Geophysical Research Abstracts, Vol. 9, 10408, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-10408
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# Indian monsoon dynamics recorded in stalagmites from Oman and Yemen (Socotra)

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High-resolution oxygen isotope ($\delta^{18}$O) profiles of Holocene stalagmites from four caves in Northern and Southern Oman and Yemen (Socotra) provide detailed information on fluctuations in precipitation along a latitudinal transect from $12^o$ N to $23^o$ N. $\delta^{18}$O values reflect the amount of precipitation which is primarily controlled by latitudinal position and strength of the ITCZ and dynamics of the Indian summer monsoon (ISM). A rapid early Holocene rise in $\delta^{18}$O indicates a rapid northward displacement in the latitudinal position of the summer ITCZ and the associated ISM rainfall belt. Decadal- to centennial-scale changes in monsoon precipitation correlate well with high-latitude temperature variations recorded in Greenland ice cores. During the middle to late Holocene the summer ITCZ continuously migrated southward and monsoon precipitation decreased gradually in response to decreasing solar insolation, a trend which is also recorded in other monsoon records from the Indian and East Asian monsoon domains. Importantly, there is no clear evidence for an abrupt middle Holocene weakening in monsoon precipitation, although abrupt monsoon events are apparent in all monsoon records. However, these events are clearly superimposed on long-term trend of decreasing monsoon precipitation. For the late Holocene there is an anti-correlation between ISM precipitation in Oman and inter-monsoon (spring/autumn) precipitation on Socotra, revealing a possible long-term change in the duration of the summer monsoon season since at least 4.5 ka B.P. Together with the progressive shortening of the ISM season, gradual southward retreat of the summer ITCZ and weakening of the ISM, the total amount of precipitation decreased in those areas located at the northern fringe of the Indian monsoon domain, but increased in areas closer to the

equator.