# Analysis of a heavy storms episode in Basque Country: the 19-20 jul 2013 case

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## 1 Introduction

The 19-20 July 2013 strong thunderstorms occur in the Basque Country. In this paper different aspects of the storms are analyzed using Basque Meteorology Agency (Euskalmet) weather radar. This radar, sited in a central location around 1200 m altitude, is a polarimetric Doppler weather radar operating in C-band.

During 19 and 20 July 2013 Basque Country is in a synoptical situation of barometric swamp with high pressures at latitudes further north of Britain. In middle and upper troposphere layers circulation undulates, forming a trough that favors dynamic instability. At mesoescale, local breezes regime is present. Stability index during those days, especially during evenings, are very high, with Total Totals Index (TTI) and Lift Index (LI) around 55 and -6 respectively compatible with severe weather thresholds for Basque Country area.

In this environment, convective cells are formed and produce very heavy showers. During the evening of 19 and 20 july different storms cells are formed specially in the interior of the country with a general NE movement. Observed reflectivities over 55 dBz, and echotop-15dBZ over 13 km are present. Lighting activity and high wind gusts are also observed. On the other hand rain over 10mm/10minutes and over 30mm/1hour are registered in different Automatic Weather Stations (AWS) in the area affected by thunderstorms.

In this work the characteristic of different storms cells are discussed, analyzing different parameters, based on the available data in Basque Country area (sounding, automatic weather stations, lightning detection system, Meteosat, etc) and specially focusing on the interpretation of the different imagery products available from the Euskalmet Radar.

## 2 Euskalmet radar

Euskalmet radar is sited in Kapildui mountain (1174 m) near the capital of Basque Country (see Fig. 1), is a METEOR 1500 Doppler Weather Radar with Dual polarization capabilities. This radar is based on a Klystron transmitter system, operates in C-band frequency and uses the advanced signal processing environment Aspen DRX as digital receiver and signal processor.

Radar operates with a configuration based on four different scans providing meteorological data every 10 min. The first volumetric scan takes 120 seconds and is configured for a maximum range of 300 km with 5 elevations from 0º to 5º, a range step of 1 km and an angle step of 0.8º. The second volumetric scan takes 363 seconds and is configured for a maximum range of 100 km with 14 elevations from –0.5º to 35º, a range step of 250 m and an angle step of 1º. The third and fourth scans are elevation scans for two selected directions. See Aranda & Morais (2006) for some details about the radar installation, construction and site selection and Gaztelumendi et al (2006) for more details about Euskalmet radar system configuration and operational aspects.

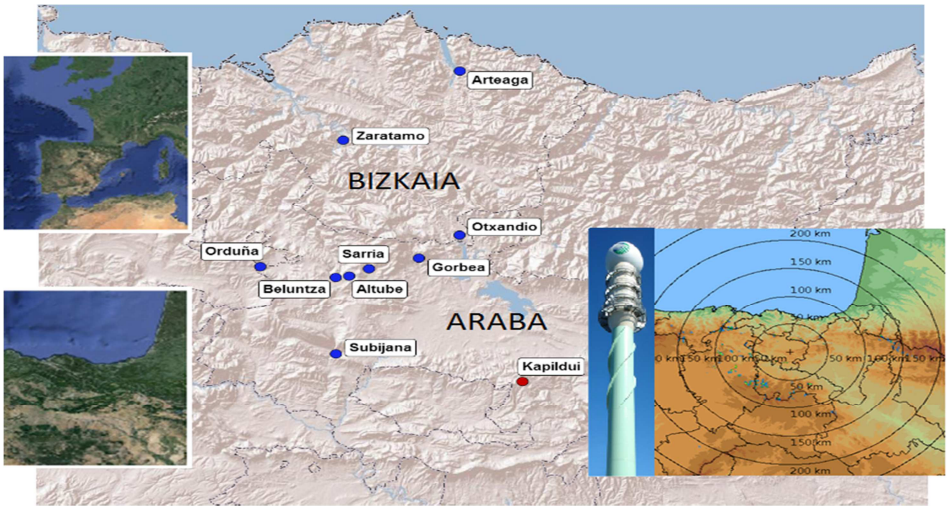


*Figure 1: Euskalmet radar and some Automatic Weather Stations (AWS) used in this study.*

## 3 The storm environment

During July 19, at 500 hPa level, the flow is almost zonal at the beginning of the day. However, an Atlantic trough starts to be formed, favouring light dynamic instability over the Iberian Peninsula. This trough is even more pronounced during next day (July 20). The temperature is relatively low in 500 hPa level (around -13ºC) with high temperature in 850 hPa layer (around 19ºC) promoting a highly thermal instability situation (see Fig. 2).

In surface, most part of Europe is under the influence of high pressure, extending from the Atlantic Ocean to Russia, with two different centers, one of them situated in the south of the Azores Islands and another one more powerful over the British Isles. British high pressures tend to move gently to higher latitudes. The Iberian Peninsula remains in a barometric swamp situation and in Basque Country local breezes regime predominates (see Fig. 2).

This situation, during the studied episode, allows a significant rise in surface temperatures during the day and the development of storms which moves from southwest to northeast in the afternoons.

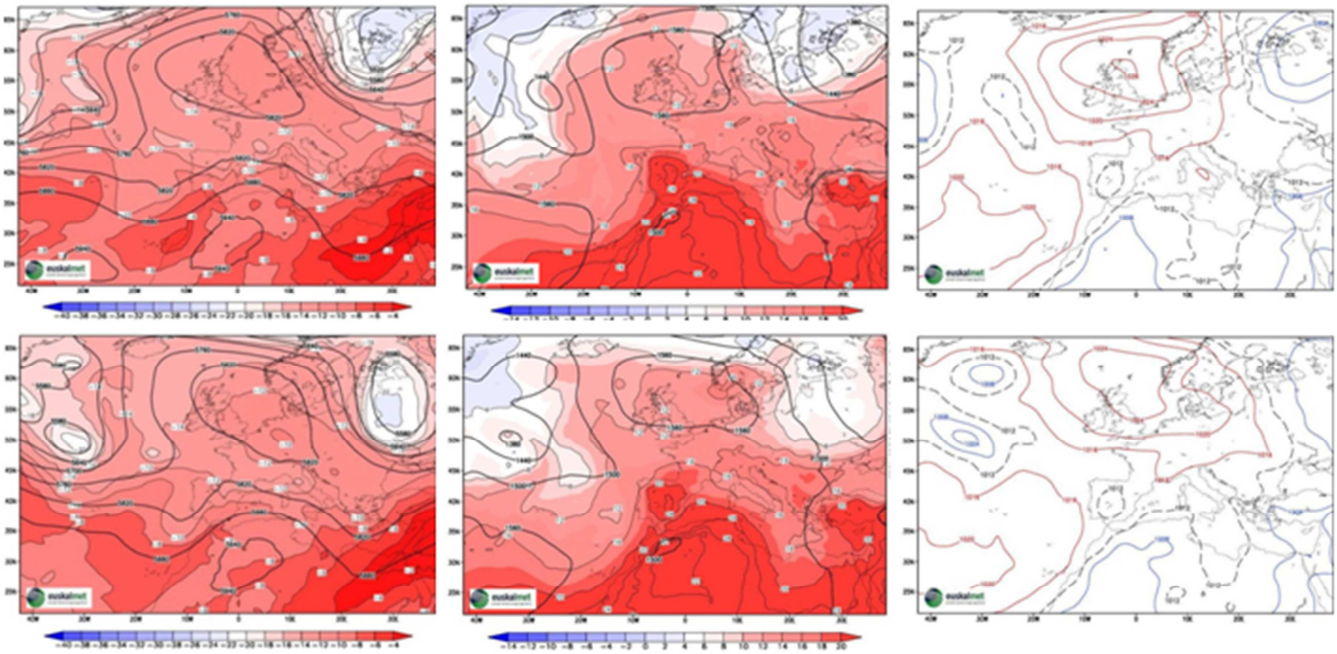

*Figure 2: Geopotential and isotherm in 500 hPa level, 850 hPa level and SLP (18:00 UTC 19/07/2013 and 19/07/2013).*

On the other hand, instability is significant in both events. Lift Index (LI) is around -6ºC both days and Total Totals Index (TTI) is around 52-53ºC and 55ºC for July 19 and 20 respectively. These values surpass established thresholds for severe storms development for Basque Country, and make clear the favorable conditions for convective activity, and high risk of severe thunderstorms and hail presence over the area (see Fig. 3).

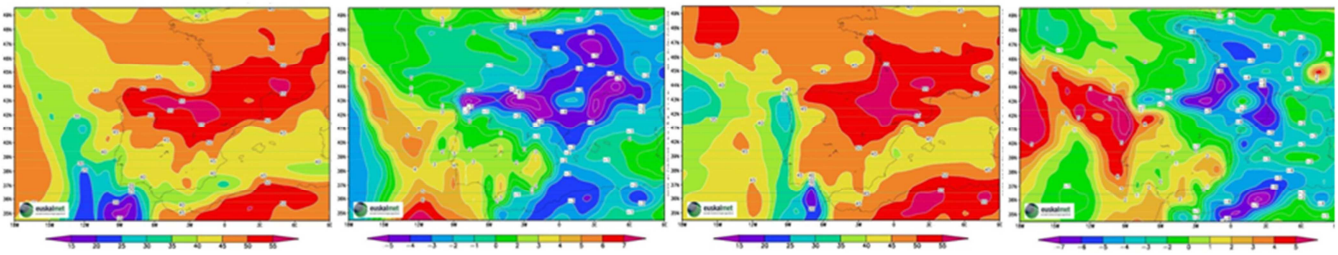

*Figure 3: Total Totals index (TTI) and Lift index (LI) for 18 UTC on 19 and 20 July.*

## 4 Episode description

The thunderstorms that take place on 19 and 20 July are quite similar, since environment conditions, associated with high thermal instability are similar both days. In addition, affected areas are very close together both days, being formed almost in the same place, since the most affected area is the western part of the Basque Country, near the boundary between the provinces of Araba (where most developed convective cells are formed) and the south of Bizkaia, but on the 20th the affected area is slightly higher. In both episodes, the convective nuclei are very active and are created in a very short period of time (with two hours apart between both episodes). In general, these cells move slowly northward and eastward, although movement of some of them is occasionally slightly different. This fact may be related to the self-propagation movement of the storm's own dynamic (see MSG HRV and IR imaginery on Fig. 4 and Fig. 5).

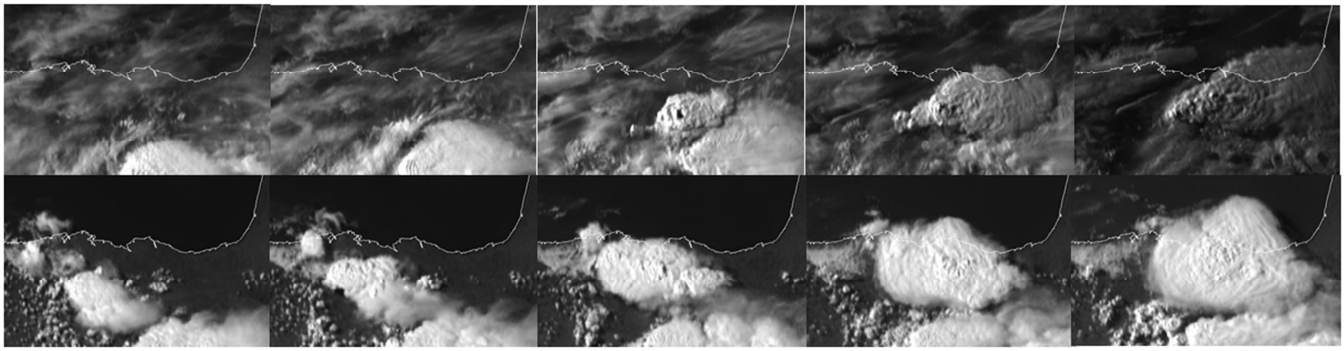

*Figure 4: MSG HRV sequence from 16:45 to 18:45 on day 19 and from 15:00 to 17:00 on day 20 (every half hour from left to right, top to down).*

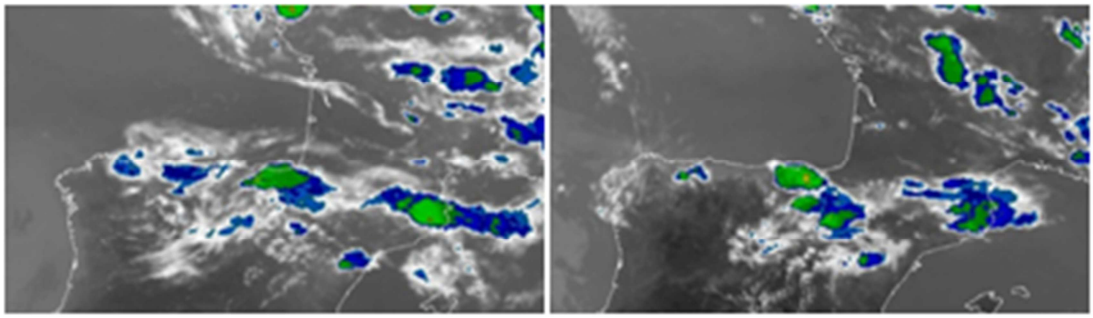

*Figure 5: MSG IR 10.8 colored (18:30 UTC 19/07/2013 and 16:15 UTC 20/07/2013).*

Focusing in data registered in the AWS available in the area, over 10mm/10minutes and over 30mm/1hour are registered in some AWS during events.The 10-minutes records of precipitation are already significant at 18:10 UTC, July 19, with values between 10 and 15 mm. The most affected area spreads from Subijana to around Altube, between 18:10 UTC and 19:50 UTC heavy (>15mm/hour) and very heavy (>30mm/hour) showers take place. In Bizkaia rainfalls are light and are limited to the south area. In Beluntza 31.1 mm/h (13.2 mm/10-min) are recorded, in Subijana 28.5 mm/h are accumulated (12 mm/10-min), in Altube 22.1 mm/h (14.1 mm/10-min) and in Sarria 17.8 mm/h (9.8 mm/10 min). In the whole day accumulated rain is 33.2 mm in Subijana and 31.1 mm in Beluntza, so almost all accumulated rainfall is recorded in a very short period of time, in just one hour. The localized temporal and spatial character of this precipitation can be seen in the Kriging maps of total rainfall in 24 hours and maximum hourly (see Fig 6 and Table 1).

Next day (20 July), between 16:30 and 18:30 UTC, heavy rainfall are registered in some AWS available in the area. The first major 10-minutes values begin to register at 16:30 UTC in the northwest of Araba, with values between 12 and 16 mm. Showers registered are very strong in Araba. Several AWS exceed 30 mm/h, such as Beluntza 39.8 mm/h (16.1 mm/10-min), Gorbea 36.5 mm/h (12.4 mm/10-min) and Altube 32 mm/h (12 mm/10-min). In other stations precititation are strong, such as in Sarria 24.1 mm/h (9.2 mm/10-min) and Otxandio 20 mm/h (8.8 mm/10-min), and slightly less in Arteaga (18.3 mm/h 9.8 mm/10-min) and Zaratamo (16.4 mm/h and 10.5 mm/10-min) (see Fig 6 and Table 1).

During those episodes showers are accompanied by hail and strong wind gusts. Very strong gusts are recorded at the Beluntza AWS and reach 92.8 km/h at 18:40 UTC on day 19, in Orduña wind gusts reach 103 km/h (16:20 UTC) and in Iurreta, an unexposed area, 91.4 km/h (17:10 UTC) on day 20 (see Table 1)

*Table 1. Representative data registered in some AWS available in the area.*


| AWS | 19/07/2013 | | | | | | | 20/07/2013 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max 10 min (mm) | TIME | Max 1 hour (mm) | TIME | Daily total (mm) | Máx wind gust (km/h) | TIME | Max 10 min (mm) | TIME | Max 1 hour (mm) | TIME | Daily total (mm) | Máx wind gust (km/h) | TIME |
| Altube | **14,1** | 18:50 | 22,1 | 19:30 | 22,3 | 54 | 18:30 | 12 | 16:40 | 32 | 17:10 | 32,5 | 57 | 16:30 |
| Arteaga | 0 | | 0 | | 0 | 28 | 13:10 | 9,8 | 18:00 | 18,3 | 18:10 | 18,3 | 41 | 17:20 |
| Beluntza | 13,2 | 19:00 | **31,1** | 19:30 | 31,1 | **92** | 18:40 | **16,1** | 16:30 | **39,8** | 16:50 | 41 | 68 | 16:30 |
| Gorbea | 4,2 | 19:10 | 9 | 19:30 | 9,3 | | | 12,4 | 16:50 | 36,5 | 17:20 | **45** | | |
| Orduña | 6,4 | 19:20 | 11,7 | 19:50 | 14,1 | 34 | 18:50 | 5,7 | 16:20 | 8,3 | 16:50 | 8,3 | **102** | 16:20 |
| Otxandio | 0,4 | 19:20 | 0,8 | 20:00 | 0,8 | 24 | 22:40 | 8,8 | 16:40 | 20 | 17:20 | 22 | 57 | 16:30 |
| Sarria | 9,8 | 18:50 | 17,8 | 19:30 | 18,3 | | | 9,2 | 16:50 | 24,1 | 17:20 | 25,3 | | |
| Subijana | 12 | 18:10 | 28,5 | 18:50 | **33,2** | | | 0,1 | 10:30 | 0,1 | 10:30 | 0,1 | | |
| Zaratamo | 0 | | 0 | | 0 | | | 10,5 | 17:30 | 16,4 | 18:10 | 16,4 | | |

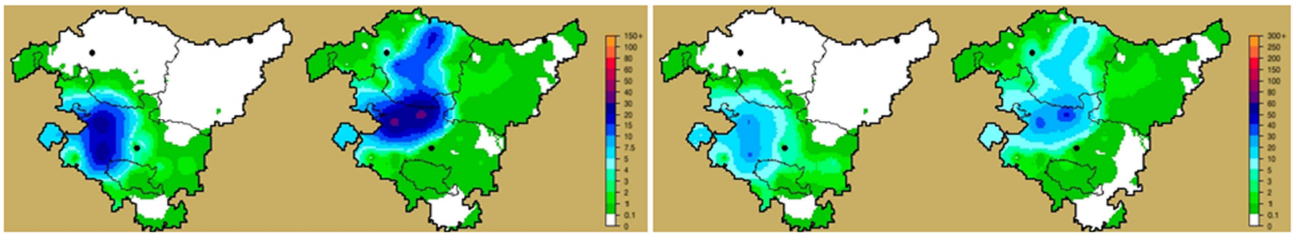

*Figure 6: Maximum hourly and daily total precipitation (mm) for 19 and 20 July 2013*

During both episodes thunderstorms are accompanied by abundant electrical activity, especially on July 20, when the density of lightning discharge recorded is higher (2448 lightning) than on July 19 (875 lightning), and the affected area is bigger. These thunderstorms occur in the afternoon, although most of lightning (positives and negatives) are recorded in a period of just two hours.

## 5 Radar analysis

On 19 July, from approximately 11:30 UTC, convective activity begins at the north of the Iberian System. During the next few hours convective activity are more significant and widespread, with southwest-northeast direction, but do not affect the Basque Country. By 17:20 UTC a relatively widespread storm cell quickly begin to be locally generated at the centre of Araba moving from south to north in the area of study as we can see in radar products (see Fig 7).

The next day, July 20, a very similar situation occurs, first cells begin to developed at 12:00 UTC at south and west part of the region, but don't affect the area of study. In the afternoon, around 15:00 UTC, storm cells coming from west and new ones locally generated affect the area, and moves from southwest to northeast merging and acquiring a large development. The area affected by heavy showers is a bit larger than the previous day, arriving to different places of Bizkaia. The most affected area is again the Mediterranean side, in the slopes of Gorbea mountain (see Fig 7).

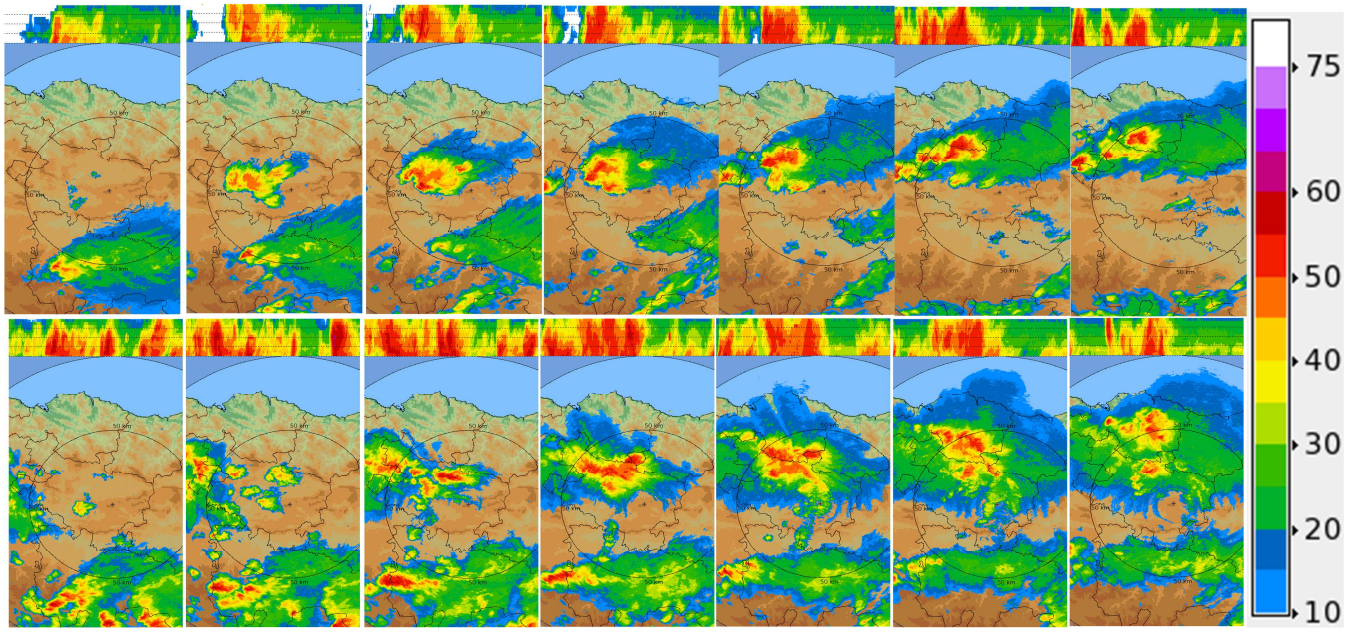


*Figure 7: MAX (2-10km) images from 17:20 to 19:20 (19/07/2013) and from 15:20 to 17:20 (20/07/2013) every 20 minutes.*

Reflectivities observed for these nuclei are high, in general fluctuating between 50 and 55 dBz, at times 55 dBz are even exceeded, as seen in MAX products, ranging from 2 km to 10 km (see Fig. 7). As mentioned, during these two days the situation is similar and showers lose intensity as they are moving northward. It is noteworthy the great vertical development that is reached by the cells in such a short period of time. Analyzing 15 dBZ Echotop (see Fig 8) and RHI products (see Fig 9), we can see that storm cells reach an altitude close to tropopause level (15 km), creating at surface severe weather with heavy showers as consequence of deep convection. There are more cells formed during the 20th than the 19th, but vertical development, as we have seen, is very similar in both cases. ZHAIL product (see Fig 10) shows high probability of hail in the studied area, as it happened in the most affected area.

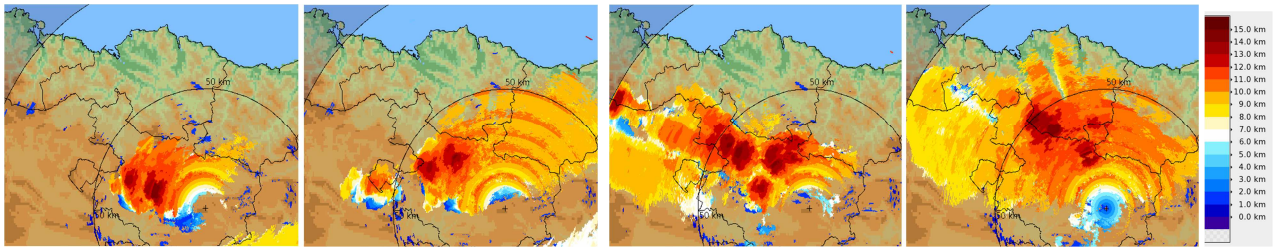

*Figure 8: Echotop products at 14:02 and 14:12 UTC on 19 july and 17:52 and 18:31UTC on 20 july.*

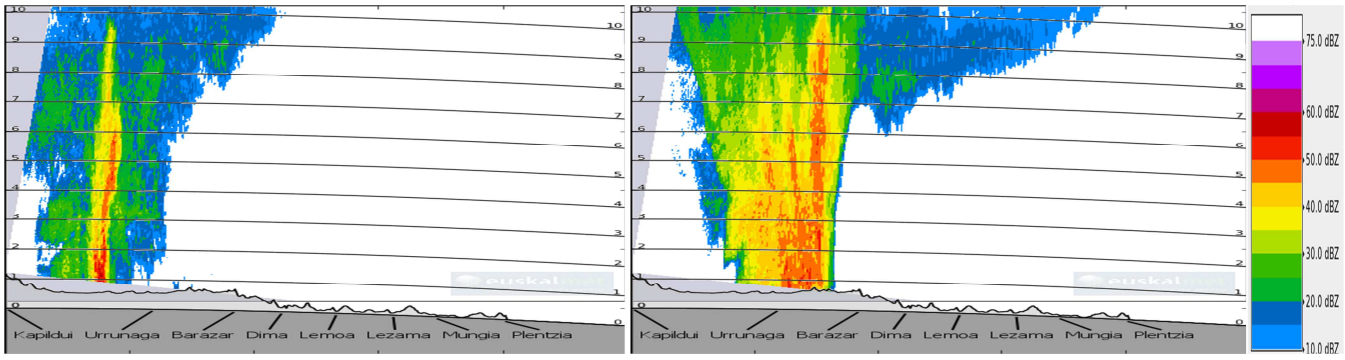


*Figure 9: RHI product for NW Azimuth on 19 July 18:08 and 20 July 16:28.*

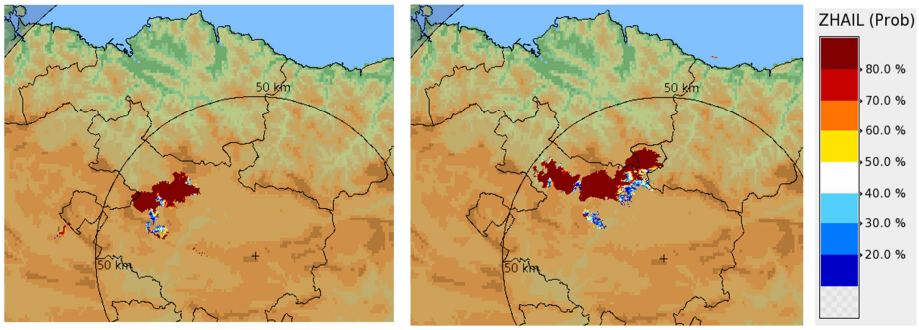


*Figure 10: ZHAIL-15dBz for 19 july 18:32 and 20 july 16:20.*

In the ZDR(Differential reflectivity) product we can observe the attenuation associated with areas of high severity (very heavy precipitation and hail in the studied area). In spite the differential reflectivity has a bias of -2.7 dB, it is possible to see some points of high reflectivity correlated to minus values of ZDR in both days (see fig 11). On 19th July, strong attenuations are present in the data since 17:52 to 19:32. On 20th higher attenuations are present since 16:32 UTC to 17:32 UTC.

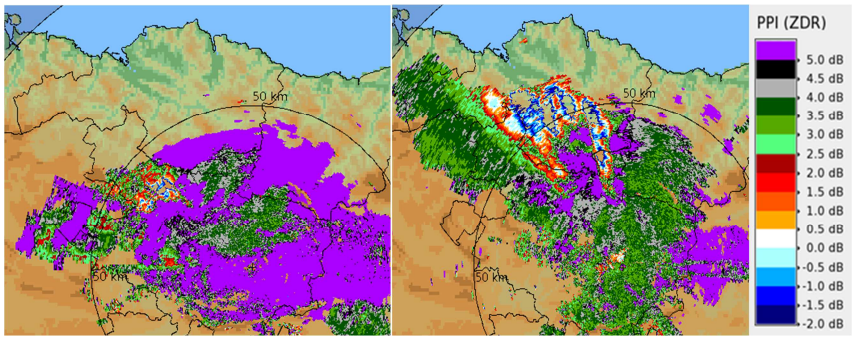


*Figure 11: PPI 0.5º (ZDR) for 18:42 19 July and 17:02 20 July.*

## 6 Summary and conclusions

This paper has presented a description of a severe convective event over the Basque Country using weather radar data and other information available in the area.

In a synoptically favorable environment for storms formation mainly due to thermal instability, two deep convection event are registered during 19 and 20 July over Basque Country area. During analyzed episodes instability indexes surpass the threshold of severe weather, and thunderstorms with large vertical extension are promoted. Hourly rain rates in some AWS in the area are over 30 mm with ten minutes precipitation surpassing 10 mm. During the event hail, electrical discharges and very strong wind gusts are registered.

In the radar imagery is clearly observed the large extension of the different convective cells and the high reflectivity during the heavy showers. The reflectivity values observed are typical for summer convective events in Basque Country. Displacement from North to South and vertical development observed are also typical.

Forecast bulletin issued by Euskalmet reported for days 19 and 20 very cloudy weather with probability of rainfalls that could be moderate and stormy during the evening. A yellow level warning was issued point out the probability of storms with possibility of heavy rain and hail from 15:00 to 24:00 Local time on both days.

Some problems, mainly due to rain intensity and hail presence, were produced in the affected area, including some incidents on roads and with campers in the area of Gorbea natural park particularly during the evening on day 19.

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