LACE
nwp central europe

ALADIN Numerical Weather Prediction Project

NWP at the Hungarian Meteorological Service

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Operational ALADIN configuration

Main features of the operational ALADIN/HU model

- Model version: CY38T1 (ALARO-0 baseline 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

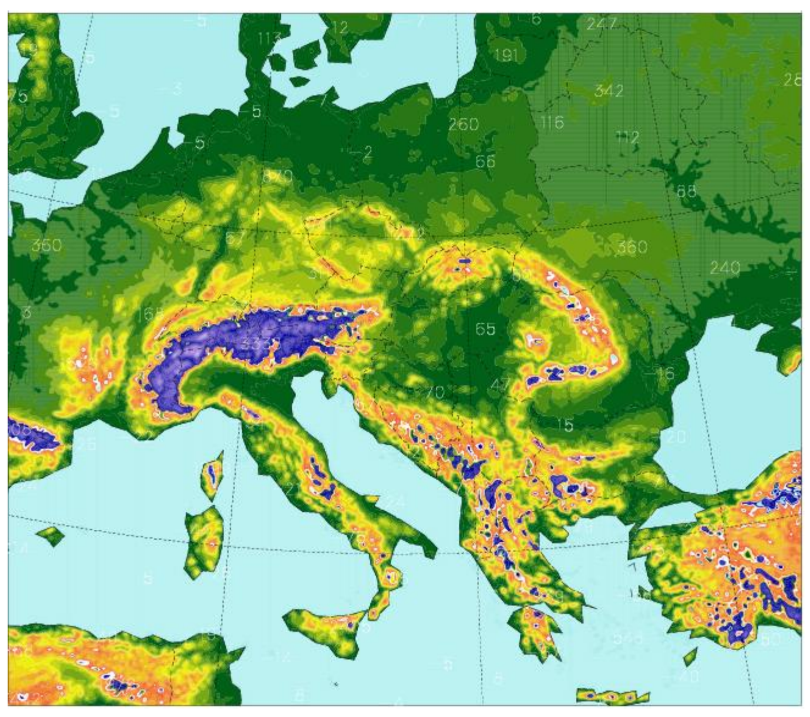
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

Operational suite / technical aspects

- Transfer ECMWF/IFS LBC files from ECMWF via 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

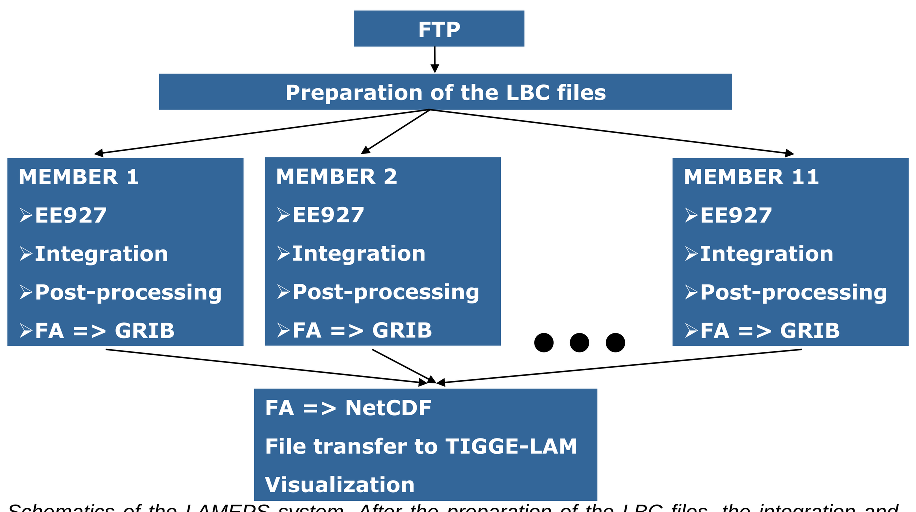
Observation usage

- 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.

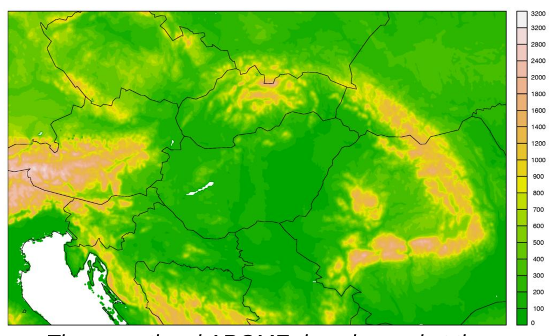


Schematics of the LAMEPS system. After the preparation of the LBC files, the integration and the post-processing are running in parallel for all the members. The preparation of the NetCDF files is done in one go for all members.

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
- Four production runs a day: 00 UTC (48h); 06 UTC (39h); 12 UTC (48h); 18 UTC (39h)
- Initial conditions: 3DVAR (upper air), interpolated ALADIN surface analysis (see details in the block below)
- 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



The operational AROME domain used at the Hungarian Meteorological Service.

We are running the AROME model over Hungary on daily basis since November 2009 (since December 2010 operationally and since March 2013 with local 3DVAR data assimilation). The model performance is evaluated regularly by our NWP group and the forecasters group. Moreover it is compared with other available models (ALADIN, ECMWF).

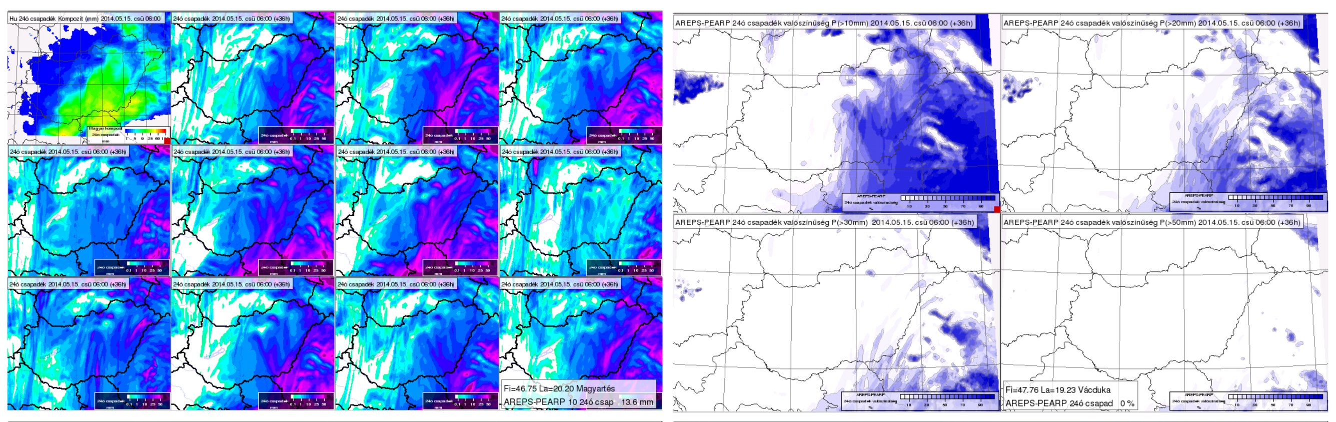
As a general conclusion, our experience is that the AROME model gives very good temperature and wind gust forecasts. Based on the SAL verification (not shown here) it also captures the size of the precipitation objects very well. However, it tends to overestimate precipitation maximum and wind gusts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

Case studies with the test version of AROME-EPS

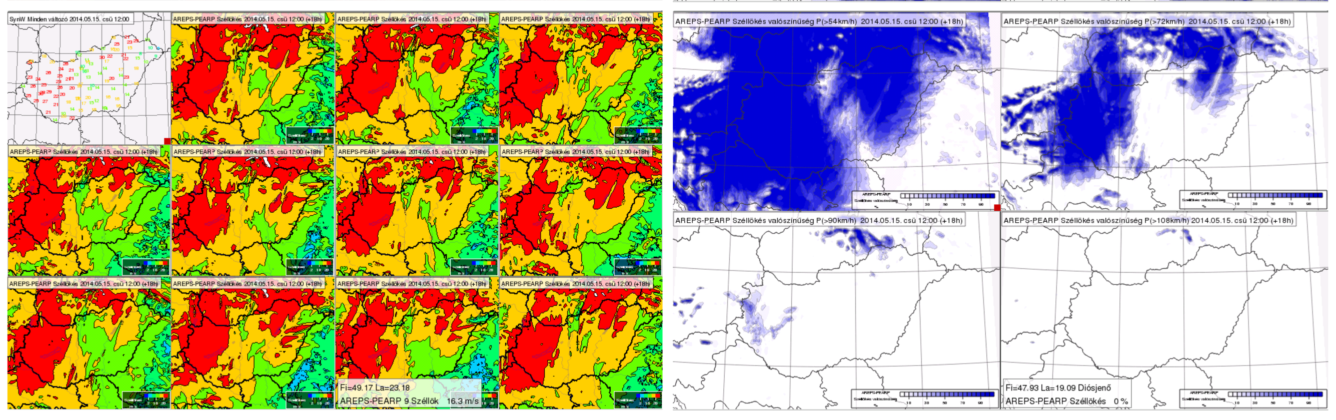
Since 2012 Hungarian Meteorological Service (HMS) is a participant of ECMWF's 'spfrbout' special project and runs AROME-EPS tests on ECMWF's supercomputer. Our long-term goal in this project is to develop a high-resolution EPS which can correctly estimate the uncertainties of the forecasts especially in such weather situations which are frequently problematic for forecasters in Hungary. In the previous years mainly two perturbation generation methods were examined:
- SPPT scheme was tested to simulate model error in this ensemble system,
- EDA was also in the focus of our interest, which can produce ICs to the AROME-EPS with good quality and correct the representation of IC uncertainties.
The effect of the above-mentioned methods was presented on our national posters in the previous two years.
Additionally different coupling strategies were also examined. Both PEARP and IFS-EPS downscaling have been applied for case studies and test periods. HMS participated in the work of TAC Subgroup to review the Optional BC Programme of ECMWF. The output of this work hopefully can help to provide ensemble boundary conditions with good quality and higher time frequency for the National Meteorological Services.

Some AROME-EPS results are represented here in connection with Yvette storm which hit the Central-European region on 12-17 of May, 2014. The storm caused serious damages in many countries because of the enormous amount of precipitation and the strong wind gusts.
AROME-EPS tests were run from three different lead time to examine how a convection-permitting EPS can forecast the probability of the extreme rain and wind gust events. The applied test configuration was the following:
- 10+1 AROME members was coupled to the first 10+1 members of PEARP,
- Forecasts ran for 36 hours on a domain covering the Carpathian-Basin,
- Forecasts were started on 13th, 14th and 15th of May, both days at 18UTC so they provided information mainly for the following day,
- Neither SPPT nor EDA were applied in these case-studies.

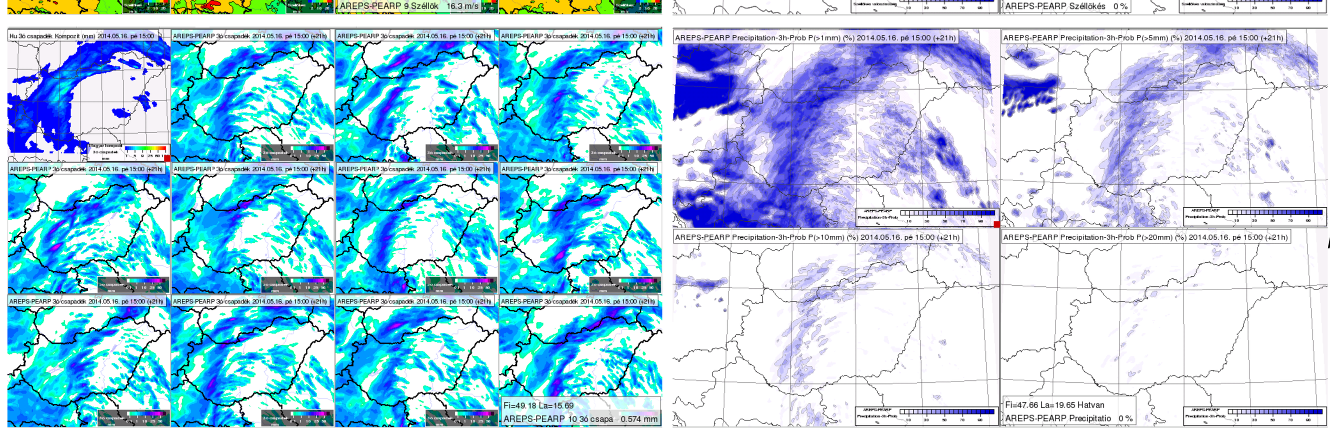
Probability and stamp diagrams are presented below from all the three ensemble runs. From the three different ensemble runs we show three different variables in accordance with the most hazardous aspect of the actual weather:
- On 14th of May the large-scale precipitation caused the biggest problems, especially in the south-eastern part of the country (upper row).
- On 15th of May the strong wind caused damages in the country especially in the area of lake Balaton where it left many beaches flooded (middle row).
- On 16th of May small-scale convective structures appeared in the middle part of the country. As a convection-permitting system AROME-EPS has advantage against hydrostatic ensemble systems in such situations (bottom row).



***24-hour precipitation** fields of 14th of May, 2014. AROME-EPS was started at 18UTC on 13th of May. **Left side**: Accumulated precipitation field was calculated from radar observations and compared with the 11 forecasted fields provided by the ensemble members. **Right side:** Maps show the forecasted probabilities of precipitation bigger than 10, 20, 30 and 50 mm/24-hour.*



***Wind-gust** fields at 12UTC on 15th of May, 2014. AROME-EPS was started at 18UTC on 14th of May. **Left side:** Wind-gust SYNOP observation were compared with the 11 forecasted fields provided by the ensemble members. **Right side:** Maps show the forecasted probabilities of wind-gust bigger than 15, 20, 25 and 30 m/s.*



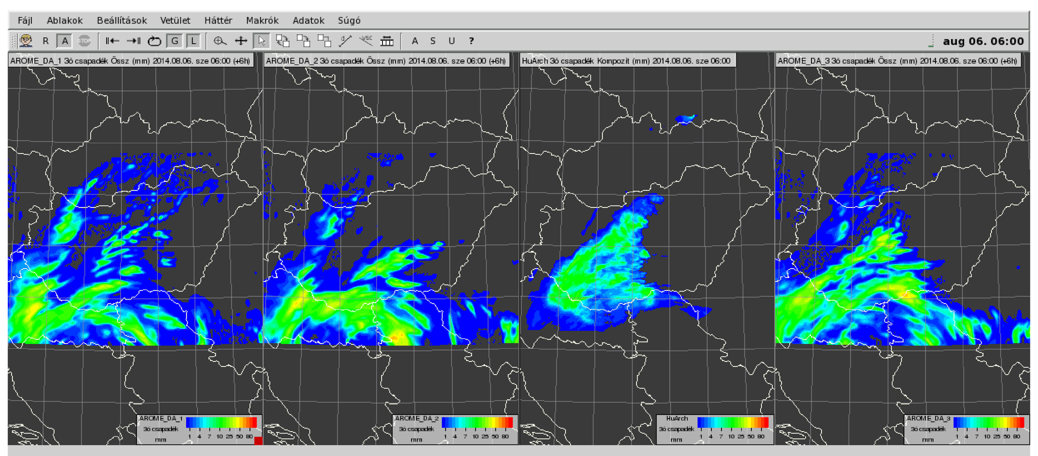
***3-hour precipitation** fields at 15UTC on 16th of May, 2014. AROME-EPS was started at 18UTC on 15th of May. **Left side:** Accumulated precipitation field was calculated from radar observations and compared with the 11 forecasted fields provided by the ensemble members. **Right side:** Maps show the forecasted probabilities of precipitation bigger than 1, 5, 10 and 20 mm/3-hour.*

The use of HRW AMV in AROME Data Assimilation system

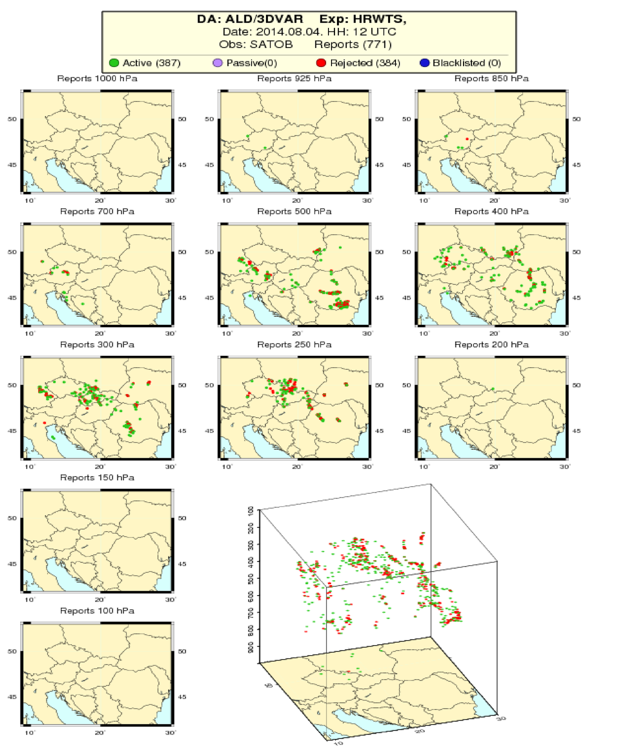
The products of the NWCSAF processing and retrieval package has been widely used at Hungarian Meteorological Service for forecasting, nowcasting and experimentally for NWP purposes. The so called High Resolution Winds (hereafter HRW) is one of the NWCSAF products which provides Atmospheric Motion Vectors (AMV) and is calculated from MSG/SEVIRI channels. Our motivation was to test HRW in mesoscale AROME model through its operational 3DVAR (three-dimensional variational) DA system. With the use of observation monitoring tool, the geographical distribution of HRW data can be taken into account. Through a typical example (figure on the right) HRW provides increased number of AMV observations mostly in the higher atmosphere (between 200 and 500hPa) compared to MPEF (Geowind) AMV (not shown) computed also from MSG products. Beside the amount of AMV observations, HRW is usually providing AMVs with better quality considering DA diagnostics and more data with higher quality indices.

The impact of HRW was investigated in AROME during a summer period including different weather situations (both convective and synoptically stable conditions). Overall the impact was found to be neutral regarding objective verification scores, however in particular case studies positive impact for precipitation forecast was observed due to the assimilation of HRW.

In an example below (figure on the left), 3 hours accumulated precipitation forecasts started from 00UTC on 6th of August were studied with respect to AROME operational configuration, AROME oper with MPEF (Geowind) AMV and AROME oper plus HRW AMV. The frontal precipitation band was mainly captured by all model configurations, but the distribution of accumulated rain was the closest to the RADAR when HRW AMV was assimilated.



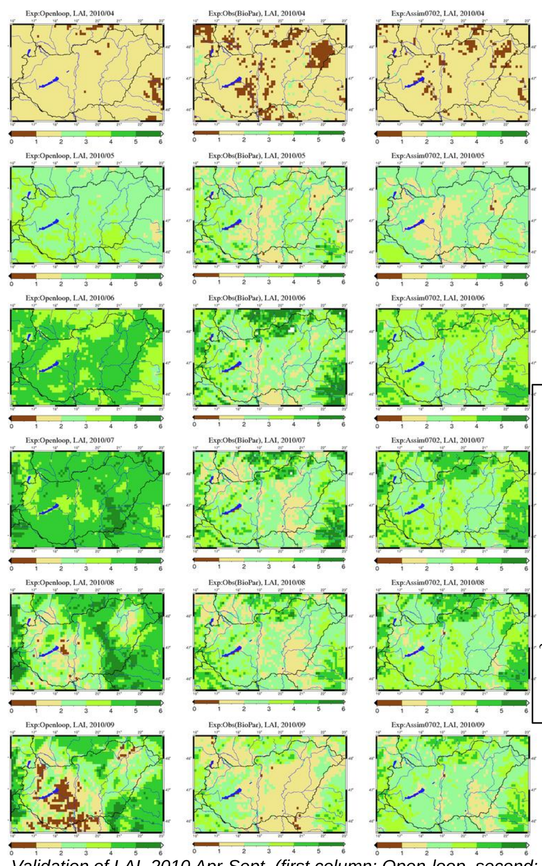
3h AROME/Hungary precipitation forecasts for 6th of August, 2014. 1.panel: Without AMV, 2.: with MPEF AMV, 3.: RADAR observation, 4.: with HRW AMV



Observation monitoring for HRW AMV at 12UTC 4th of August, 2014

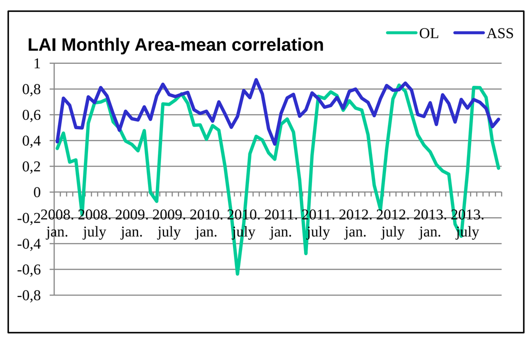
ImagineS project

In the framework of the ImagineS project (Implementation of Multi-scale AGricultural INdicators Exploiting Sentinels) a Land Data Assimilation System (LDAS) is applied at the Hungarian Meteorological to monitor the above ground biomass, surface fluxes (carbon and water) and the associated root-zone soil moisture at the regional scale (spatial resolution of 8km x 8km) in quasi real time. In this system the Surfex (SURFace EXternalisée) 7.3 model is used, which applies the ISBA-A-gs photosynthesis scheme to describe the evolution of vegetation. Surfex is forced using the outputs of the ALADIN numerical weather prediction model run operationally at HMS. First, Surfex was run in open-loop (i.e. no assimilation) mode for period 2008-2013. Secondly the Extend Kalman Filter (EKF) method was used to assimilate **LAI Spot/Vegetation** and **SWI ASCAT/Metop** satellite measurements. The EKF run was compared to the open-loop simulation and to observations (LAI and Soil Moisture satellite measurements) over the whole country and also to a selected site in West-Hungary (Hegyhátsál).



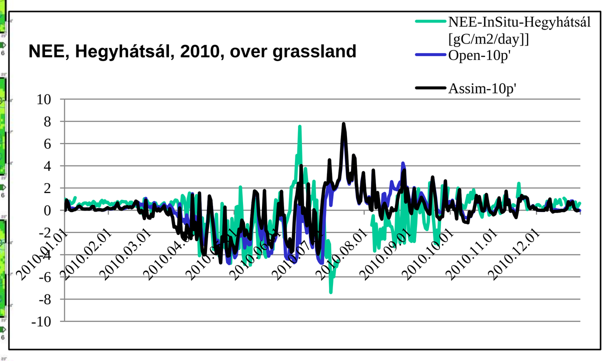
Validation of LAI, 2010 Apr-Sept. (first column: Open-loop, second: Satellite obs., third: Assimilation)

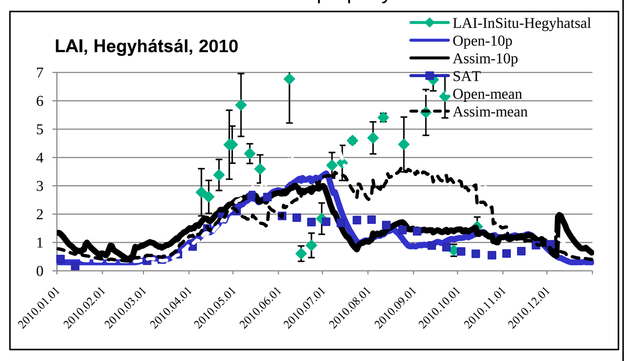
Figure on the left shows the monthly averaged LAI for the mentioned experiments for an extreme rainfall year 2010. Patch averaged LAI values were taken into account. The simulated LAI fields are closer to the satellite observation in case of assimilation than without it. The open-loop experiment over-estimates the LAI values, the assimilation run is able to correct them, but the overestimation still exists.



LAI correlation over the whole domain for 2008-2013

LAI correlation (calculated between the simulated data and the satellite measurements) is shown on the left hand side. The open-loop experiment produces low correlation at every spring time repeatedly, especially in May, and these weak correlations disappear in the summer or autumn period. In the assimilation these wrong correlations do not appear, the EKF worked properly.





Net ecosystem exchange (NEE) and LAI in Hegyhátsál over grassland area

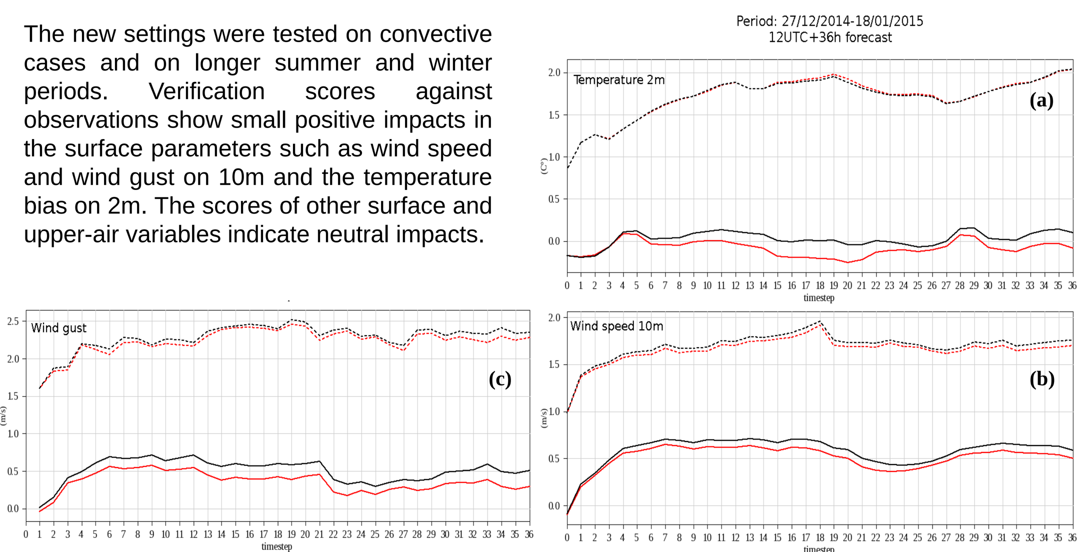
1D evaluation is presented above. NEE is well simulated almost the whole year for both experiments, except for the summer and autumn, when the experiments give positive NEE values – this means emission of CO_2, but the measurements are negative – which means uptake of CO_2. Turning to LAI it can be seen that the satellite measurements (blue points) are extremely far from the in-situ data (green points with error bars) and both experiments more or less follow the satellite values.

Tuning of SLHD scheme for noise reduction in AROME

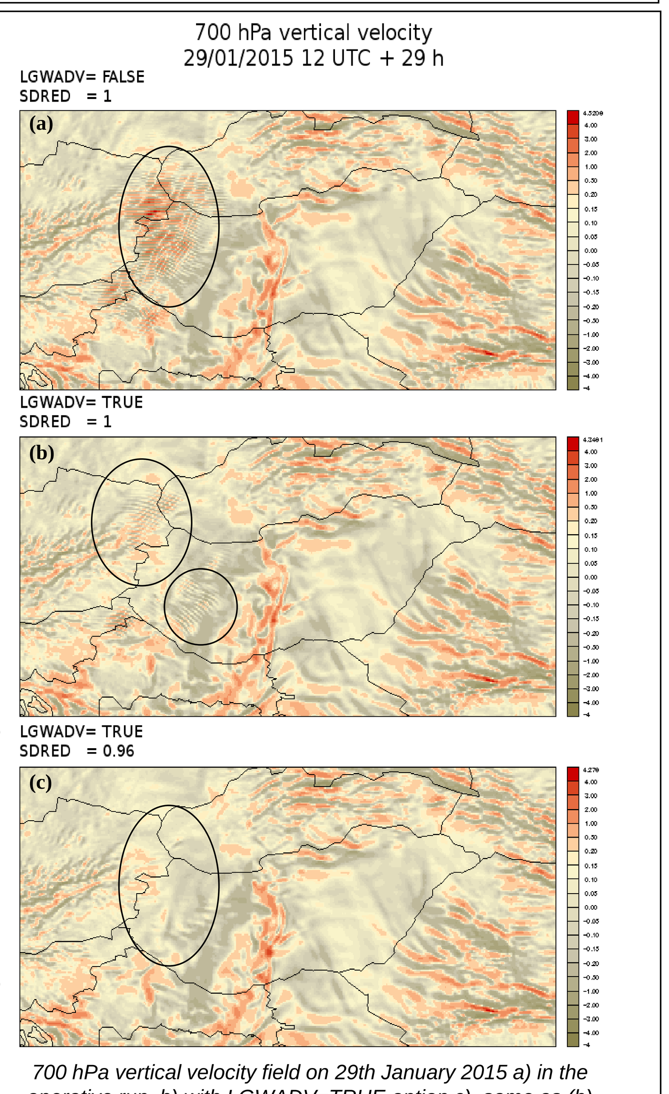
On 29th January 2015 unstable waves appeared in the Hungarian operational AROME run (see figure on the right). These waves have disappeared only if the timestep was reduced from 60 sec to 30 sec. An experiment was carried out with LGWADV=TRUE option that successfully reduced the noise but the waves did not disappear completely. This option set the prognostic vertical wind variable from vertical divergence to vertical velocity.

In the next step the reduction of spectral diffusion (SDRED) was decreased from 1 to 0.96. The purpose of the reduced spectral diffusion is an enhanced damping high in the atmosphere, but changing this parameter effects on the lower levels too. Now the model produce more intensive spectral diffusion and in this case these setting solved the problem of unrealistic waves.

The new settings were tested on convective cases and on longer summer and winter periods. Verification scores against observations show small positive impacts in the surface parameters such as wind speed and wind gust on 10m and the temperature bias on 2m. The scores of other surface and upper-air variables indicate neutral impacts.



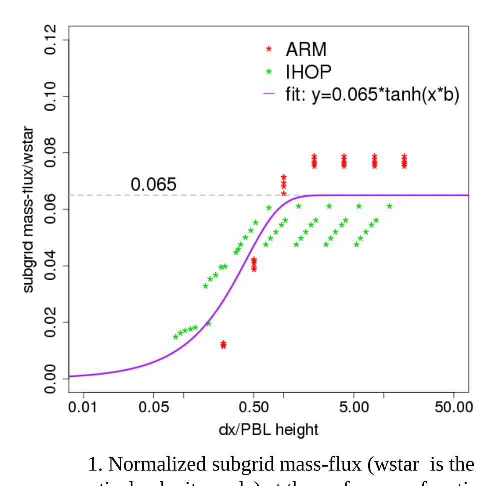
BIAS (solid) and RMSE (dashed) verification scores as a function of lead time for a three-weeks winter period for the following variables: a) temperature at 2m level b) wind speed at 10 m level c) wind gust at 10 m level. SYNOP stations below 400 m were used for the calculations.



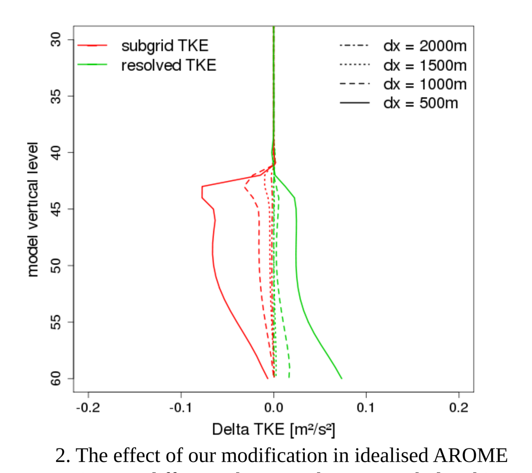
700 hPa vertical velocity field on 29th January 2015 a) in the operative run, b) with LGWADV=TRUE option c) same as (b) with less reduced spectral diffusion.

Development of shallow convection parameterization in AROME at very fine resolution

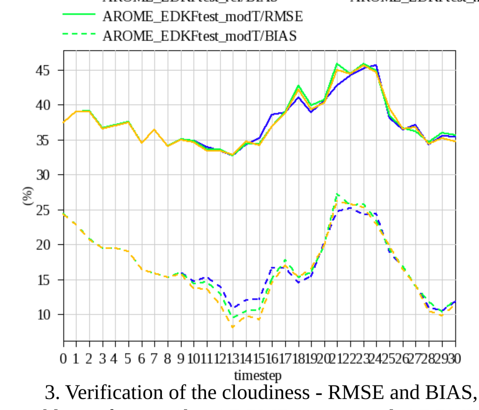
In this research at the Hungarian Meteorological Service (HMS) the focus is on the shallow convection grey zone in the AROME model at very fine resolution. At low horizontal resolution (dx > ~1 km) the effect of shallow convection eddies are parameterized, because the dynamics can not treat them. By contrast at very high resolution (dx < ~100 m – large eddy simulation (LES)) the parameterization of these eddies is not needed, they are fully handled by the dynamics. In the intermediate resolutions the eddies are only partly treated by the dynamics so they still have to be parameterized, but in a new way, dependent on the resolution.
The current shallow convection parameterization in AROME is based on the Eddy Diffusion Mass Flux (EDMF) scheme, where the thermals are represented with a mass-flux value. This value is initialized at the surface and then integrated upwards.
In our new parameterization the initialization is dependent on the dimensionless horizontal resolution. This dependency is derived from LES runs (figure 1.) of the IHOP and ARM cases made with the MesoNH (Honnert et al. (2011)). The normalization can be done optionally by the planetary boundary layer height (LUPBLH=T) or by the upward mixing length (LUPBLH=F).
At first it was tested on idealised AROME runs (figure 2.) and the modification moves the results in the desired direction. The verification was done on a 15-day-long real case period (figure 3. and 4.) at dx = 1 km horizontal resolution. The operational resolution of AROME at HMS is 2.5 km and the 1 km AROME shown in figures 3. and 4. is only a test. Compared to this, the modification produces little change, but this is still a result without tuning.



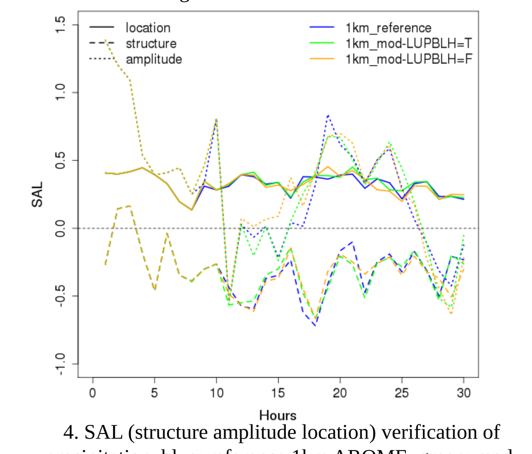
1. Normalized subgrid mass-flux (wstar is the vertical velocity scale) at the surface as a function of the normalized horizontal resolution (PBL is the planetary boundary layer - ~1 km height) according to LES experiments (IHOP, ARM)



2. The effect of our modification in idealised AROME experiments: difference between the mean turbulent kinetic energy (TKE) profiles (the simulation with modification minus the simulation without modification). The subgrid TKE decreases and the resolved TKE increases with the higher horizontal resolution.



3. Verification of the cloudiness - RMSE and BIAS, blue: reference 1km AROME, green: mod. AROME LUPBLH=T, orange: mod. AROME LUPBLH=F



4. SAL (structure amplitude location) verification of precipitation, blue: reference 1km AROME, green: mod. AROME LUPBLH=T, orange: mod. AROME LUPBLH=F

HONNERT, R., V. MASSON and F. COUVREUX, 2011: A Diagnostic for Evaluating the Representation of Turbulence in Atmospheric Models at the Kilometric Scale. J. Atmos. Sci., **68**, 3112-3131

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