Sigma_b maps in ALADIN

Antonín Bučánek, antonin.bucanek@chmi.cz
Czech Hydrometeorological Institute, 2014

LACE nwp central europe

Introduction

It would be nice to have data assimilation algorithm with nonhomogeneous and flow dependent background errors. One simple solution is already implemented in ALADIN 3DVAR scheme in which grid-point background error standard deviations could be used to introduce nonhomogeneity and potentially flow dependency. Grid-point background error standard deviations will be referred as sigma_b maps in the following text.

Strajnar [2008] adapted ARPEGE code for ALADIN and showed the potential of sigma_b maps. We revised the status of usage of the grid-point sigma_b maps outside Meteo-France with great help of Mohamed Zied Sassi (ALADIN flat-rate stay in Prague 23. 9.–18. 10. 2013).

The increments of the state vector are changed to the control variable during minimization of the cost function to achieve better convergence. The variable change involve a normalization by the background error standard deviations. By default normalization is done in the spectral space in which the control variable increments are scaled by the averaged standard deviations (sigma_b is one number per vertical level). But normalization in the grid-point space allows dependency of background error standard deviations (stde) on their geographical position. This will introduce demanded nonhomogeneity in the specification of background errors.

ALADIN/CZ cycle 36t1ope was used (Δx ~ 4.7 km, 87 levels, Δt 180 s).

Technical implementation

The grid-point sigma_b maps are used in minimization when LSPFCE = .F. in namelist NAMJG. It is expected that the grid-point sigma_b's are stored in the grib file called errgrib. At least vorticity stde or wind stde have to be present in errgrib. If only vorticity stde is provided in errgrib, unbalanced part of divergence, temperature and log surface pressure are set to values prescribed values from B matrix. But unbalanced specific humidity stde is computed by an empirical formula [Rabier et al., 1998]. When specific humidity is present in errgrib and LRDQERR = .T. is set then sigma_b maps of humidity are used instead of the empirical formula. Grid-point background stde's are computed according to following equation:

$$\sigma_b\,(i, var, lev) = \frac{\sigma_{GP}(i, var, lev)}{\langle\sigma_{GP}(i, var, lev)\rangle} * \sigma_{SP}(var, lev) * REDNMC$$

where *i* is grid-point index, *var* stands for variable and *lev* for level. *GP* denotes values given by errgrib and *SP* values computed from B matrix, REDNMC is tuning key. < . > denote computation of the mean. Fraction on the right hand side of equation we call **scaling factor** because it represent relative increase or decrease of spectral sigma_b.

Errgrib variability

We decided to use sigma_b maps computed by Assimilation Ensemble ARPEGE (AEARP) to overcome complicated task of estimation of sigma_b maps.

Scaling factor was plotted to investigate day to day change of all variables inside errgrib (global) over ALADIN/LACE domain. Maps of scaling factor are shown in the figure 1 at level 30 (~400 hPa) just before extreme rainfalls during flood event in Czech Republic. Vorticity and unbalanced divergence scaling factors changed prescribed sigma_bs just in few percent while humidity error was twice larger in central Europe after application of sigma_b maps. Quite course spatial resolution of scaling factors was due to resolution of AEARP and number of its members. One could think about ALADIN sigma_b maps, which would have better resolution, but it would require to setup an ALADIN ensemble in high resolution.

Scaling factors were also observed in particular grid-point (Prague). They showed quite reasonable change from one day to the other (see the figure 2). More details could be found in Sassi [2013]. We have concluded that it is worth to test grid-point sigma_b maps in ALADIN 3DVAR.

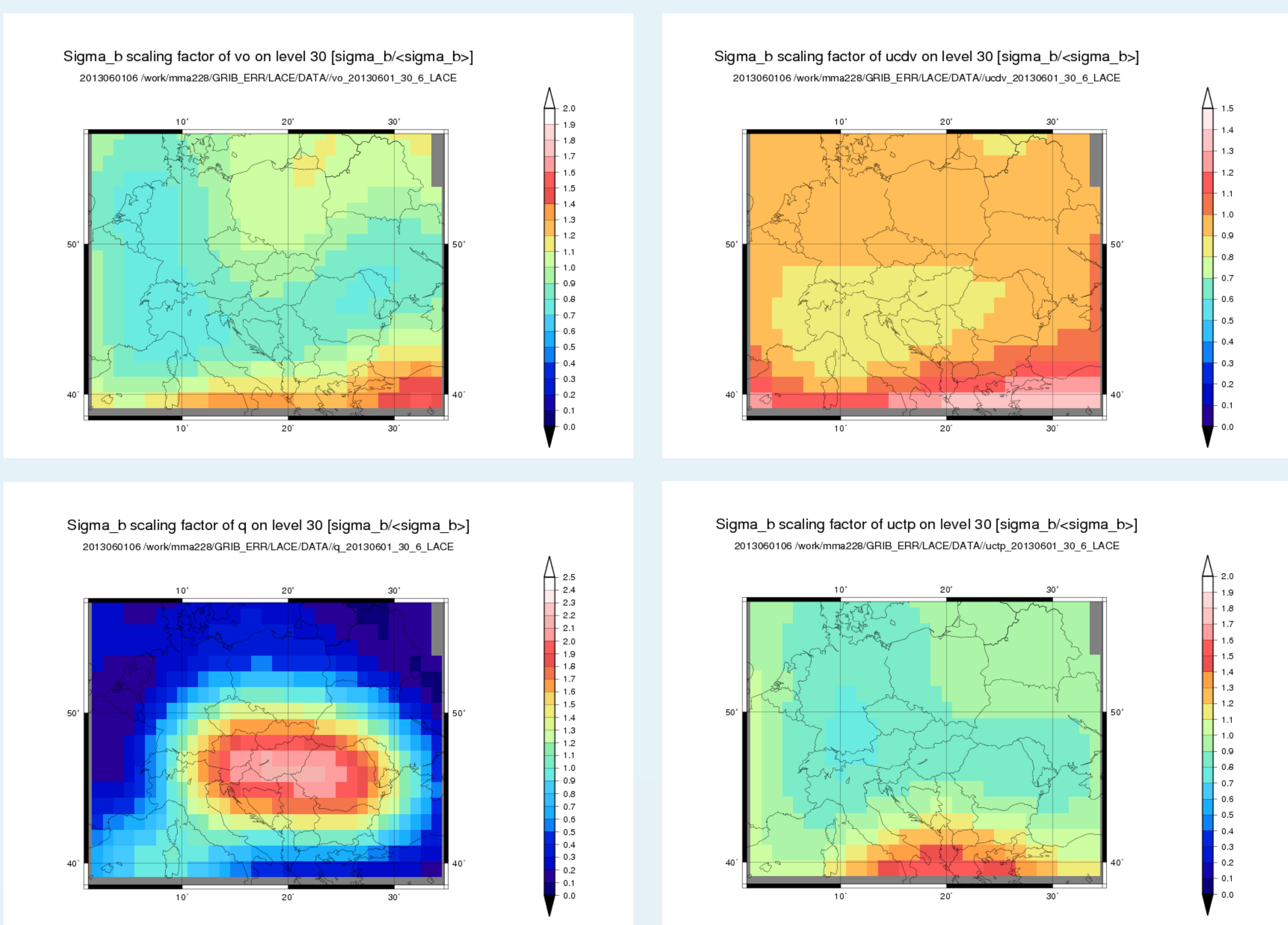

Figure 1: Map of scaling factors over LACE domain. *vo* stands for vorticity, *ucdv* is unbalanced divergence, *q* is specific humidity and *uctp* is unbalanced temperature.

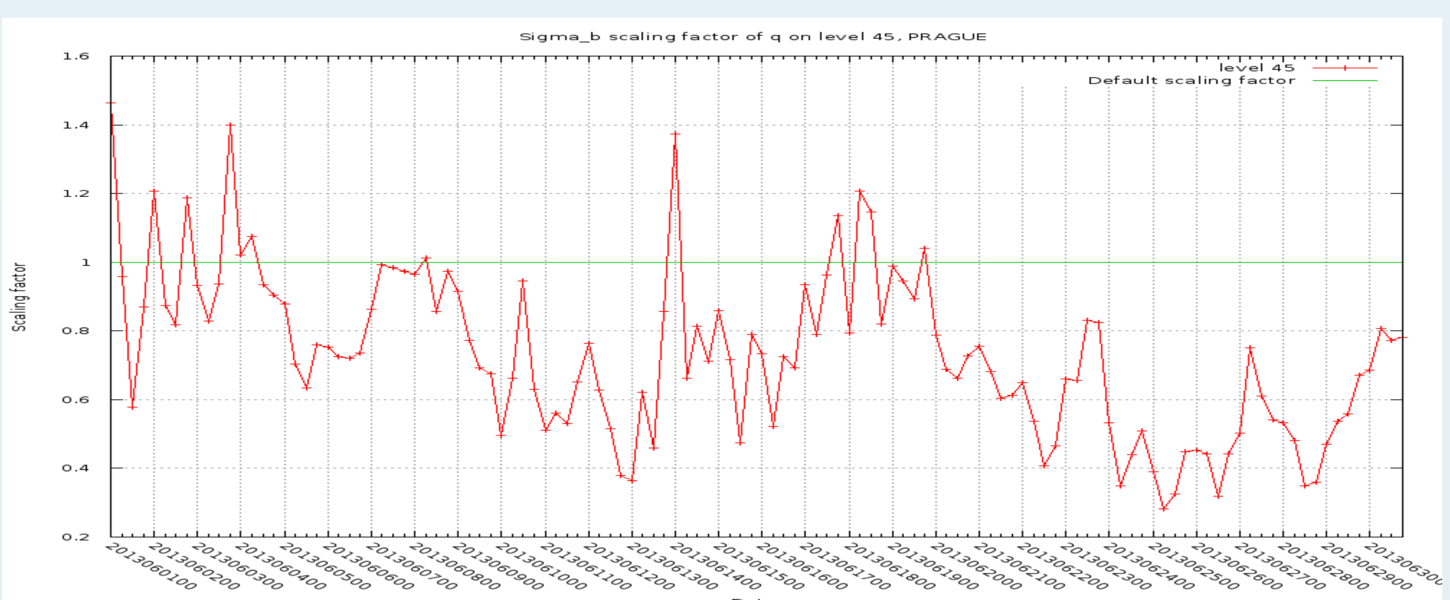

Figure 2: Time evolution of humidity scaling factor (at ~640 hPa) in the nearest grid-point to Prague.

Single observation experiment

Single observation of temperature at 500 hPa near Prague was used to test different setup of artificial errgrib file. Prepared pattern were inserted to all vertical levels.

Errgrib with constant values over small area

Unbalanced temperature was preset to 1 in the small area while the rest of the domain was filled with zeroes (figure 3d). It implied that the scaling factor inside the area was ~ 7.58 whereas 0 outside. The other parameters were kept constant. The analysis increments were negligible outside the area as was expected (see figure 3a). The maxima of analysis increments inside the area was roughly 7 times larger than the reference (figure 3c). The result confirm our expectation and convince to test further.

Errgrib with linearly increasing values over small area

The experiment was expected to make analysis increments larger on the east side of the area. Values in the errgrib field of unbalanced temperature are linearly increasing from zero on the west side to one on the east side of the area (fig 3d). The other setup was similar as previous experiment. The increased values of the analysis increments were located in the east side of the area (fig 3b). This experiment confirmed that analysis increments could be strongly influenced by sigma_b maps although the used errgrib file shows rather extreme scenario.

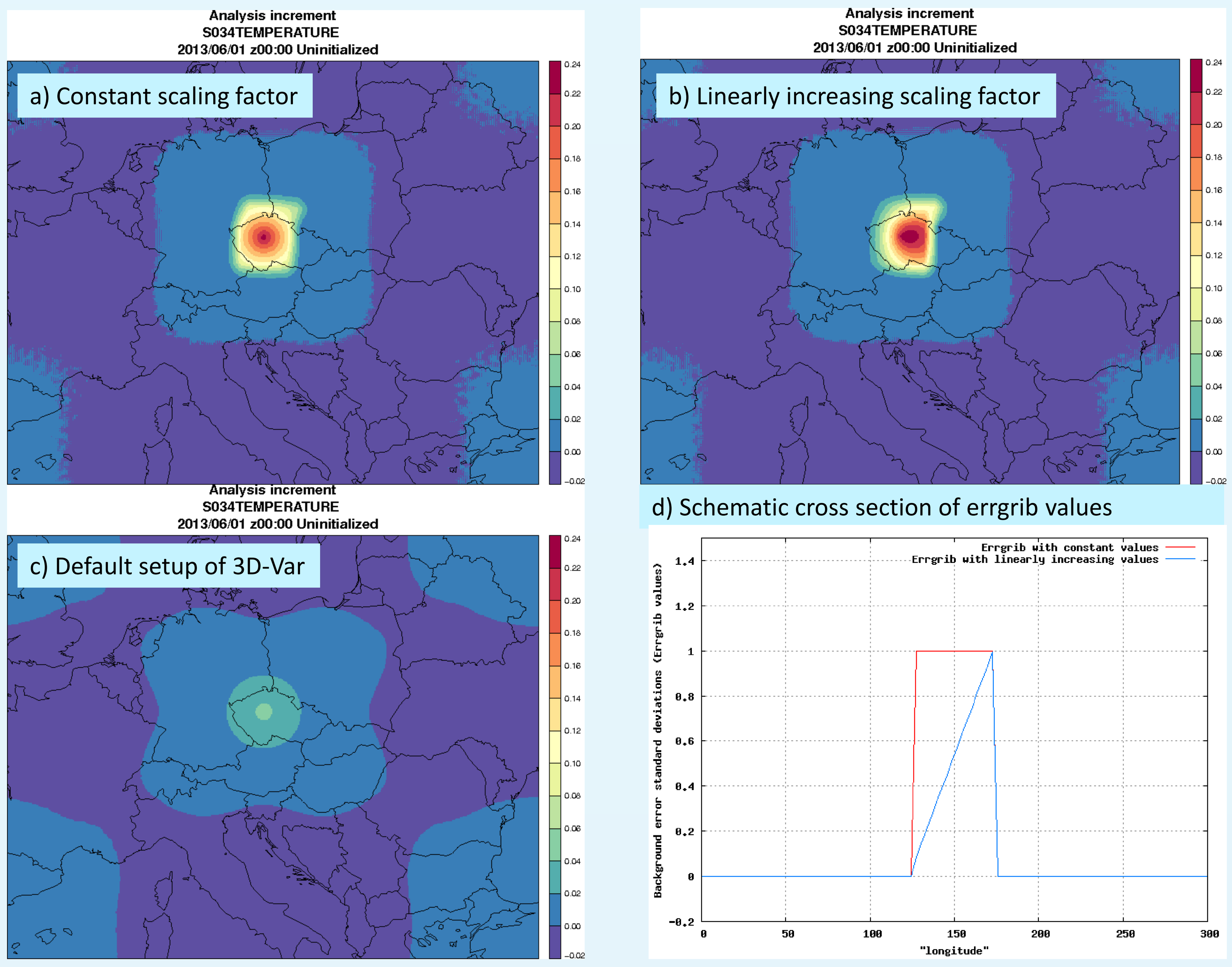

Figure 3: Analysis increments for two artificial setups of sigma_b maps, default set up of 3D-Var and schematic cross section of scaling factor.

Full observation experiment

A case study using AEARP sigma_b maps has been computed over the period of severe floods in Czech Republic (from 26.5. to 10.6. 2013). BlendVAR setup with sigma_b maps was used to assimilate SYNOP, TEMP, AMDAR, AMV observation. Reference was BlendVAR without sigma_b maps. Verification was made against TEMP and SYNOP observations and shows rather neutral results (figure 4a).

On the 1st of June 2013 there were extreme precipitation rates in Czech Republic, we were curious how experiment with sigma_b maps competes operation setup. Frequency bias for categorical forecasts and Fraction skill score were computed for precipitations cumulated in 24h (the best score is one in both cases). Figure 4b shows clear skill improvement in both lendVAR options against operational setup, but it is not clear if sigma_b maps leads to better forecast.

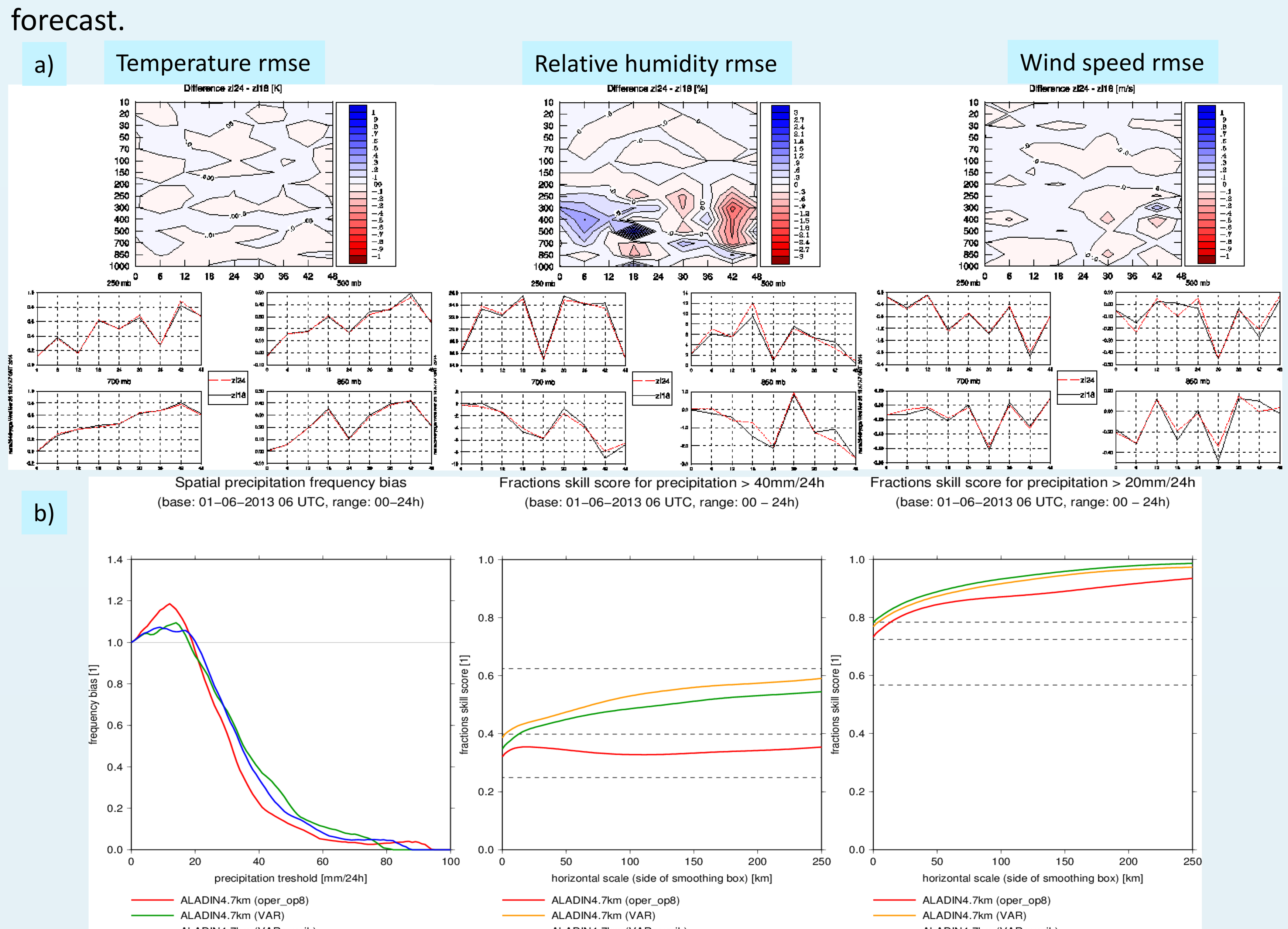

Figure 4: a) RMSE scores – red line denotes experiment with sigma_b maps, b) Frequency bias and fraction skill score for forecast on 1. 6. 2013 06 UTC

Conclusion

Although verification scores do not show clear improvement of sigma_b maps, they are promising to incorporate nonhomogeneity and flow dependency to assimilation scheme. There is one conceptual problem, we expect that AEARP and ALADIN have the same geographical dependence of background errors. But I would expect significant differences between sigma_b maps generated by AEARP and ALADIN.

There still remains a few technical problems that are depicted in "Study of spatially varying flow-dependent background error variances in ALADIN implementation outside Meteo-France II", see rclace.eu