Limited area modelling activities at the Hungarian Meteorological Service (HMS)

LACE
nwp central europe

ALADIN Numerical Weather Prediction Project

OMSZ Hungarian Meteorological Service

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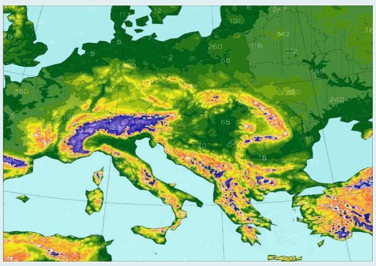
Operational configuration

Main features of the operational ALADIN/HU model

- Model version: AL33T1
- Initial conditions: local analysis (atmospheric: 3dVar, surface: OI)
- Four production runs a day: 00 UTC (54h); 06 UTC (48h); 12 UTC (48h); 18 UTC (36h)
- Lateral Boundary conditions from the ECMWF/IFS global model

Model geometry

- 8 km horizontal resolution (349*309 points)
- 49 vertical model levels
- Linear spectral truncation
- Lambert projection



The ALADIN/HU model domain and orography

Assimilation settings

- 6 hour assimilation cycle
- Short cut-off analysis for the production runs
- Ensemble background error covariances
- Digital filter initialisation
- LBC coupling at every 3 hours

Forecast settings

- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

Observation usage

- SYNOP (geopotential, T, RH)
- SHIP (geopotential, u, v)
- TEMP (T, u, v, q)
- ATOVS/AMSU-A (radiances from NOAA 15, 16, 17, 18) with 80 km thinning distance
- ATOVS/AMSU-B (radiances from NOAA 16, 17 and 18) with 80 km thinning distance
- SEVIRI radainces (water vapor channels from MSG-2)
- AMDAR (T, u, v) with 25 km thinning distance and 3 hour time-window, together with a special filter (that allows only one profile in one thinning-box)
- AMV (GEOWIND) data (u, v)
- Wind Profiler data (u, v)
- Web-based observation monitoring system

Operational suite / technical aspects

- Transfer ECMWF/IFS LBC files from ECMWF via RMDCN, ARPEGE LBC files (as backup) from Météo France (Toulouse) via Internet and ECMWF re-routing.
- Model integration on 32 processors
- 3D-VAR and Canari/OI on 32 processors
- Post-processing
- Continuous monitoring supported by a web based system

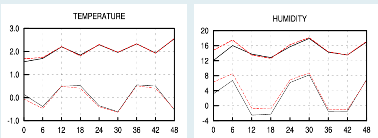
The computer system

- SGI Altix 3700
- CPU: 200 processors from which 92 are for NWP (1,5 Ghz)
- 304 Gbyte internal memory
- IBM TotalStorage 3584 Tape Library (capacity: ~ 30 Tbyte)
- PBSpro job scheduler

Data Assimilation

Use of observations

- New data: Since June 2009 SEVIRI radiances from MSG-2 and SYNOP temperature and relative humidity observations were added to the operational data assimilation system. The experimental use of these observations has a long history at the Hungarian Meteorological Service with an intensive participation of other ALADIN colleagues from the Czech Republic and Turkey. The operational setup contains only the water vapor channels of SEVIRI. The new 2m data from SYNOP stations are used both during the day and night (unlike in the Météo France setup for instance). The impact of these observations is shown on the figures on the right over a 16 day period in May 2009. Also a map of the used SYNOP stations is displayed on the right, showing the analysis increments for relative humidity.
- The observation preprocessing system for LACE (OPLACE) has been used to feed the operational data assimilation suite since July 2009. OPLACE is a centralized observation preprocessing system distributing input data for assimilation purposes among LACE member services in a proper format.



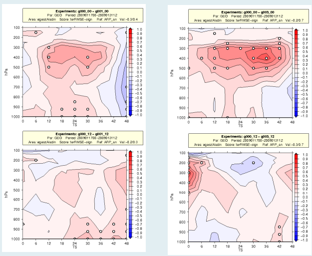
RMSE and BIAS scores of 2 day forecasts with (black solid) and without (red dashed) the new observational sets (SEVIRI + SYNOP temperature and humidity) Period: 07.05 – 23.05 2009

Cycle frequency and FGAT (First Guess at Appropriate Time)

Tests were carried out with the Hungarian ALADIN 3DVAR assimilation system by increasing the cycle frequency from 6 to 3 hours and by applying the FGAT option. All these tests aim to make use of the available observations as much as possible (e.g. a 3DVAR analysis with 6 hour cycling uses about 15-50% of the available observations only). Experiments with the following setups were run over a 15 days period (January 2009):

- 6h cycling with FGAT
- 3h cycling
- 3h cycling with FGAT

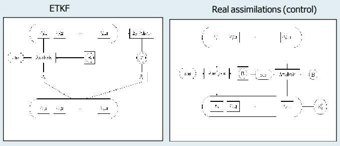
These experiments were compared to the reference run (6h cycling without FGAT), which is our present operational setup. The main conclusions from these tests are that 3h cycling (which roughly doubles the active data in the data assimilation cycle) improves significantly the analysis and the forecasts for all the variables compared to the 6h cycling. This improvement is more emphasized for the 00 UTC runs. On top of the 3h cycling the FGAT option improves further the scores for 00 UTC and degrades a bit for the 12 UTC. The reason for this latter finding is not discovered yet. The impact of the FGAT option with 6h cycling is very small and in the 12 UTC runs it does not clearly improves for all ranges. Parts of these conclusions are demonstrated in the figures on the right. Verification for precipitation showed some improvements for the 3h cycling for POD (probability of detection) and FAR (false alarm rate) for the 00 UTC but not for the 12 UTC runs.

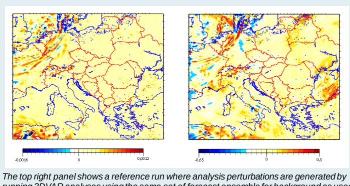


Vertical cross-sections of RMSE differences with significance tests. The positive impact of „3h cycling" (left) and „3h cycling + FGAT" (right) for 00 (top) and 12 UTC (bottom) are shown with redish colors. Blue colors stand for a negative impact.

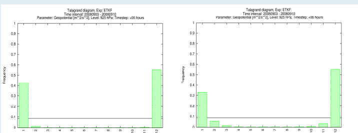
ETKF (Ensemble Transform Kalman Filter)

- The primary objective of the application of the ETKF method at the Hungarian Meteorological Service is to compute flow-dependent background errors for the operational ALADIN 3D-VAR data assimilation system. Hence the implementation was embedded into the operational version of the ALADIN model in Hungary. Yet, we were concentrating on the preliminary testing of the ETKF algorithm and performed the first, basic validations of the system. The results of these first validations are presented on the right. The top-left panel shows the schematics for generating ETKF analysis perturbations where x_f stands for forecasts and x_a for analyses, T is the transform matrix projecting the Z_f forecast perturbations into the Z_a analysis perturbations.
- The structure of the perturbation fileds is rather similar in the north-west, where they are linked to a cold front, however some differences are visible over the Black-Sea. Also the amplitude of the perturbations is about 100 times smaller for ETKF than for the control. According to these results we consider that the ETKF perturbations are correctly generated (link to real meteorological features) but are too small, which implies that an inflation is needed to increase them.
- An inflation method was then implemented and our latest tests consisted of diagnosing its impact in a 7 day cycling experiment (keeping still the background errors constant in time). The spread of the background errors was diagnosed with the help of Talagrand diagrams and these diagnostics clearly indicated that the spread of the analysis and forecast ensembles were insufficient in spite of the fact that the inflation improved the characteristics of the forecast ensemble in a very slight extent (see the figures on the right).
- It was also proven that the perturbed lateral boundary conditions further improved the spread of the ensemble, however it was still far from being optimal (not shown).
- It has to be kept in mind that the primary goal for the ensemble generation is to provide a sample of forecast errors for the computation of a time-dependent B matrix at every assimilation step. This implies that a background ensemble is required with a variable spread depending on the quality and reliability of the actual background forecast. In other words, when the background forecast is good (bad) the ETKF ensemble must have a small (large) spread implying small (large) error variances and covariances in the B matrix. In this sense the Talagrand diagram might not be the best diagnostic for our purpose but we should look into spread-skill relationship in the future, which normally compares the root mean square error (RMSE) of the ensemble mean with the ensemble spread.





The top right panel shows a reference run where analysis perturbations are generated by running 3DVAR analyses using the same set of forecast ensemble for background as used in the ETKF for initial forecast ensemble (these forecast ensembles were taken from the downscaling of the French global EPS, the PEARP system). The figures in the bottom show a chosen perturbation from the ETKF (left) and from the control (right) experiments.



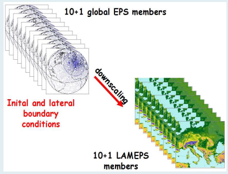
Talagrand diagrams for the 6-hour forecasts started from the ETKF initial perturbations. Left: ETKF perturbations were generated without an inflation. Right: ETKF perturbations were generated with an inflation.

The operational LAMEPS system of the Hungarian Meteorological Service (HMS)

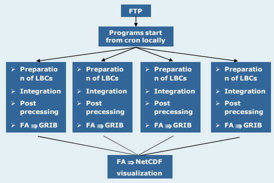
Characteristics of the system

The operational short-range limited area ensemble prediction system of HMS is running on the SGI Altix computer.

- The system is based on the ALADIN limited area model and has 11 members.
- For the time being we perform a simple downscaling, no local perturbations are generated.
- The initial and lateral boundary conditions are provided by the global PEARP ensemble system (LBCs every 6 hours).
- The LAMEPS is running once a day, starting from the 18 UTC analysis, up to 60 hours.
- The horizontal resolution is 12 km, the number of vertical levels is 46 (hybrid coordinates).



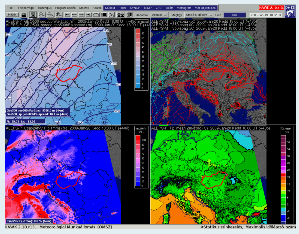
Schematics of the downscaling method: each PEARP member is interpolated to the Hungarian LAM domain and is used as initial and lateral boundary conditions for local forecasts.



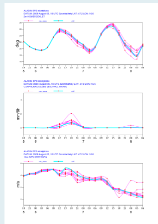
Technical aspects:. Ensemble members are organized into 4 groups, each group running independently from the other groups until the preparation of the NetCDF files, which is done in one go for all members.

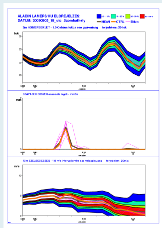
Visualization

The LAMEPS forecasts are available for the forecasters via the HAWK (Hungarian Advanced WorKstation) visualization system developed at HMS. Beside HAWK, the results of the operational LAMEPS system can be seen on meteograms and plume diagrams on th intraweb of HMS.



Visualization of the ensemble forecasts in HAWK. Z500 mean and spread (top left), temperature spaghetti diagrams on 850 hPa (top right), probability map for precipitation > 1mm/6h (bottom left), 2m temperature ensemble mean (bottom right).

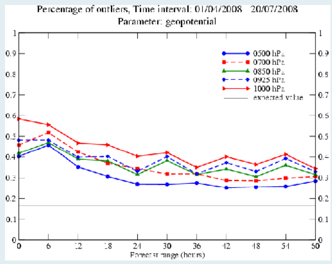


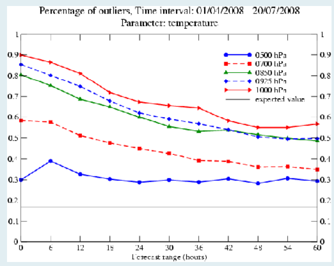


Two different types of plume diagrams for Szombathely based on the LAMEPS forecast started on 05/08/2009. It displays the time evolution of the distribution of 2m temp (top), precipitation (in the middle) and 10m windspeed (bottom).

Verification results

Verification of the operational LAMEPS system was performed for a longer period using the common LACE verification package. In the verification of upper level parameters the dataset is derived form the ECMWF analyses and in the case of surface parameter the data used are collected from observations. Some features of the LAMEPS verification are highlighted in the figures below, where the percentage of outliers diagrams for geopotential and temperature are plotted. Values are shown for different levels: 500, 700, 850, 925 and 1000 hPa. It can be seen clearly, that results are better for higher levels. Best scores were obtained for 500 hPa, but even for this level the spread of the system is not satisfactory, the verifying analysis falls out of the ensemble too often. In order to improve the LAMEPS system further work on the computation of local perturbations is planned. Experiments are ongoing to compute singular vectors with the ALADIN model.





Verification results: percentage of outliers diagram for geopotential (left) and temperature (right) for different levels such as 500, 700, 850, 925 and 1000 hPa. Verification interval: 01/04/2008 - 20/07/2008. The horizontal line (black solid) is the expected value.

Impact of the town surface scheme (TEB) on precipitation

We have studied whether the application of the town scheme in SURFEX has any impact on precipitation and if yes, in what extent.
There is a possibility to run SURFEX without TEB by removing every cover for which $f_{town}>0$ and replace them with rock cover (LRM_TOWN=T). However these covers may also contain nature fraction which have different properties than rocks (e.g. non-zero vegetation). This means that if we use this method also the properties of nature fractions will be changed. Therefore we applied a different method: we have replaced just the f_{town} fraction of the specific cover with f_{nature} and this nature fraction possesses the properties of rock.

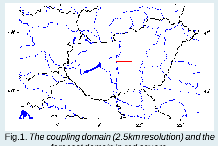


Fig.1. *The coupling domain (2.5km resolution) and the forecast domain in red square.*

We have run AROME model over a small domain around Budapest with 1km horizontal resolution. (The LBCs were taken from an other AROME run on a domain over Hungary, with 2.5km resolution.)
We have studied two cases:

1. Weak and localized convection occured in the afternoon on the 14th of April 2009.
2. Strong, cold front induced convection occured in the morning on the 14th of July 2008.

The results of the first case can be seen in Fig. 2. The first convection cell developed above Budapest at 14:55 UTC. As we can see if TEB was used, the forecast was more successful since it was able to generate the convective precipitation system, which developed above the center of Budapest, while the run without TEB did not get it. In both cases (with and without TEB) a false forecast of a convective storm was given east of Budapest but in the run with TEB the intensity was smaller.
The difference in 1h accumulated precipitation between the 2 forecast runs exceeded 5mm and using TEB the forecast was more successful since it gave more precipitation to the south-west.

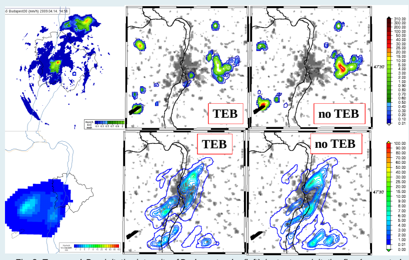


Fig. 2: *Top panel: Precipitation intensity of Budapest radar (left), instant precipitation flux (converted to mm/h) of AROME forecast with TEB (middle), instant prec. flux without TEB. 14/04/2009, 14:55 UTC Bottom panel: 1h accumulated radar picture (left), 1h accumulated precipitation using the TEB scheme (middle), 1h accum. prec. without TEB scheme. 14/04/2009 17 UTC.*

In the second case there was no difference between the two forecasts regarding the precipitation. There can be several explanations for that:

1) The convection occured in the morning when difference in the sensible heat flux is smaller for the two model runs.
2) The effect of the town appears much farther, i.e. outside of the domain.
3) The effect of the town is too weak.

To test which of the above mentioned explanation is correct we have run the same experiment but enlarged the height of buildings and the anthropogenic heat fluxes by a factor of 5 (to simulate a big town with lot of industry and traffic). The 1h accumulated precipitation difference for TEB-noTEB is shown in Fig. 3 for both cases (with original and modified settings). We can see that the difference is still very small (less than 0.5 mm) and appears quite far to north-east of Budapest.

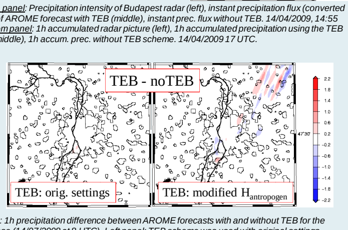


Fig. 3: 1h precipitation difference between AROME forecasts with and without TEB for the 2nd case (14/07/2008 at 8 UTC). Left panel: TEB scheme was used with original settings. Right panel: we run the TEB scheme with enlarged antropogenic heat flux (factor 5) and using higher buildings.