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Precession-scale variability of upwelling in the Arabian Sea and its implications for proxies of Indian summer monsoon

Chetankumar Jali^{1,2}, Jayaraman Srinivasan², and Arindam Chakraborty^{1,2}

¹Indian Institute of Science, Centre for Atmospheric and Oceanic Science, Bangalore, India (jalihal@iisc.ac.in)

²DST-Centre of Excellence in Climate Change, Divecha Centre for Climate Change, Indian Institute of Science, Bangalore, India

Upwelling along the western boundary of the Arabian Sea and the Indian summer monsoon rainfall are positively correlated in modern observations. Upwelling transports nutrients into the euphotic zone and thus controls primary productivity. Therefore, primary productivity in the region of upwelling has been used to reconstruct monsoons of the distant past. Such reconstructions suggest that monsoons lag insolation by about 9 kyrs (nearly out-of-phase), contrary to several speleothem-based reconstructions that indicate a more in-phase relation of monsoon with insolation. Using results from transient as well as time-slice experiments, we have shown that factors other than the Indian monsoon affect upwelling on the precession time scales. These factors modulate the spatial extent of upwelling, resulting in the precession-scale variability in primary production. This is in contrast with modern observations, where most of the variations in primary productivity are a result of changes in the intensity of upwelling. We find that the spatial extent of upwelling is nearly out-of-phase with insolation. Thus, primary productivity lags insolation. We conclude that primary productivity in the Arabian Sea is not a good proxy for the Indian summer monsoon rainfall.