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The precipitation isotopes and deuterium excess affected by local hydrological processes

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The precipitation isotopes are important tools in tracing the hydrological cycle. In this regard, the isotope effects as well as the global/local meteoric water line are commonly employed. Meanwhile, the deuterium excess, which is defined as $d = \delta^2H - 8 \cdot \delta^{18}O$ (Dansgaard, 1964), has shown specific potential in hydrological studies for tracing past and present precipitation and evaporation processes. However, the local hydrological processes of sub-cloud evaporation and moisture recycling could modify the precipitation isotopes and their derivative.

The influence of the processes of moisture recycling and sub-cloud evaporation on the precipitation isotopes is illustrated in Fig. 1. The variation of precipitation $\delta^{18}O$ values follows the orange solid line during the process of sub-cloud evaporation. As a result, the $\delta^{18}O$ values increase and the d excess values decrease. Meanwhile, the recycled moisture has lower $\delta^{18}O$ and higher d excess values along the dark blue line. Therefore, the $\delta^{18}O$ values decrease and the d excess values increase during the process of moisture recycling.

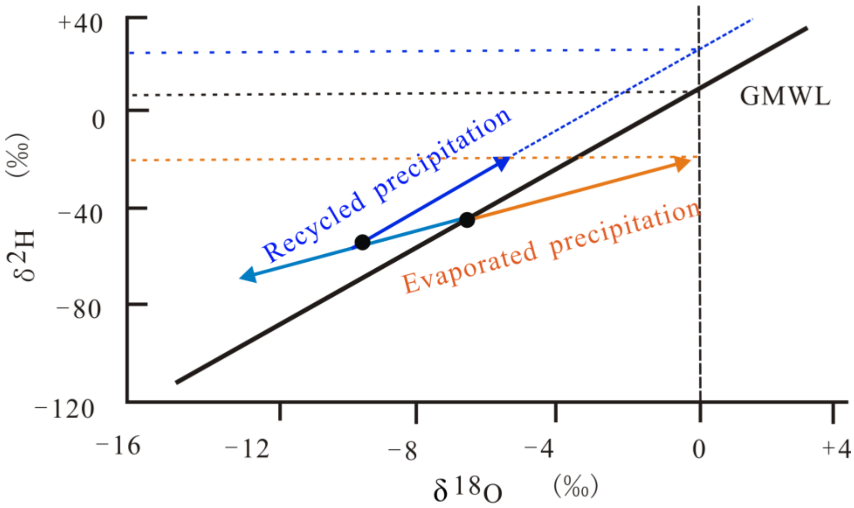

Fig. 1 The evolution of precipitation isotopes during the processes of sub-cloud evaporation and moisture recycling (Cited from Kong and Pang (2016))

Evaluating long-term isotope measurements of precipitation at the GNIP (Global Network of Isotopes in Precipitation, operated by IAEA and WMO) station Urumqi and monitoring precipitation isotopes at two stations with higher altitude in the Tianshan Mountains, Pang et al. (2011) found a hysteresis effect in the d-excess – temperature relationship which has been interpreted in terms of seasonal changes of moisture recycling. In a follow-up paper, Kong et al. (2013) improved the deuterium excess model (Froehlich et al., 2008) and estimated the recycled fraction in precipitation at the Tianshan mountain stations (less than 2.0 ± 0.6 %) and at the Urumqi station (up to 15.0 ± 0.7%). This makes the temperature effect could only be identified at temperature < 0℃ and the resulted isotope – altitude gradient is 0.12‰/100m, which is distinguished from the common -0.28‰/100m (Poage and Chamberlain, 2001). A quantitative model on the influence of sub-cloud evaporation and moisture recycling on the isotope-altitude gradient is built to explain the positive gradient found in the Tianshan Mountains.

In future, the method to quantify the influence of local hydrological processes on precipitation isotopes should be verified through the field test in consideration of the uncertainties of isotopic parameters in different water bodies.

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