Space-based Deformation Monitoring of Coastal Urban Areas: The Case of Limassol's Coastal Front

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Abstract
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Abstract

The notable urban and infrastructure growth of the last five years in Limassol, Cyprus, has determined the necessity to provide a detailed deformation monitoring analysis of land subsidence of the coastal zone. Following the crisis events of 2013, Cyprus government promoted incentives for land development as a measure to restart the Cyprus economy. Consequently, Limassol arose to be the fastest growing city in Cyprus in the field of construction, with skyscrapers built one after the other along the coastal front, in almost 20km. This massive development generated increasing concern that a combination of factors, such as overexploitation of groundwater, the structures' load, the sea level rise driven by the global climate change, and the intense earthquake activity, may holistically trigger land subsidence phenomena. The later poses an imminent threat for the socio-economic equilibrium of the country, as well as an incremental factor for the risk of possible floods in the specific area. The combination of using space and ground-based data for detecting and monitoring changes in the coastal zone of Limassol after the rapid growth, can be characterized as innovative since no case of detecting changes in urban areas in Cyprus has been studied in the past.

The integrated use of multiple space-borne InSAR (interferometric synthetic aperture radar) techniques are, undoubtedly, among the most effective methods to monitor land subsidence and, therefore, assess the impact of urban infrastructures on the coastal zones. Techniques such as the Persistent Scatterer Interferometry (PSI) with Synthetic Aperture Radar (SAR) became indispensable parts in ground deformation monitoring analysis of urban areas as it may provide cm- to mm-level accuracy products. The PSI technique detects and measures specific points (buildings, stable rocks, roads etc) on the surface of the Earth that are phase-coherent and stable over a period of time. The number of the persistent scatters was computed in three main stages: identifying as many scatterers as it possible in the study area, extracting the possible scatterers with minimum value of coherence equals to 0.80 and isolating the final scatterers that correspond to tall buildings or skyscrapers in every pixel. Processing and analysing Copernicus Sentinel-1 data, from 2016-2021 using the Sentinel Application Platform (SNAP) and the Stanford Method for Persistent Scatters (StaMPS). A case study for the identification and analysis of the elements (PS) in pixels in a series of interferograms, and then, the quantity of the land displacements in the Line of Sight, in the Limassol coastal front, is presented in this research. As the 'master' image in the pre-processing procedure, the image that minimizes the sum decorrelation, of all interferograms was chosen. Sentinel-1 data products that are used, are Single Look Complex (SLC) images with similar characteristics (polarization, sensor and acquisition mode), creating a time-series sequence over the passing five years. For the validation of the detected deformation, accurate ground-based geodetic measurements along the coastal area were used.

As a secondary objective, this research investigates the possibility to automatically monitor land subsidence in urban coastal areas, which consist of skyscrapers and tall buildings by means of space-based techniques. Concordantly, taking into account that there is a significant number of skyscrapers that is planned to be built, this study attempts a preliminary assessment of the impact these structures will

pose on the coastal front of the area of Limassol through the Cyprus Continuously Operating Natural Hazards Monitoring and Prevention System (CyCLOPS) strategic research infrastructure unit.

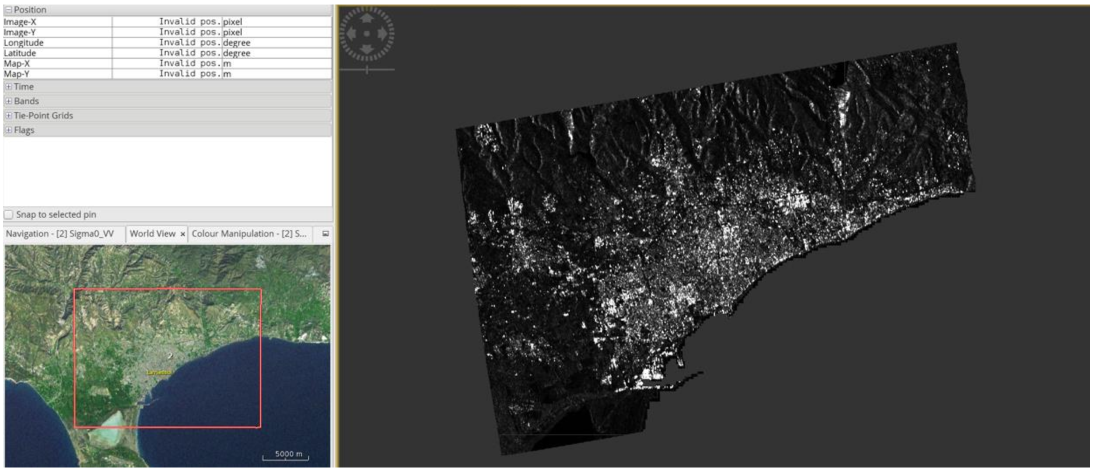

Figure 1. Back Scatter Coefficient processing in SNAP, Limassol Coastal Area, Cyprus

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