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Low oxygen isotope values of fossil cellulose indicate an intense monsoon in southeast China during the late Oligocene

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Quantitative estimates of monsoon strength in south China are commonly reported from Neogene and Quaternary aged substrates. Similar data for the Paleogene, however, are generally lacking, leading to much uncertainty and debate over the early strength and evolution of the monsoon system. Here we report oxygen isotope measurements on tree-ring cellulose ($\delta^{18}O_{cell}$) extracted from 43 Oligocene age mummified wood fossils collected from Nanning, Guangxi, south China. Comparison with modern $\delta^{18}O_{cell}$ values collected from trees currently living in Nanning Basin indicates significantly lower $\delta^{18}O_{cell}$ values in the Oligocene than present. Today, such low $\delta^{18}O_{cell}$ values are found only in trees growing at sites with low mean annual temperature (MAT) (e.g., eastern Canada: MAT = -3 to -8 ^{o}C), at high elevation (e.g., Nepal: elevation 3550 m), and in monsoon climates of east and southeast Asia that experience greater precipitation amounts than in Nanning Basin. Because independent evidence precludes very low MAT or high elevation in the region during the Oligocene, we propose these low Oligocene $\delta^{18}O_{cell}$ values result from intense summer rainfall in south China during the Oligocene. Using existing relationships between $\delta^{18}O_{cell}$ and precipitation amount, we estimate summer rainfall rates ~2 times greater during the late Oligocene than today. These data are consistent with an intense summer monsoon climate in south China during the Oligocene, and provide a rare quantitative estimate of monsoon precipitation in East Asia during the greenhouse to icehouse transition.