THE EFFECT OF OBLIQUE SHOREFACE-CONNECTED RIDGES ON ALONGSHORE TRANSPORT AND SHORELINE CHANGE

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INTRODUCTION

Shoreface-connected ridges (SFCR) are series of ridges and troughs obliquely oriented towards the shore in the inner-continental shelf. They exist sporadically from Long Island to Florida on the North American Atlantic Shelf with maximum expression on the Delmarva peninsula (Swift et al., 1978), including the western half of Fire Island, NY. The long-term historic shoreline record of Fire Island (e.g., Allen and LaBash, 1997) shows persistent undulations in shoreline shape at an alongshore scale similar to the alongshore scale of the ridges (Figure 1). These ridges and troughs are spaced approximately every 2 to 3 km in the alongshore and occupy a total length about 14 km in the cross-shore direction with an average crest to trough height of 2 m.

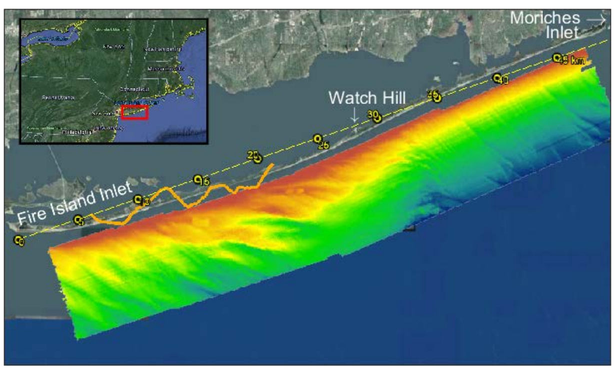

Figure 1 - Bathymetry of Fire Island showing the SFCR on the western side and the exaggerated persistent shoreline undulations in orange.

MODEL SETUP

To study the effect of ridges without the other complexities in the bathymetry and forcing, SWAN (Simulating WAves Nearshore) is configured to simulate wave transformation on a simplified, synthetic bathymetry replicating the scales of the SFCR (Figure 2), forced with a variety of realistic wave parameters based on observations near Fire Island collected by the National Data Buoy Center. ROMS (Regional Ocean Modeling System) is coupled with SWAN along with the sediment module to obtain the alongshore sediment transport driven by alongshore currents and the shoreline change.

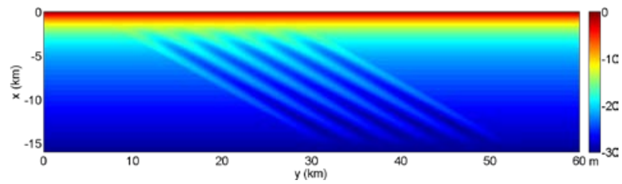

Figure 2 - Synthetic bathymetric created to match the general characteristics of the SFCR on the western side of Fire Island

RESULTS

The ridges act as a wave guide, producing areas of wave focusing and defocusing, particularly for waves approaching from the easterly direction along the axis of the ridges. Figure 3 shows the wave height anomalies with the alongshore averaged height subtracted for various incoming wave angles as labeled. The maximum variation occurs for waves with an incoming wave angle similar to the orientation of the long axis of the ridges. In addition, the location of the maximum wave shifts to opposite sides of the ridge as the wave angle relative to the ridge changes.

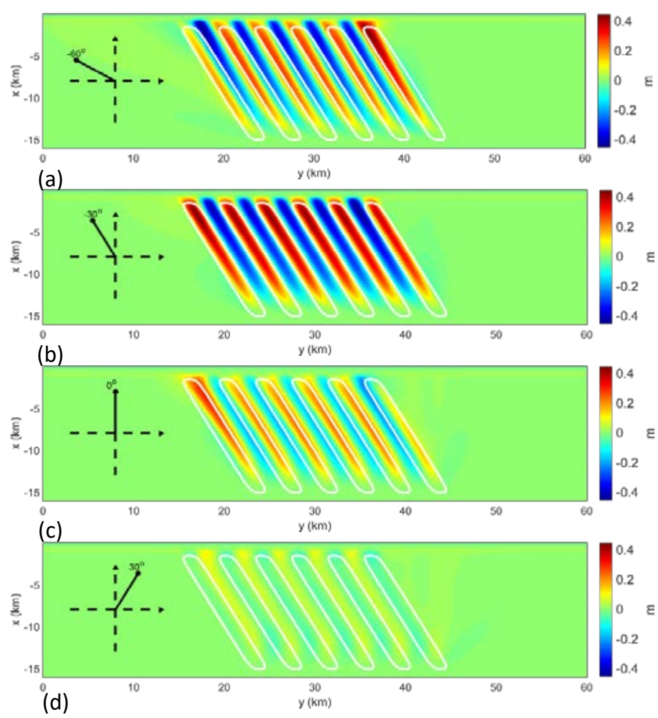

Figure 3 - Wave height difference for bathymetry with and without ridges. White contours are the outline of ridge crests. Attached compass shows the mean incoming wave angles, which are from top to bottom (a) $\theta_m = -60^o$, (b) $\theta_m = -30^o$, (c) $\theta_m = 0^o$ and (d) $\theta_m = 30^o$.

After passing over the ridges, the waves approach the shore and break, driving alongshore currents and wave setup. Figure 4 shows the alongshore variation of the breaking wave height and wave angle. Clearly, the ridges cause the focusing and defocusing of the wave field producing alongshore variations with the same scale as the ridge wave length.

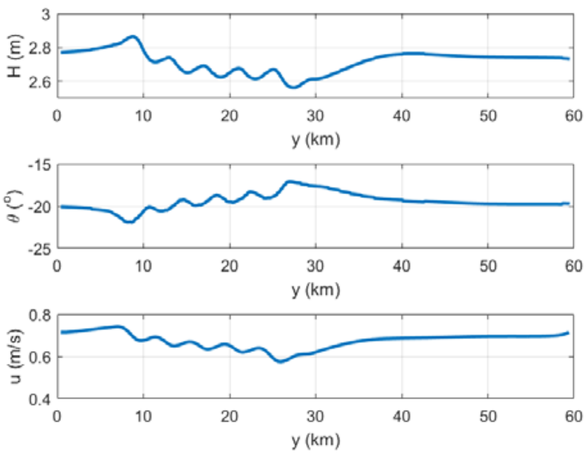

Figure 4 – Alongshore variation of the breaking wave height, wave angle and the maximum alongshore current.

As seen in the alongshore momentum balance shown in the top panel of Figure 5, the breaking acceleration has alongshore variability (primarily due to the variability in wave direction) on the scale of the entire ridge field and to a lesser extent on the scale of individual ridges. In the cross-shore direction, the wave forcing produces wave setup, which is larger and smaller in regions of wave focusing and defocusing, respectively. The variability in wave setup induces an alongshore pressure gradient (Figure 5) on the scale of individual ridges. The combination of these forcing terms are balanced by the bottom stress which indicates the total variability in the alongshore currents on both the ridge and ridge field scales.

The alongshore transport is computed using the CERC formula and the COAWST sediment transport module (Figure 5). Both methods show the alongshore variation in transport on the scale of the ridge field and individual ridges. The overall magnitudes differ, but could be calibrated to match. Both methods produce shoreline change at the alongshore scale of the ridges; however, the relative locations of accretion and erosion differ, indicating the role the pressure gradient has in shifting locations of shoreline change.

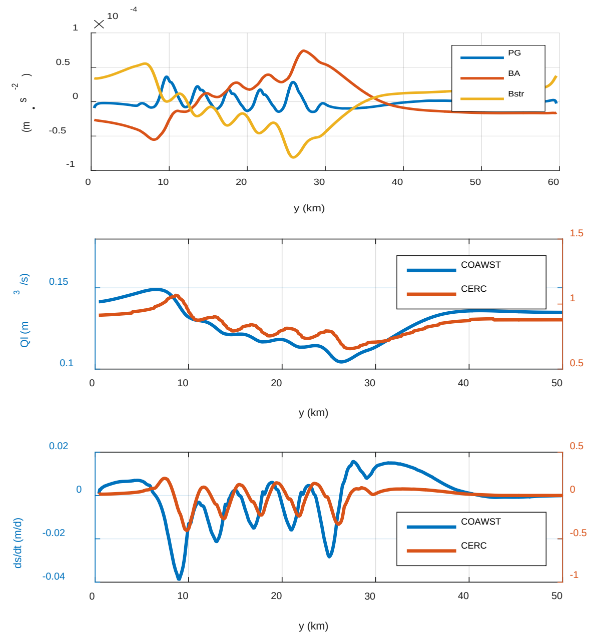

Figure 5 – Alongshore variation of (top) alongshore momentum balance with the alongshore mean removed on the 4m contour (PG-pressure gradient, BA-breaking acceleration, Bstr-bottom stress), (middle) alongshore sediment transport rate, and (bottom) shoreline rate of change.

REFERENCES

Allen and LaBash (1997) Measuring shoreline change on Fire Island. Maritimes, 39 (1):13-16.

Swift, Parker, LanFredi, Perillo, and Figge (1978) Shoreface-connected sand ridges on American and European shelves: a comparison. Estuarine and Coastal Marine Science, 7(3):257-273.