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Factors controlling the Indian summer monsoon onset in a coupled model

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The observed Indian Summer Monsoon (ISM) onset occurs around 30 May and 2 June, with a standard deviation of 8 to 9 days, according to the estimates. The relationship between interannual variability of the ISM onset and SSTs (Sea Surface Temperature) remains controversial. The role of Indian Ocean SSTs remain unclear, some studies have shown a driving role while other suggests a passive relation between Indian Ocean SSTs and ISM. The intrinsic impact of ENSO (El Nino-Southern Oscillation) is also difficult to estimate from observations alone. Finally, the predictability of the ISM onset remains drastically limited by the inability of both forced and coupled model to reproduce a realistic onset date.

In order to measure objectively the ISM onset, different methods have been developed based on rainfall or dynamical indices (Ananthakrishnan and Soman, 1988 ; Wang and Ho 2002 ; Joseph et al. 2006). In the study we use the Tropospheric Temperature Gradient (TTG), which is the difference between the tropospheric temperature in a northern and a southern box in the Indian areas (Xavier et al. 2007). This index measures the dynamical strength of the monsoon and provides a stable and precise onset date consistent with rainfall estimates. In the SINTEX-F2 coupled model, the ISM onset measured with the TTG is delayed of approximately 10 days and is in advance of 6 days in the atmosphere-only (ECHAM) model. The 16 days lag between atmospheric-only and coupled runs suggests a crucial role of the coupling, especially SST biases on the delayed onset.

With the help of several sensitivity experiments, this study tries to identify the keys regions influencing the ISM onset. Many studies have shown a strong impact of the Arabian Sea and Indian Ocean SST on the ISM onset. Nevertheless, the correction of the SSTs, based on AVHRR, in the tropical Indian Ocean only slightly corrects the delayed onset in the coupled model, which suggests an impact of SST in others regions on the ISM onset. During May and June, the main tropical SST biases in the coupled model are a strong warm bias in the Atlantic Ocean and a warm bias in the tropical Pacific Ocean, except along the equator around 140°W-100°W, where there is a cold tongue bias. The correction of the warm bias in the Atlantic Ocean slightly improves the onset date. Conversely, the correction of SST biases in the tropical and equatorial Pacific Oceans advances the onset date of 12 and 10 days, respectively, compared to the control coupled run. This result suggests that, at least in this model, the ISM onset is mainly control by the Pacific Ocean SSTs. Even if ENSO has an impact on the onset date it does not explain the delay, which is related to the biased SST mean state in the Pacific Ocean.