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Advanced Interferometric Synthetic Aperture Imaging Radar (InSAR) for Dune Mapping

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Aeolian morphologies are formed in the presence of sufficient wind energy and available lose particles. These processes occur naturally or are further enhanced or reduced by human intervention. The dimensions of change are dependent primarily on the wind energy and surface properties. Since the 1970s, remote sensing imagery, both optical and radar, have been used for documentation and interpretation of the geomorphologic changes of sand dunes. Remote sensing studies of aeolian morphologies is mostly useful to document major changes, yet, subtle changes, occurring in a period of days or months in scales of centimeters, are very difficult to detect in imagery.
Interferometric Synthetic Aperture Radar (InSAR) is an imaging technique for measuring Earth's surface topography and deformation. InSAR images are produced by measuring the radar phase difference between two separated antennas that view the same surface area. Classical InSAR is based on high coherence between two or more images. The output (interferogram) can show subtle changes with an accuracy of several millimeters to centimeters. Very little work has been done on measuring or identifying the changes in dunes using InSAR methods. The reason is that dunes tend to be less coherent than firm, stable, surfaces.
This work aims to demonstrate how interferometric decorrelation can be used for identifying dune instability. We hypothesize and demonstrate that the loss of radar coherence over time on dunes can be used as an indication of the dune's instability. When SAR images are acquired at sufficiently close intervals one can measure the time it takes to lose coherence and associate this time with geomorphic stability. To achieve our goals, the coherence change detection method was used, in order to identify dune stability or instability and the dune activity level.
The Nitzanim-Ashdod coastal dunes along the Mediterranean, 40 km south of Tel-Aviv, Israel, were chosen as a case study. The dunes in this area are of varying levels of stability and vegetation cover and have been monitored meteorologically, geomorphologically, and studied extensively in the field. High resolution TerraSAR-X (TSX) images covering the entire research area were acquired for the period of 2011 to 2012. Analysis was performed in imaging processing and GIS software.
The coherence results display minor changes on the dune crest (0.42-0.49), compared to bigger changes in windward slope (0.31-0.37). The level of change depends on the dune location relative to its distance from the sea. Furthermore, the coherence results show decreasing over time. Field results indicate erosion/deposition of sand ranging from -99 to 137 mm/year.
The results of this study confirm that it is possible to monitor subtle changes in sand dunes and to identify dune stability or instability, only by the use of SAR images, even in areas characterized by low coherence.