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Ice cloud analysis using Himawari-8 data

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The Himawari-8 satellite was launched in October 2014 and carries the Advanced Himawari Imager (AHI) that has 16 spectral bands in visible to thermal infrared spectra. Spatial resolution and observation frequency have been significantly improved. Nine bands are in the thermal infrared at 6?13.5 micron wavelengths. This study aims at obtaining optical and microphysical properties of ice cloud, and we are developing a cloud analysis system that uses the thermal infrared bands of the AHI. Our group has been studied ice cloud properties by using three bands of 8.5-, 11- and 12-micron of MODIS onboard the Aqua satellite (Iwabuchi et al., 2014). The cloud top temperature was obtained from the MODIS operational product and used as a priori for inversion. To extend the retrieval method to the AHI, we have modified the method to use multiple bands including the CO2 and water vapor absorption bands.

First we have developed a forward model that computes brightness temperatures and its partial derivatives with respect to several variables. The input data are atmospheric temperature and humidity profile and surface properties. The radiative transfer calculation is made at only a single wavelength band for each sensor band, using the correlated-k distribution (CKD) method (Sekiguchi & Nakajima, 2008) with several quadrature points. Optical properties of water droplets are computed by the Lorenz-Mie theory, and those of ice particles are obtained from a database made by Yang et al. (2013). Ice cloud habit models include hexagonal column and plate, and the General Habit Mix (GHM) model (Cole et al., 2013) with different degrees of surface roughness. Double-layer clouds are modeled, and radiative transfer is solved by the two-stream approximation. Brightness temperature biases due to model approximation are removed by empirical formulae.

Absorption by ice particles is stronger at wavelengths longer than 10 micron. As suggested by prior studies, a combination of multiple bands in the window region of 8?13 micron wavelengths allows inferring effective particle size of ice cloud. Ice particle habits do not significantly affect the brightness temperatures, but water phase (liquid/ice) is moderately important to spectral differences in brightness temperatures. Measurements are sensitive to ice cloud with cloud optical thickness of 0.05?12 and effective particle radius of 2?100 micron. Top pressure of lower cloud in multi-layer cloud column can be retrieved if the upper cloud optical thickness is less than about 5.

Background surface and atmospheric data needed for the cloud analysis are interpolated spatially and temporally from MODIS products and MERRA reanalysis. The optimal estimation method (Rodgers, 2000) is used to infer cloud properties including cloud water path, effective particle radius, cloud-top pressure, and background surface temperature in single-layer cloud cases. Top-pressure of lower cloud is inferred in multi-layer cloud cases, instead of background surface temperature. Measurement?model biases due to errors in atmospheric data and model approximations and assumptions are evaluated by comparing to simulated and measured brightness temperatures. The biases are removed, and remaining errors are evaluated for use in the optimal estimation. Initial test analysis will be presented in the presentation.

Keywords: Himawari-8, ice cloud