
The FloodHub and FireHub systems for early warning and crisis management

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National Observatory of Athens – IAASARS – BEYOND Center of Excellence

http://beyond-eocenter.eu
The services of the BEYOND Center

24/7 Real-Time Forest Fire Monitoring service - Diachronic Burnt Scar Mapping (> 35 years)

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

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

Early warning and monitoring of geophysical disasters (earthquakes, landslides, volcanic eruptions)

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

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

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

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

Satellites

- Geostationary Orbit
  - MSG SEVIRI

- Polar Orbit
  - X-/L-band Station

Sentinel Mirror Site

Manned & Unmanned Aerial Vehicles

In-situ networks and crowdsourcing

Satellites Polar Orbit

Hellenic Mirror Site

(Copernicus satellite missions)

http://beyond-eocenter.eu/index.php/web-services/hellenic-mirror-site

Sentinels GreekHUB

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
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

Analysis of the flood in west Attica on 15/11/2017
Mandra 2020: Architecture of the FloodHUB system

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
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
Integrated near-real-time flood monitoring system
Integrated near-real-time flood monitoring system
Integrated near-real-time flood monitoring system
Hydrologic & hydraulic simulation

RIVER BASIN
57 km²

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 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
Hydrologic & hydraulic simulation

HYDROLOGIC MODELING:
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Run: all scenarios

Output: flow hydrographs
**HYDRAULIC MODELING:**
* HEA-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

### Antecedent Soil Moisture Conditions

<table>
<thead>
<tr>
<th>CN I Dry conditions</th>
<th>T = 50 years</th>
<th>T = 100 years</th>
<th>T = 200 years</th>
<th>T = 500 years</th>
<th>T = 1000 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>T50 CNI D3</td>
<td>T100 CNI D3</td>
<td>T200 CNI D3</td>
<td>T500 CNI D3</td>
<td>T1000 CNI D3</td>
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<table>
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<tr>
<th>CN II Average conditions</th>
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## Flood mapping results

**T = 50 years**

<table>
<thead>
<tr>
<th>T = 50 years</th>
<th>d = 3 hours</th>
<th>d = 6 hours</th>
<th>d = 9 hours</th>
</tr>
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<tbody>
<tr>
<td><strong>CN I</strong></td>
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<tr>
<td>Dry conditions</td>
<td><img src="image4.png" alt="Map" /></td>
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<tr>
<td><strong>CN II</strong></td>
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<tr>
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<tr>
<td><strong>CN III</strong></td>
<td><img src="image13.png" alt="Map" /></td>
<td><img src="image14.png" alt="Map" /></td>
<td><img src="image15.png" alt="Map" /></td>
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<tr>
<td>Wet conditions</td>
<td><img src="image16.png" alt="Map" /></td>
<td><img src="image17.png" alt="Map" /></td>
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### Flood mapping results

**T = 100 years**

<table>
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<tr>
<th>Condition</th>
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<td><strong>CN I</strong>&lt;br&gt; Dry conditions</td>
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# Flood mapping results

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### Flood mapping results

**T = 500 years**

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

Blue: Simulation of flood scenario T1000 CNIII d6

Pink: VHR satellite-based mapping (Meteoview)
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:

1. Zero Hunger
2. Zero Poverty
3. Clean Water and Sanitation
4. Industry, Innovation and Infrastructure
5. Sustainable Cities and Communities
6. Climate Action
7. No Poverty
8. Zero Hunger
9. Clean Water and Sanitation
10. Industry, Innovation and Infrastructure
11. Sustainable Cities and Communities
12. Climate Action

✓ 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
Stakeholders’ trainings in the operational FloodHUB system
FireHub
Prediction - Early detection and continuous forest fire monitoring and management service based on satellite remote sensing

- Click the FireHUB Button to visit the 24/7 Real-Time Fire Monitoring service
- Click the FireHUB Button to visit the Diachronic Burnt Scar Mapping
- Click the FireHUB Button to visit the Forest Fire Information System in Europe, N. Africa, Middle East, Balkans, Black Sea
- And a pilot service for fire risk prediction
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
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

24/7 Real-Time Fire Monitoring service
24/7 Real-Time Fire Monitoring service

- FireHub continuously ingesting real time satellite acquisitions every 5 minutes
Beyond was monitoring the wildfire from the ignition and every five minutes.
• 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
Diachronic Burnt Scar Mapping

1984-2020, Greece, ~1100 satellite images LANDSAT TM, SPOT, IKONOS, SENTINEL-2
Diachronic Burnt Scar Mapping

The Burnt Scar Mapping (BSM) data layers depict:

a. The burned areas (fire polygons) per year. The year of interest is selected using the sliding selector function.
b. Areas which have been burned more times through the studied years. Different colors are used to depict the number of times a fire has occurred in the same area (Fire Frequency Layer).
c. All fire polygons mapped through the years over Greece - Diachronic BSM Layer.

Auxiliary Layers:

a. The CORINE Land Cover
b. A heatmap layer, which at the same time thematically depicts the size, the location and the density of the fire events per year.
c. A “mask out” layer depicting areas that were not studied due to the omission of satellite data in the USGS archives.
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
Forest Fire Information System

Informational Data:
Sensor: NOAA 20
First Detected:
2020-08-01T09:04:43Z
Last Detected:
2020-08-14T06:42:52Z
Confidence (min -> 0, max -> 1): 0.91
Reliability (min -> 0, max -> 1): 0.97
Burned Area (HA): 2432.63
Photointerpretation: false

Burned Areas per Corine Usage
- Traditional woodland/shrub: 4052.7
- Coniferous forest: 813.6
- Broad-leaved forest: 76
- Natural grassland: 649.0
- Sclerophyllous vegetation: 1359.9
- DZ
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.
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)
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.
Forest Fire Prediction System

- MODIS ndvi, evi, LST
- Temperature
- Wind
- Precipitation
- Topography
- CORINE

Data cube

Feature extraction
- Daily max/dominant wind speed/direction
- Daily max/min/mean temperature
- 7 day accumulated precipitation
- NDVI, EVI, LST
- CORINE, DEM, aspect, slope, curvature

ML algorithms

Time series analysis
Forest Fire Prediction System

Tests on 2019

12.08.2019

3.2019
Forest Fire Prediction System

• 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

Cephalonia island

Fire ignition
The BEYOND Center of EO Research & Satellite Remote Sensing

Thank you for your attention!