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Design and development of a high-resolution two-dimensional VHF lightning-flash mapping system

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Lightning is a large-scale natural electrostatic discharge in the atmosphere. It is a natural phenomenon occurring widely on Earth. Yet, very little is known about its initiation and propagation processes, associated high-energy emissions and other phenomena related to it. Most of the lightning takes place within the clouds, making it challenging to perform observations.

Lightning processes such as the breakdown of virgin air during channel formation and leader progression in pre-existing channels generate a high rate of emissions in the VHF band. Either Time of Arrival (TOA) or interferometric technique can be applied to geolocate sources of these VHF emissions to generate high-resolution maps of lightning channels in two or three dimensions. Multi-station TOA system consists of time-synchronized sensors typically placed at a separation of 10-40 km over a region 50-80 Km in diameter.

On the other hand, interferometric systems are single station instruments composed of an array of closely spaced coherent sensors. Recent availability of high-speed digitizers with deep memory has made it possible to acquire broadband VHF emissions for the entire flash duration continuously. Continuous recording for the whole flash duration allowed to process data using overlapping sliding windows, which greatly enhanced the quality of lightning maps by locating several lakhs of radiating sources within the flash [1]–[4]. This makes VHF broadband continuous sampling lightning mapping systems one of the best tools available for understanding the physical processes related to a lightning flash.

Recently, a VHF broadband high-resolution two-dimensional lightning-flash mapping system has been developed at National Atmospheric Research Laboratory, Gadanki, (13.5°N, 79.2°E). This system operates in 20-80 MHz frequency band and computes lightning VHF source direction in every 300 ns and thus provides the spatial and temporal progression of the lightning leaders. A new Direction of Arrival (DOA) algorithm has been developed to improve the accuracy at the lower computation time. In this paper we present the design details, DOA algorithm, simulation and empirical performance of the developed system.

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