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Monitoring of desert dune field migration process by multi angle sensors

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At the present time, the sandy desert is rapidly expanding worldwide, and this can potentially result in increased risks for socioeconomic as well as anthropogenic activities. For example, the increasing occurrences of mineral dust storms, which have presumably originated in the sandy deserts in northwest China, have become a serious threat to human activities as well as to public health over Far East Asian areas, as the interpretations by the MODIS analysis (Zhang et al., 2007) and the particle trajectory simulation with HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) (Kim et al., 2011) have identified. Since sand-dune activity has been recognized as an essential indicator of progressive desertification, it is important to establish a monitoring method of the aspects of the topographic characteristics, such as local roughness. Therefore, we employed an MISR (Multi-angle Imaging SpectroRadiometer) image sequence to extract Multi-angle Viewing (MAV) topographic parameters such as NDAI (Normalized Difference Angular Index), which represents the characteristics of the targeted desert topography. In this study, NDAI was expanded to all the viewing angles of MISR channels to constitute the feature spaces monitoring the local surface roughness. Then the extracted roughness values over the targeted sandy desert and the surrounding land covers, respectively, were compared. It showed very strong consistencies according to the land-cover type and especially over the dynamic dune fields. On the other hand, the variation of NDAIs of sandy desert combined with the meteorological observations, such as the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-Interim, were examined and showed a correlation between intensified sand-dune activities and surface wind conditions.

For the validation of our observations based on the MAV sensor, two auxiliary datasets were further employed. At first, the geometric roughness from airborne LiDAR over dune fields and EO-ALi images were compared with NDAI values. In addition, ICESat beam-broadening effects, which are interpreted as topographic roughness parameters, were analyzed over the target area. These tasks revealed the correlations between the meter-scale height variations and NDAI values over the desert dune fields, proving the effectiveness of NDAI to represent the surface condition for the progress of aeolian interaction.

In conclusion, we proved that the trace of the sandy-desert boundaries for a long observation period is feasible with the multi-angle orbital sensor observation by investigating the expanded NDAIs from various sample sand-dune fields. However, it is quite uncertain whether the consistency of MISR NDAIs over sandy deserts originated from the aeolian microstructures, the reflectance of sand, or the aspect angle of dune morphology. Therefore, in the next stage, the local roughness properties extracted from MISR data analysis will be compared with the topographic information from high-resolution stereo satellite imagery. Consequently, this will correctly evaluate the suitability of multi-angle observation parameters as a dune-activity indicator.