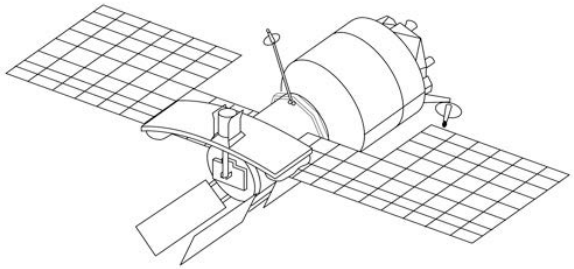
BEYOND Center of Excellence: Geophysical activity ‘seen’ from Space



Ioannis Papoutsis

National Observatory of Athens

Institute for Astronomy, Astrophysics, Space Applications & Remote Sensing

Geomapplica Conference
9 September 2014
Skiathos, Greece

FP7-Regpot-2012-23-1

Outline

- 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

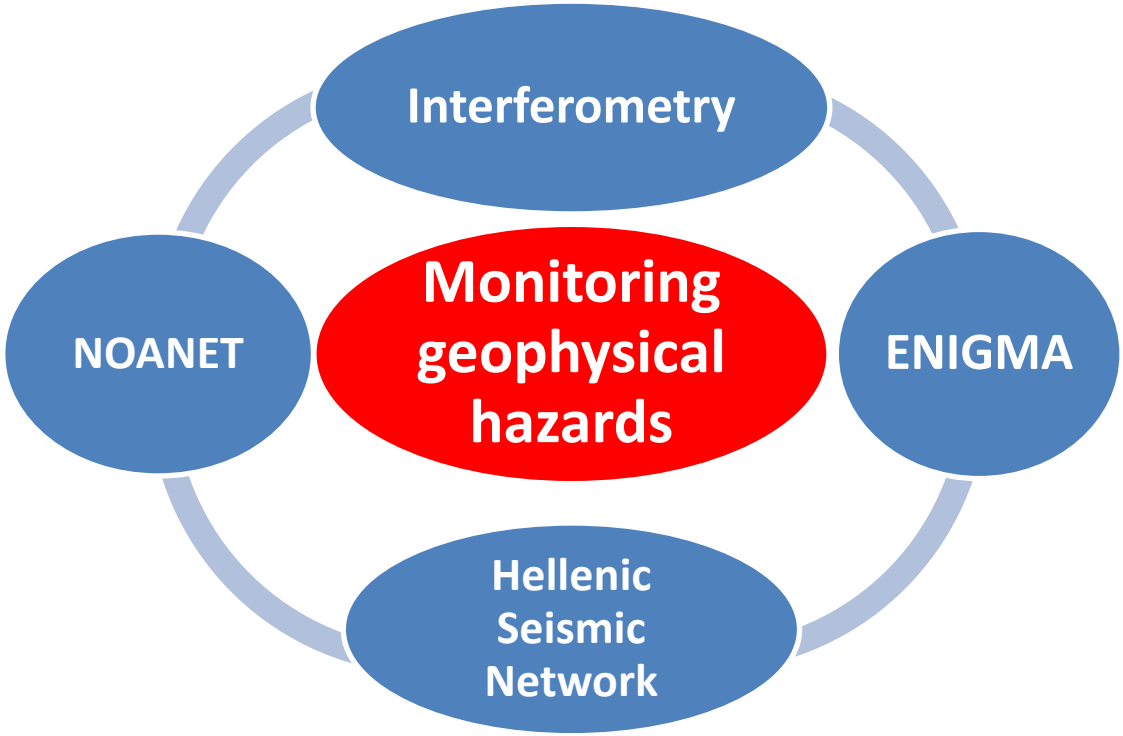
Centre of Excellence for

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



Schematic concept

National Seismological Network

NOANET

ENIGMA

Earth Observation - SAR Interferometry

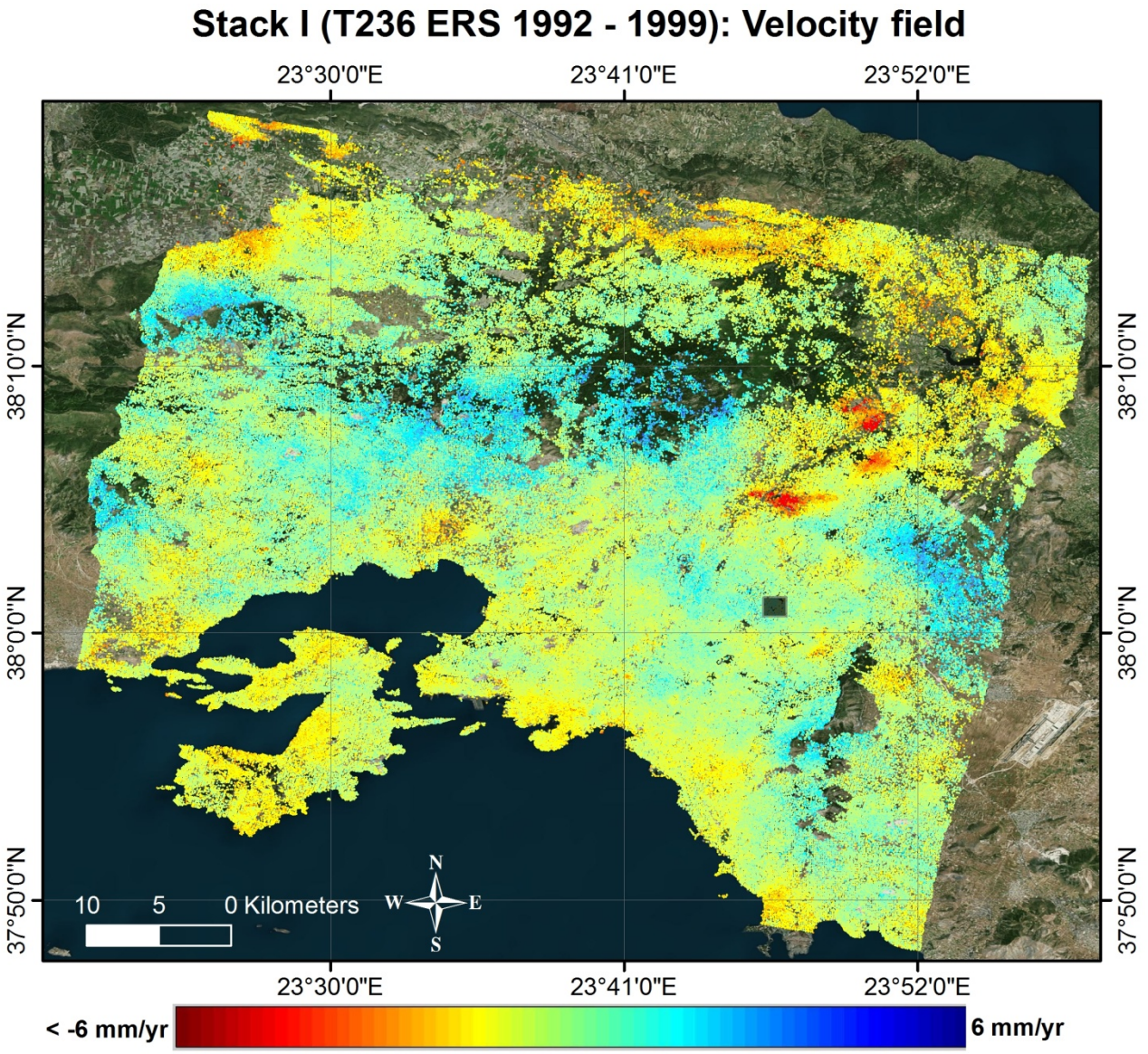
Geodesy | Modeling | Hazard assessment | Distributed processing

Volcanoes | Tectonics | Landslides | Subsidence | Tsunami

Time-series for monitoring slowly evolving phenomena

Diachronic mapping of ground motion in Attica

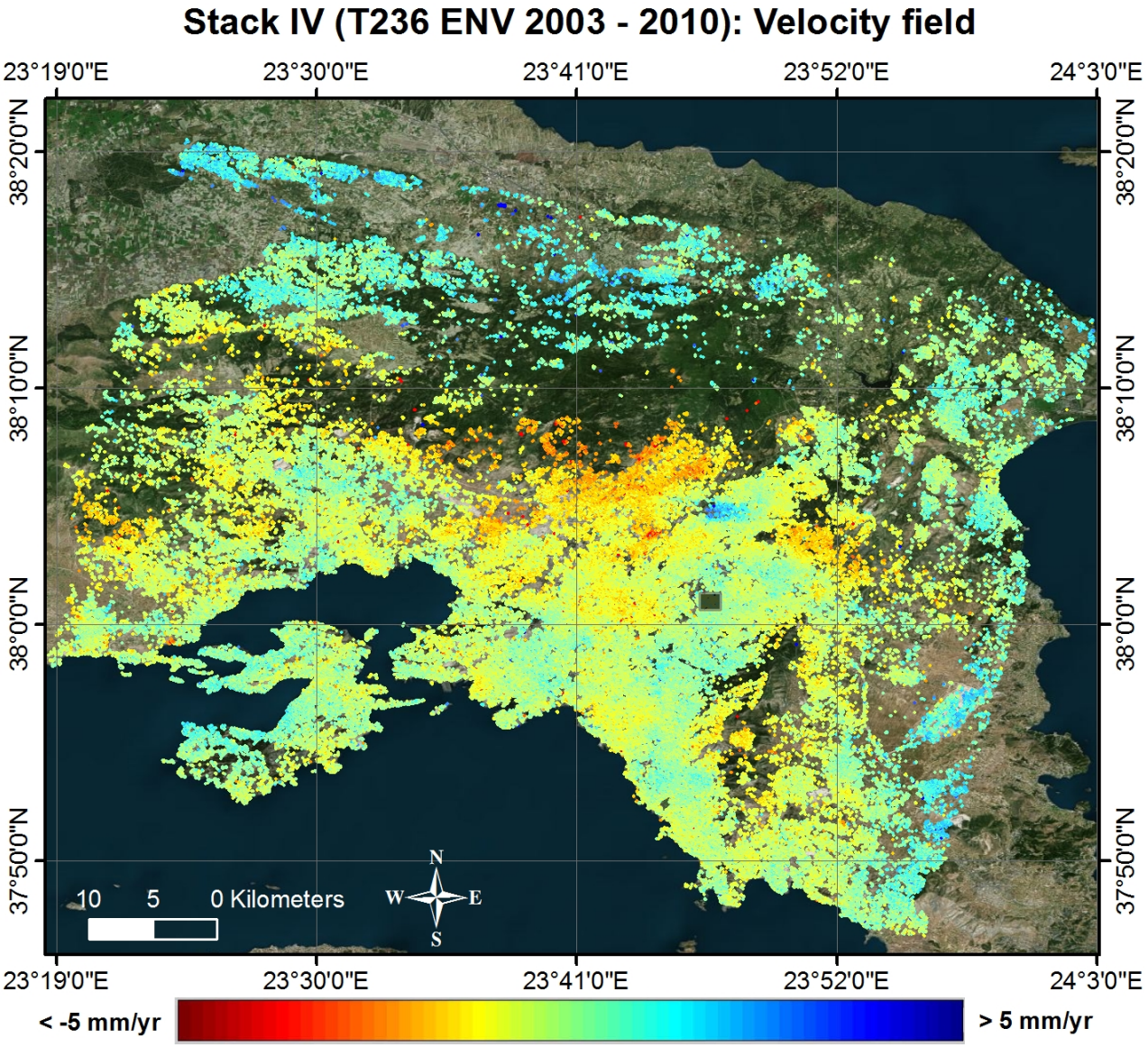
- ERS-1,2 & Envisat data
- Permanent scatterers even in non-urban areas
- Large field of view
- High Permanent Scatterer density, increased spatial sampling of the deformation signal



Time-series for monitoring slowly evolving phenomena

Diachronic mapping of ground motion in Attica

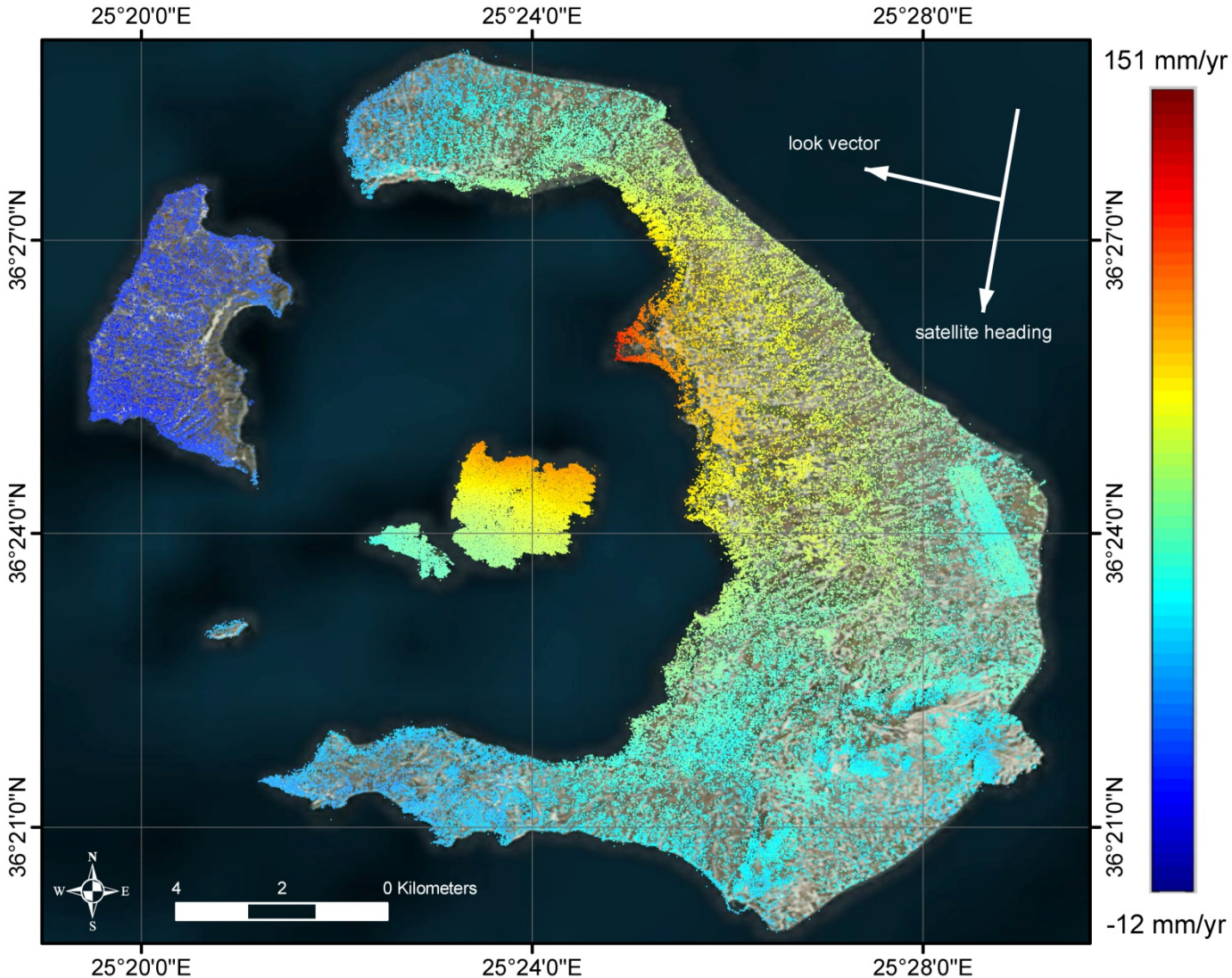
- Kifissia was subsidising in 1992-1999 and has been uplifting since 2002
- Deformation observed is attributed to water extraction activities that ceased in 1996. Since then Kifissia is in a physical restoration phase



Time-series for monitoring rapidly evolving phenomena

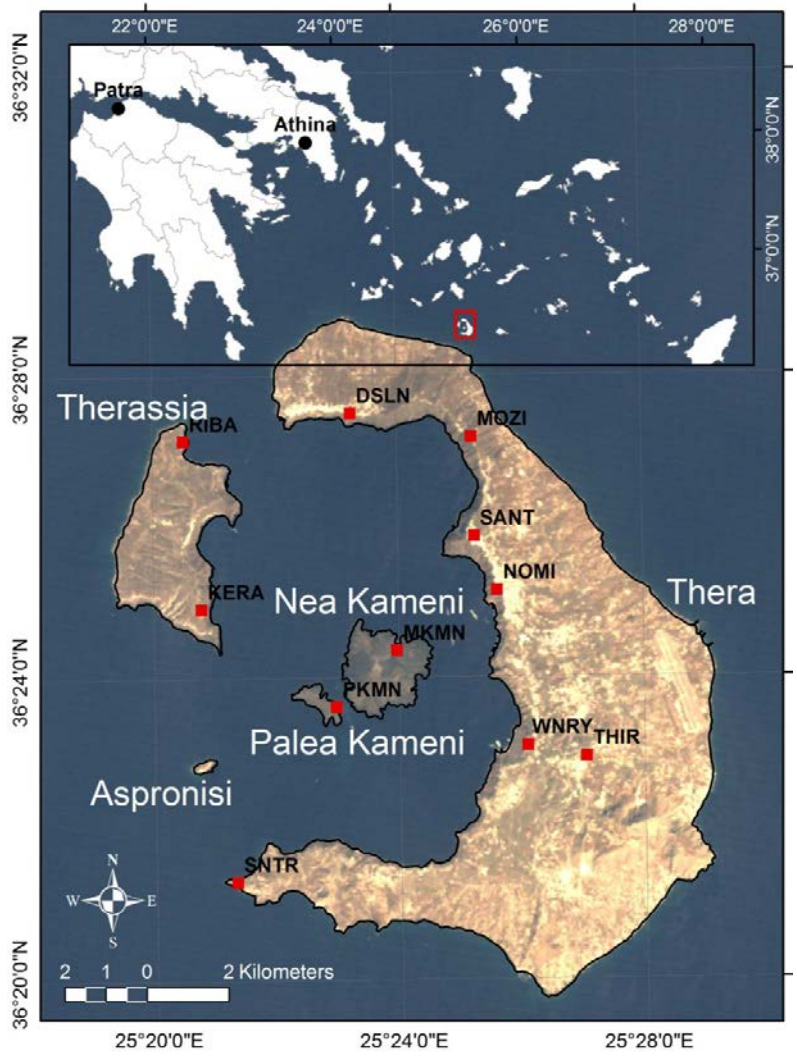
The Santorini inflation episode

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



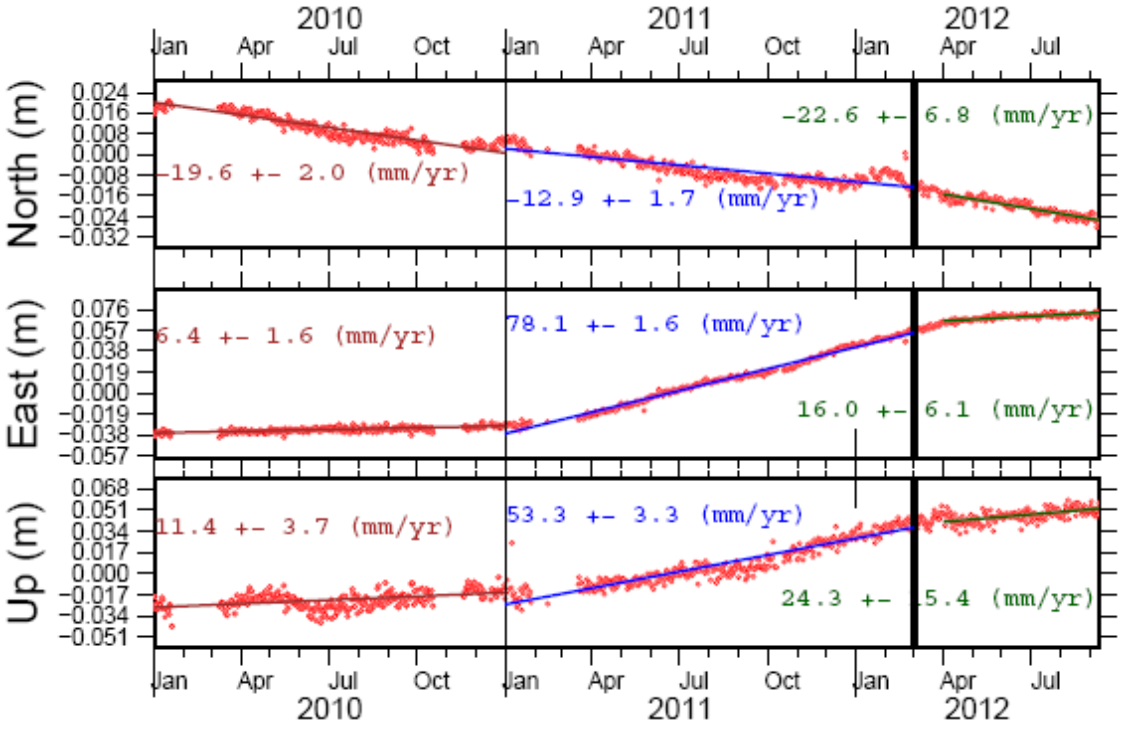
Papoutsis et al., Geophysical research letters, 2013

Time-series for monitoring rapidly evolving phenomena



The Santorini inflation episode

Time-series monitoring with in-situ GPS stations

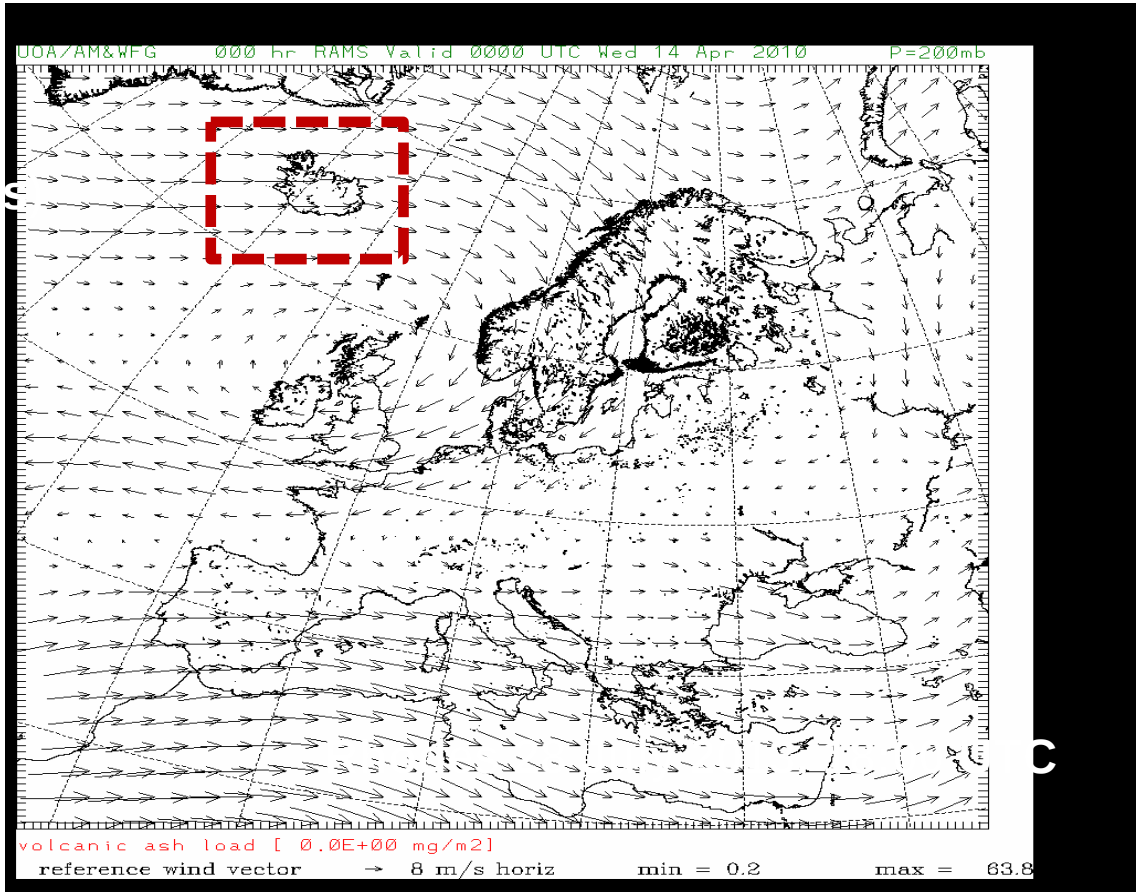


GPS data processing by Dionysos Satellite Observatory

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

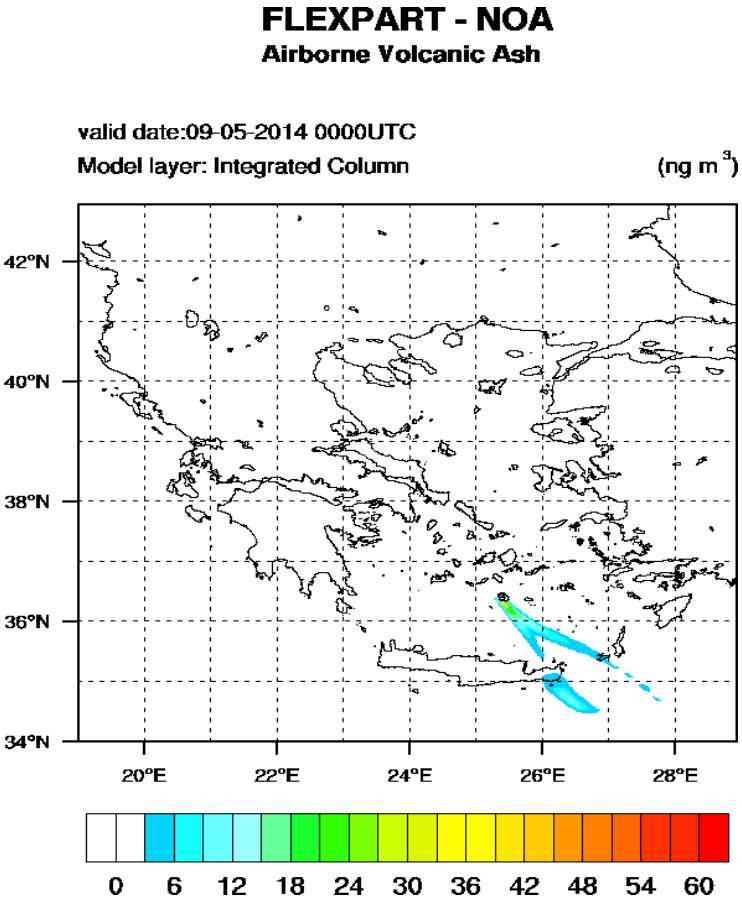
Satellite image of volcanic ash from Etna , July 24, 2001. (NASA SeaWiFs)

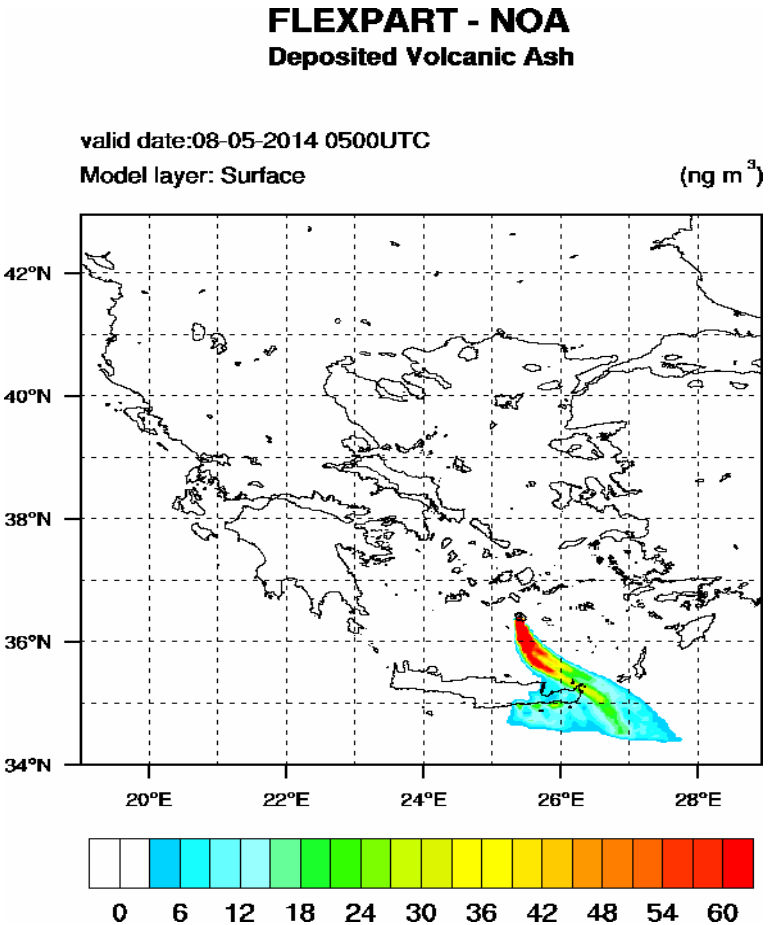
- Mapping of active volcanoes and their potential for ash cloud emissions for the development of an early warning system

- The system is based on WRF / FLEXPART simulations

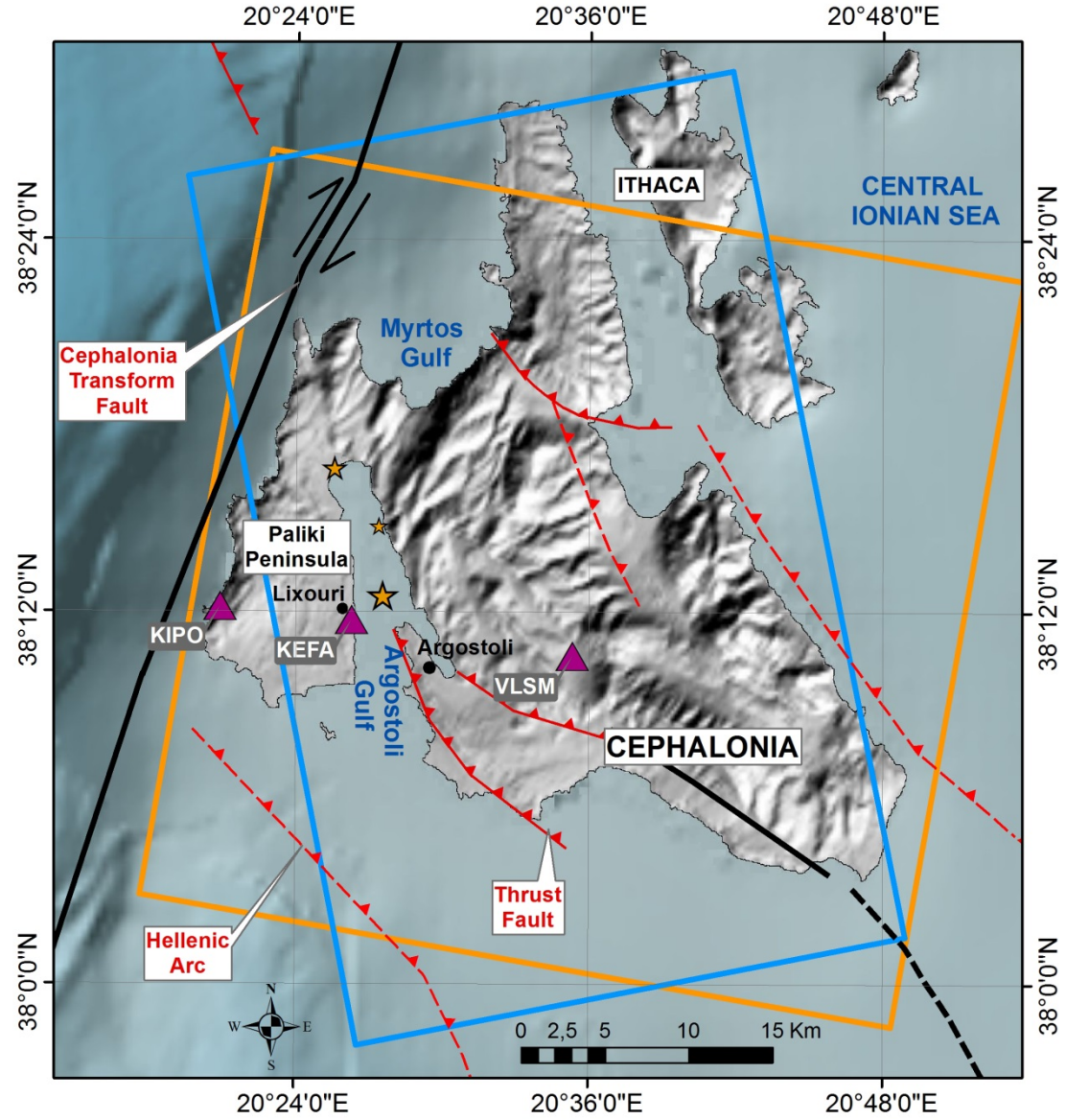
Modeling dispersion of volcanic ash

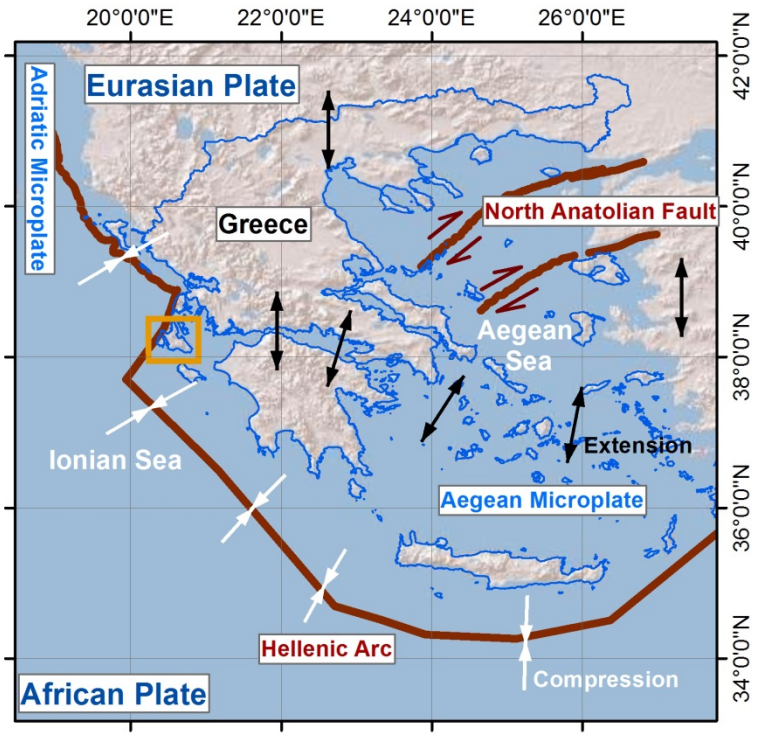
- Preliminary results from the early warning system developed in the framework of BEYOND
- The specific hypothesis assumes 60 hours of continuous emissions at 1.5 km height column
- More work is underway for the identification of Santorini potential emission characteristics





Cephalonia earthquakes





Mapped faults

- Strike-slip inferred
- Strike-slip
- Reverse inferred
- Reverse

Main earthqauke events

- 26/1/2014 ML 5,1
- 3/2/2014 ML 5,7
- 26/1/2-14 ML 5,9

GPS stations

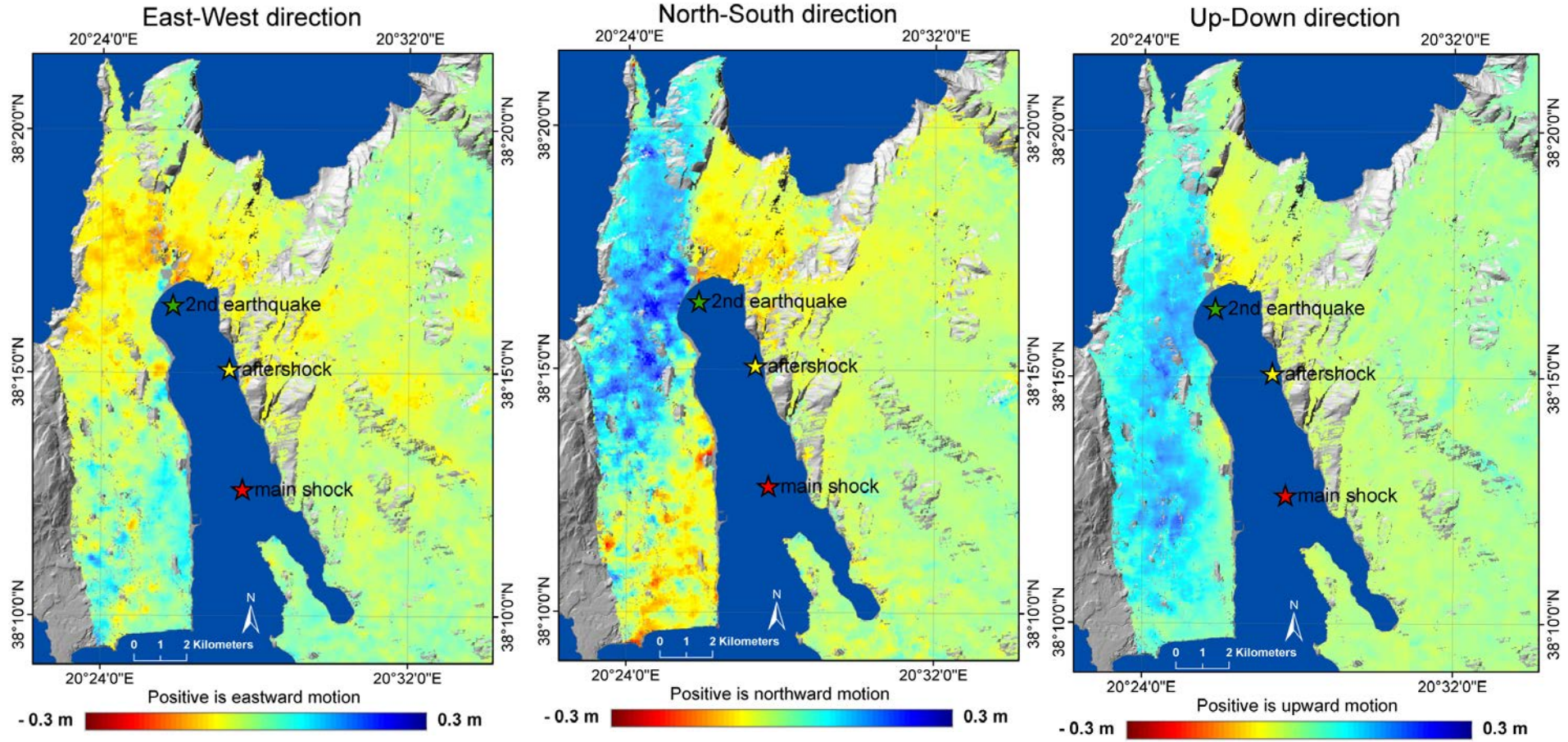
- cGPS

SARframes

- COSMO-SkyMED
- TerraSAR-X

Cephalonia earthquakes

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



Accepted for publication at Seismological Research Letters

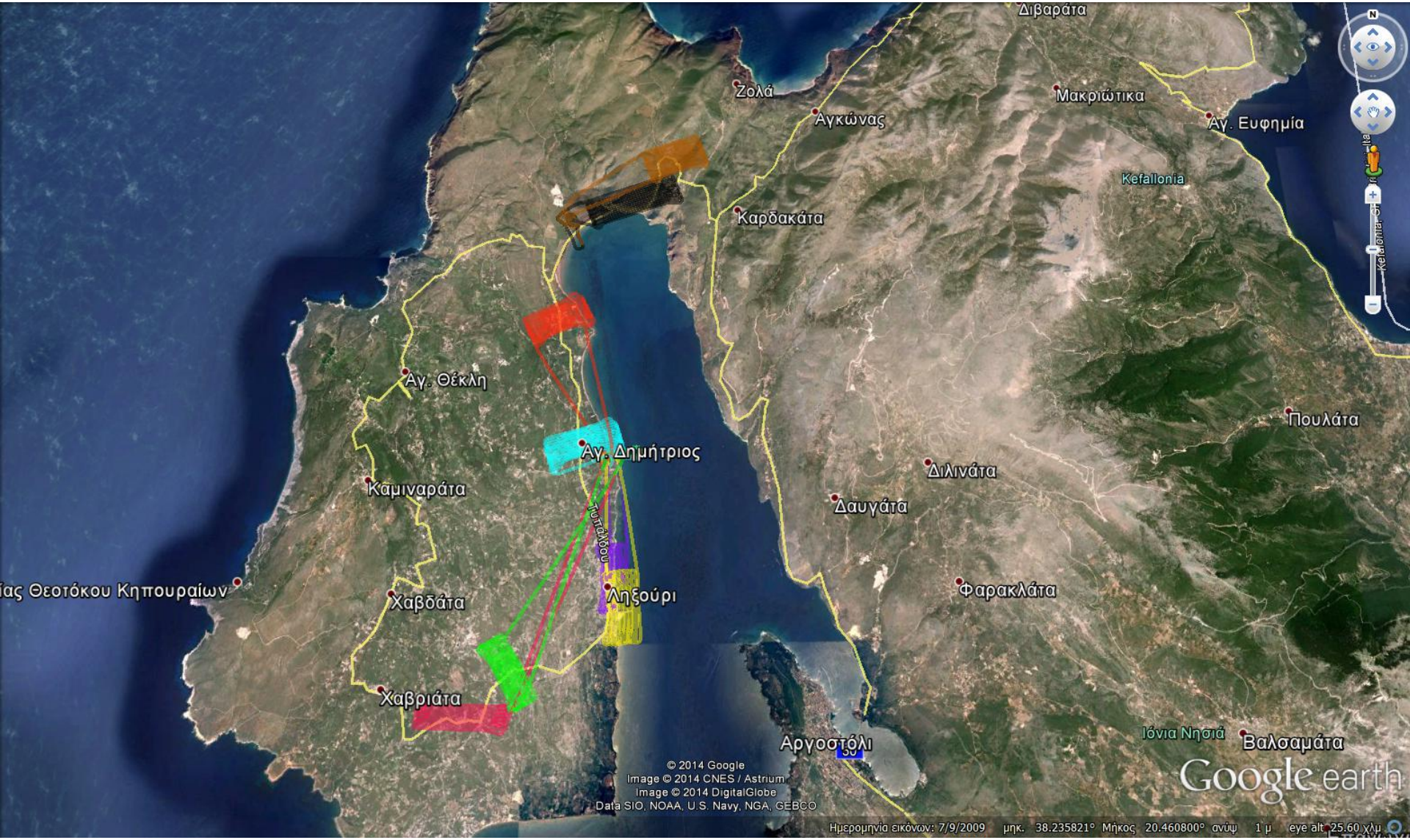
Mapping earthquake damages

UAV Flight Preparation

Mapping earthquake damages

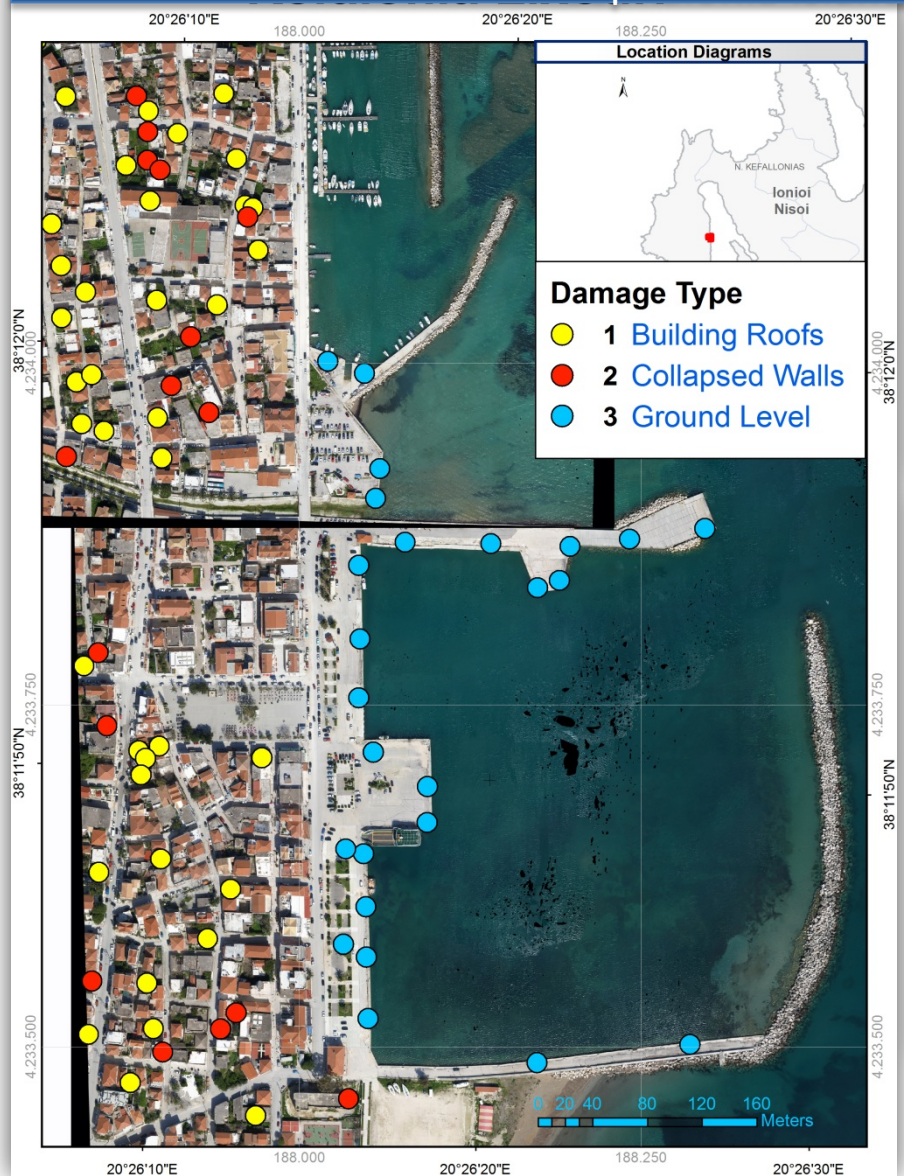
Mapping earthquake damages

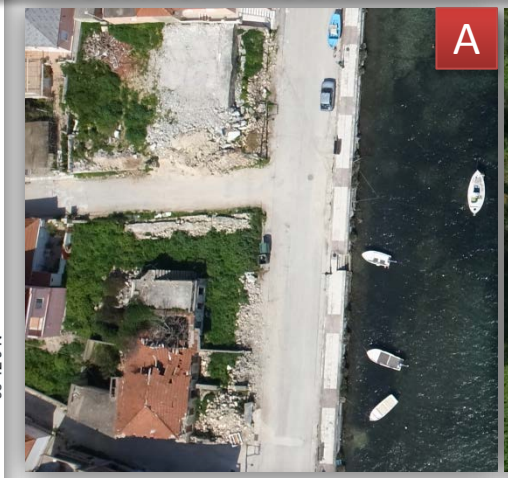
UAV Flight Paths

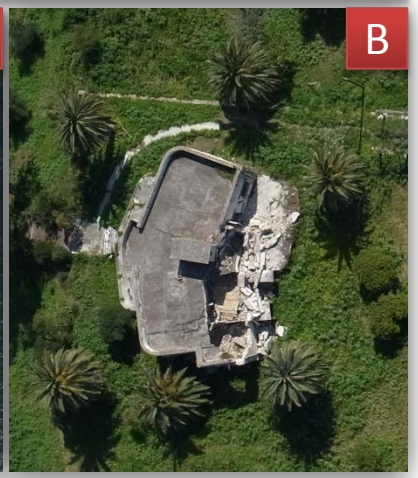


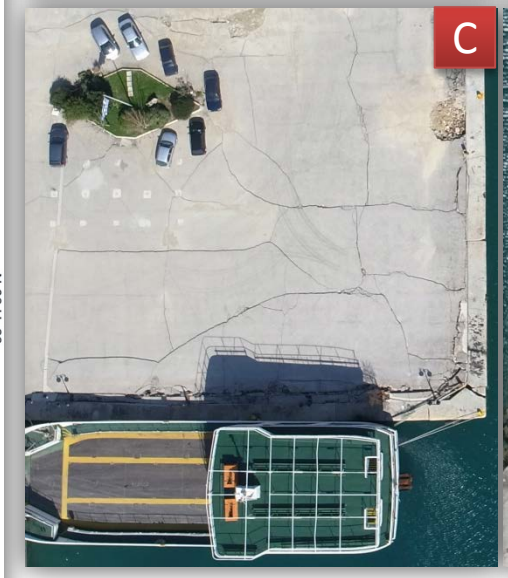
Mapping earthquake damages

Cephalonia Island – Town of Lixouri



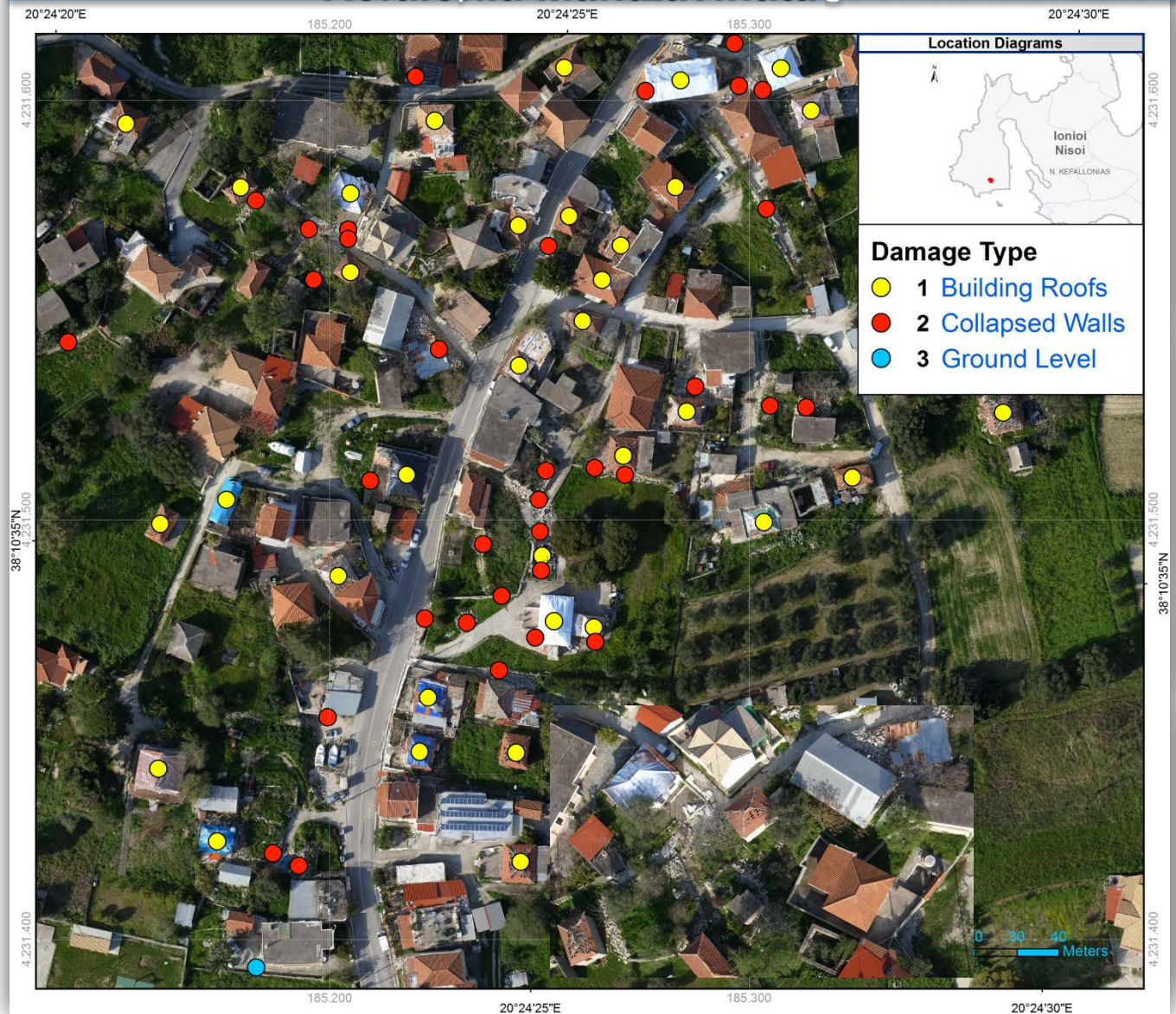


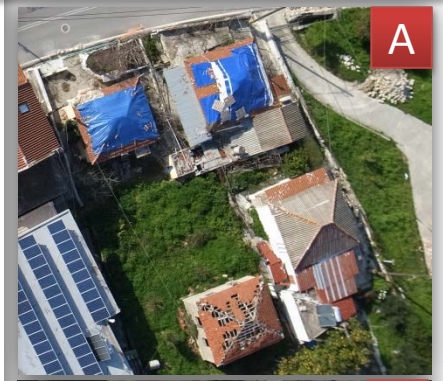


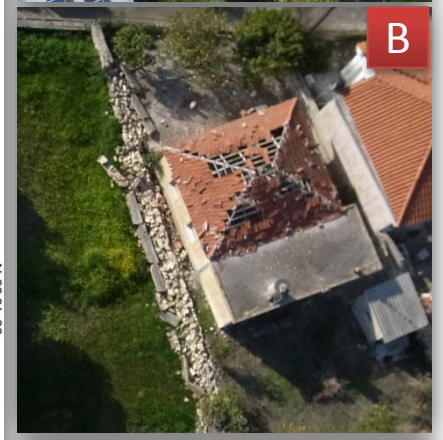


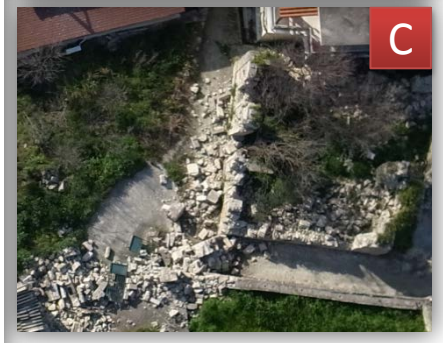
Mapping earthquake damages

Cephalonia Island – Village of Mantzavinata









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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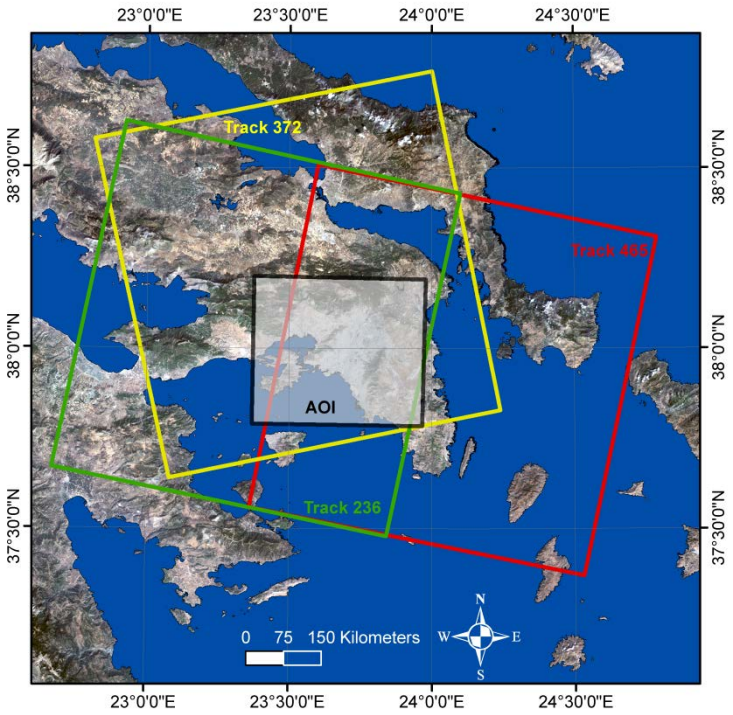
Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation in Attica

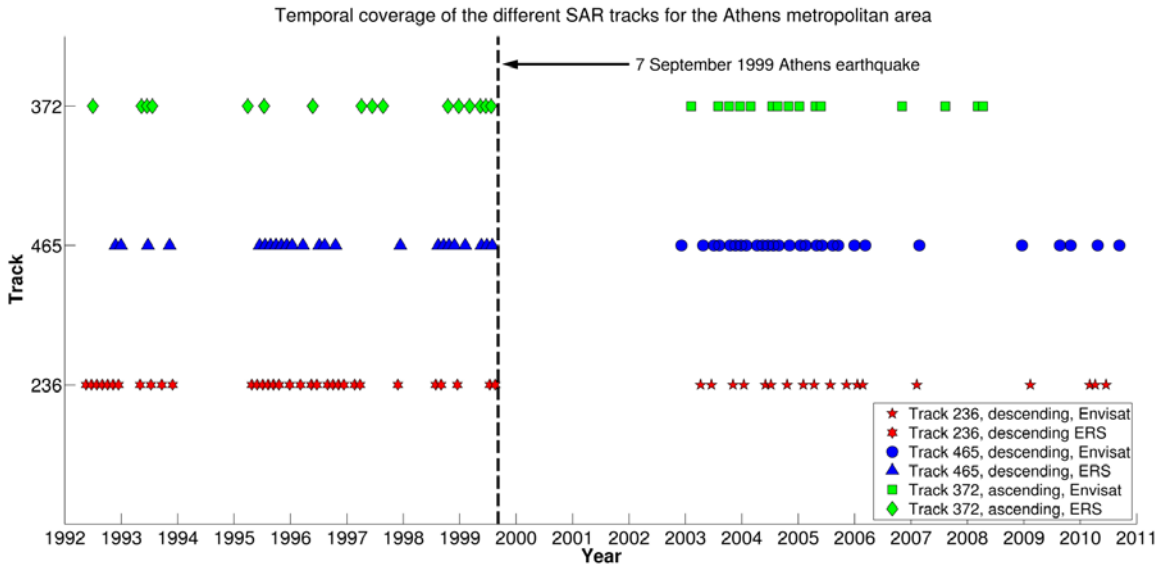
The interferometric stacks processed

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



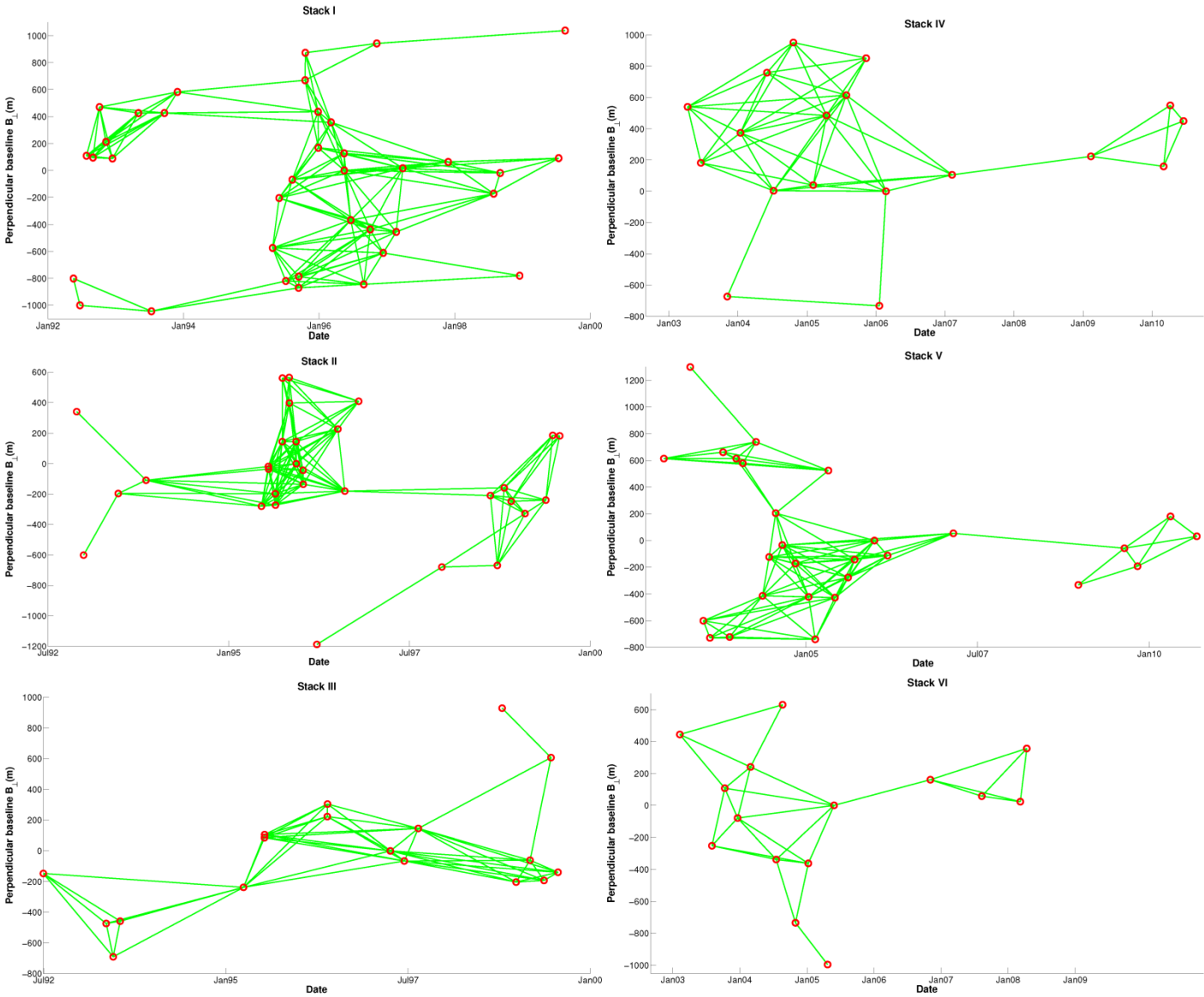
Temporal coverage of the six stacks



Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation in Attica

- Formed more 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

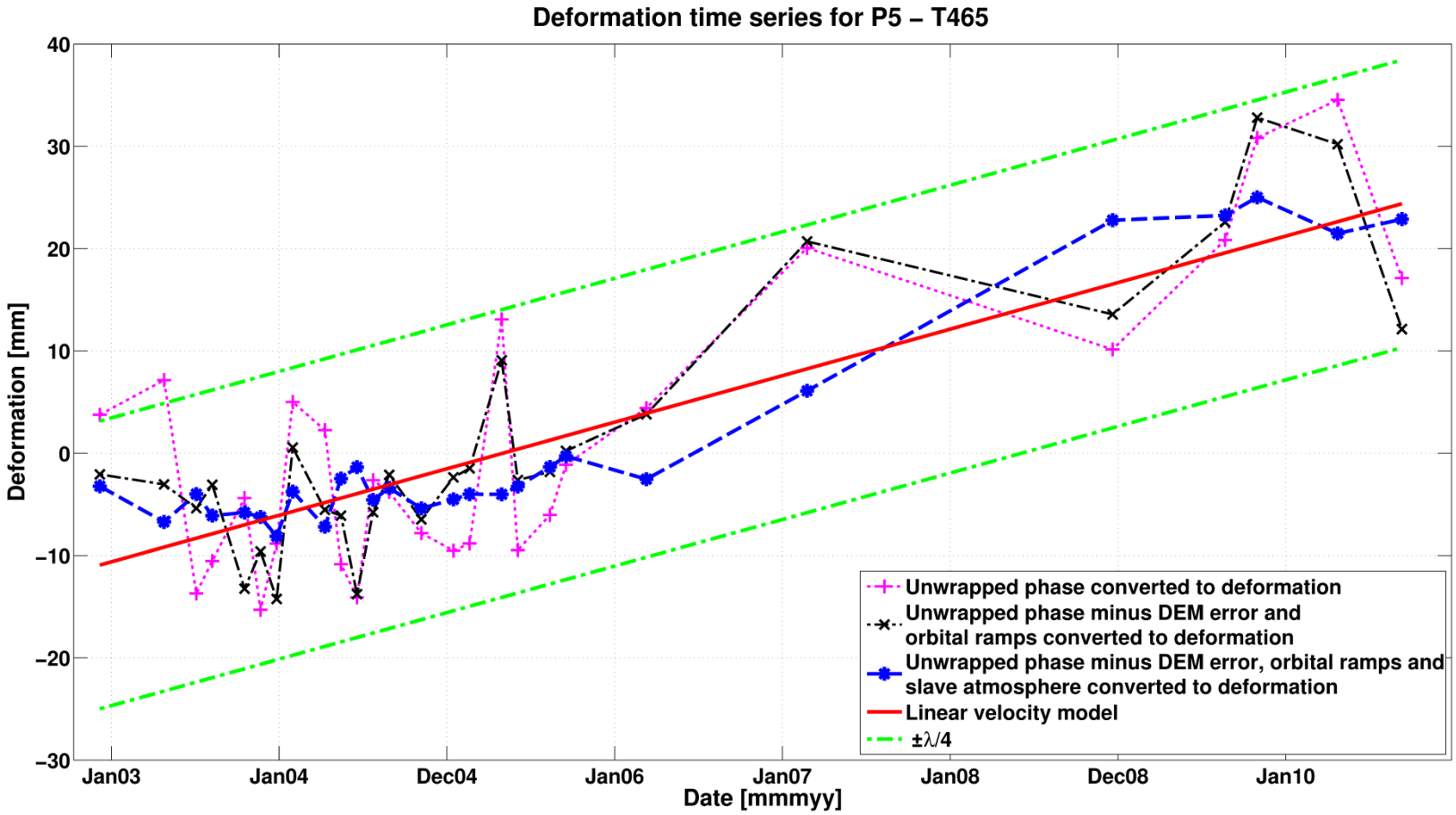


Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation in Attica

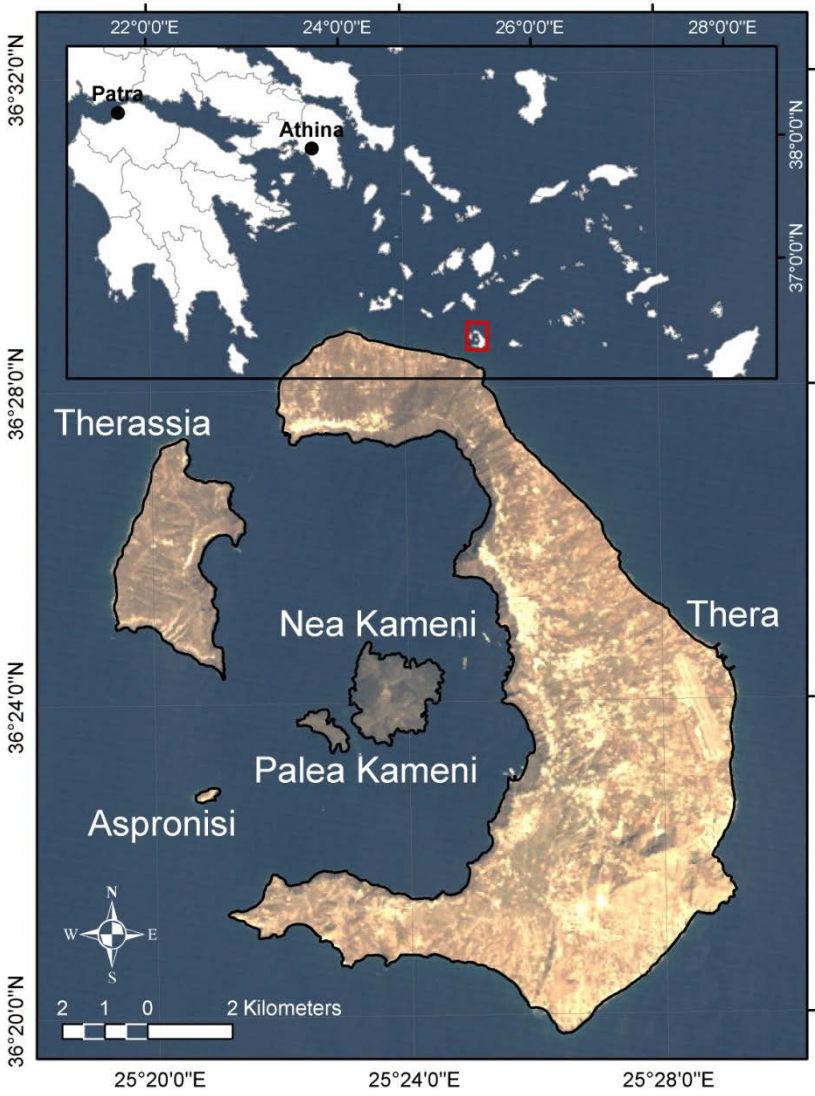
Deformation histories show the non-linear motion in Kifissia

1992-2010



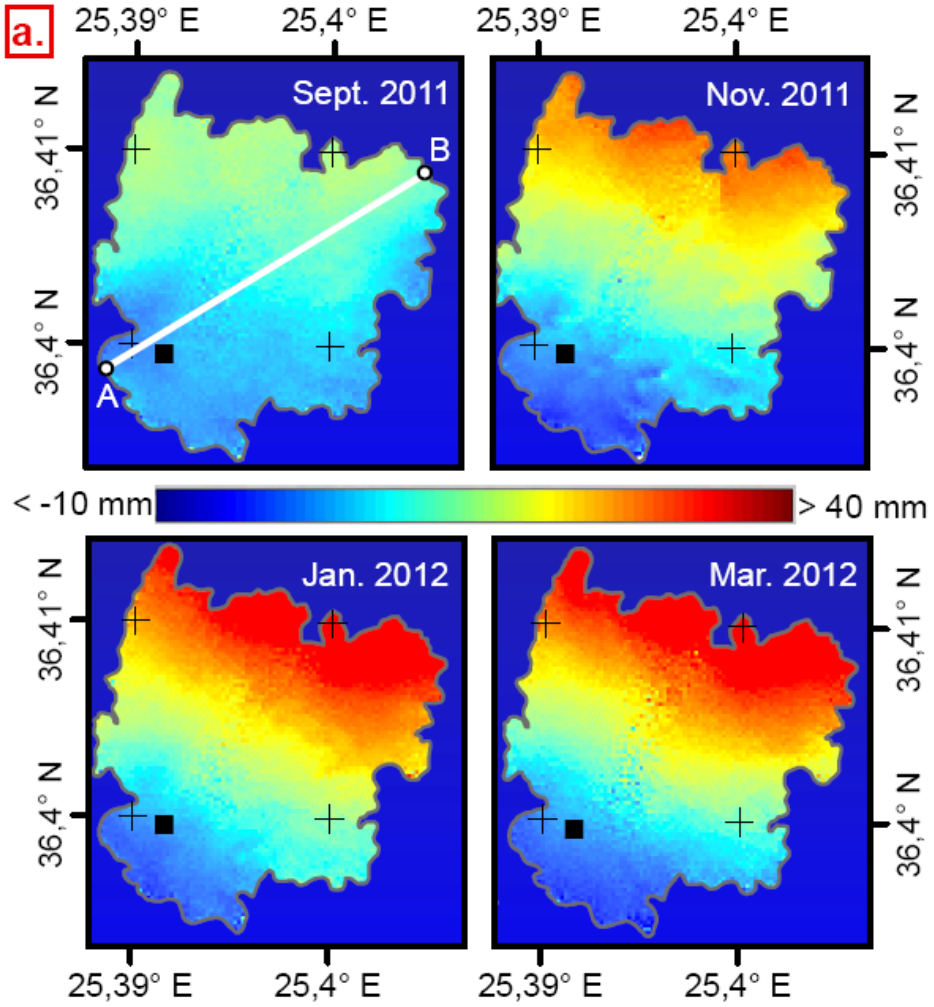
Background information on Santorini

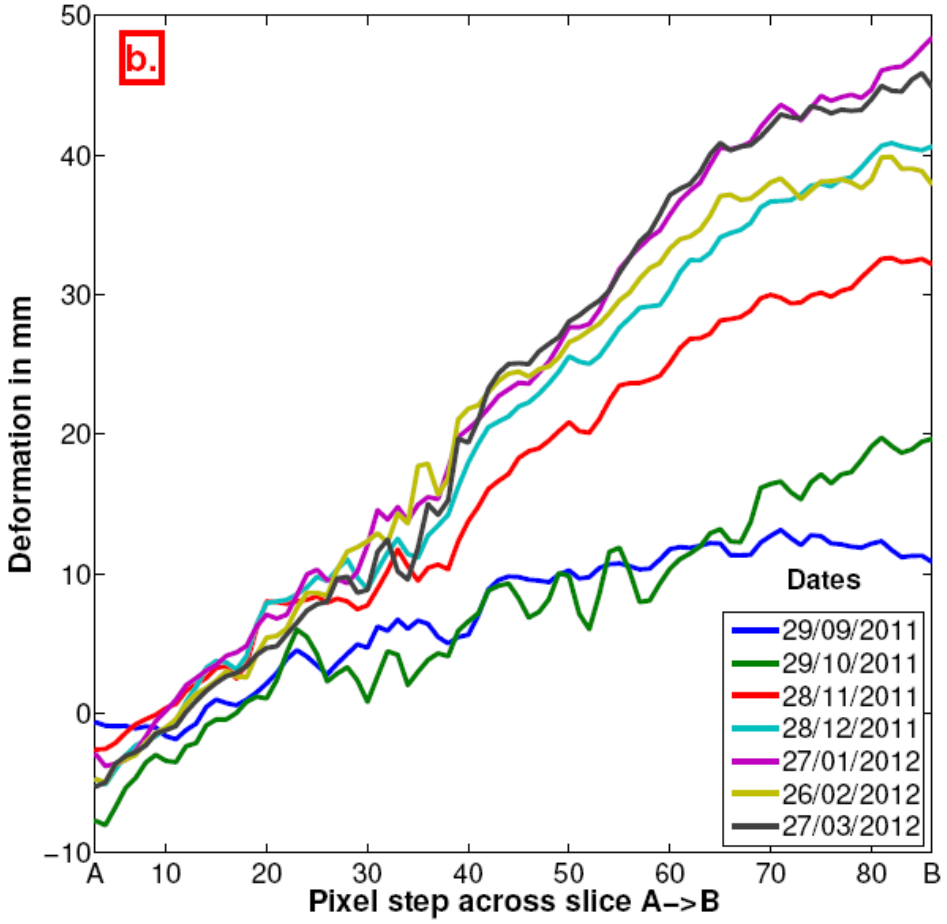
- Santorini Volcanic Complex is the most active part of the South Aegean (Hellenic) Volcanic Arc.
- Several eruptions led to the present form of the Kameni islands (197 BC, 46 AD, 726, 1570, 1707, 1866, 1925, 1939, 1950)
- Most recent seismic sequence ended in 1950
- Since then, Santorini volcano has been in a ‘quite’ phase, with insignificant deformation (confirmed by GPS and InSAR)



The end of the episode

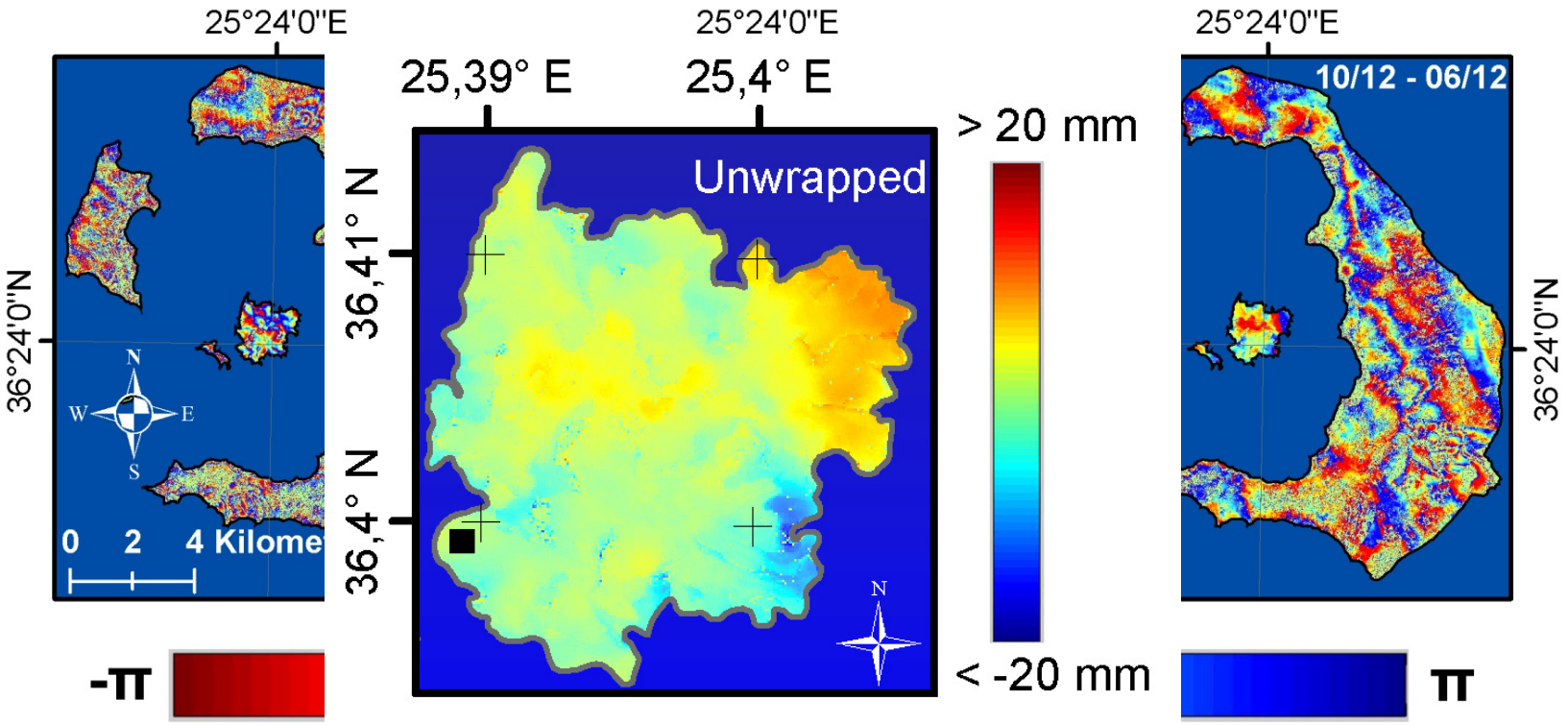
InSAR





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