AN EVALUATION OF REAL-TIME FORECASTS FROM A WEATHER-CHEMISTRY FORECASTING MODEL USING OBSERVAITONS FROM THE TEXAS AQS 2000 FIELD EXPERIMENT

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I. Introduction

The meteorological conditions during high surface ozone episodes in the Houston area are characterized by weak large-scale flow. This allows for the transport of ozone and its precursors to be driven by local circulations, especially the land-sea breeze front. Observations have indicated that the re-circulation of ozone and its precursors by the land-sea breeze cycle is associated with the heaviest pollution episodes in the Houston area. Additionally, the growth and development of the planetary boundary layer (PBL) play an important role in the formation and transport of ozone and its precursors.

In this study, meteorological observations taken during the Texas Air Quality Study 2000 are evaluated using the forecasts of a real-time coupled weather-chemistry forecasting model. This study focuses on a meteorological evaluation of the performance of the coupled model by comparing the model results with data sets from NCAR's Electra aircraft, wind profilers, and rawinsondes for the high surface ozone episode during the time period of 25-30 Aug 2000.

II. Model Description

The coupled weather-chemistry forecasting model combines a modified version of the fifth-generation Penn State/NCAR Mesoscale Model (MM5) and the chemical mechanism of the Regional Acid Deposition Model Version 2 (details about the coupled model can be found in Grell *et al.* 2002). The transport of chemical species (grid-scale and sub-grid scale) is treated simultaneously with meteorology. Photolysis, biogenic emissions, and deposition are also calculated "online". The model was run on multiple 1-way nested meshes of 60 km, 15 km, 5 km, and 1.67 km resolutions. The 60-km mesh was initialized using the Forecast System Laboratory/Rapid Update Cycle (FSL/RUC) analyses. The boundary conditions are provided by NCEP's ETA model forecasts. The chemical fields are initialized with the previous forecast to take into account the effect of accumulation. The emission inventory was compiled with databases from EPA and TNRCC (see Bao *et al.* 2002, Grell *et al.* 2002 and McKeen *et al.* 2002).

III. Results

The MM5-coupled chemistry model results were compared to wind profiler data, aircraft data and rawinsonde data in order to investigate how well the model simulated the land-sea breeze front and the PBL structure. Additionally, the model was also initialized with the AVN and Eta model analyses to investigate the sensitivity of the errors in the model performance to the initial conditions.

3a Comparison with the land-sea breeze front

Since the formation and transport of ozone and its precursors are affected by local circulations, the first step of this study is to compare the model forecasted evolution of the land-sea breeze front with wind-profiler measurements.

Figure 1 presents the time-height series of model forecast and wind-profiler observations of the horizontal winds for a 24-h period at southwest Houston (29.54°N, 95.47°W) within the first 4 km above the surface. The land-sea breeze cycle is clearly seen in the forecast (Fig. 1b), while the forecasted time-height distribution of the winds is, in general, smoother than the observations (Fig. 1a). The forecasted near-surface wind shows a clear diurnal cycle that agrees well with the observations although the prevailing direction and magnitude of the forecasted nocturnal low-level jet are different than those shown by the observations. It is also interesting to note that the forecasted day-time mixing layer height (denoted by the circles) agrees well at its peak time with the observations, but its growth rate is greater than that indicated by the observations.

3b Comparisons with the aircraft data

Figure 2 presents a sounding comparison of water vapor mixing ratio, potential temperature, temperature and winds between the model at 1.67 km resolution and the aircraft data on the 25 Aug 2000 over the Galveston Bay. Note that at the lower levels on this day, there is a cold temperature bias. Comparisons of model output and observations on other days indicate that this bias occur when the prevailing low level winds are from the Gulf of Mexico. When the low level winds are from inland, the PBL temperature is in better agreement with observations (not shown).

The wind direction comparisons on this day, and other days as well, indicate an easterly wind bias at low levels as seen in Fig. 2. Since simulating the wind direction is so important in air quality work, an additional sensitivity experiment was done for 25 Aug 2000. In this experiment, MM5 was run with three different initial conditions, one that used the RUC analyses as the first guess field, one that used the Eta analyses, and one that used the AVN analyses. The comparison between the model wind direction and observed wind direction shown in Figure 3 indicates a sensitivity to the initial conditions. The agreement between the observations and the model is better when the Eta analyses are used as the initial conditions (Fig. 3b) then when the RUC analyses are used (Fig. 3c). The agreement is even better when the AVN initial conditions are used (Fig. 3a).

3c Sounding comparisons

In addition to the aircraft data, sounding data was also available at 95.54°W 29.9°5 N. Sounding comparisons reveal that the model does have a tendency to have a cold bias in the lowest levels during the day (an example is shown in Fig. 4). This is consistent with the comparisons of the model with the aircraft data. The soundings taken during the night and early morning indicate that the model does not properly form a nocturnal inversion layer (not shown).

IV. Preliminary Conclusions

The comparison of the model output with wind-profiler observations indicate:

- The forecasted land-sea breeze cycle is in good agreement with the wind-profiler observations, but differences do exist in the wind direction and speed.
- The forecasted nocturnal flow within the lowest 4 km is smoother than that shown by the observations; the low-level winds ahead the sea-breeze front are improved when the model's resolution increases.
- The forecasted PBL mixing layer grows faster than that shown in the observations although its on-set and maximum height agree very well with the observations.

In addition, the comparison of the model output with both aircraft and rawinsonde observations shows that the model forecasts have biases:

- Model forecasts possess a cold bias at low levels.
- The PBL temperature is colder than that observed when the prevailing low level winds are from the Gulf of Mexico. When the low-level winds are from inland, the PBL temperature is in better agreement with observations.
- A cold bias in the marine boundary layer is suggested.
- The vertical resolution needs to be increased in order to better describe the PBL top entrainment and the PBL evolution.

4. References

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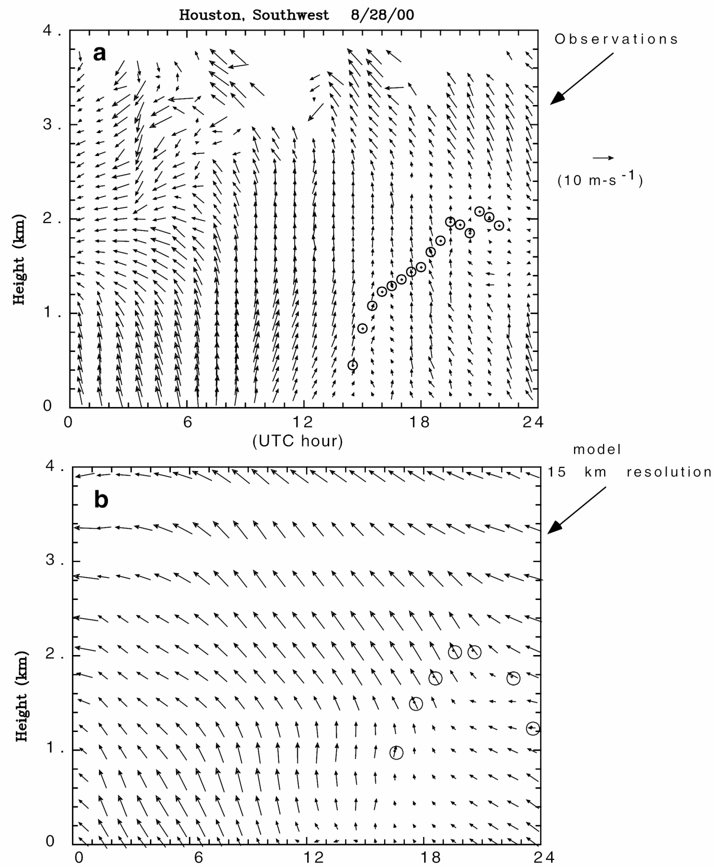


Figure1 The time-height series of model forecast and wind-profiler observations of the horizontal winds for a 24-h period at southwest Houston (29.54°N, 95.47°W) within the first 4 km above the surface.

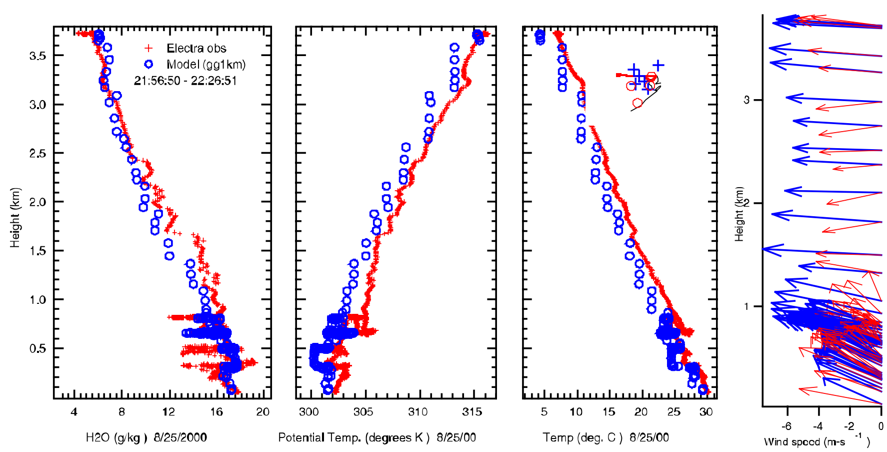
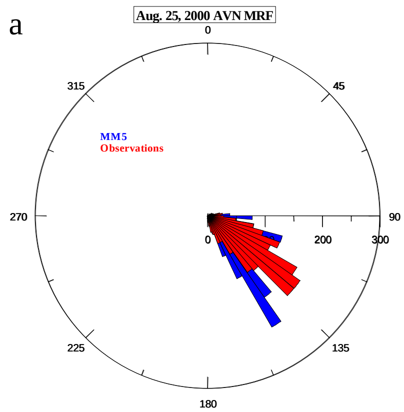
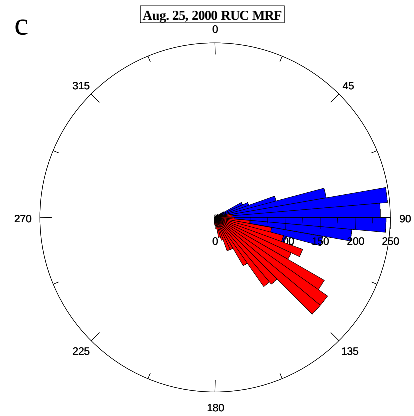


Figure 2 Ccomparison of water vapor mixing ratio, potential temperature, temperature and winds between the model at 1.67 km resolution and the aircraft data on the 25 Aug 2000 over Galveston Bay.





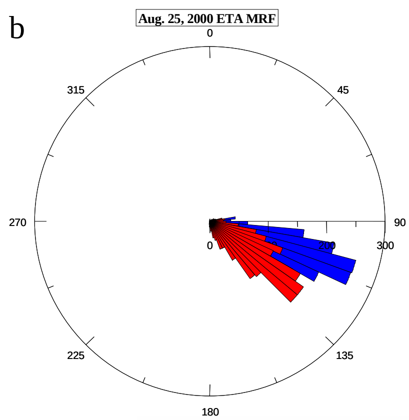


Figure 3 Wind rose diagrams to illustrate the sensitivity to the initial conditions. Black indicates model, gray-shaded indicates observations.

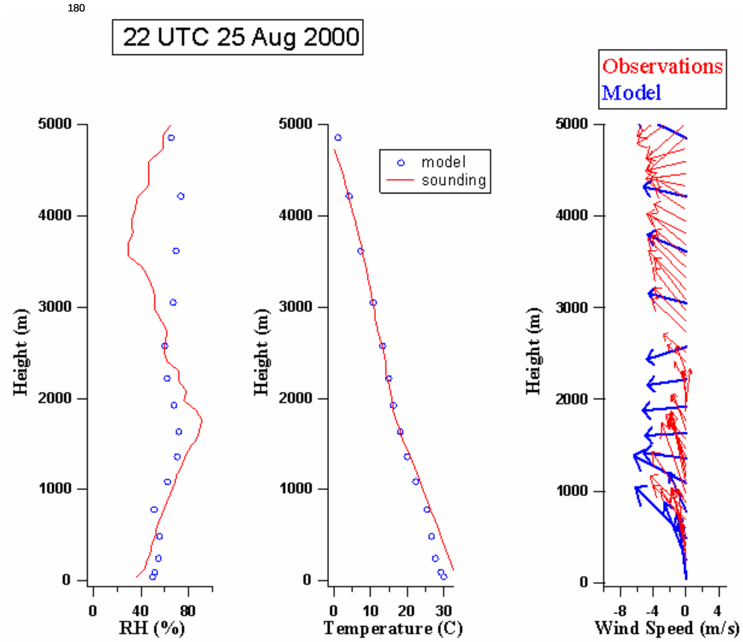


Figure 4 Comparison of the observed and forecasted soundings at 95.54°W 29.9°5 N.