Monitoring ground deformation through time-series analysis of SAR data: An application to Chalkidiki peninsula, Greece.

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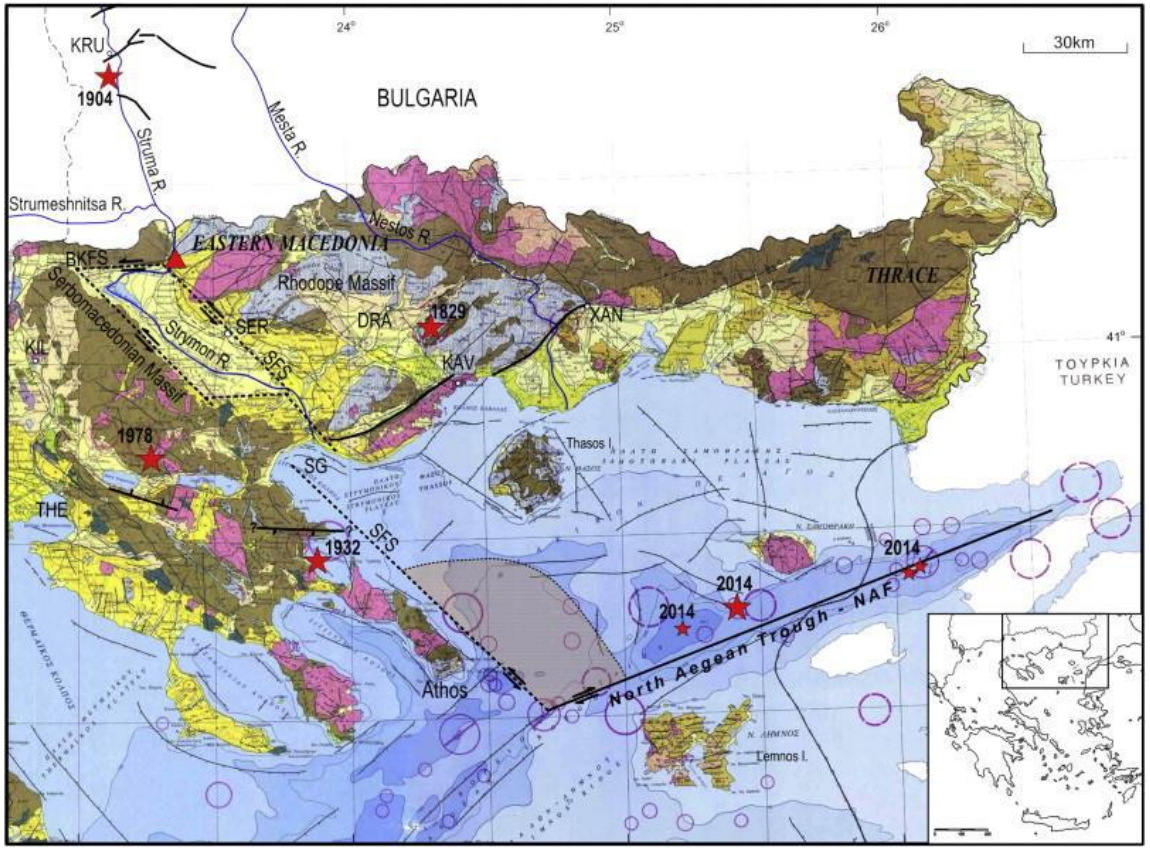
Background information on Chalkidiki peninsula



Courtesy of: Mouslopoulou et al., Tectonophysics , 2014.

- North Aegean Trough
- 1932 Ierissos earthquake, M_w=7
- 1978 Thessaloniki earthquake, M_w=6.5

Geodetic and InSAR studies on Chalkidiki area

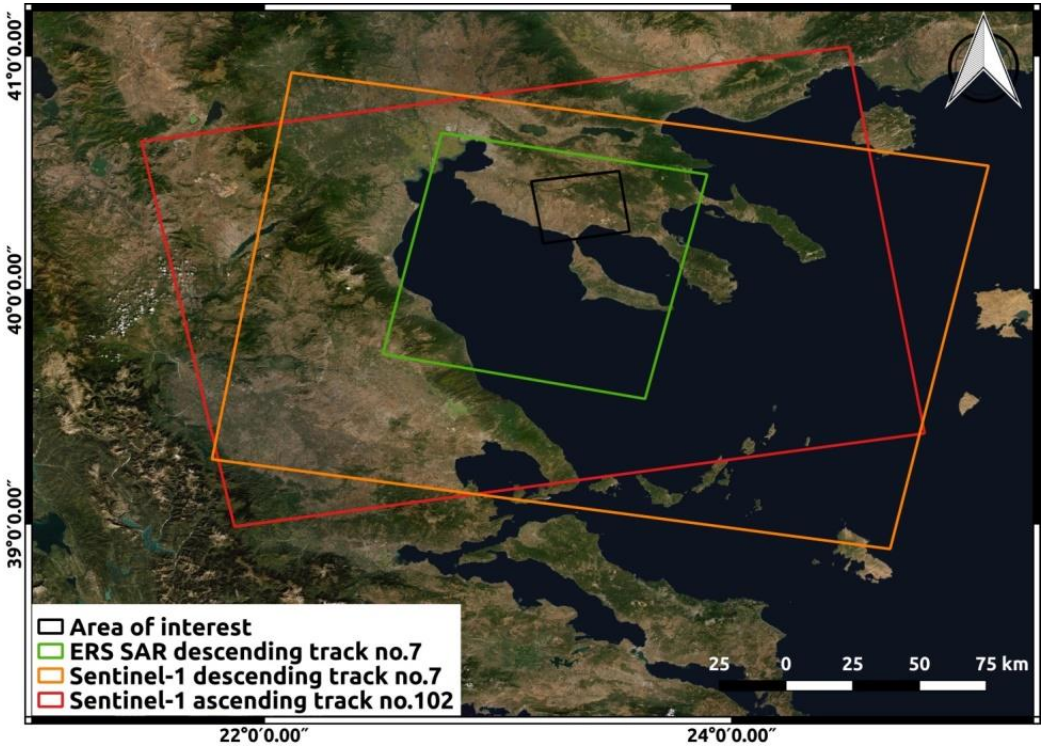
- Geodetic studies with observations spanning from 1994 to 2016
  - Cruddace et al., Geodesy Beyond, 1999
  - Rontogianni, Journal of Geodynamics, 2010
  - Mouslopoulou et al., Tectonophysics, 2014
  - Alatza et al., EGU General Assembly, 2015

- InSAR studies
  - *Raucoules et al., Nat. Hazards Earth Syst. Sci., 2008*
  - Mouratidis et al., Fringe Workshop, 2009
  - Raspini et al., Nat. Hazards Earth Syst. Sci., 2013
  - Svigkas et al., Eng. Geol., 2016
  - Svigkas et al., Environ. Earth Sci., 2017
  - Triantafyllou et al., JISDM, 2019
  - Svigkas et al., Arab. J. Geosci., 2020
  - Svigkas et al., Remote Sensing, 2020

Research objective:

InSAR analysis focused on the central part of Chalkidiki peninsula, to map ground deformation.

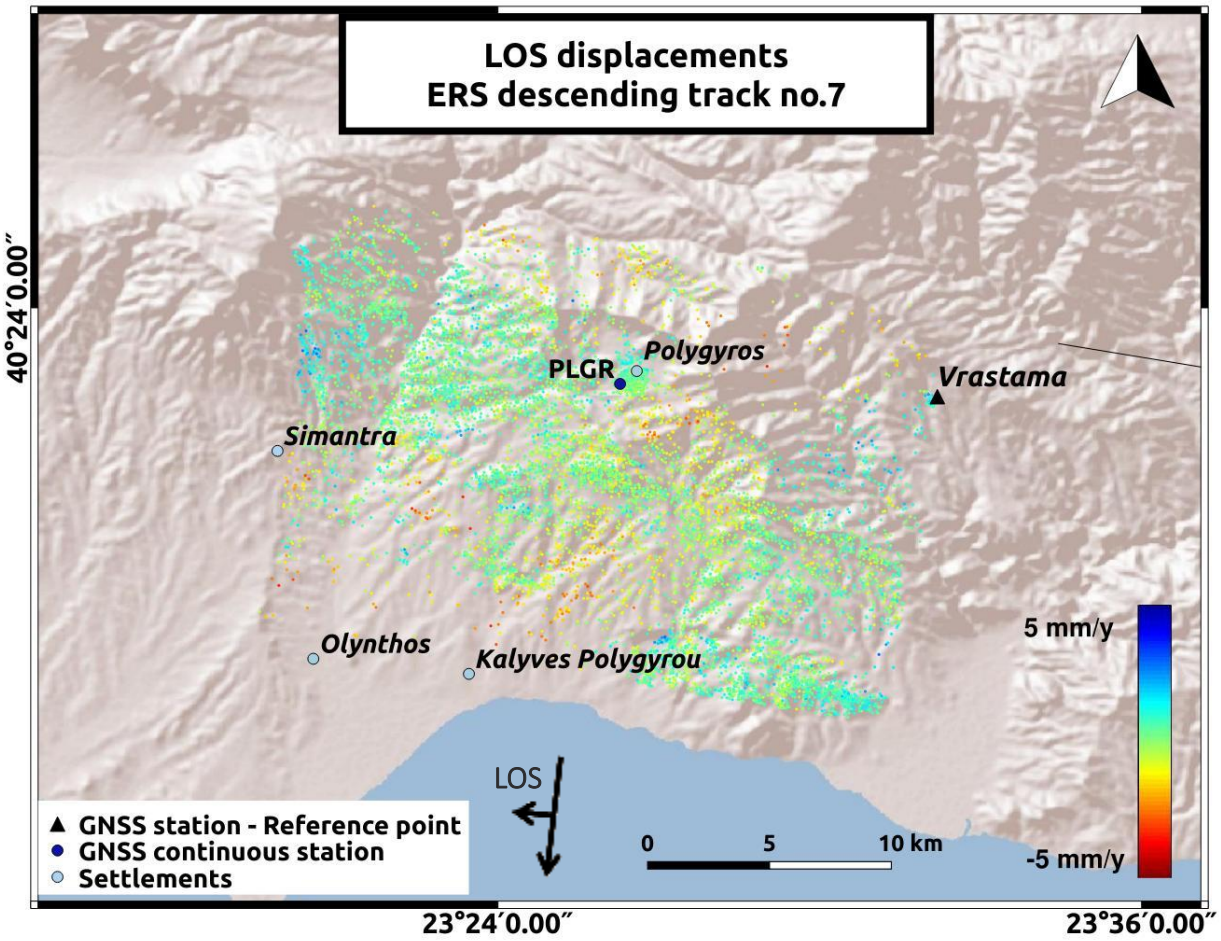
1. Data-set information and methodology



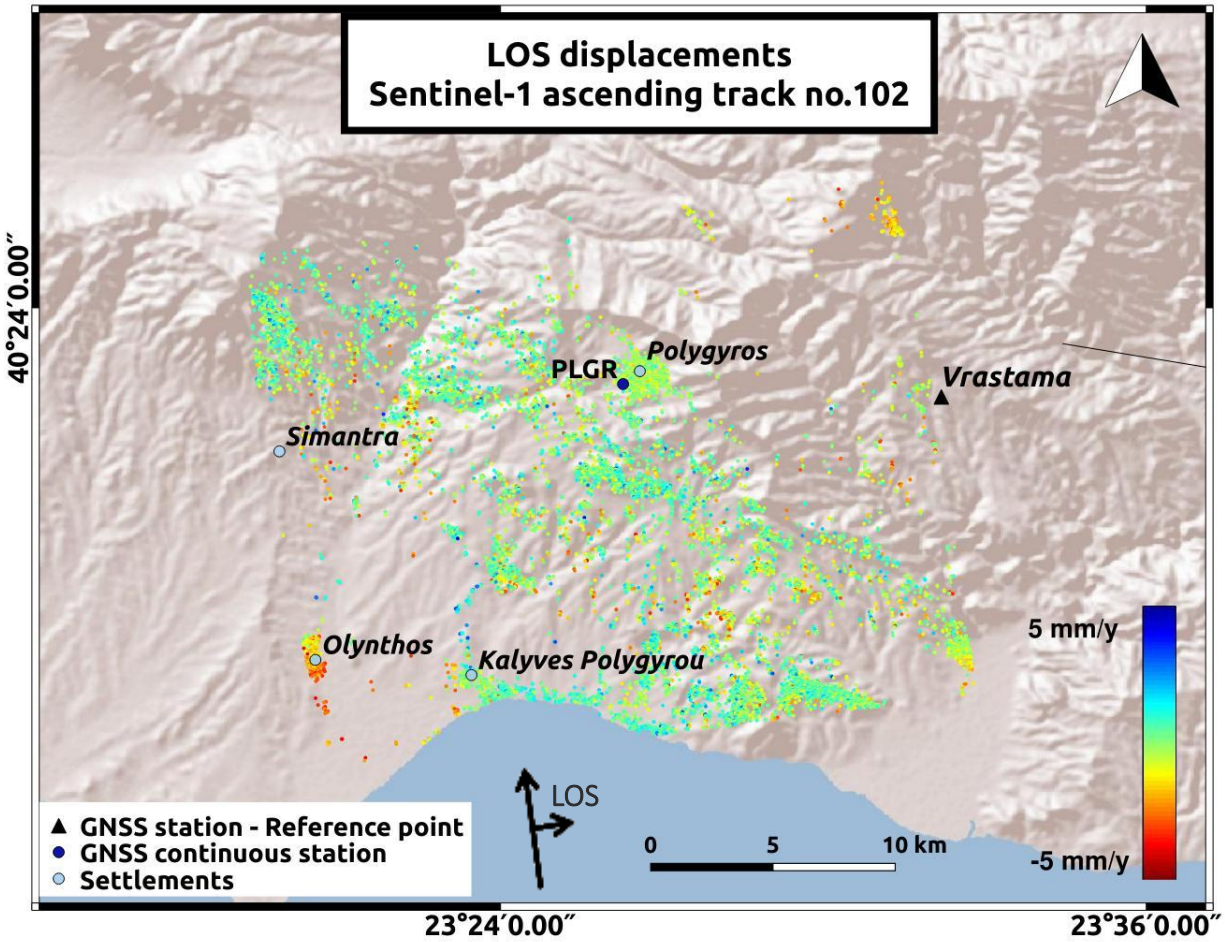
	ERS SAR	Sentinel-1	
No of scenes	27	34	30
Relative orbit	7	7	102
Time interval	1992-2002	2014-2018	2014-2018
Sensor's pass	Descending	Descending	Ascending
SAR mode	n/a	IW	IW

- S/W: DORIS (Kampes et al., Fringe Workshop, 2003), SNAP (with automated open-source package by Foumelis et al, IGARSS, 2018), StaMPS (Hooper et al., JGR, 2007), TRAIN (Bekaert et al, Remote Sensing of Environment, 2015).
- Methods: PSI, SBAS, MTI.
- ERS data oversampled by a factor of 2.
- Reference area near VRAS GPS station (v_N=0.8 mm/y).

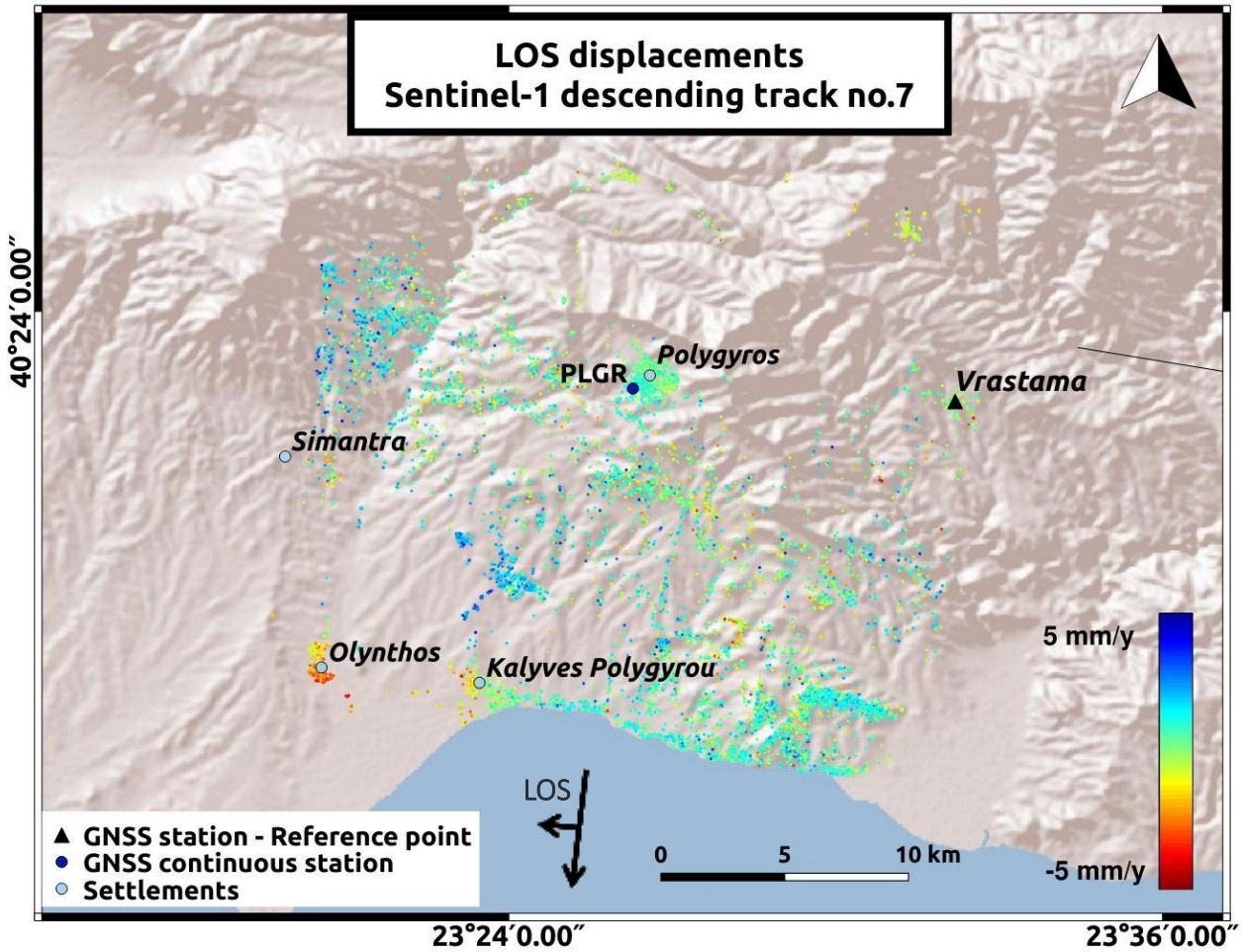
2. ERS LOS displacements (mm/y) (1992-2002)



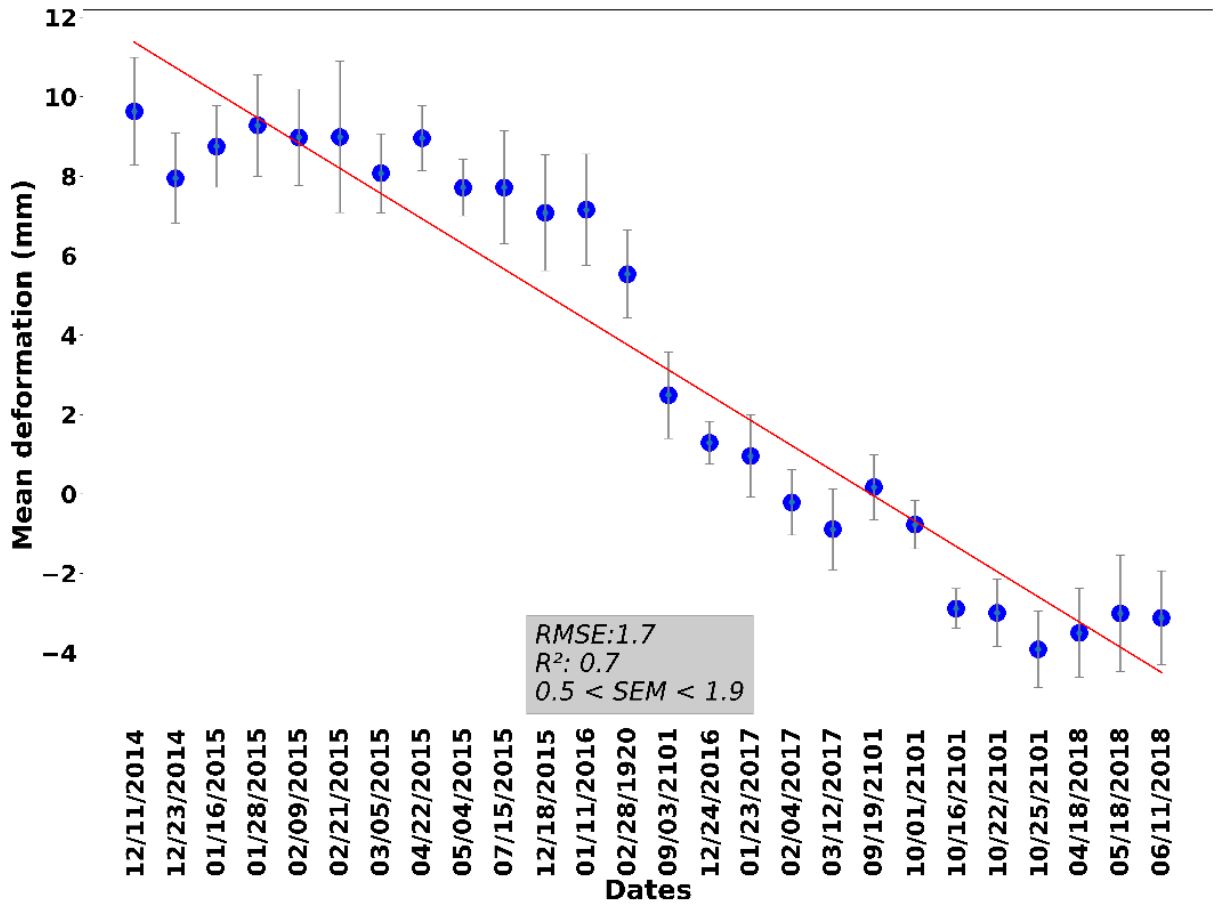
3. Sentinel-1 LOS displacements (mm/y)
Ascending track no.102 (2014-2018)



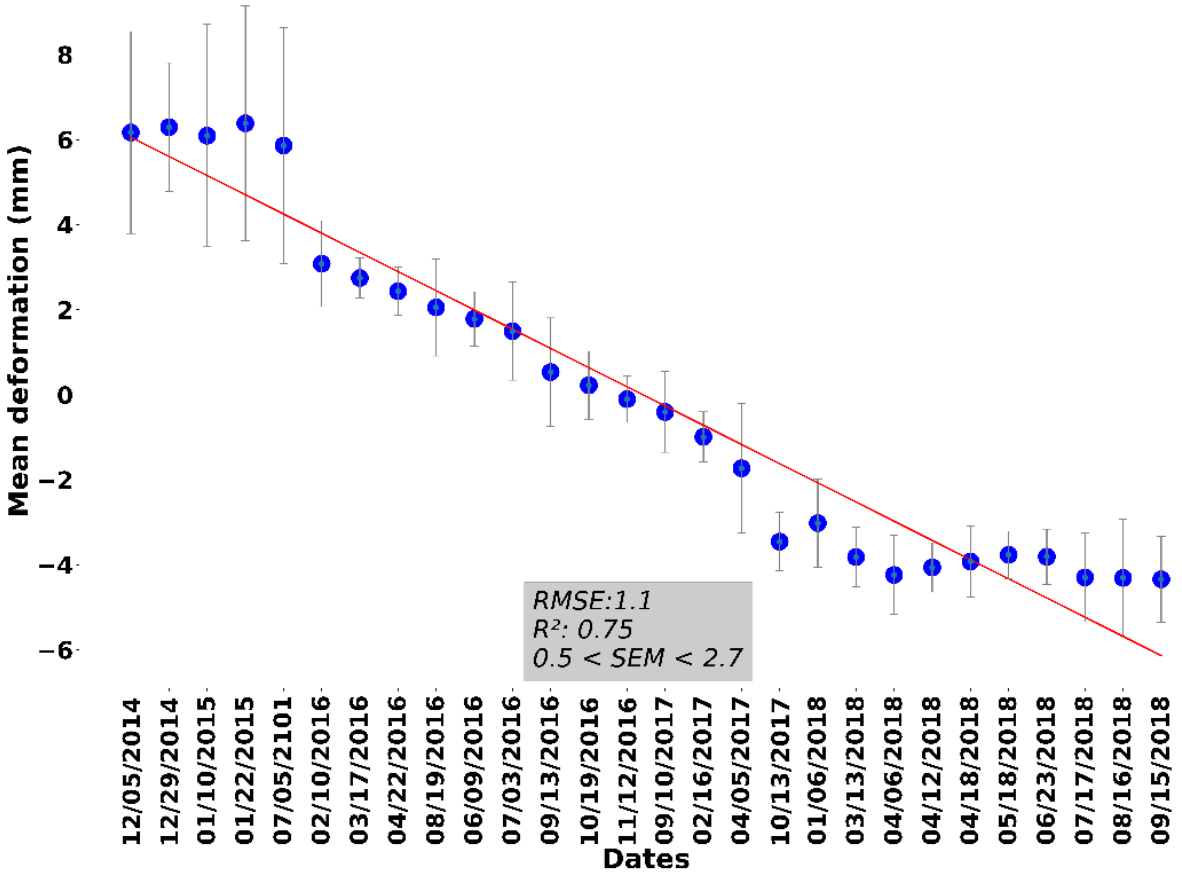
4. Sentinel-1 LOS displacements (mm/y)
Descending track no.7 (2014-2018)



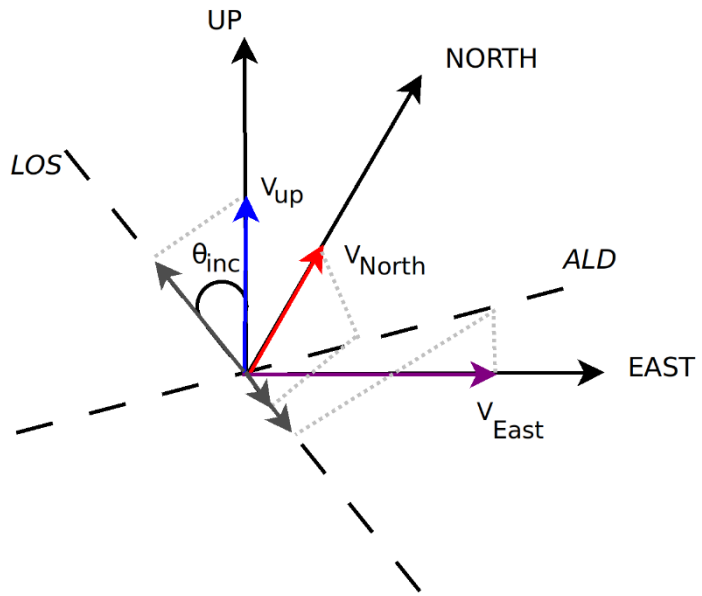
5. Mean LOS deformation (S-1 ascending track no.102)

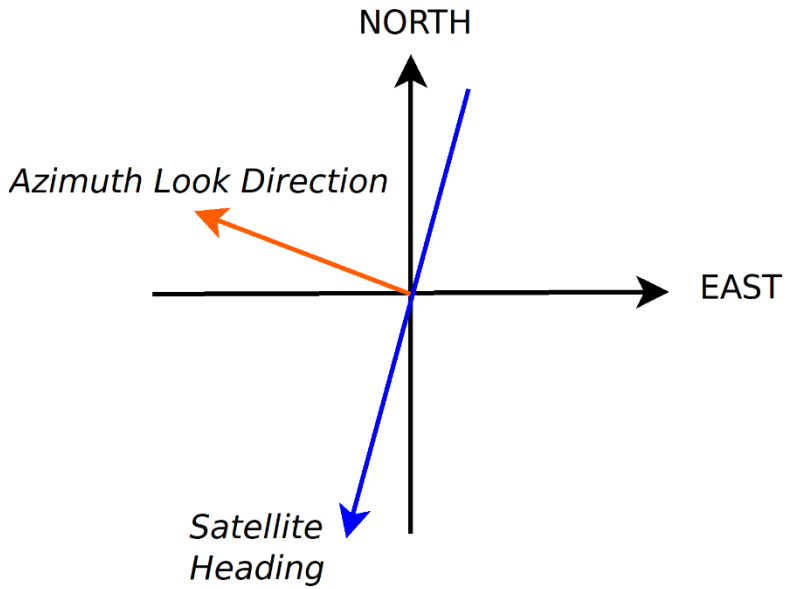


6. Mean LOS deformation (S-1 descending track no.7)



7. S-1 LOS decomposition to vertical velocities

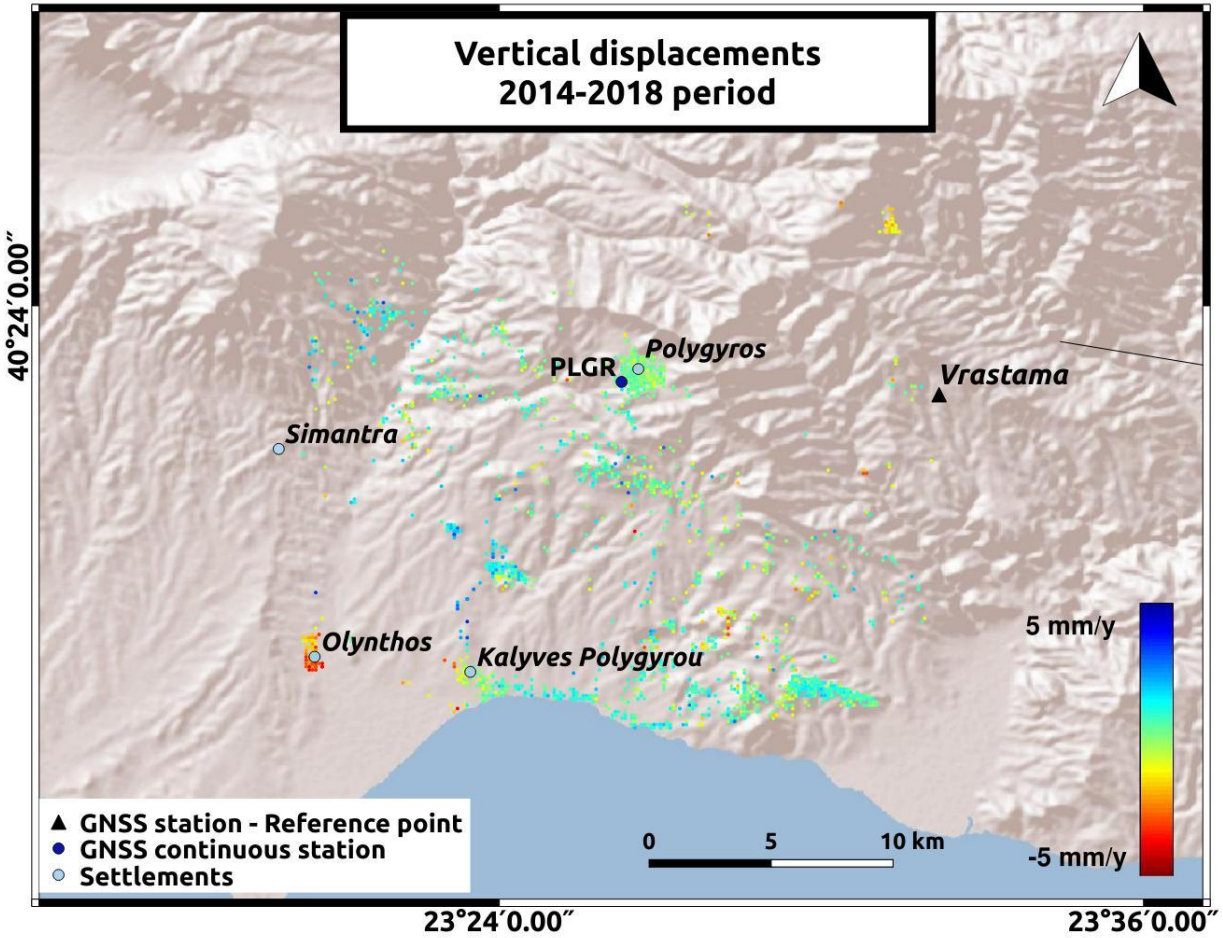




$$v_{LOS} = v_{(LOS)Up} + v_{(LOS)East} + v_{(LOS)North}$$

- Samieie-Esfahany et al., Fringe, 2009
- Papoutsis et al., Remote Sensing, 2017

8. Vertical displacements for the 2014-2018 period



- The western Chalkidiki region is a weak deforming block.
- Active Olynthos dextral strike-slip fault.
- Kougoulis et al., Bulletin of the Geological Society of Greece, 2007

9. GPS network

- Since the late 90s, several GPS stations were established in Greece, to monitor tectonic motion.
- GPS/GNSS stations in the broader area of Chalkidiki, by Dionysos Satellite Observatory (DSO) of National Technical University of Athens (NTUA).
- Three GPS campaigns (September 1998, October 1999, September 2000) (Alatza et al, 2015).
- Research program Seismic Hazard in Greece (SING) (Cruddace et al., Geodesy Beyond, 1999).

10. GPS observations

GPS station's code	V_N (m/y)	V_E (m/y)	**V_U (m/y)**	σ_{V_N} (m/y)	σ_{V_E} (m/y)	**σ_{V_U} (m/y)**	Sensing period (years)	Sensing intervals
PLGR	0.00526	0.00251	-0.00077	0	0	0	2013-2016	4

$$v = v_{Up}\cos(\theta_{inc}) - \sin(\theta_{inc})[v_N \cos(\alpha_h - 3\pi/2) + v_E \sin(\alpha_h - 3\pi/2)]$$

Time period	PLGR
2013-2016	0.1408 mm/y

11.Changes in the aquifer system of western Chalkidiki region

- Panteli, European Water Journal, E.W. publications, 2016
- Theodossiou, Environmental Processes, 2016
- Siarkos and Latinopoulos, Hydrogeol J, 2016
- Veranis et al., Bulletin of the Geological Society of Greece, 2016
- Svigkas et al., Remote Sensing, 2020

Conclusions

- An extensive deformation study over the central part of Chalkidiki peninsula, was performed.
- Relative comparison between SAR results and GPS velocities projected to LOS direction denote a non-deforming region around Polygyros city.
- Small-scale deformation near Olynthos site is identified.
- Vertical displacements with a maximum rate of 5mm/y are identified for the 2014-2018 time period in Olynthos village.
- The western Chalkidiki region is a weak deforming block. Active Olynthos dextral strike-slip fault. (Kougoulis et al., Bulletin of the Geological Society of Greece, 2007)
- Over-exploitation of Moudania watershed.
- Extension of the present study with a wider study area and the addition of SAR observations spanning from 2002 to 2014 .
- Complete overview of the deformation field in the central part of Chalkidiki peninsula.

Thank you!

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