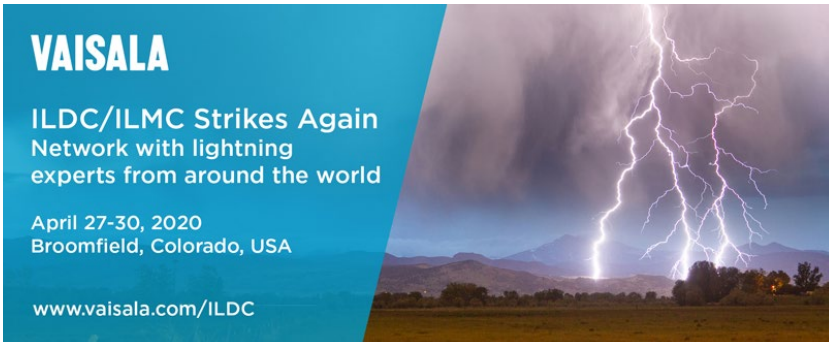

Why does the Säntis Tower have the Highest Observed Number of Fast Pulses per Flash?

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Abstract

With about 100 flashes per year, the 124-m tall Säntis Tower, located in the Northeastern part of Switzerland, is by far the structure with the highest number of reported lightning strikes in the world. Most of the flashes to the tower are of the upward type. The typical current associated with a negative upward flash is composed of an initial continuous current (ICC) on which a number of pulses, called ICC pulses, are superimposed [Rakov 2011]. These pulses can be of different nature: fast pulses (called mixed mode pulses) or slow pulses (called M-component type pulses), see e.g., [Zhou et al., 2015; Azadifar et al., 2016; He et al., 2018]. After the extinction of the ICC, one or several downward leader/return strokes similar to subsequent strokes in downward lightning can occur.

In this paper, we present a statistical analysis of the multiplicity of fast pulses (either ICC pulses with risetime of less than 8 µs [Flache et al., 2008] or return stroke pulses) in upward negative lightning flashes.

The data for fast pulses from the Säntis Tower are compared with those observed at other instrumented towers [Miki et al., 2005] and in rocket-triggered lightning [Qie et al., 2014]. The number of fast pulses is found to be significantly higher in upward flashes observed at the Säntis Tower than in other locations. For example, the average number of fast pulses is twice as high as that observed at the Gaisberg Tower. Interestingly, no mixed-mode pulses have been observed at the rocket triggering sites in Florida and China in more than 70 triggered flashes [Qie et al., 2014]. In these locations, the height of the -10 °C isotherm is more than 6 km above the initiation level [Miki et al., 2005; Zhang et al., 2016].

Results from different sites agree with recent observations that fast pulses during the initial stage of upward lightning are due to the connection of a new channel or the reactivation of a decayed branch connected to lower parts of the channel [Zhou et al., 2015]. The high number of fast pulses in upward flashes observed at the Säntis Tower could be due to the fact that the tower top is typically located just below the main negative charge region in the cloud [Pineda et al., 2019], providing charge for mixed-mode pulses that can be initiated in the lower part of the lightning channel.

The steepness of the Säntis mountain compared to other mountains on top of which instrumented towers are located

might provide additional favorable conditions for the initiation of mixed-mode pulses. Indeed, one of the main differences between the Säntis Tower and the Peissenberg and Gaisberg Towers is the sharpness of the mountains. While the Säntis Tower is at an altitude of 2500 m, the surrounding area over a region of about 25 km is at an altitude of about 1350 m. The isolated geographical location of the Säntis mountain could also be a determining factor, providing more charge to the Säntis Tower, which constitutes the preferential channel for cloud-to-ground discharges in that area.

The extended version of paper will present a more detailed analysis of the initiation of mixed-mode pulses via an interferometric lightning observation system that was installed in the Säntis area during the Summer of 2019.

Topic Areas

Lightning Physics, Characteristics and Measurements, Tower-Initiated and Rocket Triggered Lightning

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