NWP at the Hungarian Meteorological Service

LACE nwp central europe

ALADIN Numerical Weather Prediction Project

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Operational ALADIN configuration

Main features of the operational ALADIN/HU model

- Model version: CY38T1 (ALARO-1 physics)
- Initial conditions: local analysis (atmospheric: 3dVar, surface: OI)
- Four production runs a day: 00 UTC (60h); 06 UTC (48h); 12 UTC (60h); 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

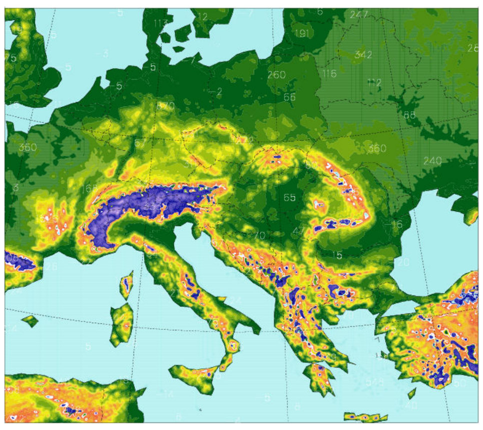
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

Operational suite / technical aspects

- Transfer ECMWF/IFS LBC files from ECMWF via Internet, 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

- IBM iDATAPLEX Linux cluster
- CPU: 500 Intel Xeon processors (2,6 Ghz)
- 1.5 Tbyte internal memory
- IBM FlashSystem 840
- Torque job scheduler



The ALADIN/HU model domain and orography

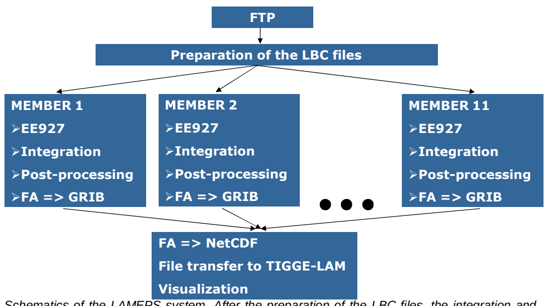
Observation usage

- 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 18) with 80 km thinning distance, passively NOAA 19, Metop A/B
- ATOVS/AMSU-B (radiances from NOAA 17 and 18) with 80 km thinning distance, passively NOAA 19, Metop A/B
- METEOSAT-10/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 integration of the single members is similar than in 'deterministic' ALADIN/HU case (see above): same resolution, same physics, etc.
- The forecast process starts every day from cron at 23:50 UTC and finishes around 02:00 UTC.

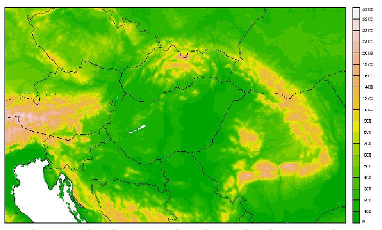


Schematics of the LAMEPS system. After the preparation of the LBC files, the integration and the post-processing are running in parallel for all the members. The preparation of the NetCDF files is done in one go for all members.

Operational AROME configuration

Main features of the AROME/HU model

- Model version: CY38T1
- 2.5 km horizontal resolution (500*320 points)
- 60 vertical model levels
- Eight production runs a day: 00 UTC (48h); 03 UTC (36h); 06 UTC (48h); 09 UTC (36h); 12 UTC (48h); UTC (36h); 18 UTC (48h); 21 UTC (36h)
- Initial conditions: 3DVAR (upper air), interpolated ALADIN surface analysis
- Lateral Boundary conditions from ECMWF/IFS with 1h coupling frequency
- To calculate the screen level fields we use the SBL scheme over nature and sea

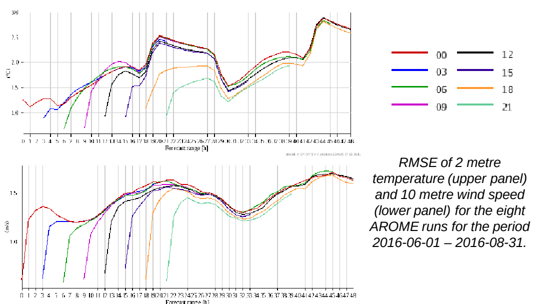


The operational AROME domain used at the Hungarian Meteorological Service.

Eight AROME forecasts runs per day

Since 9th March 2016 AROME at the Hungarian Meteorological Service is run eight times per day, using analyses from the three hourly Rapid Update Cycle (RUC) of AROME. For the time being the runs starting at 03, 09, 15 and 21 UTC are run for +36h only, but this is planned to be extended in future. The main motivation for the introduction of the new forecast runs was that in situations with severe weather events the more frequently updated AROME products could help forecasters in issuing warnings.

Figures on the right show scores of the new AROME runs over Hungary during summer 2016. It can be concluded that the new runs could give a benefit as compared to older runs only in the first 3-4 hours of the forecasts (especially for temperature), after this range the systematic errors of the model dominate. However, it is expected that after the operational introduction of the assimilation of remote sensing instruments (Radar, satellites, GNSS) this time range could be extended.



RMSE of 2 metre temperature (upper panel) and 10 metre wind speed (lower panel) for the eight AROME runs for the period 2016-06-01 – 2016-08-31.

ECMWF ENS-BCs in the LAMEPS of OMSZ

Our current LAMEPS has been described at Operational ALADIN configuration (top left box). It contains 11 members which are the dynamical downscaling of the first 11 members of the 18UTC French ARPEGE-EPS (PEARP). Model integrations run for 60 hours with the available 6-hours coupling frequency. While at the moment there is no local data assimilation and perturbation generation in our ensemble system we have already tested ensemble data assimilation (EDA) method producing initial conditions (ICs) with better quality and describing the initial uncertainties better. The results of such tests underlined that the quality of a data assimilation cycle can be negatively influenced if global information is available only once a day (only 18UTC run) with a relatively rare frequency (6-hours).

In the previous years we have produced several tests with ECMWF's ENS-BCs in our LAMEPS. These tests were motivated mainly by the following reasons:

●Earlier studies showed possible improvement with the change of BC strategy;

●There is a need to stay consistent with our "deterministic" systems which is coupled to ECMWF's HRES model runs;

●Because of the above-mentioned reasons there is a need for more frequent BC production (more runs, more LBCs per run), which can be particularly important in an EDA system.

After the extension of Optional BC project (July, 2015) ENS-BCs became available for us and we reached the possibility to carry out a longer test period:

●Which goes from 11th of December 2015 to 31st of January 2016;

●In this first configuration (similar to out operational configuration) runs start at 18UTC and they are the dynamical downscaling of the ECMWF's ENS members;

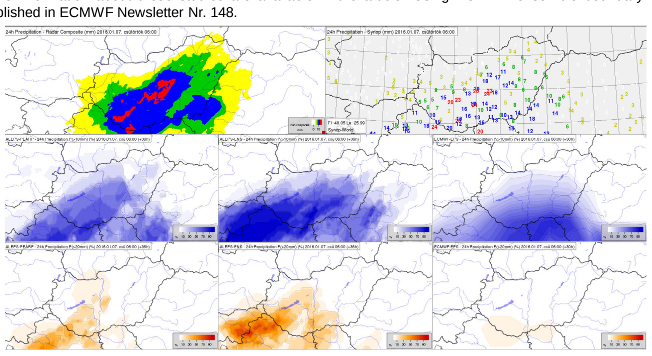
●There is no assimilation in the system. Surface fields have to be changed from ARPEGE runs, but surface perturbations of ENS BCs can be added to them.

LAMEPS results were also compared with the first 11 members of the pure ECMWF ENS forecasts. Scores showed that various LAMEPS configurations were not able to outperform ENS (see figures on the right side). At the same time in case studies it became clear that different LAMEPS versions have an important benefit in predicting extreme weather events (see figures on the bottom).

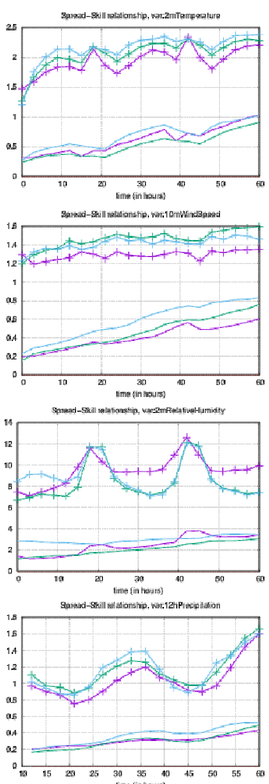
In comparison of two coupling method, generally we can say that the application of ENS BCs improves the quality of the single members and decreases the root mean square error of the ensemble mean. At the same time they slightly decrease the spread of the system as well (see figures on the right side).

Hopefully in the future ENS-BCs can also support our EDA related efforts. For the maintenance of the data assimilation cycle we can use LBCs on the same way than in our "deterministic" system (4 runs per day and 3-hourly coupling frequency).

More information about these studies are available in the article "Using ECMWF ensemble boundary conditions" published in ECMWF Newsletter Nr. 148.



The radar measurement based estimation (top left) and the synop observations (top right) of the 24-hour precipitation at 06UTC on 7 January 2016. Middle row maps show the forecasted probability of reaching the 10mm threshold respectively for PEARP coupled LAMEPS, ENS coupled LAMEPS and 11 members of pure ENS. Bottom row represents the same but for 20mm threshold.

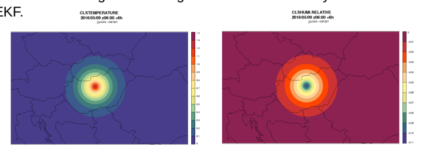


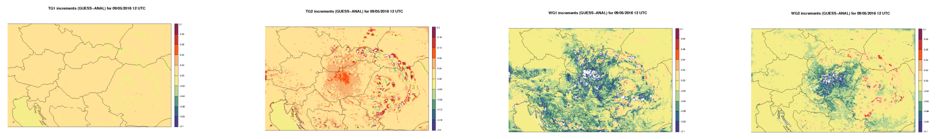
The root mean square error of the ensemble mean (line with crosses) and the the spread of the members around the ensemble mean (solid line) in case of 2meter temperature (top), 10meter wind speed (second top), relative humidity (second bottom) and 12-hour precipitation (bottom). The verified ensemble systems are the ECMWF ENS coupled LAMEPS (green line), the PEARP coupled LAMEPS (blue line) and the first 11-members of ECMWF ENS (purple line).

EKF Surface Assimilation in AROME model

The Extended Kalman-Filter assimilation was installed and tested with AROME/Hungary model. Previously it has been investigated only in experimental frameworks in the ALADIN community, therefore a quasi-operational AROME and SURFEX model environments were built. Validation of the gridded observation procedure (CANARI) and the EKF analysis has been carried out with conventional observations (from T2m and Rh2m) analyzing TG1, TG2 and WG1, WG2. The increments of EKF method were also compared with those of OI_MAIN for making further validation.

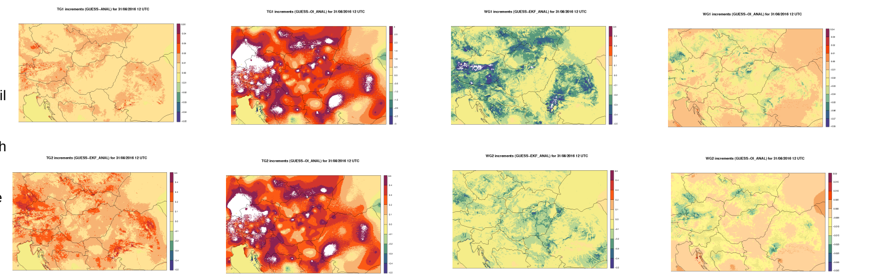
Single observation experiment was carried out with using only sreen-level synop (T2m and Rh2m) from Budapest. The warm and dry soil fields of the guess were changed in the right direction in the analysis created by the EKF.





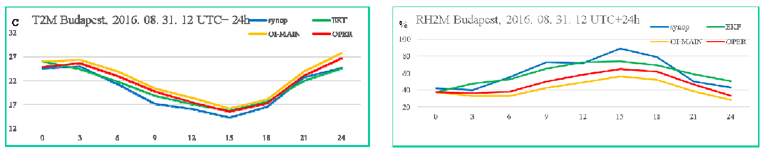
TG1, TG2, WG1 and WG2 increments (GUESS-ANAL)

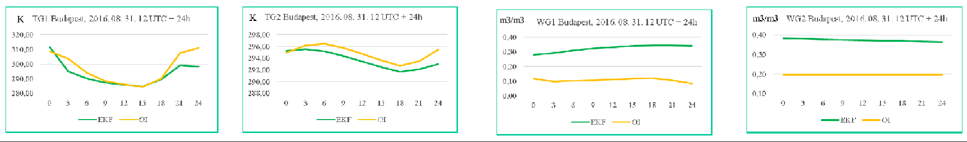
Test with all observations. The soil temperature and soil moisture increments were compared for both methods. OI-MAIN produced warmer and drier soil fields than the EKF.



TG1, TG2, WG1 and WG2 increments (GUESS-ANAL), created by EKF and OI-MAIN respectively

Impact on the forecast (+24h) over Budapest. EKF was able to correct the forecast of the screen-level parameters compared to the operational model, while OI-MAIN produced too warm and dry predictions. The soil moisture forecasts are also very different for the two methods.



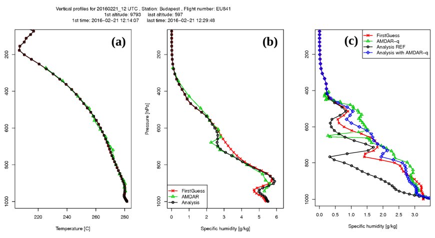


Assimilation of AMDAR humidity

Direct temperature and wind measurements from aircraft are important data in our operational AROME data assimilation system because we use only conventional observations. Recently humidity data are also available in more and more AMDAR reports not only in the USA but also in Europe. These data are especially useful when the aircraft is in descending or ascending phase so it observes vertical characteristics of the troposphere more frequently than radiosondes. The sensor measures mixing ratio of water vapor which can be converted to specific humidity for the assimilation.

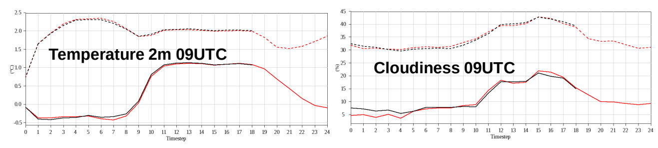
As a first step radiosonde and aircraft humidity data were compared when both observation types were available. Visual check of vertical profiles indicates a good agreement between the two measurements so in the next step only single specific humidity profile from AMDAR report was assimilated. On the vertical profile of the first guess and the analysis it can be seen well that after the assimilation, humidity profile is closer to the observations, but without these measurements this is not the case.

The impacts of AMDAR humidity were studied on a longer time period. A summer period was chosen from 1st to 22th June 2016. 24 hours forecasts from 00, 09 and 12 UTC were prepared with 3-hour data assimilation cycle. Biggest impact can be seen in the 09 UTC run (no radiosondes), especially in cloud cover.

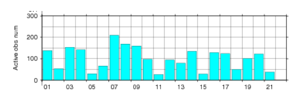


Vertical profiles of a) temperature and b) specific humidity from AMDAR (green) and model background (red) and analysis (black) over Budapest at 12UTC on 21st February 2016.

c) Vertical profiles of specific humidity of AMDAR (green), first guess (red), analysis without AMDAR-q (black) and analysis with AMDAR-q (blue) on 25th March 2016 at 18UTC over Budapest.



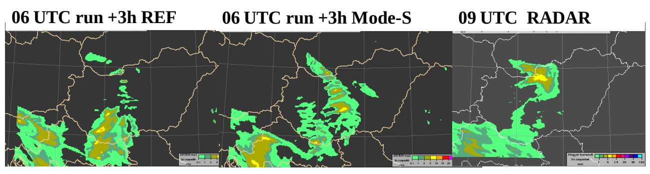
BIAS (solid) and RMSE (dashed) verification scores as a function of lead time for the three-weeks summer period (09 UTC runs). SYNOP stations below 400 m were used for the calculations. Black lines indicate the operational run and red lines are the experiment with additional AMDAR humidity data.



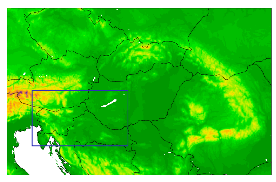
The number of AMDAR-q observations during the studied longer summer period at 12UTC.

Assimilation of Slovenian Mode-S MRAR

Mode-S MRAR observations were received from Slovenia and since our AROME domain contains Slovenia we were interested in the impact of these observations. First of all a case study was carried out. On 10th May 2016 a cyclone arrived from the direction of Slovenia to Hungary with precipitation. From the 06 UTC run the 3h-precipiation indicates more reasonable precipitation, especially in the middle of the Slovenia.

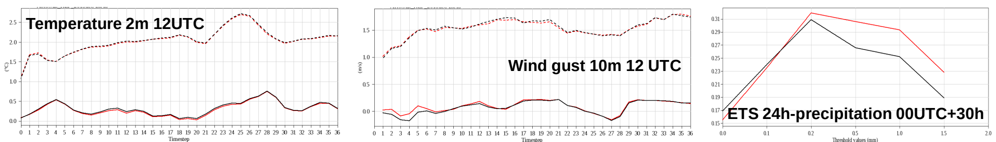


Case study: 10th May 2016. Cyclone arrived from direction of Slovenia.



The operational AROME domain with the area (blue rectangle) where the verification was performed.

The impacts of the new observations were studied on a longer time period. A winter period was chosen from 6th to 31st December 2016. 36 hours forecasts from 00 and 12 UTC were prepared with 3-hour data assimilation cycle. Observations arrives from a small area compared to the AROME domain, so verification scores were calculated over a smaller domain (Slovenia + southwest Hungary). Results show mainly neutral impact, bias of wind gust and ETS of precipitation indicate a little improvement.



BIAS (solid) and RMSE (dashed) temperature and wind gust verification scores and 24-h precipitation ETS as a function of lead time for the three-weeks winter period. SYNOP stations below 400 m were used for the calculations. Black lines indicate the reference and red lines the experiment with Slovenian Mode-S MRAR data.

High resolution AROME experiments – testing of a new shallow convection parameterization

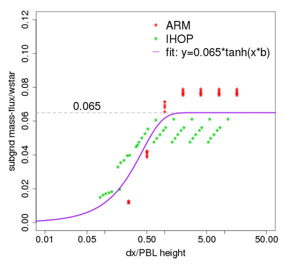
The main goal of the AROME experiments with high horizontal resolution (dx = 1000 m, 500 m) was to test a new shallow convection turbulence parametrization (Honnert et al. 2016), which was developed to improve the forecast in the shallow convection grey zone. In the grey zone the resolution is fine enough to partially treat the shallow convection eddies by the dynamics, but the rest should be still parametrized. The currently used parametrization does not handle this problem properly.

The new parametrization is made resolution dependent, based on large eddy simulations: the initialization of the mass-flux at the surface is the function of the normalized horizontal resolution (1).

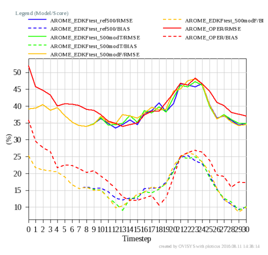
A 15-day-long verification was made for a summer period (2). As there is no operational AROME run with 500 m horizontal resolution a test run was needed to be made to compare. The operational 2.5 km AROME has often outperformed the high resolution experiments, as they are not tuned and do not use data assimilation.

The cloudiness was slightly improved during daytime, but at the same time the 2 m temperature was worse for the modified AROME.

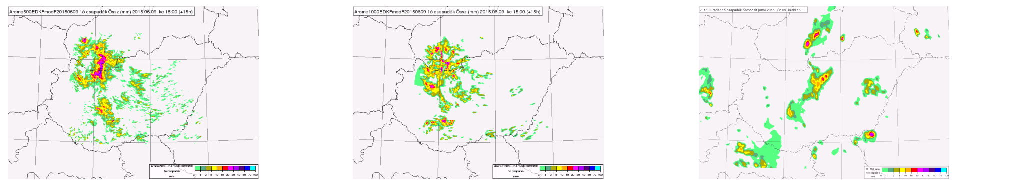
A case study was made for the day 9. June 2015 with stormy weather. The modification increased the number of the deep convection cells (3).



1. Normalized subgrid mass-flux (wstar is the vertical velocity scale) at the surface as a function of the normalized horizontal resolution (PBL is the planetary boundary layer) according to LES experiments (IHOP, ARM)



2. Verification of the cloudiness - RMSE and BIAS, blue: reference 500 m AROME, green: mod. AROME LUPBLH=T, orange: mod. AROME LUPBLH=F



3. 1 hour precipitation from 500 m (left) and 1000 m (middle) modified AROME experiments and from radar data (right) at 15.00 UTC on 9. June 2015

Honnert, R., F. Couvreux, V. Masson and D. Lancz, 2016: Sampling the structure of convective turbulence and implications for grey-zone parametrizations, Bound.-Lay. Meteorol.,160, 133-156, doi: 10.1007/s10546-016-0130-4