A study of a tornado event in Basque Country: the 4^{th} July 2018 case.

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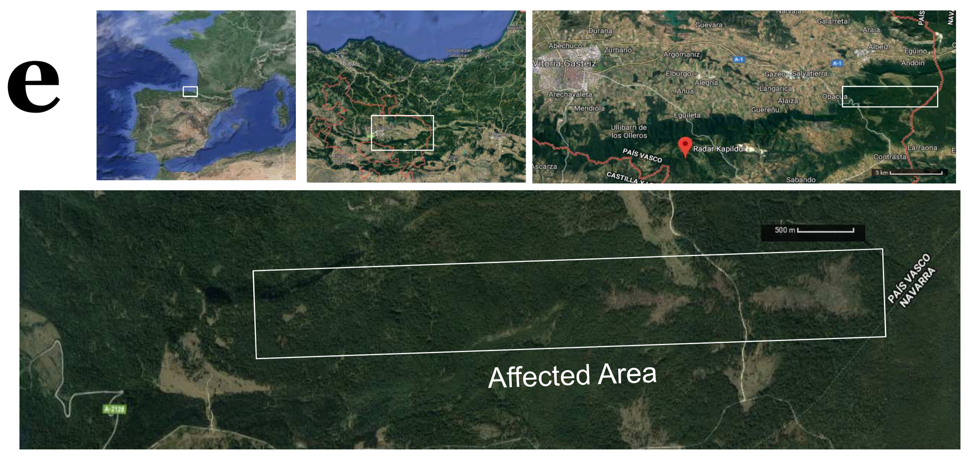

Fig 1. Basque Country location and affected area

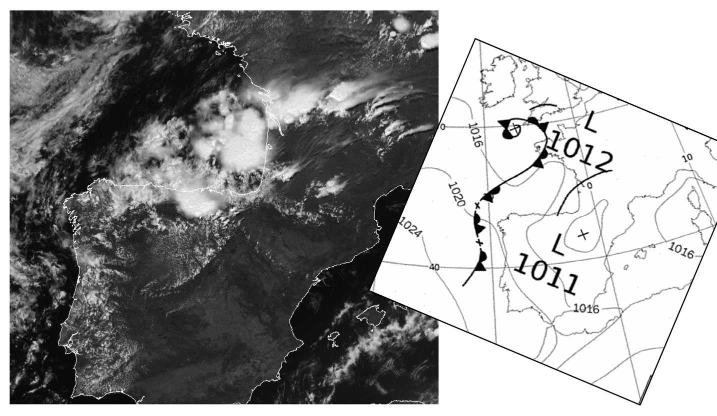

Fig 2. HRV MSG Image and metoffice analysis for 12:00 UTC on tornado day.

Abstract

In this study we describe the occurrence of a tornado during the 4th July 2018 in the southern part of Basque Country that affects an uninhabited wooded area (the Legaire fields in the Entzia mountain range). The tornado touched down in a beech forest causing significant damage, with hundreds of trees uprooted or cut by the wind. A total of 72 hectares delimited by a perimeter of 11 Km, in an area of 2 Km long and widths up to 200 meters in some places. During this day, much of the Basque Country is affected by storms with heavy rains, hail and wind gust, particularly the Álava territory and its capital Vitoria-Gasteiz, where urban floods and minor damages are produced.

In this work we focus on the study of meteorological situation during the event and on the atmospheric conditions for the occurrence of the tornado. We present an analysis of the general environment focusing on the relevant aspects that favor severe convection development, using different synoptic and mesoescale information, including Radar data and Meteosat images. Finally we include an evaluation of surface aspects and damages in the affected area.

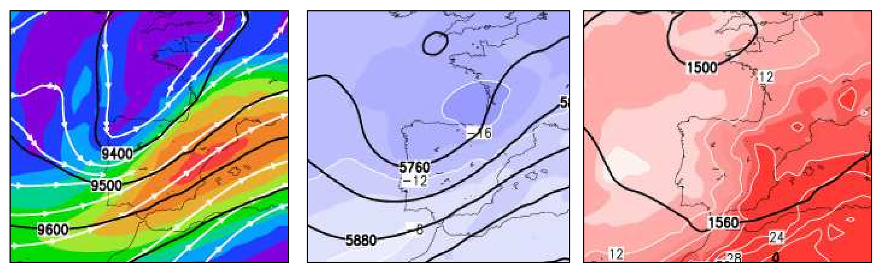

Fig 3. 300hPa Geopotential height and Jetstream, Geopotential and isotherms at 500hPa and 850hPa (form left to right)

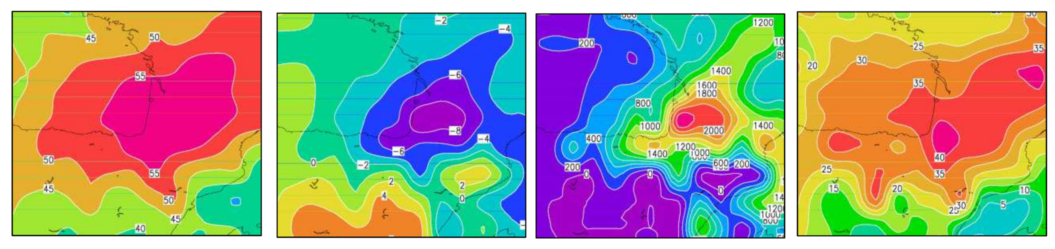

Fig 4. Some instability index for 12:00 UTC (TTI, LI, CAPE and K from left to right).

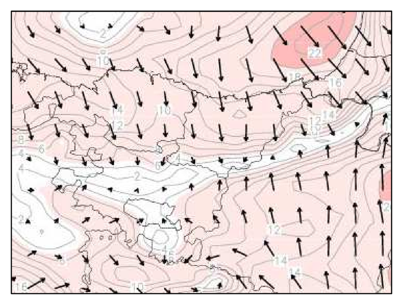

Fig 5. 12:00 UTC Surface wind.

Introduction

Tornado cases in Europe (e.g. Leitao 2002, Tyrrel 2003, Marshall 2006, Giaiotti 2007, Rahuala 2012, Antonescu 2015), Iberian Peninsula (e.g. Gaya 2005, 2011b, Riesco 2015), and particularly in Mediterranean area (Catalonia, Balearic Islands, and Andalusia) (e.g. Martin 1997, Homar 2001, Bech 2007, Gaya 2011), are relatively often observed in Cantabric area (north of Iberian Peninsula) they are very unusual, in fact in Basque Country just another case is previously documented in recent history: the 23rd June 2014 case (Gaztelumendi 2015, 2016). In former 23 jun 2014 the event also happened in Araba, in that case in Bernedo municipality (near Izki area) where about 3 hectares of pine forest were affected by a short lived F2 tornado. Like in this new event, on that time the tornado also affected unpopulated area without direct human observation.

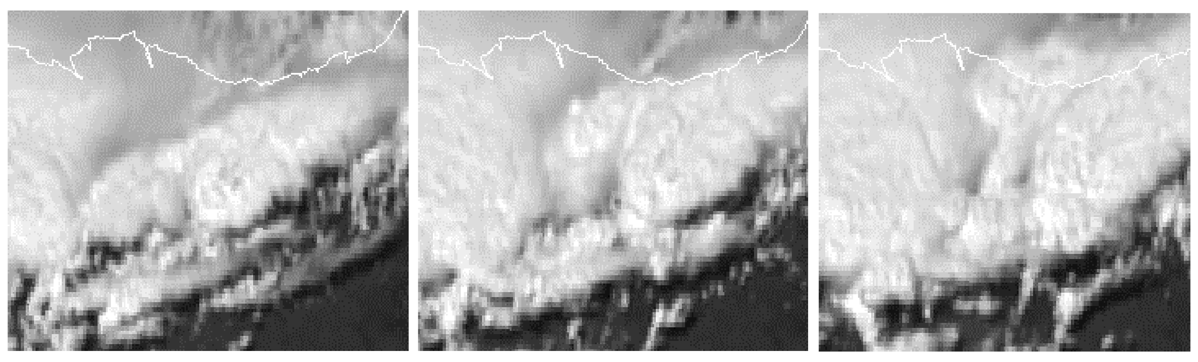

Fig 6. HRV MSG Image for 12:45 UTC to 13:15 each 15 min (from left to right and top to down).

Results & Discussion

General environment

General environment is marked by high degree of dynamic and thermal instability. On the one hand, we are to the right of the trough axis, on the other hand, cold air in medium and high levels generates a line of instability that moves from west to east (see figure 1 and 2).

The synoptic situation is determined by a cold air bagging that moves from west to east by the northern peninsular third, generating marked instability. On the surface, the north component flows predominate due to the stretching of the Azores anticyclone towards the Cantabrian and the formation of relatives lows to the east of the Iberian Peninsula (see figure 2).

Around noon instability indices and convection parameters indicate high degree of instability (TTI = 58 ºC, LI = -6/-7 ºC, CAPE = 1400/1600 J/kg) with PW = 25/30 kg/m2, moderate to high shear values (0-6km DLS = 20 m/s) and low level convergence (see fig 3 and 4).

Storm environment and Radar data

During the study day and particularly from noon different stormy cells develop and affect the Basque Country, leaving very strong showers (13.7 mm/10minutes in Salvatierra 29.4 mm/1hour in Arkaute) with hail of relevant size (3-4 cm in Araia area) and very strong wind gusts (72.3 km/h in Arkaute). Thunderstorms with vertical development up to 12-13km are very active with 8540 CG lightning strokes registered all over the area.

From 12:00 a storm core quickly begins to grow with a SW-NE translation, in a early stage this core splits in two storms cells that evolve independently, first one to the north and second one to the east. This one, half hour later, gets supercell characteristics with a great vertical extent (see Fig. 6 and 7), with cloud top reaching the tropopause (13-14 km) (see Fig. 8). Mesocyclone evolution can be seen in figure 9 where the radar radial wind images marks the cyclonic eddy spatio-temporal extent and storm rotation structure. Note how large relatively weak storm couplet evolves including smaller and stronger couplets inside general storm structure, as a plausible sign of tornadogenesis over the affected area.

In between 13:02 and 13:12 (see Fig 7) we can appreciate a kind of temporary collapse of the supercell probably also related with tornadogenesis.

In figure 10 we can appreciate a zoom with the surface (cappi 2km) radar signature for 12:52 to 13:22 each 10 minutes. In the 13:02 image we can see a kind of hook echo pattern showing the storm rotation and precipitation structure at west of the main affected area. During next 20-30 minutes radar signatures are compatible with a plausible tornado event moving to the east.

We must consider that complex orography in the area (sharp slope and funnel terrain configuration) favors the modification of the shear in low layers and the conversion and potentiation of horizontal vorticity into vertical vorticity near surface promoting tornadogenesis.

Damages and impact analysis

The affected area (see fig 1 and 11) is located in the forest of Legaire in the Sierra de Entzia, which is a karst terrain, in a high area (between 900 and 1,000 meters of altitude), relatively flat and totally unpopulated. The forest is a fully mature beech forest with large specimens, mostly above 40 cm in diameter, with heights from 20 to 30 meters. The tornado (or tornados ?) probably touched the ground along 11 km path, although in first kilometers fallen trees are scarce and in small and scattered areas in the final 2-3 km fallen trees are very abundant and in large areas where 72 hectares of mature woodland was almost completely uprooted (see figure 11). Being a karst area, the soil is not very abundant, but the trees and their roots uprooted the soil along with the calcium carbonate rocks where the soil settled (see fig 12).

The most severely affected area is a two kilometers long with wide that exceeds 200 meters at certain points. The trees are mostly specimens with 50-100 years, with diameters ranging from 30 cm in the smallest to the one meter in diameter and heights that generally range from 20 to 30 meters. The configuration of the fallen tree trunks is, for the most part to the east, except on the north bank of the formed clearing, which fell mostly to the west. The clearing has a Y-shape, especially in its western section, so the presence of two tornadoes cannot be ruled out. Tornado (or tornados?) have a general movement from west to east. Among the uprooted trees, from time to time trees with treetops damages, broken branches at heights of 5-15 meters and with the wood totally splintered and burst are seen in the surroundings of the plausible tornado path. Some of the busted tree trunks have widths greater than 30-40 cm. Since these are healthy specimens, the damages observed in the forest are compatible with wind speeds greater than 180 km/h.

Therefore, given the characteristic of the damage, the trajectory, the directions of the trunks and uprooted trees probably one or more tornadoes reaches the surface in the affected area with wind gusts much greater than 180 km /h.

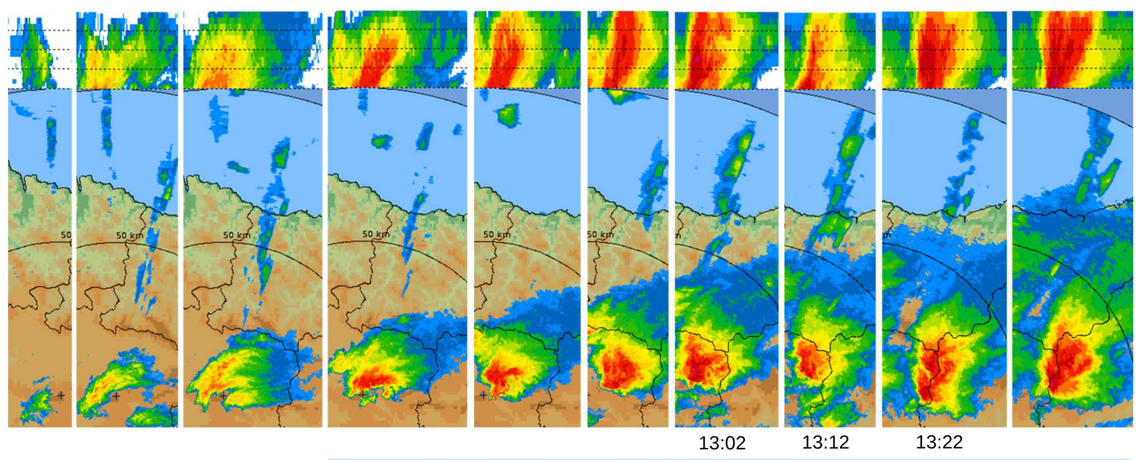

Fig 7. Max 2-10km from 12:02 to 13:32 each 10 minutes (from left to right)

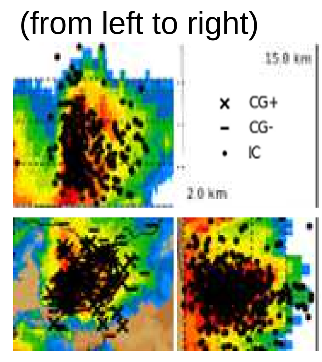

Fig 8. Max 2-15km with lightning for 13:02

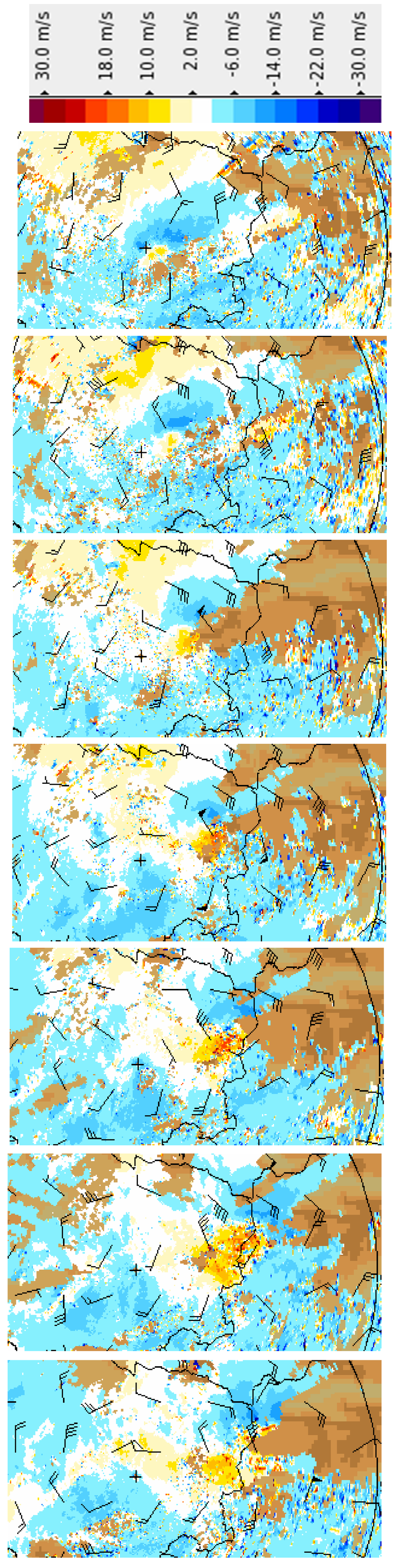

Fig 9. Cappi radar product with radial velocity and hwind (0.250 km / pixel) from 12:30 to 13:30 each 10 minutes (from top to down).

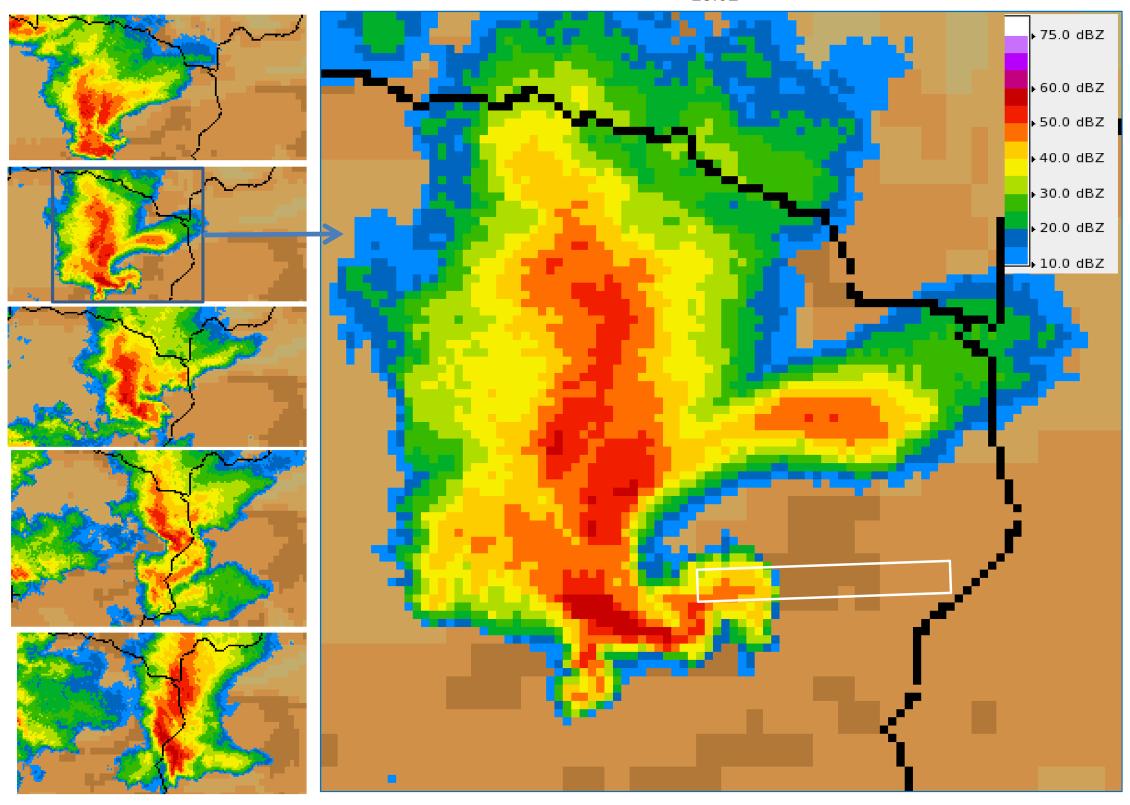

Fig 10. Cappi 2km radar product (0.250 km / pixel) from 12:52 to 13:32 each 10 minutes (left top to down) with zoom for13:02 and affected area (white area).

Fig 11. Aerial Images for main affected area with zoom for details in selected zones.

Conclusions and remarks

The studied case is the second documented tornado event in recent history of the Basque Country. Even though there is no direct human observation of the tornado, the distribution and characteristics of fallen trees (no diffluent damages are observed) are compatible with the effect of a short lived F2 tornado (or tornados).

Unless the Euskalmet Operational C–band Doppler Radar is quite near the affected area (20 km to the SW), it can't see the tornado itself because lack of resolution of operational products. In any case different radar products indicates the presence of different signatures compatible with tornadogenesis like mesocyclone, supercell structures, hook echoes in precipitation images and wind couplets in radial wind products.

Further work must be done in order to a better as possible off-line radar characterization of this event and also an in deep analysis of plausible trajectory. Is important to note that radar characteristics are tuned for general precipitation surveillance and that the different products shown here are real time routine operational products.

Fig 12. Some pictures taken at surface with uproot trees details.

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