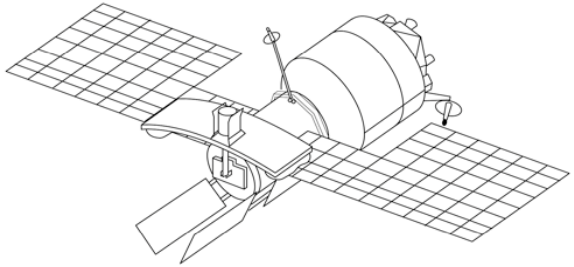
Monitoring geophysical activity from Space, in the framework of BEYOND Center of Excellence



Ioannis Papoutsis

National Observatory of Athens

Institute for Astronomy, Astrophysics, Space Applications & Remote Sensing

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 **twining organizations.**

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

Geophysical hazards in BEYOND

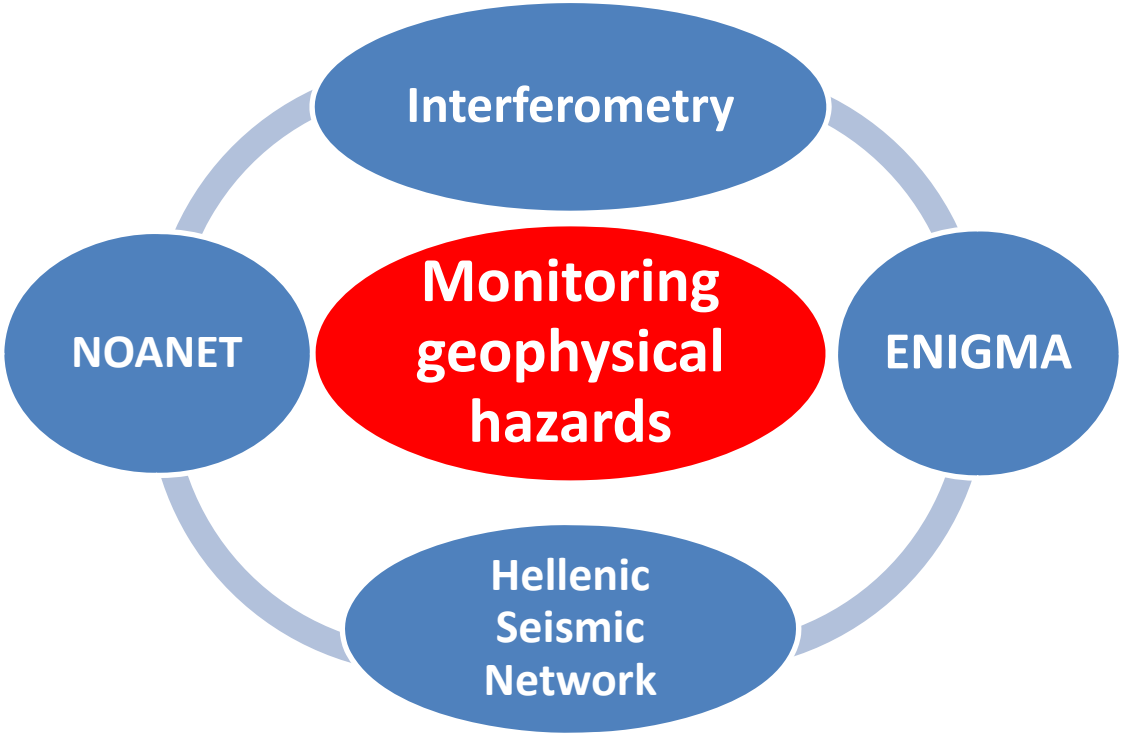
Centre of Excellence for

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



- Compliance with GEOSS Strategic Target for Disasters
  - Support the implementation of the Hyogo Framework for Action 2005-2015

Schematic concept

BE OND

National Seismological Network

NOANET

ENIGMA

Earth Observation - SAR Interferometry

Geodesy | Modeling | Risk assessment | Distributed processing

Volcanoes | Tectonics | Landslides | Subsidence | Tsunami

GEO GROUP ON EARTH OBSERVATIONS

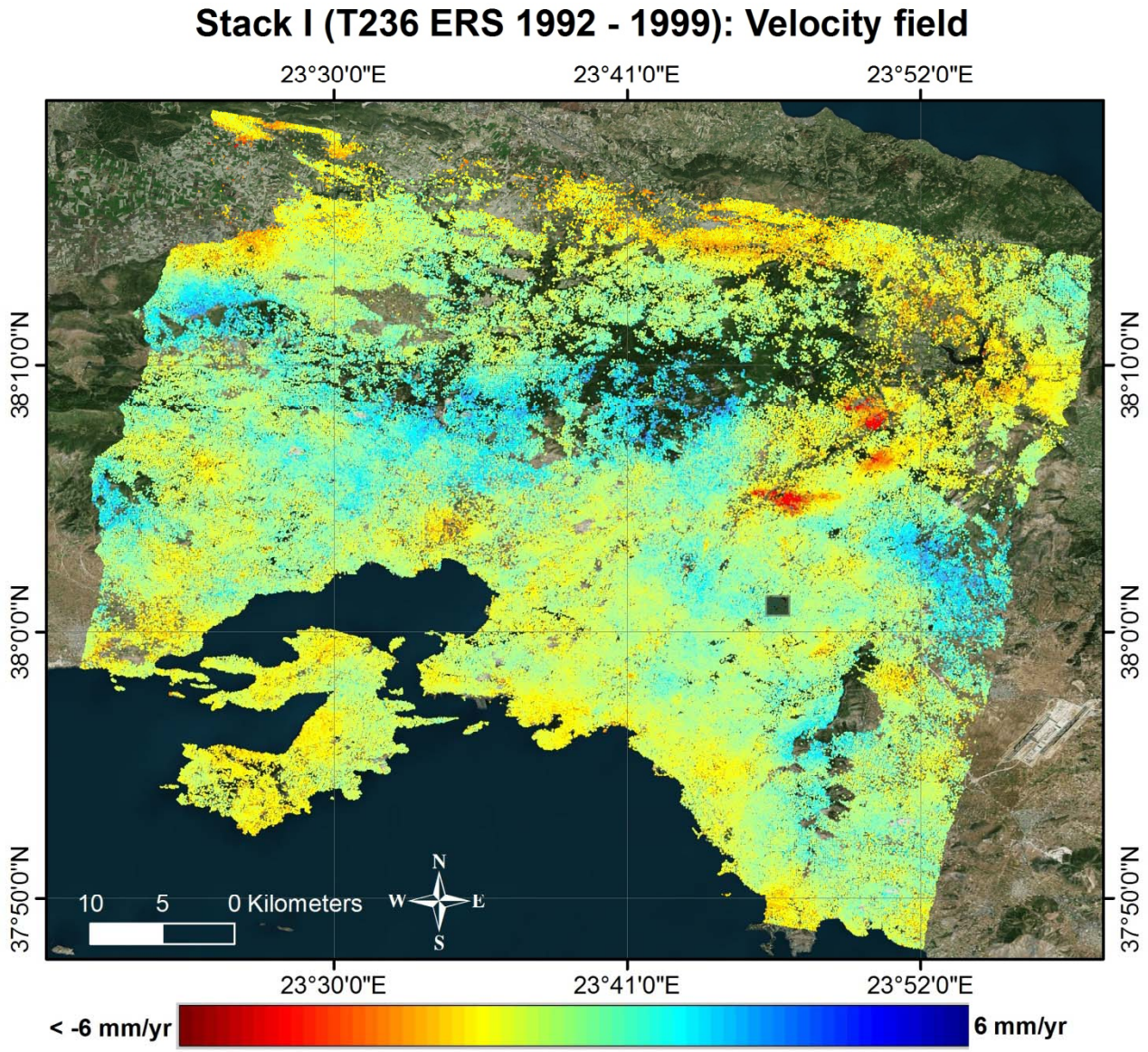
+

GEOSS Common Infrastructure

Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation in Attica

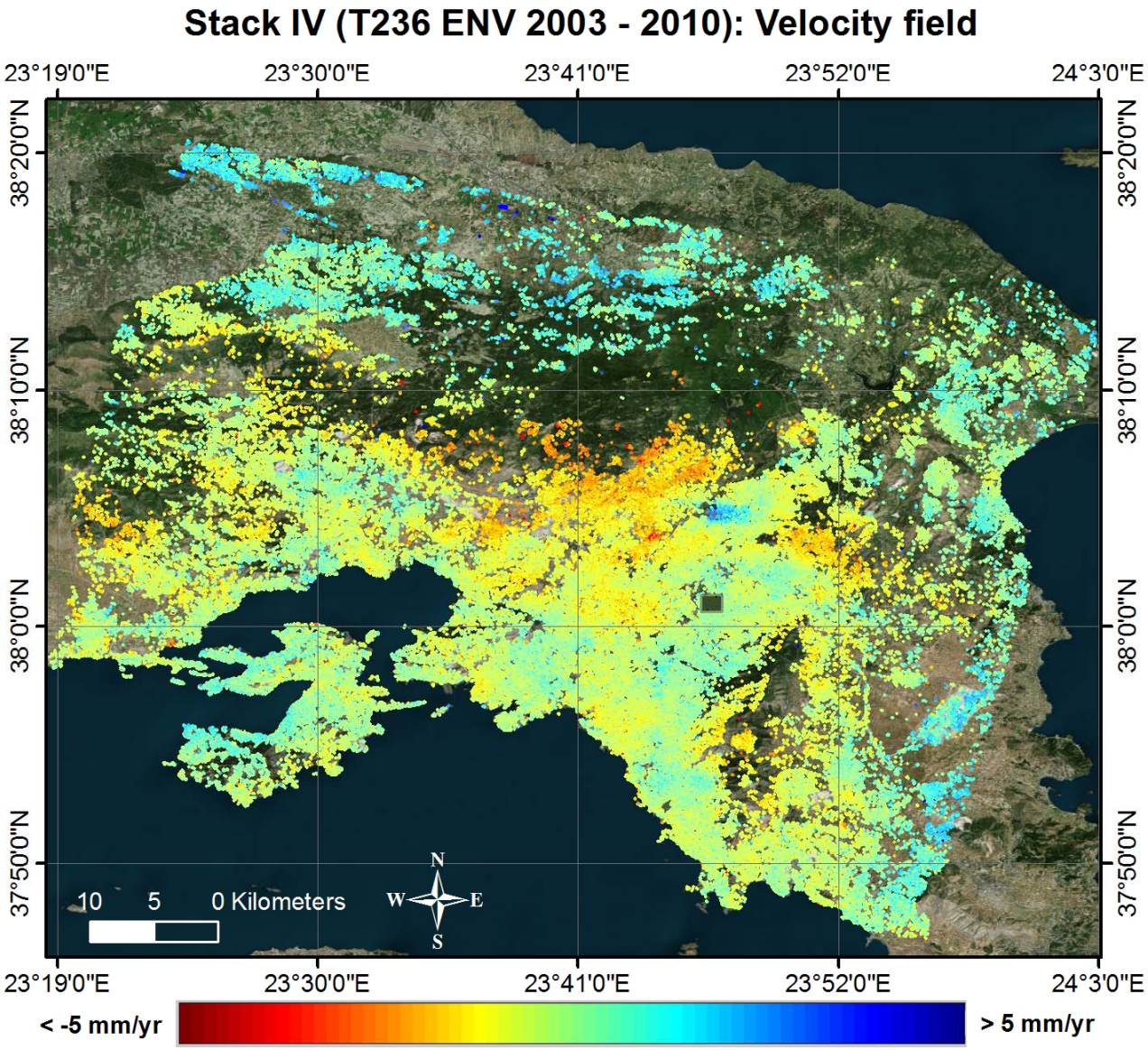
- ERS-1,2 & Envisat data
- Permanent scatterers even in non-urban areas
- Large field of view
- High Permanent Scatterer density, increased spatial sampling of the deformation signal



Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation in Attica

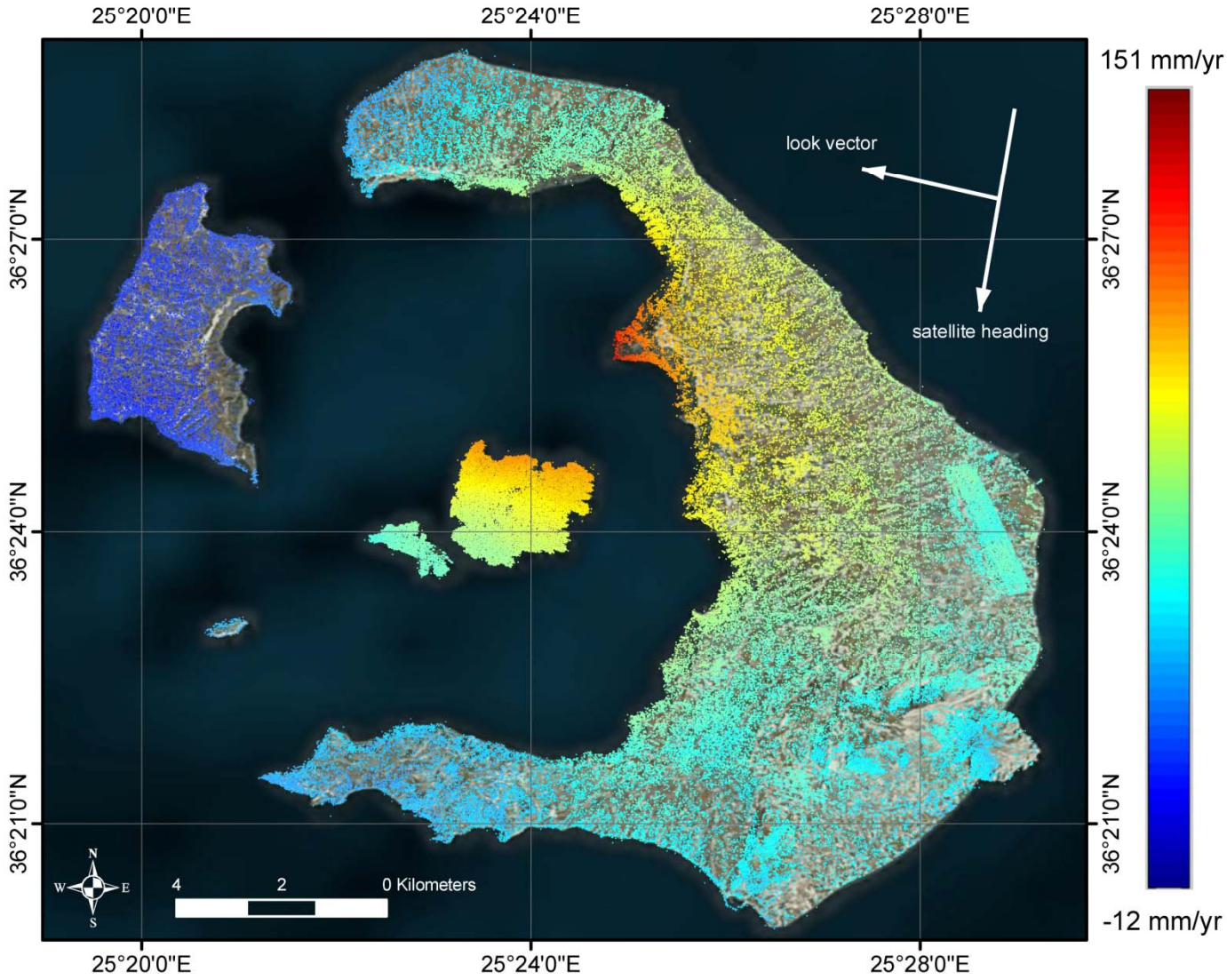
- Kifissia was subsidising in 1992-1999 and has been uplifting since 2002
- Deformation observed is attributed to water extraction activities that ceased in 1996. Since then Kifissia is in a physical restoration phase



Time-series for monitoring rapidly evolving phenomena

The Santorini inflation episode

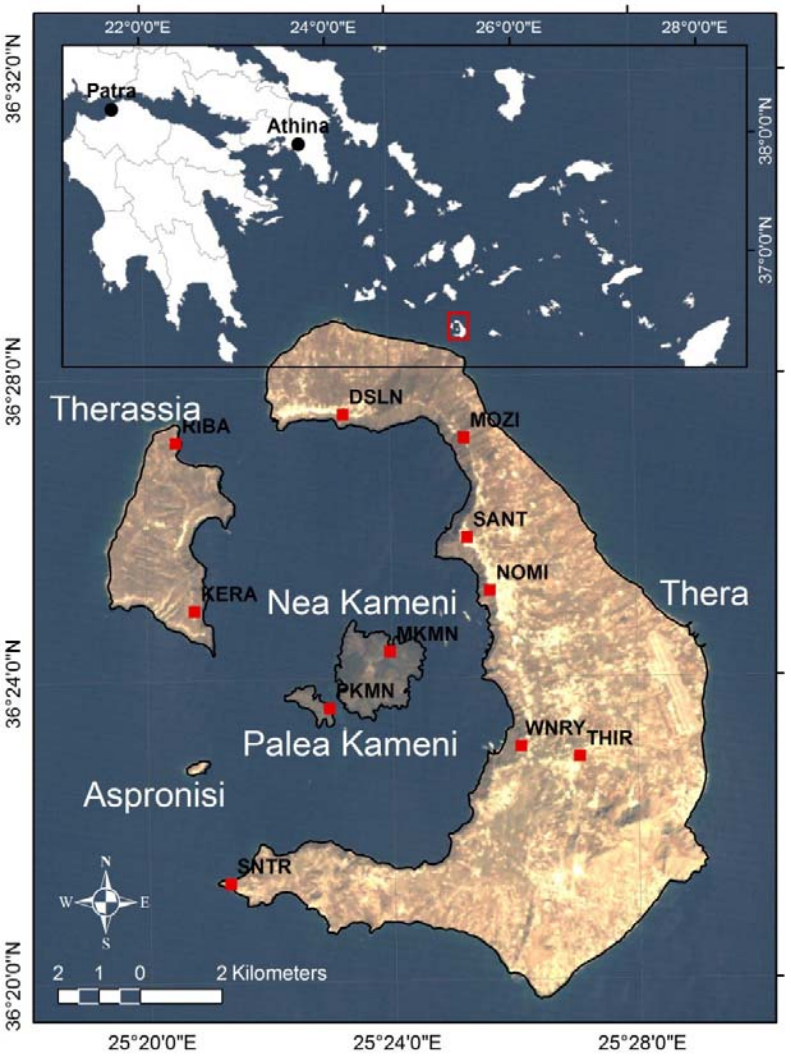
- ASAR Envisat data
- Uplift with a radially decaying pattern in amplitude and velocity from the center of deformation
- 150 mm/yr maximum deformation



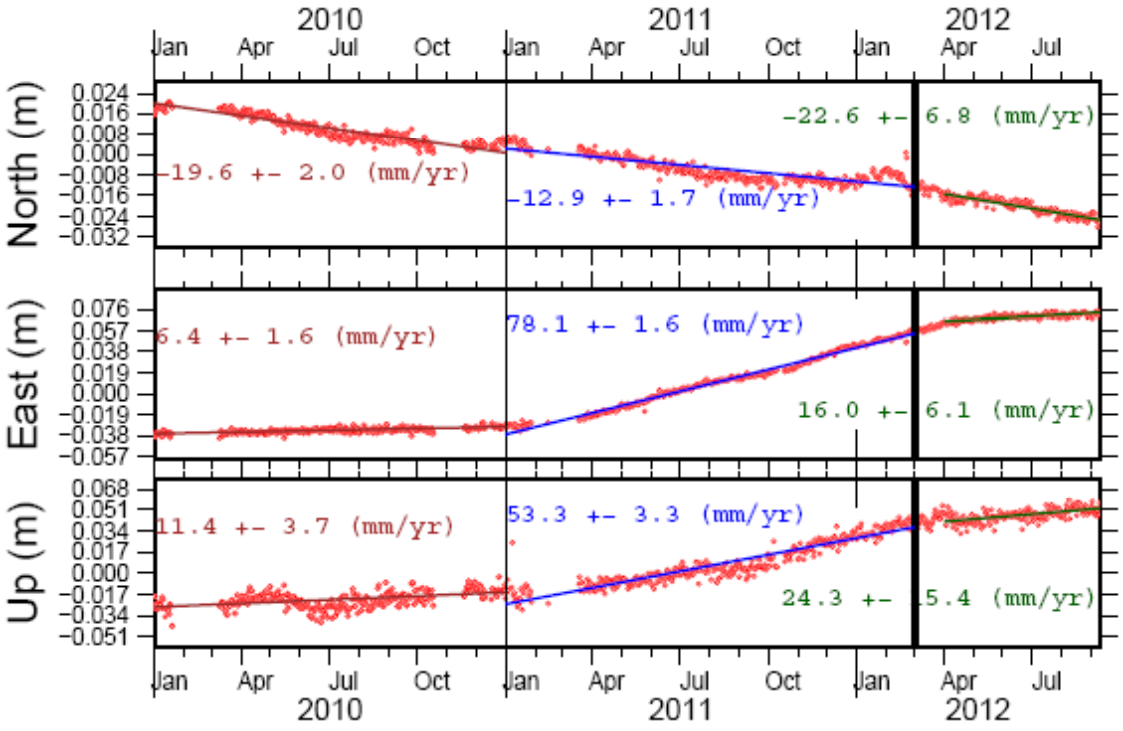
Papoutsis et al., Geophysical research letters, 2013

Time-series for monitoring slowly evolving phenomena

The Santorini inflation episode



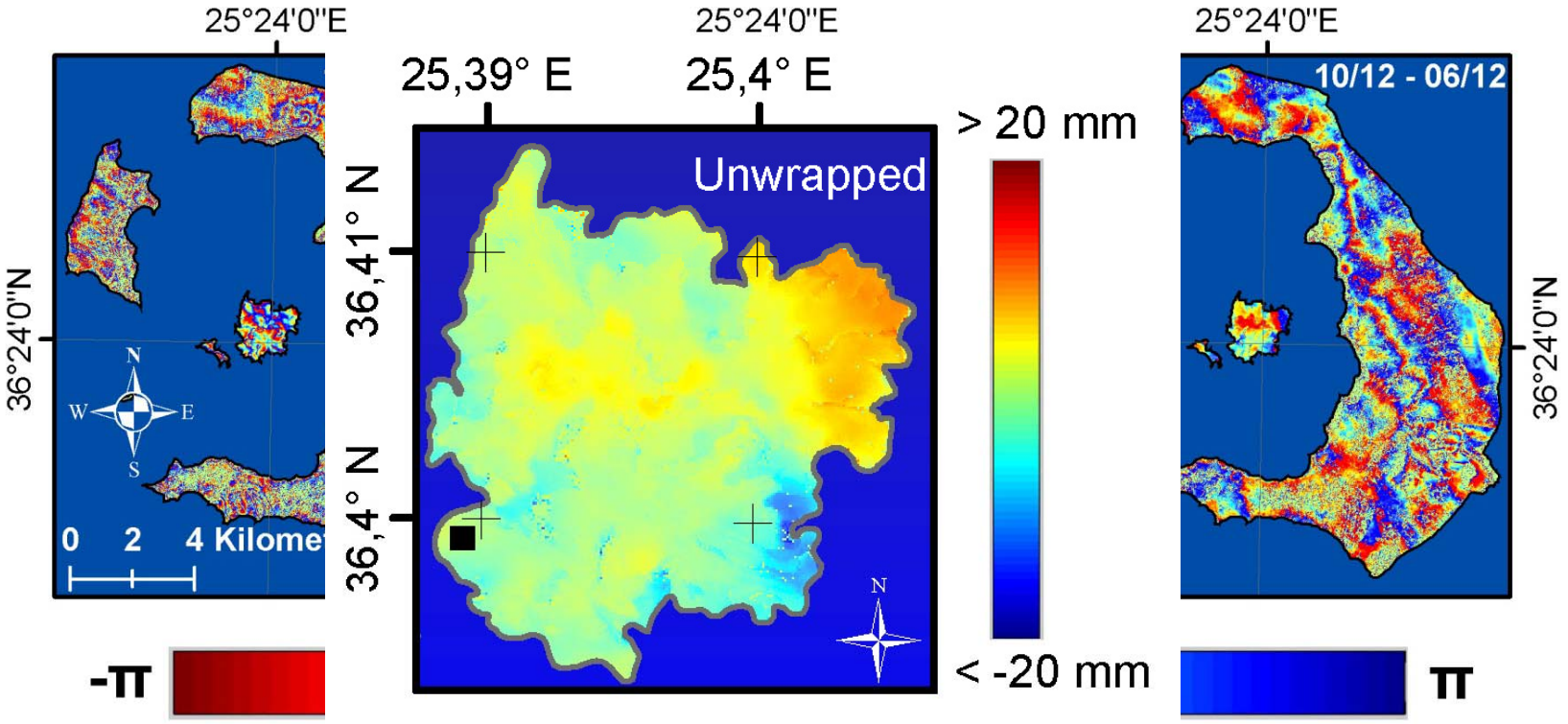
Time-series monitoring with in-situ GPS stations



GPS data processing by Dionysos Satellite Observatory

Keep on monitoring Santorini

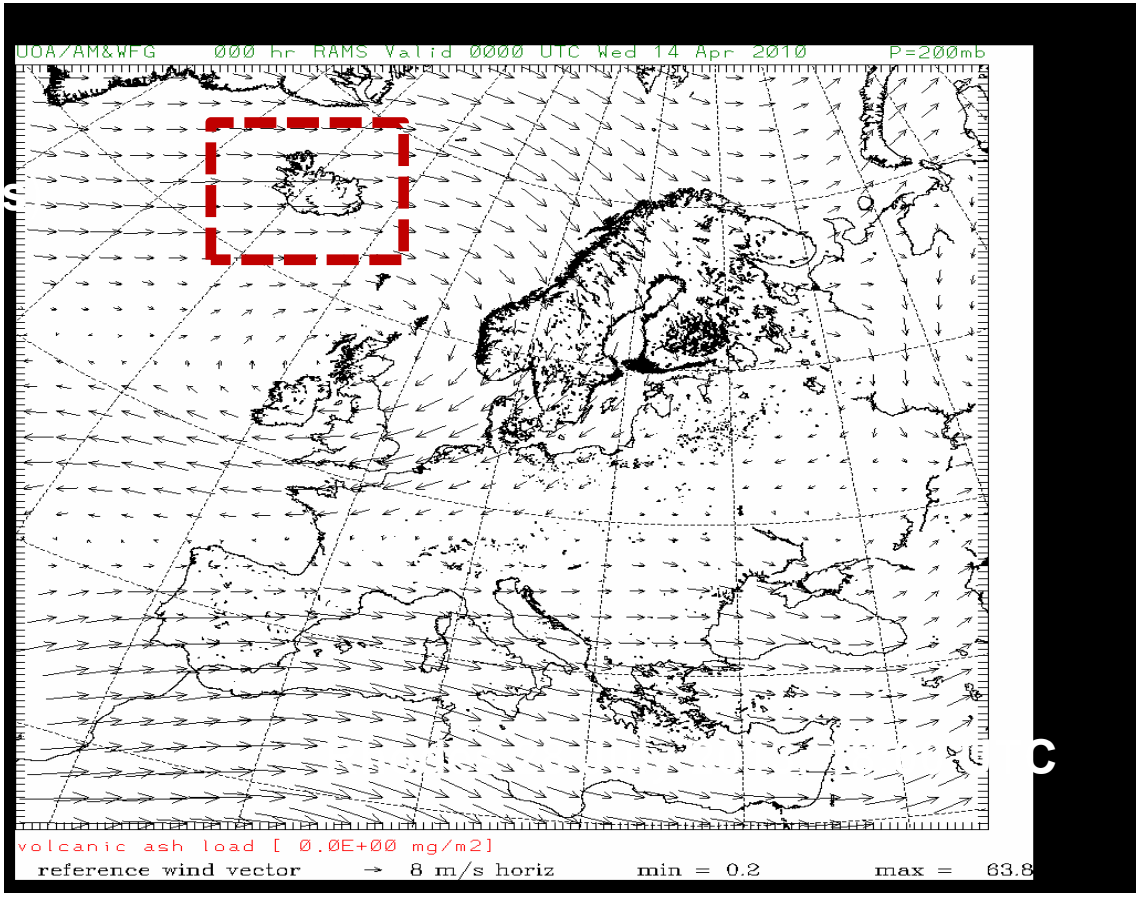
- Four (4) ongoing research projects (ESA, DLR, ASI, CSA) granting access to diverse SAR data: TerraSAR-X, COSMO-SkyMED, RADARSAT-2, ERS-1,2, Envisat, ALOS
  - ➢ Ongoing work with COSMO-SkyMed SAR data



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

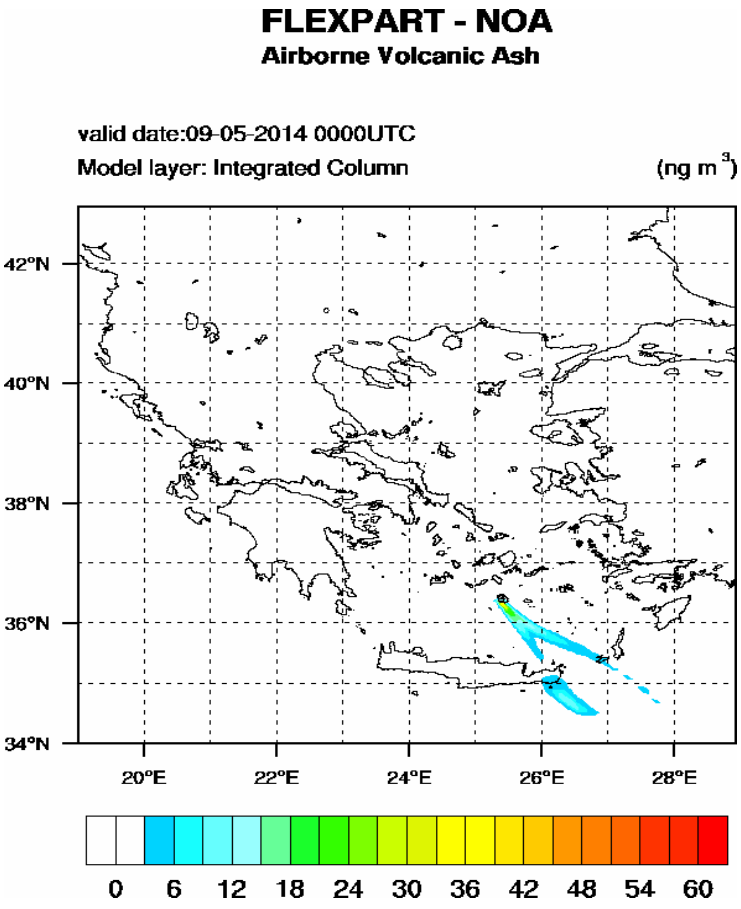
Satellite image of volcanic ash from Etna , July 24, 2001. (NASA SeaWiFs)

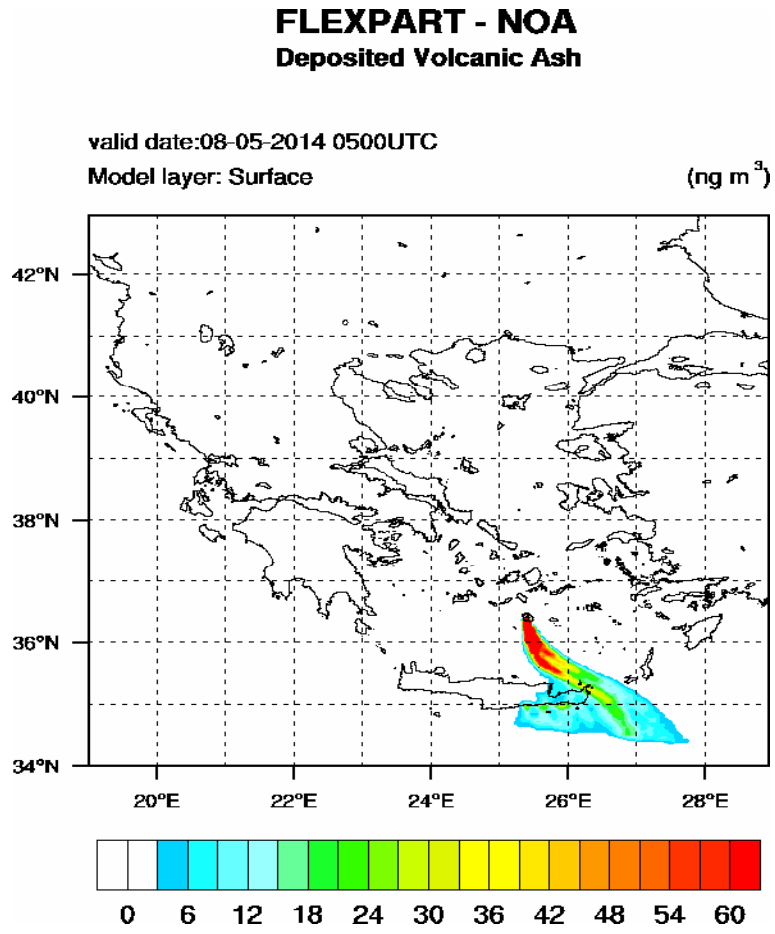
• Mapping of active volcanoes and their potential for ash cloud emissions for the development of an early warning system

• The system is based on WRF / FLEXPART simulations

Modeling dispersion of volcanic ash

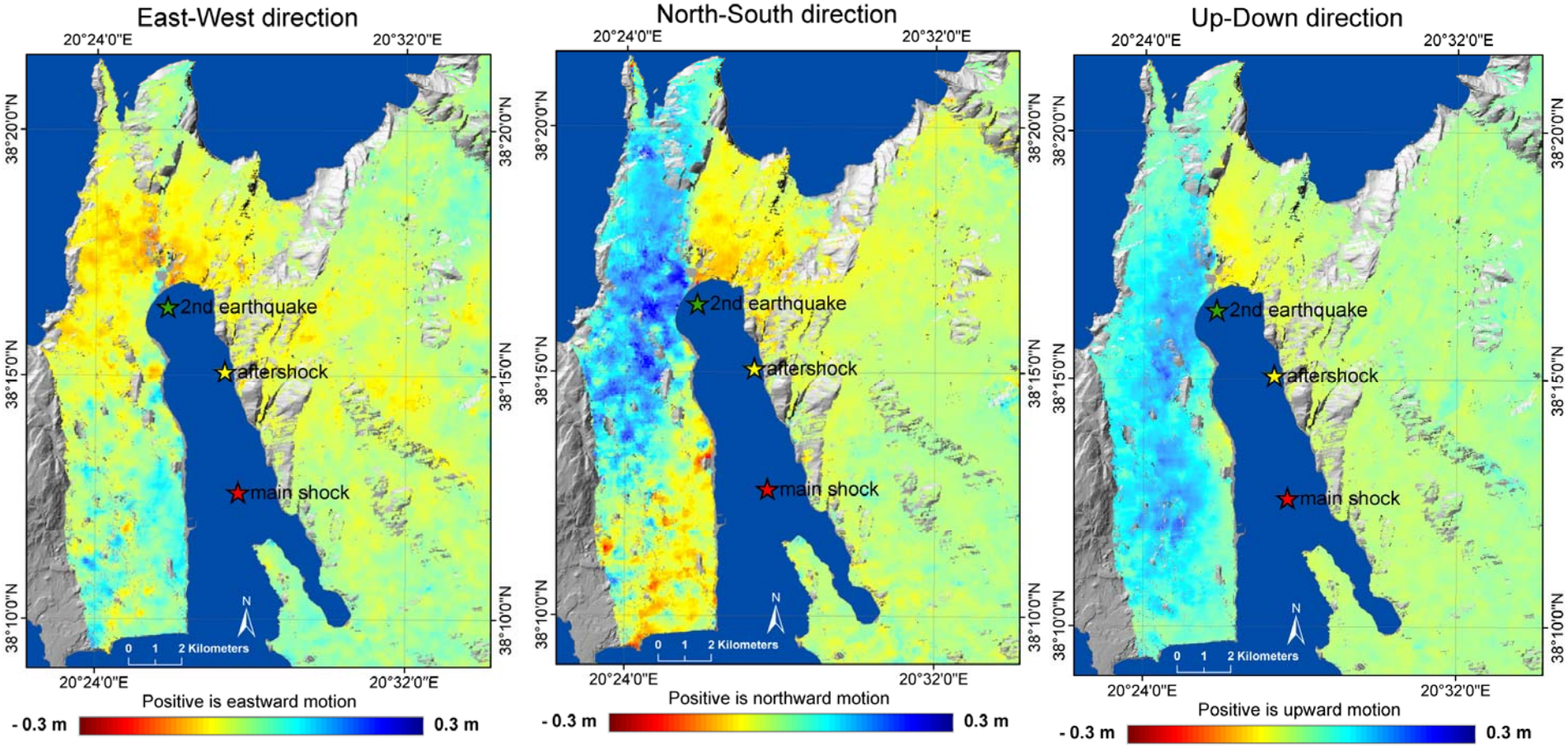
- Preliminary results from the early warning system developed in the framework of BEYOND
- The specific hypothesis assumes 60 hours of continuous emissions at 1.5 km height column
- More work is underway for the identification of Santorini potential emission characteristics





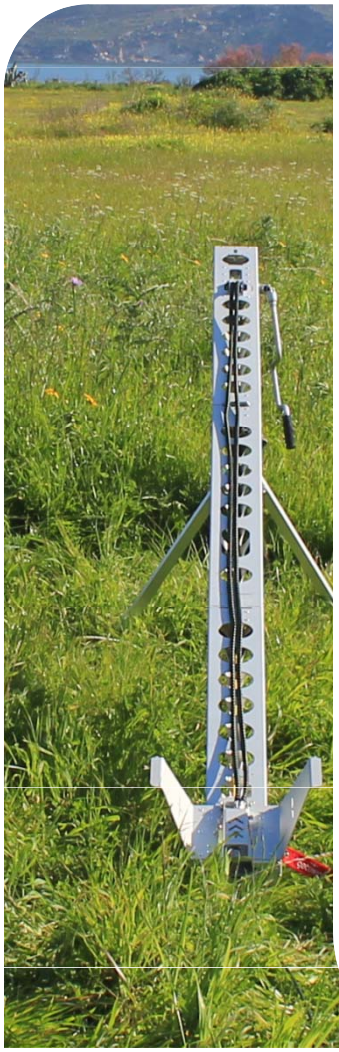
Cephalonia earthquakes

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



Mapping earthquake damages

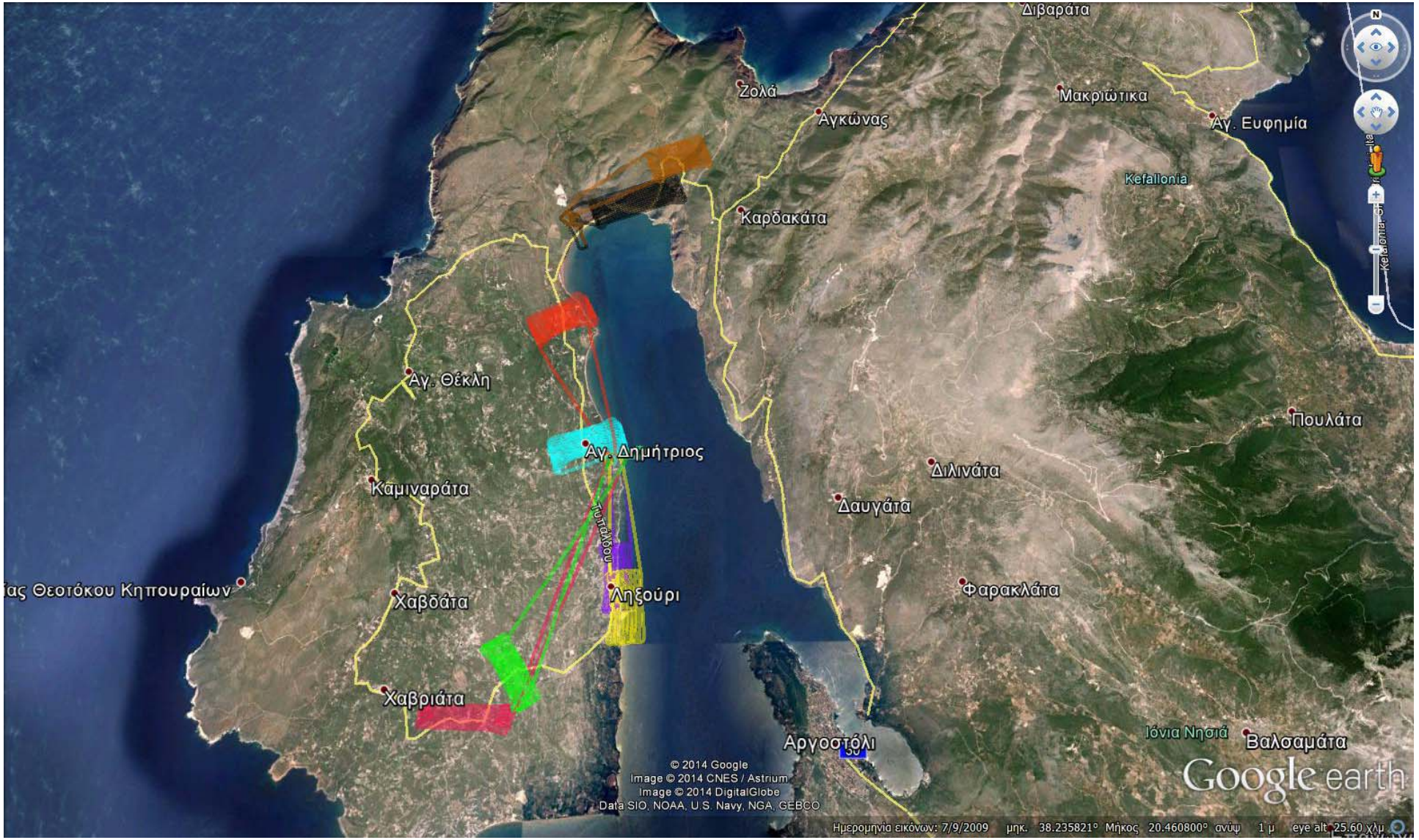
UAV Flight Preparation



Mapping earthquake damages

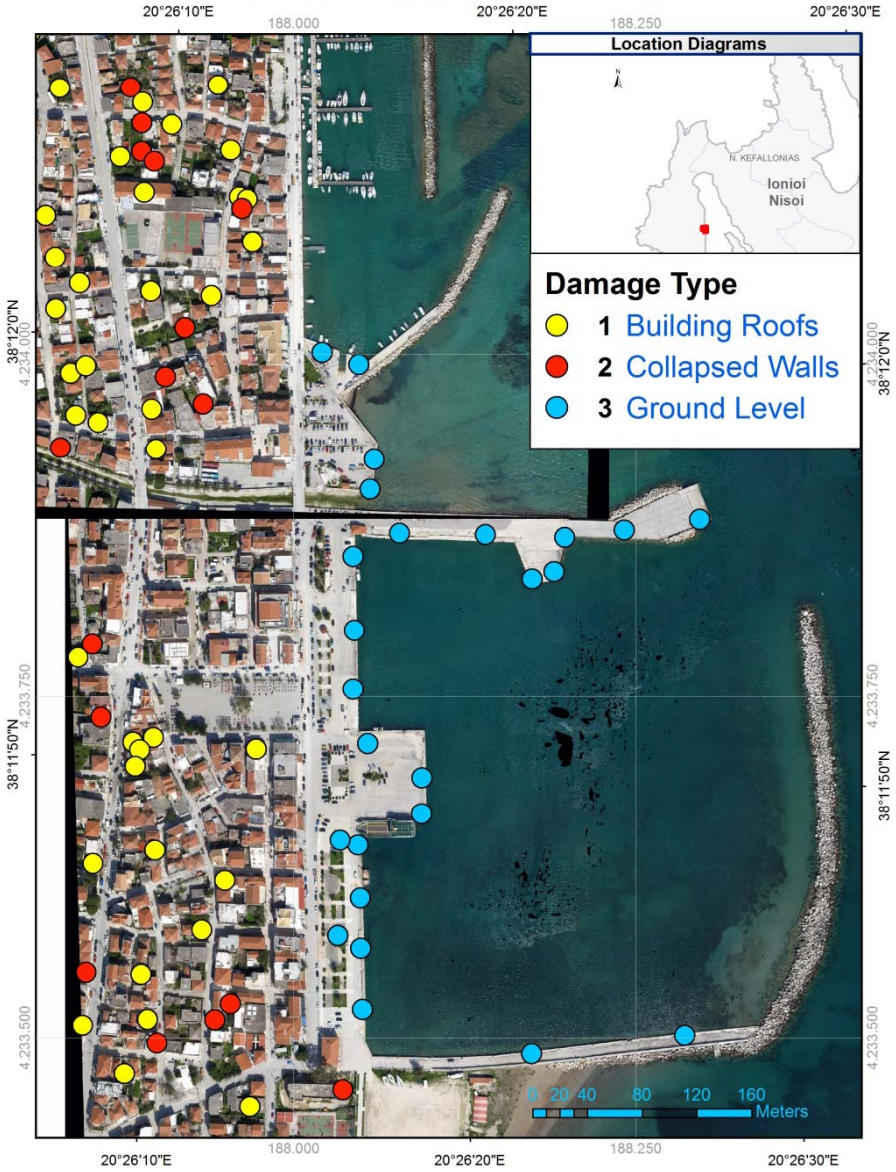
Mapping earthquake damages

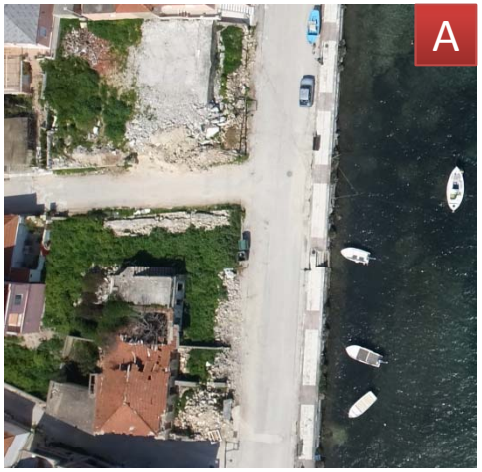
UAV Flight Paths

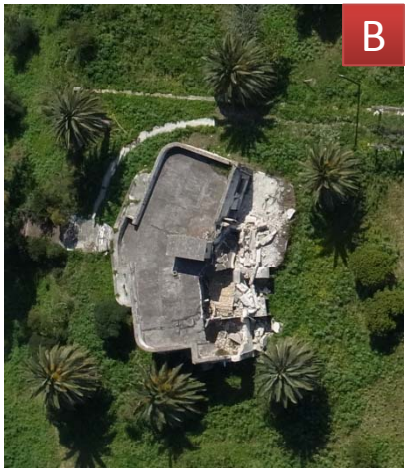


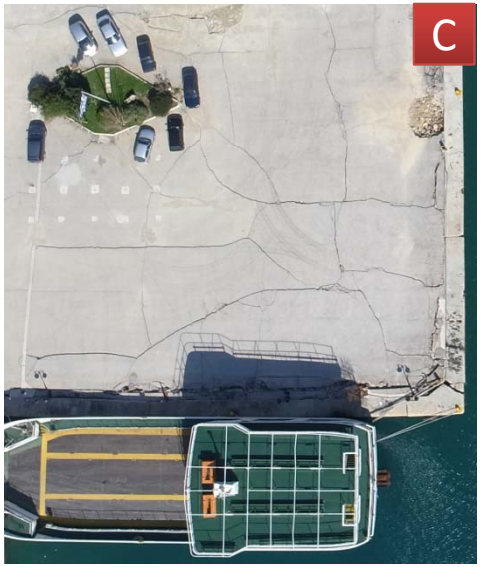
Mapping earthquake damages

Cephalonia Island – Town of Lixouri



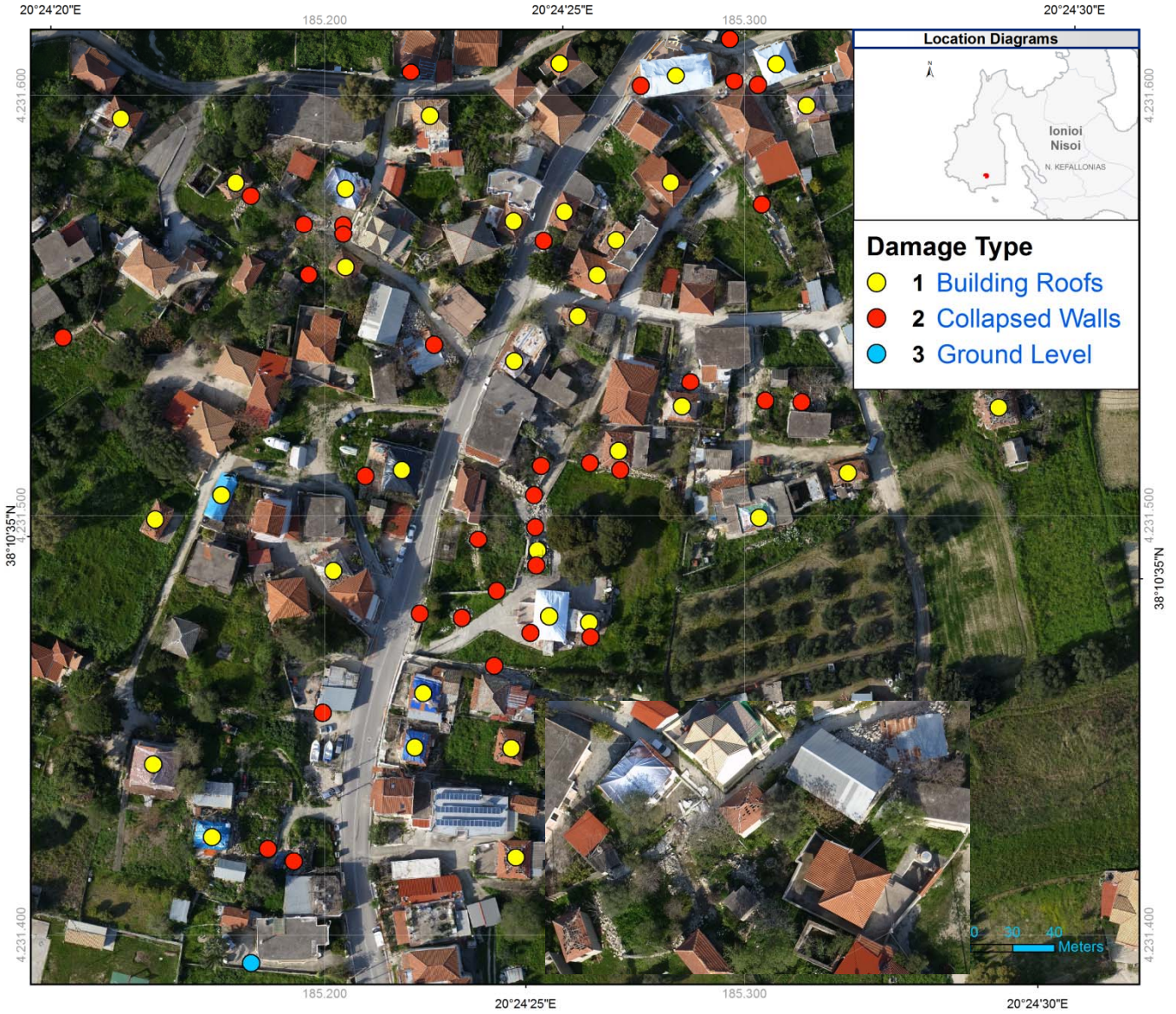


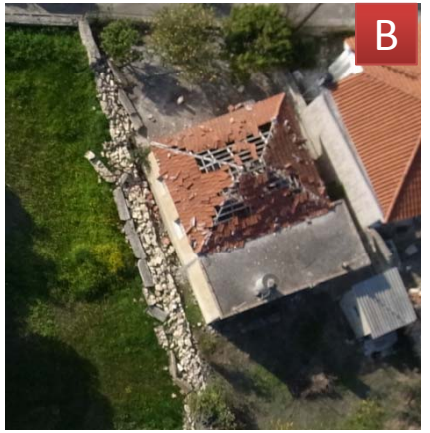




Mapping earthquake damages

Cephalonia Island – Village of Mantzavinata





Conclusions & remarks

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

❖ Integrated 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?

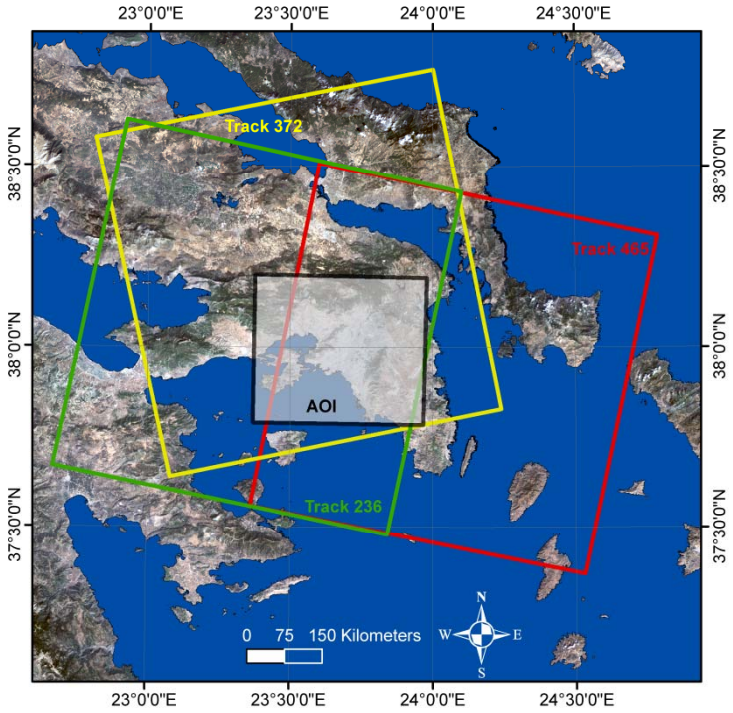
Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation in Attica

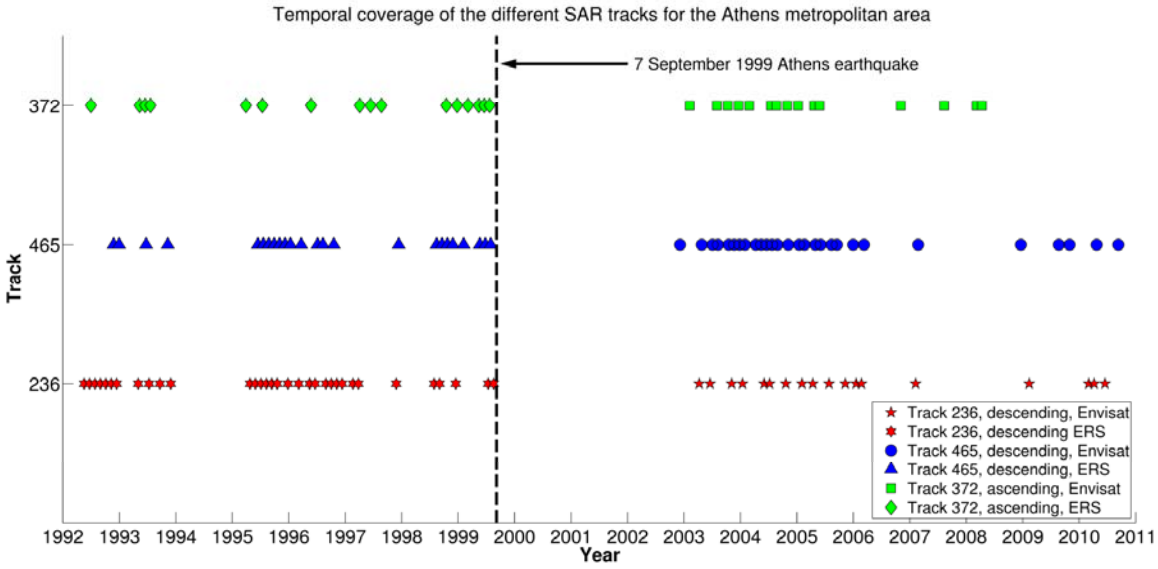
The interferometric stacks processed

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



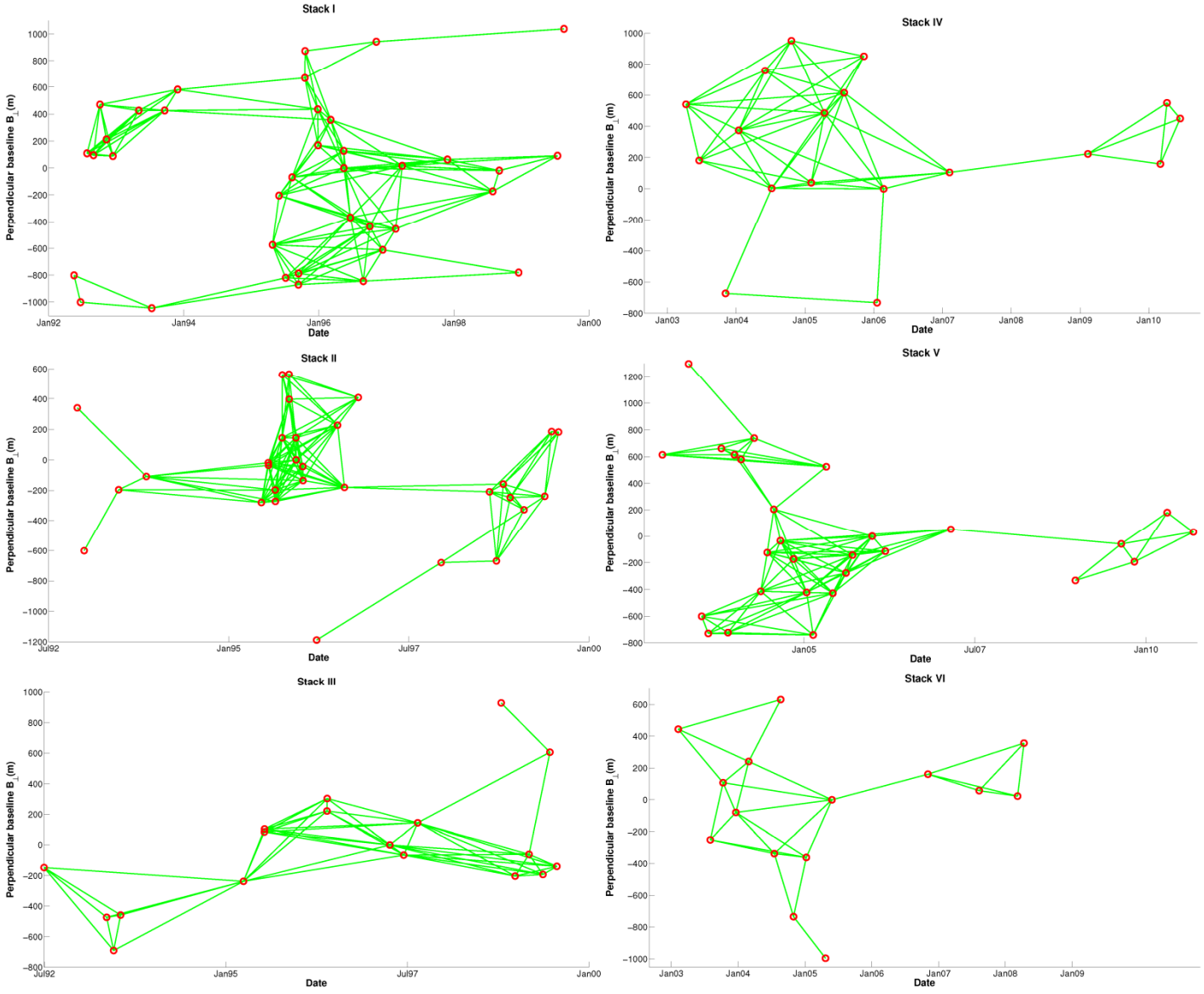
Temporal coverage of the six stacks



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

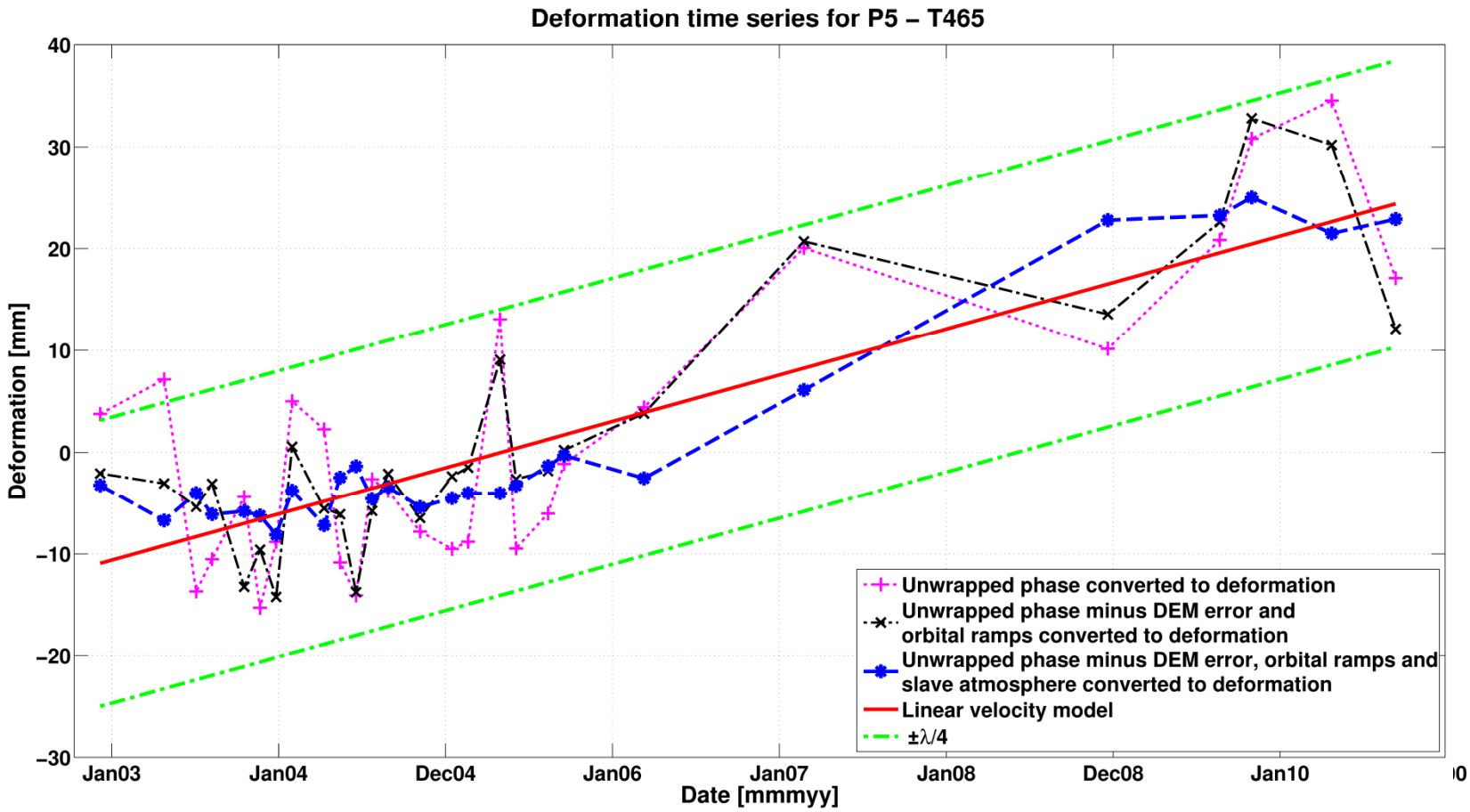


Time-series for monitoring slowly evolving phenomena

Diachronic mapping of crustal deformation in Attica

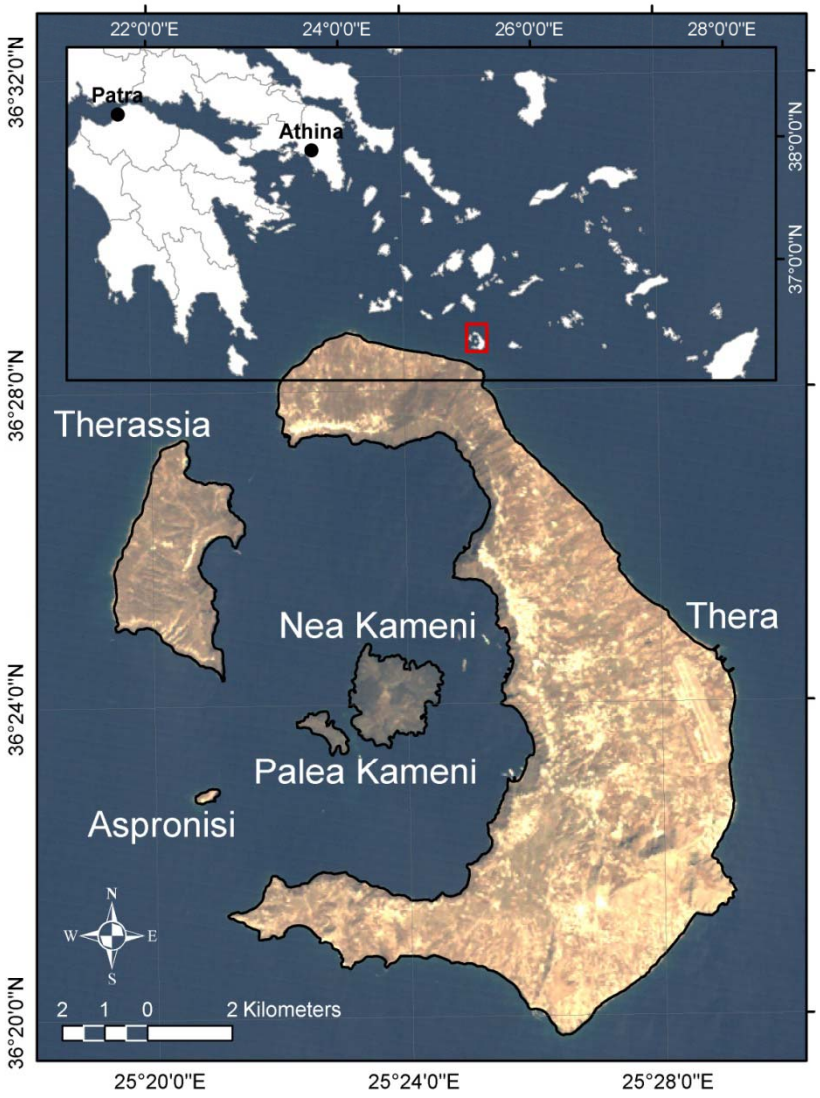
Deformation histories show the non-linear motion in Kifissia

1992-2010

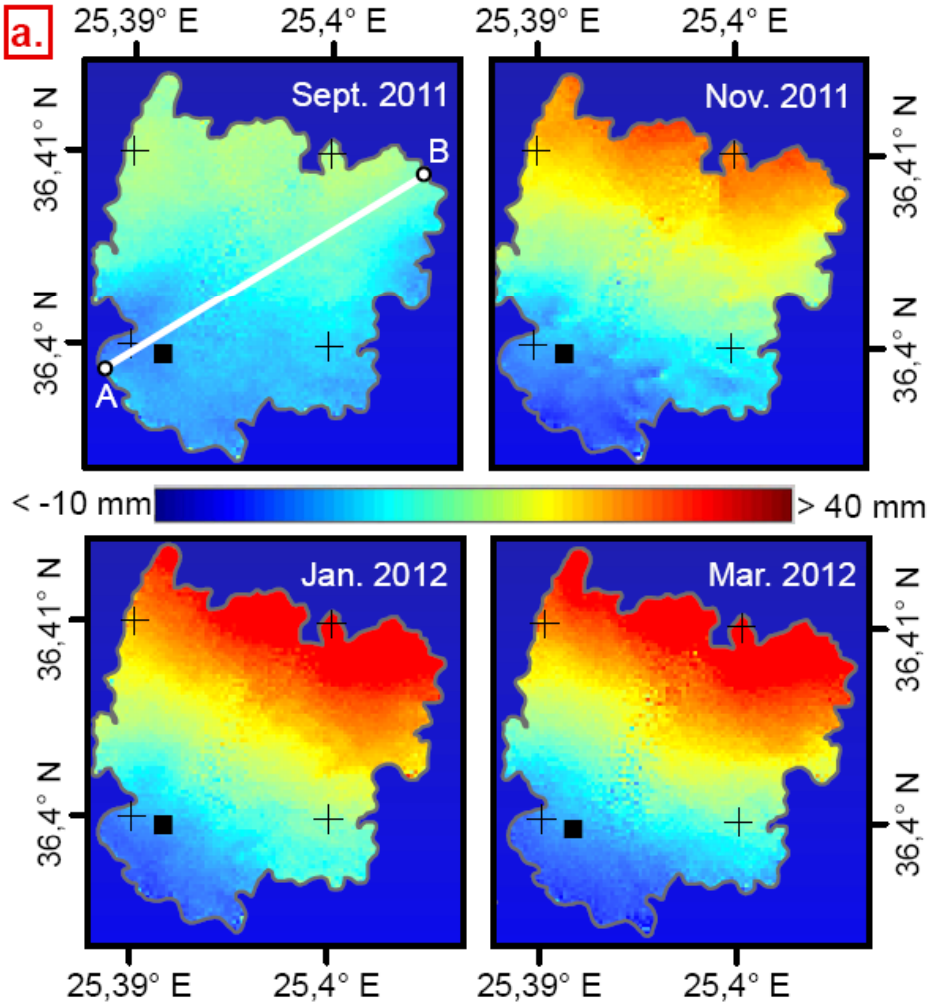


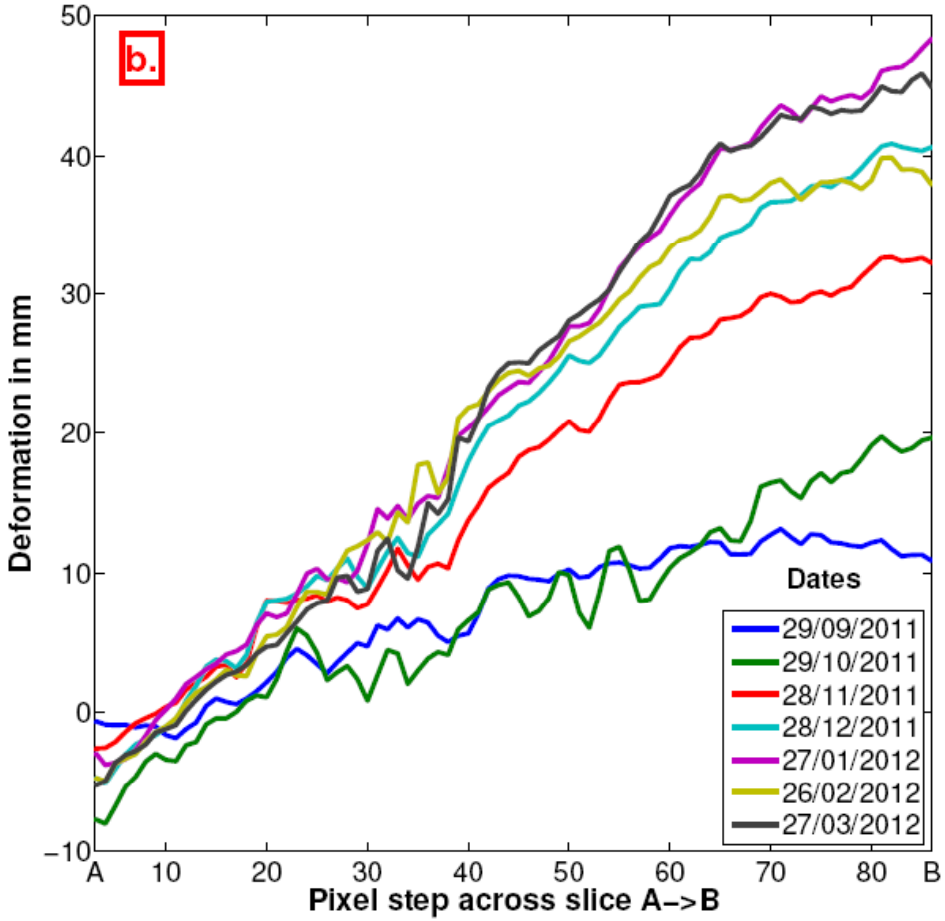
Background information on Santorini

- 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





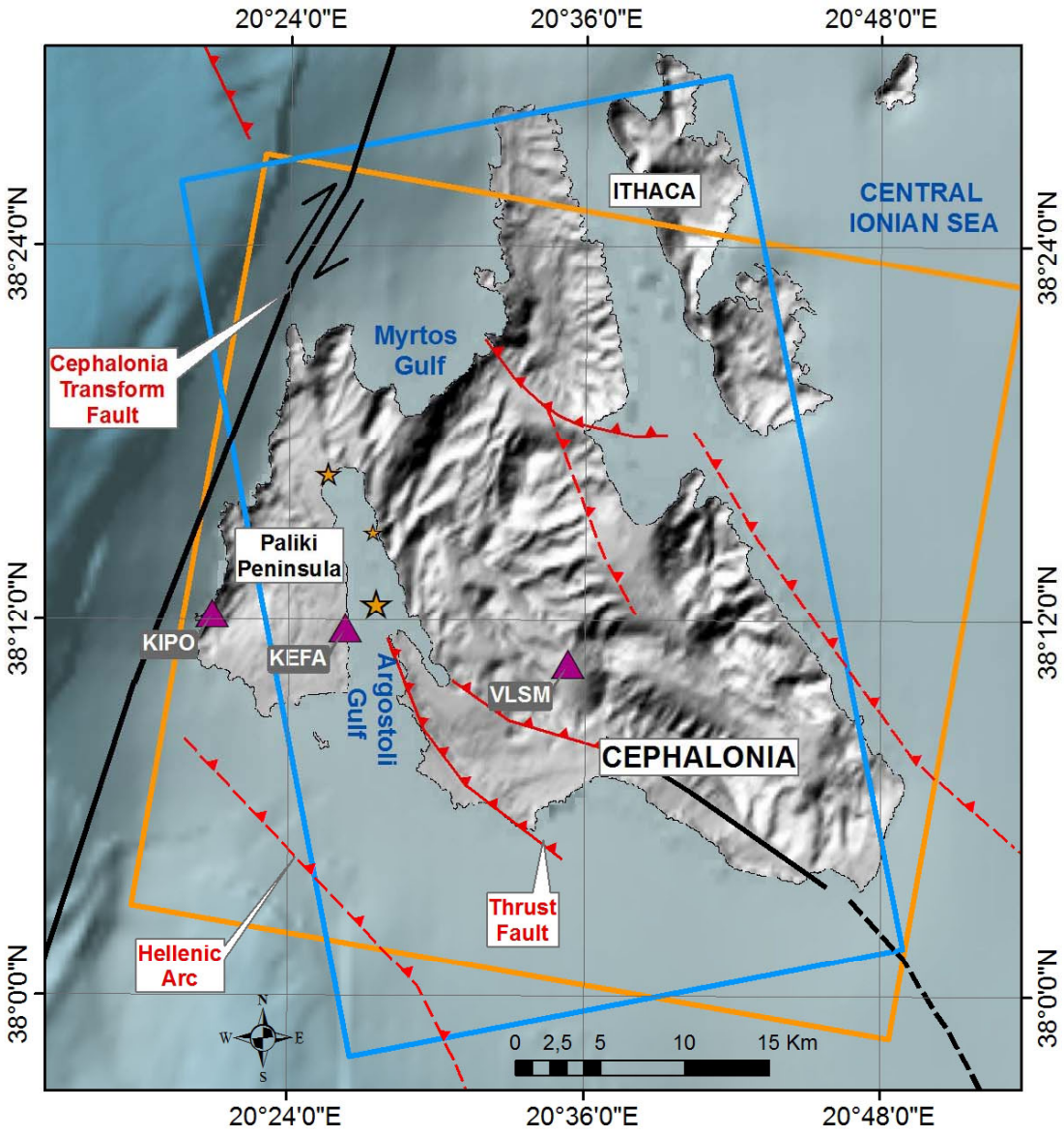
Modeling dispersion of volcanic ash

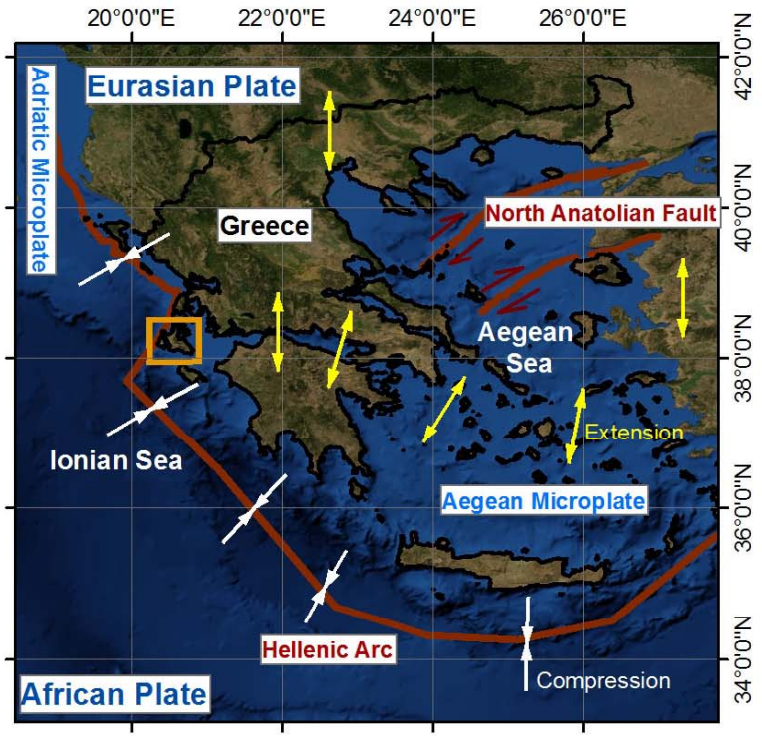
Examples of recorded aviation incidents related to volcanic ash

KLM Flight 867, 15 December 1989

British Airways Boeing 747-200, 24 June 1982

Cephalonia earthquakes





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

GPS stations
- cGPS

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

SARframes
- COSMO-SkyMED
- TerraSAR-X