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Timing and pacing of middle to late Miocene intensification of the Indian Ocean-Atmospheric circulation system

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A recent biostratigraphic re-evaluation of Ocean Drilling Program (ODP) Site 722 (Bialik et al., accepted, Paleoceanogr. and Paleocl.) provides new insights into the history of monsoon driven upwelling in the Arabian Sea between 15 and 8.5 Ma. They suggest the modern monsoon was only established after tectonic preconditioning, linked to the uplift of the Himalayas, closure of the Tethyan Seaway, and the inception of Indonesian Throughflow restriction. But the requisite topography for the Indian monsoon was already in place by at least the late early Miocene which suggests another driver. However, as northern hemisphere latitudinal heat gradients continued to be shallower than modern throughout the Miocene, steepening southern hemisphere gradients during the middle Miocene glaciation of Antarctica ~14.8 Ma (Pound et al., 2012, Earth-Sci. Rev., 112) may have played an important role in pacing the monsoon system during the middle to late Miocene.

Here we further explore these findings by using recently acquired X-ray fluorescence (XRF) core scanning data from two additional ODP sites located in the central (Site 707) and southern (Site 752) Indian Ocean. We trace the timing and pacing of these environmental changes along a cross hemispheric transect within key areas of the larger Indian Ocean-Atmospheric system: (1) the monsoonal upwelling regions along the Oman Margin (Site 722); (2) the Somali/Findlater jets (Site 707); and (3) the high-pressure zone in the southern horse latitudes (Site 752).

Using updated age constraints at all sites, we show that the intensification of upwelling at Site 722 is tightly linked to climatic and oceanographic changes in the southern high latitudes (e.g., Groeneveld et al., 2017; Sci. Adv.). This close co-evolution of southern hemisphere climatic shifts and monsoon dynamics hints at a strong contribution of increasing southern hemisphere thermal gradients on the middle to late Miocene evolution of the Indian Ocean circulation system and Indian monsoon dynamics. Our findings thus re-emphasize the Indian summer monsoon as the result of a complex cross-hemispheric ocean-atmospheric system spanning the Indo-Pacific (e.g.,

Gadgil, 2018, J. Earth Syst. Sci., 127). We postulate that the Indian Ocean-Atmospheric system experienced a gradual intensification that began after the Middle Miocene Climatic Optimum with Antarctic Ice Sheet expansion. These changes then culminated in a synchronous shift ~11 Ma during the Ser4/Tor1 sea level lowstand (Haq et al., 1987; Science, 235). Future chrono-, chemo- and cyclostratigraphic work at ODP Sites 707 and 752 will further help to constrain the timing of these events, and fully place them in the context of the global climatic evolution during the Miocene.