# Necessary and Sufficient Conditions for Tropical Cyclogenesis: Will we get answer from GRIP-PREDICT-IFEX?

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NSF/NCAR PREDICT: Pre-Depression Investigation of Cloud Systems in the Tropics (**P**)
NASA GRIP: Genesis and Rapid Intensification Processes (**G**)
NOAA IFEX: Intensity Forecast Experiment (**I**)

Coincident and consecutive flights provides a high *temporal* and spatial resolution dataset of tropical cyclogenesis and rapid intensification events

1. Describe the time evolution of inner core thermodynamic properties (*All PGI Cases + previous years*)

2. Describe the relationship between deep convective episodes and the time evolution of the thermodynamic characteristics of the developing inner core (*Karl and Matthew*)
   - Is the developing disturbance moistened as a result of deep convection?
   - What ultimately determines the fate of the disturbance?

Synthesize in-situ (dropsonde) data from all P-G-I and USAF aircraft, conventional IR data, as well data from numerous passive microwave instruments

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2. Describe the differences between developing and non-developing disturbances

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# Data and Methodology

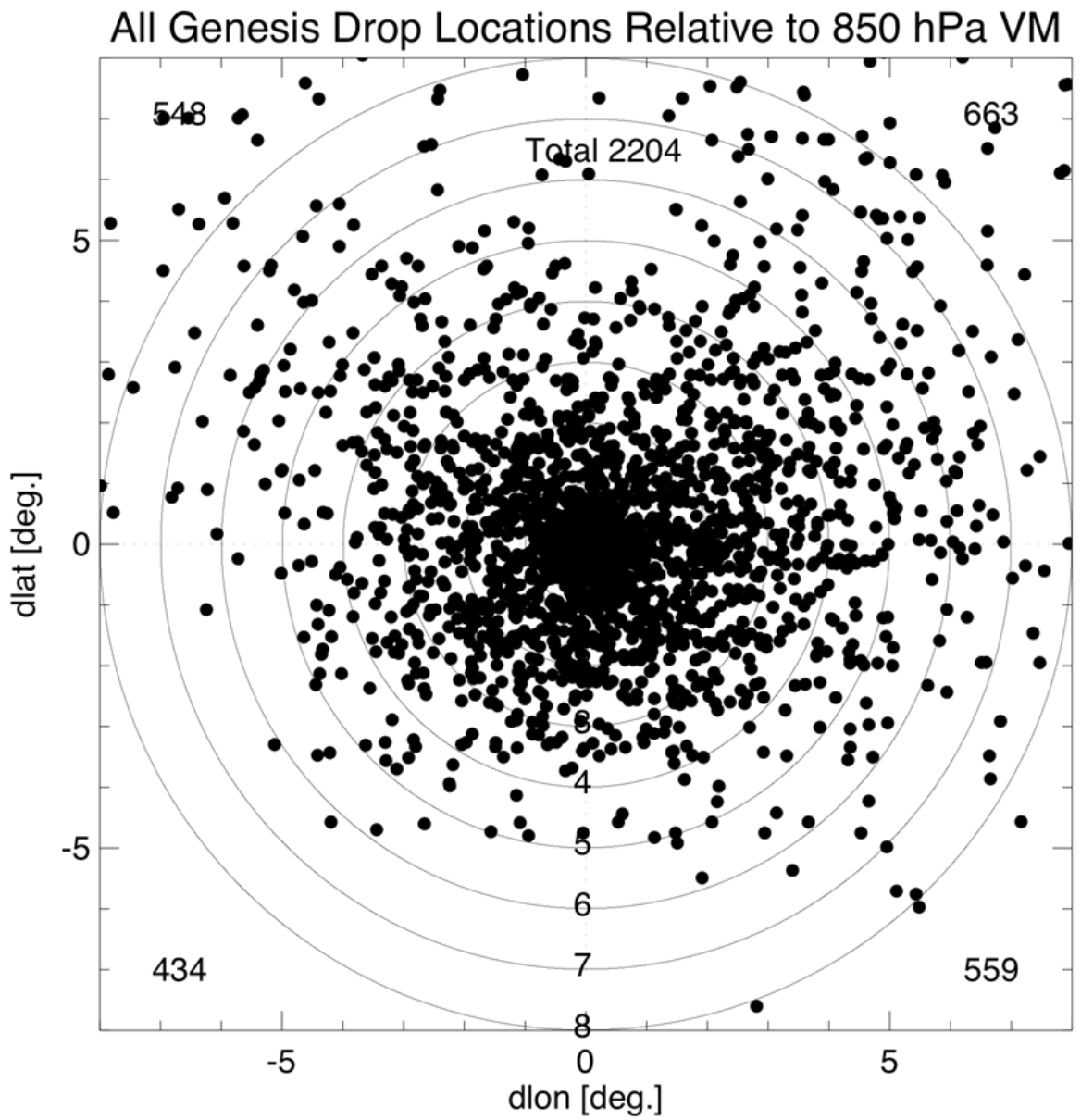
Manually tracked 925, 850, 700, 600 hPa vorticity maxima (VM)
In NCEP FNL analysis
– all analyses based on 850 hPa VM

**1. Dropsonde Dataset**

- All 1700 PGI and USAF drops included – both DEV & NDEV
- Also: Gert (2005), Nuri (2008), Fay (2008), Kyle (2010), Danny (2009), TD02 (2010), Bonnie (2010)….and more to come.
- **TOTAL: 2546**
- Interpolated to 17 pressure levels
- All drops before/after genesis included
- p, z, T, $T_d$, $T_v$, θ, $θ_e$, $θ_v$, $θ_{es}$, RH, w, $w_s$, q, u-, v-wind, wind dir/spd
- Time before/after genesis (NHC TD classification)
- Radial distance from 850 hPa VM (pouch) center
- Includes coincident NCEP FNL model analysis and NCEP/NCAR reanalysis profile – time/space correction with zonal phase speed of wave

How well does the model (re)-analysis represent the genesis environment?

# Data and Methodology



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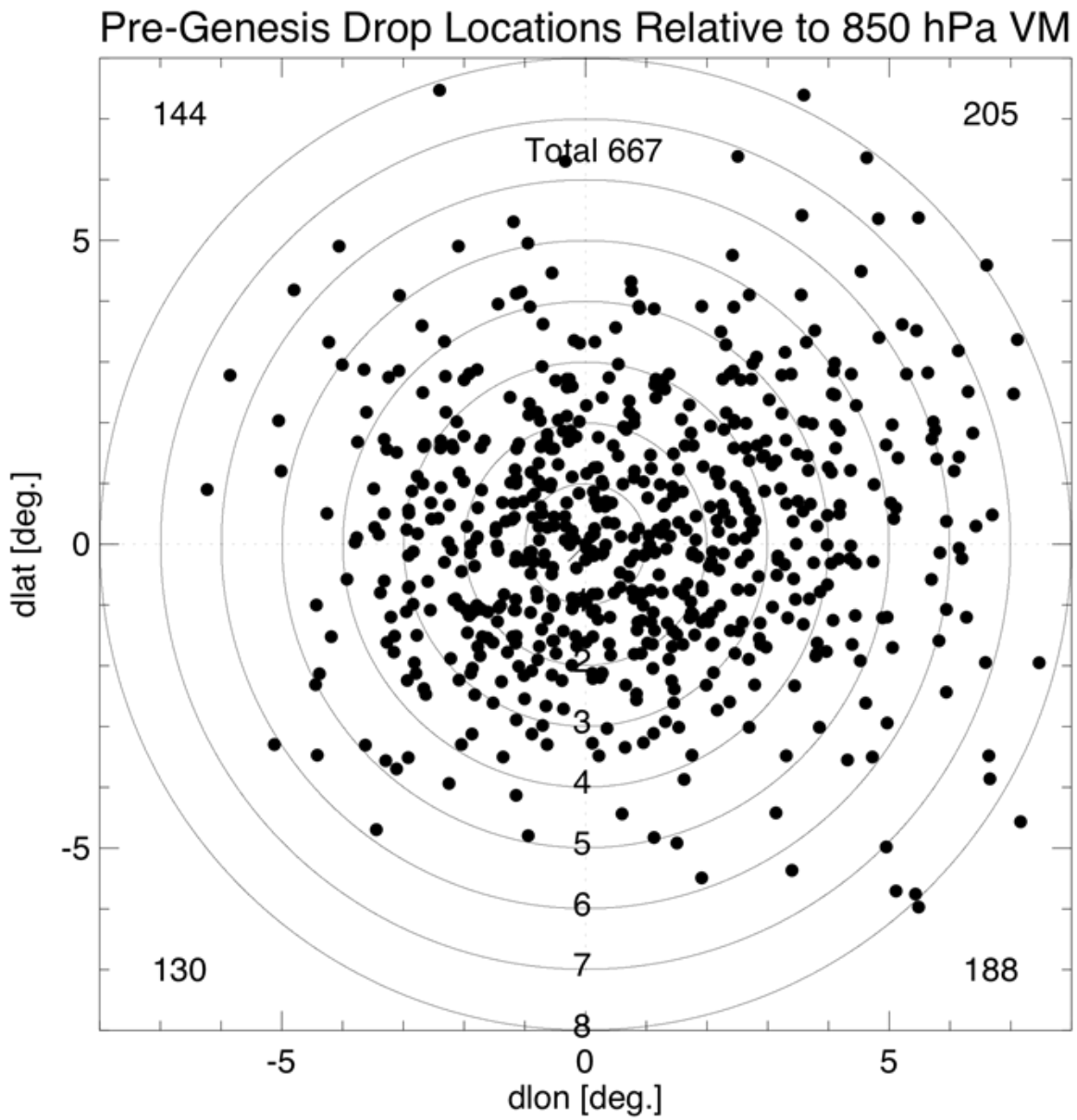

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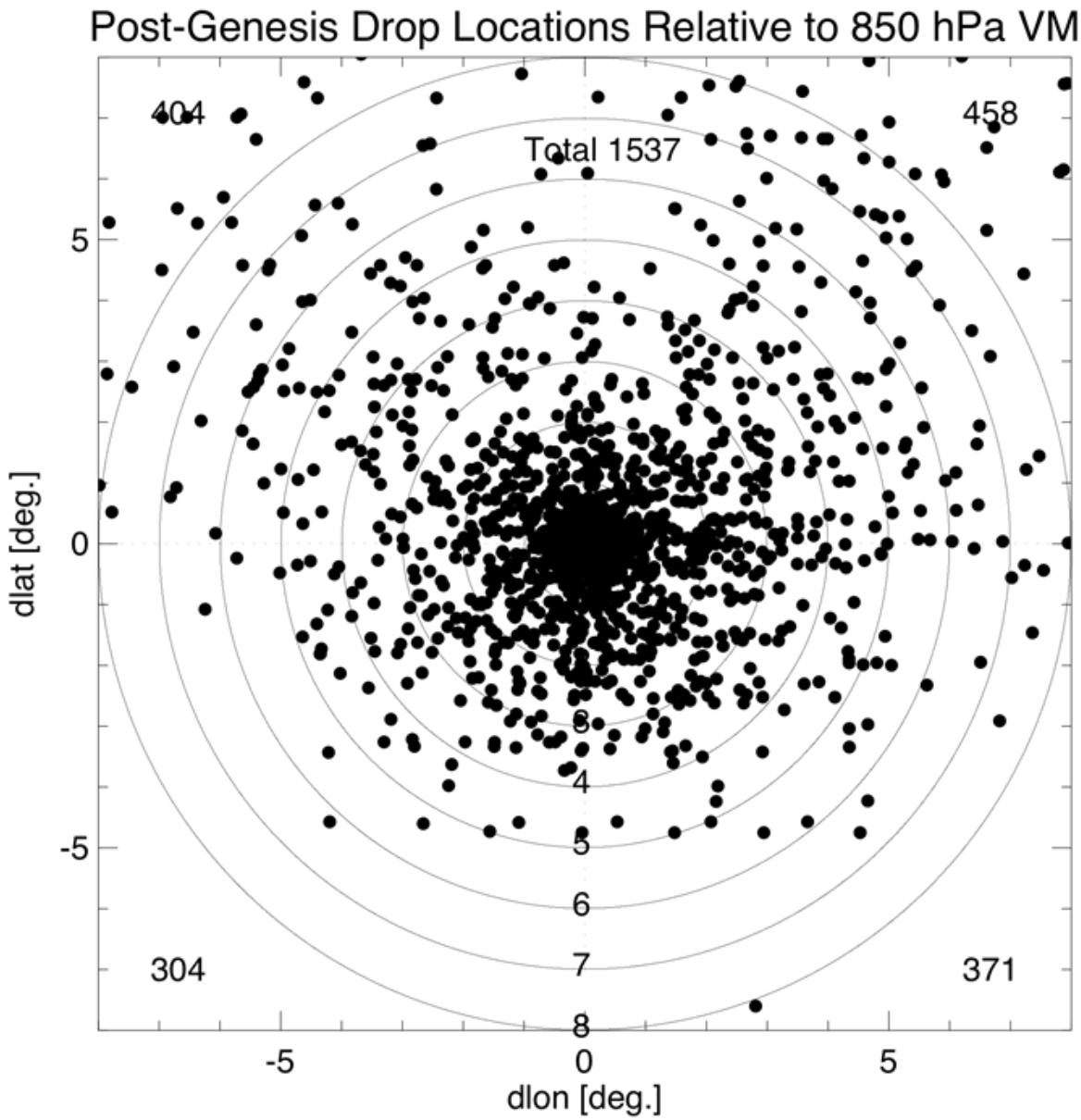
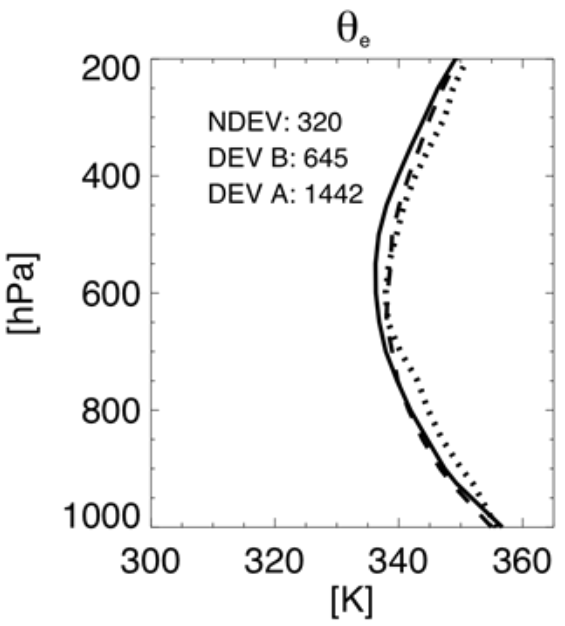
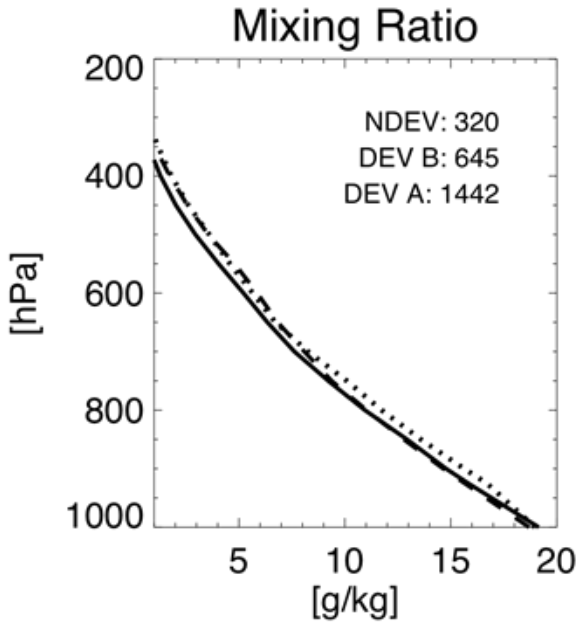
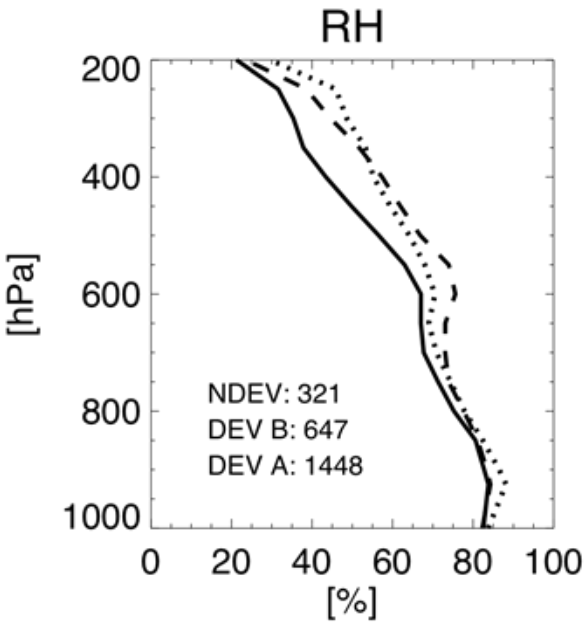
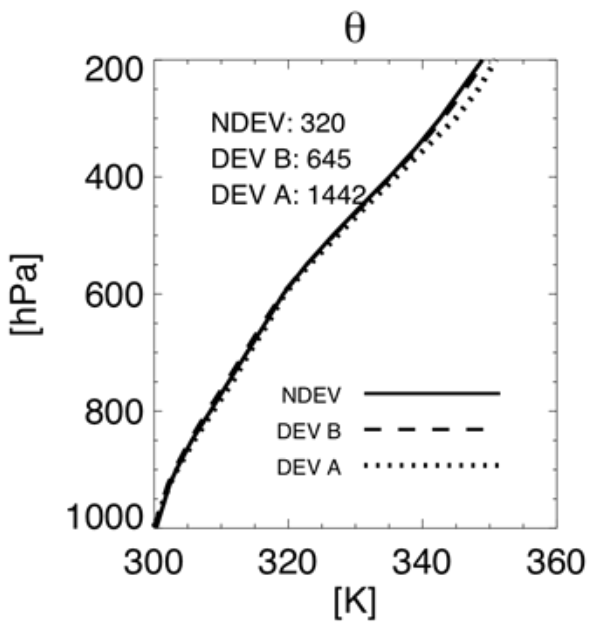


# Developing vs. Non-developing




## Moisture

- DEV B and DEV A have higher midlevel $\theta_e$ – *moisture* – than NDEV
- DEV A has higher low level $\theta_e$ – *moisture* – than DEV B & NDEV

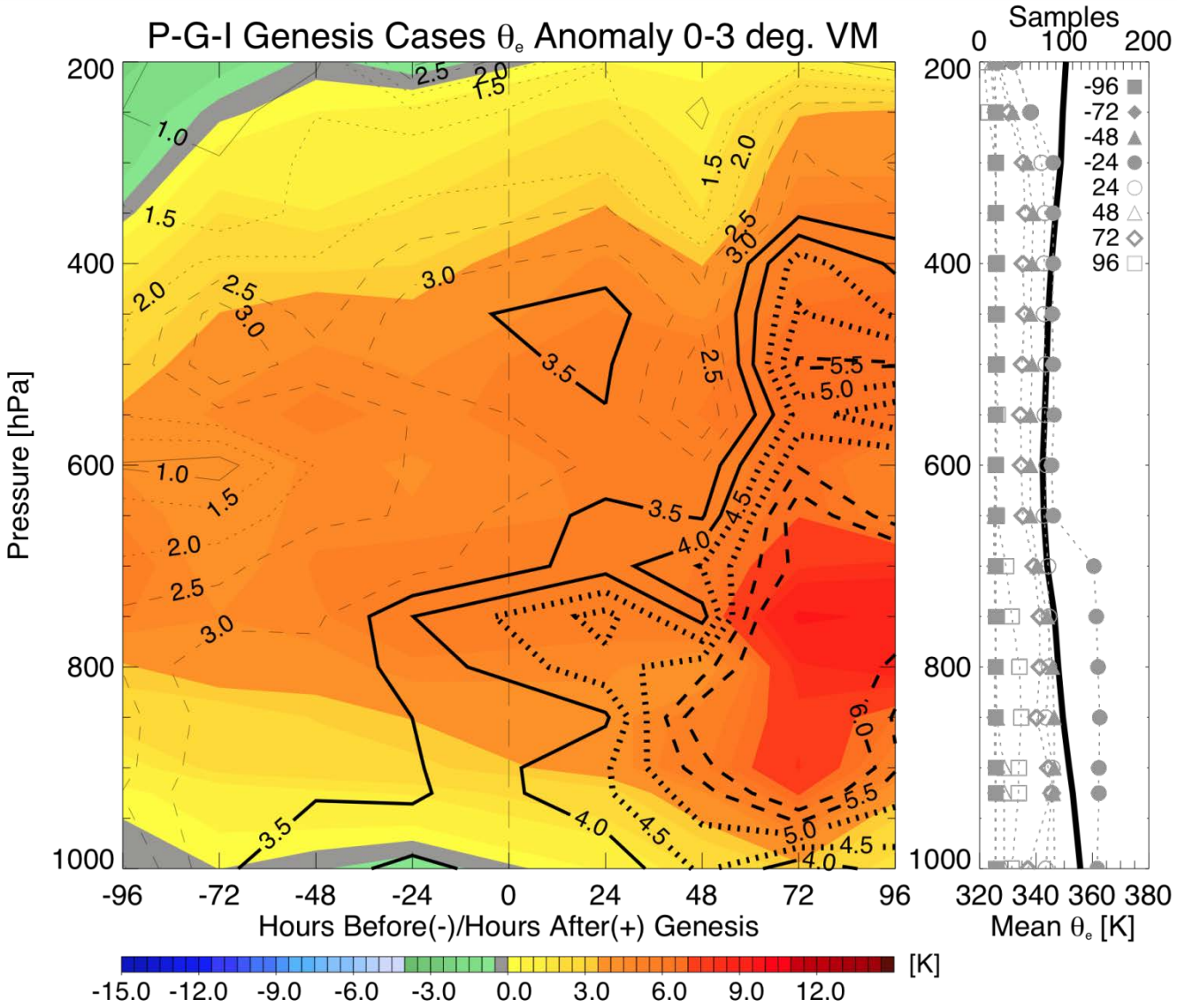
## RH

- NDEV has lower RH at mid-levels than DEV B & DEV A

## Temperature

- Little difference b/w DEV & NDEV; DEV B slightly cooler at low-levels

# Anomaly: Mean Inner Core – Mean of Environmental (3-7° ) Soundings from all PGI Flights




Midlevel $\theta_e$ is higher than the environment and will increase slightly each day; very little increase at low-levels

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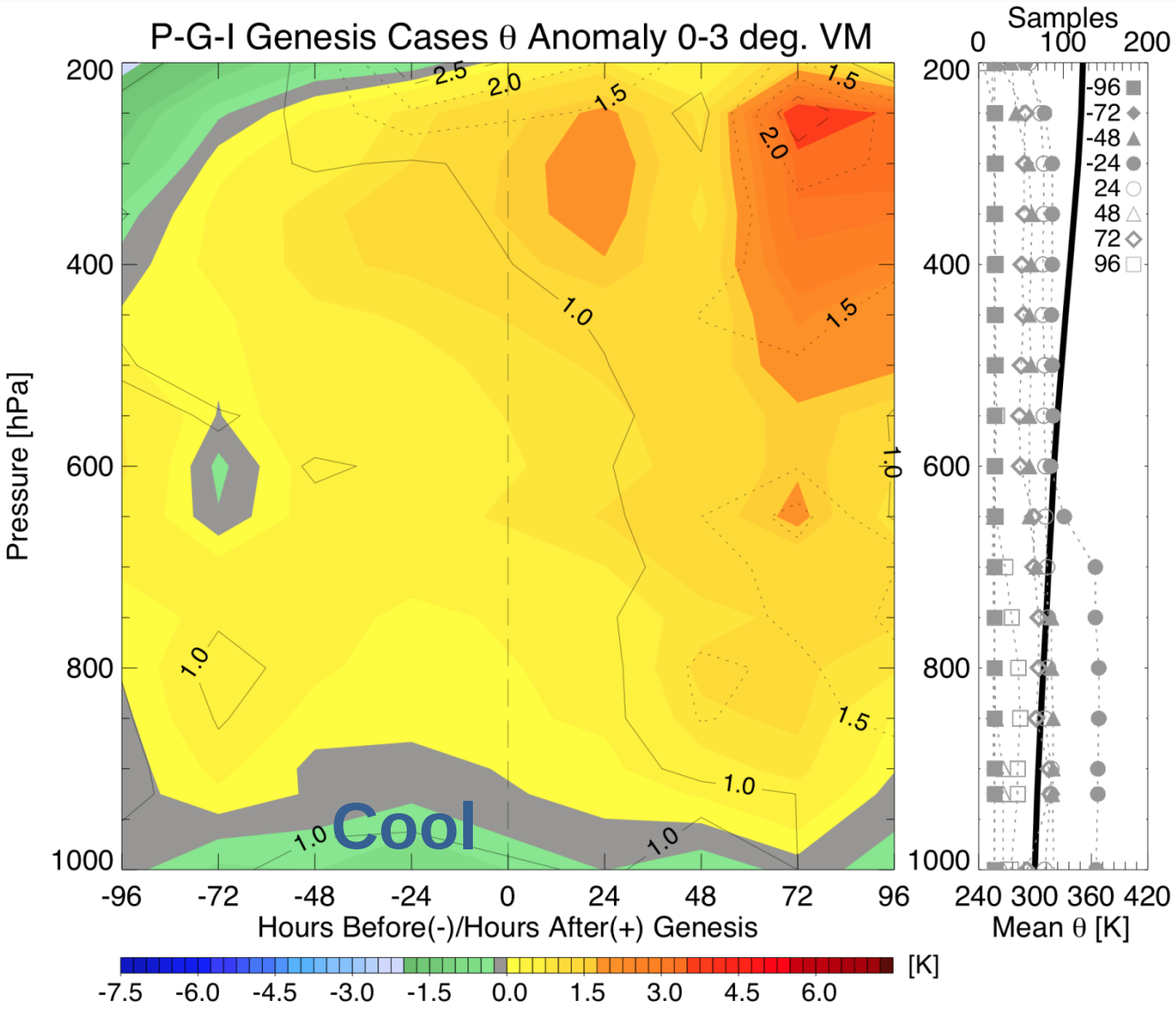
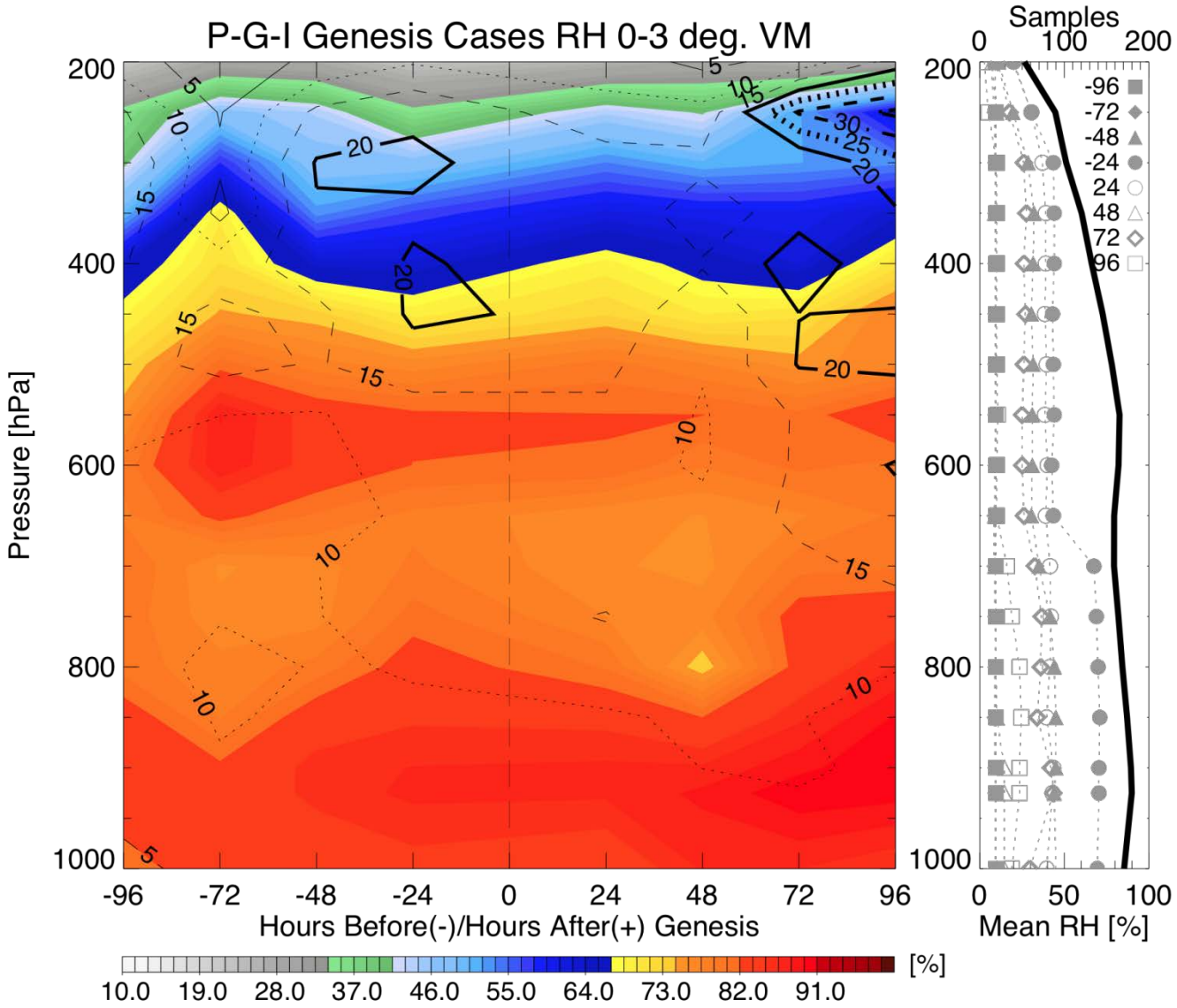



Warm core is developing at mid- to upper-levels as many as 3 days before formation

Increase in $\theta_e$ anomaly at mid-levels is attributed to a small increase in moisture




No noticeable increase in relative humidity during the formation process at mid-levels; only a slight increase at low-levels

# Summary and Conclusions

- Developing disturbances exhibit greater moisture and RH at *mid-levels* than non-developing disturbances
- The developing inner core exhibits greater $\theta$ & $\theta_e$ (moisture) than the surrounding environment; warm core seen up to 3 days prior to genesis
  - wvMR increases 1-2 g/kg at mid-levels prior to formation
- Once the inner core is moist, diurnal convection does little to further increase inner core moisture in the *pre-cursor* disturbance (i.e., there is little evidence to support 'progressive moistening')
- For genesis, wave vorticity must be predominately from *curvature*
- VM & pouch must be *vertically aligned*
- *May be that the combination of these conditions occur less frequently*

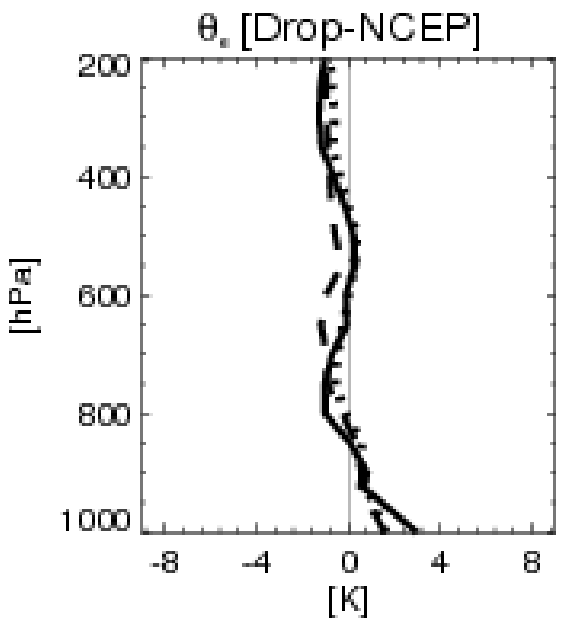
# Summary and Conclusions

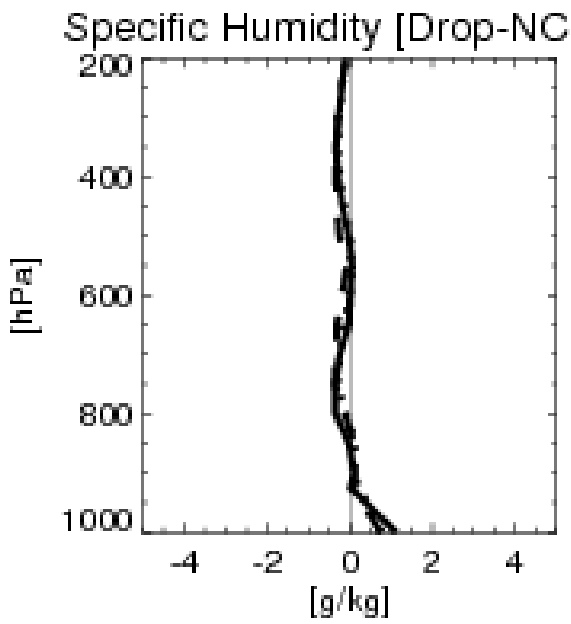
Necessary and Sufficient Conditions for Tropical Cyclogenesis:

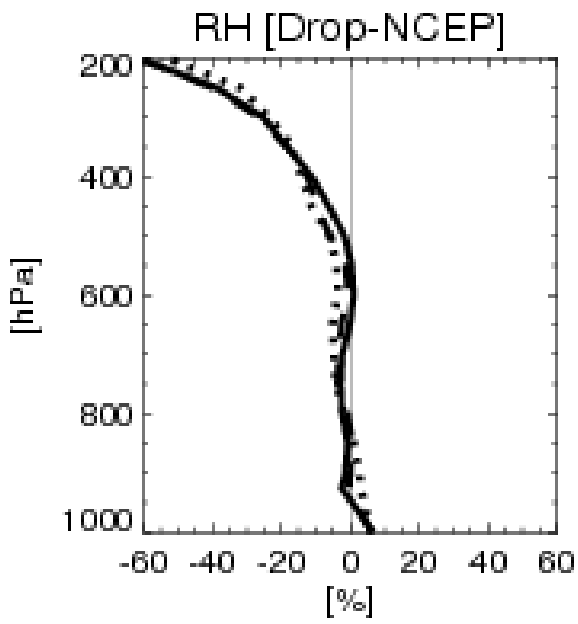
Will we get answer from GRIP-PREDICT-IFEX?

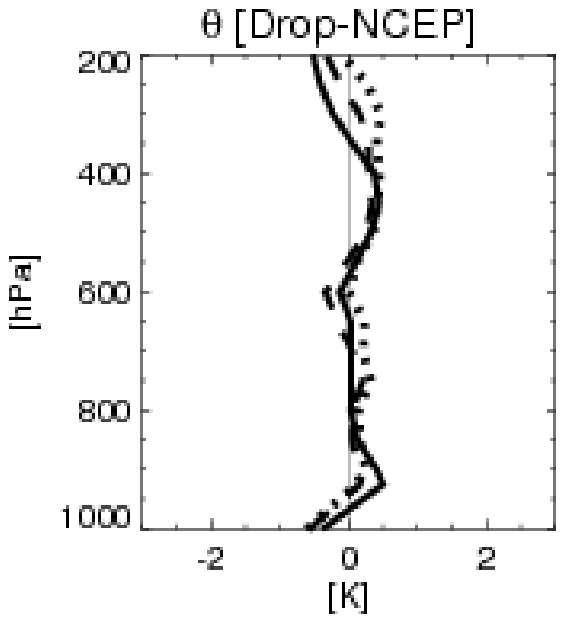
**MULTIPLE PATHWAYS TO TROPICAL CYCLOGENESIS**

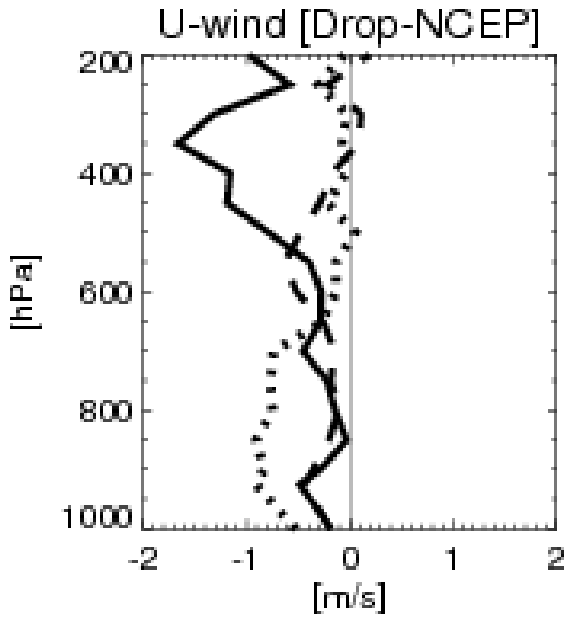
# Dropsonde-NCEP FNL

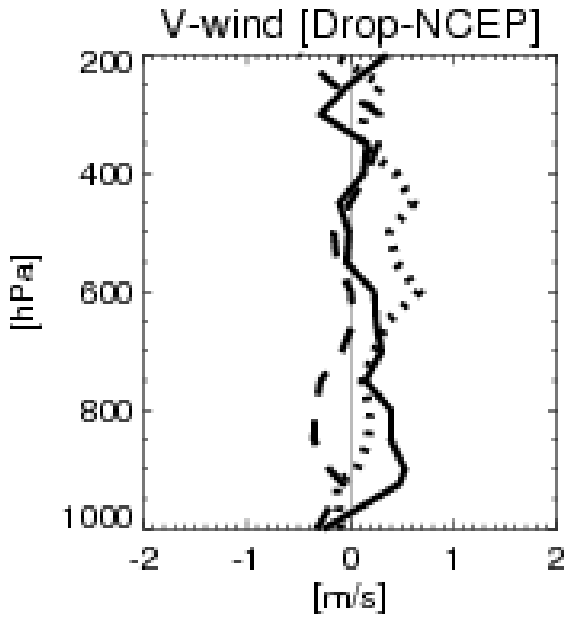


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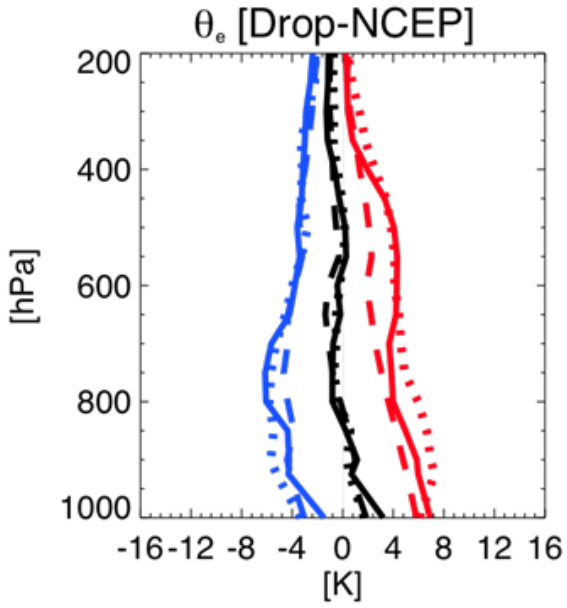
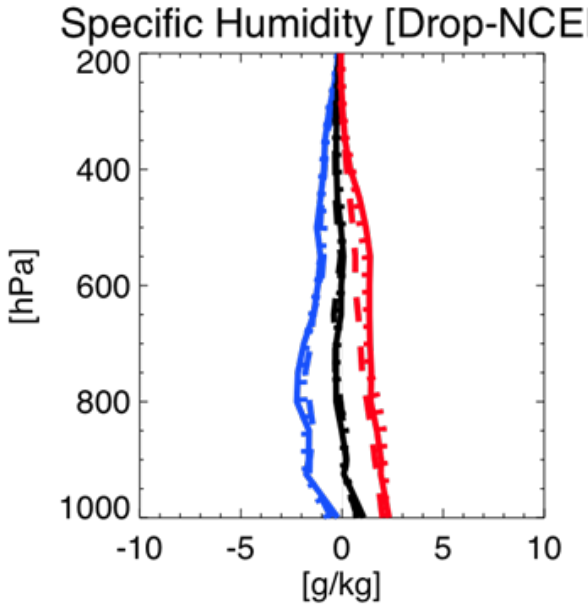
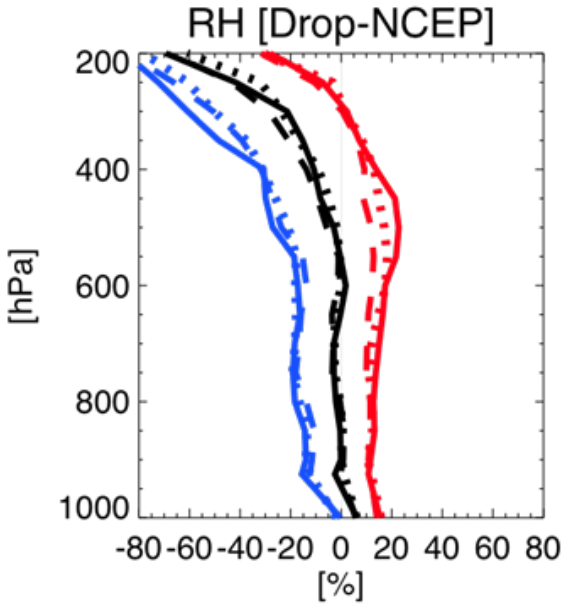
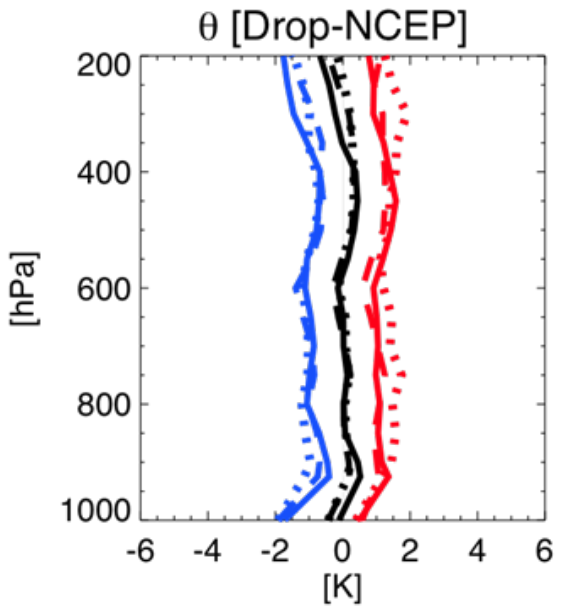
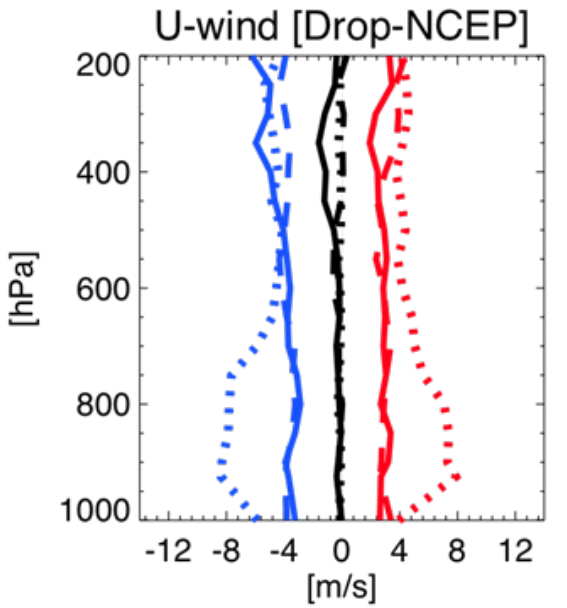
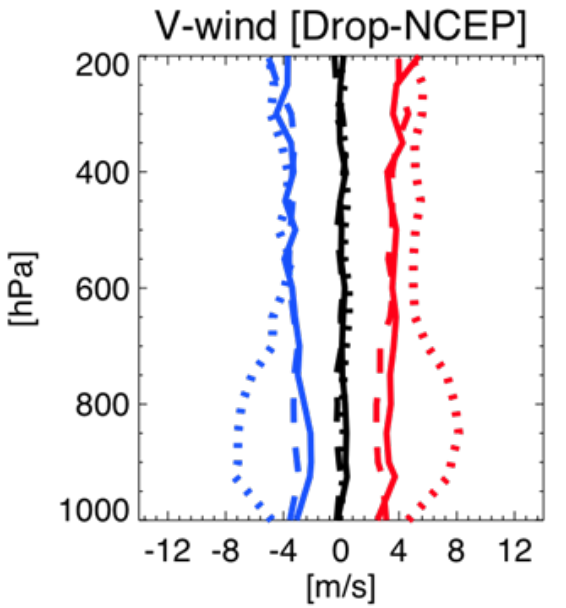


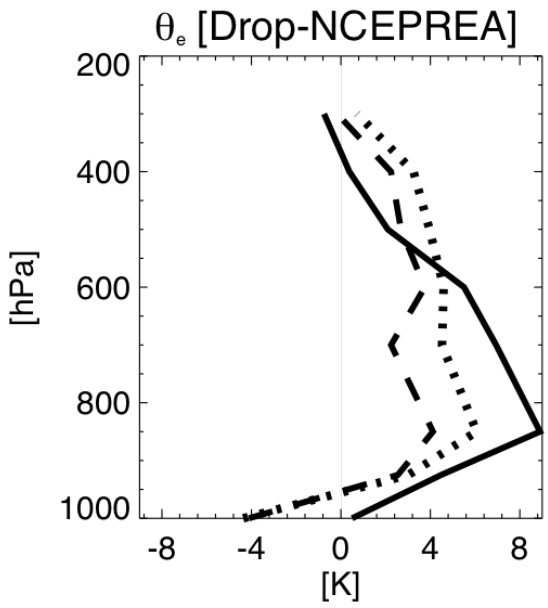



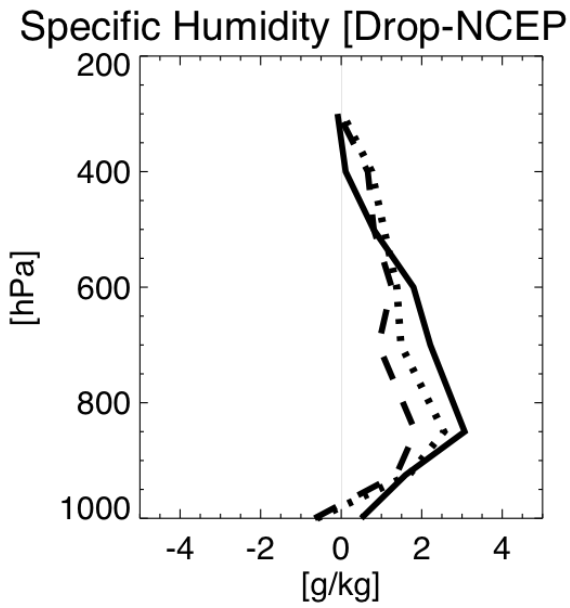



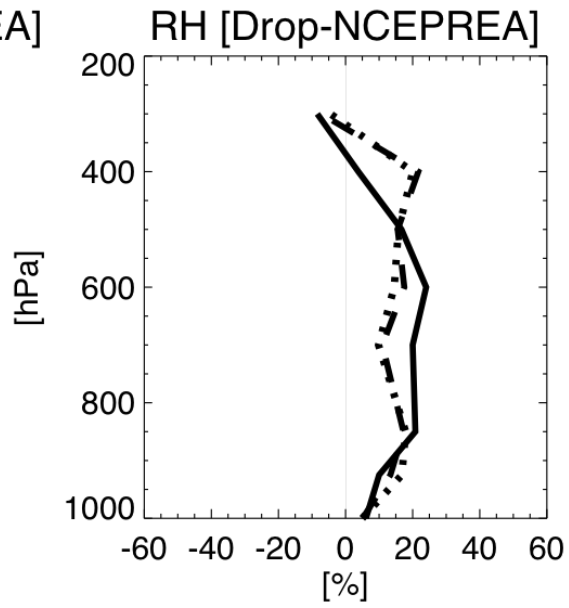



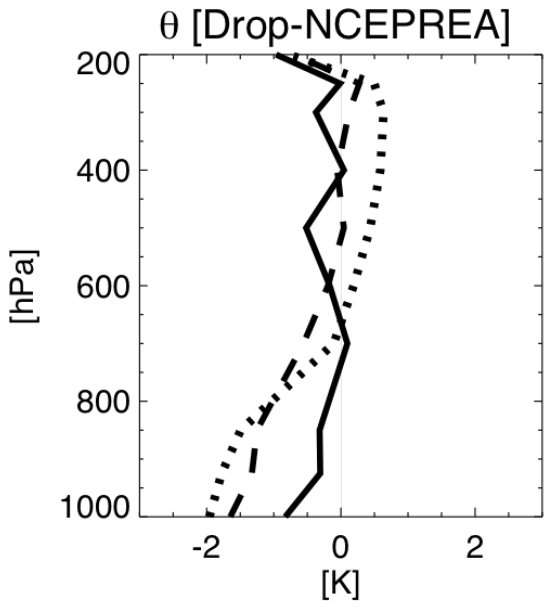



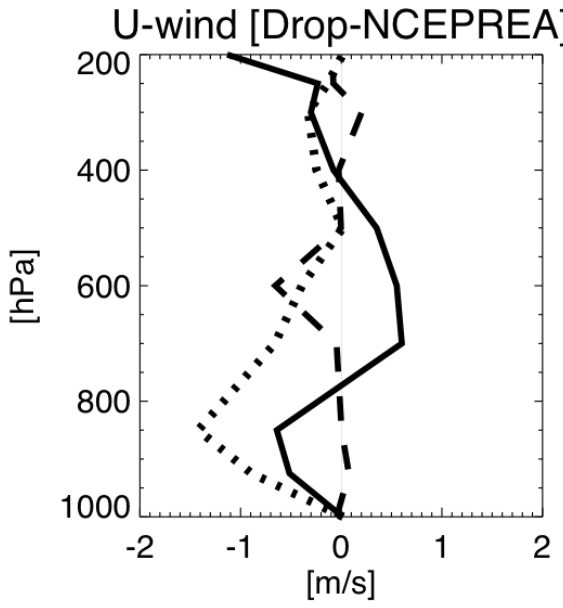
# Dropsonde-NCEP/NCAR Reanalysis

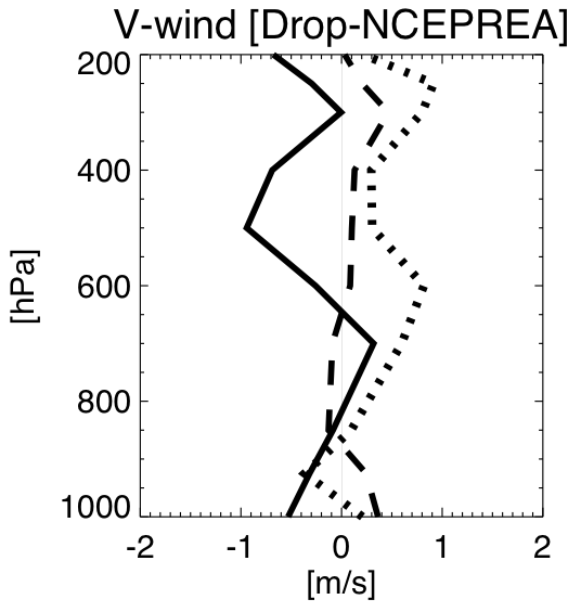


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