Consideration of charge distribution inside thunderclouds by means of VHF broadband digital interferometer

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It is known that VHF/UHF impulses are mainly radiated from the tip of breakdown like at the stepped leader tip especially in case of negative breakdown. From this aspect it is noticed that the VHF impulse source location during leader developing phase is equivalent to the imaging of the negative leader progression. Moreover, the locations of VHF impulse sources related to negative breakdown after the occurrence of a RS or during the continuing current phase give the positive charge distribution inside the thundercloud. In other words, we are able to get information on positive charge distributions by VHF observations. This paper gives some consideration of positive charge distribution inside thunderclouds using observation results by the VHF broadband digital interferometer (DITF).

Lightning Research Group of Osaka University (LRG-OU) revealed that the EM radiation intensity in 327 MHz-band due to negative breakdown is about 15 dB stronger than that of the positive breakdown. Shao et al., (1999) reported that the VHF radiation intensity due to a negative leader is at least 25 dB stronger than that of a positive leader, and predicted that only VHF/UHF radiation associated with the negative leader can be detectable because of the masking effect. Therefore the features of 3D localizations of EM radiation sources for a negative and a positive CG flashes are completely different. In the observation results by the narrowband interferometer, ordinary downward progressing leader can be shown in case of a negative CG flash. That means we can image the downward negative leader, as expected. In case of a positive CG, on the contrary, EM radiation source locations do not go downward straightforward to the ground, but they show the tendency of concentration at certain and quasi-constant altitude of possible positive charge region. On the other hand, after a positive RS the locations of EM radiation sources proceed very rapidly and penetrate into the thundercloud horizontally. This period may correspond to the continuing current phase, and we may image the progression of negative breakdown. Consequently, it can be inferred from these studies that the VHF impulse sources localized by the broadband DITF are mainly related to the negative leader progression, and negative breakdown, which follows a positive RS in case of a CG flash, propagates into positive charge region. A visualization of lightning channels inside a thundercloud by the broadband DITF could give us information on positive charge distribution.

J- or K- processes are also discussed. Since these processes are phenomena moving very high-speed close to the velocity of light, the time resolution of the VHF broadband DITF is not sufficient to visualize them. However, if we consider the various factors together, we are able to understand the total lightning activity including the high-speed phenomena. The possible factors are the imaging of slower moving phenomenon like stepped leader, intensity of VHF radiation, E-field change, and so forth.

Though to make the conclusion clearly we need more data accumulations, this chapter proposed the use of the VHF broadband DITF to study charge distribution inside thunderclouds. These results contribute to more detailed understanding for the mechanisms of lightning discharges.