Radiance assimilation experiments using LETKF.

First approach at DWD.

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Motivation

The data assimilation technique currently implemented at DWD is the 3DVAR. The background error is introduced as a fix matrix calculated using the NMC method. Ensemble data assimilation techniques will be used in the future in order to add flow dependent information on the background error and to provide initial conditions for probabilistic forecasts.

LETKF, proposed by Hunt *et. al* (2007), provides a simple and fast algorithm to use an ensemble forecast to bring dynamical information to the analysis cycle. It also provides a full set of new ensemble members that are in agreement with the analysis update statistics.

References

- Elana J. Fertig, Brian R. Hunt, Edward Ott, and Istvan Szunyogh. *Assimilating non-local observations with a local ensemble Kalman Filter.* Tellus, 59A:719{730, 2007}.

-B. R. Hunt, E. J. Kostelich, and I. Szunyogh. *Efficient data assimilation for spatiotemporal chaos: a local ensemble transform Kalman Filter.* Physica D, 230:112{126, 2007}.

- Mark Buehner. *Ensemble-derived stationary and ow-dependent background-error covariances: Evaluation in a quasi-operational NWP setting.* Q.J,R.Meteorol.Soc, 131:1013{1043, 2005}.

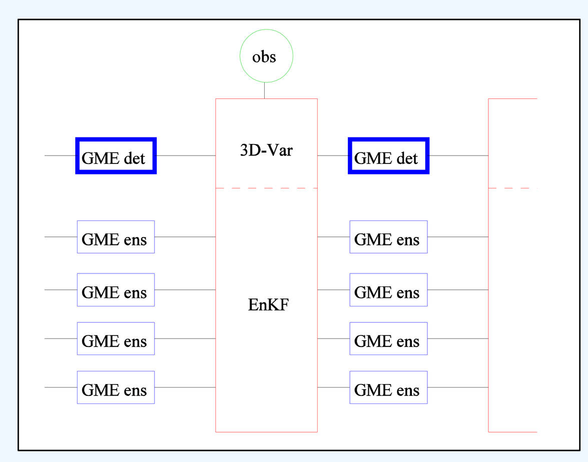
Operational implementation

DWD runs a global model (GME, 30Km) and a local model (COSMO-DE, 2.8Km). Different versions of ensemble data assimilation algorithms are planned for each of these setups.

GME - Variational approach

The analysis will use information both from the static 3DVAR B-Matrix and the ENKF dynamical info. (Buehner, 2005).

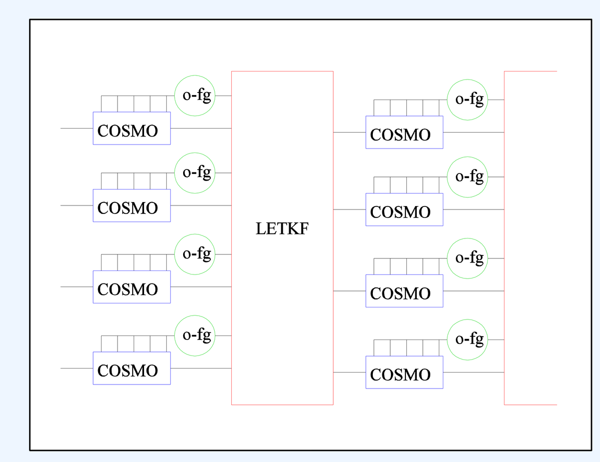
b) Additional control variables are added to the state vector.
c) Nonlinear observation operators are used.
d) Localization is applied to the Ensemble-B-Matrix.



COSMO - LETKF

Ensemble members and analysis mean are calculated with the LETKF.

b) An analysis is performed independently at every grid-point.
c) Analysis is made in a sub-space spawn by the ensemble members.
d) Noise is introduced due to the limited number of ensemble members. Localization in the R matrix, instead of the B matrix, is used to decrease the information from distant points.
e) 4D assimilation can be easily implemented.



Vertical localization issues

Localization

Ensemble data assimilation methods require localization (further reduction of the ensemble correlation for large distances) in order to suppress noise and to increase the rank of the implied B-Matrix.

In the LETKF this localization is applied in the R-matrix for computational convenience. This is straight forward in the case of in situ observations, however represents a problem in the case of non-localized observations such as satellite radiances. In this case a nominal height is chosen where the sensitivity of the observation to the temperature profile is highest.

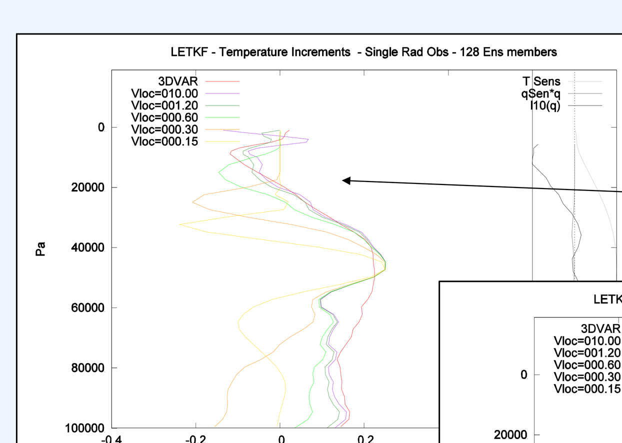
Experimental setup

A comparison between the operational 3DVAR and the LETKF in a single update cycle was performed. A 128 member background ensemble was artificially created using random perturbations dressed with the B-Matrix of the 3DVAR. This way we ensure that both assimilation techniques have similar error statistics.

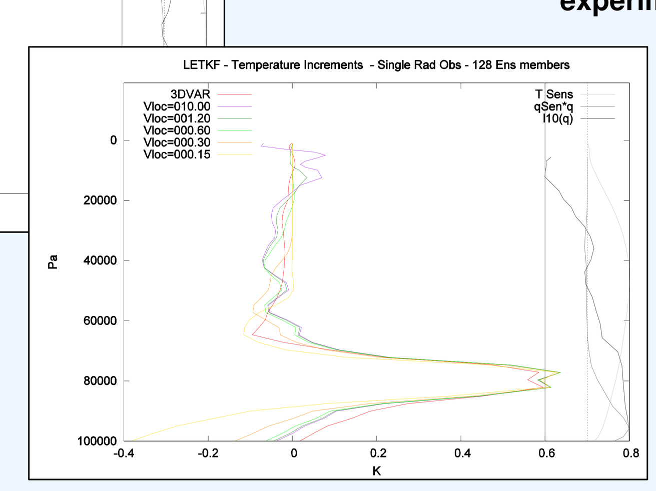
In situ and radiance observations

We want to study the impact of a radiance observation and a in situ on a vertical profile using different vertical localization values. As obs. we used a AMSUA5 radiance and an artificial rawinsonde measurement at 800HPa. We impose a obs. minus first guess equal to the standard error of each observation.

It can be seen that satellite observations need a wider vertical localization. We repeat the experiment using both observations at the same time setting a fixed localization value of 1.2 for the radiance and selecting different loc values for the in situ obs. (Fertig, 2007). For small in situ localization radii we get an over-shooting of the analysis increments at the nominal height of the AMSUA radiance observation. In this case the impact of the in situ observation analysis increment on AMSU-A radiances is not accounted for. Consequently the analysis increment due to the radiance observation will be different.



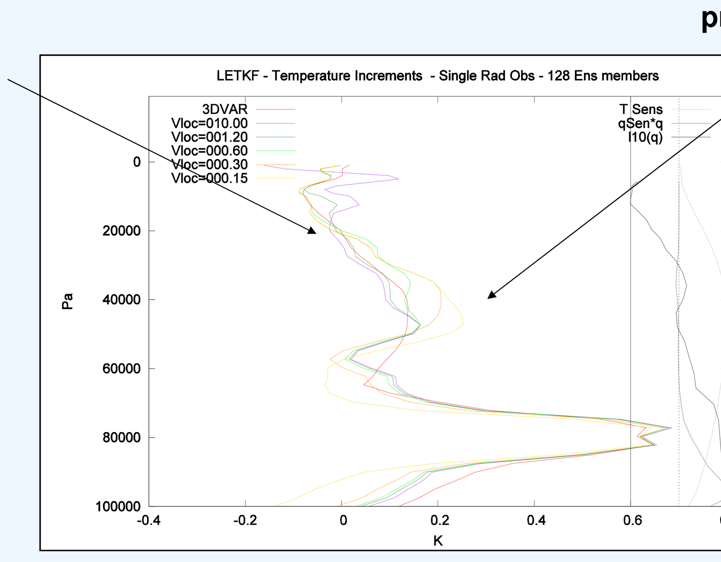
AMSUA5



Temp 800HPa

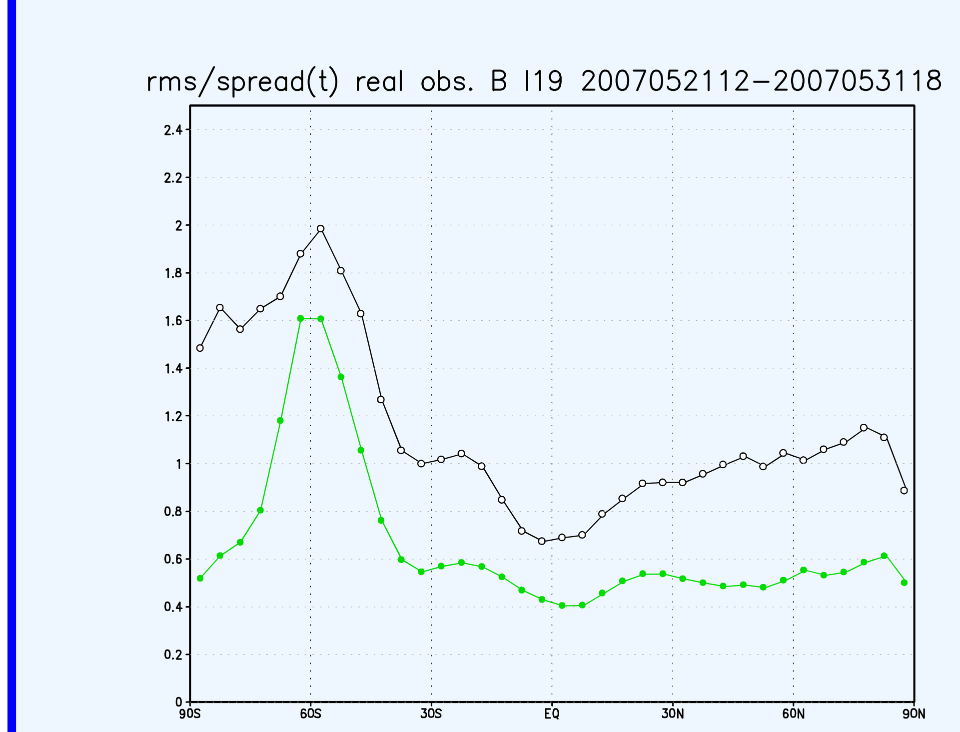
Less over-shooting in the new experiment.

Still some problems.

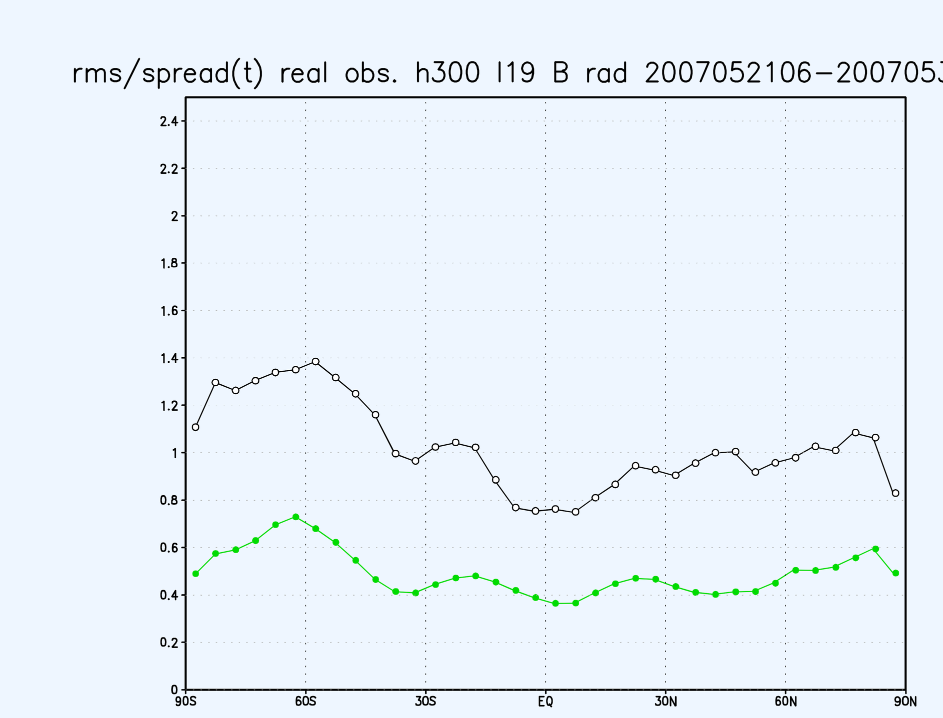


AMSUA5 + Temp 800HPa

Global impact of radiances



RMSE (black) and spread (green) (K) of the temperature T at 500 hPa as a function of the latitude, averaged over the period from 2007 05 21 12 UTC – 2007 05 31 18 UTC. Only conventional observations were used.



As left but using radiances and for the same period of the previous case. We used radiances from NOAA 15, 16 and AQUA satellites. Both RMSE and spread are reduced, especially in the southern hemisphere.

Summary and Outlook

Two experiments have been performed, one for a single column experiment and a second using a full set of radiances in a assimilation cycle during a 10 day period.

In the first case we could observe the impact of different localization values on the noise and the accuracy of the increments compared to a 3DVAR update with the same statistics.

The second experiment demonstrates the importance of using radiances in a LETKF assimilation cycle. Especially in the southern hemisphere, where in situ obs. are scarce, a reduction of RMSE and SPREAD is achieved when this observation type is used.

It still not clear which is the best way to assimilate radiances and other non-local observations and this topics need to be further investigated.

Acknowledgement

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