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Estimation of the Uncertainty in Global Precipitation Observations and Its Propagation to Model Simulations of Evapotranspiration and Runoff

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In this study, the uncertainties of five (three ground measurements and two satellite hybrid products) global observed precipitation datasets and its translation into evapotranspiration and runoff through ensemble hydrological simulations are estimated. A dimensionless index Ω, is used to quantify the "similarity" among the simulations of ensemble members which is assumed as a surrogate of "uncertainty" within them. The uncertainty in precipitation is in general amplified in simulated runoff and damped in evapotranspiration, and global average of Ω_P, Ω_{ET} and Ω_R are 0.84, 0.89 and 0.65, respectively. A relatively low Ω_P is found in certain mountainous areas, deserts, and Central Africa around the equator and 20˚N. Zonal summation of gauge station numbers and zonal mean of Ω_P exhibit a similar pattern. Globally, the spatial distribution of Ω_{ET} shows a similar pattern of Ω_P but generally with higher values, which indicates more similar temporal variability among ensemble members of simulated evapotranspiration. However, some considerable differences can also be observed in certain regions. Based on Ω_P and Ω_{ET}, the patterns of uncertainty propagation from precipitation to evapotranspiration can be classified into the following four groups: (1) High Ω_P (> 0.8) and higher Ω_{ET} (> 0.9), (2) Low Ω_P and high Ω_{ET} (Ω_{ET} – Ω_P > 0.3), (3) High Ω_P and low Ω_{ET} (Ω_{ET} – Ω_P) $<$ -0.3, and (4) Ω_P (< 0.5) and Low Ω_{ET} (< 0.5). Most regions in the northern Hemisphere, except for arid regions, are included in Group 1, some tropical regions (e.g., archipelago of South Pacific Ocean) are classified as Group 2, large regions of Central Africa are shown as Group 3, and Group 4 includes mostly arid regions and regions where observational networks are sparse. The uncertainty of simulated runoff (Ω_R), in turn, globally marks lower value than Ω_P. It means that the uncertainty in precipitation translates into the amplified uncertainty in runoff simulated, and, therefore, Ω_R – Ω_P shows negative value globally. This amplified uncertainty propagation in runoff simulation is mainly due to the weak uncertainty propagation in evapotranspiration simulation. In terms of water balance, precipitation is partitioned into evapotranspiration and runoff through water storage components (here, snow pack and soil moisture), and the uncertainty also should be allocated through the same mechanism. In global scale, evapotranspiration is rather insensitive to the precipitation uncertainty, and it even dampens the uncertainty since plant growth in many of terrestrial regions is constrained by energy (i.e., radiation and temperature) rather than water availability. It results in much part of precipitation uncertainty translates into an uncertainty in runoff, and the greater size of precipitation (about 2 fold) leads to bigger uncertainty in the standardized index Ω. As a result, global average of Ω_R (0.65) marks a much smaller value than Ω_{ET} (0.89) and ΩP (0.84). In regional scale, it is found that a number of relatively small Ω_R – Ω_P values are located in transitional regions (e.g., around 10˚N and 20˚S – 40˚S) between water-limited region (e.g., near 20˚N) and water-abundant region (e.g., tropical region), as similar to the spatial pattern of Ω_{ET} – Ω_P, and a high peak is observed near the equator.