MASTER OF SCIENCE
IN
METEOROLOGY AND PHYSICAL OCEANOGRAPHY

A NUMERICAL INVESTIGATION OF MESOSCALE PREDICTABILITY

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As mesoscale models increase in resolution, there is a greater need to understand predictability on smaller scales. The predictability of a model is related to forecast skill. It is possible that the uncertainty of one scale of motion can affect the other scales due to the nonlinearity of the atmosphere. Some suggest that topography is one factor that can lead to an increase of forecast skill and therefore predictability.

This study examines the uncertainty of a mesoscale model and attempts to characterize the predictability of the wind field. The data collected is from the summer, when the synoptic forcing is relatively benign. Mesoscale Model 5 (MM5) lagged forecasts are used to create a three-member ensemble over a 12-hour forecast cycle. The differences in these forecasts are used to determine the spread of the wind field. Results show that some mesoscale features have high uncertainty and others have low uncertainty, shedding light on the potential predictability of these features with a mesoscale model.

Results indicate that topography is a large source of uncertainty. This is seen in all data sets, contrary to other studies. The ability of the model to properly forecast the diurnal cycle also impacted substantially on the character and evolution of forecast spread. The persistent mesoscale features were represented reasonably well, however, the detailed structure of these features had a fair amount of uncertainty.

KEYWORDS: Mesoscale Modeling, Model Verification, Predictability, MM5

A COMPARISON OF IN-SITU MEASUREMENTS AND SATELLITE REMOTE SENSING OF UNDERWATER VISIBILITY

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SeaWiFS data converted to optical properties of the ocean, in the form of vertical and horizontal underwater visibility products, are compared to in-water diver and optical instrument measurements during the Model Diver Visibility (MoDiV) experiment. Results were collected from 19 to 21 August in the Mississippi Bight region of the United States.

The SeaWiFS satellite data was processed with the Automated Processing System (APS) developed by the Naval Research Lab (Code 7333). APS converted radiance values into specific parameters studied: the beam attenuation coefficient, the diffuse attenuation coefficient, vertical visibility, and horizontal visibility. These values were compared to the AC-9 instrument, a-Beta instrument, Secchi disk, and the observed measurements from the divers.

The results indicated that the beam attenuation coefficient and the diffuse attenuation coefficient are underestimated as compared to the in-situ measurements. These values then overestimate the vertical and horizontal visibility as compared to the Secchi disk and diver sightings. The visibility products from SeaWiFS should be used on an experimental basis for Naval operational planning. It is recommended that the use of in-water diver reports noting variability of SeaWiFS visibility product estimates are necessary for validation and offer feedback to the research and development field for algorithm improvement.

KEYWORDS: SeaWiFS, Underwater Visibility, APS

MESOSCALE FORCING OF OCEAN WAVES DURING GULF STREAM NORTH WALL EVENTS

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Under meteorological conditions associated with extreme cold air outbreaks (CAO) off the U.S. East Coast, large ocean waves sometimes develop along the North Wall of the Gulf Stream. These wave events produce wave heights above those expected, given the short fetch and moderate winds. The highest waves are often very localized, which suggests localized forcing by the atmosphere. In this study, results from four cases are examined to characterize the role of high resolution, mesoscale wind forcing in generating localized regions of large ocean waves during events with large air-sea temperature differences. A known "true" atmosphere is simulated through the use of the Navy's Coupled Oceanographic and Atmospheric Mesoscale Prediction System (COAMPS). Model surface wind output from COAMPS is used to generate a wave field using Wavewatch Three (WW3), which is then compared to buoy observations and ship reports. Results of these cases show the mesoscale wind forcing of ocean waves during CAO and the importance of mesoscale atmospheric modeling in localized generation of ocean wind waves. Additionally, empirical wave forecast techniques are compared to WW3 model output for these cases to further reinforce the mesoscale atmospheric forcing during rapid growth of wind wave events in fetch limited environments.

KEYWORDS: Mesoscale Effects, North Wall, Gulf Stream, Cold-air Outbreak, Near-shore Wave Growth

AN INVESTIGATION OF DIURNAL VARIABILITY IN WIND AND OCEAN CURRENTS OFF HUNTINGTON BEACH, CALIFORNIA

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In conjunction with the Huntington Beach Phase III Investigation, the diurnal variability in the wind and ocean currents from July 1-October 12, 2001, over the San Pedro Shelf, is investigated. Results suggest that the diurnal currents are driven by the diurnal winds, but that the strength of the ocean response is modulated by the low frequency flow regime. The spectral peak of the near-surface currents is at the diurnal frequency, which is below the inertial frequency (1.107 cpd). The diurnal currents are surface-intensified, decaying with depth to a minimum at 10-13 m and increasing slightly in strength below that. The near-surface diurnal currents are in phase across the shelf, and are close to in phase with the winds over the shelf. The amplitude modulation of the diurnal energy of the ocean currents is correlated with the direction of the low frequency flow along the shelf; the energy is enhanced when the flow is equatorward, and weak when the flow is poleward. The amplitudes of the diurnal near-surface currents are also correlated with the diurnal winds. However, the low frequency currents and winds are not well correlated.

KEYWORDS: Diurnal Variability, Near-surface Ocean Currents, Diurnal Wind Forcing, Land-sea Breeze, San Pedro Shelf

BEDFORM EVOLUTION AND SEDIMENT TRANSPORT UNDER BREAKING WAVES

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Observations of the temporal evolution of ripples are analyzed in terms of geometry, migration, crest orientation, and their predicted geometry, by models using wave orbital velocities. Two weeks of bedform data were obtained in the surf zone during the RIPEX/SBE in April 2001. Bed sediment consists of medium- to coarse-grained sand (D_{50}=0.43mm). Models capture temporal trends in ripple geometry, but regression analyses show that they do not handle the range in forcing characteristics and geometries in the surf zone well. Transport models of bedload and total load formulated under uni-directional flows qualitatively capture the temporal evolution of observed transport by ripples, suggesting that under low to moderate forcing, bed load and suspended load occur mostly within the bed-following bottom boundary layer, and are measurable by ripple migration alone. Models predict large transport rates when flat beds were observed, so that at higher forcing, ripples cannot be used to measure total sediment transport. Using a two-dimensional probability density function (PDF) of vector displacement peaks, a new ripple analysis model is proposed, incorporating a hierarchy of forcing complexity that includes such physical processes as directional spreading, axis rotation, orbital asymmetry, superimposed currents, and infragravity wave velocities. The two-dimensional PDF's are compared with concurrent three-dimensional bed maps and are found to assist in describing ripple sizes, types, orientations, and migration velocities.

KEYWORDS: Oceanography, Nearshore, Waves, Currents, Bedform Evolution, Sediment Transport, Orbitals