Computation of background error statistics of a double nested limited area model

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The presented paper will summarize the work on background error statistics to be used in the data assimilation system of the limited area model (LAM) ALADIN (Horányi et al., 1996). Beside a brief overview of the general developments, we would like to focus on the work performed with the Hungarian domain of the ALADIN model (ALADIN/HU[1]).

Computation of background error covariances is required in the context of data assimilation in order to estimate the solidity of first guess information obtained by an earlier model forecast. The so called NMC method is a widely used algorithm for the definition of background errors in numerical weather prediction models (Parrish and Derber, 1992). This method estimates the background errors as the deviation of model forecasts with different forecast ranges (usually 36 and 12 hours) but valid for the same time. The background error statistics are computed thus on forecast differences accumulated for a few months (typically 3). As the straightforward application of the method (originally used in global models) didn't prove to be convenient to provide mesoscale analysis in the ALADIN model, the so called lagged-NMC method was developed (Široká et al., 2001). The lagged-NMC method is very similar to the original one (standard-NMC) described above with the modification that the lateral boundary conditions are exactly the same for the two forecasts taking part in the computation of the departures. The background error statistics computed using the lagged method put indeed the emphasis on the mesoscale features in the analysis through an error variance maxima shifted towards small scales and through sharper spatial structure functions.

Recently an extensive study of lagged background error statistics was performed in Budapest at the Hungarian Meteorological Service, exploring the sensitivity of the statistics to the forecast range. It means that not only 36h-12h, but all possible combination of forecast differences were created and accumulated as a base of the statistics. While the model is integrated until 48 hours the forecast range can vary between 6 and 48 hours and the time gap between the subtracted forecasts from 6 to 42 hours. The main goal of this study was to choose the optimal statistics for the 3D-VAR scheme used in ALADIN and also to obtain some information about the predictability properties of the model. Many investigations were made in order to digest the various impacts on the statistics while playing with the forecast ranges taking part in the NMC differences. The most important remarks can be summarized as follows: increasing the forecast ranges but keeping a constant time gap, both the total error variance reduction and the shift of the error variance maxima towards smaller scales is enlarging (illustrated on fig.2). Both phenomena are due to the rising number of common lateral boundary conditions that results an increasing loss of information in the context of forecast differences. While an overshot error variance reduction leads to unsatisfactory spatial structure functions, one has to be careful when choosing the optimal background statistics. A compromise must be done to have the most shifted variance maxima still keeping a necessary amount of the total error variance. In order to make an optimal choice of the total variance reduction, 3D-VAR single observation experiments were run with the full set of statistics. Surprisingly, the experiments produced very weak analysis increments compared to the standard-NMC statistics, even using those lagged-statistics with highest error variances. On fig.1 one can compare the impact of the lagged method in case of ALADIN/HU and ALADIN/LACE[2] models (which is the driving model of ALADIN/HU). We would like to point on the reduction of the absolute values of analysis increments due to the lagged method, which is around 6 times stronger in case of the Hungarian domain. This new result is thought to be the consequence of the double nesting which is in fact done in the case of ALADIN/HU model. Namely, it is supposed that the small

[1] A version of the ALADIN model covering the Carpathian basin with $1600km * 1152km$ domain size and $\delta x = 8km$ resolution.

[2] A version of the ALADIN model covering Central-Europe with $2922km*2630km$ domain size and $\delta x = 12.2km$ resolution.

difference in the resolution and geometry of ALADIN/HU and its driving model ALADIN/LACE allows a strong influence even on smaller scales of the previous through the lateral boundary conditions coming from the latter. This strong influence was recently supported by a parallel verification of the two model versions leading to very similar scores. In the context of lagged-NMC forecast differences it means a loss of information not only on larger, but on small scales as well, resulting in a reduction even on the small-scale part of the error variance spectra. This small-scale variance reduction, appearing also on fig.2, was not found in the case of ALADIN/LACE model (Široká et al., 2001) probably because of more emphasized differences between its resolution and the resolution of its driving model, ARPEGE[3].

Plans for the future are to obtain more information on the applicability of lagged-NMC statistics in the double nested model and the tuning of a scalar factor in front of the background error cost function, which is a possibility to avoid the unwanted impacts of exaggerated total error variance reduction.

References

[1] Horányi A., Ihász I., Radnóti G., 1996: ARPEGE/ALADIN: A numerical weather prediction model for Central-Europe with the participation of the Hungarian Meteorological Service. *Időjárás*, 100, 277-301

[2] Parrish, D. F. and J. C. Derber, 1992: The National Meteorological Centre's spectral statistical interpolation system. *Mon. Wea. Rev.*, 1747-1763

[3] Široká, M., C. Fischer, V. Cassé and J-F. Geleyn, 2001: The definition of mesoscale selective forecast error covariances for a limited area variational analysis. *Meteor. Atmos. Phys. special issue of the SRNWP Workshop on high-resolution modeling, Offenbach, 25.-27. 10. 1999*, submitted.

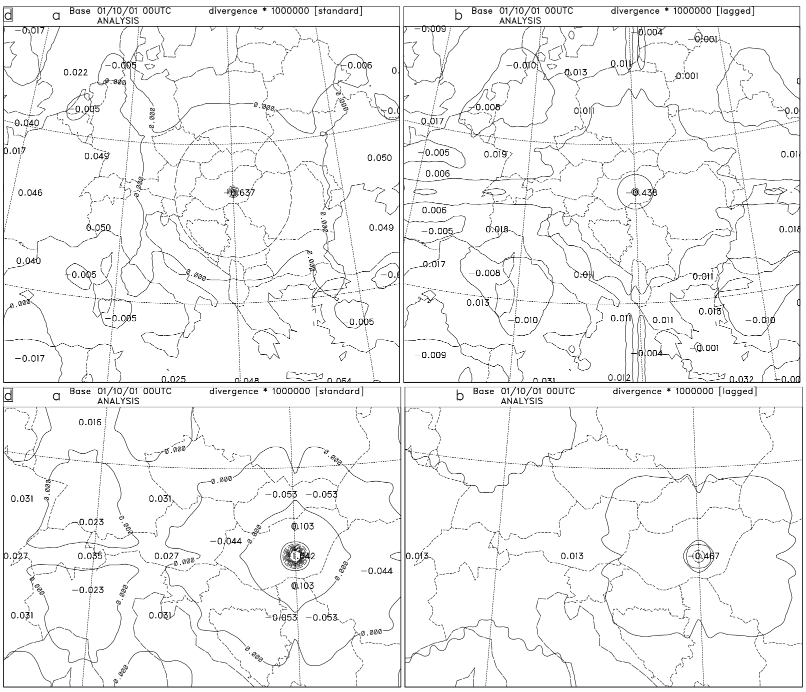

Figure 1: Divergence analysis increment of a single observation experiment ($\delta T = 1°$) on model level 16. Top-left: ALADIN/LACE with standard statistics ($min = -0.637$), top-right: ALADIN/LACE with lagged statistics ($min = -0.438$), bottom-left: ALADIN/HU with standard statistics ($min = -1.642$), bottom-right: ALADIN/HU with lagged statistics ($min = -0.467$).

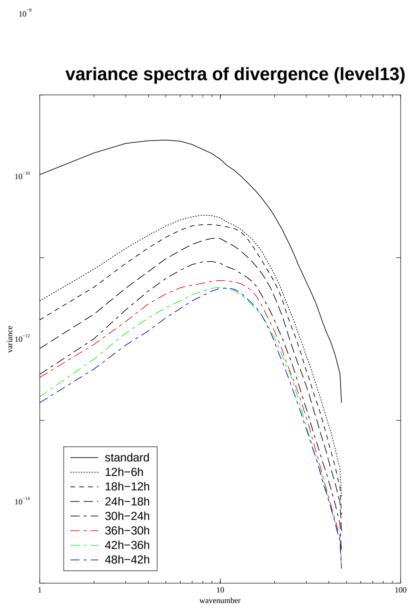

Figure 2: Background error variance spectra of divergence on model level 13. The spectra of lagged-NMC statistics while the time gap is 6 hour in the NMC differences and the spectra of standard statistics as a comparison.

[3] A global model using stretched geometry with an average around $20 km$ resolution over the ALADIN/LACE domain.