Mechanisms of mid-tropospheric moistening and transitions from shallow to deep convection in Madden-Julian Oscillation

Samson M. Hagos, Zhe Feng, Kiranmayi Landu, and Chuck Long

Pacific Northwest NATIONAL LABORATORY

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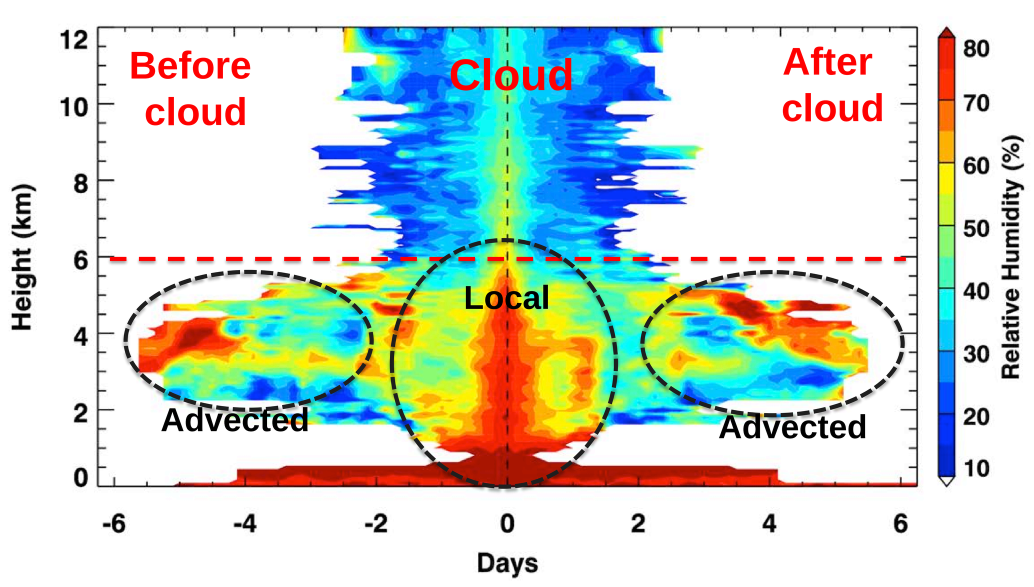
Motivation

- Our lack of understanding and representation of the mechanisms of mid-tropospheric moistening that precede the initiation and eastward propagation of MJO is believed to be the primary factor for the difficulty of simulating it in GCMs.

Objectives

- To identify the processes responsible for the rapid-moistening of the mid-troposphere that leads to large-scale shallow-to-deep transitions using AMIE/DYNAMO observations and high-resolution regional modeling.

Moisture profile and cloud populations observed during AMIE/DYNAMO



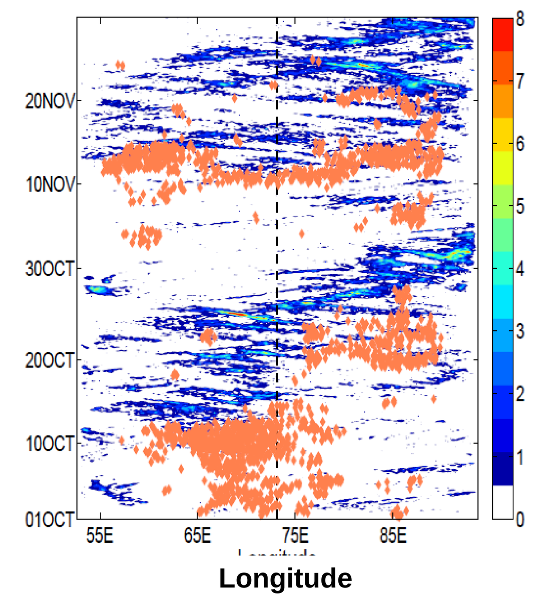
Composite RH with respect to timing of local clouds

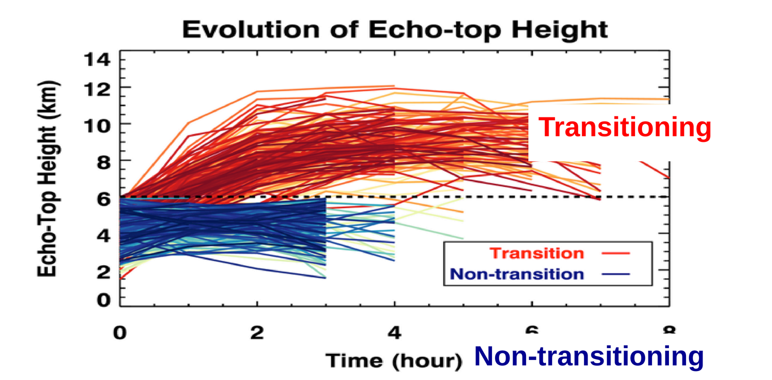
New observations show that moisture detrained from previous convection can stay aloft long enough to be advected by prevailing winds.

Methodology

- Performed a regional cloud permitting model simulation.
- Tracked convective cells that do and do not transition from shallow to deep convection.
- Analyzed the relative humidity profiles preceding the transitioning and non-transitioning cells.

Identification of Convective Transitions

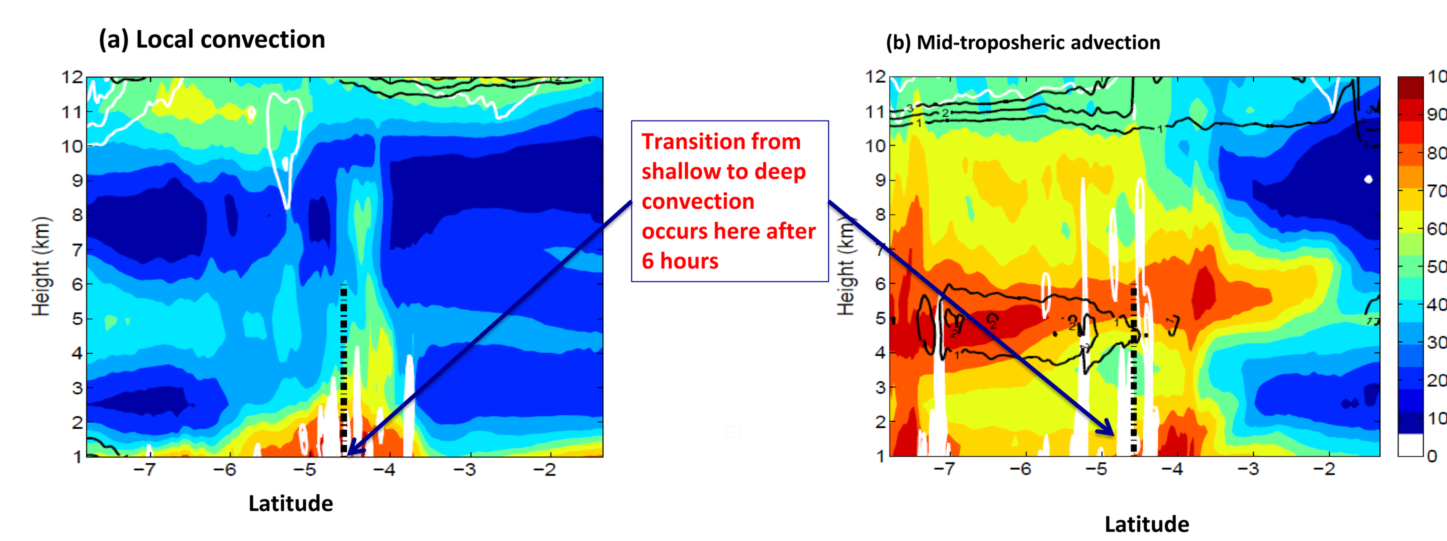




Right : Rain rate (mm/hour) averaged between 5ºS and 5ºN (left) . Location of Transitioning systems (dots).
Top: Evolution of echo-top heights for each tracked convective clusters.

- Identified 2026 transitioning systems and 2553 non-transitioning systems.
- These transitions are associated with both initiation and propagation of the MJO episodes.

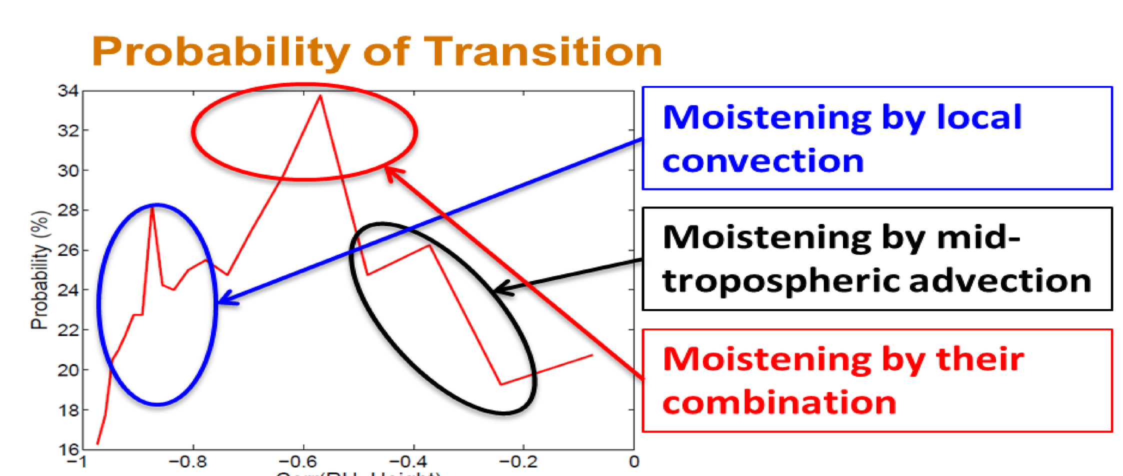
Examples of the mechanisms of moistening



Meridional cross-section of relative humidity (shading), hydrometeor mixing ration “cloudiness” (white contours) and meridional wind (black contours).

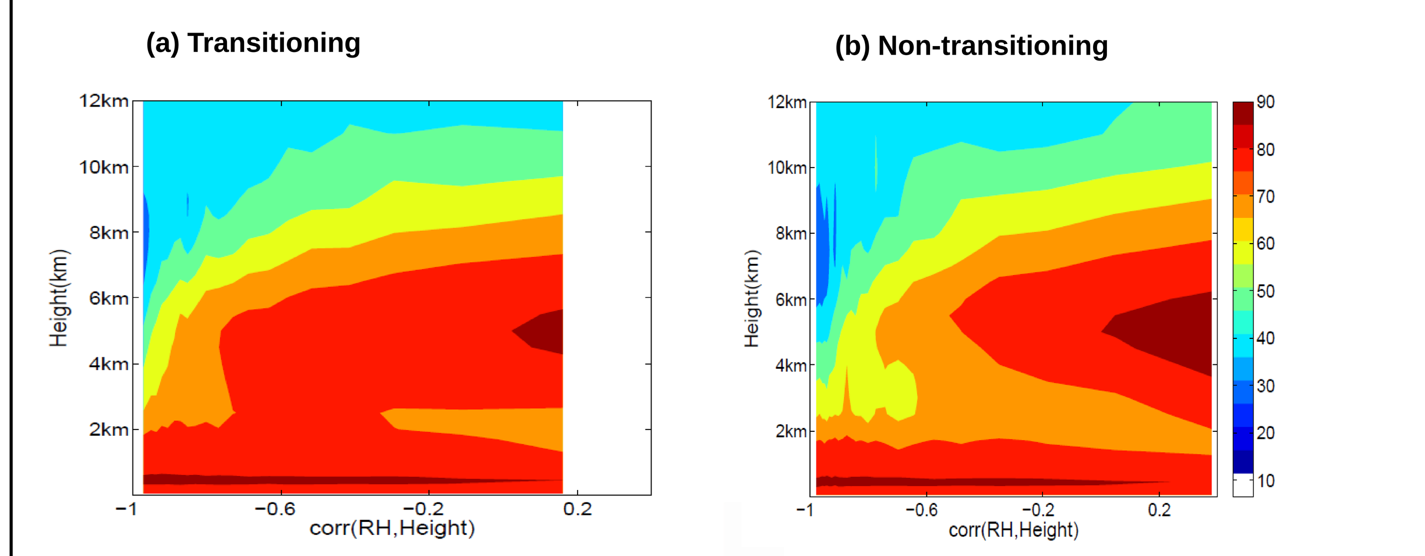
As observed in the AMIE/DYNAMO data, mid-tropospheric moistening can take place due to local convection (from the boundary layer) and by large-scale advection.

Probability of Transition



The likelihood of transitions is highest in the presence of both, but either can suffice.

Profiles of Relative Humidity in Transitioning and Non-transitioning systems

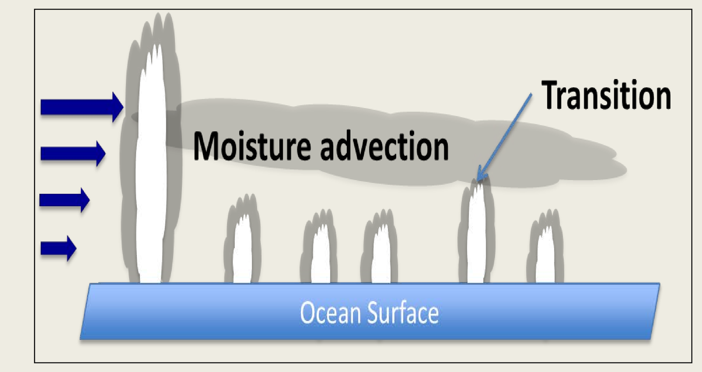


Mean profiles of relative humidity (%) for transitioning systems as a function of their correlation with height six hours earlier.

- Correlation of relative humidity with height is used to identify local convective vs mid-tropospheric moistening.
- Transition to deep convection accelerated when the local convection is deep enough to reach mid-troposphere already moistened by advection.

Summary

- AMIE/DYNAMO field campaign data and regional cloud permitting model simulation are used to identify mechanisms for rapid transitions from shallow to deep convection.
- While local moistening by shallow convection is generally sufficient for shallow to deep transitions, mid-tropospheric advection of moisture detrained from deep convection elsewhere accelerates them.
- **Future Work:** The representation of moistening of mid-troposphere by advection of detrained moisture in GCMs will be examined.



The schematic of the proposed mechanism of transition.

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Atmospheric Systems Research

samson.hagos@pnnl.gov, 509-375-7395

www.pnnl.gov