Study on lightning and precipitation activities by EM observations

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The lightning and precipitation activities are studied in this paper by Ku-band broadband radar (Ku radar), VHF Broadband Digital Interferometer (DITF) and Lightning Location System (LLS) observations. The authors have been conducting cooperative lightning observations in Toyama, Japan, in where winter thunderstorm are developed. This paper focuses on the time development of thunderstorm activities.

Ku radar is a low-power high-resolution Doppler radar for meteorological applications. Ku radar employs bistatic system which is composed of a pair of Luneberg Lens Antenna, and solid state amplifier which transmits the wideband signal (80 MHz) in Ku-band. The pulse compression technique, which has the advantage that high range resolution profiles can be acquired by low transmitting power, is applied. However, the range sidelobe of a compressed signal may contaminate the neighboring rain echo. To overcome this disadvantage, the intermediate frequency (IF) signal is acquired by a high-speed analog-to-digital converter (ADC), and then it is processed by sets of digital signal processors (DSPs). In the pulse compression processing, the cross correlation between the signal received from precipitation and reference, namely presampled transmitted signal. Observation time resolution for a full volume scanning and range resolution less than 1 minute and 2.5 m are realized with Ku radar, respectively.

DITF is a system to locate a source of VHF impulse based on the digital interferometric technique. A remarkable feature of DITF is its wide detection frequency range. The system observes the electric field change due to a lightning discharge in the ultra-wide VHF band, and Fast Fourier Transform (FFT) is applied to calculate various frequency components of the received electromagnetic (EM) pulse. Computed phase difference for each Fourier component between two antennas is a function of the incident angle of the EM pulse against the baseline. A couple of antennas as a two-element array of DITF are able to estimate the incident angle. Two pairs of antennas, and independent two baselines, enable two-dimensional (2D) mapping of sources in azimuth and elevation format.

At the time period of most active lighting activities, the bright band radar echo is disappeared. The reflectivity decreases in order of height from highest to lowest with active lightning. It indicates that the relations between deep convective and lightning.

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