Thunderstorm characteristics favouring downward and upward lightning to wind turbines

Nicolau Pineda, Joan Montanyà, Albert Salvador, Oscar A. van der Velde, Jesús A. López

PII: S0169-8095(18)30073-5
DOI: doi:10.1016/j.atmosres.2018.07.012
Reference: ATMOS 4317

To appear in: *Atmospheric Research*

Received date: 16 January 2018
Revised date: 10 July 2018
Accepted date: 10 July 2018

Please cite this article as: Nicolau Pineda, Joan Montanyà, Albert Salvador, Oscar A. van der Velde, Jesús A. López , Thunderstorm characteristics favouring downward and upward lightning to wind turbines. Atmos (2018), doi:10.1016/j.atmosres.2018.07.012

THUNDERSTORM CHARACTERISTICS FAVOURING DOWNWARD AND UPWARD LIGHTNING TO WIND TURBINES

Nicolau Pineda [a,b], Joan Montanyà [a], Albert Salvador [a,b], Oscar A. van der Velde [a], Jesús A. López [a]

[a] Lightning Research Group, Technical University of Catalonia, Carrer Colom 1, 08222 Terrassa, Spain

[b] Meteorological Service of Catalonia, Carrer Berlín 38-46, 08029 Barcelona, Spain

Contact: npineda@meteo.cat

ABSTRACT

Meteorological conditions and thunderstorm characteristics related to lightning threats to wind turbines are discussed in this paper. Due to the rotating blades, wind turbines may be regarded peculiar tall objects, more susceptible to lightning strikes than other tall man-made structures. In the present study, Lightning Mapping Array and weather radar observations allowed to draw a clear picture of the thunderstorm characteristics leading to lightning strokes to wind turbines, in a coastal area of the Mediterranean basin. Results showed that lightning threats to wind turbines tend to occur during transitional periods (spring and autumn), although the main thunderstorm activity concentrates in the warm summer months. Thunderstorms with downward strokes to wind turbines presented particular features, like a limited vertical development and a dominant lower positive charge layer. Downward cloud-to-ground strokes hitting wind turbines were mainly of negative polarity and with peak currents above the average. On the other hand, conditions for self-initiated upwards from wind turbines resemble those reported in Japan and the U.S winter thunderstorms, with low-cloud based large electrified stratiform regions. These particular conditions, leading to lightning threats to wind turbines, should be properly included in lightning protection standards.

KEY WORDS: lightning mapping array, thunderstorm charge structure, downward and upward lightning, wind turbines

1. INTRODUCTION

The observations of lightning strokes to tall objects have been extensively reported in the literature (e.g. McEachron, 1939; Berger, 1967; Eriksson, 1978). A summary of the research efforts on this subject can be found in Rakov and Uman (2003). Interest in lightning to tall structures has grown in recent years, in particular due to the rapid expansion of wind energy globally (e.g. Rachidi et al., 2008; Foley et al., 2012).

Structures of limited height (below 100 m) will suffer from downward strikes whereas tall structures like wind turbines (hereafter, WT) are more prone to initiate upward lightning (e.g. Rachidi et al., 2008; Zhou et al., 2010). High towers (>100 m height) are exposed to strong local electric fields under thunderclouds, being prone to initiate upward propagating leaders (Berger, 1967). Besides, local topography plays a role on the effective height of the structure. Towers on mountain tops are said to have an effective height that is considerably larger than the physical height of the tower (e.g. Risk 1990; Rachidi et al., 2008; Zhou et al., 2010). The concept of effective height is used to account for the additional field distortion (enhancement)