Algorithm Development for Discriminating Cloud and Precipitation Particle Type using CloudSat/CPR and CALIPSO/CALIOP Observation

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Cloud and precipitation take key roles in the climate system. Information on the cloud phase, shape, rain and snow (hereafter, hydrometeor particle types) are among the major factors that determine the radiative properties of cloud and precipitation. The knowledge on the hydrometeor types is also necessary to retrieve their microphysical properties, such as liquid/ice/rain/snow water contents and effective radius. In this study, we developed an algorithm that discriminate the hydrometeor particle types using the cloud profiling radar (CPR) onboard CloudSat and Mie-scattering lidar, Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP), onboard Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO). The CloudSat and CALIPO satellites are in operation since June 2006 and they have accumulated vertical profiles of cloud and precipitation over the globe for ten years. The CALIOP is sensible to thin to moderately thick clouds and the CPR is sensible to moderately thick clouds to light precipitation. Therefore, the development of the synergetic algorithm that discriminate hydrometeor particle types for the CPR and CALIOP observation would not only derive the global picture of cloud-precipitation typing but also would offer opportunities to further study the cloud-precipitation process and to evaluate its representativeness in global and regional numerical models.

The CALIOP cloud particle type discrimination algorithm was based on the previous scheme originally developed by Yoshida et al. [2010] and modified by Hirakata et al. [2014]. The CPR algorithm consisted of three main steps: (1) initial type classification by radar reflectivity and European Center for Medium-range Weather Forecasting (ECMWF) temperature; (2) cloud-precipitation partitioning correction by attenuation corrected surface radar reflectivity; and (3) spatial continuity test. The initial type classification was conducted by selecting a type from a look-up-table of radar reflectivity and temperature. The look-up-table was constructed using the cloud particle type discrimination from CALIOP and the precipitation detection by Precipitation Radar (PR) onboard Tropical Rainfall Measuring Mission (TRMM). For each CloudSat bin, an initial type was selected from the look-up-table that corresponded to the observed radar reflectivity and ECMWF temperature. The second step was the cloud-precipitation partitioning correction where each profile was determined whether it was a precipitating profile or not by a simple threshold method of attenuation corrected surface radar reflectivity (Haynes et al. [2009]). If the profile was detected as precipitation but the initial classification had been registered as a cloud profile, the initial classification of the lowest hydrometeor classification was corrected to precipitation (and visa-versa). The last step of the CPR algorithm was the spatial continuity test to eliminate spike misclassification. The final CPR-CALIOP synergy scheme classified the hydrometer particles into 13 types: warm water, supercooled water, randomly oriented ice crystals (3D-ice), horizontally oriented plates (2D-plate), 3D-ice + 2D-plate, liquid drizzle, solid drizzle, rain, snow, mixed phase, water+liquid drizzle, water+rain and unknown. Taking the advantage of CPR's capability to penetrate cloud and light precipitation and CALIOP's capability to detect thin clouds, the synergy algorithm derived the global vertically resolved distribution of hydrometeor particle types from thin cirrus clouds to light precipitation.

The hydrometeor particle type algorithm is considered to be applied in upcoming Earth Clouds, Aerosols and Radiation Explorer (EarthCARE) Level 2 Standard Products that will be processed and released from JAXA to observe global and vertical distribution of the hydrometeor particle types.

Keywords: cloud radar, lidar, satellite, cloud observation, precipitation observation