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Measuring the spatial variation in surface moisture on a coastal beach with an infra-red terrestrial laser scanner

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Coastal sand dunes provide essential protection against marine flooding. Consequently, dune erosion during severe storms has been studied intensively, resulting in well-developed erosion models for use in scientific and applied projects. Nowadays there is growing awareness that similarly advanced knowledge on dune recovery and growth is needed to predict future dune development. For this reason, aeolian sand transport from the beach into the dunes has to be investigated thoroughly. Surface moisture is a major factor limiting aeolian transport on sandy beaches. By increasing the velocity threshold for sediment entrainment, pick-up rates reduce and the fetch length increases. Conventional measurement techniques cannot adequately characterize the spatial and temporal distribution of surface moisture content required to study the effects on aeolian transport. Here we present a new method for detecting surface moisture at high temporal and spatial resolution using the RIEGL VZ-400 terrestrial laser scanner (TLS). Because this TLS operates at a wavelength near a water absorption band (1550 nm), TLS reflectance is an accurate parameter to measure surface soil moisture over its full range. Three days of intensive laser scanning were performed on a Dutch beach to illustrate the applicability of the TLS. Gravimetric soil moisture samples were used to calibrate the relation between reflectance and surface moisture. Results reveal a robust negative relation for the full range of possible surface moisture contents (0% - 25%). This relation holds to about 80 m from the TLS. Within this distance the TLS typically produces O(10^6-$10^{7)}$ data points, which we averaged into soil moisture maps with a 0.25x0.25 m resolution. This grid size largely removes small moisture disturbances induced by, for example, footprints or tire tracks, while retaining larger scale trends. As the next step in our research, we will analyze the obtained maps to determine which processes affect the spatial and temporal surface-moisture variability.