

# Using radar data for analysis of a very heavy precipitation episode in Bilbao area

J. Egaña<sup>1,2</sup>, S. Gaztelumendi<sup>1,2</sup>, V. Palacio<sup>1,2</sup>, O. Principe<sup>1,2</sup>, M. Maruri<sup>1,2</sup>

<sup>1</sup> Basque Meteorology Agency (Euskalmet). Vitoria-Gasteiz, Spain

<sup>2</sup> Tecnalia, Meteorology Area. Vitoria-Gasteiz, Spain

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## 1 Introduction

The objective of this work is to present a preliminary analysis of a very heavy precipitation event that occurs the 28 August 2013 in Bilbao city through the use of Euskalmet Radar information available for the Basque Country area.

The synoptic situation is marked by the Atlantic anticyclone that goes in Europe, favouring the north wind in surface. In the middle and upper layers of the atmosphere exists meridional circulation, with cold air ( $-15^{\circ}\text{C}$  at 500 hPa level) over the Bay of Biscay. Sea surface temperature in that moment is around  $22^{\circ}\text{C}$ . Although stability indices are low, form convective cells in the sea and close to the coast that go into the Cantabrian side, leaving heavy showers especially in Bilbao.

In this episode, it is interesting to analyze convective cells generation, and to note that forecasted and observed stability indices were not so high. Vertical structure of storms cells were not exceptional. Cells with relatively little vertical development and a slow and irregular movement from north to south (not usually observed during summer in this region) promote heavy showers all around the area.

A study of this event, that it was a rather surprising situation, is made analyzing different parameters, based on the available data and specially focused on the interpretation of the different imagery products of the Euskalmet radar.

Euskalmet radar is sited in Kapildui mountain, a central location at 1221 m. It 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 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  $339^{\circ}$ ) and the last one is an elevation scan oriented to the south (SW  $241^{\circ}$ ). 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. Scanner is made every ten minutes. See Gaztelumendi et al (2006) for more details about Euskal radar system configuration and Aranda and Morais (2006) for some details about the radar installation, construction and site selection.

## 2 Environment

The Atlantic anticyclone extends toward Europe, generating north flow in Bay of Biscay, which provide moisture to the Basque Country. In the south of the Iberian Peninsula a thermal low is formed as is typical during summer (see Fig.1).

In the upper troposphere, at the level of 300 hPa, the circulation is closed forming a cold pool that is also reflected in the level of 500 hPa with temperatures around  $-15^{\circ}\text{C}$  and not closed cyclonic circulation over the Bay of Biscay (see Fig.2). In lower layers the flow is from the northeast, with temperatures at 850 hPa around  $10^{\circ}\text{C}$  (see Fig.2), so the vertical temperature gradient is not very important. At this level does not reflect the detached or cyclonic circulation that exist higher levels, and north and northeast flow provides moisture in lower layers.

This cyclonic configuration at the middle and upper levels of troposphere generates an area of vertical ascents related to the maximum vorticity advection. Moreover, we must add to this dynamic instability, thermal instability due to the contrast with the sea temperature ( $22^{\circ}\text{C}$ ). The sea-surface temperature average in August in the eastern part of the Cantabrian sea is  $22^{\circ}\text{C}$ . It is the time of year when the sea-surface temperature is higher. This means that near coastal places TTI modified shows more relevant values (see Fig.3) that TTI and LI. In this case TTI and LI values are not relevant (see Fig.3). The divergence is significant in high layers, favouring the ascent. The convective cells are generated in the land-sea boundary, so perhaps the dynamic instability due to the relatively pronounced cyclonic settings, along with the thermal instability heavily influenced by sea temperature and moisture convergence in lower layers due to light northeast wind, generate convective cells reach limited vertical development (6-7 km), and electrical activity. The displacement of convective cells is slow with northeast-southwest movement following the light wind of the lower layers

The available sounding indicates that the top of the clouds is around 6000 m and the base around 400-500 m. Moreover, the wind vertical profile shows that in surface northwest wind prevails but in the first 2500 m rotates to northeast in clockwise direction. Around 3100 m dominates south wind and above 4000 m acquires westerly direction. Therefore, the vertical wind shear is weak, especially in medium-high levels (DLS, Deep Layer Shear is 6.4 m/s). These environments tend to decrease the effects of cloud-environment mixing and generate slower movements. On the other hand, the hodograph has a cyclonic curvature, which favors the generation of new cells to the right of translation movement (see Fig.4).

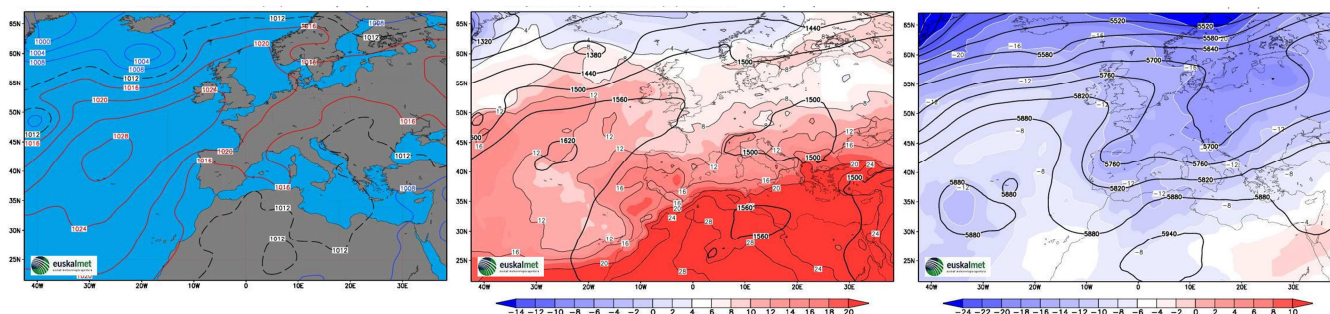


Figure 1: See level pressure ,Geopotential and Isotherms at 850 mb and 500 mb (28/08/2013 12:00).

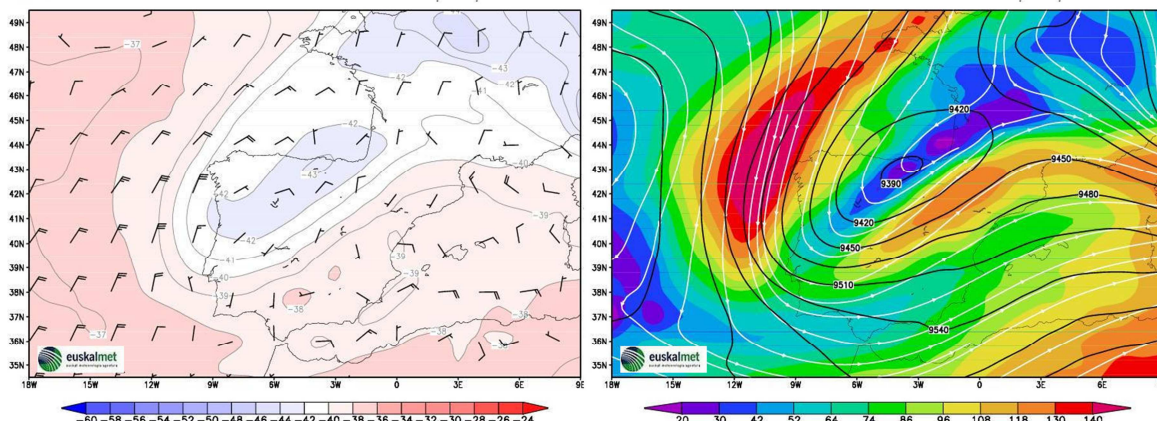


Figure 2: Geopotential, wind and temperature at 300 mb (21:00 UTC).

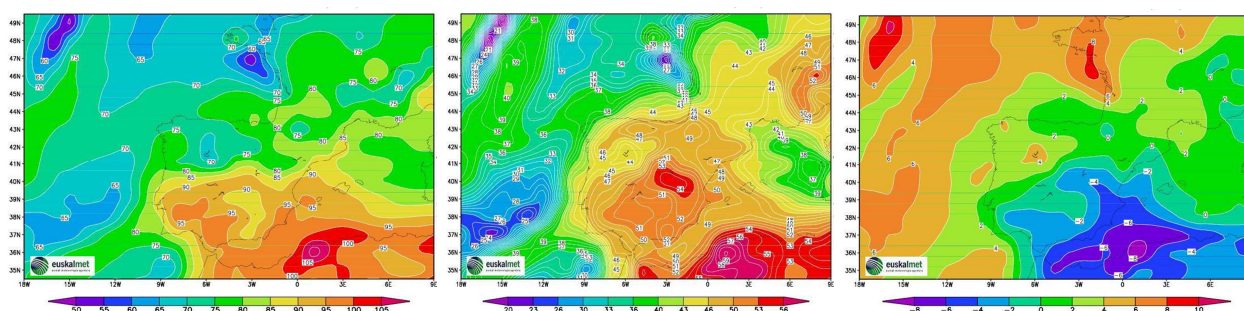


Figure 3: Modified Total Totals index, Total Totals Index and Lifted Index (12:00 UTC).

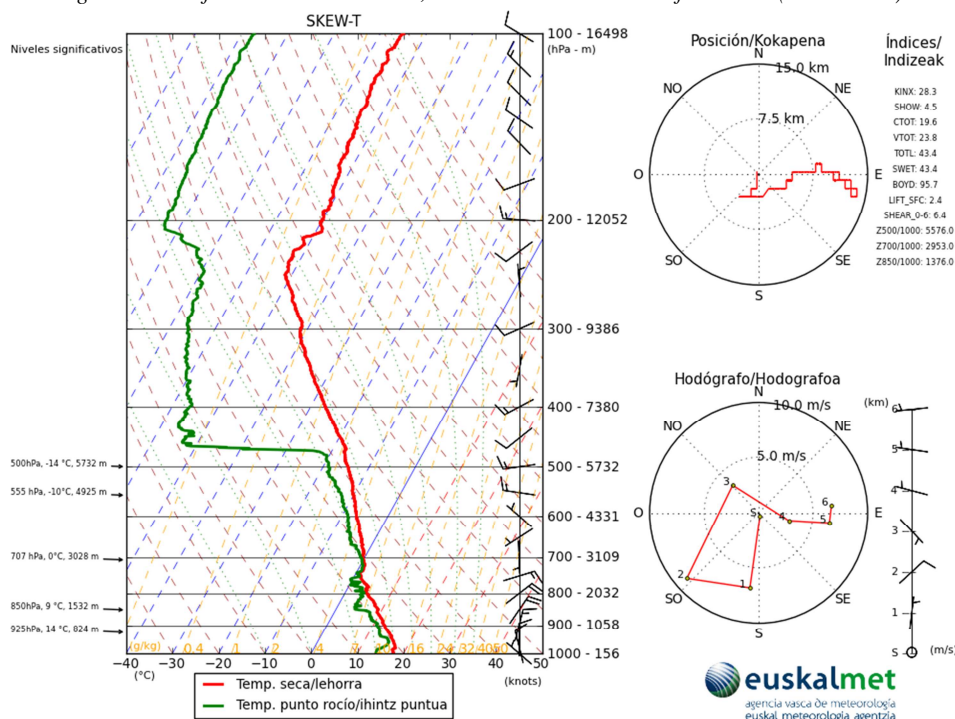


Figure 4: Euskalmet sounding (12:00 UTC 28/08/2013)

### 3 Episode description

Early in the morning the first storm cells begin to form over the eastern part of the Cantabrian Sea, near France, and move towards the eastern coast of the Basque Country. Around 8:00 UTC moderate showers begin to be registered. These precipitations do not exceed 15 mm in one hour, although some of them are noteworthy.

Around 9:30 UTC convective nuclei begin to form in front of the western coast of the Basque Country moving slowly northeast-southwest direction. It is a convective cell with a multicellular structure and with continuous generation of new convective cells to the right of translation movement. It is a structure with anomalous movement and has longer duration than the other structures. In this case translation is mainly due to subsynoptic factors and factors of the storm itself (self-propagation) and not to the average general flow.

These cells produce heavy precipitation in some places of the west of the Basque Country. In Mungia 8.7 mm in 10 minutes and 25.4 mm in one hour are recorded. But it is in the area of Bilbao where the showers are very heavy and important amounts of precipitation are registered in ten-minute and hourly values (over 30 mm/h and 10mm/10minutes).

We have to emphasize notable records of more than 10 mm in 10 minutes at various stations such as Sangroniz, Abusu and Deusto (see fig.5, fig 6 and table 1). In Deusto was measured a rate of 42.3 mm/h (14.4 mm/10-min at 11:50 UTC). If this amount is compared to the total precipitation accumulated throughout the day, 44.4 mm in 24 hours, it is possible to have an idea of the virulence of rainfalls from August 28, which are very localized in space and time. In Sangroniz weather station are collected 23.5 mm/h (11.6 mm/10-min and 24.4 mm/24h) and in Abusu 20.7 mm/h (10.5 mm/10-min and 22.8 mm/24h).

Table 1: Registered precipitation data on some Automatic Weather Stations (AWS) available in the area.

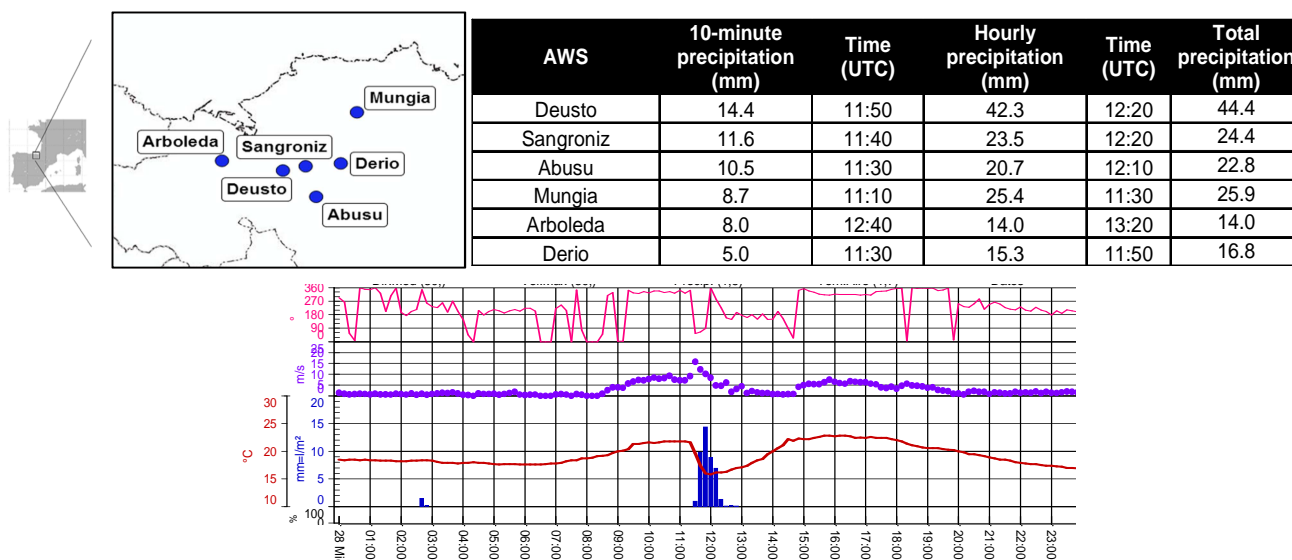


Figure 5: Evolution of wind, precipitation and temperature in Deusto AWS.

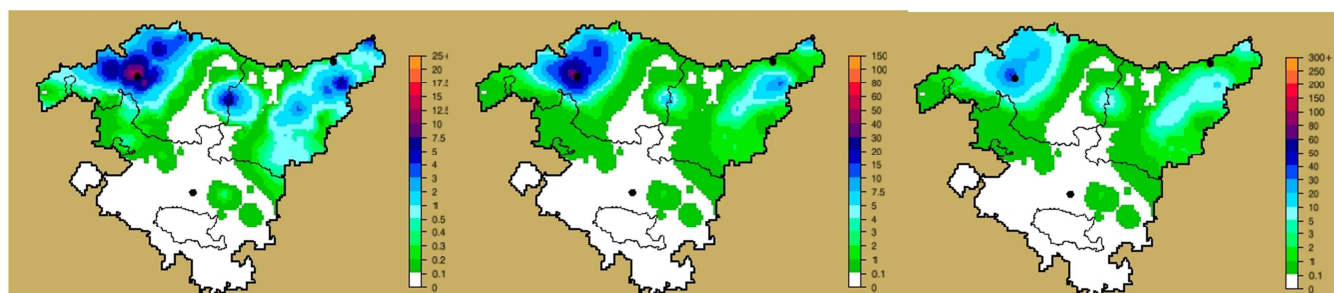


Figure 6: Maximum 10-minute, maximum hourly and daily total precipitation (mm).

During August 28, lightning discharges have a very concentrated distribution in the west of the Basque Country, specifically in the area of Bilbao and from there to the sea in north-east direction. This is due to the quite localized storm events that occurred that day, with maximum lightning densities of about 6 lightning per km<sup>2</sup>. In the hourly distribution of strokes (see Fig.7) we can appreciate that the thunderstorms are produced in the morning and midday, until 12:00 UTC. 120 strokes are detected in the Basque Country, most of them positives. The most intense positive Cloud-Ground stroke registered has a peak current of 60-100 kA and the most intense CG negative stroke reaches intensities between -10 and -30 kA.



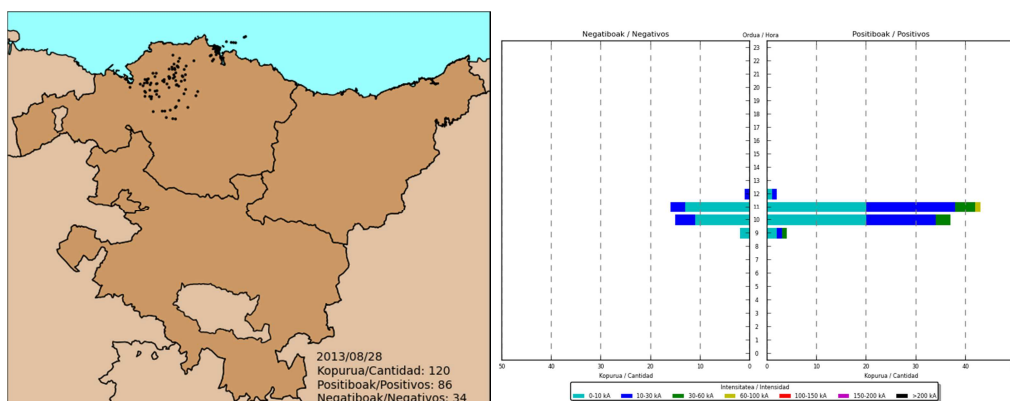


Figure7: Geographic and hourly distribution of lightning in the Basque Country August 28.

#### 4 Radar analysis

Analyzing Max product from 2 to 10 km, it is observed the multicellular structure of the storm and very active cells with reflectivities of 50-55 dBZ in the northwest area of the Basque Country (see Fig.8). They do not show a very large vertical development (6-8 km), and even if in their movement prevails north-south direction, they have a quite erratic movement. Probably because the maritime origin of the storms, the vertical profile reflectivity could be typical from warm seas, where the reflectivity increases more than usual as it gets closer to the surface. The area where the storms take place is distant from the Radar location, so is very difficult to make analysis of lower layers in this area.

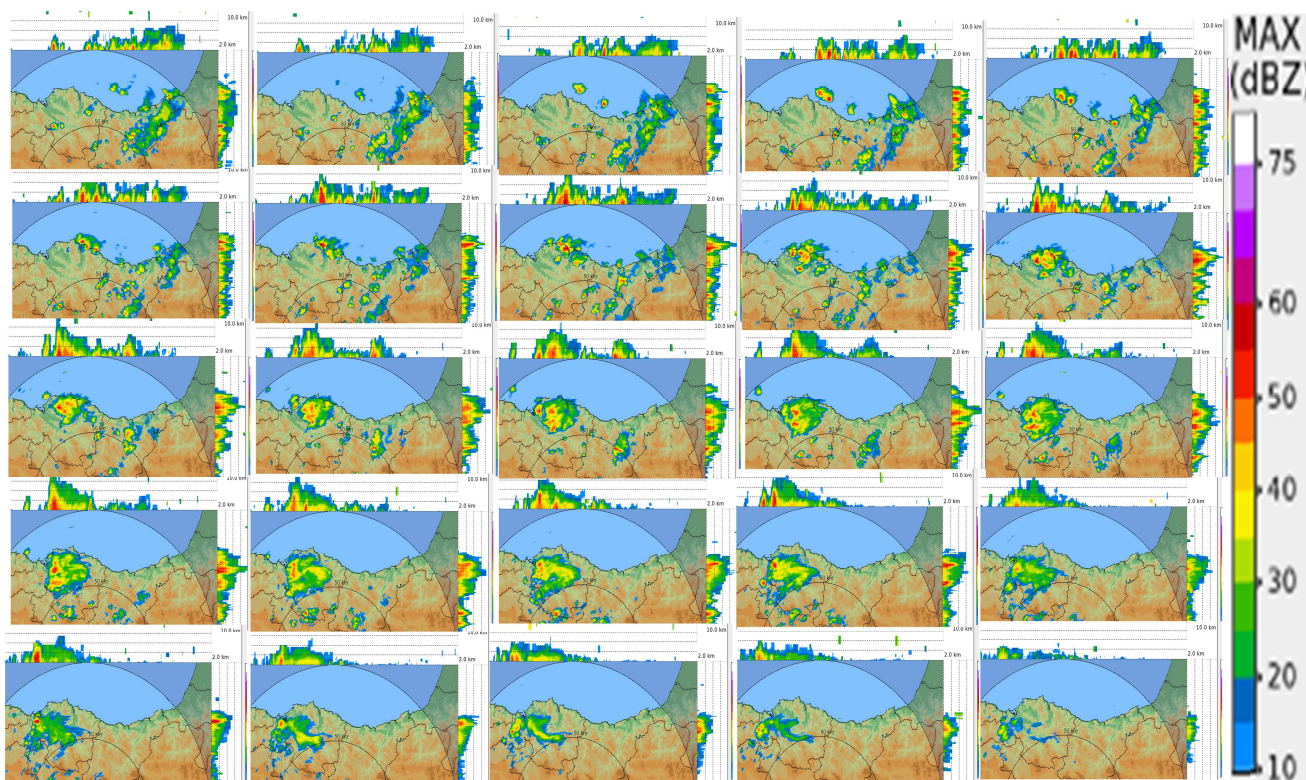


Figure 8: Max 2-10 km (from 09:00 UTC until 13:00 UTC every 10 minutes (28 August 2013)

The image of CAPPI (wind) in the vicinity of Bilbao (see Fig.9) shows that the radial velocity at 2 km above the sea level is from southeast in the south of the convective cell and from north in the north of the storm. That confirms that in the most active cells, at this level, there is a rotation movement.

The echotop values of 15 dBZ show that the convective cell reach 6-8 km, same values as presents the vertical scan in 339 ° direction (see Fig 10 and Fig 11). On the other hand in Zhail products no probability of hail are present, as usual in such events with reduced convective vertical development. In the ZDR product, areas of maximum attenuations are correlated to maximum rain records in the AWS ( area of Bilbao at 11:32 UTC). The attenuation of zdr (the white and blue colours in figure 11) are associated with areas of very heavy precipitation.

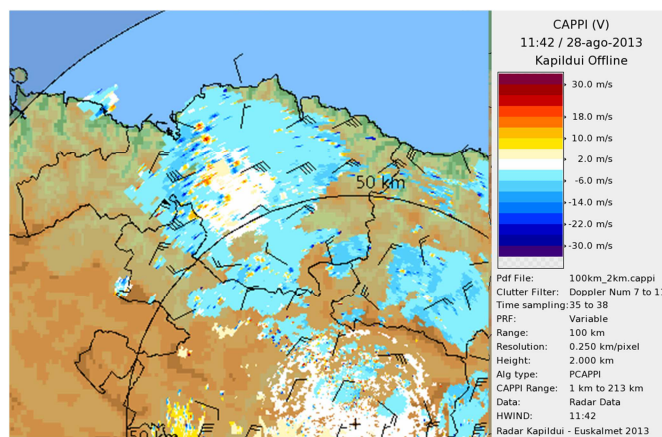


Figure 9: CAPPI V (Constant Altitude Plan Position Indicator 2 km - VI) at 11:42 UTC 28 August 2013.

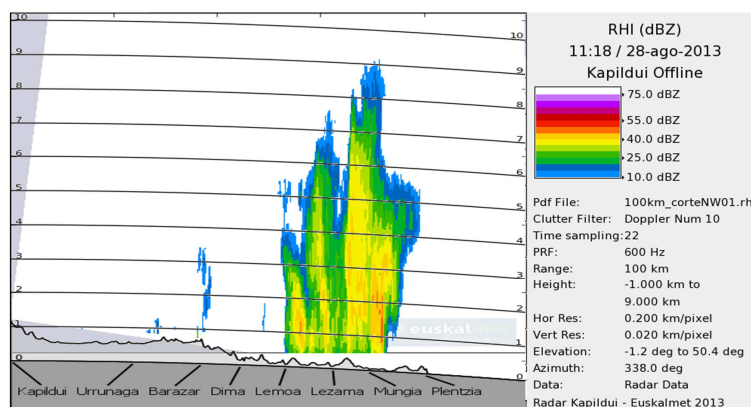


Figure 10: Range Height Indicator NW ( RHI 339°) 11:18 UTC 28 August 2013.

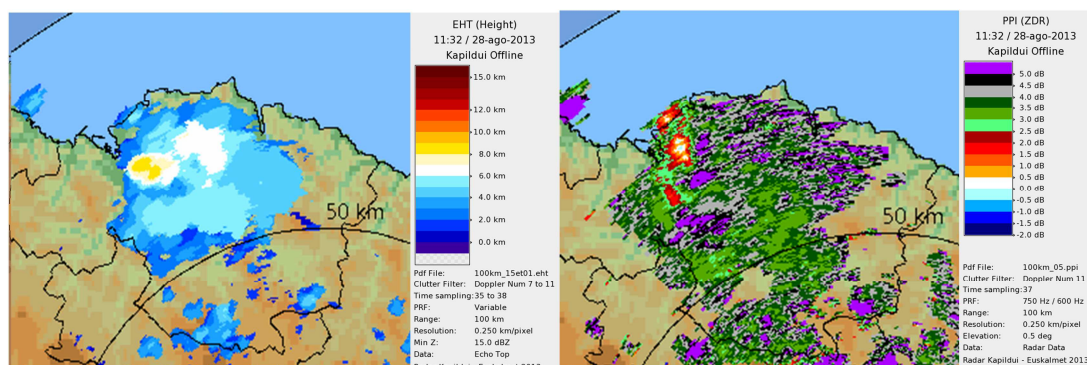


Figure 11: 15 dBZ Echotop and ZDR 11:32 UTC 28 August 2013.

## 5 Summary and conclusions

In this work we have analysed a very heavy precipitation event that occurs the 28 August 2013 in Bilbao city. The storm that is formed in the area is not a typical summer storm. During summer, usually storms movement is southwest-northeast due to southwest wind in high layers, usually have large vertical developments and high electrical activity, and they can generate very heavy precipitation, very large hailstones and very strong wind gusts. Nevertheless, as in this case, the storms with maritime origin show limited vertical developments with low electrical activity, without hail and with high precipitation efficiency.

The storms are registered in the morning and midday. The principal cause for the formation of the convective nuclei is rather more dynamic instability than thermal instability. The sea surface temperature (maximum value of the year) also contributes to destabilize lower layers.

The reflectivity values observed during the episode do not exceed 55 dBz over the area, the different products of the Radar do not indicate high vertical developments of storms and neither high reflectivities, nevertheless the precipitation was very heavy, with intensities between 5-15 mm in ten minutes.



The severe storm that leave an amount of precipitation of 42.3 mm in one hour, affects Bilbao, the most populated area of the Basque Country. It causes some problems due to water accumulation in several roads and plenty of 112 calls due to minor incidents associate with heavy precipitation in the city (see Fig.12).



Figure 12: Observed incident in the area of Bilbao during the episode.

## Acknowledgement

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