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Estimation of land evapotranspiration over China based on Fengyun satellite

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Abstract: Evapotranspiration (ET) is the largest component of the terrestrial water cycle after precipitation, and accurate quantification of terrestrial ET is fundamental for understand the Earth's energy and water budgets under climate change. Although numerous diagnostic models based on remote sensing data have produced various ET products worldwide, most rely heavily on the Moderate Resolution Imaging Spectroradiometer (MODIS) or ultra-high-resolution radiometer AVHRR as the key remote sensing driving. This may result in limitations in data continuity and reliability, particularly in the event of sensor degradation, satellite failure, or restrictions related to data policies. The Medium-Resolution Spectral Imager II (MERSI-II), installed on the Fengyun-3D (FY-3D) polar-orbiting meteorological satellite, has been recognized as one of the most advanced imaging instruments in the world, with capabilities comparable to MODIS. The leaf area index (LAI) product of FY-3D MERSI-II is a key operational product of the Fengyun-3D satellite, their potential to help generating an independent ET dataset are not achieved. Given the global need to diversify remote sensing data sources and to enhance resilience in Earth system monitoring, the FY-3D MERSI-II LAI product offers a promising alternative for ET estimation, particularly in regions where MODIS data availability may be uncertain or constrained.

In this study, we developed a high-resolution evapotranspiration dataset for China based on the LAI products provided by the Chinese produced Fengyun-3D satellite remote sensing, as well as the near-real-time product dataset of the China Meteorological Administration's Land Surface Data Assimilation System (CLDAS-V2.0) meteorological forcing data. The diagnostic biophysical model PML-V2, which is grounded in the carbon-water coupling theory, was employed to estimate ET. The resulting dataset, referred to as FY_PML-V2, provides daily ET at a 1 km spatial resolution covering the period from 2020 to 2024. To evaluate its performance, the model outputs were validated against observations from 10 eddy covariance flux towers including major six plant functional types distributed across China. Model accuracy was quantified using multiple statistical indicators, including Root Mean Square Error (RMSE), Bias, and the Nash–Sutcliffe Efficiency (NSE).

The results demonstrated that FY_PML-V2 achieved robust accuracy, with RMSE, Bias, and NSE ranging from 0.642~1.350 mm/d, -0.687~0.234 mm/d, and -0.179~0.799, respectively, across all validation sites. When the daily FY_PML-V2 results were aggregated to an 8-day scale, the model performance improved further. At most sites, they performed better than international mainstream ET products (such as GLASS, GLEAM, MOD16), with improvements of 9.1%~75.9% and 0.15~2.03 in RMSE and NSE. To further assess the reliability of FY-3D LAI as a driver for ET estimation, we conducted a comparative analysis by running the PML-V2 model with MODIS LAI data (MODIS_PML-V2). The two products displayed highly comparable accuracy, with differences of only -11.6%~18.5% and -0.11~0.46 in RMSE and NSE. This finding indicates that the FY-3D MERSI-II LAI product is fully capable of replacing MODIS LAI for ET estimating, thereby validating its potential as an independent and robust alternative data source.

Overall, our results indicate that the FY_PML-V2 ET product can achieve accuracy levels comparable to international mainstream products, while ensuring consistency in spatial distribution across different ecosystems in China. More importantly, this study demonstrates the feasibility of using FY-3D MERSI-II LAI products for ET estimation, effectively alleviating the current situation where ecological environment monitoring and remote sensing evapotranspiration estimation over-reliance on MODIS or other single-source datasets. The FY_PML-V2 dataset provides a reliable data foundation for water cycle research, climate impact assessments, and water resources management across China. Looking ahead, future research will extend the use of FY-3D satellite products to global ET estimation and focus on model improvements, parameter optimization, and uncertainty reduction. This will further advance the application of Chinese satellite products in Earth system science and strengthen the international capacity for long-term, multi-source evapotranspiration monitoring.

Keywords: *Evapotranspiration, Fengyun-3D, Penman-Monteith Leuning model, MODIS*

