NEWSLETTER 3
APRIL 2021

SCIENCE

SCIENCE:
SpaCeborne SAR Interferometry as a Non-invasive tool to assess the vulnerability over Cultural hEritage sites

CASE STUDY: HERAKLION CITY WALLS IN CRETE, GREECE

In the framework of the Heraklion City Walls case study (Fig.1) a variety of Persistent and Distributed Scatterers are combined aiming to produce highly accurate deformation maps (Persistent Scatterers & Distributed Scatterers Interferometry – PS/DS-InSAR) for predicting the vulnerability of the Venetian city walls to ground deformation in time and space.

The dataset that has been utilised is consisted of 175 Single Look Complex (SLC) images acquired by the Copernicus Sentinel-1A & B satellites in descending orbit for the time period from October 2014 to September 2020.

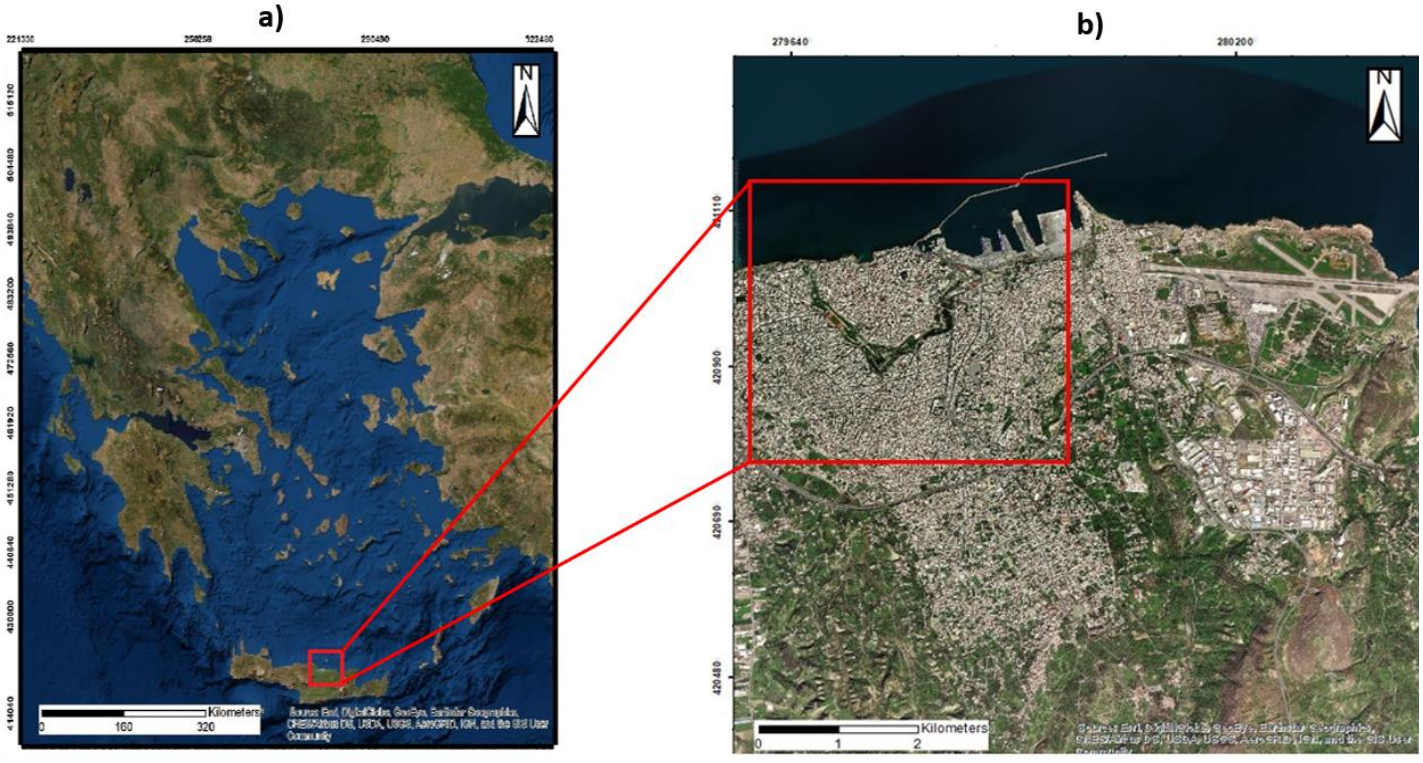

Figure 1. Location maps of a) the Crete island in Greece, b) the Heraklion city (including the Heraklion City Walls) in Crete (red square).

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Figure 2. Photo of a part of the Heraklion City Walls in Crete (Photo credits: NTUA).

The city walls were built by the Republic of Venice according to the principles of the bastion fortification. Their construction began during the 15th century.

The walls remain largely intact to this day, and they are considered to be among the best-preserved Venetian fortifications in Europe (Fig.2).

The Heraklion city lies upon pre-Neogene rocks form the alpine basement over which the basin's sediments have been deposited.

Basement rocks comprise bodies of the upper nappes of Crete (Ophiolite, Pindos and Tripolitza nappes).

Mesozoic to Eocene limestones occur in the margins of the basin and as isolated bodies within the basin. Eocene flysch sediments occur at its northeastern margins.

THE METHOD

A Multi-Temporal Interferometric SAR (MT-InSAR) processing approach is exploited in the framework of the case study of Heraklion City Walls using the Interferometric Point Target Analysis (IPTA) method, involving the extraction of a network of targets including both Persistent Scatterers (PS) and Distributed Scatterers (DS) to augment the monitoring capability across the varied land cover of the Heraklion City.

PS are artificial objects that reflect the radar signal well, such as metal structures, buildings and rock outcrops, and are used in Persistent Scatterers Interferometry (PSI). In particular, there is a prevalence of PS in urban areas, and PSI methods allow for analysis of even individual structures on the ground.

DS reflects lower radar energy compared to PS targets and usually spans several pixels in high-resolution SAR images, which exhibit similar scattering properties and can be used together for deformation estimation. The identification and monitoring of such targets is helpful especially in suburban areas, where the density of PS can be low.

Subsequently, for the case study of the Heraklion City Walls in Crete the combination of PS and DS is important for effective displacement monitoring of the monument and for the urban-suburban area.

RESULTS

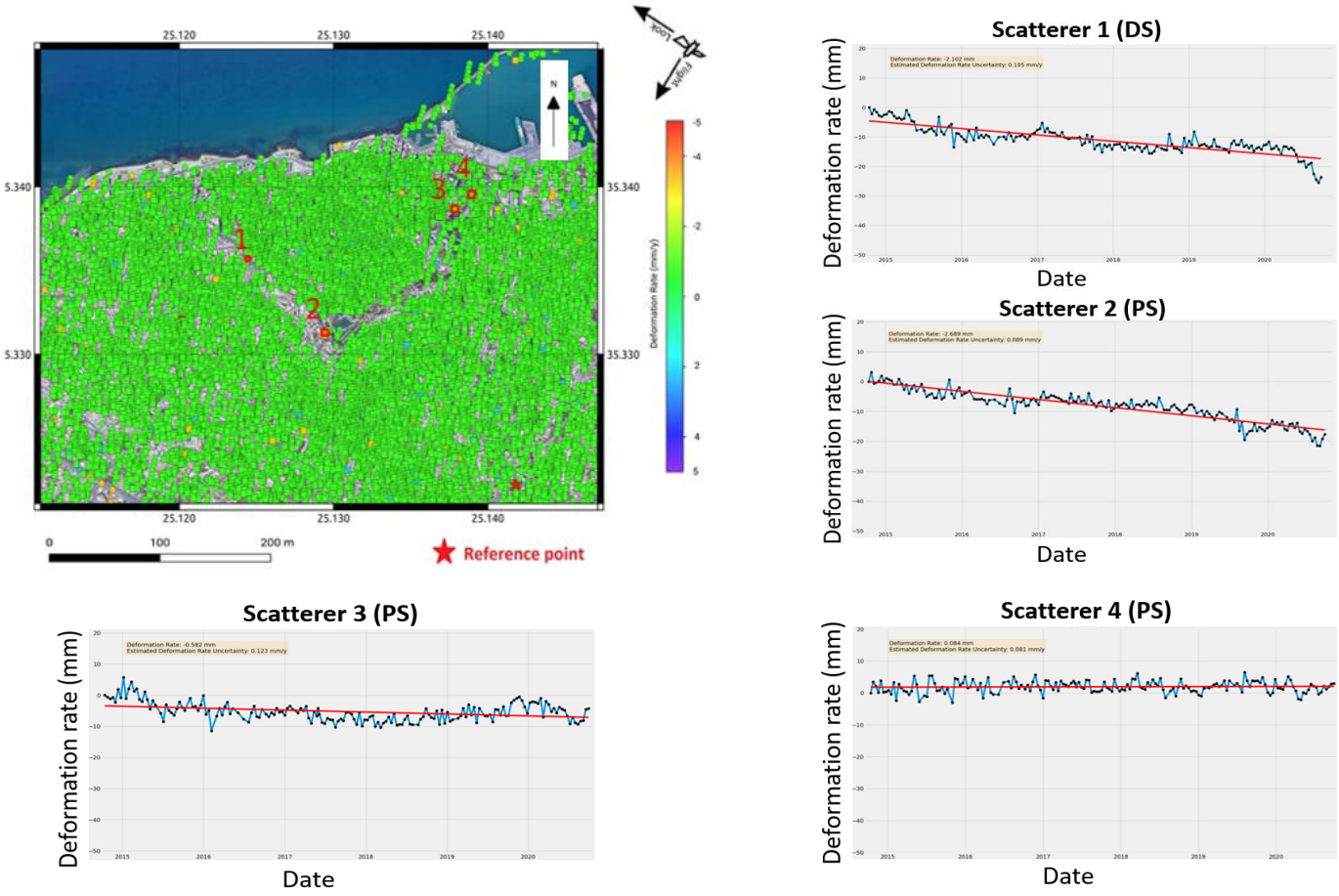

Figure 3. presents the PS/DS-InSAR of the case study of Heraklion City Walls in Crete, Greece and the multitemporal deformation diagrams of Scatterers 1,2,3,4 of Heraklion City Walls.

According to Fig.3, the multitemporal deformation diagrams 1,2,3 and 4 of Scatterers 1 to 4 located on the Heraklion City Walls presents the movement of the selected scatterers along the Line-Of-Sight (LOS).

In particular, the negative values in the presented multitemporal diagrams corresponded to the movement of the scatterer away from the LOS of the satellite and the positive ones corresponded to the movement of the scatterer towards the satellite.

As it can be shown comparing the four selected scatterers during the time-period of October 2014 to May 2020:

Scatterers 1 and 2 move away from the LOS of Sentinel-1 compared to scatterers 3 and 4, which show stability.

The Heraklion City Walls stability is linked to geotechnical factors, which will be investigated furthermore in order to determine as a next step the structural capacity and risk assessment of the monument by comparing the MT-InSAR results with geotechnical field observations.

CASE STUDY: THE ACROPOLIS OF ATHENS

On Friday 16/04/2021, members of the National Technical University of Athens (NTUA) research team visited the Acropolis of Athens accompanied by the Acropolis Restoration Service (YSMA) team members aiming to inspect specific sites susceptible to deformations. The Pedestal of Agrippa (Fig.4) was the main concern of the survey as the occurring deformations can be easily verified by the ruptures recorded at the footing of the monument as well as by the clearly visible declination of the entire structure. Further works took place at the Parthenon and at the SE corner of the walls (Fig.5).

Figure 4. The Pedestal of Agrippa (Photo credits: YSMA).

Figure 5. illustrates the overhanging rock bearing the footing of the SE corner of the walls as well as the monitoring system installed by YSMA at the ruptures of the pedestal`s footing (Photo credits: YSMA & NTUA).

RELATED PUBLICATIONS

Chen F., Zhou W., Xu H., Parcharidis I., Lin H., Fang C., (2020) Space technology facilitates the preventive monitoring and preservation of the Great Wall of the Ming Dynasty: a comparative study of the Qingtongxia and Zhangjiakou sections in China, in *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, doi: 10.1109/ JSTARS.2020.

Tompolidi, A.-M., Parcharidis, I., Loupasakis, C., Fragiadakis, M., Soupios, P., Grigorakou, E., Achmet, Z., Kalousi, G., Eleftheriou, V., Michalopoulou, D., Christodoulopoulou, R., Kanaki, E., Mavromati, D., Sythiakaki, V., Elias, P., and Gatsios, T., SpaCeborne SAR Interferometry as a Noninvasive tool to assess the vulnerability over Cultural hEritage sites (SCIENCE), EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-13397, https://doi.org/10.5194/egusphere-egu21-13397, 2021.

Gatsios, T., Cigna, F., Tapete, D., Sakkas, V., Pavlou, K., & Parcharidis, I. (2020). Copernicus Sentinel-1 MT-InSAR, GNSS and Seismic Monitoring of Deformation Patterns and Trends at the Methana Volcano, Greece. *Applied Sciences*, *10*(18), 6445.

Antoniadis, N., Karathanou - Nicholaidi, M.-M, & Loupasakis K. (2020). Parametric simulations on the stability conditions of the masonry wall of Chandakas, EUROENGEO 3rd European Regional Conference of IAEG, Athens 2020.

UPCOMING EVENT

Virtual Workshop of SCIENCE project in Early October of 2021 hosted by Harokopio University of Athens through Google Meets platform in collaboration with all the partners of the bilateral Greece-China collaboration. The leaflet and the official program of the Workshop will be presented soon.

Follow the upcoming Workshop announcements in:
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PROJECT COORDINATORS – PRINCIPAL INVESTIGATORS

Chinese part
Chen Fulong, Dr. & Professor
Aerospace Information Research Institute, Chinese Academy of Sciences

Greek part
Issaak Parcharidis, Professor
Department of Geography, Harokopio University of Athens

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