# Impact of a cold pool parameterization on the diurnal cycle and intraseasonal variability in the GEOS AGCM

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## Introduction

Cold pools and sub-grid organization offer a potential solution to the "entrainment dilemma," an apparent tradeoff between realistic convective variability and biases in the mean state.
Here we implement a cold pool (CP) parameterization based on Del Genio, *et al.* (2015) in the NASA GEOS AGCM run with Grell-Freitas convection. We examine two potential CP effects on deep convection: (1) Entrainment is made a decreasing function of cold pool area, and (2) source parcel moist static energy is drawn from the non-cold pool environment.

## Cold pool parameterization

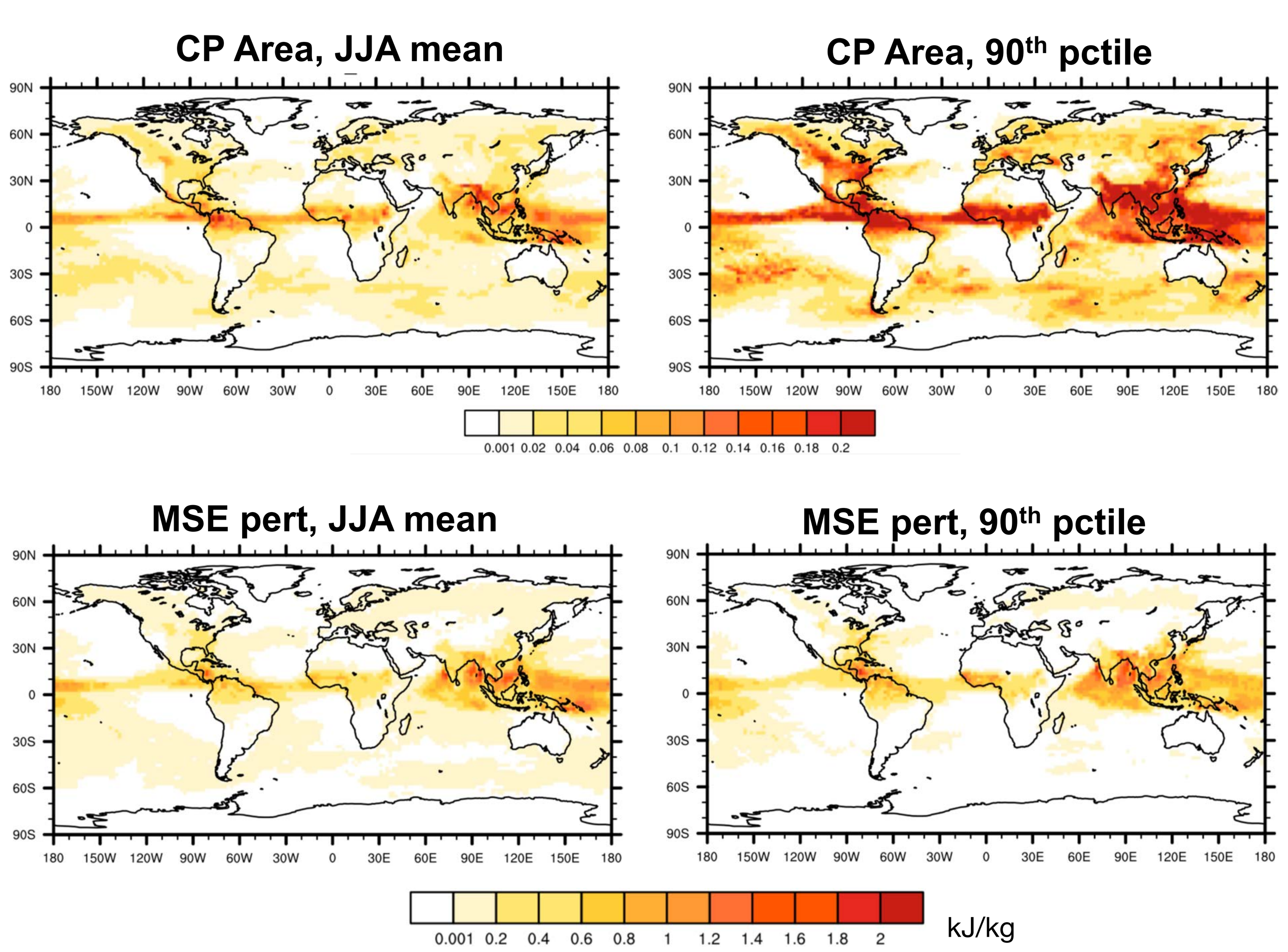
Downdrafts are generated by congestus and deep plumes from the Grell-Freitas convection scheme. New cold pools are initiated when downdraft $\theta_v$ is at least 0.5 K colder than the environment. Cold pool area fraction, $a_{cp}$, $\theta_{cp}$ and $q_{cp}$ evolve prognostically based on additional downdraft input and a decay timescale of 4 hours.

$$\frac{\partial a_{cp}}{\partial t} = \frac{m_d g}{\Delta p} - \frac{a_{cp}}{\tau} \qquad \tau = 4 \text{ hr}$$

Environmental properties are diagnosed,

$$\theta_{env} = \frac{\overline{\theta} - a_{cp}\theta_{cp}}{1 - a_{cp}} \qquad \theta' = \theta_{env} - \overline{\theta}$$

where $\theta'$ is the convective source air perturbation (similarly for $q'$). In "ENT" experiments, deep convective entrainment is scaled based on cold pool area.



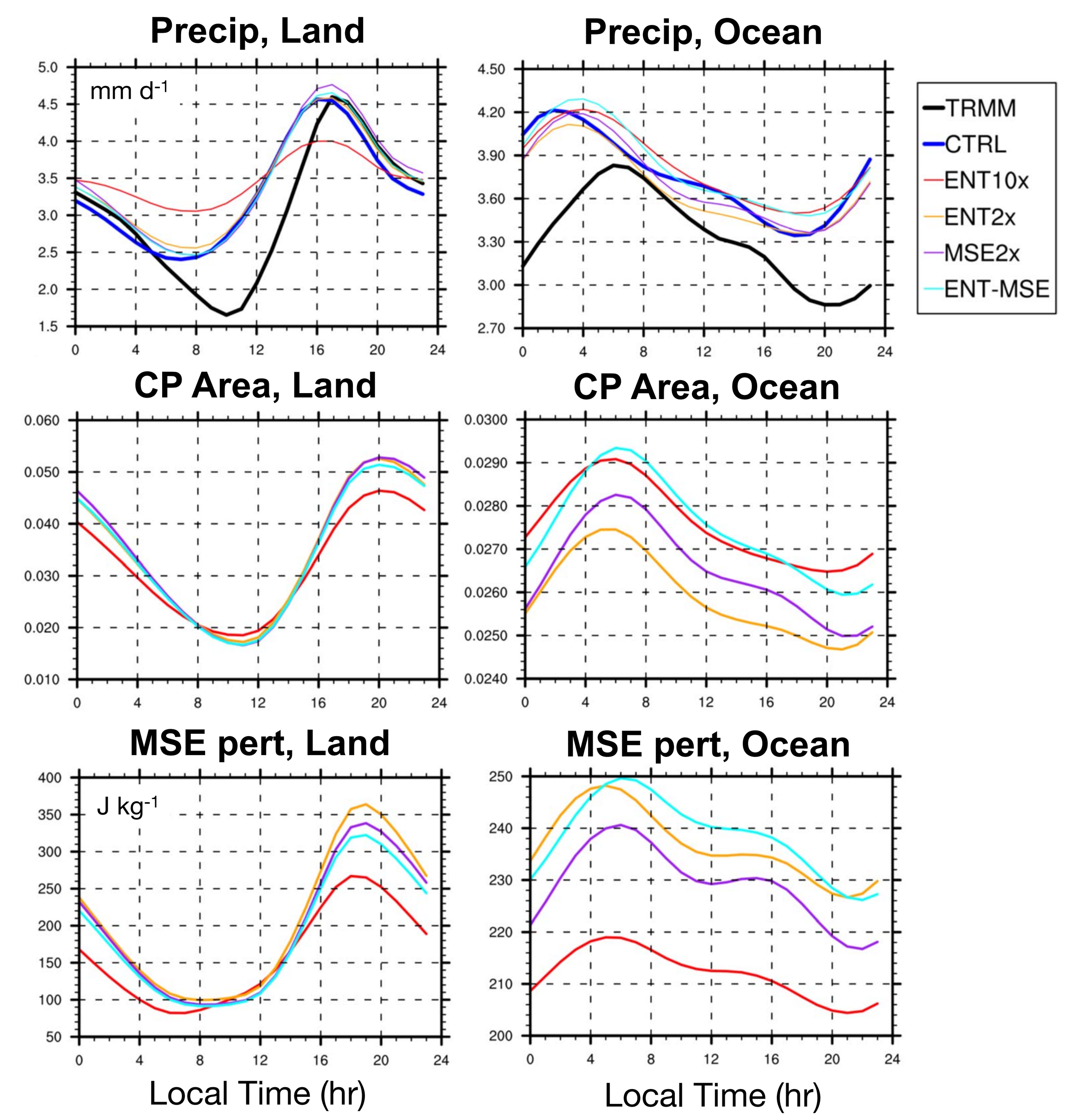

## Diurnal cycle

Diurnal cycle averaged 30S-30N over land and ocean.

A high entrainment factor reduces diurnal cycle magnitude.

Both approaches delay (~1 hour) the peak precipitation.

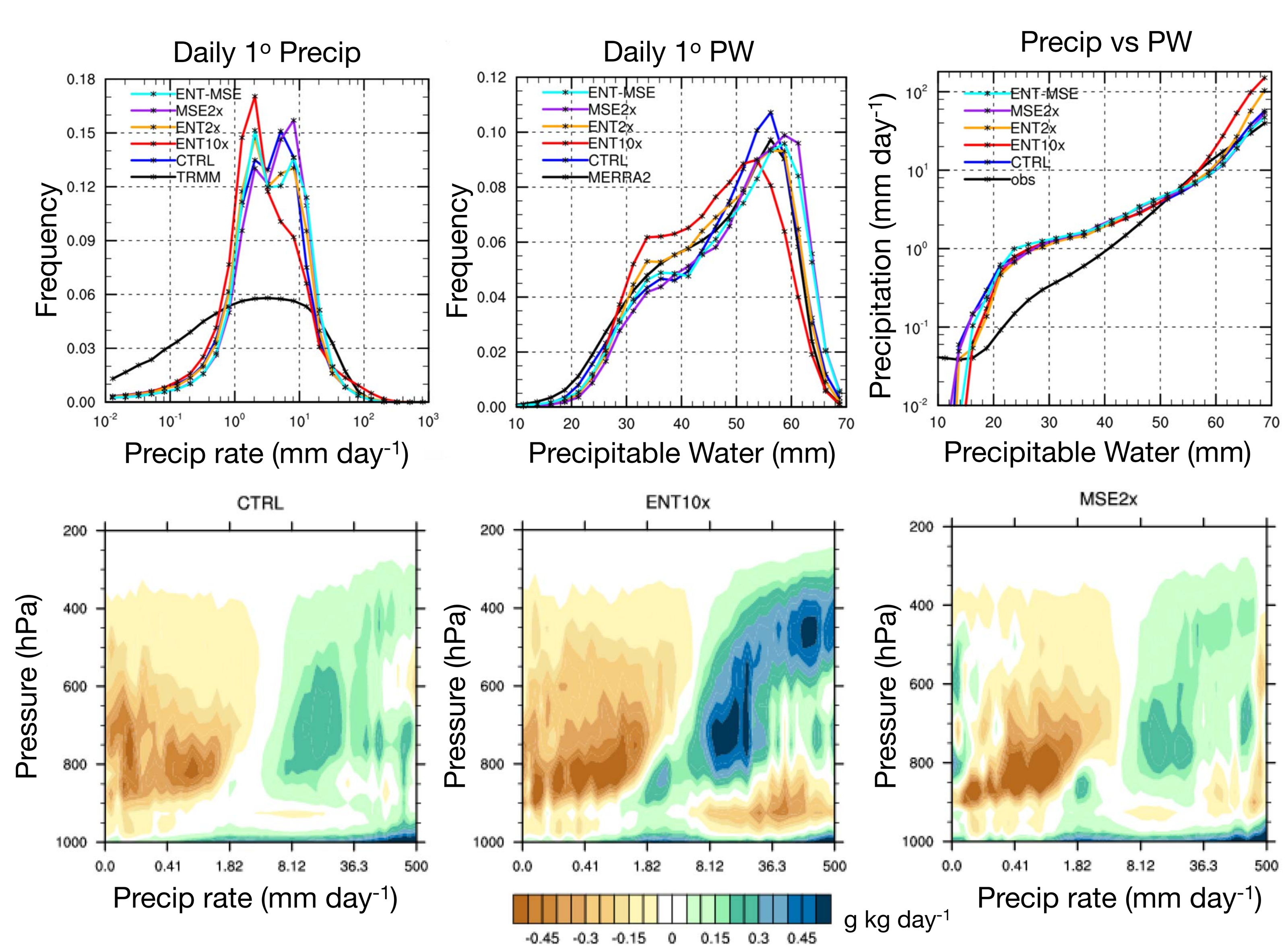
Cold pool area and source air MSE perturbation peak in early evening, following maximum precipitation.




| | |
|---|---|
| **CTRL** | GEOS AGCM with prescribed SST, no cold pools |
| **ENT10x** | Deep convection entrainment factor 10x, decreasing to 1x at CP area 0.15, no MSE perturbation |
| **ENT2x** | Convective entrainment factor 2x, decreasing to 0.2x at CP area 0.15, no MSE perturbation |
| **MSE2x** | Entrainment factor 1, with MSE perturbation doubled |
| **ENT-MSE** | Entrainment factor 2x decreasing to 0.2x at CP area 0.15, MSE perturbation 2x |

## Process metrics

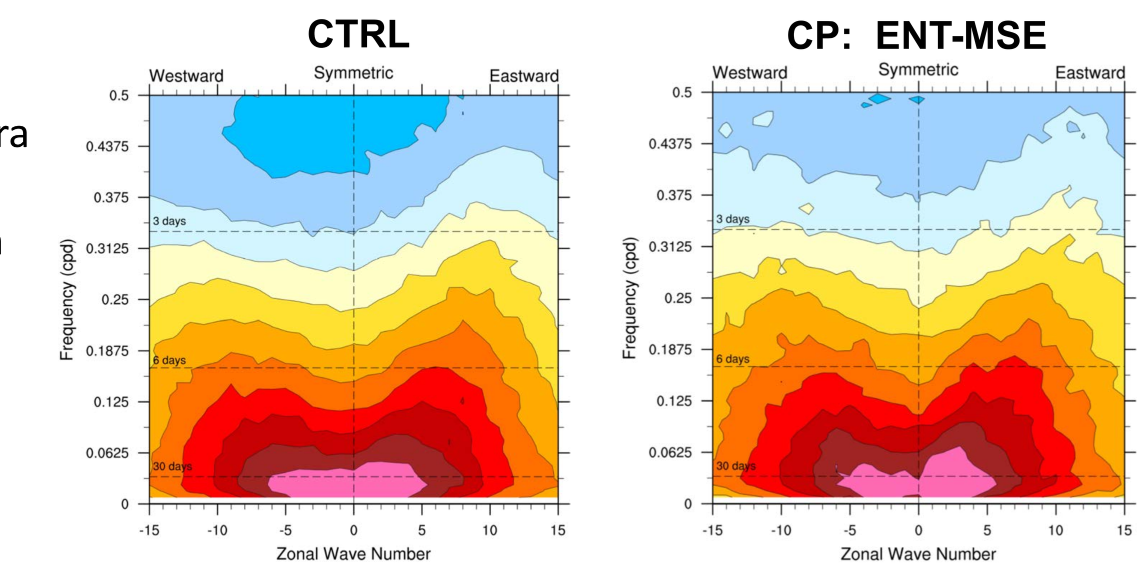
(top) PDFs of precip, precipitable water, and their relationship.
(bot) Profiles of humidity tendency binned by precip rate, for three cases.

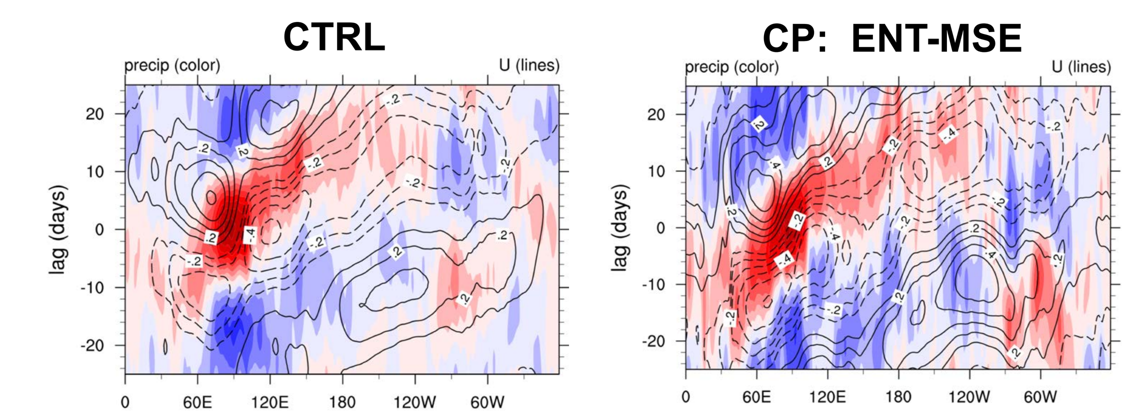


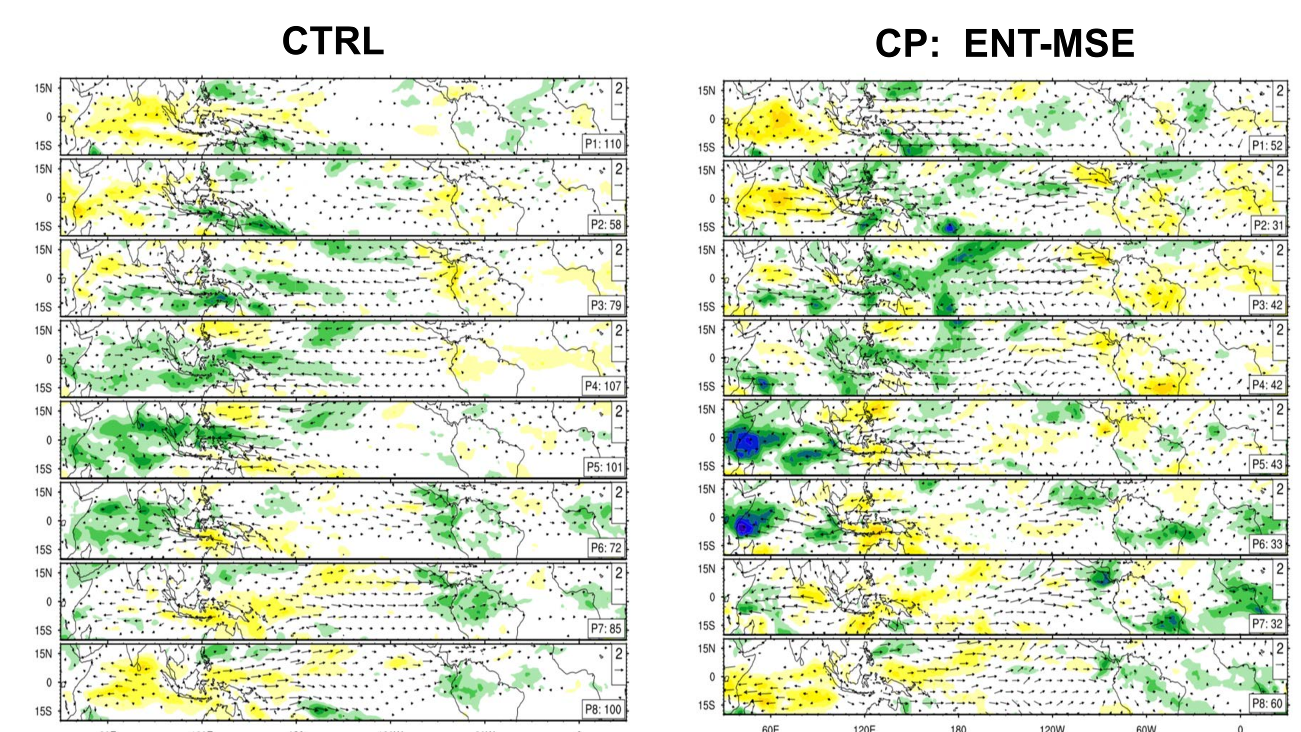

## Intraseasonal variability

Wavenumber-frequency spectra of OLR show a small increase in eastward variance.

Lag-correlation diagrams of precip (shading) and U850 (contours) show possible extension of eastward propagation.




## Summary

- Source parcel MSE perturbation and variable entrainment linked to cold pool area both produce a modest (~1 hr) delay in diurnal peak precipitation.
- Combined effects have a weak impact on MJO statistics.
- Variable entrainment shifts PW distribution to drier values, weaker precipitation, and strengthens relationship between precipitation rate and moisture tendency.
- MSE' shifts distributions to wetter PW, stronger precip.

### References


- Freitas, S. R., et al., 2018: Assessing the Grell-Freitas Convection Parameterization in the NASA GEOS Modeling System. *J. Adv. Model. Earth Syst.*, 10(6): 1266–1289.
- Mapes, B. and R. Neale, 2011: Parameterizing Convective Organization to Escape the Entrainment Dilemma, *J. Adv. Model. Earth Syst.*, 3.
- Del Genio, A., et al, 2015: Constraints on Cumulus Parameterization from Simulations of Observed MJO Events. *J. Climate*, 28, 6419-6442.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