A STUDY OF INSTABILITY INDEXES IN SUMMER SEVERE STORMS CASE IN THE BASQUE COUNTRY AREA

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I. INTRODUCTION

In this work is presented a study about the correlation between several instability indexes and the severe summer storm situations, focus on the usefulness supporting the actions of operational weather forecast for the Basque Country area in this type of episodes.

In the Basque Country severe storms take place usually from May to September (summer period). In this work the cases are selected basing on a precipitation rate threshold criteria and lightning activity presence. As representative for severe storms cases summertime events with precipitations that exceed ten millimetres in any rain gauge from the Basque Country Automatic Weather Station Network (BCAWSN) are studied in the last years.

II. PRESENTATION OF RESEARCH

Severe storms events for the summer period (defined from May to September) for the last 10 years have been considered. In the summer period, the troposphere is warmer and can afford more water vapour. During this period, the sea temperature reaches the highest values of the year (21-22 ºC), the last years have been registered punctual values of 25-26 ºC. Take into account these characteristics the risk of heavy and intense precipitations increase. As an example, the most important flooding in the Basque Country in last years happened in August of 1983.

Cases are selected basing on a precipitation rate threshold criteria and lightning activity presence. Events with precipitations that exceed ten millimetres in ten minutes usually produce some kind of problems in this area, so, days with this threshold surpassed in any rain gauge from BCAWSN are considered.

To characterize severe storm events, an analysis of the most significant parameters (500 hPa topography, sea level pressure and some instability indexes), that have influence in the development or activity of convective cells, will be made. The most used instability indexes in the Basque meteorology agency operational tasks for the forecast of these events will be taken into account. The propose of this work is to do a study of the synoptic situations associated with these summer storms events, in order to characterize these severe weather events and to improve some prediction techniques that are used in the operational weather forecast in the Basque Meteorological Agency (EUSKALMET).

Due to climatic and meteorological variability, to classify the synoptic patterns is a complex job. Nowadays, for the scientific community, don't exist a unified classification of weather types for the Iberian Peninsula. In addition, due to the characteristics of the Basque Country a valid classification for the Iberian Peninsula could be not quite good for our region. In our case the classification is subjective and is the same we used for some analysis and forecast tasks. Once the classification has been made, the similar situations are grouped when, in general terms, comply with basics criteria. For example, being maritime type, i.e. surface winds come directly from the sea and exist instability in height (due to a Cut Off Low or a marked trough).

The most useful instability indexes or those which warn better the risk of these extreme events in the Basque Country case are shown. Among others TTI (Total Total Index), LI (Lifted Index) and CAPE (Convective Available potential energy calculated from surface) have been analyzed.

Three sections are defined in our subjective synoptic classification: type, circulation and shape. Type is related with surface flux direction. Maritime Type: Surface wind direction has north component (northwest, north and north-northeast). Iberic Type: wind direction has south component (southwest, south and southeast). Continental Type: East and northeast winds. Local Type: wind direction is variable. Circulation is referred to the zonal circulation index in medium and high levels of the troposphere. High index is zonal circulation; low index is meridian circulation and detached circulation when the zonal circulation is broken. Shape is related with the surface pressure patterns, low and high pressures location.

III. RESULTS AND CONCLUSIONS

In this study is taken into account, only, the summer period. In the study area (Basque Country) hardly have been found, very heavy rain episodes (>10 mm in 10 minutes) in the rest of periods. In summer period stand out June and September months (see fig 1). In June the insolation reaches maximum values and heats significantly the Iberian Peninsula producing thermal lows in surface. The warming in low layers contributes to the creation of convective cells than can turn to severe storms, when exist suitable conditions in high levels. In September, take place the most of analysed events of this work. In this month, with high sea temperature, begin the detaching of cold swamps from high latitudes that favour the instability conditions.

The number of very heavy rain (>10 mm in 10 minutes) events, is also analyzed for the 2001-2010 period. Tendencies can not be deduced, there are some years with an increasing number of events that have been followed by years with a very little number of days (see fig 2).

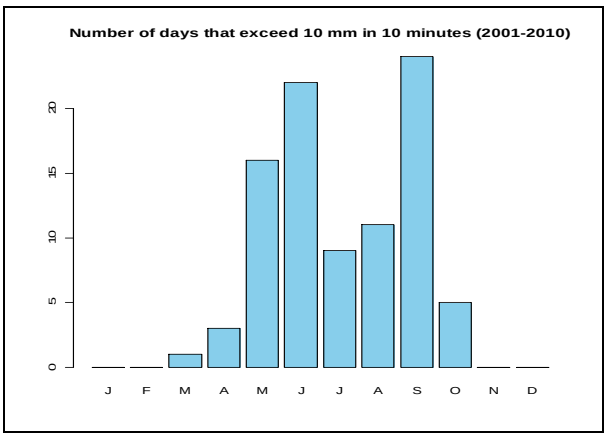


FIG. 1: Monthly distribution of events.

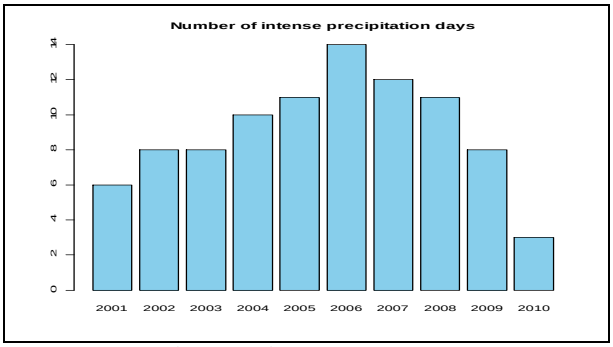


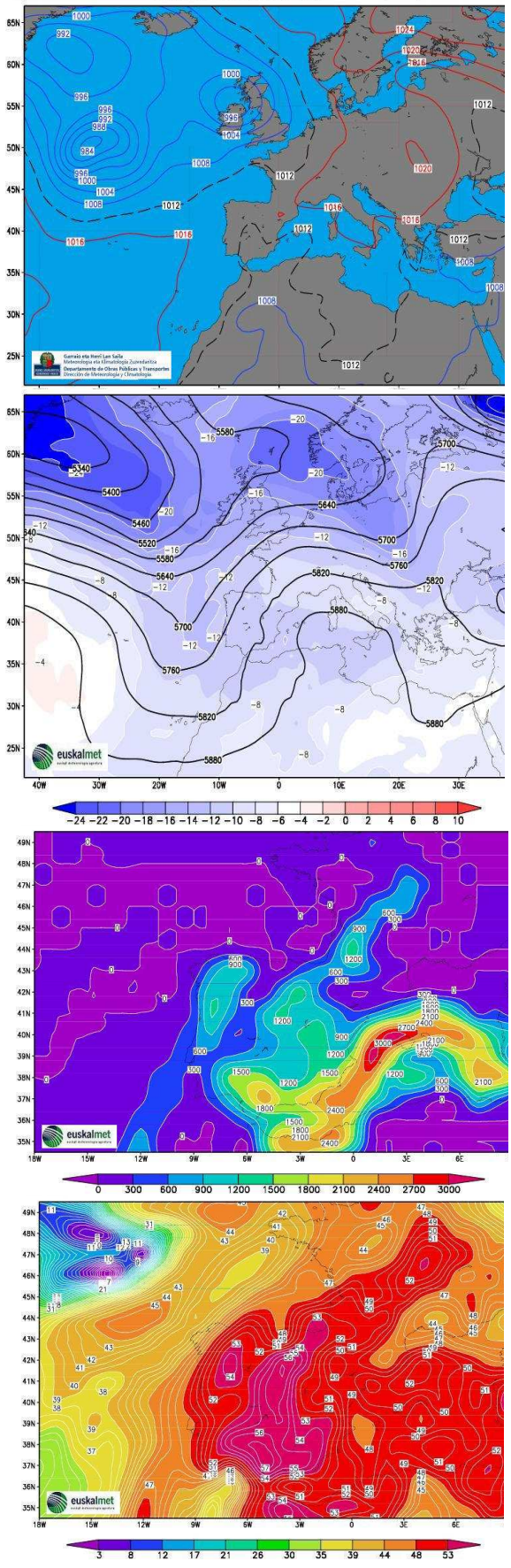
FIG. 2: Evolution of number of events (2001-2010).

Take into account the synoptic classification, the maritime (49%) and local (48%) type situations produce these sort of severe storms in almost every case. Iberic types (3%) are residuals and are limited to a passage of a squall line.
Analyzing the synoptic classification for the study days, the synoptic patterns can be grouped as is shown in table 1:

Type	Circulation	shape	Freq (%)
maritime	meridian or detached	Mediterranean or Euro-Mediterranean low	19
maritime	meridian or detached	Bay of Biscay low	14
maritime	zone	Britannic low	8
maritime	meridian	Britannic low	5
maritime	meridian	Atlantic high	1
maritime	detached	undefined	1
maritime	zone	undefined	1
local	meridian or detached	Barometric swamp	26
local	meridian or detached	Iberian or Iberian termal low	11
Local	zone	Iberian thermal low	6
Local	meridian	undefined	3
Local	zone	undefined	2
Iberic	detached	Atlantic low	3

TABLE. 1: Synoptic patterns and characterization of events by type.

The most part of convective intense precipitations analysed are observed with few defined situations in surface i.e. barometric swamps or relative thermal lows, joint to instability in high levels. Cold pools in high levels centred in the west of the Iberian Peninsula or troughs with its axis located in the west of the Iberian Peninsula are patterns that imply instability in high levels (see fig 4).



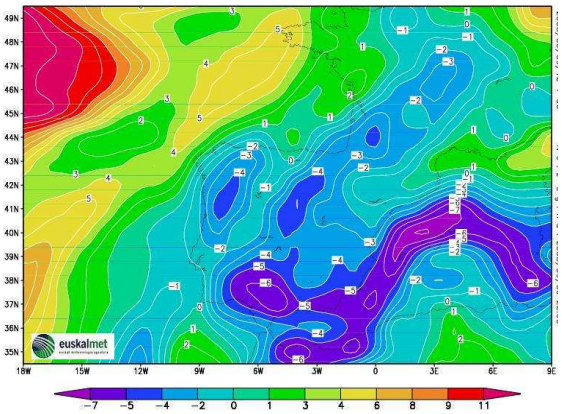


FIG. 4: Synoptic characteristics and instability indexes of the most frequent situation (sea level pressure, Geop and isoter for 500hPa, sfc CAPE, TTI and LI for 2008/09/09/ 18:00 as an example).

Instability indexes show high values, more noticeable in local situations (see table 2). In maritime situations, thermal instability is not required to produce intense precipitation. Instability in high levels and surface humidity contribution is enough, with a significant wind shear.

Type	**TTI (ºC)**	**LI (ºC)**	**CAPE** (J/kg)
Local	52	-3,1	765
Maritime	51	-1,5	526
Iberic	50	-1,5	500
Total	51,4	-2,2	639

TABLE 2: Mean values obtained of instability indexes.

The severe storm cells are observed with TTI indexes greater than 53 ºC, LI (Lift Index) lower than -4 ºC and CAPE greater than 500 J/kg. These situations generate precipitations higher than 10 mm in ten minutes, with a hail sizes above 1 cm and can generate very strong wind gusts associated. Anyway, these situations, usually, not transform in mesoscale convective system (MCS).

MCSs have been observed with significant synoptic patterns, with cold pool, and retrograde fluxes (from East towards west) in high levels with northeast and north wind in surface.

The extreme values of instability indexes for the analyzed days are LI = -6 ºC, TTI=58 ºC and CAPE=2000 J/kg. These three values are similar to the registers showed in other studies of extreme situations, specially LI and TTI values.

In the study of very heavy rain events (>10 mm in 10 minutes), is observed that TTI and LI indexes allow determine with a high degree of probability the severe weather events, agreeing with similar studies and authors. In the other hand, looking the analyzed days, CAPE index does not provide substantial information for these events, comparing with the usefulness showed in several works related with forecast of possible severe weather episodes.

IV. ACKNOWLEDGMENTS

The authors would like to thank the Basque Government for the public provision of data from the Basque Country Automatic Weather Station Network and for 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.

V. REFERENCES

Doswell C. A., 2001: Severe convective Storms. Meteorological Monographs. American Meteorology Society.

Egaña J., Gaztelumendi S, Mugerza I, Gelpi I.R. 2005: Synoptic patterns associated to very heavy precipitation events in the Basque Country. 5th EMS. Utrech (Netherlands).

Egaña J., Gaztelumendi S., Gelpi I.R., Otxoa de Alda K., 2006: Synoptic characteristics of extreme wind events in the Basque Country. 6 EMS. Ljubljana (Slovenia).

Egaña J., Gaztelumendi S., Gelpi I.R., Otxoa de Alda K., 2007: A preliminary analysis of summer severe storms in Basque Country area: Synoptic characteristics. 4th ECSS Trieste (Italy)

Gaztelumendi S., Otxoa de Alda K., Egaña J., Gelpi I.R., Pierna D., Carreño S., 2009: Summer showers characterization in the Basque Country. 5th ECSS. Landshut (Deutschland)

Martín-Vide, J. 2001: Limitations of an objective weathertyping system for the Iberian peninsula. Weather, 56 (7), 248-250.

Romero R., Sumner G.N., Ramis C., Genove´s A., 1999: A classification of the atmospheric circulation patterns producing significant daily rainfalls in the Spanish Mediterranean area. Int. J. Climatol., 19, 765–785.

Giaiotti D. B., Stel F., 2006: Environmental Variables Affecting the Hailstone Size Distribution at the Ground. Atmos. Res., 20 109-112.