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QBO/Solar Modulation of the Boreal Winter Madden-Julian Oscillation: A Prediction for the Coming Solar Minimum

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The Madden-Julian Oscillation (MJO), also known as the 30-60 day oscillation, is the strongest of the intraseasonal climate oscillations and consists of an eastward propagating pattern of alternately intense and weak tropical convection and precipitation. It has significant derivative effects on extratropical circulation and intraseasonal climate, including effects on the North Atlantic Oscillation during northern winter. It has recently been found that the stratospheric quasi-biennial oscillation influences the amplitude of the MJO during northern winter such that amplitudes are larger during the easterly phase (QBOE) at 50 hPa than during the westerly phase (QBOW) [Yoo and Son, GRL, 2016]. The initiating mechanism is a decrease in static stability near the tropopause under QBOE conditions resulting from relative upwelling associated with the QBO induced meridional circulation. Positive feedbacks from below further enhance the response during the northern winter season. Here, evidence is presented that the QBO modulation of the boreal winter MJO is itself modulated by the 11-year solar activity cycle. Using real-time multivariate (RMM) MJO amplitude and phase data covering the 1980-2015 period (36 years), it is found that the increase in MJO mean amplitude during December, January, and February (DJF) under QBOE conditions is especially large under solar minimum (SMIN) conditions while the decrease in MJO amplitude under QBOW conditions is largest under solar maximum (SMAX) conditions. Consistently, the DJF mean static stability calculated from ERA-Interim reanalysis data in the lowermost stratosphere over the warm pool region is especially low under QBOE/SMIN conditions and is largest under QBOW/SMAX conditions. Specifically, while the mean MJO amplitude in DJF is $\sim$ 33% larger in QBOE than in QBOW, it is $\sim$ 56% larger in QBOE/SMIN than in QBOW/SMAX. Conversely, the mean MJO amplitude in DJF is only $\sim$ 14% larger in QBOE/SMAX than it is in QBOW/SMIN. This dependence on the solar cycle is consistent with a solar-induced increase in relative tropical upwelling under SMIN conditions and a decrease (relative downwelling) under SMAX conditions. However, these results are based on a limited time record. For example, only 5 winters qualify for the QBOE/SMIN category while 7 winters qualify for the QBOW/SMAX category. During the coming solar minimum, at least one additional winter in the QBOE/SMIN category should occur (possibly as early as 2017/2018) during which especially large MJO amplitudes are expected and an initial test of the proposed relationship will be possible.