Data Assimilation within Regional Model Forecasts: Results from Recent TexAQS-2000 Analyses

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**Experimental Design**

1. Use nudging to assimilate wind profiler data for period Aug. 28-31, 2000 in 4 km grid
2. Withhold individual profilers to provide an independent verification data set.
3. Compare various nudging settings
4. Compare with simple wind analysis schemes
Results

1. Optimal nudging has vector accuracy of 1.8 m/s within network, 2.2 m/s outside network
2. Accuracy is best near the midpoint of the daytime boundary layer
3. Simple wind analysis schemes produce more accurate winds (1.4 m/s to 1.8 m/s)

Conclusions

1. Numerical simulations of winds with nudging will have inherent inaccuracies of close to 2 m/s
2. Profiler-based trajectory tools will have inherent vector inaccuracies of 1.5 m/s and speed inaccuracies of about 1 m/s

**Experimental Design**

1. Control run: regional simulation of MM5 during late August 2000
2. Generate an MM5 model with an incorrect parameterization (too much vertical mixing)
3. Generate “observations” from control run, with noise
4. Assimilate observations into the bad MM5 using Ensemble Kalman Filter
5. Include mixing factor in model state vector
Result

Mixing converges to true value within 1 day of assimilation

Conclusion

Proof of concept: sophisticated data assimilation data can correct model parameterizations

Outstanding Issues

1. Design of tunable parameterizations
2. Assimilation with real data – parameterizations may not be tunable to reality
3. Application to photochemical models

**Experimental Design**

1. Control ozone episode selected: August 30, 2000 (Houston)
2. Apply small, realistic meteorological perturbations to initial and boundary conditions of 20 ensemble members
3. MM5 ensemble simulations drive CAM-x photochemical simulations
Results

1. Control simulation is reasonable match to (but underestimate of) observed ozone
2. Ozone predictions by ensemble members vary by 10%-50%
3. No ensemble members reach peak ozone amplitude
4. Ensemble spread is nonlinear function of perturbation amplitude: develops skew toward low values

Conclusions

1. Unavoidable meteorological uncertainty/errors can be expected to cause a 20% error in ozone concentrations
2. Emissions and structural model errors cannot be overcome by meteorological tweaks

**Experimental Design**

1. Two-dimensional model spanning coastline
2. Ensemble with perturbed initial and boundary conditions
3. Tracer source mimicking Houston urban area
4. Create surface tracer measurements, assimilate using Ensemble Kalman Filter
5. No assimilation of meteorological observations
**Results**

1. Assimilation of tracer data produces accurate meteorological analyses
2. Greatest information content from tracer observations near sea breeze front

**Conclusions**

1. Proof of concept: chemical data assimilation can improve the meteorology
2. Keeping chemical observations at arm’s length from meteorological simulations is sub-optimal