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Shoreline response to climate change in a model of large-scale coastal change

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Gradients in wave-driven alongshore sediment transport cause long-term change in the shape of sandy coastlines. Recent modeling work (Ashton, et. al. 2001) suggests coastlines can attain shapes that are in quasi-equilibrium with a regional wave climate—the distribution of wave influences as a function of wave-approach angles. Changes in storm frequency and/or magnitude will alter the wave climates affecting coastlines. Such a shift in wave forcing will tend to alter large-scale shapes of sedimentary coastlines, causing rapid shifts in local shoreline positions.

Mid-latitude winter storms and tropical cyclones, for example, dominate the wave climate off of the Southeast coast of the United States. The resulting wave distribution likely determines the basic shape of the Carolina cape system, which extends along 400 kilometers of coastline. Global warming-related changes in storm (and therefore wave) patterns will likely cause this coastline pattern to adjust. In preliminary computer simulations, Murray, et. al. (in review) demonstrate coastline evolution accelerating by a factor of two to three times for a 5% increase in storminess and four to five times for a 10% increase in storminess after 200 years.

Our modeling approach builds upon one-line coastal engineering models. It incorporates wave shadowing; protruding coastal features may shadow other parts of the coast from waves. Using the model, Ashton, et. al. (2001) show that large-scale coastal features (e.g. capes and cuspate spits) may self-organize as smaller coastal features grow and merge by interacting over large distances through wave shadowing. These simulations start with a cape-like shoreline, resembling the Carolina coastline, which we generated using the one-line model driven by the statistical average of 20 years of hindcast wave data measured off Cape Lookout, NC (WIS Station 509). In our experiments, we explored the effects four different wave climate scenarios have on shoreline evolution over 200 years: (a) unchanged, (b) increased winter storms, (c) increased tropical storms, and (d) decreased storminess.

The change in wave climate causes the shoreline shape to evolve to a new state of quasi-equilibrium. Under the existing wave climate, the cape tips continue their southward migration at roughly 1 km/century, consistent with historical observations. When we increase the prevalence of winter storms, the capes accelerate their southward migration. Accretion concentrates near the cape tips, and erosion spans the entire cuspate bays. When we increase the prevalence of tropical storms, the capes now migrate northward. Under a decreased storminess scenario, the cape tips erode (smooth out) while the cuspate bays accrete.

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