NWP at the Hungarian Meteorological Service

LACE nwp central europe

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
- 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

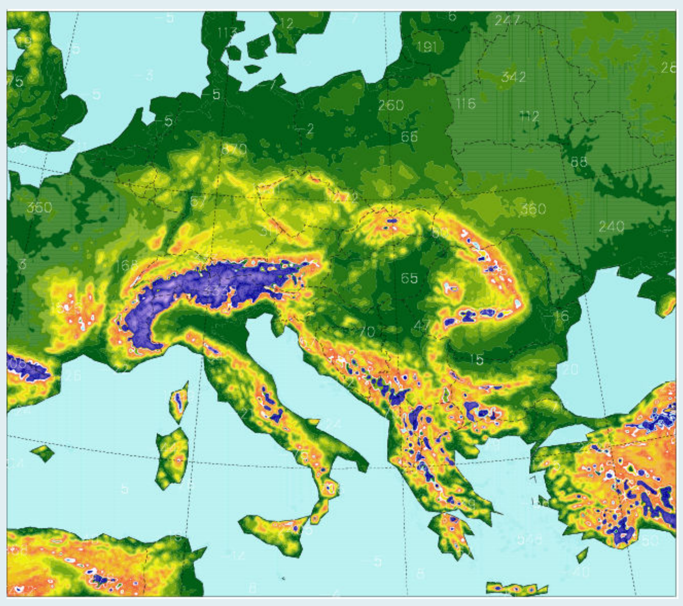
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

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

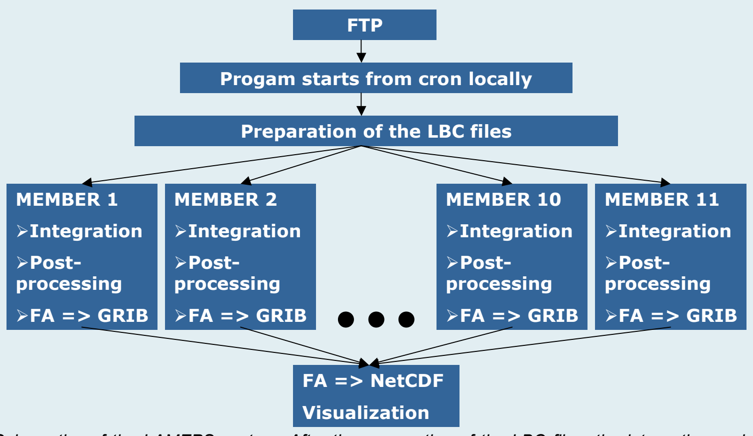
Observation usage

- 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.



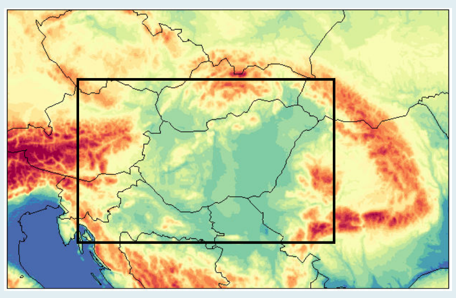
Schematics of the LAMEPS system. After the preparation of the LBC files, the integration and the post-processing are running in parallel for all the members. The preparation of the NetCDF files is done in one go for all members.

Operational AROME configuration

Main features of the AROME/HU model

- Model version: CY35T1
- 2.5 km horizontal resolution (300*192 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).



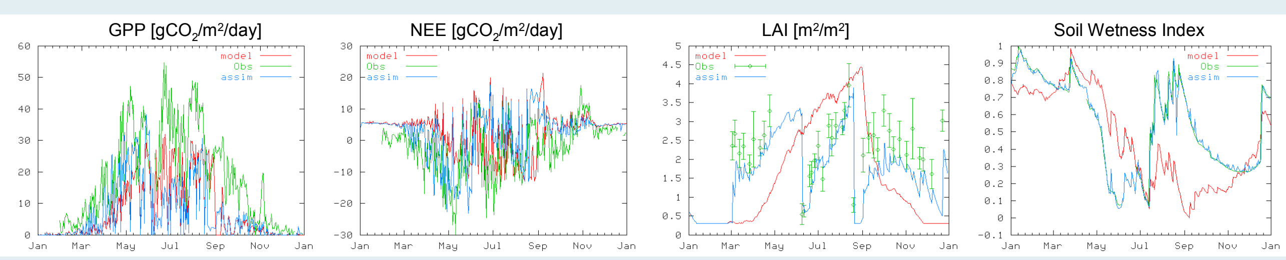
The orography of the current (black line) and future operational AROME domain

As a general conclusion, our experience is that the AROME model gives significantly better temperature and windgust forecasts than ALADIN. It improves the the low level cloudiness and the precipitation as well. Extensive tests on a one-month summer period revealed large sensitivity to the driving model (ECMWF vs. ALADIN). Results show, that after the first 6 hours of the simulation the direct ECMWF coupling yields better forecasts (see also Balázs Szintai's talk).

Experiments with ISBA-Ags

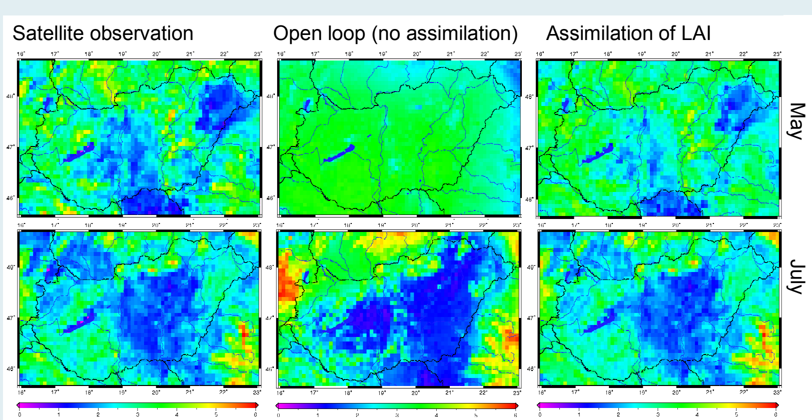
HMS is taking part in the Geoland2 EU project. We are involved in the Land-Carbon Core Information Service work package. The goal is to model the carbon and water vapor fluxes as well as the evolution of leaf area index (LAI) and soil moisture.
The ISBA-A-gs version of the SURFEX model is used in offline mode. The scheme parametrizes 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, the physiography of the model was configured accordingly: only one patch was 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 almost all over the year.
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)

Research on local perturbations in the ALADIN ensemble system

The operational ALADIN-EPS consists of downscaling of ARPEGE EPS (based on PEARP3.0). In the global system the perturbations are generated by using singular vectors (SVs) and an ensemble data assimilation (EDA) system. Although these perturbations can be ideal in a global system, downscaled into a limited area model they are not always satisfactory. Despite the amplitude of the perturbations were increased during the updates of PEARP, the system is still under-dispersive especially in the lower levels. Additionally perturbations generated in a global system can not describe the uncertainties of a the finer scales in general.

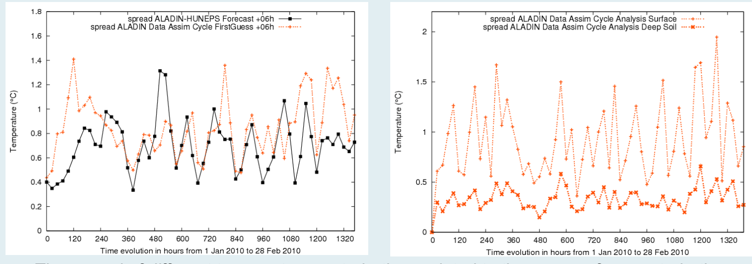
Due to the above mentioned reasons we decided to start research on the generation of local perturbations which are able to improve the spread-skill relationship of ALADIN-EPS and correctly represent the uncertainties on the applied scale. Two main methods were in the focus in the last year: surface perturbations and singular vector based perturbations. Beside some promising results, interesting questions appeared, although both of the experiments are in a preliminary status.

Surface Perturbation Experiments:

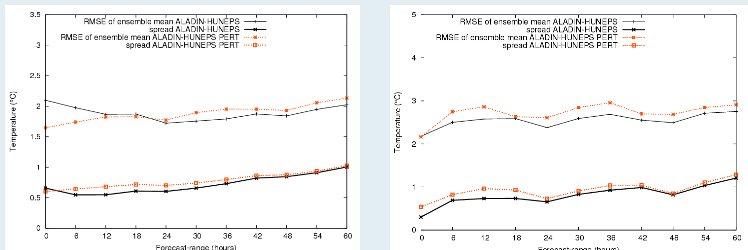
One of the main effort in the ensemble prediction is the estimation of the correct initial perturbation at near surface. To create such kind of perturbations there are several methods and techniques, but the most progressive one is a method based on data assimilation algorithms. The near-surface observations are perturbed with a Monte-Carlo method and different perturbed analyses are created for the different ensemble members. The amplitude of the perturbations is scaled with the observation errors. The ALADIN model and the CANARI optimum interpolation scheme were applied to create the surface ensemble data assimilation like process where an observation perturbation effects a perturbation of the soil temperature and soil moisture.

An ensemble assimilation cycle was built with 6 hours frequency to produce the perturbed initial conditions for the ALADIN LAMEPS runs. Some diagnostics were computed to evaluate the efficiency of the method. A comparison of the spread for 2m temperature in the data assimilation cycle and in the 6h forecasts of the reference ALADIN LAMEPS can be seen on the upper left figure. Another diagnostic of the perturbations can be seen in the upper right figure where the amplitude of the spread of soil temperature are plotted. The spread of these parameters equals to zero in the initial conditions of LAMEPS forecasts

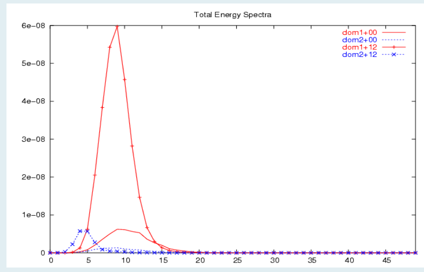
With the perturbed initial conditions, experimental LAMEPS forecasts were run for a 2 months period (1 January 2010 to 28 February 2010) and compared with the operational LAMEPS. Objective verification scores were also computed. Bottom left figure below shows the spread-skill relationship for temperature for 1000hPa and bottom right figure shows the same score for 2m. It can be seen the method has a slightly positive impact for the near-surface temperatures at initial times, but some degradation also can be seen in case of RMSE scores. It is important to note the local perturbations usually suppressed by the LBC after 24h lead time.



The spread of different temperature perturbations related to the near-surface perturbation scheme. Left panel: the spread of the first guess in the experimental data assimilation cycle and in the operational ALADIN EPS. Dashed lines correspond with the spread of the first guesses at 2 m. Solid line marks the spread of the 6 h operational ALADIN HUNEPS forecasts at 2 m. Right panel: the spread of the surface temperature analyses at two different surface layers in the data assimilation cycle with near-surface perturbations. Dashed line correspond to the surface values and the thick dashed lines mark the values at soil level nearest to the surface (at around 1.5 m depth). Period: 1 January 2010 to 28 February 2010.



Spread-skill relationship (left for 1000hPa, right for 2m) of the operational (solid) and experimental (dashed) ensemble systems. In the panels the lower (thick) lines indicate the spread and the upper (thin) ones the RMSE of the ensemble mean. Period: 1 January 2010 to 28 February 2010.

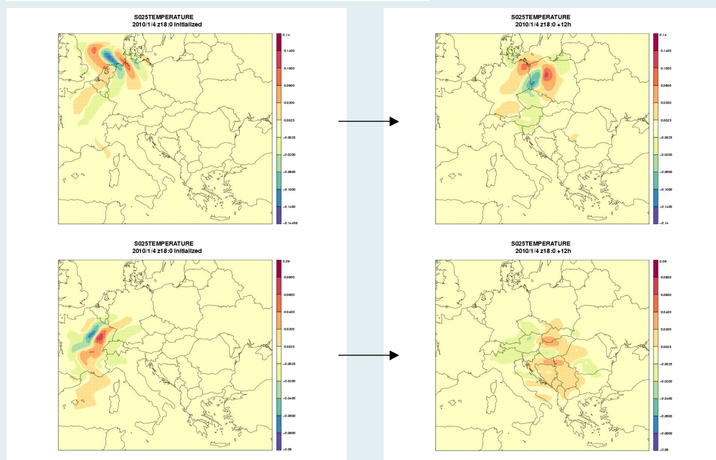


Total energy spectrum of leading initial (without X) and evolved (with X) SV for domain1 (red) and domain2 (blue). In this case SV computation was started from 18UTC 4th of January 2010 with 12 optimization time. Spectra is drawn for model level 25 which is vertical maximum of total energy of the leading SV

Singular Vectors Experiments:

SVs method is widely used to generate perturbations in global medium-range ensemble forecast system. The main benefit of this method is that one can have a quite big impact in the forecast after 24 or 48 hours (depends on the optimization time) with perturbing just a very few number of unstable directions. In a limited area system the target domain is also limited during the SV calculation and the optimization time is usually shorter, because of the computational cost and the fast-growing impact of the LBCs. According to this feature targeted SV-based perturbations can not guarantee such an effective total energy growth than the global ones. From another point of view they have the advantage that the targeted domain can be the area of interest (for example the examined country). On example shown at the left two different targeted domain's impact are compared. Domain1 is targeted for the whole territory of model integration (33.7-55.7°N, 1.9-39.7°E), domain2 is targeted only for the area of Hungary (45.7-48.7°N, 16-23°E). However the total energy of leading evolved SV is significantly bigger in the domain1 case, but perturbations are more focused and more useful in the case of domain2 for a forecast in Hungary.

Further investigations are planned with SV based perturbations, which includes targeting not only horizontally but vertically and scale-wise. The main goal is to generate perturbations, which can increase the spread of the system especially that part of the vertical profile or energy spectrum where the global system based limited area EPS is the most under-dispersive.



The temperature perturbations of leading singular vector in initial time (left) and in the optimization time (right), which is 12 hours. Upper pair of figures shows the case of using domain1, bottom pair of figures shows the case of using domain2 to SV calculation, which was started from 18UTC 4th of January 2010.

Reference: *Horányi A., M. Mile, M. Szűcs,* 2011: Latest developments around the ALADIN operational short-range ensemble prediction system in Hungary. Tellus. DOI: 10.1111/j.1600-0870.2011.00518.x

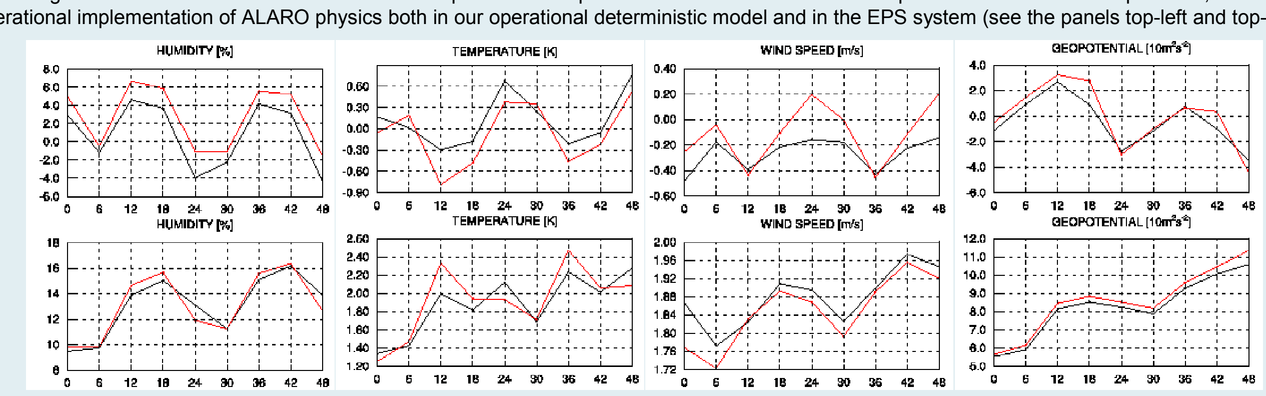
First experiments with ALARO

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

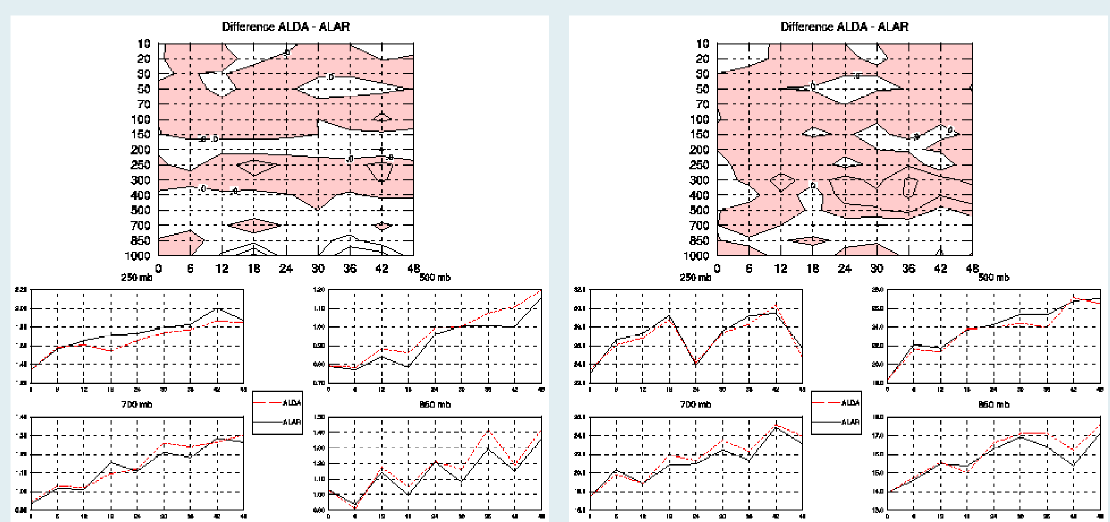
In this experiment the model was run in dynamical adaptation mode (without local data assimilation, by interpolating the IFS analysis to the LAM grid and using ARPEGE analysis at the surface) up to two days forecast range. The reference for the ALARO experiments are dynamical adaptation runs too with the current operational physics settings of ALADIN/HU (using envelope orography). The experiment was run for a summer period: 18th July 2010 – 15th August 2010. Three different verification was made:

- verification against SYNOP and TEMP (with Veral package)
- verification against ECMWF analysis
- precipitation verification against radar (using 6h accumulated radar data) averaged over a domain approximately the size of a grid box (in order to smooth the radar image).

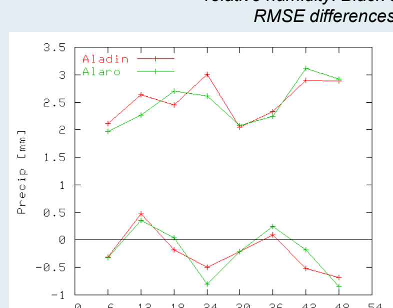
Preliminary conclusions and futrure plans:
these first results (especially temperature scores and humidity scores at 700 hPa) are rather encouraging. As a consequence ALARO physics will be tested together with data assimilation and will be compared to our operational model. In case of similar performance as in this experiment, we aim for the operational implementation of ALARO physics both in our operational deterministic model and in the EPS system (see the panels top-left and top-right).



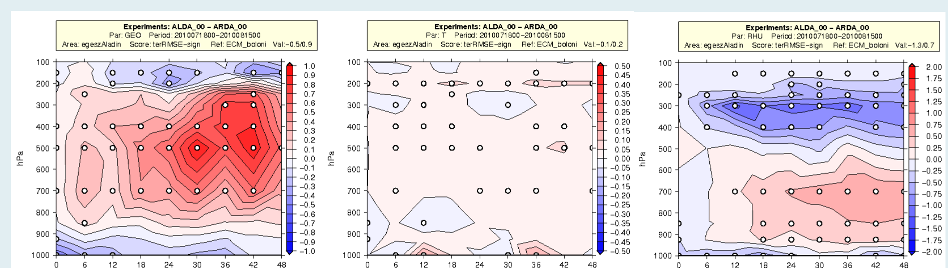
Verification against SYNOP data averaged over the whole model domain (Veral package). Black solid line: ALARO physics, Red dashed line: operational ALADIN/HU physics. Top row: BIAS, Bottom row: RMSE



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.



Precipitation BIAS and RMSE compared to 6h cumulated radar data. The radar data have been averaged to the grid scale of the model. Green: ALARO physics, Red: operational ALADIN/HU physics



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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