GPM SLH latent heating retrievals with a study on extratropical precipitation systems

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Diabatic heating associated with convection plays essential roles in energy budget in the global atmosphere, driving large-scale circulation, and intensifying various kinds of storms. Dual-frequency Precipitation Radar on board the Global Precipitation Measurement core satellite (GPM DPR) has expanded our ability to consider such convective latent heating in the extratropical regions, in addition to tropical regions where we have estimated the latent heating with the Tropical Rainfall Measuring Mission Precipitation Radar (TRMM PR) observations (TRMM Spectral Latent Heating algorithm; Shige et al. 2004, 2007, etc.). In order to construct an algorithm to retrieve the convective latent heating in the extratropics, we examined the relationship between the precipitation and latent heating in extratropical environments, utilizing GPM DPR data with the aid of cloud-resolving numerical model simulations, contrasting it with tropical precipitation.

For the SLH retrieval algorithm in the tropics, we simulated the TOGA-COARE precipitation with the Goddard Cumulus Ensemble Model, from which we made three spectral look-up tables (LUT) of latent heating profiles for convective, shallow stratiform rain, and deep stratiform rain. Utilizing TRMM PR rain profiles as well as GPM Ku-band Precipitation Radar (KuPR) rain profiles with these tables, we retrieved the latent heating associated with precipitation in tropical and subtropical regions.

Extratropical precipitation consists of systems very different from the tropics. The most dominant system there is the extratropical cyclone and associated frontal systems. The largest difference may reside in the stratiform precipitation. While deep stratiform precipitation is associated with deep convection in the tropics almost without exception, in the extratropics, large-scale ascent associated with frontal systems can result in deep stratiform precipitation from the large-scale condensation. The deep stratiform cloud base in the tropics is, therefore, almost fixed at the freezing level, but it does not necessarily correspond to the freezing level in the extratropics.

As a strategy to obtain adequate LUTs for extratropical systems, with a collaboration of the JMA numerical weather forecast group, we collected forecast run outputs for extratropical systems with the JMA Local Forecast Model (LFM). With these data, we analyzed the simulated precipitation and latent heating for extratropical systems, to produce LUTs for GPM KuPR.

To this end, we had to overcome several hurdles: (1) To obtain consistent LFM and KuPR precipitation flux, (2) to attain consistent convective/stratiform separation, (3) to obtain adequate cloud-base and freezing level relationships, (4) to detect cloud base adequately from the GPM KuPR, and (5) to handle multi-layer precipitations. After solving these problems, we obtained convective precipitation tables looked up with precipitation top heights, and stratiform precipitation tables looked up with cloud-base precipitation intensities. Results from applications of GPM KuPR data to these latent heating LUTs also will be discussed.

