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Zonal scales of Madden-Julian Oscillation in model experiments with and without continents

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The low-frequency eastward propagating Madden-Julian Oscillation (MJO) impacts weather and climate around the globe. MJO has zonal wavenumber 1-5, but the reason why these characteristic spatial scales arise are not clearly understood. We use the aquaplanet version of the Community Atmospheric Model (CAM-5), with perpetual spring equinox forcing and zonally symmetric sea surface temperature (SST), to study tropical intraseasonal oscillations (ISO), including MJO. In the first two experiments, we specify zonally symmetric SST profiles that mimic observed climatological July and January conditions. In the January SST simulation, we find a zonal wavenumber 1 mode with dominant period of 60 days, moving east at about 6 m/s. This mode, which resembles the Madden-Julian Oscillation (MJO), is absent when the model was forced by July SST. This shows the importance of the meridional gradient of SST on generation of MJO in this model.
For further investigation of the influence of tropical SST on ISO and convectively coupled equatorial waves (CCEW), we conduct experiments with idealized symmetric SST profiles having different widths of warm ocean centered at the equator. When the latitudinal extent of warm SST is comparable to or larger than the equatorial Rossby radius, we find a dominant low frequency (50-80 days) eastward mode that resembles the MJO, as in the January SST experiment. Our study shows that wider, meridionally symmetric SST profiles are necessary for a stronger MJO-like mode. In contrast to many other aquaplanet studies, a significant finding is the existence of westward propagating 30-120 day Rossby waves with zonal wavenumber 1 to 3, and meridional wavenumber 1, 3 and 5. However, in all the aquaplanet simulations, the MJO variance occurs at zonal wavenumber one.
To understand the role of land-sea distribution on zonal wavenumber of MJO, we perform a third set of experiments by introducing continents with realistic orography in the model. These experiments show a much more realistic MJO-like mode with higher zonal wavenumber, in the presence of broad meridional SST profiles. Moreover, the variance of westward propagating low frequency Rossby waves is considerably enhanced in the presence of continents.