

Improving GSMaP Precipitation Spatial Patterns and Diurnal Cycle

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Abstract

In the satellite era, numerous sensors have been deployed to observe precipitation from space, spanning the electromagnetic spectrum from high-frequency visible bands to low-frequency microwaves. Each sensor type offers global precipitation estimates based on its unique sampling characteristics, yet these estimates differ in accuracy and temporal resolution. To mitigate these individual sensor limitations, multi-sensor has become a key focus. The Global Satellite Mapping of Precipitation (GSMaP), developed by JAXA, exemplifies this approach by combining infrared (IR) and microwave observations to generate hourly global precipitation data. However, IR-based estimates, which depend on cloud-top brightness temperatures, often misrepresent the timing of precipitation peaks. In contrast, microwave-based estimates are physically more reliable but suffer from sparse temporal sampling because satellites observe any location only at specific time intervals, making complete diurnal sampling challenging. These constraints introduce temporal biases in IR-derived diurnal cycles within GSMaP, particularly over coastlines, mountainous regions, and oceans.

To overcome diurnal cycle limitations in GSMaP, we adopted a satellite data fusion strategy designed to enhance diurnal cycle of precipitation. This approach leverages extensive satellite observations from TRMM Precipitation Radar (PR) and GPM Ku-band Precipitation Radar (KuPR), collected across diverse diurnal phases, to construct a blended PR–KuPR dataset that provides the most comprehensive global diurnal sampling of precipitation. Building on this foundation, we implemented a data assimilation framework using a Kalman Filter to integrate the climatological diurnal cycle derived from PR–KuPR into the GSMaP algorithm. The resulting diurnal cycle-corrected (DCC) version of GSMaP significantly improves the depiction of precipitation diurnal cycle patterns over oceans, coastlines, and complex terrains.

This integration of PR and KuPR blended observations with data assimilation techniques represents a pivotal step toward reducing biases in satellite-based precipitation diurnal cycle products and enhancing their reliability for both scientific and operational applications. This advancement enables robust global climatological analyses of precipitation's diurnal variability, providing a more accurate foundation for hydrological studies, climate modeling, and extreme weather assessments.