Optimization of Blendvar at 2.3 km

Report for a stay at CHMI

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1 Introduction

The main purpose of this stay was to compute and validate Background error covariance matrix (B matrix) with the Ensemble Data Assimilation (EDA) approach suitable for the High Resolution operational suite (HR suite), described in section 2. Two EDA based B matrices were computed, one with perturbed Sea Surface Temperature (SST) and one without, see section 3. The new EDA B matrices were compared with the spin-up ensemble B matrix operationally used in the HR suite (see section 4). Performance of the new B matrices was investigated in experiments simulating HR suite in section 5. Summary can be found in section 6.

2 Setup of the ALADIN model

ALARO-1, CY43t2 (CHMI cy43t2pt_op1):

- domain: Δx 2.325 km, 1080 x 864 GP
- 87 vertical levels
- time step 90s
- 3h space consistency coupling ARPEGE
- forecasts up to +72/+54h at 00, 06, 12 and 18 UTC
- weak IDFI of short cut-off production analysis

Upper air analysis – BlendVar scheme

- BlendVar = DF Blending followed by 3D-Var
- 6h assim cycle, no IDFI in the next +6h assim guess
- ±1.5h assim window, spin-up ensemble B
- VARBC 24h cycling
- Assimilated observations:
  SYNOP (Ps), TEMP (t, q, u, v), AMDAR (t, u, v), AMV,
  SEVIRI (channels: 2, 3, 4, 6, 7), Mode-S MRAR CZ (t, u, v),
  Mode-S EHS from KNMI (t, u, v)

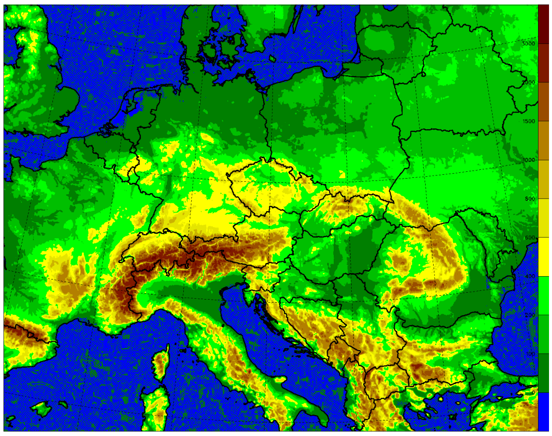

Figure 1: HR Suite Domain

Surface analysis – OI based on SYNOP (T2m, RH2m), SST from ARPEGE

3 Computation of B matrices

The current operational B matrix (B_spin) used in the HR suite was computed with a spin-up ensemble coupled with global assimilation ensemble ARPEGE (AEARP).

The new B matrices were computed with Ensemble Data Assimilation approach (Berre et al., 2006) similarly to Brousseau et al. (2011). The 6 independent 3D-Var assimilation cycles with perturbed screen level and upper-air observations are used to create the sample for B matrix computation. All ALADIN members started from the same guess but each member is coupled with one member of AEARP. The same period as the B_spin was used, which allows the comparison of B matrices without the influence of the meteorological conditions.

Almost a third of CHMI domain is covered by sea (see Figure 1). Therefore, we considered to investigate the impact of Sea Surface Temperature perturbation on the B matrix computation. Thus, two B matrices were computed: B_eda and B_pertsst (with SST perturbation).

SST perturbation method is inspired by Météo-France approach as suggested by Yann MICHEL (see section 3.1).The B matrices computation setup is summarized in the table bellow.

Table1: B matrices Setup

	B_spin	**B_eda**	**B_pertsst**
Period	Winter: 10 - 24 February 2016 Summer: 06 - 20 July 2016		
LBC	AEARP		
Member	6 Members		
Observations perturbations	-	Upper-air + Screen level	Upper-air + Screen level
Other perturbations	-	-	SST
Ensemble experiment name	e14 (already ran by A. Bučánek)	e17	e18

3.1 SST Perturbation

On this stay, we tried the new method used in operational AROME EDA at Météo-France to perturb the sea surface temperature. Formerly, the SST perturbation was done (until cycle 42) with the configuration c931, which takes the SST from Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA product) and performes the perturbation. Since the c931 configuration is not yet parallelized (on going work at Météo-France), it was taking too much time in each assimilation cycle run. This was not suitable for operational use.

Therefore, Météo-France uses now an another method to perturb SST based on the work of F. Bouttier. This method relies on making SST perturbation within the routine pertsurf.F90 (incorporated in the code starting from cycle 43t2_op2). The general idea of this method is to first generate random 2D white noise and then to apply smoothing by digital filter and normalization.

This routine perturbs SST and first two levels of ground temperature (TG1 & TG2). To perturb only SST, we need to activate the LAEARO key in namelist file "nampert".

```
&NAMSFC
  ISEED=xxMEMBxx,          #  Member
  IRADIUS=10,              #  Radius of perturbation length scales
  INBITER=10,              #  Number of smoother iterations
  ZCLIP=3,                 # Clipping ratio (unit =stdev)
  NPAR=1,                  # Number of parameter to perturb
  CPARNAME='SST',          # Parameter to perturbed
  ZPERTSTD=-0.5,           #  Perturbations are either multiplicative (if negative) or additive (if
                              positive)
  LAEARO=.TRUE.,           # To perturb just SST
/
```

Perturbation radius should be adapted to the resolution of the domain. For AROME ensemble data assimilation at Météo-France, the radius is equal to 14 for 3.2 km resolution. For ALARO-1 at CHMI, the radius is equal to 10 for 2.3 km resolution as recommended by Yann Michel.

The program ***pertsurf*** is expecting as input/output a file named "analyse.sfx" where the SST field is named "SUFRSST.CLIM.". At CHMI we adapted the code of pertsurf.F90 to read, instead of "SUFRSST.CLIM.", the field "SURFTEMPERATURE" that contains temperature of sst and land surface from ARPEGE analysis.

Output of pertsurf (perturbed SST field) is than copied to the surface analysis. For that we use the key LECSST in CANARI, which expects input file named ICMSH${CNMEXP}ESST, where CNMEXP is defined in CANARI namelist.

This approach require another renaming of fields. The "SURFTEMPERATURE" from analyse.sfx is copied to two new fields "SURFSEA.ICECONC" and "SURFSEA.TEMPERA" in the file ICMSH${CNMEXP}ESST by a local tool in CHMI.

So the procedure adopted at CHMI is to :

- copy ARPEGE analysis as analyse.sfx
- apply the perturbation by pertsurf
- use local tool to copy field “SURFTEMPERATURE” from analyse.sfx to fields “SURFSEA.ICECONC” and “SURFSEA.TEMPERA” in the file ICMSH${CNMEXP}ESST
- use the file ICMSH${CNMEXP}ESST as the SST file in CANARI (with sst relaxation coefficient RCLISST=1, the perturbed SST is copied to the CANARI analysis)

```
&NACTEX
    RCLISST=1,
    LECSST=.T.,
/
```

A simple script and a namelist to run ***pertsurf*** can be found on kazi:
/home/mma249/pertsurf.tar.
To run the script two arguments should be passed: the $date (YYYYMMDDRR) and the $member.

Example: sbatch pertsurf 2016021000 4

3.2 Comparison of SST Perturbation

Figure 2 shows the comparison of EDA experiments with perturbed SST (e18) and without (e17) for two different members (members 6 and 5) on 10 February 2016 at 00H.

The maximum amplitude of the differences is around 1.6 K. Besides, we have different SST perturbations in term of localization and intensity for two different members.

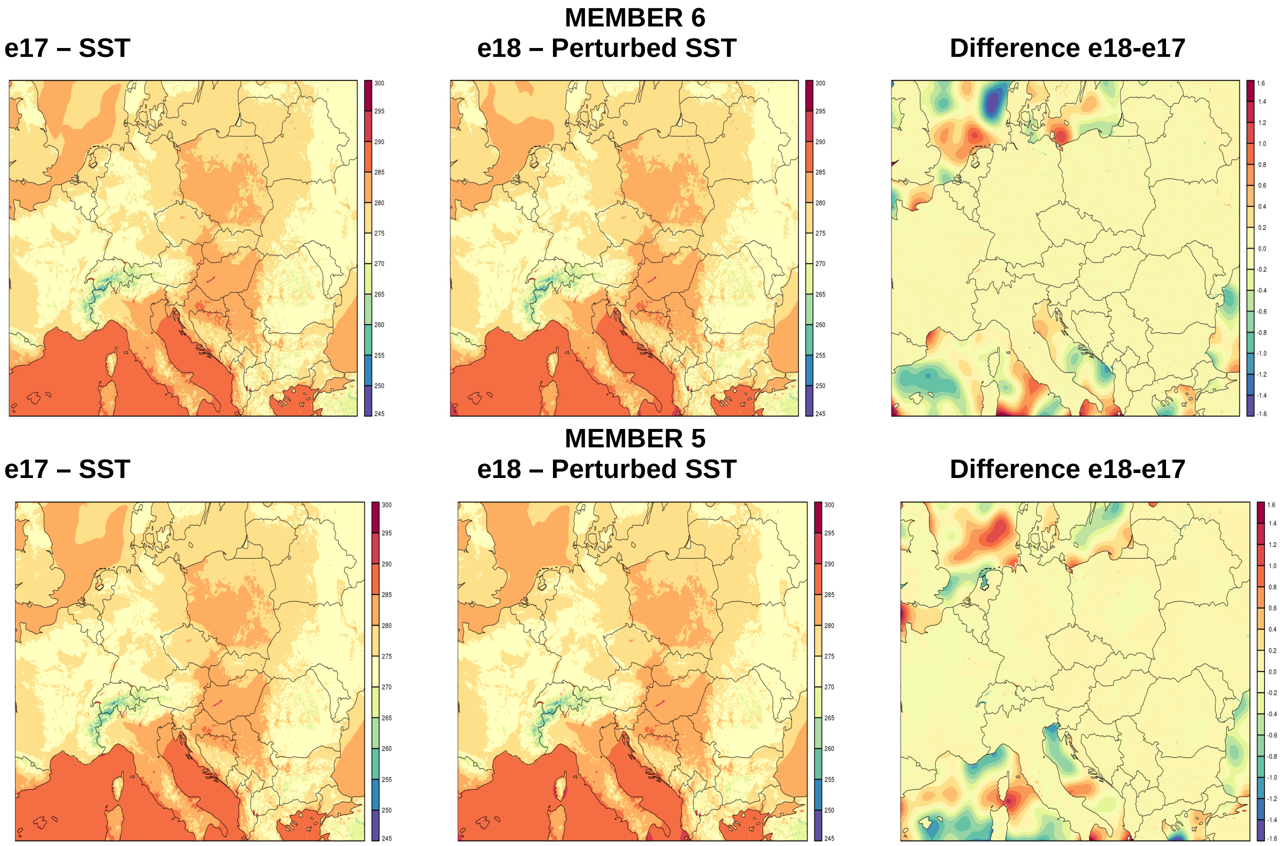

Figure 2: SURFTEMPERATURE Differences between e17 (eda) and e18 (eda with perturbed SST) on 2016021000 run for Member 6 and Member 5

4 Diagnostics of B matrices

The comparison of the three B matrices: B_eda, B_pertsst and B_spin was based on diagnostics.

Spin-up B versus EDA B matrices:

When examining the differences between the new B matrices with EDA approach against the spin-up one, we can notice that:

- length scales which represent sharpness of auto-correlation function are shown on Figure 3 for B_spin and B_eda. There is very small difference between length scales.

- the standard deviation vertical profile (Figure 4) kept the same shape and the values of the EDA B matrices are larger for the temperature, divergence and vorticity almost at all the vertical levels especially between 850 hPa and 300 hPa. However for the specific humidity, starting from 700 hPa, the standard deviation is smaller for the EDA B matrices especially near 1000 hPa.

- the variance of the temperature, divergence and vorticity for the EDA B matrices are higher than the spin-up B for all the vertical levels (level 850 hPa shown in Figure 5) due to the effect of the cycling in the data assimilation ensemble with the evolving of small scales perturbations. It is worth noticing too that regarding the specific humidity, at large scale and in the low troposphere, the variance of the EDA B matrices are smaller than the spin-up B.

- cross covariances were not studied due to lack of time.

B_eda versus B_pertsst:

Except a rather small increase of the standard deviation of the temperature and the specific humidity of the B_pertsst near the surface, there is no significant difference in the the diagnostics between B_eda and B_pertsst.

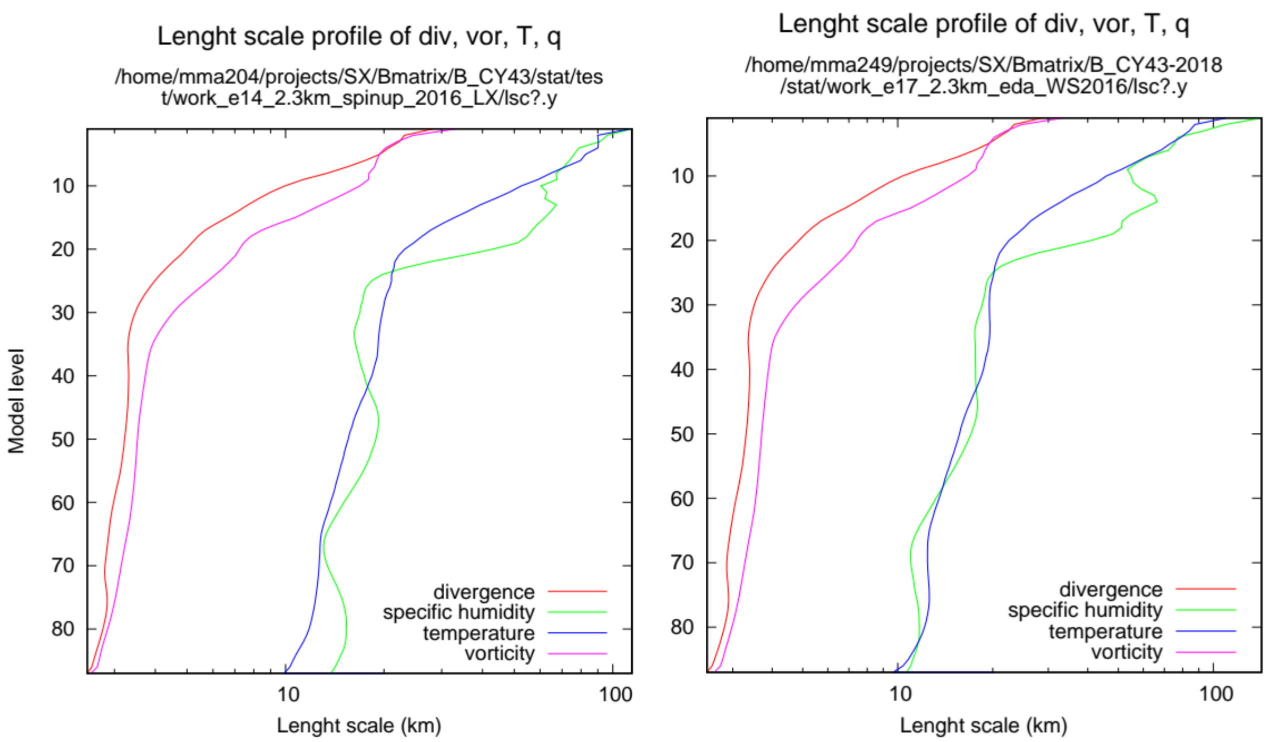

Figure 3: Vertical profile of length scale for B_spin (left) and B_eda (right)

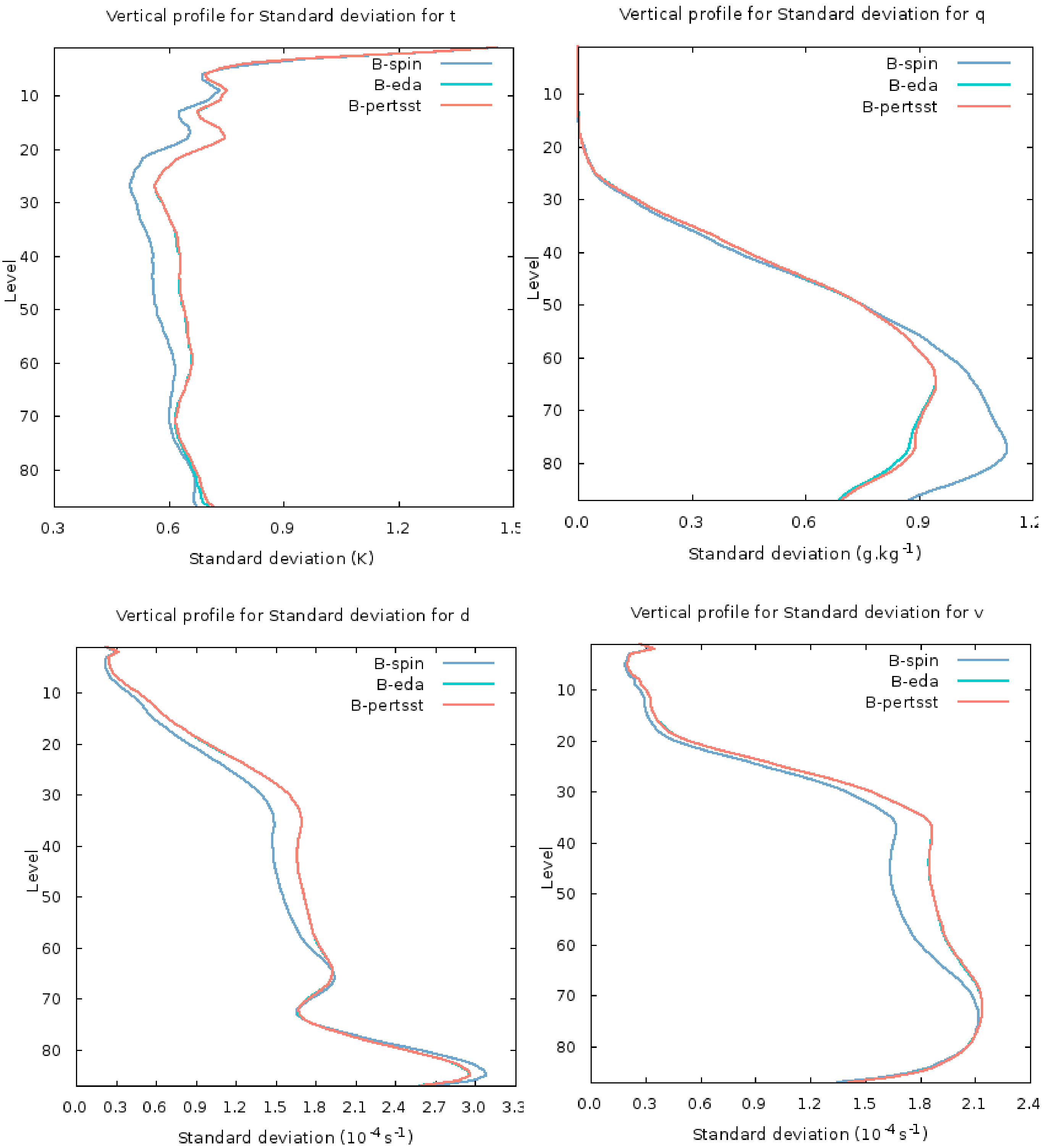

Figure 4: Vertical profile for standard deviation for (from up-left to down-right) temperature, specific humidity, divergence and vorticity for B_spin (blue), B_eda (green) and B_pertsst (red)

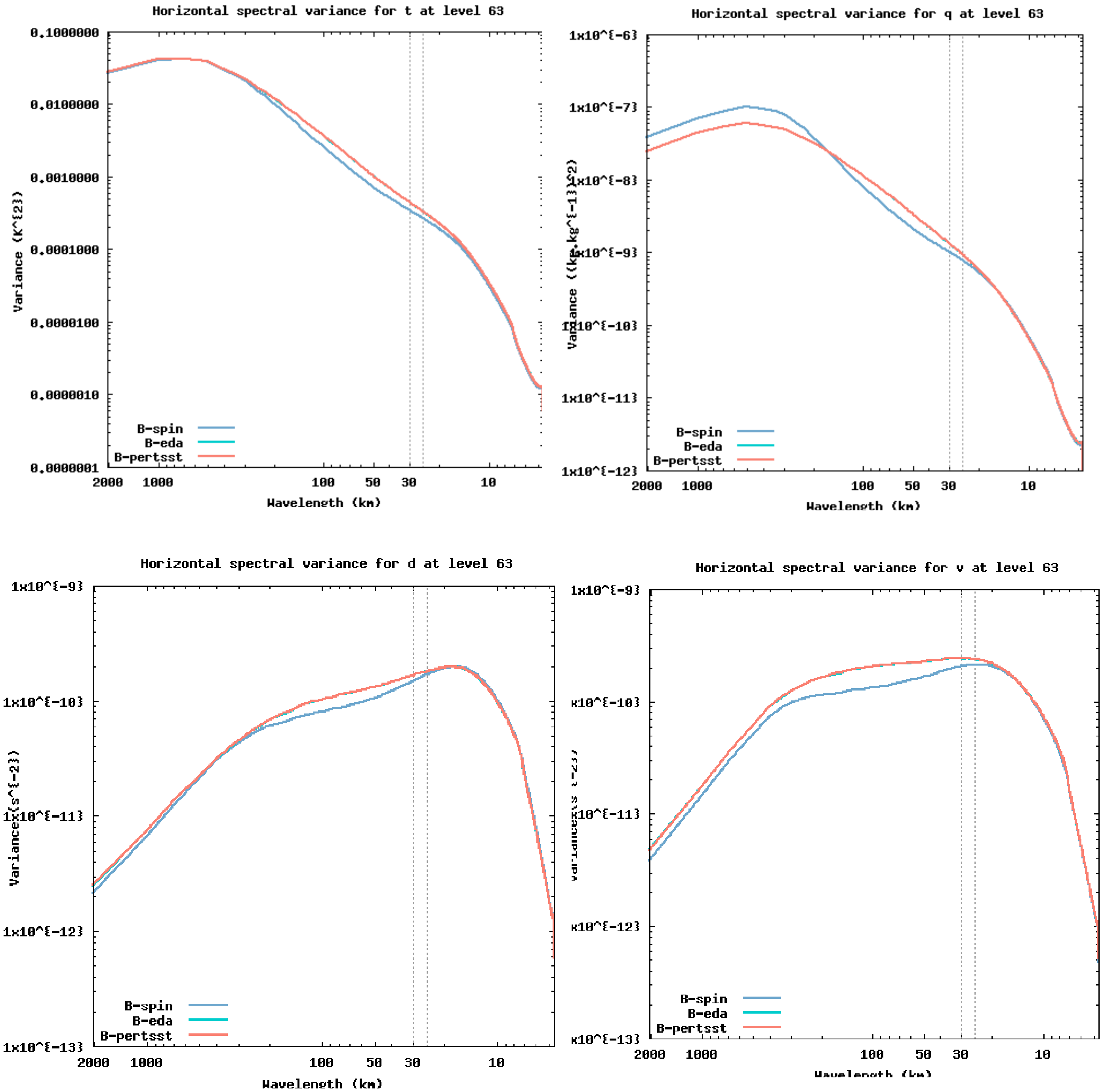

Figure 5: Horizontal spectral varaince at 850hPa for (from up-left to down-right) temperature, specific humidity, divergence and vorticity for B_spin (blue), B_eda (green) and B_pertsst (red)

5 Experiments

Two experiments, as shown in the Table 2 bellow, were performed to assess the impact of the new ensemble data assimilation B matrices (B_eda & B_pertsst). The reference experiment was based on the operational setup of ALADIN/CZ (section 2).

Table2: Verification experiments

Experiment	**zig**	**zih**	**Reference** (**Aref**)
B matrix (Folder path on kazi)	**B_eda**: /home/mma249/projects/SX/Bmatrix/B_CY43-2018/stat/work_e17_2.3km_eda_WS2016	**B_pertsst:** /home/mma249/projects/SX/Bmatrix/B_CY43-2018/stat/work_e18_2.3km_pertsst_WS2016	**B_spin**: /home/mma204/projects/SX/Bmatrix/B_CY43/stat/work_e14_2.3km_spinup_2016_LX
Cycle	CHMI cy43t2plus_op1		
Setup	Same setup (namelist, REDNMC, ...)		
Period	10-24 September 2019		
Forecast Hour	00 H & 12 H		
Forecast Ranges	+48 H		

The scores were rather neutral when comparing the experiment with the B_eda against the reference with a small improvement of the humidity and temperature at analysis time at some vertical levels (Figures 6, 7 and 8).

(more results can be found on kazi:
/home/mma249/work/exp/zig/scores/plot/prod_verif_zig_ref).

Neutral scores also were noticed when comparing the experiments using B_pertsst against B_eda.

Results are not shown in the report but they can be found on kazi:
/home/mma249/work/exp/zih/scores/plot/prod_verif_zih_zig).

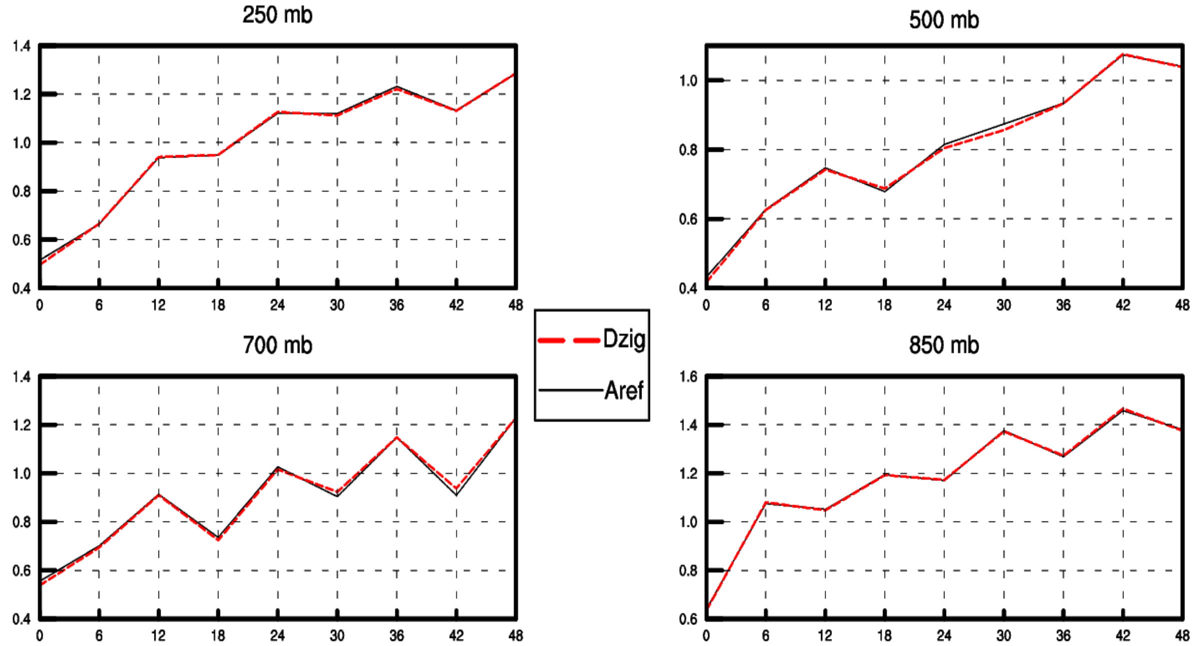

Figure6: Temperature RMSE for the B_eda (zig in red) and B_spin (reference in black) experiments

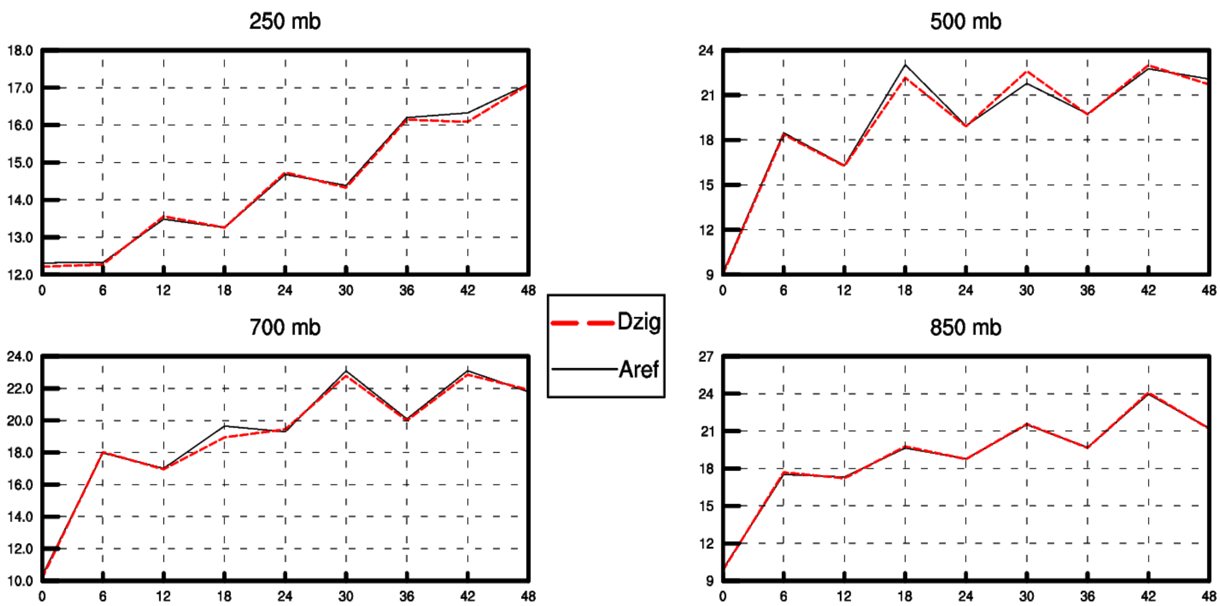

Figure7: Relative humidity RMSE for the B_eda (zig in red) and B_spin (reference in black) experiments

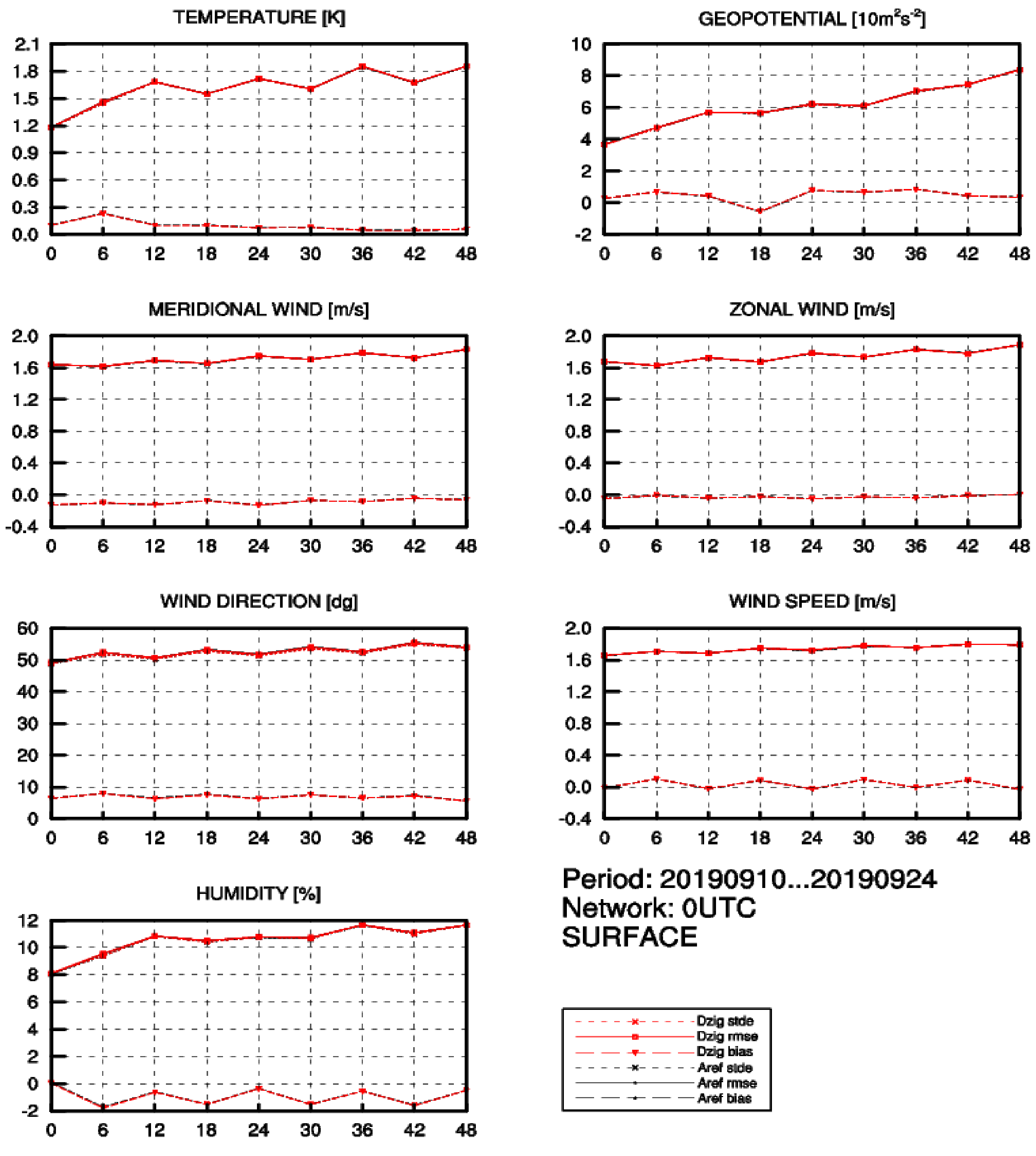

Figure 8: Surface Verification for the B_eda (zig in red) and B_spin (reference in black) experiments

6 Summary

In this stay, two background error covariance matrices were computed based on the ensemble data assimilation approach. The diagnostics of the EDA based B matrices were compared with the spin-up B matrix. It is worth mentionning that the version of ALADIN was moved by the time between spin-up B matrix and EDA based ones. The differences are visible at standard deviations, variance spectra and also cross covariances which are not included in the report.

The experiments, which should assess the performance of the new B matrices, were very short (only 14 days). The scores obtained show improvement at analysis time for temperature and relative humidity at some vertical levels and rather neural impact in term of forecast scores in the cycling experiments with the EDA B matrices when compared against the operational setup. More extended verification and experimentation will be done before operational implementation of EDA based B.

A new method for perturbing sea surface temperature was tested in the implementation of the EDA ensemble. The first results did not show significant differences between B matrices (the B with perturbed sea and the one without). Further tuning with the perturbations length scale radius could be considered.

7 Acknowledgments

I would like to thank Alena Trojáková and Antonín Bučánek for their help and support during the stay and for all the constructive exchanges of views. I would like also to address my sincere gratitude for all the colleagues in CHMI NWP group for the hospitality and the warm welcome. I am grateful for the support given by Meteo-France colleagues especially Yann Michel for explanation how the SST perturbations are constructed in AROME EDA.