Resolving Needles and Fine-Scale Lightning Processes with 100-200 MHz VHF Interferometry

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Abstract

We have developed a new short-baseline VHF broadband interferometer with a maximum frequency of 200 MHz and find that the higher bandwidth enables lightning imaging with significantly higher spatial resolution than our previous system with a 60 MHz maximum frequency. We will highlight the improvements with a close examination of several stages of lightning flash development. Fine-scale lightning structures such as positive leader needles (about 70 m long by 5 m wide, Hare et al., 2019) are resolvable in this single site system. In one observation of an intra-cloud lightning flash, needles, needle-initiated negative leaders, a nearby bidirectional leader, and their interactions were well mapped. In agreement with the one previous report [Hare et al., 2019], the needles were approximately 60 m long by 10 m wide and flickered once per 5–10 ms at speeds of 1-10x10^5 m/s. The needles move forward continuously and are distributed along a several km long positive channel with source density decreasing from the front-end to the back end, which seems not consistent with the disconnection model [Hare et al., 2019]. These rarely observed yet perhaps common lightning processes are analyzed comprehensively to give new insight into the origin and impact of needles on positive lightning leaders. Our observation also shows that sufficient bandwidth enables a 3-sensor single site VHF interferometer to provide resolvable details on lightning processes and thus opens up the possibility for new theories about lightning physics.

Topic Areas

Lightning Physics, Characteristics and Measurements

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