Simplified physics in Arpège/Aladin

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METEO FRANCE
Toujours un temps d'avance

Introduction

- Simplified physics is the basis for developpement of linear-tangent and adjoint models used for:
  - variational assimilation (Arpege/IFS 4D-VAR)
  - singular vectors computations
  - adjoint sensitivity studies (in Arpege/Aladin...)
- Now only dry simplified physics used operationally at Météo-France $\Rightarrow$ need for better representation of moist processes

Position of the problem

- Parametrization of moist processes highly nonlinear in the full physics: how to represent them with more regular simplified parametrizations ?
- How close to the full physics must simplified parametrizations be ?
  For practical reasons a strategy with simplified parametrizations kept independent from the full physics was made.
- Validity of LT hypothesis when going to higher resolutions (as in Aladin France or Arpege in the future) ?

Existing simplified parametrizations (TL/AD)

Param.	Type of scheme	Used in Arpege 4DVAR
Vertical Diffusion	K taken from trajectory	Yes
Large scale precip	$P \propto (q - qsat)$	No
Gravity wave drag	Close to old oper. version	Yes (but LT hypothesis)
Convection	Simplified Mass-Flux Scheme	No
Radiation	Simplified scheme	No
Mesospheric drag		Yes but little impact

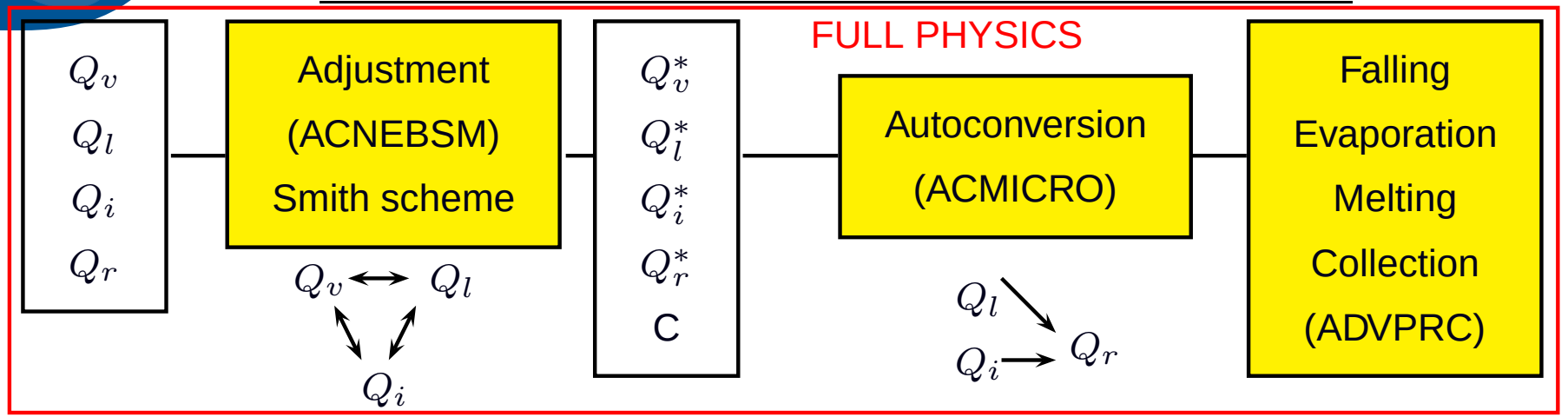
Several tasks ongoing for simplified physics:

- New LSP scheme (done), fix of the old one (done)
- Improvement of GWD scheme by neglecting perturbations of some terms in the GWD formulation (done and currently in test)
- New convection scheme (in progress)

Outline of the talk

- Description of new simplified scheme for large-scale precipitation (LSP)
- Results in Arpege
  - LT diagnostics
  - 4D-VAR results
- Tests in Aladin France

Full and simplified moist physics in Arpege/Aladin



Full and simplified moist physics in Arpege/Aladin

FULL PHYSICS

Q_v
Q_l
Q_i
Q_r

Adjustment
(ACNEBSM)
Smith scheme

$Q_v \leftrightarrow Q_l$
$Q_v \leftrightarrow Q_i$
$Q_l \leftrightarrow Q_i$

Q_v^*
Q_l^*
Q_i^*
Q_r^*
C

Autoconversion
(ACMICRO)

$Q_l \searrow Q_r$
$Q_i \rightarrow Q_r$

Falling
Evaporation
Melting
Collection
(ADVPRC)

Q_v
$Q_l = Q_i = 0$
$Q_r = 0$

$P = max(0, \frac{Q_v - Q_{sat}}{1 + L/C\partial_T Q_{sat}})$
$Q_v^* = Q_v - P$

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C=0 or 1

Old. simp. param

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Autoconversion

Precipitation and
removal of all
condensed water

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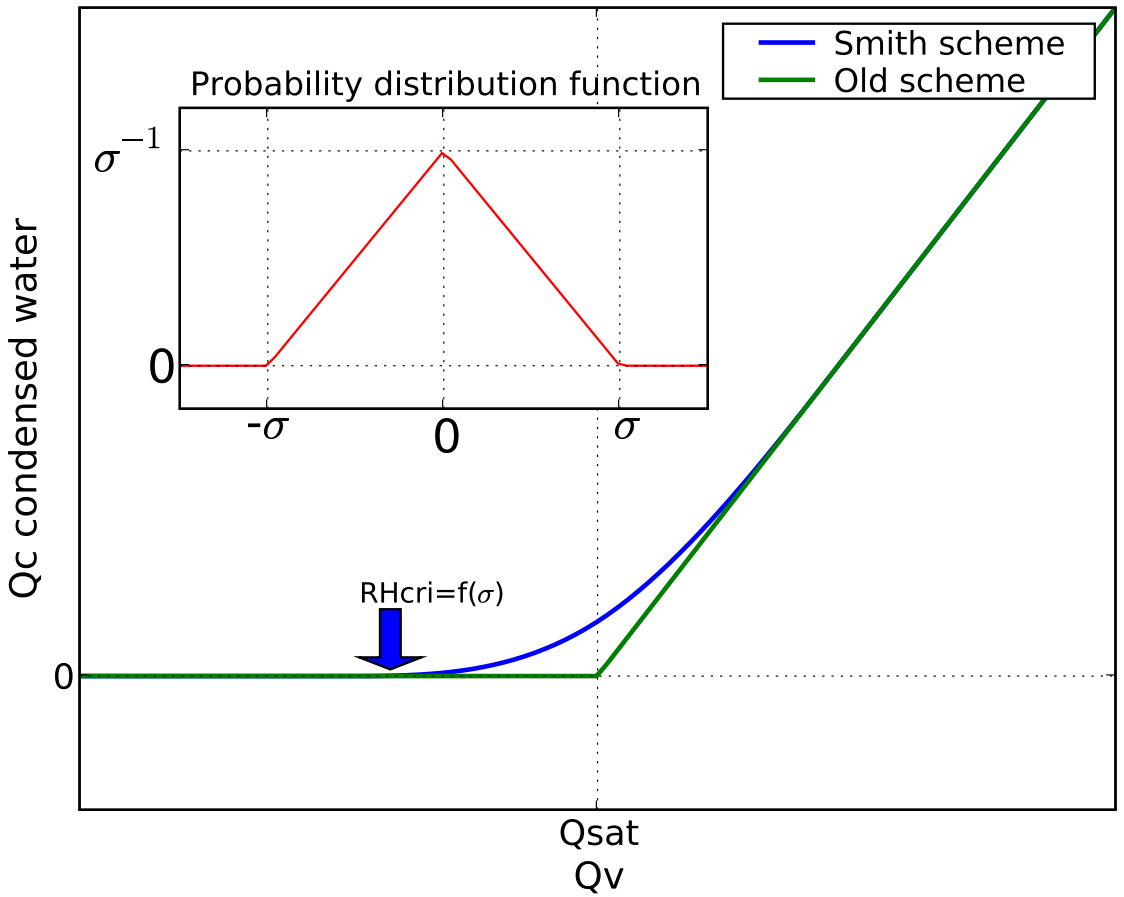
Old. simp. param

Computation of condensed water using the Smith scheme

- $Q_c = Q_v - Q_{sat}$
- Inside a gridbox: $q'_c = Q_c + s$ with s the local variation of Q_c.
  Statistics of s are given by a distribution function G(s)
- $q_c = \int_{-Q_c}^{\infty} (Q(c) + sG(s))ds$ and $N = \int_{-Q_c}^{\infty} G(s)ds$

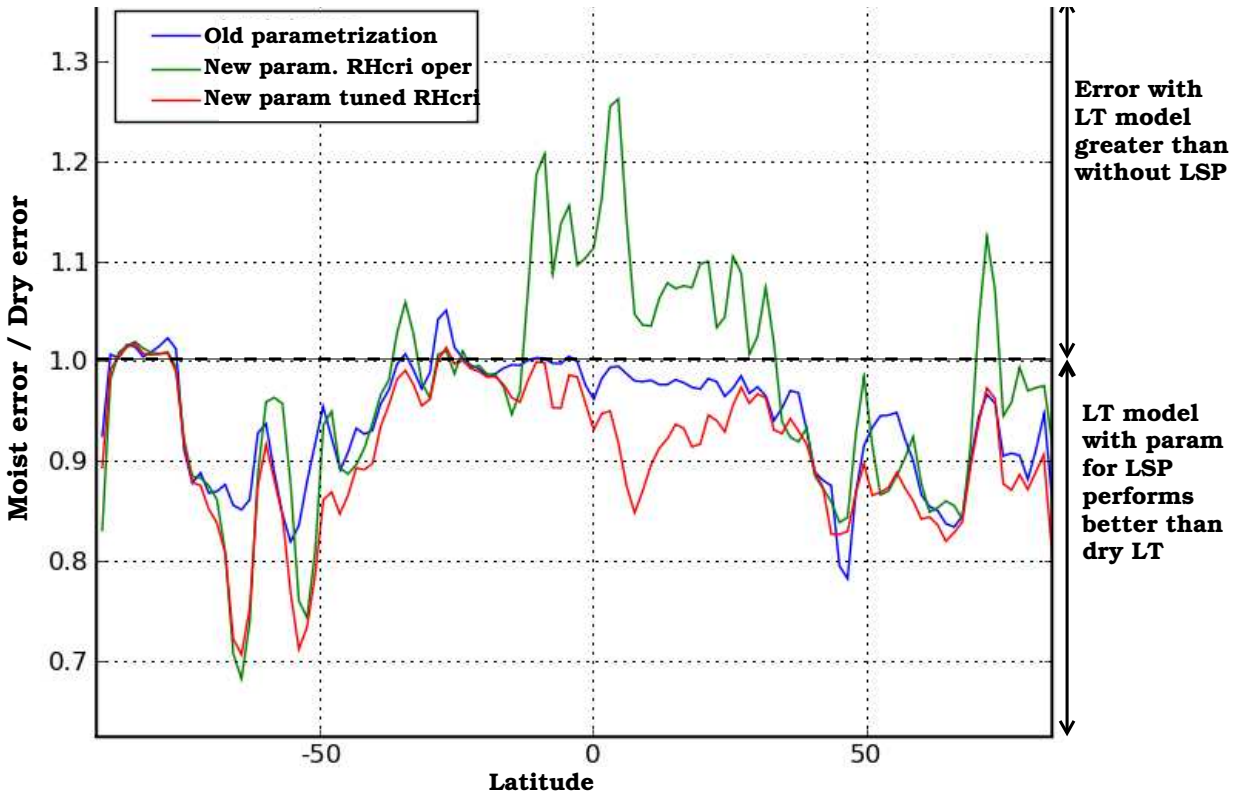


Overview of the new scheme

- Smith scheme used for computing Q_C in a **diagnostic** way $\Rightarrow$ No condensed water and/or precipitation handled prognostically.
- Retrieval of a cloud fraction C taking any possible value between 0 and 1: scheme more suitable for linearization.
- Diabatic heating corresponding to precipitation of all Q_c (to be improved ?)
- Possible evolutions:
  - Choice of a more regular probability distribution function
  - Prognostic Q_c
  - Activation of autoconversion (coded)

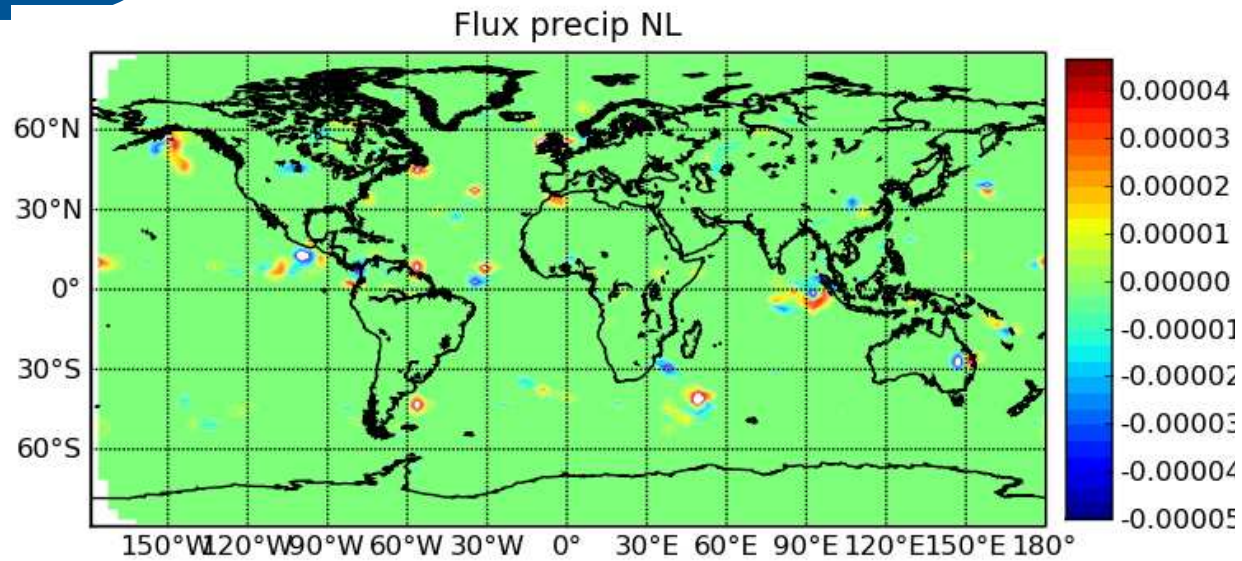
Tuning of distribution's shape.

- LT diagnostics show large sensitivity to choice of σ
- After tuning of σ, reduction of ϵ_{moist} in the tropics and in the midlatitudes.

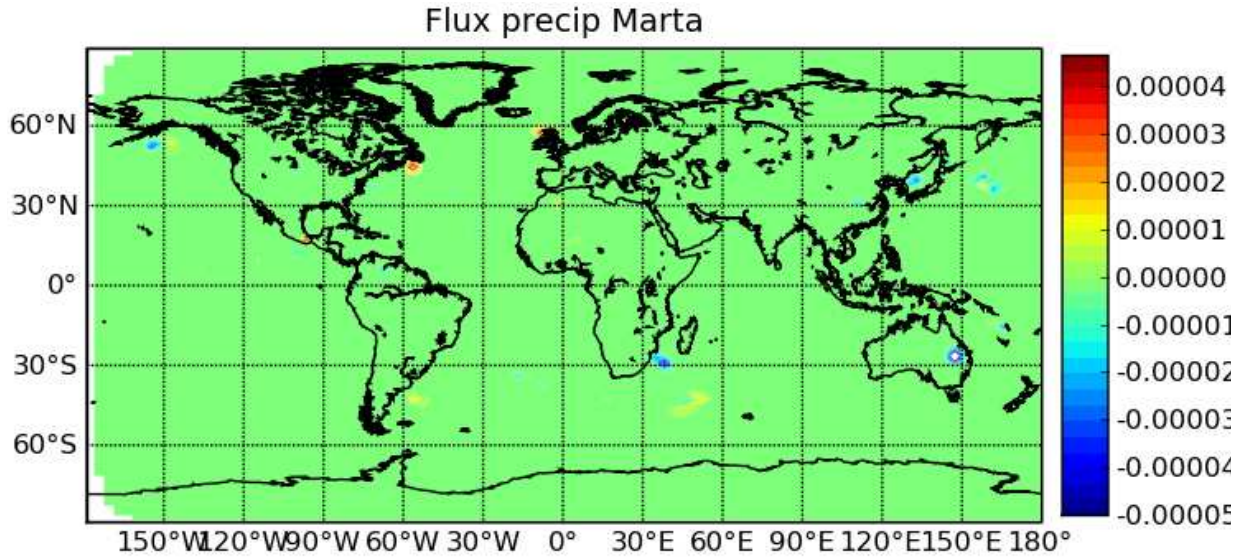


$\epsilon_{moist}/\epsilon_{dry}$ with $\epsilon = \|M(X_0 + \delta X_0) - M(X_0) - L\delta X_0\|$

Comparison of linear and nonlinear evolution of increments.



$$M(\delta X_0 + \delta X_0) - M(X_0)$$

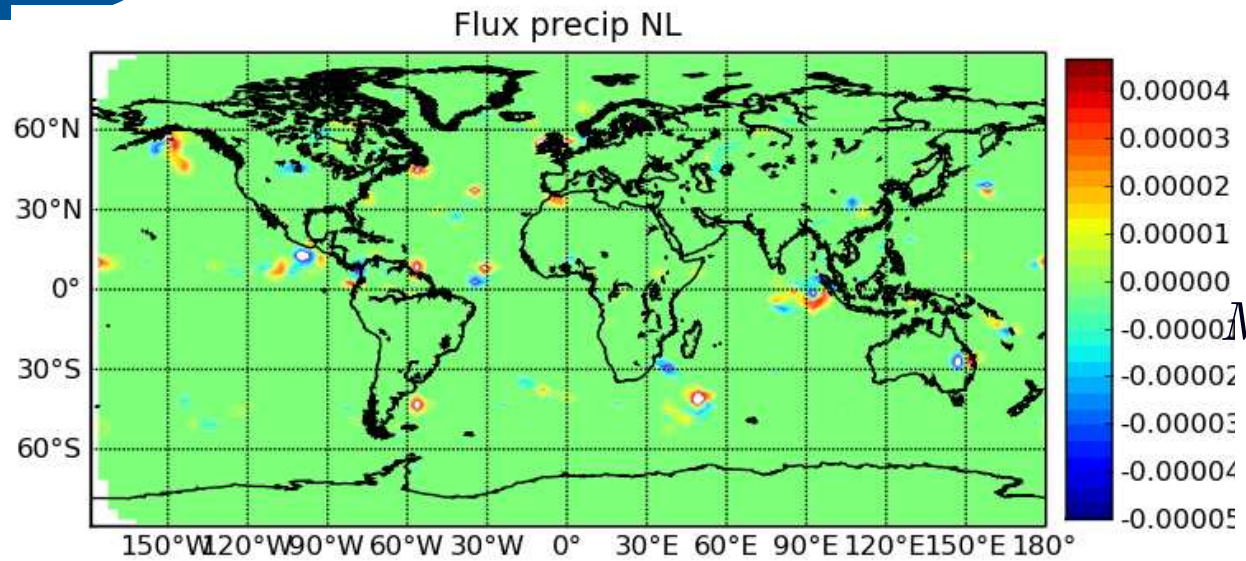


$$L\delta X_0$$

old scheme

$\Rightarrow$ A lot of lacking structures in the tropics with the LT model using the old param. for resolved precipitation

Comparison of linear and nonlinear evolution of increments.



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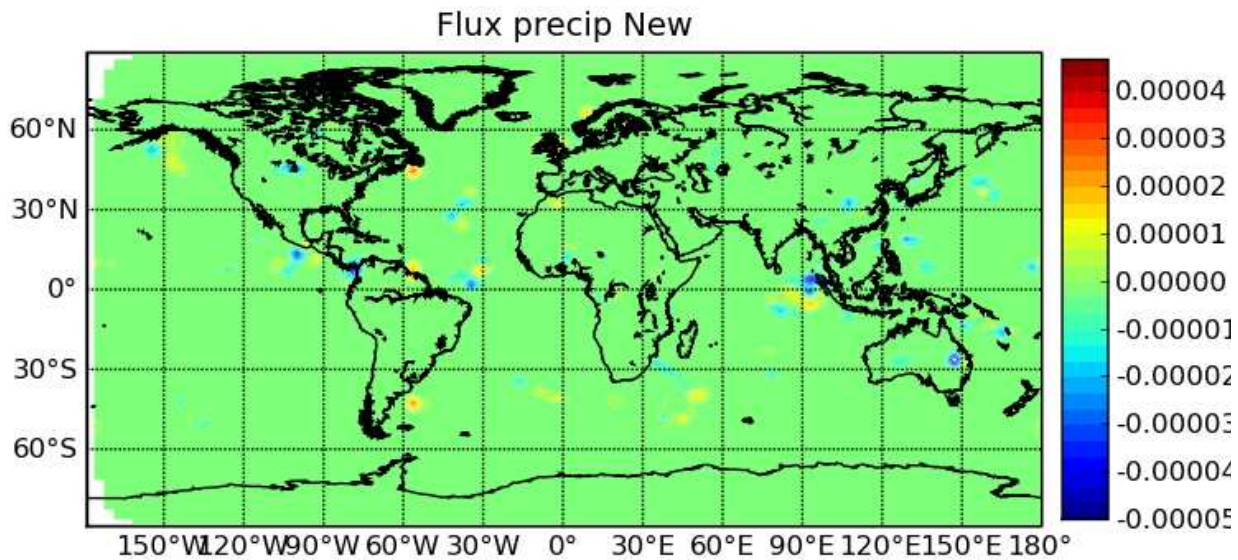


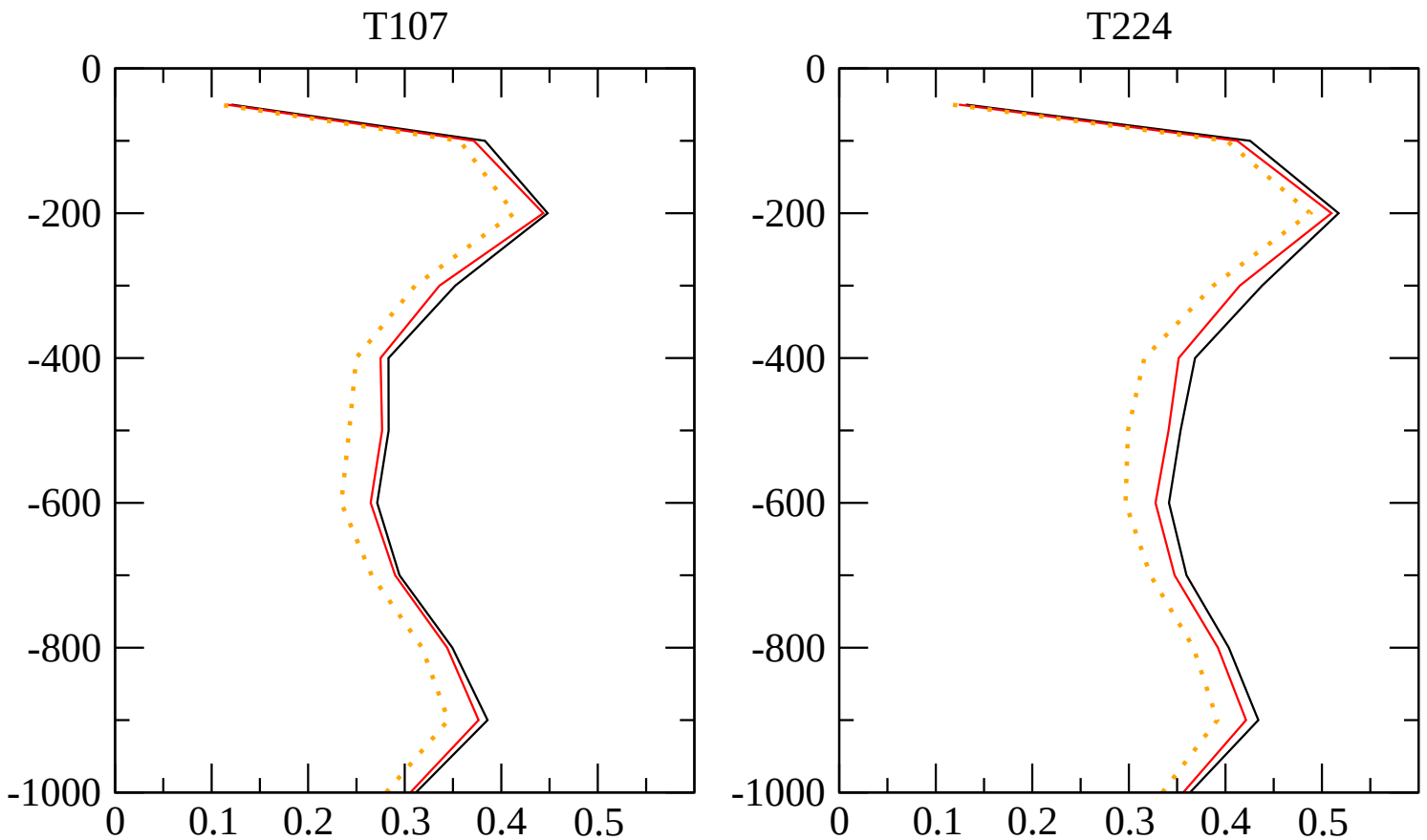
$$L\delta X_0$$

new scheme

$\Rightarrow$ Structures well positionned but with amplitude underestimated with the new LSP parametrization.

Tangent-linear diagnostics: impact of precipitation 1/2

RMS of $\epsilon = M(X_0 + \delta X_0) - M(X_0) - L\delta X_0$ **averaged over the globe (3h)**



Vertical Diffusion, VD+ old LSP scheme, VD+ new LSP scheme

Tangent-linear diagnostics: impact of precipitation 2/2

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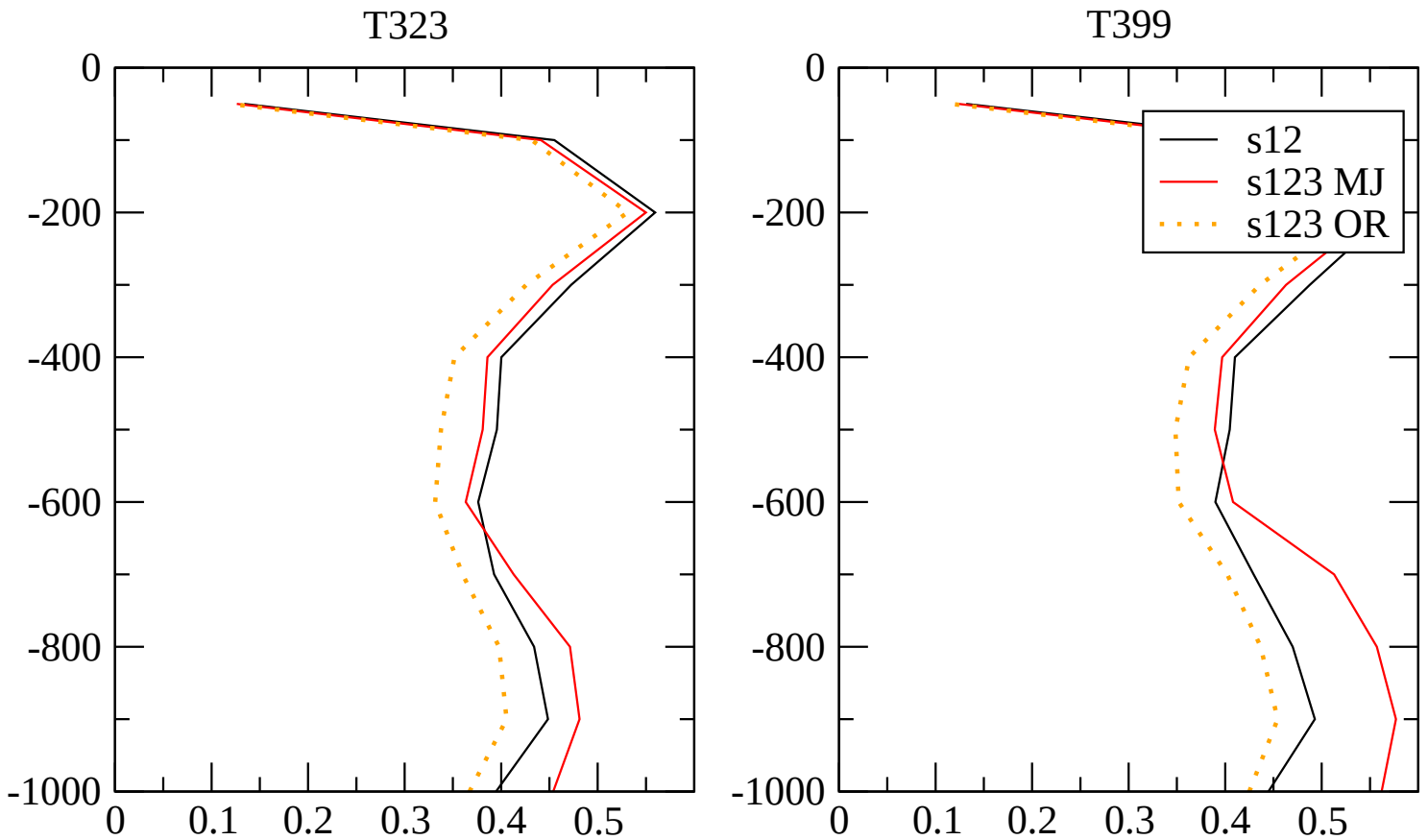
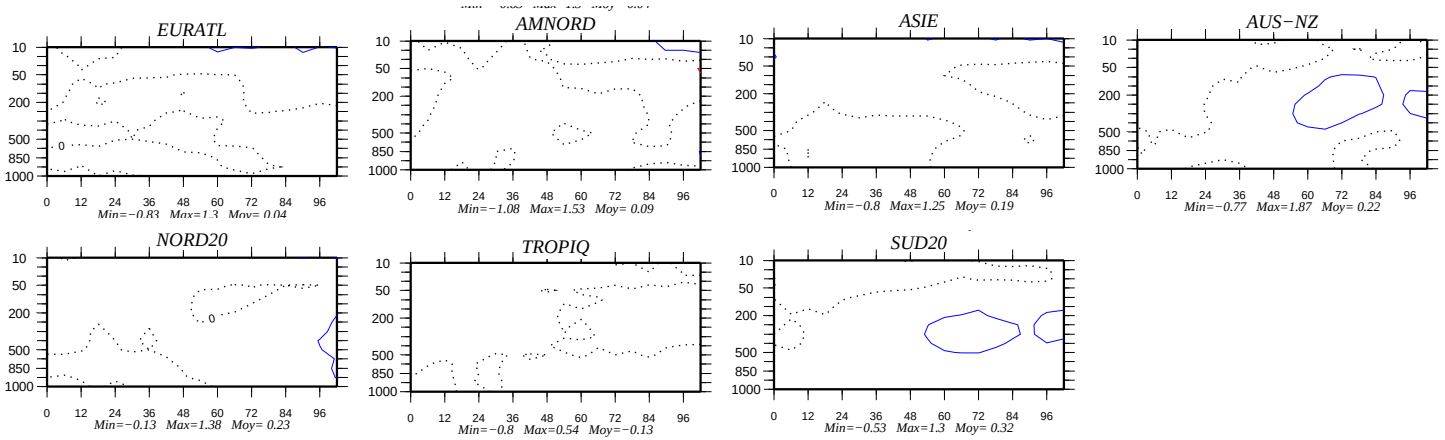


Vertical Diffusion, VD+ old LSP scheme, VD+ new LSP scheme

Application to Arpege's 4DVAR

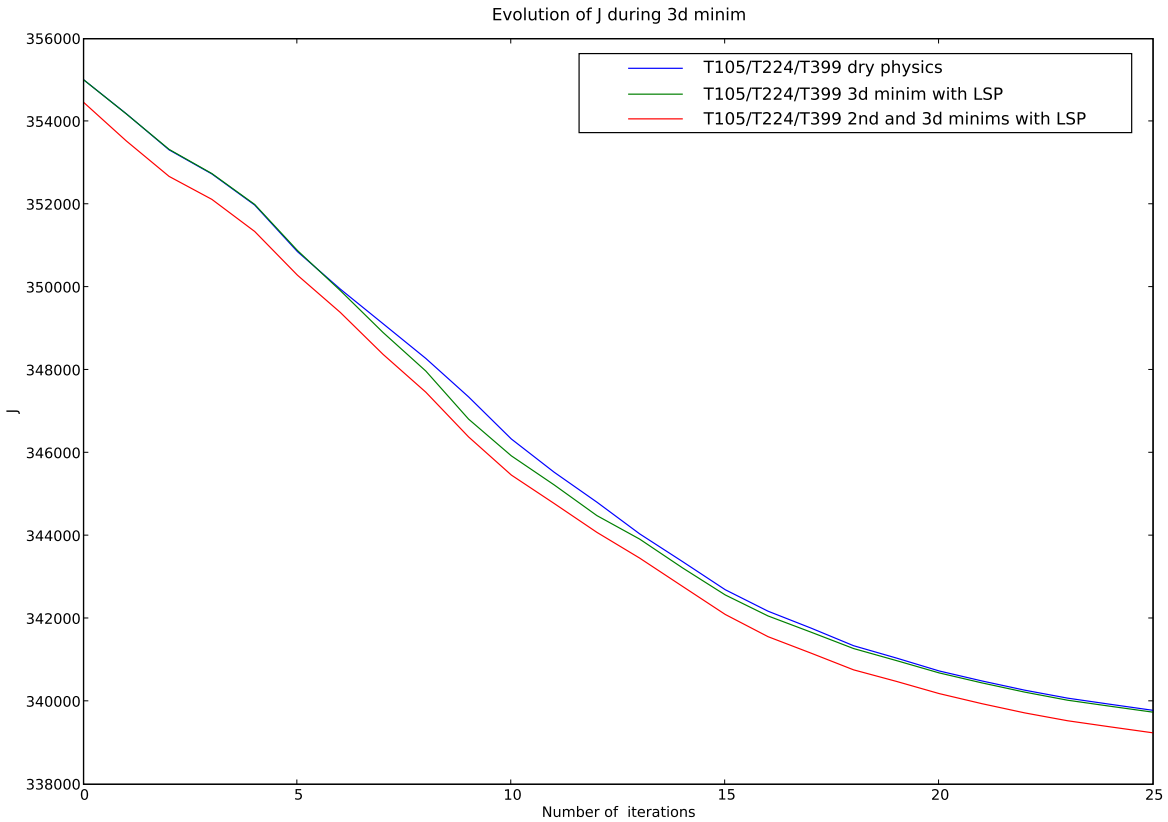
- E-suite: 20 days experiment (4/02/09->25/02/09)
- Same resolution than operational suite (forecast:T538,minim1:T107,minim2:T224)
- New simplified parametrization for LSP included in both minimizations.

Application to Arpege's 4DVAR: first scores.



- Reference: ECMWF analysis
- Blue: introduction of LSP improves forecast compared to operational suite
- Scores neutral to slightly positive
- New moist parametrization performs better than old one (not shown)
- Tests currently done at higher resolution (T105/T224/T399)

When to introduce moist processes in 4D-VAR ?

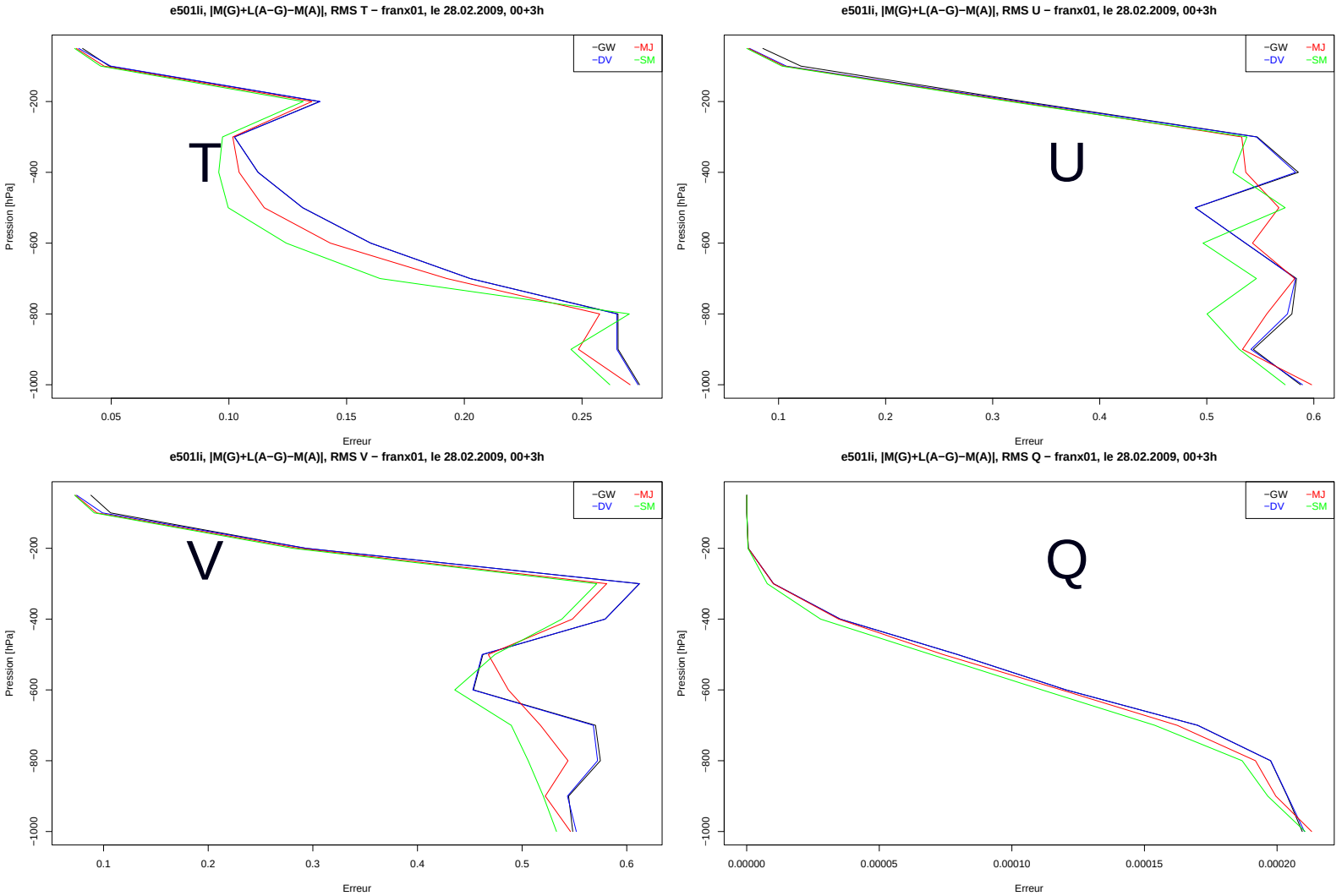


- Largest positive impact of inclusion of moist processes especially if introduced during two last minimizations.

Tests of the linearized physics in Aladin France

- Adjoint and LT models are also mantained in Aladin.
- Basic configuration of Aladin 4D VAR (not validated) is existing under Olive
- Tangent-linear diagnostics (Conf 501li):
  - $M(X + \delta X) - M(X)$ compared to $L\delta X$
  - δX: guess-analysis taken from Aladin-FR oper. suite.
  - Tests performed over 3 and 6h
  - Domain: Aladin France

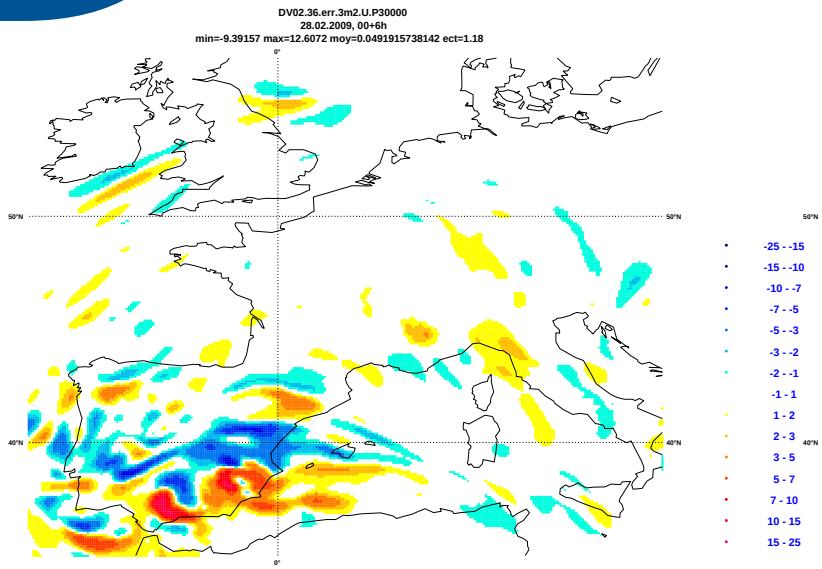
Linearization error in Aladin over 3h with different simplified physics



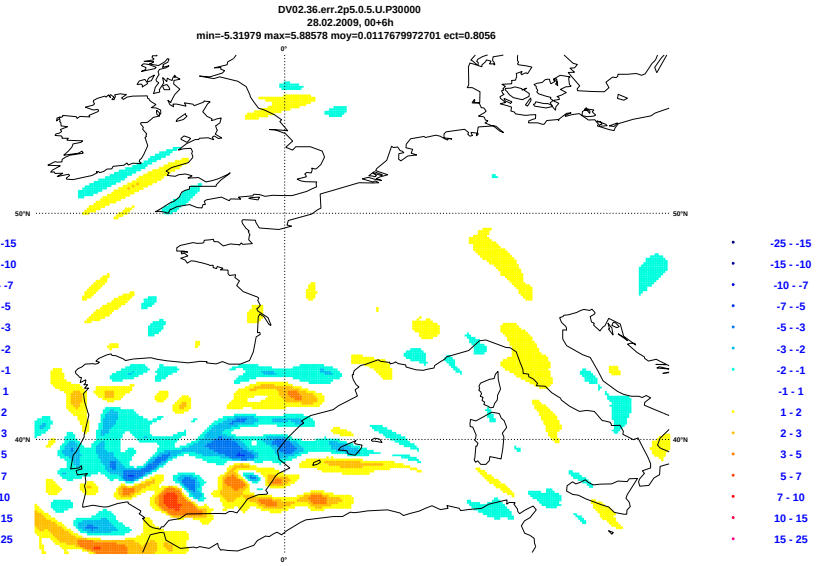
Vertical diffusion (VD) ,VD+old LSP,VD+new LSP,VD+GWD

$\Rightarrow$ Important error around 300 hPa: dynamics ?

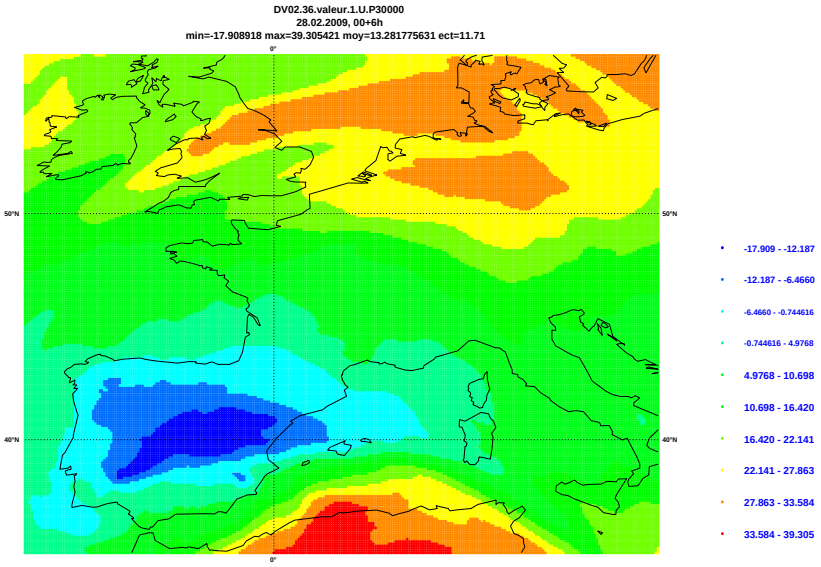
Limits of LT hypothesis



$$M(X_0 + \delta X) - M(X_0) - L\delta X$$



$$\frac{M(X_0+\delta X)+M(X_0-\delta X_0)-2M(X_0)}{2}$$



U_0 (300hPa)

- at 300 hPa, LT approximation is no longer valid even after 3h at 10km resolution (role of dynamics ?)
- important limitation for methods based on use of LT/AD models at those resolutions

Conclusion

- New LSP simplified parametrization performs well in terms of LT approximation and slightly increases scores in 4D-VAR but more added value is expected at higher resolutions
- New GWD parametrization cheaper in terms of CPU and improving LT model
- Ongoing work on convection with a simplified Betts-Miller scheme coded and LT version being tested.
- At very high resolution, role of the nonlinearities to be assessed.