MASTER OF SCIENCE IN METEOROLOGY AND PHYSICAL OCEANOGRAPHY

A FINE RESOLUTION MODEL OF THE LEEUWIN CURRENT SYSTEM (LCS)

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To investigate the role of wind forcing, bottom topography and thermohaline gradients on classical as well as unique features of the Leeuwin Current system (LCS), five experiments are conducted with a sigma coordinate, primitive equation model on a beta-plane. The first experiment, which investigates the pressure gradient force error, shows that velocity errors, inherent in three dimensional sigma coordinate models, can be successfully reduced from ~100 cm/s to ~1 cm/s in the LCS. The second experiment, which highlights the effect of annual wind forcing on a flat bottom with horizontally averaged climatology, portrays some classical features of eastern boundary currents such as an equatorward surface current and upwelling. The third experiment again uses horizontally averaged climatology and annual winds, but adds realistic topography to investigate its role in the LCS. This results in a different upwelling pattern and a poleward surface current inshore of the main equatorward current. The fourth experiment uses annual temperature and salinity values to investigate the effects of the thermohaline gradient without the annual wind over topography. The addition of the thermohaline gradient drives a strong poleward (equatorward) surface current (undercurrent). The final experiment attempts to model the LCS using full climatology and annual winds over realistic topography. The results show that despite equatorward winds, the thermohaline gradient continues to force a surface poleward current (equatorward undercurrent).

KEYWORDS: Primitive Equation Model, Leeuwin Current System, Sigma Level, Princeton Ocean Model (POM)

MARITIME FRONTOGENESIS

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Numerical experiments are conducted with a hydrostatic primitive equation model initialized in a baroclinically unstable state to simulate the passage of cold fronts over the ocean. The model includes K-theory planetary boundary layer (PBL) parameterization with implicitly defined diffusion coefficients. An adiabatic and inviscid simulation provided the control for these experiments. The PBL simulations are integrated 1) with z_o held constant at 0.4 m and no heat flux; 2) with sea surface temperature (SST) set equal to θ_1 at t = 0 h; 3) with a 5° warmer SST; 4) with diffusion coefficients set equal to 1. Horizontal resolution is increased to achieve smaller scale fronts in the inviscid and ocean simulations. The frontogenetic effects of shear, tilting, convergence, and the PBL on isentropic surfaces are evaluated.

Relative to the inviscid simulation, the PBL simulations produce reduced frontogenesis. Surface heat and momentum fluxes combined with turbulent mixing of heat promote the development of a deep, well-mixed layer whose depth is dependent on the air-sea temperature difference. The rate of frontogenesis is extremely dependent on the parameterization of the PBL, specifically surface roughness lengths. Smaller scale fronts were produced during the ocean simulations than the PBL land case. Forcing in all simulations is due primarily to shearing deformation initially. As the wave grows in amplitude, convergence contributes more to frontogenesis than shear. Other terms in the frontogenetic equation become important in the PBL simulations.

KEYWORDS: Frontogenesis, Numerical Simulation, Boundary Layer, K Closure

THE CONTRIBUTION OF SYMMETRIZATION TO THE INTENSIFICATION OF TROPICAL CYCLONES

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Operational ability to forecast tropical cyclone motion is much better than the ability to forecast intensity change. Several recent works have studied the mechanisms that bring about the symmetrization of various types of asymmetries in tropical cyclones. This study was conducted to add to that knowledge by examining the transfers of kinetic energy between scales and how those energy transfers alter the wind structure of the cyclone. Adding to the understanding of how this process can alter winds is a step toward increasing ability to forecast these changes.

A non-divergent barotropic spectral model was used to integrate annular bands of enhanced potential vorticity, simulating hurricane eyes, with varying degrees of offset from the center of the vortex. Offset monopoles of vorticity, simulating asymmetric convection in tropical storms, were also integrated. As discovered by previous researchers, these unstable eyes broke down into a series of mesovortices, which merged and eventually relaxed to monopolar or tripolar final states. The offset monopoles formed spiral bands and became symmetric as well. Kinetic energy was transferred from the mean flow to the asymmetries as mesovortices formed and then transferred back to the mean flow as symmetrization occurred. These energy transfers occurred very quickly. As energy was transferred from asymmetry to mean flow, the azimuthally averaged wind increased in a band of about 70 km from the center of the vortex, even though the maximum wind decreased. Azimuthally average wind in the monopole cases also increased, but the change was confined to a smaller radial band near the radius of maximum wind.

KEYWORDS: Tropical Cyclone Intensity, Asymmetric Convection, Mesovortices, Kinetic

PLANETARY AND TOPOGRAPHIC BETA EFFECTS ON THE NORTHERN CANARY CURRENT SYSTEM (NCCS)

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To investigate planetary and topographic beta effects on classical as well as unique features in the northern Canary Current System (NCCS), several numerical experiments using the Princeton Ocean Model are explored. To isolate the dependence of Coriolis parameterization (β-plane vs. f-plane) from the topographic beta effect, the first (last) two experiments use a flat bottom (topography). In all experiments, classical eastern boundary condition (EBC) features are produced including an offshore surface equatorward meandering jet, coastal surface and subsurface poleward currents, upwelling, meanders, eddies and filaments. Due to the beta effect, the surface coastal jet does not have to be confined to within a

Rossby radius of deformation of the coast. The beta effect also plays an important role in the development and westward propagation of Meddies, a unique feature of the NCCS. Bottom topography is shown to play an important role in narrowing, intensifying, and trapping coastal currents. These results show that, while wind forcing is the primary mechanism for generating classical EBC features, planetary and topographic beta also play important roles in the generation, evolution, and maintenance of classical as well as unique features in the NCCS.

KEYWORDS: Primitive Equation Model, Northern Canary Current System, Currents, Meanders, Eddies, Filaments, Undercurrent, POM, Meddies, F-Plane, Beta-Plane

VALIDATION OF GLOBAL WAVE PREDICTION MODELS WITH SPECTRAL BUOY DATA

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Global wave predictions produced at two U. S. forecasting centers, Fleet Numerical Meteorology and Oceanography Center and the National Centers for Environmental Prediction are evaluated with spectral buoy measurements. In this study, the fidelity of frequency-directional spectra predicted by WAM and WAVEWATCH III at the operational centers is examined with data from 3-meter discus and 6-meter nomad buoys operated by the National Data Buoy Center in the Atlantic and Pacific Oceans and Datawell Directional Waverider buoys deployed along the California coast by the Scripps Institution of Oceanography Coastal Data Information Program. Only buoys located in deep water are used in the comparisons. Model nowcasts of frequency spectra and mean wave directions are compared to buoy measurements over a six-month period from 1 October 2000 to 31 March 2001. At the Pacific buoy locations, individual swell events were identified in the spectra from the three models and the buoy data. Predicted and observed swell frequencies and arrival directions are compared as well as the total energy transported past the buoy over the duration of each individual event. At all buoy locations, predicted and observed wave energy fluxes integrated over fixed frequency ranges are compared. All three models yield reliable nowcasts of swell arrivals at the buoy locations. In most cases, the models under-predict the energy measured by the buoys. WAVEWATCH III better resolves low-frequency swells than WAM, possibly owing to a superior numerical scheme. Swell predictions at NCEP forced with AVN winds are more accurate than those at FNMOC forced with NOGAPS winds.

KEYWORDS: Global Wave Prediction Models, WAM, WAVEWATCH III, Swell, Wave