# *Environmental controls on tropical mesoscale convective system precipitation intensity*

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**AIRS Science Team Meeting**

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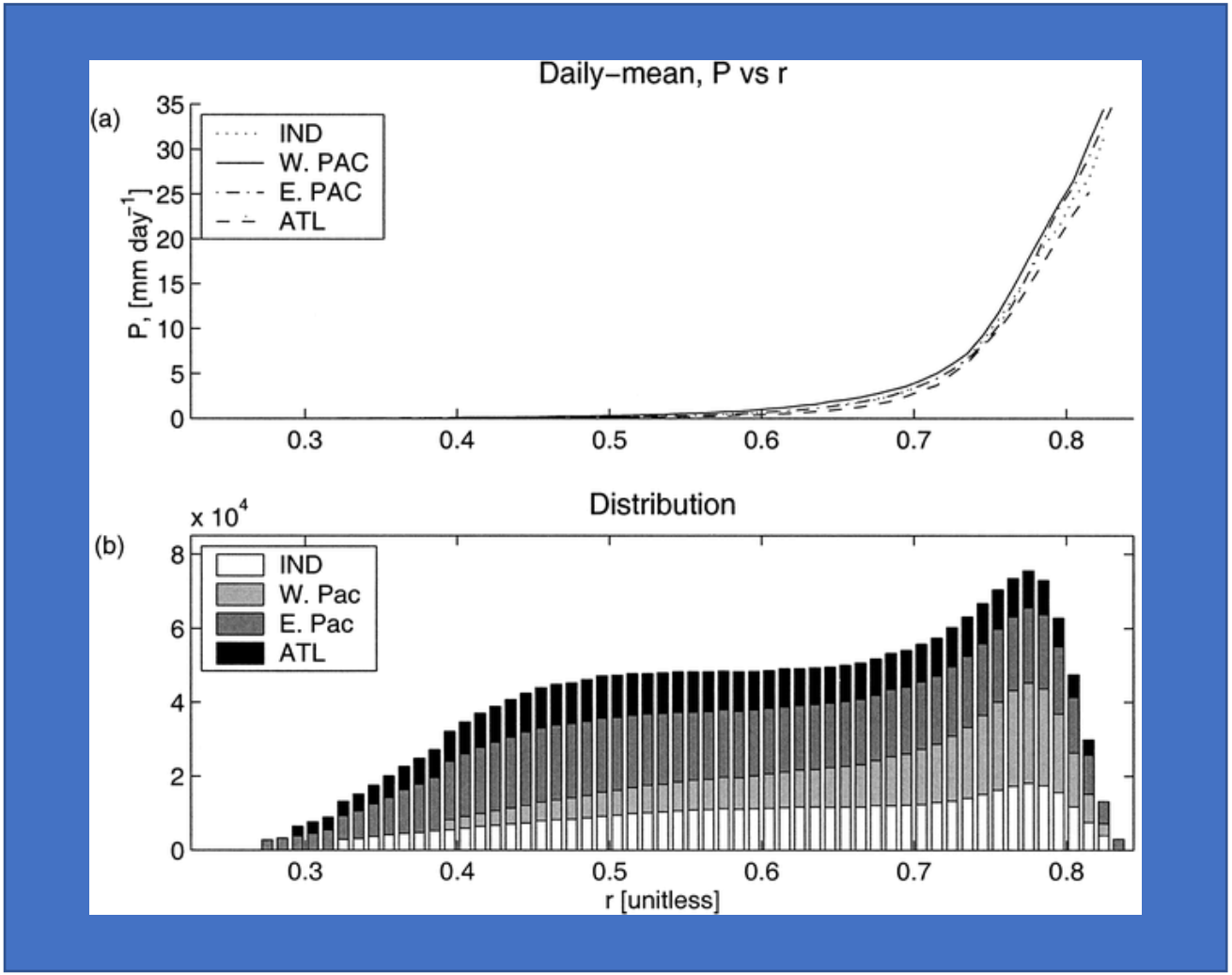
In collaboration with Hui Su (JPL), Greg Elsaesser (GISS), Sylvia Sullivan (KIT), Pierre Gentine (Columbia), Jonathan Jiang (JPL), Yi-Hung Kuo (UCLA), David Neelin (UCLA)

*(Image: © Alexandros Maragos/Getty Images)*

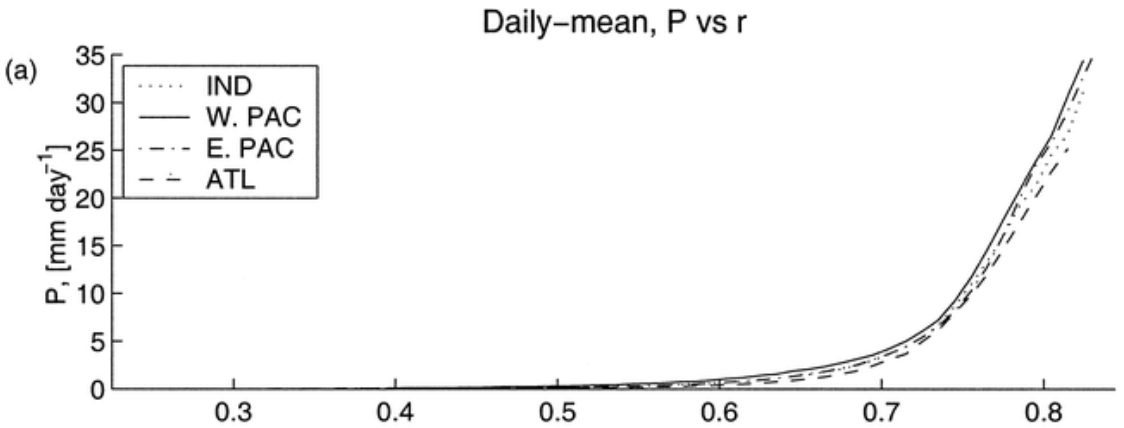
**Acknowledgments**

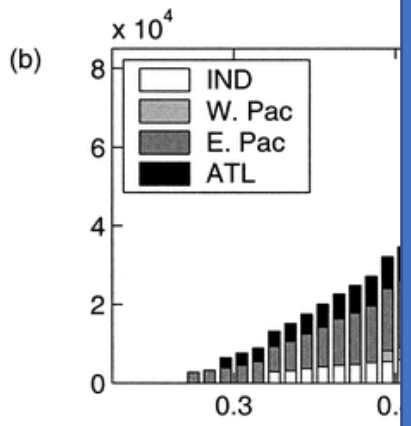
We gratefully acknowledge NASA ROSES Terra/Aqua/SNPP funding
+ support from NASA ROSES NEWS, ACMAP/AST, CCST

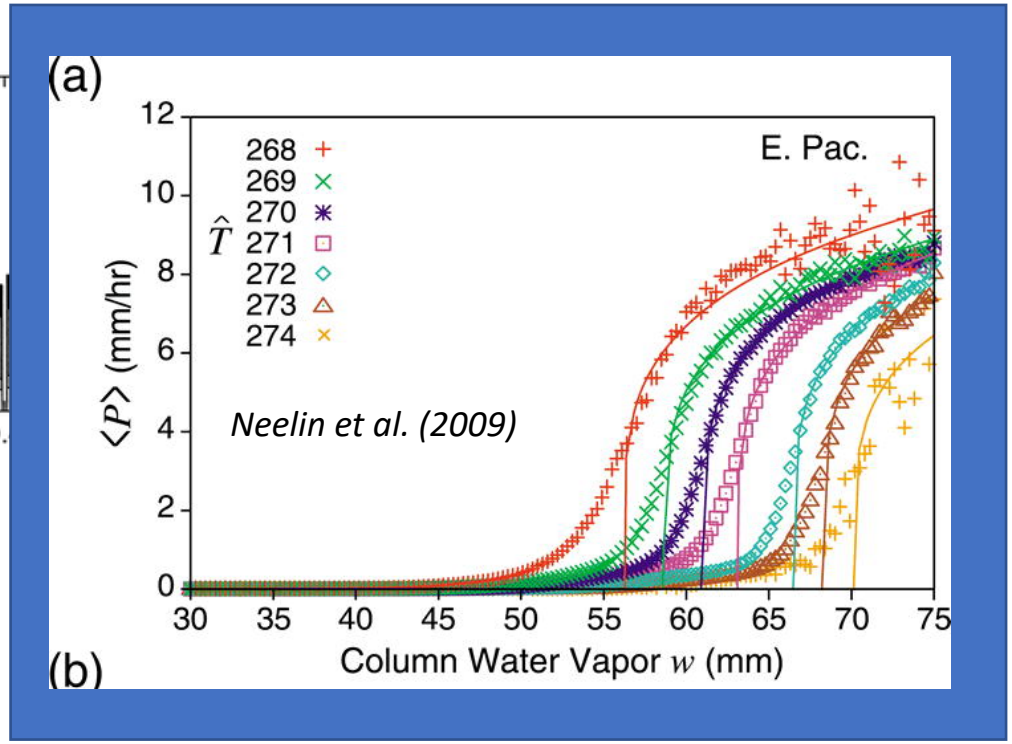
*Bretherton et al. (2004)*

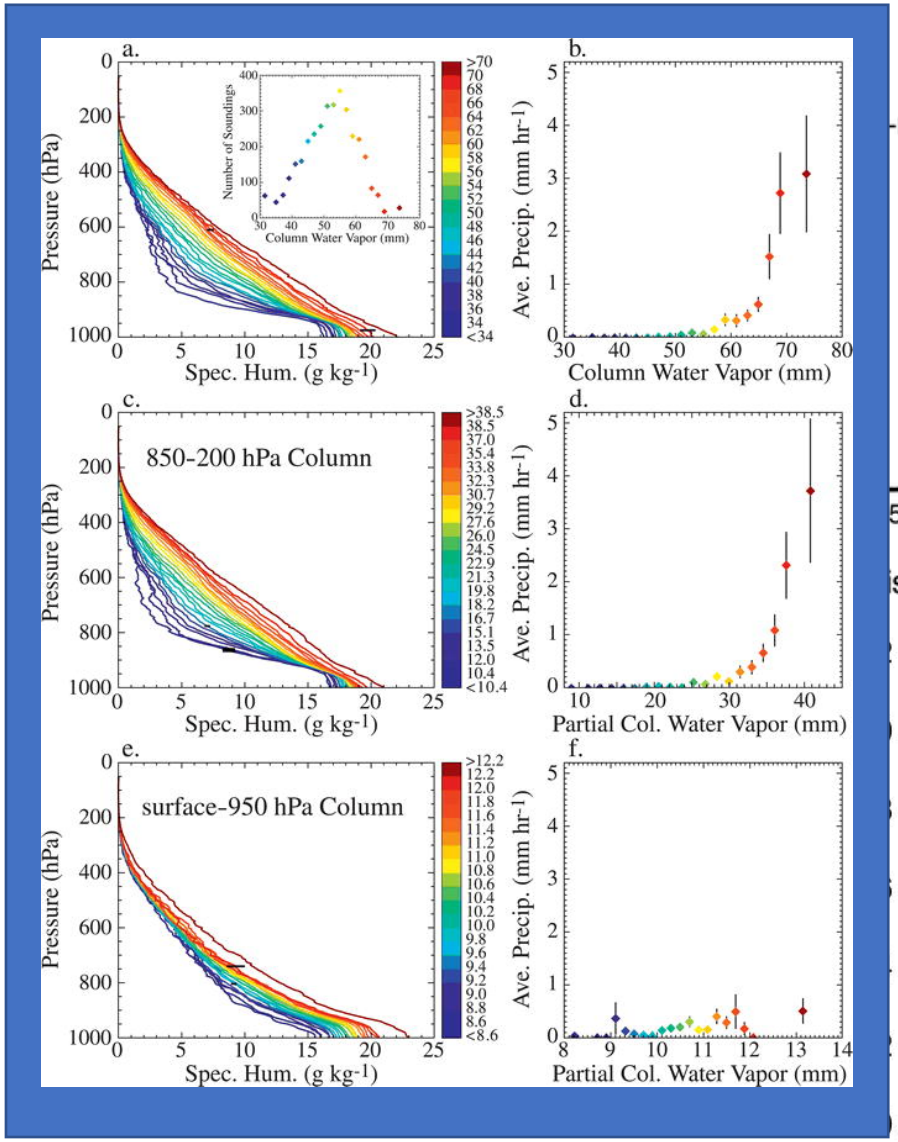


*Bretherton et al. (2004)*



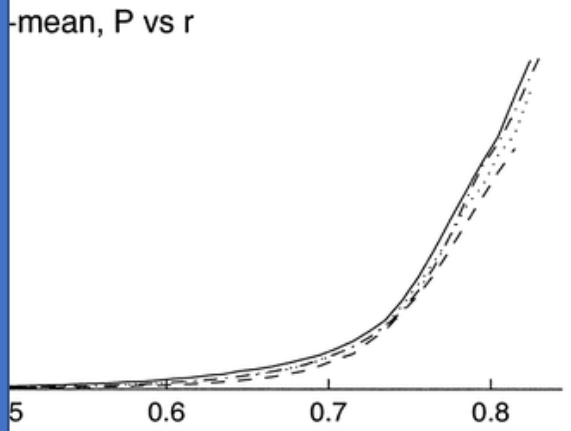



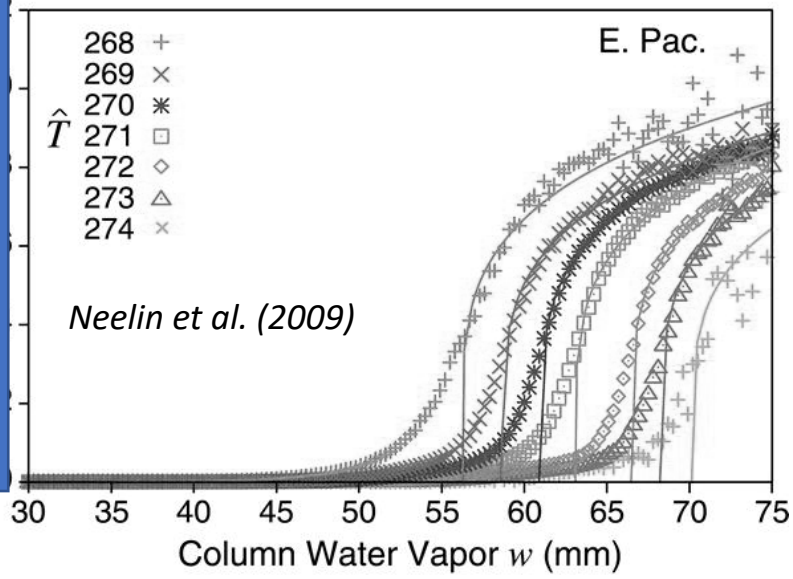



Holloway and Neelin (2009)

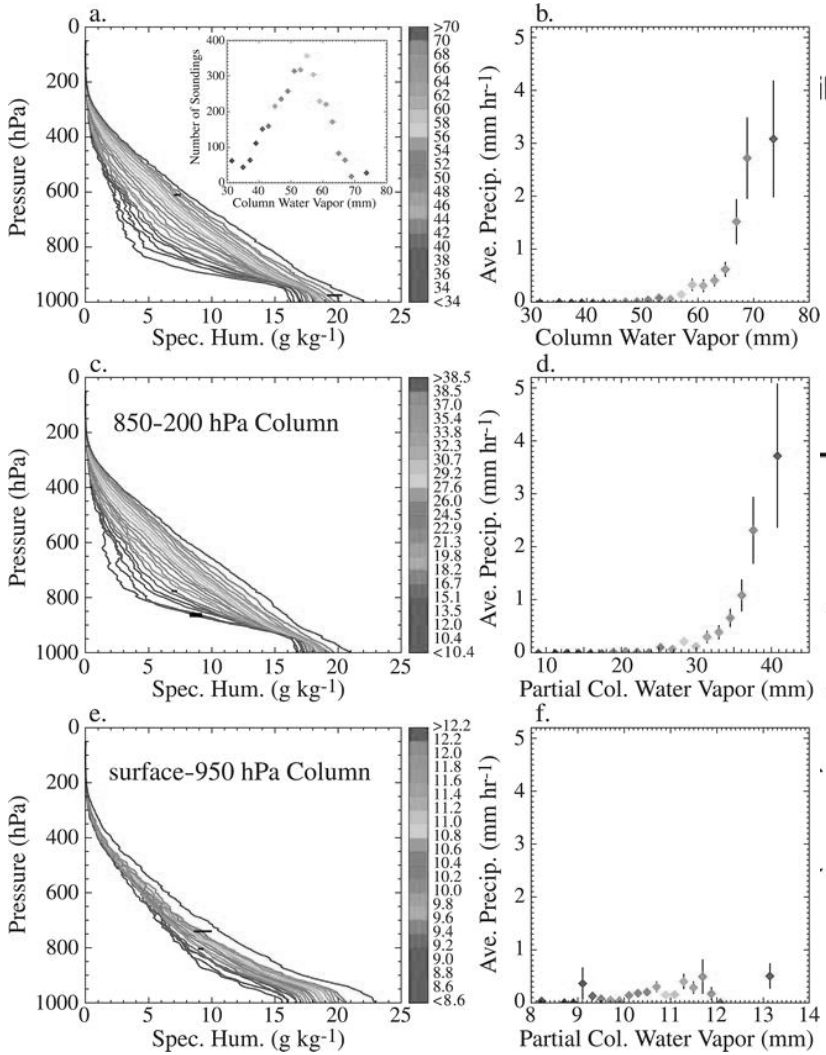
(b)

Bretherton et al. (2004)




Neelin et al. (2009)

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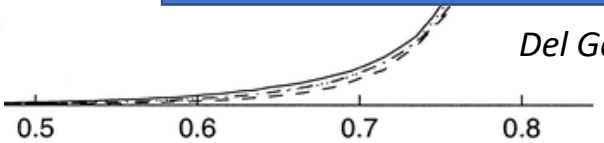
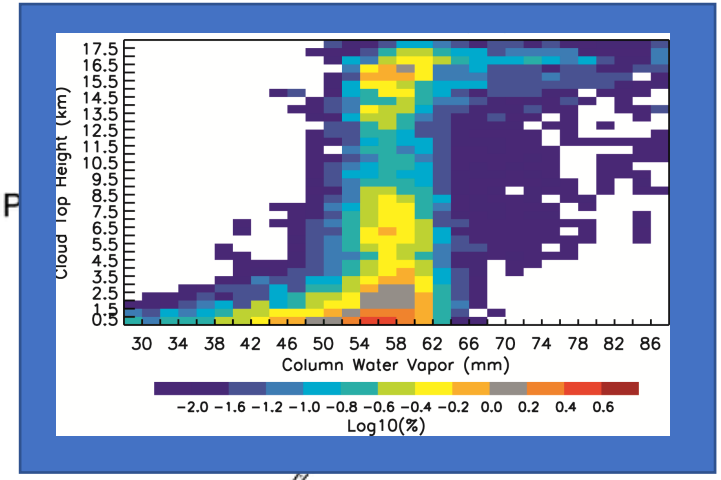
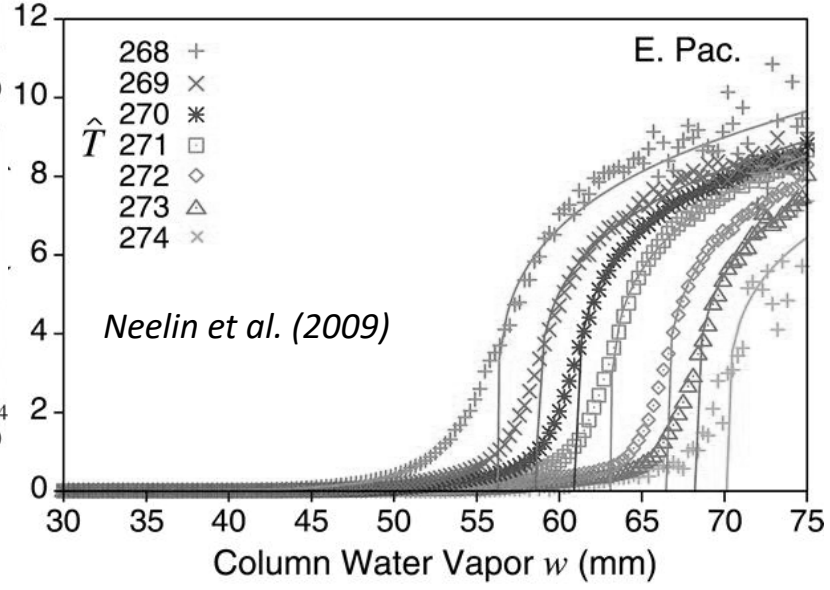



Distribution




Del Genio et al. (2012)

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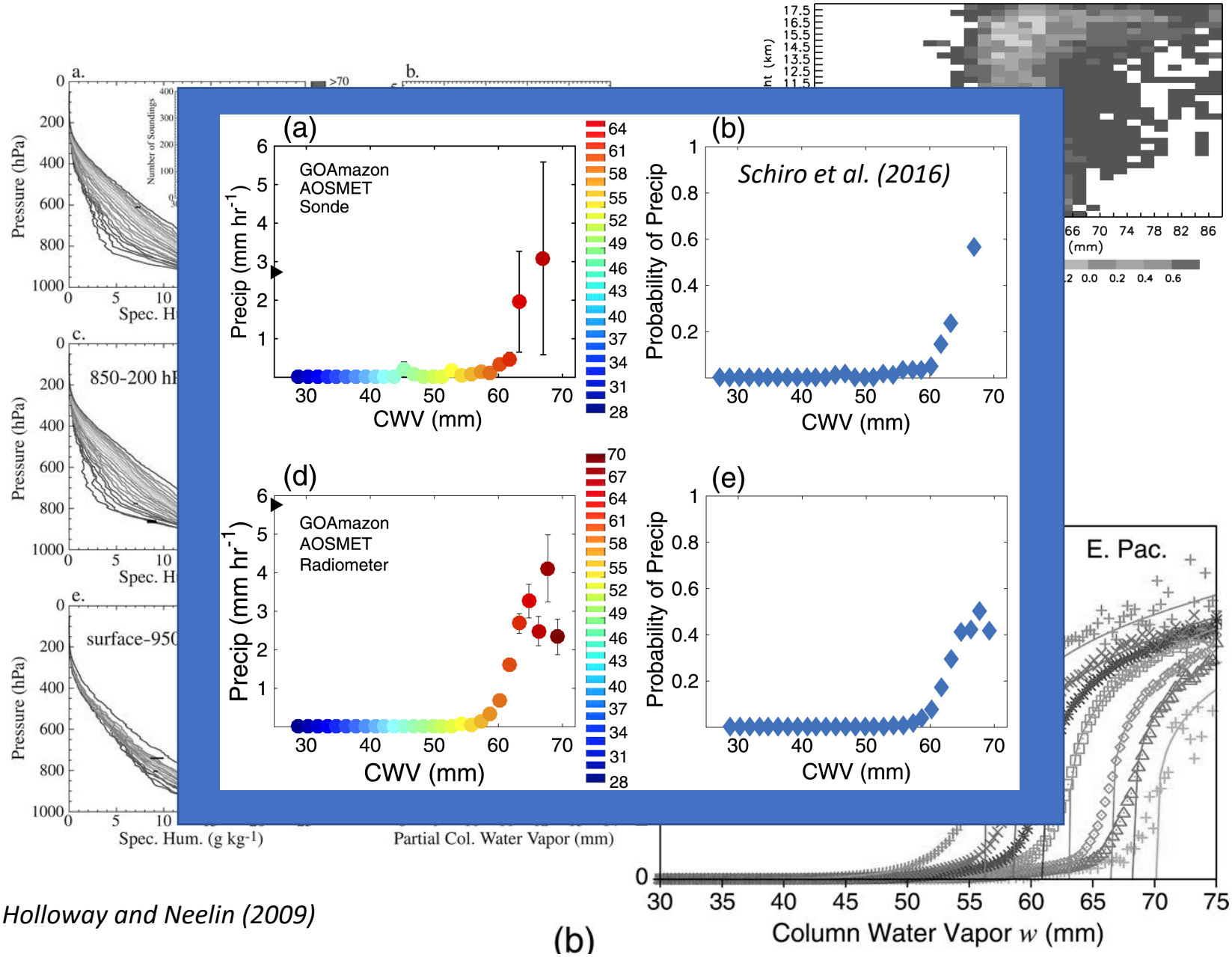



*Holloway and Neelin (2009)*

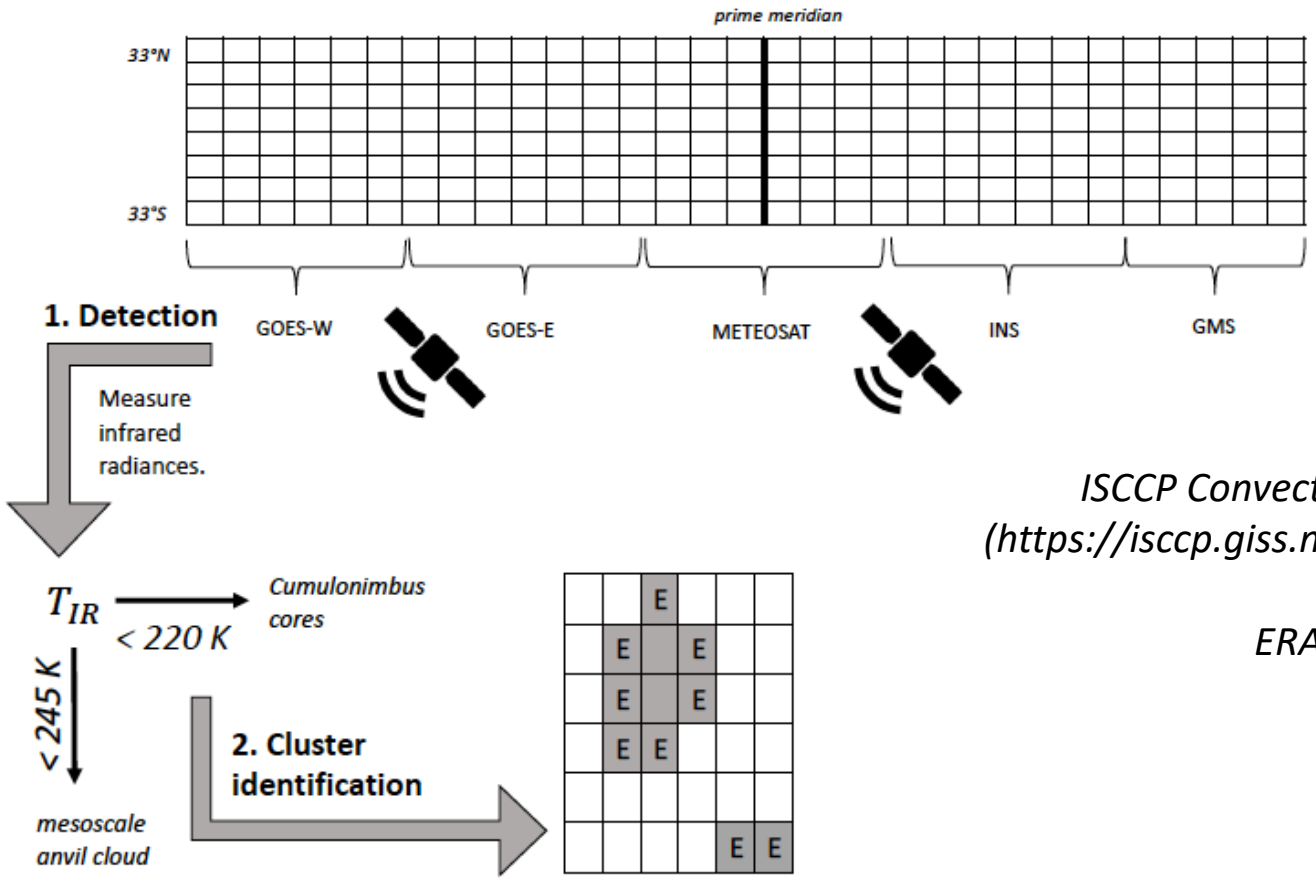
## *Do organized systems interact differently with their environments?*

Photo: NASA

# *What controls tropical MCS precipitation intensity?*

Photo: NASA

# *Data and Methods*




*ISCCP Convective Tracking (https://isccp.giss.nasa.gov/CT)*
*MSWEP*
*ERA-I reanalysis*
*TRMM PR*
*ISCCP B1*
*AIRS*

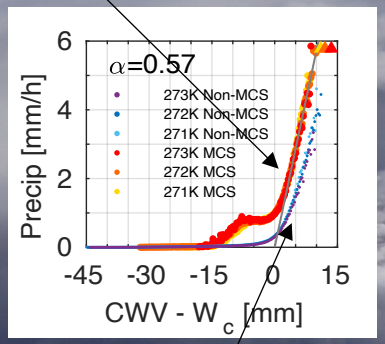
*Sullivan et al. (2019)*

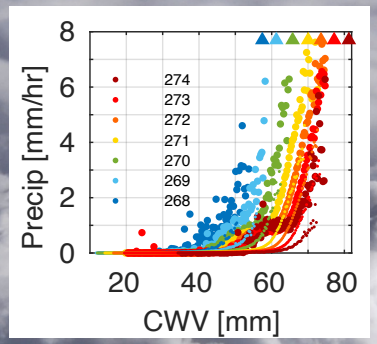
Photo: NASA

# *MCS and non-MCS precipitation strongly dependent on CWV.*

**MCS (large dots)**

Data: TRMM TMI CWV, TRMM PR, ISCCP B1




**non-MCS (small dots)**

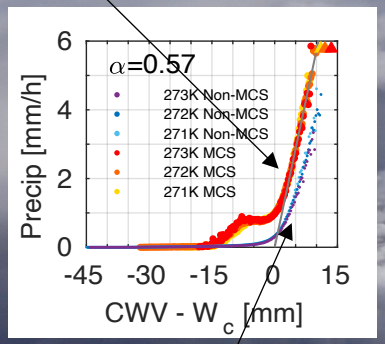
*Schiro et al. (2020, JAS)*

Photo: NASA

# *Larger systems rain more heavily.*

**MCS (large dots)**

Data: TRMM TMI CWV, TRMM PR, ISCCP B1

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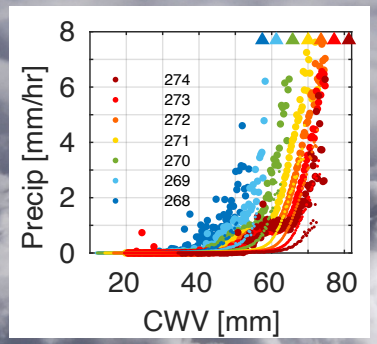


MCS precipitation systematically higher than non-MCS systems for the same thermodynamic environment

*Schiro et al. (2020, JAS)*

Photo: NASA

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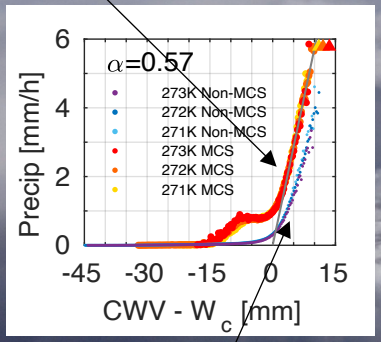


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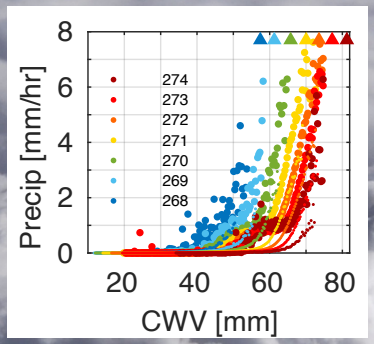


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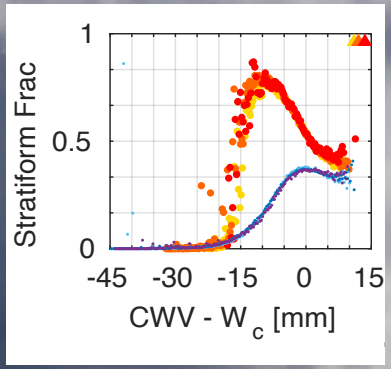


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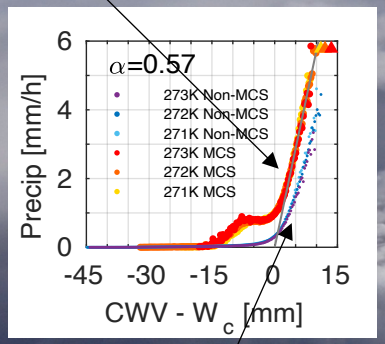


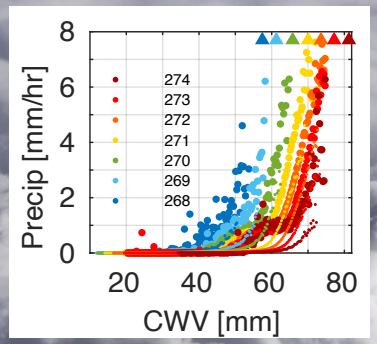


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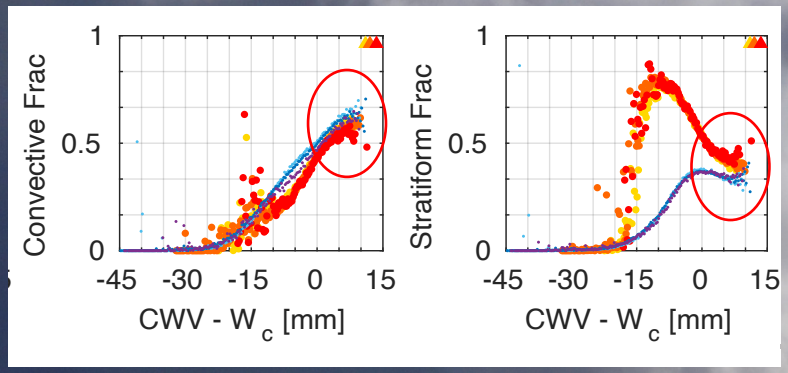


Not because fraction of precipitating points is lower for non-MCS systems

*Schiro et al. (2020, JAS)*

Photo: NASA

# *Larger systems rain more heavily.*

**MCS (large dots)**

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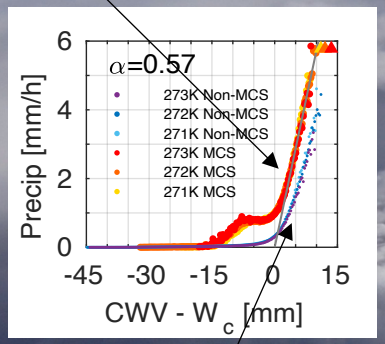


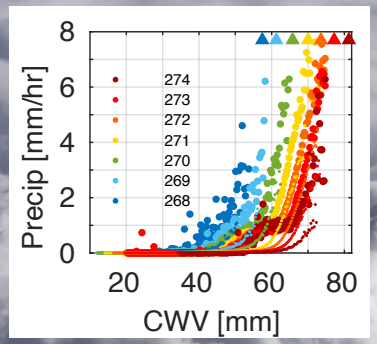


MCS precipitation systematically higher than non-MCS systems for the same thermodynamic environment

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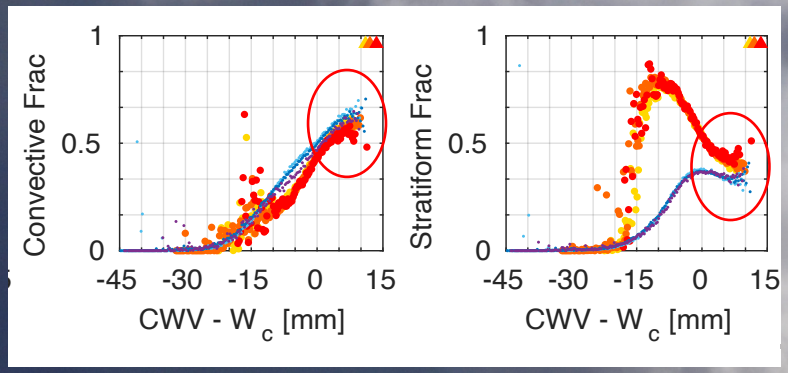


WHY?

Not because fraction of precipitating points is lower for non-MCS systems

*Schiro et al. (2020, JAS)*

Photo: NASA

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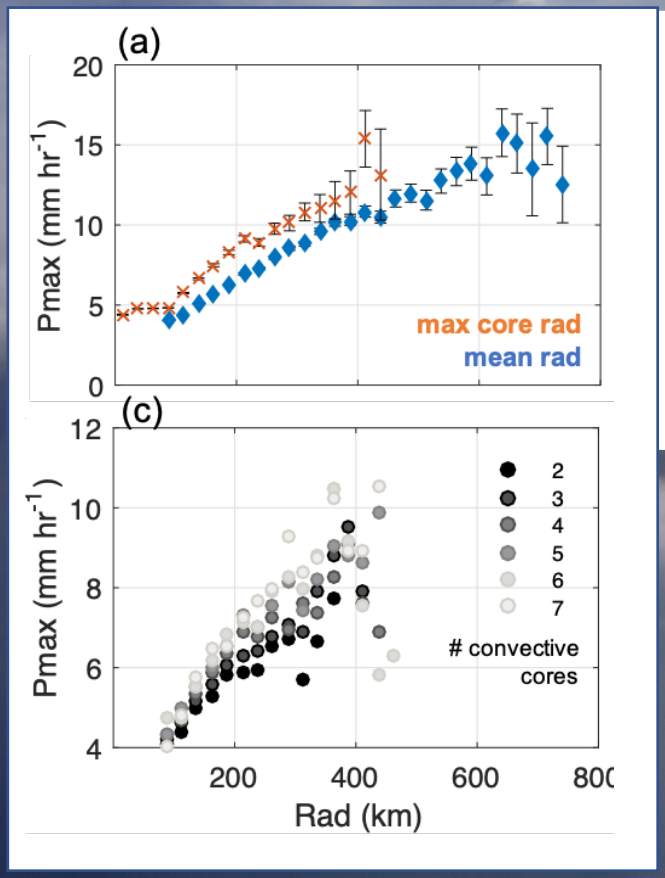
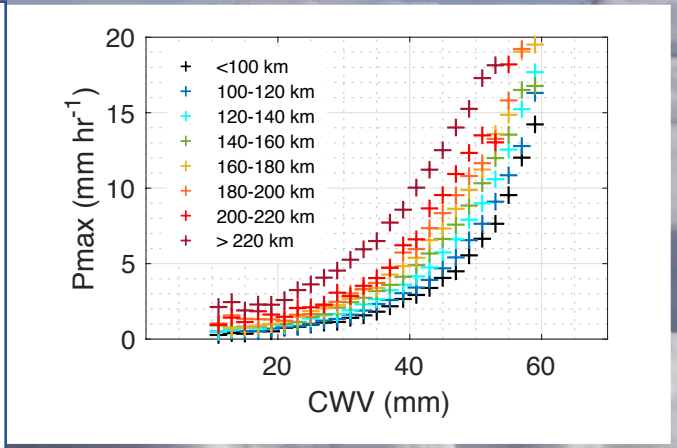


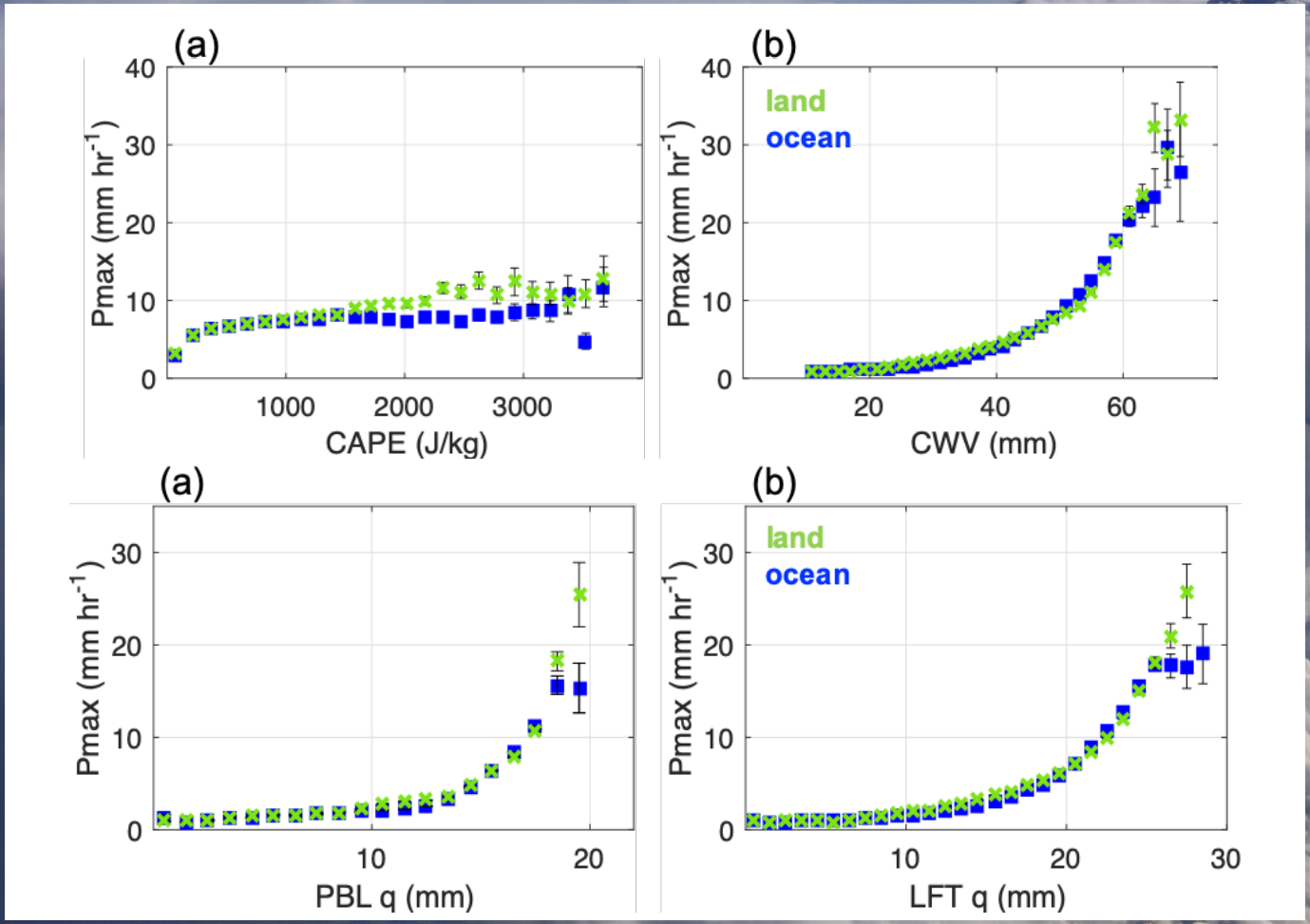

Data: ISCCP Convective Tracking (IR brightness temperature < 245 K to detect convective systems > 90 km radius), MSWEP precipitation

- Greater number of convective cores (**cause**)
- More intense systems may detrain more and create more extensive anvils (**effect**)
- Increasing radius likely reduces dilution due to dry air entrainment and re-evaporation of precipitation (**cause**)

*Schiro et al. (2020, JAS)*

Photo: NASA

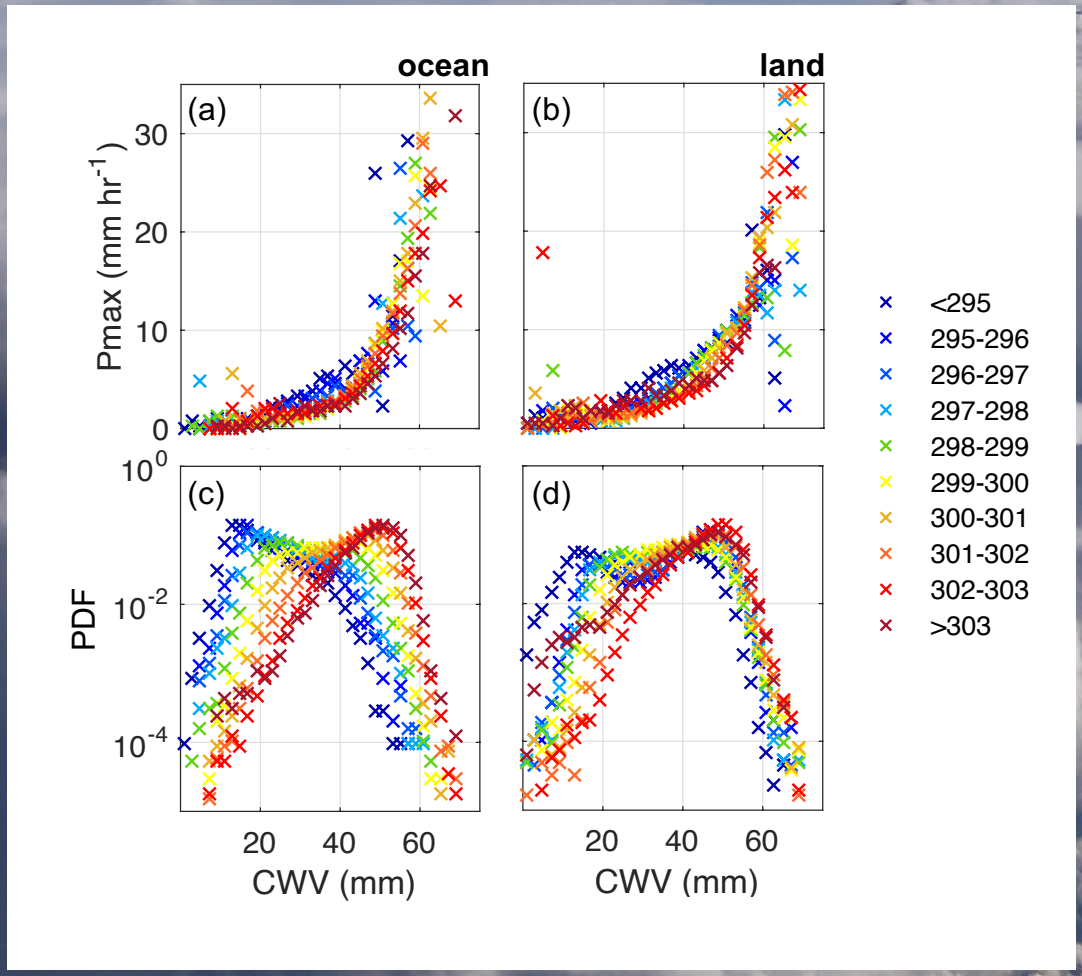
# *Remarkably similar relationships over land and ocean*




*Schiro et al. (2020, JAS)*

Photo: NASA

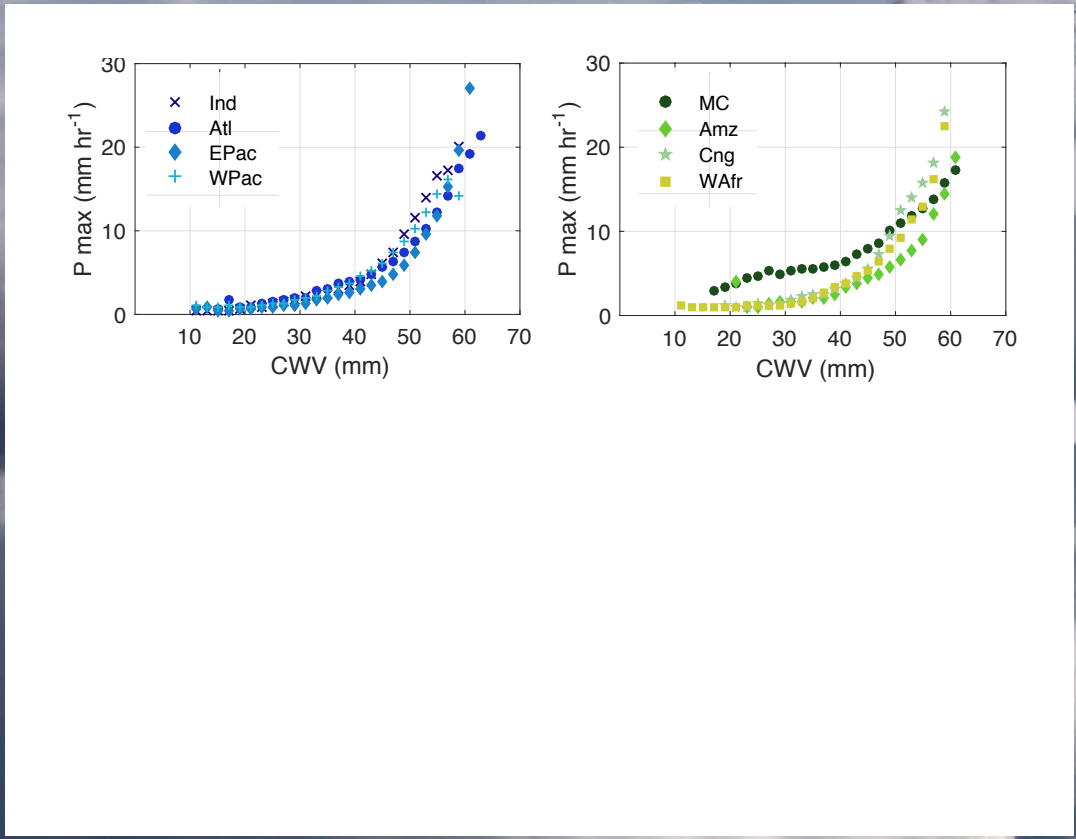
# *CWV-Pmax relationship largely independent of surface temperature*




*Schiro et al. (2020, JAS)*

Photo: NASA

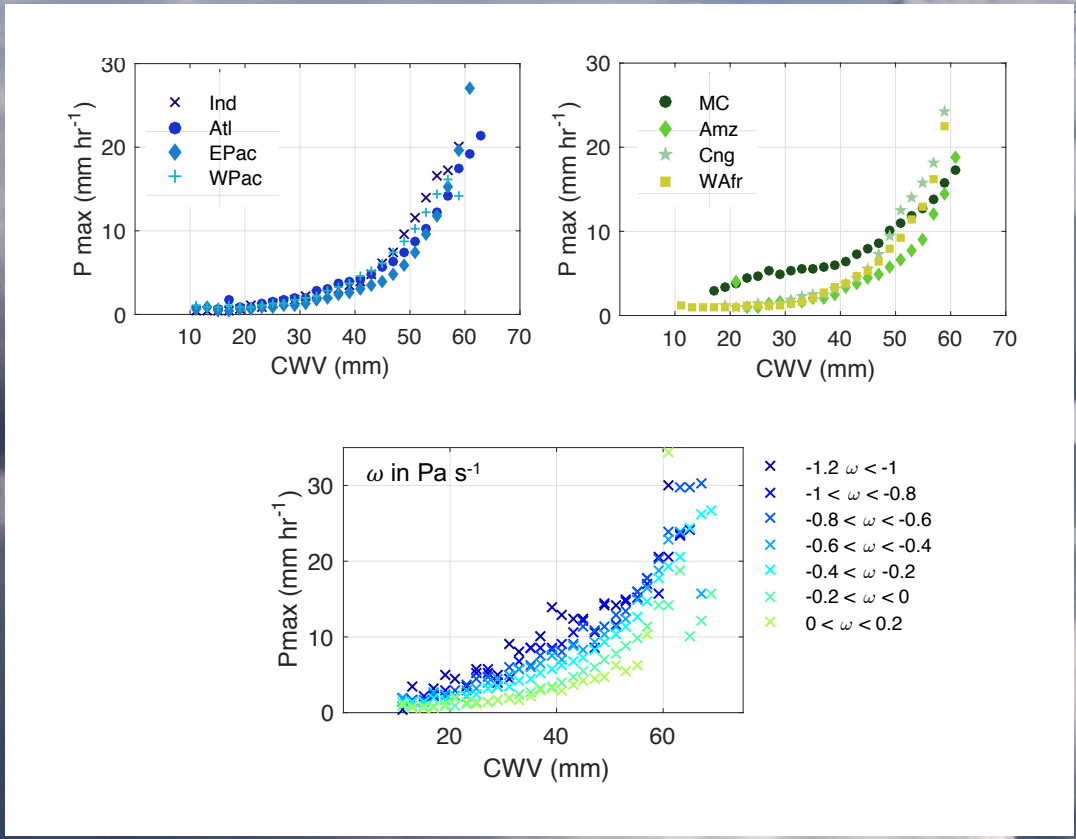
# *Regional differences*




*Schiro et al. (2020, JAS)*

Photo: NASA

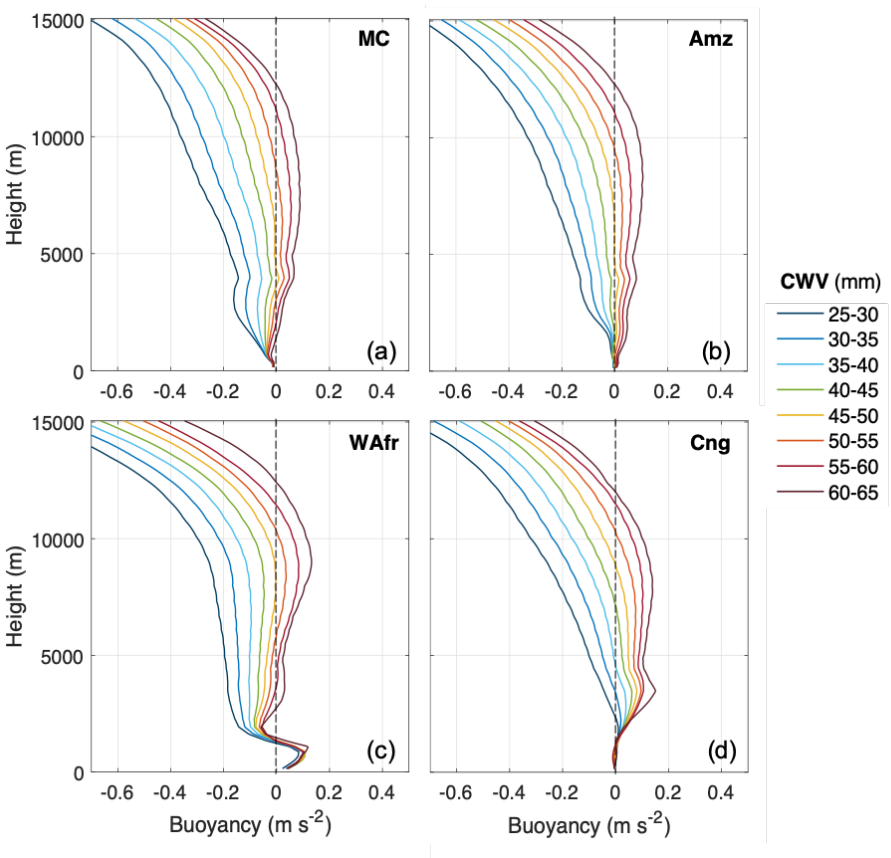
# *Regional differences may be related to large-scale dynamical regime*




*Schiro et al. (2020, JAS)*

Photo: NASA

# *Regional differences may be related to differences in buoyancy*




*Schiro et al. (2020, JAS)*

Photo: NASA

# *What controls tropical MCS precipitation intensity?*

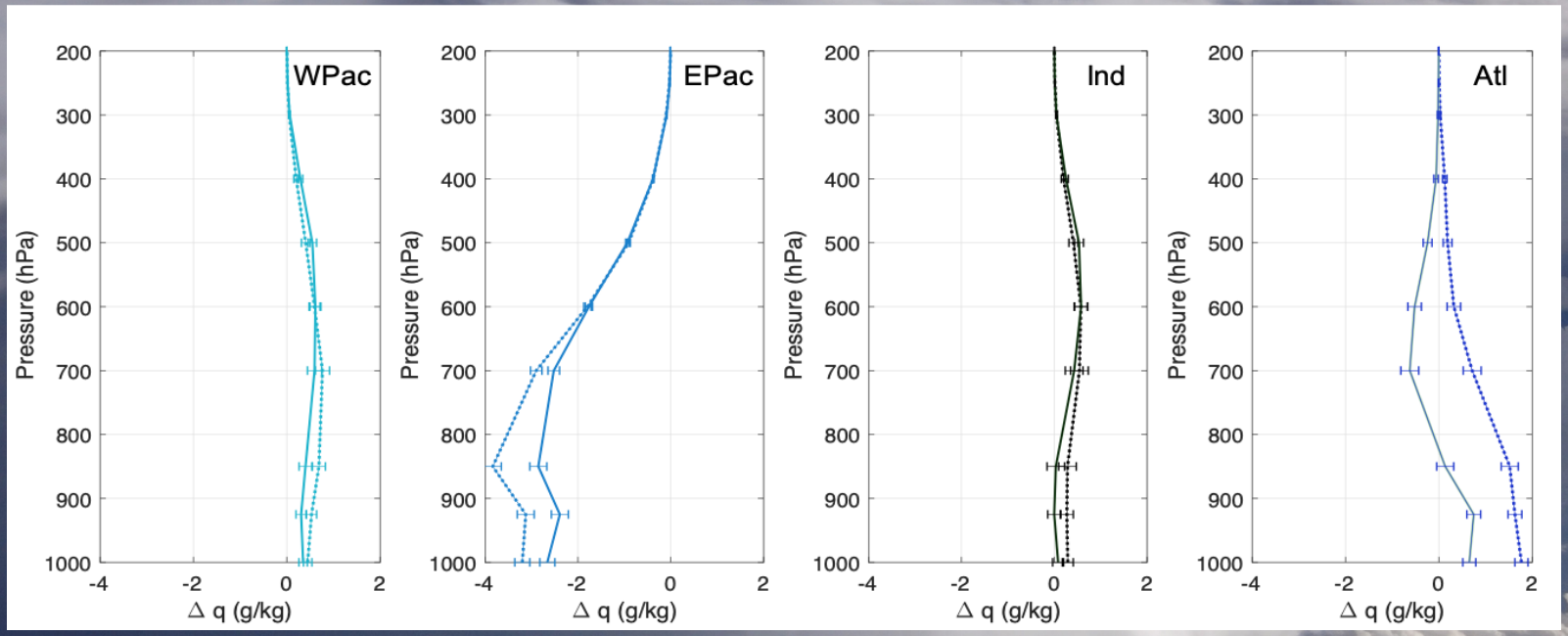
- Total column moisture and buoyancy available to deep convection
- System radius – larger storms rain more intensely
  - larger convective cores = less entrainment into convective cores?
    reduced re-evaporation of precipitation?
- SST does not seem to strongly modify precipitation intensity at local scales
  - It does, however, condition the large-scale environment to favor high moisture and buoyancy

*Schiro, K. A., Sullivan, S. C., Kuo, Y. H., Su, H., Gentine, P., Elsaesser, G. S., Jiang, J. H., & Neelin, J. D. (2020). Environmental controls on tropical mesoscale convective system precipitation intensity. Journal of the Atmospheric Sciences, 1-48.*

Photo: NASA

# *What environmental conditions favor MCSs?*

**Data**: AIRS L3 1° collocated with lat/lon of MCS centroid 6 hours preceding MCS detection

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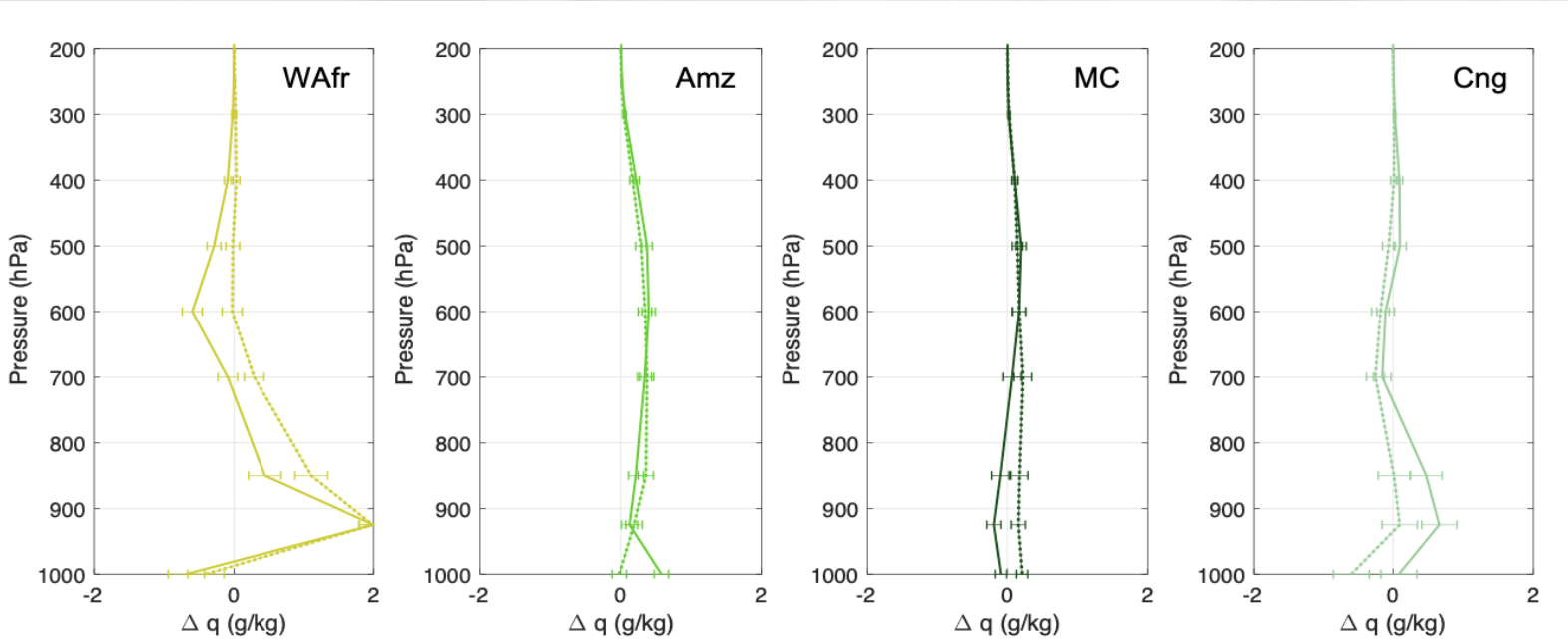


Temporal lead-lag analysis suggests that anomalous moisture in the lower-middle troposphere favors convective organization over most regions

*Schiro et al. (2020, JAS)*

Photo: NASA

# *What environmental conditions favor MCSs?*

- AIRS shows anomalously high moisture in the lower troposphere leading convection in many regions in composites 6 hours preceding convection
  - Magnitudes and vertical structure of the anomalies differ regionally and diurnally

**FUTURE WORK**

- Using AIRS to study the moisture-convection coupling in terms of causality
- How do regional differences in the vertical thermodynamic structure of the atmosphere relate to regional differences in convective characteristics and extreme precipitation?

*Schiro, K. A., Sullivan, S. C., Kuo, Y. H., Su, H., Gentine, P., Elsaesser, G. S., Jiang, J. H., & Neelin, J. D. (2020). Environmental controls on tropical mesoscale convective system precipitation intensity. Journal of the Atmospheric Sciences, 1-48.*

Photo: NASA