BEYOND Center of Excellence: Geophysical activity ‘seen’ from Space

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Our tools for monitoring geophysical activity in BEYOND
  ➢ Earth Observation
  ➢ Ground based infrastructure

Service #1: Estimation of diachronic ground motion

Service #2: Estimation of earthquake crustal deformation

Service #3: Early warning system for volcanic ash

Service #4: UAV-based damage assessment

Example studies:
  ➢ Ground motion in wider Athens
  ➢ Santorini volcanic unrest in 2011
  ➢ Cephalonia earthquake sequence in 2014
Geophysical hazards in BEYOND

Centre of Excellence for EO-based monitoring of Natural Disasters

- Fires & Floods
- Urban heat waves
- Geophysical hazards
- Atmospheric & Weather related disasters
Objective

- Focal point for regional geophysical observational networks
  - Integrated approach, interdisciplinary research

![Diagram with nodes: Interferometry, Monitoring geophysical hazards, NOANET, ENIGMA, Hellenic Seismic Network]
Diachronic mapping of ground motion in Attica

- ERS-1,2 & Envisat data
- Permanent scatterers even in non-urban areas
- Large field of view
- High Permanent Scatterer density, increased spatial sampling of the deformation signal

Time-series for monitoring slowly evolving phenomena
Diachronic mapping of ground motion in Attica

- Kifissia was subsidising in 1992-1999 and has been uplifting since 2002

- Deformation observed is attributed to water extraction activities that ceased in 1996. Since then Kifissia is in a physical restoration phase
Time-series for monitoring rapidly evolving phenomena

The Santorini inflation episode

- ASAR Envisat data
- Uplift with a radially decaying pattern in amplitude and velocity from the center of deformation
- 150 mm/yr maximum deformation

Papoutsis et al., Geophysical research letters, 2013
Time-series for monitoring rapidly evolving phenomena

The Santorini inflation episode

Time-series monitoring with in-situ GPS stations

GPS data processing by Dionysos Satellite Observatory
Modeling dispersion of volcanic ash

Dispersion of particles from volcanic eruptions has significant implications for:

- Health
- Aviation Safety
- Weather and climate

RAMS simulation of volcanic ash dispersion from Eyjafjallajökull - Iceland, 14-20 April 2010

Solomos et al., (Air Quality conf. Athens 2012)
Modeling dispersion of volcanic ash

Dispersion of volcanic ash is controlled by:

1. Particle size distribution
2. Injection height
3. Weather pattern

• Mapping of active volcanoes and their potential for ash cloud emissions for the development of an early warning system
• The system is based on WRF / FLEXPART simulations
Modeling dispersion of volcanic ash

- Preliminary results from the early warning system developed in the framework of BEYOND
- The specific hypothesis assumes 60 hours of continuous emissions at 1.5 km height column
- More work is underway for the identification of Santorini potential emission characteristics
Cephalonia earthquakes

3D crustal deformation from TerraSAR-X & COSMO-SkyMed data

Accepted for publication at Seismological Research Letters

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Mapping earthquake damages

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Mapping earthquake damages
Mapping earthquake damages

UAV Flight Paths
Mapping earthquake damages

Cephalonia Island – Town of Lixouri

Damage Type
- 1 Building Roofs
- 2 Collapsed Walls
- 3 Ground Level

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Mapping earthquake damages

Cephalonia Island – Village of Mantzavinata

Damage Type
1. Building Roofs
2. Collapsed Walls
3. Ground Level
Conclusions & remarks

BEYOND Center of Excellence is a key player for monitoring regional geophysical activity and hazard mapping

- Integrated services using space-, air- and ground- based instrumentation

- Four (4) ongoing research projects (ESA, DLR, ASI, CSA) granting access to diverse SAR data: TerraSAR-X, COSMO-SkyMED, RADARSAT-2, ERS-1,2, Envisat, ALOS

- NOA has become an ESA mirror site for the collection, management, distribution and processing of Sentinel data
Questions?

Thank you!

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Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation in Attica

The interferometric stacks processed

<table>
<thead>
<tr>
<th>Stack</th>
<th>Time interval</th>
<th>Satellite track</th>
<th>Satellite</th>
<th>Mode</th>
<th>Total scenes</th>
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</tbody>
</table>

Two descending and one ascending tracks

Temporal coverage of the six stacks

Temporal coverage of the different SAR tracks for the Athens metropolitan area
Time-series for monitoring slowly evolving phenomena

**Diachronic mapping of crustal deformation in Attica**

- Formed more 500 interferograms for PSInSAR and SBAS
- Each stack was analysed in patches (more than 5 million pixels per patch)
- Processed more than 700 patches independently => ~ 4 TB of data
Diachronic mapping of crustal deformation in Attica

Deformation histories show the non-linear motion in Kifissia

2002-2010

Time-series for monitoring slowly evolving phenomena
Background information on Santorini

- Santorini Volcanic Complex is the most active part of the South Aegean (Hellenic) Volcanic Arc.

- Several eruptions led to the present form of the Kameni islands (197 BC, 46 AD, 726, 1570, 1707, 1866, 1925, 1939, 1950)

- Most recent seismic sequence ended in 1950

- Since then, Santorini volcano has been in a ‘quite’ phase, with insignificant deformation (confirmed by GPS and InSAR)
The end of the episode

InSAR
Keep on monitoring Santorini

- Ongoing work with COSMO-SkyMed SAR data
Modeling dispersion of volcanic ash

Examples of recorded aviation incidents related to volcanic ash

KLM Flight 867, 15 December 1989

British Airways Boeing 747-200, 24 June 1982