Proof of Concept for Atmospheric Profiling with the High Definition Sounding System (HDSS)

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Objective

- **Measure outflow layer jets and inner core 'roots':**
  - **pattern,**
  - **strength,**
  - **structure and**
  - **orientation**
- **Relate to:**
  - **Hurricane intensity change and size: Vmax, Pmin, Rmax**
  - **Boundary layer and inner-core structure**
- **Provide *BALANCED* initialization of TC models**

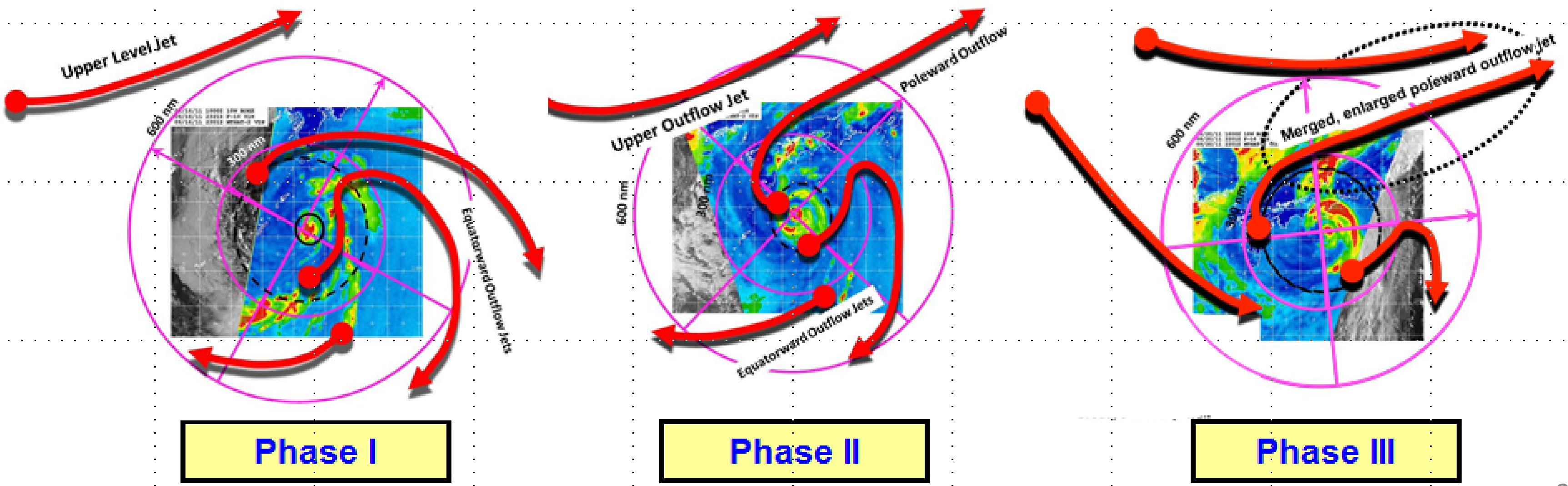
Approach

- **Utilize aircraft-based, in-situ, new-generation atmospheric profiling dropsondes:**
  - **Global Hawk UAV: AVAPS-II minisonde**
  - **WB-57: HDSS/XDD-2014**
- **Synthesize with state-of-the-art remote sensors:**
  - **Global Hawk- CPL, SHIS, HAMSR, HIRAD, HIWRAP**
  - **WB-57- HIRAD, HIWRAP**
- **Synthesize with satellite-derived Atmospheric Motion Vectors (AMVs)**

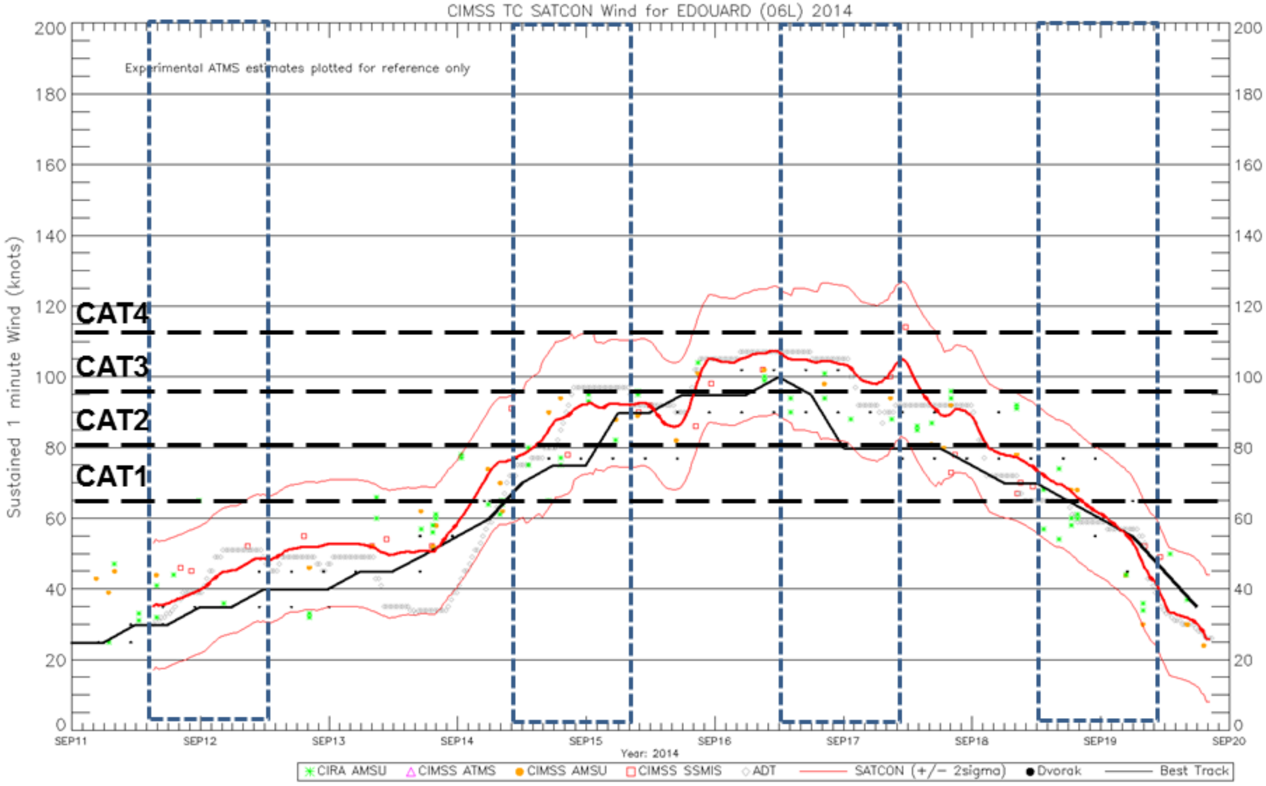
HYPOTHESIS

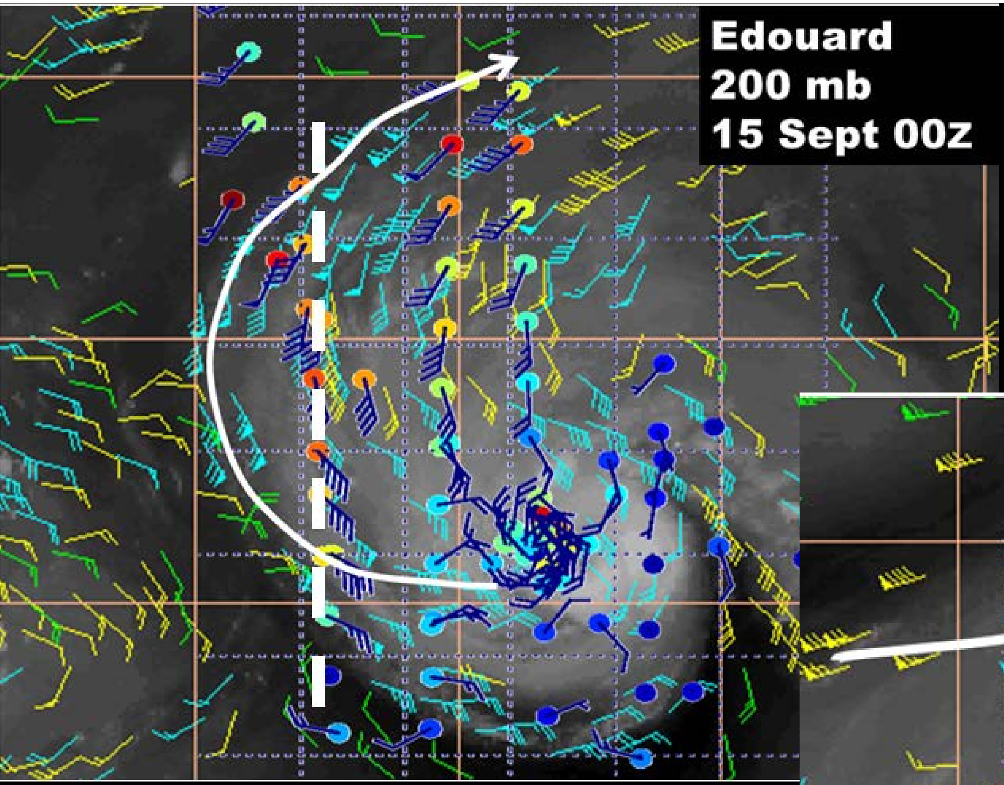
TC Life Cycle, including Rapid Intensification (RI) and Rapid Decay (RD), is associated with environmentally-forced and inner-core convectively-forced outflow jet evolution:

I. **TC development- Single Equatorward-directed Jet**
II. **Intensification and RI: Dual Equatorward and Poleward Jets**
III. **Mature & decay (ET): Primarily, single Poleward-directed Jet**

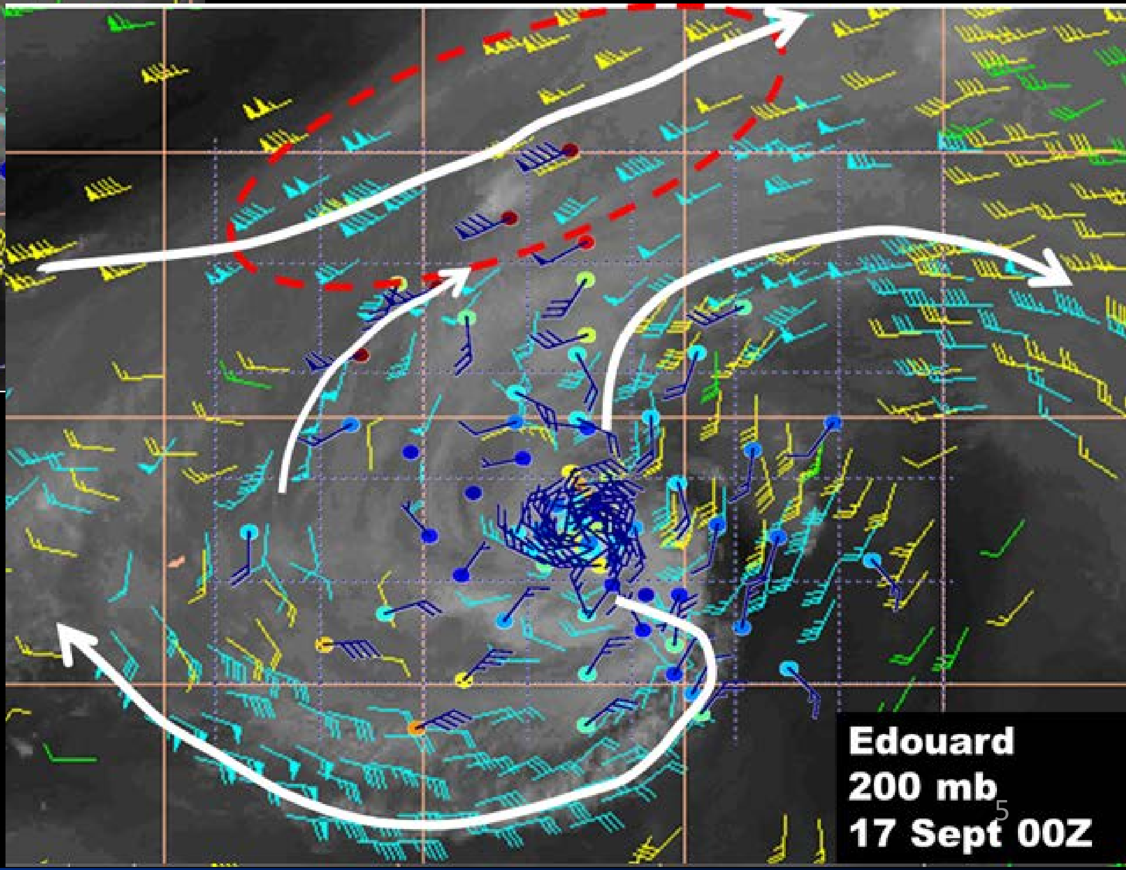


Edouard 2014
Global Hawk UAV
AVAPS Minisondes
Synoptic Forcing



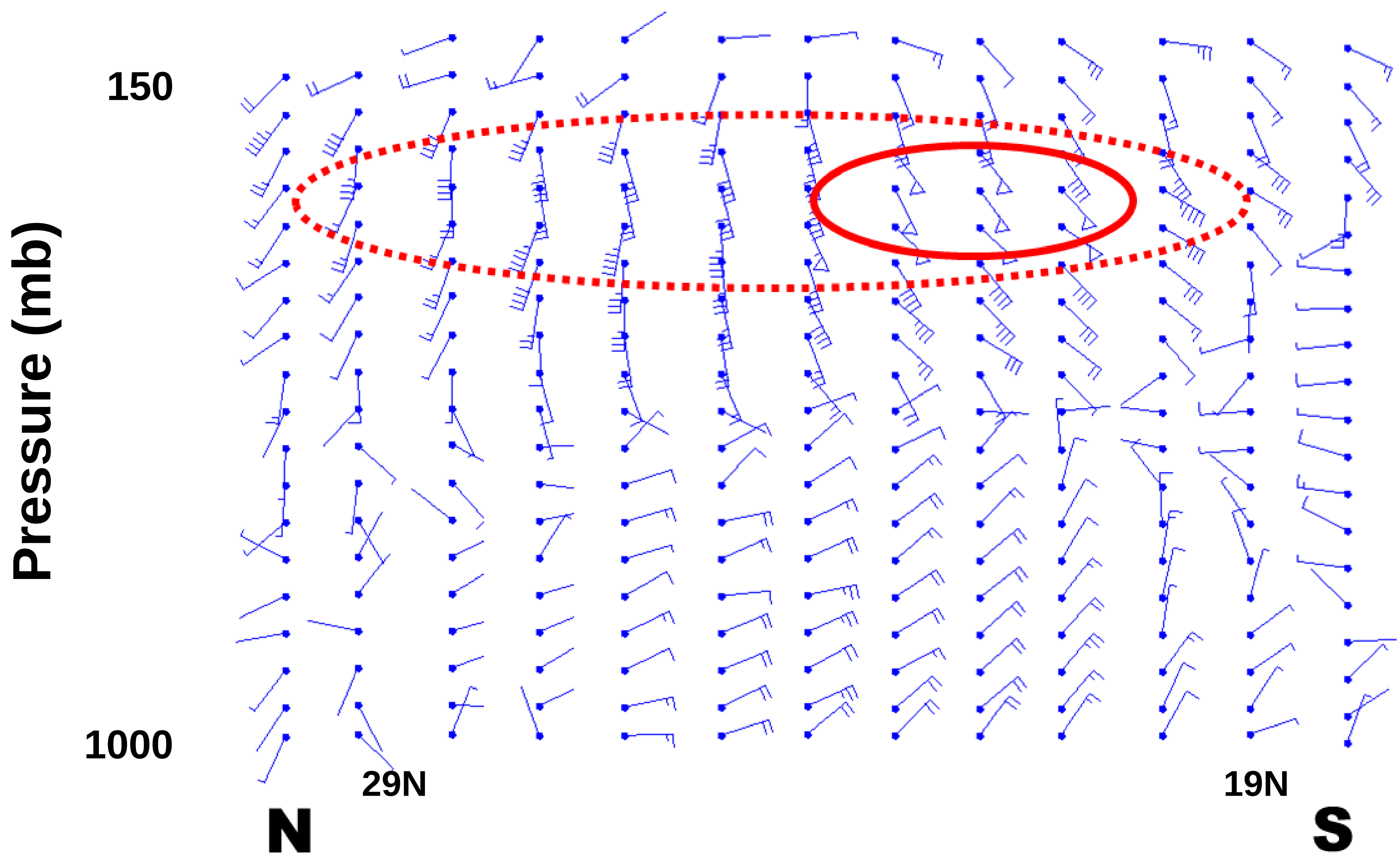


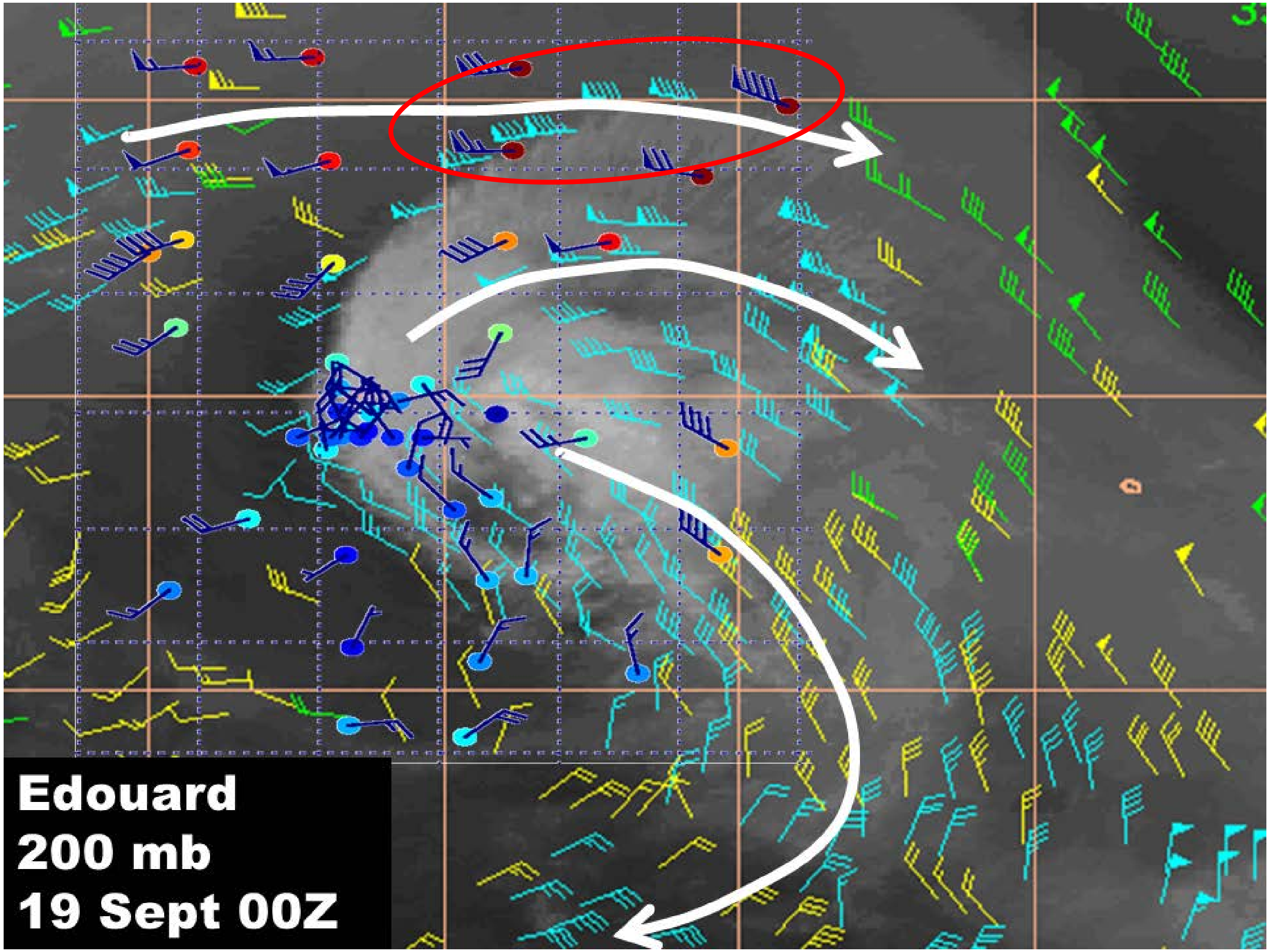
Phase II



Phase I

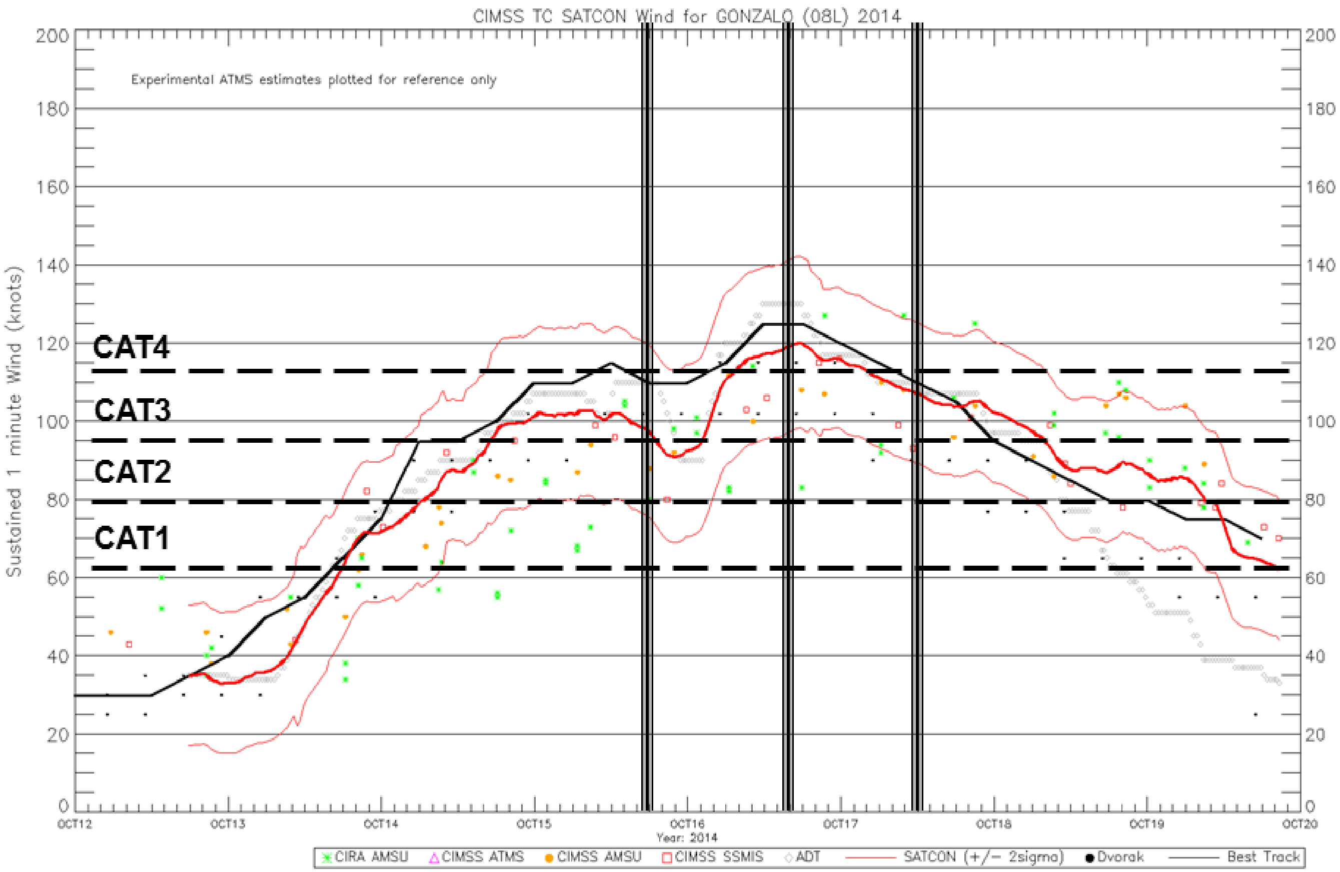
(Sonde plots courtesy Scott Braun, NASA Goddard)
(Rapid-Scan AMVs courtesy CIMMS)


150
1000
Pressure (mb)
29N
19N
N
S

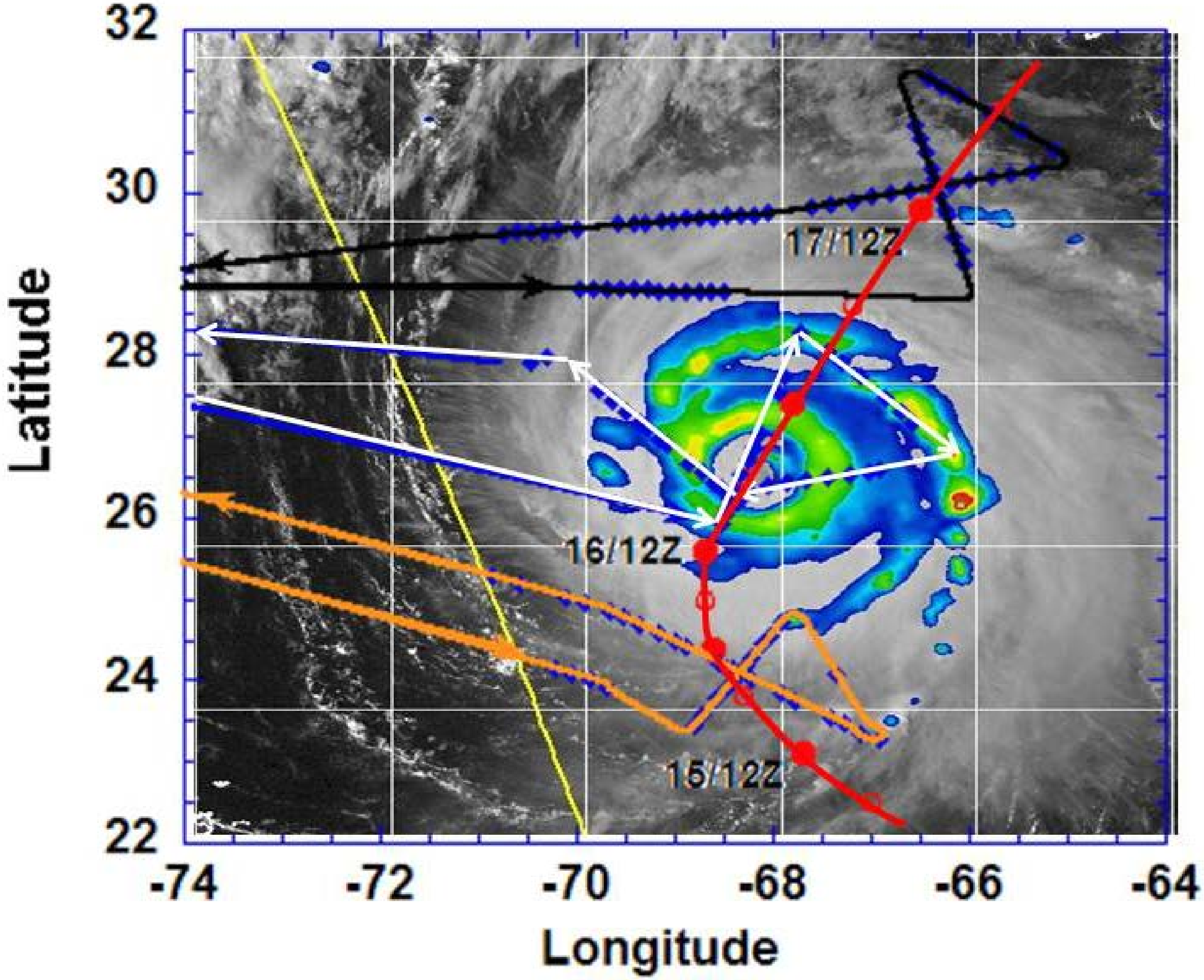


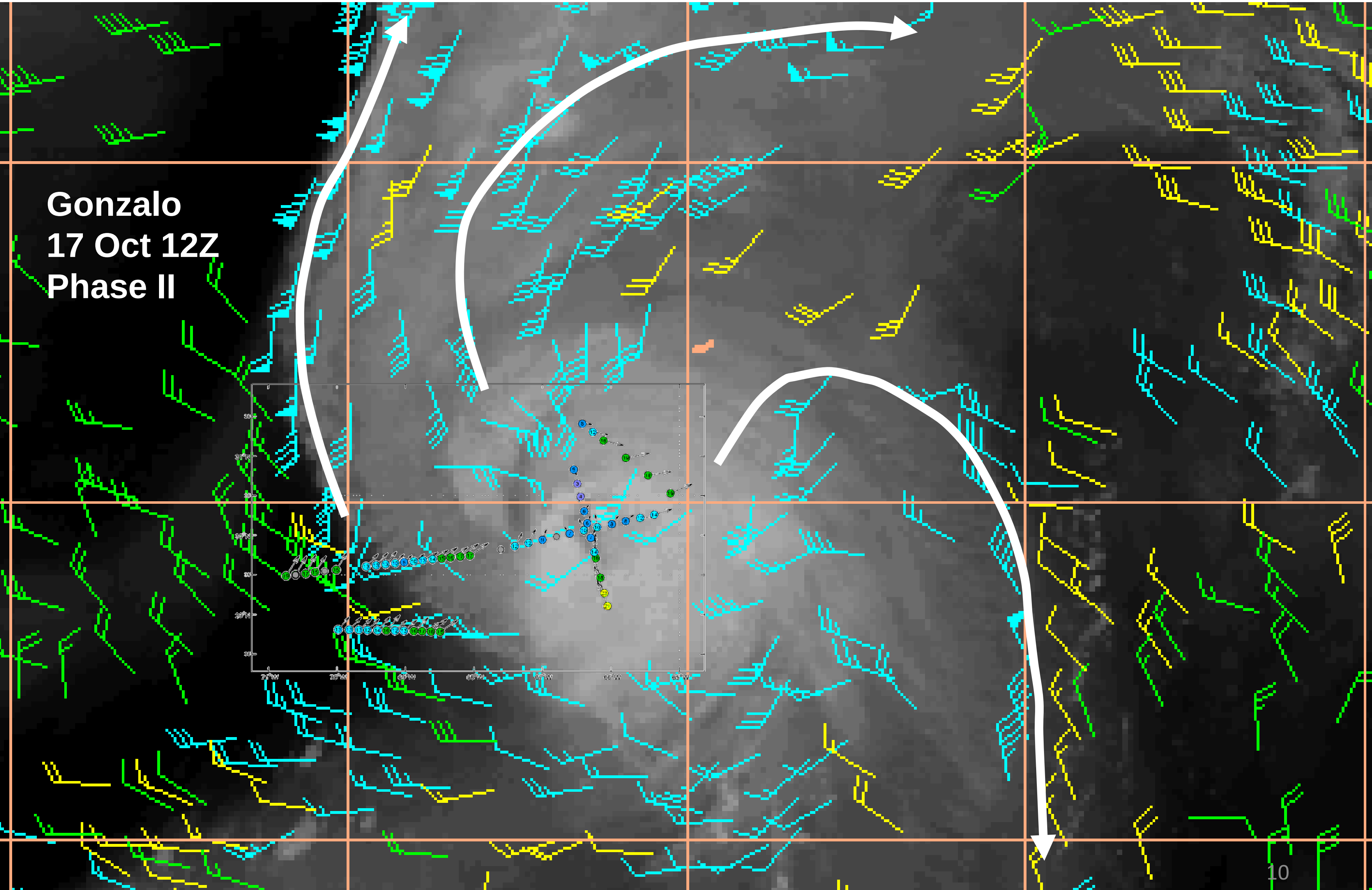
Phase III

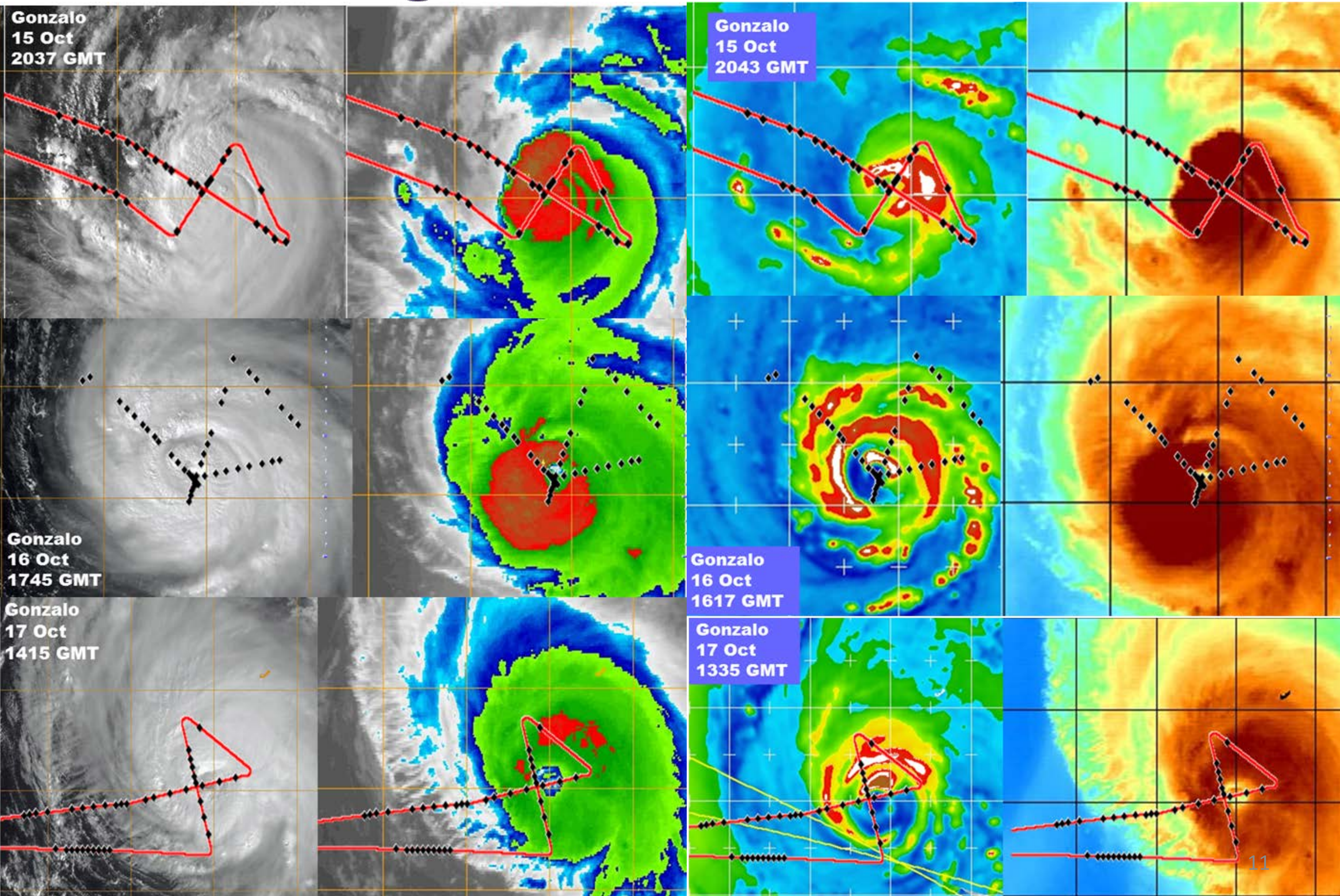
Gonzalo 2014
WB-57F
HDSS/ XDD sondes
Convective Forcing



Gonzalo Best Track WB-57 Track XDD Drops

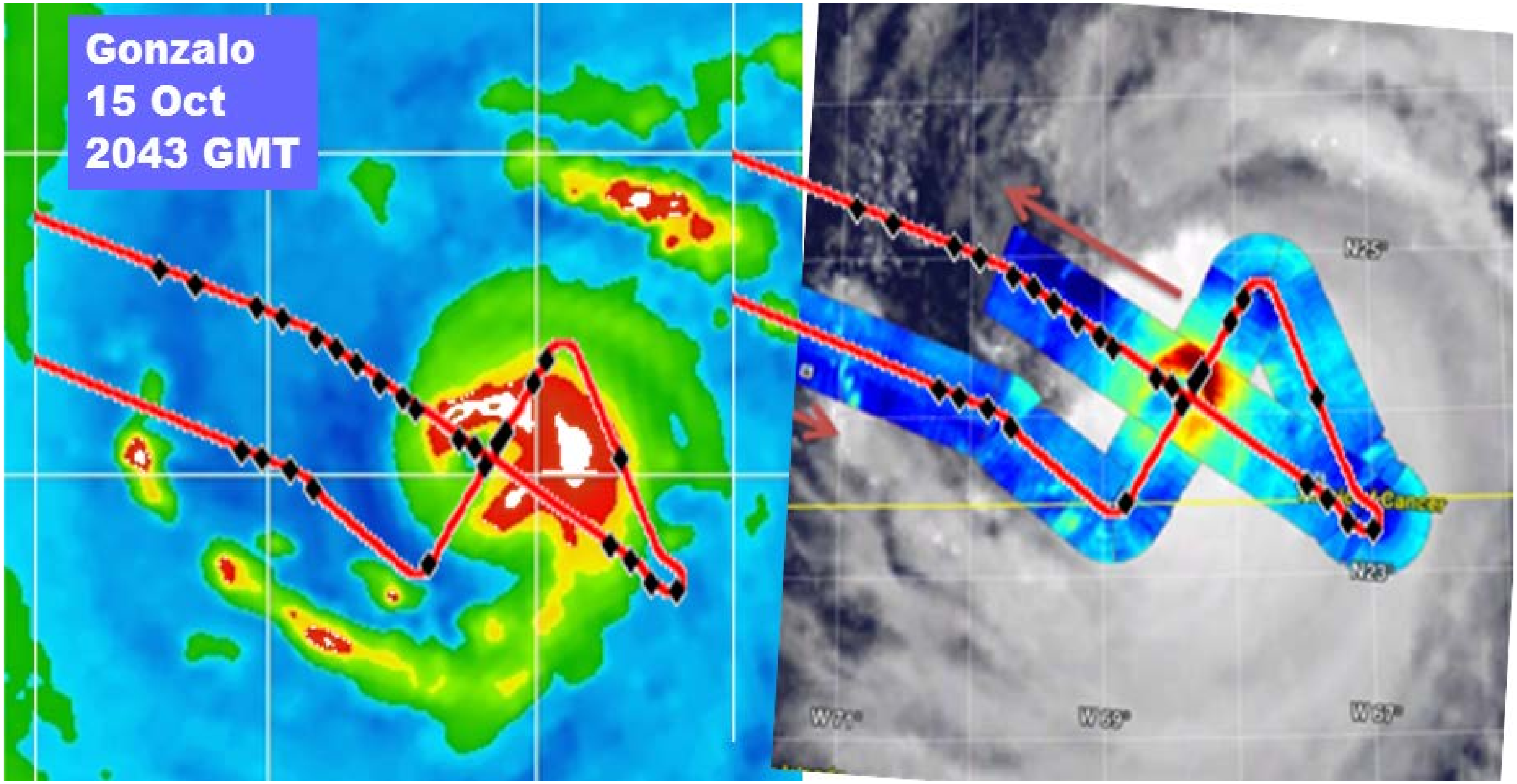



Gonzalo
17 Oct 12Z
Phase II


Gonzalo
15 Oct
2037 GMT
Gonzalo
15 Oct
2043 GMT
Gonzalo
16 Oct
1745 GMT
Gonzalo
16 Oct
1617 GMT
Gonzalo
17 Oct
1415 GMT
Gonzalo
17 Oct
1335 GMT

Microwave 91GHz Tb SSMIS

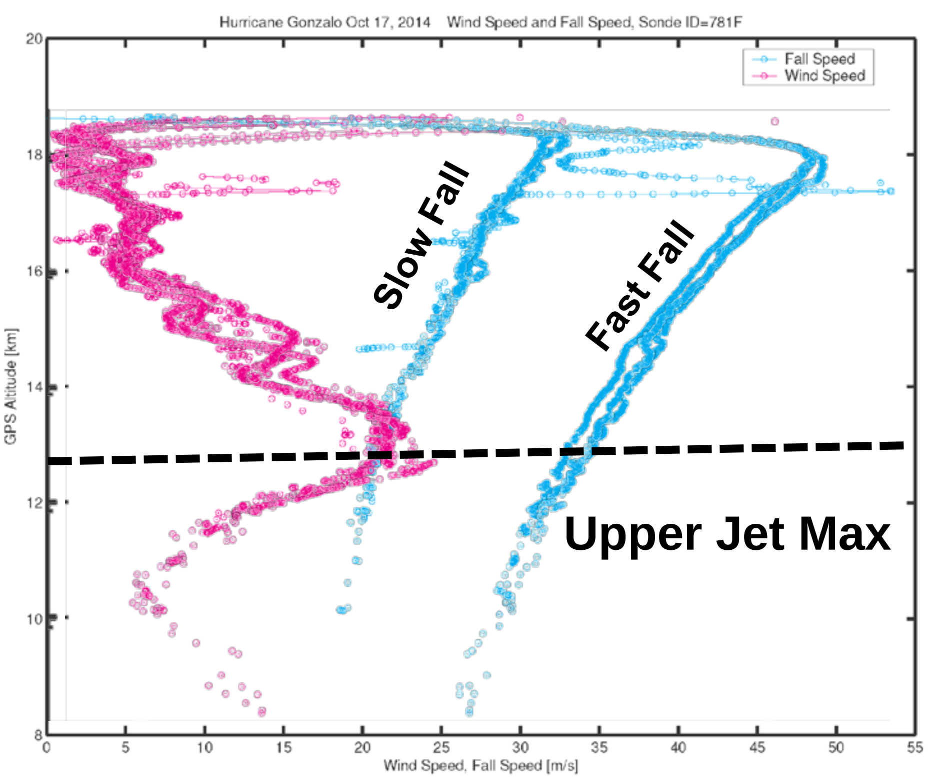
HIRAD 4GHz Tb
15 Oct

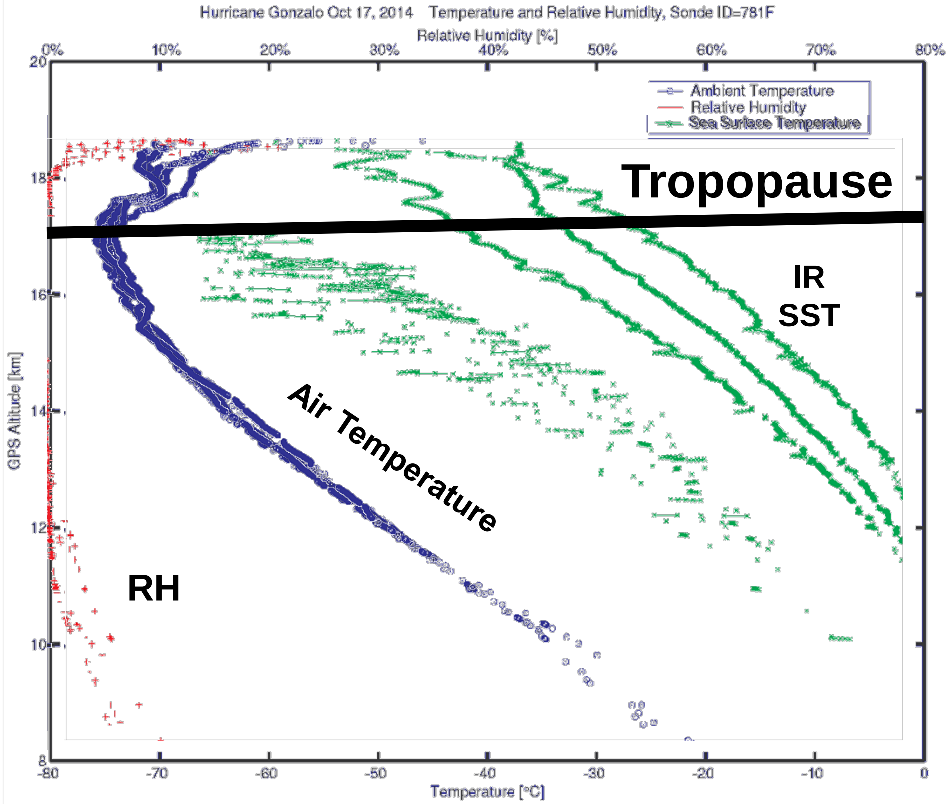


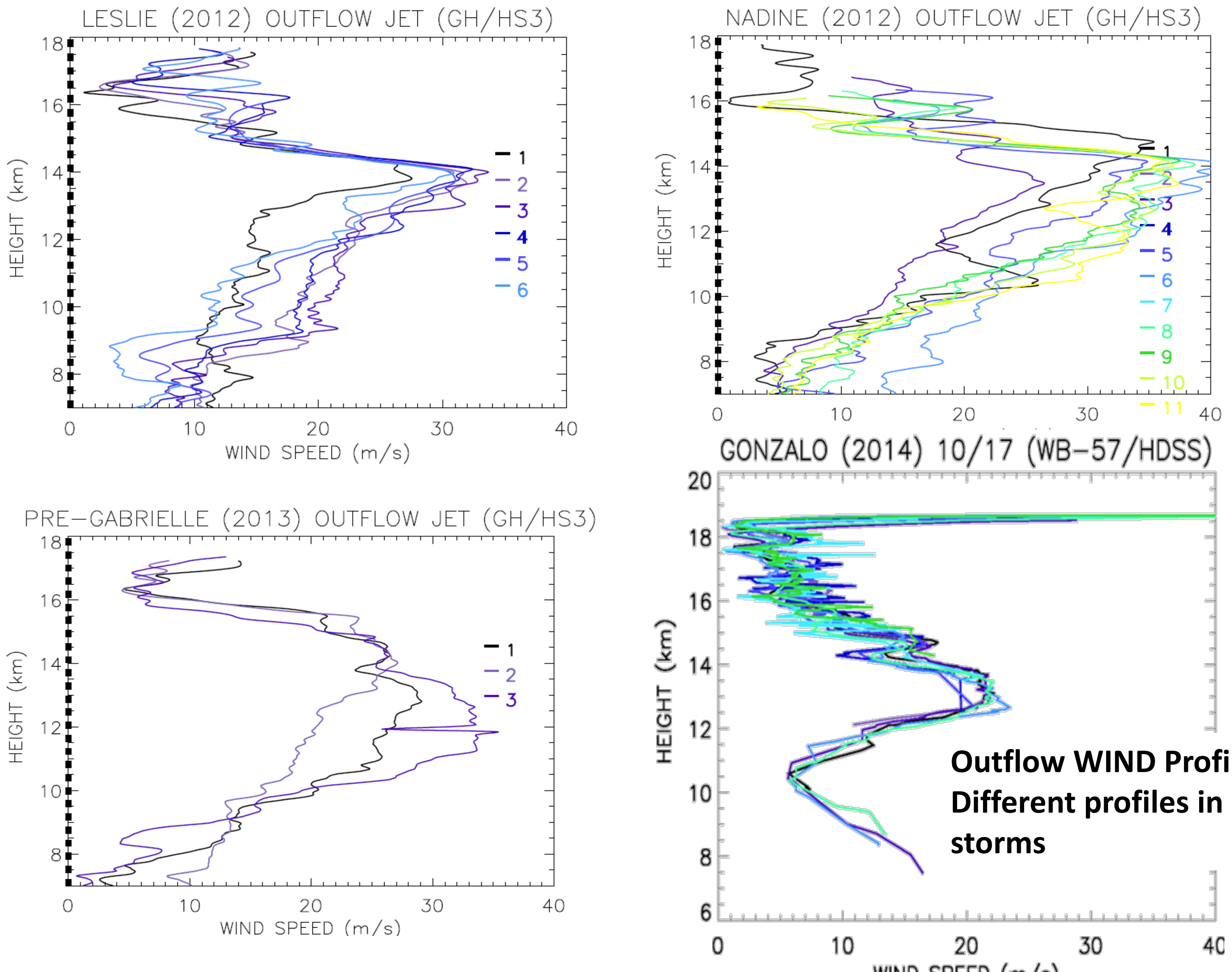
HIRAD image courtesy Dan Cecil, NASA Marshall

Gonzalo 2014
WB-57F
HDSS/ XDD

Multiple sondes observe consistent upper level structure at slow- and fast-fall rate



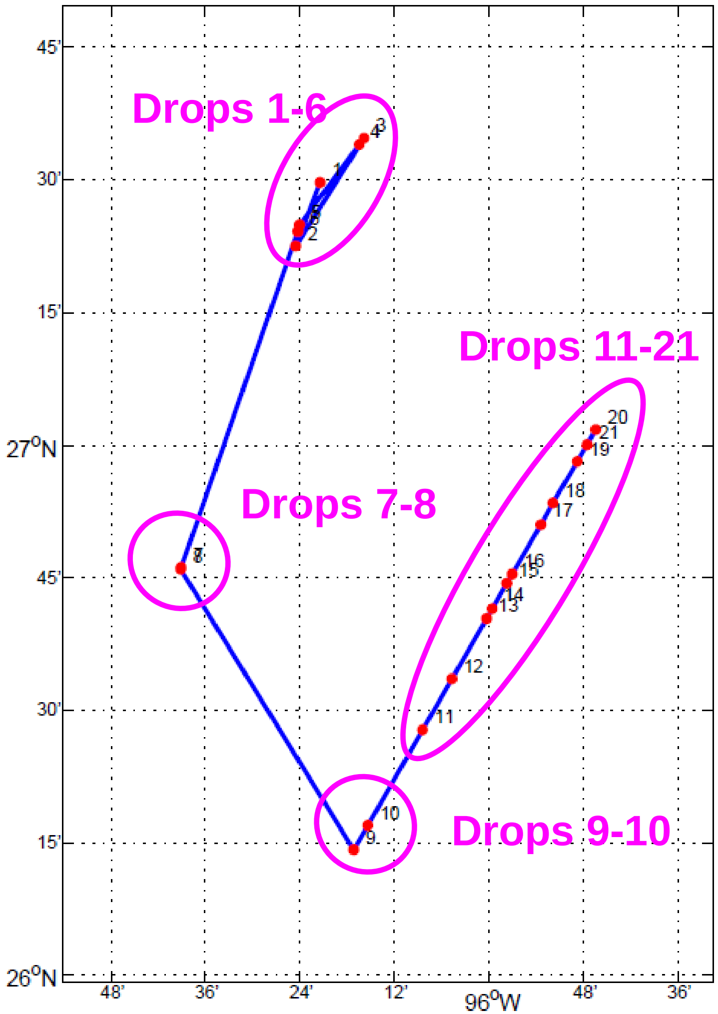


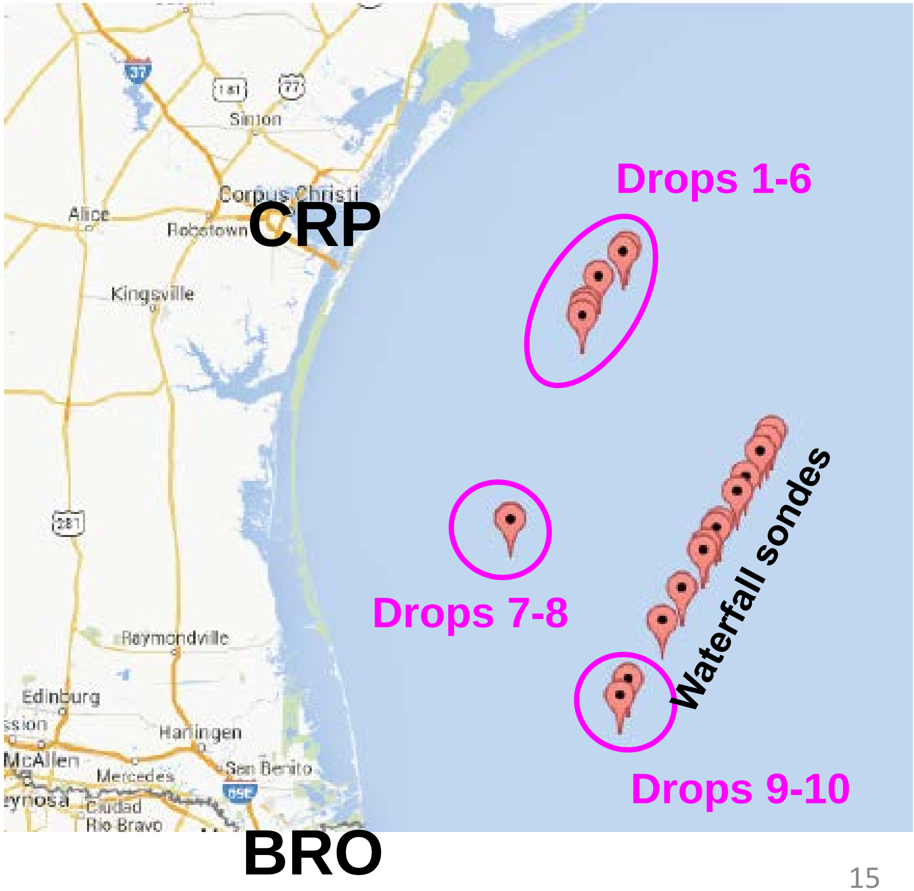


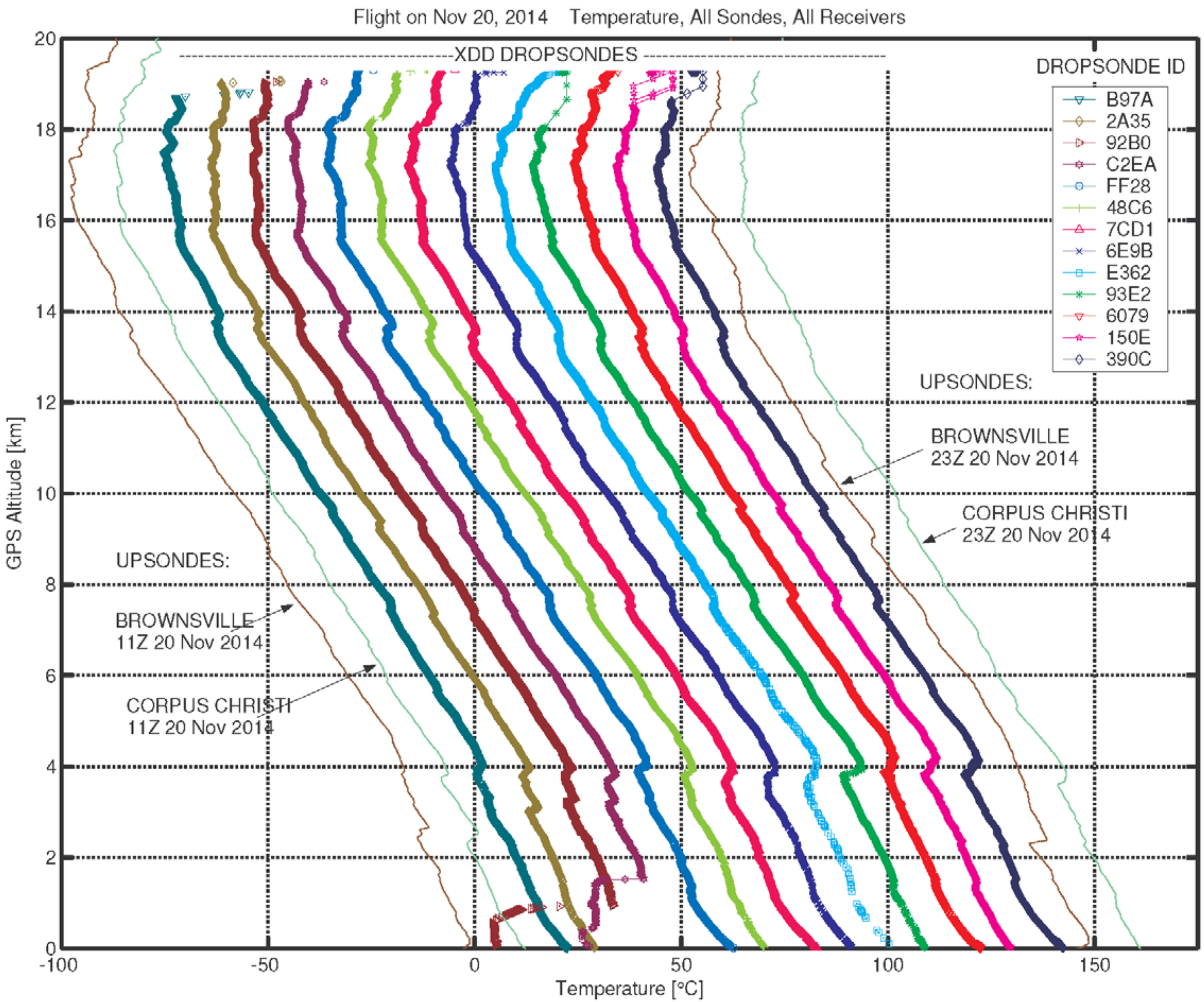
Outflow WIND Profiles: Different profiles in different storms

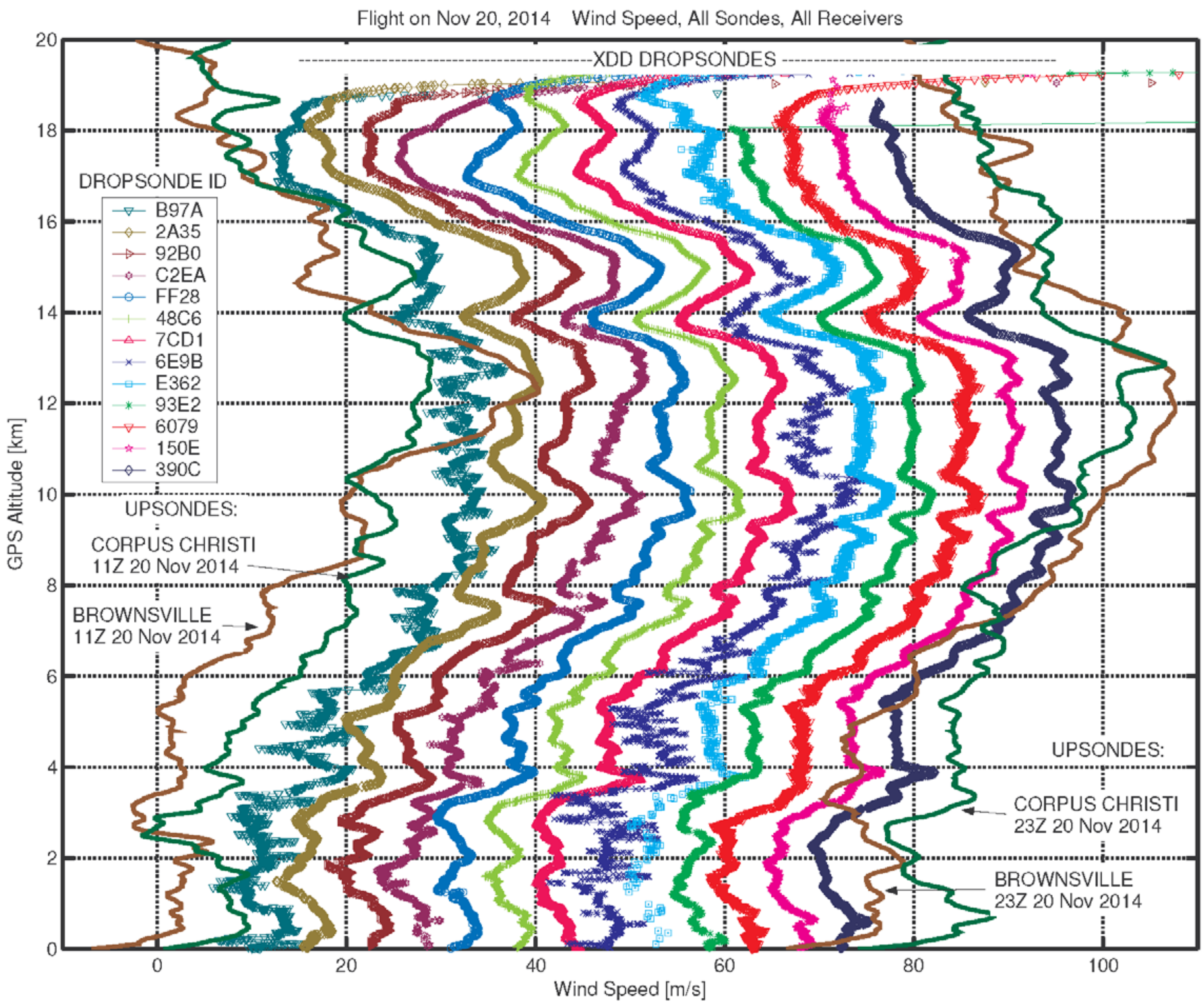
11/20 test flight: Comparison of HDSS to radiosondes

The HDSS sondes were dropped between 2045z and 2145z on 11/20. Here we will compare the HDSS results with those of the Brownsville (BRO) and Corpus Christi (CRP) radiosondes from 00z 11/21. The maps below show the dropsonde groupings and their locations.

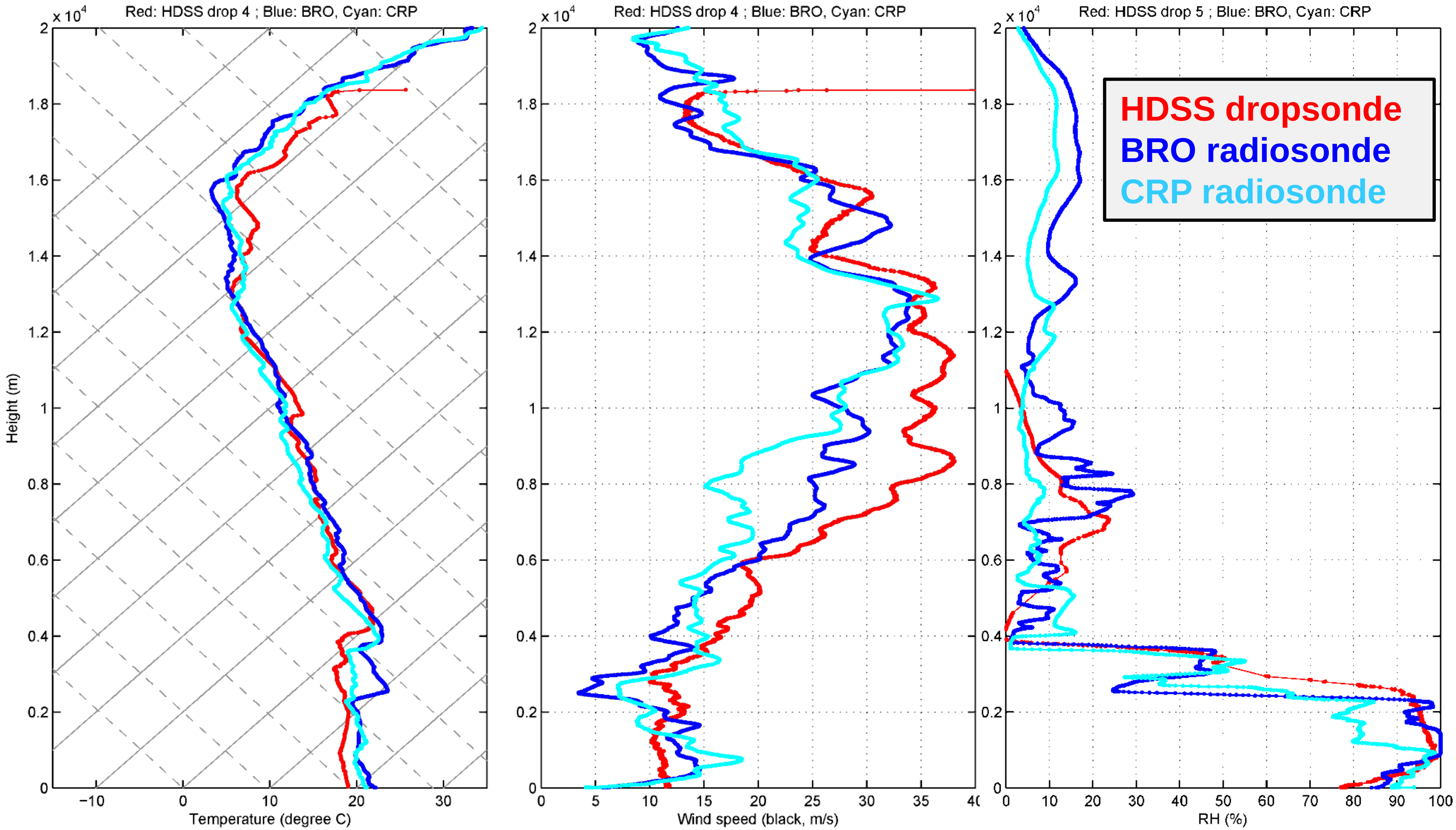




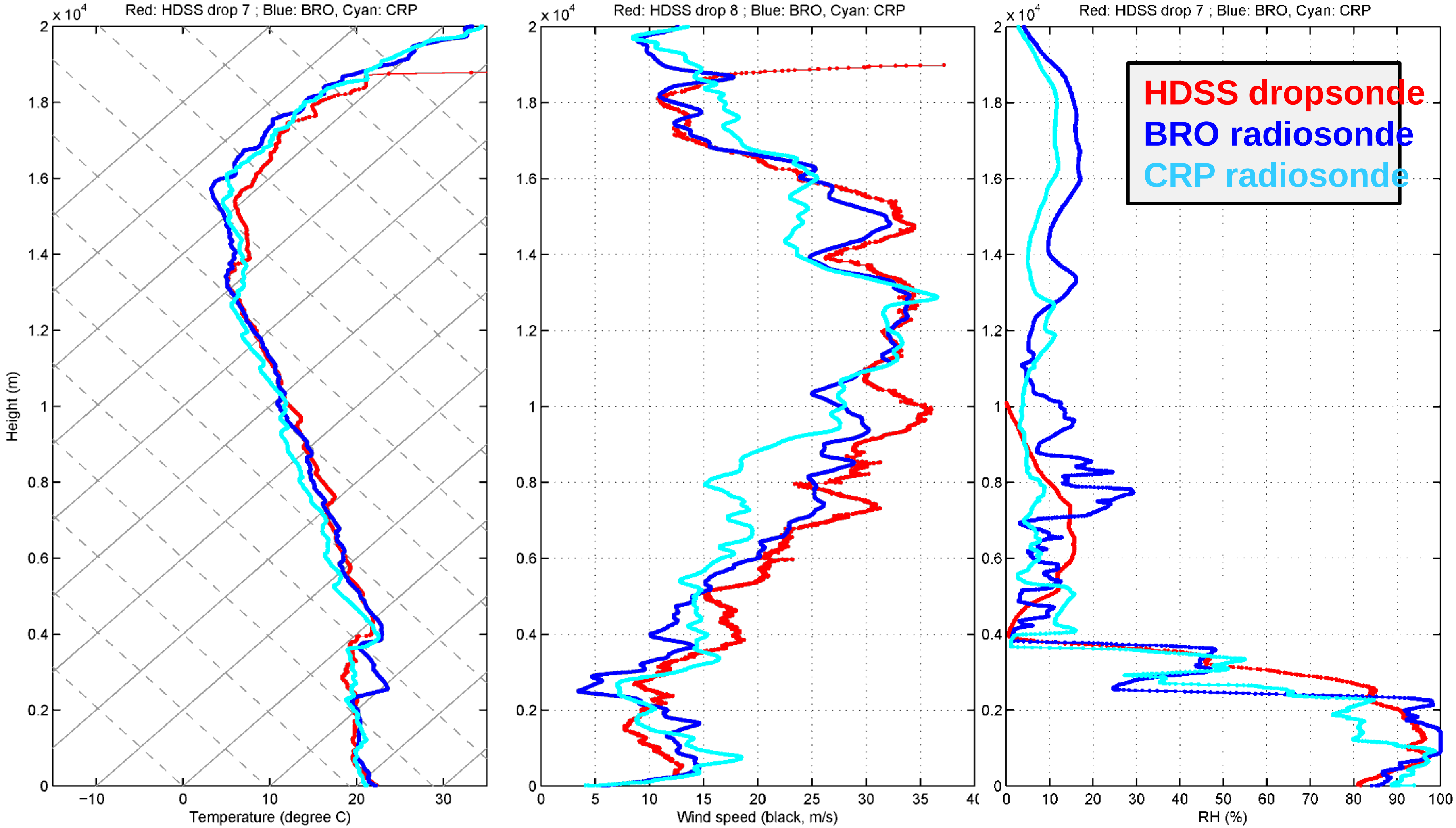

Flight on Nov 20, 2014   Temperature, All Sondes, All Receivers
XDD DROPSONDES
DROPSONDE ID
B97A
2A35
92B0
C2EA
FF28
48C6
7CD1
6E9B
E362
93E2
6079
150E
390C
UPSONDES:
BROWNSVILLE
23Z 20 Nov 2014
CORPUS CHRISTI
23Z 20 Nov 2014
UPSONDES:
BROWNSVILLE
11Z 20 Nov 2014
CORPUS CHRISTI
11Z 20 Nov 2014
GPS Altitude [km]
Temperature [°C]
0
2
4
6
8
10
12
14
16
18
20
-100
-50
0
50
100
150



Flight on Nov 20, 2014 Wind Speed, All Sondes, All Receivers
XDD DROPSONDES
DROPSONDE ID
B97A
2A35
92B0
C2EA
FF28
48C6
7CD1
6E9B
E362
93E2
6079
150E
390C
UPSONDES:
CORPUS CHRISTI
11Z 20 Nov 2014
BROWNSVILLE
11Z 20 Nov 2014
UPSONDES:
CORPUS CHRISTI
23Z 20 Nov 2014
BROWNSVILLE
23Z 20 Nov 2014
GPS Altitude [km]
Wind Speed [m/s]

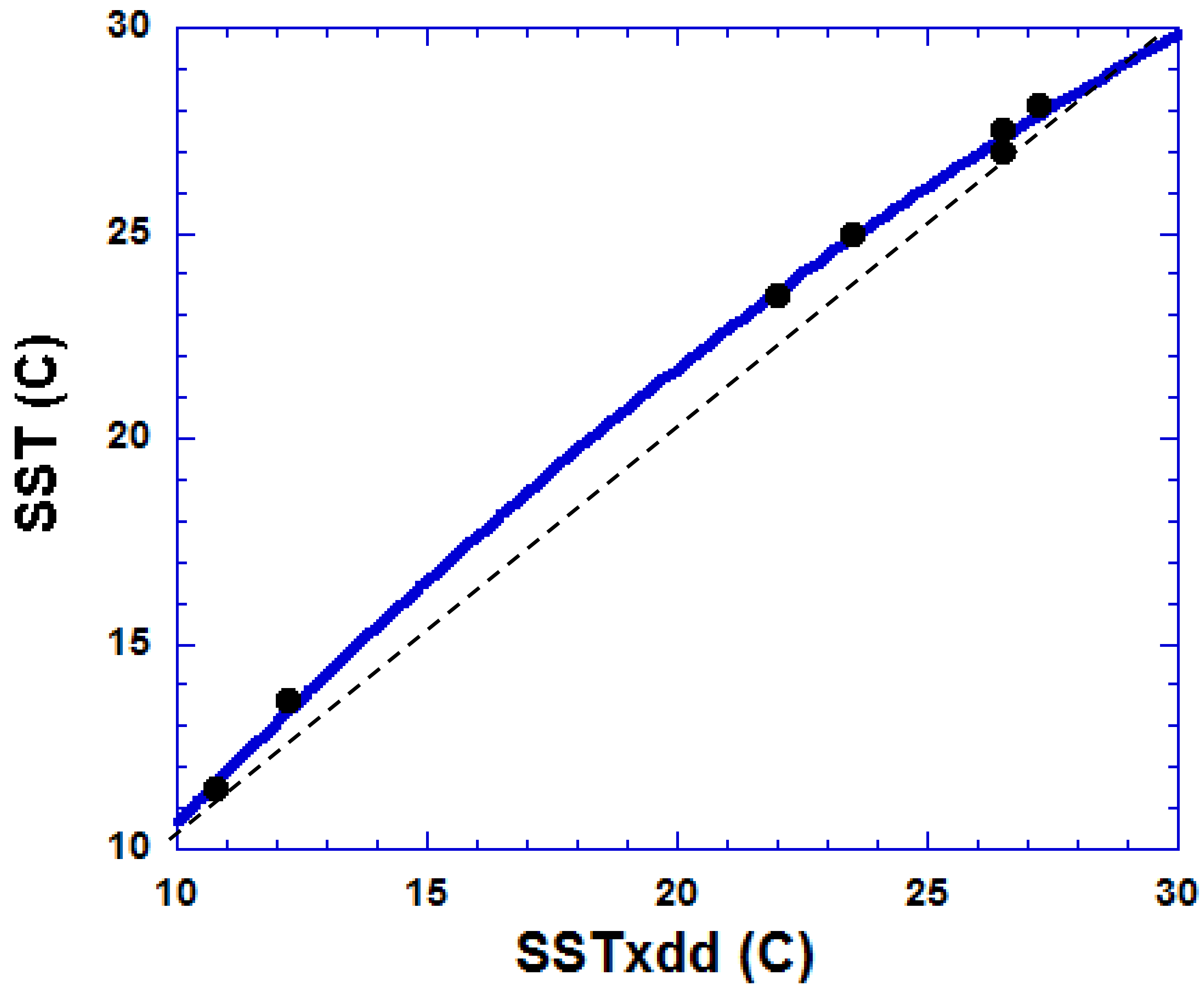


Plots show temperature (left), wind speed (middle), and RH (right) comparisons for **HDSS dropsondes** from the **drop #1-6 grouping**, which was closest to the **Corpus Christi radiosonde (CRP)**



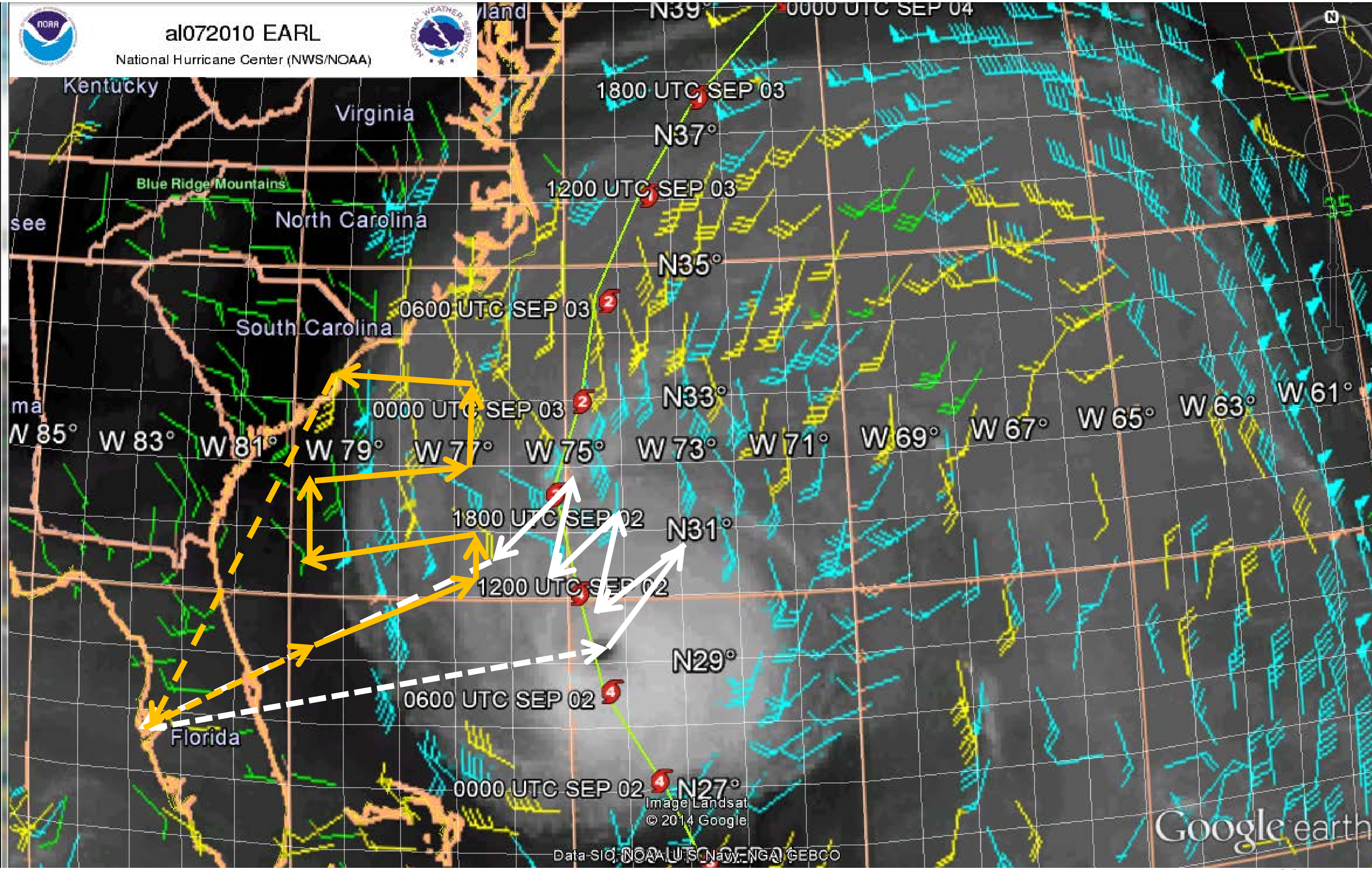
Plots show temperature (left), wind speed (middle), and RH (right) comparisons for **HDSS dropsondes** from the **drop #7-8 grouping**, which was furthest west and a bit closer to the **Brownsville radiosonde (BRO)** than the **Corpus Christi radiosonde (CRP)**

The radiosonde data is at 1Hz, while the HDSS data is at 2Hz for the temperature and RH and 4Hz for the wind speed. Radiosonde ascent begins at 23 UTC and takes 80 min to reach 20 km, whereas XDD descent begins at 2120-2150 UTC and takes 12 or 20 min (fast-fall or slow-fall) to reach the surface.



30
25
20
15
10
SST (C)
10
15
20
25
30
SSTxdd (C)

Nov/19/2013 07:01:16
WB-57 FWD
SQUALL LINE
XDD Deployed


al072010 EARL
National Hurricane Center (NWS/NOAA)
Kentucky
Virginia
Blue Ridge Mountains
North Carolina
South Carolina
Florida
0000 UTC SEP 04
1800 UTC SEP 03
1200 UTC SEP 03
0600 UTC SEP 03
0000 UTC SEP 03
1800 UTC SEP 02
1200 UTC SEP 02
0600 UTC SEP 02
0000 UTC SEP 02
N39°
N37°
N35°
N33°
N31°
N29°
N27°
W 85°
W 83°
W 81°
W 79°
W 77°
W 75°
W 73°
W 71°
W 69°
W 67°
W 65°
W 63°
W 61°
Image Landsat
© 2014 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth

Outflow Layer Analysis

Achievements and Key Findings

- ❑ **Three TC outflow layers sampled 2012-13: Leslie, Nadine, Pre-Gabrielle.**

- ❑ **Outflow layer jets appear to precede intense inner core convection**

  - — **Thin peripheral outflow jets are forced by environmental features: Leslie**
    - ✓ **Subtropical jets**
    - ✓ **Upper cold lows**
    - ✓ **Tropical Upper Tropospheric Troughs (TUTTs)**
  - — **Thick inner-core outflow jets associated with convective bursts: Nadine and Pre-Gabriel**

- ❑ **Here-to-for unknown outflow jet fine-structure may lead to instabilities which enhance outflow layer mixing not yet adequately modelled.**

- ❑ **Outflow jets appear to have diurnal modulation.**