# Latest developments in physics parametrizations

EWGLAM 2009

Y. Bouteloup, Y. Seity, V. Masson…

METEO FRANCE
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# Outline of the talk

- Developments in Arpège/Aladin physics
- Arome v2 physics

# Arpège/Aladin: new physical parameterizations, in operation since 04/02/2009

➔ A Prognostic Turbulent Kinetic Energy (TKE) scheme as it is described in Redelsperger and Sommeria (1981), Cuxart et al (2000) and Cheng et al (2002). Bougeault Lacarrère (1989) mixing length is used

➔ A shallow convection mass flux scheme which comes from the approach of Kain and Fritsch (1993) and was written for Meso-NH by Peter Bechtold (Bechtold et al., 2001).

➔To improve the representation of strato-cumulus, the scheme uses a top-Planetary Boundary Layer entrainment parametrization following the ideas of Grenier and Bretherton (2001) and Grenier (2002).

➔Finally, following Lock and Mailhot (2006), it was decided to amend both the mixing length and the TKE production when a shallow cloud is present

➔ ECUME = Sea surface fluxes bulk iterative scheme based on field experiments (Belamari, 2005)

➔ 6 spectral bands in radiation scheme (instead of 2)

➔ New ozone climatology

# The TKE scheme

**It's a diffusion scheme :** $\overline{w'\psi'} = -K\frac{\partial \psi}{\partial z}$

**K are computed using a prognostic Turbulent Kinetic Energy (TKE) :**

$K = Cl\sqrt{e}$ **Where l is a mixing length**

**and e being the TKE ➔** $\frac{\partial e}{\partial t} = [Advect] + diff_{vert} + P_{dyn} + P_{ther} - diss$

**With**

$diff_{vert} = -\frac{1}{\rho}\frac{\partial}{\partial z}\left(\rho\,\overline{e'w'}\right)$ $P_{dyn} = -\left[\overline{u'w'}\frac{\partial u}{\partial z} + \overline{v'w'}\frac{\partial v}{\partial z}\right]$ $Diss = C_e\frac{e\sqrt{e}}{l_e}$

**and**

$P_{ther} = \beta\,\overline{w'\theta'_{vl}} = \beta\left(E_\theta\overline{w'\theta'_l} + E_q\overline{w'q'_t}\right)$

**New thermal production term coming from the shallow convection**

**Becomes :**

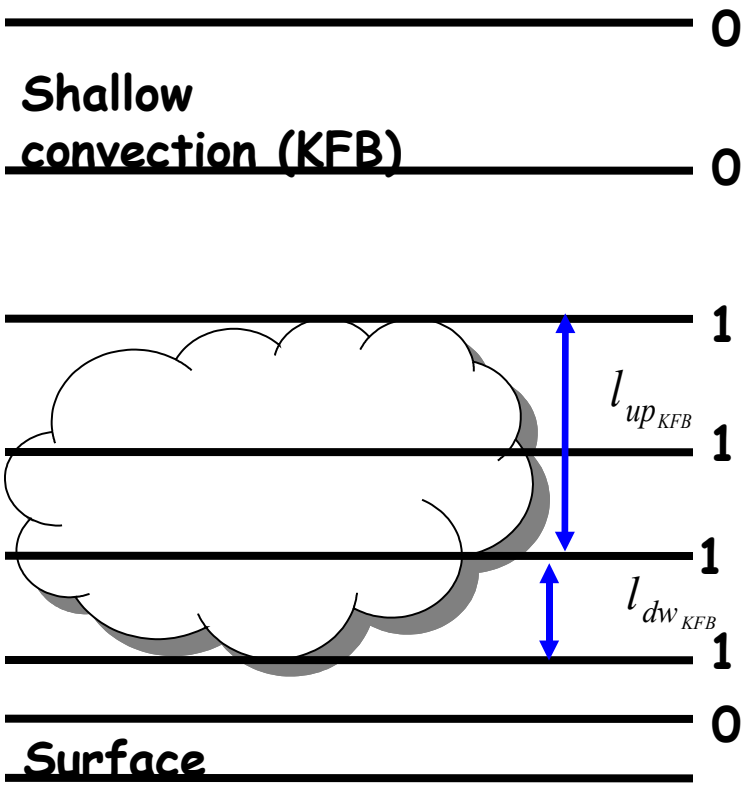
$P_{ther} = \beta\left(E_\theta\overline{w'\theta'_l} + E_q\overline{w'q'_t}\right) + \beta\left(\overline{w'\theta'_l}\right)_{KFB}$

# Computation of the mixing length

**Mixing length are computed using the approach of Bougeault Lacarrère (1989)**

$$L_{BL89} = \left[ \frac{\left(l_{up}\right)^{-\frac{2}{3}} + \left(l_{down}\right)^{-\frac{2}{3}}}{2} \right]^{-\frac{3}{2}}$$

**Where $l_{up}$ and $l_{down}$ are computed using dry buoyancy**




**They are modified in a shallow cloud following :**

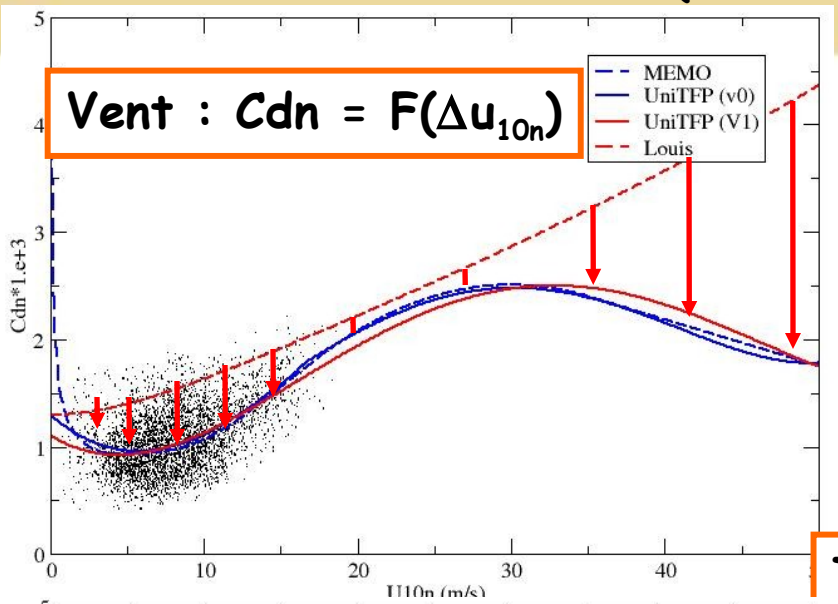
$$l_{up_{cvpp}} = Max\left(l_{up_{bl89}}, l_{up_{KFB}}\right)$$

$$l_{dw_{cvpp}} = Max\left(l_{dw_{bl89}}, l_{dw_{KFB}}\right)$$

**They are also modified in a similar way in deep-convection active layers**

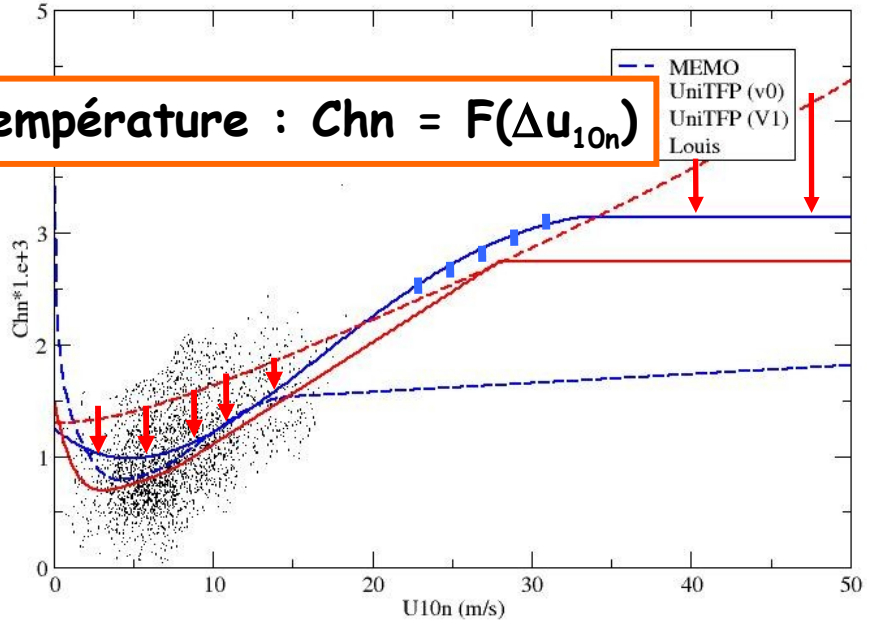
# ECUME= Exchange Coefficients from Unified Multi-campaigns Estimates (CNRM/GMGEC/MEMO)

**Vent : Cdn = F($\Delta u_{10n}$)**

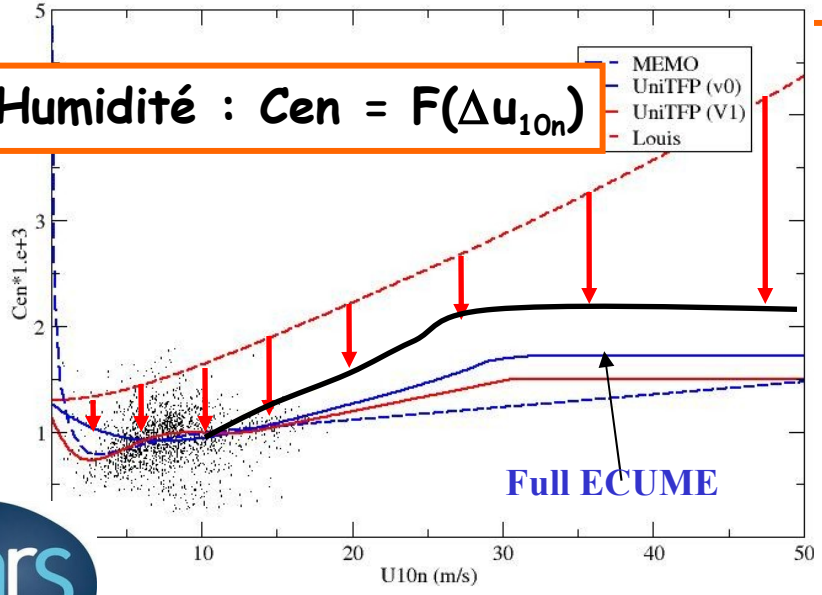



$$Cd = Cd_{ecume}$$
$$Ch = Ch_{ecume}$$
$$Ce = 0.75 * Ce_{ecume} + 0.25 * Ch_{ecume}$$

**Température : Chn = F($\Delta u_{10n}$)**



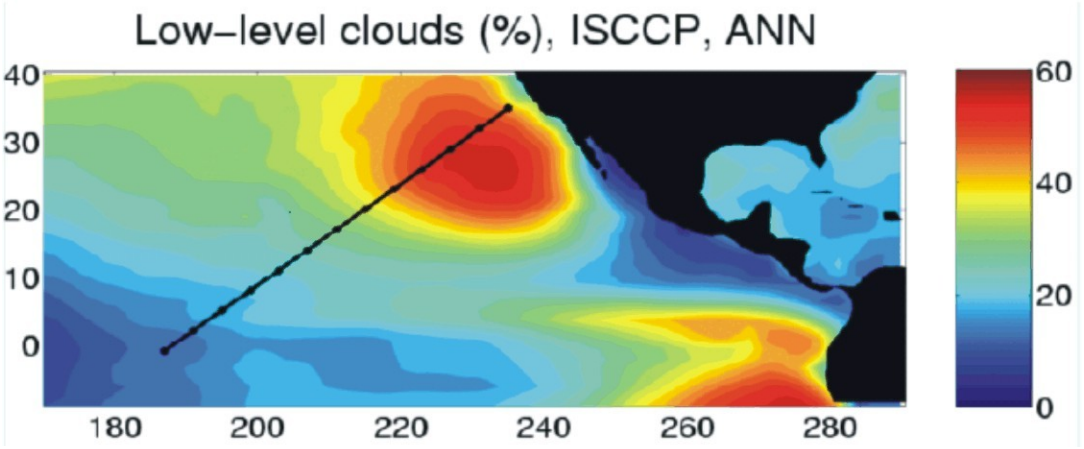

**Humidité : Cen = F($\Delta u_{10n}$)**

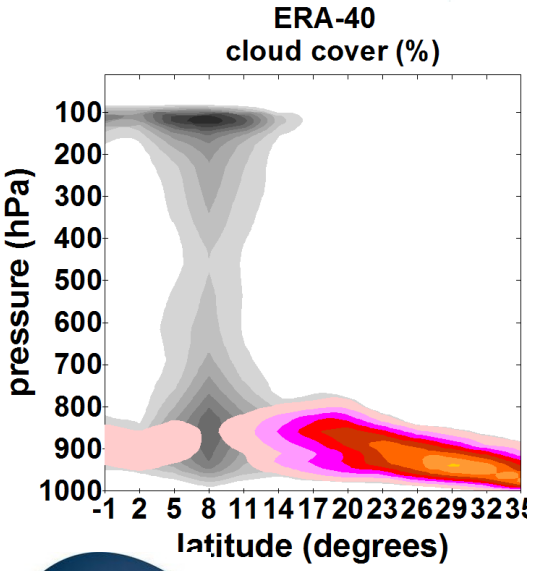


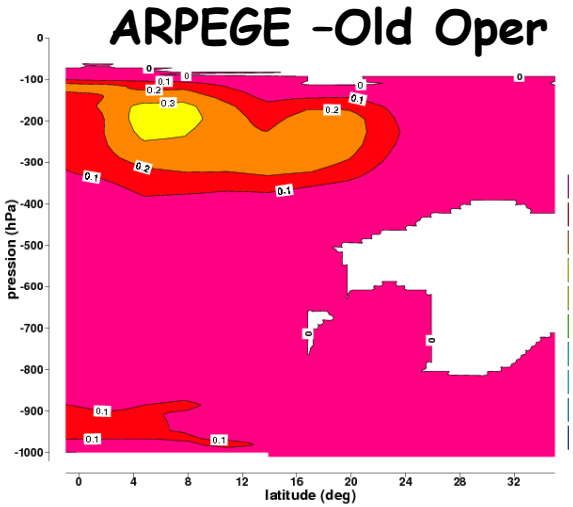

Thanks to Sophie Belamari (CNRM/GMGEC/MEMO)

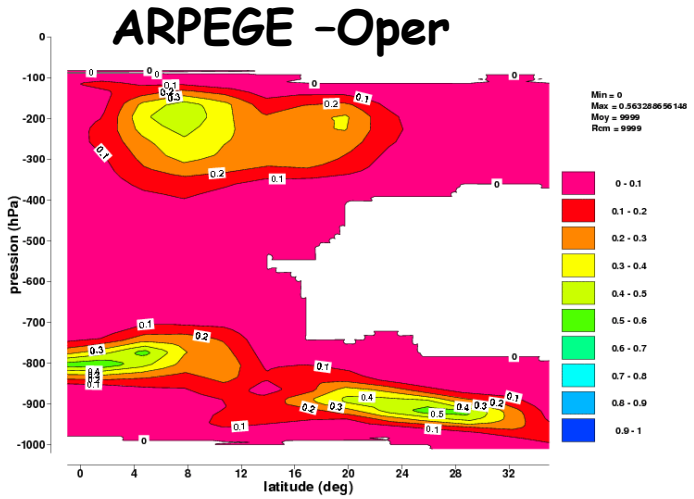
# GPCI : Gewex Pacific Cross-section Intercomparison

Courtesy Cecile Hannay (NCAR)

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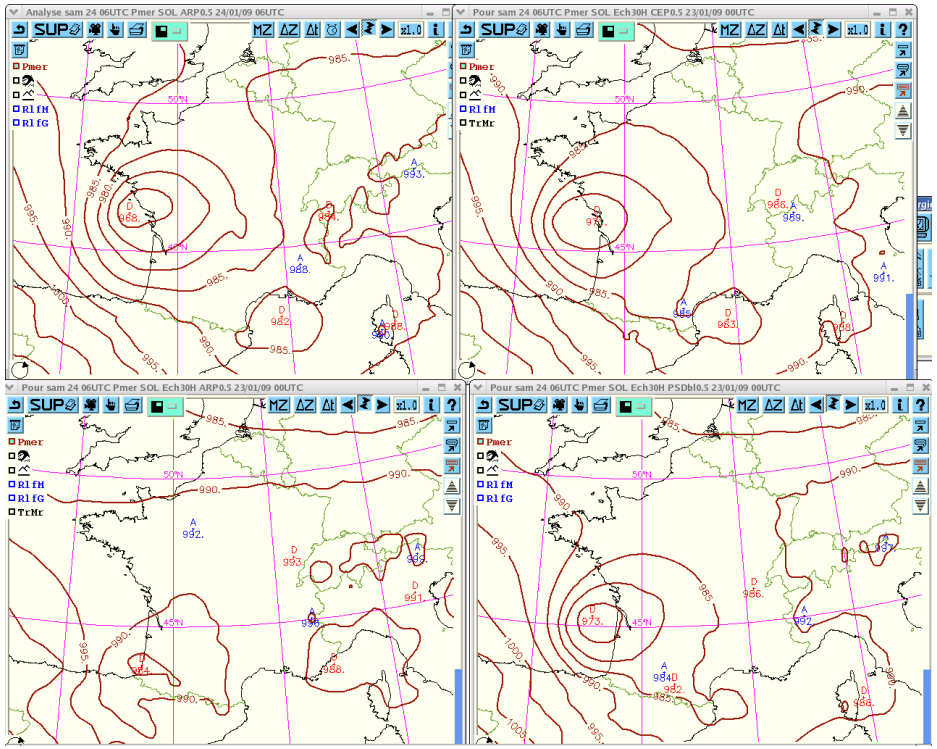
# STORM 24/01/2009 (mslp)

**Analysis 24/01/2009 06TU**

**ECMWF +30h**

**Analysis 24/01/2009 06TU**

**ECMWF +54h**



**ARPEGE Old+30h**

**ARPEGE NEW+30h**

**ARPEGE Old+54h**

**ARPEGE NEW+54h**

cnrs
dépasser les frontières

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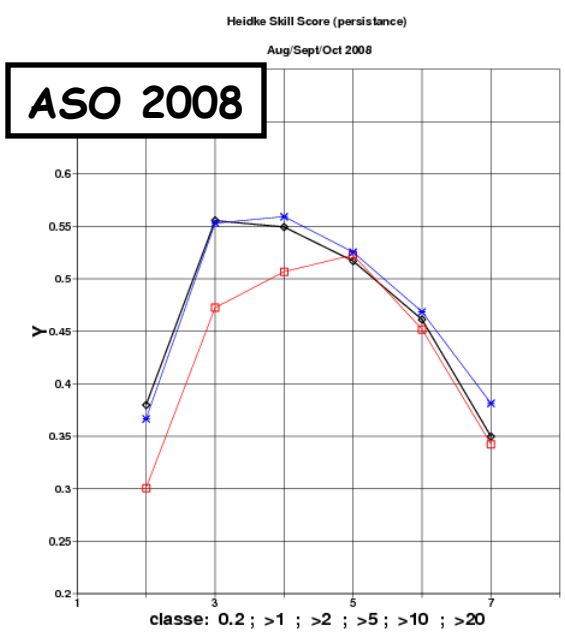
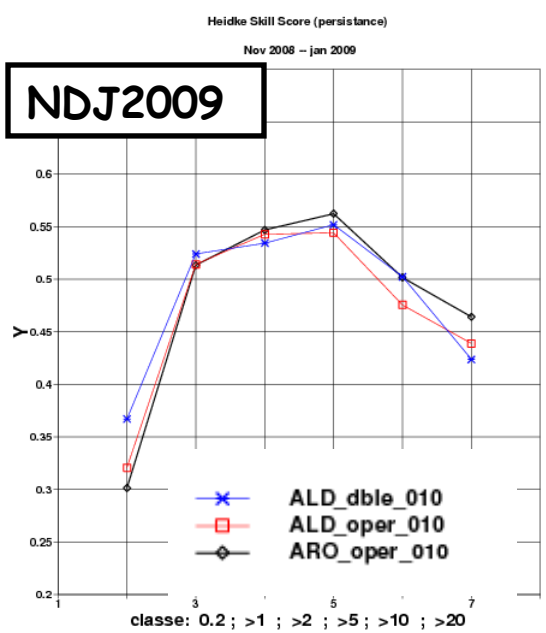
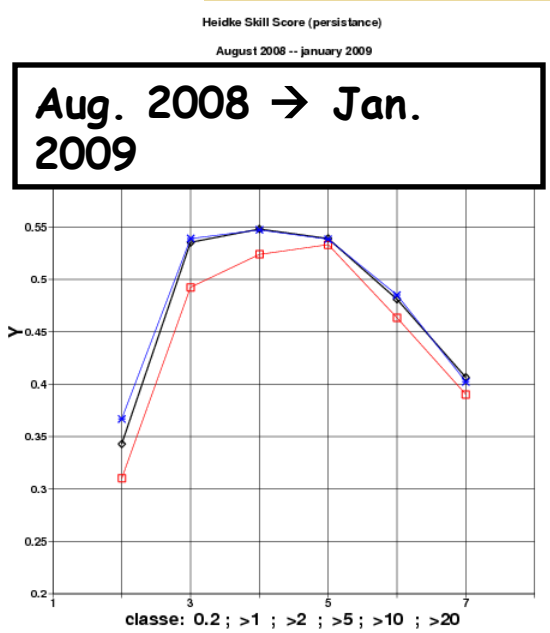
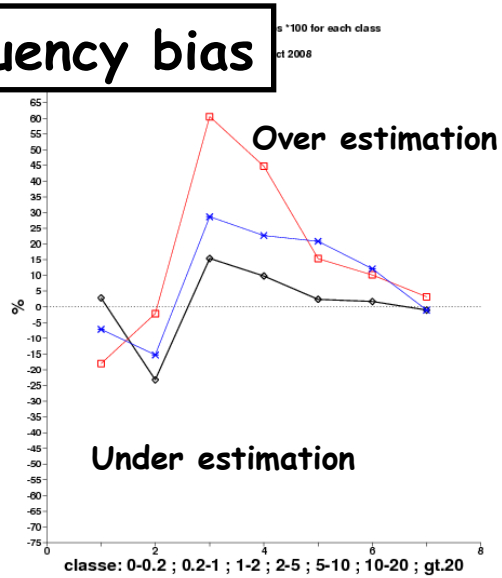
# Heidke Skill Score ALADIN Rainfalls 30h-06h

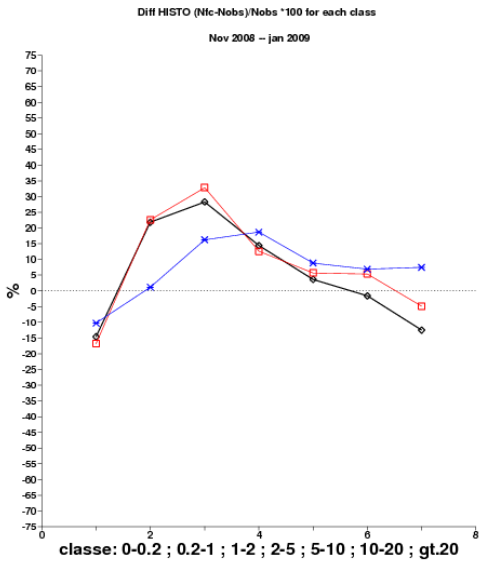


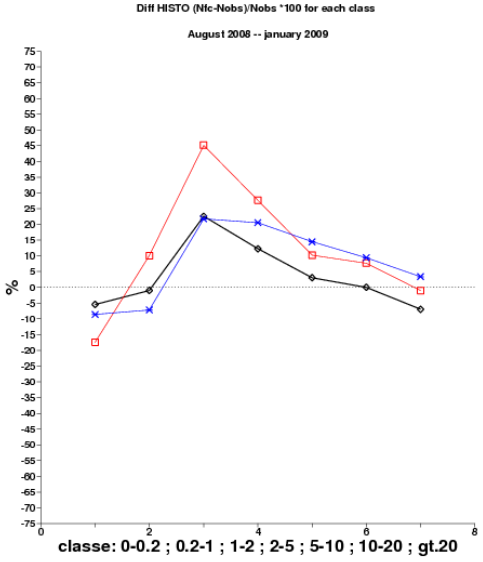




## Frequency bias



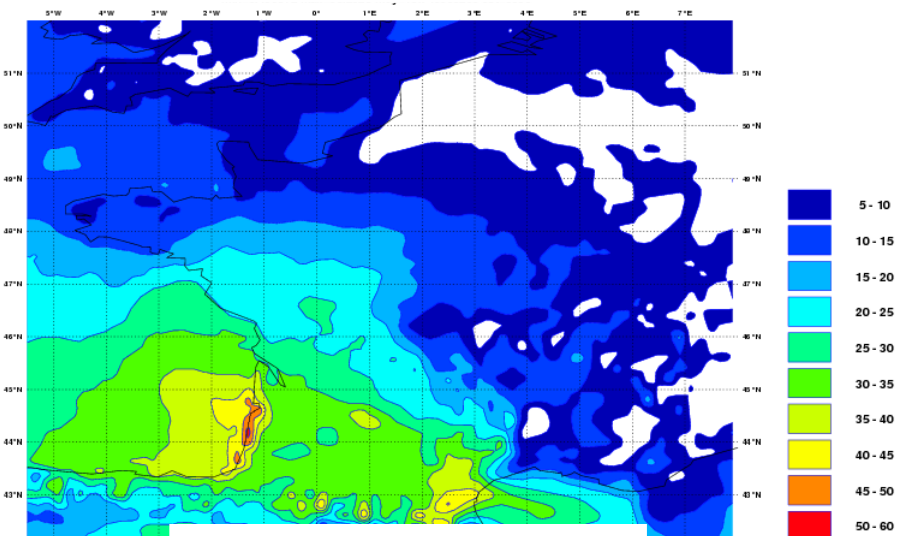



# Impact of advection of TKE

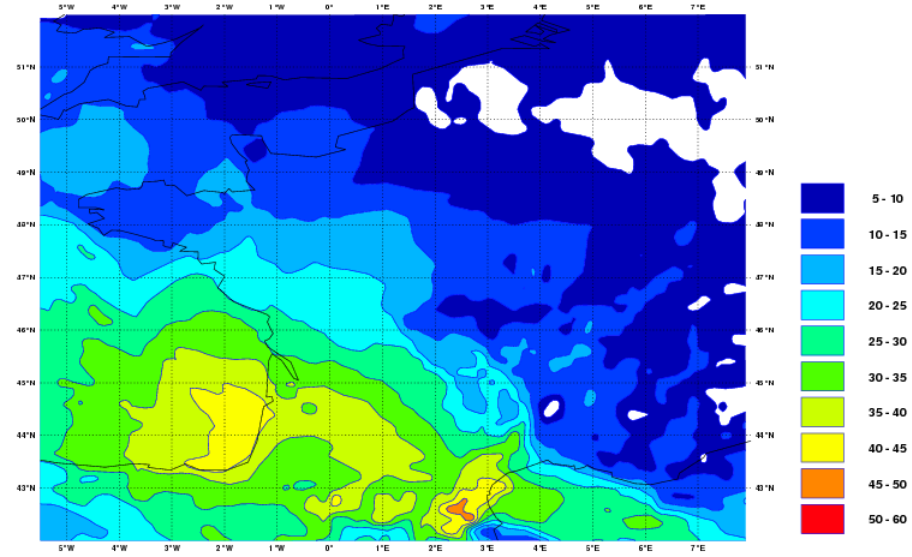
**Advection of TKE has no impact in term of synoptic scores, but during the storm of 24/01/2009 an impact was observed on wind gusts**

$$\begin{cases} U_{gust} = \overline{U} + \alpha\sqrt{e} \\ V_{gust} = \overline{V} + \alpha\sqrt{e} \end{cases}$$

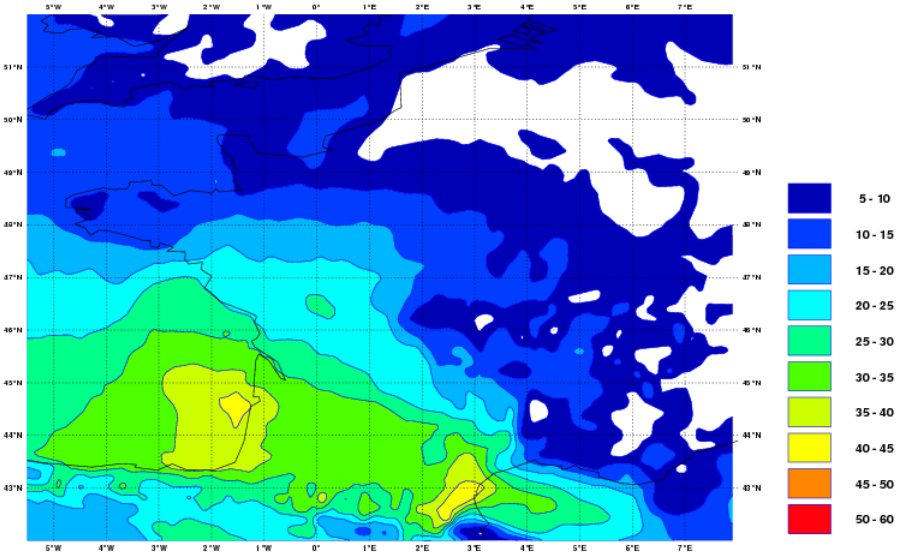
**Aladin without advection**




**Arome**




**Aladin with advection**



# Conclusions and prospects for Arpège/Aladin …

- Modifications of subgrid vertical mixing has a large beneficial impact on the quality of the models (global and LAM).

- The use of ECUME has a large impact on the quality of the hydrological cycle of the global model

- Micro-physics adjustment is always computed using a triangular probability-density function (Smith, 1990) It would be interesting to use a mixed symmetric (Gaussian) and asymmetric (Exponential) function, in order to represent the Cumulus and the Strato-Cumulus, respectively.

- KFB shallow convection scheme doesn't take into account dry thermal below the cloud. A new mass flux shallow convection scheme is used in AROME (EDKF) It is planned to test it in ARPEGE and ALADIN

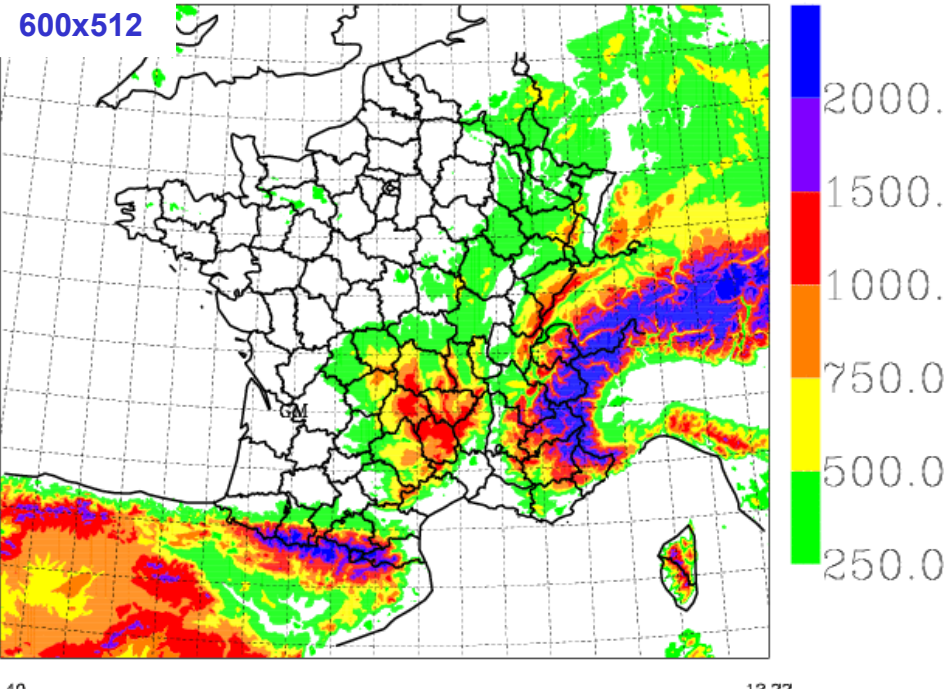
- It is also planned to test the 3MT deep convection scheme of ALARO built to operate in the « gray-zone » (~4km)

More information and references can be found in :

Bouteloup, Y., E. Bazile, F. Bouyssel and P. Marquet 2009: Evolution of the physical Parametrizations of ARPEGE and ALADIN-MF. ALADIN-Newsletter, 35,.p.48-58.
http://www.cnrm.meteo.fr/aladin/spip.php?action=autoriser&arg=1220

# AROME-France is operational since Dec 18 2008

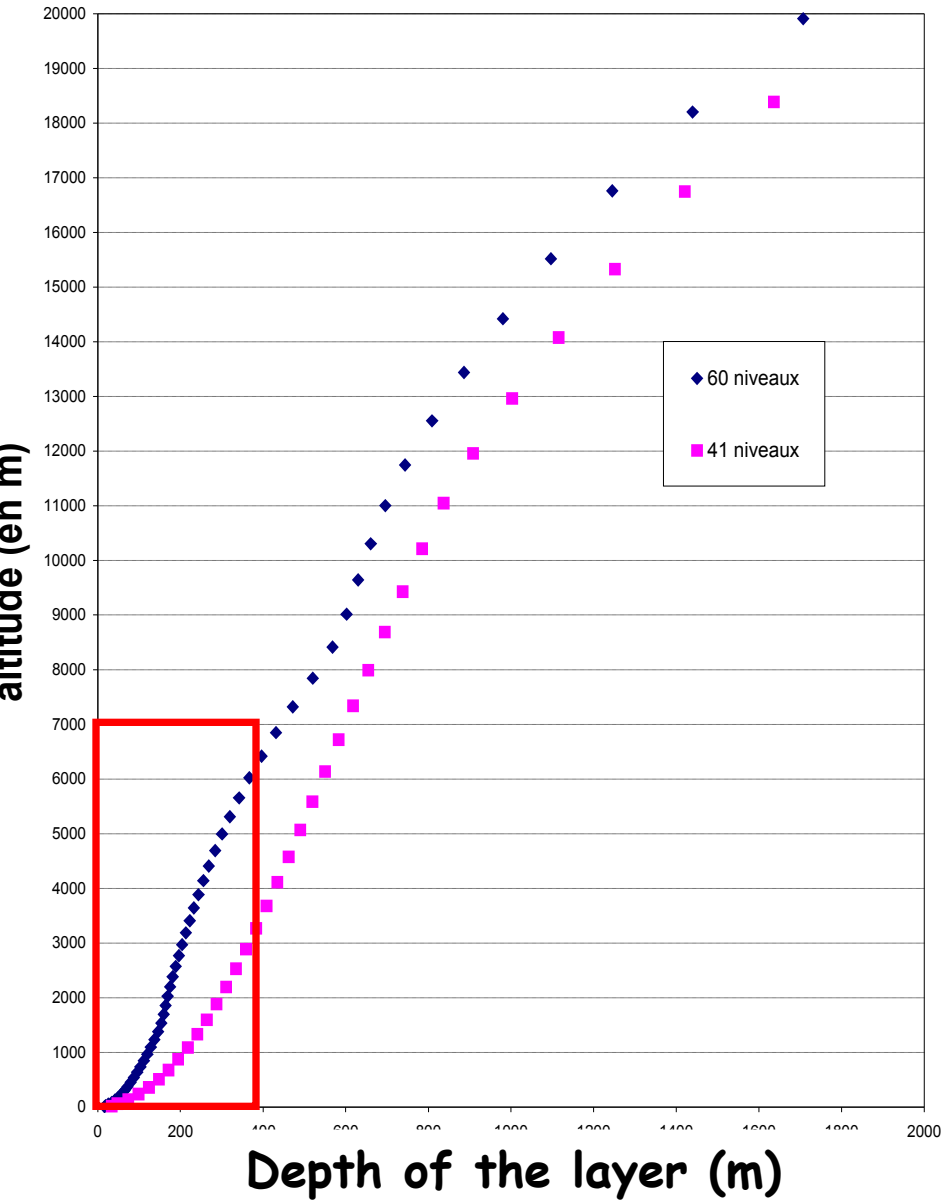
## Computational Domain



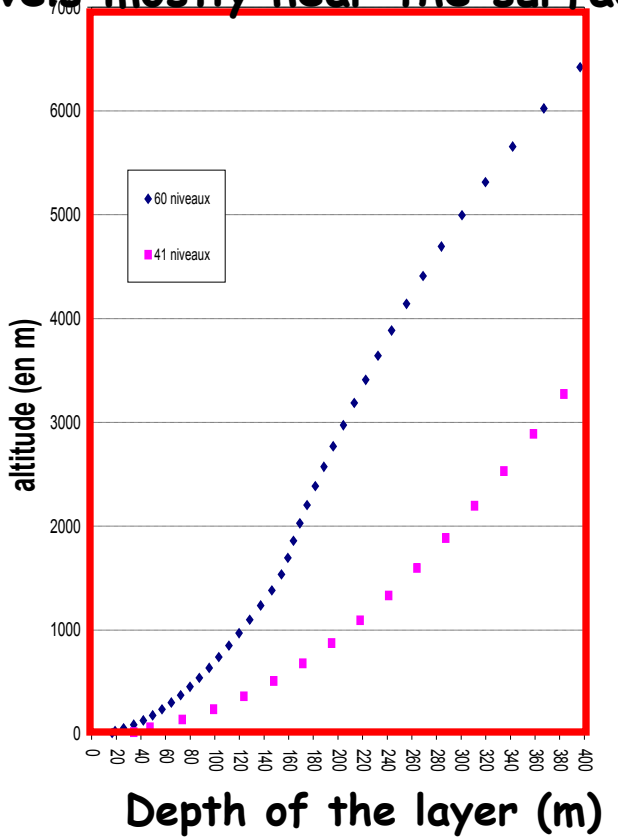

**600x512pts, Dx=2.5km, 41L, Dt=1mn**

- four 30-h forecasts per day over France (600x512 grid, **2.5km resolution,** 41 levels)
- 3-hourly **3DVar assimilation** cycle including radar doppler radial winds, Meteosat radiances, synop T, Hu, wind
- **NH model** with 5-species "ICE3" microphysics, 1D TKE scheme, "EDKF" shallow convection, ECMWF radiation
- "SURFEX" surface model with tiles: soil/vegetation, sea, lake, town

# L60 for AROME-v2




Added levels mostly near the surface




from L41 to L60 (+ 37% CPU)

1st level at 10m (17m in L41)

27 levels below 3000m (15 in L41)

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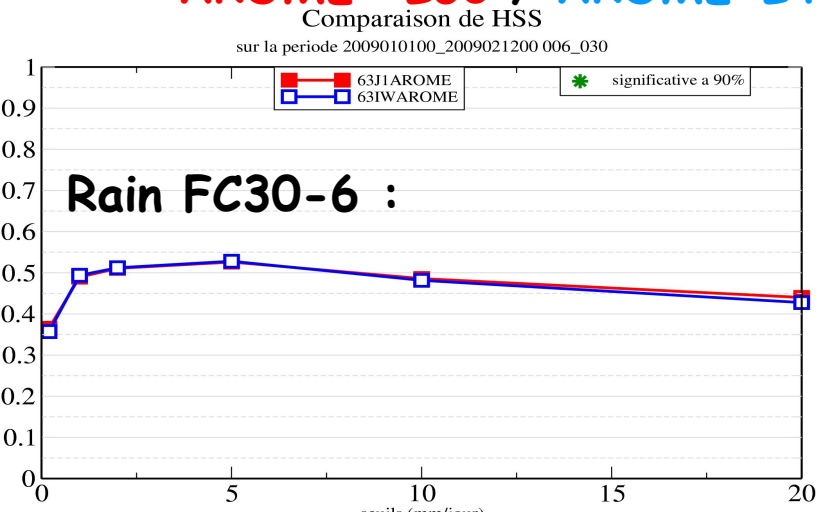
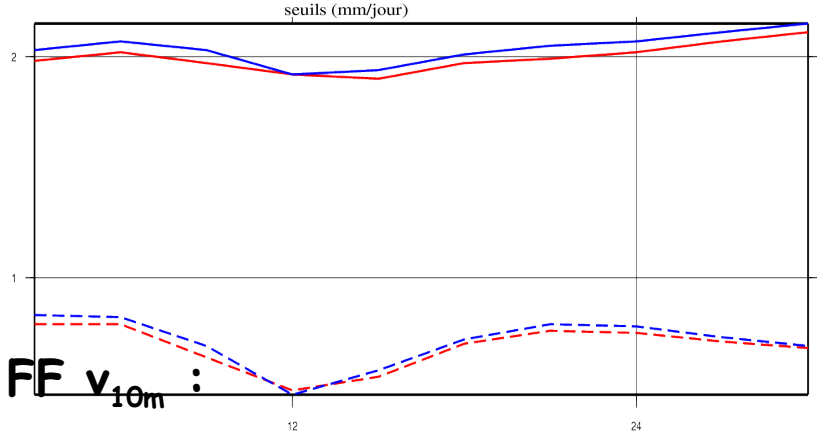
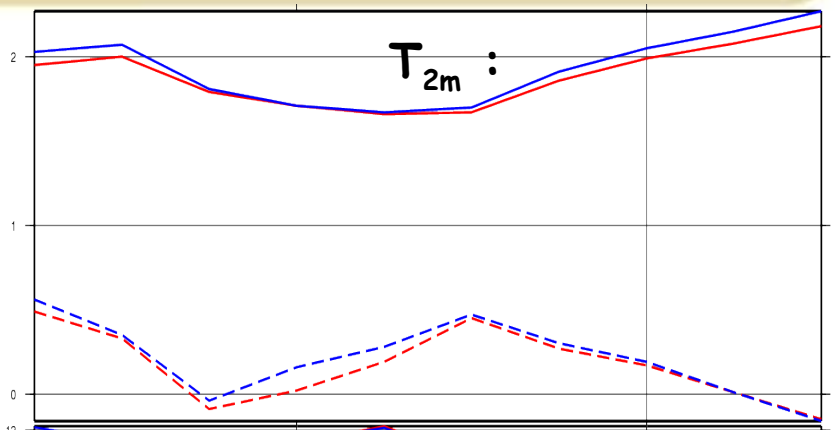
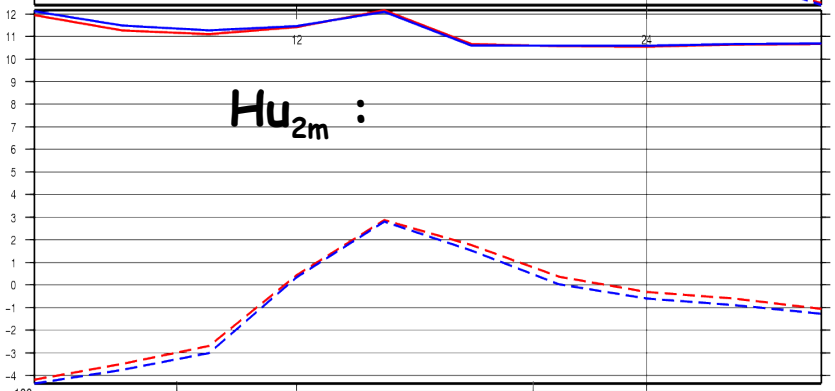
# Scores Jan 1st - Fev 12th 2009

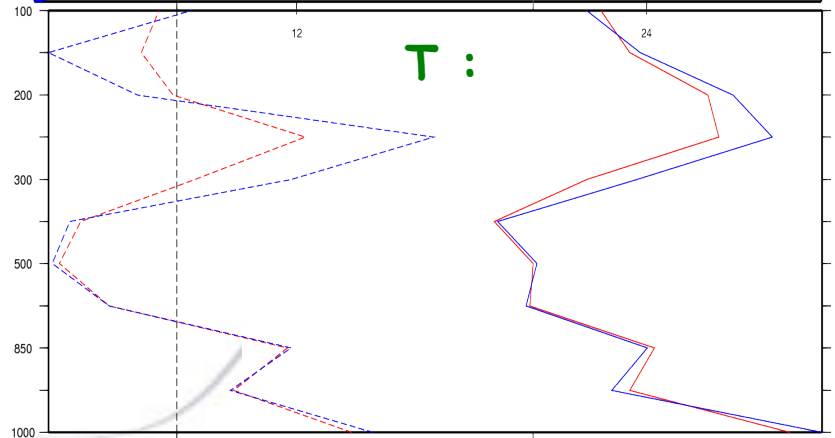
## AROME- L60 / AROME-L41




No impact on precipitations, but improvements on $FFv_{10m}$, $T_{2m}$, $Hu_{2m}$, T

# New entrainment/detrainment in the Dry thermal & Shallow convection scheme (EDKF)

**Entrainment & detrainment changed in the dry part of the thermal (in the BL) :**

| operational | new |
|---|---|
| $\varepsilon = f_\varepsilon(z)$<br>$\delta = f_\delta(z)$ | $\varepsilon$ prop. to $B_u / w_u^2$<br>$\delta$prop. to $-B_u / w_u^2$<br>Bu ; wu : updraft buoyancy & vert. speed. |
| → Strong thermal independantly of degree of unstability in the BL | →BL thermal takes well into account the degree of unstability of the BL :<br>→Weak thermal in slightly thermal conditions (ex: marine stratocumuli)<br>→Strong thermal in continental boundary layer in sunny days… |

# New entrainment/detrainment in the Dry thermal & Shallow convection scheme (EDKF)

**Entrainment & detrainment changed in the dry part of the thermal (in the BL) : *1D simulation of stratocumulus case (FIRE) compared to LES***

**Cloud contect At 06 local time**

**Liquid Water Path**

**Cloud contect At 12 local time**

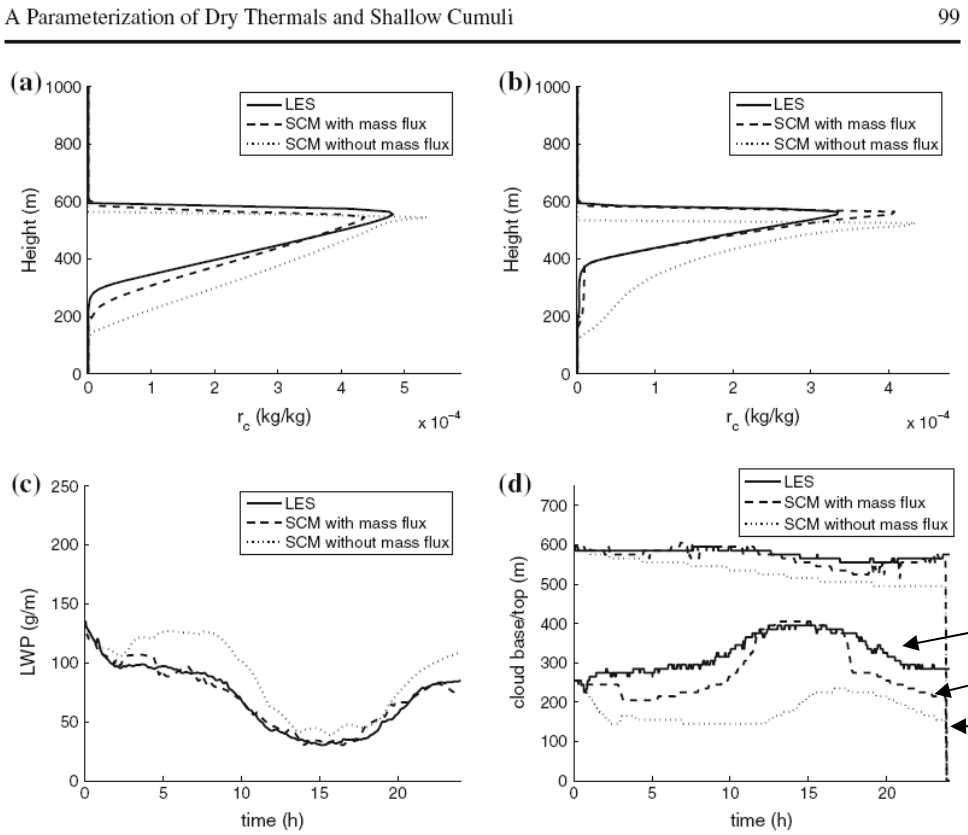



Fig. 11 FIRE case: Vertical profiles of liquid mixing ratio $r_c$ at **a** 0600 and **b** 1200 local time. *Solid thin line* shows LES results, *dashed line* the 1D profile with the new parameterization, and *dotted line* the profile obtained using only the turbulence scheme; **c** and **d** the liquid water path (LWP) and heights of cloud base and top as a function of local time

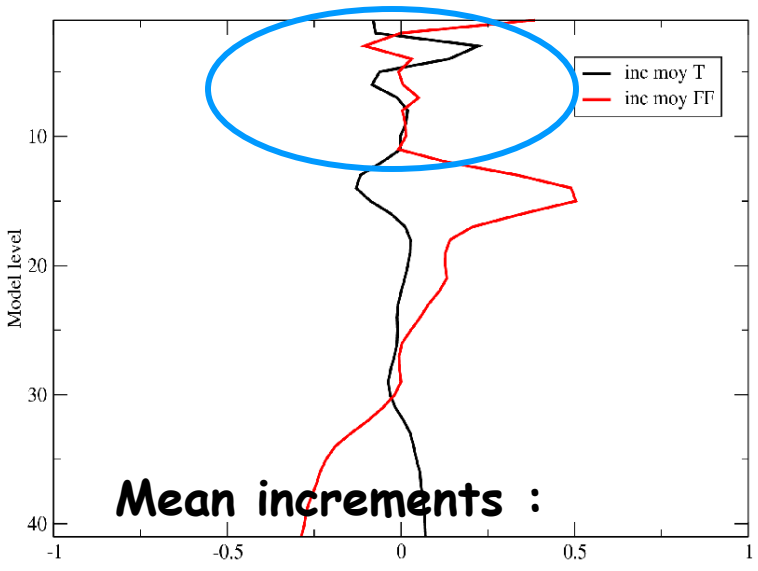
**<u>Base and Top of Sc</u>**
- **LES**
- **turb. + EDKF**
- **turb. only**

# Coupling to Aladin at the highest levels

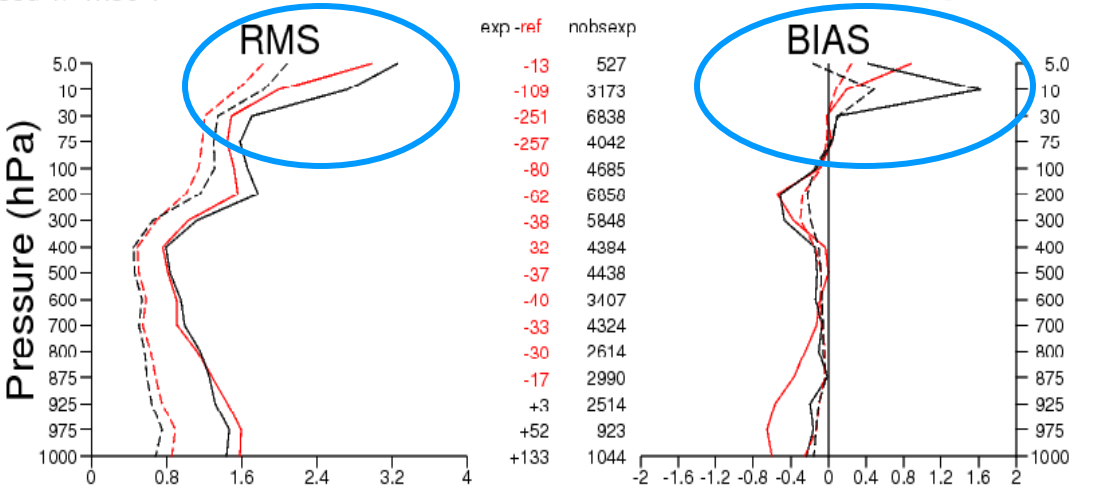
- Method used to solve some instabilities in cases at 500m in the top of the model. Suspected to occur also at 2.5 km in some particular cases.
- Unrealistic mean increments variability in the highest model levels, and strong biais and RMSE encourage us to activate it at 2.5km

$$X_{arome}(t) = (1-\alpha)\, X_{arome}(t) + \alpha X_{aladin}(t)$$

- Coupling with ALADIN, for spectral fields :
  - Vor,div,T
  - On the levels higher than 200 hPa
  - For the 20 first wave numbers (based on variancy spectrums of coupling files)




**Obstat : Wind strength / Radiosoundings, AROME ALADIN**



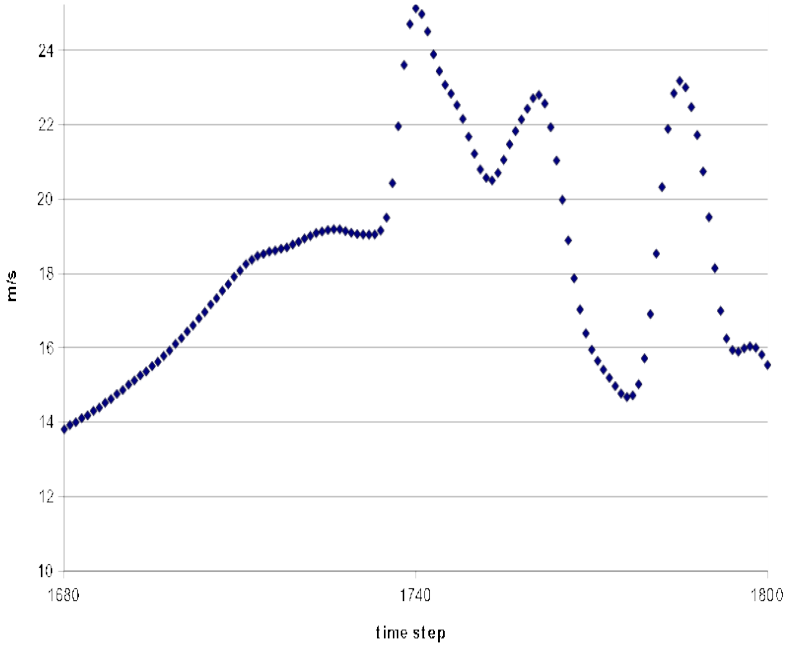
# Diagnostics : Gust wind and mean $V_{10m}$

- Same computation in ARPEGE/ALADIN/AROME : $U_{gust}=U_{10m} + \alpha.TKE(h)^{\frac{1}{2}}$

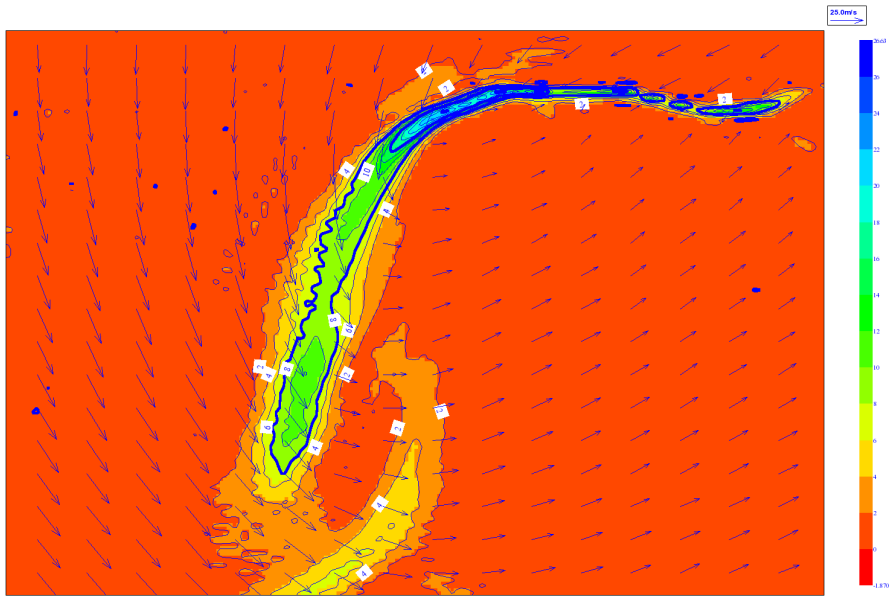
-Strong variability within an hour: maximum value during last 10 or 60 minutes before output written into file. Preliminary tests show reduction of bias.

- 10 minutes averaged wind now coded, neutral scores but strong differences seen in some cases:

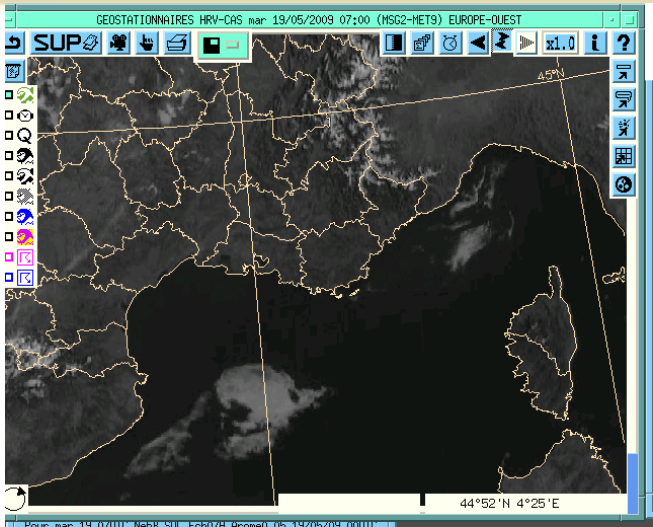
*Etemporal evolution of gust wind taken at a gridpoint each time step for two hours:*



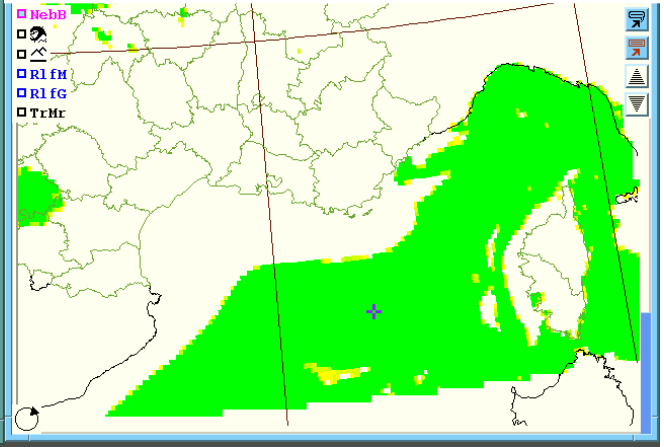

*V10-V10moy 24-01-2009 case : max=25m/s*

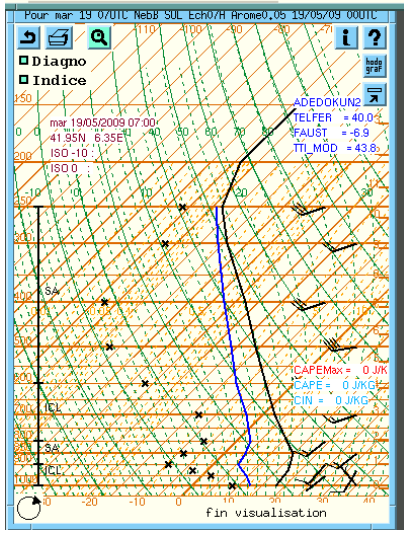


# Fog sedimentation:19 May 2009

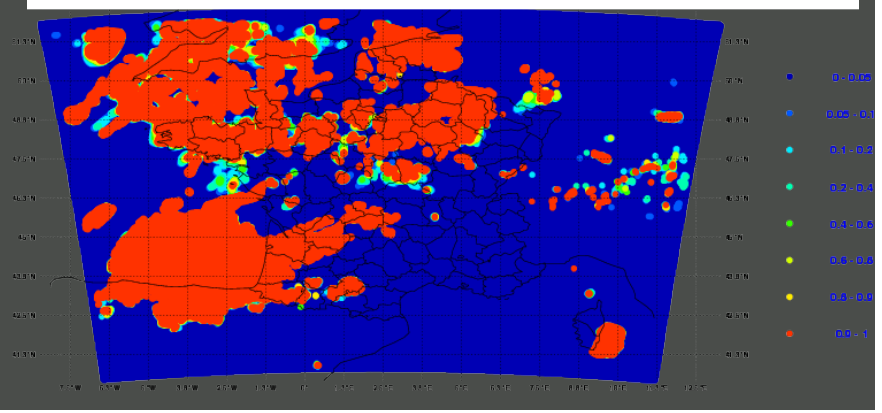



AROME – oper :



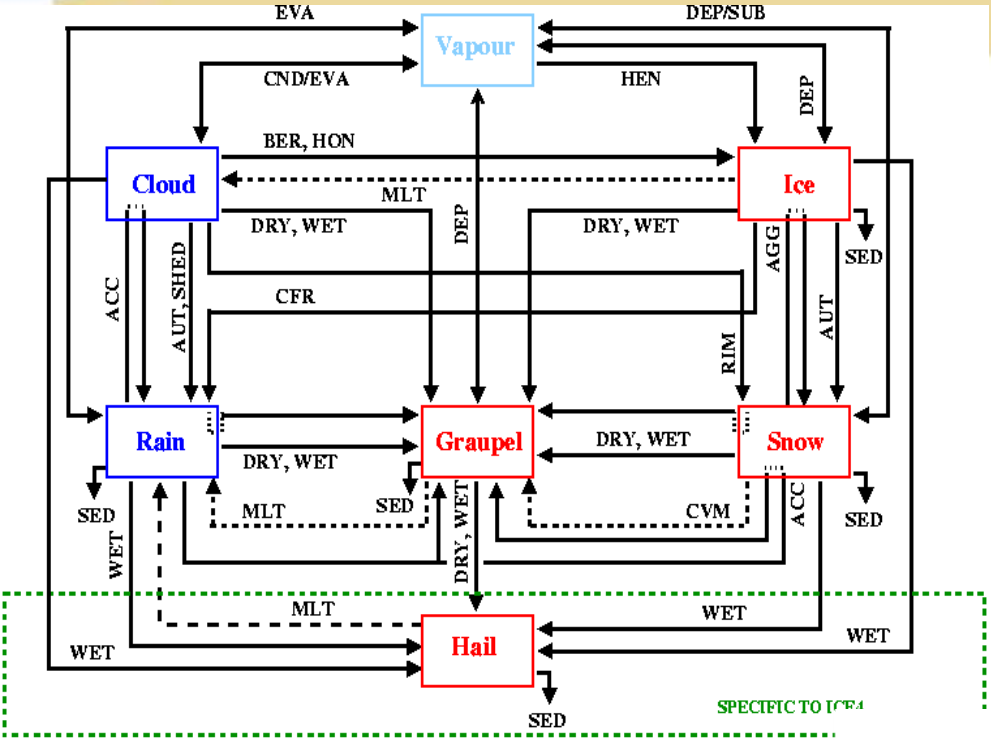




AROME – Sedim Fog :



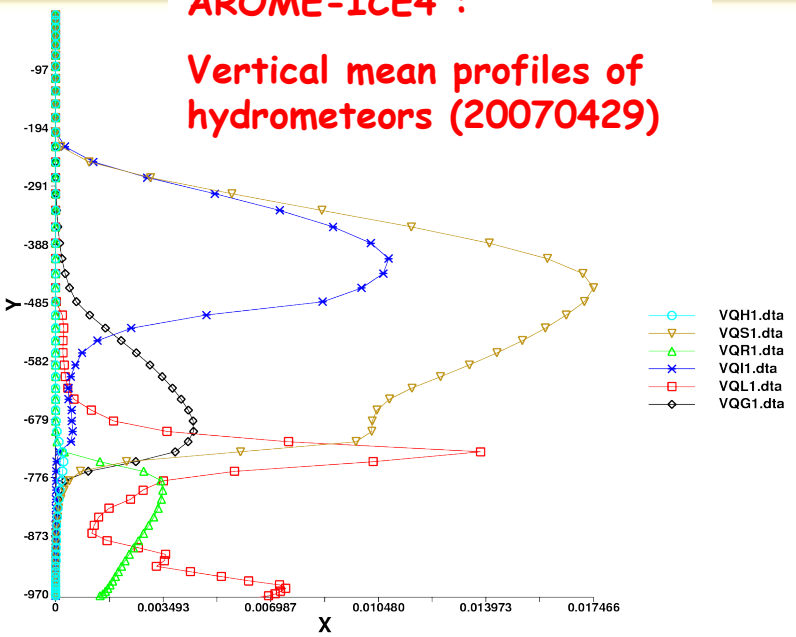
$q_c$ on the 2 lowest levels (17m and 64m). Cooling and de-coupling with the upper atmosphere in the previous forecasts. No observations to correct it, and cylcling of $q_c$

# Hail scheme

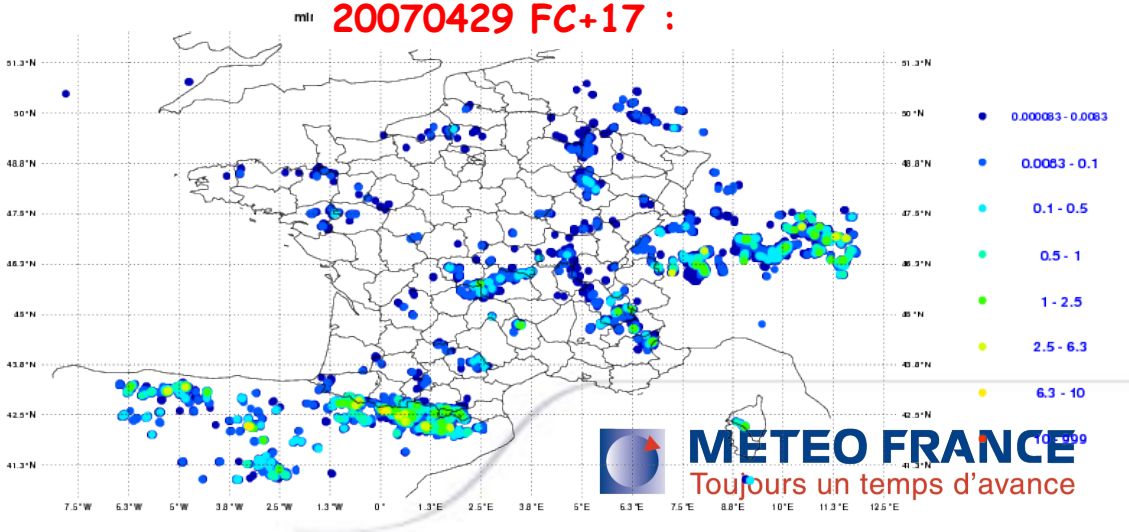



## AROME-ICE4 :

## Vertical mean profiles of hydrometeors (20070429)




## AROME instantaneous surface hail 20070429 FC+17 :




Too much hail in small amounts,

Test different ways of reconverting hail into graupel

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# Conclusion

- Next version of Arome v2 will run in parellel next autumn.  Main new features are:
  - Increase of vertical resolution (60 levels)
  - New version of EDKF
  - Coupling to host model above 200hPa
  - Correction of negative values of  hydrometeors
  - Fog sedimentation
  - Improvement of gust wind and mean V10m diagnostics
  - Test of use of Arpège as coupling model