The overall channels of the lightning discharges

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A new narrowband radio interferometer system has been developed for continuous observation of various processes of a lightning discharge at a time resolution of one microsecond. By using this system, a cloud-to-ground lightning flash containing 19 strokes was observed in inland plateau area of China. Detailed analysis of this lightning flash has revealed several new remarkable characteristics of cloud-to-ground lightning.

The VHF radio interferometer system was designed by ZHANG GuangShu, et al of Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences. By using this system, a cloud-to-ground lightning flash containing 19 strokes was observed and several new characteristics of lightning have been revealed. The study is reported in volume51, number 5 (May, 2008) of the *Science in China* (Series D, Earth Sciences).

The system in this study has five antennas that form an array in orthogonal directions, and an interactive graphic analysis procedure is used to remove the fringe ambiguities. The system error, which comes from frequency conversion, is reduced by phase detection through direct high frequency amplifying. By using the system, the whole progression process in time and space of a lightning flash can be continuously reconstructed at microsecond orders. As an example, the overall channel of a normal cloud-to-ground lightning flash that contains 19 strokes was analyzed and presented.

It is found that the preliminary breakdown event of the CG flash started from negative charge region and exhibited firstly a downward progression and then an upward propagation. Intense and continuous radiations during stepped leaders became much stronger when the first return stroke began.

In contrast, there were less and only discrete radiations during dart leaders. Stepped leader and dart leader may transform to each other depending on the state of the ionization of the path. The progression speed of initial stepped leaders was about 105 ms-1, while that was about 4.1×106 ms^{-1} and 6.0×106 ms^{-1} for dart leaders and dart-stepped leaders, respectively. M events produced hook-shaped field changes, accompanied by active burst of radiations at their beginnings. Following these active radiation processes, M events appeared to contact finally into conducting main discharge channels.

The mean progression speed of M events was about $7\times107ms^{-1}$, greater than that of the dart leaders and dart-step leaders. K events and attempted leaders (ATP) were essentially the same as the dart leaders except that they could not reach the ground and initiate return strokes.

Two methods, time of arrival (TOA) technique and interferometric technique, have been used to locate RF radiation events of lightning discharge up to now. TOA technique works better for locating isolated, impulsive radiation events. Since TOA technique has less time resolution, it is impossible to use it to study the whole process of a lightning discharge in detail. Interferometric technique works better for burst of impulses lasting several tens or hundreds of microseconds and can be used to locate the whole process of a lighting discharge in a time resolution of microsecond orders. However, the existence of so-called fringe ambiguities severely limits the measurement precision. ZHANG GuangShu, et al., researchers of Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, have

been studying the technique of the TOA and interferometer during the past 10 years and have successfully solved many problems of the previous systems.

Now, ZHANG GuangShu, et al. are working to combine various location methods in hope of developing a more powerful tool for lightning study.

Reference: Zhang G, Zhao Y, Qie X, et al. Observation and study on the whole process of cloud-to-ground lightning using narrowband radio interferometer. Sci. China Ser D-Earth Sci., 2008, 51(5): 694-708

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