8.1 MODELING OF COASTAL METEOROLOGY IN WEAKLY FORCED SITUATIONS

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1 INTRODUCTION

Accurate modeling of plume dispersion is inherently tied to the accurate modeling of the wind and temperature structure in the vicinity of the plume. The mesoscale models currently in use show good skill in such forecasts when the synoptic forcing is relatively strong. However, in weakly forced situations the models exhibit considerably lower skill, especially in situations where the topography might play a significant role. One such scenario is the complex flow patterns that are observed over coastal regions.

The Operational Multiscale Environment model with Grid Adaptivity (OMEGA) was used to explore the impact of high-resolution surface characteristics datasets on the quality of the wind and temperature forecasts, during a weakly forced summer-time scenario. In this paper, results from modeling experiments performed to support a field experiment organized and conducted by the Defense Threat Reduction Agency (DTRA), during 15-31 July 2001 are presented. The experiment region covered the central Chesapeake Bay. Special surface observations were taken at several sites in the experiment region. The paper concentrates on one specific day during the experiment period in which weak synoptic forcing was observed. The model results were compared against observations to obtain mean, mean absolute and root mean squared errors of temperature, dew point, wind speed and wind direction. The results show the significance of including accurate surface characteristics data such as the sea surface temperature (SST) and land-use definitions in the model initial conditions.

2 OMEGA MODELING SYSTEM

OMEGA is a complete, operational, atmospheric simulation system (Bacon, 2000) built upon an unstructured triangular grid, which can adapt to a variety of static user-defined fields as well as dynamically to the evolving meteorology during the simulation. The strength of the unstructured grid is that it can provide high-resolution where needed, based on any surface characteristics or meteorological fields. Also the grid can be constructed so that the edges of the computational elements follow the coastline as closely as possible, thus providing a better representation of the underlying surface. This is important in the weakly forced scenarios as the wind and temperature structure are strongly influenced by the orientation of the land-water boundaries. Boybeyi *et* al. (2001) has used OMEGA, with its embedded dispersion model, to look at the long range transport of a pollutant.

3 NUMERICAL SIMULATIONS

Five simulations were performed for the 48-hour period starting at 00 UTC, 22 July, 2001. These simulations were carried out in a forecast mode with data assimilation only at initialization. The initial first-guess field and the boundary conditions were derived from the gridded fields from U.S. Navy's NOGAPS model run starting at 00 UTC, 22 July, 2001. All available rawinsonde and surface observations were analyzed into the first-guess field to generate initial conditions for the simulations. All the simulations used a computational domain spanning 32.5°N – 43.5°N and 70.5°W – 84.5°W. The following is a brief description of the five simulations.

1. <u>Baseline simulation:</u> The baseline simulation used a grid resolution ranging from 3 to 42 km. The vertical resolution ranged from 10 m near the ground to about 1 km at the top of the domain (~12 km MSL). The baseline simulation also used the SST analysis from NOGAPS.
2. <u>No SST simulation:</u> The baseline run results indicated a large positive bias in temperature. Upon closer analysis, it was found that the SST values in the region of the bay were about 5K too warm. Hence the baseline run was repeated with SST values inferred from the air temperature at initialization.
3. <u>No_SST Hires simulation:</u> The second simulation was repeated with higher resolution (down to 1.8 km) in the bay area. The grid in the high-resolution region is shown in Figure 1.
4. <u>Coarse PBL simulation:</u> This simulation is identical to the "No_SST Hires" simulation, except the vertical resolution was relaxed to 30 m near the ground.
5. <u>New Luse simulation:</u> In order to explore the impact of using higher resolution surface characterization dataset, a new land-use dataset compiled by USGS was used. This dataset classifies land-use into 100 categories. The land-use data used in the other simulations used only 20 categories and did not include an urban classification. The "No_SST Hires" simulation was rerun using the new land-use dataset.

4 RESULTS

The simulation results were compared against observations from 17 surface sites installed in the experiment region (*cf*. Figure 1). A sample meteogram comparing temperature, dew point, pressure and winds at Silver Beach, VA, is shown in Figure 2. Three statistical measures were computed: 1) Mean Error (ME), 2) Mean Absolute Error (ME), and 3) Root Mean Squared Error (RMSE). These measures are given by

$$ME = \frac{1}{N}\sum_{i=1}^{N}\left(M_i - O_i\right),\ MAE = \frac{1}{N}\sum_{i=1}^{N}\left|M_i - O_i\right|, \text{ and}$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(M_i - O_i\right)^2},$$

where M_i and O_i refer to model and observed values and N denotes the number of data pairs.

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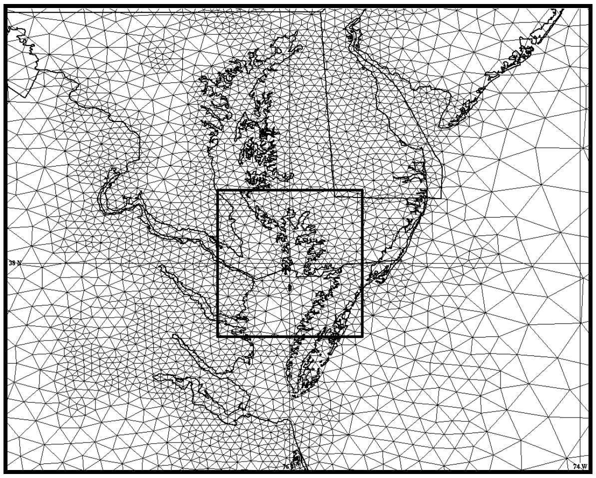

Figure 1: The high-resolution grid resolves the complex coastline of the Chesapeake Bay and the adjoining region. The square indicates the experimental region.

These measures, calculated for the 48-hour simulation period, are shown in Figure 3. From these results it can be seen that SST had a major impact in the accuracy of the temperature and dew point forecasts. Using higher resolution, improved the wind direction predictions. The use of better land-use characterizations improved temperature, dew point and wind direction predictions. These simulations underscore the significance of using accurate and representative surface parameters, especially in regions in which urban, industrial and agricultural developments are significant.

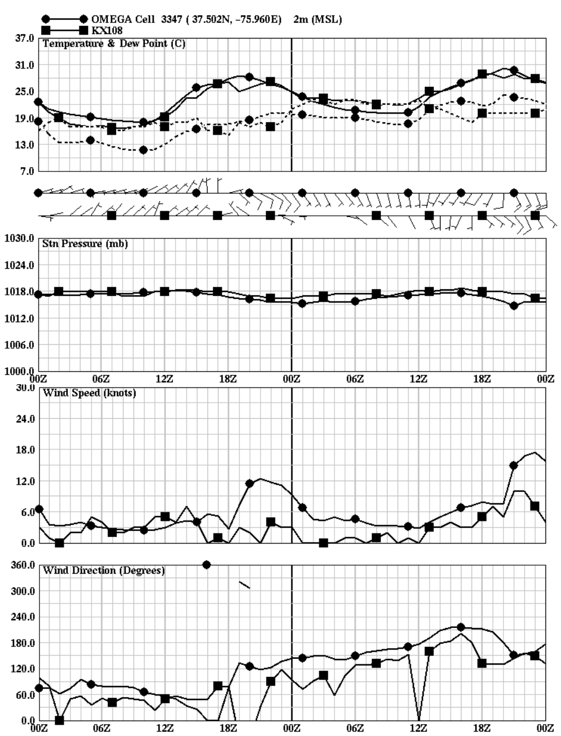

Figure 2: Meteogram comparing OMEGA forecasts (dots) to the Silver Beach, VA observations (squares).

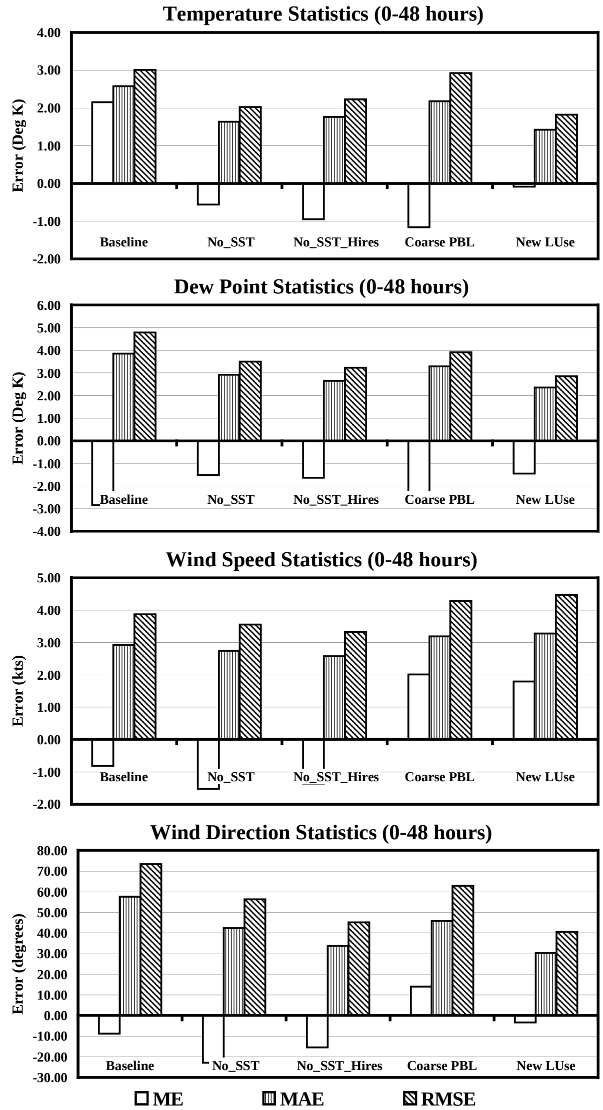

Figure 2: ME, MAE, and RMSE of temperature, dew point, wind speed, and wind direction for the five simulations calculated for the entire simulation period.

5 REFERENCES

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