Geophysical Research Abstracts
Vol. 19, EGU2017-18287, 2017
EGU General Assembly 2017

Contemporary model fidelity over the Maritime Continent: Examination of the diurnal cycle, synoptic, intraseasonal and seasonal variability

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One of the key challenges in subseasonal weather forecasting is the fidelity in representing the propagation of the Madden-Julian Oscillation (MJO) across the Maritime Continent (MC). In reality both propagating and non-propagating MJO events are observed, but in numerical forecast the latter group largely dominates. The fact that models still struggle to realistically represent the MJO over MC is generally attributed to its complex terrain and associated vigorous diurnal cycle of convection, multi-scale interactions between local and propagating modes of convection and regional air-sea interactions.

In this study, multi-model simulations from the GEWEX Atmospheric System Study (GASS) / Year of Tropical Convection (YOTC) MJO Project are analyzed to quantify contemporary model performance in representing the MC mean climate and its variability, including the diurnal cycle, synoptic, intraseasonal, and seasonal variability. This dataset has been shown to be useful in such multi-model evaluation studies over different regions and/or focusing on different physical processes (e.g. Jiang et al., JGR, 2015; Mani et al., Clim. Dyn, 2016)

For this study, comprehensive model performances are evaluated using metrics that utilize the mean precipitation pattern and the amplitude and phase of the diurnal cycle, with a particular focus on the linkage between a model's local MC variability and its fidelity in representing propagation of the MJO and equatorial Kelvin waves across the MC. Subseasonal to seasonal variability of mean precipitation and its diurnal cycle in 20 year long climate simulations from over 20 general circulation models (GCMs) is examined to benchmark model performance. Furthermore, we utilize cross model differences to gain insight into which processes are most critical to realistically represent multi-scale interactions over the MC region. This includes distinguishing the behavior between a number of land (Sumatra, Borneo, New Guinea and Southeast Asia) and ocean (Eastern Indian Ocean, West of Sumatra, between Sumatra and Borneo and Banda Sea) regions to understand regional and air-sea interaction effects.

Our results show that many models struggle to represent the precipitation pattern over complex Maritime Continent terrain, especially over land. Many models show negative biases of mean precipitation and amplitude of its diurnal cycle; these biases are often larger over land than over ocean. Furthermore, only a handful of models realistically represent the spatial variability of the phase of the diurnal cycle of precipitation. Models tend to correctly simulate the timing of the diurnal maximum of precipitation over ocean during local solar time morning, but fail to acknowledge influence of the land, with the timing of the maximum of precipitation there occuring, unrealistically, at the same time as over ocean. The day-to-day and seasonal variability of the mean precipitation follows observed patterns, but is often unrealistic for the diurnal cycle amplitude. On the other hand, the intraseasonal variability of the amplitude of the diurnal cycle of precipitation is mainly driven by model's ability (or lack of) to produce eastward propagating MJO-like signal. This confirms that the intraseasonal variability of the diurnal cycle of precipitation over the Maritime Continent is driven by the large-scale circulation associated with MJO-induced circulation.

Our results show that many models tend to decrease apparent air-sea contrast in the mean precipitation and diurnal cycle of precipitation patterns over the Maritime Continent. As a result, the complexity of those patterns is heavily smoothed, to such an extent in some models that the Maritime Continent features and imprint is almost unrecognizable relative to the eastern Indian Ocean or Western Pacific.