Kain-Fritsch in Hirlam

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1. Introduction.

Condensation schemes are one of the most important parameterisation schemes in numerical models. Everything related with water phase changes in models is important because the energy involved in them is very large.

Also precipitation is a key parameter for weather forecasts. As a consequence the condensation scheme (convection + large scale condensation) plays a key role in mesoscale models. As Hirlam is going to higher resolutions we need a convection scheme more suitable for such scales. The Kain-Fritsch (Kain and Fritsh, 1993) is the one has been chosen.

It is a very well known scheme running in the MM5 model and well tested in a wide range of convective cases at the USA.

Colin Jones from the Rossby Centre made the implementation of the Kain-Fritsch scheme in Hirlam and Viel Odegaard from DNMI made the implementation of the Rasch-Kristjansson scheme (Rasch and Kristjansson, 1997) as the large-scale condensation counterpart of KF. The RK scheme follows the ideas of Sundqvist in the parameterisation of microphysics (Sundqvist, 1993). The final result is the KF+RK scheme.

2. Cases study.

To test the new scheme we have chosen some cases study which quite a lot of convective precipitation. We did experiments with Hirlam 4.9.0 at ECMWF. A horizontal resolution of 0.25 deg. latxlon was chosen.

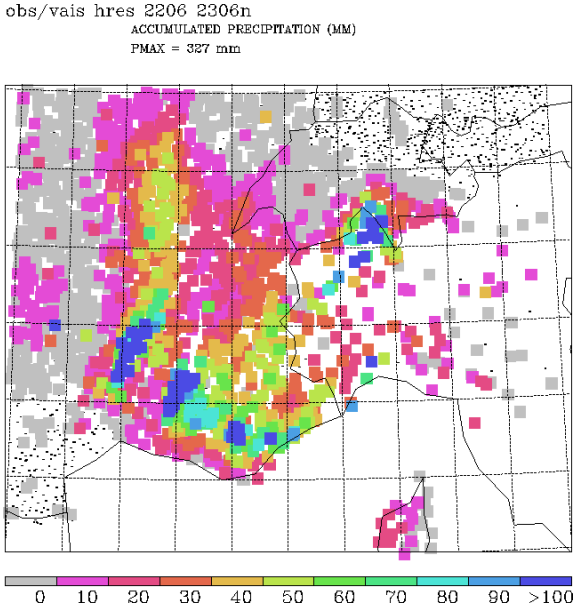
Most of the results from the different experiments were published in a recent Hirlam Newsletter (García-Moya, 2001), so we're going to present here only the most relevant ones.

2.1 Vaison-La Romaine.

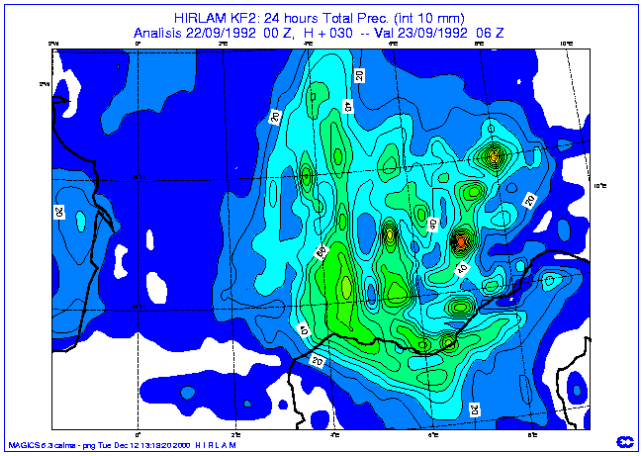
It was a typical Mediterranean convective situation. It happen in Vaison-La Romaine, at the SE of France in September the 22nd, 1992.

When a cold front approach the West Mediterranean in autumn, atmosphere become conditionally unstable and low level air is warm and wet, so convection feed by this air becomes quite intense and large amounts of precipitation are normally recorded.

In the figure below (courtesy of Meteo-France, thanks to Eric Bazile) we can see few places where more than 300 mm were recorded.



Experiments with 0.5 and 0.25 deg. horizontal resolutions and with STRACO and KF+RK show that the main improvement in precipitation is related with the increase of resolution (better representation of the orography). KF+RK also shows slightly better precipitation pattern than STRACO. We show here precipitation from the experiment at 0.25 and with KF+RK.

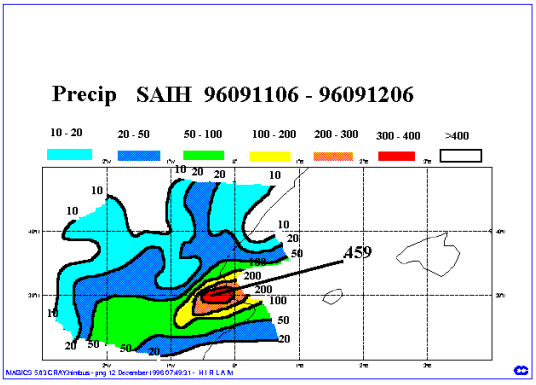


KF+RK gives more than 160 mm where more than 320 were recorded.

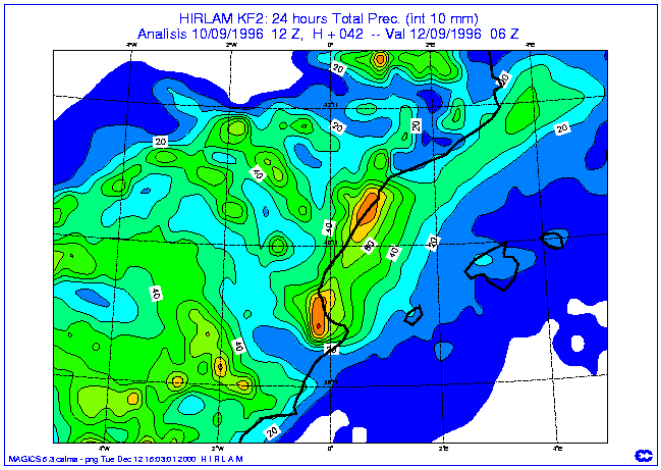
2.2 Valencia.

It is also a typical Mediterranean convective situation but in this case the convective forcing were larger than in Vaison. As a result more than 450 mm of precipitation in a few hours were recorded in some places near Valencia, at the Spanish Mediterranean coast. It happens also in autumn, September the 10th, 1996.

Convection was over the same place for a long time due to a low level jet of hot and wet air coming from the Mediterranean and converging due to orography. In the next figure we show precipitation recorded by a network of automatic observing stations in Valencia.



Although precipitation given by Hirlam is very far from recorded values, KF+RK again gives slightly better values for the maxims. Once again resolution is the key factor due to the better orography. Following we show precipitation given by KF+RK at 0.25 deg. resolution.



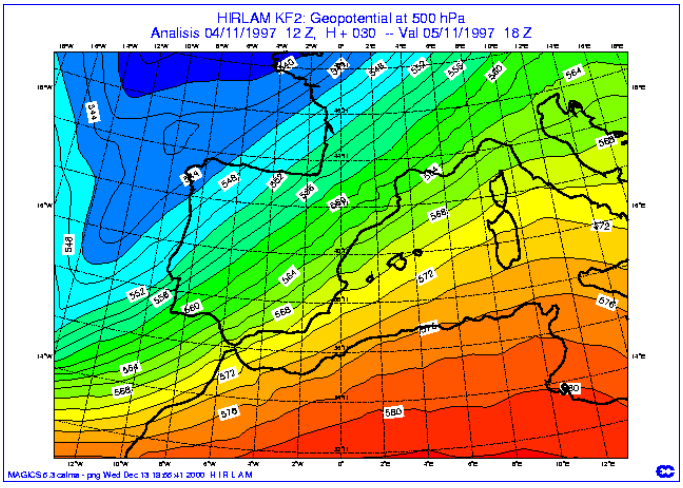
2.3 Badajoz.

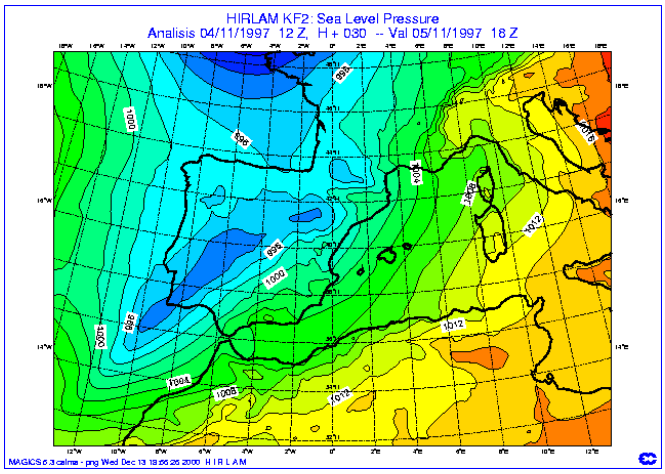
This case study is different from above, convection here is not related with mesoscale forcing but with synoptic one. At November the 4th, 1997 a shallow cyclone reach the Portuguese coast and a very fast cyclogenesis happen. When the cyclone came to Spain deepening was more than 10 hPa in just 12 hours (from 990 hPa to 980 hPa).

Convection and convective precipitation were close related with this cyclogenetic process.

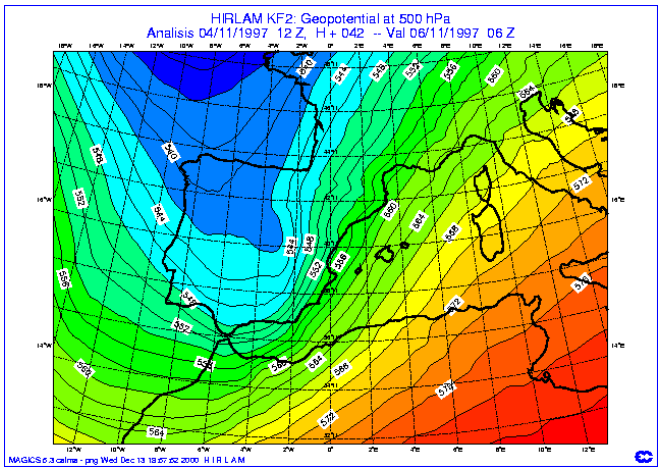
We run Hirlam for 48 hours forecast at two different resolutions (0.5 and 0.25 deg.) and also using STRACO as reference and KF+RK.

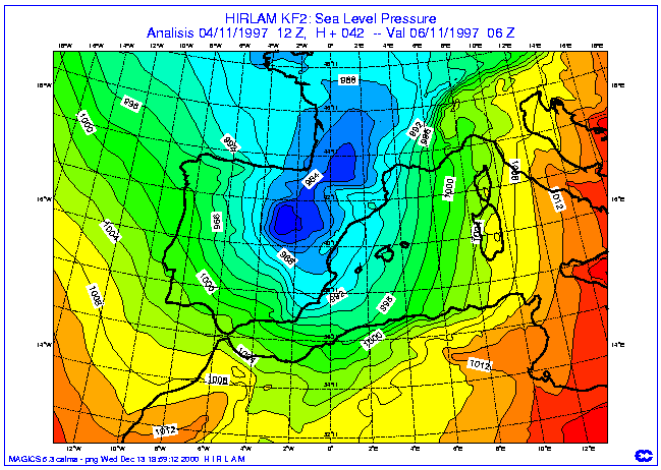
We'll show results with the new scheme, below we'll show 500 hPa and Sea Level Pressure at the beginning of the cyclogenesis (H+30, 5/11/1997 at 18 UTC).



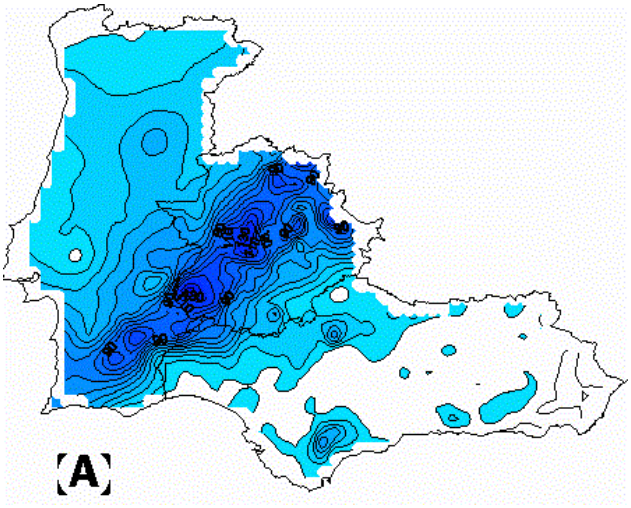


We can compare these plots with minimum pressure of 990 hPa with the pattern the 6/11 at 06 UTC (12 hours later) with a central pressure of 978 hPa.

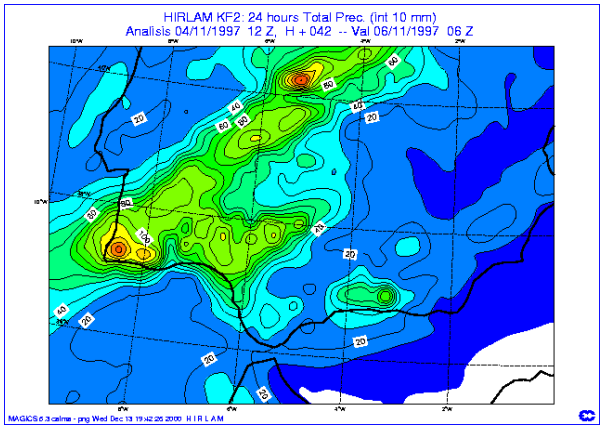




Looking for precipitation, in the figure below we show 24 hours precipitation recorded in the Spanish and Portuguese climatic network. We can see a couple of maxims with more than 140 mm. Precipitation was also organised in a narrow band that was well captured by Hirlam and KF+RK.



Precipitation given by Hirlam KF+RK at the same period is shown below.



3. Parallel tests.

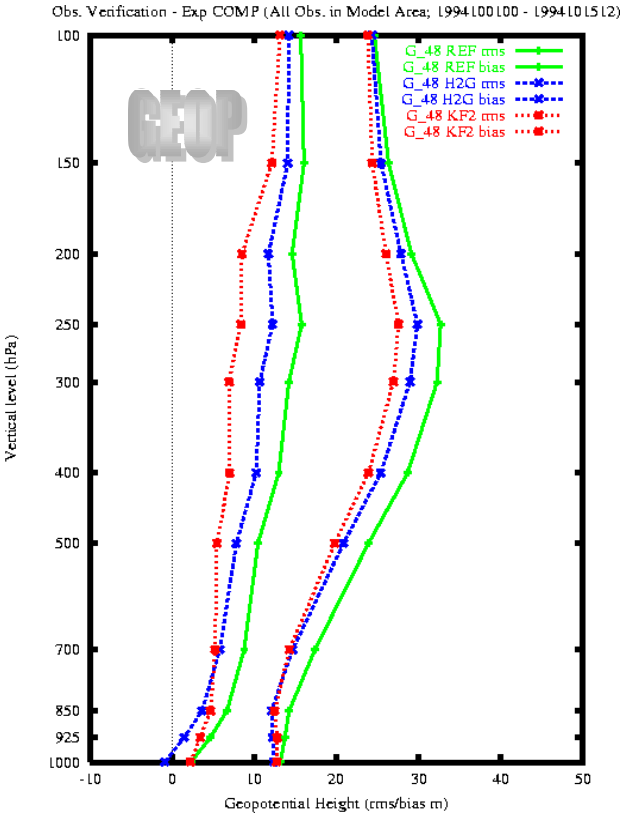
To investigate how the new scheme performs in neutral cases we have to make a parallel run. Two different periods of fifteen days were chosen. The first one in autumn 1994 and the second one in spring 1995. We did 6 hours assimilation cycle with 48 hours forecast every 6 hours. Of course, each experiment has its own assimilation cycle.

Experiment called REF represents Hirlam reference 4.9.0 at 0.5 deg. resolution, the one called H2G is the same reference but at 0.25 deg. resolution and, finally, KF2 represents KF+Rk at 0.25 deg.

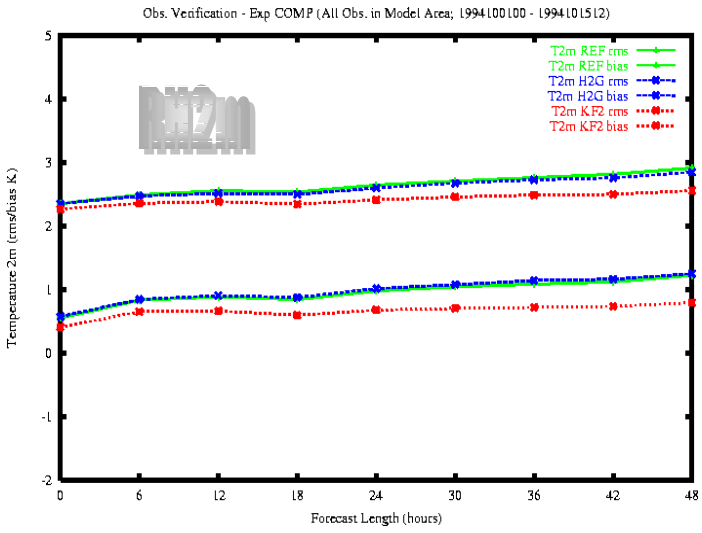
Results from the two periods chosen are slightly different, meanwhile in the autumn period the new scheme performs better than reference in geopotential and also in temperature in lower troposphere, in spring the new scheme performs slightly

worse in middle troposphere parameters and better in surface ones.

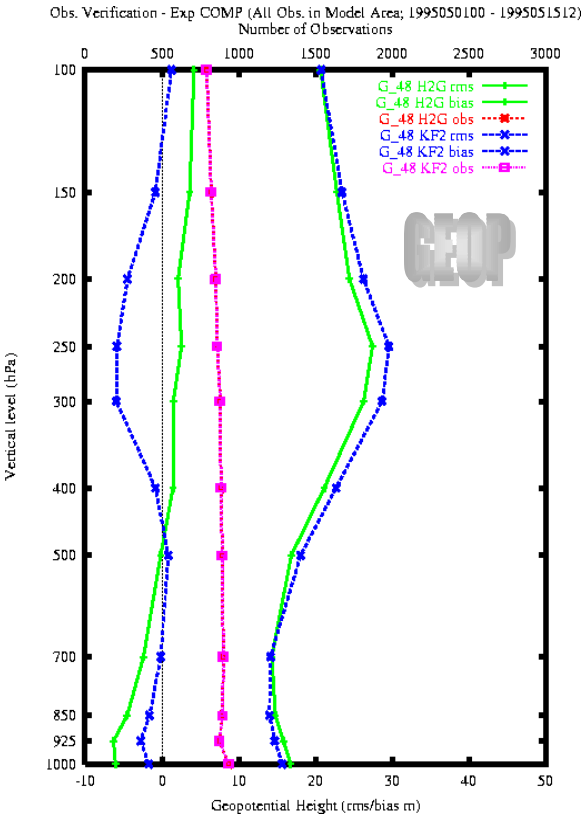
As an example we'll show in the figure below vertical structures of scores for geopotential in the autumn period.



As colours can not be seen is difficult to distinguish between the different experiments but KF2 gives the best results in both bias and rms.



Above we show scores for Relative Humidity at 2m that shows also KF+RK giving the best scores among the three experiments.



The plot above represents scores for the spring period where only H2G and KF2 experiments are shown. In this period STRACO gives better results than KF+RK.

Another important subject when we speak about operational models is performance in terms of computer time. In this case KF+RK has a lot of If blocks and the consequence is the scheme has a very bad vectorisation. Then at VPP5000 the model with the new scheme takes 200% more elapsed time than the old one. This is only the case in vector machines because using scalar processors Hirlam with the new scheme takes only 30% more elapsed time than reference.

4. Conclusions.

After the implementation of the new condensation scheme in Hirlam done by Colin Jones and Viel Odegaard, we make some test to know how the new scheme behaves in Hirlam.

We obtain very good results in convective cases study, even taking into account the role horizontal resolution plays in some of these cases. We obtain a better

representation of the amount and location of the maxims of precipitation.

In the Badajoz case we also obtain a very good simulation of the cyclogenesis with more than 10 hPa deepening in 12 hours.

We do also a parallel test in two different periods, one in autumn when convection is more active in Spain, and another one in spring. We've got better scores in autumn in middle and lower troposphere.

Thinking in optimisation of the code, perhaps some work should be done in that area before to introduce the new scheme in the reference system.

5. References.

1. Kain, J. S. and Fritsch, J. M. 1993: Convective parameterization for mesoscale models: the Kain-Fritsch scheme. *The Representation of Cumulus in Numerical Models. Meteorological monographs, Emanuel and Raymond Eds.,* ***24****, 165-170.*
2. Sundqvist, H. 1993: Inclusion of Ice Phase of Hydrometeors in Cloud Parameterization for Mesoscale and Largescale Models. *Beitr. Phys. Atmosph.,* ***66****, 137-147.*
3. Rasch, P. J. and Kristjansson, J. E. 1997: A comparison of the CCM3 model climate using diagnosed and predicted condensate parameterizations. *J. Climate,* ***11****, 1587-1614.*
4. García-Moya, José A. 2001: Kain-Fritsch in Hirlam. Convection over Spain and France. *HIRLAM Newsletter* ***37****, 35-46.*