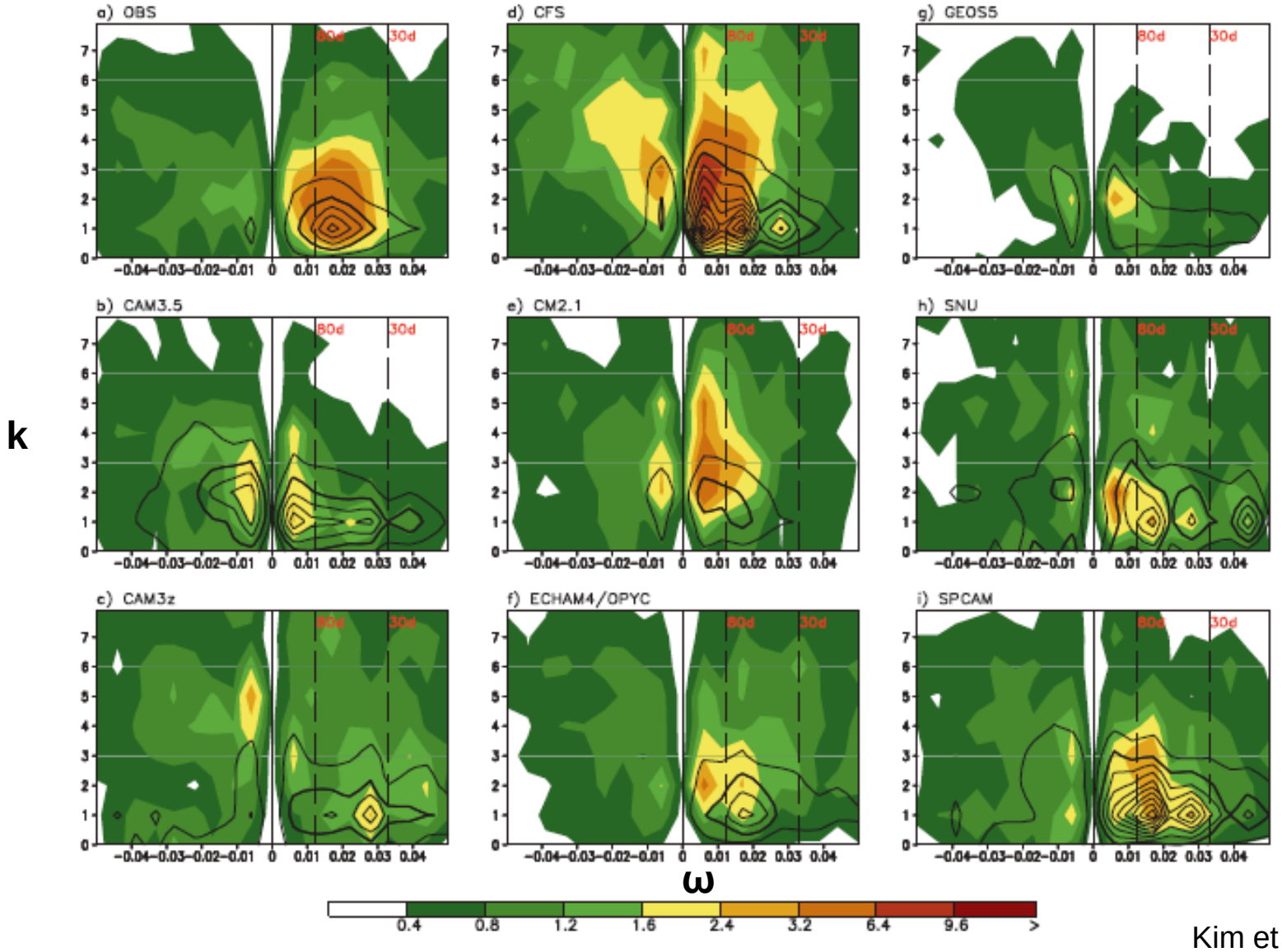
MJO REPRESENTATION IN MODELS: IMPROVEMENTS, ISSUES, AND USE OF OBSERVATIONS

Tony Del Genio

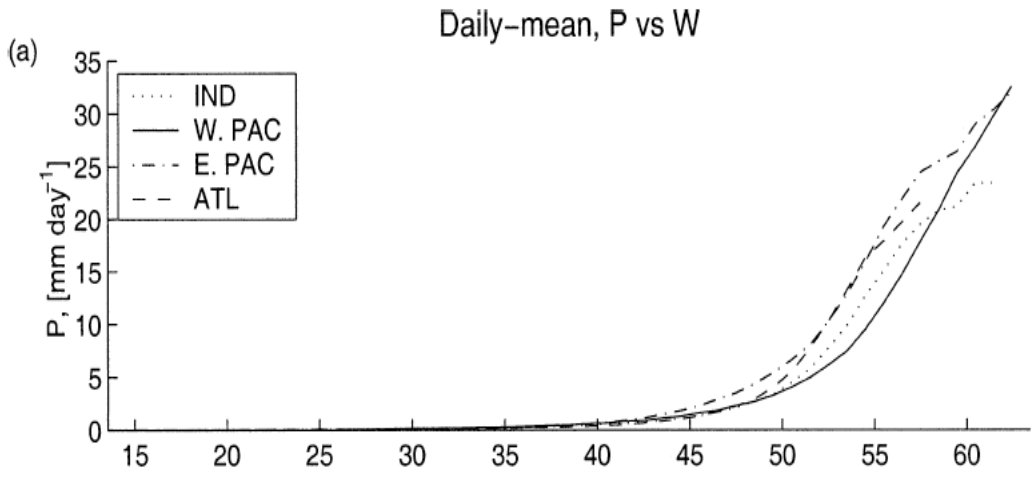
NASA/GISS

ASR, 3/30/11



Kim et al. (2009)

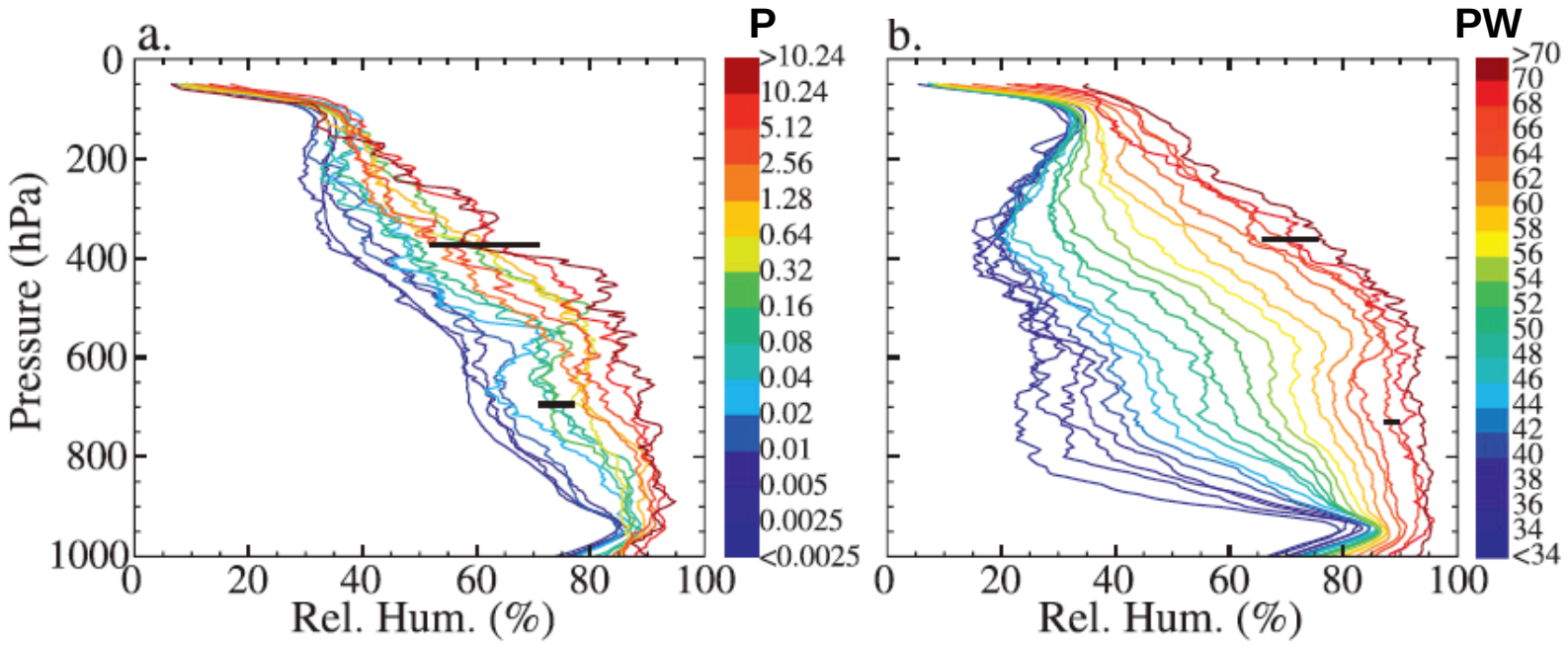
The good news: More models getting MJO-like variability now



Bretherton et al. (2004)

The key: Sensitivity of convection to free tropospheric humidity (triggers, entrainment)

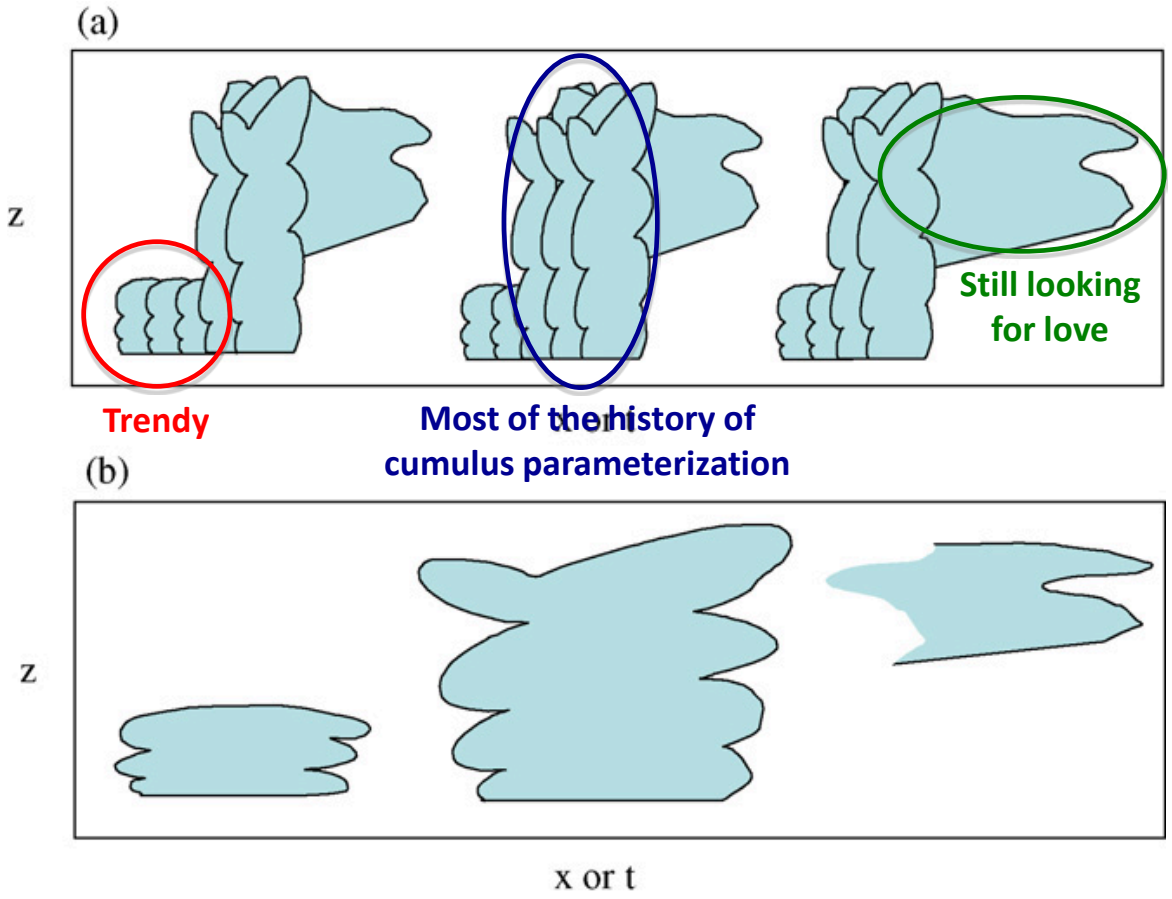
and vice-versa (rain evaporation)



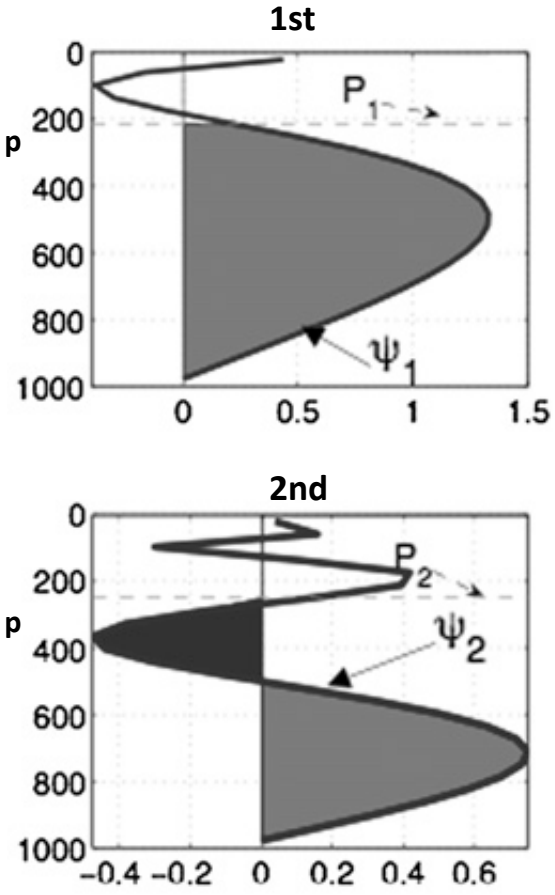
Holloway and Neelin (2009)

Convection on many scales: “Stretched building blocks”

MJO theories: Destabilization in shallow/congestus phase, or in deep/stratiform phase, and by what (clouds vs. surface)?

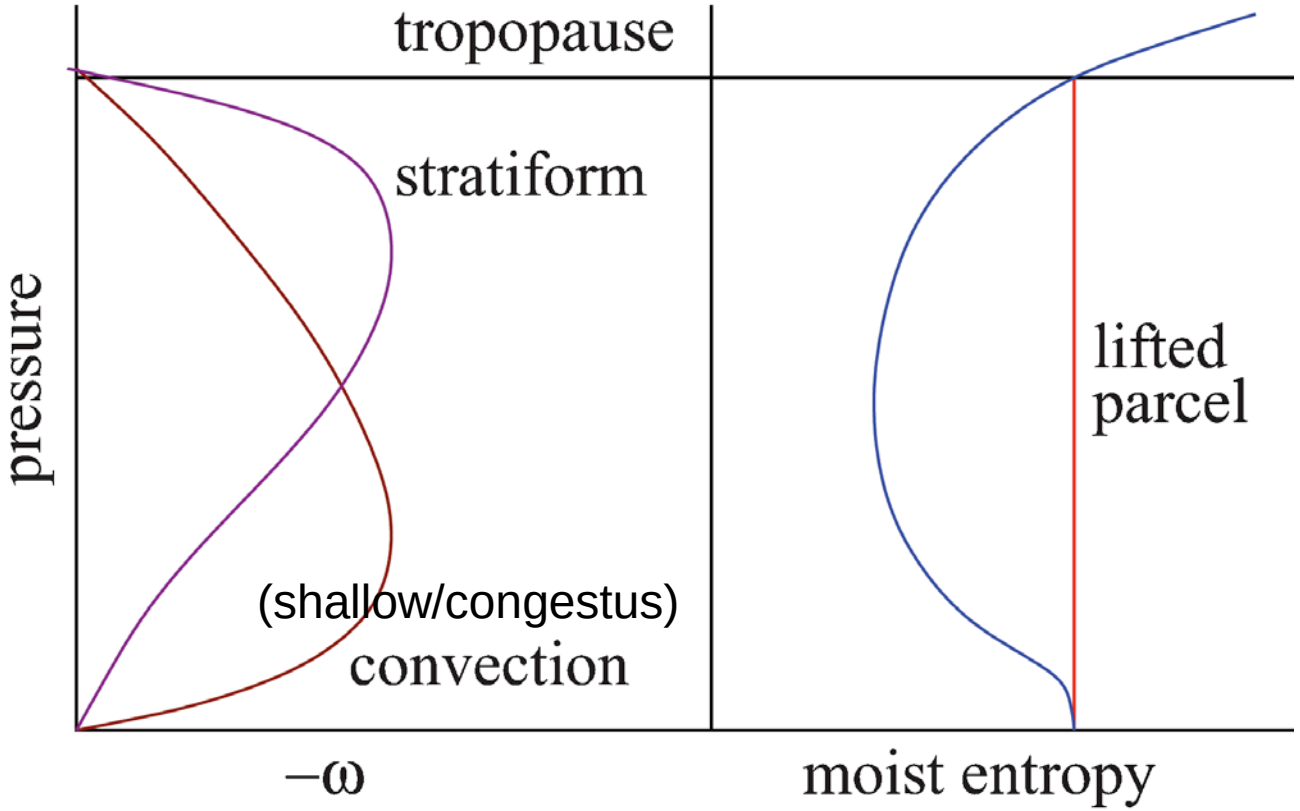


Mapes et al. (2006)



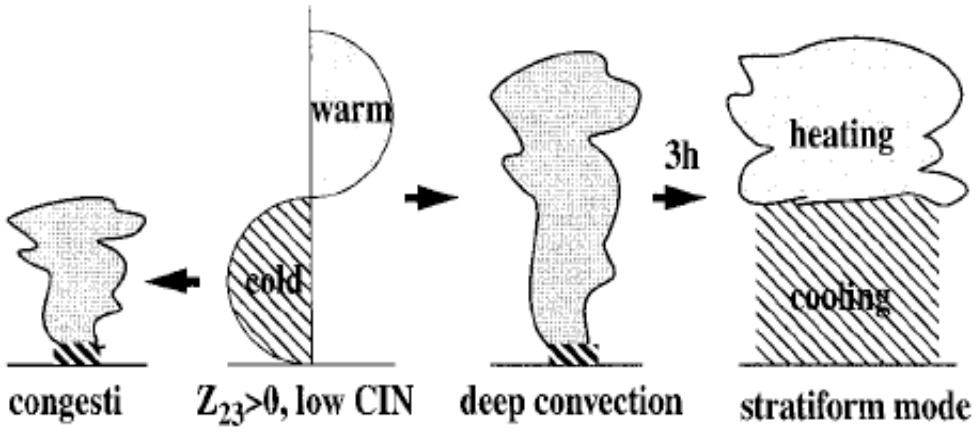
Khouider et al. (2011)

MJO due to negative (or at least small) gross moist stability?



Raymond et al. (2009)

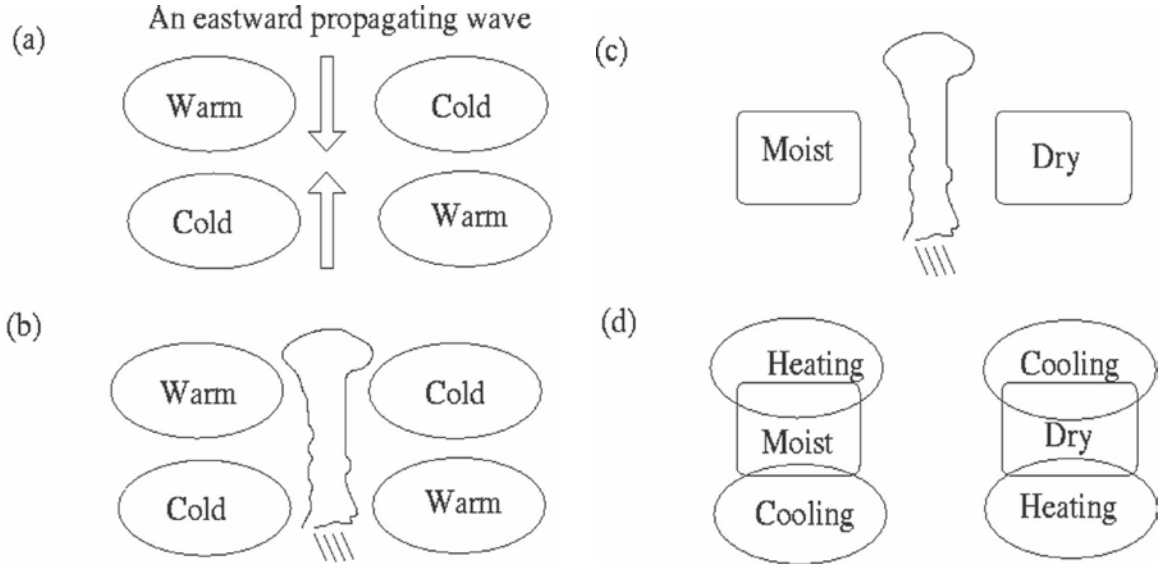
Two flavors of stratiform instability:



1. Mapes (2000):

Q ~ exp (-CIN/K)

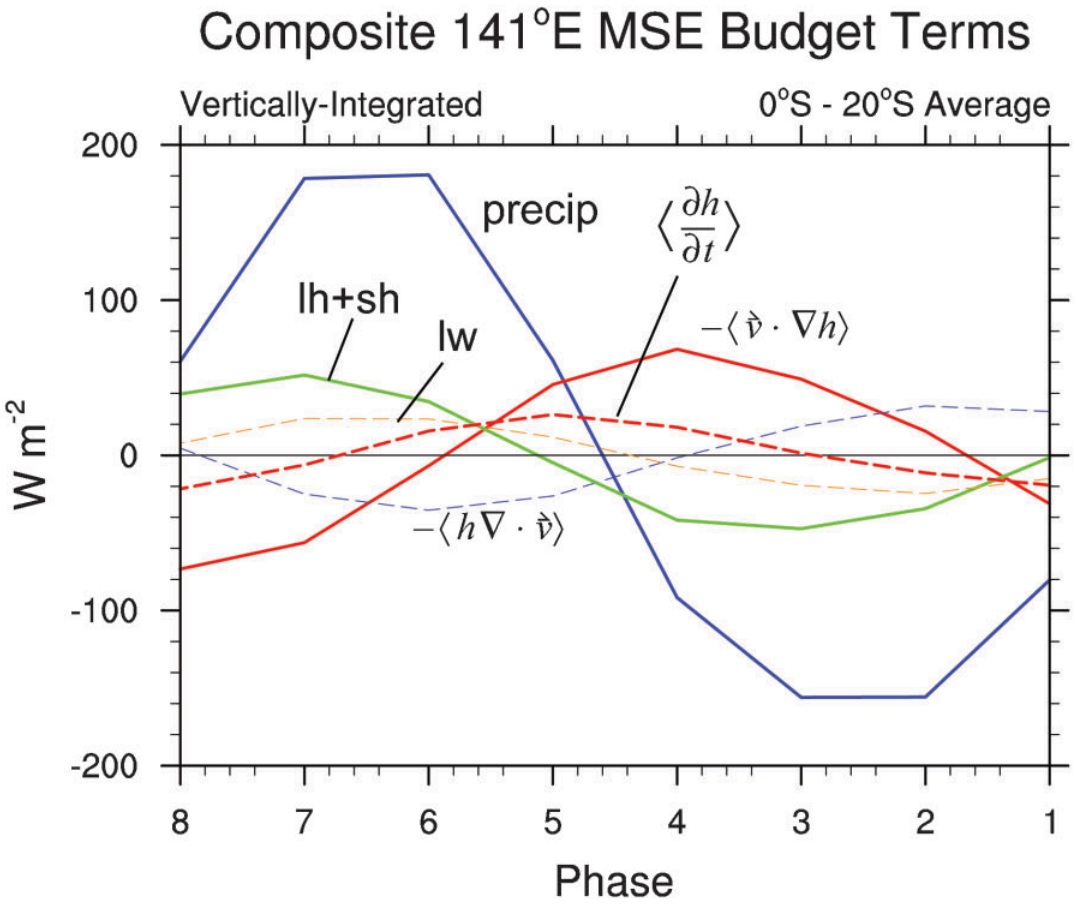
Warm/cold upper/lower troposphere reinforced by heating via reduced CIN, Increased K (downdrafts, rain evaporation)



2. Khouider and Majda (2006), Kuang (2008):

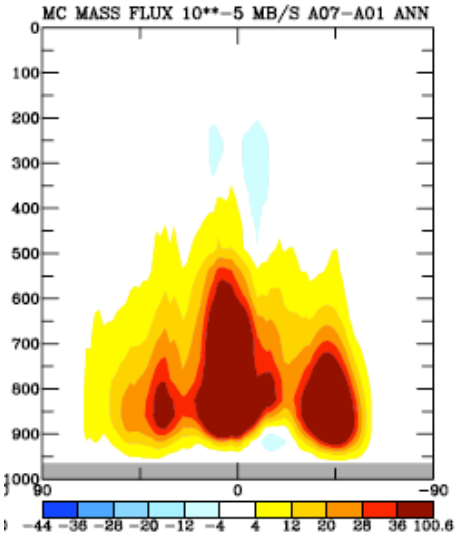
Warm/cold upper/lower troposphere reinforced by heating via congestus moistening of mid-levels which promotes deep convection

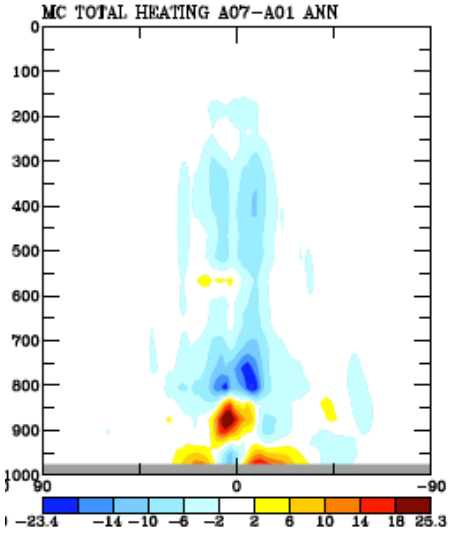
$$\left\langle \frac{\partial h}{\partial t} \right\rangle = -\langle h \nabla \cdot \vec{v} \rangle - \langle \vec{v} \cdot \nabla h \rangle + LH + SH$$
$$+ \langle LW \rangle + \langle SW \rangle,$$

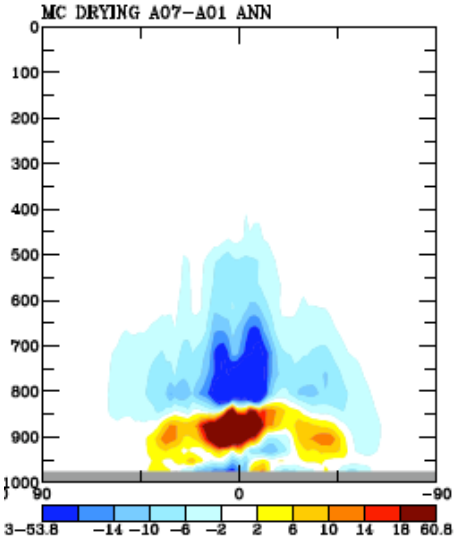


Maloney et al. (2010):

MJO in GCM with positive gross moist stability but destabilized by wind-induced surface heat exchange (WISHE)

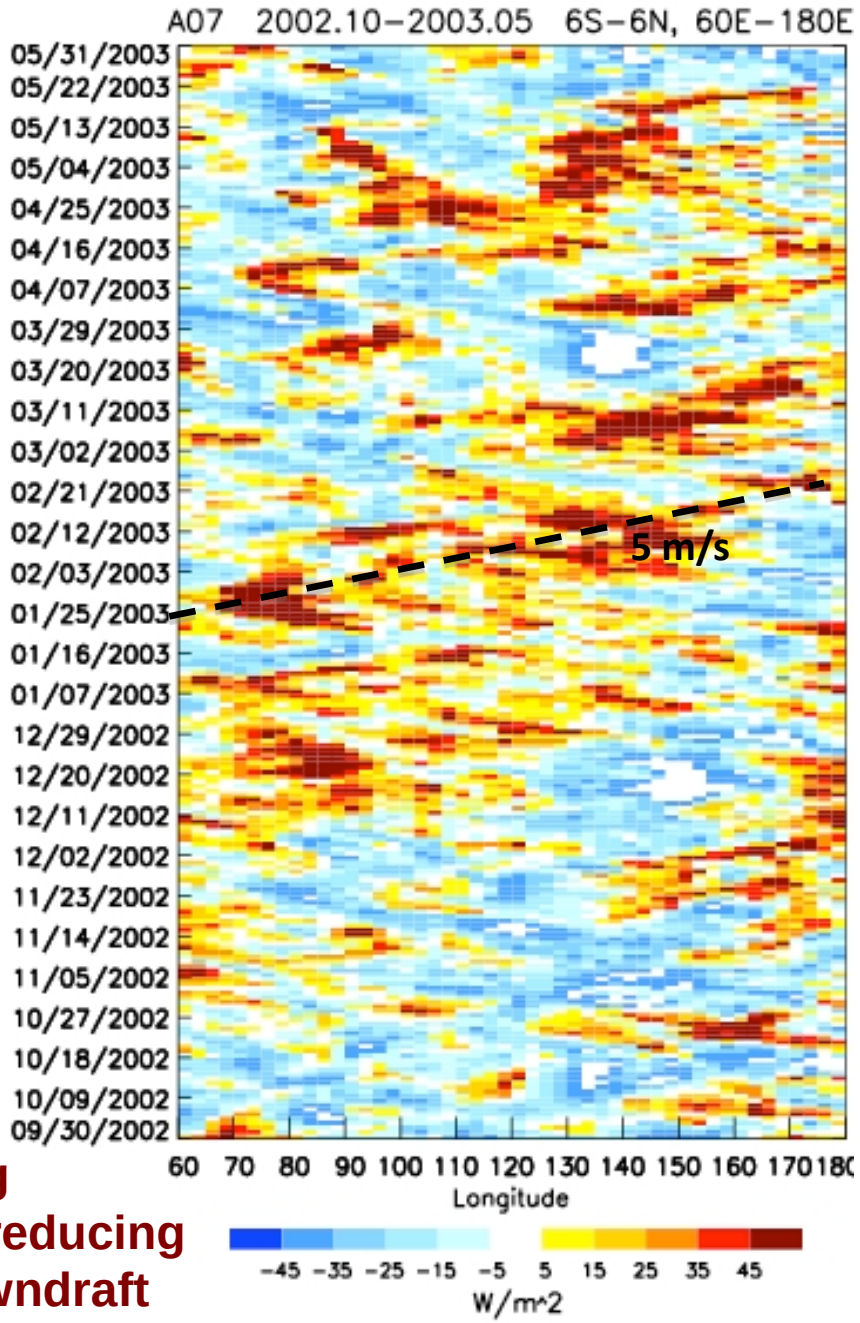




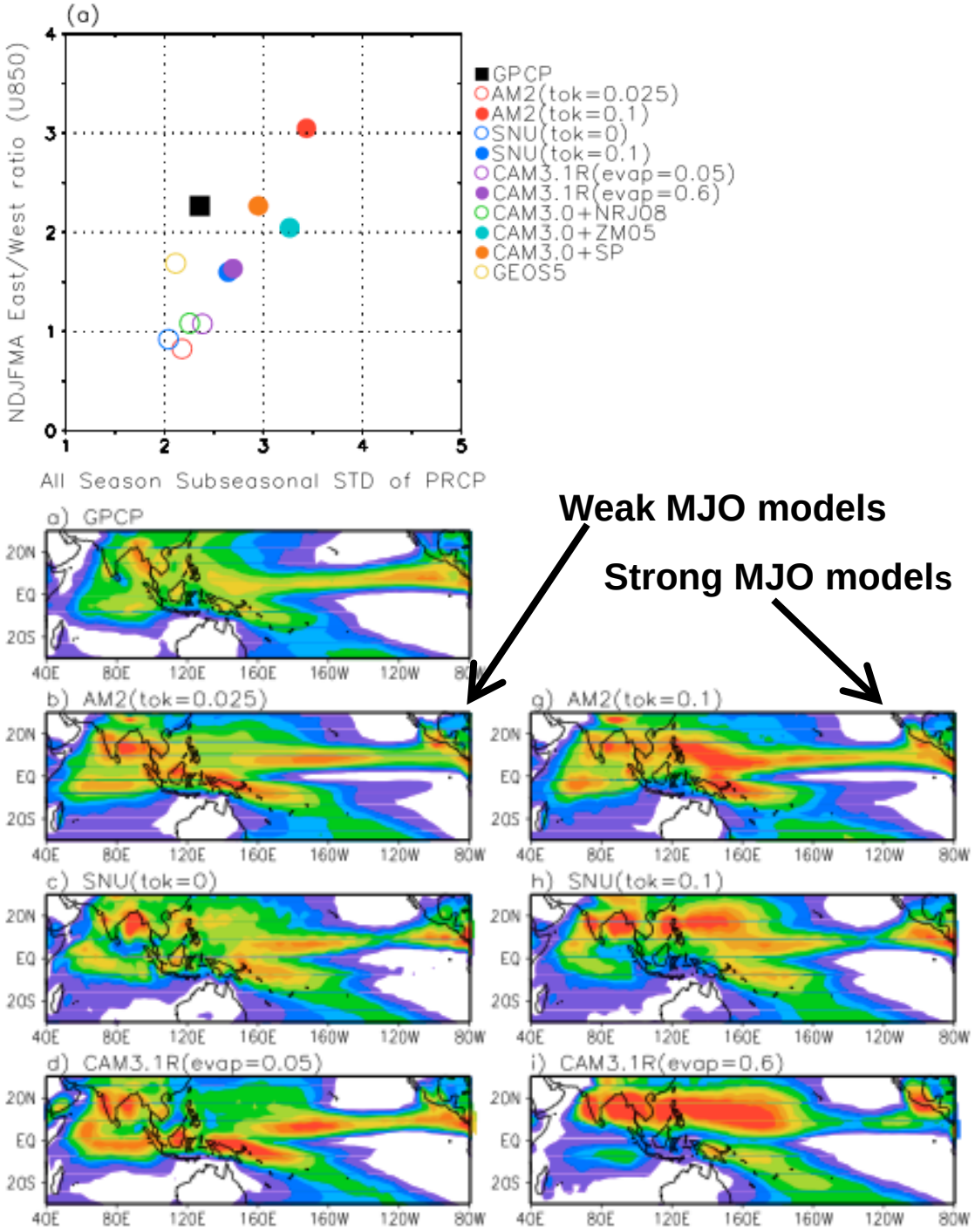


GISS GCM: MJO getting there, and with mean climate mostly OK* - stronger entrainment and rain evap + stronger downdraft to compensate

GISS GCM



***except for too strong Hadley cell, fixed by reducing entrainment after downdraft**



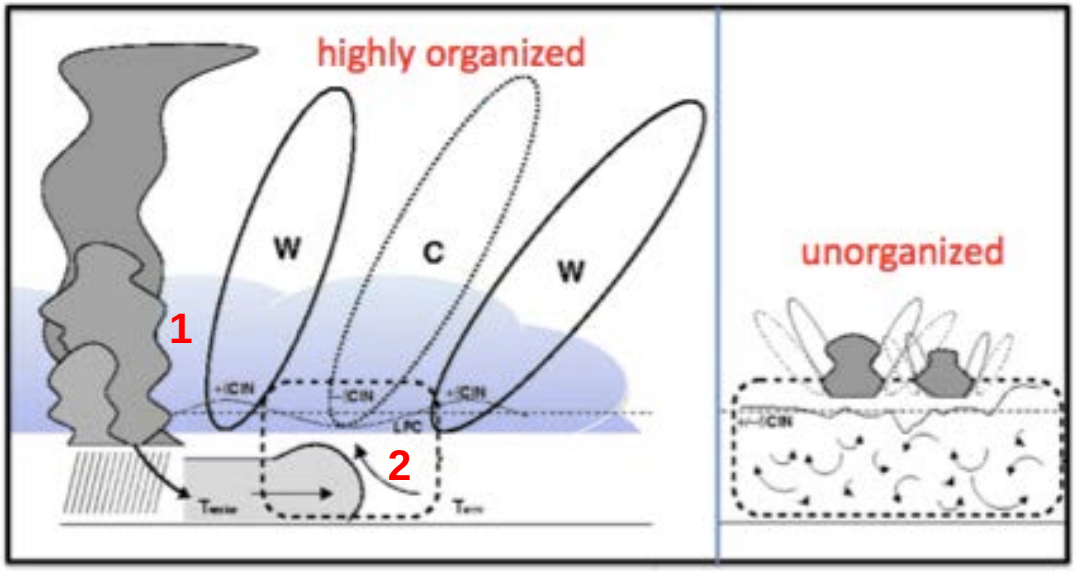
But in many models, the price of a good MJO is a degraded mean climate as well

…which may be why most *operational* GCMs have a poor MJO

What is still missing?

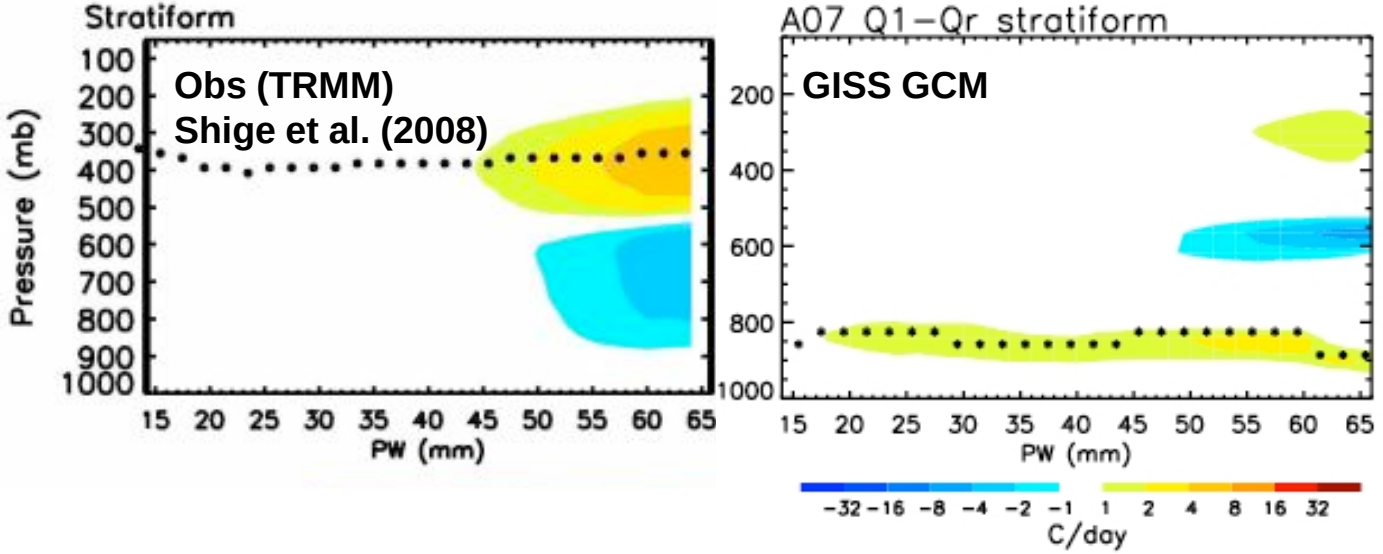
(Kim et al., 2011)

Accounting for convective organization in cumulus parameterization?



Lower troposphere issues: Entrained air more humid than mean, downdraft gust front destabilization, etc.

(Mapes and Neale, 2011)



Upper troposphere issues: Mesoscale updrafts and downdrafts, rain evaporation, 2nd baroclinic mode

What we need from AMIE

1. Documentation of cloud population, especially distribution of depths from 3-D scanning instruments, as f(time)

1. Moisture (RH) profiles from soundings

2. $Q_1 - Q_R$ and Q_2 profiles as f(time) from sounding array

3. Horizontal and vertical transport of h from sounding array

1. Surface LH and SH fluxes and atmospheric net radiative heating

1. Gan-Manus comparison: What's different that suppresses MJO over maritime continent? (e.g., more deep convection in suppressed phase, less surface LH flux)

"This is what $60M bought us?"