AROME current status and plans

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Many contributors…

Summary of Arome tests

- **Various AROME test versions have run for over 2 years now, as daily runs and offline runs, in many HIRLAM and ALADIN countries.**
- **Tests quickly showed interesting new details in the simulations: orographic adaptation, fog & low clouds, urban heat islands, organized convective structures... plus a few excellent forecast cases**
- **But detailed evaluation (objective scores & forecaster evaluation) only recently available, and showed some performance problems.**
  - **errors in the diagnostics themselves: cf. bugfixes & Canopy scheme**
  - **precipitation biases and the "fireworks" (explosive convection) model problem**
  - **I/O and scalability issues on some computer platforms**
  - **specific physical issues (valleys, subgrid convection, lateral boundary conditions...)**
  - **issues with coupling and data assimilation in many centres (e.g. soil moisture)**

Highlights of AROME development (1/2)

- **Long-term research on subgrid shallow convection, with several improvements of the KFB scheme (now called EDKF); cooperation with KNMI (among others). Recently proved to cure unrealistic low-level wind organization ("herringbone pattern").**
- **Development of a new DDH-like diagnostic mechanism, to facilitate study & intercomparison of the physics.**
- **Much work on SURFEX and the postprocessing, to improve performance and functionality (e.g. parallelisation, I/O, diagnostic fields for NWP applications). Mostly on the surface interface ("SURFEX") and the physiography preparation and coupling.**
- **Important testing & optimisation of the dynamics: deactivation of the predictor-corrector and SLHD options, retuning of the horizontal diffusion**
- **Studies of the lateral boundary coupling showed (sometimes big) sensitivity to its formulation, main plan is to smooth the orography mismatch at the edges. No easy big improvement to the LBC algorithm**

Highlights of AROME development (2/2)

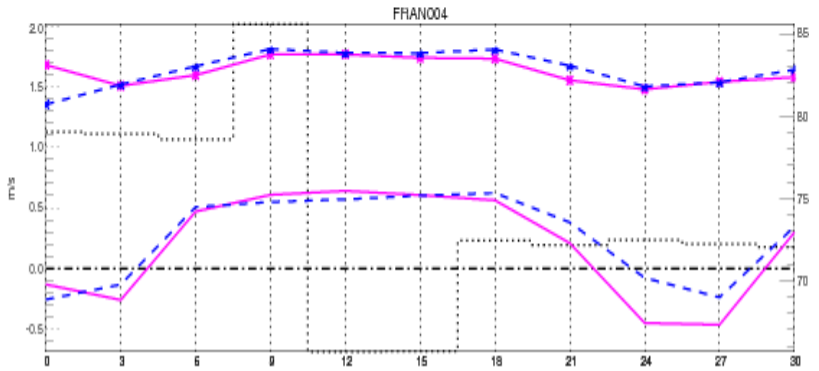
- **Data assimilation works since summer 2007, it showed small but interesting benefits (e.g. hydrometeors spinup), it is a first step for other big developments**
- **Radar data assimilation required enormous technical work, the radar doppler winds are very useful to forecast convective cases: ok for MF operations. Radar reflectivity assimilation has been tested, but not yet reliable enough for operations.**
- **Long-term work on Arome/sea coupling: research on the ocean/atm interaction, and improved flux parametrisation (Ecume scheme)**
- **The model efficiency has improved thanks to the development of a PDF-based microphysics sedimentation scheme.**

Model performance : low-level scores

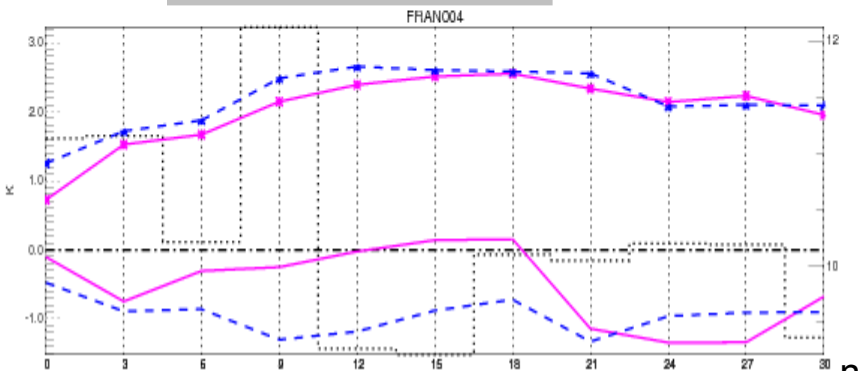
- **Objective scores of AROME-France using French automatic surface obs network (hourly data every ~30km)**
- **Beats ALADIN-France in most respects**

Scores over France for 5-18 February 2008 **(Arome in pink Aladin in blue)**

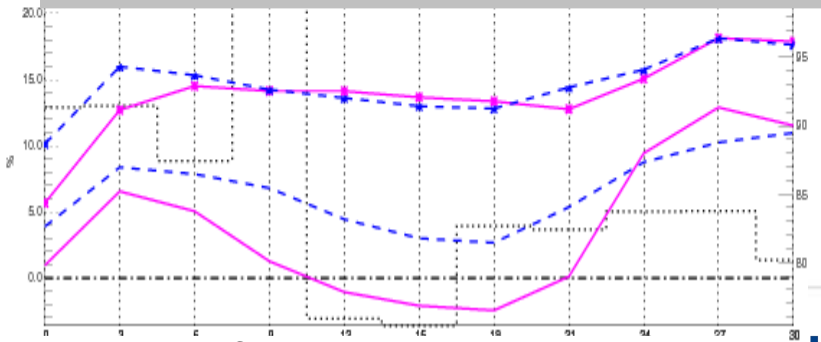
10m windspeed



2m Temperature



2m Humidity



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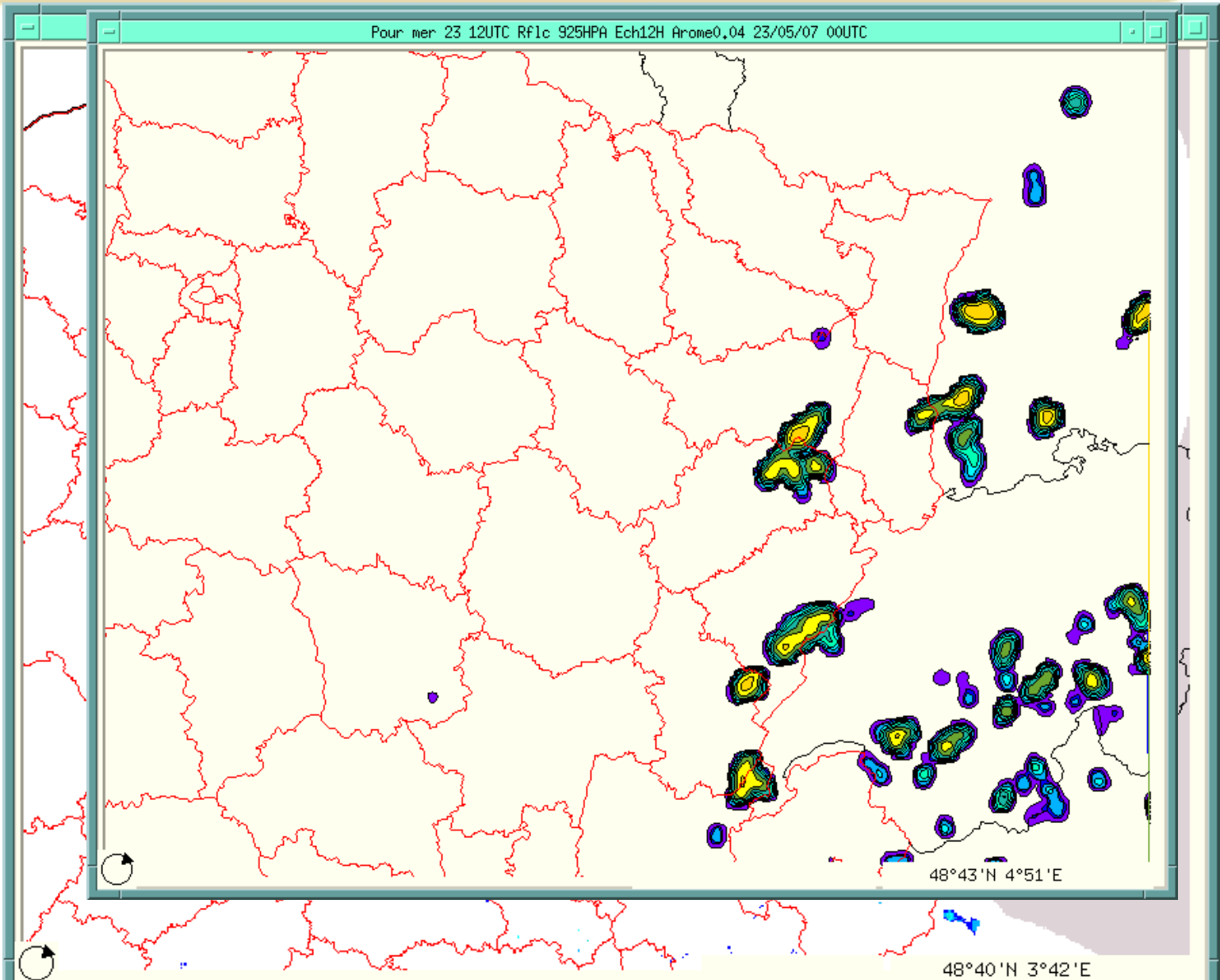
Diurnal convection triggering

Obs radar



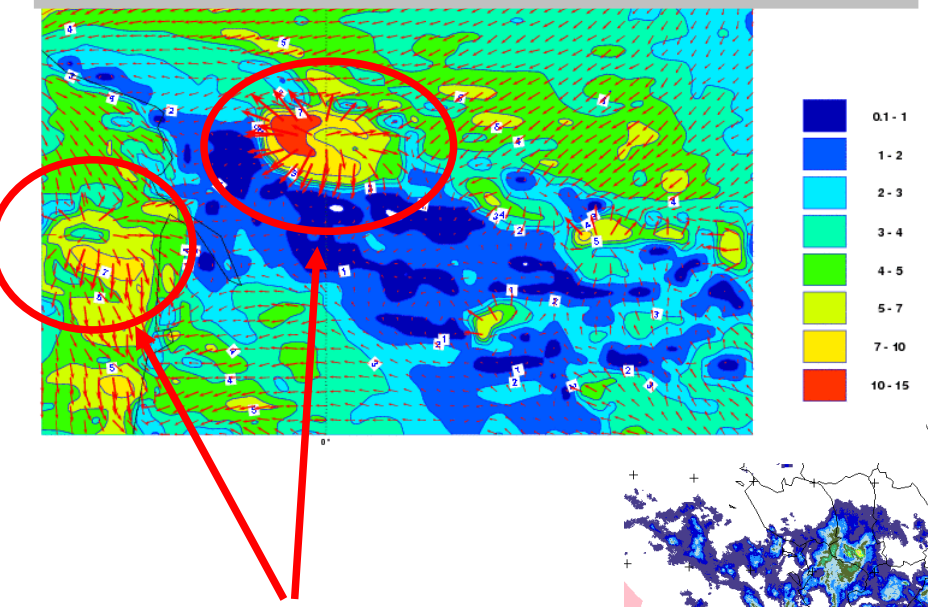
2. Recent improvements of modelling aspects

- Tuning of numerical diffusion for mesoscale
- Shallow convection scheme
- A scheme for the canopy (improve PBL diagnosis)

The "fireworks" problem

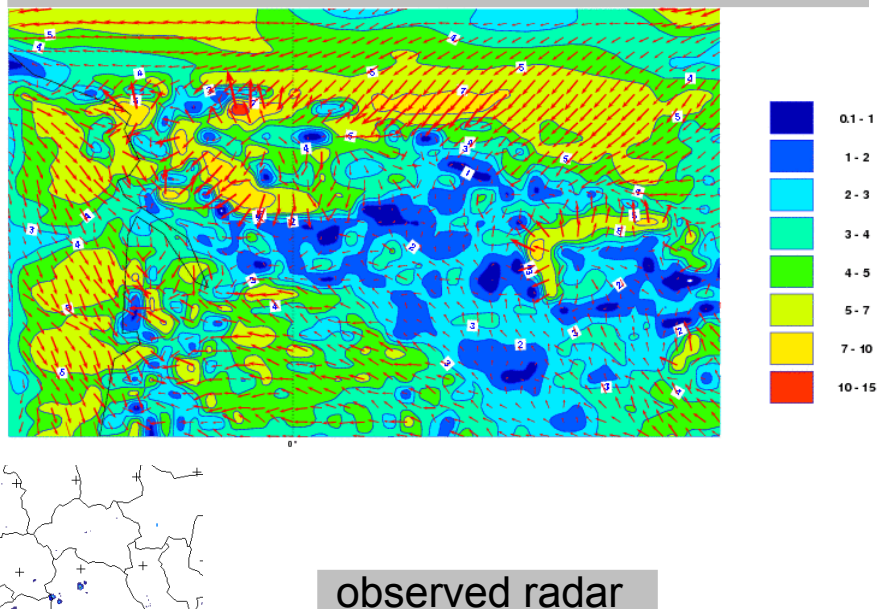
- **"fireworks": overactive thunderstorms with strong cooling and divergent wind underneath, sometimes organised as violent squall lines:**
  - **very detrimental to all AROME evaluations until end 2007**
  - **mostly solved by a recalibration (reduction) of horizontal diffusion (MF, Oct 07)**
  - **some tuning may still be needed on diffusion & microphysics**

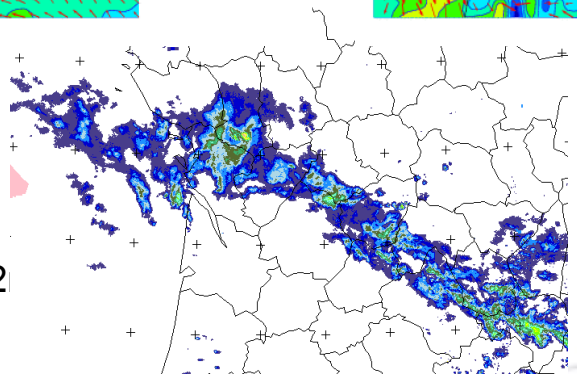
Arome low-level wind under a thunderstorm, using summer 2007 setup



'fireworks'

with new diffusion tuning





observed radar precip

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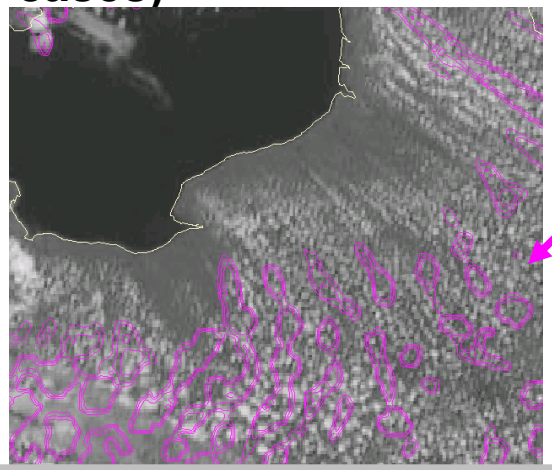
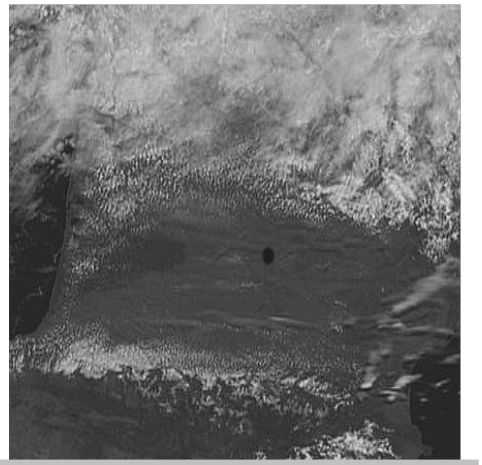
The "herringbone" problem

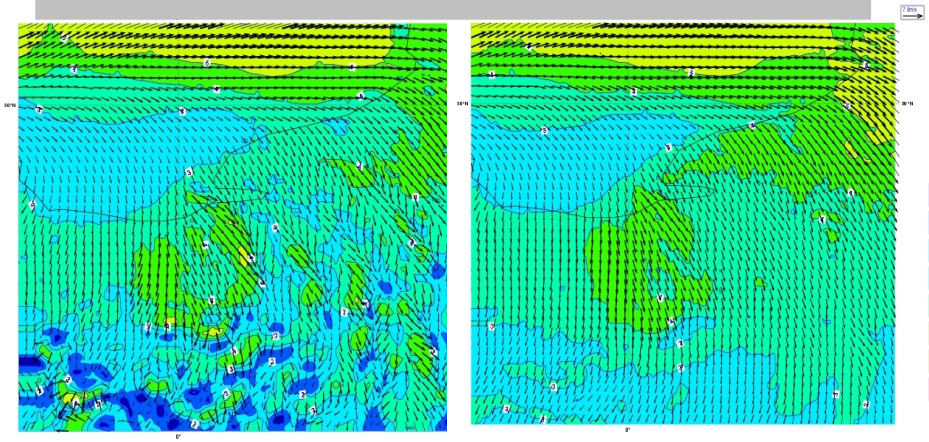
- **"herringbones": strong organisation of low-level winds and shallow cumulus in weakly convective boundary layers over land**
  - **a spurious organisation of PBL eddies as 'streets' on the model grid**
  - **solved by activation of the EDKF subgrid convection scheme (even in dry cases)**



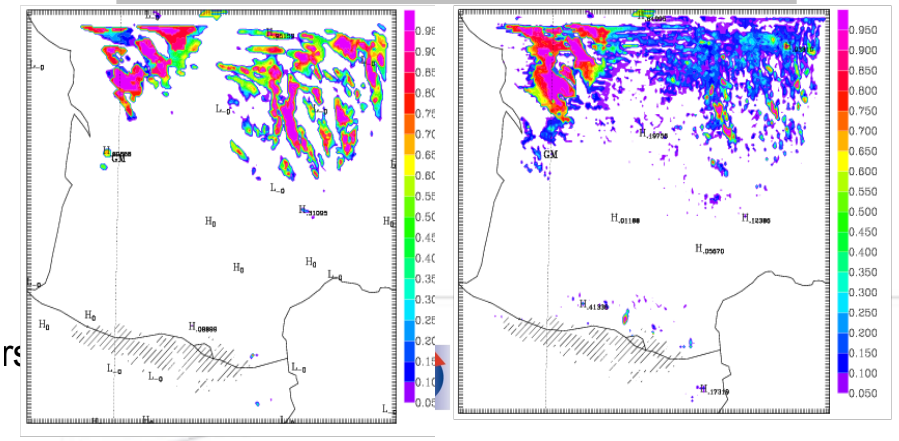
Model clouds without EDKF



Low-level winds without and with EDKF



Clouds without and with EDKF

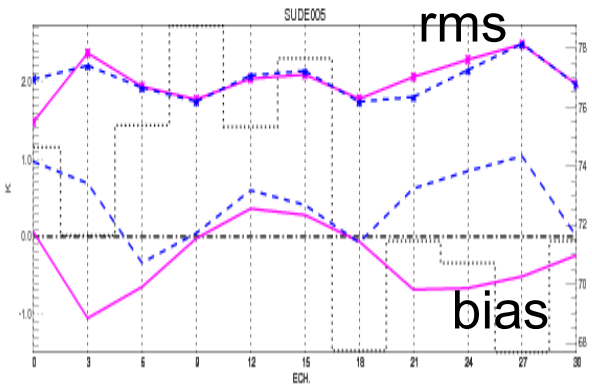


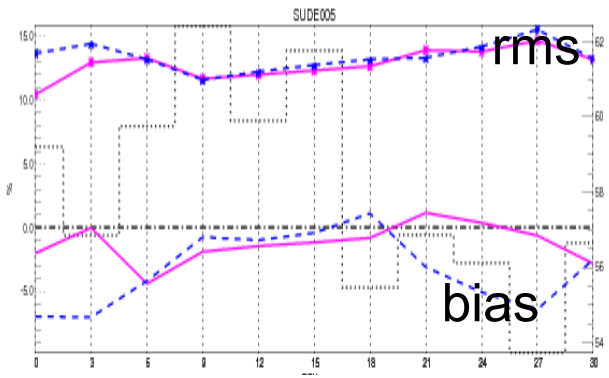
The low-level diagnostics

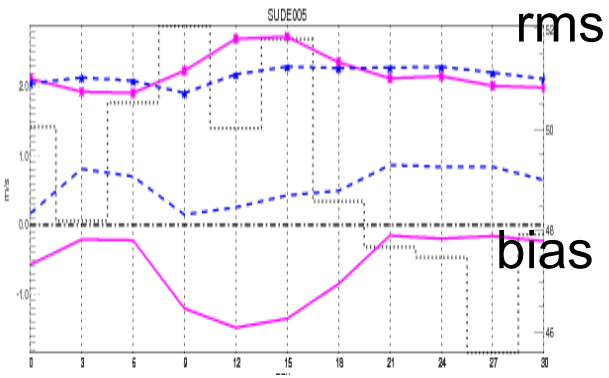
- **New option : implementation of "Canopy", a 1D-subgrid model of the low PBL**
- **At the origin to fix problems inside surfex V2**
- **Now surfex V3 gives similar results (still issues with 10m winds)**

Forecast scores with Canopy (blue) and without (pink)

T2m	HU2m	ff10m





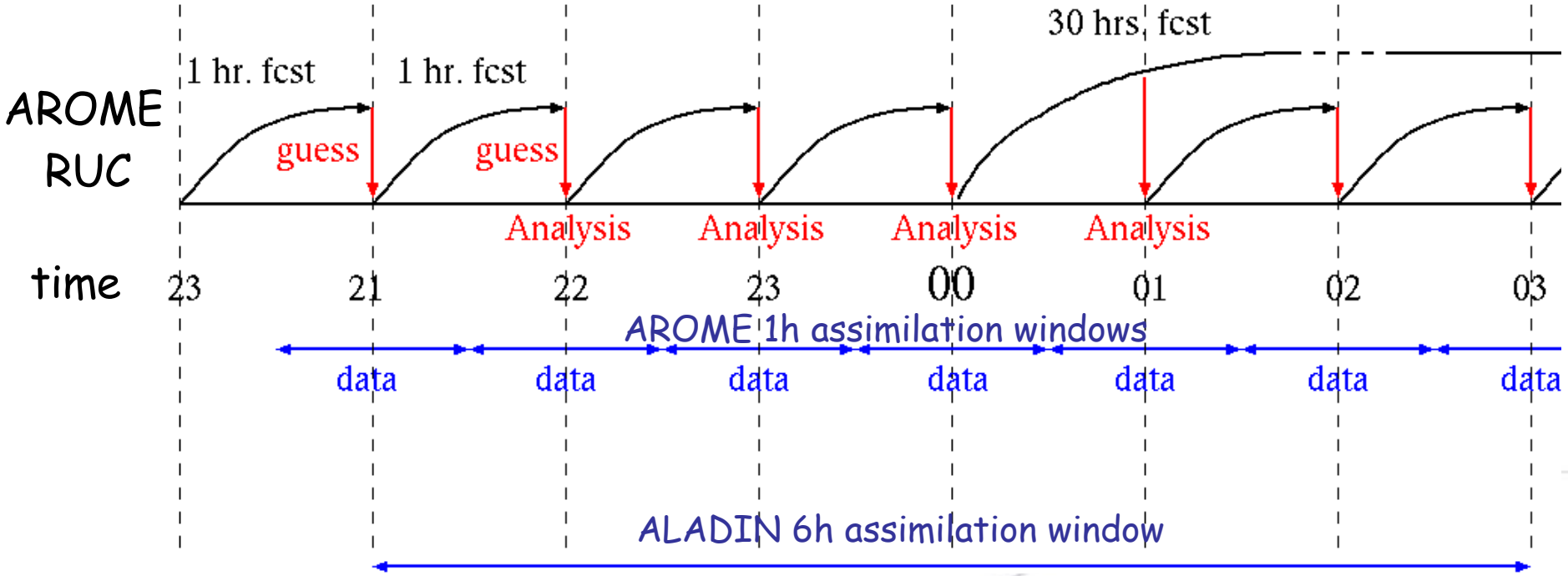


3. Data assimilation

Rapid Update Cycle

- Idea :
  - ✓ Forecasts initialized with more recent observations will be more accurate
  - ✓ Using high temporal and spatial frequency observations (RADAR measurements for example) to the best possible advantage

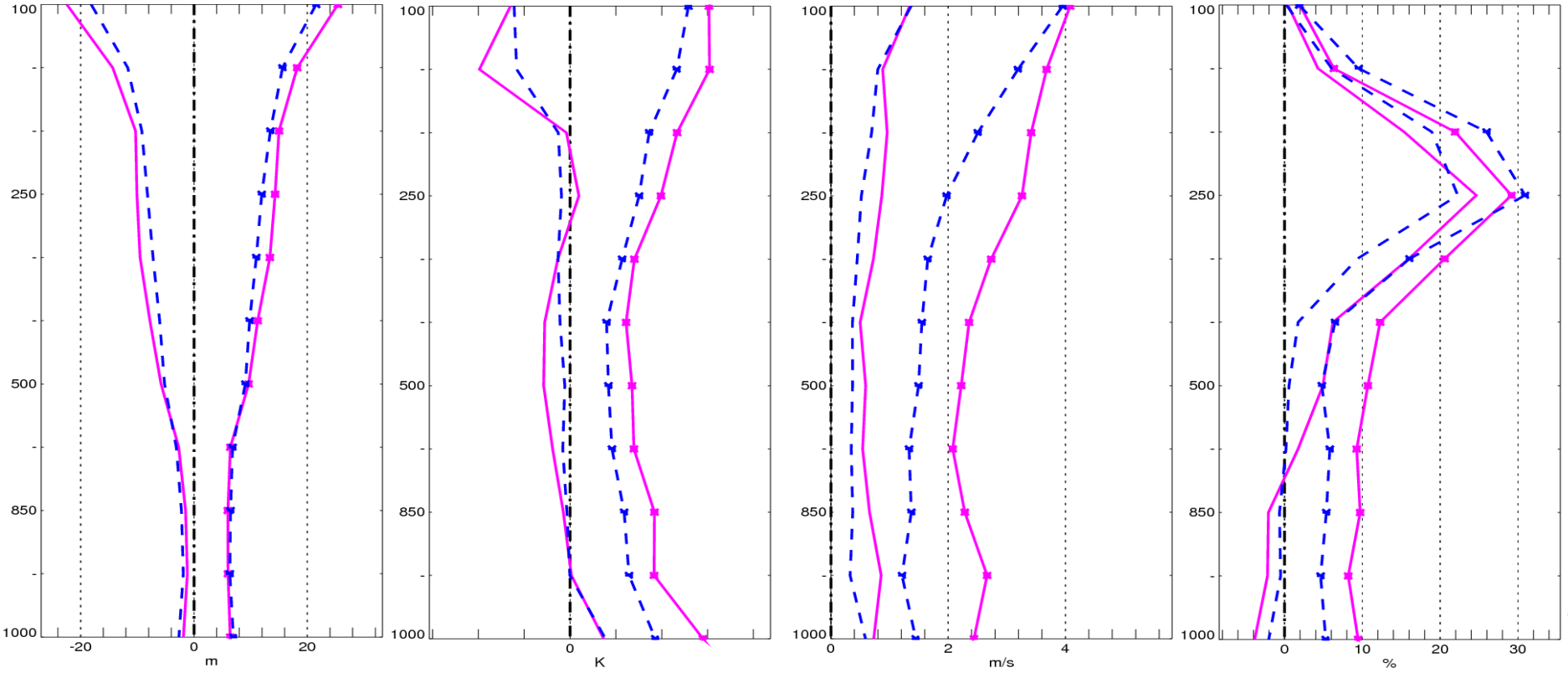
Use of a Rapid Update Cycle (Benjamin et al. 2004) in order to compensate the lack of temporal dimension in the 3D-Var



Objective scores : analysis compared to radiosonde

- Analysis from the AROME RUC compared to ALADIN analysis show an important reduction of Root Mean Square Error for all parameters all over the troposphere except for the humidity field around 200 hPa

---------- Bias --x---x-- rmse

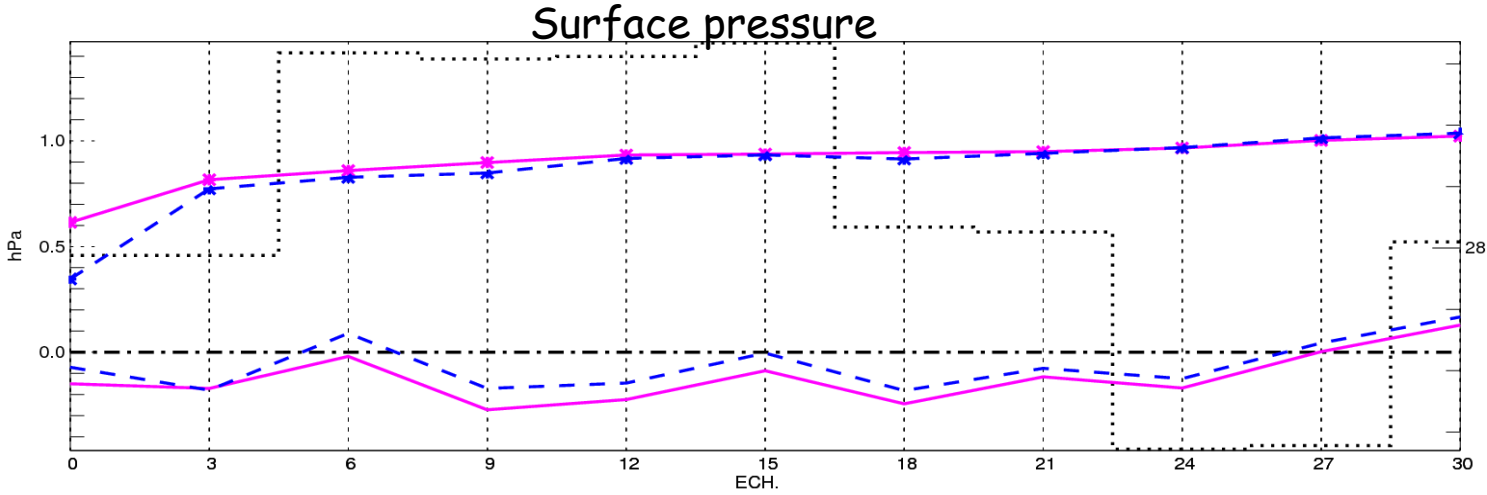


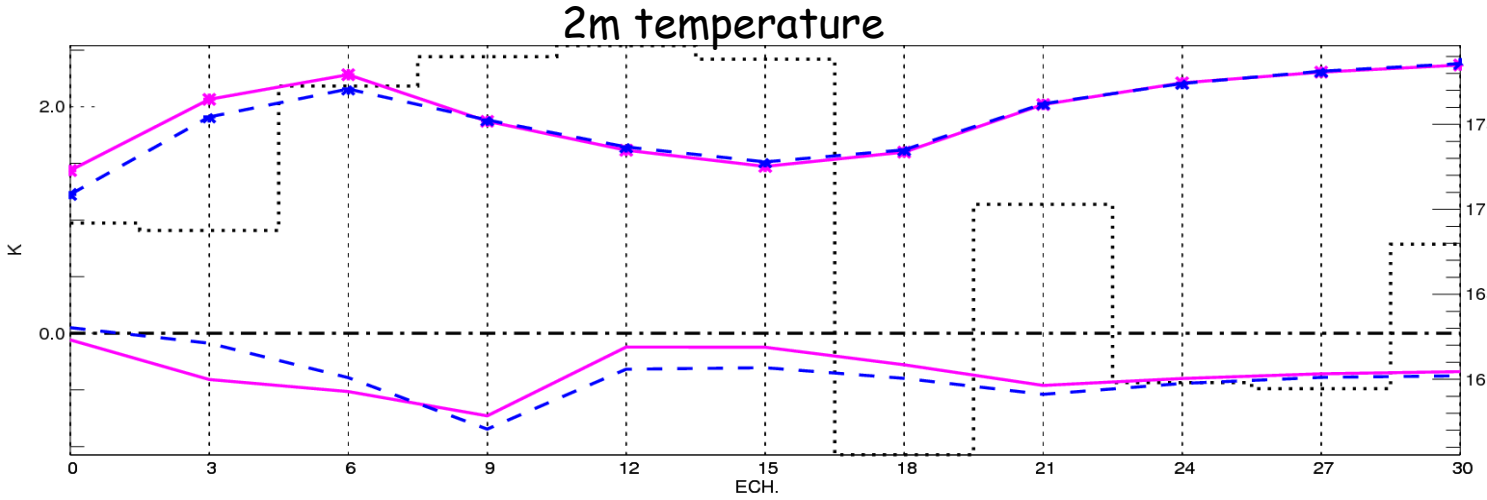
Geopotential T wind q

Objective scores : forecast compared to synop

- Same feature is observed regarding scores compared to SYNOP observations

assimilation
spin-up mode

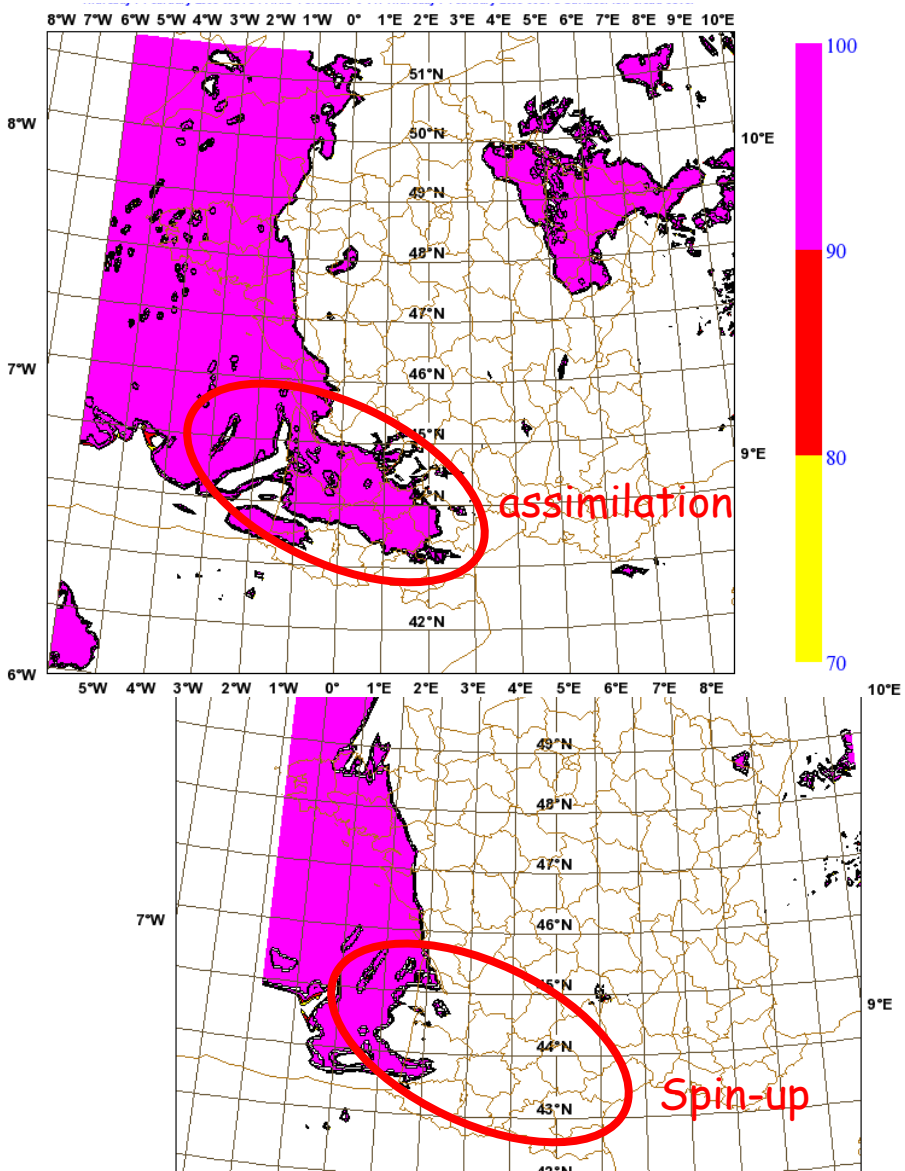




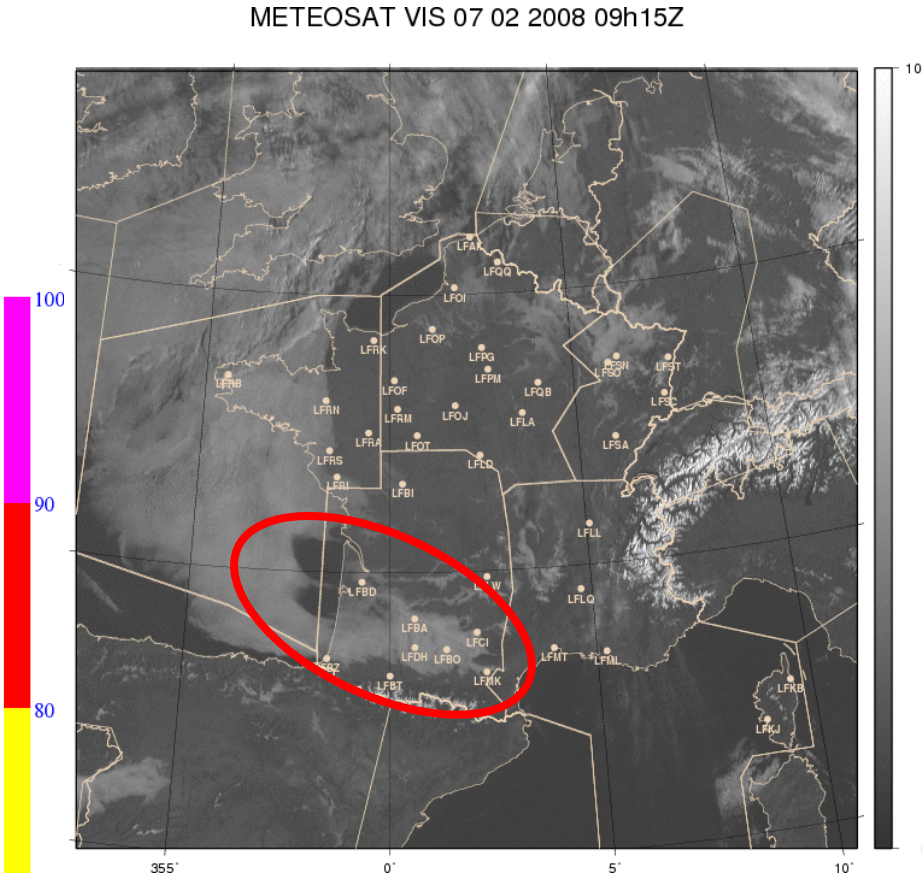
--------- Bias

--x---x-- rms

Fog event, 7 february 2008



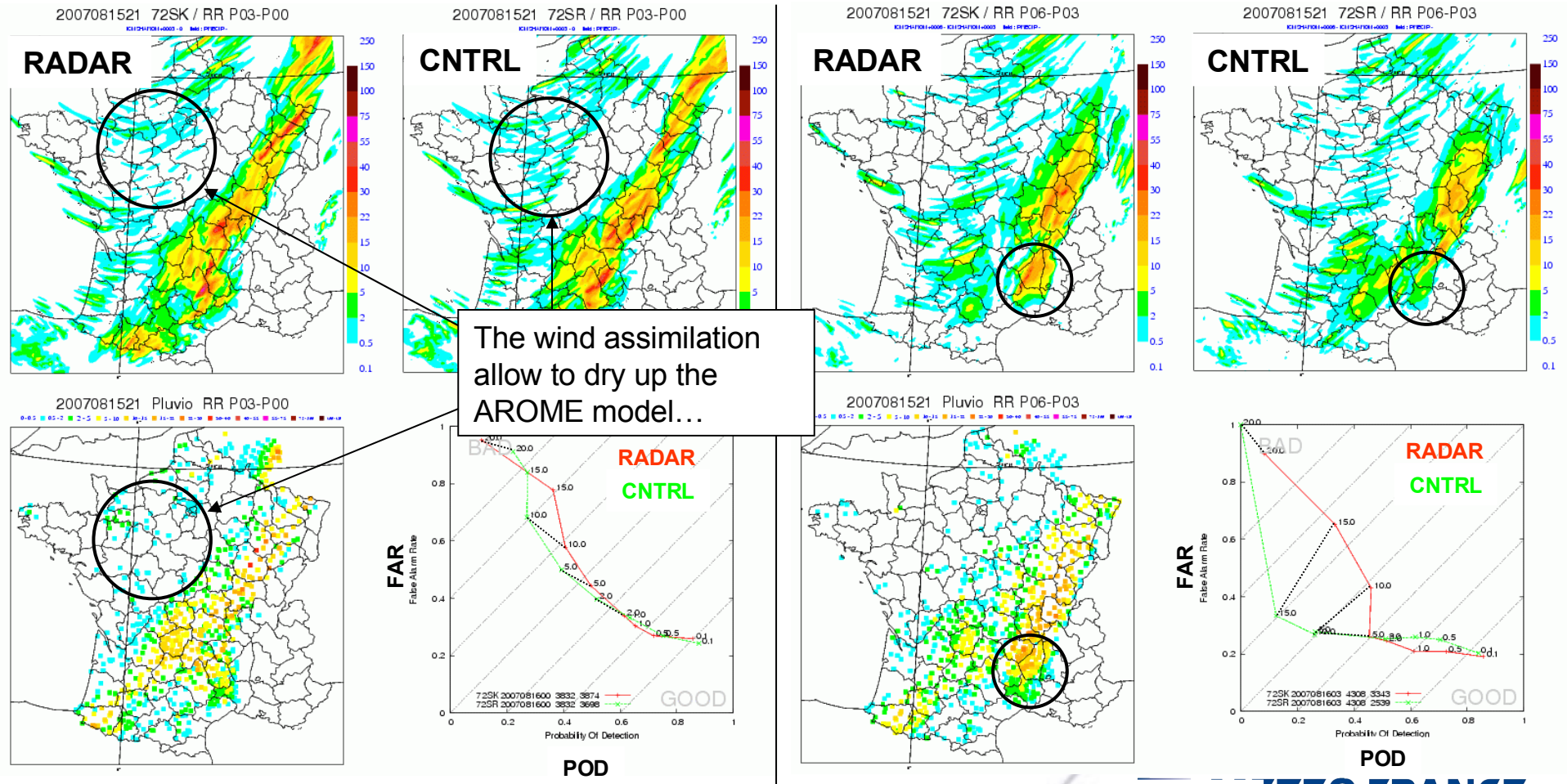
- AROME low cloud cover at 9-h UTC
- Fog is not simulated in spin-up mode



Doppler winds assimilation : Case of 15 august 2007: heavy rain on cold front

- **CNTRL** : AROME with 3h-RUC, 1st analysis on 15 august at 9h
- **RADAR** : CNTRL with Doppler winds assimilated observed by **16 radars.**

Cumulated precipitation over 3h (analysis at 21H00 UTC)



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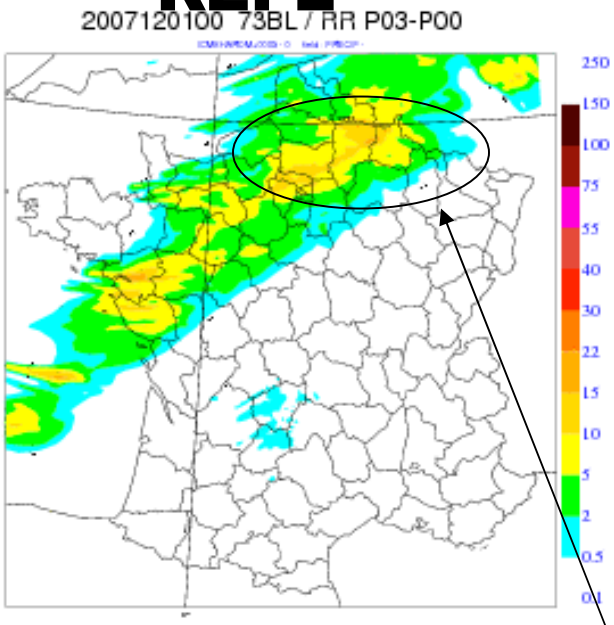
REFLECTIVITIES ASSIMILATION

3h - cumulated rain - P3-P0 r00 – 3 cycling

REFL



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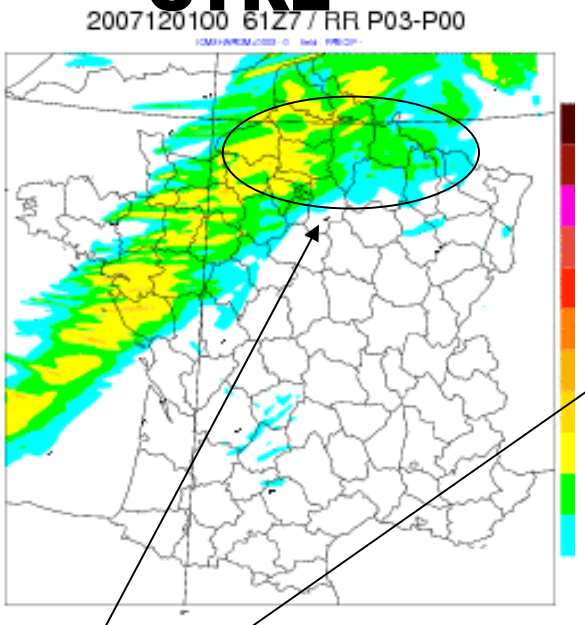
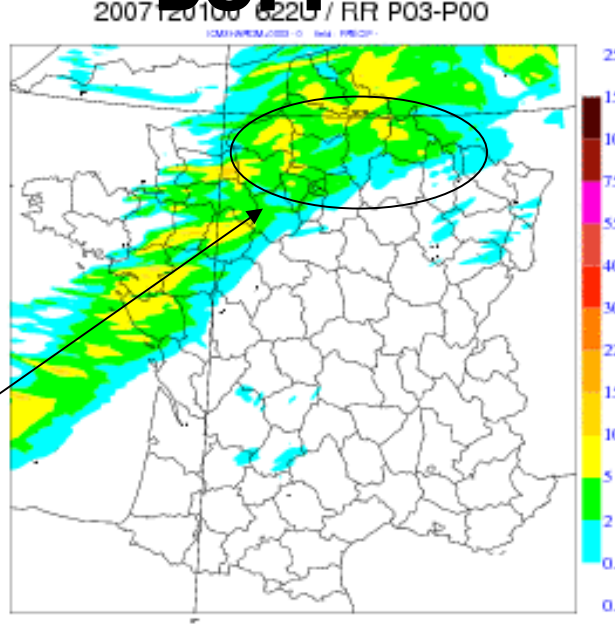
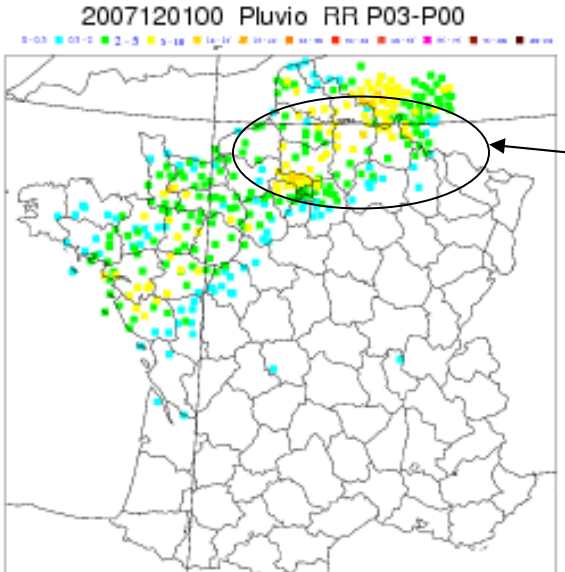


DOPP

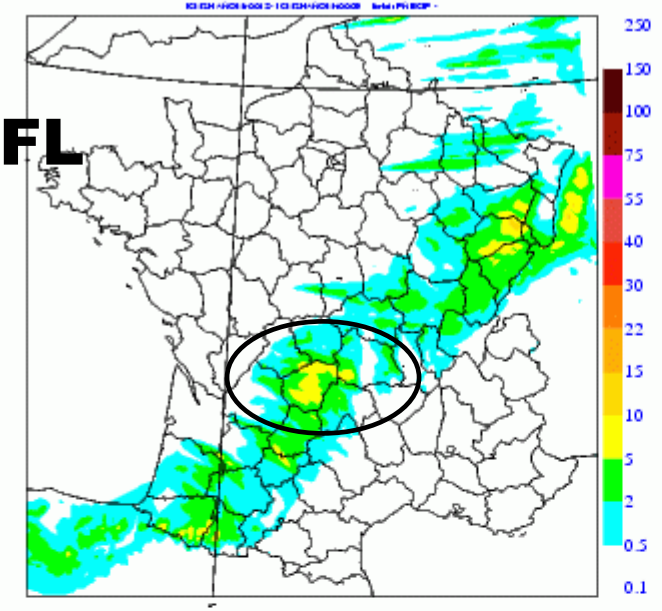




The cold front is indeed well located on the 3-hour forecast from the analysis with reflectivities…

REFLECTIVITIES ASSIMILATION

REFL



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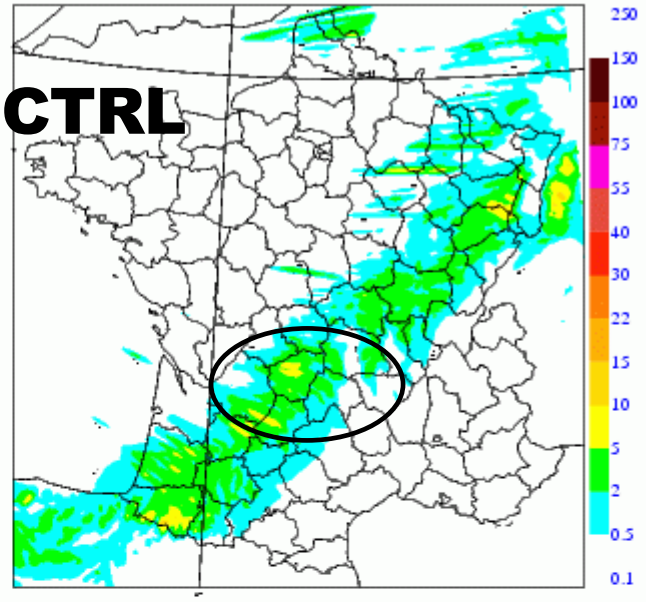
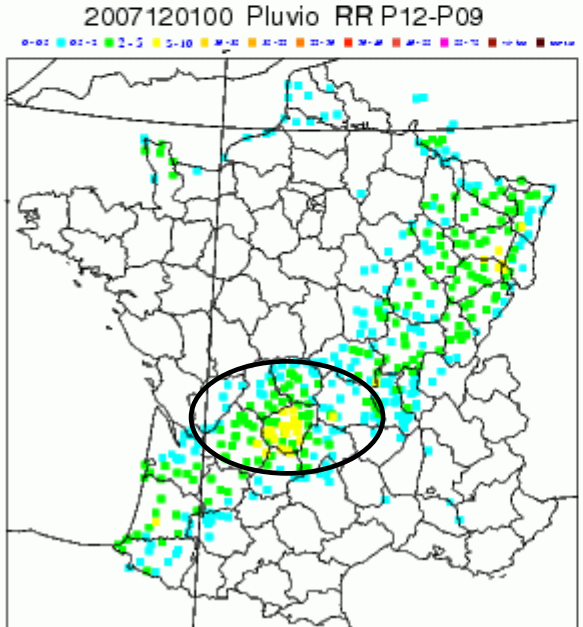
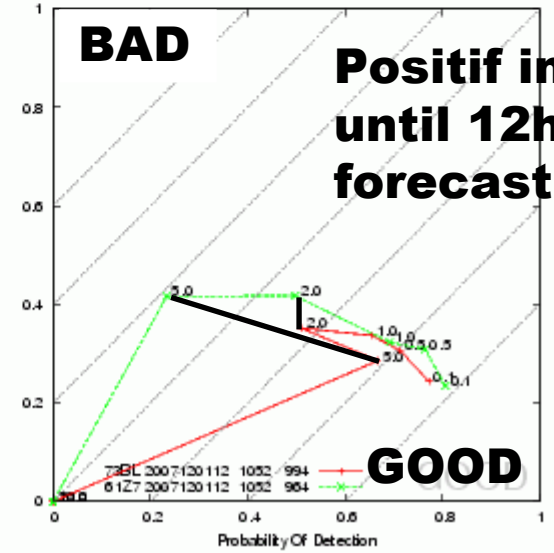




FAR



Positif impact until 12hour forecast!

Decreasing of False Alarm and increasing of detection for all the thresholds

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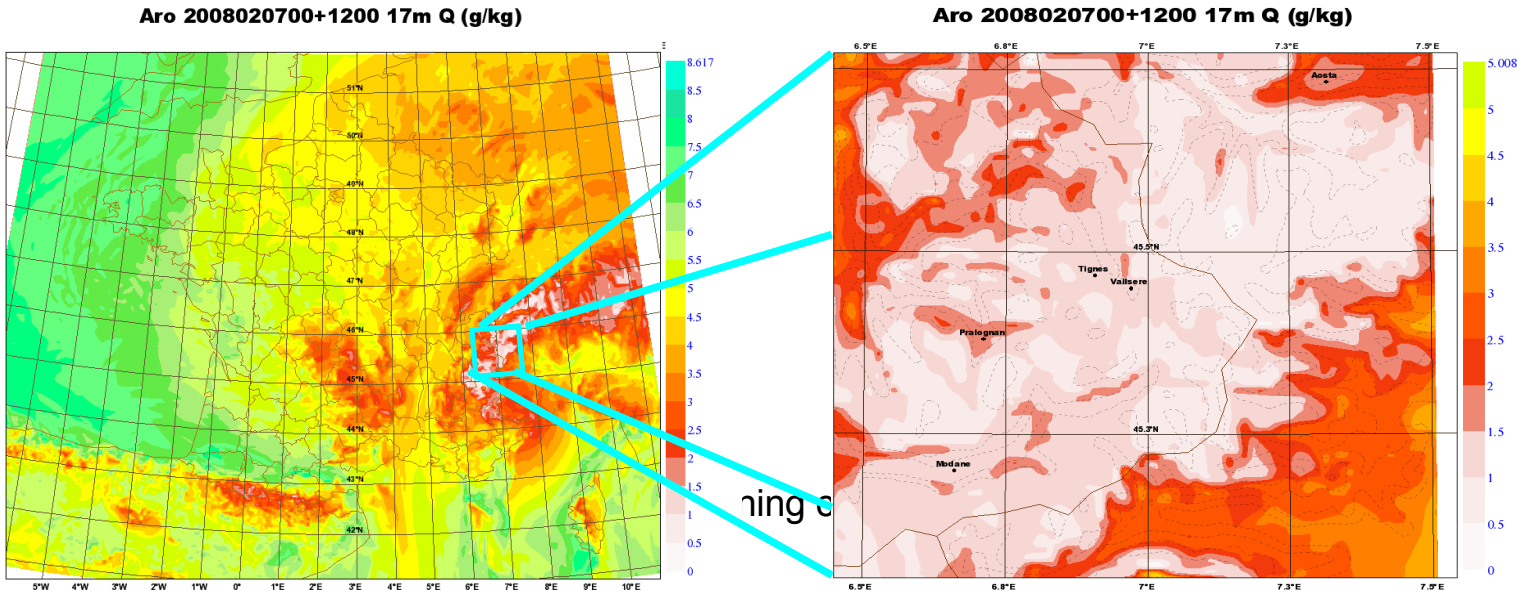
4. Operational plans at Météo-France for AROME

4 - Operational plans at MF: 2008

- **In 2008: 'V1 configuration'**
  - **2.5km 'AROME-France' model domain, 41 levels**
  - **30-h forecasts, 4 times a day**
  - **3DVar assimilation with 3-hourly cycles**
  - **assimilating Doppler radar data (on top of all ARPEGE/ALADIN datasets), not assimilating reflectivities**
  - **surface interpolated from ARPEGE**
  - **uses about as much supercomputer as the ARPEGE global 4DVar**

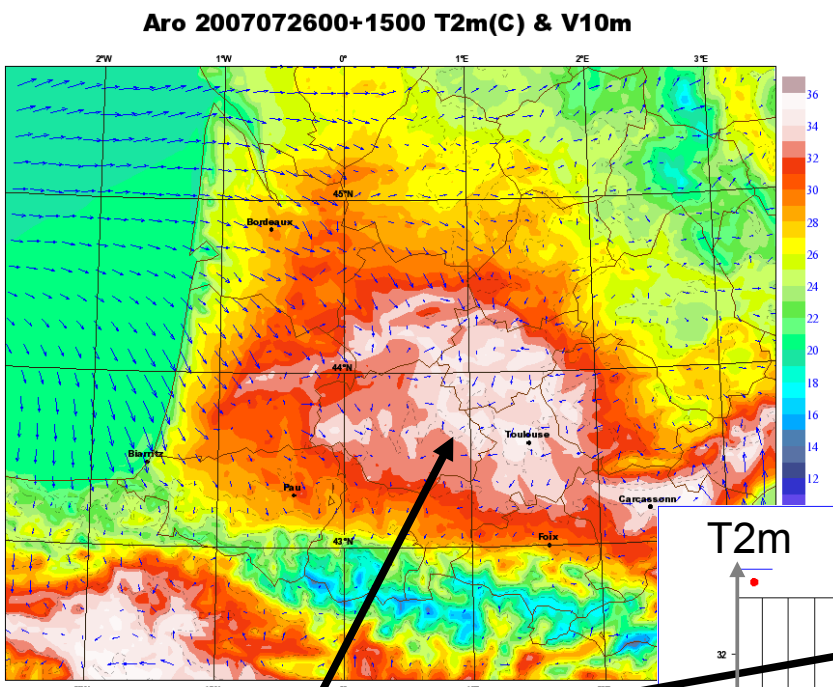
4 - Operational plans at MF: 2009

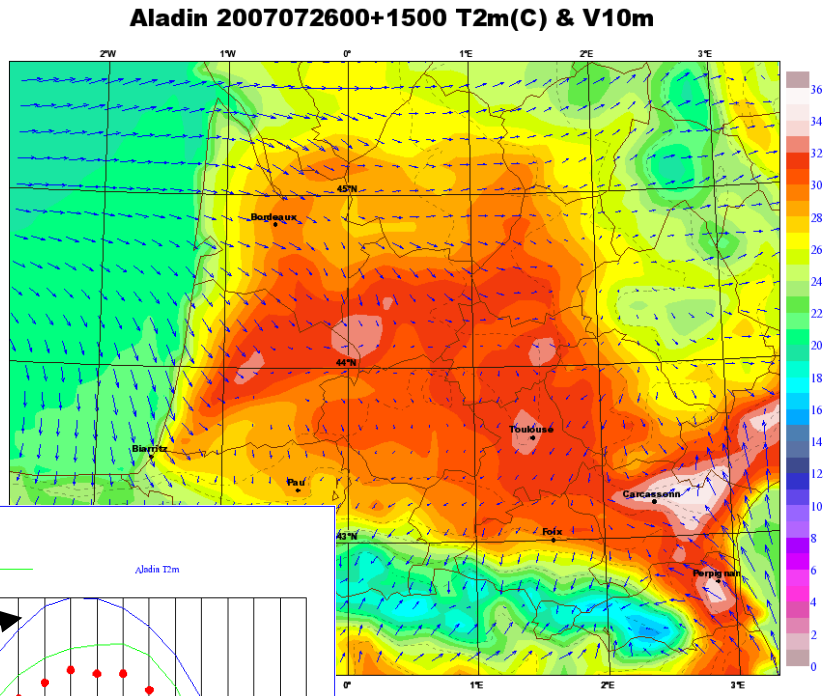
- **In 2009: 'V2'**
  - **increase vertical resolution (60 levels, 1st level at 8m, 21 levels <2000m)**
  - **better assimilation using 3DVar FGAT, Jk coupling and more data**
  - **assimilate radar reflectivities (as Bayesian humidity retrivals) (and all new ARPEGE/ALADIN datasets: IASI, new GPS ZTD...)**
  - **Arome surface assimilation (Canari plugged into surfex)**
  - **and several model improvements**
  - **(perhaps) short hourly forecasts for nowcasting applications**
  - **1-km dynamical adaptation model over the Alps**



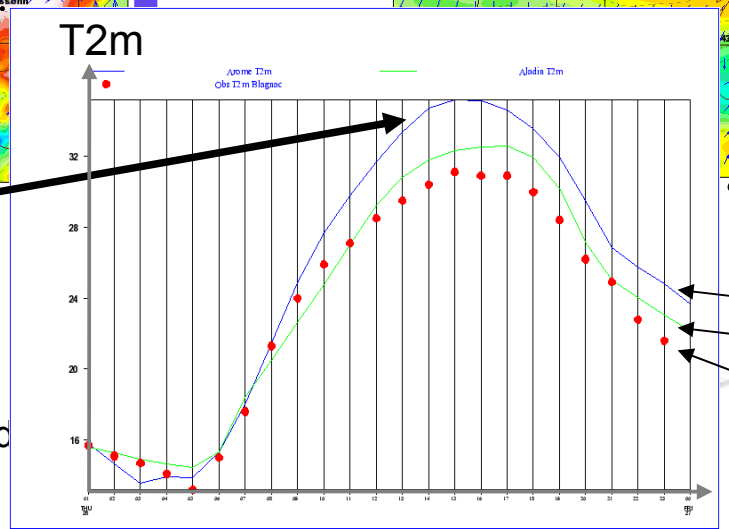
The importance of surface data assimilation

- **Converting soil moisture from one surface scheme (ARPEGE/ALADIN) to another (AROME-SURFEX) creates errors because the surface physics are different. A native AROME surface analysis is needed.**





AROME is too hot here



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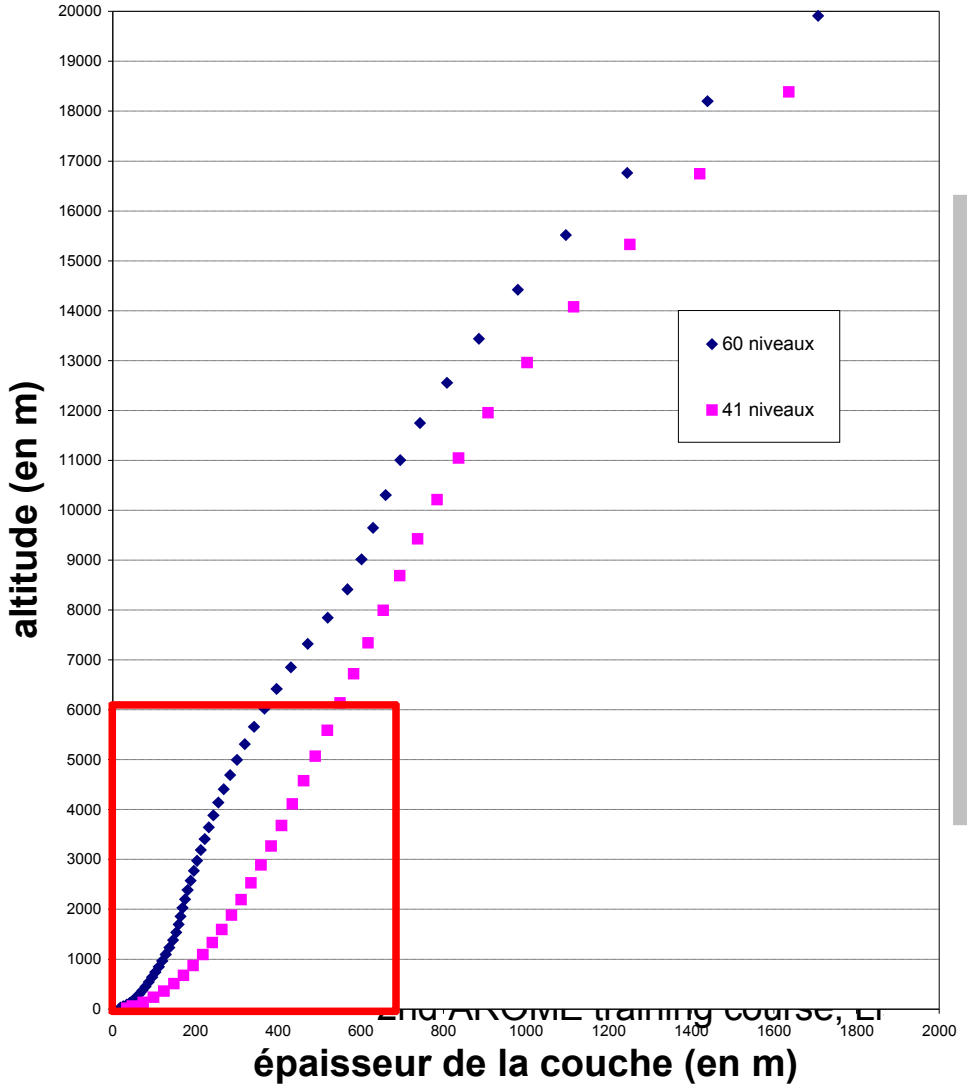
4 - Operational plan on vertical resolution

- **for 2009, double the vertical resolution in the lower troposphere :**



Moving from L41 to L60:

- costs 37% extra CPU
- 1st level at 8m (vs 17m)
- 21 levels below 2000m (vs 12)

Supposed to improve forecasts of fog and low clouds

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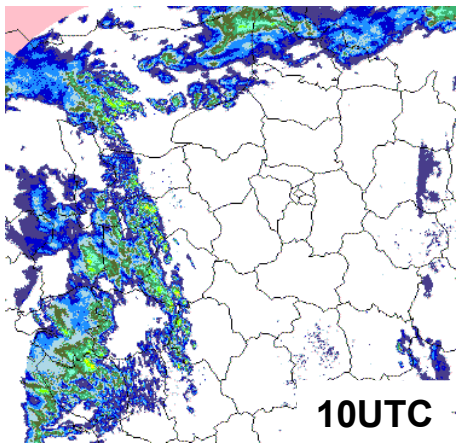
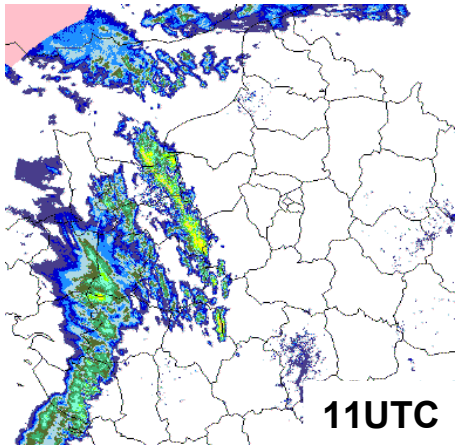
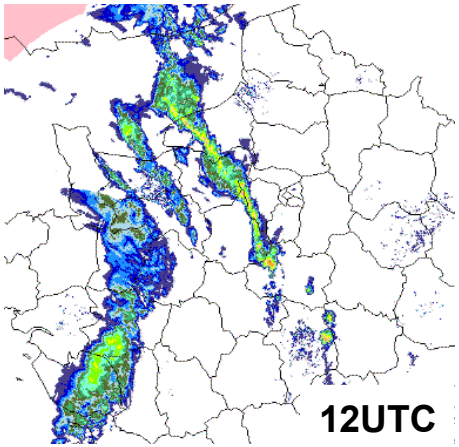
Toujours un temps d'avance

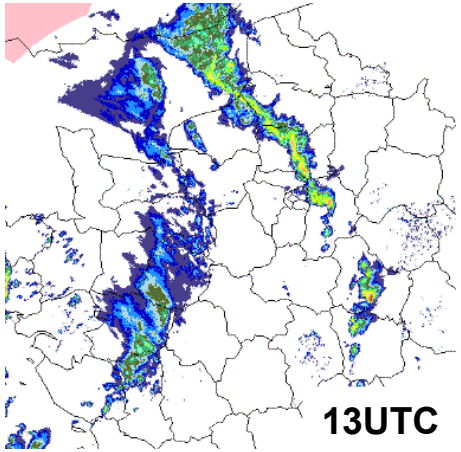
Case of 13 may 2007: squall line

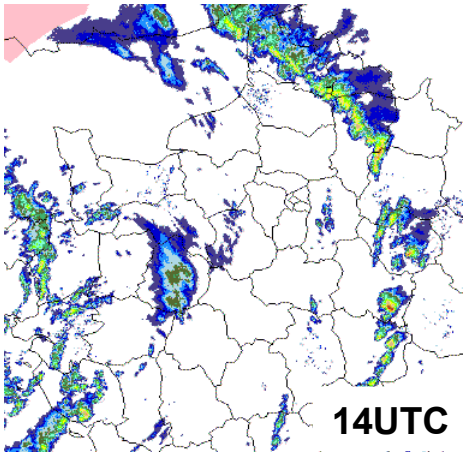
- **CNTRL** : AROME with 3h-RUC, first analyse the 13 mai at 9h
- **RADAR** : CNTRL with Doppler winds assimilation observed by the radars of Trappes, Falaise, Abbeville, Avesnes, Blaisy, Troyes, Montclar

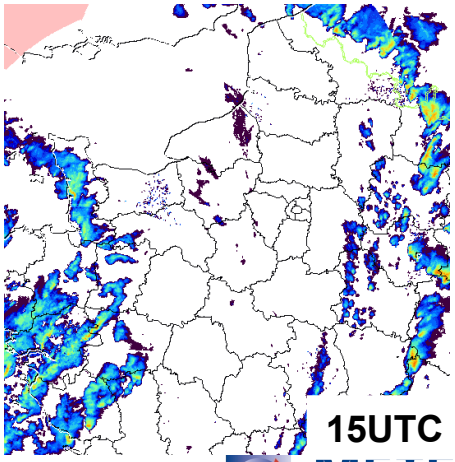








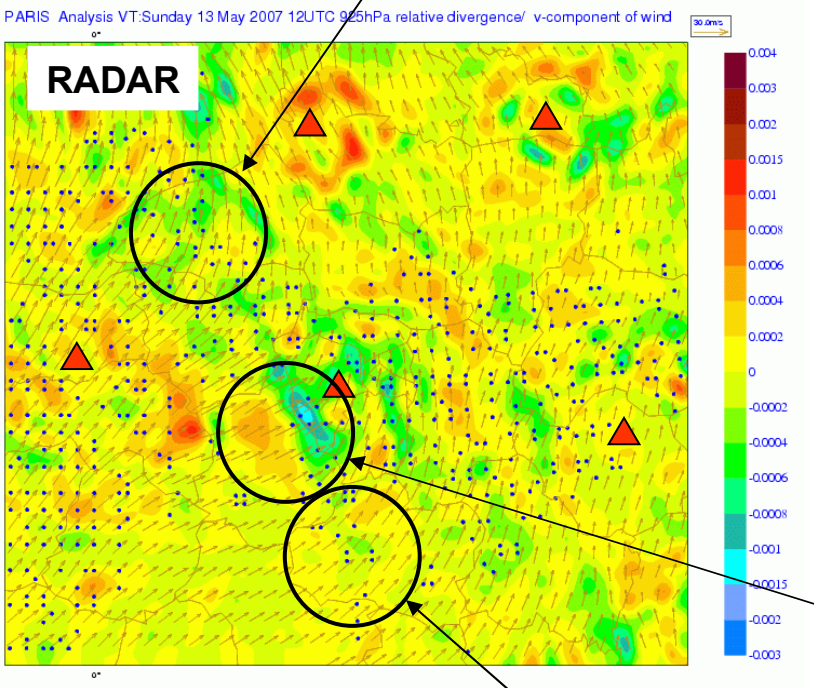




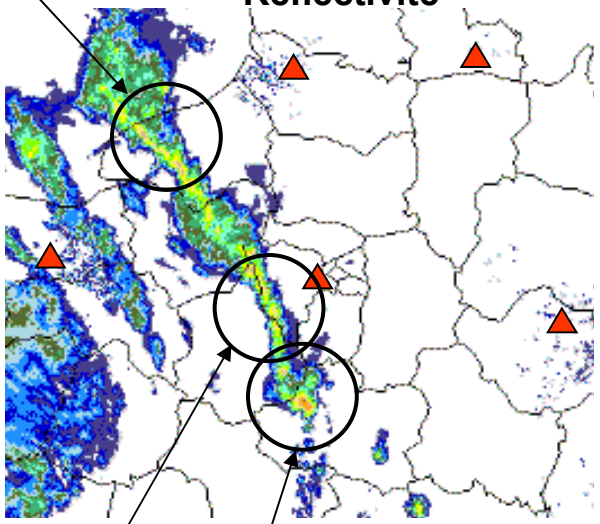
Divergence analysis (925 hPa) **12 UTC**

Convergence line at low level too far off the radars to be sampled

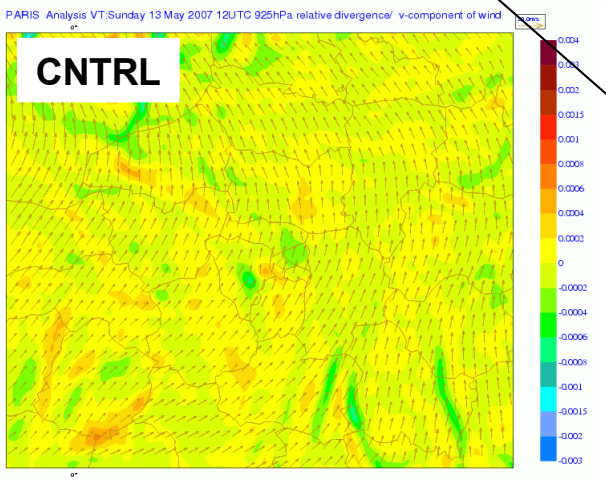
+ Données actives 1eres élev.



Réflectivité



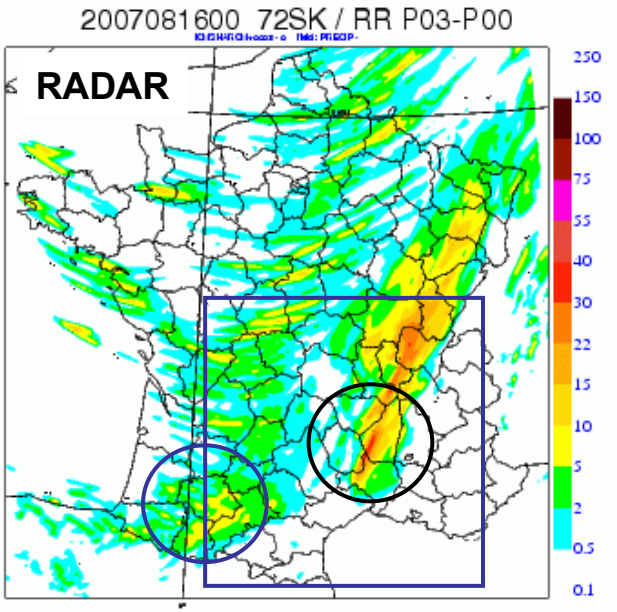
Convergence line near the radar of Trappes and perpendicular to the radial winds gradient: convergence at low level well analyzed

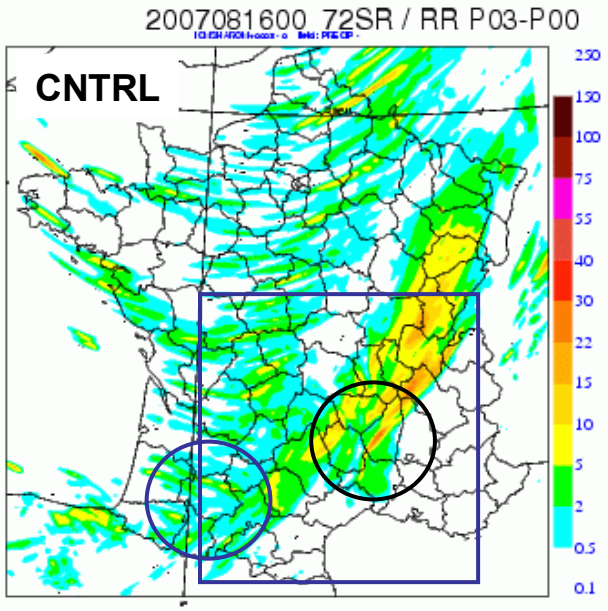


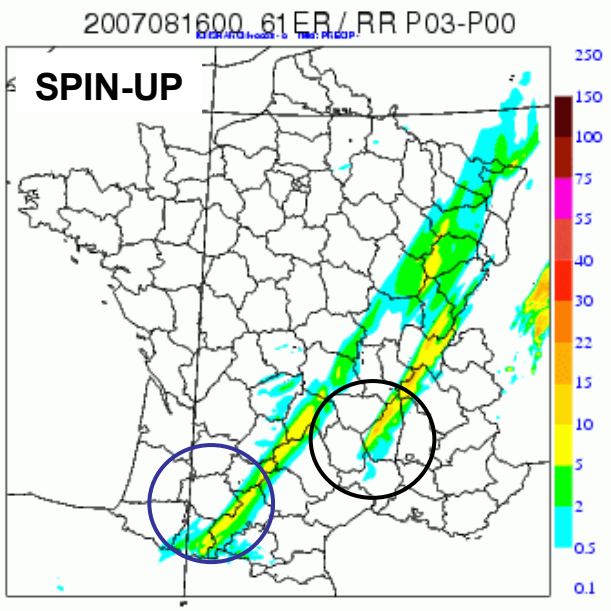
Convergence line nearly parallel to Vr (+ radar of Bourges non available): radial wind gradient too little to analyse the low-level convergence

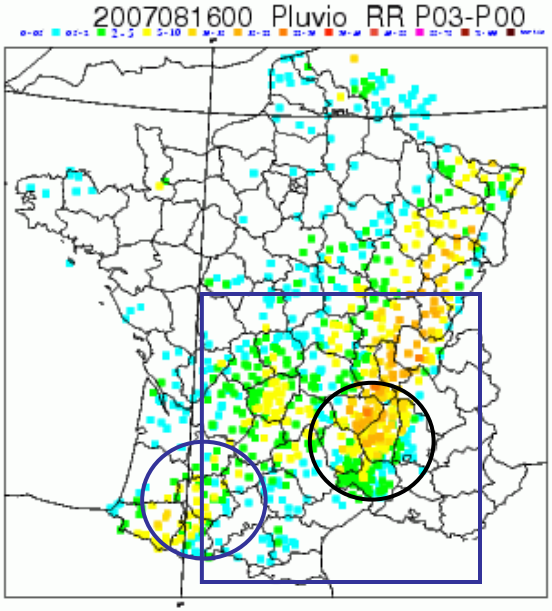
Cumulated precipitation on 3h (analysis at 00 UTC on 16 august)

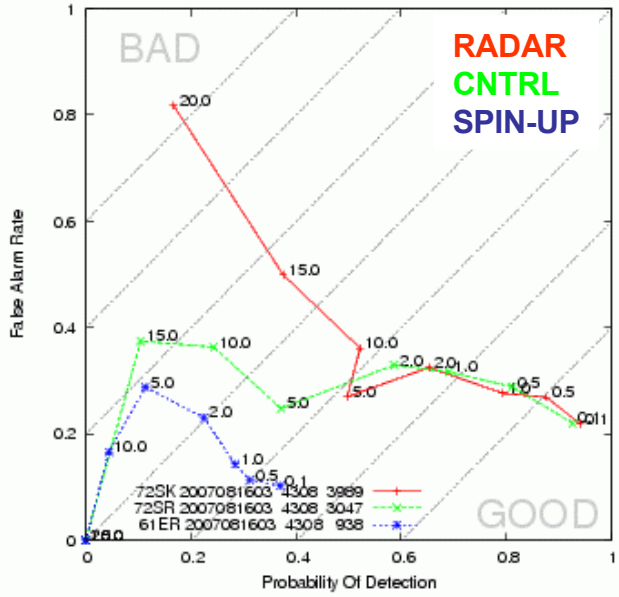
P3-P0











zoom…