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Refining Diurnal Cycle Patterns in GSMaP Satellite Precipitation Data Through Satellite Data Fusion

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With the advent of the satellite era, numerous sensors have been deployed to measure precipitation from space, utilizing different regions of the electromagnetic spectrum from high-frequency visible wavelengths to low-frequency microwaves. Each sensor type provides global precipitation estimates based on its sampling characteristics, but these estimates vary in accuracy and temporal resolution. To overcome individual limitations, several efforts have focused on integrating data from multiple sensors. Global Satellite Mapping of Precipitation (GSMaP), developed by JAXA, is one such initiative that combines infrared (IR) and microwave observations to produce hourly global precipitation estimates. However, IR-based estimates, which rely on cloud-top brightness temperatures, often misrepresent the timing of precipitation peaks. Conversely, microwave-based estimates, though physically more accurate, suffer from sparse temporal sampling because satellites observe a location only at specific times, making full diurnal coverage challenging. These limitations introduce temporal biases in IR-derived diurnal cycles, evident in GSMaP, particularly along coastlines, mountainous regions, and oceans.

To address these issues, we implemented a satellite data fusion approach aimed at refining the diurnal cycle of precipitation in the GSMaP. We leveraged extensive TRMM Precipitation Radar (PR) and GPM Ku-band Precipitation Radar (KuPR) observations collected across various diurnal periods to construct a blended PR–KuPR dataset, offering the most reliable global diurnal sampling of precipitation. Building on this dataset, we developed a data assimilation framework using a Kalman Filter to incorporate the climatological diurnal cycle from PR–KuPR into the GSMaP methodology. This process produced a GSMaP version with the diurnal cycle corrected (DCC), which significantly improves the representation of precipitation's diurnal cycle over oceans, coastlines, and complex terrains.

This integration of PR and KuPR blended observations with data assimilation techniques marks a critical step toward reducing biases in satellite-based diurnal cycle of precipitation products and enhancing their utility for 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.