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Doubling the resolution of an Ensemble Kalman Filter

The 4th EnKF workshop

Rensselaerville Meeting Center

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Overview

With improving computer facilities, it is possible to improve the resolution of the global EnKF so that it becomes more like a regional EnKF. Some parameters related to resolution:

- 100 km horizontal resolution (400 x 200 grid).
- Satellite observations are thinned in space and time to have only one per 250 km and 45 minutes.
- An assimilation is performed every 6 hours.
- 96 members are used to estimate covariances.

Horizontal resolution

With an improved horizontal resolution of the model, the quality of the forecast model improves. In addition, smaller scale dynamical features can be described with the ensemble statistics.

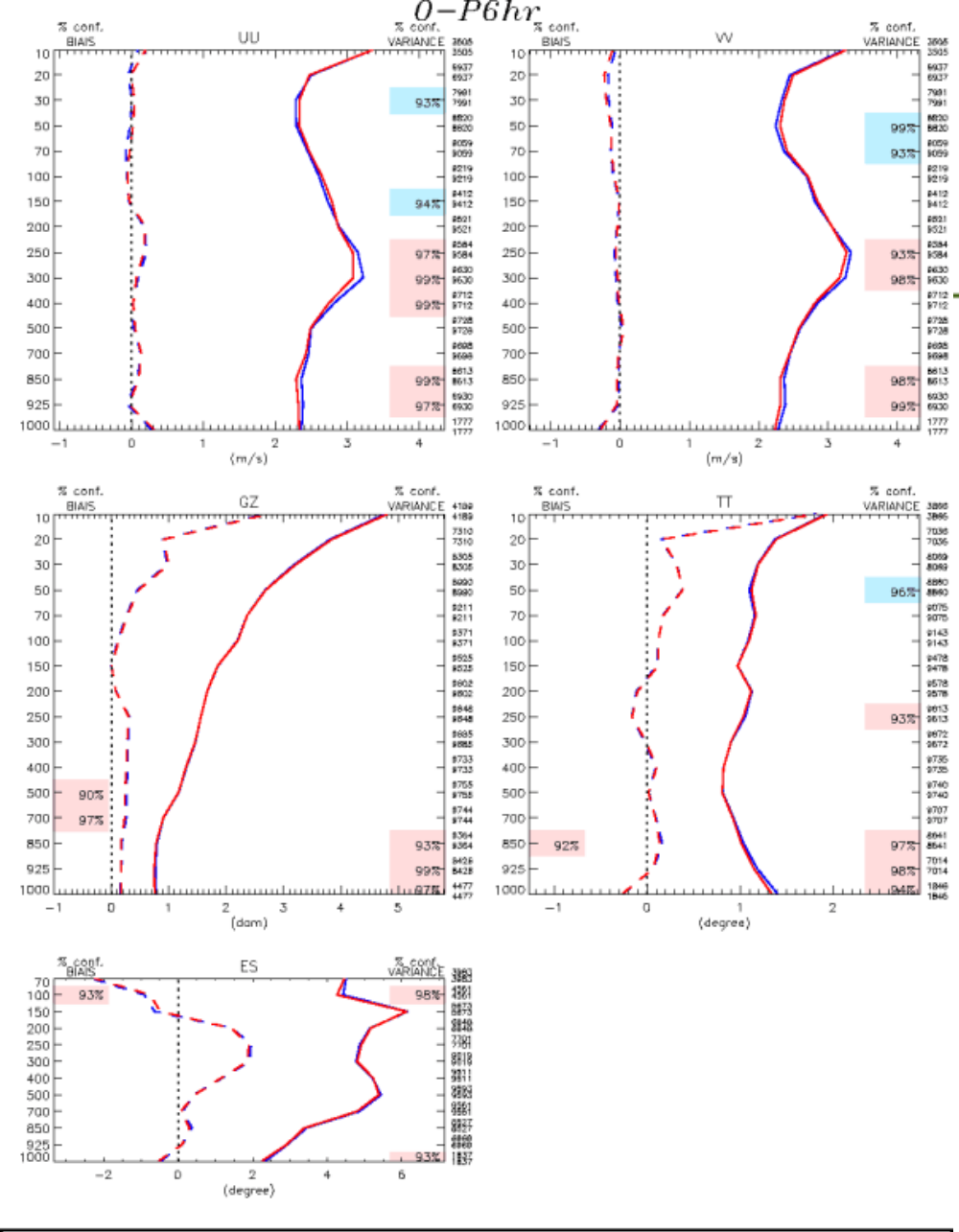
Relation with localization:

- The impact of observations drops gradually to zero in 2800 km and two scaleheights of log(p).

- *With a given ensemble size, we can only describe a limited number of features in a local area.*

- We could localize more severely, to permit having increments at smaller scales, but this would create imbalance.

==> The impact of going to a 600x300 grid is small



600 x 300 grid

increasing the horizontal resolution from 400x200 to 600x300, improves the quality of the guess fields below 200 hPa.

It degrades the guess fields above 200 hPa where we have problems with noise due to the limited number of ensemble members (96).

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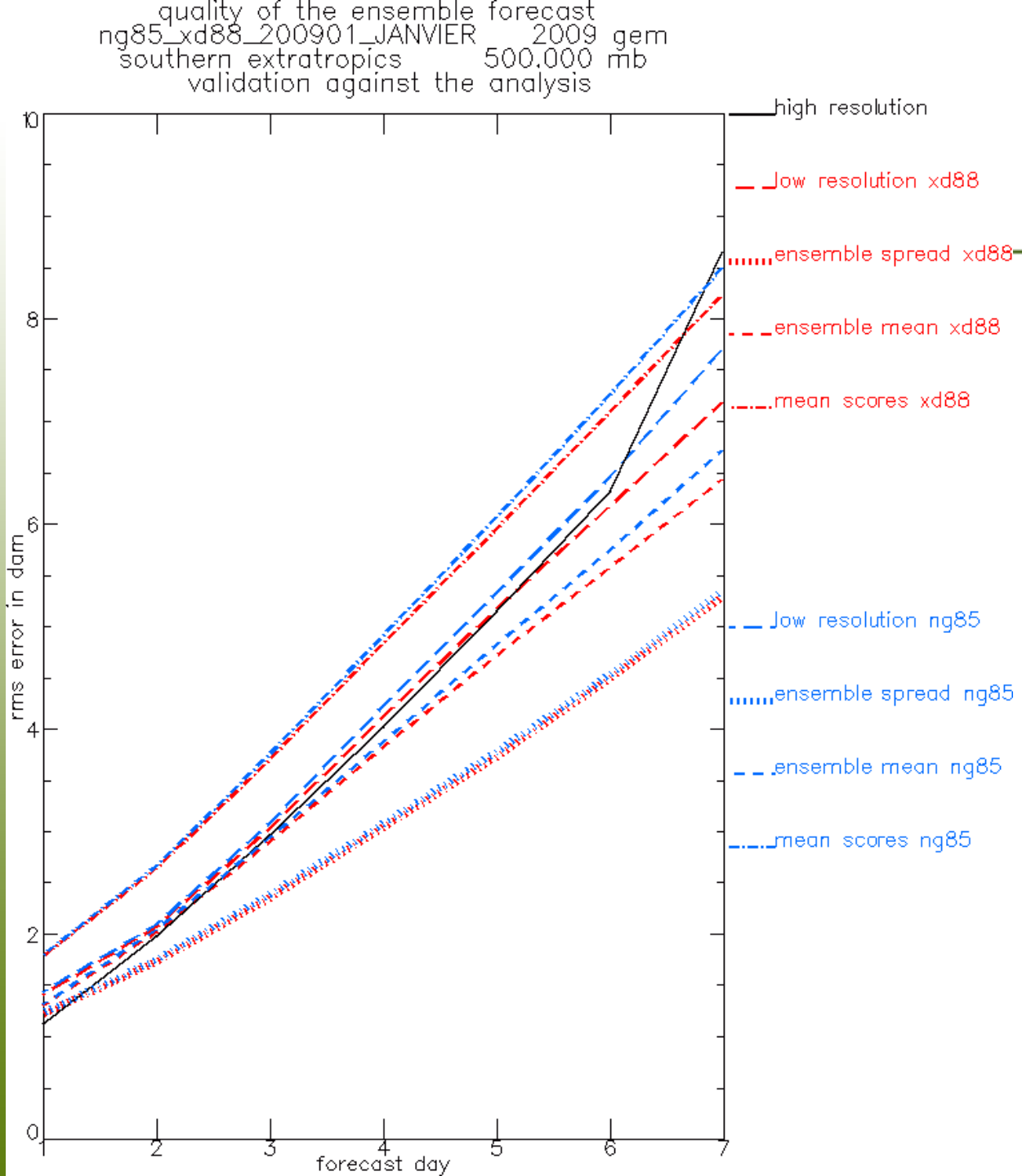
Observation thinning

Satellite observations are in principle available at high spatial and temporal resolution but are selected only once every 250 km and once every 45 minutes. Having a higher density of observations would permit obtaining relevant information on smaller scales in the analyses.

However, satellite observations are assumed to have independent errors (no horizontal or temporal observation-error correlations). *Ignoring these correlations will lead to an underdispersive ensemble.*

==> The impact of going to 150 km was small (only visible in medium-range forecasts over the southern oceans and using analyses for verification).



Thinning

For an experiment, we selected three times more AMSU data as in the control experiment.

We only observed an impact over the southern oceans and this was only visible when verifying against analyses.

The computer time needed for the analysis step doubled.

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6h assimilation window

For a very long time, our center has been using a 6h assimilation window. With a 6h window, the temporal localization in an EnKF is problematic (Bishop and Hodyss 2007). Using a shorter assimilation window would also permit the assimilation of features with a shorter predictability horizon.

However,

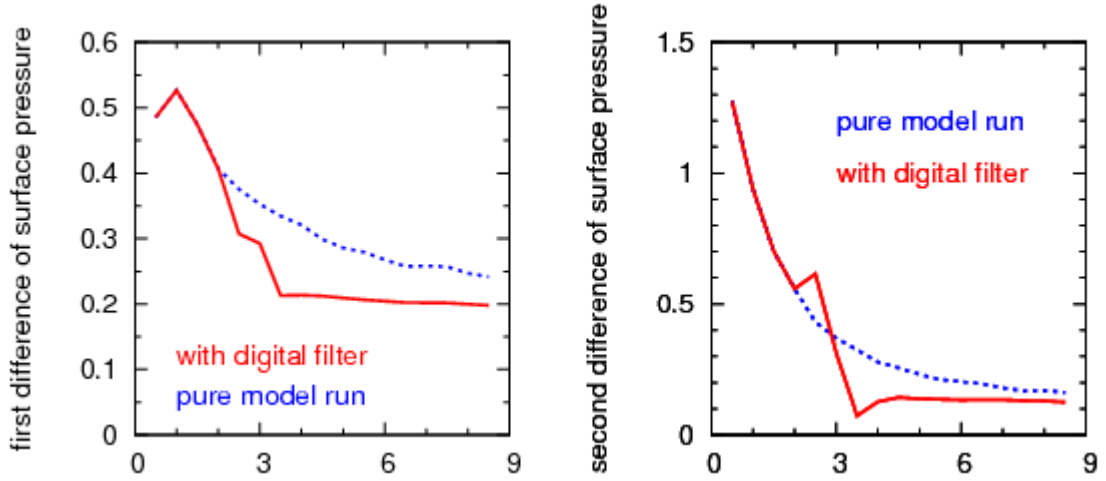
(i) we use a digital filter finalization which *explicitly filters rapid (period shorter than 6h) oscillations* from the model runs,

(ii) the *model start-up procedure re-initializes variables like cloud water*.

==> We have no success yet from moving to a 3h window.

Balancing of the initial conditions

In the digital filter finalization (Fillion et al. 1995), a weighted mean of the states of 6h model run replaces the true model state at 3h. A balanced integration is subsequently started from the filtered state at 3h.



We performed some experiments with different parameters of the digital filter. Results have been mixed. We will likely need to move to a different balancing procedure.

Ensemble size

In Monte-Carlo methods, estimation errors decrease only with the root of the ensemble size. We also need many ensemble members to extract the information from a high-density observational network.

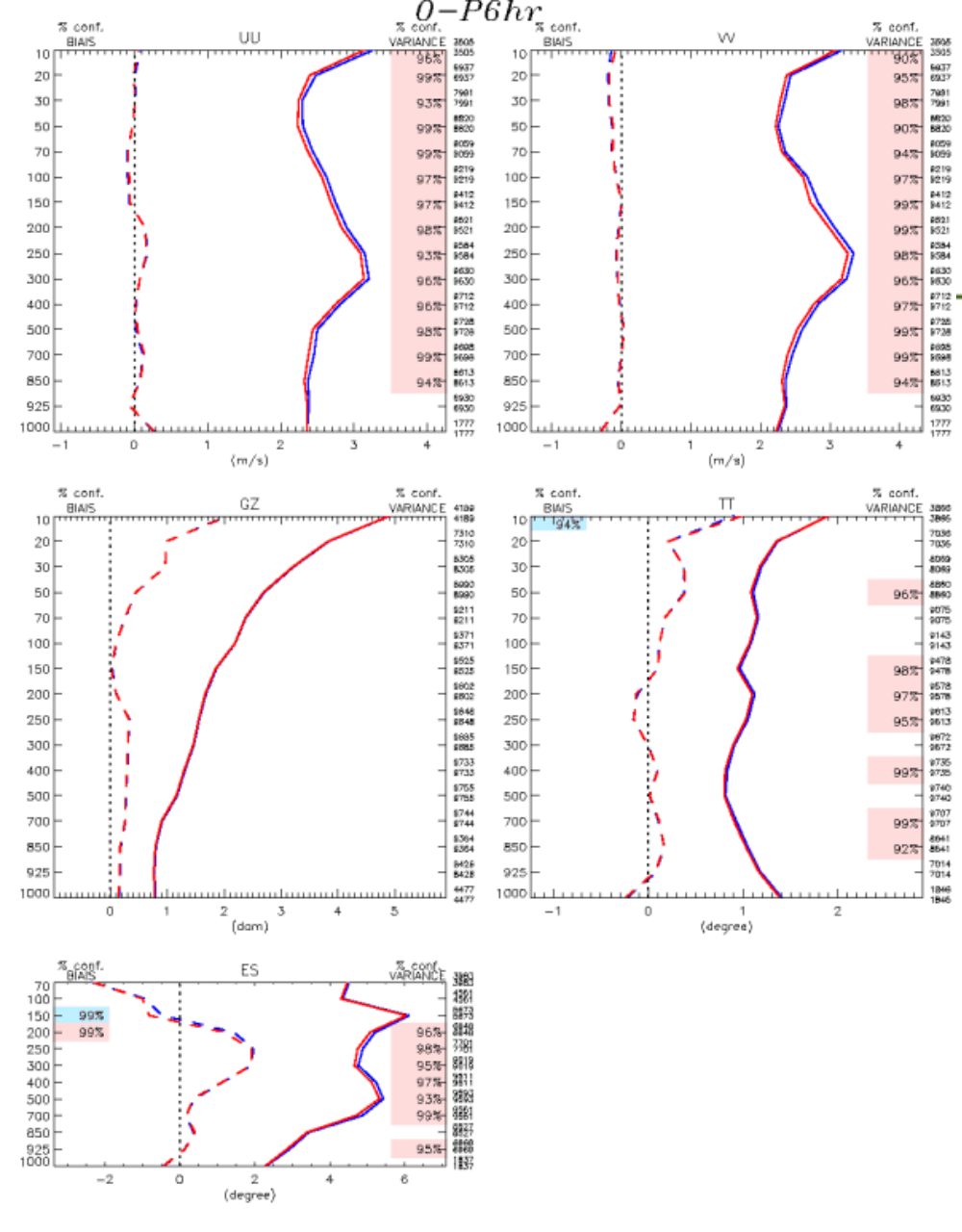
==> We have an interesting improvement in quality just from going to 192 members.

Going to 192 members did also permit us to:

- use the *B_nmc matrix to simulate model error* (this matrix has smaller scales than used before),

- better *estimate low correlations between wind and temperature in the stratosphere* (for the assimilation of AMSU channels 11 and 12).

Impact of going from 96 to 192 members



In particular for the wind components, we have a significant improvement.

This summer, we will likely transfer a configuration with 192 members to operations.

We will also move to a new (staggered) vertical coordinate and raise the top of the model to 2 hPa. See the poster by Seung-Jong Baek.

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Conclusion

Our biggest algorithmic challenge is how to reduce the length of the assimilation window. We *need an incremental initialization procedure* and we *need to reduce the mismatch between the model and the analysis*.

For now, we get the biggest improvement from using brute force (in particular from using more members). *Having more members, we might obtain a more positive impact of denser observations or a higher model resolution!*

An *operational regional ensemble* will be piloted from the global EnKF-based ensemble (autumn 2010). Experiments with a pure regional EnKF will start soon (project headed by Luc Fillion).