全天候地球同步衛星之大氣總可降水量之估算

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Abstract

Total precipitable water (TPW) is one important parameter for monitoring extreme weather warning and atmospheric correction for satellite missions such as synthetic aperture radar (SAR). Because water vapor has a rapid change feature in the troposphere, the availability in the 365/24/7 basis based on meteorological satellite observation is critical. However, due to the complexity radiation transfer process in the cloudy pixel, it is challenge to estimate and validate TPW in all sky pixels. In this study, spatiotemporal collocated data between meteorological satellite observation in the geostationary orbit and retrieved profiles from ground-based passive microwave radiometer (PMWR) retrieved temperature and moisture profiles, which are enabled to estimate the TPW in both clear and cloudy scenarios. We developed three DNN models for clear-sky, liquid-cloud, and ice-cloud conditions using one year of Himawari AHI and PMWR observations at Chia-Yi. Retrievals achieved correlation coefficients exceeding 0.93 for clear-sky and liquid-cloud conditions and 0.76 for ice clouds. Root-mean-square differences (RMSD) are below 6.2 mm, where mixed-phase clouds in ice phase give larger errors.

The model was further evaluated during the July–August 2025 Full Atmosphere Observations and Simulations Experiments (FAOSE). We evaluated against radiosondes, ERA5, GNSS, and CIMSS MIMIC-TPW2 product. TPW and layered precipitable water (LPW) time series agree well with independent observations, with only slight underestimation during rainfall. TPW varies along precipitation, while LPW changes are most pronounced in the 500–300hPa layer, indicating its potential as a precursor to rainfall. Applying the model across Asia with terrain correction produced biases generally below 5 mm compared with CIMSS and ERA5, while preserving finer spatial structures. High-layer LPW clearly reveals the moisture plume, while the water vapor decreases in rainy regions, supporting its conversion into precipitation.

In conclusion, this model performs reliably under all weather conditions and is applied to investigate moisture transport and evolution.

Key words: Total Precipitable Water (TPW), Deep Neutral Network (DNN)