REMOTE SENSING ANALYSIS OF A SEVERE CONVECTIVE STORM IN BASQUE COUNTRY

Gaztelumendi S.[12], Egaña J.[12], Lopez J.[12] ,Hernández R.[12] ,Maruri M.[12] ,Otxoa de Alda K.[12]

[1]*Basque Meteorology Agency (EUSKALMET) Parque Tecnológico de Álava, Avda Einstein 44 Ed 6, Of. 303, 01510 Miñano, Álava, Spain*

[2]*TECNALIA Meteorology Area. Parque Tecnológico de Álava, Avda Einstein 28, 01510 Miñano, Álava, Spain*

I. INTRODUCTION

In this paper an analysis of a severe convection event in Basque Country (BC) is made focusing on operational remote sensing information, including Radar, Meteosat and lightning detection system, available for the study area in Basque Meteorology Agency. We also present different aspects of the environment characterization affecting the storm evolution, at synoptic, mesoscale and local scale, including numerical modeling and registered data from Automatic Weather Stations (AWS) network.

This heavy hailstorm episode, affects the central part of BC on 30th May 2011. During this event convective cells with large vertical development reaching or exceeding 10 km are present, as a consequence radar reflectivity values observed are exceptional, mainly due to rain rate and droplet size rather than to hail size.

Some heavy (>15mm/hour) and very heavy (>30mm/hour) rain episodes, accompanied with hail, were observed all over the region. Showers are especially intense in Zuia area, where some AWS register more than 30 mm in one hour with ten-minutes rain-rates over 15 mm. In Sarria AWS this hailstorm left 115 mm precipitation in one hour, a hourly accumulation rainfall data never registered before for this location. In, Damages, due to hailstone and water accumulation, were produced in the surroundings of Gorbea Mountain including Murgia Village (3 km from Sarria AWS) (FIG 1)

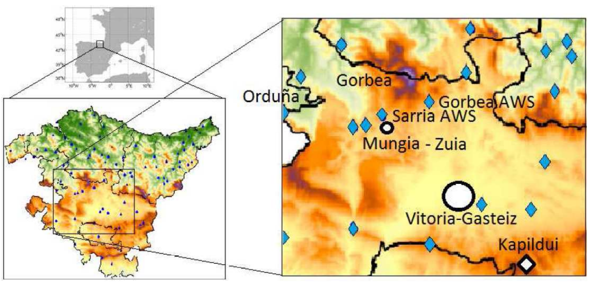

FIG. 1: Geographic location of study area including some places referred in text..

II. EPISODE DESCRIPTION

Regarding synoptic environment, a trough in height moving from west to east of the BC (-16 °C at 500 hPa) is observed, at surface an area of relative low pressure is present (FIG 2). Stability indexes have moderate values with LI around -3 and TTI around 54 showing storms probability with hail possibility (FIG 3 & FIG 4). Forecast bulletin issued by Euskalmet, reported for this day very cloudy weather with probability of rainfalls that could be moderate and stormy during the evening. A yellow level warning was issued for this day point out the probability of storms with possibility of heavy rain and hail in the central hours of the day.

Showers are especially intense in sorroundings of Gorbea mountain, due to a particular quasi-estationary convective nucleus development. Sarria AWS accumulates 115 mm/h (18.2 mm/10-min) and in the near Beluntza and Gorbea stations 45.2 mm/h (15.8 mm/10-min) and 33.4 mm/h (15.9 mm/10-min) are registered, respectively (see TAB 1 & FIG 5). This convective cell moves slowly eastwards and finally decays. During the rest of the evening, different stormy showers are formed leaving heavy and very heavy showers in other places around Vitoria city (TAB 1) as in Subijana (15.5 mm/h, 7.8 mm/10-min) or Salvatierra (39.1 mm/h, 12.5 mm/10-min).

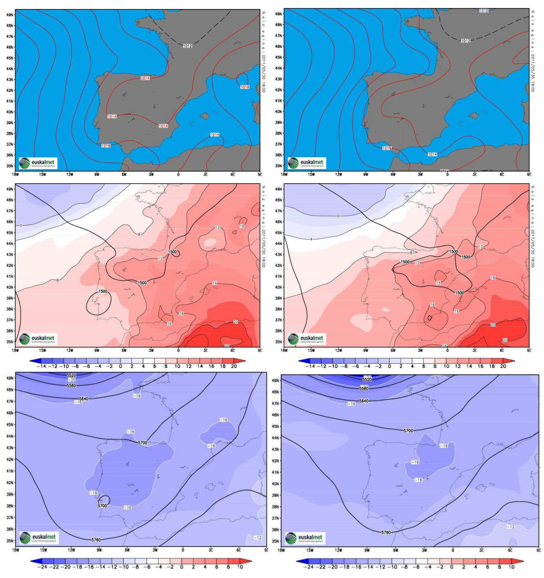

FIG. 2: SLP, Geopotential and isotherm in the 850 & 500 hPa level (12 & 18 UTC 2011 May30st) .

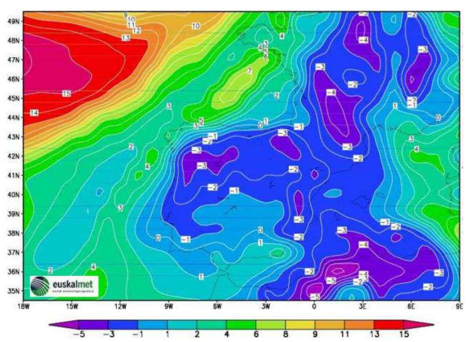

FIG. 3: Lift index (LI)) for 12 UTC 2011 May30st.

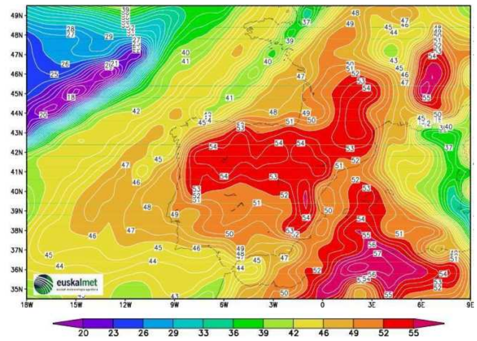

FIG. 4: Total Totals index (TTI) for 12 UTC 2011 May30st.

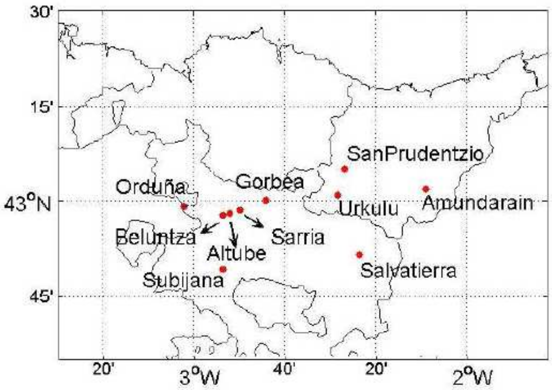

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FIG 5: Some AWS in the study area.

AWS	1h	10m (time)
Sarria	115	18.2 (14:10)
Beluntza	45.2	15.8 (14:20)
Salvatierra	39.1	12.5 (15:30)
Gorbea	33.4	15.9 (14:40)
Urkulu	23.9	10.3 (15:30)
San Prudentzio	19.5	6.9 (15:30)
Altube	19.4	9.7 (14:00)
Amundarain	19.3	7.4 (16:10)
Orduña	19.2	4.6 (13:40)
Subijana	15.5	7.8 (14:50)

TABLE 1: Hourly and 10-minutes maximum accumulated rain (l/m2) in some AWS in Basque Country.

III. MSG ANALYSIS.

In MSG images can be observed how storm nucleus begins to form, early in the afternoon, in the Basque Country vicinity, with a weak westerly flow with relatively slow storms displacement. These convective cells are formed at northwest from Vitoria-Gasteiz city (from 13:00 to 15:00) and later on at east of Vitoria-Gasteiz City (FIG 6). In Meteosat high resolution visible channel (HRV) imagery is possible to appreciate the initiation of convective activity from 12:00 at the west part of the study area, those convective cells developed with a slightly east displacement later on (FIG 6). In infrared channel (IR10.8) can be appreciated maximum activity in the area of study around 14.00 UTC (FIG 7), with bright temperature of -56ºC showing that top of convective cells are reaching tropopause.

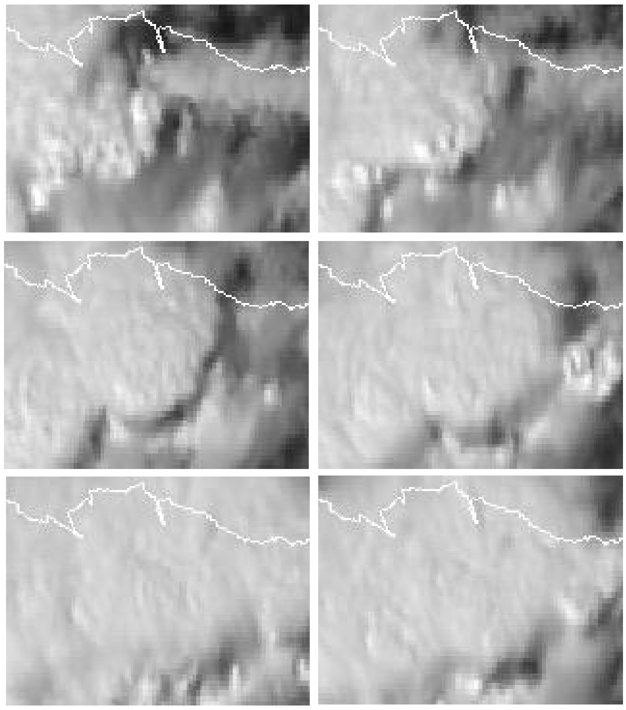

FIG.6: MSG HRV for13:30, 13:45, 14:00, 14:15, 14:30, 14:45 UTC 2011 May 30st..

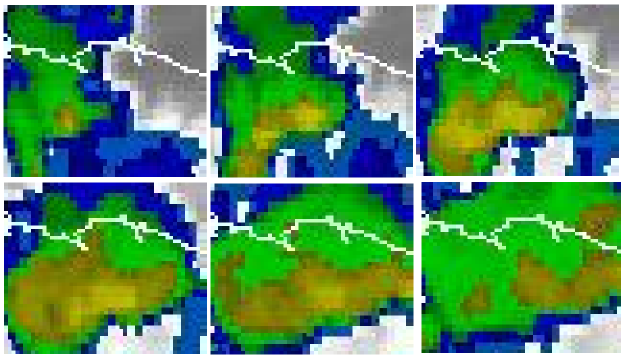

FIG.7: MSG IR 10.8 coloured for13:30, 13:45, 14:00, 14:15, 14:30, 14:45 UTC 2011 May 30st..

IV. RADAR ANALYSIS.

Euskalmet radar is a METEOR 1500 Doppler Weather Radar with Dual polarization capabilities, sited in Kapildui mountain (FIG 1). Euskalmet radar operates with a configuration based on four different scans. The first volumetric scan is configured for a maximum range of 300 km with 5 elevations from 0º to 2.5º, a range step of 1 km and an angle step of 0.8º. The second volumetric scan is configured for a maximum range of 100 km with 14 elevations from –1.5º 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.

Many products are available in Euskalmet offices in real time (10 minutes basis) from vendor Rainbow software and our own developments. Simple and standard products as CAPPI (FIG 8) or MAX (FIG 9) can be used for analysis. In those products, can be observed the formation of convective structures in the study area, with cells deepening and moving slowly eastwards. Reflectivities over 50 dBz are widely observed. Convective activity is clear and heavy showers are probable all over the area. In some storm cells values over

55 dBz are present, so hail presence is feasible as a consequence of deep convection. Some convective cells rest for more than 50 minutes in Zuia area, and moves slowly northeastwards. Period of highest activity lasts from 13:32 to 14:42 UTC, with maximum reflectivities over 60 dBz in the 2-6 km layer inside some cells affecting the Zuia area.

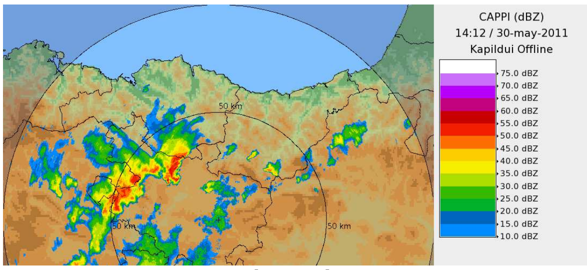

FIG 8: CAPPI 2km product at 14:12 UTC

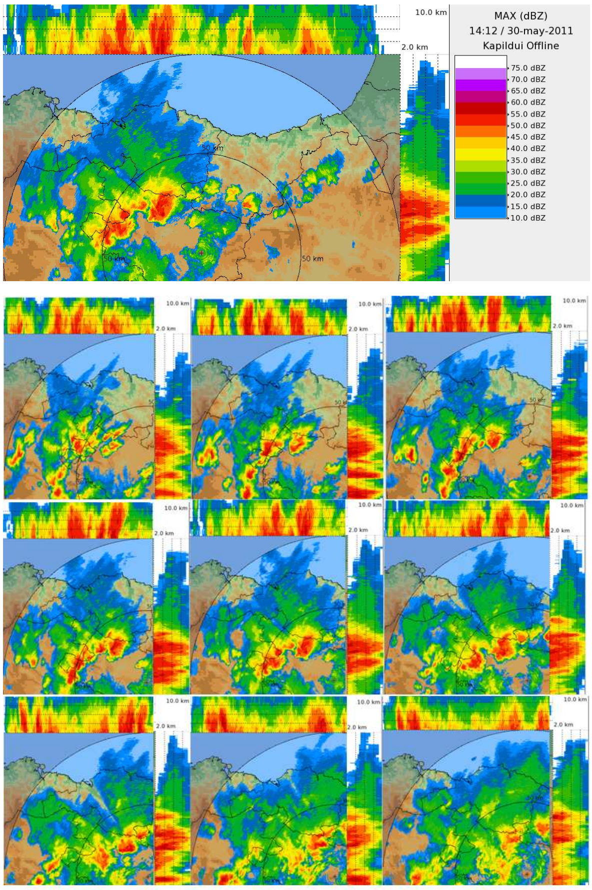

FIG.9: MAX product at 14:12 UTC and sequence of MAX product images from 13:32 to 14:52 on

The ECHOTOP values of 15 dBz surpassed the 12-13 km height (FIG 10) near tropopause level. With such a vertical extension, heavy showers, wind gust and electrical activity are observed. The largest vertical extension for this single cell occurs around 14:00 UTC.

In the RHI product (Range Height Indicator for 339º) (FIG 11), can be appreciated the vertical homogeneity of reflectivity values in vertical, with values around 55 dBz from surface to more than 3 km, as usual in storm environment with hail presence.

In the Zhail products set we can see single cells with more than 80% probability of hail presence over the area (FIG 12), from 13:42 to 13:48 the convective cell over study area presents an extended area of hail probability, hail probability reduces as storms go through the east

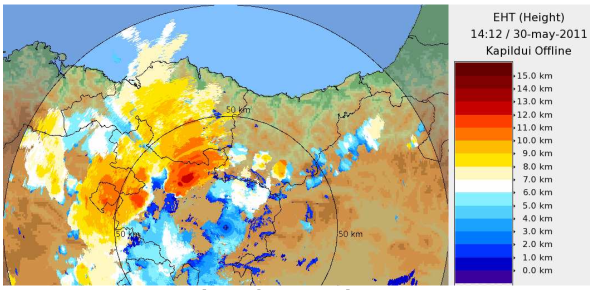

FIG.10: 15 dBz Echotop product at 14:12 UTC

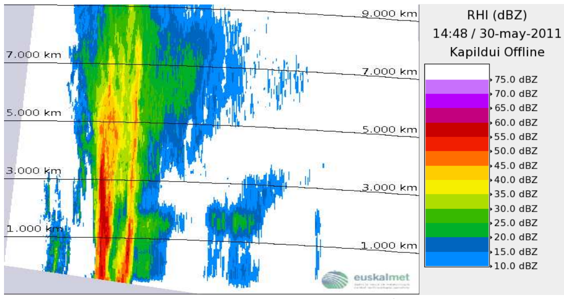

FIG.11: RHI product NW azimuth cut for 14:48 UTC

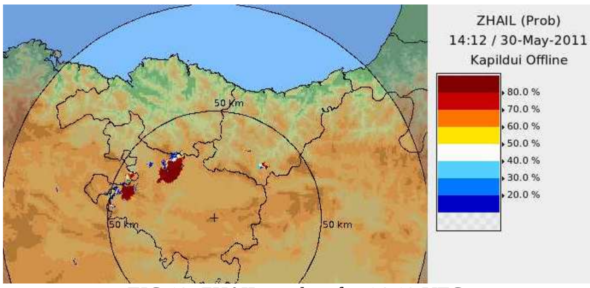

FIG 12. ZHAIL product for 14:12 UTC.

V. LIGHTING DETECTION NETWORK ANALYSIS

The Basque Country Lightning Detection network began its operation in November 2008. Four LS8000 sensors manufactured by Vaisala integrate this network. In these sensors two detection technologies are combined:

- Time of arrtival (TOA) and magnetic direction finding (MDF) in the LF frequency band are used for detecting cloud to ground lightning discharges
- The interferometry technique is used for detecting radiation sources in the VHF frequency band. This technology is used for detecting intra cloud discharges

On the other hand, four sensors of the LINET network were installed in the Basque Country in 2009. These sensors perform detections in the VLF frequency band, and provide data relative to Cloud to ground (CG) and intracloud (IC) discharges, with an estimation of the height at which these last ones occur.

Regarding the information retrieved by the lightning detection networks during this event (FIG 13), the LF sensors located 90 CG lightning discharges during the entire hailstorm, all of them of the negative type. In the ten minutes between 13:50 and 14:00 UTC, the time correlations obtained for the CG detections performed by the LF and the VLF sensors show 24 strokes. Sixteen of them can be grouped into flashes of multiplicity between 2 and 5. In these ten minutes no intracloud activity was detected by the VLF network, whereas 19 VHF radiation sources are time correlated to the CG strokes.

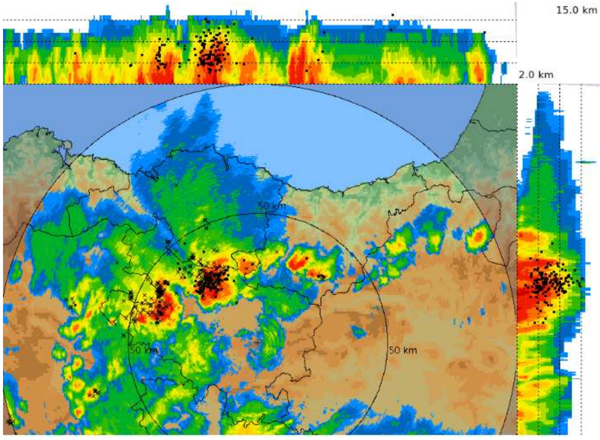

FIG.13: Combined MAX and lightning discharges product using LINET (dots for IC, cross for CG).

VI. SUMMARY AND CONCLUSSIONS

During the case study (30 May 2011) the synoptic situation affecting Basque Country is marked by a trough passage from west to east, with relatively cold air in height. This trough was reflected in low atmospheric levels, with the formation of relative low pressures and the passage of an instability line associated with. Early in the afternoon of May 30, storm cells start to form in the vicinity of the Basque Country; these convective cells have a large vertical development reaching or exceeding 10 km in the vertical. Some heavy rains episodes, accompanied with hail, were observed especially in the surroundings of Gorbea Mountain where over 110 mm in one hour was registered as a consequence of a single cell storm passage.

During the episode, storms have a large vertical extension getting more than 10 km and even tropopause level, promoting heavy showers and hail presence. Although reflectivities over 60 dBz could indicate big hailstone presence, in this case, they are probably more related with the precipitation rate and rain droplet size than with the hail size.

Mature stage for the storm cell affecting Zuia area is observed in 13:52 and 14:02 radar images, with deep convection and a large vertical extension over 10 km. In fact the hailstone shower observed over Murgia village begins around 13:40 UTC and last for more than half an hour with 1-2 cm hail-size (for no more than 5 minutes) and heavy shower (FIG 14 & FIG 15). Nearly at same time in Sarria AWS precipitation rates around 15mm/10-min is registered during 40 minutes.

VII. ACKNOWLEDGMENT

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FIG.14: Showers, local floods and hail in Murgia Village.

FIG.15: Hail accumulated in a garage in Murgia Village.

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