フェーズドアレイレーダーと雷放電の三次元観測により得られた積乱雲内の電荷構造と鉛直流の関連
Relationship between charge structure and vertical air motion in a thunderstorm revealed by a phased array weather radar and 3D lightning mapper

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Thunderstorm observation has been conducted in Osaka, Japan, with a use of an X-band phased array weather radar (PAWR) and a 3D lightning mapper, called Broadband Observation network for Lightning and Thunderstorm (BOLT), for further understanding of relationship between electrification mechanism and vertical air motion, which plays an important role in non-inductive charging process. PAWR employs mechanical and electrical scans, respectively, in azimuthal and elevation direction, succeeding in quite high volume scan rate. BOLT is a LF sensor network that receives LF emission associated with lightning discharges and locates LF radiation sources in 3D. BOLT is capable of estimating charge structures removed by both intra-cloud (IC) and cloud-to-ground (CG) flashes. In this presentation, we focus on lightning activity and charge structure in a convective cell recorded on 30 July 2015. The convective cell involved severe lightning activity in 15 minutes and the both IC and CG flash rate (the number of flash per minute) changed drastically within the 15 minutes. We divide the 15 minutes lightning activity into three stages; the first, the second and the last 5 minutes, respectively, are termed developing, mature, and dissipating stages, based on IC and CG flash rates. In the developing stage, IC flash rate increased drastically from a few to about 10 flashes min^{-1}. In the mature stage, IC flash rate are quite high and had a peak of 12 flashes min^{-1}, while CG flash rate increased gradually. In the dissipating stage, IC flash rate drastically decreased, while CG flash rate had a peak of 5 flashes min^{-1}. In the developing stage, updraft in the mid-level (about 7 km) developed into the upper level (10 km or more in AGL). In this presentation, we estimate existence of updraft from Doppler velocity and ascending echo. The echo top of the convective cell increased rapidly. The main positive charge region estimated by BOLT was located around the updraft region in the upper level. In the mature stage, the updraft was further intensified and the echo top reached the tropopause altitude of 14.5 km. The main positive charge region was again located in the updraft of the upper level. In the dissipating stage, divergence at the echo top produced cold downdraft in the rear flank of the convective cell. The cold downdraft descended to mid-level (about 7 km) and suppressed the updraft at mid-level so that the updraft in the upper level was weakened. These observation results indicate a strong relationship between electrification for IC discharges and updraft strength. In the dissipating stage when CG flash rate peaked, main negative and pocket positive charge regions estimated by BOLT were located near the mixture region of the cold downdraft and updraft from the lower level. We speculate that the pocket positive charge region was mainly produced by the collisions between graupel in the downdraft originated form in the upper level and the ice pellets ascending form the lower level. These simple speculation support that non-inductive charging mechanism in thunderstorms.

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