Geophysical Research Abstracts
Vol. 19, EGU2017-2643, 2017
EGU General Assembly 2017

Scale dependent behavior the foredune: Implications for barrier island response to storms and sea level rise

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The impact of storm surge on a barrier island tends to be considered from a single cross-shore dimension, dependent only on the relative elevations of the storm surge and dune. However, the foredune line is rarely uniform, and can exhibit considerable variation in height and width at a range of length scales ranging from tens of meters to several kilometers. LiDAR data from barrier islands in Texas and Florida are used to explore how shoreline position and dune morphology vary alongshore, and to determine how this variability is altered or reinforced by storms and post-storm recovery. Wavelet analysis reveals that a power law can approximate long-term shoreline change across all scales, but that storm-scale shoreline change ($\sim$10 years) and dune height exhibit similar scale-dependent variations at swash (0-50 m) and surf zone scales (<50-1000 m). The in-phase nature of this relationship between dune height and storm-scale shoreline change indicates that areas of greater storm-scale shoreline retreat are associated with areas of smaller dunes. Decoupling of storm-scale and long-term shoreline change at swash and surf zone scales suggests an alongshore redistribution of sediment towards a more dissipative shoreline over time. Post-storm recovery for Gulf Islands in Florida is dissipative at the smallest scales, which suggests that given sufficient time between storms it is possible that small-scale variations in dune height can be repaired through alongshore recovery and expansion of vegetation, but the timescales of recovery exceed the time between storms capable of eroding and overwashing the dune. Since historical shoreline retreat is correlated with dune height variance at swash and surf zone scales, the persistence of the variations in dune height are argued to be an important control on island transgression in response to sea level rise.