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UNIVERSITÄT BONN GEOGRAPHIE ZFL

UN-SPIDER / ZFL Regional Virtual Expert Meeting for Southern Africa "Space-based Solutions for Disaster Risk Management and Emergency Response" 13-15 July 2021

The FloodHub and FireHub systems for early warning and crisis management

Haris Kontoes, Alexia Tsouni, Stella Girtsou

National Observatory of Athens – IAASARS – BEYOND Center of Excellence

BEYOND Centre of EO Research & Satellite Remote Sensing

FloodHUB FireHUB

http://beyond-eocenter.eu

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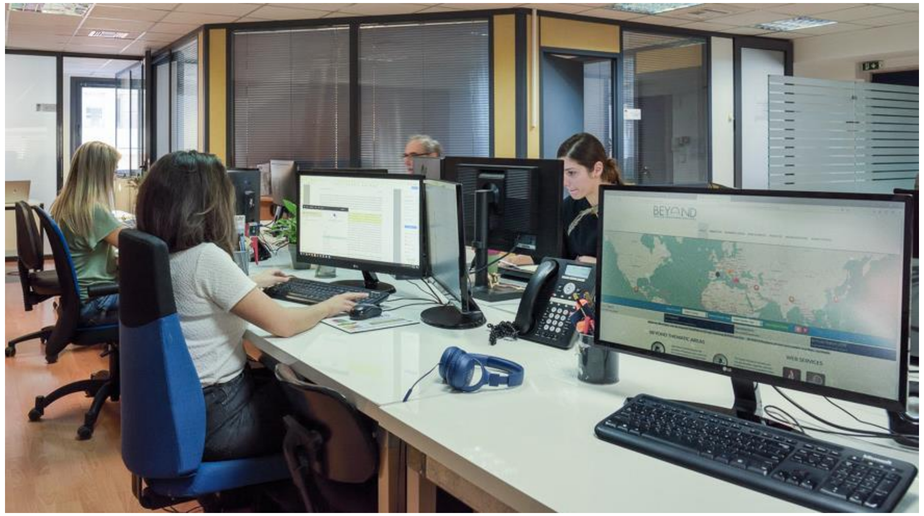
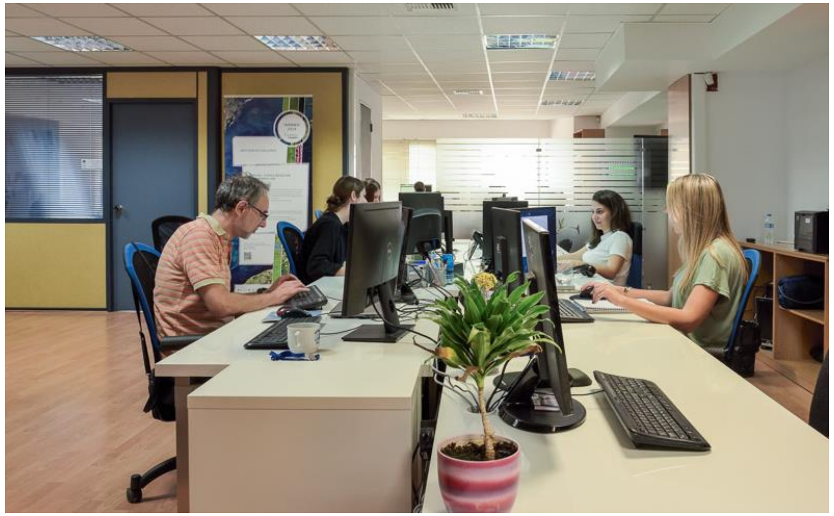
The BEYOND Center of EO Research & Satellite Remote Sensing

BEYOND
Centre of EO Research & Satellite Remote Sensing

FloodHUB





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The services of the BEYOND Center

BEYOND Centre of EO Research & Satellite Remote Sensing

FloodHUB

FireHUB — 24/7 Real-Time Forest Fire Monitoring service - Diachronic Burnt Scar Mapping (> 35 years) - Fire Risk assessment (http://beyond-eocenter.eu/index.php/web-services/firehub)

DustHUB — Detection and diffusion of desert dust, dust, volcanic ash and toxic gases (http://beyond-eocenter.eu/index.php/web-services/dusthub)

FloodHUB — Rapid Flood Mapping - Diachronic Flood Mapping - Flood monitoring and early warning (http://beyond-eocenter.eu/index.php/web-services/floodhub)

GeoHUB — Early warning and monitoring of geophysical disasters (earthquakes, landslides, volcanic eruptions) - Ground Displacement Mapping (http://beyond-eocenter.eu/index.php/web-services/geohub)

SolarHUB — Solar Atlas Service - Solar Energy Nowcasting Service - Short-term Forecasting System (http://beyond-eocenter.eu/index.php/web-services/solarhub)

ClimaHUB — Data Extraction Application for Regional Climate (http://beyond-eocenter.eu/index.php/web-services/climahub)

EYWA — Early Warning System for Mosquito Borne Diseases (http://beyond-eocenter.eu/index.php/web-services/eywa)

COVID - 19 — Global spread monitoring of the COVID-19 pandemic (http://beyond-eocenter.eu/index.php/web-services/covid-19)

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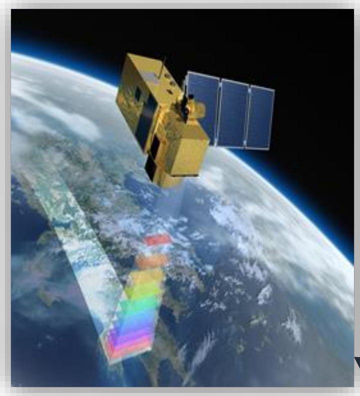
The monitoring systems of the BEYOND Center

BEYOND Centre of EO Research & Satellite Remote Sensing

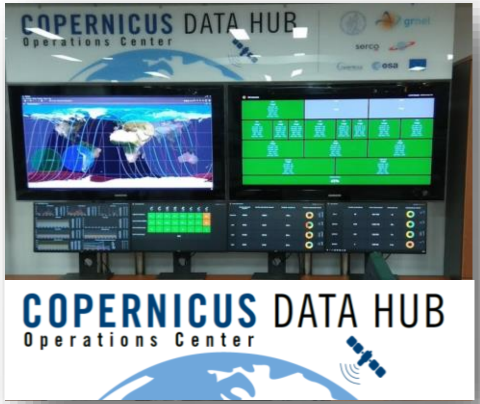
FloodHUB

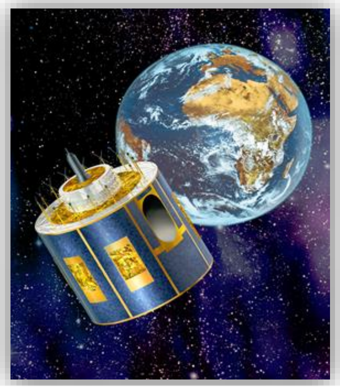


Satellites Polar Orbit

X-/L-band Station

Sentinel Mirror Site





Satellites Geostationary Orbit
MSG SEVIRI

HELLENIC MirrorSite

Ελληνικό Mirror Site (Copernicus satellite missions)
http://beyond-eocenter.eu/index.php/web-services/hellenic-mirror-site)

GreekHUB

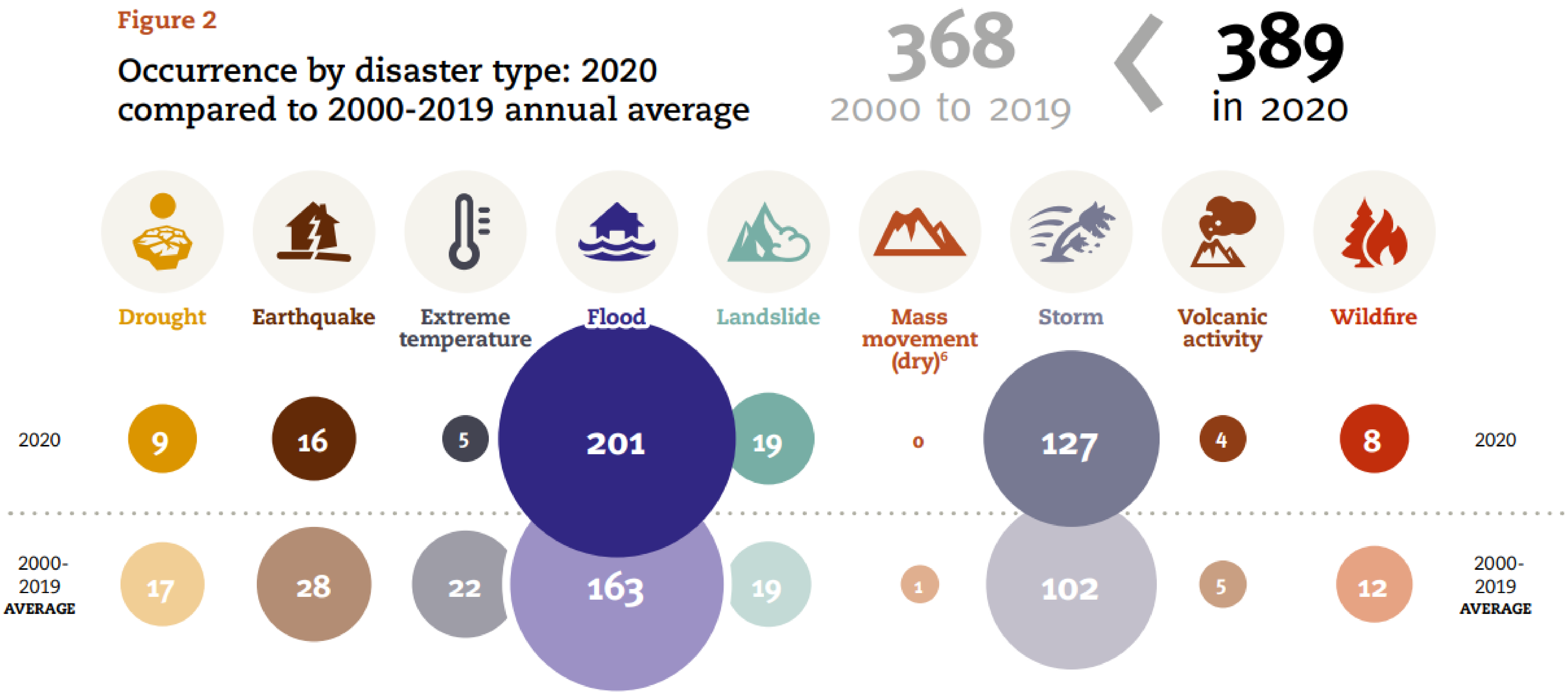
Sentinels GreekHUB
(http://beyond-eocenter.eu/index.php/web-services/sentinels-greekhub)

Manned & Unmanned Aerial Vehicles

In-situ networks and crowdsourcing

in-situ

Flood was the most frequent type of disaster in 2020



Source: Centre for Research on the Epidemiology of Disasters & UN Office for Disaster Risk Reduction, 2021

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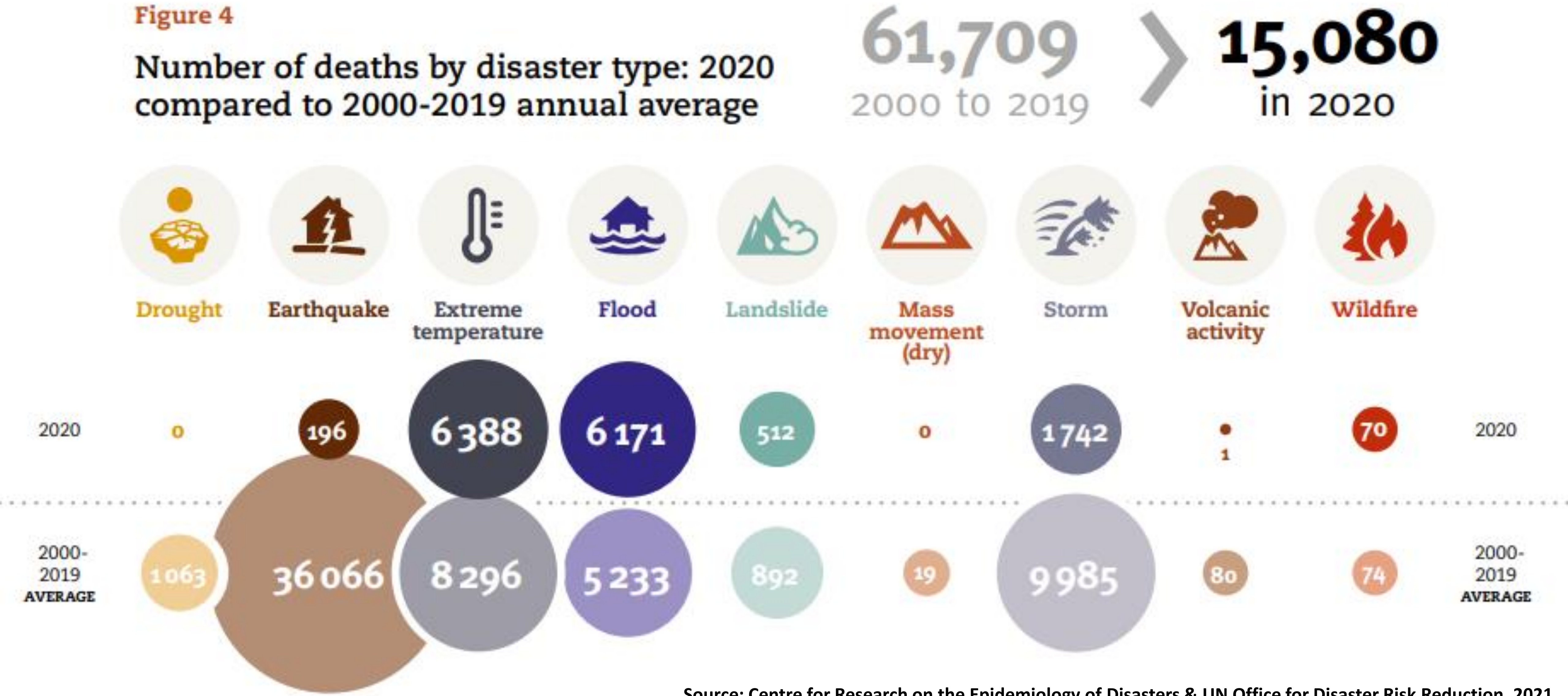
Flood was the only type of disaster increasingly deadly in 2020



Source: Centre for Research on the Epidemiology of Disasters & UN Office for Disaster Risk Reduction, 2021

Mandra flood 2017:
Setup of an integrated web GIS platform

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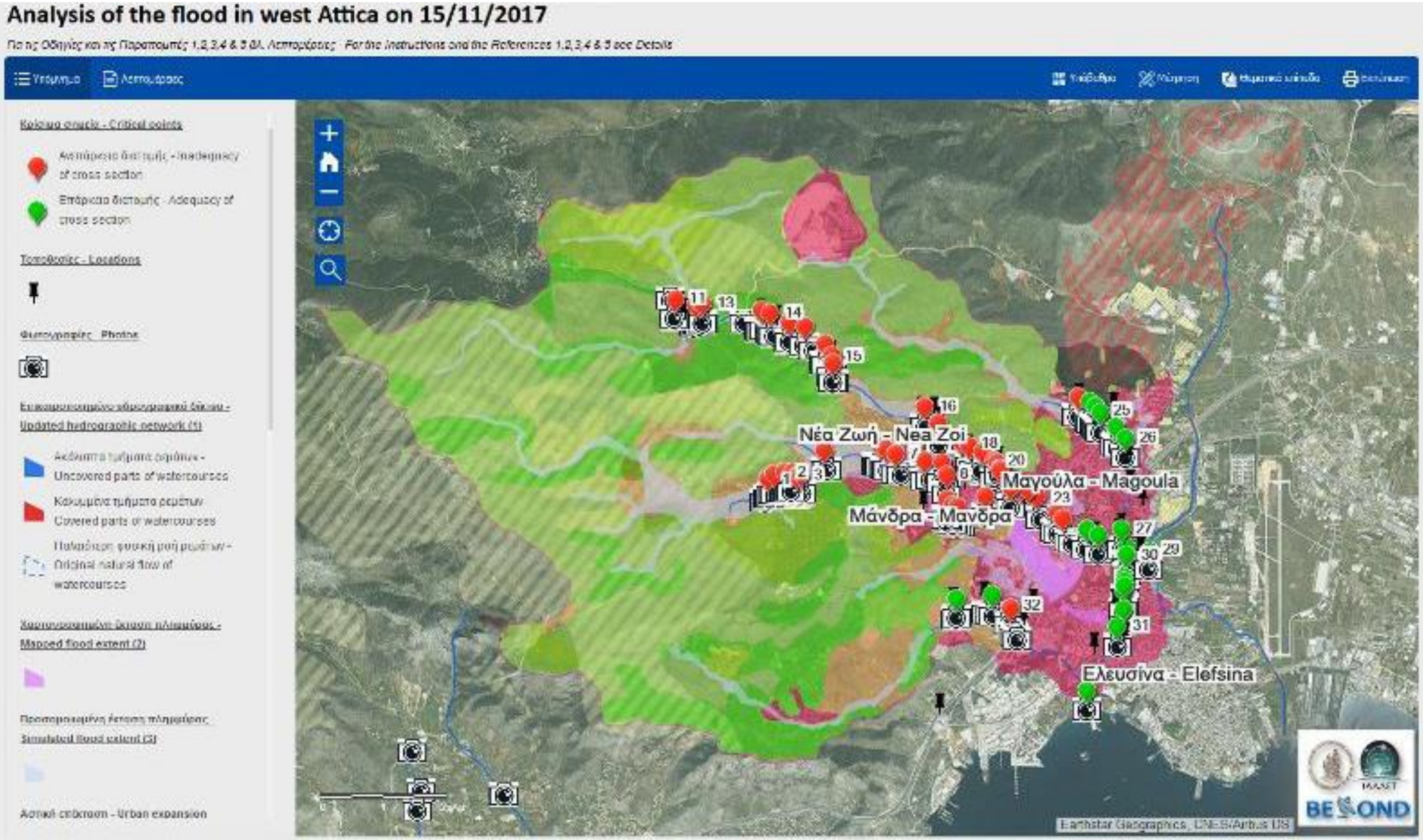

EuroGEO
Disaster Resilience Action Group

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Mandra 2020: Architecture of the FloodHUB system

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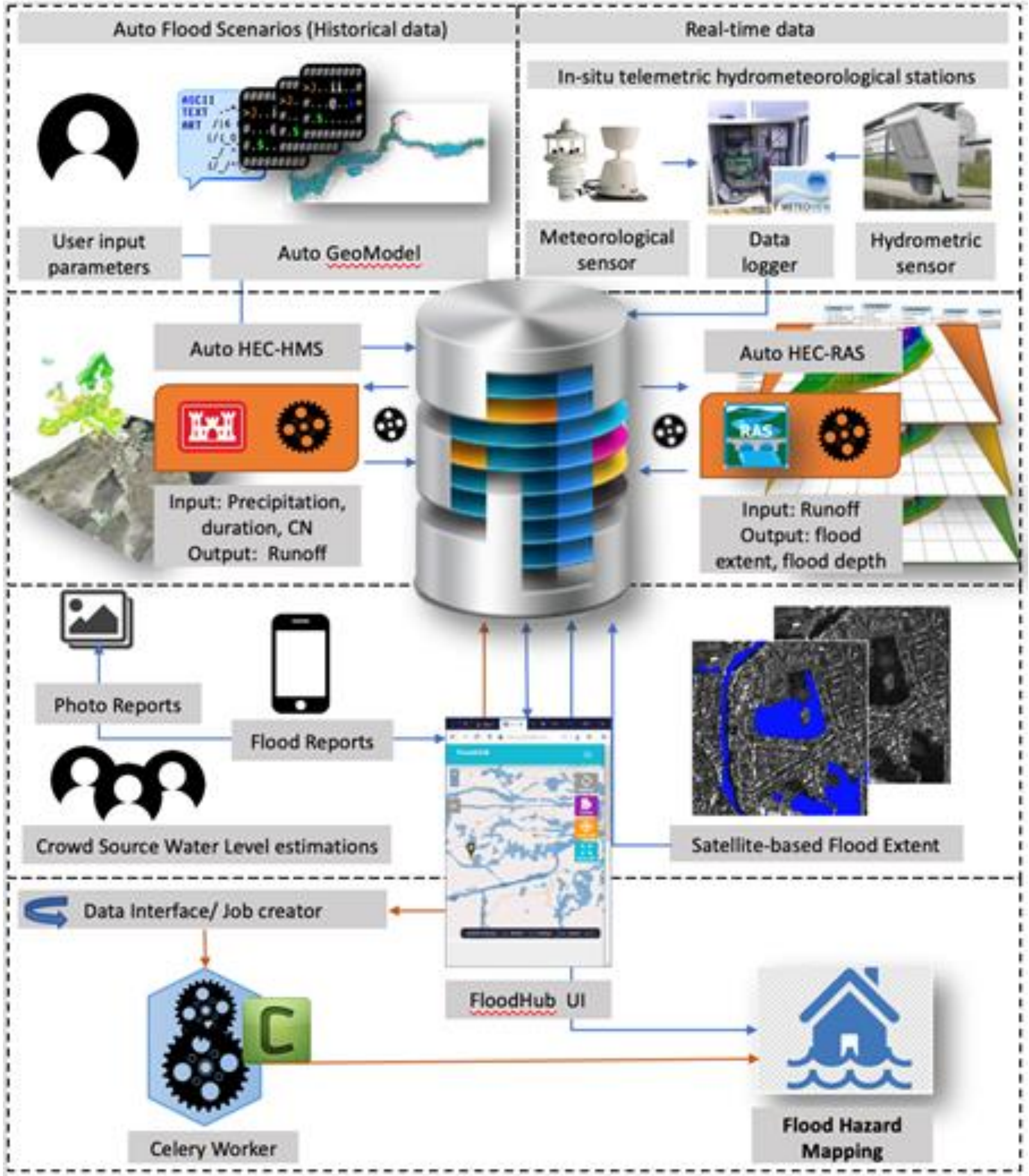
FloodHUB

An integrated near-real-time flood monitoring system:

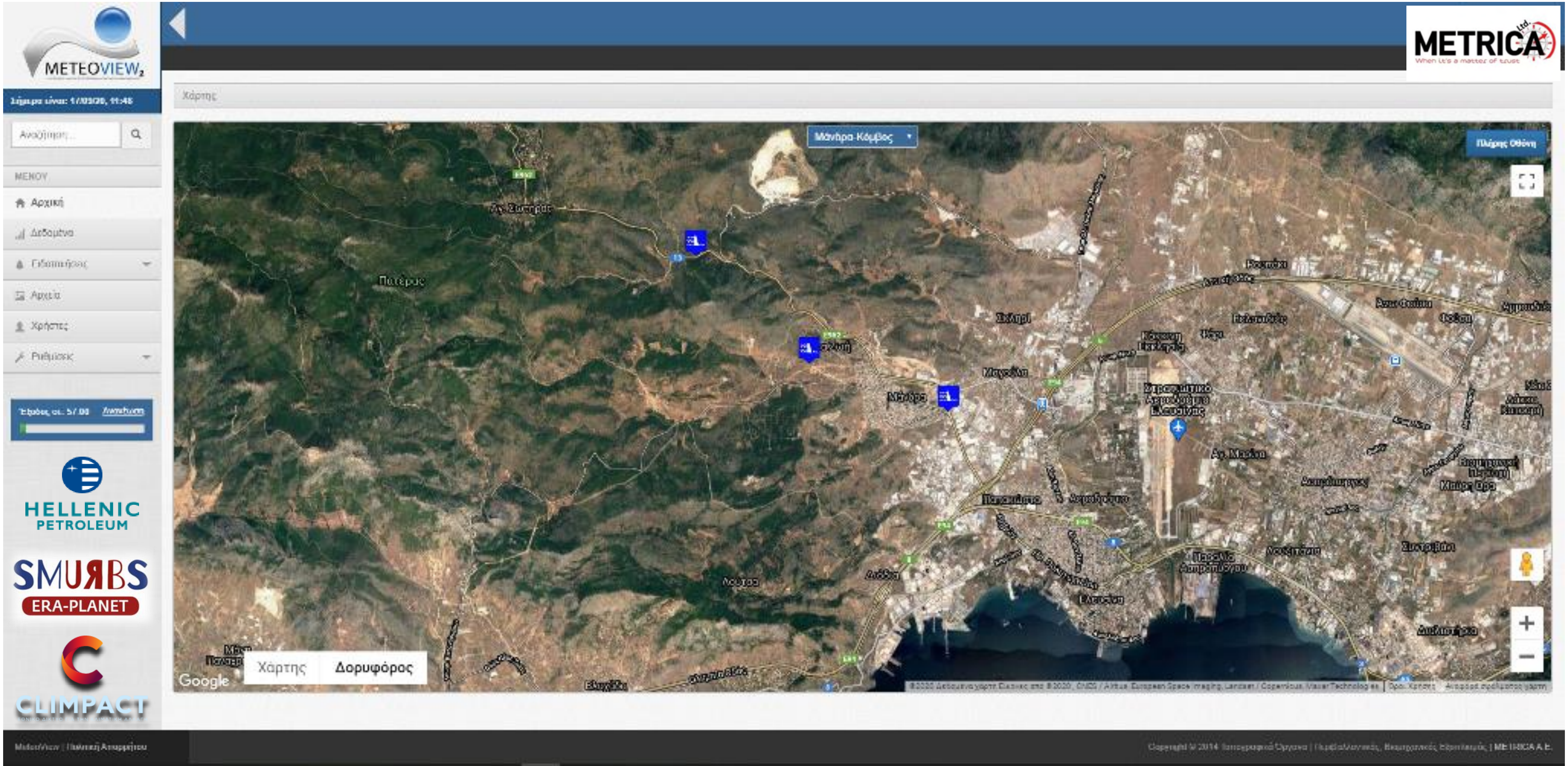
- based on modeling, multi-source EO and crowdsourced data
- with a fully scalable and transferable modular architecture
- delivering a reliable operational awareness picture of the crisis every 5-15 minutes to all the relevant authorities



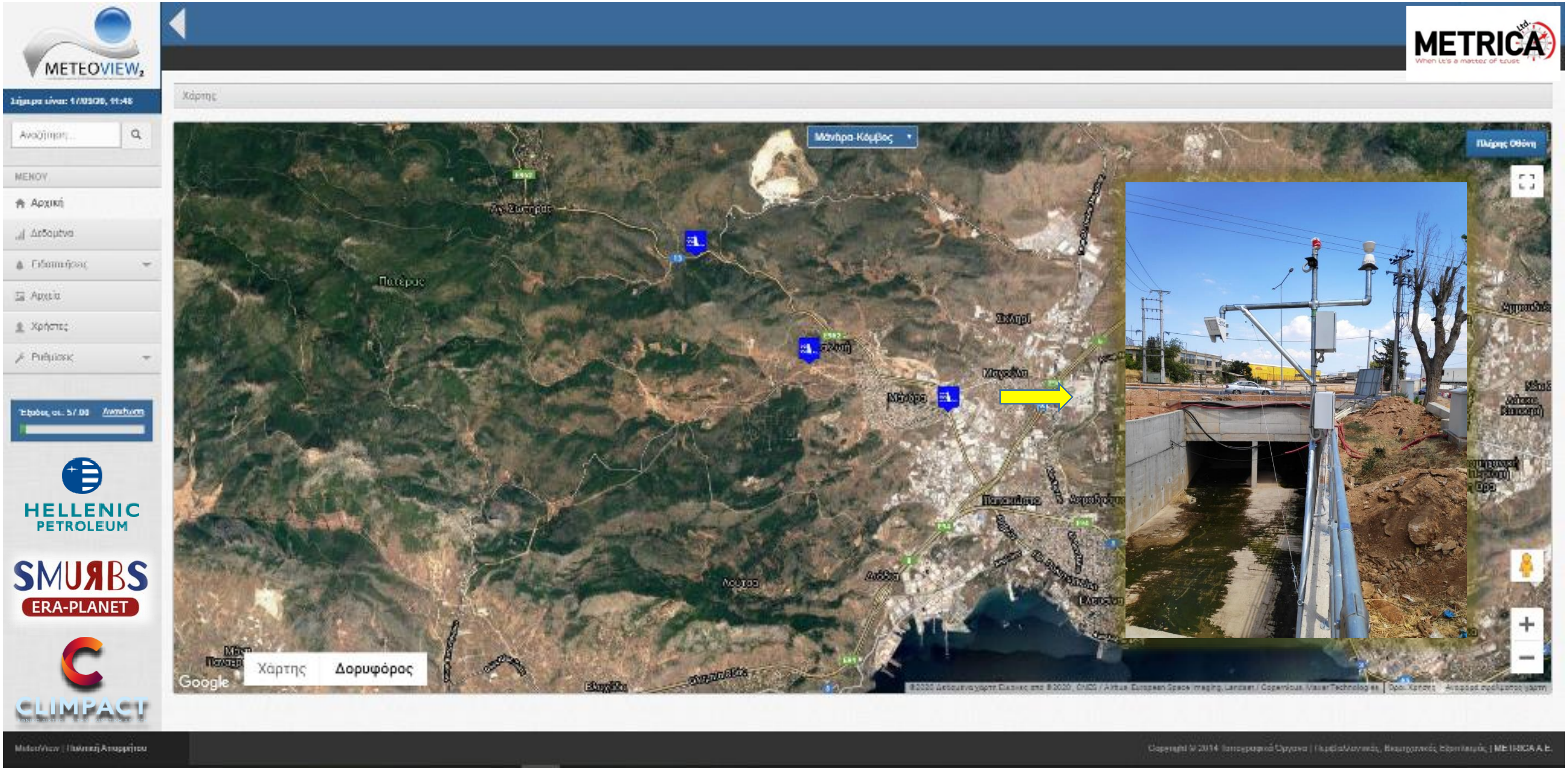
Near-real-time ingestion and assimilation of:

- hydrometeorological parameters measured at 3 in-situ telemetric stations (installed at 3 critical locations)
- satellite data (e.g. from high resolution Sentinels collected from the Hellenic Mirror Site)
- crowdsourced data (collected via the dedicated crowdsourcing platform).

Web platform of the 3 telemetric hydrometeorological stations



Web platform of the 3 telemetric hydrometeorological stations



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Web platform of the 3 telemetric hydrometeorological stations

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Web platform of the 3 telemetric hydrometeorological stations

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Web platform of the 3 telemetric hydrometeorological stations

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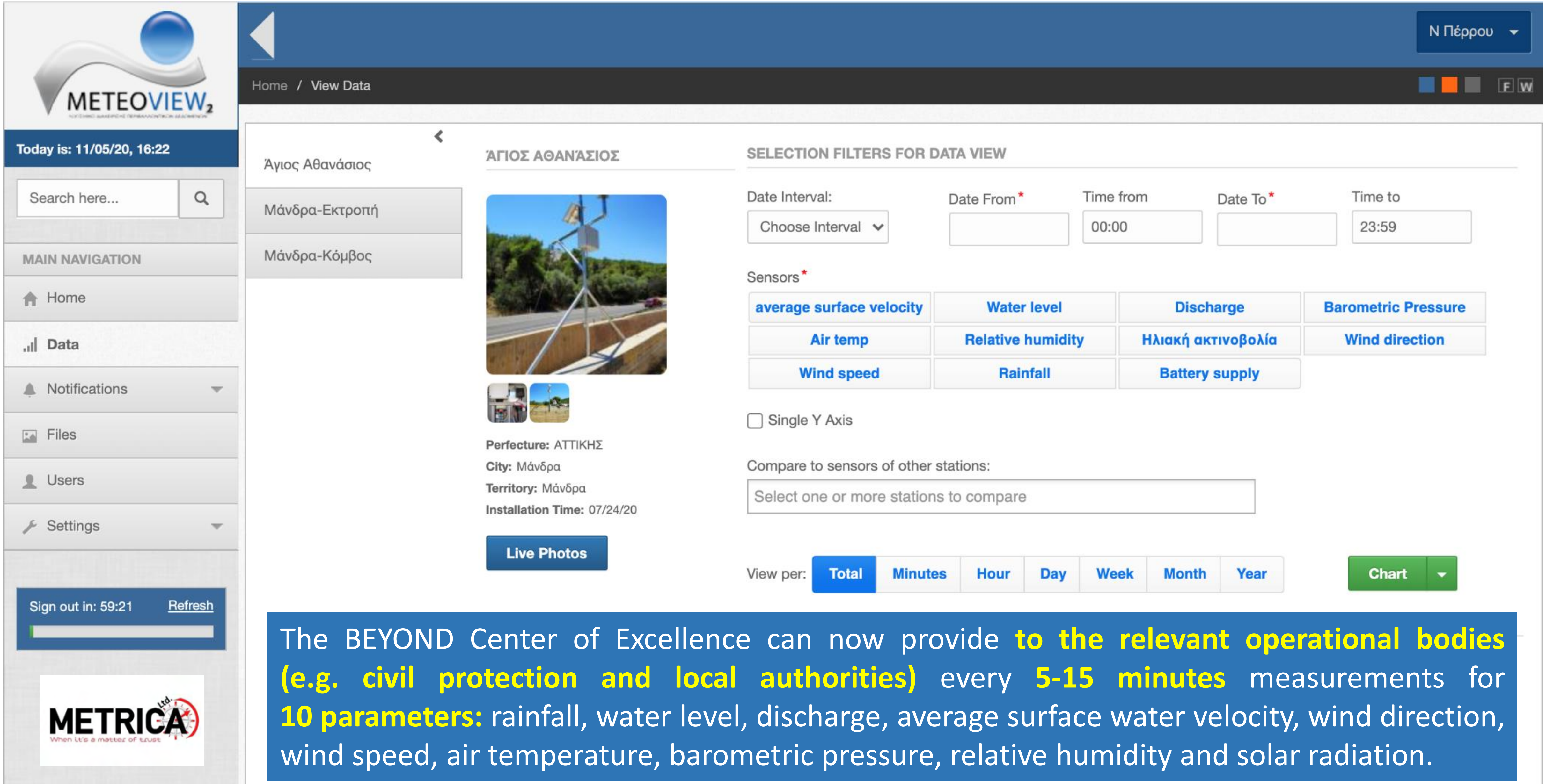

The BEYOND Center of Excellence can now provide **to the relevant operational bodies (e.g. civil protection and local authorities)** every **5-15 minutes** measurements for **10 parameters:** rainfall, water level, discharge, average surface water velocity, wind direction, wind speed, air temperature, barometric pressure, relative humidity and solar radiation.

Real-time crowdsourcing platform for staff and volunteers

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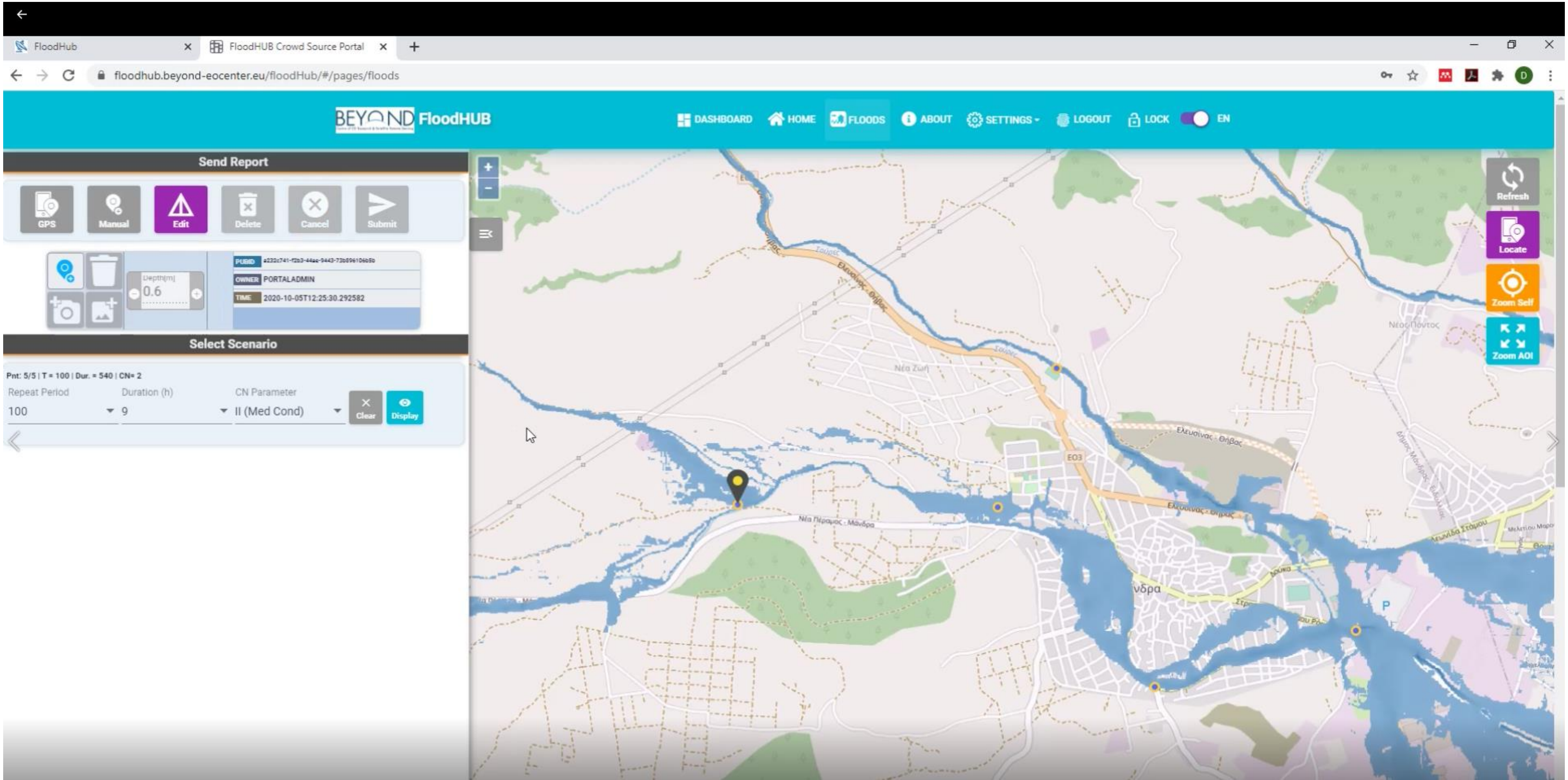

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Integrated near-real-time flood monitoring system

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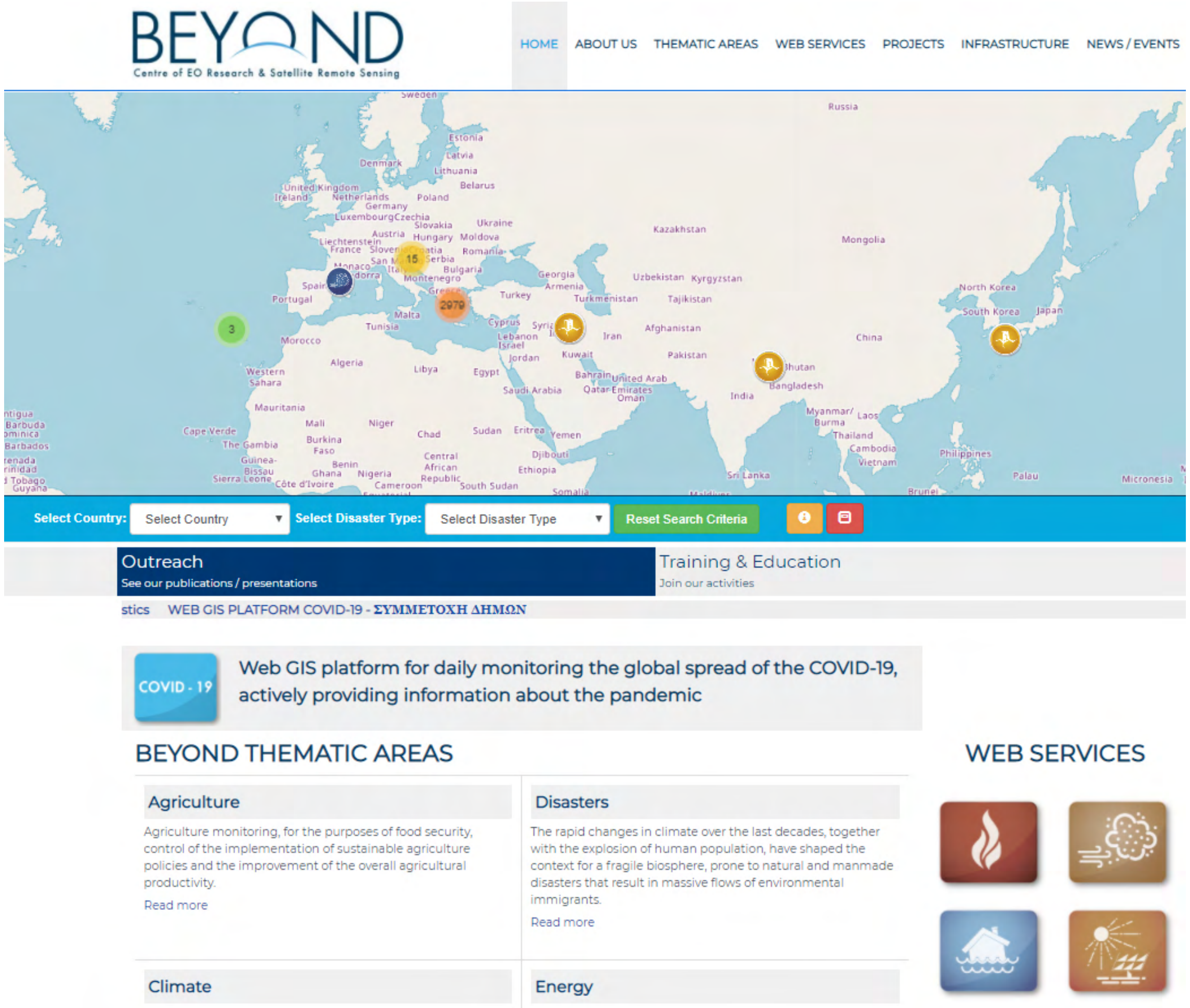
FloodHUB



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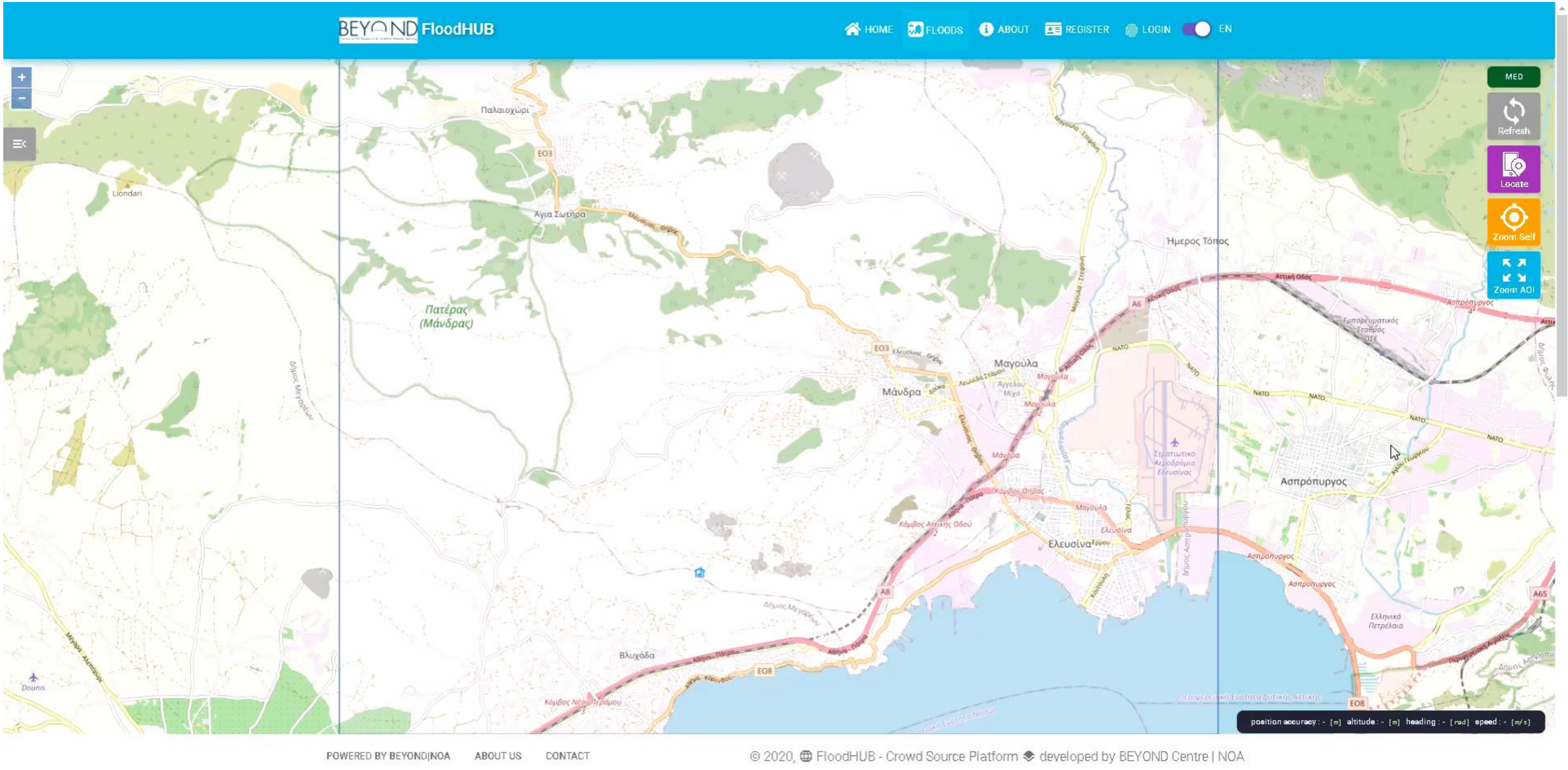
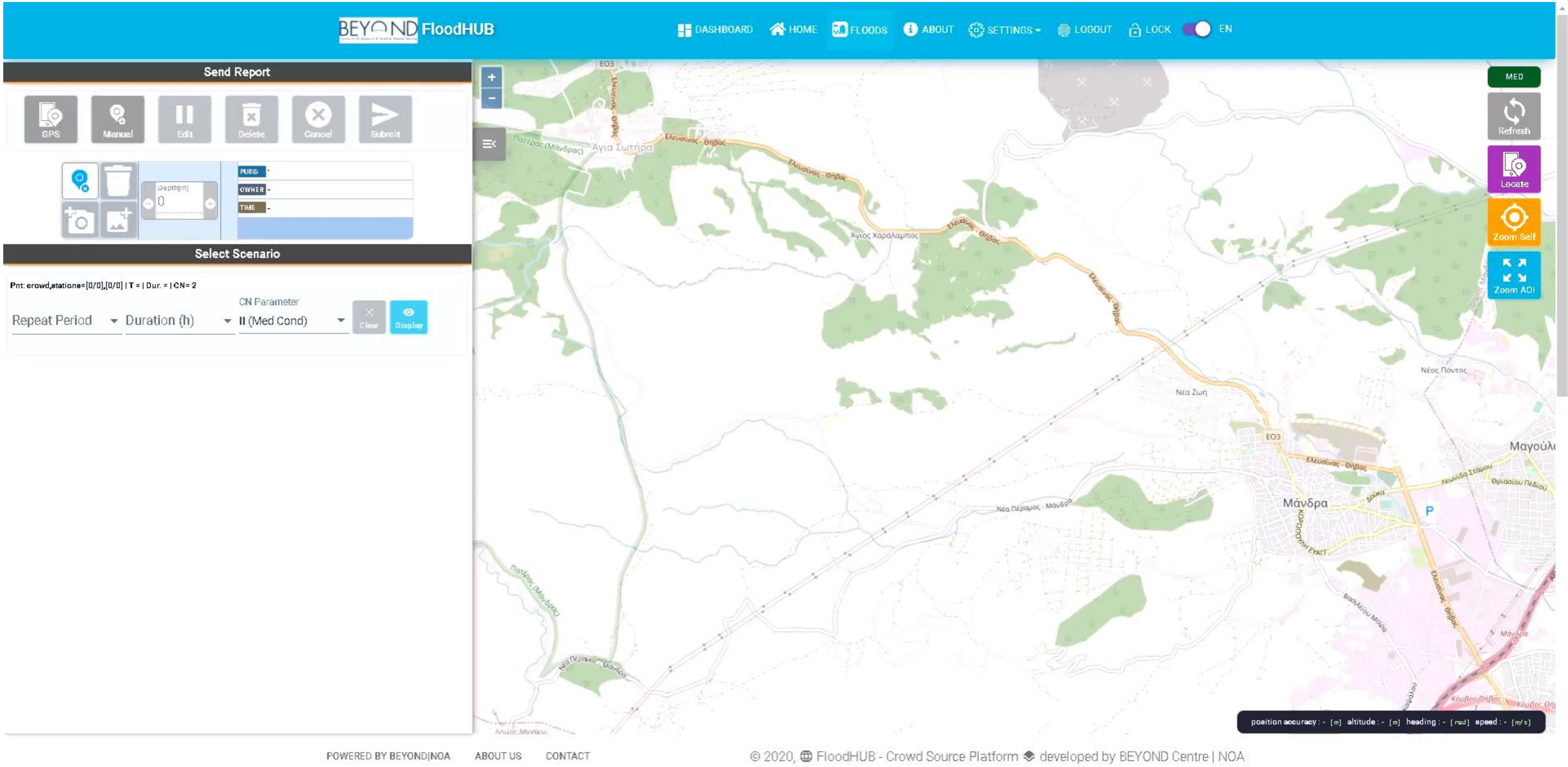
Integrated near-real-time flood monitoring system

BEYOND
Centre of EO Research & Satellite Remote Sensing

FloodHUB



Integrated near-real-time flood monitoring system



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Hydrologic & hydraulic simulation

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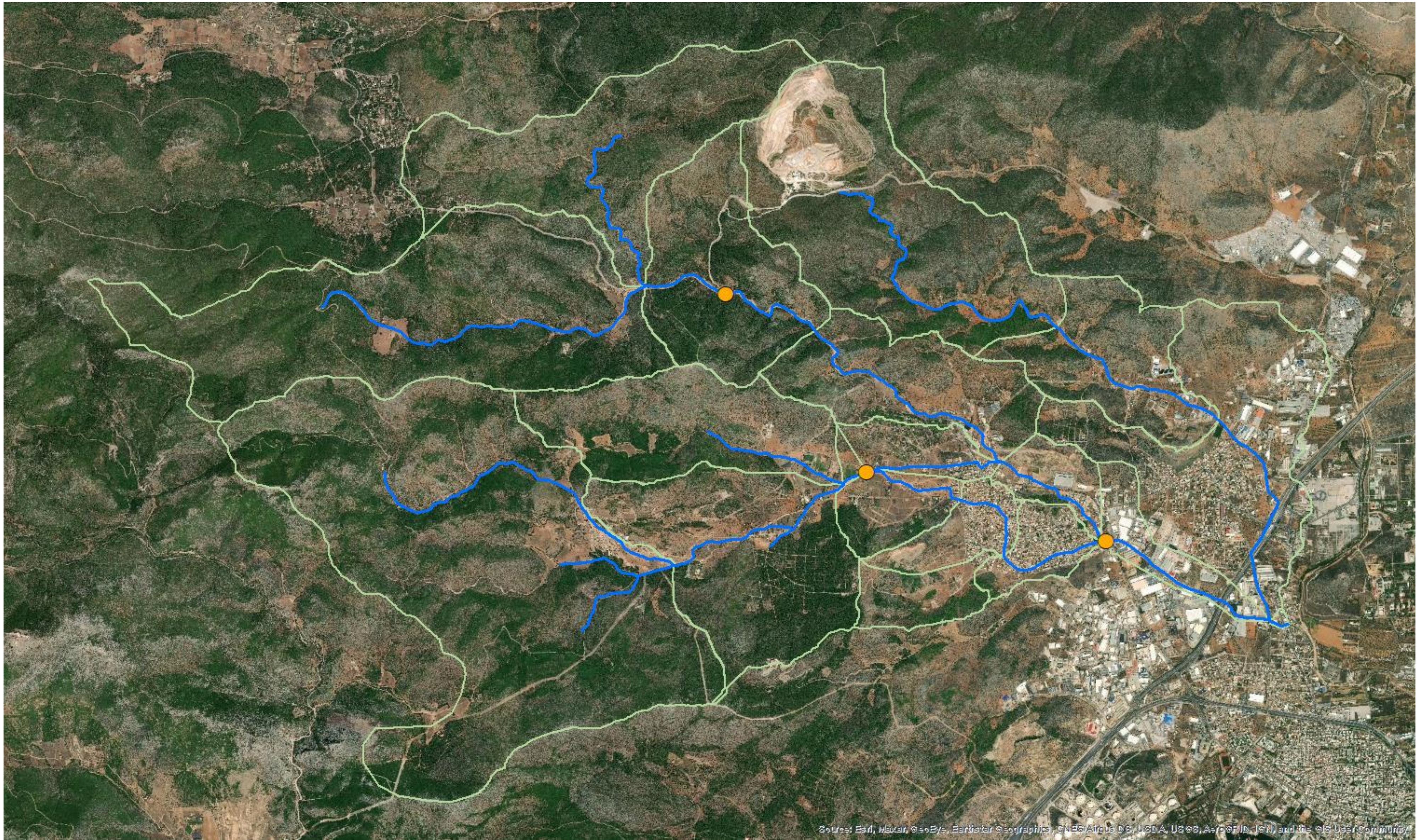
FloodHUB



RIVER BASIN
57 km^2

SUBBASINS
19

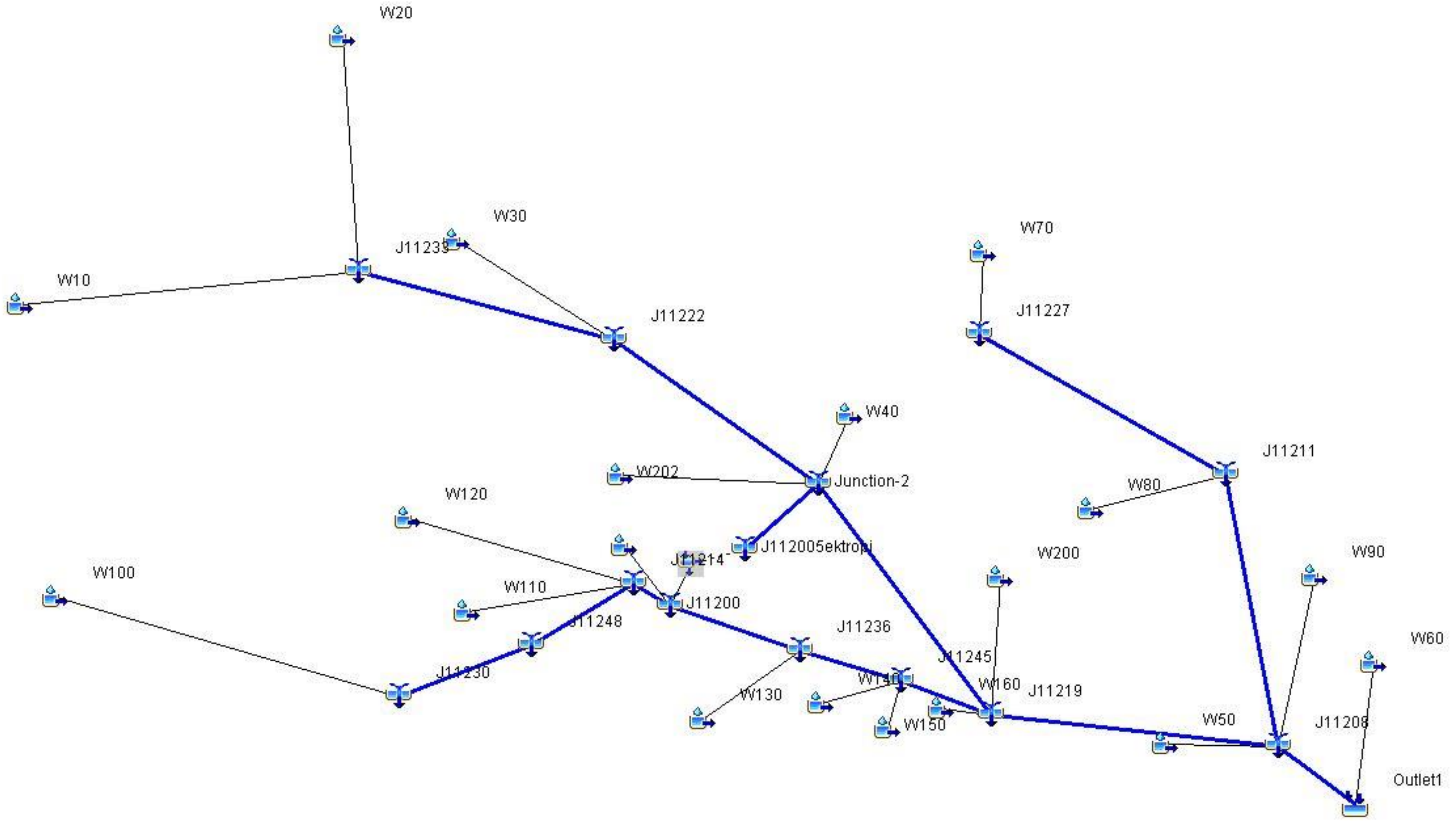
RAINFALL IDF CURVE
Koutsoyiannis & Baloutsos, 2000

$$i\,(d,T) = 40.6\,(T^{0.185} - 0.45)/(d + 0.189)^{0.796}$$

DISTRIBUTION
Worst profile method

TIME OF CONCENTRATION
Kirpich (SCS) method

Hydrologic & hydraulic simulation



HYDROLOGIC MODELING:
HEC-HMS
(free & open access)

Input: rainfall data through HEC-DSS for various combinations of return periods T (years) and rainfall duration d (hours)

SCS-CN (Curve Number) method for extracting the excess from the gross rainfall, and the unit hydrograph, for propagating the surface runoff to the basin outlet

Run: all scenarios

Output: flow hydrographs

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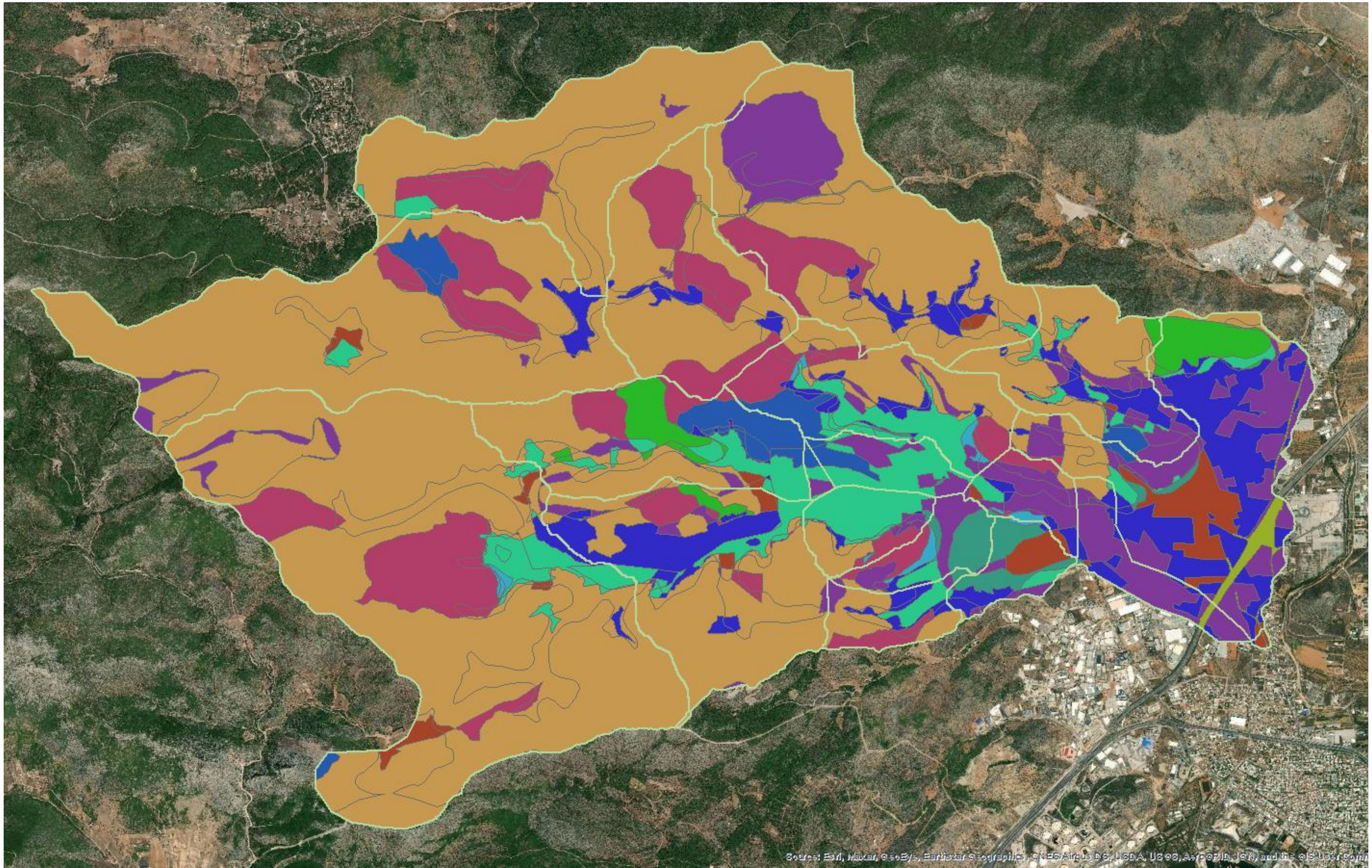
Hydrologic & hydraulic simulation



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Hydrologic & hydraulic simulation

Antecedent Soil Moisture Conditions	T = 50 years	T = 100 years	T = 200 years	T = 500 years	T = 1000 years
CN I Dry conditions	T50 CNI D3	T100 CNI D3	T200 CNI D3	T500 CNI D3	T1000 CNI D3
	T50 CNI D6	T100 CNI D6	T200 CNI D6	T500 CNI D6	T1000 CNI D6
	T50 CNI D9	T100 CNI D9	T200 CNI D9	T500 CNI D9	T1000 CNI D9
CN II Average conditions	T50 CNII D3	T100 CNII D3	T200 CNII D3	T500 CNII D3	T1000 CNII D3
	T50 CNII D6	T100 CNII D6	T200 CNII D6	T500 CNII D6	T1000 CNII D6
	T50 CNII D9	T100 CNII D9	T200 CNII D9	T500 CNII D9	T1000 CNII D9
CN III Wet conditions	T50 CNIII D3	T100 CNIII D3	T200 CNIII D3	T500 CNIII D3	T1000 CNIII D3
	T50 CNIII D6	T100 CNIII D6	T200 CNIII D6	T500 CNIII D6	T1000 CNIII D6
	T50 CNIII D9	T100 CNIII D9	T200 CNIII D9	T500 CNIII D9	T1000 CNIII D9

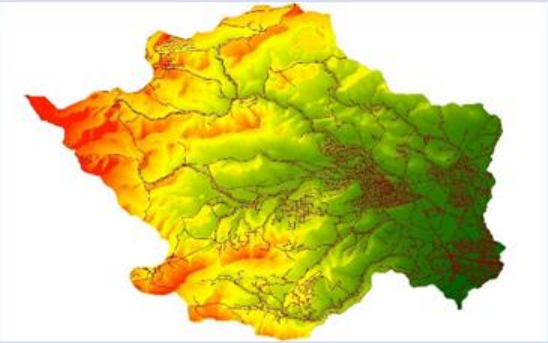
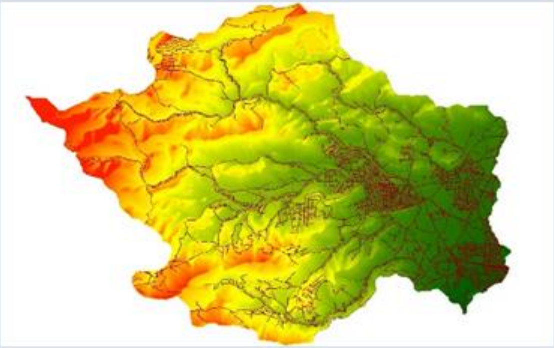
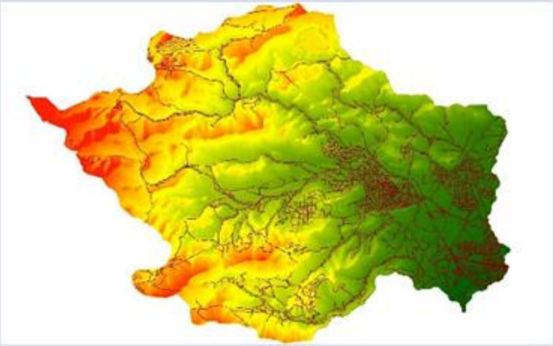
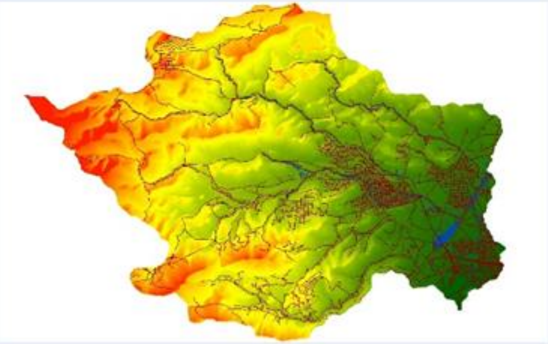
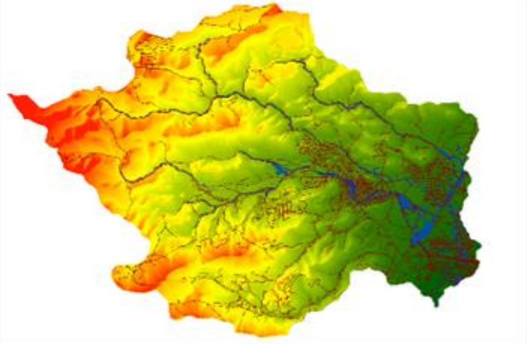
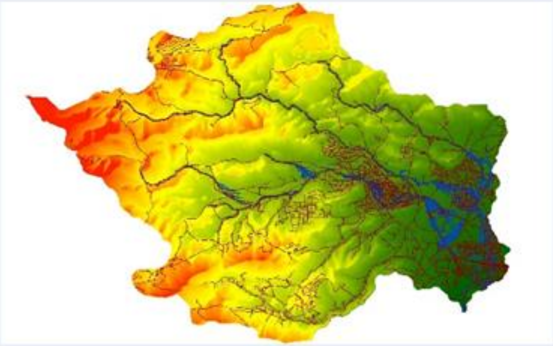
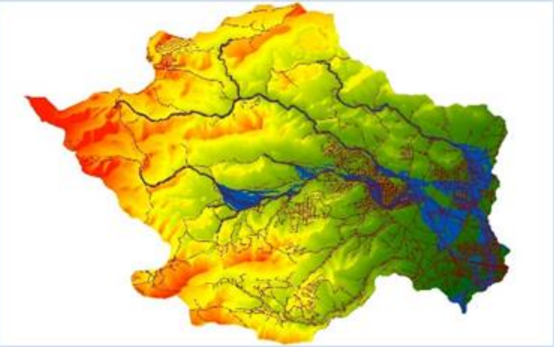
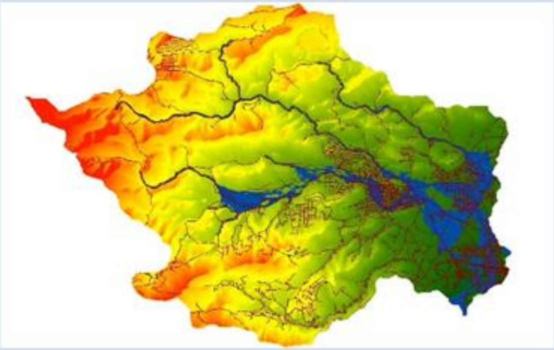
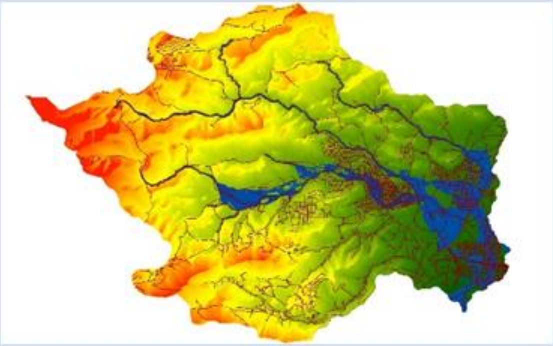
HYDRAULIC MODELING:
HEC-RAS
(free & open access)

Input:
* flow hydrographs for each stream of the hydrographic network
* banks and road network through breaklines
* DEM at 5m spatial resolution provided by the National Cadastre and Mapping Agency SA of Greece

Run: All scenarios at 10m spatial resolution (2D mesh)

Output: flood extent

Flood mapping results
T = 50 years

T = 50 years	d = 3 hours	d = 6 hours	d = 9 hours
CN I Dry conditions			
CN II Average conditions			
CN III Wet conditions			

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Flood mapping results
T = 100 years

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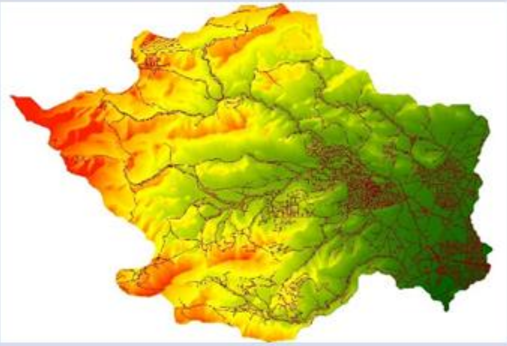
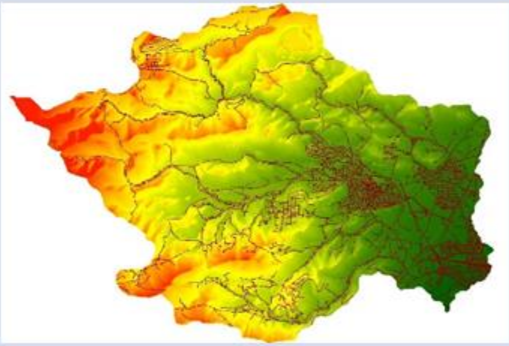
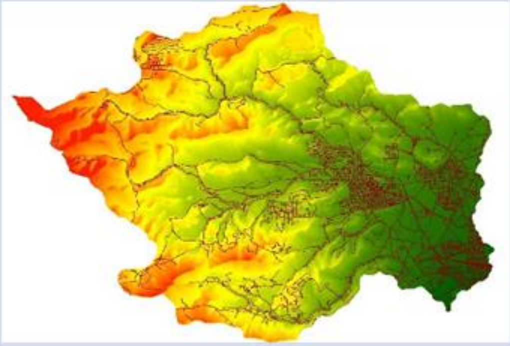
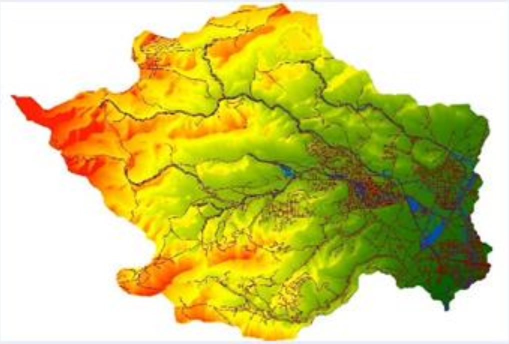
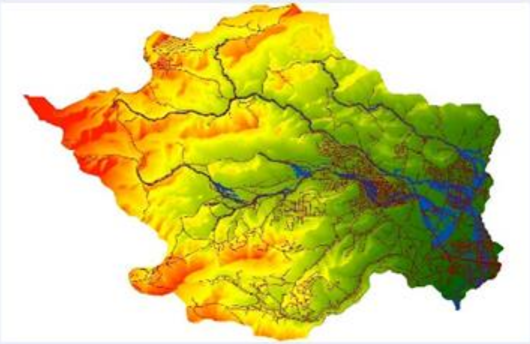
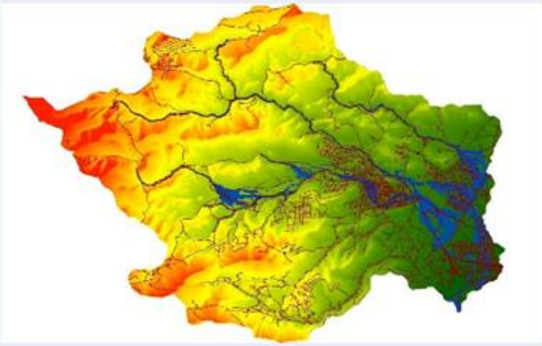
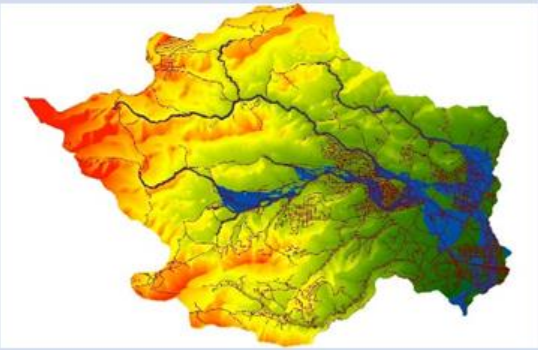
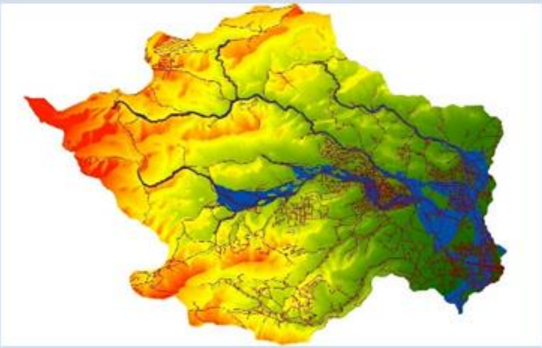
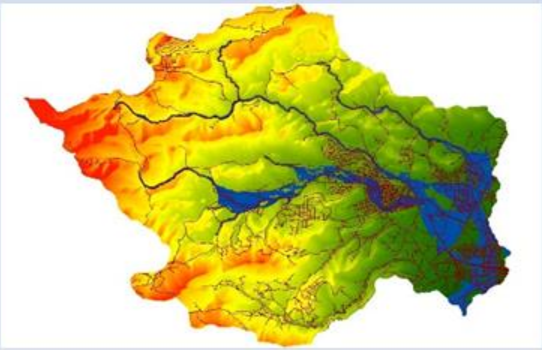
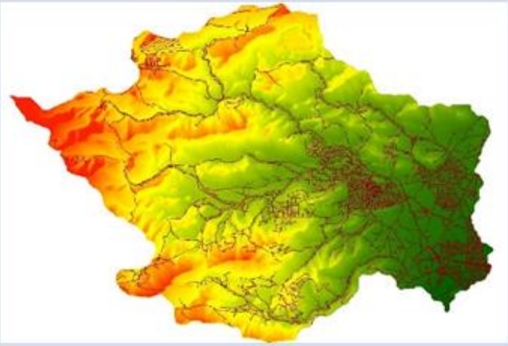
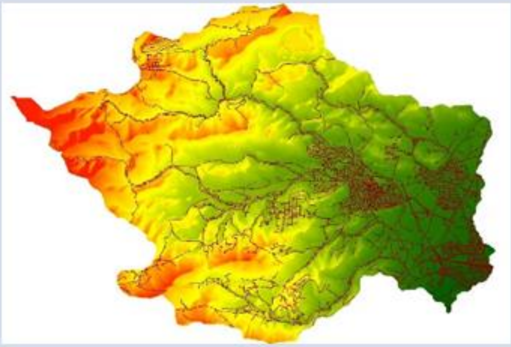
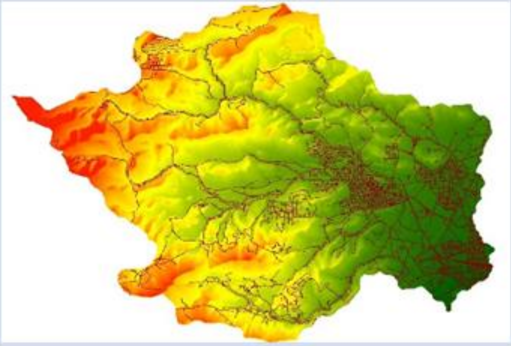
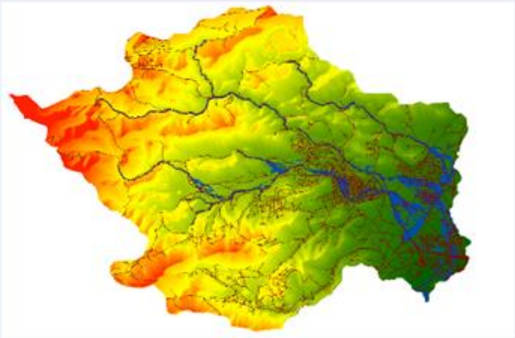
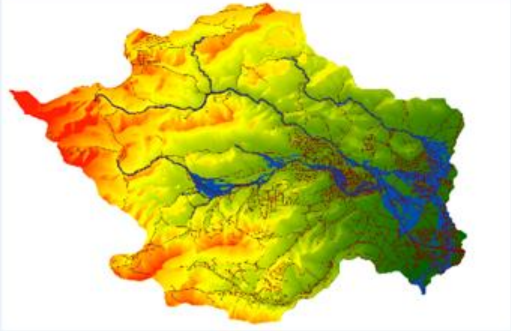
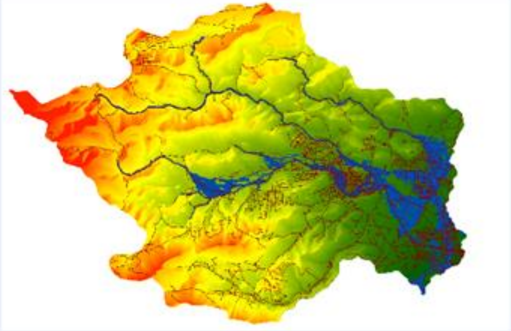
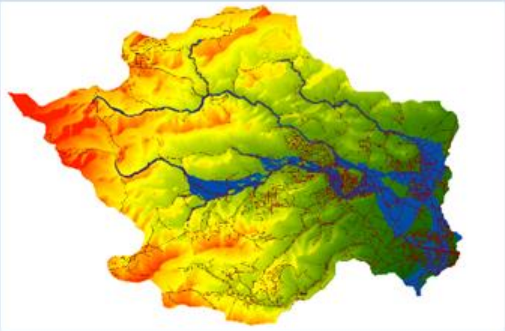
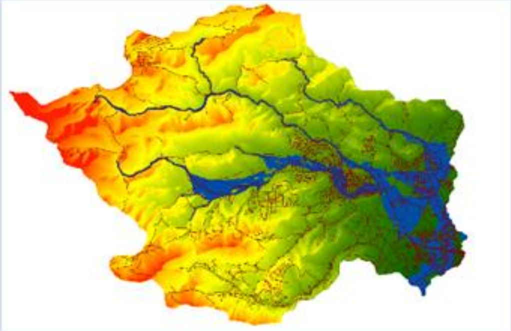
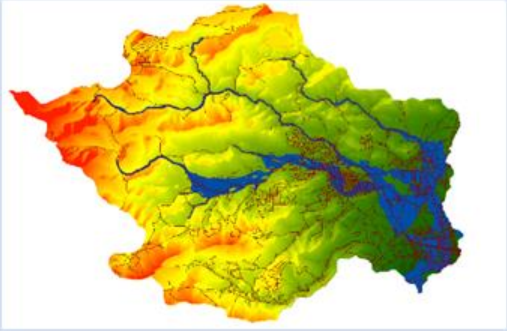
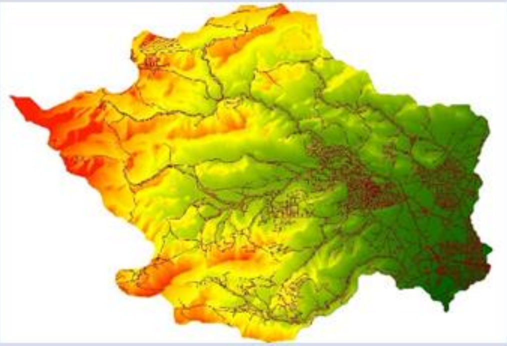
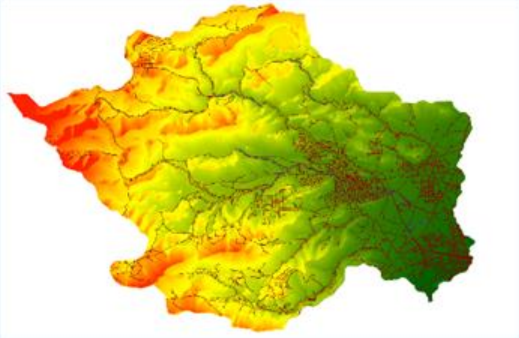
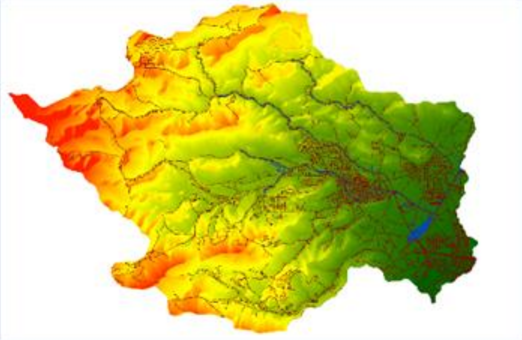
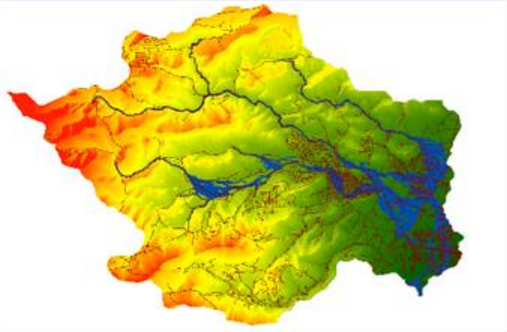
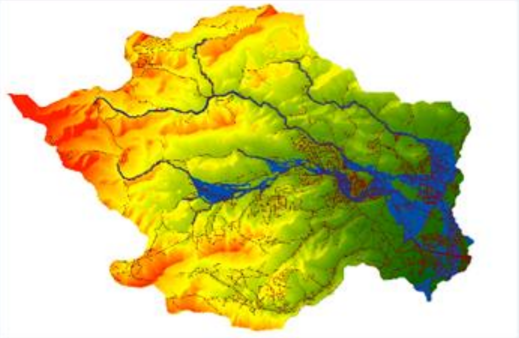
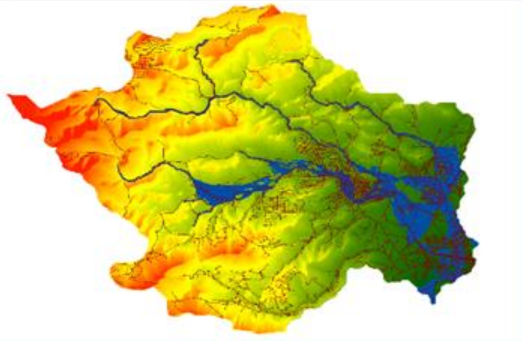
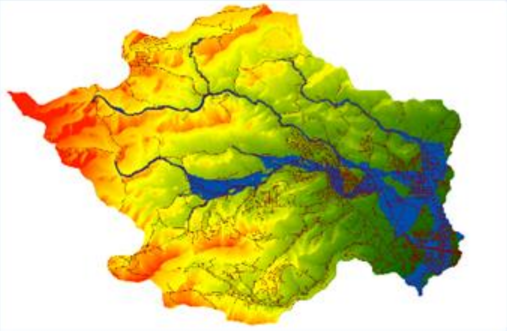
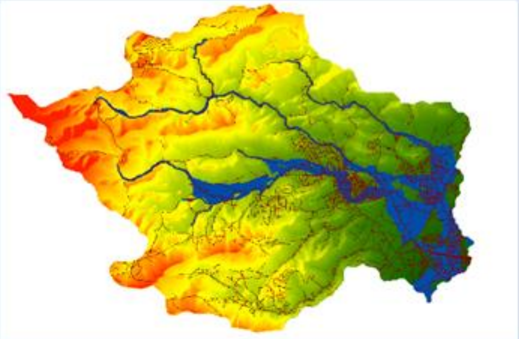
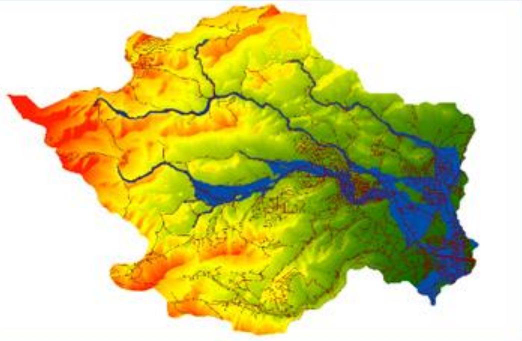
T = 100 years	d = 3 hours	d = 6 hours	d = 9 hours
CN I Dry conditions			
CN II Average conditions			
CN III Wet conditions			

Flood mapping results
T = 200 years

T = 200 years	d = 3 hours	d = 6 hours	d = 9 hours
CN I Dry conditions			
CN II Average conditions			
CN III Wet conditions			

Flood mapping results
T = 500 years

T = 500 years	d = 3 hours	d = 6 hours	d = 9 hours
CN I Dry conditions			
CN II Average conditions			
CN III Wet conditions			

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Flood mapping results
T = 1000 years

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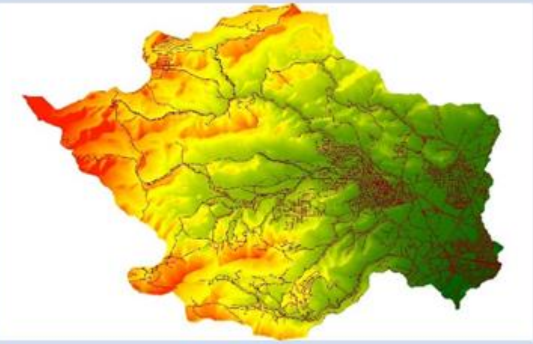
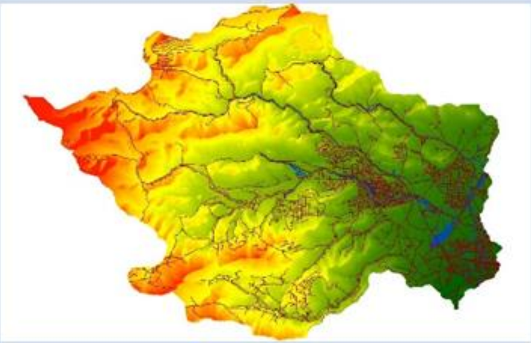
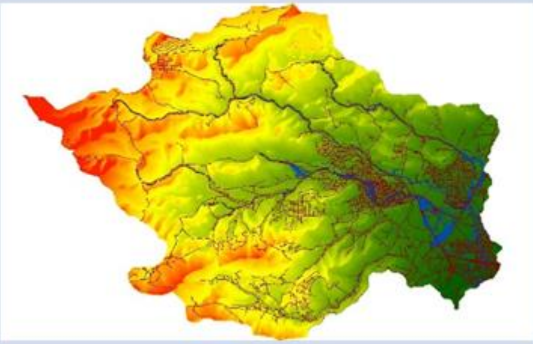
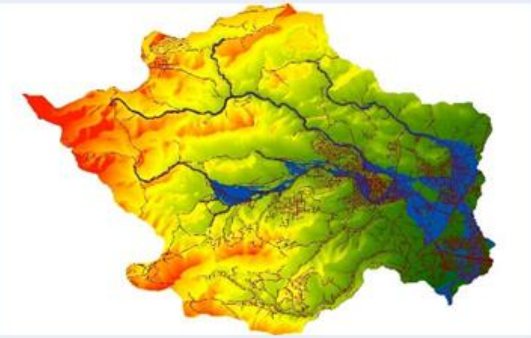
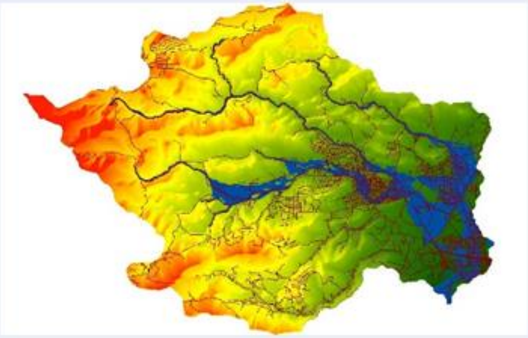
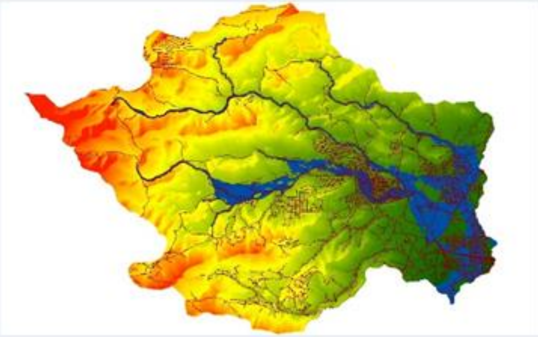
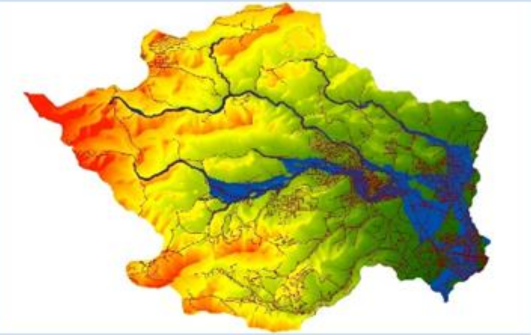
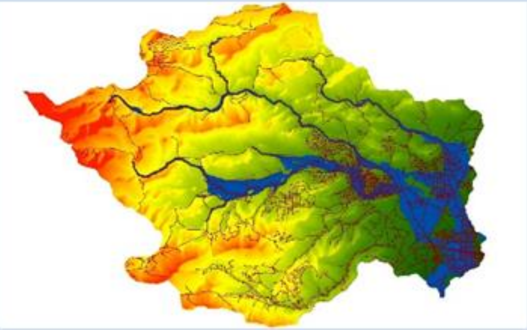
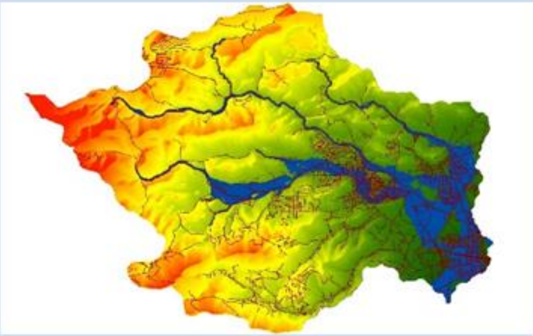
T = 1000 years	d = 3 hours	d = 6 hours	d = 9 hours
CN I Dry conditions			
CN II Average conditions			
CN III Wet conditions			

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Mandra flood 2017: modelling (blue) vs EO mapping (pink)

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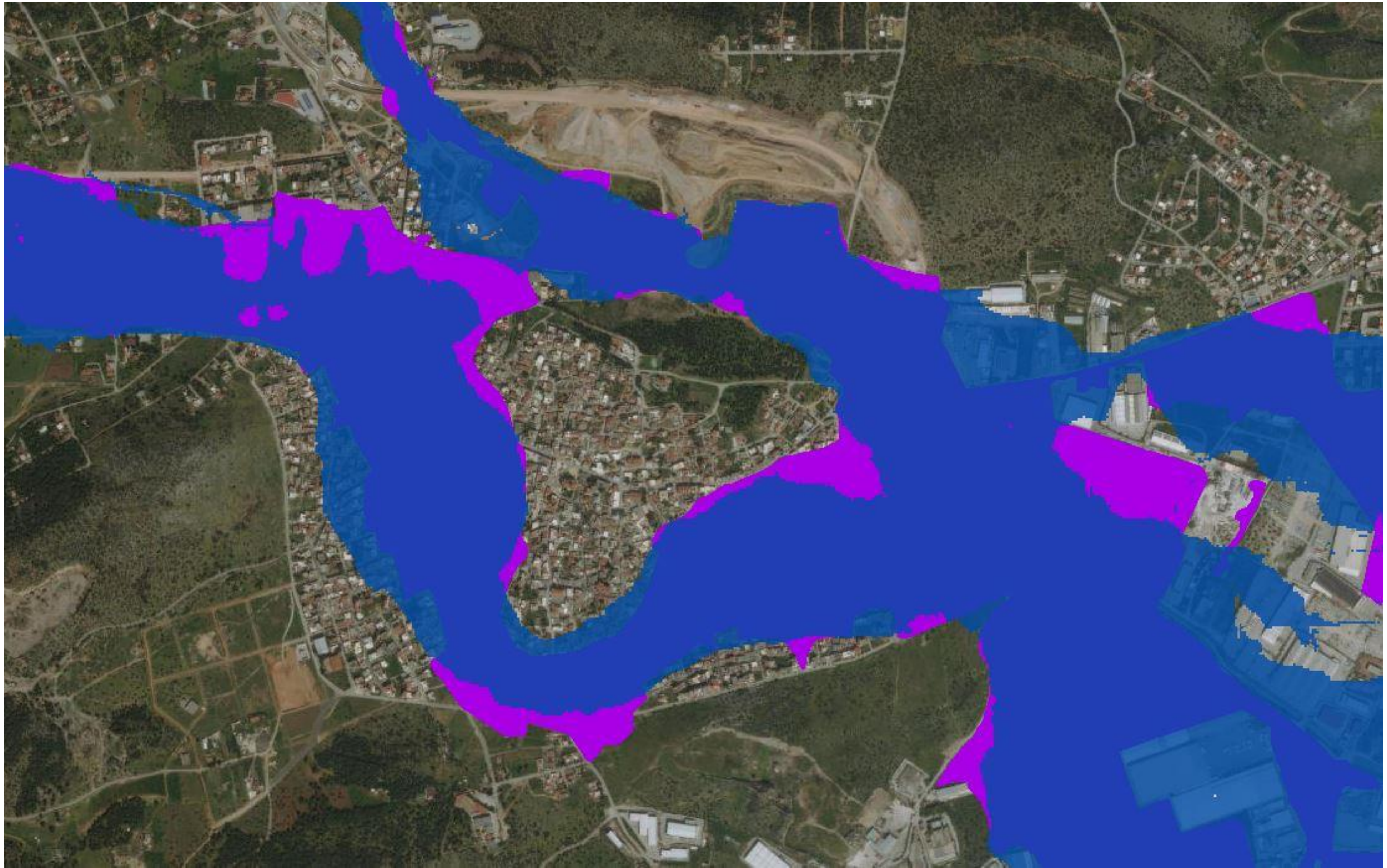
Blue: Simulation of flood scenario T1000 CNIII d6



Pink: VHR satellite-based mapping (Meteoview)

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FloodHUB system in support of the decision makers

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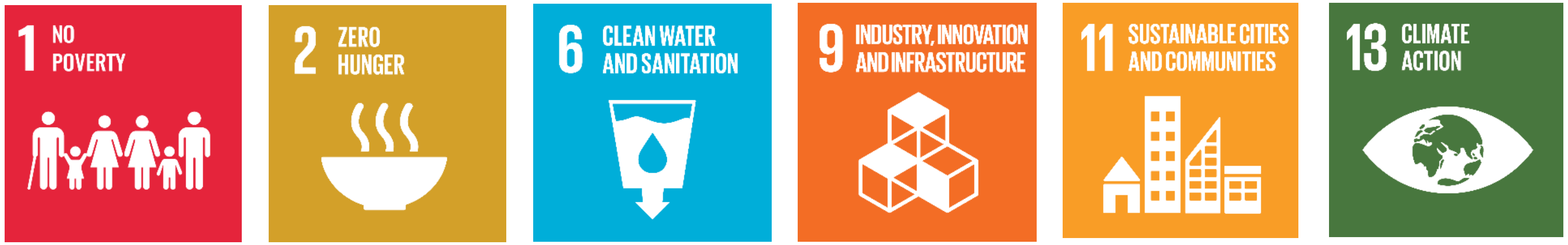
In line with the requirements for the implementation of the:

- ✓ **EU Floods Directive 2007/60/EC "on the assessment and management of flood risks"**
- ✓ **Sendai Framework for Disaster Risk Reduction**
- ✓ **UN SDGs:**



- ✓ **GEO's Societal Benefit Areas:**
  - Disaster Resilience
  - Sustainable Urban Development
  - Water Resources Management
  - Public Health Surveillance
  - Food Security and Sustainable Agriculture
  - Infrastructure and Transportation Management

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Stakeholders’ trainings in the operational FloodHUB system

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FireHUB

FireHub

Prediction - Early detection and continuous forest fire monitoring and management service based on satellite remote sensing

FireHUB Click the FireHUB Button to visit the 24/7 Real-Time Fire Monitoring service

FireHUB Click the FireHUB Button to visit the Diachronic Burnt Scar Mapping

FireHUB Click the FireHUB Button to visit the Forest Fire Information System in Europe, N. Africa, Middle East, Balkans, Black Sea

FireHUB And a pilot service for fire risk prediction

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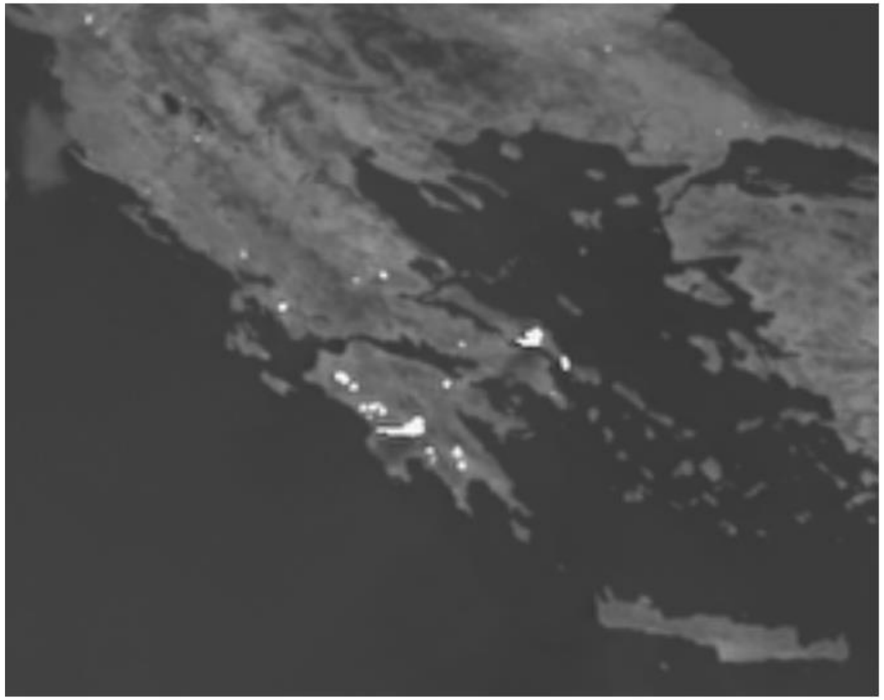
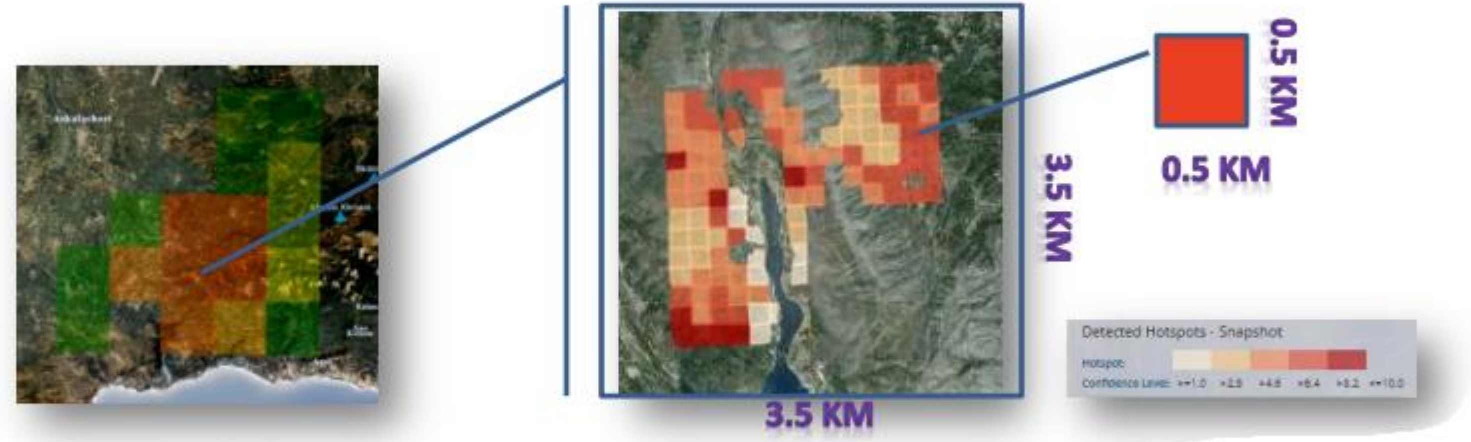
24/7 Real-Time Fire Monitoring service

- Active fire detection by MSG SEVIRI Instrument (IR 3.9, IR 10.8)
- 3 Classification steps:
    1. EUMETSAT Fire mapping algorithm (**FIR**) based on fixed thresholding approach, applied on the spectral bands IR 3.9 and IR 10.8
    2. Create and integrate classification evidence through geospatial ontology schemes and reasoning queries, accounting for the a) thematic consistency by eliminating false alarms and b) time persistence of the fire observations
    3. Downscaling the first classification output and calculate the fire occurrence probability in sub-areas of **500m x 500m** wide, inside the initial observation area of 3.5km x 3.5km



24/7 Real-Time Fire Monitoring service

- The downscaling process accounts for the real meteorological, physical / ecological, and morphological conditions in the affected area such as a) Wind conditions (speed/direction), b) Fuel types and fuel type's proneness to fire, c) Altitudinal zone, d) Slope and Aspect elements of each of the 500mx500m area



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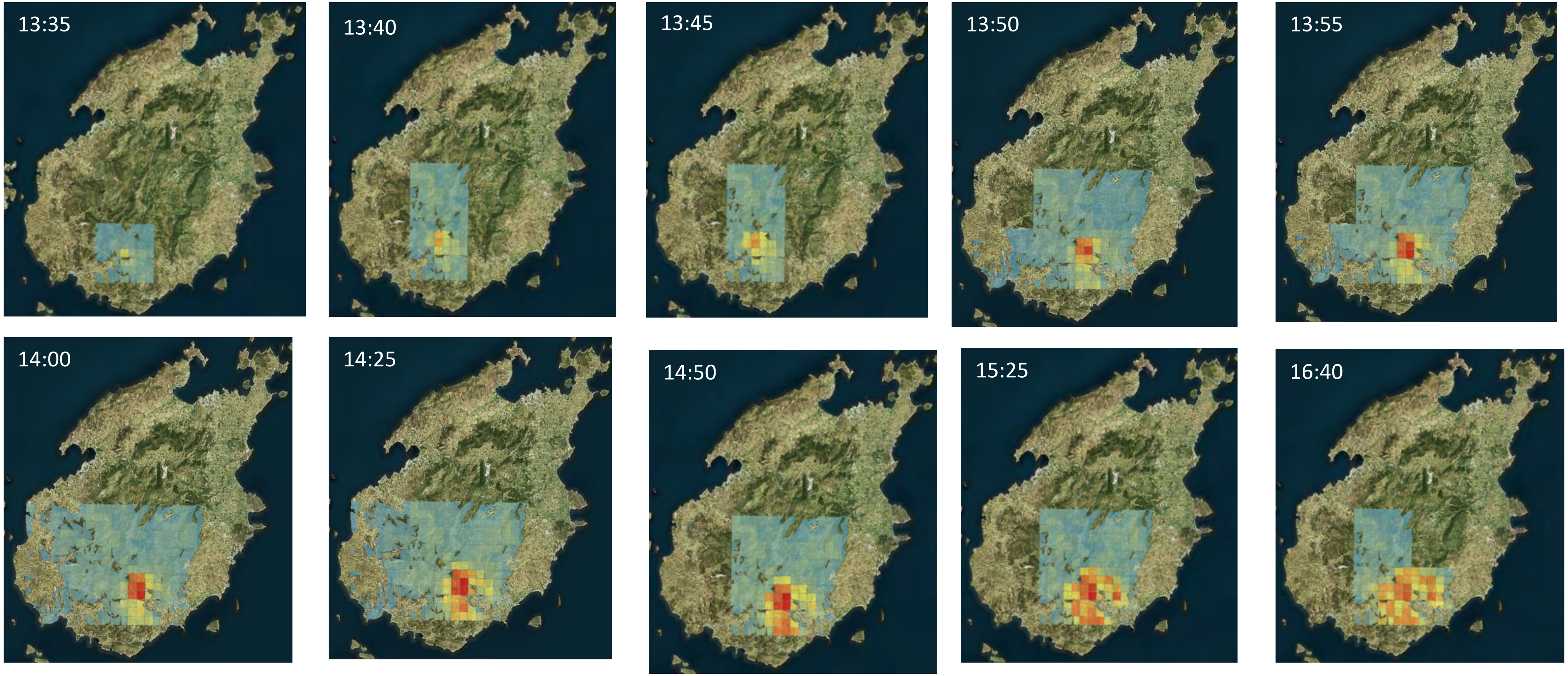
24/7 Real-Time Fire Monitoring service

- FireHub continuously ingesting real time satellite acquisitions every 5 minutes



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FireHUB

24/7 Real-Time Fire Monitoring service

Fire at Mati, Attica

Fire Events Query Data

EID	AREA(ha)	Sensor	Municipality	Beginning Time
54251		SEVIRI	Δ. Λουτρακίου - Αγίου Θεοδώ	2018-07-23 09:10:0
54267		SEVIRI	Δ. Μαραθώνος	2018-07-23 14:05:0
54268		SEVIRI	Δ. Ξυλοκάστρου - Ευρωστινη	2018-07-23 14:45:0

Beyond was monitoring the wildfire from the ignition and every five minutes

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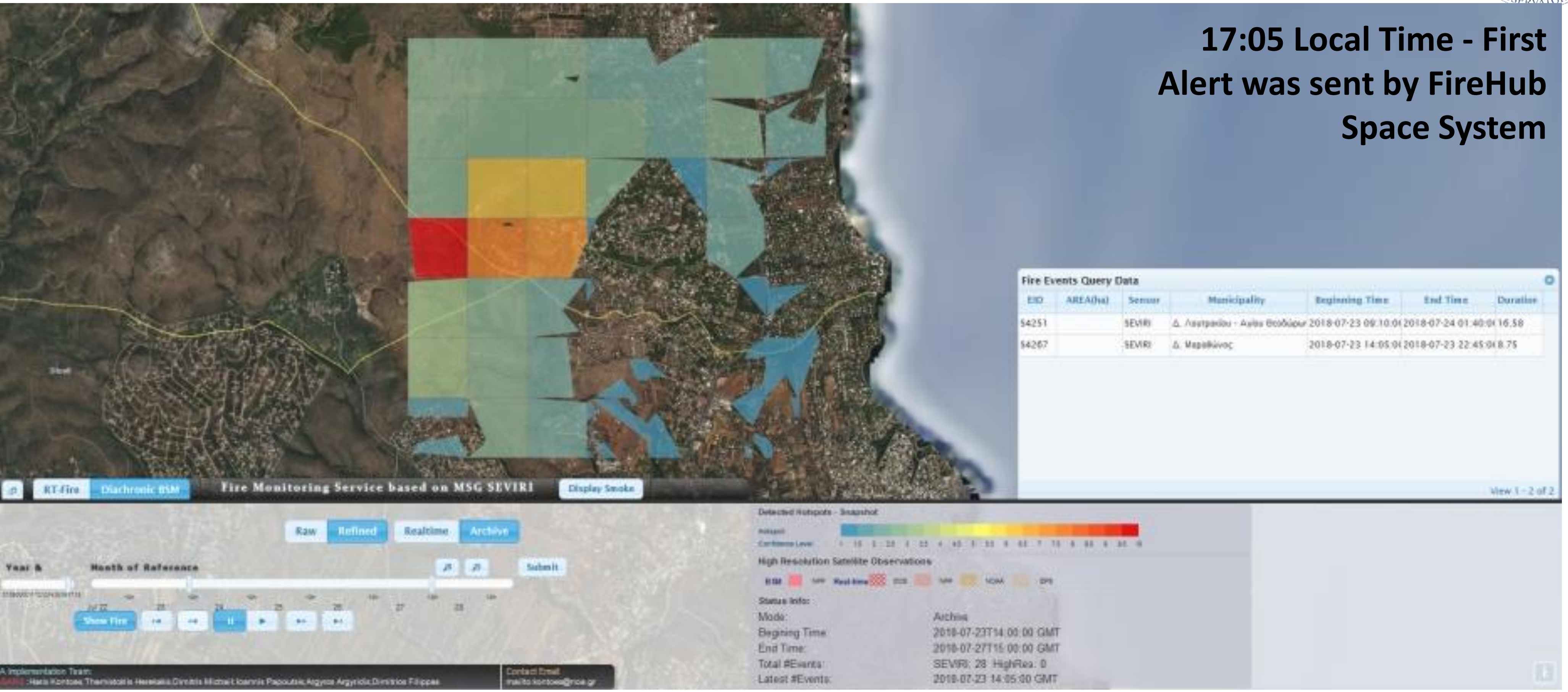
17:05 Local Time - First Alert was sent by FireHub Space System



- **This screen shows the first alert that was sent by the FireHub system of BEYOND at 17:05 local time, that is 5-7 minutes later than the official start of the fire (between 16.55-17:00).** The FireHub web site is open and accessible at that time by all and the authorities of Fire Brigades at http://195.251.203.238/seviri/
- The system provided the starting area (red rectangle - 500mx500m wide) at 17:05 local time and was updating the situational picture every five minutes. The more reddish the cell the higher the active fire occurrence in it. The masked out area is what FireHub considers as urban. FireHub is not made so as to update the fire occurrence picture inside the urban zones. The urban area fringe is also apparent by looking at the background Google Earth map.

24/7 Real-Time Fire Monitoring service

- 25-30% of the detected fires are reported 10 -15 minutes earlier than Fire Brigades logs
- 60% of the detected fires, are reported in the first ~15 minutes after the ignition time stamp reported in the Fire Brigade logs
- All the larger fires than the 112ha are completely detected without any omission
- Smaller fires, that are in the range of [4.7ha - 112 ha] are 50% detected
- The smallest detected fire has been of the order of 4.7 ha
- The omitted fire detections, are summing up to the 5,8% of the total Burned Area.
- Omissions are caused mainly due to, a) cloud cover, b) fire intensity (e.g. small fires – small burned areas), c) area topography, and d) fuel characteristics (e.g. less vegetative areas, pasture lands, sparse vegetation resulting in low fire intensities)
- The 82-85% of the 500mx500m cells which are assigned a high fire occurrence probability that is in the range of [6, 10], are located in the Burned Area Polygons

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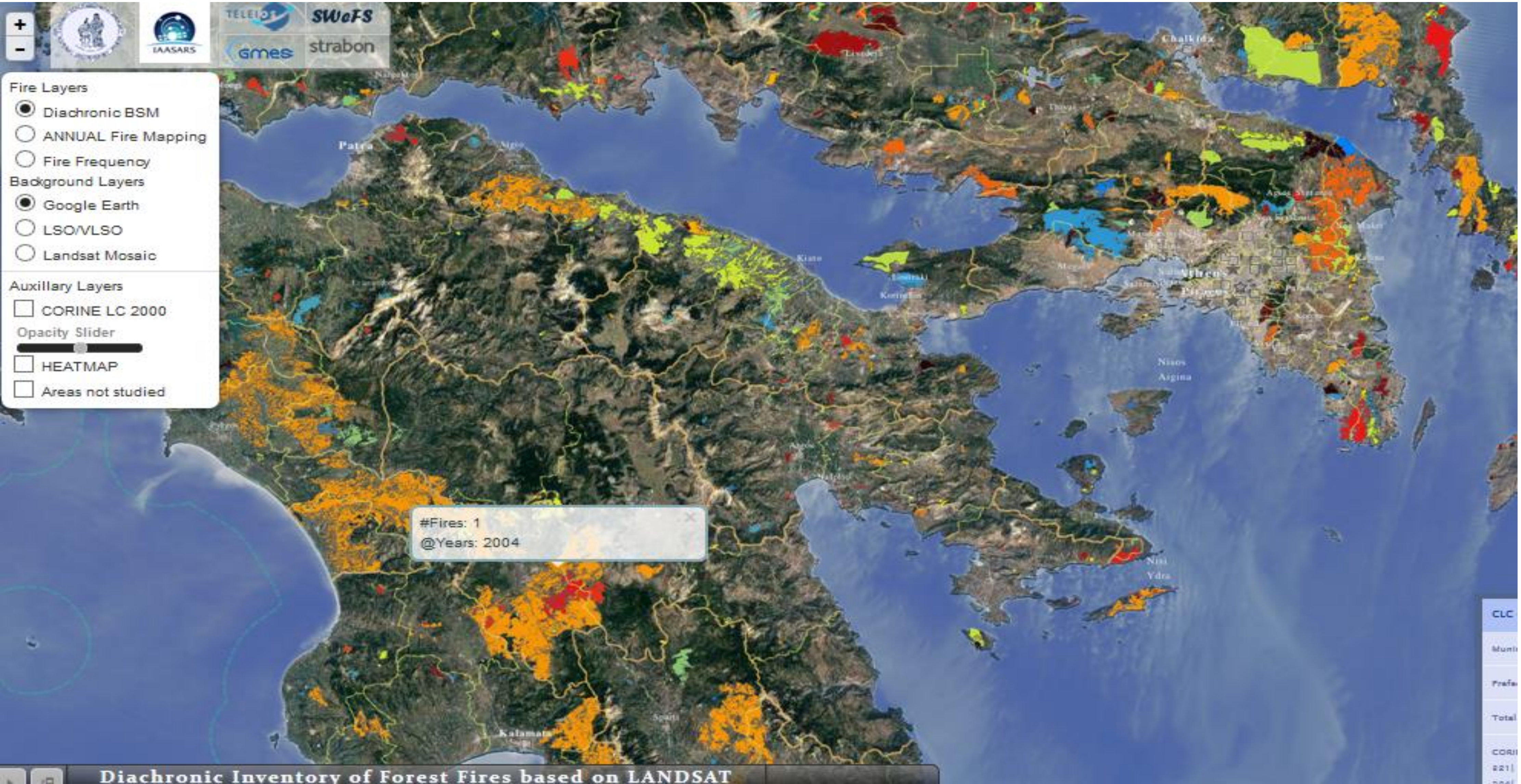
Diachronic Burnt Scar Mapping



1984-2020, Greece , ~1100 satellite images LANDSAT TM, SPOT, IKONOS, SENTINEL-2

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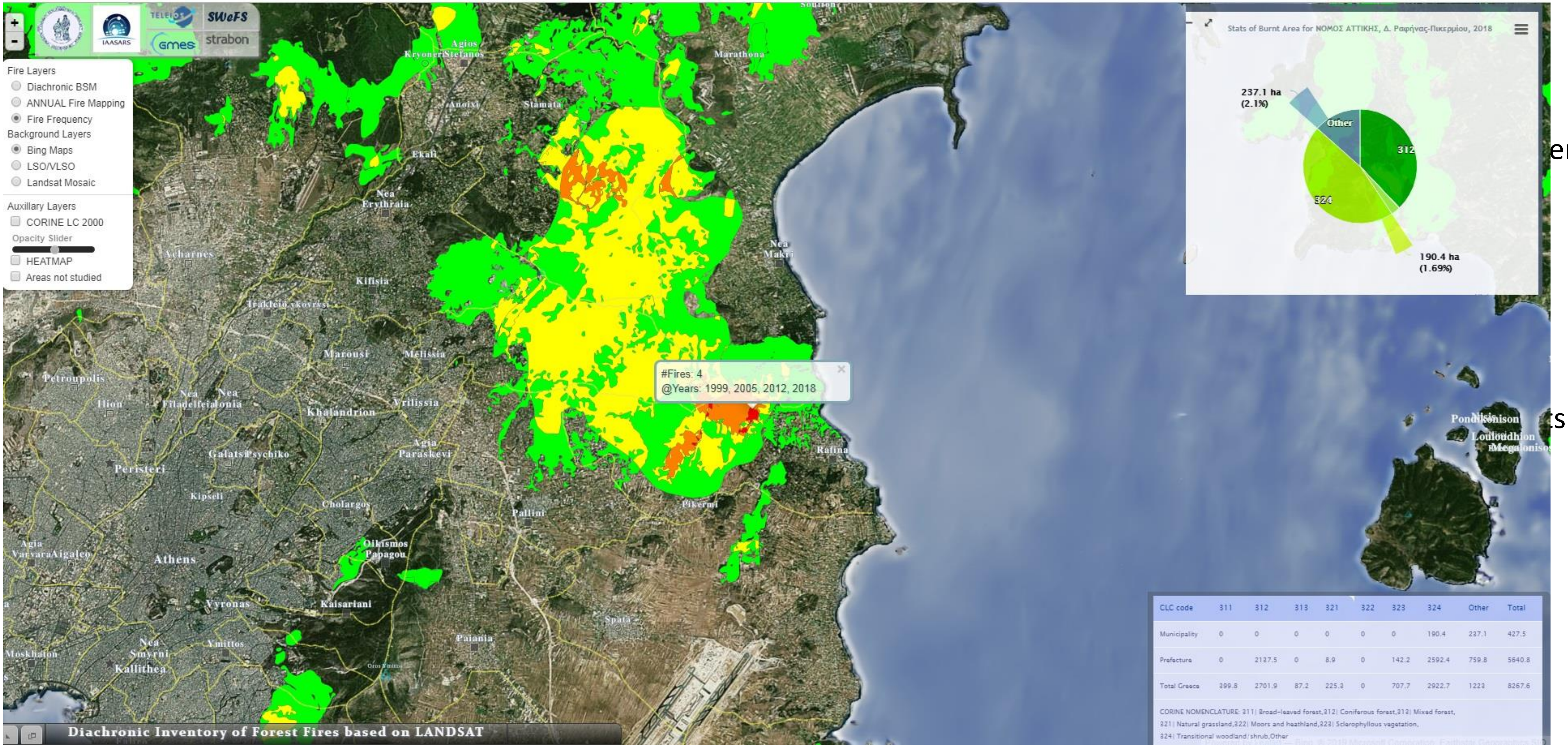
Diachronic Burnt Scar Mapping



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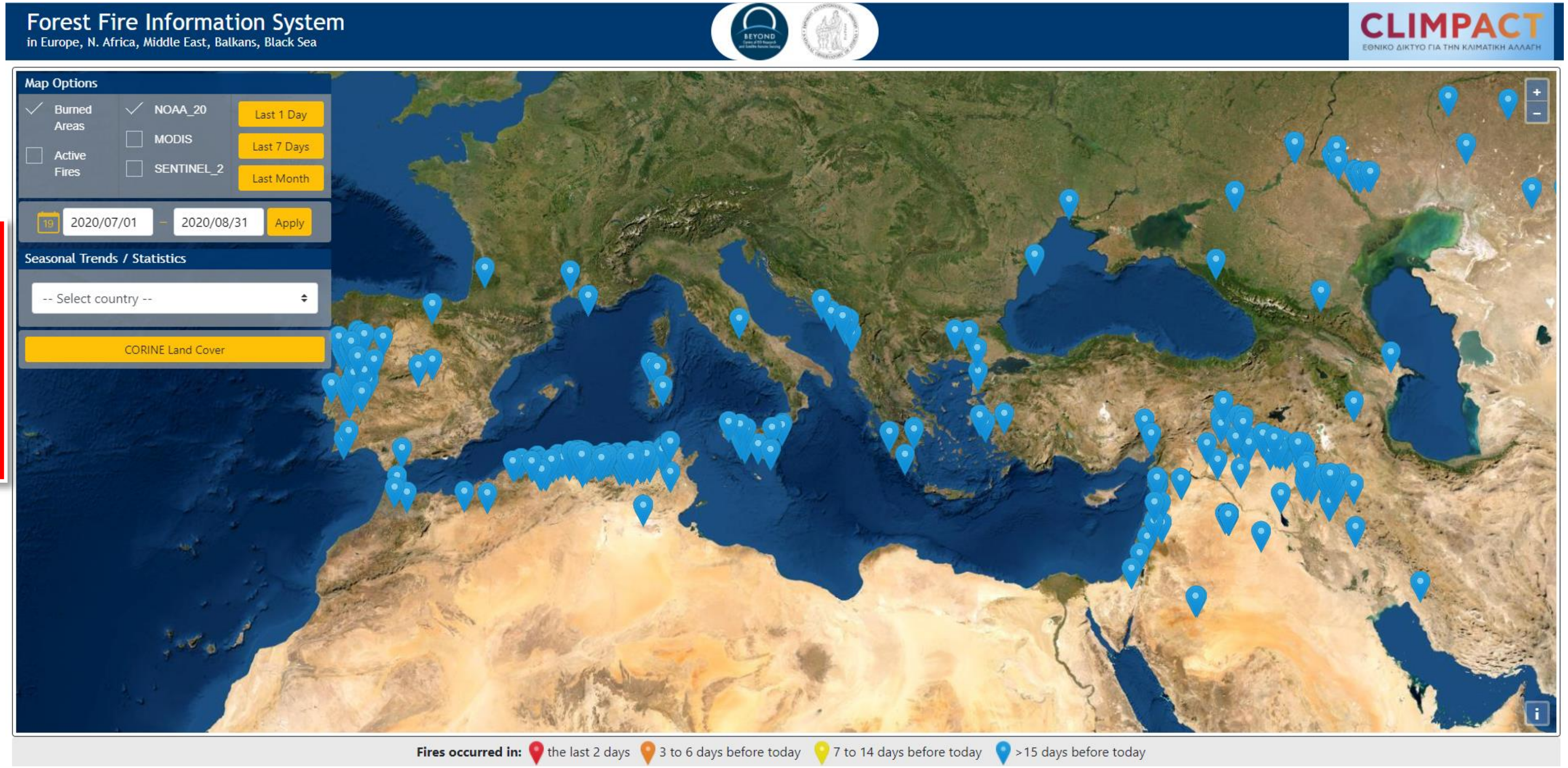
Forest Fire Information System

A new service has been developed, known as Forest Fire Information System in Europe, N. Africa, Middle East, Balkans, Black Sea and provides daily near real information on **active fires** and **burned areas**, as well as statistics on the affected areas per time period and country over the large area covering Europe, North Africa, Middle East, Balkans, and Black Sea.

Processing in Real Time of SUOMI-NPP, NOAA-20, MODIS, and S-2 data



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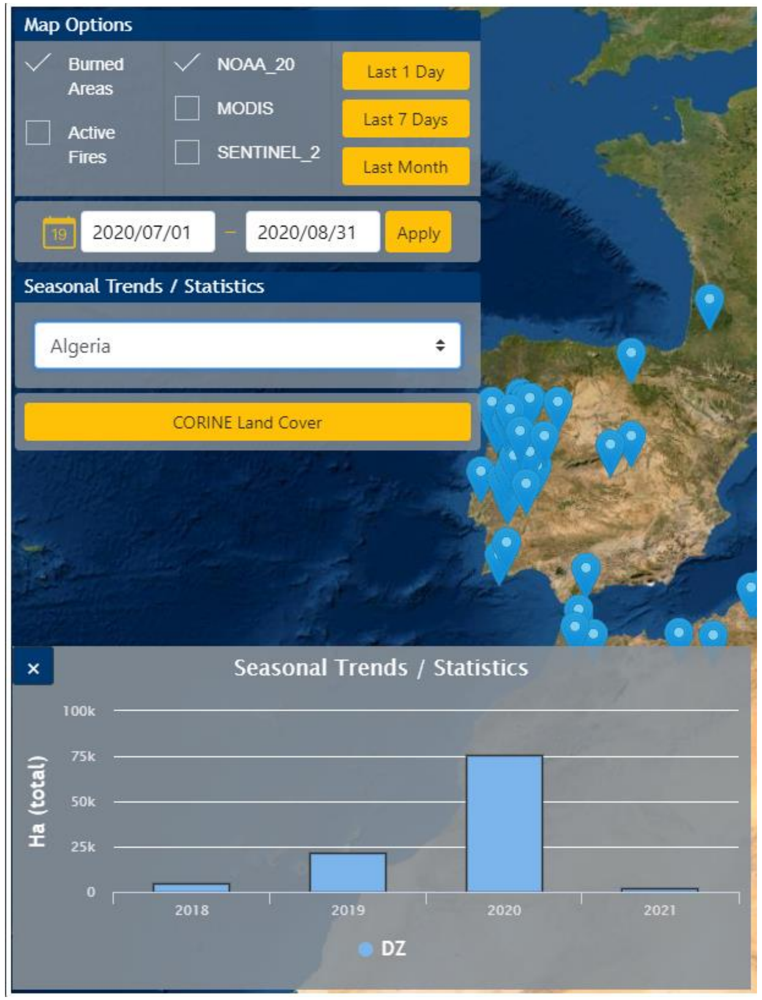
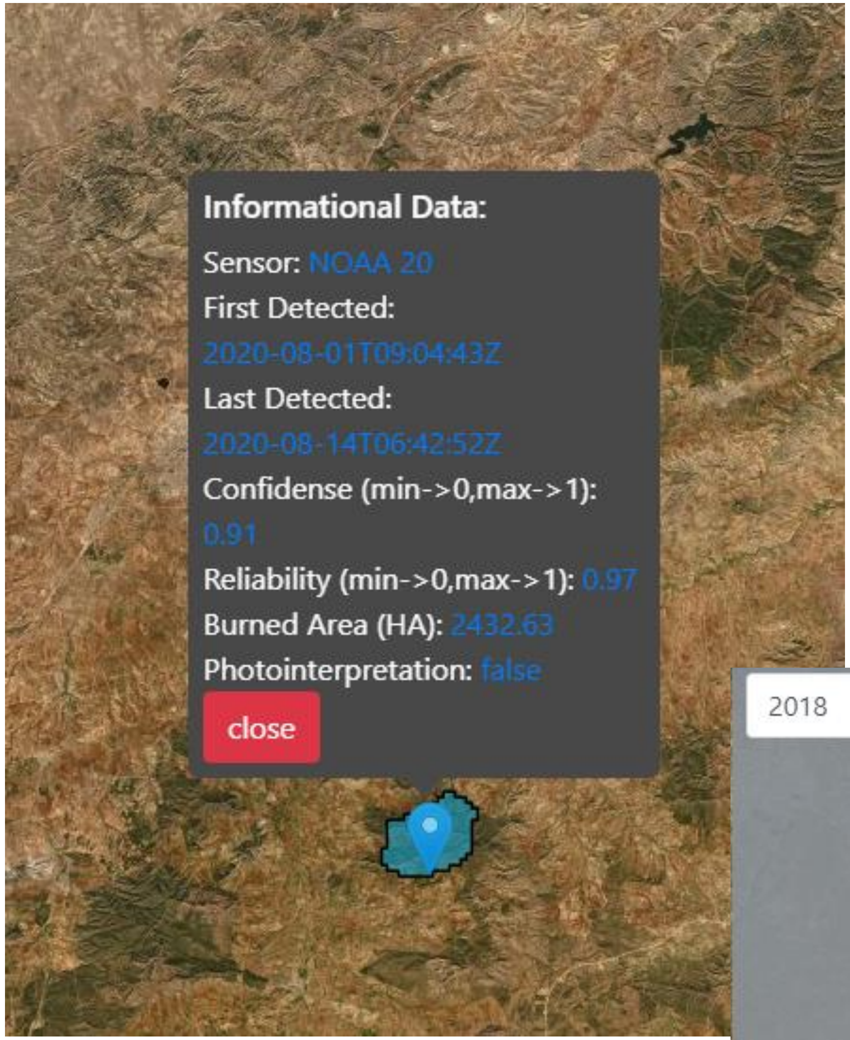
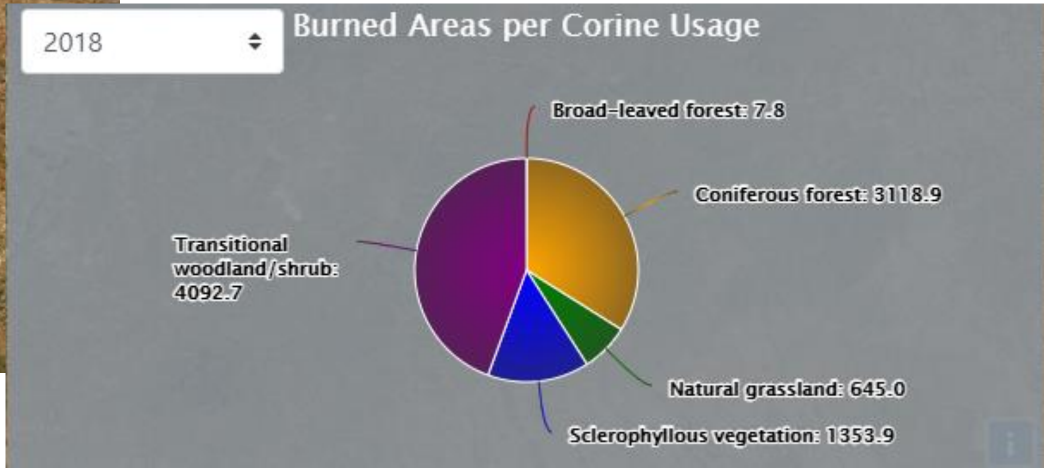
Forest Fire Information System







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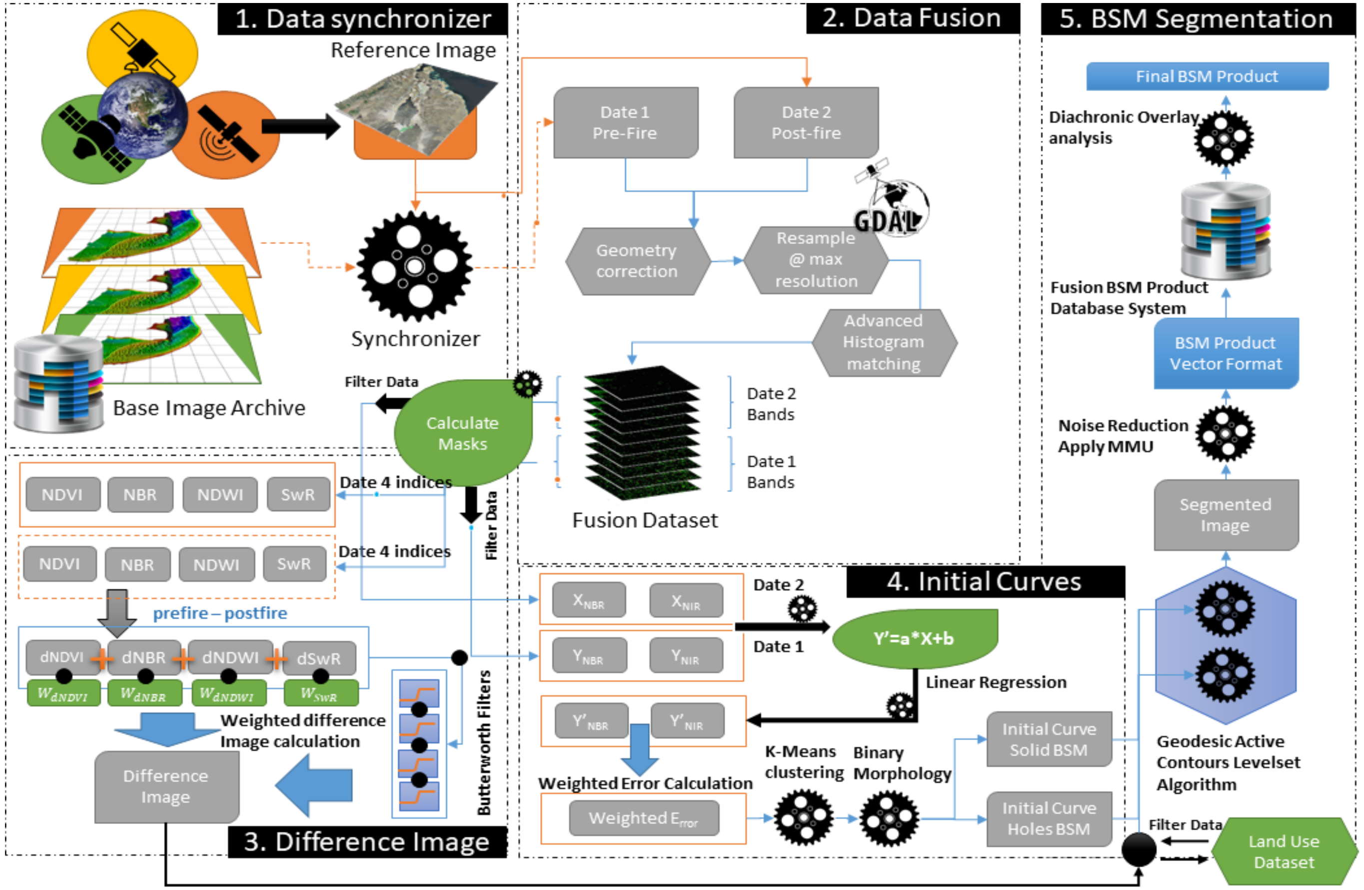
Forest Fire Information System



3 steps prototype Algorithm for Burnt Scar Mapping (BSM)

- Basic preprocess of the acquired images
- Generation of cloud and sea masks and enhanced histogram matching of pre and post fire images.
- Temporal changes detection by the analysis of numerous diverse spectral features for base and reference image.
- Custom spatial database post-processing chain stores, attributes, validates and keeps track of the BSM polygons that are about to be published in the WebGIS platform.

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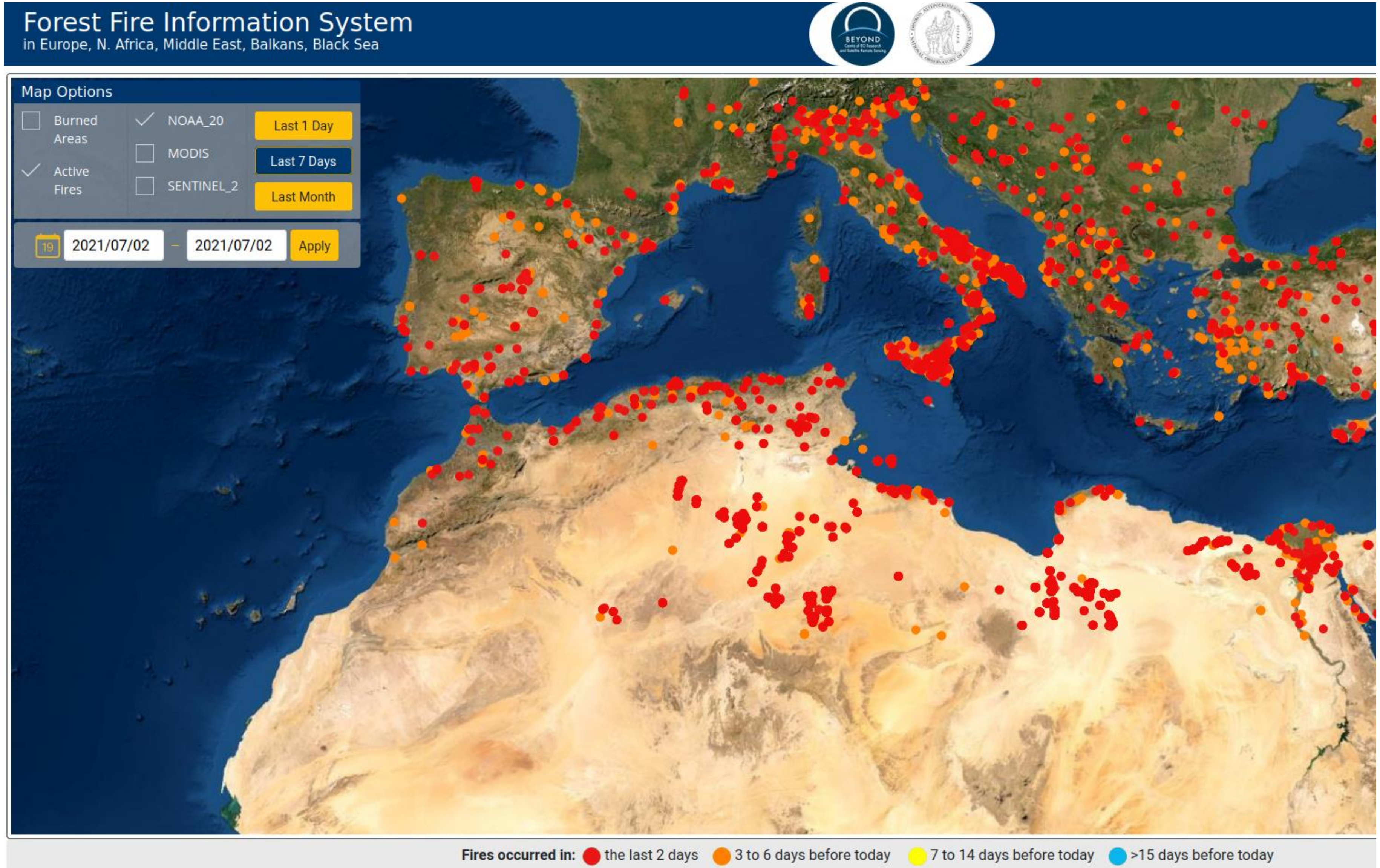
Forest Fire Information System



- Active fire detection from NASA-FIRMS algorithm
- Active fires integrate with burned areas to raise the confidence level
- They are produced within 2 hours from the acquisition to NOA's Ground Segment (for VIIRS and MODIS images)

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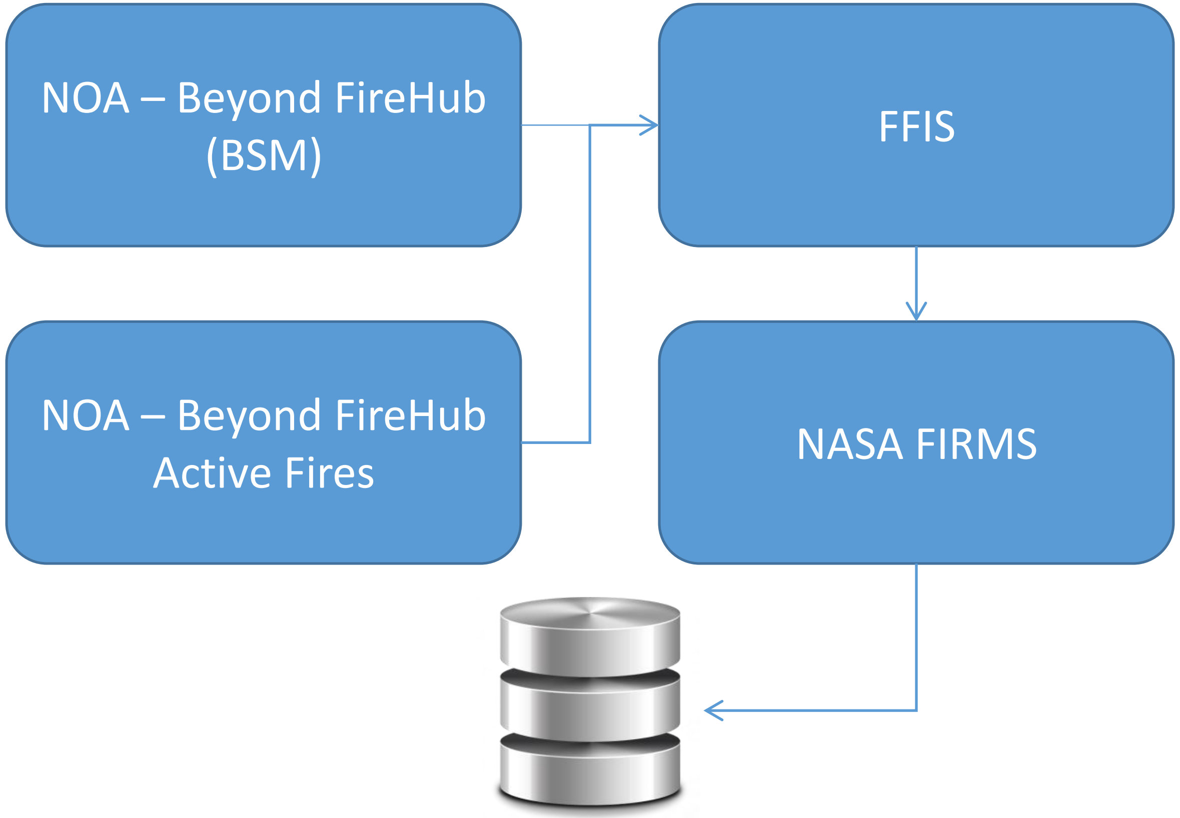
Forest Fire Prediction System

- Theoretical models (i.e. FWI) are entirely based on equations that describe the physics of the related to the fire ignition physical phenomena
- Machine Learning algorithms are designed to automatically formulate the complex mathematical relations between the input parameters.



Fire Inventory 2010-2018 at 500m grid resolution for ML training

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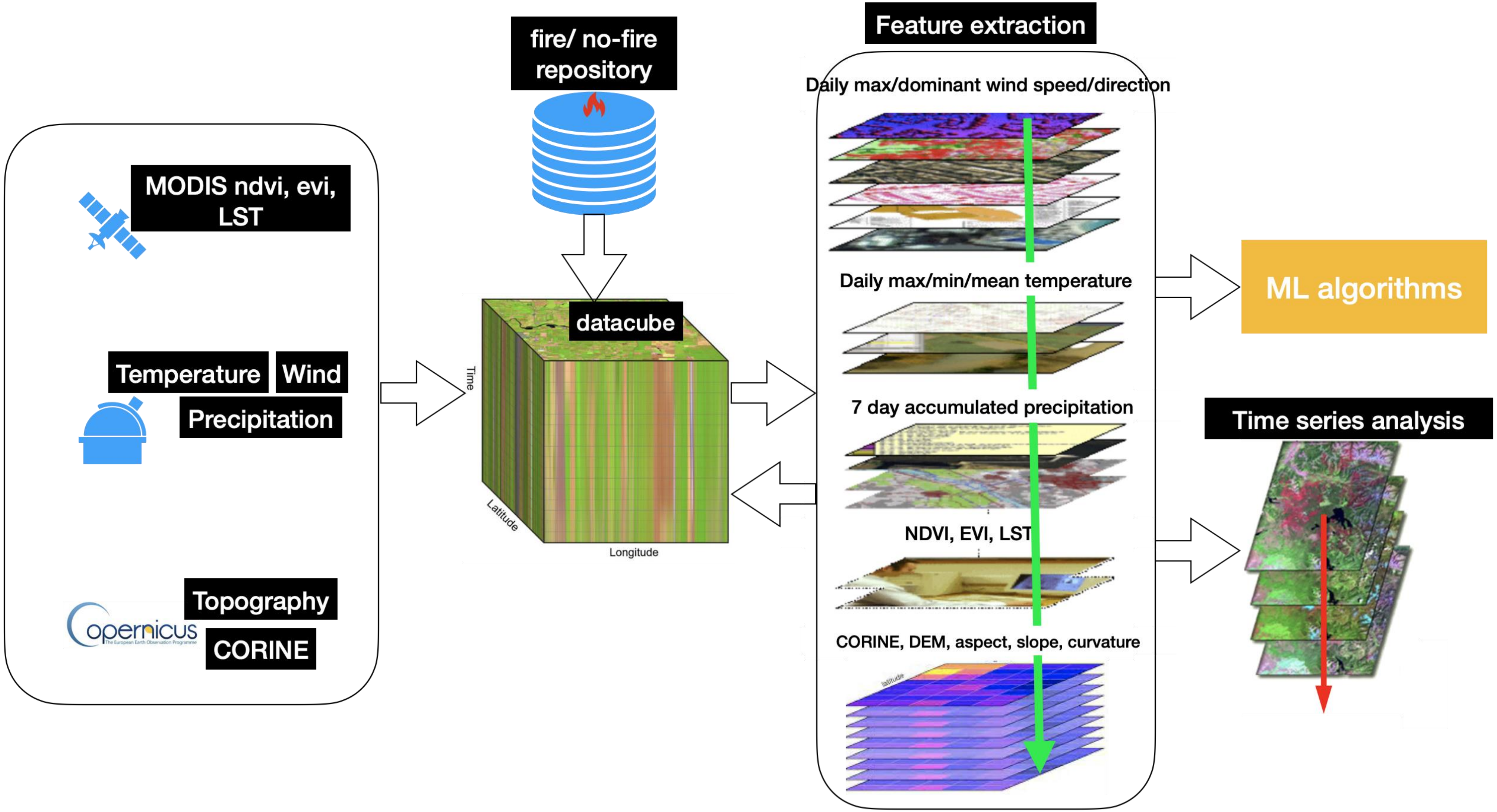
Forest Fire Prediction System



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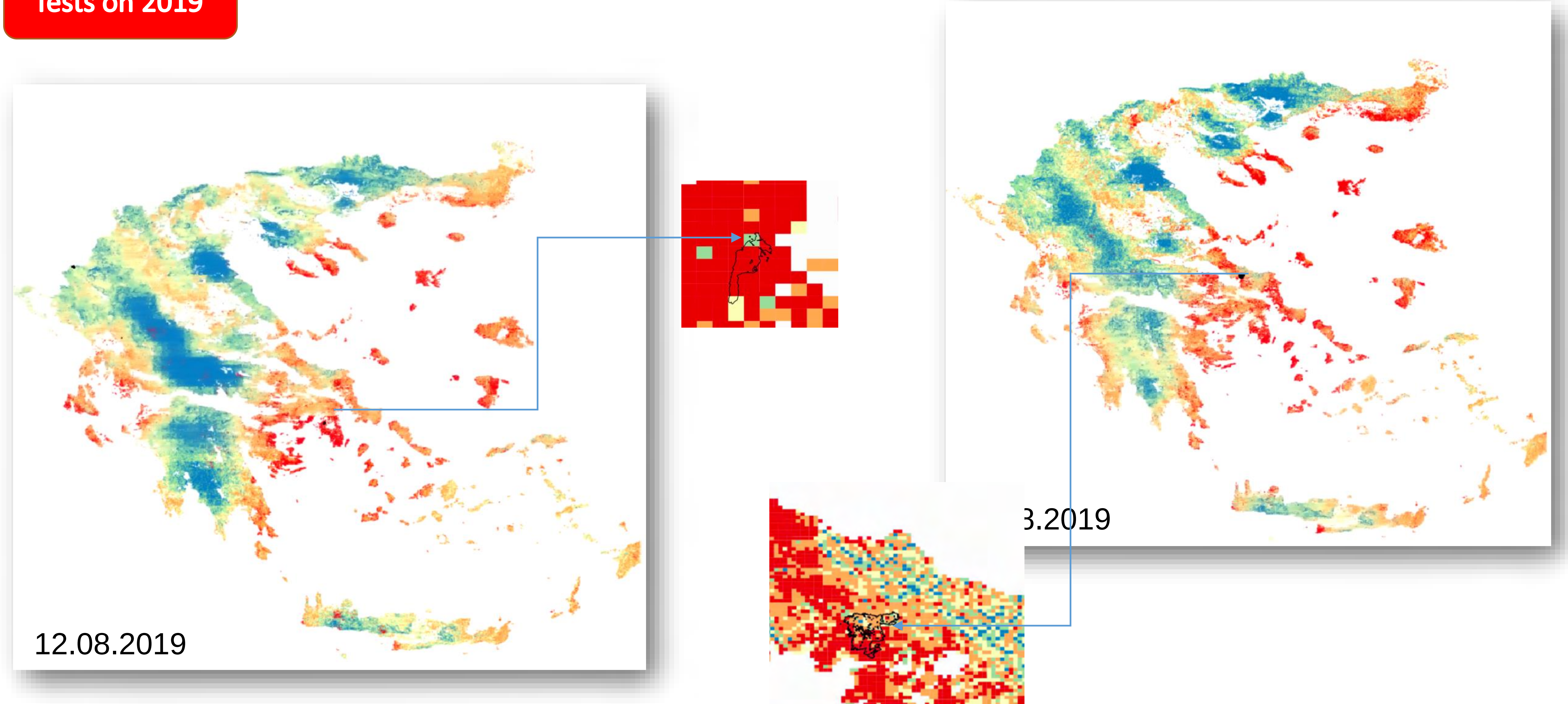
Forest Fire Prediction System

Tests on 2019



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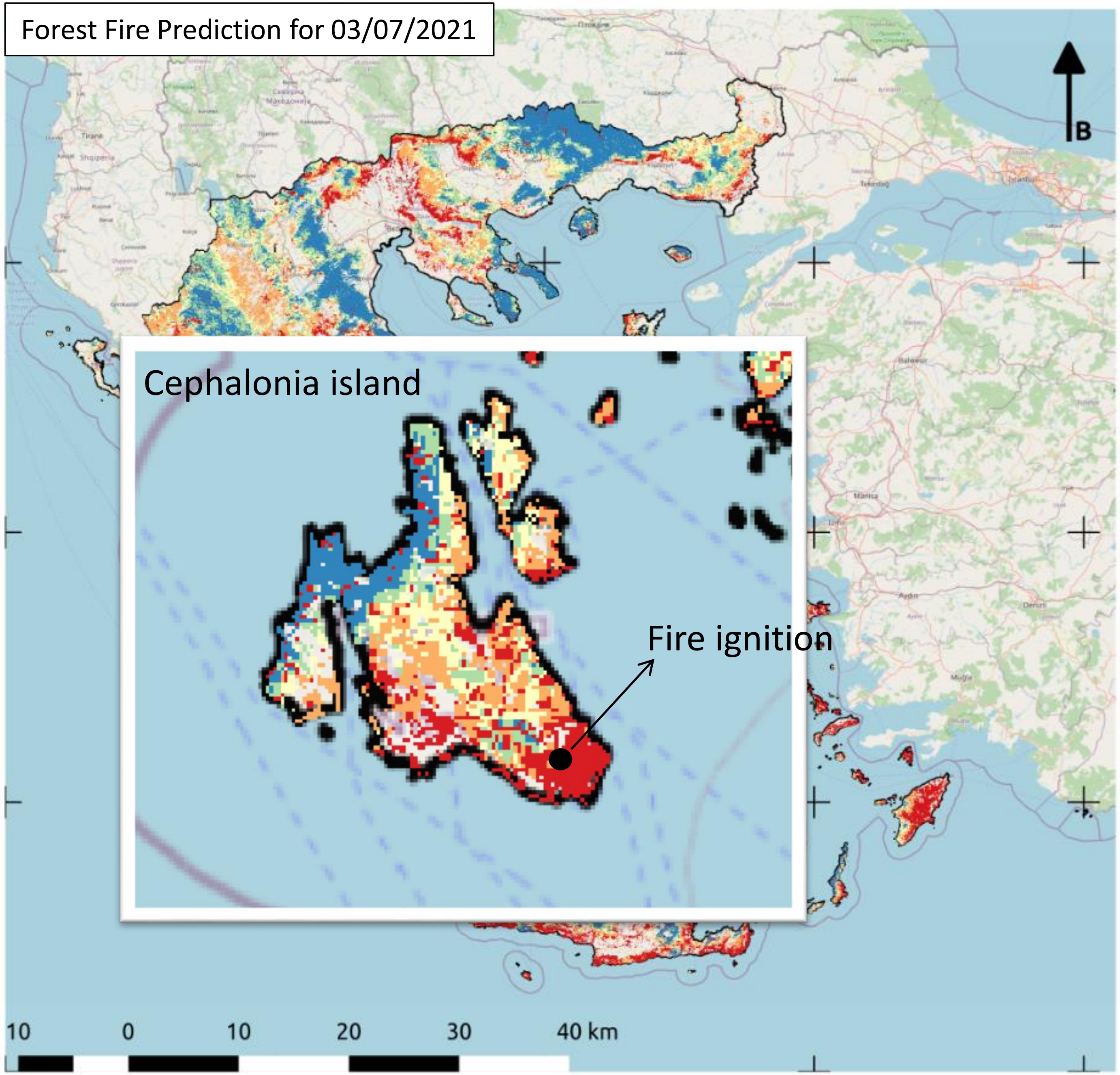
- The system is in a test phase
- Next day's risk maps are produced and sent to the authorities for validation
- Results are validated daily by Beyond experts as well
- Over 90% of the wildfires occur in high and very high risk areas



BEYOND
Κέντρο Επιστημών Παρατήρησης της Γης και Δορυφορικής Τηλεπισκόπησης

Ημερήσιος χάρτης πρόβλεψης κινδύνου πυρκαγιάς

Πληροφορίες χάρτη

Ο χάρτης έχει δημιουργηθεί από το Κέντρο Παρατήρησης της Γης και Δορυφορικής Τηλεπισκόπησης Beyond (www.beyond-eocenter.eu) του Εθνικού Αστεροσκοπείου Αθηνών. Βασίζεται σε συνδυασμό τεχνολογιών και μοντέλων Μηχανικής Μάθησης, που αξιοποιούν γνώση αναφορικά με την συμπεριφορά της πυρκαγιάς στην Ελλάδα τις τέσσερις τελευταίες δεκαετίες, προγνώσεις καιρού για την επόμενη ημέρα, καθώς και δυναμική εκτίμηση περιβαλλοντικών παραμέτρων. Ο χάρτης απεικονίζει τον κίνδυνο έναρξης πυρκαγιάς στην χωρική ανάλυση των 500 μέτρων.

Υπόμνημα

Ακτογραμμή

Επίπεδα ρίσκου

- Very high risk
- High risk
- Medium risk
- Low risk
- No risk

Χαρτογραφική προβολή: WGS 84 / Pseudo-Mercator, ESPG:3857

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Thank you for your attention!