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Contribution of InSAR deformation analysis to monitoring Coastal Erosion in the Region of Central Macedonia

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Introduction

- The Interferometric Synthetic Aperture Radar (InSAR) tehnique is used to measure centimeter-level surface displacements, based on representations of phase differences between SAR acquisitions that cover the same area but were acquired at different times, called interferograms.

- In this study, we applied the Small Baseline (SB) (Berardino et al., 2002) approach to detect and measure displacements affecting coastal areas in the Region of Central Macedonia in Northern Greece, which contribute to the analysis of erosion phenomena over the area of interest.

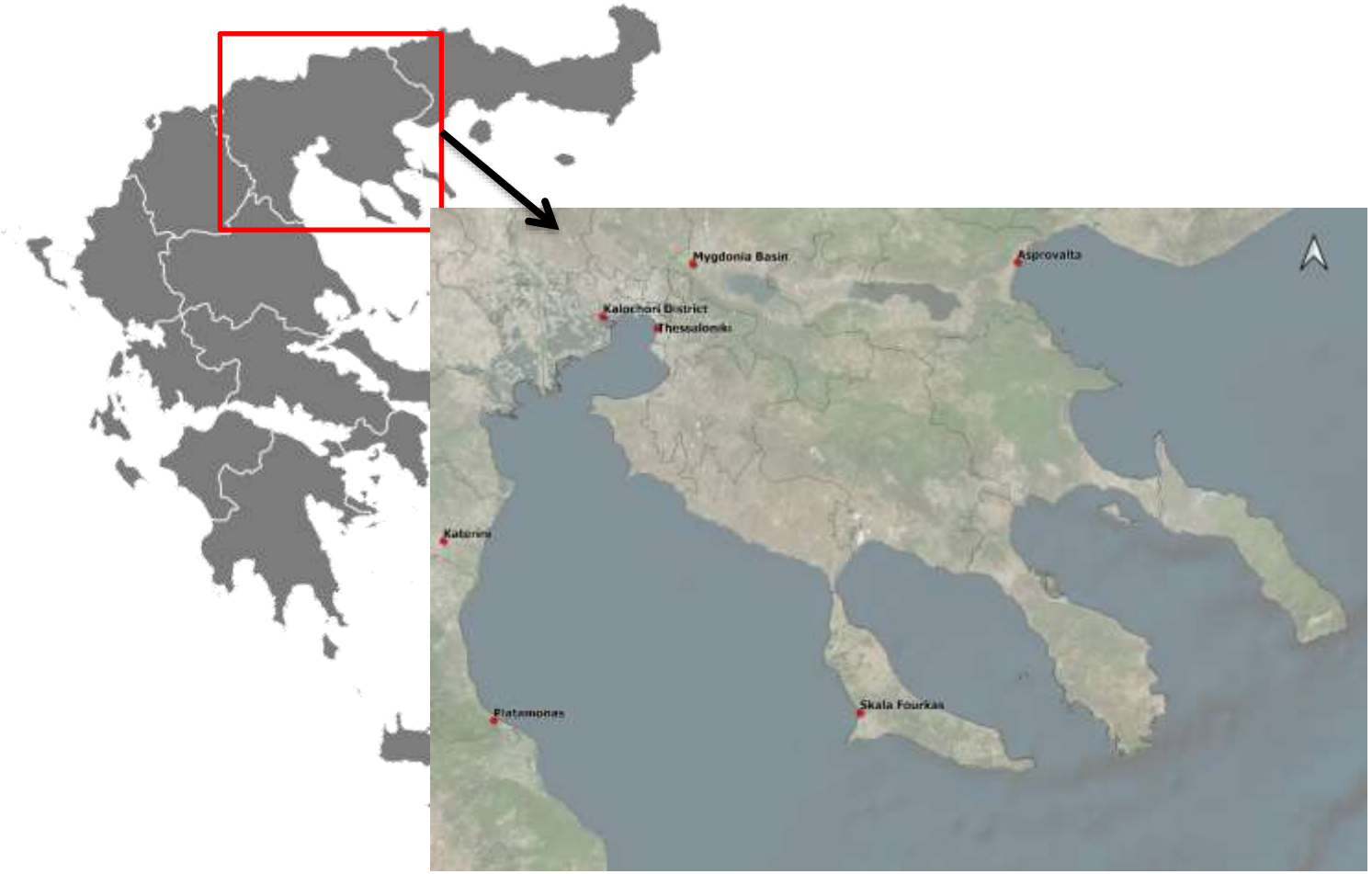
- Furthermore, SAR-derived deformations are fused with traditional ground-based geodetic measurements (GNSS, UAVs, echo sounding) to derive the vulnerability of the study area to coastal erosion.

Study Area

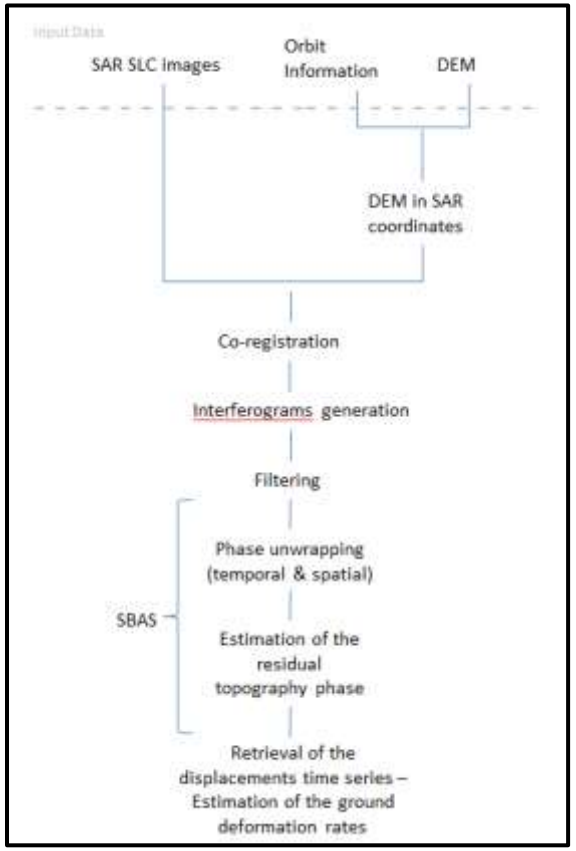
The Region of Central Macedonia

- Subsidence and uplift phenomena are observed in the area under study, where natural, anthropogenic activities and environmental changes have taken place (Mouratidis et al., 2010; Savvaidis et al., 2006)

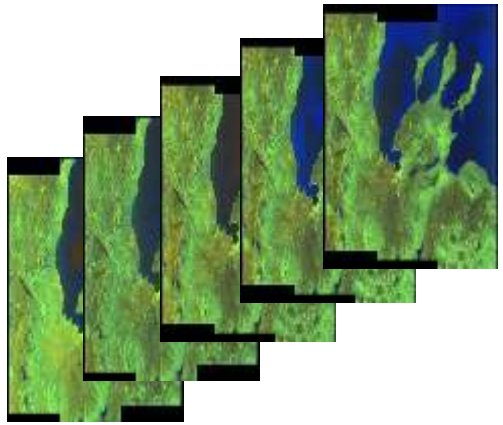
- In the majority of the cases, the local authorities remained unnoticed until intense damages happened.



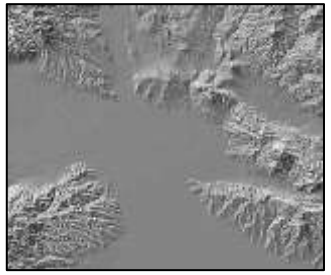
Methodology



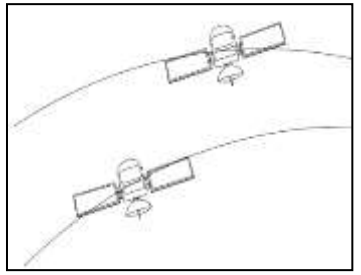
The applied precessing chain



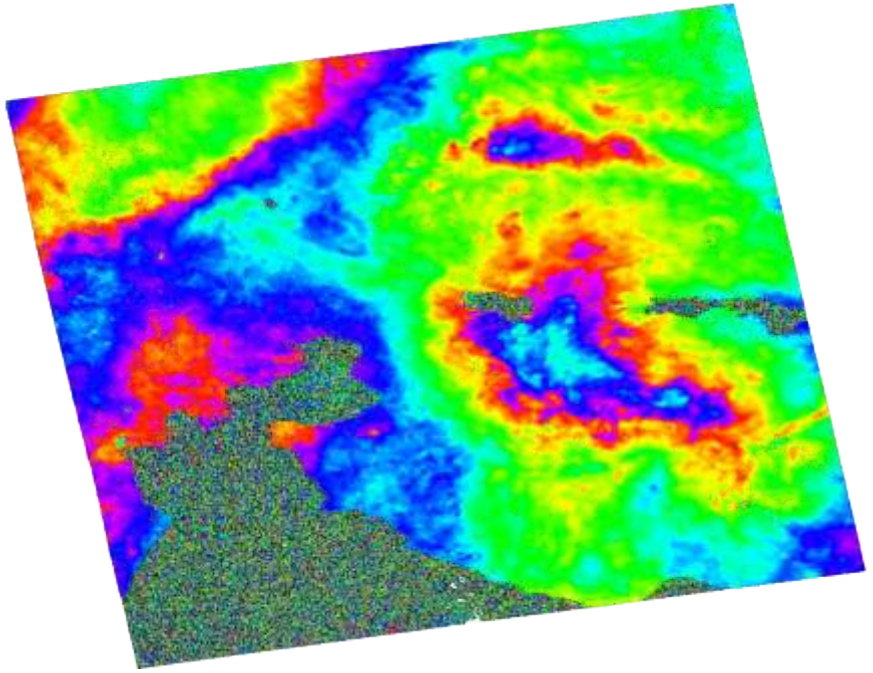
Sentinel -1 SLC SAR images



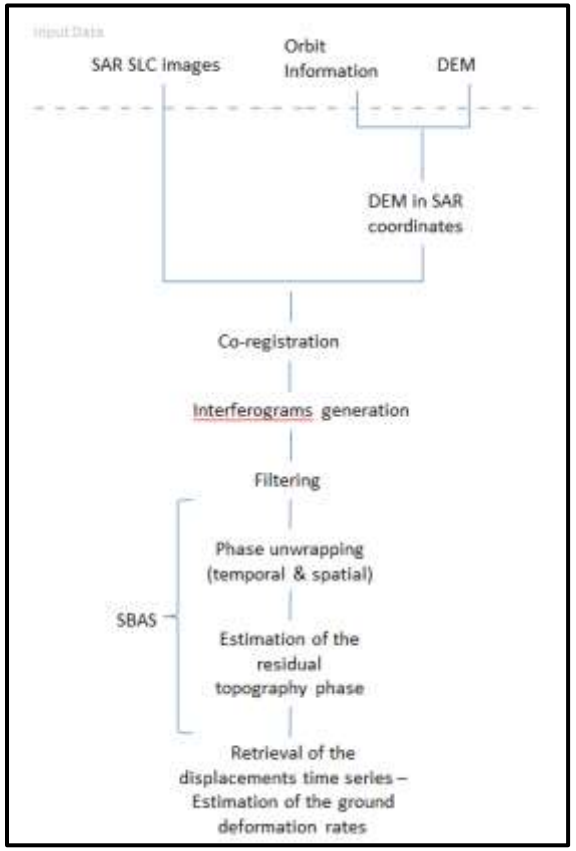
SRTM1 DEM



Orbital Information



Methodology



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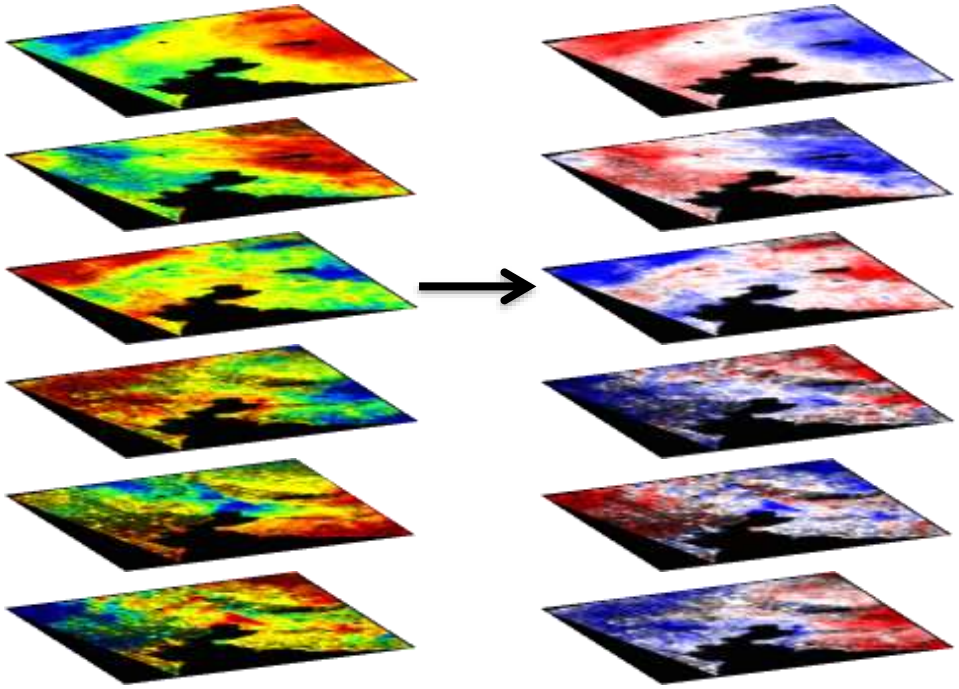
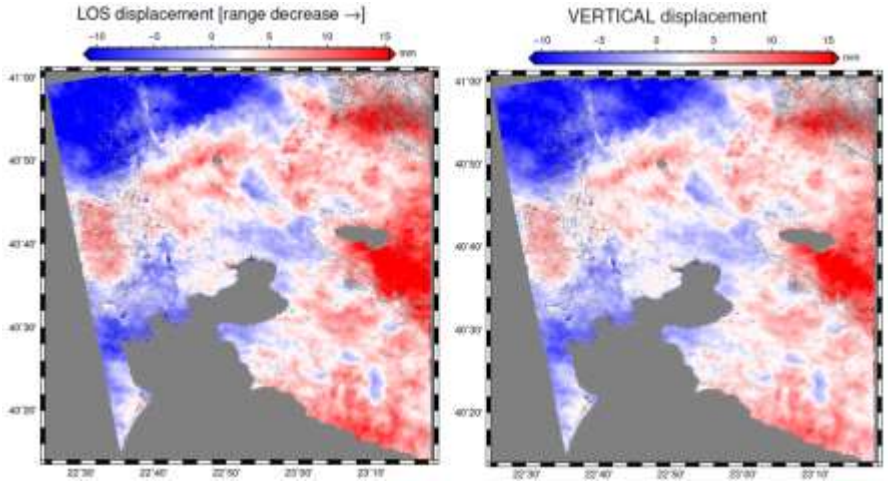




$$d_{LOS} = d_u \cos\theta_{inc} + d_n \cos a_h \sin a_h - d_e \cos a_h \sin a_h$$

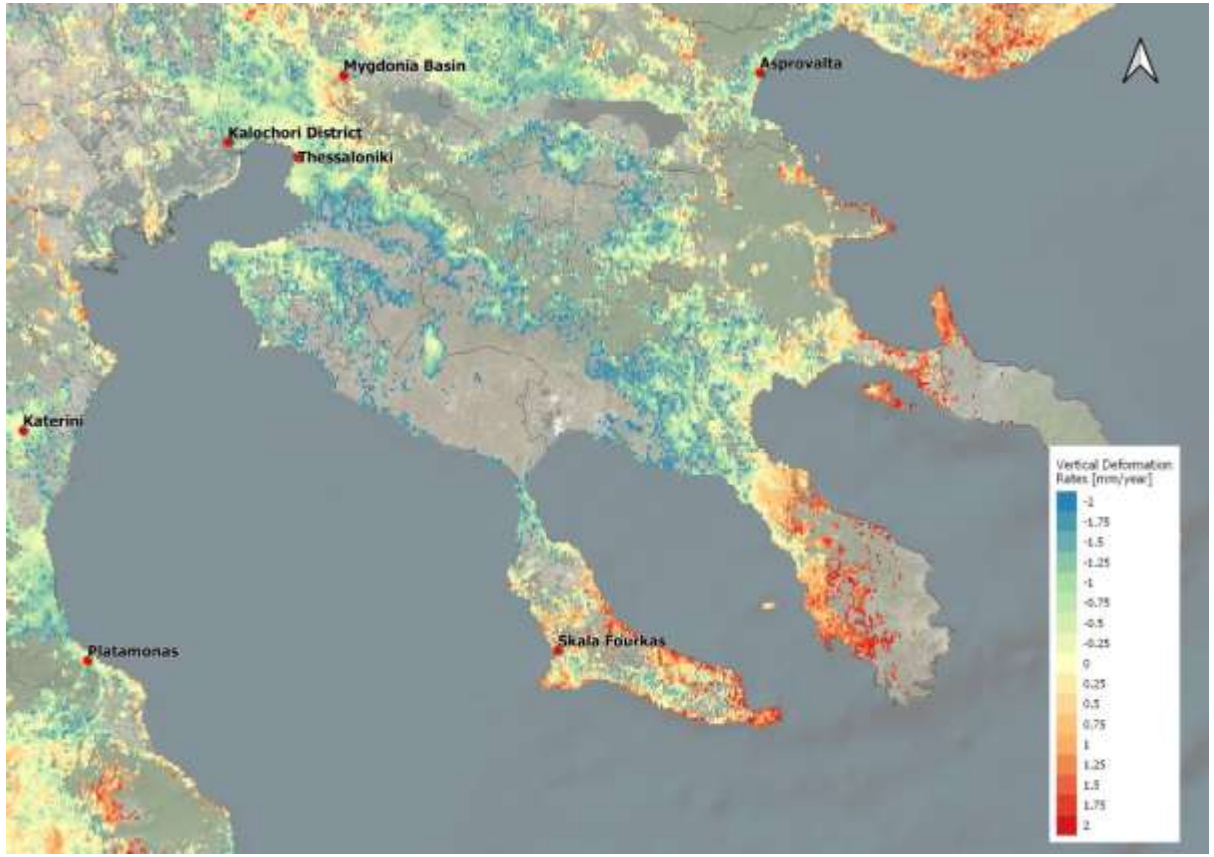
θ_{inc} = ≈ 15° to 45° (S1A/B satellites)

a_h = azimuth

Results

Mean Deformation Rates [mm/year]

- The derived velocities ranged from -2 mm/yr to +2 mm/yr
- High negative values (from -0.75 to -1.75 mm/yr), are detected close to Kalochori, Anthemountas Basin, Asprovalta and Platamonas.
- Along the coastline of Halkidiki, the deformation rates imply an uplift trend that has not been reported in previous studies.
- The noisy areas have a coherence threshold lower than 0.8. (Lu et al., 2018) and therefore have been excluded.

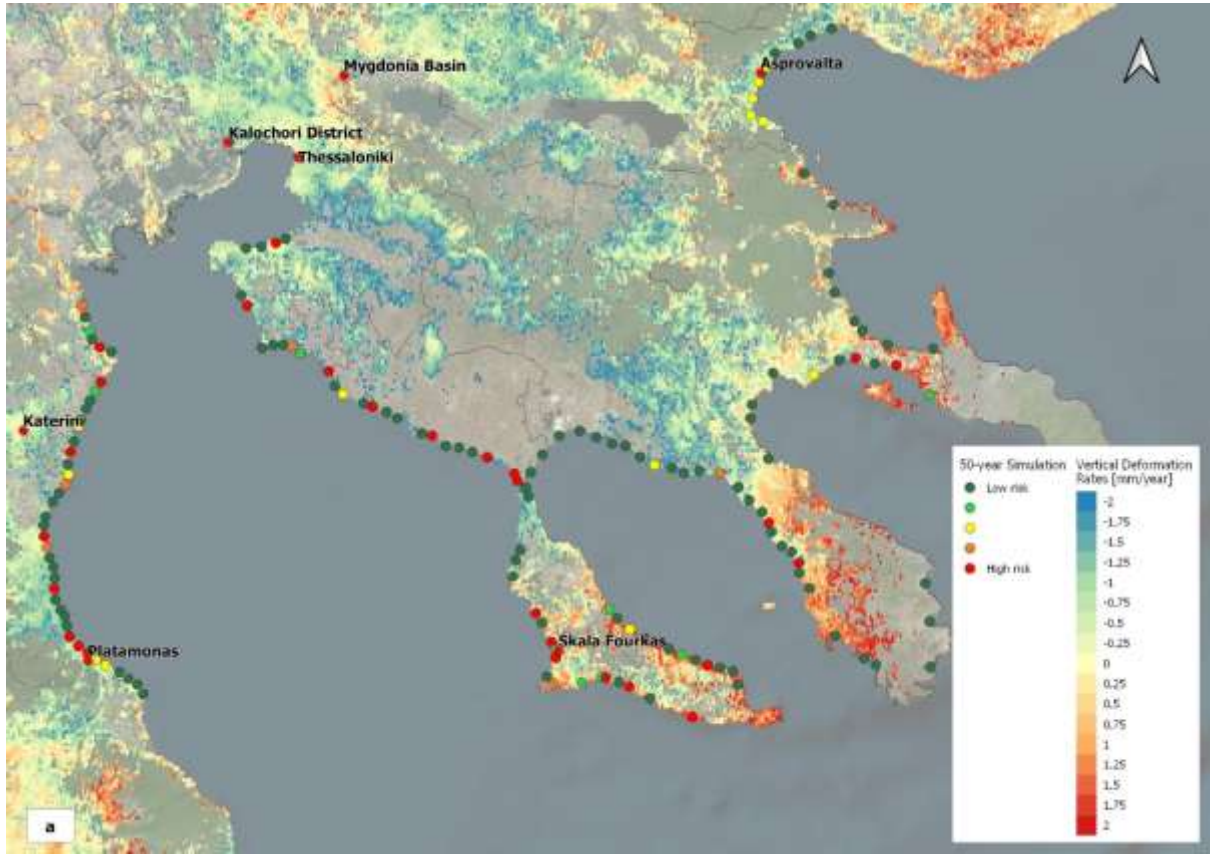


Results

The 50- and 100-year vulnerability simulation

- The deformation rates were juxtaposed with topo/bathy measurements to derive a green-yellow-red index showing vulnerability to coastal erosion.

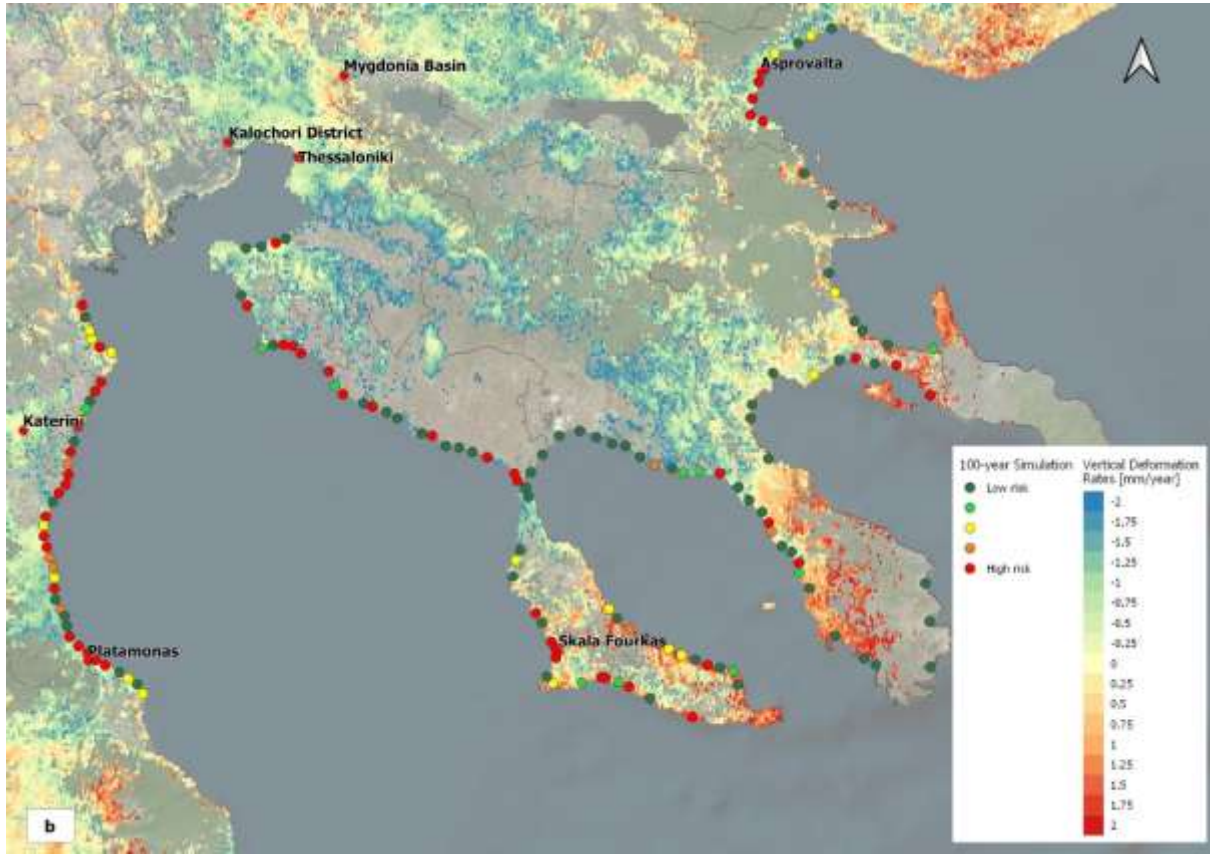
- During this study, in situ data from GNSS receivers, sand samplings, DEM and bathymetric models have been combined, for the estimation of a 50- and 100-year index of vulnerability of the coastal area, under the pressure of tidal waves (Tsakoumis et al., 2019)



Results

The 50- and 100-year vulnerability simulation

- The most vulnerable areas within a 50- and 100-years period, under high pressure of tidal waves are close to Platamonas, Katerini and Asprovalta.
- The majority of the SAR velocities that indicate subsidence are observed in areas that should be considered as vulnerable.
- Close to Anthemountas basin, the risk does not seem to be high, whereas close to Kalochori district there were no data due to the peculiar topography of the area.



Results

Erosion Risk Comparison (50-year simulation)

- Platamonas (high risk):

InSAR deformation rates range from -0.74 to -2.0 mm/year.

- Katerini (high risk):

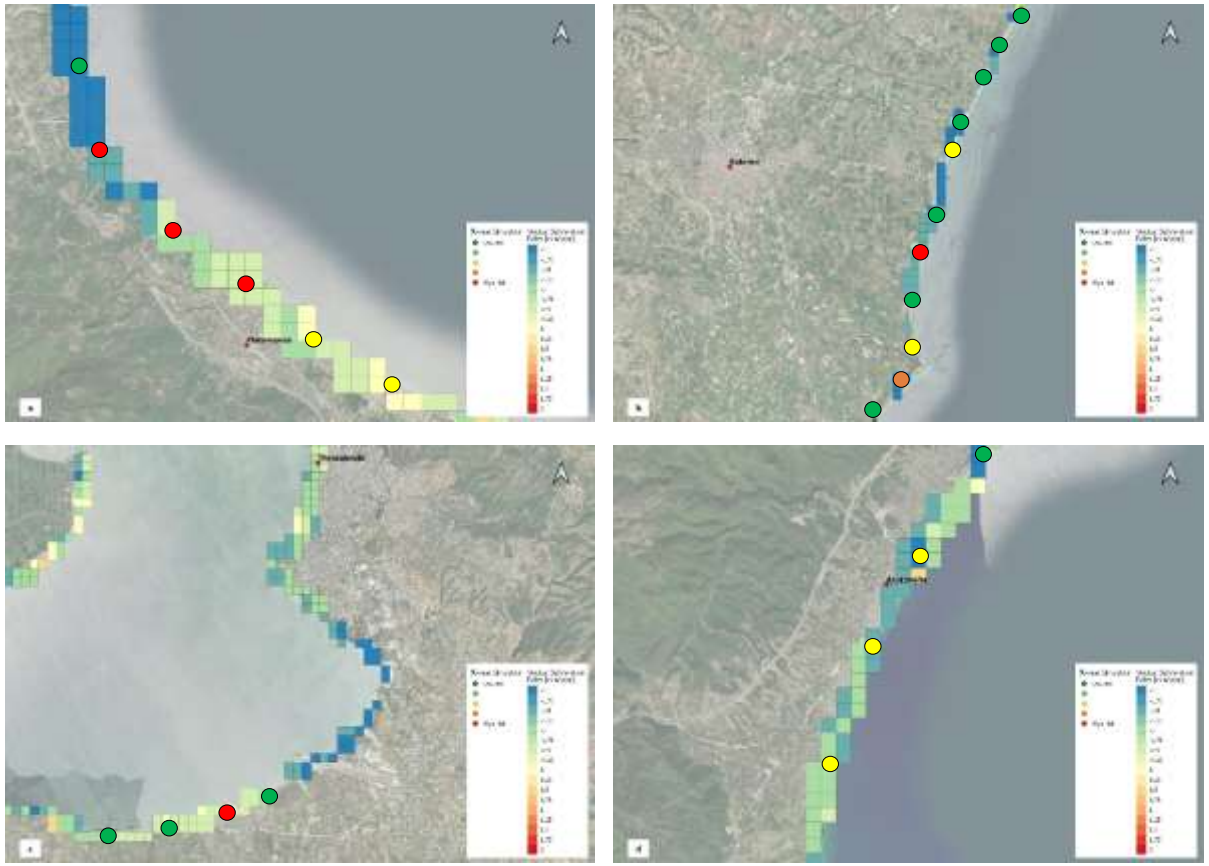
InSAR deformation rates range from -1.5 to -2.0 mm/year.

- Anthemountas Basin (no data):

InSAR deformation rates are about -0.75 mm/year.

- Asprovalta (high risk):

InSAR deformation rates range from -0.75 to -2.0 mm/year.



The erosion risk in comparison to the deformation rates on the coastline of Platamonas (a),Katerini (b), Anthemountas Basin (c) and Asprovalta (d)

Conclutions

- A correlation between the InSAR derived velocities and the 50 and 100 – year simulation of the coast vulnerability to erosion is observed.
- Correlation is high in coastal areas where negative deformation rates were computed and the vulnerability to erosion was high.
- Our results imply that using a long time series of SAR images can lead to derive information regarding the temporal evolution of the coastline, over large areas, even though they lack the spatial resolution provided by traditional geodetic surveying methods.
- Given the fact that InSAR is an inexpensive and widely accessible technique, it outbalances the monitoring and planning over extended areas.

Thank you for your attention!

ACKNOWLEDGEMENT

The data on the vulnerability to coastal erosion for the coastal area of the Region of Central Macedonia were generated during the “MONITORING CLIMATE CHANGE INDUCED COASTAL EROSION IN THE REGION OF CENTRAL MACEDONIA WITH SATELLITE AND IN-SITU DATA” project, financed by the Managing Authority of the Region of Central Macedonia. Use of these data is gratefully acknowledged.