Analysis of the deformation pattern along the subduction zone of Crete, Greece, using multi-temporal ERS data

Maria KASKARA[1], Aggeliki BARBEROPOULOU[1], Ioannis PAPOUTSIS[1], Charalampos KONTOES[1], Athanassios GANAS[2], Vassilios KARASTATHIS[2]

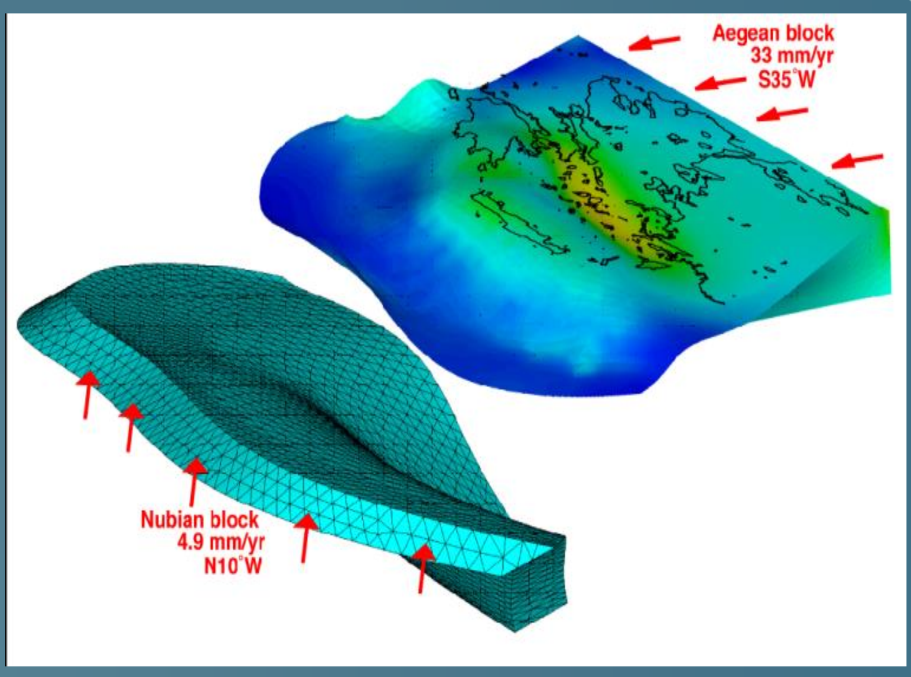
1 National Observatory of Athens, Institute of Space Applications and Remote Sensing, Athens, Greece, mariakaskara@noa.gr, aggeliki@noa.gr, ipapoutsis@noa.gr, kontoes@noa.gr
2 National Observatory of Athens, Institute of Geodynamics, Athens, Greece, aganas@noa.gr, karastathis@noa.gr

Abstract. Crete lies in the forearc basin of the collision zone between the Eurasian and African plates - one of the highest seismicity regions in the world. The purpose of this study is to map the estimation of the ground deformation using time series analysis. The key difference between space-based measurements and GPS or in-situ analysis is the good spatial coverage and the sensitivity of InSAR in the vertical direction. Using Persistent Scatterers and Small Baseline Subset techniques, deformation maps of the entire island of Crete are produced for the first time and geophysical interpretation is provided. A significant uplift is observed at the center of the island due to the subduction zone processes. Subsidence phenomena are also detected at Messara valley located at Southern part of central Crete due to anthropogenic activities.

Background

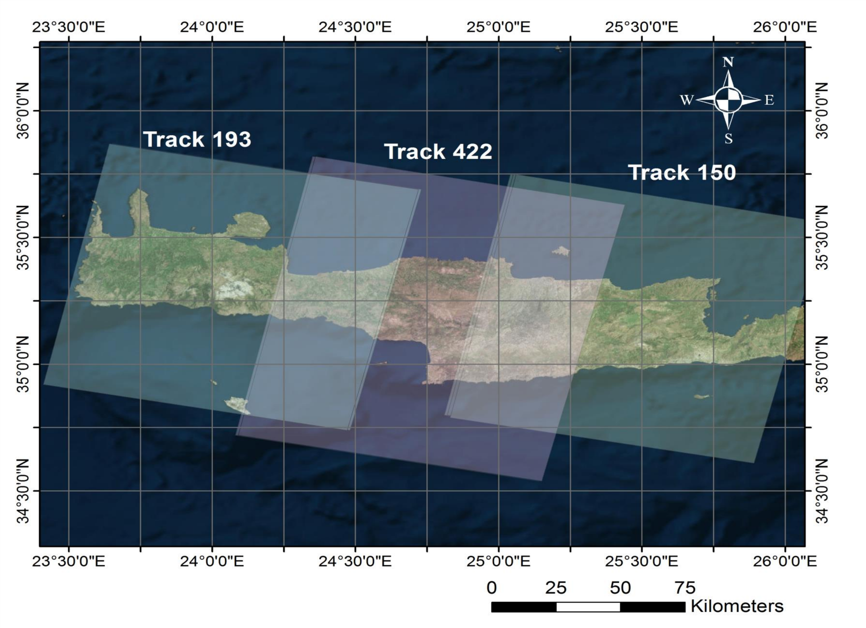
Hellenic arc

- ✓ African plate sinks into the mantle underneath the Eurasian plate – subduction zone
- ✓ Most seismically active part of Europe
- ✓ Capable of producing M8+ earthquakes
- ✓ 120 earthquakes M>5.0 from 550 B.C to 2014 A.D.



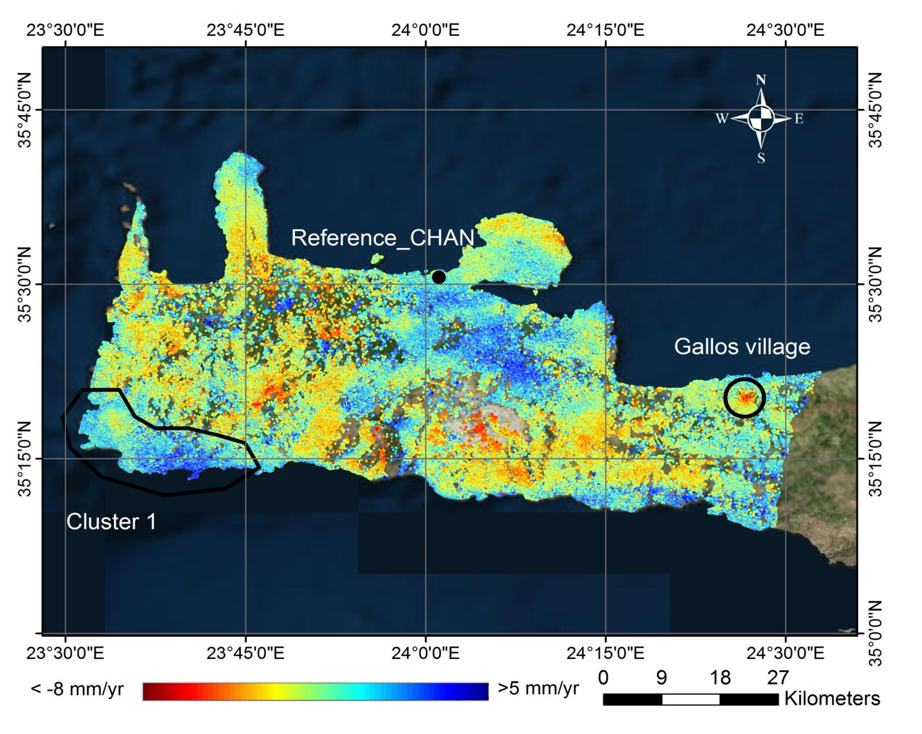
Ganas & Parsons (2009)

Input data

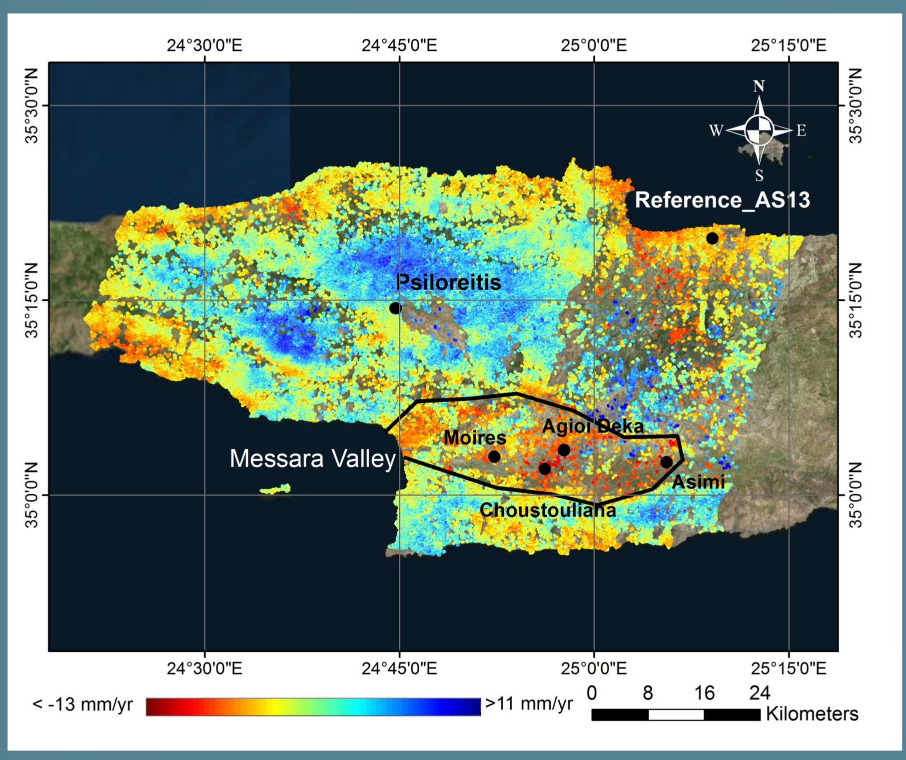


- ✓ Tracks: 193, 422 & 150
- ✓ 84 ASAR ERS1 & ERS2 descending mode
- ✓ Dates: 1992-2001
- ✓ SARscape: SBAS & Modelling
- ✓ DORIS, ROI_PAC, StaMPS (Hooper et al., 2007): Combined MTI Processing

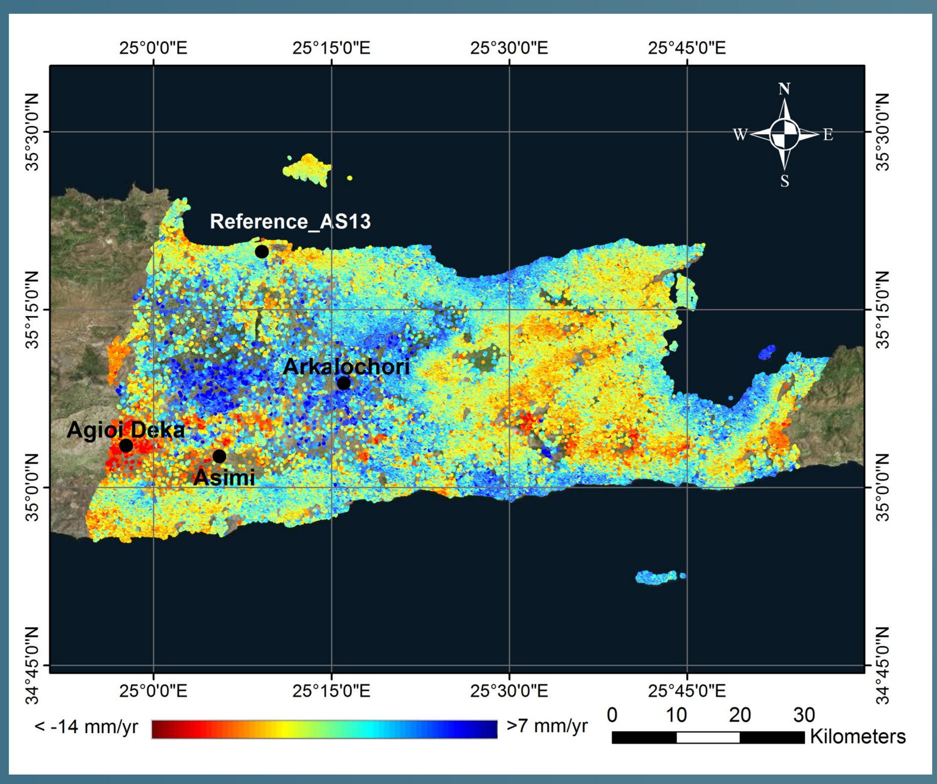
Results



Track 193



Track 422

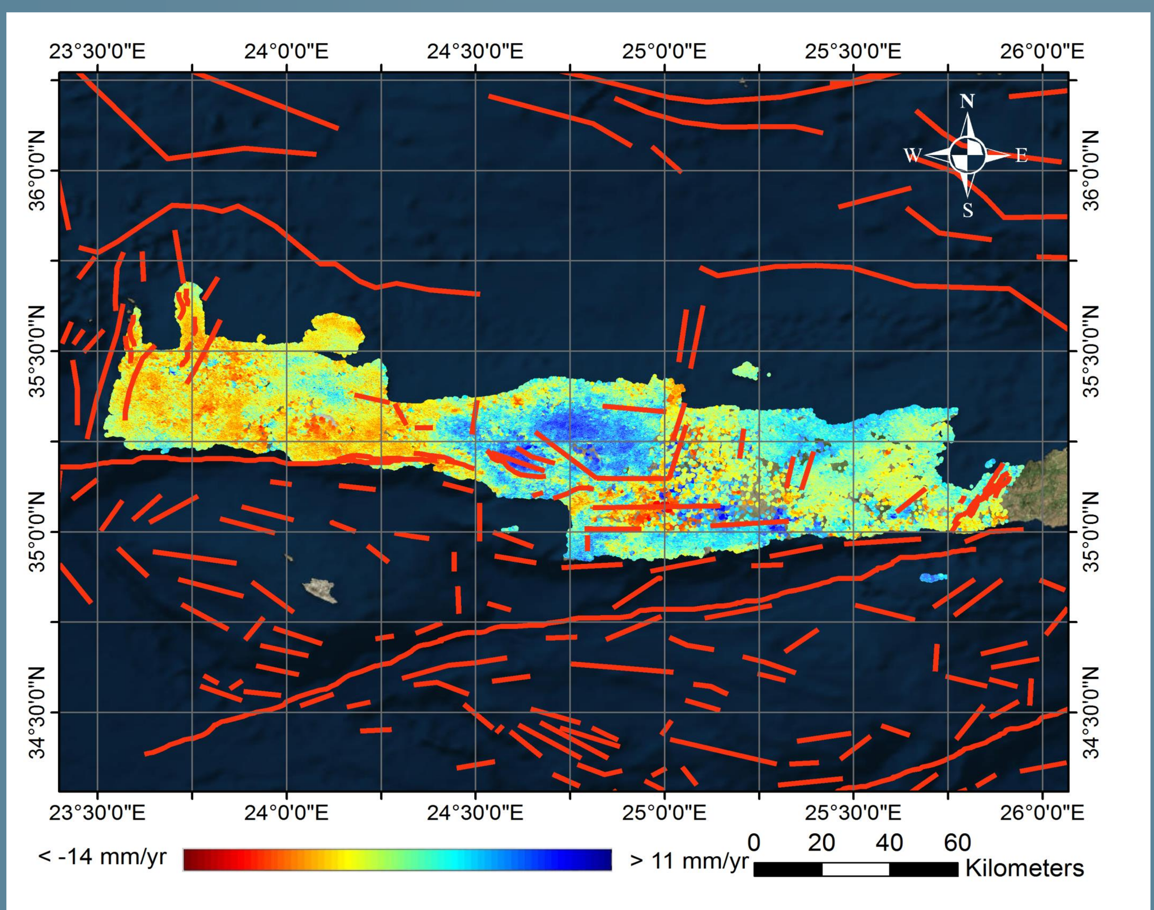


Track 150

Track 193:
- Uplift Northwestern part (+5mm/yr)
- Subsidence at Gallos village (-4mm/yr)

Track 422 & 150:
- Uplift near Psiloreitis (+6mm/yr)
- Subsidence of Messara basin due to aquifer exploitation (-7mm/yr), (Mertikas et al., 2009)
- Areas with greatest subsidence are: "Asimi", "Moires", "Choustouliana" and "Agioi Deka"

Conclusions



- ✓ Detect strong uplift (up to + 10 mm/yr) attributed to the convergence of Eurasian and African plate
- ✓ Local displacement patterns revealed: Most prominent subsidence (-10 mm/yr) is located at Messara basin due to anthropogenic activities.

Modelling

To explain the deformation obtained from the time series processing we used a model of subduction as explained by Savage (1983). In this model strain accumulation and release at a subduction zone are attributed to a locked (no slip) zone.

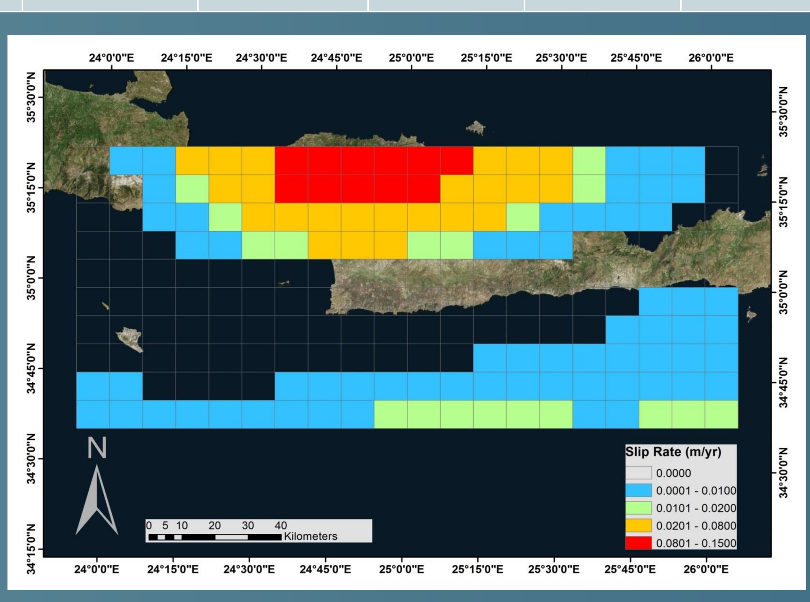
Assuming the plate interface is known and fixed we inverted for the slip rate. To account for uncertainties in the plate interface:

- We used three simple rectangular faults. Case A is shown in table 1. The other two cases had smaller dip angle and source location further south
- We also tried a fault surface made up of two surfaces with different strike angle that followed more closely the curvature of the Hellenic arc

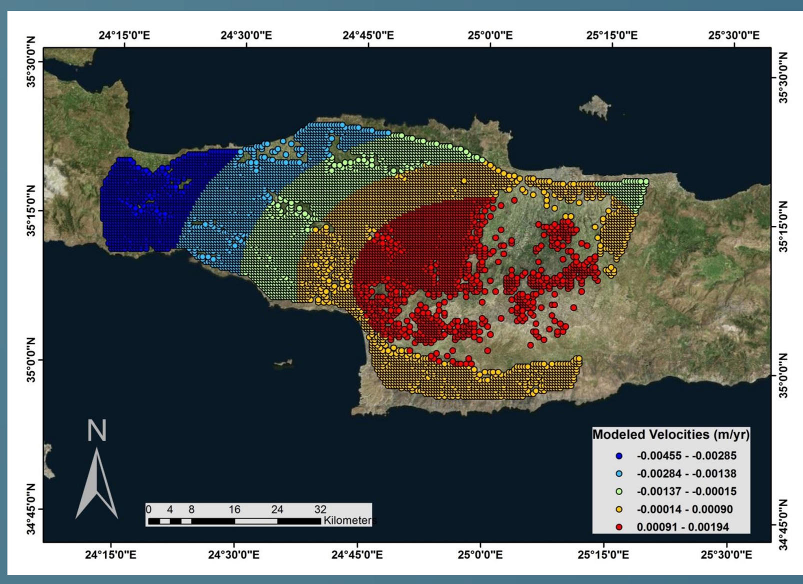
Fault surface

- For all cases fault surfaces were made up of 10km x10km patches
- Okada (1992) equations were used to model deformation on the surface and inverted for slip

Length (km)	Width (km)	Strike (deg)	Dip (deg)	Rake (deg)	Lat	Lon
200	100	270	30	90	35 N	25 E



Interseismic slip rate distribution as obtained from the linear inversion for the Central part of Crete Island



Modelled velocities of central Crete

- ✓ Velocities cover only the northernmost part of the surface projection of the fault surface
- ✓ Modeled Velocities over Central Crete resolve the circular pattern of uplift observed from PS/SBAS processing
- ✓ The two surface fault attempted explains better the uplift observed in South West Crete and Central Crete

References & Acknowledgments

Ganas, A. & Parsons T. (2009). Three-dimensional model of Hellenic Arc deformation and origin of the Cretan uplift, J. Geophys. Res., 114, B06404.

Hooper, A. Zebker, H. Segall, P. & Kampes, B. (2004). A New Method for Measuring Deformation on Volcanoes and Other Natural Terrains Using InSAR Persistent Scatterers, Geophys. Res. Letters, 31, L23611.

Mertikas, S. P., Papadaki, E. S. & Paleologos, Ev. (2009). Radar Interferometry for Monitoring Land Subsidence due to over-pumping Ground Water in Crete, Greece. Proceedings of the Fringe Workshop, Frascati, Italy, p. 4.

The work was supported by the European Union Seventh Framework Programme (FP7-REGPOT-2012-2013-1), in the framework of the project BEYOND, under Grant Agreement No. 316210 (BEYOND - Building Capacity for a Centre of Excellence for EO-based monitoring of Natural Disasters- http://www.beyond-eocenter.eu).

We would like to thank the European Space Agency for the provision of the SAR data and the staff of the sarmap team: Alessio Cantone and Simone Atzori for their help and valuable feedback .