EFFECTS OF WAVE SKEWNESS AND ASYMMETRY ON THE EVOLUTION OF FIRE ISLAND, NEW YORK

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INTRODUCTION

Bedload transport of sediment by waves and currents is one of the key physical processes that affect the evolution of coasts, nearshore areas, and the engineering practices there. Wave skewness and asymmetry, both of which increase as waves shoal, result in a net bedload sediment flux over a wave cycle. The impacts of this mechanism on large-scale coastal and shoreline change are investigated in this study, using field observations and Coupled Ocean Atmosphere Wave Sediment Transport (COAWST), a hydrodynamic process-based numerical modeling system (Warner et al., 2010). The study site is Fire Island, New York, located at the Atlantic Coast of the USA, with a focus on the persistent shoreline shape, at the western half of this 50-km-long barrier island, that has been hypothesized to be linked to the sand deposits at the shoreface.

METHOD

Previous modeling efforts on Fire Island showed that the alongshore sediment transport by itself cannot fully explain the formation of this persistent shoreline shape (Safak et al., 2017a). In this study, it is hypothesized that accounting for cross-shore sediment transport and the effects of wave skewness and asymmetry will improve the skill of COAWST in modeling this coastal evolution. Accordingly, COAWST is equipped with two formulations of bedload sediment transport (Kalra et al., 2019; Warner et al., 2020). The first formulation (Soulsby and Damgaard, 2005; SD) includes the effects of wave asymmetry by adding a second harmonic to the basic wave harmonic. The second formulation (Van der A et al., 2013; VdA) is based on a more advanced *half-wave-cycle* concept that can account for unsteady phase-lag effects between velocities and concentrations, flow acceleration skewness, and boundary layer streaming.

RESULTS

In the representative storms studied here using realistic forcing, the alongshore sediment transport patterns are relatively similar between the applications of each formulation, however, cross-shore sediment transport is found to be largely sensitive to the formulation used: i) SD gives strictly offshore bedload fluxes; ii) VdA indicates mostly onshore bedload fluxes except at relatively shallow depths; iii) accounting for boundary layer streaming in VdA causes the bedload fluxes at those shallow depths to become onshore as well. Onshore fluxes are correlated with skewness in wave-induced velocity and acceleration (Figure 1). Compared to previous results based only on alongshore transport, preliminary results incorporating cross-shore flux using the VdA method improve model skill to reconstruct the persistent shoreline shape along most of the Fire Island. Onshore fluxes dominate parts of the shoreline that previously had sediment deficit; offshore fluxes dominate parts of the shoreline that previously had sediment excess.

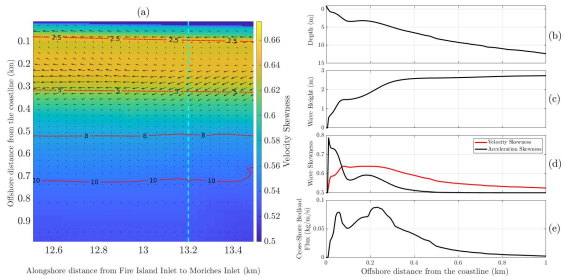

Figure 1 - (a) Velocity skewness (color-coded) depth contours and total sediment fluxes (arrows indicate magnitude and direction of total sediment fluxes). (b-e) Cross-shore profile (see in (a) the cyan dashed line) of depth, wave height, wave skewness, cross-shore bedload sediment flux.

REFERENCES

Kalra, Suttles, Sherwood, Warner, Aretxabaleta, Leavitt (2019): Investigating bedload transport under asymmetrical waves using a coupled ocean-wave model. Proc. Coastal Sediments'19. Eds: P.Wang, J.D. Rosati, M. Vallee.

Safak, List, Warner, Schwab (2017): Persistent shoreline shape induced from offshore geologic framework: effects of shoreface connected ridges, J. Geophys. Res.- Oceans, 122.

Soulsby, Damgaard (2005): Bedload sediment transport in coastal waters, Coastal Engineering 52, 673-689.

Van der A, Ribberink, Van der Werf, O'Donoghue, Buiksrogge, and Kranenburg (2013): Practical sand transport formula for non-breaking waves and current. Coas. Eng. 76, 26-42.

Warner, Armstrong, He, Zambon (2010): Development of a coupled ocean-atmosphere-wave-sediment transport (COAWST) modeling system. Ocean Modell. 35:230-244.

Warner, Sherwood, Aretxabaleta, Hegermiller, Kalra, Himmelstoss, Brothers (2020): Comparison of longshore and cross-shore sediment transport processes influencing shoreline change. Abstract#EP061-0001, AGU Fall 2020.