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Lagged Response of MJO-Related Subseasonal Climate to Short-Term Solar Ultraviolet Variations

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The tropical Madden-Julian oscillation (MJO), also known as the 40-50 day oscillation, is an eastward-propagating,convectively-coupled wave which functions as a key driver of sub-seasonal to seasonal convection and precipitation variability in the tropics (e.g., Madden and Julian 1994). The MJO generates a Rossby wave train that strongly influences weather in the extratropics on subseasonal time scales and evolves continuously through eight phases. Each phase is associated with either suppressed or enhanced convection within sub-regions of the tropics that progress eastward with time. Previous research has shown that the stratospheric quasi-biennial oscillation (QBO) modulates the strength of the MJO during boreal winter (e.g., Yoo and Son, GRL, 2016). The modulation is such that the MJO is about 40% stronger and persists about 10 days longer during the easterly QBO phase (QBOE) than during the westerly phase (QBOW).

Recent composite analyses over 6 solar maximum periods supports the existence of a response of MJO-related tropical convection and precipitation to short-term (~27-day) solar ultraviolet variations (Hoopes, Hood, & Galarneau, GRL, 2024, https://doi.org/10.1029/2023GL107701). Following solar UV peaks, the response consists of an increase in average convection and precipitation in the equatorial Indian Ocean and a decrease in the western and central tropical Pacific, with maximum amplitude at a lag of 4 to 8 days. The opposite occurs following short-term solar UV minima. The observed responses are most detectable when the Madden-Julian oscillation (MJO) is active and appear to be related to a reduced ability of the MJO to propagate across the Maritime Continent barrier following solar UV peaks relative to UV minima. A similar behavior has previously been found when the QBO is in its westerly phase relative to its easterly phase.

Following solar UV peaks, the hypothesized mechanism involves direct solar UV increases of ozone production and radiative heating in the upper stratosphere, a slowing of the residual meridional (Brewer-Dobson) circulation, relative downwelling in the tropics, and an increase in static stability in the tropical lower stratosphere. The current results apply specifically to the ~27-day solar rotational time scale. However, observational evidence on this time scale supports the view that similar effects should also occur on the 11-year time scale. Thus, MJO eastward propagation across the MC barrier may also be inhibited near 11-yr solar maxima relative to solar minima. In this sense, the MJO may represent a key link between solar spectral irradiance variability, which directly affects only the tropical upper stratosphere, and tropospheric climate.

Current work in progress is aimed toward an initial investigation of the extratropical consequences of the ~ 27-day modulation of MJO convection and precipitation. In particular, we are investigating effects on the Northern Hemisphere storm track, which is strongly influenced by the MJO. Results will be presented at the conference.

Solicited or Contributed

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