The Madden-Julian Oscillation and Climate Change

*Eric D Maloney[1], Hien X Bui[1], Wei-Ting Hsiao[1], Elizabeth A Barnes [1]

1. Colorado State University Fort Collins

Recent modeling studies project that precipitation variability associated with the Madden-Julian oscillation (MJO) will increase in intensity in a warmer climate, while wind variability either decreases or increases at a slower rate than precipitation. This potential weakening of MJO winds relative to precipitation would have important consequences for prediction of extreme events modulated by the MJO, as many MJO impacts are regulated by the wind response. After briefly reviewing these recent findings, the CMIP5 archive is used to demonstrate that changes in the relative strength of MJO wind to precipitation amplitude can be detected as early as the period 2020-2040 in RCP8.5 relative to the historical record. It is also shown using reanalysis data from ERA5 and MERRA that a weakening of MJO winds relative to precipitation may already be detectable in the historical record. How increased tropical dry static stability in a warming climate regulates the MJO wind response to warming is discussed.

Finally, an aquaplanet version of the NCAR Community Atmosphere Model run in uncoupled mode and coupled to a slab ocean is used to better understand physical processes underlying changes in MJO behavior in a warmer climate. MJO changes are minimal when $4xCO_2$ forcing is applied but surface temperatures are held fixed at $1xCO_2$ conditions, indicating that MJO changes in a warmer climate are primarily driven by the SST change. The MJO propagates faster in the coupled model with SST warming. It is shown that this speed-up is due primarily to changes in horizontal moisture advection, with both zonal and meridional advection contributing. The slowing of the MJO zonal circulation per unit precipitation anomaly weakens drying by zonal advection to the east of the MJO precipitation center, causing more rapid MJO propagation in a warmer climate.

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