An update on the 2002 Gard flood simulation with the ALARO-10 prototype in 2004

A comparison between ALADIN, Méso-NH, ALARO-10 and AROME

G. Hello, Météo-France, CNRM/GMAP

23 February 2005

1. SUMMARY

In summer 2004, some preliminary testing was run using a model consisting of the AROME prototype software at 10-km resolution plus a subgrid convection scheme. This model is called "ALARO-10" in this paper although the contents of the ALARO-10 subproject changed in 2005. Preliminary results from the tests were shown on four cases. Runs on the Gard case were published in ALADIN Newsletter 26. Later, in December 2004, it turned out that the precipitation diagnostics from these runs were incorrectly interpreted : the displayed cumulated rainfalls did not include the cumulated rain coming from the parametrized convection. That is the reason why there was too little rainfall in the output of ALARO-10. This article shows the new results with the corrected ALARO-10 runs on the GARD case.

The Gard case is a very extreme meteorological flood event over the South-East of France, it is also a major case for the qualification of the AROME prototype.

2. CHARACTERISTICS OF THE DIFFERENT RUNS USED

The GARD case is a 12 hours forecast run, starting on 08/09/2002 at 12 UTC and ending on 09/09/2002 at 00 UTC.

2.1 ALADIN-oper

The characteristics of the ALADIN-oper runs are the same as ALADIN-France operational in September 2002 (i.e. not the present operational physics) :

- Semi-Lagrangian dynamics with 2 time-levels, hydrostatic formulation
- Time-step = 415,318s (7 minutes), Δx = 9.5 km, 41 vertical η-levels and coupling every 3h to ARPEGE.

2.2 Méso-NH

- Eulerian dynamics with anelastic formulation
- Time-step = 15s, Δx = 10 km, 41 vertical z-levels and coupling every 3 hours to ARPEGE.
- Radiation scheme: RRTM, convection scheme: KFB (called every 5 minutes), externalised surface, complete micro-physics with prognostic water variables, and prognostic turbulent kinetic energy.

2.3 ALARO-10

- Semi-Lagrangian dynamics with 2 time-levels, hydrostatic formulation.
- Time-step = 60s, Δx = 10 km, 41 vertical η-levels and coupling every 3 hours to ARPEGE
- Same physics as Méso-NH except that the convection scheme is called every time-step.

2.4 AROME

- Semi-Lagrangian dynamics with 2 time-levels, non-hydrostatic formulation with a PC (ICI) scheme.
- Time-step = 60s, Δx = 2.5 km, 41 vertical η-levels and coupling every 3 hours to ALADIN-France or Méso-NH.
- Same physics as Méso-NH or ALARO-10, but no convection scheme (the convection is assumed to be resolved).

3. RESULTS

3.1 Boundary layer fields

We look there at temperature at 2 m and wind at the lowest level for the different models. Observed 2 m temperature and 10 m winds are also shown.

3.1.1 2m temperature field

The 2m temperature field on the 09/09/2002 at 00 UTC shows a cooling under the thunderstorm. This is an important feature of this case. The cooling area is outlined on the following figure (Fig. 1) with T2m observations.

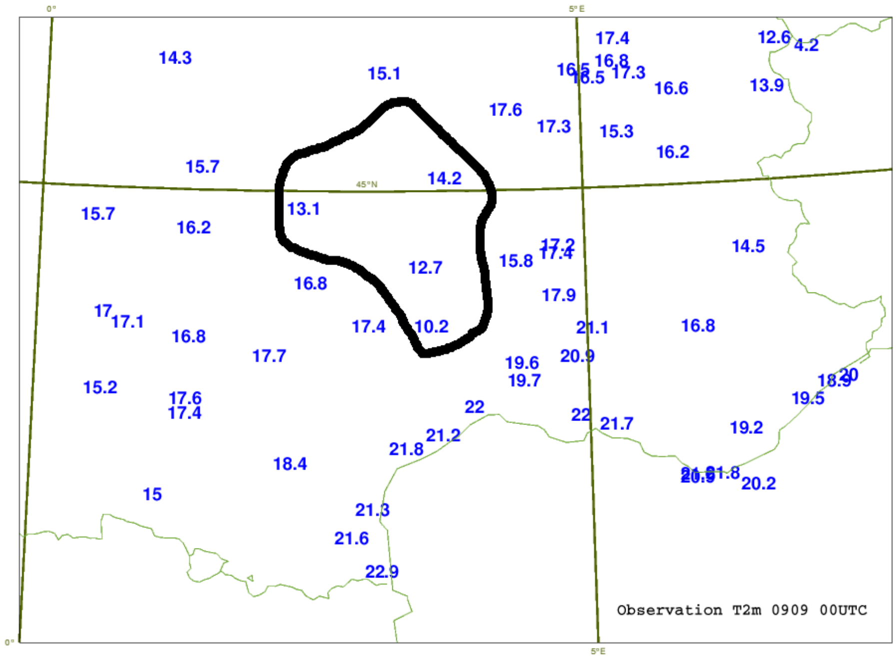

Figure 1 : Observations of 2m temperature on 09/09/2002, 00 UTC, on Southern France.

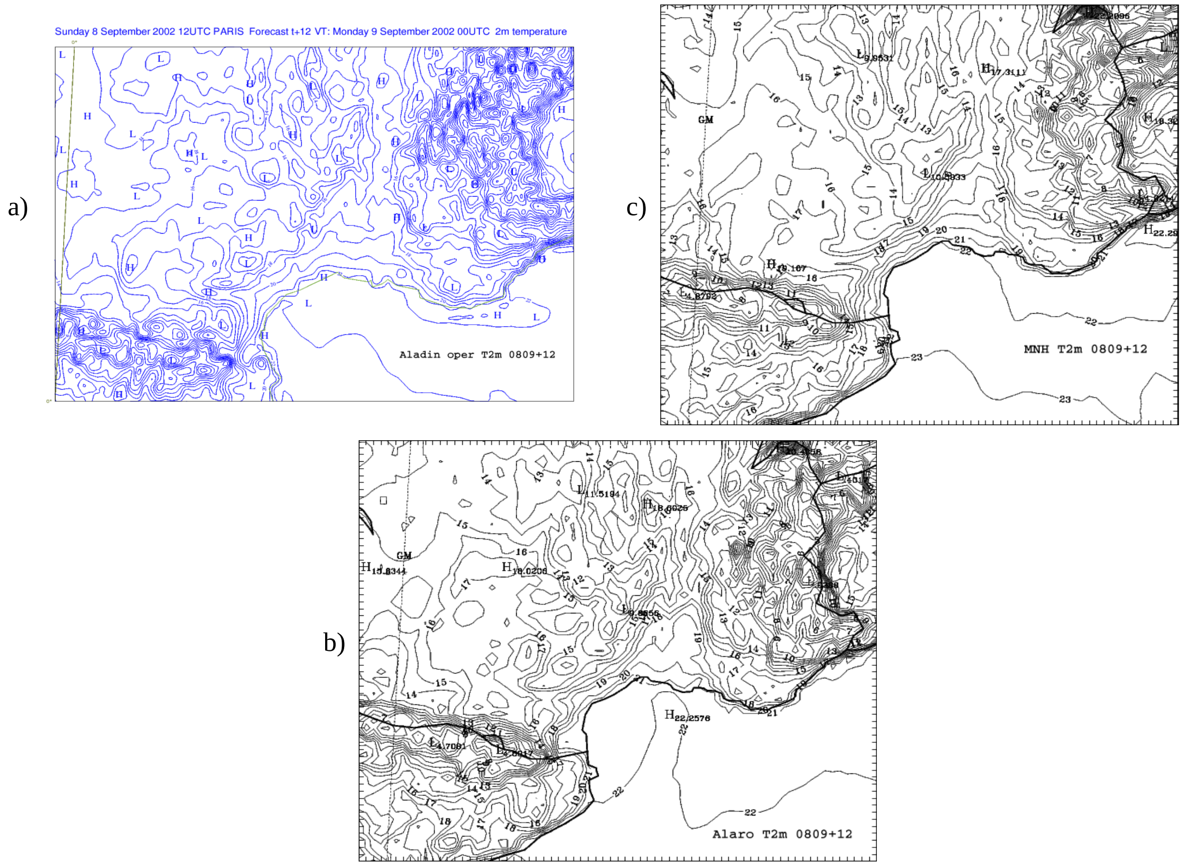

Figure 2 : 12 h forecasts of 2 m temperature, valid at 09/09/2002 00 UTC.
a) ALADIN-oper (Δx = 9.5 km), b) ALARO-10 (Δx = 10 km), c) Meso-NH (Δx = 10 km)

The cooling is seen by the several models : Méso-NH at 10 km, ALARO-10 and ALADIN-oper, the corresponding 12 hours forecasts are show on Figure 2. The minimum temperature in the cooling area is 10°C for Méso-NH and ALARO-10, and 13°C for ALADIN-oper. The other remarkable features, such as the heating inside the Rhone Valley, are similar between the three models.

3.1.2 Low-level wind

The low-level wind shows a South/Southeast flux that brings hot and moist air from the Mediterranean sea to the convective system. This is well seen on the 12 hours forecasts of all models. The inland penetration of the southeasterly flux is deeper in ALADIN-oper than in ALARO-10 and Méso-NH, and its leading edge is better defined in ALARO-10 and Méso-NH than in ALADIN-oper outputs, in terms of consistency with the observed wind values (Fig. 3)ure, the centre panel is the Méso-NH low-level wind).

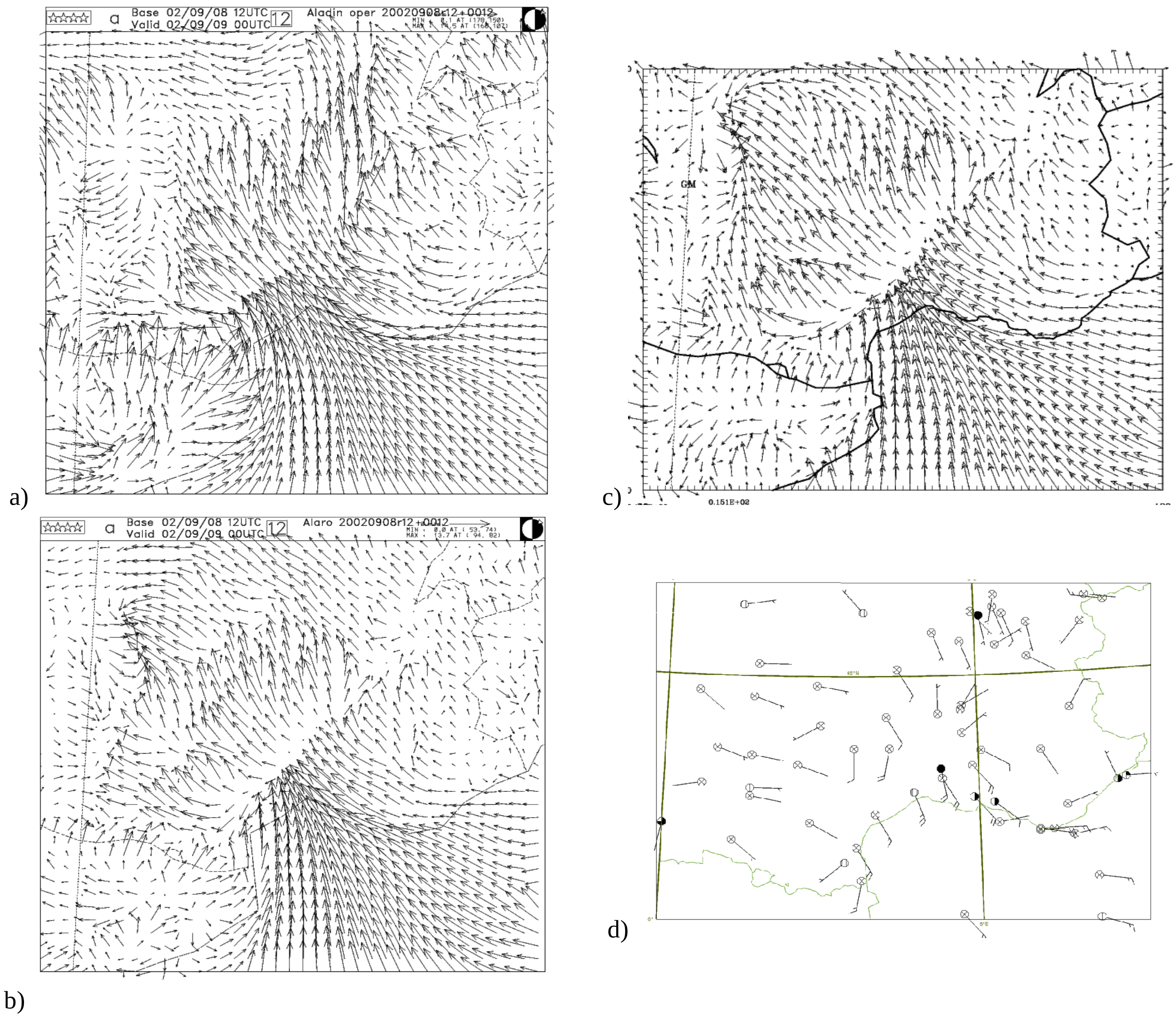

Figure 3 : 12 h forecasts of lowest-level wind, valid at 09/09/2002 00 UTC, and observed values of 10 m wind. a) ALADIN-oper (Δx = 9.5 km), b) ALARO-10 (Δx = 10 km), c) Meso-NH (Δx = 10 km), d) SYNOP data.

3.2 Cloudiness

The cloudiness field is shown by distinguishing between low, medium and high cloud cover as is done in operations. Note that the cloudiness is a 3D field for AROME, ALARO-10 and Méso-NH, so the cloudiness field interpretation is intentionally biased towards the ALADIN-oper post-processing. The low, medium and high cloud cover are built from the 3D cloud field in the layers

15-2200 m, 2200-7300 m, 7300 m-model top, respectively. An infrared satellite image is used as observed truth. The imagery shows a large cloud system made of a cluster over western France and another one associated to the convective system over Southeast France. Southwest France has mostly clear skies. These features are shown by all forecasts with some differences from the IR image.

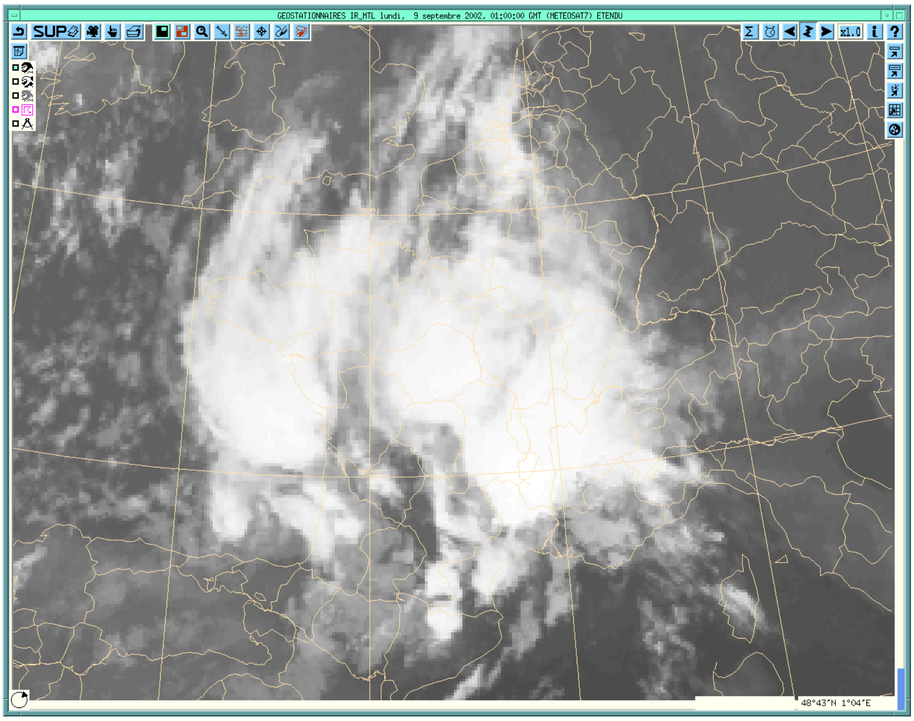

Figure 4 : Infra-red satellite image (Meteosat 7) valid on 09/09/2002, 01 UTC.

The model clouds are shown in the next figures (5-7). I is a feature of the Meso-NH plotting that high clouds are shown as a colour plot. The Meso-NH and ALARO-10 clouds are similar to the imagery. In both models, the clear part over southwestern France is well represented as well as the convective system over the Southeast. The high clouds are similar to the imagery except for a positional weakness on the northwestern cluster, which is too far South in both models. The ALADIN-oper cloud products have their own problems such as too many high clouds over the Mediterranean Sea and too many low clouds in the northwestern part of the domain. The convective system is well seen by all models from the point of view of cloudiness.

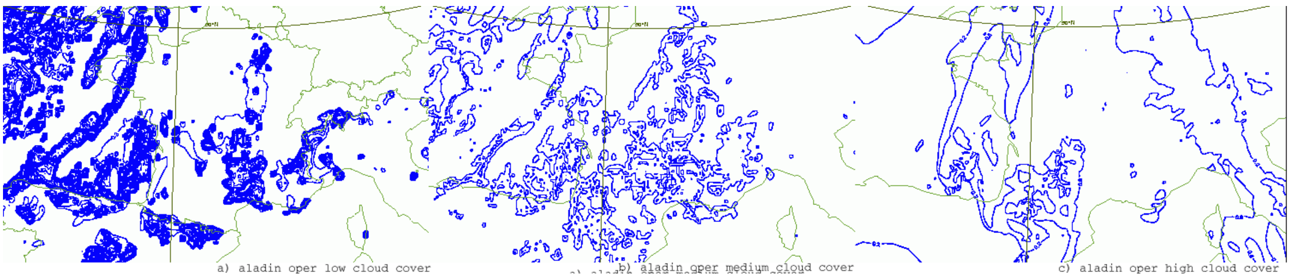

Figure 5 : ALADIN cloud-covers (12 h forecast valid at 09/09/2002, 00 UTC. low, medium, high, from left to right.

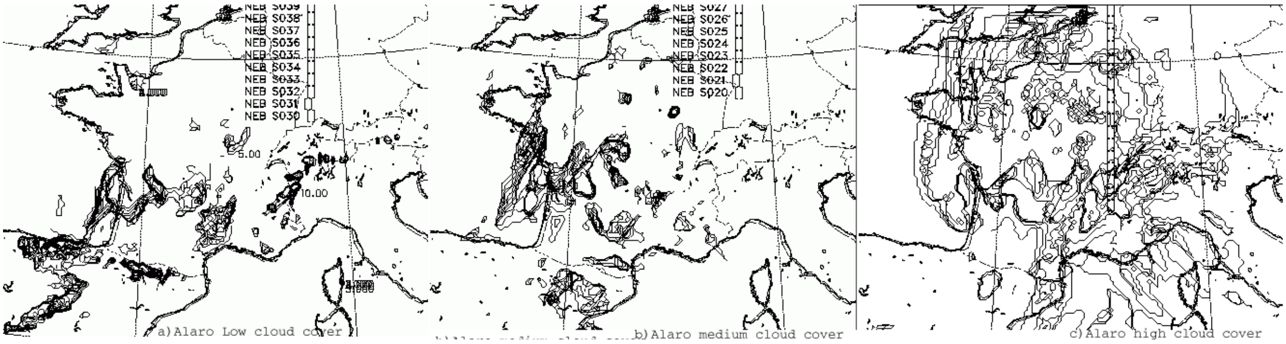

Figure 6 : As Fig. 5 but for ALARO-10.

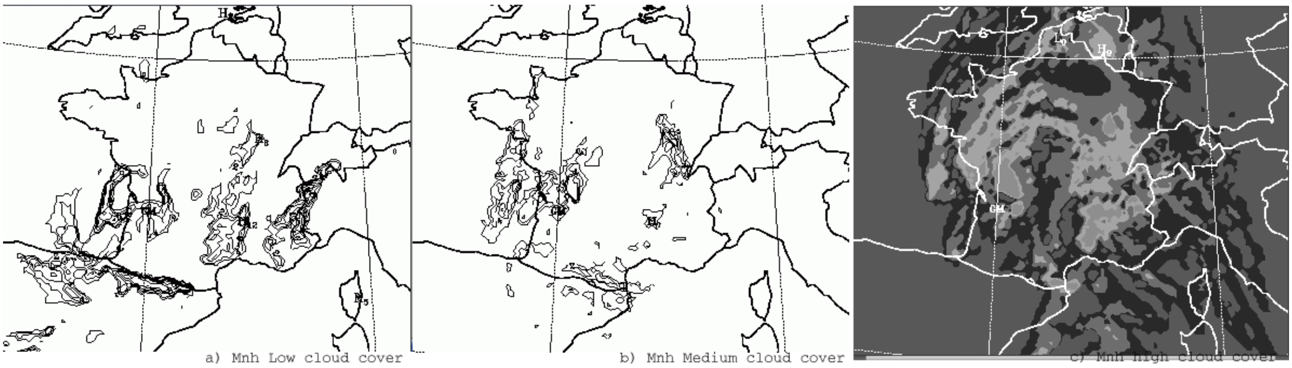

Figure 7 : As Fig. 5 but for Meso-NH (at 10 km)

3.3 Rain

Cumulated rain amounts are shown for the three models, on the integration domain (Fig. 10) and with a zoom on a smaller domain, at the same model resolution (Fig. 11). We also show results from Meso-NH and AROME with a 2.5 km horizontal mesh-size in order to show the improvement brought by a finer horizontal resolution (Fig. 12). The corresponding observations from radar data are shown in Figs. 8-9.

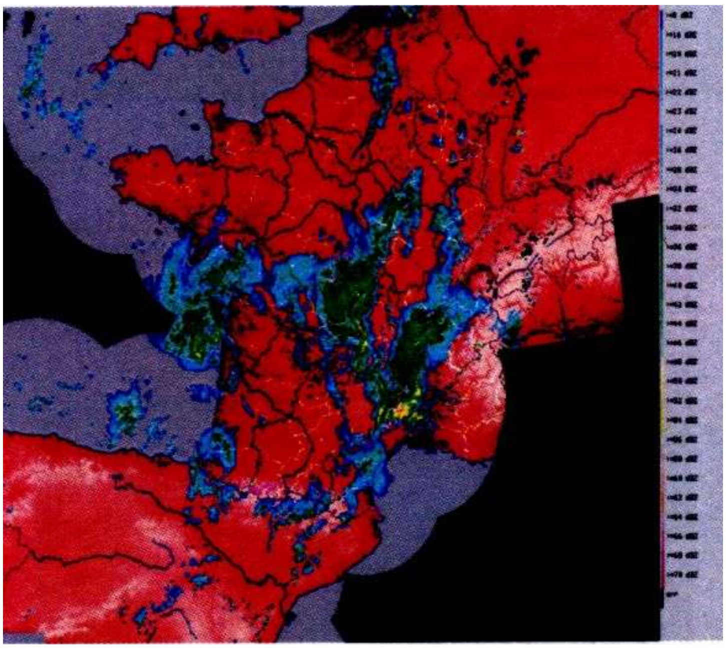

Figure 8 : Radar reflectivities , 09/09/2002 00 UTC.

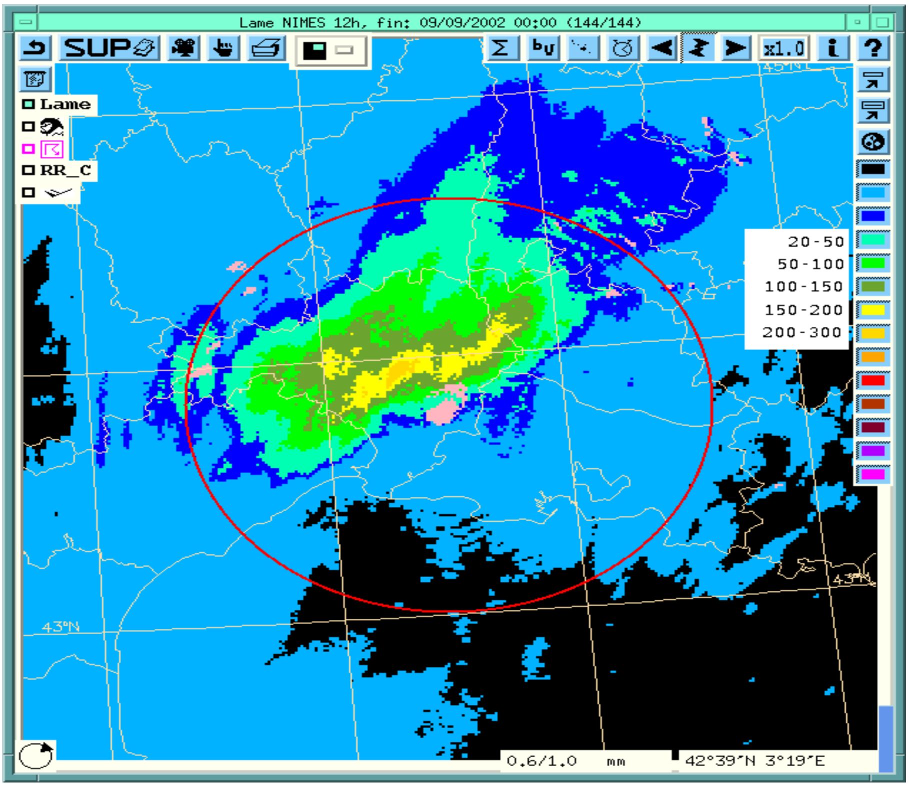

Figure 9 : Cumulated rainfall derived from radar data, zoom over South France (Nîmes radar only).
Cumul over 12 h, valid on 09/09/2002 00 UTC.

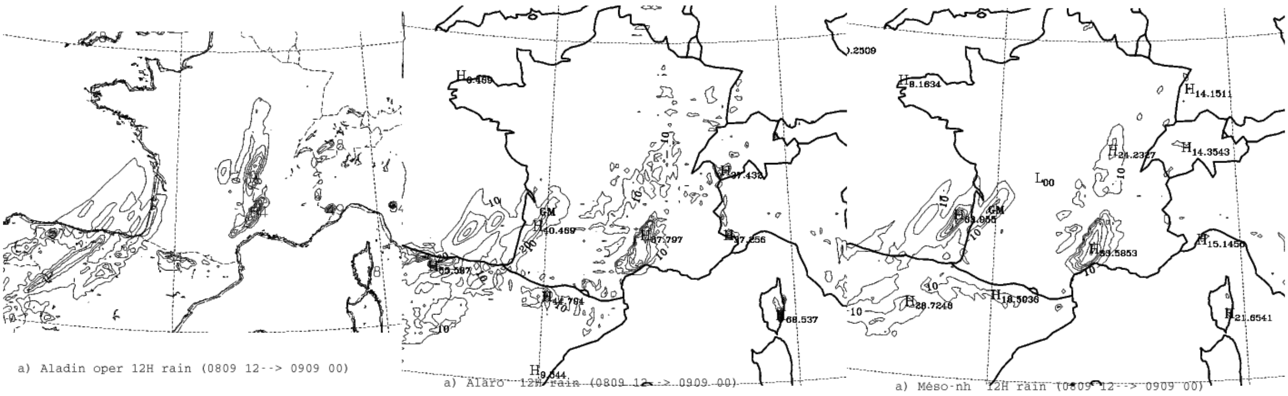

Figure 10 : 12 h-cumulated rainfall
From left to right : a) ALADIN-oper (Δx = 9.5 km), b) ALARO-10 (Δx = 10 km), c) Meso-NH (Δx = 10 km)

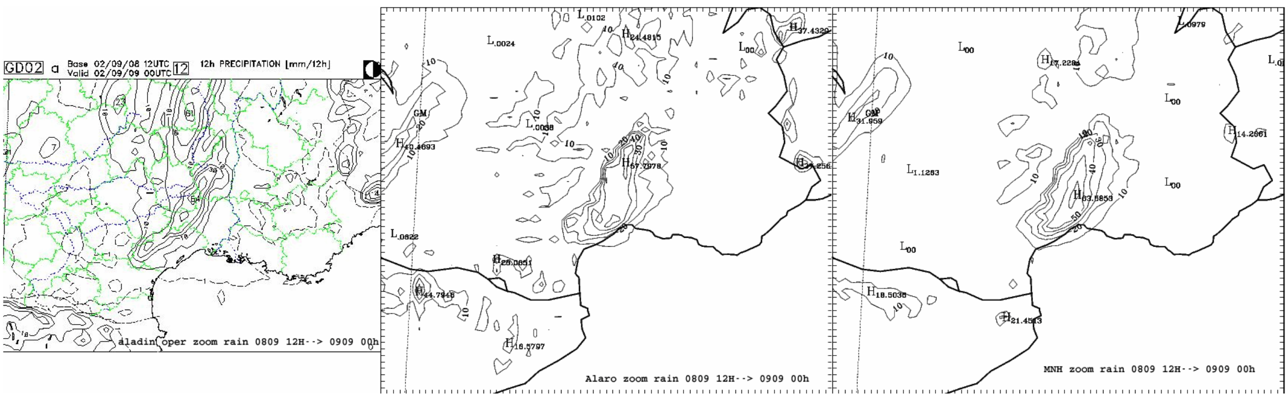

Figure 11 : Zoom of Fig. 10 over southern France.

The ALARO-10 and Meso-NH results are similar except that the output from ALARO-10 is noisier. The reason for that is not yet understood. Looking at the convective event, the amount of precipitation is about the same between all models at 10 km resolution (~ 60 mm in 12 h), which is far from what is given by the observations and by the finer-scale models (~ 300 mm in 12 h). Regarding the location of the convective system, no 10-km resolution model is satisfactory, they have the common problem that the simulated system has a too North-South orientation. The high resolution runs exhibit a better West-East orientation. It is important to note that the location and orientation of the system is very sensitive to the initial and coupling conditions which are different in the high resolution runs (thanks to with fine-scale data assimilation with bogussing of humidity data).

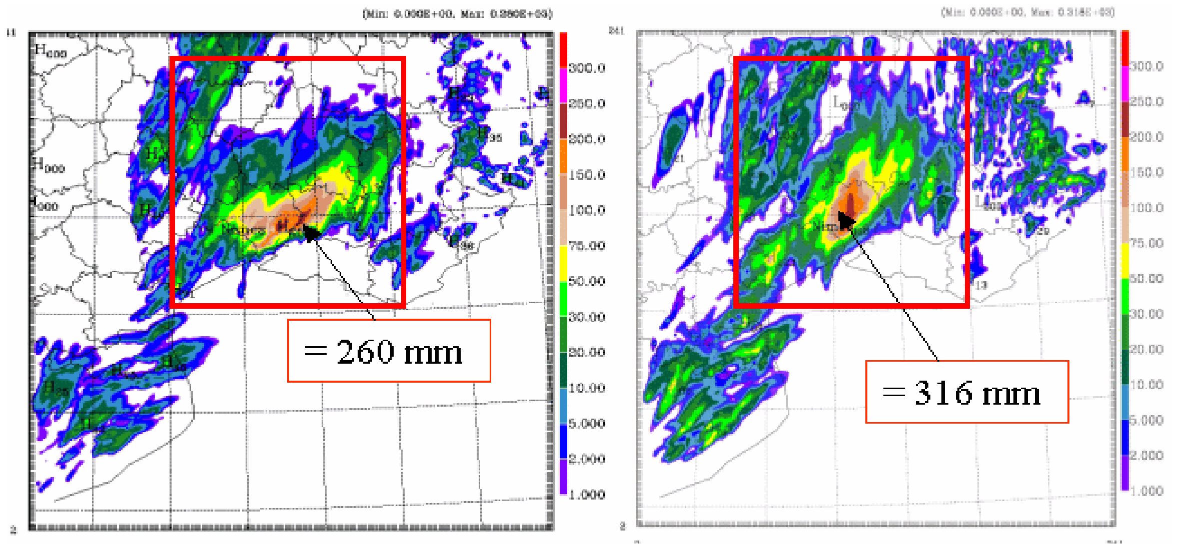

Figure 12 : Meso-NH (left) vs AROME (right) simulations at a resolution of 2.5 km.
Meso-NH is used in grid-nesting mode, with an intermediate run at 10 km, and coupling every 3 h at each level.

4. CONCLUSION

One cannot draw a final conclusion about the relative merits of ALADIN and ALARO-10 on the sole basis of these experiments. It can only be said that each model behaves in a physically reasonable way, and has its own weaknesses. ALARO-10 was never optimized physically or algorithmically, so it could probably be improved. At the time of writing it is unlikely that CNRM will be able to perform any more work to understand or improve this ALARO-10 model, since all the available ALADIN-2 workforce in the GMAP group has been shifted to new priorities.

CONTENTS