MJO Simulation in CMIP5 Climate Models:

MJO Skill Metrics and Process-Oriented Diagnosis

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Abstract

The Madden-Julian Oscillation (MJO) simulation diagnostics developed by the US CLIVAR MJO Working Group and the process-oriented MJO simulation diagnostics developed by the WGNE MJO Task Force are applied to thirty-seven Coupled Model Intercomparison Project phase 5 (CMIP5) models. The Relative Humidity Composite based on Precipitation (RHCP) diagnostic, the Normalized Gross Moist Stability (NGMS) diagnostic, and the Greenhouse Enhancement Factor (GEF) diagnostic are employed as the process-oriented MJO simulation diagnostics. Numerous scalar metrics are developed from the diagnostic results to assess model skill in representing amplitude, period, and coherent eastward propagation of the MJO, and to establish a link between MJO simulation skill and parameterized physical processes.

Most CMIP5 models underestimate MJO amplitude, especially when outgoing longwave radiation is used in the evaluation, and exhibit too fast phase speed while lacking coherent eastward propagation between precipitation and the wind field. The RHCP-metric, indicative of the sensitivity of simulated convection to low-level environmental moisture, and the NGMS-metric, indicative of the efficiency of a convective atmosphere in exporting moist static energy out of the column, show robust correlations with a large number of MJO skill metrics. The GEF-metric, indicative of the strength of the column-integrated longwave radiative heating due to cloud-radiation interaction, is also correlated with the MJO skill metrics, but shows relatively lower correlations compared to the RHCP- and NGMS-metrics.

Our results suggest that modifications to processes associated with the moisture-convection coupling, and the gross moist stability might be the most fruitful for improving simulations of the MJO. Though the GEF-metric exhibits fewer significant correlations with the MJO skill metrics, the longwave radiation feedback is highly relevant for simulating the weak precipitation anomaly regime that may be important for the establishment of shallow convection and the transition to deep convection.