Recent results with the regional Arome-France data assimilation and forecast system

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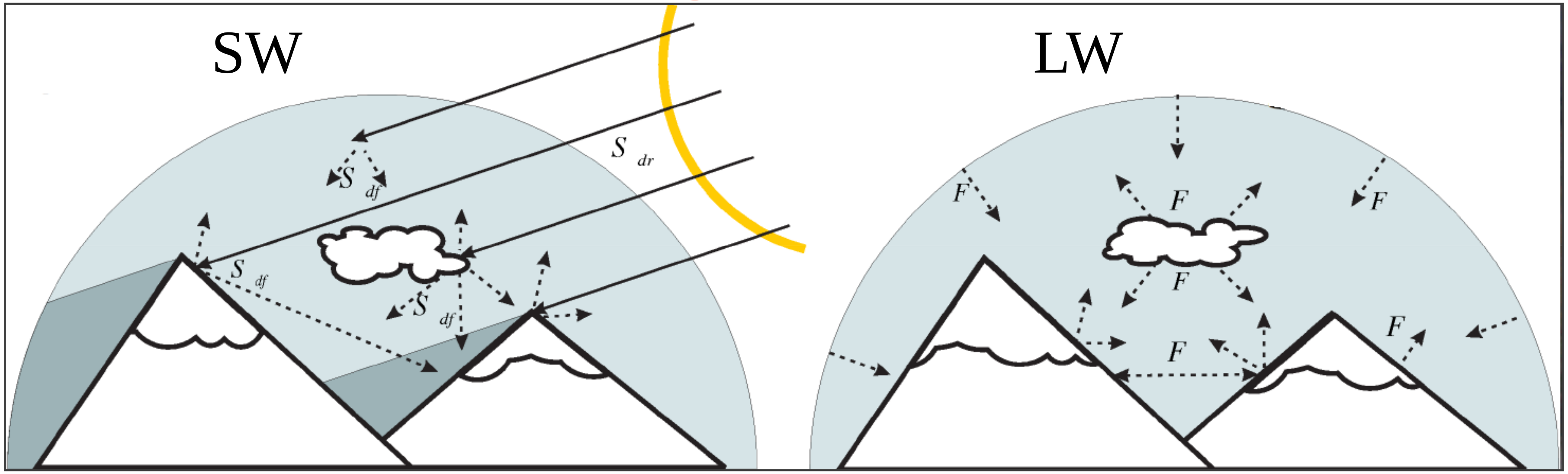
Outline of the talk:

- On the fct model side: ORORAD, other
- Assimilation: increased density of radar data, other
- Research in DA methods: EnVar

Effects of mountains on the surface radiative budget (MF, ZAMG, FMI)



1. Direct incoming radiation:

- Effect of mountain's own slope
- shadowing on neighbouring hills

2. Scattered radiation: Sky View Factor

1. Sky View Factor (SVF)

(Note: shadowing of clouds is not taken into account in the model)

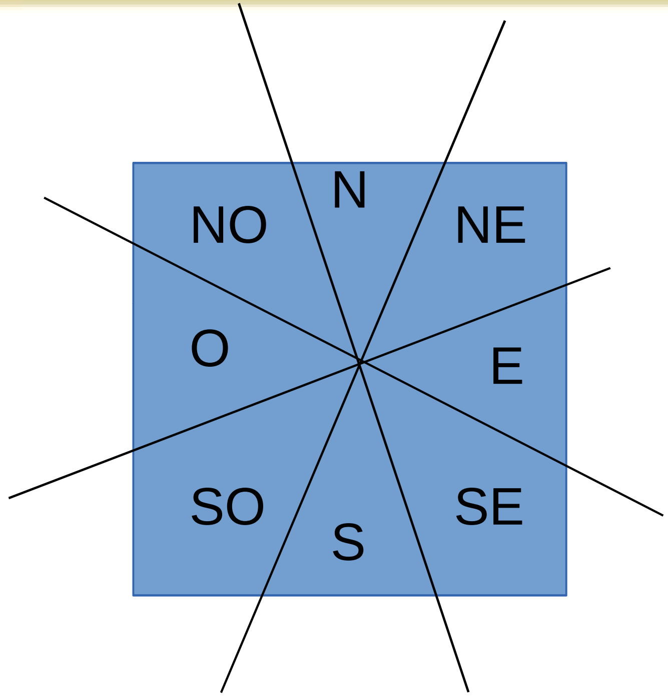
Based on Senkova et al.,2007.

Collaboration HIRLAM-ALADIN (C. Wastl, C. Wittman, L. Rontu, A. Mary, Y. Seity)

=> ORORAD parametrization

ORORAD : slopes and shadowing

For each of the 8 angular sectors, one computes:
- (sl): a mean correction to take into account the local angular rotation of the direction of sun w/r to the (geodesic) solar azimuth
- (sh): the effect of the mean height of the horizon in any of the sectors when the sun is in that sector



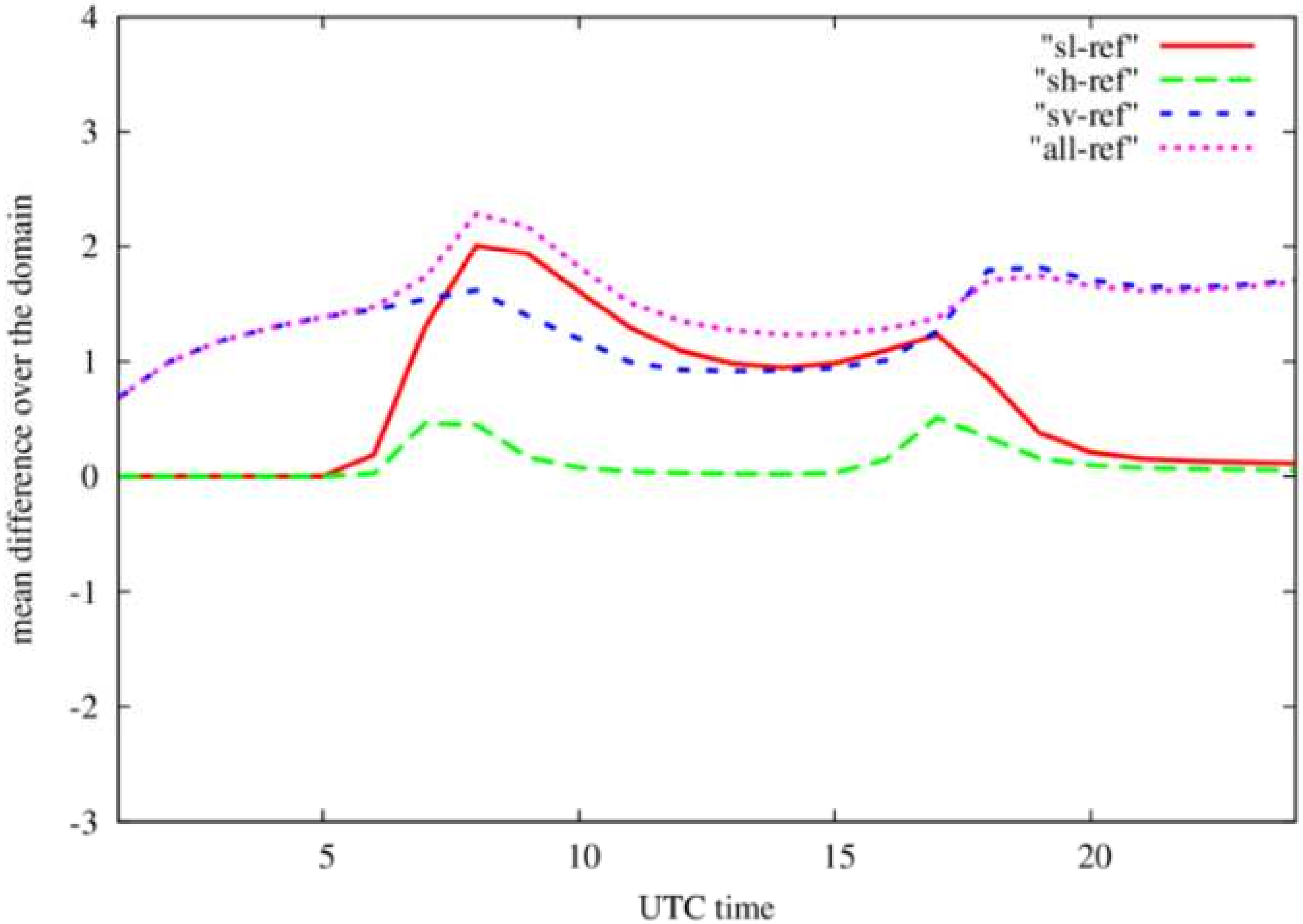
Effect of (sl+sh) on the direct solar radiation : $S_{\downarrow dr} = [\delta_{sl}\delta_{sh}]S_{\downarrow dr,0}$

Effect of Sky View Factor on diffusive radiation (scattering)
Both in LW and SW: *not yet included in pre-operational Arome because Of a positive bias on forecast T2m*

Mean impact (ABS(Ts_exp-Ts_ref))

14-03-2014

Dx = 1.25 km



- the impact of ORORAD increases as horizontal resolution increases
- the impact is maximum in winter
- SVF has the largest impact in night; slopes have the largest impact in day

Other aspects in preparation for the autumn 2015 E-suite of Arome-France:

- Changes in the impact of clouds in radiation scheme:
  - Increased the factor of inhomogeneity
  - Used more recent param of cloud optical properties
  - Following Nielsen etal. (2013)
- Diagnostic of T2M following a proposal by Geleyn (1988), within the assimilation cycle
- Improved computation of snow height
- Retuning of aspects linked with « Psurf instability » of 1.3km model version:
  - Diagnose now P=Phydro + Pnh
  - Retuning of timestep parameters (some small time decentering allowed)

PLAN

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In view of the next Arome E-suite:

- Assimilation of radar data at higher density:

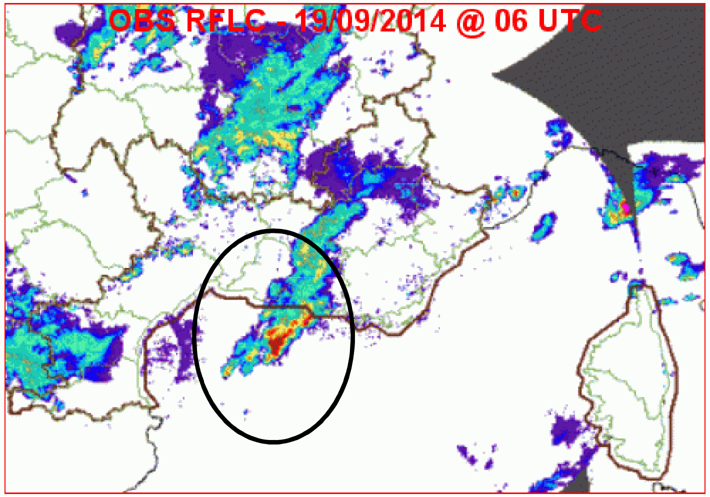
→ 8 km inter-distance of radial wind (Vr) and reflectivity pixels assimilated (against 15 km in operations now)

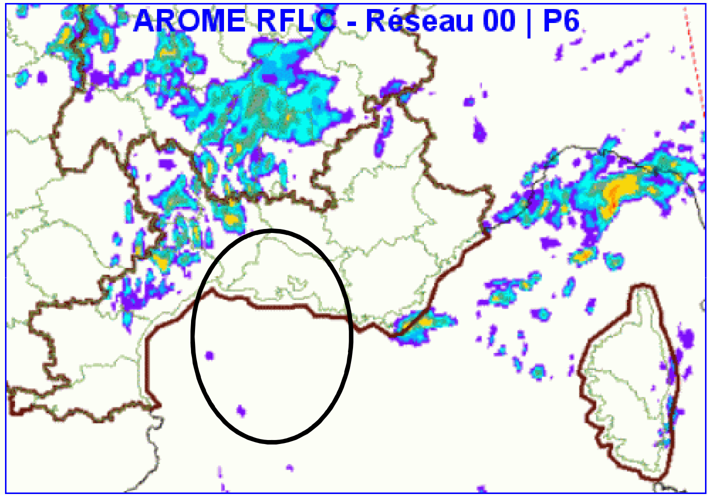
→ Revisited Obs Error Stdev for Vr

→ Retuned parameters for the Bayesian retrieval of RH profiles from reflectivity profiles

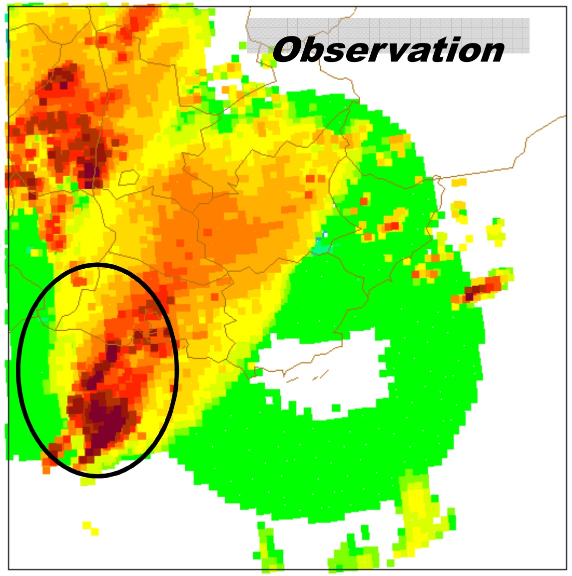
☞ these combined changes seem to have a positive effect on the onset of heavy convection in cases where model first guess and radar data have large discrepancies

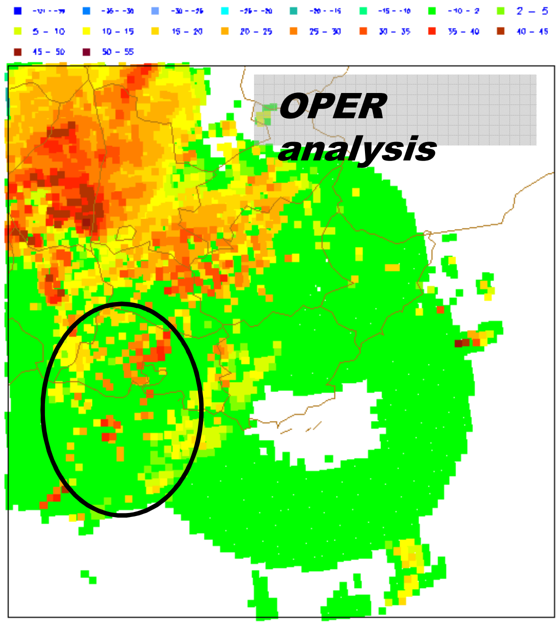
Illustration – Toulon supercell case (19/09/14)





HD radar plus tuning of Sigma_o and tuned param of Refl retrieval





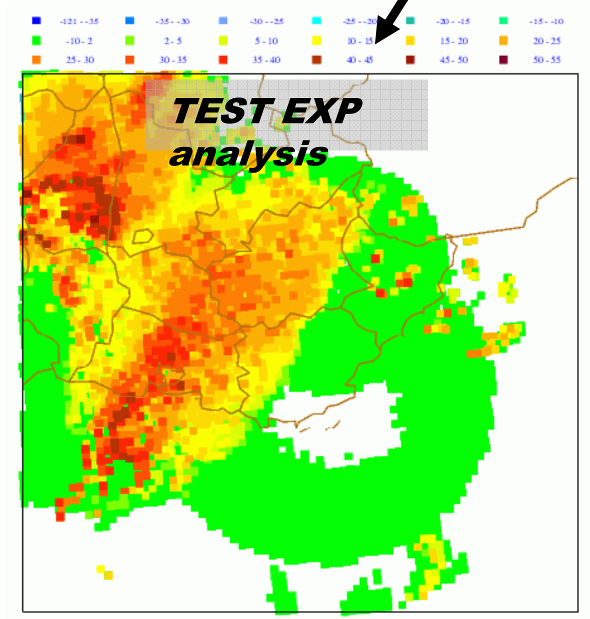
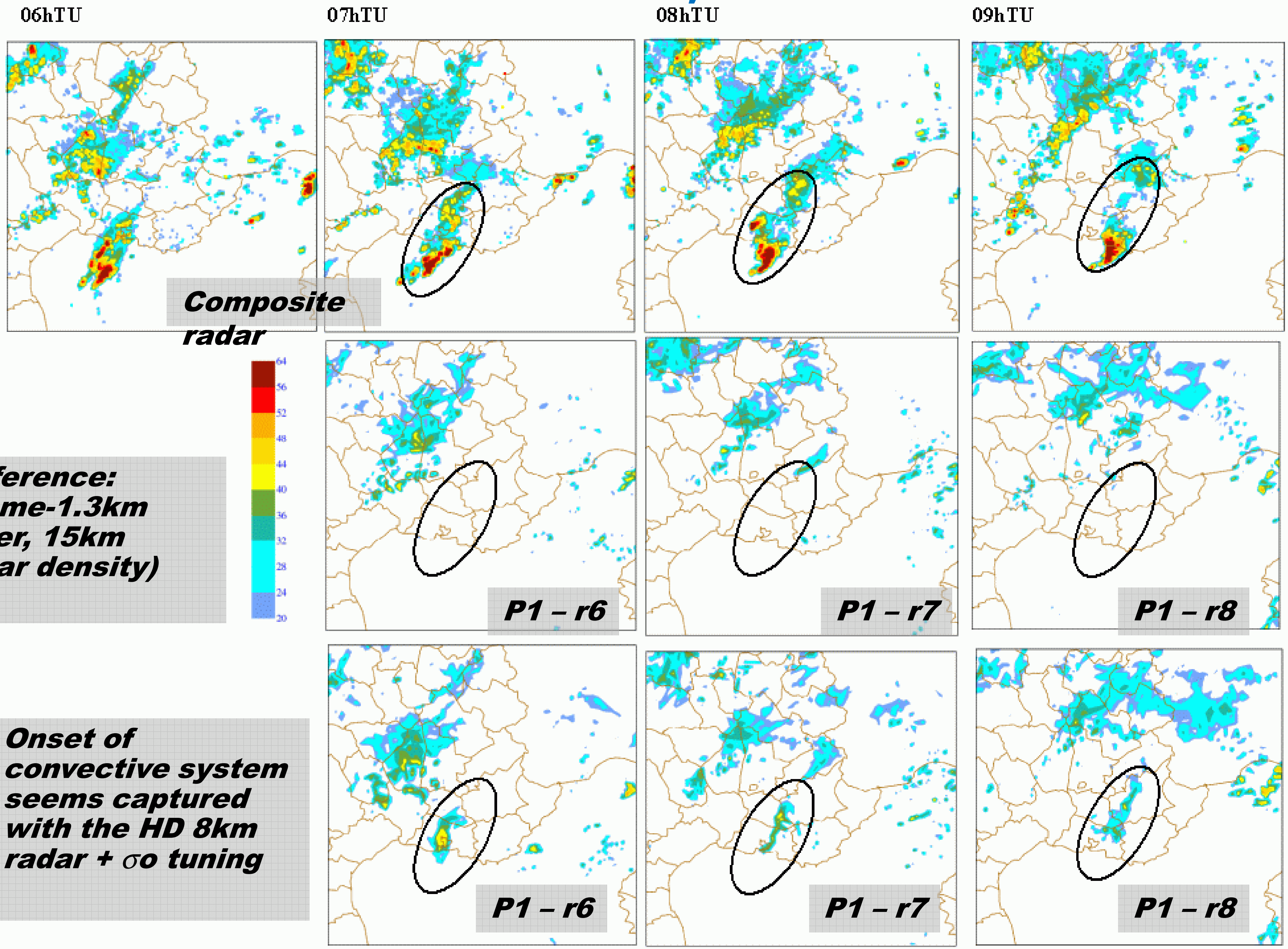


Illustration – Toulon case, onset of convection



Reference: Arome-1.3km (oper, 15km radar density)

Onset of convective system seems captured with the HD 8km radar + σo tuning

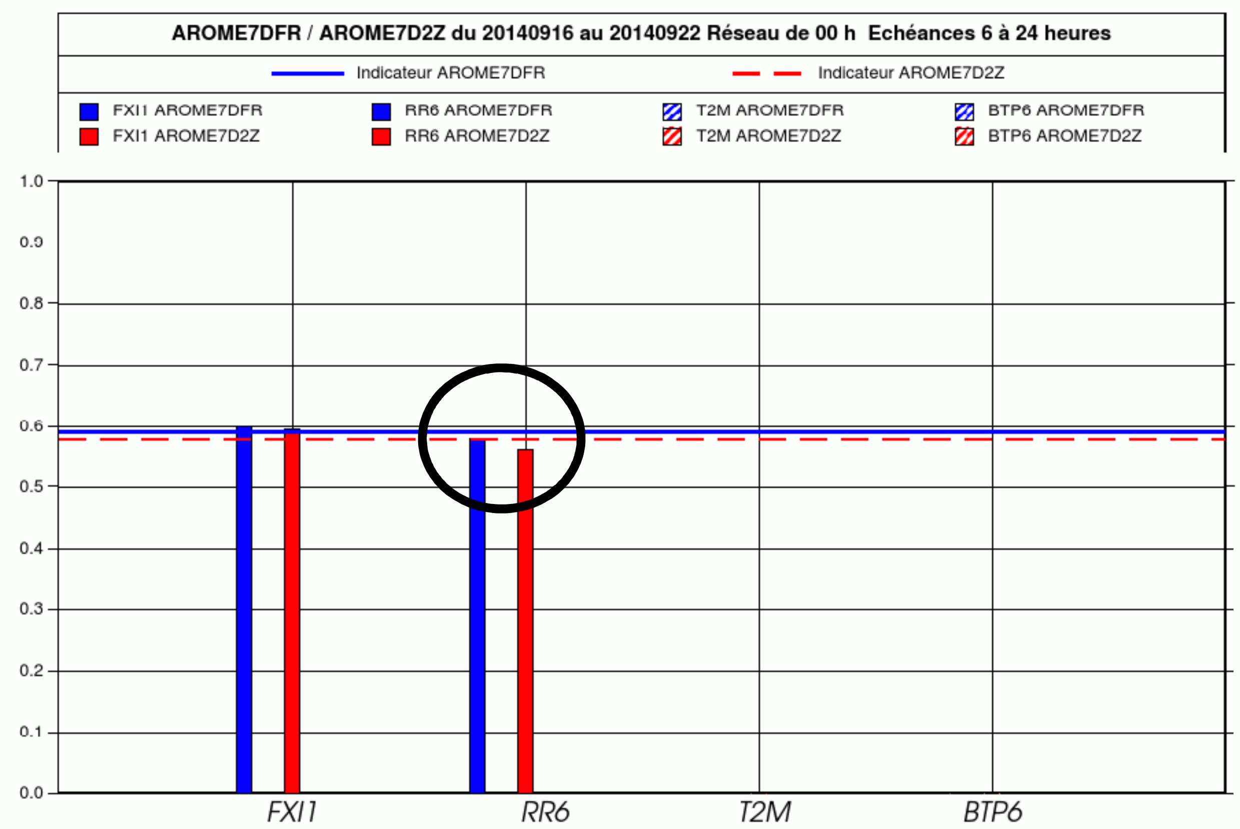
Brier-Skill scores for the 19/09/14 period

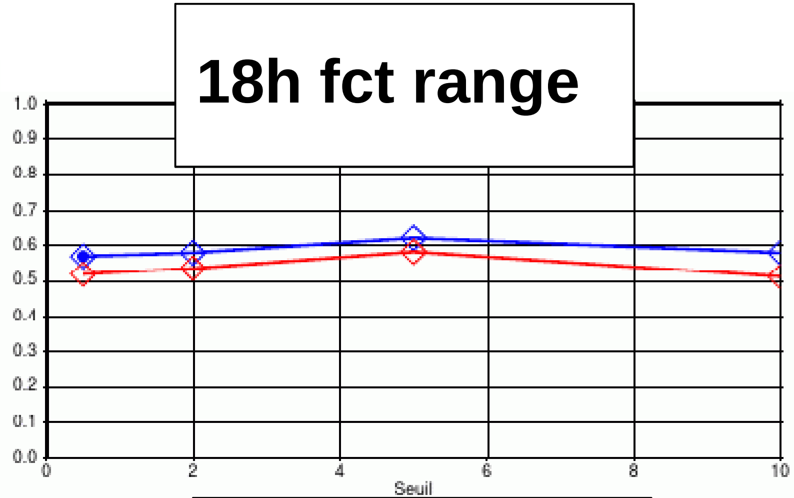
Blue: HD radar

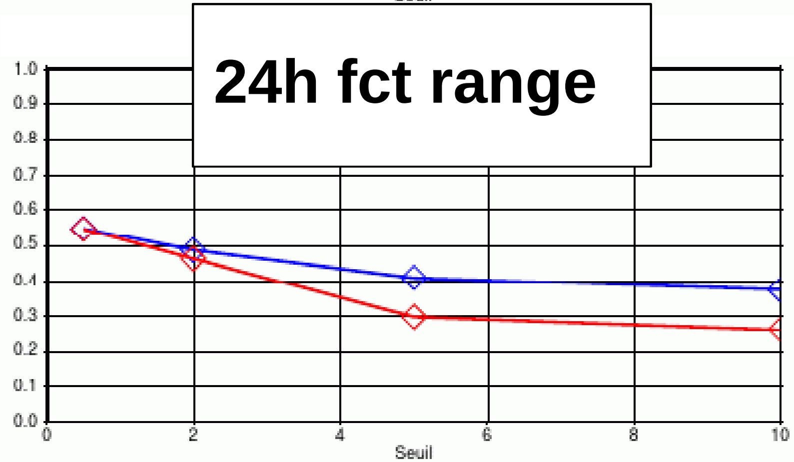
Red: Arome ref oper – 1.3 km

Scores are for the 00 UTC network fcts

Improved BSS for short and mid-term forecast ranges







Other changes in Arome-France assimilation for the next E-suite:

→ Revisited Sigma_O for MHS, HIRS Metop-B

→ Added 5 water vapor channels of CrIs

→ Increased spatial density of SEVIRI and IASI (including cloud detection) under evaluation

→ Monitoring of two X-band Doppler radar: Colombis and Vars

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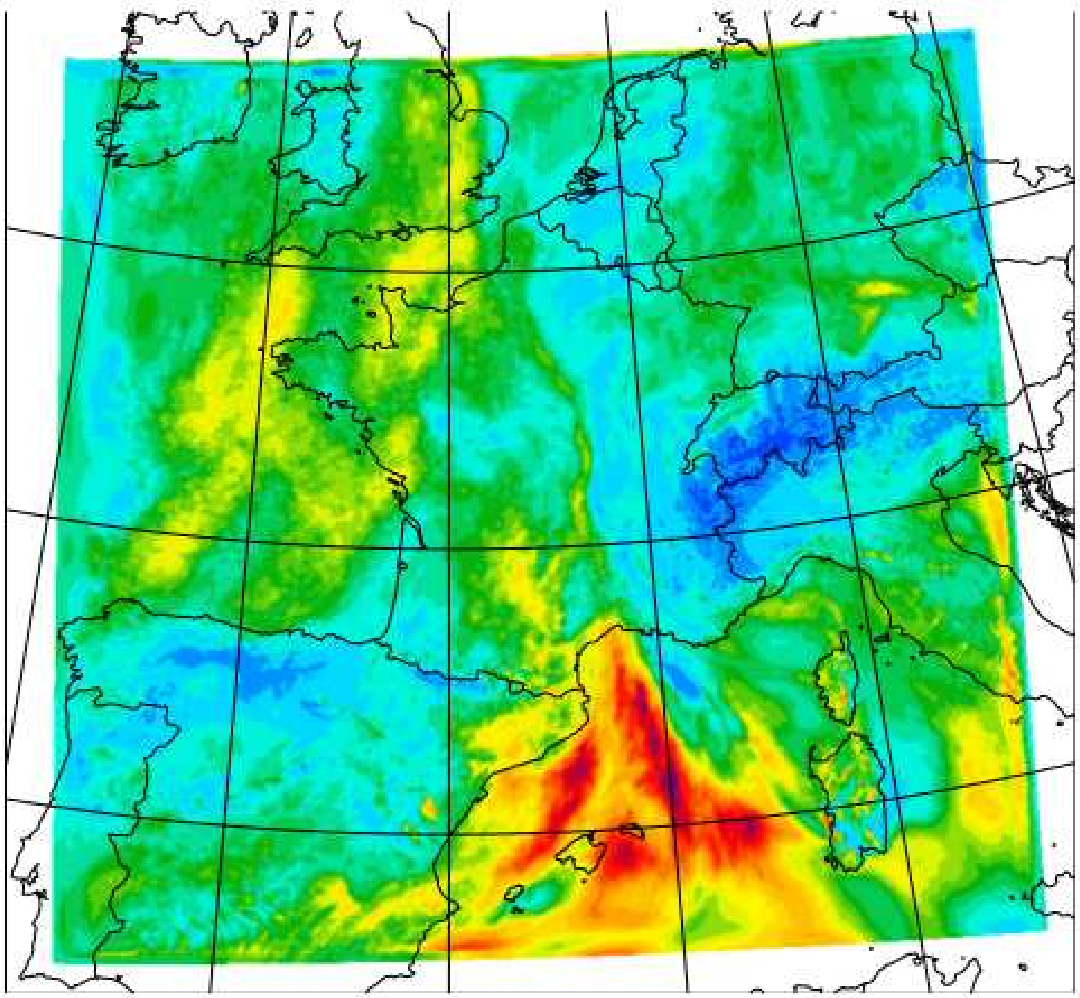
Introduction

Forecast errors at convective scale are strongly inhomogeneous and anisotropic because of the explicit convection, of diabatic processes, of the type of surface, of the coupling files…

AEARO 90



Background error variance for the low-level specific humidity deduced from an AROME ensemble of 90 members (Ménétrier et al. 2014)

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Toujours un temps d'avance

Introduction

Forecast errors sampled from an ensemble following a Monte-Carlo approach can add flow dependency in VAR.

En-VAR methods use entirely or partially covariances deduced from an ensemble in VAR (Hamill and Snyder (2000); Lorenc (2003); Buehner (2005)) :

$$\mathbf{B}_h = \gamma^2 \mathbf{B}_c + (1-\gamma^2)\mathbf{B}_e$$

Hybrid En-VAR merges the advantages of both approaches in a flexible way (oper. at global scale at CMC (Buehner et al, 2010) and at the MO (Clayton et al, 2012), impl. for LAM (Zhang et al, 2012))

Here we will show preliminary results of an En-3DVar that has been set up for AROME in the IFS/OOPS framework.

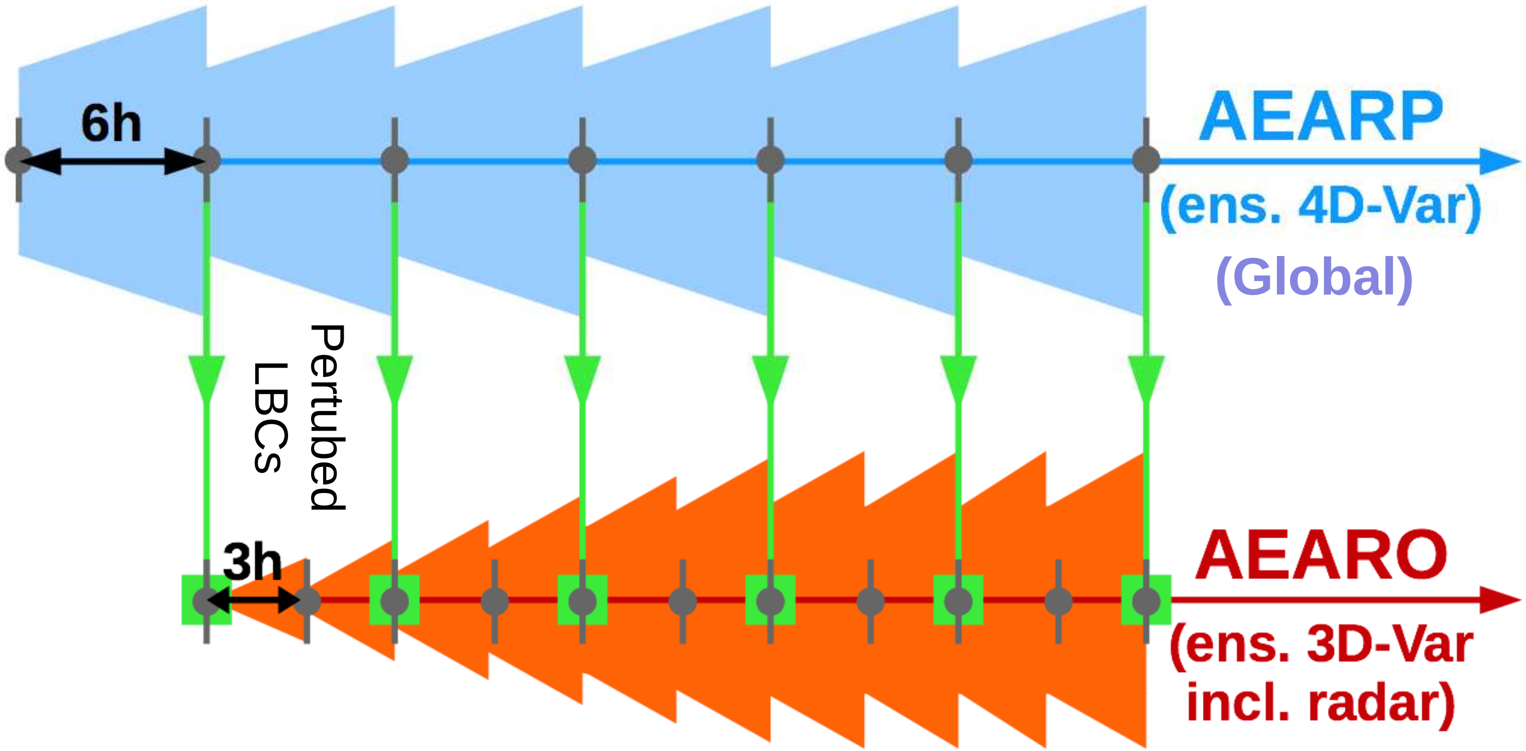
En3DVar for AROME : perturbations

Use of an EDA based on AROME at 4 km (AEARO) with *L* members to compute background perturbations :

$$\delta\widetilde{\mathbf{x}}_p^b = \frac{1}{\sqrt{L-1}}(\widetilde{\mathbf{x}}_p^b - \langle\widetilde{\mathbf{x}}^b\rangle)$$

- Explicit obs. perturb.
- Implicit Bckgd perturb.

- Explicit obs. and LBCs perturb.
- Implicit bkgd perturb.

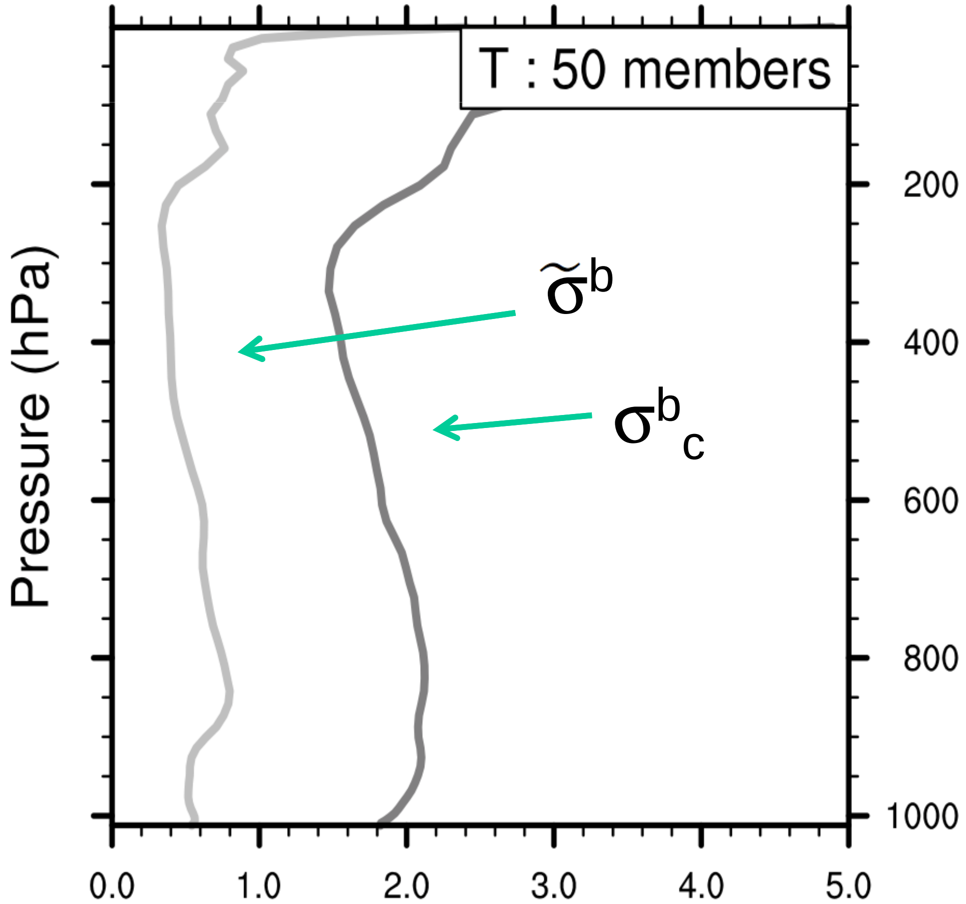


Fisher 2003 ; Kucukkaraca and Fisher (2006); Berre et al 2006

En3DVar for AROME : perturbations

Ensemble spread

$$\widetilde{\mathbf{B}} = \frac{1}{L-1}\sum_{p=1}^{L}\left(\widetilde{\mathbf{x}}_p^b - \langle\widetilde{\mathbf{x}}^b\rangle\right)\left(\widetilde{\mathbf{x}}_p^b - \langle\widetilde{\mathbf{x}}^b\rangle\right)^{\mathbf{T}}$$



Horizontally averaged background error standard deviations for Temperature

$\mathbf{B}_c$ has been calibrated using a mix of summer convective and winter cases (Brousseau et al. 2011), whereas here $\widetilde{\mathrm{B}}$ is computed for a winter case

$\Rightarrow$ Less dispersion in $\widetilde{\mathrm{B}}$

$\Rightarrow$ An inflation of 2 is applied to each perturbations

Other ingredients studied (work in progress)

- Formulation of EnVar following Desroziers etal. (2014) QJRMS
- Localization
- Pre-conditioning
- Coded in the framework of the OOPS library (Object-Oriented IFS codes)

En3DVar for AROME : formulation

From these L sampled perturbations, a localized $\mathbf{B_e}$ is computed

$$\mathbf{B}_e = \widetilde{\mathbf{B}} \circ \mathbf{C} = \mathbf{X}^b \mathbf{X}^{b^T} \circ \mathbf{C}$$

with :

$$\mathbf{X}^b = \left[\delta\widetilde{\mathbf{x}}_1^b, \ldots, \delta\widetilde{\mathbf{x}}_L^b\right]$$

The localization matrix **C** aims in reducing sampling noise by damping covariances with range (*Houtekamer and Mitchell (2001)*)

Use of a simplified **C** :

$$\mathbf{C} = \begin{pmatrix} \mathbf{I}_N \\ \vdots \\ \mathbf{I}_N \end{pmatrix} \mathcal{C} \left(\mathbf{I}_N \ldots \mathbf{I}_N\right) = \mathbf{1}_N \mathcal{C} \mathbf{1}_N^T$$

$\mathbf{I}_N$ is a N x N identity matrix, $\mathbf{1}_N$ is composed of M (x (K+1)) $\mathbf{I}_N$ blocks, and $\mathcal{C}$ is a N x N correlation matrix

En3DVar for AROME : Localization

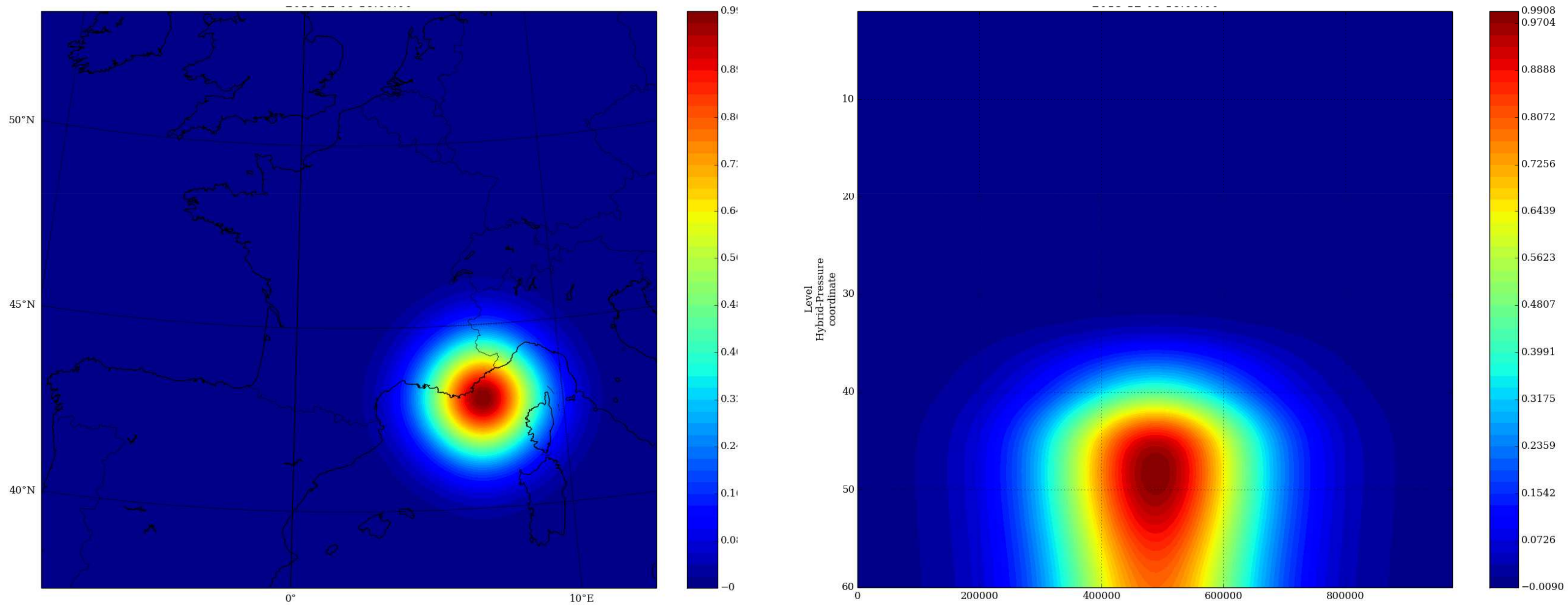
- In this formulation, applying the same vertical variations of L_h for all variables is possible
- Gaspari and Cohn (1999) compactly supported function is chosen on both directions
- Horizontally, two versions have been implemented :
  - ✓ Spectral, using bi-Fourier decomposition $\mathcal{C} = \mathbf{S}^{-1}\mathcal{C}^{S}\mathbf{S}^{-T}$
  - ✓ Grid-point, using recursive filters (Purser et al, 2003)
- Vertically, recursive filters with a grid deformation can also be activated, following Michel (2012)

En3DVar for AROME : Localization

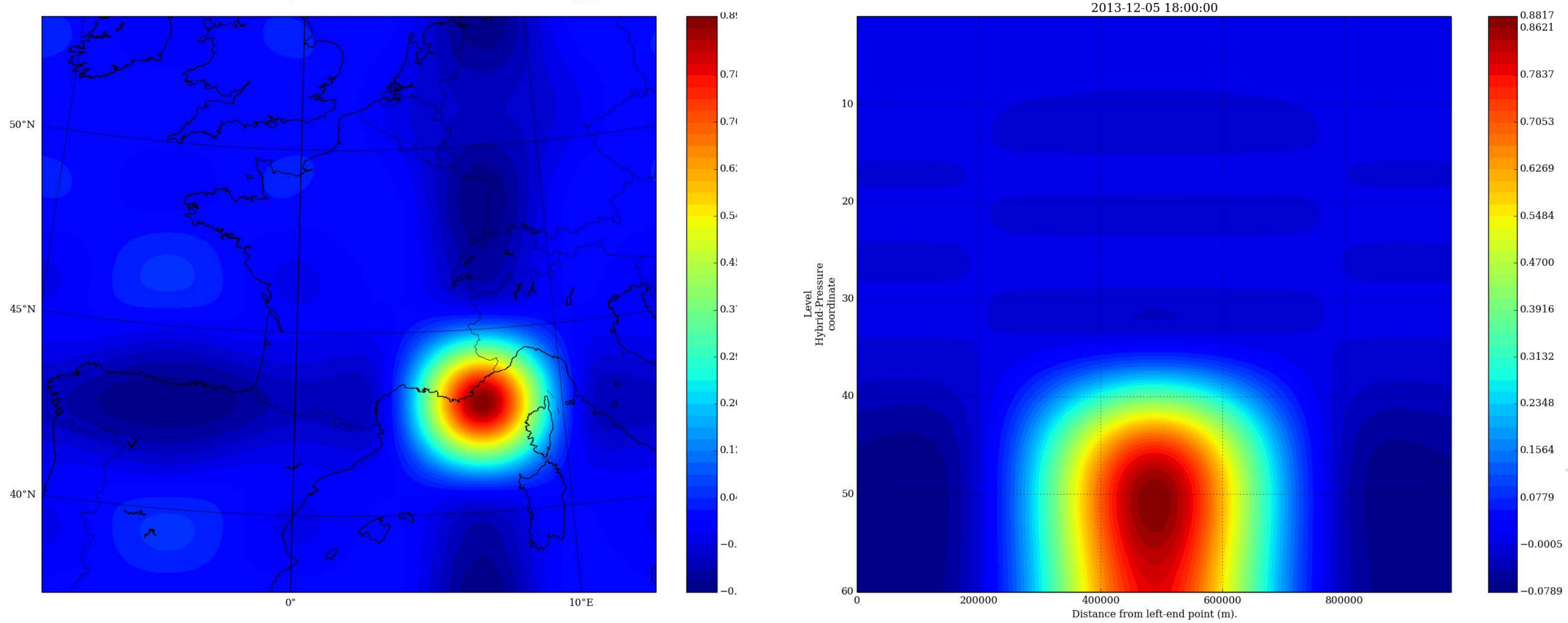
Localization functions with L_h = 250 km and L_v = 0.2 (log(P) levels) :

$\delta_{i,j,k}$ **C**

Recursive filters

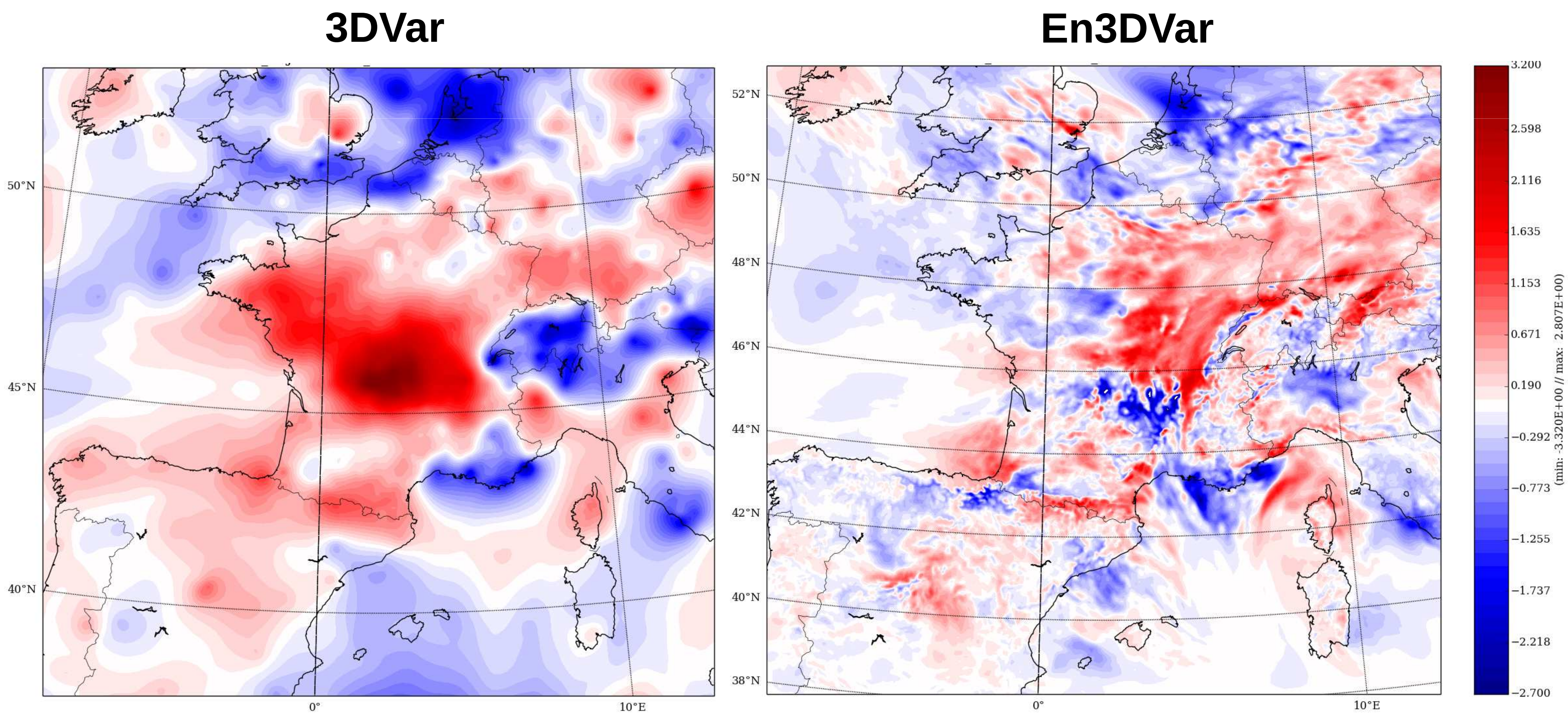


Bi-Fourier



Compared 3D-VAR/En3DVar analyses

With conventional observations



Horizontal cross-sections of T increments at 850 hPa

End

Hvala na pažnji

cnrs dépasser les frontières

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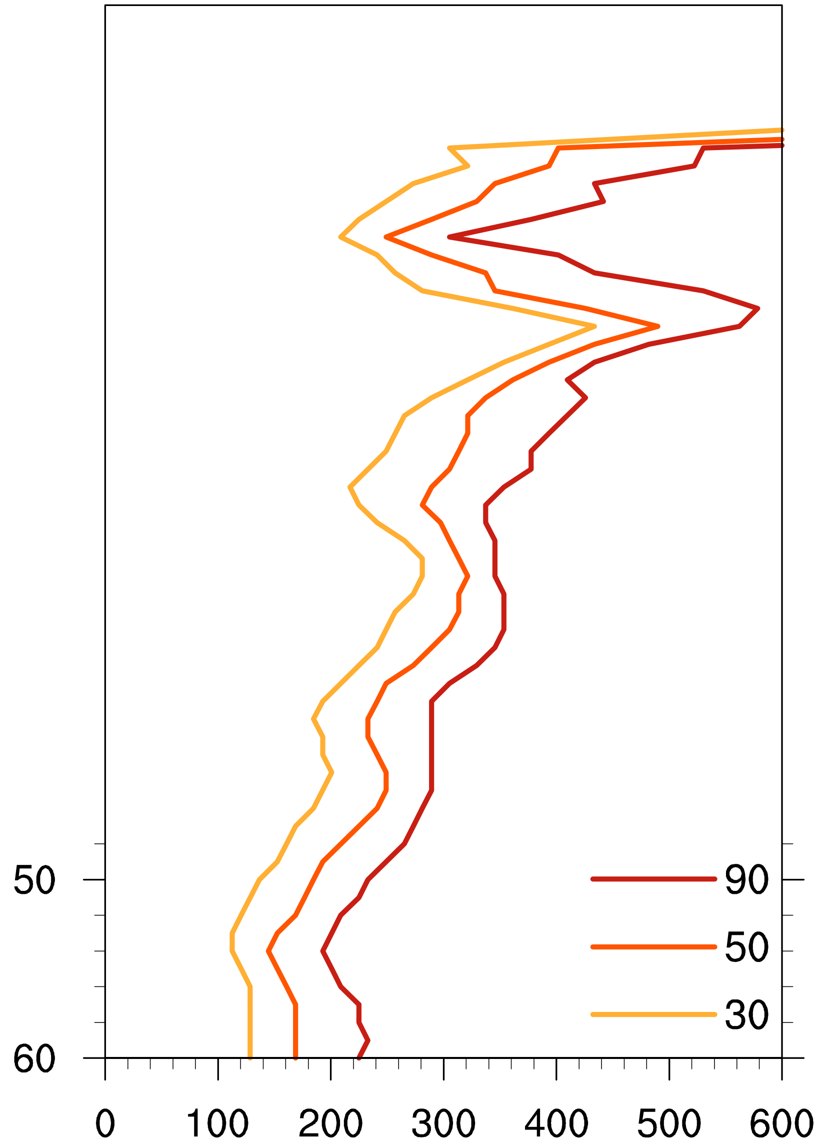
En3DVar for AROME : Localization

Optimal L_h have also been diagnosed from the ensemble using Ménétrier et al. (2015) iterative mehod

⇒ Variations with vertical levels, variables and ensemble size have been found



L_h in km for Temperature and for different ensemble sizes

En3DVar for AROME : Pre-conditionning

- A pre-conditionning by $\mathbf{B_e}$ is applied instead of $\mathbf{B_e}^{1/2}$.

- The DPCG algorithm (Derber and Rosati, 1989; Gürol et al, 2014) is used with $d\mathbf{x}$ as control variable (dim: M x N x $(K+1)$)

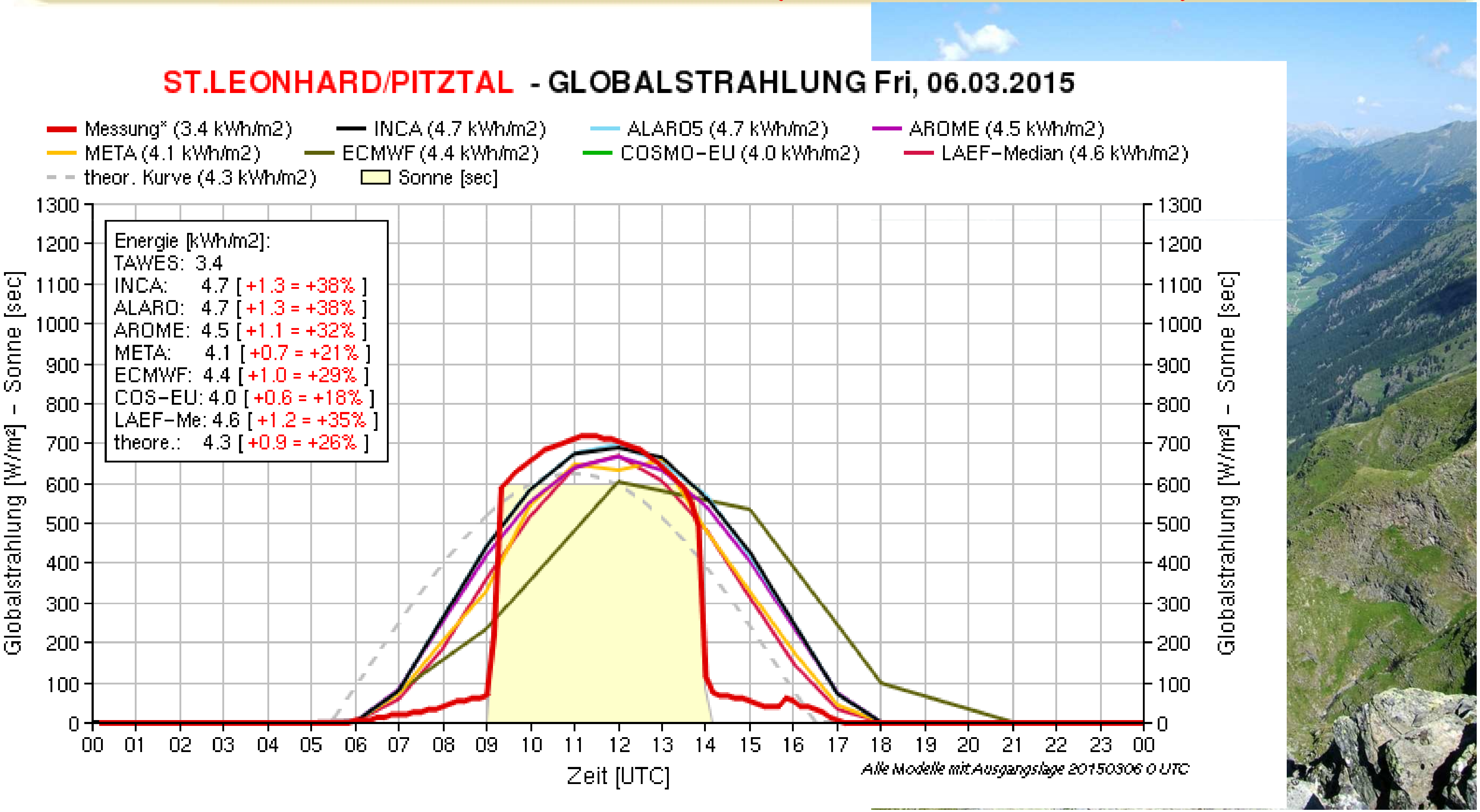
- At each iteration, the quantity $\mathbf{h} = \mathbf{B_e}\ \mathbf{g}$ has to be computed, which is equivalent to solve for the m parameter at time k (Desroziers et al., 2014) :

$$h_{k,m} = \sum_{l=1}^{L} \sum_{k'=0}^{K} \sum_{m'=1}^{M} \delta\widetilde{\mathbf{x}}^b_{l,k,m} \circ (\mathbf{S}^{-1} \mathcal{C}^S \mathbf{S}^{-T} (\delta\widetilde{\mathbf{x}}^b_{l,k',m'} \circ g_{k',m'}))$$

$\Rightarrow$ No control variable change nor additional alpha-variable

$\Rightarrow$ Easy implementation of hybrid versions : simply replace $\mathbf{B}_\mathrm{e}$ by $\mathbf{B}_\mathrm{h}$ in the conjugate gradient

Improving the radiative effects at the surface, in mountain areas (MF, ZAMG, FMI)



Austria Tyrol (ZAMG, C. Wittmann & C. Wastl)