The Evolution of Dispersion Spectra in Blending cycle

Czech Hydrometeorological Institute, 2012
Antonín Bučánek, antonin.bucanek@chmi.cz

In order to study evolution of dispersion spectra during assimilation cycle with digital filter spectral blending two independent assimilation cycles were set up for each of two members of AEARP (Assimilation Ensemble ARPege).
Analysis and 3, 6 hour forecasts (coupling files) of AEARP members were first downscaled from T399 (Δx~50km) to telecommunication resolution with Δx~15.4 km. They were downloaded and downscaled to ALADIN resolution (~9km). We studied how dispersion evolves :

1) In dynamical adaptation mode, forecast with DFI was run up to 6 hour from downscaled AEARP analysis , only for comparison with blending
2) with blending cycle,
3) with surface OI (Canari) and upper air spectral blending cycle
4) Blending in spin up mode

ALADIN

- ALADIN cycle 35t1star.bf5 (ALARO-0 with 3MT), Canari cycle 36t1ope
- LACE domain (309x277 grid points, linear truncation E159x143, Δx~9km)
- 43 vertical levels, mean orography
- time step 360 s, 3h coupling interval

Blending

- The idea is to combine AEARP analysis with information from scales which are not resolved by AEARP but by ALADIN. Digital filter spectral blending of the upper air fields is used to insert that additional information from 6h ALADIN guess to analysis
- filtering at truncation E29x26 which is almost ALADIN equivalent of AEARP native resolution, no DFI in the next +6h guess integration

Period

- 2.February -28. February, 4 forecasts a day, 108 samples

Studied statistics:

- Variance spectra of divergence, vorticity, temperature , specific humidity and surface pressure at 4 levels for state differences of two member ensemble,

$$Var(\varepsilon) = Var[\mathbf{x}(i) - \mathbf{x}(j)]$$

where **x**(i) is state vector of i member of ensemble

Level	13	22	29	41
Pressure [hPa]	300	550	750	100 m above surface

- Vertical profiles of standard deviation

2) Blending cycle

Blending cycle consists of: downscaling AEARP analysis from ALADIN resolution to low spectral resolution E29x26 on ALADIN grid. Performing digital filter and interpolation back to ALADIN spectral resolution. The same is done for ALADIN guess (6h prediction of ALADIN valid at the time of AEARP analysis). Finally difference of these filtered models is added to ALADIN guess. Then a 6 hour prediction without DFI is performed.

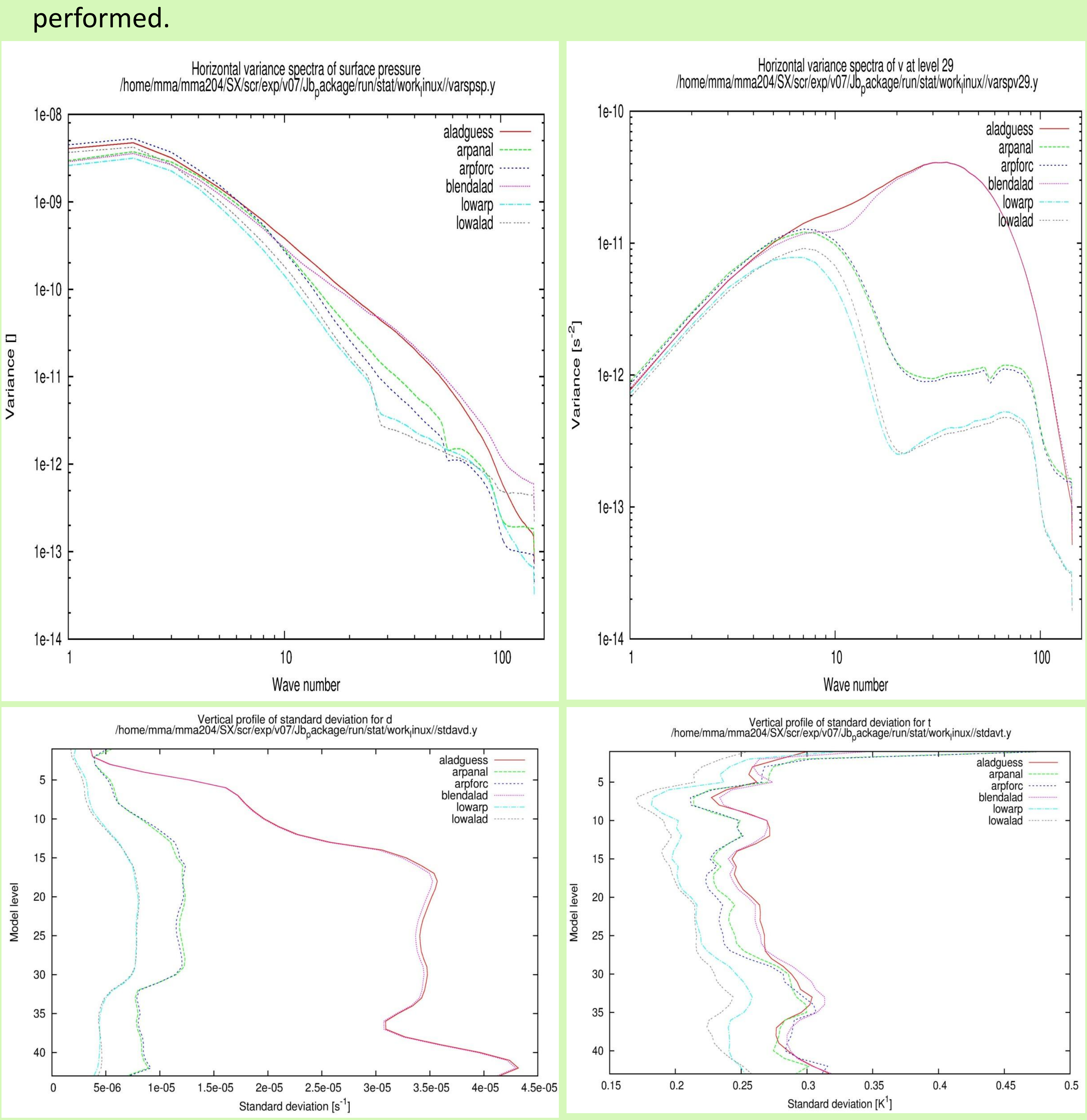

Figure 1: Upper left - variance spectra of logarithm of surface pressure, upper right – horizontal variance spectra of vorticity at level 29, bottom left – standard deviation profile of divergence, bottom right – std. profile of temperature, **aladguess**= ALADIN 6hour prediction, **arpanal**= AEARP analysis in ALADIN resolution, **arpforc**= AEARP 6h forecast in ALD. res., **blendalad**= after blending (combination of lowalad, lowarp, aladguess), **lowarp**= AEARP analysis downscaled to low res., filtered and up scaled back to ALADIN resolution, **lowalad**= ALADIN guess downscaled to low res., filtered and up scaled back

AEARP analysis dispersion was expected to be smaller than AEARP 6h forecast for all wave lengths, levels and variables as was shown in Ştefănescu (2006) because analysis should reduce errors of model state. However, it can be seen on Figure 1 (upper left), that analysis variance is slightly greater for long waves up to wave number 5 than AEARP forecast. Similar behavior can be seen in divergence and temperature standard deviation profiles. Greater analysis variance in long waves could be introduced by greater perturbation in observation incoming to assimilation of AEARP, but it is only hypothesis. Short waves spectra of AEARP analysis in surface pressure are also higher than AEARP forecast but it is likely caused by interpolation to higher resolution of ALADIN, the shortest AEARP wave has equivalent of wave number 28 in ALADIN resolution. It means, that variance spectra for wave numbers greater than 28 are completely introduced by interpolation itself.
ALADIN 6h prediction increases dispersion mainly in short waves and slightly decreases it in long waves compared to AEARP analysis. Main impact of ALADIN forecast can be seen in small scales which are not resolved by AEARP, maximal variance of vorticity is around wave number 40 (Figure 1). It means that error statistics derived from ensemble differences underestimate background error statistic for poorly resolved scales.
Blended file behaves as expected, dispersion in short waves is similar to ALADIN guess and long wave dispersion approximates to dispersion of AEARP analysis.

3) Blending cycle with Canari

Blending process is the same as in point 2) but it is preceded by surface OI with perturbed observations. Perturbations are constructed as normally distributed random numbers with variance equal to assumed observation error variance.
As expected there is very small signal in temperature and humidity (they were assimilated) near surface.

4) Blending in spin up mode

It means to perform blending step on ALADIN guess from dynamical adaptation i.e. downscale AEARP, run ALADIN 6h forecast and make blending with AEARP analysis valid at the same time as ALADIN 6h forecast. This is done only to see how one blending influences variances without accumulation.

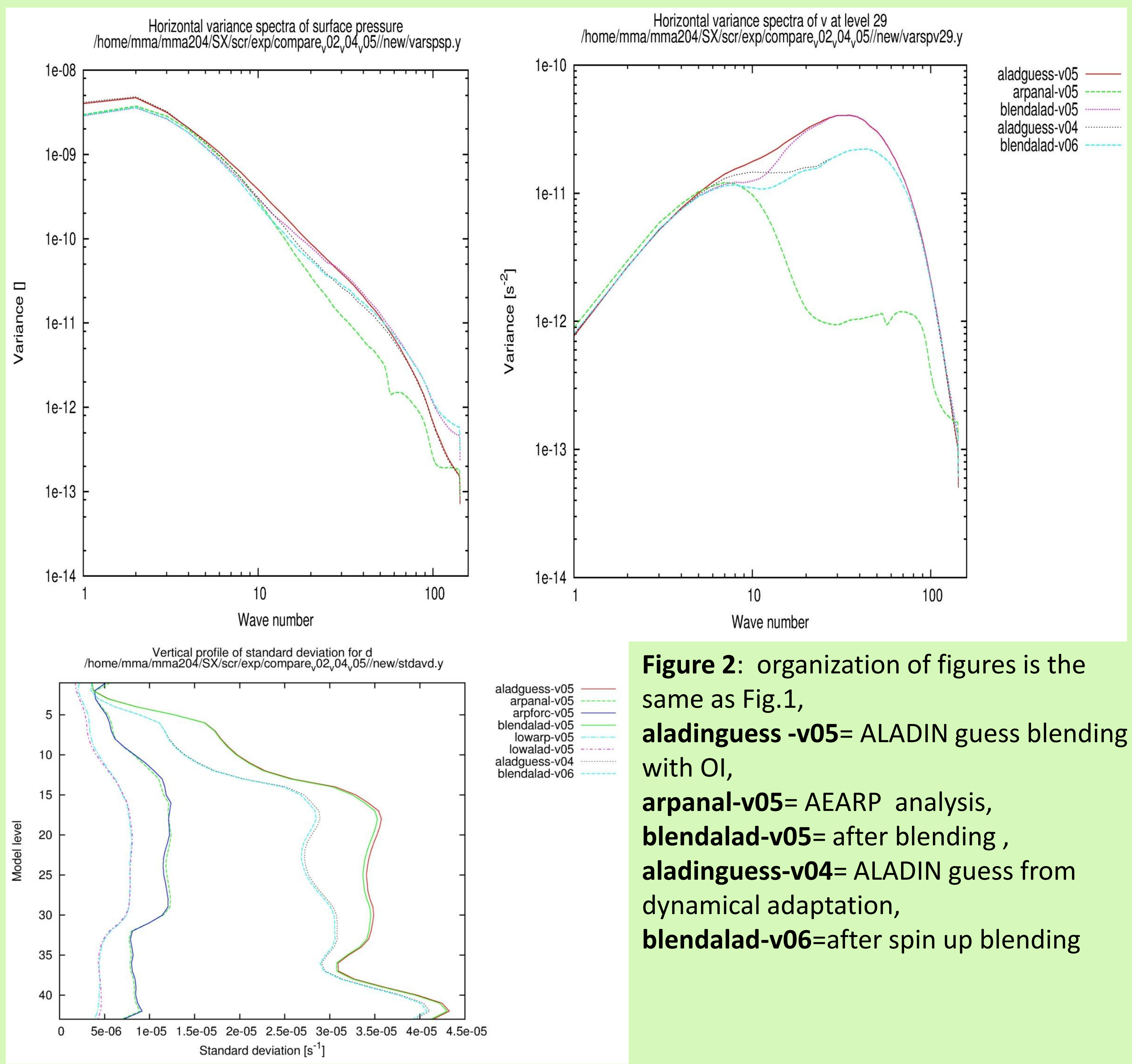

Figure 2: organization of figures is the same as Fig.1,
aladinguess -v05= ALADIN guess blending with OI,
arpanal-v05= AEARP analysis,
blendalad-v05= after blending ,
aladinguess-v04= ALADIN guess from dynamical adaptation,
blendalad-v06=after spin up blending

Standard deviation and variance of ALADIN guess produced in blending cycle are significantly increased against ALADIN guess from dynamical adaptation. The increase is mainly caused by cycling of blending, partial proof can by done by spin up blending which decreases dispersion of ALADIN guess from dynamical adaptation in similar amount as blending in a cycle.

Conclusion

Two member LAM ALADIN ensemble was prepared and dispersion of their difference was studied in successive steps of blending. It was shown that blending approximates in large scales to AEARP analysis and in small scales to ALADIN guess. Also it was shown that blending with cycling increases dispersion significantly.
In the next step we will study differences between model ALADIN and AEAR forecasts and their scale decomposition, inspired by Ştefănescu (2006). Changes in dispersion after 3DVar assimilation step will also be studied .

References

1) Blending of initial fields in ALADIN (2001), technical documentation, www.crnm.meteo.fr/gmapdoc/spip.php?article10&lang=en
2) Ştefănescu , S. E., L. Berre, and M. Belo Pereira, 2006: The evolution of dispersion spectra and the evaluation of model differences in an ensemble estimation of error statistics for a limited area analysis. *Mon. Wea. Rev.*, **134**, 3456-3478