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Closing the Combined Water and Energy Balance of Global Watersheds Based on Satellite Data

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Satellite-based remote sensing offers potential pathways for accurately closing the water and energy balance of watersheds from observations, a fundamental challenge in hydrology. However, previous attempts based on purely satellite-based estimates have been hindered by large data uncertainties and lack of estimates for key components, such as runoff. Here, we use a novel approach based on the Budyko hypothesis to quantify both the degree of closure and its uncertainties in watershed-scale water and energy balance closure arising from an ensemble of 56 global satellite datasets for precipitation (P), terrestrial evaporation (ET), and net radiation (Rn). We use 7 quasi-global precipitation datasets which include CHIRPS, CMORPH, PERSIANN, PERSIANN-CCS, PERSIANN-CDR, TRMM 3B42RT, TRMM 3B43. For ET, we use 8 datasets - AVHRR, SSEBOp, MOD16A3, GLEAM v3.3a, GLEAM v3.3b, CSIRO-PML, BESS, and FluxCom. For Rn, we use the CERES dataset. We find large spatial variability along with aridity, elevation and other gradients. Results show that errors in water and energy balance closure can be attributed primarily to uncertainties in terrestrial evaporation data. These findings have implications for improving the understanding of global hydrology and regional water management and can guide the development of satellite remote sensing datasets and earth system models. In addition, we rank the P and ET datasets that perform the best in closing the combined water and energy balance of global catchments. For P, we see that gauge-calibrated datasets such as PERSIANN-CDR, TRMM 3B43 perform the best. In terms of ET, we see that BESS performs the best in the northern boreal forests and GLEAM performs the best in drylands.