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Scale interaction between the MJO and the diurnal cycle of precipitation over the Maritime Continent

Simon Peatman (1), Adrian Matthews (1,2), and David Stevens (1)

(1) School of Mathematics, University of East Anglia, Norwich, UK, (2) School of Environmental Sciences, University of East Anglia, Norwich, UK

The Maritime Continent is a highly-populated region of many islands and shallow oceans, located in the oceanic warm pool, between the Indian and Pacific Oceans. A strong diurnal cycle of precipitation exists due to onshore breezes causing strong convergence of moist air – enhanced by topographic effects – over the land during the day time, peaking during afternoon-evening. The respective diurnal cycle over the ocean is far weaker and does not peak until early in the morning.

On intra-seasonal time-scales the greatest source of variability in the tropics is the Madden-Julian Oscillation (MJO). The convectively active part of the MJO propagates slowly ($\sim$5 ms^{-1}) eastward through the warm pool from the Indian Ocean to the western Pacific, followed by the convectively suppressed part. The complex topography of the Maritime Continent means the exact nature of the propagation through this region is unclear. Model simulations of the MJO are often poor over the region, leading to errors in latent heat release and, subsequently, global errors in medium-range weather prediction and climate simulation.

Using 14 northern hemisphere winters of high-resolution satellite data it is shown that, over regions where the diurnal cycle is strong, more than 80% of the variance in precipitation during an MJO cycle is accounted for by changes in the amplitude of the diurnal cycle. A canonical view of the MJO is of smooth eastward progression of a large-scale precipitation envelope over the warm pool. However, by computing "MJO harmonics" it is shown that the leading edge of the precipitation envelope advances over the islands of the Maritime Continent approximately 6 days or 2000 km ahead of the main body. This behaviour can be accommodated within existing theories of MJO propagation.

When the active convective MJO envelope is over the eastern Indian Ocean, frictional moisture convergence and topographic blocking in the easterlies of the equatorial Kelvin wave response supply moisture to the islands of the Maritime Continent. When combined with the relatively clear skies and strong short-wave flux, the low thermal inertia of the islands allows a rapid response in the diurnal cycle which rectifies onto the lower-frequency MJO. Hence, an accurate representation of the diurnal cycle and its scale interaction appear to be necessary ingredients for models to simulate the MJO successfully.