NWP at the Hungarian Meteorological Service

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ALADIN Numerical Weather Prediction Project

OMSZ Hungarian Meteorological Service

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Operational ALADIN configuration

Main features of the operational ALADIN/HU model

- Model version: CY35T1 (ALARO physics)
- 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

Assimilation settings

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

Model geometry

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

Forecast settings

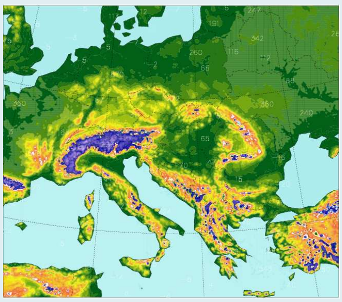
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

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 48 processors
- Post-processing
- Continuous monitoring supported by a web based system

The computer system

- IBM iDATAPLEX Linux cluster
- CPU: 500 Intel Xeon processors (2,6 Ghz)
- 1.5 Tbyte internal memory
- Torque job scheduler



The ALADIN/HU model domain and orography

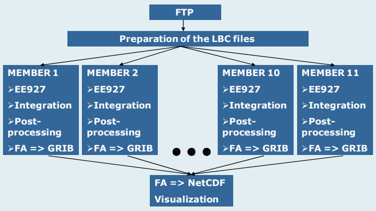
Observation usage

- Maintenance and use of the OPLACE system (Operational Preprocessing for LACE)
- SYNOP (T, Rh, Z)
- SHIP (T, Rh, Z, u, v)
- TEMP (T, u, v, q)
- ATOVS/AMSU-A (radiances from NOAA 16, 18) with 80 km thinning distance
- ATOVS/AMSU-B (radiances from NOAA 16, 17 and 18) with 80 km thinning distance
- METEOSAT-9/SEVIRI radiances (Water Vapor channels only)
- AMDAR (T, u, v) with 25 km thinning distance and 3 hour time-window,
- Variational Bias Correction for radiances
- AMV (GEOWIND) data (u, v)
- Wind Profiler data (u, v)
- Web-based observation monitoring system

Operational ALADIN ensemble system

The main characteristics of the operational short-range limited area ensemble prediction system of HMS is listed below.

- 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 ARPEGE ensemble system (PEARP3.0).
- LBCs are coupled in every 6 hours
- The LAMEPS is running once a day, starting from the 18 UTC analysis, up to 60 hours.
- The horizontal resolution is 8 km, the number of vertical levels is 49 (hybrid coordinates).
- The forecast process starts every day from cron at 23:50 UTC and finishes around 03:00 UTC.



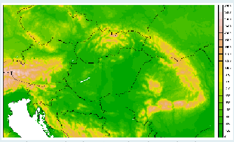
Schematics of the LAMEPS system. After the preparation of the LBC files, the integration and the post-processing are running in parallel for all the members. The preparation of the NetCDF files is done in one go for all members.

Operational AROME configuration

Main features of the AROME/HU model

- Model version: CY35T1
- 2.5 km horizontal resolution (500*320 points)
- 60 vertical model levels
- Four production runs a day: 00 UTC (48h); 06 UTC (36h); 12 UTC (48h); 18 UTC (36h)
- Initial conditions: from ALADIN/HU
- Lateral Boundary conditions from ALADIN/HU with 1h coupling frequency
- To calculate the screen level fields we use the SBL scheme over nature and sea

We are running the AROME model over Hungary on daily basis since November 2009 (since December 2010 operationally). The model performance is evaluated regularly by our NWP group and the forecasters group. Moreover it is compared with other available models (ALADIN, ECMWF).



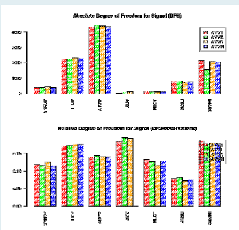
The operational AROME domain used at the Hungarian Meteorological Service.

As a general conclusion, our experience is that the AROME model gives the best temperature and cloudiness forecasts. Based on the SAL verification (not shown here) it also captures the size of the precipitation objects very well. However, it tends to overestimate precipitation maximum and wind gusts in strong convective cells (see also the SLHD tuning on right panel)

ALADIN Data Assimilation Activities

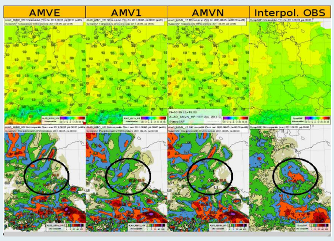
The impact of the AMV data (both the –locally retrieved - HRW and of those received through the EUMETCast and used in the operational analysis system) was assessed trough data-denial experiments for the period between 15th of July till 20th of August 2011, accounting the first four days as warming the data assimilation system. Our aim was to evaluate the impact of the new HRW AMV (exp. AMV1) and to compare with the operational (exp. AMVE where GEOWIND included) assimilation sets.

The impact of the AMV data on the analyses was evaluated through the computation of the Degrees of Freedom for Signals (DFS) of each observation in the system. The results of the DFS computation indicated a high relative importance of AMV data in the ALADIN Hungary limited-area model operational assimilation system (left figure below). The high importance of AMV data is also visible in different case studies, e.g. at 7th of August 2011 when a high precipitation event occured and the HRW AMV observations could improve the capture of the precipitation.



Absolute DFS on the top and Relative on the bottom.

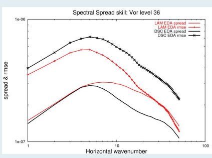
AMV1 – ALADIN with HRW AMV; AMVE – ALADIN with GEOWIND; AMVN – ALADIN without AMV and AMVA ALADIN with HRW and GEOWIND AMV



Case Study at 7th of August 2011.

AMV1 – ALADIN with HRW AMV; AMVE – ALADIN with GEOWIND; AMVN – ALADIN without AMV and Interpolated observations

For the simulation of background errors the Ensemble Data Assimilation technique has been applied in the Hungarian version of the ALADIN model. This consist of running an ensemble (5 members) of LAM assimilation cycles implied by random perturbation of input observations. This error simulation technique was compared with the (presently operational) downscaling of a global EDA system in terms of spectral diagnostics and in terms of assimilation and forecast experiments. The figure on the right shows the spread-skill relationship in spectral space for the LAM EDA (red) and the downscaled EDA (DSC EDA) experiments (black). Note that the RMSE was computed against 3DVAR-VARPACK diagnostic analyses, that is to gridded fields being close to the observations. It is sensible that the LAM EDA experiment improves the spread-skill relationship especially at the small scales (by both reducing the RMSE and increasing the spread).



Using the combination of the LAM EDA error simulation technique and the multi-physics approach the contribution of analysis, LBC and model errors to the full background error have been studied.

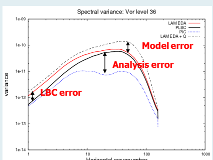
$$\varepsilon_b = \mathbf{M}\varepsilon_a + \varepsilon_M$$

LBC error | Analysis error | Model error

The separation of background error components has been achieved by running LAM EDA:

- assessment of pure LBC errors: „perfect” model and initial conditions (only LBCs are perturbed)
- assessment of pure analysis errors: „perfect” model and LBCs (only the analysis is perturbed)
- assassment of model (physics) errors: using ALARO physics in the control member while perturbed members use „old ALADIN” physics.

Results: model (physics) errors are the most important on the smallest scales, analysis errors have a large contribution over intermediate scales, LBC errors have some contribution at large scales

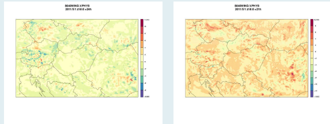


First tests with AROME-EPS

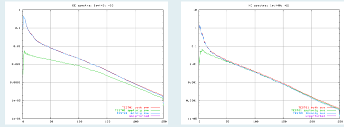
Hungarian Meteorological Service is a participant of an ECMWF special project called ‘Continental winter weather prediction with the AROME ensemble prediction system’ (special thanks to Francois Bouttier and ECMWF). Our long-term goal in this project is to develop a high-resolution EPS which can correctly estimate the uncertainty of the forecasts especially in such weather situations which are frequently problematic for forecasters in Hungary. Low clouds and fog are typically from these weather types in the Carpathian Basin but heavy snowfall and strong wind events are also in the focus of our interest.

The first technical tests aimed to implement a copy of the experimental French AROME-EPS configuration to the Hungarian domain (using identical settings as the Hungarian operational deterministic AROME) and to couple it to ARPEGE EPS (PEARP). LAM version of Stochastically Perturbed Physics Tendencies (SPPT) scheme was introduced to the AROME which was used through the model integration. Three tests were compared in the first sensitivity studies, each of them contained 11 ensemble members. Integrations run for +36 hours:

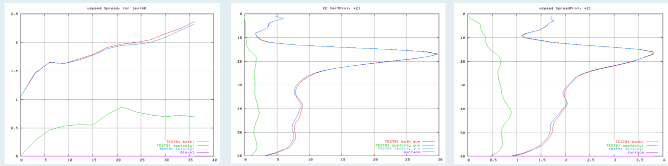
-’lbconly’: Each member was a simple downscaling of a PEARP member. No SPPT was activated.
-’spptonly’: Each member was coupled to the PEARP control member and SPPT was activated to perturb the tendencies.
-’both’: Each member was coupled to a PEARP member and SPPT was also activated.



Wind speed differences between an SPPT-perturbed and a non-perturbed member at +3hours (left side) and at +21hours (right side)



Kinetic energy spectra of the perturbations for the three various test versions at +3hours (left side) and at +21hours (right side)

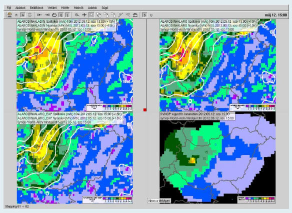


On the left side: The time evolution of the spread of the 40th level wind speed for the three various test EPS. In the middle: The vertical profile of the kinetic energy of the perturbations at +21 hours for the three various EPS. On the right side: The vertical profile of the spread at +21 hours for the three various EPS.

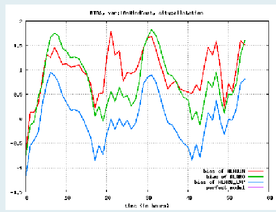
According to the above results, a preliminary statement can be done: the SPPT perturbation shows an ability to increase the spread of the meso-scale EPS system thoroughout the atmosphere, especially on small scales near the surface. After these preliminar results more tests are planned. First goal is it to tune SPPT scheme and find the settings which could produce perturbations representing the model error. Second goal is to find test periods which are related to the above-mentioned winter weather events and examine them with objective scores and case studies.

Wind gust settings in ALARO

ALARO physics was introduced in November, 2011 in LAMEPS and in March, 2012 in the so called deterministic system (both of them runs at 8km resolution). After some months of operational application, forecasters summarized their experiences and underlined the wind gust overestimation as a main problem after the physics upgrade. The overestimation was especially strong in post-frontal situations.
It was decided to manage the problem simply through namelist settings modification. The so called FACRAF variable was decreased from 15 to 12 which moderated the wind gusts by 10-25% (depending on the weather situation).



Strong wind gust values behind a massive cold front on 12th of May 2012. Old ALADIN settings (top left), original ALARO settings with FACRAF=10 (top right), new ALARO settings with FACRAF=12 (bottom left) and observations (bottom right)

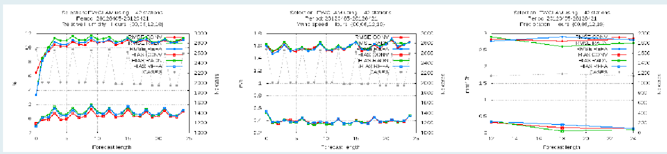


BIAS values based on a one month (June, 2012) verification. Old ALADIN settings (red), original ALARO settings with FACRAF=15 (green), new ALARO settings with FACRAF=12 (blues)

AROME Data Assimilation Activities

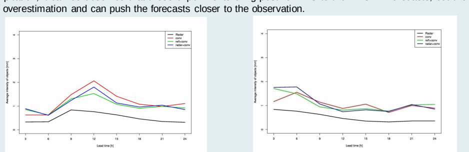
In order to achieve more accurate AROME mesoscale forecasts, a data assimilation (DA) system is developed at HMS to improve initial conditions of the model. We have been investigating different observations inside our system to evaluate the impact on analysis and forecast. One of our main concerns is the DA of RADAR observations (Reflectivity and Radial Wind). A test period of April 2012 was selected when observations of 3 hungarian RADAR stations were available for this DA purposes. For reference an AROME DA using the conventional data (SYNOP,TEMP,AMDAR) has been run providing a reference with respect the DA runs where RADAR data have also been assimilated on the top of the conventional observations.

The assimilation experiments using RADAR reflectivity and full RADAR (Reflectivity and Radial Wind) data were calculated for period 5th of April to 21th of April 2012. For these tests a double nested AROME system were applied (like in our operational AROME dynamical downscaling), where the surface parameters were initialized from the driven ALADIN model and only upper air fields came from the AROME 3DVAR analysis. The results of the experiments were compared with the reference scores (conventional run) using the Harmonie verification package.



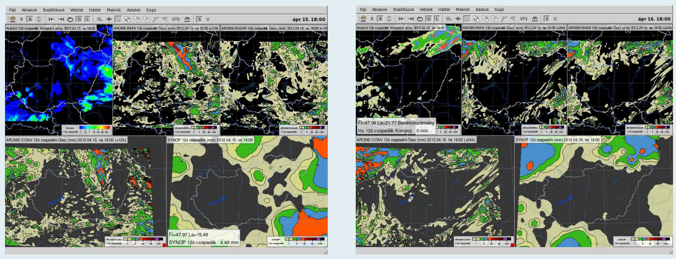
Verification against EWGLAM SYNOP data averaged over the whole model domain for Relative Humidity(left), Wind Speed(middle) and 12h Precipitation(right). Blue lines: AROME/HU+Reflectivity, Red lines: AROME/HU+Conventional. Green lines: AROME/HU+full RADAR, Line with dots: RMSE, Line with boxes: BIAS

The skill of the 3 experiments is quite similar but we can remark some important differences. RADAR data can help to improve the forecast scores at analysis time for relative humidity and temperature(not shown) but imply some degradation against the reference experiment thereafter. In the 10m wind speed a relatively large BIAS can be observed at initial time which has to be investigated. For longer ranges the runs produce similar results. The RMSE and BIAS of the 12h precipitation forecast is a bit better with full RADAR at 18UTC and 24UTC, but the differences are quite small. If we see the diurnal cycle of the average precipitation, it can be observed that these experiments bring postive BIAS to the AROME forecasts, but the assimilation of RADAR data can reduce a bit this overestimation and can push the forecasts closer to the observation.



Diurnal Cycle of the Average Intensity of Precipitation Objects: Left figure at 06 UTC, Right Figure at 12 UTC, Red line: reference AROME, Blue line: AROME with full RADAR, Green line: AROME wirh Reflectivity

Several case studies were also verified to see the performance of the experiments and mainly the precipitation events during the period. To highlight typical cases, a small precipitation event in Hungary at 15th of April 2012(left figure below) and a convective event at 16th of April 2012(right figure below) are shown here. It can be seen in the first case that the precipitation amount was overestimated by the reference and the AROME with reflectivity experiments but better estimated by the AROME with full RADAR. On the other case a convective system touched the northern part of Hungary where the AROME with full RADAR was the best among these runs.



Case studies: Upper left box: RADAR, Upper middle box: AROME with Reflectivity, Upper right box: AROME with full RADAR, Bottom left box: AROME with only conventional and Bottom right box: Interpolated precipitation observation

Left figure: 12h precipitation forecast from 18UTC 15/04/2012, Right figure:24h precipitation forecast from 18UTC 16/04/2012