Lightning activity associated with a convective cell involving multiple precipitation cores

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A multi-cellular storm, which consists of several convective cells, typically lasts more than one hour, and sometimes causes localized heavy rains. Recent observation with a use of fast scanning weather radars showed that individual convective cells sometimes involves multiple precipitation cores that developed and dissipated within a short time. Kim et al [2012], observing a multi-cellular storm in Japan during summer with a use of a radar network, consisting of two X-band dual-polarized radars, showed that 17 of 20 convective cells in the multi-cellular storm had single precipitation core and the other three convective cells involved multiple precipitation cores that developed and dissipated in short time. Shusse et al. [2015], observing thunderstorms using an X-band dual-polarization radar, reported that three cumulonimbus clouds involved total of 15 precipitation cores. The durations of these precipitation cores about 13.9 minutes in average. They speculated that these precipitation cores were caused by periodic updrafts above the 0 ºC isotherm level.

While some multi-cellar storms cause localized heavy rain, they also involve lightning activity. Understanding of relationship between storm kinetics and lightning activity is very useful for practical uses, such as prediction of lighting activity from radar observations [e.g., Sakurai et al., 2015]. However, the lightning activity in precipitation cores of a convective cell has been little paid attention.

In this presentation, we have been conducting thunderstorm observation campaign during summer in Japan with a use of a Phased Array Weather Radar (PAWR) and Broadband Observation network for Lightning and Thunderstorm (BOLT). PAWR is an X-band radar that employs electrical and mechanical scanning, respectively, in the elevation and azimuth directions, resulting in whole-sky observations in as short as 10 s [Yoshikawa et al., 2013]. BOLT is a LF sensor network to locate both intra-cloud (IC) and cloud-to-ground flashes in 3D [Yoshida et al., 2014].

We succeeded in observing a convective cell that involved at least four precipitation cores. Each precipitation core lasted about 10 minutes. In the precipitation cores, rapid increases of maximum altitudes of 30 dBZ in radar reflectivity are recognized, indicating that strong updraft regions existed in the precipitation cores. BOLT observations indicated that flash rates, which is the number of flashes per minute, peaked almost at the same time when maximum altitudes of 30 dBZ peaked. Furthermore, in two of the four precipitation cores, altitudes of upper positive charge regions contributing to charge transfer in IC flashes increased as maximum altitudes of 30 dBZ increase, implying that the ascent of upper positive charge region was caused by the updraft in the precipitation cores.

1. D.-S. Kim, M. Maki, S. Shimizu, and D.-I. Lee, "X-band dual-polarization radar observations of precipitation core development and structure in a multi-cellular storm over Zoshigaya, Japan, on August 5, 2008", *J. Meteor. Soc. Japan*, **90**, 2012, pp. 701–719, doi:10.2151/jmsj.2012-509.
2. Y. Shusse, M. Maki, S. Shimizu, K. Iwanami, T. Maesaka, S. Suzuki, N. Sakurai, and R. Misumi, "Relationship between precipitation core behavior in cumulonimbus clouds and surface rainfall intensity on 18 August 2011 in the Kanto region, Japan, *J. Meteor. Soc. Japan*, **93**, 2, 2015, pp. 215–228, doi:10.2151/jmsj.2015-012.
3. N. Sakurai, S. Shimizu, Y. Shusse, S. Suzuki, T. Maesaka, K. Kieda, and K. Iwanami, "Relationships between updraft characteristics and cloud-to-ground lightning activity in warm-season convective storms in the Kanto Region, Japan", *SOLA*, **11**(0), 2015, pp. 177-180, doi:10.2151/sola.2015-039.
4. E. Yoshikawa, T. Ushio, Z. Kawasaki, S. Yoshida, T. Morimoto, F. Mizutani, and M. Wada, "MMSE Beam Forming on Fast-Scanning Phased Array Weather Radar", *IEEE Transactions on Geoscience and remote sensing*, **51**, 5, 2013, pp. 3077-3088, doi:10.1109/TGRS.2012.2211607.
5. S. Yoshida, Wu, T. Ushio, K. Kusunoki, and Y. Nakamura, "Initial results of LF sensor network for lightning observation and characteristics of lightning emission in LF band", *J. Geophys. Res. Atmos.*, **119**, pp. 12,034–12,051, doi:10.1002/2014JD022065.