Thermodynamic Differences between Developing and Non-Developing Disturbances using the PREDICT-GRIP-IFEX Dropsonde Database

Jonathan Zawislak and Ed Zipser

Dept. of Atmospheric Sciences, The University of Utah, Salt Lake City, UT

Introduction

In response to the need for a more extensive dataset on developing and non-developing disturbances, NASA took part in a tri-agency field effort during August-September of 2010. The NASA Genesis and Rapid Intensification Processes (*GRIP*) campaign, based in Ft. Lauderdale, FL and NASA Dryden, CA, was conducted concurrently with the NOAA Intensity Forecast Experiment (*IFEX*) and NSF/NCAR Pre-depression Investigation of Cloud Systems in the Tropics (*PREDICT*) campaigns. The tri-agency effort provides an unprecedented collaboration on non-developing, genesis and rapid intensification events, with in some cases, near-continuous coverage with dropsonde-equipped aircraft. Aircraft include: the NASA DC-8, NCAR G-V, NOAA P-3's and NOAA G-IV.

The objective of this work is to combine dropsonde datasets from each aircraft into a robust, easy-to-use database, and utilize the database to compare the composite soundings, and time evolution, of the thermodynamic environment in developing and non-developing disturbances investigated during the field campaigns.

Dataset Overview

PGI #	DEV/NDEV	# of Drops	Aircraft
27	NDEV	47	G-V
29	NDEV (ex-TD5)	59	DC-8, P-3, G-IV
30	NDEV	28	G-V
34	DEV (Earl)	478	DC-8, P-3, G-IV
36	DEV (Fiona)	81	DC-8, G-V
38	NDEV (ex-Gaston)	143	DC-8, G-V
44	DEV (Karl)	400	DC-8, G-V, P-3, G-IV
46	DEV (Matthew)	144	DC-8, G-V, G-IV
48	NDEV	26	G-V
50	DEV (Nicole)	47	G-V
0	'Test' Flights	35	
Total Drops		**1488**	

PGI (PREDICT-GRIP-IFEX) # denotes the pouch # tracked by the PREDICT forecast team

**DEV: developing**   **NDEV: non-developing**

Dropsonde data is interpolated to 17 pressure levels:
1000, 925, 900, 850, 800, 750, 700, 650, 600, 550, 500, 450, 400, 350, 300, 250, 200 hPa

Dropsonde Dataset variables include:
- Pressure
- Height
- Temperature
- Relative Humidity
- U-Component Wind
- V-Component Wind
- θ - Potential Temperature
- θ$_e$ - Equivalent Potential Temperature
- θ$_v$ - Virtual Potential Temperature
- Mixing Ratio
- Radial distance from VM/PCH center*
- Nearest grid point NCEP analysis profile for similar variables[+]

* Using NCEP FNL (1°x1°) Analysis, the radial distance from the 925, 850, 700, and 600 hPa vorticity maxima (VM) and pouch (PCH) are computed. VM and PCH are manually tracked every 6 hours on flight days

[+] Also using NCEP FNL, nearest grid point analysis profiles are stored after the location of the drop is time/space corrected, using the zonal phase speed of the disturbance, to the closest in time NCEP analysis
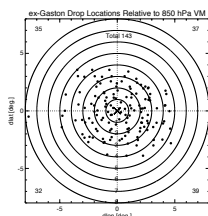
PGI-34
(Hurricane Earl)
Aug. 28, 29, 30, 31
Sept. 1, 2, 3, 4
Genesis: Aug. 25

Flight days are listed Red denotes genesis day, defined as first classification as TD by NHC

PGI-44
(Hurricane Karl)
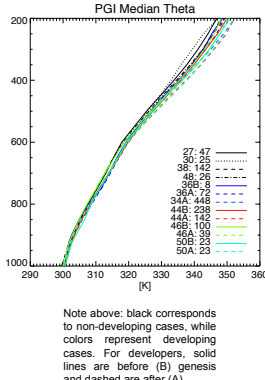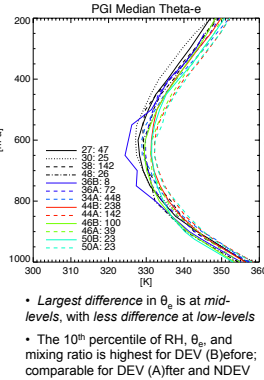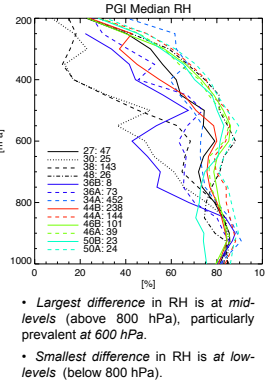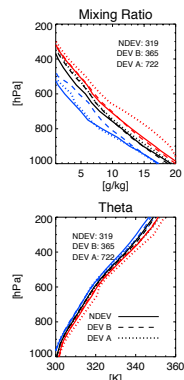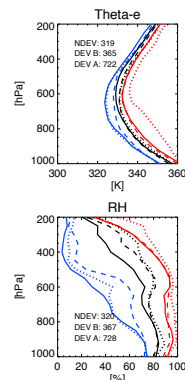Sept. 10, 11, 12, 13, 14, 16, 17

Advantage: Can separate data by radius or quadrant!

PGI-46
(T.S. Matthew)
Sept. 20, 21, 22, 23, 24

PGI-38
(ex-Gaston)
Sept. 2, 3, 5, 6, 7

Developing vs. Non-Developing Composites & PGI Overviews

B: Before Genesis
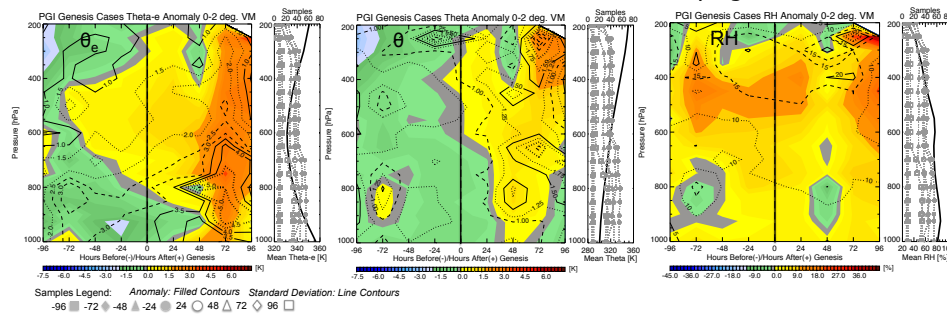A: After Genesis

Numbers listed are sample sizes for each case

10th percentile   Median   90th percentile

- *Largest difference* in RH is at *mid-levels* (above 800 hPa), particularly prevalent *at 600 hPa*.
- *Smallest difference* in RH is *at low-levels* (below 800 hPa).
- NDEV cases have noticeably *lower* mid-level RH than DEV cases
- The median RH is *similar* for DEV before (B) and after (A)

- *Largest difference* in θ$_e$ is at *mid-levels*, with *less difference* at *low-levels*
- The 10th percentile of RH, θ$_e$, and mixing ratio is highest for DEV (B)efore; comparable for DEV (A)fter and NDEV
- Potential temperature has less difference among cases at low- and mid-levels; greatest at upper-levels

Note above: black corresponds to non-developing cases, while colors represent developing cases. For developers, solid lines are before (B) genesis and dashed are after (A)

*** 'Eye' soundings have not been removed *** In the future, NHC best track centers will be added to aid in selection

Time Evolution of PGI Developing Cases

Note: Mean Profile is for all drops associated with developing cases

*** 'Eye' soundings have not been removed ***

- θ$_e$ shows a mid-level positive anomaly progressively deepening towards low-levels through the genesis time
- A similar observation in θ, except only *after* genesis
- Therefore, positive θ$_e$ anomaly may be associated with higher moisture at mid-levels prior to genesis
- At low-levels, a negative θ$_e$ anomaly!

Samples Legend: Anomaly: Filled Contours   Standard Deviation: Line Contours

Time Evolution of Non-Developing Ex-Gaston

Gaston was briefly a Tropical Storm on Sept. 1 and downgraded to T.D. on 2nd/00UTC and a Low by 2nd/18UTC

Despite a small increase in low-level θ$_e$, flights on each progressive day indicate progressive mid-level drying

Similar to the composites, RH below 800 hPa has little change
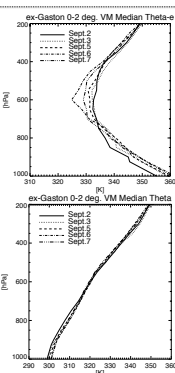
Summary and Conclusions

- The high spatial and temporal resolution tri-agency (PREDICT, GRIP, IFEX) dropsonde database provides an unprecedented opportunity to investigate the time evolution of the thermodynamic environments associated with developing and non-developing tropical disturbances.

Early findings indicate that:
- The underlined mid-level θ$_e$ (moisture) and RH show the largest difference between DEV and NDEV
- The low-levels (below 800 hPa) are less important when distinguishing DEV and NDEV
- In the 3 days before genesis, a mid-level positive moisture anomaly is progressively seen at lower levels; however, below 800 hPa, a negative anomaly remains through 24 hours after genesis

Coming soon:
- With the addition of co-located NCEP profiles, can readily compare observations with model analysis
- *** How can results be related to rainfall characteristics?
- Similar comparisons for pouches

Corresponding contact: jon.zawislak@utah.edu