Working Area Predictability

Progress Report

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Period: 2015

Date: February 2016

Progress summary

Our research in 2015 was mostly focused on the topics related to the model uncertainty simulation in ALADIN-LAEF system. The combination of initial conditions uncertainty generated by the ensemble of surface data assimilations with the stochastically perturbed physics tendencies was implemented and tested. This comprises the application of stochastic physics within a full assimilation cycle with the perturbed observations.

In parallel, the research on convection-permitting ensembles were carried on at both Hungarian and Austrian national services. However, this task was affected by the limited computer resources. Thus the perturbation methods were sometimes tested rather utilizing a high resolution ALARO model instead of AROME.

Executed were also some preliminary experiments involving pure dynamical downscaling of the operational ALADIN-LAEF forecast on 11 km into the high resolution grid at 5 km. In spite of initially negative signal, the repeated experiments with adapted integration namelists brought already some promising results.

There were four LACE stays executed by Predictability working group at ZAMG during 2015. Martin Belluš (SHMU) spent 5 weeks processing the combination of the IC uncertainty generated by the ESDA with the stochastically perturbed physics tendencies of the surface prognostic variables in ALADIN-LAEF and 5 weeks on the implementation of stochastic perturbation of physics tendencies in new CY40T1 with ALARO-1 physics. Simona Taşcu (NMA) spent 8 weeks verifying the operational ALADIN-LAEF ensemble system against the lagged ensemble created out of high-resolution ALARO deterministic runs, and also a heavy precipitation event from June 2013 was investigated in case study. Mihály Szűcs (OMSZ) spent 6 weeks on testing of possible SPPT developments.

The long term effort, which has been put into the research in the area of ensemble forecasting, was crowned by the submission of several scientific papers in peer-reviewed journals. The paper “On the impact of the choice of global ensemble in forcing a regional ensemble system” (Weidle, Wang, Smet) was already published by AMS in Weather and Forecasting in January 2016. Another paper “Perturbing surface initial conditions in a regional ensemble prediction system” (Belluš, Wang, Meier) was finally submitted to Monthly Weather Review in January 2016 and now waits for the peer reviews. The paper “Ensemble forecasting in numerical weather prediction” (Szűcs, Horanyi, Szépszó) was submitted to the special issue of Mathematical Problems in Meteorological Modelling by Springer and now waits for the final decision.

A successful project founded by European Commission called PROFORCE, joining together the effort of Hungarian and Austrian weather services, came into its final stage in 2015. Introduced was an innovative seamless probabilistic forecast chain joining different NWP models and products. It works with forecast lead times from week to hours and spatial scales from regional to kilometric in order to give an early warning and mitigate the possible impact of extreme weather events like heavy rain, flash floods or strong wind. At the same time, the system was tailored to suit well the civil protection and the other stakeholders. The outcome of the cooperation in form of the probabilistic forecast products have been published on the dedicated web portals, which are used by the concerned authorities.

Scientific and technical main activities and achievements, major events

S1 Action/Subject/Deliverable: Optimization of ALADIN-LAEF

Description and objectives: This subject summarizes ongoing and completed tasks of the ALADIN-LAEF research and development. Achieved results, new tested implementations and gained expertise are going to be used for the further improvement of our regional ensemble forecasting system.

- **Combination of IC and model uncertainties for the surface prognostic variables in ALADIN-LAEF system:**

Generally speaking, there are two different sources of uncertainties in NWP modelling. The first one is the uncertainty of the initial and boundary conditions and the second one is the uncertainty of the numerical models themselves. Here we do not mean the exact accuracy of the computations, but rather the approximation of the nature by half-empirical physical parameterizations or by their inevitable simplifications due to limited computer resources (from the computational point of view).

In ALADIN-LAEF system we already implemented and heavily tested the following perturbation methods:

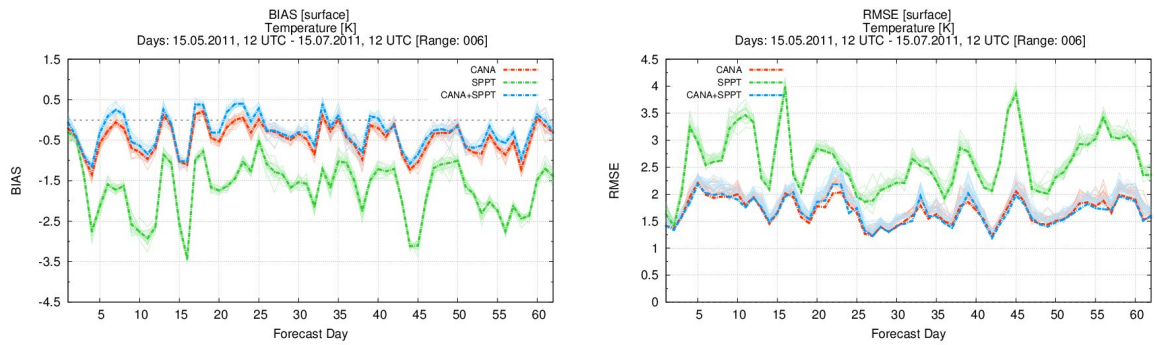
- IC uncertainty: Non-Cycling Surface Breeding (NCSB), Ensemble of Surface Data Assimilations (ESDA), upper-air breeding-blending
- model uncertainty: multi-physics (MP), Stochastically Perturbed Physics Tendencies (SPPT)

Stochastic physics, for the perturbation of surface prognostic fields through their parameterized tendencies, was introduced into the ALADIN-LAEF R&D version last year (see RC LACE report: M. Belluš, 2014: Stochastically perturbed physics tendencies of surface fields in ALADIN-LAEF system). Nevertheless, it was tested only in so called dynamical adaptation mode without any other LAEF system components, nor it was put to operations. Hence, further logical step towards its

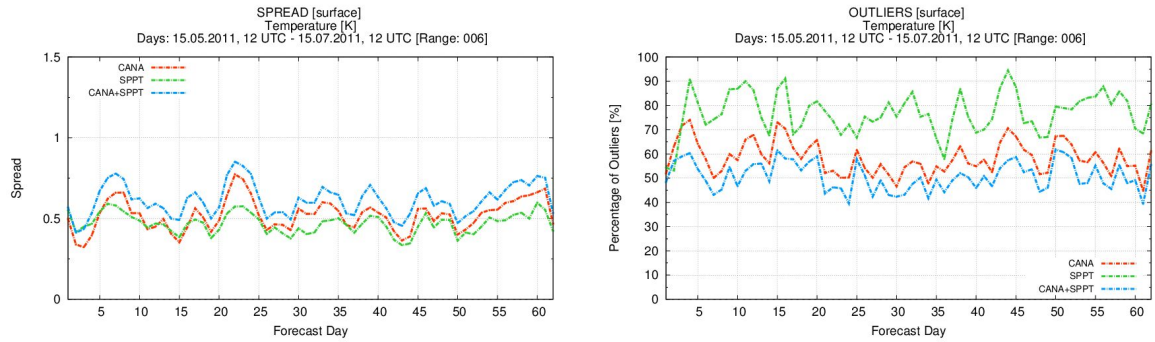
operational implementation was to test it in combination with the IC perturbation. Among the other things, this meant to run SPPT in full assimilation cycle with the perturbed observations.

In order to do that, it was necessary to migrate firstly the modular R&D version of ALADIN-LAEF system to the new CRAY supercomputer at ECMWF. A tricky technical task was not only the re-compilation of model and its tools on new platform, but rather the emulation of dependencies between the jobs, because such feature is missing in PBS queueing system used on CRAY cluster. The introduction of the appropriate running scripts was needed to run fully automated long term experiments on new machine out of the SMS environment.

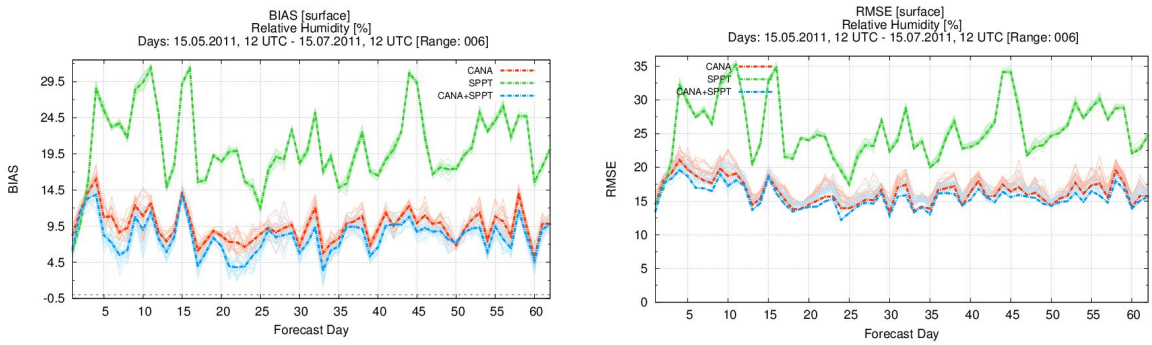
Positive impact gained by the combination of IC and model uncertainties, applying both the ESDA and SPPT for the surface prognostic variables, can be observed for screen level temperature, relative humidity as well as for wind speed (not shown).



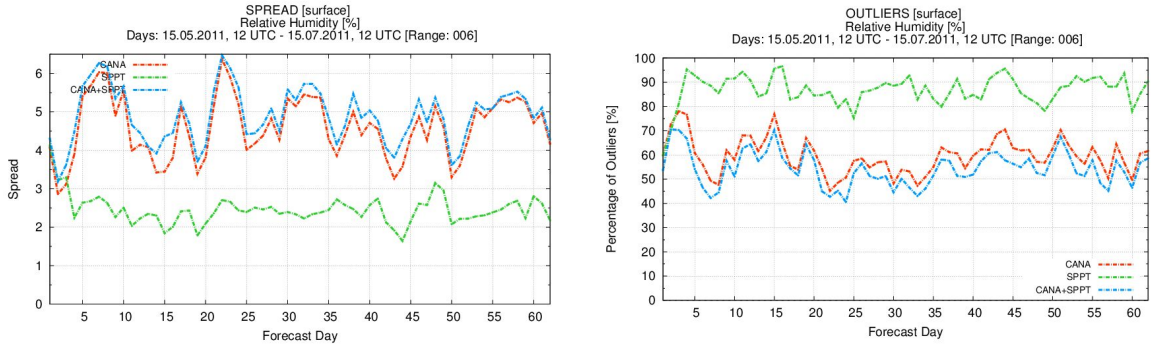
Temperature at 2m: Time series (+6h forecast) of BIAS (left) and RMSE (right) for the 62 days of the validation period for the experiments CANA (red), SPPT (green) and CANA+SPPT (blue).



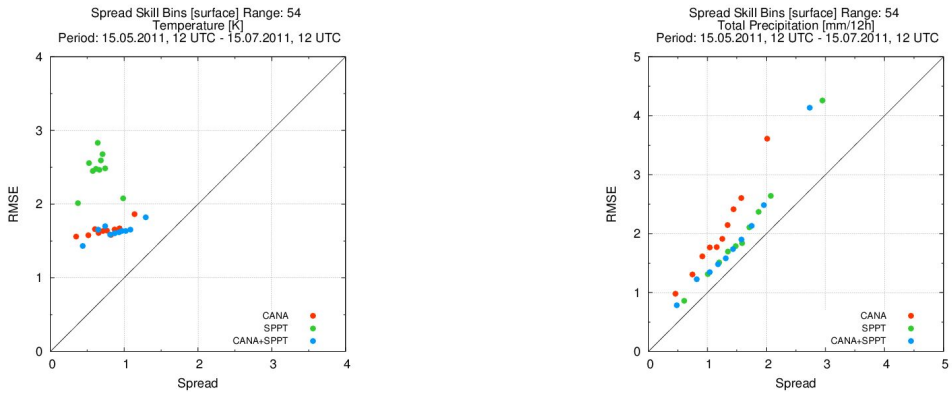
Temperature at 2m: Time series (+6h forecast) of ensemble SPREAD (left) and OUTLIERS (right) for the 62 days of the validation period for the experiments CANA (red), SPPT (green) and CANA+SPPT (blue).



Relative Humidity at 2m: Time series (+6h forecast) of BIAS (left) and RMSE (right) for the 62 days of the validation period for the experiments CANA (red), SPPT (green) and CANA+SPPT (blue).



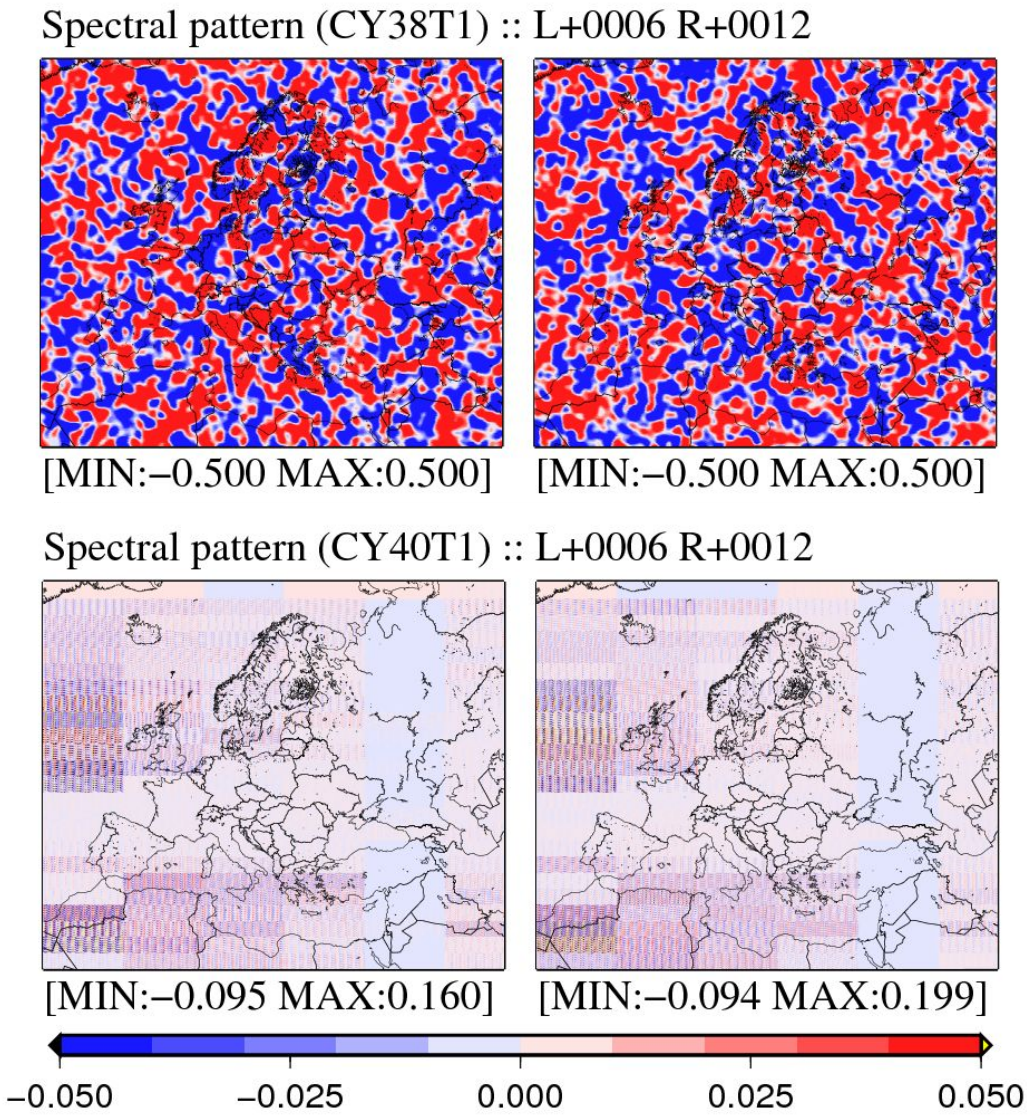
Relative Humidity at 2m: Time series (+6h forecast) of ensemble SPREAD (left) and OUTLIERS (right) for the 62 days of the validation period for the experiments CANA (red), SPPT (green) and CANA+SPPT (blue).



Spread Skill for the verification bins for 2m temperature (left) and 12h accumulated precipitation (right) valid at +54h, computed from 62 days experiment with CANA (red), SPPT (green) and CANA+SPPT (blue).

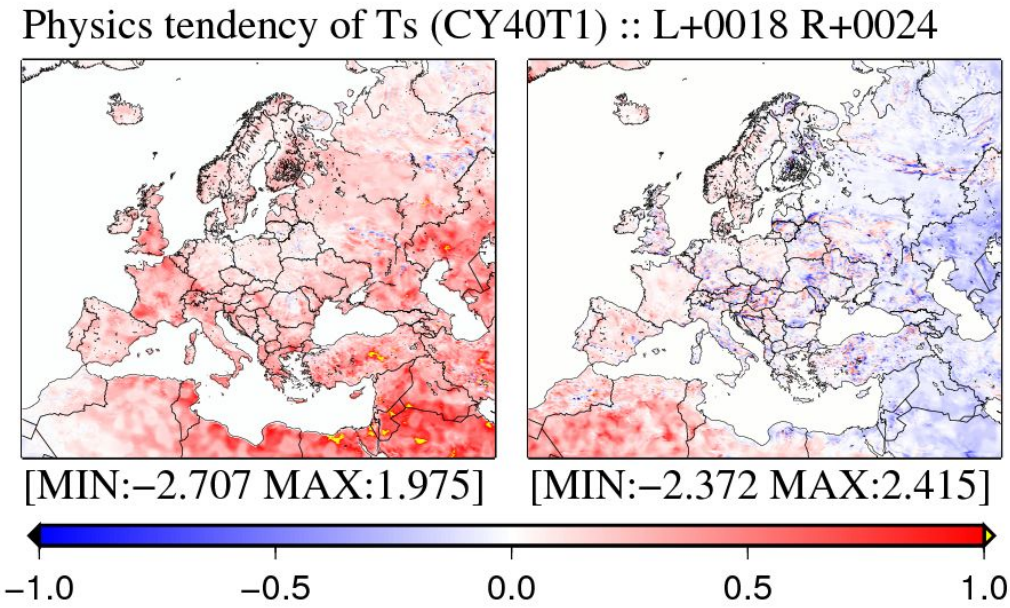
- **Stochastic perturbation of physics tendencies in new CY40T1 with ALARO-1 physics**

The implementation of SPPT in the new export version of CY40T1 was not that straightforward as expected. First experiments were spoiled and quite a lot of time was spent by tracking down the real source of the error. Finally, we identified the problem directly in the array storing the stochastic pattern (PGDSDT2D) and with a great help of Christoph Wittmann and Mihály Szűcs, who did some parallel testing of the same problem on SGI at ZAMG, the bug was eventually found in CPG routine. Stochastic pattern passed to MF_PHYS was declared but never correctly filled with the random numbers, i.e. the content of PGDSDT2D was unpredictable chunk of memory.

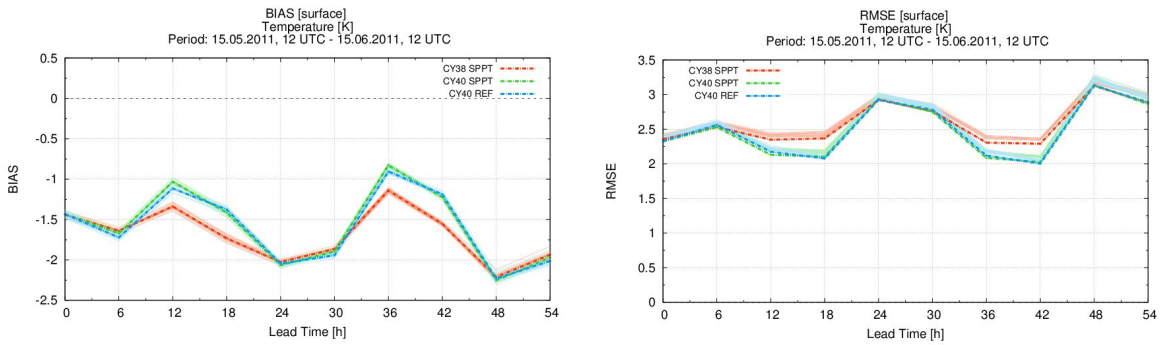


Spectral pattern in CY38T1 (first row) and CY40T1 (second row) for sigma=0.25, tau=2h and L=500 km for the ranges +06 (left) and +12 (right).

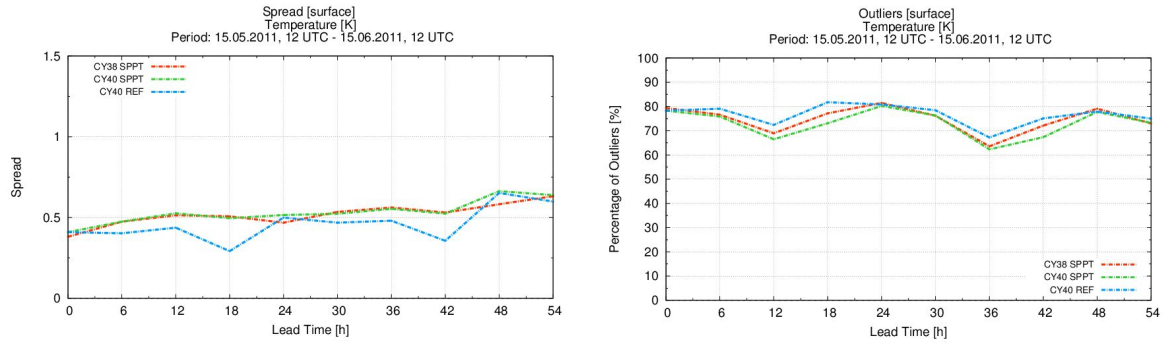
Following experiments with the fixed CPG routine in CY40T1 including surface SPPT development (mf_phys.F90, sppten_isba.F90) on CRAY at ECMWF gave already expected results. It can be concluded, that we have discovered an important issue in the export version of CY40T1 (bf5) and the implementation of SPPT was finally successful. Results from the statistical verification of one month period show significant improvement in CY40T1 over CY38T1 for screen-level temperature forecast during night hours, but that is most likely due to improved physics in ALARO-1 package (looking on the comparison with the reference). Nevertheless, some slight enhancement of the scores obviously came from SPPT as well (see figures).



Perturbed physics tendency of surface temperature in bugfixed CY40T1 for range +18 (06h in the morning, left) and +24 (12h at noon, right).



Temperature at 2m BIAS (left) and RMSE (right) for SPPT experiments on CY38T1 (red) vs CY40T1 (green) and the reference without SPPT on CY40T1 (blue) computed over the one month verification period.



Ensemble SPREAD (left) and OUTLIERS (right) of temperature at 2m for SPPT experiments on CY38T1 (red) vs CY40T1 (green) and the reference without SPPT on CY40T1 (blue) computed over the one month verification period.

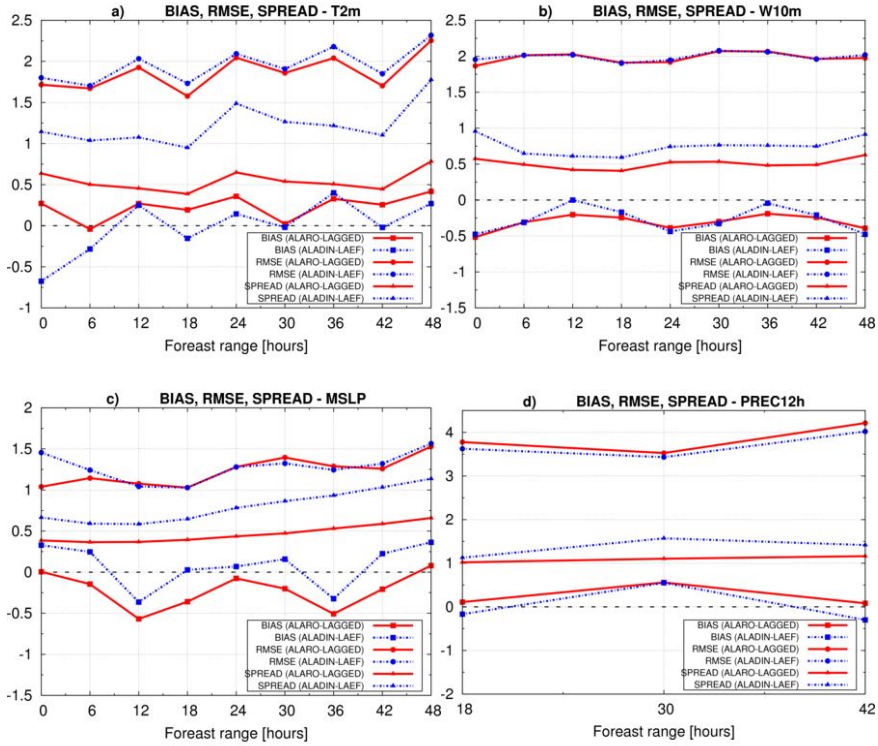
- **ALADIN-LAEF regional ensemble system comparing to the ALARO higher resolution deterministic model:**

The main purpose of this study was to evaluate the forecasts provided by the deterministic model ALARO and the regional ensemble system ALADIN-LAEF. Using the available operational ALARO forecasts counting the 4 deterministic runs per day, a time-lagged ensemble (ALARO-LAGGED) was created. It consists of 5 consecutive model runs. Therefore, 16 members of ALADIN–LAEF and 5 members of ALARO-LAGGED were used in the evaluation.

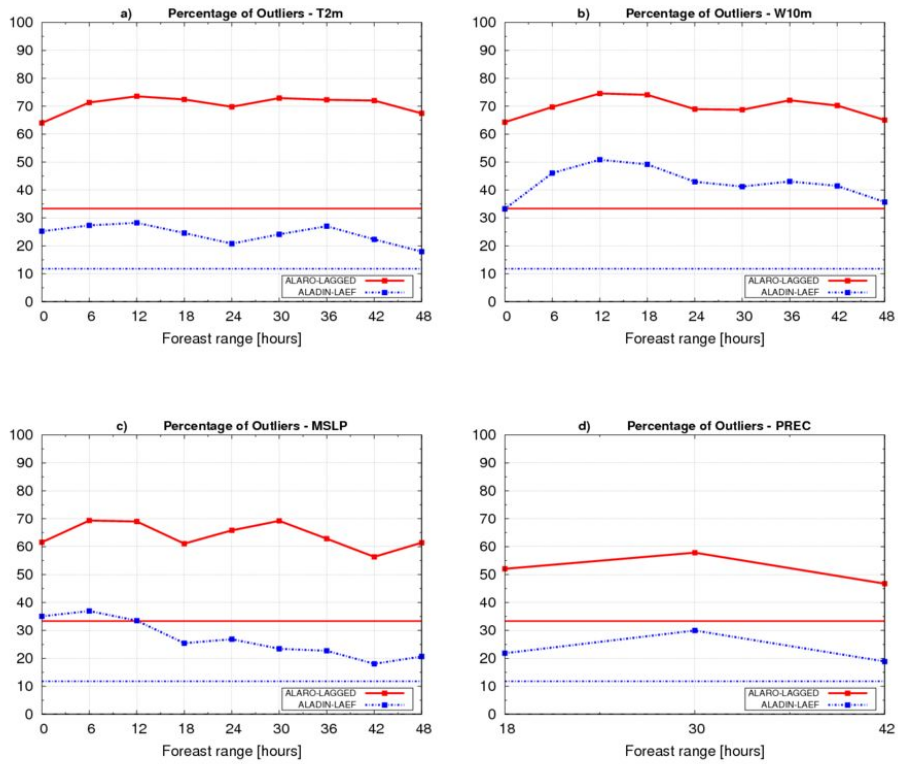
Both systems were tested for 2 months period (23rd April to 23rd June 2013, forecast up to 48 hours), while the output data were interpolated at 0.04° x 0.06° resolution for ALARO-LAGGED and at 0.1° x 0.14° for ALADIN-LAEF. The verification was performed over a domain which covers Europe and the verified parameters were 2m temperature, 10m wind speed, 12 hourly accumulated precipitation and mean sea level pressure.

While the results show that ALARO-LAGGED has a similar ensemble mean RMSE compared to the one of ALADIN-LAEF, its spread is obviously smaller and it has also more outliers. Although, it can be noticed that the accuracy of both systems is quite similar, ALADIN-LAEF is statistically more reliable.

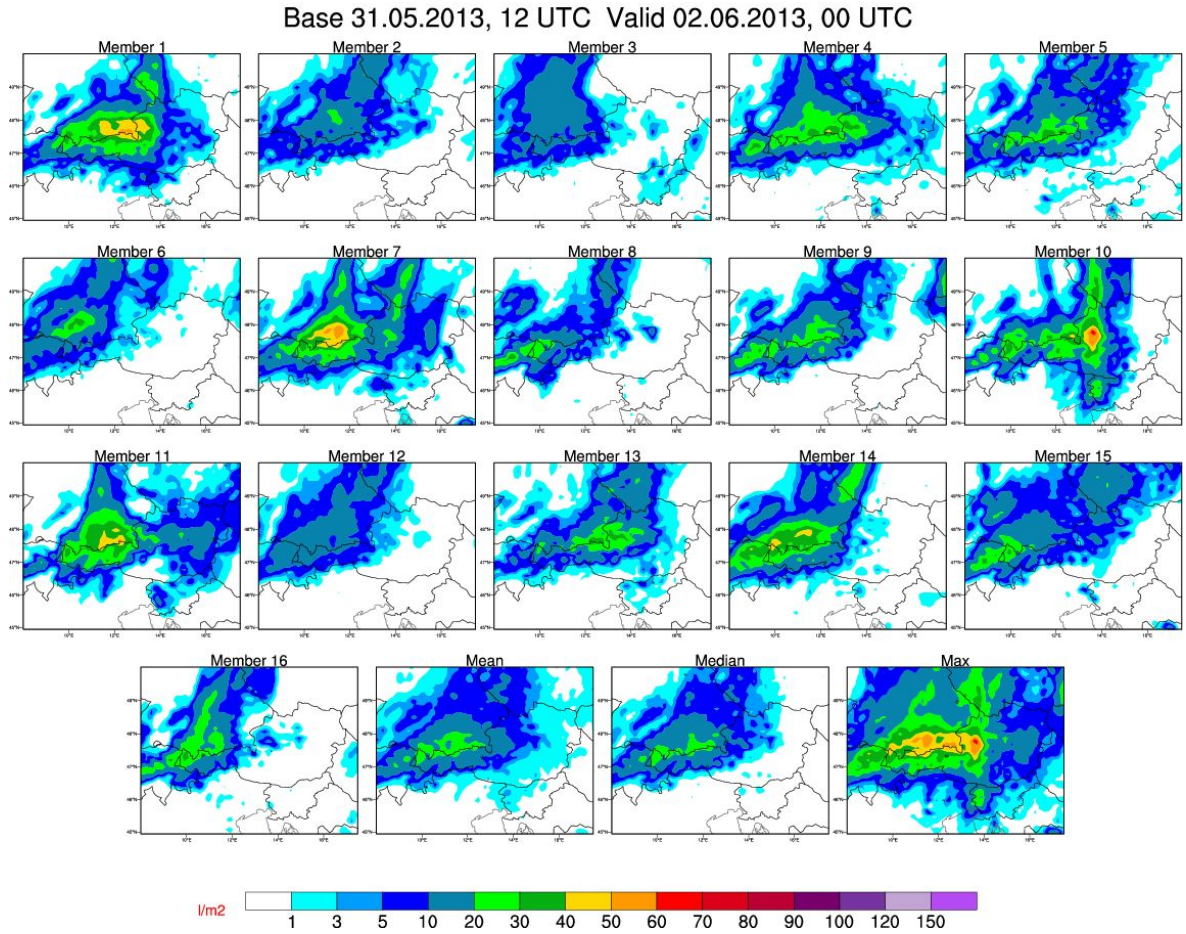
Furthermore, a case study reflecting the heavy precipitation and flooding event which occurred during 31st of May till 3rd of June 2013 in Central Europe, is included. The ALARO-LAGGED and ALADIN-LAEF forecasts are confronted. In Austria, between 31st of May, 00 UTC and 3rd of June, 00 UTC the highest amount of precipitation reached up to 300 mm/72h.



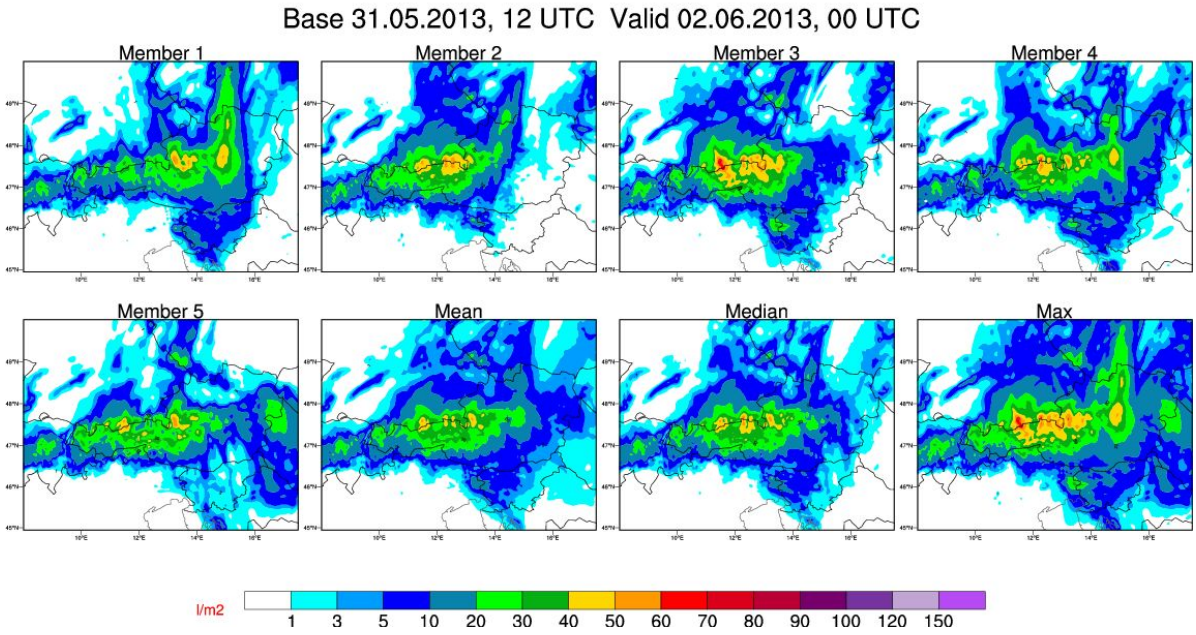
BIAS, RMSE of ensemble mean and ensemble SPREAD for ALARO-LAGGED (red) and ALADIN-LAEF (blue): a) temperature; b) wind speed; c) MSLP and d) 12h accumulated precipitation.



Percentage of outliers for ALARO-LAGGED (red) and ALADIN-LAEF (blue): a) temperature; b) wind speed; c) MSLP and d) 12h accumulated precipitation.



6h accumulated precipitation for all ALADIN-LAEF members + mean, median and maximum of the ensemble, 31.05.2013, 12 UTC + 36h.

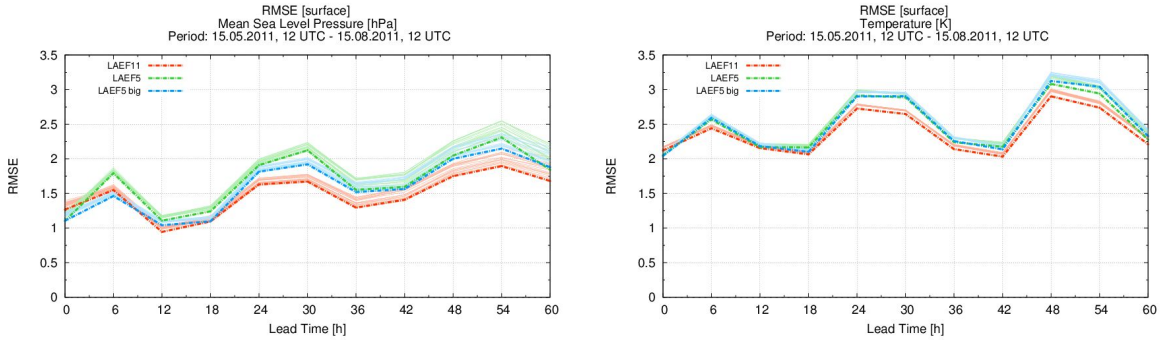


6h accumulated precipitation for all ALARO-LAGGED members + mean, median and maximum of the ensemble, 31.05.2013, 12 UTC + 36h.

❑ The first experiments with ALADIN-LAEF 11 km versus 5 km

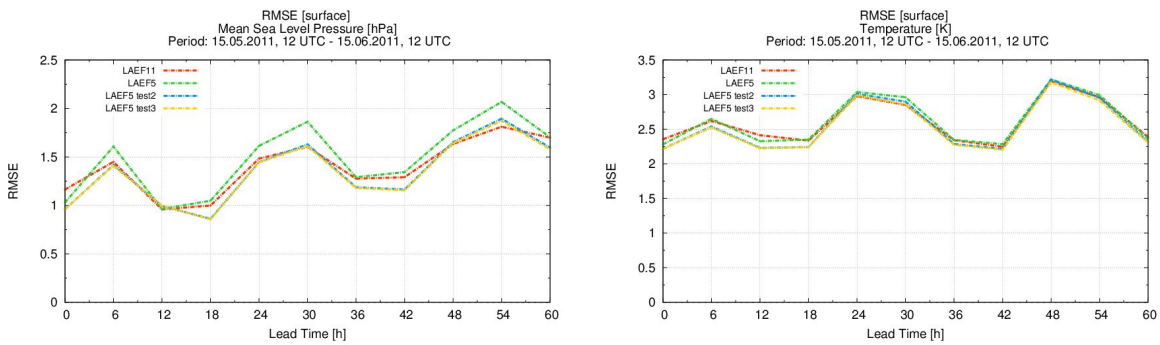
Indeed, a very simple experiment was performed as a first step towards the higher resolution ALADIN-LAEF regional ensemble. For standard 3-months verification period in 2011 a pure dynamical downscaling of ALADIN-LAEF forecast was carried out. The LAEF forecast on 11 km grid was used to couple the same system, but on 5 km grid - firstly on smaller domain covering just the central Europe and then on a bigger domain (to exclude the effect of boundaries).

In the first attempt it turned out that the pure downscaling of such complex system is far from ideal and it can not be used without some special tunings valid at the higher resolution.



RMSE of MSLP (left) and T2m (right) for the ensemble mean and 16 ensemble members of ALADIN-LAEF 11 km (red), 5 km - small domain (green) and 5 km - big domain (blue).

It was found, that the most sensitive e001 namelist parameter is LREGETA, which defines ETA level spacing in Semi-Lagrangian interpolators. While TRUE value is normally used in ALADIN for regular ETA level spacing, FALSE value is used by Meteo-France. In ALADIN-LAEF we are using both values within the different MP settings to enhance the ensemble spread. But we found it responsible for the scores deterioration on 5 km resolution. Another parameter that we have changed, but with much weaker effect was GENVSRH (coefficient driving use of RH integral in the entrainment).



RMSE of MSLP (left) and T2m (right) for ALADIN-LAEF 11 km (red), 5 km - (green) and 5 km - modified namelist (blue - LREGETA=.F., yellow - LREGETA=.F. and GENVSRH=1.).

It can be expected, that the quality gain of 5 km ALADIN-LAEF against the current 11 km operational version in the first forecast hours will be bigger, when also higher resolution uncertainty source in IC is incorporated (e.g. ESDA cycle for the surface and breeding-blending for the upper-air). In the downscaling experiment instead of the native high resolution IC perturbations mostly the noise from the interpolation was included.

Efforts: 6 PM (4 PM LACE stays)

Contributors: Martin Belluš (SHMU), Simona Taşcu (NMA), Yong Wang (ZAMG), Endi Keresturi (PhD at ZAMG)

Documentation: Reports on stays; scientific papers submitted or in the preparation phase

Status: Ongoing

S2 Action/Subject/Deliverable: ALADIN-LAEF maintenance

Description and objectives: The main objective of this task is to maintain and monitor the operational suite of ALADIN-LAEF running at ECMWF. As a result a stable operational suite of ALADIN-LAEF is guaranteed and the delivery of probabilistic forecast products (GRIB files, plots) for the LACE partners is ensured.

No special tasks nor upgrades of the system were scheduled for this year. Hence, the technical details of ALADIN-LAEF operational version running on CRAY HPCF at ECMWF are without the significant changes:

- 10.9 km horizontal resolution and 45 vertical levels
- 00 and 12 UTC runs up to +72h
- 16 perturbed members + 1 unperturbed control run
- lagged (by 12h) ECMWF-EPS coupling (first 16 ECMWF-EPS members are used)
- multi-physics (16 different MP combinations and tunings for micro-physics, deep/shallow convection, radiation and turbulence)
- ensemble of surface DA by CANARI with perturbed T2m and RH2m observations for the soil and surface IC perturbations
- upper-air spectral blending by DFI to combine ECMWF-EPS perturbations with ALADIN-LAEF breeding vector for IC perturbations on model levels
- production and dissemination of multi-GRIB files with the ensemble forecast

Efforts: 0.5 PM

Contributors: Florian Weidle (ZAMG)

Documentation: LAEF flow charts

Status: Permanent maintenance tasks

S3 Action/Subject/Deliverable: AROME-EPS

Description and objectives: This task covers quite wide area of research and development regarding convection-permitting ensembles. Such high-resolution ensembles utilizing non-hydrostatic model AROME are developed concurrently at OMSZ and ZAMG institutes. In this subject is included also the seamless ensemble cascade system developed within the European project PROFORCE, which successfully finished at the end of the year.

- **New development and the experiments at OMSZ:**

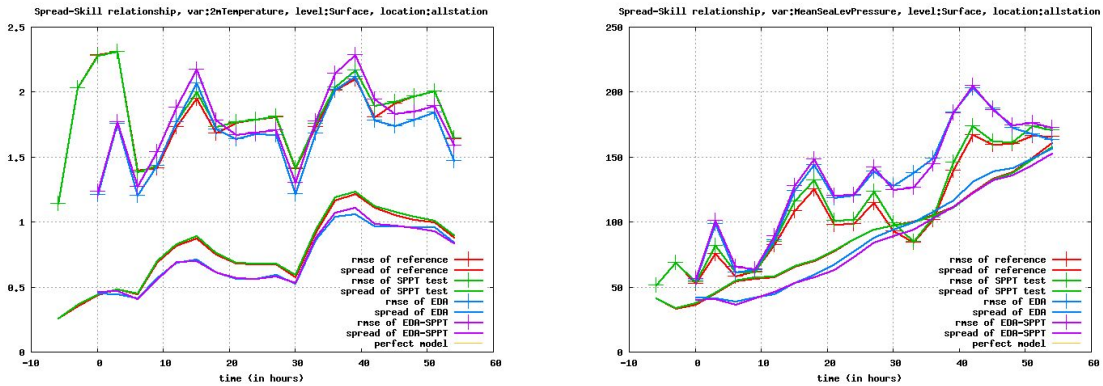
At OMSZ they are primarily focusing on their future convection-permitting EPS. However, it was decided to make some final development on the current ALARO-EPS 8 km version. ALARO-EPS will be in operation till a new machine is available at OMSZ, where an high-resolution AROME-EPS can smoothly run. Therefore, some tests mainly with ALARO-EPS were performed concerning the topics:

- ensemble data assimilation
- stochastic perturbation of physics tendencies
- ECMWF-EPS boundary conditions tests

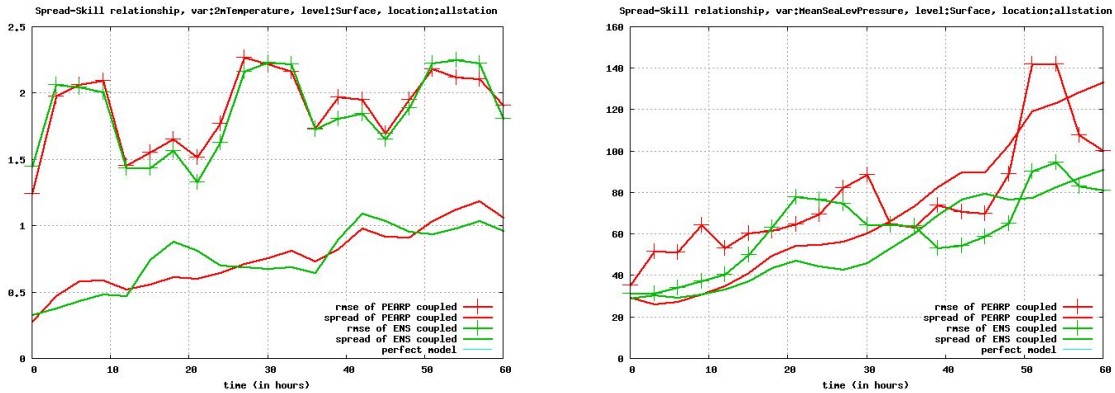
However, the results are not quite satisfactory, mainly because the data assimilation did not perform nicely. It means that DA caused quality degradation on an unperturbed control member. Suspicious is the way how the data assimilation cycle was installed. PEARP LBCs were used, which are updated just once a day and have only 6-hour frequency. After all it was decided to change to ECMWF-EPS LBCs, which makes possible a better coupling strategy in a DA cycle. Currently this new coupling model is tested at OMSZ and then it will be again possible to examine how:

- DA affects the control member
- EDA affects the whole ensemble

Recently also SPPT in ALARO-EPS was tested in both the forecast and DA cycle. Its impact was very slight, but since now everything is restarted from the new LBC choice, there is a chance that the results will be different. On the following plots one can see the pure and the combined impact of EDA and SPPT. EDA always decreased spread but in case of MSLP it made degradation also in RMSE score. On the other hand, SPPT has not a big impact at all.



RMSE and SPREAD for T2m (left) and MSLP (right) for EDA-SPPT combination (violet), EDA alone (blue), SPPT alone (green) and the reference (red).



RMSE and SPREAD for T2m (left) and MSLP (right) for system coupled to PEARP (red) and to ECMWF-EPS (green).

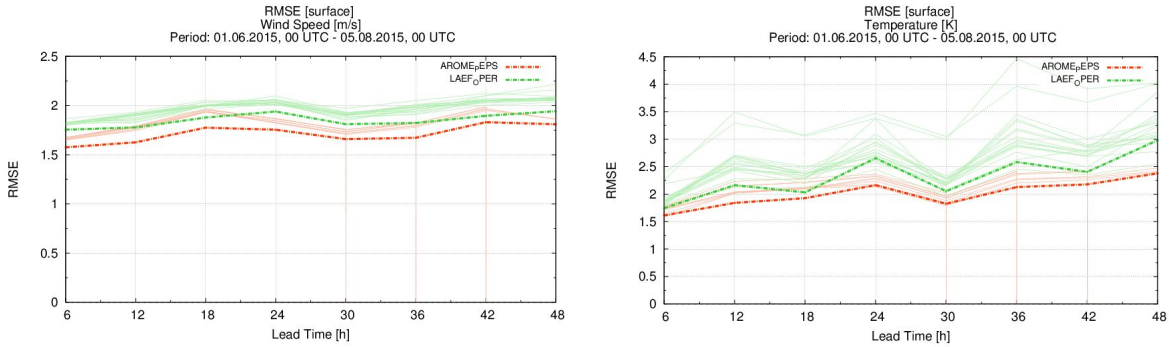
- **AROME-PEPS experiments at ZAMG:**

AROME-EPS exists at ZAMG, but due to the limited computing resources it is available just “on demand” in critical weather situations. Therefore, at the moment the experiments with cheap lagged ensemble system AROME-PEPS have been started. The ensemble system is constructed from the operational deterministic AROME runs, which are available 8-times per day every 3 hours. Since deterministic AROME model is integrated up to +60h, 8 subsequent runs can be used to cover the next 36 hours.

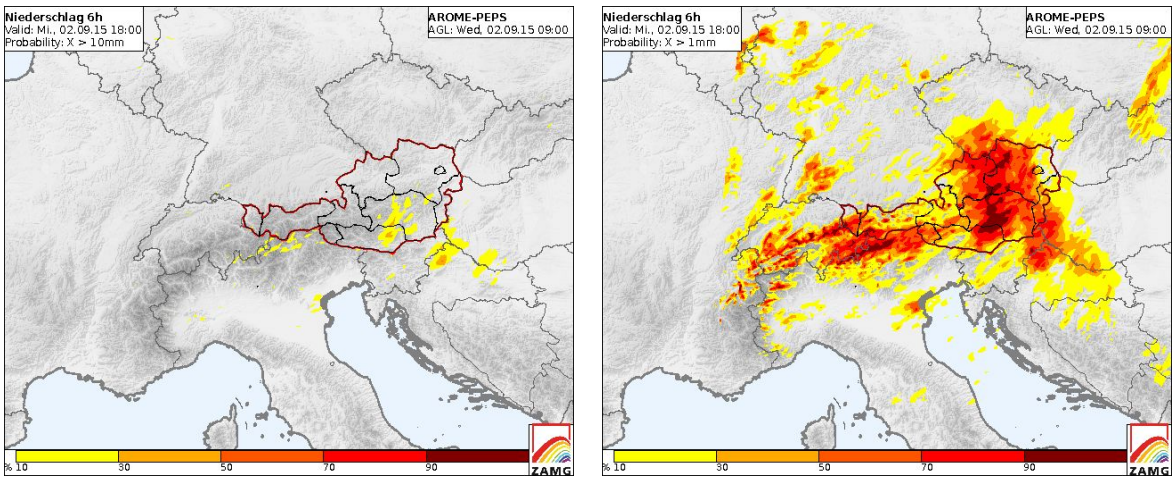
Technical specifications of AROME-PEPS:

- domain size: 600 x 632 grid points
- horizontal resolution: 2.5 km
- vertical levels: 90
- time step: 60s
- ensemble members: 8
- forecast length: +36h (8 runs per day)

- ❏ initialization: 3D-Var + CANARI (3h assimilation cycle)
- ❏ coupling: ECMWF (time-lagged 6h)
- ❏ coupling frequency: 3h



RMSE of wind speed (left) and T2m (right) for AROME-PEPS (red) and ALADIN-LAEF (green) computed over the 2 months summer period in 2015.



An example of AROME-PEPS precipitation probability maps for RR>10 mm/6h (left) and RR>1 mm/6h (right).

In addition, an AROME-RUC system is running in test mode. That is an hourly updated AROME nowcasting version, which assimilates also the radar data. It runs on a slightly smaller domain than operational AROME, so it can be coupled to it. This AROME-RUC runs 24-times per day, producing 12h forecasts.

- ❏ **Tests of possible SPPT developments:**

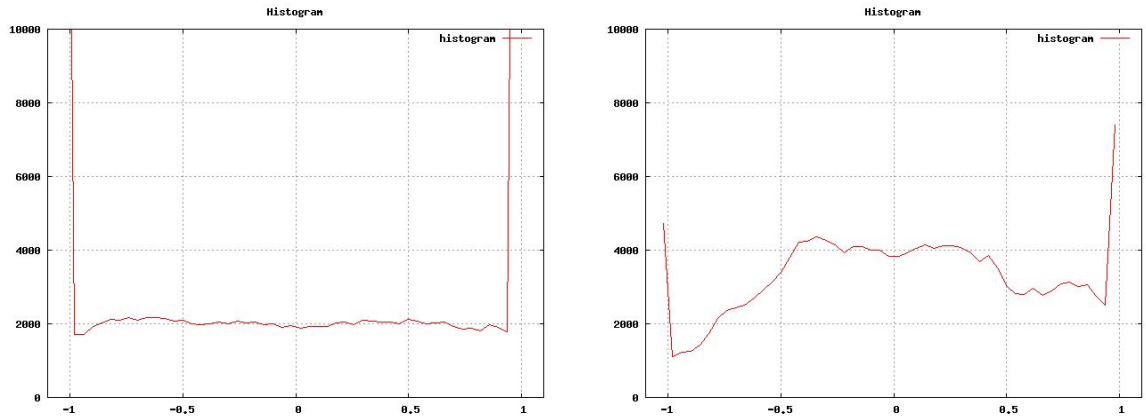
In the previous years there was a growing interest regarding model error representation also in limited area ensemble systems, especially in convection-permitting ensembles. That was a motivation inside ALADIN community to implement the SPPT scheme in the limited area version of ARPEGE-IFS code

which was done by Francois Bouttier (Météo France) and tested in an AROME-EPS framework.

Several experiments were already done using AROME-EPS on 2.5 km horizontal resolution for the Hungarian domain, without noticing any significant impact of the SPPT scheme (Szintai et al. 2015). Last year during the LACE stay at ZAMG an ALADIN code modification was done in order to make SPPT available also in ALARO physics package (Szűcs 2014). Therefore, the recent experiments could have been done using ALARO on 8 km horizontal resolution with the significantly lower computational costs in comparison to AROME. However, it is expected that such tests are "scheme-oriented" and thus the same conclusions would be valid in case of AROME utilization. Tests were focusing on the following three topics:

- ❏ spectral random pattern generator in LAM versions

It was discovered that the real distribution of random numbers returned be the generator in LAM version of the code does not quite corresponds to the normal Gaussian (bell shaped) distribution. This unexpected result have to be further investigated, the consequences must be examined and everything will be consulted with the Meteo-France experts.



Histogram of random number values of the spectral pattern generator for σ=0.5, clipping ratio=2 (left) and for σ=0.25, clipping ratio=4 (right).

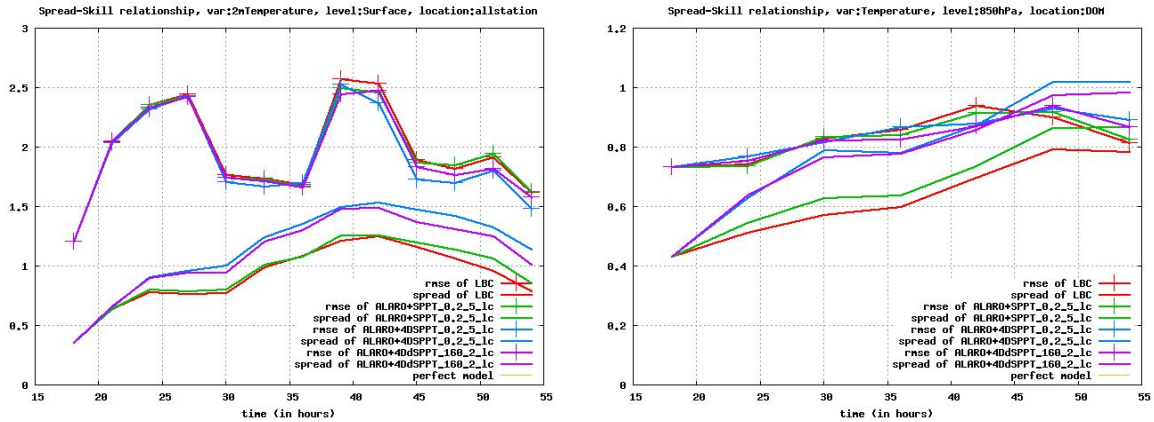
- ❏ impact of the modification of vertical tapering function

Importance of the vertical tapering was confirmed. The switching-off of the tapering for temperature and humidity can give bigger spread near the surface in case of ALARO physics but it causes some model crashes in case of AROME physics. However, the idea of tapering not simply enabled or disabled but tuned carefully along the vertical (e.g. to have bigger transition layer between 0 and 1 values) seems to have a potential. Further investigation should be put in this topic in the near future.

- ❏ dimensional extension of SPPT

Originally the same random number is used for all the physics tendencies in a given

vertical column. For the two wind components on a given level it means that both of them are in principle multiplied by the same number. Thus the length of the wind tendency vector is changed but not the direction. The new idea is to apply various random numbers, one for each of the 4 prognostic variables. Such a realization can ensure bigger variability because not only the size of the tendency vector but also its direction is perturbed. The original "direction" should be anyhow perturbed stronger than the other directions. While the other directions can be defined as orthogonal ones and perturbed with a smaller amplitude. In this proposal four independent patterns are generated which ensures four independent random numbers in every grid-point.

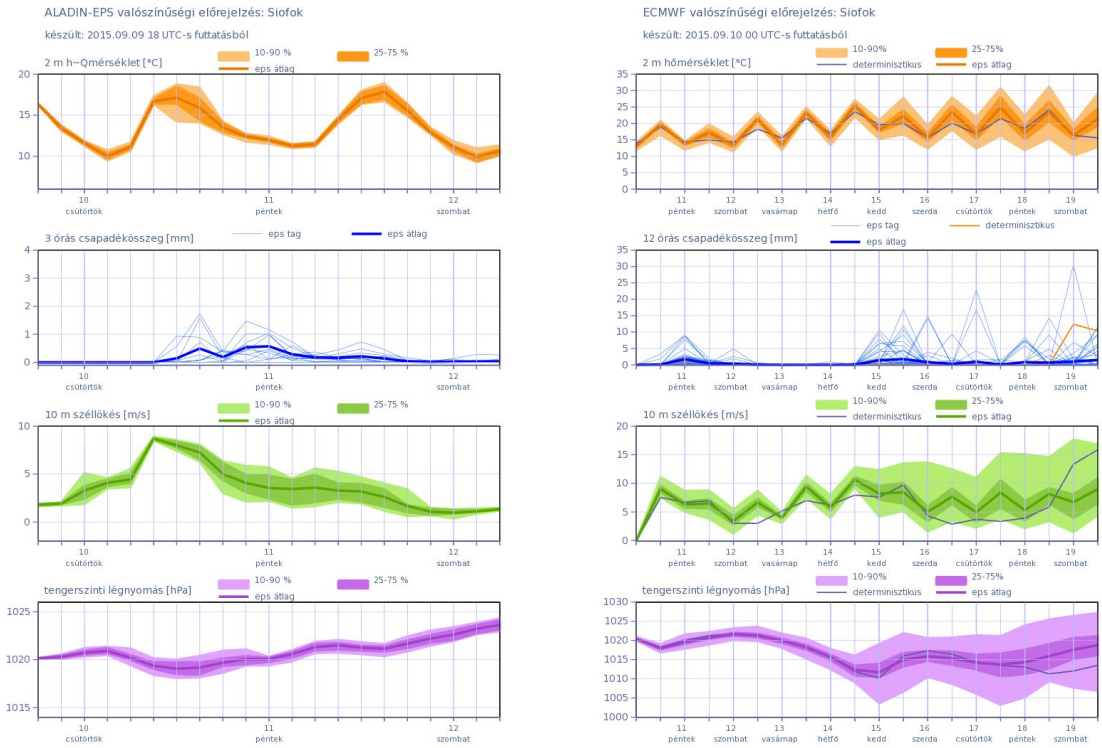


RMSE of the ensemble mean and the SPREAD of the ensemble for the temperature at 2m (left) and temperature at 850 hPa (right) for different SPPT experiments (red lines - downscaling of PEARP, green lines - original SPPT, blue and purple lines - SPPT with the independent perturbations of T, Q, U, V).

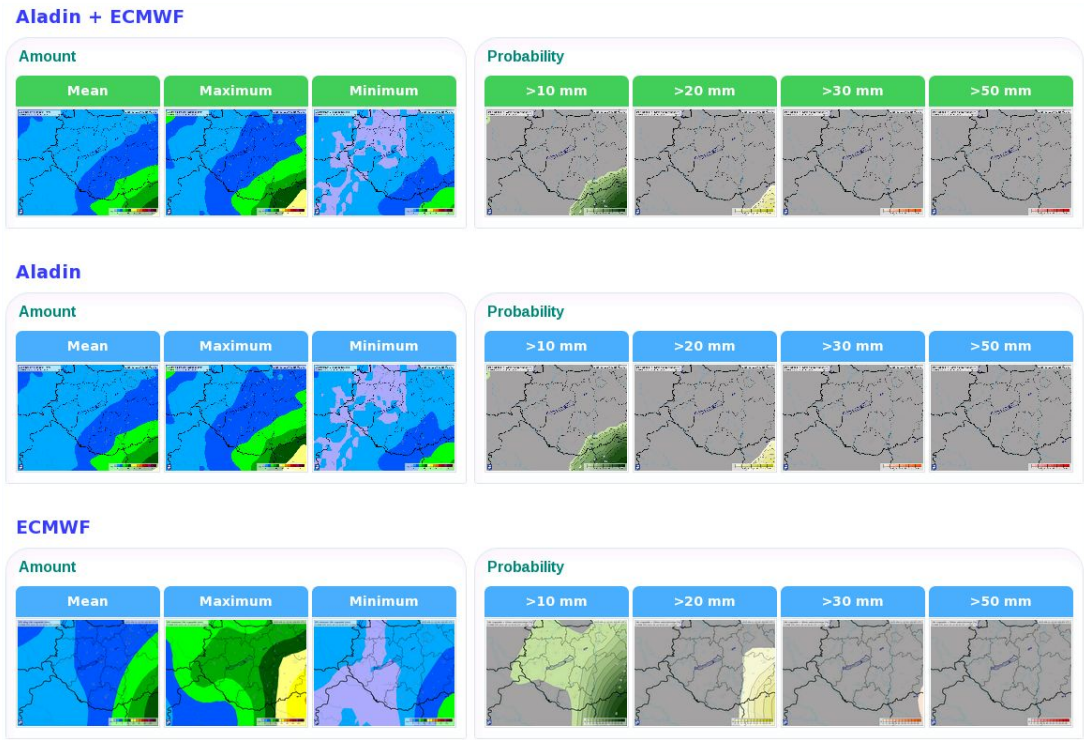
- **Seamless ensemble forecasting system:**

The project bridging probabilistic forecasts and civil protection named PROFORCE was initiated at the end of 2013. It was co-financed by the European Commission. There were only two participating countries - Hungary and Austria with OMSZ and ZAMG institutes involved together with their local civil protection authorities. Its main aim was to build up a seamless ensemble-based forecasting system for the purpose of predicting extreme weather events. Seamless means, that the forecasts of different ensembles, from medium-range (ECMWF-EPS) to short-range (ALADIN-LAEF, ALARO-EPS, AROME-EPS, Ens-INCA) are integrated into one prediction chain (integrated from the application point of view, not numerically).

In May 2015 there was organized a training session in Tulln, at the headquarter of Provincial Government of Lower Austria. Both ZAMG and OMSZ institutes also finalized their own PROFORCE related web sites. The project successfully finished in November 2015.



En example of probabilistic plume diagrams from PROFORCE web page for Siofok town (southern shore of lake Balaton), ALADIN-EPS forecast (left) and ECMWF forecast (right).



An example of graphical interface used at PROFORCE web page to show the probabilistic forecasts of precipitation.

Efforts: 8 PM (1.5 PM LACE stays)

Contributors: Yong Wang, Clemens Wastl, Christoph Wittmann (all ZAMG), Mihály Szűcs, Brigitta Brajnovits (both OMSZ)

Documentation: PROFORCE documentation and web sites; project reports; paper for publication in scientific journal in preparation

Status: Ongoing

S4 Action/Subject/Deliverable: EPS - Verification

Description and objectives: A robust and reliable verification tool is very important in order to establish the quality of a weather forecast system, either deterministic or probabilistic one. Knowing the statistical scores and limits of our forecasting system, is the key to future improvements. The huge amount of data are processed from one or more ensemble systems (experiments), which requires an appropriate, optimized and flexible verification tool. That is essential to assess and manipulate such big data volumes.

Efforts: -

Contributors: Simona Taşcu (NMA), Martin Suklitsch (ZAMG)

Documentation: -

Status: Ongoing

S5 Action/Subject/Deliverable: Collaborations

Description and objectives: Activities merging different areas, collaboration with other consortia, applications.

The closer collaboration with HIRLAM EPS group has been already started. We are exchanging our scientific plans and the ideas. We agreed on a closer cooperation regarding the topics where both sides can profit from each-other. These are especially the expertise on the model uncertainty simulation, e.g. multi-physics and stochastic physics.

Efforts: 0.5 PM

Contributors: Martin Belluš (SHMU), Yong Wang (ZAMG)

Documentation: -

Status: Ongoing

S6 Action/Subject/Deliverable: Publications

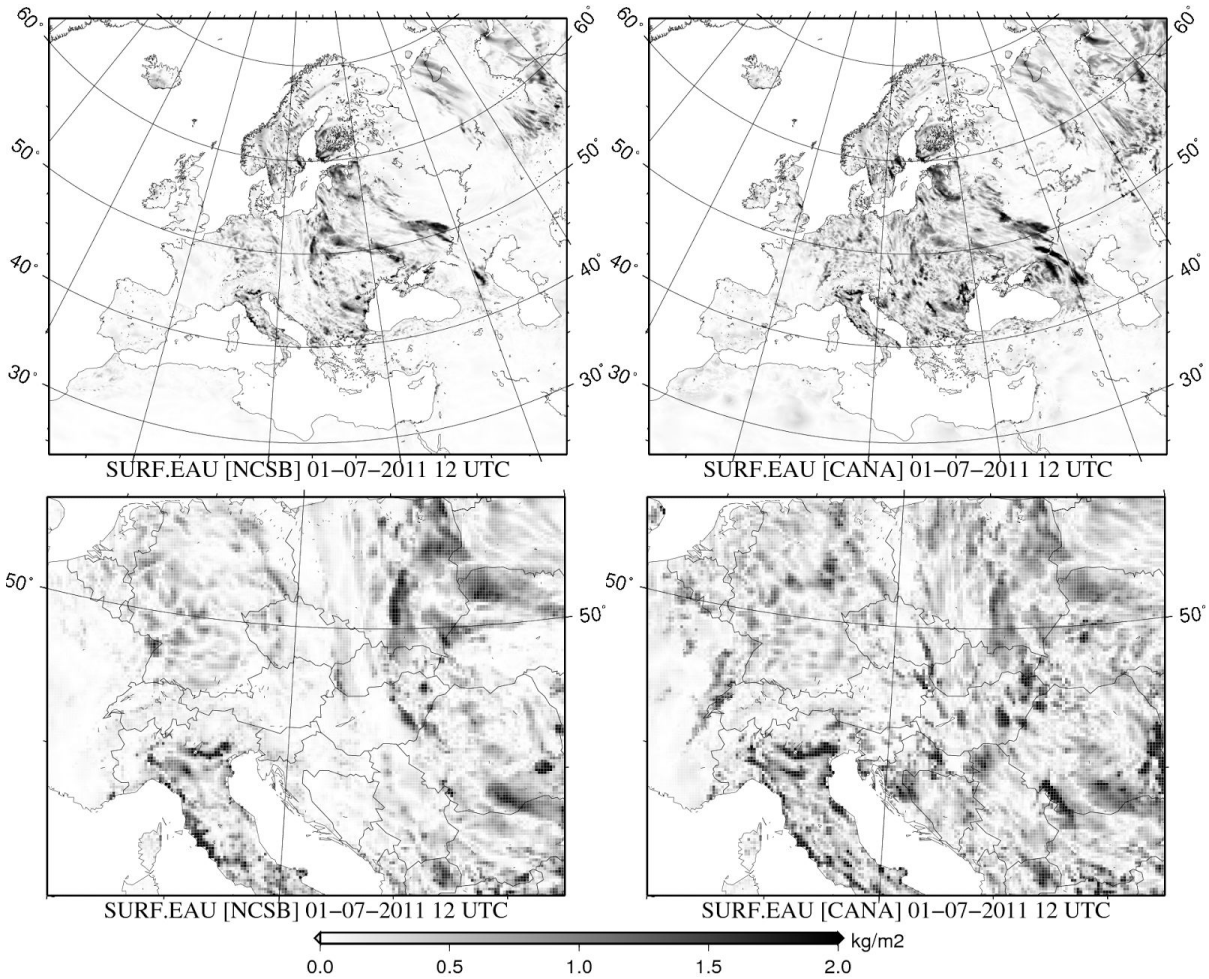
Description and objectives: The scientific achievements of the LACE EPS R&D activities are being presented at the international workshops and published in the scientific journals. It has always been very important to present widely the current results of a scientific work and also do it without unnecessary delays. Unfortunately, in reality it has never been an easy task, mostly due to the limited human resources. In the following we provide an overview of submitted papers and documents in preparation.

This year we finally managed to submit two papers into the Weather and Forecasting journal and one to the special volume by Springer. The first paper is discussing the forecast skills of a convection-permitting ensemble system, especially in a comparison with the regional ensemble system running on a much coarser spatial resolution and utilizing only hydrostatic equations. It is a 2.5 km non-hydrostatic ensemble system AROME-EPS versus 11 km meso-scale ensemble system ALADIN-LAEF. The evaluation focuses on the abilities of the ensembles to quantitatively predict precipitation during a 3-month convective summer period. An area consisting of mountains as well as lowlands is taken into account. The statistical verification uses surface observations and 1 km x 1 km precipitation analyses. The verification scores involve state-of-the-art statistical measures for deterministic and probabilistic forecasts and also the novel spatial verification methods. The results show that a convection-permitting ensemble outperforms its meso-scale counterpart in case of the precipitation forecasts. In particular, the positive impact is larger for the mountains and smaller for the lowlands. Moreover, there is a clear improvement for higher precipitation thresholds.

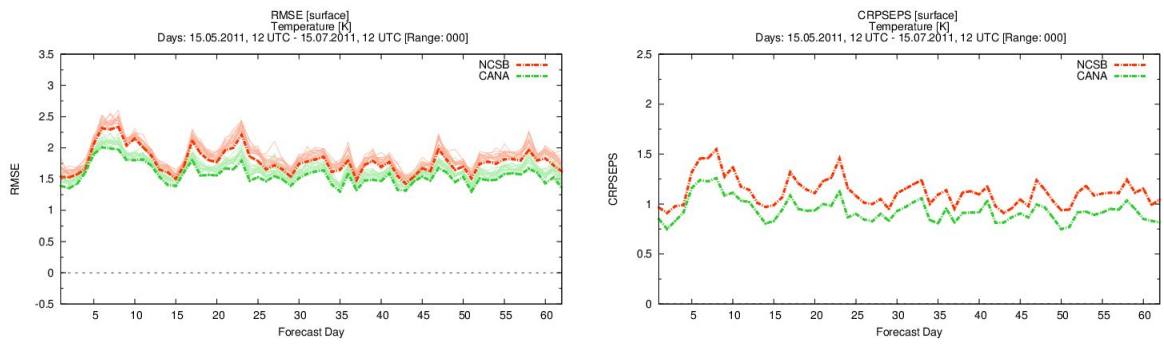
The second paper submitted to the Weather and Forecasting journal was already published (January 2016). It investigates the impact of large scale IC perturbations and the LBC perturbations obtained from different global ensemble systems on the forecast quality of a regional EPS. For this purpose several experiments are conducted where the single model based regional ensemble ALADIN–LAEF is coupled with two of the world leading global ensembles ECMWF-EPS and GEFS. The results indicate that coupling with GEFS performs better for the surface parameters, while at the upper levels the coupling with ECMWF-EPS is superior. Adopting the perturbations from GEFS lead to a considerably higher spread in ALADIN-LAEF, which is beneficial near the surface where regional ensembles are usually under-dispersive. At the upper levels the coupling with GEFS even leads to an over-dispersion of ALADIN-LAEF due to the large spread of some parameters, while ECMWF-EPS based perturbations provide statistically more reliable ALADIN-LAEF forecasts for the atmospheric fields.

Another paper was submitted to Monthly Weather Review (January 2016). It introduces two techniques for perturbing the surface and soil initial conditions in the regional ensemble prediction system ALADIN-LAEF. The former technique, called Non-Cycling Surface Breeding (NCSB), combines short range surface forecasts driven by perturbed global atmospheric forcing and the idea of breeding for generating the perturbations on surface initial conditions. The newer technique applies an Ensemble of Surface Data Assimilations in which the screen level

observations are randomly perturbed (ESDA). Both techniques are evaluated over a two-month-long trial for a summer period. The results show that the later technique helped to improve statistical scores like RMSE and ensemble spread mostly for the perturbed surface parameters, while for the other parameters as well as for the upper air fields it is rather neutral.



Surface layer (1 cm) soil moisture content perturbation for the experiments NCSB (left) and ESDA (right) with zoom over Central Europe (second row).



Temperature at 2m: Time series at analysis time (+0h) for the 62 days of the validation period: RMSE (left) and CRPS (right), ESDA (green) and NCSB (red).

For the exact titles and authors of the mentioned papers, please refer to the "Documents and publications" section.

Unfortunately, due to the lack of man power some of the other long-term planned papers must have been again postponed. That is the document which should deal with the different approaches to boundary condition interpolation, i.e. spatio-temporal consistency and its hypothetical exploitation as a generator of the targeted initial perturbations. Postponed was also the paper about the promising method for model uncertainty simulation by the stochastic perturbation of physics tendencies for the surface prognostic variables in ALADIN-LAEF system.

Efforts: 6 PM (0.5 PM LACE stays)

Contributors: Yong Wang, Theresa Schellander-Gorgas, Florian Weidle, Alexander Kann, Christoph Wittmann, Florian Meier (all ZAMG), Geert Smet (KMI), Martin Belluš (SHMU), Simona Taşcu (NMA), Mihály Szűcs (OMSZ)

Documentation: Reviewed papers

Status: Ongoing

List of actions, deliverables including status

S1 Subject: Optimization of ALADIN-LAEF

Deliverables: Reports on LACE stays; papers in preparation for scientific journals; improvement of current regional ensemble system through the results of R&D

Status: In progress

S2 Subject: ALADIN-LAEF maintenance

Deliverables: ALADIN-LAEF operational suite running at ECMWF HPC; probabilistic forecast products delivered to the LACE partners

Status: Permanent

S3 Subject: AROME-EPS

Deliverables: Reports on LACE stays; papers submitted to scientific journals

Status: In progress

S4 Subject: EPS - Verification

Deliverables: Upgrades of LAEF Verification package; bug-fixes

Status: Ongoing

S5 Subject: Collaborations

Deliverables: Exchange of the expertise between LACE and HIRLAM groups

Status: Ongoing

S6 Subject: Publications

Deliverables: 1 paper published, 3 papers submitted and 1 paper in preparation (see list of publications)

Status: Ongoing

Documents and publications

Published papers:

- Weidle F., Y. Wang and G. Smet, 2015: "On the impact of the choice of global ensemble in forcing a regional ensemble system", Weather and Forecasting, doi: http://dx.doi.org/10.1175/WAF-D-15-0102.1

Submitted papers (currently in review):

- Belluš M., Y. Wang, F. Meier, 2015: "Perturbing surface initial conditions in a regional ensemble prediction system", Monthly Weather Review, submitted in January 2016
- Schellander-Gorgas T., Y. Wang, F. Meier, F. Weidle, Ch. Wittmann, A. Kann, 2015: "On the forecast skills of a convection permitting ensemble", Weather and Forecasting, submitted in June 2015
- Szűcs M., A. Horanyi, G. Szépszó, 2015: "Ensemble forecasting in numerical weather prediction", Mathematical Problems in Meteorological Modelling, Springer (waiting for the final decision)

Papers in preparation for the submission:

- Taşcu S., Y. Wang, Ch. Wittmann, F. Weidle, 2015: "Forecast skill of regional ensemble system comparing to the higher resolution deterministic model", in preparation for local meteorological journal (Romania)

Stay reports:

- Martin Belluš, 2015: Combination of IC and model uncertainties for the surface prognostic variables in ALADIN-LAEF system, Report on stay at ZAMG, 25/05 - 26/06/2015, Vienna, Austria
- Simona Taşcu, 2015: ALADIN-LAEF regional ensemble system comparing to the ALARO higher resolution deterministic model, Report on stay at ZAMG, 06/07 - 28/08/2015, Vienna, Austria
- Mihály Szűcs, 2015: Tests of possible SPPT developments, Report on stay at ZAMG, 28/09 - 06/11/2015, Vienna, Austria

- Martin Belluš, 2015: Stochastic perturbation of physics tendencies in new CY40T1 with ALARO-1 physics, Report on stay at ZAMG, 14-25/09 + 12-30/10/2015, Vienna, Austria (in preparation)

Activities of management, coordination and communication

- 25th ALADIN Workshop & HIRLAM All Staff Meeting 2015, 13-17 April 2015, Copenhagen, Denmark (presentations Martin Belluš, Clemens Wastl).
- 37th EWGLAM/22st SRNWP joined meetings, 5-8 October 2015, Belgrade, Serbia (presentation Martin Belluš).
- 2nd ALADIN Forecasters meeting, 21-23 October 2015, Lisbon, Portugal (presentation Florian Weidle).

LACE supported stays – 6 PM in 2015

There have been four stays executed in 2015:

- Martin Belluš [**S1**], 25th May - 26th June 2015, ZAMG (5 weeks)
- Simona Taşcu [**S1**], 6th July - 28th August 2015, ZAMG (8 weeks)
- Martin Belluš [**S1+6**], 14th-25th Sep. + 12th-30th Oct. 2015, ZAMG (5 weeks)
- Mihály Szűcs [**S3**], 28th September - 6th November 2015, ZAMG (6 weeks)

Summary of resources [PM]

Subject	Manpower		LACE		ALADIN	
	plan	realized	plan	realized	plan	realized
S1: Optimization of LAEF	**10**	**6**	**5**	**4**	**1**	**0**
S2: LAEF maintenance		**0.5**				
S3: AROME-EPS	**7**	**8**	**1**	**1.5**		
S4: EPS – Verification						
S5: Collaborations	**2**	**0.5**				
S6: Publications	**6**	**6**		**0.5**		
Total:	**25**	**21**	**6**	**6**	**1**	**0**