WAVE-DRIVEN COASTAL DYNAMICS: CAN WE RELY ON PHASE-RESOLVING MODELS?

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INTRODUCTION

Phase-resolving numerical models are known to serve as a great tool for simulating the nearshore gravity wave dynamics. Another strength of these models is that their formulations allow for the generation and propagation of infragravity (IG) waves. However, it is not clear how well a simulated wave field represents the one observed in a complex environment with realistic forcing under high-amplitude input conditions. Furthermore, aside from using these models for particular applications, the relative performance of different phase-resolving models has not been quantified.

Wave simulations from two Boussinesq-type models: BOSZ (Roeber & Cheung, 2012) and FUNWAVE (Shi et al., 2012), and a non-hydrostatic model: XBeach (Roelvink et al., 2009), are compared to observational data in a harbor and along the exposed coast of northwest O'ahu Island, Hawai'i, under highly energetic sea/swell forcing conditions. In the present comparison we attempt to address whether the models can (i) reproduce the observed spectra at different locations over a fringing reef and inside a harbor, and; (ii) draw a consistent 2-dimensional picture of the gravity and IG wave fields throughout the computational domain.

METHODS

The comparisons between the field observations and data from the three models are carried using auto- and cross-spectral techniques, at several locations inside the harbor and over the reef. Two-dimensional (2-D) spectral maps are created to visualize the spatial distribution of energy in selected IG period bands.

RESULTS

The simulations reveal good qualitative agreement among the models and between the models and the observations, as inferred from the spectral analyses. The 2-D spatial distributions of the wave fields produced by the models are qualitatively consistent among them; they all predict the same general wave structures in the sea/swell and multiple IG period bands. At IG periods, all models reveal cross-shore standing wave patterns that have alongshore symmetry throughout much of the domain. An example of such patterns can be seen in Figure 1, that shows the free surface power spectral density in the 2-4 min period range. This map reveals a strong and narrow maxima that stretches along the entire coastline, and is followed by a series of minima and maxima going offshore, until the IG spectral levels sharply drop at the reef edge (around 20 m depth). It also reveals an alongshore variability that is strongly affected by the deep channels in the domain.

CONCLUSIONS

We find good qualitative agreement between all three models, despite some significant disagreements in spectral amplitudes. These disagreements could result from the different model formulations, and the different ways that each model handles the directional spectral input and boundary conditions. The results presented here suggest that all three models are suitable for replicating the observed characteristics in both frequency and wavenumber spectra.

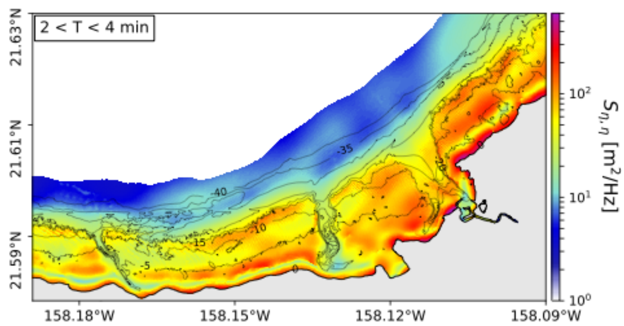

Figure 1 - Modeled free surface power spectral density in the 2 - 4 min period range, along O'ahu's North Shore coast, under strong sea/swell forcing conditions. Black contours indicate bathymetry (5m interval).

REFERENCES

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