Presentation available online:
www.itia.ntua.gr/2021/

European Geosciences Union General Assembly, Online, 4-8 May 2020
HS3.2: Innovative sensing techniques for water monitoring, modelling, and management: Satellites, gauges and citizens

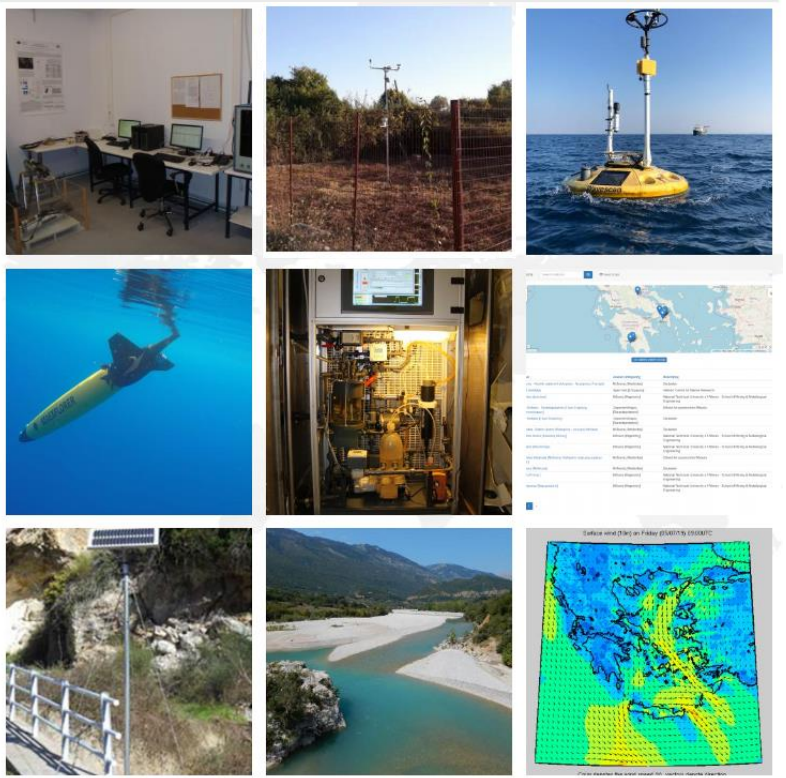
Open Hydrosystem Information Network: Greece's new research infrastructure for water

Andreas Efstratiadis[1], Nikos Mamassis[1], Antonis Koukouvinos[1], Demetris Koutsoyiannis[1], Katerina Mazi[2], Antonis Koussis[2], Spyridon Lykoudis[2], Elias Dimitriou[3], Nikos Malamos[4], Antonis Christofides[5], and Demetris Kalogeras[5]

(1) Department of Water Resources & Environmental Engineering, National Technical University of Athens; (2) Institute for Environmental Research & Sustainable Development, National Observatory of Athens; (3) Institute of Marine Biological Resources & Inland Waters, Hellenic Centre for Marine Research; (4) Department of Agriculture, University of Patras; (5) Institute of Communication and Computer Systems, National Technical University of Athens

Broader infrastructure: “Hellenic Integrated Marine Inland water Observing, Forecasting and offshore Technology System”

- Large scale research infrastructure for national waters
- Launched in January 2018 (preparatory phase)
- 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**: https://www.himiofots.gr/en



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

Open Hydrosystem Information Network (OpenHi.net)

Key research tasks:

- Recording and evaluation of existing gauging infrastructure over Greece;
- 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, University of Ioannina

From in-situ observations to data services

River monitoring (stage, quality)

↓

Data transmission

↓

Storage to a central database

↓

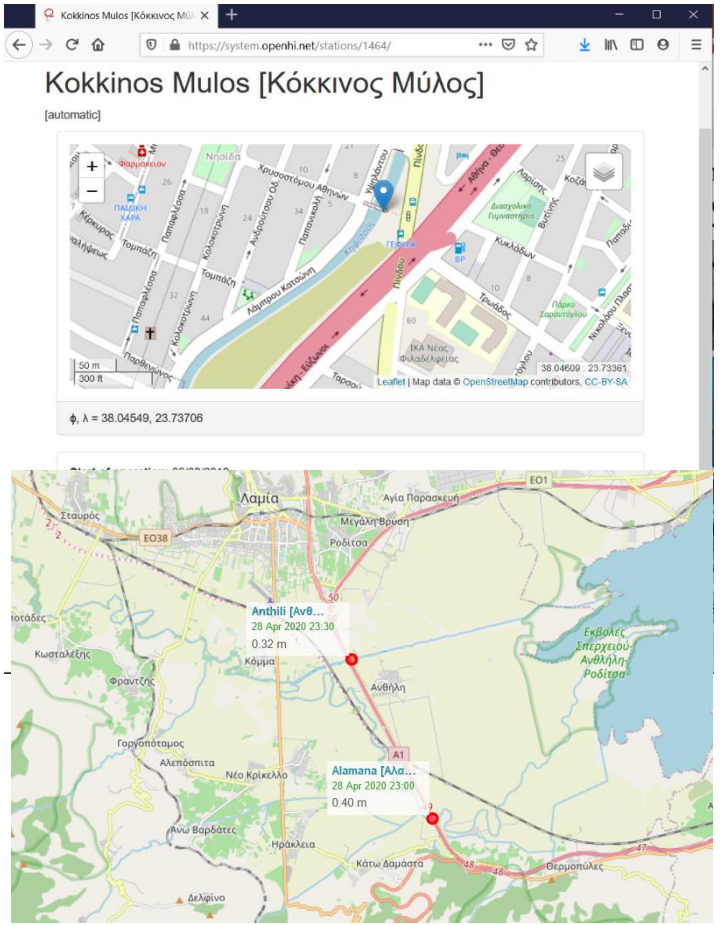
Automatic controls of raw data

↓

Checked time series available to users

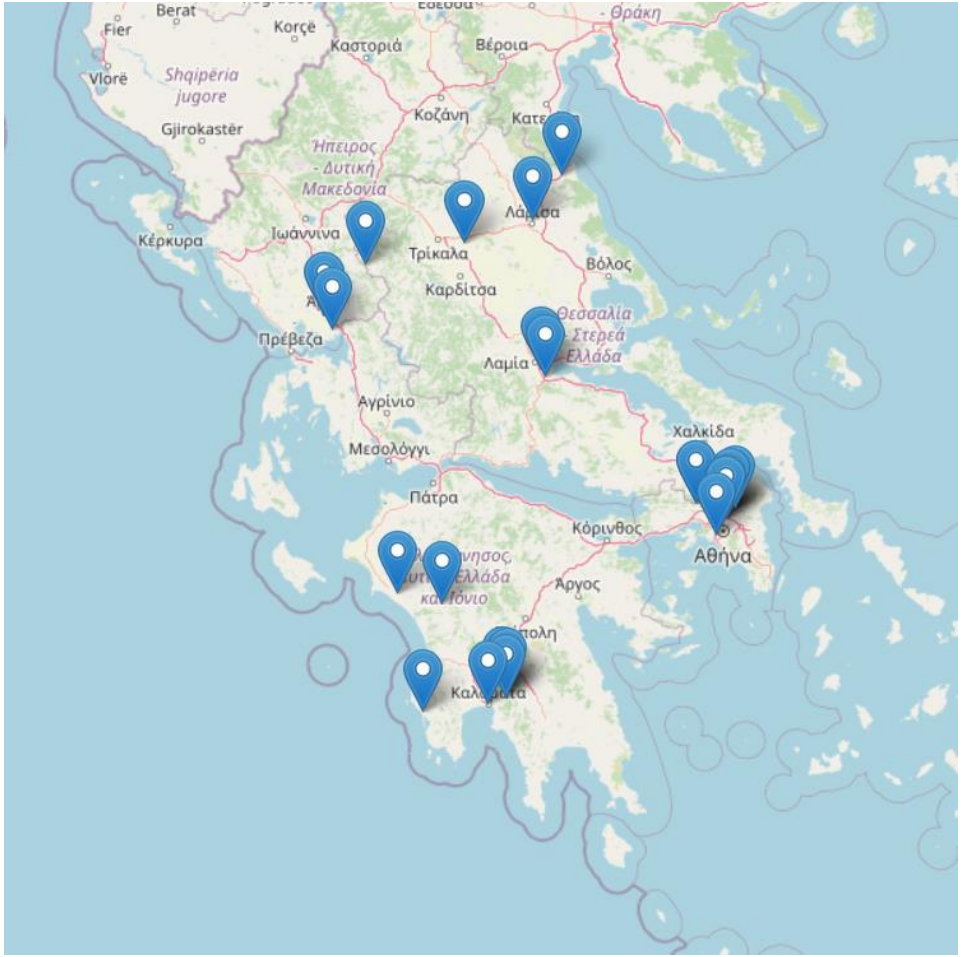
↓

Post-processing (statistical analyses, stage-discharge);



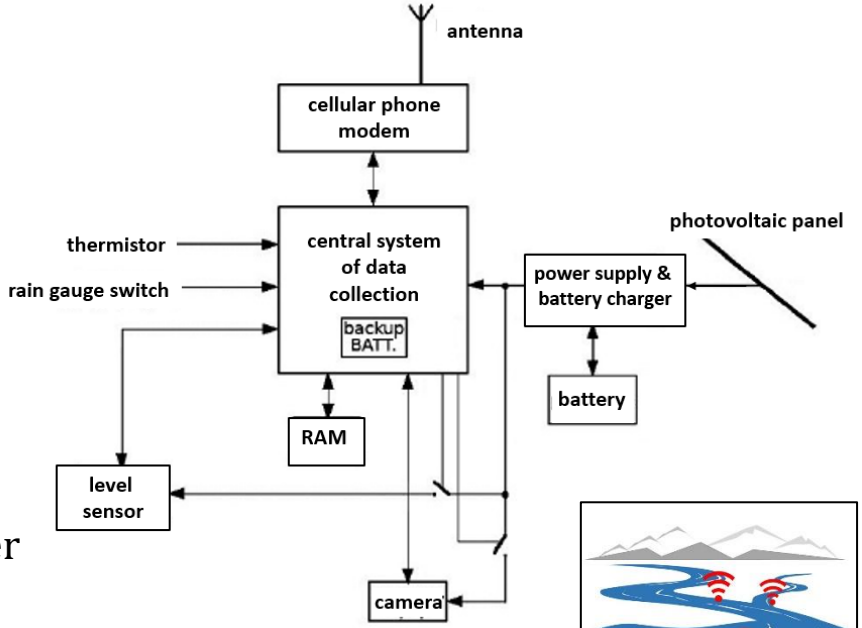
Monitoring stations

- Today status: ~30 telemetric stations in operation, across nine river basins;
- All stations are equipped with automatic stage recorders;
- At 8 stations, additional data related with water quality are also provided (pH, water temperature, dissolved oxygen, salinity, electrical conductivity);
- Typical time interval of data transmission: 10 or 15 min.
- Stations are developed and hosted by:
  - Institute for Environmental Research & Sustainable Development, NOA;
  - Institute of Marine Biological Resources & Inland Waters, HCMR;
  - Third-parties, uploading their data (the system offers **free accessibility**);



HYDRO-NET: Hydro-telemetric network for surface waters (NOA)

Self-designed station w. camera
cost: ~50% of commercial station



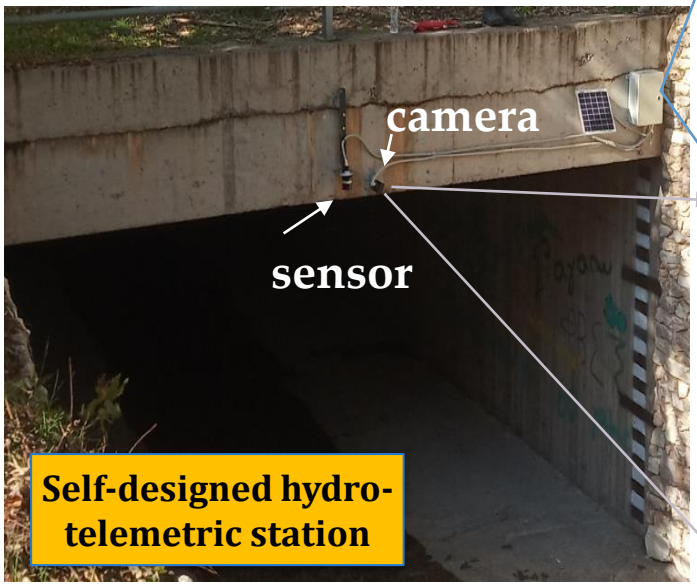
- Self-designed stations
- Commercial WL stations
- Commercial WL + PPT stations
- PPT stations

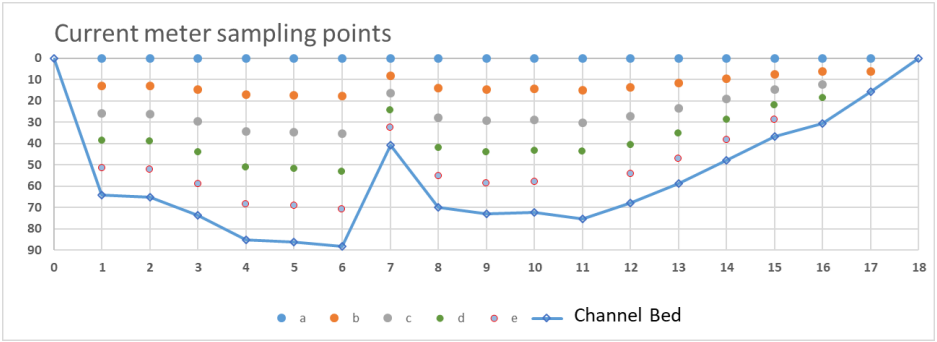
- Installed network, today comprising 19 stations over Peloponnese and Attica;
- Both commercial and self-designed river stage data monitoring, storage and transmission system;

HYDRO-NET
Hydro-telemetric Network for Surface Waters

Technological advances in telemetry and hydrometry

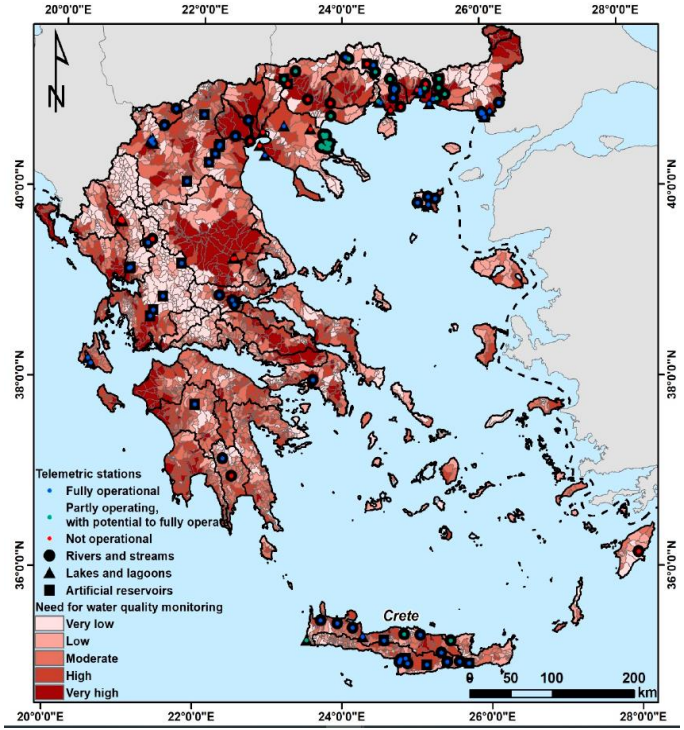
Field campaigns: velocity measurements with current meter & surface-velocity radar





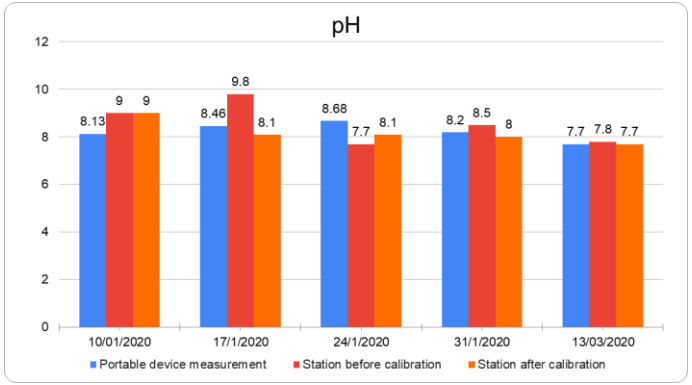
Network of water quality monitoring stations (HCMR)

- Assessment of W/Q monitoring needs and existing infrastructure;
- Identification of monitoring gaps;



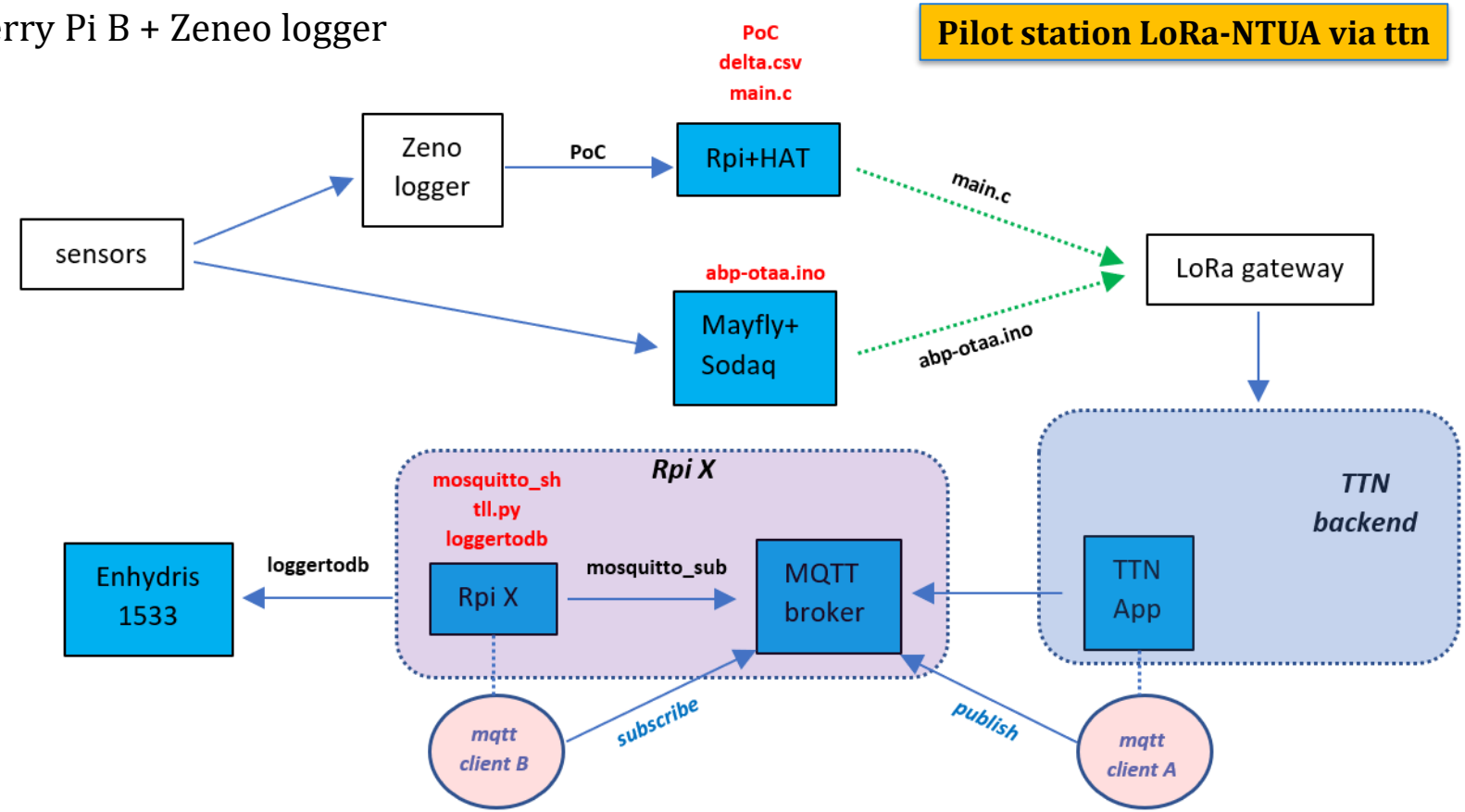
Calibration and quality control of W/Q monitoring stations

- Regular field visits for sensor cleaning and calibration;
- In-situ portable device measurements and quality control;



Further advances in data transmission: LoRa (Long Range) WAN

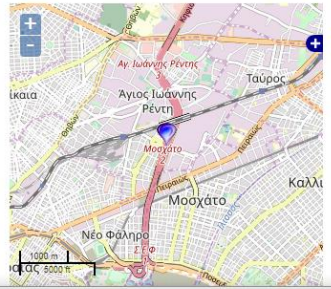
- Evolutionary approach – keep existing components
- Raspberry Pi B + Zeneo logger



The OpenHi.net platform

Main page of selected station

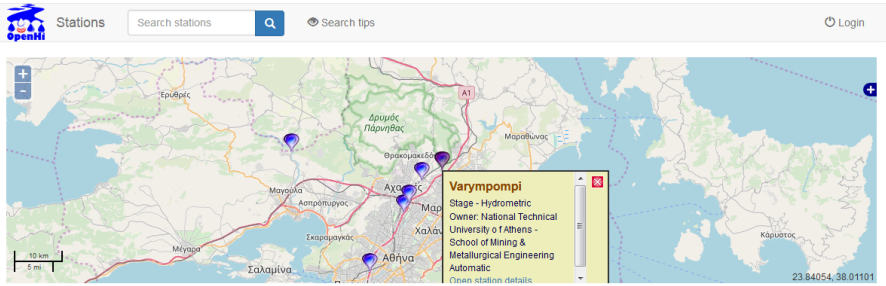
Rentis [Ρέντης]



Station Details

Edit

ID	1466
Name	Rentis [Ρέντης]
Remarks	
Water Basin	Kifissos [Κηφισσός]
Water Division	ΑΤΤΙΚΗ
Political Division	ΑΤΤΙΚΗΣ
Co-ordinates	37.96093, 23.67619
Altitude	
Owner	National Technical University o f Athens - School
Type	Stage - Hydrometric [Υδρομετρικός]

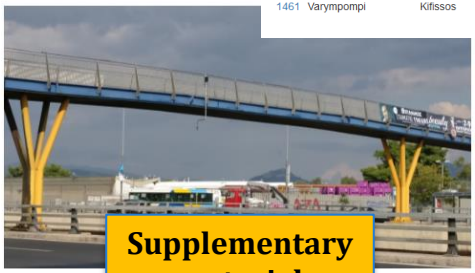


id	Name ↓	Water basin	Water division	Political division	Owner	Type
1360	Alagonia - Rentifis watermill	Νέδοντας	ΔΥΤΙΚΗ ΠΕΛΟΠΟΝΝΗΣΟΣ	ΜΕΣΣΗΝΙΑΣ	Deukalion	Stage - Hydrometric
1458	Anthili	Sperchios	ΑΝΑΤΟΛΙΚΗ ΣΤΕΡΕΑ ΕΛΛ	ΦΘΙΩΤΙΔΑΣ	Hellenic Centre for Marine Research	Water quality
1462	Dekeleia	Kifissos	ΑΤΤΙΚΗ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

List of stations

Photos - Red_Cross.jpg

Photos - Rentis (2).jpg

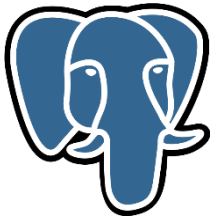


Supplementary material

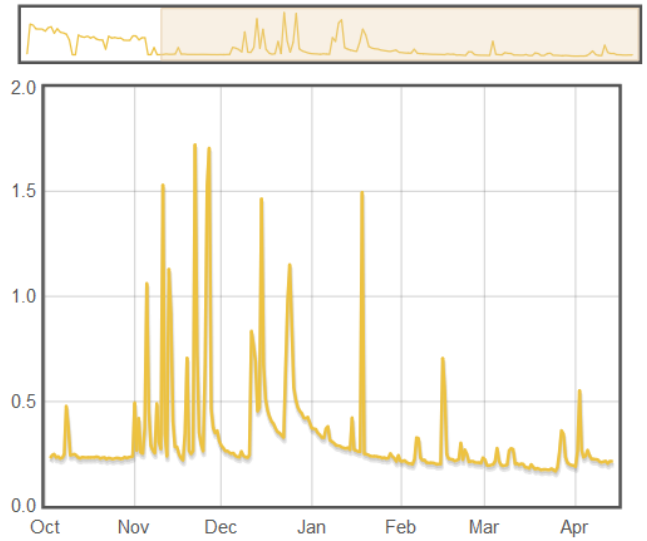
OpenHi web page: https://openhi.net/en/

Backbone software: Enhydris

- Enhydris is developed by NTUA in the last 10 years;
- Free software, available under the **GNU AGPL v3 or later**;
- Multilingual, small and extensible;
- The core functionality is just a database of stations and their time series; in OpenHi we are developing three add-on applications (*autoprocess*, *synoptic*, *openhigis*);
- Enhydris stores timeseries data in TimescaleDB, a modern PostgreSQL add-on that enables fast querying and aggregation of time series data.
- Other technologies that Enhydris is using are **Python**, **Django**, **pandas**, and **PostGIS**.



Enhydris main functionalities: Time series visualization and download options



Download data

ID	
Related Station	
Name	
Variable	
Unit Of Measurement	
Precision	
Time Zone	
Remarks	
Start Date	2019/08/07 16:10
End Date	2020/04/14 02:40
Time step	10min

Opening 9732.csv

You have chosen to open:

9732.csv

which is: Microsoft Excel Comma Separated Values File (131 KB)

from: https://system.openhi.net

What should Firefox do with this file?

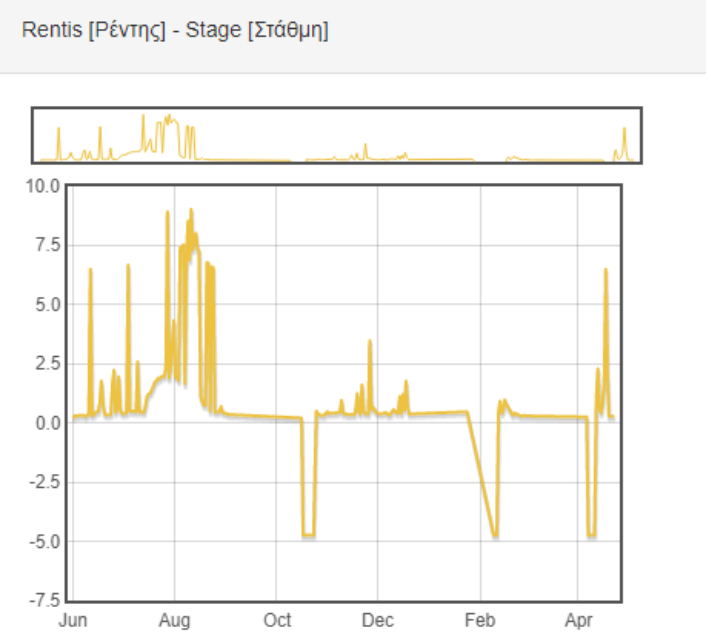
Open with Excel (default)

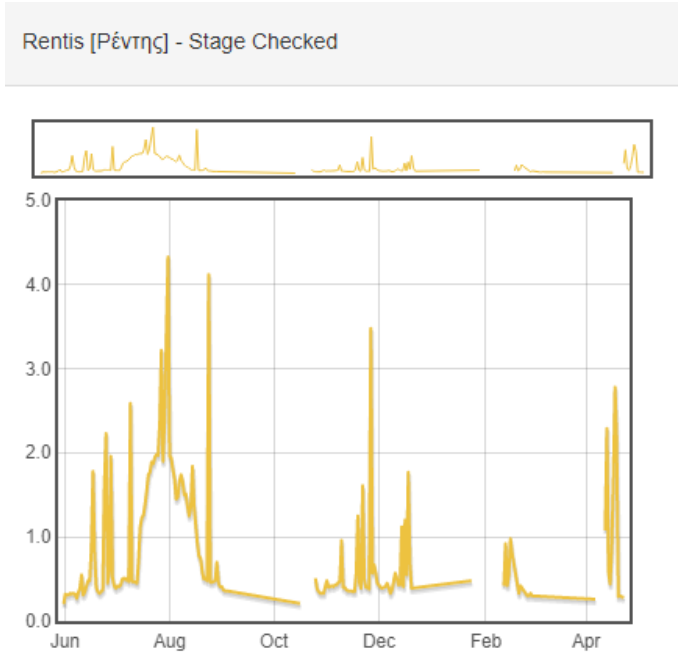
Save File

Do this automatically for files like this from now on.

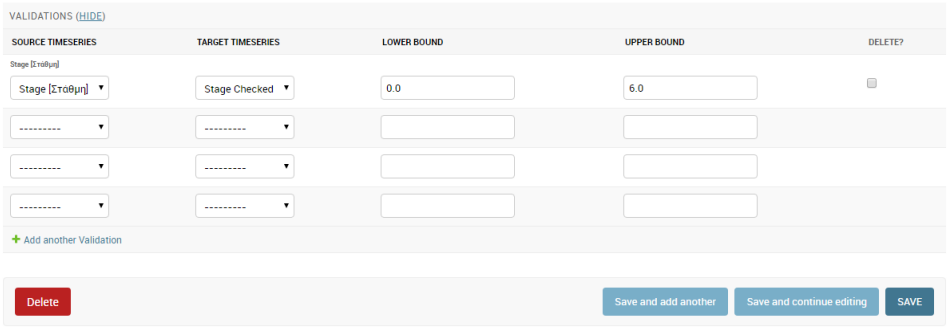
OK Cancel

Enhydris add-ons: *enhydris-autoprocess*

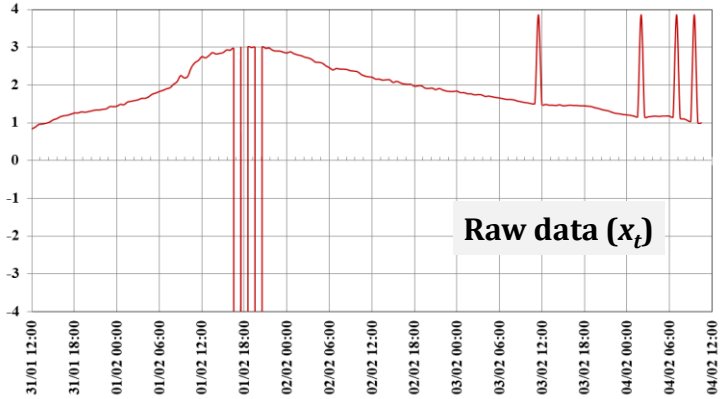




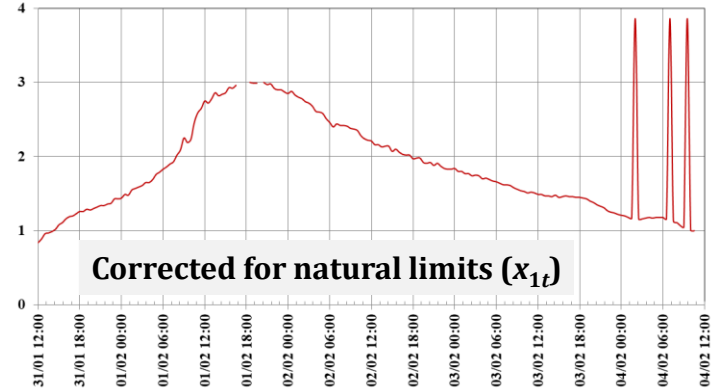
- Cut-off of infeasible values (assignment of low/upper physical thresholds)
- Flagging of suspicious values (check of extremes, check of change rates)



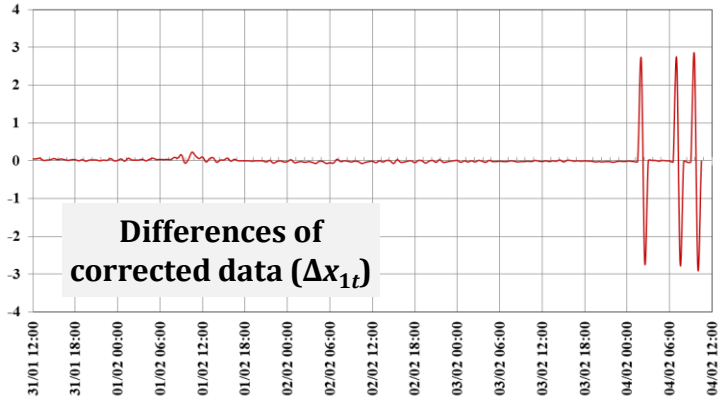
Automatic controls of river stage data



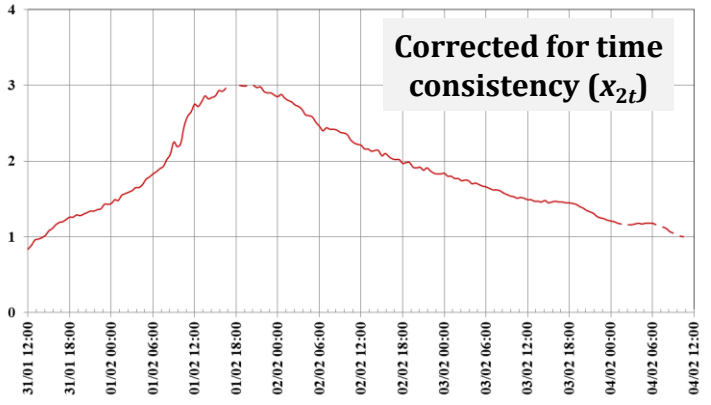
If $0 < x_t < 4$ then $x_{1t} = x_t$ else $x_{1t} =$ ""



$\Delta x_{1t} = x_{1t} - x_{1t-1}$



If $-2 < \Delta x_t < 2$ then $x_{2t} = x_{1t}$ else $x_{2t} =$ ""



Advanced data controls: Statistical detection of extreme stage differences

(1) Calculation of stage differences for multiple time lags

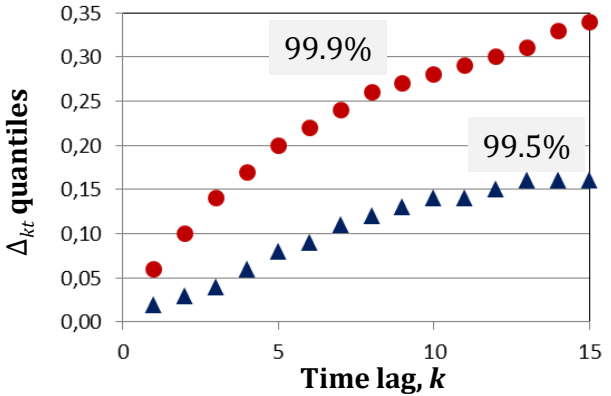
$$\Delta_{1t} = x_t - x_{t-1}$$

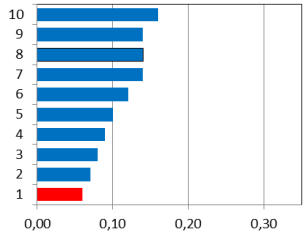
$$\Delta_{2t} = x_t - x_{t-2}$$

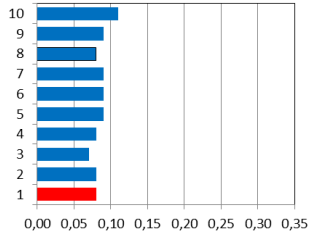
$$\ldots\ldots\ldots$$

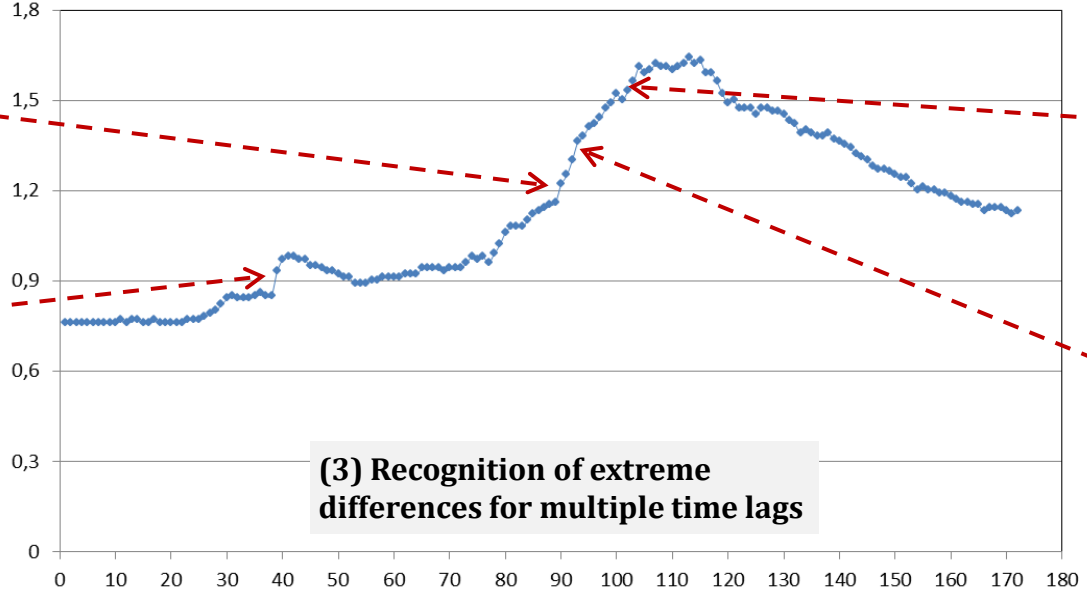
$$\Delta_{kt} = x_t - x_{t-k}$$

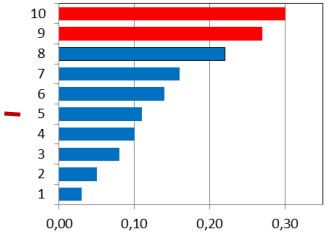
(2) Estimation of thresholds (99.9% & 99.5% quantiles)

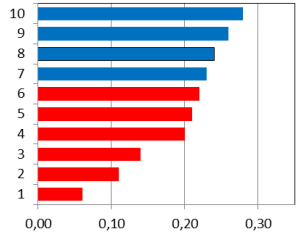






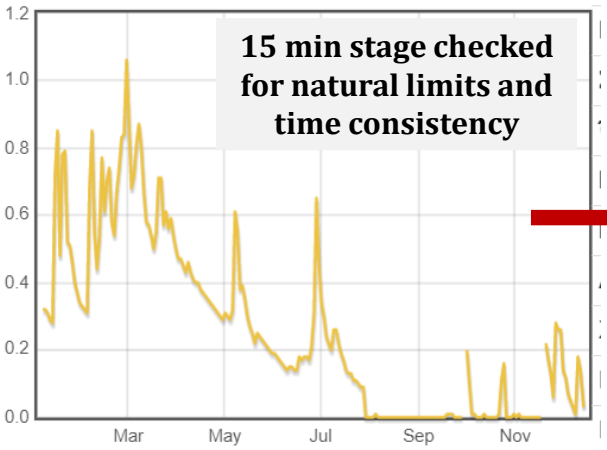


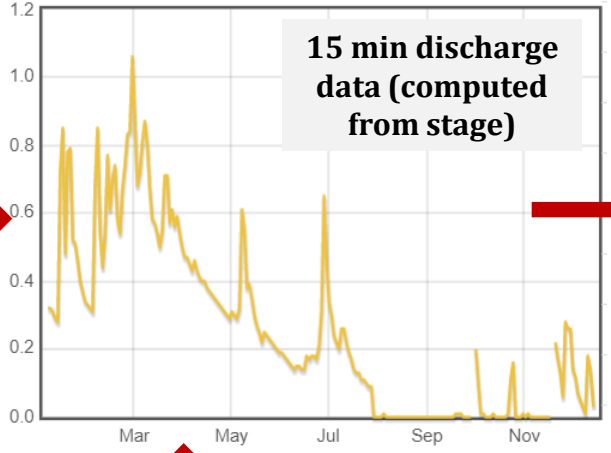


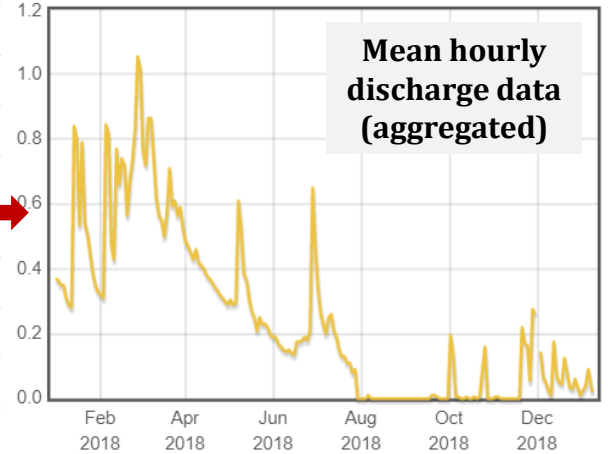


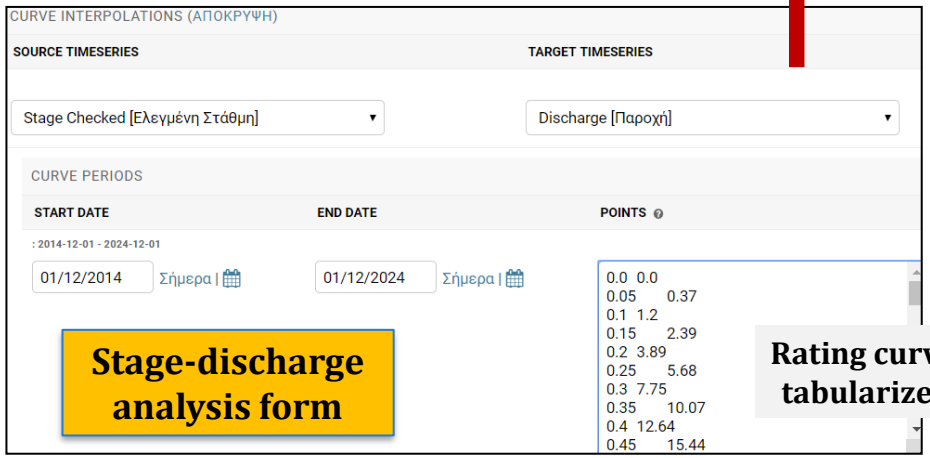
(3) Recognition of extreme differences for multiple time lags

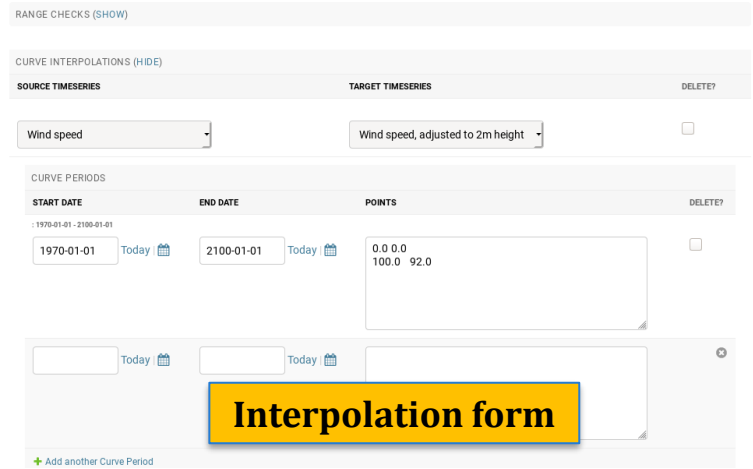
Processed data: stage-discharge, aggregations, interpolations





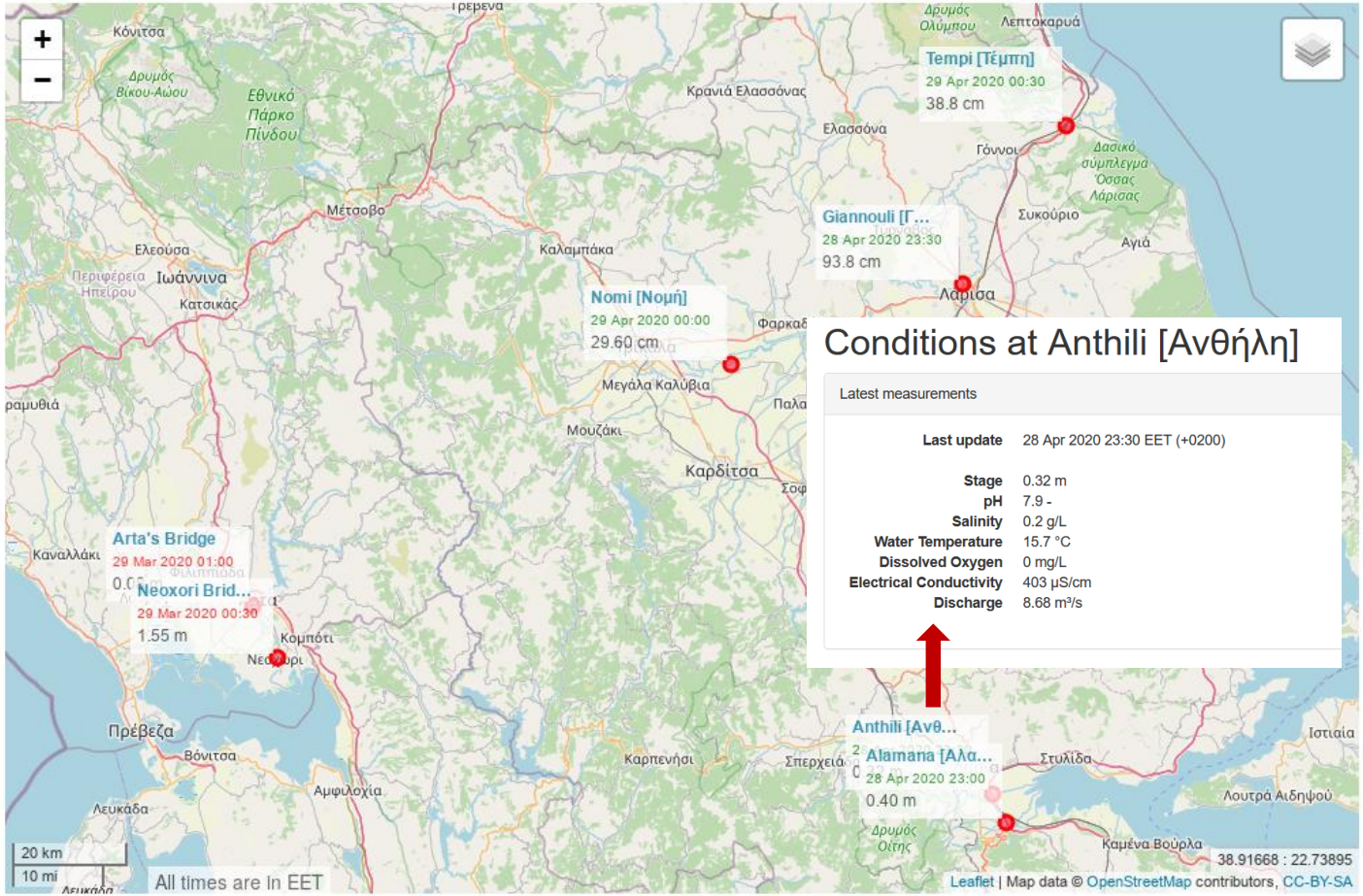






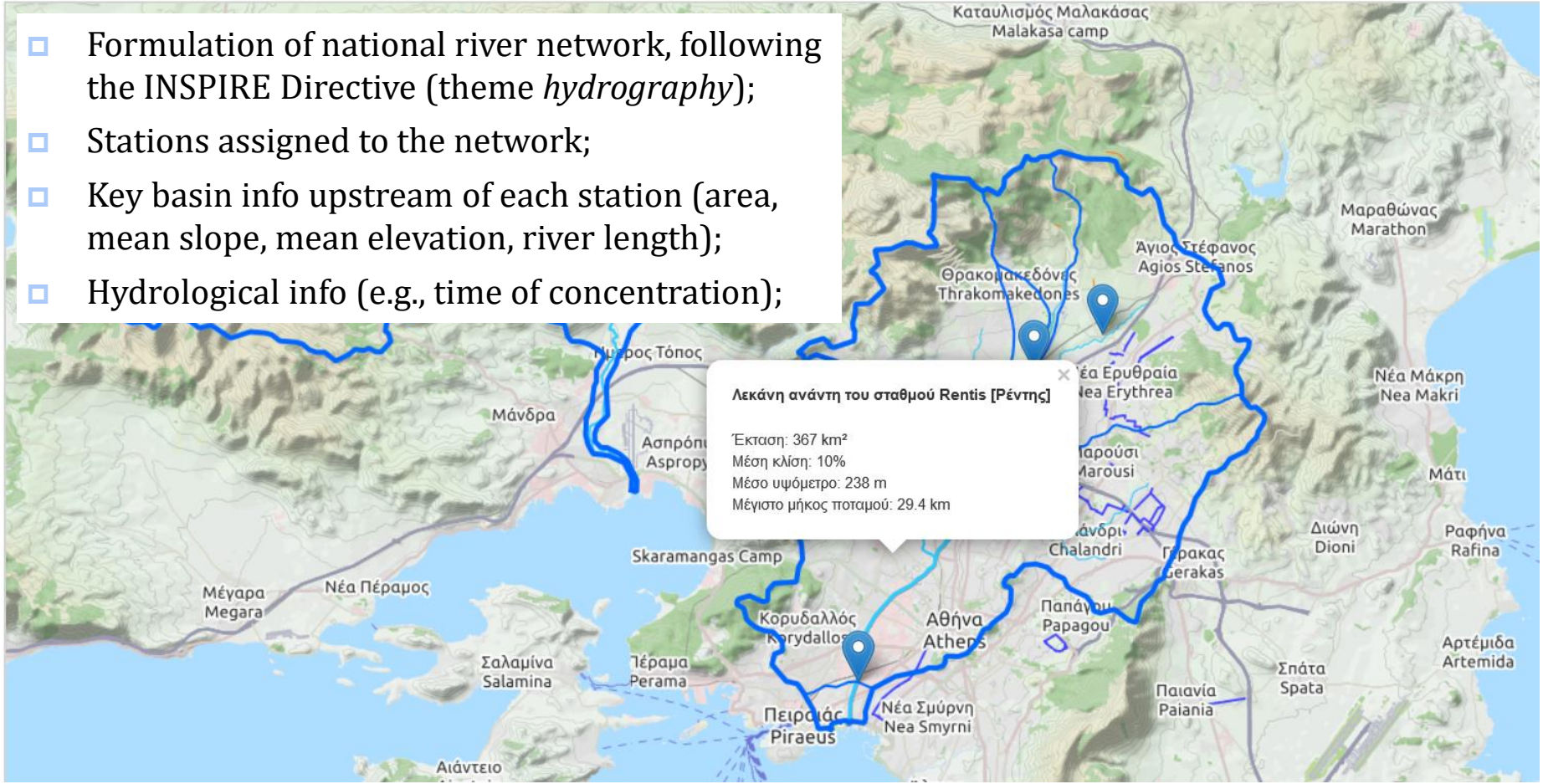
Enhydris add-on applications: *enhydris-synoptic*

- Dynamic map, showing current observations for each selected variable (almost in real-time);
- Highlighting of too low and too high values, based on pre-defined thresholds;
- To be evolved into a notification system.



Enhydris add-on geodatabase: *enhydris-openhigis*

- Formulation of national river network, following the INSPIRE Directive (theme *hydrography*);
- Stations assigned to the network;
- Key basin info upstream of each station (area, mean slope, mean elevation, river length);
- Hydrological info (e.g., time of concentration);



Operational apps: DSS for optimal irrigation scheduling in Arta

- The Enydris platform supports a participatory system for irrigation management (IRMA), which is operational since 2013;
- It covers an area of 400 km^2, including 6 land reclamation organizations, that operate large scale irrigation networks;
- Unique open and free to use online DDS for optimal irrigation scheduling in Greece;
- It uses real-time agrometeorological data from seven stations, which are available at: https://system.irrigation-management.eu;
- It provides irrigation advices, based on historical data and weather forecasts (http://arta.interregir2ma.eu).
- Evaluation of results using conventional soil moisture sensors that are deployed across several pilot fields.