

Satellite-based Services for Disaster Risk Management

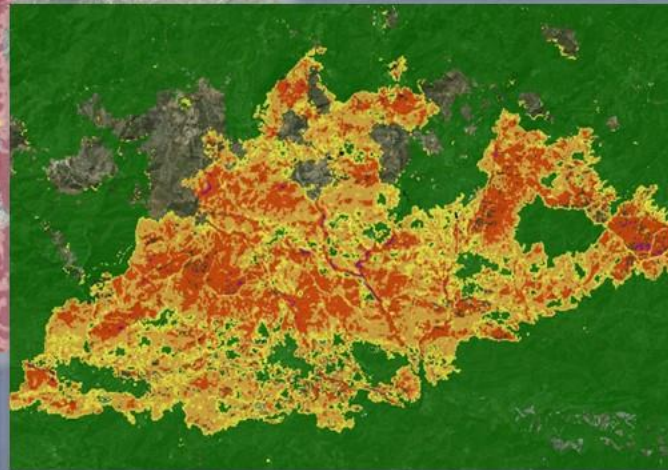
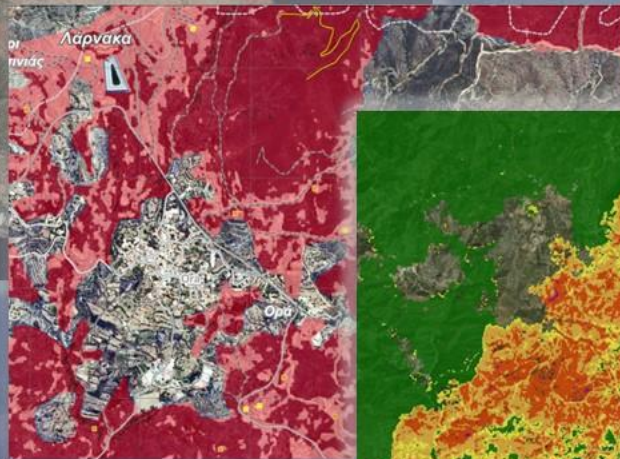
17th May 2023

9:30 - 15:30 EEST

HILTON NICOSIA

Achaion 1, Egkomi

Nicosia, Cyprus



In cooperation with the Department of Electronic Communications |
Deputy Ministry of Research, Innovation and Digital Policy



Water Quality Monitoring Service as a candidate evolution service element of the Copernicus Emergency Management Service

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Dirkarpaz
Ριζοκάρπασο

Yeni Erenköy
Γιαλούσα

Bafra
Βόκολίδα

Tatlısu
Ακανθού

Girne
Κερύνεια

Yeni İskele
Τρίκωμο

Yeni Boğaziçi
Αγ. Σέργιος

Gazimağusa
Αμμοχώστος

Nicosia
Λευκωσία

Lakatomia
Λακαταρία

Güzelyurt
Μόρφου

Lefke
Λεύκα

Poli
Crysochous
Πόλη
Χρυσοχούς

Paphos Forest
Δάσος Πάφου

Mount
Olympus
Χιονίστρα

Cyprus
Κύπρος

Ayia Napa
Αγ. Νάπα

Oroklini
Ορόκλινη

Larnaca
Λάρνακα

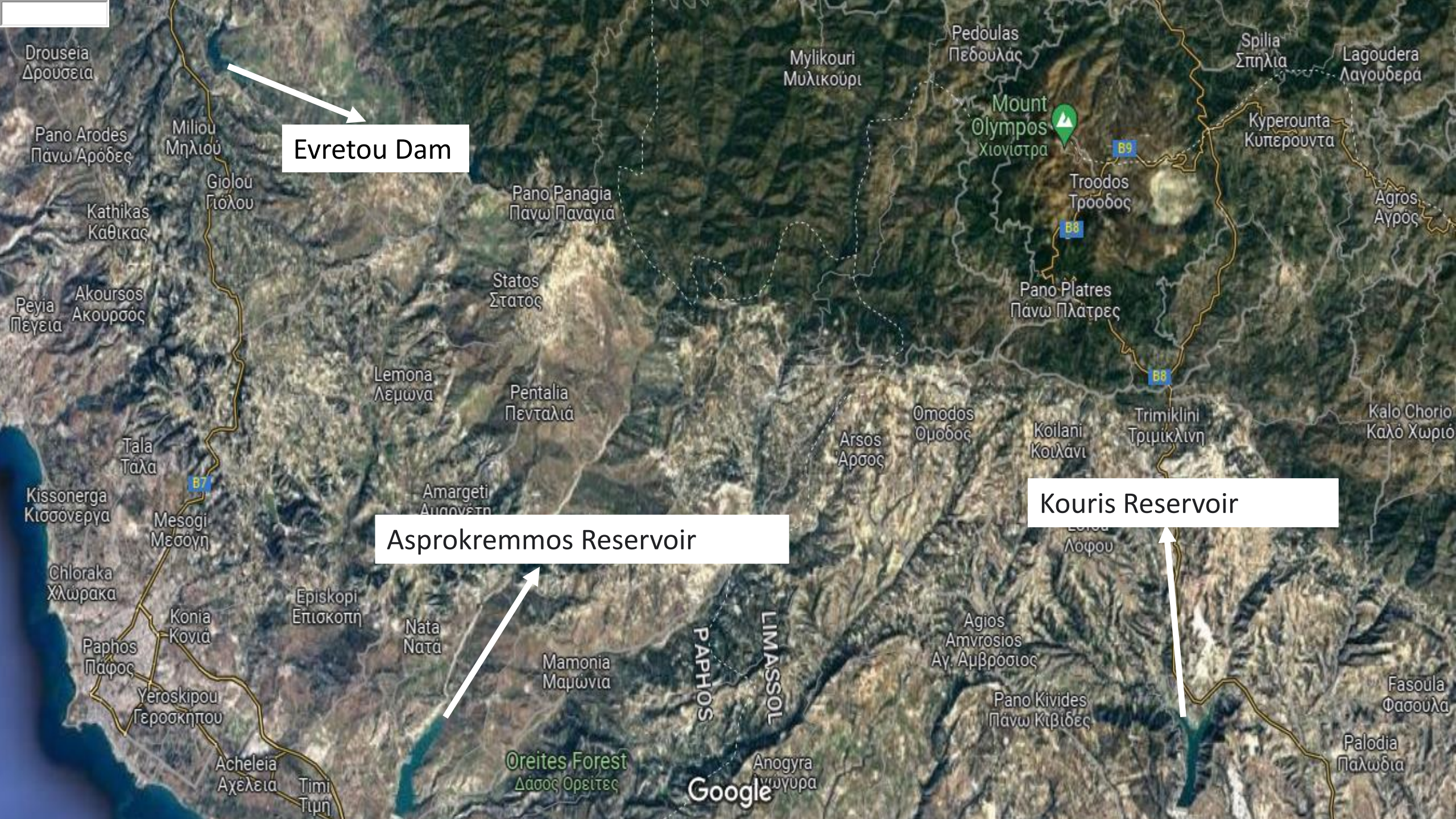
Omotos
Ομοδος

Peyia
Πεγεια

Paphos
Πάφος

Pissouri
Πισσούρι

Limassol
Λεμεσός



Evretou Dam

Asprokremmos Reservoir

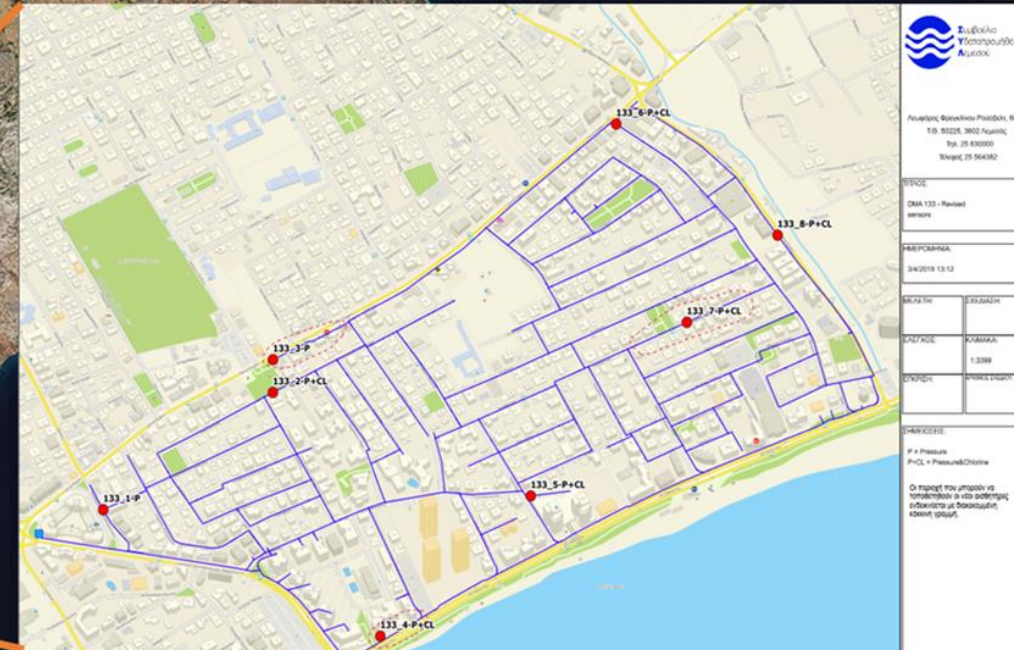
Kouris Reservoir



Water providers have to guarantee the supply of **clean** and **safe** water to all consumers.



The network is segmented into Pressure Zones and DMA's, each with 50-5.000 properties.



Typical challenges

Prolonged draughts

High cost of water production

Increased water demand

Losses, contamination



New technologies produce large volumes of data

Sensors (flows, pressures, water quality parameters)

Smart metering

GIS



Need to provide solutions to make the operation of the system more effective and efficient



Data analytics and Decision making

Nokia Water Utility Employee Faces Charges of Involuntary Manslaughter

The police investigation into the contamination of the municipal water system of the town of Nokia has been completed. An employee of the local water utility is under suspicion of two counts of involuntary manslaughter in the case dating back to late 2007. The matter is to be taken up by Pirkanmaa regional prosecutors later this week.

Share



Over 100 hospitalized in Daghestan after drinking tainted water

16 JANUARY 2020 BY OC MEDIA

Nokian jätevedenpuhdistamon virhevesitutki (katkaisttu). Josta vesikriisi sai alkunsa. Image: Antti Fintola / Yle

Gaza water too contaminated to drink, say charities

Gaza's only fresh source of water is too dangerous to drink because of contamination by fertiliser and human waste, a new report says.

The charities Save the Children and Medical Aid for Palestinians say the number of children being treated for diarrhoea has doubled in five



Fixing Flint's contaminated water system could cost \$216m, report says

A bruising litany of infrastructure repairs would happen over the next several decades - with \$80m



JANUARY 15, 2020

Exposure to chemicals in drinking water associated with 5% of annual bladder cancer burden in Europe

by Barcelona Institute for Gl



Turkey earthquake: Lack of clean water and toilets puts survivors at risk of disease

Water Services Regulation Authority

Southern Water hit by £126m penalty for 'serious failures'

Regulator rules that group deliberately deceived customers over water quality

Thousands Without Water After Spill in West Virginia

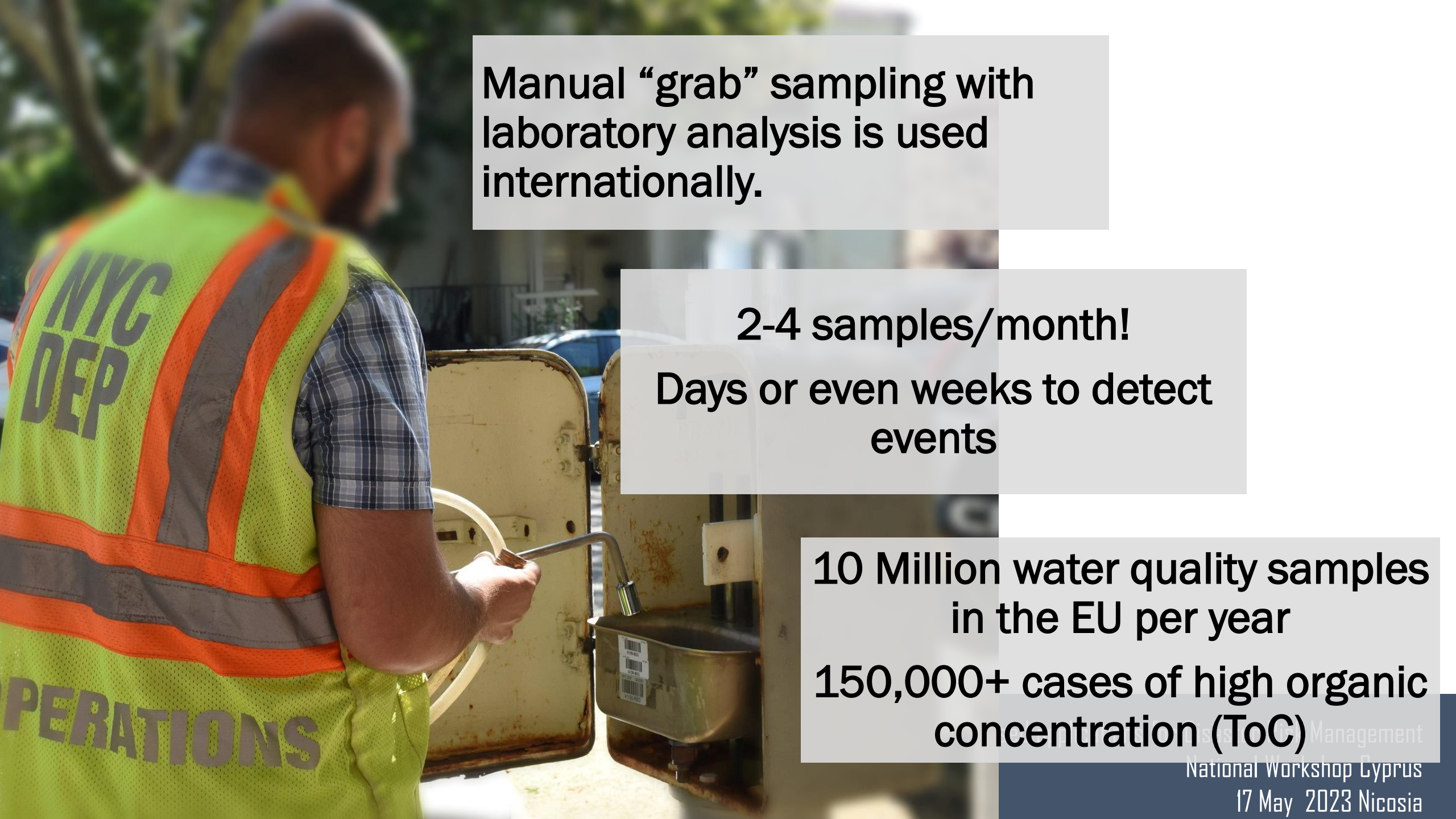
By TRIP GABRIEL JAN. 10, 2014



Contamination events can cost the utility around €500 for each affected consumer. In case of deaths, this can escalate to €1000s.



▲ Protesters hold up jugs of discolored water outside the Farmers Market in Flint, marking the one year anniversary of the city switching from using Detroit water to Flint River water. Photograph: Sam Owens/AP



Manual “grab” sampling with laboratory analysis is used internationally.

2-4 samples/month!
Days or even weeks to detect events

10 Million water quality samples
in the EU per year
150,000+ cases of high organic
concentration (ToC)



Go to of:

long/lat - WGS84

Remote eyes on the quality of our water sources...

Legend & layer control

- ☐ Open Data - Turbidity - Saidenbach
- ☒ Open Data - Turbidity - Polyphytos
- ☐ Open Data - Turbidity - Ojos
- ☐ Open Data - Turbidity - Mayes
- ☐ Open Data - Turbidity - Judio
- ☐ Open Data - Turbidity - Eibenstock
- ☐ Open Data - Turbidity - Carlsfeld
- ☐ Open Data - Sea Surface Temperature
- ☐ Open Data - Secchi Disk Depth - Saidenbach
- ☒ Open Data - Secchi Disk Depth - Polyphytos
- ☐ Open Data - Secchi Disk Depth - Ojos
- ☒ Open Data - Secchi Disk Depth - Mayes
- ☐ Open Data - Secchi Disk Depth - Judio
- ☐ Open Data - Secchi Disk Depth - Eibenstock
- ☐ Open Data - Secchi Disk Depth - Carlsfeld
- ☒ Open Data - Chlorophyll-a - Saidenbach
- ☐ Open Data - Chlorophyll-a - Saidenbach
- ☐ Open Data - Chlorophyll-a - Polyphytos
- ☒ Open Data - Chlorophyll-a - Ojos
- ☒ Open Data - Chlorophyll-a - Mayes
- ☐ Open Data - Chlorophyll-a - Marathusa

In-situ measurements in the emergency incident field to detect pathogens...

GRANADA Pilot Site <

Dashboard

Manage

Component Management

LoRa

Export

Alarms 1

GRANADA Site 2

Site

Search...

Components

Test Device 1 (Granada site 2) – Sensor

Test Device 2 (Granada Site 2) – Sensor

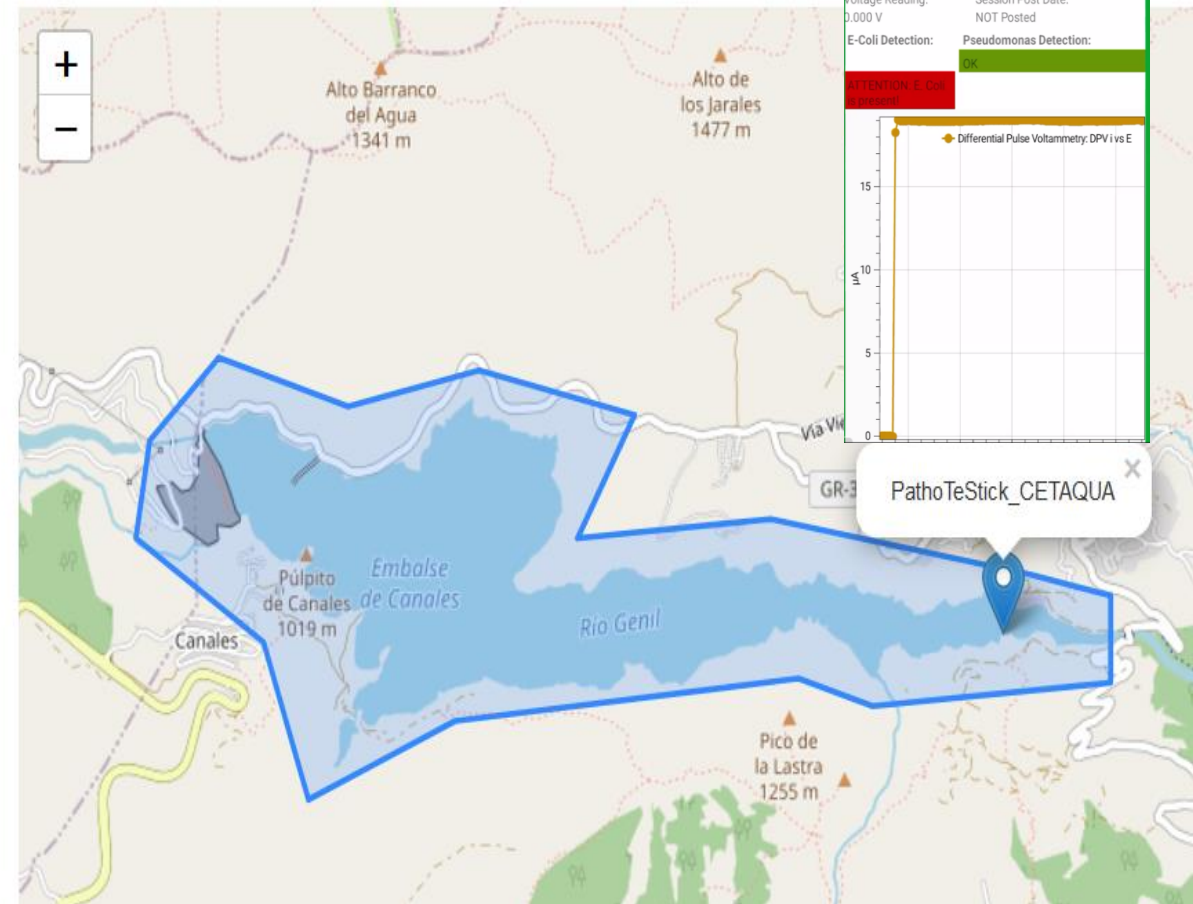
PathoTeStick_UMF – Sensor

PathoTeStick_CETAQUA – Sensor

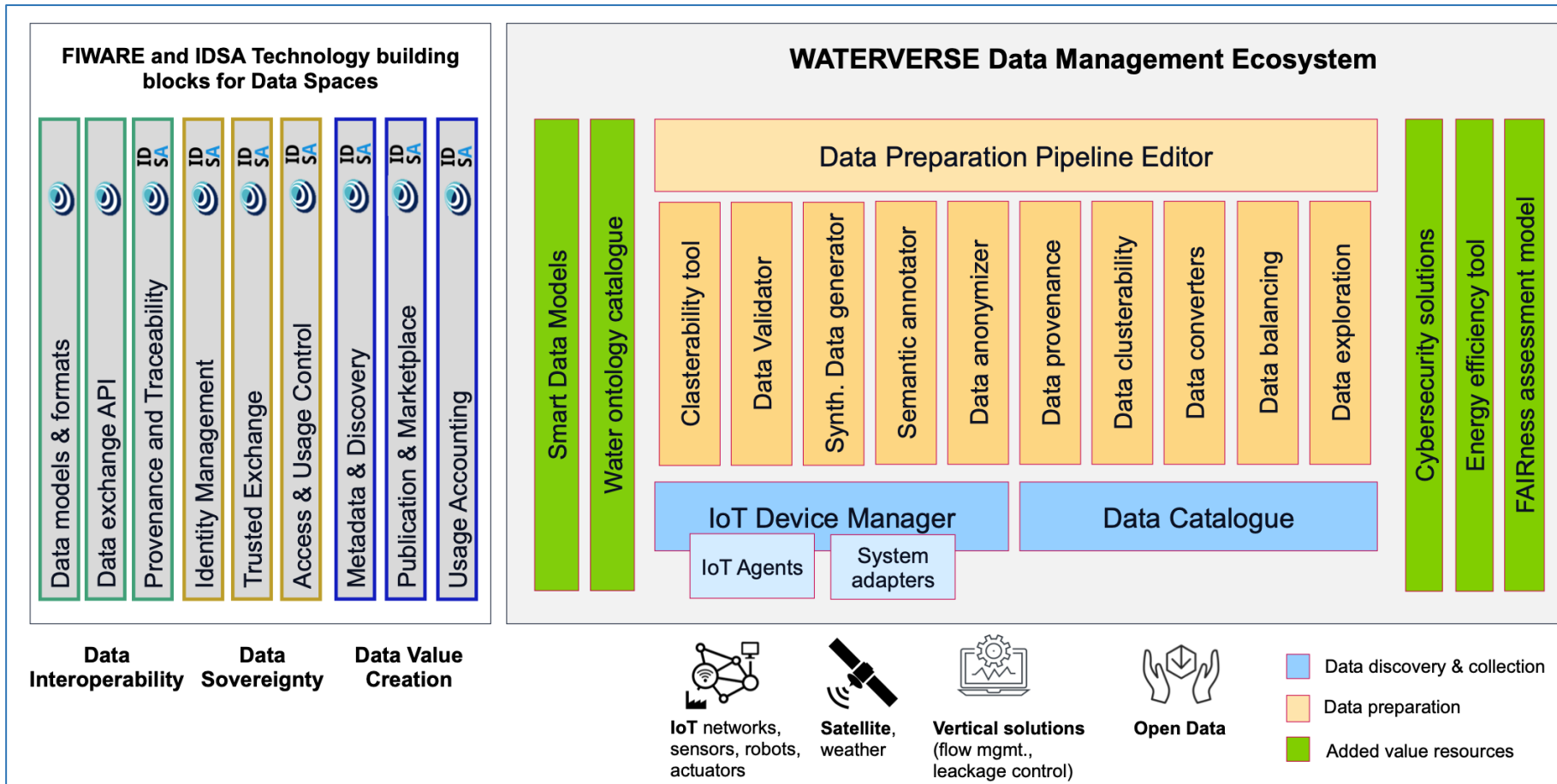
AQUA-Sense 2 – Sensor

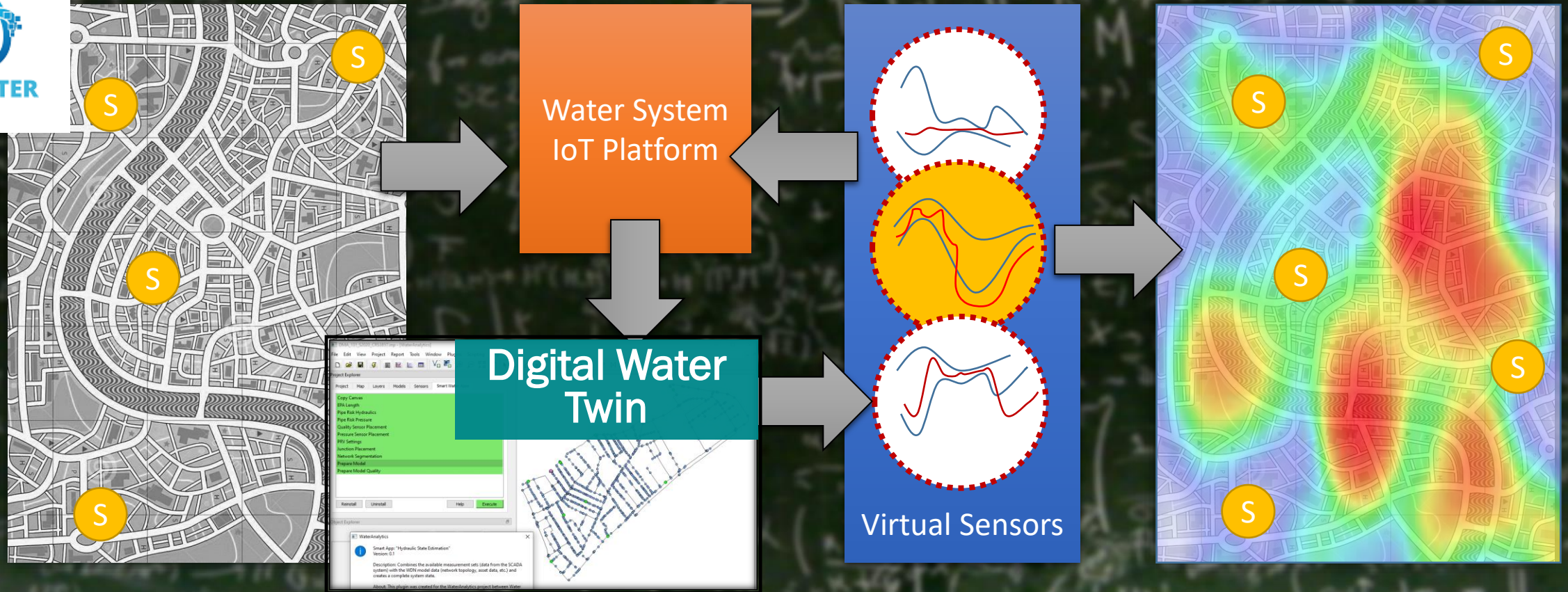
Install Component

Location



Organise the Water Data Space





10s of hydraulic
and quality
sensors
optimally
placed

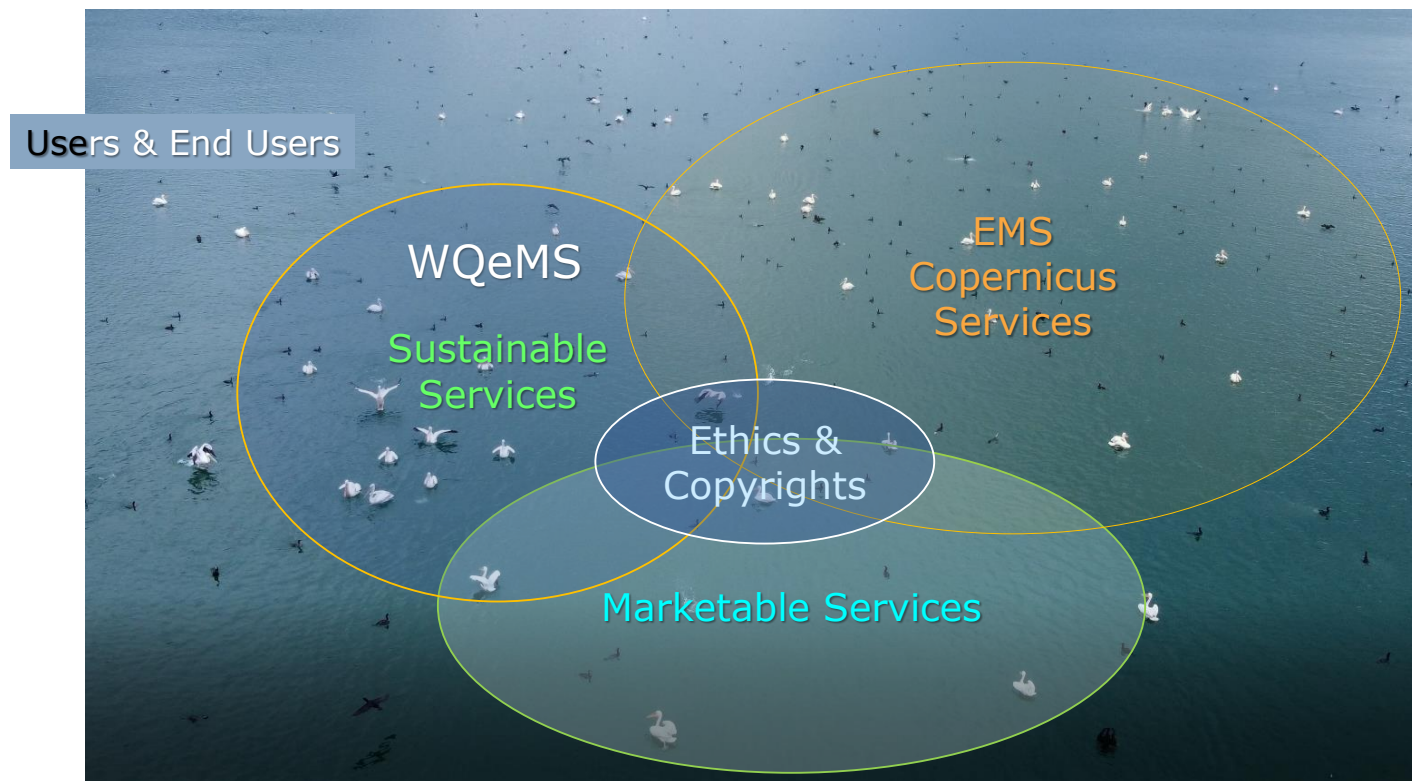
Mathematical
Models and
Machine
Learning

100,000s
virtual sensors
Bounds
estimation

Context-aware
IoT Platform
Plug-and-play

Analytics for
knowledge
extraction
Cost-effective
decisions

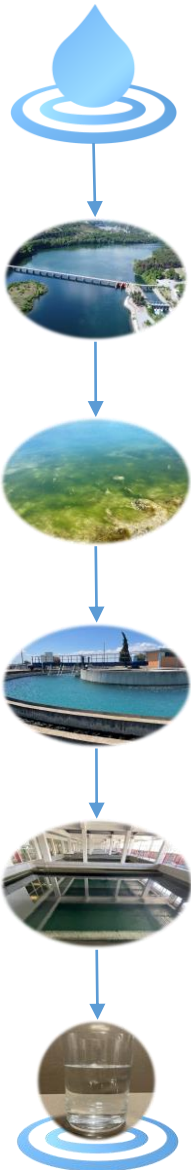
Water Quality Monitoring Service as a candidate evolution service element of the Copernicus Emergency Management Service



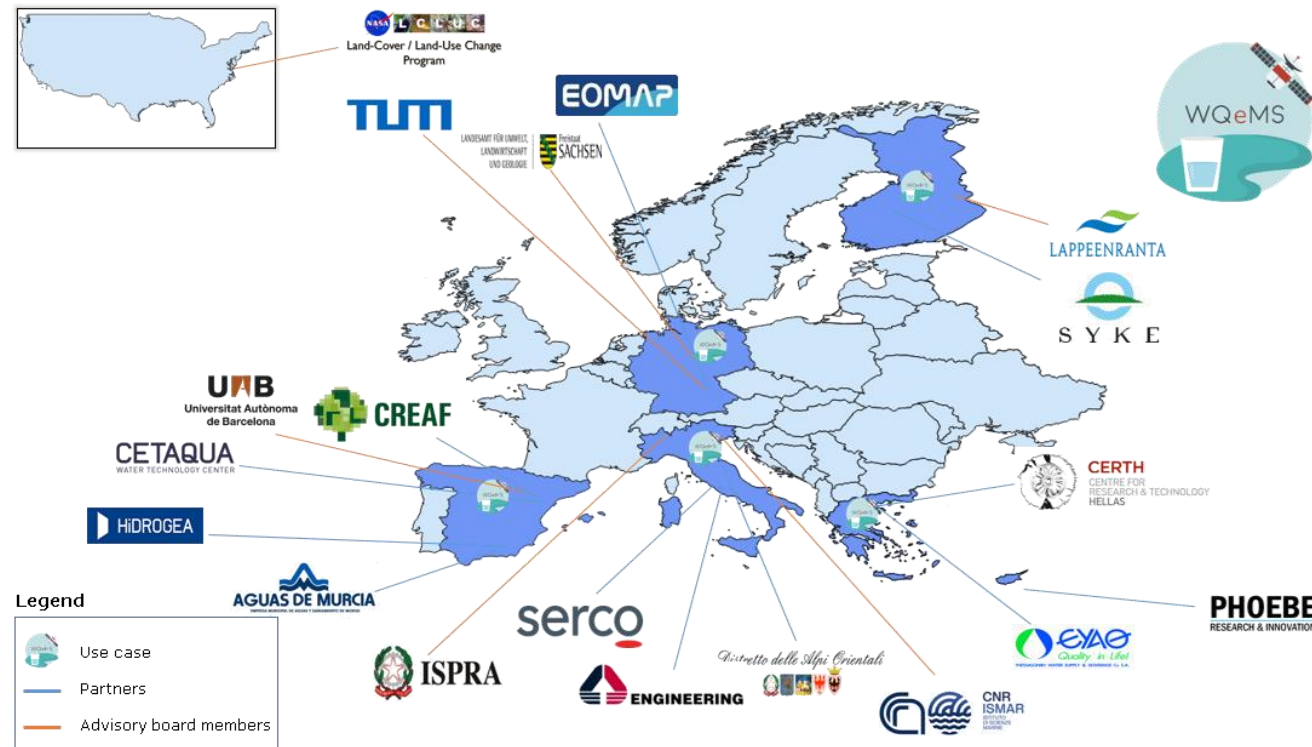
This project has received funding from the European Union's Horizon 2020 Research and Innovation Action programme under Grant Agreement No 101004157



An open surface Water Quality Emergency Monitoring Service (WQeMS) to the water utilities' industry leveraging on the Copernicus products and services



Water we drink...



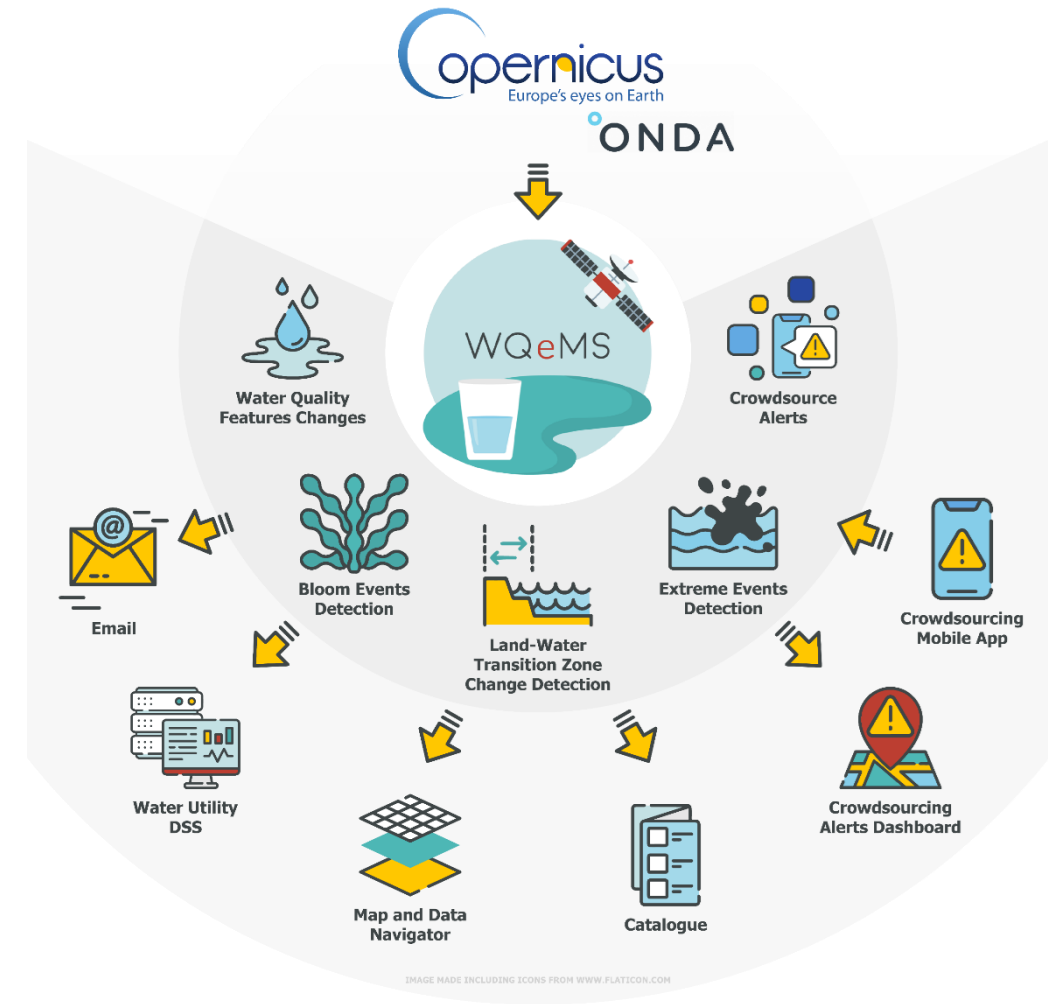
This project has received funding from the European Union's Horizon 2020 Research and Innovation Action programme under Grant Agreement No 101004157



End users involved (inhabitants directly served = ~2.690.000)

WQeMS Platform

- Facilitate the **adoption of EO monitoring services** in the water utilities' operations
- **Increased awareness of the water utilities** in relation to **water-related issues** (early warning, **fast response to phenomena**)
- Adopting both standard and modern protocols for the **interconnection of systems** (i.e., APIs, OGC Web Services)
- **Interoperability** with existing Decision Support Systems and multiple DIAS



The WQeMS platform

1

Send requests for data products on dates interval (on demand or continuous monitoring)

2

Access the generated data products (both GeoTIFF and metadata)

3

Get statistical data (i.e. time-series) obtained analysing the tiff files generated for the area of interest

4

Request a PDF report for a water body to be sent by email

5

Configure the platform to send alert notifications by email or to HTTP API of an external system

Copernicus Assisted Lake Water Quality Emergency Monitoring Service

ogeo provides an emergency water quality monitoring service to the water authorities in relation with the quality of the water body. Copernicus water quality monitoring service is designed to be able to detect the quality of the water body in real time, providing an early warning system to the water authorities. The service is designed to be able to detect the quality of the water body in real time, providing an early warning system to the water authorities. The service is designed to be able to detect the quality of the water body in real time, providing an early warning system to the water authorities.

Continuous Monitoring

Continuous monitoring is the process of monitoring the water quality of a water body in real time. This is done by using a network of sensors that are deployed in the water body. The sensors measure the water quality parameters and send the data to a central server. The server then processes the data and generates a report. The report is then sent to the water authorities. This process is repeated continuously, providing a real-time monitoring system.

On-demand Mapping

On-demand mapping is the process of generating a map of a water body in real time. This is done by using a network of sensors that are deployed in the water body. The sensors measure the water quality parameters and send the data to a central server. The server then processes the data and generates a map. The map is then sent to the water authorities. This process is repeated on-demand, providing a real-time mapping system.

Platform Overview

The platform overview shows the main components of the system. It includes a map of the water body, a list of sensors, and a list of data products. The map shows the location of the sensors and the data products. The list of sensors shows the name of the sensor, the location, and the data product. The list of data products shows the name of the product, the location, and the data product.

Service Components

The service components include the sensors, the central server, and the data products. The sensors are deployed in the water body and measure the water quality parameters. The central server processes the data and generates the data products. The data products are then sent to the water authorities.

Tools and Functionalities

The tools and functionalities include the map, the list of sensors, and the list of data products. The map shows the location of the sensors and the data products. The list of sensors shows the name of the sensor, the location, and the data product. The list of data products shows the name of the product, the location, and the data product.



HTTP File Server



WQeMS: RestAPI

Alert Configuration APIs

- POST /api/v1/alert-config/{waterbodyid}/config
- GET /api/v1/alert-config/{waterbodyid}/complete/{id}
- GET /api/v1/alert-config/{waterbodyid}/complete/{id}/status
- GET /api/v1/alert-config/{waterbodyid}/complete/{id}/status/{id}
- DELETE /api/v1/alert-config/{waterbodyid}/complete/{id}

Measure Type APIs

- GET /api/v1/measure-type/{id}/continuous/config

Social Alert Type APIs

- POST /api/v1/social-alert-type/{id}/config

WQeMS. Copernicus Assisted Lake Water Quality Emergency Monitoring Service

Layer Turbidity - Polyphytos

Layer download

Download the complete layer

Legend & layer control

- Turbidity - Polyphytos
- Turbidity - Chlorophyll a
- Turbidity - Chlorophyll b
- Turbidity - Chlorophyll c
- Turbidity - Chlorophyll d
- Turbidity - Chlorophyll e
- Turbidity - Chlorophyll f
- Turbidity - Chlorophyll g
- Turbidity - Chlorophyll h
- Turbidity - Chlorophyll i
- Turbidity - Chlorophyll j
- Turbidity - Chlorophyll k
- Turbidity - Chlorophyll l
- Turbidity - Chlorophyll m
- Turbidity - Chlorophyll n
- Turbidity - Chlorophyll o
- Turbidity - Chlorophyll p
- Turbidity - Chlorophyll q
- Turbidity - Chlorophyll r
- Turbidity - Chlorophyll s
- Turbidity - Chlorophyll t
- Turbidity - Chlorophyll u
- Turbidity - Chlorophyll v
- Turbidity - Chlorophyll w
- Turbidity - Chlorophyll x
- Turbidity - Chlorophyll y
- Turbidity - Chlorophyll z

Situation map

Current position

Modify the name

Zoom to layer

Add layer

Share layer

Remove layer

Move layer

Up

Down

To the end

Metadata

Feedback

Edit style

Histogram

Statistic

Selection

Reclassification

Retrieve styles

WQeMS Report

The data included in this report is related to Ojos water body in the period of time from 01/01/2017 to 01/01/2022

Aggregated values

Water Quality - Turbidity

Measure Name	Unit of Measure	Aggregation Type	Value
Max Value of Turbidity	Number of Transfer Units	Average	111.24
Mean Spatial Value of Turbidity	Number of Transfer Units	Average	49.79
Median Value of Turbidity	Number of Transfer Units	Average	48.21
Min Value of Turbidity	Number of Transfer Units	Average	23.24
10-Quantile Value of Turbidity	Number of Transfer Units	Average	37.0

Mean Area Flood Segments

WARNING: YOU HAVE A NEW ALERT FROM THE WQeMS PLATFORM

You have a new alert generated by your alert configuration **Polyphytos Alert Configuration** related to the water body **polyphytos**.

The alert was generated for the following reasons:

The condition you set has happened. The measured value of Mean Spatial Value of Turbidity is 3.21 NTU which is greater than 1.4262 NTU.

See more details:

- Map and Data Navigator: <https://www.ogc3.grumets.cat/woems/>
- HTTP File Server: https://cog-wqems.opsi.lecce.it/water-quality/tur/polyphytos/waterquality-tur_polyphytos_20220103_SENT2_m10-WQeMS.tif

WQeMS project - Grant Agreement No 101004157

Rules

Select a phenomena: Water Quality - Turbidity

Select a measure: Mean Spatial Value of Turbidity

Select a relationship: greater than

Lower Limit: 40

ntu

Delete Rule

Add Rule

WQeMS service components (SC)

Service	Sub-service
Water Quality	Turbidity
	Chlorophyll-a
	Coloured Dissolved Organic
	Secchi Disk Depth
	Sea Surface Temperature
Bloom Event Detection	Harmful Algae Bloom Indicator
Land Water Transition Zone	Two Dates
	Hydroperiod
Extreme Event Detection	Oil Spill
	Muddy Water
	Flood



There are three different types of output data (for each service component) managed by the platform: **GeoTiff** files, **statistical data** in json format, and **metadata** in xml format

Metadata

An XML file describing the metadata of each GeoTiff image.

For example, some parameters are: the file size, the HTTP link to the file, the Data Provider, and so on.

GeoTiff

A raster layer that contains data about a specific feature monitored by each service.

Statistical Data

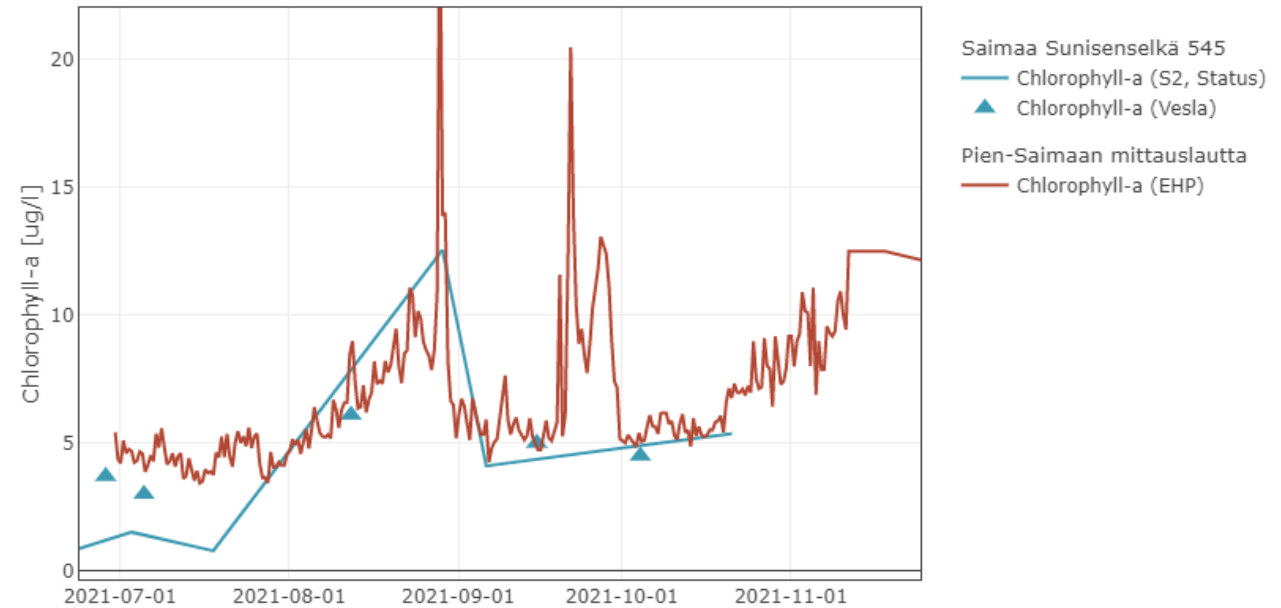
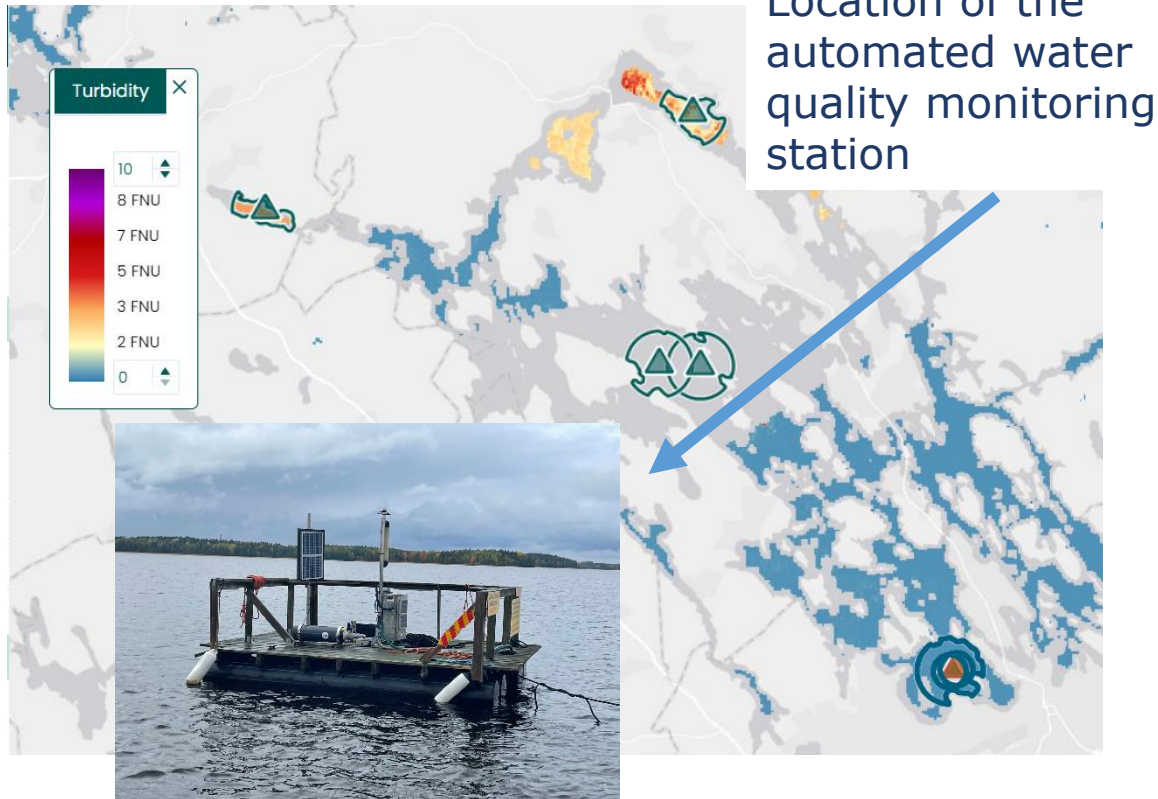
A JSON that contains some statistical values associated with the GeoTiff image,

such as mean value, maximum value, median, and so on

(SC1) Water Quality Features

Comparison of in situ and satellite observations about water quality

Learning from the free and open water quality information through Syke's TARKKA web application and EOMAP's Modular Inversion Processor



Chl-a values observed at the location of the automated station with Sentinel-2 satellite (S2, blue line), laboratory samples (Vesla, blue triangles) and automated instruments (EHP, red line)

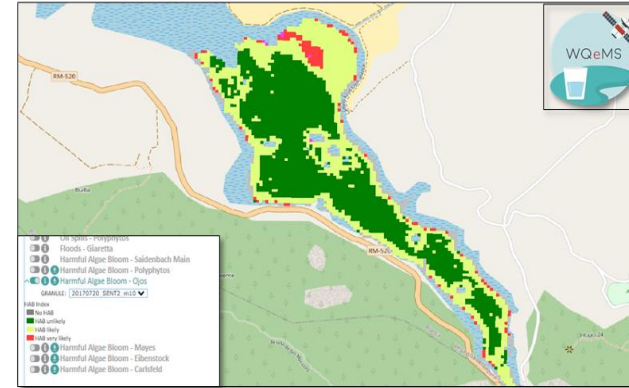
Innovation: Expansion of known workflows and techniques for the needs of the water utility industry.

(SC2) Harmful Algal Blooms



- In situ sampling (Azud de Ojós and DWTP Reservoir) to adjust the values detected in the Sentinel-2 images.

- Historical data of algal monitoring are used to test performance of hyperspectral images.



Same workflow result with WorldView, 0.5m



Innovation:

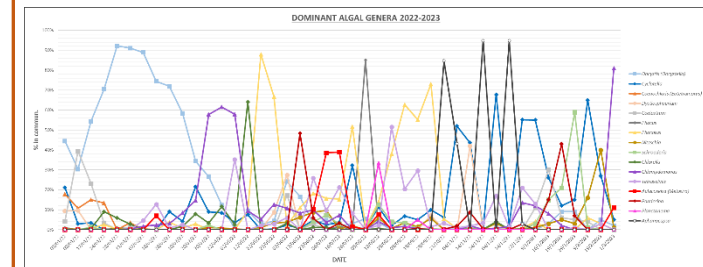
- **Detection of potentially harmful cyanobacteria blooms**
- **Worldwide data even for small water bodies (> 1ha)**
- **For emergency and baseline scenarios**

- Tested (in GR, DE, FI) and in an operational DSS in Spain

...using **different type of sensors and data sources** (it combines data from satellite and in-situ online monitoring station; data from regional water basin agency and national weather agency, etc.)

...able to provide **forecast of cyanobacteria risk from coupled models** based on machine learning methods

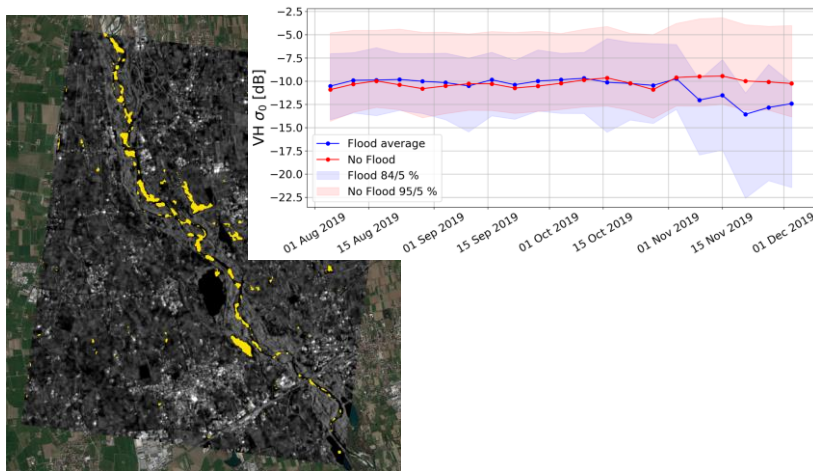
...in a form that has been **co-created with and for the Drinking Water Plant Operator** that is using it since 2021



(SC3) Extreme Events

Extreme Events service uses Copernicus satellite data to detect extreme events occurring in inland drinking water reservoirs that contribute to water quality degradation

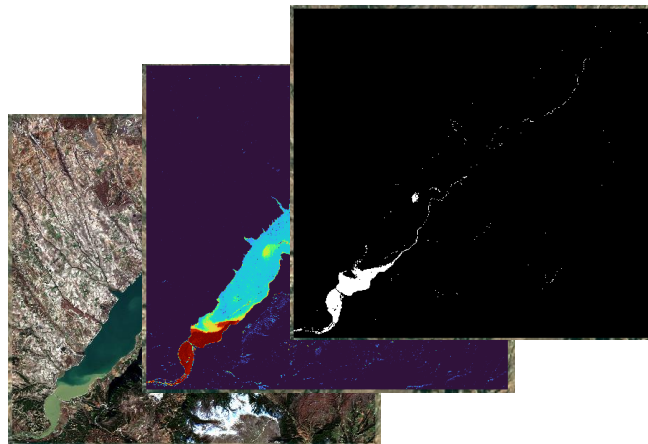
Flood sub-service maps extreme flood events using **Sentinel-1** every **~6 days** (both satellites) with a **10m** pixel size based on **Deep Learning**



Innovation:

- Explicitly exploits time series patterns
- Uses deep learning
- **AOI-invariant model**

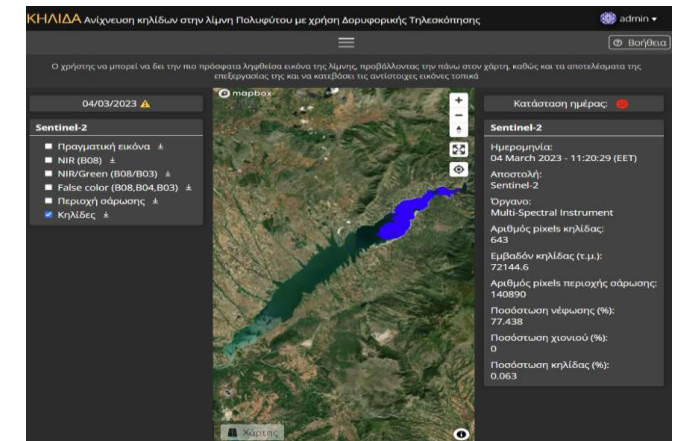
Muddy water sub-service maps muddy waters (extreme suspended sediment values in the water) using **Sentinel-2** every **~5 days** with **10m** pixel size based on **Ensemble Machine Learning**



Innovation:

- Unique muddy water mapping service using machine learning

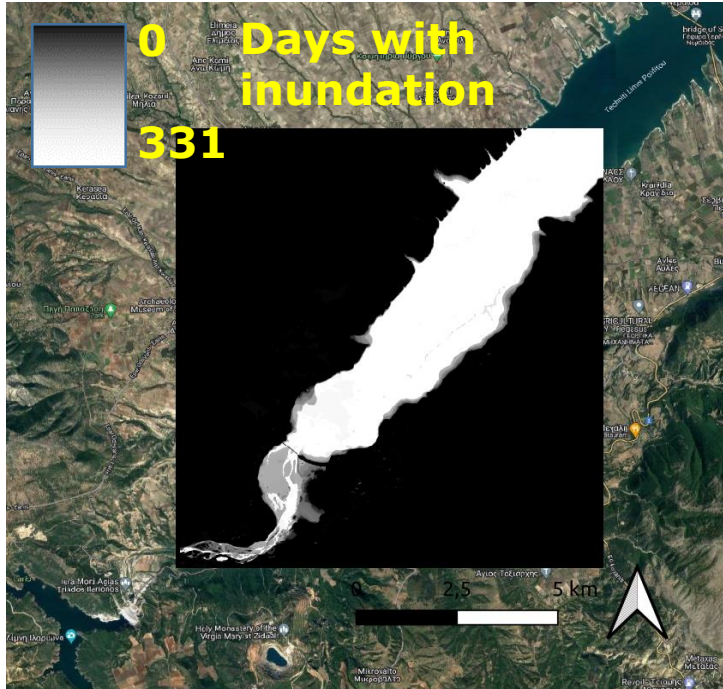
Oil spill sub-service maps potential hydrocarbons using **Sentinel-2** every **~5 days** with **10m** pixel size based on **Deep Learning**



Innovation:

- Unique hydrocarbon mapping service for inland waters using deep learning & optical data

(SC4) Land-Water transition zone



Three modes for two-dates service:

- S2 mode: Only Sentinel 2 data
- S2-S1: Based on the user dates, the products (either S2 or S1), whose acquisition date is the closest to the user preference, will be used for the processing.
- S1 mode: Only Sentinel 1 data

Two modes for hydroperiod service:

- S2 mode
- S2-S1 mode



Polyphytos Lake (subset), land to water change detection between: 21-10-2017 and 02-12-2017

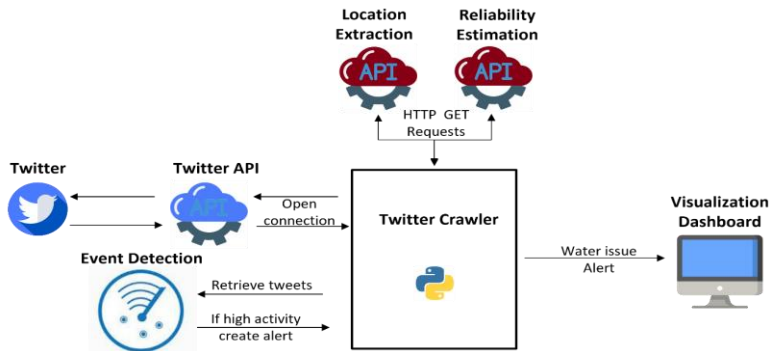
Innovation:

- **Proven and adapted workflows at multiple sites across Europe** reaching up to **98% accuracies** (multiple alternative methods for various scenery types)
- Exploitation of **both optical and radar data to enhance frequency of information** retrieval with proven credible results
- **Fully unsupervised performance**

(SC5) Alerts Generation

The Social Media Crawler collects water related tweets from Twitter in real time.

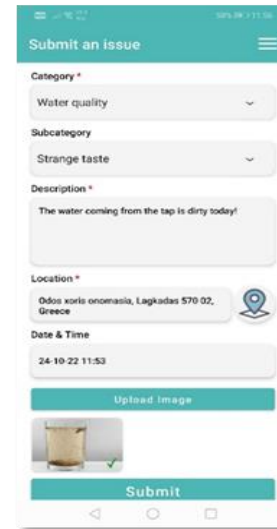
- Analysis of each retrieved tweet:
 1. Extract tweet location from text
 2. Estimate whether tweet is fake or not
- Detect water related events based on Twitter activity and location.



Innovation:

Analyzes **large volumes of crowdsource water related information in real time** and provides potential water issues that need to be investigated.

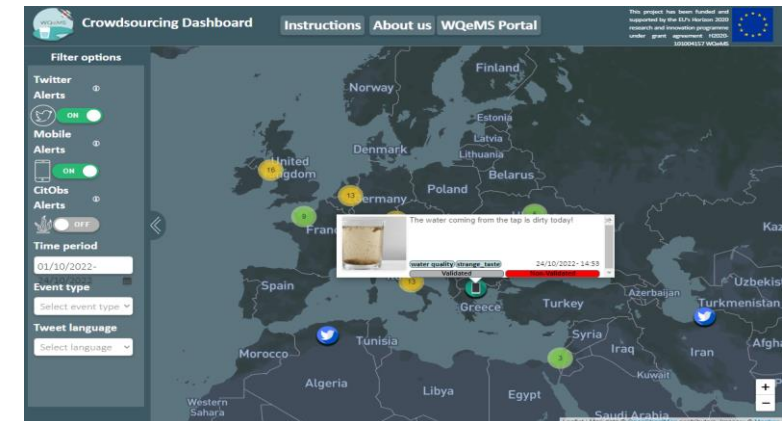
The Crowdsourcing Mobile App allows citizens to post water related complaints through their smartphone.



Innovation:

Enables a more efficient and **streamlined way for water utilities to receive and handle complaints** and improving the quality of service and customer satisfaction.

The Crowdsourcing Dashboard visualizes the alerts collected from multiple sources including alerts generated by social media crawlers and complaints submitted through the crowdsourcing mobile app



Innovation:

The crowdsourcing Dashboard combines and **visualizes data from multiple sources**, enabling quick identification and responding to emerging issues.

(SC6) Capacity Building

WQeMS e-Training Platform

(<https://training.wqems.eu>)

Content

- **Understanding Copernicus data and services**
- **Technical aspects in earth observation services**
- **Inland water features' estimation services enabled by earth observation**
- **Use-cases and applications**

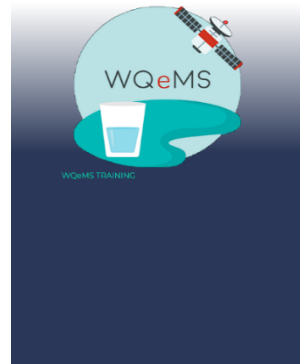


Training guidance

- **Training Pathway 1: Full-range training**
- **Training Pathway 2:** Familiar with background knowledge; Requiring **strong WQeMS-related skills for specific services**
- **Training Pathway 3:** Training to **attract interest of domain experts**
- **Training Pathway 4:** Focusing on **Academia**
- **Training Pathway 5:** Focusing on **Industry**

Innovation:

- **Dedicated training pathways** through the material per level of competence and target audience..
- **Facilitate the acquisition of required skills and competences** by WQeMS users, related to the operation and **content interpretation of the developed solutions.**
- Help **sustain the operation of the WQeMS platform beyond project duration.**



(SC7) Metadata & Feedback

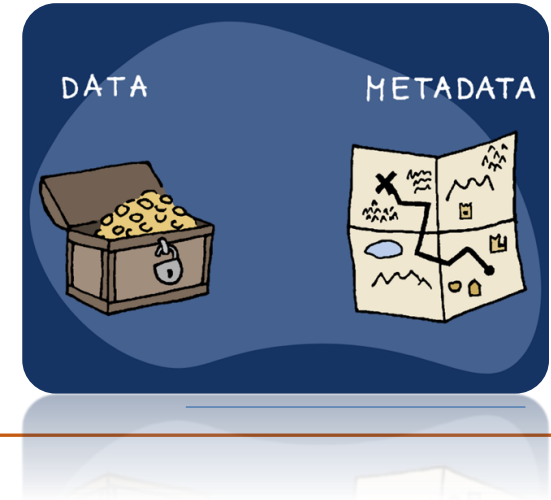
WQeMS follows the FAIR principles: Data should be **Findable, Accessible, Interoperable and Reusable** to the greatest extent possible

How to decide that a dataset is useful for our purposes (fit per purpose)?

How to choose the best dataset in terms of the quality of the data?

How policy makers can know better the results of policy and monitoring?

➡ METADATA!



Innovation:

- **New keywords that describe the dataset in a way to bring it closer to management, monitoring and policy**, following the GEO Essential Water Variables, i.e. "Lakes/reservoir levels", "Water Quality", "Water use/demand", "Evaporation", etc. and the UN Sustainable Development Indicators, i.e. Target 6.3.

- **Quality parameters included in the metadata based on QualityML dictionary.**

```
<gmd:errorStatistic>  
  <gco:CharacterString>https://www.qualityml.org/1.0/metrics/RootMeanSquareError</gco:CharacterString>  
</gmd:errorStatistic>
```

- All Metadata is **uploaded to the GeoNetwork catalogue** and also allows connection to the **GEO yellow pages**

- Metadata is also available through **the interoperable WQeMS Map and Data Navigator**, by which **feedback to the dataset can be provided.**

Main innovative elements of services

- **Use of multi-sensor-fusion technologies**
- **Spatial and temporal resolution, and product consistency**
- **Treatment of small (also uneven shaped) open surface water reservoirs**
- **Minimization and documentation of uncertainty**
- **Ontology and semantics of water quality supporting regulations**
- **Metadata tool documentation**
- **Interoperability with existing Decision Support Systems and multiple DIAS**
- **Cloud based micro-services structure**
- **Federated approach, enabling further service providers to expand WQeMS service portfolio**

WQeMS Service Components

<https://portal-wqems.opsi.lecce.it/>

Water Quality



[Read more →](#)

Bloom Events



[Read more →](#)

Land Water Transition Zone



[Read more →](#)

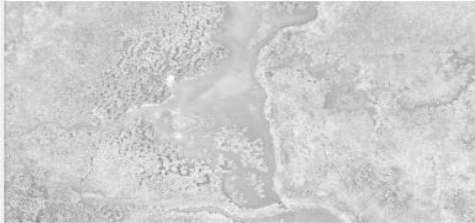
Extreme Events



[Read more →](#)

Other WQeMS Tools and Functionalities

Map and Data Navigator



[Read more →](#)

Catalogue



[Read more →](#)

Data Access



[Read more →](#)

Crowdsourcing Mobile App



[Read more →](#)

Crowdsourcing Dashboard



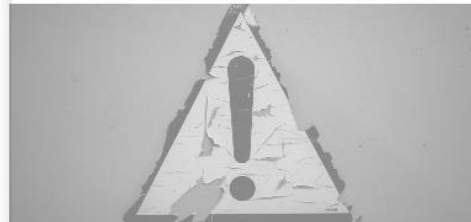
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Pathogen Contamination Emergency Response Technologies



Water Data Management Ecosystem for Water Data Spaces



A Digital Twin for AI-enabled water quality monitoring and actionable decision support in Water Distribution Networks



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Thank you!

