Recent activities and outlook on data assimilation at Météo-France and partner Aladin countries

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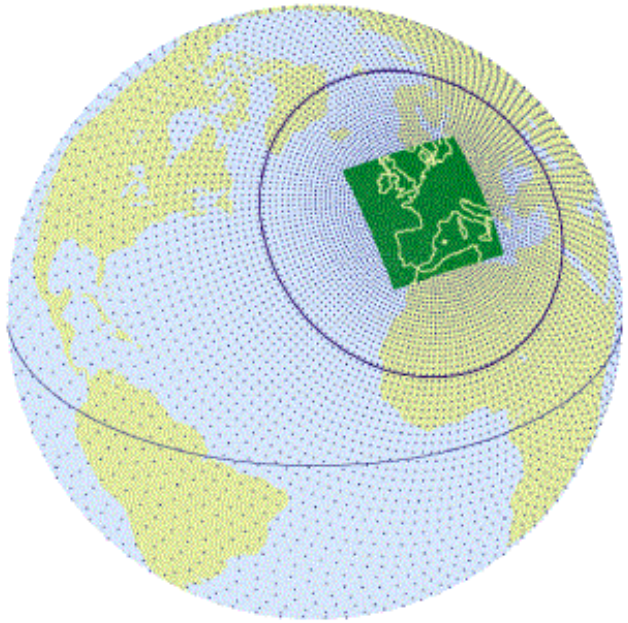
METEO FRANCE
Toujours un temps d'avance

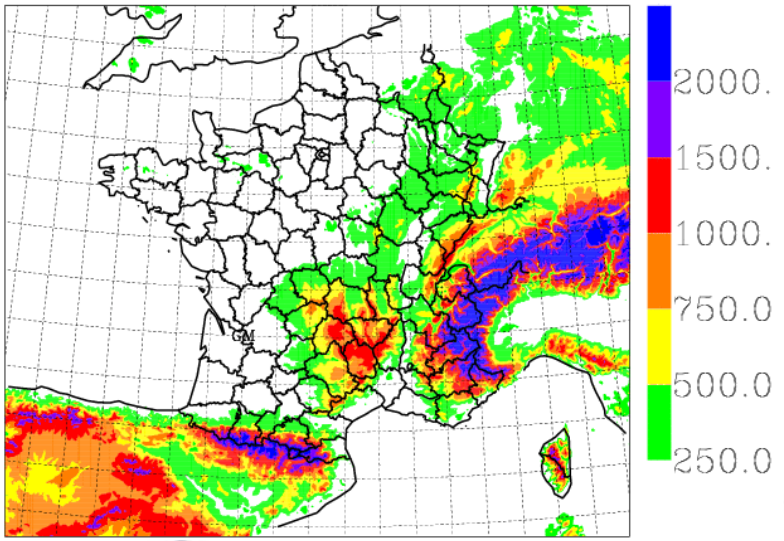
Operational D.A. systems at MF

- Daily run data assimilation systems at Météo-France :
  - ARPEGE 4D-VAR: global model (15 km over Europe, 90km over the S.-W. Pacific)
  - ALADIN-France 3D-VAR: regional model (9.5km)
  - AROME(-France) 3h 3D-VAR: convective scale model (2.5km)
  - ALADIN-Réunion 3D-VAR: regional model over the Indian Ocean (10km)

ARPEGE stretched grid and ALADIN-FRANCE domain



AROME France domain



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Change of horizontal thinning for radiances in ARPEGE

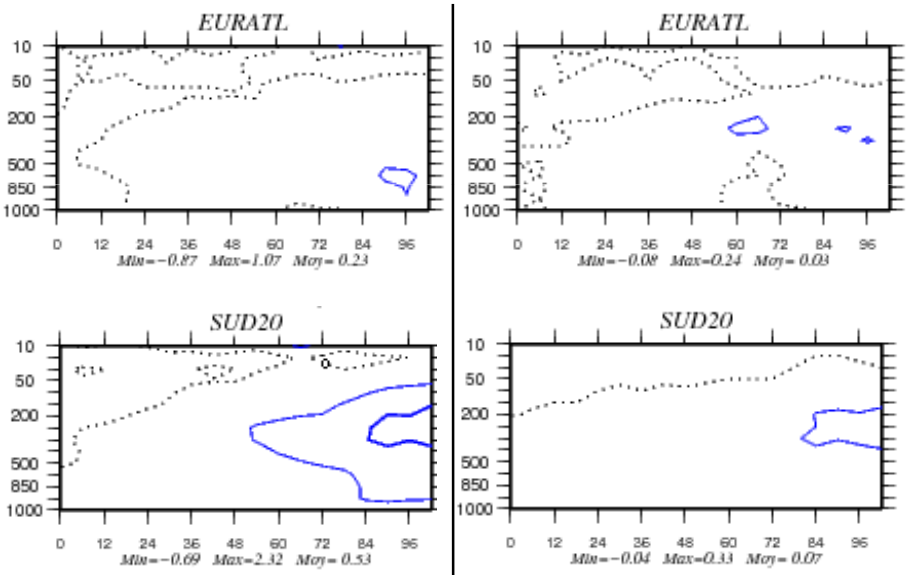
- Operational horizontal thinning presently is 250 km

- In E-suite, horizontal thinning is decreased to 125 km
  => ~ 3.5 times more radiances are assimilated

  More impact in Southern Hemis. because this area has less conventional data
  & because we assimilate more data over sea than over land

Example: increased density only for IASI

Scores with respect to ECMWF analyses over a 3-week period
RMS(250km) – RMS(125km)

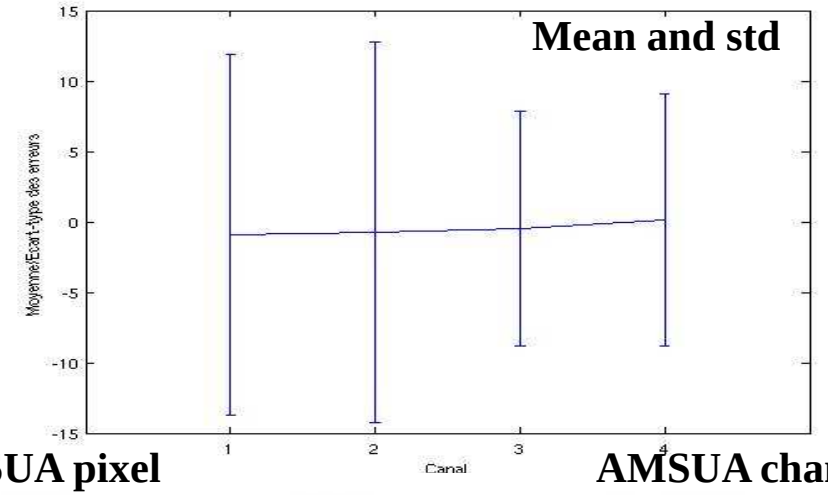


Geopotential height
1 isoline = 1 m

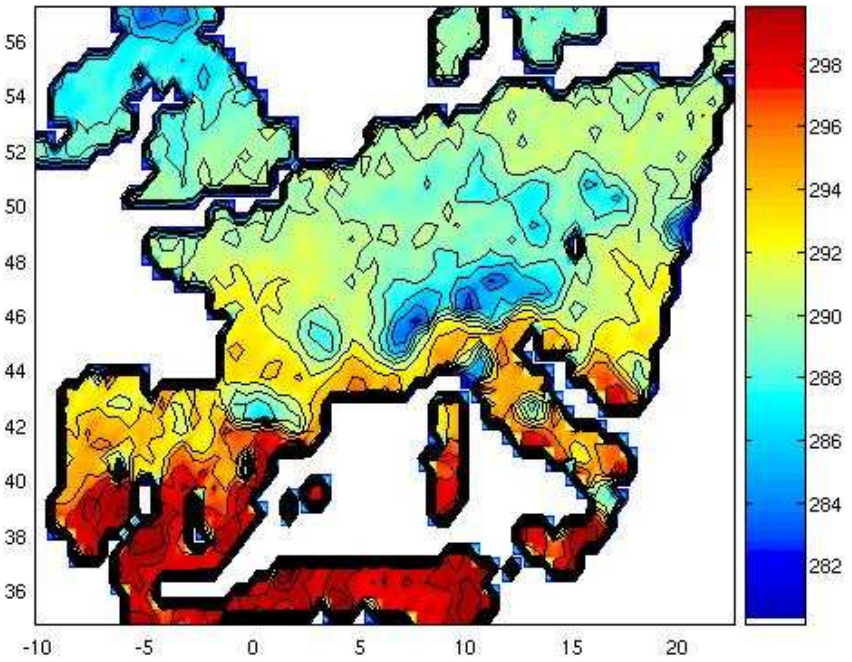
Wind
1 isoline = 0.2 m/s

Ts retrieved from AMSU-A channels w/r conventional T2m measurements / Synop + RS / (Z. Sahlaoui, F. Karbou, E. Gérard)

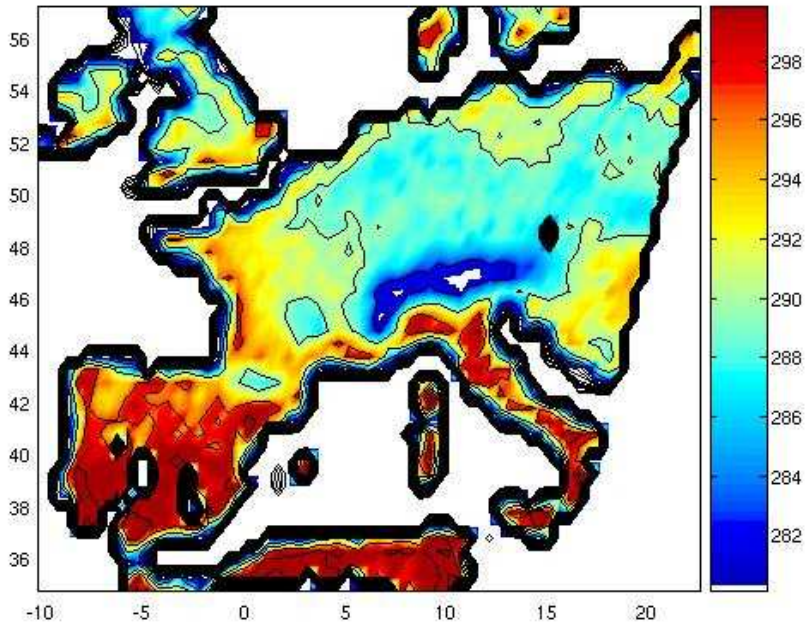
$$T_{skin} = \frac{T_b - T_{\uparrow} - T_{\downarrow}(1-\varepsilon_{atlas})\Gamma}{\varepsilon_{atlas}\Gamma}$$



Conventional T2m interpolated to AMSUA pixel



AMSUA channel 3



Forthcoming changes in ARPEGE 4D-VAR:

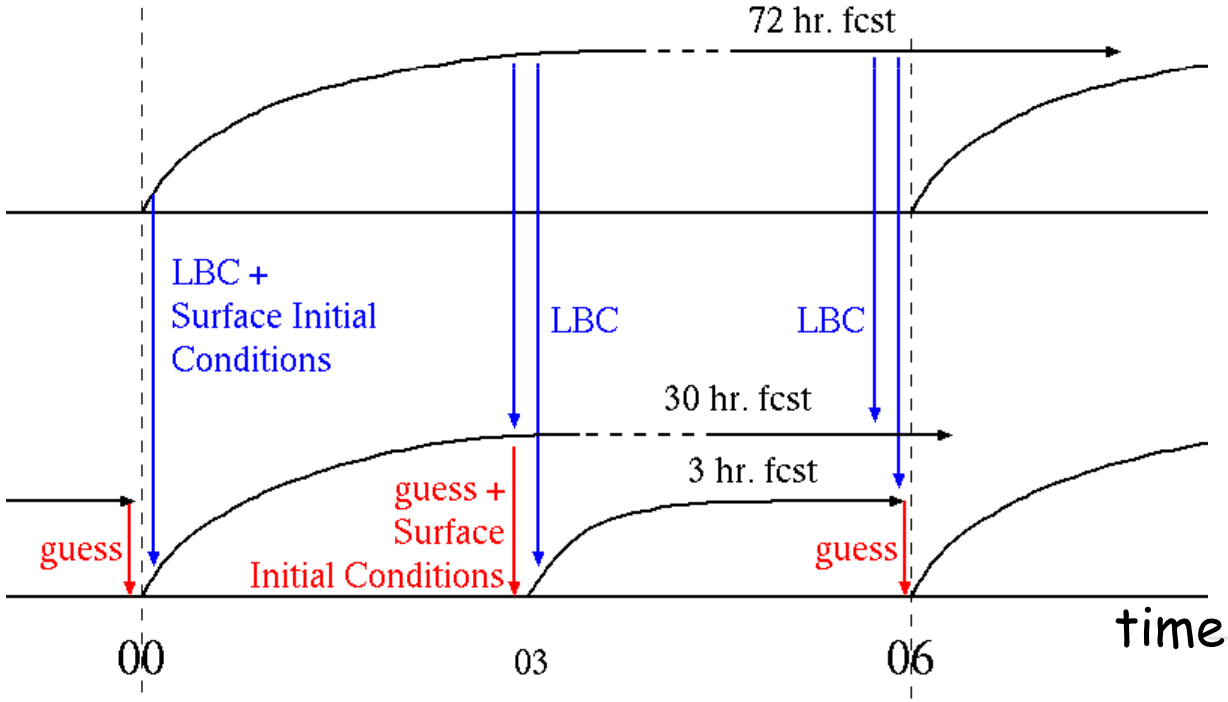
- Change of resolution in forecast model: T800C2.4L70 (10km Europe / 60km S.-W. Pacific)
- New resolution for the 4D-VAR analysis increment: between T340L70 and T400L70
- Move to 3 outer loops and minimizations
- New tunings for the background and observational error standard deviations (for σb: from 2.0 to 1.6; for σo: from 1.0 to 0.9)
- New moist simplified physics scheme including some microphysics in TL/AD models
- Progressively increase the usage of Ensemble Assimilation information (6-member parallel D.A. suites); link with the EPS system (PEARP)
- Double the density of about all radiance types (change the scale of data use from one spot every 250 km to one every 125 km), with a higher priority put on IASI
- NOAA-19

AROME operational configuration

- AROME operational configuration uses a 3-h frequency continuous assimilation cycle and performs 30-hr forecasts at synoptic times (00, 06, 12 and 18 UTC).
- the ALADIN-FRANCE operational suite provides :
  - Lateral boundary conditions
  - Surface initial conditions : CANARI analysis (OI) at 00, 06, 12 and 18 UTC (the previous AROME forecast is used otherwise).

ALADIN cycle

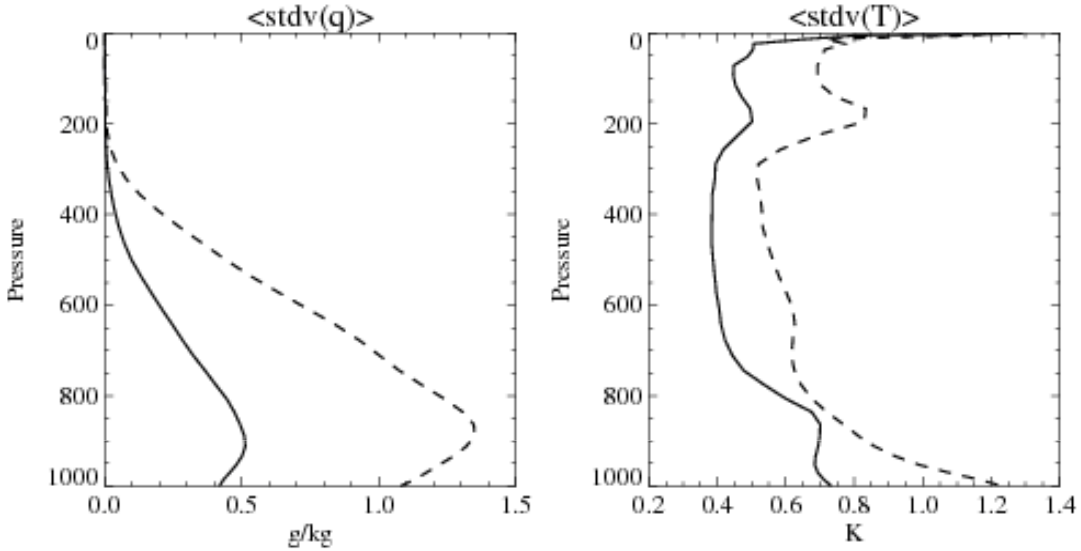
AROME cycle



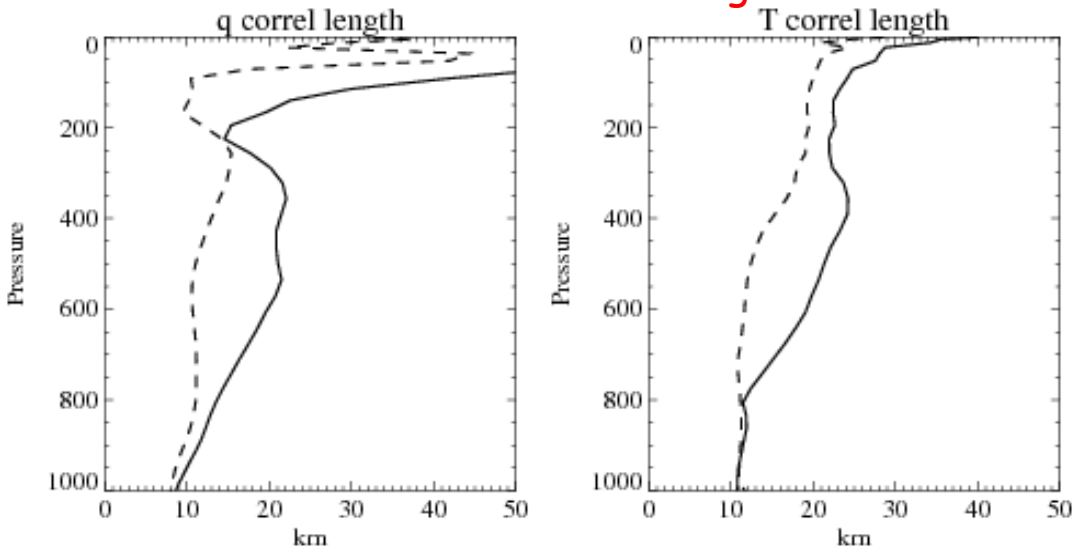
Background error statistics "B" : winter/summer

- Background error statistics depend on the meteorological situation => limitation of a "climatological" B matrix
- Use of statistics "of the day" ?

Background error standard deviation



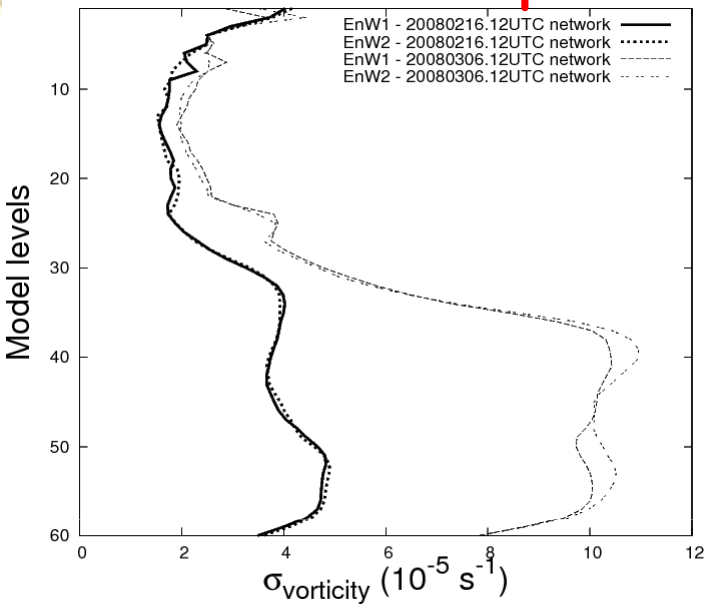
Horizontal correlation length scales

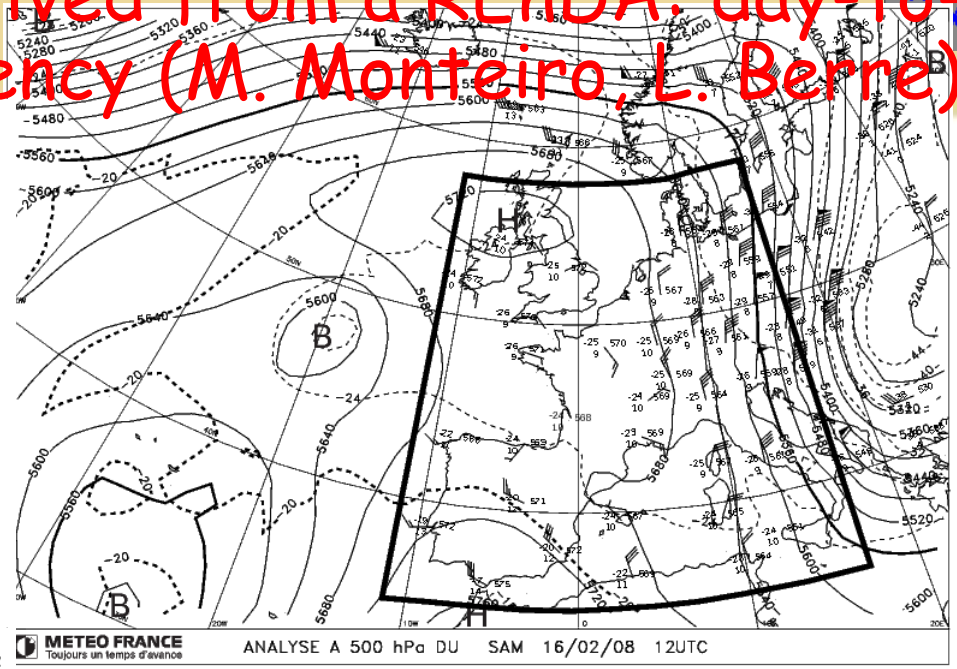


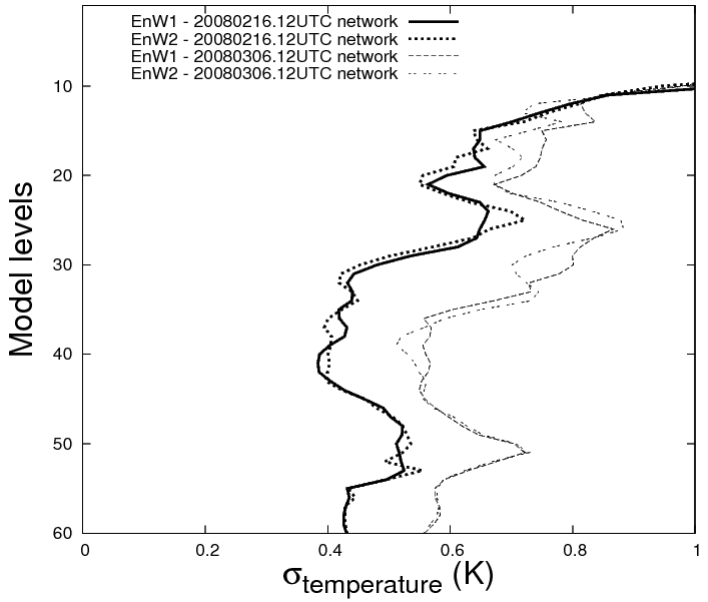
____ winter

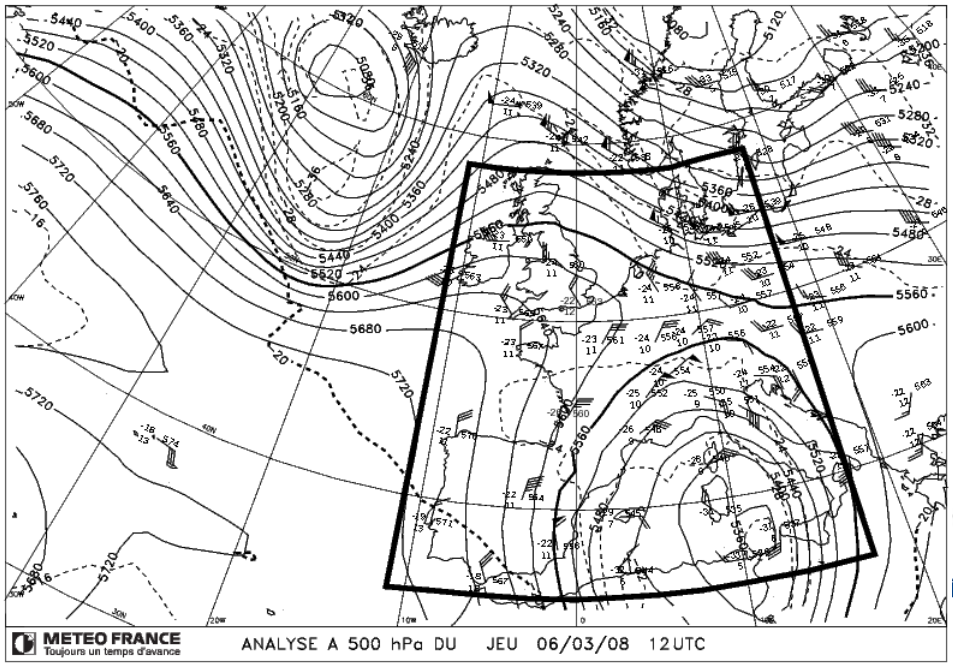
---- summer

Variability in "B" derived from a REnDA: day-to-day and flow dependency (M. Monteiro, L. Berre)









Background error statistics : heterogeneous B matrix

Thibault Montmerle (Following P. Courtier, 1998, already tested by M. Buehner, 2008).

- Use specific background error statistics in clear air and precipitating areas, resp. :

$$\mathbf{B} = \alpha\mathbf{B}_r + \beta\mathbf{B}_{nr} \qquad \text{With:} \qquad \alpha = \mathbf{FMF}^{-1} \quad \text{and} \quad \beta = \mathbf{F(1-M)F}^{-1}$$

$\mathbf{M}$: grid point mask derived from observed radar reflectivity.

$\mathbf{B}_r$ and $\mathbf{B}_{nr}$ are separately computed by performing statistics on an assimilation ensemble of precipitating cases, considering a mask based on simulated precipitations.

- The increment is written:

$$\delta x = \mathbf{B}^{1/2}\chi = \left(\alpha^{1/2}\mathbf{B}_r^{1/2} + \beta^{1/2}\mathbf{B}_{nr}^{1/2}\right)\begin{pmatrix}\chi_1\\ \chi_2\end{pmatrix}$$

$\Rightarrow$ Which implies doubling the control variable χ and the gradient $\nabla_\chi J$

- Comparisons between structure functions :
  - Smaller horizontal correlation length scales in precipitating areas
  - Smaller σ_b for q and T in precipitating areas because the statistics are performed using saturated profiles

$\Rightarrow$ Precipitating observations can be used with higher density

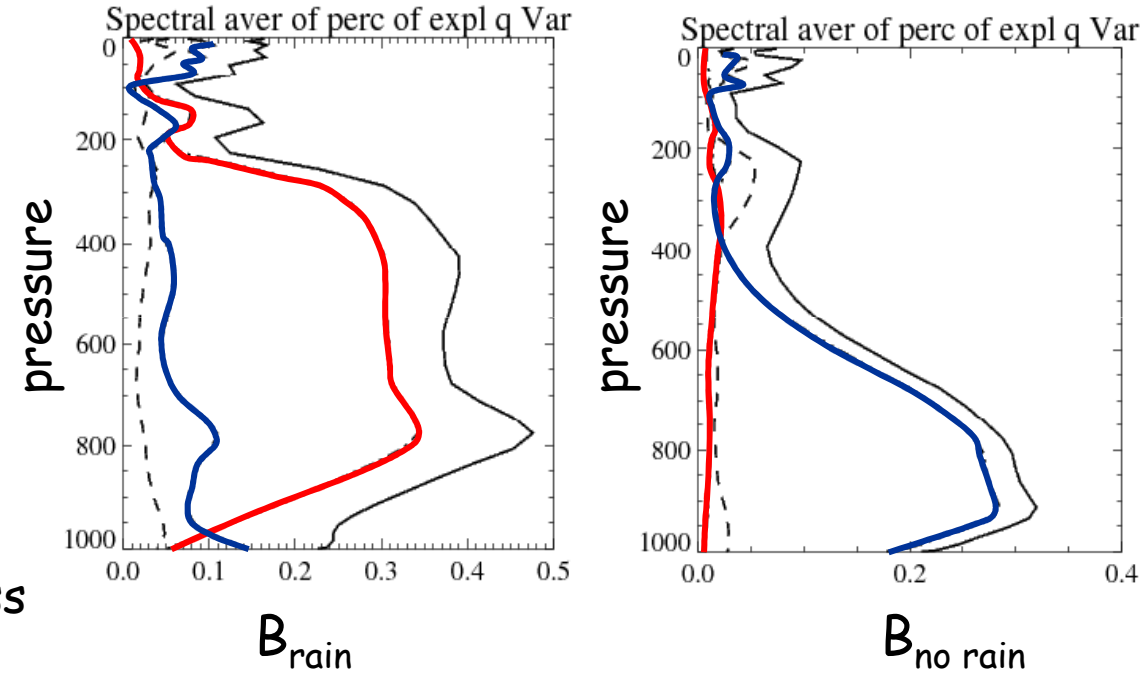
Background error statistics : heterogeneous B matrix (2)

Multivariate formulation of errors:

$$\zeta = \zeta$$
$$\eta = \mathcal{M}\mathcal{H}\zeta + \eta_{\mathrm{u}}$$
$$(T,\ P_{\mathrm{s}}) = \mathcal{N}\mathcal{H}\zeta + \mathcal{P}\eta_{\mathrm{u}} + (T,\ P_{\mathrm{s}})_{\mathrm{u}}$$

In precipitating areas, σ_b(q) is mostly explained by η_{u} at mesoscale, whereas it is almost univariate and linked to the mass field in clear air

Vertical profile of spectral averages of the percentage of explained humidity variance

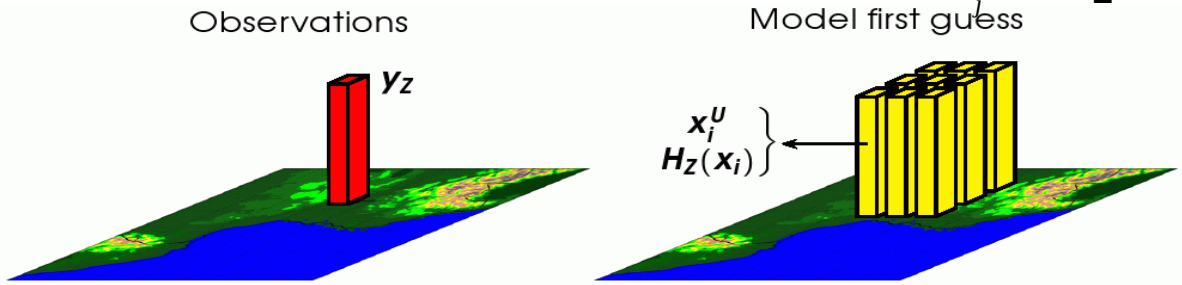


$\Rightarrow$ B_r and B_{nr} are characterized by very different structure functions, which is coherent with the model's physics in both precipitating and non-precipitating areas.

Radar data assimilation : Inversion method of reflectivity profiles

Caumont, 2006: use of model profiles in the vicinity of the observation as representative database

$$E(x) = \sum_j x_j \frac{\exp \frac{-1}{2} \cdot \| y_0 - y_s(x_j) \|^2}{\sum_j \exp \frac{-1}{2} \cdot \| y_0 - y_s(x_j) \|^2}$$



$$y_{po}^U = \sum_{\substack{i \in \\ \text{neighbours}}} x_i^U \frac{\exp\left(-\frac{1}{2}\|y_Z - H_Z(x_i)\|^2\right)}{\sum_{\substack{j \in \\ \text{neighbours}}} \exp\left(-\frac{1}{2}\|y_Z - H_Z(x_j)\|^2\right)}$$

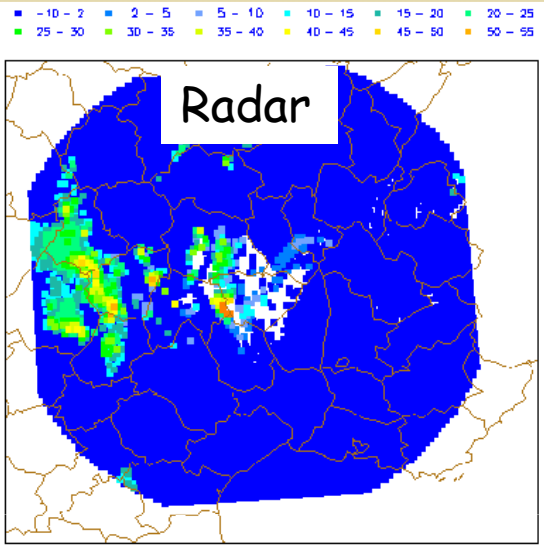
y_{po}^U: column of pseudo-observed relative humidity,
y_Z: column of observed reflectivities,
x_i^U: column of relative humidity,
$H_Z(x_i)$: column of simulated reflectivities.

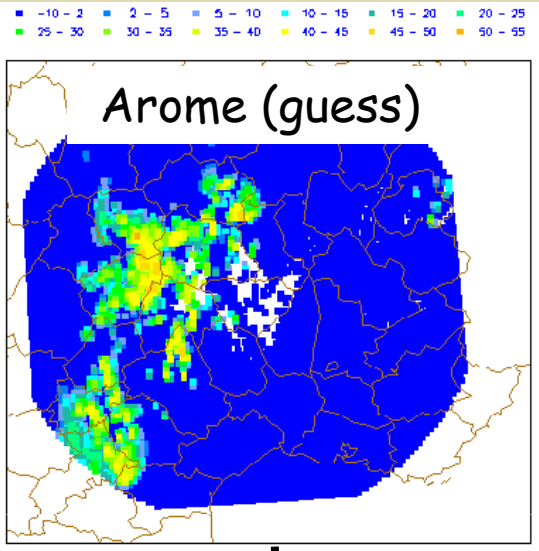
- Consistency between the retrieved profile and clouds/precipitations that the model is able to create
- Possibility of wrong solution if the model is too far from reality… needs check

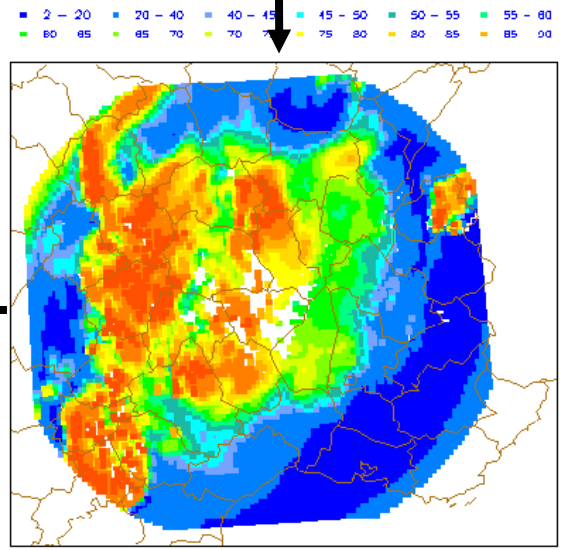
Radar data assimilation : one radar assimilated

Reflectivity -

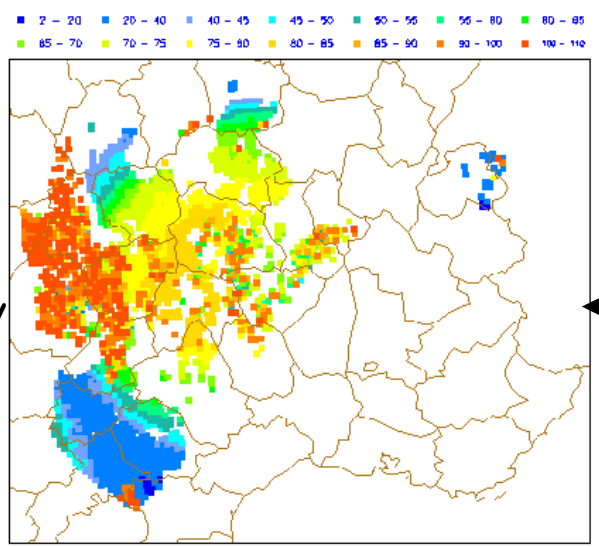
Elevation 0.44°







Arome (guess)



Pseudo-observation

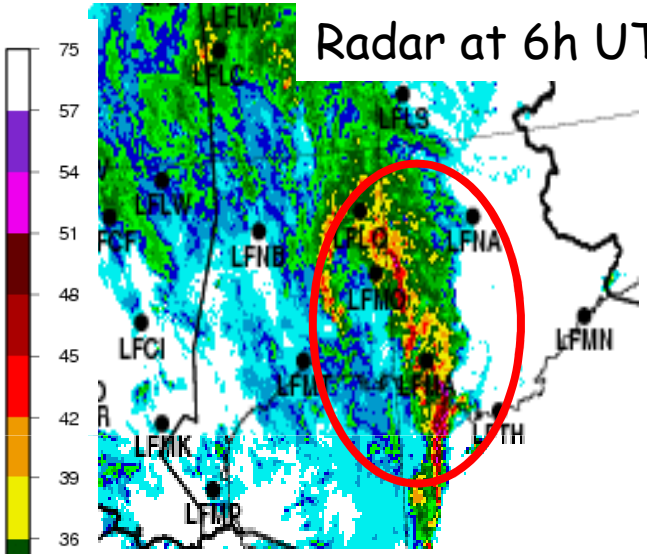
Relative humidity

Radar data assimilation : case study

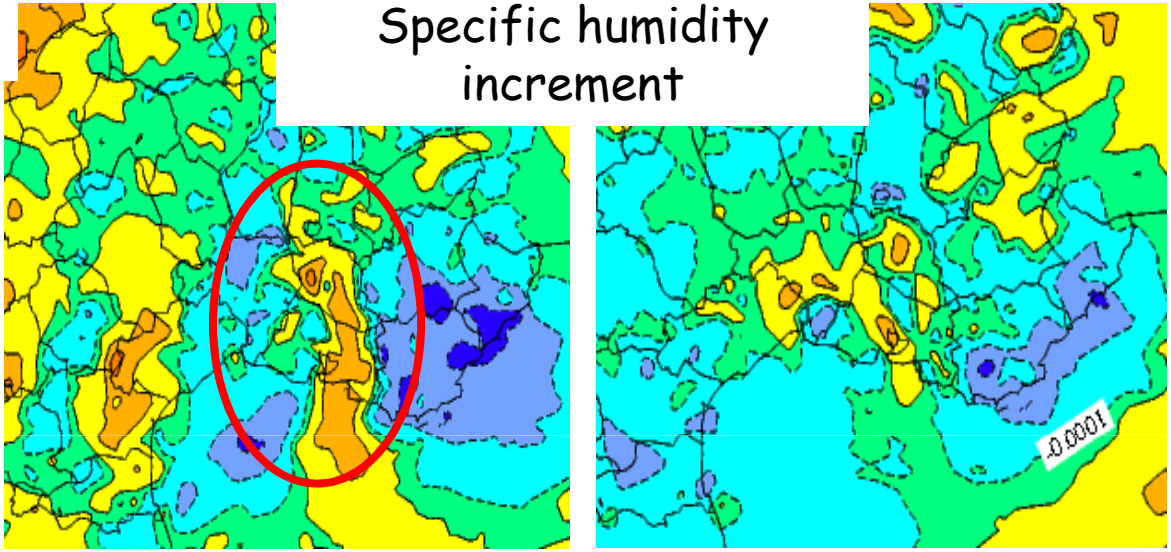
With reflectivities

Without reflectivities

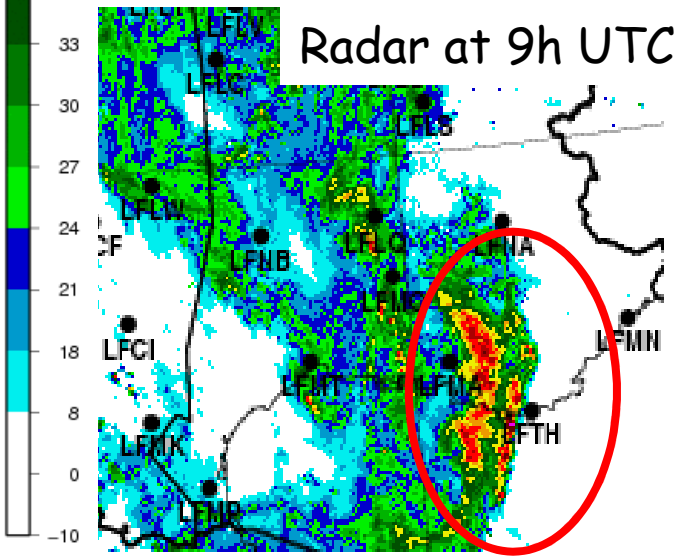
Radar at 6h UTC



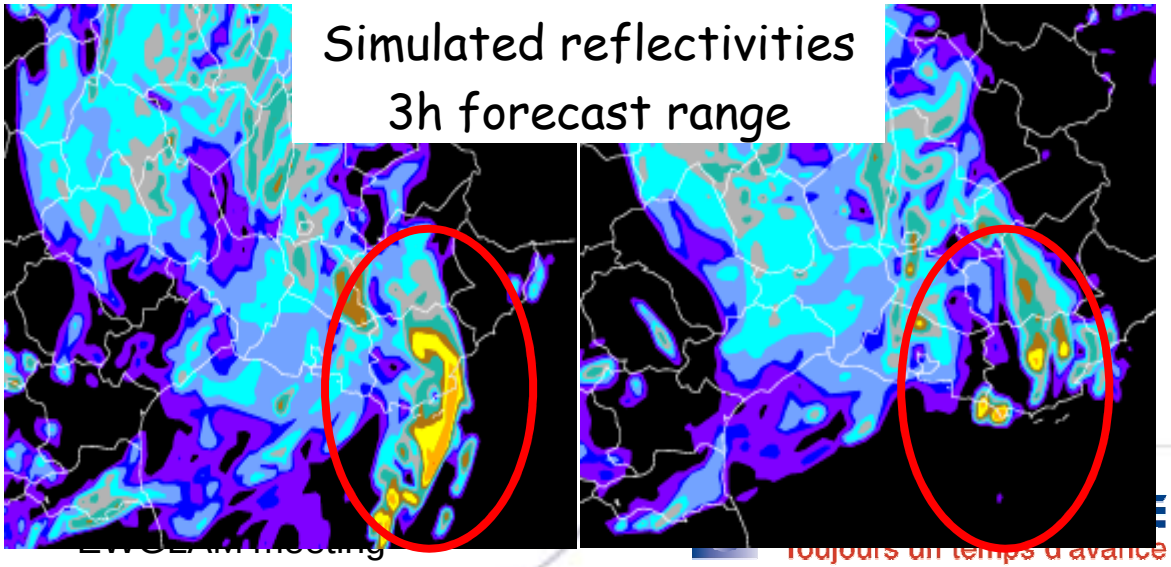
Specific humidity increment



Radar at 9h UTC



Simulated reflectivities 3h forecast range



Outlook for LAM's

- ALADIN-France:
  - Change of resolution: 7.5 km, 70 levels
  - Probably switch off Aladin-France as intermediate coupling model between global and convective scale systems by end of 2009 or beg. Of 2010
- ALADIN 3D-VAR elsewhere:
  - Aladin-Réunion, Aladin Outre-Mer (Polynesia, New Caledonia, Antilles-Guyana)
  - Morocco: new computer platform in 2010
  - Several LACE countries (=> refer to Gergö's talk)
  - R&D on 2D plane wavelets (A. Deckmyn, Belgium)
- AROME: works currently in progress on :
  - the use of observations at a higher spatial resolution (Aircraft, IR rad. Etc.)
  - the assimilation of reflectivities (in pre-operational suite next winter)
  - a surface assimilation coherent with the model's surface scheme and resolution (=> refer to talks by Alena and Ludovic)
  - Further plans on algorithmics :
    - take a better advantage of high-frequency observations using :
      - 3D-FGAT (First Guess at Appropriate Time)
      - Incremental Digital Filter Initialization allowing 1-h cycling (?)
    - Use flow dependent forecast error statistics : ensemble assimilation based

The end of the talk

- σας ευχαριστώ για την προσοχή σας