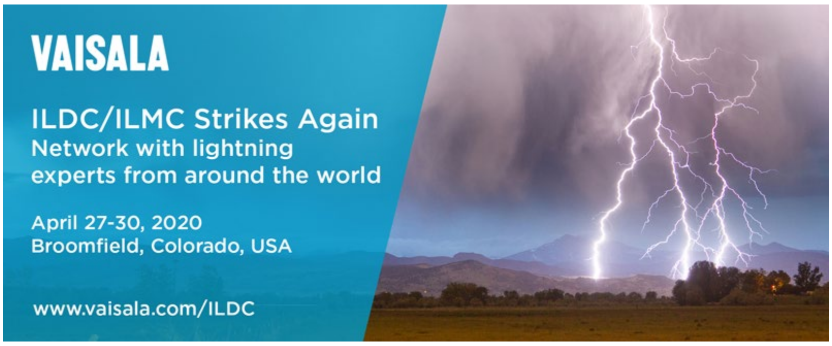

Calibration and Assessment of Broadband VHF Interferometer Systems using 3-dimensional Lightning Mapping Array Data

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Abstract

Broadband Very High Frequency (VHF) Interferometry has become an increasingly important tool for mapping lightning progression in recent years. In its most common configuration, 3 VHF antennas are deployed in a compact triangular arrangement with baseline lengths on the order of 10 to over 100 meters. The raw VHF data is sampled and cross-correlated in order to determine the 2D azimuth and elevation angle progression of VHF sources with submicrosecond time-resolution. In contrast, a Lightning Mapping Array (LMA) utilizes at least 6 widely-spaced stations (several to tens of kilometers) which asynchronously sample the time and log-RF value of the VHF peak within fixed window lengths of either 10 or 80 microseconds. This information is used to determine 3D locations of VHF sources, albeit with 1-2 orders of magnitude less data points than is typical for 2D broadband VHF interferometry.

With a bandpass typically of 60-66 MHz, an LMA operates within the passband of most broadband VHF interferometer systems. The continuous raw VHF data of an interferometer can be digitally bandpassed-filtered to match the frequency response of an LMA station. The hilbert transform can then be applied to create a power-envelope, from which the times of peaks can be determined and compared with those predicted from the expected arrival time of LMA VHF source radiation. The timing of the interferometer system can often be aligned to within 10 nanoseconds of the LMA for any given flash using pair-wise matches of VHF sources. These pair-wise matches are saved into a database, from which full antenna patterns have been determined over the course of numerous flashes in different parts of the sky. Other parameters of interest have been obtained such as the minimum detectable source power as a function of range as well as the relative sensitivity of different antenna designs across different campaigns and interferometer systems.

The accurate 2D mapping of sources by a broadband VHF interferometer system is critically dependent on the precise measurement of the relative signal delays between the VHF antennas. Offsets of only a few tenths of a nanosecond can cause noticeable angular offsets, especially at low elevation angles. Such offsets can arise from temperature dependent effects in the front end electronics, for instance, and hence can be a function of time. It is usually most convenient to determine the angular offsets in the native cosine space of the interferometer 2D maps on a flash-by-flash basis via a comparison with LMA cosine projections into the interferometer reference frame. This information has then been used to improve the accuracy of interferometer 2D azimuth and elevation locations for flashes of interest.

Topic Areas

Lightning Detection Systems Technology and Performance

Submission Format

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