



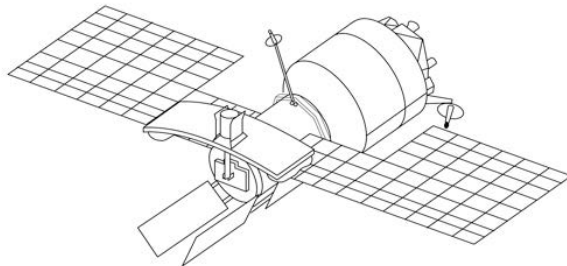
*Building Capacity for a Centre of Excellence for
EO-based monitoring of Natural Disasters*

Δορυφορική και εναέρια παρακολούθηση γεωκινδύνων - BEYOND GeoHUB

Γιάννης Παπουτσής

ΙΑΑΔΕΤ

Εθνικό Αστεροσκοπείο Αθηνών



The Final BEYOND Workshop
17 May 2016
Athens, Electra Palace



FP7-Regpot-2012-23-1

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

Fires & Floods

Geophysical hazards

Atmospheric disasters

Urban environment

Data & methods tier

Sentinel Mirror Site

NSN

ENIGMA

NOANET

In-situ

Earth Observation - SAR Interferometry

Services tier

Geodesy

Modeling

Hazard assessment

Large scale processing

Applications tier

Volcanoes

Tectonics

Landslides

Subsidence

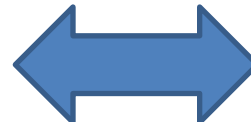
Users tier

WEB GIS

GIS



The Web



GeoHUB

An overview



Service	Status	Input data	Scale
Mapping of large-scale ground velocities & 3D decomposition	Operational	SAR, GPS	National
Estimation of earthquake 3D crustal deformation	Operational	multi-angle SAR, GPS	Local
Seismic risk estimation	pre-operational	SAR, in-situ, GIS	Local
UAV based damage assesement	Operational	Aerial data	Local
Mapping of tectonic hazard areas in subduction zones	Research	SAR, GPS	Regional
Monitoring of volcanic activity	Operational	SAR, GPS, in-situ	Local
Monitoring dispersion of volcanic ash	pre-operational	Weather data	Regional
Detection of new landslides	Operational	SAR	Local
Update of landslide inventory maps	pre-operational	SAR, in-situ	Regional
Estimation of landslide susceptibility	pre-operational	SAR, in-situ, GIS	Regional
Detection of subsidence in urban & peri-urban areas due to manmade activities & physical processes	Operational	SAR, GPS	Regional
Monitoring of construction activities in urban environment	Operational	SAR, GPS	Local

GeoHUB

Earthquake deformation mapping



Data

NSN

NOANET

ENIGMA

In-situ

Services

Geodesy

Modeling

Hazard Ass.

Large Proc.

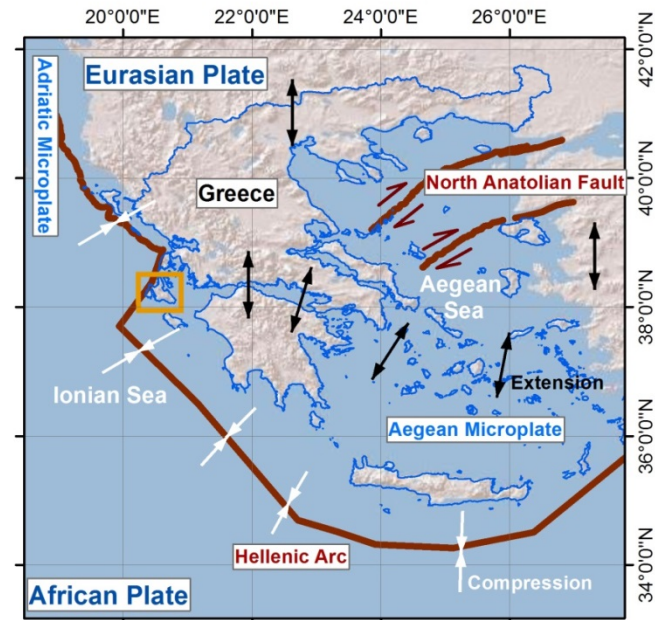
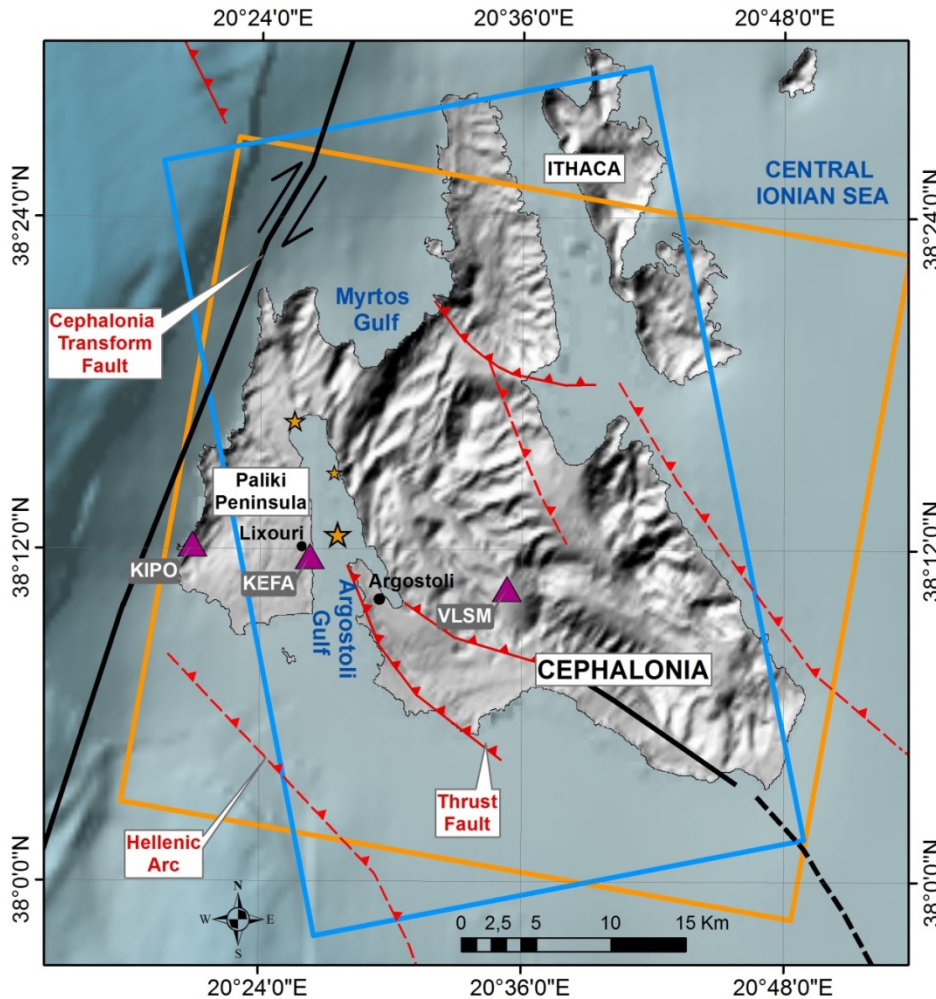
Applications

Tectonics

Volcanoes

Landslides

Subsidence



Mapped faults

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

GPS stations

- ▲ cGPS

Main earthquake events

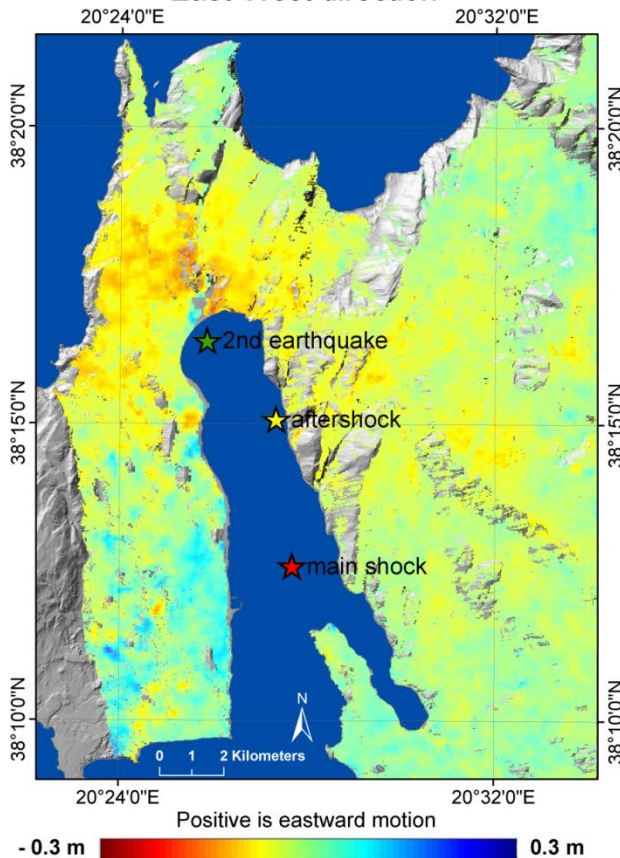
- ★ 26/1/2014 ML 5,1
- ★ 3/2/2014 ML 5,7
- ★ 26/1/2-14 ML 5,9

SARframes

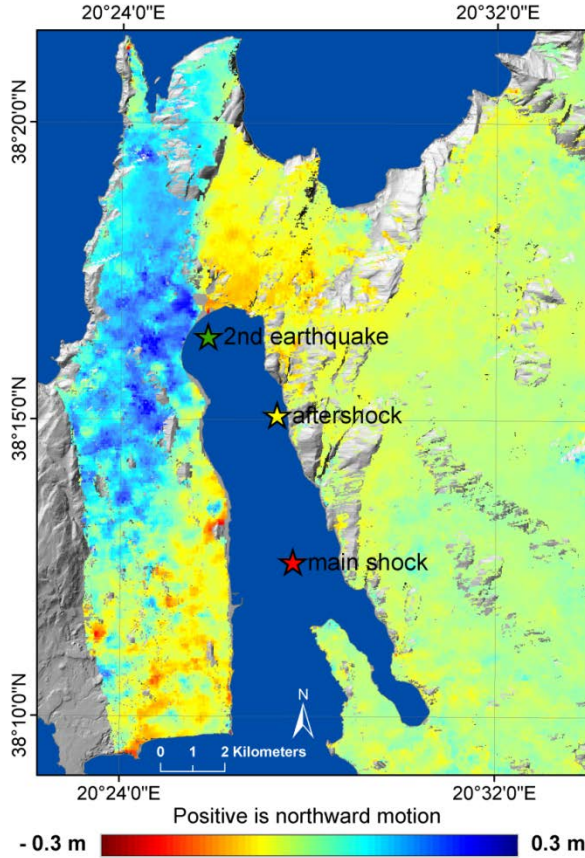
- COSMO-SkyMED
- TerraSAR-X

- 3D crustal deformation from TerraSAR-X & COSMO-SkyMed data
- Inversion to estimate fault parameters

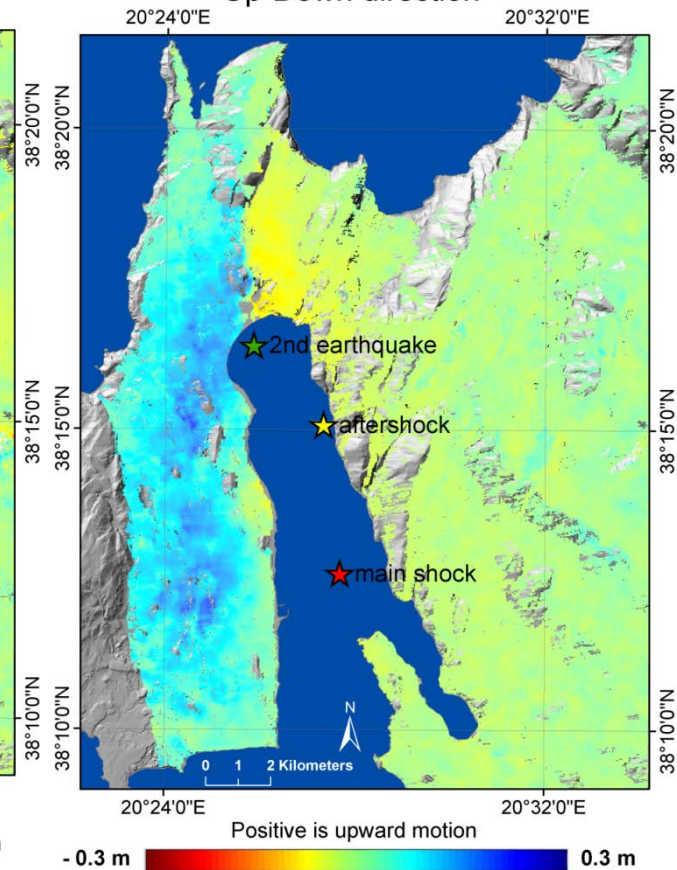
East-West direction



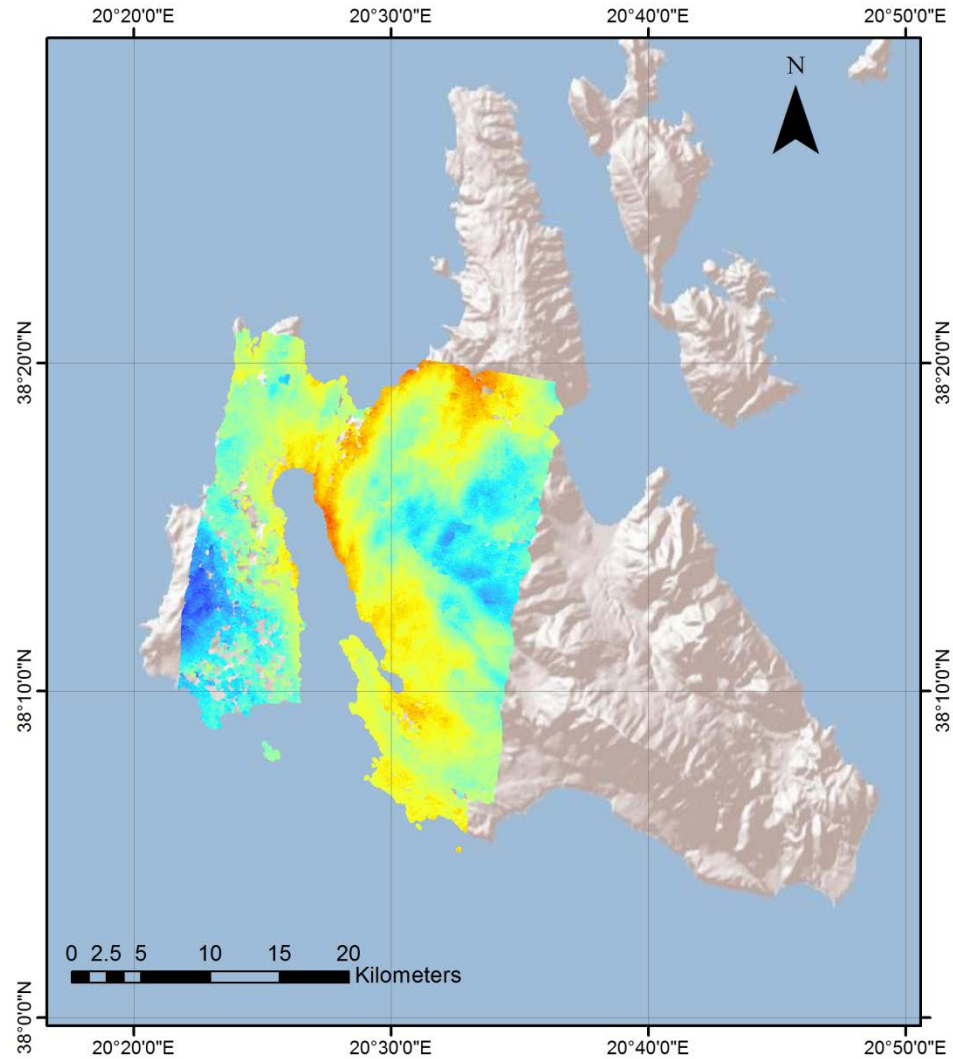
North-South direction



Up-Down direction



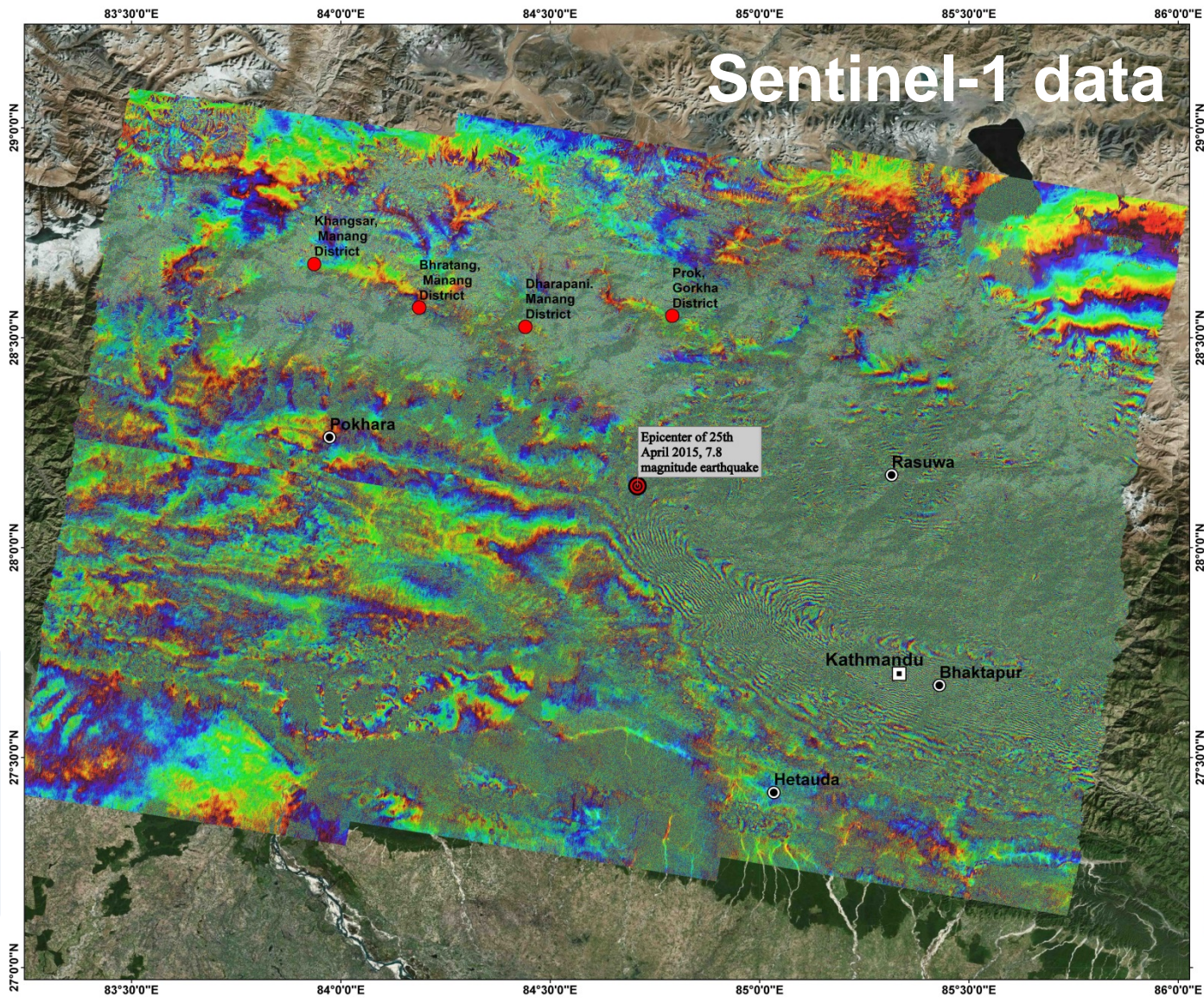
Post-seismic slip,
measured with
COSMO-SkyMed
data



-40 mm/yr  **+40 mm/yr**

GeoHUB

Earthquake deformation mapping



Sentinel-1 data

Nepal, South Asia Earthquake Mapping Assessment Map: Interferogram
 Production Date 15/06/2015

Location Diagrams
 Shows a map of Nepal with a red box indicating the area covered by the interferogram.

Cartographic Information
 Scale: 1:50 000 for A1 prints. Full color A1, high resolution (300dpi)
 Grid: Geographic Datum: WGS 1984 Tick Marks: Lat/Lon (DMS), Datum: WGS 84

Legend

- Epicenter of 25th April 2015 epicenter
- Kathmandu capital city
- Major cities
- Landslides locations triggered by 25th of April Nepal earthquake
- Area of Interest

Map Information
 On April 25 2015, a Mw 7.8 earthquake hit Nepal, 81km northwest of Kathmandu capital city. Shortly after the earthquake, two Sentinel-1 Synthetic Aperture Radar images were acquired, one before (17/04/2015) the devastating earthquake and one after (08/05/2015). They were combined to form an interferogram that depicts ground deformation due to the earthquake. This map shows the fringe pattern associated with the event, where each color cycle demonstrates phase difference of π (1/2), interpreted as ground deformation equal to 2.8 cm in the direction of the satellite.

Data Sources
 Sentinel-1 descending SAR data © ESA through the Hellenic National Sentinel Data Mirror Site (<http://sentinel.hellaspace.roe.gr/>)
 Landslide locations © The Hellenic National Data Exchange (<https://data.helix.melita.org/>)
 Microsoft © BingMaps TM
 World Topo Map © ESRI, ARCGIS services online

Software used
 Interferometric processing: SARscape 5.2 beta, sarmap SA
 Raster manipulation: ENVI 5.0, Exelis Inc.
 Map production: ArcMap 10.2, ESRI ArcGIS

Dissemination/Publication
 No restrictions on the publication of the mapping apply.

Framework
 The present map is generated in the context of BEYOND Center of Excellence (<http://www.beyond-eu.com/>) established at the National Observatory of Athens and funded by the European Commission as part of the FP7 REPOSIT framework initiative (GA: 214270). BEYOND provides products and services for its stakeholders, aimed at the scientific and operational monitoring of natural disasters from space. BEYOND activities are boosted by the Hellenic National Sentinel Data Mirror Site, also established in NCA, under the current ESA-NCA agreement, in the frame of the Collaborative Ground Segment Initiative. The goal is to support the rapid dissemination and almost near real time production of Sentinel-based products, towards the scientific monitoring and effective management of natural disasters for preparedness and risk reduction activities.

Map Production
 This map was generated by processing TOPSAR Sentinel-1 data using SARscape v5.2. Conventional radar interferometry techniques were employed, customised for Sentinel-1 data. Depending on the interferogram, noise levels (different measurement accuracy of the technique) is about 1 cm in the line-of-sight to the satellite.

Production team
 Christian Pournazeris, Ioanna Papanicolaou, Name of the Hellenic Inspector Quality Control, NCA, Hellenic Organization Meteorology/Operational Affairs
 ©2015 The National Observatory of Athens

Data

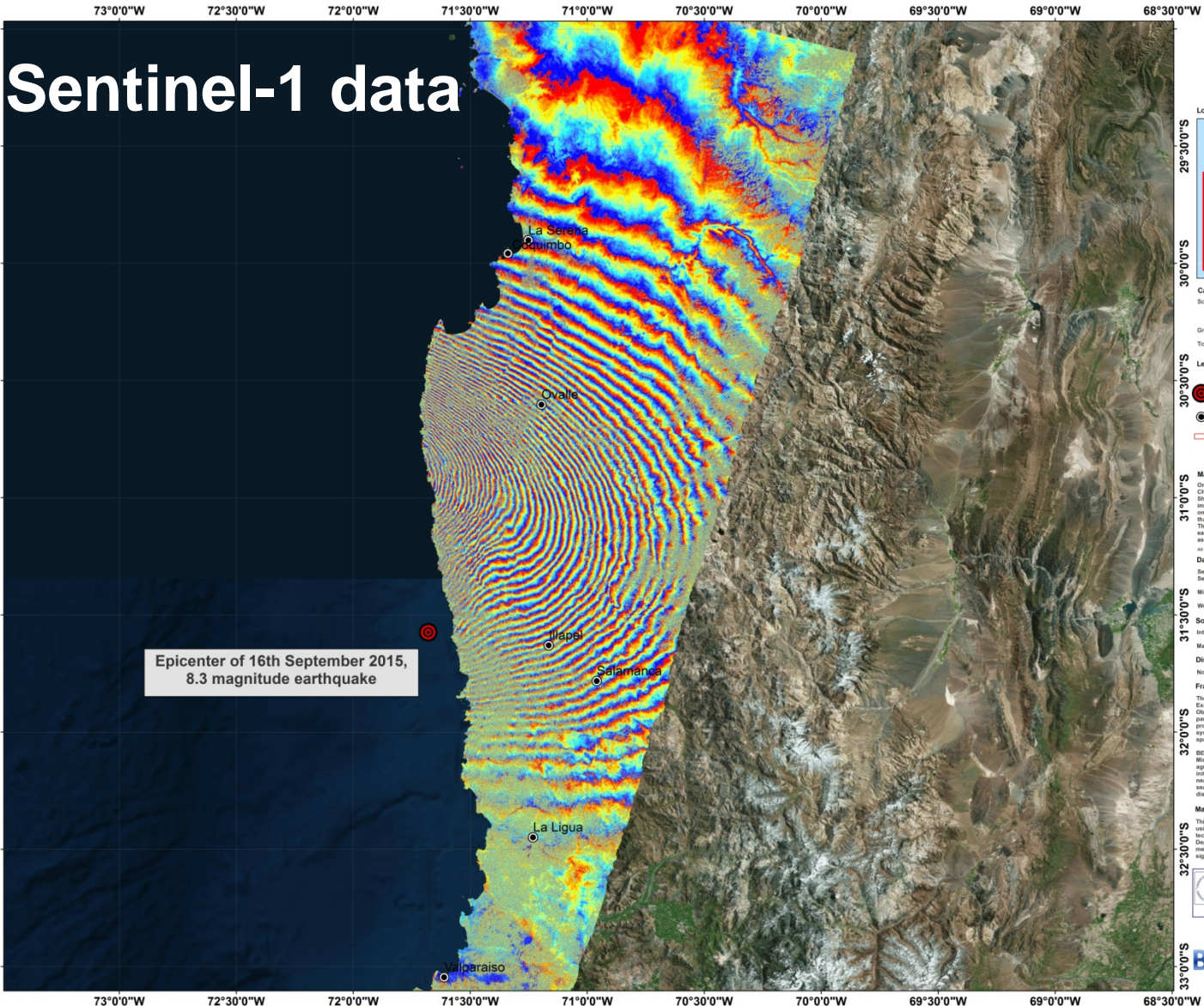
- NSN
- NOANET
- ENIGMA
- In-situ

Services

- Geodesy
- Modeling
- Hazard Ass.
- Large Proc.

Applications


- Tectonics
- Volcanoes
- Landslides
- Subsidence




Sentinel-1 data

Epicenter of 16th September 2015, 8.3 magnitude earthquake

Coast of Central Chile
Earthquake Mapping
 Assessment Map: Interferogram
 Production Date 06/10/2015

Location Diagrams


Cartographic Information
 Scale: 1:60 000 for A1 prints Full color A1, high resolution (300dpi)
 GCS: Geographic Datum: WGS 1984
 Tick Marks: Lat/Lon (DMS); Datum: WGS 84

Legend

 ● Epicenter of 16th September 2015 earthquake
 ● Major Cities
 □ Area of Interest
 Color scale for LOS phase change from -10 to 10.

Map Information
 On September 16 2015, a Mw 8.3 earthquake hit the coast of Central Chile, west of Illapel city. Shortly after the earthquake, two Sentinel-1 Synthetic Aperture Radar images were acquired, one before (13/09/2015) the shake event and one after (17/09/2015). They were combined to form an interferogram that depicts the ground deformation due to the earthquake. This map shows the fringe pattern associated with the event, where each color cycle demonstrates phase difference of π (or $\pi/2$) interpreted as ground deformation equal to 2.8 cm along the line of sight (LOS). All monthly interferograms features are captured with the best effort but in some cases may not be complete.

Data Sources
 Sentinel-1 descending SAR data © ESA through the Hellenic National Sentinel Data Mirror Site (<http://sentinelspace.noa.gr/>)
 Microsoft © BingMaps TM
 World Topo Map © ESRI, ArcGIS services online

Software used
 Interferometric processing: Sentinel-1 Toolbox version 1.1.5
 Map production: ArcMap 10.3, ESRI ArcGIS

Dissemination/Publication
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 BEYOND activities are boosted by the Hellenic National Sentinel Data Mirror Site, also established in NOA, under the current ESA - NOA agreement, in the frame of the Collaborative Ground Segment initiative. The goal is to support the rapid dissemination and almost real-time exploitation of Sentinel-1 products towards the seamless monitoring and effective management of natural disasters/preparedness and risk reduction activities.

Map Production
 This map was generated by processing TOPSAR Sentinel-1 data using Sentinel-1 Toolbox v.1.0. Conventional radar interferometry techniques were employed, customized for Sentinel-1 data. Depending on the interferogram noise levels the inherent measurement accuracy of the technique is about 1 cm in the line-of-sight to the satellite.

Production team: Christina Psychogios, Ioanna Papadopoulou, Christoforos Koutavas (Quality control) NOA
 Responsible organization: National Observatory of Athens
 ©2015 The National Observatory of Athens. E-mail: ipapadop@noa.gr

Data

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Data

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ENIGMA

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Hazard Ass.

Large Proc.

Applications

Tectonics

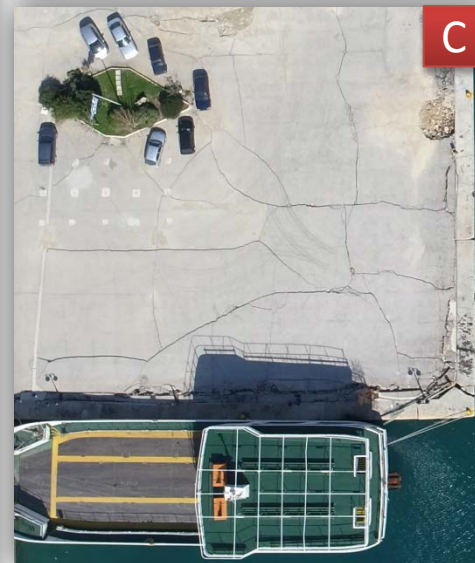
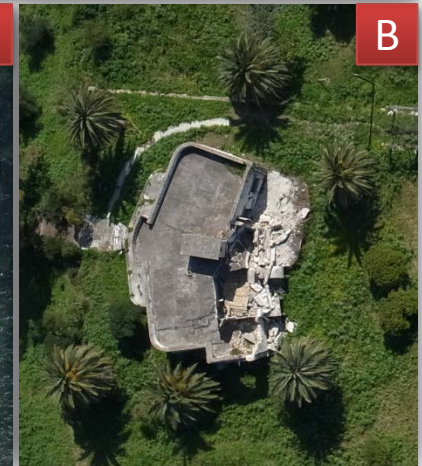
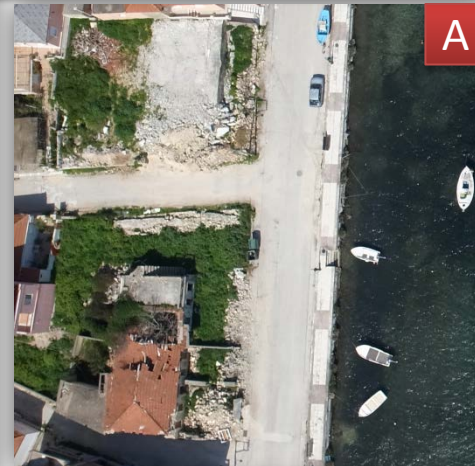
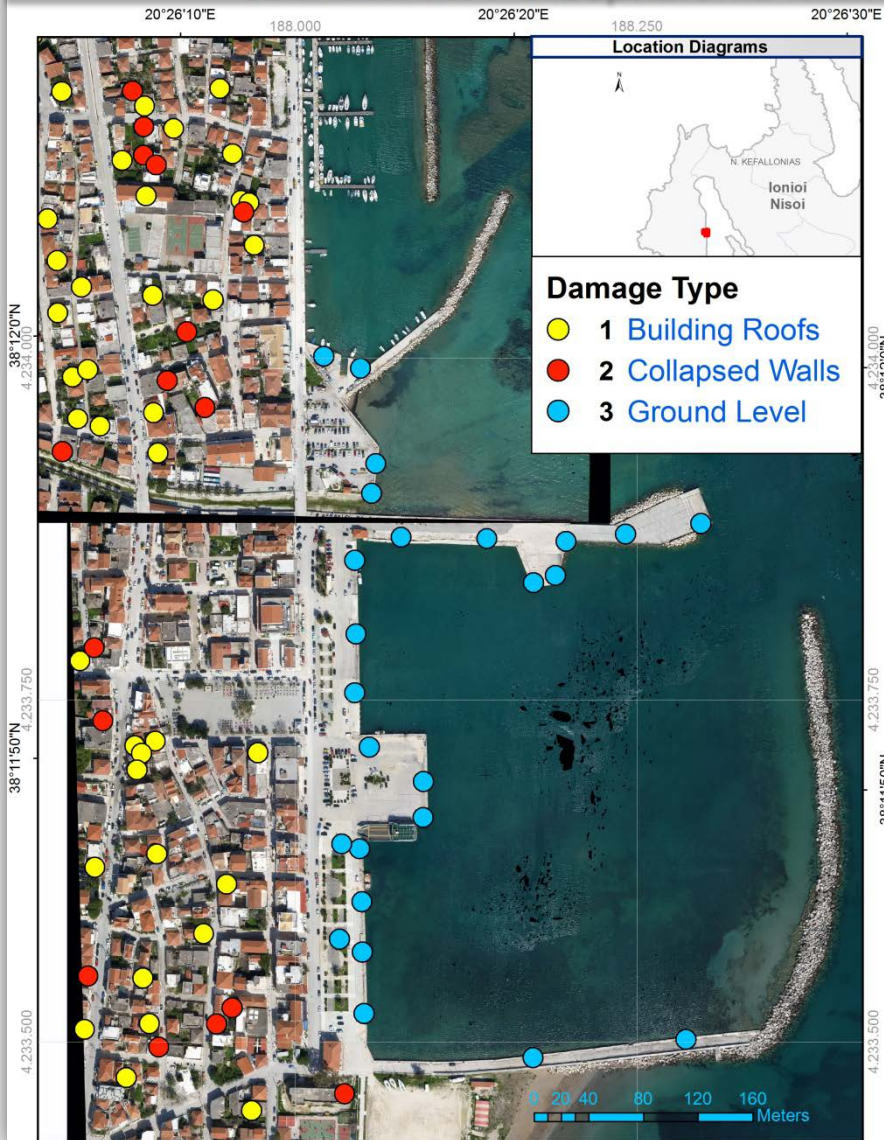
Volcanoes

Landslides

Subsidence



Cephalonia Island – Town of Lixouri



GeoHUB

UAV octocopter





Data

NSN

NOANET

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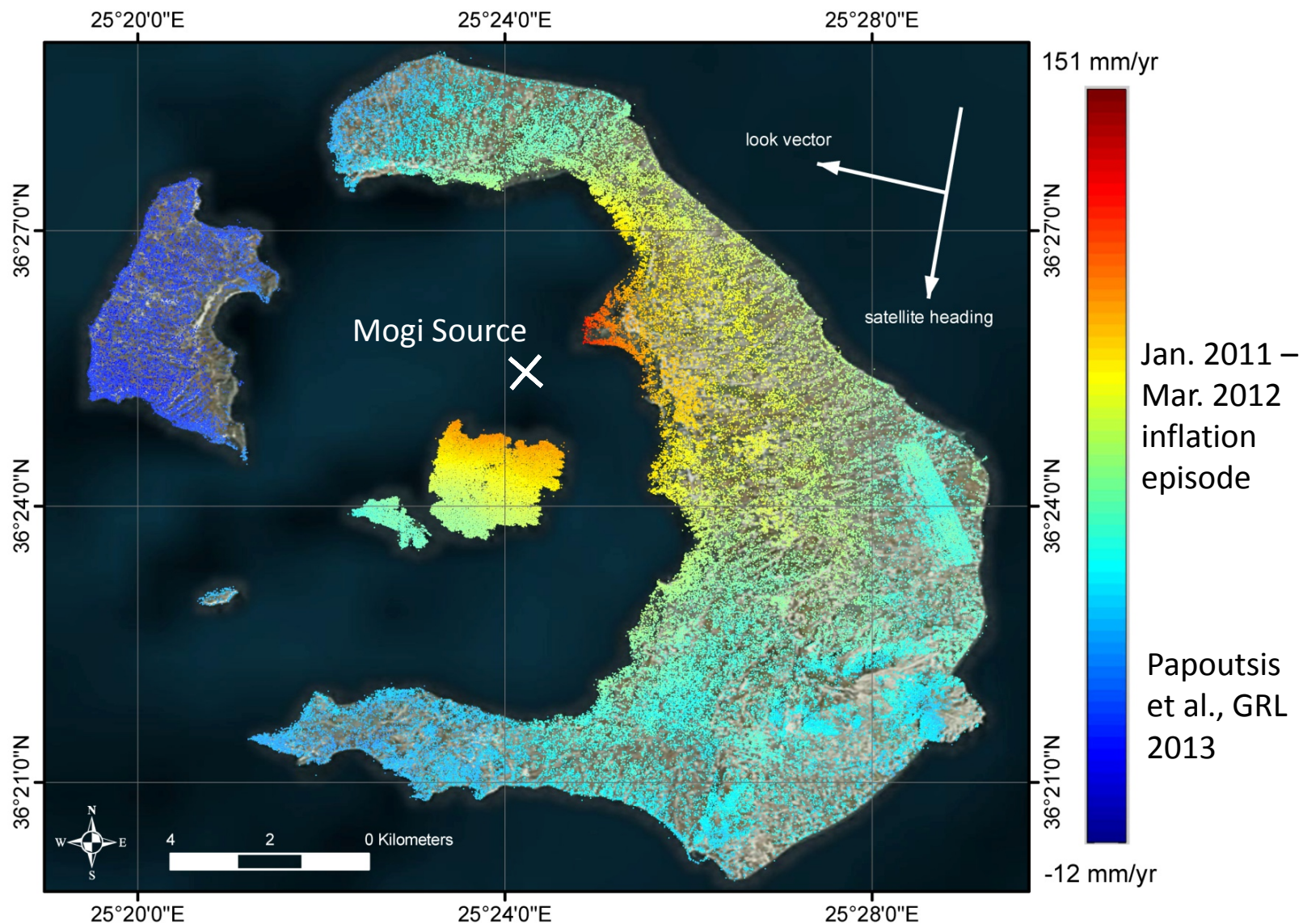
Applications

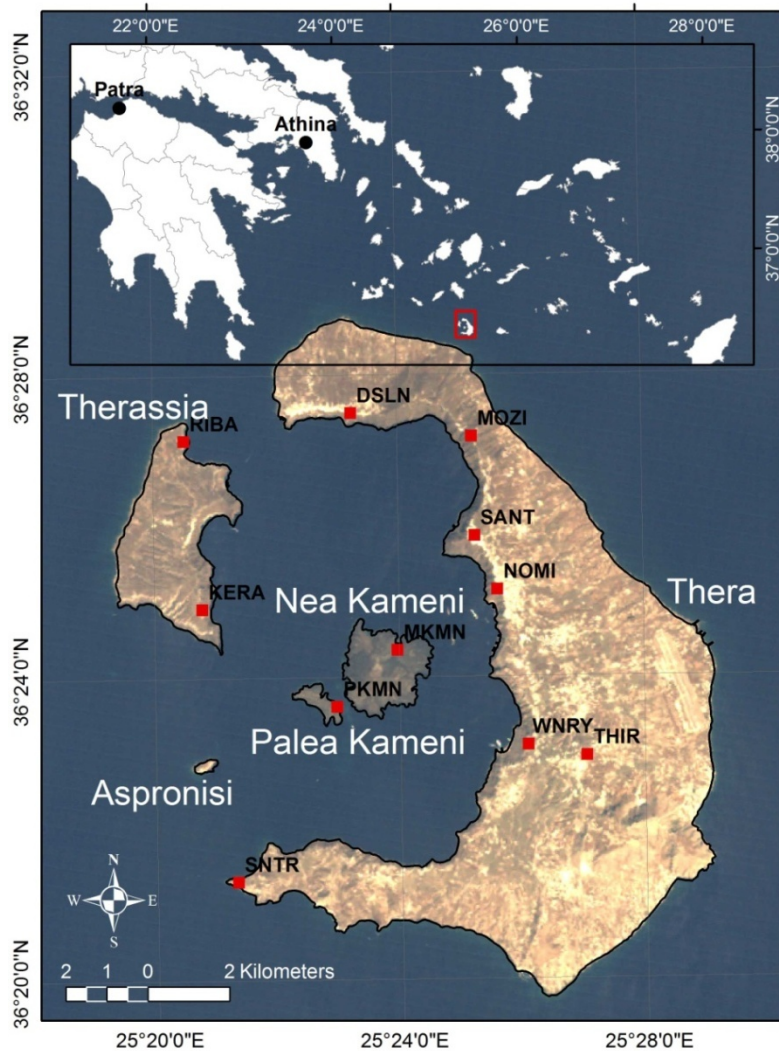
Tectonics

Volcanoes

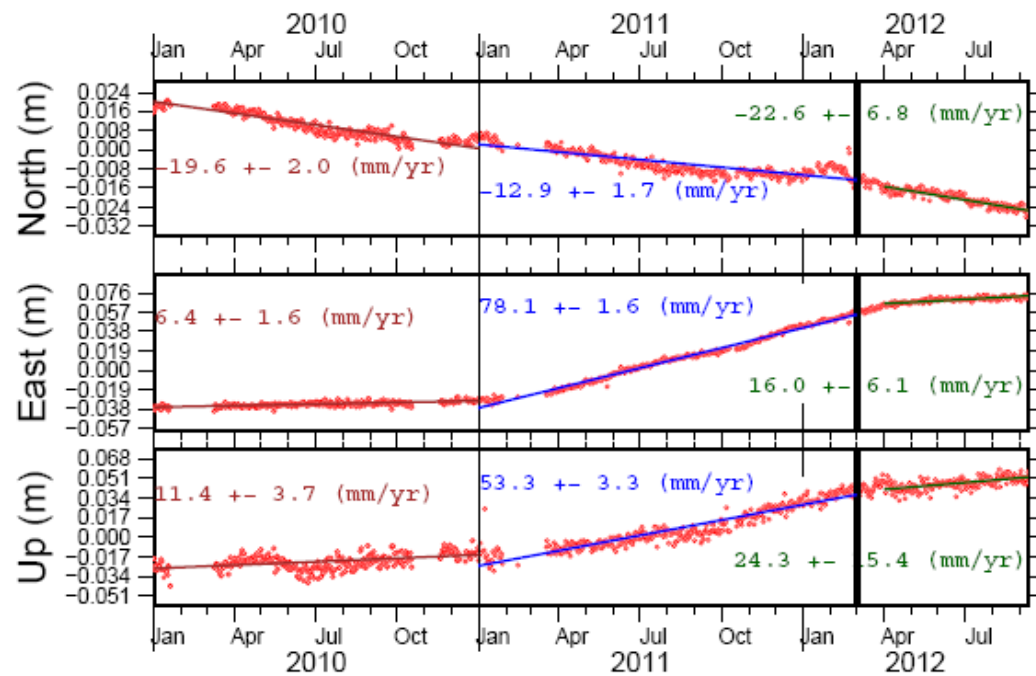
Landslides

Subsidence

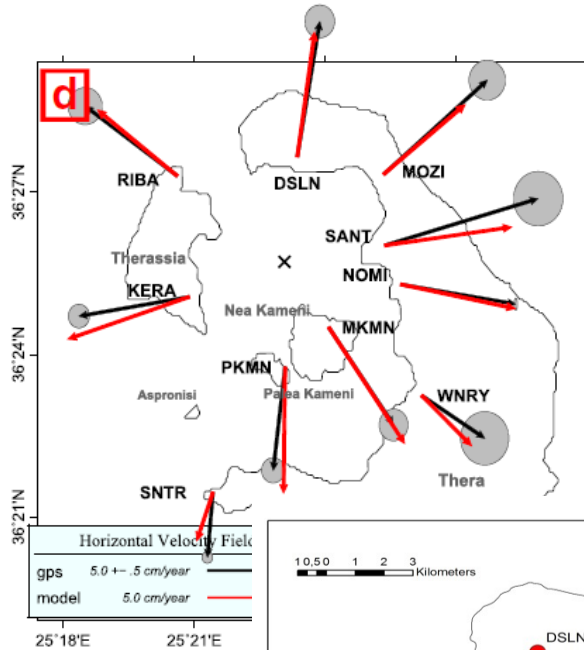




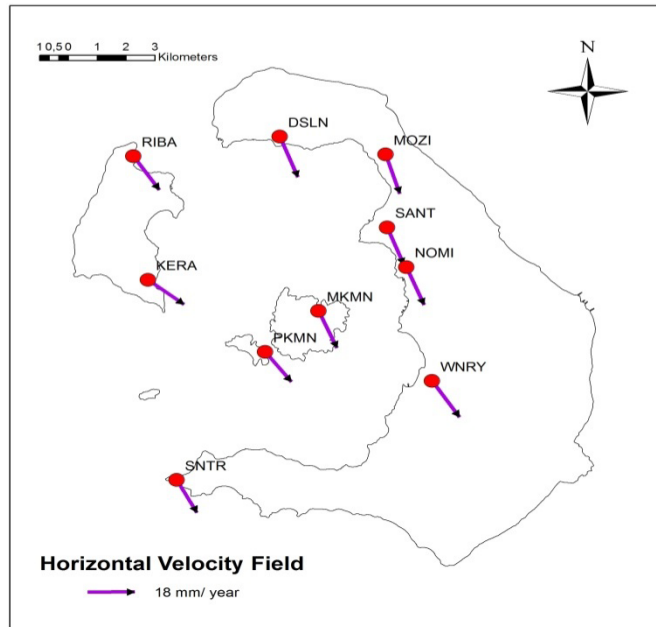
Time-series monitoring with in-situ GPS stations



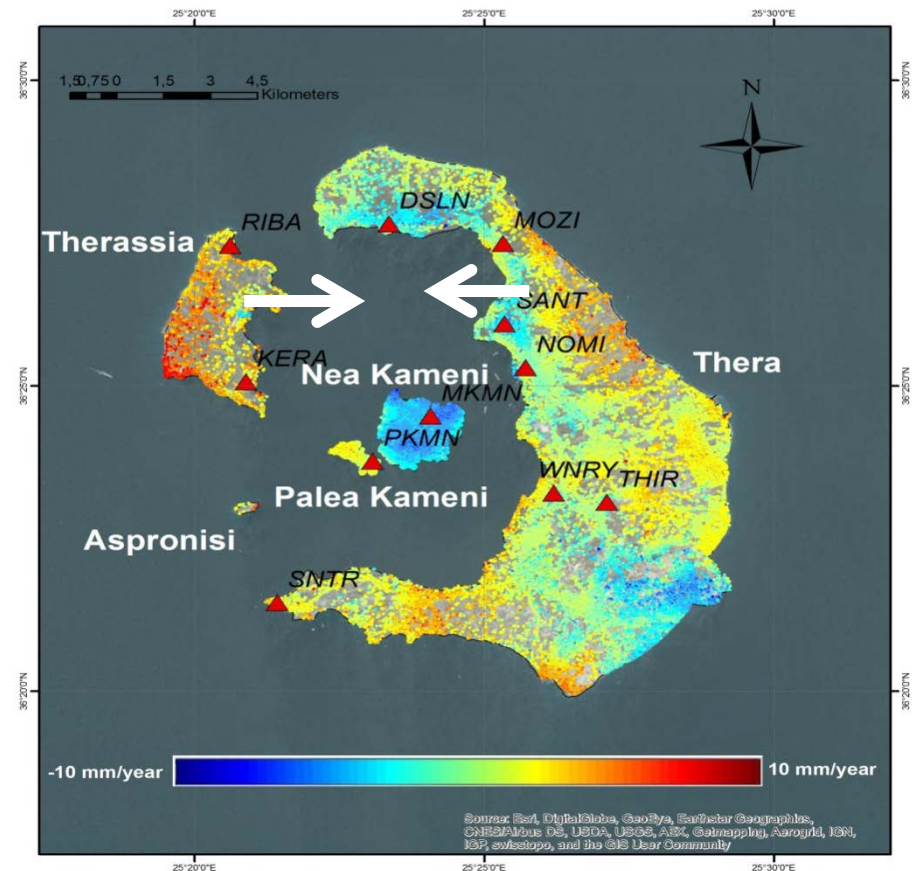
GPS data processing by Dionysos Satellite Observatory



Kaskara et al.,
LPS 2016



Post-inflation monitoring



Data

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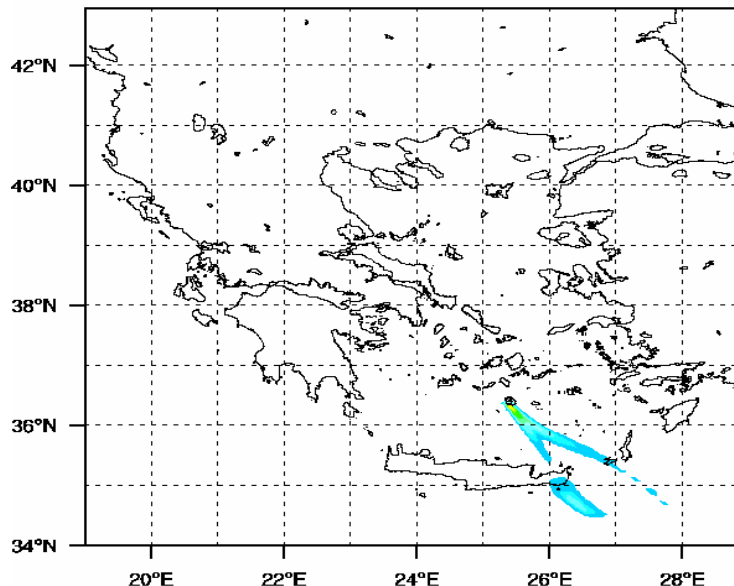
- Early warning system being developed in the framework of BEYOND
- The specific hypothesis assumes 60 hours of continuous emissions at 1.5 km height column

FLEXPART - NOA Airborne Volcanic Ash

valid date:09-05-2014 0000UTC

Model layer: Integrated Column

(ng m⁻³)

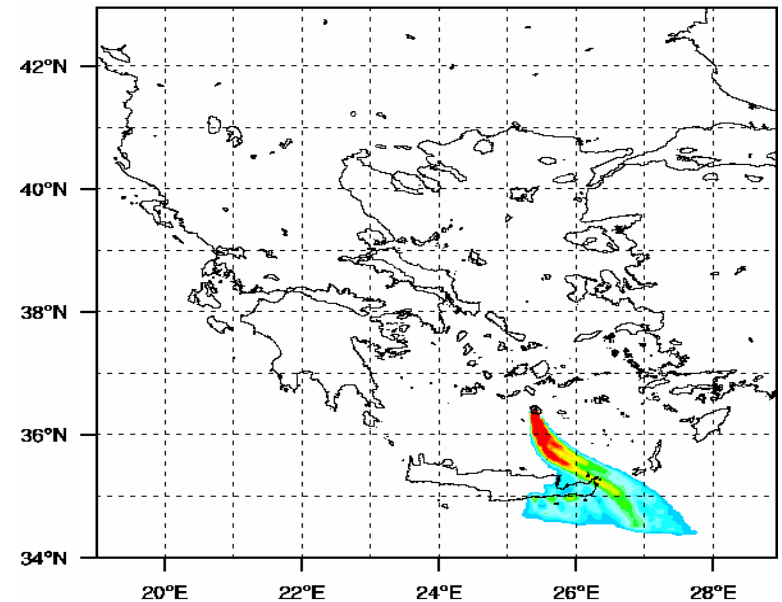


FLEXPART - NOA Deposited Volcanic Ash

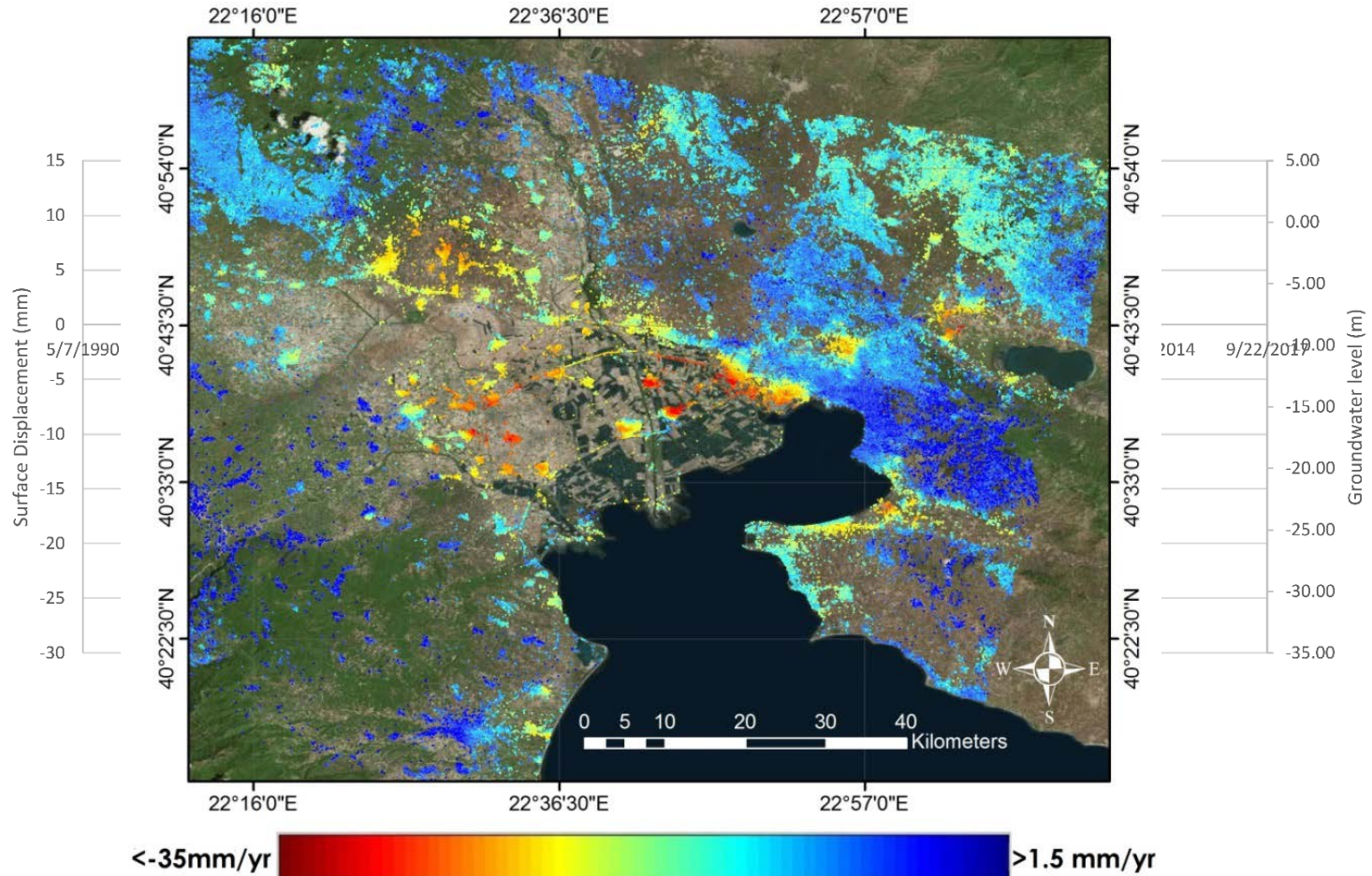
valid date:08-05-2014 0500UTC

Model layer: Surface

(ng m⁻³)



Thessaloniki (1992 - 2001, 2002 - 2010)



Driver: water over-pumping, Svigkas et al., Engineering Geology, Under review

Data

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GeoHUB

Seismic risk estimation



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Large Proc.

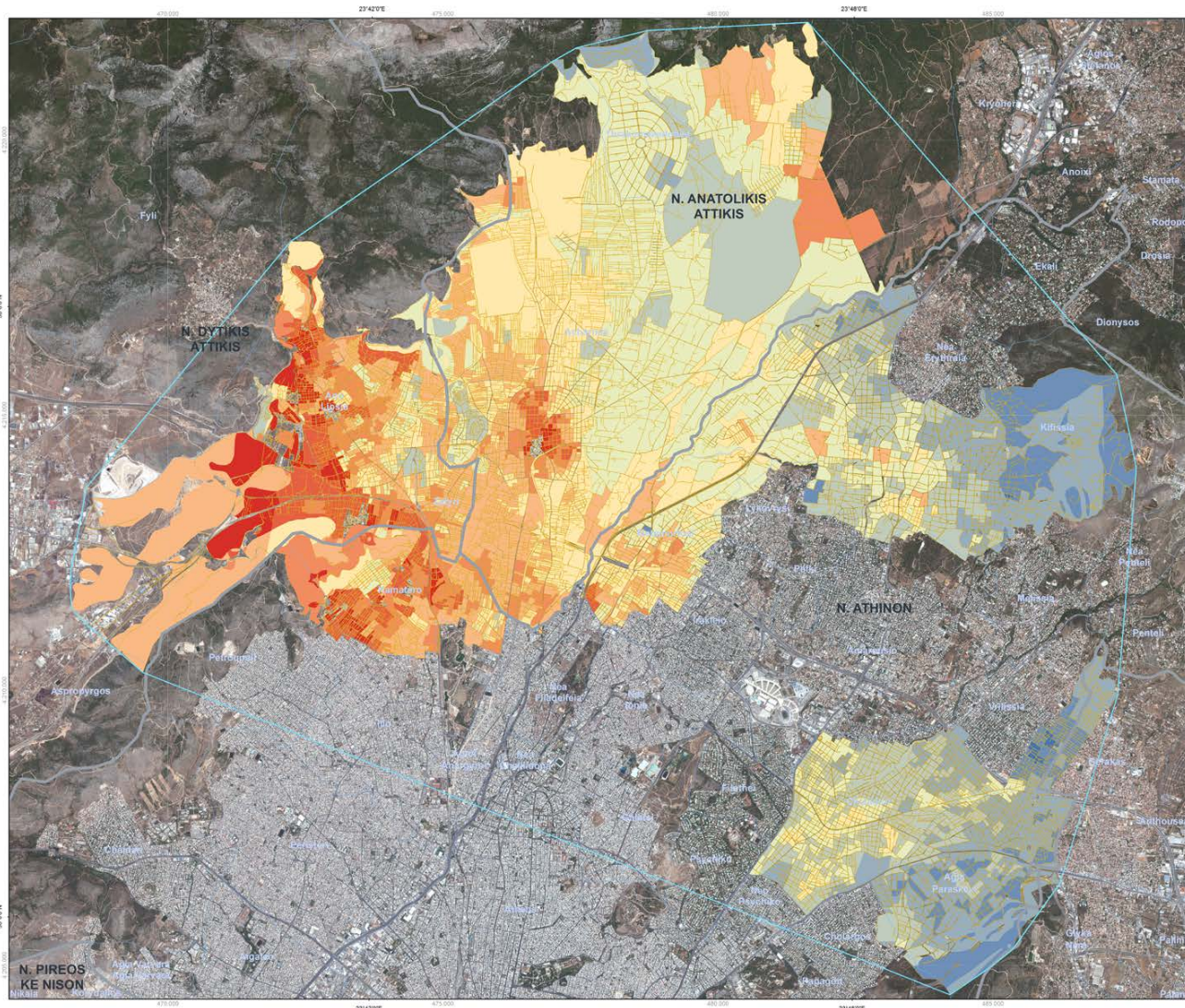
Applications

Tectonics

Volcanoes

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Subsidence

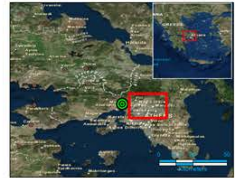


GLIDE number: EG-1999-000302-GRC Activation ID: GR-Dr-26_1 Product N: GR-Dr-26_1 (V01)

Greece - Attiki, Ano Iosia
Seismic Risk Scenario (Athens Earthquake of 07/09/1999)
Pre-disaster Situation Map: Seismic Risk Map

Production Date 30/11/2010

Location Diagrams



Cartographic Information

Scale: 1:31 000 for A1 prints Full color A1, high resolution (200dpi)
Scale: 1:740 Meters
Datum: D_GRS, 1987
Tic Mark: Lambert (GRS), Datum: WGS 84

Legend

Location Diagram		Seismic Risk	
●	Earthquake Epicenter	●	1.00 - 1.38
●	Peak Earthquake	●	1.39 - 1.77
■	Main Map	■	1.78 - 2.15
■	Area Of Interest	■	2.16 - 2.54
■	N.ATHINON Prefecture	■	2.55 - 2.92
■	Municipality	■	2.93 - 3.30
■	Postell	■	3.31 - 3.69
■	Census Block	■	3.70 - 4.07
■		■	4.08 - 4.45
■		■	4.47 - 4.84

Map Information

The Seismic Risk Map used as scenario the Athens Earthquake of September 7, 1999 (magnitude M=5.8) that hit the western side of the larger metropolitan area of Athens, capital city of Greece (GR). The map was produced in the framework of the MASSIVE project which provided the Civil Protection authorities with accurate and up-to-date maps of seismic risk, urban vulnerability, and building damage risk at census block scale, together with state-of-the-art uncontrolled population reconstruction models.

All results (hazard maps) are captured with best effort in vector cases may not be complete.

Data Source

© Hellenic Statistical Authority (EL-STAT), where applicable
© Copernicus Sentinel-1 satellite imagery
© Copernicus Sentinel-2 satellite imagery

Dissemination/Publication

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Delivery formats are GeoTIFF, GeoPDF, GeoPDFG

Framework

MASSIVE has attempted to provide indication as appropriate as possible, however all geographic information has limitations due to the wide-ranging modeling situations, update and interpretation of the original source materials. Accordingly, MASSIVE maps are distributed as "without any warranty, either expressed or implied, including but not limited to, warranties of suitability for a particular purpose or use. The entire risk as to the results of the use of these maps rests with the user and the applicable laws. No liability for any damage or inconvenience caused as a result of reliance on the mapping.

Map Production

Seismic Risk depends on three main parameters (a) the seismic sources that produce the hazard, (b) the ground motion that is attenuated away from the earthquake epicentre (c) the local soil conditions defined from a geologic map.

The seismic risk, which is closely related to the expected damage (D) is a function of hazard (H) and Vulnerability (V), $D = H \cdot V \cdot I$

Hazard in a particular area is expressed by Peak Ground Acceleration (PGA) while Vulnerability is expressed by parameter I , related to building age hence: $D = PGA \cdot I^2$

In a particular area the relationship between PGA and macroseismic intensity (I) is denoted through an empirical relationship: $\log PGA = f(I)$ where I is expressed in the 12-grade Mercalli-Sieberg scale

The Area Unit is the Building Block.

All Formations applied for Damage Computation is presented in the following table

Height	Area	Damage
Height < 3.00 x Area < 0.500	1.20 log (I ² * A ^{0.5})	0.100 - 0.200 (20-20%)
Height < 3.00 x Area < 0.500	1.20 log (I ² * A ^{0.5})	0.200 - 0.300 (30-30%)
Height < 3.00 x Area < 0.500	1.20 log (I ² * A ^{0.5})	0.300 - 0.400 (40-40%)
Height < 3.00 x Area < 0.500	1.20 log (I ² * A ^{0.5})	0.400 - 0.500 (50-50%)
Height < 3.00 x Area < 0.500	1.20 log (I ² * A ^{0.5})	0.500 - 0.600 (60-60%)
Height < 3.00 x Area < 0.500	1.20 log (I ² * A ^{0.5})	0.600 - 0.700 (70-70%)
Height < 3.00 x Area < 0.500	1.20 log (I ² * A ^{0.5})	0.700 - 0.800 (80-80%)
Height < 3.00 x Area < 0.500	1.20 log (I ² * A ^{0.5})	0.800 - 0.900 (90-90%)
Height < 3.00 x Area < 0.500	1.20 log (I ² * A ^{0.5})	0.900 - 1.000 (100-100%)

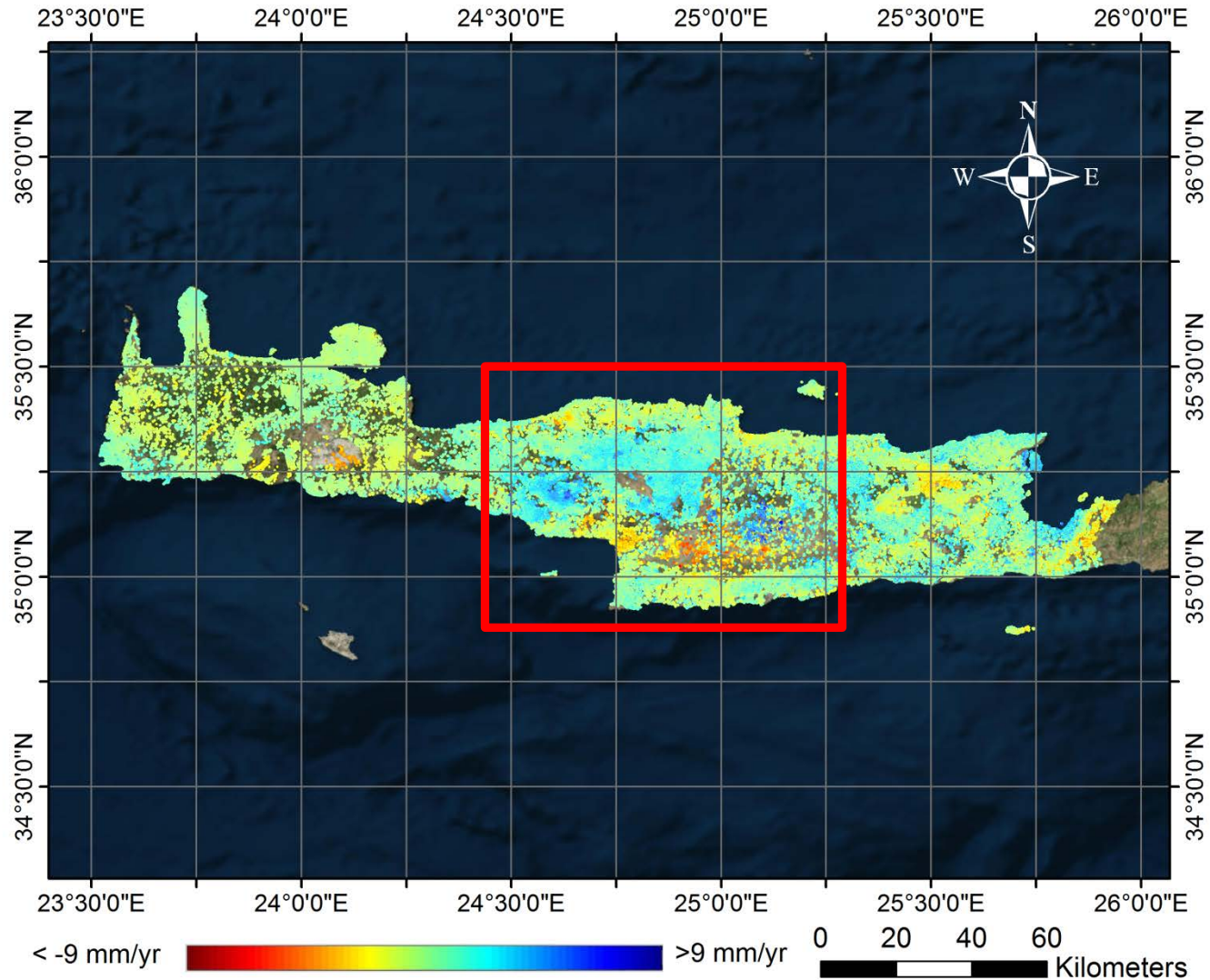


1992-2001

- Data
- NSN
 - NOANET
 - ENIGMA
 - In-situ

- Services
- Geodesy
 - Modeling
 - Hazard Ass.
 - Large Proc.

- Applications
- Tectonics
 - Volcanoes
 - Landslides
 - Subsidence



Hazard scale characterization of slow-moving landslides

Data

NSN

NOANET

ENIGMA

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Large Proc.

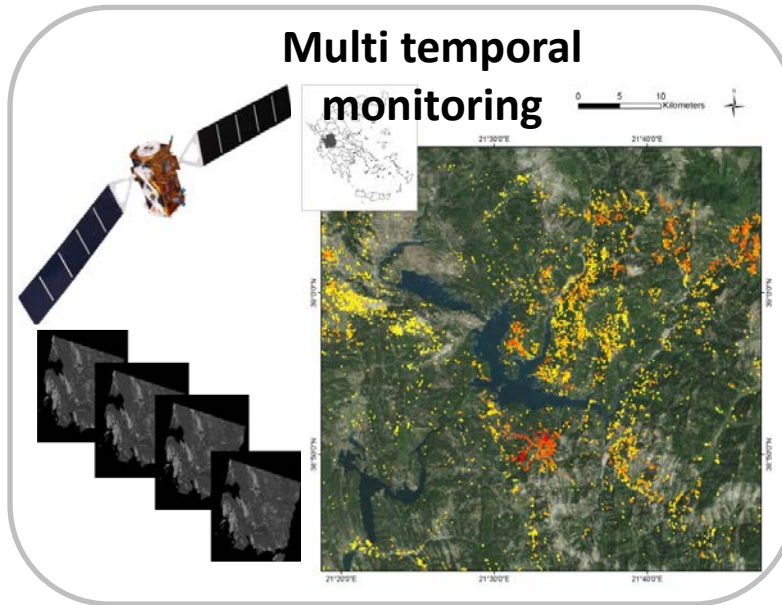
Applications

Tectonics

Volcanoes

Landslides

Subsidence



Geospatial layers

Elevation

Slope angle

Slope aspect

Geology

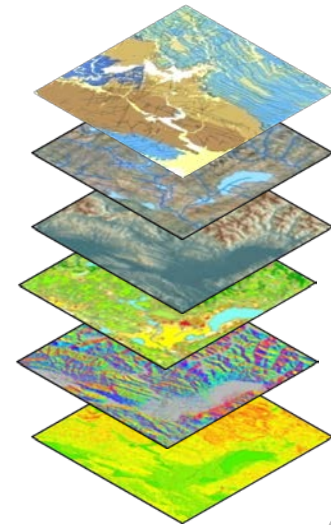
Soil properties

LU/LC

Hydrology

Faults

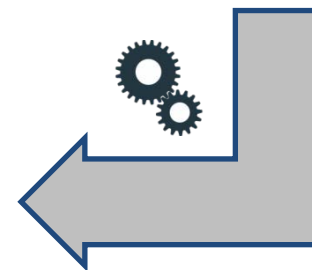
Precipitation



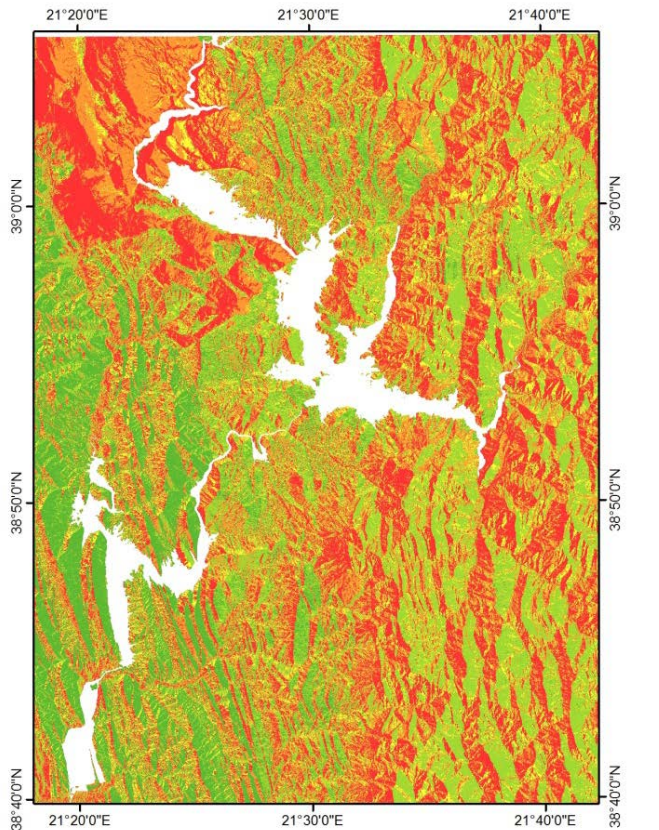
GIS-Statistical processing

Probability models

- Weights of evidence
- Logistic regression
- Neural networks



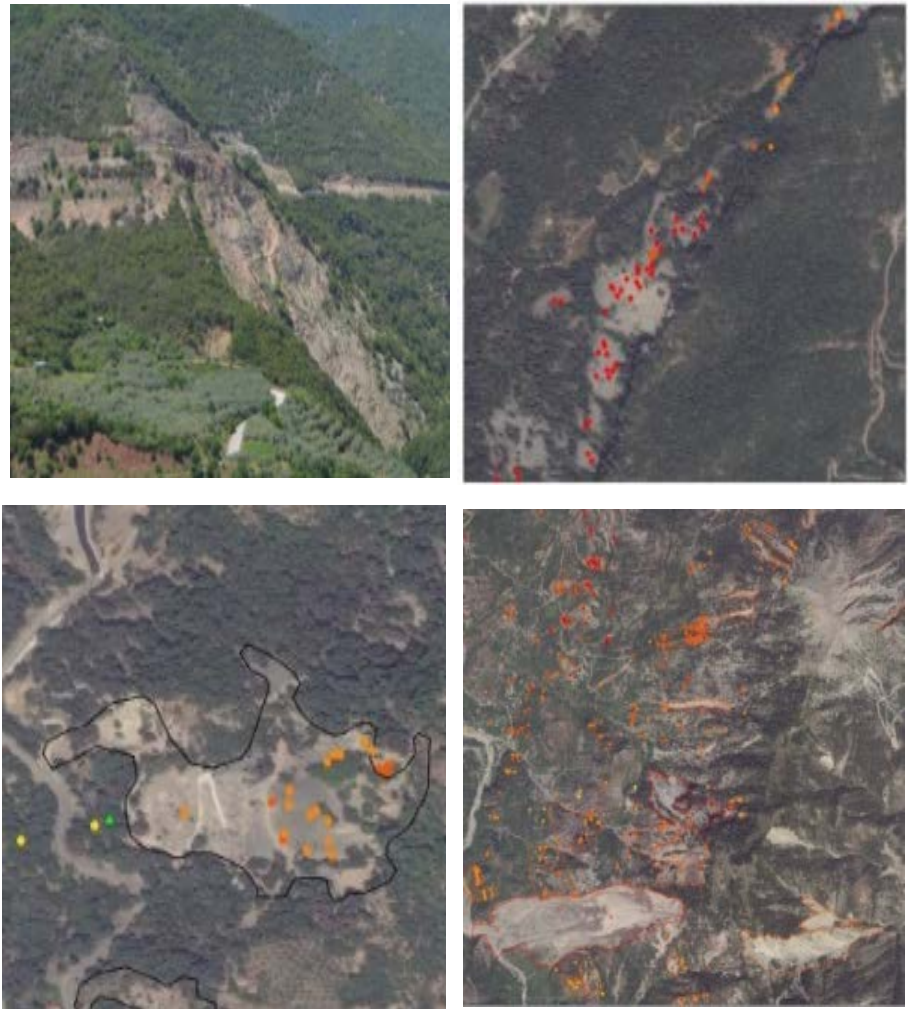
Landslide Susceptibility map



Landslide Susceptibility

- Very low
- Low
- Medium
- High
- Very high

0 3 6 12 Kilometers



NOA hosts a **Sentinel Collaborative Ground Segment**

- Adaptation of existing services, deployment of new services
- Dynamic ingestion of Sentinel data for real-time applications
- Big data management, exploitation of high revisit times
- Databases of geodetic observations

Thank you for your attention!



Ioannis Papoutsis: ipapoutsis@noa.gr

Haris Kontoes: kontoes@noa.gr