Pre-operational testing of a 3D-VAR assimilation in ALADIN-France

C. FISCHER

T. MONTMERLE, L. BERRE

1. Summary

We explain the aim, strategy and first results for the implementation of an operational variational data assimilation system in the ALADIN-France model. Starting from the experiences gathered over the last five years with 3D-VAR in ALADIN as a research configuration, the goal is to settle a continuous, permanent assimilation cycle with an initial update frequency of 6 hours. ARPEGE data plus extra data (Meteosat-8 radiances to start with) are considered. The goal is to obtain at least as good conventional scores over Western Europe as with ARPEGE, plus a beneficial effect on short-range wind, temperature and precipitation forecasts. The retained solution offers such an improvement, with better precipitation "scores" at least up to 12 hours. In 2005, this assimilation cycle will be improved by more frequent updates and additional algorithmic facilities.

2. Initial choices

The core choices are the following, starting from earlier experiences gathered in the four leading ALADIN centres (Budapest, Casablanca, Prague, Toulouse) :

- analysis every 6 hours, in a continuous cycle, to mimic the ARPEGE system,
- lagged Jb formulation with a specific error variance inflation (after the works by M. ŠIROKA, W. SADIKI),
- ARPEGE observations to ensure a maximum of variety and coverage of observations acting as the main constraint in the problem, at our present knowledge (and technical ability),
- accompanying developments : Olive configuration, interaction with the AROME project and the GMME group,
- evaluation using a mixture of conventional COMPAS-type scores (for synoptic and meso-alpha scales) and subjective evaluation on chosen situations for meso-beta and large convective scales.

3. Impact of B matrix and statistical behaviour of the assimilation

The first striking results from a one-month cycle were very bad scores on temperature, bias errors in the stratosphere and at tropopause level. Investigations have shown that this bias is due to a model error, present both in ARPEGE and ALADIN, though we have not been able to pinpoint the actual cause (dynamics or physics for instance). This negative behaviour, in the analysis itself (the analysis being even worse than the initial state of dynamical adaptation), had a detrimental impact on 6 hour forecasts and background scores, throughout most of the troposphere and for all fields. The cure was to change both the B matrix (sampling) and the global tuning of error variances (REDNMC). Thanks to S. Stefanescu's investigations on an ensemble-derived B sampling, we have switched to the ensemble Jb which does have statistical characteristics intermediate between the lagged and standard NMC ones. For instance, correlation length-scales are shorter than in the classical NMC case, which is suitable for keeping mesoscale analysis increments, but larger than in the lagged case, which allows to spread the observation information content into data-poor areas where the background may be of low quality. Additionally, the error variances are significantly inflated (by a factor of 1.8^2). Figure 1 shows the scores for background and analysis, for experiments using the lagged (red) and ensemble (black) Jb formulations, in the space of radiosonde temperature observations. The improvement of the analysis is striking, for the ensemble case.

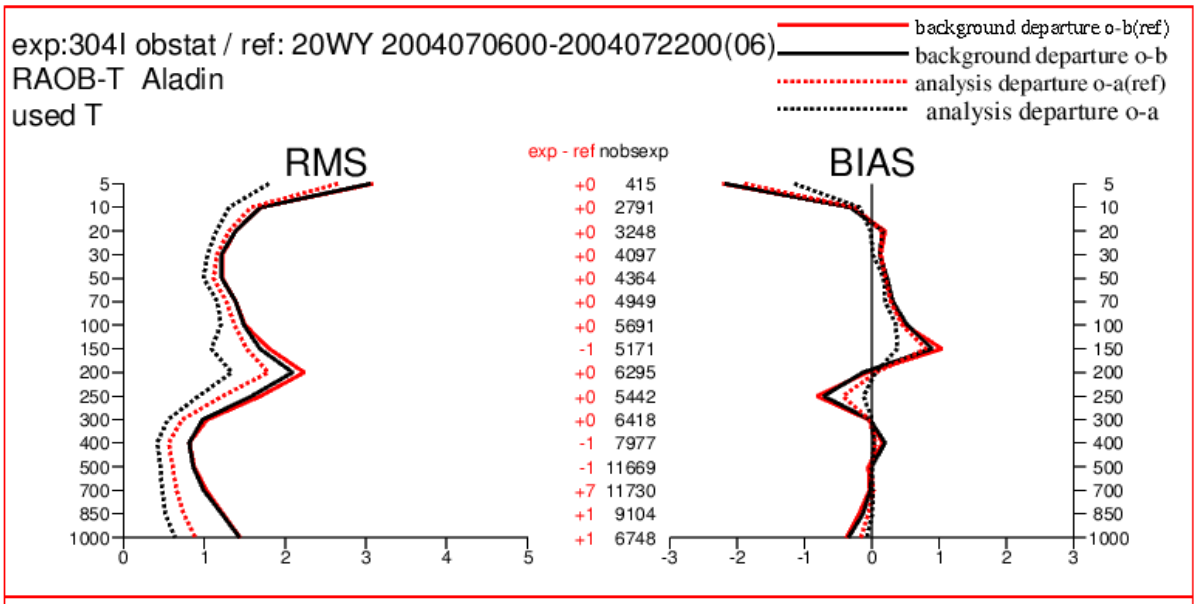

Figure 1: RMS and bias computed for radiosonde temperatures. Lagged Jb (red), Ensemble Jb (black)

4. Case studies

4.1 20/07/04

This is a case with a synoptic-scale front passing over France and Germany at the time of interest. The front exhibits interesting mesoscale features, such as a maximum over the Mosel valley in Germany (unfortunately no rain-gauge coverage is available for this area, Figure 2), small-scale maxima over the Western edges of the Massif Central and the Dordogne area. The operational ALADIN-France dynamical adaptation over-exaggerated the Mosel valley event, and produced a wide shed of rain over South-Western France (Figure 3), where mostly dry conditions were observed. The data assimilation cycles produce more realistic amounts of precipitations over Germany and the Massif Central. With a lagged Jb, the front has a very narrow and strong structure, which is not the case with the ensemble Jb. This latter, wider structure, probably is closer to the truth. The data assimilation cycles generally produce no or little precipitation over South-Western France.

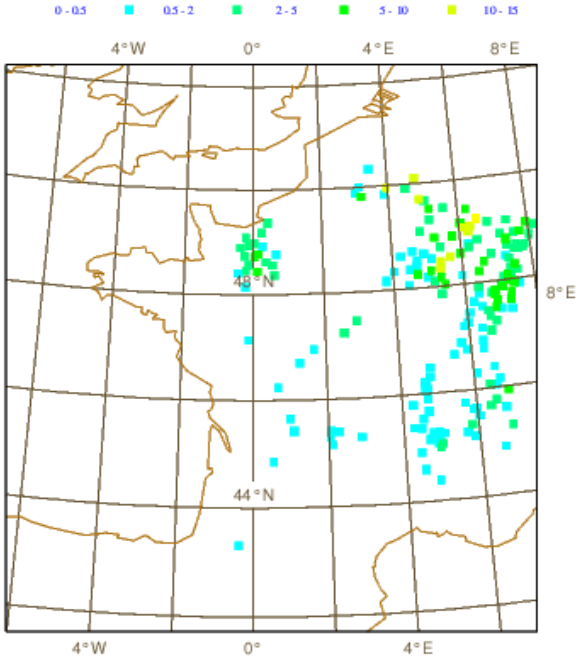

Figure 2 : Rain-gauge measurements

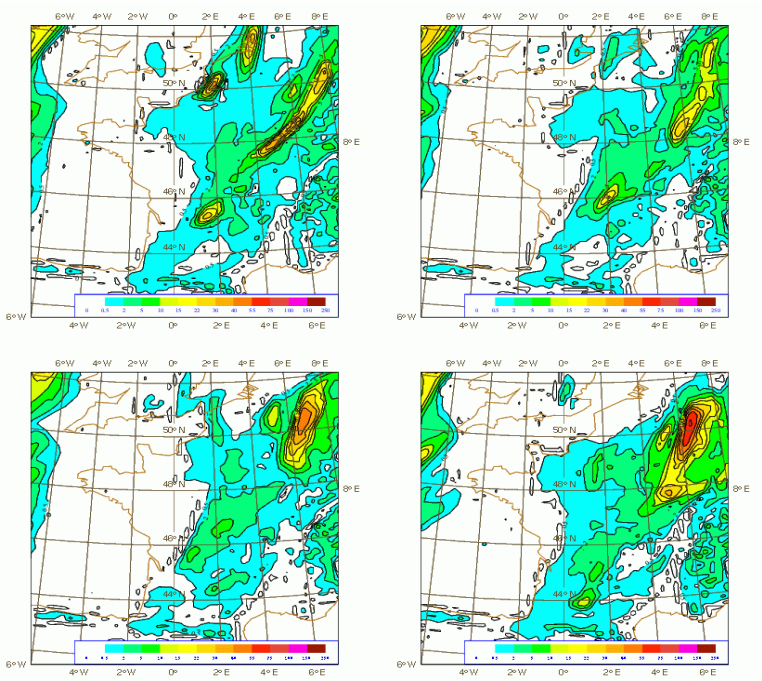

Figure 3: 12h-6h cumulated precipitations. Lagged Jb (top left), ensemble Jb + DFI (top right), ensemble Jb – no DFI (bottom left), dynamical adaptation (bottom right)

4.2 22/07/04

In this case, an upper-air trough is moving northward along the Western French coast. Doing so, it triggers a mixed stratiform and convective activity over Central Western France, with a maximum of precipitations over Vendée and lower Loire valley. In dynamical adaptation, the precipitations are quite small, far below observed values. Taking into account the rather large mesoscale size of the phenomenon and the (hopefully) ended time of dynamics/physics spin-up in the operational version, the result is disappointing for a short-range forecast. In data assimilation mode, the core of the system and its overall geographical spread are visible. At fine scale (~100 km)

however, each solution exhibits its particular structure, with sometimes an exaggerated activity in the Southern part of the system (Charente and Vienne valleys). The amounts of precipitations are fairly well predicted

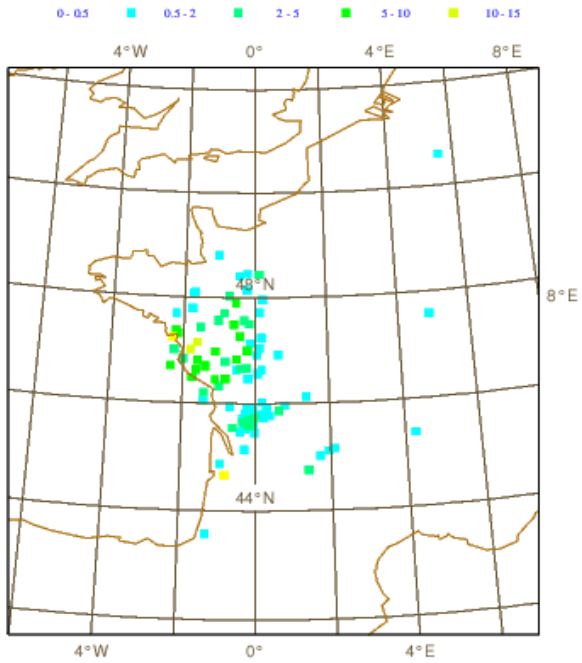

Figure 4 : Rain-gauge measurements

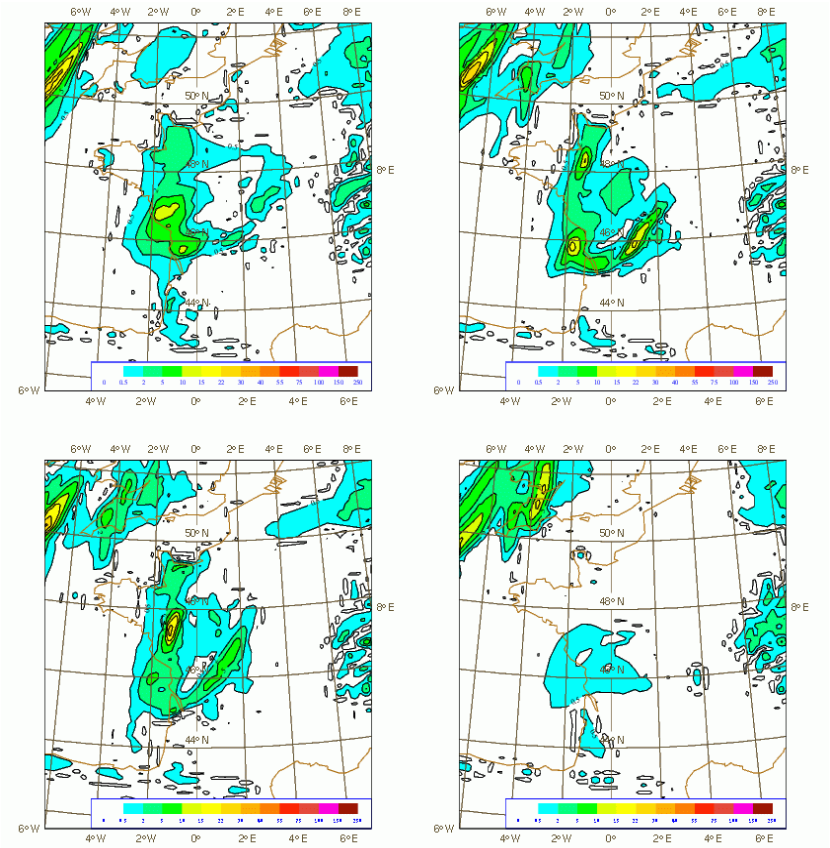

Figure 5: 12h-6h cumulated precipitations. Lagged Jb (top left), ensemble Jb + DFI (top right), ensemble Jb – no DFI (bottom left), dynamical adaptation (bottom right)

5. Conclusions and outlook.

The following general conclusions arose from the test experiments, performed over two periods of respectively one month (03/06/03 through 02/07/03) and two weeks (06/07/04 through 22/07/04) :

- Conventional scores match those of ARPEGE 4D-VAR over Western Europe. There is an impact on large scale scores ("output statistics") when the B matrix is changed ("input statistics").
- The 3D-VAR data assimilation cycle has a beneficial impact on almost all fields in the analysis. After between 6 and 12 hours, statistical scores go back to those of dynamical adaptation. After 12 hours of integration, the improvement of the initial state is lost in a statistical sense, using conventional observational networks as a reference.
- Precipitations are improved qualitatively and quantitatively for forecast lead-times between +3 and +12 hours. Before (0-3 h), spin-up/spin-down processes are probably active and more investigation would be necessary. For the time being, we have decided to maintain non-incremental digital filter initialization in both the assimilation cycle and in "production" forecasts. We have however decreased the strength of the filter, in a manner similar to DF blending, following the Prague experience.
- Not shown specifically here, the inclusion of the Meteosat-8 radiances generally further improves the precipitation features, especially when activity was under-estimated. A slight positive bias (over-estimation) of wide, weak precipitations remains as the major shortcoming of these data. We refer to Thibaut Montmerle's contribution in the same Newsletter and associated technical reports for more details.
- An E-suite is planned for about February 2005, based on CY29T1. Meteosat-8 radiances will be included.

6. Bibliography

Montmerle, T.: Use of geostationnary SEVIRI radiances in ALADIN 3DVAR, *ALADIN Newsletter 27*, 2005

Sadiki, W. and Fischer, C.: A posteriori validation applied to the 3D-VAR ARPEGE and ALADIN data assimilation systems, *Tellus*, **57A**, pp. 21-34, 2005

Široka, M., Fischer, C., Cassé, V., Brozkova, R. and Geleyn, J.-F.: The definition of mesoscale selective forecast error covariances for a limited area variational analysis, *Meteor. Atmos. Ph.*, **82**, pp. 227-244, 2003

Stefanescu, S.E., Berre, L. and Belo Pereira, M.: An ensemble estimation of error statistics for a limited area model analysis. Part I: The evolution of dispersion spectra and the evaluation of model differences, 2005, in preparation

Berre, L., Stefanescu, S.E. and Belo Pereira, M.: An ensemble estimation of error statistics for a limited area model analysis. Part II: A formal and experimental comparison with two other error simulation methods, 2005, in preparation

CONTENTS