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## Vertical precipitation profiles estimated by satellite-based passive microwave retrievals

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Passive microwave (MW) observation from low Earth-orbiting satellites is one of the major sources of information for global precipitation monitoring. Although various precipitation retrieval techniques based on passive MW observation have been developed, most of them focus on estimating precipitation rate at near surface height. Vertical profile information of precipitation is meaningful for process-based understanding of precipitation systems. Also, a previous study found that the use of the vertical precipitation profile information can improve sub-hourly surface precipitation estimates (Utsumi et al., 2019).

This study investigates the precipitation vertical profiles estimated by two passive MW algorithms, i.e., the Emissivity Principal Components (EPC) algorithm developed by authors (Turk et al., 2018; Utsumi et al., 2021) and the Goddard Profiling Algorithm (GPROF). The vertical profiles of condensed water content estimated by the two passive MW algorithms for the Global Precipitation Measurement Microwave Imager (GMI) observations are validation with the GMI + Dual-frequency Precipitation Radar combined algorithm (CMB) for June 2014 – May 2015. The condensed water content profiles estimated by the passive MW algorithms show biases in their magnitude (i.e., EPC underestimates the magnitude by 20 – 50% in the middle-to-high latitudes; GPROF overestimates the magnitude by 20 – 50% in the middle-to-high latitudes and more than 50% overestimation in the tropics). On the other hand, the shapes of the profiles are reproduced well by the passive MW algorithms. The relationship between the estimation performances of surface precipitation rate and vertical profiles are also investigated. It is shown that the error in the profile magnitude shows a clear positive relationship with the surface precipitation error. The estimation performance of the profile shapes also shows connection with the surface precipitation error. This result indicates that physically reasonable connections between the surface precipitation estimate and its associated profiles are achieved to some extent by the passive MW algorithms. This also implies that properly constraining physical parameters of the precipitation profiles would lead to the

improvements of the surface precipitation estimates.

#### References

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