Kain-Fritsch in Hirlam. Convection over Spain and France.

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1. Introduction.

Precipitation and cloudiness are some of the most important variables forecasted by a numerical model. For general public in fact, precipitation is the most important one. Consequently, we have to take into account that condensation and convection should be a key issue in the Hirlam scientific plan.

STRACO (Sass 1997, Sass et al. 1999) is the current scheme in the Hirlam reference system. One of the main advantages of this scheme is that it makes smooth transitions between convective and no convective columns. As horizontal resolution of the reference Hirlam system will (should) increase in the next future, a new convection scheme is needed in order to match mesoscale convective features.

After some internal discussion it was decided to use the Kain-Fritsch scheme (Kain and Fritsch 1993). It is a very well known scheme and very much tested in mesoscale cases. At the same time it was decided to change the old Sundqvist condensation scheme (Sundqvist 1993) for the new formulation made by Rasch and Kristjansson (Rasch and Kristjansson 1997).

Then a new condensation and convection scheme was built (hereafter the K-F scheme) by Colin Jones from the Rossby Centre and Viel Odeegard from DNMI. In this short note we'll show the first tests of the new scheme in some convective cases over Spain and France, and also two preliminary parallel runs comparing also the new scheme with the Hirlam reference system (STRACO).

2. Hirlam experiments.

We have used two different versions of Hirlam, the one installed at INM, which is Hirlam 4.6.2, running on a Cray C94 and Hirlam 4.9.0 running on the VPP5000 at Ecmwf. Two different horizontal resolutions have been used, 0.5 deg. latxlon and 0.25 deg. latxlon.

The integration area is the same in all experiments (15.5-65.0 N; 66.5 W-30.0 E), also the vertical resolution was the same (31 levels) and finally eulerian dynamics was used with a timestep of 240 sec. for 0.5 resolution (both STRACO and K-F) and 120 sec. for 0.25 deg. resolution.

3. Case studies.

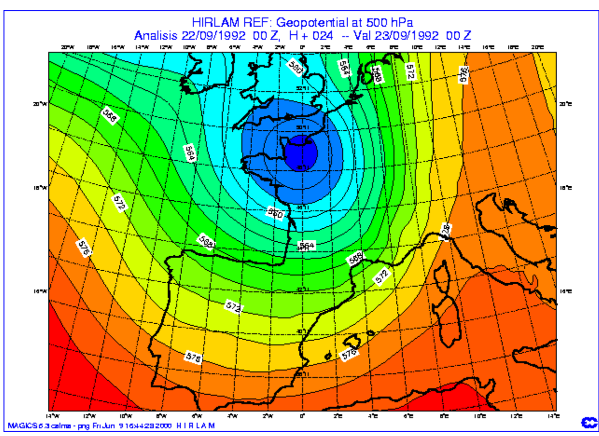
Three cases have been selected to test the new condensation and convection scheme. Strong convective precipitation in a short period was recorded in every case. Two cases were over Spain and one over France. Two cases are related with typical Mediterranean convective situations and the other one is related with convection forced by a fast deepening cyclone coming to the Iberian Peninsula from the Atlantic.

Results of different experiments are presented for the three case studies.

3.1 Vaison La Romaine.

In September the 22nd, 1992 a deep through came to France from the Atlantic. In a quite typical evolution the cold front forced a convective activity all over SE France. Such convection was fed, as sometimes happen, by a southeasterly wind that drives warm and moist air from the West Mediterranean Sea. This is a typical autumn evolution: the sea is warmer than the air and the zone has a strong convective capability.

Synoptic situation is sketched in figures 1 and 2, representing 500 hPa geopotential and 850 hPa.



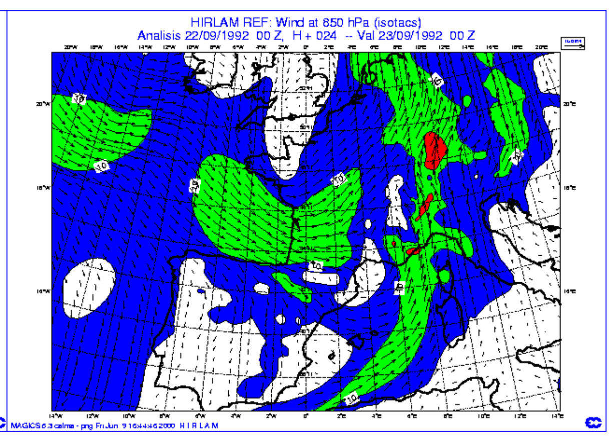


Figure 1. Figure 2.

Figure 3 shows the amount of precipitation recorded in 24 hours in the SE of France (thanks to Eric Bazile from MeteoFrance). We can see four places with more than 100 mm (maximum was 327 mm). We have to pay attention to the three maxima near the coast because they are the places where most of the floods happened.

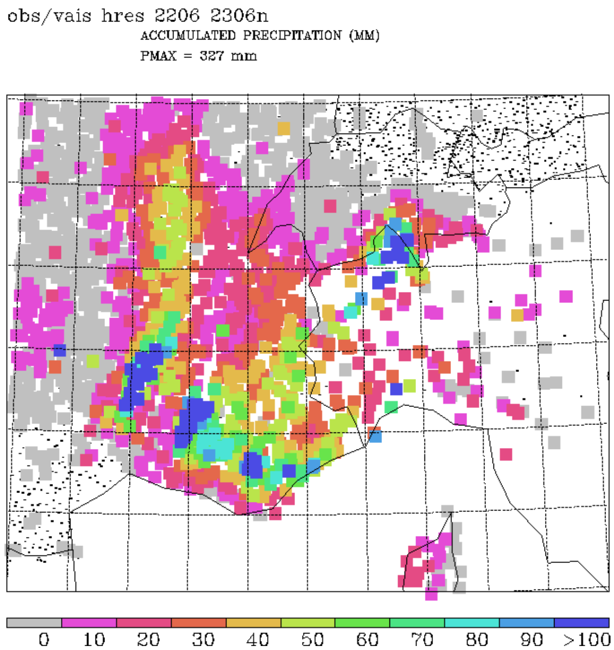
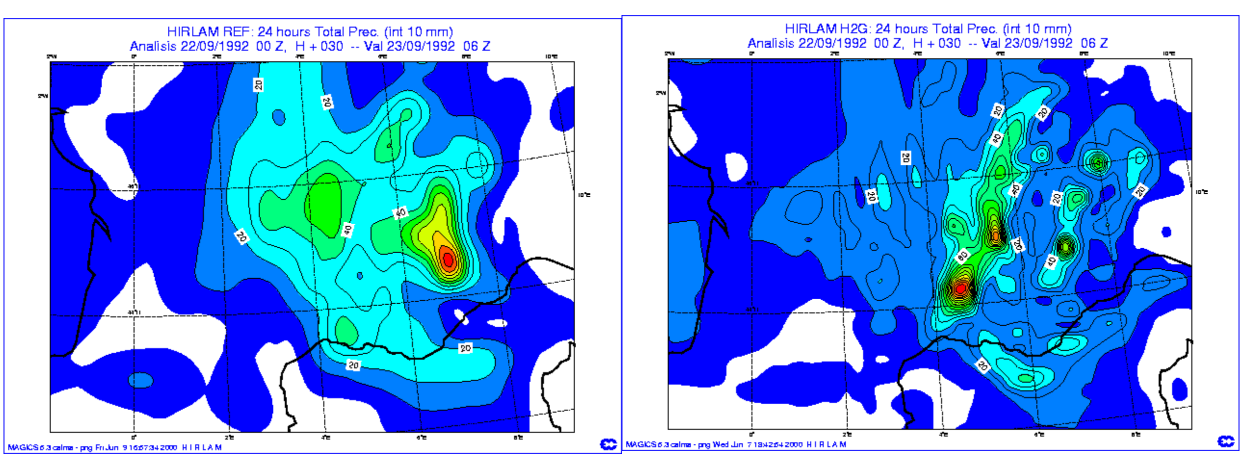


Figure 3.

Four experiments were done for this case, all of them with analysis and 30 hours forecast starting the 22nd at 00 UTC and using Hirlam 4.9.0 at Ecmwf. REF stands for reference (0.5 and STRACO), KFK stands for 0.5 resolution but K-F, H2G for 0.25 deg. resolution and STRACO and, finally, KF2 stands for 0.25 and K-F.

As a summary of results Figure 4 show total precipitation of the four experiments.



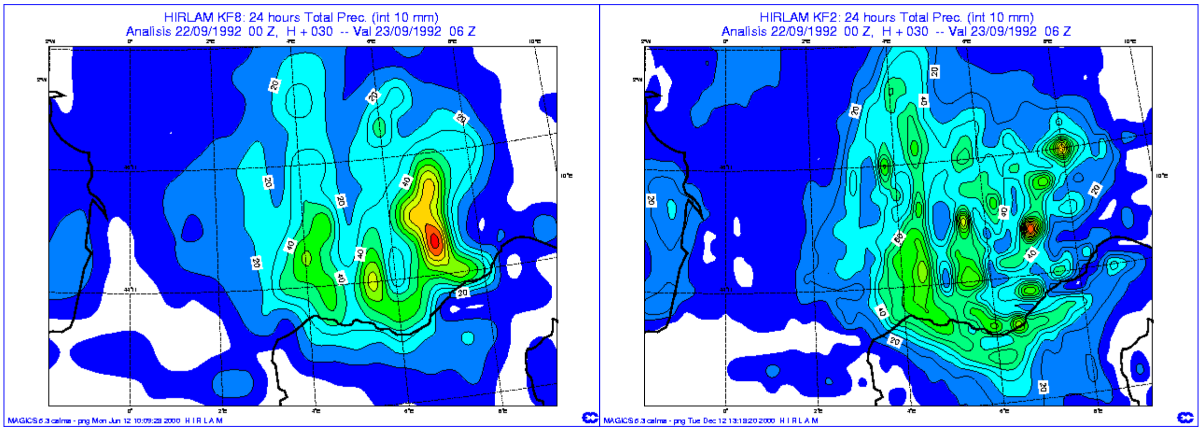


Figure 4.

The increase of horizontal resolution affects significantly to the amount of precipitation. That is quite normal because in this kind of situation precipitation is close related with the role orography plays triggering the convective activity. However, K-F gives more precipitation than STRACO (much better results in higher resolution).

3.2 Valencia.

This is also a “Mediterranean” case, where forcing due to orography and low-level winds are very important in triggering and feeding convection. Figure 5 shows synoptic situation on September 11th, 1996.

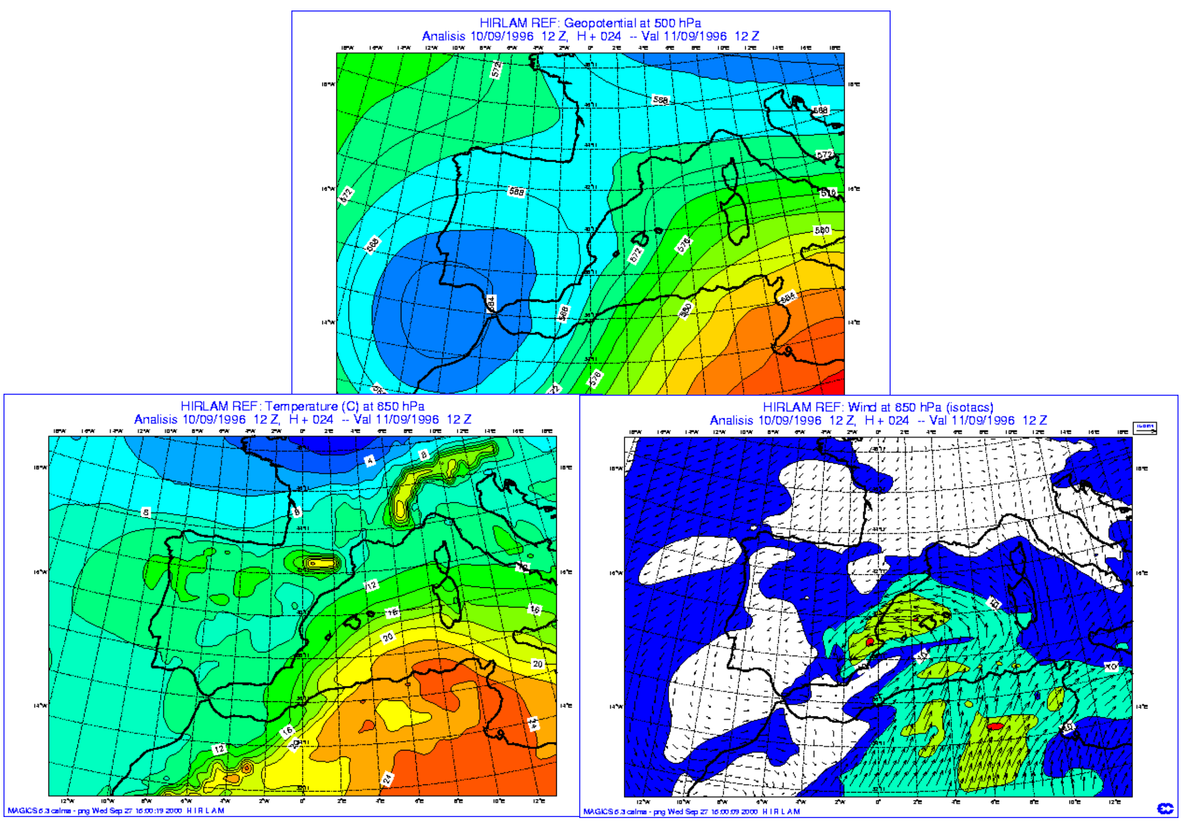


Figure 5.

It is clear that low level wind supplies moist air to convective systems. In the Figure 6 we can see precipitation recorded in the regional network of Valencia, where most of the precipitation fell down. Maximum was 459 mm in 24 hours (red zone means more than 300 mm).

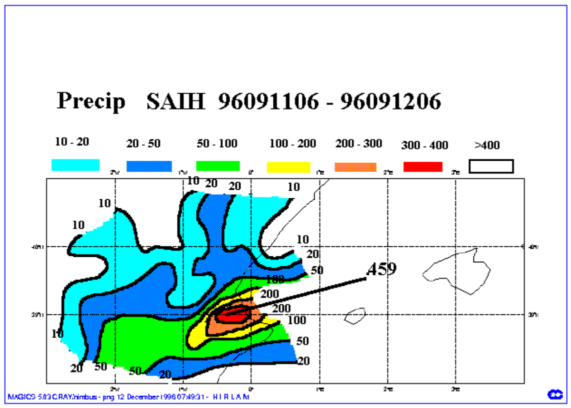


Figure 6.

For this case only REF, H2G and KF2 were performed, because we know from the previous case that the role of the resolution is larger than the one of the convection scheme. Figure 7 shows precipitation of H2G and KF2, both at 0.25 deg. resolution.

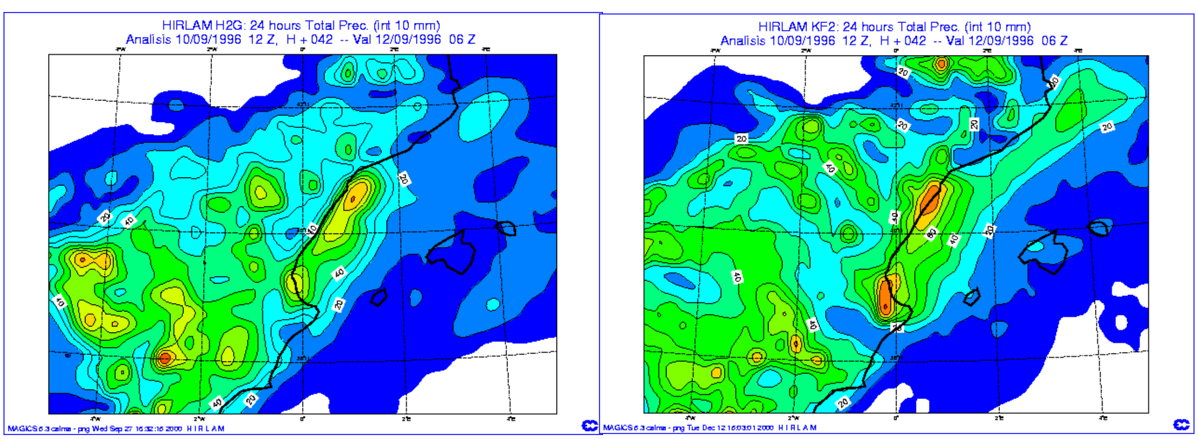


Figure 7.

Both experiments fail to match the maximum at the Gulf of Valencia but it seems that precipitation is a little bit better predicted by K-F.

3.3 Badajoz.

November the 4th, 1997 is one of the deepest cyclones ever recorded over Spain. The fast cyclogenesis made that a shallow low-pressure centre developed near the Portuguese coast became a deep cyclone just in a few hours. Together with the cyclone a large convective system was developed and more than 140 mm of precipitation were recorded. Although precipitation was smaller than in typical Mediterranean cases, it is very important to take into account that there was no source of moist air and forcing was primarily synoptic (it is orographic in the Mediterranean cases).

Figure 8 shows the situation the 5th at 12 UTC and Figure 9 the 6th at 00 UTC.

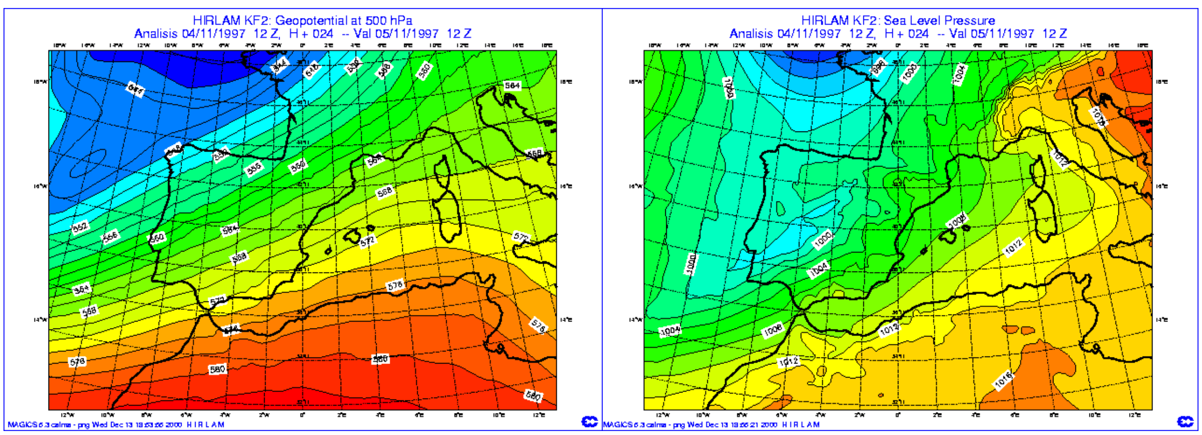


Figure 8.

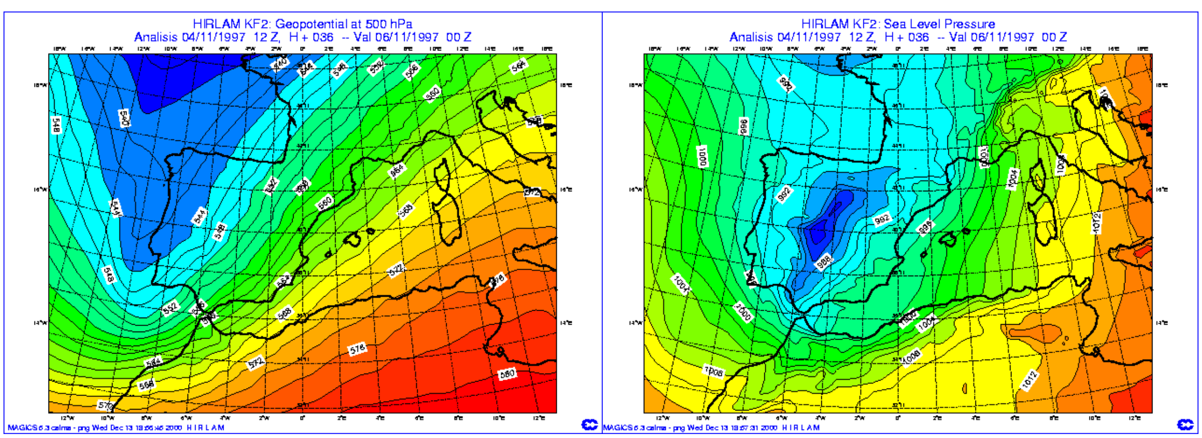


Figure 9.

Only experiments H2G and KF2 were performed, however the model gives a deepening of 12 hPa in 12 hours with a well caught trajectory of the low centre.

Looking at precipitation Figure 10 shows amounts recorded the 5th by the INM network (more than 140 mm in two places).

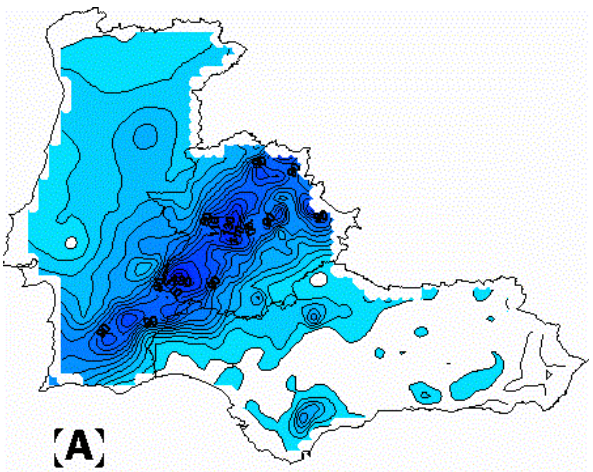


Figure 10.

We can compare with precipitation from the experiments H2G (STRACO) and KF2 (using K-F and resolution of 0.25) that gives more than 110 mm. Location of maxima are better in KF2 than in H2G.

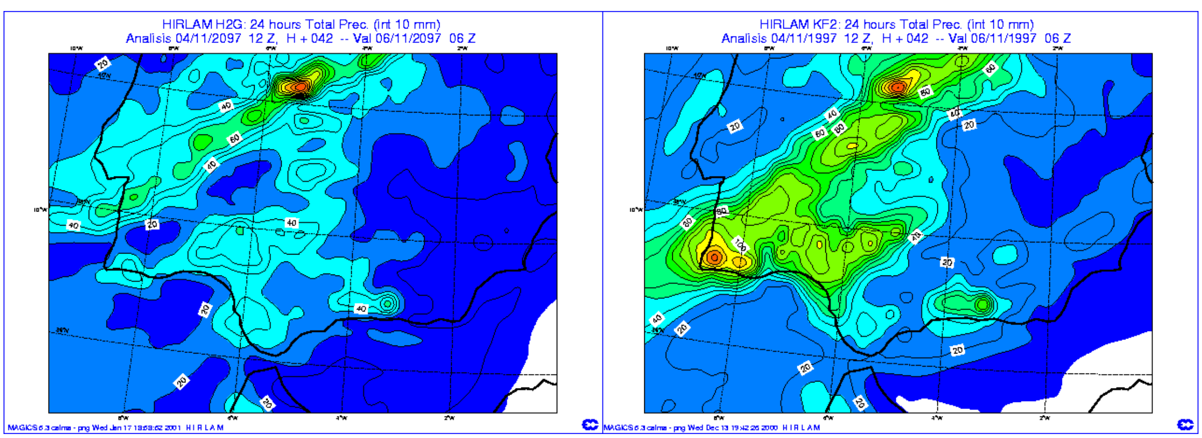


Figure 11.

4. Parallel tests.

After these case studies a set of parallel tests were performed to know if K-F is able to improve scores comparing with Hirlam reference system.

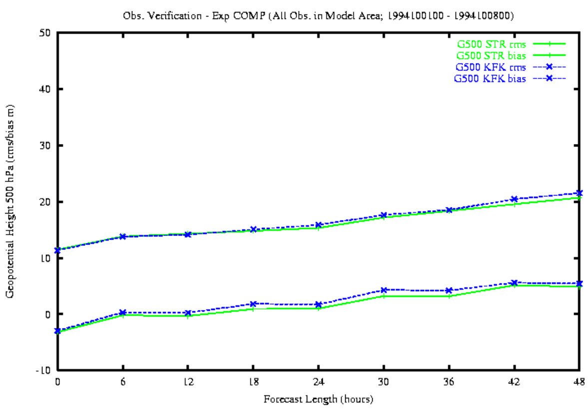
We use the integration area and resolutions that we show in the experiments above and we did two set of parallel test, one at INM with Hirlam reference 4.6.2 and 0.5 deg. of horizontal resolution, and the other one at Ecmwf using both 0.5 and 0.25 deg.

The validation period was in both systems October 1994, from the 1st to the 15th. All the experiments had their own assimilation cycle every 6 hours and 48 hours forecast period.

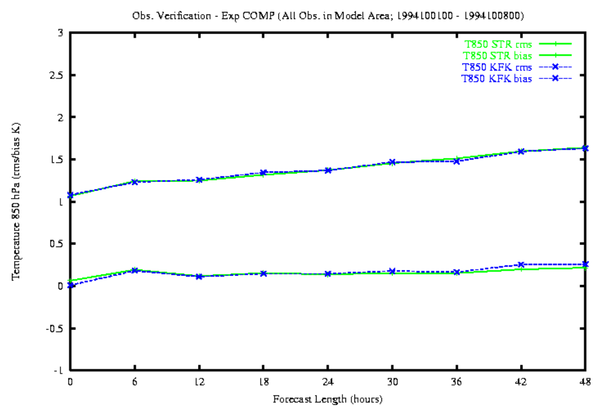
4.1 At INM (Hirlam 4.6.2).

At INM only two tests were performed; STR for the reference system and KFK for K-F, both at 0.5 deg. resolution.

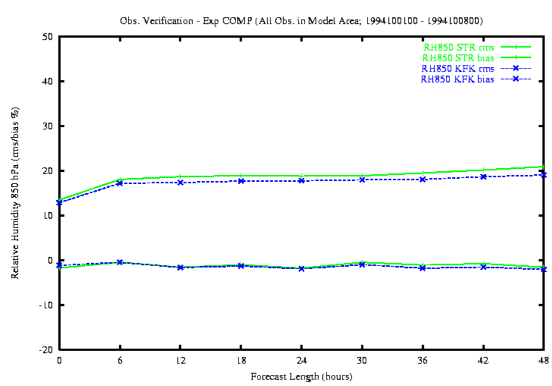
In the score plots we can see that there is no impact in middle troposphere and only relative humidity shows an small improvement (Figure 12). In all of these plots blue is used for K-F and green for STRACO.



500 hPa Geopotential



850 hPa Temperature



850 hPa Relative humidity

Figure 12.

K-F shows better results in almost all surface parameters except in Sea Level Pressure as it can be seen in Figure 13.

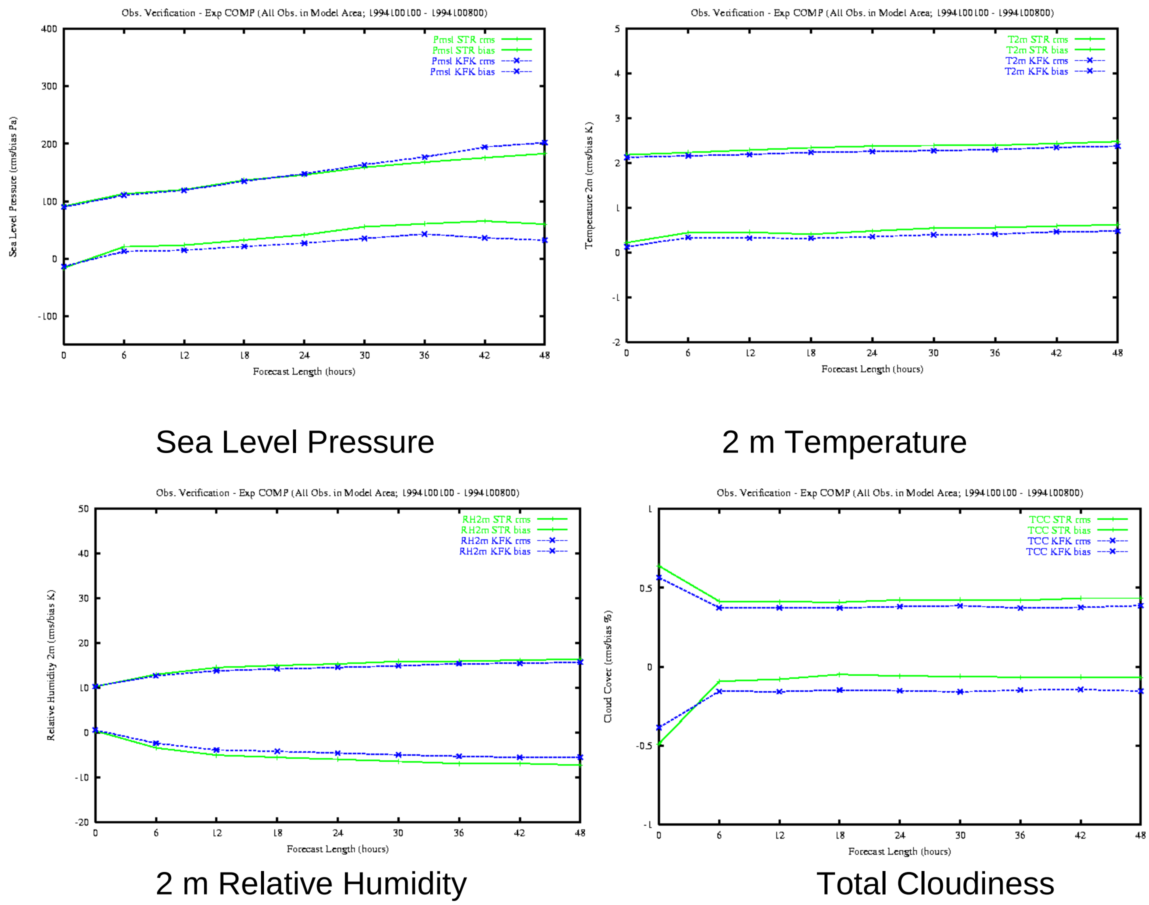


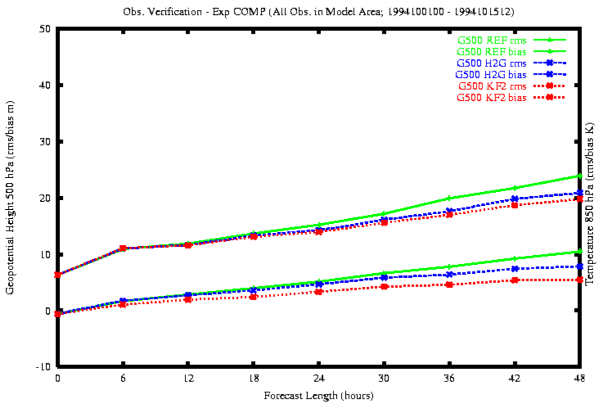
Figure 13.

4.2 At Ecmwf (Hirlam 4.9.0).

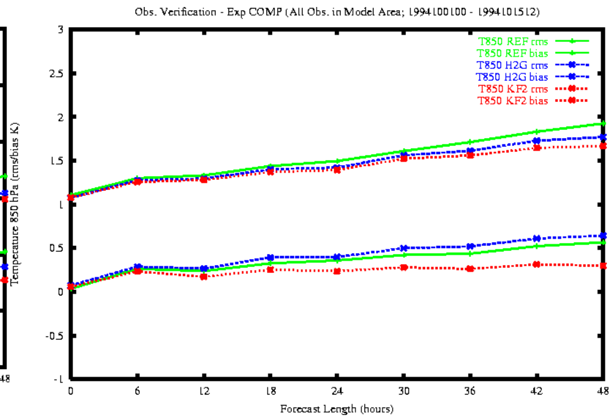
In this case we performed three different experiments, REF as reference (4.9.0) at 0.5 deg. resolution (green lines), H2G with 0.25 deg. and also the reference system (blue lines) and finally KF2 that means, as above, 0.25 deg. resolution and K-F (red lines).

The period was the was the same as it was used for INM integration (October 1994), 6 hours assimilation cycle and 48 hours forecast were performed for all experiments.

Results can be summarised as follows, the large impact came from the increase of horizontal resolution, this means that H2G and KF2 have much better scores than REF. Additionally, KF2 improves a little bit H2G scores almost everywhere as it can be seen at Figures 14 and 15.

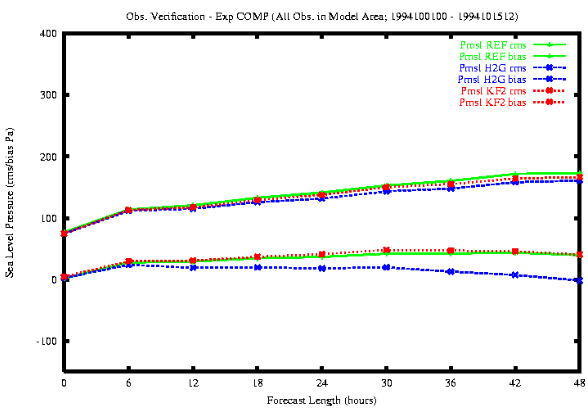


500 hPa Geopotential

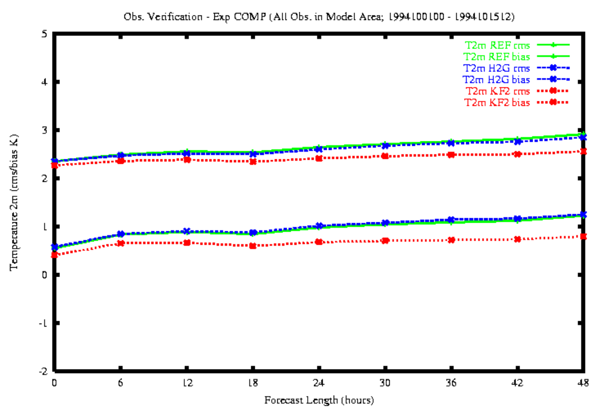


850 hPa Temperature

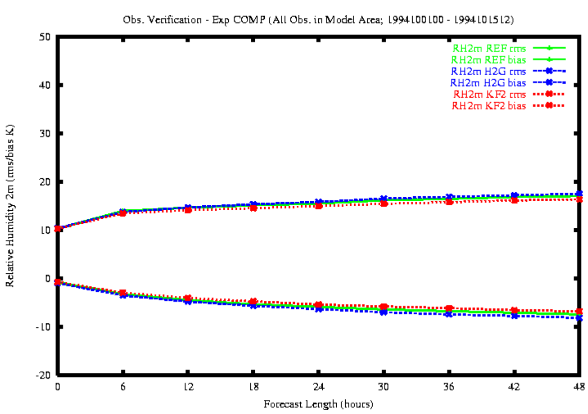
Figure 14.



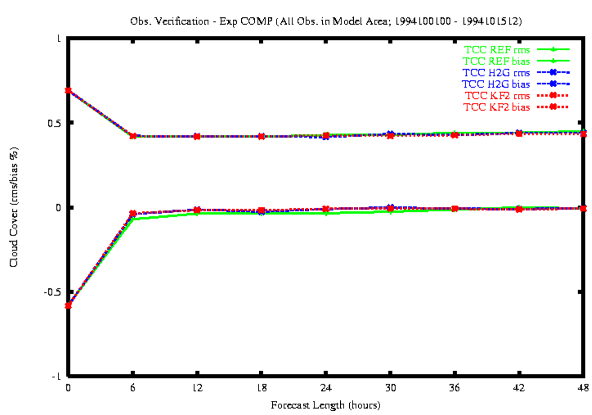
Sea Level Pressure



2 m Temperature



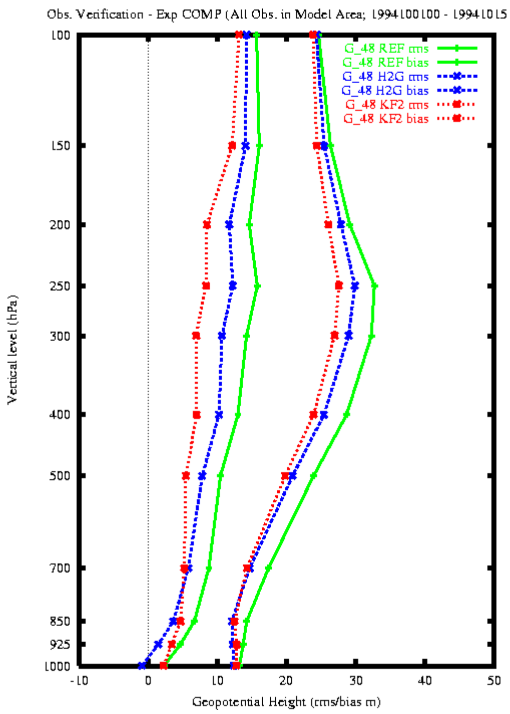
2 m Relative Humidity



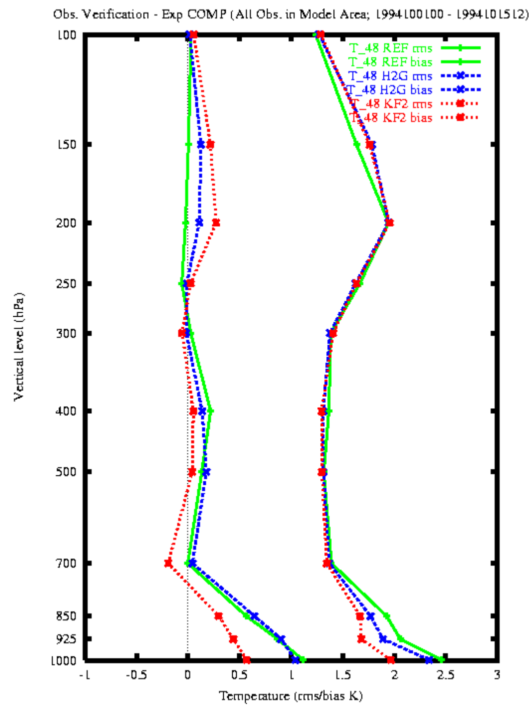
Total Cloudiness

Figure 15.

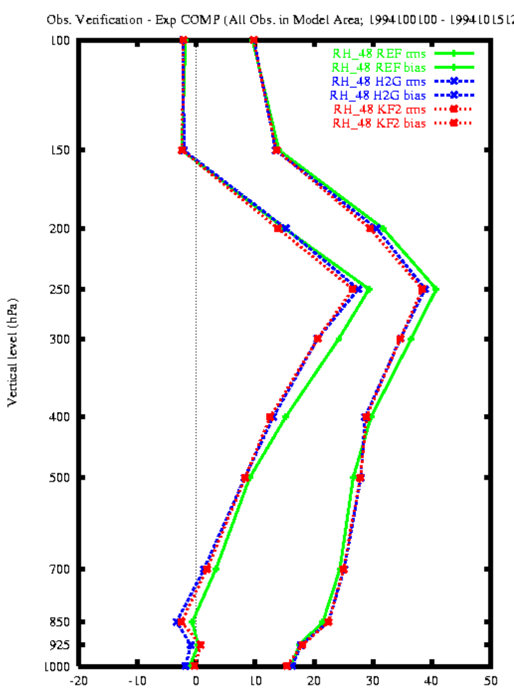
The vertical structure of the error is shown in figure 16. Plots are for 48 hours forecast where differences among the experiments are clearer.



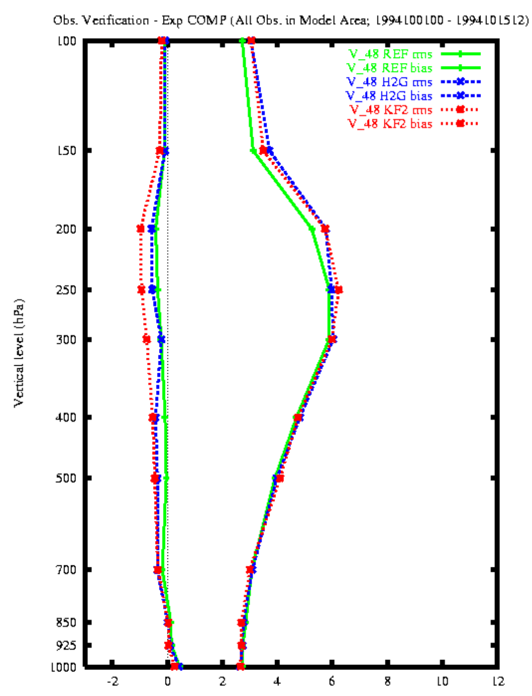
Geopotential



Temperature



Relative Humidity



Wind

Figure 16.

5. Conclusions.

From the above following preliminary conclusions can be drawn about the performance of K-F+R-K in the Hirlam reference system:

- Good results in convective cases (even taking into account the role of the horizontal resolution).

- Better representation of the amount and location of precipitation.

- First results in parallel tests, we need another period.

- Slightly better results in 0.5 resolution, both mainly in low levels and moisture variables.

- Better results in 0.25, middle troposphere and surface.

6. References.

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