LACE
nwp central europe

ALADIN Numerical Weather Prediction Project

NWP at the Hungarian Meteorological Service

OMSZ Hungarian Meteorological Service

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Operational ALADIN configuration

Main features of the operational ALADIN/HU model

- Model version: CY36T1 (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

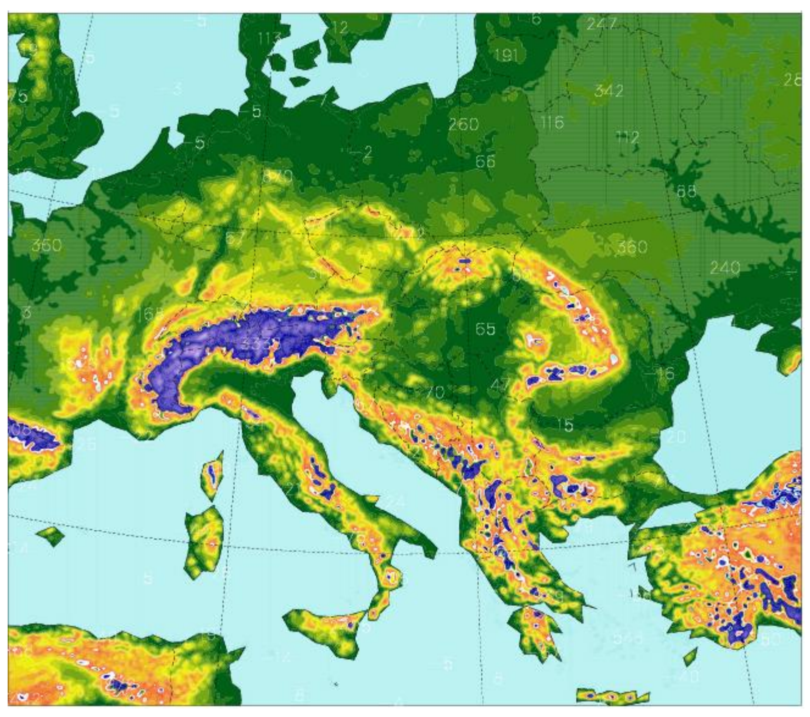
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

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 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

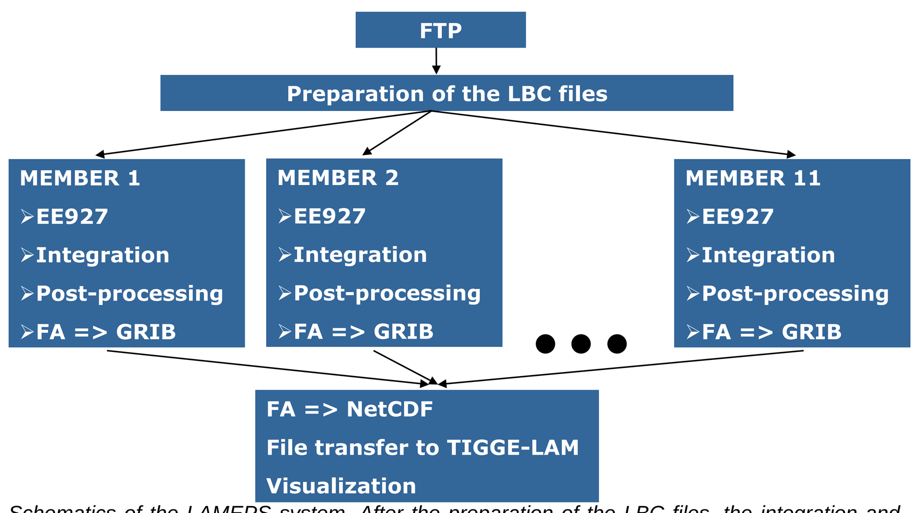
Observation usage

- 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 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.

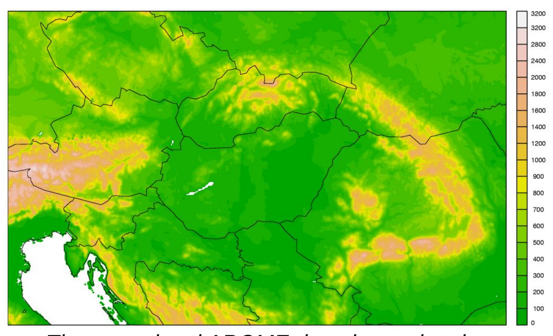


Schematics of the LAMEPS system. After the preparation of the LBC files, the integration and the post-processing are running in parallel for all the members. The preparation of the NetCDF files is done in one go for all members.

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.

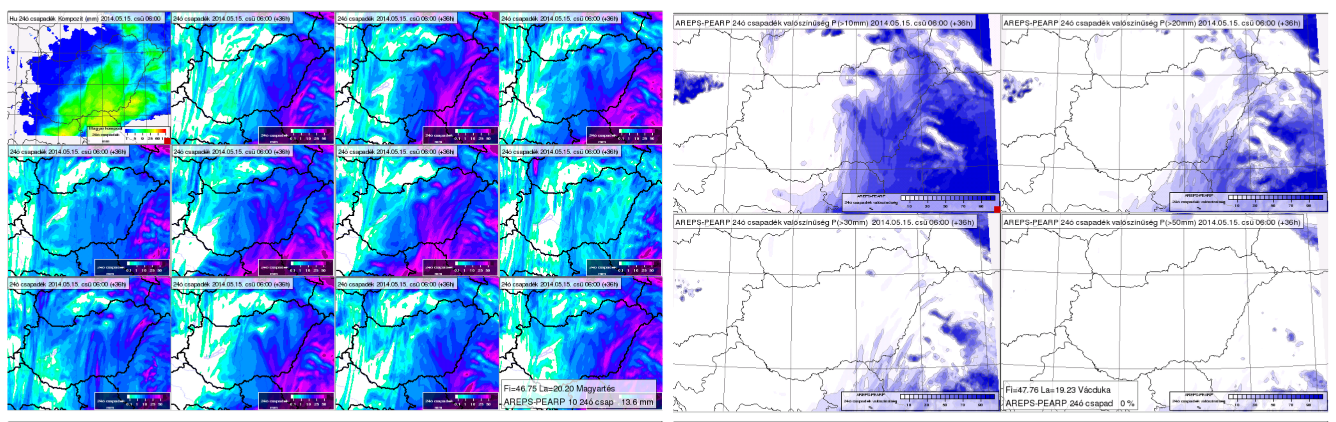
Case studies with the test version of AROME-EPS

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.

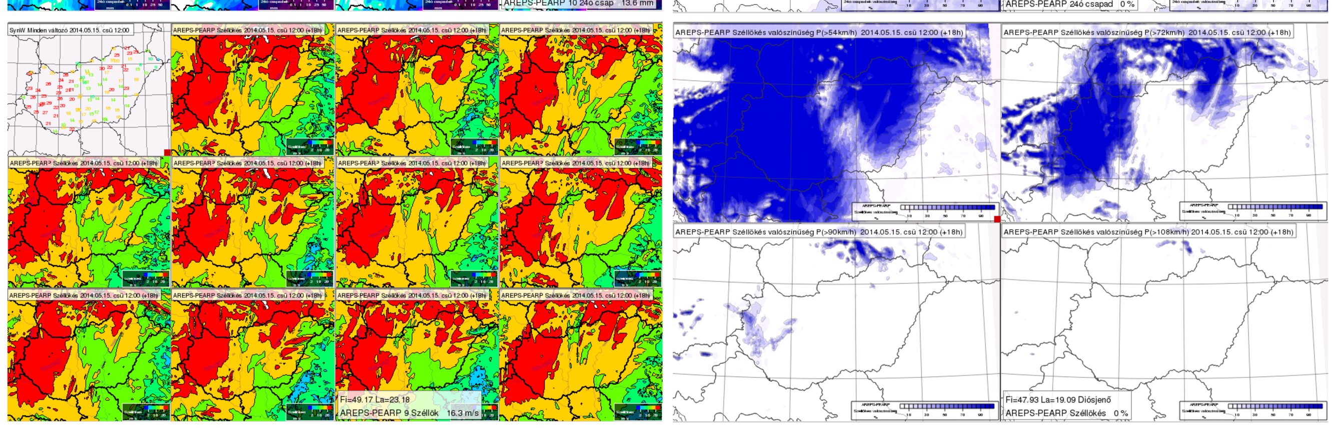
Some AROME-EPS results are represented here in connection with Yvette storm which hit the Central-European region on 12-17 of May, 2014. The storm caused serious damages in many countries because of the enormous amount of precipitation and the strong wind gusts.
AROME-EPS tests were run from three different 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.

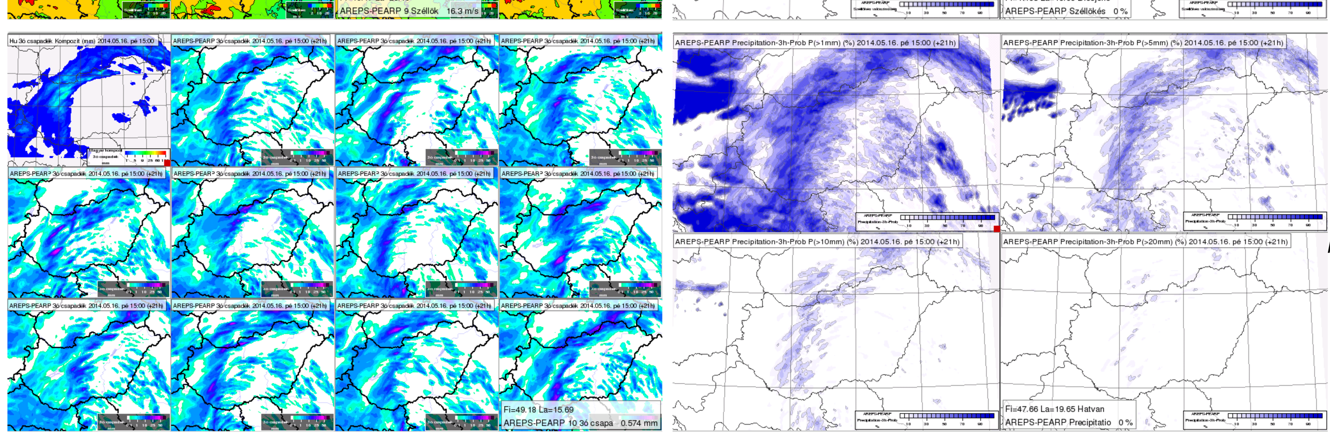
Probability and stamp diagrams are presented below from all the three ensemble runs. From the three different ensemble runs we show three different variables in accordance with the most hazardous aspect of the actual weather:
- On 14th of May the large-scale precipitation caused the biggest problems, especially in the south-eastern part of the country (upper row).
- On 15th of May the stormy 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.*



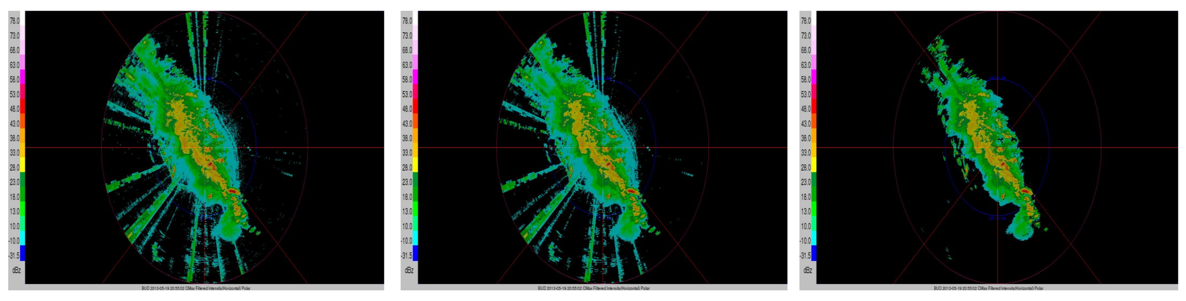
***Wind-gust** fields at 12UTC on 15th of May, 2014. AROME-EPS was started at 18UTC on 14th of May. **Left side:** Wind-gust SYNOP observation were compared with the 11 forecasted fields provided by the ensemble members. **Right side:** Maps show the forecasted probabilities of wind-gust bigger than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



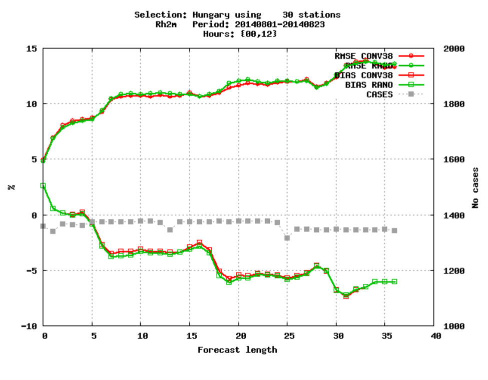
***3-hour precipitation** fields at 15UTC on 16th of May, 2014. AROME-EPS was started at 18UTC on 15th of May. **Left side:** Accumulated precipitation field was calculated from radar observations and compared with the 11 forecasted fields provided by the ensemble members. **Right side:** Maps show the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

RADAR reflectivity and radial wind in AROME DA system

The operational data assimilation system of AROME Hungary is using only SYNOP, TEMP and AMDAR reports. The assimilation of RADAR reflectivity and radial wind has been started with data from 3 Hungarian RADAR sites. The Quality Contol and file format conversion (to MF BUFR) were developed specifically for Hungarian RADARs by remote sensing division of OMSZ.



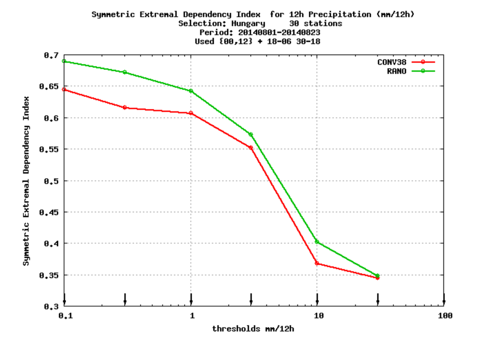
An example of RADAR reflectivity QC steps are plotted started from raw data on the left, after RaySmooth in the middle and after RLAN filter on the right figure.



RMSE and BIAS of 2m relative humidity forecasts for summer period of 2014.

The Hungarian RADAR QC basically contains RLAN filter, RaySmooth, Clear-sky echo removal and Velocity Filter procedures. After QC, conversion to MF BUFR is produced for reflectivity and radial wind as well by a locally developed so called HunBUFR tool. So far quality indexes number 0 and 6 are used in MF BUFR for norain and rainy pixels.

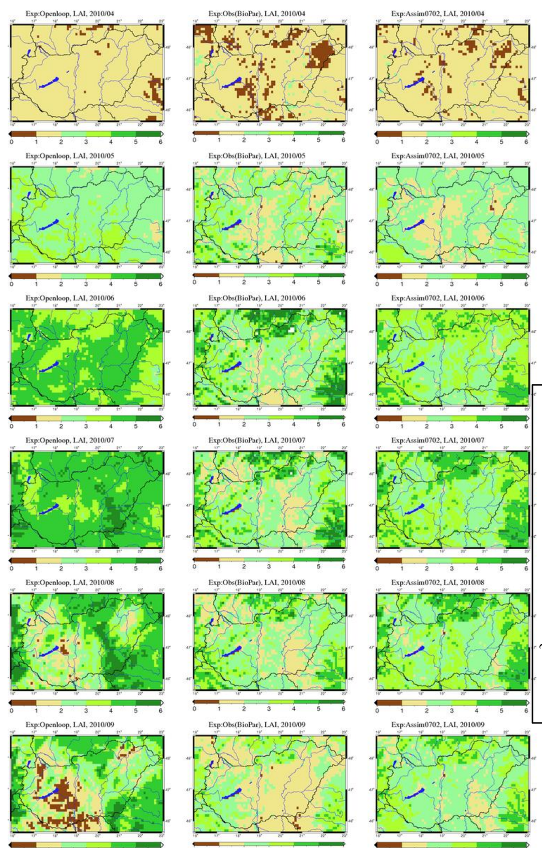
The impact of RADAR observations has been verified for summer period of 2012 and 2014. For these data assimilation OSEs, AROME 3h RUC 3DVAR and common cycle CY38t1 were used. Similar results (comparing the study of 2012 and 2014) have been obtained where RADAR assimilation did not change scores significantly (however sometimes minor improvement, sometimes minor degradation can be seen as well in RMSE-BIAS scores), but better precipitation skill scores were gained. Typical examples from the verification results can be seen on the right figures where green lines indicate the experiment using RADAR data as well and red lines show the performance of the operational version of AROME Hungary.



SEDI for 12h precipitation forecasts for summer period of 2014

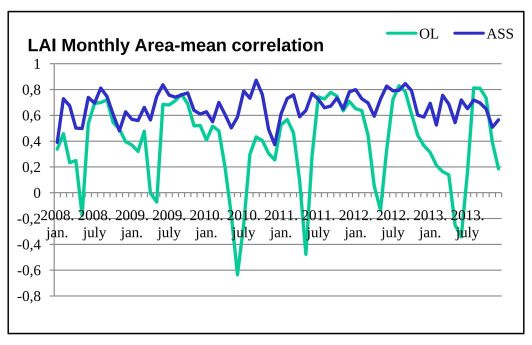
ImagineS project

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).



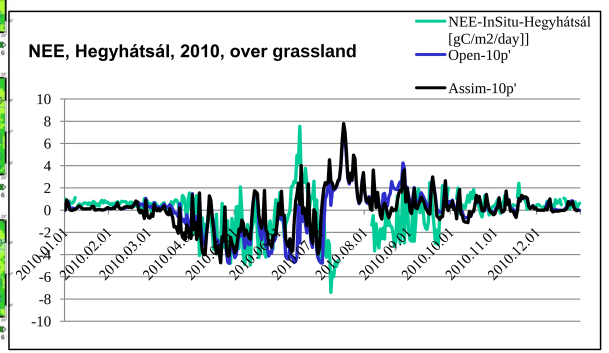
Validation of LAI, 2010 Apr-Sept. (first column: Open-loop, second: Satellite obs., third: Assimilation)

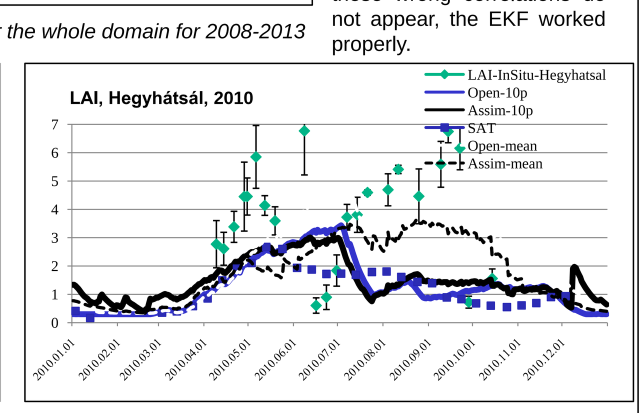
Figure on the left shows the monthly averaged LAI for the mentioned experiments for an extreme rainfall year 2010. Patch averaged LAI values were taken into account. The simulated LAI fields are closer to the satellite observation in case of assimilation than without it. The open-loop experiment over-estimates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

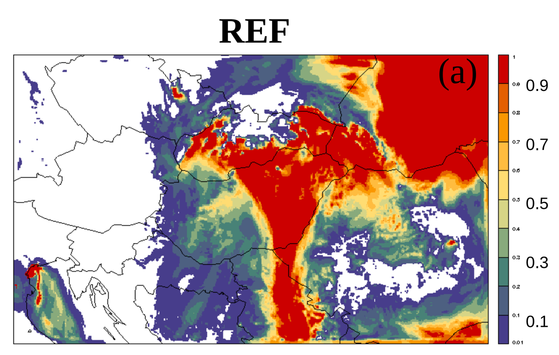
1D evaluation is presented above. NEE is well simulated almost the whole year for both experiments, except for the summer and autumn, when the experiments give positive NEE values – this means emission of CO_2, but the measurements are negative – which means uptake of CO_2. Turning to LAI it can be seen 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.

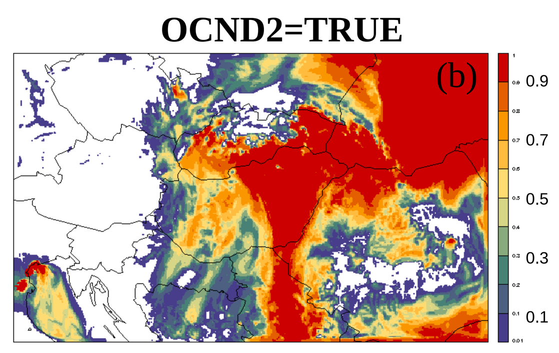
Low cloud experiments with AROME

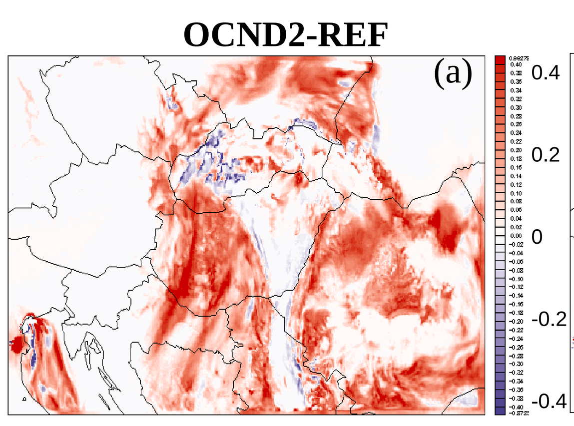
In wintertime thermal inversion with fog and stratus cloud is a common phenomenon over the Carpatian Basin. It often lasts 7-10 days and only a strong cold front is able to sweep out from the basin. During this period the scenario of each day is very similar: at night stratus sinks down to the surface forming fog then after sunrise fog begins to elevate because cloud top becomes an emissive surface where condensation starts. NWP models usually predict well the nighttime fog but they tend to dissolve the stratus layer in daytime.

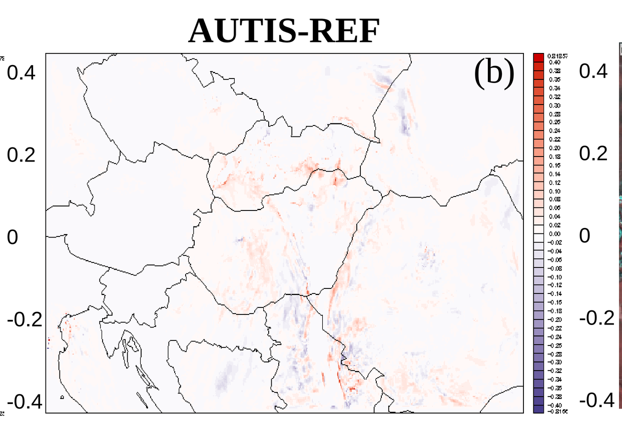
Sensitivity experiments by Szintai et al. (2014) indicated that the cause of the underestimation of low cloud cover can be searched in the microphysics parameterization. It was suggested to tune the autoconversion function and by now this modification has become operational. It was experienced that increase of the critical value of the autoconversion is not able to solve the problem in all of the cases, so developments continued and the modification of cloud physics (ICE3) suggested by Karl-Ivar Ivarsson (2014) was implemented our AROME configuration (cy38) which can be switched with LOCND2 logical variable from namelist. This modification pack consist of a more rigorous separation of the liquid water and ice phases in the calculation of the mixed phase clouds.

In the case study 16th December 2013 the modification of autoconversion did not change significantly the low cloud cover forecast while in the run with the OCND2 version the stratus layer increased. In the earlier studied case (day of 30th November 2011) the cloud fraction also increased with OCND2=TRUE setting but on a different way than with the autoconversion modification (not shown). The cloud became thinner and more homogenous on the area contrary to the reference run where only in a small area remained from the stratus but there the cloud fraction was 100%.

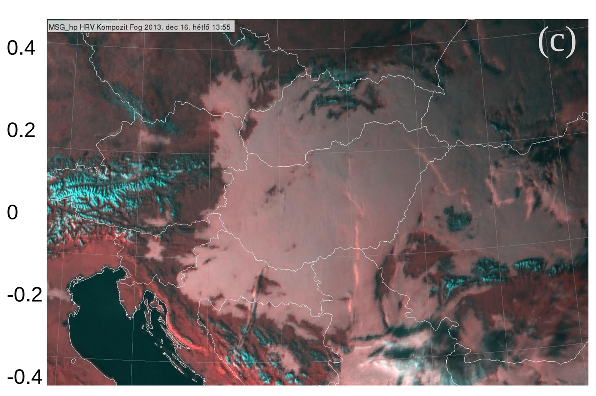






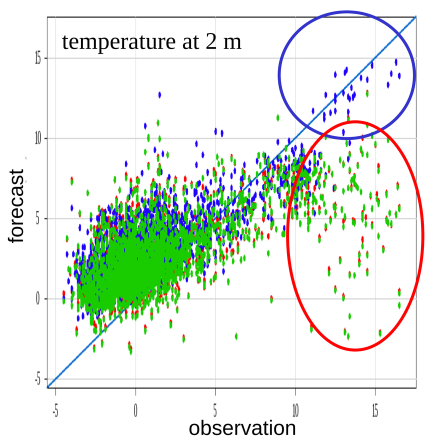


Low cloud cover forecast difference fields on 16th December 2013 at 14 UTC a) OCND2 modification vs. reference run b) autoconversion modification vs. reference run.

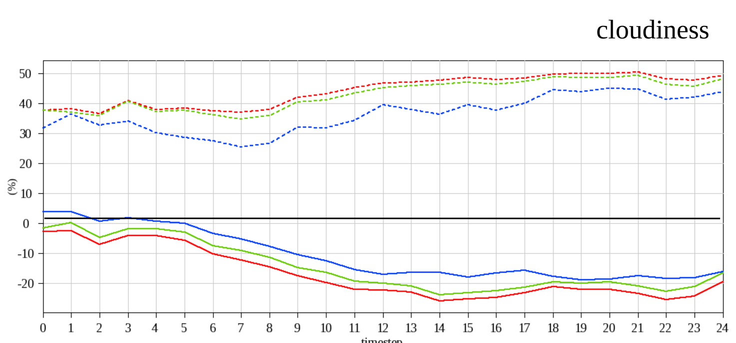


Low cloud cover forecast fields on 16th December 2013 at 14 UTC a) in the reference run, b) with OCND2 modification c) MSG satellite image.

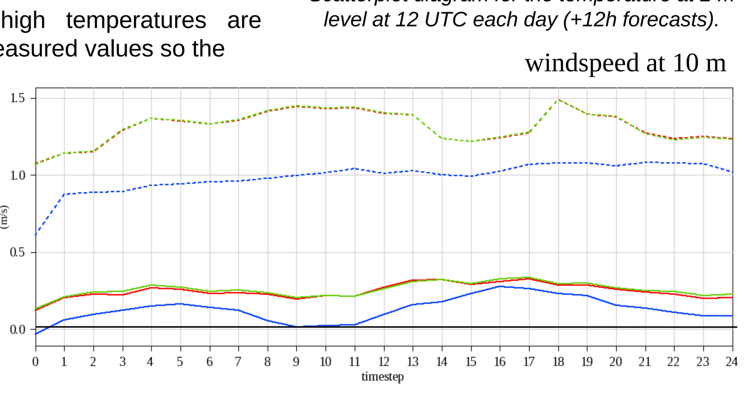
The two modifications was tested together for a two-weeks period from 18th November to 2nd December 2011 when the conditions were given for the above mentioned meteorological situation almost during the whole period. Each day a 24 hours forecast was run starting at 00 UTC. The results shows smaller bias and root mean square error in cloud forecasts. The temperature RMSE also decreased in the new experiment but the bias increased in daytime. In the previous experiments low temperatures were overestimated and high temperatures were underestimated but in the OCND2 modified run high temperatures are closer to the measured values so the bias comes from only the low temperatur overestimation. Windspeed shows better scores as well.

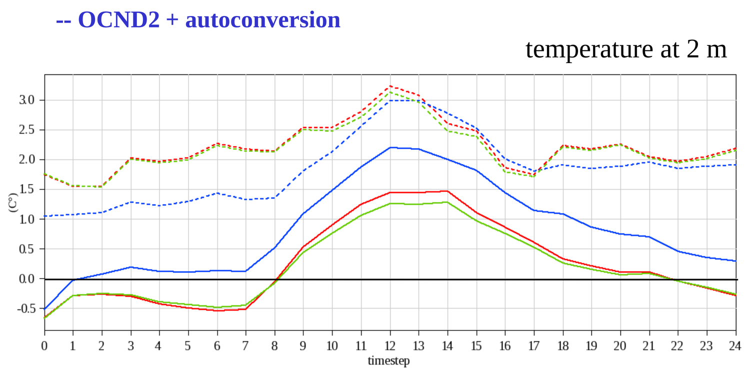


Scatterplot diagram for the temperature at 2 m level at 12 UTC each day (+12h forecasts).



-- reference run
-- autoconversion modification
-- OCND2 + autoconversion





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

Szintai, B., Bazile, E., Seity,Y. (2014): Improving wintertime low cloud forecasts in AROME: sensitivity experiments and microphysics tuning. *ALADIN-HIRLAM Newsletters*, No. 3., 45-58.

Ivarsson, K.-I. (2014): Modification of AROME ICE3 cloud physics, a status report. *METCOOP MEMO*, No. 2, 32 pp.

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