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## NASA Energy and Water Studies Climatology Project: Multi-source estimation of long-term terrestrial water budget for major global river basins

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The global hydrological cycle plays a central role in the Earth's environmental system. It is a critical research task to accurately quantify the water and energy components at the land surface at various scales from global to local, and how these vary in time and under a changing climate. This can help our understanding of various aspects of the terrestrial environment such as the underlying physical mechanisms of budget variations, scaling behavior, interactions with the atmosphere, the response to climate perturbations, and so on. Improved estimates can also contribute to applications such as water resources management, flood and drought mitigation, environmental protection, urban/agricultural planning, and ecosystem evaluation and restoration. Ultimately, the knowledge and data obtained here will enable us to build and improve our forecasting capabilities of the Earth's environmental system for better planning and decision-making. However, current observational based estimates of terrestrial water and energy variables are generally spatially incomplete, inconsistent and do not provide budget closure at any scale. Although remote sensing provides encouraging potential to provide all components at global scale, there are a number of challenges to overcome, including budget closure, self-consistency, inter-product consistency and sampling issues. To address these challenges we draw from the wealth of in-situ, remotely sensed and modeled data products, and merge them through data assimilation to provide long-term and physically consistent estimates of large-scale water and energy variables. By utilizing information from multiple sources, it is expected that the data record will provide a best possible estimate that can be used as a baseline for various hydrological and climate studies. We use empirical knowledge to assess the confidence of different estimation systems based on characteristics such as data collection, sensor changes, model physics, parameterization schemes, past validation studies, and so on, as well as statistical tools to quantify errors. We then apply constrained data assimilation techniques to merge these datasets to form a 23-year dataset for 1984-2006, which provides the largest overlap of large-scale estimates from in-situ, remote-sensing, and modeled datasets. The analysis is performed over 32 major global river basins at monthly time scale, as this is commensurate with the availability of measured streamflow data, which forms a robust constraint on the water budget. The merged datasets provide insights into the global variation in uncertainties in each variable in relation to the total budget and how these vary seasonally and on inter-annual time scales.