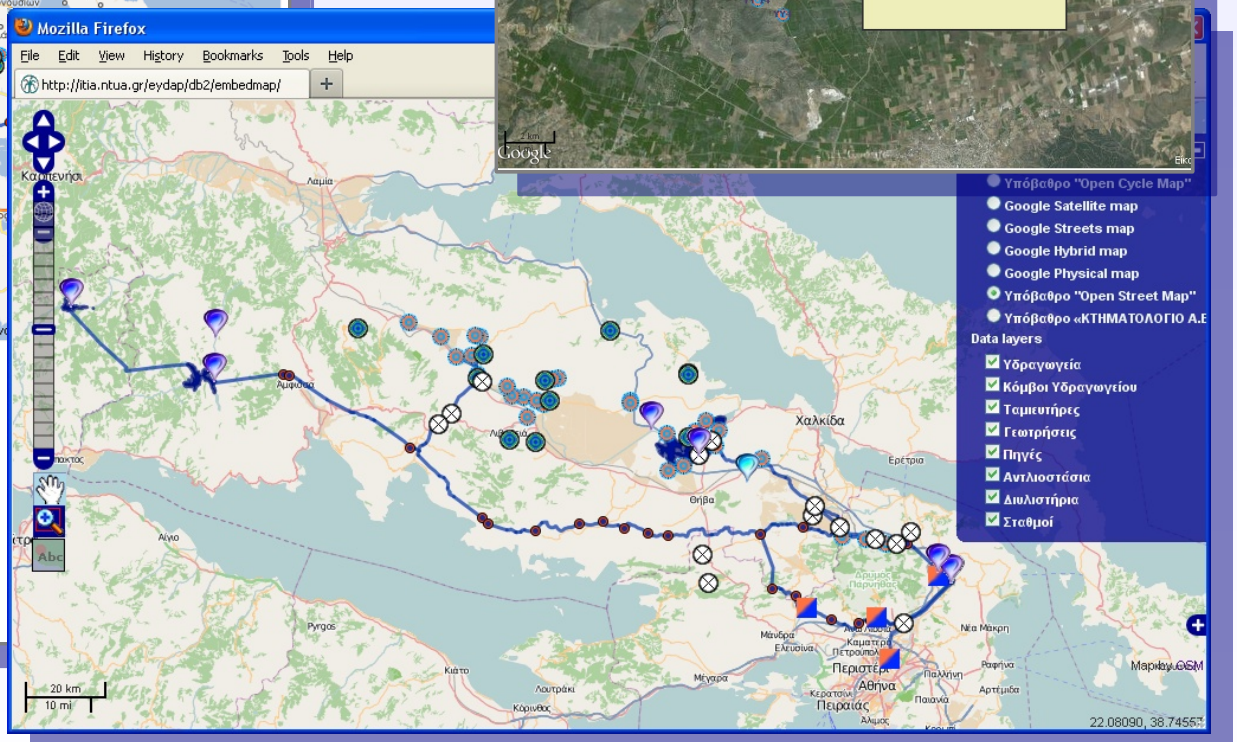
Submit

Search structures by name, description, etc.

Search



id	Name	Water Basin	Political Division	Type	Extra information
7776	ΥΥ 9			Γεώτρηση	Borehole group: Ν.Δ. Υλίκης
7786	ΥΥΣ2			Γεώτρηση	Borehole group: Μουρικίου
7796	ΧΡ1			Γεώτρηση	Borehole group: Β.Α. Πάρνηθας
7798	ΧΡ2			Γεώτρηση	Borehole group: Β.Α. Πάρνηθας
7805	ΧΡ3			Γεώτρηση	Borehole group: Β.Α. Πάρνηθας
7797	ΧΡ4			Γεώτρηση	Borehole group: Β.Α. Πάρνηθας
7847				Αντλιοστάσιο	
7846				Αντλιοστάσιο	
7845	BALCKE			Αντλιοστάσιο	Pump active
7839	No 1			Αντλιοστάσιο	Pump active
7840	No 2			Αντλιοστάσιο	Pump active
7835	No 3			Αντλιοστάσιο	Pump active



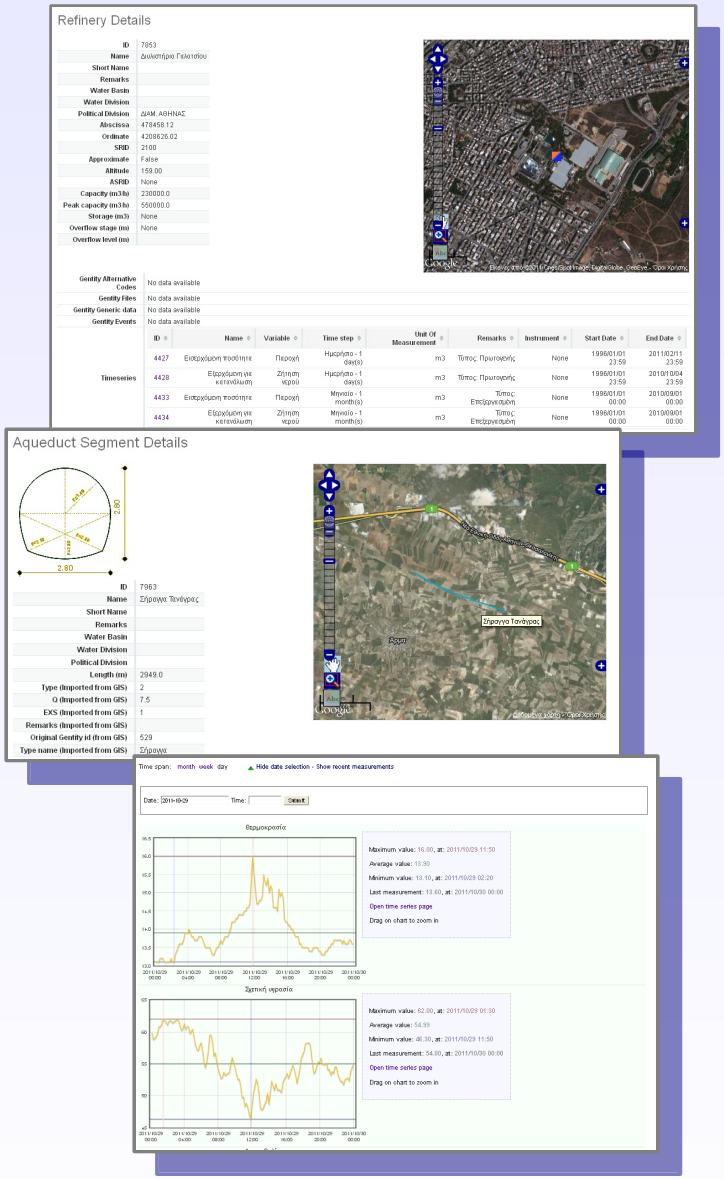
7. Components – time series – online data

Enhydris is extensible. It is this extensibility that has made it possible to add aqueducts, WTP, reservoirs, and so on, when the only object type supported by the core of *Enhydris* is the measuring station. These new types have been added as a separate add-on, without needing to touch the core of the application.

For each of the network components and stations, several descriptive and quantitative information is stored to help organize the data and also to help the supervision of the water resources system. Information fields can be of general interest such as names, locations, remarks etc.

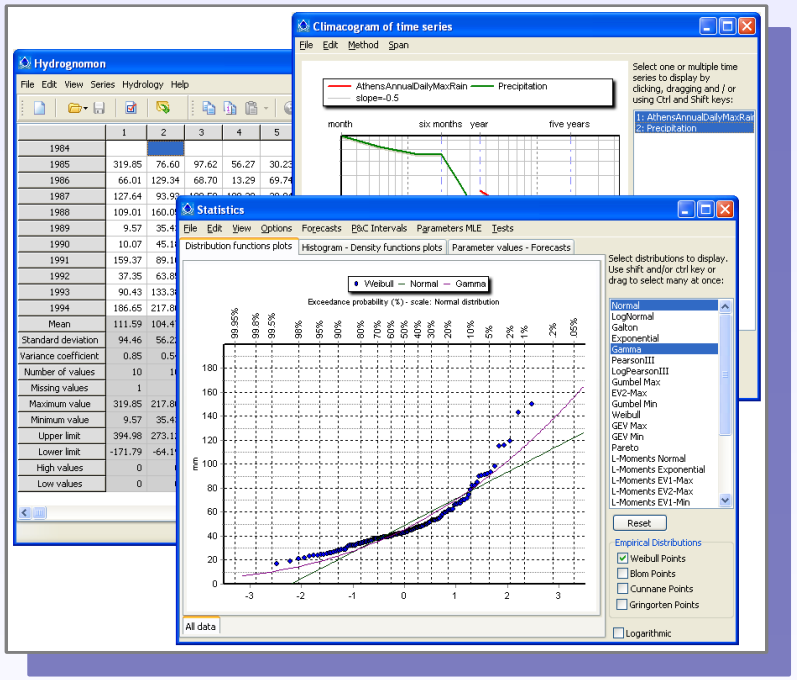
For most entities, time series can be stored as well as curves (like elevation – storage curves of reservoirs), logs of events, and multimedia items like photos and videos.

Time series can be uploaded by privileged users or created and updated automatically. With the **loggertodb** script, bundled with our software applications, the automatic retrieval of online data and storage to the database is possible. In the current setup, four (4) automatic meteorological stations are connected with GSM modems. Monitoring of online data is implemented with a charting web-application (right). It is of course possible to download time series in plain text format for further processing in *Hydrognomon* or any other software. The automatic update of data is completed with operations such as time series aggregation etc.



8. Standalone applications

The management and the supervision of the Athens water resources system is completed by a series of standalone applications. These applications are used for the time series processing (*Hydrognomon*) as well as for the stochastic simulation, the geo-hydrological simulation of river basins, and the simulation and optimization of the water resources system (*Castalia*, *Hydrogeios* and *Hydronomeas*).



With **Hydrognomon** (see left), numerous kinds of analysis and processing of hydrological data can be performed, such as time step aggregation and regularization, interpolation, regression analysis and infilling of missing values, consistency tests, data filtering, graphical and tabular visualization of time series, statistics, and more. *Hydrognomon* is free software and the source code is available through the website of the **openmeteo.org** project.
The *Hydrognomon* web site is:

http://hydrognomon.org/

The rest of the applications (*Castalia*, *Hydrogeios* and *Hydronomeas*) are free for download and use, however the source code cannot be publicly released until some licensing issues are resolved. The link for more information and download of the applications is:

http://itia.ntua.gr/en/software/

Information system:

http://itia.ntua.gr/eydap/db/

Poster download:

http://itia.ntua.gr/1201