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Late Miocene and mid-Pliocene enhancement of the East Asian monsoon as viewed from the land and sea

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The late Miocene onset of the Indian monsoon and the late Miocene and middle Pliocene enhancement of the East Asian monsoon appear to be the result of coeval uplift episodes in the Himalayan-Tibetan region. A decrease of the abundance ratio of planktonic foraminifera *G. sacculifer/G. ruber* and increase of *Neogloboquadrina* approximately 8 Myr at ODP site 1146 in the South China Sea indicate lowering of the surface temperature and increased productivity, which are interpreted to have been caused by an intensified influence of the East Asian winter monsoon winds. In the Arabian Sea, monsoon-driven upwelling indicated by the appearance and abundance of planktonic foraminifera *G. bulloides* and radiolaria increased remarkably at $\sim$ 8 Myr. Wind-blown sediment started to accumulate over a wide area of the Chinese Loess Plateau at $\sim$ 8 Myr, about the same time as a pronounced pulse of eolian dust to the North Pacific, as revealed at ODP site 885/886, indicating onset of widespread aridity in the Asian interior. At 3.6 Myr the accumulation of eolian sediment increased by about an order of magnitude, both at proximal settings in China and in the distal North Pacific Ocean. The planktonic foraminifera *Neogloboquadrina* also underwent a further increase in abundance in the South China Sea at this time.

Existing evidence from inland Asia and the surrounding seas suggests a late Miocene onset (or significant intensification) of the East Asian and Indian monsoons, the reason being their link with the uplift of the Himalayas and the Tibetan Plateau. The first increase in mean sediment flux to the Indian Ocean at 11 Myr and strong peak beginning between 9 and 8 Myr indicates the rising of the Himalayas. That rise could have reached sufficient height to produce a rain shadow in Central Asia, causing aridity and providing a source of dust to be transported eastwards into north China and the North Pacific. Further rapid uplift of the entire Tibetan Plateau at 3.6 Myr, as evidenced by

the extensive conglomerates of that age on the north flank of the Plateau, resulted in further aridity in the basins of central and eastern Asia, an enhanced East Asian monsoon, and a second, late Pliocene, pulse of terrigenous sedimentation in the Indian Ocean.