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Deconstructing a polygenetic landscape using LiDAR and Multi-resolution analysis

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In many aeolian systems characteristic morphologies are associated with various regimes both past and present. Such landscapes contain a variety of features differentiated largely through morphometry, which in turn reflects age and divergent process regimes. It is notoriously difficult to deconstruct a complex polygenetic landscape into distinct process-form regimes using digital elevation models (DEMs) and fundamental land-surface parameters. Using quantitative analysis of high-resolution elevation data to generate detailed information regarding morphometries characteristic of particular process-form regimes enables geomorphologists to effectively map regimes from a distance. Combined with satellite imagery and other remotely sensed data, the outputs can even help to delineate phases of activity within aeolian systems. The differentiation of regimes and identification of relict features together lends a greater level of rigor to analyses leading to field-based investigations, which are highly dependent on site-specific historical contexts that often obscure distinctions between separate process-form regimes.

This study describes a multi-resolution analysis approach for extracting geomorphological information from a LiDAR-derived DEM over a stabilized aeolian landscape in south Texas that exhibits distinct process-form regimes associated with different stages of landscape evolution. Multi-resolution analysis was used to generate average altitudes using a Gaussian filter with a maximum radius of 1 km at 20 m intervals, resulting in 50 generated DEMs. We present results from a Principal Components Analysis (PCA) performed on these models. The first 4 principal components (PC) account for 99.9% of the variation, and classification of the variance structure reveals distinct multi-scale topographic variation associated with different process-form regimes and evolutionary stages. The components are used to generate a map of aeolian morphometric signatures for a portion of the landscape. Several of these areas do not immediately appear to be aeolian in nature in satellite imagery or LiDAR-derived models yet field-collected soil cores and historical imagery reveal the PCA did in fact identify stabilized and relict dune features.

This methodology enables researchers to generate an automated morphometric classification of the land surface, particularly in aeolian systems. We believe this method is a valuable and innovative tool for researchers identifying process regimes within a study area, particularly in field-based investigations that rely heavily on site-specific context.