Strategies of the Local Ensemble Kalman Filter with a Limited Area Model

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Outline

Motivation

What is the potential of data assimilation in high-resolution limited area models?

What are the challenges?

Limited Area Models

- Potential: local forecasts, severe weather and air-quality prediction, local climate studies ...
- Challenge: to get proper initial and boundary conditions
- Problems: global $\times$ regional model, different spatial resolution, different physics packages

Sources of uncertainties in the forecast:

- regional initial conditions
- global initial conditions
- boundary conditions

Solution

Efficient strategy must be developed to propagate information about uncertainties properly.

We believe *Local Ensemble Transform Kalman Filter* is an efficient method for data assimilation, because it can estimate background-error covariance matrix. That is even more important for finer scales, where geostrophic and hydrostatic balances are week and existing data assimilation method use stationary background covariance matrix.

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Components

- Global Forecast System (NCEP GFS)
- Regional Spectral Model (NCEP RSM)
- Local Ensemble Kalman Filter (LEKF)
- Observing Network

The Regional Spectral Model (RSM)

- Operational model at NCEP
- Using the same physical parameterization packages as the NCEP GFS (it minimizes the effects of the adjustment processes between global and regional model)
- Perturbation model: high resolution forecast is combination large scale flow, provided by NCEP GFS and a high-resolution perturbation.
- Advantage: RSM uses information from global model in the troughout regional domain

REGIONAL MODELS

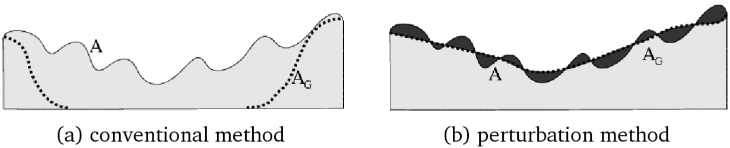
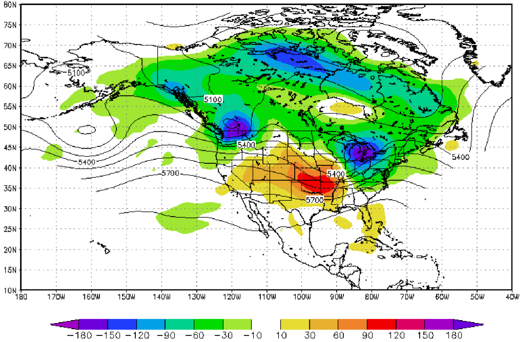


FIGURE: One-dimensional representation of an arbitrary scalar variable in the regional model: (a) for a conventional limited area model; (b) for a perturbation model such as the NCEP RSM. The dotted curve represents the contribution from the global model, while the grey area represents the full high-resolution field.

PERFECT MODEL SCENARIO

FIGURE: Snapshot of the difference between the high- and low-resolution true states. The difference (shades) and high-resolution *true state* (contours are shown for the geopotential height of the 500*hPa* level.



THE LOCAL ENSEMBLE TRANSFORM KALMAN FILTER

- Ensemble based assimilation system
- Original algorithm (LEKF) proposed in Ott et al. (2004)
- Modified by Hunt et al. (2007)
- Tested for GFS by Szunyogh at al. (2007)
- Main unique features:
  - analysis is obtained independently at each model grid point
  - algorithm assimilates all the observations that may affect analysis simultaneously at given grid point

Observing Network

Real Observations

All the observations used in the NCEP GDAS during winter and summer season 2004, except satellite radiances.

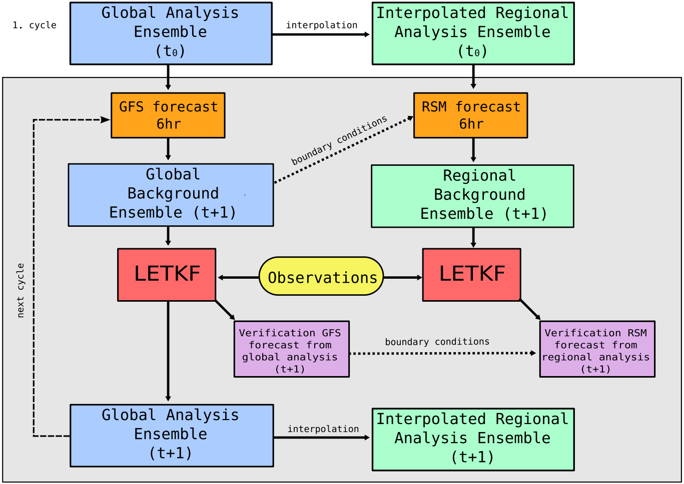
EXPERIMENTAL DESIGN

- Testing period: 01/01/2004-02/29/2004
- 40 ensemble members; horizontal radius of local volume 500-800km; vertical depth of local volume is function of altitude

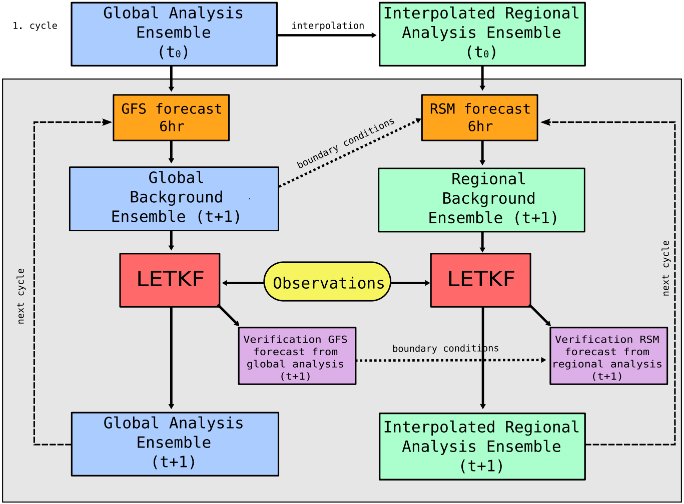
RSM

- Dynamical core is consistent with NCEP GFS; hydrostatic
- Resolution: 48 km horizontal resolution, 28 vertical levels
- Domain: Extended North American region (192 x 139 horizontal grid points)
- Boundary and initial conditions: provided by NCEP GFS (T62 horizontal resolution, 28 vertical levels)

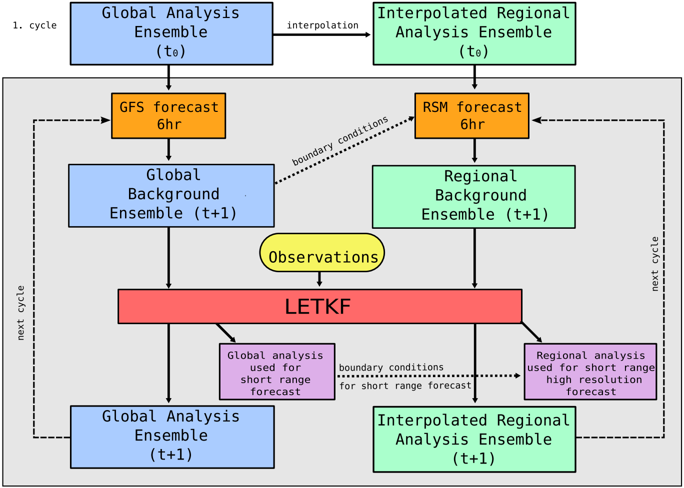
INITIAL (NONCYCLED) IMPLEMENTATION OF THE LETKF ON THE NCEP RSM



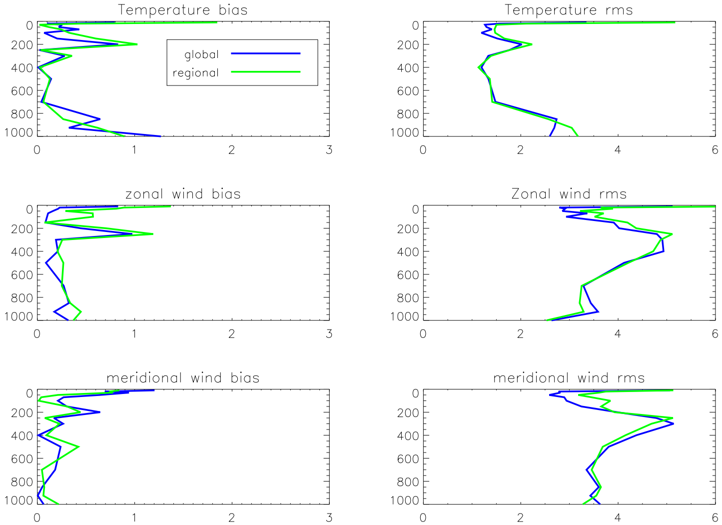
Cycled Regional Analysis



Feedback Analysis

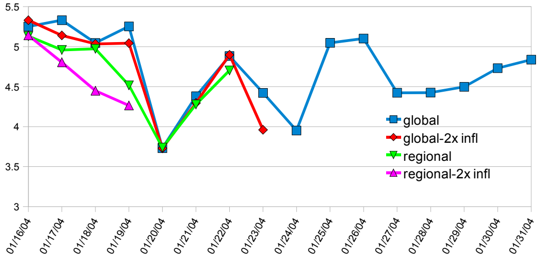


RESULTS


Temperature bias
global
regional
0
200
400
600
800
1000
0
1
2
3
Temperature rms
0
2
4
6
zonal wind bias
Zonal wind rms
meridional wind bias
meridional wind rms

RESULTS

FIGURE: RMS error (m/s) of the meridional wind at 500hPa level.



FUTURE WORK

- High impact weather case scenario
- Increasing resolution of the regional model