J3.5 **THE MJO PROBLEM IN GCMS: WHAT ARE THE MISSING PHYSICS?**

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ABSTRACT

The Madden-Julian Oscillation (MJO) is well recognized as a key source of untapped predictability in the tropics. It affects a wide range of tropical weather such as the onset and breaks of monsoons and the formation of tropical cyclones. Being a strong tropical heating source, it also drives teleconnections to extratropics and affects precipitation events in western United States and South America. However, the MJO is poorly simulated in current general circulation models (GCMs). The simulated signals are generally too weak and propagate too fast. This constitutes one of the major tropical biases in current GCMs, and is detrimental to both weather prediction and climate prediction.

We will first report the results of our evaluation of the tropical intraseasonal variability, especially the fidelity of MJO simulations, in 14 climate models participating in the Inter-governmental Panel on Climate Change (IPCC) Fourth Assessment Report (Lin et al. 2005a). Many of the models have signals of convectively coupled waves, with Kelvin and MRG-EIG waves especially prominent. However, the majority of the models with good signals show phase speeds that are too fast, and scale these disturbances to equivalent depths which are larger than the observed value. Interestingly, this scaling is consistent within a given model across modes, in that both the symmetric and antisymmetric modes scale similarly to a certain equivalent depth. Excessively deep equivalent depths suggest that these models may not have a large enough reduction in their "effective static stability" by diabatic heating.

Although the eastward MJO precipitation variance in most models is smaller than in observations, it does approach the observed value in several models. Moreover, the eastward MJO variance in many models is significantly larger than its westward counterpart. However, the model variances in the MJO frequency band usually come from part of an overreddened spectrum, and not from a pronounced spectral peak. The only model with a prominent spectral peak in MJO frequency band is CNRM-CM3. We did not find a systematic dependence of MJO variance on closure assumptions of the deep convection schemes, or on model resolution. Air-sea coupling significantly increases the MJO variance in the only model for which we have compared an uncoupled run with a coupled run. It is found that equatorial precipitation in most of the models has stronger persistence than in observations, which tends to make their spectra too red.

Because the MJO problem is a common problem in many GCMs, our hypothesis is: *The MJO problem is caused by some missing physics in current GCMs.* We will discuss about a framework to synthesize the existing MJO theories, and to guide our search for the missing physical processes important for the MJO. Our parallel diagnostics of observational data (satellite, field experiment and reanalyses) and GCM simulations have revealed three missing physical processes that are likely important for the MJO. They include:
(1) self-suppression processes in tropical deep convection, including convective downdrafts (saturated and unsaturated), mesoscale downdrafts, and control of deep convection by lower troposphere moisture (Lin et al. 2005a);
(2) convective momentum transport by shallow convection (Lin et al. 2005b); and
(3) stratiform precipitation and stratiform heating profile (Lin et al. 2004; Mapes and Lin 2005).

It would be interesting to install these missing physics into GCMs and test their impacts on the MJO simulation.

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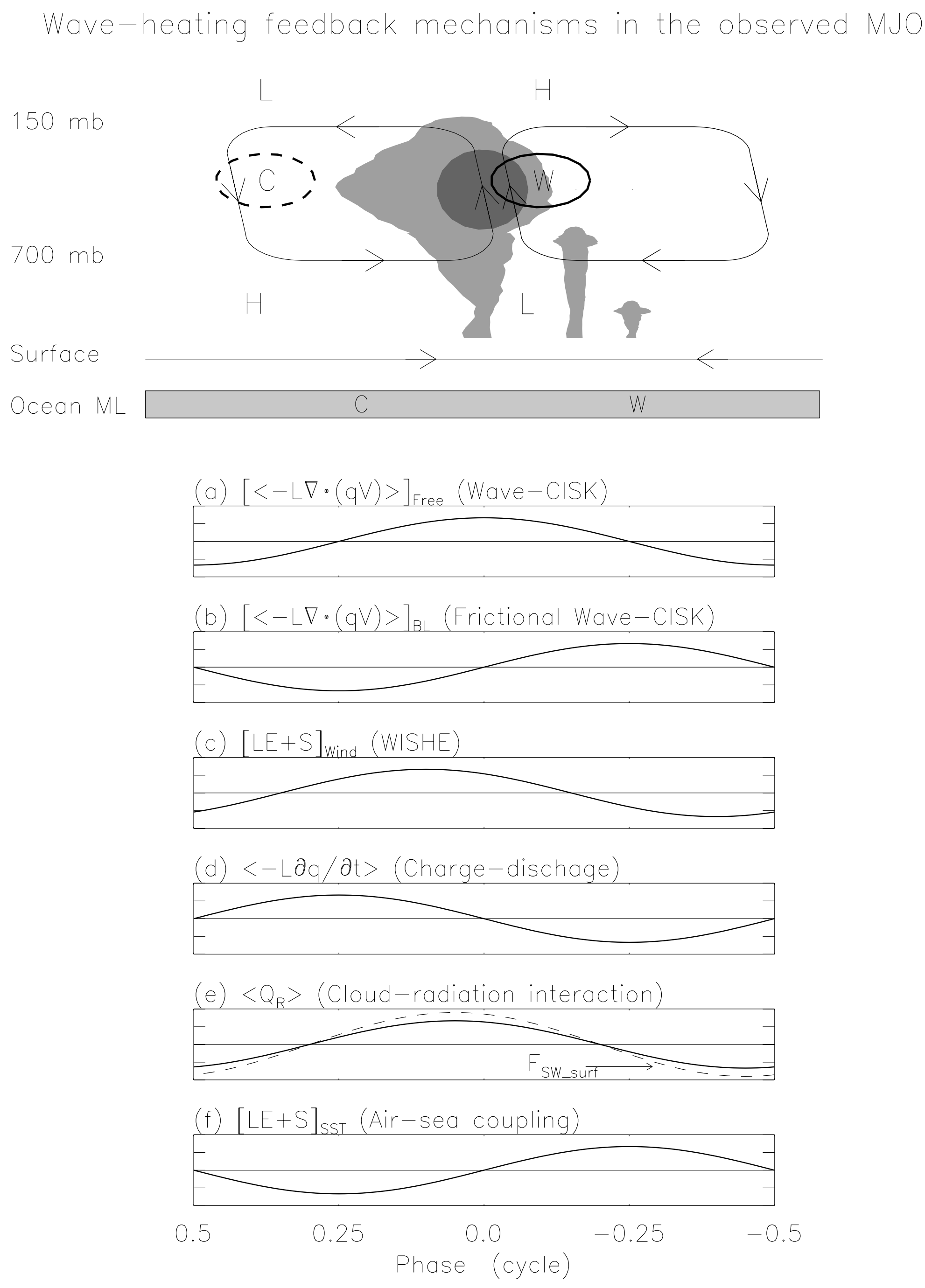

Figure 1: Schematic depiction of the wave-heating feedback mechanisms in the observed MJO. The upper part represents the wave structure in the equatorial vertical plane. Regions of enhanced large-scale convection are indicated schematically by the clouds. The dark shading inside the clouds represents the maximum of the diabatic heating. The arrows represent the anomalous wind. “H” and “L” represent the high and low geopotential height anomalies, respectively. “W” and “C” represent the warm and cold temperature anomalies, respectively. Panels (a)-(f) shows the phase of the six major components of column-integrated diabatic heating.