



Research paper

Late Holocene vegetation dynamics and Indian Summer Monsoon evolution from the Core Monsoon Zone, India

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ABSTRACT

Understanding the vegetation response to the Late Holocene Indian Summer Monsoon (ISM) variability from the Core Monsoon Zone (CMZ), India, during the Late Holocene, is the principal aim of the present study. Pollen analysis of a lacustrine sediment core from the Korba District of Chhattisgarh State (CMZ) demonstrated that between ca. 3560 and 2860 cal yr BP, savannah vegetation dominated the landscape in a cool-dry climate, suggesting reduced ISM rainfall. A shift in the vegetation from savannah to wooded savannah during ca. 2860 to 1960 cal yr BP was observed in a moderately strengthened ISM rainfall regime. From ca. 1960 to 890 cal yr BP, the region experienced a transformation from the wooded savannah vegetation to mixed tropical deciduous forests in a warm-humid climate, reflecting a comparatively increased ISM rainfall. From ca. 890 to 225 cal yr BP (CE1060–1725), dense mixed tropical deciduous forests came into being in a warm and relatively more humid climate, indicating intensified ISM rainfall. The initial part (CE 1060–1400) of this phase corresponds with the global Medieval Climate Anomaly (MCA; CE 700–1400). Agricultural practices and other human activities were suggested, based on the presence of Cerealia pollen, and other cultural pollen taxa, respectively.

1. Introduction

The Indian Summer Monsoon (ISM) is a significant component of the Asian Summer Monsoon System, which plays a vital role in mediating the interhemispheric transportation of heat and vapor between the Asian continent and the Indian Ocean (An et al., 2011; Jia et al., 2024; Quamar et al., 2024). The ISM is also known as South Asian Summer Monsoon, Southwest Monsoon, Southwest Summer Monsoon or simply Monsoon. The ISM provides ~80% of the annual precipitation throughout the Indian subcontinent, except in a few regions of southern and eastern India, during the months of June to September (JJAS). The ISM also impacts agriculture and socio-economic development for roughly two-thirds of the world's population (Gadgil, 2003; Pant and Rupa Kumar, 1997; Benn and Owen, 1998; Rawat et al., 2015, 2021; Quamar et al., 2024; Rahman et al., 2025). The ISM intensity varies over the Indian landmass, due to the variations in latitude, altitude and distance from the sea (Kale, 2003; Kale et al., 2003). A 10% deviation from the normal ISM rainfall can severely affect the agricultural production and water availability across the region.

The Holocene is significant in many respects, particularly for human settlement and cultural development. The Holocene, in fact, allowed civilizations to develop and evolve, as well as to perish owing to the gradual and/or abrupt climatic changes during the epoch (Petit et al., 1999; Kumaran et al., 2014; Misra et al., 2020). The ISM strengthened during the Early Holocene and subsequently weakened during the Mid- and Late-Holocene, especially at 8.2 ka BP and 4.2 ka BP (sudden rainfall reduction; Berkelhammer et al., 2012; Dixit et al., 2014, 2018, 2024). The abrupt monsoon reduction at 4.2 ka BP had significant societal impact, resulting in the migration of population of Indus-Harappan Valley Civilization to new areas to the east for domestic and agricultural use, as reliable seasonal flooding of the river system around the edge of Thar desert disappeared (Giosan et al., 2012), and also the agricultural productivity of the Harappan settlements decreased in response to the weakened summer monsoon (Berkelhammer et al., 2012; Dutt et al., 2018; Gupta et al., 2020; Jahan and Quamar, 2024). Thus, addressing the variability of the ISM is imperative to understand the present climatic perturbations and also for projecting future climatic trends having societal relevance (Royer, 2008; Cai et al., 2010; Singhvi

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