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New insights into the Holocene Asian summer monsoon dynamics and the evolution of the Indus Civilisation based on a pollen record from the high-alpine lake Tso Moriri (NW Himalayas)

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Based on a new fossil pollen record from Tso Moriri located in the NW Himalayas (India) we reconstruct changes in mean annual precipitation (MAP) during the last 12000 years. The region is characterised by open vegetation and a MAP <300 mm, which is controlled by the Indian Summer Monsoon (ISM) and winter westerly-associated precipitation. Results indicate that precipitation levels varied significantly during the Holocene. After a rapid increase in MAP, a phase of maximum humidity was reached ca. 11.0-9.6 cal ka BP, followed by a gradual MAP decline. This trend parallels the reduction in the Northern Hemisphere summer insolation. The long-term trend of ISM weakening is overlaid with several short periods of greater dryness, which are broadly synchronous with the North Atlantic cold spells, suggesting reduced amounts of westerly-associated winter precipitation. Compared to the mid and late Holocene, it appears that westerlies had a greater influence on the western parts of the ISM domain during the early Holocene. During this period, the westerly-associated summer precipitation belt was positioned at Mediterranean latitudes and amplified the ISM-derived precipitation. The pollen record and moisture reconstructions also suggest that changes in climatic conditions affected the ancient Harappan Civilisation, which flourished in the greater Indus Valley from approximately 5.2 to 3.0 cal ka BP. The prolonged Holocene aridification, punctuated by an interval of increased dryness (ca. 4.5-4.3 cal ka BP), may have pushed the Urban/Mature Harappa society (ca. 4.5-3.9 cal ka BP) to develop more efficient agricultural practices to deal with the increasingly acute water shortages. The amplified aridity associated with North Atlantic cooling ca. 4.0-3.6 and around 3.2 cal ka BP further hindered local agriculture, possibly causing the deurbanisation that occurred from ca. 3.9 cal ka BP and eventual collapse of the Harappan Civilisation ca. 3.5-3.0 cal ka BP.