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Significance of meltwater in estimating runoff using Budyko framework in Northwest Xinjiang, China

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Budyko framework has been widely used to estimate the partitioning of precipitation into evapotranspiration and runoff as a function of an aridity index (i.e., ratio of potential evapotranspiration to precipitation) in catchments where snow or glaciers are absent. Where snow or glaciers exist, meltwater from either may considerably affect the performance of the Budyko framework. However such effects have not been investigated in the Xinjiang territory of Northwest China, which features many meltwater-dependent river systems. To analyze the effects of meltwater on hydrological cycles in Xinjiang, we utilized a calibrated hydrological model (Soil and Water Assessment Tool, SWAT) to estimate meltwater from snow or glaciers. The water budgets of 21 catchments across three major mountain ranges of Xinjiang showed that normalized contributions of meltwater to river runoff were respectively 89.9%, 77.0%, and 55.6% in the catchments of Altay, Kunlun and Tienshan Mountains. The results showed that the catchments of Altay Mountains with the highest meltwater ratio (defined as the ratio of meltwater to the sum of meltwater and rainfall, 0.572 ± 0.075) had the lowest Budyko parameter ω (1.238), while those of Tienshan Mountains with the lowest meltwater ratio (0.239 ± 0.143) had the highest ω value (1.348). This indicated that the Budyko parameter ω was negatively correlated to meltwater ratio across three mountains. Incorporating meltwater from snow and glaciers into the Budyko framework significantly increased the values of ω in all three mountain ranges, indicating that the Budyko framework without inclusion of meltwater could under-estimate evapotranspiration in Xinjiang, China. There results derived from this research also implied that both surface runoff and evapotranspiration may increase under a warming climate in mountain areas.