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Lightning initiation from a tall structure in the Basque Country

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ABSTRACT

Lightning detection in the Spanish Basque Country is performed using the LF TOA, VHF interferometer and the VLF lightning detection technologies in which two independent networks are based, providing a better detection quality due to the combination of these different techniques. Total lightning activity related to the tall structure of the weather radar operated by the Basque Meteorology Agency (Euskalmet) is presented. The tall structure is a 50 m tower located on the top of Kapildui Mountain (at about 1169.48 m ASL). Remarkable electrical activity associated to this place has been witnessed in the last two years. Two particular flashes during November 30th 2009 caused damage to the weather radar. Two different lightning detection networks detected five and six cloud-to-ground strokes, respectively. Only nine VHF sources were detected in the first flash without any VLF detection classified as intracloud. But for the second flash non VHF source was detected and two detections were reported by the VLF system. In both cases some intracloud detections were reported before cloud-to-ground strokes and some others during the flash. This paper presents the study of a winter episode with a special impact in the tower, the research carried out for characterizing the lightning events and the measures taken in order to achieve a better protection mechanism for the radar site.

1. Introduction

Tall structures such as communication towers and buildings represent a suitable place for lightning hazard under thunderstorm conditions. Tall instrumented man-made structures at the ground have been employed to investigate properties of lightning for many years (e.g., McEachron, 1941; Berger, 1967; Berger et al., 1975; Gorin et al., 1977; Fuchs, 1998; Diendorfer et al., 2009). Besides the interest on lightning parameters, lightning to tall towers have provided known targets for the analysis of remote lightning detection systems (e.g., Diendorfer et al., 1998; Schulz and Diendorfer, 2003; Diendorfer and Pichler, 2004; Lafkovici et al., 2006, 2008; Baba and Rakov, 2007; Pavanello et al., 2009). On the other hand, lightning protection for such structures has been widely studied.

In the case of ground radars, different protection techniques have been discussed, and different configurations have evolved from the basic installation of an air terminal in the zenith of the protective radome, such as a zenith air terminal with lateral rods for providing more points for lightning attachment or vertical poles around the tower linked with conductors (Mazur, technical report).

When lightning strikes a ground radar, usually the most affected part is the protective radome. The electronics can also be damaged due to high electromagnetic fields and surges produced by the lightning discharge. Moreover, although electronic equipment may keep on working after a lightning

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discharge, inaccuracies and instabilities may remain in the system and the overall quality will be affected. In the radar site under study, different protection systems for avoiding these hazards have been tried. The location of the site and the associated weather conditions make it a very suitable point for lightning discharges to happen. Lightning hazard to the radar tower has been witnessed during both hot and cold seasons. The objective of this study is to characterize the mechanisms under certain thunderstorm conditions that lead to direct lightning discharges to the tower. This also implies an understanding of the behavior of the lightning protection systems and how they can be improved for such a case.

Despite the large number of different works about lightning to tall towers and the detections provided by different lightning location systems, no total lightning activity (intracloud and cloud-to-ground) has been yet presented. In this paper, a special case of total lightning activity at a particular Basque Country weather radar tall structure is related.

The weather conditions under which the lightning flashes occurred are under study. A close relation between this winter thunderstorm and those already studied in different places such as Japan (Michimoto, 1991, 1993; Michimoto et al., 2003) and Austria (Diendorfer et al., 2007) has been found. It seems clear that under these winter conditions the radar tower is prone to be a perfect point for lightning initiation and attachment. Total lightning analysis provides a deeper insight of these phenomena, and this study is useful as a start point for the research concerning tall structures and total lightning. Moreover, it allows the evaluation of the performance of the protection system installed and the proposal of a different solution for a better protection of such a critical tower.

2. Data

Lightning detection in the Basque Country has been performed since November 2008. By that time, a LS8000 sensor network (Gaztelumendi et al., 2009) combining TOA/LF and Interferometry/VHF detection techniques was calibrated and, since then, it has been fully operated by the Basque Meteorology Agency (Euskalmet). Apart from this local lightning detection network, four VLF/LF sensors of the LINET (Betz et al., 2004) network have been operative in the Basque Country area since mid 2009. Fig. 1 shows the distribution of both types of sensors. The combination of these technologies allows total lightning detection in the territory, a better representation of the electrical activity related to thunderstorms over the Basque Country and a necessary redundancy that allows quality studies by comparison of the performance of the two detection techniques and a better reliability in the measurements provided. In these years, monthly statistics of the lightning events detected by the two networks have been obtained both for the entire Basque Country and for local areas of special interest (López et al., 2010).

The dual Doppler weather radar in the Basque Country provides a description of the evolution of the precipitating masses in real time. Different products calculated from the volumetric reflectivity data provided by the radar are obtained for weather surveillance and can be used for the study of particular cases (Gaztelumendi et al., 2006). In this study, an analysis of the maximum reflectivities and cloud heights provided by vertical cuts around the radar site by the time the lightning flashes occurred are presented.

The meteorological phenomena related to the winter lightning episode described in this paper will be studied using all the information available from Euskalmet and other sources, such as the radio soundings available from the Internet. Special emphasis will be done in the lightning detection data and the information available from the weather radar itself.

3. The affected weather radar tower

The dual Doppler weather radar operated by Euskalmet in the Basque Country (Fig. 2.) is located at the top of Kapildui Mountain (at 1169.48 m ASL). The location of the weather radar in such a high place, where severe weather conditions are usual, was selected in order to provide the best coverage possible, taking into account the complicated geography of the territory. The radar machinery and the antenna are installed on the top of a 49.593 m metal tower for ensuring the coverage range (Aranda and Morais, 2006). The radar antenna is protected by a sandwich panel spherical radome with an external diameter of 9.2 m. Taking into account the heights of the mountain and the tower we could consider an effective height for the tower. As referred in Rakov and Uman (2003), a 40 m tower on the top of ~1000 m mountains in Italy present an effective height of 500 m (Garbagnati and Lo Piparo, 1982). This indicates that the

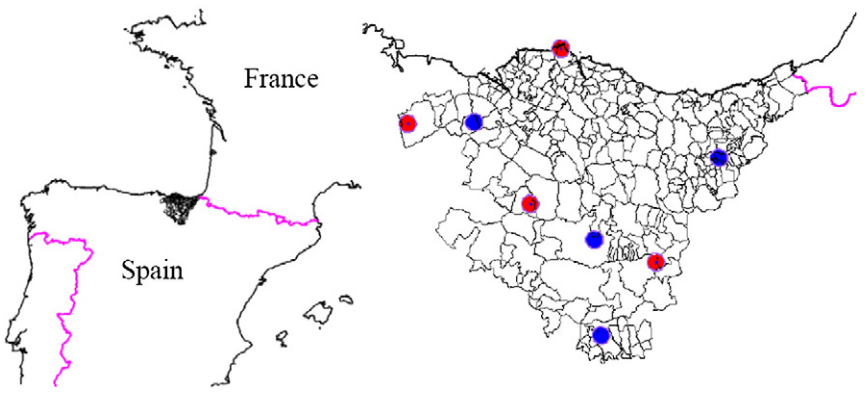

Fig. 1. Location of the Basque Country in the Iberian Peninsula and distribution of the LF/VHF sensors (red) and the VLF sensors (blue) in the Basque Country.