



BEYOND

Centre of Earth Observation
Research and Satellite
Remote Sensing

National Observatory of Athens



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Poised to generate significant services for the ultimate benefit of all European citizens!

Our mission is to introduce new perspectives on space-based information and provide authoritative services by mapping the needs of the users, making the most of our data, support decision-making and address priorities of stakeholders.

Our vision is to establish and maintain a European Excellence Centre for cutting edge remote sensing science, and for developing operational applications based on mature research outputs.





The BEYOND Centre of Excellence for Earth Observation Research and Satellite Remote Sensing is an operational unit of the National Observatory of Athens (NOA). It develops state-of-the-art research and innovative services for the containment of disaster risks, triggered either by natural or man-made causes in the wider region of Southeast Europe, the Balkans, the Middle East and North Africa, by utilizing large satellite data acquisition antennas located at NOA premises. Its aim is to provide timely information to relevant disaster management and emergency management authorities and stakeholders, and, by utilizing space technology, to aid them in decision making for civil protection measures across the entire spectrum of crisis management.

Moreover, through the systematic activation of the Copernicus Emergency Management Services program (<http://beyond-eocenter.eu/index.php/thematic-areas/disasters/ems-activations>), BEYOND also serves the global community of Disaster Management Agencies and Civil Protection Authorities in a wide range of natural disasters. The BEYOND Centre of Excellence specializes in monitoring of natural disasters and human induced disasters such as fires, extreme weather events, volcanic eruptions, landslides, soil erosion, water scarcity, industrial accidents and toxic clouds, earthquakes, floods, and dispersion of Sahara dust and smoke. Through its participation in flagship European programs, the Centre has also provided cross sector research and services in a number of crucial domains

of economic development such as food security, exploitation of renewable energy resources, health services, and cultural heritage preservation.

BEYOND has been operating at the premises of the NOA since 2013, and was developed under the EU FP7- REGPOT - 2012-2013-1 program receiving an initial funding of € 2,3 million, thus creating excellence and large infrastructures in its area of expertise. Its operation is fully autonomous, and secured exclusively through funding from competitive research and operational programs in Space (e.g. Copernicus, FP7, H2020, ESA). Consequently, the most important services that are provided by the Centre to decision making bodies for civil protection worldwide are summarized in the following.



FireHUB

Forest fire monitoring
and management service
based on satellite
remote sensing



DustHUB

Desert Dust
Monitoring
Service



AgriHUB

Satellite technology
as a tool to shape
agricultural policy and
ensure food security



FloodHUB

Flood monitoring
service



SolarHUB Nowcasting

Solar energy continuous
monitoring service



GeoHUB

Geohazards monitoring
service using satellite
radar interferometry





FireHUB

Forest fire monitoring
and management
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Wildfire in Mati, Attica, July 23, 2018

The wildfire in Mati, which took place on July 23rd, 2018, represents the most devastating fire incident in Greece, leaving behind 102 dead victims, smoldered properties, and unprecedented grief. BEYOND closely monitored the evolution of the wildfire from the moment it sparked (5:05pm), with 5 minute intervals and a 500m spatial resolution, and it was continuously informing in real time the Fire Brigade Operations Centre with regards to the development of the disaster. By utilizing satellite data, the BEYOND Centre offered the first assessment of the burned area in the wider region surrounding the Mati settlement (East Attica) which at the time was estimated to be around 1300 hectares. Furthermore, through the use of drones and a lightweight aircraft, the Centre mapped in detail the full extent of the disaster within the settlement, down to a residency scale at the level of few centimeters of accuracy. From this detailed mapping it was inferred that the 70% of the residential area was completely burnt out. All estimates and detailed maps of the disaster were immediately provided to the Greek Ministry of Infrastructure and Transport, for the purposes of managing and rectifying the effects of the disaster and aiding its victims.

FireHUB system of services detects and monitors the evolution of wildfires in Greece every 5 minutes at a spatial resolution of 500 m, while it simultaneously models the smoke dispersion. FireHUB also provides dynamic daily burnt areas and damage assessments at medium (250-400 m) and high spatial resolution (10-20 m). These products use satellite imagery collected in real-time by the ground stations of BEYOND, as well as high spatial resolution Copernicus Sentinel II data accessed from the Hellenic Mirror Site Hub operated by BEYOND. The FireHUB system of services provides fire risk assessments for settlements worldwide, and provides historical fire behavior assessments at country level. Towards this, it regularly updates a unique database of burnt scars for all fire events of Greece for the last 35 years.

<http://beyond-eocenter.eu/index.php/web-services/firehub>



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FloodHUB

Flood monitoring service

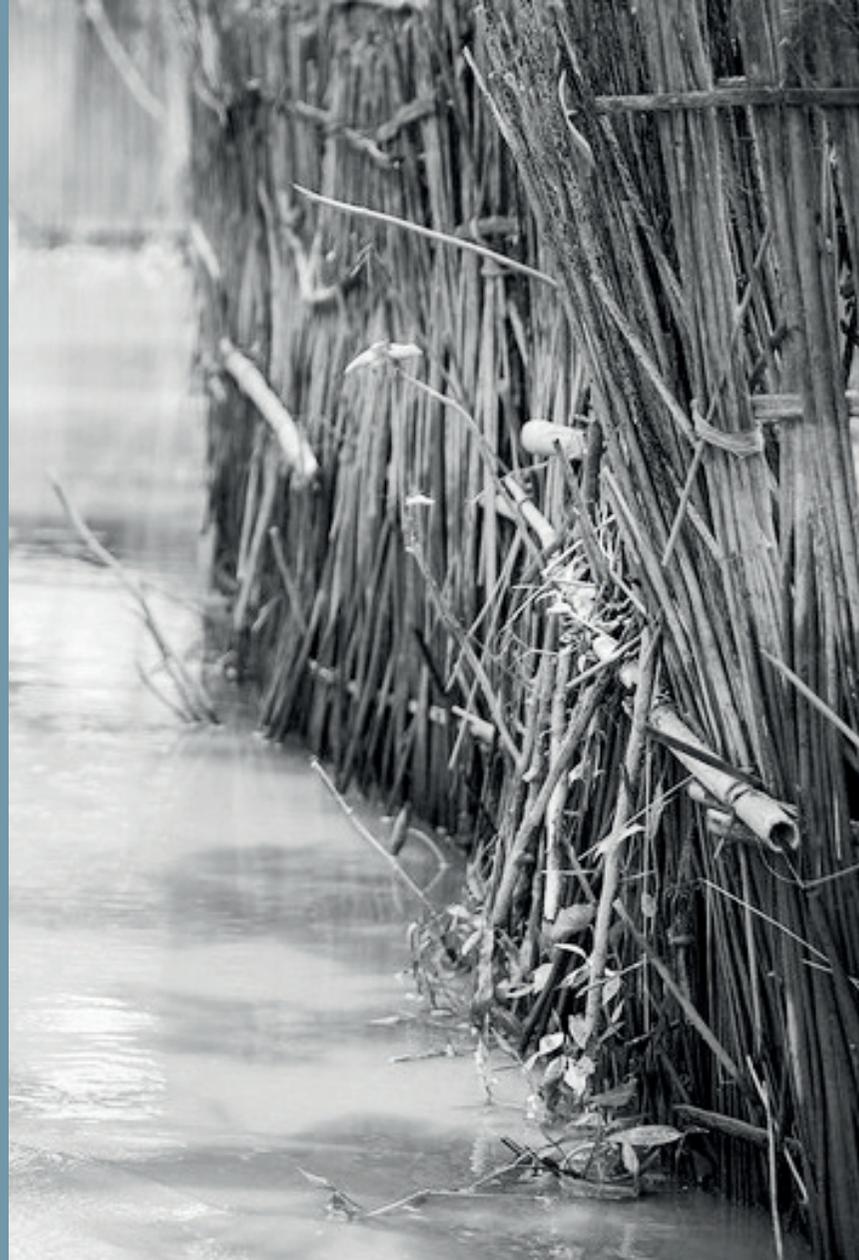
Flood in Mandra, Attica, November 2017

On November 15, 2017 a sudden flood was recorded after heavy rainfall, affecting the areas of Mandra and Nea Peramos in Attica. The tragic account of the disaster was 24 dead victims, as well as multiple assets and critical infrastructures that were completely or partially destroyed. The FloodHUB system of services was immediately activated by BEYOND Centre and reported the incident, both through the use of satellite imagery as well as on-site visits in the region that provided crucial data collection and detailed analyses of the scope of the disaster. The process revealed both uncovered and covered portions of streams and identified their older natural flow, while also identifying 66 critical points, examining the adequacy of the cross-section of streams and technical works, and formulating appropriate measures for repair and prevention of similar failures and disasters in the future. FloodHUB's* interactive web application produced detailed maps depicting the updated and verified hydrographic network as it stands today, after human intervention, the maximum extent of the floods (both by mapping and through simulation), as well as some of the critical factors that contributed to the huge disaster such as arbitrary human intervention in the riverbed, inadequacy of existing technical works and complete absence of flood protection and road drainage measures. The mapping of the maximum extent of the flood (534 hectares) was carried out using satellite remote sensing, as well as data collected during the autopsy.

*www.arcgis.com/apps/MapTools/index.html?appid=5dc29991a9f746fe87d5ecb1c4eac837/

The FloodHUB system of services is activated as soon as a major flood event occurs and gives a near-real-time picture of the disaster using hydrological and hydraulic modeling and special machine-learning technologies. It dynamically leverages objective satellite remote-sensing observations and crowdsourcing data from networks of citizens and volunteers, as well as in-situ data from in-field visits in the area (as appropriate). The FloodHUB service can potentially be activated for any flood event, in any watershed. Moreover, the service builds on the history of flood events in an area, and gives estimates of flood risk in advance accounting for both routine and extreme weather scenarios, in order to support emergency response plans and early preparedness and mitigation measures against flood risk.

<http://beyond-eocenter.eu/index.php/web-services/floodhub>



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GeoHUB

Geohazards
monitoring service
using satellite radar
interferometry

Eruption of Kīlauea volcano in Hawaii, 2018

The GeoHUB service was automatically activated in the case of the eruption of the the Kīlauea volcano in Hawaii (May 17th 2018) which triggered a powerful 6.9Mw earthquake - the largest seismic activity recorded in the wider region in the past 43 years. The service provided a timely estimation of the spatial deformation, by processing Sentinel-1 SAR satellite imagery, and highlighted the territorial deformation that accompanied the movement of magma along the crack zone, which eventually caused the outflow of magmatic material to the eastern edge of the aforementioned zone. In this instance, the maximum deformation recorded along this zone was 60-70 cm, and was placed between the top of the volcano and the area where the lava eruption was observed on 3/5/2018. This information was deemed crucial for the local authorities responsible for taking measures to contain the disaster and protect the citizens. The GeoHUB service is automatically activated whenever a major earthquake or volcanic eruption is recorded worldwide, and provides the results of its differential interferometry with the deformation fields immediately, systematically and free of charge to the scientific community through the website <http://geobservatory.beyond-eocenter.eu/>.

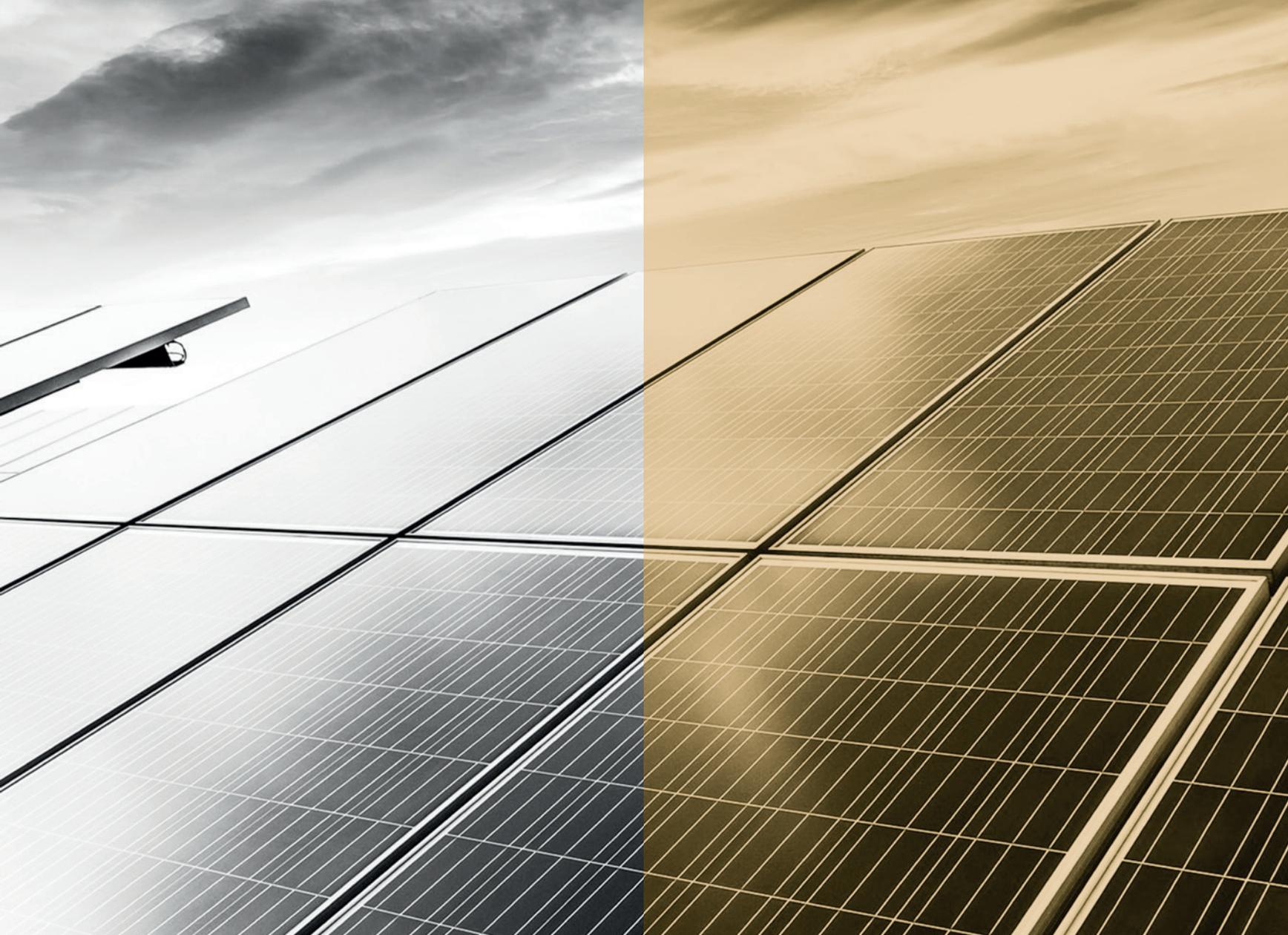
GeoHUB service is an ecosystem of services for monitoring geohazards. It exploits primarily Synthetic Aperture Radar imagery and employs interferometric techniques to assess ground deformation. GeoHUB generates products for the systematic and diachronic monitoring of earthquakes, volcanoes, landslides and urban subsidence, attributed to construction activities and other manmade interventions to the natural environment. The GeoHUB system is providing also the service GeObservatory that is activated fully automatically whenever an earthquake or a volcanic eruption takes place over the world. It consists a global observatory of geophysical phenomena depicting the corresponding deformation fields calculated from the differential interferometry processing of Sentinel-1 SAR satellite data.

<http://beyond-eocenter.eu/index.php/web-services/geohub>



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SolarHUB Nowcasting

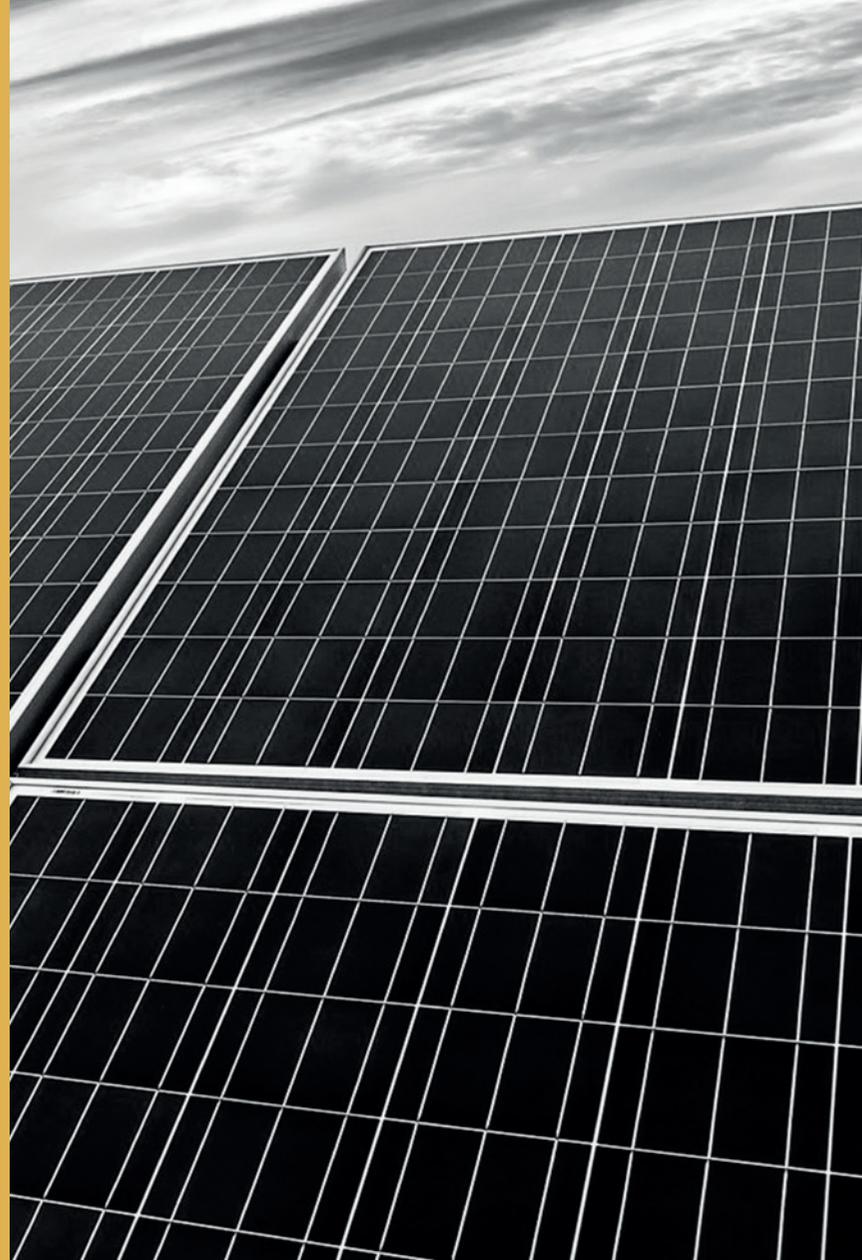
Solar energy continuous monitoring service

Solar energy support services - A success story in Egypt

The SolarHUB system of nowcasting and solar atlas services of BEYOND provide the opportunity for efficient planning and management of solar energy using Earth Observation data and technologies (e.g. SENSE) in Egypt. The official solar atlas was created for the needs of the ministry of electricity and renewable energy. In this study 29 specific locations were selected for the construction of new solar farm projects, one of which has been the site of Benban, where a 1.8 GW solar farm was completed at the end of 2019 providing green energy to more than 80K houses and actively contributing in the energy mix in Egypt. The Madgi Yacoub Heart Foundation in Aswan has also used the SolarHUB service for assessing the proper energy production monitoring solutions for an under construction photovoltaic park, covering the energy needs of the hospital and the residential area, i.e. almost 15K people. The contribution of these services to the society in Egypt was awarded and highlighted by the Minister of Electricity and Renewable Energy, the Minister of Immigration and Egyptian Expatriate Affairs and the Minister of State for Military Production.

The SolarHUB Nowcasting service provides data and maps of the surface solar radiation and energy in real-time for the European and North African regions. The data are based on the continuous monitoring and forecasting systems SENSE and nextSENSE, which were developed and scientifically evolved at the BEYOND Centre of Excellence in collaboration with the World Radiation Center in Switzerland (PMOD/WRC) in the framework of project awarded through European and other competitive funding schemes (e.g. GEO-CRADLE <http://geocradle.eu/en/>, e-shape <https://e-shape.eu>). These systems combine satellite data collected in real time at the acquisition facilities of BEYOND (e.g. satellite data antennas, Hellenic Mirror Site) with machine learning and neural network techniques.

<http://beyond-eocenter.eu/index.php/web-services/solarhub>



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AgriHUB

Satellite technology
as a tool to shape
agricultural policy and
ensure food security

Satellite Remote Sensing in the implementation of the Common Agriculture Policy (CAP)

The AgriHUB service has multiple applications in the wide area of agricultural monitoring, by providing tools to farmers, agricultural advisers and rural aid payment agencies in order to support their relevant actions. Its use has ensured effectiveness while also automating compliance checks with regards to the CAP regulations relating to adequate environmental protection and good agricultural practices ("cross compliance" regulations), to the benefit of producers. Moreover, AgriHUB is currently supporting the actions of the Greek Ministry of Agriculture, the Institute of Rural Economy (KREI) and the Rural Development Administration (RDA) of South Korea, by leveraging big satellite data thanks to engineering and deep learning technologies, in order to assess the overall size of paddy fields, to monitor the evolution of the plants at a parcel level, and finally offer accurate estimates of expected production.

The BEYOND Centre has developed and successfully applied state-of-the-art artificial intelligence algorithms for the monitoring of food security, the control of the Common Agricultural Policy (CAP), but also for precision agriculture. The effective, efficient and general monitoring of the obligations imposed by the CAP, but also the timely food security related decision making at national and international scale, demand the systematic observation of agricultural land. Therefore, there is an obvious need for the effective management and the efficient processing of Big Earth Observation Data associated with such applications. In view of the aforementioned realizations, AgriHUB invests in the exploitation of parallel and distributed processing algorithms in High Performance Data Analytics (HPDA) environments, developing large scale agriculture monitoring applications.

<http://beyond-eocenter.eu/index.php/thematic-areas/agriculture>



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DustHUB

Desert Dust Monitoring Service

Polar Vortex, Khamsin, Foehn and Extreme Dust Episodes

On March 22, 2018, 6.340 ($\mu\text{g} / \text{m}^3$) of desert dust was measured in Crete, the highest concentration ever measured in Greece (*Solomos et al., 2018, Atmosphere*). Analysis of the phenomenon within the BEYOND-DustHUB service showed that a weakening of the polar vortex allowed the descent of cold air masses towards the Mediterranean and North Africa. This created a strong low pressure system in the Mediterranean with subsequent strengthening of the SW Khamsin wind which transported huge amounts of dust from the Sahara to the Mediterranean. Finally, the steep topography of Crete contributed to the creation of the local wind Livas (Foehn) which led to an increase in dust concentrations near the ground. Regarding climate change considerations, a possible change in polar vortex intensity will increase the incidence of such phenomena. This study was posted on the SDS-WAS website of the World Meteorological Organization (<https://sds-was.aemet.es/news/multi-scale-dust-modeling-to-describe-near-surface-pm10-concentrations>).

DustHUB provides a three-day forecast of desert dust concentrations and dispersion in the atmosphere over the regions of North Africa, Middle East, Mediterranean and Europe. The forecast is based on mesoscale simulations with NMME-DREAM model at 20 kmx20 km spatial resolution. The system assimilates the satellite data of dust from the MSG-SEVIRI sensor received in real time by the BEYOND acquisition antennas and also initial and boundary meteorological conditions from the global GFS-NOAA model. DustHUB products include dust particle concentrations at all heights of the atmosphere, as well as dry and wet depositions of dust on the surface.

<http://beyond-eocenter.eu/index.php/web-services/dusthub>



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Specialized services

The BEYOND Centre is a living entity, that is constantly evolving its services through the development of new scientific methods and the exploitation of emerging technologies and modern infrastructures, for the extraction of high level information and knowledge for the benefit of the citizen and the environment.



Copernicus Emergency Management System (EMS):

Rapid Exposure, Vulnerability and Risk Assessment Service for Natural Disasters

<http://beyond-eocenter.eu/index.php/thematic-areas/disasters/ems-activations>

The Copernicus EMS Risk & Recovery Mapping service is activated by the European Civil Protection authorities around the world, and entities of the European Union. It has global coverage and is a totally operational action. Its products and studies on risk assessment are delivered within 20 business days after the Copernicus EMS activation arrives at the BEYOND Centre. This service provides exposure, vulnerability, and risk assessments, and offers plans for dealing with a wide range of natural hazards such as: fires, floods, earthquakes, volcanoes, tsunamis, landslides, industrial accidents, as well as soil and coastal erosions. In addition to that, BEYOND conducts studies following the EMS standards for the needs of various users that



operate under European programs or national programming agreements, such as the needs of the International Organization for Migration (IOM) under the ERAPLANET / SMURBS program (<http://smurbs.eu/>). BEYOND has been activated by the Copernicus Emergency Management System (EMS) 21 times for various cases of natural disasters and in multiple countries around the globe. Similar activations of BEYOND that follow the EMS standards, have also been conducted for the purposes of international organizations such as the United Nations, UNESCO, the World Bank, etc. An illuminating example is the activation of the EMS service by UNESCO for assessing the exposure, vulnerability and risk in three different regions - Arica (Chile), Tacna (Peru) and Maputo (Mozambique)- in order to protect the local communities, public spaces, critical public utilities and schools from destruction caused by earthquakes, landslides, soil and coastal erosions and floods.



Multiple natural disaster risk assessment and design of preventive measures for the open refugee housing facility in Ritsona

As part of BEYOND's collaboration with the European SMURBS ERA-PLANET program (<http://smurbs.eu/>), a new scientific action is being developed to provide support for the safe design and implementation of a holistic refugee accommodation unit. This action assesses the most likely risks potentially faced by the population of the facility and records critical information and the infrastructure in the area of interest. Consequently, mitigation and response measures are proposed, as well as evacuation plan of the facility in situations of emergency. A prime example of that is the study of mitigation measures in cases of fire and flood events at the Ritsona Refugee Reception Unit - the largest one in Greece. This action is designed in collaboration with the Greek office of the International Organization for Migration (IOM).

Early Warning System for Mosquito-borne diseases based on Satellite Earth Observation Data

<http://beyond-eocenter.eu/index.php/thematic-areas/epidemics>

Mosquito-Borne Diseases (MBDs) infect almost 700 million people every year and are recognized in over 100 countries, causing millions of deaths annually. The changing climatic and ecological conditions, global travel and trade, human behavior, as well as the rapid and unplanned urbanization, are key factors that influence the seasonal and geographic distribution of vectors' population and therefore the transmission of the pathogens, causing the re-emerging and even more emerging of these diseases in countries where they were previously unknown. West Nile Virus (WNV) infection, caused by the Culex Pipiens vector, have been recorded in humans

and animals in various areas of Greece, during the years 2010-2014 and 2017-2019, but also in other regions in Europe reaching an unusual high record in 2018. The Asian tiger mosquito (*Aedes albopictus*) is another important vector in Europe for transmitting viral diseases, including Zika, chikungunya and dengue. Several disease outbreaks transmitted by *Aedes albopictus* have been reported in Europe: chikungunya in Italy and in France in 2010, 2014 and 2015, as well as local transmissions of dengue in France and Croatia in 2010.

The BEYOND Centre has been working on the development of an Early Warning System (EWS) that utilizes big satellite Earth Observation (EO) data collected by the acquisition antennas and the Hellenic Mirror Site maintained by BEYOND. The big satellite data serve as input parameters in dynamic

models (seasonal predictions) and machine learning algorithms (short-term predictions) with the purpose of forecasting and risk mapping the outbreak of mosquito-borne diseases using Data Cube architectures. The EWS proves its transferability by being applied for multiple diseases such as WNV, Dengue fever, Chikungunya and Zika virus in the geographical areas over Europe (e.g. Italy, German, Greece, France, etc).



Access to data

BEYOND Centre of Excellence operates infrastructures for the regular acquisition, management, and redistribution of real-time Earth observation data from space-based satellite missions and terrestrial systems. The coverage of this infrastructure is international and addresses the needs of the research community as well as institutional decision-makers throughout SE Europe, North Africa, the Middle East and the Balkans.





Hellenic Mirror Site (Copernicus satellite missions)

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

The Hellenic National Sentinel Data Mirror Site (HNSDMS) is part of the ESA Mirror Sites of Collaborative Ground Segment ecosystem. The HNSDMS is a hub for the collection, management and distribution of large volumes of satellite data and products gathered by Sentinel -1, - 2, -3, 5P missions, serving the needs of a wide user community based mostly in Europe, but also in the Middle East and North Africa. Users of the Hellenic Mirror Site belong to the entire spectrum of value-adding processes active in providing services with Earth Observation products, as well as in the decision-making sector, such as ministries, civil protection agencies, research teams etc. The Greek Mirror Site is a key infrastructure of the BEYOND Centre.

Sentinels GreekHUB

<http://beyond-eocenter.eu/index.php/web-services/sentinels-greekhub>

Sentinels international operational ground-based collection and global distribution centre for satellite missions (known as Sentinels GreekHUB) is part of the EU's ground-based space program infrastructure for Global Observation and Monitoring (Copernicus). Its scope is global, serving users worldwide - including NASA, NOAA, Australia Geophysics and the United States Geological Survey (USGS) - who are interested in gaining free access to Sentinel satellite data for the development of space applications. The GreekHUB Centre meets the growing demand of users by providing immediate access to satellite data, just few hours after the initial reception at the Payload Data Ground Segment (PDGS), as well as

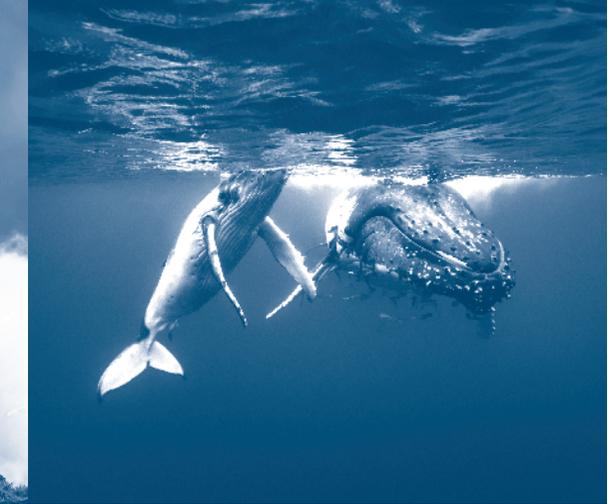
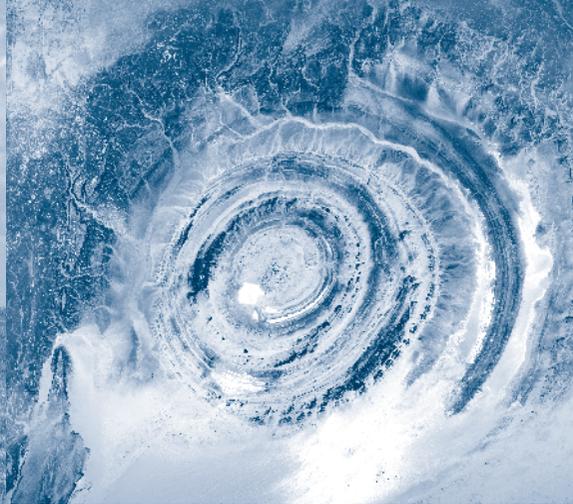
access to the Sentinels product archive of the past 4 weeks that geographically covers the entire planet. GreekHUB is one of the 3 sites maintained by the European Space Agency (ESA) in order to make Sentinels available worldwide. It distributes 2.85 Petabytes of S-1, S-2, S-3, S-5P data per month across the globe, at a speed of 10 Gbps, using the GEANT network and computational resources provided by GRNET SA - National Infrastructures for Research and Technology. GreekHUB is a key infrastructure, operated on 24/7 basis by the BEYOND Centre.



What inspire us

Worldwide efforts have been stepped up to take action on climate change and it is in this sense that the European Union and the International Community have taken coordinated actions. In this context, the Centre develops research and supports the role and mandate of civil protection, locally and internationally, with a focus on mitigation, preparedness, response and recovery by delivering accurate information through Earth Observation.





UN 2030 Agenda for sustainable development

The EU is fully committed to be a frontrunner in implementing the 2030 Agenda for Sustainable Development, together with its Member States. The Agenda is a shared roadmap for a peaceful and prosperous world, of paramount importance to the values of the EU and the future of Europe.

SENDAI Framework for Disaster Risk Reduction

The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) was the first major agreement of the post-2015 development agenda and provides Member States with concrete actions to protect development gains from the risk of disaster.

PARIS Agreement on Climate Change

The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change.

EU Floods Directive

Directive 2007/60/EC on the assessment and management of flood risks requires Member States to assess if all water courses and coast lines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and coordinated measures to reduce this flood risk.

EU Civil Protection Mechanism

The overall objective of the EU Civil Protection Mechanism is to strengthen cooperation between the EU Member States and 6 Participating States in the field of civil protection, with a view to improve prevention, preparedness and response to disasters.

EU Adaptation Strategy to Climate Change

In 2013, the European Commission adopted an EU strategy on adaptation to climate change, welcomed by the EU Member States. The strategy aims to make Europe more climate-resilient. By taking a coherent approach and providing for improved coordination, it aims to enhance the preparedness and capacity of all governance levels to respond to the impacts of climate change.

Imagination
takes us
BEYOND
our limits



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