Use of reflectivity to validate Hirlam

Irene Sanz, J.A. García-Moya

INM – Madrid, Spain.

ABSTRACT

Nowadays, one of the main concerns in the validation and verification of numerical prediction models is the verification of the precipitation. This variable is more difficult to verify than the rest of one because of the precipitation has a high variability in space and time. To do it, one suitable parameter is the reflectivity. At INM, a model used to simulate radar reflectivities (Radar Simulation Model, RSM) is running, thanks to it, it is possible to get simulated and observed reflectivity with the same resolution and compare them.

In this paper, RSM has been used in a case of a convective severe thunderstorm that took place in the Eastern part of Spain in 2001. Forecast fields of Hirlam with three different resolutions and actual files of radar network have been needed for this work. Several images obtained for this case will be presented.

1.INTRODUCTION.

Most of the meteorological variables observed are verified at INM, in special the surface variables, such as pressure at sea surface level, 2meter temperature, 10meters wind, cloud cover and 2 meter moisture. Nevertheless, there is one variable that is not verified, the precipitation. .

Precipitation verification is more complicated than the rest of the variables because of the high variability of precipitation in space and in time. For this reason it's necessary look for parameters related with the precipitation and with homogeneous horizontal and vertical distribution.

A valid parameter to help the verification and validation of Hirlam is the reflectivity. There are actual reflectivity measurements of radars in a short period of time in several heights of the atmosphere.

A good tool to verify the precipitation could be Radar Simulation Model (RSM), because thanks to it, it is possible to obtain simulated reflectivity and compare it with actual reflectivity obtained from radar network.

2.HIRLAM MODEL.

Hirlam at INM is running in the multiprocessor supercomputer Cray-X1. Thanks to it, it is possible to run higher horizontal resolutions for Hirlam, reaching 0.16 degrees and 0.05 degrees. The version used of Hirlam is 6.1.2. and the forecast fields covers hours from 00 to 72 every hour. The features of three experiments used in this work are shown in the table below.

Horiz. resol.	*lat x lon*	*Vertical levels*	*Area coordinates*				*South Pole*	
0.20	194 x 100	31	50.0 N	66.5 W	15.5 S	30.0 E	-90.0	0.0
0.16	582 x 424	40	32.18 N	46.5 W	35.5 S	46.46 E	-35.0	-15.0
0.05	366 x 272	40	10.75 N	15.0 W	10.7 S	15.25 E	-49.5	-6.0

Table 1. Features of Hirlam experiments

The areas of these experiments are represented in the figures in red points, in the case 0.2 degrees (Figure 1) and enclosed by the blue line in the others figures.

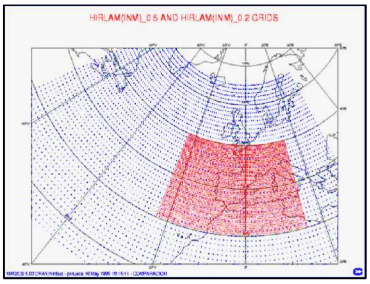
Figure 1. area 0.2 deg.

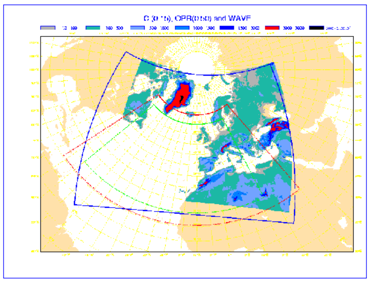
Figure 2. area 0.16 deg.

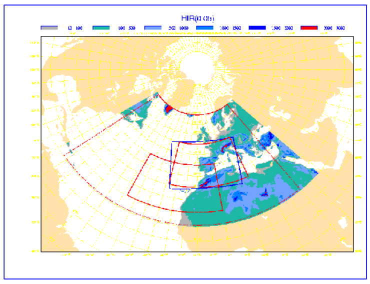
Figure 3. Area 0.05 deg.

3.RADARS AT INM.

Radar network at INM is formed by 13 radars located all over Iberian Peninsula plus one in Canary Island. All radars can work in two different modes of action, normal mode and Doppler mode.The radius of action and the resolution of radars depend on the mode. In the Normal Mode, the radius of action is 240 Km and the resolution is 2x2 Km^2 and in the Doppler Mode the radius of action is 120 Km and the resolution is 1x1 Km^2.

There are 20 elevation angles and for each elevation angle the radar covers 360 degrees. In next table these angles are shown.

Elevation angles																		
0.5	1.4	2.3	4.1	5.0	5.9	6.8	7.7	8.6	9.6	10.7	12.0	13.4	14.9	16.6	18.4	20.4	22.6	25.0

Table 2. Elevation angles.

Radar images are obtaines every 10 minutes. Then, these images are processed in Regional Radar Centres where orographic filters are applied to them. After that, the polar coordinates (PPI) are turn into cartesian coordinates (CAPPI), so that products obtained from Regional Radar Centres are CAPPI's or vertical sections. The main features of these reflectivity products are:

a) PPI (Plan Position Indicator): it's a product created in the lowest angle. It's a flat image, so it is useless to visualize the three dimension structure. Data can be obtained in normal mode and in Doppler mode and they are available every 10 minutes.

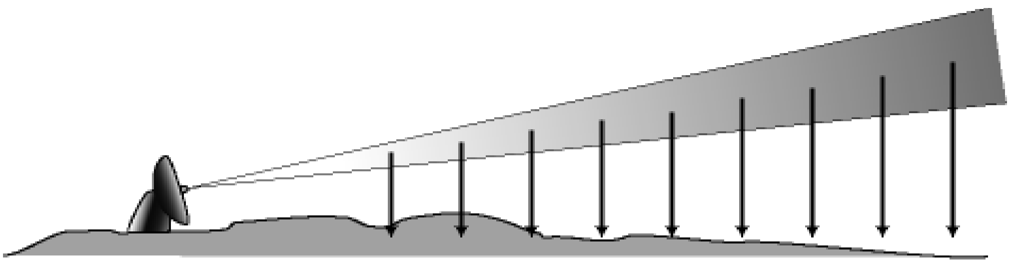
Figure 4. PPI proyection

b) CAPPI (Constant Altitude Plan Position Indicator): it's a vertical section that represents the values on a horizontal plane. Data can be obtained only in normal mode every 10 minutes. There are 12 CAPPIs and each of one has a heigh over sea surface level that is equal for all radar except the CAPPI 1 where this heigh depends on the radar. The heights of the Cappi's are represented in table 3.

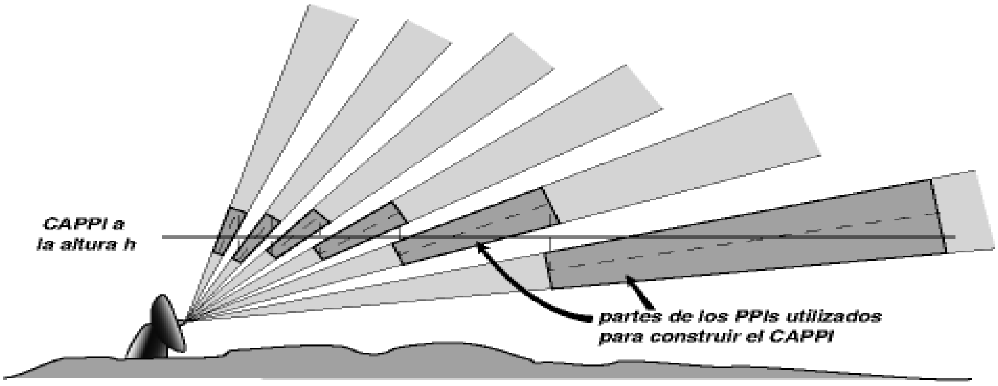

Figure 5. CAPPI proyection

CAPPI 1	***(1000-2100) m***	***CAPPI 7***	***7500 m***
CAPPI 2	***2500 m***	***CAPPI 8***	***8500 m***
CAPPI 3	***3500 m***	***CAPPI 9***	***10000 m***
CAPPI 4	***4500 m***	***CAPPI 10***	***12000 m***
CAPPI 5	***5500 m***	***CAPPI 11***	***14000 m***
CAPPI 6	***6500 m***	***CAPPI 12***	***16000 m***

Table 3. Heights of CAPPI's.

4.RADAR SIMULATION MODEL.

RSM uses forecast files of Hirlam and actual files of radar to simulate radar reflectivities. Then this files are converted in images getting two different images (the actual and the simulated ones). Both of them can be compared to obtain the relation between them.

To obtain these images, the RSM calculates simulated and observed reflectivity at the same resolution as the Hirlam forecast fields. The observed reflectivity is computed converting radar data (which are in ASCII format) into Hirlam grid.

In this work, this model has been used with three resolutions. The figures show the images obtained by RSM and the actual image obtained by radar network.

5.CASE OF STUDY.

On the night of October the 10th in 2001 there was a convective situation associated with a severe supercell over Southeast of Iberian Peninsula (around Murcia and Alicante). This caused important damages in areas around Murcia and Alicante because of the size of kernels hail. Heavy rain in a short time took place. There aren't references about tornados or intense winds in surface in this date.

Radar and sounding data from Murcia are available. At first, the storm was located about 30-50Km away from this radar, and then it moved 120 Km towards the northeast. This situation lasted about 2 hours.

During the day and the previous, in middle-upper levels there was a CUT-OFF over Cadiz Gulf area (in the Southwest of the peninsula). As a consecuence of it, a lot of cloudy bands appeared in the north of Africa which swept over South and Southeast of Spain, apart from this, convective cells in the Southern Mediterranean coast area were developed.

In surface level the peninsula was influenced by high pressure located on southern French coast and by a wide area of low pressures over Alboran Sea. This gave rise to a flow from the East that brought humidity to the eastern part of the peninsula from the Mediterranean coast.

From satellite images we can see how the cell was developing between 21 and 22 pm (at these hours was the convection was more important).

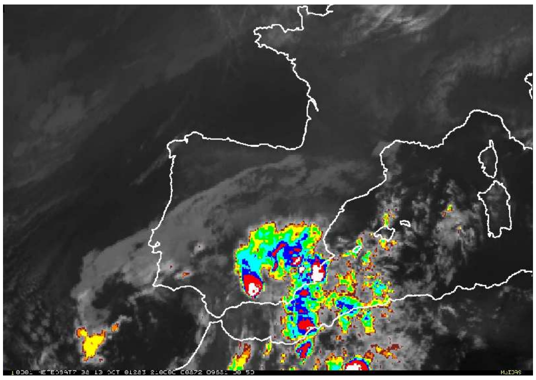

Figure 6. IR satellite image (21:00)

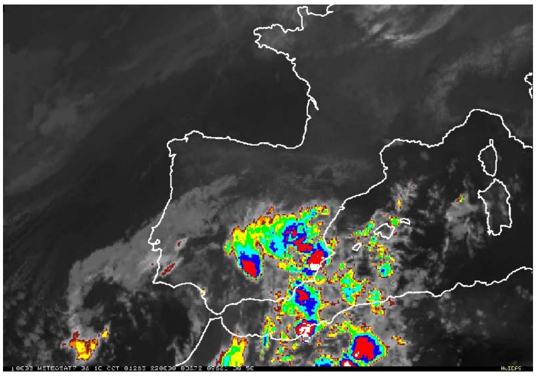

Figure 7. IR satellite image (22:00)

Enhance images: Temperatures range from -32 ºC and changes in colour are each -4ºC: red, with limits between -56ºC and -59ºC, white between -60ºC and -63ºC and grays between -64ºC and -67ºC.

To study this case we used Murcia's radar data. The resolution of the radar data is $2x2Km^2$. Murcia radar is at 1270 metres over SSL.The lower exploration is made at 0.5 degrees of elevation so at 35 Km. of distance this beam is raised at 100-200 meters over the high of the radar and at 120 Km. this is at 1600-1700 meters. Therefore the convective structure was located between 1400 and 3000 meters over SSL.

The pictures below show the actual images obtained by Murcia radar, in them the shift of the cell towards the northeast can be seen.

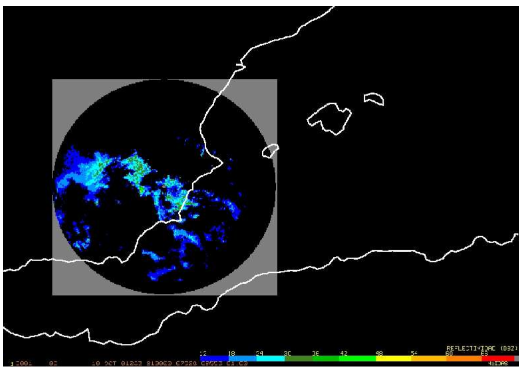

Figure 8. actual radar image (21:00)

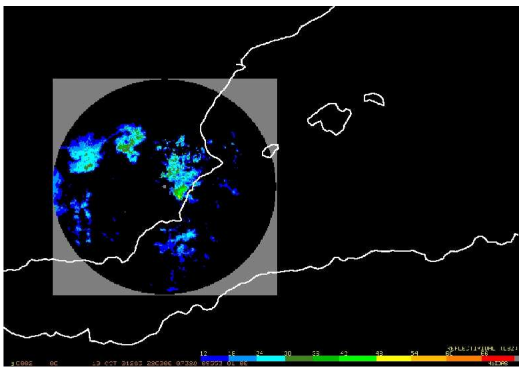

Figure 9. Actual radar image (22:00)

The vertical profile obtained at 22 pm. is shown in Figure 10. The heights of these CAPPIS are: Cappi1=1800m, Cappi3=2500m, Cappi5=5500m and Cappi8 = 8500m. There is a echo's movement in vertical and in lower levels the structure of image has the shape of a hook.

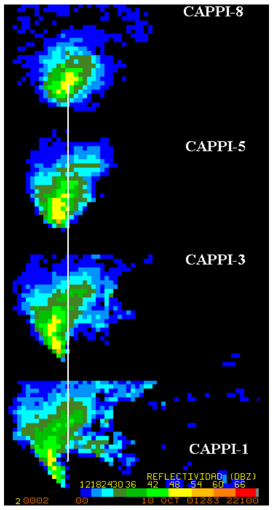

Figure 10. Vertical profile

6.RESULTS.

RSM has been used in the case of study to simulate reflectivities at three resolutions. Three different figures are shown for each resolution. The simulated and observed reflectivity obtained by RSM and the actual radar images are plotted in the following figures. Note that simulated and observed reflectivity images have the same resolution, whereas the resolution of the actual radar image is 2x2 Km^2 (because RSM uses radar files obtained in normal mode). The scale represents reflectivity in dBZ. Figures obtained from RSM are plotted using Metview (white background) and the figures obtained directly from radar network are plotted using McIdas (black background).

In this case of study we have files of Hirlam from 00 of 10th October to 12 of 11st October (36 hours) every hour, but we only have six files of Murcia radar (between 21 of 10th October and 02 of 11st October), so the comparasion between simulated reflectivity and observed reflectivity done for these hours.

The minimun value of reflectivity is -30.0 dBZ and the maximun value is 72 dBZ. In the images only positive values are represented.

The reflectivities obtained from RSM and the actual reflectivity are plotted in pictures below. The difference between the actual and the observed image is due to the change of resolution.

The main results obtained for each resolution are shown by Figs. 11-20 at the next page:

7.CONCLUSIONS

The use of RSM to validate mesoscale Hirlam is better when the horizontal resolution of Hirlam is more similar to the resolution of radar (2x2 Km^2). In the three experiments used in this work both reflectivities (simulated and observed) have been obtained and in the third case, with 0.05 degrees of resolution the images of simulated reflectivity are closer to the actual one.

RSM can be useful for nowcasting when it is operational at INM. To achieve this, it is necessary to use parallel programming, due to the long run times with one processor.

This model is expected to be operational at the end of this summer.

A. 22 Km resolution (0.2 degrees).

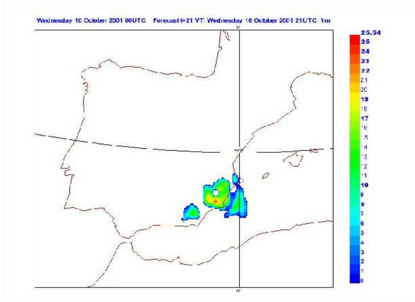

Figure 11. Simulated reflectivity (21:00)

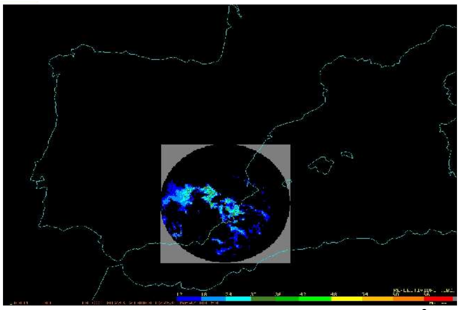

Figure 13. Actual radar image (21:00) 2x2Km^2

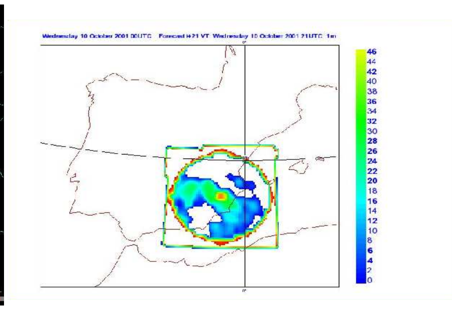

Figure 12. Observed reflectivity (21:00)

B. 16,6 Km resolution (0.16 degrees).

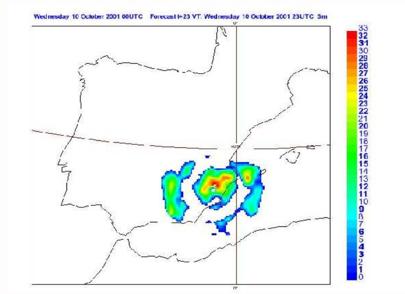

Figure 14. Simulated reflectivity (23:00)

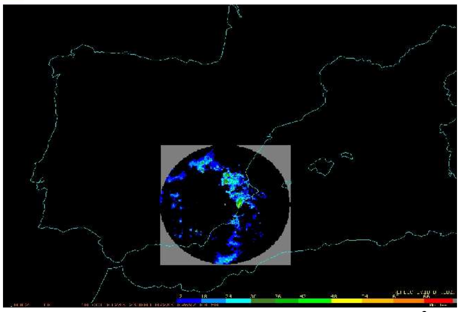

Figure 16. Actual radar image (23:00) 2x2Km^2

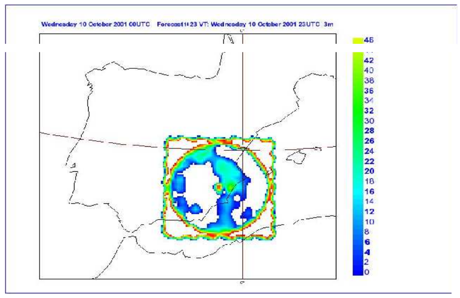

Figure 15. Observed reflectivity (23:00)

The cell moving towards Northeast can be seen in the following sequence of figures:

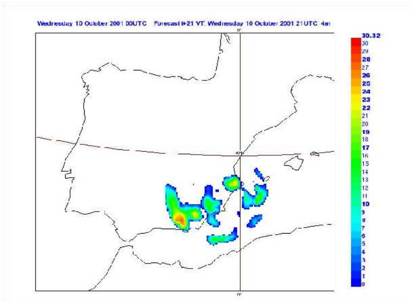

Figure 17. (21:00)

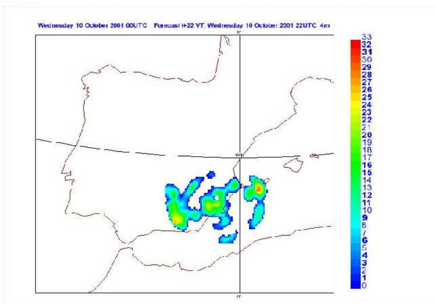

Figure 19. (22:00)

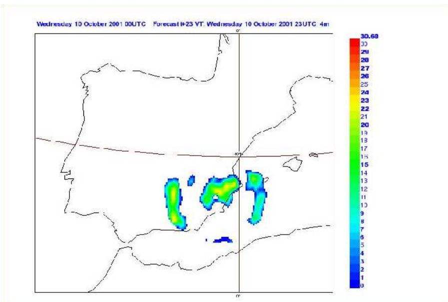

Figure 18. (23:00)

C. 5,5 Km resolution. (0.5 degrees)

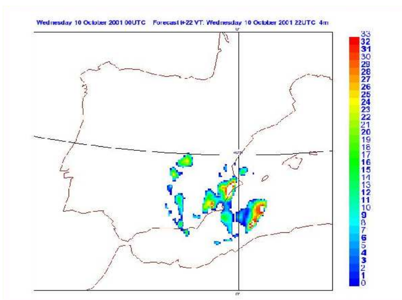

Figure 20. Simulated reflectivity (22:00)

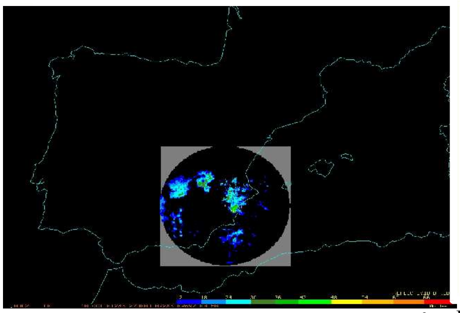

Figure 22. Actual radar image (22:00) 2x2Km^2

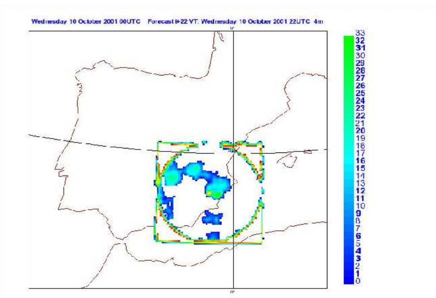

Figure 21. Observed reflectivity (22:00)