Recent Data Assimilation activities in Hungary
(RC LACE report compiled for the Data Assimilation Working Days 2012)

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1. Short description of DA systems

At OMSZ two LAM DA systems are run. The one feeding the ALARO forecasts model (dx=8km, 49 levels) is run operationally and the one feeding the AROME forecast model (2.5km, 60 levels) is in an experimental phase being tested with additional observations (i.e. radar reflectivity and wind) compared to the ALARO DA system. The main characteristics of the two DA systems are as follows:

- Methods: 3DVAR for the atmospheric levels and OI for the surface/soil (CANARI for ALARO and OI MAIN for AROME)
- Cycling: 6 hour frequency for ALARO and 3 hour frequency for AROME
- Bmatrix: We are using the usual statistical balance relationships developed by ECMWF and Meteo-France. For the sampling of simulated errors we are using the Ensemble technique. More precisely:
  - i) for ALARO we used 3 month downscaling of 6h forecasts from the AEARP Ensemble Data Assimilation (EDA) system (2 members)
  - ii) for AROME we used 1 month downscaling of an ALADIN/HU EDA system (5 members)
- Observational data usage: for ALARO we are using synops, synop-ships, radiosonds, AMDARs, MSG AMV winds, NOAA (16 and 18) ATOVS radiance (AMSU-A, AMSU-B), MSG SEVIRI radiances. For AROME we are testing conventional (synops, synop-ships, radiosonds, AMDARs, MSG AMV) and radar data (both reflectivity and radial wind). All the above data (except radar) are used from the OPLACE system.
- Bias correction: the Variational Bias Correction is applied for all the radiance data. For other observations we do not apply any bias correction method.
- Methods for impact studies: most commonly we are using Observing System Experiments (OSE) to measure the impact of certain observations. The sensitivity of the analysis system to the observations is assessed through the observation monitoring statistics, which are regularly computed as well as through the computation of the DFS (Degrees of Freedom for Signal) attributed to each assimilated observation. Concerning the sensitivity of the forecast system to the assimilated observations, a scheme (MTEN – Moist Total Energy Norm) based on the computation of the moist total energy loss attributed to the withdrawn observations from the analysis system is now being implemented.
- Verification: the methods used to evaluate OSEs are point verification against observations (Veral) and SAL (Structure Amplitude Location) verifications for precipitation.

2. AROME data assimilation experiments

Recently our main focus is building up an AROME data assimilation system. To do this, the following main developments were done:

- Test AROME with OI MAIN in SURFEX: our strategy is to test and implement the OI MAIN surface assimilation independently from 3DVAR. If the performance of AROME with OI MAIN is superior to the AROME dynamical adaptation then an AROME OI MAIN assimilation cycle will be implemented operationally firs. Several AROME OI MAIN experiments have been run. Results show that the OI MAIN can improve short range forecasts in dry regimes, when usually the surface/soil of the driving model (ALARO) is too wet causing cold and wet biases at 2m. Scores from a dry regime are plotted in Fig 1. for the AROME operational forecasts and those initialized by OI MAIN.

- Computation of a B matrix for the AROME/HU domain: due to a bug in the computation of forecast differences (related to the fact that AROME FA files contain specific humidity in grid-point space) the B matrix for the AROME/HU domain had to be recomputed (downscaling of a 5 member ALADIN/HU EDA system). After the elimination of the bug, the noisy features of the B matrix have also been removed.
- Build an assimilation cycle script system for 3 hourly analyses including the cycling of hydrometeors.
- Diagnosis of the spin-up in short range forecasts: the spin-up noise in short-range forecasts have been diagnosed through Ps tendency plots. I was found that the spin-up in AROME forecasts is reduced in general in case of running a local 3DVAR analysis compared to dynamical adaptation (due to the interpolation noise from 8km ALARO to 2.5km), which is demonstrated in Fig. 2 (left). Another important point is that in case of a time-consistent coupling (the 0th coupling file is the interpolated field of the driving model) there is a significant noise generated in the coupling zone, which then travels through the whole domain depending on the advection. This can be cured by using space-consistent coupling (the 0th coupling file is the local analysis of AROME itself), which is demonstrated in Fig. 2. (right).

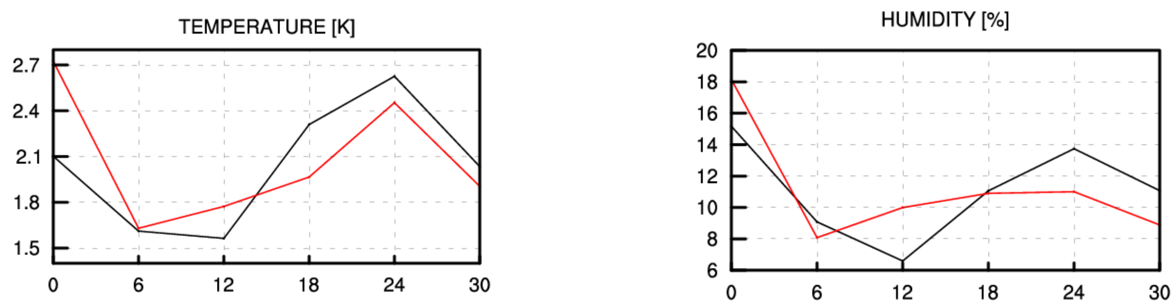

Fig.1: 2m temperature and relative humidity RMW scores for the AROME operational (red) and AROME OI MAIN (black) forecasts (Period: 01-31.08.2011 where the first 15 days are discarded from the verification to let OI MAIN to warm up).

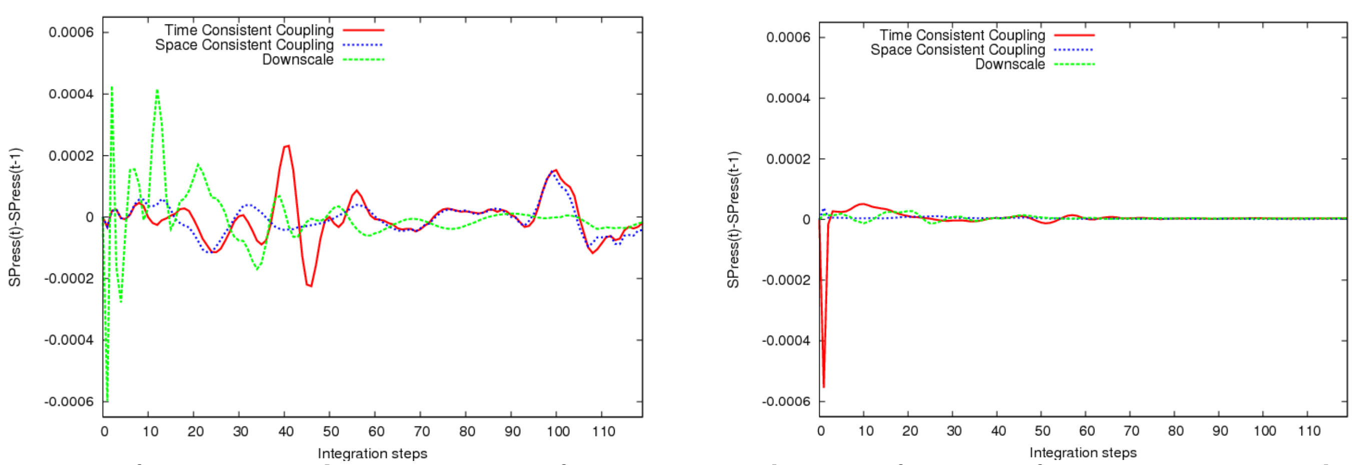

Fig.2: Surface pressure tendency as a measure of spin-up noise in short range forecasts. Left: mountainous point, Right: point close to the domain border. Blue: 3DVAR with space-consistent coupling, Red: 3DVAR with space consistent coupling, Green: dynamical adaptation

- Run impact studies with 3DVAR using conventional data: first results showed slight improvements in temperature and humidity at 2m but a significant degradation in 10m wind speed as well. These results were obtained still by using the B matrix used in the operational AROME/France, which is conceptually wrong (even if that works technically). These experiments will thus be repeated using the AROME/HU B matrix.
- Test radar data assimilation: a key element of high-resolution DA in AROME is to feed it by high-resolution radar (radial wind and reflectivity) data. In the past half year ODB generation has been checked using 3 Hungarian radars as well as screening statistics. Recently analysis increments induced by reflectivity are being checked on a case by case basis. The selected case (Fig. 3) shows a cold front entering Hungary. The analysis with radar observations (reflectivity and radial wind together) “speeded up” the front by moistening the lower troposphere ahead and drying behind the front. The analysis increments are rather close to the radar sites and are spread in space realistically. More detailed evaluation and other case studies are planned to explore the capability of radar assimilation to improve (especially precipitation) forecasts.

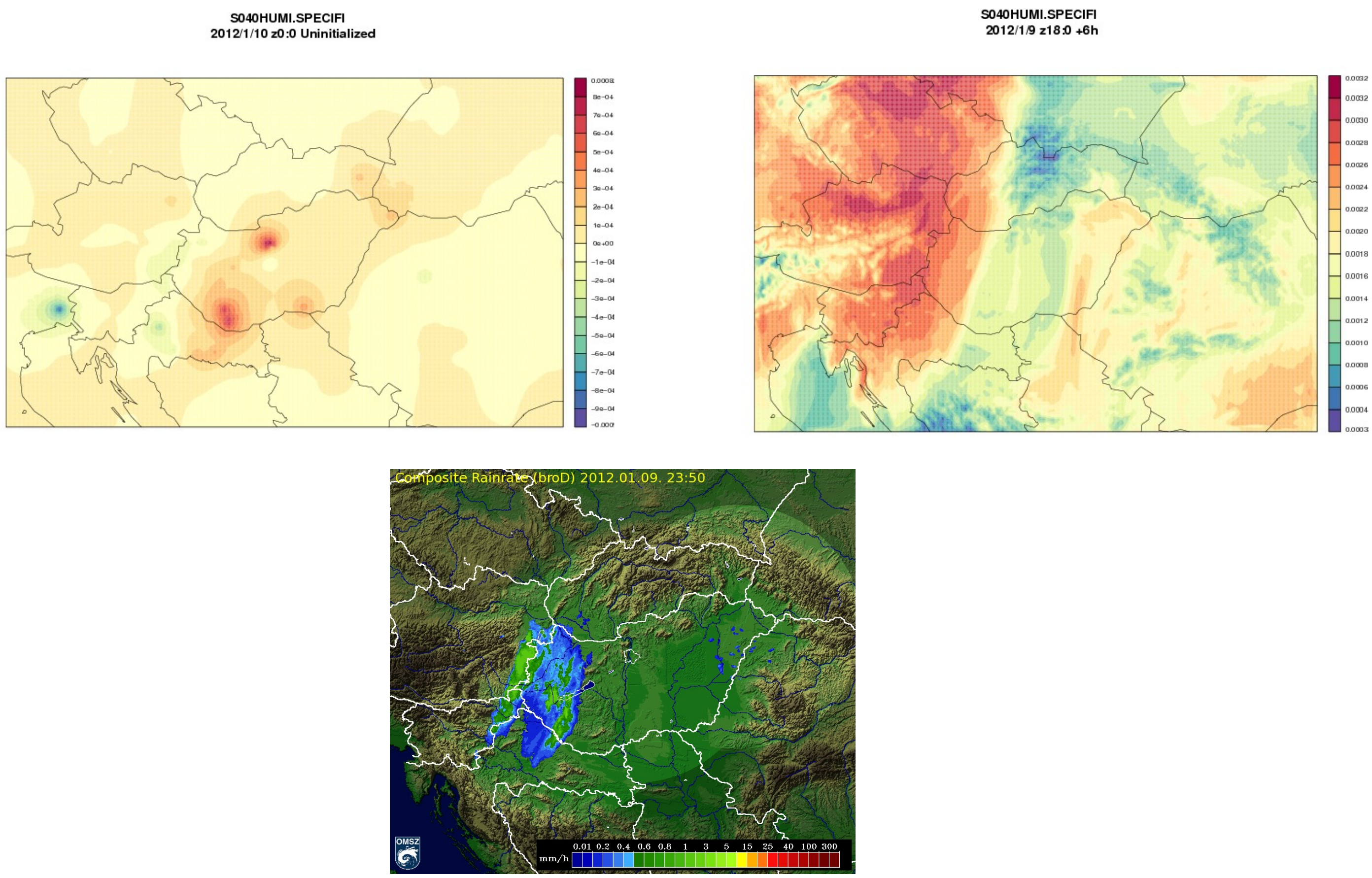

Fig.3: Case study assimilating radar reflectivity in AROME. Top Right: first guess specific humidity field at model level 40 (~2000m), Top Left: specific humidity analysis increment at model level 40 (2000m), Bottom: radar composite

3. Impact studies

The most important impact studies have been done in the ALADIN/HU (predecessor of ALARO) DA system

- ATOVS radiance blacklisting: it was found that the earlier blacklisting of AMSU-A,B and MHS channels was too restrictive (it was based on obs-guess statistics). The blacklisting has been released letting only middle-tropospheric peaking channels (AMSU-A channels 8-10, AMSU-B channels 3-4) enter the analysis, which improved analyses and forecasts in a small extent as expected in the middle troposphere. We have also learned from this experiments that the lower peaking channels (channels 5-7 for AMSU-A and channel 5 for AMSU-B) are also important.
- High resolution AMV assimilation: AMV data from MSG have been assimilated via local preprocessing applying SAF NWC tools (instead of taking data from EUMETCast). This allowed to use the data in somewhat higher resolution but not significantly. It has been shown that AMV data have very different contribution to the analysis impact depending on the data availability (Fig. 4). A positive impact of locally processed AMV data was found, which is demonstrated in Fig. 5. The case studies showed that the AMV data received through EUMETCast have different impact at different assimilation time, which suspect that the use of the retrievals based on the visible channels are efficient. This last statement needs further investigation.

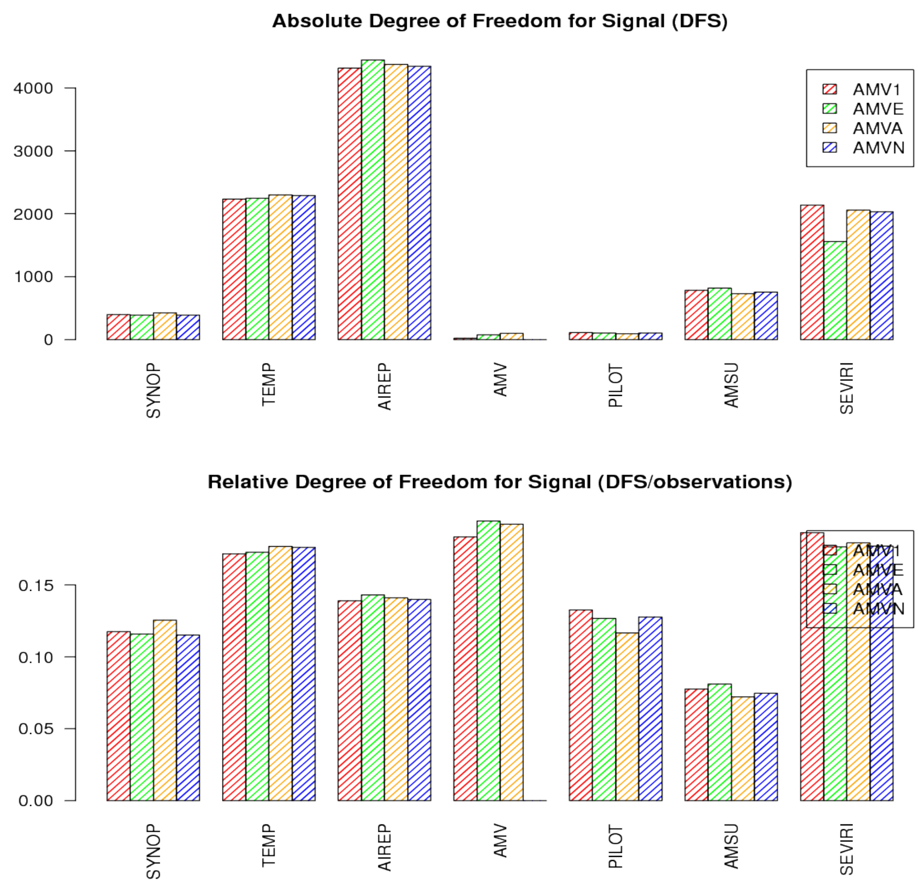

Fig.4: DFS statistics showing contributions to the analysis impact. Top: all analysis times used during the test period. Bottom: only those analysis times used where the availability of AMV data was high.

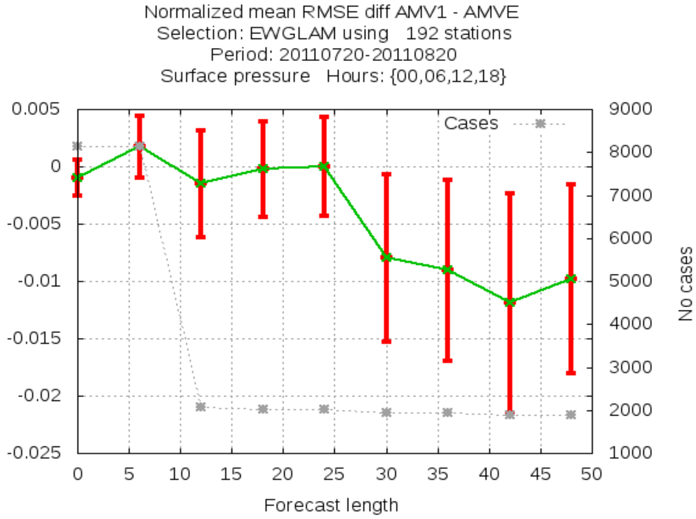

Fig.5: Impact of locally processed AMV data compared to the control (all observations except AMVdata used) in terms of RMSE differences. Negative values demonstrate positive impact.

- IASI impact studies: a new channel selection is being proposed and tested. Findings are to be collected and conclusions to be drawn in the near future.
- Radar impact studies: after being able to inject Hungarian radar data to ODB the validation of radar assimilation (screening and minimization) has been at stake. Based on a few case studies, the 3DVAR minimization implies realistic increments due to radar observations (humidity and temperature profiles derived by the 1D Bayesian method). See Fig. 3 as an example.

4. Future plans

- AROME assimilation: operational implementation of AROME OI MAIN and 3DVAR with 3 hourly update frequency and using observations in a higher resolution (less strict thinning) than in ALARO.
- B matrix: use the ALADIN EDA native B matrix in the operational ALARO DA system; run a few months of AROME EDA to generate sample for an improved AROME B matrix. For the 8km DA system the ALADIN EDA native error sampling brings benefit in forecast scores on the test periods evaluated so far (Fig. 6)
- Minimization: test the CONGRAD technique for AROME, whether a faster convergence can be obtained (in terms of CPU)
- Observations: implementation of more ATOVS (from NOAA and METOP) IASI, GPS and AMV in high resolution. In AROME implement radar (reflectivity and wind) assimilation.
- EPS and DA: implement an EDA component for the ALARO LAMEPS system, the control member being the deterministic ALARO model with data assimilation.

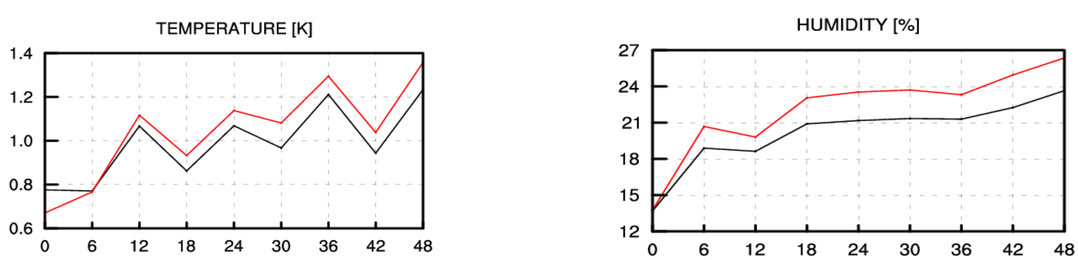

Fig.6:Temperature and relative humidity RMSE forecast scores for 2 experiments. Red: 3DVAR using the presently operational B matrix (sampled from downscaled AEARP), Black: experimental B matrix sampled from ALADIN EDA native forecast differences

5. Topics raised on the last Working Days (June 2011)

We have been progressing in the following topics:

- Testing the OI MAIN surface analysis in SURFEX: for our AROME model we have been testing OI MAIN intensively. See the conclusions above in the report (section 3)
- Sort out E-GVAP data policy for LACE: presently only Croatia and Hungary are members of the E-GVAP programme, which means that they can have a free access to all E-GVAP data. We have been in contact with the E-GVAP programme manager (PM) to sort out whether other LACE countries can access (and if yes how) the E-GVAP data through OPLACE? Presently we are waiting for the answer of the E-GVAP PM.

We did not find time to progress in the following subjects:

- Investigate the lack of soil moisture increments in CANARI (SURFRESERV.EAU) depending on FA packing options.
- Test the decoupling of Pb (vorticity balanced geopotential) and temperature in the background error balances to see whether Ps/geopotential analysis increments harm temperature analysis increments through the balances.
- Try to reproduce negative specific humidity in AROME analysis fields
- Investigate whether GPS can be read directly from BUFR in BATOR and how the bias correction is applied.
- Inclusion of LandSAF albedo to OPLACE