

# *Evolution of MJO Convection during DYNAMO Deduced from Atmospheric Sounding Arrays*

Richard H. Johnson

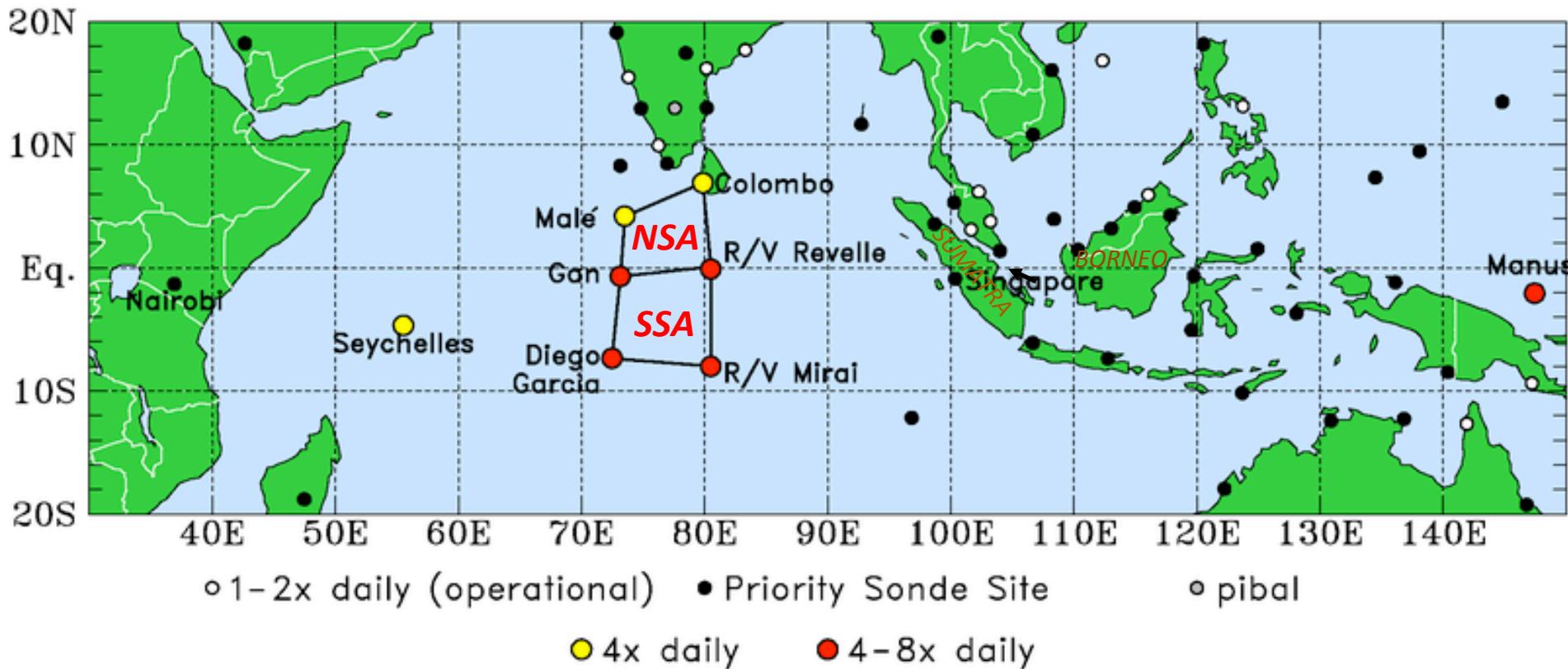
Paul E. Ciesielski

*Colorado State University*

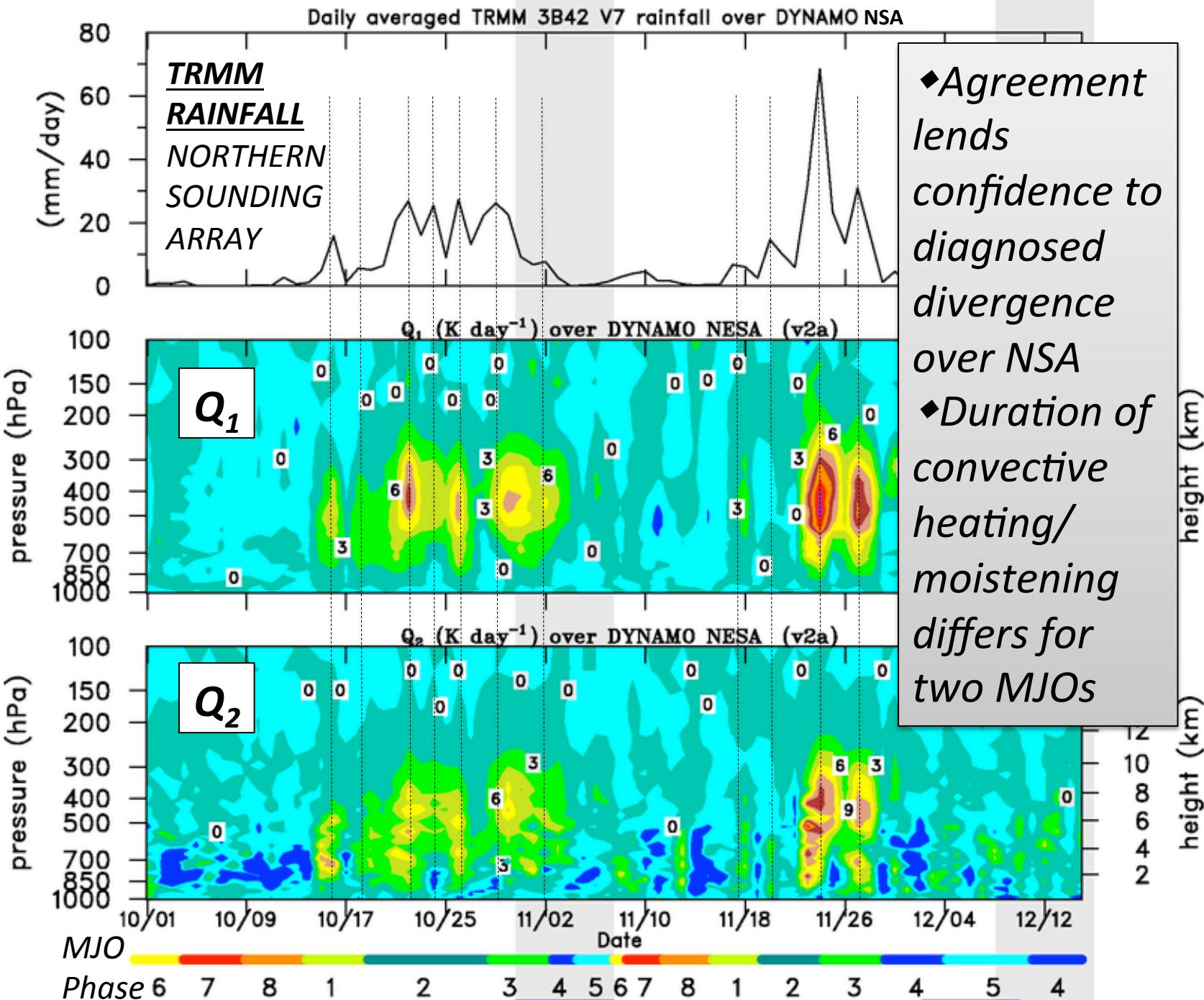
*Own Shieh*

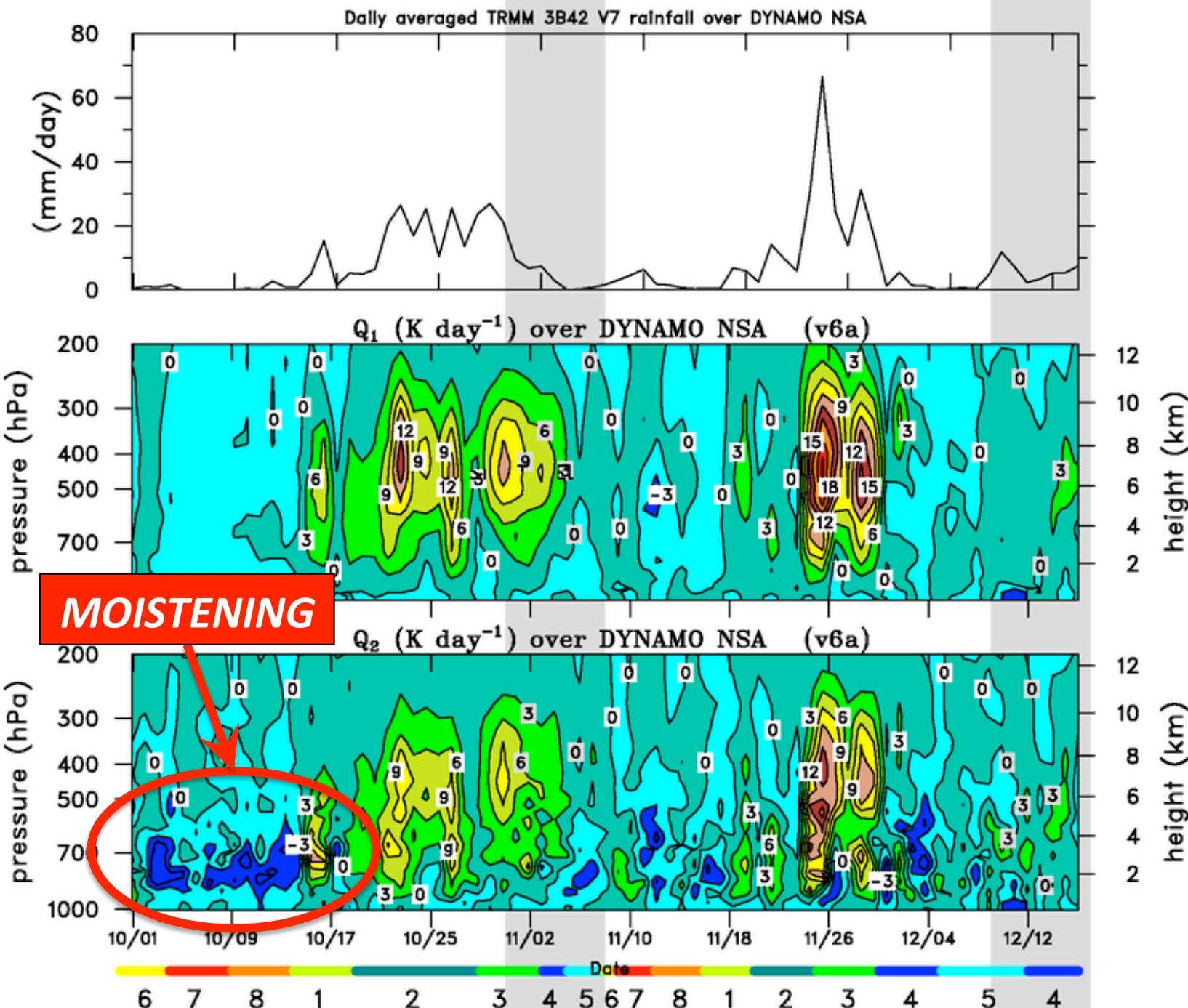
# DYNAMO/CINDY Sounding Arrays

DYNAMO/CINDY/AMIE network and priority sonde sites

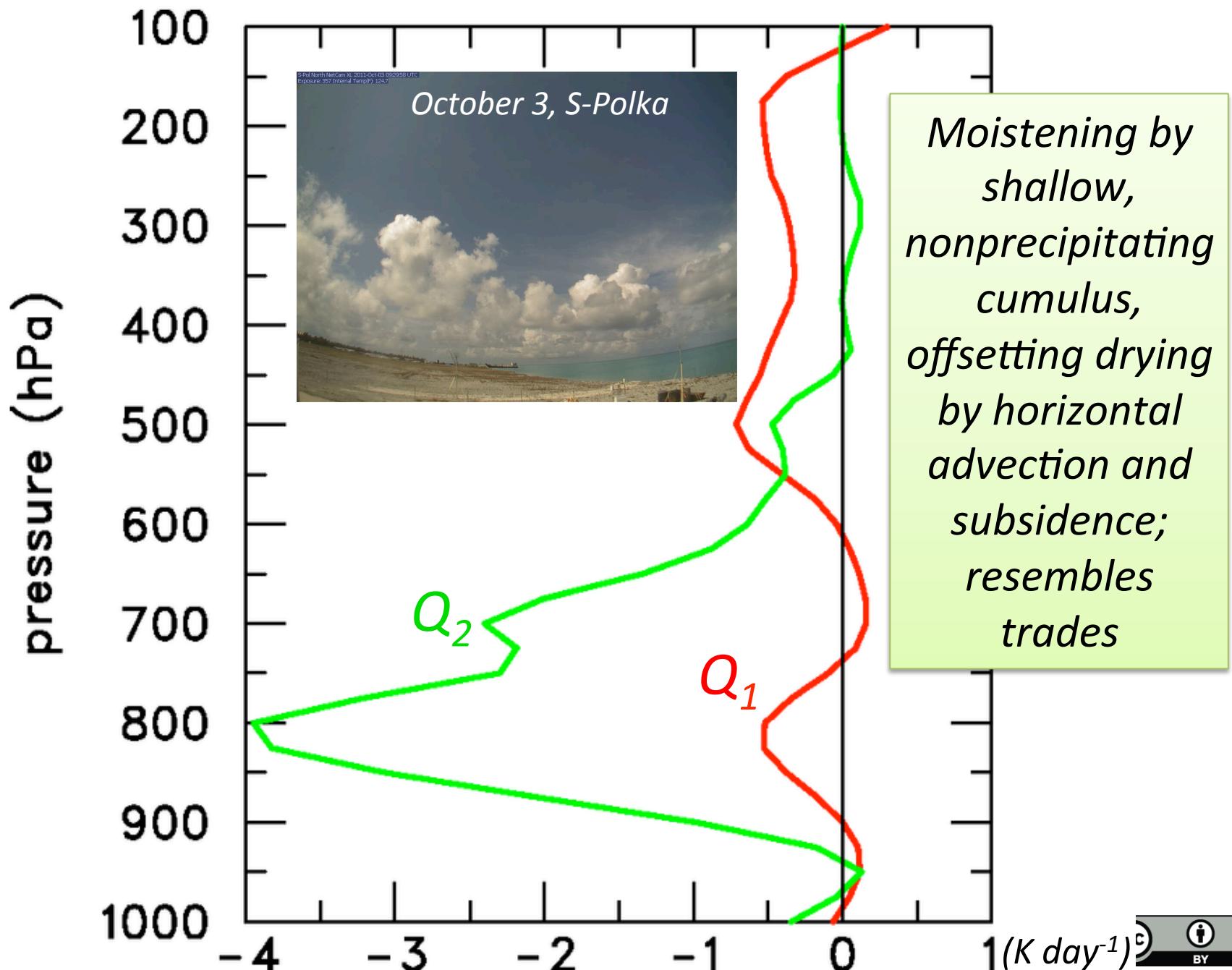


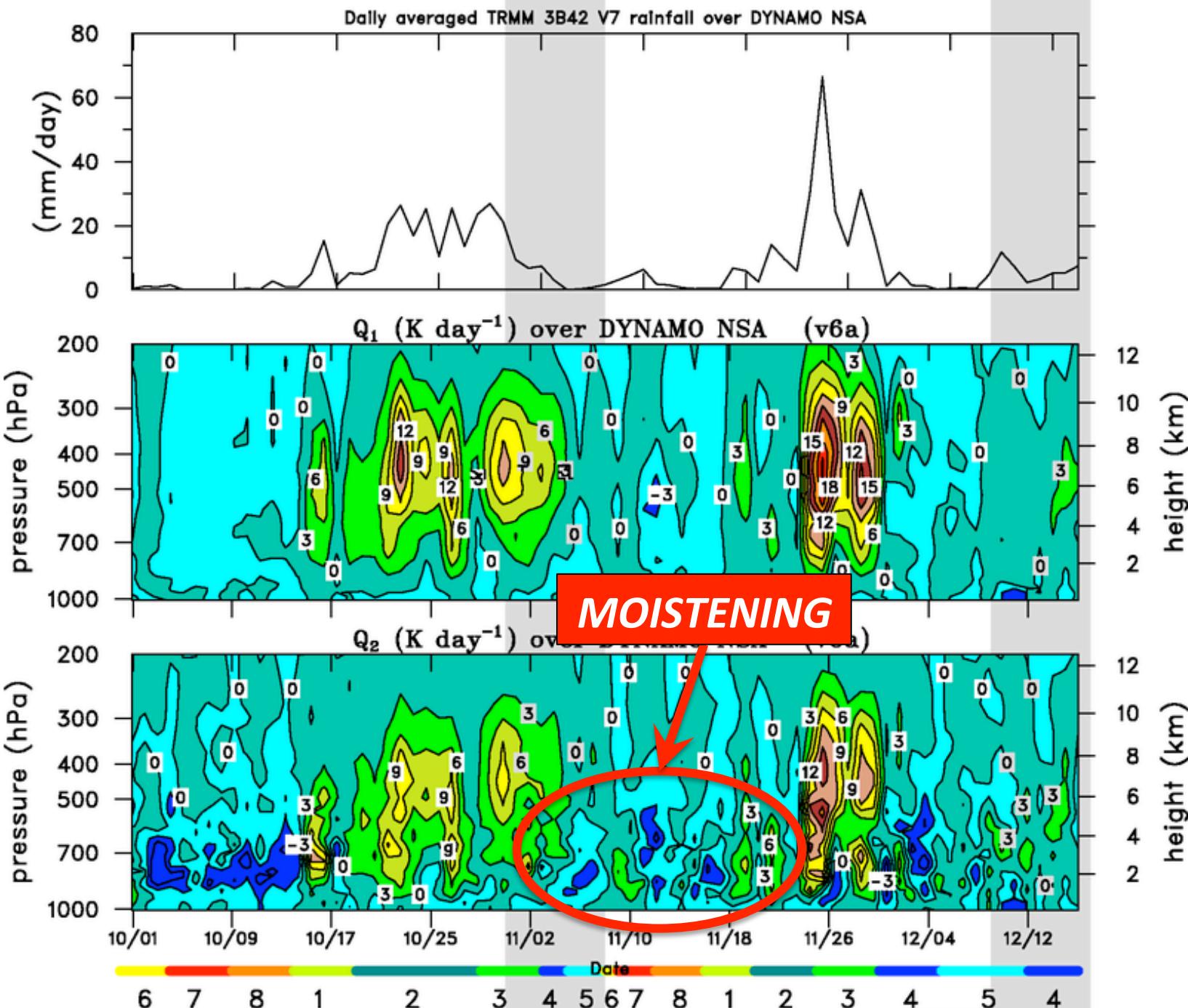
- Northern Array (NSA): October-early December, 4/day soundings
- Southern Array (SSA): October-November, 8/day soundings
- Two prominent MJOs in October & November, signal strongest over NSA; 3<sup>rd</sup> MJO-like event in December
- Analyses based on sounding data only; no model data





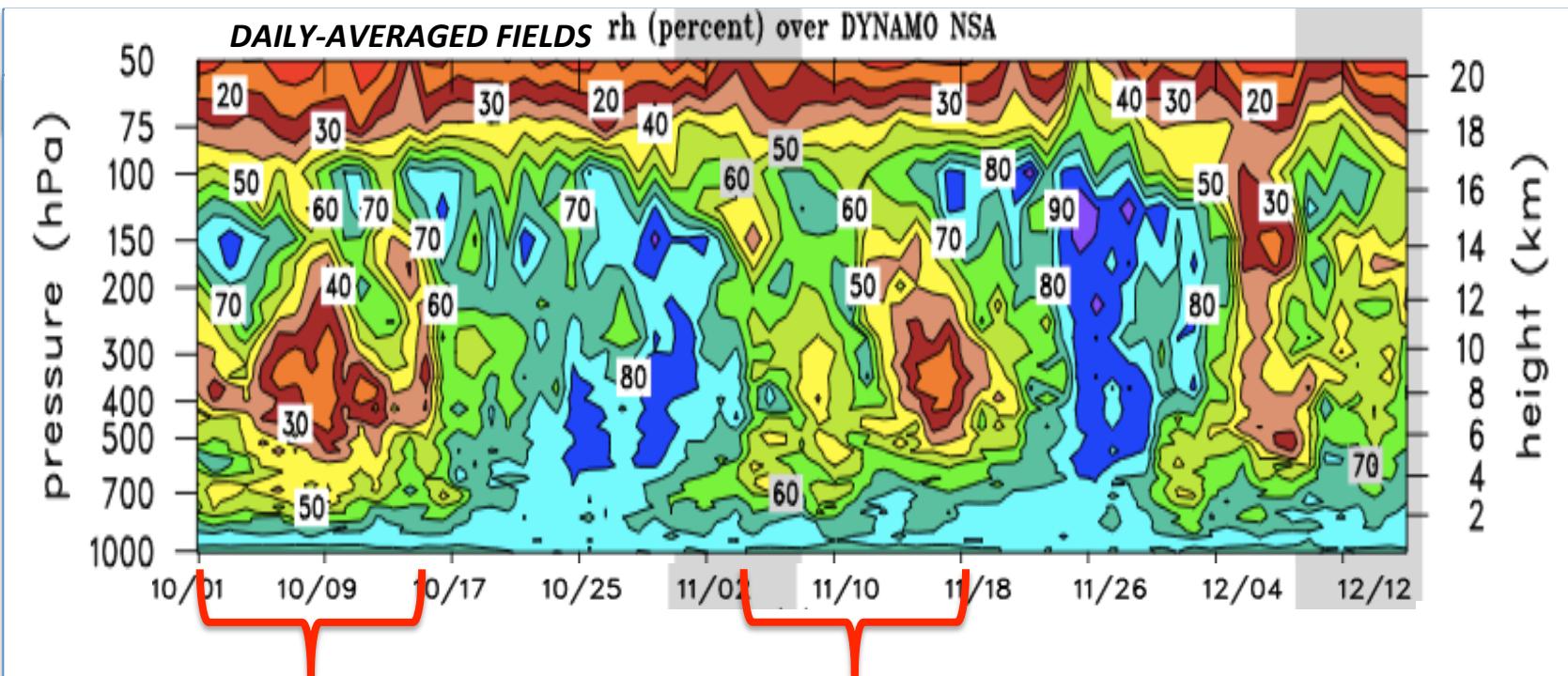
# $Q_1$ (red), $Q_2$ (green) for 1–14 Oct. N.Array





# RELATIVE HUMIDITY (%)

NORTHERN ARRAY

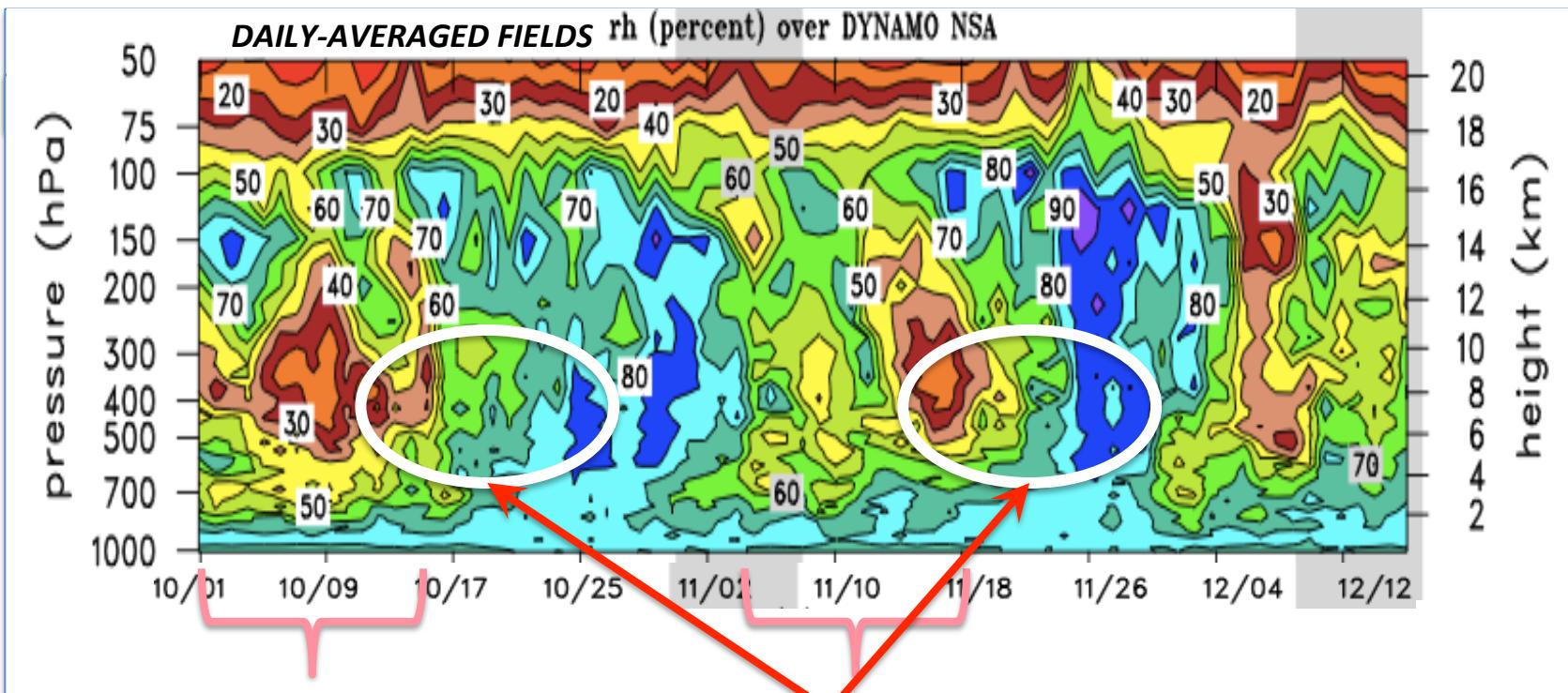


*Periods of negative  $Q_2$ : dry mid-troposphere; slow moistening of lower troposphere*

- Build-up of low-level moisture over ~2-3 week periods, leading up to active MJO phases

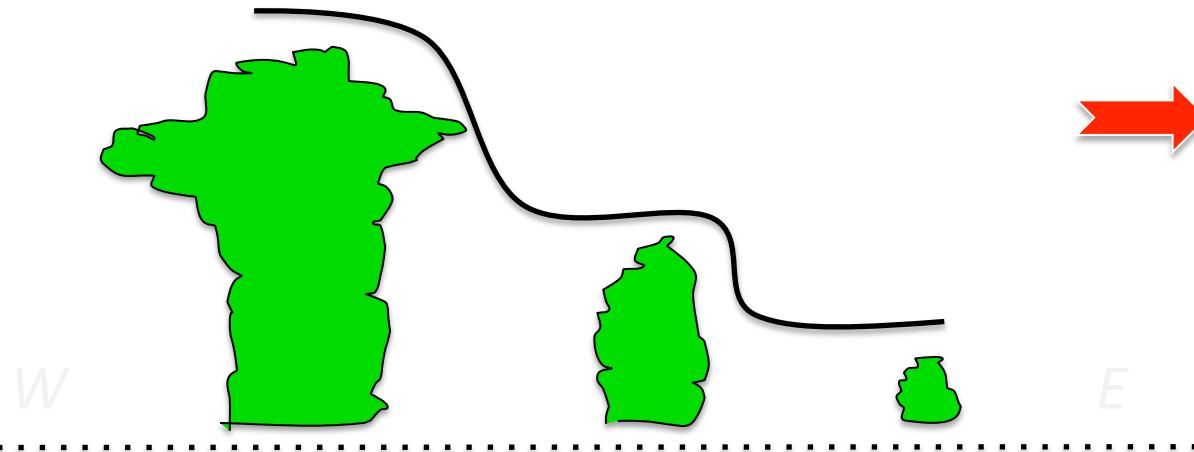
# RELATIVE HUMIDITY (%)

NORTHERN ARRAY



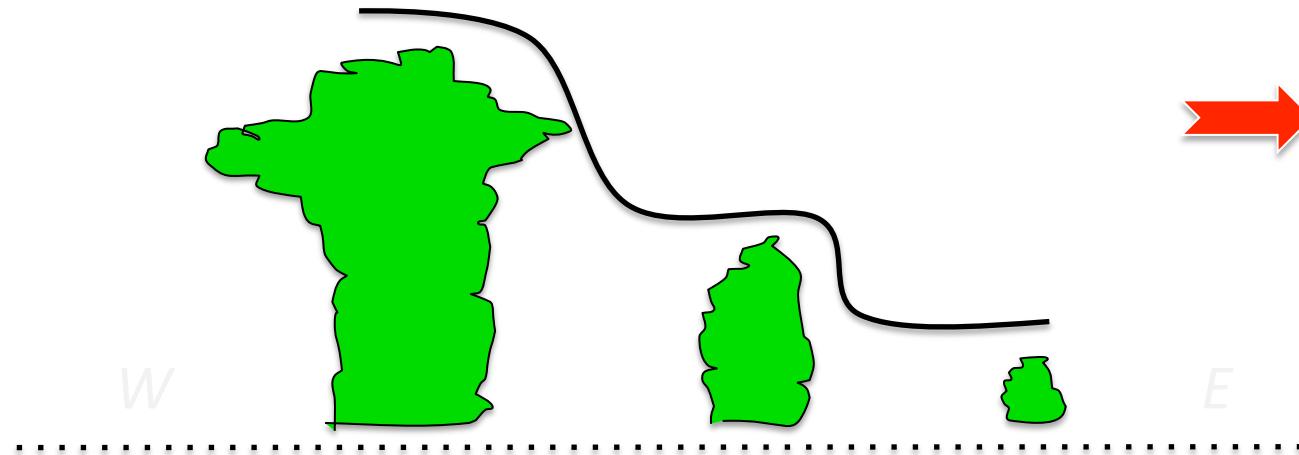
*Moistening subsequently deepens to midlevels*

# *“Stepwise” Evolution of Clouds/Moisture During MJO Build-up Phase*

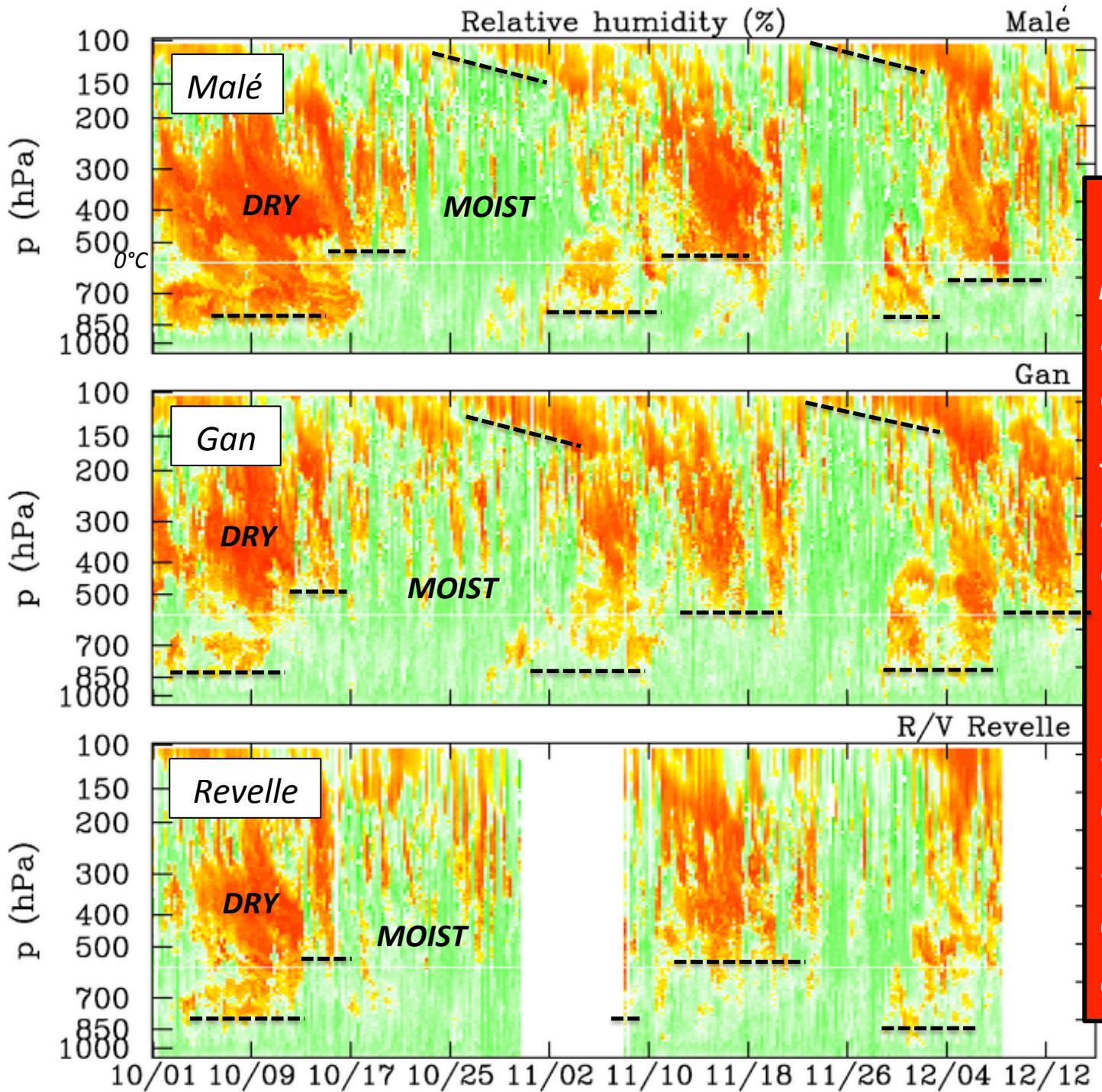


- **1992-93 TOGA COARE: Kikuchi and Takayabu (2004)**
- **2006 MISMO: Katsumata et al. (2009)**
- **CALIPSO/CloudSat data: Virts and Wallace (2010); Del Genio et al. (2012)**

# *“Stepwise” Evolution of Clouds/ Moisture During MJO Build-up Phase*

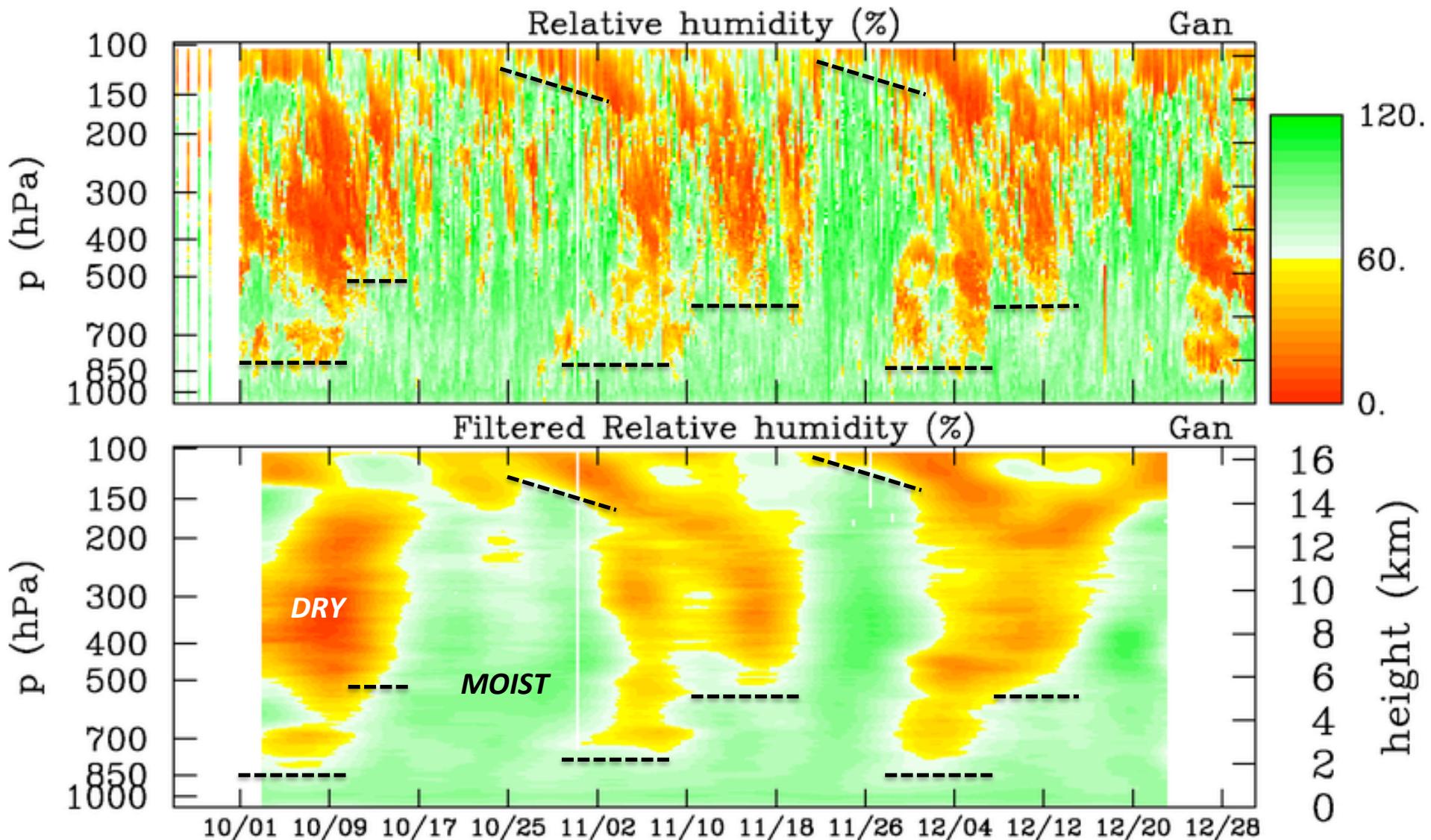


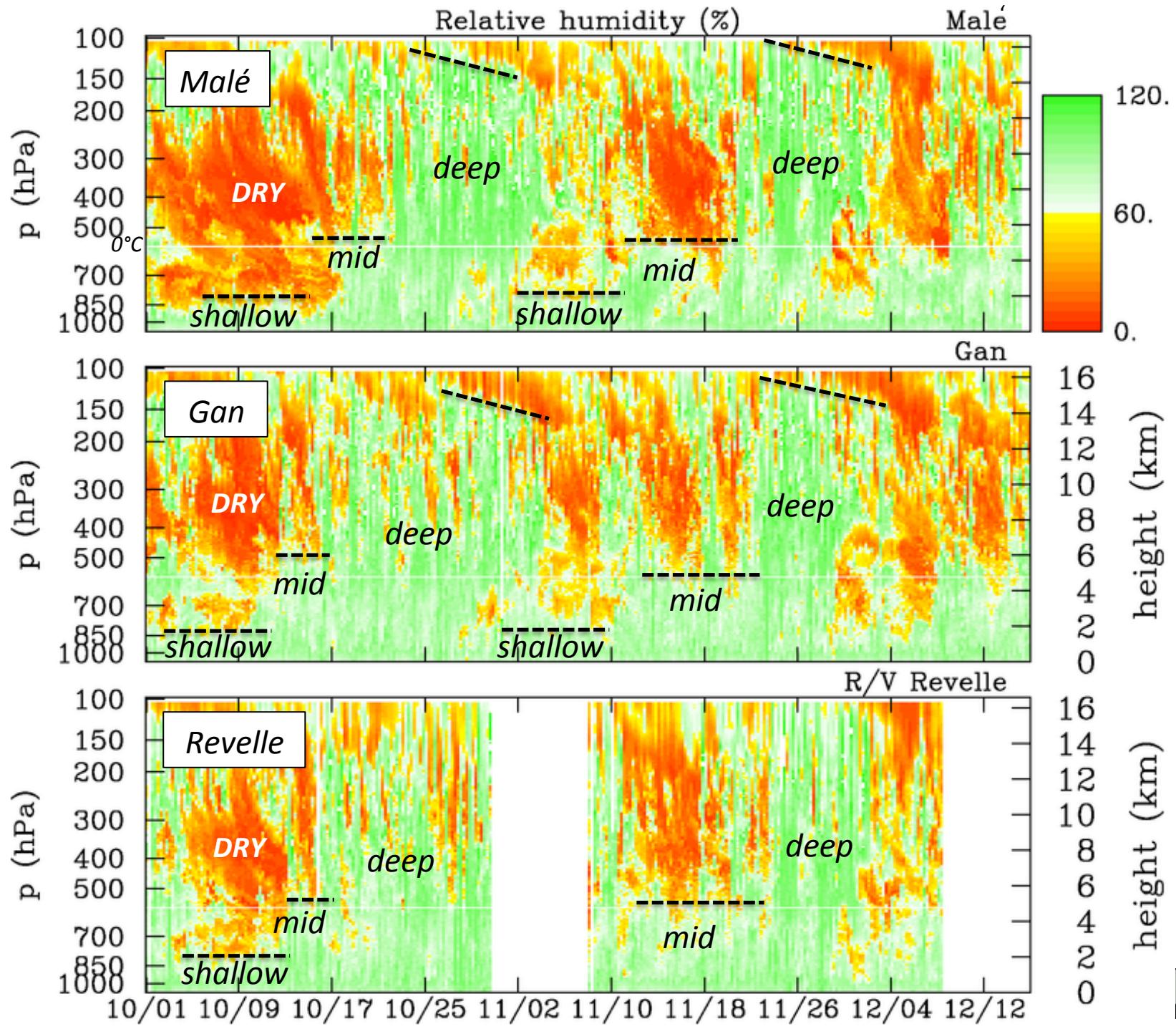
- *Are these findings supported by results from CINDY/ DYNAMO?*



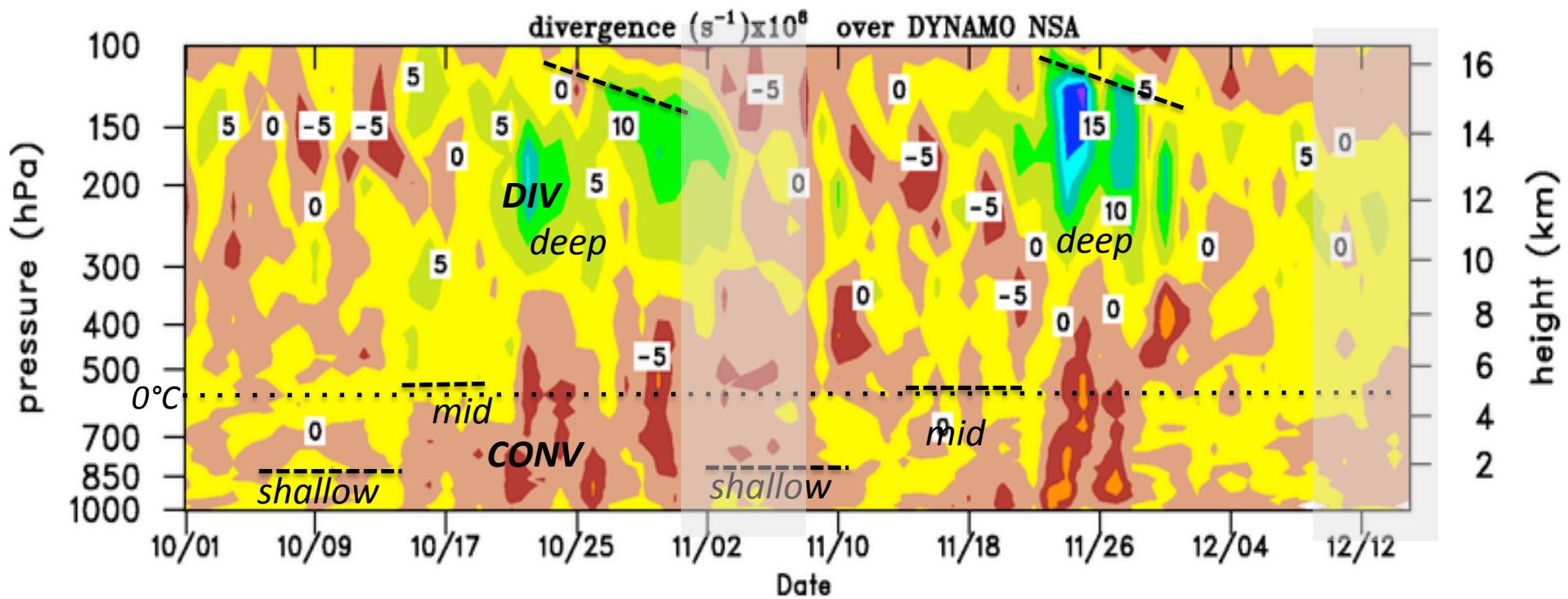
- ◆ *Similar pattern of moistening/drying at 3 sites in northern array*
- ◆ *Descent at tropopause: Kelvin wave excited by MJO convective envelope*

# *Unfiltered RH vs. 10-day Low-Pass Filtered RH*



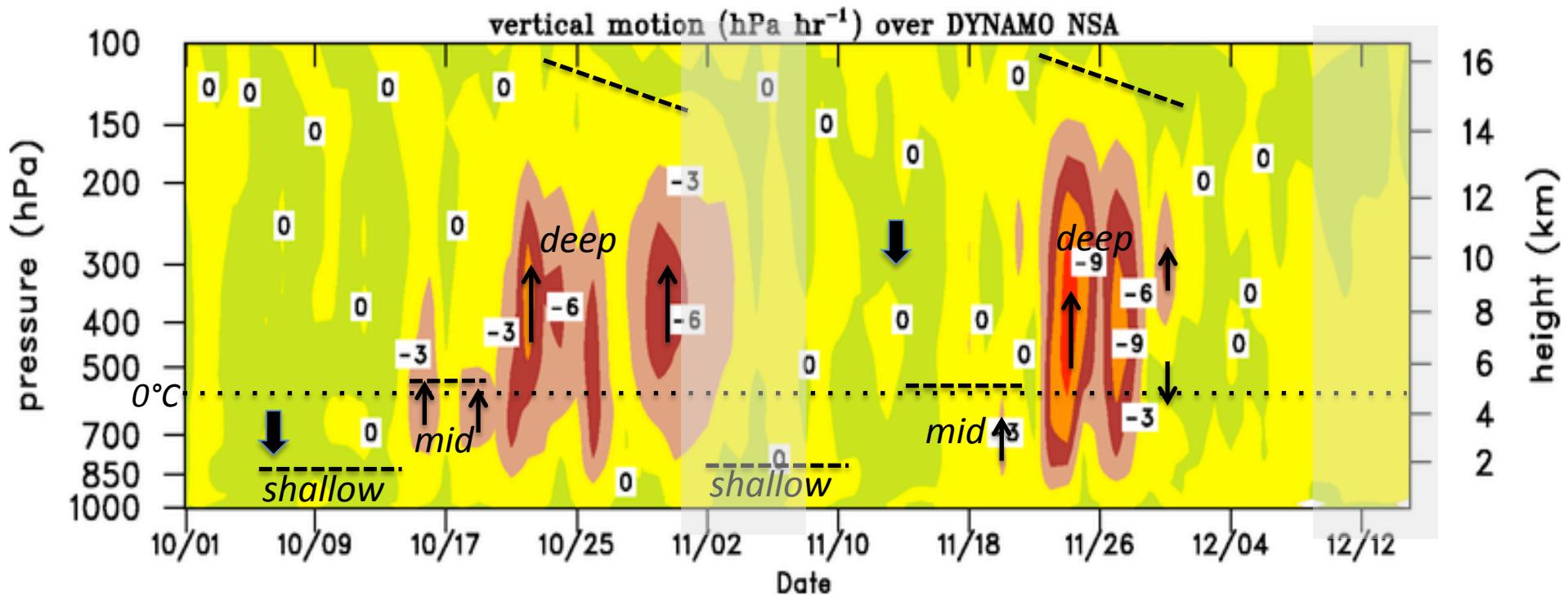


# Divergence



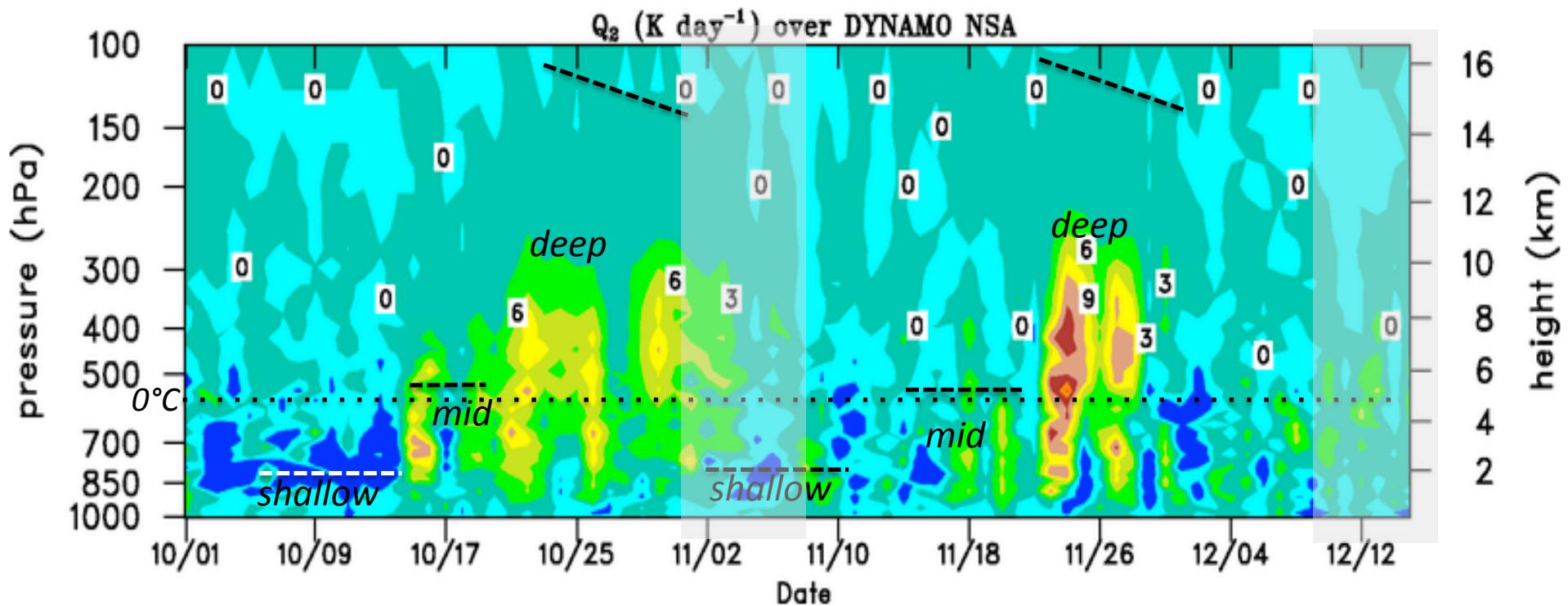
- Deepening convergence; ascending divergence maxima
- Descending level of peak divergence near tropopause during active phase: Kelvin wave response to MJO heating envelope

# Vertical Motion



- Ascending vertical motion maxima; more rapid onset to deep vertical motion in November
- Stratiform-like (top-heavy) vertical motion profiles at end of active periods

# *Apparent Moisture Sink $Q_2$*



- *Low-level convective moistening in first halves of October/November*
- *Stepwise evolution in  $Q_2$  leading up to active phase*

# *Summary*

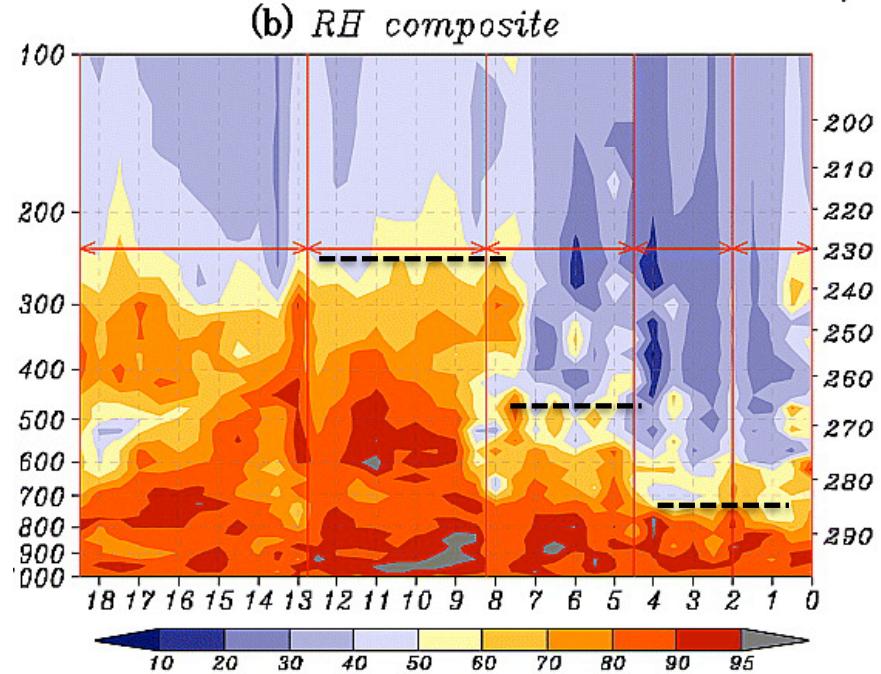
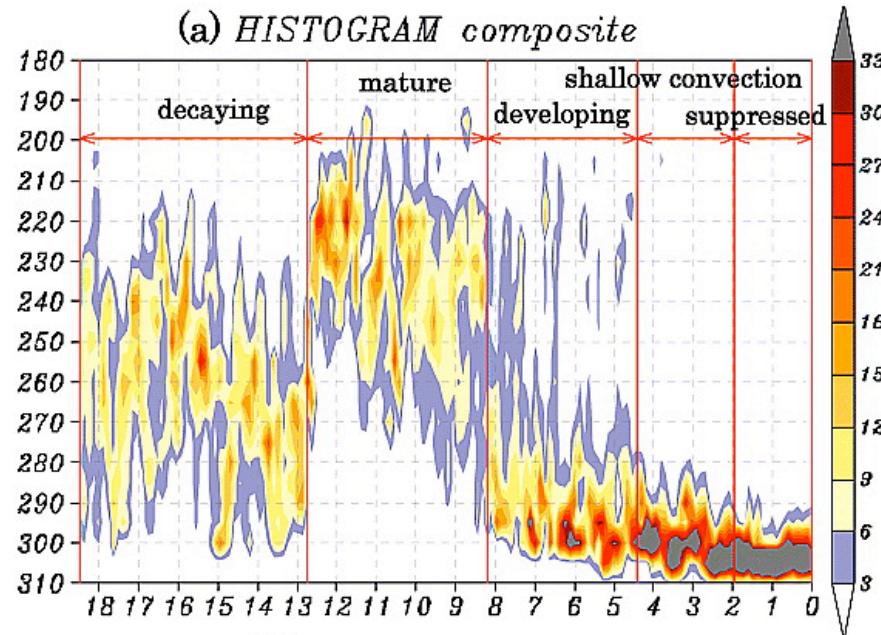
- *Trade-like shallow moistening by cumulus during suppressed phase of MJO*
- *...followed by fairly rapid deepening of moist layer to near 0°C level; persists for 6-10 days; then deep moistening ➔ stepwise evolution*
- *Moisture layers: roughly correspond to layers of divergence/vertical motion/ $Q_2$*
- *Next steps:*
  - *Relate to evolving cloud populations*
  - *Sort out causes/effects*

# *Extra Slides*

# 1992-93 TOGA COARE

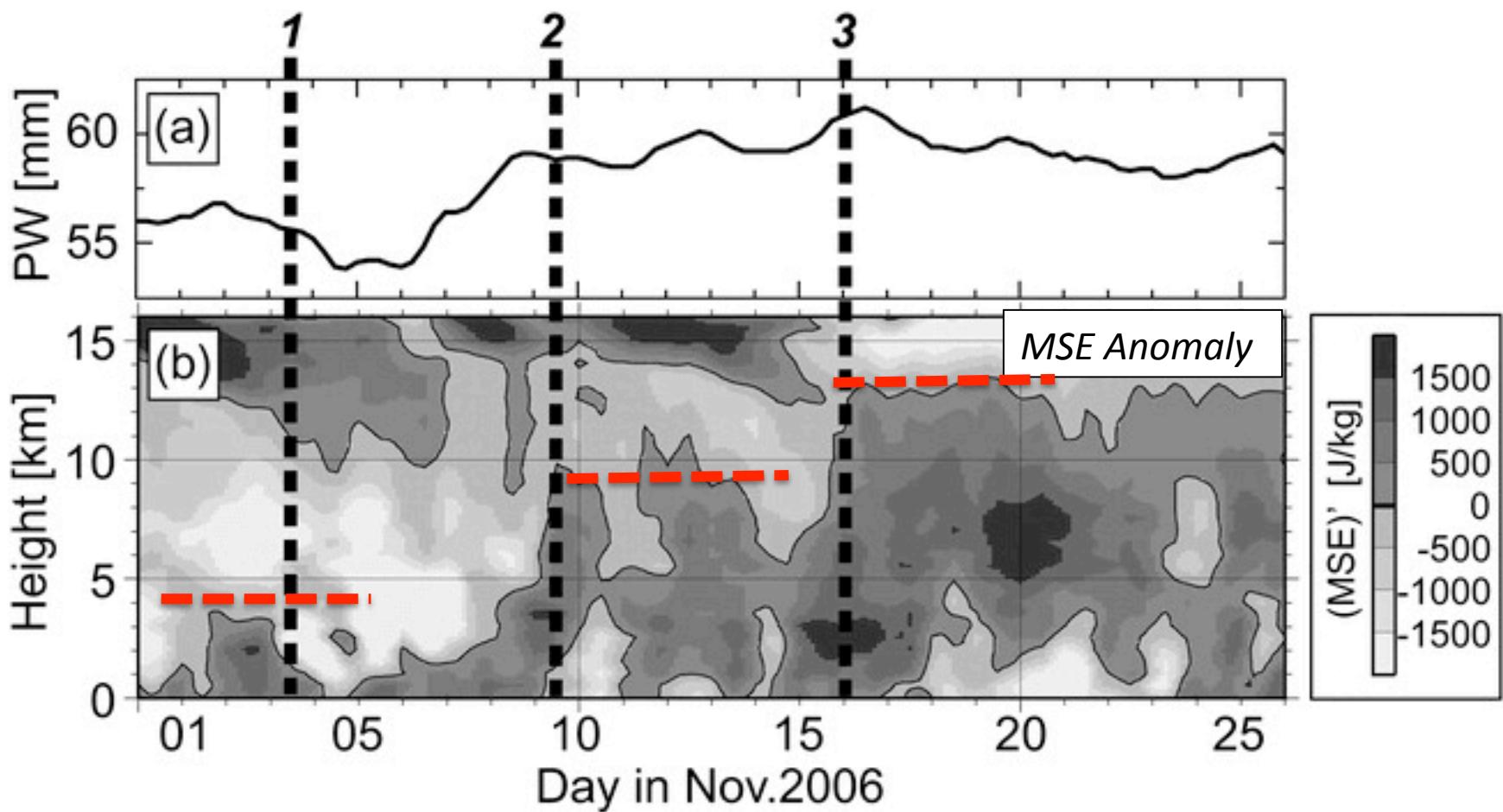
Kikuchi and  
Takayabu (2004)

*Three stages of  
convective  
development and  
associated  
moistening*



# *MISMO 2006, Indian Ocean*

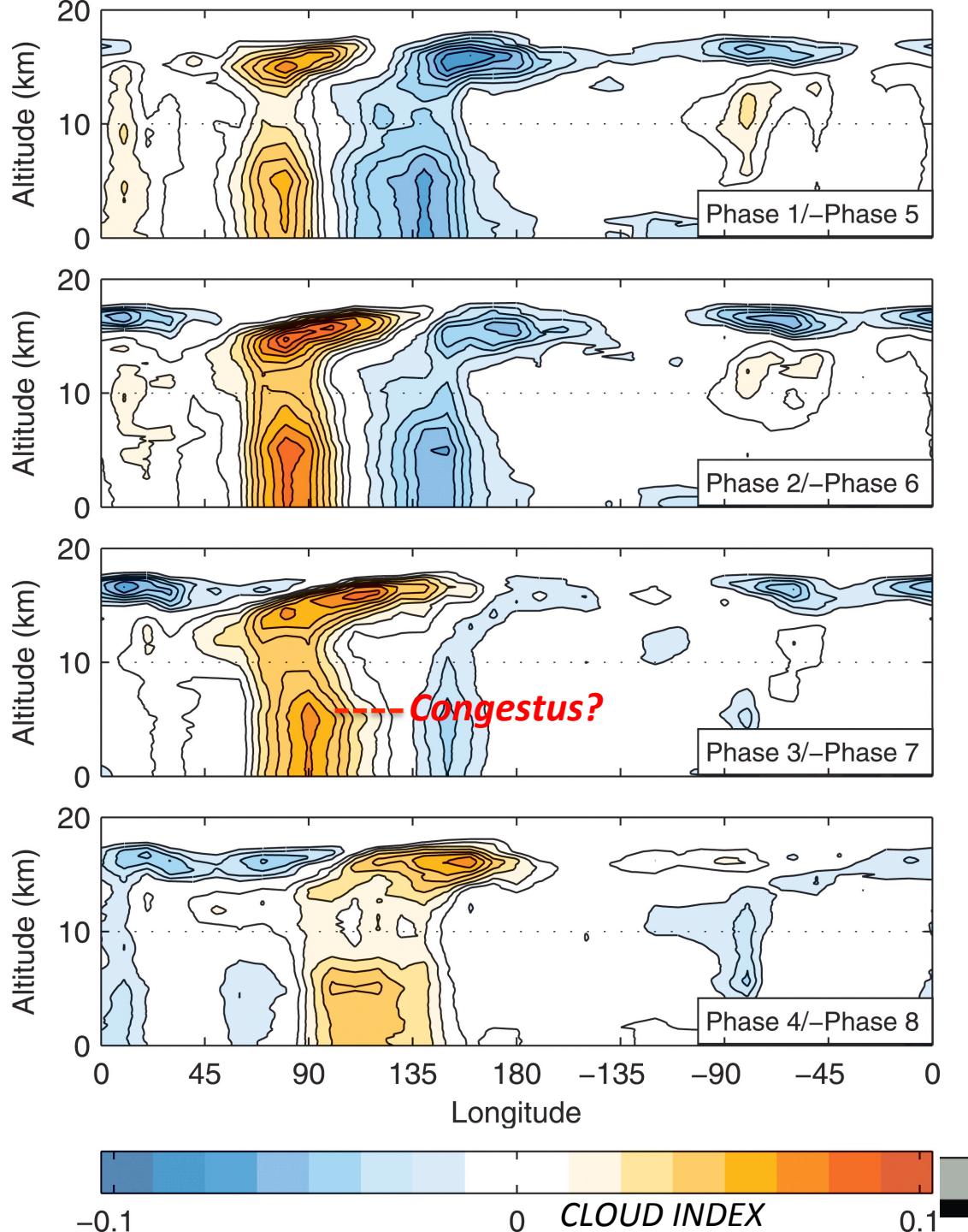
## *“Stepwise” evolution to moisture field*



Katsumata et al. (2009)

## Virts and Wallace (2010)

- ◆ CALIPSO (3 years)  
*height-dependent*  
*cloud index regressed*  
*onto phases of MJO*
- ◆ Cirrus 30° in  
*advance of deep*  
*convection due to*  
*Kelvin wave excited*  
*by MJO*
- ◆ Congestus in Phase  
3?



*Del Genio et al.  
(2012)*

*CloudSat/  
CALIPSO ten MJO  
composite: found  
shallow-to-  
congestus-deep  
transition*

