Forecasting Coastal Vulnerability to Hurricanes: Application to the 2004 Hurricane Season

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The number and intensity of hurricanes are predicted to increase over the next decade. Evidence of this is the 2004 hurricane season wherein four major hurricanes impacted the State of Florida within a six-week period, causing significant destruction to beaches and coastal property. The coast's vulnerability and spatially variable response to hurricanes may be predicted by examining the relationship between spatial variations in coastal topography and hurricane-driven fluid forcings. The relative elevations of foreshore dunes and extreme wave runup are compared using Sallenger's storm impact scaling model (2000) in a forecasting mode to determine the likelihood of the occurrence of dune erosion and overwash for hurricane conditions. Data collected after hurricanes Charley, Frances, Ivan, and Jeanne are used to help test and further develop the hurricane vulnerability-assessment model.

Hurricane Charley, a Category 4 storm, came ashore August 13, 2004, as a significant wind event with limited storm surge. This narrow storm moved quickly onshore, carving a 450-m-wide breach across Captiva Island. Hurricanes Frances and Jeanne made landfall near Vero Beach, FL, within three weeks of each other during September 2004. Frances, a Category 2 storm, did not cause as severe impacts as have been observed during other recent Category 2 landfalls. However, it eroded much of the protective beach and fore-dunes along Florida's central east coast, leaving coastal structures more vulnerable to the arrival of Category 3 Jeanne. In this area, the impact of successive hurricanes and the timing of storm events can be examined. Hurricane Ivan, a Category 3 storm that made landfall on September 16, 2004, was a major surge event that caused significant dune erosion and overwash along the panhandle of Florida. Offshore wave heights of 14 m and a broad, strong wind field created significantly elevated water levels along 100 km of coastline.

Dense measures of dune height and beach slope along the Florida coast were extracted from lidar-based surveys of beach topography collected prior to hurricane season. Estimated extreme water levels associated with each category hurricane were calculated as the combined effects of wave runup, storm surge, and tide using a field-data-based empirical parameterization. Areas where predicted water-level elevation exceeds the dune elevation are expected to overwash during the hurricane; other areas are expected to experience dune erosion. Detailed comparisons of lidar surveys of beach topography collected before and after hurricane landfall were used to test the performance of the vulnerability model as well as to measure the nature, magnitude, and variability of coastal change in response to the hurricanes.

Reference

Sallenger, A.H., 2000. Storm impact scale for barrier islands. *Journal of Coastal Research*, 16, 890-895.