Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

ACG09-P04 Room:Convention Hall Time:May 27 18:15-19:30

Evaluation of Satellite-Borne Radar, Lidar, and Imager Algorithm for Retrieval of Cloud Microphysical Properties

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We developed algorithm for the retrieval of effective radius (R_{eff}) and cloud water content (CWC) of clouds by using collocated CloudSat 94 GHz cloud radar, CALIPSO lidar and MODIS imager. Main aim of the study is to evaluate uncertainties of the algorithm. The radar and lidar retrieval algorithm was initially developed by Okamoto et al., (2010) for ice cloud region detected by radar and lidar. And Sato and Okamoto (2011) extended the range of applicability to the ice regions detected radar or lidar. Then Okamoto et al., (2014) further extended the algorithm by introducing optical thickness (τ_{vis}) information from MODIS that can be applicable to both ice and water clouds, and rainy regions detected radar or lidar. Here RL and RLI denote radar or lidar algorithm and radar/lidar with τ_{vis} algorithm from imager (RLI). Major source of uncertainties in the RL is the treatment of radar only detected clouds and precipitation where lidar signal is totally attenuated and we introduced empirical formula in radar-only region derived from ground-based Doppler cloud radar observations.

In this presentation, cloud microphysics of convective clouds was analysed in September 10, 2006 over the Pacific Ocean. We examined the vertical distribution of R_{eff}, CWC, τ_{vis} as well as cloud water path (CWP). By using τ_{vis} as a constraint, R_{eff} is ~ 50 μm smaller than RL results and ~ 300 μm smaller than RL results in the water cloud region below ~ 5 km. Responding to this trend, IWC was 0.5 g/m^3 larger and LWC was 0.01 g/m^3 larger compare to the RL ones. We also compared τ_{vis} and CWP between from MODIS, RL, and RLI.

Instead of retrieved τ_{vis}, MODIS reflectance was also combined with RL and we examined the uncertainties in the both versions of RLI algorithms, due to the possible variability of ice particle shape and orientations.

In 2017, the joint European and Japanese satellite mission EarthCARE, which will carry a Doppler cloud radar, high-spectral resolution lidar, multi-spectral imager, and broadband radiometer, is scheduled to launch. We discuss how to use Doppler information to reduce the retrieval errors. The algorithm described above will be adapted to the standard algorithm.

Keywords: synergy, radar, lidar, imager, cloud microphysics