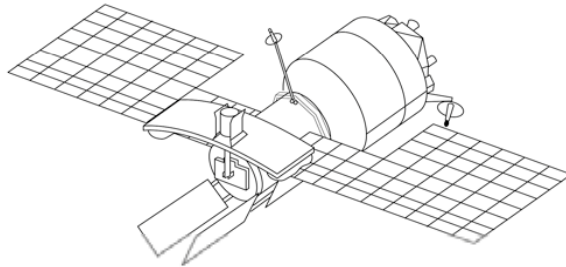




## ***BEYOND Center of Excellence for monitoring geophysical activity and geo-hazard mapping***

I. Papoutsis, C. Kontoes, A. Ganas, V. Karastathis, N. Svigkas, C. Physchogiou, M. Kaskara, A. Barberopoulou, G. Balasis, S. Solomos, V. Amiridis, T. Herekakis, A. Prokos



**National Observatory of Athens**

**Institute for Astronomy Astrophysics Space Applications and Remote Sensing  
&  
Institute of Geodynamics**

2<sup>η</sup> Ημερίδα Τεκτονικής Γεωδαισίας,  
14/5/2014  
ΟΑΣΠ





FP7-Regpot-2012-23-1

# Outline

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- ❖ What is the BEYOND Center of Excellence
- ❖ Our tools for monitoring geophysical activity
  - Earth Observation
  - Ground based infrastructure
- ❖ Study #1: Santorini volcanic unrest in 2011 + 
- ❖ Study #2: Diachronic mapping of ground motion in wider Athens
- ❖ Study #3: Crustal deformation associated with the recent Cephalonia earthquakes + 
- ❖ Conclusions & remarks

## BEYOND concept

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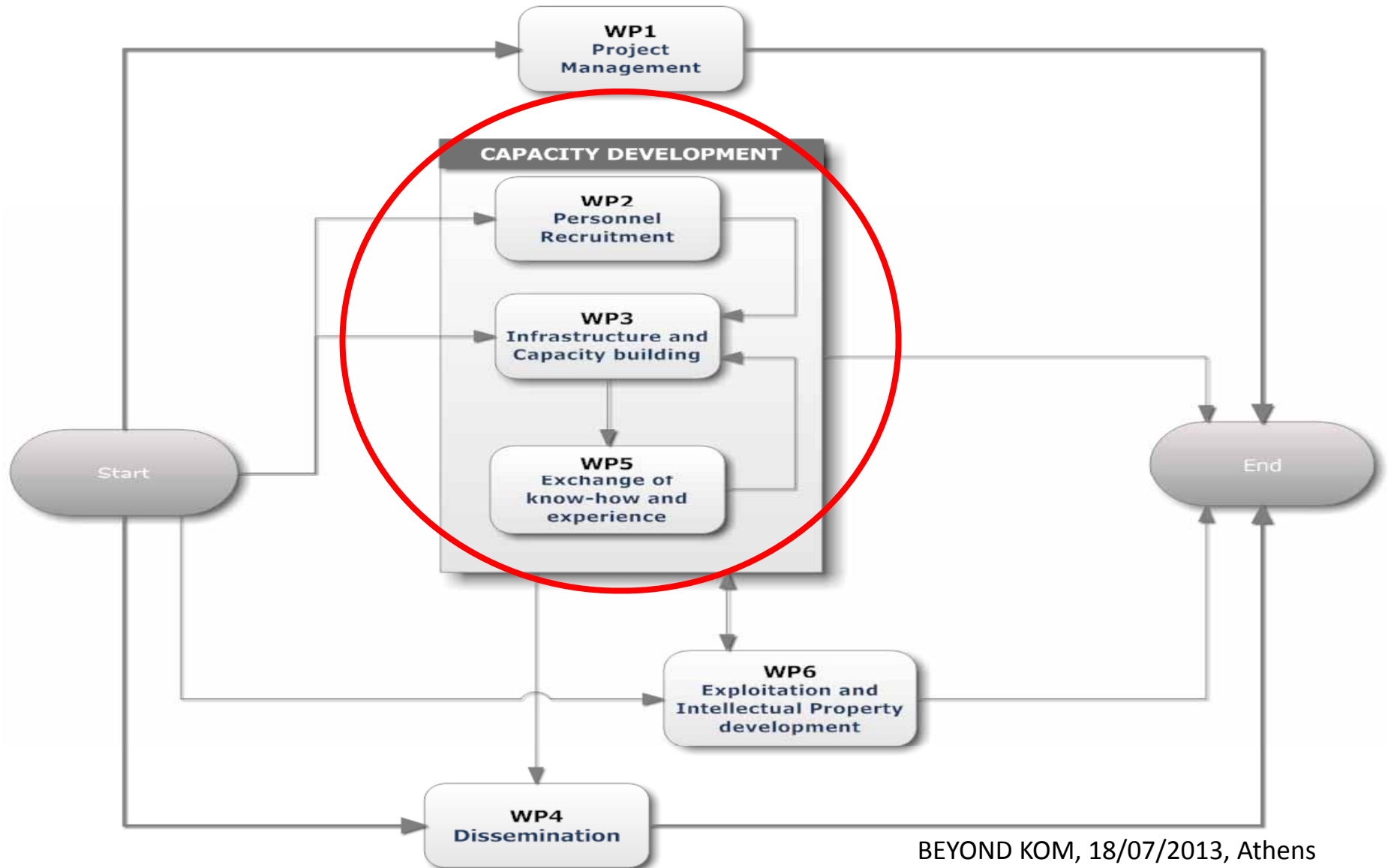
**BEYOND** (2.3 M€, 2013-2016) aims to maintain and expand the existing state-of-the-art interdisciplinary research potential, by

**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 **twining organizations**.

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

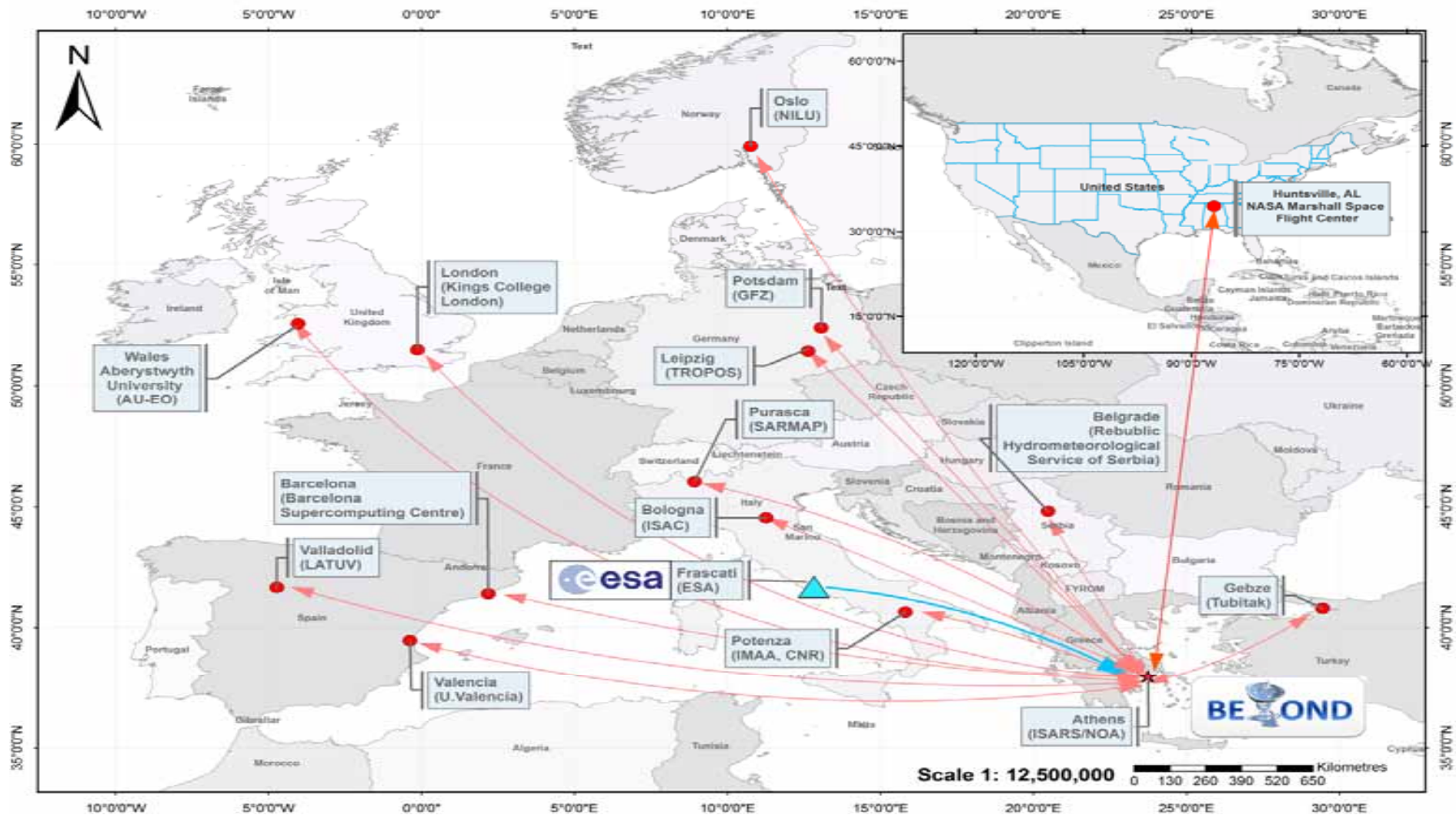
# BEYOND activities



# Know-how exchange



Twinnings with partnering organisations



*Centre of Excellence for  
EO-based monitoring of Natural Disasters*

Fires & Floods

Urban environment

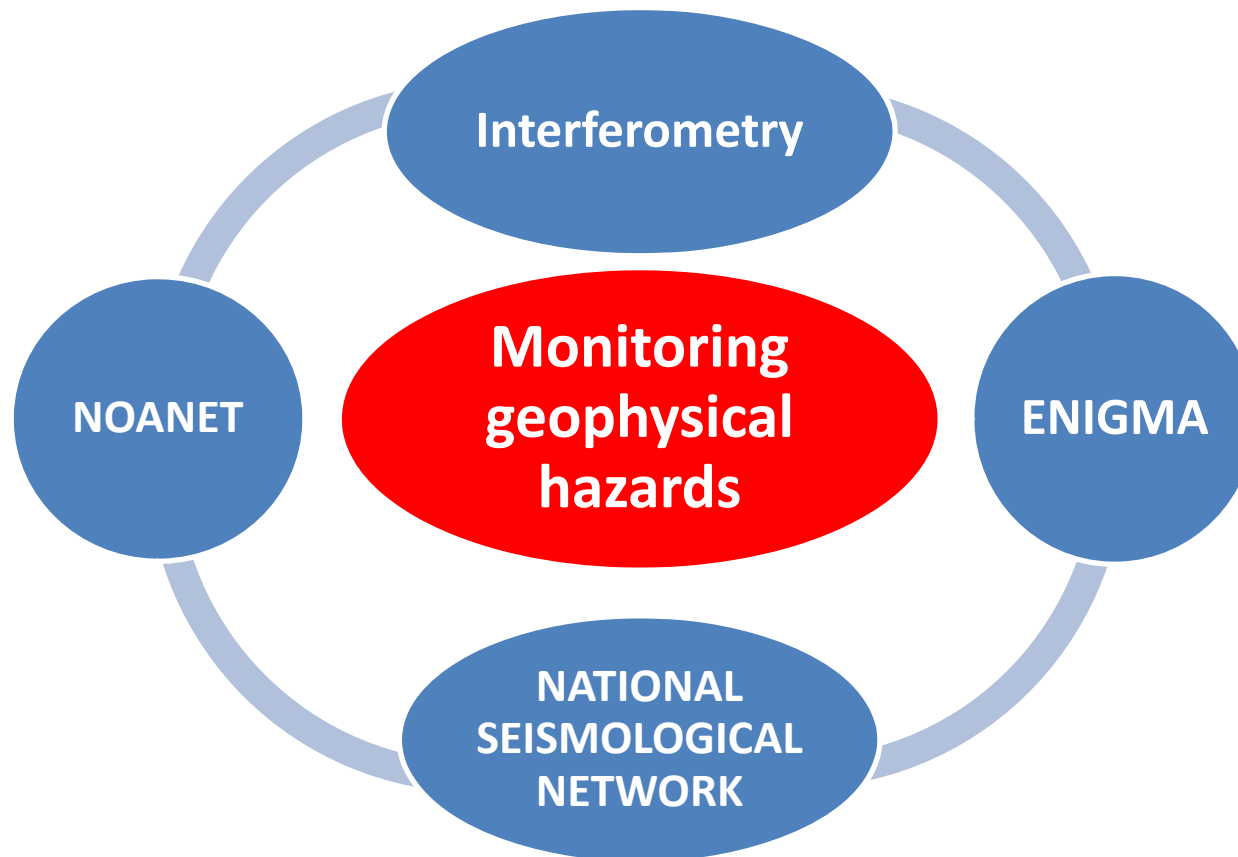
**Geophysical hazards**

Atmospheric & weather related  
disasters

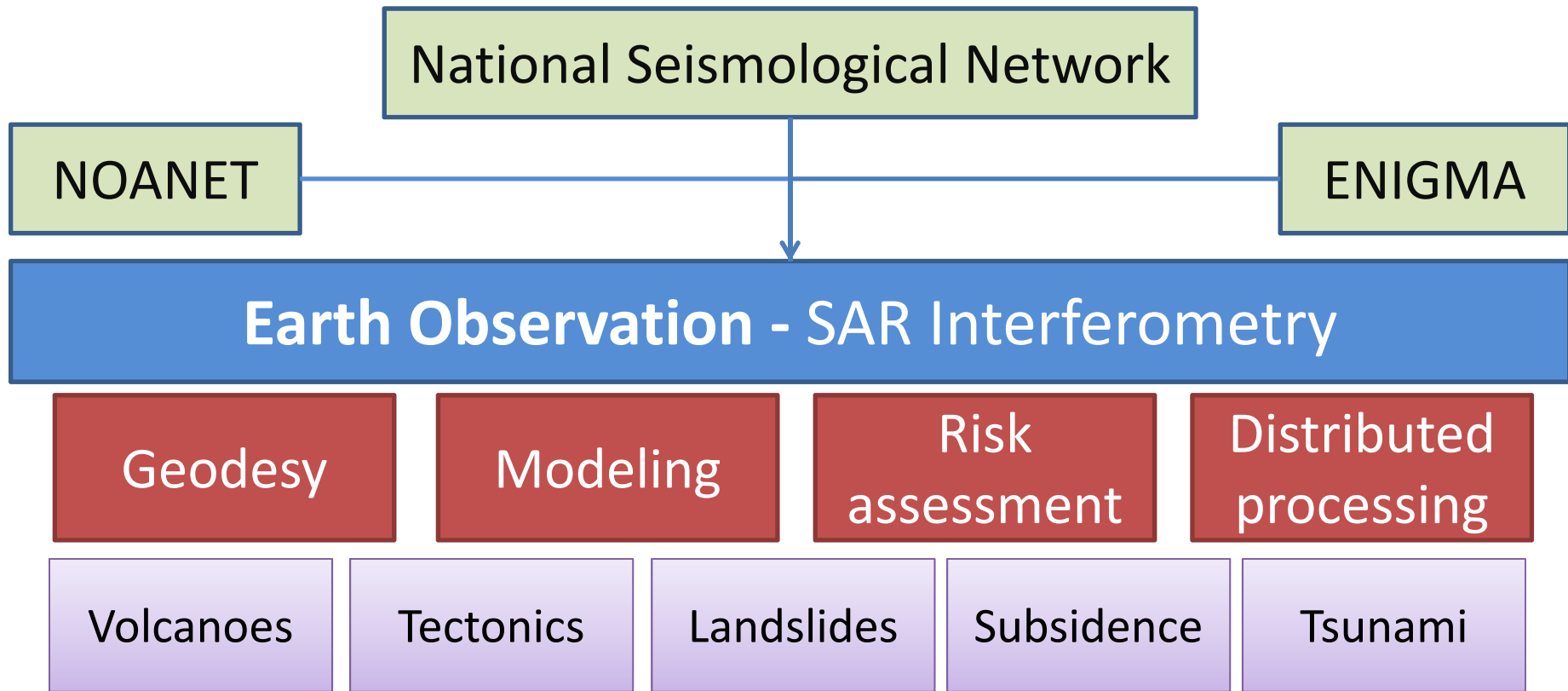
# Objective



- Focal point for regional geophysical observational networks
  - Integrated approach, interdisciplinary research
  - Systematic delivery of products



# Schematic concept



## WEB GIS

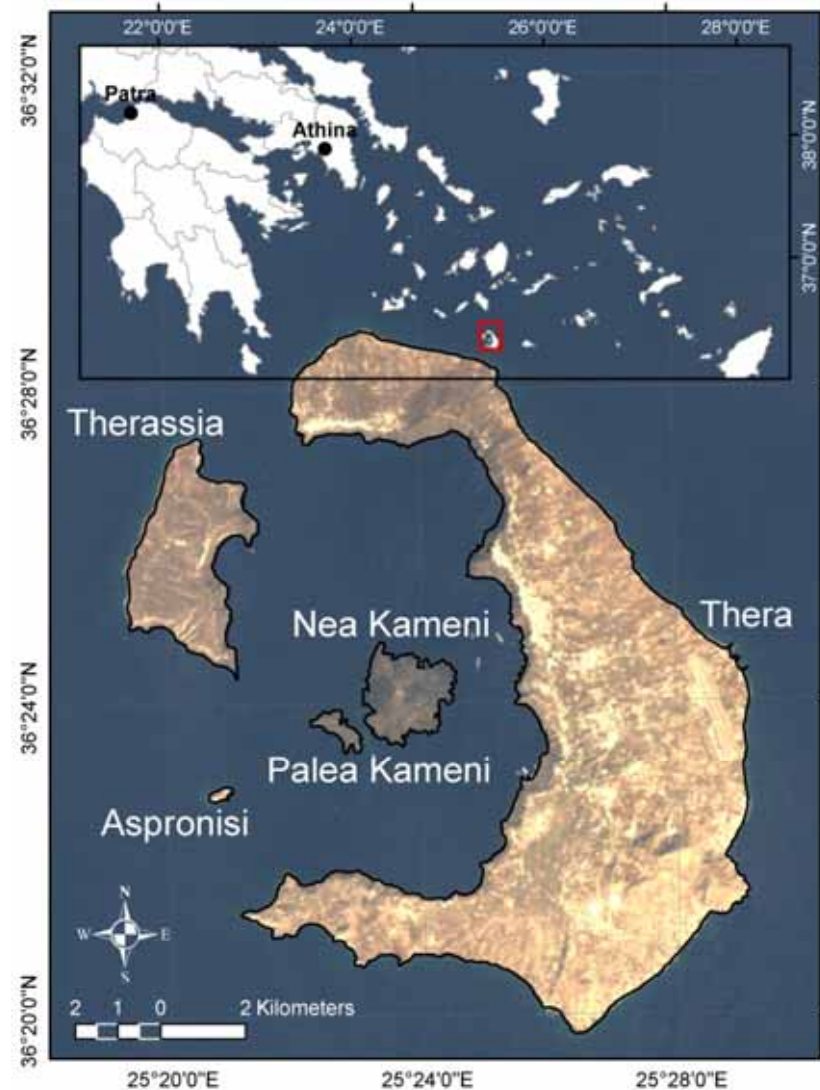




# Background information on Santorini



- 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)

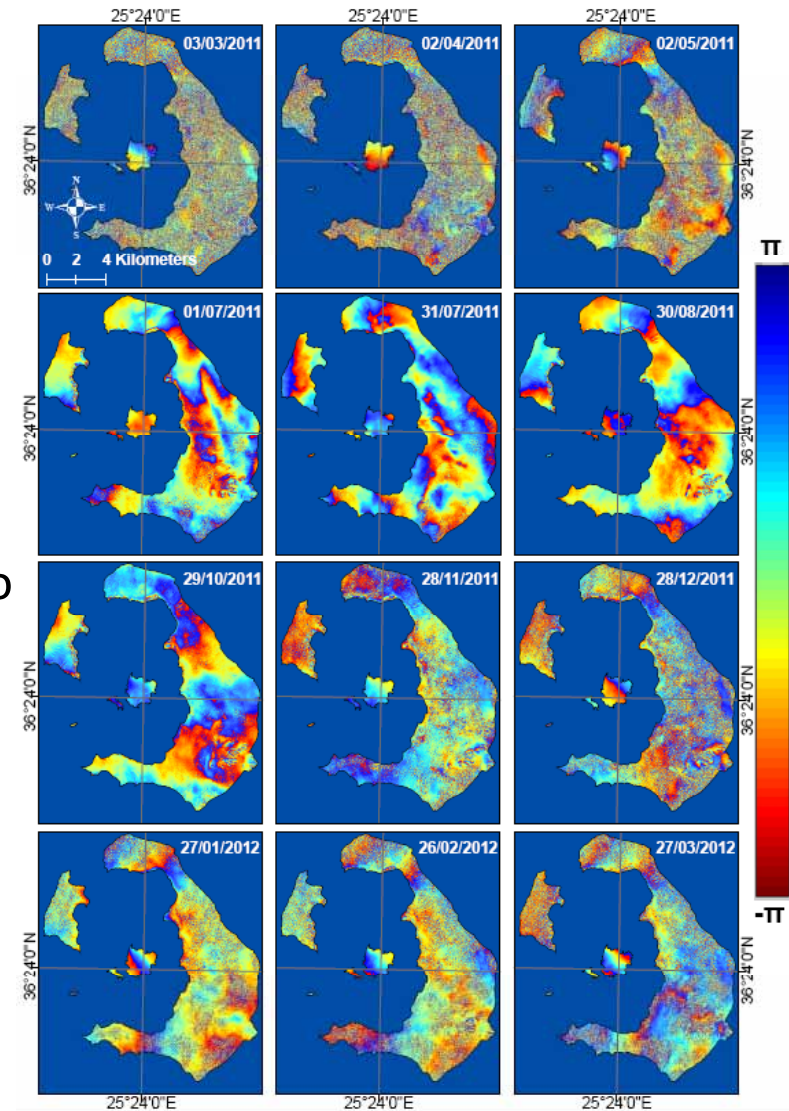


# Time-series for monitoring rapidly evolving phenomena



## The Santorini inflation episode

- ASAR ENVISAT, descending mode
- Last orbit before the end of the mission in April 2012
- Time span: March 2011 – March 2012
- Short spatial & temporal baselines
- Swath I6, leading to increased sensitivity to the E-W horizontal components
- S/W: Gamma, ROI\_PAC, DORIS, StaMPS
- Persistent Scatterer Interferometry techniques (PSInSAR & SBAS)
- Papoutsis et al., Geophysical Research Letters, Jan. 2013

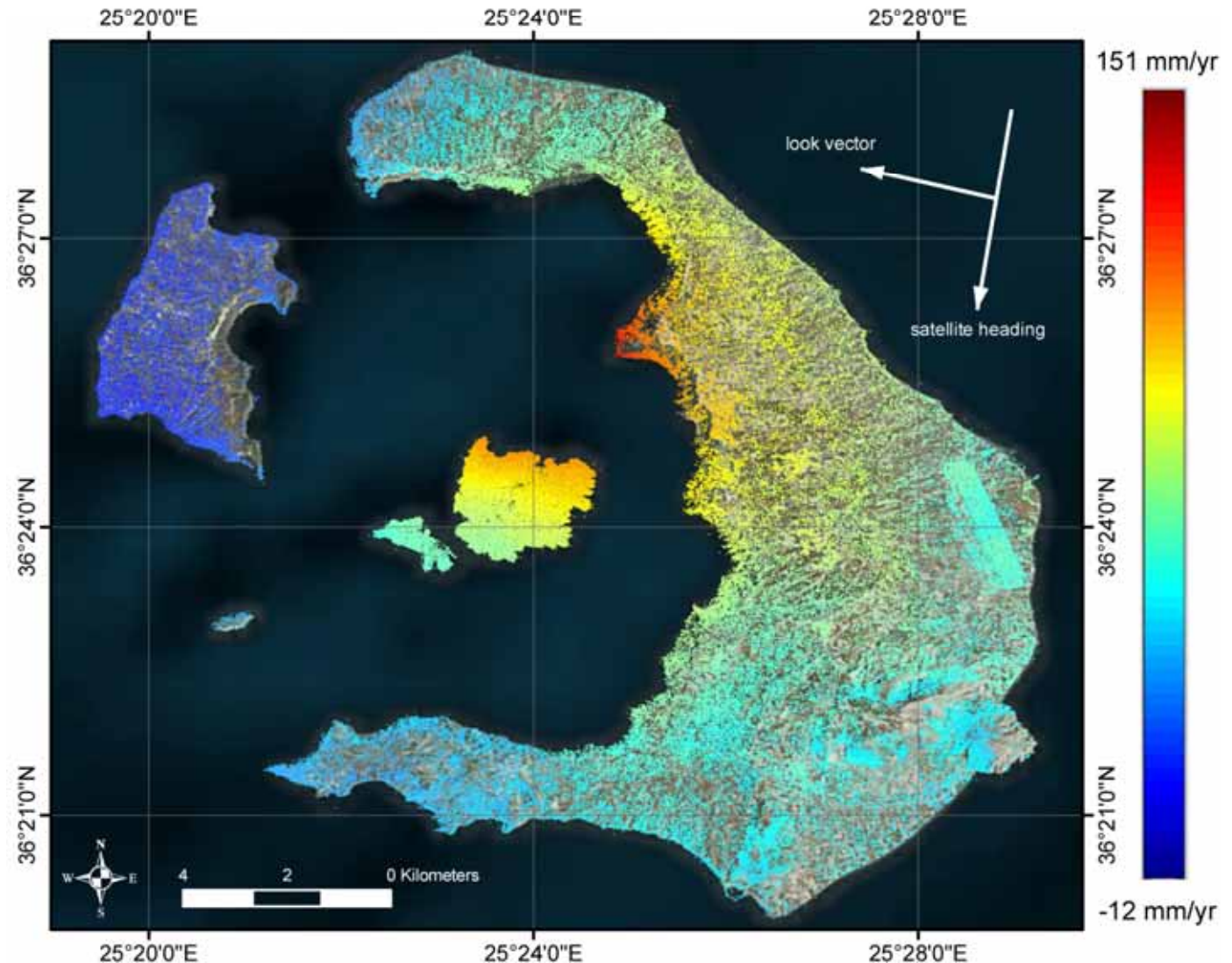


# Time-series for monitoring rapidly evolving phenomena



## The Santorini inflation episode

- Wide coverage and highly accurate velocity maps
- High spatial resolution of the deformation pattern
- Uplift with a radially decaying pattern in amplitude and velocity from the center of deformation
- 150 mm/yr maximum deformation

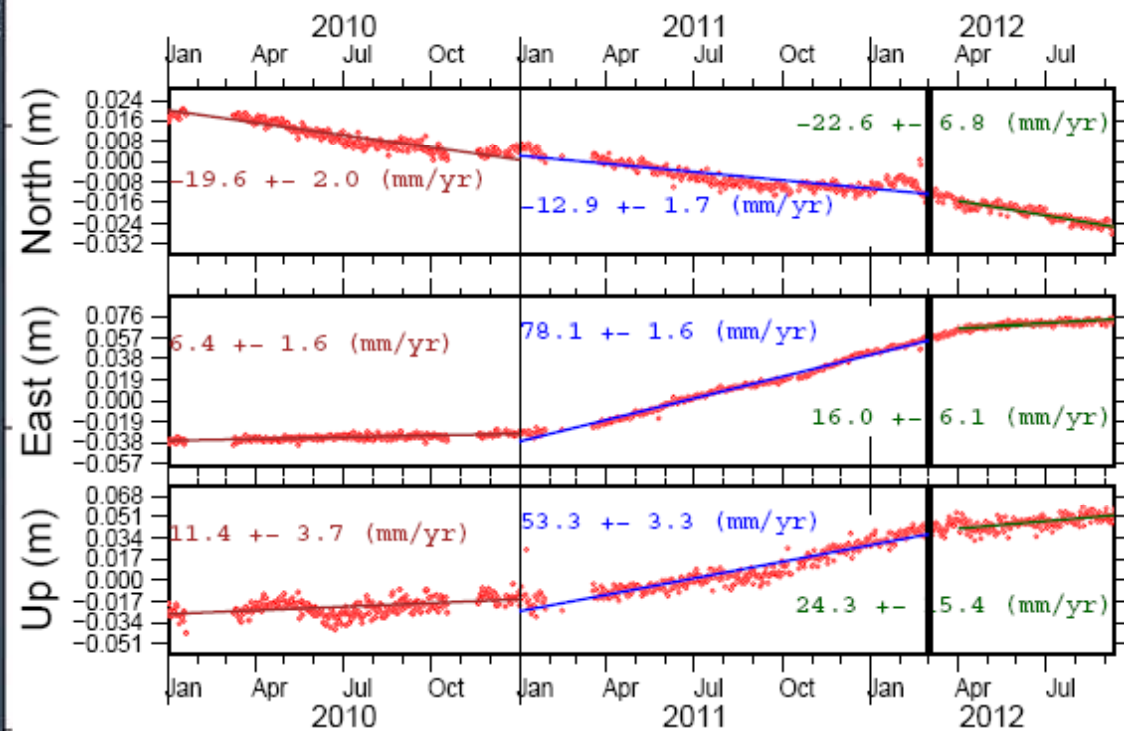
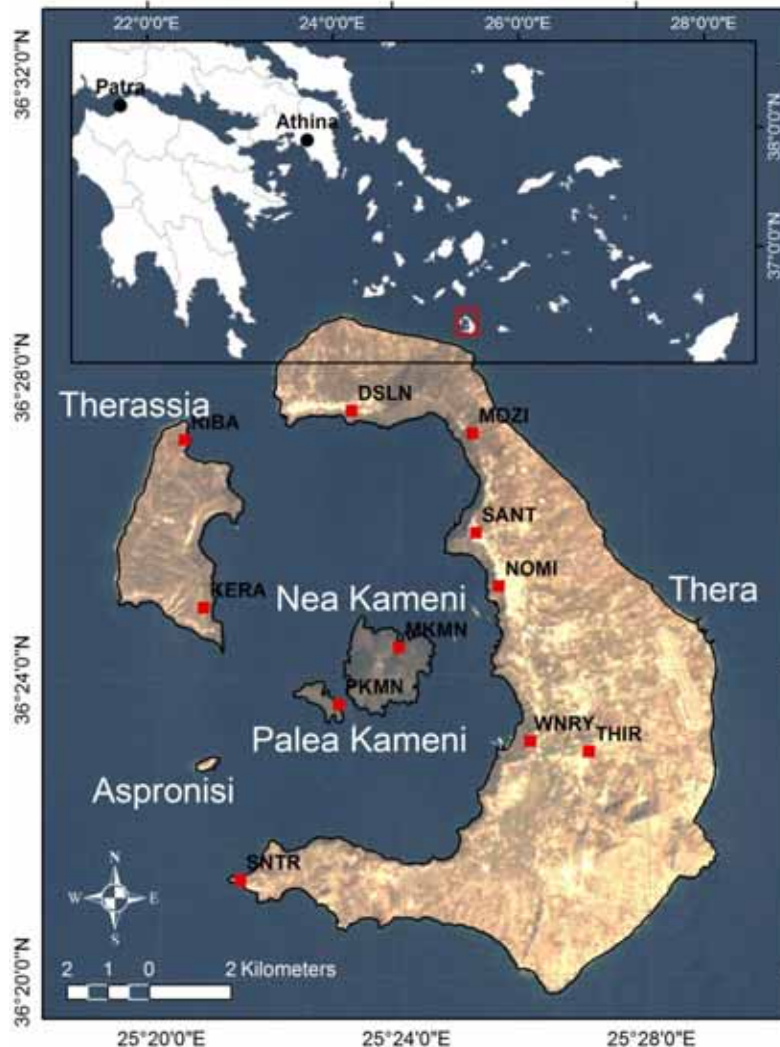


# Time-series for monitoring slowly evolving phenomena



## The Santorini inflation episode

Time-series monitoring with in-situ GPS stations



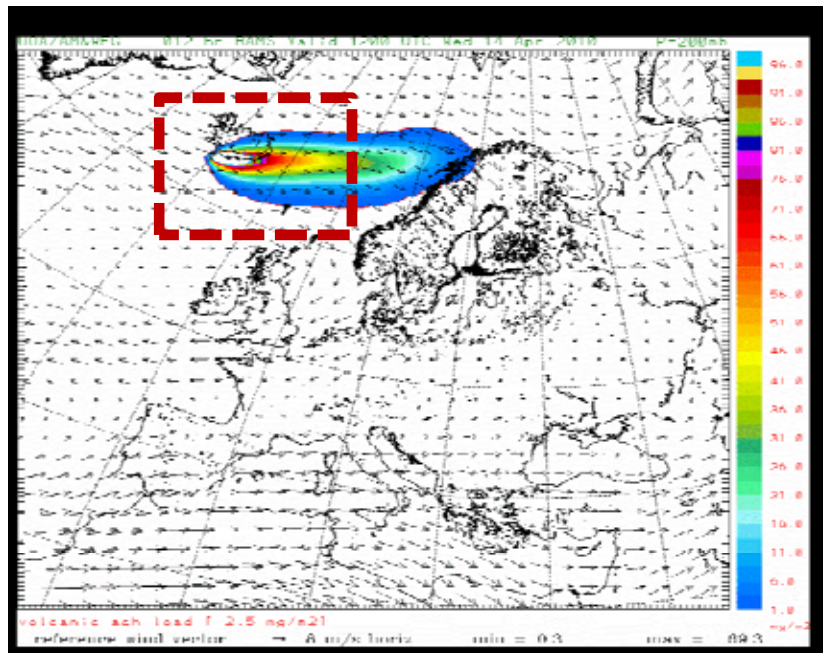
GPS data processing by Dionysos Satellite Observatory

# 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



Satellite image (visible) showing the volcanic ash plume (brown color)

*Solomos et al., (Air Quality conf. Athens 2012)*

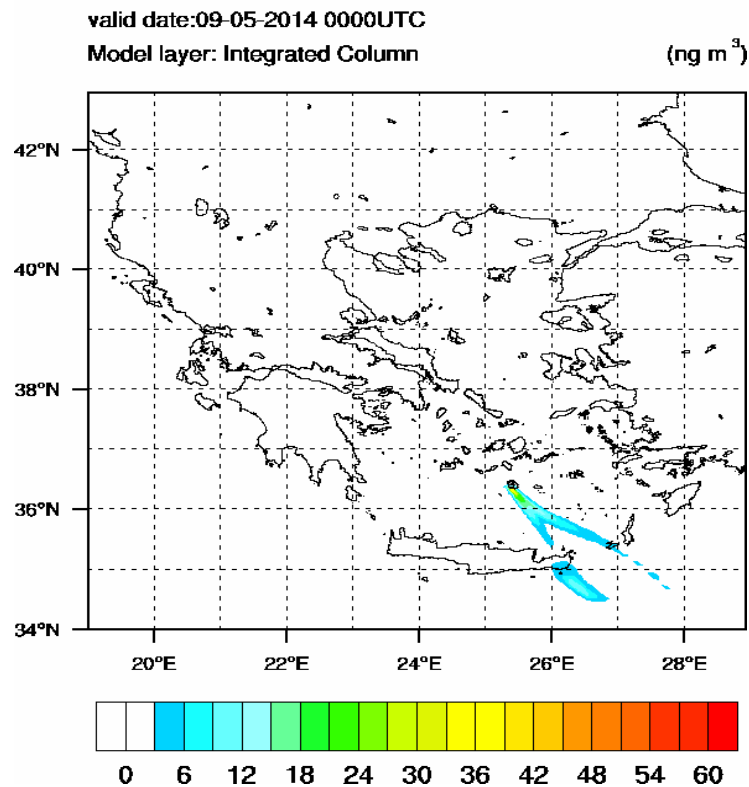
# Modeling dispersion of volcanic ash



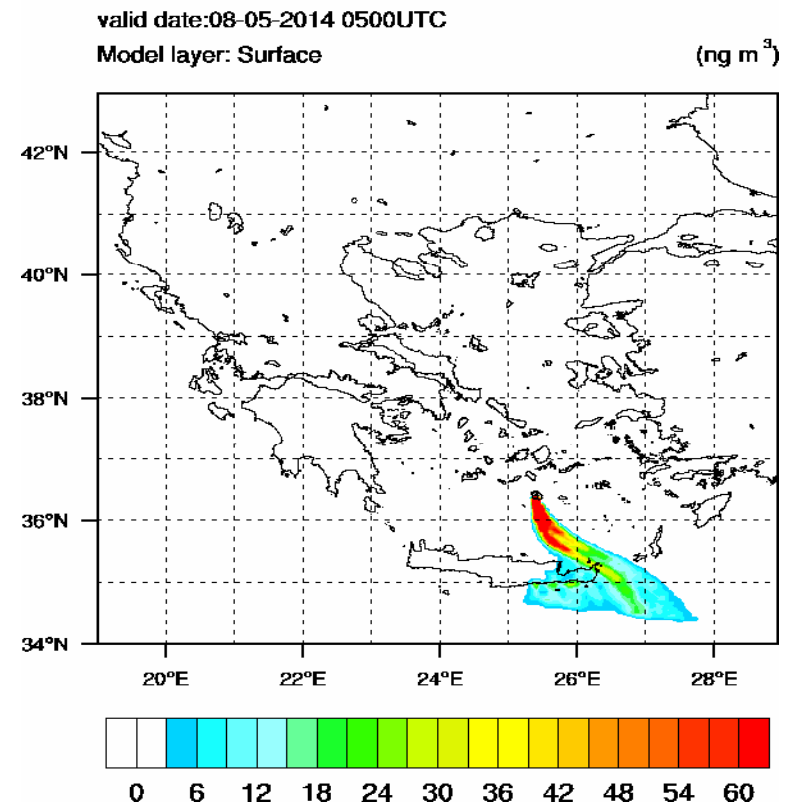
- Preliminary results from the early warning system developed in the framework of BEYOND
- The specific hypothesis assumes 60 hours of continuous emissions at 1.5 km height column
- More work is underway for the identification of Santorini potential emission characteristics



**FLEXPART - NOA**  
Airborne Volcanic Ash



**FLEXPART - NOA**  
Deposited Volcanic Ash



# Time-series for monitoring slowly evolving phenomena



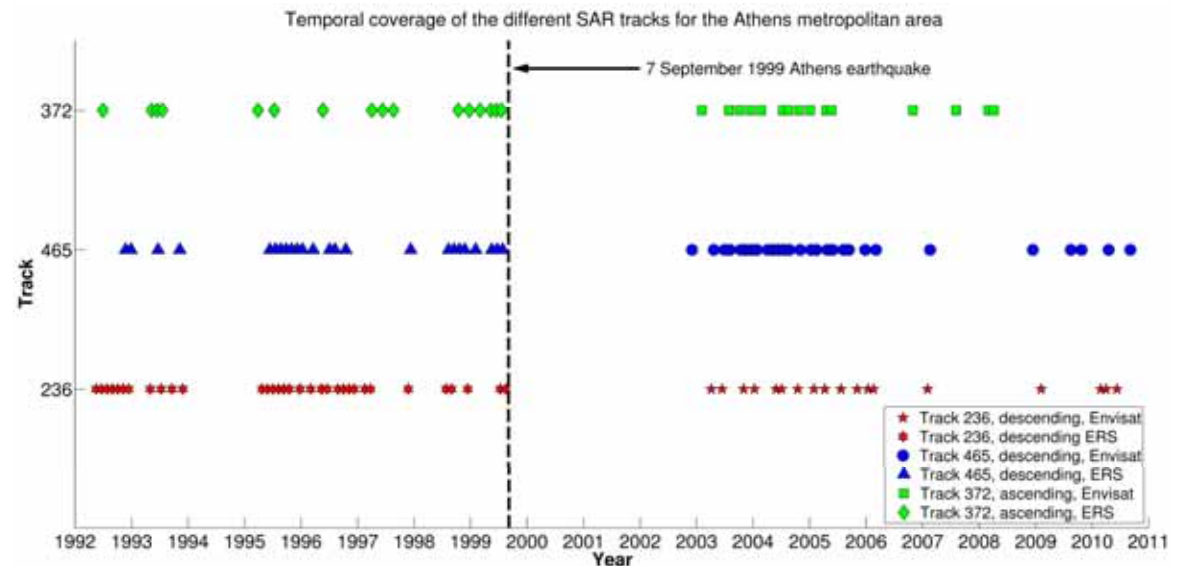
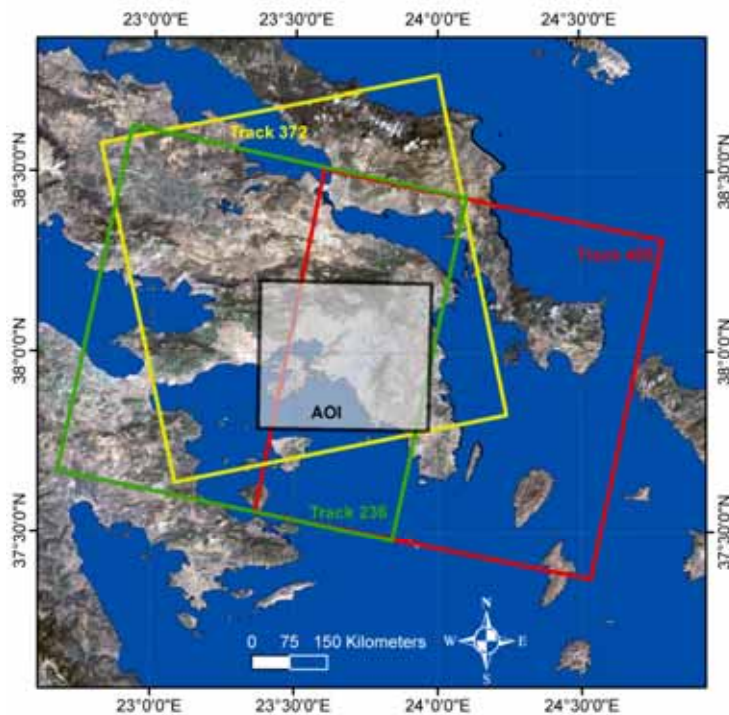
## Diachronic mapping of crustal deformation in Attica

## The interferometric stacks processed

Stack	Time interval	Satellite track	Satellite	Mode	Total scenes
I	1992-1999	236	ERS	Descending	37
II	1992-1999	465	ERS	Descending	30
III	1992-1999	372	ERS	Ascending	18
IV	2003-2010	236	Envisat	Descending	18
V	2002-2010	465	Envisat	Descending	28
VI	2003-2008	372	Envisat	Ascending	15

Two descending and one ascending tracks

## Temporal coverage of the six stacks

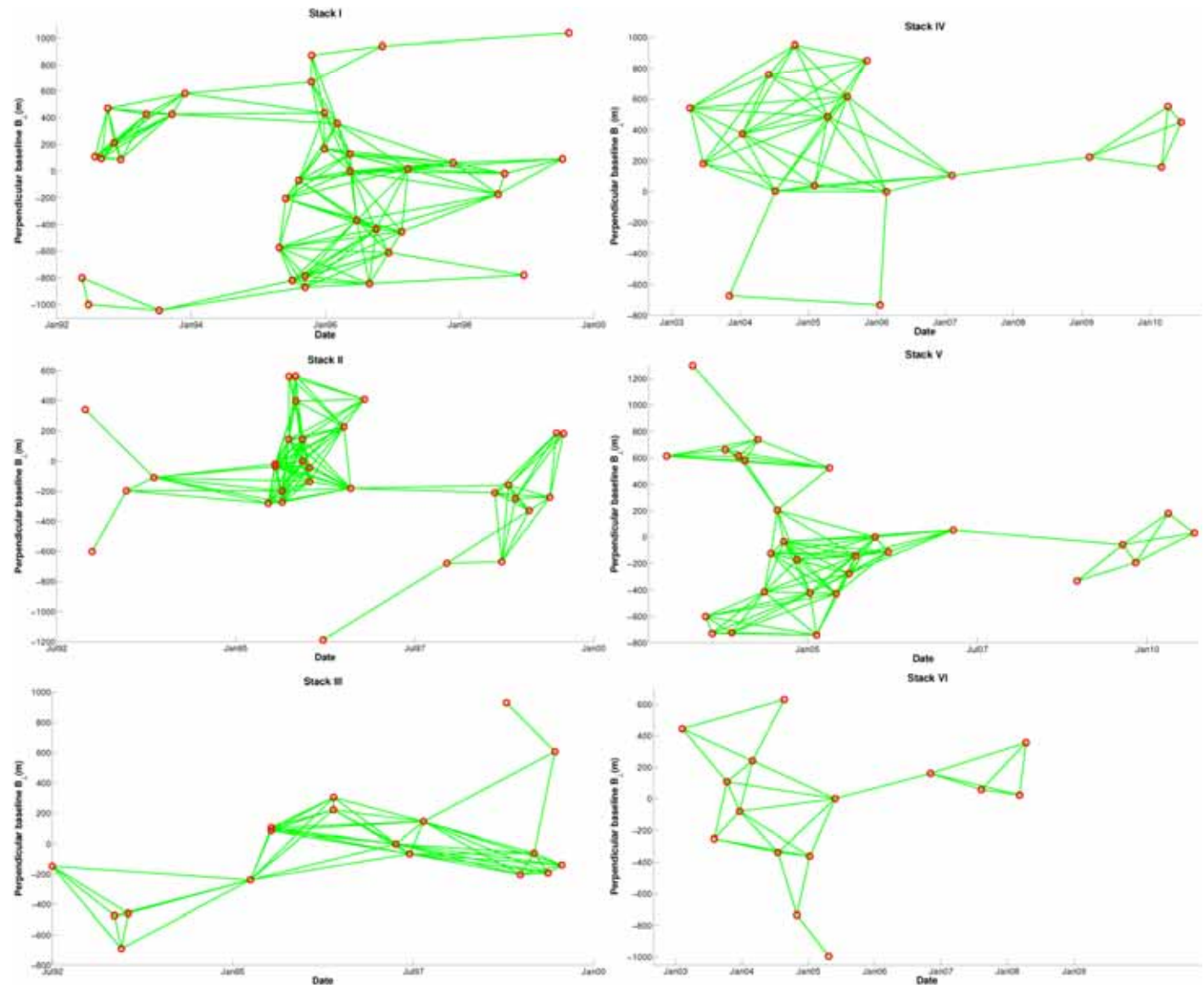


# Time-series for monitoring slowly evolving phenomena



## 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



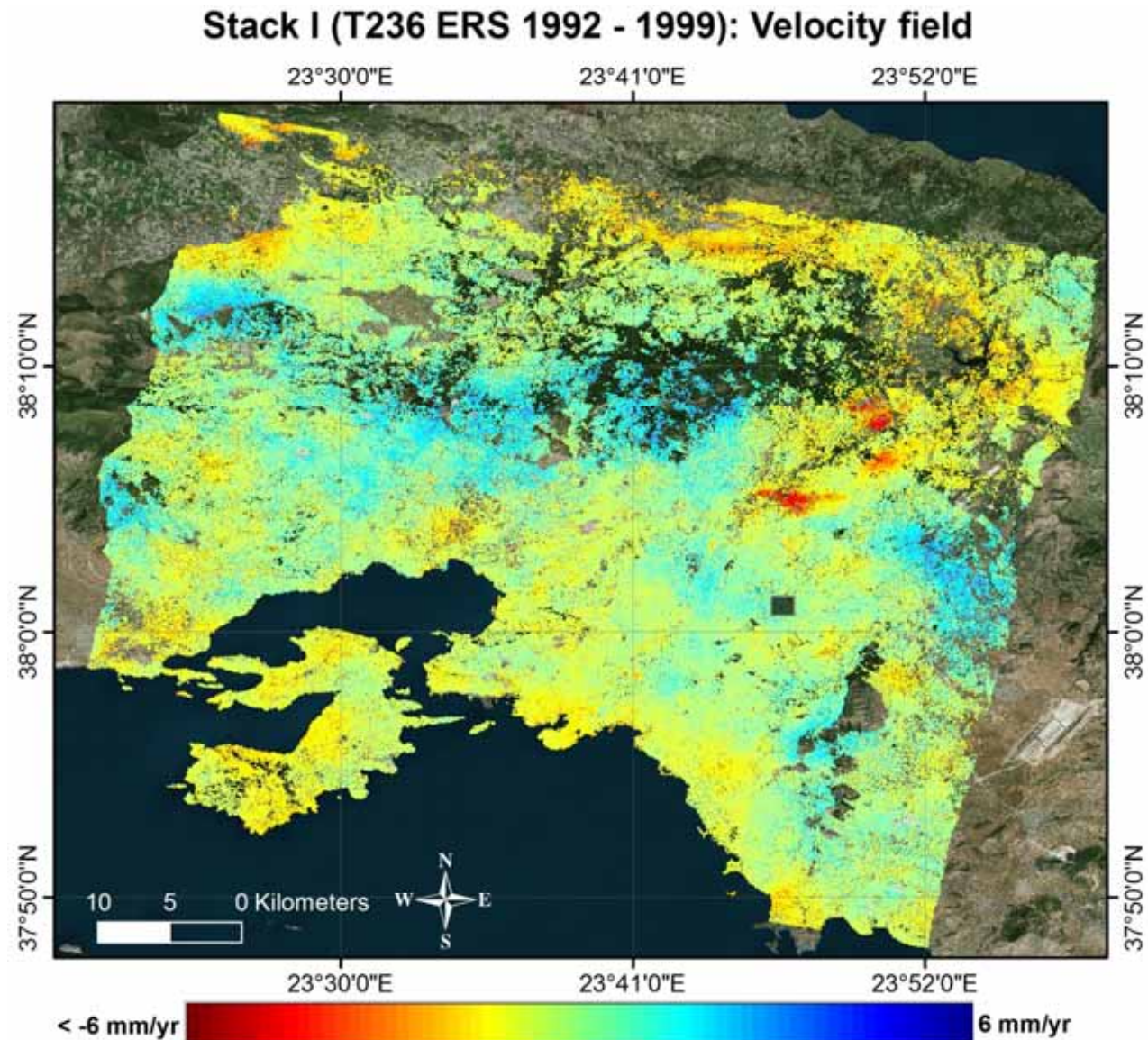


# Time-series for monitoring slowly evolving phenomena



## Diachronic mapping of crustal deformation in Attica

- Identified permanent scatterers even in non-urban area
- Large field of view
- High Permanent Scatterer density, increased spatial sampling of the deformation signal

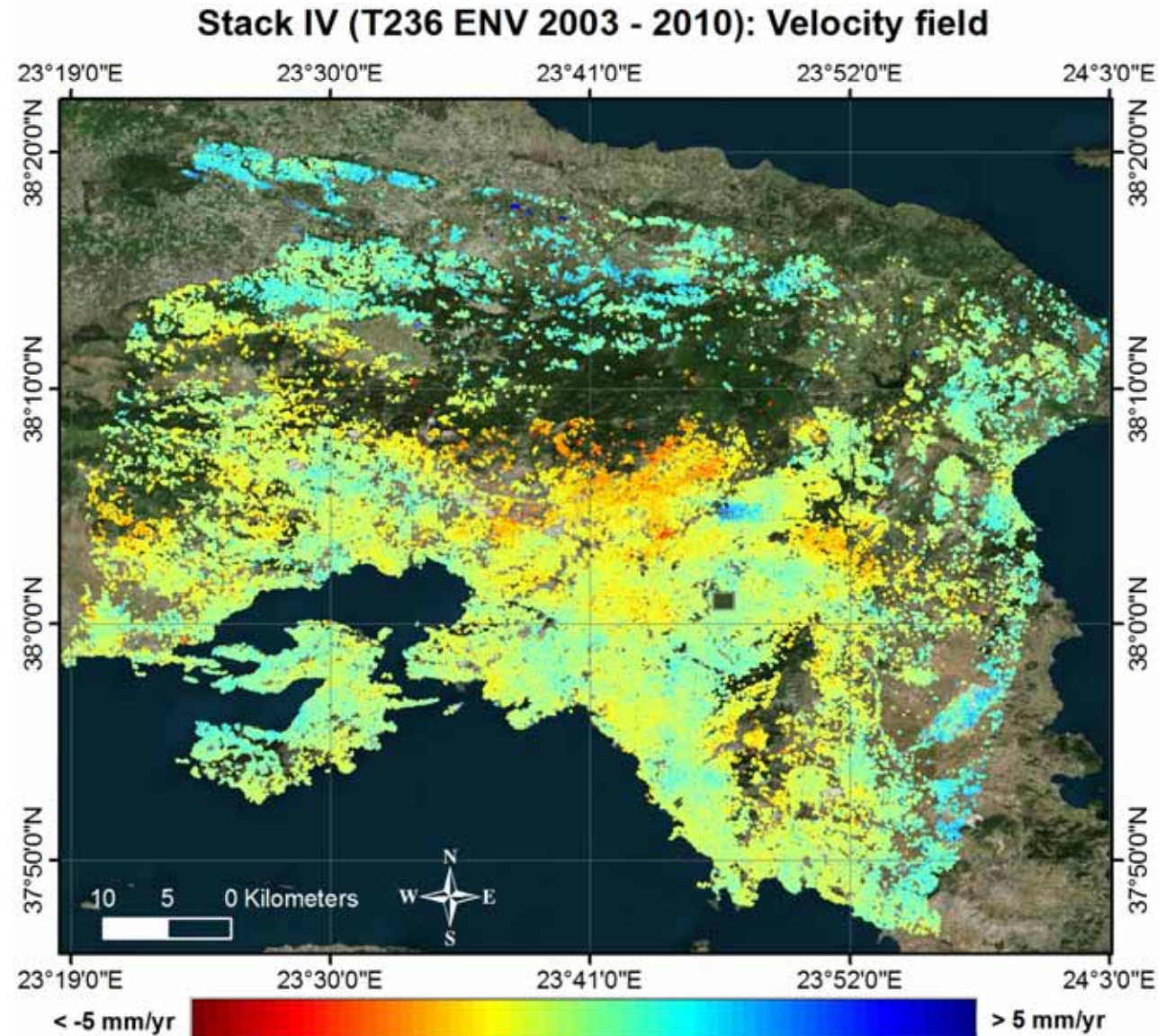


# Time-series for monitoring slowly evolving phenomena



## 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



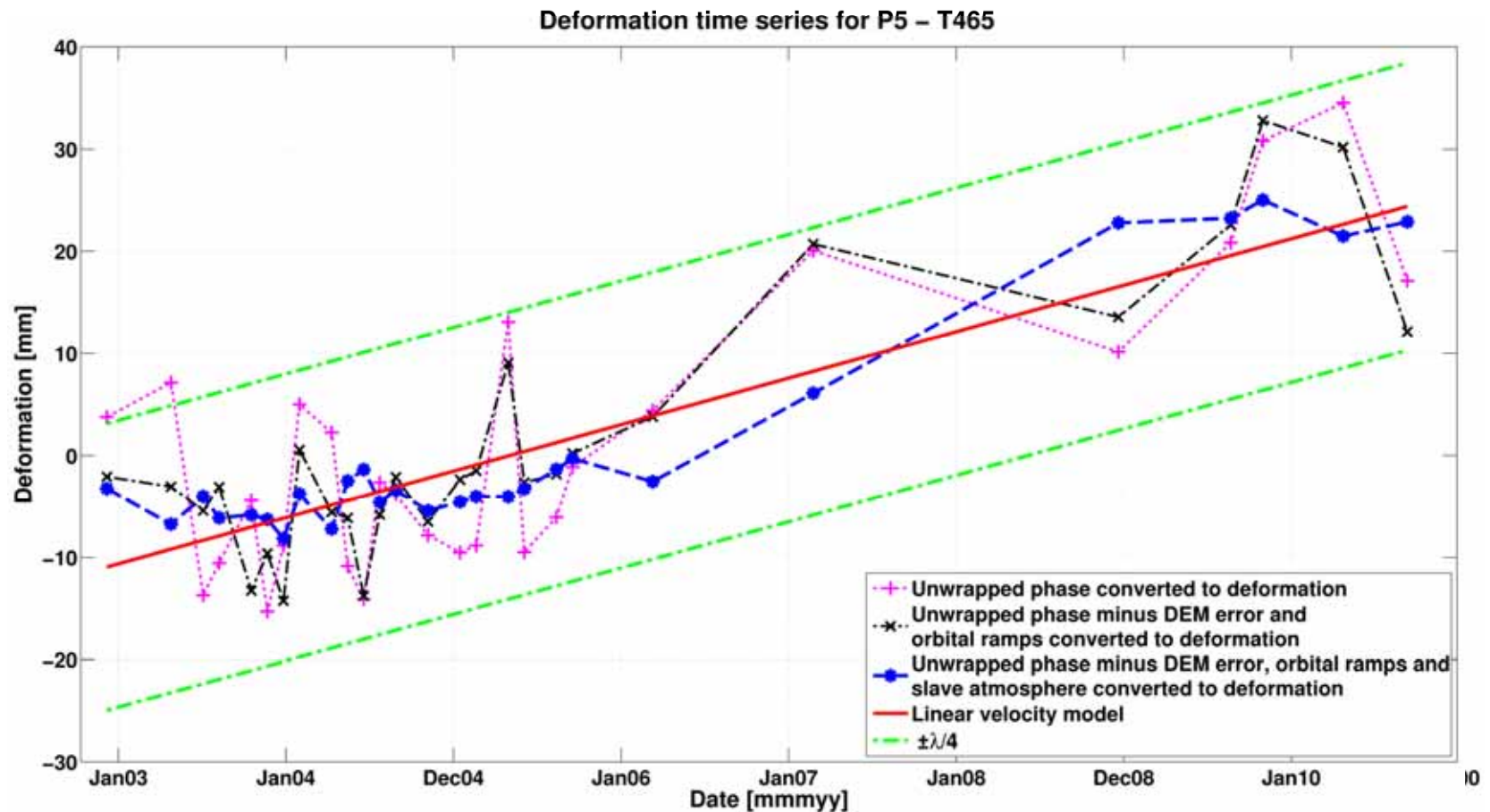
# Time-series for monitoring slowly evolving phenomena



Diachronic mapping  
of crustal  
deformation in Attica

Deformation histories show the non-linear motion in Kifissia

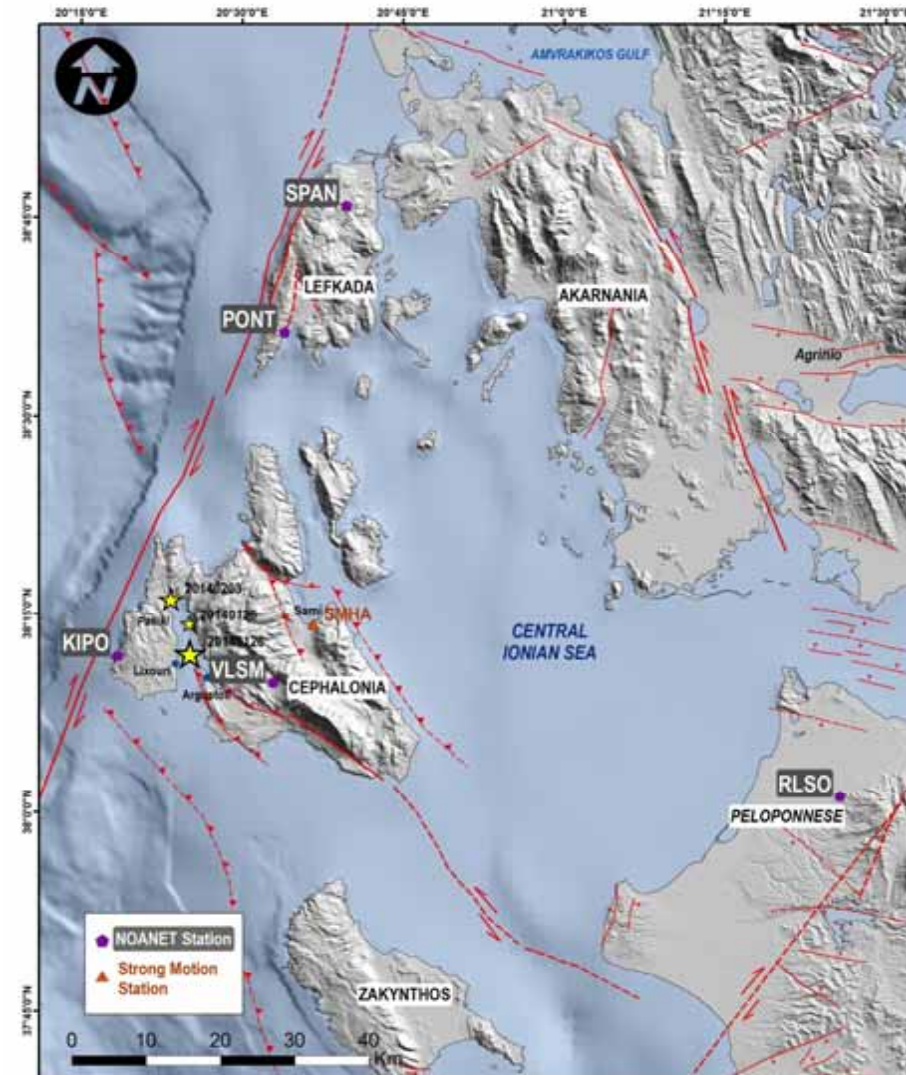
2002-2010



# Cephalonia earthquakes



- Frequent earthquake activity along the right-lateral Cephalonia Transform Fault
- EQ #1: Jan. 26, ML(NOAA) 5.8, EQ #2: Feb. 3, ML(NOAA) 5.7
- Extensive structural damages and environmental effects (liquefaction, road failures, rock falls and small landslides)
- Near-vertical right lateral strike-slip faults
- Co-seismic measurements from GPS stations (Ganas et al., 2014)



# Mapping earthquake damages



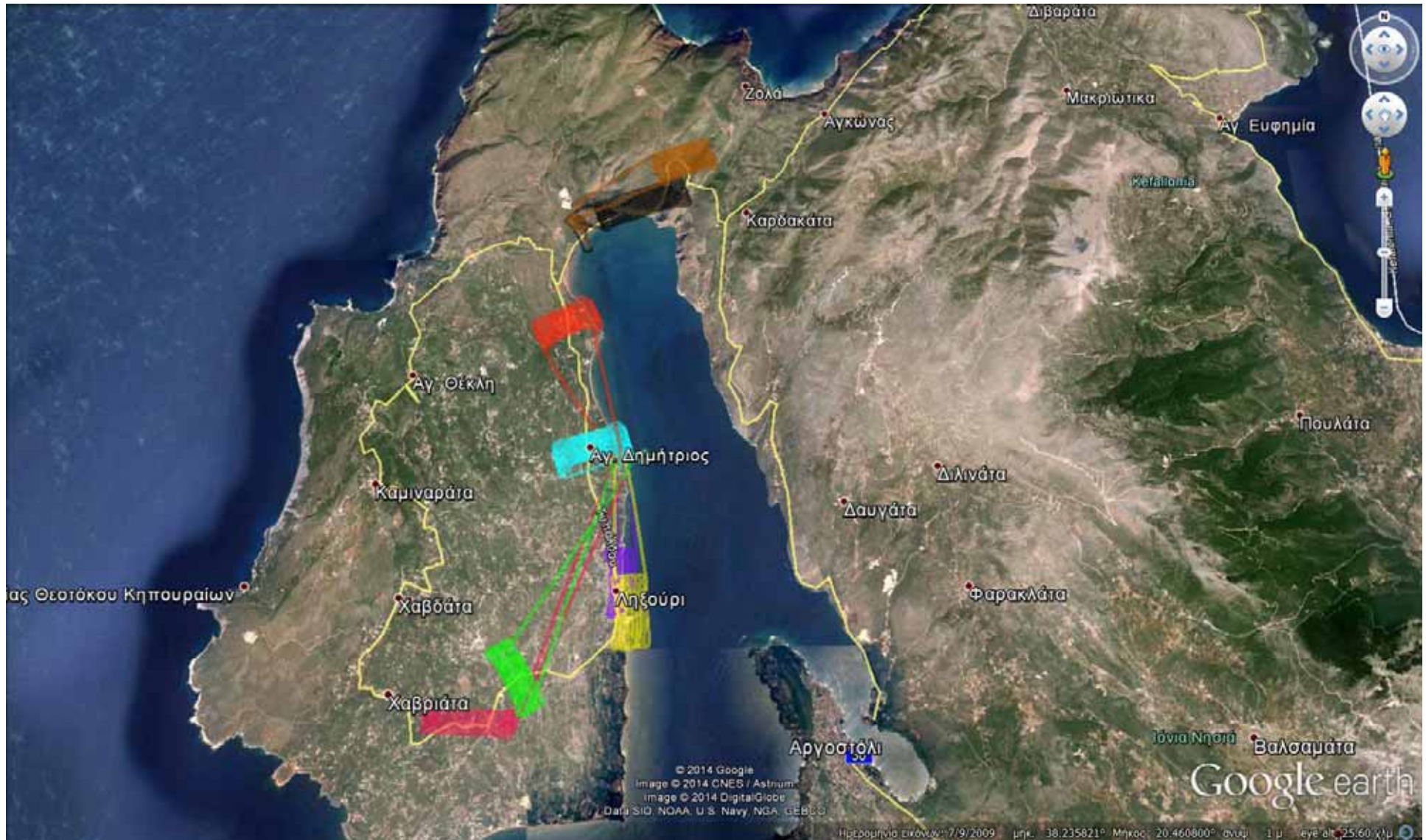
## UAV Flight Preparation



# Mapping earthquake damages



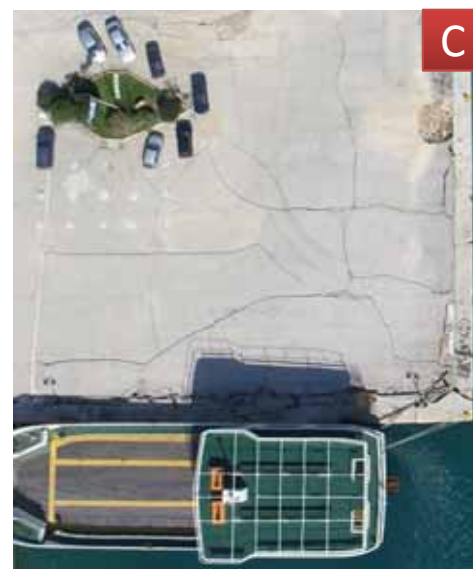
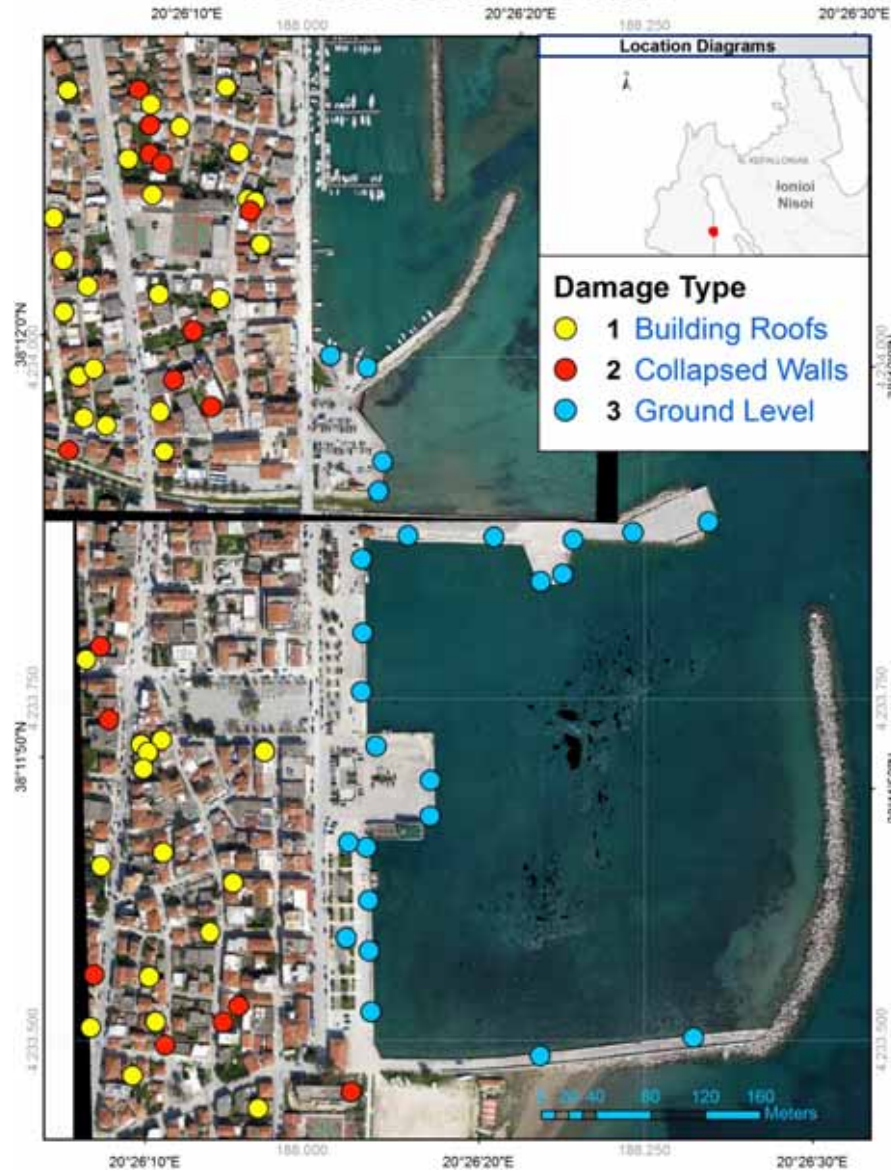
## UAV Flight Paths



# Mapping earthquake damages



## Cephalonia Island – Town of Lixouri



## Conclusions & remarks

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- ❖ 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
- ❖ Access to a huge archive of data:
  - 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!**