Evaluation of simulated ice clouds using joint CALIPSO and CloudSat satellite observations

*Tatsuya Seiki[1], Chihiro Kodama[1], Masaki Satoh[2], Tempei Hashino[3], Yuichiro Hagihara[4], Hajime Okamoto[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. The University of Tokyo, 3. Kyushu University, 4. Japan Aerospace Exploration Agency

This study developed a new method to evaluate simulated ice clouds using joint CloudSat and CALIPSO satellite observations. This method used joint histogram of cloud optical depth from cloud top and cloud microphysical properties (e.g., ice water content or effective radius) in comparison between simulated results and observations. To examine observed cloud optical depth, we integrated extinction coefficient with 550 nm wave-length observed by the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP Lidar). Ice cloud microphysical properties were retrieved by using the radar-lidar algorithm developed by Okamoto et al., [2010] with cloud masking and cloud-phase detection techniques [Hagihara et al., 2010; Yoshida et al., 2010]. This method was limited to around cloud top (cloud optical depth smaller than about 2) because the lidar signal was fully attenuated in deeper cloud layers.

This study first evaluated global ice clouds and then focused on ice clouds over major mountain regions (e.g., the Andes). We used a global non-hydrostatic atmospheric model NICAM [Tomita and Satoh, 2005; Satoh et al., 2008; 2014] with a double-moment bulk cloud microphysics scheme [Seiki and Nakajima, 2014; Seiki et al., 2014; 2015] for global simulations. The simulated results were processed by the Joint Simulator for Satellite Sensors package [Hashino et al., 2013; Satoh et al., 2016]. This simulator provided us with consistent radiative signals with those observed by space-borne optical sensors. We performed sensitivity experiments by changing cloud microphysics and model resolutions to optimize uncertain ice cloud microphysics.

We found that cloud optical depth from the cloud top was a good measure to evaluate vertical profile of cloud microphysical properties instead of using altitude as a vertical coordinate. In particular, vertical profiles of cloud microphysical properties in the altitude-coordinate were found to be affected by change in cloud dynamics rather than cloud microphysics. Using this analysis method, we suggested that improvement in cloud microphysics had more impact on reproducing observed vertical profiles of cloud microphysical properties when the model horizontal resolution was finer than 14 km.

Keywords: Cloud Microphysics, Ice Clouds, Climate Modeling