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Strategic plan for establishing a national-scale hydrometric network in Greece: challenges and perspectives

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Presentation available online: www.itia.ntua.gr/1937/

Motivation: Status of hydrometric data in Greece

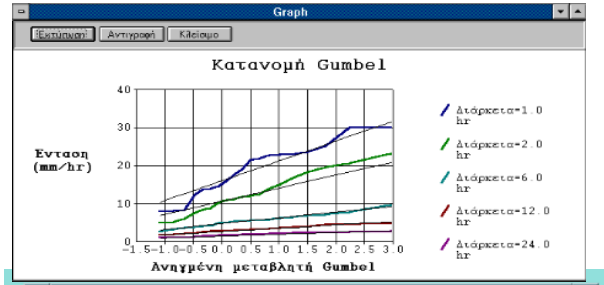
Overview of water monitoring infrastructure in Greece:

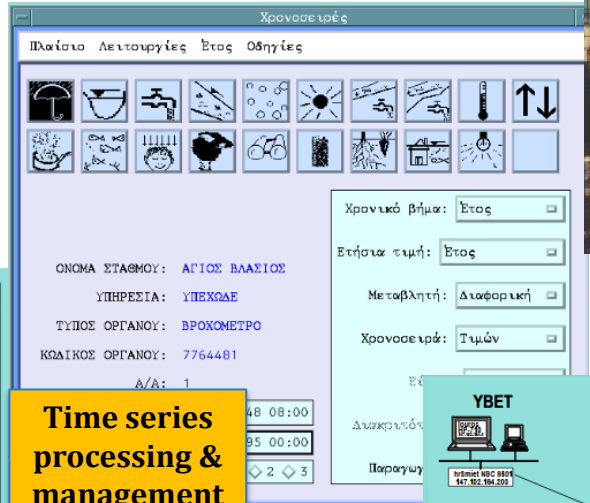
- Significant portion of hydrometric stations that are operated by public organizations are abandoned or not maintained efficiently;
- Data monitoring and management technologies are generally outdated;
- Many sections are not suitable for establishing reliable stage-discharge relationships or such data are missing, thus making impossible to extract flows on the basis of observed stage data ;
- Access to raw observations is hard or impossible;

Encouraging exceptions:

- Few yet well-monitored stations, operated by the Public Power Corporation, in rivers associated with hydroelectric development;
- Increasing number of automatic monitoring systems, mostly developed within research initiatives, which are yet subject to the limited budget and duration of the associated projects;
- Recent establishment of a systematic monitoring program, focused to water quality characteristics of surface water bodies (not to flows), following the obligations imposed by the 2000/60/WFD.

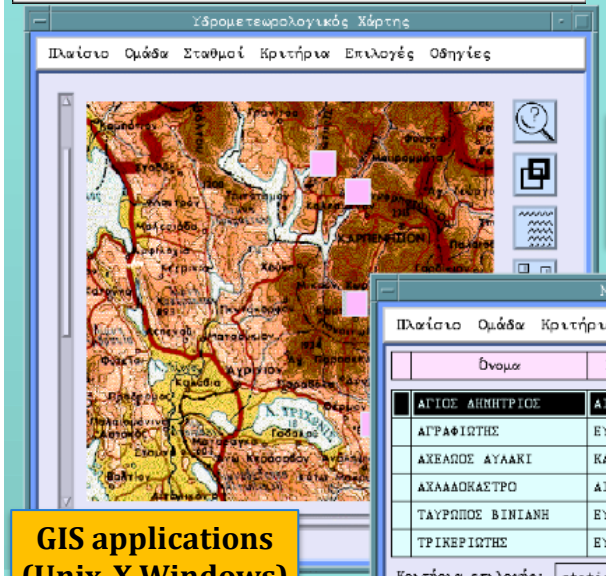
Hydroscope: Early efforts for organizing hydrological data in Greece (mid '90s)



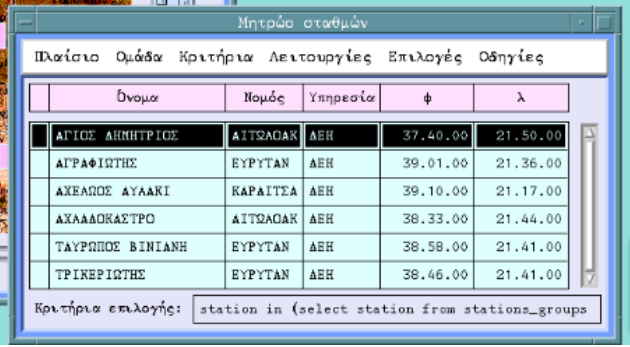


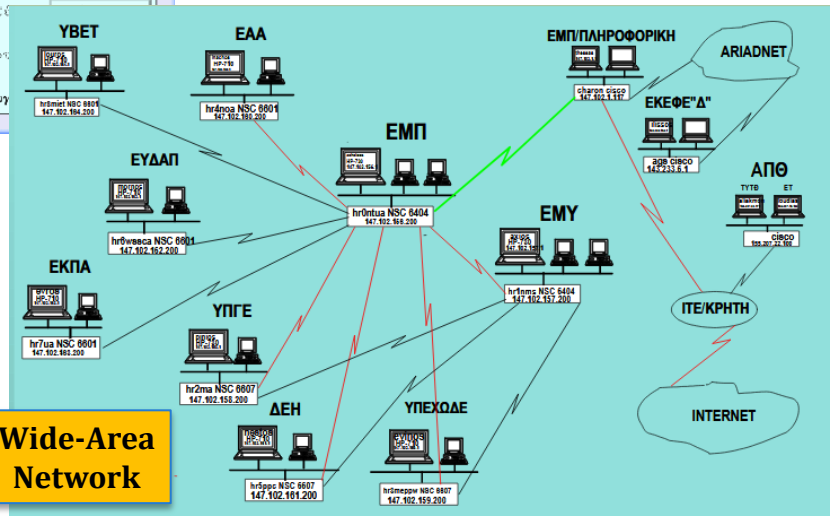
First telemetric meteorological station in Greece (NTUA campus, 1994)

Time series processing & management



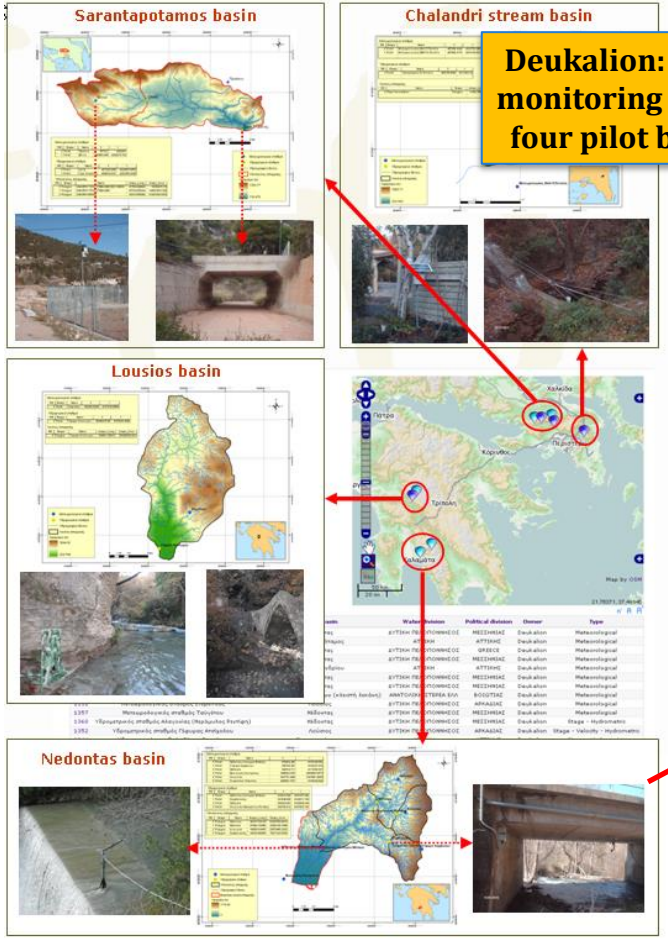
GIS applications (Unix-X Windows)



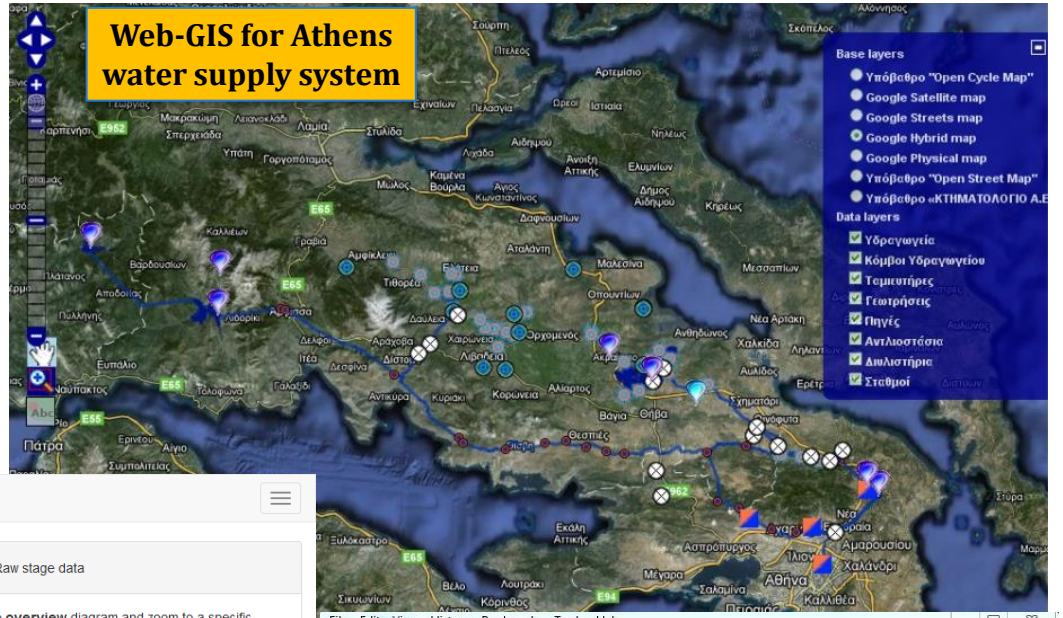


Wide-Area Network

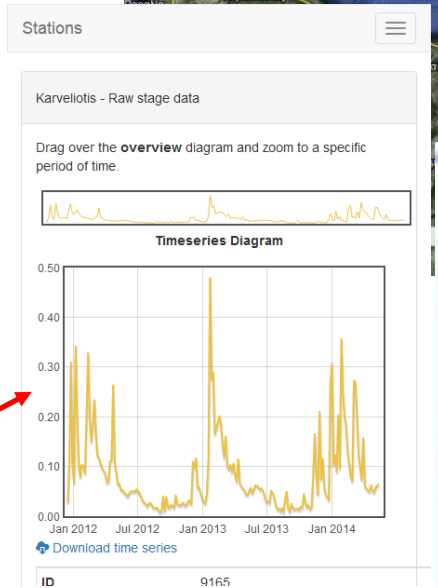
Recent research initiatives

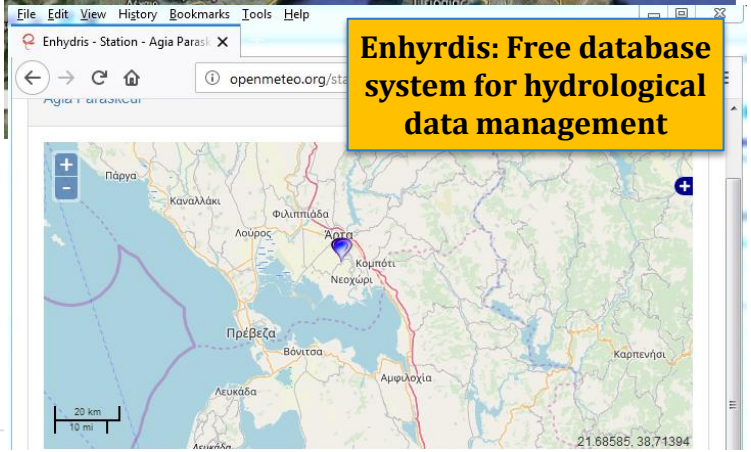


Deukalion: Flood monitoring across four pilot basins



Web-GIS for Athens water supply system





Enhyrdis: Free database system for hydrological data management

ESFRI "Hellenic Integrated Marine Inland water Observing, Forecasting and offshore Technology System"

- Launched in January 2018 (three-year preparatory phase; full RI duration seven years)
- Host Institute: Hellenic Centre of Marine Research
- Partners: 6 academic and 3 research institutes
- Included in the National Roadmap for Research Infrastructures (2014)
- Comprises **two district research infrastructures**, for marine and inland (surface) waters, respectively:
  - Hellenic Integrated Marine Observing and Forecasting System (HIMOFS)
  - Open Hydrosystem Information Network (OpenHi.net)
- **Web page**: http://imbriw.hcmr.gr/en/himiofots/

Overall concept of HIMIOFoTS: Open research network, providing free access to monitoring infrastructure and data

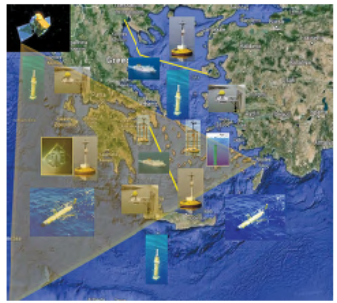
Greek Roadmap for Research Infrastructures

Hellenic Integrated Marine and I
Observing, Forecasting and offsh
System (HIMIOFoTS)

The Hellenic Integrated Marine Inland water Observing, Forecasting and offshore Technology System (HIMIOFoTS) includes integrated approaches in Marine observation and forecasting systems, coastal monitoring, an innovative Hydro-Environmental Monitoring and information Network and also a world class Marine land-based facility for testing and marine engineering (deep water multifunctional tank). The infrastructure incorporates three interrelated components:

1. The Hellenic Integrated Marine Observing and Forecasting System (HIMOFS) is essentially a cluster of already-existing (or under-implementation) observation offshore and coastal systems (buoys, profilers, gliders, Ferrybox systems, HF radars, drifters, sea level stations, cabled platforms) coupled with a full range of forecasting operational models. HIMOFS will be coordinated by the Institute of Oceanography of the Hellenic Centre for Marine Research (HCMR), which operates the POSEIDON Operational Oceanography System for almost fifteen years and participates in European Infrastructure networks such as the ESFRI's EUROARGO floating drifters and the EMSO cabled seabed observatories with the relevant Greek nodes (Greek Argo, Hellenic-EMSO). A coastal component (Environmental Monitoring and Management of Coastal Zone) intends to compile an effective and readily available monitoring and sampling system. The overall challenge is the creation of a solid and transparent organisation towards an operational service for the timely, continuous innovative observation and sustainable delivery of high quality environmental data, forecasting capabilities and information products related to the offshore and coastal environment of the East Mediterranean Sea.
2. The Open Hydrosystem Information Network will integrate and harmonise the information provided by the National Hydro-Environmental inland water Monitoring Network (NHEMN) under an open-access platform with appropriate web services with semantic intelligence, accompanied by web applications with GIS functionality for data visualization, processing and modelling. Under this platform that focuses on inland water resources, existing measuring systems, currently operated by authorised organisations and individuals will be integrated, and also new stations will be deployed by taking advantage of modern, low-cost technologies for remote control. These will be strategically distributed to provide critically needed but scarce data, especially for the implementation of the legal obligations of Greece towards the EU (e.g. river flows, lake and reservoir stages, inflows from transboundary basins, and water withdrawals across major hydrosystems).
3. A world class Marine land-based offshore basin testing facility (deep-water multifunctional wave tank) for marine and offshore technology applications to cover scaled-down physical model test campaigns that are required to produce new solutions, both for the marine research and the marine & offshore technology fields of application (including maneuverability and sea keeping of special-purpose ships) in a multi-disciplinary and holistic design approach which will be developed.

The RI is linked to the ESFRI-EU facilities of EMSO and EuroArgo, and also to the I3 facilities of JERICO and FixO3. Additionally, HIMIOFoTS will make a significant contribution to the RD&I ecosystem since the observation systems and forecasting models will be upgraded to carry out excellent science through the adoption of cutting-edge marine technologies, innovative sensors and methodological approaches. The RI will further enhance the RD&I ecosystem through its implementation of EU policies such as Horizon 2020, WFD, MSFD and ICZM.



Open Hydrosystem Information Network (OpenHi.net)

Key research tasks:

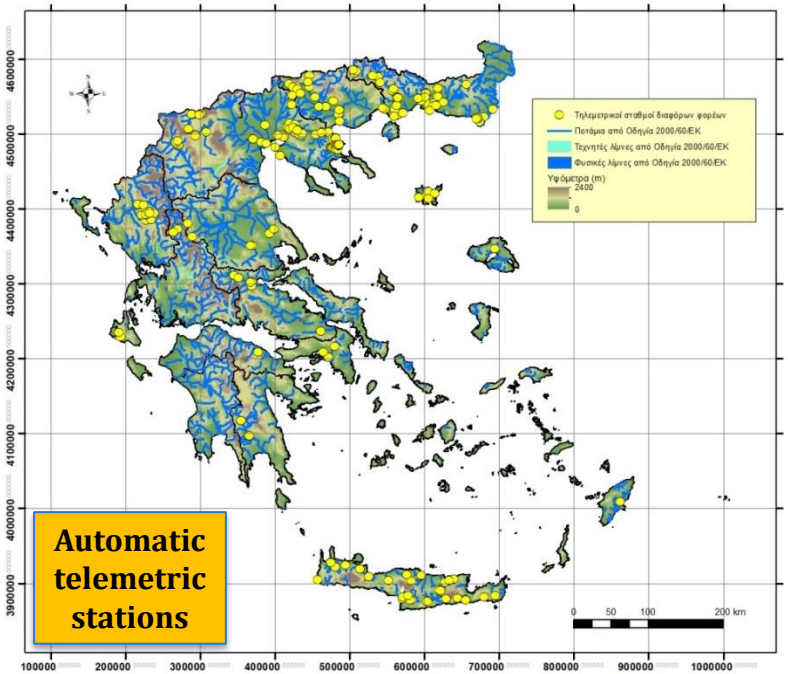
- Recording and evaluation of existing gauging infrastructure;
- Elaboration of strategic plan for establishing a national monitoring network for quantitative and qualitative characteristics of surface water bodies;
- Organization of associated spatial and operational data;
- Configuration of a topologically consistent hydrographic network at the national scale;
- Development of a web-platform for data processing and management;
- Development of smart, low-cost hydrometric and telemetric technologies;
- Installation of pilot stations (including third-party stations) and their integration to OpenHi.net;

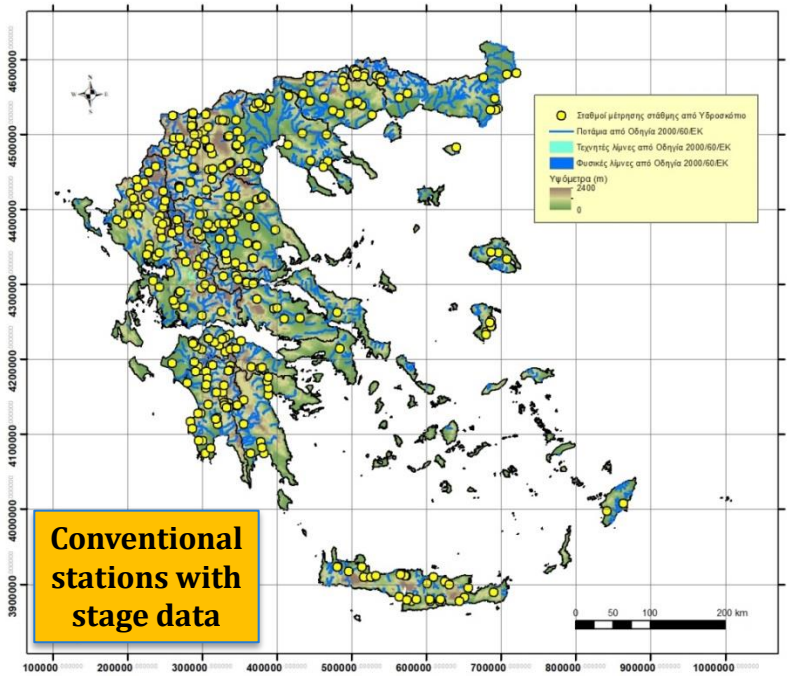
OpenHi.net consortium:

- Department of Water Resources & Environmental Engineering, National Technical University of Athens
- Institute for Environmental Research & Sustainable Development, National Observatory of Athens
- Institute of Marine Biological Resources & Inland Waters, Hellenic Centre for Marine Research
- Institute of Communication & Computer Systems, National Technical University of Athens
- Department of Agricultural Technology, Technological Educational Institute of Epirus

Geodatabase of monitoring sites

- Listing of all state and private organizations involved with monitoring and management of water quantity and quality (personal contacts and surveys);
- Listing of hydrometric stations, including abandoned monitoring sites and stations with sparse data;





- Extraction of a short list comprising stations located across the main hydrographic network of Greece (as defined within 2000/60/WFD);
- Organization of key station data in a web-GIS, also establishing consistency with the topological model of the **national hydrographic network**.

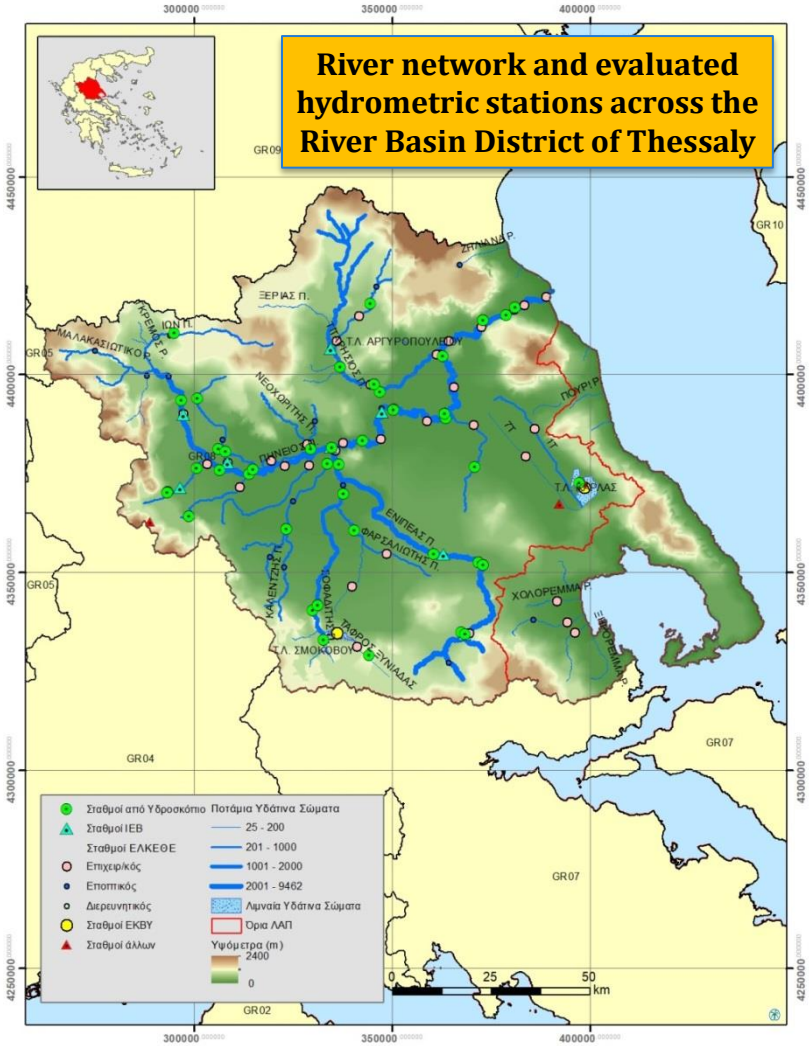
Evaluation approach

Stations of high priority:

- Stations in operation & under systematic supervision;
- Automatic telemetric stations;
- Stations installed at hydraulically suitable sites;
- Stations with long and reliable data;
- Stations of historical interest;
- Stations located in areas under hydrological and environmental stresses (e.g., flood prone zones);

Evaluation criteria:

- River section geometry and hydraulic properties;
- Instruments (technology, age, maintenance);
- Length and quality of observed data;
- Frequency and reliability of flow measurements;
- Accessibility and telecommunication facilities;
- Risk exposure to natural disasters and vandalisms;



Examples of station evaluation

Sarakina bridge @ Peneios river

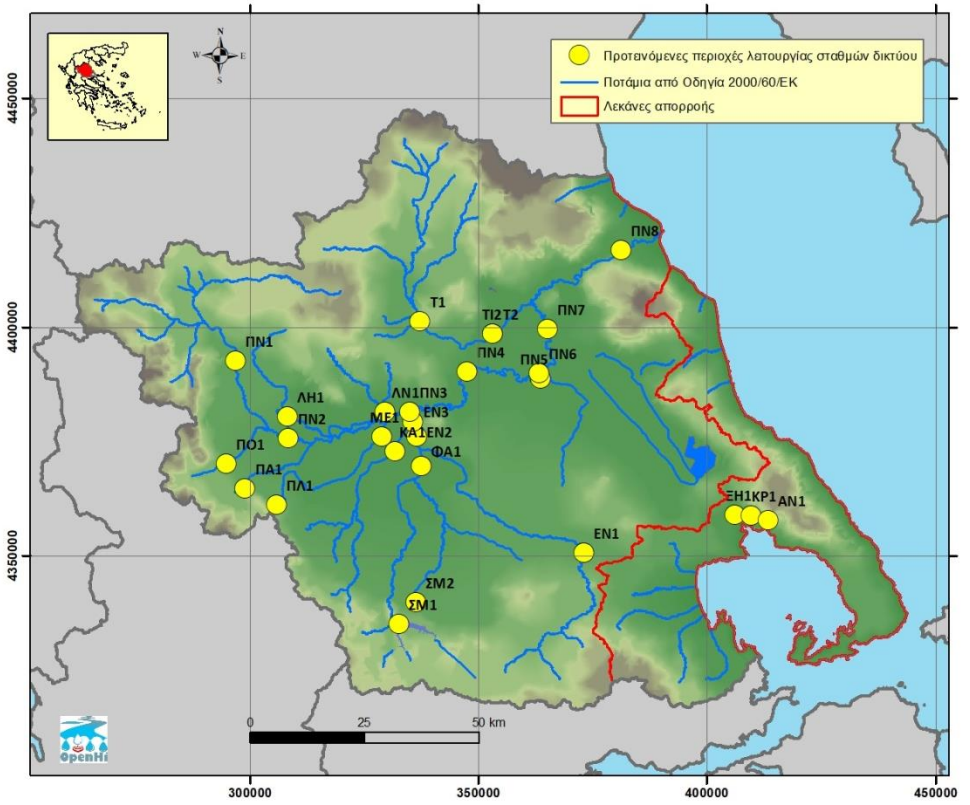
- Two hydrometric stations, established in 1950 and 1966, by different authorities, equipped with conventional instruments;
- Inappropriate hydraulic conditions (meandering river, separated flow, unstable section due to sediment deposits);
- Historical stage data contains shifts and gaps, estimated flows at daily basis are little reliable;
- Controls the upper course of Peneios (1070 out of 9500 km^2);
- **Recommendation**: important station, to be upgraded and transferred downstream, in a more appropriate site

Anthili bridge @ Spercheios river

- Recently installed automatic telemetric station, measuring water level and quality characteristics (temperature, dissolved oxygen, electrical conductivity, pH, salinity) at 15-min intervals;
- Good hydraulic conditions (lined, stable, relatively narrow section);
- Easily accessible (adjacent to the national road network);
- Controls significant portion of runoff produced by the river basin;
- **Recommendation**: to be included in the national monitoring network (station data are available via the OpenHi.net platform)

Strategic planning towards a national monitoring network

- Identification of high-priority sites for installing automatic monitoring stations;
- Hierarchical multicriteria approach, aiming to cover all major water bodies of Greece (rivers, lakes, reservoirs), as well as smaller rivers of specific interest (e.g., urban rivers);
- The national hydrometric network will include existing stations (to be upgraded, if necessary) and new sites, to be equipped with modern monitoring infrastructure;
- Site-selection is indicative, since the exact allocation of (new) stations will require detailed technical studies and in situ visits (this task is planned for a next phase of RI);
- In its full extent, the national network will comprise 250-300 operational stations, to be integrated within OpenHi.net.



Recommended sites for strategic development of telemetric hydro-environmental monitoring stations across Thessaly

Hydro-telemetry networks of surface water: Instrumentation, smart technologies, installation & operation

Main goals

- **Establishment of a new hydro-telemetric network** in Peloponnese and in the Attica region (around Athens), in the context of pilot studies.
- **Field campaign** for systematic measurement of water level and velocity in streams using in combination a variety of instruments: current meters for point measurements at the cross section where the water level is measured, surface velocity radars and video simultaneously at the same location, in order to produce discharge rating curves for the specific locations.
- **Development and application of low cost technologies with telemetry**

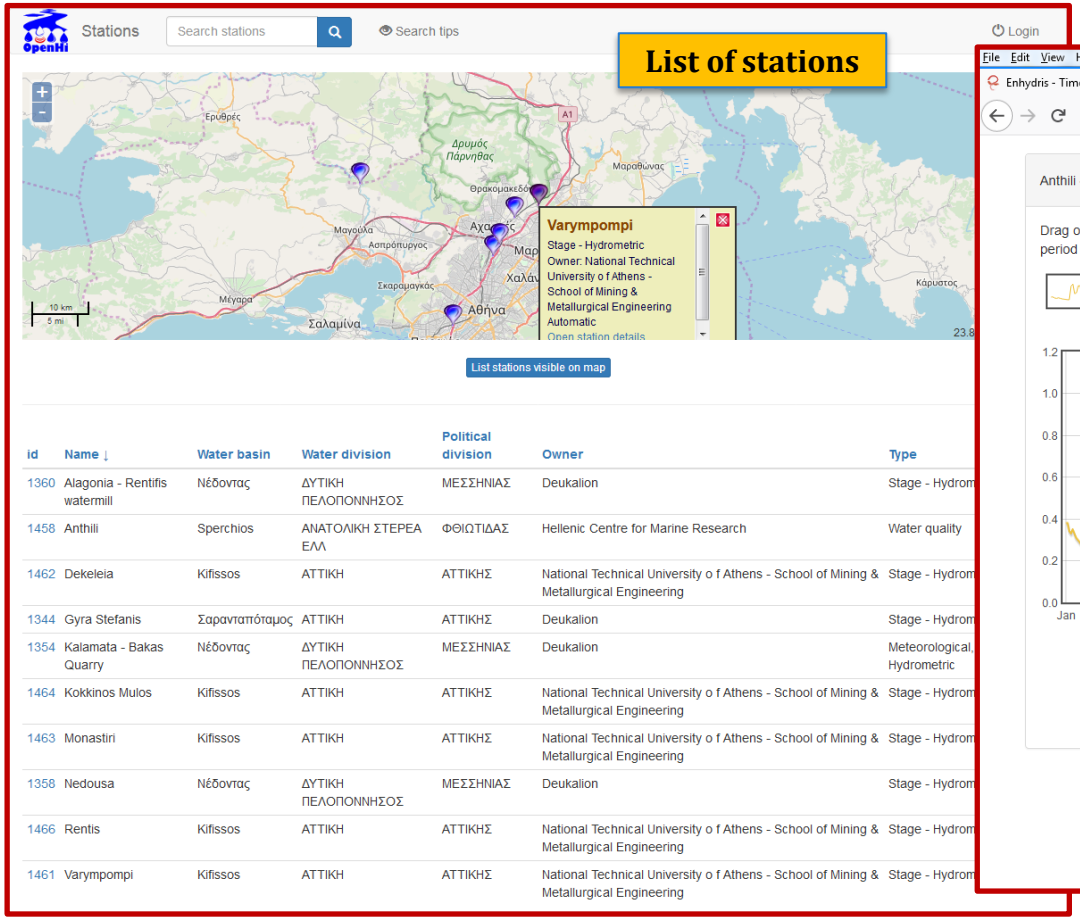
  New instrumentation: equipped with self-build and assembled hardware, with appropriate software, combining a water level sensor with an optical recorder (camera), temperature sensor, telecom and data-logging units, at about 1/3 the cost of equivalent commercial units.
- **Development of a combined water and hydro-mechanical or hydraulic calculation method for assessing the discharge in a stream**

  Development of a new scientifically validated method for estimating the discharge in a stream/river through water level measurement and measurement of surface velocity only. This method will allow estimating water discharge without performing costly, time consuming and often impossible (due to relief and conditions in the river bed: high flow, high level) classical measurements of the field velocity with the current meter.

From surface velocity to discharge

Since the deterministic velocity profile is unknown, **we treat the velocity and the geometry as random variables**. Then, by assigning a probability distribution function to each one of them, we find that the velocity distribution is *close-to-Gaussian* for a *uniform* sampling distribution of the geometry. Therefore, the velocity profile over the depth is close to a square-logarithmic expression (rather than a logarithmic one, as in the case of the model of von Karman). Applying the above within a **stochastic-deterministic framework** one can estimate the river discharge (with a better than **10% accuracy**) by measuring only the surface velocity, for example, with a hand-held radar velocimeter.

OpenHi.net platform (under construction)



id	Name ↓	Water basin	Water division	Political division	Owner	Type
1360	Alagonia - Rentifis watermill	Νέδοντας	ΔΥΤΙΚΗ ΠΕΛΟΠΟΝΝΗΣΟΣ	ΜΕΣΣΗΝΙΑΣ	Deukalion	Stage - Hydrom
1458	Anthili	Sperchios	ΑΝΑΤΟΛΙΚΗ ΣΤΕΡΕΑ ΕΛΛ	ΦΘΙΩΤΙΔΑΣ	Hellenic Centre for Marine Research	Water quality
1462	Dekeleia	Kifissos	ΑΤΤΙΚΗ	ΑΤΤΙΚΗΣ	National Technical University o f Athens - School of Mining & Metallurgical Engineering	Stage - Hydrom
1344	Gyra Stefanis	Σαραντάπόταμος	ΑΤΤΙΚΗ	ΑΤΤΙΚΗΣ	Deukalion	Stage - Hydrom
1354	Kalamata - Bakas Quarry	Νέδοντας	ΔΥΤΙΚΗ ΠΕΛΟΠΟΝΝΗΣΟΣ	ΜΕΣΣΗΝΙΑΣ	Deukalion	Meteorological, Hydrometric
1464	Kokkinos Mulos	Kifissos	ΑΤΤΙΚΗ	ΑΤΤΙΚΗΣ	National Technical University o f Athens - School of Mining & Metallurgical Engineering	Stage - Hydrom
1463	Monastiri	Kifissos	ΑΤΤΙΚΗ	ΑΤΤΙΚΗΣ	National Technical University o f Athens - School of Mining & Metallurgical Engineering	Stage - Hydrom
1358	Nedousa	Νέδοντας	ΔΥΤΙΚΗ ΠΕΛΟΠΟΝΝΗΣΟΣ	ΜΕΣΣΗΝΙΑΣ	Deukalion	Stage - Hydrom
1466	Rentis	Kifissos	ΑΤΤΙΚΗ	ΑΤΤΙΚΗΣ	National Technical University o f Athens - School of Mining & Metallurgical Engineering	Stage - Hydrom
1461	Varympompi	Kifissos	ΑΤΤΙΚΗ	ΑΤΤΙΚΗΣ	National Technical University o f Athens - School of Mining & Metallurgical Engineering	Stage - Hydrom