Regional Cooperation for
Limited Area Modeling in Central Europe

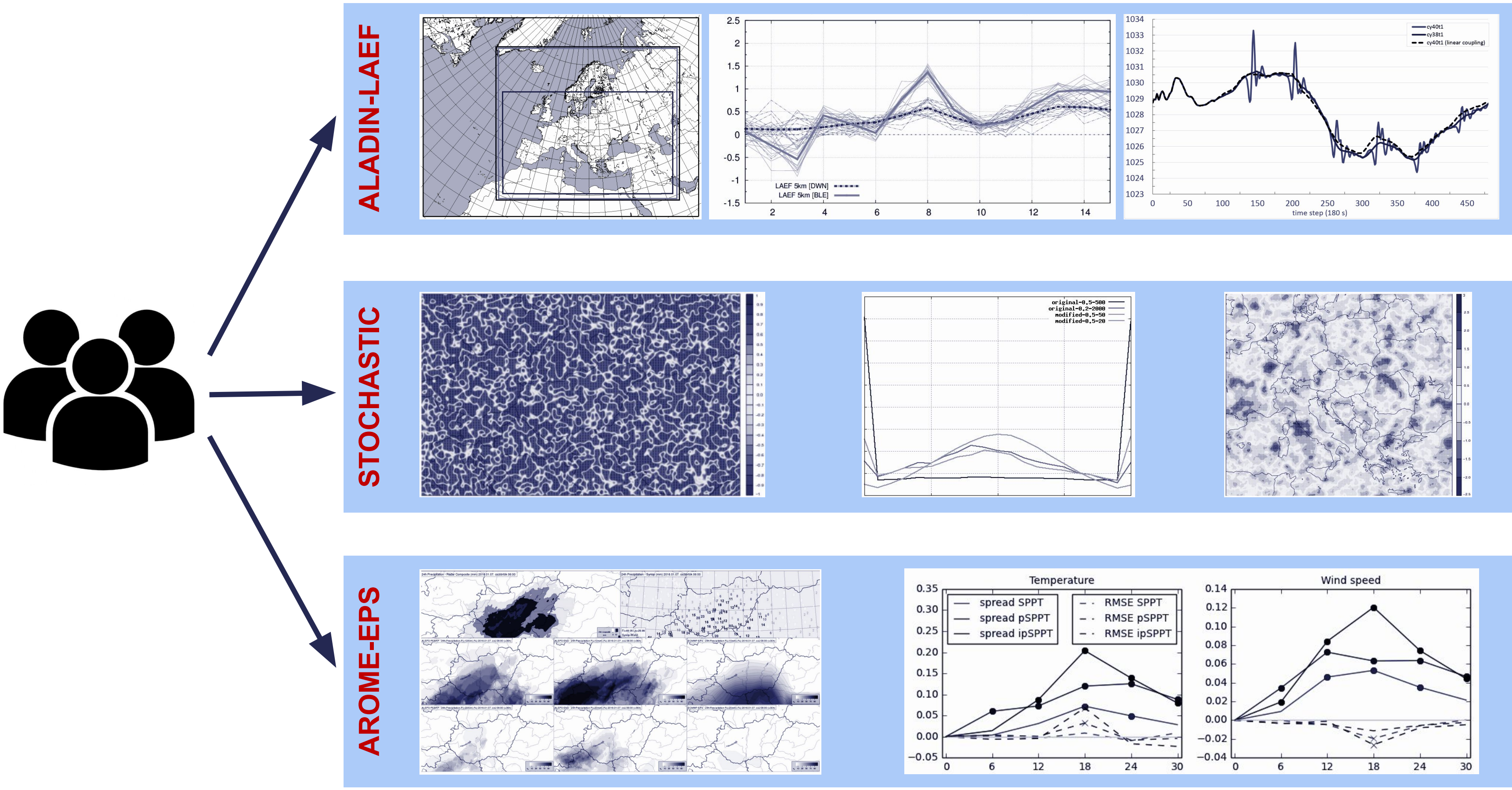
LACE
nwp central europe

LAM-EPS activities in LACE

Martin Belluš with contributions of A. Trojáková, M. Szűcs, Ch. Wittmann, F. Weidle, Y. Wang, C. Wastl, S. Taşcu, J. Cedilnik and E. Keresturi

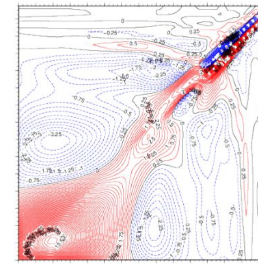
DHMZ SHMU ARSO METEO Slovenia OMSZ ZAMG ROMANIA ANM

Overview of activities since last AHW



Our research has been mostly focused on the ALADIN-LAEF system upgrade towards the higher resolution LAM EPS, defining new computational domain and implementing new methods for IC uncertainty simulation (ENS BlendVar) and model uncertainty simulation (new multiphysics, new stochastic pattern). Local work on AROME-EPS continued.

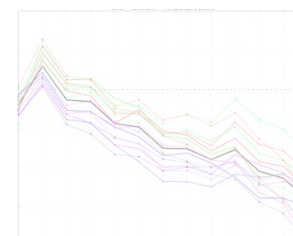
ALADIN-LAEF



Research tasks:

- IC perturbations by 3DVAR in ALADIN-LAEF
  - breeding-blending upgraded to EDA (ENS BlendVar)
  - background error statistics (B-matrix) by ensemble approach for 1 month period

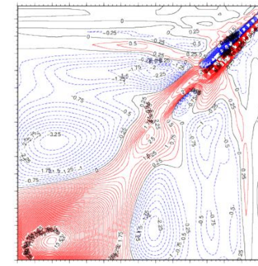
- New high resolution ALADIN-LAEF on CY40T1 with ALARO-1 physics
  - new domain 4.8 km, 60 levels, 1250 x 750 points
  - change of quadratic to linear grid (NMSMAX=624, NSMAX=374)
  - blending truncation recomputed (NMSMAX=72, NSMAX=43)
  - ALADIN-LAEF upgraded to CY40T1 (bf6)



- Optimization of ALADIN-LAEF at 5 km horizontal resolution
  - reduced number of namelists for multiphysics (4-5 instead of 16)
  - sensitivity experiments based on ALARO-1 using just a few namelist changes
  - target on convection, microphysics and turbulence
  - ALARO-1 vs. ALARO-0 difference used for impact judgement

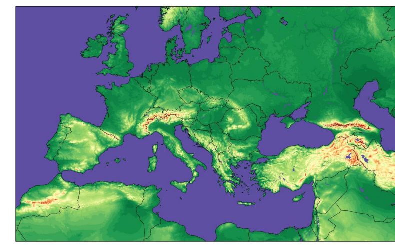
- Spectral blending on high resolution issue
  - LBCs: interpolation from 91 vertical levels instead of 45
  - implementation of incremental digital filter initialization (IDFI)
  - discovery of spurious oscillations (turned to be QCPL bug in CY40T1)

ALADIN-LAEF

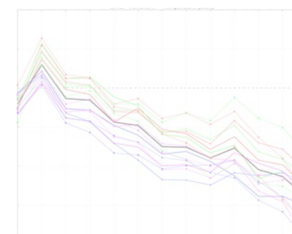


Research tasks:

- IC perturbations by 3DVAR in ALADIN-LAEF
  - breeding-blending upgraded to EDA (ENS BlendVar)
  - background error statistics (B-matrix) by ensemble approach for 1 month period



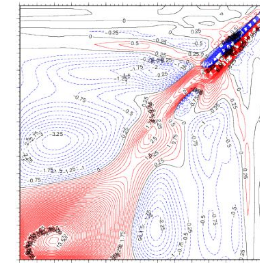
- New high resolution ALADIN-LAEF on CY40T1 with ALARO-1 physics
  - new domain 4.8 km, 60 levels, 1250 x 750 points
  - change of quadratic to linear grid (NMSMAX=624, NSMAX=374)
  - blending truncation recomputed (NMSMAX=72, NSMAX=43)
  - ALADIN-LAEF upgraded to CY40T1 (bf6)



- Optimization of ALADIN-LAEF at 5 km horizontal resolution
  - reduced number of namelists for multiphysics (4-5 instead of 16)
  - sensitivity experiments based on ALARO-1 using just a few namelist changes
  - target on convection, microphysics and turbulence
  - ALARO-1 vs. ALARO-0 difference used for impact judgement

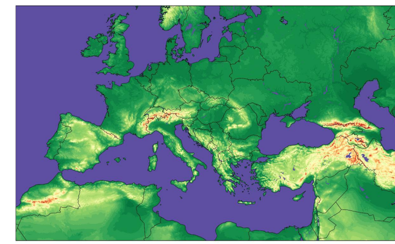
- Spectral blending on high resolution issue
  - LBCs: interpolation from 91 vertical levels instead of 45
  - implementation of incremental digital filter initialization (IDFI)
  - discovery of spurious oscillations (turned to be QCPL bug in CY40T1)

ALADIN-LAEF

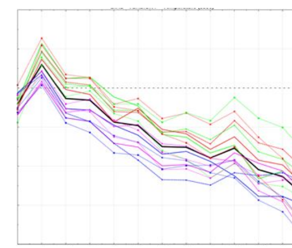


Research tasks:

- IC perturbations by 3DVAR in ALADIN-LAEF
  - breeding-blending upgraded to EDA (ENS BlendVar)
  - background error statistics (B-matrix) by ensemble approach for 1 month period



- New high resolution ALADIN-LAEF on CY40T1 with ALARO-1 physics
  - new domain 4.8 km, 60 levels, 1250 x 750 points
  - change of quadratic to linear grid (NMSMAX=624, NSMAX=374)
  - blending truncation recomputed (NMSMAX=72, NSMAX=43)
  - ALADIN-LAEF upgraded to CY40T1 (bf6)

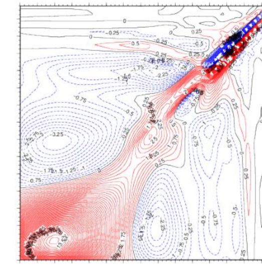


- Optimization of ALADIN-LAEF at 5 km horizontal resolution
  - reduced number of namelists for multiphysics (4-5 instead of 16)
  - sensitivity experiments based on ALARO-1 using just a few namelist changes
  - target on convection, microphysics and turbulence
  - ALARO-1 vs. ALARO-0 difference used for impact judgement

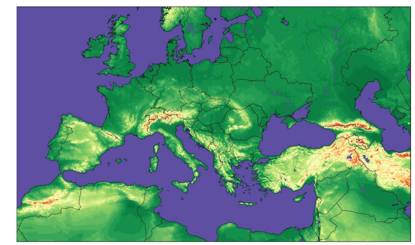
- Spectral blending on high resolution issue
  - LBCs: interpolation from 91 vertical levels instead of 45
  - implementation of incremental digital filter initialization (IDFI)
  - discovery of spurious oscillations (turned to be QCPL bug in CY40T1)

ALADIN-LAEF

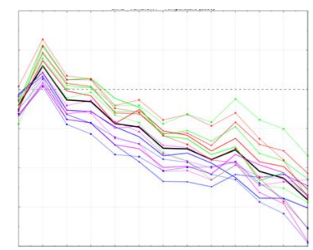
Research tasks:



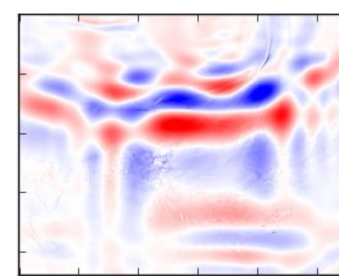
- IC perturbations by 3DVAR in ALADIN-LAEF
  - breeding-blending upgraded to EDA (ENS BlendVar)
  - background error statistics (B-matrix) by ensemble approach for 1 month period



- New high resolution ALADIN-LAEF on CY40T1 with ALARO-1 physics
  - new domain 4.8 km, 60 levels, 1250 x 750 points
  - change of quadratic to linear grid (NMSMAX=624, NSMAX=374)
  - blending truncation recomputed (NMSMAX=72, NSMAX=43)
  - ALADIN-LAEF upgraded to CY40T1 (bf6)



- Optimization of ALADIN-LAEF at 5 km horizontal resolution
  - reduced number of namelists for multiphysics (4-5 instead of 16)
  - sensitivity experiments based on ALARO-1 using just a few namelist changes
  - target on convection, microphysics and turbulence
  - ALARO-1 vs. ALARO-0 difference used for impact judgement



- Spectral blending on high resolution issue
  - LBCs: interpolation from 91 vertical levels instead of 45
  - implementation of incremental digital filter initialization (IDFI)
  - discovery of spurious oscillations (turned to be QCPL bug in CY40T1)

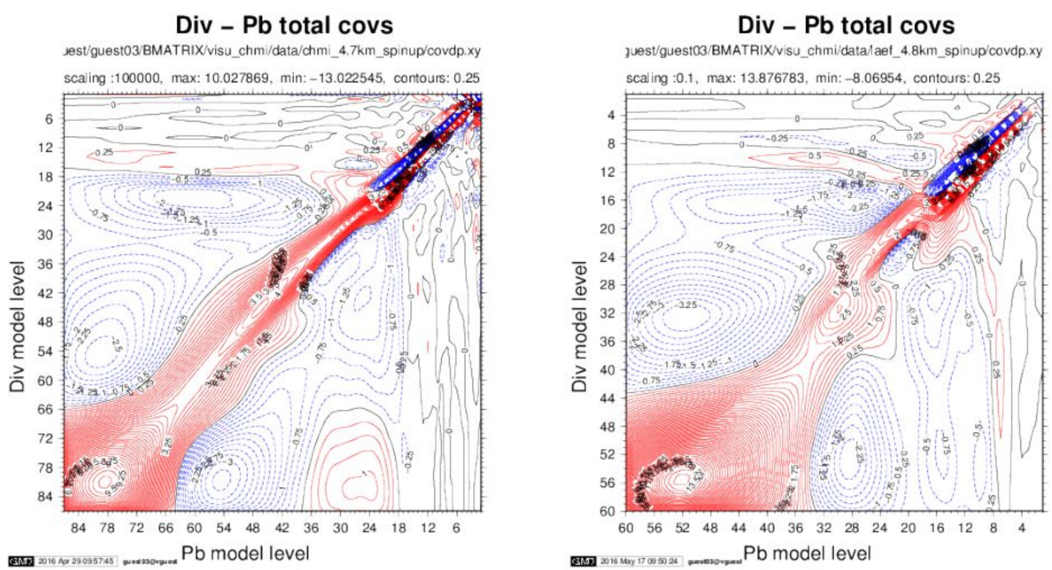
ALADIN-LAEF (ENS BlendVar)

IC perturbations by 3DVAR in ALADIN-LAEF:

The operational ALADIN-LAEF system uses spectral breeding-blending technique for the upper-air IC perturbations. The idea is to upgrade it by the ensemble of upper-air data assimilation (EDA) using 3DVar technique to capture the IC uncertainty.

Background error statistics (B-matrix):

- computation validated at ECMWF for CY40T1
- ensemble approach for 1 month period
- B-matrix sampled by 256 ALADIN-LAEF 12h forecast differences (16 members)
- diagnostics checked against ALADIN/CHMI



Mean vertical cross-covariance between divergence and vorticity-balanced for ALADIN/CHMI (left) and ALADIN-LAEF 5 km (right).

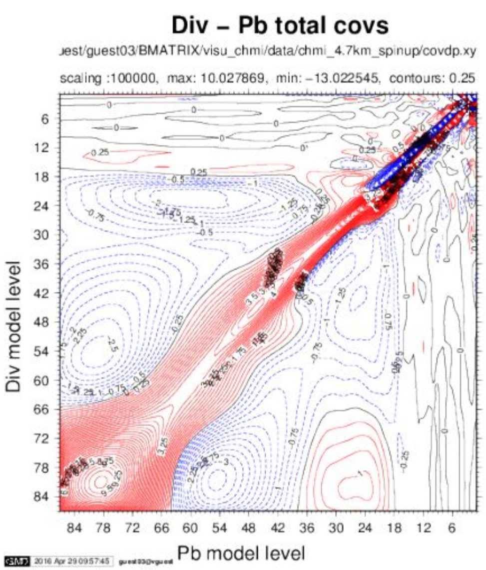
ALADIN-LAEF (ENS BlendVar)

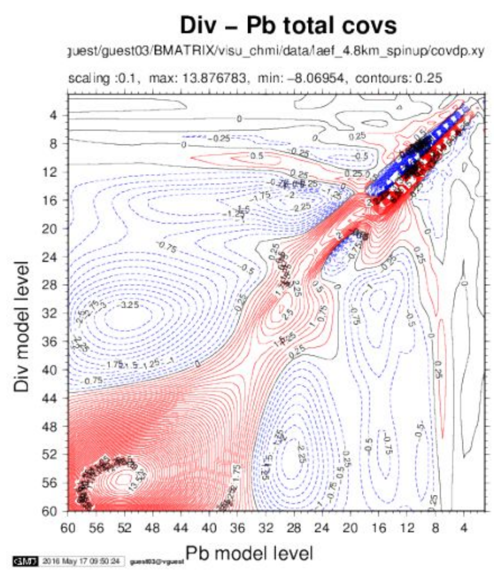
IC perturbations by 3DVAR in ALADIN-LAEF:

The operational ALADIN-LAEF system uses spectral breeding-blending technique for the upper-air IC perturbations. The idea is to upgrade it by the ensemble of upper-air data assimilation (EDA) using 3DVar technique to capture the IC uncertainty.

Background error statistics (B-matrix):

- computation validated at ECMWF for CY40T1
- ensemble approach for 1 month period
- B-matrix sampled by 256 ALADIN-LAEF 12h forecast differences (16 members)
- diagnostics checked against ALADIN/CHMI





Looks promising, but further development was postponed due to problems in blending.

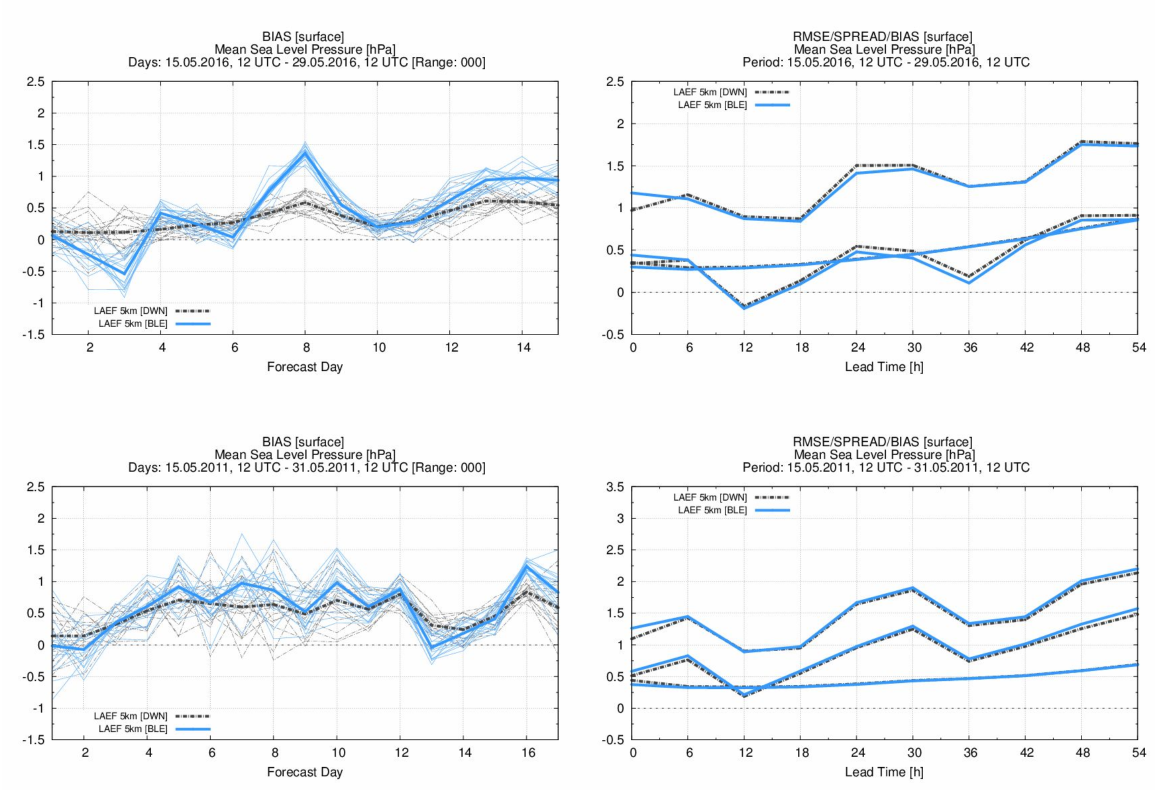
Mean vertical cross-covariance between divergence and vorticity-balanced for ALADIN/CHMI (left) and ALADIN-LAEF 5 km (right).

ALADIN-LAEF (blending issue?)

Vertical levels undersampling:

2016 (91 lev)

2011 (45 lev)

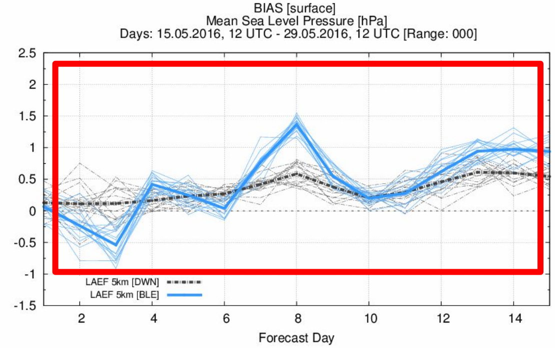


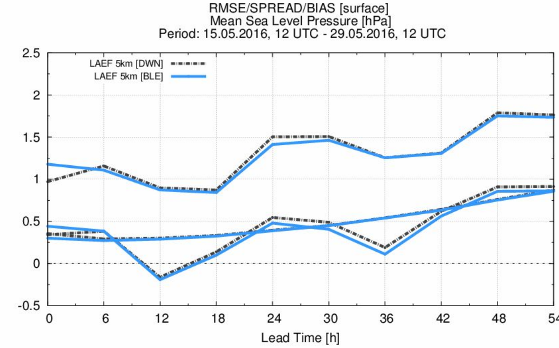
The comparison of MSLP errors when LBCs were interpolated from 91 vertical levels (case 2016, first row) and from 45 vertical levels (case 2011, second row). There is BIAS for initial time along all the experiment days (left) and RMSE, SPREAD, BIAS for the forecast ranges (right). Blue line represents the blending cycle, while the gray dashed line is just the dynamical adaptation for the reference.

ALADIN-LAEF (blending issue?)

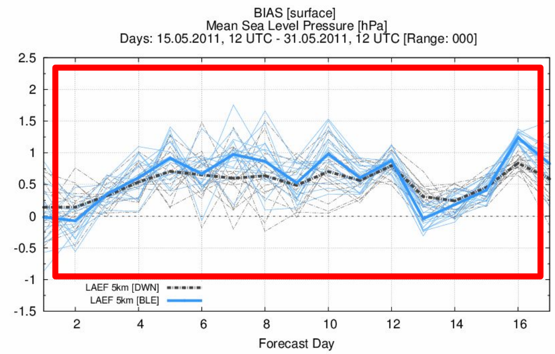
Vertical levels undersampling:

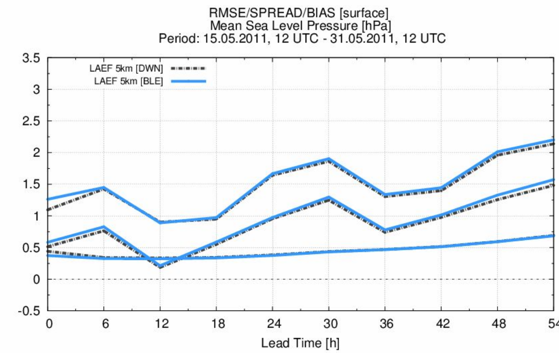
2016 (91 lev)





2011 (45 lev)





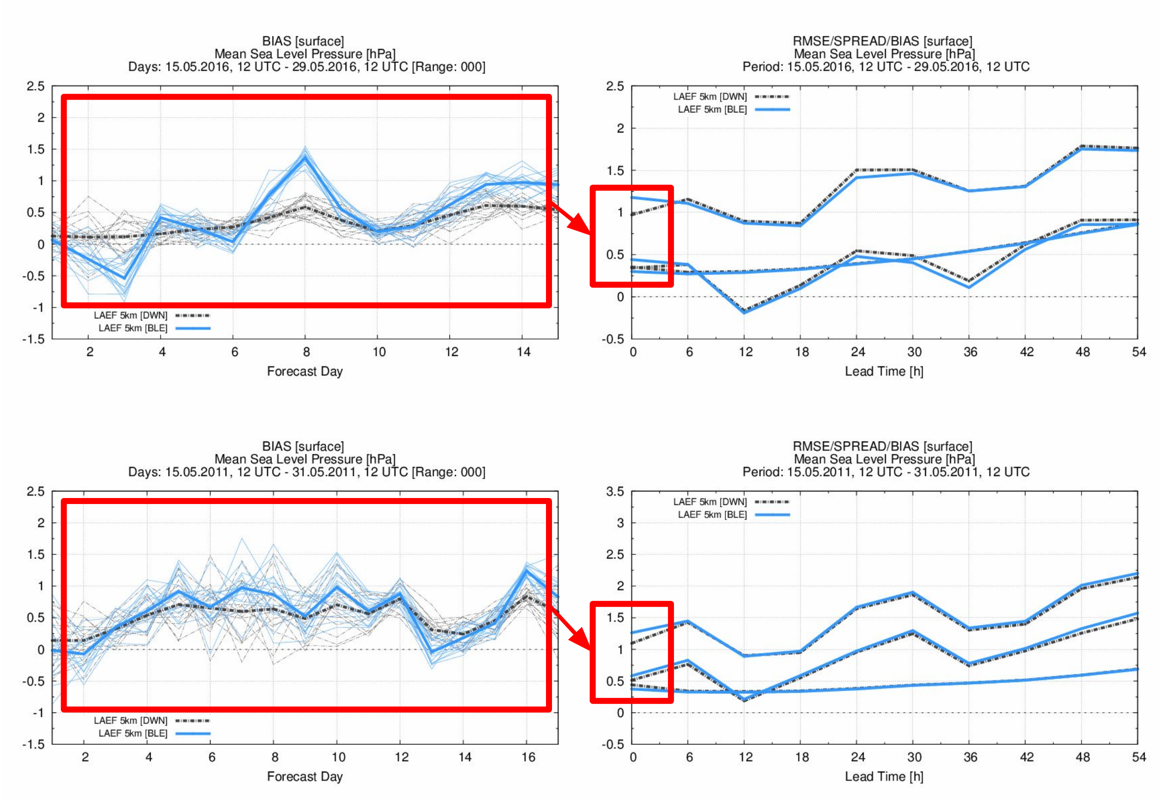
The comparison of MSLP errors when LBCs were interpolated from 91 vertical levels (case 2016, first row) and from 45 vertical levels (case 2011, second row). There is BIAS for initial time along all the experiment days (left) and RMSE, SPREAD, BIAS for the forecast ranges (right). Blue line represents the blending cycle, while the gray dashed line is just the dynamical adaptation for the reference.

ALADIN-LAEF (blending issue?)

Vertical levels undersampling:

2016 (91 lev)

2011 (45 lev)



The comparison of MSLP errors when LBCs were interpolated from 91 vertical levels (case 2016, first row) and from 45 vertical levels (case 2011, second row). There is BIAS for initial time along all the experiment days (left) and RMSE, SPREAD, BIAS for the forecast ranges (right). Blue line represents the blending cycle, while the gray dashed line is just the dynamical adaptation for the reference.

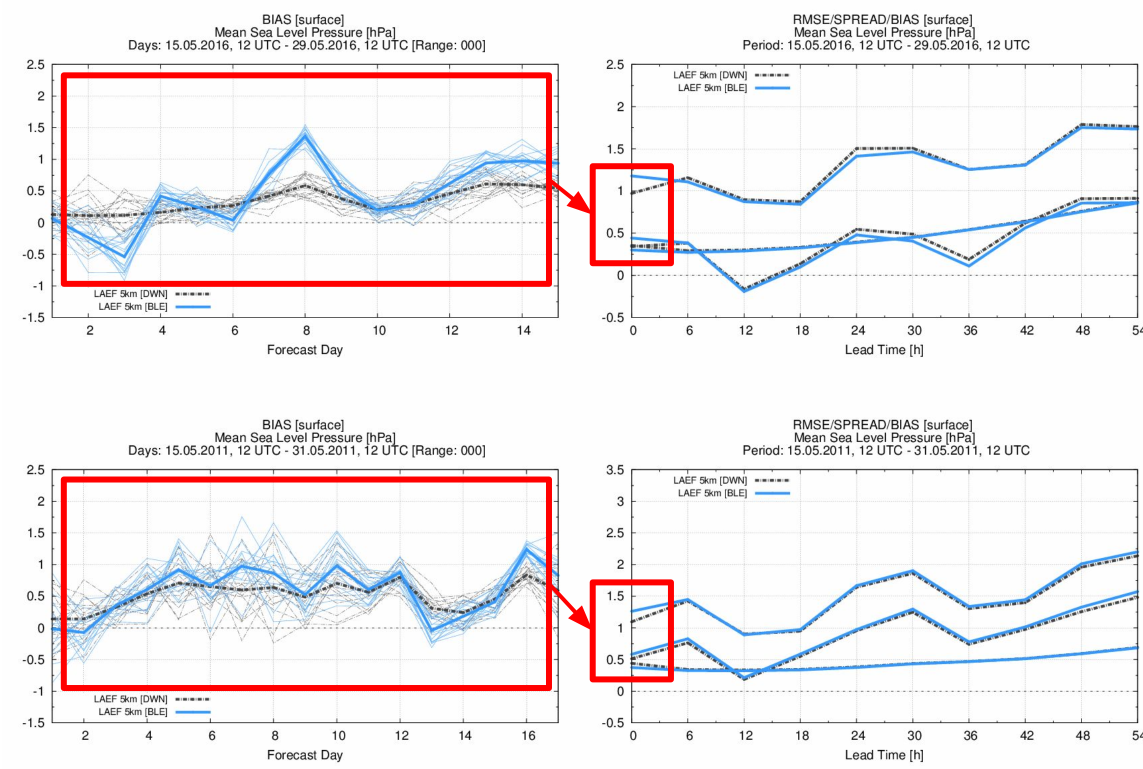
ALADIN-LAEF (blending issue?)

Vertical levels undersampling:

2016 (91 lev)

2011 (45 lev)

The errors are equal regardless of vertical resolution of the driving model.



The comparison of MSLP errors when LBCs were interpolated from 91 vertical levels (case 2016, first row) and from 45 vertical levels (case 2011, second row). There is BIAS for initial time along all the experiment days (left) and RMSE, SPREAD, BIAS for the forecast ranges (right). Blue line represents the blending cycle, while the gray dashed line is just the dynamical adaptation for the reference.

ALADIN-LAEF (blending issue?)

Incremental digital filter initialization (IDFI):

The general idea of incremental digital filter initialization is rather easy. We need to filter out the high frequency noise from the INIT file, while the high resolution information from the guess has to stay intact.

$$A' = G + I \;\; \text{...where} \;\; I = (A - G)$$

$$\overline{A'} = G + \overline{(A - G)}$$

$$\overline{A'} = G - \overline{G} + \overline{A}$$

ALADIN-LAEF (blending issue?)

Incremental digital filter initialization (IDFI):

The general idea of incremental digital filter initialization is rather easy. We need to filter out the high frequency noise from the INIT file, while the high resolution information from the guess has to stay intact.

$$A' = G + I \ \ldots where \ I = (A - G)$$

$$\overline{A'} = G + \overline{(A - G)}$$

$$\overline{A'} = \boxed{G - \overline{G}} + \overline{A}$$

...two additional steps in ALADIN-LAEF blending procedure:

```
print "\n[9] IDFI step BIAS (guess - filtered_guess):\n";
$start = time();
&idfi($ald_org, "null", "BIAS", $idfi_bias);
&spent($start);

print "\n[10] IDFI step INCR (filtered_blend_b + idfi_bias):\n";
$start = time();
&idfi($blend_b, $idfi_bias, "INCR", $idfi_incr);
&spent($start);
```

ALADIN-LAEF (blending issue?)

Incremental digital filter initialization (IDFI):

The general idea of incremental digital filter initialization is rather easy. We need to filter out the high frequency noise from the INIT file, while the high resolution information from the guess has to stay intact.

$$A' = G + I \text{ ...where } I = (A - G)$$

$$\overline{A'} = G + \overline{(A - G)}$$

$$\overline{A'} = G - \overline{G} + \overline{A}$$

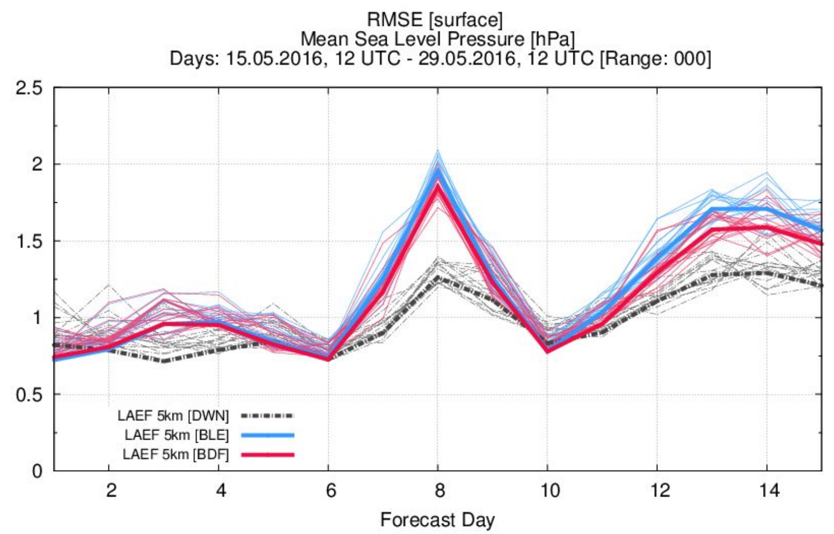
...two additional steps in ALADIN-LAEF blending procedure:

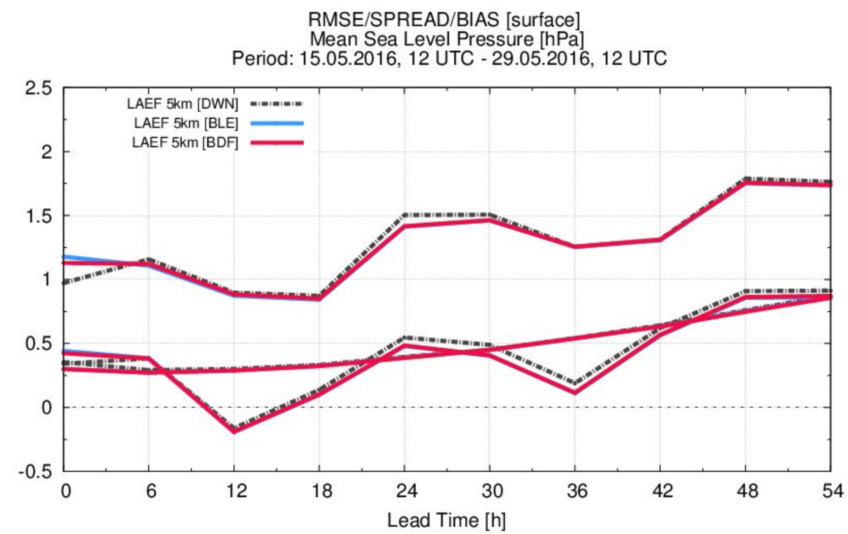
```
print "\n[9] IDFI step BIAS (guess - filtered_guess):\n";
$start = time();
&idfi($ald_org, "null", "BIAS", $idfi_bias);
&spent($start);

print "\n[10] IDFI step INCR (filtered_blend_b + idfi_bias):\n";
$start = time();
&idfi($blend_b, $idfi_bias, "INCR", $idfi_incr);
&spent($start);
```

ALADIN-LAEF (blending issue?)

Incremental digital filter initialization (IDFI):



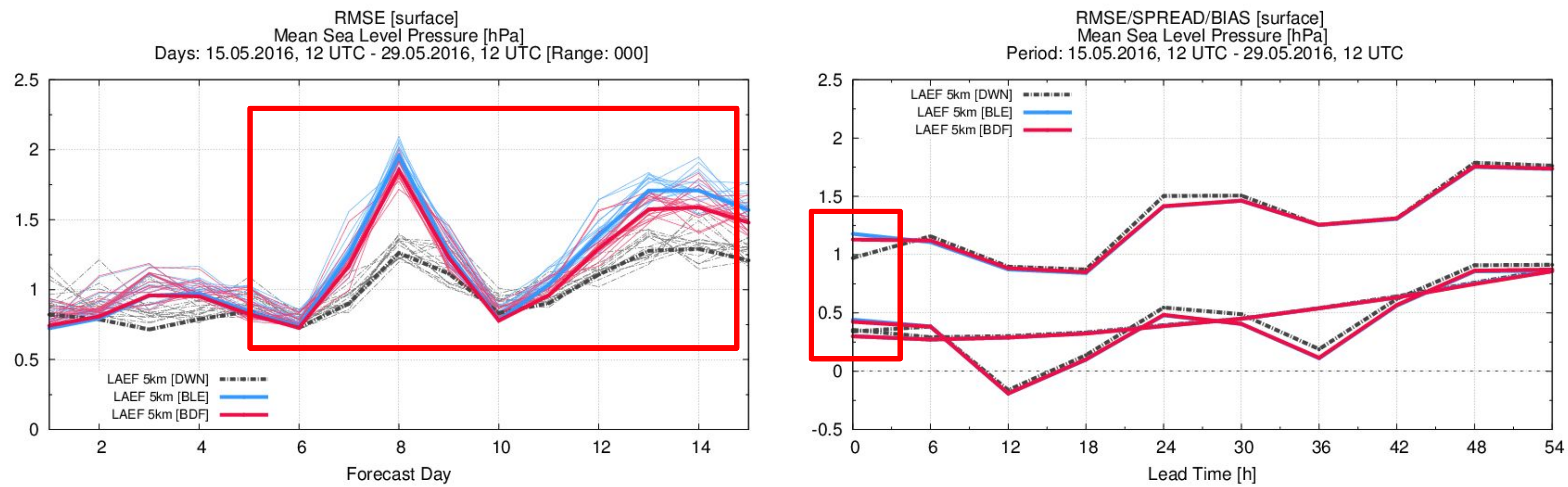


The evaluation of MSLP errors after the application of IDFI for 15-days verification period. The errors at the initial time for each experiment day (left) and for the forecast ranges (right). Blue line is the original blending, while red line is blending enhanced by IDFI functionality. Gray dashed line is just the dynamical adaptation for the reference.

ALADIN-LAEF (blending issue?)

Incremental digital filter initialization (IDFI):

The impact of IDFI can be observed only for the very first hours of integration at best where the errors are slightly reduced.



The evaluation of MSLP errors after the application of IDFI for 15-days verification period. The errors at the initial time for each experiment day (left) and for the forecast ranges (right). Blue line is the original blending, while red line is blending enhanced by IDFI functionality. Gray dashed line is just the dynamical adaptation for the reference.

ALADIN-LAEF (blending issue?)

Spurious oscillations:

The initial errors were not eliminated by:

- coupling with the higher resolution driving model
- incremental digital filter initialization
- several other things we tested (CLIM files, ALARO-1 tuning, etc.)

ALADIN-LAEF (blending issue?)

Spurious oscillations:

The initial errors were not eliminated by:

- coupling with the higher resolution driving model
- incremental digital filter initialization
- several other things we tested (CLIM files, ALARO-1 tuning, etc.)

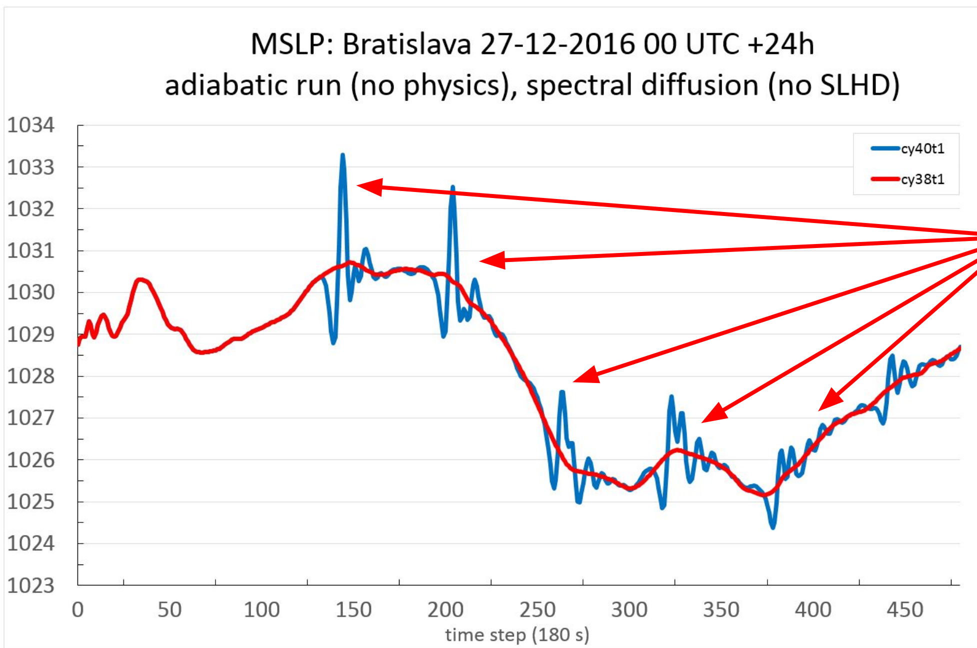
What could be the reason ?

ALADIN-LAEF (blending issue? - no, bug in CY40T1)

Spurious oscillations:

The initial errors were not eliminated by:

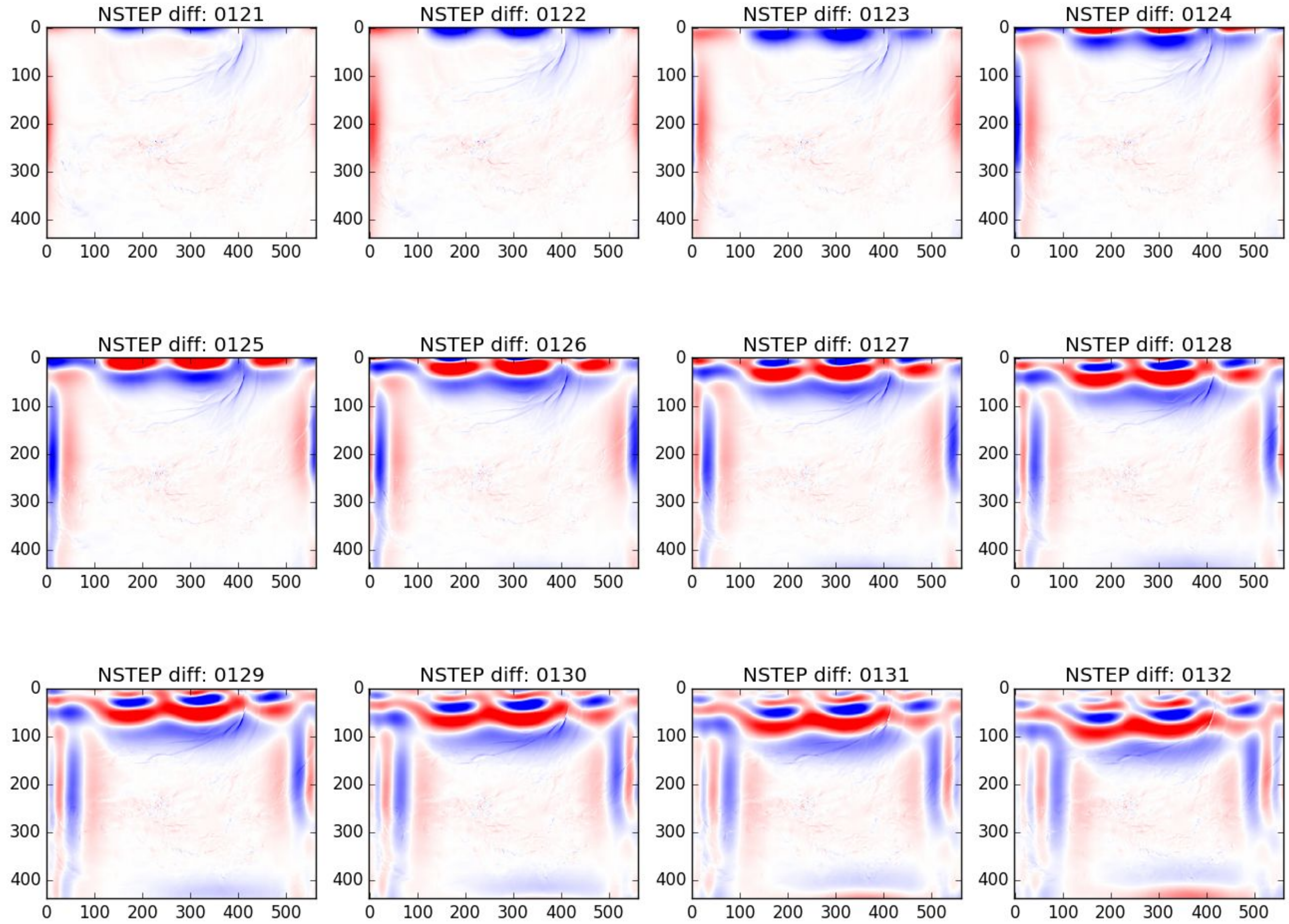
- coupling with the higher resolution driving model
- incremental digital filter initialization
- several other things we tested (CLIM files, ALARO-1 tuning, etc.)



Big pressure oscillations repeated every N hours due to the bug in QCLP in CY40T1 and above!

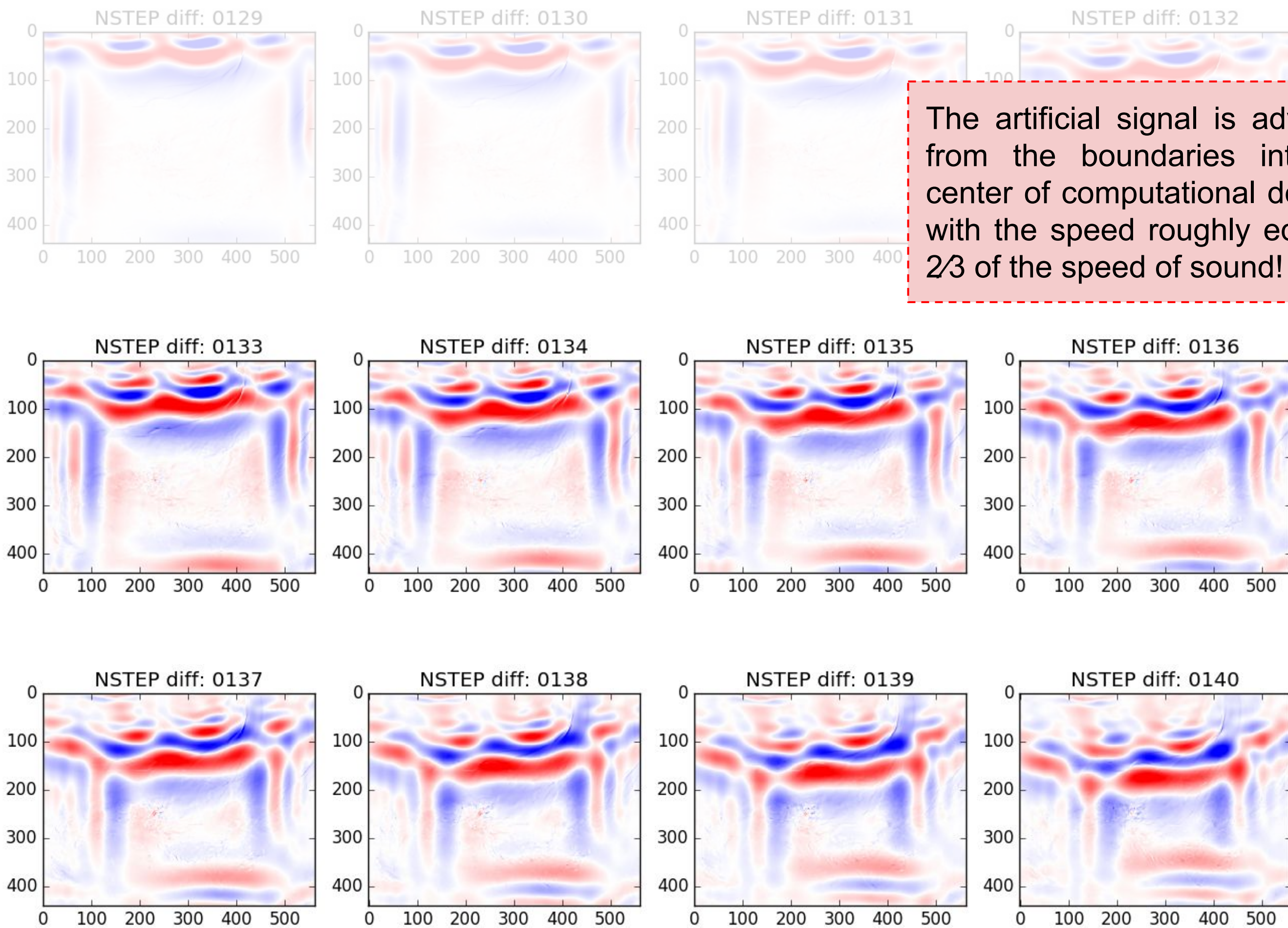
The inter-step oscillations of MSLP for one selected case at Bratislava airport up to 24 hours (TSTEP = 180 s, TEFRCL = 3 h), blue line is CY40T1, red line is CY38T1.

ALADIN-LAEF (blending issue? - no, bug in CY40T1)



The MSLP differences between the consecutive time-steps for the adiabatic run on CY40T1 with the quadratic coupling (20 steps between 6th and 7th integration hour).

ALADIN-LAEF (blending issue? - no, bug in CY40T1)

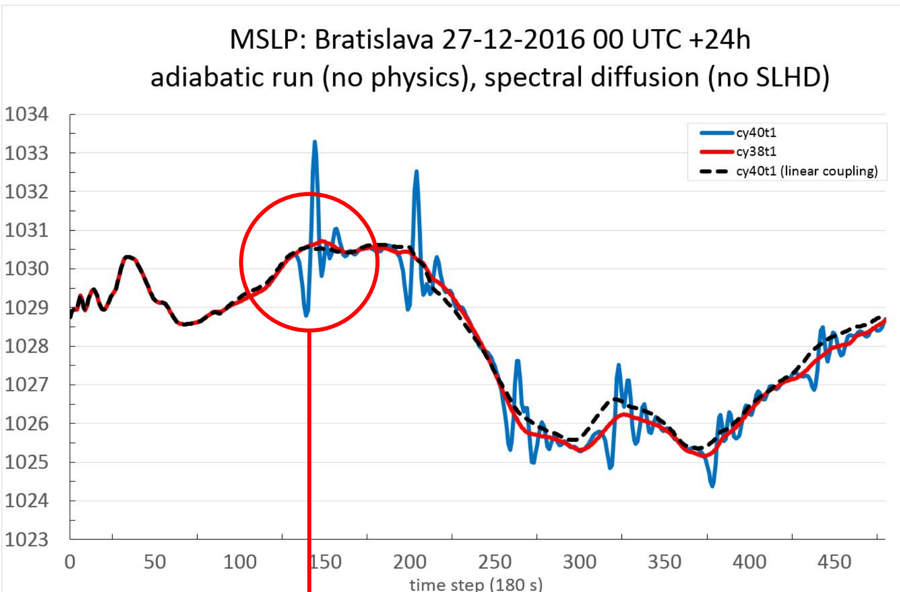


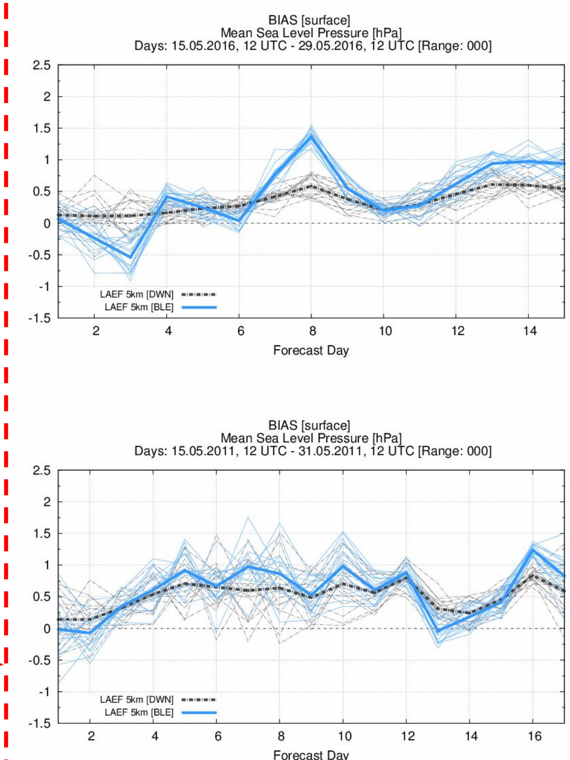
The artificial signal is advected from the boundaries into the center of computational domain, with the speed roughly equal to 2⁄3 of the speed of sound!

The MSLP differences between the consecutive time-steps for the adiabatic run on CY40T1 with the quadratic coupling (20 steps between 6th and 7th integration hour).

ALADIN-LAEF (blending issue? - no, bug in CY40T1)

How QCPL bug in CY40T1 affected the ALADIN-LAEF blending cycle:

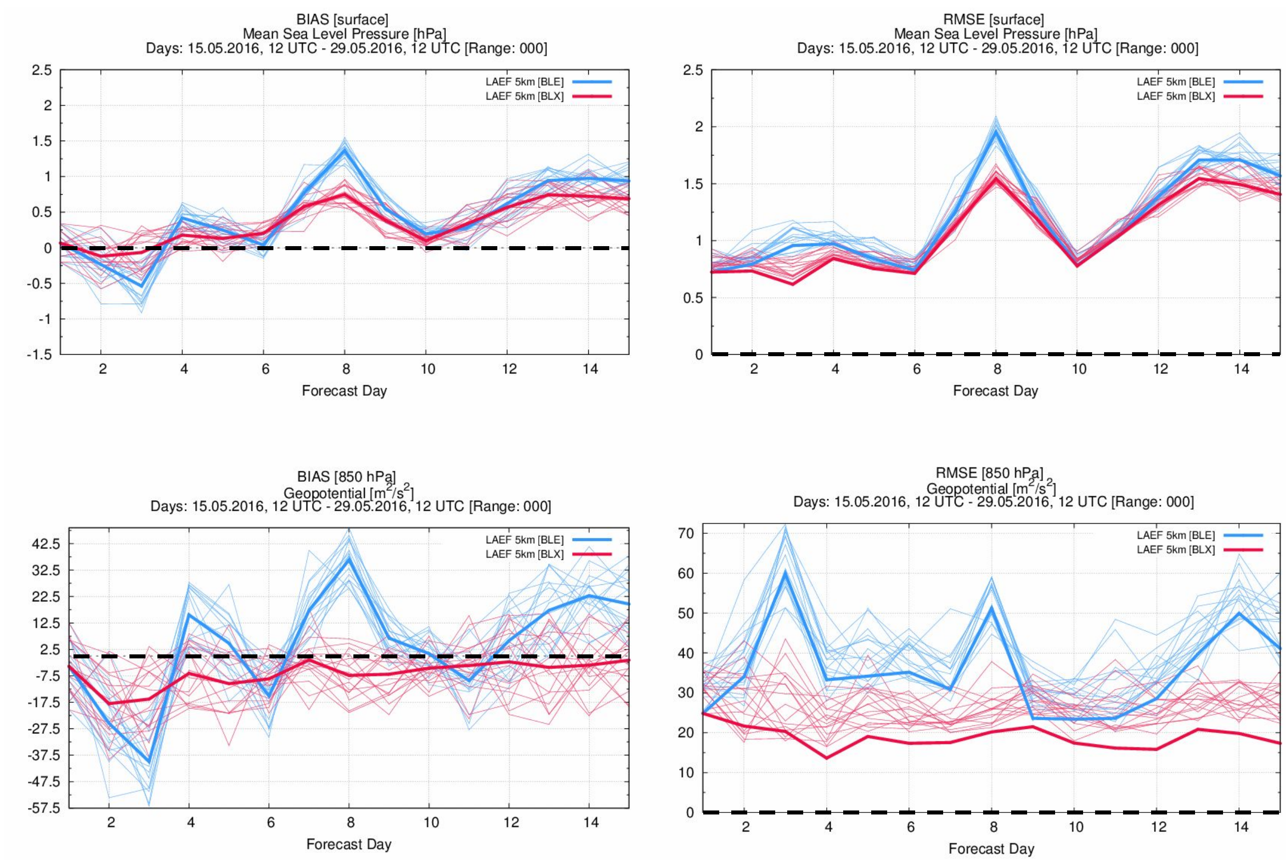




The first guess for blending!

ALADIN-LAEF (problem solved)

The scores after fixing QCPL bug in CY40T1:

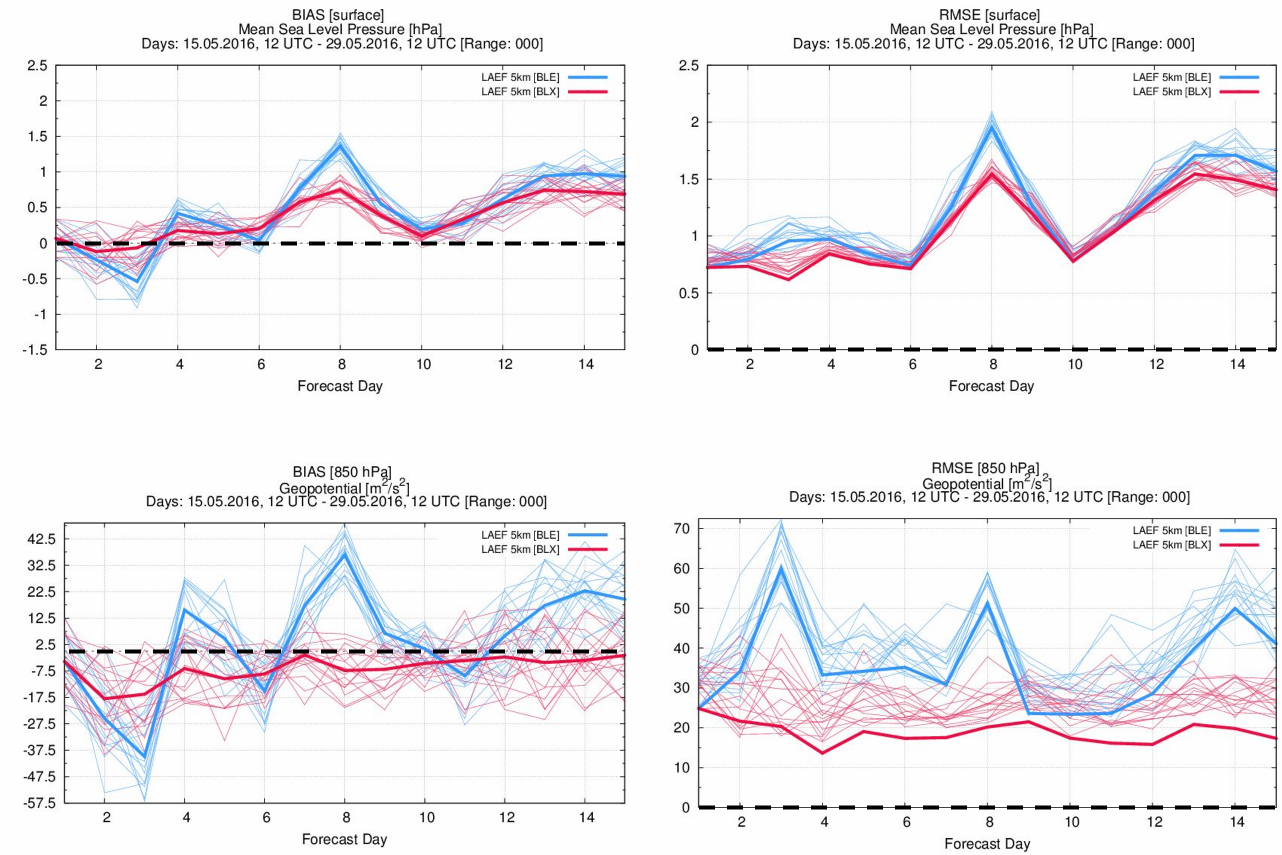


BIAS (left) and RMSE (right) for the initial time along all the experiment days for MSLP (top) and geopotential at 850 hPa (bottom). Blue line represents the blending cycle with bugged QCPL, while the red line is the same after the correction.

ALADIN-LAEF (problem solved)

Big reduction of the initial errors especially for the upper air, but evident for the surface as well.

The scores after fixing QCPL bug in CY40T1:



BIAS (left) and RMSE (right) for the initial time along all the experiment days for MSLP (top) and geopotential at 850 hPa (bottom). Blue line represents the blending cycle with bugged QCPL, while the red line is the same after the correction.

ALADIN-LAEF (new multi physics)

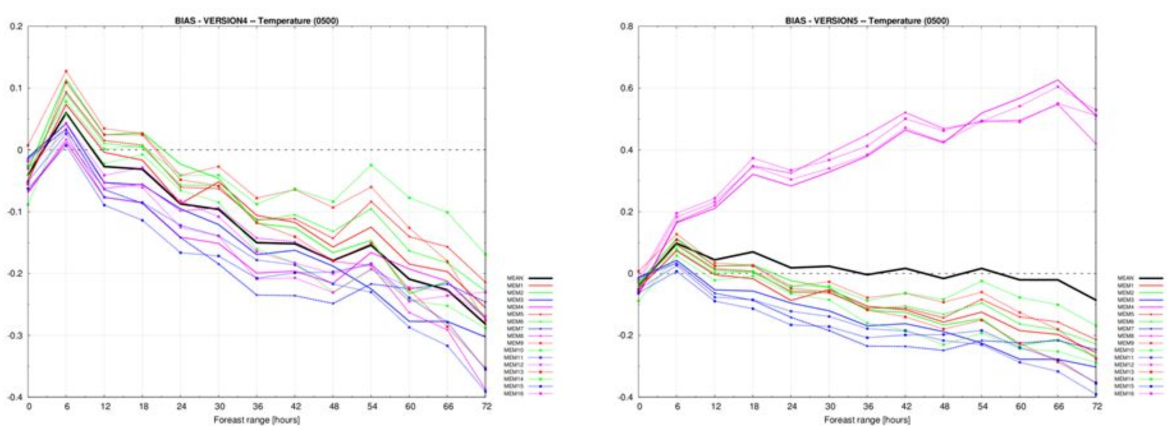
Optimization of ALADIN-LAEF at 5 km horizontal resolution:

VERSION 4					VERSION 5				
	used for members					used for members			
EXP57	01	05	09	13	EXP57	01	05	09	13
EXP01	02	06	10	14	EXP01	02	06	10	14
EXP55	03	07	11	15	EXP55	03	07	11	15
EXP58	04	08	12	16	EXP00	04	08	12	16

16 EPS members

The construction of multiphysics versions 4 (left) and 5 (right).

- EXP57 – ALARO-1 modified turbulence
- EXP01 – ALARO-1 reference
- EXP55 – ALARO-1 modified microphysics + deep convection
- EXP58 – ALARO-1 modified turbulence, microphysics and deep convection
- EXP00 – ALARO-0 reference



Temperature BIAS at 500 hPa for the ensemble version 4 (left) and version 5 (right).

ALADIN-LAEF (new multi physics)

Optimization of ALADIN-LAEF at 5 km horizontal resolution:

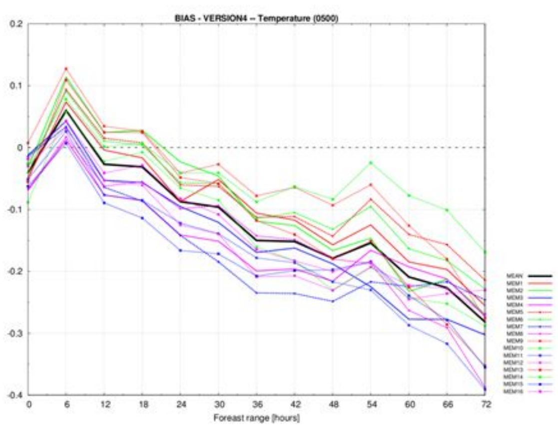
VERSION 4					VERSION 5				
	used for members					used for members			
EXP57	01	05	09	13	EXP57	01	05	09	13
EXP01	02	06	10	14	EXP01	02	06	10	14
EXP55	03	07	11	15	EXP55	03	07	11	15
EXP58	04	08	12	16	EXP00	04	08	12	16

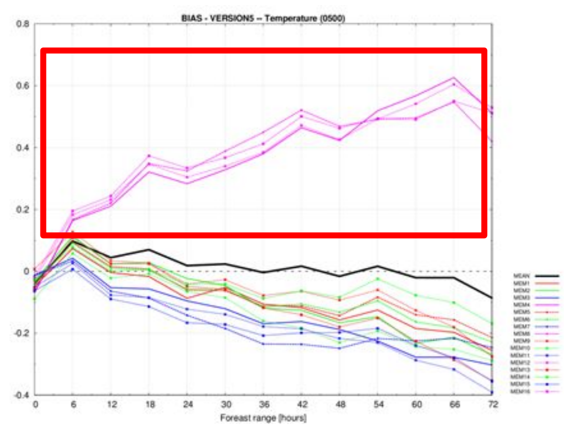
16 EPS members

The construction of multiphysics versions 4 (left) and 5 (right).

- EXP57 – ALARO-1 modified turbulence
- EXP01 – ALARO-1 reference
- EXP55 – ALARO-1 modified microphysics + deep convection
- EXP58 – ALARO-1 modified turbulence, microphysics and deep convection
- EXP00 – ALARO-0 reference

ALARO-0 physics will be excluded due to discrepant behaviour.

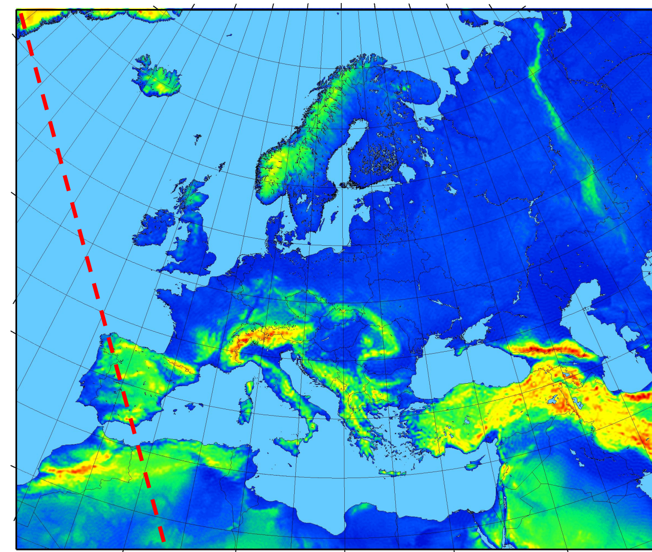


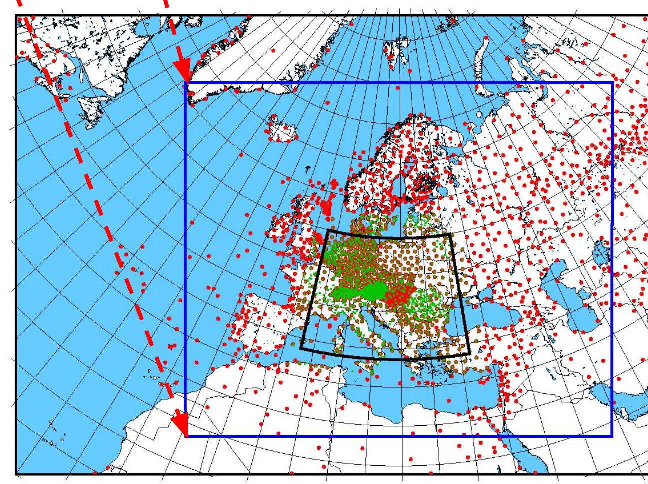


Temperature BIAS at 500 hPa for the ensemble version 4 (left) and version 5 (right).

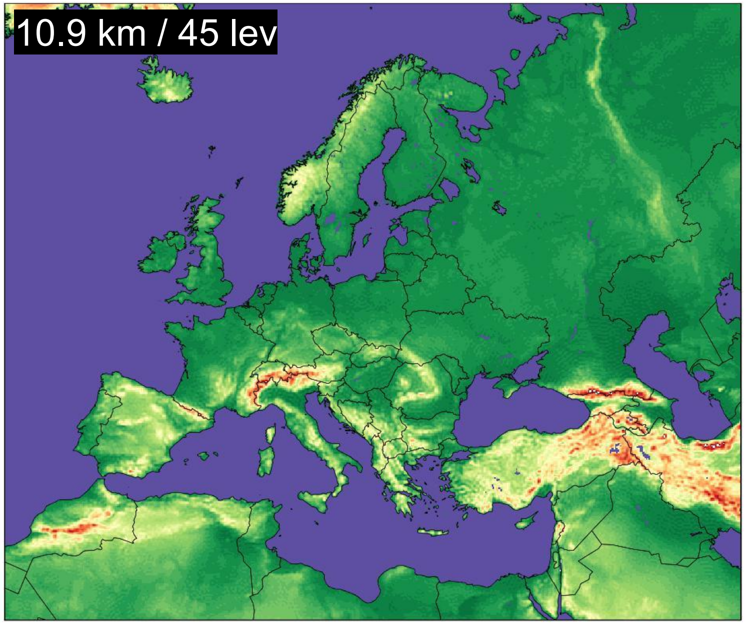
ALADIN-LAEF (operational - no change yet)

ALADIN-LAEF (running at ECMWF)	
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 (T_{2m}, H_{2m}) upper-air: ● breeding-blending
model perturbation	multi-physics: ● micro-physics ● deep/shallow convection ● radiation ● turbulence

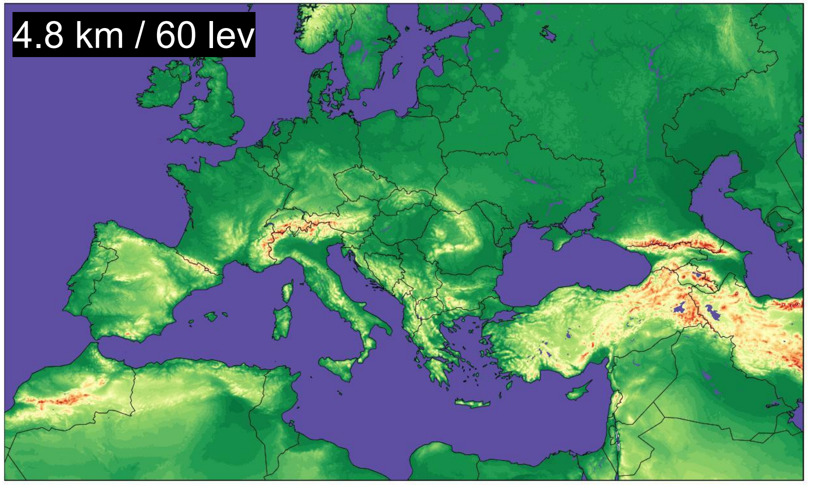




ALADIN-LAEF (upgrade)



→

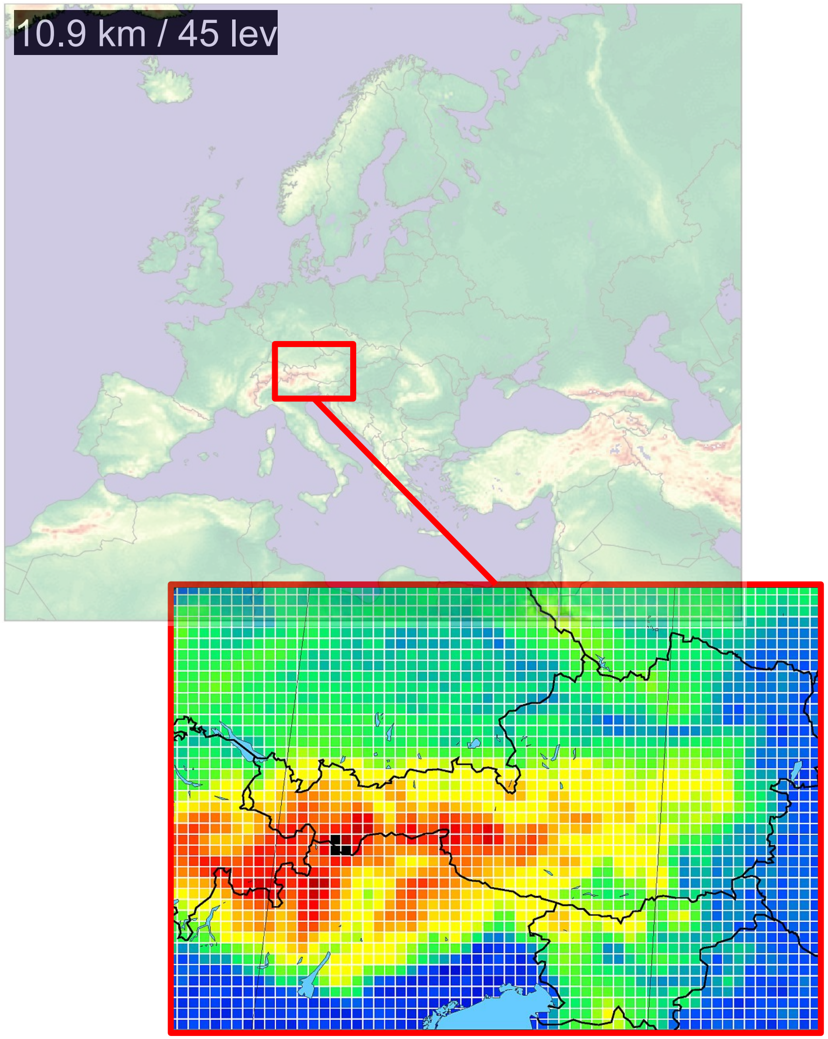


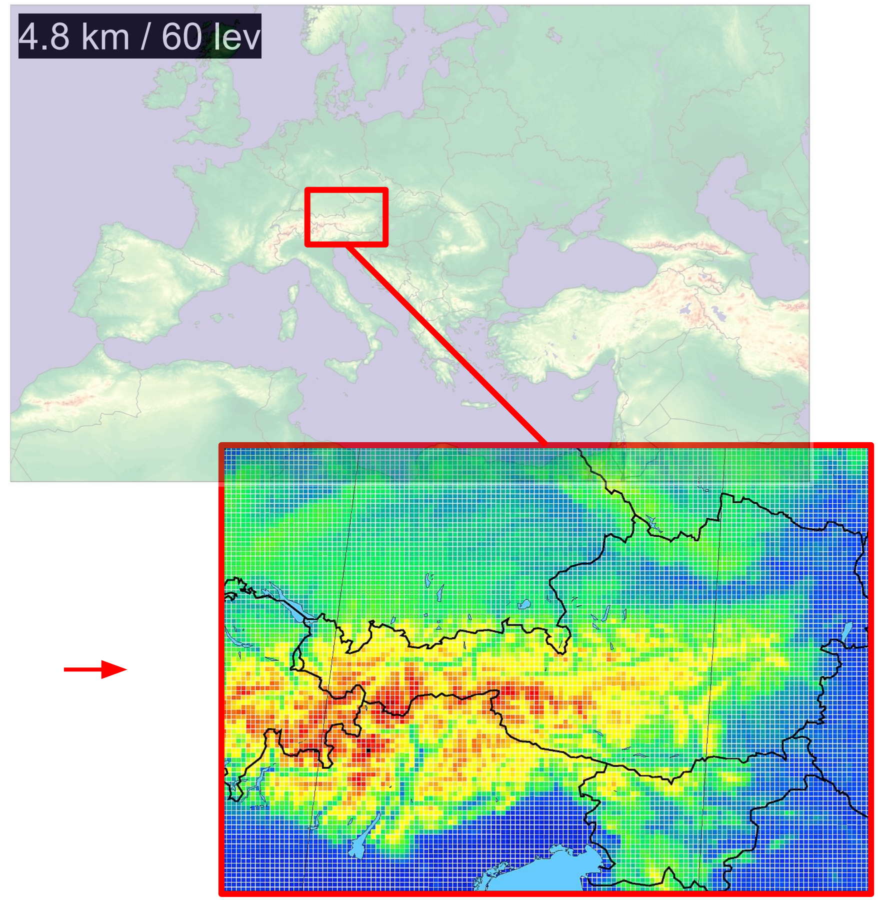
Upgrade in two steps:

ALADIN-LAEF 5 km / 60 lev
@CY40T1

- phase I: ESDA+BB (IC); SPPT+ALARO-1 MP (model)
- phase II: ENS BlendVar (instead of BB)

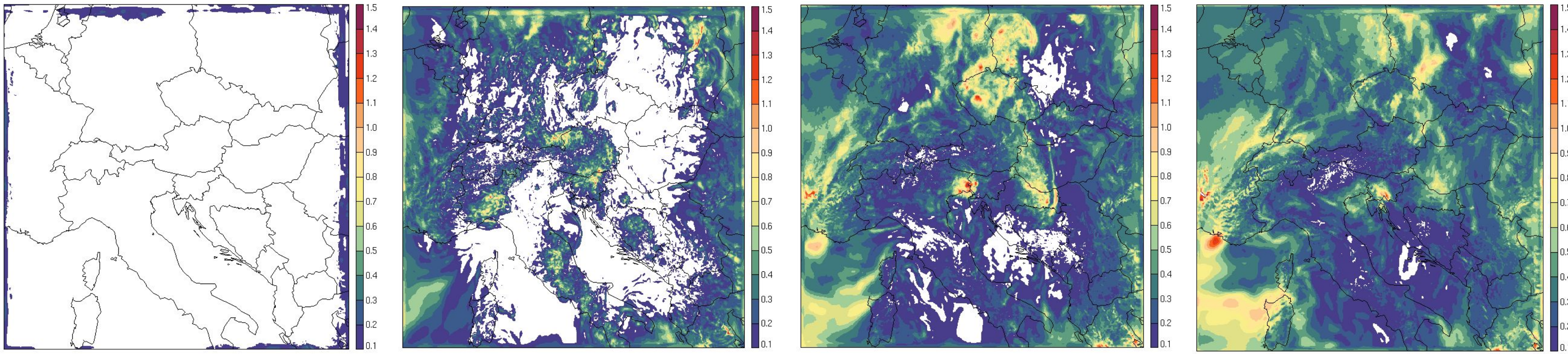
ALADIN-LAEF (upgrade)



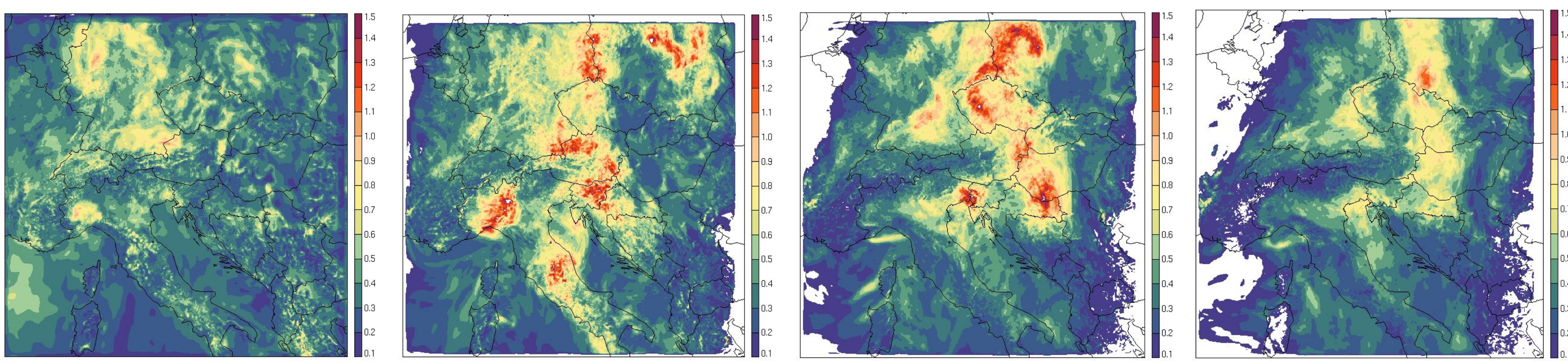


Ensemble spread evolution experiment

Unperturbed ICs vs perturbed LBCs:



Perturbed ICs vs unperturbed LBCs:



Temperature spread at 850 hPa for forecast length of 1, 6, 12 and 18 hours.

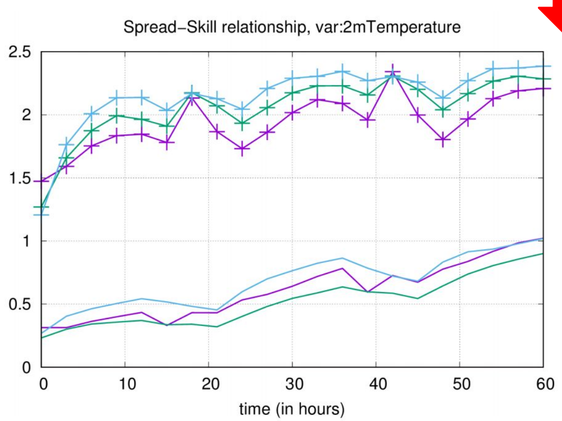
AROME-EPS (OMSZ)

Developments at OMSZ related to ensemble systems:

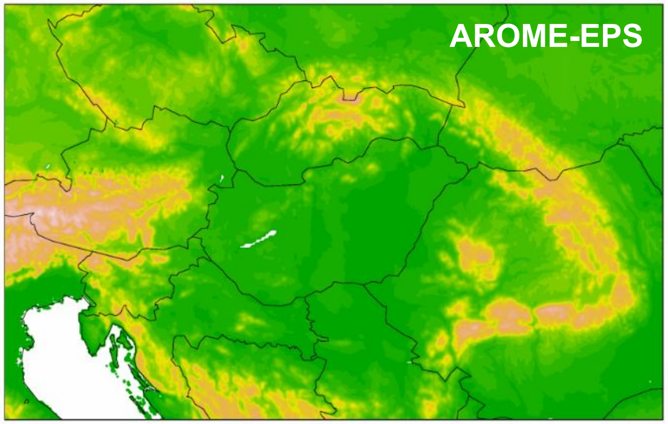
Ensembles running by OMSZ:

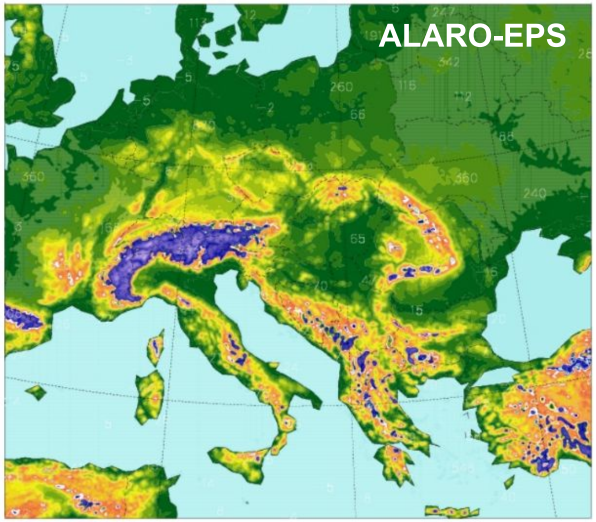
- AROME-EPS
  - test version
  - running at ECMWF on cca ('SPFRBOUT' special project)
  - 11 members starting at 18 UTC +36 h
  - coupled to PEARP (Meteo-France)

- ALARO-EPS (8 km)
  - operational version
  - running at OMSZ
  - 11 members starting at 18 UTC +60 h
  - coupled to PEARP (ECMWF EPS since October 2016)



Spread-skill relationship of T2m. ECMWF EPS with 11 members (purple), ALARO-EPS coupled to ECMWF (green), ALARO-EPS coupled to PEARP (blue). Verification period: 11 Dec, 2015 - 31 Jan, 2016.

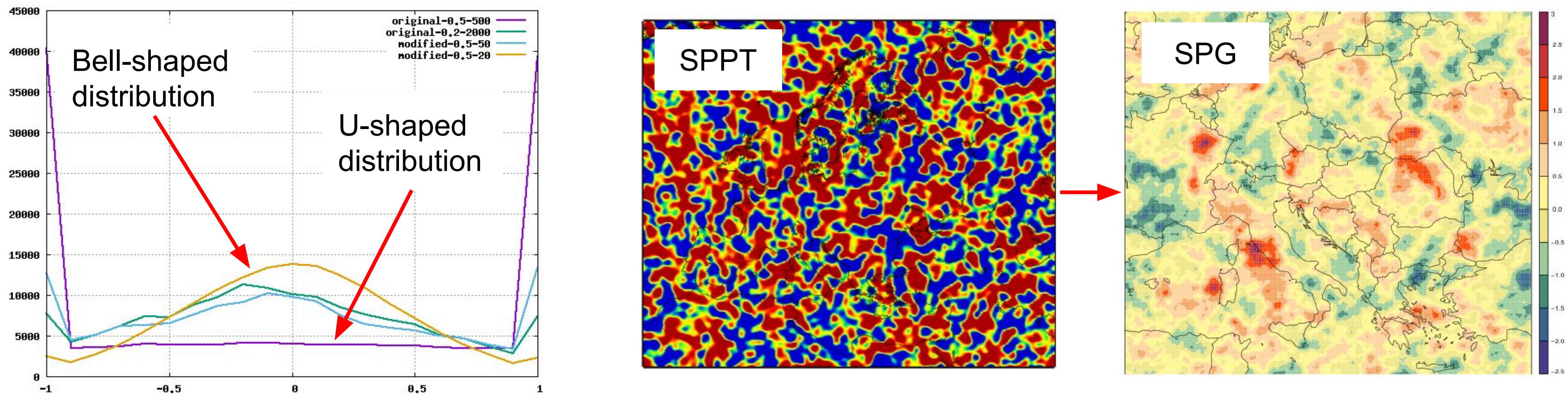




AROME-EPS (OMSZ)

Stochastic perturbation:

- modification of current SPPT (in order to have better horizontal correlation and Gaussian distribution)
- implementation of new stochastic pattern generator (SPG, Tsyrulnikov and Gayfulin, 2016)

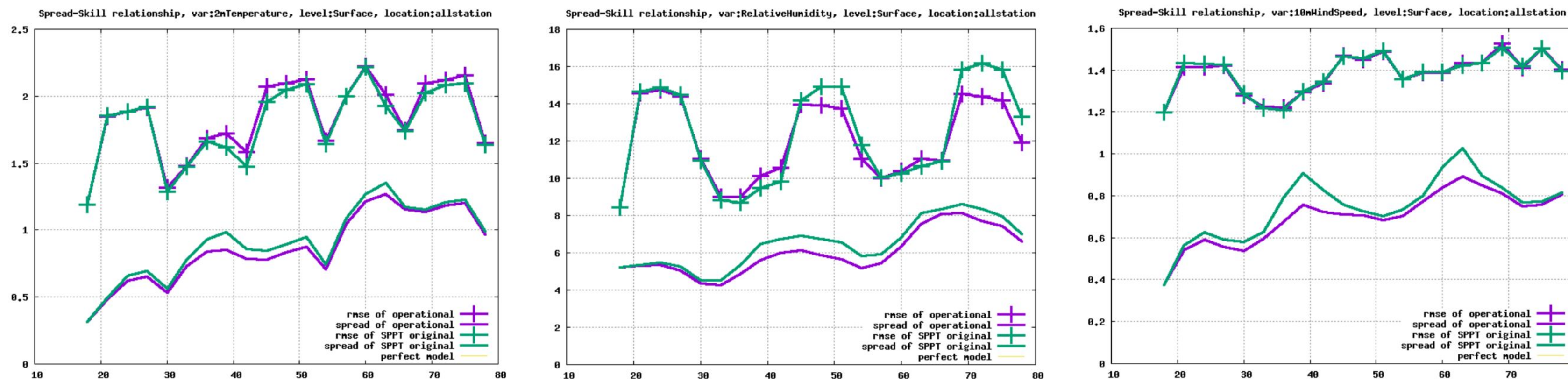


Histogram of random numbers for current SPPT version with default settings (purple), with revised setting (green) compared to the modified version with very-long horizontal correlation length (blue) and moderate horizontal correlation length (orange) - left, and random field generated by SPPT and SPG with the LACE domain specific configuration - right.

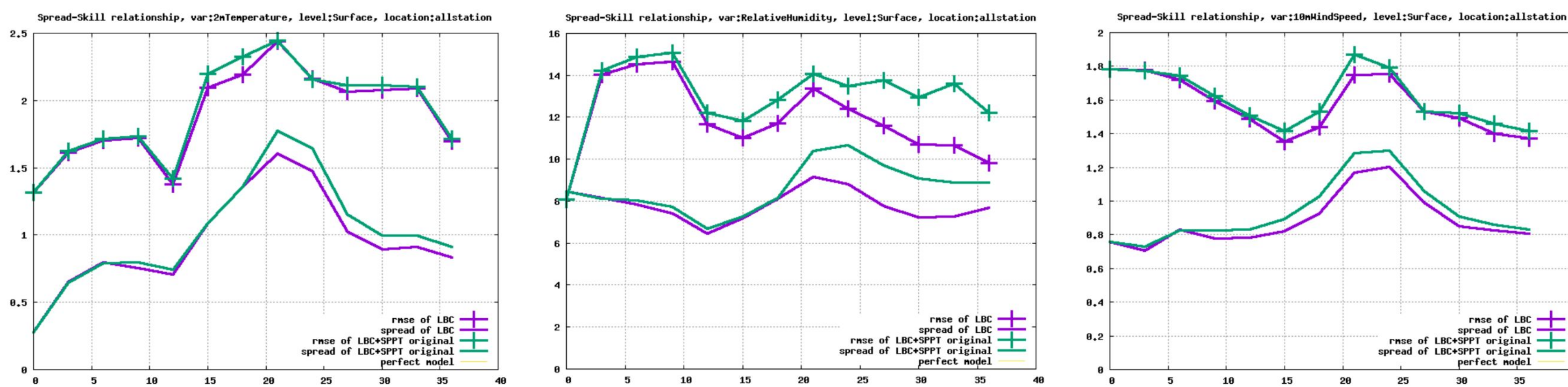
AROME-EPS (OMSZ)

Developments at OMSZ related to ensemble systems:

First results with modified SPPT (**ALARO-EPS**):



First results with modified SPPT (**AROME-EPS**):



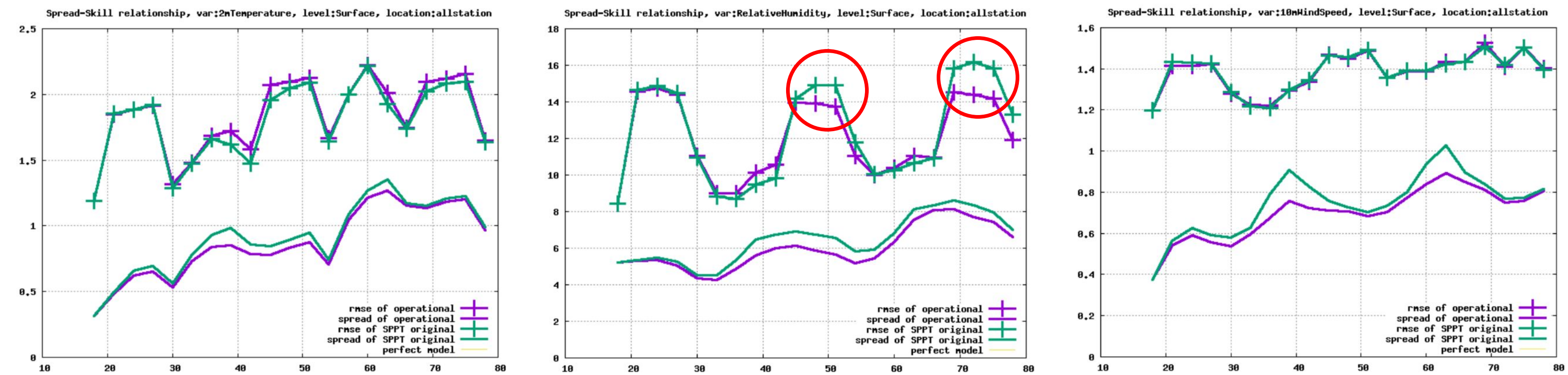
RMSE and spread of T2m (left), RH2m (middle) and W10m (right). Reference (purple) and SPPT experiment (green).

AROME-EPS (OMSZ)

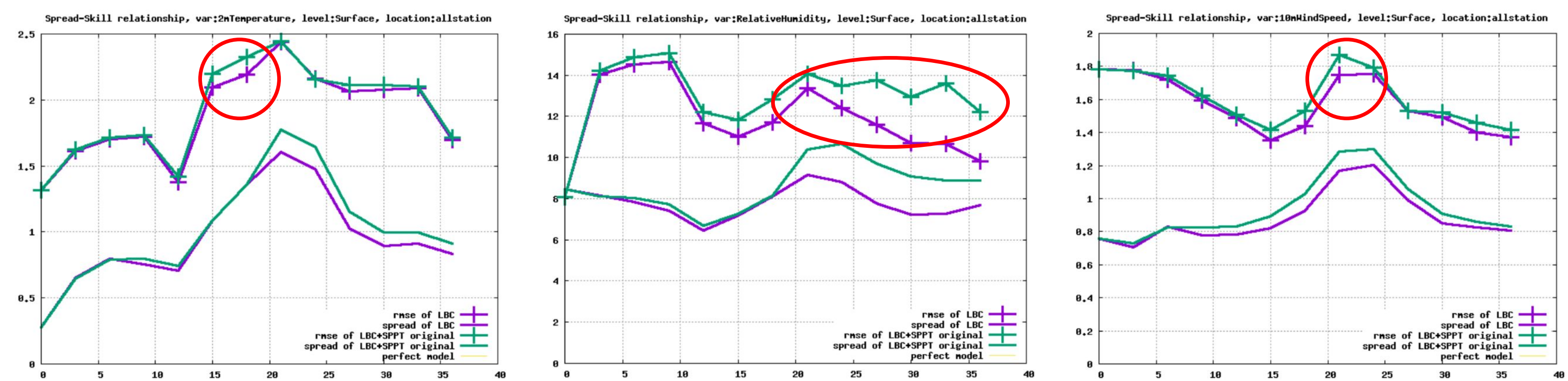
SPPT can ensure additional spread but the RMSE of ensemble mean sometimes increases as well.

Developments at OMSZ related to ensemble systems:

First results with modified SPPT (**ALARO-EPS**):



First results with modified SPPT (**AROME-EPS**):

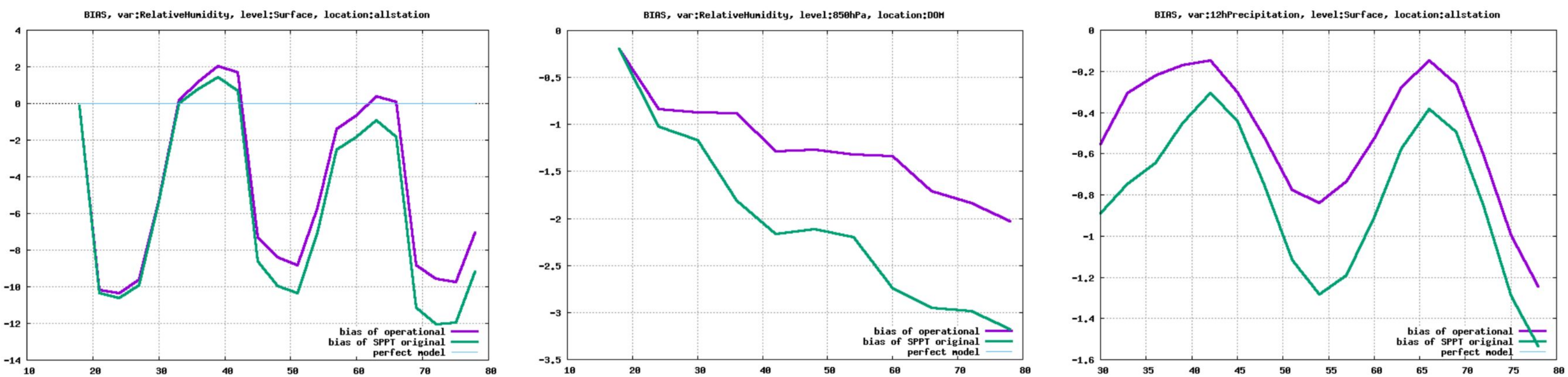


RMSE and spread of T2m (left), RH2m (middle) and W10m (right). Reference (purple) and SPPT experiment (green).

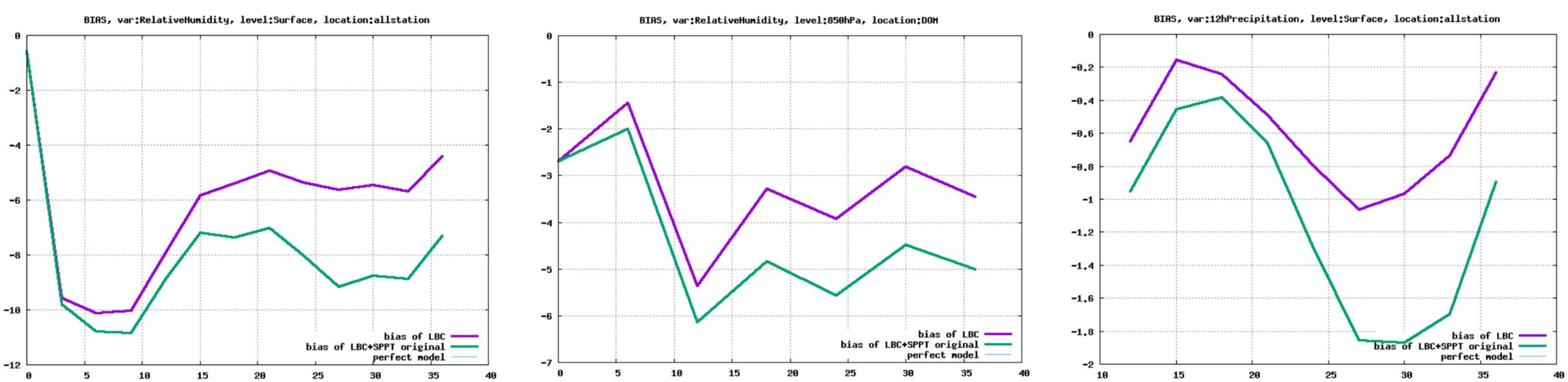
AROME-EPS (OMSZ)

Developments at OMSZ related to ensemble systems:

First results with modified SPPT (**ALARO-EPS**):



First results with modified SPPT (**AROME-EPS**):



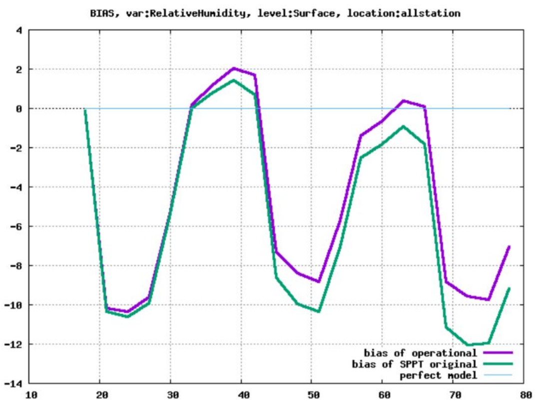
BIAS of RH2m (left), RH850hPa (middle) and 12h PP (right). Reference (purple) and SPPT experiment (green).

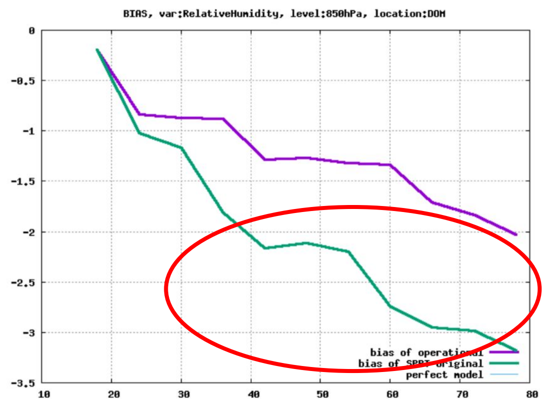
AROME-EPS (OMSZ)

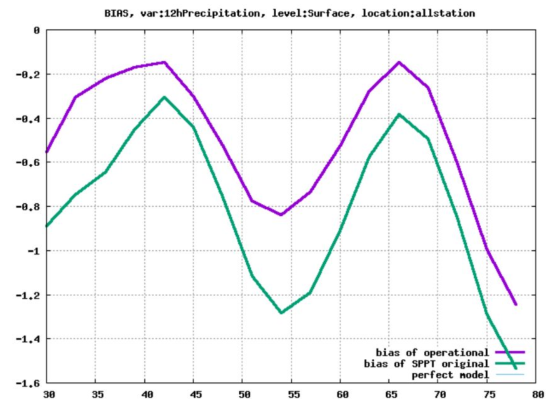
More annoying thing is the "drying effect" - negative BIAS for RH near surface and in upper-air, negative PP BIAS.

Developments at OMSZ related to ensemble systems:

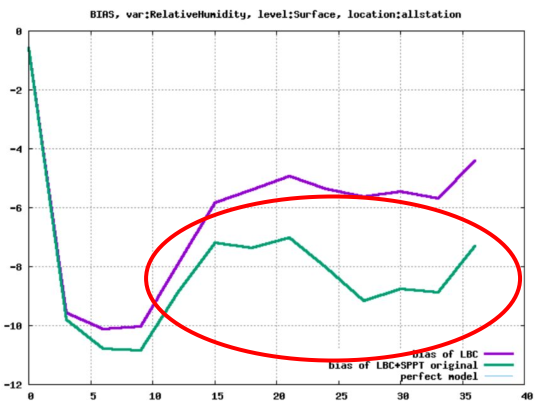
First results with modified SPPT (**ALARO-EPS**):

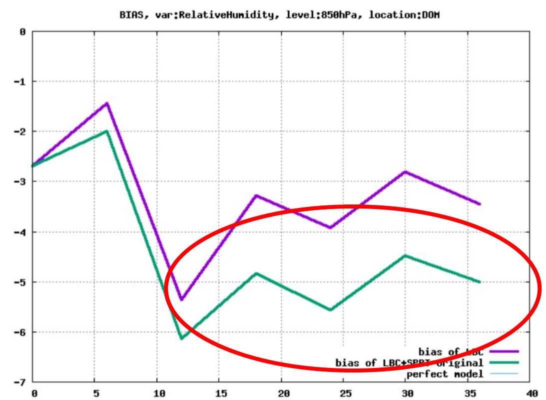


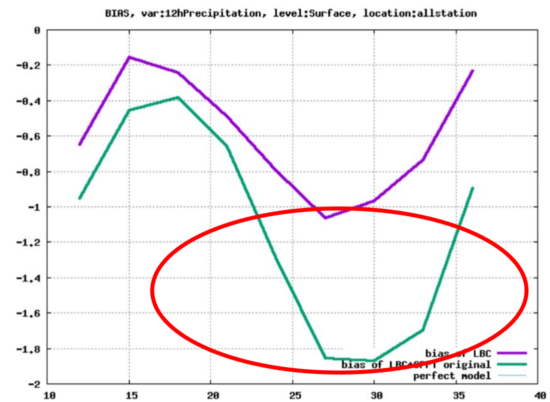




First results with modified SPPT (**AROME-EPS**):







BIAS of RH2m (left), RH850hPa (middle) and 12h PP (right). Reference (purple) and SPPT experiment (green).

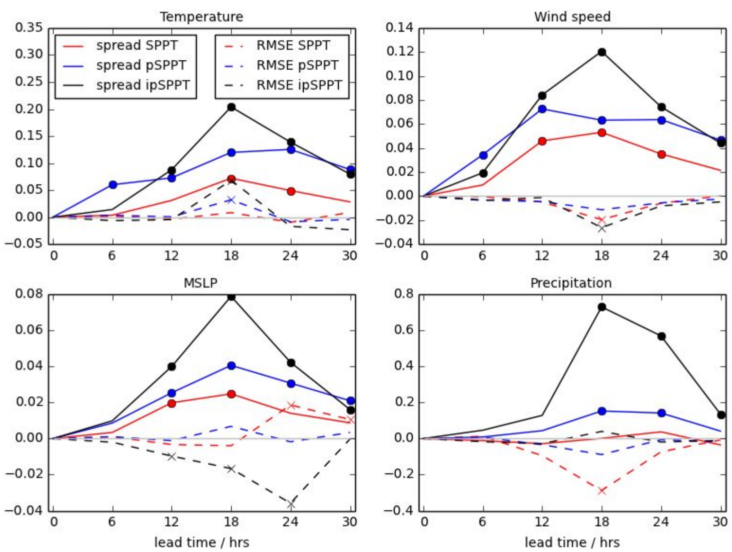
AROME-EPS (ZAMG)

AROME-EPS experiments at ZAMG:

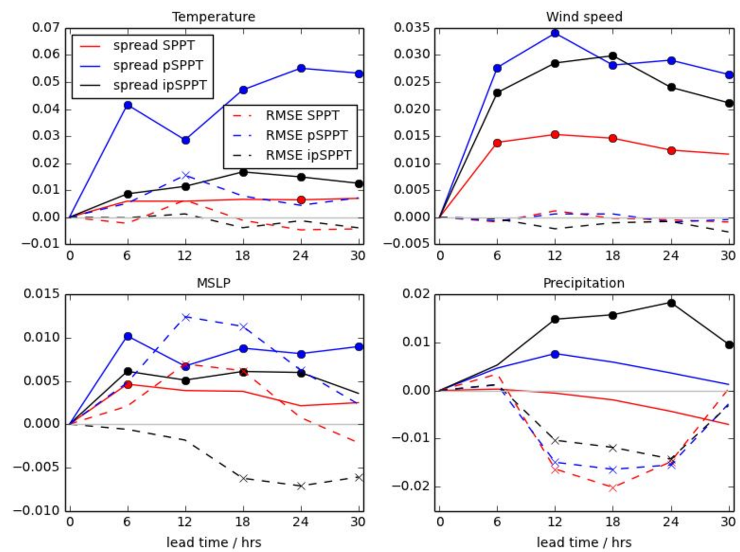
A lot of effort has been put into the investigation of different ways of perturbing model tendencies in AROME-EPS. The standard SPPT (perturbation of total tendencies of T, U, V, Q) was compared with two different ways of perturbing partial tendencies:

- the tendencies of rad., turb., shallow conv. and microphysics have been perturbed separately (pSPPT)
- the different perturbation patterns for the variables T, U, V and Q have been used in addition (ipSPPT)

July 2016 (00 UTC run):



January 2017 (00 UTC run):



Relative SPREAD and RMSE for the different experiments with tendency perturbations in AROME-EPS. Standard SPPT - total tendencies (red line), pSPPT - partial tendencies (blue line), ipSPPT - independent partial tendencies (black line). (*) In comparison with AROME-EPS without stochastic perturbations (exp - ref).*

AROME-EPS (ZAMG)

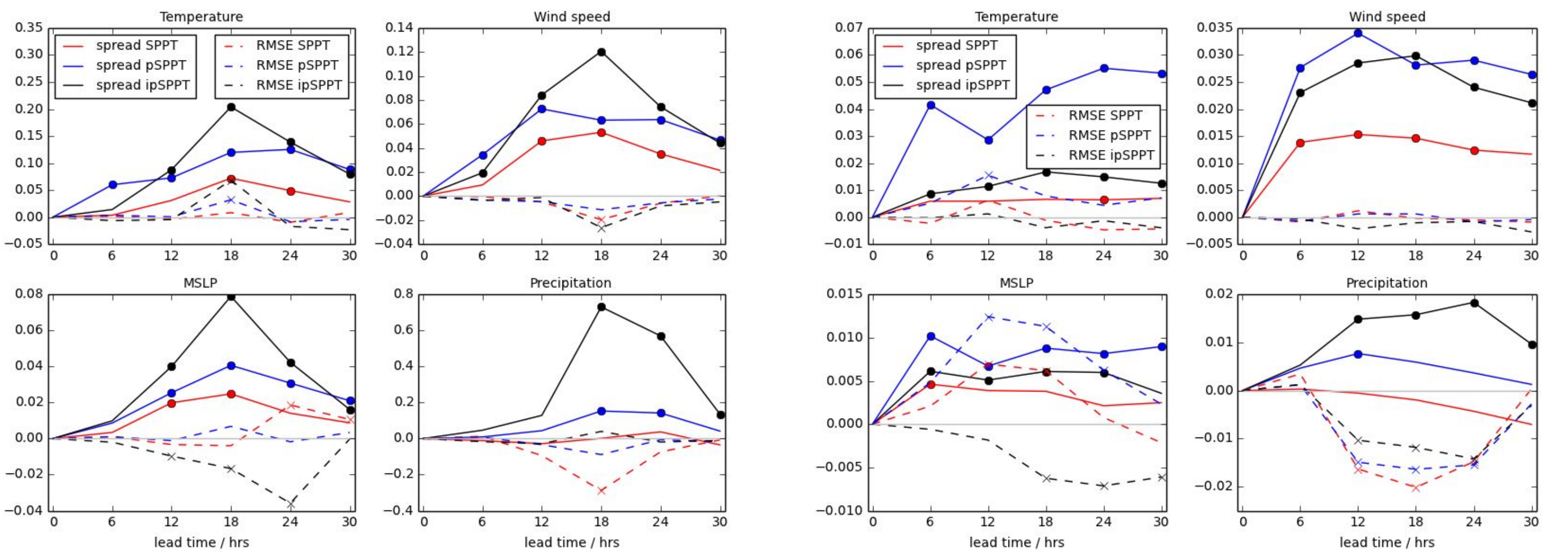
Especially ipSPPT produces higher spread and lower RMSE compared to the reference AROME-EPS.

AROME-EPS experiments at ZAMG:

A lot of effort has been put into the investigation of different ways of perturbing model tendencies in AROME-EPS. The standard SPPT (perturbation of total tendencies of T, U, V, Q) was compared with two different ways of perturbing partial tendencies:

- the tendencies of rad., turb., shallow conv. and microphysics have been perturbed separately (pSPPT)
- the different perturbation patterns for the variables T, U, V and Q have been used in addition (ipSPPT)

July 2016 (00 UTC run):   January 2017 (00 UTC run):



Relative SPREAD and RMSE for the different experiments with tendency perturbations in AROME-EPS. Standard SPPT - total tendencies (red line), pSPPT - partial tendencies (blue line), ipSPPT - independent partial tendencies (black line). (*) In comparison with AROME-EPS without stochastic perturbations (exp - ref).*

AROME-EPS (ZAMG)

Jk 3DVar method (Endi's PhD):

- general idea like spectral blending but technically different
- include global model information directly into LAM variational assimilation
- combination of large scale (GM-EPS) and small scale (LAM-EPS) perturbations
- consistent IC and LBC perturbations in convection-permitting EPS

Cost function (3DVar):

$$J(x) = \underbrace{\frac{1}{2}(x - x_b)^T B^{-1}(x - x_b)}_{J_b} + \underbrace{\frac{1}{2}(y - Hx)^T R^{-1}(y - Hx)}_{J_o}$$

Cost function in Jk blending method:

$$J(x) = J_b + J_o + \underbrace{\frac{1}{2}(x - x_{ls})^T V^{-1}(x - x_{ls})}_{J_k} = J_b + J_o + J_k$$

AROME-EPS (ZAMG)

Jk 3DVar method (Endi's PhD):

- general idea like spectral blending but technically different
- include global model information directly into LAM variational assimilation
- combination of large scale (GM-EPS) and small scale (LAM-EPS) perturbations
- consistent IC and LBC perturbations in convection-permitting EPS

16 ECMWF EPS members interpolated into AROME 2.5 km domain, 2 weeks in Jan, Apr, Jul, Oct (annual variability), 896 differences used.

Cost function (3DVar):

$$J(x) = \underbrace{\frac{1}{2}(x - x_b)^T B^{-1}(x - x_b)}_{J_b} + \underbrace{\frac{1}{2}(y - Hx)^T R^{-1}(y - Hx)}_{J_o}$$

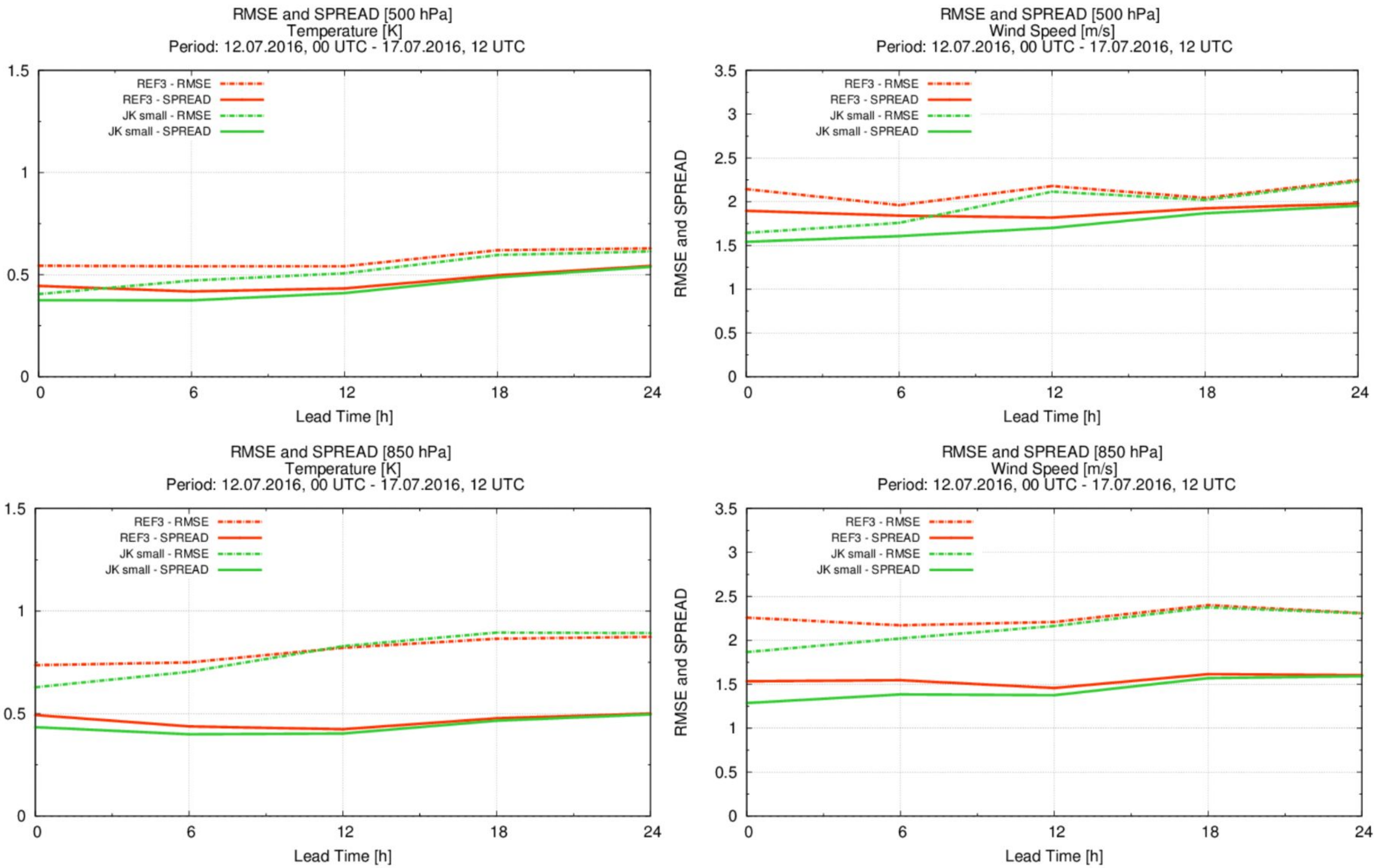
Cost function in Jk blending method:

$$J(x) = J_b + J_o + \underbrace{\frac{1}{2}(x - x_{ls})^T V^{-1}(x - x_{ls})}_{J_k} = J_b + J_o + J_k$$

Large scale perturbations.

AROME-EPS (ZAMG)

Jk 3DVar method (Endi's PhD):

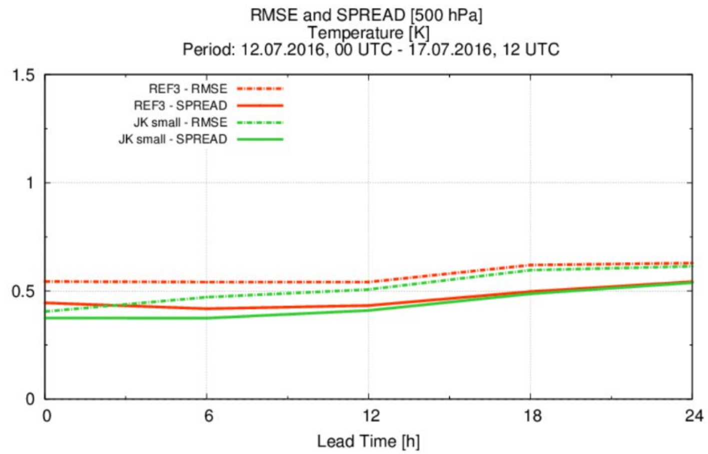


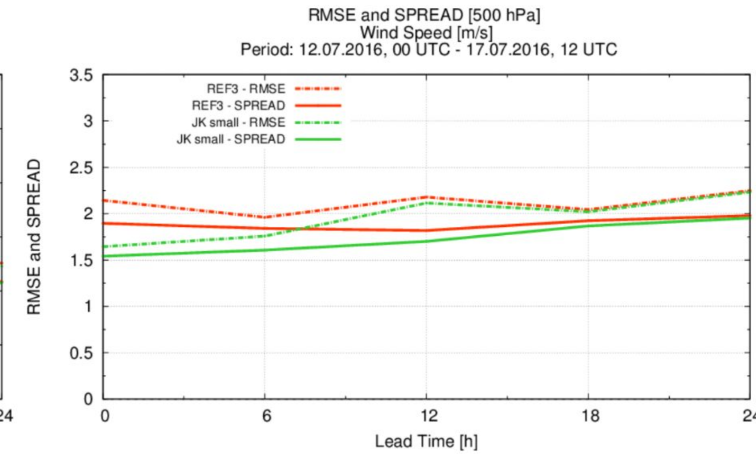
RMSE and SPREAD at 500 hPa (top) and 850 hPa (bottom) for temperature (left) and wind speed (right). The Jk experiment is green and the reference is red (AROME-EPS with 3DVar without Jk term).

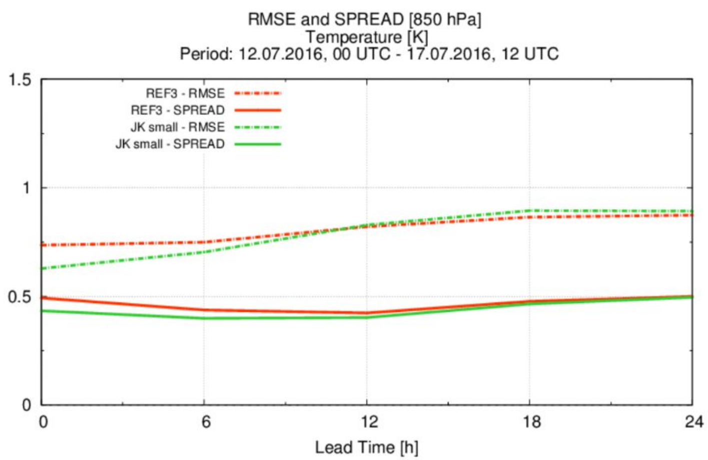
AROME-EPS (ZAMG)

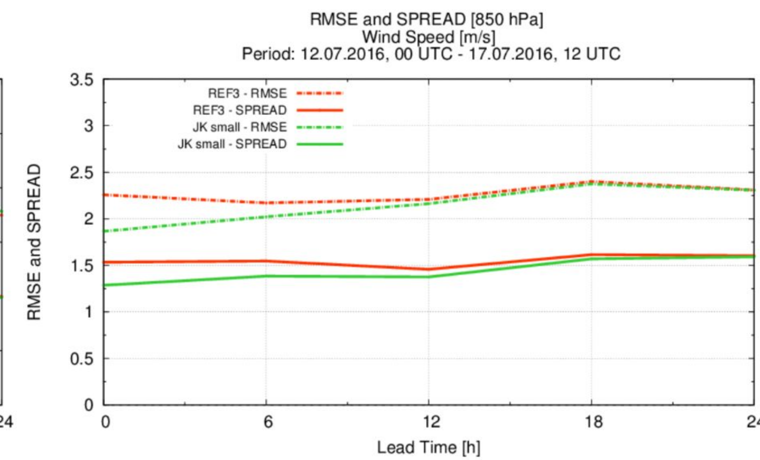
Positive impact on upper air variables, neutral for the surface (not shown).

Jk 3DVar method (Endi's PhD):









RMSE and SPREAD at 500 hPa (top) and 850 hPa (bottom) for temperature (left) and wind speed (right). The Jk experiment is greed and the reference is red (AROME-EPS with 3DVar without Jk term).

Publications

Published papers:

- Belluš M., Y. Wang, F. Meier, 2016: “**Perturbing surface initial conditions in a regional ensemble prediction system**”, Monthly Weather Review, 144 (9), pp 3377–3390, DOI: http://dx.doi.org/10.1175/MWR-D-16-0038.1 (published in September 2016)
- Schellander-Gorgas T., Y. Wang, F. Meier, F. Weidle, Ch. Wittmann, and A. Kann, 2016: “**On the forecast skills of a convection permitting ensemble**”, Geosci. Model Dev. Discuss., DOI:10.5194/gmd-2016-191 (published in August 2016)
- Szűcs M., P. Sepsi, A. Simon, 2016: “**Hungary’s use of ECMWF ensemble boundary conditions**”, ECMWF Newsletter No. 148 – Summer 2016, pp 24-30
- Szűcs M., A. Horányi, G. Szépszó, 2016: “**Ensemble Methods in Meteorological Modelling**”, In: Bátkai A., Csomós P., Faragó I., Horányi A., Szépszó G. (eds) Mathematical Problems in Meteorological Modelling. Mathematics in Industry, Vol. 24, pp 207-237. Springer. DOI: 10.1007/978-3-319-40157-7_11

Papers in preparation for the submission:

- 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

AMERICAN METEOROLOGICAL SOCIETY
AMS Journals Online
Journals Subscribe For Authors Information Online Help

Springer

Publications

Stay reports:

- Alena Trojáková, 2016: IC perturbations by 3DVAR in ALADIN-LAEF, Report on stay at ZAMG, 25/04~20/05/2016, Vienna, Austria
- Martin Belluš, 2016: New high resolution ALADIN-LAEF on CY40T1 with ALARO-1 physics, Report on stay at ZAMG, 25/04~13/05 + 06/06~10/06, 2016, Vienna, Austria
- Simona Taşcu, 2016: Optimization of ALADIN-LAEF at 5 km horizontal resolution, Report on stay at ZAMG, 04/07 - 26/08/2016, Vienna, Austria (in preparation)
- Mihály Szűcs, 2016: Stochastic pattern generators, Report on stay at ZAMG, 23/05 - 17/06/2016, Vienna, Austria
- Martin Belluš, 2016: Spectral blending on high resolution issue, Report on stay at ZAMG, 24/10~18/11, 2016, Vienna, Austria

http://www.rclace.eu

Outlook

Ongoing topics:

- provide the probabilistic forecasts based on ALADIN-LAEF for all RC LACE partners (twice a day up to 72 hrs)
- experiment with convection-permitting EPS
- collaborate with HIRLAM EPS group

Current topics:

- validate BlendVar within the full ALADIN-LAEF suite
- apply OBS perturbation in ENS BlendVar (upper-air)
- implement quality control for OBS used in 3DVar
- investigate different possibilities for B-matrix sampling (flow-dependent B)
- use new multiphysics (ALARO-1) to simulate model uncertainty
- investigate the stochastic perturbation of partial tendencies
- continue work on new SPG implementation for LAM EPS
- ensemble calibration of high resolution wind
- investigate the drying effect (supersaturation check) in SPPT

Thank you for your attention!