Monitoring geophysical activity from Space, in the framework of BEYOND Center of Excellence

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GEO European Projects’ Workshop
12/6/2014
Athens, Greece

FP7-Regpot-2012-23-1
Outline

❖ What is the BEYOND Center of Excellence

❖ Our tools for monitoring geophysical activity
  ➢ 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
BEYOND concept

BEYOND (2.3 M€, 2013-2016) aims to maintain and expand the existing state-of-the-art interdisciplinary research potential, by

Building a Centre of Excellence for Earth Observation based monitoring of Natural Disasters

in south-eastern Europe, with a prospect to increase its access range to the wider Mediterranean region through the integrated cooperation with twinning organizations.

Beneficiary is the National Observatory of Athens and Dr. Haris Kontoes is the coordinator
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

- Compliance with GEOSS Strategic Target for Disasters
  - Support the implementation of the Hyogo Framework for Action 2005-2015
Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation 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 crustal deformation 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 slowly evolving phenomena

The Santorini inflation episode

Time-series monitoring with in-situ GPS stations

GPS data processing by Dionysos Satellite Observatory
Keep on monitoring Santorini

- 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
  - Ongoing work with COSMO-SkyMed SAR data
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
Mapping earthquake damages

UAV Flight Preparation

GEO Workshop
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

GEO Workshop
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 exploitation of space-, air- and ground- based instrumentation
- Development of tools and services to be ingested by GCI
- Impact: the reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and countries
- Strong links with the regional user community
- NOA has become an ESA mirror site for the collection, management, distribution and processing of Sentinel data
Thank you for your attention!

Questions?
Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation in Attica

The interferometric stacks processed

<table>
<thead>
<tr>
<th>Stack</th>
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<th>Satellite track</th>
<th>Satellite</th>
<th>Mode</th>
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</tbody>
</table>

Two descending and one ascending tracks

Temporal coverage of the six stacks
Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation in Attica

- Formed more than 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
Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation in Attica

Deformation histories show the non-linear motion in Kifissia

2002-2010

Deformation time series for P5 - T465

- Unwrapped phase converted to deformation
- Unwrapped phase minus DEM error and orbital ramps converted to deformation
- Unwrapped phase minus DEM error, orbital ramps and slave atmosphere converted to deformation
- Linear velocity model
- ±Δ/4
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

European Geosciences Union
General Assembly 2013
Examples of recorded aviation incidents related to volcanic ash

KLM Flight 867, 15 December 1989

British Airways Boeing 747-200, 24 June 1982
Cephalonia earthquakes