OBSERVATION AND ANALYSIS OF THE MODIFICATION OF LANDFALLING STORMS BY COASTALLY TRAPPED FLOWS

J.E. Overland
NOAA/Pacific Marine Environmental Laboratory
7600 Sand Point Way NE
Seattle, WA 98115-0070
Phone: (206) 526-6795, Fax: (206) 526-6485,
e-mail: overland@pmel.noaa.gov

N.A. Bond
NOAA/Pacific Marine Environmental Laboratory
7600 Sand Point Way NE
Seattle, WA 98115-0070
Phone: (206) 526-6459, Fax: (206) 526-6485,
e-mail: bond@pmel.noaa.gov

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LONG-TERM GOALS

The goal of this project is to better understand the interaction of cool season storm features such as fronts, with coastal terrain. The focus is on gathering the information necessary to determine the current limitations of mesoscale numerical weather prediction (NWP) model forecasts of these phenomena, and ultimately to help guide improvements in their sub-grid scale parameterizations.

OBJECTIVES

Our project is intended to complement the research being conducted on warm season coastal phenomena along the U.S. West Coast, which involves a different type of marine boundary layer and large-scale background forcing. The specific objective of our work has been to collect and analyze observations of the evolution of turbulent-scale and mesoscale storm structures in the vicinity of coastal terrain. These observations are forming the basis for comprehensive validations of high-resolution NWP simulation experiments. This work is supported by ONR Marine Meteorology.

APPROACH

Observational case studies are being carried out based largely on data collected by a NOAA P-3 research aircraft during the Coastal Observation and Simulation with Topography (COAST) field experiments of December 1993 and 1995. The focus of our particular work is on documenting the characteristics of the low-level turbulence using measurements from the gust-probe/radome system on the P-3. The turbulent structures are being analyzed in the context of the mean mesoscale flow determined from the flight-level and airborne Doppler radar

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observations. These observations are being compared with specific details from high-resolution NWP simulations, currently with NRL's Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS), and in the future, with the Penn State/NCAR Mesoscale Model (MM5). Special attention is being devoted towards evaluating the turbulence parameterizations in these models.

WORK COMPLETED

The co-PI has concentrated on two cases from the December 1995 field work. The data analysis of the warm front of 12/9/95 is nearly complete. The Doppler radar observations are being used to specify the mesoscale flow as this front made landfall on Vancouver Island (see Fig. 1). The turbulence accompanying this front has been specified in three different regions: the warm sector, frontal zone and topographically-trapped flow along Vancouver Island. In collaboration with J.D. Doyle of NRL, these results are being compared with output from simulation experiments using COAMPS. Analysis is continuing on the detailed nature of the very strong (~50 m/s) low-level flow accompanying the intense storm of 12/12/95. We anticipate some very important and interesting comparisons with the turbulence parameterizations used by COAMPS and MM5. The co-PI is also collaborating with other investigators involved with the Coastal Meteorology ARI on additional cases from COAST.

RESULTS

a) An overview paper (Bond *et al.*, 1997) has been published on COAST. This paper provides visibility for an ONR-supported program, and a foundation for the individual case studies that are being presented at conferences and in the scientific literature.

b) The combined observational/modeling case study of the warm front of 12/9/95 found some important differences between the aircraft observations and the COAMPS simulations. The model appears to have properly simulated the front's offshore structure, but incorrectly handled some significant aspects of its evolution at landfall. In particular, the model underestimated the intensity of the low-level turbulence in the frontal zone and in the trapped flow along Vancouver Island, and improperly characterized the vertical profiles of wind and static stability of the trapped flow. Analysis is continuing; we expect to be able to determine the significance of these errors in the turbulent and mesoscale structures to the evolution of the tangible weather (i.e., surface winds and precipitation) accompanying this system.

c) For the storm of 12/12/95, we are focusing on the vertical profiles of the mean and turbulent properties of the PBL and capping stable layer in a region of ~50 m/s flow. Preliminary results suggest that turbulence was being generated by surface layer shear and by Kelvin-Helmholtz instabilities within the capping stable layer, with a relatively quiescent layer near the top of the PBL. The near-Lagrangian measurements of this flow made by the aircraft will be used to estimate the terms in a momentum budget.

IMPACT

The COAST experiment collected a unique set of detailed observations of landfalling storms to compare with high-resolution NWP simulations. Our focus has been on the unprecedented turbulence and airborne Doppler radar measurements collected during some of these events. In particular, we look forward to pursuing analysis of the storm of 12/12/95. We expect our work will help address some of the outstanding issues regarding the upstream effects of terrain on storms, and hence ultimately help improve coastal weather forecasts.

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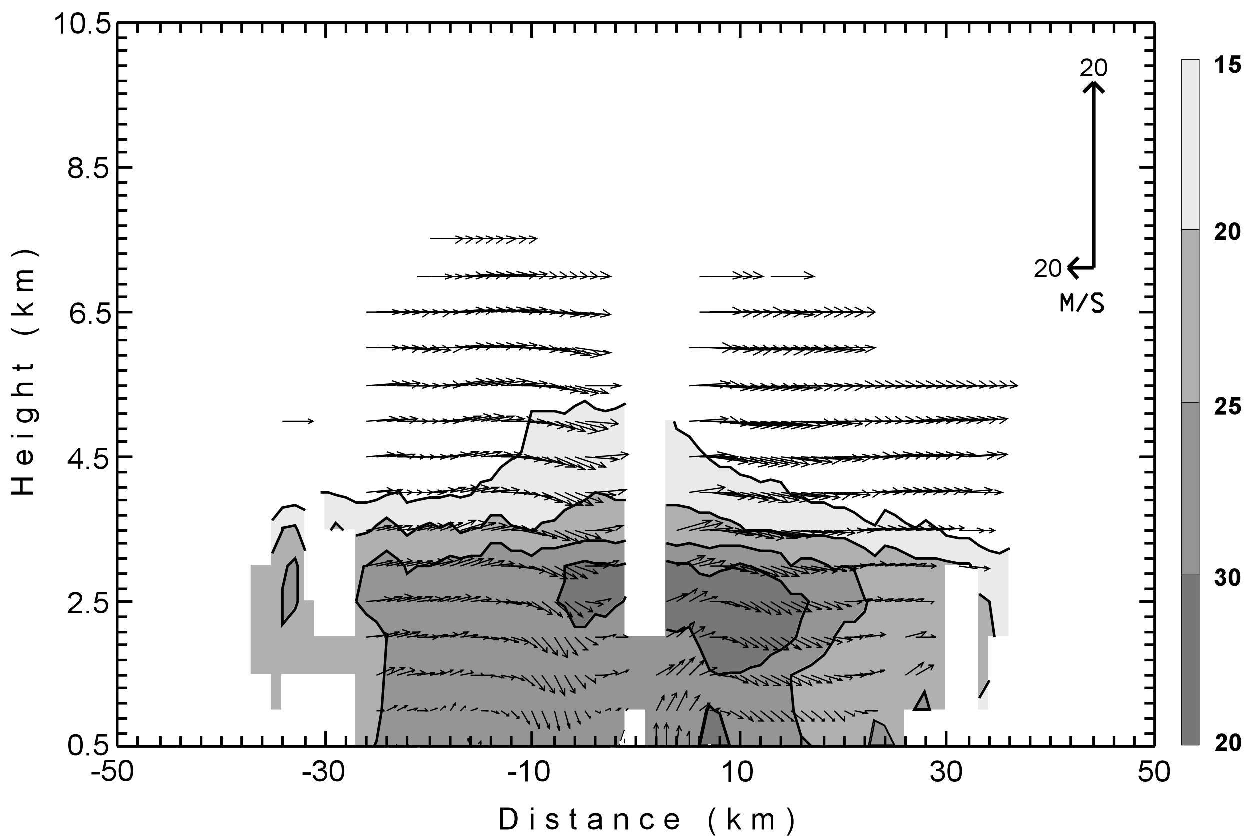

Fig. 1. Vertical cross-section of radar reflectivity (dBZ; shaded) and flow in the plane of the section (scale shown at upper right) from NOAA P-3 Doppler radar observations collected between 2223 and 2234 UTC 9 December 1995. The cross-section is oriented along 45-225 approximately normal to the axis of Vancouver Island; the coastline of Vancouver Island is located at about x = 30 km. The main updraft and enhanced reflectivity near the center of the figure are associated with a warm front approaching the coast.