

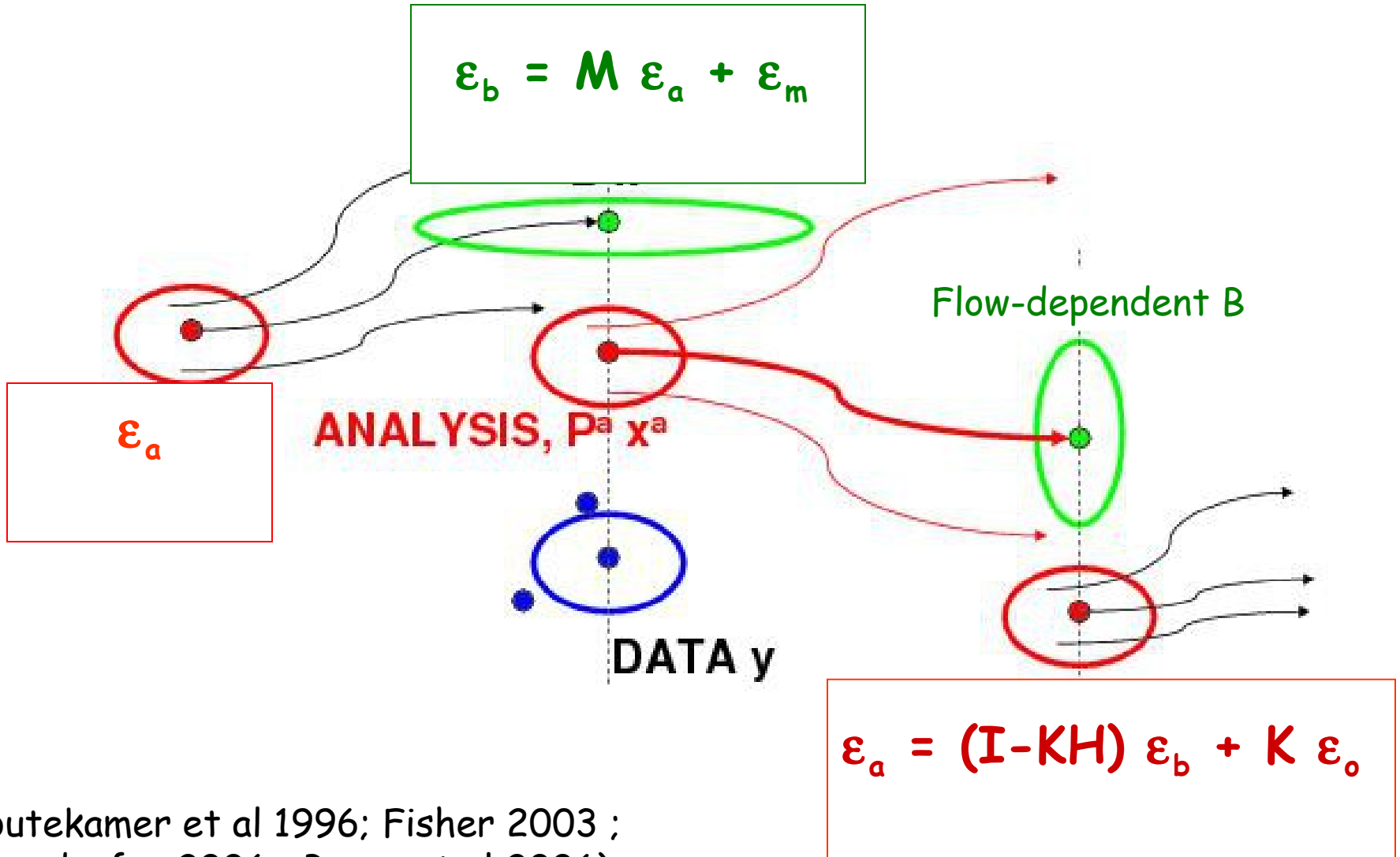
# Variational ensemble DA

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M. Monteiro, P. Brousseau, T. Montmerle, C. Labadie*

# Outline

- EnVar and its applications.
- Model error (estimation and representation).
- Wavelet flow-dependent correlations.

Ensemble assimilation (EnDA = EnVar, EnKF, ...):  
simulation of the error evolution



(Houtekamer et al 1996; Fisher 2003 ;  
Ehrendorfer 2006 ; Berre et al 2006)

## The operational M.F. ensemble Var assimilation

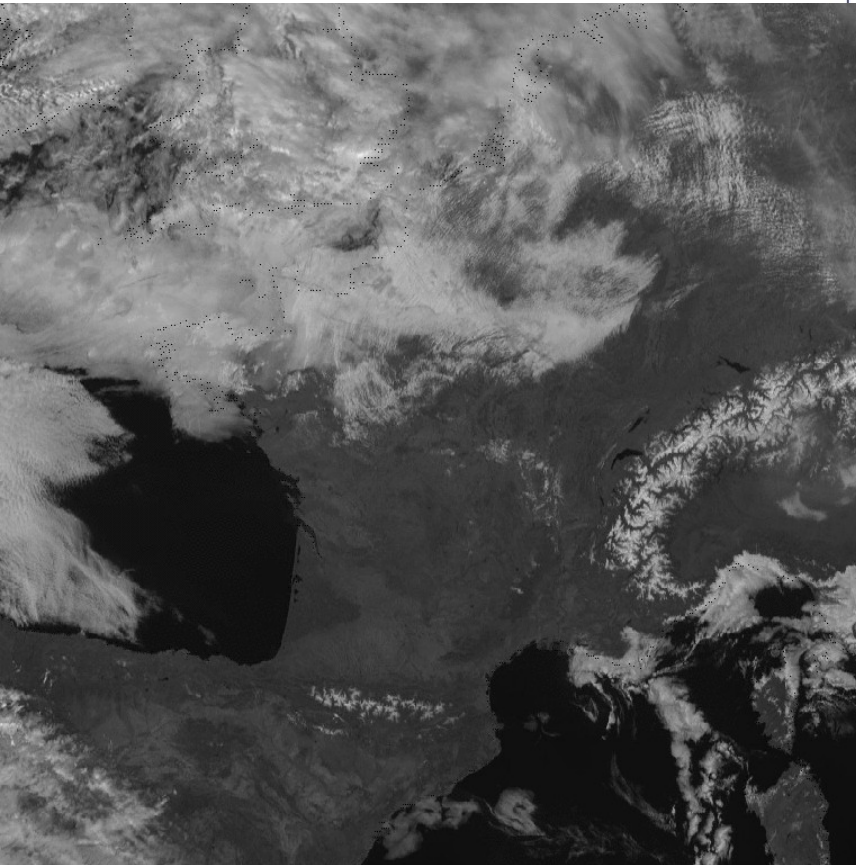
- Six perturbed **4D-Var** members (Arpege T399) :  
**consistent simulation of error cycling.**
- Objective **spatial filtering of « flow-dependent  $\sigma$ 's ».**  
(Wavelet filtering for correlations soon.)
- **Inflation** of ensemble B / model errors,  
soon inflation of perturbations (double suite).
- **Regional EnVar** (LAM) experimented,  
with Aladin (10 km) and Arome (2.5 km).

## Applications of EnDA at M.F.

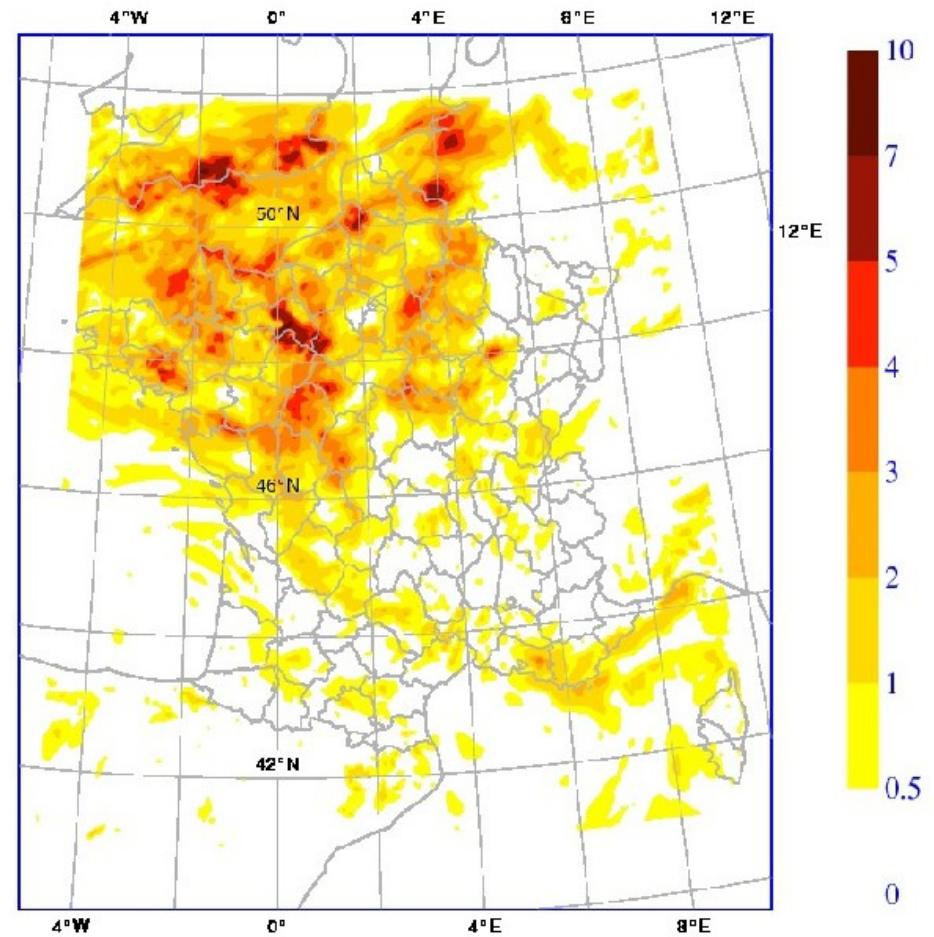
- **Flow-dependent error variances** (oper 2008)  
for all variables : mass, wind and **moisture**.  
⇒ for **obs. quality control** and for **minimizations**.
- **Flow-dependent correlations** : wavelet filtering  
(Varella et al 2011, 2012).
- **Initialisation of M.F. ensemble prediction** (PEARP)  
by EnDA (oper 2009).
- **Aladin/Arome** : oper. climatological covariances, and  
exp. flow-dependent covariances (M. Monteiro, P. Brousseau et al).

# Exp. flow-dependent variances in LAMs (P. Brousseau et al (2012), M. Monteiro et al (2010))

Low cloud cover on  
23/2/2008 (MSG)

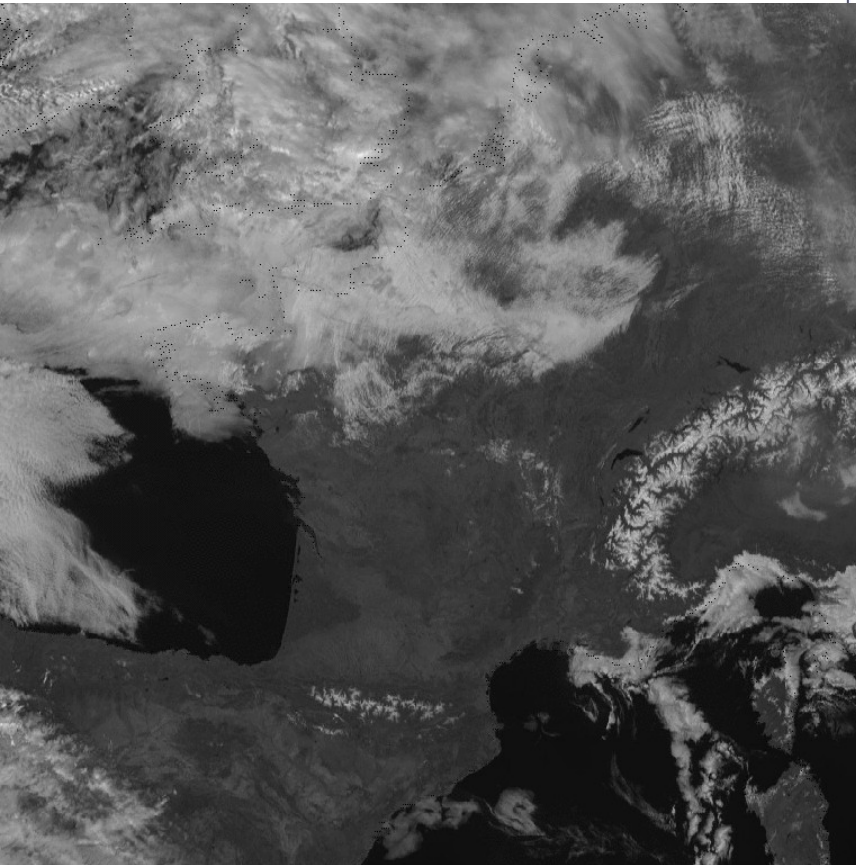


Error std of the day (T 900 hPa)  
(Arôme EnVar, 6 members)

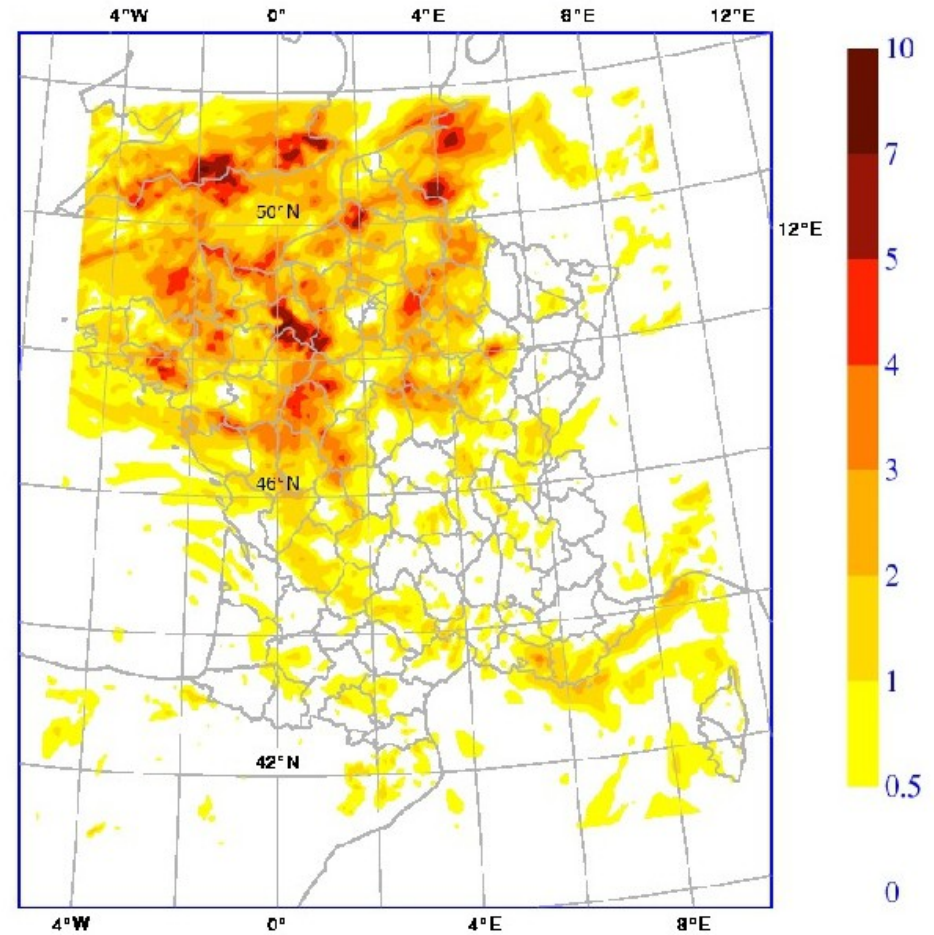


# Exp. flow-dependent variances in LAMs (P. Brousseau et al (2012), M. Monteiro et al (2010))

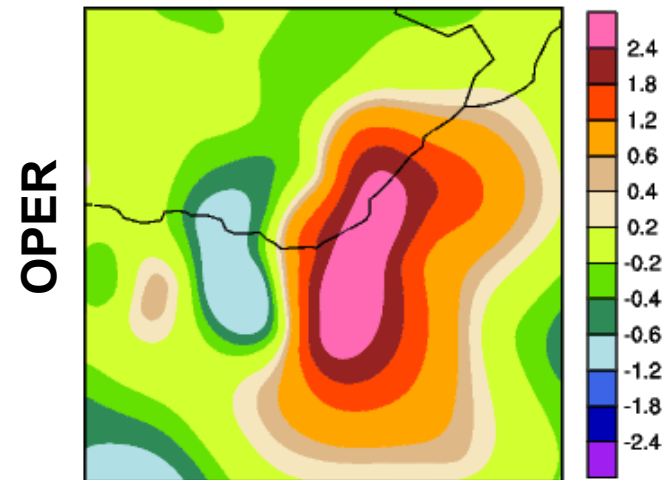
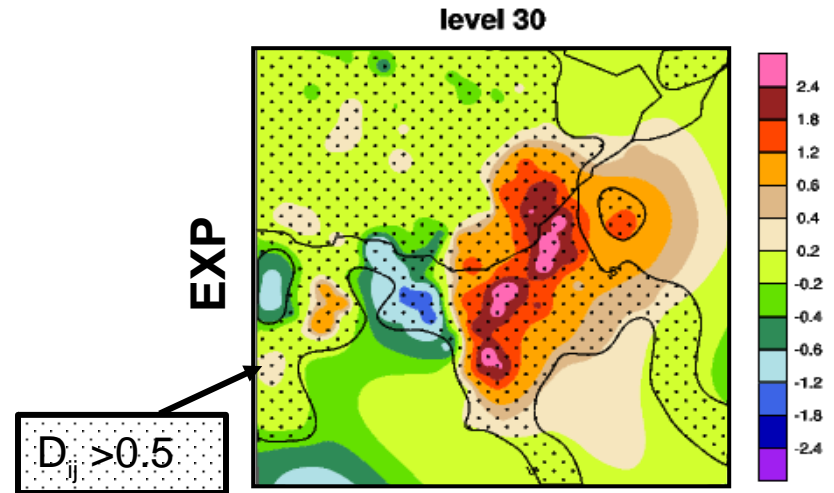
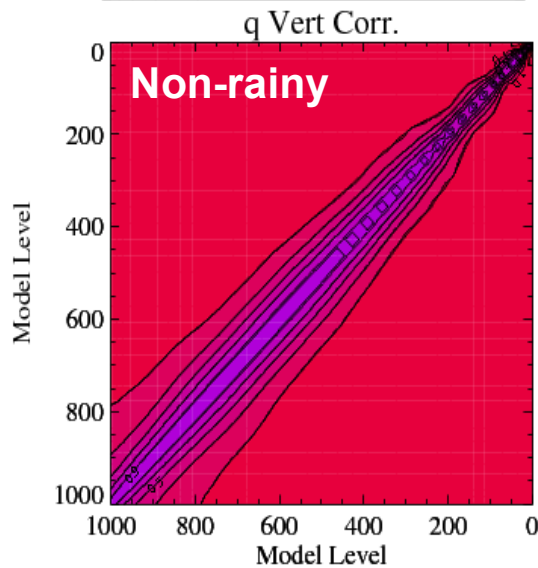
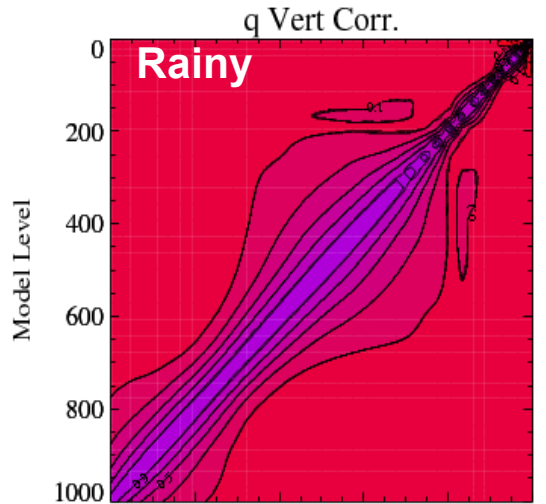
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# Heterogeneous covariances for precipitation assimilation (Montmerle et al 2010, 2012)



*Inc(q) at 600 hPa*  
*(g.kg<sup>-1</sup>)*

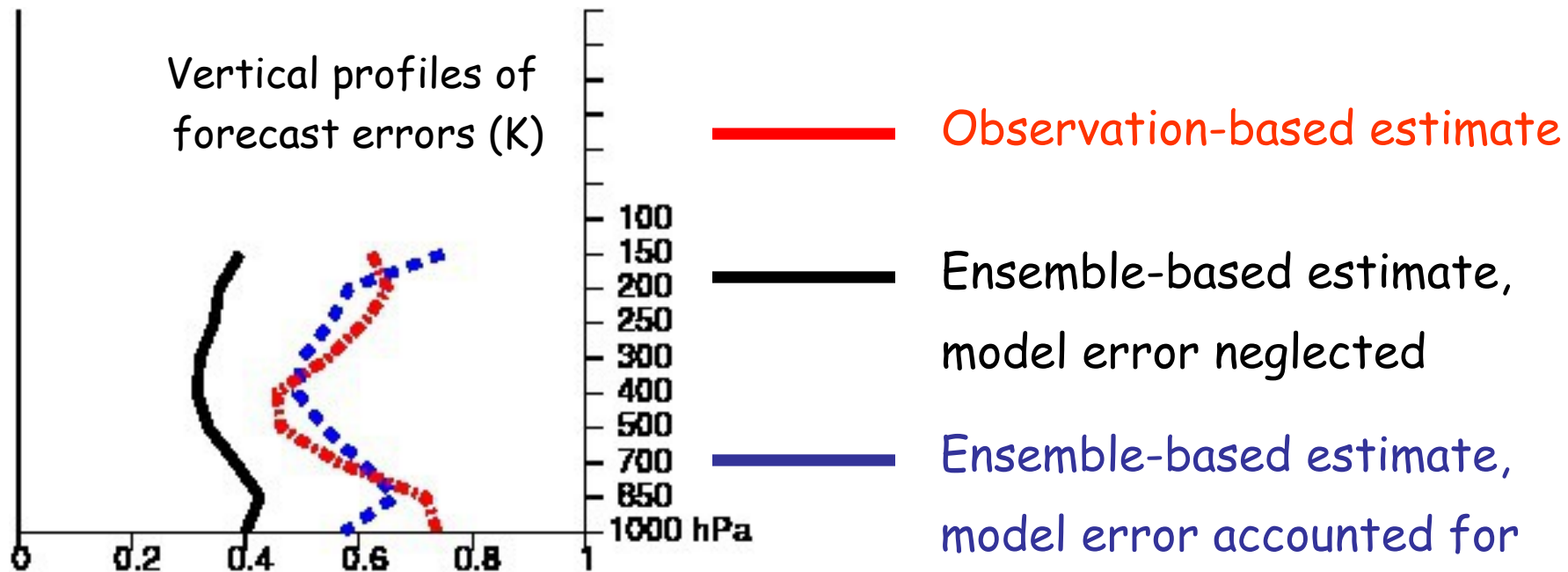


## Model error in M.F. ensemble 4D-Var (Raynaud et al 2012)

### Methodology :

1. « Total » forecast error variances  $V[ M e^a + e^m ]$   
from innovations (Jb\_min).
2. Compare / ensemble-based variances  $V[ M e^a ]$   
=> inflation factor  $\alpha$ .
3. Inflation of forecast perturbations (by  $\alpha > 1$ ).

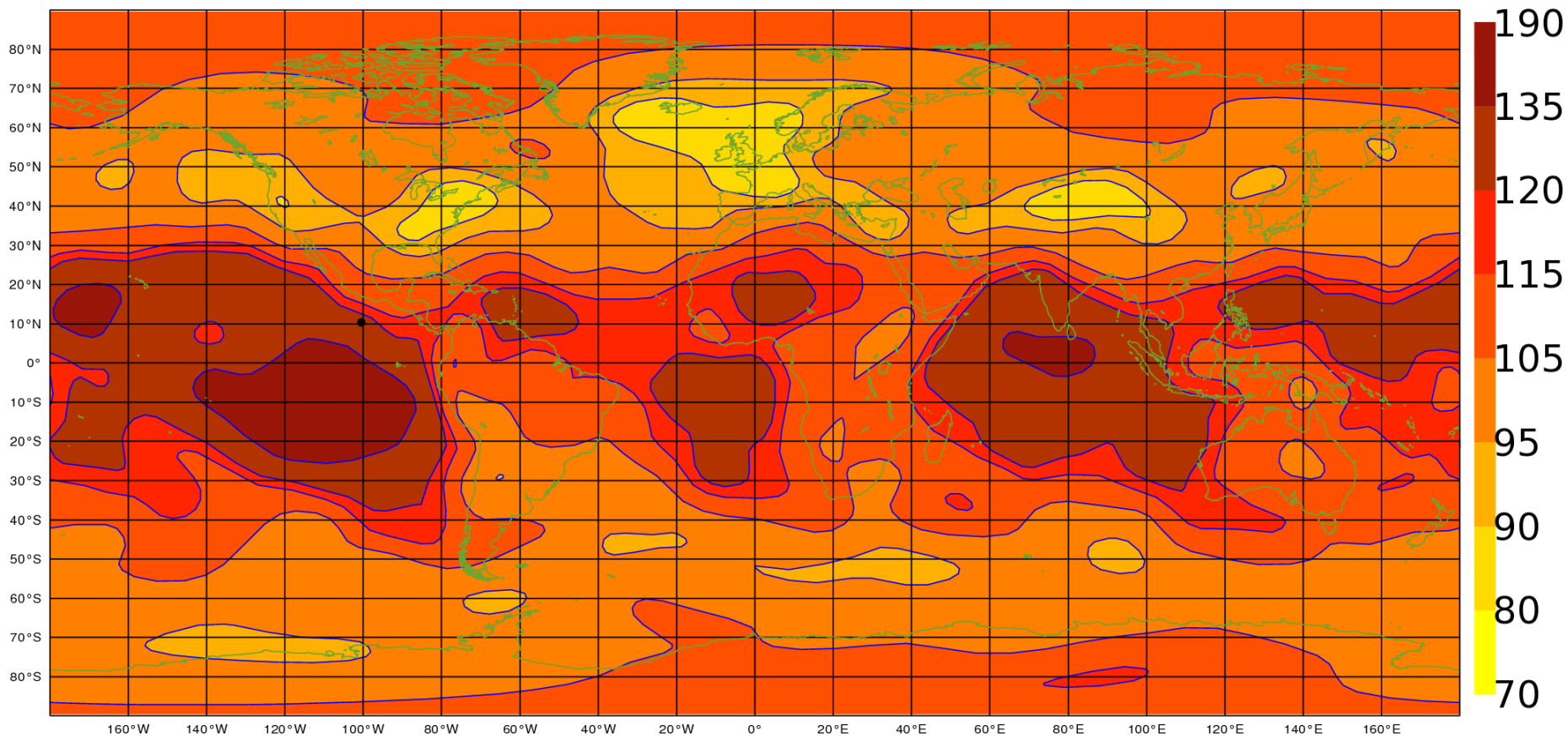
## Model error in M.F. ensemble 4D-Var



## Model error in M.F. ensemble 4D-Var

- Inflation of forecast perturbations by **15%** every 6h.
- **Much more realistic initial spread** (by a factor 2-3) for ensemble prediction.
- **A vertical and latitudinal dependence** is needed w.r.t. high level tropical winds.
- Neutral impact of new variances on the forecast quality.

# Flow-dependent error correlations using EnDA and wavelets



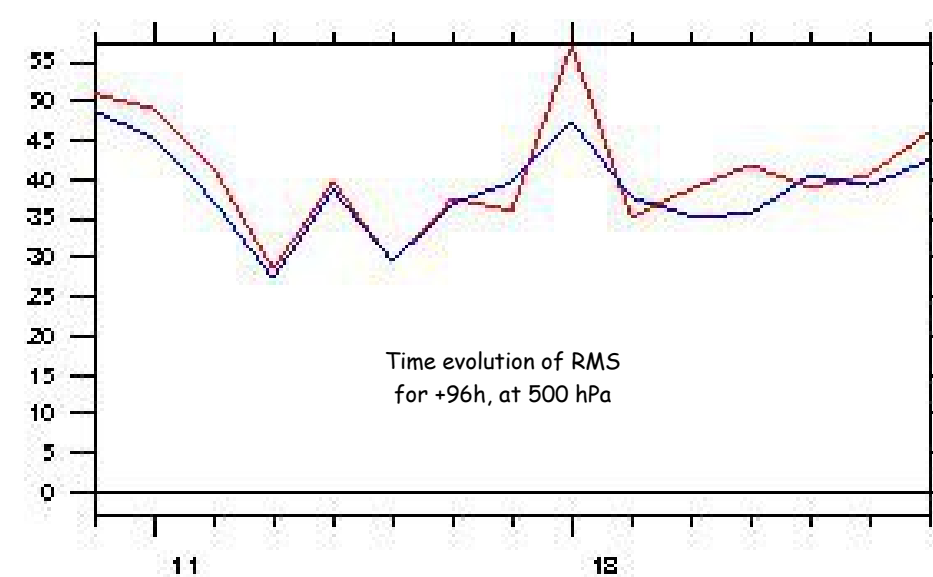
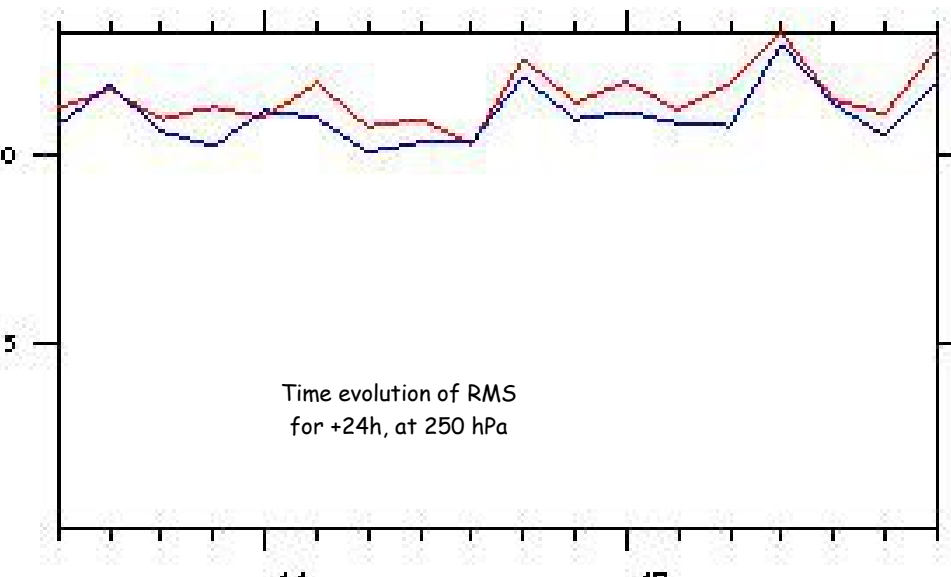
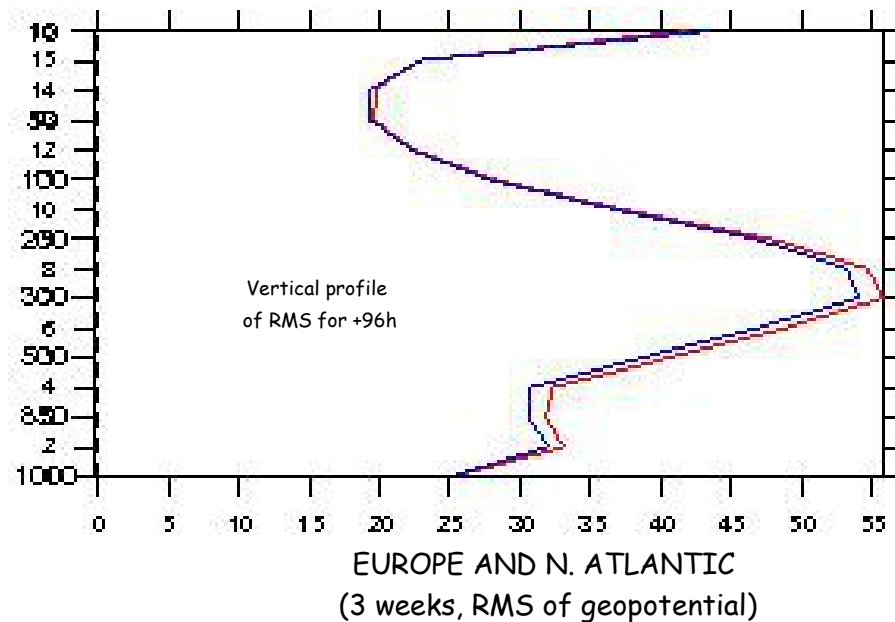
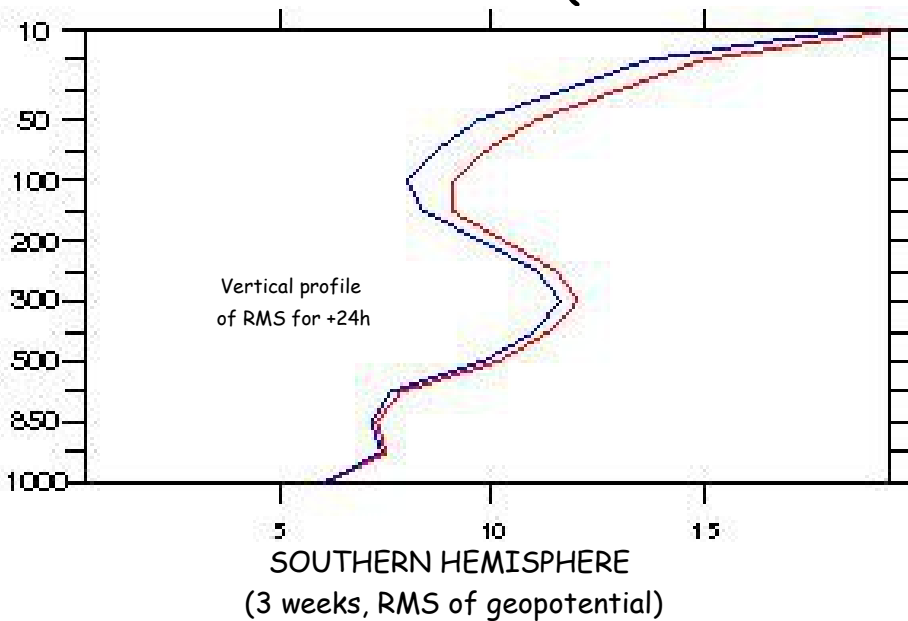
Wavelet-implied horizontal length-scales (in km),  
for wind near 500 hPa, averaged over a 4-day period.

(Varella et al 2012, and also Fisher 2003,  
Deckmyn and Berre 2005, Pannekoucke et al 2007)

## Recent experimentations of wavelet correlations (Varella et al 2012)

- Wavelets + EnDA without inflation :  
**positive impacts.**
- Wavelets + EnDa with inflation :  
**mixed results**, negative in high stratosphere (> 100 hPa).
- Wavelets + EnDa with inflation  
+ climatological correlations in high stratosphere :  
**positive impacts.**

# Wavelet flow-dependent correlations against **spectral static correlations** (December 2011, including inflation)



# Conclusions

- EnVar : **error simulation** consistent with determ. Var.
- **Optimized spatial filtering** techniques.
- **Innovation diagnostics** to estimate model errors.
- EnVar is **a major component of Météo-France EPS**.

## Future work

- High resolution **regional EnVar**.
- Towards **4D-En-Var** (Buehner 2010).



Thank you  
for your attention

