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Magnesium isotopic evidence for staged enhancement of the East Asian Summer Monsoon precipitation since the Miocene

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Knowledge of the evolution of the East Asian Summer Monsoon (EASM) provides a valuable opportunity to uncover the dynamic interactions of land-ocean-atmosphere system in the late Cenozoic. However, the evolutionary history of EASM remains debatable, mainly due to the difficulty in separating EASM precipitation and temperature signals. In this study, precipitation proxies of Sr/Ca ratio and $\delta^{26}Mg$ value in loess secondary calcite (carbonate nodule (*NC*) and fine carbonate (*FC*) (grain size <4 μm)) are further verified, with high precipitation corresponding to high $\delta^{26}Mg_{FC}$ but low $\delta^{26}Mg_{NC}$ and Sr/Ca_{NC} ratio, and vice versa. Then, these proxies are investigated in well-researched Chinese loess eolian deposits since ~22.5 Ma, suggesting that the EASM precipitation enhanced during the mid-Miocene (~16.5–14.0 Ma) and the Quaternary (~2.6–0 Ma). The mid-Miocene enhancement can be compared with the strong EASM intensity and the warmest global temperature since the Miocene. Global warming thus is considered as the dominant force for this enhancement via an expansion in the latitudinal extent of the Indoâ€'Pacific Intertropical Convergence Zone (ITCZ). In contrast, the Quaternary enhancement was accompanied by decreases in global temperature. We propose their linkage via the reinforcement of the Pacific Walker Circulation and a northward shift of the subtropical ridge in the western Pacific. Our study provides a new insight into EASM evolution and its dynamic linkage with global climate changes.