WAVE AND SEAFLOOR SPECTRA PREDICTIONS WITH THE COUPLED SWAN-NSEA MODELING SYSTEM

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INTRODUCTION

The existence and evolution of bedforms on the seafloor have significant effects in the areas of oceanography, marine geophysics, and underwater acoustics including the transport of sediment, wave energy attenuation, and seabed sonar scattering and penetration. Therefore, it is important to include the effects of the temporally and spatially varying seafloor roughness in regional wave models. We present a wave-seafloor modeling system that couples a spectral seafloor boundary layer model (Navy Seafloor Evolution Archetype, NSEA, Penko et al., 2017) to an operational wave model for the Navy (Simulating WAves Nearshore, SWAN, Booij et al., 1999) that includes the dynamic feedback between the predicted wave spectra and the wave generated bedforms on the seafloor through a bottom roughness parameter. NSEA is a seafloor spectral model that uses hydrodynamic input forcing forecasted by the wave model SWAN to predict the evolving seafloor spectra given a sediment grain diameter and an estimation of the biologic activity. The system can be used to determine the spatially and temporally varying bottom roughness under given wave forcing important for coastal morphology and acoustic applications.

MODEL DESCRIPTION

NSEA is a time-dependent spectral seafloor model that applies sediment continuity and assumes the ripples are being driven to an equilibrium spectrum given by the instantaneous wave forcing. The time rate of change of the seafloor spectra is determined by how far the present seafloor spectra is from equilibrium and an adjustment time scale that is based on the volumetric sediment transport rate and the cross-sectional area of the ripples (Traykovski, 2007). The equilibrium spectrum of the bed is generated from a Gaussian distribution of the equilibrium ripple height (η_{eq}) and length (λ_{eq}) from Nielsen's (1981) equilibrium ripple equations. The sediment transport rate is calculated using the Meyer-Peter and Müller (1948) formulation. The spectral decay due to bioturbation is approximated as a diffusive process and described with an exponential decay equation (Penko et al., 2015) when the wave energy is below the critical threshold to move the sediment bed. NSEA was validated with hindcasts of wave height, wave direction, and ripple length observations made off the coast of Panama City, FL in 2013 (Penko et al., 2017). NSEA is two-way coupled to SWAN through a roughness length scale dependent on the height of the ripples and used to calculate a new friction factor. A wave energy dissipation factor is calculated from the new friction factor and included as a sink term in the wave energy density equation in SWAN.

RESULTS

The SWAN model is set up using a multiple nested system with the outer-most parent grid (22km resolution) forced with surface winds. It is nested down to three additional simulations with resolutions of 7.4km, 1.8km, and 444m. NSEA is then coupled to SWAN in the highest-resolution (444m) nest.

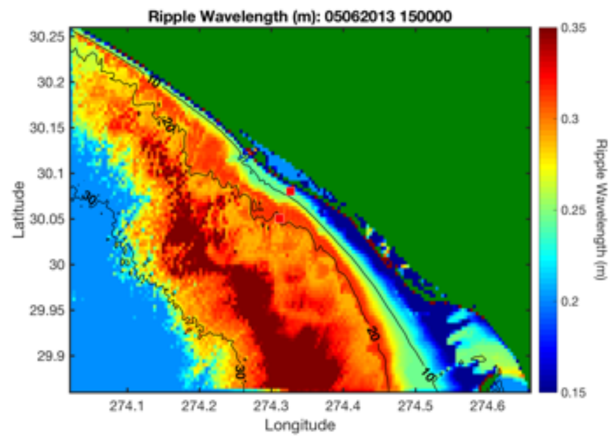

Figure 1 - Plot of the modeled ripple length in a domain off the coast of Panama City, FL.

The coupled SWAN-NSEA model provides forecasts of spatially varying seafloor spectra as well as an estimation of sediment transport at every grid point in the model domain. The model may be used in applications requiring predictions of bottom roughness spectra or ripple length and orientation such as acoustic and coastal morphology modeling.

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