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Satellite Measurements of the Madden–Julian Oscillation in Wintertime Stratospheric Ozone over the Tibetan Plateau and East Asia

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We investigate the Madden–Julian Oscillation (MJO) signal in wintertime stratospheric ozone over the Tibetan Plateau and East Asia using HARMonized dataset of satellite ozone profiles (HARMOZ). Two different MJO indices (the all-season Real-Time Multivariate MJO index (RMM) and outgoing longwave radiation-based MJO index (OMI)) are used to compare the MJO-related ozone anomalies.

The results show that there are pronounced eastward-propagating MJO-related stratospheric ozone anomalies (mainly between 20 and 200 hPa) over the subtropics. The negative stratospheric ozone anomalies are over the Tibetan Plateau and East Asia during MJO phases 3–7, when MJO-related tropical deep convective anomalies move from equatorial Indian Ocean towards western Pacific Ocean. Compared the results based on RMM index, the MJO-related stratospheric column ozone anomalies based on OMI are stronger and more persistent over East Asia based on OMI index. The MJO-related stratospheric ozone anomalies show different vertical structure over the Tibetan Plateau and East Asia. Further analysis suggests that the different sampling errors may be partly responsible for the discrepancies among different satellite measurements.

The MJO-related stratospheric ozone anomalies can be attributed to the MJO-related circulation anomalies, i.e. the uplifted tropopause and the northward shifted westerly jet in the upper troposphere. Compared to that based on RMM, the upper tropospheric westerly jet may play a less important role in generating the stratospheric ozone anomalies based on OMI. Our study indicates that the circulation-based MJO index (RMM) can better define the features of the MJO-related stratospheric ozone anomalies, especially over East Asia.

Further study investigates the relation between MJO-related ozone and El Niño-Southern Oscillation (ENSO) events. The strength of ozone anomaly and the associated circulation anomalies in La Niña winters is more intense then in El Niño winters. This difference is due to stronger MJO strength in La Niña winters than in El Niño winters. There are significant northward and westward tilt structures of negative ozone anomaly over Tibetan Plateau in La Niña winters, however the negative MJO-related ozone anomaly is nearly barotropic in El Niño winters.