Using Euskalmet Radar data for analysis of a persistent precipitation case.

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(Dated: 31 May 2012)

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1. Introduction

On September 3 of 2011, heavy and persistent precipitation is registered in the east of the Basque Country, accumulating approximately 80 mm during the episode. In the rest of the region, precipitation is substantially lower.

A cut-off low (COL) cross, from west to east, through the south region of the Iberian Peninsula. An associated instability line is formed in the eastern part of this perturbation, which moves from south to north, through the northeast region of the Iberian Peninsula, generating precipitation. In surface, the Iberian Peninsula is located between two anticyclones, one of them continental and the other one Atlantic. Meanwhile, small low pressure areas developed in the south of France and in the west region of the Mediterranean Sea.

With this synoptic pattern, a Mesoscale Convective System (MCS) develops in the north of the instability line, when different convective nuclei, that have a retrograde movement, join among them to create a convective system with relatively large dimensions and with a quasi-stationary movement. These systems are common in the western Mediterranean Sea and are usually one or twice larger and more duration than ordinary storms.

On the other hand, the MCS has a specific internal structure, with a particular life cycle, sometimes modifies the synoptic patterns surrounding it. Although meteorological models provide valuable information of these phenomena formation, it is a difficult task to know the moment when ordinary convective nuclei become an organized mesoscale system. Thus, it is very important to use short-term surveillance and other tools, such as Weather Radar.

The most common time for the formation of these systems is the period of transition between summer and autumn, especially in September. At this time, eastern Iberian Peninsula is often affected by heavy precipitations and storms which are particularly virulent.

The weather radar of the Basque Meteorology Agency (Euskalmet) is a polarimetric C-band system Meteor 1500C, manufactured by Selex-Gematronik. The polarimetric features are limited to register only one polarimetric variable that is Differential Reflectivity ZDR (dB). The scanning configuration of the Euskalmet Radar consists on four polarimetric scans. The first one is a volumetric non Doppler scan with 300 km range, the second one is a volumetric Doppler scan with 100 km range, the third one is an elevation scan oriented to the coast (NW 339º) and the last one is an elevation scan oriented to the south (SW 241º). Both elevation scans are oriented to the west due to meteorological reasons and to avoid topographical barriers in azimuth close to the main population areas.

2. Synoptic environment

During the episode, the 500 hPa level is characterized by the cross of a COL in the southern peninsula, from west to east (Fig 1). A line of instability is formed, just in front of this perturbation, which moves from south to north, through the northeast region of the Iberian Peninsula. So, in medium and high levels of the troposphere, easterly flow is predominant, causing a retrograde movement on the mesoscale structures coming from the instability line. Subsequently, the flow tends to be null in the area where the MCS is formed, favouring the stagnation of the system.

Cold air moves over the Iberian Peninsula and in the meantime, stability indices LI and TTI are around -8 and 51, respectively, over the Mediterranean Sea. The COL crosses from west to east until it disappears.

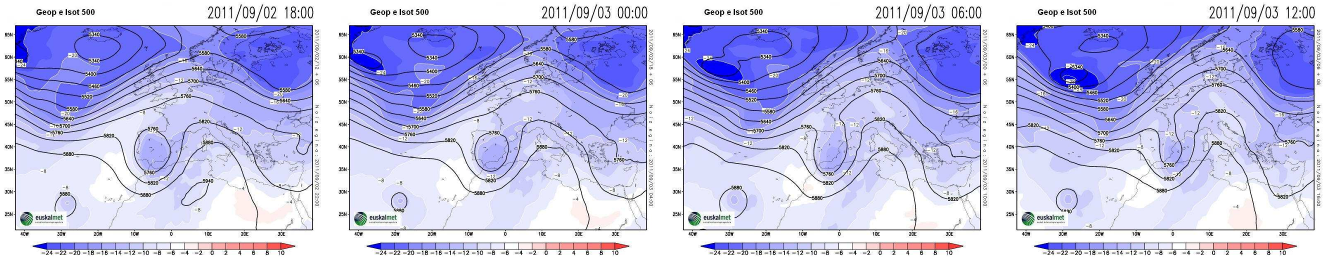

Fig. 1. Geopotential and Isotherms in 500 mb.

On the other hand, in low levels and in SLP (Fig.3), northwest winds become predominant, so there is a humidity contribution which feeds these mesoscale structures. Additionally, sea surface temperature is high, hovering around 22 ºC during this period.

The interactions among convection nuclei coming from the south create very complex structures which finally join among themselves, turning into a MCS. This principal system, located in the southwest of France, remains quasi-stationary and persists for a long time (because there is no wind in height), affecting especially the east of the Basque Country. The system gets weaker in the early hours of day 3, when cold air begins to disappear in high levels.

In Meteosat IR10.8 channel, it can be observed the evolution of the MCS, covering an axis larger than 100 km during its maximum extension. It is also observed how, during its life cycle, temperatures below -32 ºC are present in height (see colour zone in maps in Fig 4). First storms take place during the evening of September 2 and the time of maximum development of the MCS, is between 18:00 and 24:00 UTC. The maximum precipitation over the Basque Country occurred after midnight and in the morning of September 3. Around 8:00 UTC in the morning of day 3, MCS is almost defused.

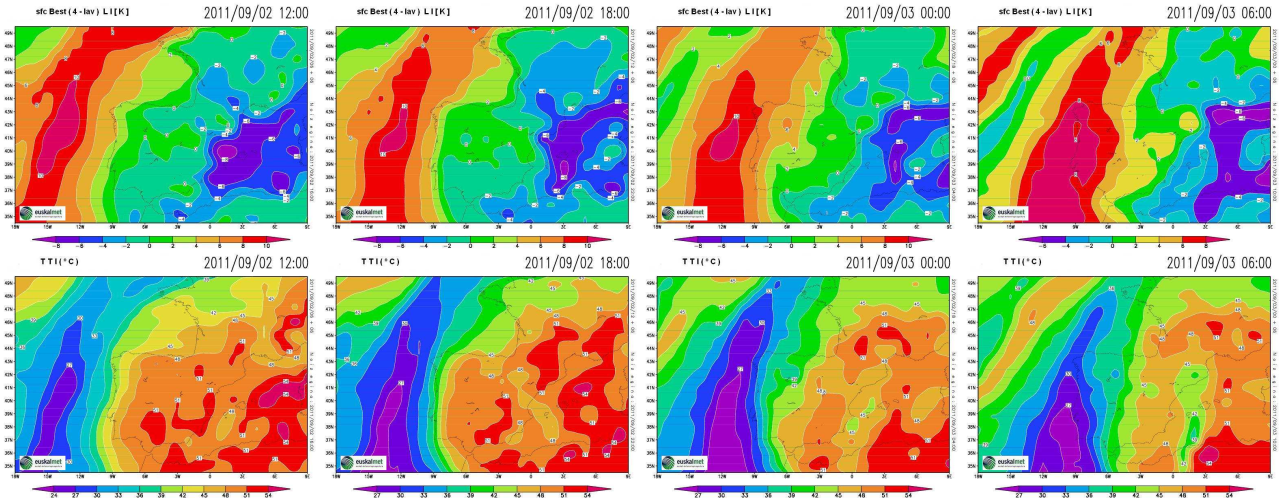

Fig. 2 Stability Index: LI and TTI

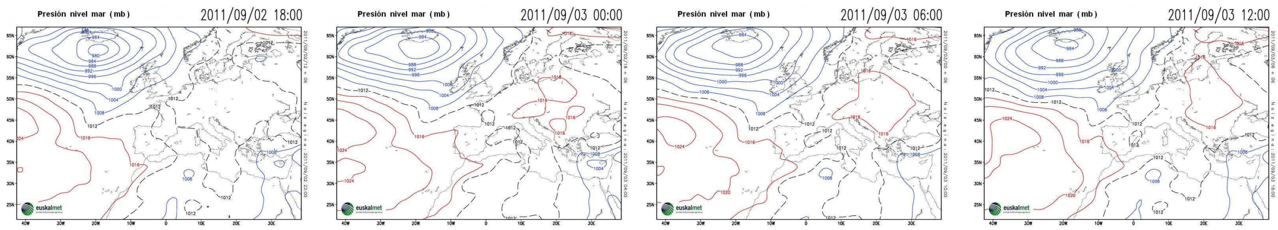

Fig. 3 Sea Level Pressure

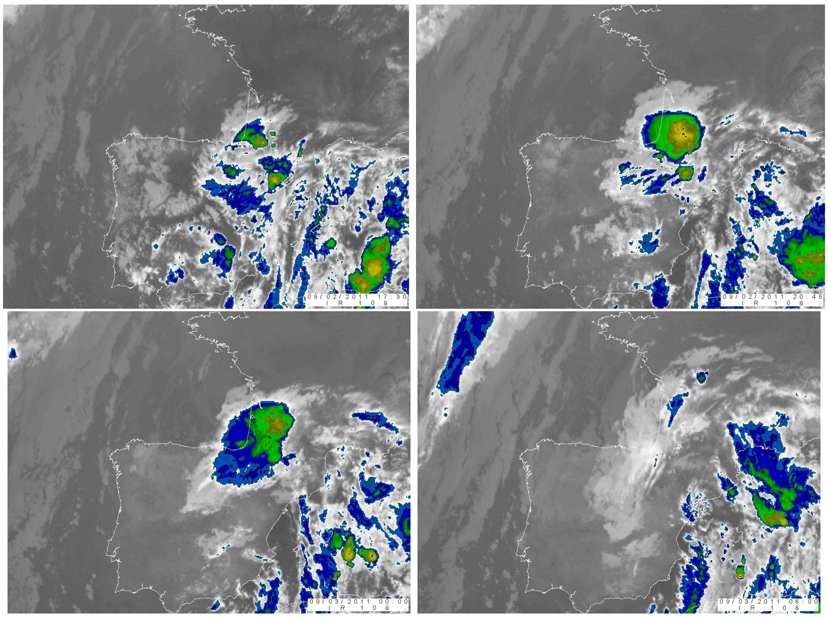

Fig.4. Images of Meteosat IR 10,8 µm, at different times of its evolution (17:30 and 20:45 UTC September 2, 00:00 and 06:00 UTC September 3). Creation and dissipation of the Mesoscale Convective System

3. Episode description

Around 23:00 UTC, on September 2, precipitations begin in the east of the Basque Country. From this time until noon on September 3, precipitations become persistent. Accumulated precipitation is remarkable, since exceeded 80 mm in 12 hours in the stations of Ereñozu and Oiartzun. In three other stations (Lasarte, Higer and Jaizkibel), precipitation exceeded 60 mm in the same time period. Apart from persistence, intensity of precipitation is also noteworthy. It exceeded 30 mm in one hour in the station of Higer, where a rate of 32.8 mm/hour was measured. This rate of rainfall is classified as very heavy precipitation. In many stations, it exceeded more than 15 mm in one hour. In the station of Lasarte a precipitation rate of 9.2 mm in ten minutes was measured (see table 1 and Fig. 5).

Although precipitation is continuous along the first 12 hours on September 3, there are two precipitation peaks. One of them is around midnight and the other one around 8:00-9:00 UTC. It should be mentioned that no more precipitation was measured after 11:00-12:00 UTC in automatic weather stations (AWS) network (Fig. 6).

The largest amount of precipitation was recorded in the east of the Basque Country, as shown in the spatial distribution map of total observed precipitation (Fig 5), while in the rest of the AWS, a small amount of precipitation was recorded.

In general, observed precipitation is higher in the second peak. However, both peaks are noteworthy because their activities are similar. For example, the highest record of recorded precipitation in ten minutes was during the first peak, in Lasarte, where 9.2 mm in ten minutes were measured.

Station	Total Precipitation (mm)
Erenozu	82.3
Oiartzun	80.9
Lasarte	76.2
Higer	71.2
Jaizkibel	70.8
Berastegi	62.1
Belauntza	60.5

Station	Hourly Precipitation (mm)
Higer	32.8
Lasarte	27.6
Oiartzun	26.3
Zarautz	24.9
Jaizkibel	23.3
Miramon	19.7
Erenozu	17.2

Station	10-minute Precipitation (mm)
Lasarte	9.2
Higer	8.7
Oiartzun	6.8
Zarautz	6.8
Jaizkibel	5.7
Miramon	5.1
Berastegi	4.6

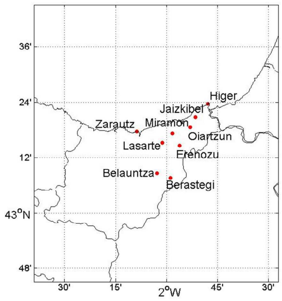

Table 1. Accumulated precipitation (mm), hourly precipitation (mm) and 10-minute data precipitation (mm)

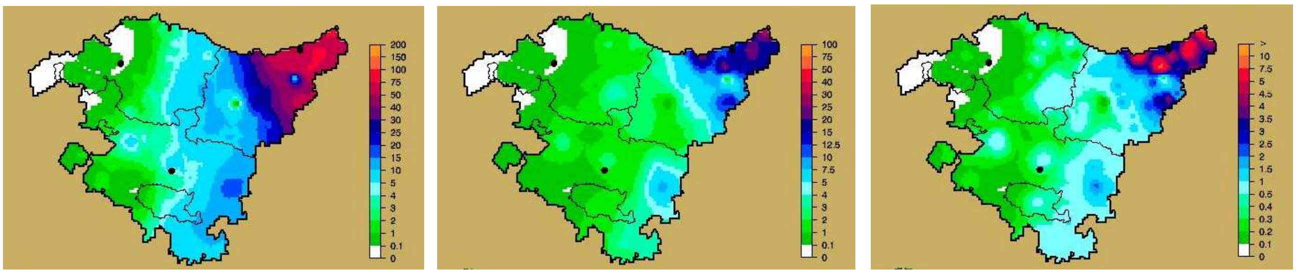

Fig. 5 Daily total, maximum hourly and maximum 10-minute precipitation (mm).

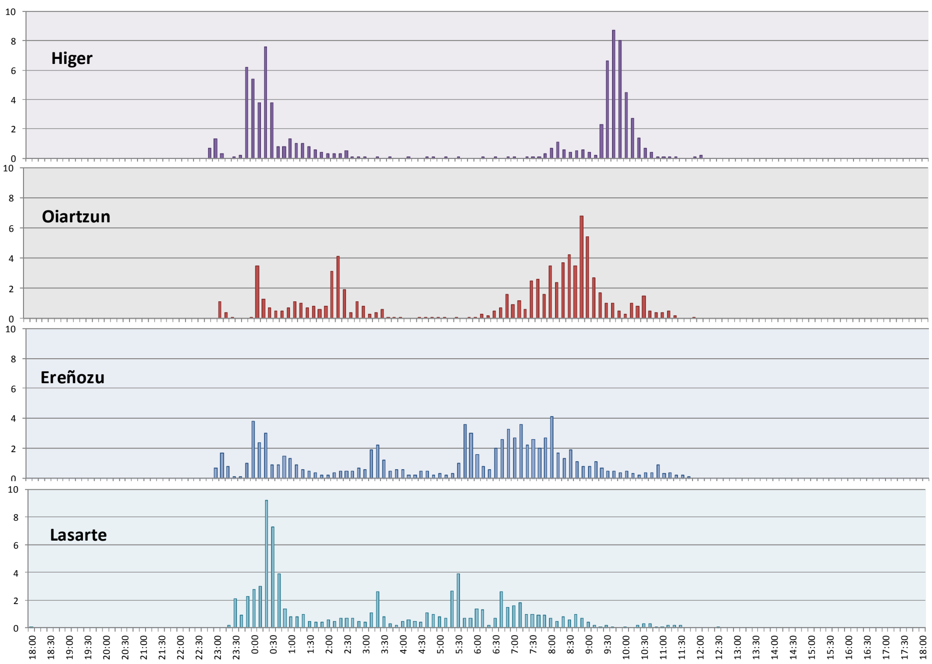

Fig. 6: Ten-minutes precipitation on some representative AWS from 18:00 day 2 to 18:00 day 3.

4. Radar analysis

Analyzing the weather radar data available for this episode, it is observed that the MCS system show stratiform and convective features over the Basque Country. Reflectivity maximums can be observed in PPI and MAX images, around 00:00 and 8:00 UTC, when largest amount of precipitation was recorded (Fig 9 and Fig 10). There are two areas clearly remarkable in the 15 dBz ECHOTOP images (Fig. 11) around 00:00 UTC, one in the east of the Basque Country and another one over the south of the region.

Focusing on convective features, it can be appreciated a significant vertical development, although the convection is not deep, especially in the first precipitation peak, around midnight. By instance, in Lasarte area, where the precipitation intensities were very high (9.2 mm/10-min), the reflectivity observed is around 45-50 dBz in the height of 2 km (see Fig 9 y FIG 12). When lower layers are analyzed in study area, e.g. from PPI 0.5 º products, must be considered, that in addition to the orographic blocking problem, altitude and distance from radar location is a handicap. In the second peak, in the early hours of September 3, in radar products can be seen how system loses activity and defuses. However, the precipitation efficiency is still high, since the activity persists in the east of the Basque Country, but with less extension (see Fig. 10 and Fig. 11). The vertical development will also disappear except in this eastern part; where there is still a significant development (see Fig 10 and 11).

In stratiform areas, observed reflectivity values are around 25-40 dBz and the precipitation ratio is 0.3-1mm/10-min. In MAX products, it can be seen a vertical profile reflectivity (VPR) typical of stratiform precipitation (see Fig 10). Moreover, as usual in stratiform situation, a bright band can be observed in the MAX images (Fig. 10), at a height of four kilometres, coincident with freezing level.

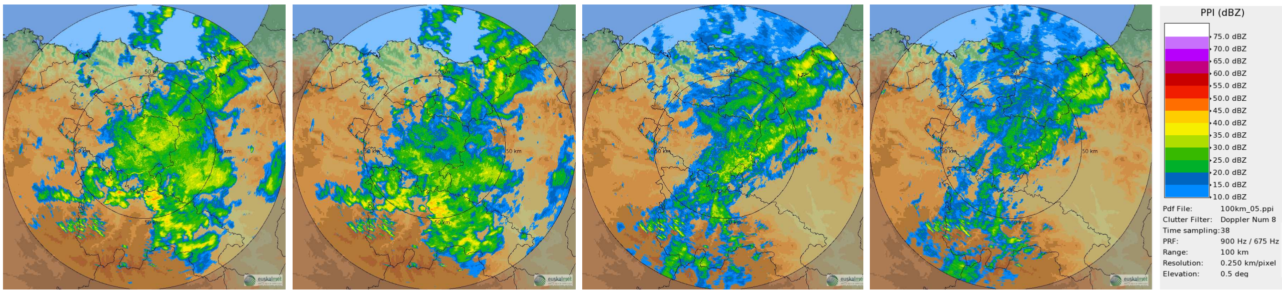

Fig. 9 PPI 0.5º (23:50 UTC September 2 and 00:10, 07:30 and 08:10 UTC September 3)

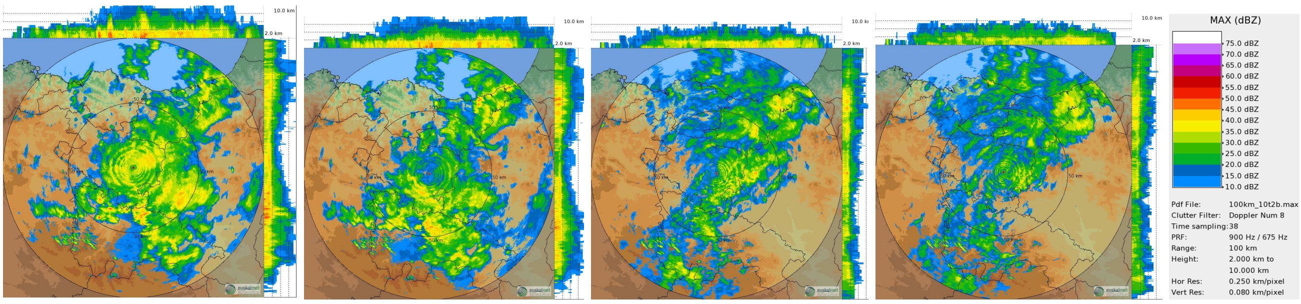

Fig. 10 Max 2-10 km (23:50 UTC September 2 and 00:10, 07:30 and 08:10 UTC September 3)

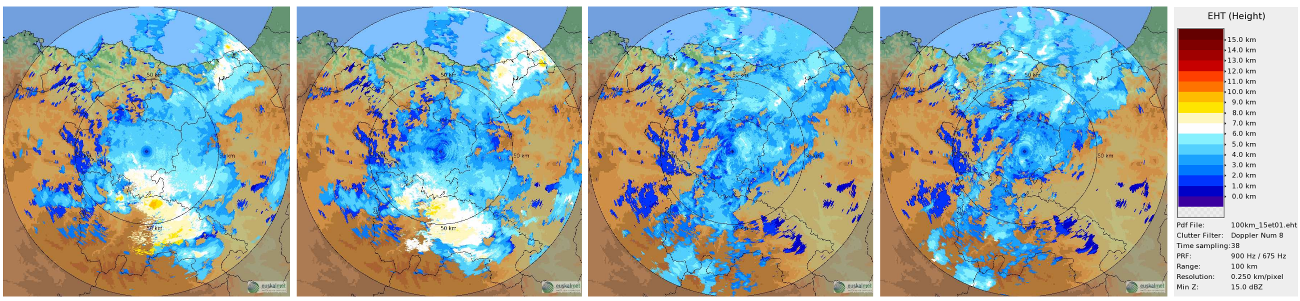

Fig. 11 Echotop (23:50 UTC September 2 and 00:10, 07:30 and 08:10 UTC September 3)

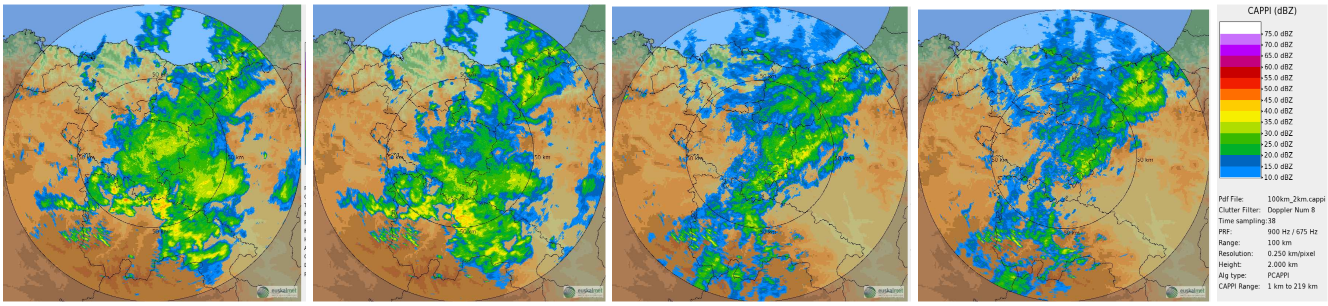

Fig. 12 PCAPPI 2 km (23:50 UTC September 2 and 00:10, 07:30 and 08:10 UTC September 3)

Finally focusing on QPE problem, in Fig 13 can be seen accumulated precipitation from PAC product (Fig 13). A strong orographic blocking in the area of interest is observed. Two areas of maximum precipitation are also observed, one in the east part of the Basque Country and other one in the south. PAC product was obtained from the sum of surface rain intensity product (SRI) for ten minutes intervals along the episode. In order to calculate SRI, the Marshall-Palmer Z-R relationship is used, considering the subtraction of ground clutter (Fig 14).

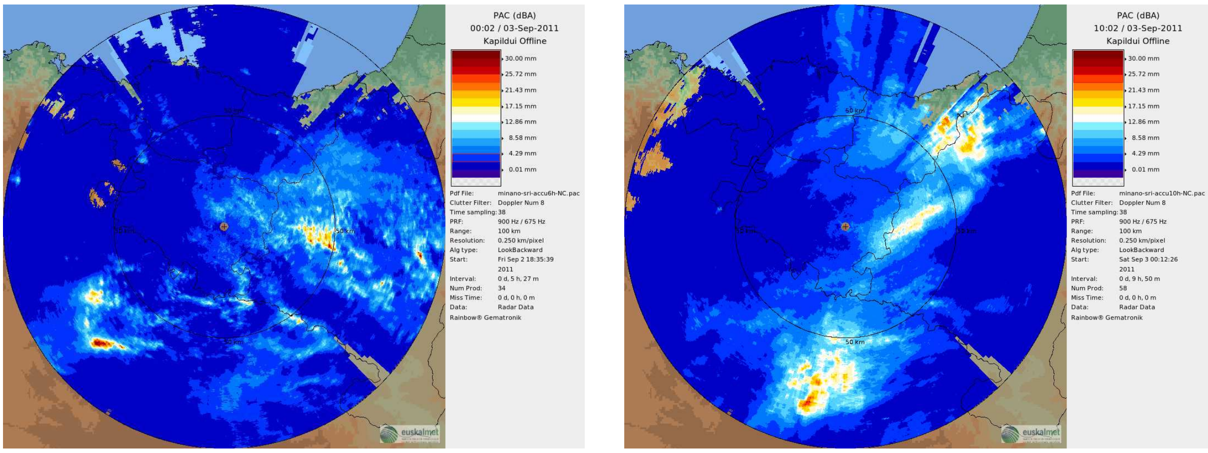

Fig. 13: PAC product during the episode (accumulated precipitation, mm, during last hours of September 2 and first 10 hours of September 3)

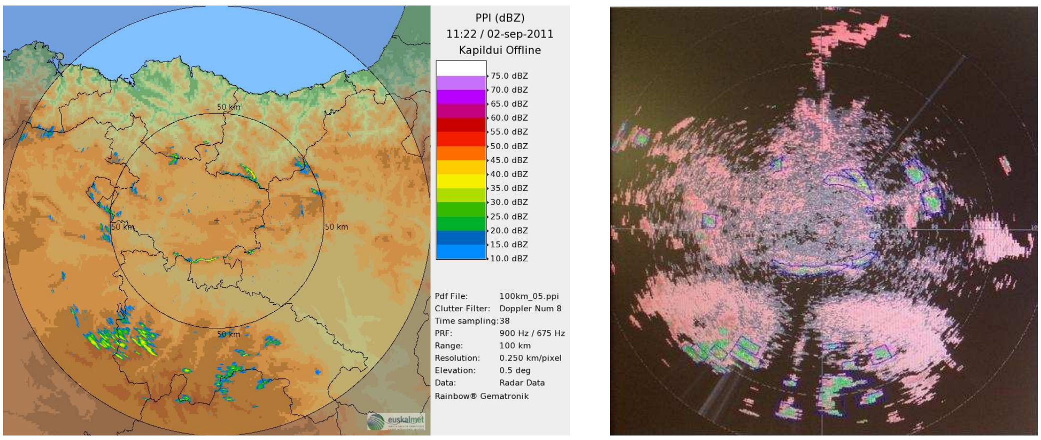

Fig. 14: PPI 0.5 º ground clutter reflectivities map and clutter mask

5. Summary and conclusions

During this episode, the synoptic situation favours the formation of a Mesoscale Convective System (MCS). It moves from south to north, until it reaches, with a retrograde movement, the southeast of France, when its development achieves the maximum and its extension is larger than 100 km. remaining quasi-stationary, affecting the east of the Basque Country. Precipitation is persistent with two peaks. In low layers, northwest winds become predominant, so there is a humidity contribution and sea surface temperature is high, hovering around 22 ºC during this period. In the east, precipitable water (PW) has maximum values, around 30 kg/m2.

This structure is composed of convective zones that leave convective precipitation, especially in the eastern part of the

Basque Country in the early hours. Other areas, however, have a vertical profile of reflectivity typical of stratiform precipitation. Since it is a situation where most of the precipitation is stratiform, Marshall-Palmer ratio could be applied in order to obtain the intensity of precipitation in areas without orographic blocking.

Reflectivity values in low layers of the critical area are underestimated due to radar location and the site topography. In other words, there is an orographic beam blockage in the study area affecting low layers. In the future, methods of horizontal and vertical interpolation will be used to obtain better QPE results. In the case of stratiform situations, the hidden areas will be replaced horizontally with the same elevation values. For convective precipitation, the best replacement would be the vertical one, because vertical profile of reflectivity is constant.

Situations of heavy precipitation with maritime origin are dangerous in coastal zone during warm seasons. The vertical profile of reflectivity (VPR) may have a curve with a substantial increase of reflectivity in low layers, so it could not be observed due to radar location. In this case, vertical development of storms is well observed by radar products, and a reflectivity increase close to the ground probably is not present.

Acknowledgment

The authors would like to thank the Emergencies and Meteorology Directorate - Interior Department - Basque Government for public provision of data and operational service financial support. We also would like to thank all our colleagues from EUSKALMET for their daily effort in promoting valuable services for the Basque community.

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