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A Kalman Filter approach for reducing uncertainty in Global Evapotranspiration: Advancing global water budget closure

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Evapotranspiration (ET) is a key component of the global water cycle, influenced by both natural processes and human activities. However, existing ET products, based on hydrological models, satellite observations, and reanalysis data, often exhibit significant disagreements particularly in human-impacted regions. These discrepancies emerge as the major source of uncertainties in closing the water budget at global scale making it a complex and integrated challenge. To address this, researchers have adopted a water-budget based approach for estimating ET using multiple precipitation, runoff and terrestrial water storage change products, thereby ensuring water budget closure. However, this approach results in multiple estimates of ET with large uncertainties, where weighted average approach fails to reduce these uncertainties. To reduce these uncertainties, a novel Kalman filter-based framework is implemented in this study. It combines multiple water budget-based ET estimates to produce a robust, data-driven ET product (KF-ET) which significantly reduces uncertainty (less than 2 mm/month) while achieving the closest approximation of water budget closure. The performance of KF-ET is evaluated at global and basin scale, with comparisons to ERA5, Fluxcom, GLEAM, and WGHM products. Results demonstrate that KF-ET improves on existing products in terms of capturing the spatio-temporal variability in ET with lower uncertainties. KF-ET aids in understanding of inter-annual and seasonal ET variability, especially in regions with complex hydrological dynamics, such as the Ganges and Amazon River Basin. Furthermore, sensitivity of KF-ET to human-driven changes, including irrigation effects, is highlighted through case study in the Ganges where it accounts for flood irrigation during the early stages of crop growth. KF-ET is also consistent with energy-limited nature of ET in Amazon River basin because of abundant precipitation and deep-root water access for trees. This Kalman Filter approach provides a promising framework for synthesizing high-quality, data-driven global ET estimates that incorporate both natural and anthropogenic influences, offering significant steps towards closing the water budget globally. KF-ET can be accessed at: https://doi.org/10.6084/m9.figshare.23800692 (Goswami et al., 2024)

Reference:

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