Data assimilation of ozone and PM2.5. Some results using WRF-Chem and the GSI

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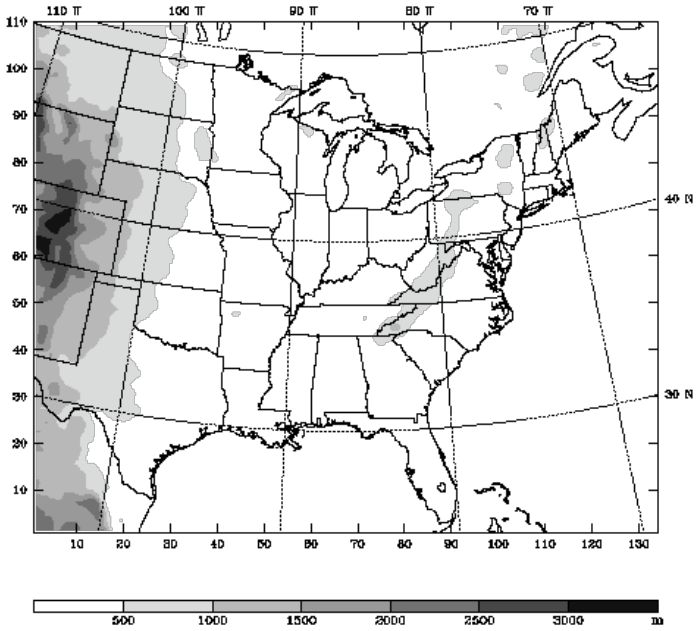
Observations and model

Real-time ozone and PM2.5 measurements network AIRNow

1 hour-averaged concentrations available round the clock



ARW WRF-Chem

Grid length ~27 km, 34 vertical levels

RADM gaseous chemistry

MADE/SORGAM modal aerosol

Assimilation

$$J(x) \equiv \tfrac{1}{2}\left[(x - x_b)^T B^{-1}(x - x_b) + (y - H(x))^T R^{-1}(y - H(x))\right]$$

B - background error covariance matrix (in GSI represented using recursive filters, need error correlation lengthscales and variances)

R - measurement and representativeness error (reflects character of urban, suburban, and rural measurement sites)

H - observation operator (for surface observations linear interpolation)

Goal: to improve initial conditions of species concentrations for the chemical model (might not be sufficient due to large uncertainties in emissions)

Assimilates observations sequentially within 1hr time window

Univariate in ozone and PM2.5

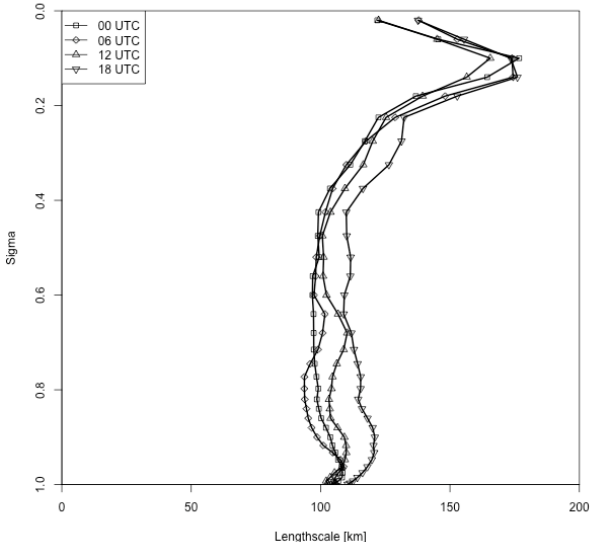
Background error lengthscales and variances derived from continuous forecasts issued at 00, 12 UTC in August 2004 using a modified NMC method (differences between forecasts at 24 and 48 hours with perturbed emissions)

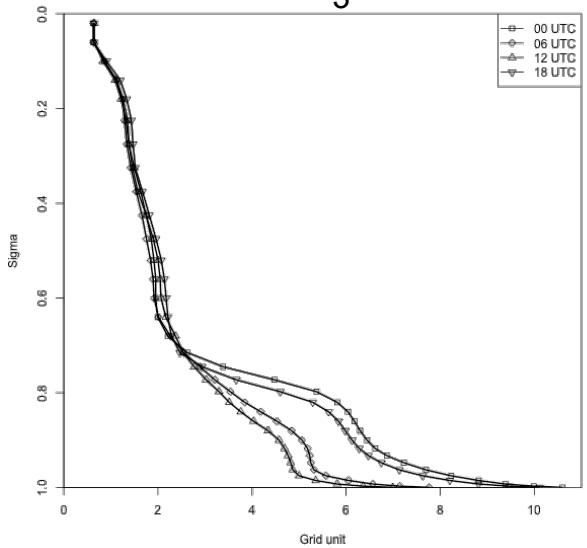
12-hour assimilation cycle and evaluation performed in August and September 2006

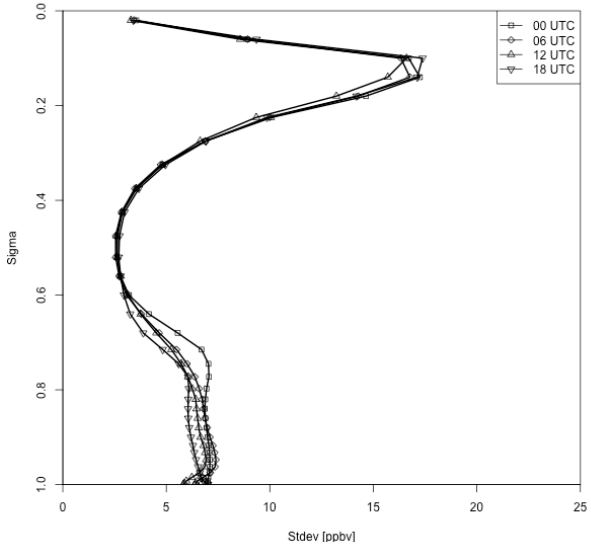
Background error covariance

Horizontal and vertical length scales and standard deviations

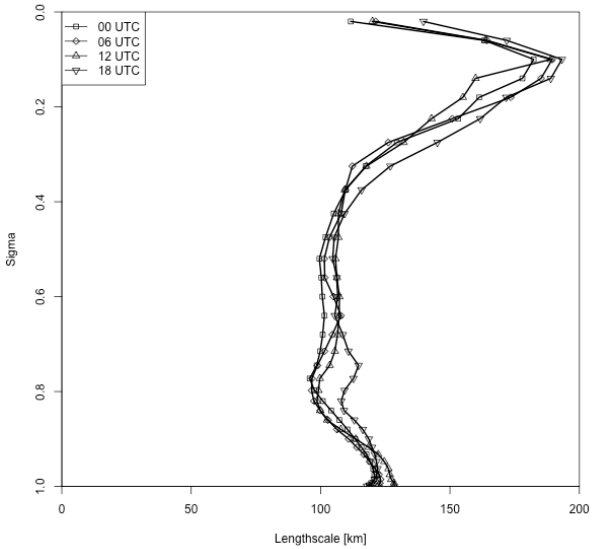
O_3

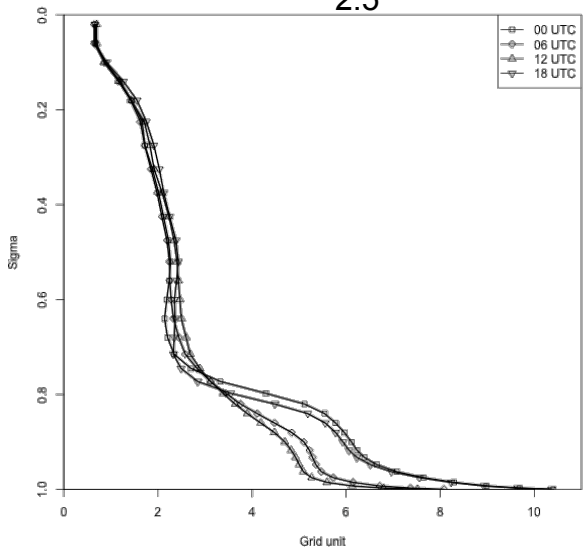


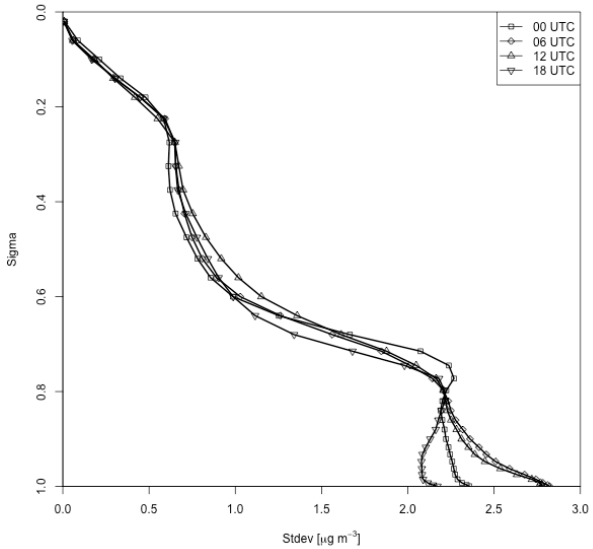




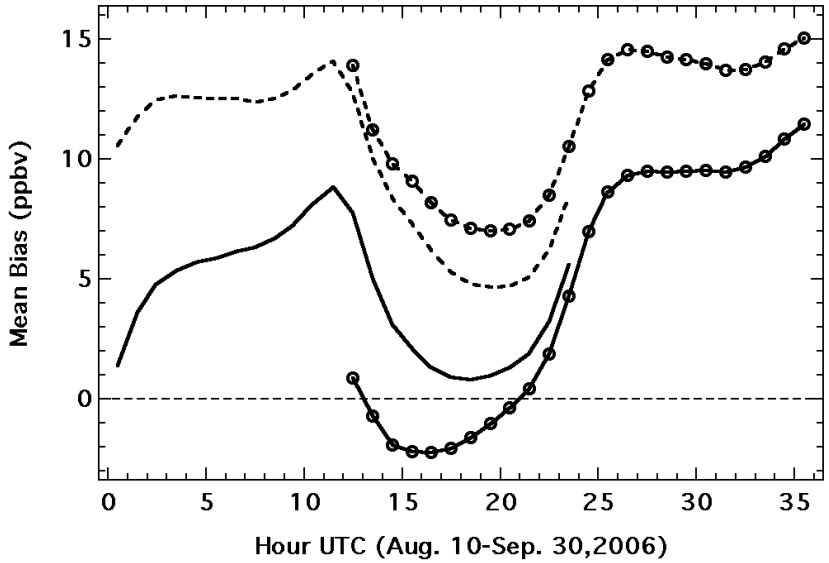
$PM_{2.5}$

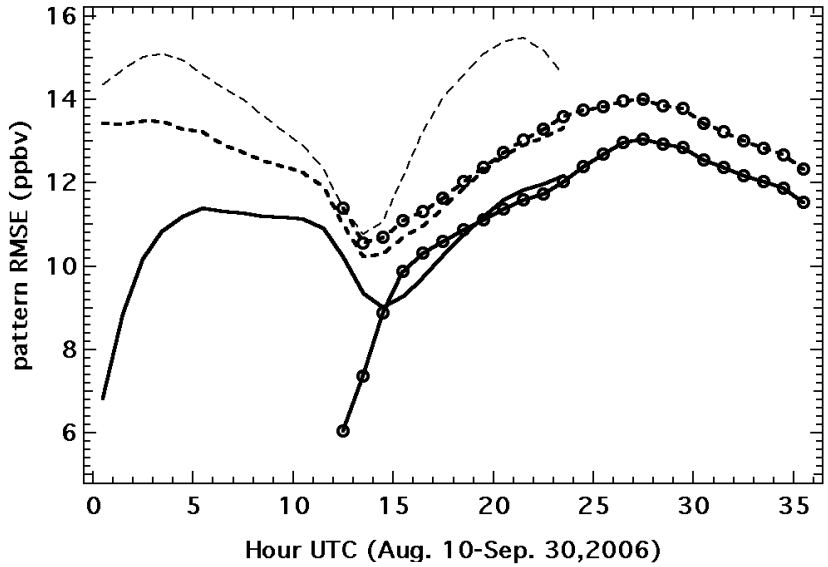


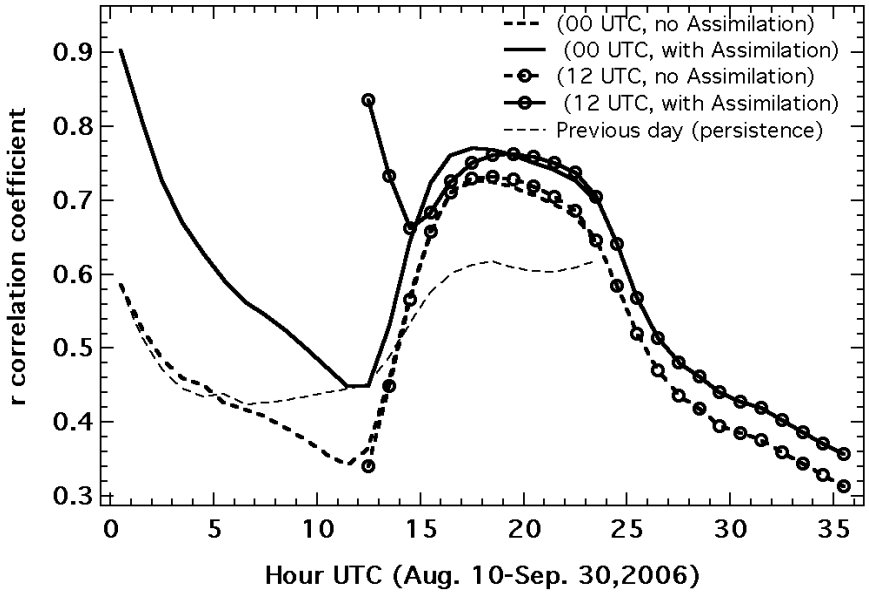




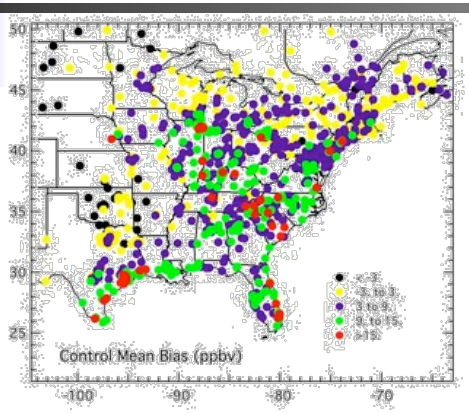
O3: 24-hour forecasts at 00, 12 UTC, Aug 10 - Sept 30, 2006

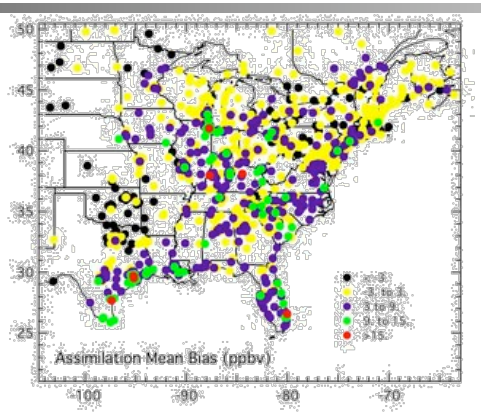


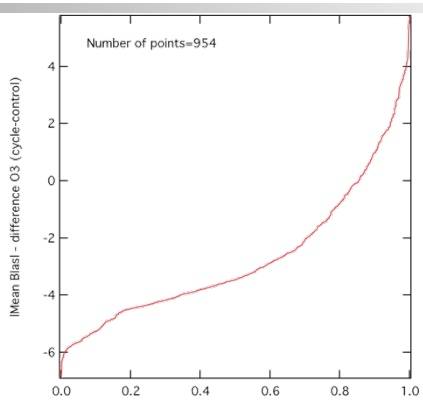




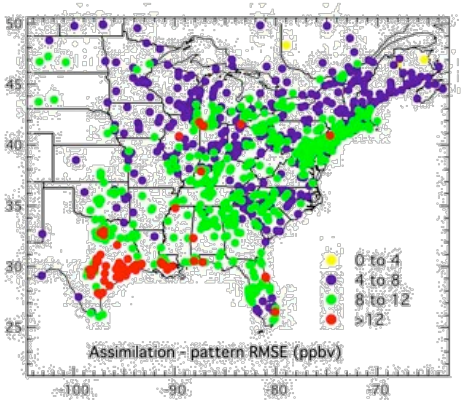
O3: next day 8-hr average maximum concentration, Aug 10 - Sept 30, 2006

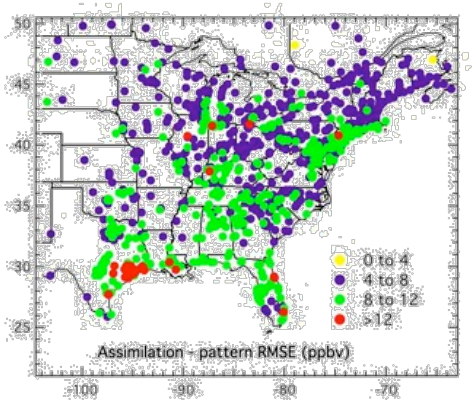


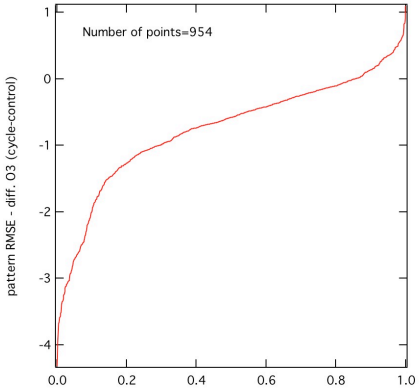




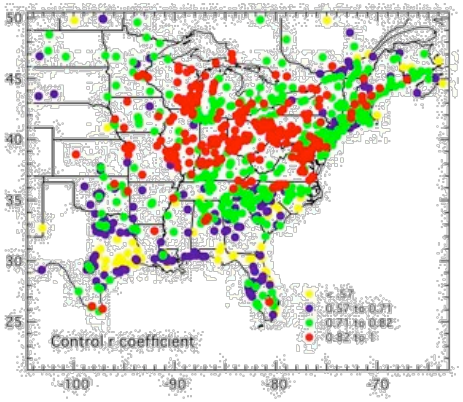
Mean Bias

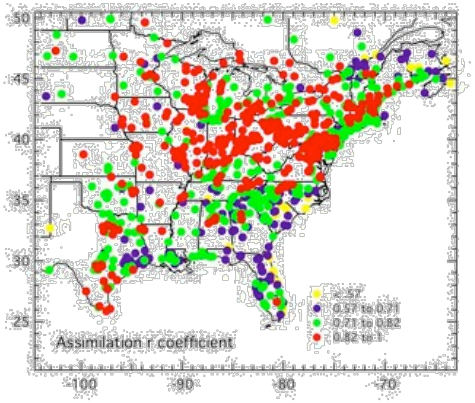


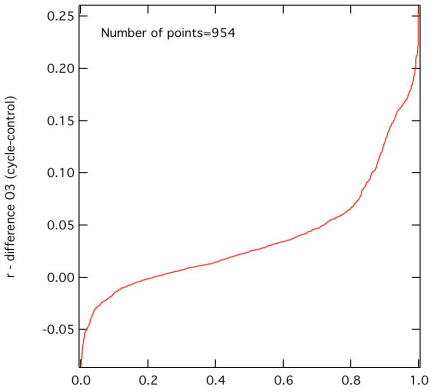




Pattern RMSE

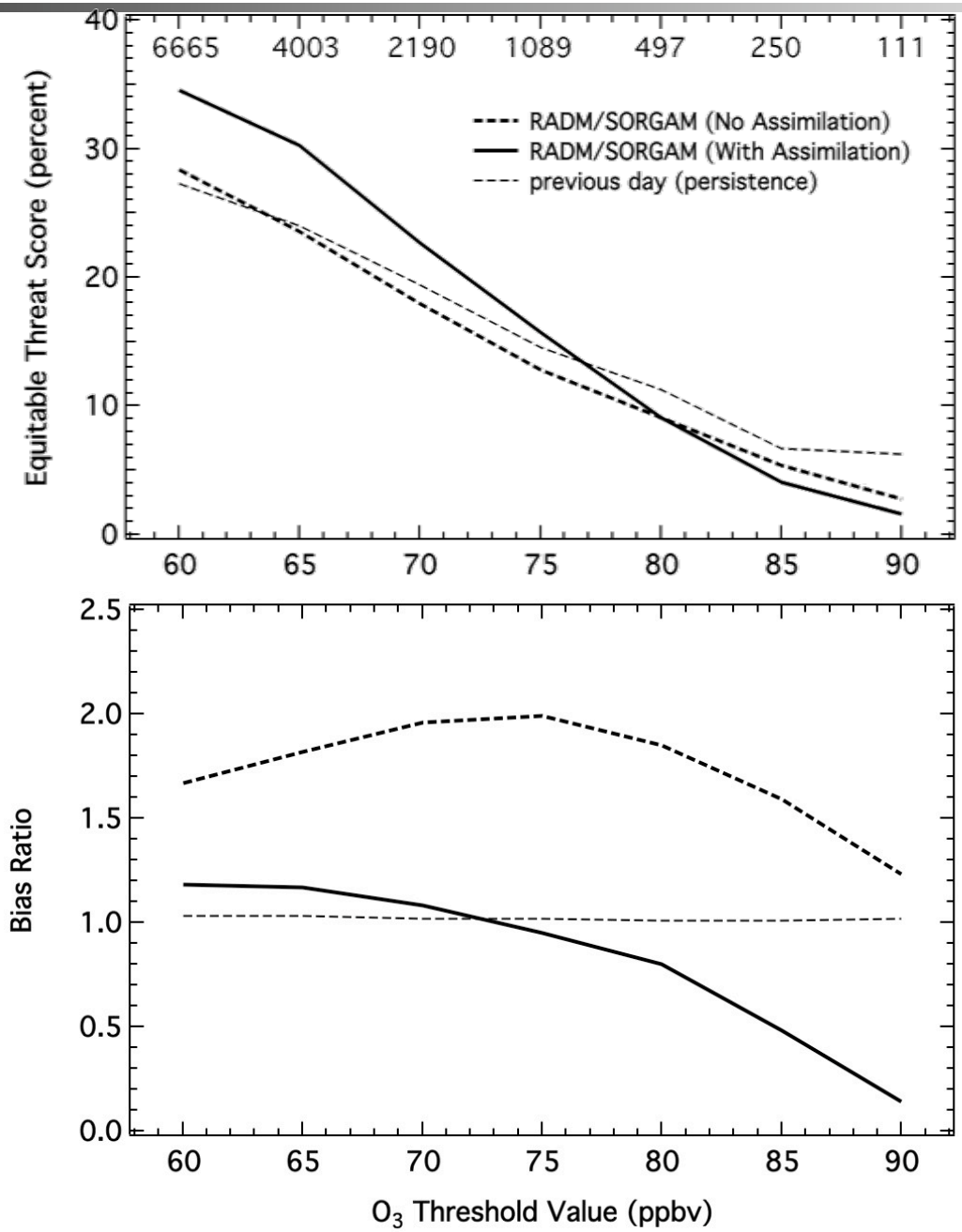




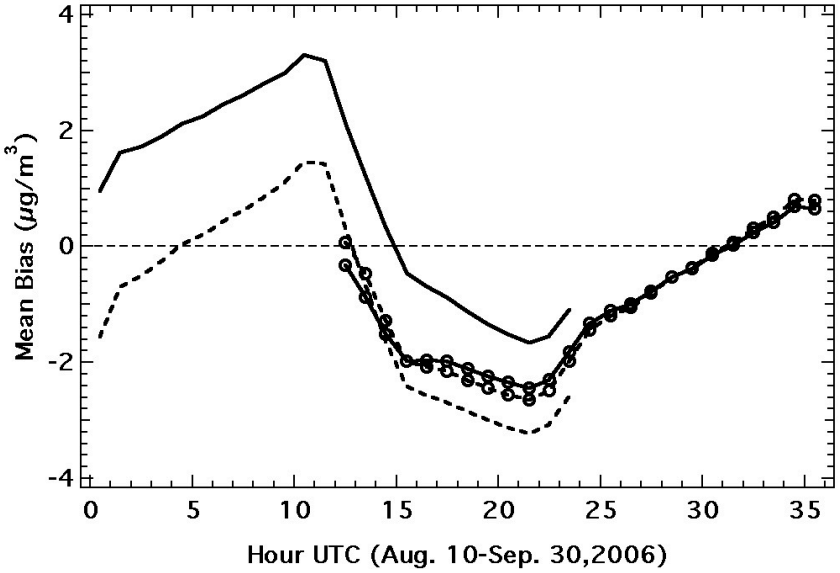


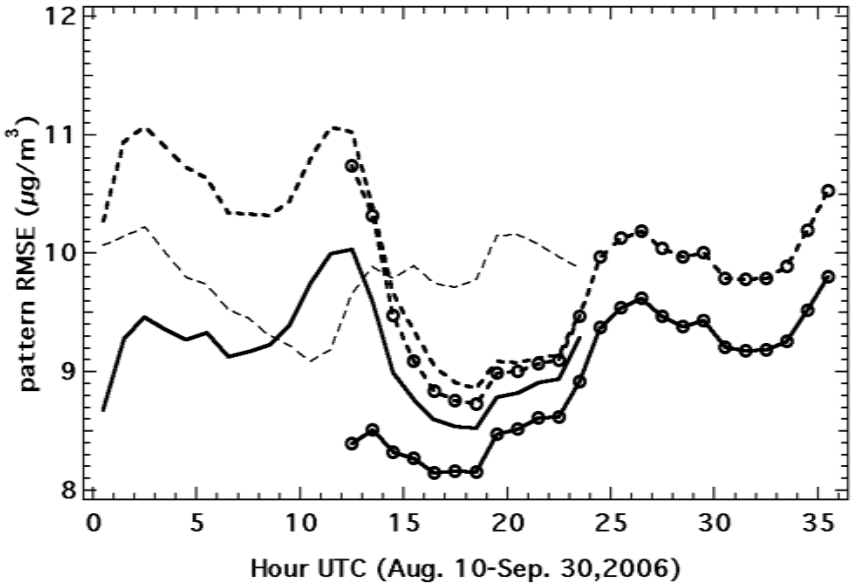
Spatial Correlation

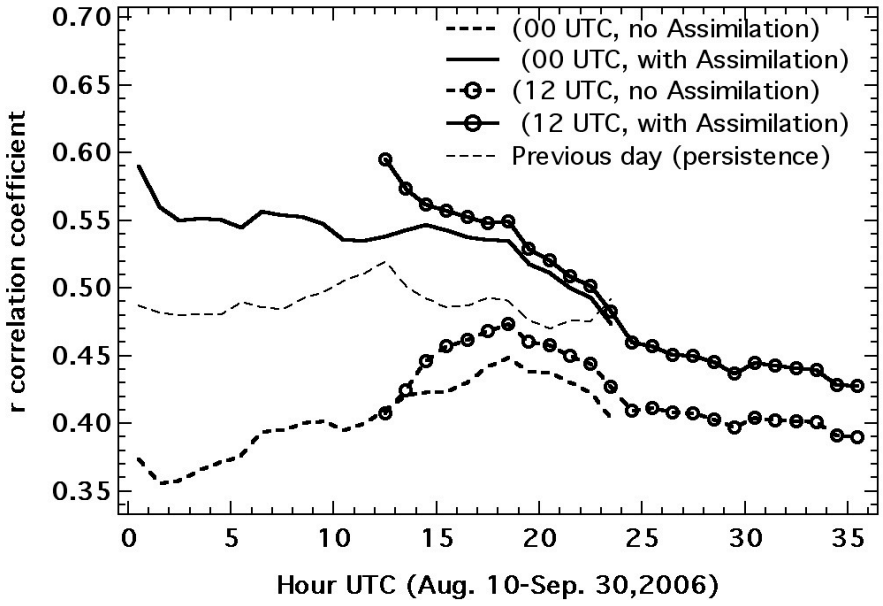
O3: next day 8-hr average maximum concentration, Aug 10 - Sept -30, 2006
ETS, Bias Ratio



PM2.5: 24-hour forecasts at 00, 12 UTC, Aug 10 - Sept 30, 2006







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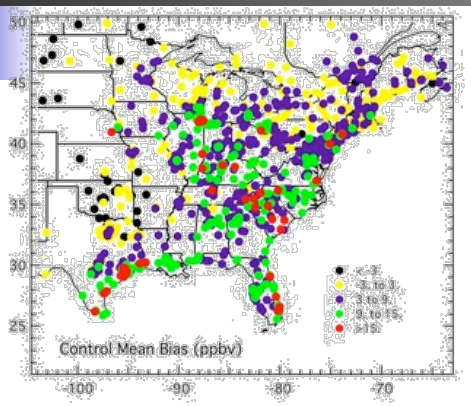

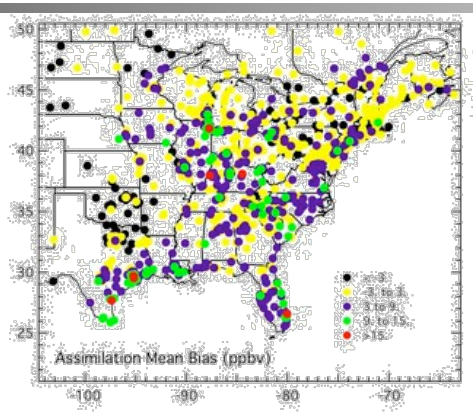

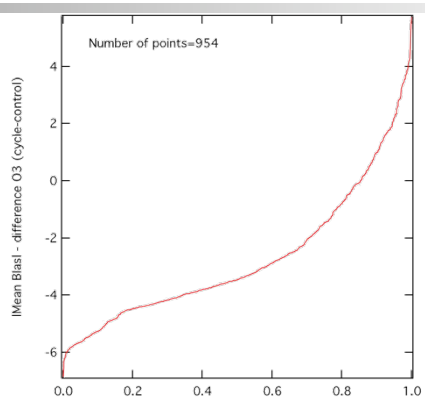

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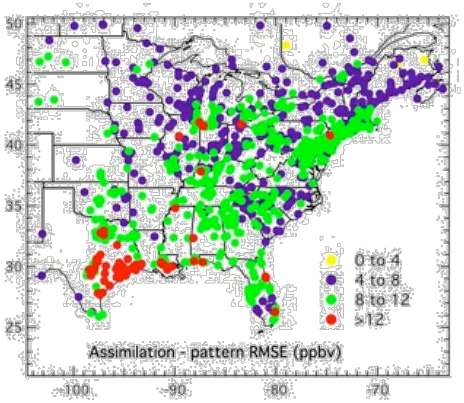

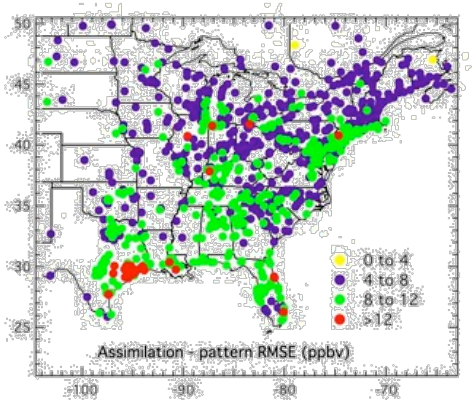

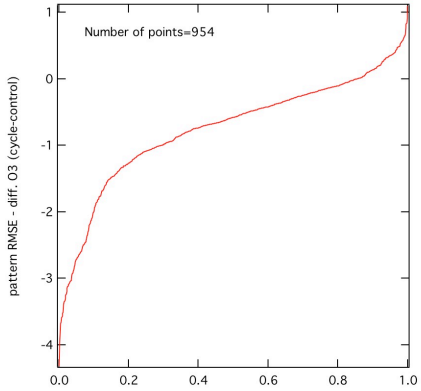

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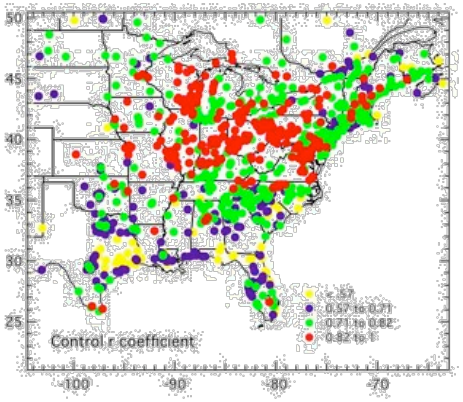

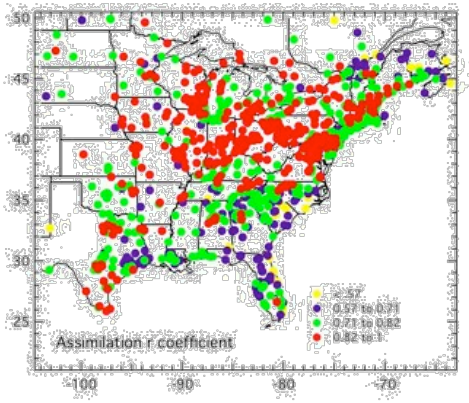

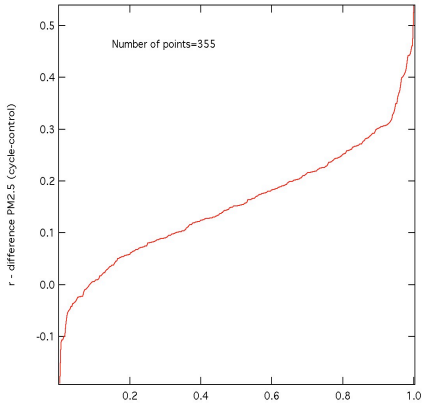

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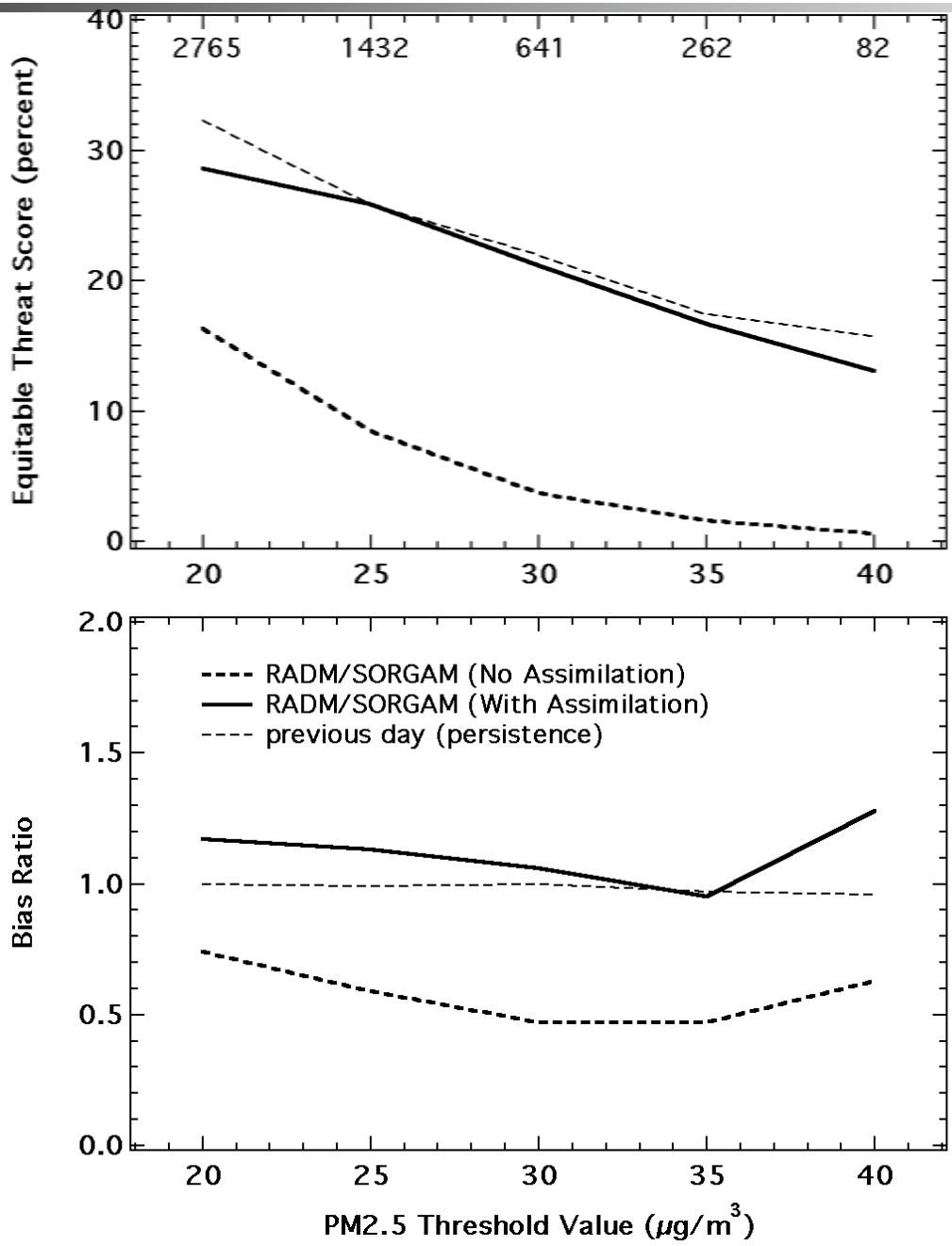
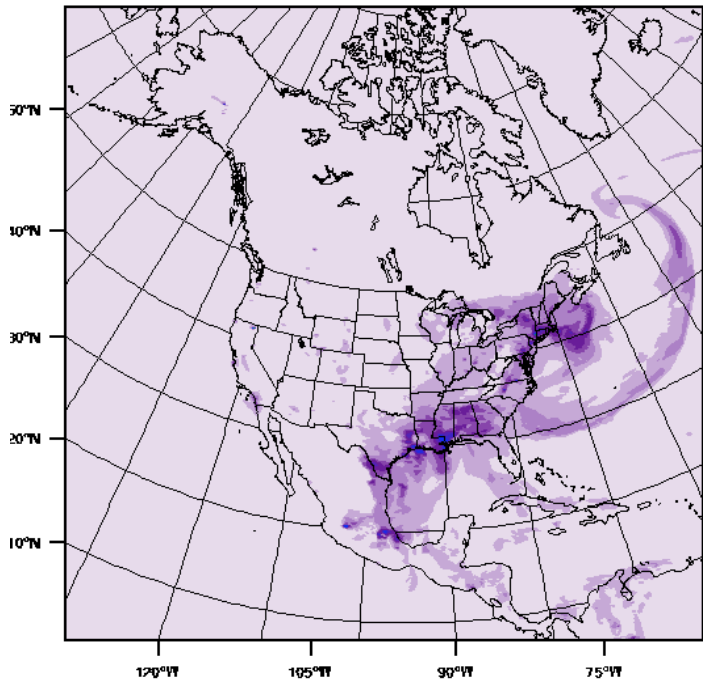


In progress/Plans

- Benefit from simultaneous meteorology and chemistry in WRF-Chem
  - ✓ regression between ozone vs. streamfunction and temperature exists but not certain if usable
  - ✓ assimilate aerosols to improve radiation
- Real-time aerosol assimilation over Rapid Refresh domain



In progress/Plans

- Collaborate with RAQMS: assimilation of satellite ozone and AOD and to use for lateral boundary conditions
- Evaluate of effects of ozone soundings on the West Coast and aircraft (MOZAIC) on forecast skill
- Experiments with EnKF using ensembles based on perturbations to emissions showed that spread is not sufficient, working on combined meteorology/chemistry ensembles
- Connect with WRF 4D-VAR