AROME : status and plans

F. Bouyssel

NETFAM Workshop: Moist Processes in Future High Resolution NWP/Climate Models
Norrköping, June 15-17 2009

Plan

- Current operational version (model & assimilation)
- Objective scores
- Subjective evaluation by forecasters
- Perspectives

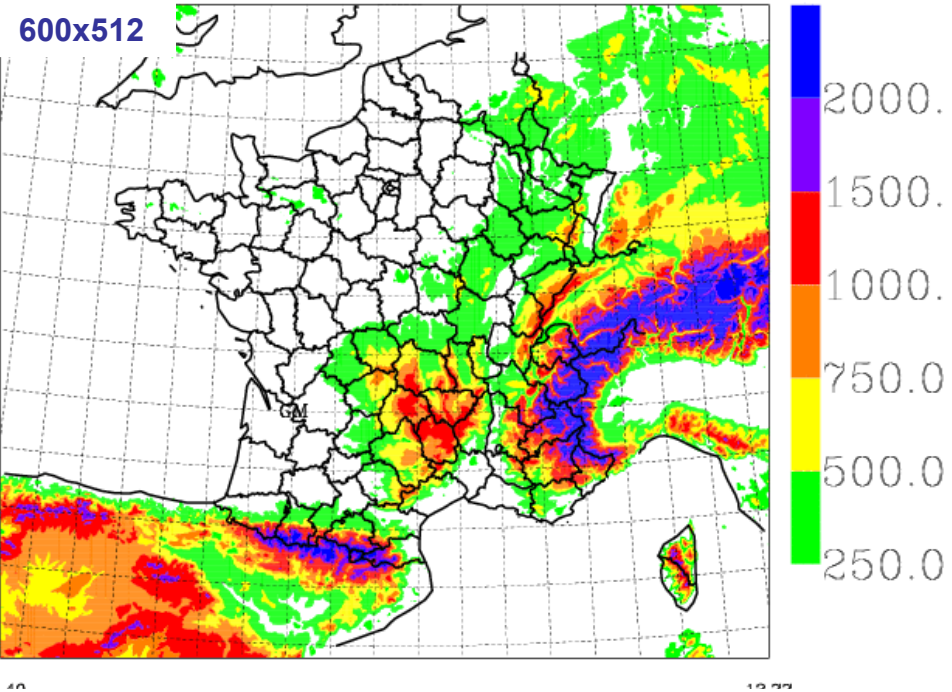
Current operational version

(model & assimilation)

AROME-France is operational since December 18th 2008

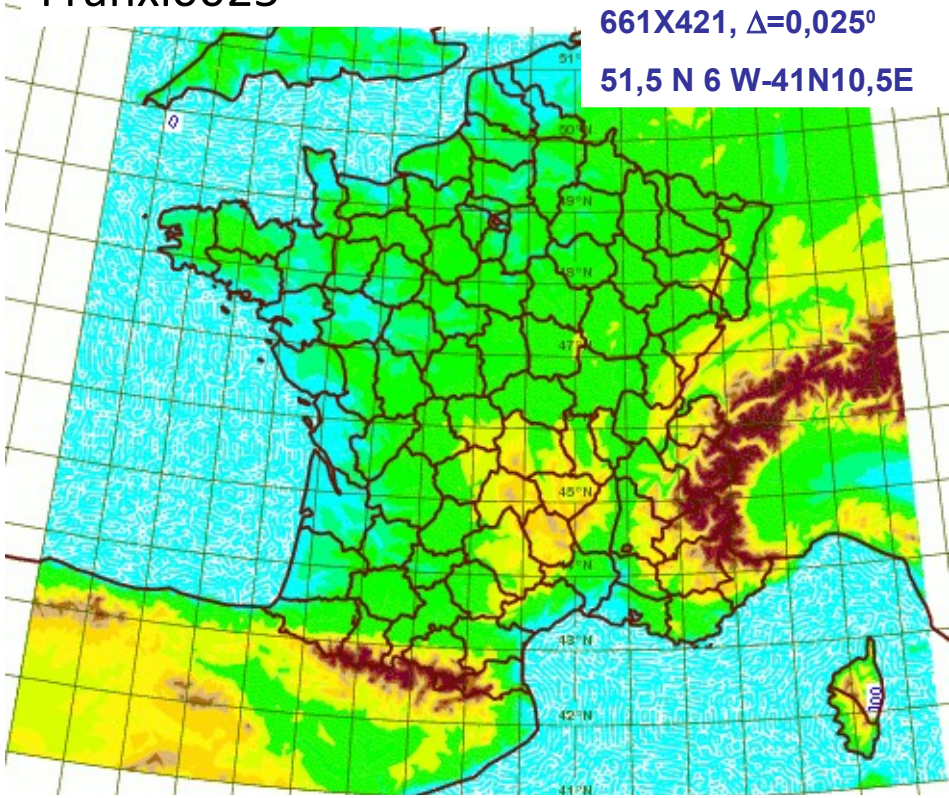
- Domain

Computational Domain



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

« production » domain (lat-lon regular)
Franxl0025



661X412, Dlon=0.025°,
Pressure & Z-level

(Y. Seity)

METEO FRANCE
Toujours un temps d'avance

First operational version (model)

Dynamical core:

- The dynamical core of Arome is the one of Aladin-NH *(Bubnova et al. 1995*). It uses also a SISL2TL with a 1 minute time step.
- The coupling to the large scale is done every hour with the operational Aladin-France

Atmospheric physical package:

- Pronostic microphysics (ICE3) with 5 water species *(Pinty and Jabouille, 1998)*
- 1D Tubulence scheme (CBR) with pronostic turbulent kinetic energy *(Cuxart and al. 2000)*
- Radiation : so called RRTM scheme in long wave *(Mlawer and al. 1997)* and Fouquart

Mocrette with 6 channels in short wave. The frequency of the radiation call is every 15

time steps

- Shallow convection : EDKF scheme (EDMF type, Pergaud et al 2009)

Surface physical package:

- Surfex witch includes the modelisation of nature (*Isba scheme Noilhan and Planton 1998*), sea (Ecume fluxes), town (TEB scheme :*Masson 2000*) and lakes. Surfex

First operational version (assimilation)

Assimilation part:

- 3D variational assimilation every 3 hours *(Fischer et al. 2006*) with a ~1h30 cut-off, coupled with ALADIN-France.
- The background error statistics are calculated using an ensemble-based method *(Berre et al. 2006).*
- Same assimilated observations as in ALADIN-France : conventional observations (SYNOP, Ship, Buoys, Pilot, Profiler, TEMP, Aircraft), geo-stationary satellites (SATOB, SEVIRI), polar orbiting satellites (ATOVS, IASI, SSMI, SCAT, GPSRO), GPS

+ radial wind for 15 doppler radars.

- Initial surface conditions interpolated from ALADIN-France every 6h
- Cycling of hydrometeors, TKE and NH variables
- 30h forecasts at 0, 6, 12, 18h UTC

(G. Hello)

Radar data in AROME

The ARAMIS radar network

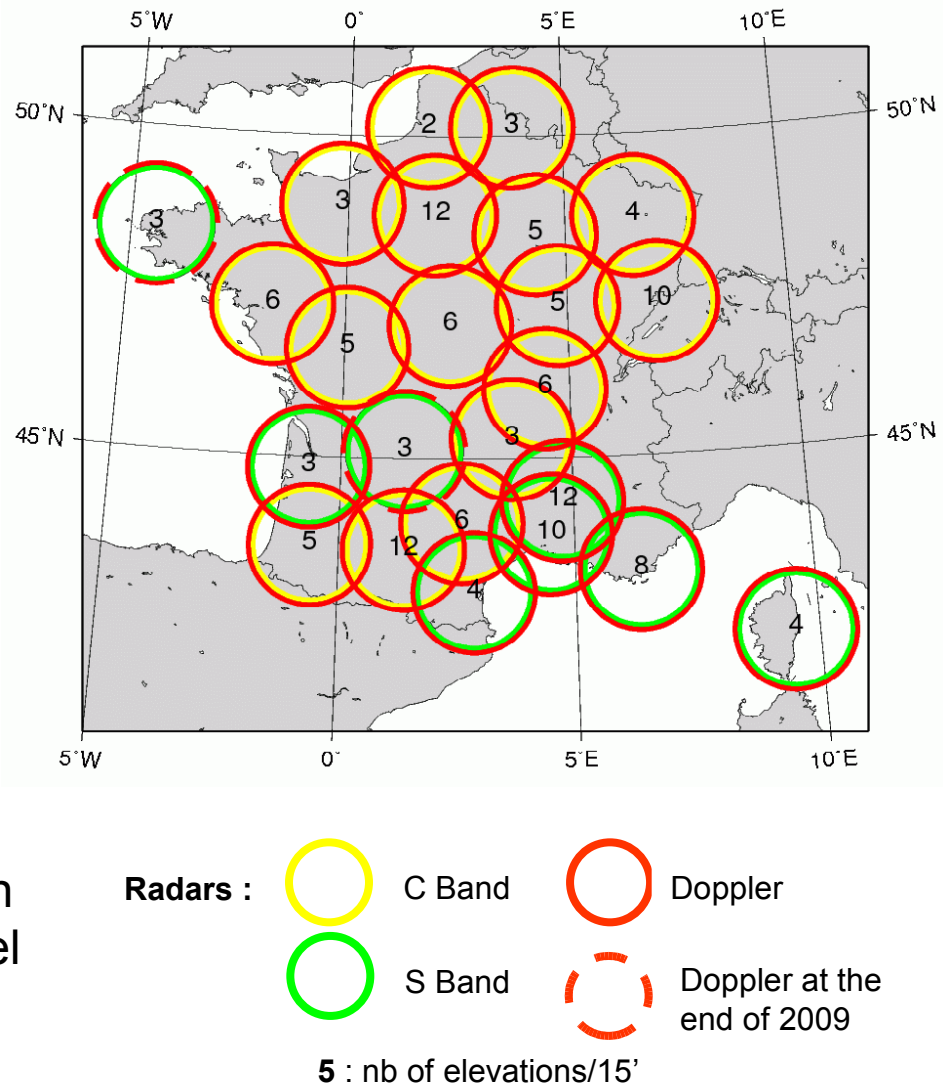
• 24 radars (incl.22 Doppler), performing between 2 and 12 PPIs/15'

In AROME:

• **Radial velocities** of 15 Doppler radars currently assimilated operationally. The remaining 7 are often contaminated by non meteological targets, but should be included this summer thanks to the use of new detection algorithm.

(For details, see Montmerle and Faccani, 2009, MWR)

• **Reflectivity** of every radars assimilated in research mode, and hopefully in the parallel suite this summer.



(T. Montmerle)

Impact of Doppler winds 1/2

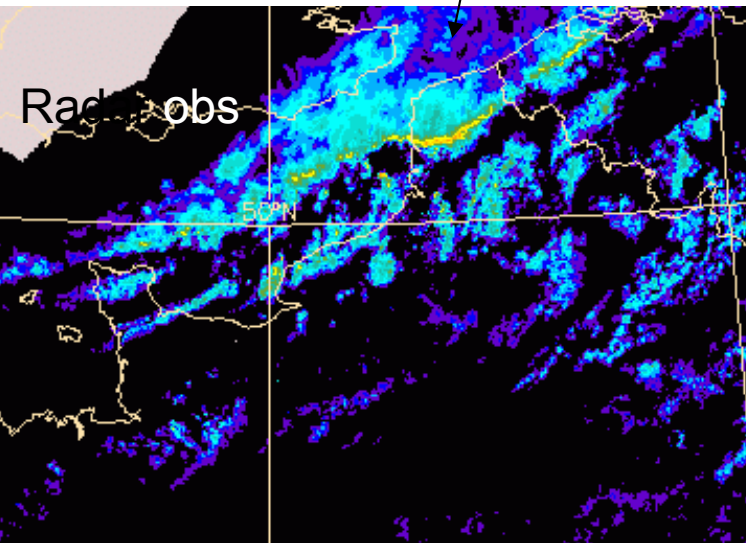
ex: 2007/11/08 case

Convergence line associated to a cold front

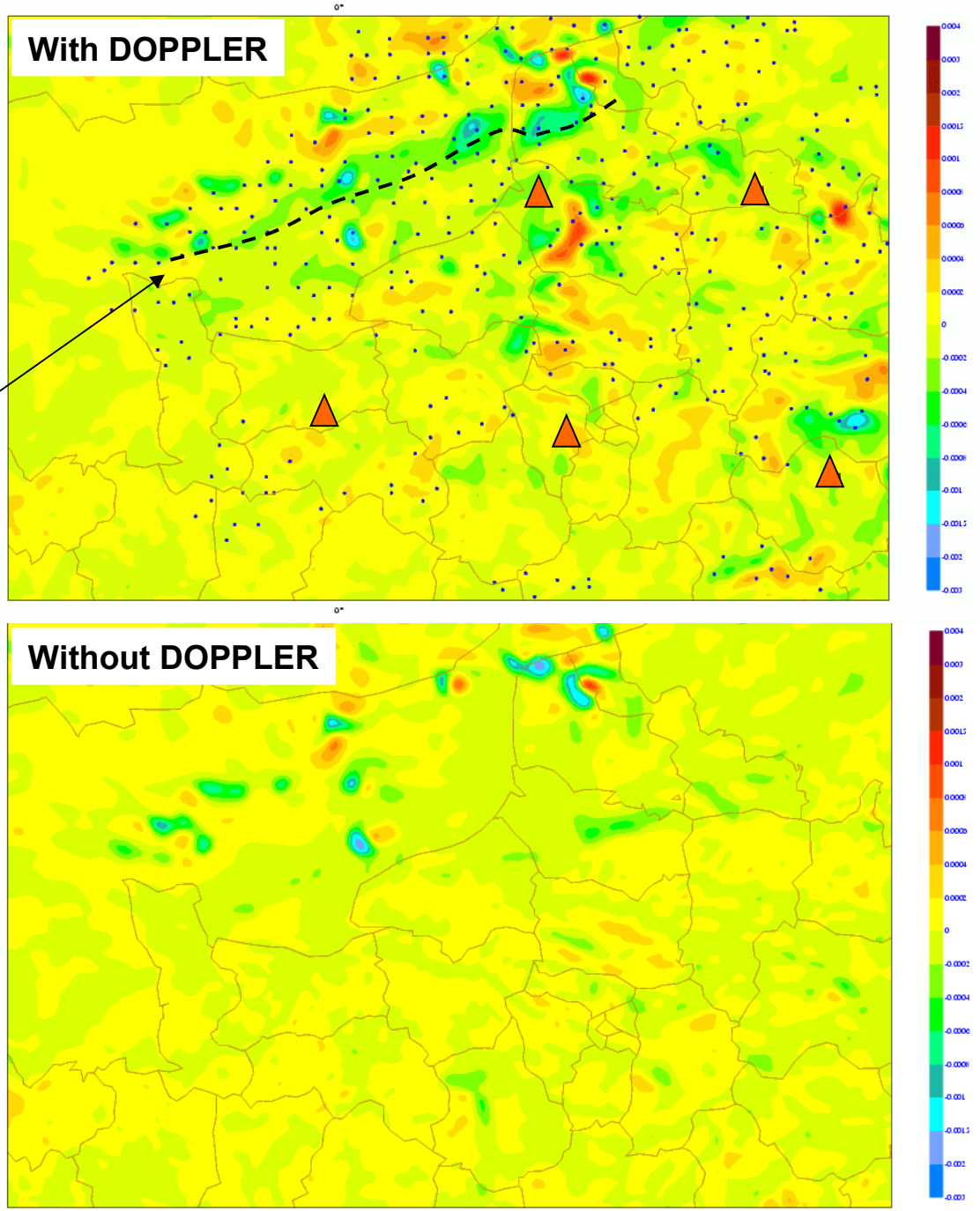
Divergence Analysis
(925 hPa)

(dots: active radar profile)

Main convergence line well analyzed
⇒ More realistic precipitation forecast up to 6 h



PARIS Analysis VT:Thursday 8 November 2007 18UTC 950hPa relative divergence



(T. Montmerle)

2007-2008: evaluation of AROME prototype and associated evolutions

3 experimentations with forecasters : Feb 2007, June-July 2007, Nov-Dec 2007 & a systematic evaluation by our forecast laboratory

Outcomes : evaluations of the prototype that lead to evolutions of the prototype contains:

Warm biais of 2m temperature ⇒ Introduction of Canopy in the proto (Oct 2007)

FA « Fireworks »: over-estimation of low-level wind circulation associated to convective celles ⇒ re-tuning of horizontal diffusion (Oct 2007)

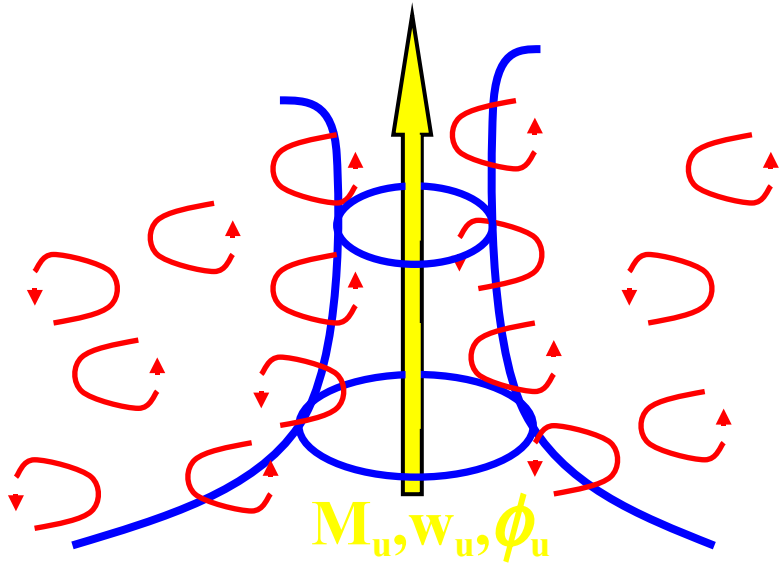
« herringbones »: same kind diagnoses but on shallow cumulus in weakly convective boundary layers over land ⇒ introduction of EDKF (Sep 2008)

Over-estimation of convection that leads to too much precipitation on intense precipitation ⇒ activation of SLHD (semi lagrangian horizontal diffusion) on hydrometeors (Sep 2008)

New shallow convection scheme "EDKF"

(J. Pergaud, V. Masson, S. Malardel)

- **Based on EDMF concept proposed by Siebesma and Teixeira, (2000) and Hourdin et al., (2002)**



$$\mathbf{EDMF} = \mathbf{TURB} + \mathbf{MF}$$

$$\overline{w'\phi'} = -K\frac{\partial\overline{\phi}}{\partial z} + M(\phi_{up} - \overline{\phi})$$

Turbulence **Mélange local** — **Convection** **Thermiques**

- **Several EDMF parameterizations have been developed :**

Hourdin et al., 2002 ; Soares et al., 2004 ; Siebesma et al., 2007 ; Rio and Hourdin, 2008

New shallow convection scheme « EDKF »

(J. Pergaud, V. Masson, S. Malardel)

- **Eq for w**

$$w\frac{\partial w}{\partial z} = aB - b\frac{E}{M}w^2$$

a= 1 b=1

- **Eq for conservative variables (+ optionnal: wind)**

$$\frac{\partial \varphi_u}{\partial z} = -\frac{E}{M}(\varphi_u - \overline{\varphi})$$

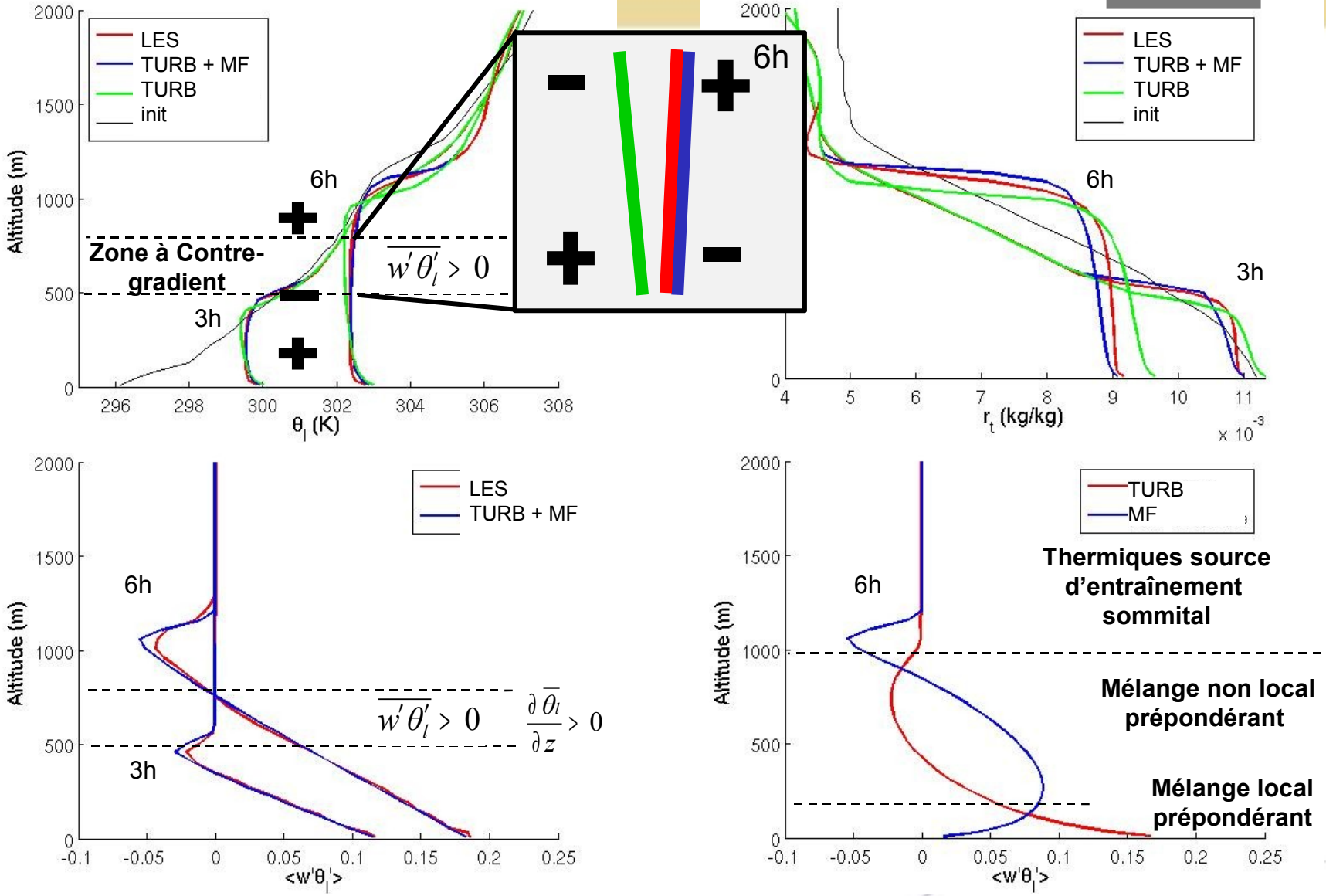
$\varphi_u \in (\theta_l, r_t)$

- **Eq for the Mass flux**

$$\frac{\partial M}{\partial z} = E - D \qquad M = \rho\sigma w$$

- **w equation is used to stop the updraft**
- **Using both equations for w and MF enable us to diagnose σ the fractional updraft area, and hence the cloud cover**
- **Entrainment & Detrainment:**
  - **In the boundary layer, E,and D depend on buoyancy and vertical speed of the updraft**
  - **In clouds, E and D comes from Kain & Fritsh buoyancy sorting**
- **Tested for: dry BL, shallow convection, Sc** (EDKF effect weakens naturally)

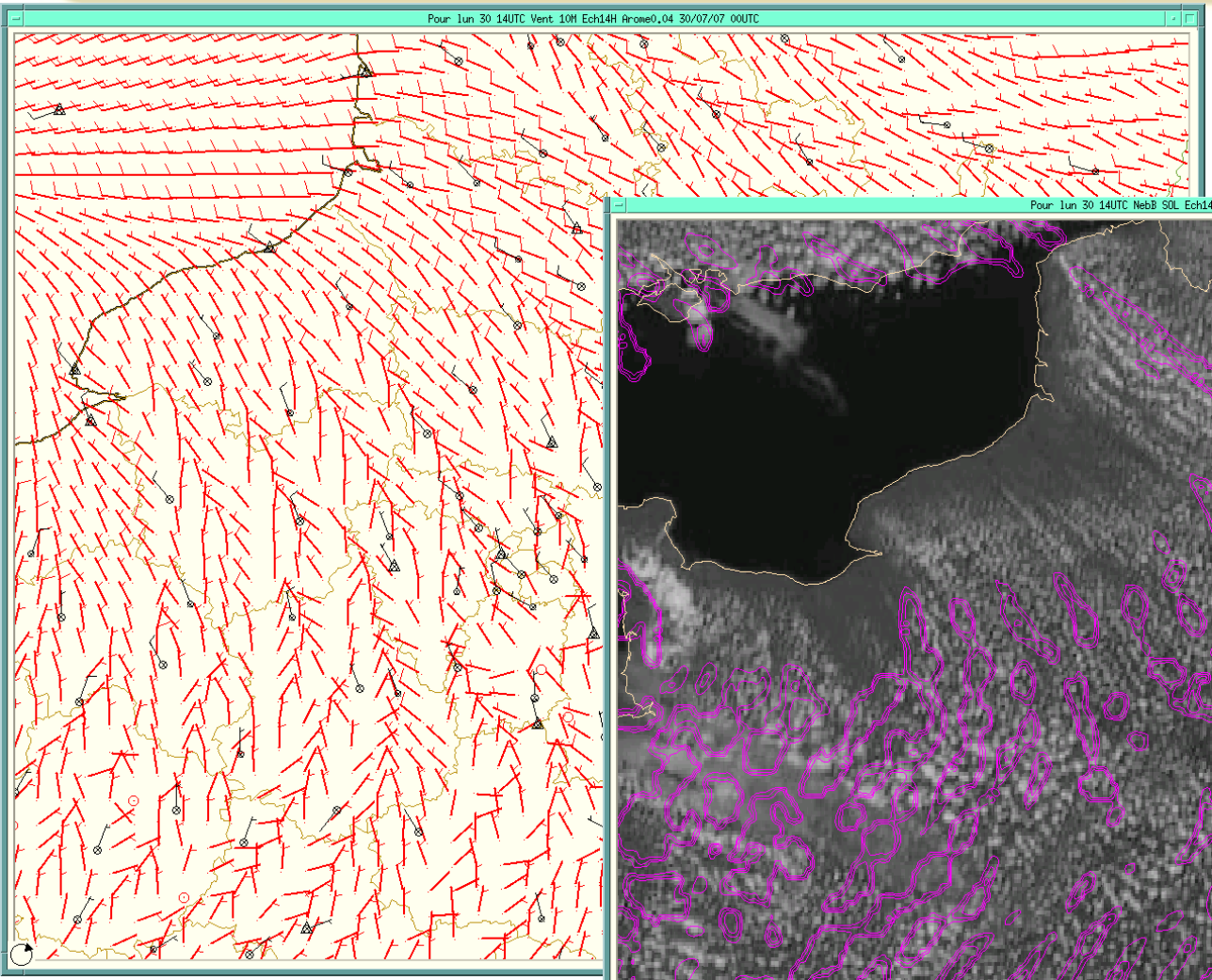
3.1/ Simulations 1D vs LES : le cas IHOP



(J. Pergaud)

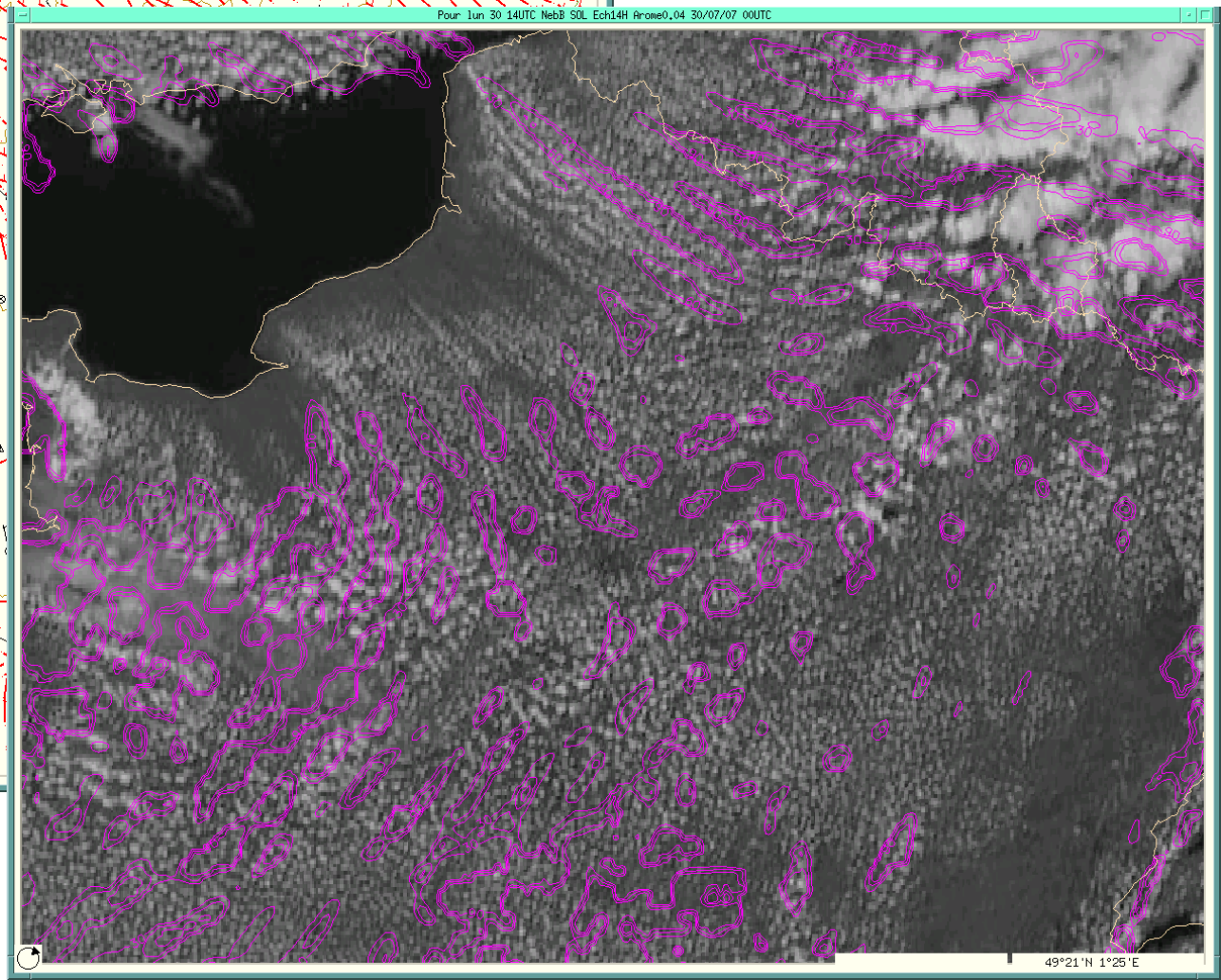
METEO FRANCE
Toujours un temps d'avance

Unrealistic 'herringbones' structures (2007-07-30)



AROME

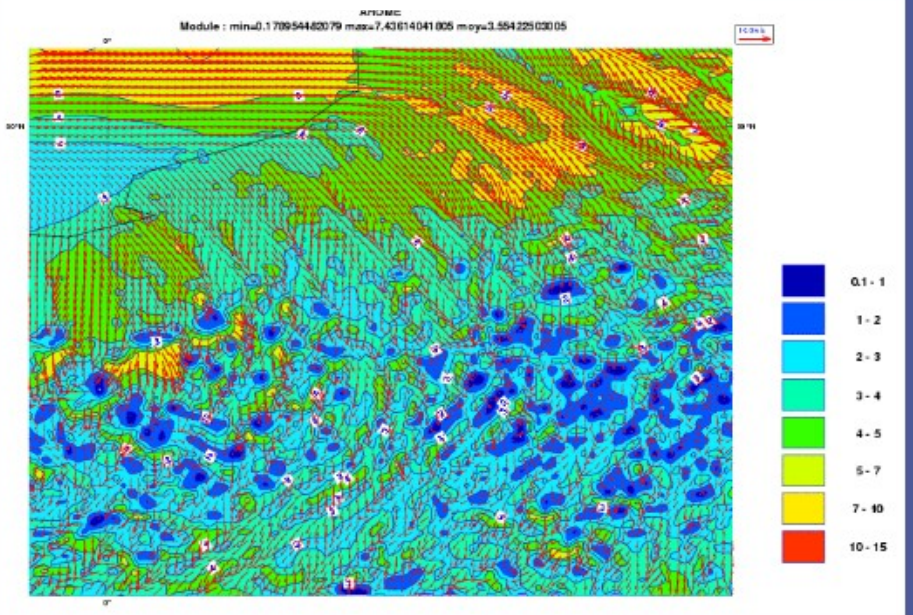
Nebul



V_{10m}

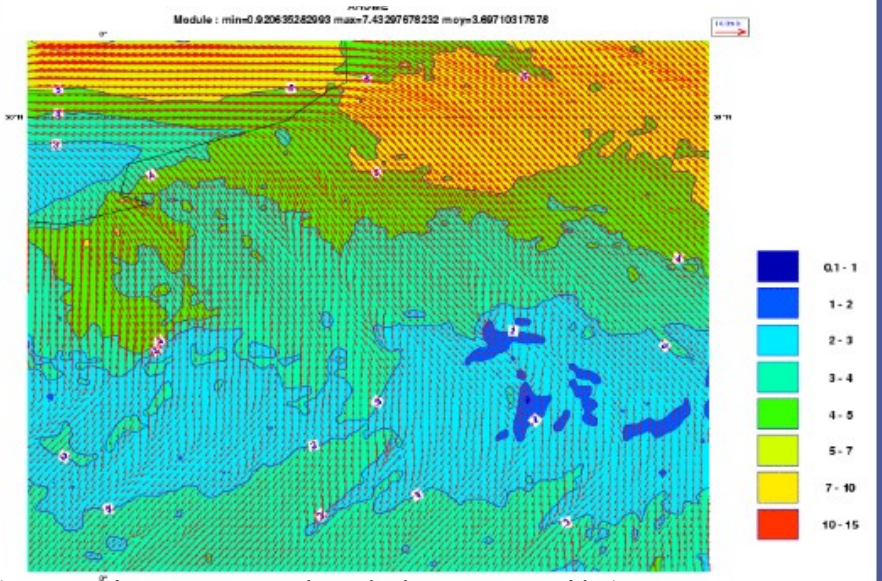
(Y. Seity, S. Malardel)

AROME without EDKF

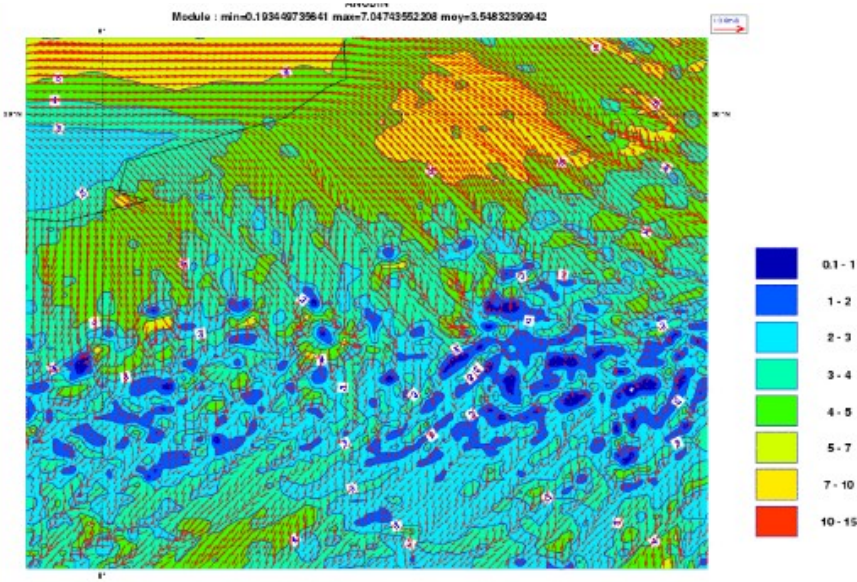


EDKF performs a mixing in dry boundary layers

AROME EDKF



ALADIN-Fr oper physics at 2.5km



(Y. Seity, S. Malardel, E. Bazile)

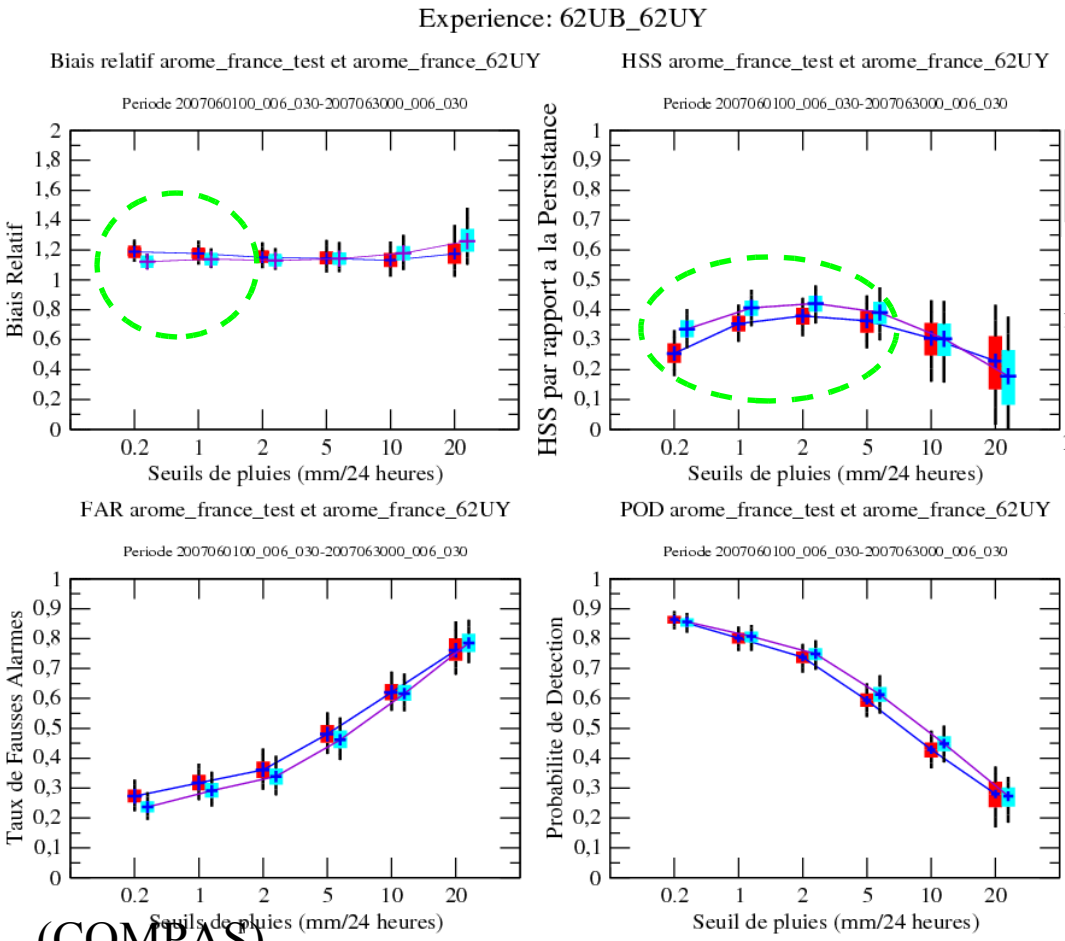
Impact of EDKF on precipitation scores

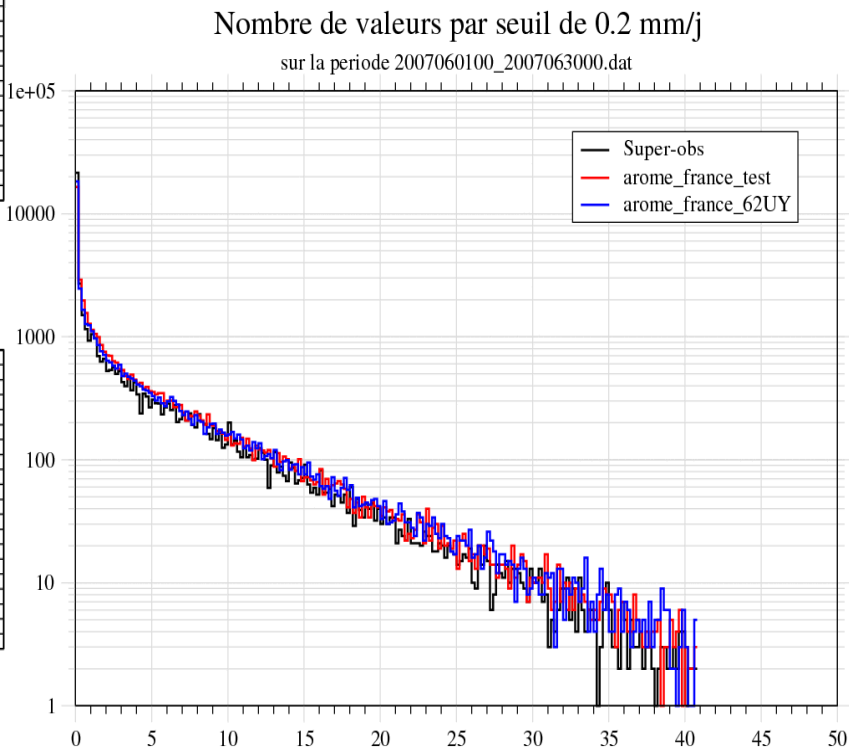
RR24 Scores FRAN June 2007

AROME+SLHDcrisg+EDKF / AROME+SLHDcrisg

EDKF improves scores for light rains

(produced nebulosity enters in the microphysics)





(COMPAS)

Impact of SLHD on qcrisg precipitation scores

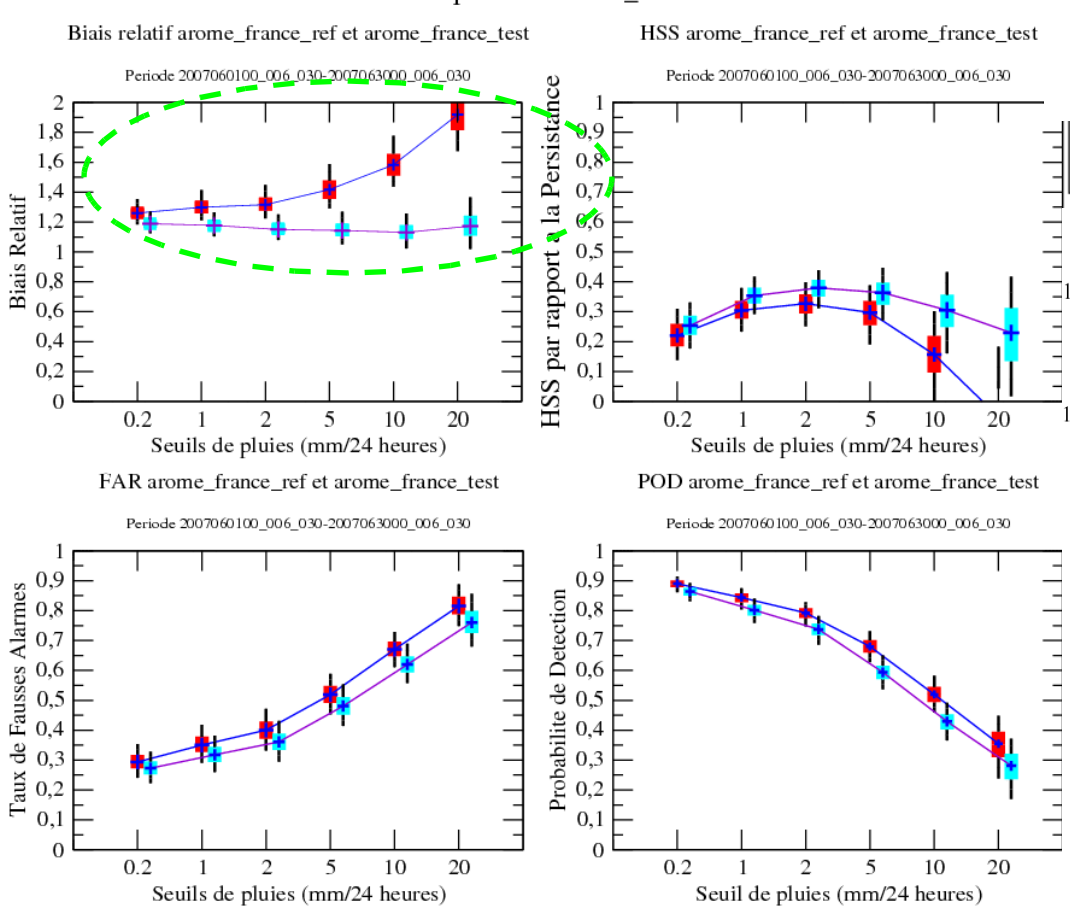
RR24 Scores over France June 2007

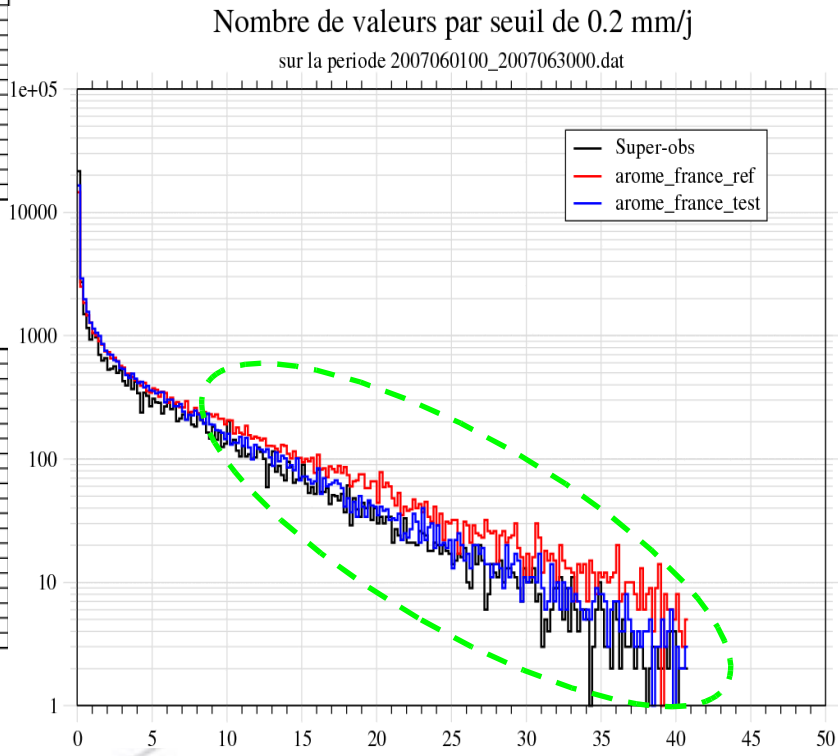
No diffusion on water condensates

SLHD on $q_c q_r q_i q_s q_g$

Strong impact on heavy rains

Neutral scores compared with radiosoundings or T_{2m} Hu_{2m} V_{10m} observations

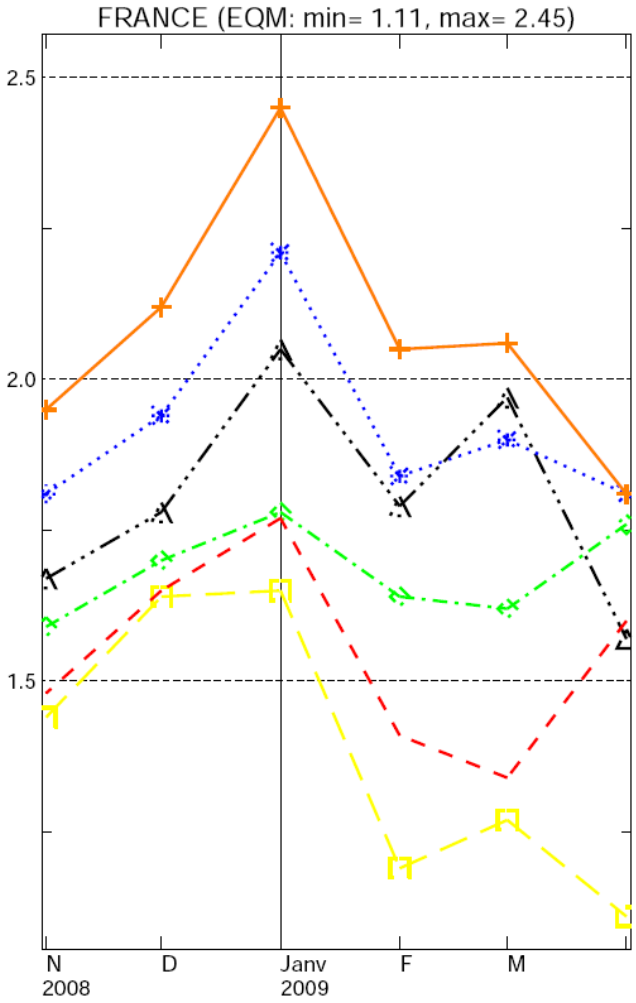




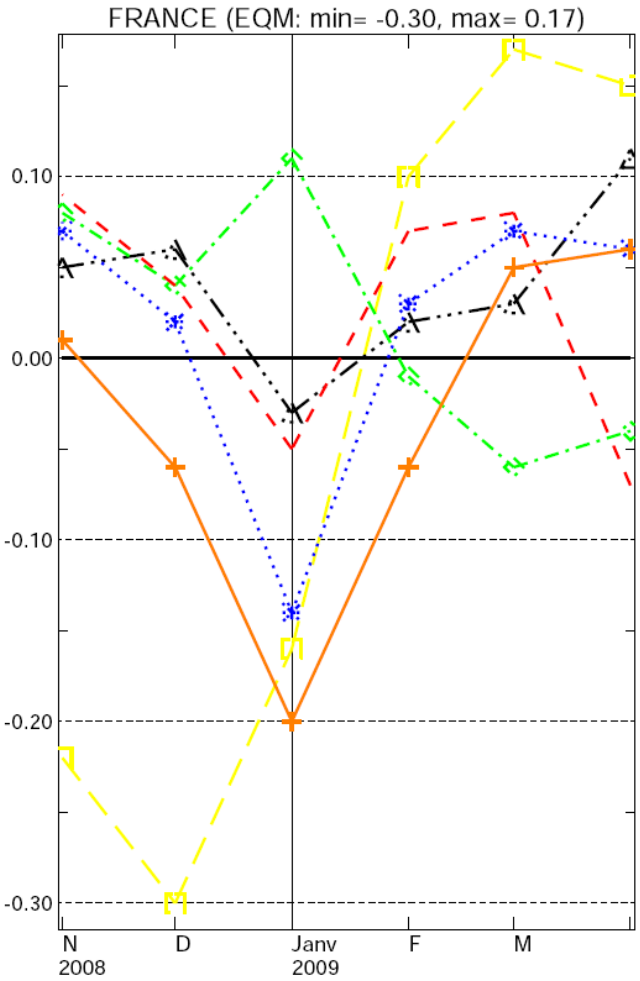
(COMPAS)

Objective scores

Verification vs « Radome » obs : T2m

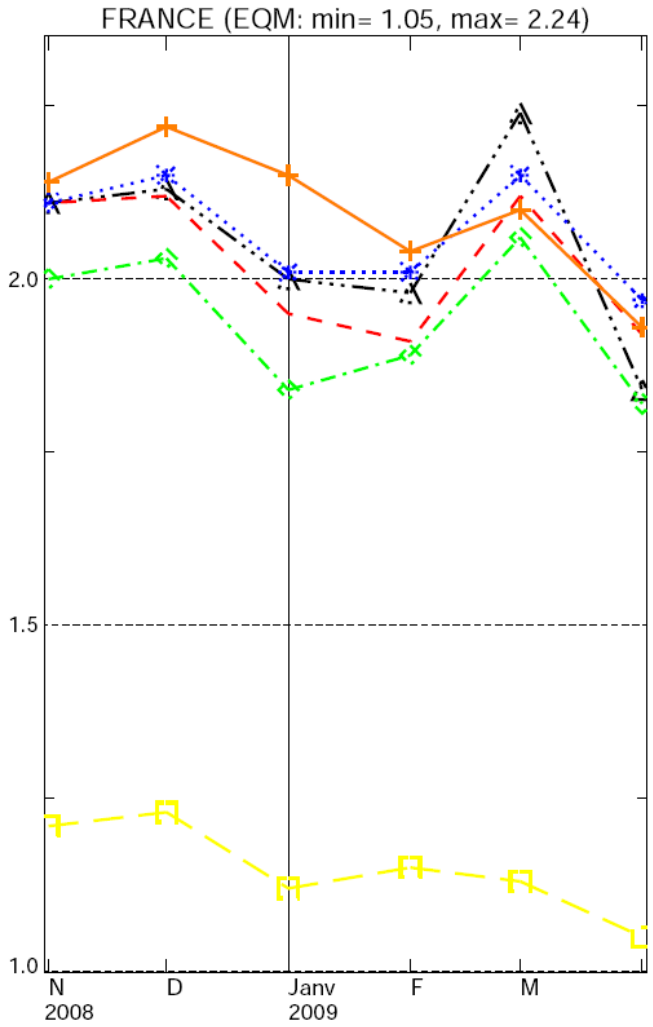


30H
24H
18H
12H
6H
0H

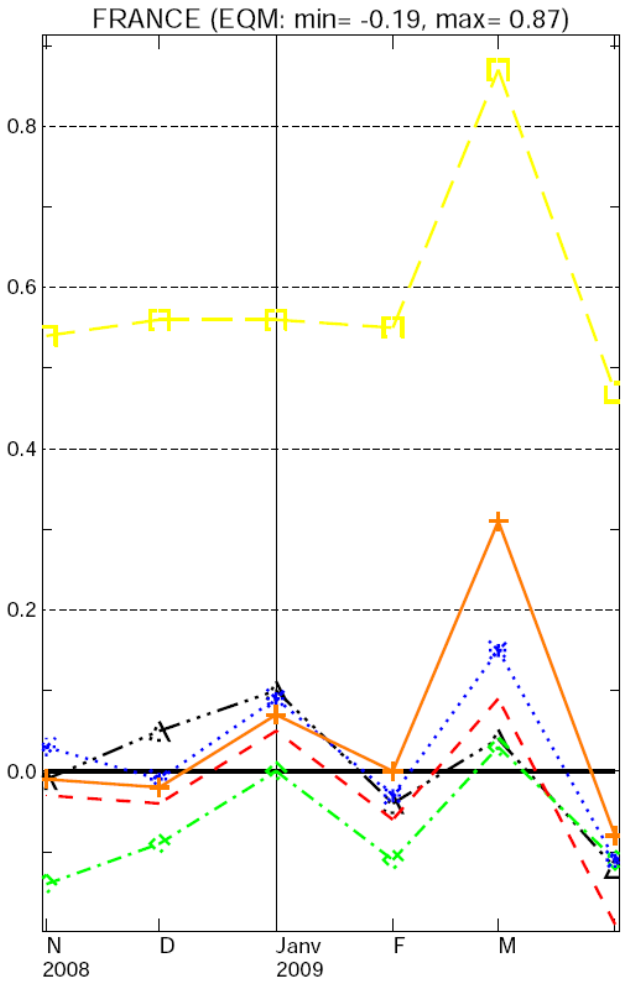


AROME better

Verification vs « Radome » obs : V10m

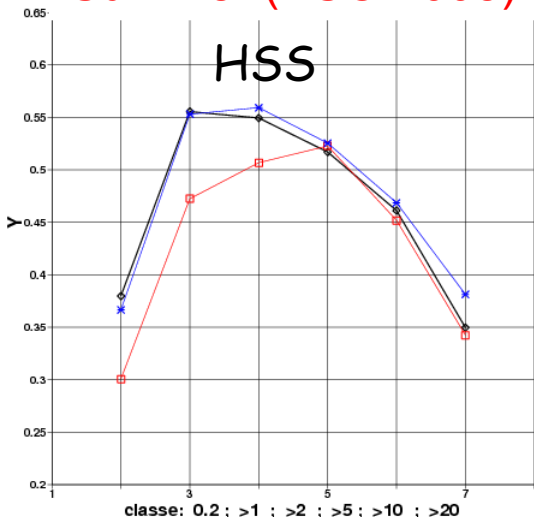


30H
24H
18H
12H
6H
0H



Rainfall scores (RR24h)

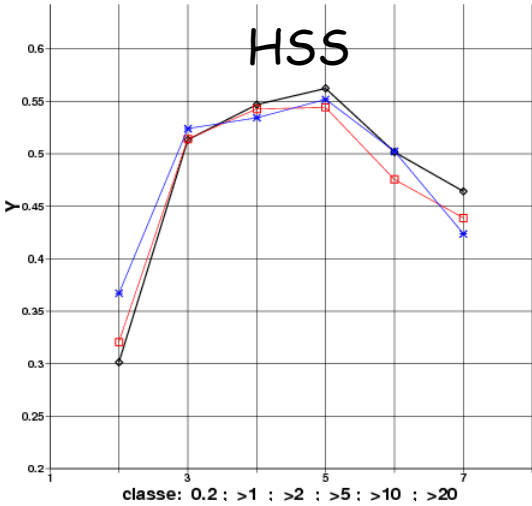
Summer (ASO 2008) :



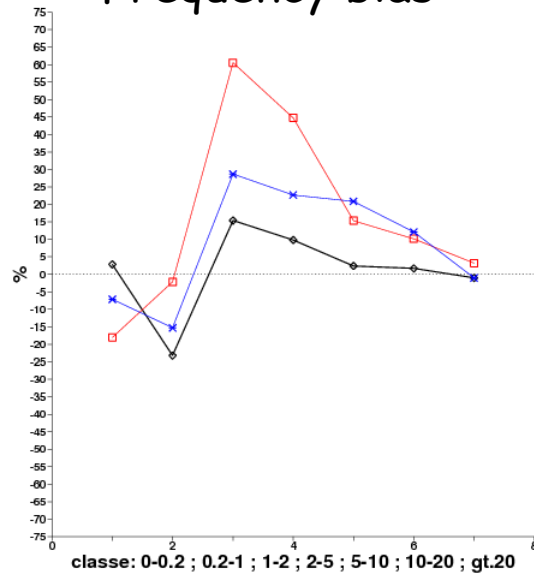
AROME, ***ALADIN-oper***, ***ALADIN-dble***

In summer, improvement of HSS for RR24 < 5mm and of frequency bias.

Winter (ND 2008 J 2009) :

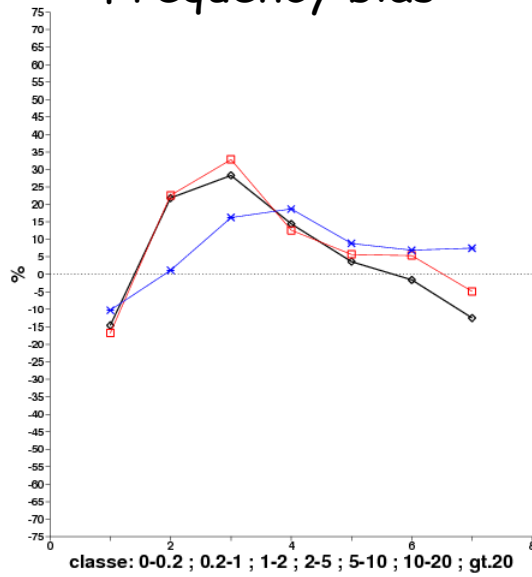


Frequency bias



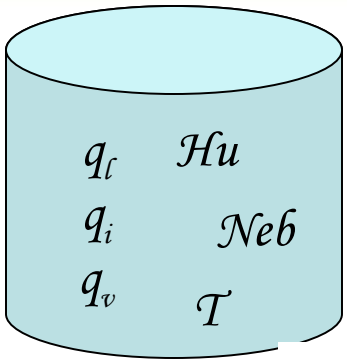
In winter, less differences with ALADIN. Improvements of HSS for RR24 > 2mm, frequency bias is reduced but is negative for RR > 20mm

Frequency bias

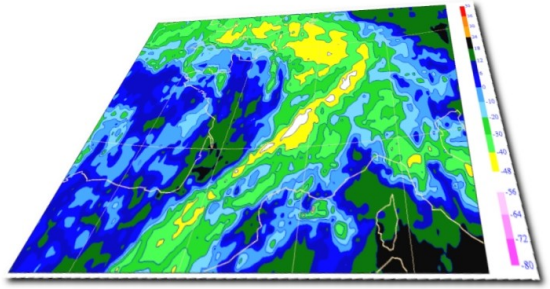


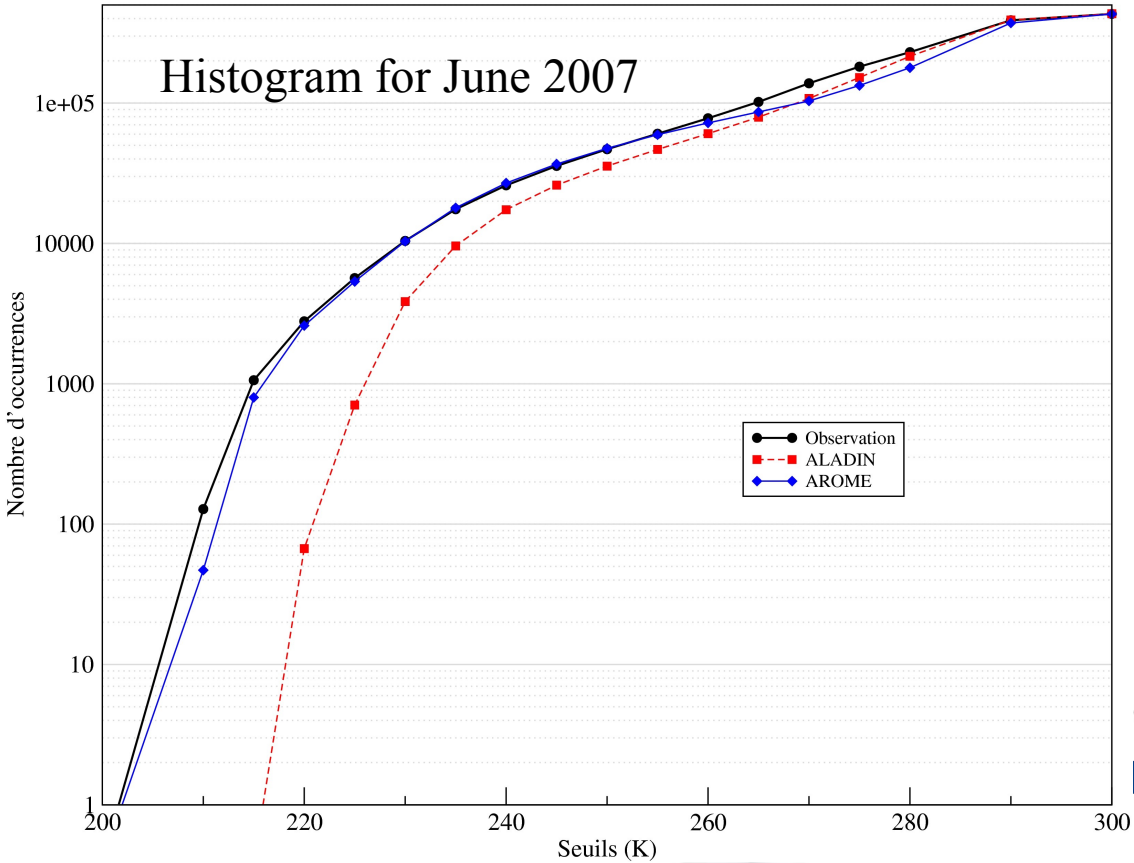
(Y. Seity, E. Bazile)

Simulated brightness temperatures



RTTOV





10.8 µm

(J. Stein et al.)

Subjective evaluation by forecasters

(on deep convection only)

Forecasting deep convection with AROME

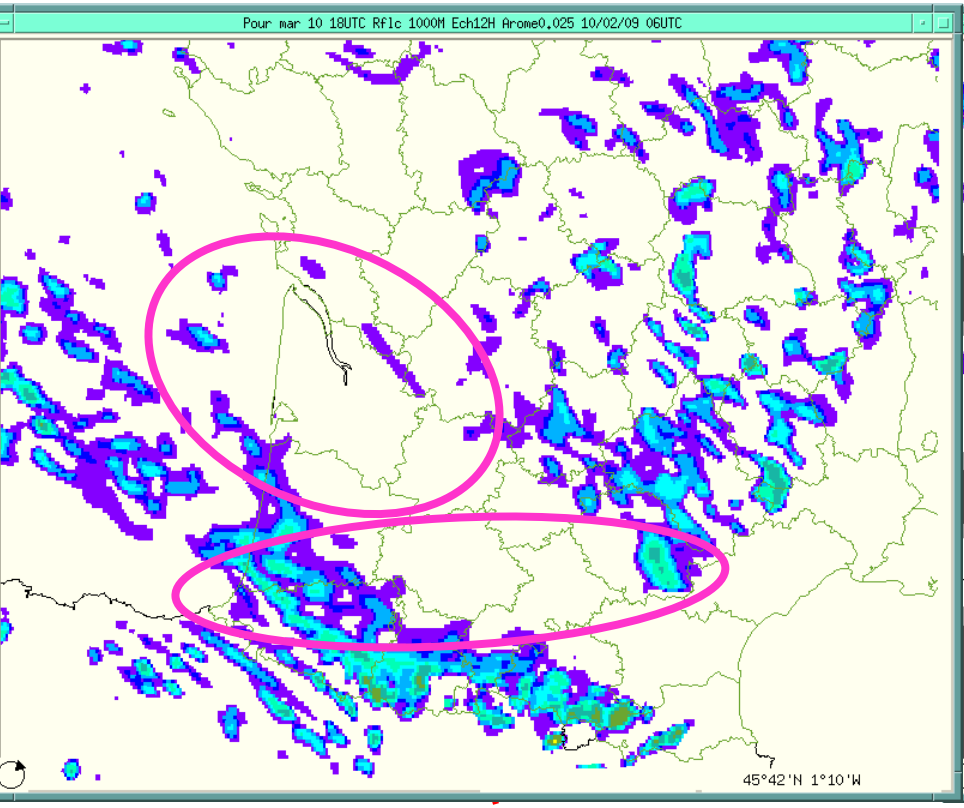
- Suspicious structures in surface winds under convection
- Underestimation of convection in cold air in plains, and overestimation over mountains
- Good performances for simulating convection in warm air :
  - Very good simulations of diurnal convection over orography, but starts too early (~1-3 hours)
  - AROME often informative of convective risk, affected areas, and even the type of convection (supercell, convective line…), but :
    - ✓ With some errors on localisation, timing, intensity ; some false alarms and no detection
    - ✓ Tendency to overestime strong convective precipitations
    - ✓ Graupel : good correlation with hail and graupel in cold air, but no graupel at the ground in case of hail in warm air
  - Improvment of AROME forecasts Amélioration « au fil des runs » most of the times, but not always

Positive evaluation for deep convection.

(P. Santurette)

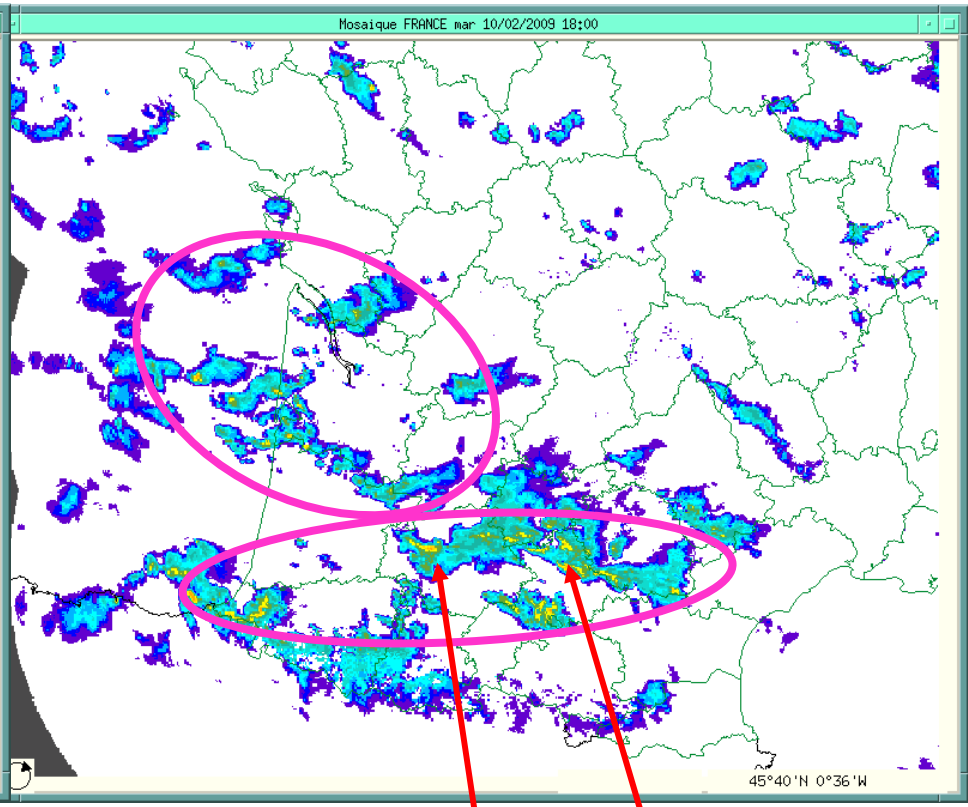
Convection in cold air (case study)

Reflectivities AROME (ech 12 h)



Graupel at the ground in AROME

Radar vd 18 UTC 10 Feb 2009

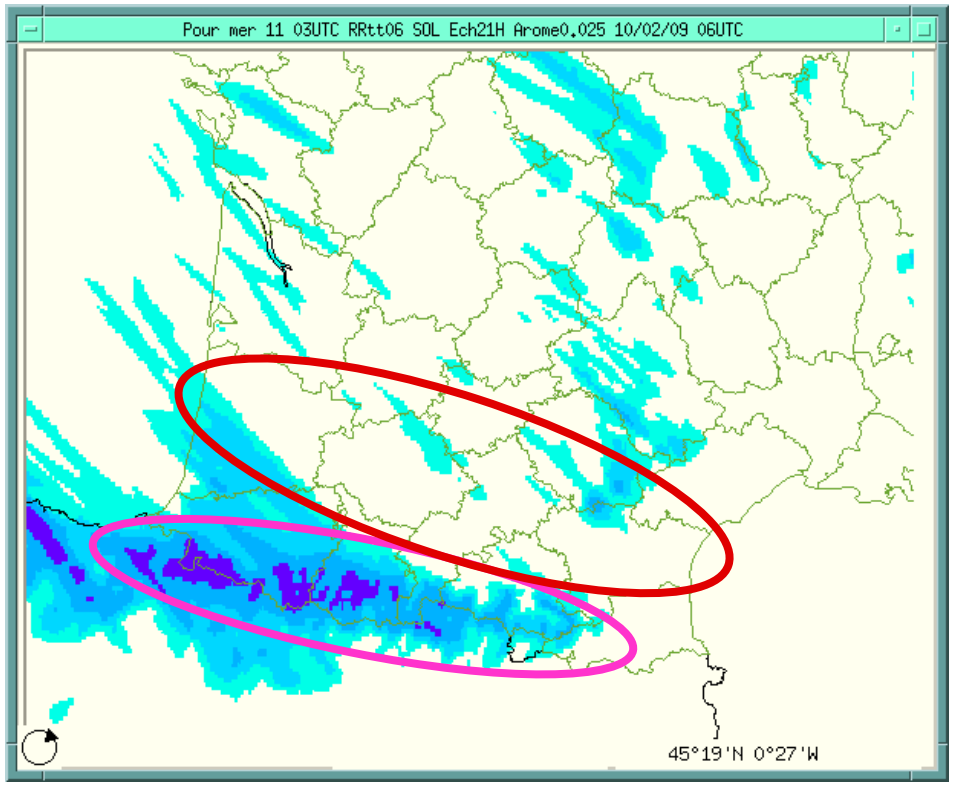


Graupel in Auch

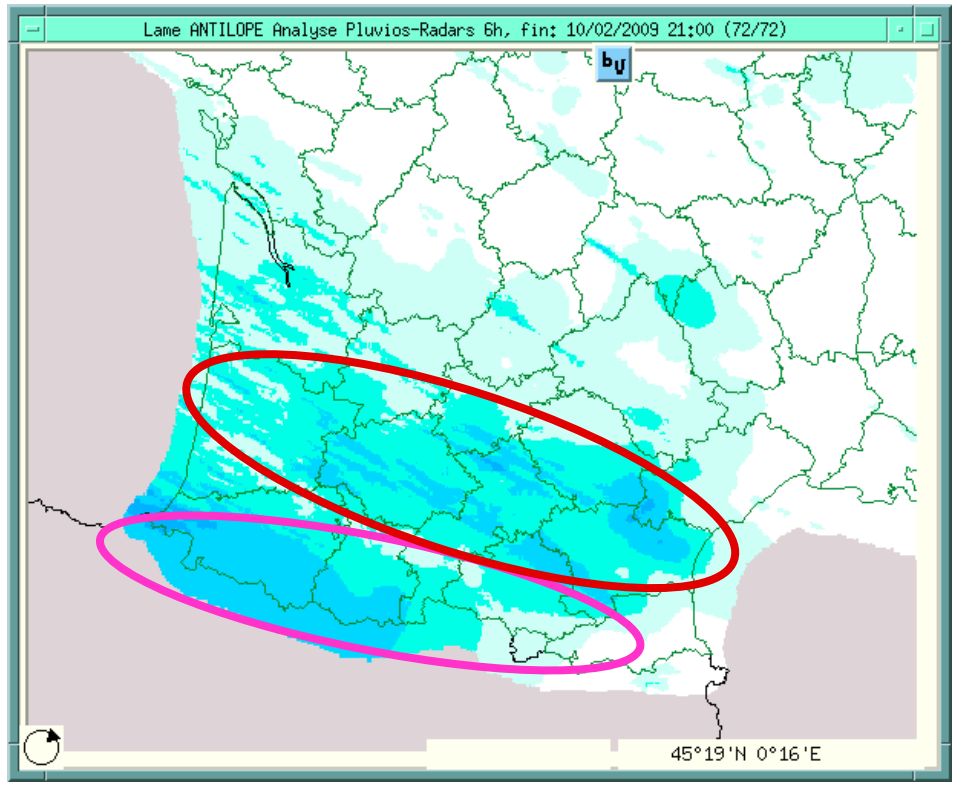
Hail in Toulouse

Convection in cold air (case study)

Cumul AROME (ech 15 h)



ANTILOPE, vd 21 UTC 10 Feb 2009



In such conditions, generally AROME overestimates covective precipitations over orography and underestimates them in plains.

METEO FRANCE
Toujours un temps d'avance

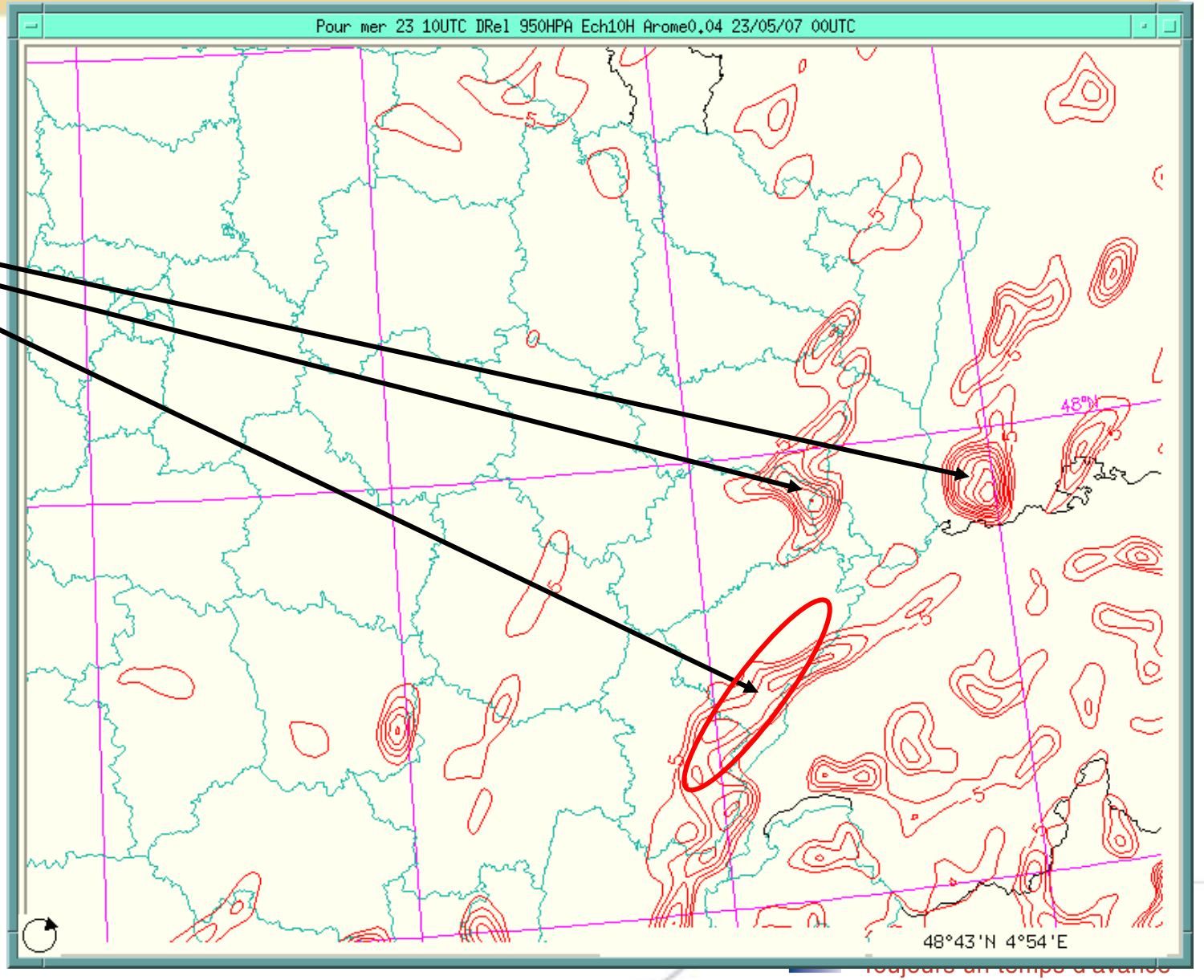
Diurnal convection over mountains (1)

AROME

Conv 950 hPa

10 UTC

Convergence getting stronger

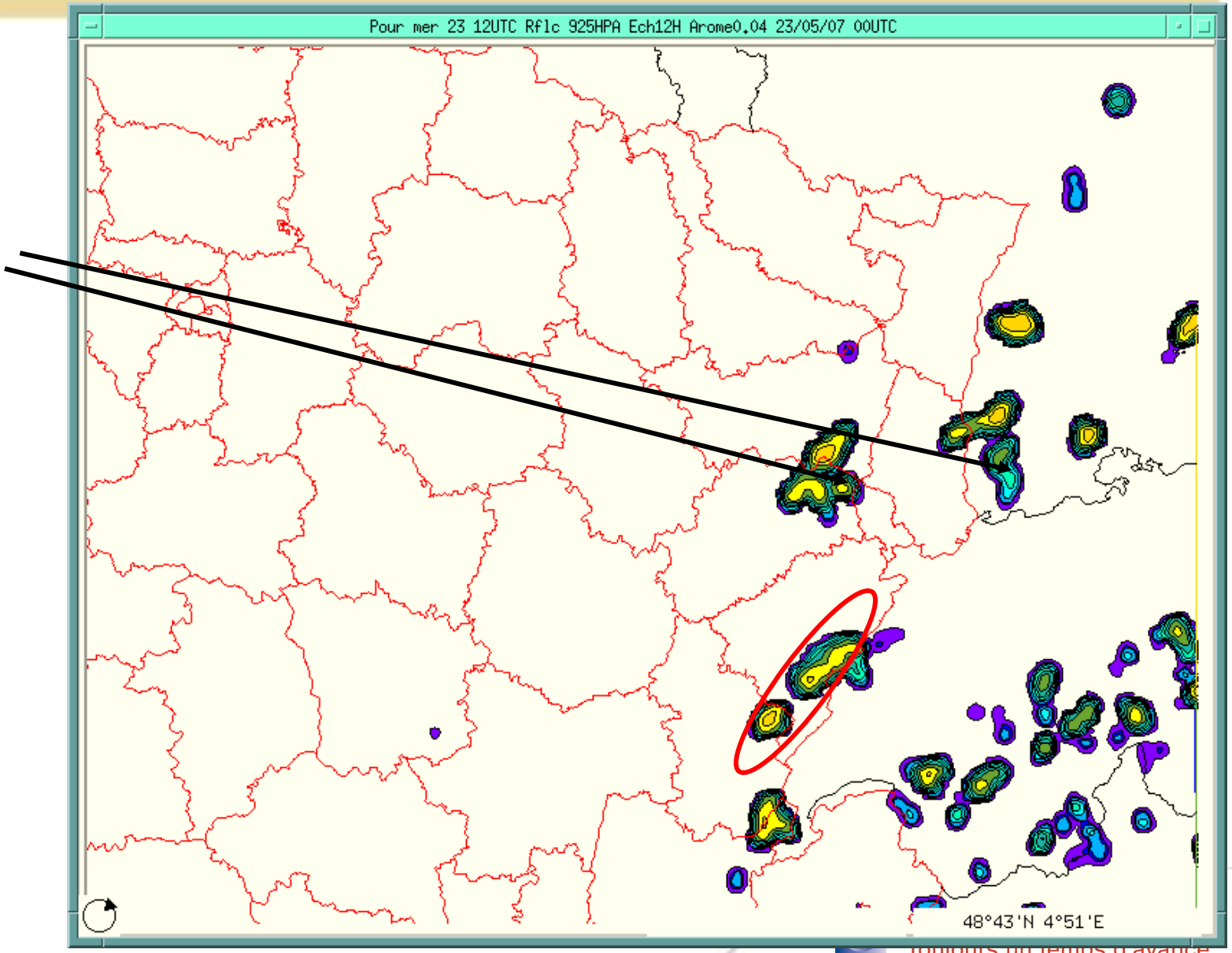


Diurnal convection over mountains (2)

AROME

Refl. 925 hPa

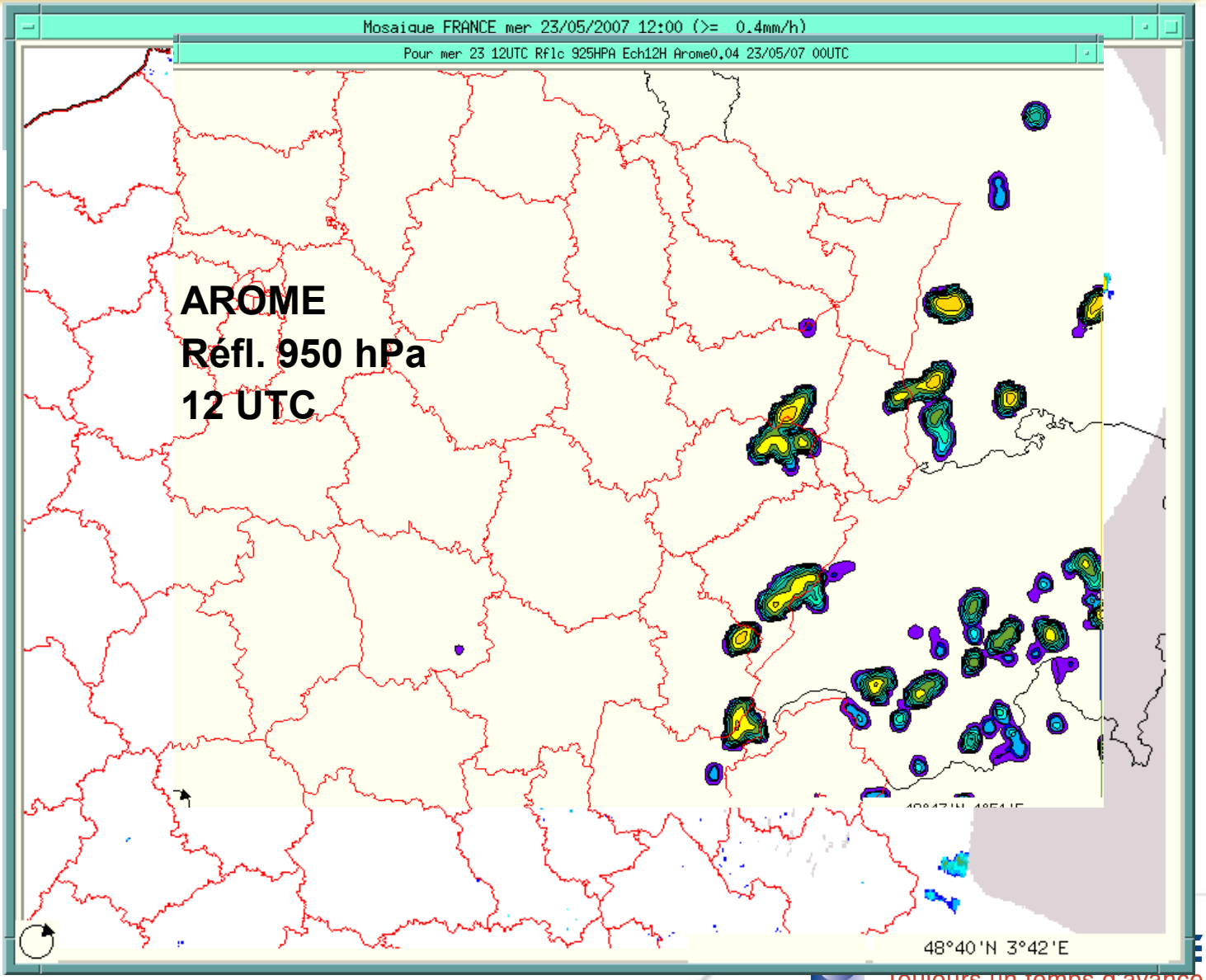
12 UTC



Diurnal convection over mountains (3)

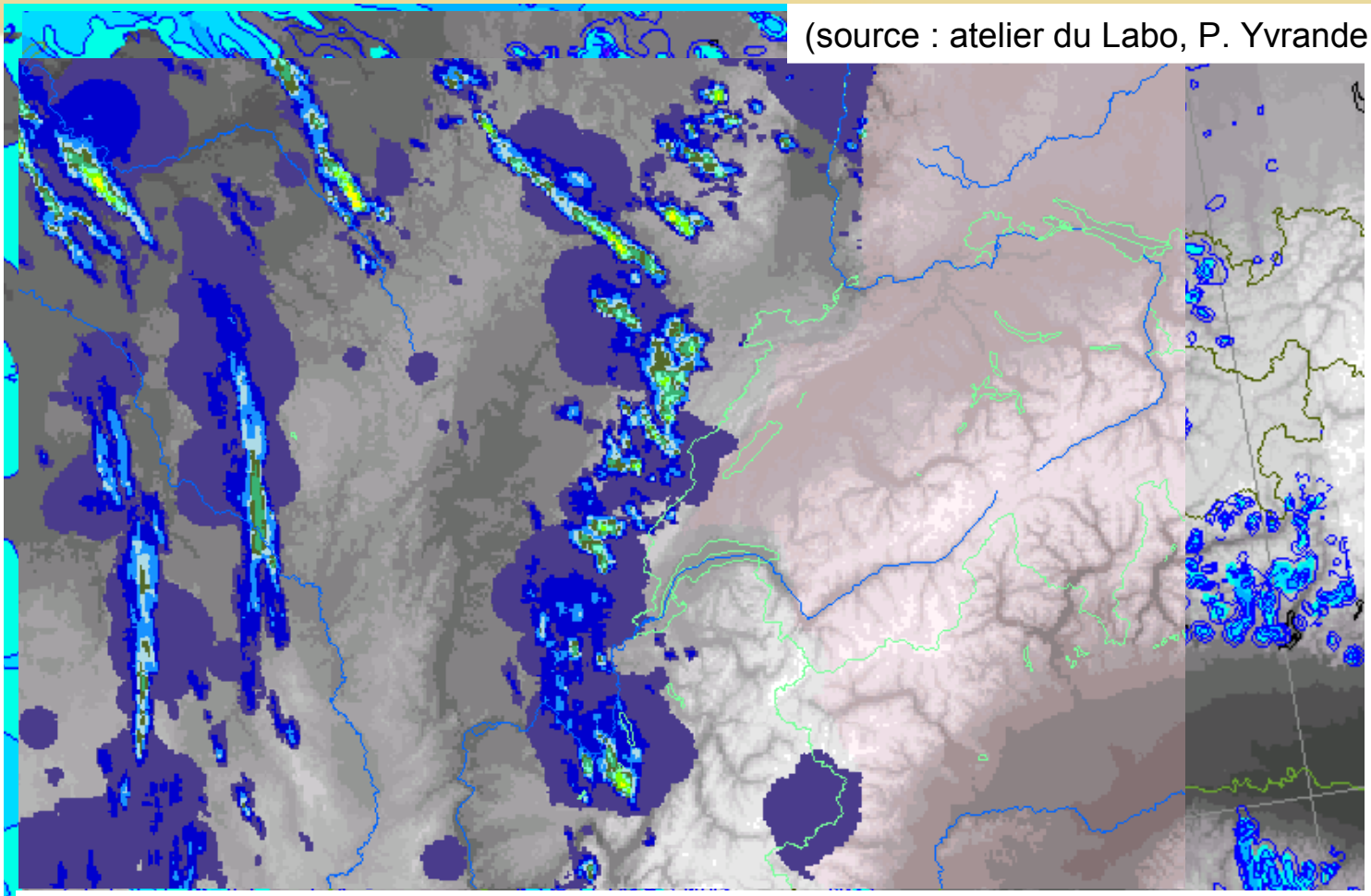
Obs radar

12 UTC



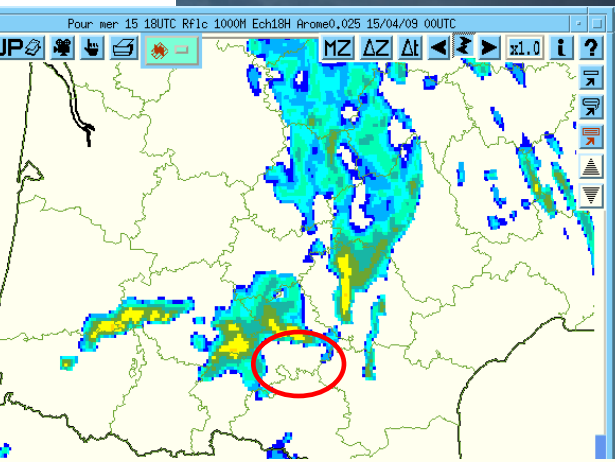
Diurnal convection over mountains (4)

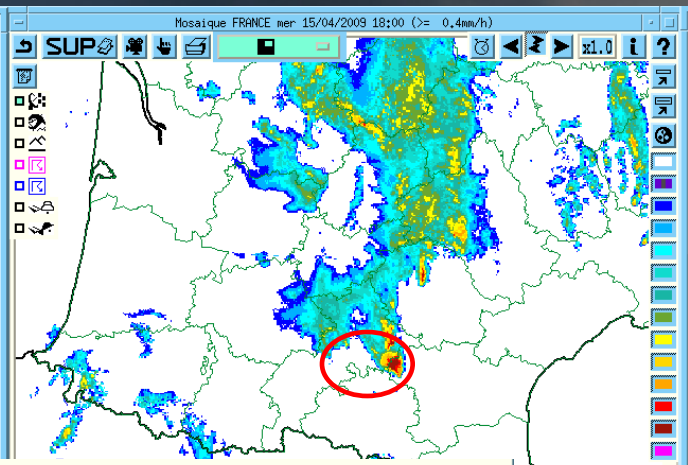
(source : atelier du Labo, P. Yvrande DDM73)

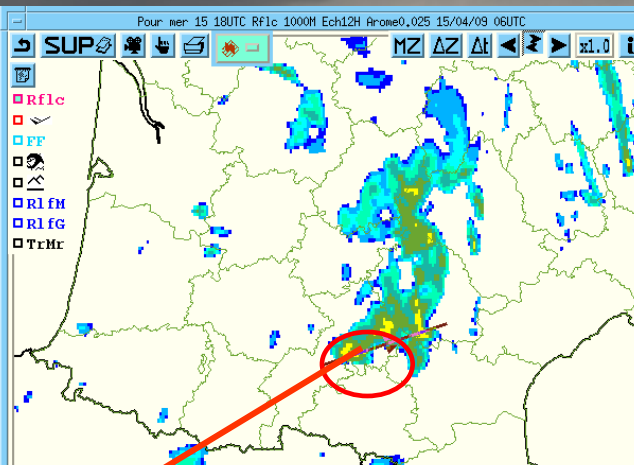


Observations le 14/04 – cumul 24h

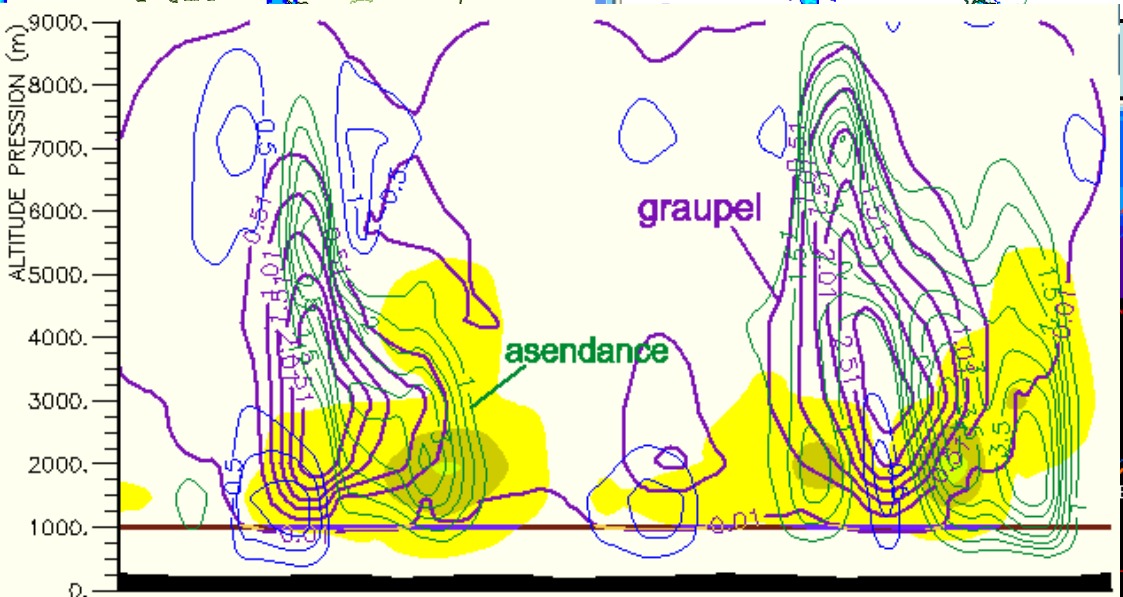
Strong thunderstorms over Midi-Pyrénées, hail over Lauragais
15 April 2009 *(1)*

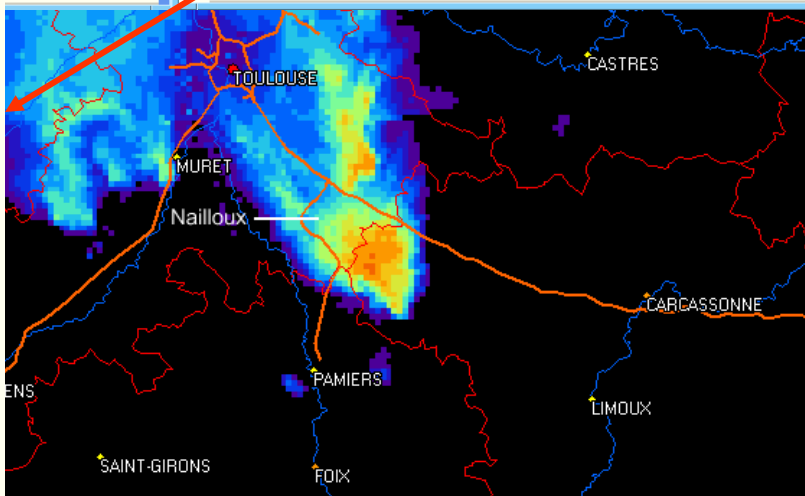




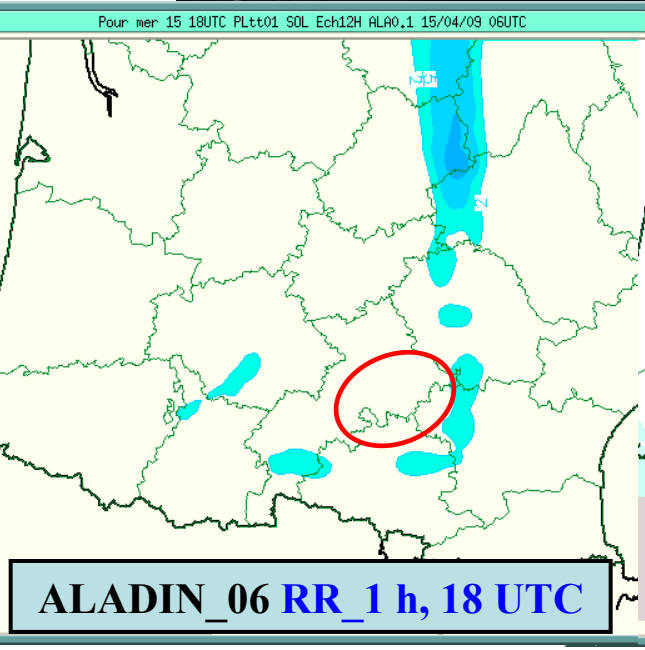


AROME_06, prévi 12 h

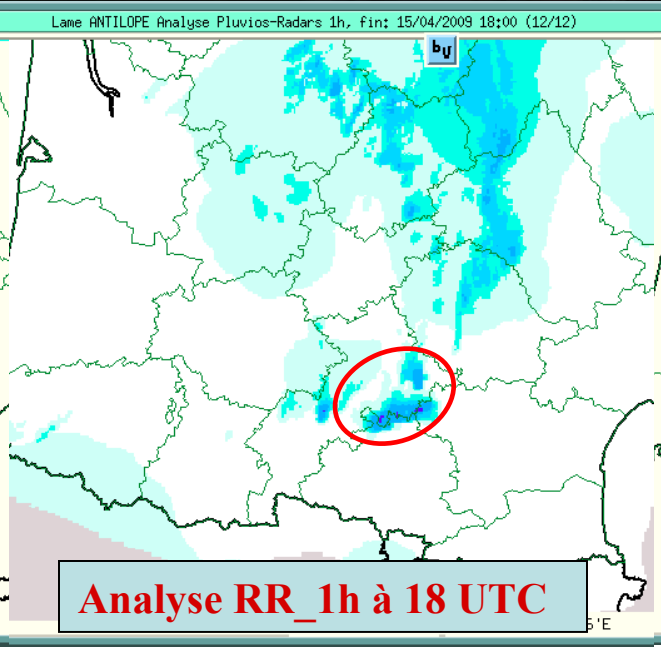




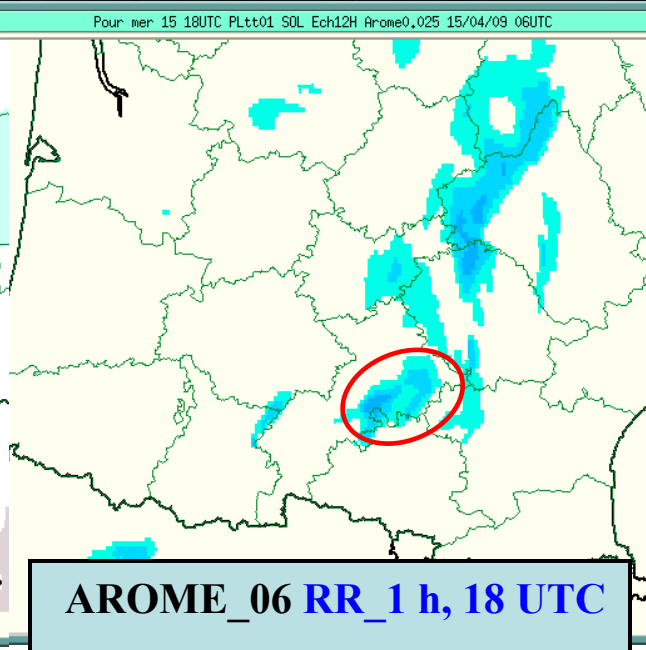
Strong thunderstorms over Midi-Pyrénées, hail over Lauragais
15 April 2009 *(3)*



ALADIN_06 RR_1 h, 18 UTC



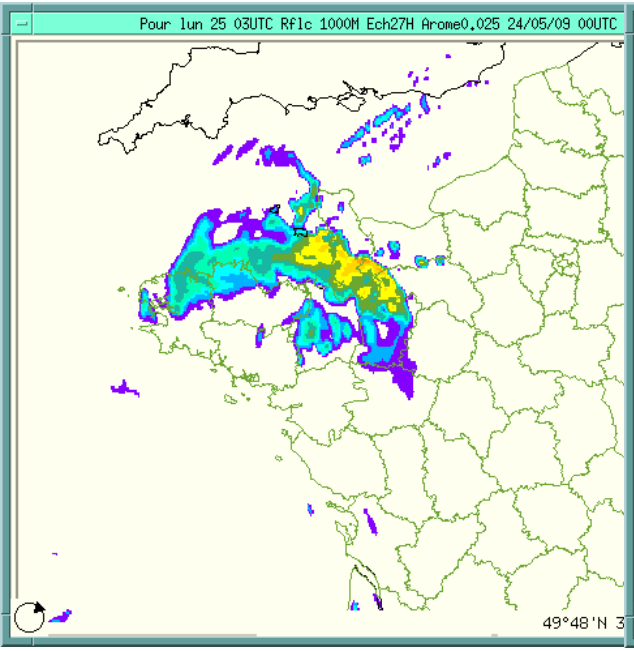
Analyse RR_1h à 18 UTC



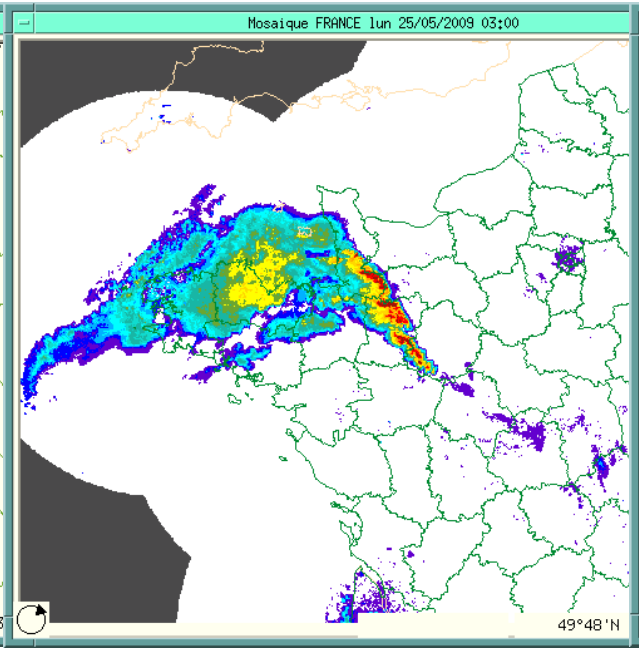
AROME_06 RR_1 h, 18 UTC

But no graupel forecasted at the soil

Strong convection, night of 24-25 Mai

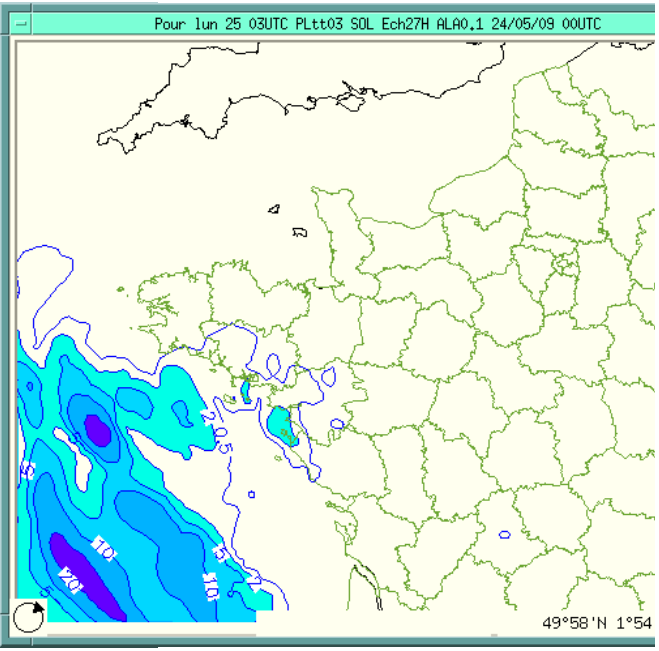


Reflectivities
AROME **run 00 la veille**



Radar

Valid 03 UTC for 25 Mai



Cumul RR_3h
ALADIN **run 00 la veille**

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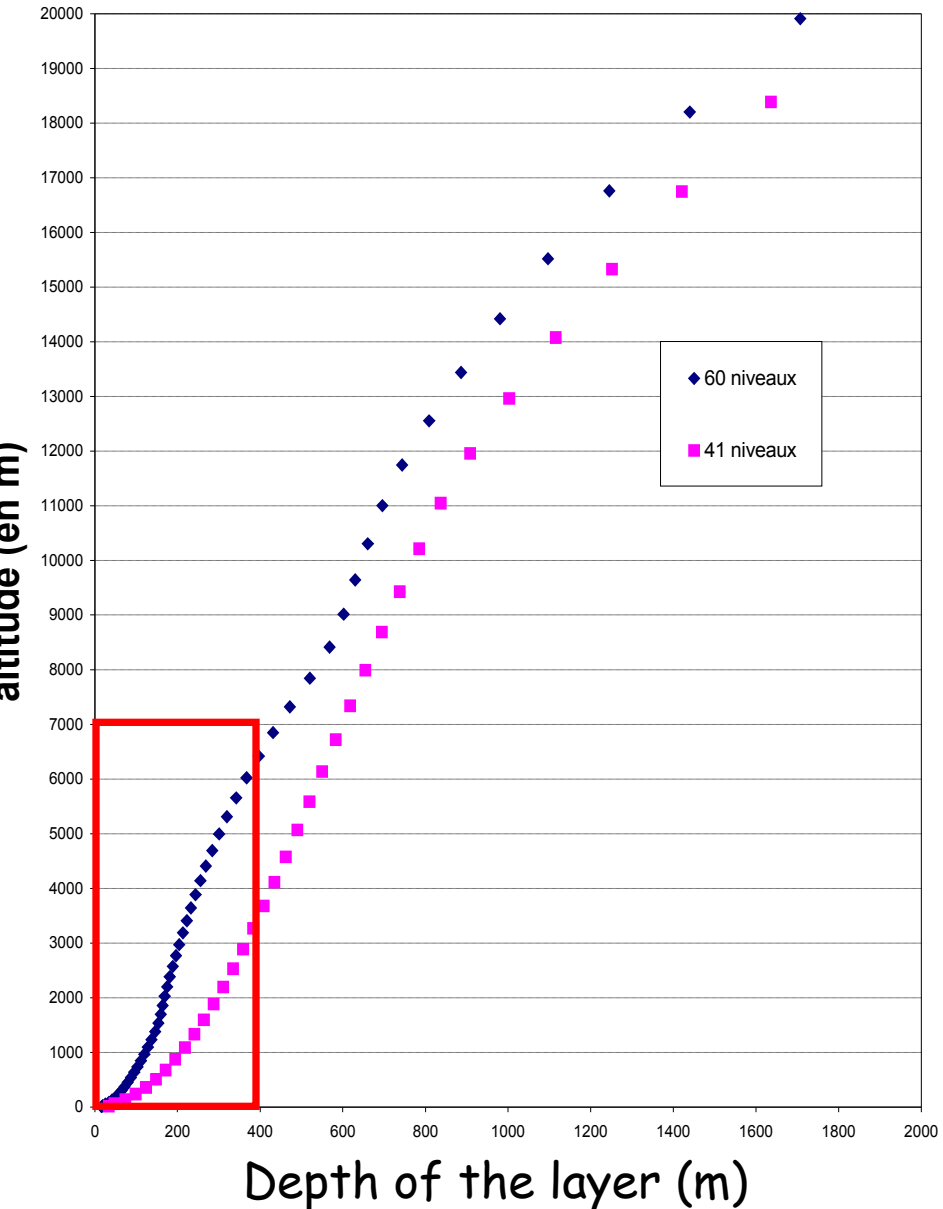
4) Perspectives

Model perspectives

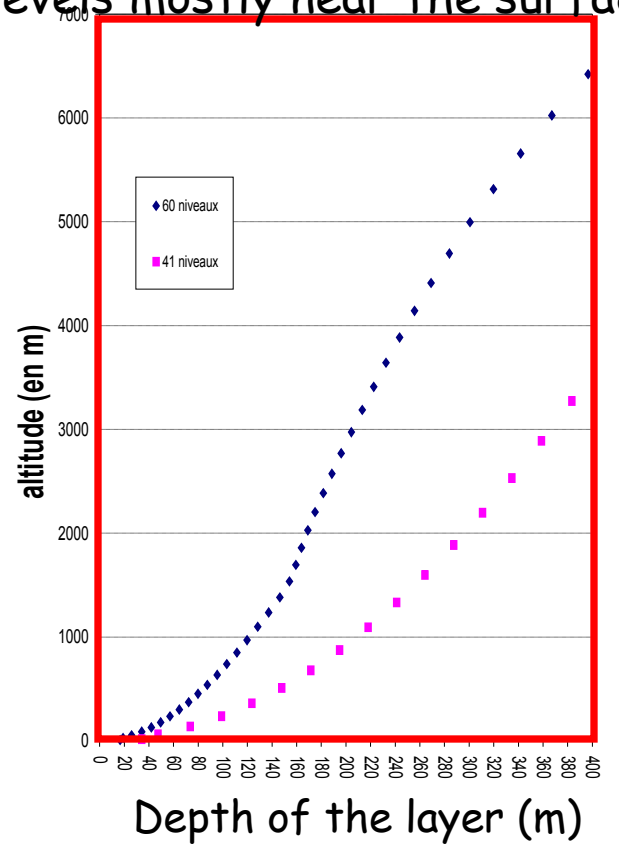
- Increase the vertical resolution (2009) and the domain (2010)
- Evaluation of direct coupling to ARPEGE (T799C2.4~10km over France)
- Higher resolutions tests (1km, 500m, …)
- Improved version of EDKF
- Parameterization of hail « ICE4 »
- New database for physiography (ECOCLIMAP-2)

- Continue working/understanding the scale of simulated convective cells (horizontal diffusion, dynamics/physics, …) including « outflow problem »
- Work on the compatibility with other models (‘convergence’)

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)

(Y. Seity)

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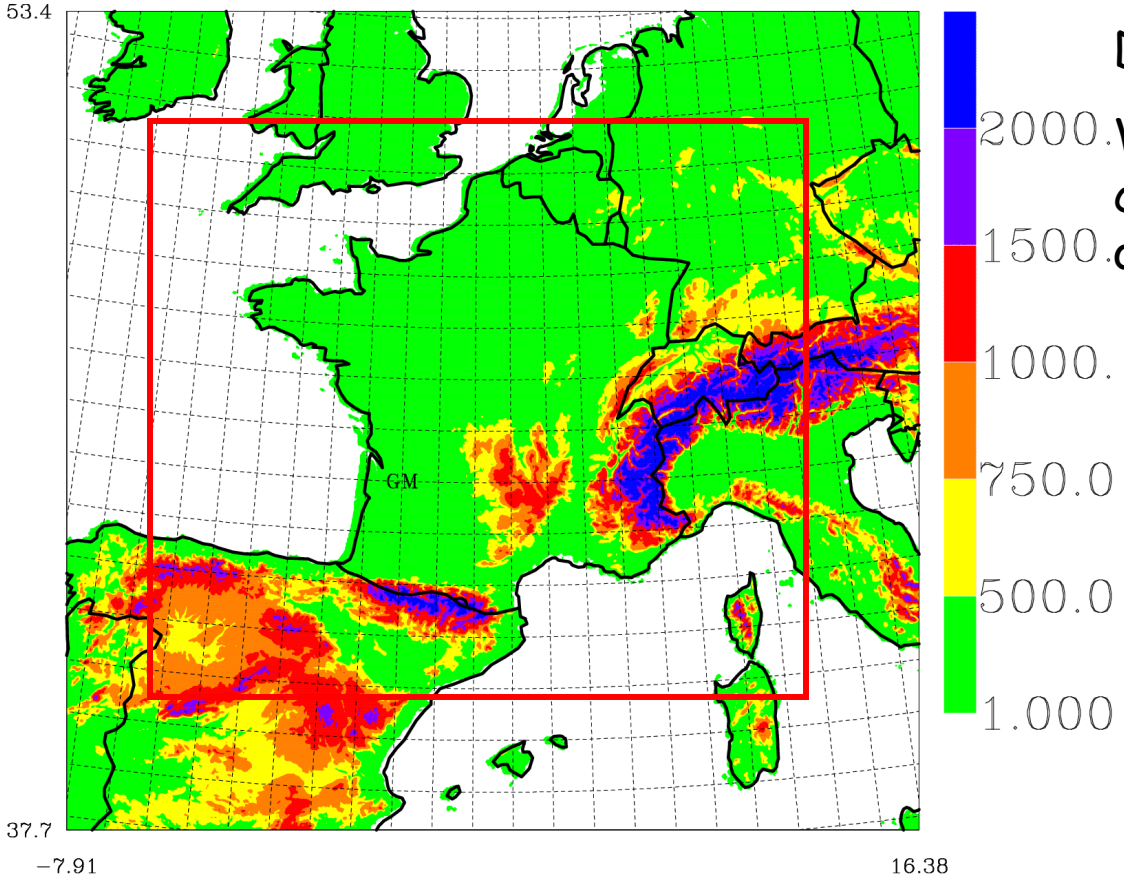
AROME-France domain for 2010

- Thanks to added processors on our NEC SX9



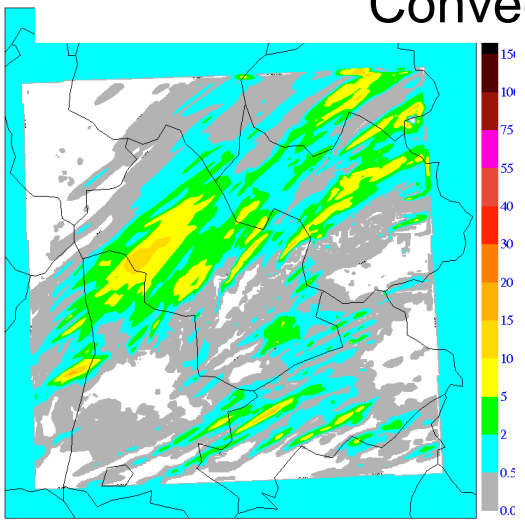
Domain 750x720 points

With L60, it represents +151 % compared with our current L41 operational domain

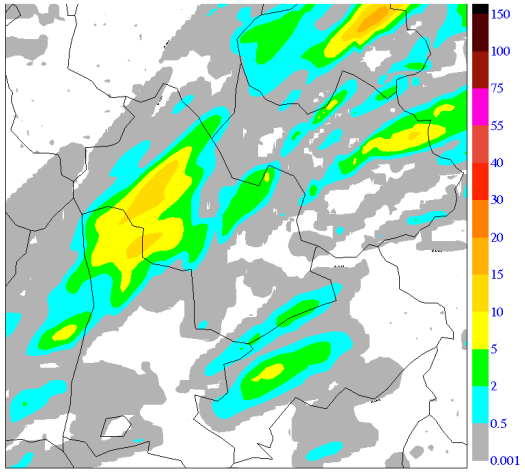
(Y. Seity)

Simulations at higher resolutions

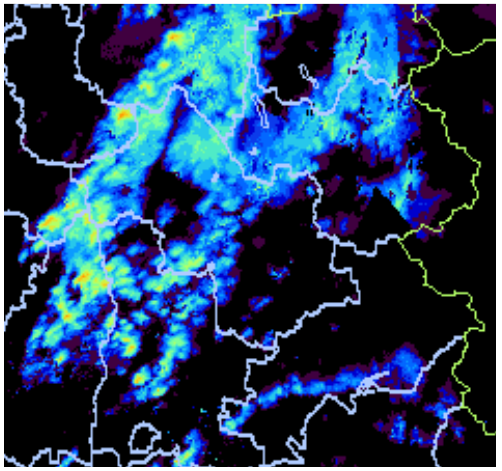
Convective case 20090819 over the alps



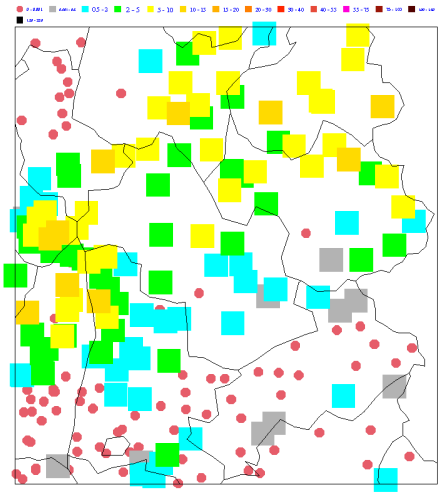
Precipitating amount 18H-19H
AROME 500m



Precipitating amount 18H-19H
AROME 2.5km



Radar 18H30



raingauges

- Convection at 500m behaves quite well
- Good spatialisation of AROME-2.5km
- More realistic small-scale features at 500m, but no huge improvement compared to raingauges for the time being. The rain maxima are comparable to AROME 2.5km

(L. Auger)

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Assimilation perspectives

- ALADIN/AROME directly benefit from studies performed in the ARPEGE framework (microwave radiances over continents, IASI, cloudy radiances…)

- **Specifically for AROME:**
  - radiances with higher horizontal resolution
  - surface analysis
  - assimilation of radar reflectivity
  - assimilation of objects based on structure matching (pseudo-observations)
  - use of a heterogeneous B matrix (clear and precipitating areas)
  - 3D-Fgat

Thank you for your attention!

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