Numerical study of the lightning frequency in tropical cyclone using a metrological model coupled with a lightning component

*Yousuke Sato[1,2], Yoshiaki Miyamoto[3,2], Hirofumi Tomita[2]

1. Faculty of Science, Department of Earth and Planetary Sciences, Hokkaido University, 2. RIKEN Center for Computational Science, 3. Faculty of Environment and Information Studies, Keio University

The relationship between lifecycle of tropical cyclone (TC) and lightning frequency and effects of aerosols on the lightning frequency in TC were investigated using a meteorological model coupled with a bulk lightning model (Sato et al. 2019).

To investigate the relationship, an idealized experiment covering from initial to steady state (SS) of TC based on (Miyamoto and Takemi 2013) was conducted. The simulation was conducted with finer horizontal grid resolution (2 km) than our previous studies in JpGU. The results of the simulation indicate that the lightning frequency is maximum before rapid intensification (RI) of TC, which supports previous observational studies (e.g.,DeMaria et al. 2012; Stevenson et al. 2016). The frequency of lightning decreases after RI and it keeps small until the TC reaches SS. Our analyses indicate that the dependency of the lightning frequency upon the TC’ s lifecycle is originated from the difference in the mechanism triggering convective clouds. Convective clouds by convective available potential energy (CAPE) are dominant before RI. After the RI, in contrast, convective clouds are mainly triggered by the updraft along with the secondary circulation. Our analyses also indicate that the timing of the maximum lightning frequency is corresponding to the pre-conditioning stage of the TC, when the convective clouds by CAPE are generated most frequently during TC’ s lifecycle.

Effects of aerosols on lightning frequency in the TC were also investigated by sweptwing the number concentration of cloud condensation nuclei (N_{ccn}). Our results indicate that the lightning frequency is largely dependent upon N_{ccn} even though the strength of TC has small dependency upon N_{ccn}.

Reference

DeMaria, M., R. T. DeMaria, J. A. Knaff, and D. Molenar, 2012: Tropical Cyclone Lightning and Rapid Intensity Change. *Mon. Weather Rev.*, **140**, 1828–1842, doi:10.1175/MWR-D-11-00236.1. http://journals.ametsoc.org/doi/abs/10.1175/MWR-D-11-00236.1.

Miyamoto, Y., and T. Takemi, 2013: A Transition Mechanism for the Spontaneous Axisymmetric Intensification of Tropical Cyclones. *J. Atmos. Sci.*, **70**, 112–129, doi:10.1175/JAS-D-11-0285.1. http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-11-0285.1.

Sato, Y., Y. Miyamoto, and H. Tomita, 2019: Large dependency of charge distribution in a tropical cyclone inner core upon aerosol number concentration. *Prog. Earth Planet. Sci.*, **6**, 62, doi:10.1186/s40645-019-0309-7. https://progearthplanetsci.springeropen.com/articles/10.1186/s40645-019-0309-7.

Stevenson, S. N., K. L. Corbosiero, and S. F. Abarca, 2016: Lightning in Eastern North Pacific Tropical Cyclones: A Comparison to the North Atlantic. *Mon. Weather Rev.*, **144**, 225–239, doi:10.1175/MWR-D-15-0276.1. http://journals.ametsoc.org/doi/10.1175/MWR-D-15-0276.1.

Keywords: Lightning, Tropical Cyclone, Cloud resolving model

