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Variations of the Indian summer monsoon over the Mio-Pliocene recorded in the Bengal Fan (IODP Exp354): implications for the evolution of the terrestrial biosphere.

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A pressing challenge in climate research is understanding the temporal evolution of the Indian monsoon system; its response to global and regional climatic controls (including warming); as well as implications in terms of vegetation (C4 expansion), erosion of the Himalaya and carbon sequestration in the Bengal Fan. Studies on climate dynamics have recently offered new insights into the mechanistic controls on the monsoon: the tectonic boundary of the Himalaya is implicated as the major control on Indian summer monsoon dynamics today. Since this region has been uplifted since at least the late Oligocene, it is possible to test the response of monsoon precipitation to global and regional climate change, and also understand feedbacks on the climate system via carbon sequestration in the Bengal Fan. The evidence for monsoon intensity changes across the Miocene and Pliocene is currently incomplete given temporal uncertainty and diagenesis in terrestrial records; biases in the records reconstructed from the distal fan; and conflicting evidence from wind speed and aridity metrics for a stronger or weaker monsoon. Our alternative approach is therefore to study the basin-wide hydrological changes recorded in a multi-proxy, multi-site study of the marine sediments of the Bengal Fan recovered during IODP expedition 354.

In turbiditic sediments of Himalayan origin, the late Miocene C4 expansion was found in all three long records recovered during expedition 354 (i.e. at sites U1451, U1450 and U1455, from East to West) based on stable carbon isotope composition of terrestrial leaf-wax compounds. Cores from sites U1455 (a reoccupation of DSDP Leg 22 Site 218) provide the highest resolution record of the C4 transition, which appears to occur abruptly within a relatively continuous series of turbiditic sequences. Bio- and magneto-stratigraphic dating of these records by members of Expedition 354 science party is underway and will provide the best stratigraphic constraint of the C4 expansion in the Himalayan system. Hemipelagic sediments generally carry 13C enriched signatures indicative of C4-dominated source areas, and based on a combination of the wind field climatology and the wetness and ecosystems of source regions today, we suggest that these would likely represent wind transport, likely from peninsular India. Interestingly we found hemipelagic horizons carrying this enriched 13C character prior to the C4 expansion recorded in turbiditic sediments, likely revealing an earlier C4 colonization of peninsular India. Based on our preliminary data we thus propose that C4 plants colonized peninsular India around 9-10 Ma.

The hydrogen isotopic composition of the same leaf-wax compounds reveals a surprisingly small (on the order of 10 ‰) isotopic shift associated with the late Miocene C4 expansion. In contrast, the hydrogen isotope composition shift observed across the last deglaciation is far greater (ca. 40‰; Hein et al., in prep.). Cores from site U1451, provide a low resolution record across at least the last 26 Myr and appear to indicate a long term hydrological change from ca. 11Ma to ca. 7Ma, as inferred from progressive D enrichment in the biomarker records. These compound specific hydrogen isotope data will be discussed in the context of changing erosion patterns and attendant variations in the strength of the Indian summer monsoon as well as with respect to the mechanisms that led to the C4 expansion.