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Considering complementary relationship of evaporation in Budyko's hydrological model

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In Budyko's hydrological model, actual evaporation was partitioned from precipitation as a function of the relative magnitude of precipitation and potential evaporation. In practice, both Penman equation and Priestley-Taylor equation have been used to estimate the potential evaporation with same Budyko curve, and they are not distinguished under Budyko framework. Nevertheless, according to the complementary relationship of evaporation, the definitions of Penman equation and Priestley-Taylor equation are absolutely different. When water availability is not limited, evaporation occurs at Priestley-Taylor's evaporation (Ew, referred to as wet environment evaporation). As the surface dries without changing the available energy, the actual and Penman's potential evaporation (Epen) rates depart from Ew with opposite changes in fluxes. So the question is: what is the difference of the Budyko's hydrological model with potential evaporation estimated by Penman or Priestley-Taylor equation? How to consider the complementary relationship in Budyko framework? In this study, for both long-term (multiyear) and annual values on water balances in the 29 non-humid catchments in the middle Yellow River Basin of China, the performances of Budyko's hydrological model with potential evaporation estimated by Epen and Ew were distinguished and compared. The catchments with larger value of Ep/Ew (ratio of Penman potential evaporation to Priestley-Taylor evaporation) are characterized with smaller evaporation ratios. The value of Ep/Ew can be served as another variable besides dryness index to partition actual evaporation from precipitation. With Priestley-Taylor equation as energy supply, an empirical formula for the parameter of the Budyko in terms of Ep/Ew and curve is proposed. Therefore, the complementary relationship of evaporation should be considered in the Budyko framework.