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Barrier Island Elevations Relevant to Potential Storm Impacts: 2. South Atlantic

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Introduction

The southeastern coast of the United States is vulnerable to severe storms (i.e. hurricanes, nor'easters) that may cause rapid coastal erosion, significant damage to infrastructure, and severe coastal flooding. To quantify the potential impact of this hazard, two geomorphic parameters (D_{high} and D_{low}, Plate 1 inset) were mapped to assess the potential vulnerability of barrier islands to storm impacts. D_{high} represents either the elevation of the foredune ridge or, if no dune is present, the elevation of the beach berm, whereas D_{low} represents the elevation of the base of the dune, which is the transition point between water-laid sand of the beach and eolian deposits of the dune (Sallenger, 2000). In the absence of a foredune ridge, D_{high} and D_{low} are equivalent. When compared to wave runup, these elevations can be used to predict the magnitude and type of coastal change that may occur during severe storms (Sallenger et al., 2000).

D_{high} and D_{low} elevations are determined using high-resolution laser altimetry data, collected in a cooperative program between NASA and the USGS. NASA's ATM (Airborne Topographic Mapper), which is mounted on a NOAA twin-engine plane, records one elevation point approximately every 2 m^2 with a vertical accuracy of about 15 cm rms (Sallenger et. al., in press). Multiple 350-m wide swaths are flown to provide coverage of the beach and foredune ridge. The system is capable of surveying hundreds of kilometers of coast within in a few hours.

The high-density elevation data are TINned and gridded using GIS software to create elevation images for digitization. A team of computer operators digitizes the spatial locations of D_{high} and D_{low} on aspect and slope images, respectively. Next, the operators execute a model to refine the spatial locations and elevation values of the two parameters. Model output contains approximately one D_{high} or D_{low} elevation for every meter alongshore. A repeatability analysis, which assessed error introduced by the subjectivity of several digitizers, suggested a vertical accuracy of 5 cm rms for coastlines with straight, well-developed foredune ridges, and 69 cm rms for coastlines with low or absent dunes and numerous seawalls. To minimize these errors, the project leader performs a quality check of the D_{high} and D_{low} results for consistency. See Elko et al. (in press) for a detailed description of the technique summarized above.

South Atlantic U.S. Coast

Baseline D_{high} and D_{low} elevations have been mapped for the South Atlantic United States coastline. We are using these data with other types of data such as lidar shorelines, wave buoy data, and wave

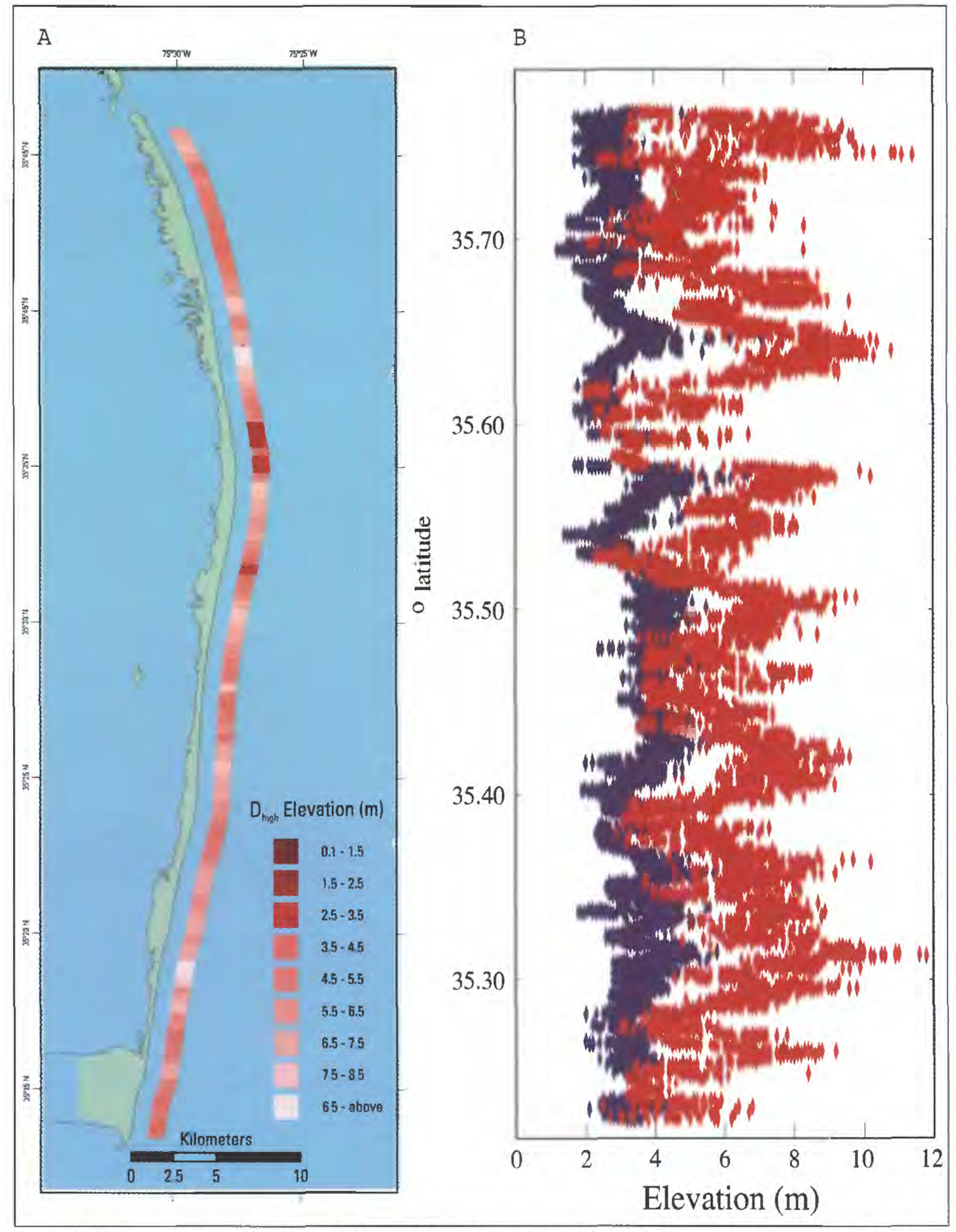

Figure 1. A) D_{high} elevations for Cape Hatteras National Seashore, NC, and B) corresponding plot of D_{high} (red) and D_{low} (blue) elevation alongshore.

refraction model output, to investigate the nature and causative mechanisms of alongshore variability in dune elevation, and also to forecast the potential impact of storms on the coast. In this report, local and regional variability of D_{high} and D_{low} over scales of kilometers to hundreds of kilometers are discussed.

D_{high} elevations from the Virginia/North Carolina border to Key Biscayne, Florida range from 0.5 to 12 m (Plate 1). Relatively high dune elevations, denoted with light reds, are prevalent in northern North Carolina and northern Florida, while lower elevations (dark reds) predominate in South Carolina and Georgia.

In addition to this regional variability, spatial variations in D_{high} occur over local scales of kilometers to tens of kilometers. For example, D_{high} elevations on Cape Hatteras National Seashore fluctuate significantly alongshore with elevations ranging from 3 to 10 m over approximately 60 km (Figure 1). This spatial variability is a result of D_{high} values representing either dune crest elevations, or in the absence of dunes, berm elevations. D_{low} elevations on Cape Hatteras National Seashore, in contrast, are fairly constant at about 3 m.

Some of the regional PDFs (probability density functions) of D_{high} have bimodal distributions (Plate 1), which may be a result of how D_{high} was defined. For example, the PDFs for South Carolina, Georgia, and southeast Florida indicate relatively low mean dune elevations of 3.2 m, 3.2 m, and 3.9 m, respectively. A lower-elevation peak is also observed at approximately 2.1 m. The higher peak corresponds to measures of dune elevations whereas the lower corresponds to elevations of berm crests. In contrast, northeast and east-central Florida have relatively high mean elevations of 4.9 m and 4.6 m, respectively, with a higher-elevation peak around 6 m. These peaks are not as easily explained by the differences between dunes and berms.

D_{high} distributions for northern and southern North Carolina differ in shape. For example, the distribution for southern North Carolina is not bimodal, but it exhibits low dune elevations (mean = 3.7 m) similar to South Carolina, Georgia, and southeast Florida. These low regions are natural barrier islands with few well-developed foredunes. Washovers breach the low dune crests during severe storms, contributing to the partial or complete absence of dunes in these regions. Alternatively, the relatively high dunes of northern North Carolina display a smooth, negatively skewed distribution (skewness = -0.3), whereas all other regional PDFs are positively skewed. The high dunes (5 to 8 m) in this anomalous region were constructed in the 1930s through extensive sand fencing and later supplemented with beach grass plantings. These high foredune ridges are eroded by wave runup during severe storms but rarely overwashed.

In summary, D_{high} and D_{low} elevations have been mapped along the South Atlantic coast from the Virginia/North Carolina border to Key Biscayne, Florida. These parameters were determined using laser altimetry data acquired by NASA, NOAA, and the USGS. Along the South Atlantic coast, D_{high} elevations show local and regional spatial variability while D_{low} elevations tend to be more stable. These data will be used not only to determine the potential vulnerability of South Atlantic barrier islands to storm impacts, but also to understand causative mechanisms of longshore variability in D_{high} and to forecast coastal change caused by severe storms.

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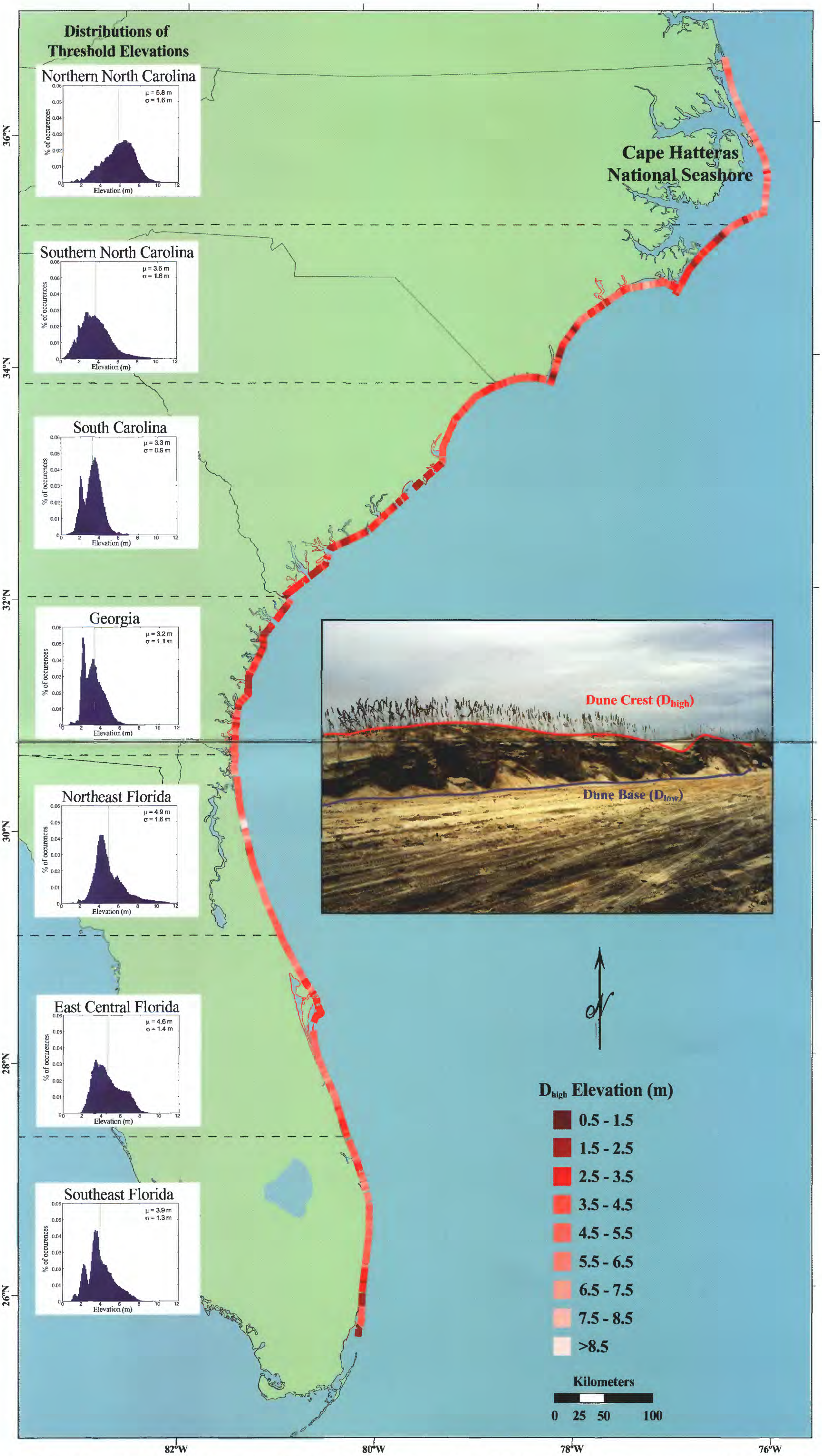

Plate 1. D_{high} elevations for the South Atlantic U.S. coast and probability density functions (PDFs) illustrating the distribution of D_{high} values for each region. The green line on the PDFs delineates the mean elevation. Inset: photograph of dunes north of Rodanthe, NC illustrating the location of D_{high} and D_{low}.