The Madden-Julian Oscillation in the Energy Exascale Earth System Model Version 1

Science

The Madden-Julian Oscillation (MJO), the dominant source of Earth system predictability on the subseasonal time scale, is a known driver of high-impact weather events across the globe. Despite notable progress in recent decades, it is still poorly represented in many Earth system and weather prediction models. We thoroughly examined MJO variability in DOE's E3SMv1 simulations to better understand the mechanism of the MJO and identify possible ways to further improve E3SM's MJO simulation fidelity.

Impact

We show that E3SMv1 adequately simulates the eastward propagation of the MJO over the Indo-Pacific warm pool, teleconnections to the mid-latitudes, and the interannual variability of the MJO associated with El Nino/Southern Oscillation. Our results also highlight the aspects of model simulation that need to be improved: interactions with the diurnal cycle of precipitation over the Maritime Continent and the coupling with the stratospheric Quasi-Biennial Oscillation.

Summary

The present study examines the characteristics of the Madden-Julian Oscillation (MJO) events represented in the Energy Exascale Earth System Model version 1 (E3SMv1), DOE’s new Earth system model. The coupled E3SMv1 realistically simulates the eastward propagation of precipitation anomalies associated with the MJO. Modulation of the diurnal cycle of precipitation in the Maritime Continent region by the MJO is also well represented in the model despite systematic biases in the magnitude and phase of the diurnal cycle. E3SMv1 reasonably captures the pattern of the MJO teleconnection across the North Pacific and North America, with an improvement in the performance in a high-resolution version, despite the magnitude being a bit weaker than the observed feature. The El Niño-Southern Oscillation (ENSO) modulation of the zonal extent of MJO’s eastward propagation, as well as associated changes in the mean state moisture gradient in the tropical west Pacific, is well reproduced in the model. However, MJO in E3SMv1 exhibits no sensitivity to the Quasi-Biennial Oscillation (QBO), with the MJO propagation characteristics being almost identical between easterly QBO and westerly QBO years.

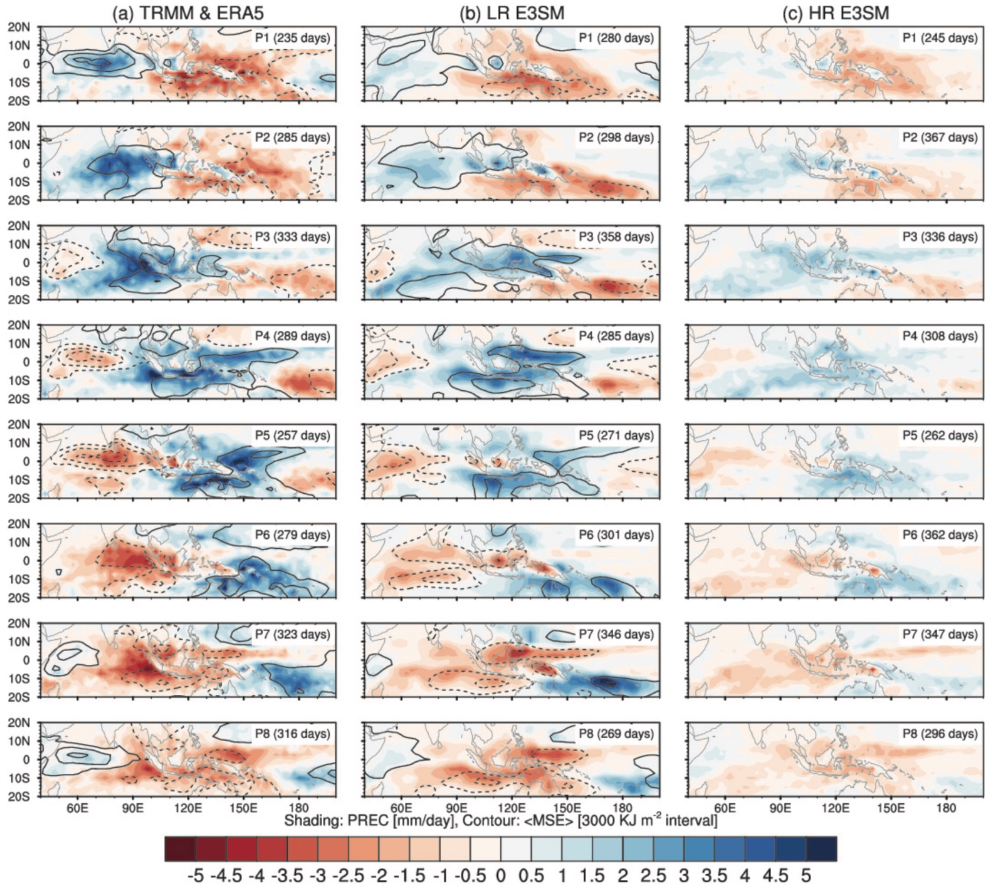

Figure MJO life cycle composite maps of intraseasonal precipitation (mm day^{-1}, shaded) and column-integrated MSE anomalies (kJ m^{-2}, contour) obtained from each RMM phase (RMM amplitude > 1) during NDJFMA: a) observations, b) LR E3SMv1, and c) HR E3SMv1. The contour interval for column-integrated MSE anomalies is 3000 KJ m^{-2}. The number of days used in each phase composite is indicated in the parentheses.

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