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Advanced InSAR imaging for dune mapping

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Aeolian morphologies are formed in the presence of sufficient wind energy and available 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 1970's, remote sensing imagery both optical and radar, are 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 images or more. 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. The reason is that dunes tend to be less coherent than firm, stable, surfaces.
This research aims to demonstrate how interferometric decorrelation, or, coherence change detection, 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 Nitzanim 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 extensively in the field.
High resolution TerraSAR-X (TSX) images, covering the entire research area were acquired for the period of October 2011 to July 2012 (15 images in total). All images were co-registreted, the first image was used as the master image. A coherence index was calculated for all the images. Analysis was performed in GIS software.
The results display minor changes (coherence index in range of 0.4-0.65) on dune crests depending on the dune location relative to its distance from the sea and distance from the city. In addition, field results indicate erosion / deposition of sand in a cumulatively amount of approximately 30mm annually.
The results of this study confirm that it is possible to monitor subtle changes in dunes and to identify dune stability or instability, only by the use of SAR images.