The European Centre of Excellence BEYOND for Earth Observation based monitoring of Natural Disasters in South-Eastern Europe

BEYOND
Building a Centre of Excellence for EO-based monitoring of Natural Disasters

Funded under FP7-REGPOT-2012-2013-1
Activity: 4.1 Unlocking and developing the research potential of research entities established in the EU’s Convergence regions and Outermost regions

Dr Haris KONTOES
Research Director of IAASARS/NOA
Project Coordinator

The European Centre of Excellence for Earth Observation based monitoring in South-East Europe

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Highly ranked priorities in BEYOND

- BEYOND aims to maintain and expand the existing state-of-the-art and interdisciplinary research potential in EO, by building a Centre of Excellence for Earth Observation based monitoring of Natural Disasters.

- BEYOND addresses societal needs of south-eastern Europe, with a prospect to increase its access range to the wider Mediterranean region through the integrated cooperation with more than 20 twining organizations.
BEYOND aspires to setting up innovative solutions for EO, allowing to a multitude of monitoring networks (space borne and in-situ) available over the region to operate in a complementary, unified, and coordinated manner.

BEYOND builds innovative research and skills capacity in the domain of EO through scientific exchange with European and regional partnering organisations.

BEYOND transforms the observations to added value products ready for down-streaming to specific societal needs in the domain of environmental monitoring and Natural Disasters.

BEYOND delivers online observations and higher level EO products and services to stakeholders, and international scientific and End User communities.

**Funding:** 2.3 MEuros EC Contribution

Additional funding from Structural Funds ~270KEuros
LDA Large-scale demonstrators in support of GMES and GNSS based services in Athens, Greece, GMES/DG ENTR

MASSIVE: Mapping Seismic Vulnerability and Risk of Cities, European Commission - DG ENV A.3 – Civil Protection

LinkER - Supporting the implementation of an operational GMES service in the field of emergency management, Invitation to Tender No: ENTR/08/028


RISK-EOS Extension to Greece - Promotion of the GSE RISK-EOS fire services portfolio in Greece, EarthWatch GMES Services Elements, ESA/GSE

MARCOAST/ISSUE-OS - Integrated system for suspect vessels emergency tracking – OIL SPILLS
BEYOND, European Center of Excellence for EO based Disaster Management

Center of excellence for EO based monitoring of natural disasters

RD1: Meteorological and human induced hazards
- LiDAR expert hardware
- LIDAR
- RHMS, TURITAK, NILU, BSC, ISAC, TROPOS

RD2: Geophysical hazards
- SARscape, SAR imagery
- Magnetometer, Gradiometer

RD3: Atmospheric Perturbations & air quality
- Lidar expert software
- Fires expert
- Atmospheric Remote Sensing Station, MSG/SEVIRI, Meteorological Network, ZEUS, Atmospheric Air Quality Network, Atmospheric Chemistry Laboratory

IP: Exploitation & Dissemination
- IT Expert
- Administrative and management support

Legend:
- Recruitment
- Infrastructure to be acquired
- Existing infrastructure
- Partnering organisations
- Capacity node

Public Stakeholders
- National Seismological Network, NDANET GPS Network, ENIGMA Magnetometer Network

Regional Industry
- Exploitation manager

Greek GEO office

Project funded by the EUROPEAN UNION
Setting up integrated satellite based observational solutions

- **X-/L-band** acquisition station for (EOS Aqua and Terra, NPP, JPSS, NOAA, Met Op, FengYun) *(part of the DB network)*
Setting up integrated satellite based observational solutions

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Setting up integrated satellite based observational solutions

- MSG SEVIRI acquisition stations of DVB-S & DVB-S2 systems exploiting high throughput provided with the new EUMETCast Europe service, based on using the EUTELSAT 10A (part of EUMETSAT’s network)

- Access to NOA’s in-situ monitoring seismological, magnetometer, and GPS networks

- Develop and Operate of NOA’s Collaborative Ground Segment (Hellenic Sentinel Data Hub-Mirror Site) dedicated to ESA Sentinel missions (Copernicus), allowing near real time acquisition of S-1, S-2, and future S3, S5P satellite missions
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**Activity in the framework of the COPERNICUS PROGRAM**
The EUROPEAN EARTH OBSERVATION FLAGSHIP PROGRAM (EU/ESA)
http://www.copernicus.eu/
- a **GSC Core Ground Segment**, with **GSC-funded Functions and Elements**, providing:
  - the primary access to Sentinel Missions data as well as
  - the coordinating access functions to Contributing Missions data
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  - the primary access to Sentinel Missions data as well as
  - the coordinating access functions to Contributing Missions data
Sentinel-1A/2A passes in IWS mode (250 km swath)

OFFICIAL ANNOUNCEMENT OF HELLENIC MIRROR SITE
ATHENS SPACE EXPO:
28 MARCH – 5 APRIL

HTTP://SENTINELS.SPACE.NOA.GR
Operation of the mobile lidar of ESA by IAASARS

Development of a state-of-the-art multi-wavelength lidar to be installed in Crete (FKL), in the framework of the BEYOND project, part of the EARLINET network.
ACHIEVEMENTS – EO SERVICES
## BEYOND, European Center of Excellence for EO based Disaster Management

<table>
<thead>
<tr>
<th>Service</th>
<th>Status</th>
<th>End Users</th>
<th>Scale</th>
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<tbody>
<tr>
<td><strong>Emergency Response/EMERGENCY</strong></td>
<td><strong>SUPPORT-METEO</strong></td>
<td><strong>RELATED HAZARDS</strong></td>
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<tr>
<td>Real Time Fire Monitoring</td>
<td>Operational GMES Standard</td>
<td>Fire Brigades, Civil Protection, Public, Private Sector</td>
<td>National, Regional</td>
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<tr>
<td>Rapid Fire Mapping</td>
<td>Operational GMES Standard</td>
<td>Fire Brigades, Civil Protection, Forestry Services, Min of Env</td>
<td>Regional, Local</td>
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<tr>
<td>Disaster Event Mapping &amp; Damage Ass.</td>
<td>Operational GMES Standard</td>
<td>Forestry Services, Min of Env (DG for Nat. Vegetation/Forest Protection)</td>
<td>Local</td>
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<tr>
<td>Seasonal/Diachronic Fire Mapping &amp; Damage Ass.</td>
<td>Operational GMES Standard</td>
<td>Forestry Services, Min of Env (DG for Nat. Vegetation/Forest Protection, Cadastral Org, Fire Brigades)</td>
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<tr>
<td>Wild Fire Smoke Dispersion</td>
<td>Research/Preoperational</td>
<td>Fire Brigades, Civil Protection, Min of Env</td>
<td>Regional, Local</td>
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<tr>
<td>Saharan Dust Episodes</td>
<td>Research/Preoperational</td>
<td>Civil Protection, Min of Env, Public</td>
<td>National</td>
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<tr>
<td>Flood Risk</td>
<td>Research/Preoperational</td>
<td>National Electric Power Org, Min of Development, Local Authorities, Civil Protection</td>
<td>Regional, Local</td>
</tr>
<tr>
<td>Heat Waves Risk</td>
<td>Research/Preoperational</td>
<td>Min of Public Health, Local Authorities, Medical Science</td>
<td>Local</td>
</tr>
</tbody>
</table>


*To be Delivered as V1.0 in 2014*: Wild Fire Smoke Dispersion, Saharan Dust Episodes, Flood Risk, Heat Waves Risk.

*To be Delivered as V1.0 in 2015-2016*: Disaster Event Mapping & Damage Ass.
## BEYOND, European Center of Excellence for EO based Disaster Management

### EMERGENCY RESPONSE/EMERGENCY SUPPORT - GEO-HAZARDS

<table>
<thead>
<tr>
<th>Phenomenon</th>
<th>Operational GMES Standard</th>
<th>Anti-seismic Planning &amp; Protection Org, EQ Scientists</th>
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<tr>
<td>Earthquake related crustal deformation field</td>
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<tr>
<td>Volcano related surface velocity field</td>
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<td></td>
<td>Local</td>
</tr>
<tr>
<td>Landslide related surface velocity field</td>
<td>Research</td>
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<td>Local</td>
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### ATMOSPHERIC DISTURBANCES - CLIMATOLOGY

<table>
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<tr>
<th>Phenomenon</th>
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<tr>
<td>3D-Climatology</td>
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<td>Global</td>
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<tr>
<td>Atmospheric Episodes</td>
<td>Research</td>
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<td>Local</td>
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</tbody>
</table>

### LULC CHANGE MONITORING - UAV / AIRBORNE / SATELLITE

<table>
<thead>
<tr>
<th>Phenomenon</th>
<th>Operational GMES Standard</th>
<th>Min of Env, Hellenic Biotopes &amp; Wetlands Centres, Cadastral Org</th>
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</thead>
<tbody>
<tr>
<td>Urban Mapping</td>
<td></td>
<td>Anti-seismic Planning and Protection Organisation</td>
</tr>
<tr>
<td>UAV Damage Recording</td>
<td>Research/Preoperational</td>
<td></td>
</tr>
<tr>
<td>Ecosystem Monitoring and Mapping (Forests/Wetlands)</td>
<td>Operational</td>
<td></td>
</tr>
</tbody>
</table>
BEYOND, European Center of Excellence for EO based Disaster Management

“FireHub: A Space Based Fire Management Hub”

“FireHub: A Space Based Fire Management Hub”
“FireHub: A Space Based Fire Management Hub”

The service consists of three pillars:

1. The real-time fire detection and monitoring application
2. The large scale Burnt Scar Mapping during and after wildfires and the Diachronic BSM
3. The fire smoke dispersion forecasting tool

Raw resolution: 3.5x3.5 km wide pixel over entire

Refined resolution: 0.5x0.5 km wide pixel over entire Greece
Classification #1: The EUMETSAT Fire mapping algorithm (FIR) based on fixed thresholding approach, applied on the spectral bands IR 3.9 and IR10.8.

Classification enhancement # 1: The thresholds are dynamically changing calculated for each image and every pixel location on the basis of the seasonally variations and time depended Solar Zenith Angle.

Classification enhancement # 2 : Create and integrate classification evidence through geo-spatial ontology schemes and reasoning queries, accounting for the

a) thematic consistency by eliminating false alarms, and

b) account for the time persistence of the fire observations
Classification enhancement # 3: Downscaling the first classification output and calculate the fire occurrence probability in sub-areas of 500 m x 500 m wide, inside the initial observation area of 3.5km x 3.5 km, accounting for the real meteorological, physical / ecological, and morphological conditions in the affected area such as, 
- Wind conditions (speed/direction),
- Fuel types and fuel type’s proneness to fire,
- Altitudinal zone,
- Slope and Aspect elements of each of the 500m x 500m area.
Regional Real Time Fire Monitoring - NOA’s MSG SEVIRI Station

Real Time Fire Monitoring Activation in Greece – Peloponnesus 2007

- Parnon Mt Fire
- Taygetos Mt Fire
- Megalopolis Fire
- Oitilon Fire
- Olympia site Fire
- Stira Euboea Fire
- Aliveri Euboea Fire
- Korinthos Fire
- Zaharo Fire

Emergency

SEVIRI MIR 070823_1030 UTC

Potential Fire

Confirmed Fire
Results @ 150 minutes after fire ignition

5 minutes basis
Demonstration of the "Real-time fire detection" functionality

Local Time: 27-07-2013 13:10
**FLEXPART – NOA**

**Biomass Burning (Organic Carbon – OC)**

Valid Date: 26-08-2007 0900UTC

Model layer: Integrated Column (ng m⁻³)

Each map represents the **cross-section of Organic Carbon concentration (ng m⁻³)** for the 09:00 UTC and 10:00 UTC time periods.

**Every one hour**

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**Valid Date: 24-08-2011 09UTC**

Model layer: Integrated Column (ng m⁻³)

**Valid Date: 24-08-2011 10UTC**
BEYOND, European Center of Excellence for EO based Disaster Management


Map titled "Αρ. Φύλλου Χάρτη Σχεδ. Νο. BSM GR11.1" showing the prefecture of Iliou.

Map titled "ΝΟΜΟΣ ΗΛΕΙΑΣ Prefecture of Iliou" with a legend "Καμένες εκτάσεις Burnt Areas".

Map titled "Πυρκαγιά Πύργου-Αρχαίας Ολύμπιας 21.297 ha. Εξω νηστηρία του Δ. Αρχαίας Ολύμπιας. Ο χάρτης βασίζεται σε δεδομένα Formosat-2 Fire at Pyrgos- Ancient Olympia 21.297 ha. Here a detail at the Municipality of Ancient Olympia is illustrated Map is based on Formosat-2 images (2mP, 8mXS, 09.07)

Map titled "ΚΑΜΕΝΕΣ ΕΚΤΑΕΙΣ ΣΤΟ ΣΥΝΟΛΟ ΤΟΥ ΝΟΜΟΥ Burnt surfaces in the entire Prefecture" with a legend "Χαρτογράφηση Καμένων Οικονομικών έκτασεων 2007 με κρητικά υπολογιστικά ηλεκτρονικά γραφεία Εκτέλεση του προγράμματος RISK-EOΣ στην Ελλάδα Burn Scar Mapping in Greece for Year 2007 RISK-EOΣ, Extention to Greece".

Map titled "FireHub" with logos and images related to fire management.

Logos for IAASARS and BEYOND.
1) More than 650 Landsat TM images acquired over Greece in the period 1984-2013 residing on USGS archives were downloaded and processed fully automatically using the NOA processing chain.

2) Yearly maps of Burned Areas have been produced.

3) Yearly statistics per land cover type and administrative data have been generated.

4) On-line dissemination of the produced maps and statistics through the NOA’s dedicated web interface.
http://ocean.space.noa.gr/bsm

DIACHRONIC INVENTORY OF FOREST FIRES OVER GREECE FROM 1984 TO PRESENT, WITH USE OF LANDSAT 4,5,7 SATELLITE DATA
BEYOND for flood monitoring

BEYOND, European Center of Excellence for EO based Disaster Management

FLOODS

OVERVIEW

Flood is defined as ‘a covering by water of land not normally covered by water’ in the European Union Floods Directive 2007/60/EC. Human activities, such as agriculture, urban development, industry and tourism, contribute to an increase in the likelihood and adverse impacts of flood events. It is thus important to establish flood risk management plans focused on prevention, protection and preparedness.

The ultimate goal of the Flood Hazard activities in BEYOND is to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. In this direction, we select river basins at high risk of flooding, we study the hydraulic behaviour of the river, and we proceed to the flood modelling validation and enhancement with the integration of satellite optical and radar data.

In the context of the implementation of BEYOND, we have established the FLOODS OBSERVATORY where we register all the flood events in Greece and we publish the results we produce following process of satellite optical and radar images.

NOA has also established cooperation with the Public Power Corporation S.A. (PPC S.A.), as there is a mutual interest in cooperation in the field of the study of floods to develop a methodology for monitoring and management of flood risks. The contribution of PPC S.A. will cover the provision of relevant expertise and data derived from the processing of the measurements of the hydrometeorological network operated by PPC S.A., and/or data relating to the management of the hydrological basins under study. This cooperation will allow the improved adjustment and calibration of the hydrological models which are to be operated by the IAASARS/NOA, as well as the development of a methodology that will provide reliable observations to the services of PPC S.A. in the future. Our first area of interest is Arachthos river basin, a river with several flood events, very close to the city of Arta, where PPC is operating a large hydroelectric plant.
We have established the BEYOND Floods Observatory where we register all the major flood events in Greece and South-Eastern Europe.
This cooperation allows the improved adjustment and calibration of the hydrological and hydraulic models which are operated by NOA, as well as the development of a methodology that will provide reliable products and services to PPC S.A.

CASE STUDY: The first case study is the river basin of Arachthos, a river with several flood events, upstream of the city of Arta, where PPC S.A. is operating two hydroelectric plants: 1) a large one known as Pournari I (effective capacity of reservoir 303 million m³) 2) a smaller one known as Pournari II (effective capacity of reservoir 4 million m³).
BEYOND’s Floods Monitoring Service for Arachthos river basin
Moreover, in the BEYOND Floods Observatory we publish the flood mapping results produced following the processing and photo-interpretation of satellite optical and radar images.

CASE STUDY: The flood event of Arachthos river on 1 February 2015. Arachthos river is in western Greece. The Public Power Corporation S.A. Hellas operates two dams just upstream the city of Arta.
Sentinel-1 based flood monitoring and mapping service in BEYOND Floods Observatory

April 2015 flood extent maps in North Greece produced by automatic ingestion and processing of satellite radar images in RT
Earth Observation - SAR Interferometry

Data & methods tier
- NSN
- ENIGMA
- NOANET
- In-situ

Services tier
- Geodesy
- Modeling
- Hazard assessment
- Large scale processing

Applications tier
- Volcanoes
- Tectonics
- Landslides
- Subsidence

WEB GIS

GIS

The Web

Users tier

WEB GIS

GIS

The Web

Users
### Geohazard services - An overview

<table>
<thead>
<tr>
<th>Service</th>
<th>Status</th>
<th>Input data</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mapping of large-scale ground velocities &amp; 3D decomposition</td>
<td>Operational</td>
<td>SAR, GPS</td>
<td>National</td>
</tr>
<tr>
<td>Estimation of earthquake 3D crustal deformation</td>
<td>Operational</td>
<td>multi-angle SAR, GPS</td>
<td>Local</td>
</tr>
<tr>
<td>Seismic risk estimation</td>
<td>pre-operational</td>
<td>SAR, in-situ, GIS</td>
<td>Local</td>
</tr>
<tr>
<td>Mapping of tectonic hazard areas in subduction zones</td>
<td>Research</td>
<td>SAR, GPS</td>
<td>Regional</td>
</tr>
<tr>
<td>Monitoring of volcanic activity</td>
<td>Operational</td>
<td>SAR, GPS, in-situ</td>
<td>Local</td>
</tr>
<tr>
<td>Detection of new landslides</td>
<td>Operational</td>
<td>SAR</td>
<td>Local</td>
</tr>
<tr>
<td>Update of landslide inventory maps</td>
<td>pre-operational</td>
<td>SAR, in-situ</td>
<td>Local</td>
</tr>
<tr>
<td>Estimation of landslide susceptibility</td>
<td>pre-operational</td>
<td>SAR, in-situ, GIS</td>
<td>Local</td>
</tr>
<tr>
<td>Estimation of landslide hazard</td>
<td>Research</td>
<td>SAR, in-situ, GIS</td>
<td>Local</td>
</tr>
<tr>
<td>Detection of subsidence in urban &amp; peri-urban areas due to manmade activities &amp; physical processes</td>
<td>Operational</td>
<td>SAR, GPS</td>
<td>Local</td>
</tr>
<tr>
<td>Monitoring of construction activities in urban environment</td>
<td>Operational</td>
<td>SAR, GPS</td>
<td>Local</td>
</tr>
</tbody>
</table>
Earthquakes – Cephalonia case

Data
- NSN
- NOANET
- ENIGMA
- In-situ

Services
- Geodesy
- Modeling
- Hazard Ass.
- Large Proc.

Applications
- Tectonics
- Volcanoes
- Landslides
- Subsidence

Mapped faults
- Strike-slip inferred
- Strike-slip
- Reverse inferred
- Reverse

Main earthquake events
- 26/1/2014 ML 5.1
- 3/2/2014 ML 5.7
- 26/12/14 ML 5.9

SARframes
- COSMO-SkyMEd
- TerraSAR-X

GPS stations
- cGPS
Earthquakes – Cephalonia case

• 3D crustal deformation from TerraSAR-X & COSMO-SkyMed data
• Inversion to estimate fault parameters

Merryman Boncori et al., SRL 2015
Earthquakes – Cephalonia case

Post-seismic slip, measured with COSMO-SkyMed data
Earthquakes – Nepal
Volcanoes – Santorini case


Papoutsis et al., GRL 2013

Data
- NSN
- NOANET
- ENIGMA
- In-situ

Services
- Geodesy
- Modeling
- Hazard Ass.
- Large Proc.

Applications
- Tectonics
- Volcanoes
- Landslides
- Subsidence
Volcanoes – Santorini case

Time-series monitoring with in-situ GPS stations

GPS data processing by Dionysos Satellite Observatory
Subsidence

**Data**
- NSN
- NOANET
- ENIGMA
- In-situ

**Services**
- Geodesy
- Modeling
- Hazard Ass.
- Large Proc.

**Applications**
- Tectonics
- Volcanoes
- Landslides
- Subsidence

**Volos (2002 -2010)**

**Thessaloniki (1992 -2001)**

**Driver:** water over-pumping

**Drivers:**
- Over-pumping
- Natural compaction of deposits
- Tectonics
Subsidence

Data
- NSN
- NOANET
- ENIGMA
- In-situ

Services
- Geodesy
- Modeling
- Hazard Ass.
- Large Proc.

Applications
- Tectonics
- Volcanoes
- Landslides
- Subsidence

Seismic Risk – Athens

Data
- NSN
- NOANET
- ENIGMA
- In-situ

Services
- Geodesy
- Modeling
- Hazard Ass.
- Large Proc.

Applications
- Tectonics
- Volcanoes
- Landslides
- Subsidence
UAV Assisted Loss Recording

Cephalonia Earthquake
Feb 2014
Cephalonia Island – Village of Mantzavinata

Damage Type
1 Building Roofs
2 Collapsed Walls
3 Ground Level
Landslides – South Pindus

Data
- NSN
- NOANET
- ENIGMA
- In-situ

Services
- Geodesy
- Modeling
- Hazard Ass.
- Large Proc.

Applications
- Tectonics
- Volcanoes
- Landslides
- Subsidence
Landslides – South Pindus

Landslide susceptibility model

Data Acquisition

Pre-existing inventory
SAR Data
MTI technique

Visual Interpretation
MTI Velocities
Time series
displacements

LS Inventory
LS distribution map

DEM
DEM Products
(Slope, aspect,
convexity maps)

Regional Geology

Statistical analysis

Susceptibility
mapping

Landslide susceptibility map

Landslide Susceptibility
- Low
- Medium
- High
- Very high

Kilometers

Global 3D climatology of aerosols and clouds
LIVAS portal under BEYOND (1x1 degree resolution)

Global AOD at VIS (532 nm) from LIVAS 4-year averages of CALIPSO observations

LIVAS AOD evaluation against AERONET
BEYOND PHASE 2 – FOLLOW UP

At the regional level ...

<table>
<thead>
<tr>
<th>ID</th>
<th>Participant Organisation Name</th>
<th>Country</th>
<th>Logo</th>
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<tr>
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<td>Italy</td>
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<td>INOSENS (INS)</td>
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<td>European Association of Remote Sensing Companies (EARSC)</td>
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<td>EURISY</td>
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<td>University of UAE (UUAE)*</td>
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<td>Saudi Arabia</td>
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<td>World Radiation Center (PMOD/WRC)*</td>
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<td>National Authority for Remote Sensing &amp; Space Sciences (NARSS) (subcontractor to CEDARE)**</td>
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<td>Royal Centre for Remote Sensing (CRTS) (subcontractor “in-kind” to EURISY)**</td>
<td>Morocco</td>
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</tbody>
</table>
At the regional level ...
Thank you for your attention!

For more information

http://www.beyond-eocenter.eu