Working Area Predictability

Progress Report

Prepared by:	Area Leader Martin Belluš
Period:	2018 (till September)
Date:	September 2018

Progress summary

Due to the general lack of manpower since the beginning of this year and several other circumstances, like transition to the new computers both at ZAMG and OMSZ, the progress on current EPS tasks was rather slowed down. Nevertheless, there were 4 regular stays realized, with the total length of 3 and half months. Iris Odak Plenković (DHMZ) spent 4 weeks at ZAMG in continuation on her work on the analog-based post-processing method for the high resolution wind field. Mihály Szűcs (OMSZ) came to Vienna for 2 weeks where he worked on 3D extension of new spectral pattern generator (SPG) by Tsyrulnikov-Gayfulin in the ALADIN code. Martin Belluš (SHMU) spent 4 weeks at ZAMG preparing the operational scripts for running ALADIN-LAEF Phase I under the ecFlow at ECMWF HPCF. Furthermore, two planned 4-weeks' stays of Simona Taşcu and Raluca Pomaga (both NMA) were unfortunately canceled due to the personal reasons. The topic, which should have been examined by Raluca, was taken over in the last moment by newcomer Martin Imrišek (SHMU), who came to ZAMG for 4 weeks and worked on the ENS 3DVar validation within new ALADIN-LAEF configuration.

It is also worth to mention, that Endi Keresturi successfully finished his stay at ZAMG and after spending 3 years working on Jk blending method he left in March for Croatia and started to work for DHMZ.

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.

- **Topic 1: B-Matrix for new ALADIN-LAEF**

The different possibilities for background error statistics computation need to be investigated, e.g. a flow dependent B-matrix creation is considered in the cooperation with DA group. However, for the time being (for the first sensitivity experiments with ENS 3DVar within ALADIN-LAEF) the standard ensemble approach for B-matrix computation was chosen. The B-matrix based on 256 samples of new ALADIN-LAEF experiment (5 km, 60 levels, ALARO-1 physics) including the whole Phase I configuration was created. The 12h forecasts from both 00 and 12 UTC network times were used to compute the differences, since this corresponds to the length of ALADIN-LAEF assimilation cycle. Model based on cycle 40t1 with the latest bugfix involving the correction of scaling factor in nmcstat.F90 routine was used for the computations. The diagnostics were qualitatively compared against the equivalent background errors computed for ALARO domain tested at that time at SHMU. The comparison of selected diagnostics is shown in the following figures. They can technically confirm the correctness of the B-matrix created for ALADIN-LAEF system.

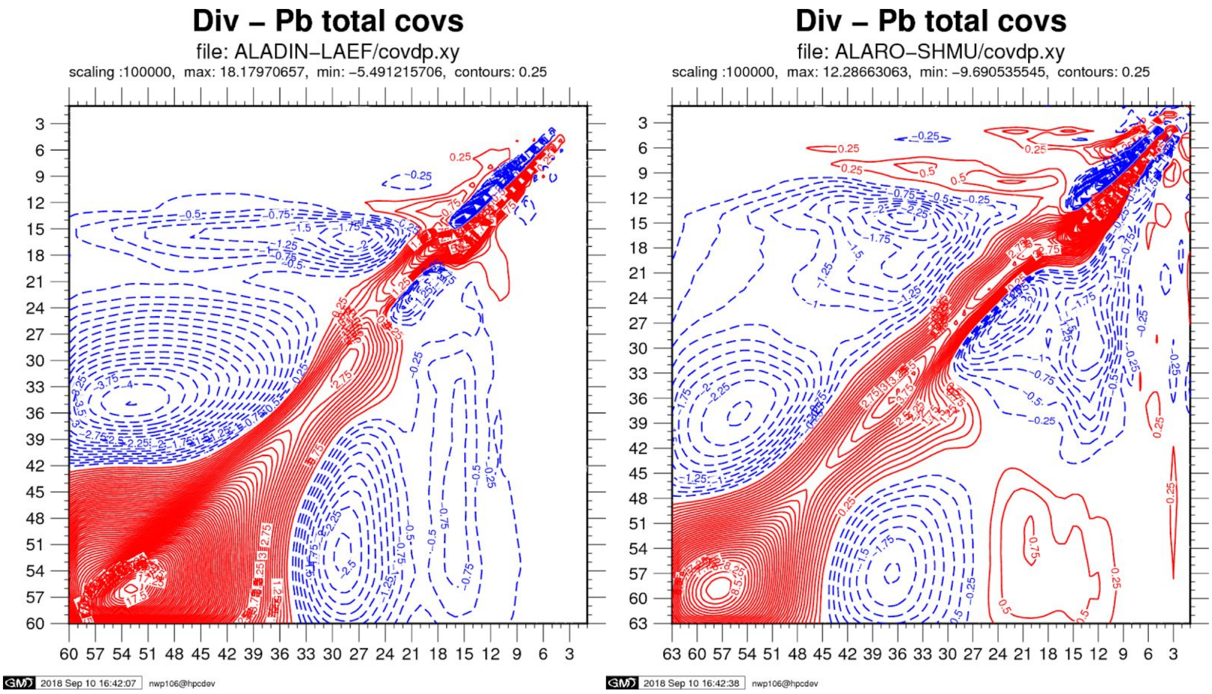

Figure 1: Mean vertical cross-covariance between divergence and vorticity-balanced geopotential for ALADIN-LAEF 4.8 km / 60 lev (left) and ALARO-SHMU 4.5 km / 63 lev (right).

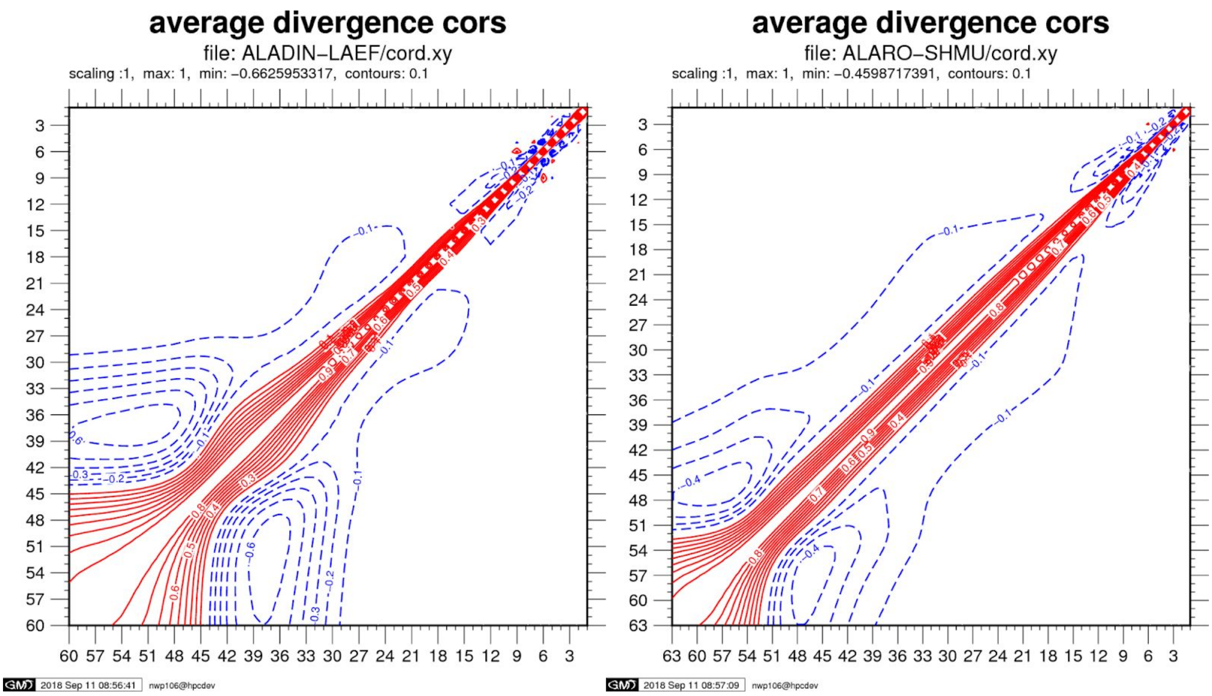

Figure 2: Mean vertical correlation of divergence for ALADIN-LAEF 4.8 km / 60 lev (left) and ALARO-SHMU 4.5 km / 63 lev (right).

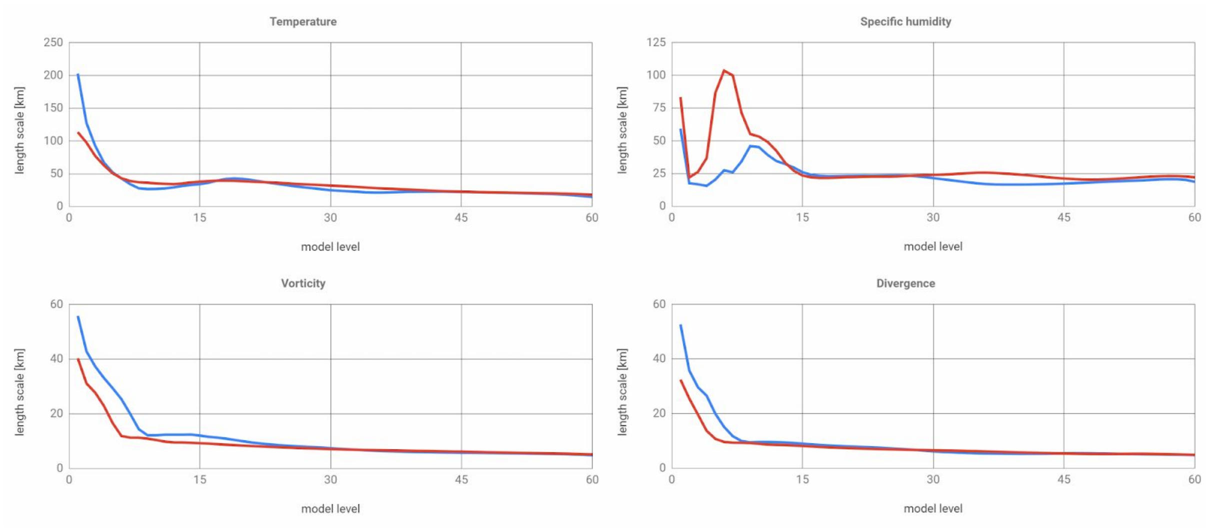

Figure 3: Vertical profile of length scales for temperature (top left), specific humidity (top right), vorticity (bottom left) and divergence (bottom right) for ALADIN-LAEF 4.8 km / 60 lev (blue) and ALARO-SHMU 4.5 km / 63 lev (red).

The cross-covariances (physical coupling between the variables) shown in figure 1 are apparently characterized by very similar patterns. An important feature of the assimilation procedure is the spatial propagation of the increments. This happens in accordance with given length scales. As one can see in the vertical profiles of length scales for different parameters and 2 models (figure 3), they are also qualitatively comparable. The discrepancy of length scales at the models' top is actually caused by the different layouts of their vertical levels (L60 vs L63). Therefore, we have considered our B-matrix suitable for sensitivity and validation experiments. It has been used in the validation of ENS 3DVar within ALADIN-LAEF Phase II.

Topic 2: Validation of ENS 3DVar within ALADIN-LAEF Phase II

The validation of new method for handling IC perturbation of the upper-air fields (ENS BlendVar) was one of the two main tasks planned for this year. Such method should replace currently used breeding-blending approach and it is meant to enter the new ALADIN-LAEF operations in its second phase (Phase II) later next year. As a first step the various data types were implemented into the 3DVar of new ALADIN–LAEF system. These were SYNOP, TEMP, AMDAR, GEOWIND (OPLACE) and GNSS zenith total delay (SUT - Slovak University of Technology). In ordinary assimilation cycle there were assimilated approx. 6200 (37.85%) SYNOP measurements (including GNSS zenith total delays), 550 (3.35%) AMDAR measurements, 32 (0.20%) GEOWIND measurements and 9600 (58.60%) TEMP measurements. There were no difficulties in the implementation of SYNOP, AMDAR and TEMP data. An example of the assimilation increments is shown in figure 4.

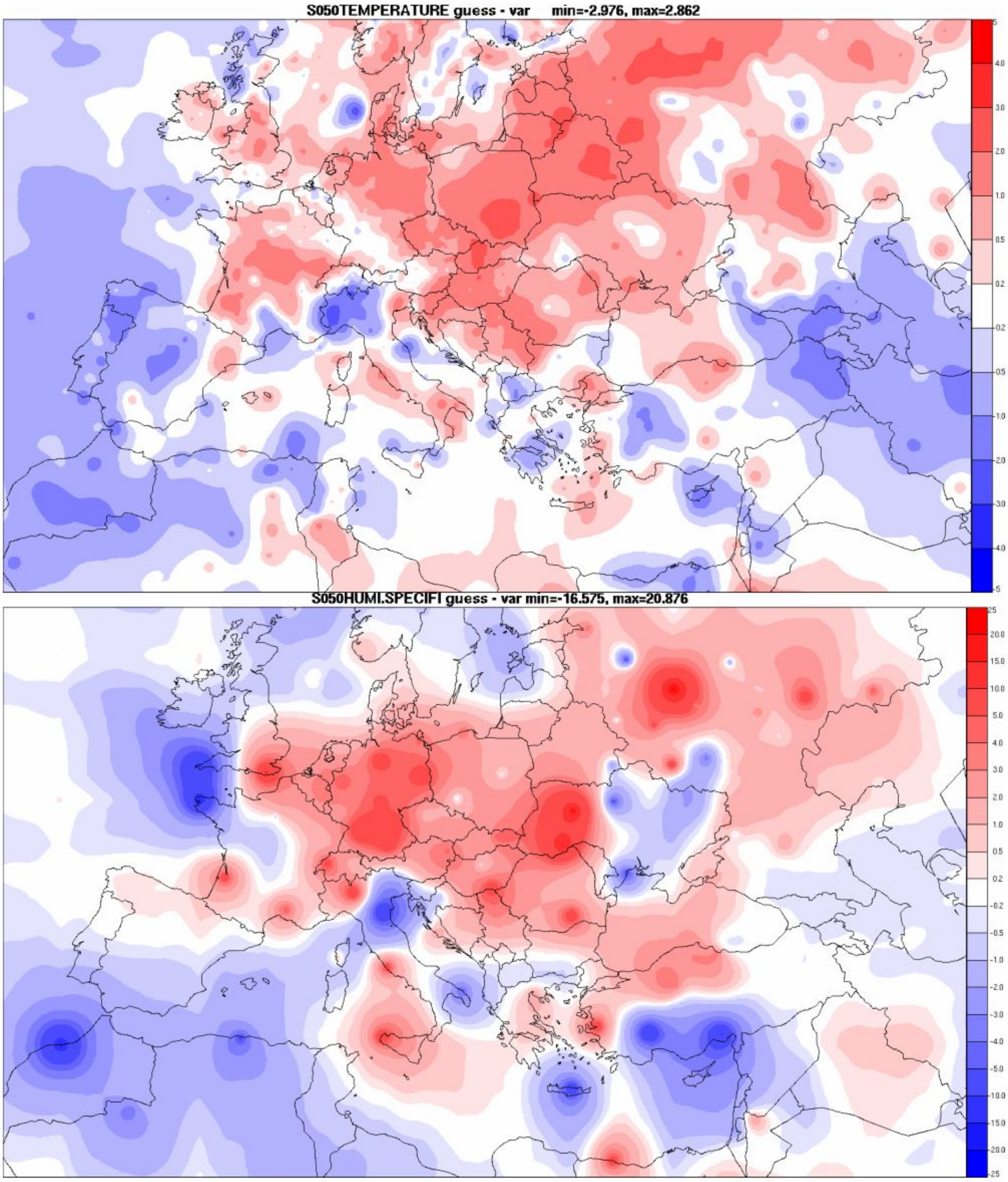

Figure 4: Temperature increments for SYNOP-only data assimilation (top) and specific humidity increments for TEMP-only data assimilation (bottom), both at the 50th model level.

Furthermore, the whitelist for GNSS permanent stations had to be assembled in order to implement these data into the assimilation procedure. The first idea, was to obtain such a whitelist by the combination of all first guess departures from all ensemble members and all terms. However, this approach turned to be inappropriate since such combination for given station made the histogram of departures too much kurtosis and the Pearson's Chi-squared test rejected the station. Further, each member was tested separately, which led to 5-12 rejected stations per member. Finally third approach was examined, based on testing all members together just for one day with Jarque–Bera test (if data have skewness and kurtosis matching a normal distribution, H0: Data set have normal distribution). This test also rejected different amount of stations for each day. Based on these results it was decided to use best day (with all members and lowest amount of rejected stations) and best member (with all days and lowest amount of rejected stations) together for whitelist estimation. Two stations were excluded due to big difference between model and real orography and two stations were excluded due to Pearson's Chi-squared test. The increments for specific humidity after GNSS zenith total delay assimilation are shown in figure 5.

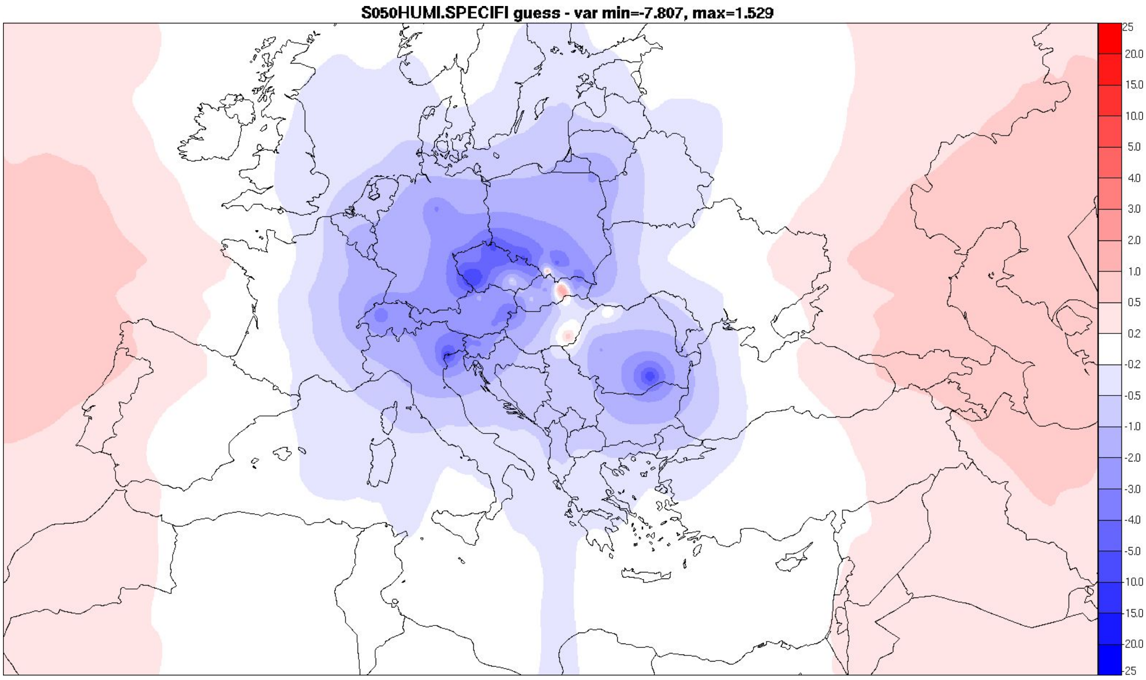

Figure 5: Specific humidity increments at model level 50 for GNSS-only (zenith total delay) data assimilation.

Afterwards, the random Gaussian perturbation was applied to all the above data using internal function of the configuration "screening". All implemented OBS types were perturbed in the ECMA database and consequently assimilated into the model. One can see the resulting perturbation of temperature field in figure 6.

Finally, the ALADIN-LAEF experiment with switched-on 3DVar (Phase II) was verified against ALADIN-LAEF experiment without 3DVar (Phase I). We have to emphasize, that there were in principle two possibilities how to integrate 3DVar into the existing ALADIN-LAEF data flow. At this stage it was investigated, whether the 3DVar upper-air assimilation should be applied before or after the upper-air spectral blending. Two experiments with all available data were carried out, i.e. the "blend-var" and "var-blend" configurations. While in blend-var clearly dominates the effect of assimilation, in var–blend the gradients in temperature increments are smaller. The model fields are also a bit smoother due to the digital filtering involved in blending. From a comparison of mean values of temperature increments we can say that the var-blend is hotter than blend-var, while the difference in chosen case was only 0.033 deg.C. The statistical scores for configuration var-blend are shown in the figure 7, which is the comparison of Phase I and Phase II (i.e. the impact of ENS

3DVar on ALADIN-LAEF scores).

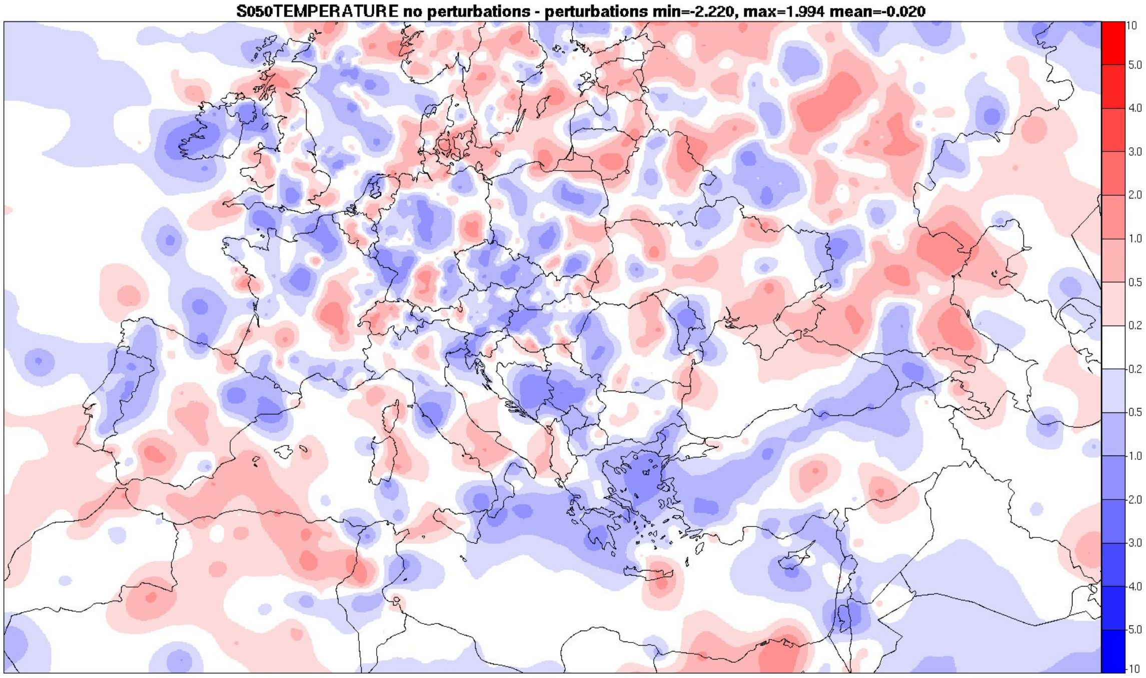

Figure 6: An example of temperature perturbation at model level 50, where all implemented data were perturbed in 3DVar screening.

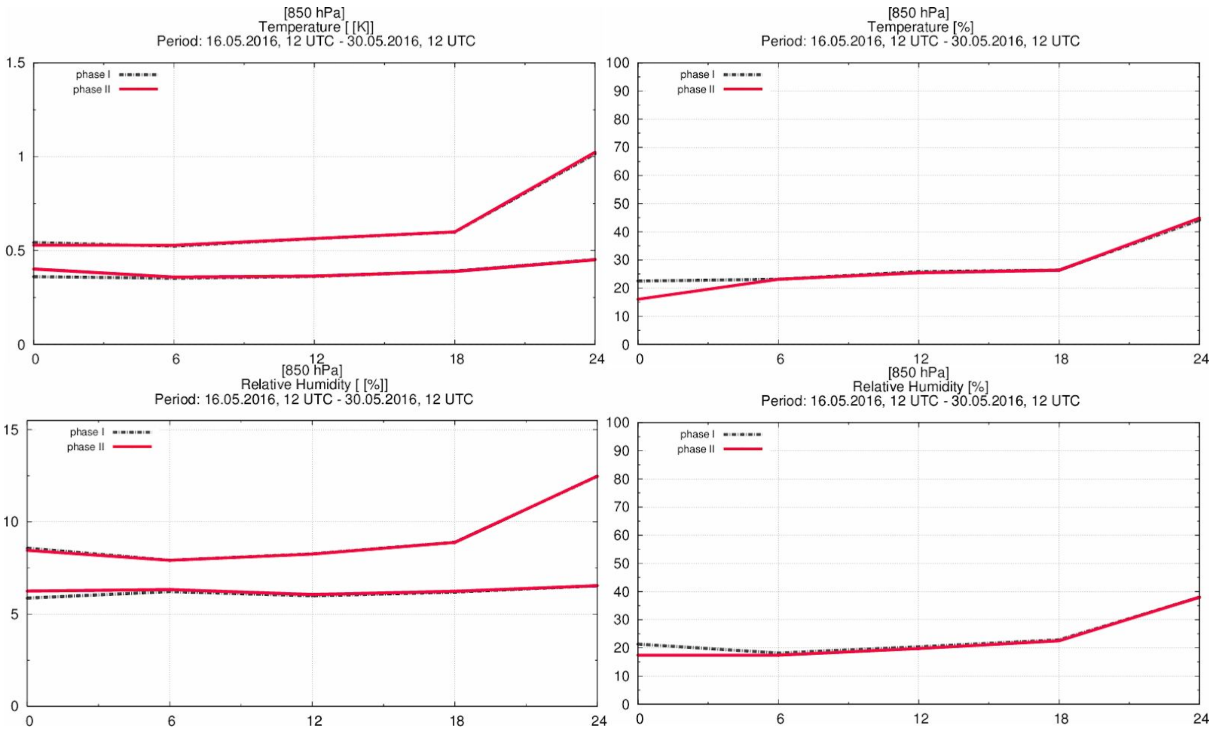

Figure 7: RMSE and SPREAD (left) and OUTLIERS (right) for temperature (top) and relative humidity (bottom) at 850 hPa level. The Phase I scores (grey dashed lines) and Phase II (red lines).

According the expectations, the impact is rather small but positive. The ensemble spread was slightly increased for the very first hours of integration, while RMSE was little bit decreased. Also the decrease of outliers for both temperature and relative humidity parameters is evident. The impact on wind can be considered rather neutral and we have observed slight degradation of the scores for geopotential (depending also on the vertical height).

- **Topic 3: Analog-based post-processing method (continuation work)**

This is the continuation work on the point-based analog-based post-processing method applied to a NWP model output, namely to the different datasets available at ZAMG. Main goal was to investigate the usability of the analogs method, which is a statistics-based methodology of creating the ensemble forecasts. The special emphasis was put into rewriting the original codes in Python, making the algorithms computationally more efficient and testing the method at least on one deterministic model.

The analog-based method uses historical data within the specified analog training period for which both the NWP model and the verifying observation are available. The analog-based method uses one consistent grid-point, which is usually the closest one to the measurement site. The AROME datasets for a period from Jan/2015 till Aug/2017 and corresponding OBS have been used. The best-matching historical forecasts to the current prediction (analogs) may originate in any past date within the training period. The quality of the analog is evaluated by the pre-defined metric. Analogs are found independently for every forecast time and location, narrowing the search around particular time of a day by a time window. The verifying observations of the best-matching analogs are the members of the analog ensemble (AN).

Building the database for the training period is computationally the most demanding part of the entire analog-based scheme. By dealing only with the stations that have more than a year of training the computational cost have been partially reduced. Also the algorithms for computing the analog-based forecasts were optimized and the execution time was significantly reduced.

The method evaluates 20 most similar analogs sorted by difference (similarity). This number can be tuned. However, based on the previous experience, approximately 15 members provide the optimal base for forecasting a common event, or even smaller ensemble is possible if forecasting a rare event. It also turned out that 3-time-steps time window (1 time step before and after the lead time for which the analog forecast is made) is sufficient to take into account. Widening the time window does not lead to any further improvements.

The algorithm was tested for the two months, one for winter (January 2017) and one for summer (June 2017) period. The analog method used the same training period (2015-2016) and the same setup for both. The analog ensemble mean forecast (AN) was computed as the average of 15 analog ensemble members.

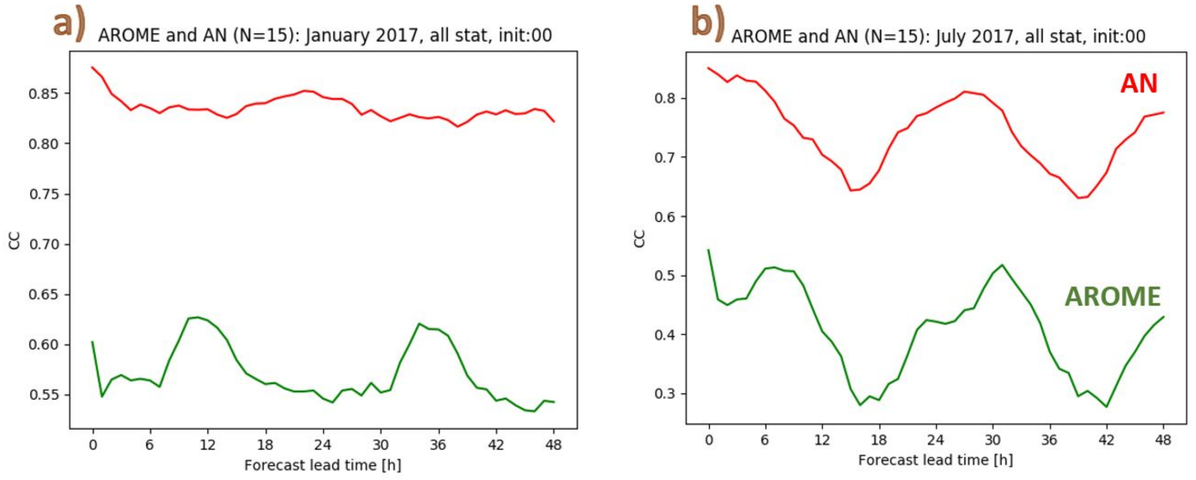

Figure 8: The correlation coefficients for AROME (green line) and AN (red line) wind speed forecasts for January (left) and July (right) 2017.

In the above figure (figure 6) the correlation coefficients for AN and AROME forecasts are shown. One can see a significant improvement achieved via this post-processing method. The values are higher in January for both forecasts, while the diurnal cycle of correlation coefficients is at the same time less pronounced. What's more, the diurnal cycle is almost non-existent for the AN in January. As expected, the values decrease with the forecast lead time for all cases, however the diurnal cycle is still dominant.

Efforts: 3 PM (2 PM LACE stays)

Contributors: Martin Belluš, Martin Imrišek (both SHMU), Iris Odak Plenković (DHMZ)

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 HPC facility. 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.

- **Topic 1: Operational ecFlow suite for new ALADIN-LAEF**

The first phase (Phase I) of planned operational changes to ALADIN-LAEF system towards the higher resolution with many other upgrades (5 km / 60 levels / linear grid / cy40t1; IC perturbation: ESDA; model perturbation: SPPT+ALARO-1 MP) has been already started. It is the second major upgrade since the beginning of its operations in 2011. The first upgrade happened in 2013, when the horizontal and vertical resolutions were increased from 18 to 11 km and 37 to 45 vertical levels respectively. That time also the domain was changed and an ensemble of surface data assimilations was implemented. The latest level of upgrade is summarized in the following table.

Table 1: ALADIN-LAEF system specifications for current and new version (new version is expected to become pre-operational till the end of 2018).

ALADIN-LAEF	current	new
Code version	cy36t1	cy40t1
Horizontal resolution	10,9 km	4,8 km
Vertical levels	45	60
Number of grid points	500x600	750x1250
Grid	quadratic	linear
Time step	450 s	180 s
Forecast length	72 h (00/12 UTC)	72 h (00/12 UTC)
Members	16+1	16+1
IC perturbation	ESDA [surface], breeding-blending [upper-air]	ESDA [surface], blending (Phase I) / ENS BlendVar (Phase II) [upper-air]
Model perturbation	ALARO-0 multi-physics	ALARO-1 multi-physics + surface SPPT
LBC perturbation	ECMWF ENS	ECMWF ENS
SBUs consumed per year	~10 mil	~120 mil

Current ALADIN-LAEF system runs from the beginning of its operations under SMS (Supervisor Monitoring Scheduler), which becomes obsolete and its development has already stopped. It is also supported only on old and tested platforms. The SMS is being replaced by ecFlow. It uses object oriented methodology and modern standardised components. The proprietary scripting language used by SMS (CDP - Command and Display Program) has been replaced by Python, which is widely used in scientific and numeric computing. Moreover, the current ALADIN-LAEF suite has not been technically updated for several years. Therefore, we decided to start building our new operational ALADIN-LAEF suite from scratch rather than converting the old one from SMS to ecFlow. Another reason for such a key decision was quite big difference between the “current” and currently developed ALADIN-LAEF components, which are now fully written in Perl.

After the detailed study of ecFlow documentation available at ECMWF webpage, it was decided to follow the recommendations and proceed with building the suite definition file by Python script (instead of shell or other alternatives). It has many advantages, e.g. Python API allows the entire suite definition structure to be specified, checked and loaded into the ecFlow server. On-the-fly generated ALADIN-LAEF suite definition file has over 1.3k lines, while the Python script which creates it has only 244 lines of code. At the same time we have been able to use existing new LAEF Perl “bricks” as native ecFlow tasks (including Perl modules for setup and support), only with minor modifications involving necessary ecFlow client communication. That helped a lot, since this counts all together more than 3k lines of reusable code.

The first functional suite was created and tested under kmxy user (Martin Belluš) at ecgate (see figure 9). The following steps towards the time critical application under dedicated LACE operational account “zla” must be done already in cooperation with the user support section at ECMWF. There are several technical details which must be resolved.

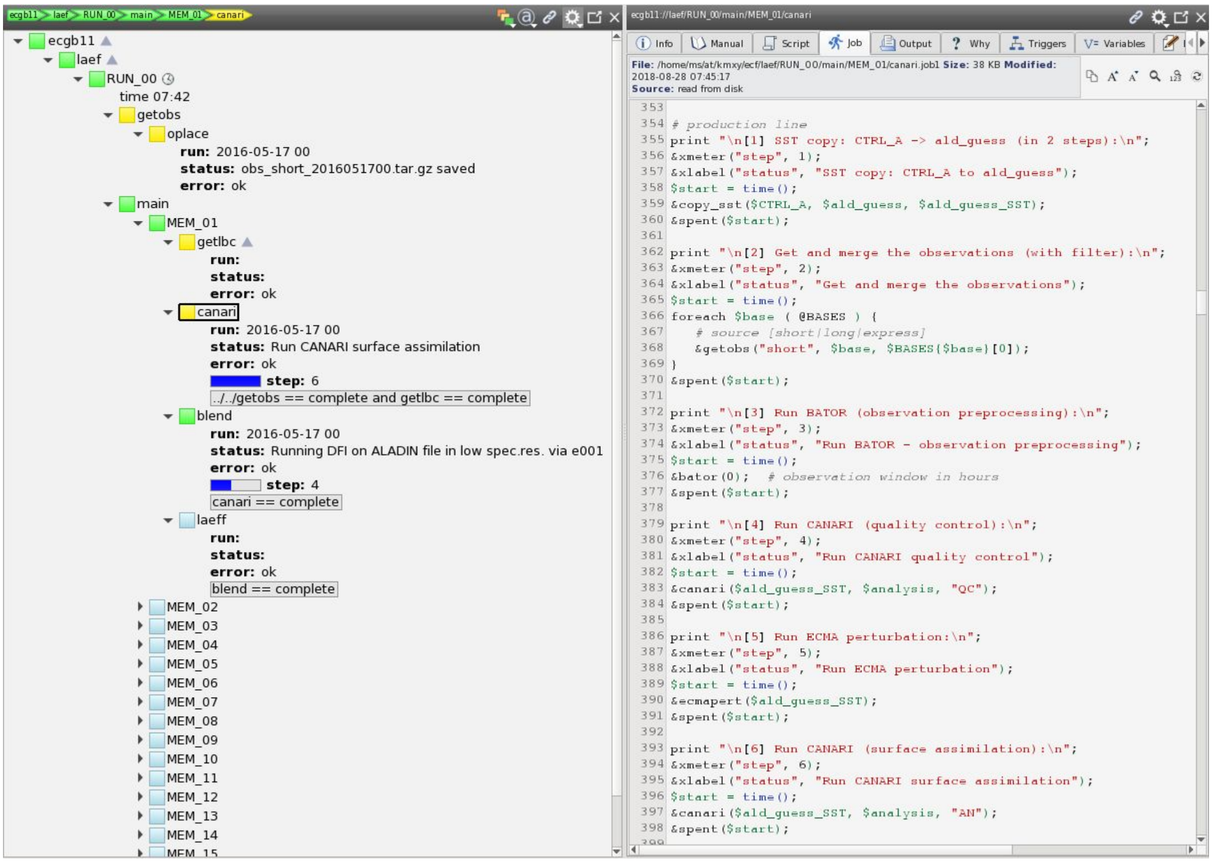

Figure 9: New ALADIN-LAEF suite (Phase I) under the ecFlow environment (ecFlow GUI screenshot). Suite definition file is generated by Python code, while all tasks, include files and configuration modules are written in Perl.

Efforts: 1.5 PM (1 PM LACE stay)

Contributors: Martin Belluš (SHMU), Florian Weidle (ZAMG)

Documentation: LAEF flow charts

Status: New development + 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.

- ❑ **Topic 1: EPS related development at OMSZ**

At OMSZ they are primarily focusing on their future convection-permitting EPS. New machine devoted to such purpose has already arrived and they progress slowly with the migration. The installation of AROME-EPS on new system in the next months is one of their priorities. Such system will fully replace current 8 km version of ALARO-EPS at OMSZ. However, in the next future the utilization of ALARO in a convection-permitting EPS at high resolution can be reconsidered.

Topic 2: EPS related development at ZAMG

There are no operational changes in local EPS implementation at ZAMG. Their plan is to finalize the initial C-LAEF configuration till the end of this year and then start to translate the system and scripts into the ecFlow. Some pre-operational runs are expected in the next year. In spite of the fact that this step was already postponed several times due to the local work on ZAMG’s new HPC, this scenario is still feasible.

There was an extreme convection event (up to 100 mm in 3h, locally even more) in Graz in April this year for which the potential benefit of C-LAEF with respect to the pseudo-EPS constructed out of 8 AROME deterministic runs (lagged EPS) have been shown. C-LAEF (16 members) in this configuration involved only the stochastic physics perturbation in combination with downscaling (i.e. no EDA). One can visually compare the forecasted precipitation fields in the following figures. It can be concluded that C-LAEF gave a bit better indication of the event.

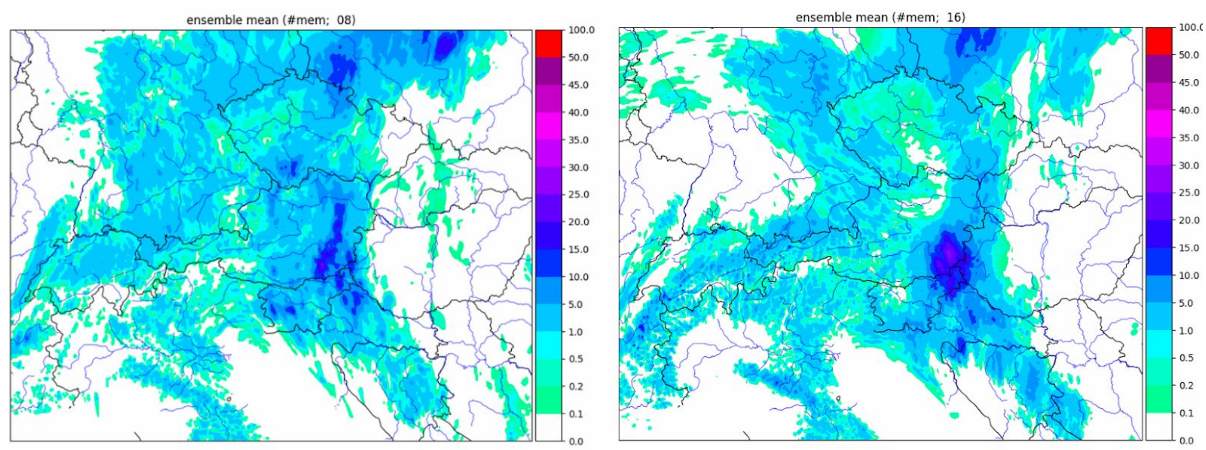

Figure 10: Extreme precipitation event from April 16, 2018. The ensemble mean of 3-hourly accumulated precipitation for AROME pseudo-EPS (left) and C-LAEF (right).

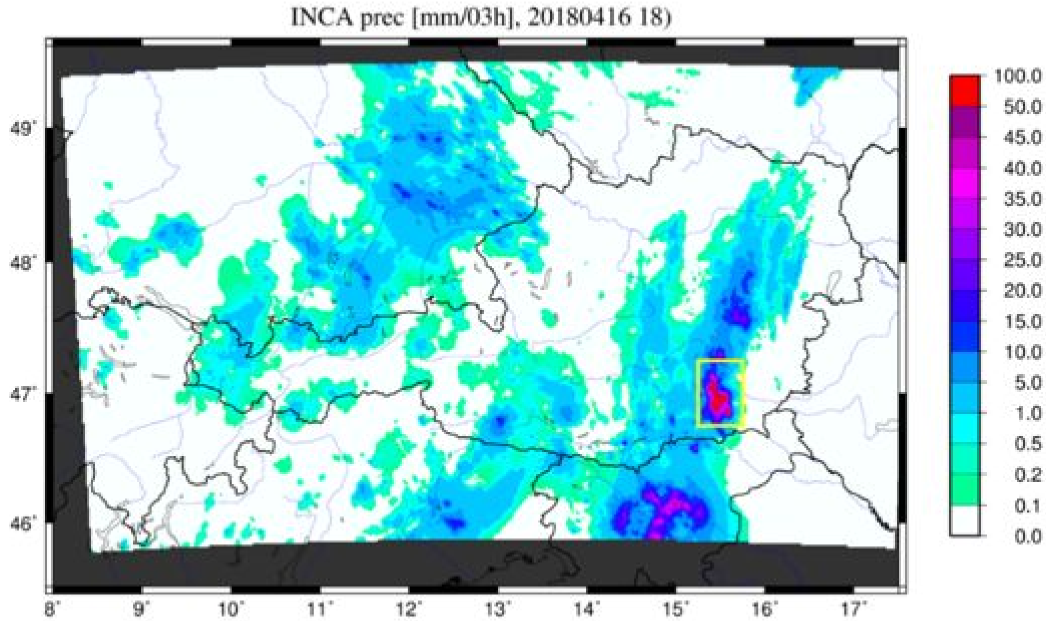

Figure 11: Extreme precipitation event from April 16, 2018. The INCA analysis [mm/3h].

- **Topic 3: 3D version of Stochastic Pattern Generator (SPG)**

This work covers the 3D extension of SPG in order to perturb the prognostic fields "independently" for every model level. Current SPG implementation allows only vertically constant random patterns to be applied on physics tendencies. A short sensitivity study with the new method was carried out as well. More details will be available after the report is delivered.

- **Topic 4: Jk 3DVar method (Endi's PhD)**

Endi has successfully finished his 3-years stay at ZAMG in March this year. The general idea of his work related to the perturbation of the upper-air initial conditions (Jk 3DVar) was already presented. It is ideologically similar to the upper-air spectral blending by digital filter, however the difference is being in completely another technique. One has to include the global model information directly into the LAM variational assimilation. As a result the combination of large scale (GM-EPS) and small scale (LAM-EPS) perturbation is obtained, which better simulates the uncertainty of the atmosphere on finer spatial resolution. Furthermore, this way is obtained also an important time and space consistency of such generated high-resolution IC and downscaled global LBC perturbations.

The verification of Endi's experiment was recently extended by one month to include August 2016, now covering the period of 62 days (July and August 2016). This resulted in an increased number of statistically significant results, which can be observed for the upper-air in figure 12 and for the surface in figure 13 (statistically significant differences are denoted by bullets).

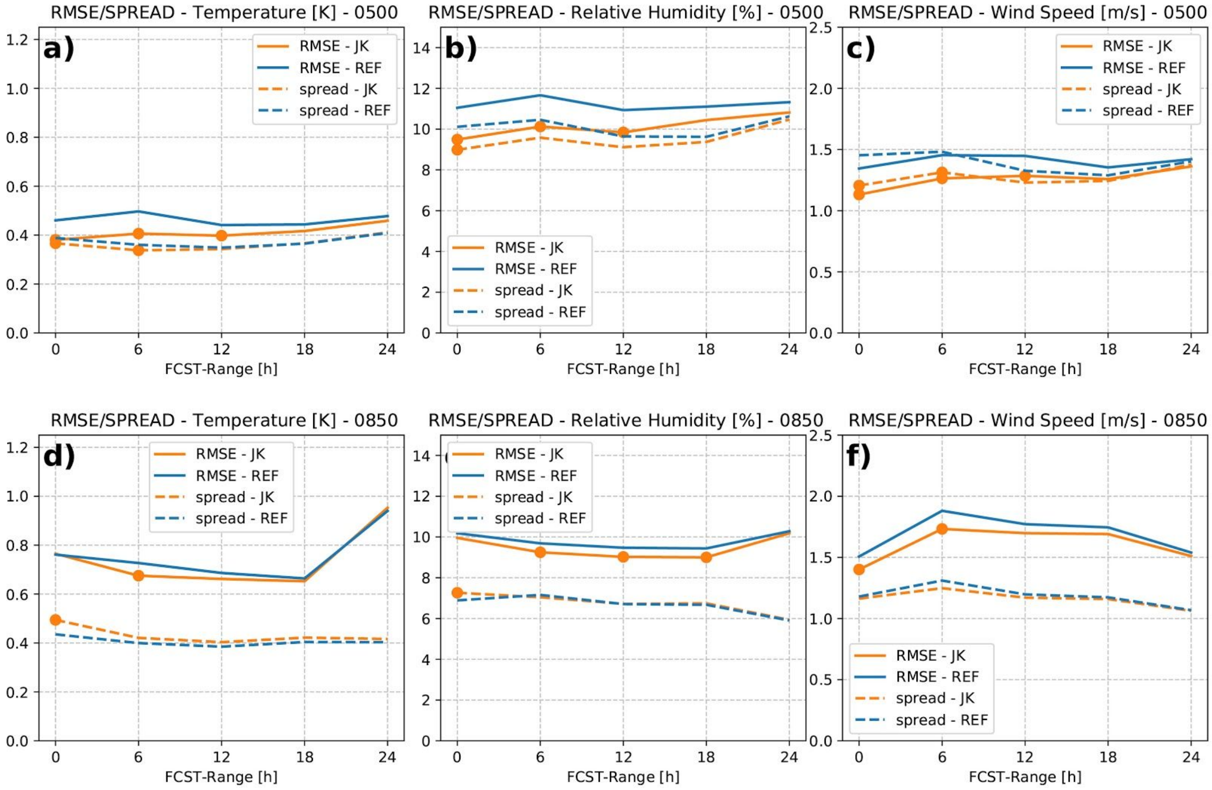

Figure 12: RMSE of ensemble mean (solid lines) and ensemble spread (dashed lines) of REF (AROME-EPS with 3DVar without Jk term) - blue and Jk - orange for (a) T500; (b) RH500; (c) W500; (d) T850; (e) RH850 and (f) W850. The verification period is July-August 2016. Forecast ranges with statistically significant differences are marked with a bullet symbol.

The implemented Jk blending method has a positive impact on the ensemble error, which was significantly reduced for the upper-air fields and the first several hours of integration (see figure 12). However, the impact on ensemble spread is not that clear. For all selected variables at 500 hPa the spread has been even decreased, but that comes together with the significant reduction of RMSE, so the ratio between both is clearly improved. Such effect cannot be observed in 850 hPa level, where one can see mostly a significant decrease of RMSE with only the slight increase of the ensemble spread for the beginning hours. For the surface fields the impact is rather neutral (see figure 13).

Precipitation was verified using fractions skill score (FSS). The figure 14 shows a comparison between the FSS of Jk blending and the reference as a function of lead time. The left panel is the median Skill Score of FSS of Jk blending to the reference (red means Jk is better than reference and blue the opposite, while white is neutral). The right panel is the significance level for that comparison, meaning the percentage of times when FSS of Jk blending was higher than the one of reference. It can be seen that at 6 h forecast range the precipitation forecast is improved for all thresholds (scales above 195 km) and for thresholds up to 5 mm (scales above 45 km). For 12 and 18 h forecast ranges the neutral results are observed, while for 24 h forecast range the precipitation forecast is improved for all scales (threshold of 1 mm) and for higher thresholds (scales above 195 km).

The overall impact of Jk blending method is clearly positive and it is planned to be used to generate the initial condition perturbation in the upper-air prognostic fields for the austrian C-LAEF system in combination with an EDA.

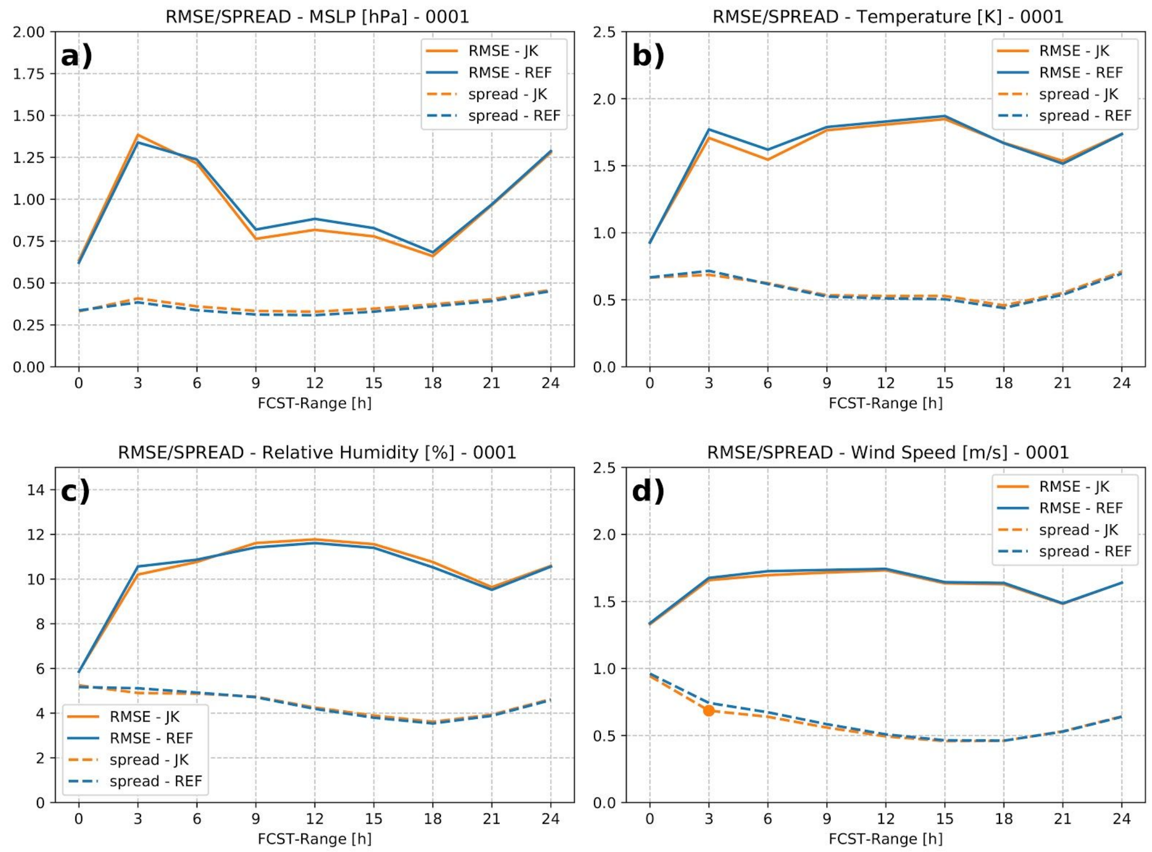

Figure 13: RMSE of ensemble mean (solid lines) and ensemble spread (dashed lines) of REF (AROME-EPS with 3DVar without Jk term) - blue and Jk - orange for (a) MSLP; (b) T2M; (c) RH2M and (d) W10. The verification period is July-August 2016. Forecast ranges with statistically significant differences are marked with a bullet symbol.

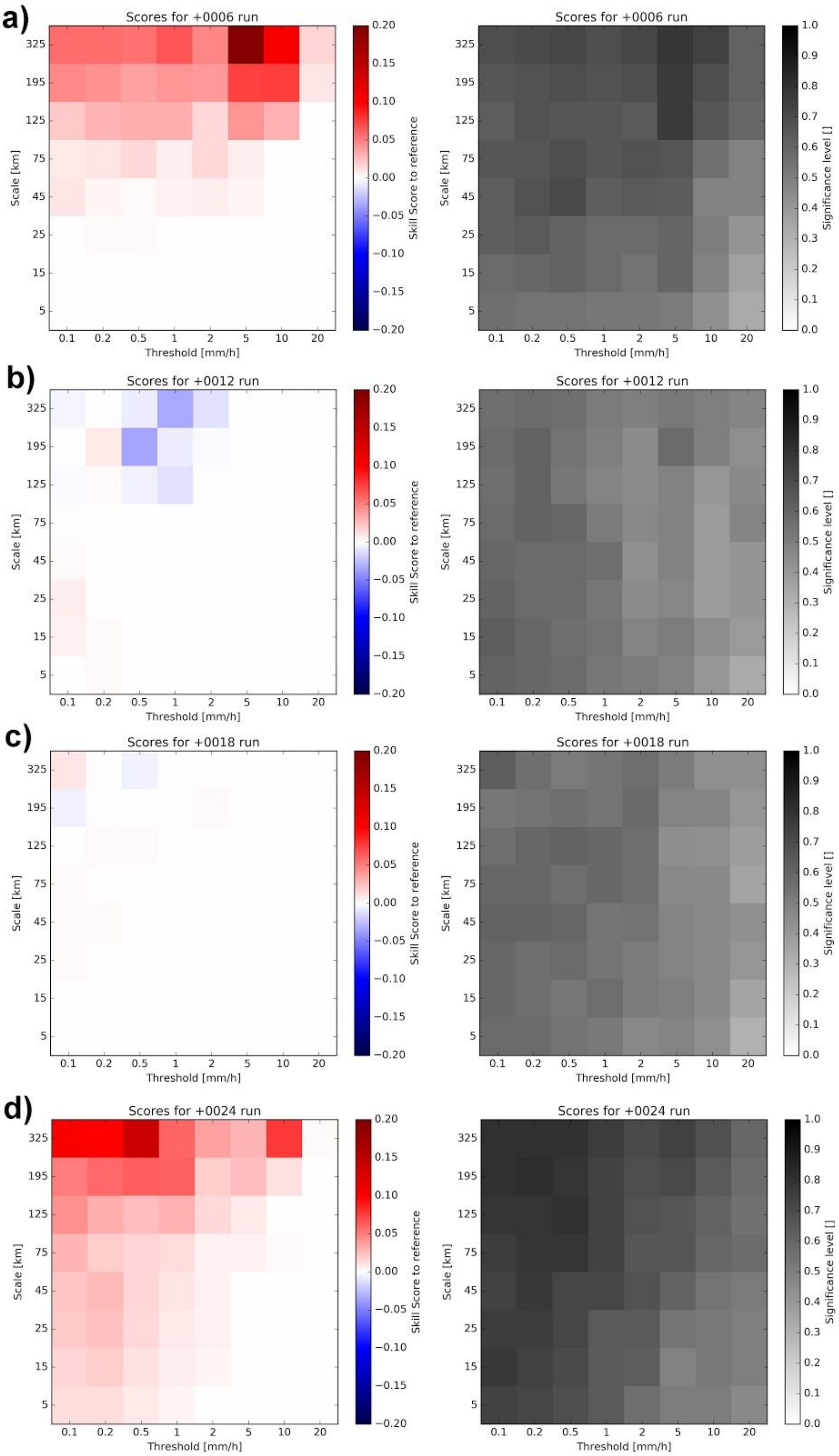

Figure 14: The median skill score of FSS (left) and significance level (right) for the comparison of Jk blending and the reference (AROME-EPS with 3DVar without Jk term) as a function of lead time (a) +6; (b) +12; (c) +18 and (d) +24 hours. Horizontal scales on y-axes and precipitation thresholds on x-axes.

Efforts: 9 PM (0.5 PM LACE stay)

Contributors: Réka Suga, Mihály Szűcs (both OMSZ), Christoph Wittmann, Clemens Wastl (both ZAMG), Endi Keresturi (DHMZ)

Documentation: Reports on stays; papers for publication in scientific journals

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 forecasting system, either deterministic or probabilistic one. Knowing the statistical scores and limits of our forecasting system is crucial for further improvements. The huge amount of data must be processed, which requires an appropriate, optimized and flexible verification software. ALADIN-LAEF verification tool is being developed, maintained and used already for several years. However, distinct versions of the source code have been created in recent years under the different users. These versions may diverge from each other and involve various level of modifications and bug fixing. Therefore, it is necessary to merge the latest development under one common library and treat the known bugs equally. Such maintenance was planned for this year, but unfortunately the stay of Simona Taşcu was canceled.

Efforts: 0 PM

Contributors: -

Documentation: -

Status: Frozen

S5 Action/Subject/Deliverable: Collaborations

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

The collaboration is currently being continued on SRNWP-EPS phase II project of EUMETNET. RC LACE is not directly involved, the cooperation is rather between the members' national meteorological services. Some related activities are carried out at Hungarian Meteorological Service. The second phase of the project was originally planned till the end of 2017, but it has been extended until 31st of December 2018. Current phase focuses on the development of new probabilistic methodologies to predict severe weather conditions like thunderstorms and fog and studying the underlying sensitivity of the models to soil conditions and the boundary layer.

The collaboration between ALADIN and HIRLAM consortia in the field of Predictability and EPS is still a bit frozen. The merging procedure between both consortia already started by the preparation of common Rolling Work Plan for this and next year, nevertheless the direct cooperation is lacking. It is partially a fail on both sides and probably also the general decrease of dedicated manpower is responsible.

Efforts: 0.5 PM

Contributors: Martin Belluš (SHMU), Mihály Szűcs (OMSZ), ??

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.

This year (July 23, 2018) our important review paper devoted to the 27th anniversary of RC LACE regional cooperation was successfully published in BAMS. The list of all other submitted papers and papers in progress can be found in the Documents and publications chapter.

Efforts: 3 PM

Contributors: Yong Wang, Florian Weidle, Christoph Wittmann, Florian Meier, Clemens Wastl, (all ZAMG), Endi Keresturi (DHMZ), Martin Belluš (SHMU), Mihály Szűcs (OMSZ)

Documentation: Reviewed papers

Status: In progress

List of actions, deliverables including status

S1 Subject: Optimization of ALADIN-LAEF

Deliverables: Reports on LACE stays; papers submitted to scientific journals; improvement of current regional ensemble system through the results and outcomes of R&D

Status: Ongoing

S2 Subject: ALADIN-LAEF maintenance

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

Status: New scripts development + permanent maintenance tasks

S3 Subject: AROME-EPS

Deliverables: Reports on LACE stays; papers submitted to scientific journals; convection-permitted ensemble system prototypes for preoperational or operational use

Status: Ongoing

S4 Subject: EPS - Verification

Deliverables: Upgrades and maintenance of LAEF Verification package; bug-fixes

Status: Frozen

S5 Subject: Collaborations

Deliverables: Exchange of the expertise between the other consortia or within the relevant projects

Status: Ongoing

S6 Subject: Publications

Deliverables: 2 papers were published, 1 paper is submitted and currently waiting for the second review and 2 others are in preparation; 1 stay report is available online via RC LACE portal, while 3 others will follow soon (see the list of publications below)

Status: In progress

Documents and publications

Published papers:

- Wang Y., M. Belluš, A. Ehrlich, M. Mile, N. Pristov, P. Smolíková, O. Španiel, A. Trojáková, R. Brožková, J. Cedilnik, D. Klarić, T. Kovačić, J. Mašek, F. Meier, B. Szintai, S. Tascu, J. Vivoda, C. Wastl, Ch. Wittmann, 2017: "27 years of Regional Co-operation for Limited Area Modelling in Central Europe (RC LACE)", published online on 23 July 2018 in BAMS, DOI: 10.1175/BAMS-D-16-0321.1
- Ihász I., A. Mátrai, B. Szintai, M. Szűcs, I. Bonta, 2017: "Application of European numerical weather prediction models for hydrological purposes", published in Időjárás on January 2018, DOI: 10.28974/idojaras.2018.1.5

Submitted papers:

- Keresturi E., Y. Wang, F. Meier, F. Weidle, Ch. Wittmann, 2018: "Improving initial condition perturbations in a convection permitting ensemble prediction system", submitted to Quarterly Journal of the Royal Meteorological Society, currently under second review

Papers in preparation:

- Taşcu S., Y. Wang, Ch. Wittmann, F. Weidle: "Forecast skill of regional ensemble system comparing to the higher resolution deterministic model", in preparation for a local meteorological journal (Romania)
- Wang Y., M. Belluš, Ch. Wittmann, J. Tang, F. Weidle, F. Meier, F. Xia, E. Keresturi: "Impact of land surface stochastic physics in ALADIN-LAEF", in preparation for Quarterly Journal of the Royal Meteorological Society

Stay reports:

- Iris Odak Plenković: Work on analog-based post-processing method, Report on stay at ZAMG, 05/02~02/03, 2018, Vienna, Austria
- Mihály Szűcs: 3D version of SPG, Report on stay at ZAMG, 04/06~15/06, 2018, Vienna, Austria (in preparation)
- Martin Belluš: Operational ecFlow suite for new ALADIN-LAEF, Report on stay at ZAMG, 30/07~24/08, 2018, Vienna, Austria (in preparation)
- Martin Imrišek: Validation of ENS 3DVar within ALADIN-LAEF Phase II, Report on stay at ZAMG, 30/07~24/08, 2018, Vienna, Austria (in preparation)

Activities of management, coordination and communication

- 30th LSC Meeting, 15-16 March, Plitvicka jezera, Croatia
- Joint 28th ALADIN Workshop & HIRLAM All Staff Meeting 2018, 16-19 April 2018, Météo-France Toulouse, France (oral presentation of Martin Belluš)
- EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2018, 3–7 September 2018, Budapest, Hungary (ALADIN-LAEF poster by Martin Belluš, presented by Martina Tudor).

LACE supported stays – 3.5 PM till September 2018

There were four stays executed:

- Iris Odak Plenković [S1], 5 Feb ~ 2 Mar 2018, ZAMG (4 weeks)
- Mihály Szűcs [S3], 4 Jun ~ 15 Jun 2018, ZAMG (2 weeks)
- Martin Belluš [S2], 30 Jul ~ 24 Aug 2018, ZAMG (4 weeks)
- Martin Imrišek [S1], 30 Jul ~ 24 Aug 2018, ZAMG (4 weeks)

Summary of resources [PM]

Subject	Manpower		LACE		ALADIN	
	plan	realized	plan	realized	plan	realized
S1: Optimization of LAEF	10	3	4	2		
S2: LAEF maintenance	3	1.5		1		
S3: AROME-EPS	11	9	1.5	0.5		
S4: EPS – Verification	1	-	1	-		
S5: Collaborations	2	0.5				
S6: Publications	6	3				
Total:	33	17	6.5	3.5	0	0