

MEASUREMENTS AND MODEL STUDIES OF WAVE-CURRENT INTERACTION IN THE VICINITY OF MESOSCALE SURFACE FEATURES

Hans C. Graber

RSMAS - Applied Marine Physics

University of Miami

4600 Rickenbacker Causeway

Miami, FL 33149-1098

phone: (305) 361-4935, fax: (305) 361-4701, e-mail: hgraber@rsmas.miami.edu

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LONG-TERM GOAL

To examine the link between the surface wave field, atmospheric forcing and mesoscale oceanographic features and the subsequent radar backscatter modulation caused by the presence of these features.

SCIENTIFIC OBJECTIVES

The scientific objectives are:

1. To determine the nature of wave-current interaction in the presence of mesoscale features;
2. To determine the evolution of the directional wave spectrum as a function of position in the feature;
3. To describe the modulation of the short-wave spectrum by longer waves and subsequently the radar backscatter modulation;
4. To determine changes in the spectral energy density as a function of direction in the vicinity of mesoscale features; and
5. To provide accurate measurements of the directional wave spectrum, wind stress and near-surface currents.

APPROACH

Measurements of directional wave spectra, near-surface currents and surface fluxes from two discus buoys will be used in conjunction with HF and interferometric SAR surface current measurements to study the effect of wave-current interactions in the vicinity of mesoscale surface features on radar backscatter. Numerical simulations of long-wave directional wave spectra will be combined with current fields from the HF radar to compute wave-current interactions and to predict

L-band Doppler spectra from a radar backscatter model. Also predicted and observed sigma-0 values will be compared and correlated to properties of the mesoscale features. Measurements of interferometric SAR images will be used to extract vector currents and to compare with coincident and concurrent HF radar current velocities.

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WORK COMPLETED

In collaboration with George Marmorino (NRI-Washington) a study is completed on the correlation of oceanographic signatures appearing in SAR and INSAR images.

Further intercomparisons and analyses are continuing with observed surface currents from the HF radar and the interferometric SAR from the other passes in collaboration with Don Thompson (JHU/Applied Physics Laboratory).

Timeseries of motion corrected wind stress and drag coefficients have been calculated from both the K-Gill and sonic anemometers onboard the buoys. These wind stress data are evaluated in the context with a similar data set from SWADE (in collaboration with Mark Donelan and Will Drennan) to examine the influence of sea state and surface currents on the drag coefficient and boundary layer profile.

Two detailed studies on the differences between in-situ (near-surface) and HF radar measurements have been completed. Computed pseudo-structure functions show that the temporal and spatial variability of HF radar and current meter measurements are comparable.

RESULTS

The High-Resolution Remote Sensing (High-Res) experiment was a successful experiment and provided new insights into measuring surface currents with radars. Much progress has been made in the determination of the accuracy of the radar surface current measurements. Two detailed studies by Chapman, et al. (1997) and Graber, et al. (1997) studied this aspect in detail. Chapman, et al. found an absolute upper bound of about 9 to 16 cm/s on the remotely sensed currents from an intercomparison of HF radar currents with four different shipborne platforms. However, they also concluded that some of the differences are attributable to errors in the in-situ measurements. This study also examined the differences between HF radar and shipborne ADCPs as a function of measurement location.

Graber, et al. explained the differences between near-surface current meter measurements and HF radar-based surface currents in terms of instrument, spatio-temporal alignment and geophysical process. The latter source of differences included the effects of Ekman and Stokes drift currents as well as baroclinic currents resulting from horizontal temperature gradients. The results of this analysis suggested that 40 to 60% of the observed differences between near-surface CM and HF radar velocity measurements can be explained in terms of contributions from instrument noise, collocation and concurrence differences and geophysical processes. The rms magnitude difference ranged from 11 to 20 cm/s at the four mooring sites. The average angular difference ranged between 15 and 25 degrees of which about 10 degrees is attributed to the directional error of the radar current vector estimates due to the alignment of the radial beams.

The correlation of oceanographic signatures were examined in SAR and INSAR imagery with in-situ measurements. The focus of this study (Marmorino, et al. 1997) was a salinity front which appeared in both images and was well measured with shipboard and in-situ measurements. The results clearly demonstrate the potential of SAR imagery for studies of coastal circulation, hydrography and frontal dynamics.

Determining a parameterization of the sea surface drag coefficient in terms of readily measured quantities such as mean wind speed and atmospheric stability has not been adequate to reduce

the considerable scatter found between experiments. Few experiments have also measured simultaneously the spectral properties of waves to examine the role waves on the surface drag. From the HIRES and SWADE measurements we found that much of the scatter in the drag coefficient is due to the presence of swell or nonstationary conditions (Drennan, et al., 1997).

IMPACT/APPLICATION

The studies of high resolution surface current estimates with HF radar systems provide a continuous new look at small-scale dynamics affecting coastal processes. While the system is limited to coastal locations, it is, however, capable of making long-term measurements in real time. To obtain high-resolution surface current measurements in time and/or space will be of significant importance for coastal ocean dynamics and for gaining new insights on the modulation of air- and spaceborne radar backscatter from wave-current interactions. Our results indicate that surface current measurements from HF radars were critical in the analysis of INSAR current measurements.

TRANSITIONS

Several formal and informal discussions have been held with scientists from NRL-Stennis to supplement on-going or planned measurements with OSCAR surface currents as well as with NAVOCEANO personnel to extend tests of the HF radar system to multi-ship based deployments.

RELATED PROJECTS

Results from the HIRES and DUCK94 experiments have led to a new NRL initiative on "Physics of Coastal Remote Sensing" and ONR funded measurement program on the Chesapeake Bay Outfall Plume experiment. Also recent results of extracting wave heights will be an important aspect for the new ONR-funded Shoaling Waves Program. The successful deployment of the HF radar (OSCAR) system in several ONR funded experiments has led to the design and fabrication of a "next generation" HF radar system (with an industrial partner) for more versatile applications in the coastal environment.

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