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Changes in the Indian Summer Monsoon during the past 600 years: A high-resolution record from the Anshupa Lake, Upper Mahanadi Delta, Core Monsoon Zone of India

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ABSTRACT

The core monsoon zone (CMZ) is an ideal region for reconstructing the Indian summer monsoon rainfall (ISMR). Mineral magnetic and organic geochemical parameters have been measured for an AMS ^{14}C-dated sediment core from the Anshupa Lake, situated in the eastern part of the CMZ, to reconstruct changes in the paleo-monsoonal precipitation on a sub-decadal scale during the past 600 years. Based on the data obtained, two phases may be recognised in the sedimentation history of the lake over the past six centuries: Phase-I (1397 to 1850 CE) comprising sediments deposited during the Little Ice Age (LIA), and Phase-II (1850 CE to the Present) comprising sediments deposited after the LIA. The measured proxies show decadal to sub-decadal scale variations. The relatively low values of mineral magnetic parameters (χ_{lf}, χ_{hf}, χ_{fd}, SIRM, χ_{ARM}/χ_{lf}, $\chi_{ARM}/SIRM$, χ_{ARM}/χ_{lf}, and $\chi_{ARM}/SIRM$) and more positive δ^{13}C values during Phase-I suggest a weak ISMR compared to Phase-II. The variations in mineral magnetic parameters suggest that the ISMR was the lowest during the Spörer, Maunder and Dalton Minima, but strong during the intervening periods. This inference resonates with the δ^{13}C and C/N profiles of the core. Bacterial magnetite is documented during the mid-16th to mid-17th century, suggesting warm and humid conditions in the intervening phase between the Spörer and Maunder Minima. The magnetic susceptibility (χ_{lf}) data exhibit a number of periodicities similar to those shown by cosmogenic nuclide-derived Total Solar Irradiance (TSI) data, reaffirming a solar influence on the Indian summer monsoon in the core monsoon zone of India.

1. Introduction

Numerous workers have carried out high-resolution paleoclimatic reconstructions for the past millennium using proxies preserved in terrestrial and marine records, which help determine the pattern of climate variability and predict future climatic changes (Arnaud-Fassetta and Provansal, 1999; Sarkar et al., 2000; Mann, 2002; Fleitmann et al., 2003; Gupta et al., 2005; Uberoi, 2012; Grove and Adamson, 2018; Fagan, 2019; Mishra et al., 2019). Both historical and proxy records suggest that the past millennium witnessed centennial scale climatic changes, covering the Medieval Climatic Anomaly (MCA) and the Little Ice Age (LIA). However, decadal to sub-decadal scale climatic variability and the related forcings remain poorly understood. Historical records show severe famines and the consequent deaths on a massive scale during the 14th and 15th centuries due to a reduction in the Indian Summer Monsoon (ISM), coinciding with periods of solar minima (Loveday, 1914; Uberoi, 2012). Several drought years with famines have been documented during the Maunder and Wolf Minima (Mitchell et al., 1979; Zhang et al., 2008; Gou et al., 2015). Both historical and instrumental records suggest alternating flood and drought events on a sub-decadal scale in the Indian subcontinent during the past few centuries (Ramdas, 1972; Pant et al., 1993; Kale and Baker, 2006). Although a few studies have documented the extreme climatic events like floods and droughts in the pre-instrumental data period, their reconstruction with

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