Effect of neutralization scheme on lighting simulation using a cloud-resolving model

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Introducing the lightning parameterization to the Cloud Resolving Storm Simulator (CReSS: Tsuboki and Sakakibara, 2002), we have simulated the location, number and types of lightning flashes. The lightning simulation includes three processes, (1) charge generation, (2) lightning propagation, and (3) charge neutralization. This study focuses on the charge neutralization scheme.
We The CReSS model adopted adopts riming electrification as the charge generation process (Takahashi, 1978). Lightning propagates along the maximum gradient of the electric potential (MacGorman et al, 2001). The net electric charge is neutralized along and around the lightning path. In this study, we used examined four neutralization schemes to evaluate the effect of neutralization scheme on lightning simulation. (1)The scheme I assumes that The the net electric charge for neutralization is distributed into each hydrometeor category according to its relative surface area (MacGorman et al, 2001). In this scheme, each category’ s charge is not necessarily decrease. (2) This The scheme II is more of the samesimilar to the scheme (1) I, but each category’ s charge is necessarily decreased. (3) This scheme is more of the same (1), butIn the scheme III, neutralization hydrometeor category is limited to same polarity as the net charge. (4) Ain the scheme IVVfter neutralization, the net electric charge is redistributed into each hydrometeor category according to its relative surface area after neutralization.
In this study, the lightning simulation calculates a case of the heavy rainfall system in the Kinki Area of Japan with a horizontal grid size of 2 km performed from 18:00 to 22:00 LST 23 August 2013. This result is compared with the observations. Compared The observation data is the Broadband Observation network for Lightning and Thunderstorm (BOLT: Yoshida et al, 2014). BOLT is a three-dimensional low-frequency lightning location system. It observes cloud-to-ground (CG) and intracloud (IC) flashes.
In the simulation of the presentthis case, thunderstorms are successfully simulated (Figure 1). This The result is compared with the observations about with regard to the temporal variation of lightning frequency. In the simulation, lightning occurred around a local maximum of rain rate, this result consistent with the observations. The temporal variation in numbers of simulated lightning is similar to observationed. However, simulated lightning number is larger than observations. Lightning number is dependent on lightning parameters and neutralization scheme. Therefore, optimizing the lightning parameter and understanding the neutralization scheme are essential for quantitative comparing comparison between the simulation and observation. Vertical cross sections of calculated lightning initiation is different from observations. In the observations, lightning initiation level is higher with higher lightning frequency is higher. However, simulated lightning height is almost constant, occurred around -10℃. This indicates that the Lightning lightning initiation height is without independent on dependence of neutralization schemes. We will investigate this result and improve lightning model in our future work.
Figure1. Locations of lightning flashes (a) observations (BOLT), (b) Scheme1Scheme I, (c)Scheme2Scheme II, (d)Scheme3Scheme III, (e)Scheme4 Scheme IVV in 19:30 LST 23 August 2013. Color indicates precipitation intensity observed JMA-radar and simulation experiments.

Keywords: lightning

