COAMPS Simulations Of The Coastal Atmosphere

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LONG-TERM GOAL

The long-range goal of this project is to improve our ability to understand and predict environmental conditions in the coastal zone.

OBJECTIVES

The objectives of this project are to conduct and analyze mesoscale model simulations of the coastal atmosphere using the Naval Research Laboratory's Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS), to provide model-based atmospheric forcing fields to coastal ocean modelers, and to investigate and quantify the coupled response of the coastal atmosphere and ocean.

APPROACH

The approach used in this project is to combine numerical model results with in-situ and remote-sensing observations to understand and quantify physical processes in the coastal, coupled atmosphere-ocean and test their representation in mesoscale atmospheric models.

WORK COMPLETED

A series of experiments have been conducted with COAMPS for offshore flow from a land surface to a cold ocean surface. Similar experiments have been performed with a large-eddy simulation (LES) model. Parameterized turbulence fields from COAMPS have been compared with the LES results, with detailed analysis of the mixing length approximations made in the COAMPS turbulence closure. Comparisons were also made between the COAMPS predictions and aircraft observations made during the Shoaling Waves experiment (SHOWEX) at Duck, NC.

This grant has also provided support for daily COAMPS simulations of the Oregon coastal atmosphere for the period 2000-2002. The results of these simulations are discussed by Perlin et al. (2003).

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RESULTS

Two sets of offshore-flow experiments were performed, the first examining the transition from a rough surface having the same temperature as the ambient lower atmosphere, to a smooth ocean surface that is 5 ^{o}C cooler. The second experiment introduced a 4 km strip along the coastline having surface temperature 5 ^{o}C warmer than the ambient atmosphere, mimicking the barrier island geography of the Duck site. In the first experiment, we find that COAMPS over predicts turbulent intensity in the upper half of the boundary layer, forcing a deeper boundary layer than the LES modelas shown by profiles 4 km offshore (Fig. 1). Both COAMPS and the LES model produce only a small change in the boundary layer shear and tend to decrease the momentum flux near the surface much more rapidly than the observations.

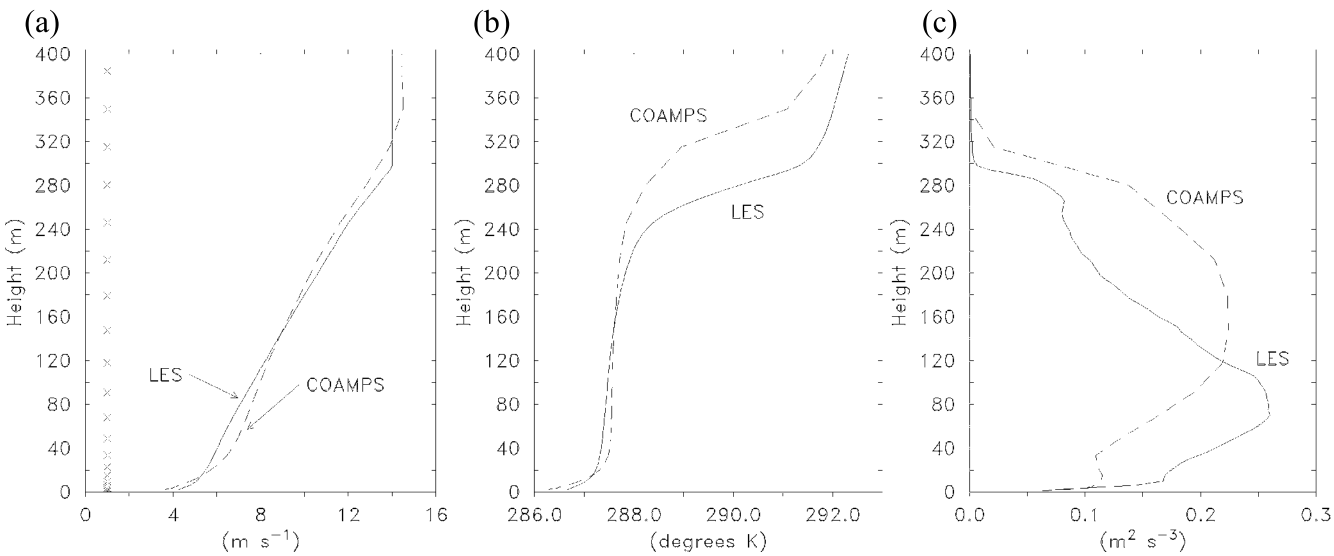

Figure 1. Vertical profiles of (a) offshore wind, (b) potential temperature, and (c) turbulent kinetic energy taken from a distance ~4 km offshore in the land-sea case. COAMPS generates a deeper boundary layer because of stronger turbulence near the boundary layer top.

Results from the second experiment are more in line with the observed momentum and turbulence structure, but still have a reduced momentum flux, as measured by the friction velocity defined as

$$\left(\overline{w'u'}^2 + \overline{w'v'}^2\right)^{1/4},$$

in the lower boundary layer in comparison with the observations (Fig. 2). We find that turbulence in the LES model generated by convection over the heated land surface is stronger than in COAMPS, and tends to persist offshore for longer distances because of greater shear in the upper boundary layer winds. Comparison of the turbulent kinetic energy budget from COAMPS with the LES model shows that shear production is too weak in COAMPS because of reduced vertical momentum transport in the convective region over the heated island. Reduced shear offshore reduces the strength of vertical mixing and downward momentum transport. Analysis of the COAMPS turbulence closure suggests that more realistic estimation of the turbulence mixing length could lead to improvements in the turbulence profiles.

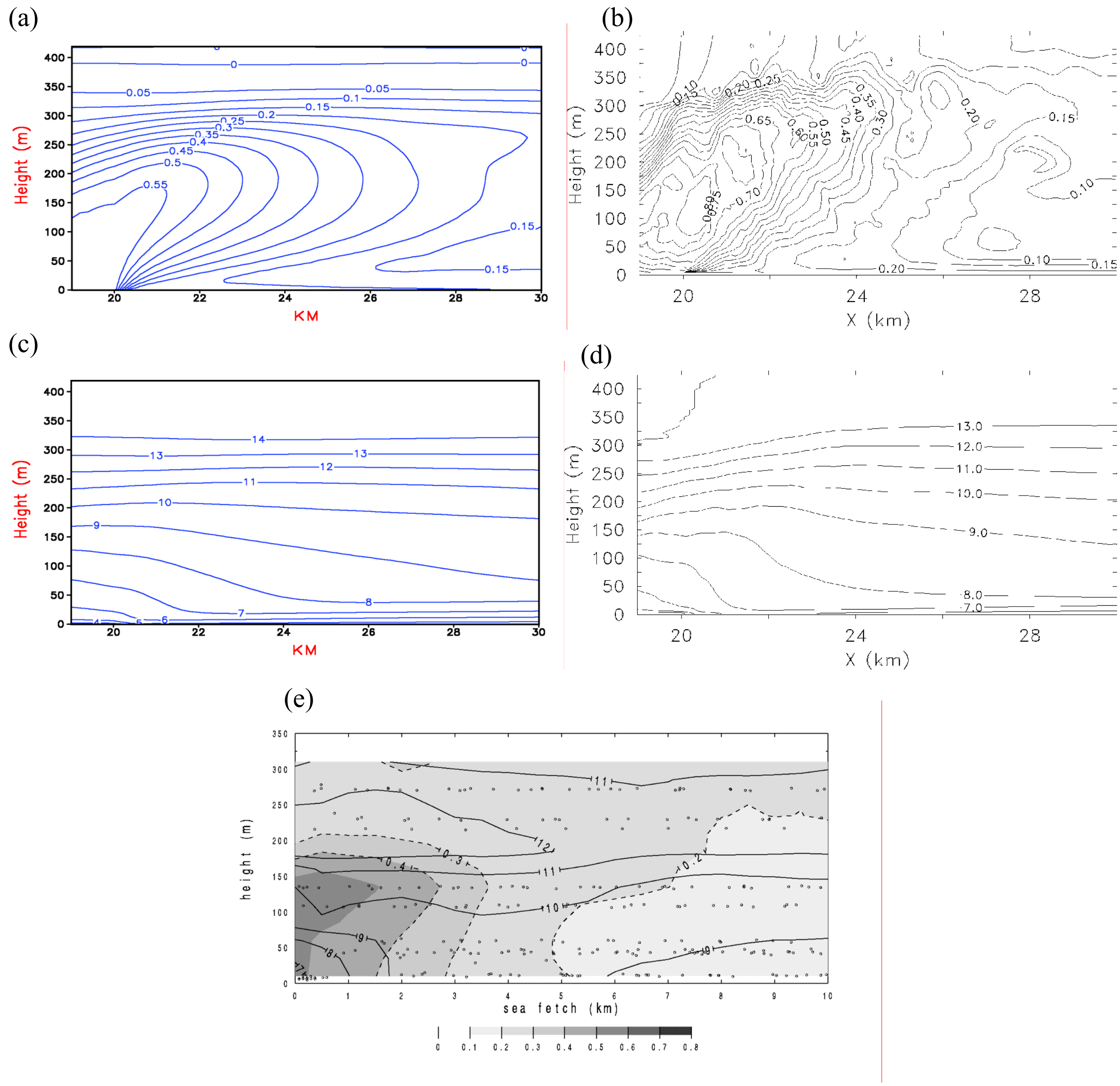

Figure 2. Friction velocity from (a) COAMPS and (b) the LES model along with offshore flow velocity from (c) COAMPS and (d) the LES model. Also shown in the observed friction velocity (shaded) and offshore velocity (contours) in (e) taken from Vickers, et al. (2001).

IMPACT/APPLICATIONS

The primary impact of these results is on the design and use of prediction systems for coastal oceanic and atmospheric conditions. In particular, our results suggest that adjustments to the turbulence closure could lead to improvements in wind stress estimation and the prediction of boundary layer depth.

RELATED PROJECTS

Continued interaction with the CBLAST-low project (Skyllingstad) is planned as part of this project. These efforts will focus on understanding and parameterizing the atmosphere and ocean boundary layer structure under low wind conditions by using a combination of COAMPS, LES and measurements obtained during the CBLAST experiment.

REFERENCES

Vickers, D., L. Mahrt, J. Sun, and T. Crawford, 2001: Structure of offshore flow. Mon. Wea. Rev., 129, 1251-1258.

PUBLICATIONS

Perlin, N., R. M. Samelson, and D. B. Chelton, 2003. Scatterometer and model wind and wind stress in the Oregon-California coastal zone. Mon. Wea. Rev., submitted.

Skyllingstad, E. D., R. Samelson, L. Mahrt, and P. Barbour, 2003. A numerical modeling study of warm offshore flow over cool water. Mon. Wea. Rev., submitted.