Working Area Predictability

Progress Report

Prepared by:	Area Leader: Clemens Wastl
Period:	2021 (Jan – Aug)
Date:	September 2021

Progress summary

A lot of EPS related work has been done so far in 2021 within RC-LACE despite the unfavorable circumstances connected to the COVID-19 crisis. All planned stays have been postponed or cancelled for this year so far. Maybe if the situation is improving significantly in autumn (highly questionable) one or two stays could still take place in 2021 (Endi Keresturi and Iris Odak Plenkovic have already announced their interest).

All three ensemble systems within RC-LACE (A-LAEF, C-LAEF, AROME-EPS) are running in full operational mode. They are running very stable and smoothly and the usage of EPS at the meteorological centers is constantly increasing. AROME-EPS in Hungary has been upgraded this year to cy43t2, a C-LAEF upgrade to cy43t2 is planned for autumn 2021. Some planned activities could not be fulfilled because of the delay of the new ECMWF HPCF in Bologna – the new plan is Q2/2022 to have full access to this supercomputer. Therefore also some possible major upgrades of A-LAEF and C-LAEF (cycle, lead time, runs/day, assimilation cycle, etc.) have to be postponed to this date. First preparatory work for using C-LAEF in Turkey has been made, a new Mediterranean Sea domain for ocean models coupling has been set-up for A-LAEF and also an OBS backup using GTS data which is uploaded to OPLACE has been installed. The upgrade of the ECMWF-ENS to cy47r2 and the increase of the number of vertical levels from 91 to 137 in May 2021 has not caused any technical problems for the LAM-EPS within RC-LACE. Together with this upgrade also the coupling file production for the convection-permitting systems AROME-EPS and C-LAEF has been merged and is now done by a time-critical option 3 at ECMWF with 903.

Also the scientific work is progressing well, new developments like the surface perturbation scheme and new parameter perturbations for C-LAEF or the precipitation phase calculation and an incremental DFI step in spectral blending procedure for A-LAEF have been made and are tested and verified continuously in parallel EPS e-suites. New EPS applications (visualizations, maps, EPSgrams) have been developed and is planned to exchange the templates for such visualizations (e.g. in Visual Weather) within the RC-LACE countries and to provide some new products on the RC-LACE webpage.
In the verification subject it seems that more and more countries (Slovakia, Poland, Hungary, Austria) are using the R-based HARP package for verifying EPS.
Some papers have been published and the EPS related work has been presented at international workshops and conferences.

Scientific and technical main activities and achievements, major events

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

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

The originally planned topics in 2021 (based on the EPS workplan generated in September 2020) were:

- ❑ Implementation and testing of new random number generator (SPG) suitable for LAM EPS environment in A-LAEF.
- ❑ Stochastic perturbation of fluxes instead of tendencies in order to preserve the energy balance in perturbed model.
- ❑ Utilization of A-LAEF operational forecasts for flow-dependent B-matrix computation to be used in local assimilation cycles of RC LACE members.
- ❑ Continuation work on methods for analog-based post-processing of probabilistic fields on a regular grid

Most of them have been postponed because these topics should have been investigated in course of LACE stays which have all been cancelled so far due to the COVID situation. Hence, the work spent on S1 topic in the period January to August 2021 comprises so far mostly long-term and case study verification (Topic 1), creation of EPSgrams (Topic 2) and the calculation of precipitation phase based on EPS output (Topic 3). Furthermore some work has been spent on the implementation and testing of incremental DFI step in spectral blending procedure in A-LAEF in the e-suite.

- ❑ **Topic 1: A-LAEF operational runs - Case studies and verification**

In the first half of 2021 a lot of work has been spent on the verification of the operational A-LAEF suite. This comprises the ongoing continuous verification with HARP (S4) as well as an extensive verification of selected case studies with severe weather. Especially during the very wet summer 2021 several catastrophic flood events occurred in Central Europe which have been investigated and reported. These situations have shown the good quality of the A-LAEF system and in general the benefit of using a probabilistic forecasting system.

- **Case study 1: Critical temperature advection in Slovakia (07/02/2021)**

On February 7 2021 there was a strong southerly advection of warm air, however, a temperature inversion developed over the border area of SK, CZ, HU, AT countries indicated by soundings and several forecasts. High differences in T2m forecasts were related to different spread of the mixed PBL region in various models (Figure 1). Most of the models forecast a “tongue” of warmer air spreading toward North, with different extension (Figure 2). T2m was overestimated by about 10 °C in the area of Bratislava. A-LAEF MP clusters 2, 3 (both using QNSE turbulence parameterization with “stable” Geleyn-Cedilnik mixing length) showed significant, systematic improvement compared to the clusters 1 and 4 (with the similar setup as of the operational deterministic model at SHMU).

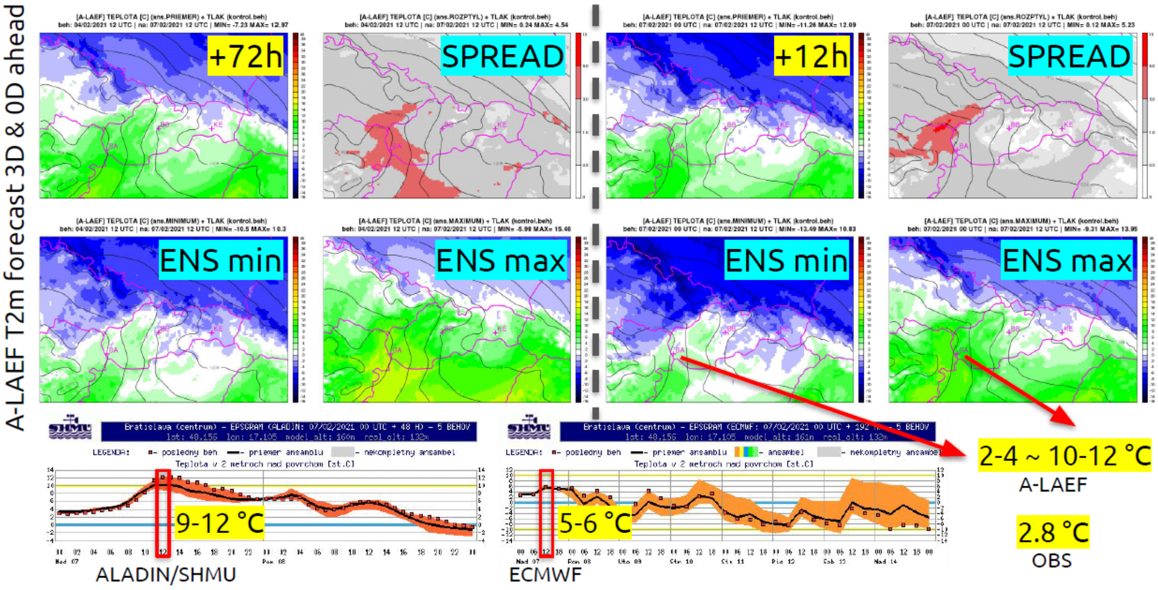
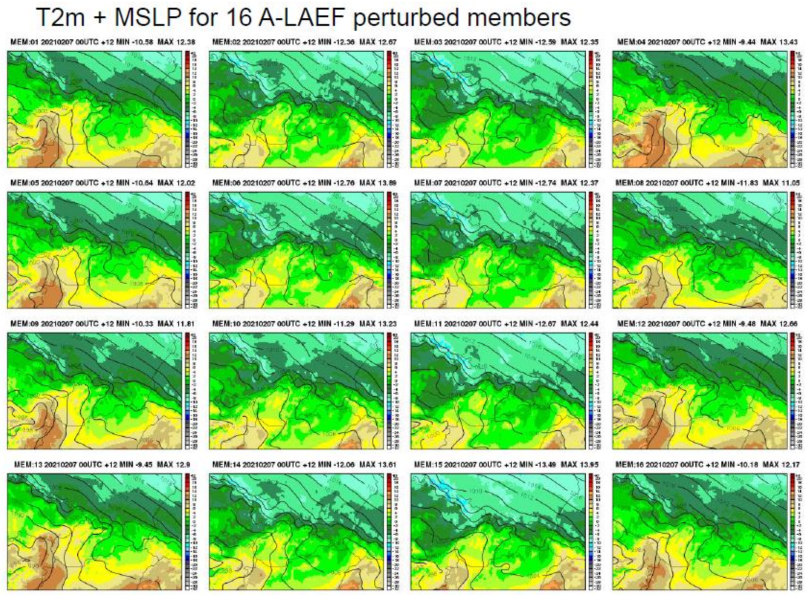


Figure 1: A-LAEF T2m forecast +72h (left) and +12h (right) for ENS average (first panel), ENS spread (second), ENS min (third) and ENS max (fourth), respectively. Lower row shows the model point forecast for A-LAEF (left) and EMCWF-ENS (right) for Bratislava.



[48.172,17.2] ERR <=3 >=5
2021-02-07 00 +12h FCST:

SHMU	12.6	d=2.80km
CHMU	5.6	d=1.11km
A-LAEF00	8.6	d=2.40km
A-LAEF01	8.1	d=2.40km
A-LAEF02	3.1	d=2.40km
A-LAEF03	2.1	d=2.40km
A-LAEF04	9.2	d=2.40km
A-LAEF05	7.5	d=2.40km
A-LAEF06	3.8	d=2.40km
A-LAEF07	3.1	d=2.40km
A-LAEF08	7.5	d=2.40km
A-LAEF09	8.0	d=2.40km
A-LAEF10	2.4	d=2.40km
A-LAEF11	2.7	d=2.40km
A-LAEF12	9.1	d=2.40km
A-LAEF13	7.9	d=2.40km
A-LAEF14	2.9	d=2.40km
A-LAEF15	3.7	d=2.40km
A-LAEF16	7.4	d=2.40km
ALARO2	10.0	d=0.24km
ICON	3.0	d=1.96km

Bratislava: T2m OBS 2.8

Figure 2: T2m and MSLP forecast for all 16 members of A-LAEF (left) and temperature forecast of different models for grid point of Bratislava (right).

- **Case Study 2: Large scale precipitation in Slovakia (14/03/2021)**

This event was characterized by a significant overestimation of precipitation amounts by the deterministic ALADIN/SHMU model. A-LAEF showed a much better performance for this event for most members (Figure 3).

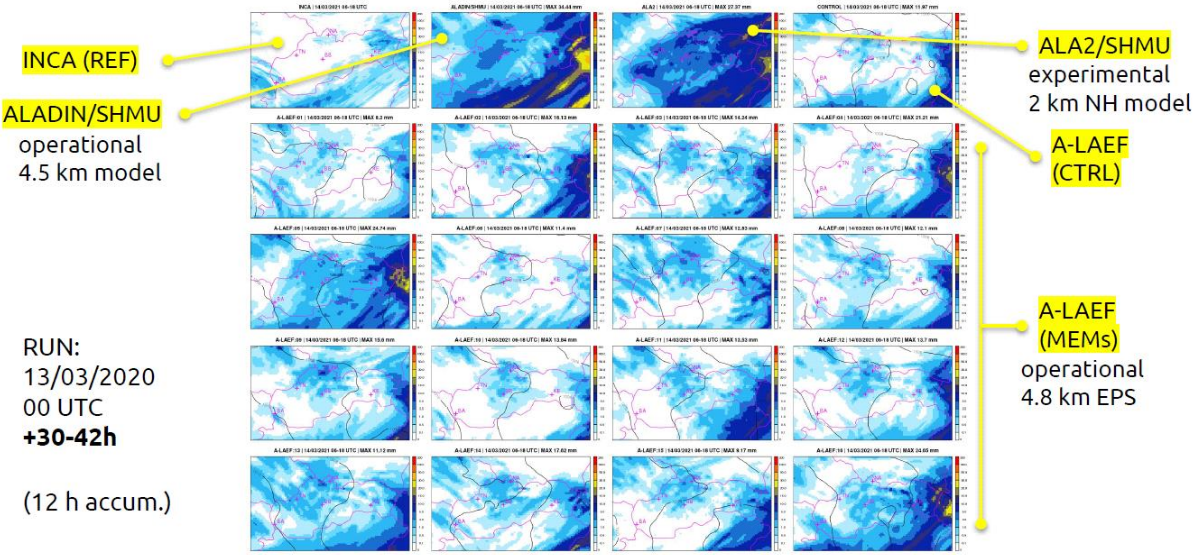


Figure 3: Total precipitation analysis (INCA, panel 1) and forecast for the period from March 14 06-18 UTC for ALADIN SHMU (panel 2), ALADIN SHMU experimental (panel 3) and the 16+1 A-LAEF members.

- **Case Study 3: Cold front passage in Slovakia (12-13/04/2021)**

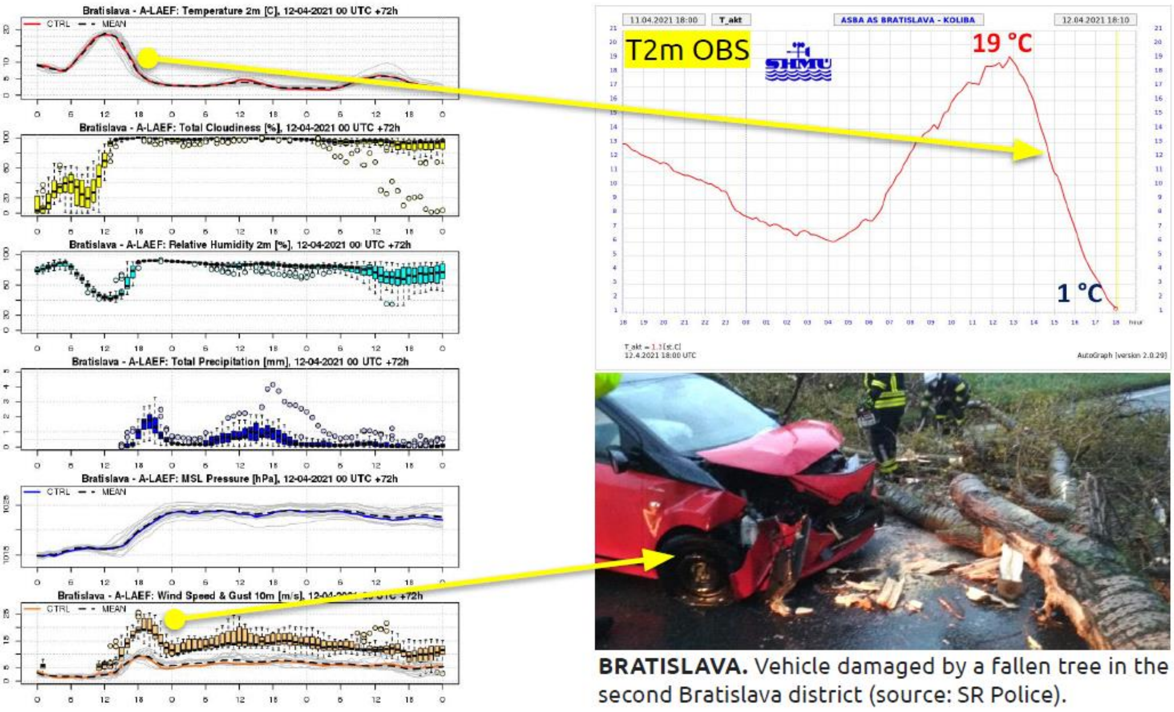


Figure 4: A-LAEF forecast (left) for temperature, cloudiness, relative humidity, precipitation, MSLP and wind gusts for Bratislava. Upper right panel shows T2m observation for SHMU station in Bratislava.

After the passage of a strong cold front on 12/04/2021, the cold air quickly invaded the southwest of Slovakia. From noon values around 20 °C, it cooled down to 1-3 °C in a few hours (Figure 4). Mixed precipitation and gradually snowfall appeared also in lowlands. Simultaneously, wind gusts exceeded 70 km/h, with a maximum of about 90 km/h. The Slovak Hydrometeorological Institute issued second level warning for strong winds in Bratislava and Pezinok districts. Several property damage was recorded mainly in connection with wind gusts. Both massive temperature drop and strong wind gusts were well captured by A-LAEF ensemble, while the uncertainty was related rather to the precise timing of the event.

- **Case Study 4: Catastrophic flood event in Germany (13-15/07/2021)**

After several episodes of heavy rain, the cyclonic weather system “Bernd” caused persistent or recurring heavy rainfall. The central parts of Germany were affected locally, but the west of Rhineland-Palatinate and the southern half of North Rhine-Westphalia were largely affected. As a result, small rivers and flash floods began to expand locally. In addition to immense property damage, over 160 people lost their lives.

A-LAEF ensemble successfully captured the precipitation event, with well localized patterns (even with unusually high probabilities of extreme precipitation amounts) – Figures 5-8.

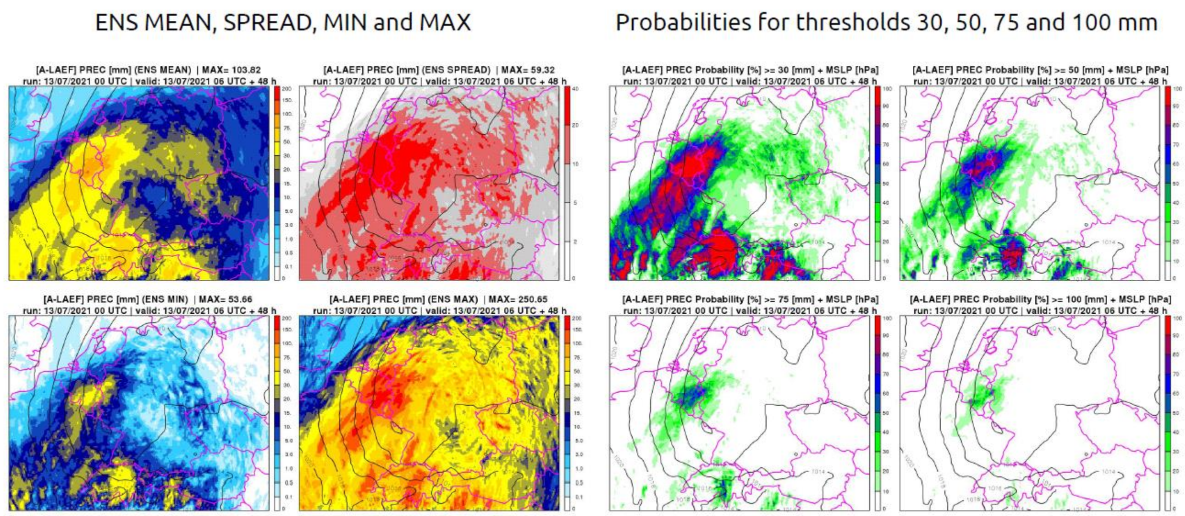


Figure 5: A-LAEF (13/07/2021 00 UTC run) precipitation forecast for the 48h period between 13/07 and 15/07/2021 06 UTC. On the left hand side ensemble mean, spread, min and max are shown, while on the right hand side probabilities for exceeding for 30, 50, 75 and 100mm are displayed.

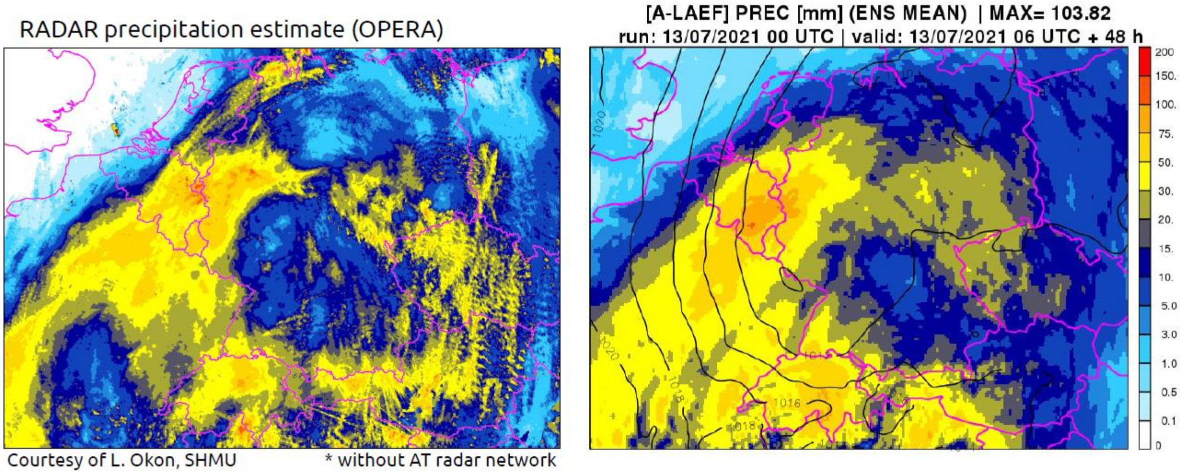


Figure 6: 48h accumulated precipitation (13/07 – 15/07/2021 06 UTC) from RADAR composite (left) and A-LAEF forecast (ensemble mean, right).

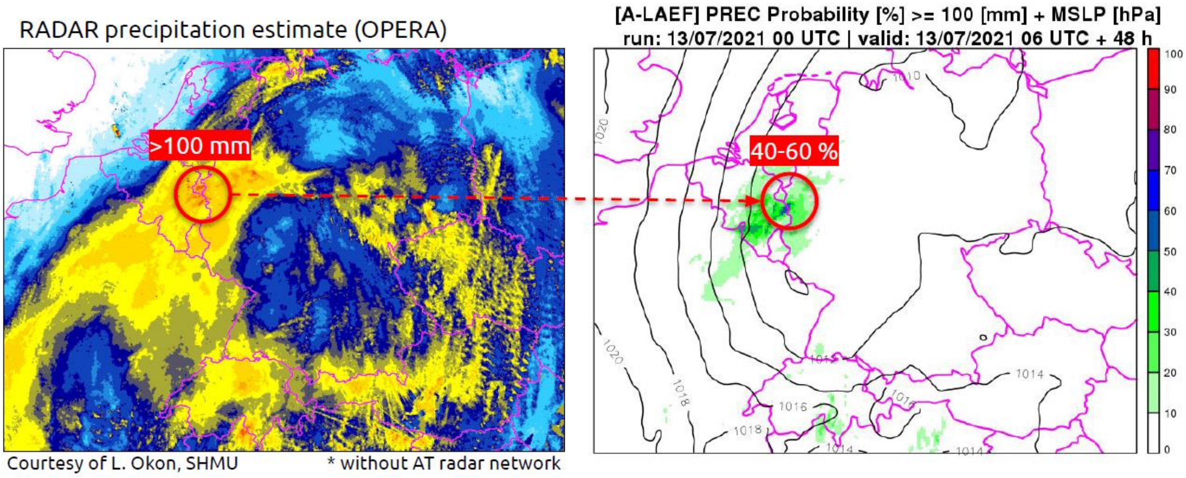


Figure 7: 48h accumulated precipitation (13/07 – 15/07/2021 06 UTC) from RADAR composite (left) and A-LAEF probability of exceeding 100mm/48h (right).

Figure 8: Some images of devastating flood in Germany in July 2021.

- **Case Study 5: Flash flood event in Austria (17-19/07/2021)**

Just a few days after the devastating flood situation in Germany the heavy rain area of the same system reached Salzburg and Tyrol in Austria. Damaging floods affected areas along the Salzach River and its tributaries in the state of Salzburg (it was reported as a 50-year flood event). The town of Hallein was particularly badly affected. Vienna experienced more than a month's rainfall in a few hours during thunderstorms on Saturday July 17. Heavy rain also created a risk of flooding and mudslides across Styria, the levels of small rivers rose quickly (Figures 9-11).

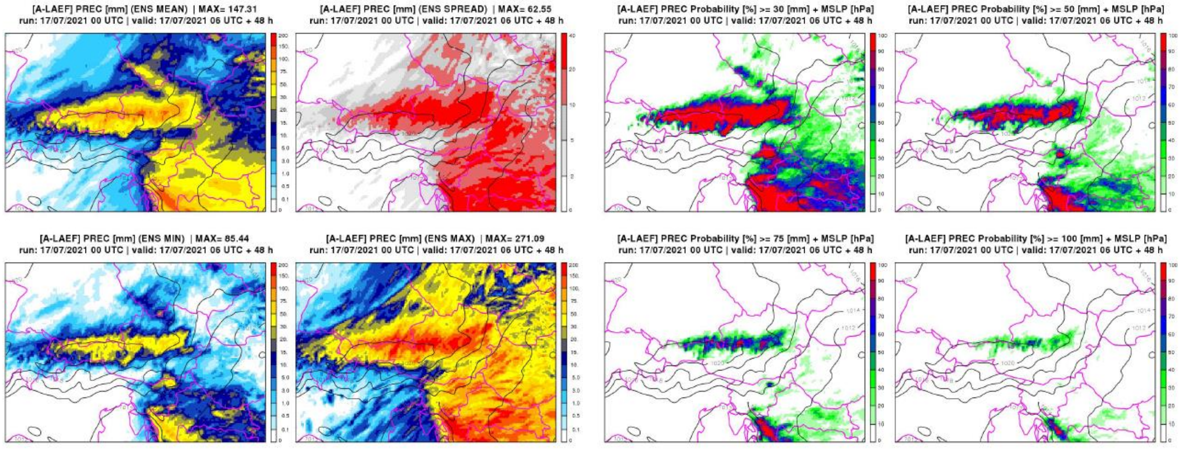
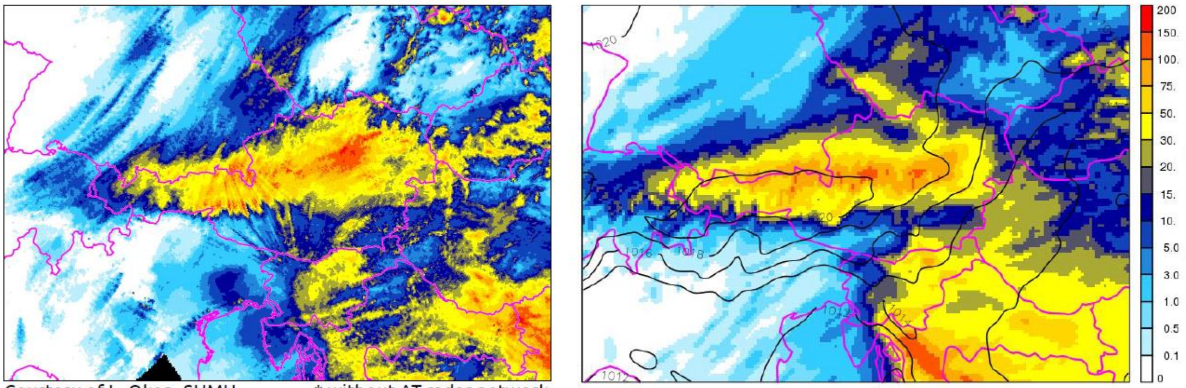


Figure 9: A-LAEF (17/07/2021 00 UTC run) precipitation forecast for the 48h period between 17/07 and 19/07/2021 06 UTC. On the left hand side ensemble mean, spread, min and max are shown, while on the right hand side probabilities for exceeding for 30, 50, 75 and 100mm are displayed.



Courtesy of L. Okon, SHMU * without AT radar network

Figure 10: 48h accumulated precipitation (17/07 – 19/07/2021 06 UTC) from RADAR composite (left) and A-LAEF forecast (ensemble mean, right).

source: floodlist.com

Figure 11: Some images of flash flood events in Austria in July 2021.

For the first 7 months in 2021 (Jan-Jul) a long-term deterministic verification of A-LAEF (ensemble mean, 16+1 members), the operational ALADIN/SHMU model and the dynamical downscaling of ARPEGE model with ALARO (ALARO NH) has been made for the surface parameters temperature, relative humidity and wind speed. Figure 12 shows the verification results (RMSE, standard deviation) over all Slovak stations. Ensemble mean of A-LAEF shows the best verification results for all investigated parameters.

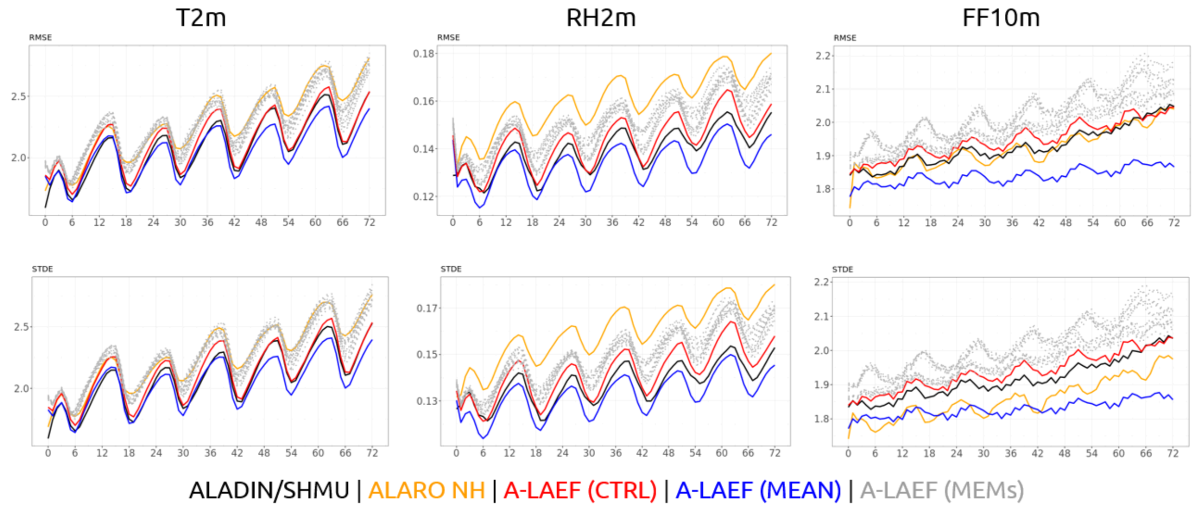


Figure 12: RMSE (upper row) and standard deviation (lower row) for T2m (left), relative humidity at 2m (center) and 10m wind speed (right) for the period Jan-Jul 2021.

❑ Topic 2: A-LAEF operational maps: EPSgrams

The existing set of probabilistic A-LAEF maps on the RC-LACE webpage prepared at SHMU has been complemented by EPSgrams for the capital cities within LACE. Figure 13 shows an example of such an EPSgram for Bratislava on 29 August 2021.

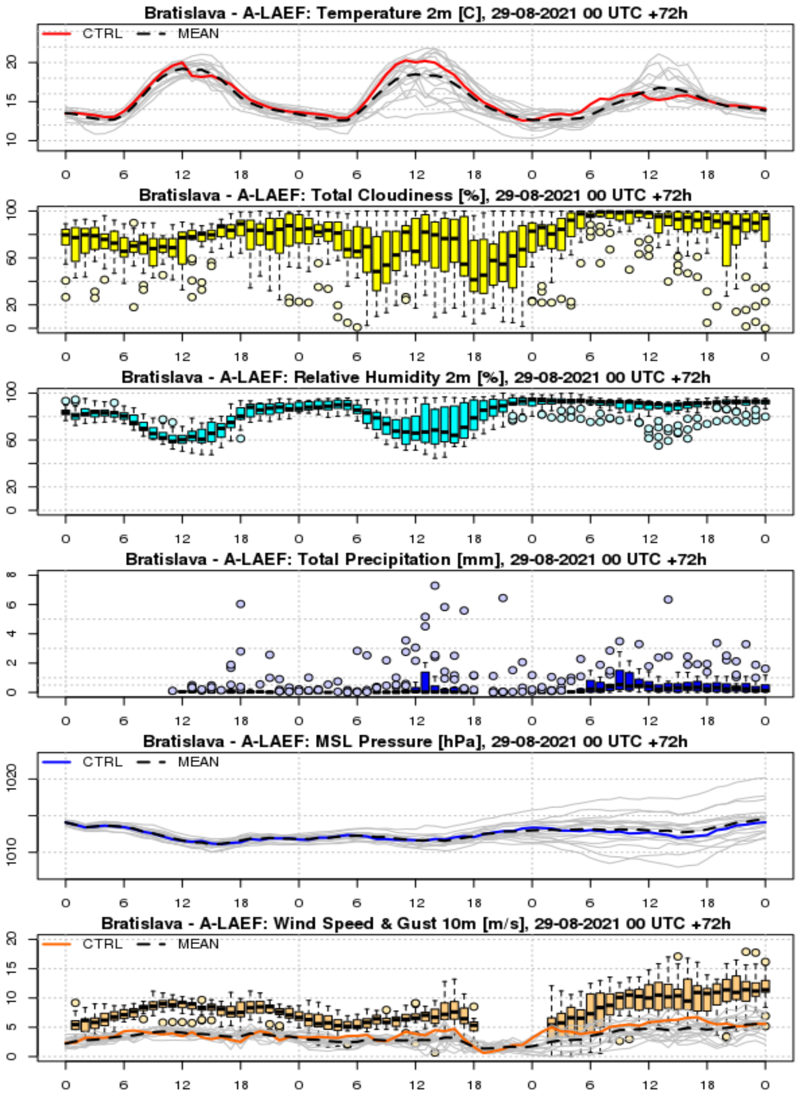
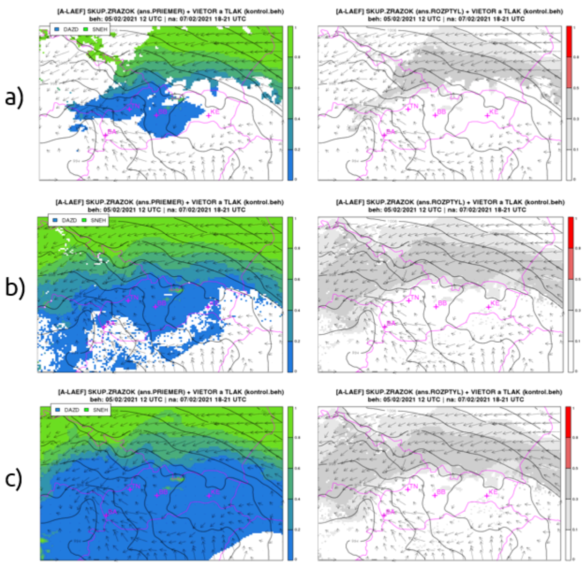


Figure 13: New A-LAEF EPSgram for Bratislava based on 29 August 2021 00 UTC run.

❑ Topic 3: Precipitation phase calculation from EPS data

Different approaches of calculating precipitation phase from EPS data have been tested in A-LAEF. Figure 14 shows three different ways of such a precipitation phase calculation applied to an A-LAEF test case on 07 February 2021. For method a) the ensemble mean of precipitation phase is only defined in areas where the total precipitation of the ensemble minimum is > 0.1mm (07/02/2021 18-21 UTC), otherwise M and S are 0. In approach c) the ensemble mean of precipitation phase is defined in areas where the ensemble mean of total precipitation is > 0.1mm (07/02/2021 18-21 UTC).



mean, snow, spread:

$$M = \frac{1}{n}\sum_{i=1}^{n}\frac{SN_i}{TP_i} \qquad S = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\frac{SN_i}{TP_i} - \frac{1}{n}\sum_{i=1}^{n}\frac{SN_i}{TP_i}\right)^2}$$

$$TP_i < 0.1 \rightarrow M = 0,\ S = 0$$

total prec.

$$M = \frac{1}{n}\sum_{i=1}^{n}\frac{SN_i}{TP_i} \qquad S = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\frac{SN_i}{TP_i} - \frac{1}{n}\sum_{i=1}^{n}\frac{SN_i}{TP_i}\right)^2}$$

$$M = \frac{\frac{1}{n}\sum_{i=1}^{n} SN_i}{\frac{1}{n}\sum_{i=1}^{n} TP_i} \qquad S = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\frac{SN_i}{TP_i} - \frac{1}{n}\sum_{i=1}^{n}\frac{SN_i}{TP_i}\right)^2}$$

$$\frac{1}{n}\sum_{i=1}^{n} TP_i < 0.1 \rightarrow M = 0$$

Figure 14: Calculation of precipitation phase (snow, rain) for a test case on 07 February 2021. The left column shows the ensemble mean precipitation phase (0=rain, 1=snow) based on the respective calculation method (a, b, c), the right column the ensemble spread.

Such precipitation phase definitions work for many cases quite well as the comparison with observations shows in Figure 15.

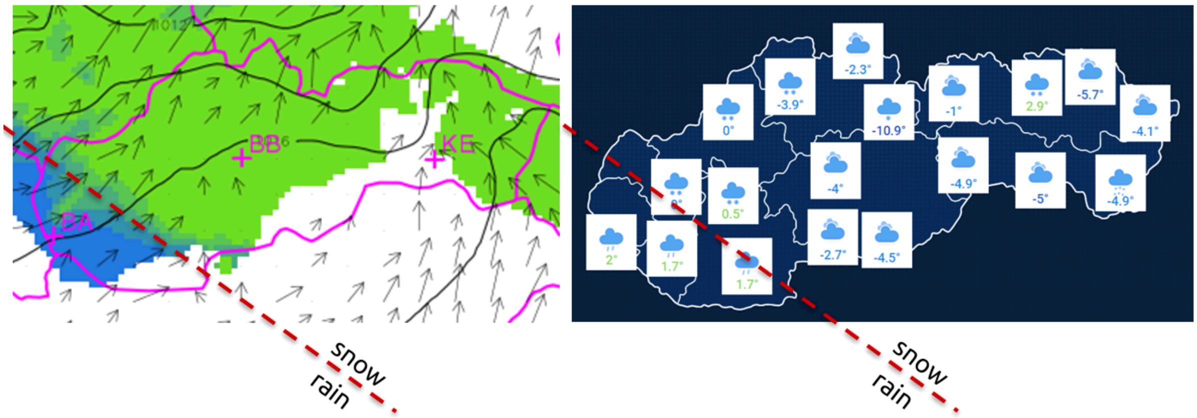


Figure 15: Precipitation phase forecast (left) and observations (right) for a test case on 19 January 2021 (18-21 UTC) in Slovakia.

Efforts: 5.5 PM

Contributors: Martin Belluš, Mária Derková (SHMU), Endi Keresturi (DHMZ)

Documentation: Reports on case stays (on webpage); papers submitted to scientific journals; improvement of current regional ensemble system through the results and outcomes of R&D

Status: Ongoing; a lot of delays and shifts in topics due to postponed stays (COVID)

S2 Action/Subject/Deliverable: A-LAEF maintenance

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

The originally planned topics in 2021 (based on the EPS workplan generated in September 2020) were:

- ❑ Migration of A-LAEF system to the new ECMWF's computer in Bologna and its upgrade to cy43 or cy46 (if available).
- ❑ Upgrade of the upper-air IC uncertainty simulation by ENS BlendVar (if feasible with respect to the available resources).
- ❑ Unification of A-LAEF grib coding and inclusion of new fullpos fields according to users' requirements.
- ❑ Technical support for Turkey with the utilization of A-LAEF operational data.
- ❑ A-LAEF coupling for the local convection-permitting EPS applications

Some of these topics (e.g. migration) have been postponed due to the delay in the availability of the new ECMWF supercomputer in Bologna which is planned now for Q2 2022. Hence, the work spent on S2 topic in the period January to August 2021 comprises so far mostly preparation of new Mediterranean Sea domain (Topic 1), ECMWF ENS upgrade to cy47r2 (Topic 2) and OBS backup based on GTS data (Topic 3). Furthermore, the A-LAEF GRIB dissemination, the scripts for archiving to ECFS and the fullpos for Turkey and Czech Republic have been optimized. Last but not least also the technical documentation of A-LAEF TC2 suite on the RC-LACE webpage has been updated.

❑ Topic 1: Preparation of Mediterranean Sea domain (MSEA) for the ocean models coupling

Since 28 April 2021 several fields (see list below) for all 16+1 A-LAEF members are processed for a new Mediterranean Sea fullpos domain (MSEA, Figure 16). These output is operationally produced (00 and 12 UTC run) and can be used for the ocean models coupling (e.g. NEMO, SHYFEM).

SURFTEMPERATURE; SURFPREC.EAU.CON; SURFPREC.NEI.CON; SURFPREC.EAU.GEC; SURFPREC.NEI.GEC; SURFFLU.RAY.SOLA; SURFFLU.RAY.THER; SURFRAYT THER DE; SURFRAYT SOLA DE; SURFFLU.LAT.MSUB; SURFFLU.CHA.SENS; SURFFLU.MSUBL.NE; CLSTEMPERATURE; SURFNEBUL.TOTALE; CLSVENT.ZONAL; CLSVENT.MERIDIEN; CLSU.RAF.MOD.XFU; CLSV.RAF.MOD.XFU; CLSHUMI.SPECIFIQ; MSLPRESSURE

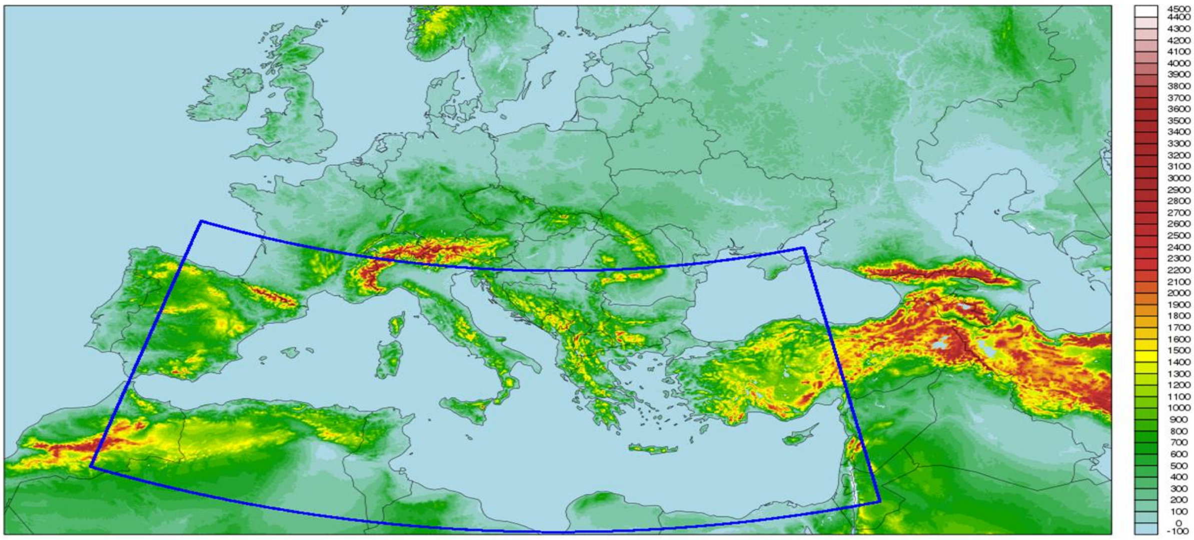


Figure 16: New Mediterranean Sea (MSEA) fullpos domain for ocean models coupling in blue.

- ❑ **Topic 2: Impact of ECMWF ENS upgrade to cy47r2 in May 2021**

The ECMWF-ENS model has been upgraded to cy47r2 on 11 May 2021 which also includes an increase of the number of vertical levels from 91 to 137. This of course has also an impact on all the coupled models like A-LAEF. The new coupling files have been provided by ECMWF in advance to test the upgrade technically. The upgrade was very smooth without any technical problems for A-LAEF. For a selected case the impact of the higher number of vertical levels in the new coupling files has been tested in A-LAEF for some parameters at the surface and in the upper air (Figure 17).

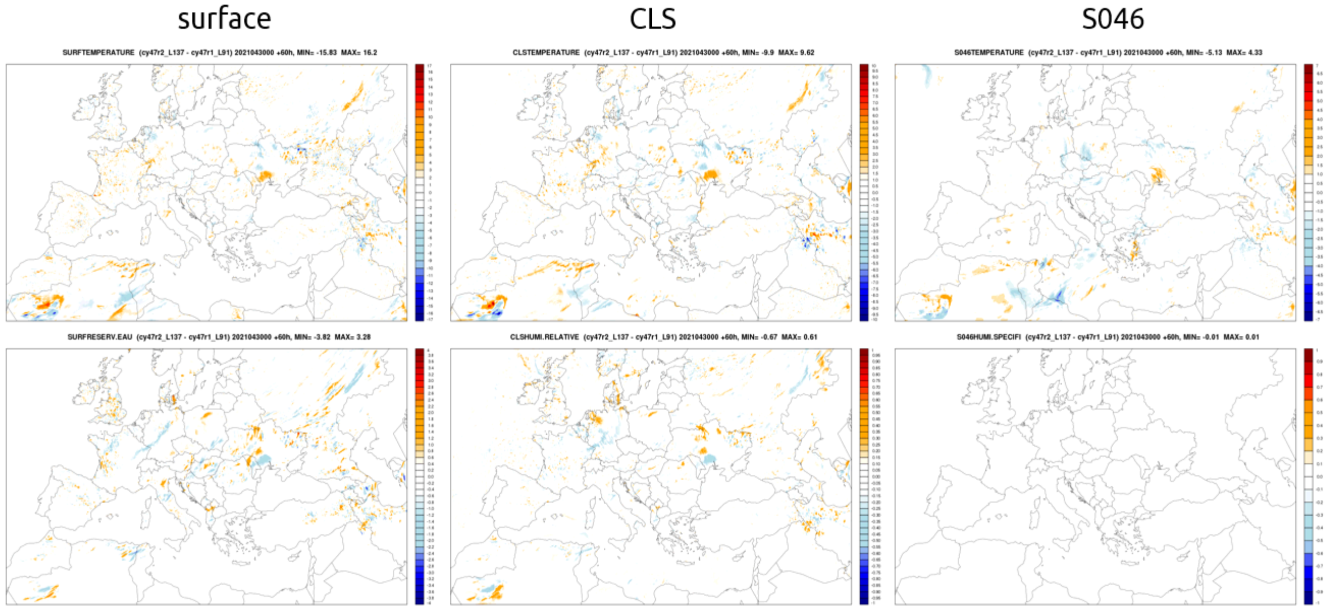


Figure 17: Impact of the higher number of vertical levels (137 vs. 91) in the new ECMWF-ENS coupling files on the A-LAEF forecast of temperature (first row) and moisture (second row). All plots show differences of a +60h A-LAEF forecast version with 137 levels – version with 91 levels.

❑ Topic 3: OBS backup for A-LAEF TC2

For the operational A-LAEF TC2 suite an OBS backup using GTS data has been implemented (Figure 18). The GTS data are generated at SHMU and uploaded to OPLACE (gtsbck_sk files).

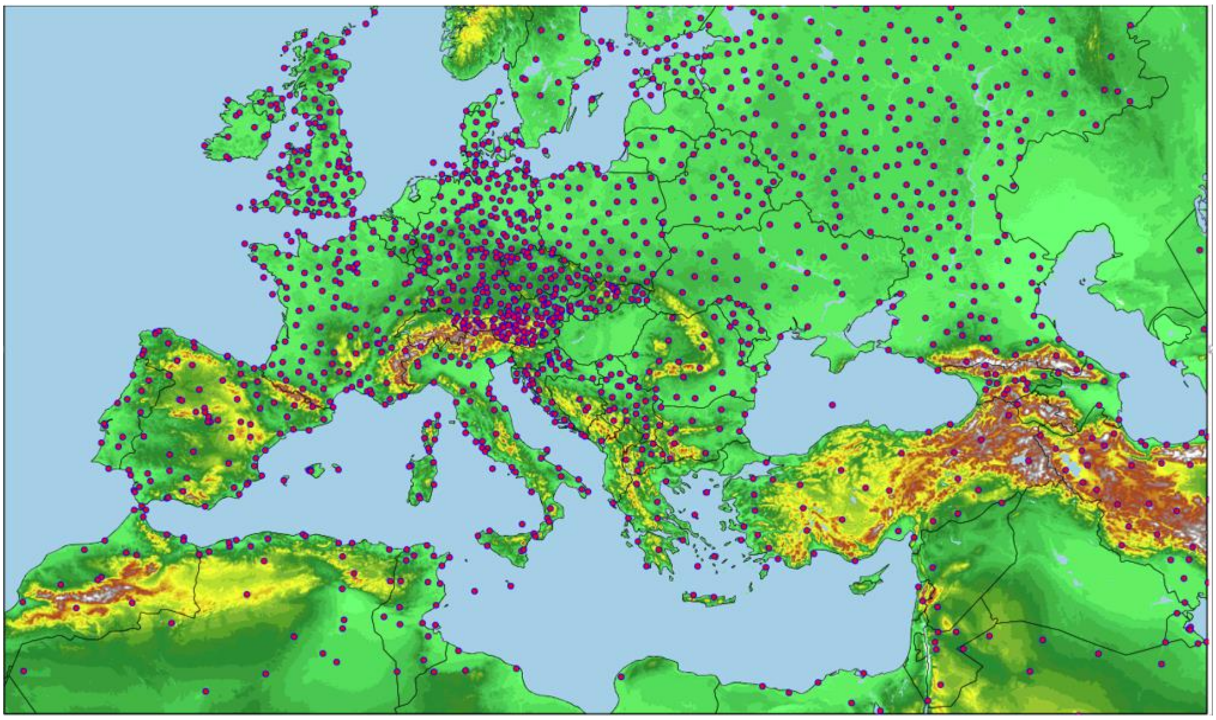


Figure 18: Stations with OBS backup using GTS data uploaded to OPLACE.

Efforts: 2 PM

Contributors: Martin Belluš (SHMU)

Documentation: **:** A-LAEF operational suite running at ECMWF HPCF; probabilistic forecast products delivered to the LACE partners and available on RC-LACE webpage; Flow charts; presentations; reports; technical documentation of A-LAEF TC2 suite running at ECMWF

Status: Ongoing; some delays and shifts in topics due to delay of new ECMWF HPC and due to postponed stays (COVID)

S3 Action/Subject/Deliverable: AROME-EPS

Description and objectives: This task covers research and development of the regional convection-permitting ensembles. Such high-resolution ensembles utilizing non-hydrostatic model AROME are in operation currently in Hungary at OMSZ and in Austria at ZAMG.

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

At OMSZ, a non-hydrostatic convection-permitting system AROME-EPS is being developed and operationally used, running on their own HPCF. New system runs once per day coupled to the 18 UTC run of ECMWF ENS. In the lagged mode the forecast from 00 UTC is produced for the next +48h. The ensemble comprises 10 members + 1 control forecast, and covers a Carpathian Basin domain with the horizontal grid spacing of 2.5 km (see Figure 19). For the time being there is no assimilation cycle involved and the initialization uses first guess (hydrometeors) and surface analysis of deterministic AROME, which runs with a 3-hourly assimilation cycle. The upper-air fields are downscaled from the boundary conditions. In April 2021 the operational AROME-EPS has been upgraded to cy43t2 (ACCORD Newsletter contribution) and in May a 1-h coupling has been implemented.

AROME-EPS runs operationally at OMSZ with the following current configuration:

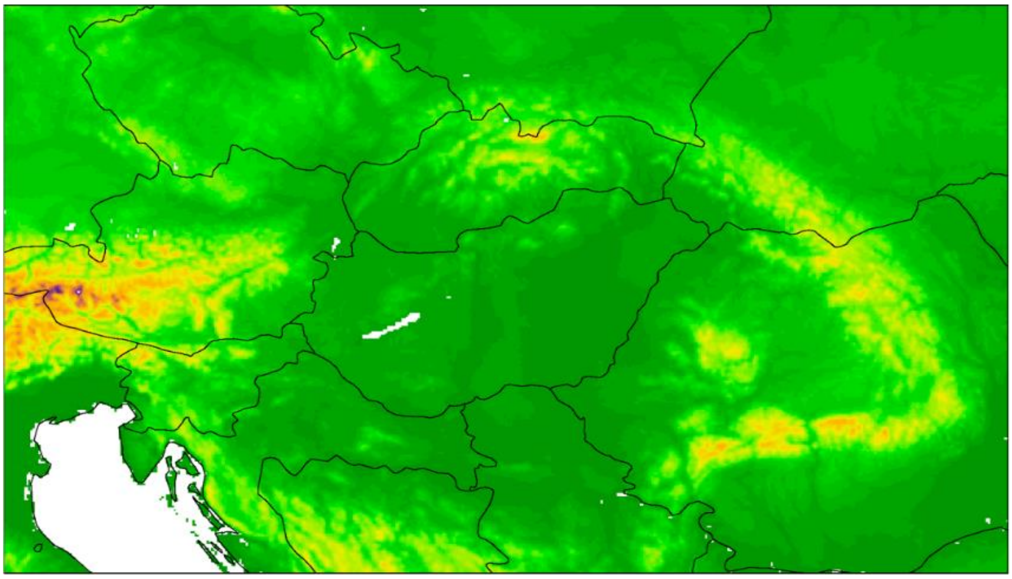


Figure 19: Integration domain of the operational AROME-EPS.

- Model cycle: cy43t2
- Domain: Carpathian Basin, 2.5 km resolution
- Vertical levels: 60 vertical levels
- Assimilation: none (surface from AROME)
- LBC coupling: ECMWF-ENS LBC coupling at every hour (10 perturbed members + control member)
- Number of ensemble members: 10+1 members
- Forecast runs: 00 UTC

- Forecast range: 48 h
- initial condition perturbation: none
- model perturbation: none

- **Testing of the higher vertical and temporal resolution of LBCs:**

Lateral boundary conditions as well as atmospheric initial condition for the Hungarian AROME-EPS are provided by ECMWF ENS. The coupling frequency was 3 hours until May 2021. ECMWF upgraded the IFS model cycle from 47r1 to 47r2 in May which brought two changes in the Hungarian LAMEPS system:

- The number of the vertical levels in the raw boundary conditions increased from 91 to 137.
- A higher, 1-hour coupling frequency was applied in AROME-EPS.

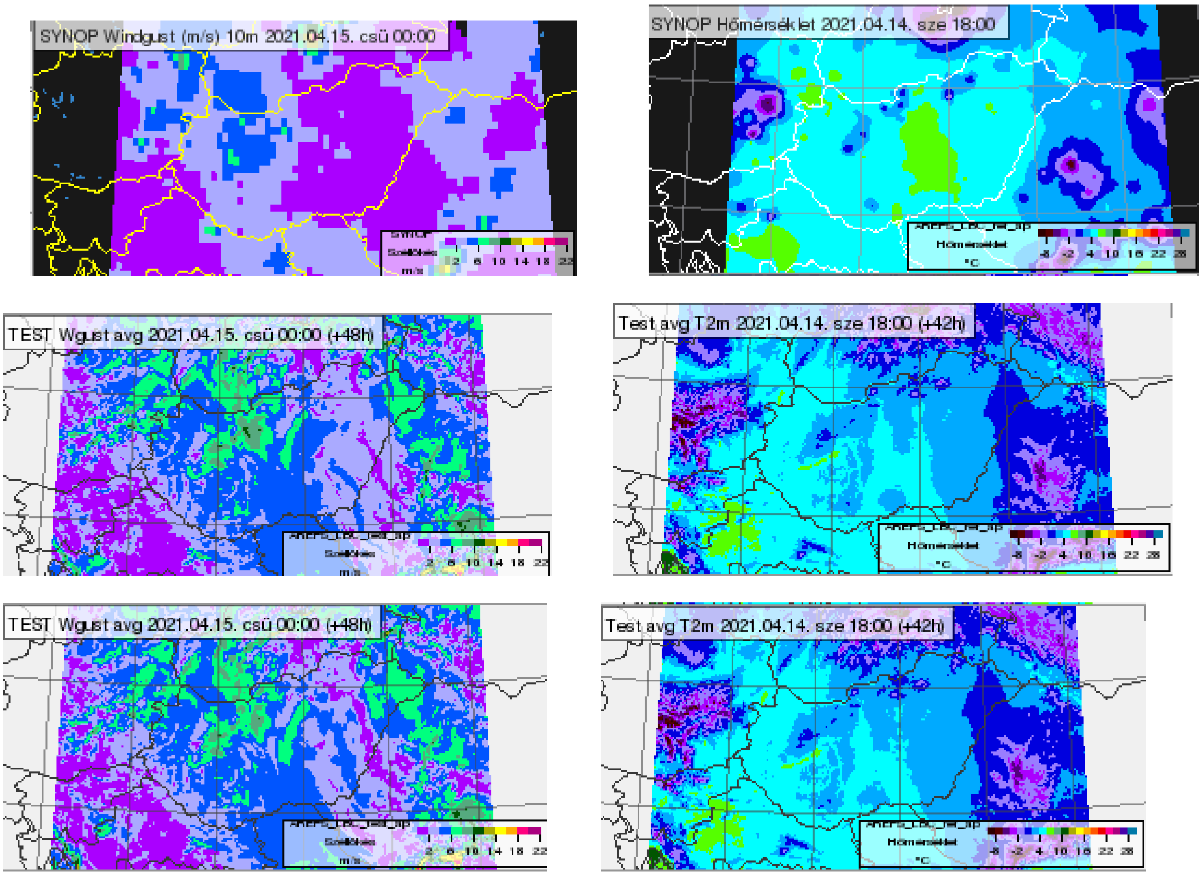


Figure 20: Wind gust at 0 UTC on 15 April 2021 (left) and 2-meter temperature at 18 UTC on 14 April 2021 (right) based on SYNOP measurements (top), ensemble mean of AROME EPS forecasts started at 0 UTC on 13 April 2021 with hourly (middle) and 3 hourly (bottom) coupled LBCs.

ECMWF provided test data before operational introduction of the new cycle and update of the LBC production (i.e. in the period of March–May). We conducted some case studies to check (1) the impact of more vertical levels and (2) the joint impact of more levels and higher coupling frequency.

Three test days were selected to compare the forecasts with the operational LBCs and the higher resolution test versions: 30 March 2021 was an uneventful, anticyclonal day, while on 13-14 April 2021 a complex front system crossed the territory of Hungary. Two experiments were conducted:

First, experiments with 3-hourly LBC coupling were run for all the three test days, using the operational settings.

The 1 hourly coupling was tested on 13 April 2021, as it was the most interesting day in terms of weather conditions.

However, significant difference was not noticed between the results of the two coupling settings, the 1-hour coupling shows a slight improvement (Figure 20).

The positive impact of the higher vertical resolution of LBCs is visible only in the forecasts longer than 24 hours (Figures 21 and 22).

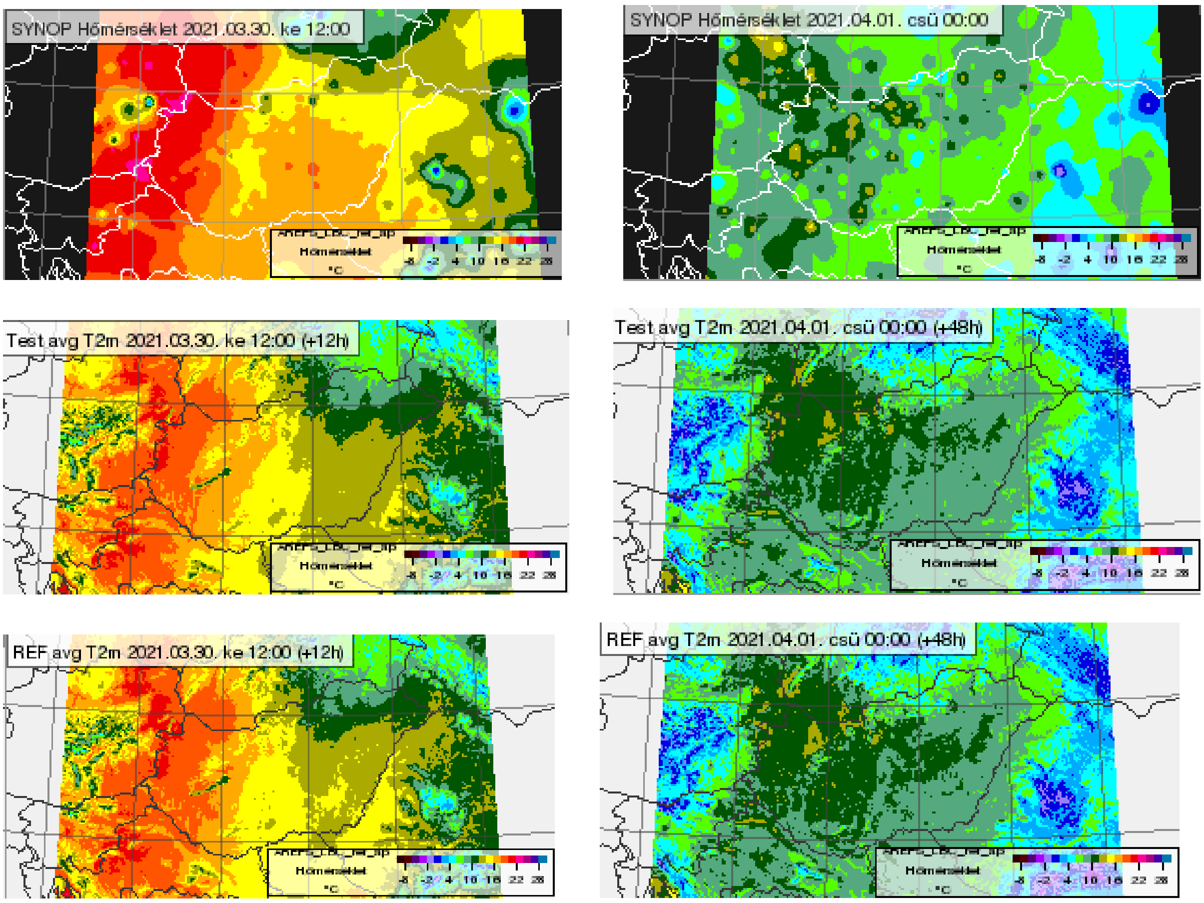


Figure 21: 2-meter temperature at 12 UTC on 30 March 2021 (left) and at 0 UTC on 1 April 2021 (right) based on SYNOP measurements (top), ensemble mean of 3-hourly coupled test (middle) and operational (bottom) AROME EPS forecasts started at 0 UTC on 30 March 2021.

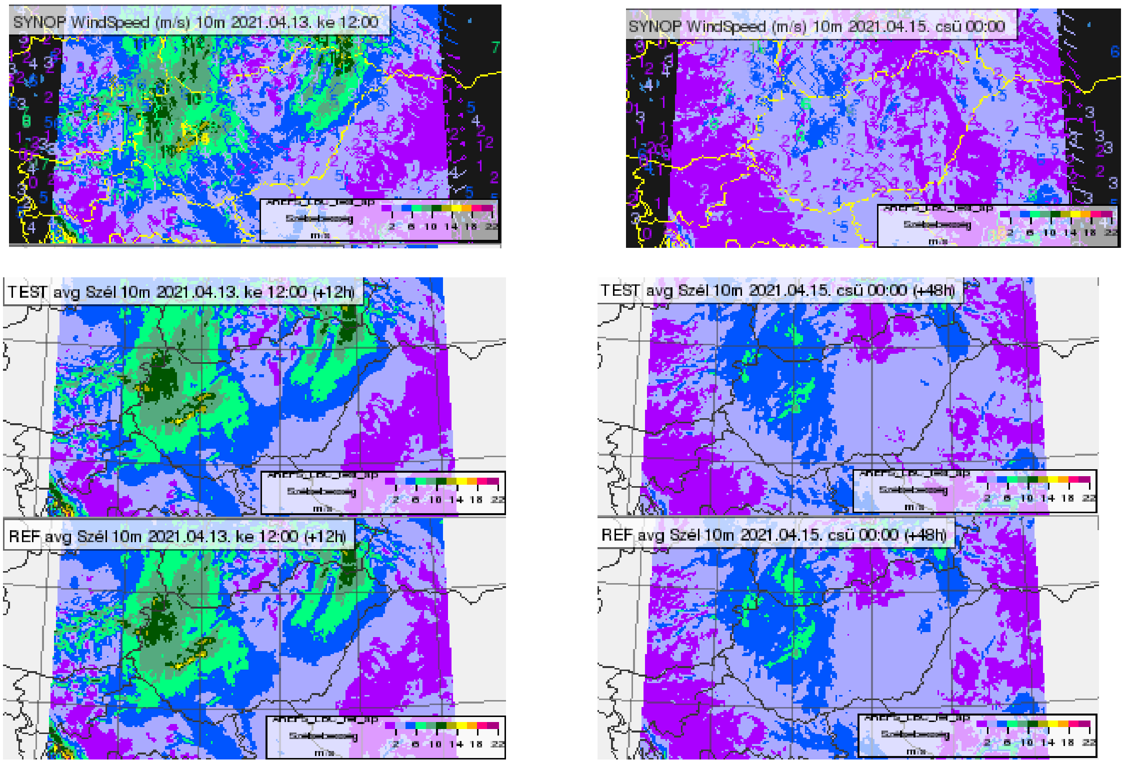


Figure 22: 10-meter wind speed at 12 UTC on 13 April 2021 (left) and at 0 UTC on 15 April 2021 based on SYNOP measurements (top), ensemble mean of the 3-hourly coupled test (middle) and operational (bottom) AROME EPS forecasts started at 0 UTC on 13 April 2021.

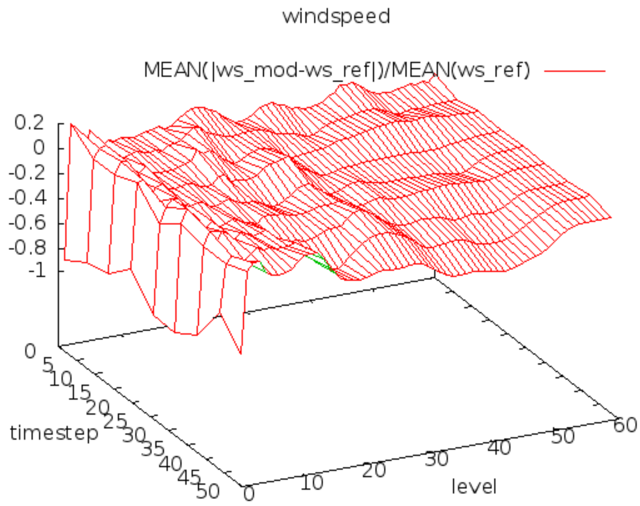


Figure 23: Mean relative difference between the wind speed forecasts of the AROME-EPS using 137-level LBCs and the operational AROME-EPS started at 0 UTC on 13 April 2021, for the control member, as function of time step and model level.

The case on 13 April 2021 was interesting as the operational AROME-EPS forecast aborted in the 4th member because of too strong wind speeds in the top model levels at the beginning of the forecast. As the problem did not appear in the experiment using the high vertical resolution LBCs over the same time period, the LBCs were comparatively investigated after being interpolated for the same AROME grid (with 60 vertical levels). Significant difference can be seen between the wind forecasts of the two experiments in the top of the model, which gradually disappears from the 3rd model level towards the surface (Figures 24-31). The experiment using the operational LBCs produced remarkably higher wind speeds in every ensemble member on the highest model levels at the beginning of the forecast period (see Figure 23 for the control member).

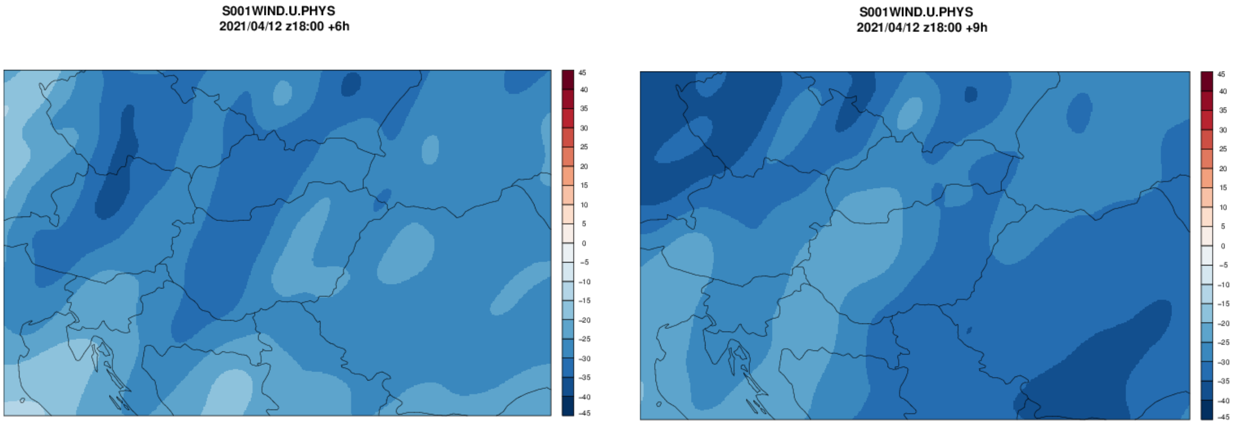


Figure 24: Differences between the LBCs interpolated from the 137- and 91-level raw LBCs to the 60-level AROME grid for U component of wind on the 1st AROME model level at 0 UTC (left) and at 3 UTC (right) for the 4th member.

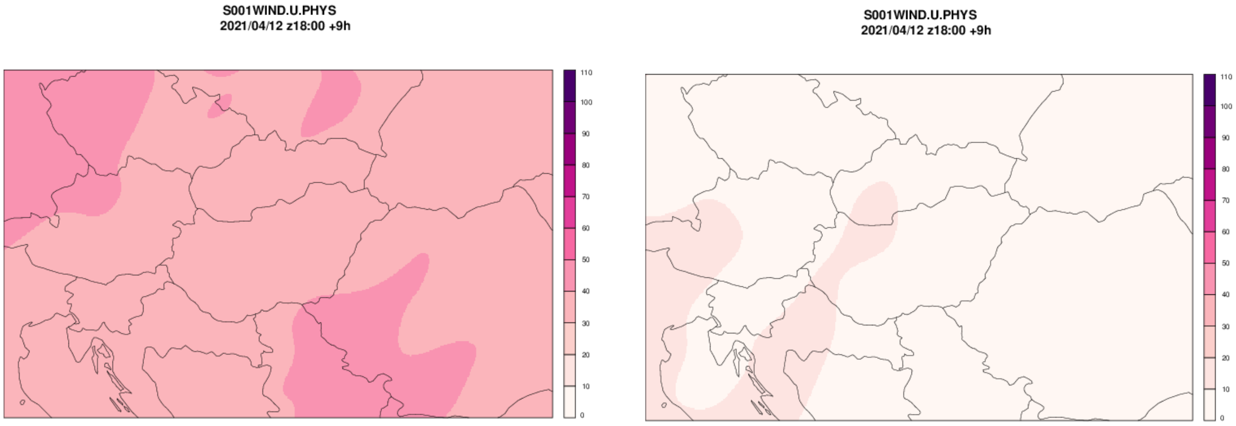


Figure 25: LBCs interpolated from the 91- (left) and 137-level (right) raw LBCs to the 60-level AROME grid for U component of wind on the 1st AROME model level at 3 UTC, for the 4th member.

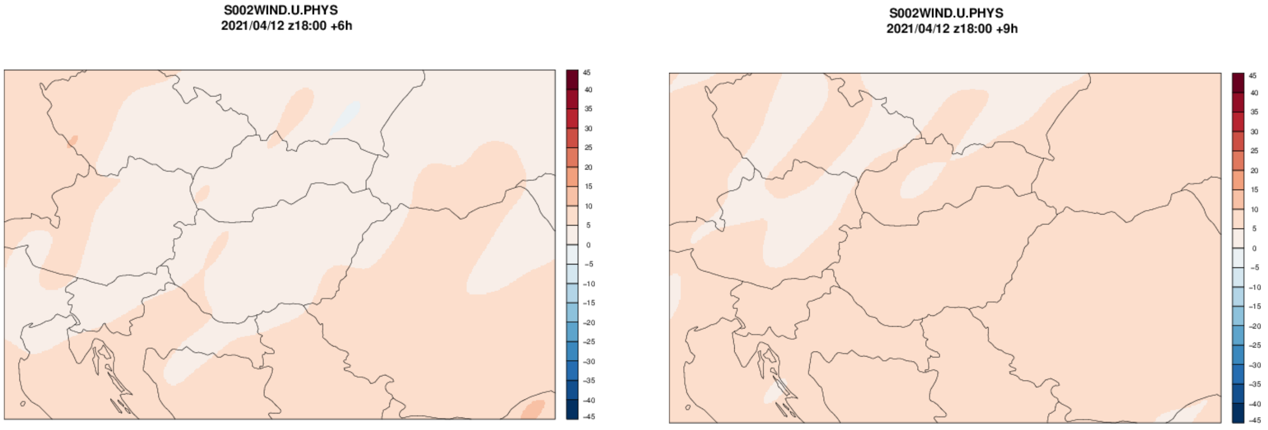


Figure 26: Differences between the LBCs interpolated from the 91- and 137-level raw LBCs to the 60-level AROME grid for U component of wind on the 2nd AROME model level at 0 UTC (left) and at 3 UTC (right) for the 4th member.

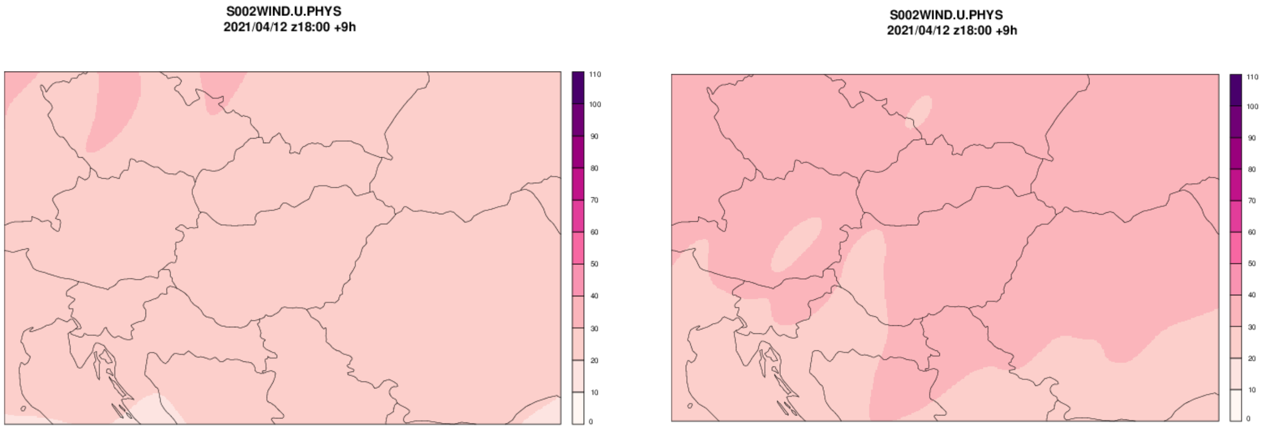


Figure 27: Same as Figure 25, but for the 2nd AROME model level.

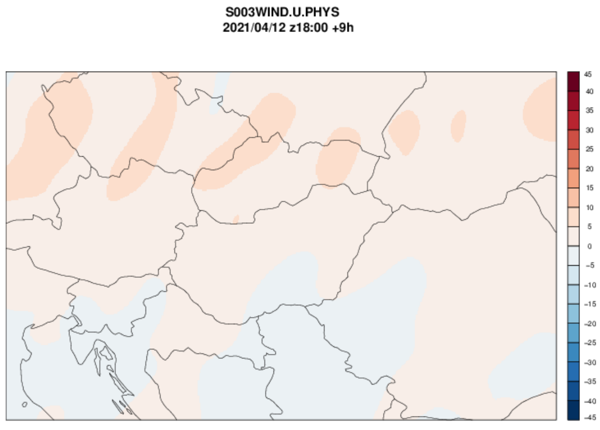


Figure 28: Same as the right panel of Figure 27, but for the 3rd AROME model level.

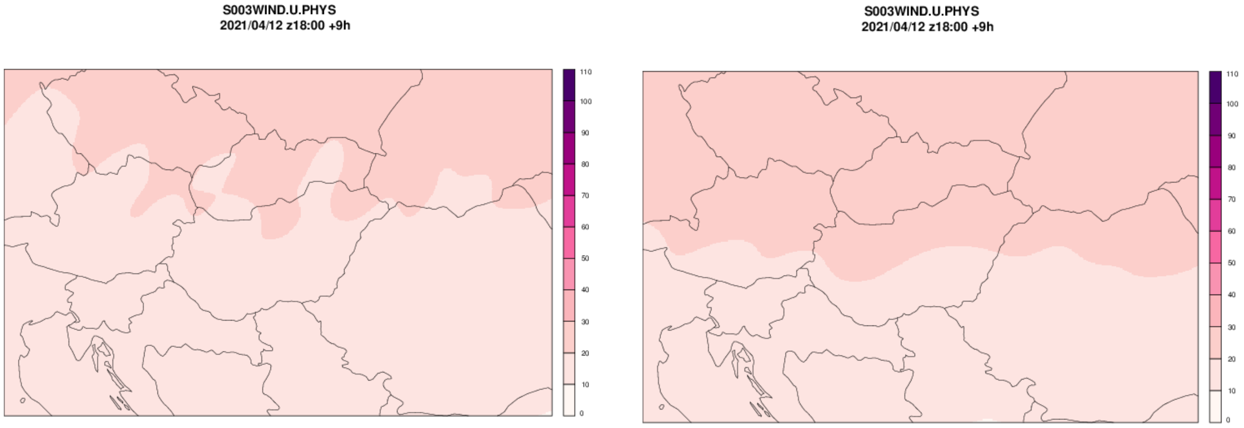


Figure 29: Same as Figure 25, but for the 3rd AROME model level.

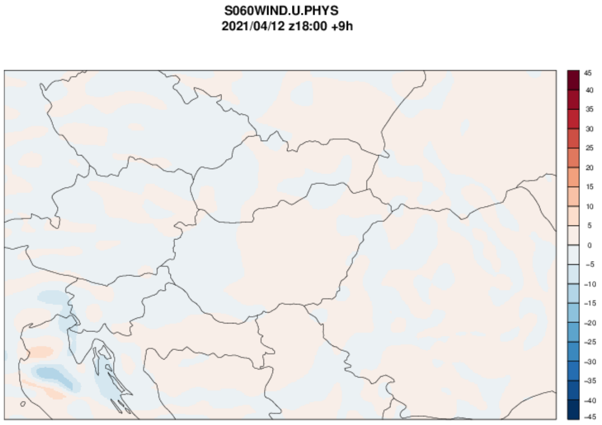
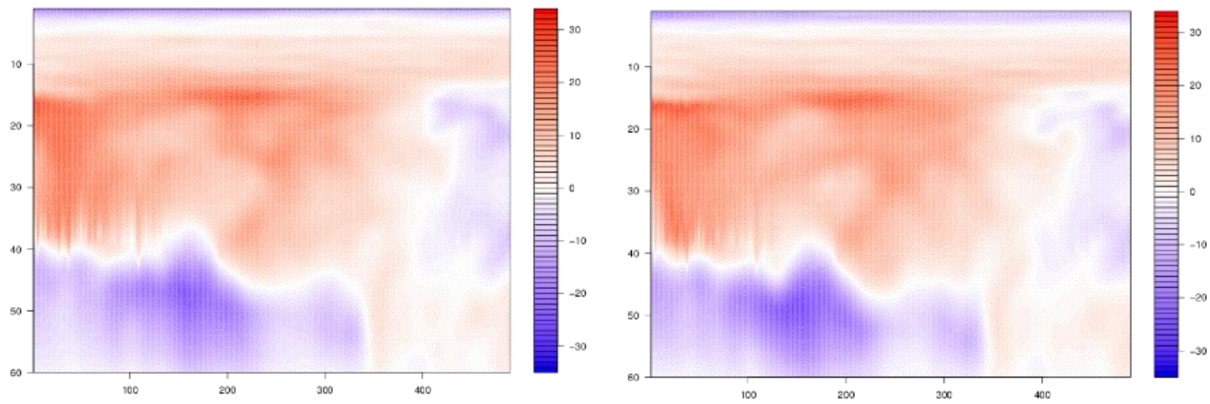


Figure 30: Same as the right panel of Figure 26, but for the 60th (lowest) AROME model level.



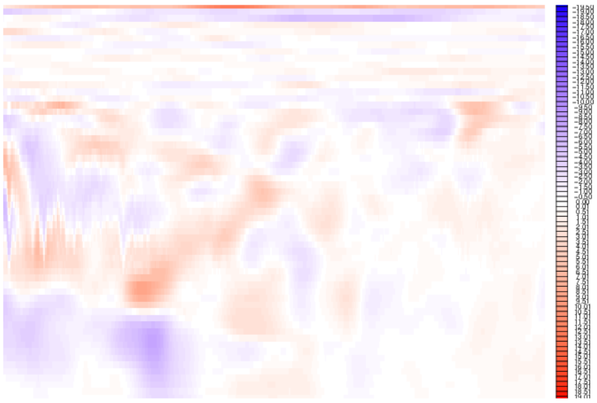


Figure 31: Vertical cross section of the V component analyses of the operational AROME-EPS (top left) and the AROME-EPS using 137-level LBCs (top right) at 0 UTC on 13 April 2021, for the 7th member and the difference between them (bottom). The section was made in x-direction in the middle of the domain.

As consequence of the high wind speed in the LBCs, the operational forecast produced much higher wind speed at the top model levels in the first few time steps of the forecast on 13 April 2021, but the difference has been balanced during the further time steps.

After the testing procedure, the higher vertical resolution LBCs were introduced into the operational AROME EPS/HU model at 0 UTC on 12 May 2021, on the first day with 3-hourly coupling. One day later, on 13 May 2021, the AROME-EPS run with 1-hourly coupling.

- **Comparison of AROME-EPS and ECMWF-ENS:**

A convective situation was chosen to compare AROME-EPS to ECMWF ENS. A high-pressure system dominated over western and central part of Europe on 30 May 2021, while a cold air drop induced some instability over the Carpathian Basin. Some showers and thunderstorms are generated during the day over North Hungary and moved to Southeast during the night. Three sets of ensembles are evaluated: (1) 11-member AROME-EPS running at 0 UTC on 30 May; (2) 51-member ECMWF ENS running at 0 UTC on 30 May; (3) 11 members of ECMWF ENS running at 18 UTC on 29 May. Comparing set 1 and set 3, we assess the added value of AROME-EPS with respect to its LBCs, while investigating set 1 and set 2, we can compare the ensemble predictions available for forecasters at the same time.

The spatial structure and the amount of small-scale precipitation are well captured by the convection-permitting AROME-EPS. The coarser resolution ECMWF ENS spread the rain over the country on the first forecast day. Its first 10 members overestimated the precipitation amount which was improved by downscaling with AROME-EPS (Figure 32). The shift of precipitation towards Southeast was predicted by all forecasts on the second day, but the chance of higher quantity was shown only by AROME-EPS (not shown). The corresponding wind gust and temperature forecasts were closer to the reality in AROME-EPS, whereas most members of ECMWF ENS overestimated the wind gust and underestimated the temperature (Figure 33) over West.

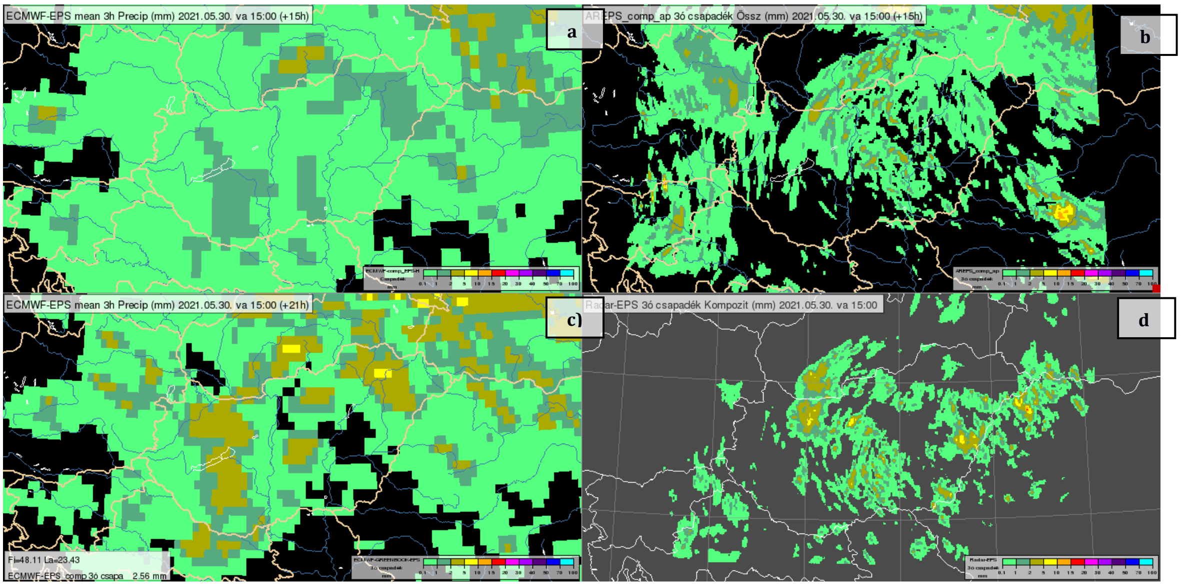


Figure 32: Ensemble mean of 3-hour precipitation forecasts on a) 30/05/2021 0 UTC + 15h by 51-member ECMWF ENS, b) 30/05/2021 0 UTC + 15h by 11-member AROME-EPS, c) 29/05/2021 18 UTC + 21h by 11-member ECMWF ENS, and d) Hungarian radar data.

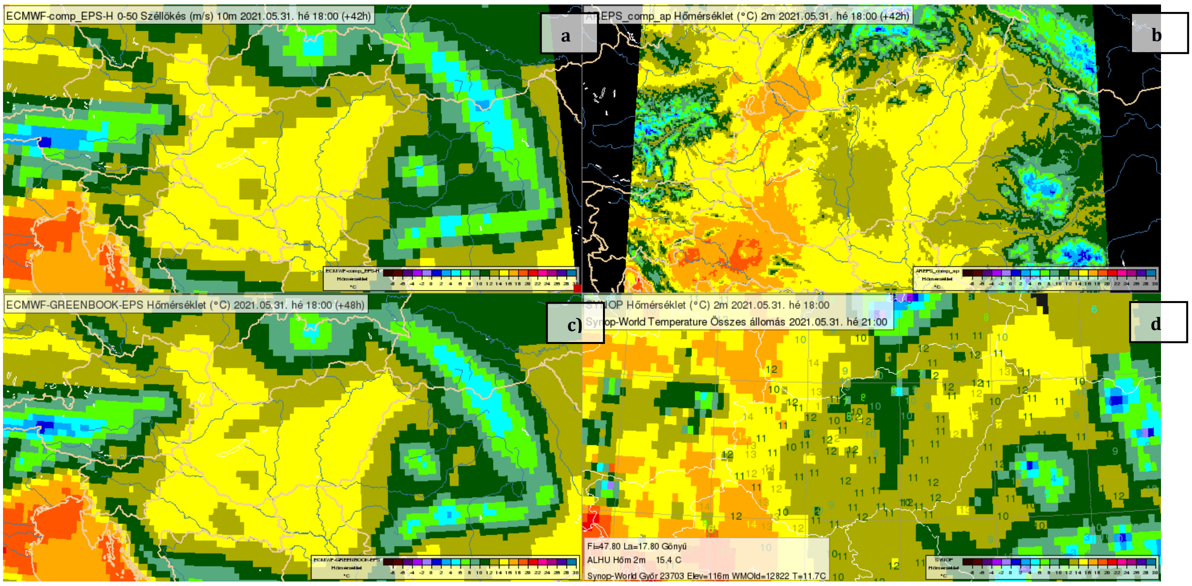


Figure 33: Ensemble mean of 2-meter temperature forecasts on a) 30/05/2021 0 UTC + 42h by 51-member ECMWF ENS, b) 30/05/2021 0 UTC + 42h by 11-member AROME-EPS, c) 29/05/2021 18 UTC + 48h by 11-member ECMWF ENS, and d) S

❑ Topic 2: EPS related development at ZAMG

Convection-permitting - Limited Area Ensemble Forecasting system (C-LAEF) has been developed at ZAMG and is running operationally at ECMWF HPCF as a time critical 2 application since November 2019.

C-LAEF is based on the non-hydrostatic AROME model with a horizontal resolution of 2.5 km and 90 vertical levels. It has 16 perturbed members (and 1 unperturbed control run) coupled to the first 16 members of ECMWF-EPS. The initial condition uncertainties are represented by 3D-Var EDA with ensemble Jk method and by screen-level observation perturbations in CANARI. The assimilation cycles are performed every 6h. Model error is represented by a hybrid stochastic perturbation scheme, where perturbations of tendencies in shallow convection, radiation and microphysics are combined with parameter perturbations in the turbulence scheme.

C-LAEF runs operationally at ECMWF HPCF with 4 runs per day (00, 06, 12 and 18 UTC). The lead times vary between +60h (00 UTC), +48h (12 UTC) and +6h (06 and 18 UTC).

In 2020, the following activities were realized:

- Full cy43t2 e-suite of C-LAEF during summer period (Jun-Sep) at the ECMWF HPCF including continuous HARP verification
- Investigation and verification of C-LAEF performance for severe weather events
- Implementation of new surface perturbation scheme in C-LAEF e-suite
- Common LACE-EF coupling file production at ECMWF (903); implementation and testing of new coupling files from ECMWF-ENS for C-LAEF
- Upscaled probabilities for C-LAEF
- Extension of C-LAEF SPP scheme by additional perturbations in physics parametrizations; implementation of SPG pattern generator
- Development and operational production of EPS maps and EPSgrams (new summer version) with Visual weather for forecasters and customers
- Preparation and provision of C-LAEF data for the SRNWP EPS project (summer 2020 period)
- Provision of C-LAEF data for the ESSL (European Severe Storm Laboratory) testbed for the period May to September 2021; deep investigation of C-LAEF performance for severe convective situations
- Set-up of C-LAEF for Turkish domain – support, scripts, input files, etc.

- **Cy43t2 e-suite of C-LAEF at ECMWF HPCF**

In autumn 2020 the cy43t2 code was compiled and implemented under the Austrian operational user at the ECMWF HPCF. It was tested (mainly technically) and was run for some selected case studies. In spring 2021 this cy43t2 e-suite was set-up to run in full parallel mode with the full ensemble size (16+1), 4 runs per day (only 1 long-term run), full assimilation cycle (6h), same resolution (2.5km) and the same perturbation schemes as in the operational C-LAEF suite. Additionally, the cy43t2 e-suite contains a new surface perturbation scheme (described later in this report). Due to the very high computational costs (about 5 Mio SBUs per month) it was decided to run the C-LAEF cy43t2 e-suite only during the summer season (June – mid of September). To have a continuous verification and to have a good overview on the daily performance of the cy43t2 e-suite especially in comparison to the operational C-LAEF suite, the HARP verification package with monitor was installed and set up at the ECMWF machines.

From the technical point of view, the e-suite was running very stable with only some small interruptions due to system sessions at the ECMWF-HPCF. The HARP verification (Figures 34-38) shows a general quite good performance for most investigated parameters, but also some weaknesses especially for T2m, global radiation and cloudiness, which are related to some general problems in C-LAEF and are also present in the operational cy40t1 version (see physics report).

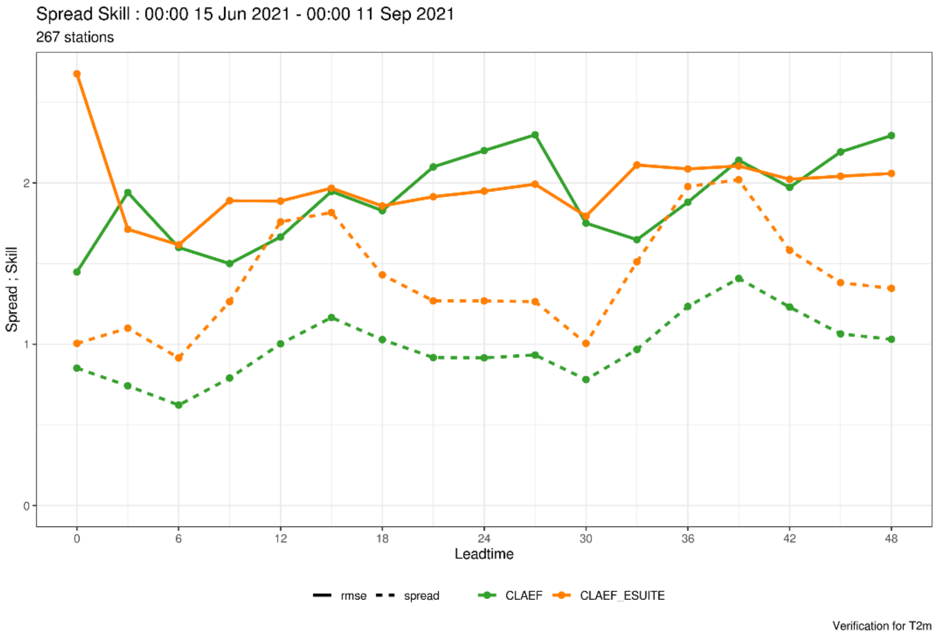


Figure 34: Spread and RMSE of T2m of C-LAEF and C-LAEF cy43t2 e-suite for summer 2021.

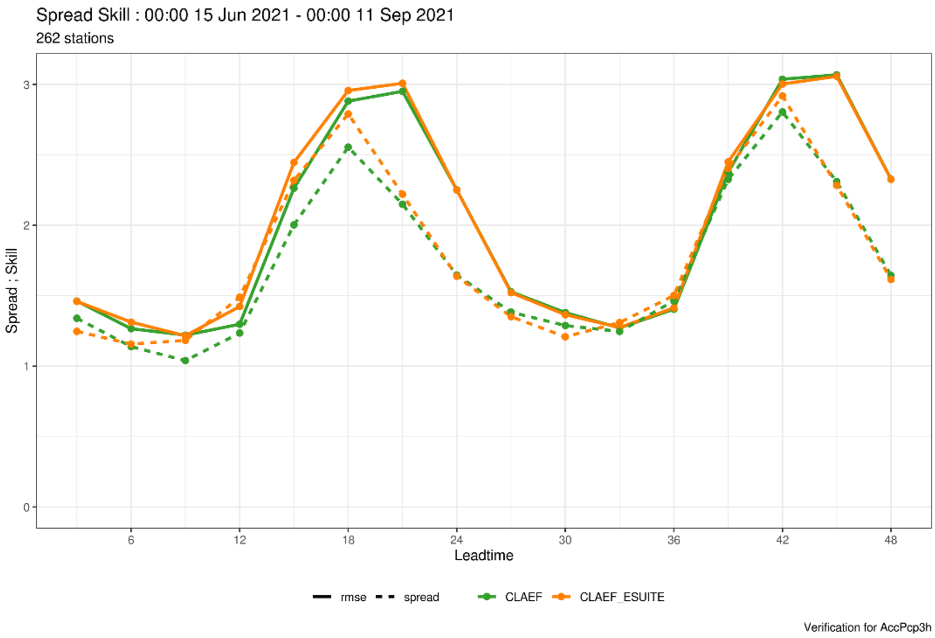


Figure 35: Spread and RMSE of 3-h accumulated precipitation of C-LAEF and C-LAEF cy43t2 e-suite for summer 2021.

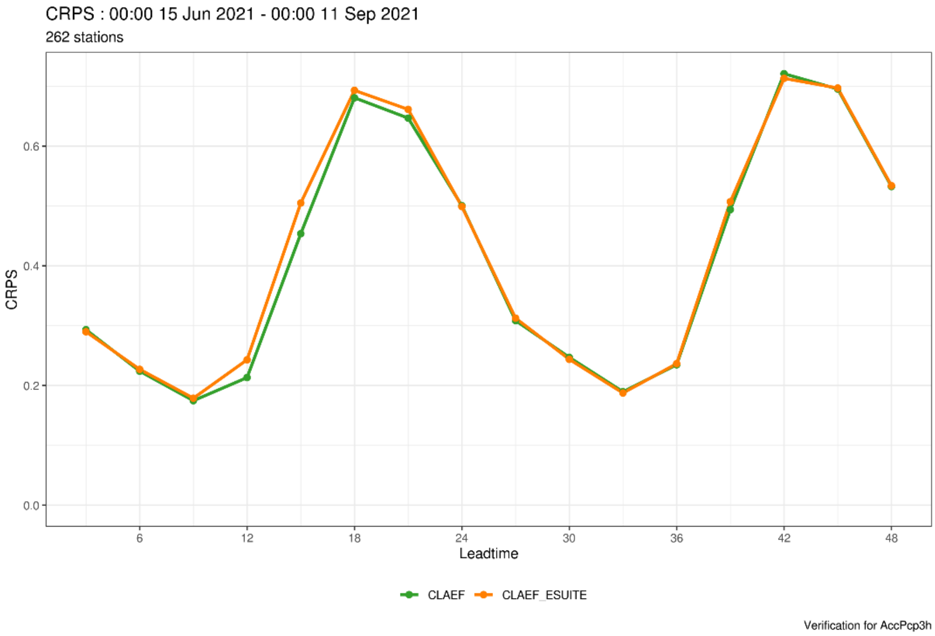


Figure 36: CRPS of 2m relative humidity of C-LAEF and C-LAEF cy43t2 e-suite for summer 2021.

Figure 37: CRPS of 700 hPa u-component of wind of C-LAEF and C-LAEF cy43t2 e-suite for summer 2021.

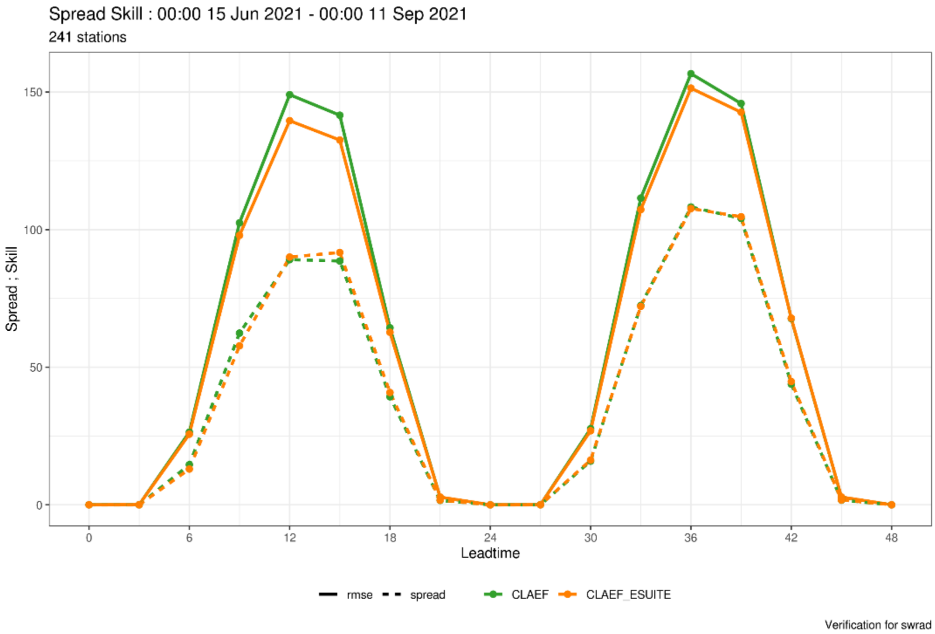


Figure 38: Spread and RMSE of global radiation of C-LAEF and C-LAEF cy43t2 e-suite for summer 2021.

With the present verification results it is planned to switch to the new cy43t2 C-LAEF version in operational mode in autumn 2021.

- **C-LAEF performance for severe weather events**

In 2021 several severe weather situations occurred in Austria where the operational C-LAEF system has shown its important role in the ZAMG forecasting and warning procedures. For this report we focus on 2 summertime events - one severe thunderstorm event and one large-scale precipitation event.

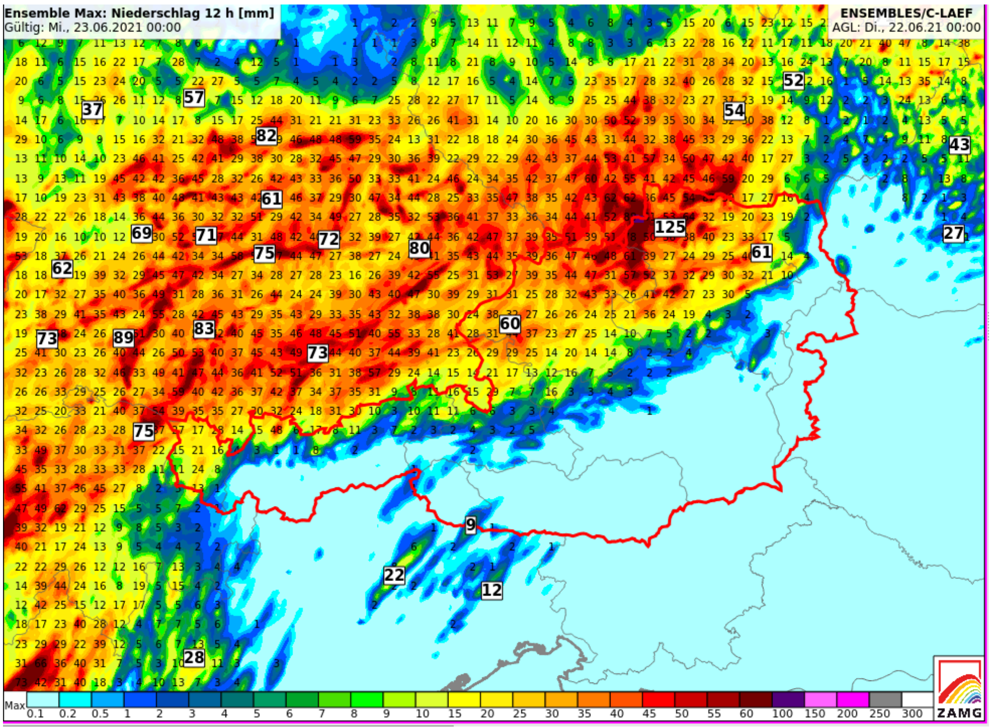


Figure 39: C-LAEF ensemble max precipitation for the 12-h period between 22/06 12 UTC and 23/06 00 UTC based on the C-LAEF run of 22/06 00 UTC.

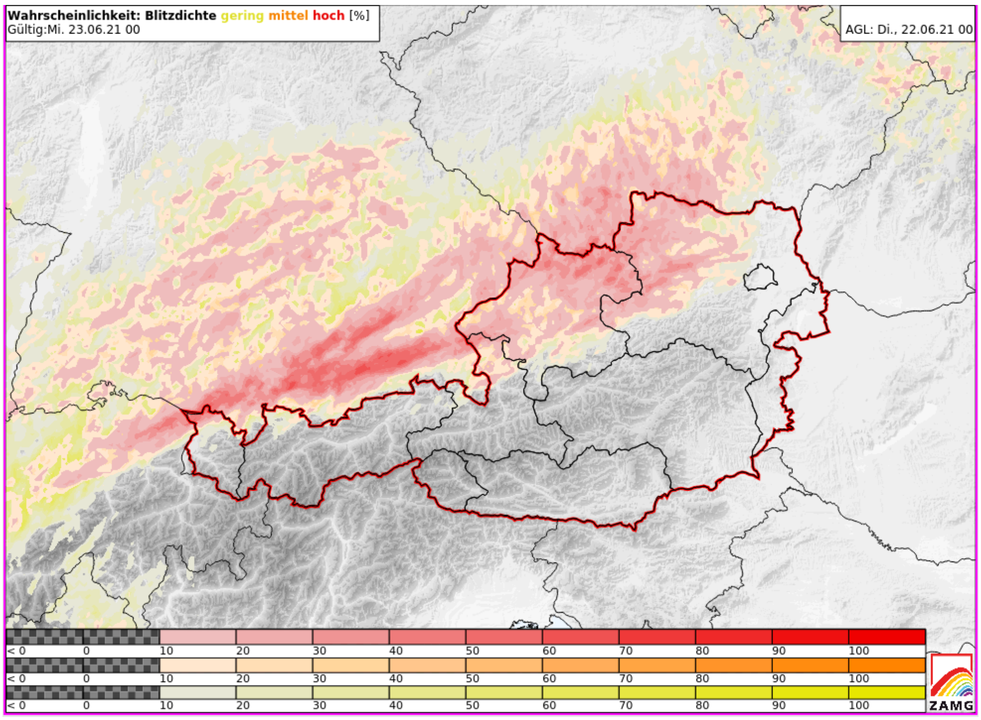


Figure 40: C-LAEF lightning probability for 23/06 00 UTC based on the C-LAEF run of 22/06 00 UTC.

The first event occurred in the afternoon and evening hours of 22 June 2021. Significant convective activity could be observed from the northern Alpine foreland in Bavaria to Lower Austria causing a lot of damage. C-LAEF predicted very high precipitation amounts (ensemble mean about 30mm, ensemble max with more than 100mm in 12h) accompanied by a high probability of lightning and hail with excessive gusts above 100 km/h (Figures 39-42) for this event. Localization and also intensity of the severe thunderstorms was very well predicted in C-LAEF. In a very similar situation, just one day later, a massive hailstorm and a severe tornado occurred near the Austrian/Czech border with about 250 persons injured. Also this situation was well captured by C-LAEF (Figure 43).

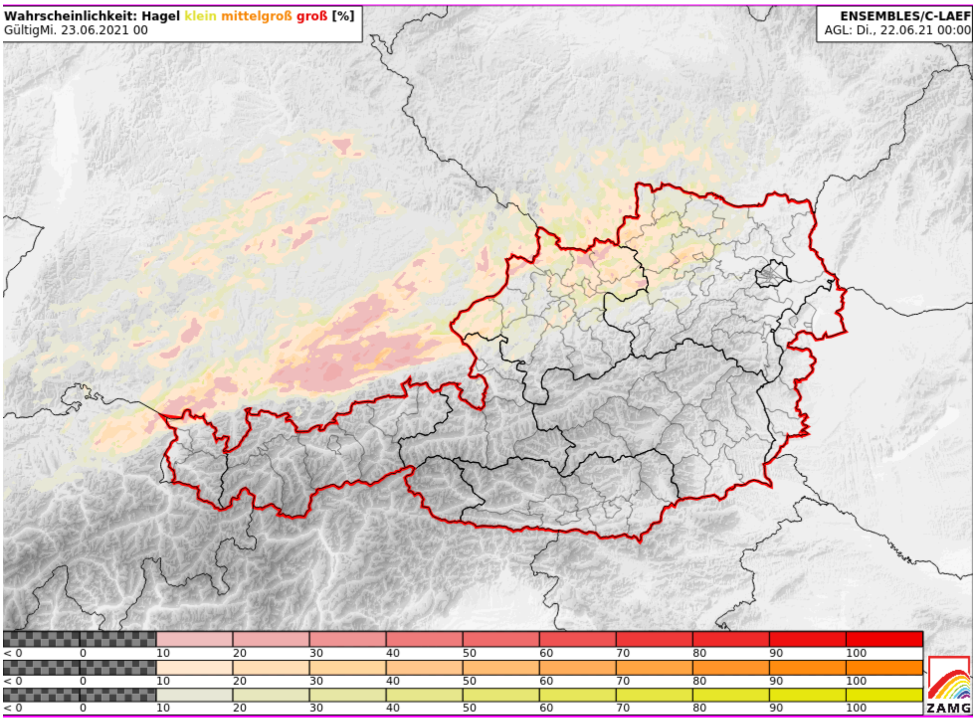


Figure 41: C-LAEF hail probability for 23/06 00 UTC based on the C-LAEF run of 22/06 00 UTC.

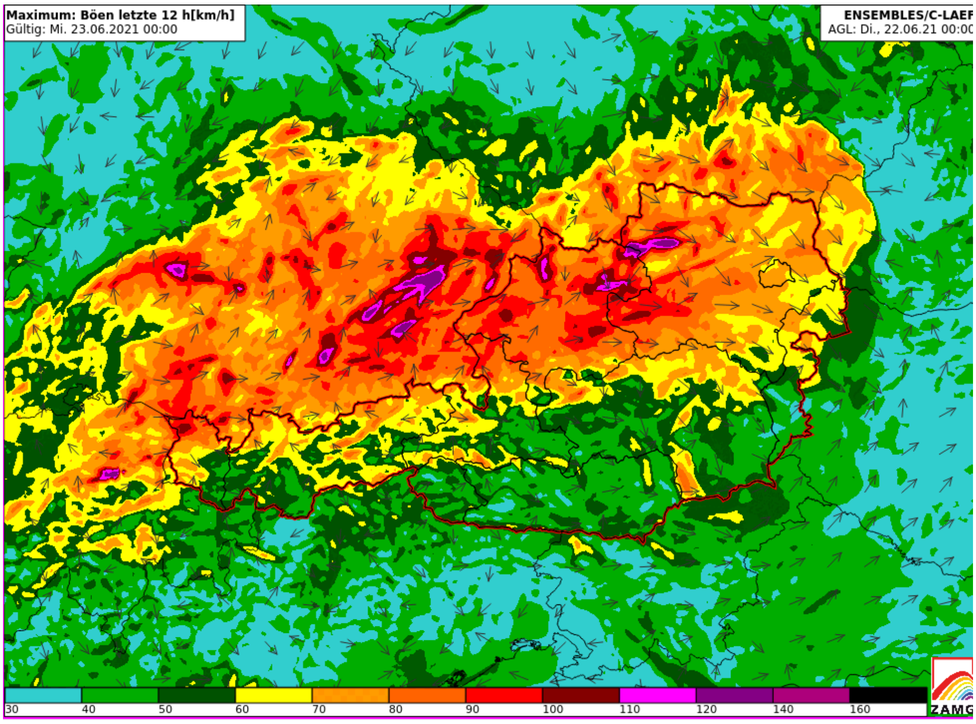


Figure 42: C-LAEF ensemble max wind gusts for the 12-h period between 22/06 12 UTC and 23/06 00 UTC based on the C-LAEF run of 22/06 00 UTC.

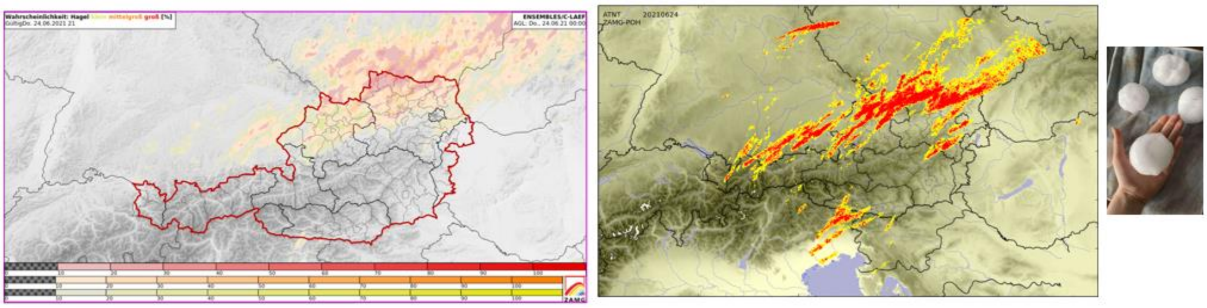


Figure 43: C-LAEF probability of hail (left) and hail analysis (right) for 24/06 21 UTC. Massive hailstones near the Austrian/Czech border (www.hagel.at).

The second event occurred on the weekend from 17 July to 19 July 2021 and was already well predicted some days before by the global IFS model. With the first upcoming C-LAEF runs covering the event it was clear that a very strong precipitation event with very likely strong flooding will occur. Figure 44 shows the INCA analysis and the forecasts from several NWP models (probabilistic and deterministic) for the main precipitation phase (17/7 00 UTC to 19/7 00 UTC). Highest precipitation sums (up to 200mm/48h) were predicted for the Northern Alps between Tyrol and Lower Austria. C-LAEF predicted high probabilities (> 80%) of exceeding the 100mm threshold for the event in large parts of this region, especially in the areas with strong orographic precipitation enhancement (Figure 45).

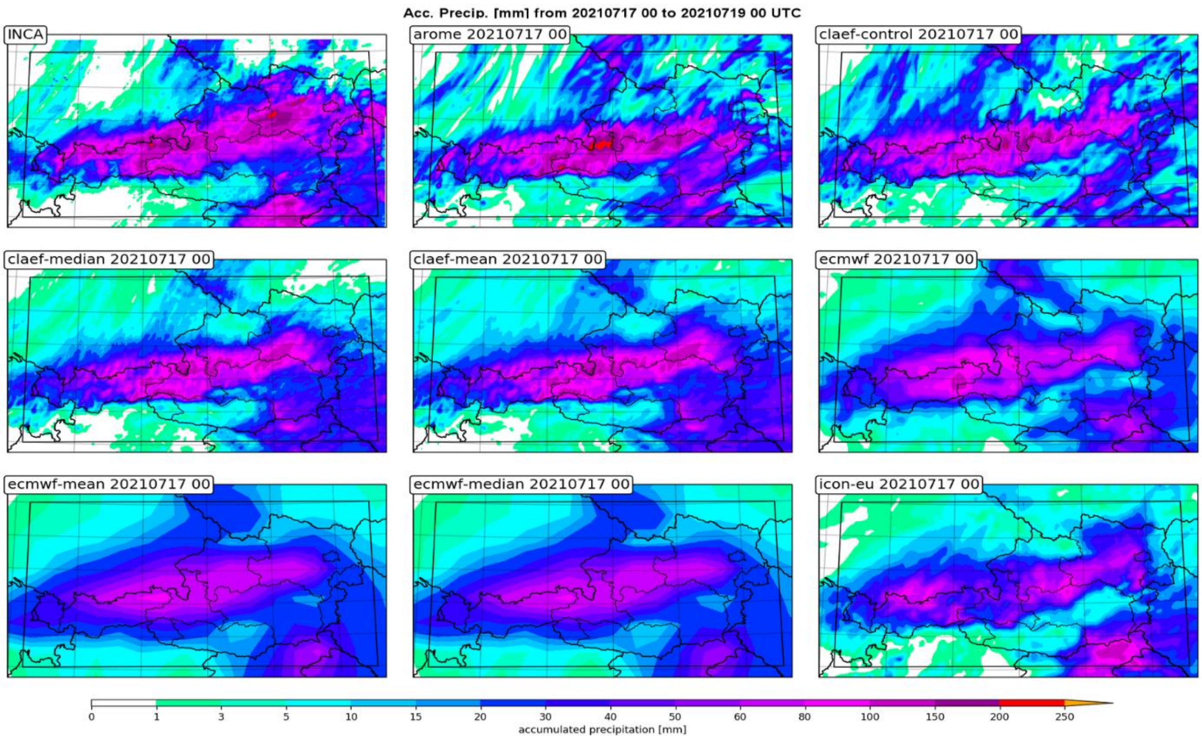


Figure 44: 48h accumulated precipitation (17/7 00 UTC - 19/7 00 UTC) based on the 17/7 00 UTC runs of several NWP models. The first panel shows the respective precipitation analysis from the INCA system.

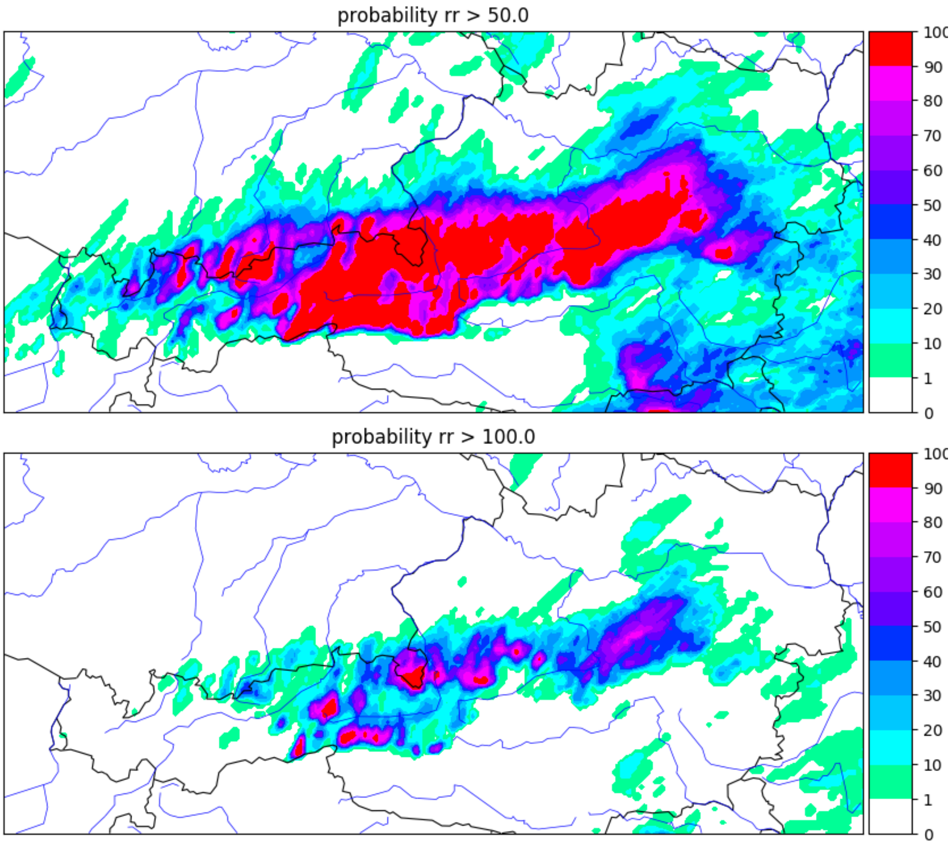


Figure 45: C-LAEF probabilities for exceeding 50mm (upper) and 100mm in 48h between 17/7 00 UTC and 19/7 00 UTC based on the 17/7 00 UTC run.

When comparing the different models (ECMWF, AROME, ICON, C-LAEF) for this event, C-LAEF showed a very strong performance with the best scores for the C-LAEF median.

- **Implementation of new surface perturbation scheme in the C-LAEF e-suite**

The perturbation scheme in the operational C-LAEF version comprises perturbations of initial conditions (observation perturbations near the surface and in the upper air; ensemble JK), lateral boundary conditions (coupling with different ECMWF-ENS members) and a combination of tendency and parameter perturbations for the representation of model error (Wastl et al., 2021). So far, no perturbation of surface parameters (e.g. LAI, snow cover, vegetation, etc.) is considered in the operational version. To close this gap the surface perturbation scheme of Météo France (Bouttier et al., 2016) has been implemented and tested in the C-LAEF e-suite. In this scheme (activation by switch LPERTSURF) the parameters in Table 1 are perturbed stochastically at the beginning of each model integration. This means that the output file of the surface assimilation (CANARI in our case) is perturbed by the external routine pertsurf.F90. In case of Météo France the surface analysis of the unperturbed control (member 00) is used in all members and this analysis is then perturbed by LPERSTURF with different seeds in each member. When we verified first runs with this scheme and compared it with the operational C-LAEF (without surface perturbation) we found a significant reduction of spread in the parameters near the surface. It turned out that this comes from using the same surface analysis in all members of the e-suite. In the operational C-LAEF version the surface analysis is made separately for each member with own observation perturbation of T2m and RH2m. To overcome this problem we have modified the Météo France LPERTSURF scheme accordingly:

- Seasonal or constant fields (vegetation index, vegetation heat coefficient, leaf area index, land albedo, land roughness length) are taken from the unperturbed control run and then perturbed with different seeds in each member (same as Météo France does)
- Prognostic fields (soil moisture, soil temperature, snow depth, sea surface fluxes) are taken from the surface analysis (CANARI) and are then perturbed with different seed in each member; this means that those parameters are cycled in each member

By doing so we can increase the spread of surface parameters like T2m or RH2m significantly compared to the Météo France method. Figure 46 shows the impact of the new surface perturbation scheme on the T2m temperature for a test case in September 2021. Spread is significantly increased over the whole forecasting range, while RMSE is not negatively influenced. This results in a much better spread/skill ratio.

Table 1: Parameters which are perturbed in the surface perturbation scheme in C-LAEF with standard deviation and perturbation type.

Parameter name	Std. dev.	Perturbation type
Vegetation index	0.1	Multiplicative
Vegetation heat coefficient	0.1	Multiplicative
Leaf area index	0.2	Multiplicative
Land albedo (all wavelengths)	0.1	Multiplicative
Land roughness length	0.2	Multiplicative
Soil/sea surface temperature (K)	1.5	Additive
Soil moisture	0.1	Multiplicative
Snow depth	0.5	Multiplicative
Sea surface fluxes	0.2	Multiplicative

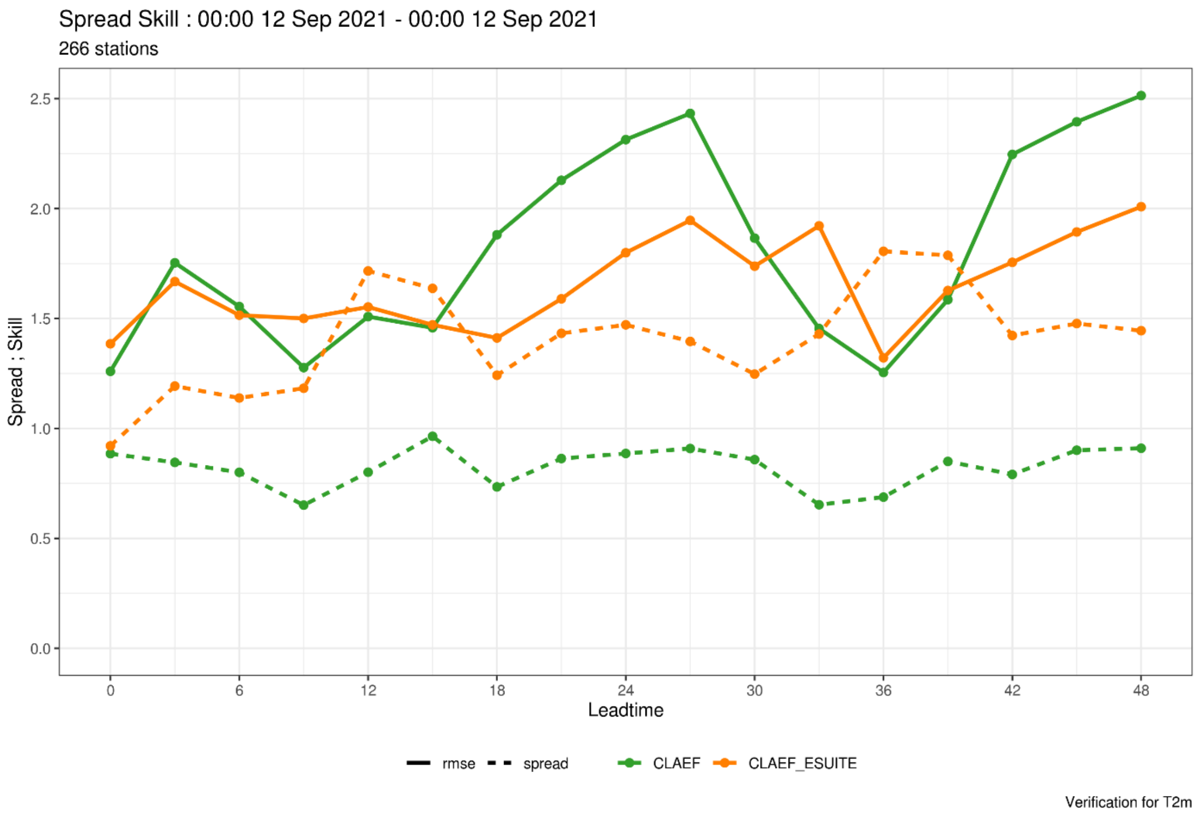


Figure 46: Spread and RMSE of T2m of C-LAEF and C-LAEF cy43t2 e-suite (with surface perturbation scheme) for 12 September 2021.

- **Common LACE-EF coupling file production at ECMWF**

Coupling files from ECMWF-ENS runs are produced under Time-critical option 3 at ECMWF and were used by Hungarian AROME-EPS as coupling files in the past. Whereas the other operational EPS systems in the LACE community produced their LBCs running configuration 903 (A-LAEF) and 901/927 (C-LAEF) on their own. Since the requirements for LBCs of AROME-EPS and C-LAEF are rather similar it was planned to find a common setup to reduce duplicated work.
The current, and as far as possible future requirements of C-LAEF and AROME-EPS were identified and communicated to ECMWF. The additional costs of the new requirements (~ 6x more expensive) were compensated by a reorganization of the 903 setup running in TC-3 at ECMWF. The switch to the new setup was implemented with ECMWF upgrade to cycle 47R2 on 11/05/2021.

Table 2: Reorganization of ECMWF ENS coupling file production for RC-LACE.

LACE_EF	47R1	Next Config - 47R2	Comments
00/12	11 Members - 3-hourly to STEP=12 47 levels	**17 Mem. - hourly to STEP=18** **60 levels**	New config ~6 times more expensive than existing one.
06/18	11 Members - 3-hourly to STEP=60 47 levels	**17 Mem. - hourly to STEP=72** **60 levels**	But cost compensated by new job organisation.

- **Upscaled probabilities for C-LAEF**

A post-processing tool was technically implemented to calculate upscaled fields of e.g. precipitation for C-LAEF. The tool reads the final C-LAEF grib files and adds the upscaled fields as new fields to the grib. It allows to calculate the mean value of a given field in a predefined radius for every grid point and/or assigns the maximum value in the given radius. The evaluation of these fields is still in progress.

- **Extension of C-LAEF SPP scheme**

Some work has also been dedicated to the model error representation in C-LAEF. Model error in the operational C-LAEF version is currently represented by a hybrid stochastic perturbation scheme, where perturbations of tendencies in shallow convection, radiation and microphysics are combined with parameter perturbations in the turbulence scheme. To increase the physical consistency in the perturbation scheme, the SPP (stochastically perturbed parametrizations; Ollinaho et al., 2017) approach has been applied to the radiation, microphysics and shallow convection scheme in C-LAEF as well. The perturbations are produced by the newly implemented SPG pattern generator (Tsyrulnikov and Gayfulin, 2017). However, a lot of tuning considering the perturbation scale and range has to be made before final operationalization. It is also planned to add some more parameters (especially in microphysics) to the perturbation list.
Due to the postponed stay of Endi Keresturi at ZAMG this topic is delayed.

- **Development and operational production of EPS maps and EPSgrams**

Strong focus on EPS related work at ZAMG since 2020 was put on the development and production of EPS maps and EPSgrams for forecasters and customers. In a close co-operation between model developers and forecasters needs and ideas were evaluated and specific probabilistic products and maps were developed. These products comprise classical probability maps such as probability of exceeding certain thresholds, extreme members, median, etc. but also EPSgrams for more than 250 points in the Alps. All these maps and EPSgrams are produced with the software Visual Weather. With the operational implementation of these EPS products, the acceptance and usage of C-LAEF within the routine work of the forecasters has significantly increased.
In 2021 a new summer version (May – September) of the C-LAEF EPSgrams has been developed with strong focus on convective indices (Figure 47). After consultation with the product developers at ZAMG it has been decided that the Visual Weather template for the C-LAEF EPSgrams will be shared within RC-LACE partners and that such EPSgrams will also be published for selected points on the RC-LACE webpage very soon.

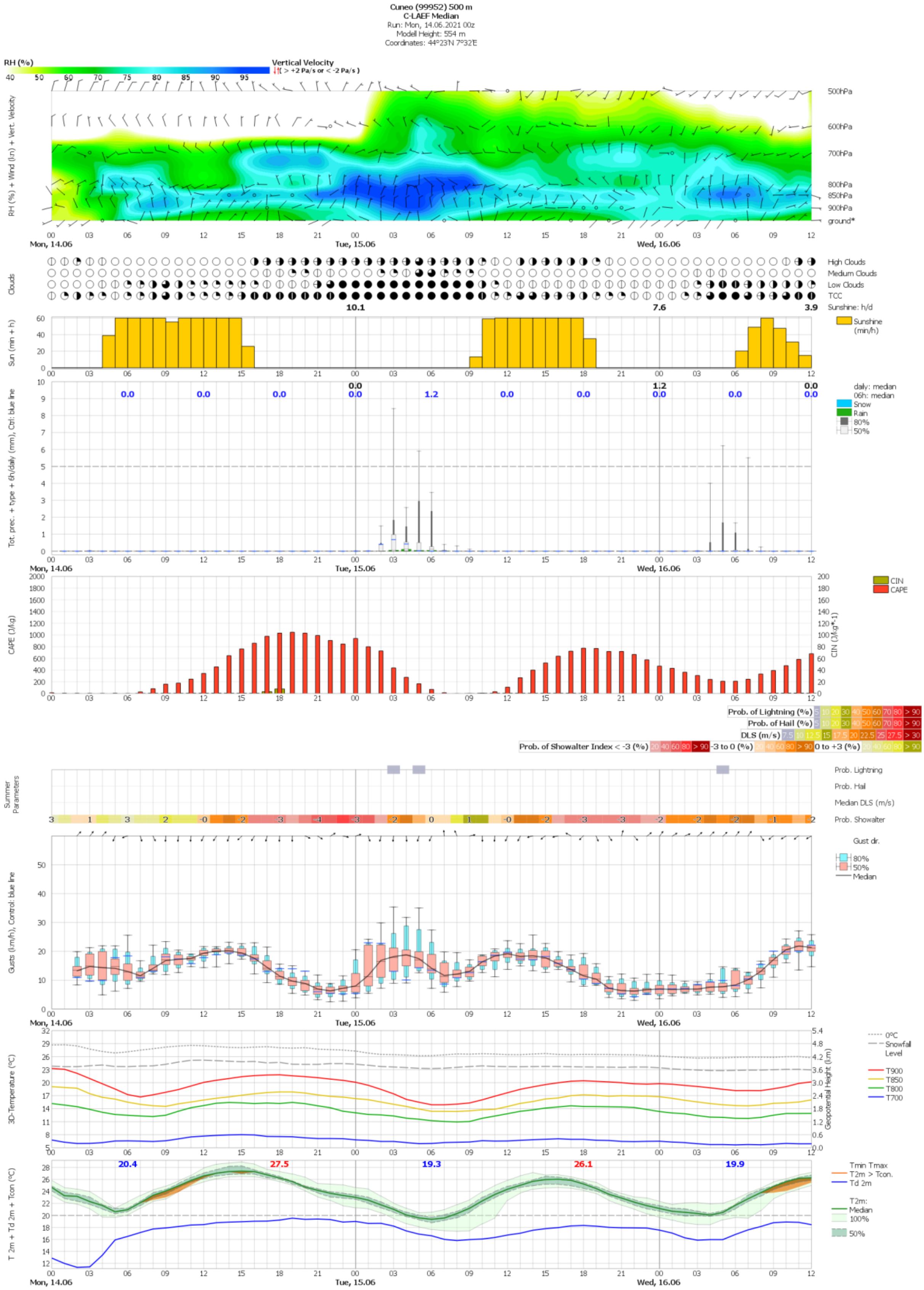


Figure 47: C-LAEF Epsgram for a point in northern Italy on June 14 2021 produced with Visual Weather.

Bouttier, F., Raynaud, L., Nuissier, O. and Ménétrier, B. (2016) Sensitivity of the AROME ensemble to initial and surface perturbations during HyMeX. Quart. J. Roy. Meteor. Soc. 142, 390-403, https://doi.org/10.1002/qj.2622

Ollinaho, P., Lock, S. J., Leutbecher, M., Bechtold, P., Beljaars, A., Bozza, A., Forbes, R. M., Haiden, T., Hogan, R. J. and Sandu, I. (2017). Towards process-level representation of model uncertainties: Stochastically perturbed parametrisations in the ECMWF ensemble. Quart. J. Roy. Meteor. Soc. 143, 408–422, https://doi.org/10.1002/qj.2931

Tsyrulnikov, M. and D. Gayfulin, 2017: A limited-area spatio-temporal stochastic pattern generator for simulation of uncertainties in ensemble applications, Meteorologische Zeitschrift 26(N 5), 549-566, DOI: 10.1127/metz/2017/0815.

Wastl, C., Y. Wang, A. Atencia, F. Weidle, C. Wittmann, C. Zingerle, E. Keresturi, 2021: C-LAEF: Convection-permitting Limited-Area Ensemble Forecasting system. Quarterly Journal of the Royal Meteorological Society, 147, 1431– 1451. https://doi.org/10.1002/qj.3986

Efforts: 8 PM

Contributors: Gabriella Tóth, Katalin Jávorné-Radnóczi, Gabriella Szépsó (all OMSZ), Christoph Wittmann, Clemens Wastl, Florian Weidle (all ZAMG)

Documentation: papers published in scientific journals; convection-permitting ensemble systems for operational use (ZAMG, OMSZ); EPS documentation at ECMWF confluence site; EPS products and visualizations

Status: C-LAEF suite implementation operational under the time critical environment at ECMWF HPCF; C-LAEF Esuite running at ECMWF HPCF; AROME-EPS operationally running OMSZ; some delays due to postponed stays (COVID)

S4 Action/Subject/Deliverable: EPS - Verification

Description and objectives:

This topic has been mainly shifted to the new area Applications and Verification

A robust and reliable verification tool is needed in order to establish the quality and weaknesses of our probabilistic forecasting systems. The huge amount of data must be processed, which requires an appropriate, optimized and flexible verification software.

The LAEF verification tool has been developed, maintained and used already for several years. Since then, distinct versions of the source code have been created under the different users. These versions may diverge from each other and involve various levels of modifications and bug fixes. If we intend to use this verification tool further, it is necessary to merge the latest development under one common library and treat the known bugs equally. Unfortunately, such actions have been frozen since 2018. With the new area “Applications and Verification” started this year, this topic might be restarted soon.

The HARP verification package, providing suitable tools for probabilistic and mesoscale forecast verification, with focus on spatial aspects as well, is more and more used also within the RC-LACE consortium. It is extensively used in Austria at ZAMG where continuous verification of operational C-LAEF and C-LAEF e-suite is done with HARP. Visualization of verification results (HARP monitor) is based on the interactive application originating from HARPVis functionalities, as well as with standard R graphics functions.
Also at SHMU in Slovakia and at OMSZ in Hungary it is used regularly and also Poland is at the moment starting to work with the HARP verification package.

Efforts: shifted to new area Applications and Verification

Contributors: Martin Petráš (SHMU), Dávid Tajti, Katalin Jávorné-Radnóczi (OMSZ), Clemens Wastl, Florian Weidle, Christoph Zingerle (all ZAMG)

Documentation: Local installations (SHMU, ZAMG, OMSZ, IMGW) and documentation of case studies with the HARP verification package

Status: Shifted to new area Applications and Verification

S5 Action/Subject/Deliverable: Collaborations

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

The new ACCORD area leader for EPS (Henrik Fedderson) has initiated stronger cooperation between the area leaders of the different consortia (Inger-Lise Frogner, Laure Raynaud, Clemens Wastl), resulting in several online meetings about RWP and common EPS topics in the first half of 2021. As a result of this stronger cooperation the ACCORD RWP has been completely reorganized from consortia based actions to thematic actions. Due to this fact it is also reasonable to reorganize the LACE workplan starting from 2022.

Some online meetings in the ACCORD consortium about EPS will take place this autumn and for next year a physical (if possible) EPS meeting is planned in Innsbruck/Austria.

Exchange of EPS data within the EUMETNET SRNWP-EPS project has also been intensified. C-LAEF has already been provided for the SRNPW-EPS database for the summer 2020 period and is also planned to provide A-LAEF data for this purpose.

Efforts: 1 PM

Contributors: Martina Tudor (DHMZ), Clemens Wastl (ZAMG)

Documentation: Exchange of the expertise between the other consortia and the new ACCORD consortium; contact with experts within the relevant projects

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.

1 paper was published in QJRM, 1 paper in HPC Focus and 2 papers were submitted to IDÖJARAS.

C. Wastl, Y. Wang, A. Atencia, F. Weidle, C. Wittmann, C. Zingerle, E. Keresturi, 2021: C-LAEF: Convection-permitting Limited-Area Ensemble Forecasting system. Quarterly Journal of the Royal Meteorological Society, 147, 1431– 1451. https://doi.org/10.1002/qj.3986

J. Vivoda, M. Belluš, M. Derková, 2021: “Vysokovýkonné počítanie a predpoveď počasia na SHMÚ”, HPC Focus, p44-53, ISSN 2729-9090

A. Simon, M. Belluš, K. Čatlošová, M. Derková, M. Dian, M. Imrišek, J. Kaňák, L. Méri, M. Neštiak and J. Vivoda, 2021: “Numerical simulations of 7 June 2020 convective precipitation over Slovakia using deterministic, probabilistic and convection-permitting approaches”, submitted to Idojaras on May 2021 (accepted for publication).

K. Jávorné-Radnóczi and B. Tóth, 2021: Short range probabilistic forecasts at Hungarian Meteorological Service: evaluation of AROME-EPS and impact of EDA, submitted to Idojaras

Efforts: 2 PM

Contributors: Yong Wang, Florian Weidle, Christoph Wittmann, Clemens Wastl, Christoph Zingerle (all ZAMG), Endi Keresturi (DHMZ), Martin Belluš, Jozef Vivoda, Maria Derková (SHMU), Gabriella Tóth, Katalin Jávorné-Radnóczi (OMSZ)

Documentation: Reviewed papers

Status: In progress

List of actions, deliverables including status

S1 Subject: Optimization of A-LAEF

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

Status: Ongoing; running e-suite of A-LAEF at ECMWF HPCF; some delays and shifts in this topic due to postponed stays (COVID)

S2 Subject: A-LAEF maintenance

Deliverables: A-LAEF operational suite running at ECMWF HPCF; probabilistic forecast products delivered to the LACE partners; Flow charts; presentations; reports; technical documentation of A-LAEF TC2 suite running at ECMWF

Status: Ongoing; some delays and shifts in this topic due to the delay of the new ECMWF HPC and due to postponed stays (COVID)

S3 Subject: AROME-EPS

Deliverables: papers published in scientific journals; convection-permitting ensemble systems for operational use (ZAMG, OMSZ); C-LAEF documentation on ECMWF confluence site; EPS products and visualizations

Status: C-LAEF suite implementation operational under the time critical environment at ECMWF HPCF; C-LAEF Esuite running at ECMWF HPCF; AROME-EPS operationally running at OMSZ; some delays due to postponed stays (COVID)

S4 Subject: EPS - Verification

Deliverables: Local installations (SHMU, ZAMG, OMSZ, IMGW) and documentation of case studies with the HARP verification package

Status: Shifted to new area Applications and Verification

S5 Subject: Collaborations

Deliverables: Exchange of the expertise between the other consortia and the new ACCORD consortium; contact with experts within the relevant projects

Status: Ongoing

S6 Subject: Publications

Deliverables: 1 paper was published in QJRM, 1 paper in HPC Focus and 2 papers were submitted to IDÖJARAS.

Status: In progress

Activities of management, coordination and communication

- 36th LSC Meeting, 23-24 March 2021 (*online*)
- 1st ACCORD All Staff Workshop 2021, 12 - 16 April 2021 (*online*), LACE EPS activities presented by Clemens Wastl
- Several online meetings within the EPS area leaders in ACCORD

LACE supported stays – 0 PM in 2021 so far

Unfortunately, due to COVID-19 pandemic, there were no research stays organized this year so far.

Summary of resources [PM] – 2021

Subject	Manpower		LACE		ACCORD	
	plan	realized	plan	realized	plan	realized
S1: Optimization of A-LAEF	10	5.5	3	0		
S2: A-LAEF maintenance	5	2	1			
S3: AROME-EPS	20	8	1	0	1	0
S4: EPS – Verification	0	0				
S5: Collaborations	2	1				
S6: Publications	6	2				
Total:	47	18.5	5	0	1	0