Mesoscale Coastal Processes

James D. Doyle
Naval Research Laboratory
Monterey CA 93943-5502
phone: (831) 656-4716 fax: (831) 656-4769
e-mail: doyle@nrlmry.navy.mil
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http://www.nrlmry.navy.mil/

LONG TERM GOALS

Increase our scientific understanding of the mesoscale coastal processes and dynamics and apply this knowledge to improve our ability to predict the atmosphere and ocean, particularly in the coastal zone.

OBJECTIVES

The primary objective is to apply numerical models to gain a more complete understanding of mesoscale processes in littoral regions. Sophisticated 3-D atmospheric and ocean models are developed to study air-sea-land interactions associated with mesoscale circulations, the formation and dissipation of clouds and precipitation associated with different scales of motion and to study the predictability of atmosphere/ocean/land coupled mesoscale circulations in littoral regions.

APPROACH

Our approach is divided into the following three components: data analysis, numerical model process studies, and theoretical development. In the data analysis component, we will make use of archived conventional, non-conventional, and special data sets from various field experiments conducted in the past. We will use multivariate analysis techniques to blend these data to develop high resolution data sets continuous in space and time which can be used in the other two components of our research. The process studies will use the Coupled Ocean/Atmospheric Mesoscale Prediction System (COAMPS), developed in Work Unit 6.2-1MESO, PE 0602435N. COAMPS includes a nonhydrostatic atmospheric model, featuring sub-grid scale mixing, explicit moist physics, and radiation effects; and a hydrostatic ocean model. COAMPS will provide a mechanism for understanding and testing theoretical formulations concerning the interactions of various scales of motion and the mesoscale circulations caused by orography and the land-sea interface. In the theoretical component, we will develop and test hypotheses for observed and modeled coastal mesoscale phenomena and utilize an adjoint of our numerical model to isolate where observational and/or model errors lead to predictability problems.

WORK COMPLETED

We used COAMPS to investigate the mesoscale dynamics of a variety of phenomena including previously undocumented wave clouds that form upstream of coastal barriers, transcritical flows, island wakes, tropical convection in the coastal zone, downslope windstorms and breaking gravity waves forced by steep coastal orography.

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RESULTS

The evolution and dynamics of a breaking gravity wave event observed by research aircraft during FASTEX was simulated using COAMPS. The preliminary results underscore the importance of the tilting of local vorticity during the turbulent wave breakdown process leading to the production of vortex filaments. Simulations of a downslope windstorm in the coastal zone have identified the modulation of the mesoscale stratification by diabatic processes associated with precipitation as important for gravity wave trapping and generation of hydraulic jumps. The landfall position of a tropical cyclone was found to depend upon orographically modulated horizontal vorticity advection. The response of the tangent linear model to perturbations was studied and compared with the nonlinear model.

IMPACT

COAMPS has been used to gain a new understanding of the mesoscale dynamics and processes associated with a number of phenomena. A highlight of this body of work is a study of flow impinging upon coastal topography that results in a trapped shock-wave response, which ultimately forces lineal coastal wave clouds due to the strong vertical velocity. This study demonstrates the promising future capability of a high-resolution modeling system such as COAMPS in the coastal zone, and underscores the importance of topography in generating significant coastal mesoscale circulations.

TRANSITIONS

Developments from this program will transition to an existing 6.2 program (PE 0602435N) for applications within COAMPS and for subsequent transition to Fleet Numerical Meteorology and Oceanography Center (FNMOC) and other potential sites for operational use.

RELATED PROJECTS

Related 6.2 projects within PE 0602435N include BE-35-2-18 which focuses on the development of the atmospheric component of COAMPS, and 3523 which focuses on the development of an ocean model for COAMPS. A related 6.4 project within PE 0603207N is X0513-02 which focuses on the transition of COAMPS to FNMOC. Another 6.4 project, within PE 0603785N is 0120-ADV which focuses on the development of a coupled data assimilation system for COAMPS.

PUBLICATIONS

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