Ensemble-Based Simultaneous State and Parameter Estimation for Treatment of Mesoscale Model Error: A Real-Data Study

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Wind speed sensitivity to 10 parameters in ACM2



Correlation between parameters & WSP



Sensitivity to p

 $K_z(z) = k \frac{u_*}{\phi} z (1 - z/h)^p$



Lower p => stronger vertical mixing => higher PBL height.

Model Configuration

- WRF 3.0.1
- 108 km, 36 km, and 12 km grids; 43 layers
- Dudhia shortwave, RRTM longwave, Grell-Devenyi cumulus, WSM6 microphysics, Noah land surface, ACM2 PBL, Monin-Obukhov surface layer on all three nests
- GFS initial and boundary conditions, except for NARR soil moisture
- Air pollution episode: 12Z 8/29/06 to 06Z 9/02/06

EnKF Configuration

- 30-member ensemble
- Zhang et al. (2004) covariance inflation (a = 0.8)
- Gaspari-Cohn 3-d localization; 30 grid point radius of influence
- Aksoy et al. (2006) spatial updating method for parameters

Parameter Constraints

- Each parameter should remain within its physically plausible range, but EnKF wants Gaussian errors
- Solution: perform parameter estimation on transformed parameters y that vary from +/infinity while real parameters x vary from A to B

$$x = A + \left(0.5 + \frac{\arctan(y)}{\pi}\right)(B - A)$$

Experimental Design

- Deterministic simulation (NoDA)
- Regular EnKF (NoPE)
- Parameter estimation EnKF (SSPE)
 - Update *p*, *Rc* simultaneously with updates of conventional state vector
 - Assimilate wind profiler data every six hours between Aug. 30-Sept. 2, 2006 over Texas
- Deterministic simulation with estimated parameters (NoDAnew)

Evolution of p



During most of the simulation, SSPE predicts *p* values lower than 2.0 (default). This corresponds to stronger diffusivity in the middle and upper daytime PBL.

Evolution of *Rc*



During the entire simulation, SSPE predicts *Rc* values higher than 0.25 (default). This corresponds to stronger mixing under weakly stable conditions.



SSPE predicts higher PBLH to match profiler data.

Wind vectors at Sept 1, 10 CST



SSPE shows the best agreement for surface wind.

Bias and error of T2



Conclusions

- Parameter variance remains sufficiently large throughout model integration period
- Estimated parameter values are systematically different from specified values
- Augmented state vector permits more accurate analyses/forecasts
- Modified parameter values improve pure forecast performance over same period