Convection Initiation and Large-scale Moisture Transport: A Perspective from GPM/IMERG and HAMSR

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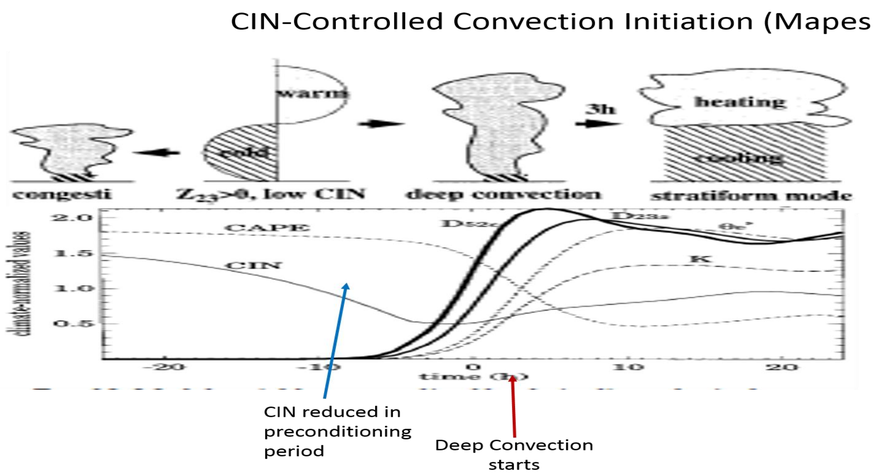
Objectives

- Determine how moist thermodynamic variables in the PBL change before convection occurs
- Analyze tropical storm Cindy's convection development with data from the NASA CPEX campaign

A Theoretical Model by Mapes (JAS 2000)



- A wave propagates to a region
- Lower tropospheric T reduced, congesti formed
- CIN reduced, triggered deep convection

Moisture Advection Ahead of Deep Convection for the Propagation of Tropical Storm Cindy

$$P - E + \frac{\partial Q}{\partial t} = -Q\nabla\cdot\vec{V} - \vec{V}\cdot\nabla Q$$

where

$$Q = \int_{ptop}^{psrf} q\frac{dp}{g}$$

$$\vec{V} = \frac{1}{Q}\int_{ptop}^{psrf}(q\vec{v})\frac{dp}{g}$$

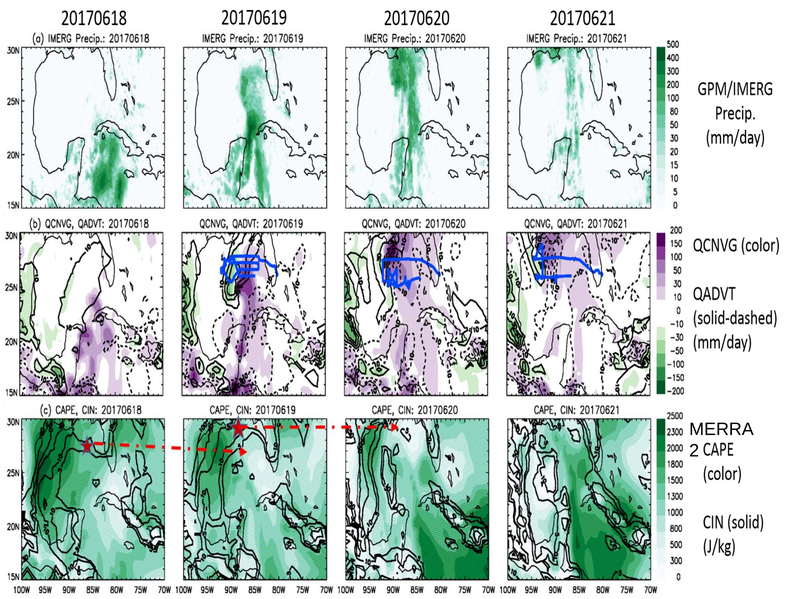
QCNVG

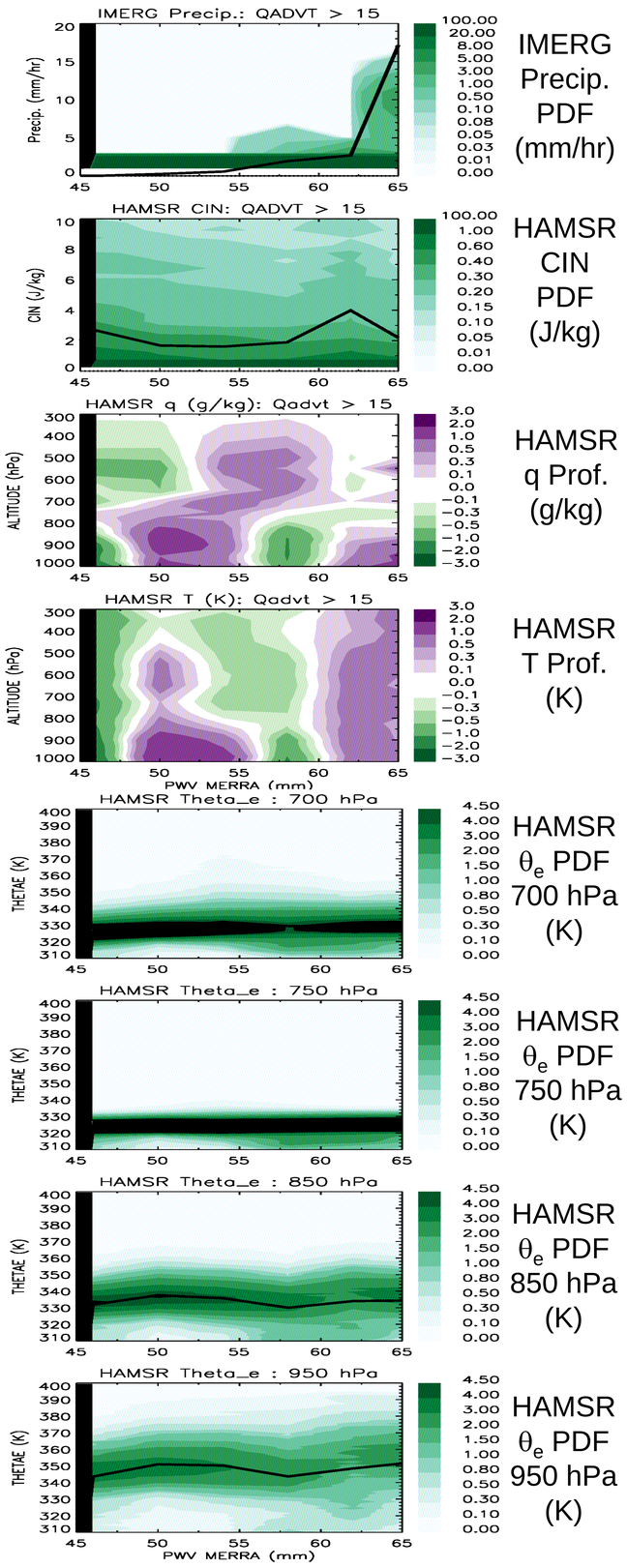
QADVT

Compute using MERRA2

P: Precipitation

E: Evaporation





Choose Regime with QADVT > 15 and Use MERRA2 PWV as Ref.

- CIN is reduced when PWV ~ 50-55 mm
- Cold anomalies begin at the top of PBL and moist anomalies in the PBL
- Precipitation begins when PWV ~55-60 mm
- Cold anomalies move into the PBL and moist anomalies rise to mid-troposphere

θ_e Fluctuation in the PBL

- Widths of the θ_e PDFs begin the spread below ~800 hPa
- Mean θ_e increases with pressure in the PBL, indicating instability
- When precipitation begins (~55-60 mm), cold ends of the PDFs shift to colder θ_e values
- High ends of the PDFs also shift to warm θ_e values

- Heavy precipitation associated with deep convection is collocated with large positive QCNVG
- Before deep convection propagates into an area, there is large positive QADVT in the area signaling preconditioning processes
- In the area with large positive QADVT, CIN is reduced and the moisture tendency ($\partial Q/\partial t$) is positively large
- This area is full of shallow convective clouds

Conclusions

- Large moist advection ($-\mathbf{V}\cdot\nabla Q$) signifies preconditioning and forebode the upcoming occurrence of deep convection
- Convection inhibition decreases with increasing moisture loading during the preconditioning period
- Increases in humidity in the PBL shift upward to mid-troposphere when precipitation begins (Q ~ 50-60 mm)
- Cooling at the top of PBL shift downward to the surface when Q ~ 50-60mm
- Fluctuations of θ_e in the PBL are enhanced when precipitation begins

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