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LONG-TERM GOAL

Our long-term goal is to contribute to the accurate prediction of surface gravity wave generation, propagation, and dissipation in coastal regions through the combined use of measurements and models.

OBJECTIVES

Our objective is to develop higher-order wave propagation schemes for the Delft shallow water SWAN model, and robust wave data assimilation methods for coastal wave models. In the process of developing the wave data assimilation techniques, we will identify the types of wave data (eg. remotely sensed or in situ) and measurement locations (e.g. at the offshore model boundary or in the nearshore) that provide the most useful constraints on model predictions.

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APPROACH

Our approach for improving the SWAN wave propagation scheme (first-order, upwind) is to explore a variety of higher-order schemes that have been developed or proposed by others in related research fields. The primary shortcoming of the first-order scheme has been the excessive directional diffusion of wave energy as it progresses through the numerical domain. This diffusion is exacerbated by complex bathymetry. Therefore, one of the principal standards for judging the higher order schemes is their improvement in this regard. The most promising higher order schemes are being implemented in the SWAN model and validated using several historical data sets from the U.S. East and West coasts to insure its applicability to a wide range of environmental conditions and geographic settings.

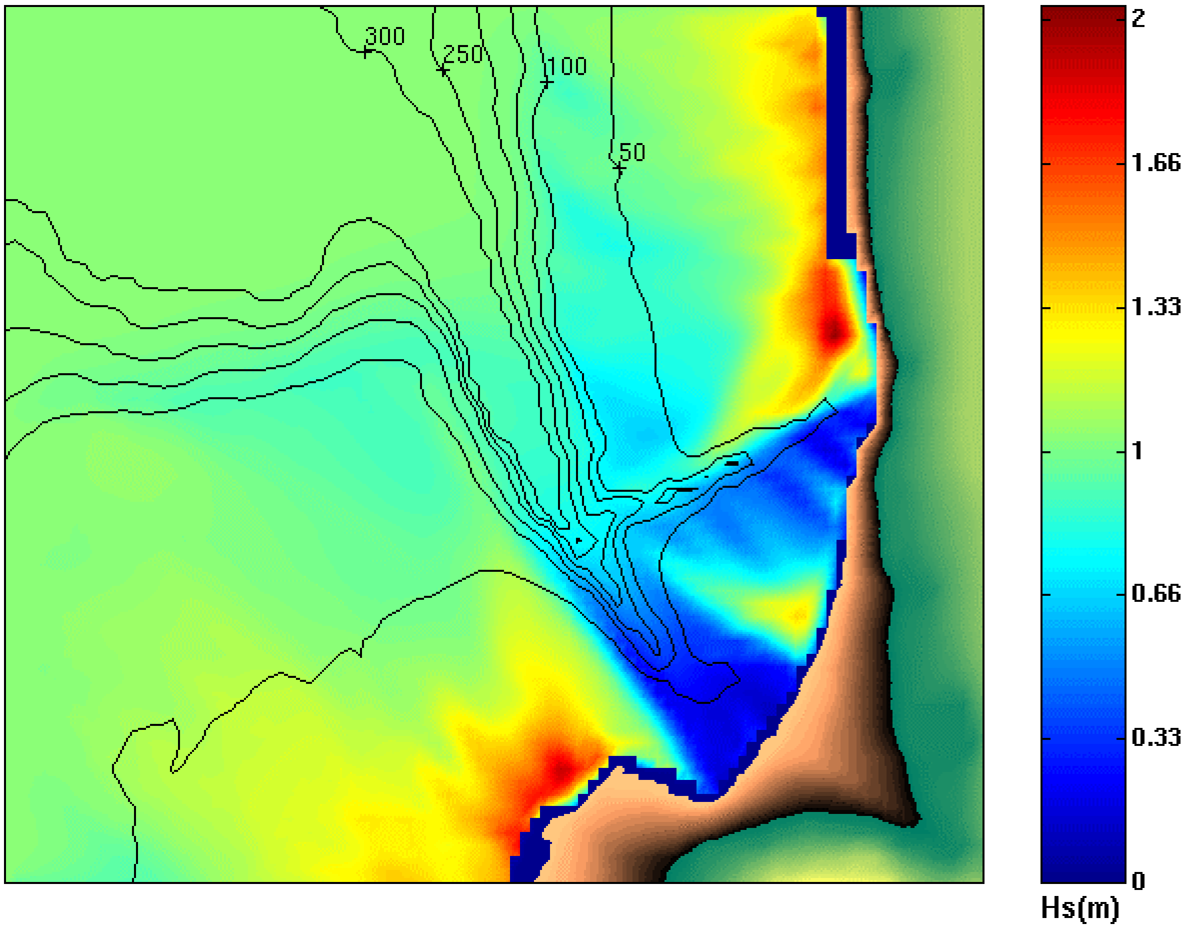
Our approach to adding data assimilation capabilities to the SWAN model is to: 1. identify the types of wave measurements available on or near the continental shelf, 2: relate these measurements to the SWAN model's spectral output with as few additional assumptions as possible, and 3: assimilate this information using methods that are computationally feasible for use in future operational products.

The wave data assimilation problem involves more than developing robust algorithms for incorporating real-time data in to the model predictions. The location of the measurements, in particular the remotely sensed data from aircraft, is a potential variable in practial applications or operational scenarios. This presents a secondary question of optimal measurement locations for assimilation on the shelf. To address this question, we can conceptually split or measurement locations into two regimes: the model boundary (initializing conditions in deep water at the shelf break) and the model interior (e.g. a swath of remotely-sensed data outside just outside the surf zone). Our approach to this question is to use an operational shallow water wave propagation model on the California coastline to address different boundary vs. interior data scenarios. Insights from this work will then be incorporated into the SWAN model as it is implemented in the same regions.

WORK COMPLETED

Development and testing of higher-order propagation schemes have been completed. Two schemes have been found to be the most appropriate candidates for inclusion into the SWAN model: the scheme of Stelling and Leendertse (1992) (referred to here as the "Stelling" scheme) and the SORDUPI (Second ORDer Upwind Implicit) scheme. The Stelling scheme is nominally of greater accuracy, but comes at a higher computational cost in stationary (time-independent) runs of the model. It is thus recommended for large - scale *non*stationary model operation (in which the increase in computational cost is nominal) or small-scale stationary operation over complex bathymetry (Figure 1). The Stelling scheme has been shown to greatly enhance the fidelity of modeling swell propagation over rugged bathymetry. The SORDUPI scheme is significantly more accurate than the present SWAN propagation scheme with only a modest increase in computational time and can be used for larger, regional applications of the model (in either stationary or nonstationary modes).

A more accurate wave propagation scheme has also been developed for global applications using great circle propagation and modified output from the FNMOC global WAM model. Wave energy source/sink information is extracted from the WAM model and archived at 12 hour intervals and great circle equations are used to extract the desired source/sink energy from the archive files to forecast swell conditions at distant locations. This method bypasses the WAM model first-order propagation scheme and eliminates errors owing to numerical diffusion and directional discretization of spectra into coarse, 15 degree bins.



1. Example of SWAN model prediction of wave heights (17 second swell arriving from the WNW), over the La Jolla and Scripps submarine canyons scheme (black depth contours in meters, using the Stelling propagation).

Work continues on the development of an experimental, real-time data assimilation model for the California coastline. We are focussing on the assimilation of data into parameterized forms of the deep water directional spectra at the shelf break (coastal model boundary). The assimilation model is designed to use real-time wave data collected by NOAA and the Coastal Data Information Program (CDIP) at Scripps, along with deep water wave nowcasts and forecasts from FNMOC, to make enhanced estimates of the incident deep water wave conditions. The data-enhanced nowcasts and forecasts will be validated using deep water directional buoys (not used in the assimilation scheme)

RESULTS

Improved wave propagation methods have been developed for the SWAN model and the global WAM model. The SWAN model improvements have been validated with field data from Duck, N.C. and the Channel Islands in Southern California.

IMPACT/APPLICATION

The new SWAN propagation schemes will significantly enhance the model's performance over large numerical domains and in areas with complex bathymetry. The new method for extracting swell information from the FNMOC global wave model will result in improved coastal swell forecasts.

TRANSITIONS

The improved SWAN propogation algorithms have been sent to Delft for incorporation into the next major release of the model. WAM-based swell forecasts are being generated in an experimental mode by NRL-Stennis and are being used by the operational Navy.

RELATED PROJECTS

1. Shoaling Waves DRI field experiment.

2. SandyDuck field experiment

3. Duck94 field experiment

4. The Coastal Data Information Program, USACE and CA Dept. of Boating and Waterways

5. MMS Study: Modeling Waves in the Santa Barbara Channel

6. Joint work with Paul Wittmann, FNMOC-Monterey

7. Joint SPAWAR work with Larry Hsu, NRL-Stennis

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Stelling, G.S., and Leendertse, J.J. 1992. Approximation of convective processes by cyclic AOI methods, *Proceedings of the 2nd International Conference on Estuarine and Coastal Modeling*, ASCE, Tampa, FL, 771-782.

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