SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year 2021

Project Title: ALARO Limited Area Ensemble Forecast (A-LAEF)

Computer Project Account: spcralae

Principal Investigator(s): Martina Tudor and Martin Belluš

Affiliation: Croatian Meteorological and Hydrological Service and Slovak Hydrometeorological Service

Name of ECMWF scientist(s) collaborating to the project (if applicable) ……

……

Start date of the project: 1.4.2020

Expected end date: 31.12.2022

Computer resources allocated/used for the current year and the previous one

(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	5.000.000		12.000.000	0 (national resources used)
Data storage capacity	(Gbytes)				

Summary of project objectives (10 lines max)

A mesoscale ensemble forecasting system A-LAEF is running operationally on ECMWF HPC as TC2 supported by national SBU quotas of Turkey, Slovenia and Croatia. The system is running using multi-scale ALARO physics in 4.8 km horizontal resolution with linear grid on 60 levels. There is one unperturbed control and 16 perturbed members. The project resources are intended for tests using new version of the forecast model and further development of perturbation methods (also in the assimilation system), focus on studying the cases of forecast failure and improvements needed, new SPG for stochastic physics, perturbation of fluxes instead of tendencies, and flow-dependent B-matrix for local 3DVar ALARO systems.

Summary of problems encountered (10 lines max)

Much of the research work within RC LACE is done during the research stays that were practically suspended during the Covid19 crisis. The same issue also caused the researchers to have to reorganize their work frequently. The work continued, but focused mostly on monitoring operational performance and adapting the suite to changes in the operational IFS (running tests using input data from a parallel suite). Adapting the time critical scripts of the TC2 suite for testing was very time consuming and it was easier to do the tests using national resources (where Austria also contributed). However, the scripts are being adapted for research purposes that could benefit from the special project SBUs.

Summary of plans for the continuation of the project (10 lines max)

Upgrade the operational forecast system from CY40t1 to CY43t1 (the latest export version of the LAM code) and the multi-physics choices used in the EPS system might need to be readjusted, testing the new SPG for stochastic perturbations of physics tendencies. Perturbing the physics fluxes instead of tendencies will be explored. Combination of an ensemble of upper-air spectral blending with the 3D-variational data assimilation will be evaluated.

List of publications/reports from the project with complete references

- 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)
- J. Vivoda, M. Belluš, M. Derková, 2021: “High Performance Computing and Weather Forecasting at SHMU”, HPC Focus, p44-53
- Report on EPS activities in RC LACE in the first half of 2021. https://www.rclace.eu/File/Predictability/reports/Report_EPS_2021_092021.pdf
- M. Belluš and A. Simon, 2021: “A-LAEF: From TC2 status to case studies”, poster from ACCORD Workshop http://www.umr-cnrm.fr/accord/IMG/pdf/a-laef_accord_2021.pdf

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

The work on EPS system was focused on several topics. New postprocessing domain over the Mediterranean Sea (see Figure 1) to couple the ocean models NEMO and SHYFEM with A-LAEF probabilistic fields was prepared and tested before the operational implementation. IFS data from parallel suite were used to evaluate the impact of cy47r2 coupling on A-LAEF forecast (see Figure 2), while the technical issues related to the originally planned provision of only a subset of 91 levels out of 137 on the day of implementation were identified and solved in advance. The optimization of A-LAEF GRIBs dissemination and of the offline postprocessing task for Turkey and Czech Republic LATLON domains have been done. Tools for archiving source codes to ECFS were prepared. Various approaches for the precipitation phase ratio calculation based on the EPS output were tested (see Figure 3). A tool for the observation preprocessing used in the data assimilation was upgraded and intensively tested to follow the rules of strict output formatting, mandatory since cy46. Also the new features like whitelisting of the measurements and support of zipped input files, were implemented. Implementation of incremental DFI step in spectral blending procedure within the assimilation cycle has been made, and its impact on model spin-up was explored in several experiments. Last but not least, the various case studies have been investigated using the A-LAEF ensemble system (see further below).

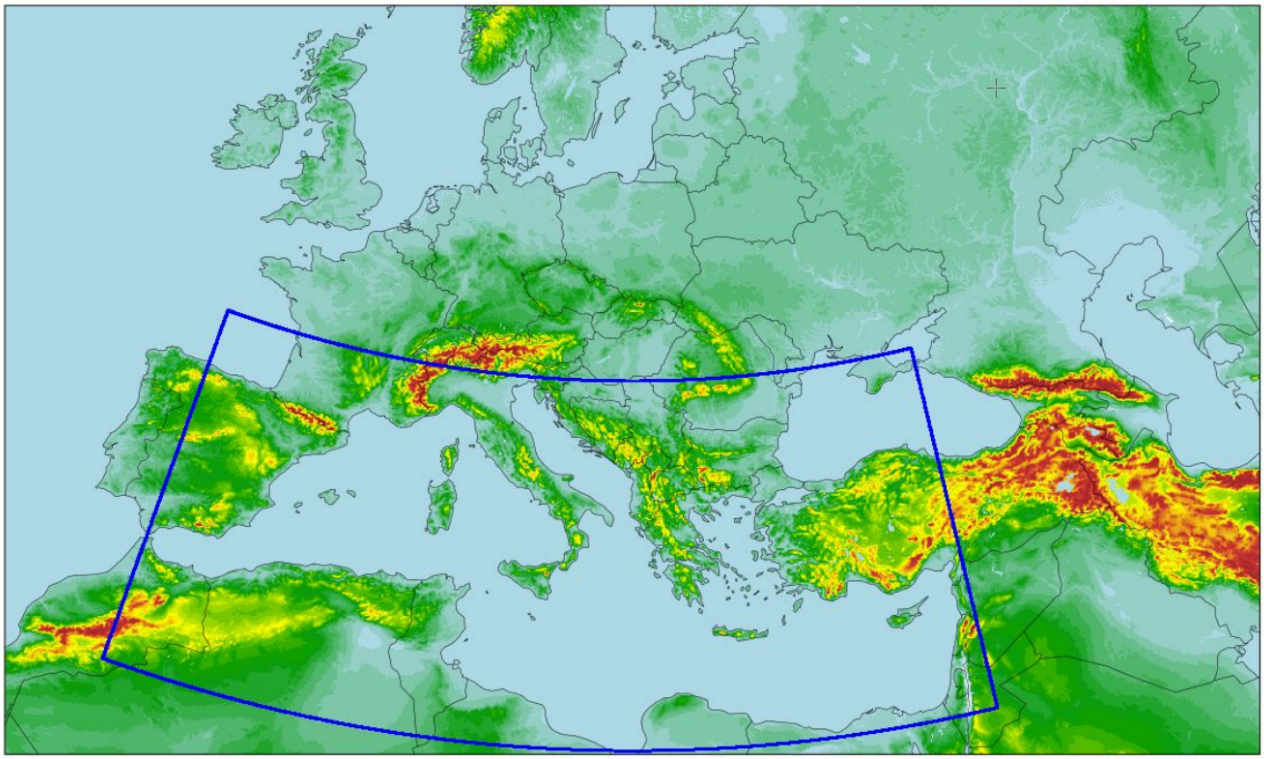

Figure 1. A-LAEF integration domain with model topography and the MSEA postprocessing domain to couple the ocean models (blue line).

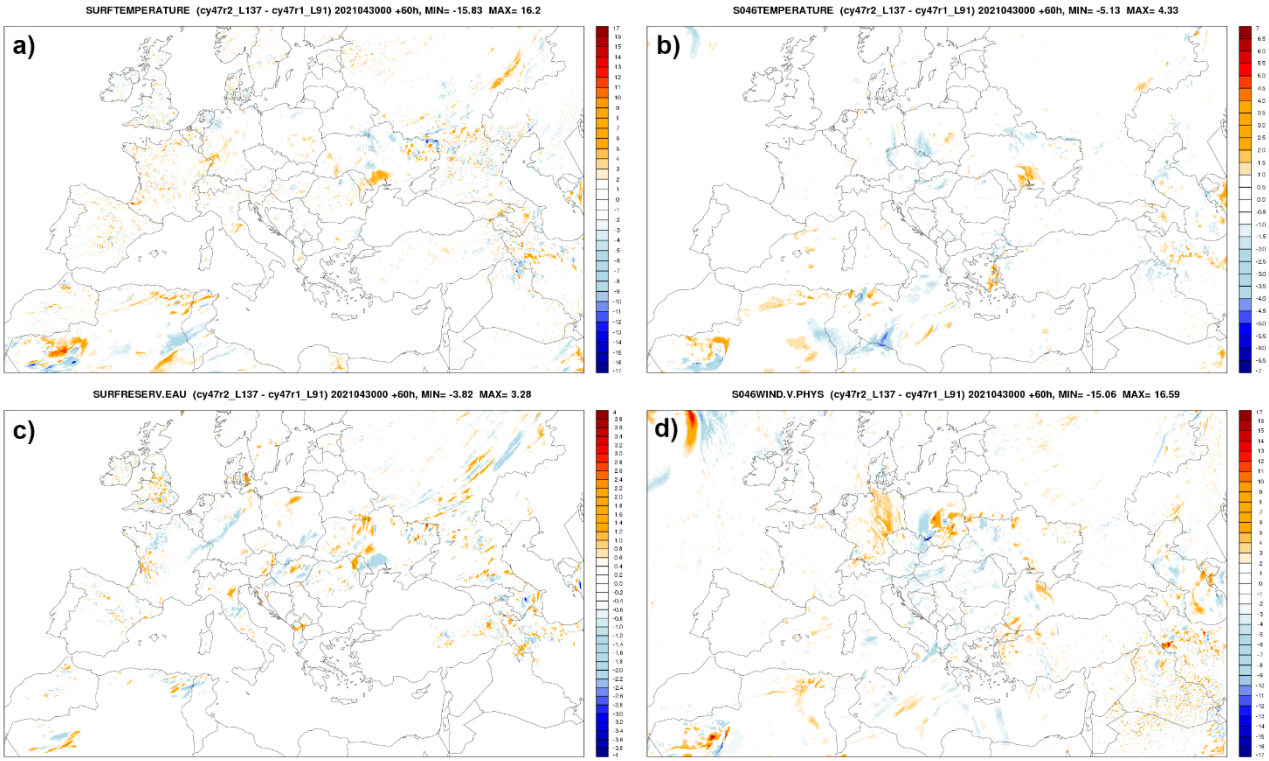

Figure 2. Differences in 60 hour A-LAEF control forecasts of surface temperature (a, range -17 to 17), level 46 temperature (b, range -7 to 7), surface water content (c, range -4 to 4) and level 46 wind v-component (d, range -17 to 17), using the cy47r2 (137 levels) and cy47r1 (91 levels) input data.

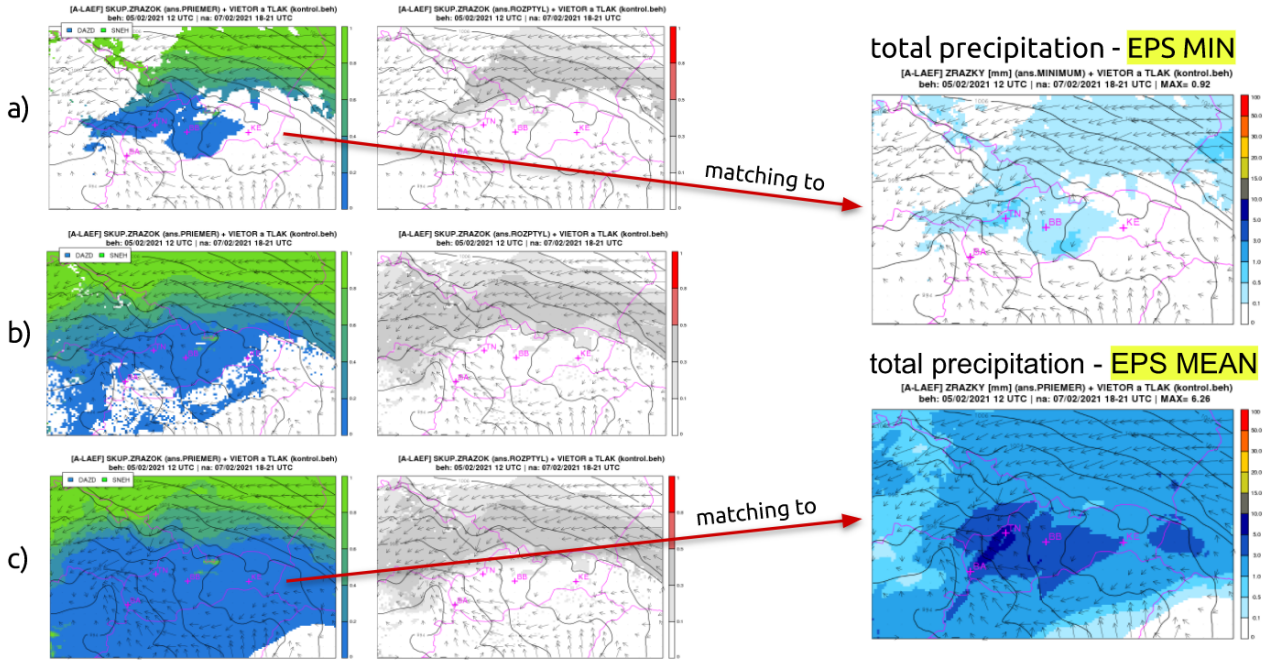

Figure 3. Various approaches (a, b, c) for precipitation phase calculation based on EPS output (snow – shades of green, rain – shades of blue).

Case studies

1. Fog situation (24/11/2020)

On 24/11/2020 there was an anticyclone over the central Europe. Fog was present over the large territories and remained during the whole day over lowlands. The visibility dropped to 100 m or even less at some places (which is relatively rare in Slovakia). Previously, there was temporal cold

advection at mid-tropospheric levels (e.g. 850 hPa) but this was soon replaced by advection of warmer air from the southwest.

Several NWP models and even EPS systems (ECMWF) predicted sunny/relatively warm weather for the noon hours (there should have been a break in the foggy character of previous and later days) and as high temperatures as +5, +6 °C but in the reality, the temperature remained somewhat over 0°C for many stations in southwest of Slovakia.

Several members of A-LAEF ensemble also predicted that the cloudiness will vanish, somewhere completely. However, low cloudiness was still present in many members, as well as on the EPS mean and EPS maximum cover forecast (see Figure 4, top left panel). Probability of low cloudiness with the coverage above 60% was still quite high, between 40-80% (see Figure 4, top right panel). Individual ensemble members in comparison with the verifying MSG composite image can be seen on Figure 4, bottom.

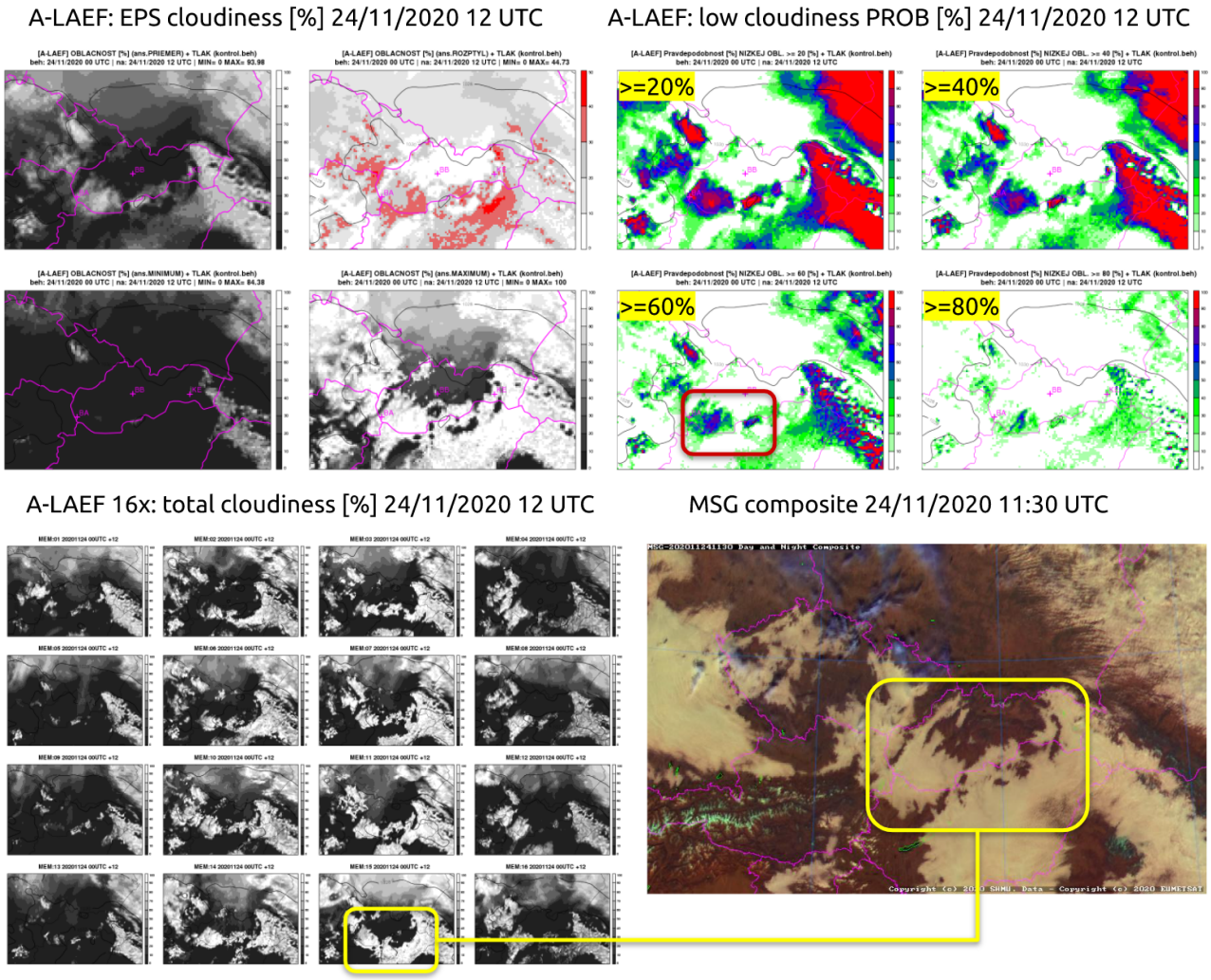

Figure 4. A-LAEF ensemble mean, spread, min and max for total cloudiness (top left panel), low cloudiness probabilities for different thresholds (top right panel), and individual ensemble members in comparison with the MSG composite picture, with depicted area of foggy weather (bottom).

2. Temperature advection (07/02/2021)

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 2m temperature forecasts were related to different spread of the mixed PBL region in various models.

Most of the models forecast a “tongue” of warmer air spreading toward North, with different extension. 2m temperature was overestimated by about 10 °C in the area of Bratislava. A-LAEF multi-physics 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), see Figure 6.

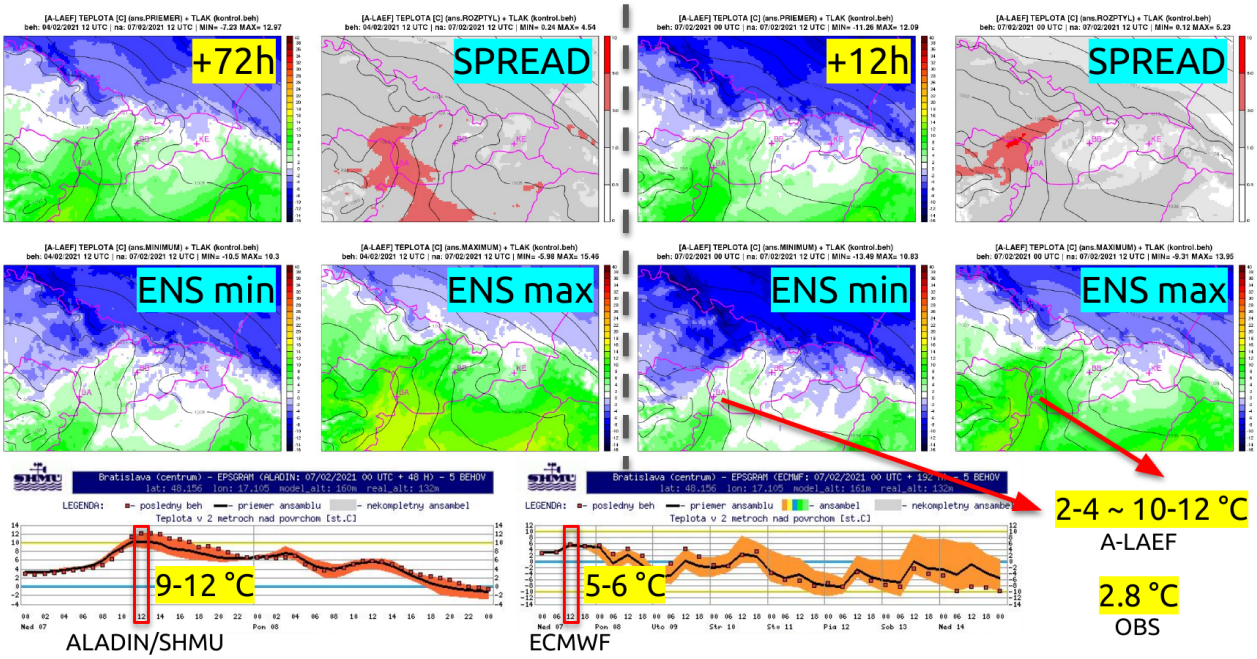

Figure 5. A-LAEF 2m temperature forecast for 12 UTC 7th Feb 2021, 3 days and 12 hours ahead show large uncertainty even at a short range.

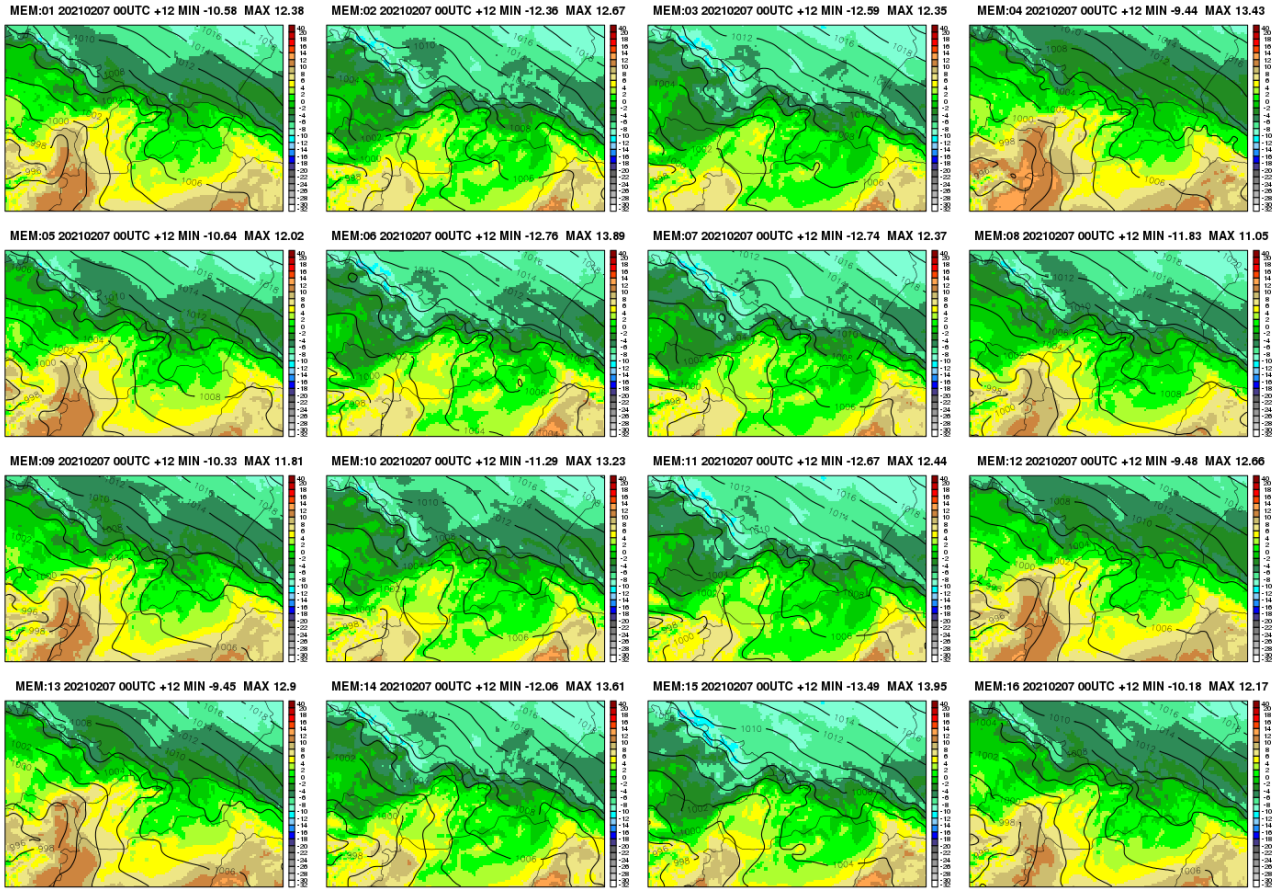

Figure 6. The 16 perturbed A-LAEF members show 2 different scenarios for forecasts of 2m temperature and MSLP, and these are grouped around the physics choices made for different members.

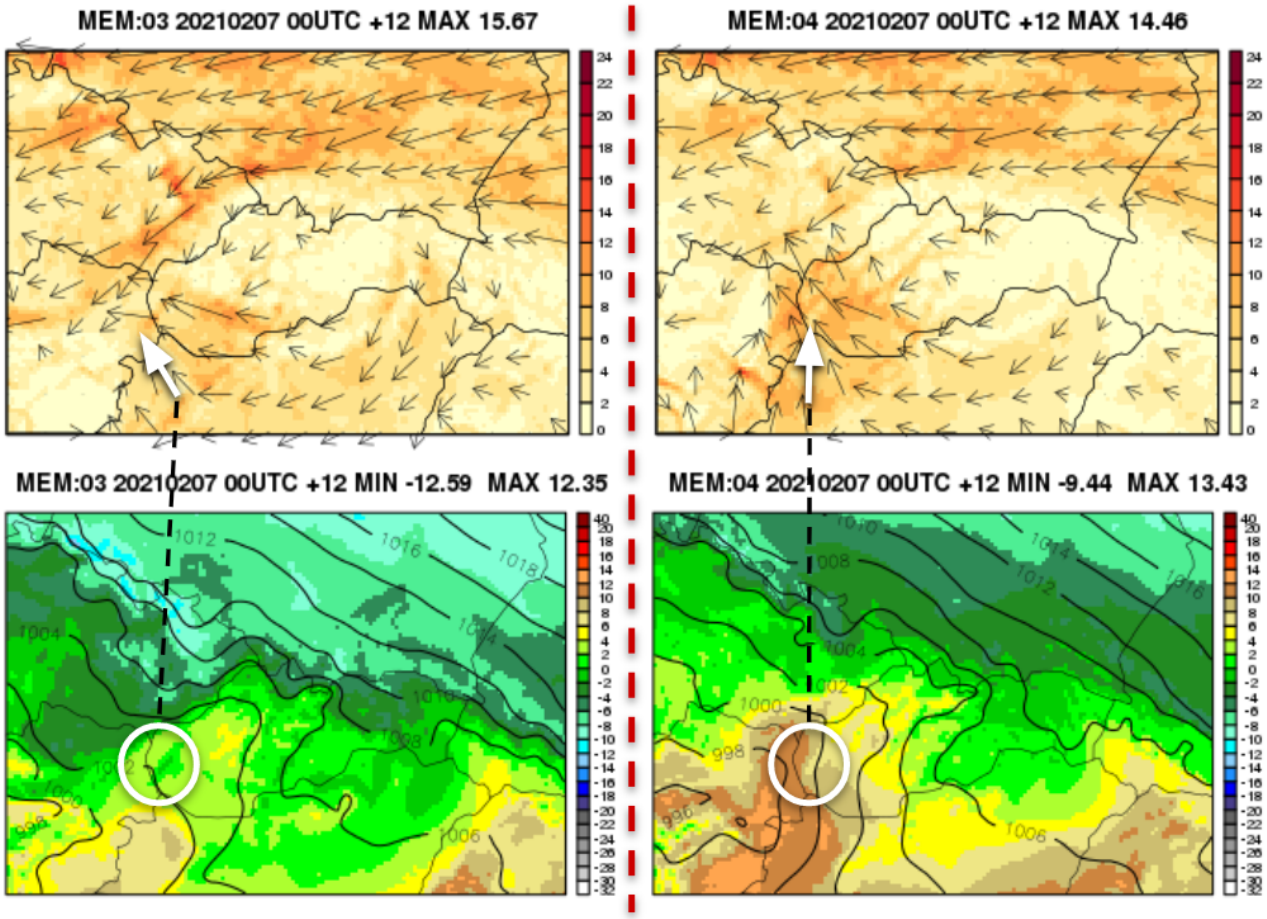

Figure 7. Wind, 2m temperature and MSLP forecasts from different physics options in the A-LAEF ensemble. The forecast on the left is from cluster 3 and the members of that cluster performed well while the forecast on the right is from cluster 4 and all these members failed in forecasting correct temperature for Bratislava.

3. Massive cold front passage (12-13/04/2021)

After the passage of strong cold front, the cold air quickly invaded the southwest of Slovakia. From noon values around 20 °C, it cooled down to 1-3 °C only in a few hours. Mixed precipitation, and gradually the 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 a gust wind.

Both massive temperature drop and strong wind gusts (see Figure 8) were well captured by A-LAEF ensemble, while the uncertainty was related rather to the precise timing of the event.

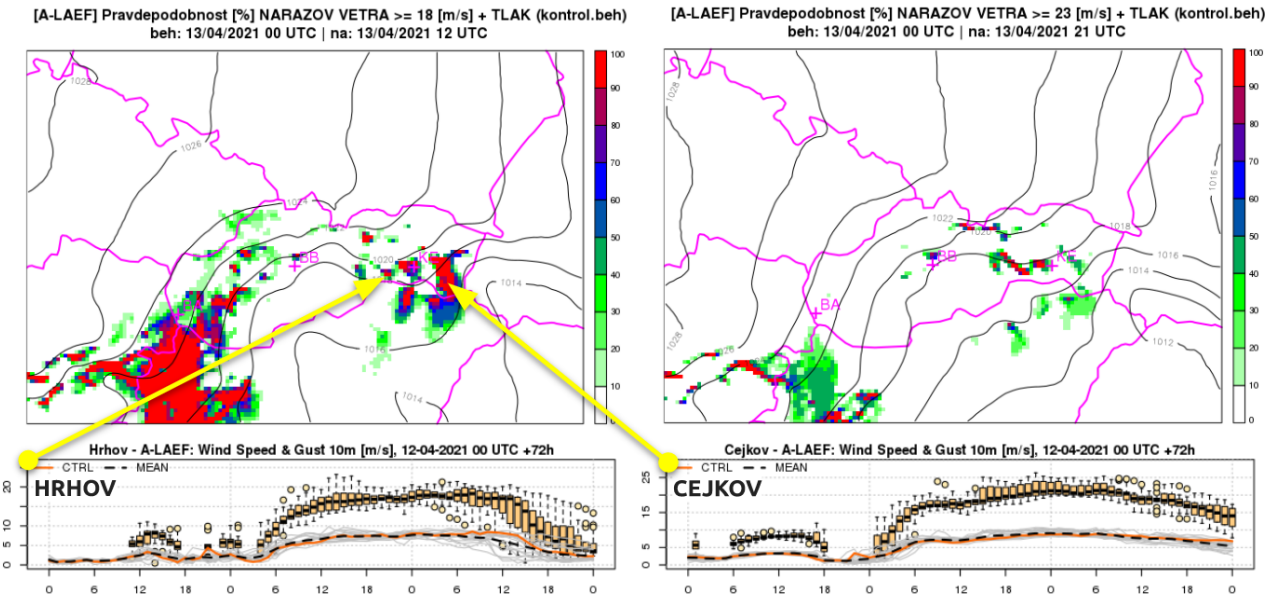

Figure 8. Probability of wind gusts exceeding 18 m/s at 12 UTC (level 1 warning, top left) and 23 m/s at 21 UTC (level 2 warning, top right), with the time evolution of forecasted wind speed and gusts for the two locations, where damage was seen on vehicles and buildings (bottom).