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Revisiting the possible links between the Quasi-Biennial Oscillation and the Indian summer monsoon using NCEP R-2 and CMAP fields

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In the past the stratospheric Quasi-Biennial Oscillation (QBO) has sometimes been proposed to explain the tendency for the Indian Summer Monsoon (ISM) to alternate between strong and weak years. In this study, NCEP Reanalysis-2 and CMAP fields have been statistically analyzed to assess the relationship between equatorial zonal winds in the stratosphere and ISM. In a first step, it is shown that zonal winds at 15hPa during the preceding winter (January-February) are the best stratospheric predictor of the summer rainfall over the Indian subcontinent as a whole. This relationship mainly holds for August and September, or the late ISM. Surprisingly, the QBO pattern is not significantly associated with the rainfall variability during June-July or the early ISM. CMAP and NCEP R-2 fields corroborate these findings and show that westerly QBO years are associated with a deepening of the monsoon trough over the Gangetic plains and decreased convective activity in the eastern equatorial Indian region. However, further statistical analysis shows that the QBO-ISM link is complex since a westerly QBO phase at 15 hPa in boreal winter leads to a weaker monsoon surface circulation with, in particular, a weakening of the Somali Jet at the beginning of the monsoon, but a much stronger circulation in September. At that time, the Tibetan High is reinforced, the tropical easterly jet at 200 hPa is stronger over India and the local reversed Hadley circulation is also strengthened north of the equator. The mechanisms by which the QBO may affect ISM have been explored through in particular correlations between stratospheric winds and tropopause temperature and pressure fields. Our results provide support for an out of phase behavior of convective

activity between the Indian sub-continent and the equatorial Indian Ocean induced by the QBO phase, especially during the late ISM. During a westerly QBO phase, convective activity is, in September, enhanced over India, which brings higher precipitation, compared to the east phase. This work also suggests that the winter QBO at 15 hPa could have some skill in foreshadowing the late ISM.