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Robustness of SST teleconnections and precursory patterns associated with the Indian Summer Monsoon

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Over the years, a lot of attention has been paid to understanding the interannual variability of Indian Summer Monsoon (ISM) rainfall and its relationship with major modes of variability such as El-Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). However, these studies have obtained different, and at times contradictory results. The purpose of this work is to test the robustness of previous findings before and after the 1976-77 climate shift, in order to unravel the possible causes for an apparent weakening of the ISM-ENSO relationship in recent decades.

To do so, we first re-examine the linear relationships between ISM rainfall and key SST indices in the Indo-Pacific regions during 1950-1976 and 1979-2006 periods. Composites of dry and wet ISM years are then carried out to test the utility of these results in terms of extreme ISM prediction. Overall, our results suggest that the variability of ISM rainfall has changed after 1979, marked by increased subseasonality and a more ambiguous relationship with ENSO. The dichotomy already observed between the first (JJ) and second (AS) part of the monsoon seems to play a significant role in these epochal changes. Indeed, during the recent period, most dry ISMs are associated with deficient rainfall anomalies in JJ, whereas most wet ISMs correspond to wet AS seasons. To evaluate the impact of this dichotomy on the ISM-ENSO relationship, ISM correlations are examined separately during El Niño and La Niña years. Results indicate that the early onset of El Niño conditions in the Pacific causes a deficient monsoon in JJ (via anomalous subsidence over India). In response to weak monsoon winds, warm SST anomalies appear in the west tropical Indian Ocean (IO), generating favorable conditions for the development a positive IOD in the equatorial region. However, by AS, the eastern IOD node seems to play a more active role on ISM rainfall activity. Indeed, by triggering air-sea feedbacks in the Southeast IO, these cold SST anomalies can induce anomalous ascent over India through a modulation of the local Hadley Cell in the east IO, and thus counteract the negative effect of El Niño on AS ISM rainfall. The JJ-AS dichotomy observed during El Niño years is thus linked to local air-sea interactions in the IO and may lead to an apparent weakening of the global ISM-ENSO signal when these feedbacks are particularly active. Results during La Niña years are consistent with this hypothesis although local processes in the Southeast IO now play a more prominent role and act to further enhance ISM rainfall in AS.
In line with previous findings, our results also highlight the existence of a biennal rhythm of the IOD-ENSO-ISM system during the recent period. The processes described in this work are thus integral parts of a larger Tropical Biennal Oscillation (TBO) signal, which evolves according to a JJ-AS dichotomy in relation to strong local IO interactions during recent decades (Meehl et al., 2003).