NWP at the Hungarian Meteorological Service

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ALADIN Numerical Weather Prediction Project

Hungarian Meteorological Service

Operational ALADIN configuration

Main features of the operational ALADIN/HU model

- Model version: CY35T1
- 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

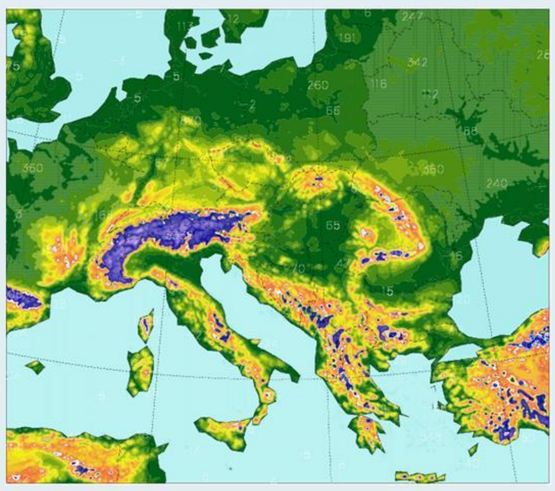
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

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

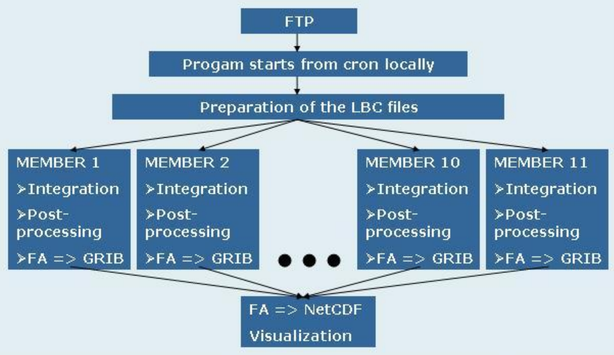
Observation usage

- 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 12 km, the number of vertical levels is 46 (hybrid coordinates).
- The forecast process starts every day from cron at 23:50 UTC and finishes around 02:00 UTC.



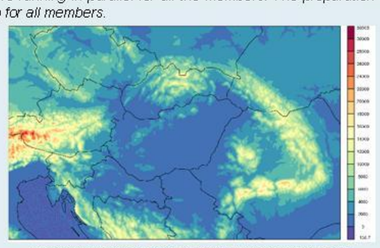
Schematics of the LAMEPS system. After the preparation of the LBC files, the integration and the post-processing are running in parallel for all the members. The preparation of the NetCDF files is done in one go for all members.

Operational AROME configuration

Main features of the AROME/HU model

- Model version: CY35T1
- 2.5 km horizontal resolution (500*320 points)
- 60 vertical model levels
- Four production runs a day: 00 UTC (36h); 06 UTC (30h); 12 UTC (24h); 18 UTC (18h)
- 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 orography of the operational AROME domain

As a general conclusion, our experience is that the AROME model gives the best temperature and windgust forecast. It improves significantly the low level cloudiness as well. However regarding the precipitation forecast it doesn't give much improvement with respect to ALADIN. We think that this is mainly due to the small domain size (see also Balázs Szintai's presentation).

Research on ALADIN limited area ensemble system

ALARO physics in limited area EPS

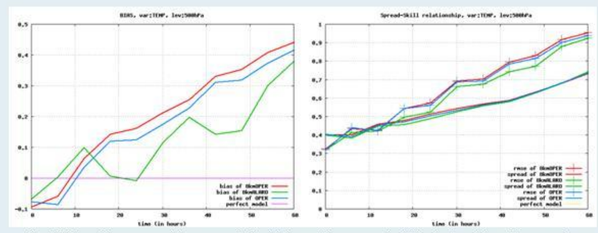
Similar to the so called deterministic system the change of ALADIN physics to ALARO in limited area EPS was in the focus recently. In connection with this upgrade a change in model resolution is also planned. To compare the impact of finer model resolution and the improved physics package, the following configurations were tested:

- Experiment called "8kmOPER" (8km horizontal resolution, 49 vertical levels, time step 300 sec, operational physics package).
- Experiment called "8kmALARO" (8km horizontal resolution, 49 vertical levels, time step 300 sec, ALARO physics package).
- Reference called "OPER" as the operational one (12km horizontal resolution, 46 vertical levels, time step 450 sec, operational physics package).

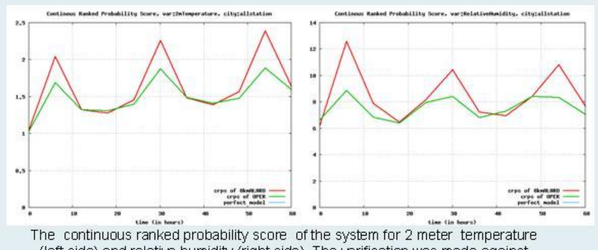
The results indicated that the resolution increase by its own does not bring clear benefit, however if it is accompanied with the enhancements of the physics package then the scores are significantly improved.

Further experiments were made to investigate the characteristics of "8kmALARO" version on a longer period. Remarkable improvements were found at almost all the variables and all the pressure levels and a slightly negative impact was seen on 700hPa at temperature and relative humidity. The conclusion of the upper-air scores were positive and mentioned to introduce the experimental configuration as an operational one.

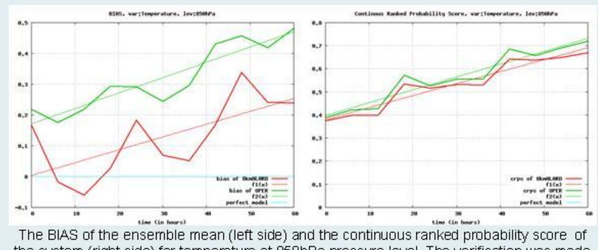
The investigation of near-surface parameters were not in accordance with the above-mentioned results. A significant degradation was seen in 2 meter temperature and relative humidity scores. The source was the increased positive temperature and negative relative humidity BIAS especially during the night periods. These characteristics are different in case of model run with and without data assimilation which is under-investigation.



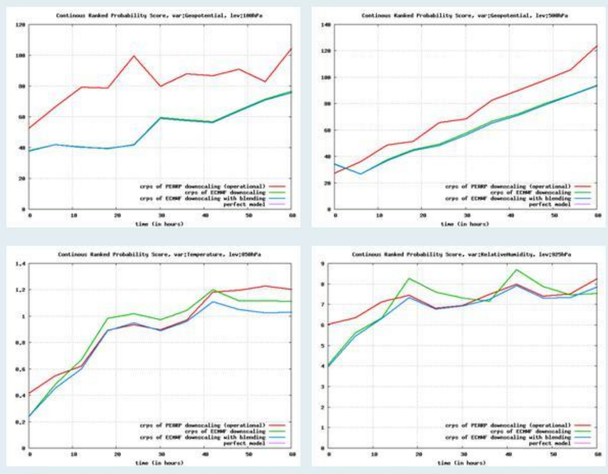
The BIAS of the ensemble mean (left side) and the spread-skill relationship of the system (right side) for temperature at 500hPa pressure level. The verification was made against ECMWF analysis and the period went 18th May 2011 - 07th of June 2011.



The continuous ranked probability score of the system for 2 meter temperature (left side) and relative humidity (right side). The verification was made against observations and the period went 18th May 2011 - 03th of July 2011.



The BIAS of the ensemble mean (left side) and the continuous ranked probability score of the system (right side) for temperature at 850hPa pressure level. The verification was made against ECMWF analysis and the period went 18th May 2011 - 17th of July 2011.



The continuous ranked probability score of geopotential at 100hPa (top left), geopotential at 500 hPa (top right), temperature at 850 hPa (bottom left) and relative humidity at 925 hPa (bottom right). The red curve shows the performance of the operational system, the green one belongs to the ECMWF EPS based limited area EPS in the case of directly used LBC files and blue line shows the case when surface fields were changed from PEARP LBC files to ECMWF LBC files (blending). There were no continuous verification period because experiments were run on 45 separated days during the year.

Usage of ECMWF EPS as LBC

In 2010 many experiments were run on ECMWF's c1a cluster as a part of a special project. In these experiments LBC files were prepared to the operational LACE domain. Then forecasts were started at the HMS with these LBC files to compare their results with the operational configuration. Similar to the operational system the forecasts were started at 18UTC which needed to use the 12UTC ECMWF EPS as LBC.

In the experiments basically the same resolution and settings were used than in the operational system. In the first set-up ECWMF EPS files were directly used while in the second set-up the surface fields were changed from PEARP (blending). By the upper-air scores this change did not have any significant impact on higher levels but the levels closer to the surface were examined the more improvements in scores were seen.

Usually downscaling of ECMWS EPS resulted a lower spread in the limited area ensemble system but decreased the BIAS and RMSE as well. CRPS was used to summarize the impact of ECMWF EPS as LBC (see the figures on the left side). The experimental configuration had clear advantages on the higher levels, however blending was really needed near the surface to gain a slightly improvement against the operational system.

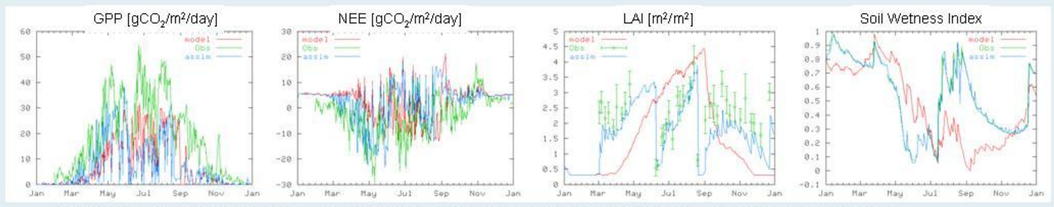
Both of the operational and experimental system are planned to test in the future with local data assimilation and perturbation which can modify their characteristics on different way.

Experiments with SURFEX ISBA-A-gs

HMS is taking part in the Geoland2 EU project. We are involved in the Land-Carbon Core Information Service work package. The goal is to model the carbon and water vapor fluxes as well as the evolution of leaf area index (LAI) and soil moisture.
The ISBA-A-gs version of the SURFEX model is used in offline mode. The scheme parameterizes the photosynthesis to calculate the carbon fluxes: GPP (Gross Primary Product), and the ecosystem respiration. The LAI is no longer determined from climatology but its evolution is modeled according to the photosynthesis and the mortality. The model uses 12 vegetation patches over the nature tile in each gridbox and makes the calculation separately for each patch.

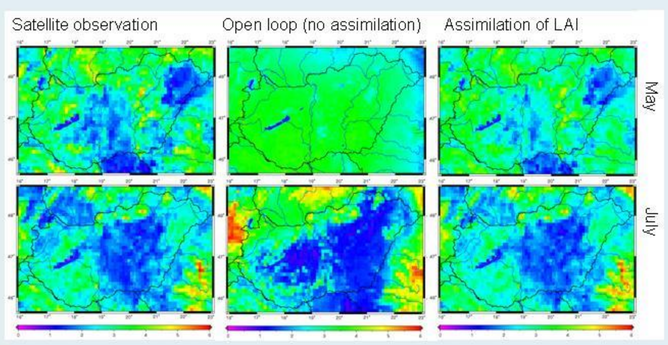
To validate the model we have run SURFEX at single point where observations are available (Hegyhátsál Flux Tower). The simulation was done for year 2008. The atmospheric forcing (T, q, press, wind, precipitation, radiation) was given by the ALADIN/HU model.
We have compared our simulation with the measurements. Since the flux tower is located over grassland, only the model fluxes over the grassland patch were taken into account. The results are shown in the figure below in red color for the model simulation. We have compared SWI and not the soil moisture directly since the latter depends on the soil texture and soil depth which may be different between model and reality.
As we can see the model failed to simulate the LAI growth during the spring which may comes from the fact that the water content was too small but it approximately reproduced the LAI evolution during the summer. GPP is overestimated.

In order to improve the simulation of the variables we have assimilated LAI and SWI. The assimilation was done with SEKF (simplified extended Kalman-Filter). The observation error for LAI was calculated from the error provided with the observations while for SWI we have used constant error: 0.1. The background error for LAI was set to constant (0.4) if LAI<2 and LAI*0.2 above. As one can see (blue lines on the figure) the evolution of LAI and SWI gets much closer to the observations. The assimilation also improves GPP and NEE forecast during spring but it degrades in summer. The explanation is that GPP is proportional to LAI and LAI was decreased by the assimilation and we already had GPP underestimation.



Simulation of GPP, NEE, LAI and SWI for 1 year (2008) over grassland with and without assimilation and comparison with observation.

We have also tested the assimilation in case of more patches. The code have to be modified since the calculation of the increments at different patches were done separately (independently of the other patches). However the increment depend on the other patches since the patch averaged value is compared to the observation. In some cases the assimilation cycle aborted since too big negative increment was added resulting in negative LAI value. To prevent the crash we have added a security check, i.e. if the analyzed value is below LAI_{min} no increment should be added.
The assimilation was done for year 2008 over the domain covering Hungary. The LAI observation was taken from Land-SAF product. As one can see in the following figure the open loop experiment (no assimilation was used) overestimates LAI while if we use assimilation the LAI value gets close to the observation.



Test of LAI assimilation over more patches. Observation (left) is compared with open loop run (middle) and with experiment using LAI assimilation (right)

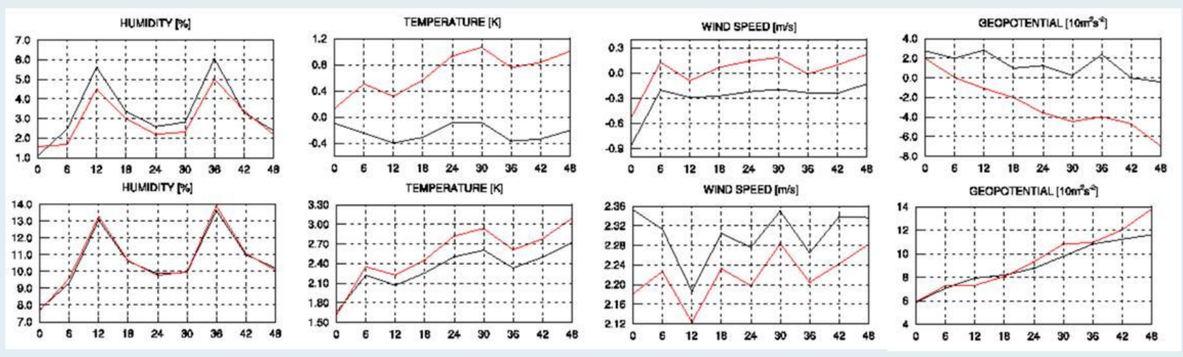
Experiments with ALARO

ALARO physics have been tested recently at HMS. The newest developments entering CY36T1 related to ALARO physics were backphased to our operational library CY35T1 based on the experiences of the Czech ALADIN team. The envelope orography was changed to mean orography to allow the application of the new gravity wave drag scheme.

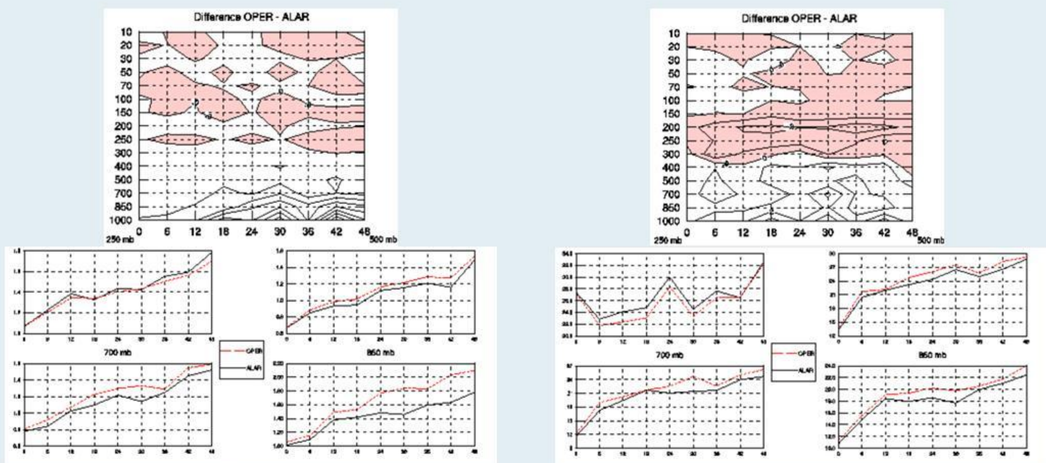
The first experiments with ALARO were run simply in dynamical adaptation mode and produced promising results which mentioned to run the model with data assimilation. To these experiments the operational ALADIN was used as a reference. This comparison made a picture about impact of the change of physics in our operational system.
The comparison was done for the following period: 07th December 2010 – 31st December 2010
Two different method were used to verify the results:

- verification against SYNOP and TEMP (with Veral package)
- verification against ECMWF analysis

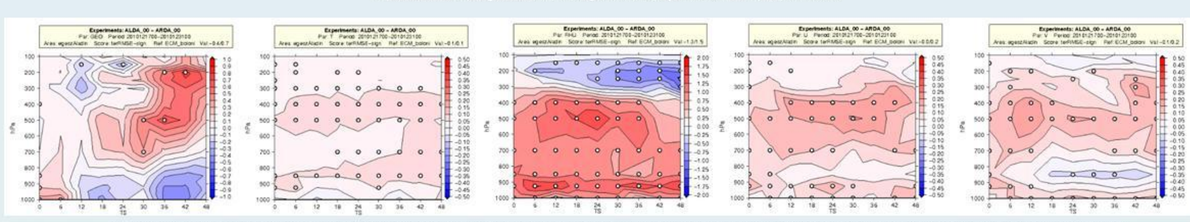
Conclusions and future plans: improvement in the upper air scores both against observations and ECMWF analyses. Degradation in the 10m wind. If managing to improve the 10m wind forecast ALARO physics are to be implemented operationally.



Verification against SYNOP data averaged over the whole model domain (Veral package). Black solid line: ALARO physics, Red dashed line: operational ALADIN/HU physics. Top row: BIAS, Bottom row: RMSE



Verification against TEMP data (RMSE) averaged over the whole model domain (Veral package). Left: temperature, Right: relative humidity. Black solid line: ALARO physics, Red dashed line: operational ALADIN/HU physics. The cross section of RMSE differences (top row) shows improvements (degradations) using ALARO physics in white (red) colours.



Verification against ECMWF analysis (RMSE differences) in the function of pressure and forecast range. Red (blue) colours mean that ALARO physics improves (degrades) the forecast compared to the present operational ALADIN/HU run. Small circles means that the RMSE difference is significantly different from zero with a 90% confidence interval.

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