Introducing new lightning schemes to a chemistry climate model CHASER (MIROC)

*Yanfeng He[1], Kengo Sudo[1]

1. Nagoya University

The formation of NO_x associated with lightning activities (hereinafter referred to as LNO_x) is estimated to contribute approximately 10% of the global NO_x source and is considered to be the most dominant NO_x source in the upper troposphere. NO_x, associated with many chemical reactions in the atmosphere, causes the production of tropospheric O_3 and OH radical which controls the oxidation capacity of the atmosphere. Consequently, LNO_x has significant influences on the atmospheric chemistry and global climate. Therefore, it is crucial to improve the prediction accuracy of lightning and LNO_x in chemical climate models.

This study implemented two new lightning schemes into a global chemical transport/climate model CHASER (MIROC). The first lightning scheme is based on upward cloud ice flux (hereinafter referred to as ICEFLUX scheme), while the second one, also adopted in the ECMWF forecasting system, calculates lightning flash rates as a function of frozen precipitation convective flux, CAPE, and convective cloud-base height (hereinafter referred to as ECMWF scheme). In the original version of CHASER (MIROC), lightning is initially parameterized by the widely-used cloud top height scheme (hereinafter referred to as CTH scheme). The lightning prediction accuracy by the ICEFLUX scheme, ECMWF scheme, and CTH scheme has been tested against the climatological lightning distributions by the LIS/OTD satellite observation.

Comparing the annual mean lightning flash rate of OTD 1996-2000 and the CHASER calculation for the years 2007-2011 exhibits spatial correlation coefficients of 0.80 and 0.79 for the ICEFLUX and ECMWF schemes respectively, which are slightly higher than that of the CTH scheme (0.78). In the case of the ECMWF scheme, by tuning the convective cloud-base height and factors for land and ocean (hereinafter referred to as modified ECMWF scheme), the spatial correlation is a bit more improved to 0.81. The RMSE of the ICEFLUX and modified ECMWF schemes are 3.30 fl./km^2/year and 3.39 fl./km^2/year respectively, which is slightly lower than that of the CTH scheme of 3.44 fl./km^2/year.

In conclusion, the new ICEFLUX lightning scheme and original/modified ECMWF lightning scheme both improved the prediction of global lightning in the CHASER model. This result suggests that LNO_x simulation in CHASER will be also improved with the new lightning schemes.

Keywords: Lightning scheme, Lightning NOx, Chemistry climate model, NOx

