Chemical data assimilation of ozone and fine aerosols.
Initial results using the NMM-WRF/Chem
and the Gridpoint Statistical Interpolation (GSI) Analysis System

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1. Introduction

Data assimilation is an essential part of weather forecasting in all major meteorological centers. Until now, however, few attempts have been made to assimilate chemical species for air quality forecasting. Usually, air quality forecasts are initialized using concentrations of species obtained from the previous day's forecasts with no regard to the observations. This approach generally leads to better forecasts compared to those initialized with the climatological values of concentrations of the species.

Recently, data assimilation of ozone and fine aerosols has been implemented into NMM-WRF/Chem using Gridpoint Statistical Interpolation (GSI, Wu et al., 2002). To date efforts have concentrated on the development of background error covariances for ozone and fine aerosols and the implementation of these species in the GSI. Background error covariances were derived using NMC method (Parrish and Derber, 1992) using differences between forecasts at 24 and 48 hours issued over a period of about four weeks in summer 2004. The data assimilation experiment was performed in summer 2006 over a period of three weeks using surface observations collected by the AIRNow network. The assimilation of observations occurs each day at 00 UTC using data within one hour time window.

2. Results

a. Ozone

In Fig. 1 mean bias of the 8hr maximum ozone concentration on the following day is shown for control and assimilation experiments. In Fig. 2 mean bias, RMSE, and correlation coefficient of control simulations and simulations with data assimilation are shown. WRF/Chem exhibits significant positive bias that is largely reduced during the 24 hour forecast. The correlation of forecasts with observations also benefits during this period. After 24 hours positive effects of assimilation are minor. The quality of forecasts would further improve with more frequent assimilations. In our view, it is quite remarkable that such volatile species as ozone can benefit from a direct assimilation that does not take into account chemical balance considerations during its formation.

b. PM2.5

In case of aerosol, concentration of total assimilated PM2.5 was proportionally distributed to accumulation and Aitken modes (80% and 20%, respectively). As for ozone, basic statistics for fine aerosols are shown in Figs. 3 and 4. Effect of the assimilation is generally similar to that of ozone with significant reduction of bias and RMSE and less pronounced effect on the correlation coefficient. Benefits of data assimilation for fine aerosols extend for a shorter period than for ozone when model errors overcome effect of the initial conditions.

3. Future work

Our immediate plans include implementation of data assimilation to ARW-WRF/Chem which in the past produced more reliable forecasts than NMM-WRF/Chem. Also, we plan to increase frequency of the assimilation cycle that will also include vertical profiles of the species. In longer, but not too distant term we will develop adjoints of chemical reactions to properly distribute effects of assimilation on concentrations of other species.

Acknowledgements

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References

Parrish, D.F., and J.C. Derber, 1992, The National Meteorological Center spectral statistical interpolation analysis system, Mon. Wea. Rev., 120, 1747-1763.

Wu, W-S., R. J. Purser, and D. F. Parrish, 2002: Three-Dimensional Variational Analysis with Spatially Inhomogeneous Covariances. Mon. Wea. Rev., 130, 2905-2916

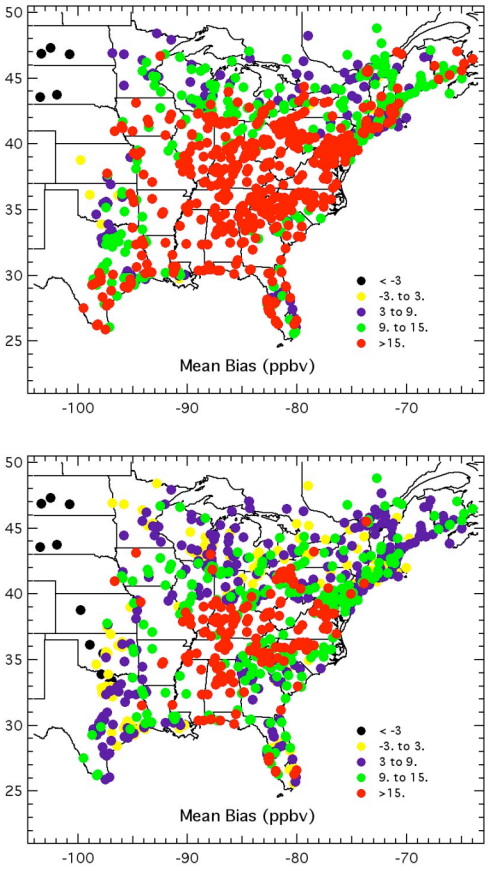

Fig. 1. Mean bias of ozone control (top) and assimilation (bottom) experiments for 8hr maximum concentration.

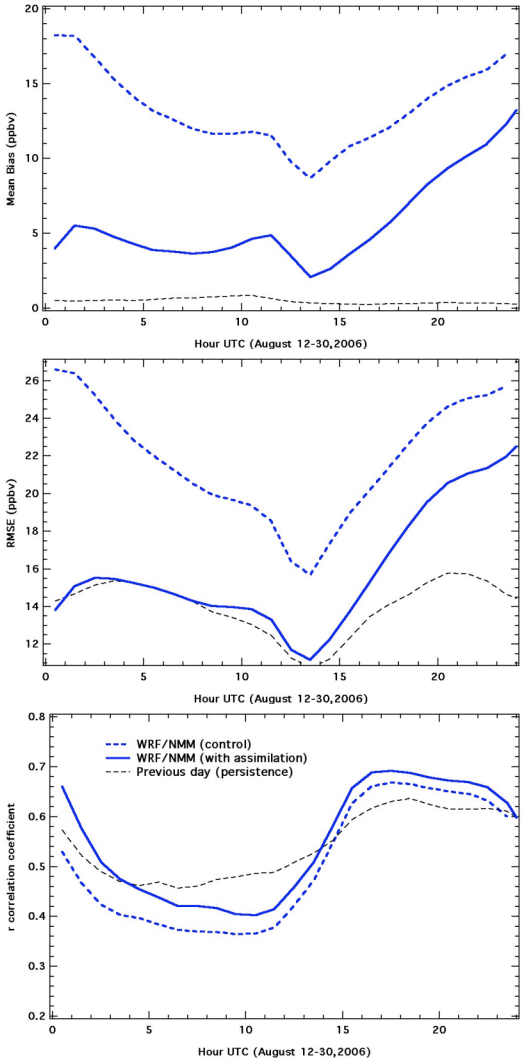

Fig. 2. Time series of the bias, RMSE, and correlation coefficient for ozone control and assimilation experiments.

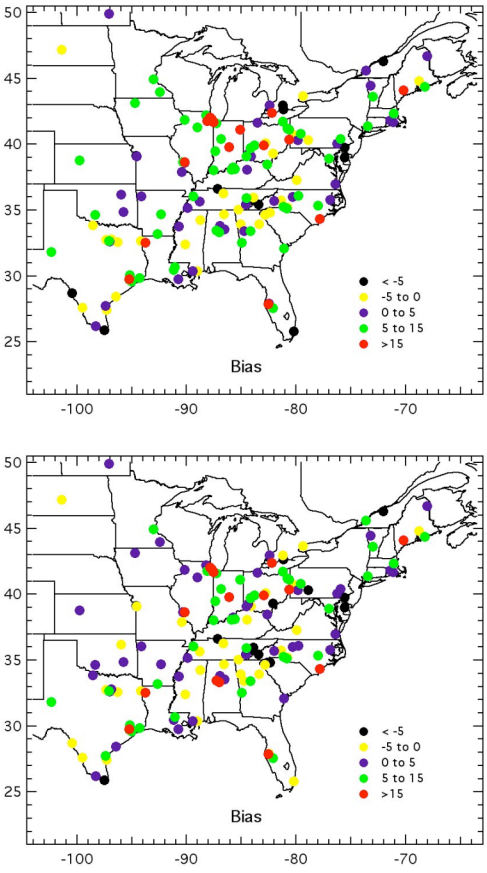

Fig. 3. Mean bias of PM2.5 control (top) and assimilation (bottom) experiments for 24hr average concentration.

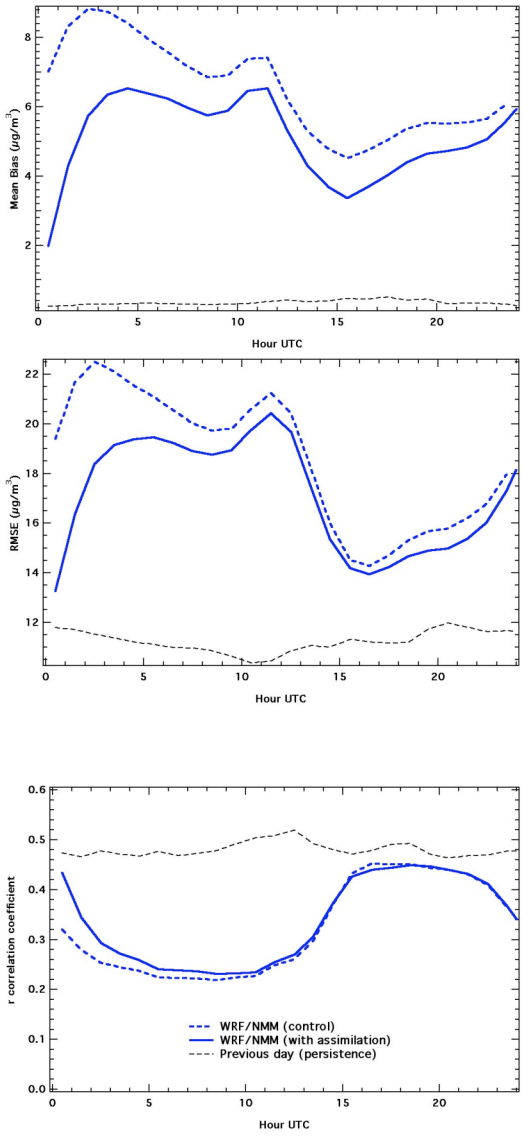

Fig. 4. Time series of the bias, RMSE, and correlation coefficient for PM2.5 control and assimilation experiments.