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Fate and changes in moisture evaporated from the Tibetan Plateau (2000–2020)

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The Tibetan Plateau (TP) has been termed the “Asian water tower” and it plays an important role in regulating the Asian water cycle, which affects billions of people. Although the areal mean evaporation of the TP is not high, the total evaporation integrated over the vast terrain of the TP is huge and may strongly influence downwind regions. However, the ultimate fate of this evaporation moisture remains unclear. This study tracked and quantified TP-originating moisture using an extended WAM2Layers model. The findings reveal that the involvement of moisture from the TP in the downwind precipitation is most pronounced near the eastern boundary of the TP and gradually diminishes eastward. Consequently, the TP moisture ratio in precipitation reaches the highest of over 30% over the central-eastern TP. 44.9–46.7% of TP annual evaporation is recycled over the TP, and 65.1–66.8% of the TP evaporation is reprecipitated over terrestrial China. Moisture recycling of TP origin shows strong seasonal variation, with seasonal patterns largely determined by precipitation, evaporation and wind fields. High levels of evaporation and precipitation over the TP in summer maximize local recycling intensity and recycling ratios. Annual precipitation of TP origin increased mainly around the northeastern TP during 2000–2020. This region consumed more than half of the increased TP evaporation. Further analyses showed that changes in reprecipitation of TP origin were consistent with precipitation trends in nearby downwind areas: when intensified TP evaporation meets intensified precipitation, more TP moisture is precipitated out. This study also analyzed the uncertainty due to different tracking modes in WAM2Layers, i.e., backward and forward moisture tracking. In forward moisture tracking, the annual precipitation recycling ratio (PRR) of the TP was estimated to be 26.9–30.8%. However, due to the non-closure issue of the atmospheric moisture balance equation, the annual PRR in backward tracking could be ~6% lower.