



The seasonal and zonal differences in the temperature, circulation and composition of the tropical upper troposphere and lower stratosphere due to the MJO

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The intraseasonal (20-90 day) variability of the tropical upper troposphere/lower stratosphere (UTLS) is dominated by the Madden-Julian Oscillation (MJO). Previous studies showed a strong connection between the MJO and variability in the UTLS circulation and trace gases. However, seasonality of UTLS circulation and trace gas response to the MJO has received very little attention in the literature. In this study, we use observations of trace gases (ozone, carbon monoxide and water vapor) and temperature from the Microwave Limb Sounder (MLS, version 4) and meteorological fields from the Modern-Era Retrospective analysis for Research and Applications, version 2 (MERRA-2) reanalyses to examine and explain the seasonal and zonal differences in the UTLS temperature, circulation, and trace gas anomalies associated with the MJO propagation. We find that the response of the UTLS during boreal summer months (June -September, JJAS) is different from the response during boreal winter months (November -February, NDJF). Ozone, temperature and circulation anomalies during JJAS are more zonally symmetric with a stronger Kelvin wave response than during NDJF. These differences are explained in terms of seasonal variations in vertically propagating Kelvin waves that strongly depend on the zonal structure of the climatological zonal winds. The trace gas response to the MJO is in agreement with circulation anomalies, showing strong seasonal differences. The analysis of MLS observations presented in this study may be useful for evaluation and validation of the MJO-related physical and dynamical processes in a hierarchy of models.