# Operational implementation of ALADIN 3DVAR at the Hungarian Meteorological Service

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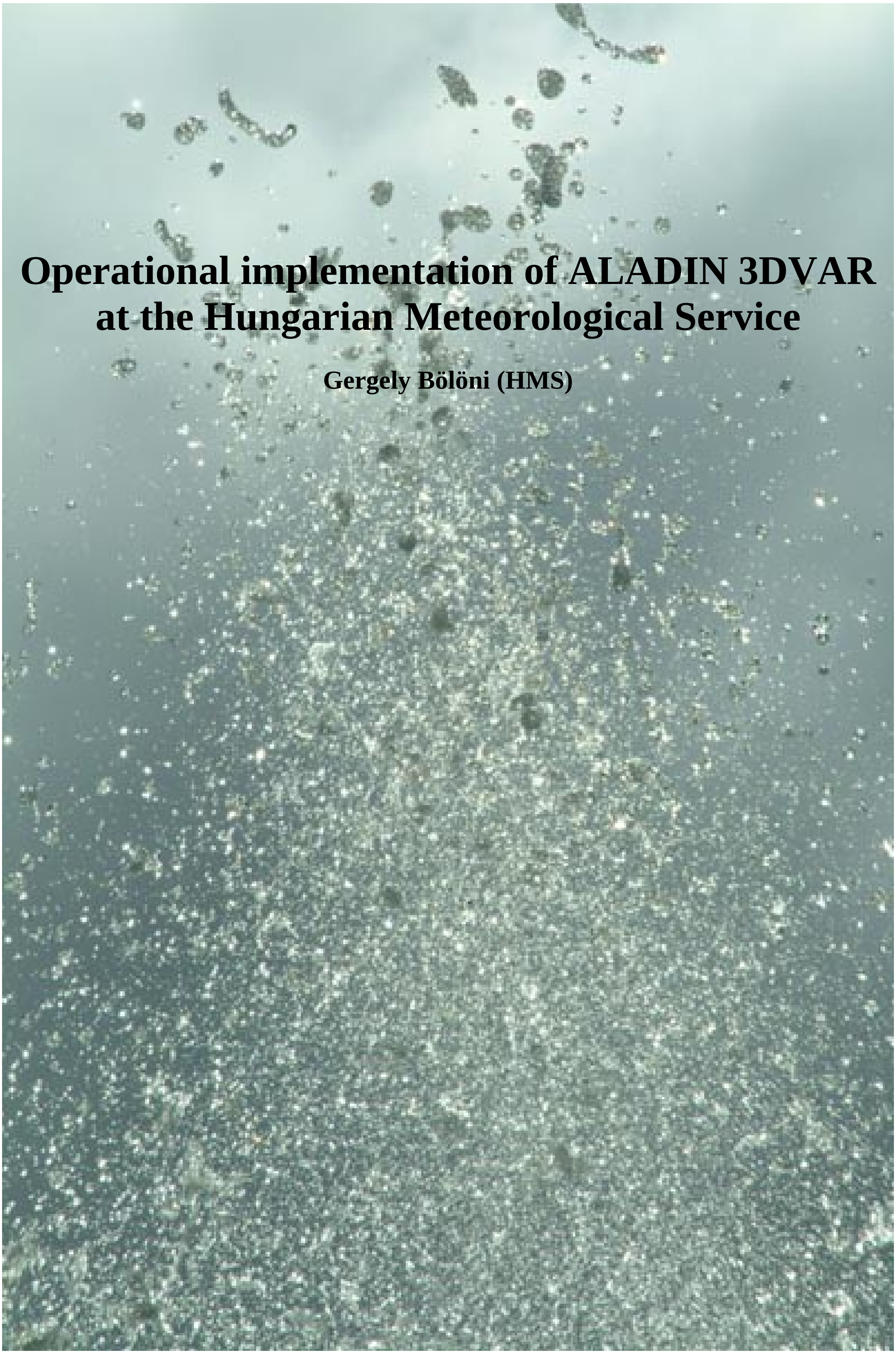

## 1. Introduction

ALADIN 3DVAR was first implemented at the Hungarian Meteorological Service (HMS) in June 2000 based on the cycle AL13. The first real time experimental assimilation cycle was then, set up during the summer 2001 on the former operational machine (SGI Origin 2000) of the service. That time the system was using only SYNOP and TEMP data over a small domain covering Hungary. As a next step the 3DVAR assimilation cycle was run as a quasi-operational application over the former ALADIN/LACE domain from November 2002 on an IBM p699 machine. At the same time, experimentations started in order to use satellite (ATOVS/AMSU-A) and aircraft (AMDAR) data. Since the end of May 2005, ALADIN 3DVAR is used operationally at HMS. This paper describes the operational assimilation system set up recently, and summarizes its results based on different verification methods and some case studies.

## 2. Main characteristics

The presently used operational domain (the same for assimilation and production) uses linear grid, 8km horizontal resolution and 49 vertical levels. The domain covers roughly the same area as the former LACE domain. The assimilation cycle is run with a 6 hour frequency which means 4 « long cut-off » analyses per day (00, 06, 12, 18 UTC) using all the actually available data and 2 « short cut-off » analyses at 00 and 12 UTC in addition to provide initial conditions for the 48 h production runs (figure1).

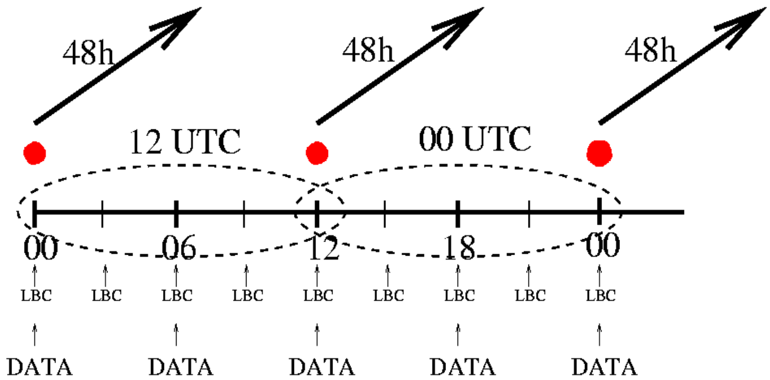


Figure 1 : The assimilation cycle

In every assimilation step, the surface (soil) analysis is taken from ARPEGE, more exactly the surface (soil) fields of the background are overwritten with those of the actual ARPEGE analysis interpolated on the ALADIN grid. The upper air fields are provided by the 3DVAR analysis. The presently used background error covariance matrix is computed following the standard NMC method. The background is a 6 hour forecast of the model which starts from the DFI initialized local analysis. During the integration a 3 hour coupling frequency is used. Namely, at 00, 06, 12, and 18 UTC the ARPEGE « long cut-off » analyses, at 03, 09, 15, and 21 UTC the 3 hour ARPEGE forecasts starting from the corresponding « long-cut off » ARPEGE analyses are used as coupling fields.

## 3. Observational data

The system presently uses surface, radiosonde, satellite and aircraft observations. The table below summarises all the observed parameters by observation type used in the system.

| | |
|---|---|
| SYNOP surface reports | surface pressure |
| TEMP upper air reports | temperature, wind, geopotential, specific humidity |
| ATOVS satellite observations | AMSU-A radiances |
| AMDAR aircraft reports | temperature, wind |

Table 1 : The observational data entering the assimilation system

It is important to mention, that all the observation types above are used in the ARPEGE 4DVAR assimilation system as well. However, the local assimilation system benefits from some useful additional observational input coming from local SYNOP reports (not disseminated through GTS), and due to weaker thinning of satellite (80 km for AMSU-A) and aircraft (25 km for AMDAR) data. Another remark which might be interesting is that a new procedure has been developed for the preprocessing of the AMDAR data, allowing a global quality control on the whole aircraft database in one go (the original screening of the data was done flight by flight) in order to avoid problems while using the aircraft data in a non-continuous way in time (3DVAR and not 4DVAR).

## 4. Validation & Results

The validation of the assimilation system is done by plotting objective scores (observation minus model BIAS & RMSE) and performing a subjective verification procedure. The subjective verification consists of an everyday briefing comparing the different model versions (i.e. dynamical adaptation and the data assimilation system) performance for the actual situation. Finally, a note (a number from 1 to 5) is given to each model version by the members of the verification team that includes forecasters and modellers as well. According to the objective scores the impact of local data assimilation compared to dynamical adaptation can be summarized as follows (some selected figures are shown for illustration from the period 22.03.2005 – 05.04.2005):

- improvement on temperature and wind on all vertical levels (figure 2)
- improvement on geopotential on high levels (figure 3)
- small negative impact for mean-sea-level pressure (negative BIAS) (figure 3)
- mixed impact on humidity depending on forecast range (figure 4)
- negative impact on high-level humidity

The conclusions drawn according to the subjective verification, i.e. the daily comparison of the forecasted weather parameters, are listed below. For illustration the scores are plotted for a half-year period on figure 5.

- improvement in the 2m temperature forecast (0 – 24 h)
- improvement in the precipitation forecast (0 – 48 h)
- degradation (0 – 24 h) / neutral impact (24 – 48 h) in cloudiness
- neutral impact on wind

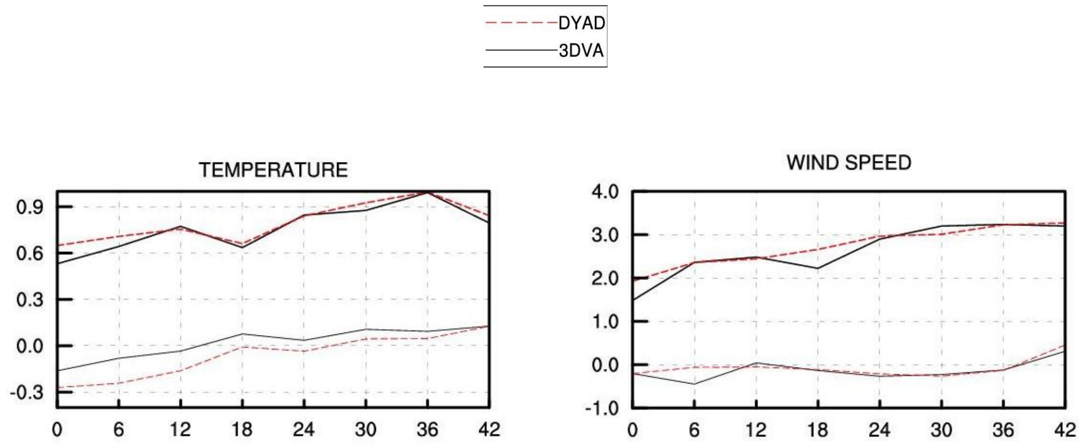


Figure 2 : RMSE and BIAS of the temperature and wind forecasts on 500 hPa

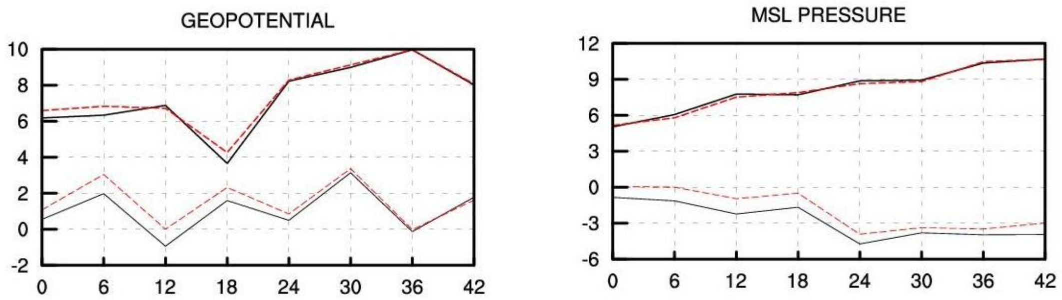


Figure 3 : RMSE and BIAS of geopotential on 700 hPa (left) and mean sea level pressure (right)

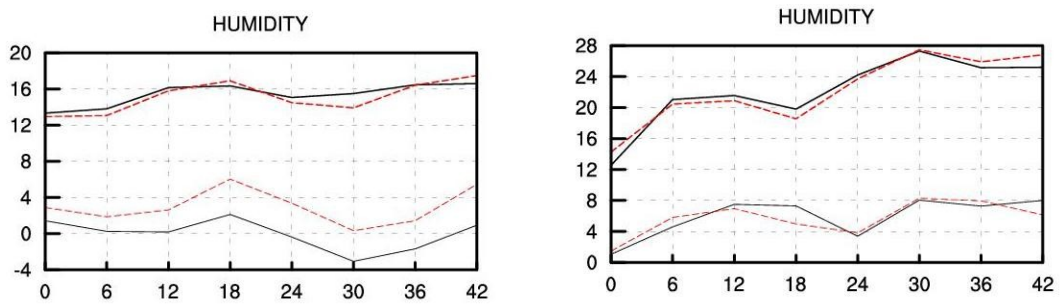


Figure 4 : RMSE and BIAS of humidity on the surface (left) and on 500 hPa (right)

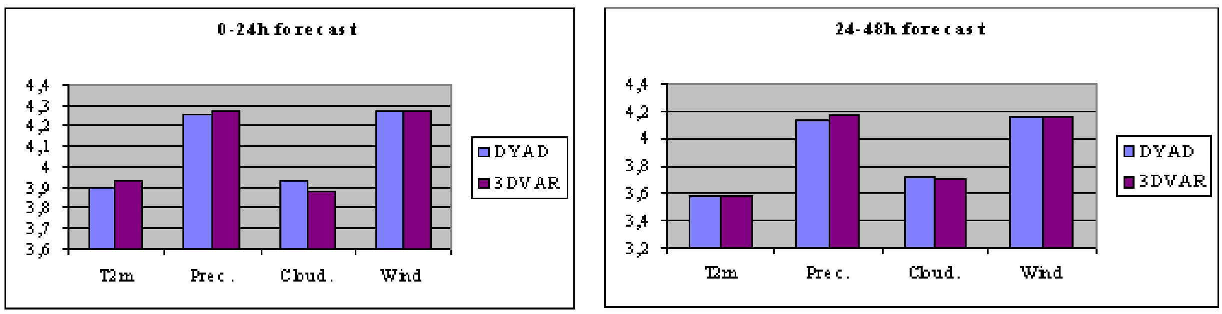


Figure 5 : Subjective scores of the dynamical adaptation (DYAD) and the assimilation system (3DVAR) for the first (left) and the second (right) day of the forecast (period: 01.07.2004 – 31.12.2004)

To close the presentation of the performance we show a case study. On the 18th of May 2005 a fast moving cold front was passing over Hungary, which was linked to a Mediterranean cyclone. It induced thunderstorms, strong wind gusts (> 100 km/h) and heavy precipitation (~ 45 mm/ 24 h) in several places over the country.

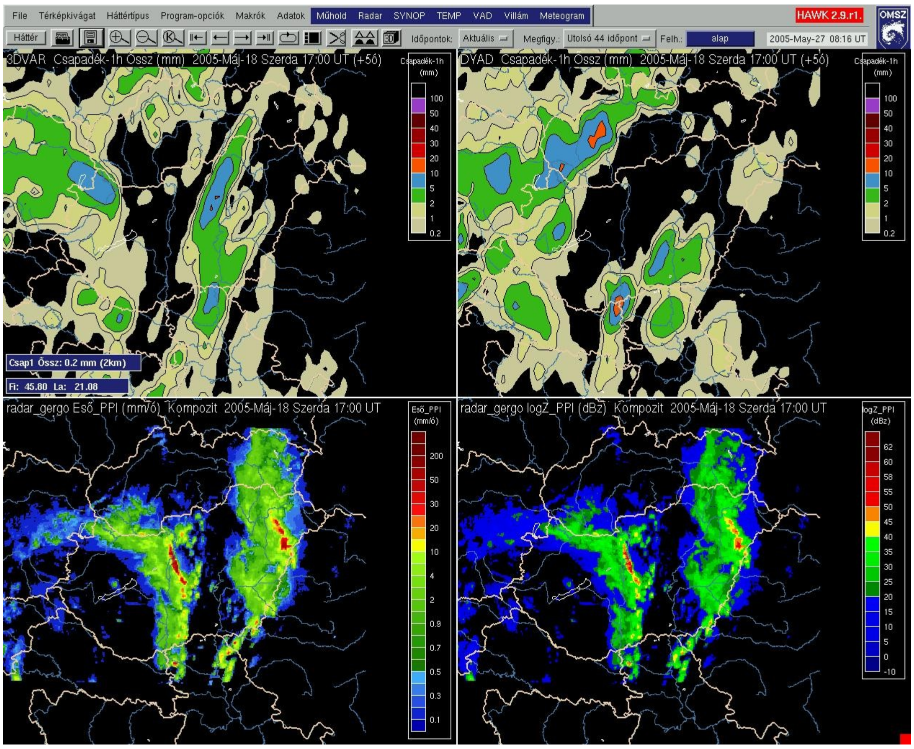


Figure 6 : Forecasted (top left: 3DVAR, top right: dynamical adaptation) precipitations (+5h) and observed reflectivities (bottom left: precipitable water, bottom right: logZ)

Considering the precipitation forecast, the 3DVAR assimilation system performed much better than the dynamical adaptation as we illustrate on figure 6. There we show the radar reflectivities at an important moment of the event and the corresponding precipitation forecasts. On the figure we try to illustrate, that the structure of the precipitation patterns were better predicted by the assimilation, catching both band of precipitations being present in reality, during the whole integration up to +18 h, when system left Hungary and decayed. The comparison of observed and forecasted 6 h cumulated precipitations also indicated a better performance of the assimilation system (not shown).

## 5. <u>Monitoring of the system</u>

In order to be able to follow the operation of the system a web interface has been developed which makes it possible to follow the different steps of the assimilation procedure and model forecast as well as the used observational data base. We put the emphasis on the presentation of the latter as it was a necessary development connected specially to data assimilation. The observation monitoring system is based on the ODB mandalay viewer, which provides ascii dump of the ODB data base, then space and time statistics are computed on the ascii data (obs – guess, obs – analysis, observation quality flags) in order to represent the quality and availability of the data. Some examples are shown below.

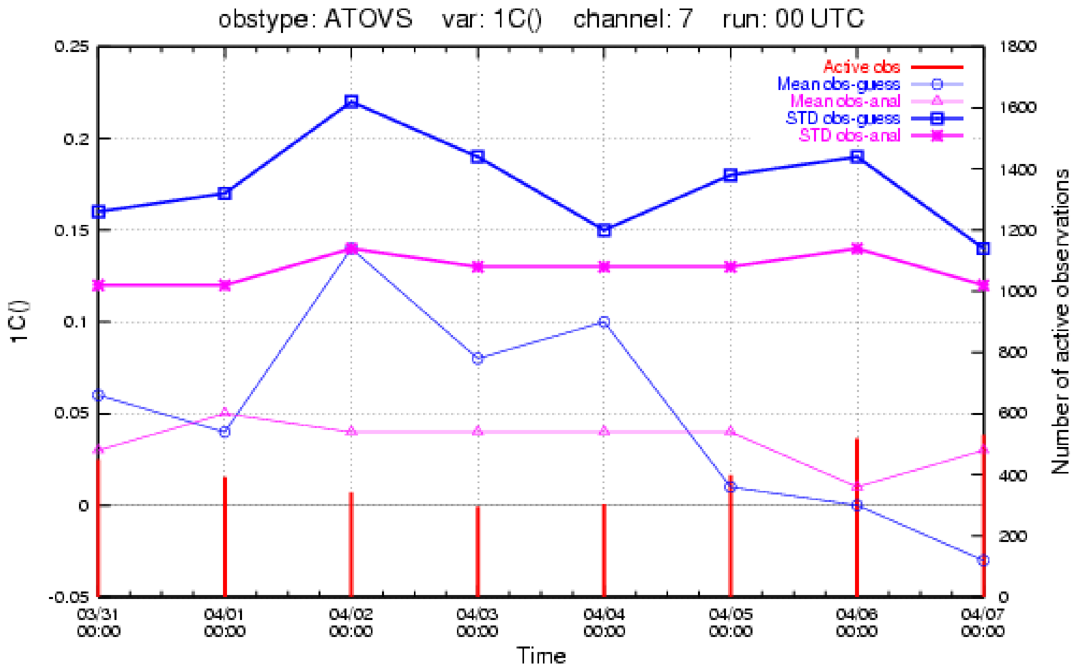


Figure 7 : Time evolution of the different properties (mean and standard deviation of obs – guess and obs - analysis, number of active observations) of the ATOVS/AMSU-A data (channel 7)

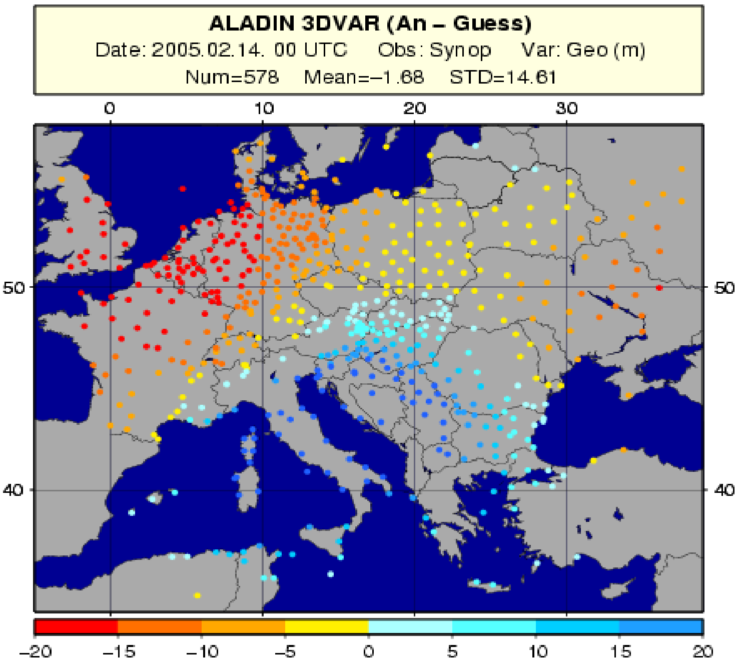


Figure 8: Horizontal map of the mean-sea-level pressure analysis – guess differences at the location of SYNOP observations, which shows the increments caused by the used observations (in the north-west the guess was corrected by the observation of a low-pressure system, in the south-east the guess was corrected by the observation of a high pressure system)

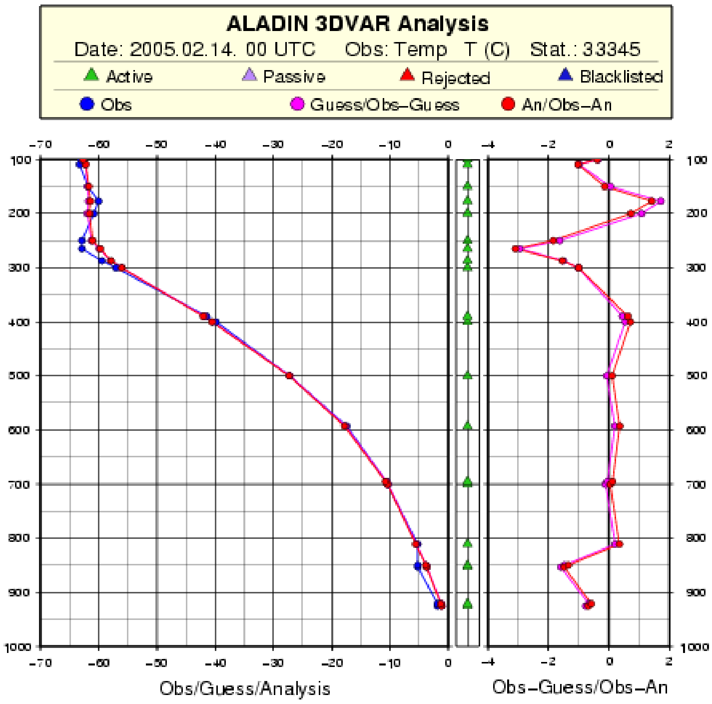


Figure 9 : Profiles of different quantities (obs, guess, analysis, obs-guess, obs-analysis) for a given analysis at the location of a radiosonde observation. The status of the observations is also indicated.

## 6. Conclusions and Outlook

According to the experiences at HMS, the local ALADIN assimilation can be beneficial in the everyday forecasting especially concerning the precipitation events and the 2m temperature, in the short range up to 24 hours. However, there is no common improvement for all variables and even some degradation for some variables (high level humidity analysis and forecast, mean sea level BIAS) was noticed in the objective scores compared to the dynamical adaptation, for the concerned periods. This will probably motivate the HMS team for trying to improve the system. We are looking forward to continue to include other new types of observations in the assimilation in the near future (ATOVS/AMSU-B, MSG wind, wind profilers) and to recompute the background error covariance matrix using the "Ensemble method". For longer term even further observation types are considered to be included (SEVIRI radiances, T2m and RH2m from SYNOPs), and the testing and possible application of the so-called $J_k$ term or "variational blending" is also foreseen as well as experimentations with 3D FGAT.

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