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Circulation effect of $\delta^{18}O$ in precipitation and its implication for paleoclimate

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The amount effect of $\delta^{18}O$ in precipitation on a monthly scale proposed by Dansgaad in 1964 is widely applied to explain and reconstruct the variation of monsoon intensity or precipitation amount over the paleoclimate research. However, it encounters difficulty in the monsoon regions of China (MRC), which have composite water vapor sources. Here, the author points out that, according to observed data, there is another isotope effect in the MRC: circulation effect. For most of the eastern parts of the MRC, the Pacific Ocean provides the adjacent source of water vapor, while the Indian Ocean provides the distant source of water vapor. The variability in the ocean and atmosphere circulations, such as the changes in the tropical Pacific SST gradient, or the West Pacific subtropical high, etc, could induce the changes in the ratio of water vapor from the Pacific Ocean and the Indian Ocean, which can then lead to the changes in the atmospheric precipitation $\delta^{18}O$ ($\delta^{18}O_p$): no matter how much of the precipitation amount, the $\delta^{18}O_p$ value is relatively high if the water vapor from the Pacific Ocean, whereas the $\delta^{18}O_p$ value is relatively low if the water vapor from the Indian Ocean. This is namely "circulation effect" of the $\delta^{18}O_p$. The conception of circulation effect, which is presented based on the principle of the Rayleigh rainout process, could provide a more reasonable re-explanation for $\delta^{18}O$ as a paleoclimatic proxy.