Recent developments in Météo-France Physics (AROME & ARPEGE)

Eric Bazile, Yves Bouteloup, Rachel Honnert,
Sébastien Riette, Yann Seity

34th Ewglam & 19th SRNWP joined meetings
Helsinki 8-11 october 2012

cnrs INSU Observer & comprendre

METEO FRANCE Toujours un temps d'avance

Plan

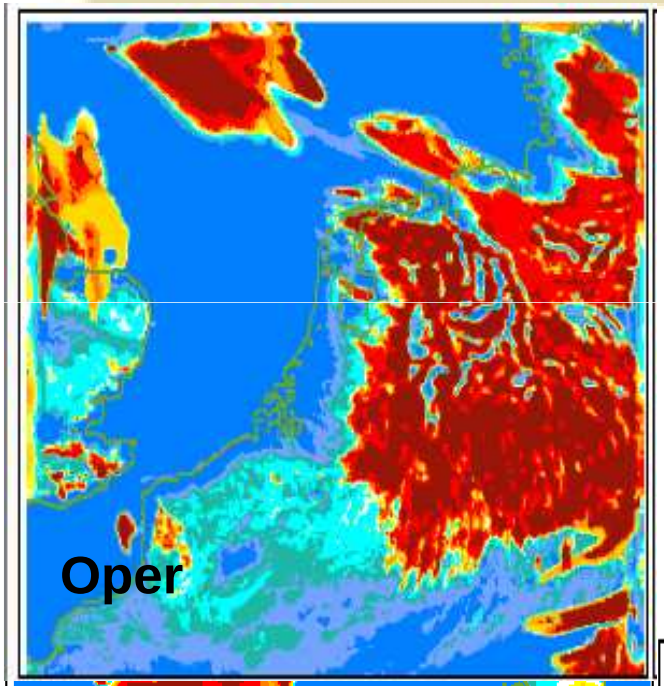
-> Modifications in operational AROME, 37t1-op1 since 25 september (Sébastien Riette and Yann Seity)

- Cloud scheme and shallow convection
- New orography
- New clay and sand climatologies
- Modification of hydrometeors coupling

-> On going work on (Shallow convection, stable case, high resolution)

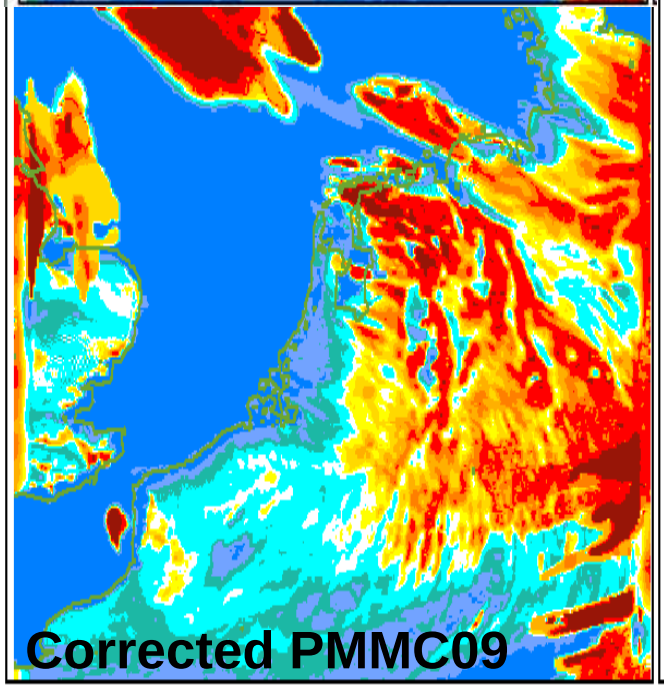
- Rio et al (2010) formulation in PMMC09
- Turbulence in stable case (Eric Bazile)
- 90 levels, 1.3km resolution for AROME (yann Seity)
- High resolution experiments (Rachel Honnert)

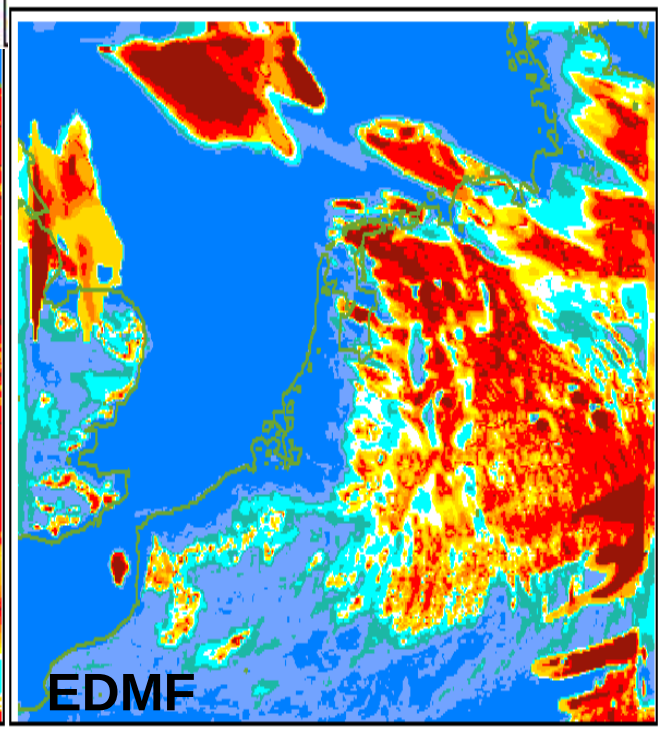
Modifications in shallow convection scheme



Corrections in PMMC09 *(Pergaud et al, 2009)* scheme (ice, guess used, convergence)
-> results closer to EDMF, used at KNMI

(Total cloud fractions, 9 April 2010 12TU)

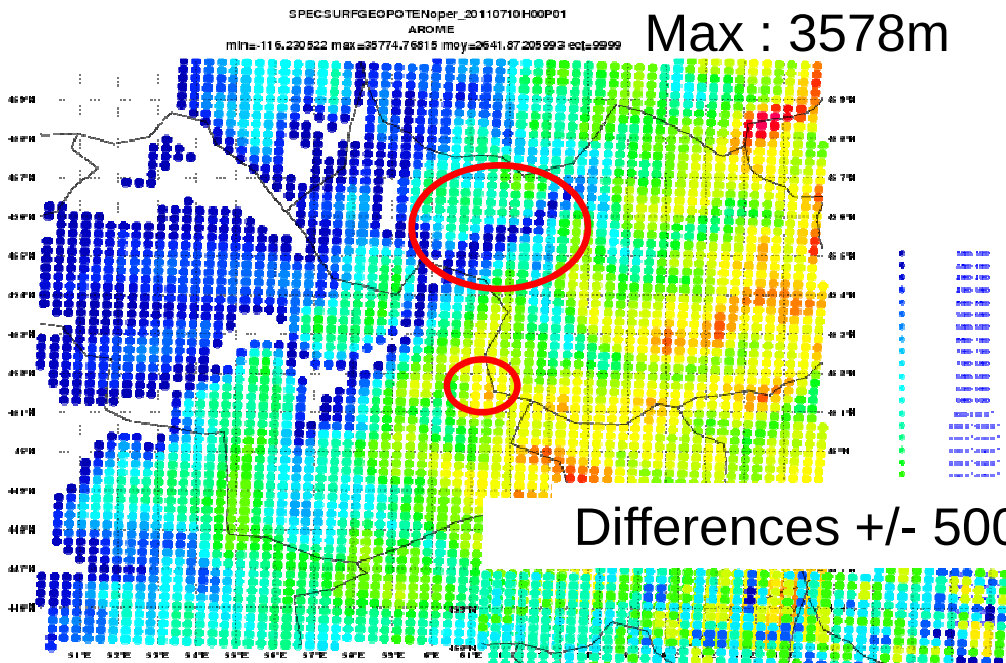




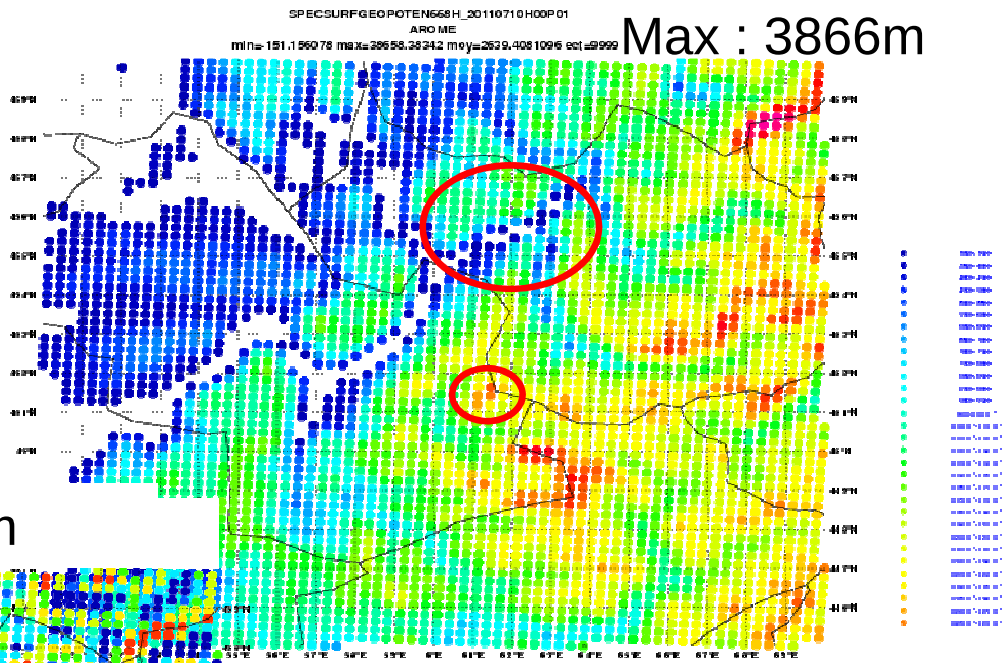
New orography

Zoom over the Alps :

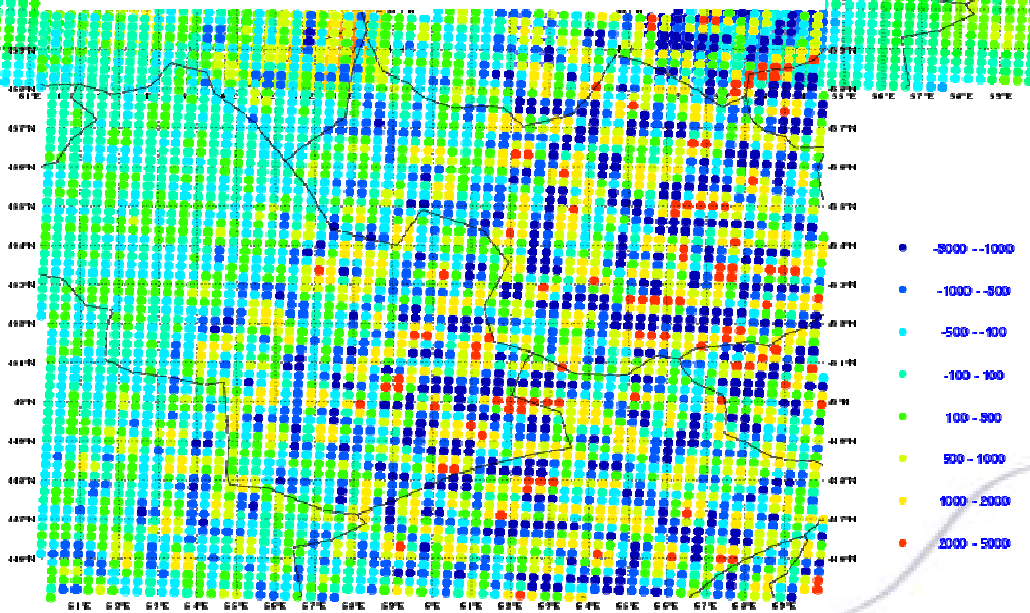
Oper (base GTOPO30 – 5 km)



New (base GTOPO30 – 1 km)



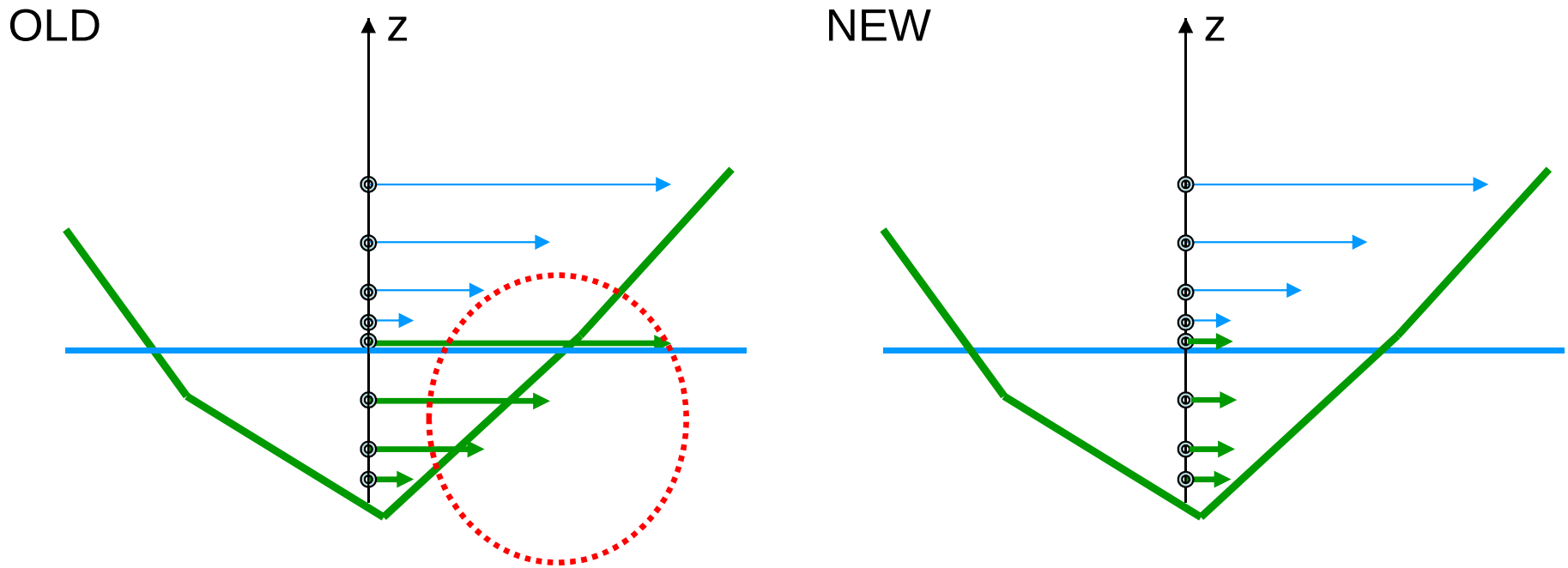
Differences +/- 500m



cnrs INSU Observer & comprendre

METEO FRANCE Toujours un temps d'avance

Problem without data assimilation



Forecast blows up after a few time steps (Lot of SMILAG TRAJECTORY UNDERGROUND)

Wind is not correctly adjusted to the orography.

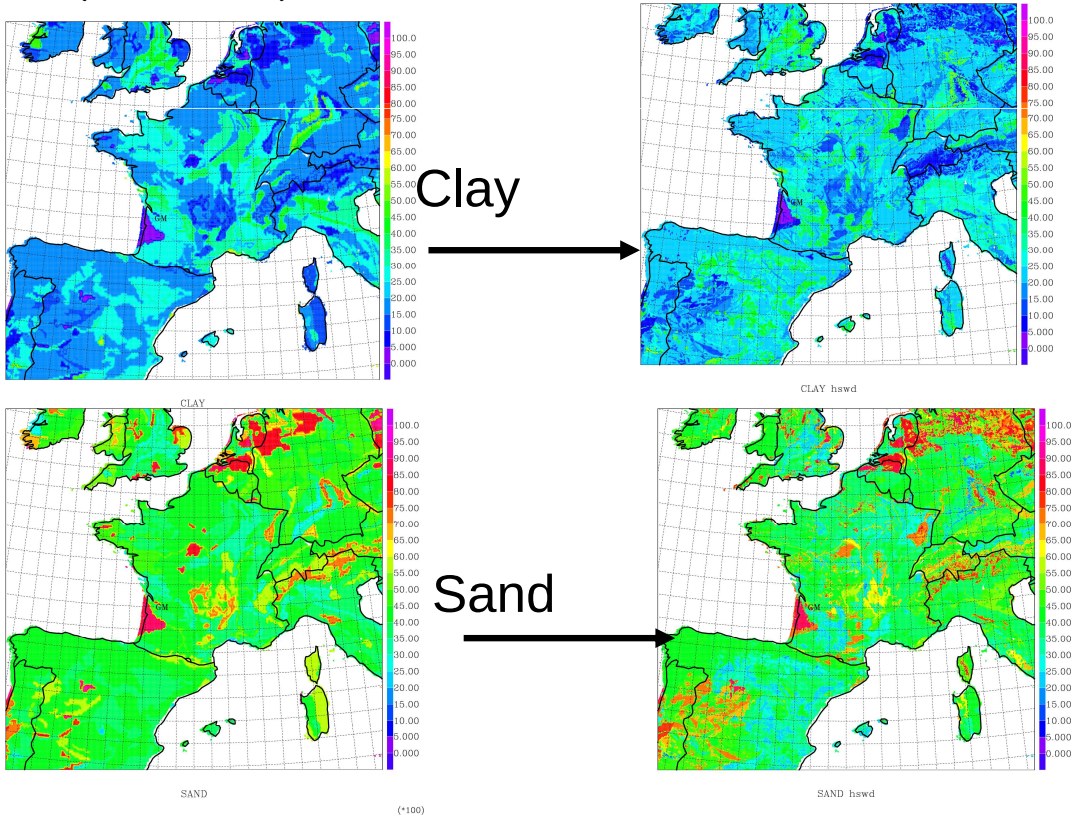
-> modification of wind interpolation during preparation of initial file (apache.F90 in E927)

ARPEGE AROME

New clay and sand climatologies :

OPER (FAO : 10km)

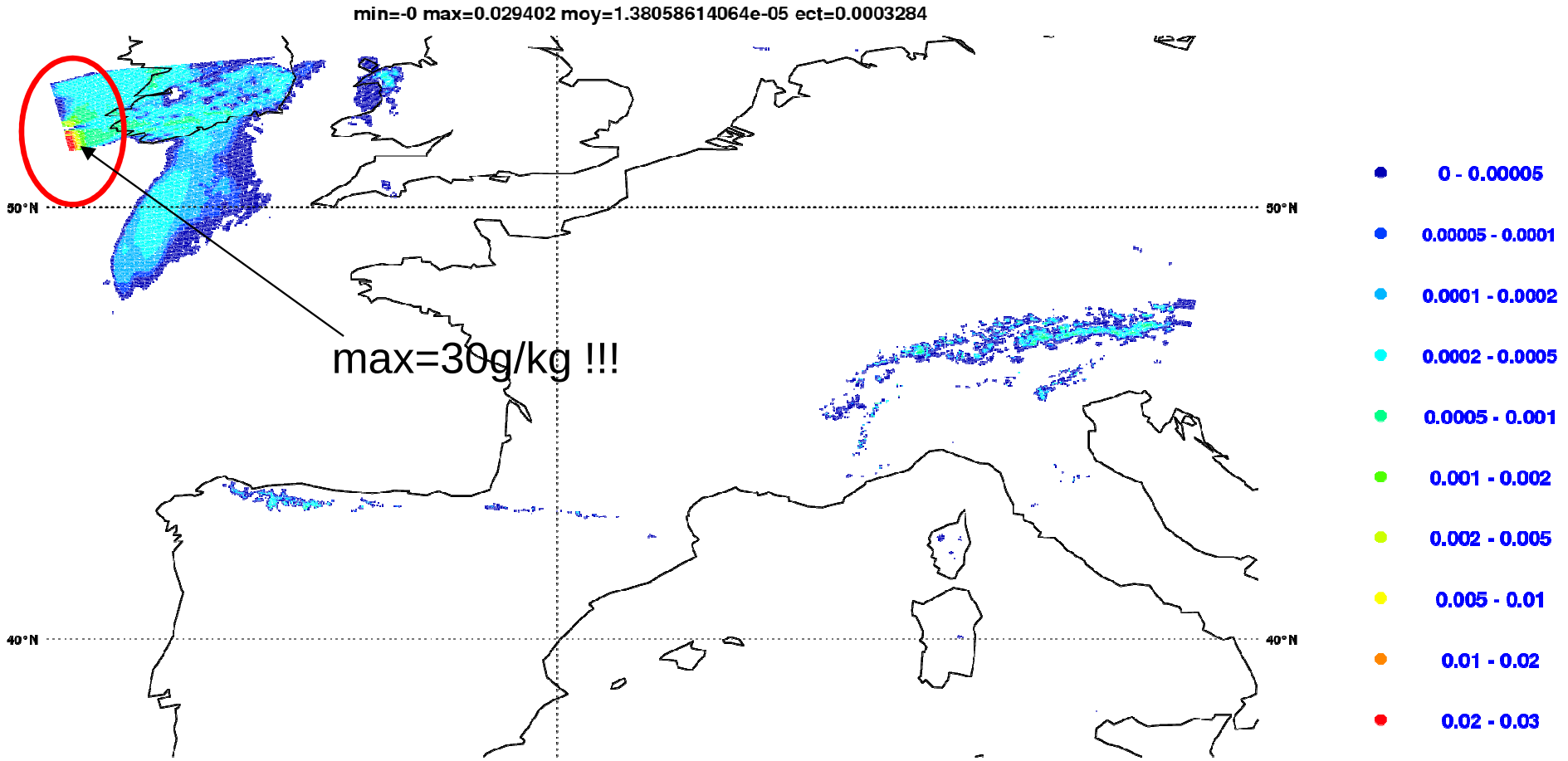
Test (1km HWSD)



- Neutral impact with and without data assimilation

Modification of hydrometeors coupling (in oper, only q_v is coupled)

Example of q_c horizontal cross section (level 50) AROME 6 July 2010 :



Inconsistancies between Arpege fields imposed on the domain's border and AROME physics which cannot modify q_v (infinite source of water) !! -> they persist until ARPEGE profiles allow physics to evaporate them, or until being removed by rainfalls. They can be advected inside the domain.

->coupling q_c with 0 to remove them. Neutral impact on scores.

METEO FRANCE
Toujours un temps d'avance

Plan

-> Modifications in operational AROME (37t1-op1 since 25 september)

- Cloud scheme and shallow convection
- New orography
- New clay and sand climatologies
- Modification of hydrometeors coupling

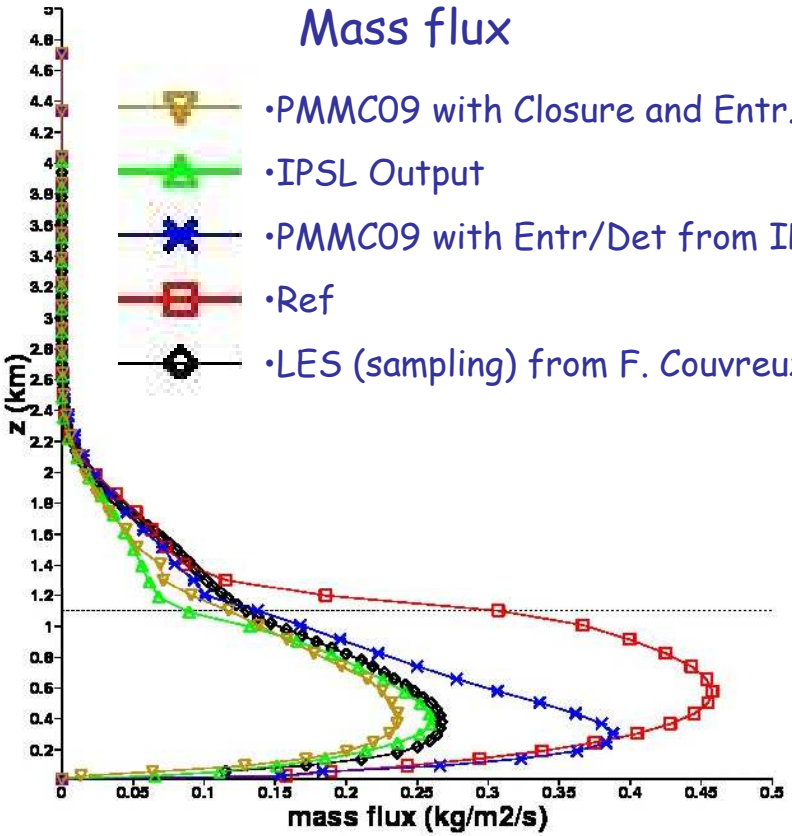
-> On going work on (Shallow convection, stable case, high resolution)

- Rio et al (2010) formulation in PMMC09
- Turbulence in stable case (Eric Bazile)
- 90 levels, 1.3km resolution for AROME (yann Seity)
- High resolution experiments (Rachel Honert)

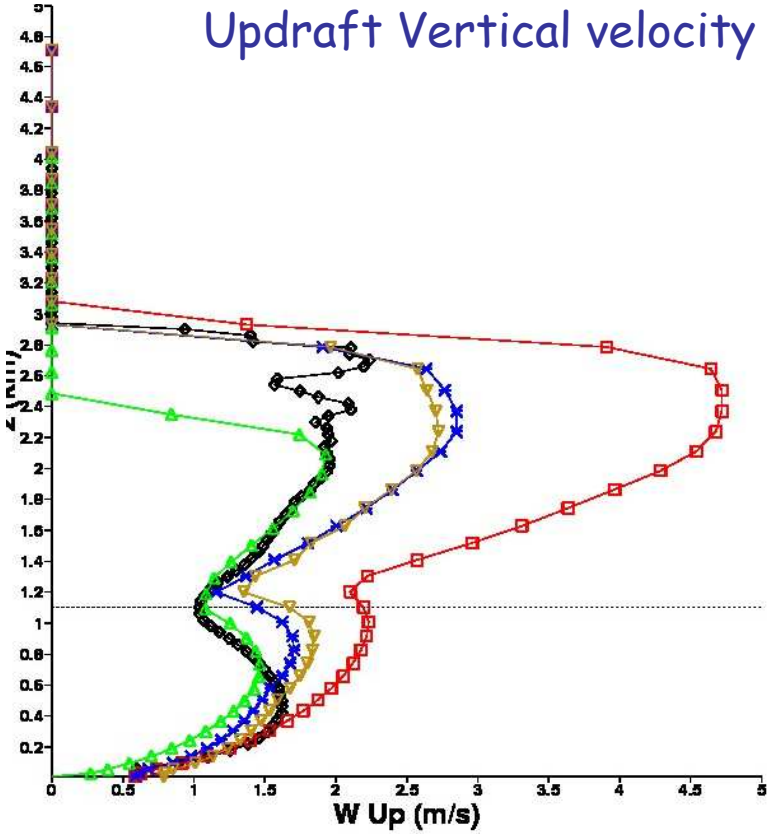
Impact in 1D model for ARM cumulus case scientific modifications

- Entrainment and detrainement from Rio et al (2010)
- Closure assumption from Rio and Hourdin (2008)

Mass flux



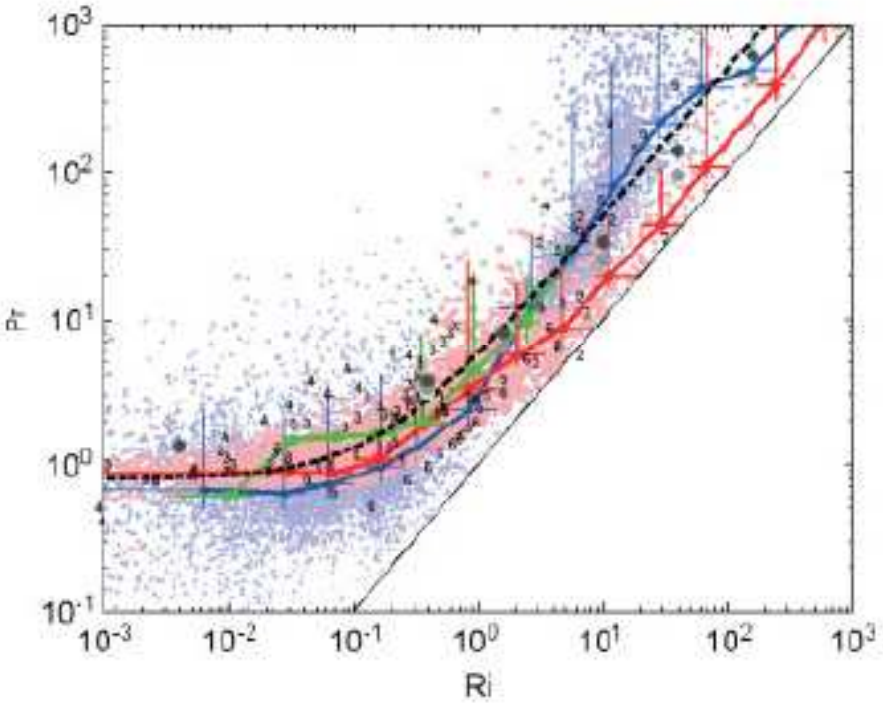
Updraft Vertical velocity



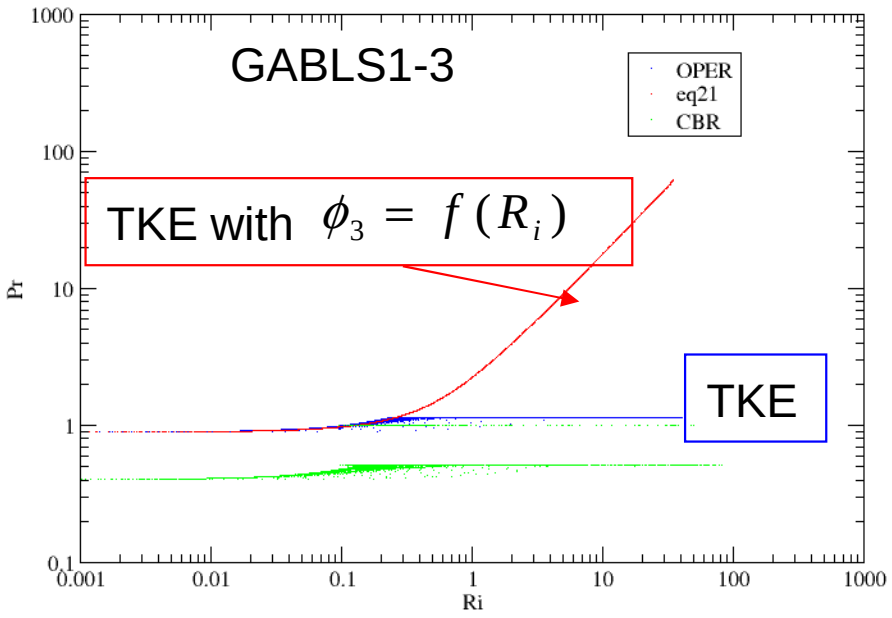
First developed for ARPEGE but also possible to use in AROME (not yet tested)

Turbulence : stable case : Some weaknesses …

1. We still have warm bias over snow (Northern Europe, South and North Pole) → interaction with the surface and the snow scheme
2. Following Galperin et al 2007 and Zilitinkevich et al 2008 turbulence survives for Ri>>1. It is not the case with the TKE scheme used in ARPEGE/AROME…



From Zilitinkevich et al 2008



$$\mathrm{Pr} = \frac{K_m}{K_h} = \frac{1}{\alpha_\theta \phi_3}$$

with $\alpha_\theta = 1.13$

$0.78 < \phi_3 < 2.2$

Impact of Phi3=f(Ri)

$$(\overline{w'\theta_l'}) = -\alpha_\theta \alpha_u l \sqrt{\overline{e_T}} \cdot \frac{\partial \overline{\theta_l}}{\partial z} \cdot \phi_3 \qquad (\overline{w'q_t'}) = -\alpha_\theta \alpha_u l \sqrt{\overline{e_T}} \cdot \frac{\partial \overline{q_t}}{\partial z} \cdot \phi_3$$

$$\phi_3 = \frac{1}{1 + C \cdot \beta \frac{L_m^2}{\overline{e_T}} \frac{\partial \overline{\theta_l}}{\partial z}}$$

Default formulae from

(Cuxart (2000) eq19)

or in a stationary equilibrium of TKE

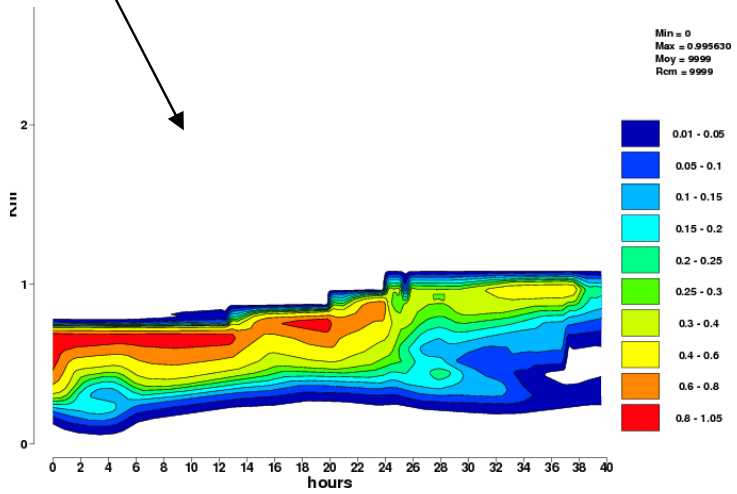
(Cuxart (2000) eq21)

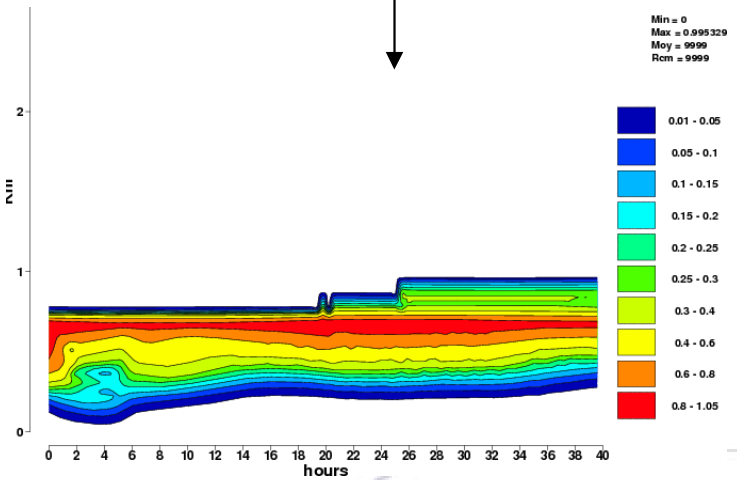
$$\phi_3 = \frac{1}{1 + C_4 R_i / f(R_i)}$$

$$f(R_i) = 0.5\left(1 - (C_3 + C_4)Ri + \left((1 - (C_3 + C_4)Ri)^2 + 4C_4 Ri\right)^{0.5}\right)$$

Cloud Cover ASTEX Lagrangian Case (Euclipse)

Cloud Cover : impact of Phi3





Impact of Phi3=f(Ri)

$$(\overline{w'\theta_l'}) = -\alpha_\theta \alpha_u l \sqrt{\overline{e_T}} \cdot \frac{\partial \overline{\theta_l}}{\partial z} \cdot \phi_3 \qquad (\overline{w'q_t'}) = -\alpha_\theta \alpha_u l \sqrt{\overline{e_T}} \cdot \frac{\partial \overline{q_t}}{\partial z} \cdot \phi_3$$

$$\phi_3 = \frac{1}{1 + C \cdot \beta \frac{L_m^2}{\overline{e_T}} \frac{\partial \overline{\theta_l}}{\partial z}}$$

Default formulae from

(Cuxart (2000) eq19)

or in a stationay equilibrum of TKE

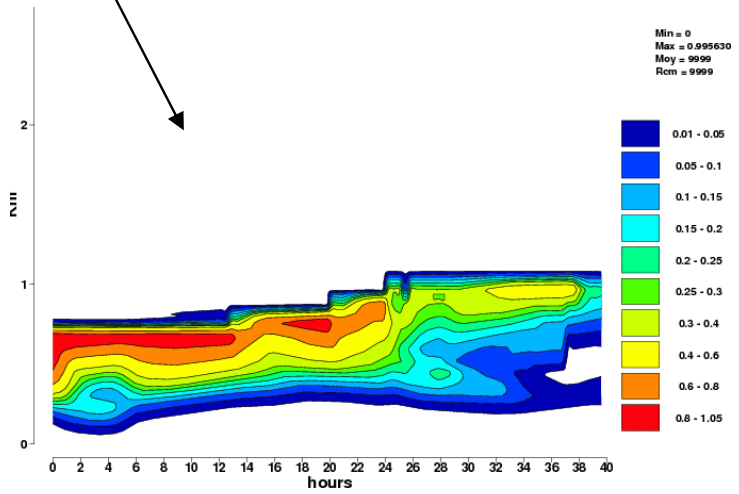
(Cuxart (2000) eq21)

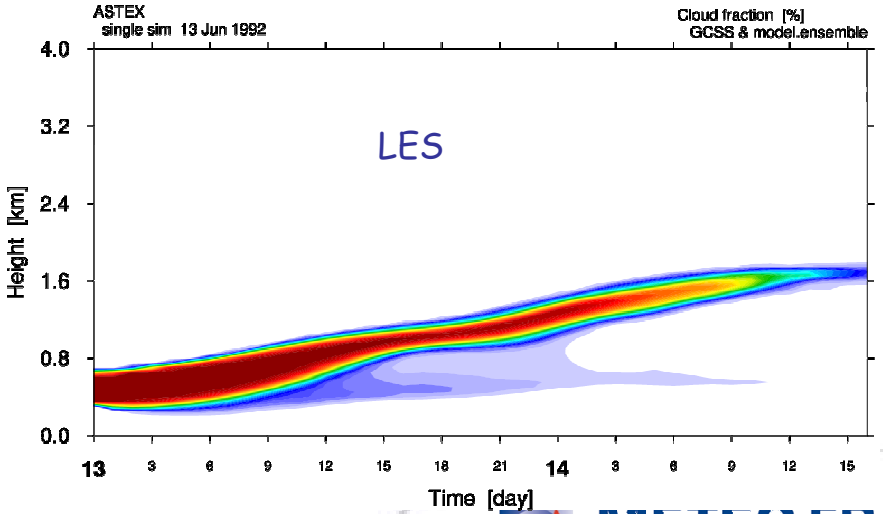
$$\phi_3 = \frac{1}{1 + C_4 R_i / f(R_i)}$$

$$f(R_i) = 0.5\left(1 - (C_3 + C_4)Ri + \left((1 - (C_3 + C_4)Ri)^2 + 4C_4 Ri\right)^{0.5}\right)$$

Cloud Cover ASTEX Lagrangian Case (Euclipse)

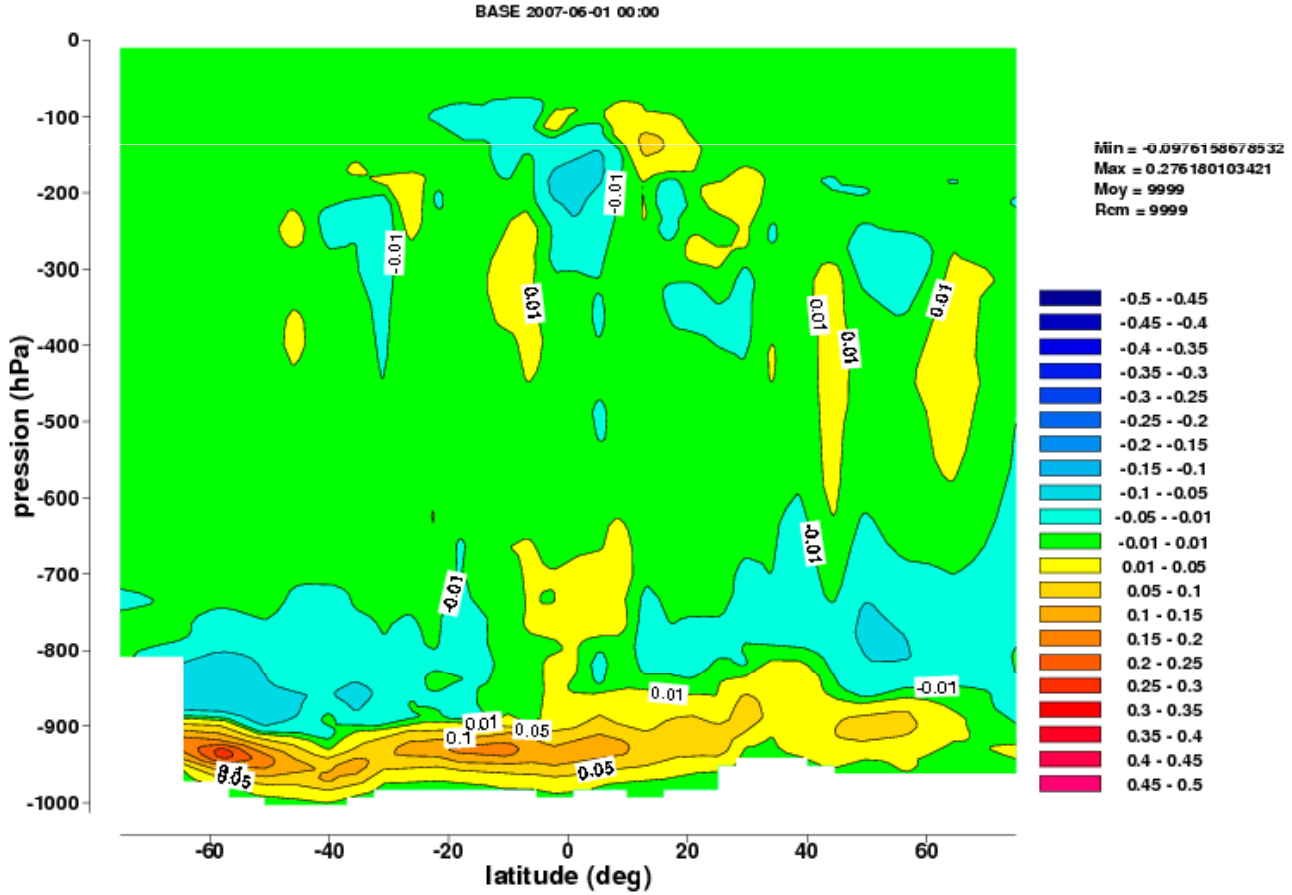
Cloud Cover : impact of Phi3





Impact of Phi3=f(Ri) in ARPEGE 3D

Cloud Cover (Zonal mean) : Phi3=f(Ri) – Ref

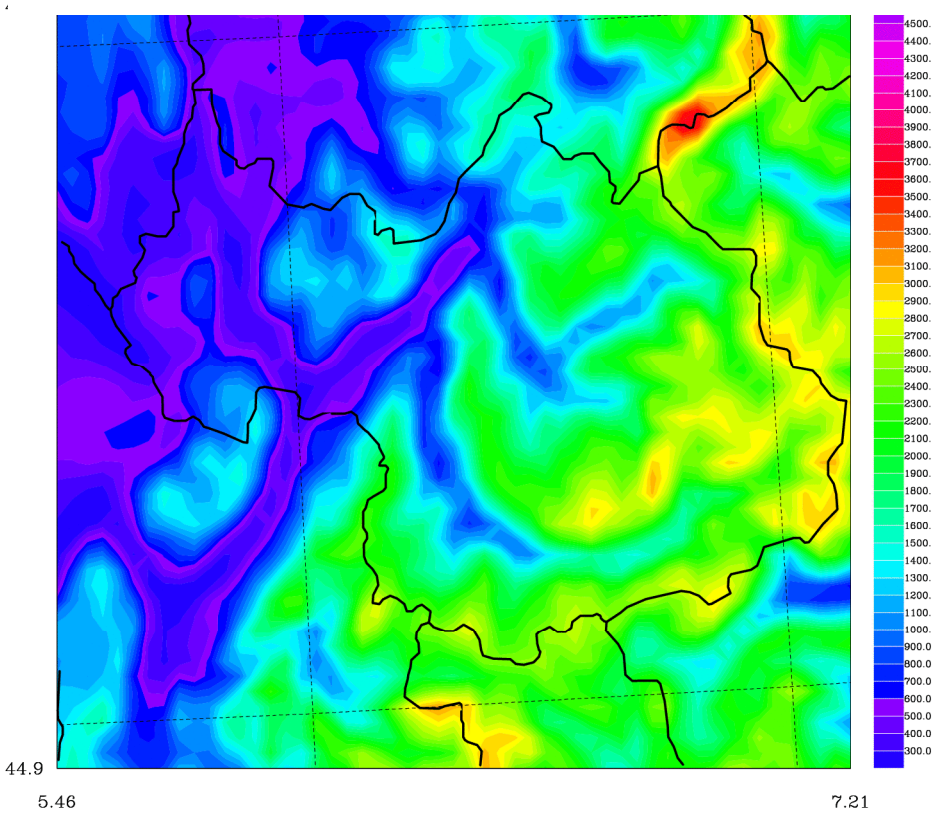


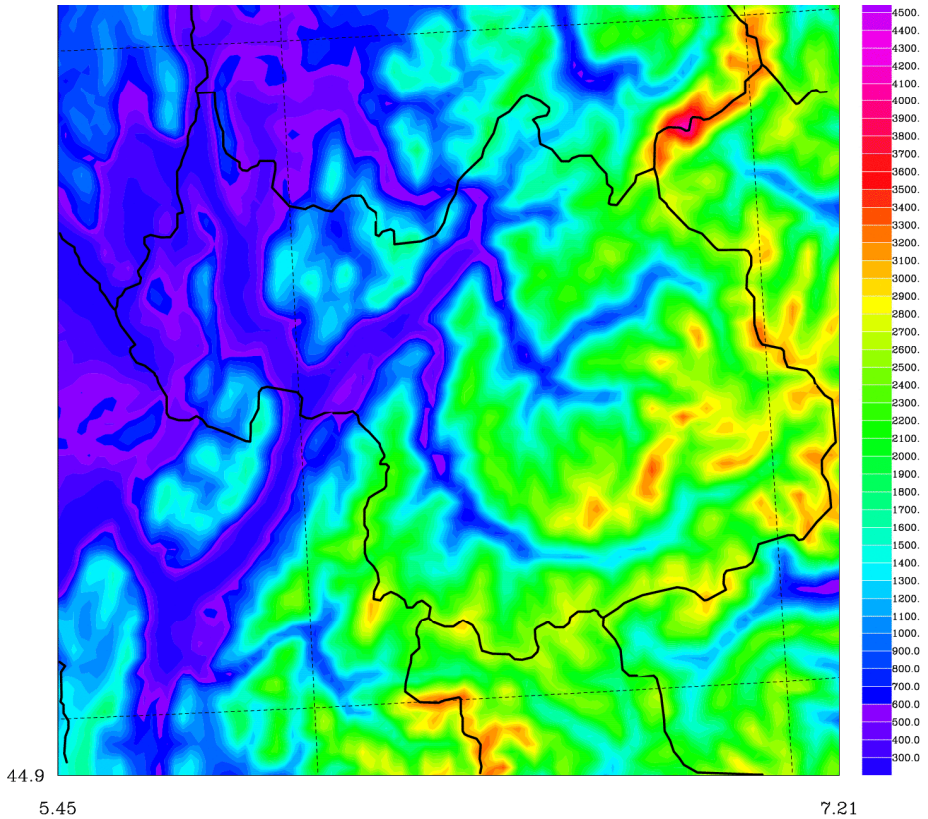
Phi3=f(Ri) increases the humidity in the PBL → more low cloud

Preparation of AROME-France 1.3km

- Increase horizontal and vertical resolution in 2014 (1.3 kmxL90?)

  « deeper valleys, higher peaks » -> max slope = 39° (versus 23° in oper 2.5km)

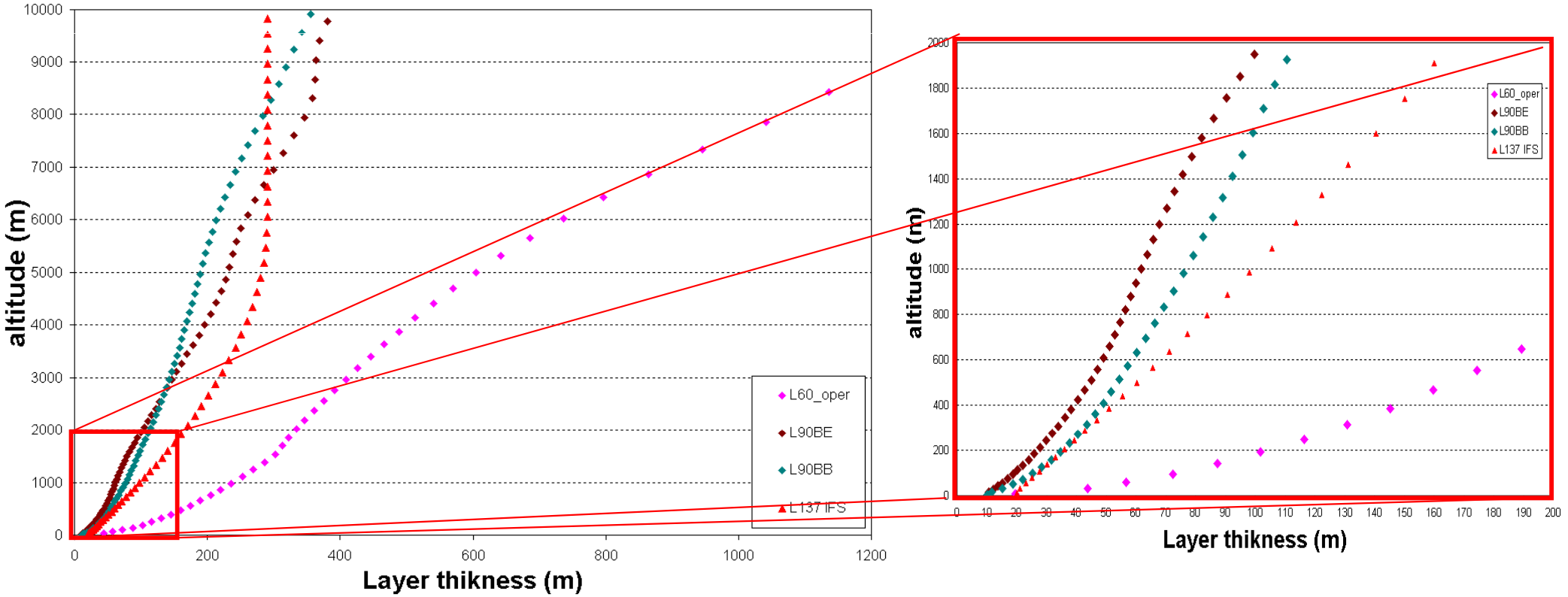




Preparation of AROME_1.3km (vertical resolution)

- Lowering model's roof to prevent instabilities in stratosphere

- Compromise between numerical efficiency (time step), lowest model level height, meteorological scores

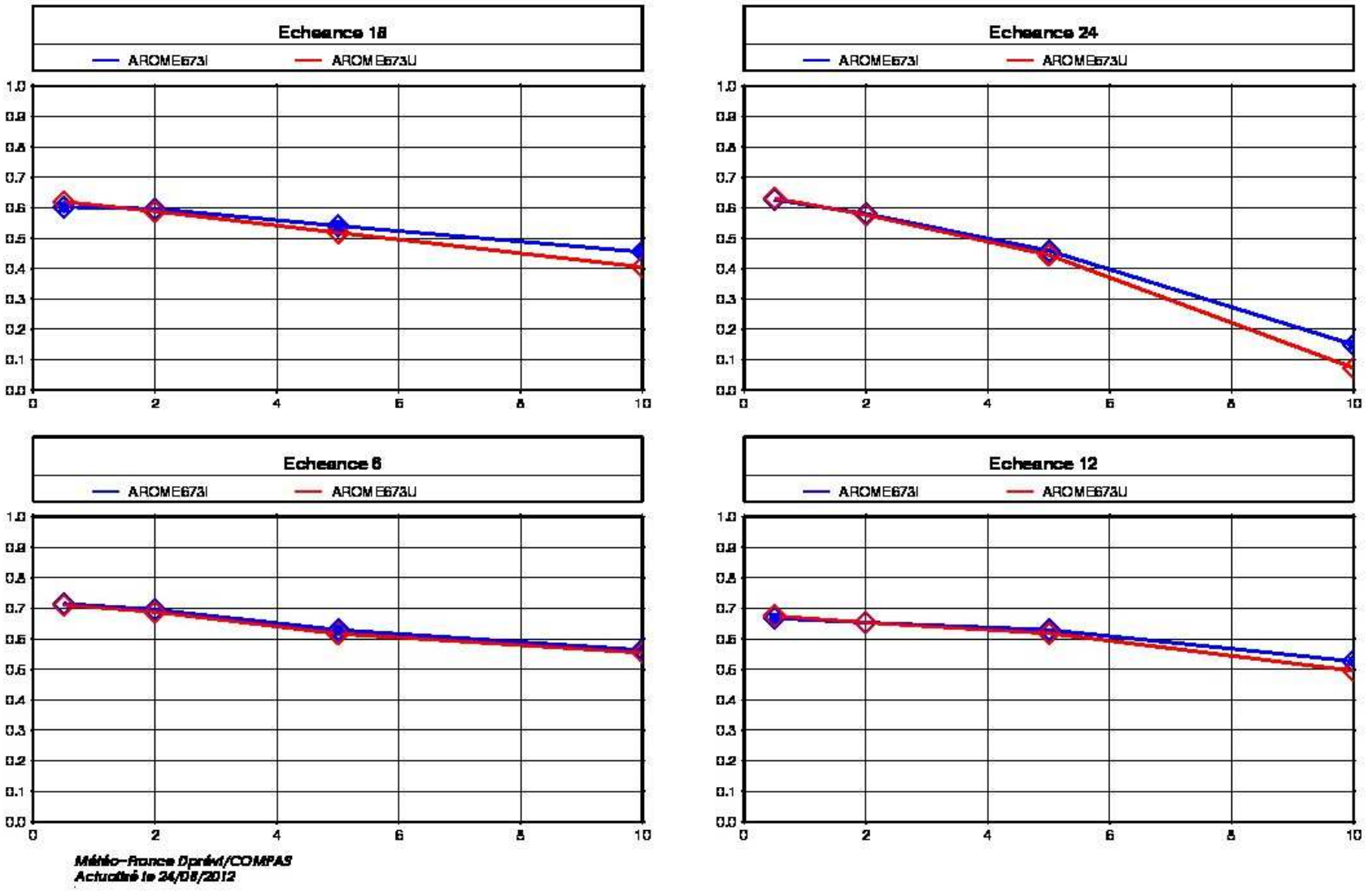


-2 L90 vertical resolutions are presently under tests : First level at 5m, PC scheme and dt=45s

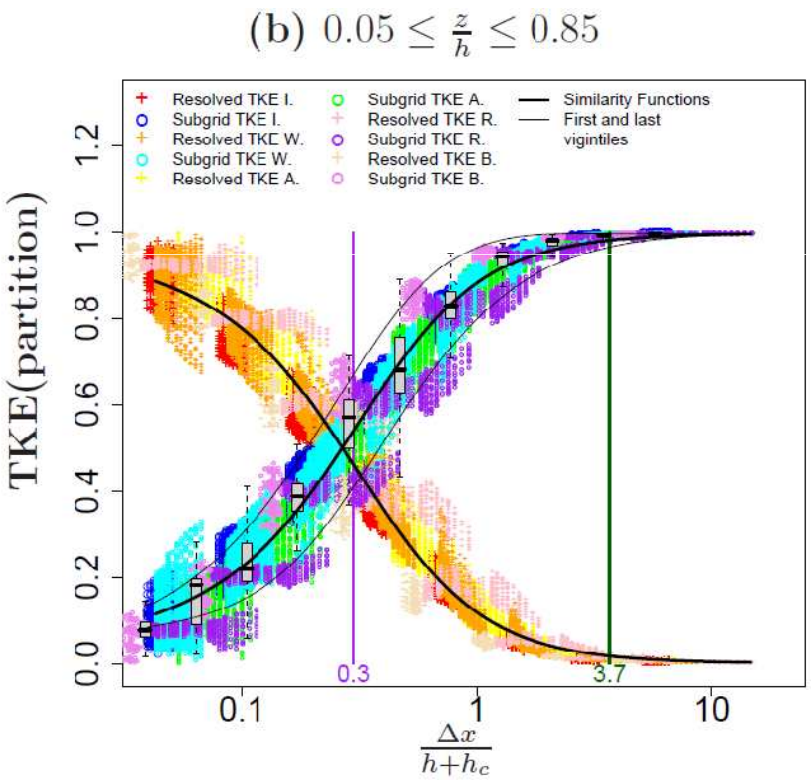
-First tests on Xynthia storm case -> lowest model levels below 4m requires too small dt

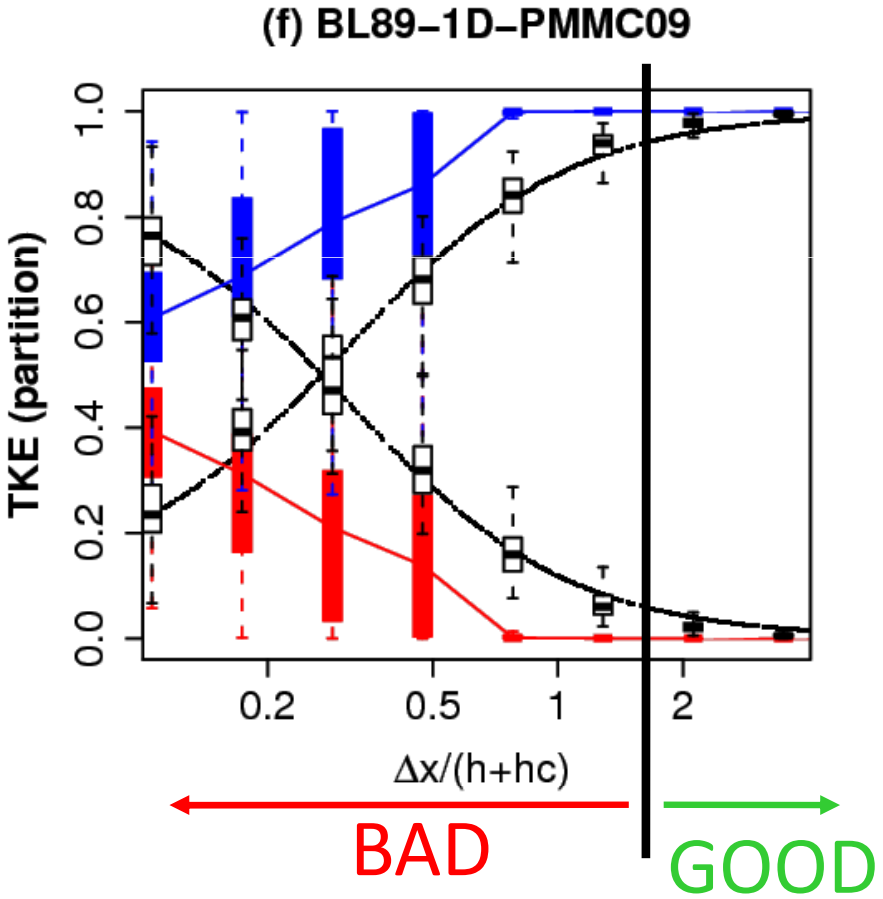
Preparation of AROME_1.3km (First results)

-Probabilistic control of precipitation (BSS function of threshold of precipitation)



TURBULENCE : Convective Boundary Layer





- Adaptation of the Mass-Flux scheme equations for the grey zone
- Dependence of the closure on the resolution

Honnert et al. (2011, 2012)

Thank You for your attention