

What the Heck Is an MJO?

And Why Should You Care?

Jim Benedict
Kate Thayer-Calder



CMMAP SEMIANNUAL MEETING, FORT COLLINS, AUG 2007

Colorado
State
University

THE MJO IN THE POPULAR MEDIA

“Back in 1971, two scientists named Roland Madden and Paul Julian analyzed a decade's worth of readings from the tropical Pacific and discovered that the atmosphere down there periodically coughs up a massive bubble of acute meteorological disturbance.”

“A quick peek at forecasts of the Madden-Julian Oscillation (MJO) suggests that the atmosphere over the tropical western North Pacific Ocean is becoming favorable for tropical storms and typhoons. Anyone wishing to explore the MJO may wish to click [\[here\]](#). Unfortunately, I know next to nothing about the MJO...”



OUTLINE

1. Overview and definitions
2. MJO in observations
3. Theory
4. MJO: SP-CAM vs. observations
5. MJO: SP-CAM vs. CAM



BASICS: TWO STAGES OF THE MJO

WET



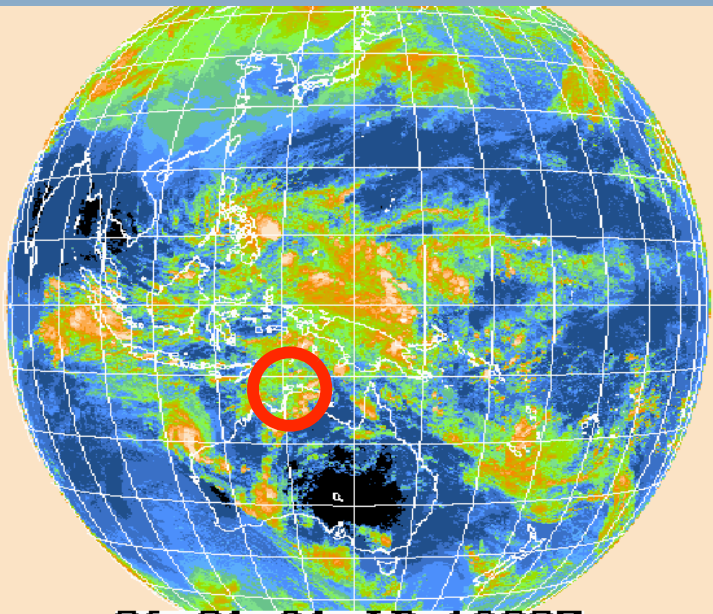
DRY



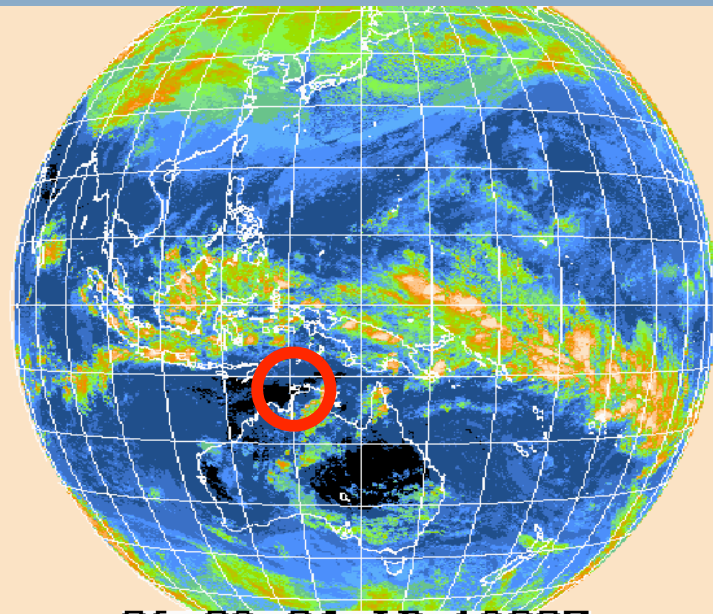
WET



DRY



06 01 21 IR 1200Z



06 02 04 IR 1200Z



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THE MJO RAINY PHASE



Another day at the TWPICE marine office



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WHAT THE HECK IS AN MJO?

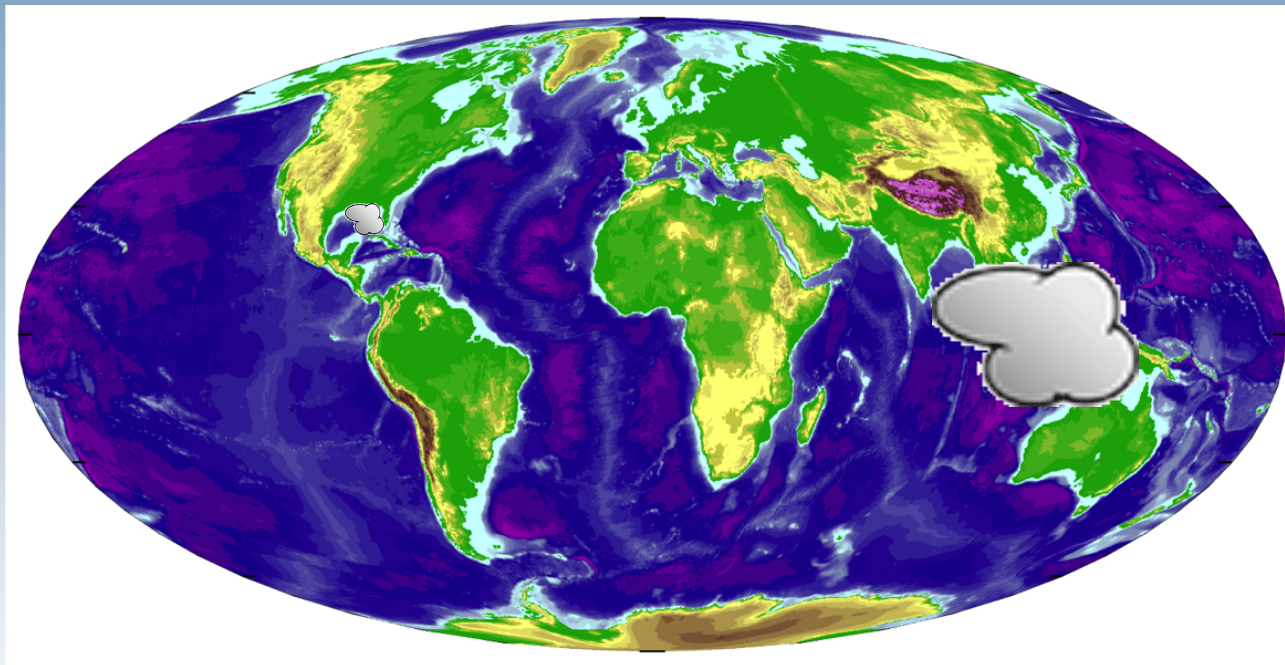
- Planetary scale disturbance (zonal wave numbers 1-4)
- Generally equatorially trapped, but can move northward or southward in certain cases
 - Covers 10° - 20° of latitude (N-S)
 - Spans 50° - 100° degrees of longitude (W-E)
- Very low frequency, disturbance moves at around 4-6 m/s
 - Disturbance can speed up over Pacific Ocean or spawn Kelvin waves which propagate eastward



WHAT THE HECK DOES THAT MEAN?

- *Planetary scale disturbance*
(zonal wave numbers 1-4)

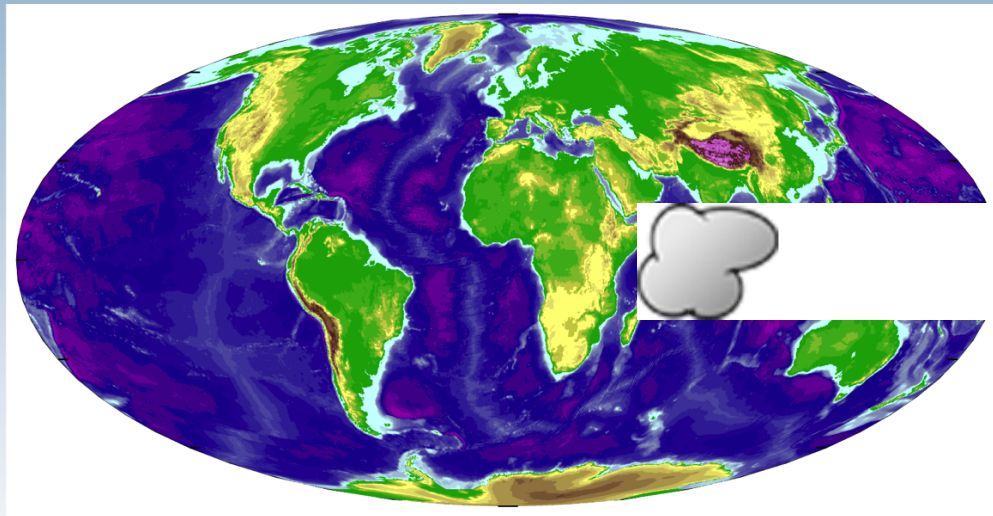
Translation: It's a really huge (GINORMOUS) area of convection (clump of storms).



WHAT THE HECK DOES THAT MEAN?

- *Generally equatorially trapped, but can move northward or southward in certain cases*

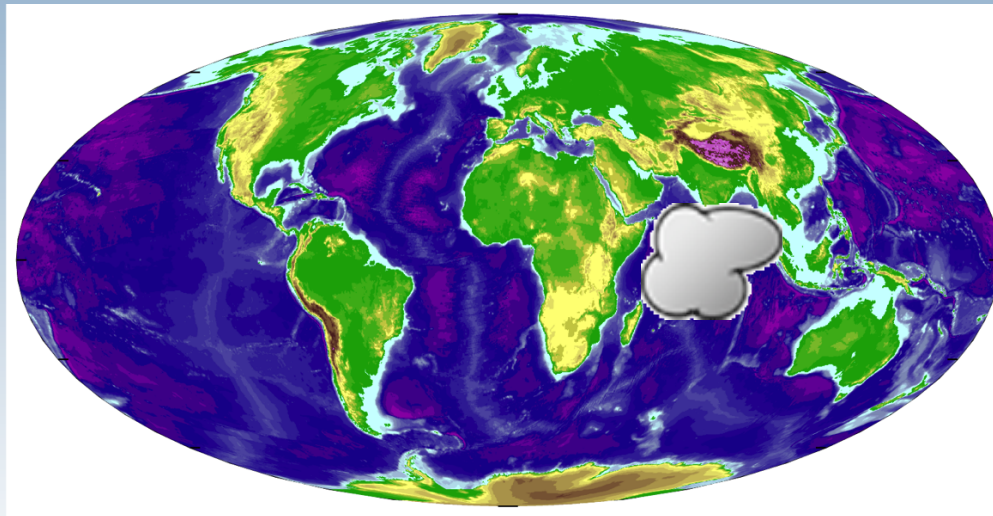
Translation: It travels to the east along the equator. Some people have published papers showing it heading north or south occasionally.



WHAT THE HECK DOES THAT MEAN?

- *Very low frequency, disturbance moves at around 4-6 m/s*
 - *Disturbance can speed up over Pacific Ocean or spawn Kelvin waves which propagate eastward*

Translation: It's sloooooow, but it can weaken and morph into a smaller, faster type of storm and continue eastward across the Pacific.



A dramatic seascape with a dark, cloudy sky and a turbulent sea. The sky is filled with heavy, grey clouds, with a bright patch of light breaking through near the horizon. The sea is dark and choppy, with white foam from the waves visible in the foreground. The overall mood is somber and intense.

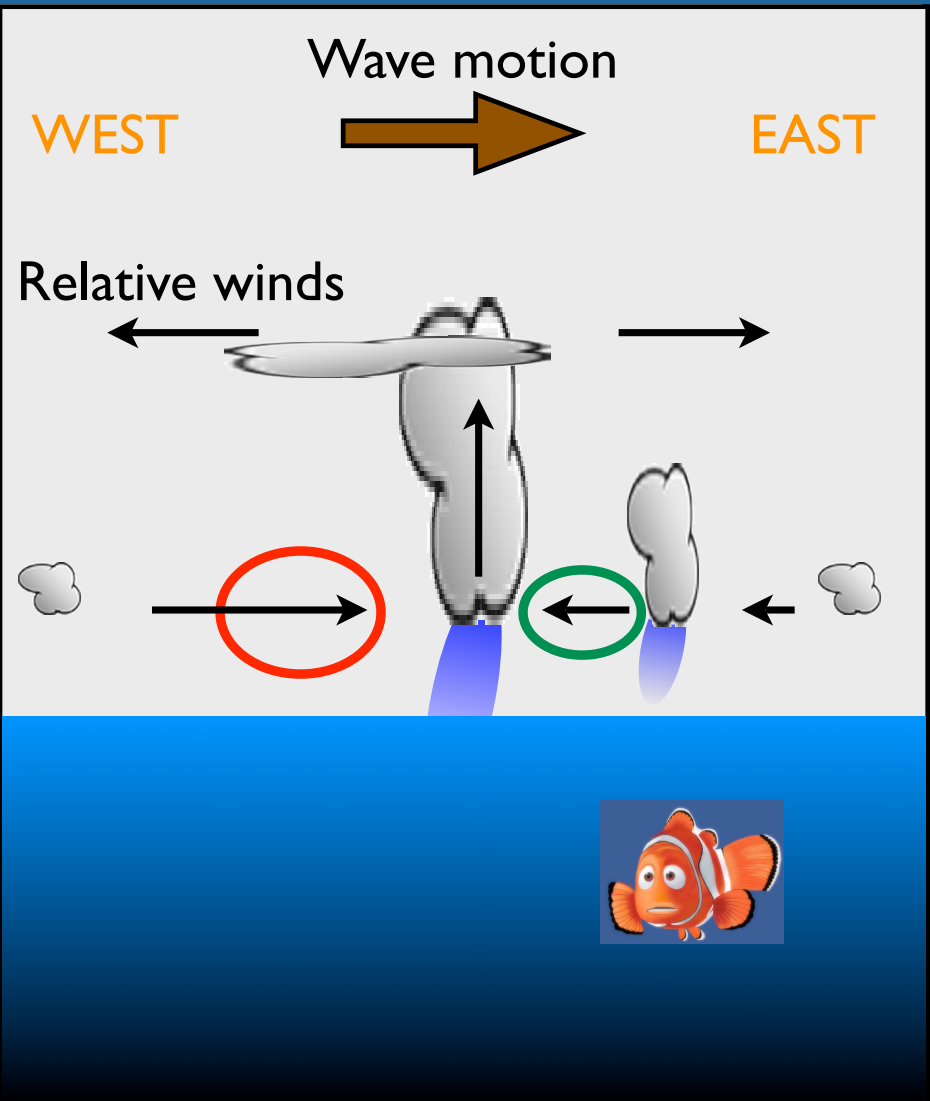
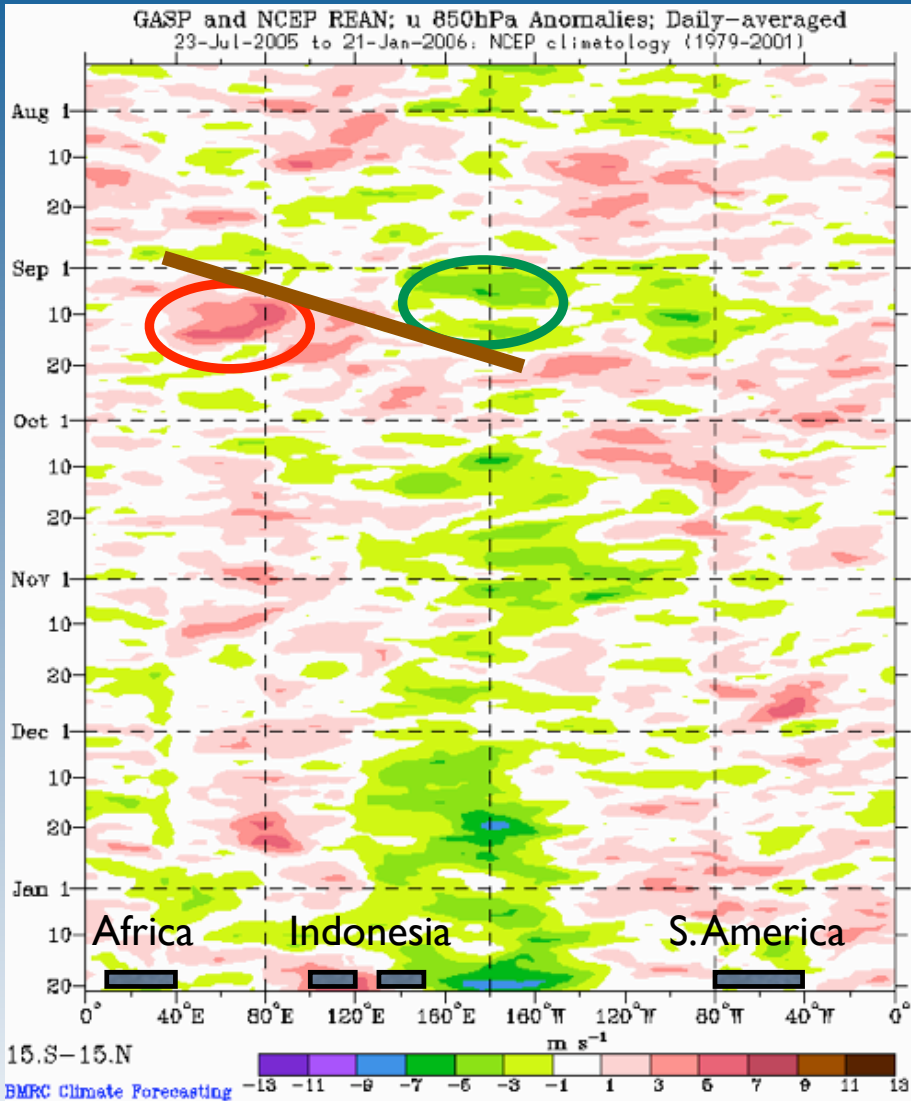
THE MJO PLAYERS!

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FINDING MJO



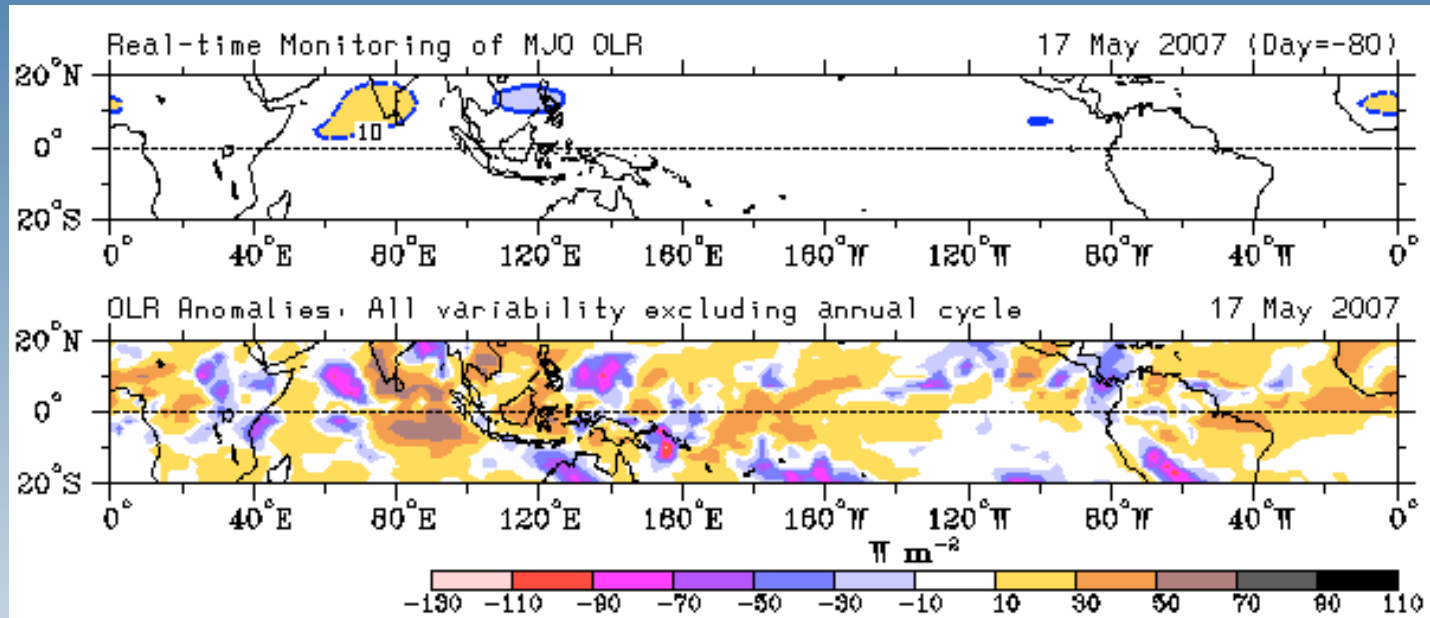
Plots courtesy of M.Wheeler



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FINDING MJO



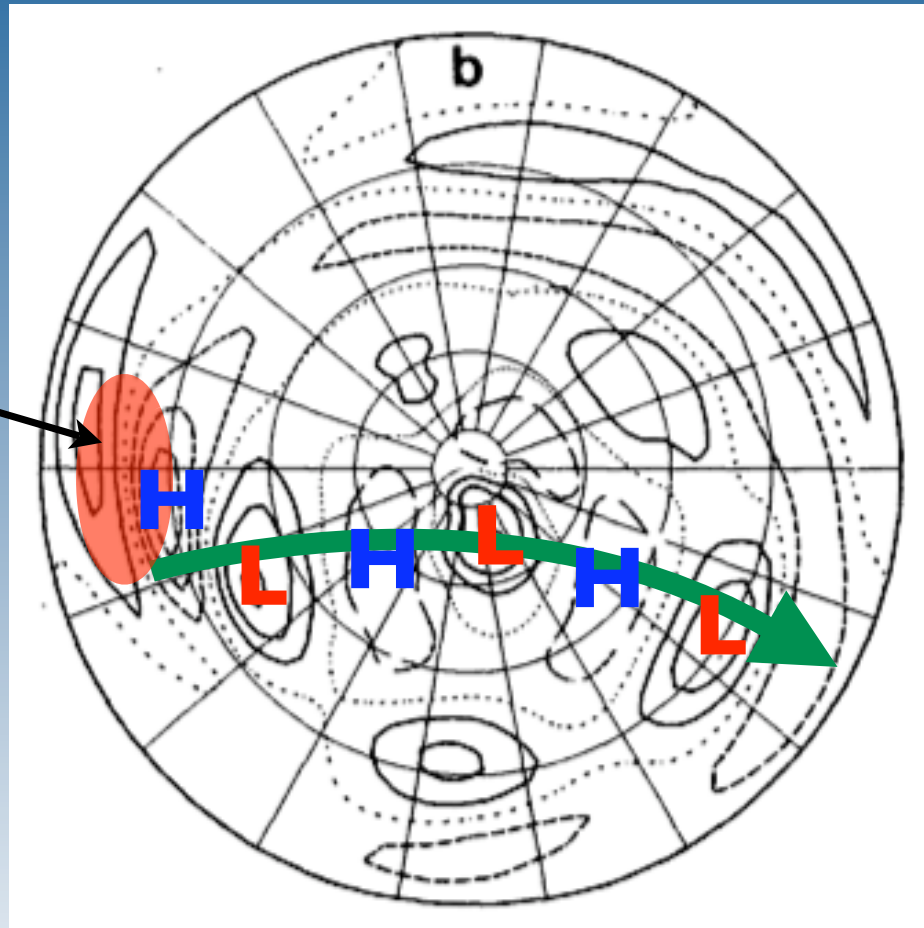
Plot courtesy of M.Wheeler



FAR-REACHING EFFECTS OF THE MJO

Viewpoint:
(We're looking
down onto the
North Pole)

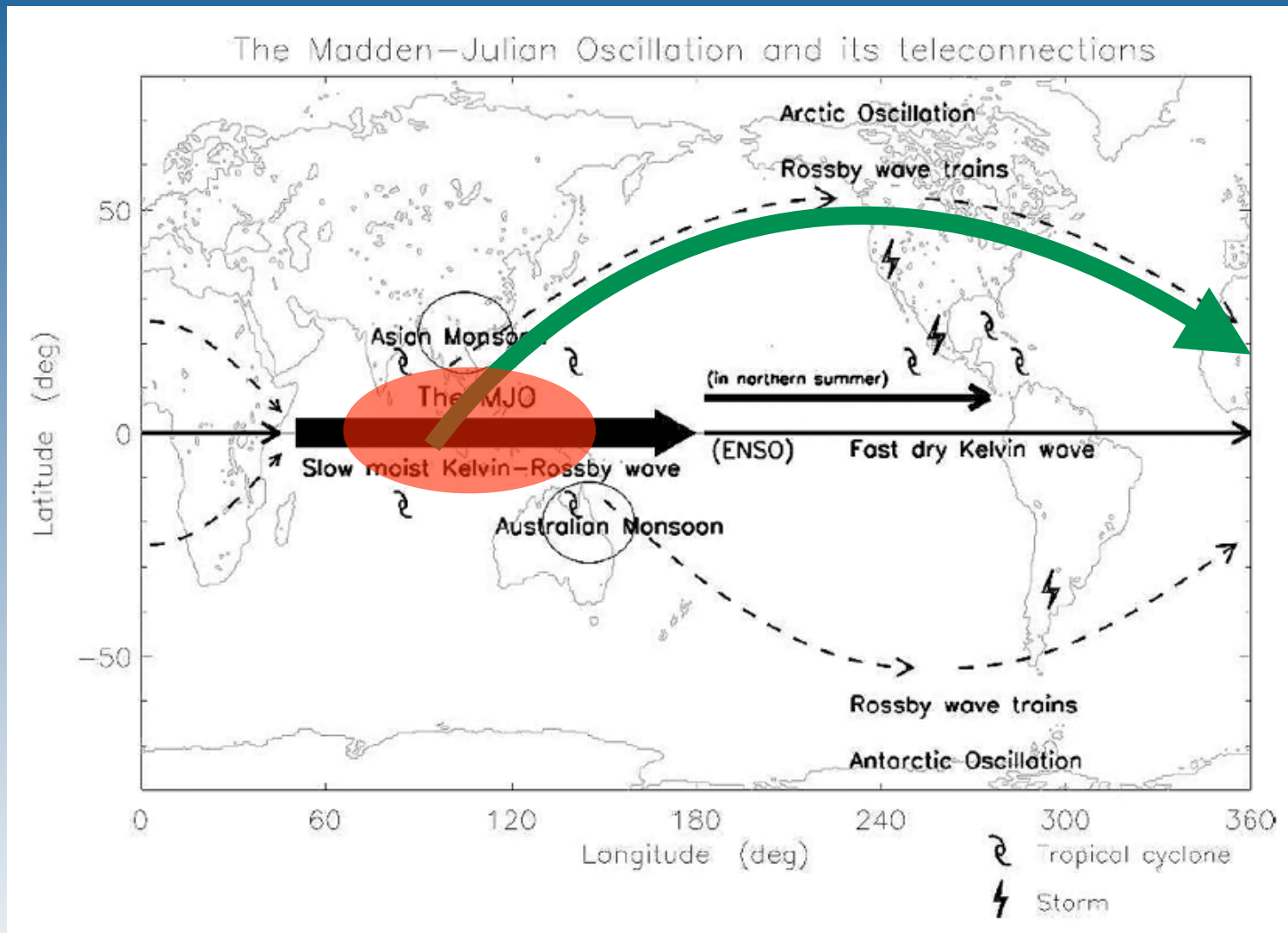
Example: Heating
(storminess) here



Hoskins and Karoly 1981



FAR-REACHING EFFECTS OF THE MJO



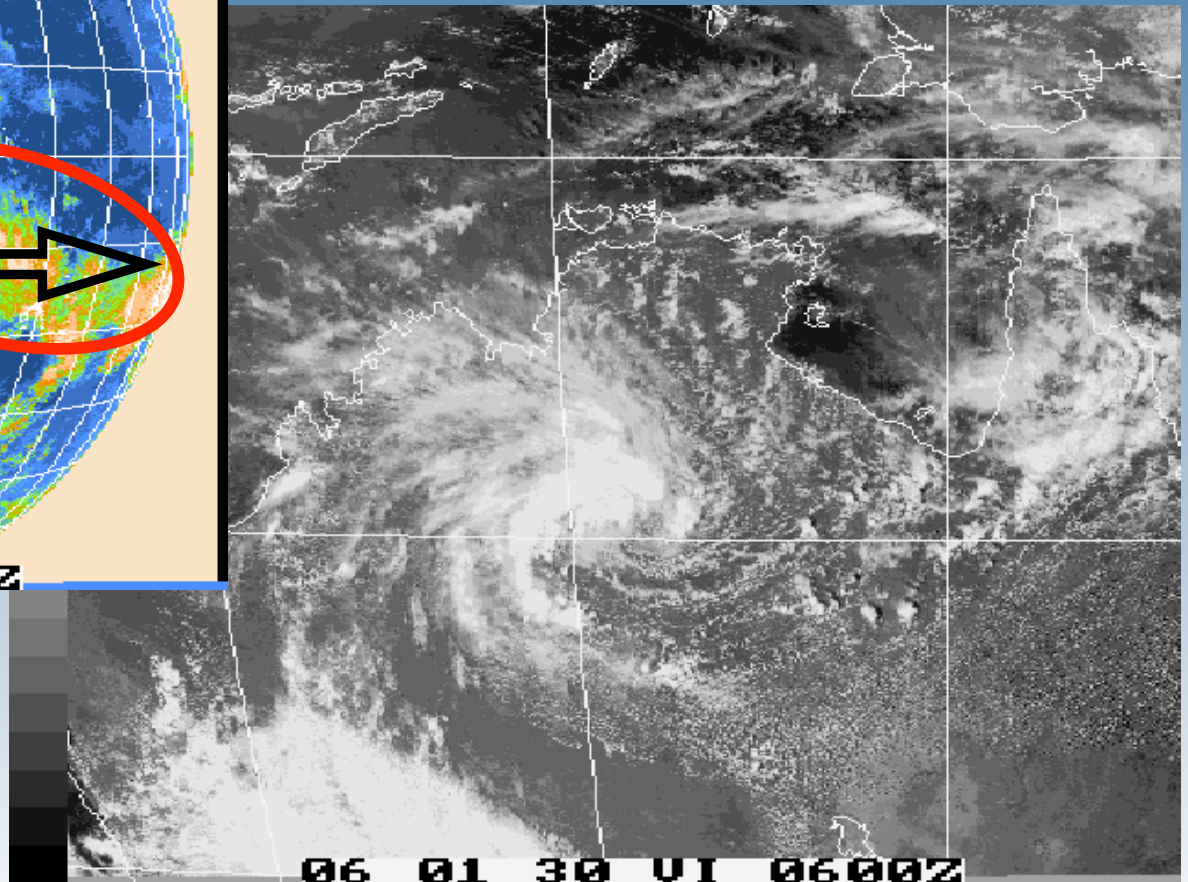
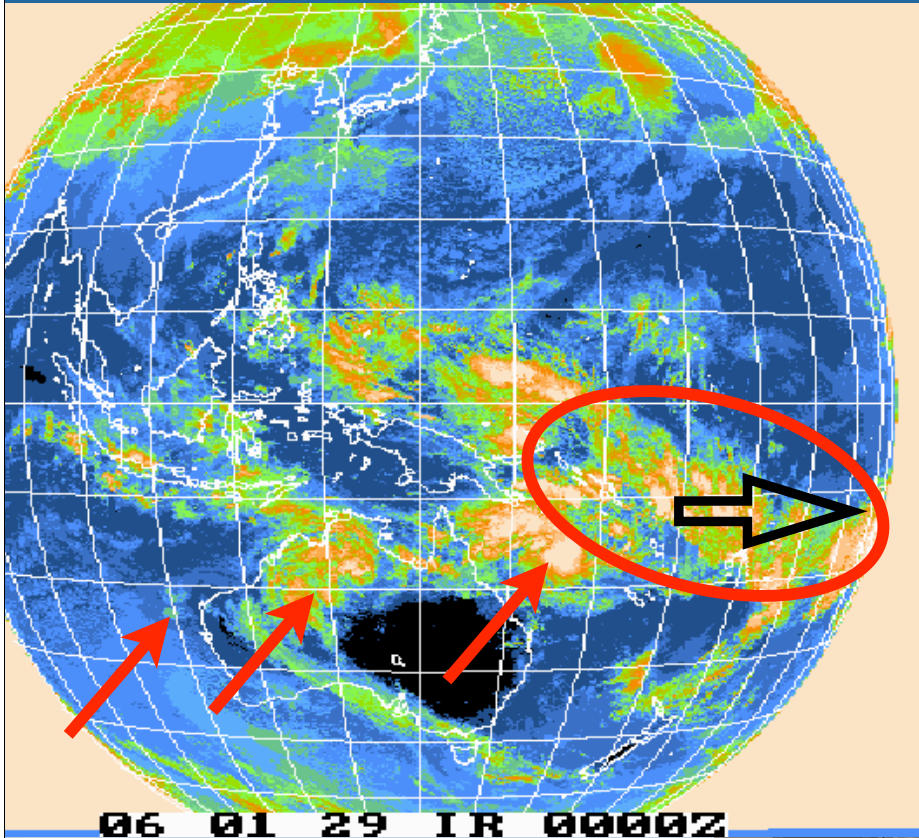
Lin et al. 2006



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TROPICAL CYCLONE FORMATION



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WHY DOES IT HAPPEN?

- Many theories describing the existence, scale and speed of the MJO have been proposed, but many are incomplete or lack support in modeling or observational studies.

Translation: Nobody is really sure.

- Many climate models have trouble reproducing the strength or speed of the wave, and forecasts often have trouble predicting its onset.

Translation: That's a problem.

- The following slides give a quick overview of some popular theories on the mechanisms of the MJO

Translation: Check these out...



Discharge-Recharge

- Large scale destabilization (charging) over time in the tropics. A trigger sets off convection (discharge) which travels eastward and stabilizes the atmosphere behind it.
- Photo Flash

Stratiform Instability

- Towering clouds evolve into flat clouds, rain from flat clouds cools air above warmer surface causing unstable situation.
- Echo Effect

Wave-CISK

- Convection is triggered and its associated latent heat release helps drive a secondary circulation, causing additional large-scale convergence.
- Domino Effect

Frictional Convergence

- Low level easterlies pile up moisture ahead of the wave, spawning intense convection which then propagates eastward towards further convergence.
- Bad Traffic



OUTLINE

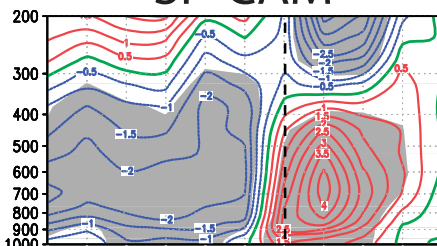
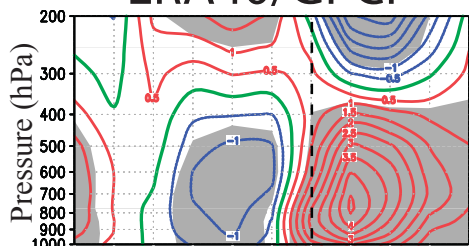
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ERA40/GPCP

SP-CAM

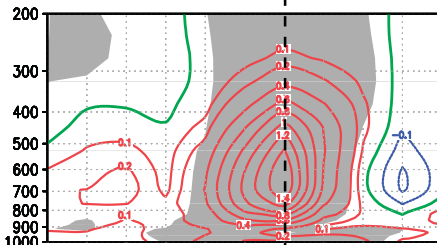
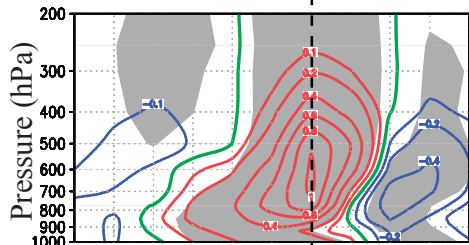
u'
(m/s)



15 km ↑
Height
0 km ↓

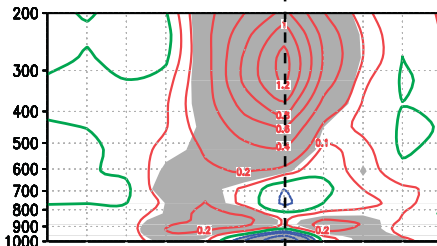
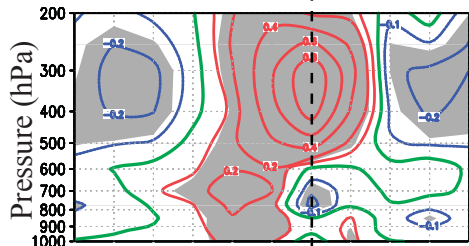
West-east
winds

q'
(g/kg)



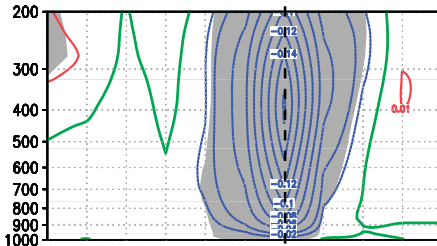
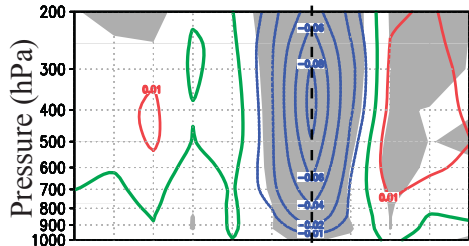
Moisture

T'
(K)



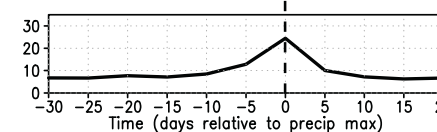
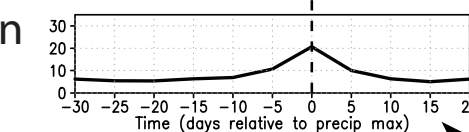
Temperature

ω'
(Pa/s)



Vertical air
motion

Total rain
(mm)



4 weeks before Time 3 weeks after

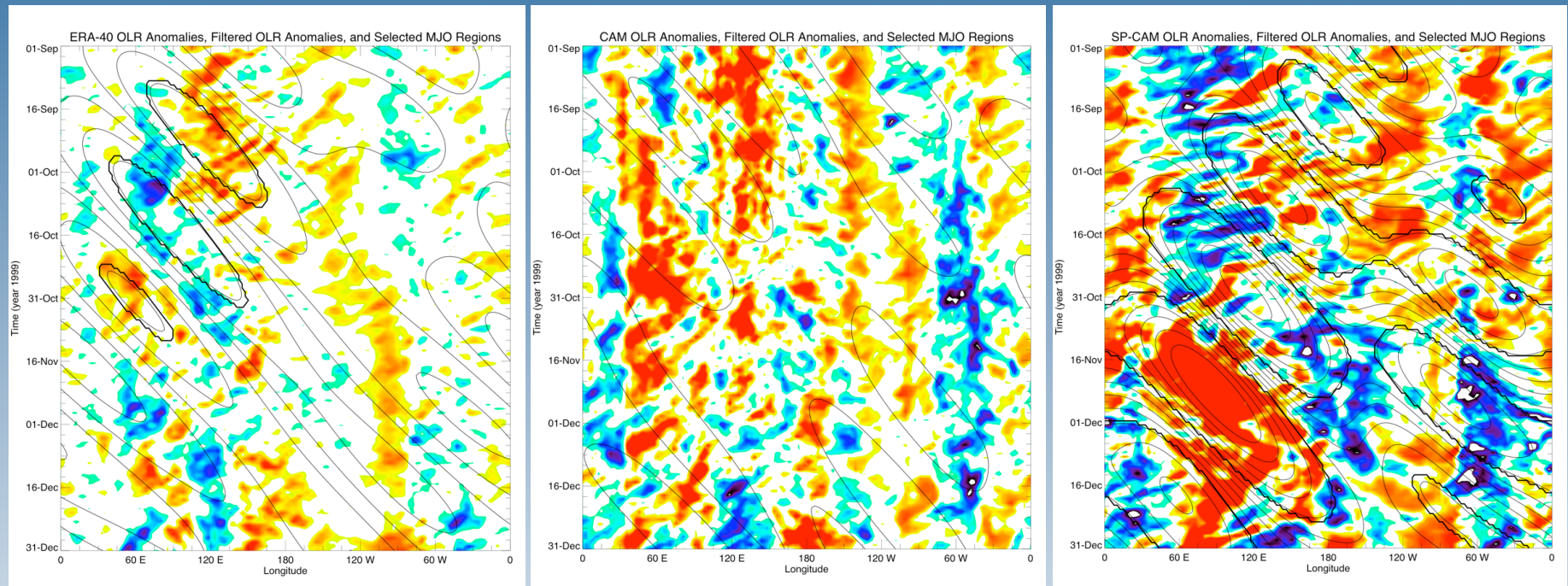


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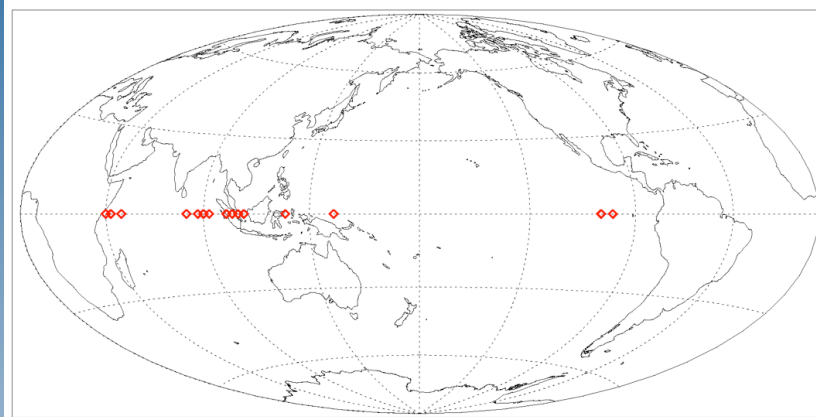
What does it look like in models?



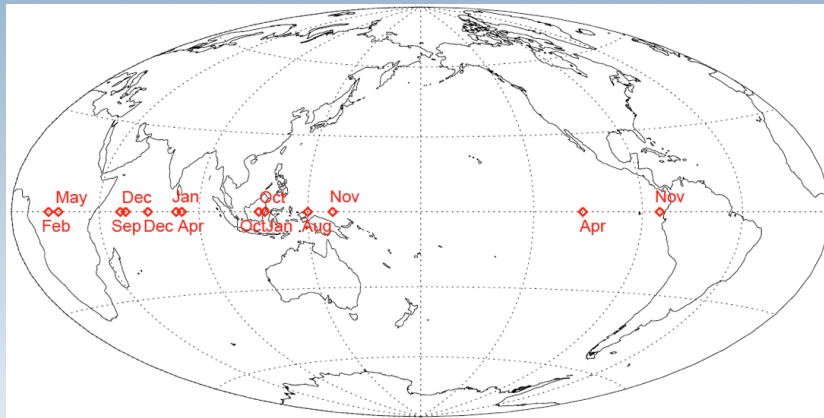
The CAM has very little MJO activity, but the SP-CAM has a **HUGE MJO**.



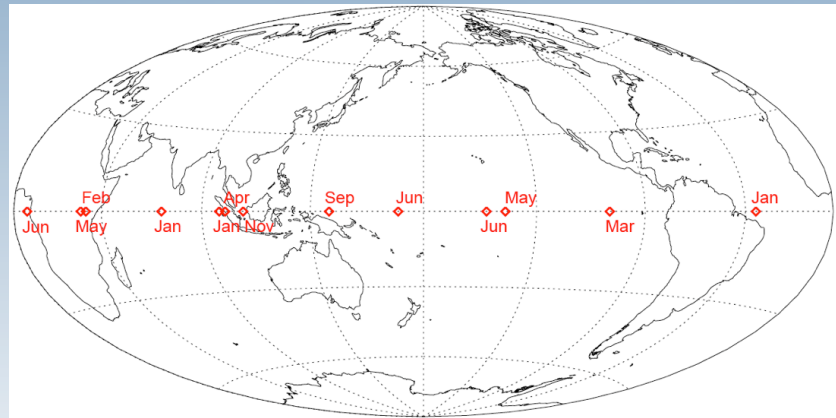
What does it look like in models?



Locations of Filtered OLR Minima 06/98-06/02 (ERA-40)

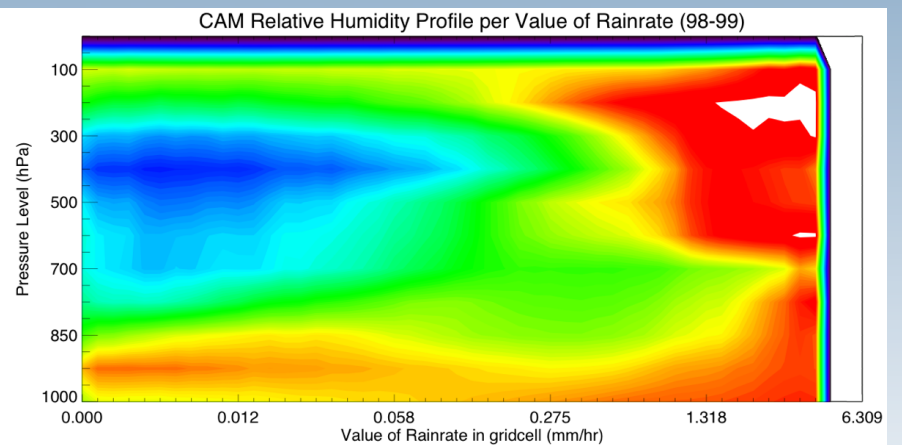
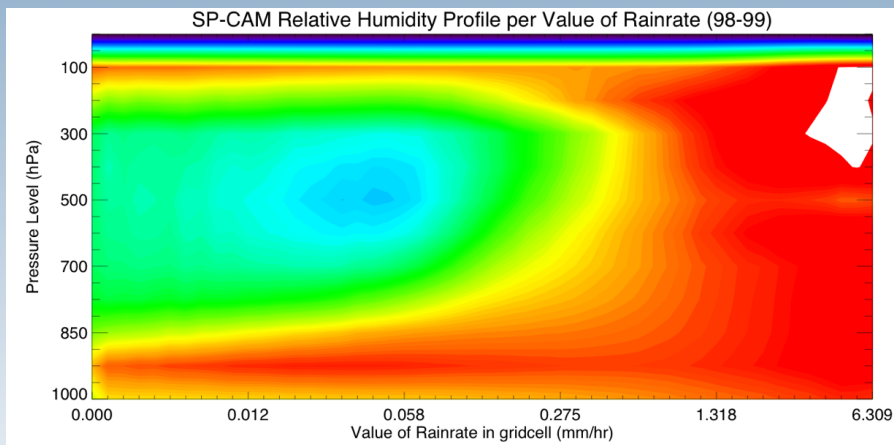
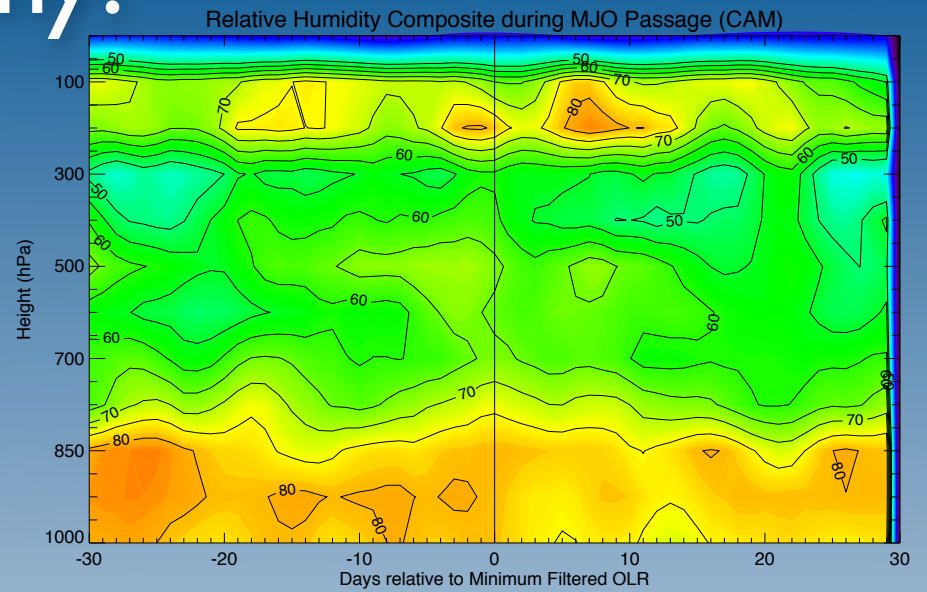
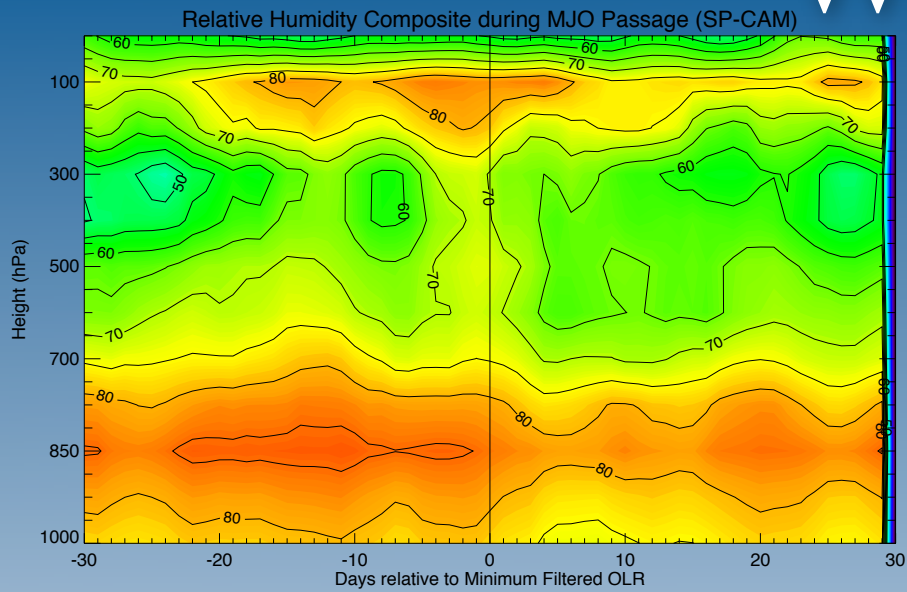


Locations of Filtered OLR Minima from 6/98-6/02 (SP-CAM)



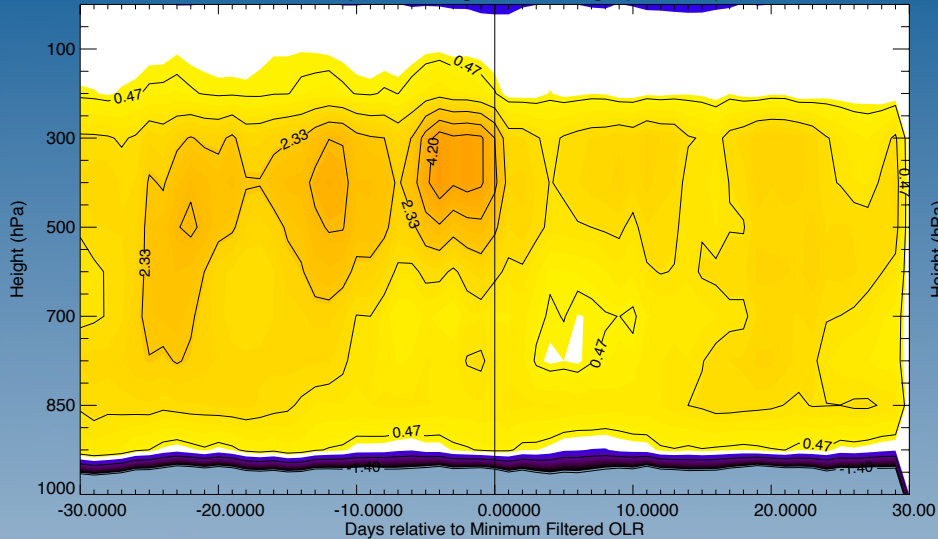
Locations of Filtered OLR Minima from 6/98-6/02 (CAM)

Why?

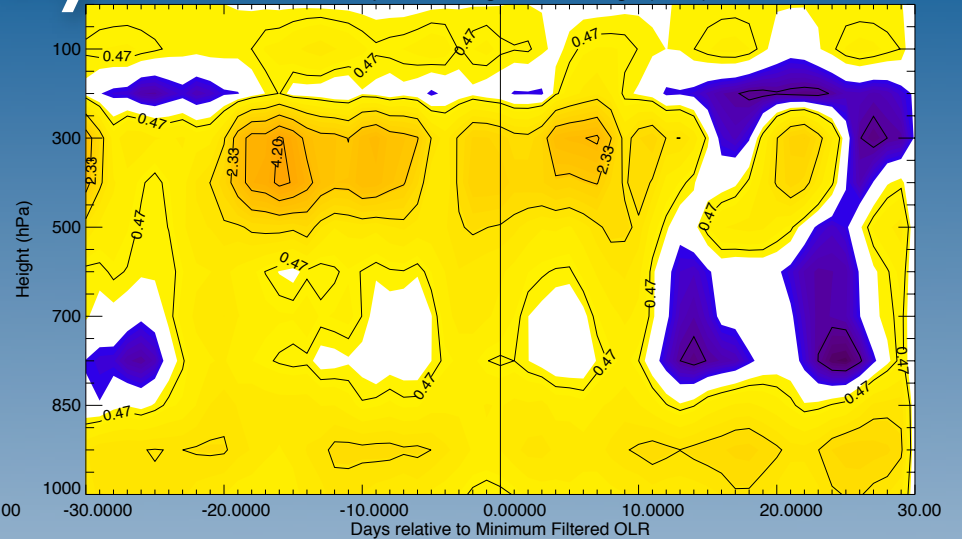


Why?

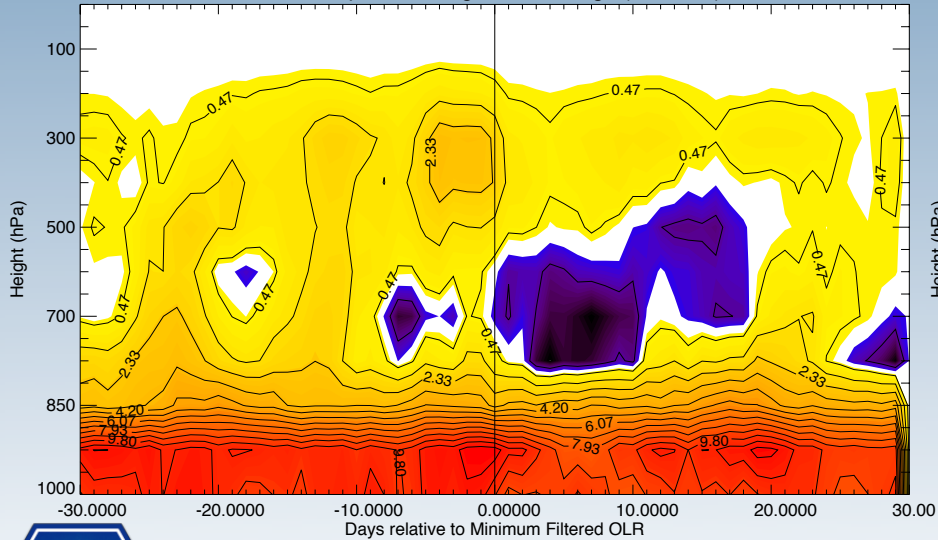
Q1 Composite during MJO Passage (SP-CAM)



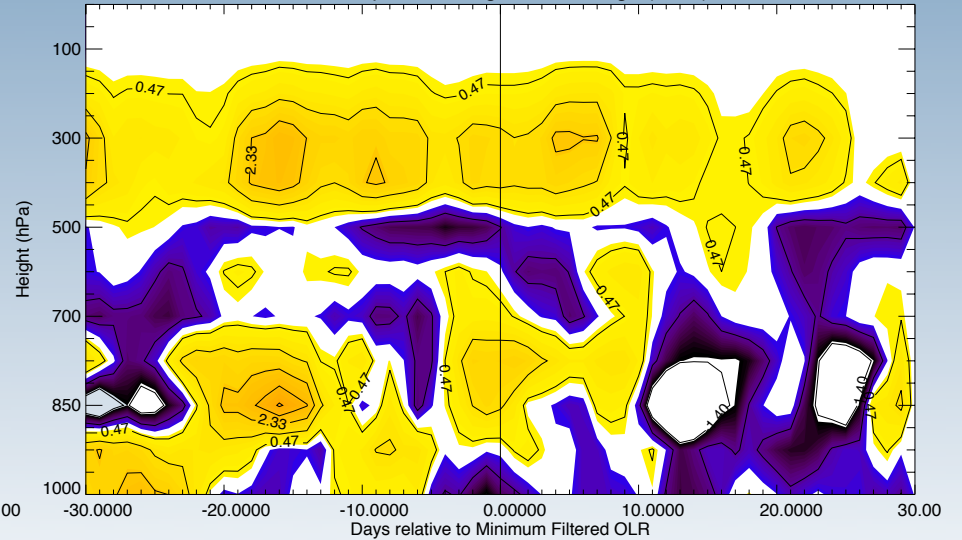
Q1 Composite during MJO Passage (CAM)



Q2 Composite during MJO Passage (SP-CAM)



Q2 Composite during MJO Passage (CAM)



IN SUMMARY

- **The MJO: in the Tropics, a huge chunk of convection (rain) followed by weeks of “drier” air.**
 - Starts in the Indian Ocean, convection propagates eastward
 - Dies out in the central Pacific Ocean
- It is hard to explain every aspect of the wave at once.
- It affects weather and climate all over the planet.
- We have a lot of work left in getting it right in our climate models and predicting it accurately.
- **SP-CAM: better, but MJO a little “overactive.”**



ANY QUESTIONS?

