Has eastern China always been summer wet?

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Rainfall in eastern Asia provides water to nearly one fifth of the world's population. The stepwise spring to summer northward progression of the rain band in this region results from seasonal shifts in the latitude of the westerly jet stream, which are especially large due to deflection by the Tibetan Plateau. Shifts in jet position may also explain a component of millennial scale Pleistocene rainfall variability in eastern China. However, the response of rainfall in this region to shifts in the jet under globally warmer condition has not been investigated. Therefore, we measured oxygen and clumped isotope compositions of paleosol carbonate nodules from the late Miocene and Pliocene Red Clay Formation at Jiaxian on the northern Chinese Loess Plateau. Soil water $\delta^{18}O$ values decreased during the late Miocene reaching minimum values around 6 Ma. Soil water $\delta^{18}O$ values then increased by about 3‰ at the beginning of the Pliocene, reaching maximum values at 5 Ma and around 3.5 Ma, before decreasing again, closely tracking changes in the meridional sea surface temperature gradient. We show by comparison of these data with previously published records that spring rainfall in eastern China was abundant during the warm Pliocene and that the seasonality of rainfall shifted toward summer as the climate cooled into the Pleistocene. This change in rainfall seasonality is consistent with the jet transition hypothesis if the mean position of the westerly jet was shifted substantially northward during the Pliocene as suggested by models. Changes in rainfall seasonality also explain the late Pliocene increase in dust accumulation rates on the Chinese Loess Plateau and provide a dynamic mechanism for the enigmatic occurrence of Pliocene rainfall maxima during obliquity minima. Global warming is expected to result in rainier springs in eastern China.