# Using open source software for the supervision and management of the water resource system of Athens European Geosciences Union (EGU) General Assembly, Vienna, Austria, 22 - 27 April 2012 **Session HS3.3: Poster Session on Open Source Computing in Hydrology**



### 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<sup>2</sup> 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 backend 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

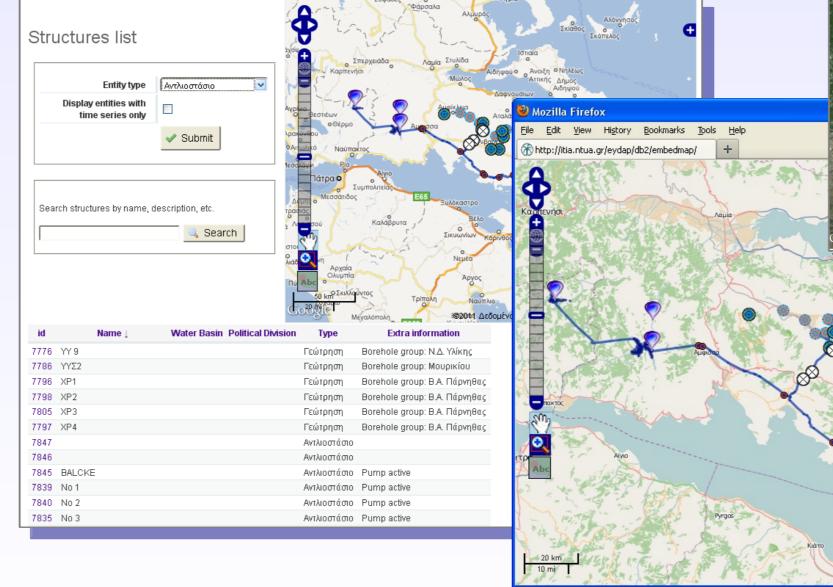
*Enhydris* is extensible. It is this extensibility that The core of the information system for the management of the water resources system of Athens is the has made it possible to add aqueducts, WTP, Enhydris server software application. Enhydris is a database system for the storage and management of Name Διυλιστήρια Γαλατσ reservoirs, and so on, when the only object type hydrological and meteorological data. It allows the storage and retrieval of raw data, processed time series, supported by the core of Enhydris is the model parameters, curves and meta-information such as measurement stations overseers, instruments, measuring station. These new types have been events etc. The database is accessible through a web interface, which includes several data representation Approximate False added as a separate add-on, without needing to features such as tables, graphs and mapping capabilities. Data access is configurable to allow or to restrict Altitude 159.00 touch the core of the application. apacity (m3/h) 230000.0 user groups and/or privileged users to contribute or to download data. With these capabilities, Enhydris can be ak capacity (m3/h) 550000.0 Storage (m3) None used either as a public repository of free data or as a secured – restricted system for data storage. Time verflow stage (m) None Overflow level (m) For each of the network components and series can be downloaded in plain text format that can be directly loaded to Hydrognomon. More information stations, several descriptive and quantitative on *Enhydris* can be found on its own web site: Gentity Files No data availab information is stored to help organize the data http://openmeteo.org/enhydris/ and also to help the supervision of the water as well as to the 2011 EGU poster presentation about *Enhydris*: resources system. Information fields can be of general interest such as names, locations, http://itia.ntua.gr/1120 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 5. The information system like photos and videos. Name Σήραγγα Τανάγρας Short Name Water Basin e span: month week day 💦 🔺 Hide date selection - Show recent measurements Water Division We made a special setup of *Enhydris* and customized the system for the needs of the Athens Water Supply Time series can be uploaded by privileged users Political Division Length (m) Date: 2011-10 and Sewerage Company (EYDAP). The information system contains data and time series of the components or created and updated automatically. With the of the water resource system comprising reservoirs, boreholes, aqueducts, pumping stations, small **loggertodb** script, bundled with our software EXS (Imported from GIS) aximum value: 16.00, at: 2011/10/29 11:50 hydropower plants, water treatment plants (WTP), as well as measurement equipment, such as Driginal Gentity id (from GIS) Average value: 13.90 applications, the automatic retrieval of online (vpe name (Imported from GIS) Minimum value: 13.10, at: 2011/10/29 02:20 meteorological stations etc. The web address to access the information system is: Last measurement: 13.60, at: 2011/10/30 00:00 data and storage to the database is possible. In Open time series page Drag on chart to zoom in the current setup, four (4) automatic http://itia.ntua.gr/eydap/db/ meteorological stations are connected with GSM The style-sheet of *Enhydris* as well as modems. Monitoring of online data is Ελληνικά 💌 🔄 Go Σχετική υγρασία the web templates are configured to implemented with a charting web-application Maximum value: 62.00, at: 2011/10/29 01:30 match the EYDAP main web page Average value: 54.99 (right). It is of course possible to download time Minimum value: 46.30, at: 2011/10/29 11:50 design (see image on the right). The Last measurement: 54.80, at: 2011/10/30 00:00 series in plain text format for further processing in Open time series page Enhydris multilingual environment Drag on chart to zoom in Hydrognomon or any other software. The allows the web pages to be available υο της ΕΥΔΑΠ, λογισμικά για την διαχείριση του συστήματος καθώς και σχετικά έγγραφα automatic update of data is completed with in Greek for EYDAP employees and κεντρωτικά υλικό που αφορά τη διαχείριση σης της Αθήνας αρμοδιότητας της Ε operations such as time series aggregation etc. customers as well as in English for **ακτηριστικά του δικτύου** που απαρτίζετα <u>γές, αντλιοστάσια/ΥΗΣ, διυλιστήρια</u> και <u>κόμβου</u> the international public. Data ιστήματος της ΕΥΔΑΠ είναι καταχωρημέν γν ΥΠΕΧΩΔΕ) της ευρύτερης γεωγραφικ availability to the public is configured χρονοσειρές πρωτογενών και επεξεργασμένων by the administrators of the system. αθώς επίσης και χρονοσειρές συνιστωσών του Only privileged users can add new <u>εδομένα διυλιστηρίων</u> και <u>ταμιευτήρων</u> δες του <u>Εύηνου</u>, του <u>Μόρνου</u>, 8. Standalone applications content to the service and edit data. ιακό τόπο και προσφέρουν περαιτέρω δυνατότητές επεξεργασίας υδρολογικών δεδομένων καθώς The main web page of the service ισμό με σύστημα διαχείρισης υδρολονικών δεδομένα The management and the supervision of the Athens water resources system is completed by a series of (right) has the appropriate links to ) ανάλυσης και επεξεργασίας υδρολογικών δεδομένων. Μπορεί να χρησιμοποιηθεί και σε συνδιασμό standalone applications. These applications are used for the time series processing (Hydrognomon) as well as θείας λήψη και προβολή υδρολογικών δεδομένων. browse the components of the είο για τη διαχείριση σύνθετων συστημάτων υδατικών πόρα for the stochastic simulation, the geo-hydrological simulation of river basins, and the simulation and φορά έγγραφα και παρουσιάσεις σχετικά με τα <u>ερευνητικά του ΕΜΠ για την ΕΥΔΑΠ</u> hydrosystem, to download data and to optimization of the water resources system (Castalia, Hydrogeios and Hydronomeas). draw dynamic maps. Some static links are also included to access important With Hydrognomon (see left), numerous documents, software downloads (e.g. Επικοινωνία · Δημιουργοί <u>ΒΜΠ</u> και ΕΥΔΑΠ ΑΕ · Powered by Enhydris 🤬 kinds of analysis and processing of limacogram of time series Hydrognomon) etc. Edit Method Span hydrological data can be performed, such as /drognomon Select one or multiple time series to display by clicking, dragging and / or using Ctrl and Shift keys: File Edit View Series Hydrology Help AthensAnnualDailyMaxRain —— Precipitation time step aggregation and regularization, i 🗁 🔒 🖬 👒 🕴 📭 👘 👘 interpolation, regression analysis and six months year five years 1 2 3 4 5 infilling of missing values, consistency tests, 6. The Geographical Information System (GIS) 19.85 76.60 97.62 56.27 3 data filtering, graphical and tabular 66.01 129.34 68.70 13.29 visualization of time series, statistics, and ile Edit View Options Forecasts P&C Intervals Parameters MLE Tests An integrated GIS in the *Enhydris* system based on the PostGIS more. *Hydrognomon* is free software and the ribution functions plots Histogram - Density functions plots Parameter values - Forecasts Select distributions to displa and OpenLayers visualizes the network components such as Use shift and/or ctrl key or source code is available through the website • Weibull — Normal — Gamma drag to select many at one Exceedance probability (%) - scale: Normal distributi aqueducts, reservoirs, pumps and boreholes as well as the of the **openmeteo.org** project. 99.95% 99.5% 99.5% 90.% 90.% 90.% 10% 10% 10% 10% 10% 10% 10% 10% meteorological station positions. The user can produce The *Hydrognomon* web site is: customized - dynamic maps and easily browse the entities. Gumbel Max Cumbel Max Gumbel Min Weibull GEV Max GEV Min Pareto L-Moments Normal http://hydrognomon.org/ Missing values Maximum value Minimum value Upper limit Lower limit High values 394.98 273 The rest of the applications (Castalia, Structures list 25 A L-Moments Exponenti L-Moments EV1-Max L-Moments EV2-Max L-Moments EV1-Min Hydrogeios and Hydronomeas) are free for Low values Entity type Αντλιοστάσιο download and use, however the source Display entities with Reset time series only code cannot be publicly released until some Empirical Distributio Veibull Points licensing issues are resolved. The link for Blom Points Cunnane Points more information and download of the Grindorten Point ch structures by name, description, e applications is: 🔍 Search http://itia.ntua.gr/en/software/ Google Hybrid map Google Physical map Υπόβαθρο "Open Street Map" Υπόβαθρο «ΚΤΗΜΑΤΟΛ

🗹 Κόμβοι Υδραγωγεί

☑ Ταμιευτήρες ☑ Γεωτρήσεις ☑ Πηγές

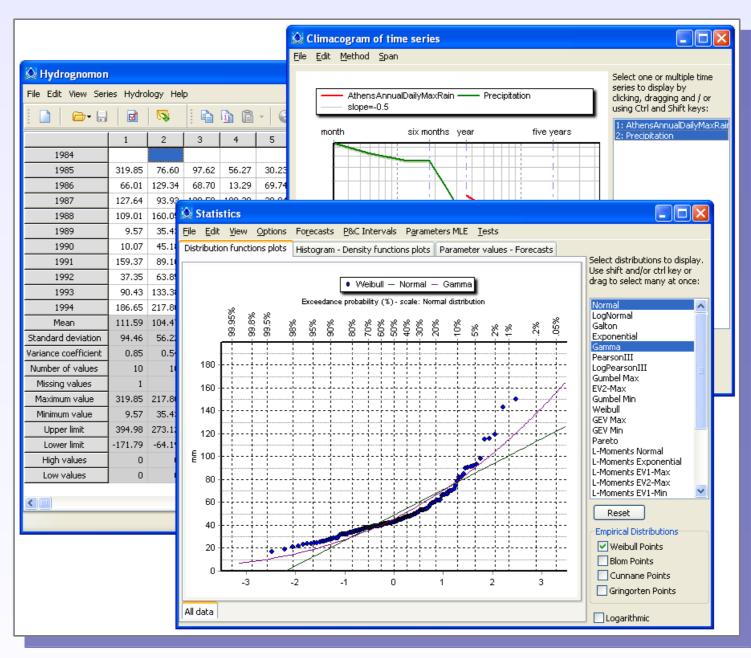
Αντλιοστάσια
 Διυλιστήρια
 Σταθμοί

ΘΕΥΔΑΠ	
Υδρολογικά δεδομένα	
Σταθμοί	Δεδομένα από το μετρητικό δίκτυ
Yõpoµεтрікоі	Ο παρών δικτυακός τόπος παρουσιάζει σ του συστήματος υδατικών πόρων ύδρε όπως έχει προκύψει από ερευνητικά προ
Σταθμημετρικοί	Συγκεκριμένα, παραθέτει τα βασικά <b>χαι</b> από: <u>ταμιευτήρες, υδραγωνεία, γεωτρήσεις, τ</u> Εκτός από τα δεδομένα του μετρητικού
Μετεωρολογικοί	σταθμοί και άλλων φορέων (π.χ. του π; περιοχής του δικτύου, Όλες οι συνιστώσ διαδραστικό χάρτη.
Δίκτυο	Τα υδρολογικά δεδομένα αφορούν δεδομένων των σταθμών πολλά από αυτοματοποιημένα με σύστημα τηλεμετρίκ δικτύου όπως <u>στάθμες υπόγειων υδροφορέων</u>
<b>Ταμιευτήρες</b>	ισοζυγίου ταμιευτήρων δίνονται από τι Μα <u>ραθώνα</u> και της <u>Υλίκης</u> . Επίσης δίνοντ διαγράμματος.
Υδραγωγεία	Τα <b>λογισμικά</b> που υποστηρίζουν τον δι και προσμοίωσης της διαχείρισης υδροσυ
Γεωτρήσεις	<ul> <li>Ενυδρίς, Βάση δεδομένων σε συνδ</li> </ul>
Πηγές	<ul> <li><u>Υδρογνώμων</u>. Εξελιγμένο λογισμικ με το σύστημα Ενυδρίς για την απ</li> </ul>
Αντλιοστάσια/ΥΗΣ	<ul> <li><u>Υδρονομέας</u>, Επιχειρησιακό εργαλε</li> </ul>
Διυλιστήρια	Επίσης παρατίθεται περαιτέρω υλικό που
Κόμβοι	
	Copyright 2003 - 2012 EY&AN AE

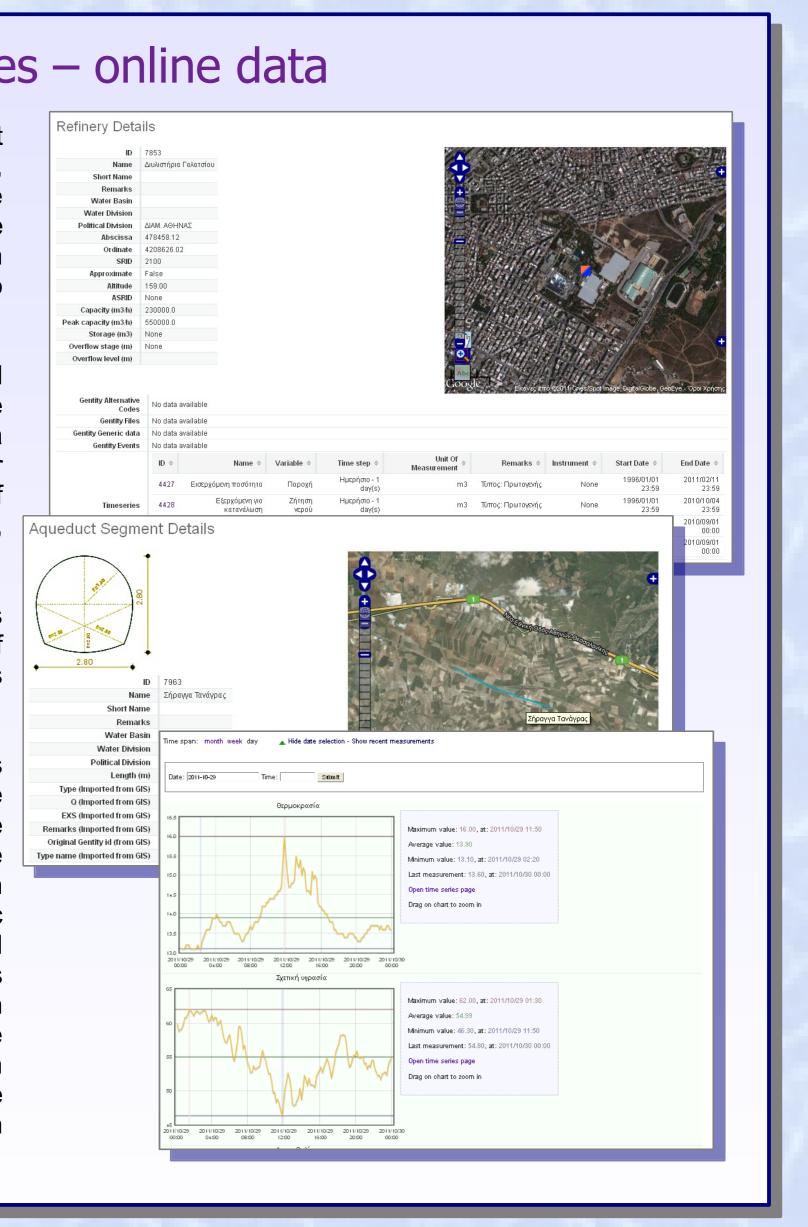


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### 7. Components – time series – online data



Poster download:



Information system: <a href="http://itia.ntua.gr/eydap/db/">http://itia.ntua.gr/eydap/db/</a> http://itia.ntua.gr/1201