Evaluation of the potential use of lightning features as a storm severity indicator in Basque Country

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Abstract

The main goal of the present work is to provide evidence of the potential use of lighting characteristics in order to provide the basis for the development of a detection system of convective storm severity on the ground. In such a way that they can be applied to surveillance tasks and for nowcasting purposes in Basque Country.

Introduction

Different studies from different places all around the world indicate that rapid increases in radar lightning severity, termed “lightning jumps” (LJ) (Wilhite et al., 1990) are produced between some (1-2) storms. Therefore, the occurrence of severe weather on the ground (e.g. Buisson et al., 2000; Bristow et al., 2005; Stagg et al., 2001; Gray et al., 2000; Sharp et al., 2000). Such phenomena are the basis for the implementation of nowcasting tools for severe weather in different European countries.

Methodology and data

In this work, all strokes data available for 2010-2018 period in Basque Country area and surroundings are used. Raw data are cleaned from noise and other bad data, and further data cleaning is performed following a procedure described in the study (Wu et al., 2018). The static point of view in which the question is whether a certain flash is “important” is the problem, on the other hand, is to characterize the activity based on the characteristics and temporal evolution of strokes that occur within a given radius (fixed here in 12 km). In this work, groupings of strokes to flashes have been performed.

Results & Discussion

In figure 1 we can see the 36 flashes defined for spatial aggregation of strokes with 26 selected locations for this study. We can define a “120 percentage” of the strokes to cover the terrain and to produce sufficient data for the different aggregations. Those areas are defined with the intention of incorporating most of the strokes for a particular storm in the hope that poorly correlated strokes from other storms do not affect the statistical analysis.

In figure 3 we can see the distributions of one minute rates for thresholds in the considered area. Such variables are lightning (TL), Cloud to ground (CG), Incloud (IC), The positive fraction (POS), the negative fraction (NEG), the CG positive (CPPOS), the CG negative (CNNEG), the IC positive (CIPPOS) and negative (CINEG), the fraction of CG POS with current < 5 kA (CPPOS), the CG NEG < 5kA (CNNEG) and the fraction of IC between 5 and 10 kA (IC), between 5 and 10 (IC, 10) and over 10 kA (IC, > 10).

In figure 4 we can see the monthly distribution for TL and IC and one-minute rates and aggregated for 26 selected locations for a selected year. Note that monthly distribution varies depending on thunderstorms behaviors, so it is advisable to group by season and to localize geographical aspects.

In figure 5 we can see box-plots for spatially aggregated 5-minute rates and some selected details. We use 20 minutes of the thunderstorm’s recent variable rate history (XTRC) to understand if the current behavior of a storm’s variable rate (XTRC) is abnormal. In figure 6 we can see box-plots for spatially aggregated 5-minute rates of time changes of 1-minute intervals in the past 20 min (XTRC).

Summary and concluding remarks

Independently of the controversy about some aspects related with LINET data system (e.g. very weak strokes detection, CG-DG discrimination, ...), here we present a very preliminary check of its potential utility and usability in order to extract some parameters that could be used as early identification of severity.

Although the correlation between different parameters and the severity of the storms is beyond doubt in particular cases, we have not found general and conclusive results from the whole period. Mostly due to the used methodology and the Euskelnet perspective.

In the future we will repeat this study applying the Lagrangian paradigm, that is, considering each storm individually applying grouping of storms in order to have guarantees that the strokes considered are fully correlated and from the same convective cell.

References


The selection of the different parameters used in this work has been established based on a selection of the most widely used in different contexts when characterizing severe events and particularly in the context of LJ (e.g. Pineda et al. 1997, Peterson at al. 1998, Schultz 2009, 2014, Gatlin et al. 2010, Chronis et al. 2015, Fresnel et al. 2017, Rigs 2018)

The all parameters are calculated for the entire time period and for all locations in order to have a full data set useful for climatological purposes in order to characterize typical values in different seasons. Finally, we also analyzed their behavior during different months with the aim of detecting some kind of correlation in between those variables and severity at daily level in a climatic perspective including some kind of segmentation for severe weather.

In figure 7 we can see the Pearson correlation coefficients between daily precipitation (24-hour, 1-hour and 10-minute), variables and temporal rates of change of lightning variables. Although in general, a little behavior with derived IC variables, and particularly with IC rates at high levels.

In figure 8 we present for Malavia AWS during 2018-06-03 heavy precipitation event: the temporal evolution of minute rate, 5 minutes rate and 20 minutes time rate change for TL, CG, and IC. In figure 9 we present the same for Malavia AWS during a tornadic event including the temporal rate of change and a plausible representation of the lightning jump threshold evolution during the storm (based on standard deviation of time rate of change during the 20 min), note that LJ occurs when this value exceeds the first. It is possible to find more details on these events in two events in two test cases presented in this same congress.

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