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A 900-year (600 to 1500 A.D.) record of the Indian summer monsoon precipitation from the core monsoon zone of India

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[1] We present a near-annually resolved record of the Indian summer monsoon (ISM) rainfall variations for the core monsoon region of India that spans from 600 to 1500 A.D. from a ^{230}Th-dated stalagmite oxygen isotope record from Dandak Cave. Our rainfall reconstruction, which spans the Medieval Warm Period (MWP) and the earliest portion of the Little Ice Age (LIA), indicates that the short instrumental record of ISM underestimates the magnitude of monsoon rainfall variability. Periods of severe drought, lasting decades, occurred during the 14th and mid 15th centuries and coincided with several of India's most devastating famines. **Citation:** Sinha, A., K. G. Cannariato, L. D. Stott, H. Cheng, R. L. Edwards, M. G. Yadava, R. Ramesh, and I. B. Singh (2007), A 900-year (600 to 1500 A.D.) record of the Indian summer monsoon precipitation from the core monsoon zone of India, *Geophys. Res. Lett.*, *34*, L16707, doi:10.1029/2007GL030431.

1. Introduction

[2] The seasonal rainfall brought by the Southwest Indian summer monsoon (ISM) supplies nearly 80% of Southeast Asia's annual precipitation and is vital to sustaining the region's agriculture, which supports nearly a quarter of the world's population. The instrumental record of ISM (~150 years) reveals strong interannual to inter-decadal variability associated with the El Nino Oscillation events (ENSO). As recently as the late 1960s, El Niño related ISM failure for three consecutive years resulted in 1.5 million deaths within India [*Center for Research on the Epidemiology of Disasters*, 2005]. A longer record of ISM variability is necessary to determine whether longer intervals of monsoon failure occurred in the past and assess future risk.

[3] A growing array of evidence indicates that during the past 1500 years centennial-scale natural climate oscillations affected broad areas of the Earth. These include the Little Ice Age (LIA, ca. 1400 to 1850 A.D.) [*Mann*, 2002a] and Medieval Warm Period (MWP, ca. 900 to 1300 A.D.) [*Mann*, 2002b]. These century-scale climate oscillations were not restricted to the high latitudes and appear to have involved a significant perturbation in tropical ocean temperatures as well as monsoon rainfall [*Newton et al.*, 2006]. While pre-instrumental historical accounts of ISM variations exist during this time interval, they document ISM variability mainly in terms of extreme events such as occurrences of droughts, floods, and famines [*Pant et al.*, 1993] and therefore are of limited use in assessing the full frequency spectrum of ISM variability. Consequently, multi-century ISM reconstructions derived from proxy records of precipitation are vital to assess pre-instrumental patterns of ISM variability and examine relationships with other components of the climate system.

[4] Efforts to extend our knowledge of ISM variability beyond the instrumental and historical records have largely focused on marine proxies that reflect the extent of upwelling and wind intensity in Arabian Sea sediments [*Anderson et al.*, 2002; *Gupta et al.*, 2003; *Overpeck et al.*, 1996; *Schulz et al.*, 1998]. However, these ISM reconstructions have several disadvantages for assessing monsoon rainfall variations and its potential impact on human populations. In particular, these marine records do not sample hydrologic conditions within the core monsoon zone of India where most human populations are located and are of lower temporal resolution, so only the longer-term variations in monsoon wind intensity is monitored. It is the amount of rainfall and the inter-regional pattern of monsoon rainfall variability, particularly drought that is of greatest importance to human populations.

[5] Recent work has shown that speleothems can be excellent archives of monsoon rainfall variability [*Burns et al.*, 2002; *Fleitmann et al.*, 2003, 2007; *Neff et al.*, 2001; *Sinha et al.*, 2005; *Yadava and Ramesh*, 2005; *Yadava*, 2002; *Yuan et al.*, 2004]. The oxygen isotopic composition (δ^{18}O) of speleothem calcite from tropical and monsoon locations is primarily controlled by the δ^{18}O value of precipitation, which in turn varies inversely with rainfall amount [*Dansgaard*, 1964] and/or fraction of water vapor removed from maritime air masses as they move away from their source regions [*Rozanski et al.*, 1993].

2. Cave Location and Climatology

[6] The δ^{18}O of speleothems collected from Dandak Cave, (19°00′N, 82°00′E; elevation ~400 m), is an ideal archive of rainfall variability within the core monsoon region of India (Figure 1). First, instrumental rainfall data from the core monsoon region (Figure 1), which is comprised of the following Indian meteorological sub-divisions 6–8, 18–22, 24–27, is strongly correlated with the area weighted "All India Summer Monsoon Rainfall" (AISMR) time series [*Gadgil*, 2003]. Furthermore, the instrumental rainfall data from Jagdalpur, the nearest meteorological

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