Ensemble filtering for meso- and convective-scale assimilation

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Meso- and convective scale DA

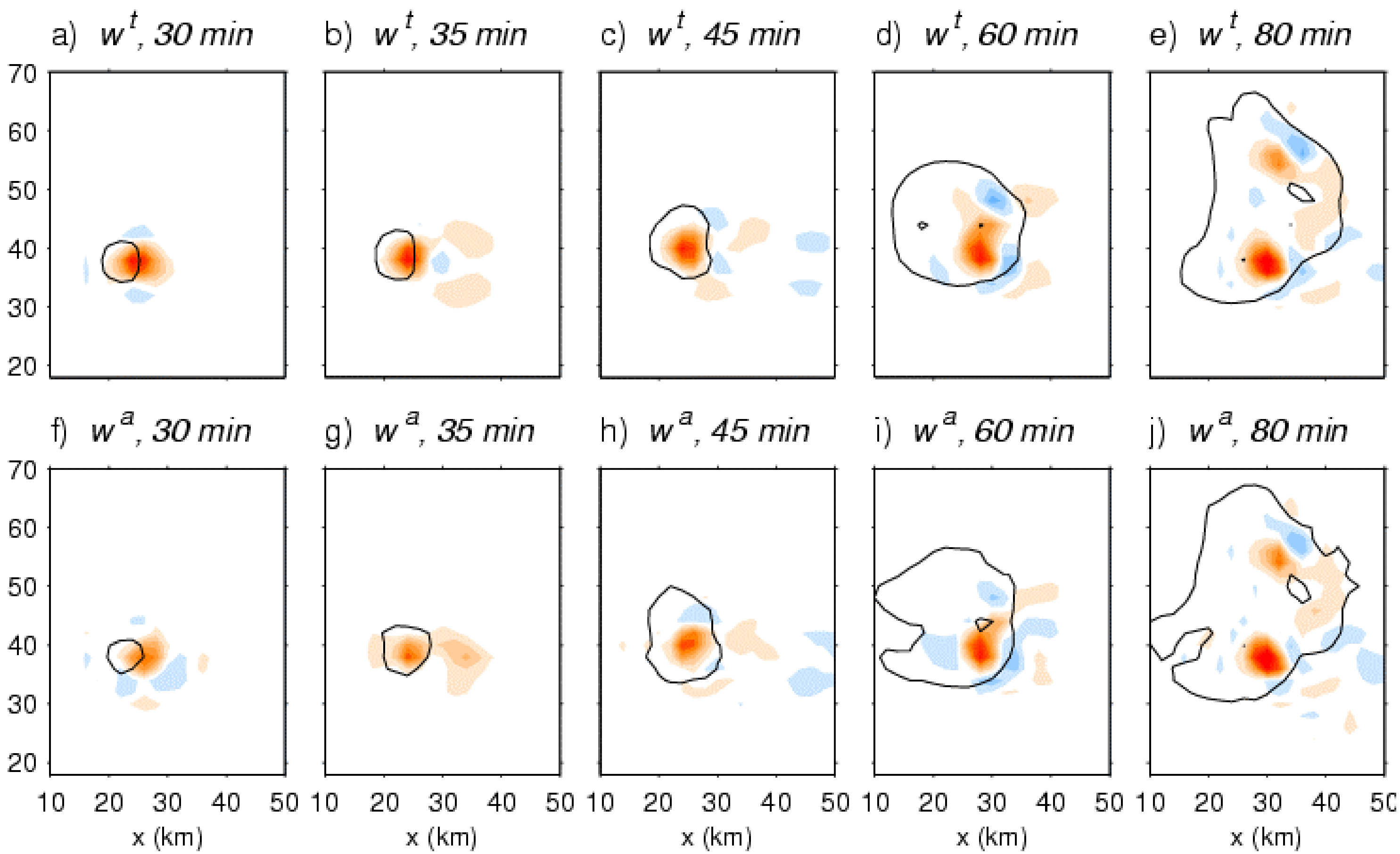
- Lots of obs, but
  - Only certain variables, certain levels
  - Asynoptic and (very) spatially inhomogeneous
- A priori relations among variables absent or weak (e.g. geostrophic balance)
- Phenomena are intermittent with coherent spatial structure (fronts, vortices, convective organization)
- Short time scales make probabilistic forecasts crucial

- Thus, need DA scheme that
  - Uses covariances that incorporate dynamical info from eqns of motion
  - Handles asynoptic obs gracefully, together with wide spatial/temporal variations in obs network
  - Returns info on analysis uncertainty, for use in IC's for ensemble forecasts
- For research, also nice to minimize devel. effort
- Ensemble filters can potentially fulfill these reqs

- Short range f/c for meso- and convective scales is frontier of NWP; large potential societal benefits
- Assimilation for these scales largely untried. Existing forecasts have significant initial spin up/down.
- Research complements present operational efforts.

Initial studies with the EnKF

- Convective scale, using Doppler radar obs
  - Snyder and Zhang (2003): simulated obs
  - Also: Dowell et al (2004) (real obs), Caya et al (2004) (comp'n with 4DVar)



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- PBL and surface obs
  - Hacker and Snyder (2004): single-col. PBL, simulated obs
- Limited-area domains, dx < 100 km
  - Barker (2004)
  - Caya and Snyder, ongoing

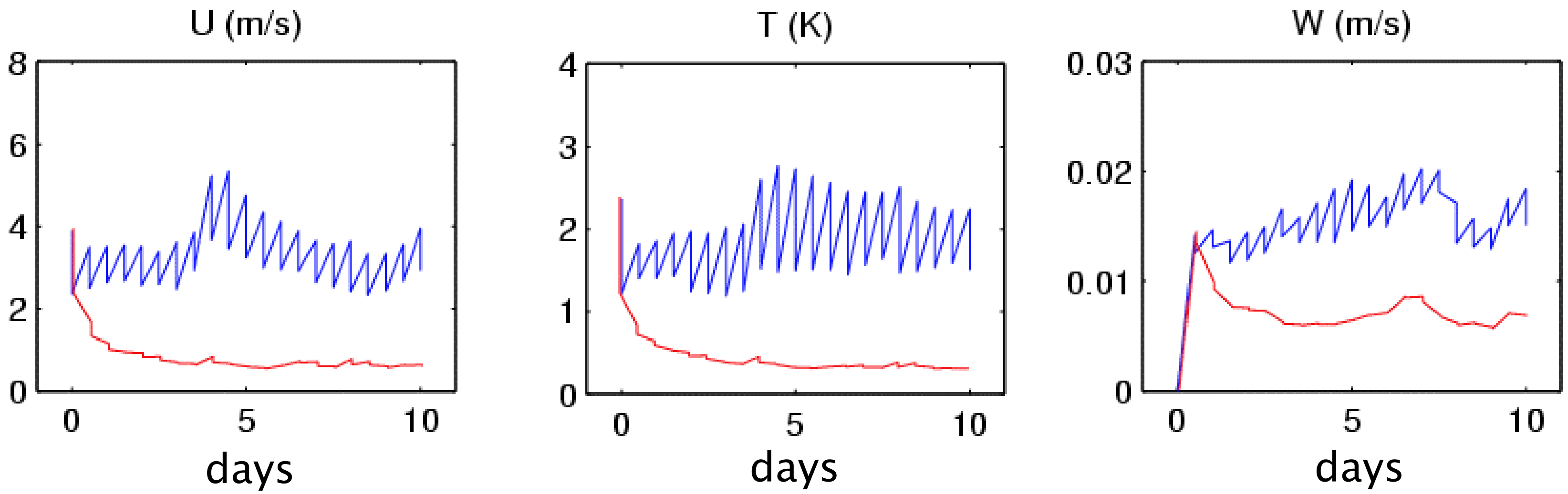
WRF/DART Development

- Have prototype system (Caya, Skamarock, Rizvi, Snyder)
- Capable of updating nested domains
- In use within NCAR
  - Caya: retrieve low-level winds from clear-air radar returns
  - Hacker: assimilation of surface obs in complex terrain
  - Caya/Barker/Snyder: tests on CONUS domain, comparison with WRF 3DVar
- Initial tests by university collaborators underway
  - Dowell (OU/CIMMS), Zhang (Texas A&M), Hamill (CU/CIRES)

OSSE's in WRF/DART

- "True" solution from WRF simulation using AVN analyses +perturbations as IC's and LBC's
- 9000 km x 9000 km, CONUS domain; dx = 200 km
- Simulated radiosondes: every 12h at locns of NA network
- 20 members, localization radius ~ 2000 km
- IC's and LBC's for each member also AVN analyses + perturbations
- Perturbations for IC's, LBC's are scaled deviations from approximate climatology
- Standard, deterministic/square-root filter

OSSE Results

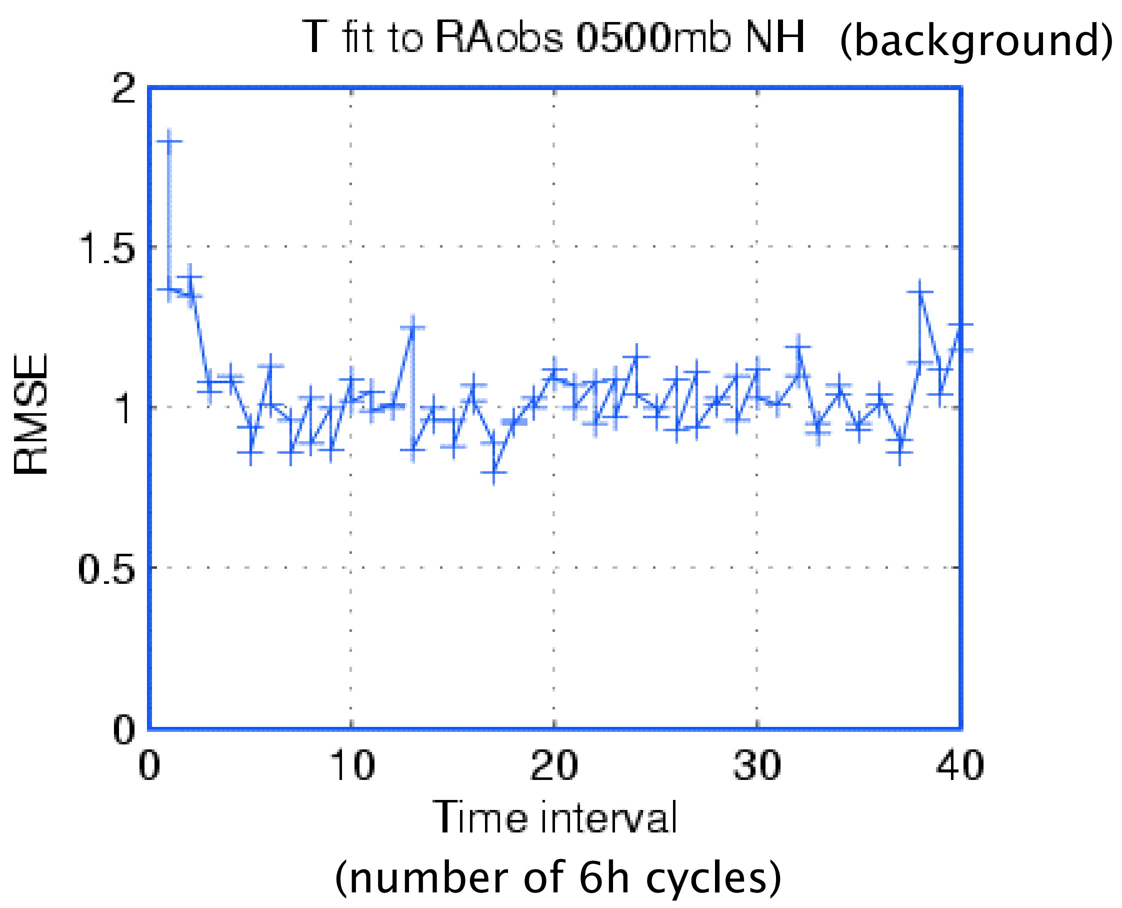


Blue: LBCs uncertain
Red: perfect LBCs

Real-data Expts in WRF/DART

- Domain, resolution as in OSSE’s
- Ensemble-mean LBC’s from AVN analyses
- Each member’s LBC perturbed using scaled deviations from climo
- Filter details as in OSSE’s
- Every 6h, assimilate radiosondes, ACARS, satellite winds

Results from Real-Data Expts



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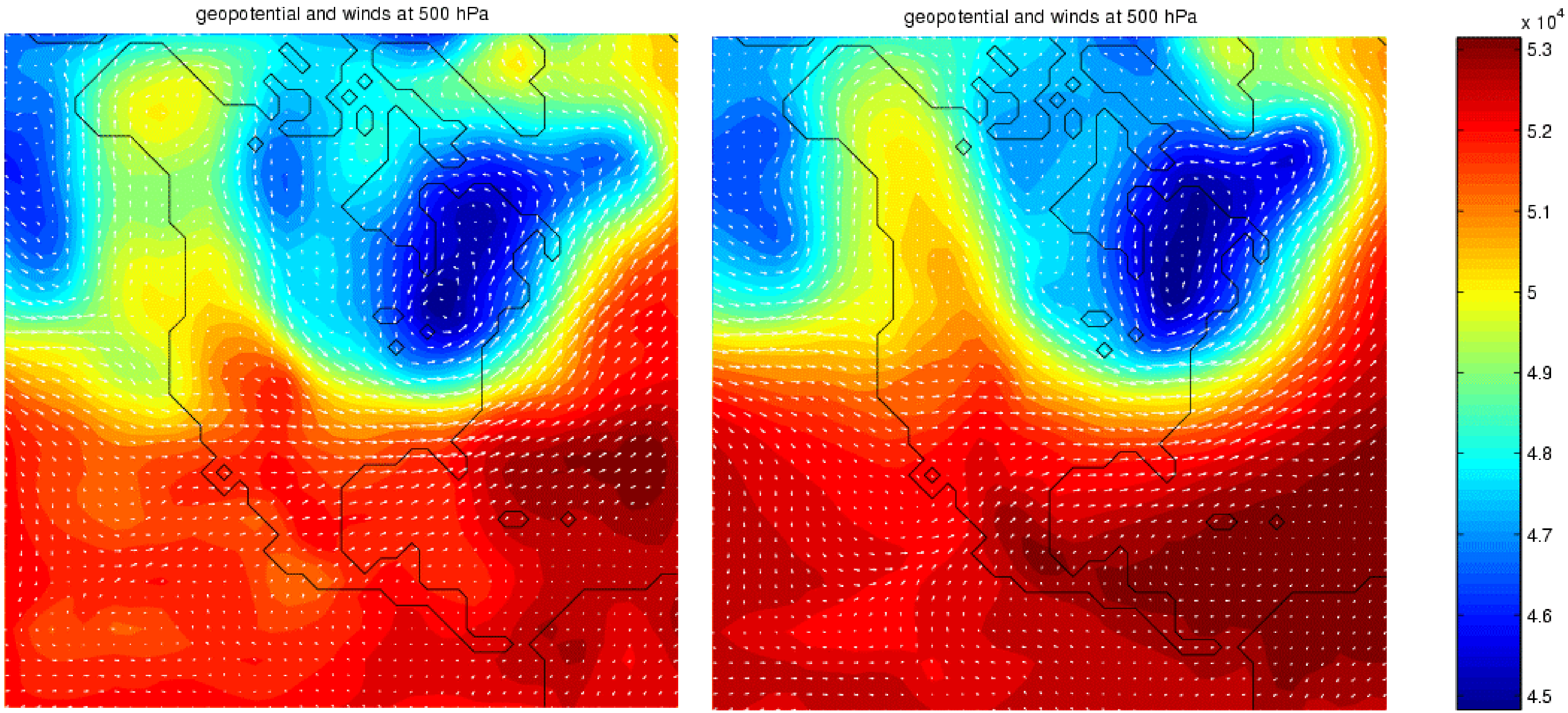

WRF/DART EnKF background

AVN analysis

Valid 0Z 10 Jan 10 (10 days cycling)

Next steps and near-term issues

- Comparison w/ WRF 3DVar
- Use of perturbations drawn from N(0,B), w/ B = 3DVar covariance model
- Quantify level of gravity-wave activity in analyses and forecasts. Do we need to initialize?
- Use of observation across multiple domains/resolutions. Should characteristics of localization vary?
- Identification of model biases

Opportunities from DART

- Capitalize on development of obs operators (e.g. GPS occultation)
- Capitalize on EnKF products from other systems (e.g. LBC's from CAM EnKF)
- Focus for improvements and refinements in filtering techniques

Challenges for DART

- Effective assimilation of reflectivity
- Lateral boundary conditions and nested domains