Physics in ARPEGE/ALADIN & AROME

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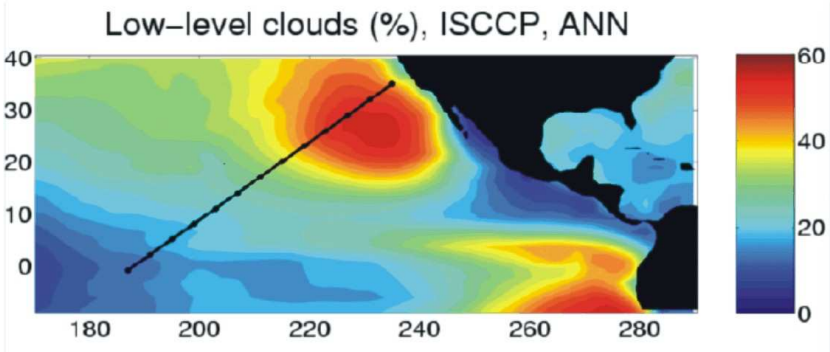
Talk's Overview

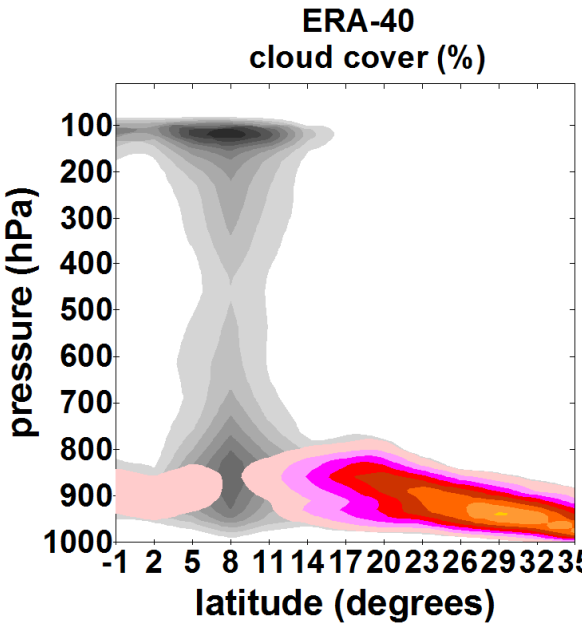
- ARPEGE/ALADIN Physics : what's new in 2010 ?
- AROME : forecasters' point of view after 2 years
- AROME physics: what's new in 2010
- Developments on cloud physics

ARPEGE physics (since Feb 2009)

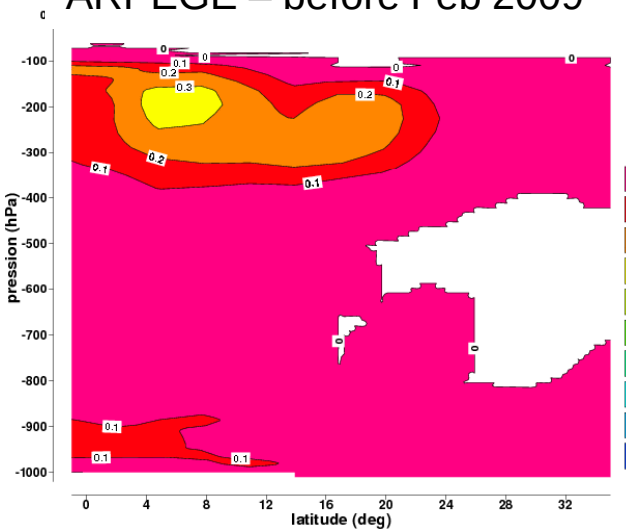
- Classical Shallow convection (Kain-Fritch-Bechtold)
  - Will be tested an EDMF approach next year
- TKE turbulence scheme
  - Much better results than the Louis scheme
- Deep convection (from Bougeault 1985)
- Microphysics with 4 prognostic species (Lopez)
- Radiation scheme (Morcrette in SW, RRTM in LW)
- Gravity wave drag (Geleyn)

- New resolution in April 2010:
  - 70 vertical levels
  - ~10km hor. Resolution over Europe

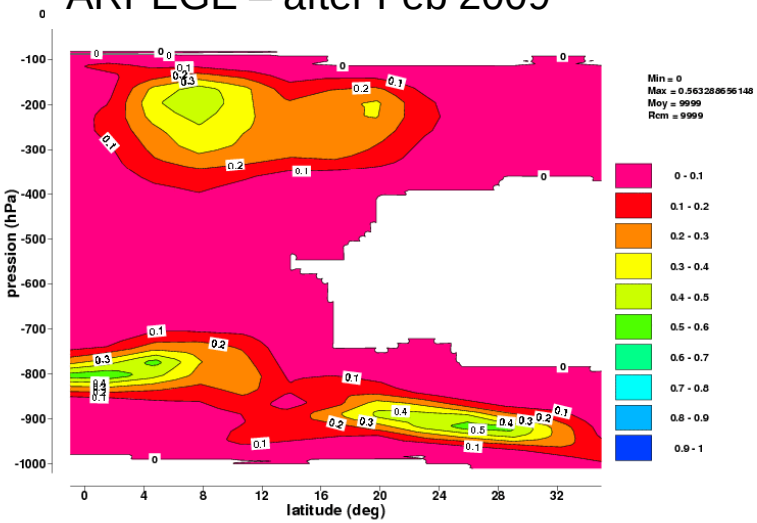




ARPEGE – before Feb 2009



ARPEGE – after Feb 2009



GPCI : Gewex Pacific Cross-section Intercomparison

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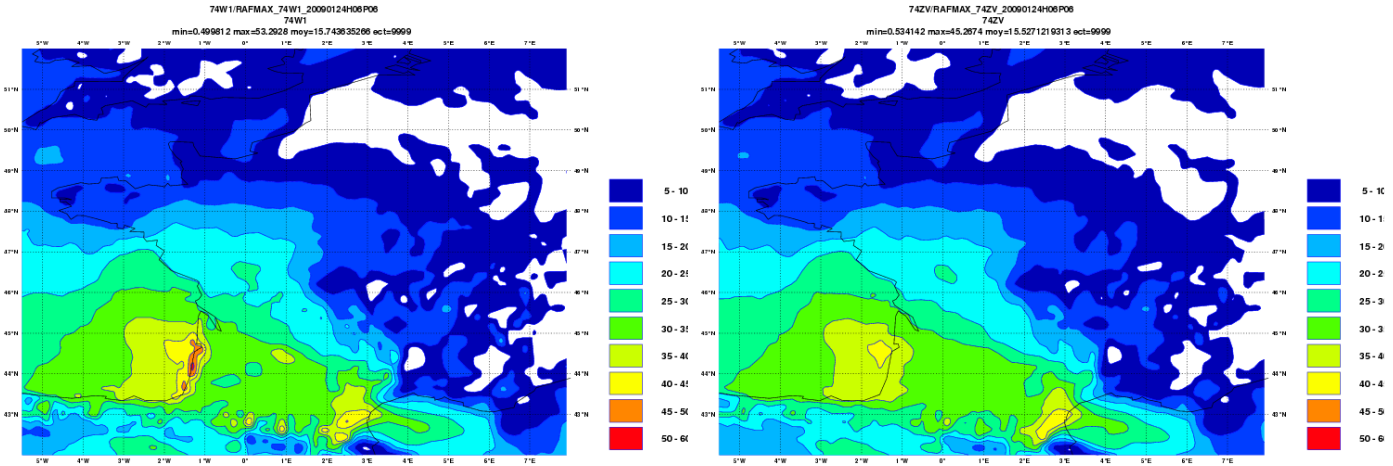
ARPEGE Physics modifications this year

- New diagnostics of gusts (as in AROME)

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

- Advection of TKE →



- Removal of the entrainment at Boundary Layer top
- Sedimentation of cloud dropplets (water & ice), new snowfall speed, rain freezing
- Modification of roughness length on orography (now only affects momentum)

cnrs dépasser les frontières

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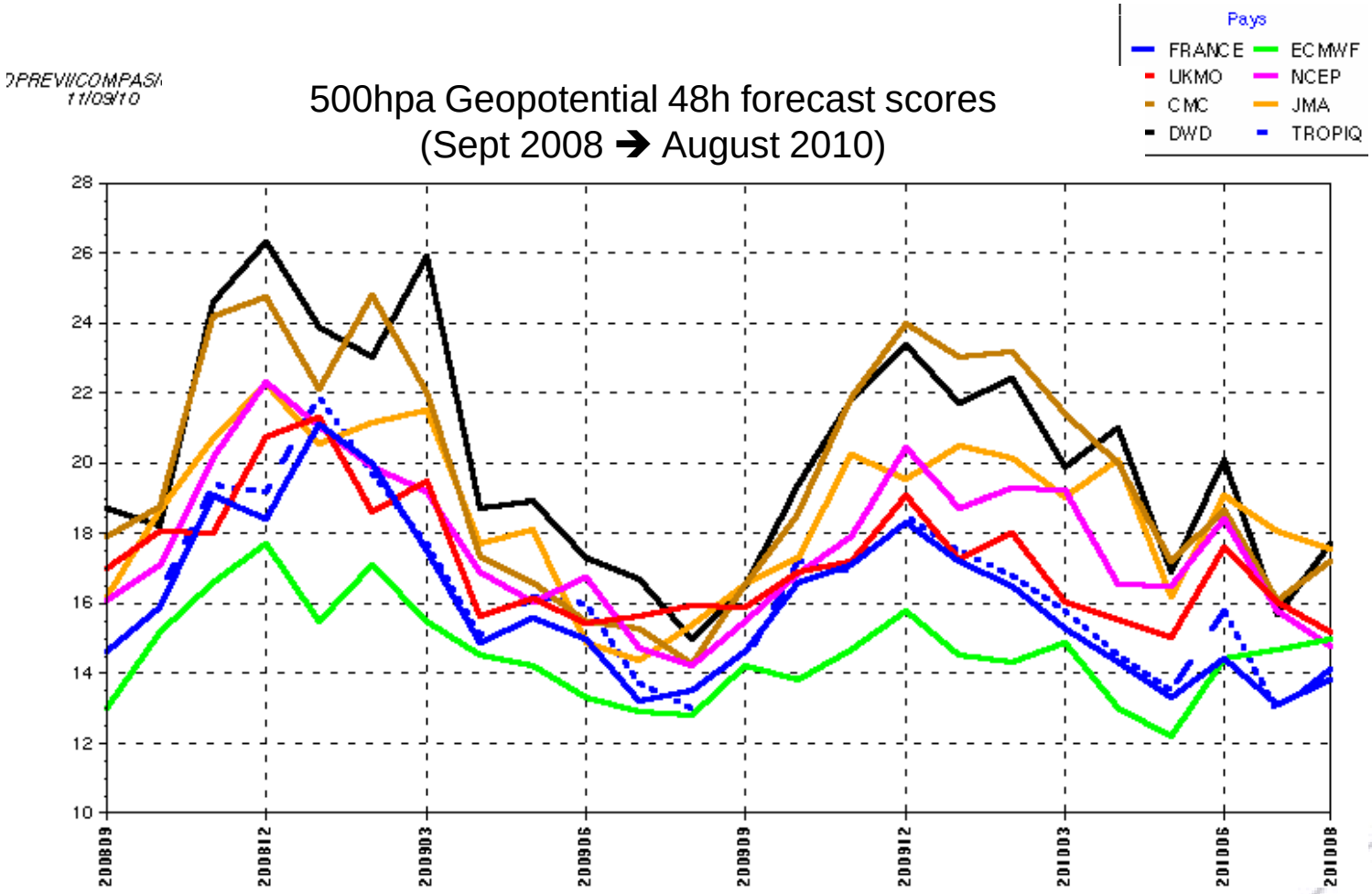
Monthly scores over Europe

- New physics (especially TKE turbulence scheme and KFB shallow convection) improved the scores in the Boundary Layer as well as the precipitation scores
- Physics is not directly the reason why the synoptic scores improved
- But the new turbulence scheme allowed a smooth increase of vertical resolution



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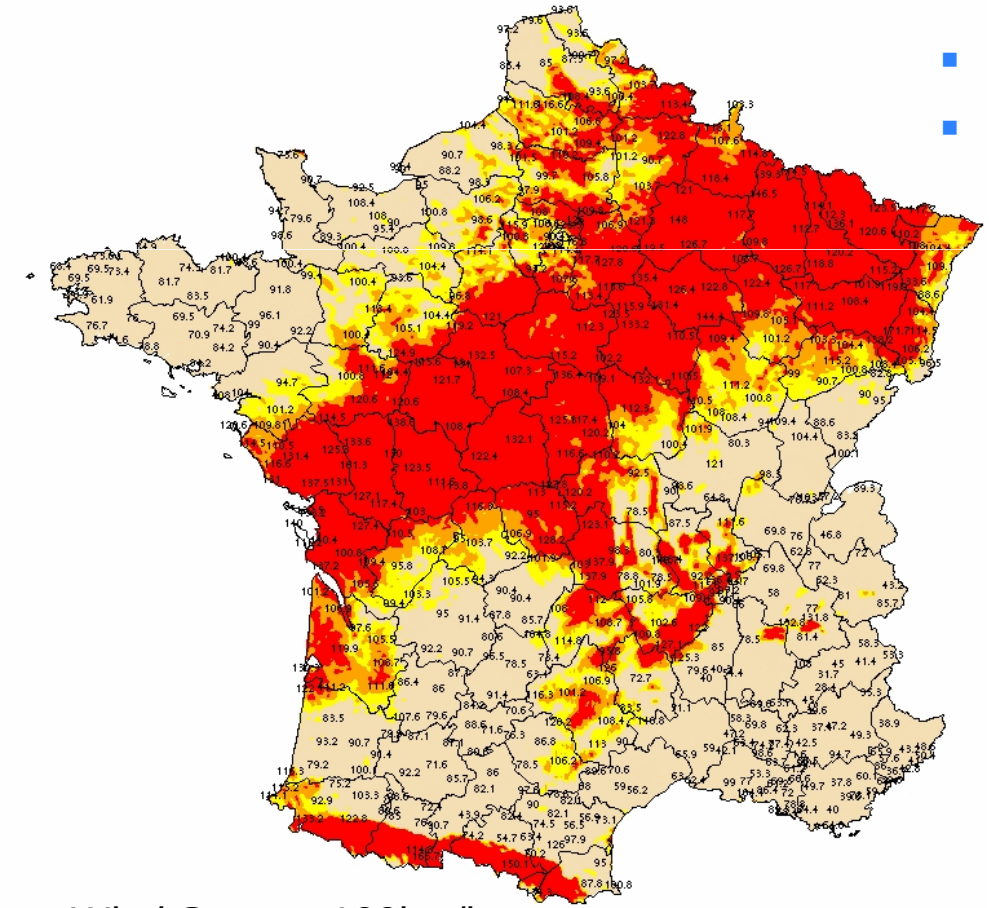
Talk's Overview

- ARPEGE/ALADIN Physics : what's new in 2010 ?
- AROME : forecasters' point of view after 2 years
  - Xynthia wind storm
  - A few examples
  - Forecasters' scores & analysis
- AROME physics: what's new in 2010
- Developments on cloud physics

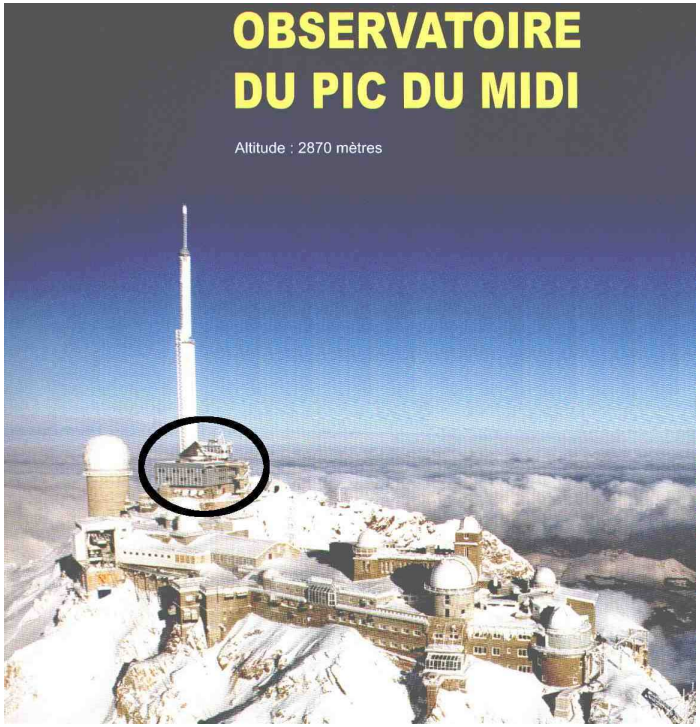
XYNTHIA storm : 27-28 February 2010



Wind Gusts > 100km/h

Rafale en km/h par krigeage - 27 et 28 fevrier 2010 seuils 95 100 105 km/h

- Dramatic flood on the West Coast
- And also intense gust winds in the Pyrenees



238 km/h at Pic du Midi
Very strong winds in the valleys : 1 death in Luchon

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Wind storm : Xynthia

- A lot of damage in all ski resorts
- On pics and high plateaus:
  - 238 km/h at 2880 m of alt.
  - 191 km/h at 2445 m of alt.
  - 167 km/h at 1600 m of alt.
- Also strong winds In valleys
  - 115 km/h measured

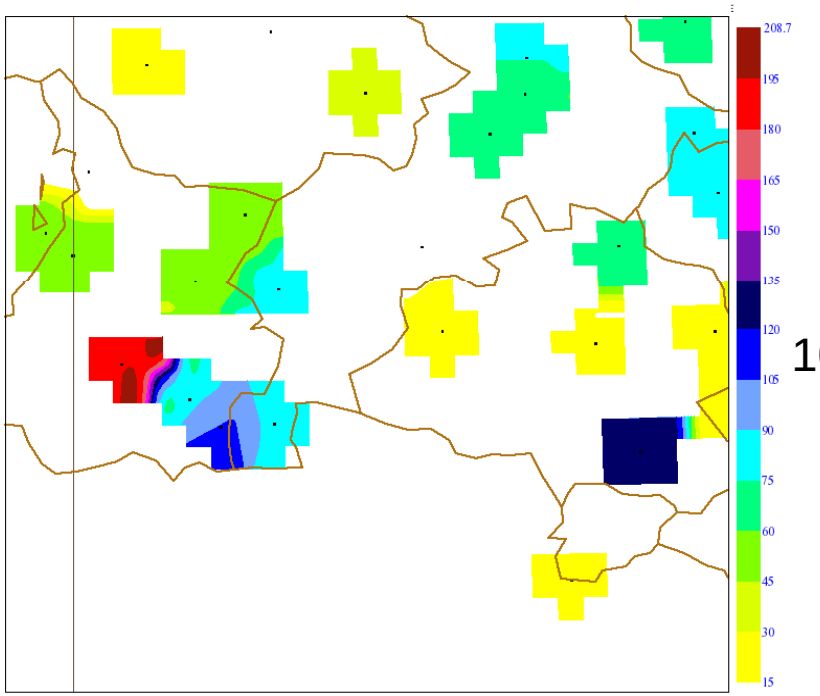
Wind storm : Xynthia

- Before AROME, mountain Forecasters usually used their knowledge of mountain climatology
- The AROME grid-mesh (2.5km) should allow numerical forecast in mountaineaous areas
- For Wind storms, it should give pertinent information on
  - Gust Area,
  - Chronology of the storm,
  - Maximum winds

- Forecasters are globally happy with the AROME forecast for Xynthia

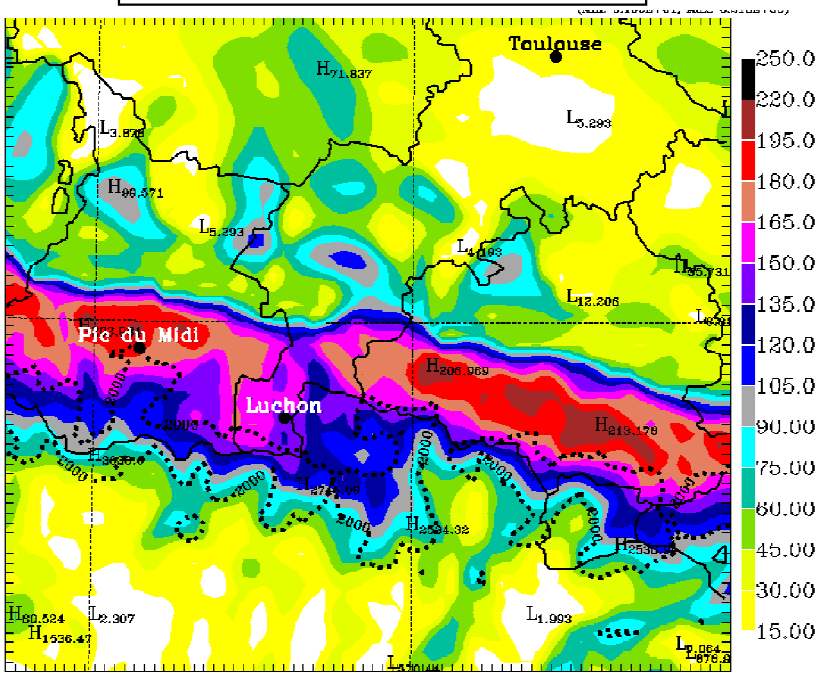
Good forecast on the Pyrenees with AROME, with a band of strong winds on the north of the Pyrenees in the South wind

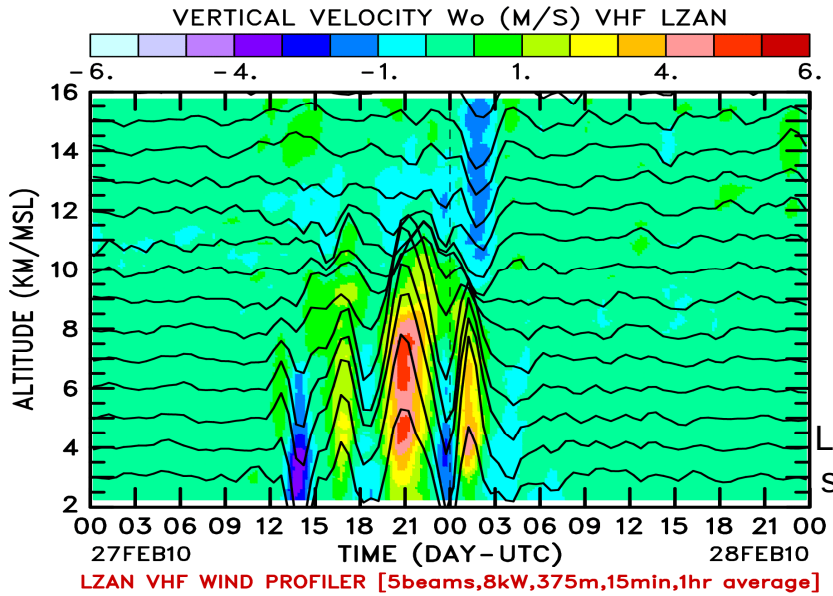
OBSERVATION Max=209km/h



10m gust wind (km/h) 21H

AROME Max=213km/h





Lannemezan wind profiler shows a structure of trapped gravity waves

- Good forecast on the Pyrenees with AROME :
  - wind storm on the downwind slope
  - winds on peaks but also in valleys
- Good forecast of the trapped lee-waves

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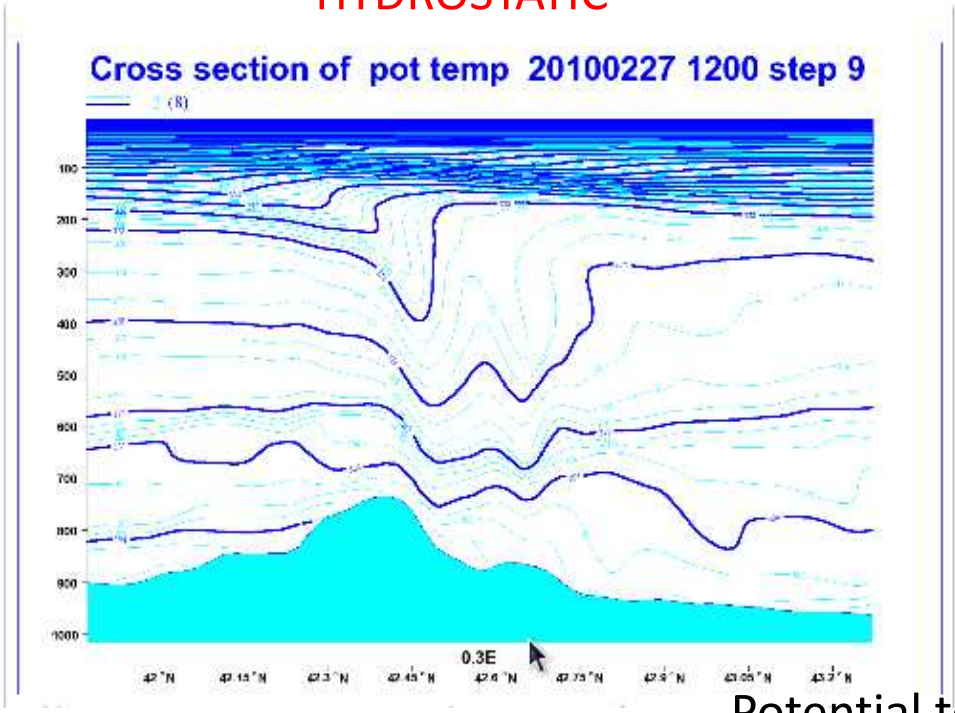
Wind storm : Xynthia → positive impact of NH

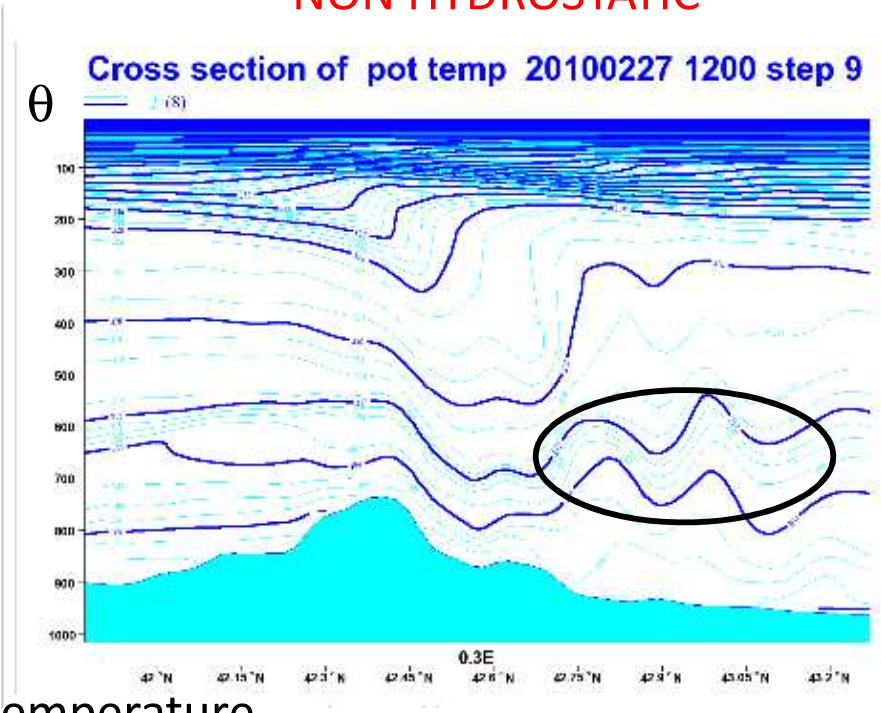
- The trapped waves are only reproduced with the non hydrostatic assumption.
- In Hydrostatic, wind in valleys is weaker (80 km/h instead of 120 km/h)

→ Positive impact of the NON HYDROSTATISM

HYDROSTATIC



NON HYDROSTATIC

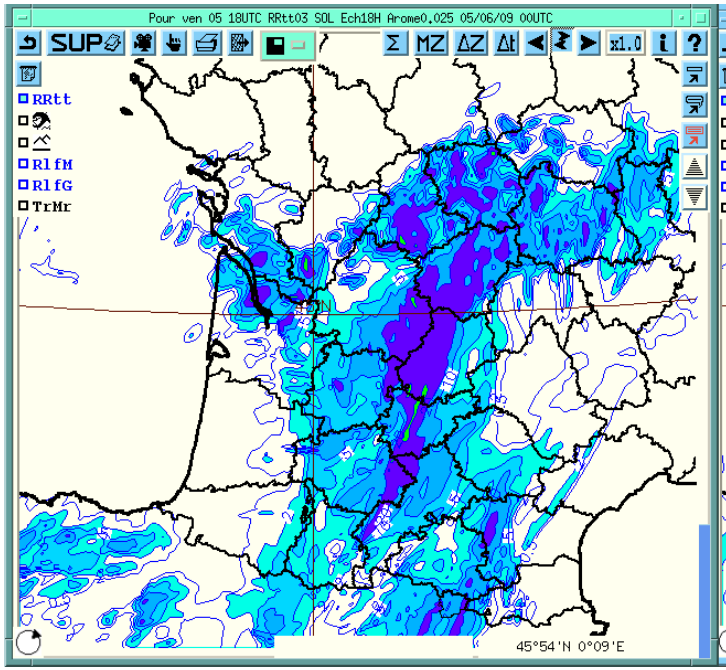


Potential temperature

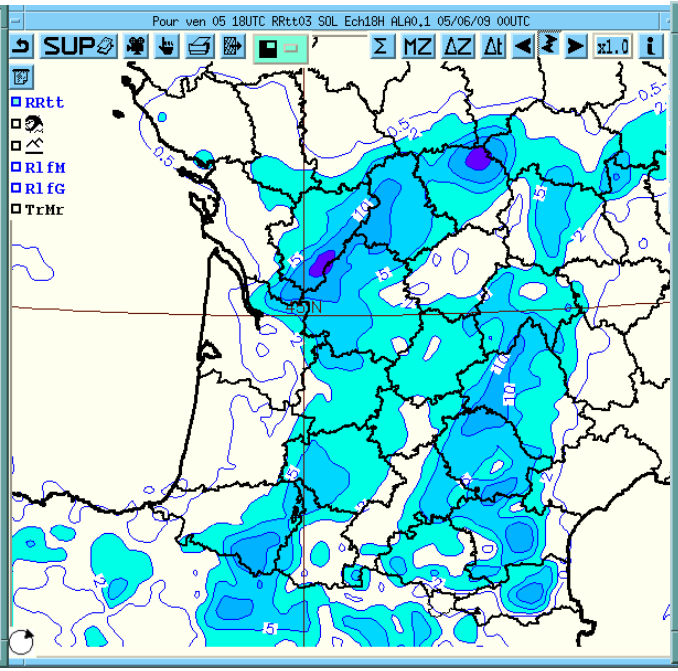
Convection

Case of the 5th June 2009

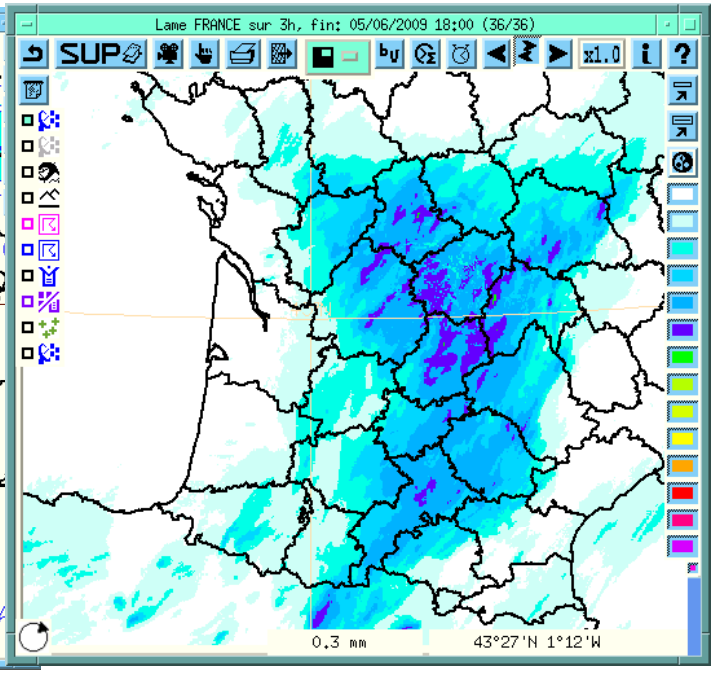
Arome 0h



Aladin-France 0h



Obs. (15h-18h)



- AROME better localized for the strongest rainfall
- Better spatial structure
- But a few thunderstorms behind the front

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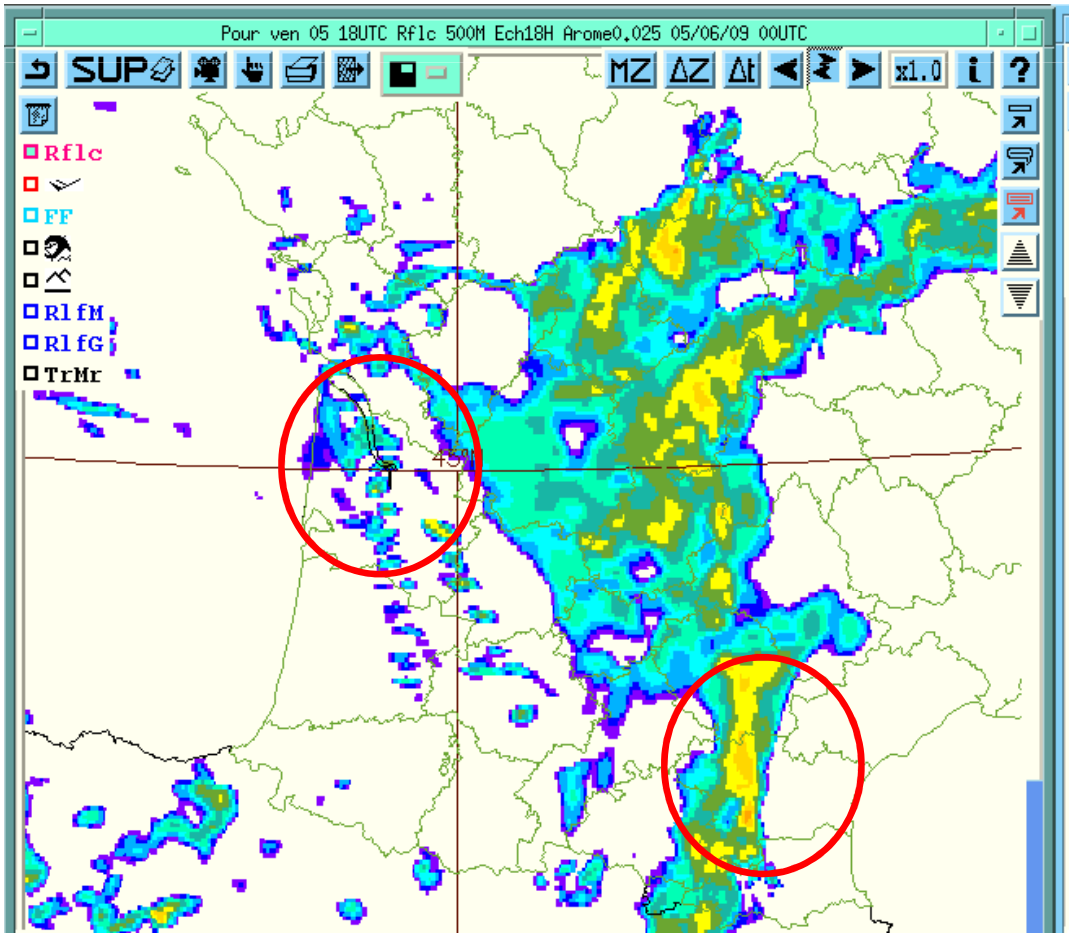
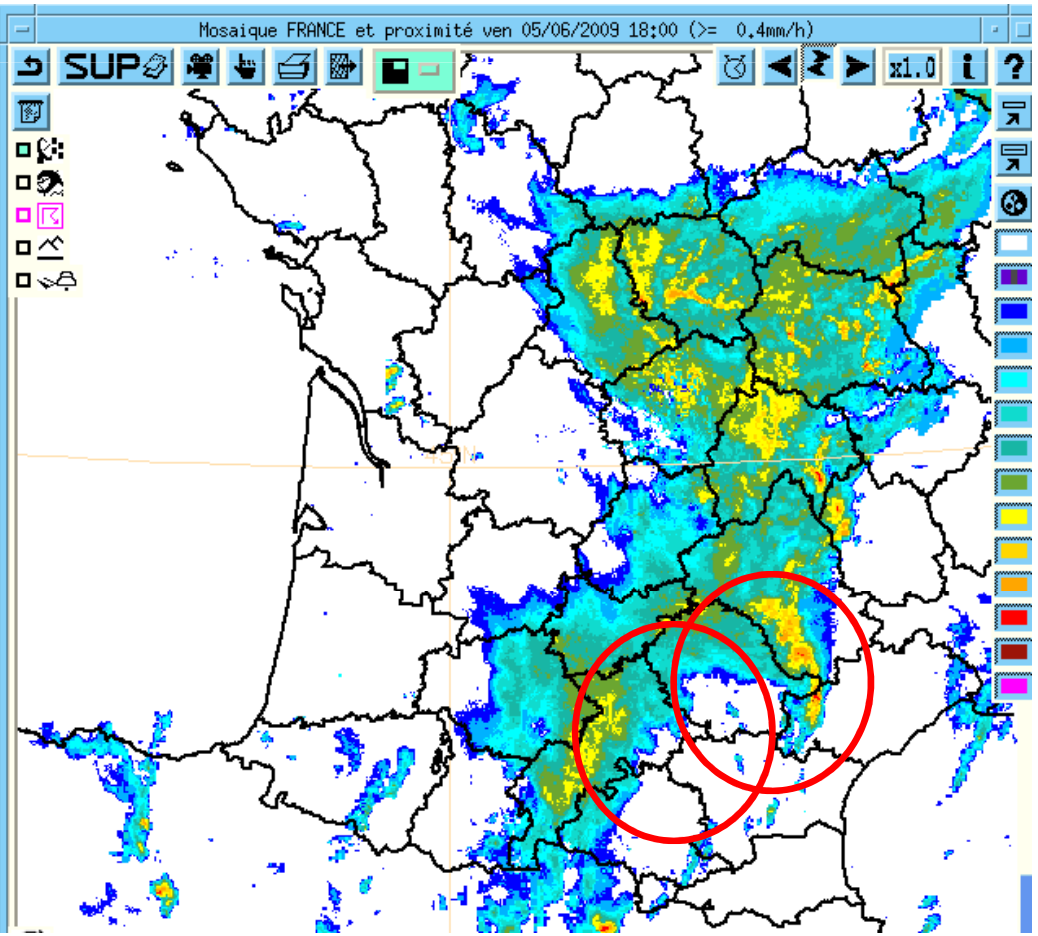
Convection

Case of the 5th June 2009

Arome 0h



Radar



- Good simulation of the squall line

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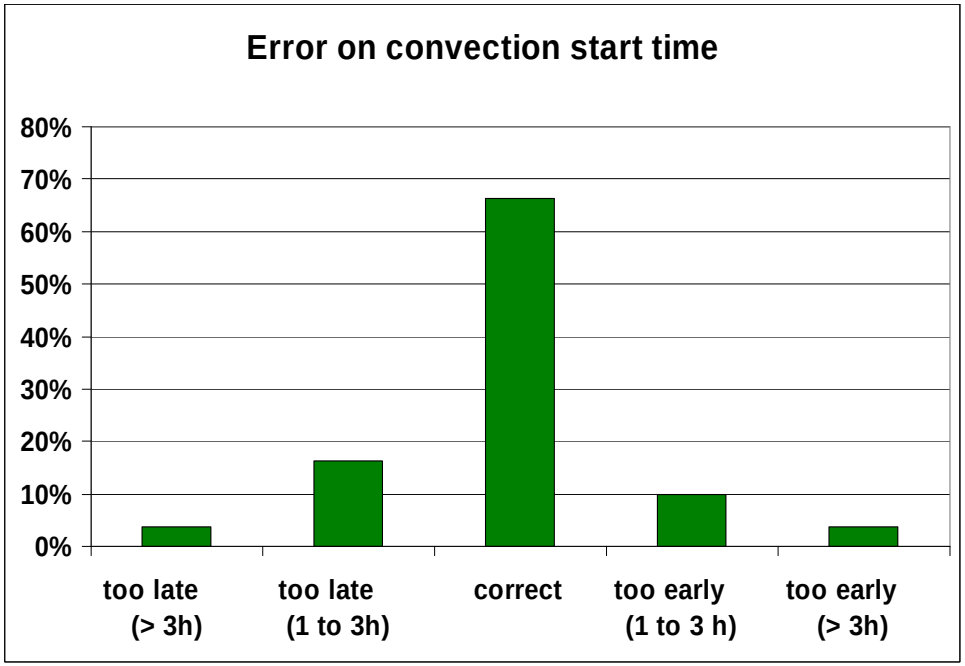
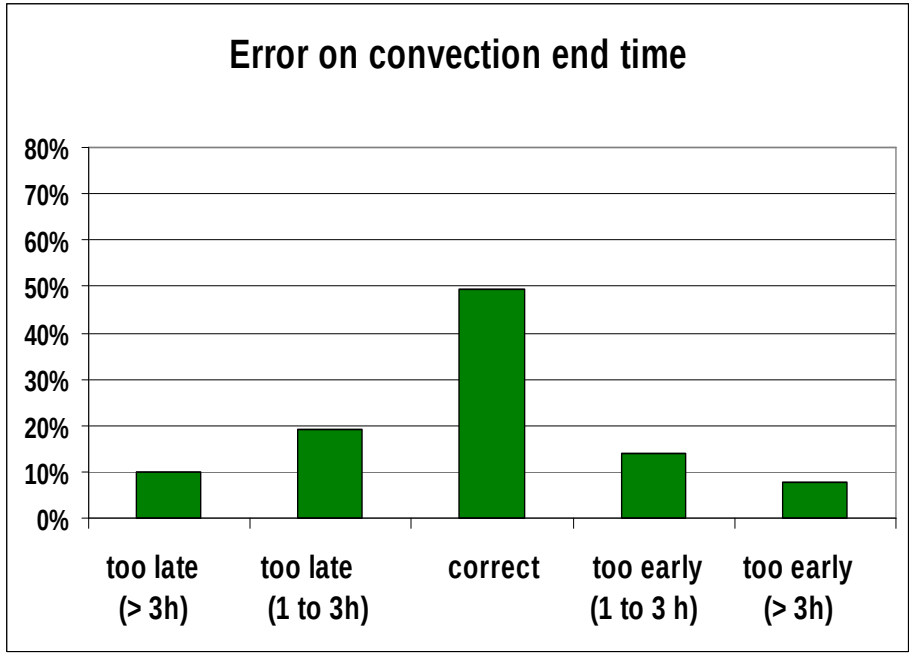
AROME : Forecasters' Point of View

Convection



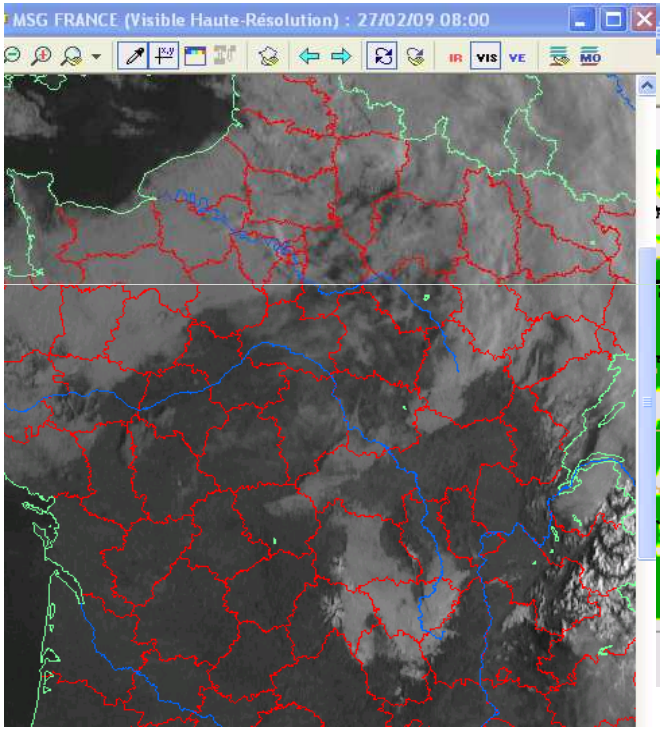


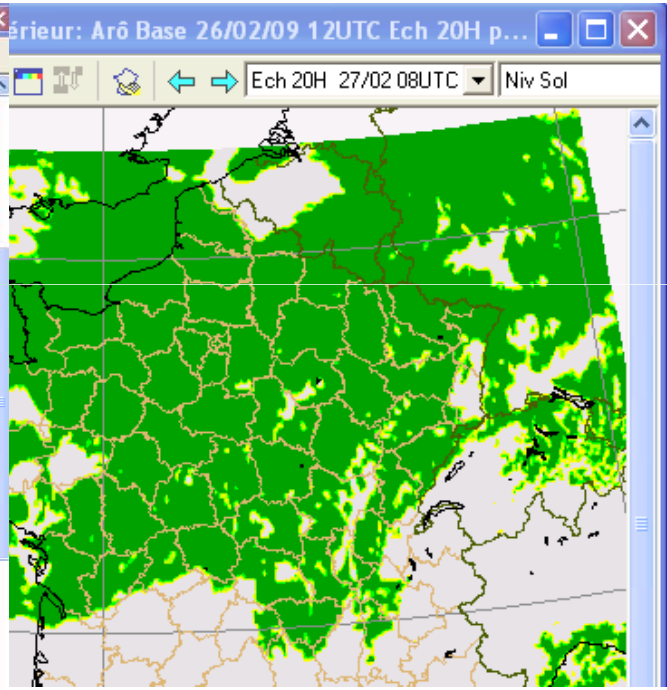
⇒ Convection starts and ends at the right time !

⇒ Convection : often shifted by 50 to 150km

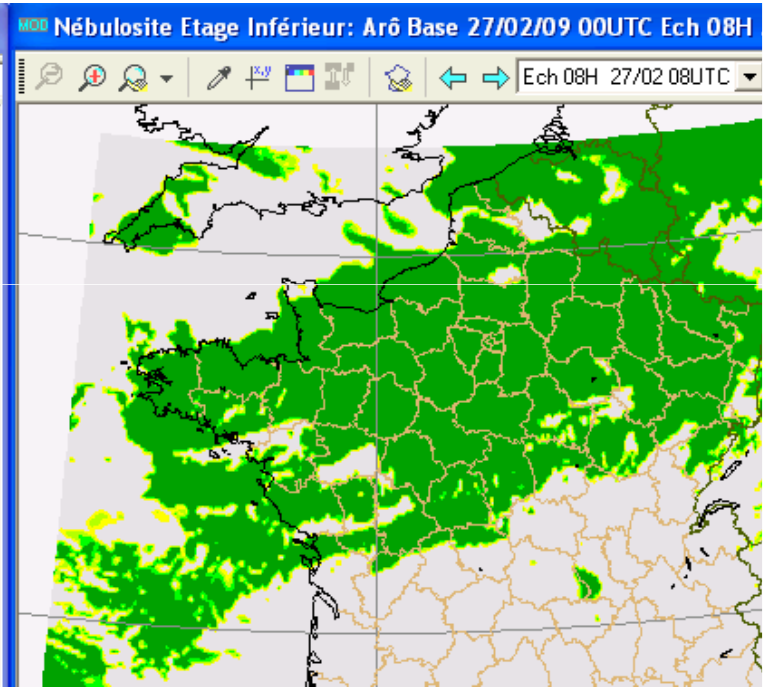
⇒ Convection very well localized in the Alps

Fog : overview





Fog
Base: 26 feb, 12h
Forecast : 27 Feb, 8h

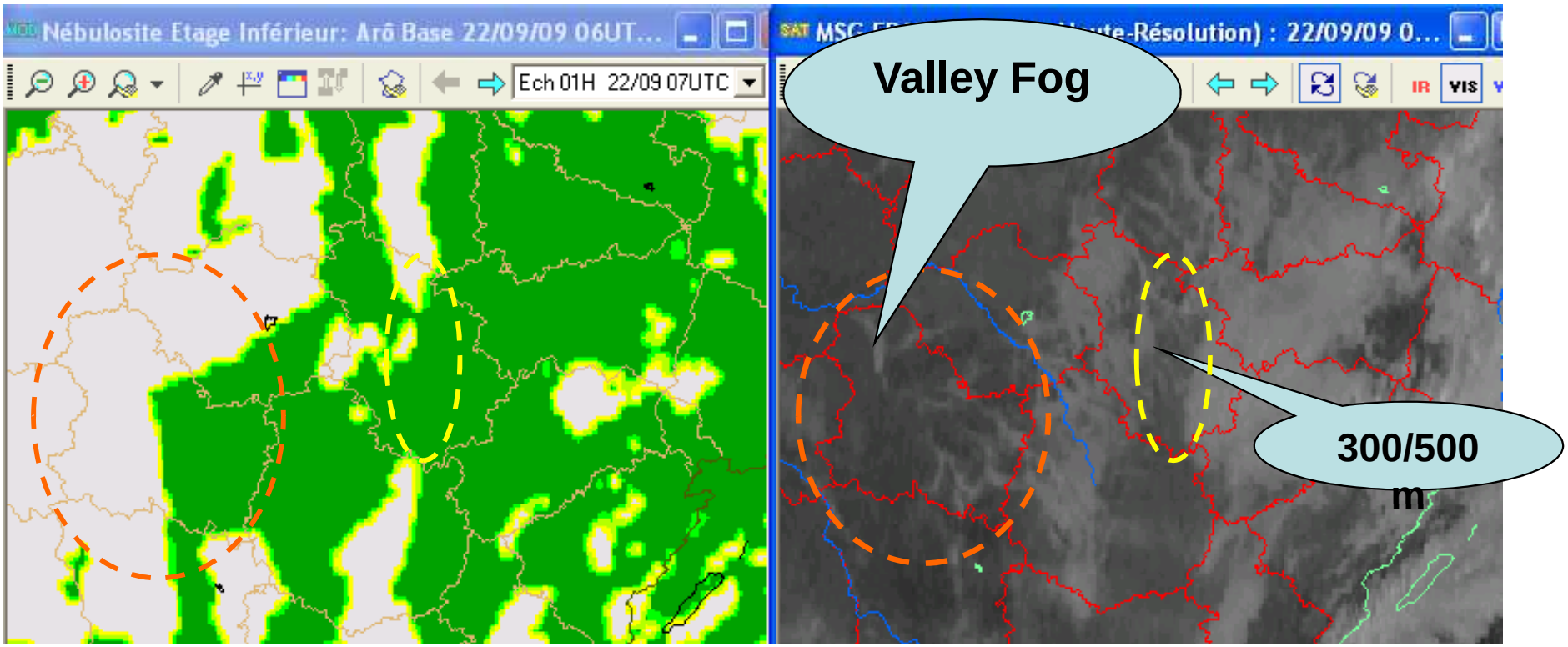


Fog
Base: 27 feb, 0h
Forecast : 27 Feb, 8h

- For regional fogs: AROME is correct
- Locally, sometimes too much fog, linked to too few dew

Fog : details

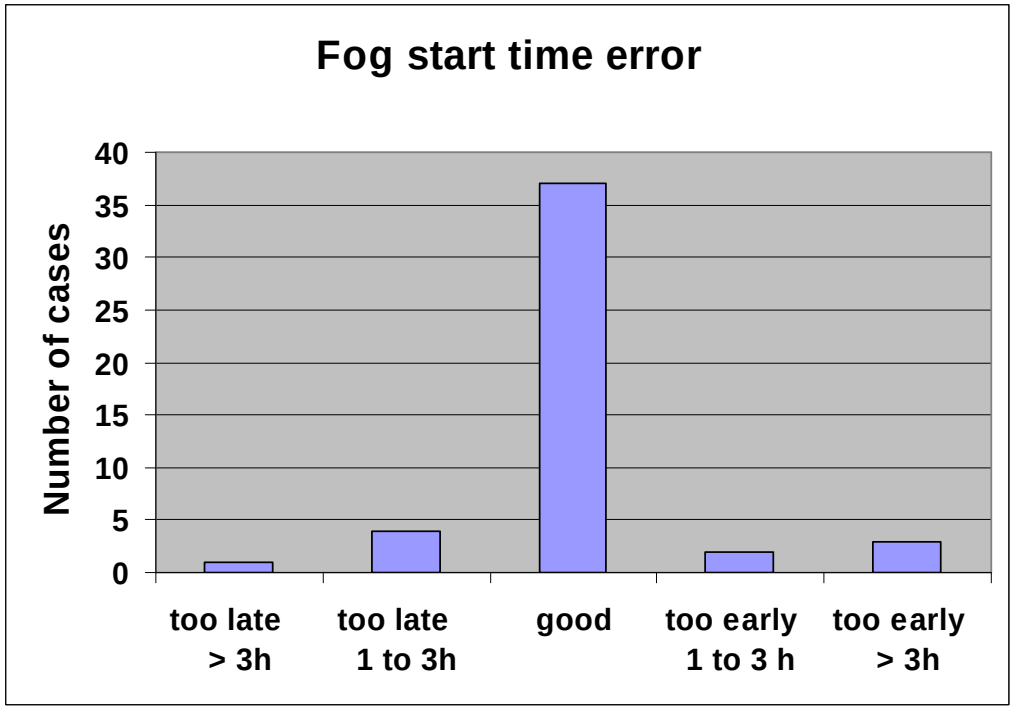
Orography & Fog

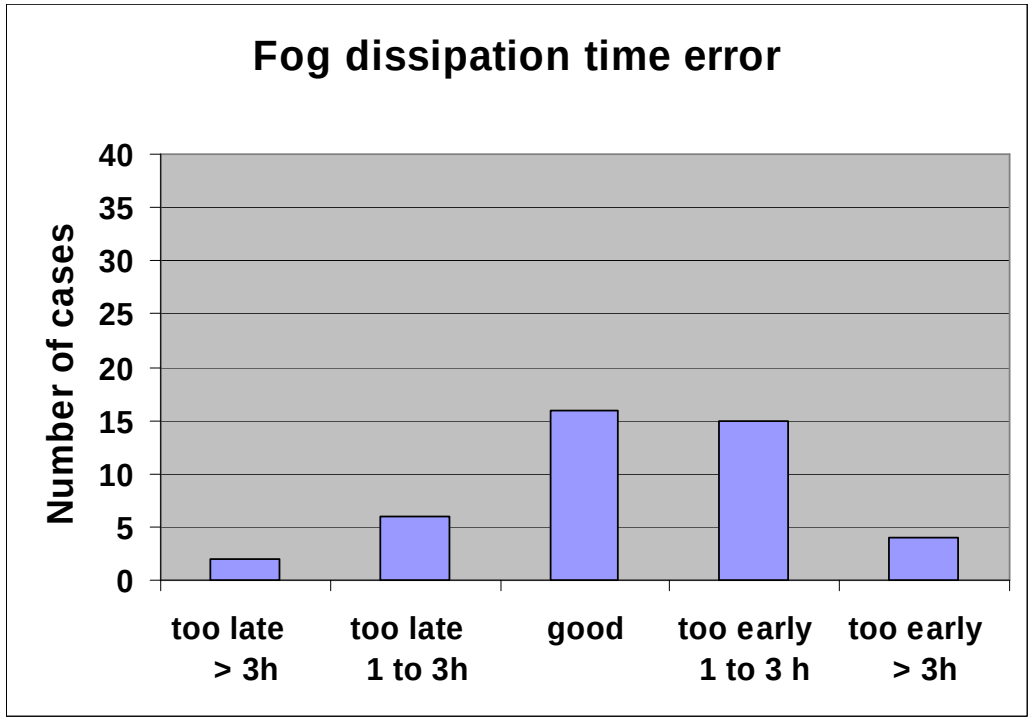


- Fog in small valleys is not correct yet
- A small hill (400m) seems not to behave logically : AROME puts fog on it while it should be clear

AROME : Forecasters' Point of View

Fog



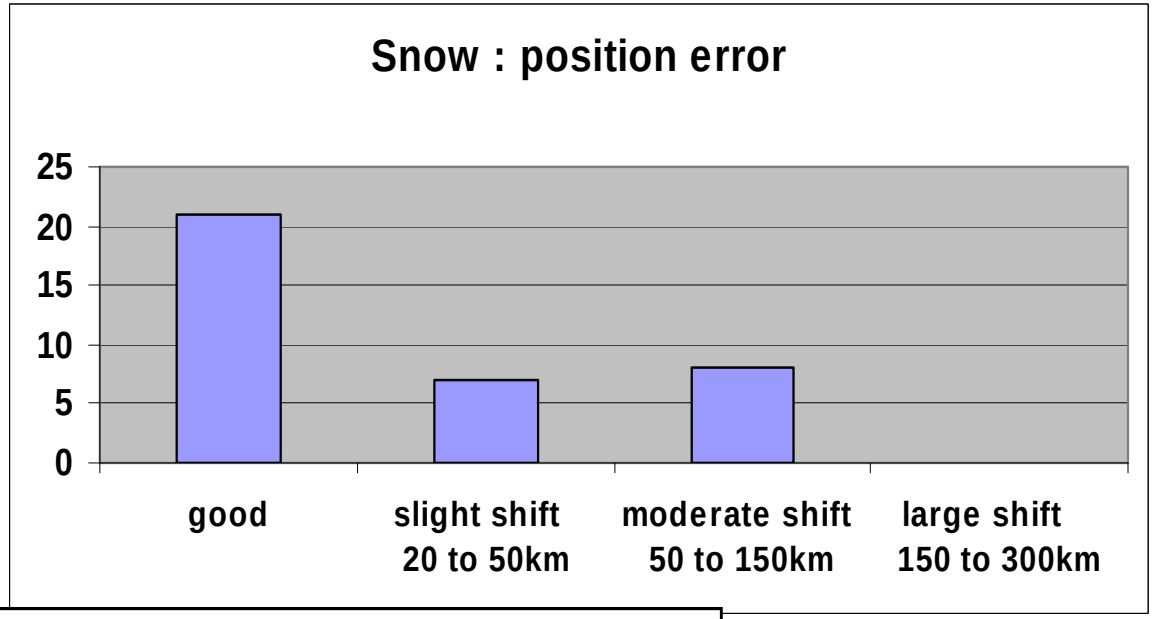


⇒ No bias for the fog formation

⇒ Tends to dissipates fogs too early

AROME : Forecasters' Point of View

Snow



⇒ Good localization 3 times over 5

⇒ Spatial extension :

⇒ Correct for 40% of the cases

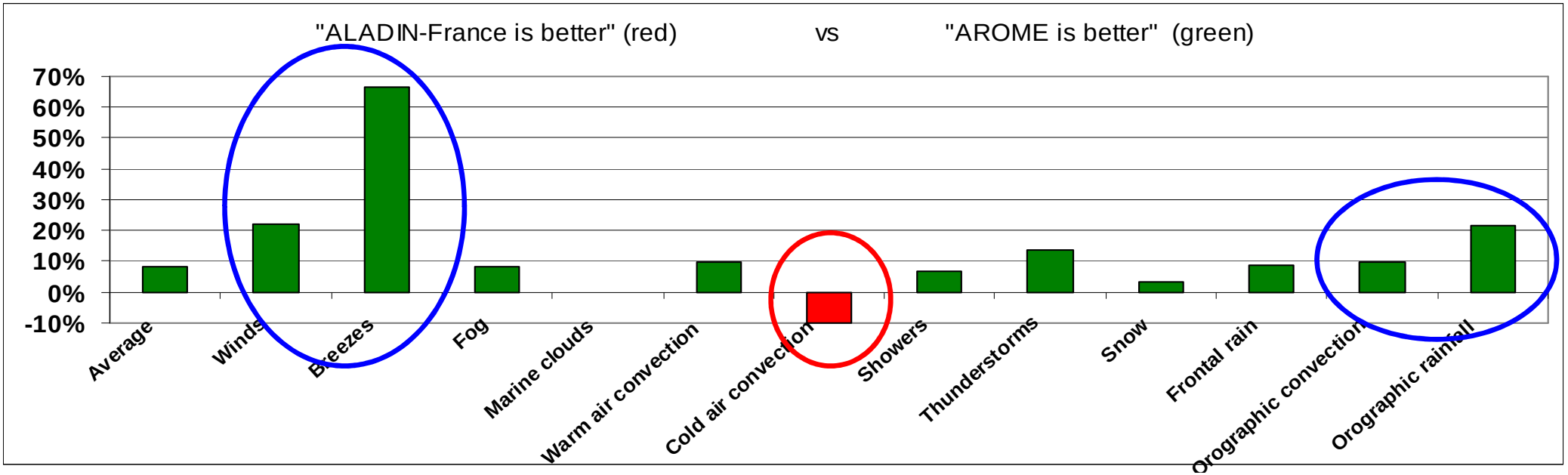
⇒ underestimated also for 40% of the cases

⇒ Intensity : slight overestimation for 40% of the cases, 33% of correct intensity

AROME : Forecasters' Point of View

Comparison between ALADIN-France and AROME

- Comparison a posteriori, for each type of meteorological situation



- AROME is globally better than ALADIN-France

AROME : Forecasters' Point of View

- Very Good behaviour
  - Deep convection on orography
- Good behaviour
  - Deep convection in general
  - Wind storms
- To be improved
  - Boundary layer clouds
  - Fog
- Specific comments:
  - Beware to « details » : for example a forecaster should not overinterpret the position of a single thunderstorm (if not linked to orography)
  - AROME is globally better than ALADIN-France

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- ARPEGE/ALADIN Physics : what's new in 2010 ?
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- AROME physics: what's new in 2010 ?
- Developments on cloud physics

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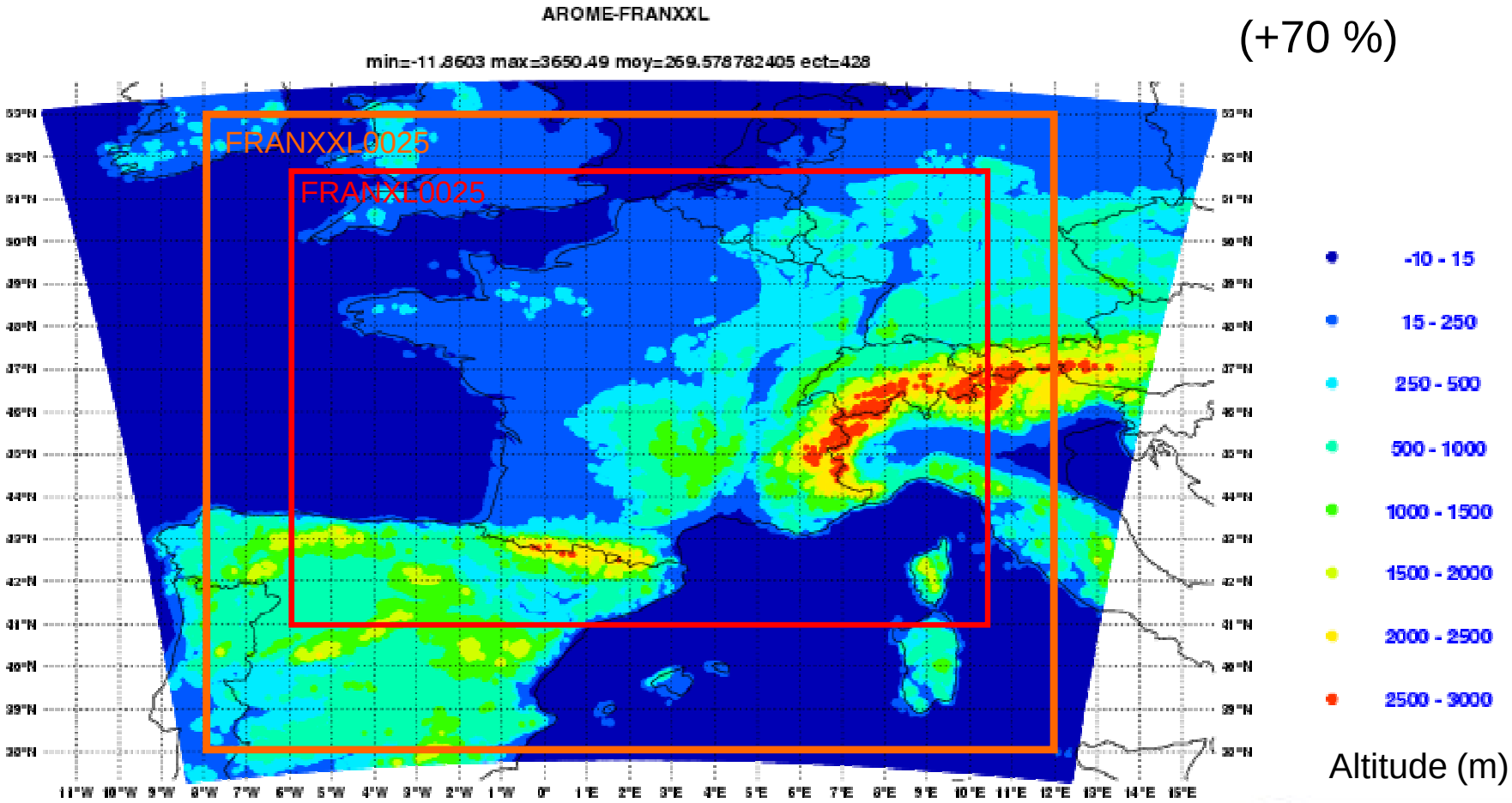
AROME France v3 domain

- As requested by our forecasters, and thanks to added processors on our NEC SX9 :

(will start this summer)

Domain 750x720 points

(+70 %)



Performances : cf Ryad's talk

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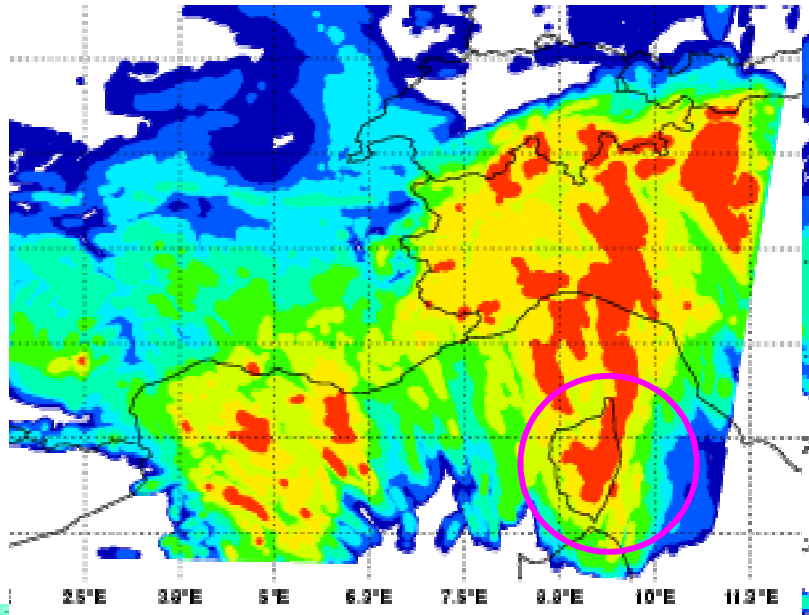
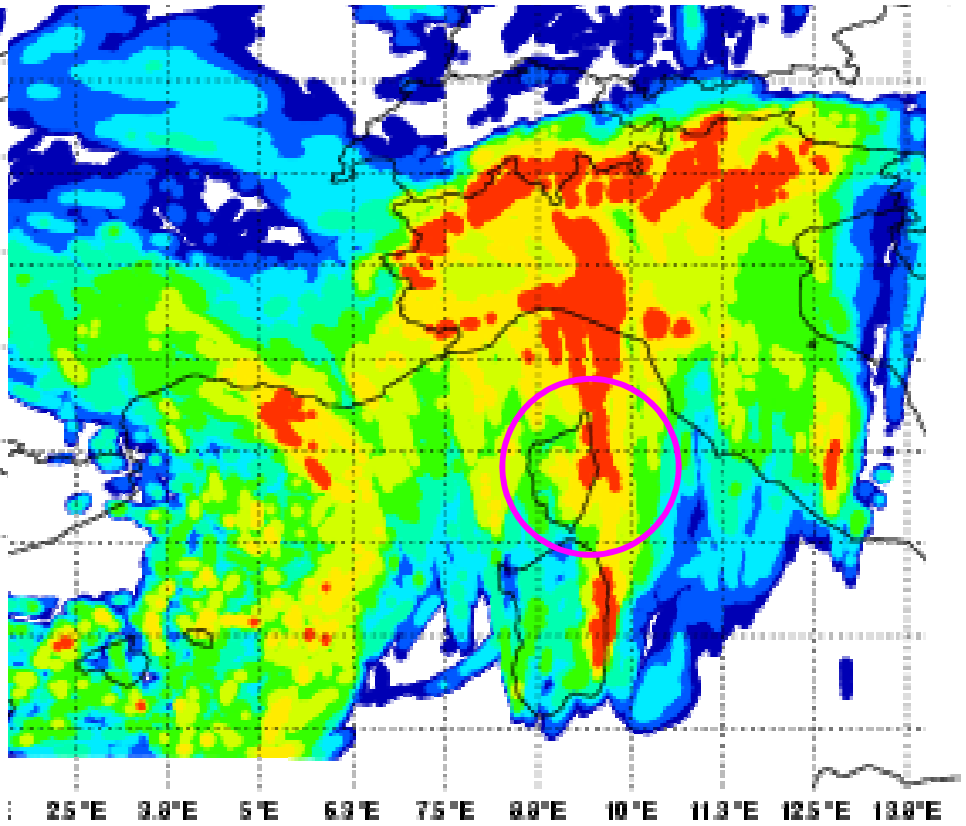
AROME France v3 domain

AROME-oper :

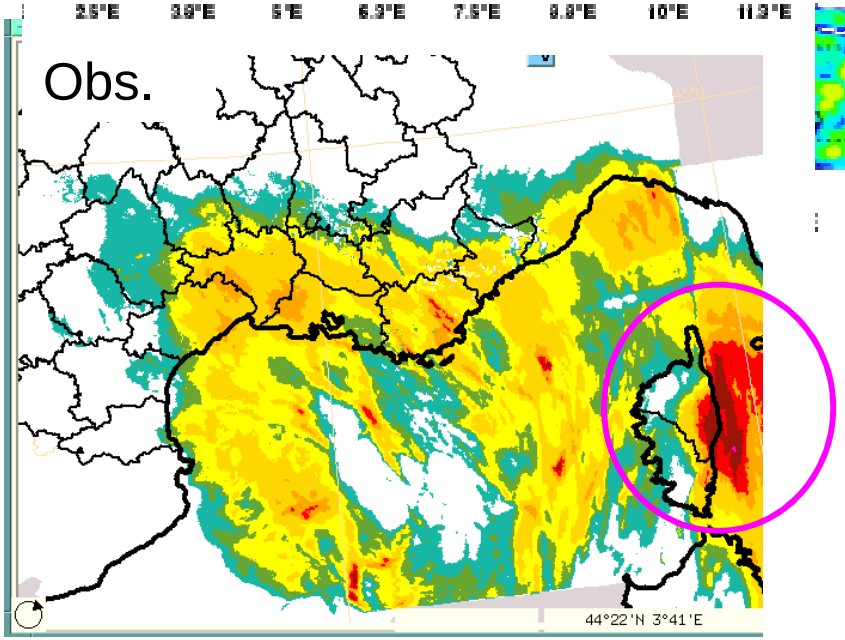


AROME-new domain :



F.Saix

- 1 - 3
- 3 - 7
- 7 - 15
- 15 - 30
- 30 - 50
- 50 - 75
- 75 - 200



24h Rainfall

The 4th Novembre 2009

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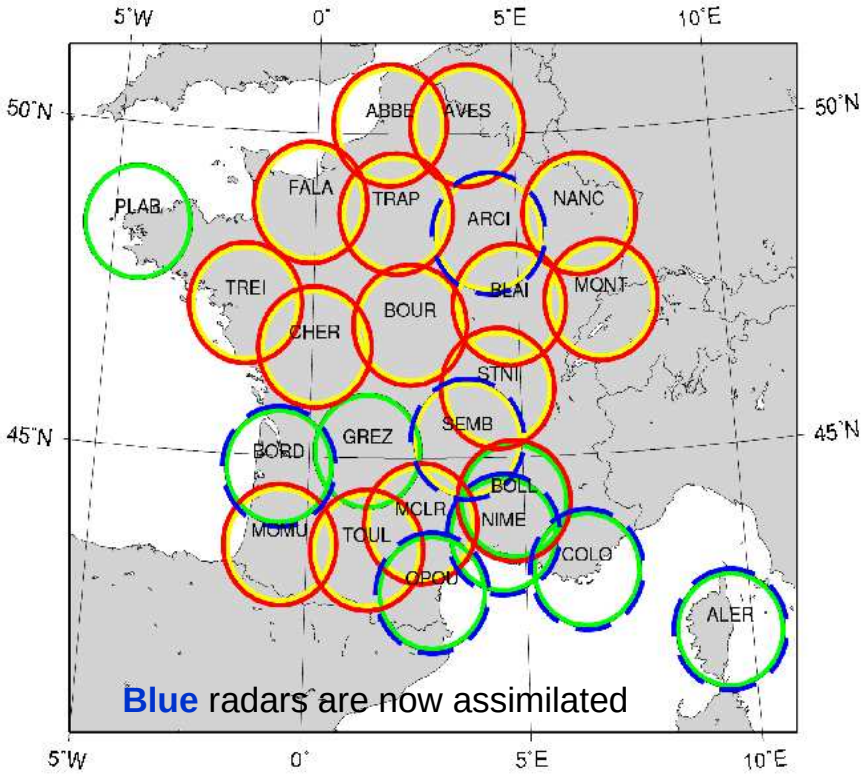
AROME France v3 content

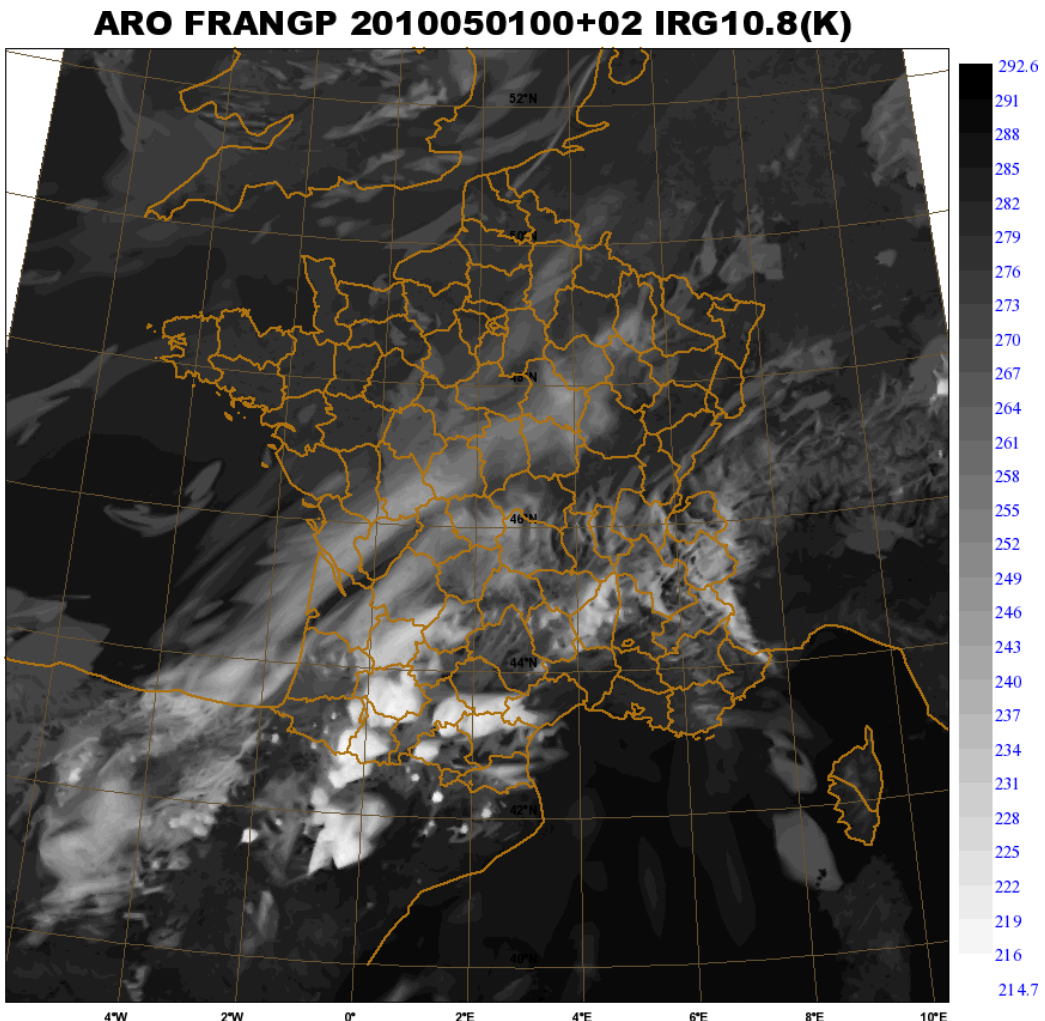
- Assimilation
  - Surfex surface analysis (cf talk J-F Mahfouf)
  - More data assimilated :
    - additionnal IASI and AIREP data,
    - 7 more wind doppler radars
    - Better assimilation of radar reflectivities

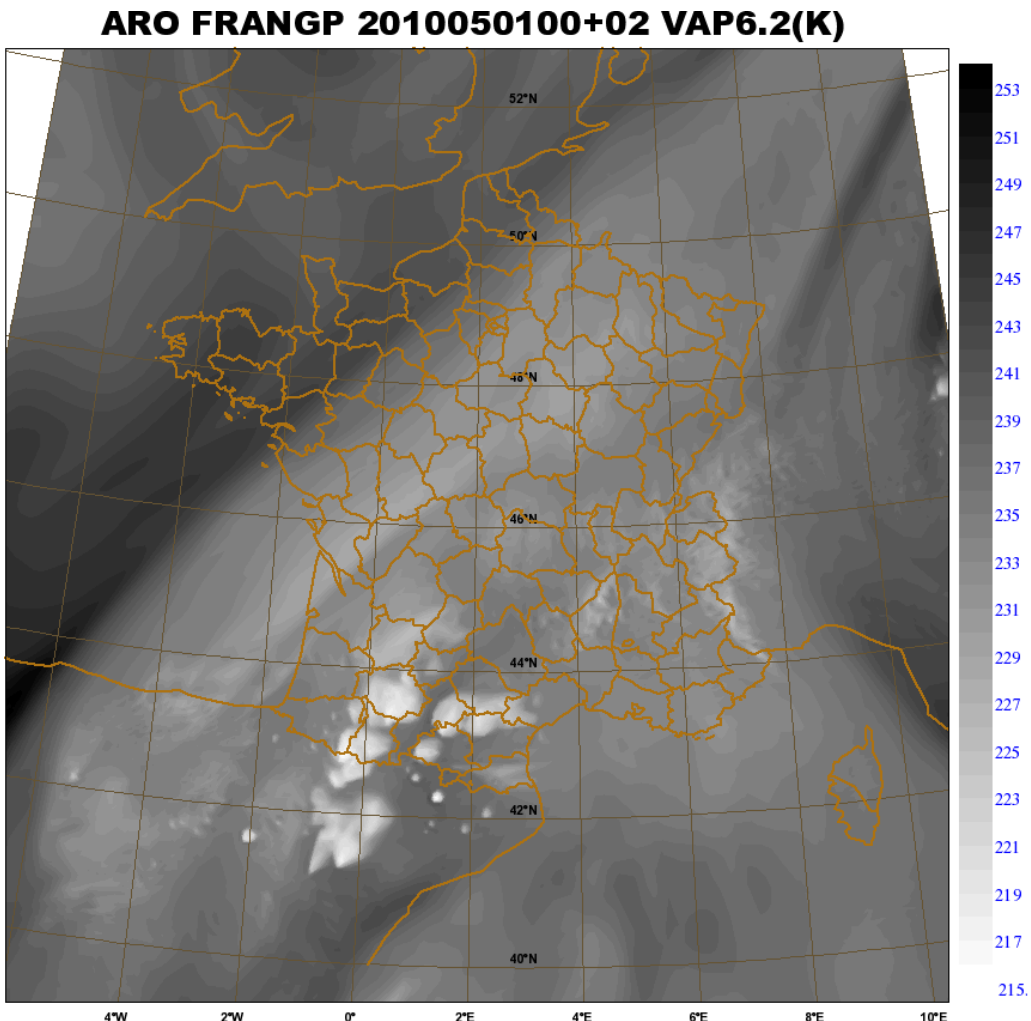
- New diagnostics (PBL height, modelled satellite imagery using RTTOV)
- Modifications of orographic roughness length
- Code optimisation (for our EDMF scheme)



AROME France v3 content : new diagnostics

- Brightness temperature (IR 10.8 µm channel)
- Water vapor (WV 6.2 µm channel)

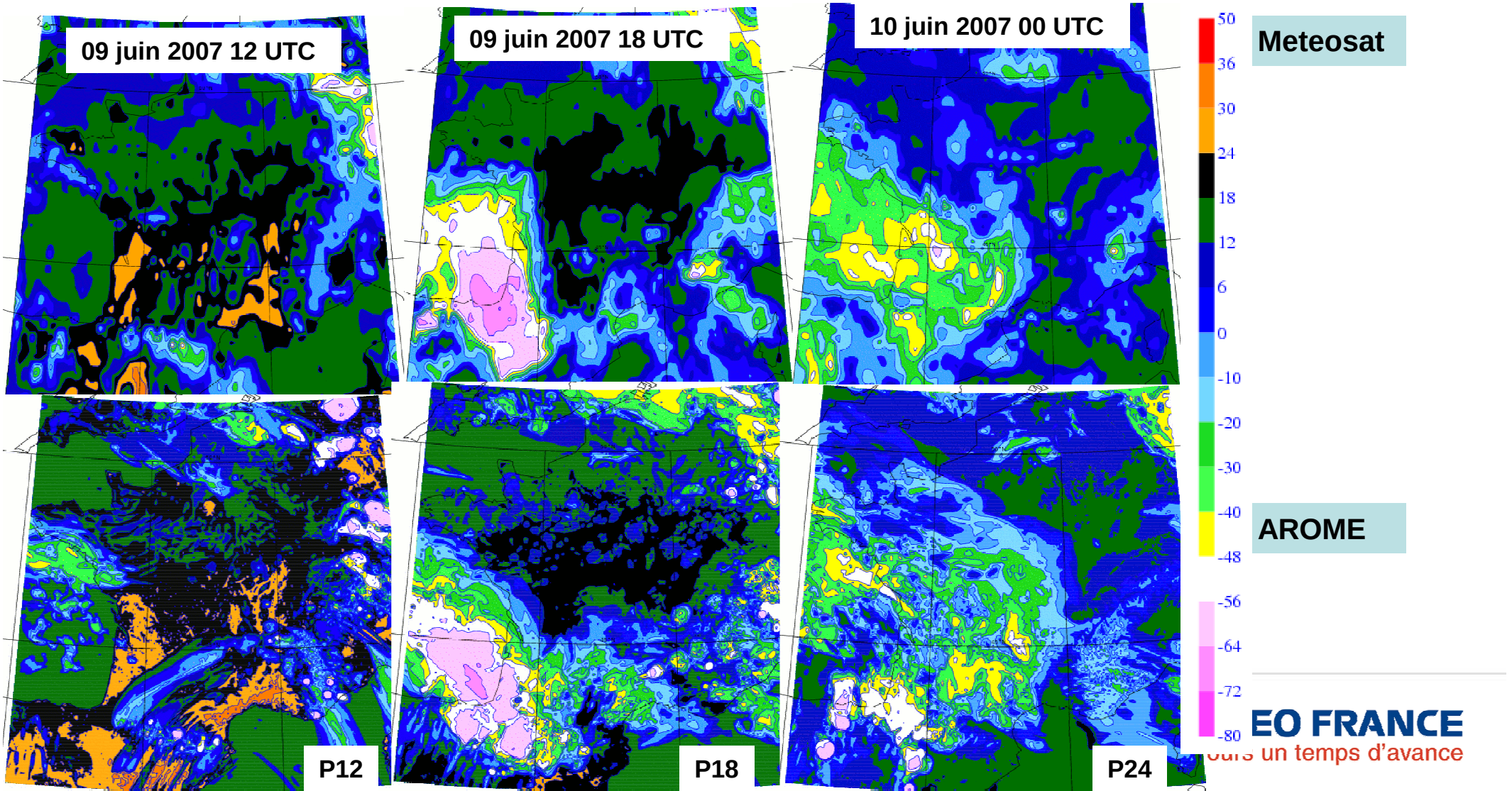




AROME France v3 content : new diagnostics

- These diagnostics are used during the forecast

(e.g. to follow a cloud system, as here over the SW of France)

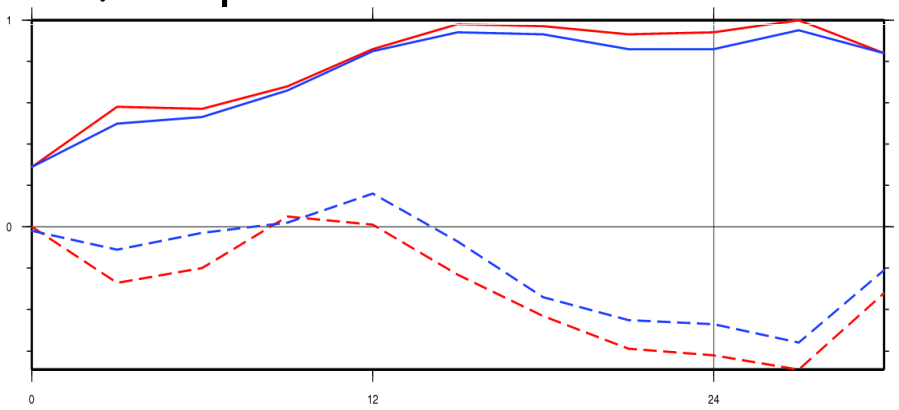


AROME France v3 scores

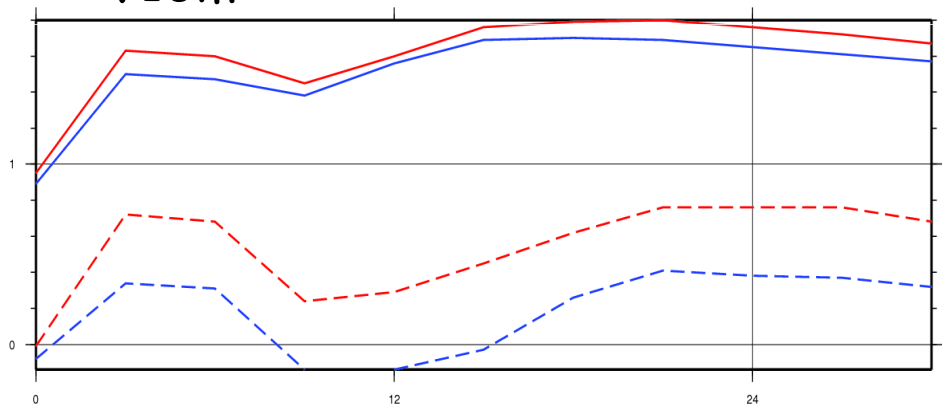
Surface scores (from 20 August to 13 September 2010) : AROME_v2, AROME_v3

—RMSE – – Bias

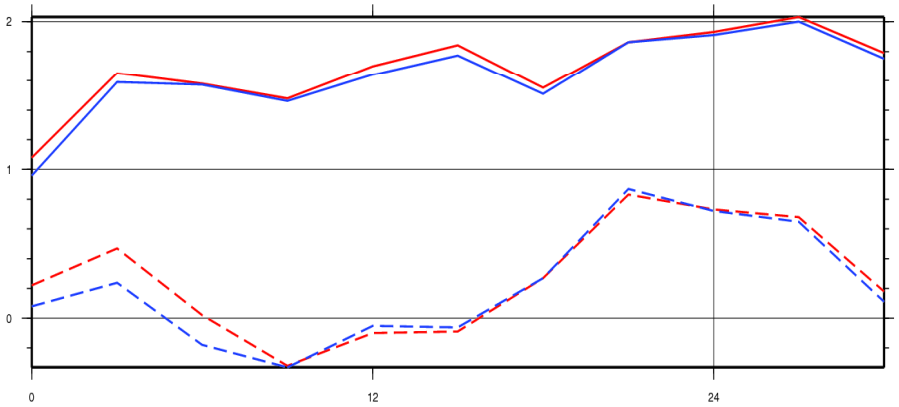
Surface pressure :



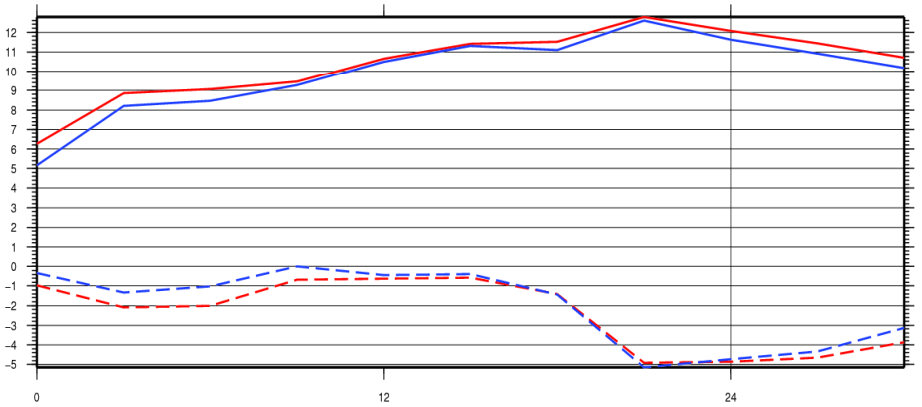
V10m :



T2m :



Hu2m :



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- AROME : forecasters' point of view after 2 years
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- Developments on cloud physics
  - Hail
  - Boundary layer clouds

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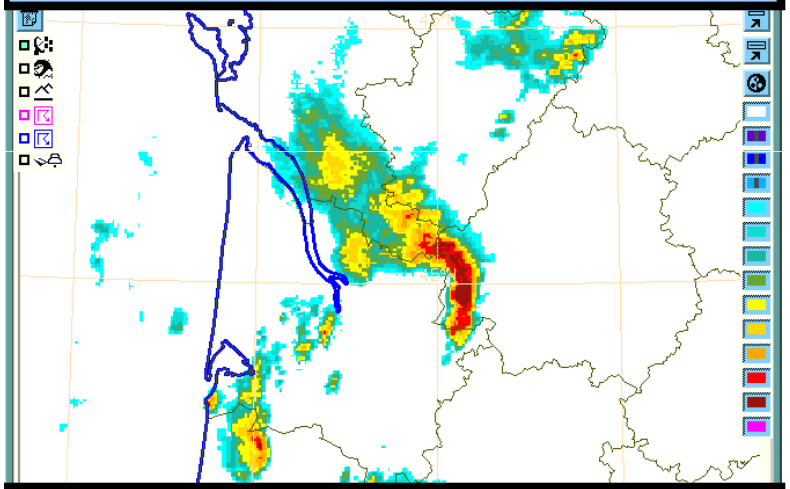
Hail: case of the 13 May 2010

OBSERVATIONS :

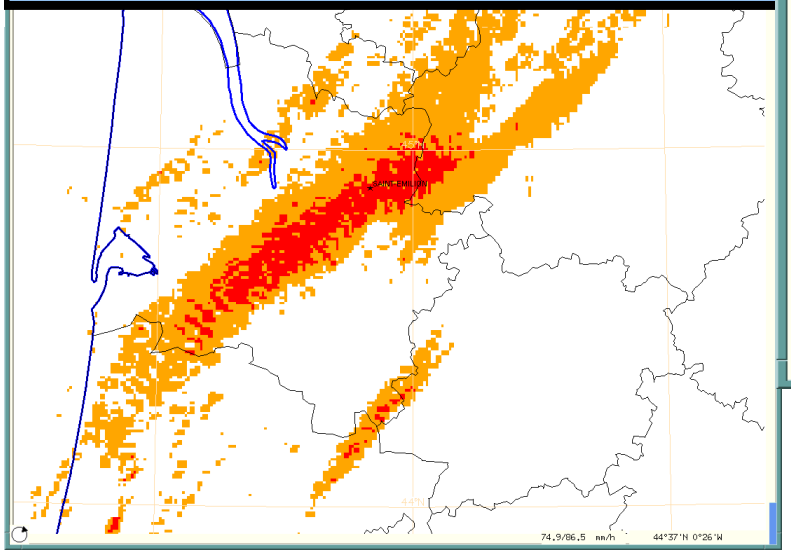
Observation (reflectivity at 2h30 UTC)



Hail risk (from radar)

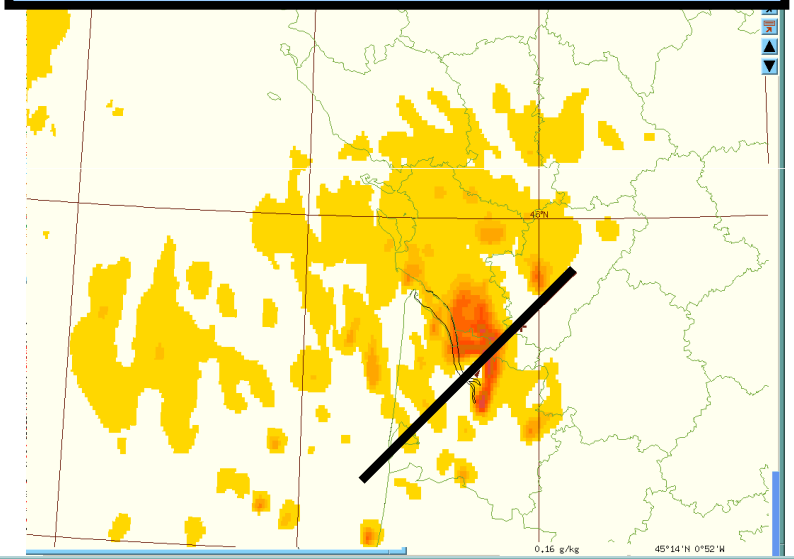
Orange : hail probable

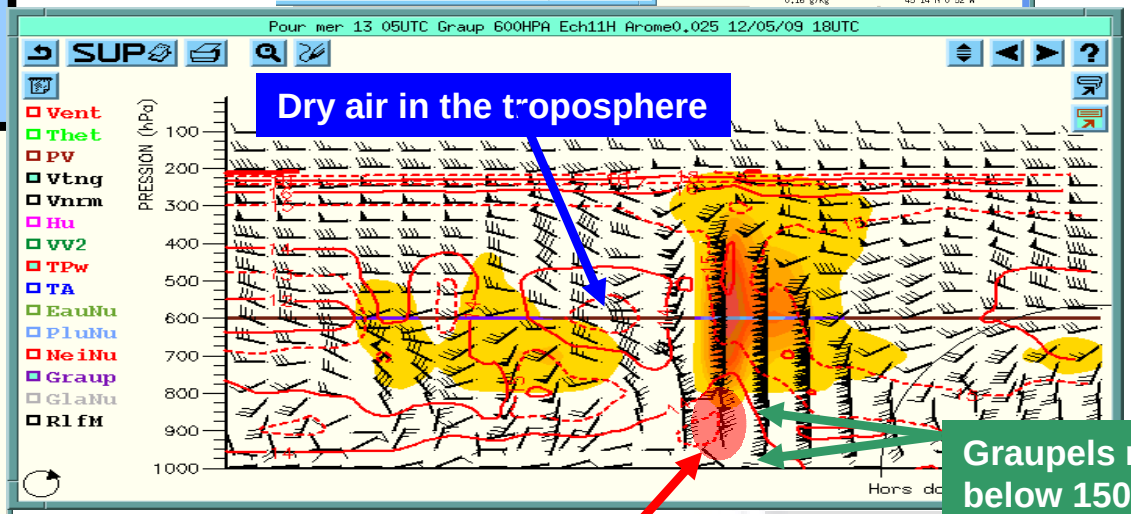
Rouge : strong hail probable



AROME-oper :

Graupels at 600hPa at 5UTC (r18)





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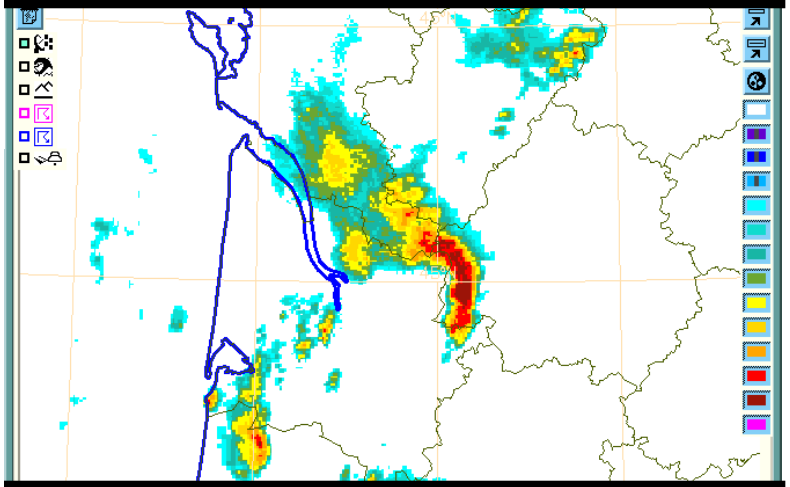
Hail: case of the 13 May 2010

OBSERVATIONS :

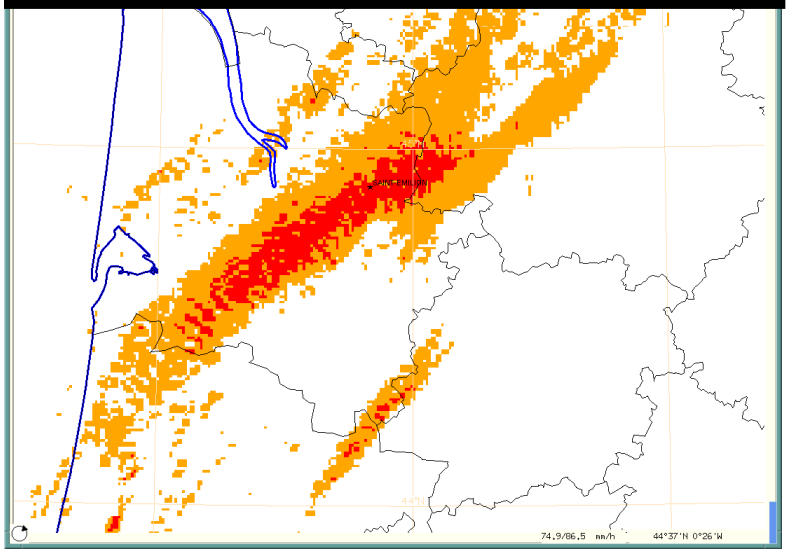
Observation (reflectivity at 2h30 UTC)



Hail risk (from radar)

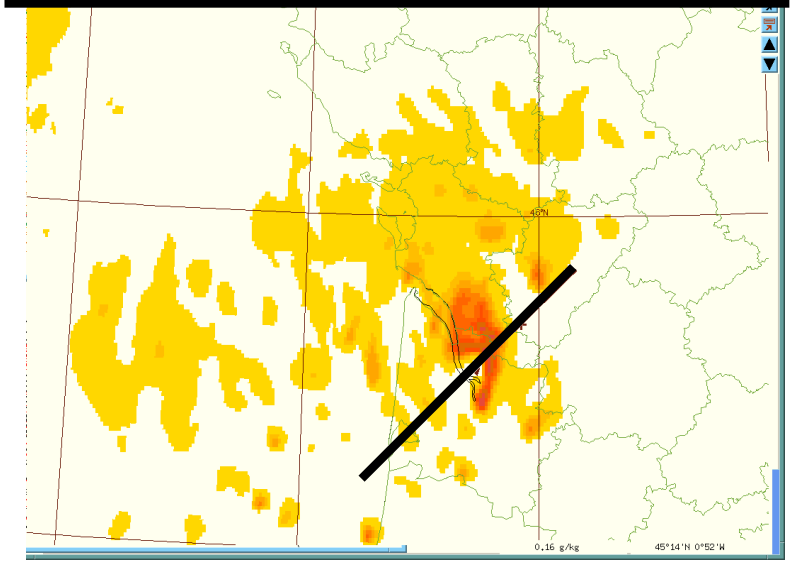
Orange : hail probable

Rouge : strong hail probable

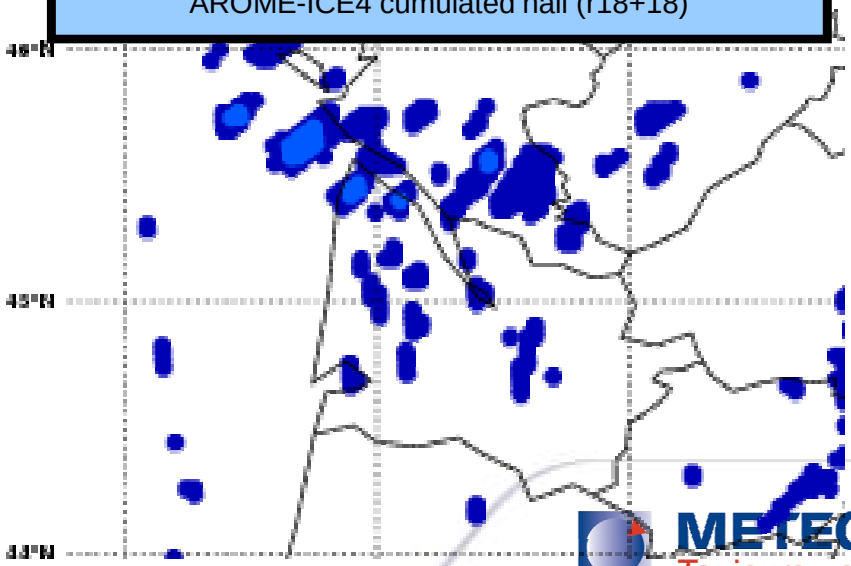


AROME-oper :

Graupels at 600hPa at 5UTC (r18)



AROME-ICE4 cumulated hail (r18+18)



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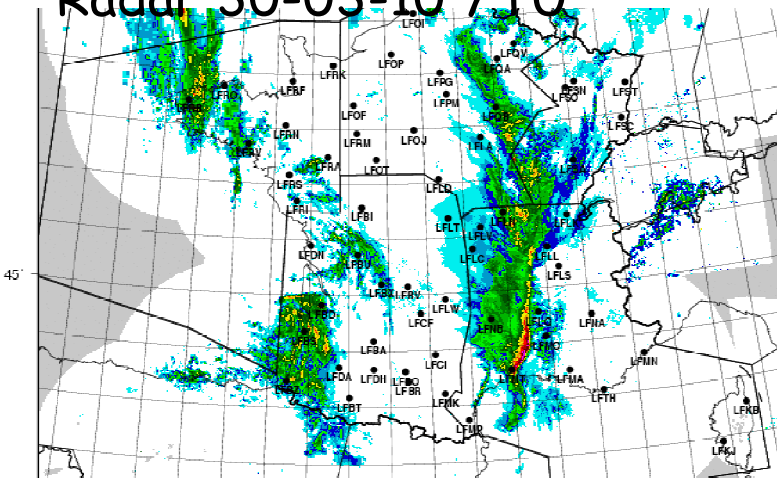
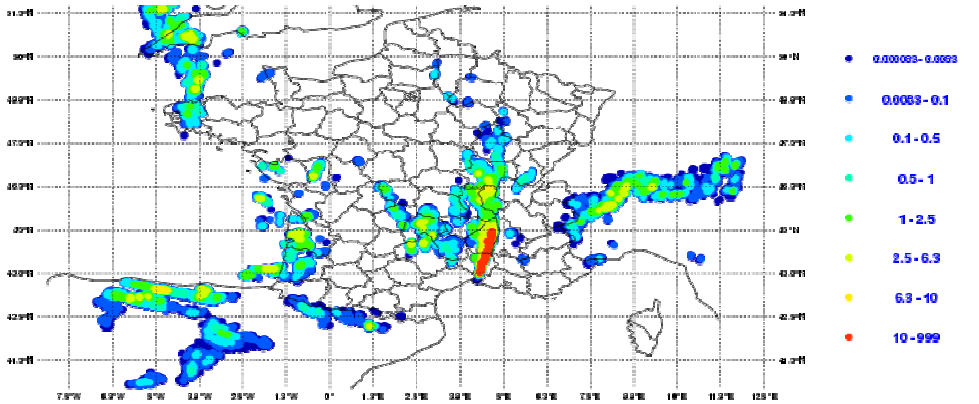
But… the 30 march 2010 case

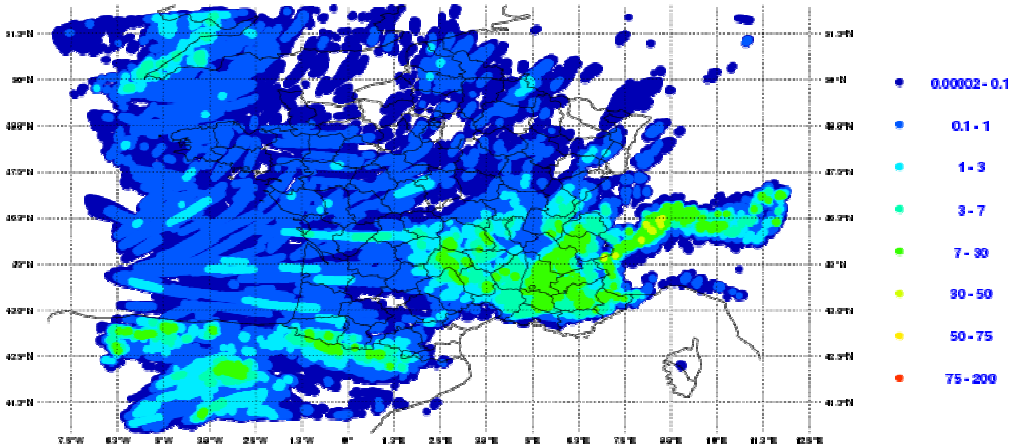
Radar 30-03-10 7TU



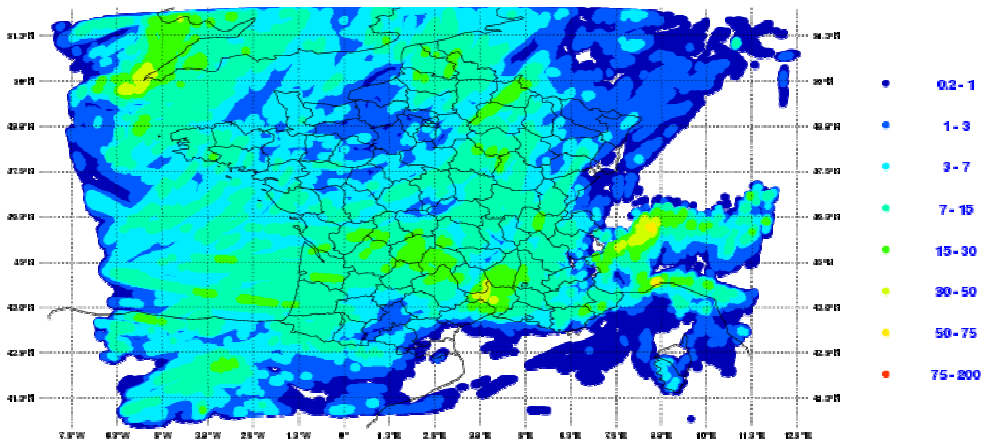
AROME-ICE4 inst. surface hail 30-03-10 7TU



Cumulated hail 30-03-10 12 TU



Cumulated rain 30-03-10 12 TU



- Tendency to over-estimate the occurrence of hail (especially small values)
- Therefore, prognostic hail is still a long-term development
- First step : building a diagnostic for hail

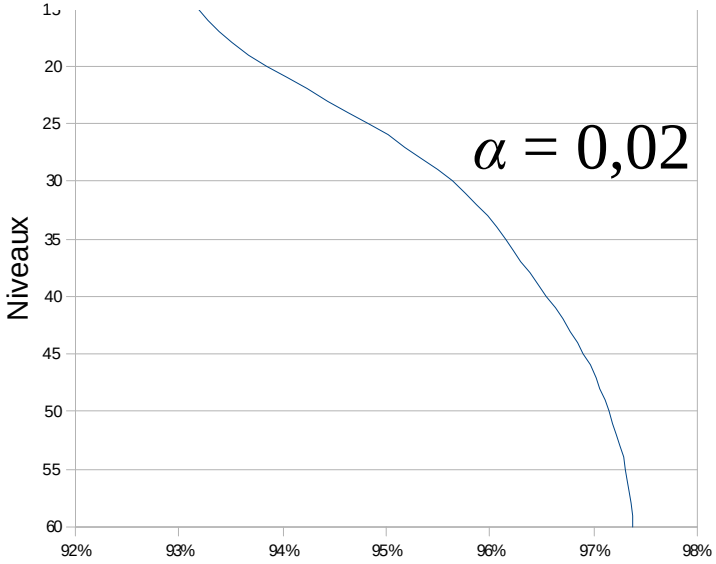
Low clouds variability

- Several scales of variability and processes for boundary layer clouds:
  - Turbulent motions (parameterized with ED schemes)
  - Shallow cumulus forces by BL thermals (with MassFlux scheme)
  - Mesoscale variability (e.g. gravity waves, humidity heterogeneity in nocturnal & residual boundary layer, orography, residual clouds from previous convection, etc…)

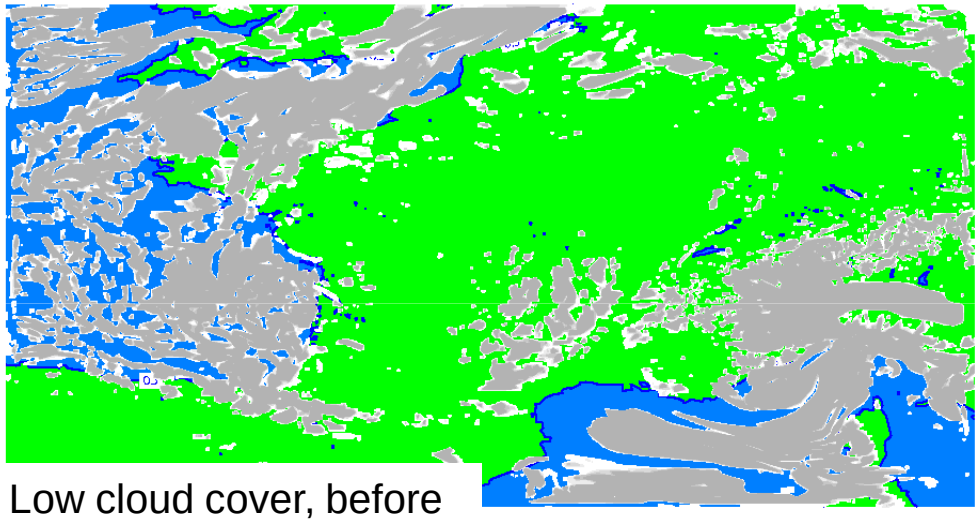
- Wim de Rooy formulae used for mesoscale cloud variability
  - The statistical cloud scheme uses: $Q = \frac{q_t - q_{sat}}{\sigma_s}$
  - IT condensates for : $Q > Q_c$
  - If $\sigma_s = \alpha \times q_{sat}$
  - One will have condensation for :

$$Hu > Hu_c = Q_c \times \alpha + 1$$

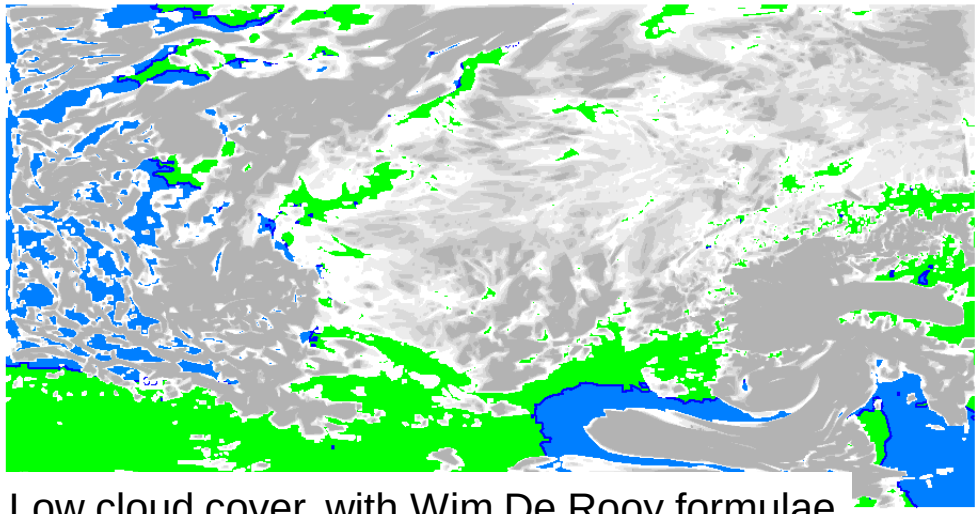
Critical saturation humidity



10th January 2010

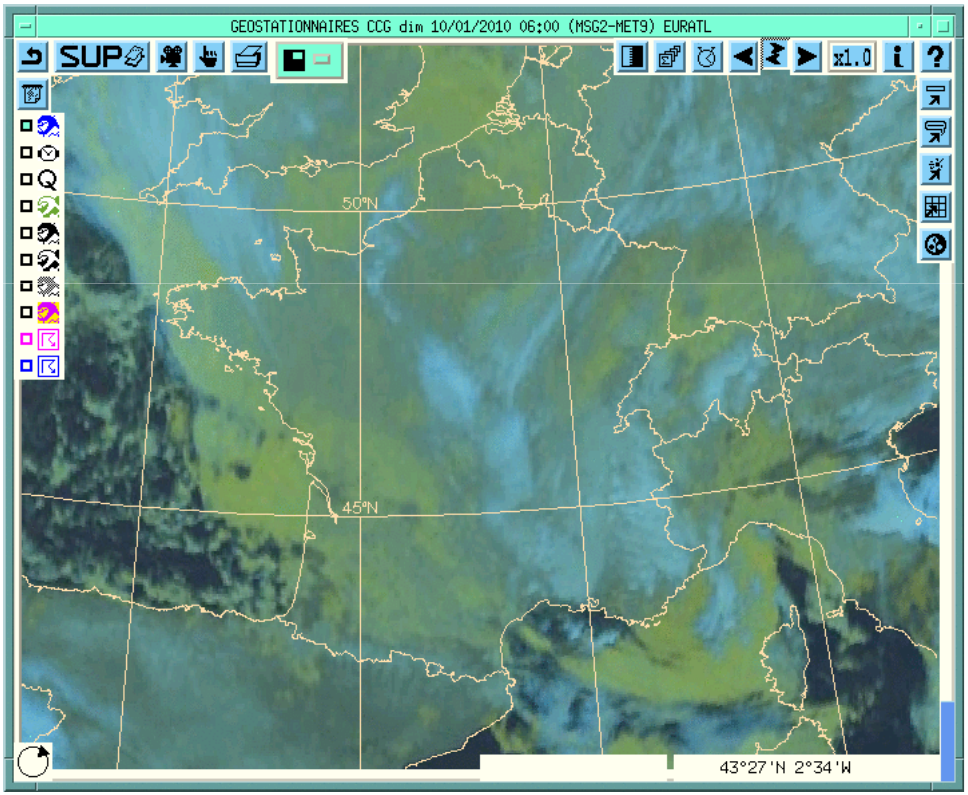


Low cloud cover, before



Low cloud cover, with Wim De Rooy formulae

1.5
0.8
0.6
0.4
0.2
0



Partial cloud cover is much better,
Even if some clouds are still missing near the coasts

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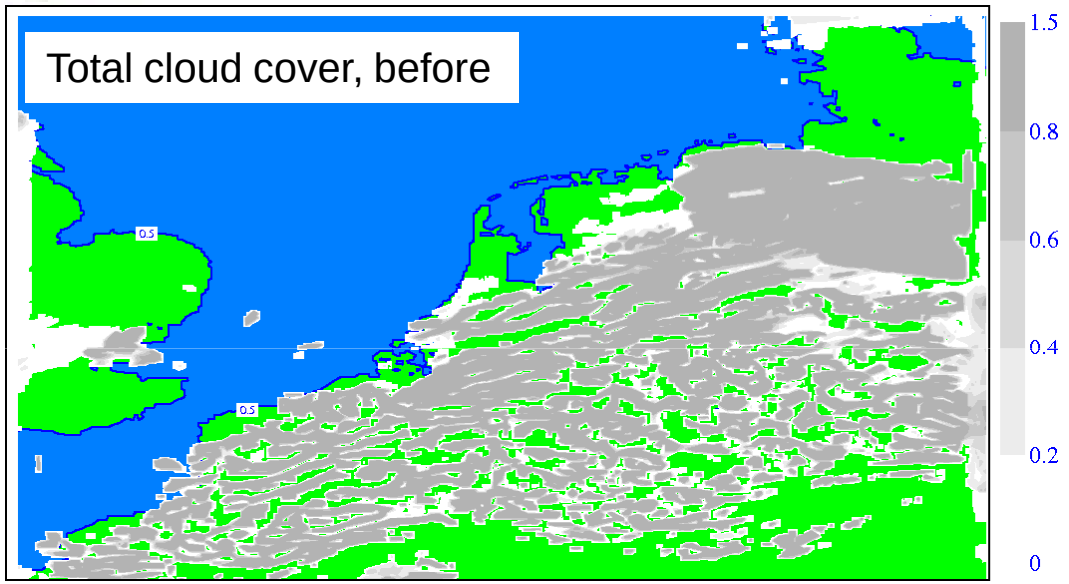
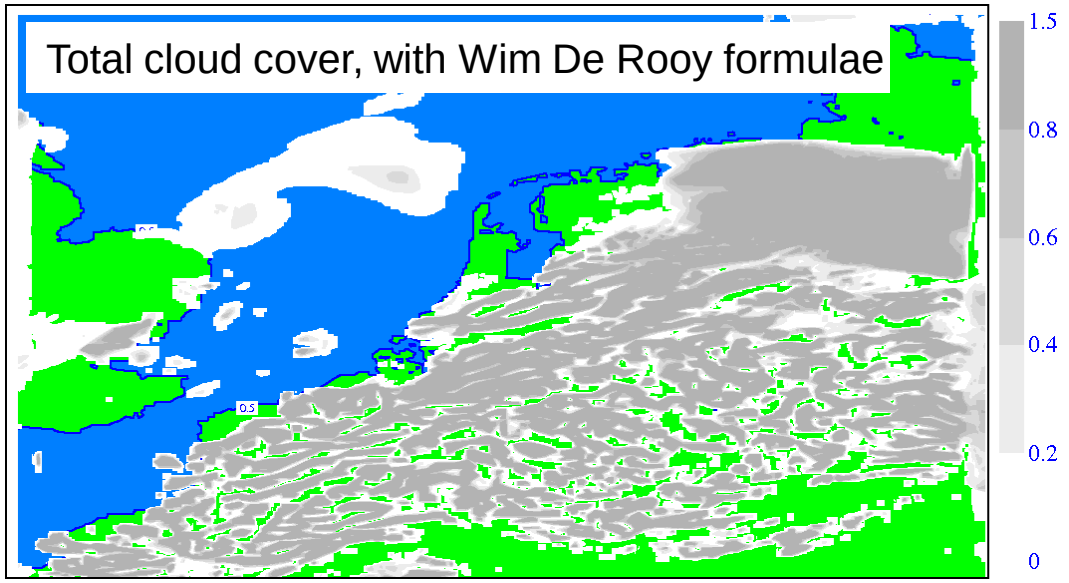
13th May 2008





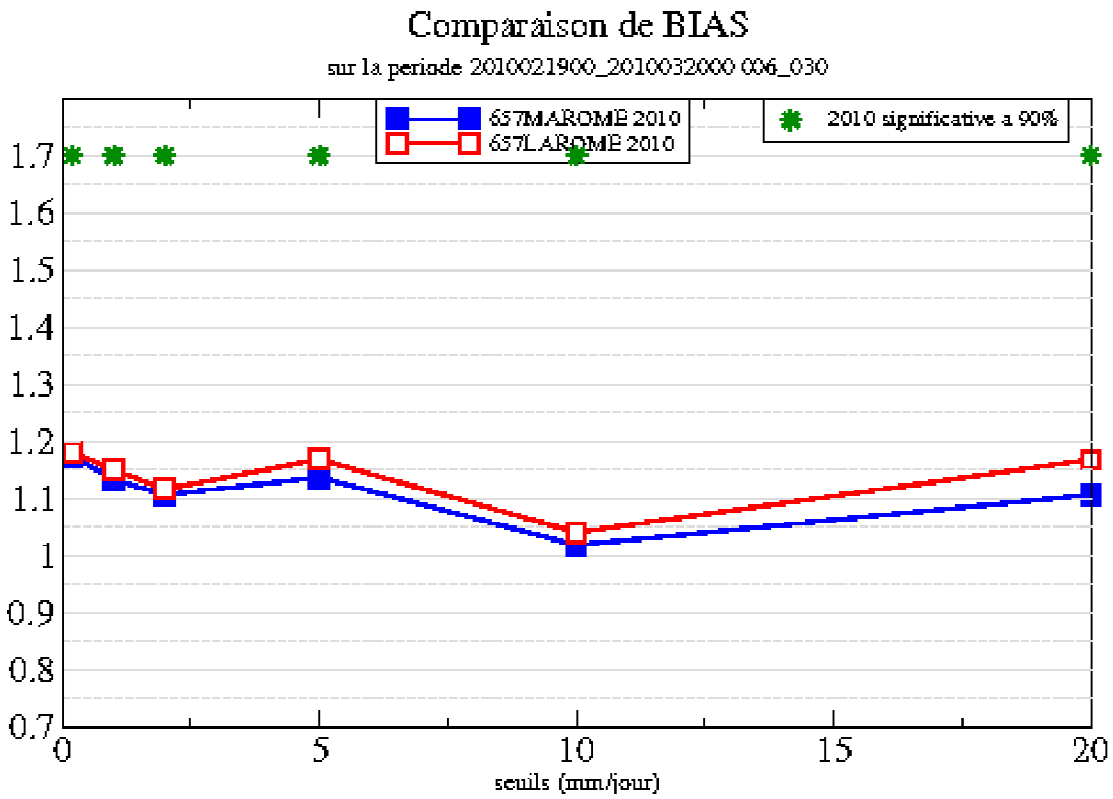
- The modifications allow to add clouds where they were the most missing
- Still too large cloud fractions for the shallow cumulus in the South

Impact on precipitations

- Precipitation improved significantly for all rainrates

Réference

New (Wim de Roy formulae)



Perspectives

- To continue the evaluation of the Wim De Rooy term
- Improve cumulus scheme :
  - 2 New detrainment/entrainment (Wim De Rooy and Rio et al.) in clouds in our MassFlux scheme
  - New statistical cloud scheme (explicitely separating cumulus contribution)
- To validate the AROME clouds modifications against :
  - Surface downwards solar radiation
  - Cloud experiments databases
  - Satellite images

Conclusions

- ARPEGE/ALADIN Physics are now more similar to AROME's:
  - Same radiation and turbulence
  - Still some differences on shallow convection, surface, microphysics
  - Next step : test of the AROME's EDMF approach

- AROME is better than ALADIN-France
  - Better rainfall : explicit deep convection
  - Better resolution → improved mesoscale processes (winds, breezes, fog)

- New Developments on cloud physics
  - Hail diagnostics
  - Boundary layer clouds

The end

Thanks

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