Convection Sensitivity to Atmospheric State During the Developing Stage of the MJO

DYNAMO, Gan Island (courtesy D. Kim)

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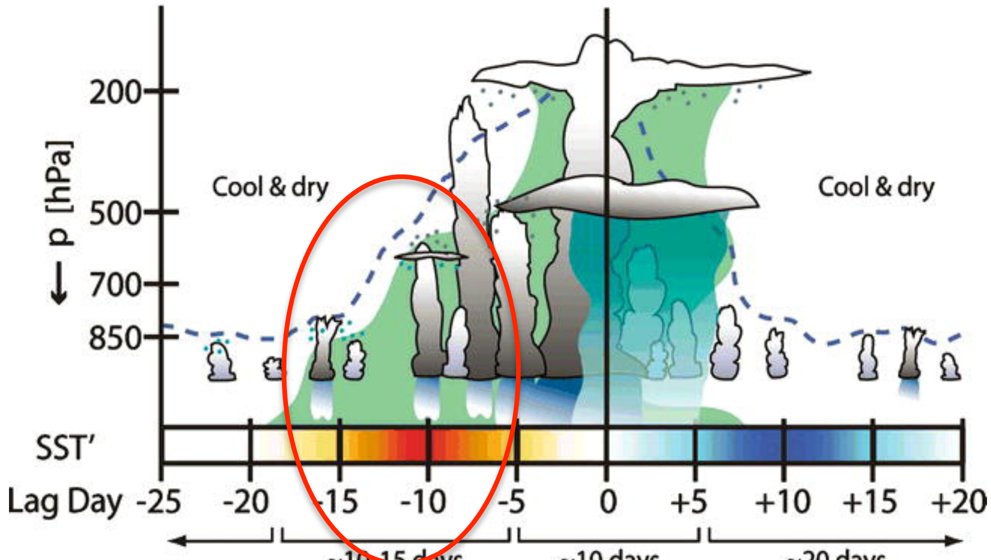


Benedict and Randall (2007)

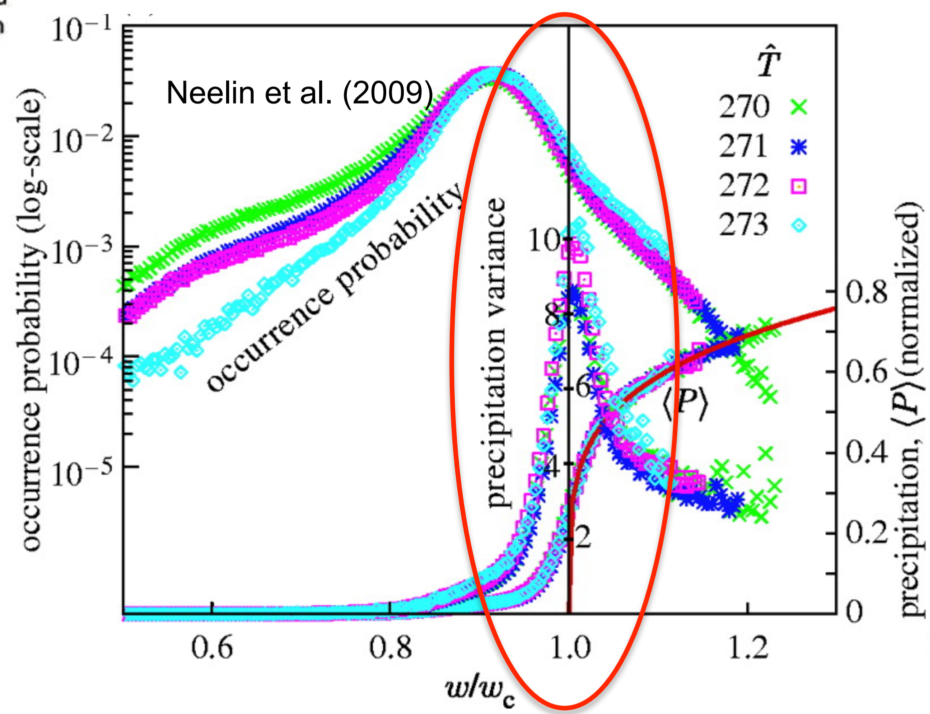
Emerging view of MJO initiation: moisture buildup by shallow/congestus clouds eventually triggering deep convection

A challenge for GCMs, which tend to simulate MJO poorly

But actually more interesting than simple picture suggests

TRMM TMI precipitation vs. column water vapor:

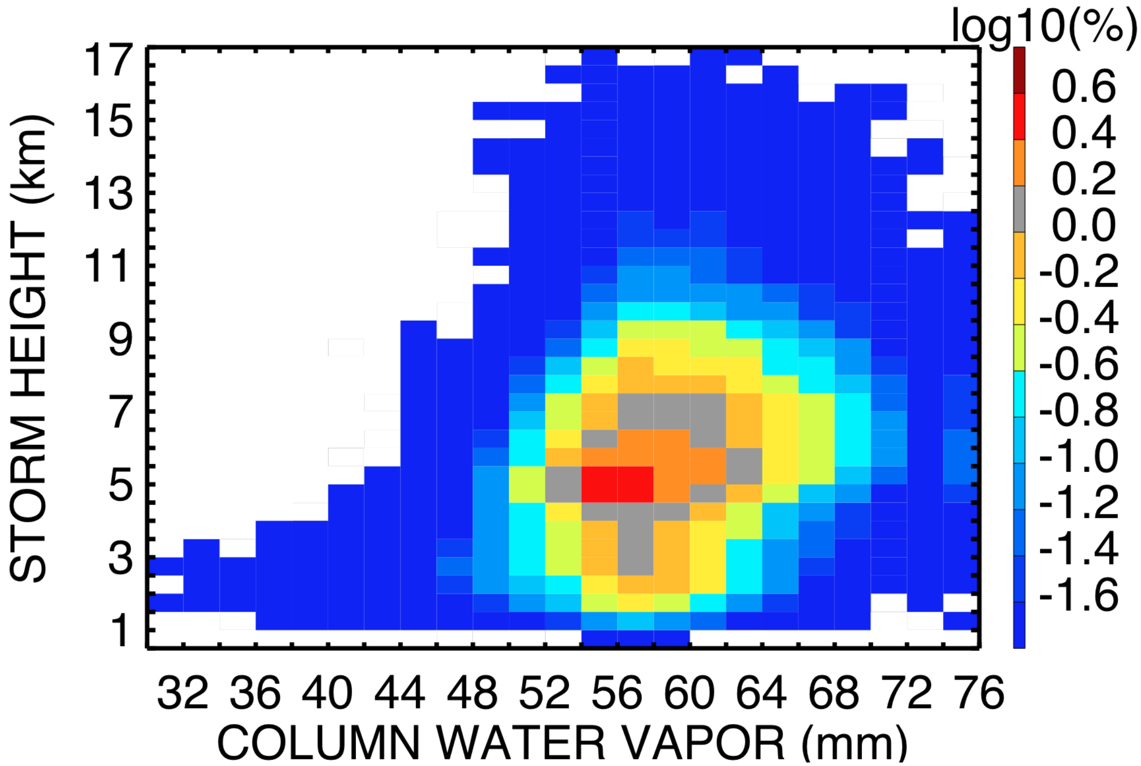
Sharp increase in P at "critical" CWV, maximum rainfall variance and occurrence probability near critical value



Approach

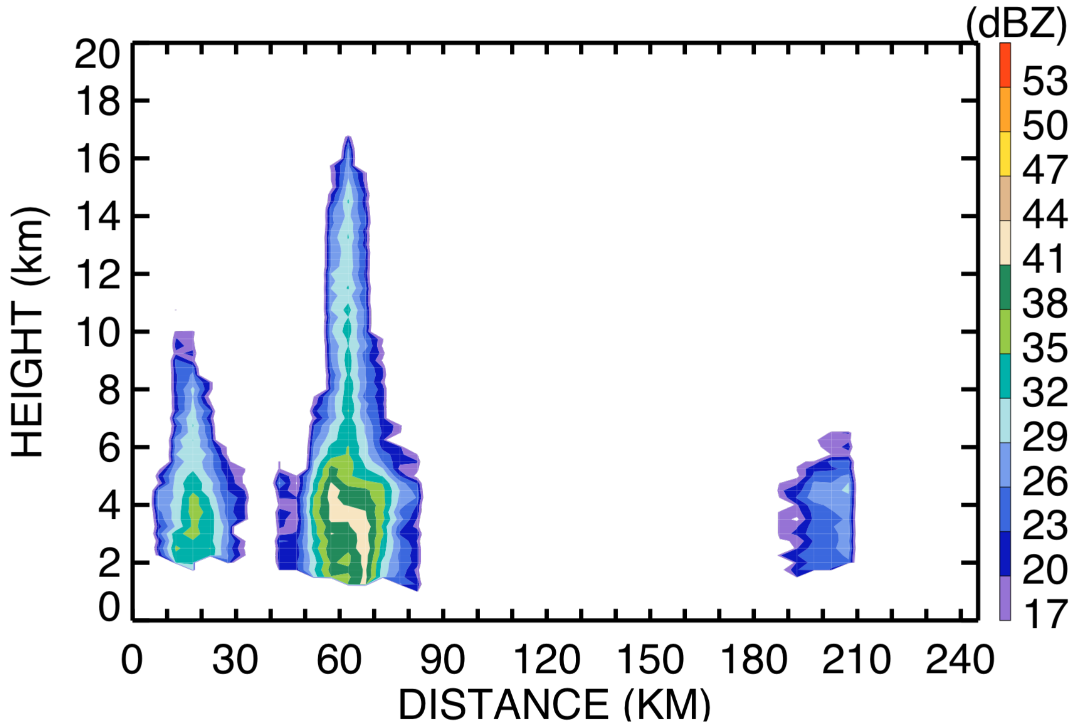
- **Wheeler-Hendon + NOAA CPC MJO indices: 10 boreal non-summer MJO peaks (2006-2010) in equatorial Indian Ocean, Maritime Continent, West Pacific; focus on transition from suppressed to disturbed phase (10-14 days before peak)**
- **TRMM PR storm heights + TMI column water vapor**
- **CloudSat/CALIPSO GEOPROF-LIDAR convective cloud top heights + AMSR-E column water vapor**
- **GISS Model E2 GCM CMIP5 version + stronger convective entrainment and rain evaporation**

PR storm height statistics during MJO transition phase



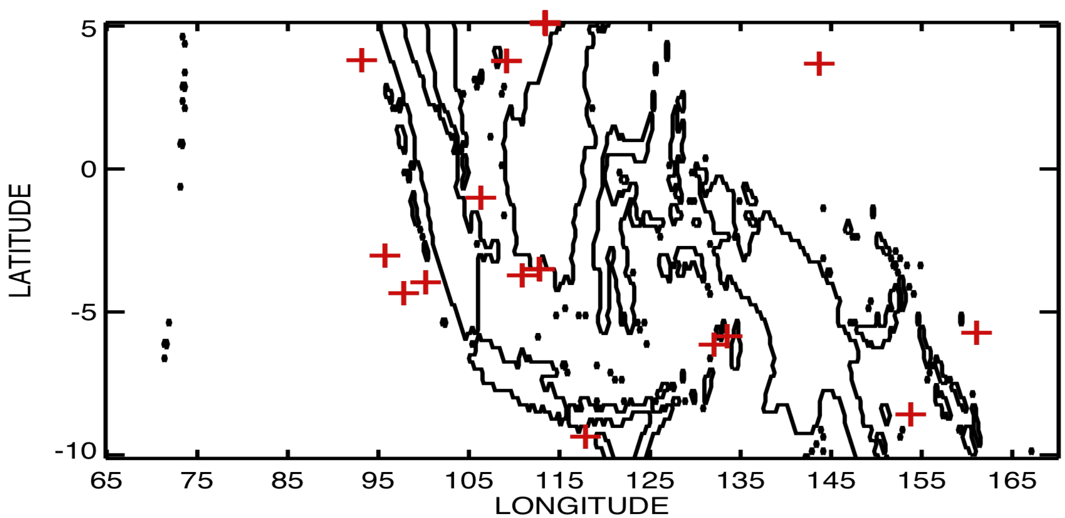
- **Transition to deep Convection at CWV~ 50-66 mm**
- **Maximum convective depth variance in critical CWV range, explains P variance**
- **Also maximum frequency of occurrence near critical CWV**

- **Deepest storm heights at intermediate rather than wettest CWV – why?**
- **Some storms as deep as 16-17 km – are these real?**



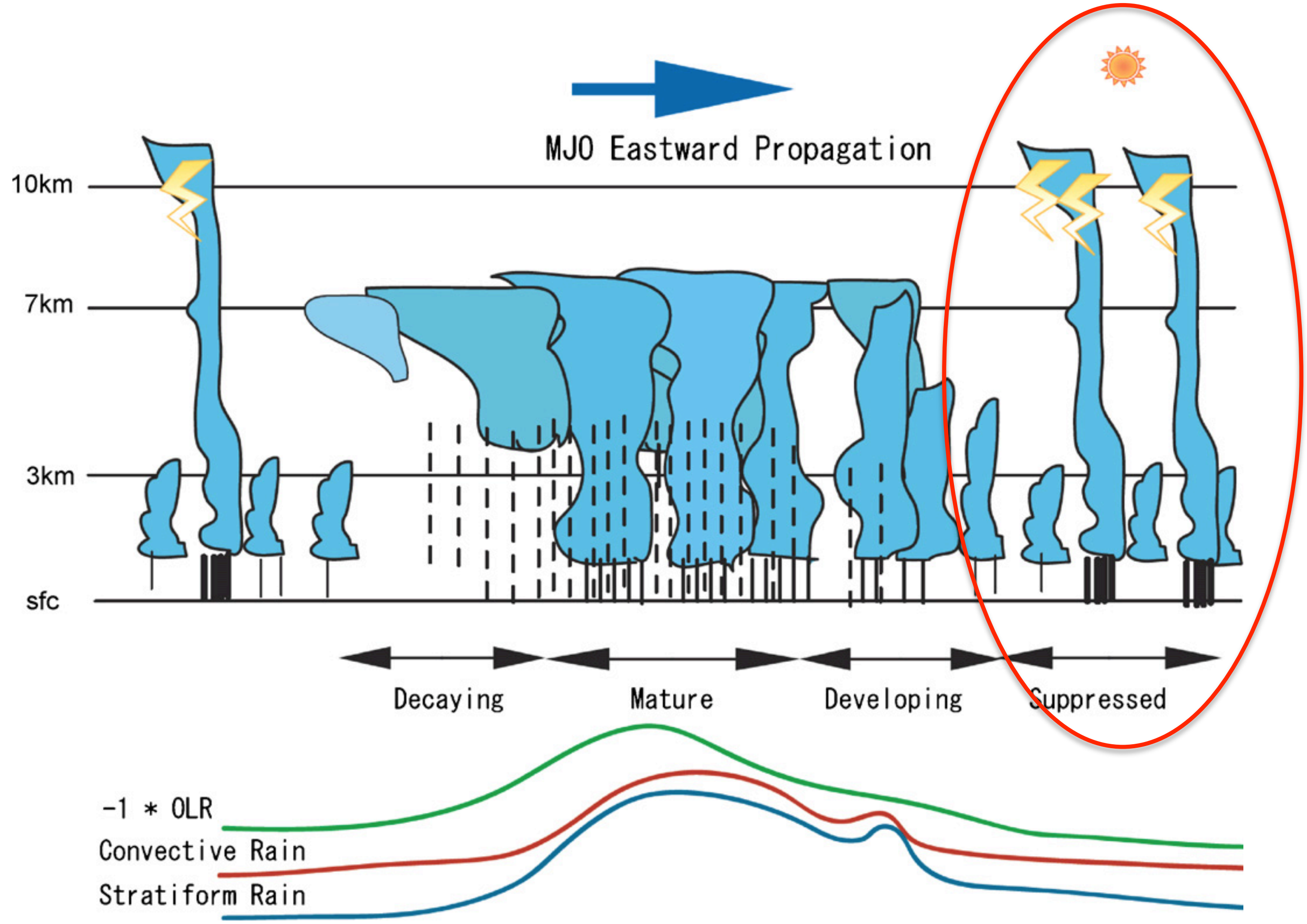
Sample PR reflectivity profiles for one case: ~30 dBZ up to 15 km

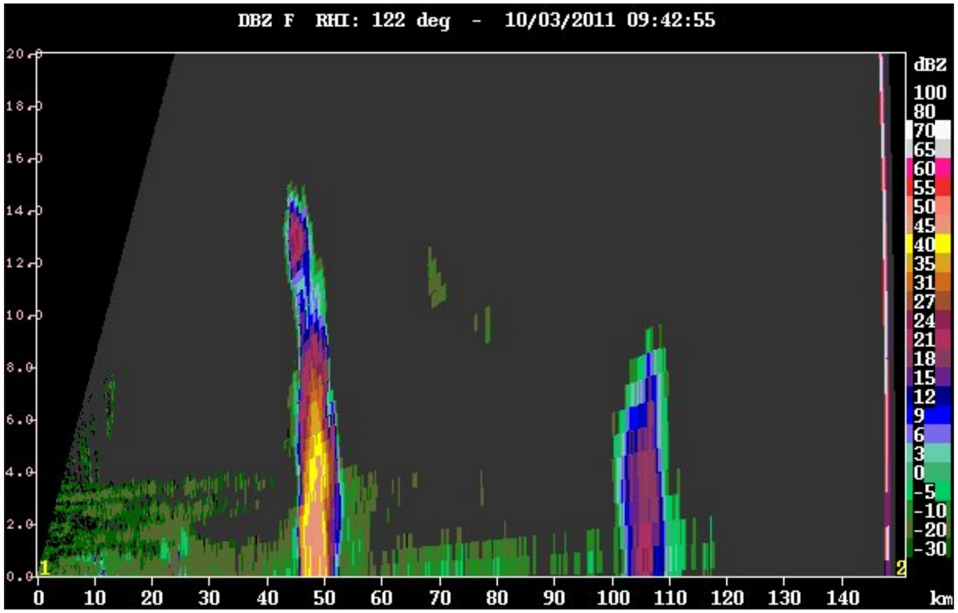
Isolated cells

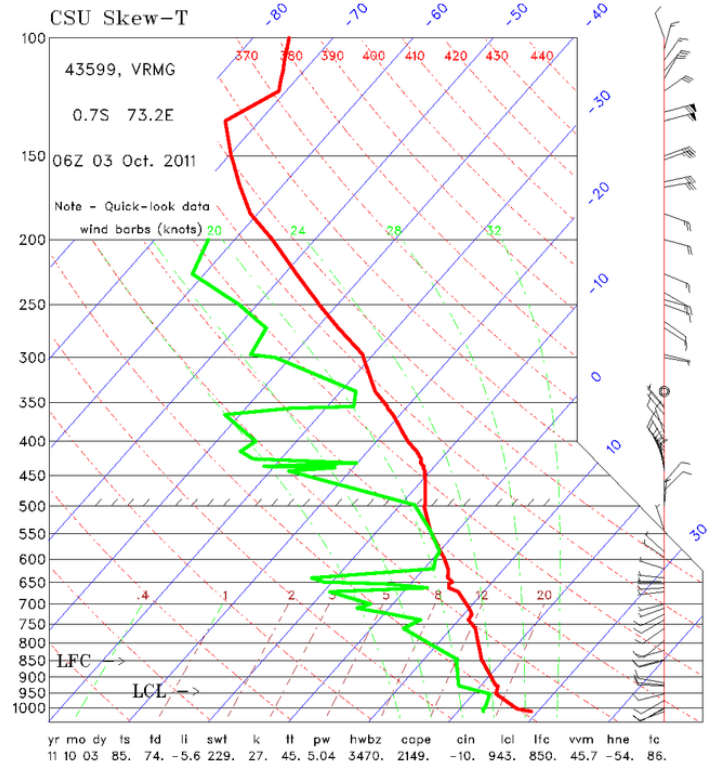


All located in Maritime Continent, over very warm water, maybe continental influence?

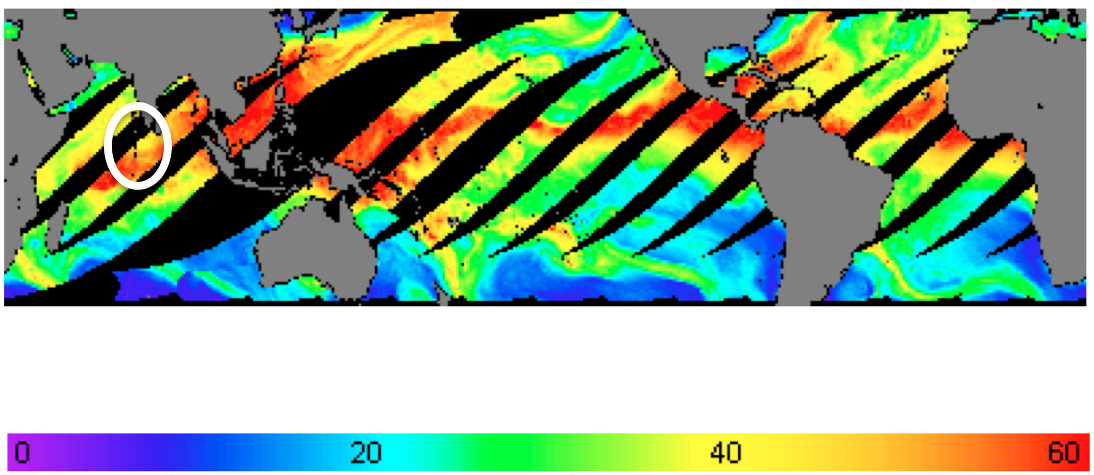
Morita et al. (2006): ~11 km TRMM PR rain top heights and LIS lightning during suppressed MJO phase







TMI CWV 10/3/11

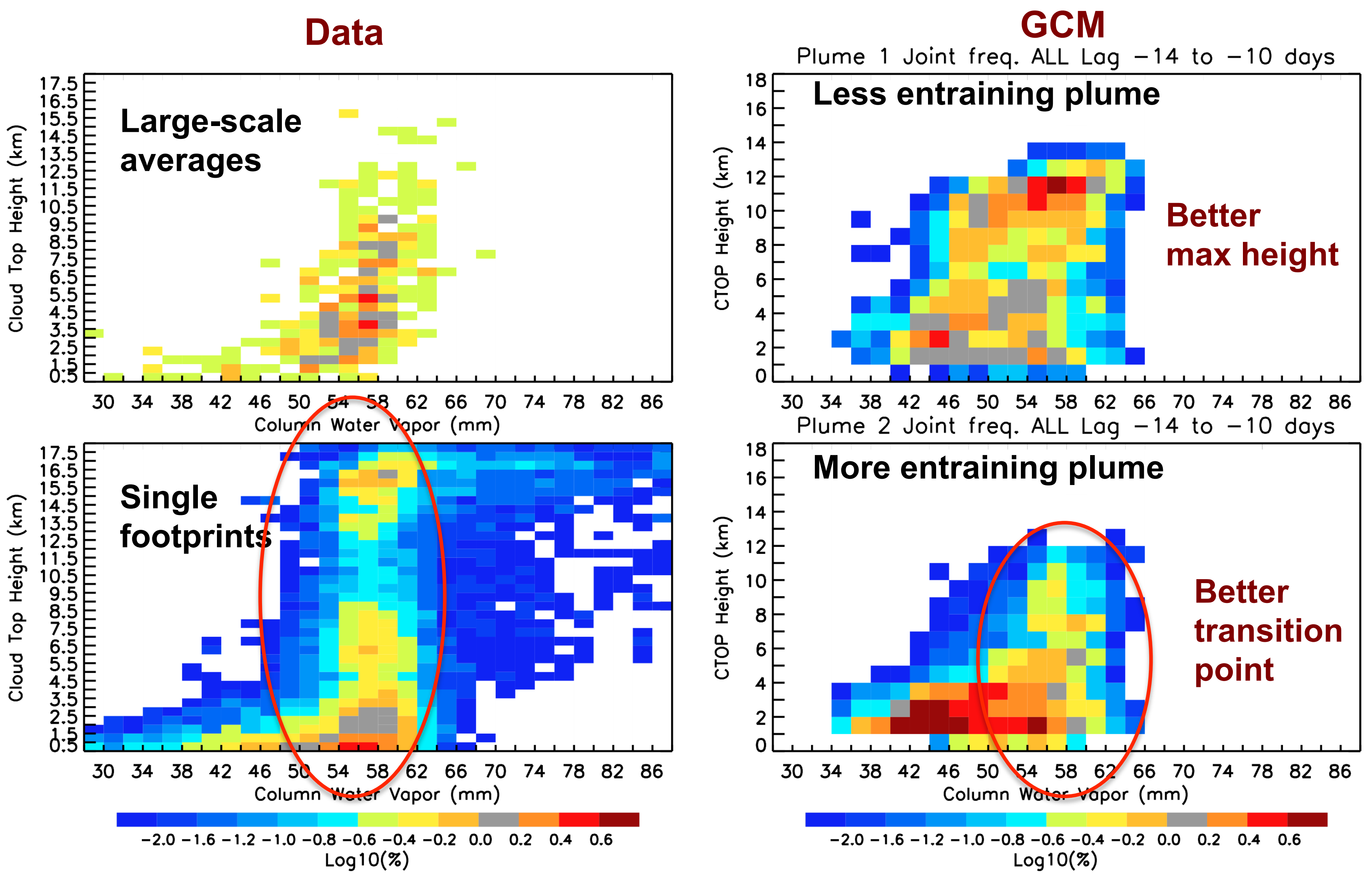


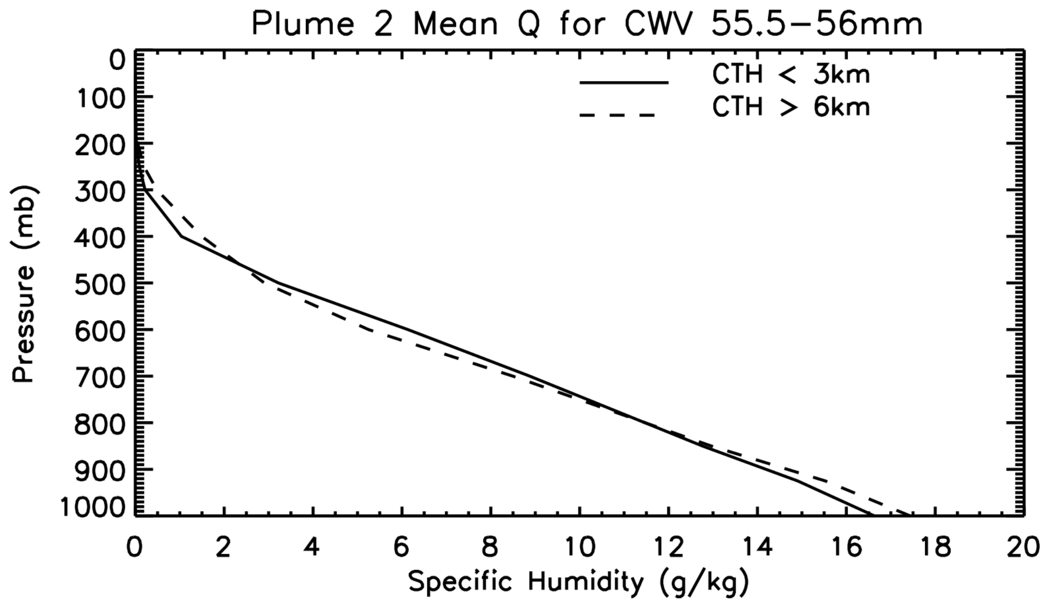
***Thanks to Eric Maloney and Bob Houze for pointing out this case on the DYNAMO blog**

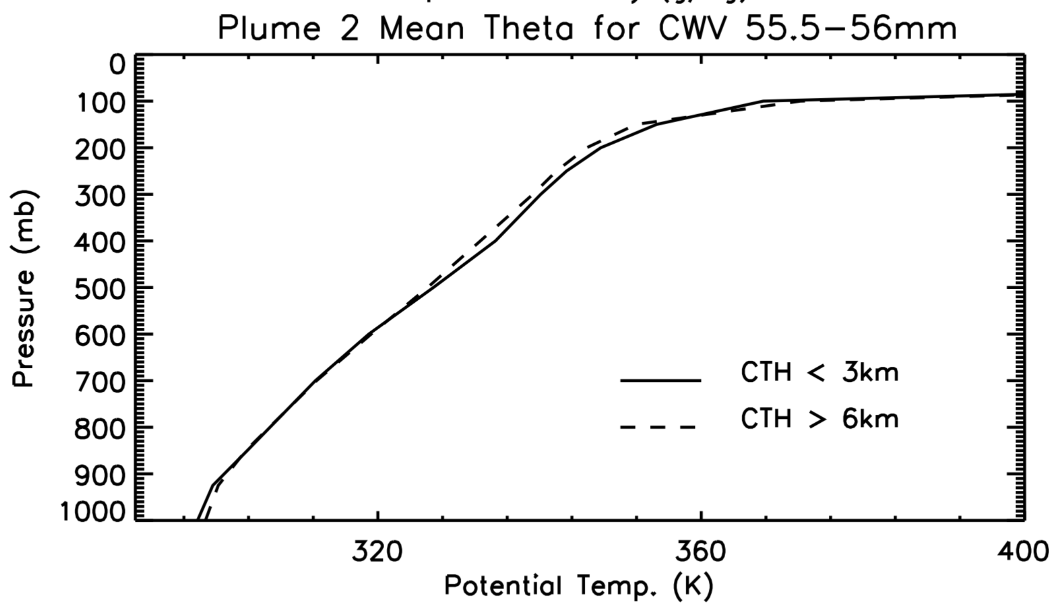
DYNAMO Gan Island case, 10/3/11*:

- **Fairly low CWV due to mid-troposphere dry layers**
- **But fairly unstable lapse rate**

CloudSat/CALIPSO convective cloud top heights: Deepest tops at wettest CWV just as deep as those at lower CWV; GCM can match data but only with strong entrainment







How does GCM produce convection depth variance for a given value of CWV with a deterministic parameterization?

Deeper when PBL is a bit warmer/wetter

Gregory entrainment scheme ($\varepsilon \sim B/w^2$) implies:

Warmer/wetter rising parcel -> stronger updraft -> weaker entrainment -> better able to penetrate drier mid-troposphere

Summary

- **TRMM PR storm heights indicate large variability in convection depth at intermediate CWV during transition from suppressed to disturbed phase of MJO**
- **Storm heights deeper when column is moderately moist than when it is most humid; associated with isolated convective cells**
- **Comparison to CloudSat/CALIPSO indicates that peak convection depth is similar at intermediate and high CWV; PR storm height behavior thus suggests stronger storms in more unstable environment when CWV is lower**
- **GISS GCM is capable of reproducing observed transition from shallow to deep convection and associates deeper convection with warmer, wetter PBL; but weak entrainment must be restricted to very specific conditions**