Regional **C**ooperation for
Limited **A**rea Modeling in **C**entral **E**urope

LACE
nwp central europe

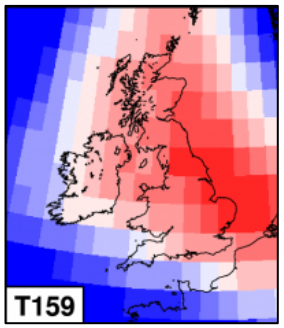
Recent activities on LAM-EPS in LACE

Martin Belluš with contributions of Florian Weidle, Mihaly Szűcs, Simona Taşcu, Yong Wang, Christoph Wittmann and Endi Keresturi

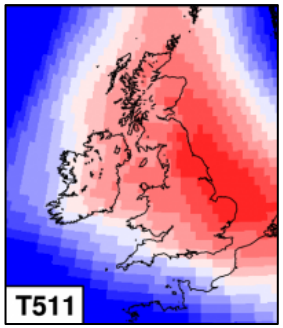
DHMZ SHMU OMSZ ZAMG ROMANIA ANM

Introduction & motivation

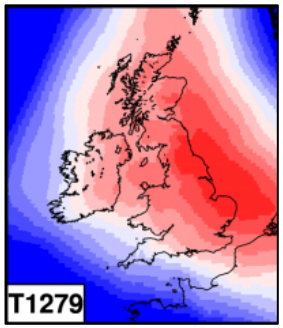
~126km



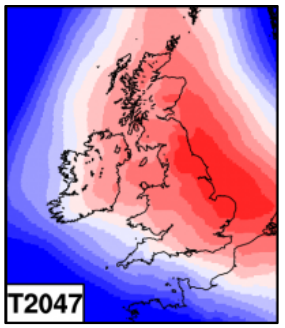
~39km



~16km



~10km



Faster computers → **Higher resolutions**

The small scale uncertainties tend to grow up along the forecast lead time into the synoptic scales and eventually, in the unstable situations with very little predictability, are capable of changing completely the weather scenario even on the short ranges.

Probabilistic approach seems to be the only answer, but:

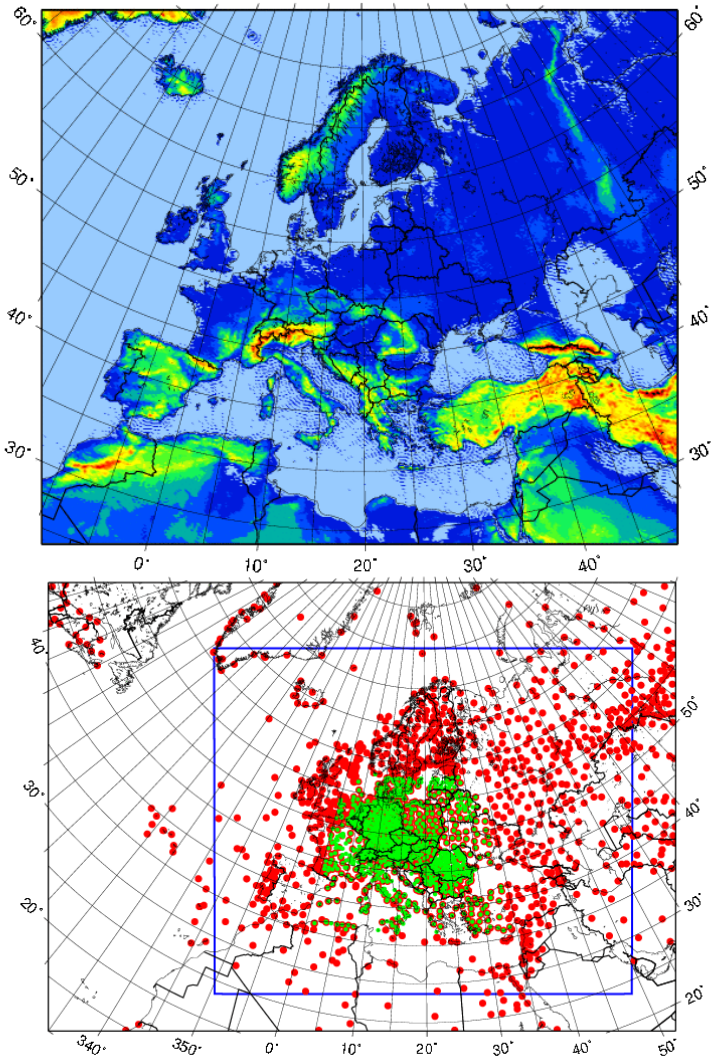
- **how to perturb the IC and LBC?**
- **how to simulate the model uncertainty?**

Outline

- EPS systems of LACE
- Research & Development
- Plans for 2016

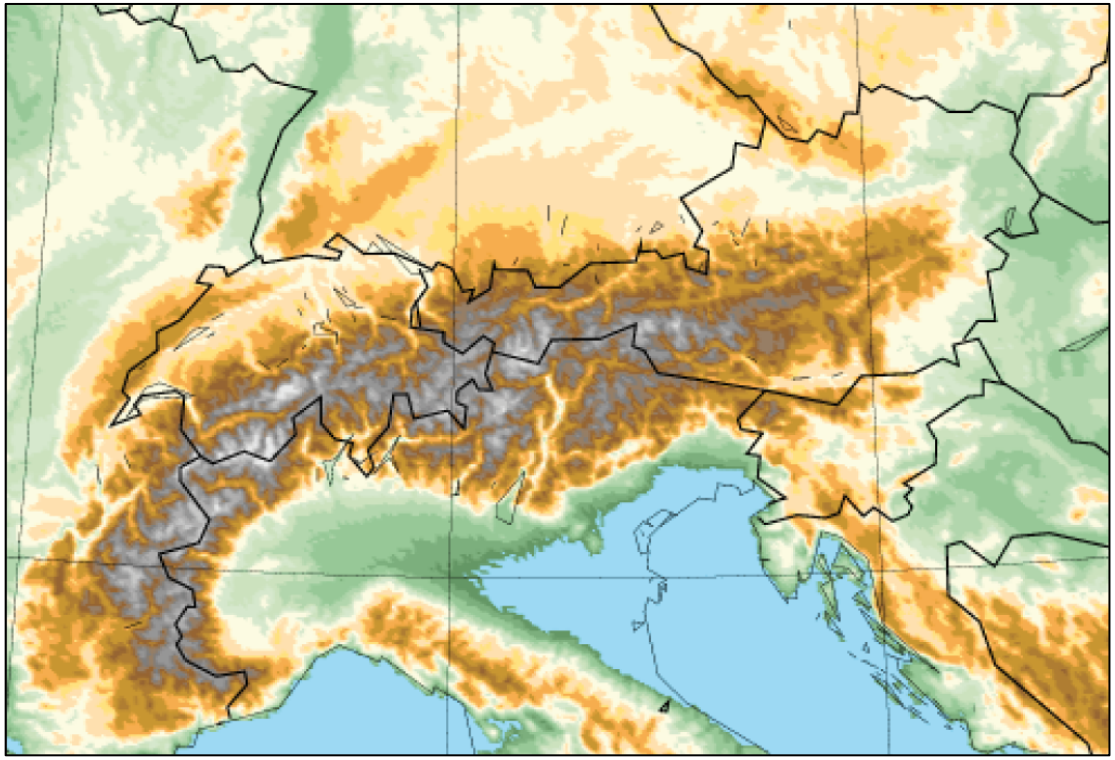
EPS systems of LACE - regional

ALADIN-LAEF (LACE, operational)	
ensemble size	16 + 1
Δx / vertical levels	10.9 km / 45
time-lagged coupling	ECMWF EPS (6h frequency)
runs per day	00 and 12 UTC (+72h forecast)
IC perturbation	surface: • ESDA by CANARI (T2m, RH2m) upper air: • breeding-blending
model perturbation	multi-physics: • micro-physics • deep/shallow convection • radiation • turbulence



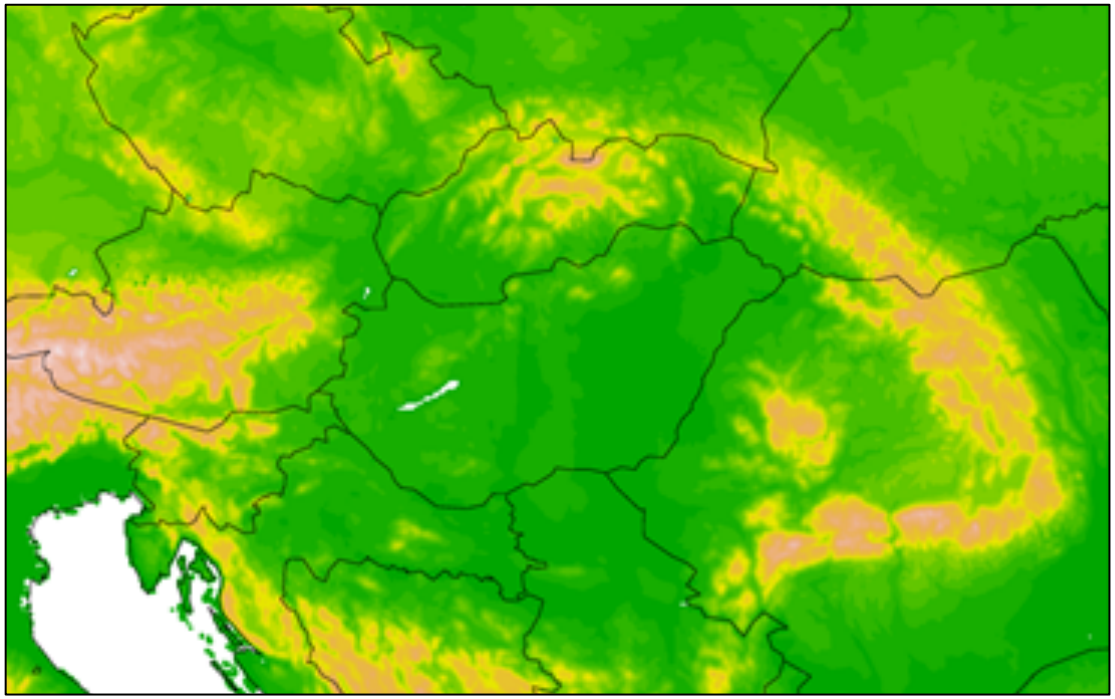
EPS systems of LACE - convection permitting

AROME-EPS **(Austria, on demand)**	
ensemble size	16 + 1
Δx / vertical levels	2.5 km / 60
coupling	ALADIN-LAEF (3h frequency)
runs per day	00 and 12 UTC
IC perturbation	surface: • none upper-air: • none
model perturbation	• none



EPS systems of LACE - convection permitting

AROME-EPS **(Hungary, in development)**	
ensemble size	10 + 1
Δx / vertical levels	2.5 km / 60
coupling	PEARP/ECMWF (1h frequency)
runs per day	00 and 12 UTC
IC perturbation	ENS-DA with conventional OBS and AMV
model perturbation	upper-air: • SPPT



Research & Development

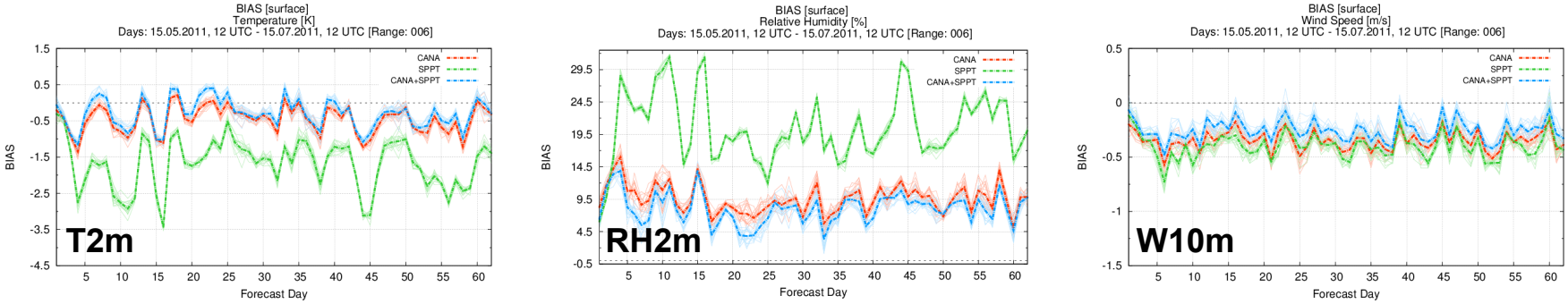
- **Combination of IC and model uncertainties for the surface prognostic variables in ALADIN-LAEF system:**

In ALADIN-LAEF system we have already implemented and tested several perturbation methods:

- ❏ IC uncertainty: NCSB, **ESDA** (surface), breeding-blending (upper-air)
- ❏ model uncertainty: **SPPT** (surface), MP

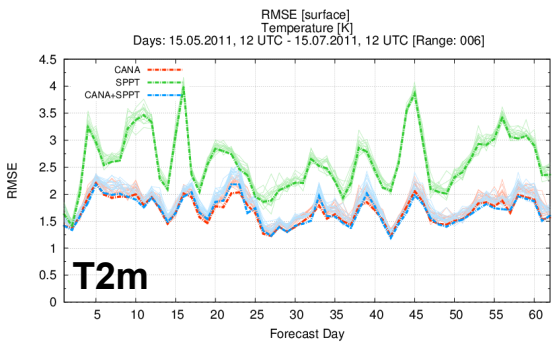
Stochastic physics, for the perturbation of surface prognostic fields through their parameterized tendencies, was introduced into the ALADIN-LAEF R&D version last year. Nevertheless, it was tested only in dynamical adaptation mode. Hence, further logical step towards its operational implementation was to test it in combination with the IC perturbation by ESDA.

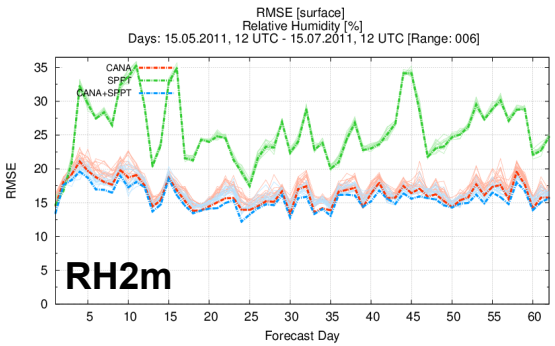
Positive impact gained by the combination of IC and model uncertainties (**ESDA** + **SPPT**) in ALADIN-LAEF:

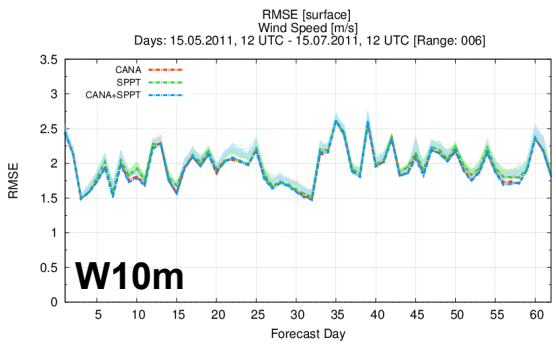


BIAS: *Time series (+6h forecast) for 62 days of validation period for the experiments **ESDA**, **SPPT** and **ESDA+SPPT***

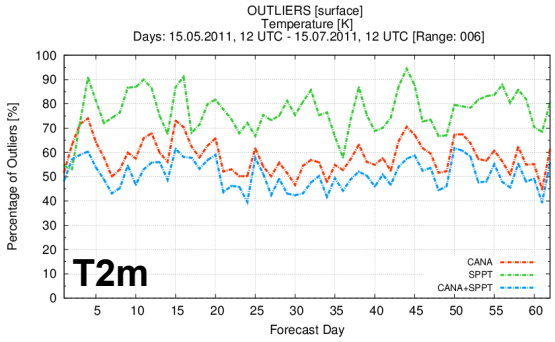
Research & Development

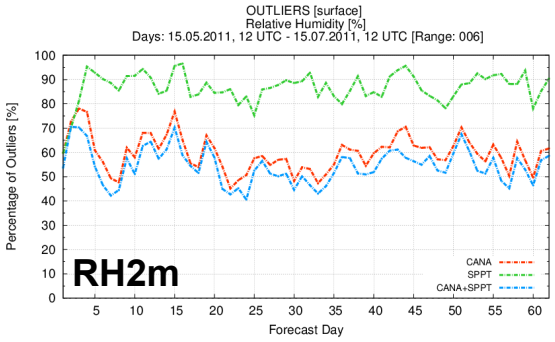


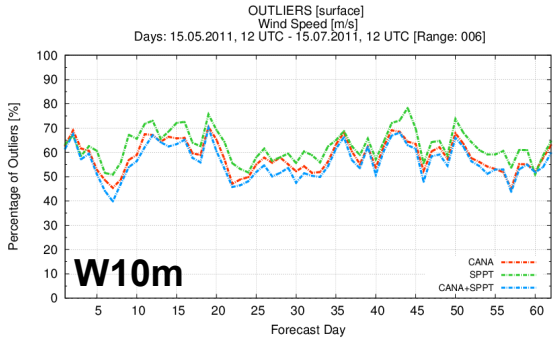




RMSE: *Time series (+6h forecast) for 62 days of validation period for the experiments* ***ESDA****,* ***SPPT*** *and* ***ESDA+SPPT***

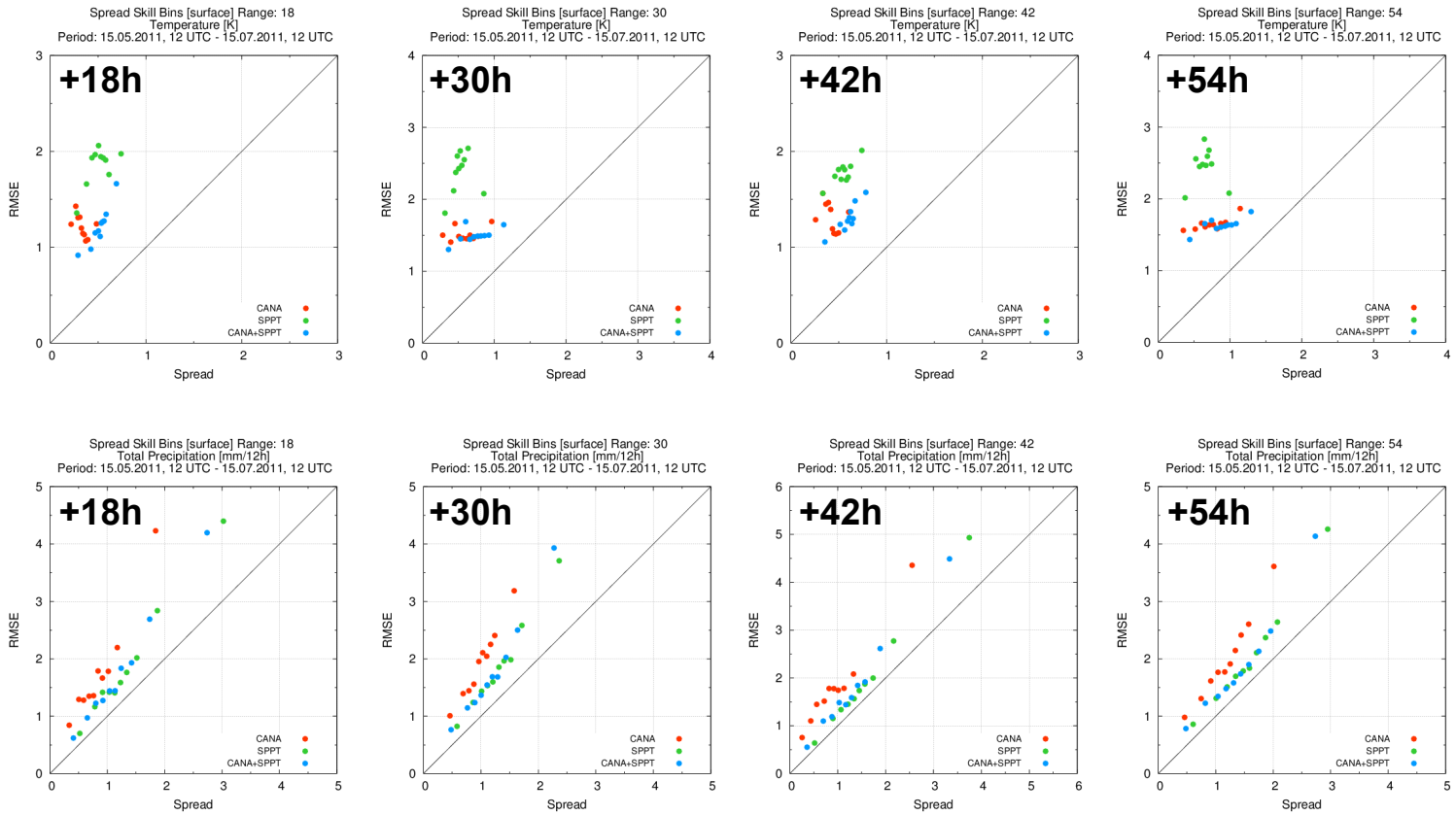






OUTLIERS: *Time series (+6h forecast) for 62 days of validation period for the experiments* ***ESDA****,* ***SPPT*** *and* ***ESDA+SPPT***

Research & Development

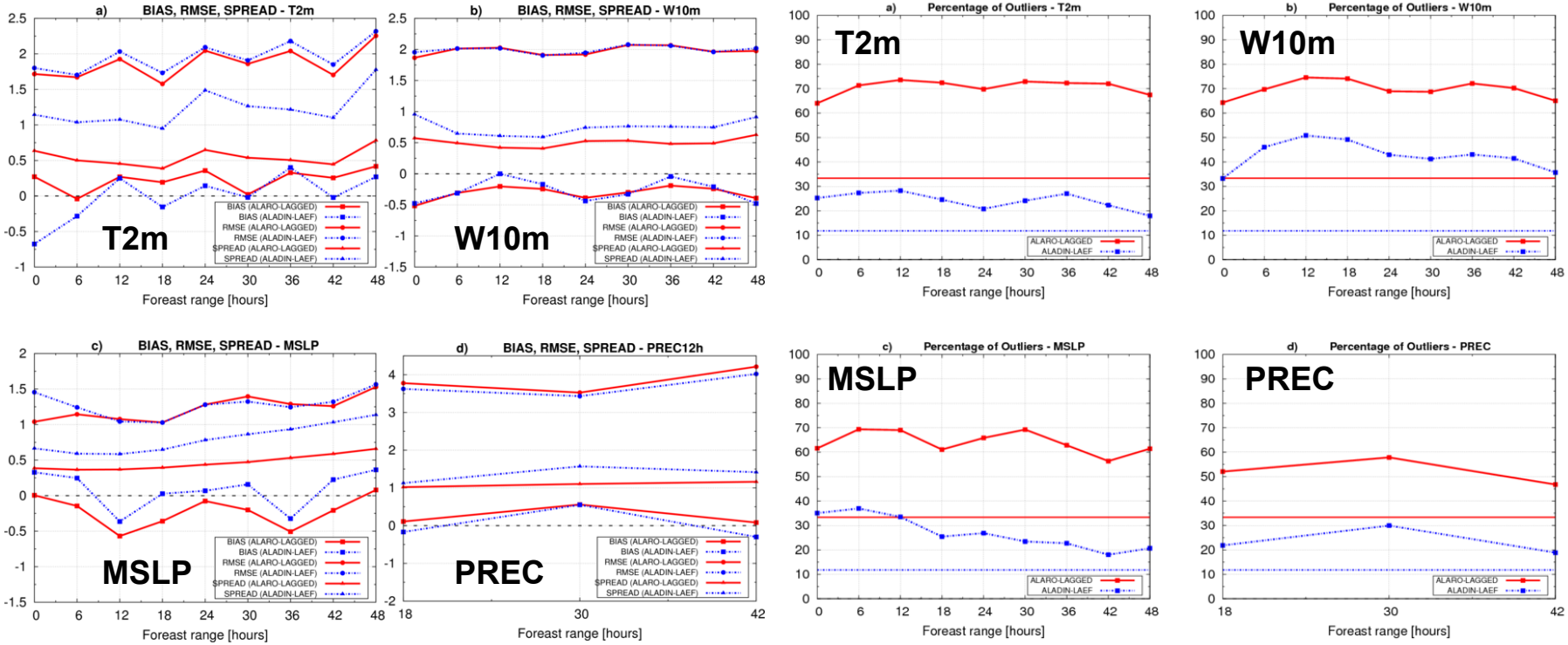


Spread Skill *for the verification bins for* ***T2m*** *(top) and* ***12h accumulated precipitation*** *(bottom) valid at different ranges, computed from 62 days experiment with* ***ESDA****,* ***SPPT*** *and* ***ESDA+SPPT***

Research & Development

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

Evaluation of ALADIN-LAEF against ALARO-LAGGED consisting of 5 consecutive deterministic ALARO runs. Therefore, 16 members of ALADIN–LAEF and 5 members of ALARO-LAGGED forecasts up to +48h were used in the verification for 2 months period in 2013.

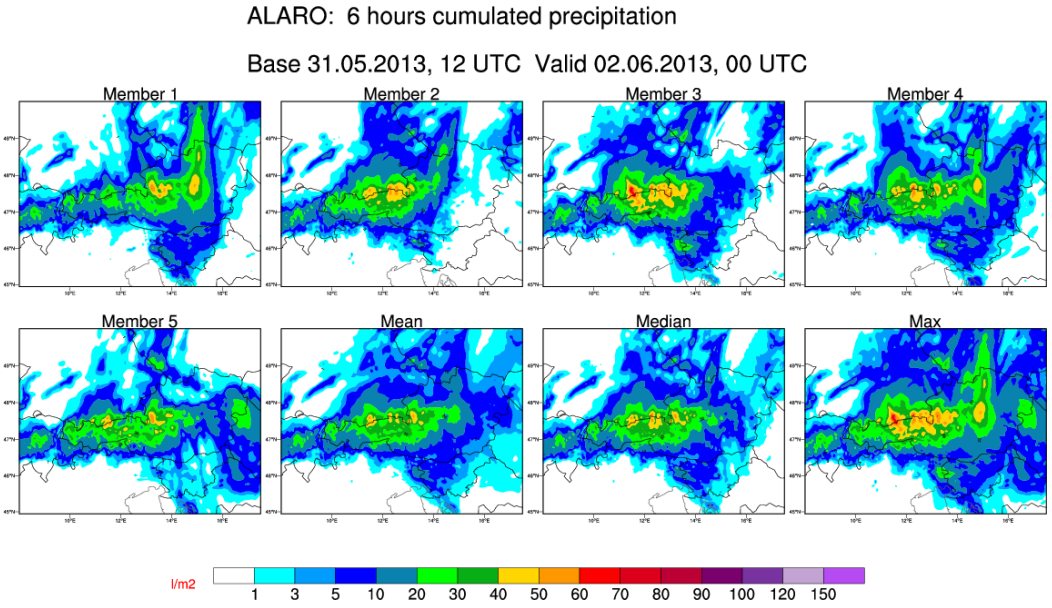


BIAS**, **RMSE**, **SPREAD** (left) and **OUTLIERS** (right) for **ALARO-LAGGED** and **ALADIN-LAEF

Research & Development

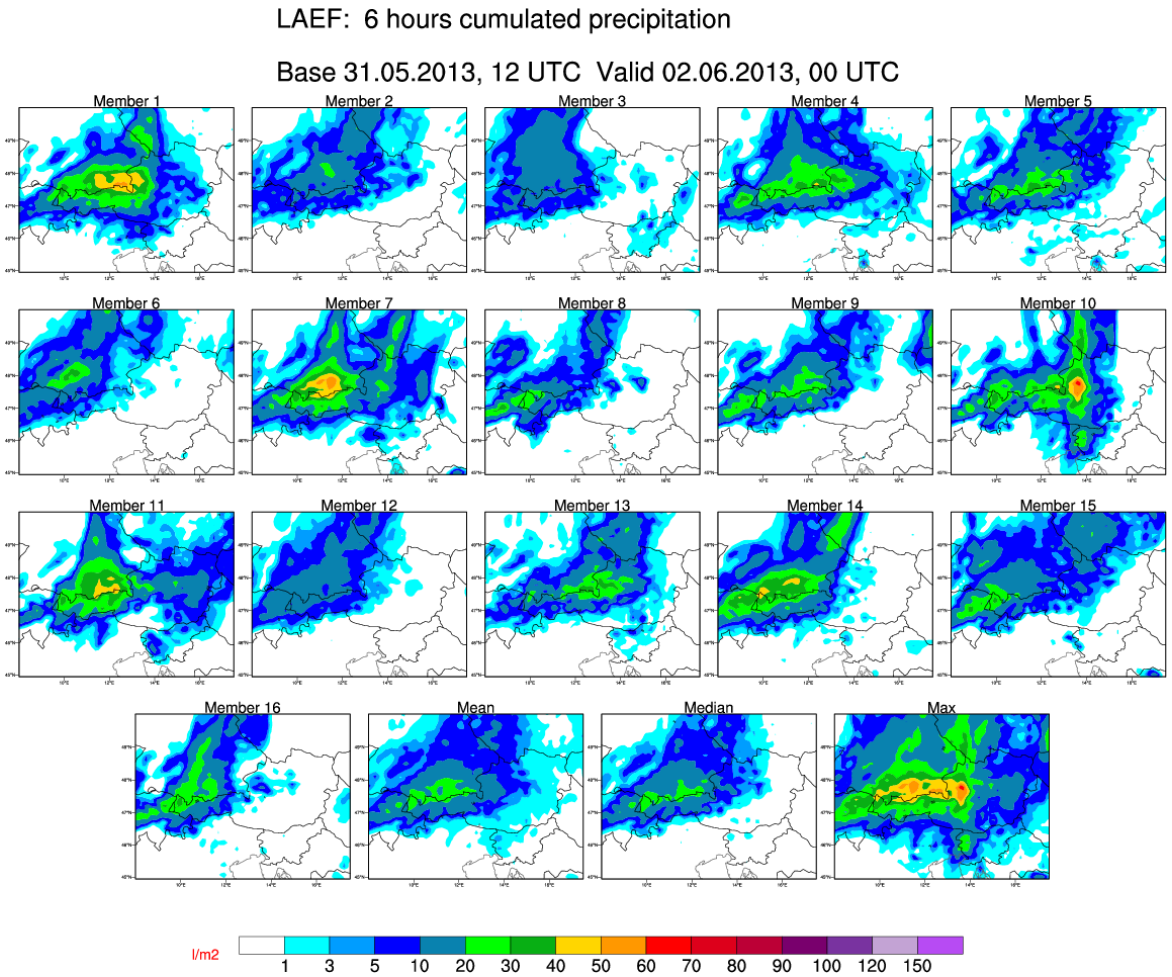
- **ALADIN-LAEF comparing to the ALARO-LAGGED for heavy precipitation event:**

Evaluation of a case study - heavy precipitation and flooding event (31st of May till 3rd of June 2013 in Central Europe). In Austria, between 31st of May, 00 UTC and 3rd of June, 00 UTC the highest amount of precipitation reached up to 300 mm/72h.



***ALARO-LAGGED**: 6h accumulated precipitation (+36h forecast)*

Research & Development

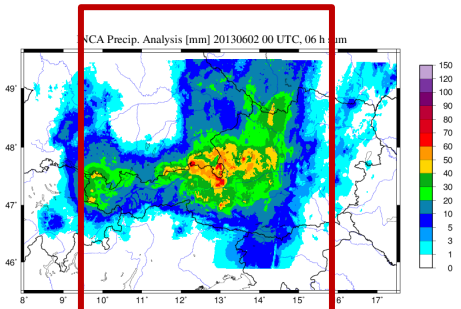


***ALADIN-LAEF**: 6h accumulated precipitation (+36h forecast)*

Research & Development

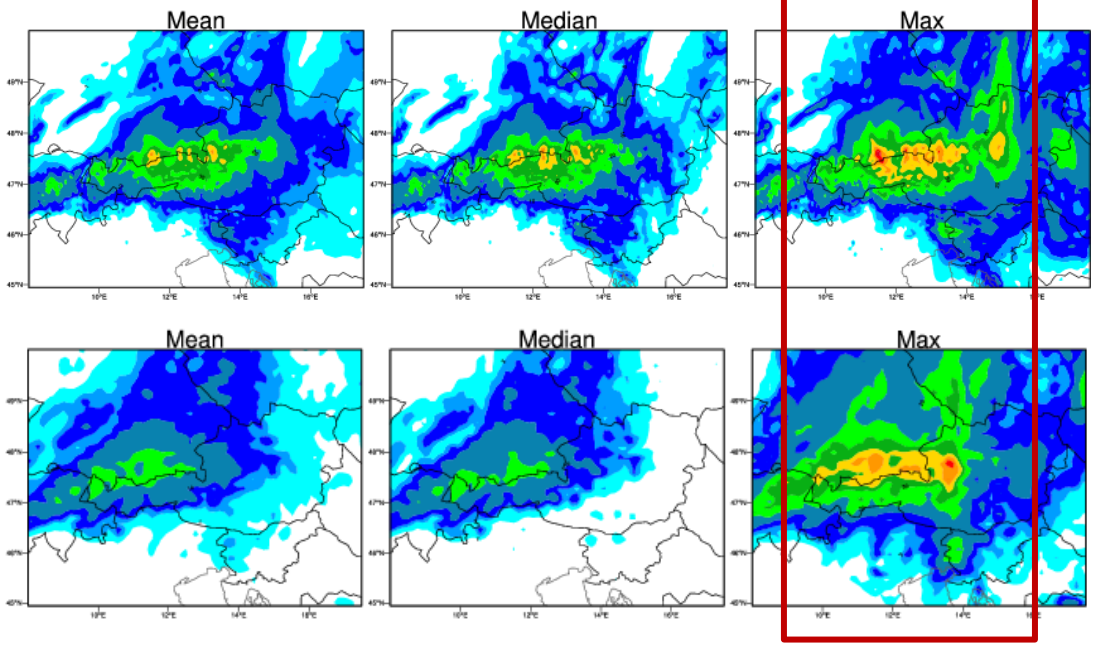
Both ensembles captured very well the extreme precipitation already 36 hours in advance. Spatial maximum of the ensembles corresponds the best to the reality.

INCA analysis



ALARO-LAGGED

ALADIN-LAEF

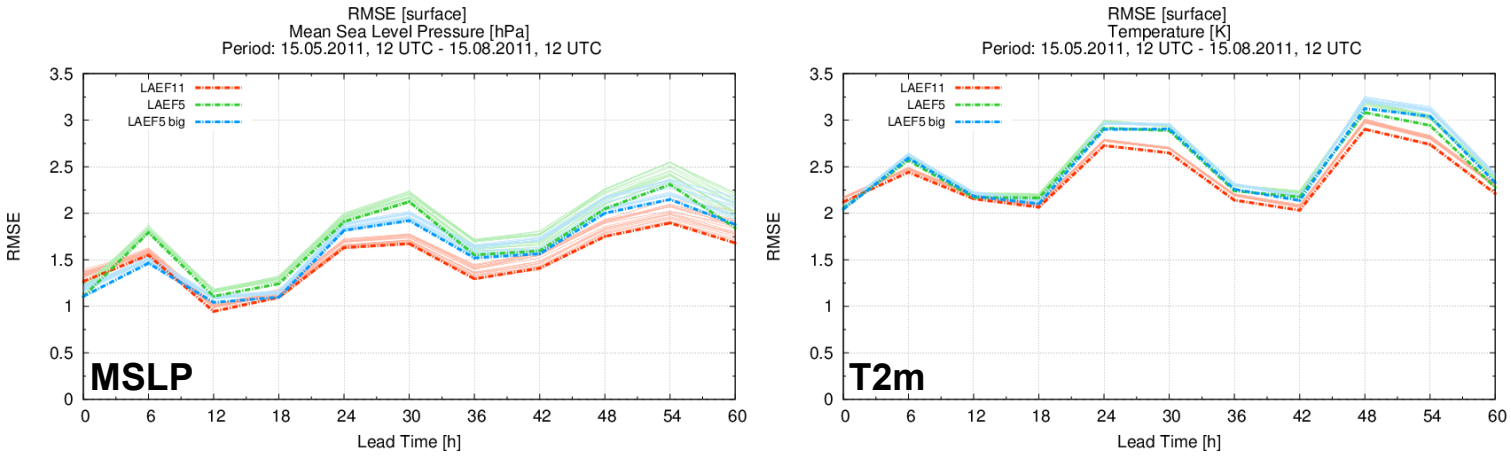


***6h cumulated precipitation**: 01.06.2013, 18 UTC – 02.06.2013, 00 UTC (+36h forecast)*

Research & Development

- **The first experiments with ALADIN-LAEF on 5km:**

For 3-months verification period (dataset 2011) a pure dynamical downscaling of ALADIN-LAEF forecast was carried out. The ALADIN-LAEF forecast on 11km grid was used to couple the same system, but on 5km grid.



***RMSE** for the ensemble mean and 16 ensemble members of ALADIN-LAEF **11km**, **5km** - small domain and **5km** - big domain*

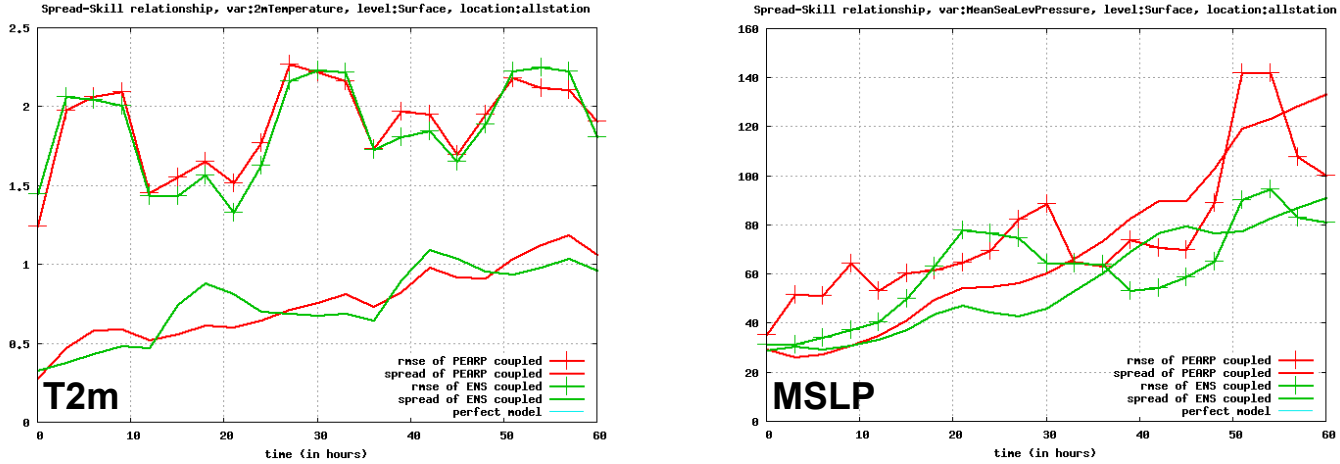
Pure downscaling of such complex system is far from ideal and it can not be used without some special tunings valid at the higher resolution. The quality loss is most probably caused also by the absence of its own uncertainty source in the IC at higher resolution. Thus, instead of native high resolution perturbations, the downscaled version included mostly the noise from the interpolations.

Research & Development

- **New development and the experiments in Hungary (OMSZ):**

At OMSZ they are primarily focusing on their future convection-permitting EPS. However, it was decided to make some final development on the current ALARO-EPS 8km version, which will be in operation till a new machine is available for running high-resolution AROME-EPS. Upper-air SPPT together with EDA was tested.

The results were not satisfactory, DA caused quality degradation on an unperturbed control member. Suspicious was the coupling with PEARP system, having LBCs updated just once a day with only 6-hour coupling frequency. Hence, it was decided to change to ECMWF-EPS boundary conditions and make a better coupling strategy in a DA cycle.



RMSE** and **SPREAD** for ALARO-EPS system coupled to **PEARP** and to **ECMWF-EPS

Research & Development

- **AROME-PEPS experiments in Austria (ZAMG):**

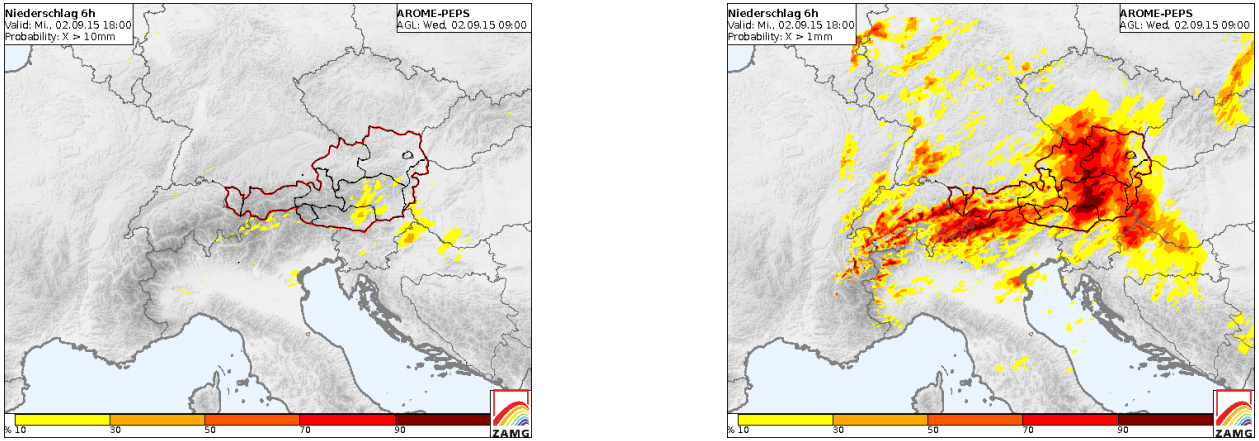
AROME-EPS exists at ZAMG, but due to the limited computing resources it is available just “on demand” in critical weather situations. Therefore, at the moment the experiments with cheap lagged ensemble system AROME-PEPS have been started.

The ensemble system is constructed from the operational deterministic AROME runs, which are available 8-times per day every 3 hours. Because deterministic AROME model is integrated up to +60h, 8 subsequent runs can be used to cover the next 36 hours.

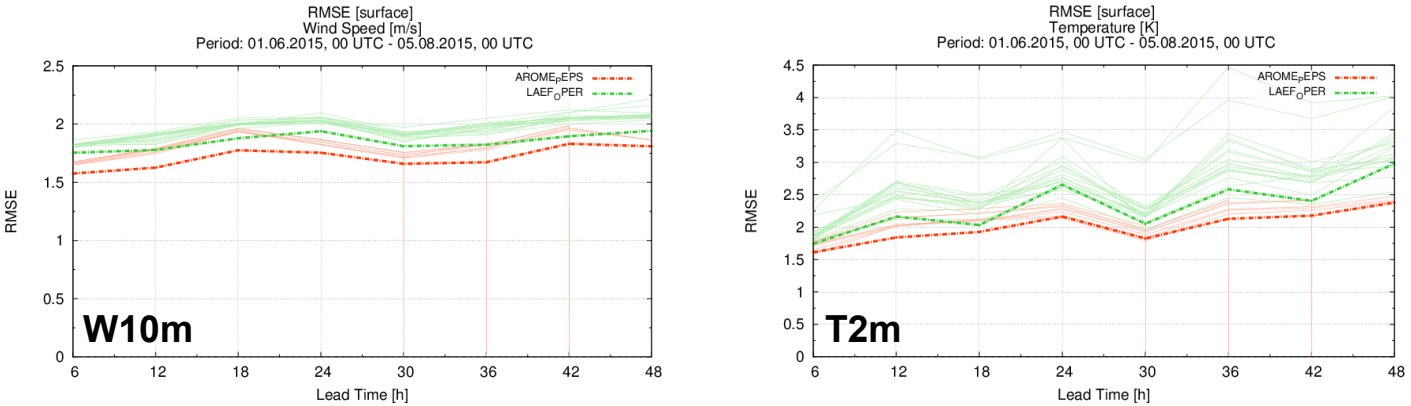
Technical specifications of AROME-PEPS (lagged ensemble):

- **Domain:** 600 x 632 grid points
- **Resolution:** 2.5km and 90 vertical levels
- **Time step:** 60s
- **Members:** 8
- **Forecast:** 00, 03, 06, ...21 UTC runs (8 per day) up to +36h
- **Initialization:** (AROME) 3D-Var + CANARI (3h assimilation cycle)
- **Coupling:** ECMWF (time-lagged) with 3h coupling frequency

Research & Development



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

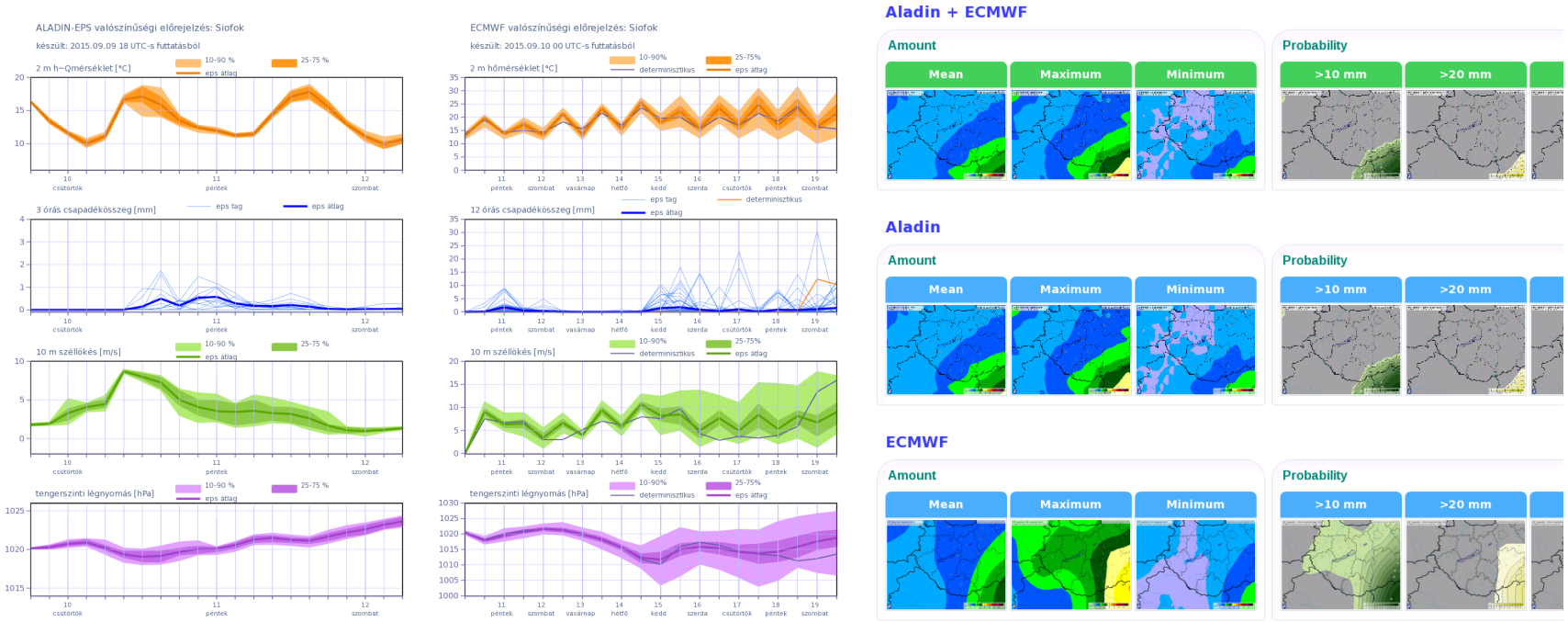


***RMSE** for **AROME-PEPS** and **ALADIN-LAEF** computed over the 2 months summer period in 2015*

Research & Development

- **Seamless ensemble forecasting system - PROFORCE:**

A successful project founded by European Commission called PROFORCE, joining together the effort of Hungarian and Austrian weather services, continued with its main goal to provide a seamless probabilistic forecast chain to help predict severe weather events. Forecasts of different ensembles, from medium-range (ECMWF-EPS) to short-range (ALADIN-LAEF, ALARO-EPS, AROME-EPS, ENS-INCA) are integrated into one prediction chain (integrated from the application point of view, not numerically).



Example of probabilistic plume diagrams and precipitation maps from PROFORCE web site

Research & Development

- **Publishing Activities:**

Submitted papers (currently in review):

- Schellander-Gorgas T., Wang Y., Meier F., Weidle F., Wittmann Ch., Kann A., 2015: "*On the forecast skills of a convection permitting ensemble*", Weather and Forecasting, submitted in June 2015
- Weidle F., Wang Y. and Smet G., 2015: "*On the impact of the coupling global ensemble in a regional ensemble system*", Weather and Forecasting, submitted in August 2015
- Szűcs M., Horanyi A., Szépszó G., 2015: "*Ensemble forecasting in numerical weather prediction*", Mathematical Problems in Meteorological Modelling, Springer

Papers in preparation for the submission:

- Belluš M., Wang Y., Meier F., 2015: "*Perturbing surface initial conditions in a regional ensemble prediction system*", in preparation for Monthly Weather Review
- Taşcu S., Wang Y., Wittmann Ch., Weidle F., 2015: "*Forecast skill of regional ensemble system comparing to the higher resolution deterministic model*", in preparation for Weather and Forecasting

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Plans for 2016

- **Revision of ALADIN-LAEF multi-physics.** The aim is to reduce the amount of different parameterizations to a few maintainable configurations with inclusion of improved ALARO-1 physics and its different tunings. In order to keep the ensemble spread reasonable, new multi-physics should be combined with SPPT.

- **Implementation and testing of the ensemble of 3D-Var assimilations in LADIN-LAEF.** Together with the upper-air spectral blending it will be used for generating the IC perturbations of the atmospheric fields. This would ensure better control analysis and thus less initial bias in the perturbed members.

- **Preparation of ALADIN-LAEF 5km version with 16+1 members** but on a smaller computational domain, with increased coupling frequency (3h, ECMWF-EPS), ALARO-1 package based multi-physics (preferably on cy40t1) supplemented by SPPT and possibly with BlendVar.

- **Introduction of SURFEX in ALADIN-LAEF** and its inter-comparison with ISBA scheme. Application of SURFEX in order to reduce 2m temperature negative BIAS in ALADIN-LAEF.

- **Continue work on SPPT** as a tool for model uncertainty simulation:
  - testing the stochastic physics as a combination of both the ATM and SFC perturbations
  - implementing different weights for perturbing individual variables

- **Parallel experiments with lagged convection-permitting EPS** formed by several deterministic AROME runs. Evaluate this “cheap” solution to the current (but yet not operationally feasible) AROME-EPS.

Thank you for your attention!