Changes in the MJO under Greenhouse Gas-Induced Warming in CMIP5 Models

* This study was supported by NASA Grant: 80NSSC17K0227

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Research Question: How does the MJO's behavior change in a warmer climate?

Objective: The goal of this study is to explain changes in the MJO characteristics due to a greenhouse gas-induced global warming.

Analysis: We use wavenumber-frequency filtering to obtain the MJO's amplitude, phase speed, and zonal wavenumber over four 20-year periods of the Representative Concentration Pathway 8.5 simulation in five Coupled Model Intercomparison Project Phase 5 models. We seek to explain the changes in the MJO phase speed using the linear moisture mode theory for the MJO by calculating the percentage changes of the meridional moisture gradient, gross dry stability, convective moisture adjustment timescale, and zonal wavenumber.

Findings: The MJO's amplitude and phase speed increase in a warming climate. The MJO's amplitude increase is likely due to increases in the background precipitation variability. The MJO's phase speed increase can be explained using the linear moisture mode theory as a result of an increases in the meridional humidity gradient, the gross dry stability, convective moisture adjustment timescale, and the decrease in zonal wavenumber (Table below).

Significance: This study provides a theory-based explanation of the MJO's acceleration in a warmer climate

	Actual phase speed change	***Predicted phase speed change***	***Changes in the parameters that are used for MJO phase speed change prediction (based on moisture mode theory)***			
Model	$\left[\frac{\delta \ln(c_{\mathrm{MJO}})}{\delta T_s}\right]_a$	$\left[\frac{\delta \ln(c_{\mathrm{MJO}})}{\delta T_s}\right]_p$	$\frac{\delta \ln \partial_y \overline{\langle q \rangle}}{\delta T_s}$	$-\frac{\delta \ln \overline{M_s}}{\delta T_s}$	$-\frac{\delta \ln \tau_c}{\delta T_s}$	$-\frac{2\delta \ln k}{\delta T_s}$
All models	2.44	2.55	6.56	−3.67	−3.14	2.80
CMCC-CM	2.27	2.24	6.47	−3.85	−2.10	1.72
CMCC-CMS	2.33	2.15	7.39	−4.02	−3.87	2.65
CNRM-CM5	4.56	5.49	6.95	−2.63	−2.54	3.71
MRI-CGCM3	2.62	3.65	4.29	−2.90	1.24	1.02
IPSL-CM5B-LR	1.80	−1.03	6.67	−3.63	−7.89	3.82

Table: Percentage changes per kelvin of surface warming for phase speed calculated from the models (1st column) and phase speed predicted in this study(2nd column). The predicted value is the sum of the percentage changes of the meridional humidity gradient (3rd column), gross dry stability (4th column), convective moisture adjustment time scale (5th column), and zonal wavenumber (6th column). The first row shows the multimodel mean changes, and subsequent rows are the results for the individual models.

Rushley, S. S., D. Kim, and Á.F. Adames, 2019: Changes in the MJO under Greenhouse Gas-Induced Warming in CMIP5 Models. *J. Climate,* **32**, 803-821 .doi: 10.1175/JCLI-D-18-0437.1