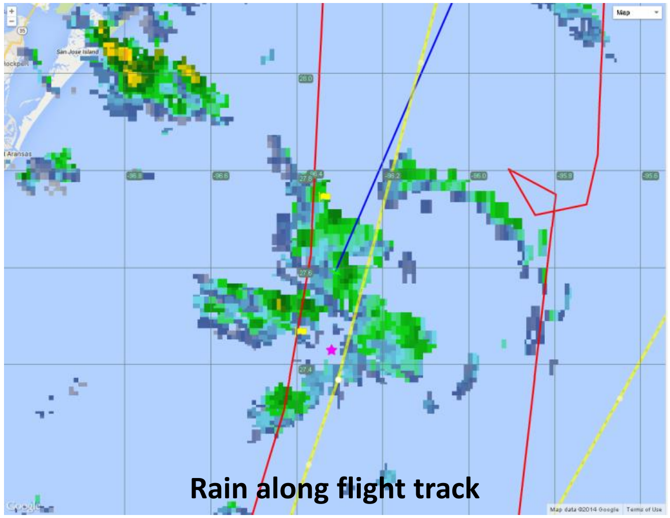
Gonzalo HDSS Summary

- There is some useful data for characterizing structure of upper troposphere/lower stratosphere
  - Fast fall: over 90% of XDDs have good U/V/T data from ~12-18 km
  - Slow fall: over 90% of XDDs have good U/V/T data from ~15-18 km
- However, many interesting atmospheric features (e.g., outflow jets) were not observed well by HDSS (only 50% of fast-fall sondes have data to 10 km and resolution is sparse low in the profile)
- Relative humidity (RH) data generally not good.
  - Below 12 km, where the instrument appears to start being sensitive to moisture, vertical resolution is coarse and many sondes have no data
- Fast-fall sondes have better quality data than slow-fall sondes, however only 31% of sondes were fast-fall
- There are issues with “spikes” in meteorological parameters (e.g., wind speed) associated with variability in fall speed – the data needs to be processed to remove these

11/20 Test flight summary

- **Overall HDSS performance was far better than for the Gonzalo science flights**
- Only 4 of 21 sondes had missing data for all variables in a segment of over ~0.5 km
- 75% of the sondes (not counting the streamer sonde) fell in fast-mode, which generally have data recovery rates of >95% and are less susceptible to noisy winds
- 2 sondes had no data or bad data for temperature over the entire profile
- 3 sondes had bad temperature data only in the lower troposphere, and 8 sondes had bad RH data only in the lower troposphere. Rain showers wetting the instrument could be the culprit (speculation)
- Instrument is not sensitive to RH above about 10 km



- Comparison of the RH profiles with the Brownsville sounding suggests the HDSS RH measurements lag reality as they fall through the middle troposphere. The lag is worse for the fast-fall than the slow-fall sondes. The HDSS is not sensitive to RH in the upper-troposphere and lower stratosphere.

HDSS Discussion Topics Based on Nov Test Flight Capability

- Does the HDSS dataset from the Nov 20, 2014 Test Flight meet our science needs? What do we need from HDSS from a science perspective?
- What data density do we need?
- RH and temperature issues in the lower troposphere
- Data transmission
- Fast Fall vs. Slow Fall

Extra Slides

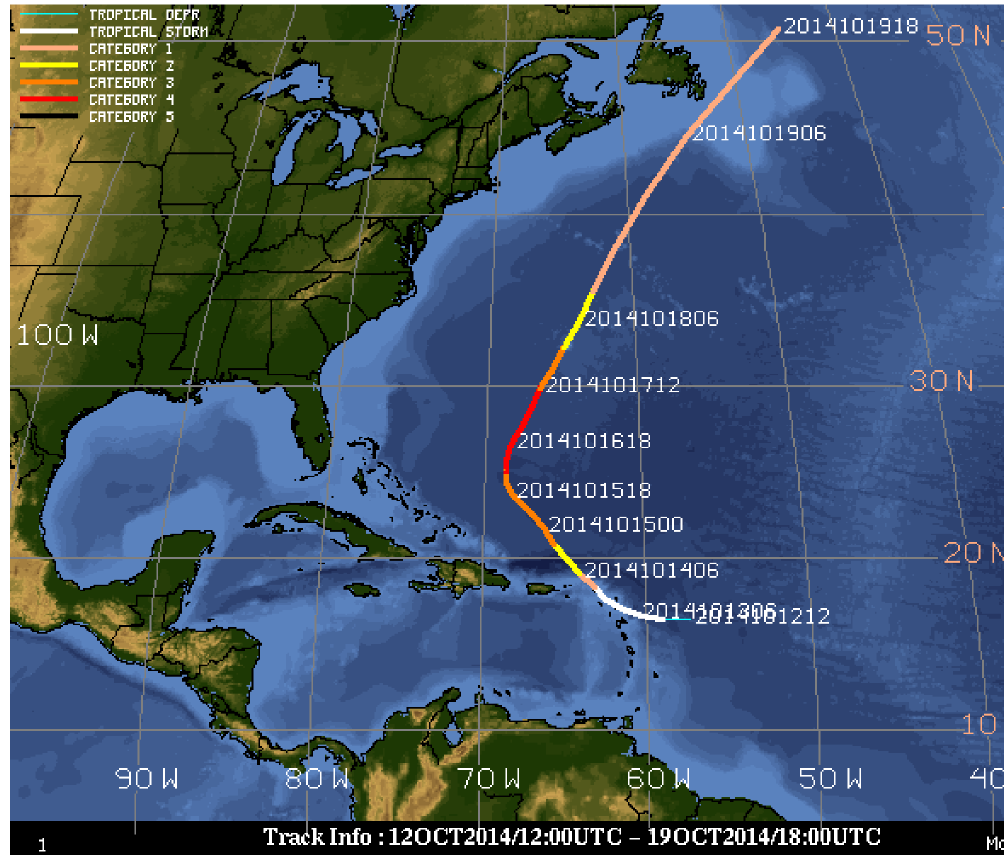
Part 1: HDSS sonde results for WB-57 Gonzalo science flights

Three science flights into Gonzalo:

- 10/15/2014 (sf1015): 28 data files
- 10/16/2014 (sf1016): 44 data files
- 10/17/2014 (sf1017): 60 data files

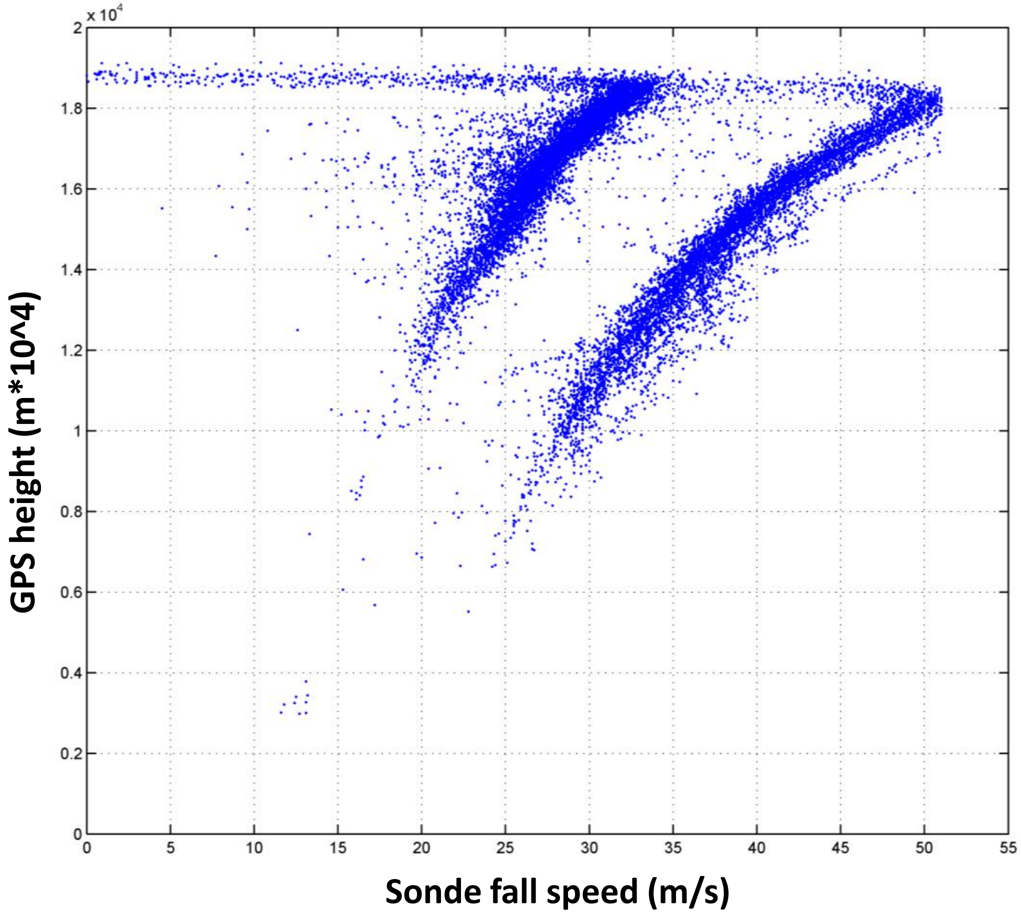
Sonde data files are text files sent out by Lee Harrison soon after the flights. Unless otherwise noted, the plots here pertain to the text files as is, without quality control or other post-processing.

The data shown is at a frequency of 1Hz, the same as the GPS height data frequency provided in the files.



Gonzalo track (plot from CIMSS)

Fast-fall and slow-fall sondes



	Total sondes	No data	Fast-fall	Slow-fall	Both modes
sf1015	28	2	8	15	3
sf1016	44	0	14	30	0
sf1017	60	2	16	41	1
Total	**132**	**4**	**38**	**86**	**4**

- Plot shows fall speed vs. height for all the HDSS drops into Gonzalo
- Sondes generally fall in either a "fast-fall" mode or "slow-fall" mode, with a couple sondes switching fall-mode during flight. See table for details. Most sondes were slow-fall.
- Fast-fall sondes generally return obs from further down in the atmosphere than slow-fall sondes. This is an important distinction. See next slide for further analysis.
- Fast-fall sondes also appear to have less random ob error in the horizontal wind observations than slow-fall sondes.
- Random ob error in temperature appears similar between fast-fall and slow-fall sondes
- There is no basis for comparing RH random ob error, as the sondes do not start giving non-negligible RH values until below 12 km, where little slow-fall data exists

Percentage of Sondes with Data Below Given Level

ALL SONDES

	OCT. 15	OCT. 16	OCT. 17
16000 m	93%	98%	97%
14000 m	74%	75%	95%
12000 m	44%	46%	53%
10000 m	30%	23%	22%
8000 m	11%	9%	10%
6000 m	4%	2%	3%

SLOW FALL

	OCT. 15	OCT. 16	OCT. 17
16000 m	88%	97%	95%
14000 m	65%	63%	93%
12000 m	18%	20%	36%
10000 m	6%	3%	2%
8000 m	0%	3%	0%
6000 m	0%	3%	0%

FAST FALL

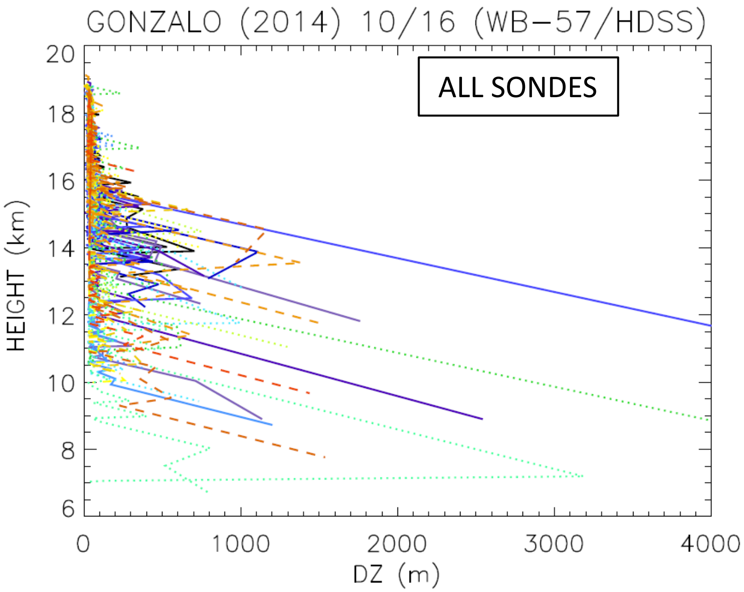
	OCT. 15	OCT. 16	OCT. 17
16000 m	100%	100%	100%
14000 m	90%	100%	100%
12000 m	90%	100%	100%
10000 m	70%	64%	75%
8000 m	30%	21%	38%
6000 m	10%	0%	13%

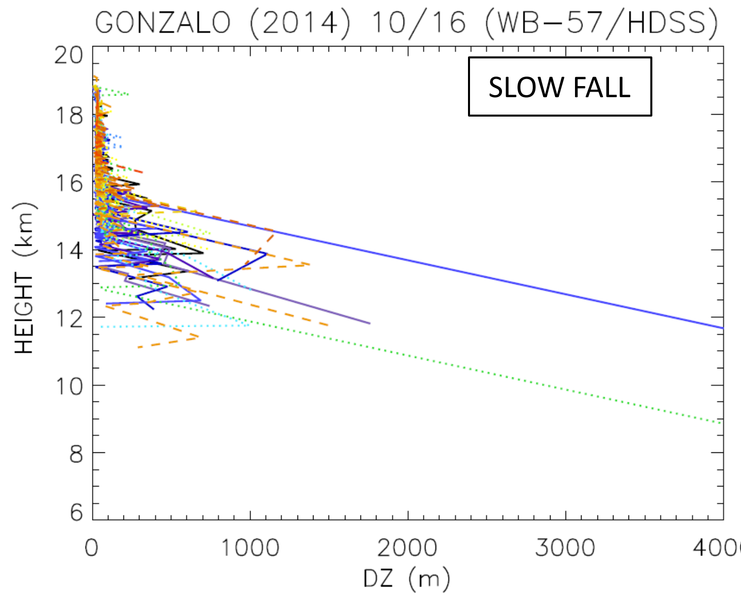
Slow-fall sondes can typically obtain data regularly to 16 km (~88-95%), and approximately one-half the sondes have data to 13-14 km.

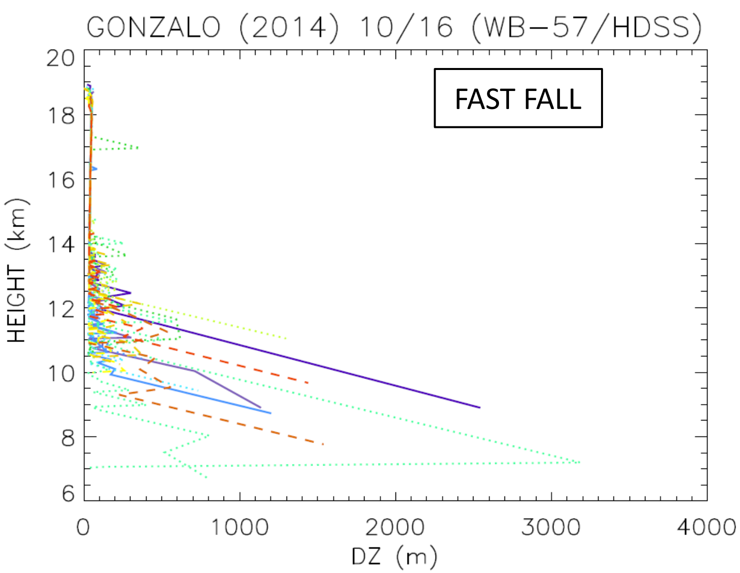
Fast-fall sondes can typically obtain data regularly to 12 km (~90-100%), and approximately one-half the sondes have data to 9-10 km.

With current data retention, it is not guaranteed to obtain full structure of outflow jets with fast-fall sondes since only one-half get to 9-10 km.

Vertical Resolution of Data







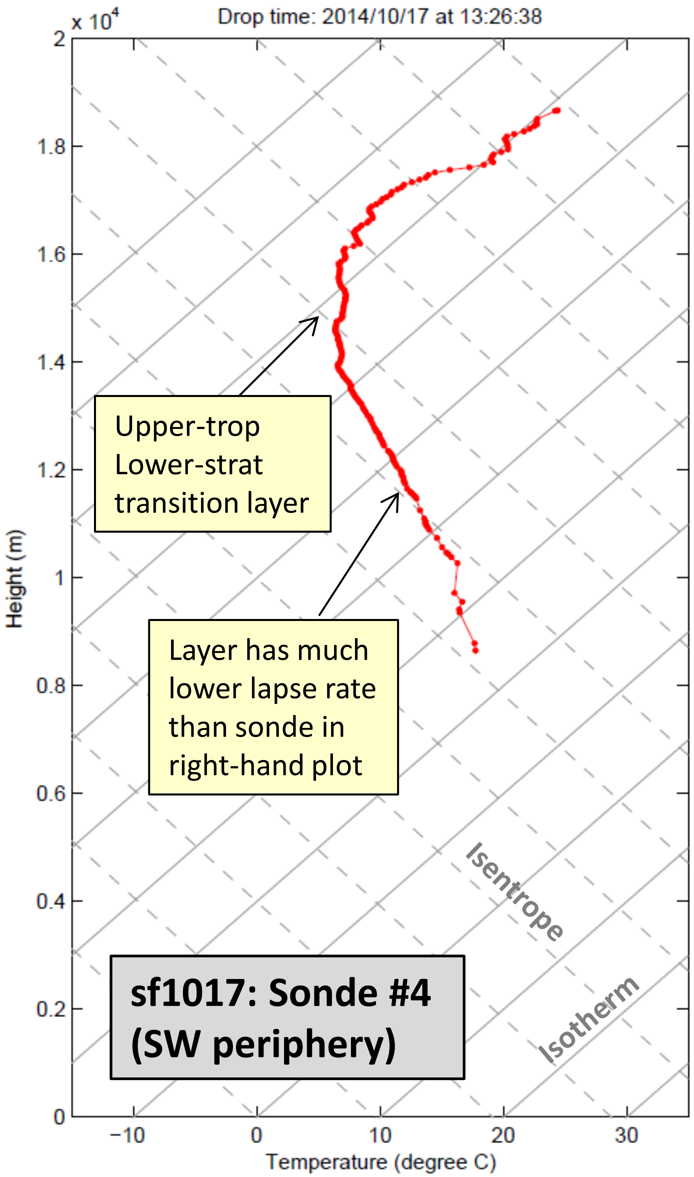
For slow fall sondes, the vertical resolution becomes coarse starting at approximately 15-16 km.

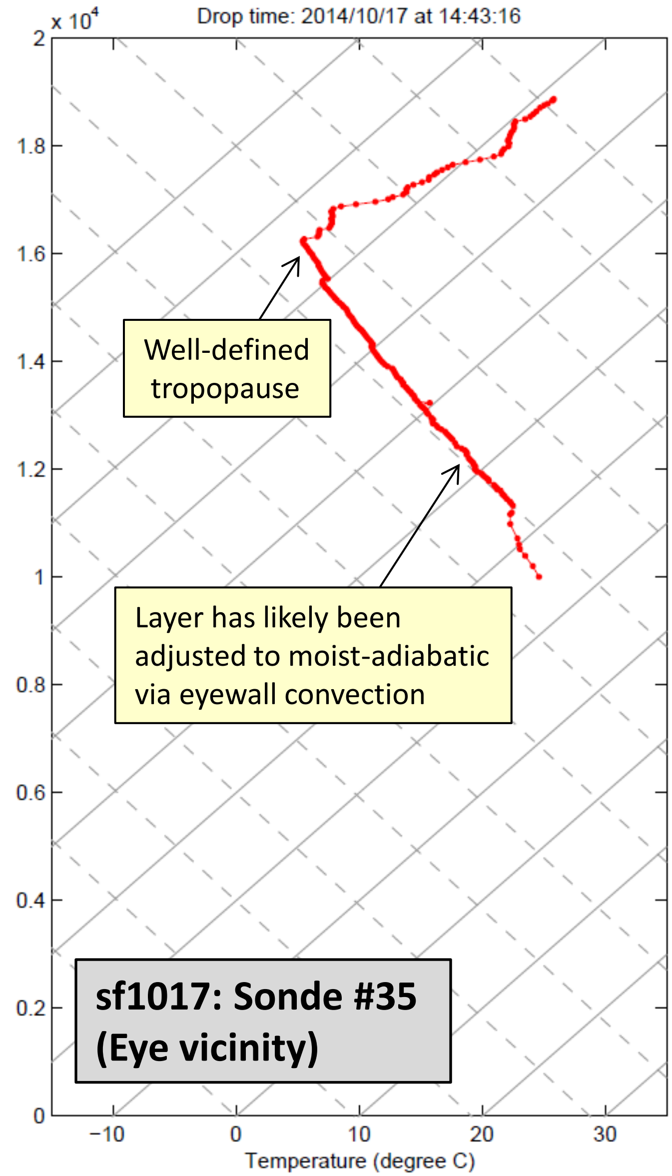
For fast fall sondes, the vertical resolution becomes coarse at 12 km.

For slow-fall sondes, data below 15 km may not have adequate vertical resolution to map out features

For fast-fall sondes, data beloe 12 km may not have adequate vertical resolution to map out features

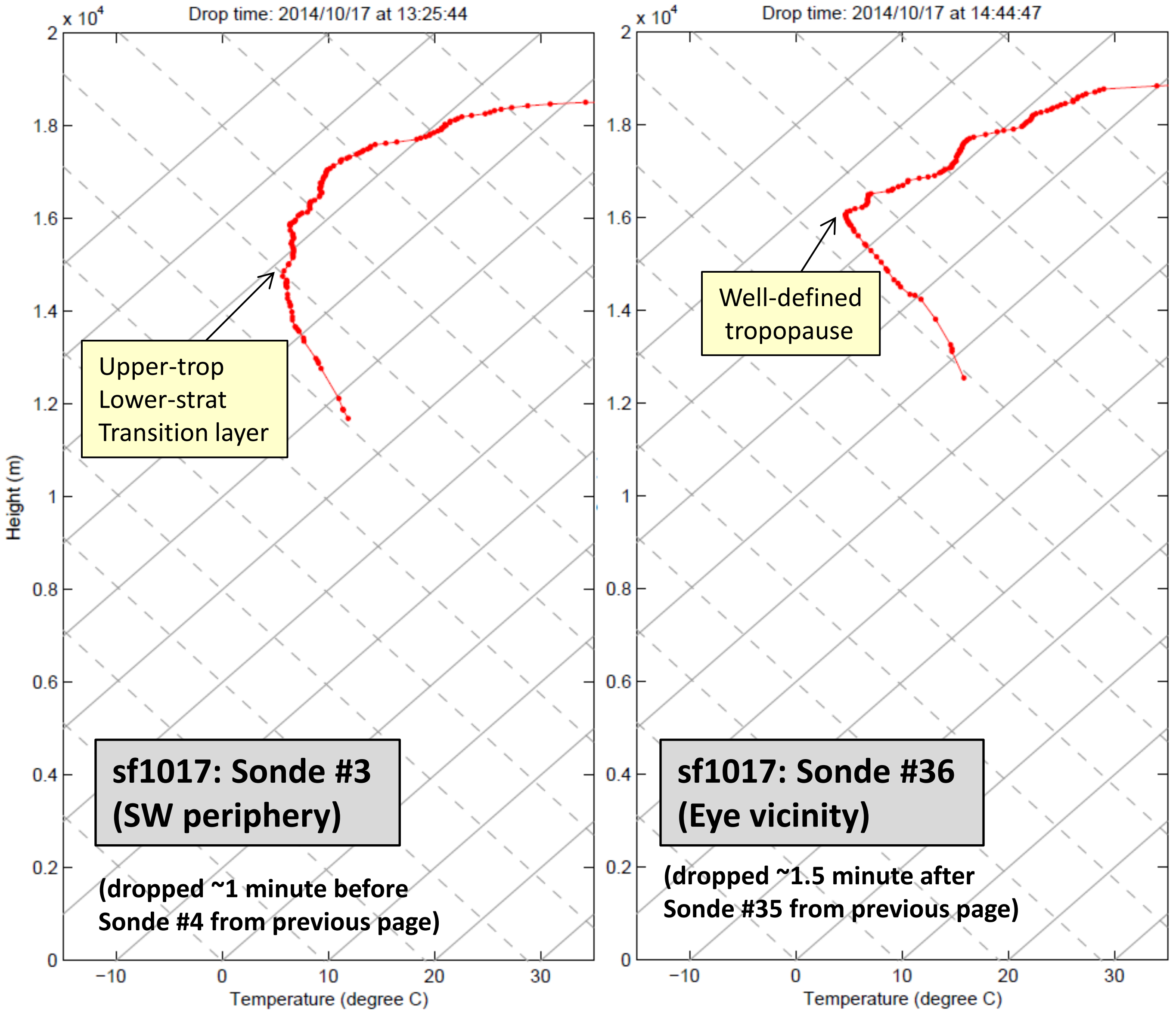
Temperature: Fast-fall sonde profile examples





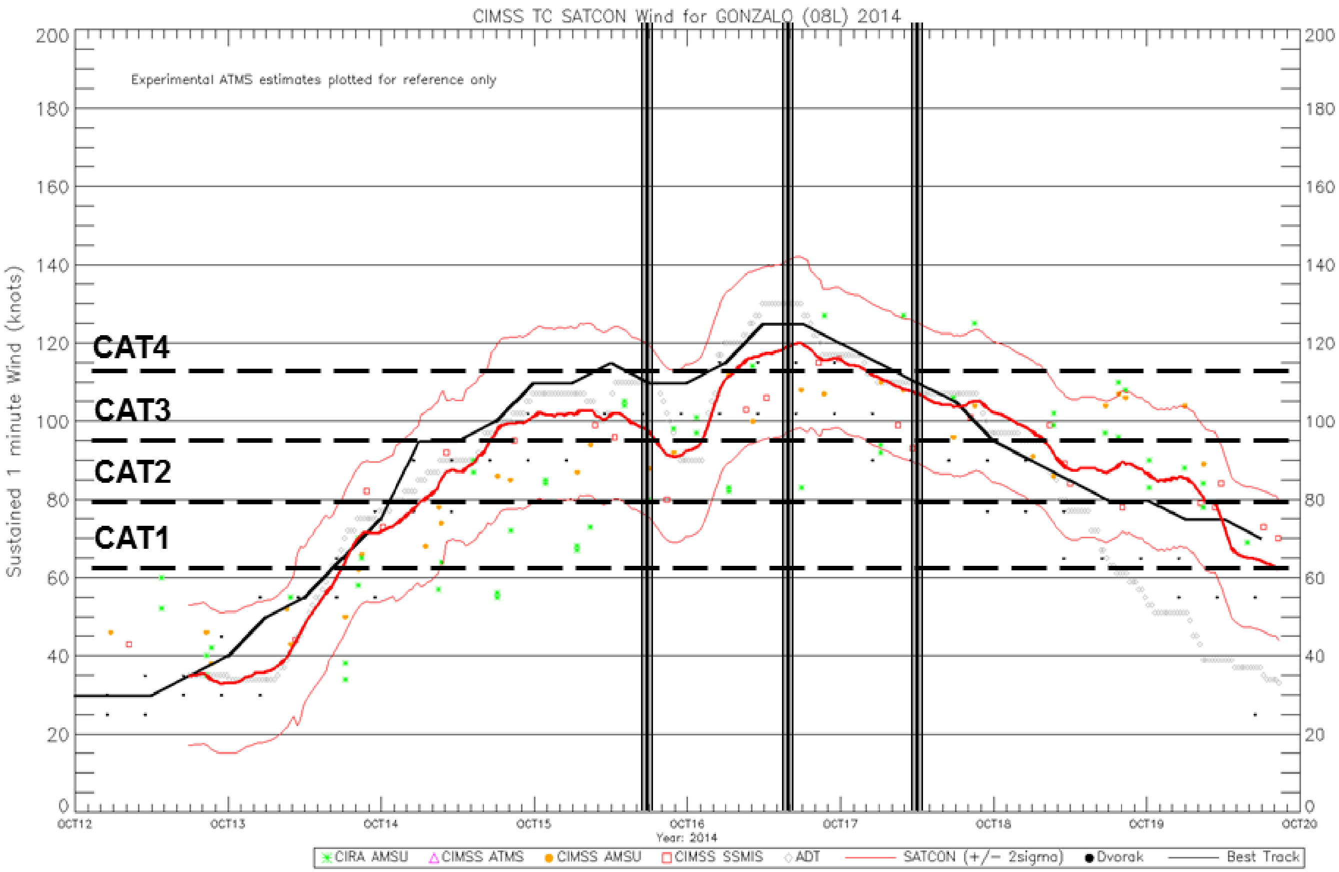
- Markers are plotted at data points and connected with lines. Note that lower in the profile, the vertical resolution of the data decreases.
- Overall, fast-fall sondes almost always have high-resolution temperature data down through 12 km. Below 12 km, the data becomes sparser and eventually stops. The fast-fall sondes provide sufficient data to study most of the outflow layer, but not the middle and lower troposphere.

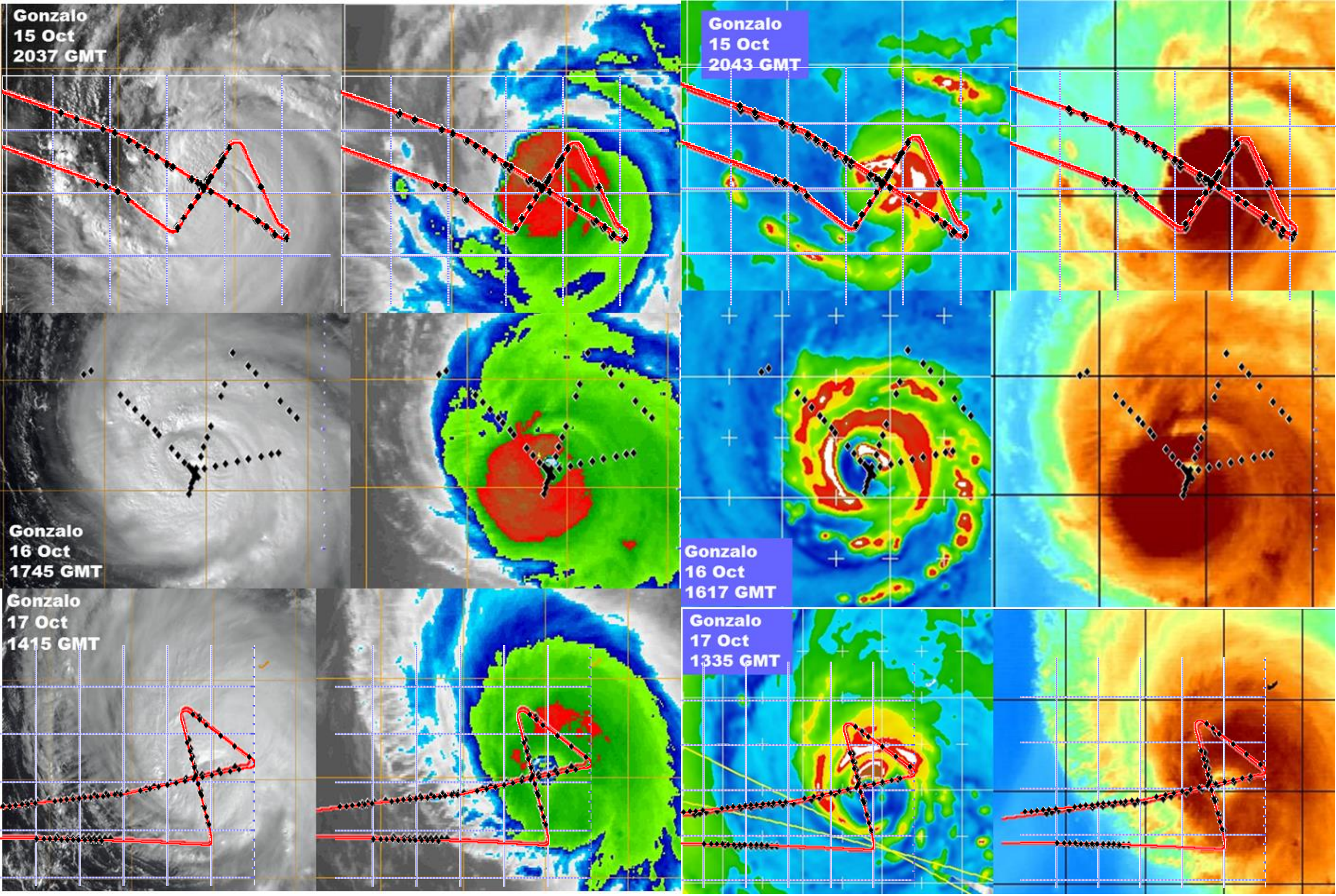
Temperature: Slow-fall sonde profile examples



- Markers are plotted at data points and connected with lines. Note that lower in the profile, the vertical resolution of the data decreases, just like for the fast-fall sondes. However, this occurs at a higher altitude than for the fast-fall sondes
- Most slow-fall sondes have data through 14 km, though it is sparse sometimes. This data is scientifically useful for studying the tropical tropopause/UTLS layer and the upper portion of the outflow layer. The slow-fall sonde data is sparse for the lower part of the outflow layer and non-existent lower than that.

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

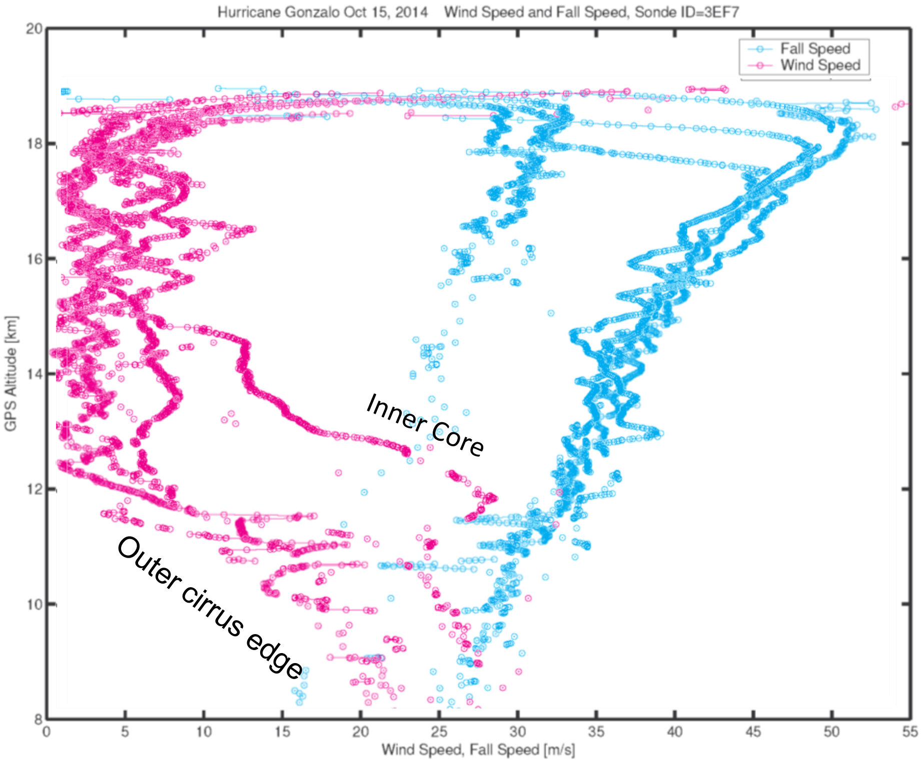




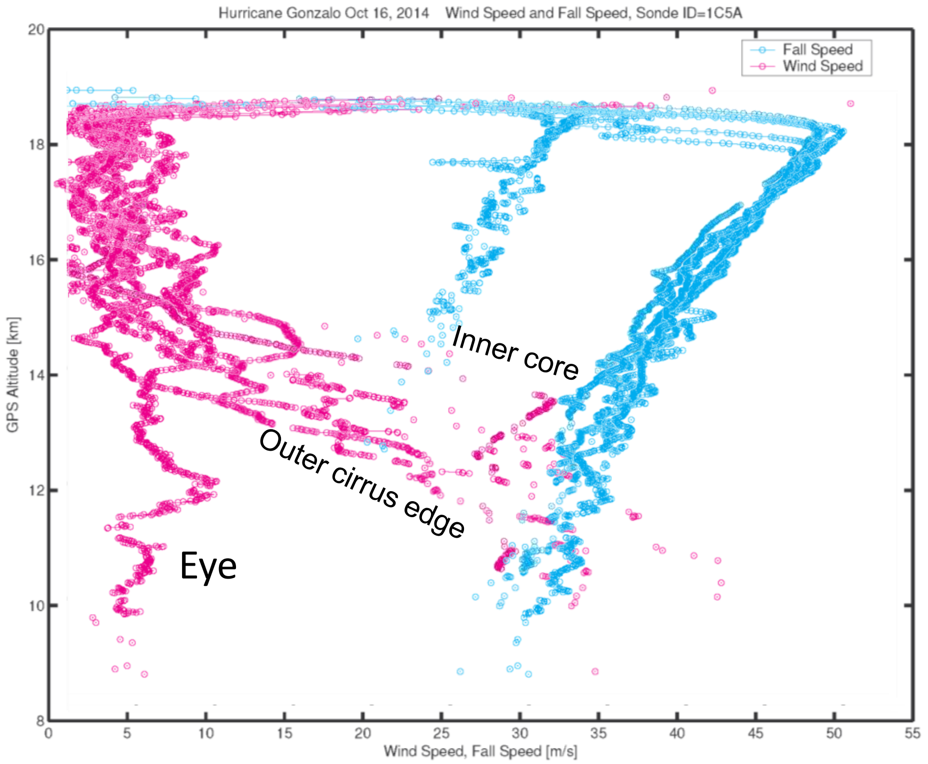
Flight tracks and XDD deployment locations relative to visible, infrared, microwave and water vapor features for 3 WB-57 flights on Oct 15, 16 and 17. No flight track on Oct 16 due to aircraft computer failure. Outflow jet at edge of cirrus canopy and inner core convective features were targeted.

Gonzalo 2014
15 October
WB-57F
HDSS/ XDD

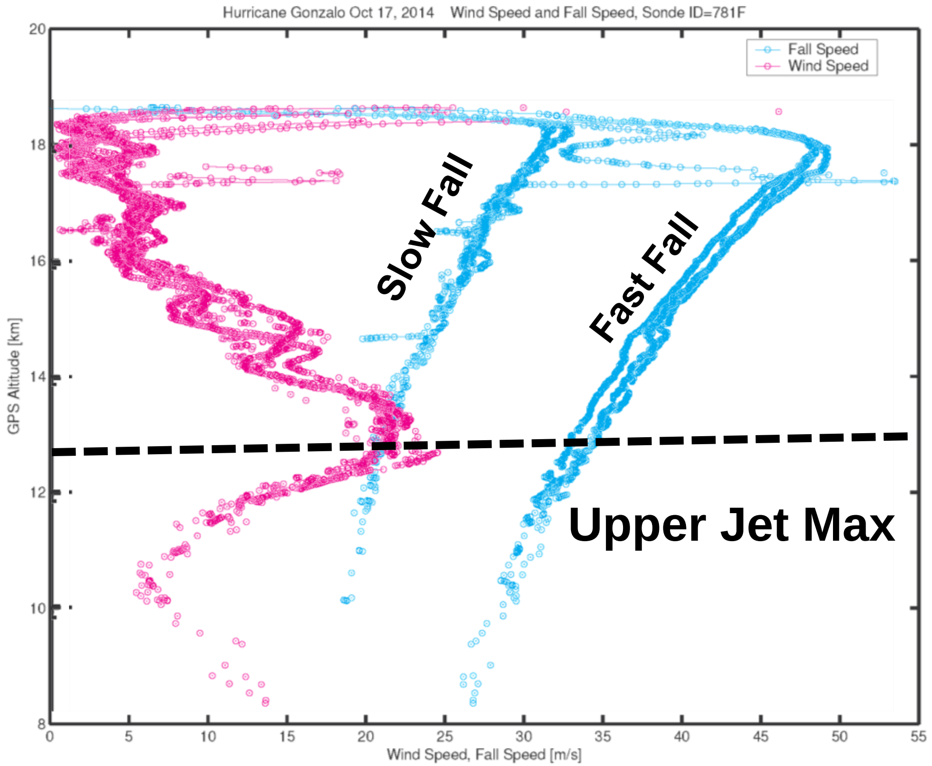
Wind plots done at 4 hz rate with interpolate GPS heights
Temperature plots done at 2 Hz rate
Multiple sondes observe consistent upper level structure at slow- and fast-fall rate

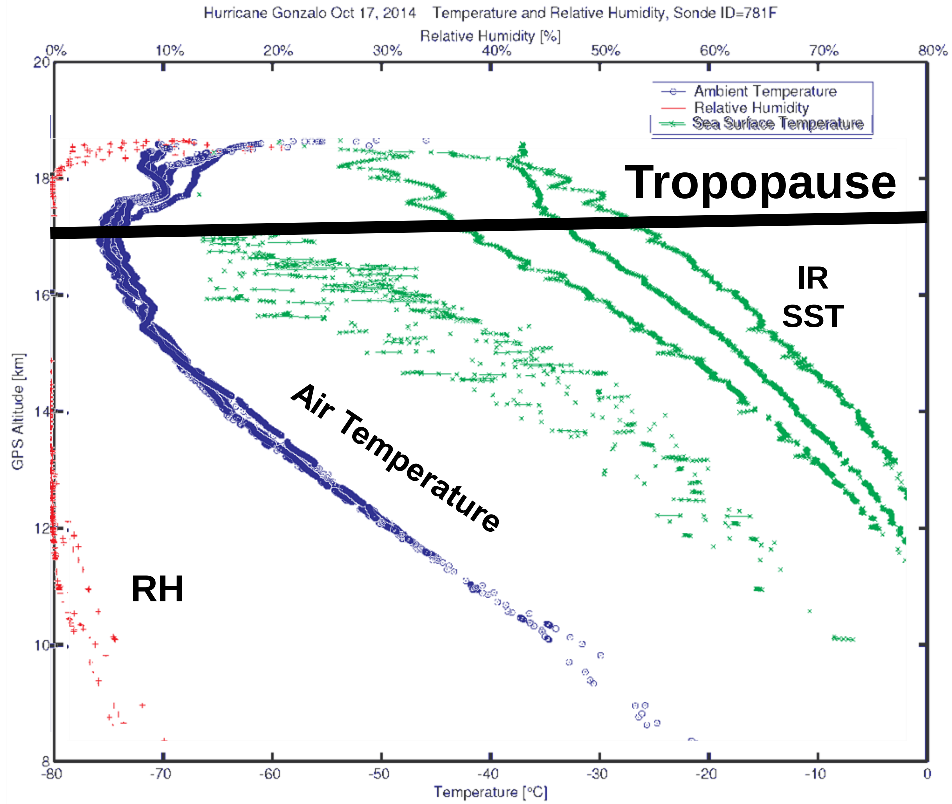


Gonzalo 2014
16 October
WB-57F
HDSS/ XDD
Multiple sondes observe consistent upper level structure at slow- and fast-fall rate

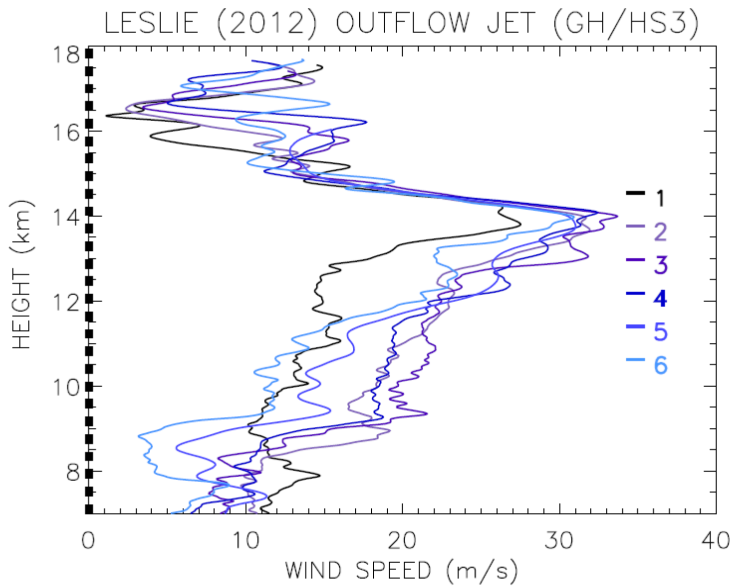


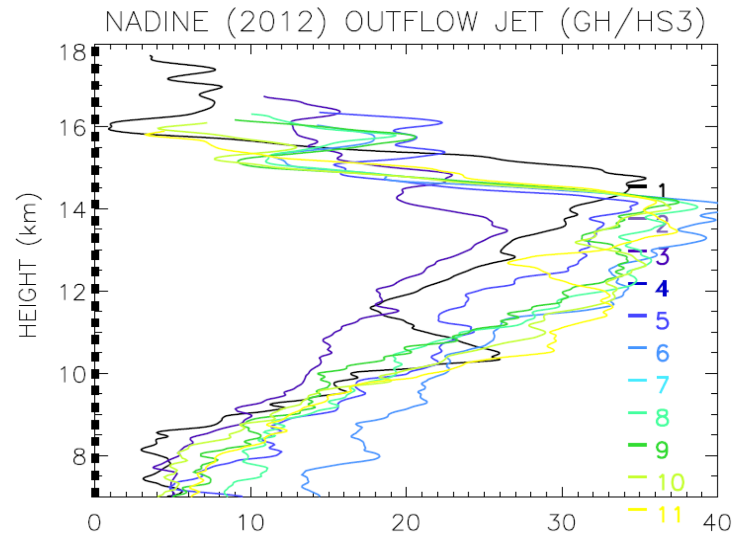
Gonzalo 2014
17 October
WB-57F
HDSS/ XDD
Wind plots done at 4 hz rate with interpolate GPS heights
Temperature plots done at 2 Hz rate
Multiple sondes observe consistent upper level structure at slow- and fast-fall rate

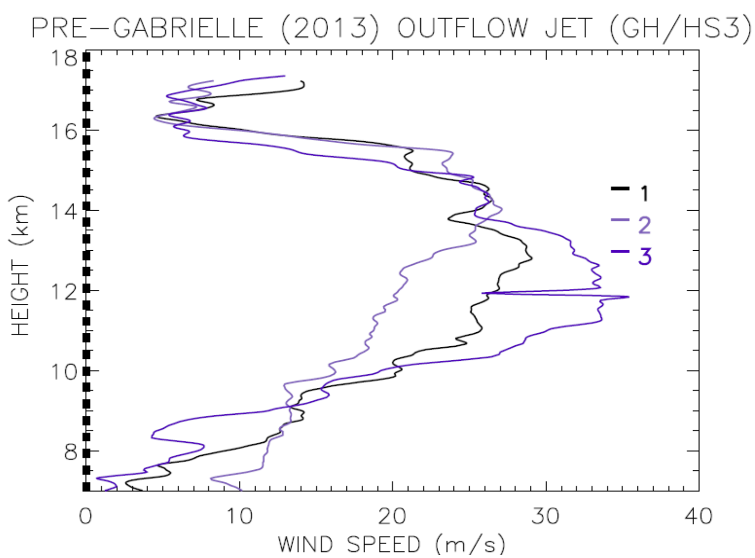


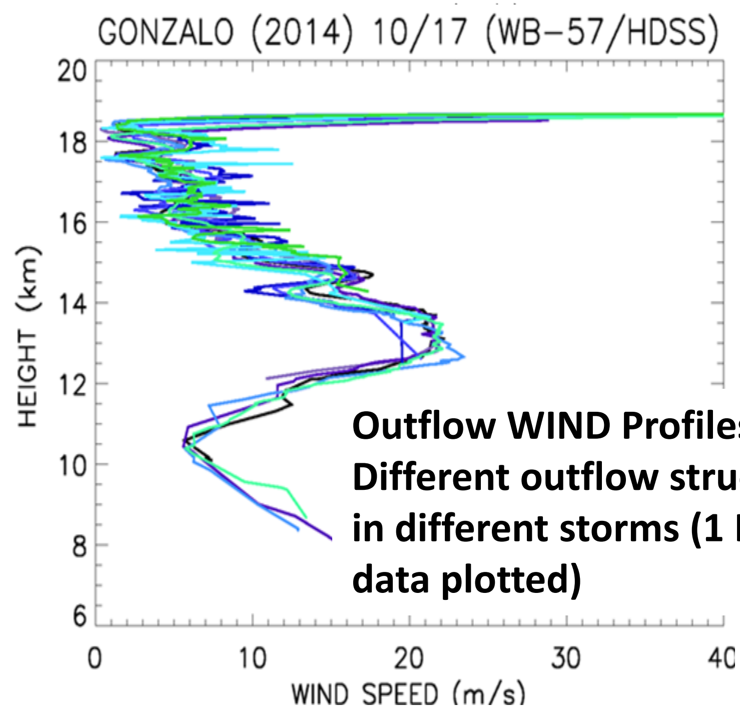


Comparison of outflow jet structures in 4 storms- HS3 cases use AVAPS mini-sonde and ASPEN post-processed data: de-spiked, smoothed and plotted at 4 Hz rate.



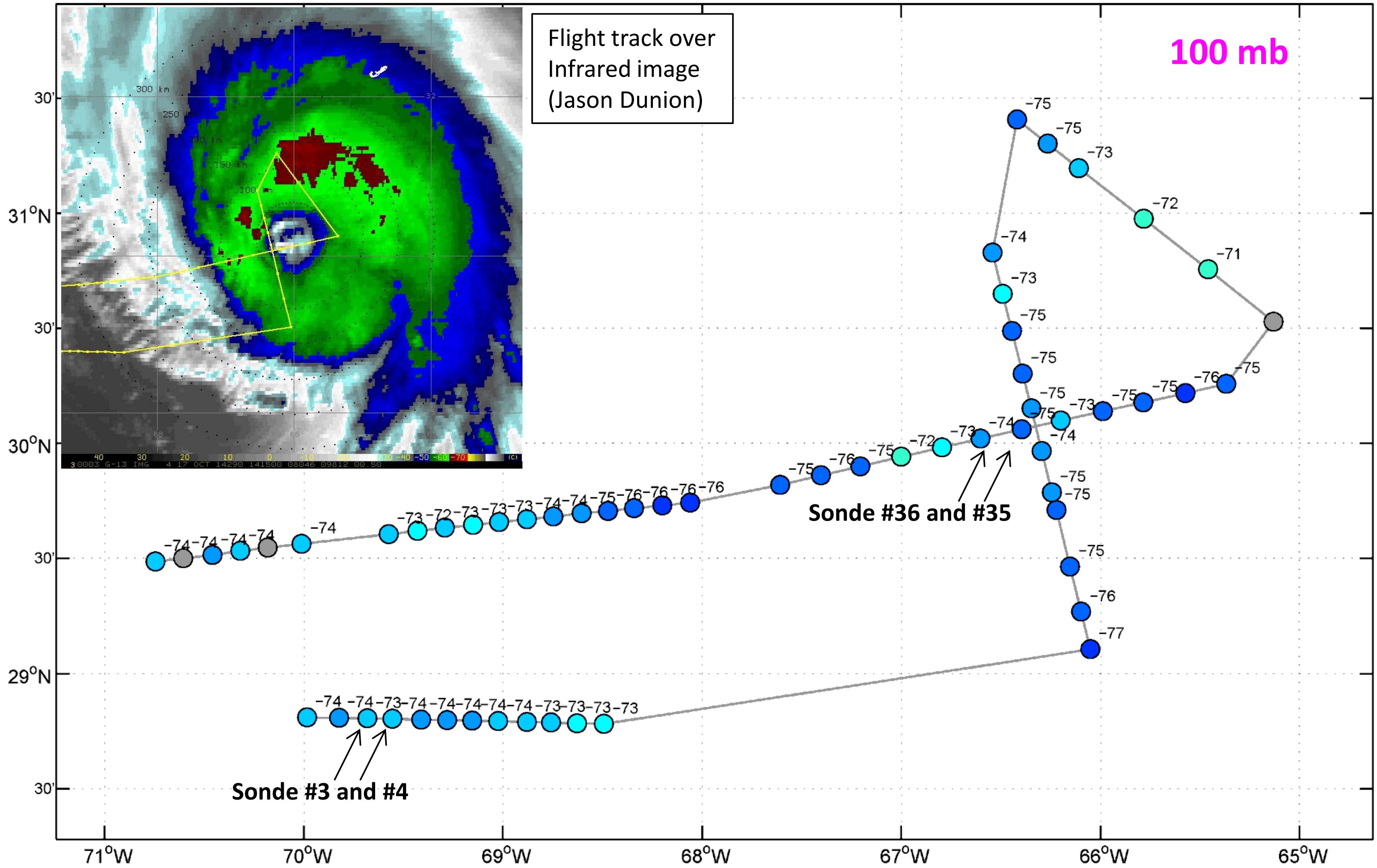






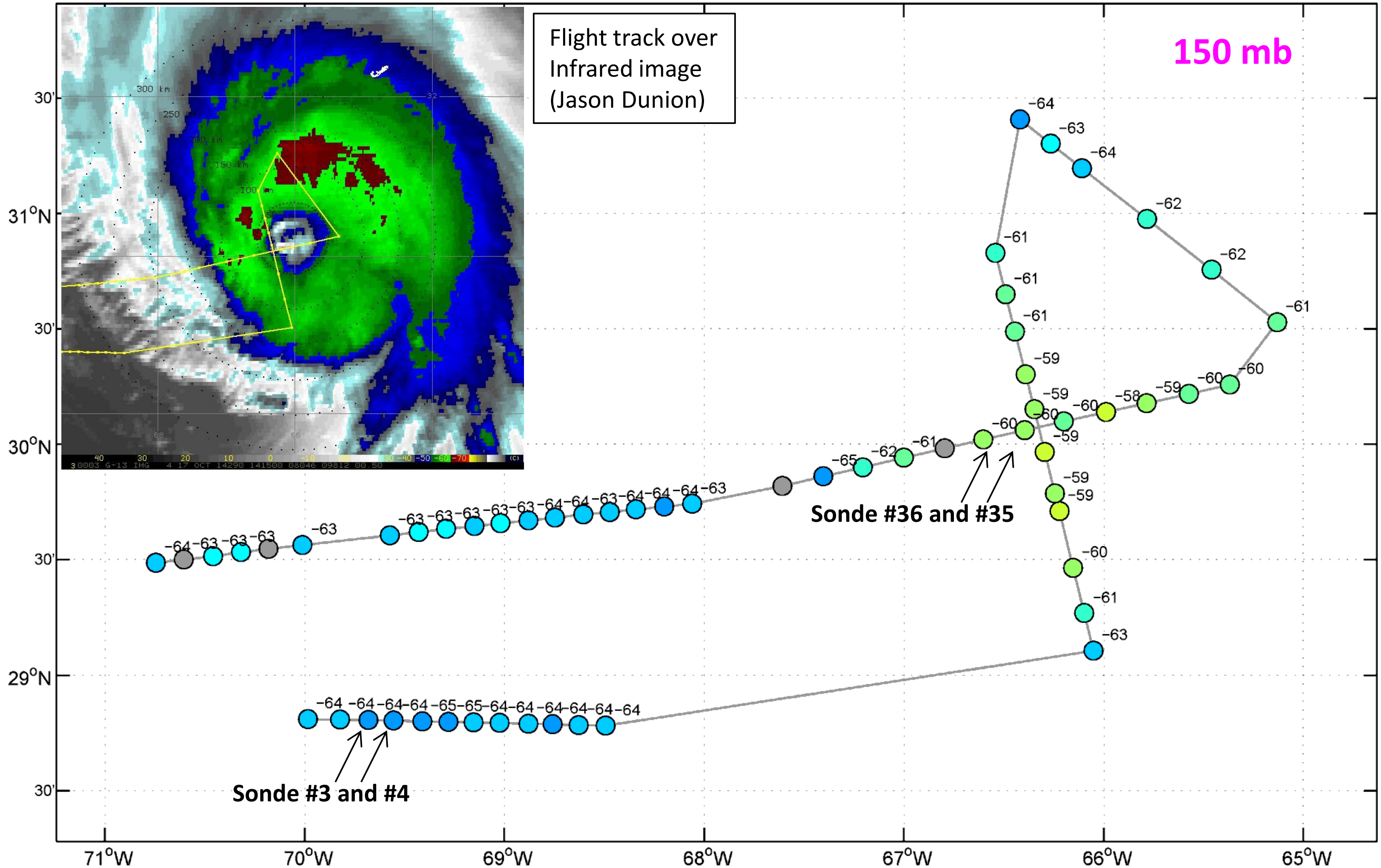
Outflow WIND Profiles: Different outflow structures in different storms (1 Hz raw data plotted)

Temperature: Horizontal coverage (sf1017 example)



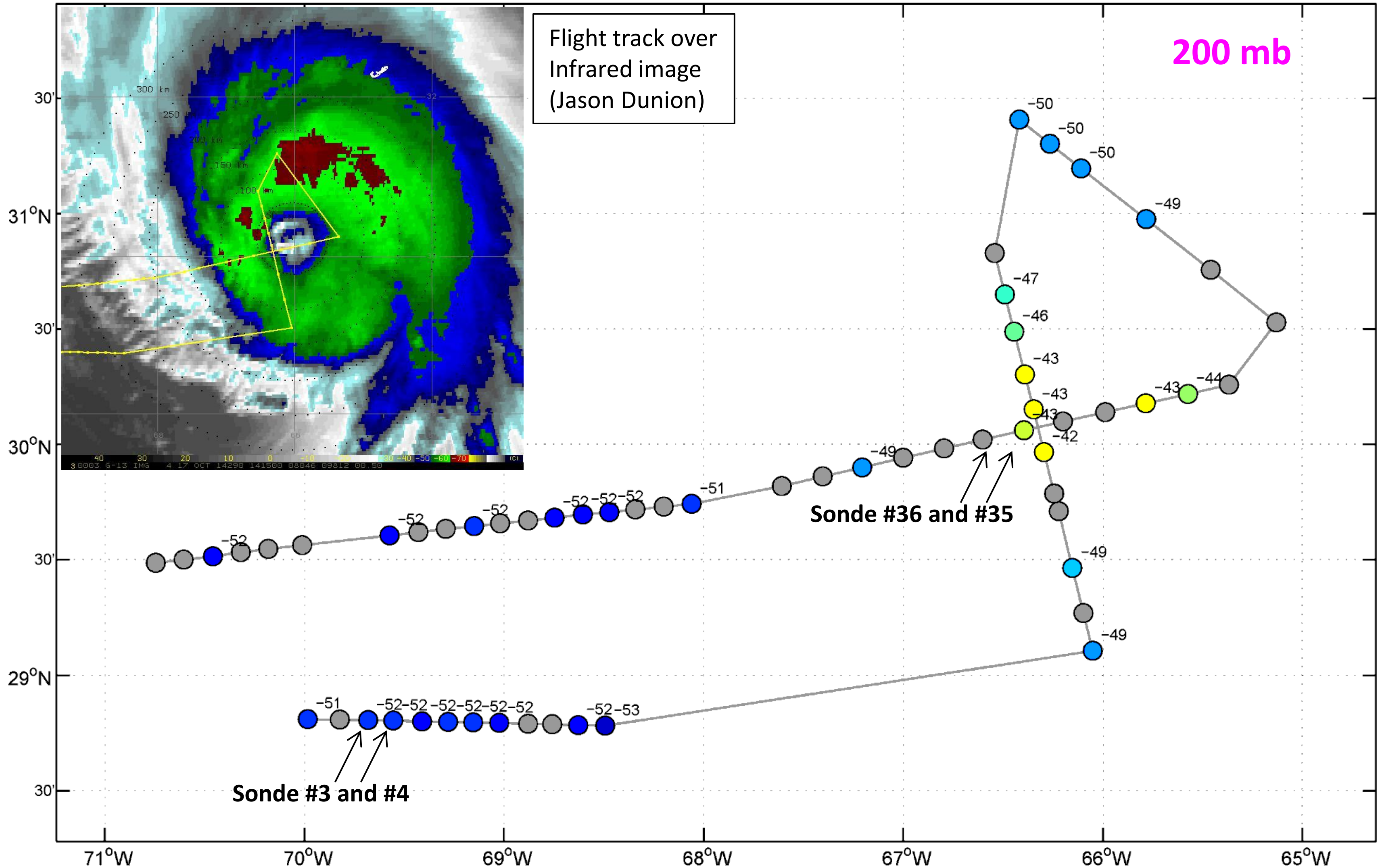
Sonde launch locations are color-coded according to observed temperature if data exists, and are gray if not. The observed temperature is also written next to the colored dot. Data is considered to “exist” if an observation was made within +25 and - 25 mb of the level in question. Linear interpolation is used to arrive at the displayed value. Temp in deg C.

Temperature: Horizontal coverage (sf1017 example)



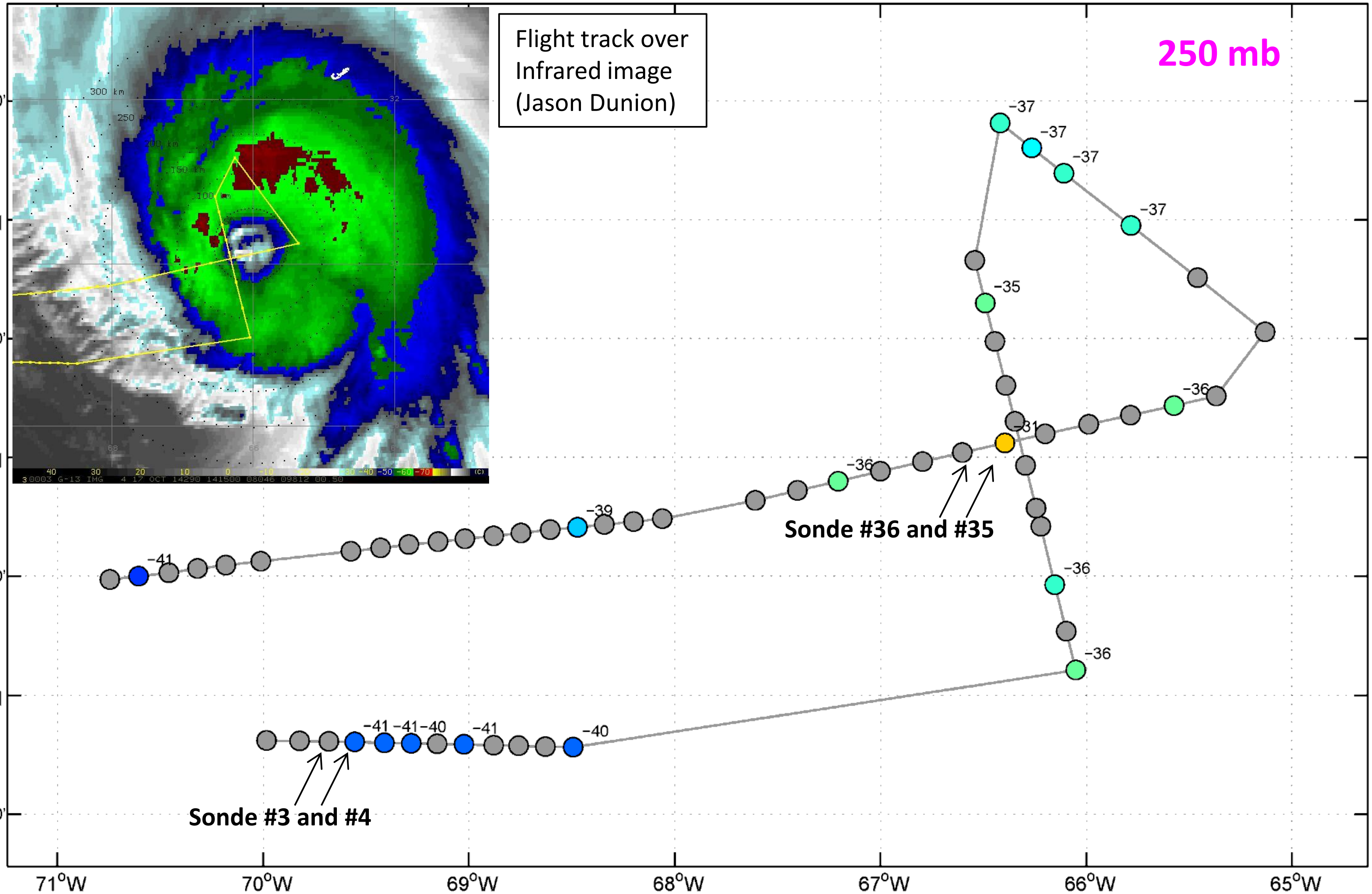
150 mb is generally around the top of the outflow layer in the Atlantic. Almost all sondes have temperature data at this level. The warm core is evident at this level. Adjacent sondes in the western part of the pattern show good consistency in temperature values. There should not be much variation out there.

Temperature: Horizontal coverage (sf1017 example)



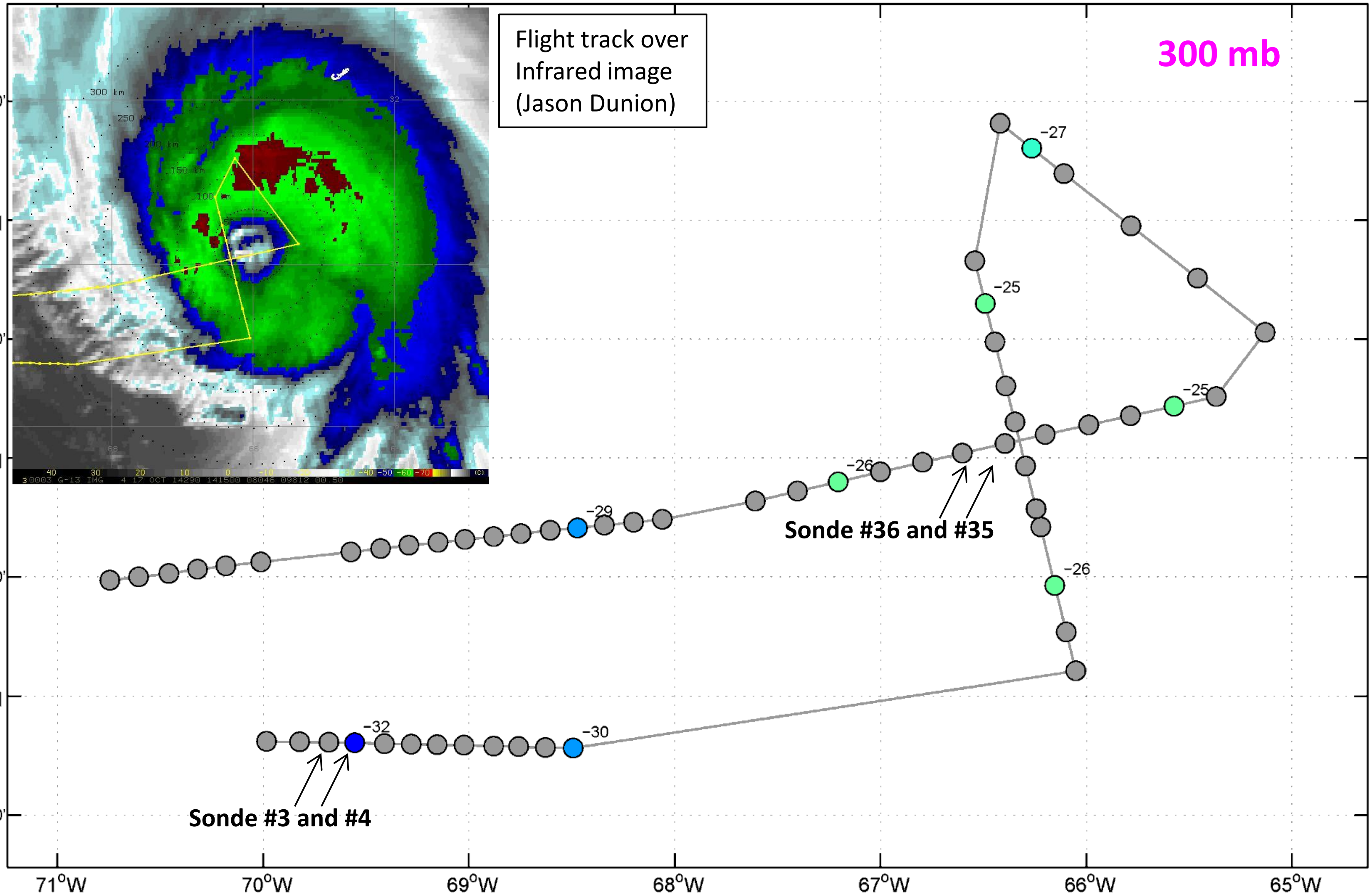
200 mb is generally towards the middle of the outflow layer in the Atlantic. Many of the slow-fall sondes have no data at this level; 31 out of 60 sondes have data under the assumptions used to make this plot. Large warm anomaly of 8-10 degrees in eye of storm is evident.

Temperature: Horizontal coverage (sf1017 example)



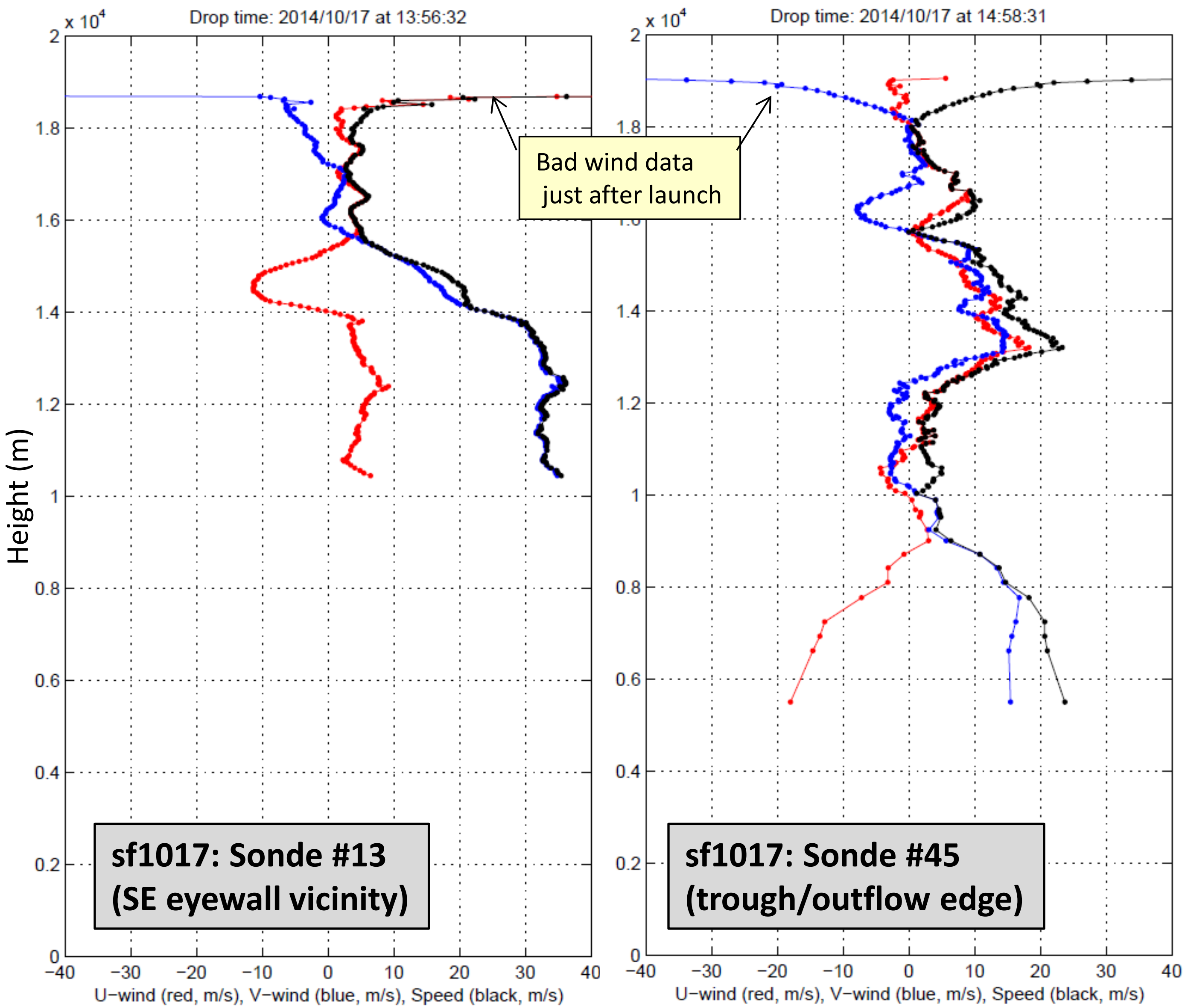
250 mb is generally near the base of the outflow layer in the Atlantic. Almost all of the slow-fall sondes have no data at this level; 17 out of 60 sondes have data under the assumptions used to make this plot.

Temperature: Horizontal coverage (sf1017 example)



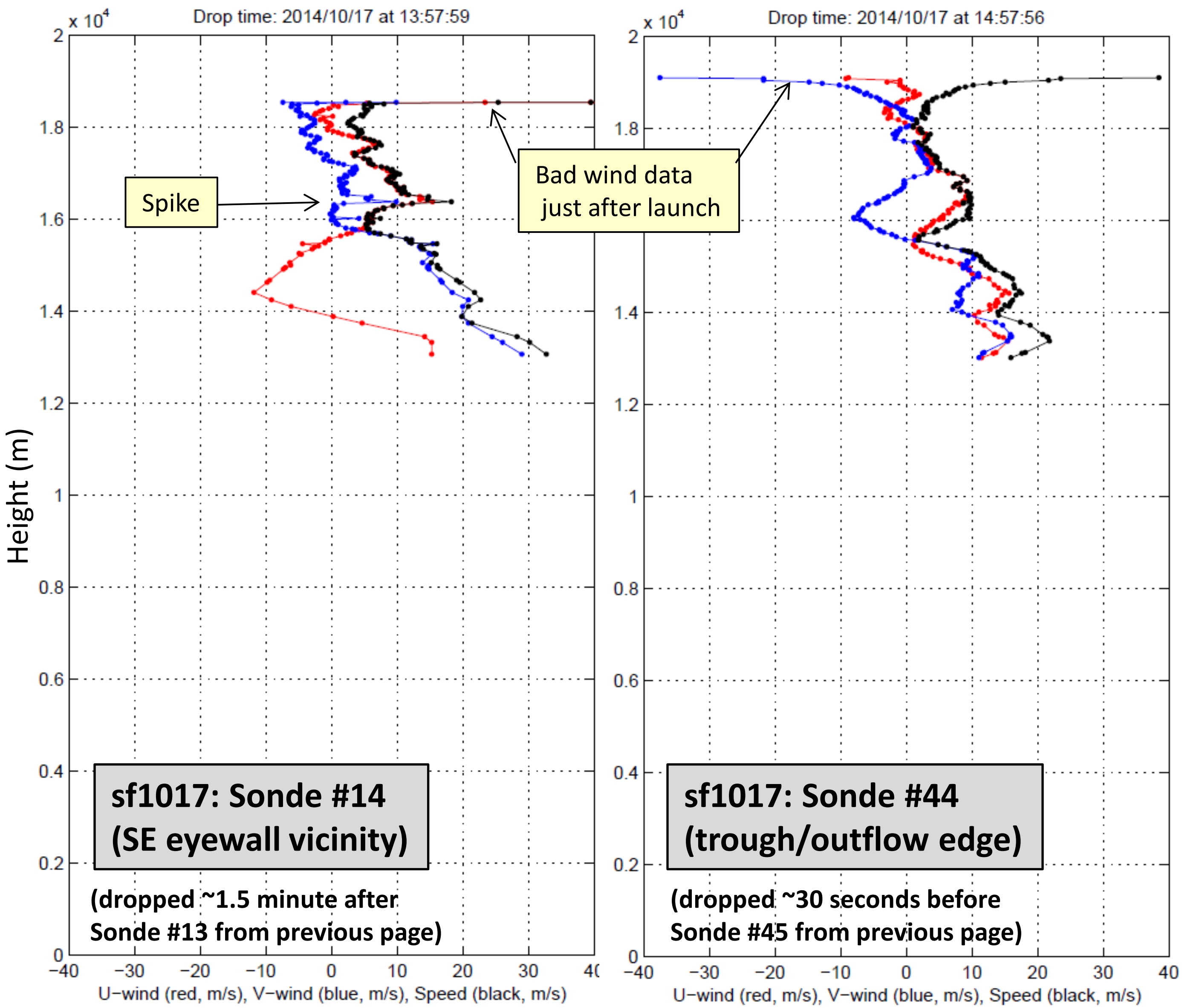
At 300 mb, data is coming from a limited set of the fast-fall sondes. This is not too useful for mapping out the details of the upper-tropospheric temperature structure.

Winds: Fast-fall sonde profile examples



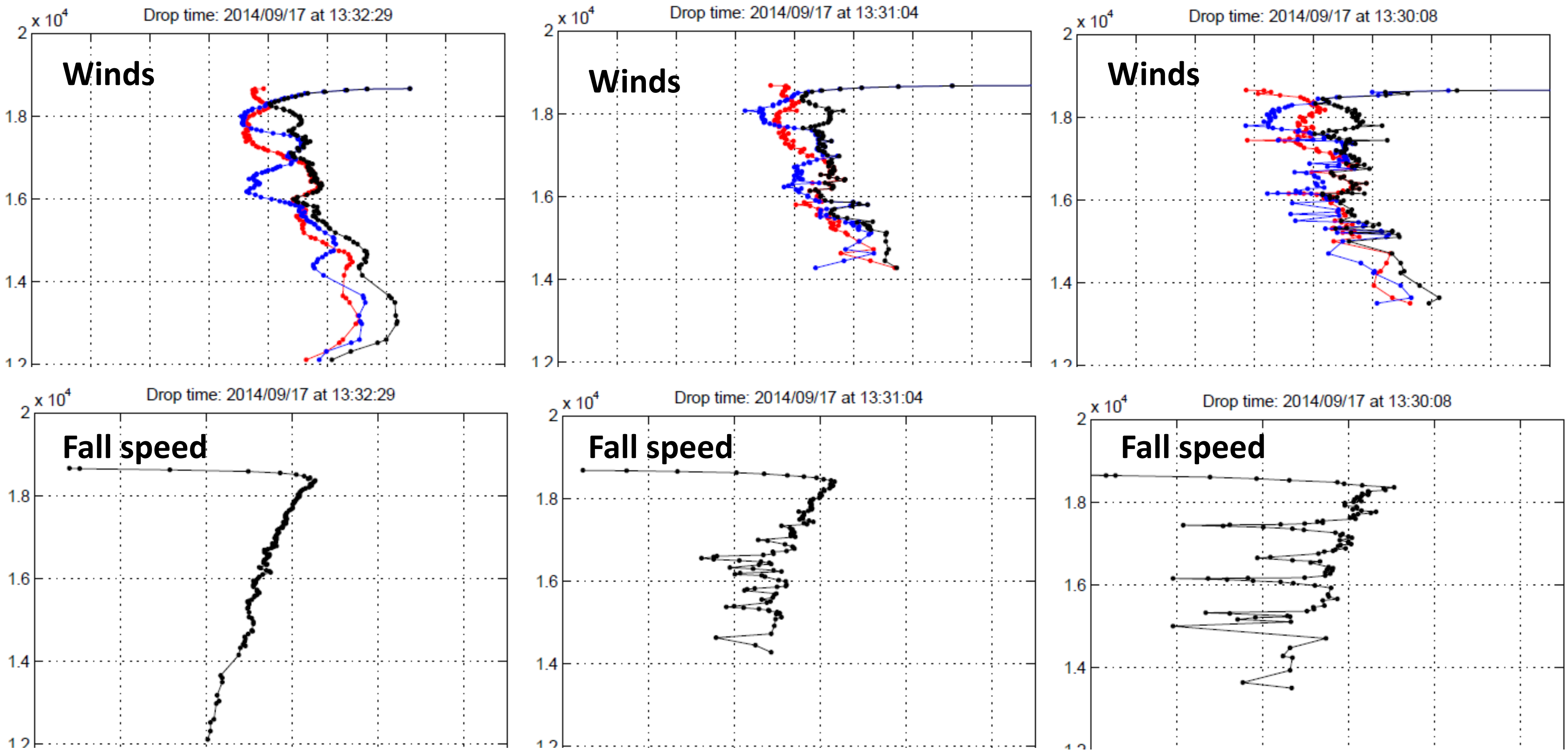
- Markers are plotted at data points and connected with lines.
- The vertical extent and resolution of fast-fall wind data is the same as for temperature.
- Additional consideration for winds is smoothness of the profile. Fast-fall wind profiles are typically smooth, like the example on the left. Sometimes there is some additional random variations, like the example of the right. These variations could be smoothed out with additional postprocessing.

Winds: Slow-fall sonde profile examples



- Markers are plotted at data points and connected with lines.
- The vertical extent and resolution of fast-fall wind data is the same as for temperature.
- Slow-fall sonde winds tend to be much messier than fast-fall sonde winds, perhaps due to larger variations in slow-fall fall speed (next slide). These examples are relatively good, with decent continuity in the vertical and just one or two spikes in the left example.

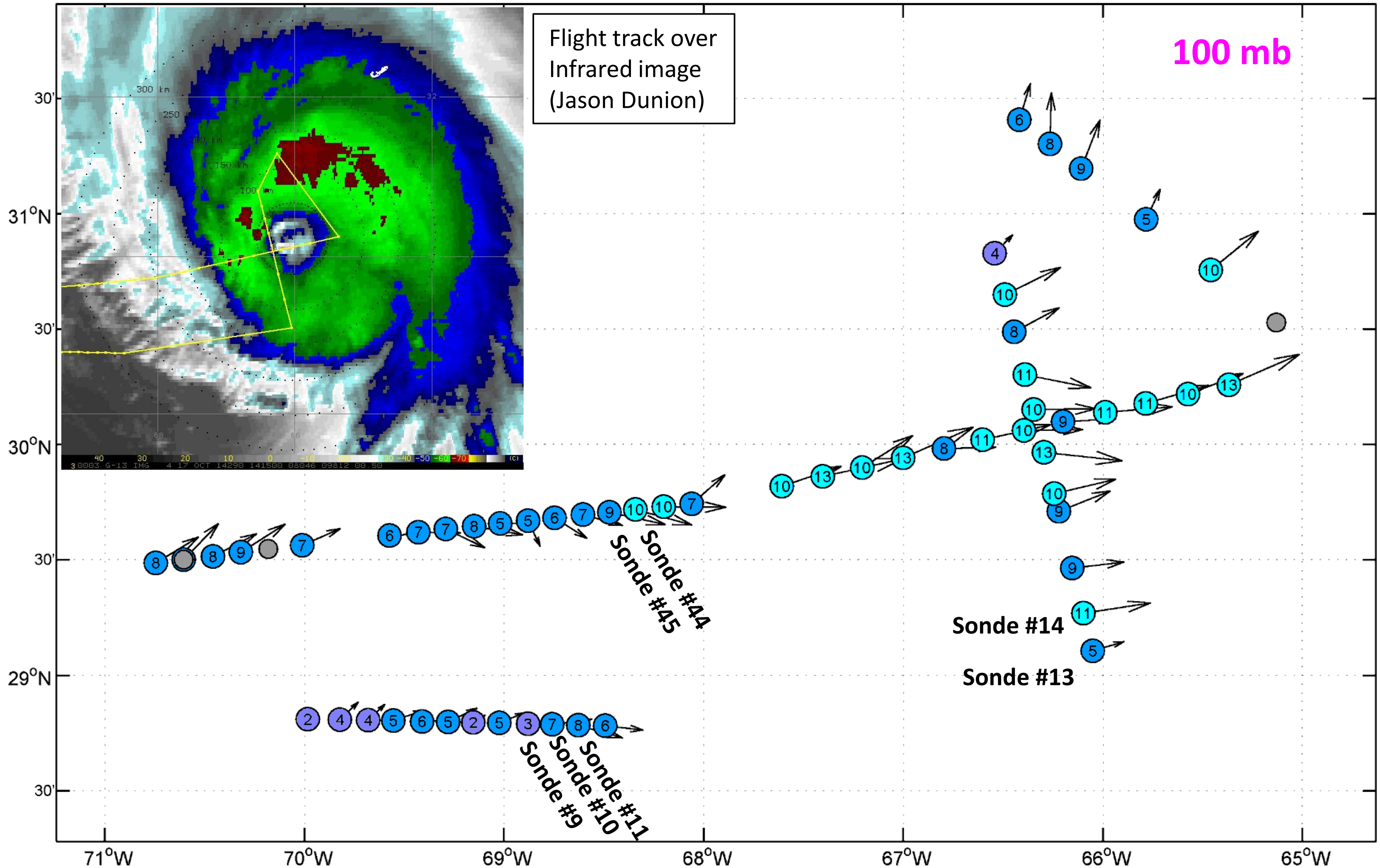
Winds: More Slow-fall sonde profile examples



sf1017: Sonde #11 | **sf1017: Sonde #10** | **sf1017: Sonde #9**

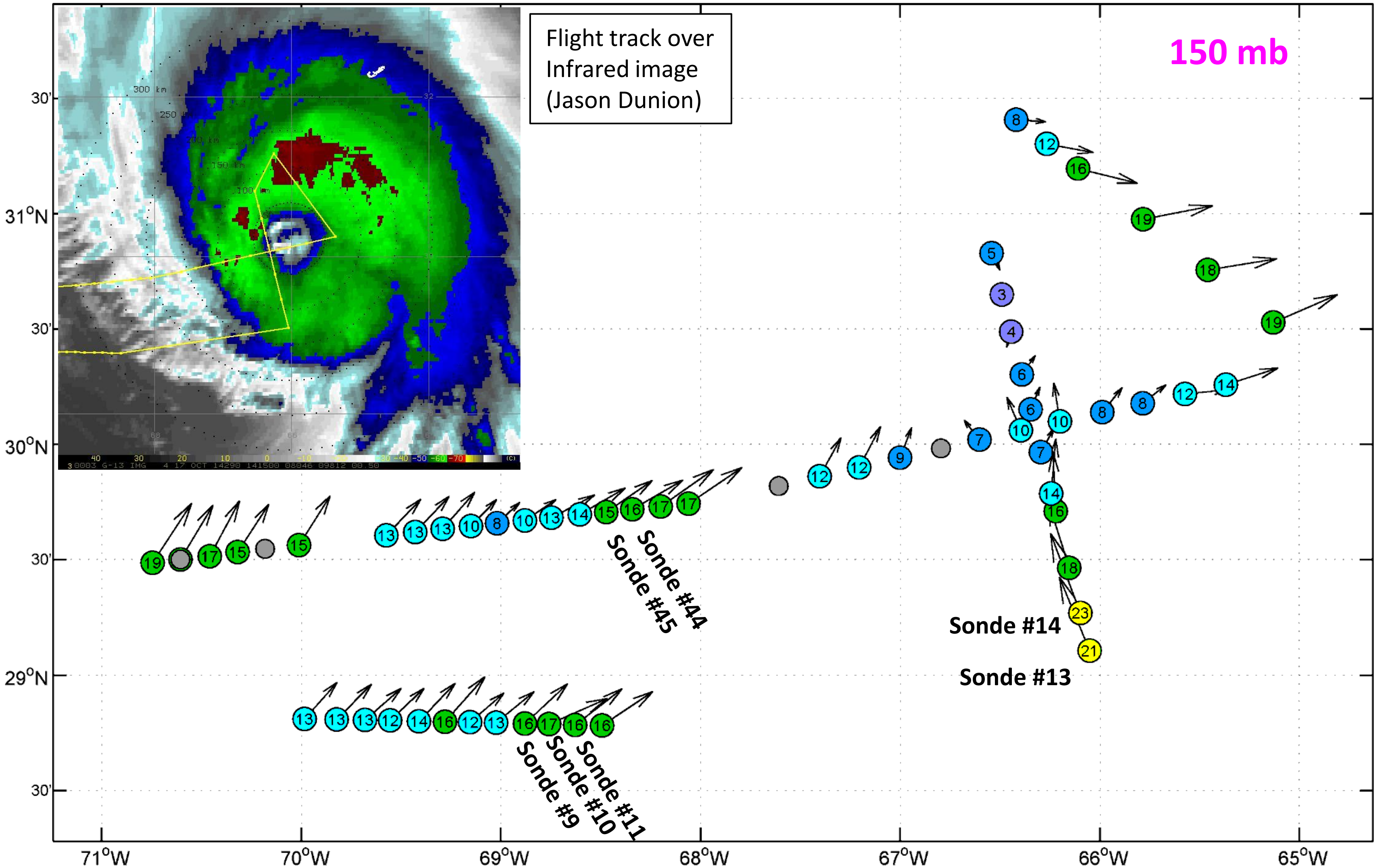
These sondes were dropped within 2.5 minutes in an area where there probably should not be too much horizontal variation in the winds. There is an increasing amount of variability in winds from the left example to the right example, in conjunction with increasing variability in the fall speed. It will take some time to devise a quality control algorithm that can recover the signal in the wind observations from some of the messier slow-fall sondes.

Wind: Horizontal coverage (sf1017 example)



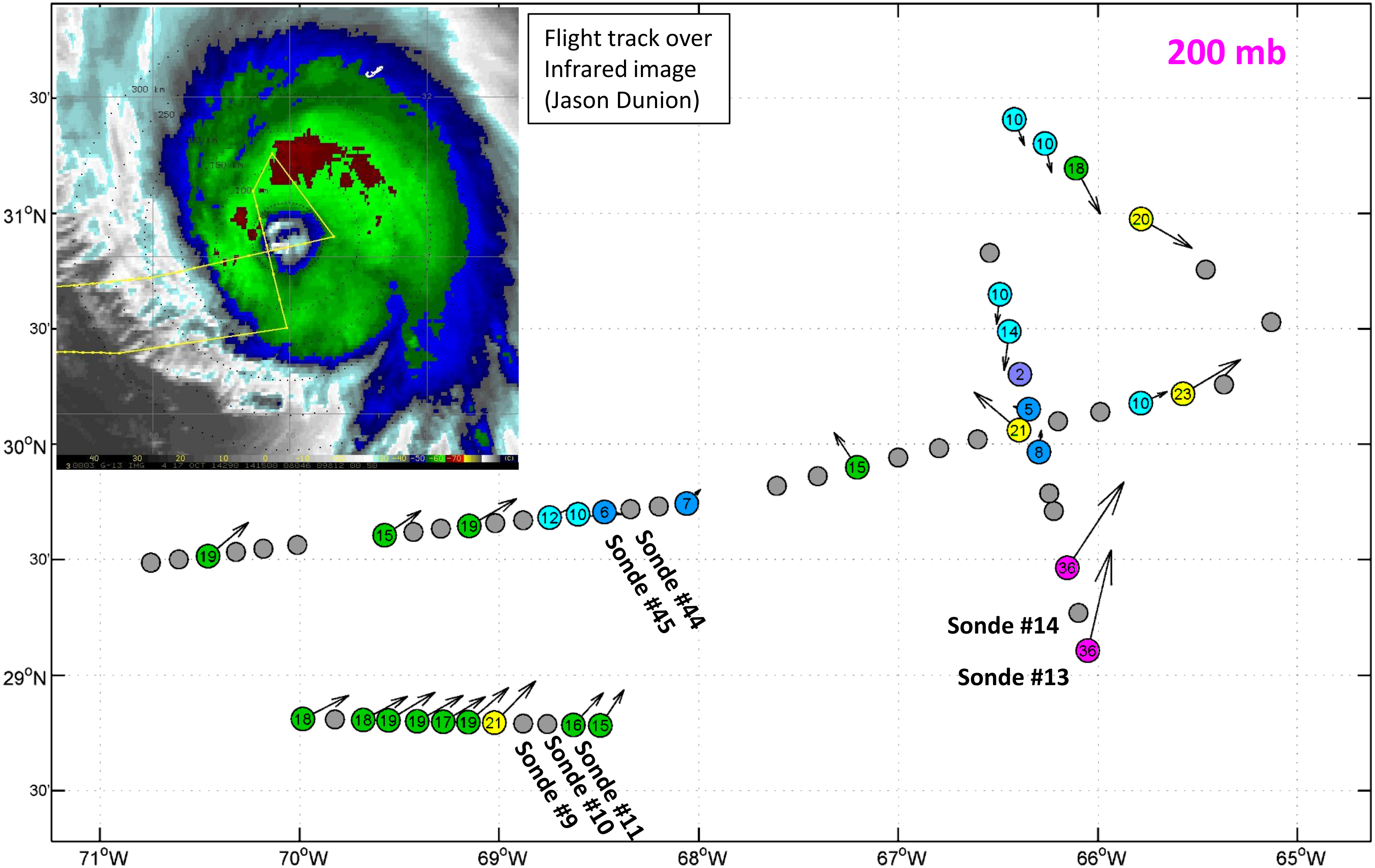
Sonde launch locations are color-coded according to observed wind speed if data exists, and are gray if not. The observed wind speed is written in the dot and a wind vector is drawn. Data is considered to "exist" if observations of u and v were made within +25 and -25 mb of the level in question. Linear interpolation is used to arrive at the displayed value. Wind speed in m/s.

Wind: Horizontal coverage (sf1017 example)



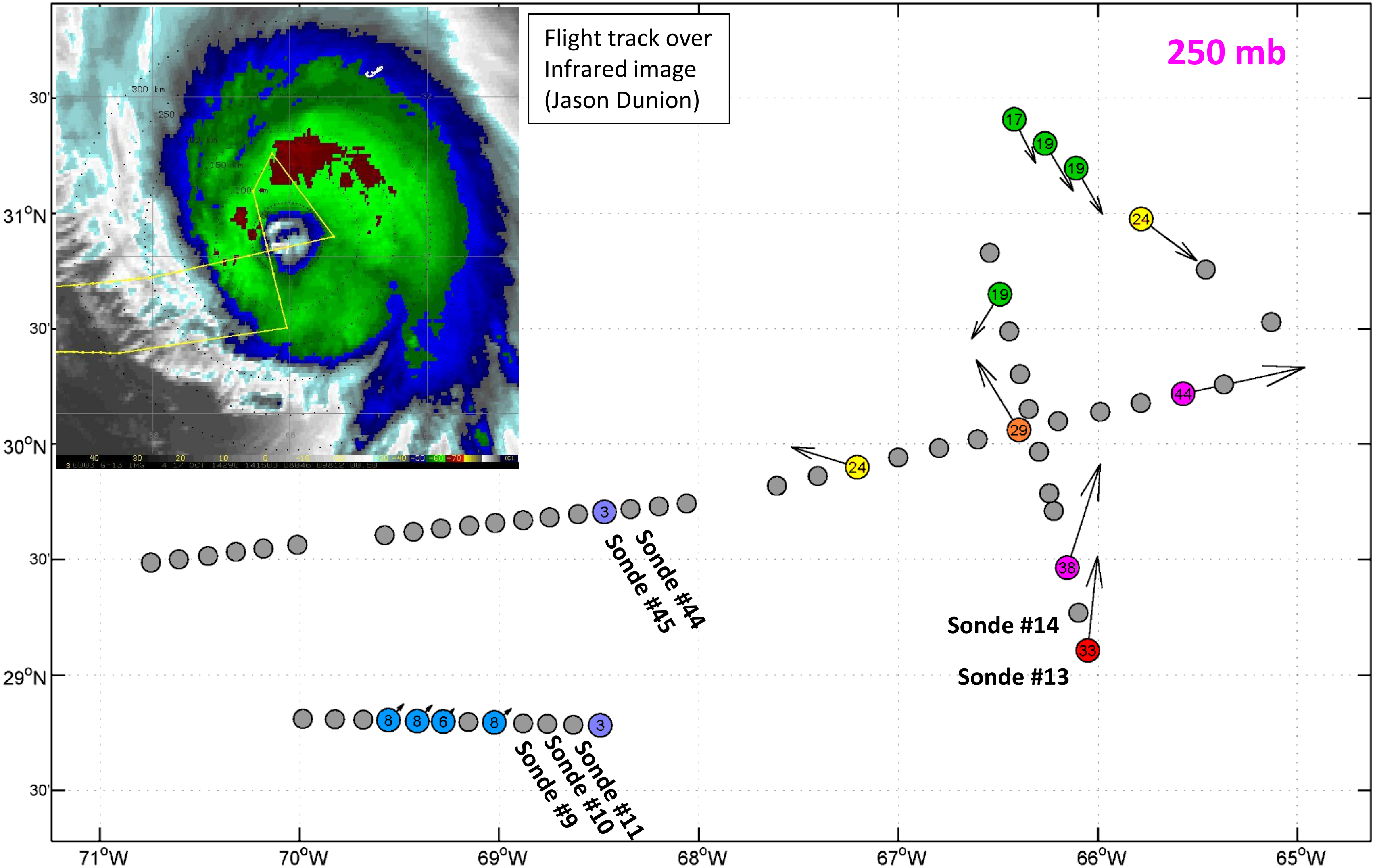
150 mb is generally towards the top of the outflow layer in the Atlantic. Almost all sondes have wind data at this level. The flow is predominantly southwesterly. Adjacent sondes in the western part of the pattern show decent consistency in wind speed values, despite aforementioned issues with some slow-fall sondes.

Wind: Horizontal coverage (sf1017 example)



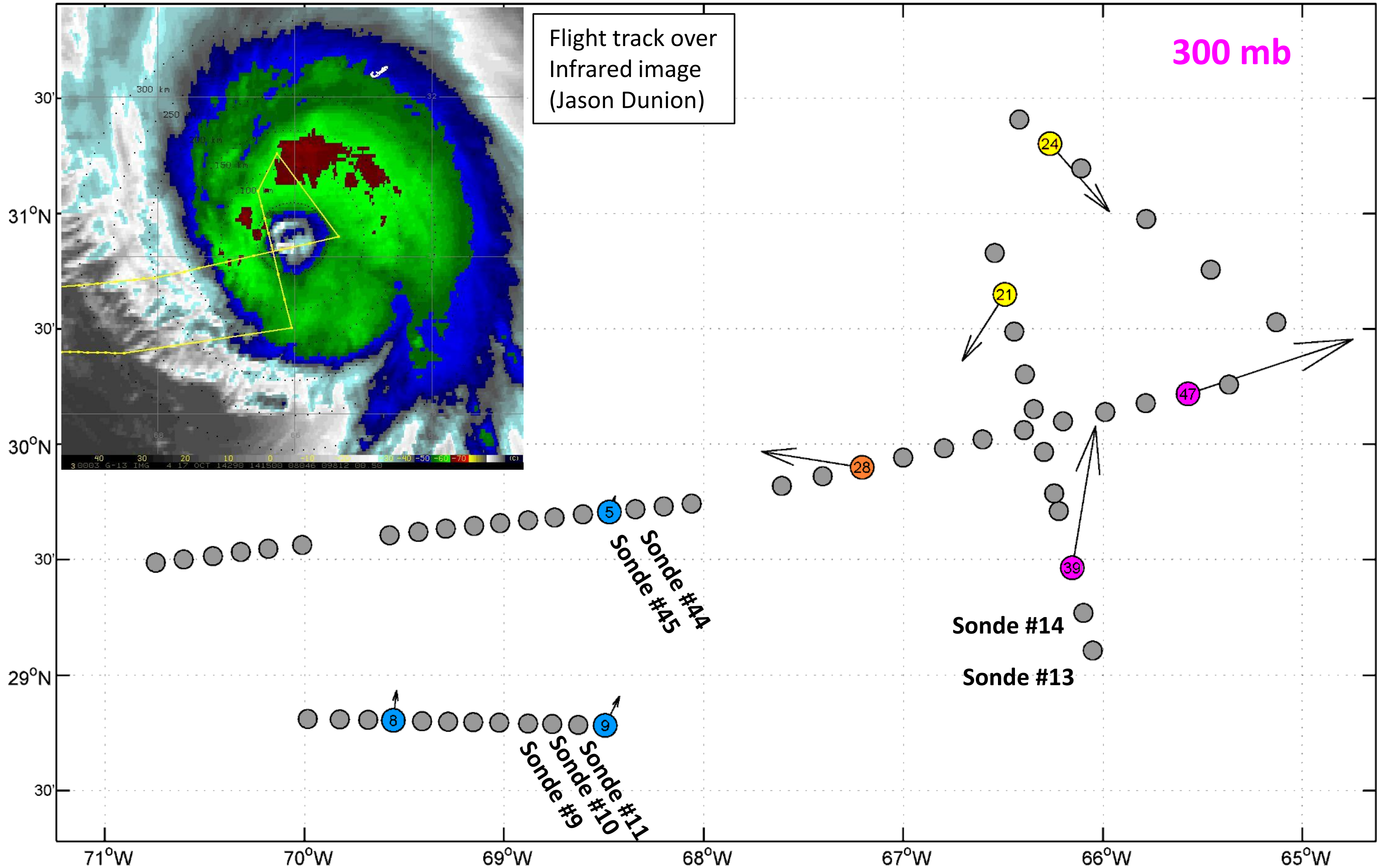
200 mb is generally towards the middle of the outflow layer in the Atlantic. Many of the slow-fall sondes have no data at this level; 31 out of 60 sondes have data under the assumptions used to make this plot, just like for temperature.

Wind: Horizontal coverage (sf1017 example)



250 mb is generally near the base of the outflow layer in the Atlantic. Almost all of the slow-fall sondes have no data at this level; 16 out of 60 sondes have data under the assumptions used to make this plot.

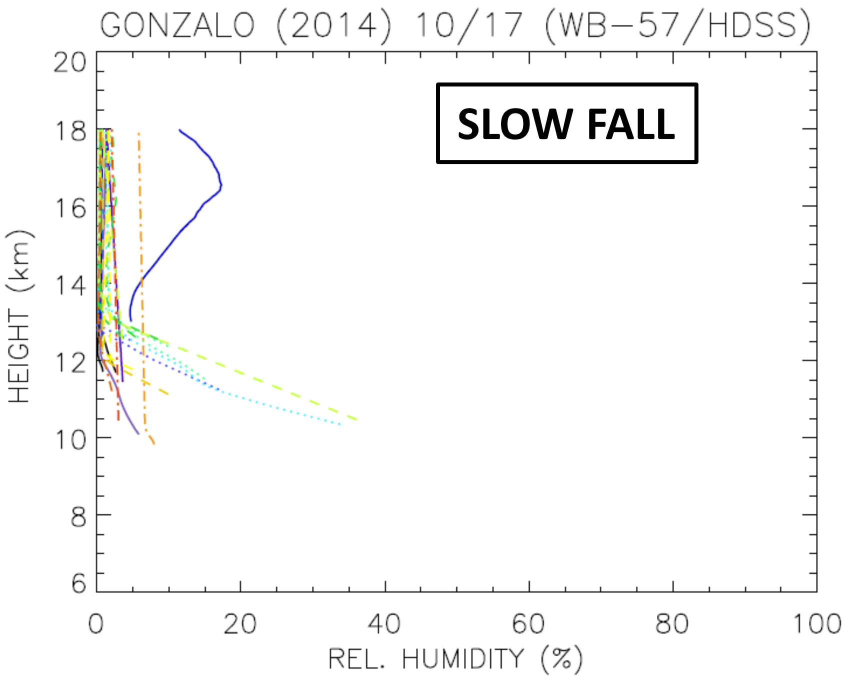
Wind: Horizontal coverage (sf1017 example)

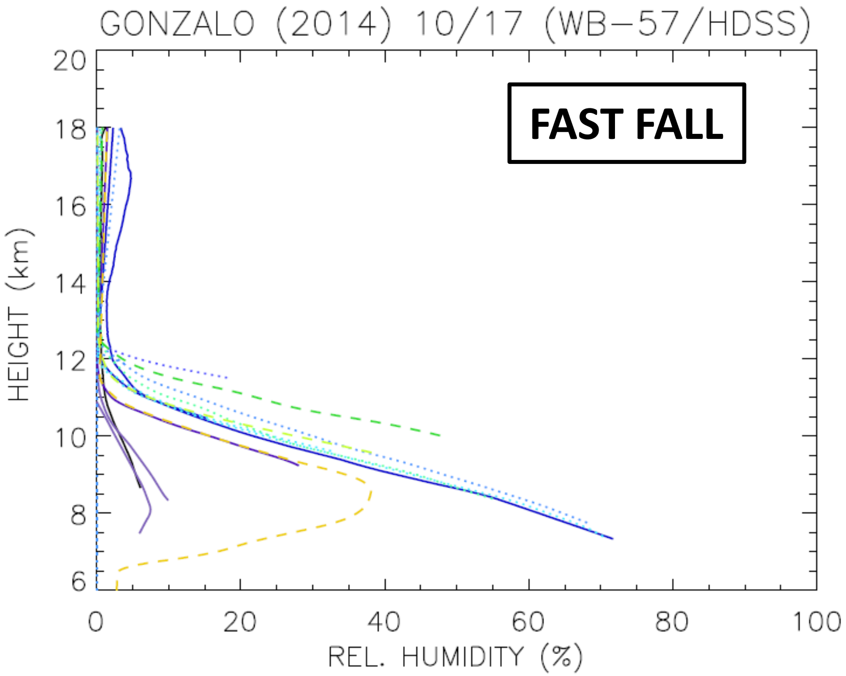


At 300 mb, data is coming from a limited set of the fast-fall sondes. This is not too useful for mapping out the details of the upper-troposphere.

Example Results: Stratified slow and fast fall

Relative Humidity



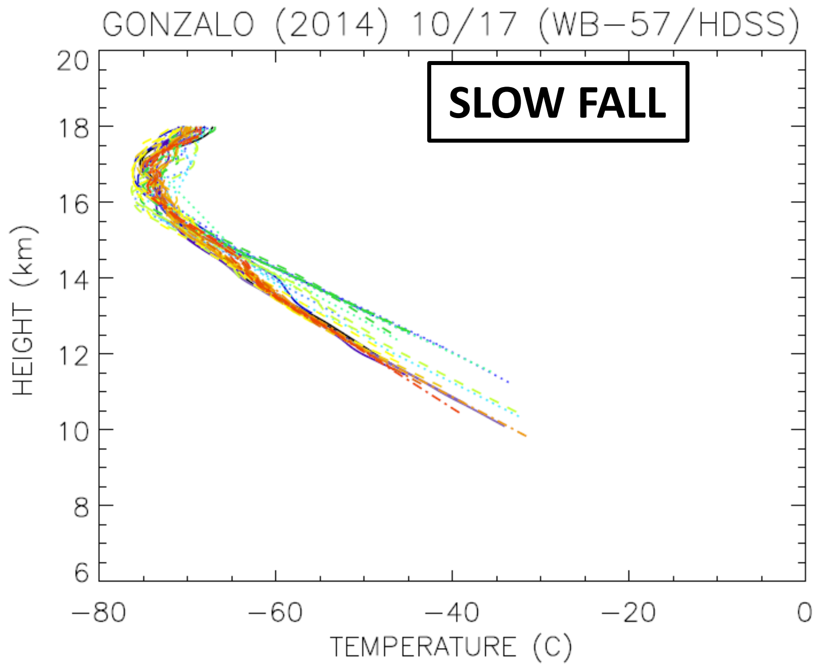


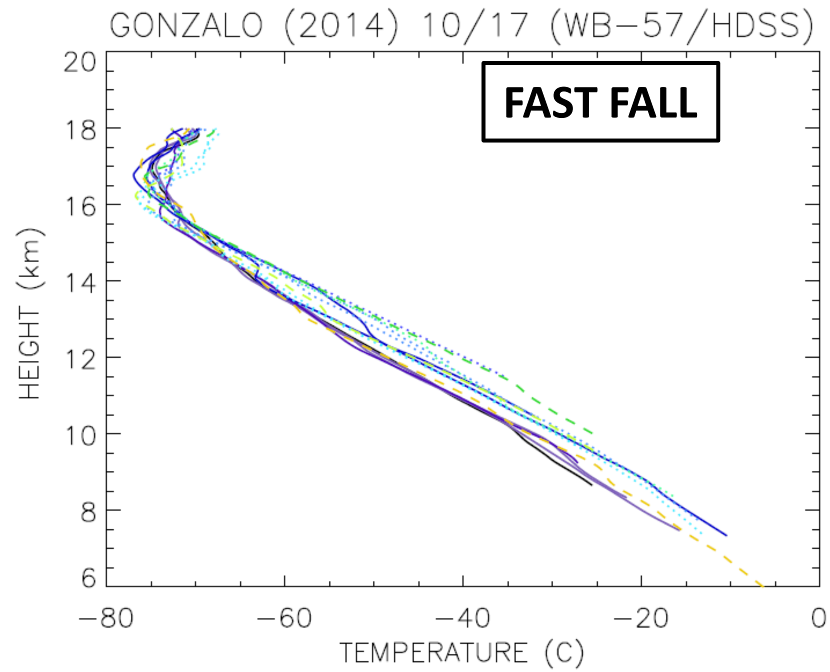
Both sondes are generally not able to capture the interesting variability in the middle to upper troposphere, as the vertical resolution of the data becomes large, however fast-fall sondes do have some useful relative humidity data

*Note: these results are filtered and smoothed to give an idea of what may come out of a "processed" data set. Data above 18 km is removed and the results are smoothed in the vertical

Example Results: Stratified slow and fast fall

Temperature



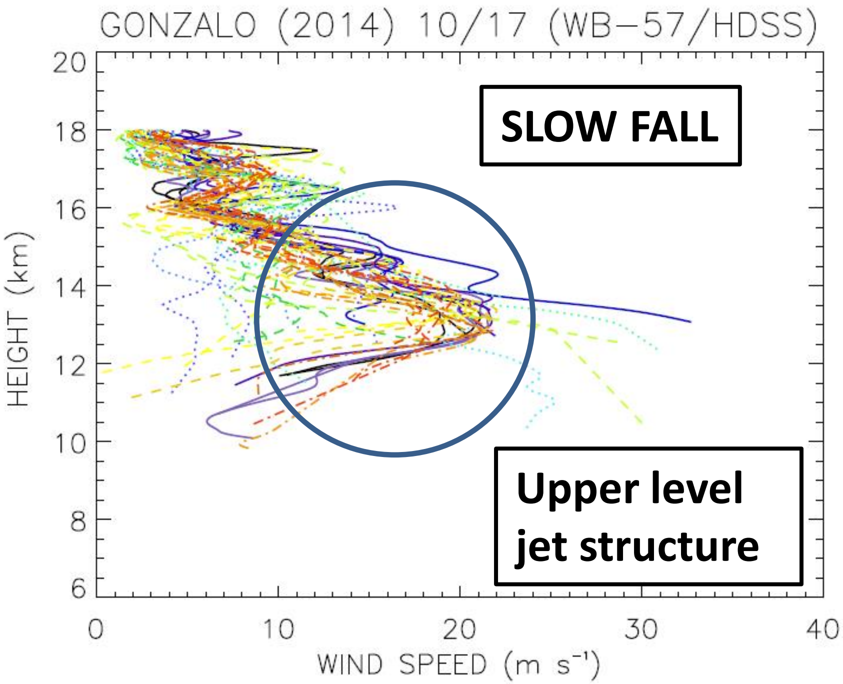


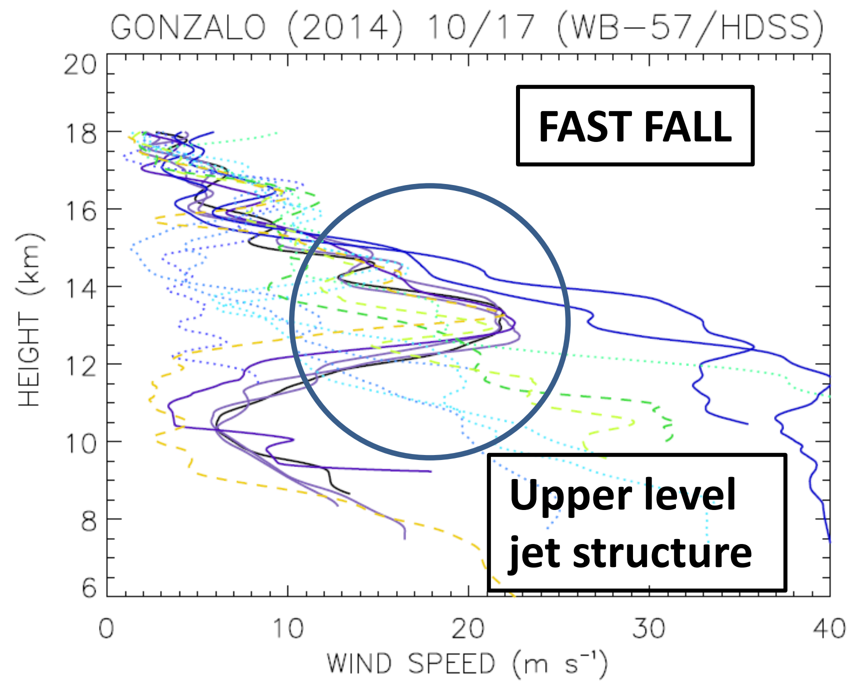
Both slow and fast fall sondes can capture the structure of the upper troposphere and lower stratosphere, and details of the tropopause

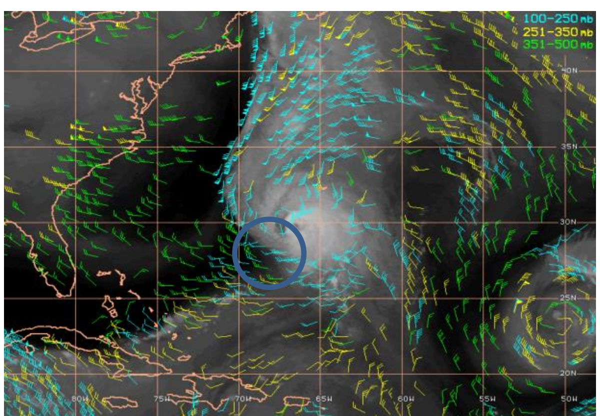
*Note: these results are filtered and smoothed to give an idea of what may come out of a "processed" data set. Data above 18 km is removed and the results are smoothed in the vertical

Example Results: Stratified slow and fast fall

Wind Speed





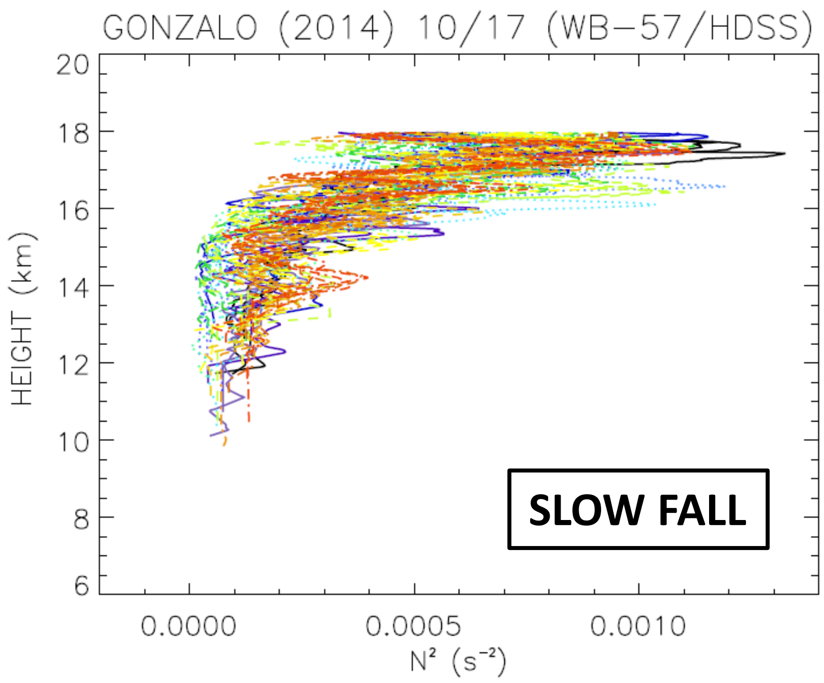


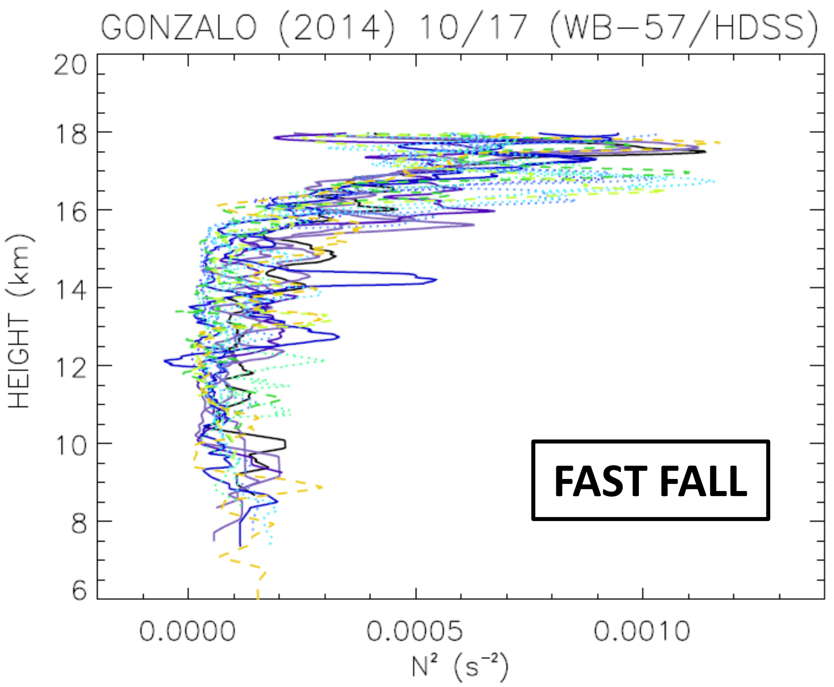
For this case on Oct. 17, the fast-fall sondes are generally able to capture the vertical structure of the upper level jet. The slow-fall sondes capture the peak winds of the jet, but not the entire vertical structure underneath. Some fast-fall sondes have data just at the threshold of capturing the jets (9-10 km), however this data is often more sparse below 12 km.

*Note: these results are filtered and smoothed to give an idea of what may come out of a “processed” data set. Data above 18 km is removed and the results are smoothed in the vertical

Example Results: Stratified slow and fast fall

Static Stability (derived quantity)



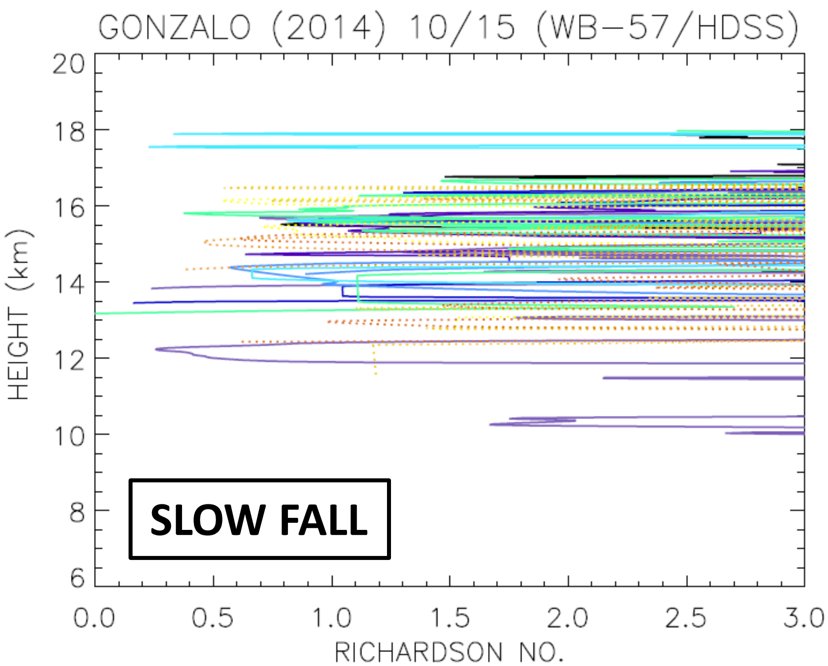


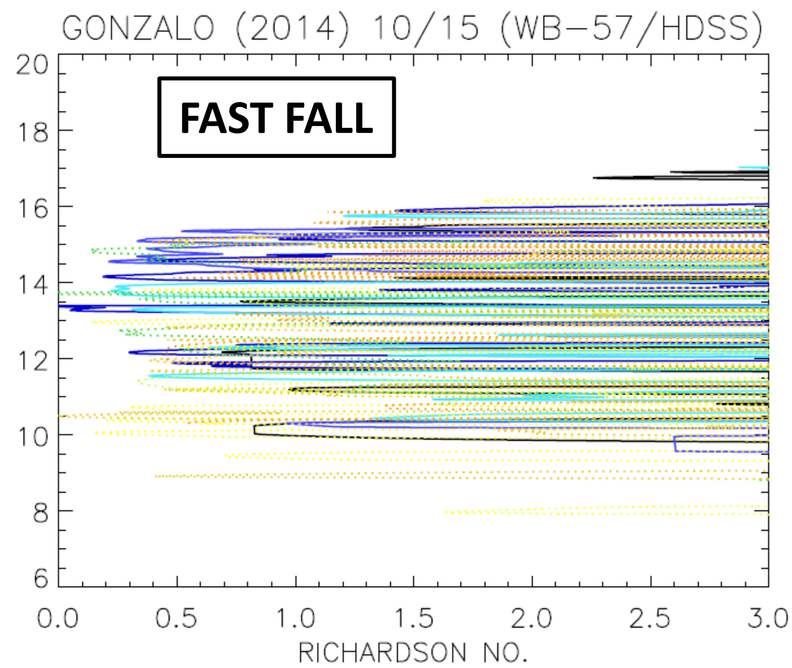
Both slow and fast fall sondes can capture the dramatic shift in static stability at the tropopause (16 km). Fast-fall sondes give additional data from 8-12 km in the upper troposphere. This is important since critical Richardson number values typically occur here.

*Note: these results are filtered and smoothed to give an idea of what may come out of a "processed" data set. Data above 18 km is removed and the results are smoothed in the vertical

Example Results: Stratified slow and fast fall

Richardson Number (derived quantity)





Fast-fall sondes can capture regions in the outflow (10-14 km) where the Richardson number falls below critical value (Ri < 0.25). Richardson number profiles of this nature have been observed with the AVAPS (GH/HS3).

*Note: these results are filtered and smoothed to give an idea of what may come out of a "processed" data set. Data above 18 km is removed and the results are smoothed in the vertical

Gonzalo HDSS Summary

- There is some useful data for characterizing structure of upper troposphere/lower stratosphere
  - Fast fall: over 90% of XDDs have good U/V/T data from ~12-18 km
  - Slow fall: over 90% of XDDs have good U/V/T data from ~15-18 km
- However, many interesting atmospheric features (e.g., outflow jets) were not observed well by HDSS (only 50% of fast-fall sondes have data to 10 km and resolution is sparse low in the profile)
- Relative humidity (RH) data generally not good.
  - Below 12 km, where the instrument appears to start being sensitive to moisture, vertical resolution is coarse and many sondes have no data
- Fast-fall sondes have better quality data than slow-fall sondes, however only 31% of sondes were fast-fall
- There are issues with “spikes” in meteorological parameters (e.g., wind speed) associated with variability in fall speed – the data needs to be processed to remove these

Further Thoughts

– HDSS issues identified include:
  - Low percentage of fast-fall sondes (31% of total)
  - No full profiles from fast-fall sondes (only 50% of sondes have any data below 10 km)
  - Vertical resolution of fast-fall data is poor below 12 km

– Test flights in November were conducted to see if the performance of the HDSS system on the WB-57 could be improved relative to these Gonzalo results

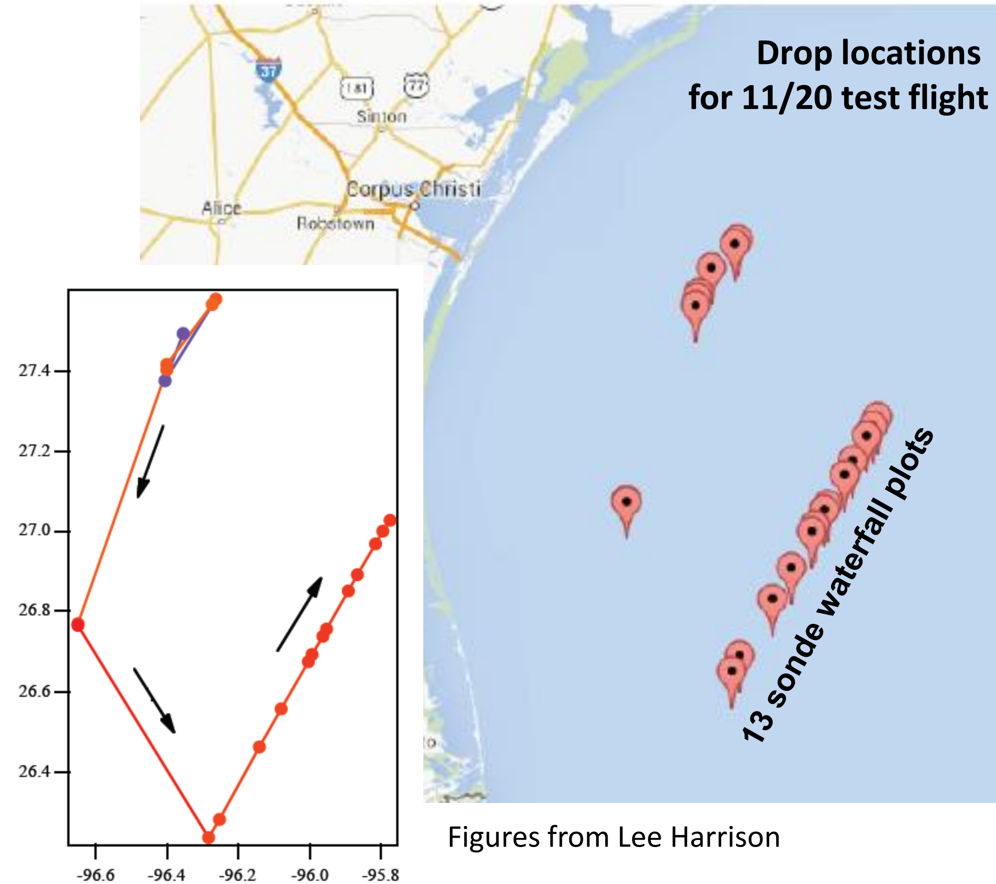
Part 2: HDSS sonde results for WB-57 November test flights

There were three November test flights:

- 11/13/2014 (tf1113): 11 data files
- 11/14/2014 (tf1114): 15 data files
- 11/20/2014 (tf1120): 21 data files

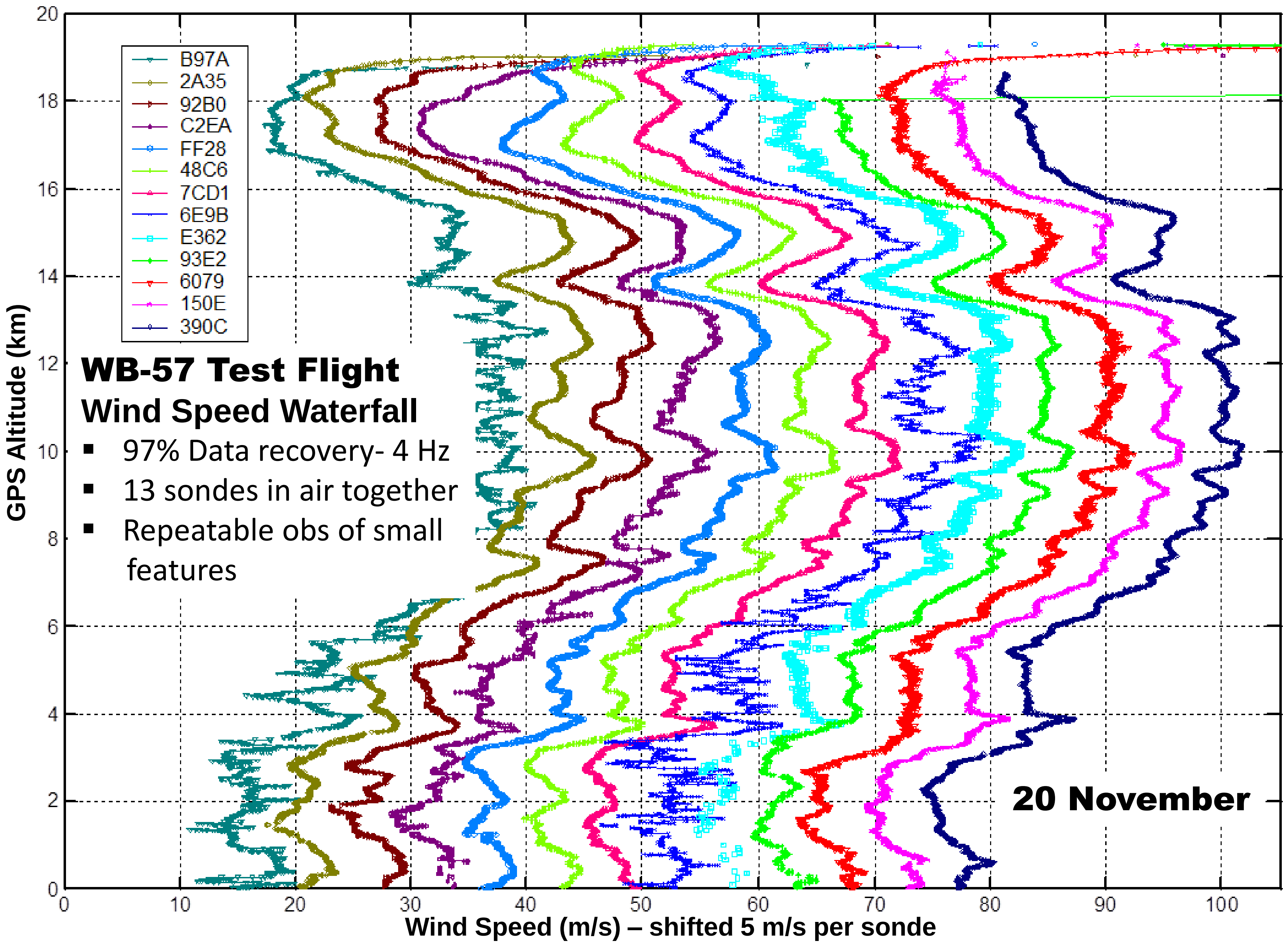
Unlike the Gonzalo sondes in part 1, the data files are “Level 1” files reprocessed by Lee Harrison to interpolate GPS height to 4Hz. With the 4Hz height data, the wind data presented here is 4Hz and the temperature/RH data is 2Hz. There is no additional quality control or postprocessing, so this should still be considered “raw” data

The test flight on 11/20 had the most sondes and best performance, so we will concentrate solely on that flight to demonstrate the progress made in addressing the performance issues seen in the Gonzalo flights.

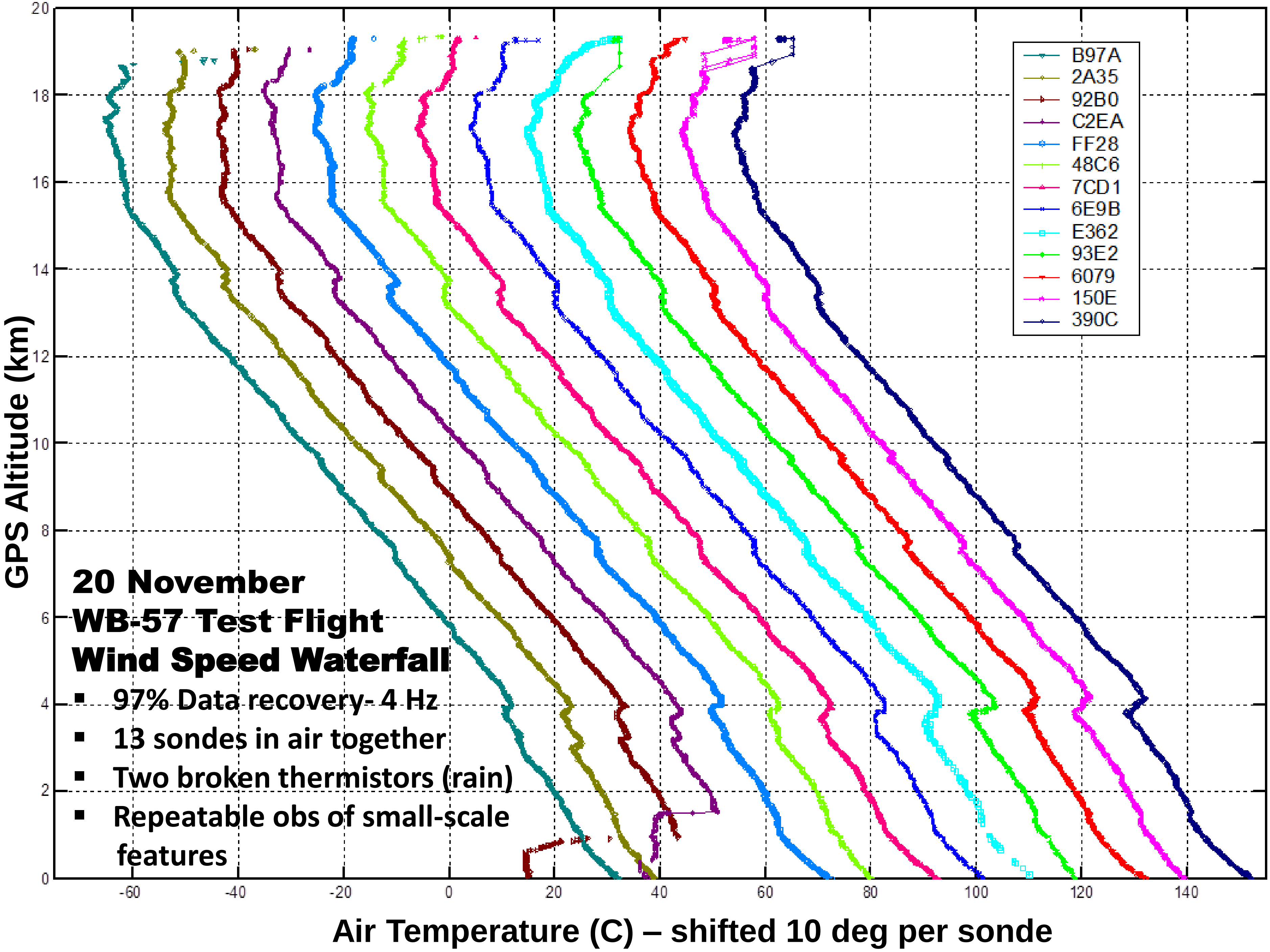


Figures from Lee Harrison

The first two sondes (purple) were launched from 30K feet; then the plane climbed to altitude (>60K feet) and launched the remaining 19 sondes



WB-57 Test Flight
Wind Speed Waterfall
97% Data recovery- 4 Hz
13 sondes in air together
Repeatable obs of small features
B97A
2A35
92B0
C2EA
FF28
48C6
7CD1
6E9B
E362
93E2
6079
150E
390C
20 November
GPS Altitude (km)
Wind Speed (m/s) – shifted 5 m/s per sonde
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
40
50
60
70
80
90
100


GPS Altitude (km)
Air Temperature (C) – shifted 10 deg per sonde
B97A
2A35
92B0
C2EA
FF28
48C6
7CD1
6E9B
E362
93E2
6079
150E
390C
20 November
WB-57 Test Flight
Wind Speed Waterfall
▪ 97% Data recovery- 4 Hz
▪ 13 sondes in air together
▪ Two broken thermistors (rain)
▪ Repeatable obs of small-scale features

Fast-fall and slow-fall sondes

Like the Gonzalo flights, sonde fall speed is generally either "slow" (left cluster) or "fast" (right cluster). The yellow line is the fall speed profile for an experimental sonde including a streamer.

Of the 20 sondes (not including the streamer sonde), 15 were fast-fall and 5 were slow-fall. This is different from the Gonzalo flights for which most of the sondes were slow fall.

In general, the fast-fall sondes have less variability in the fall rate and noise in the horizontal winds relative to the slow-fall sondes. Fast-fall sondes also have superior data recovery rates (see next slide)

Something else to note here is that data is recovered all the way to the surface in all but a couple sondes, a huge improvement over the Gonzalo flights.

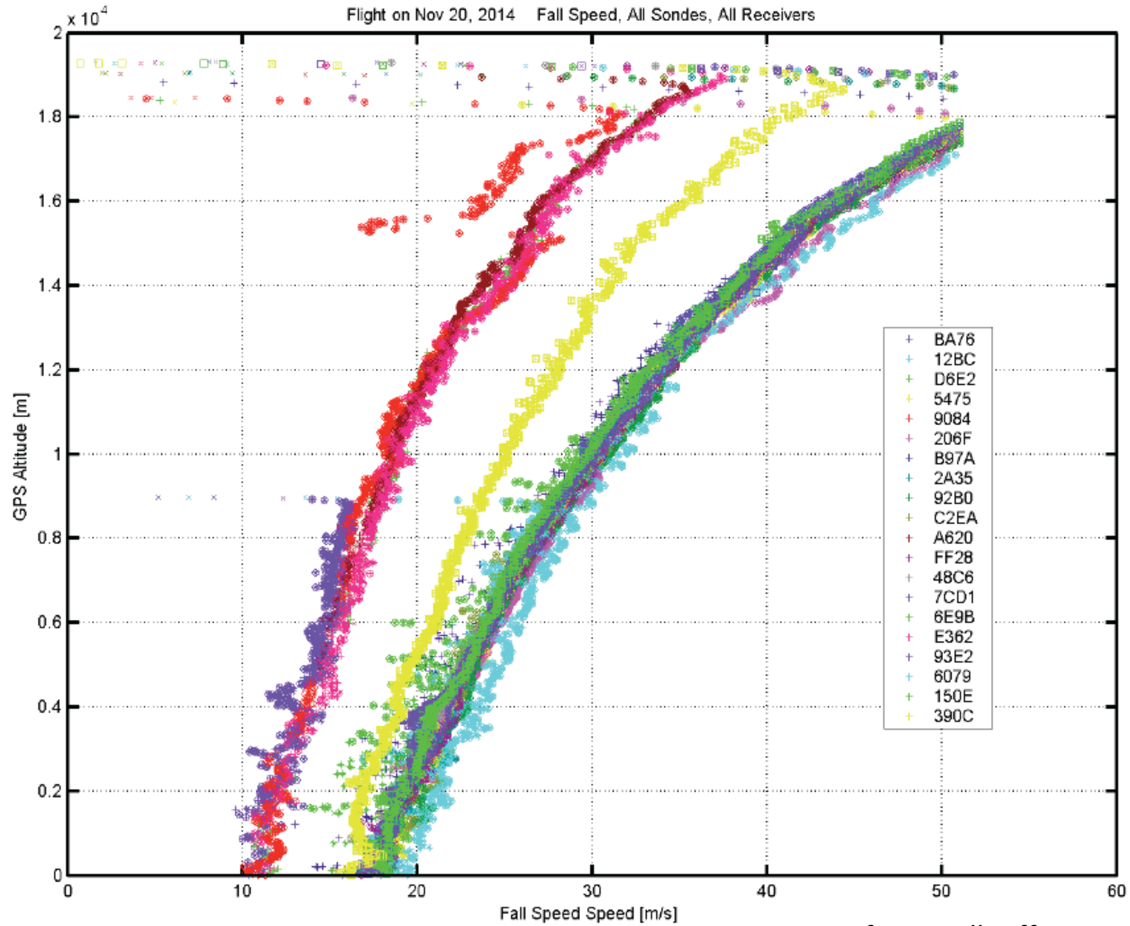
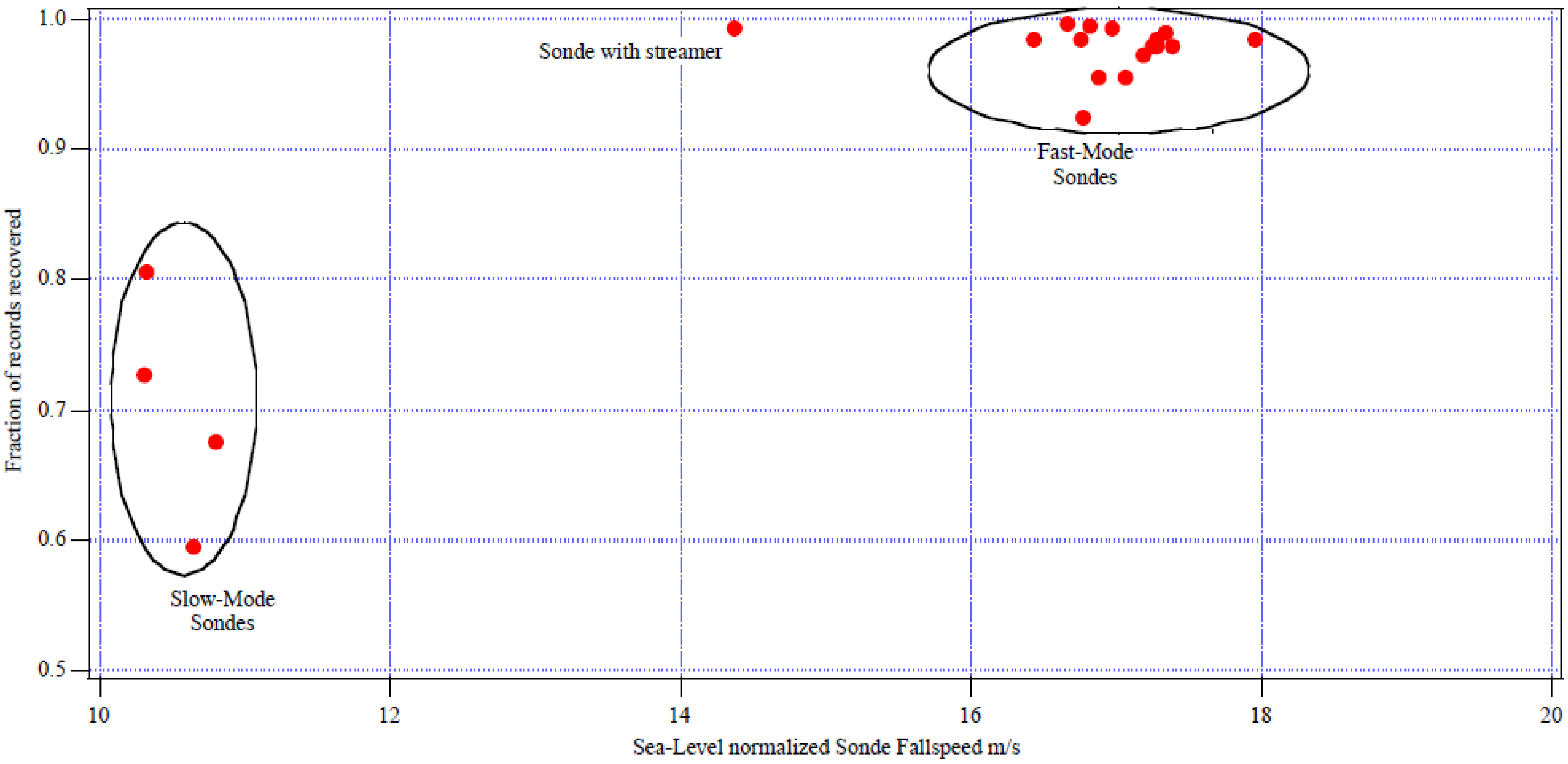


Figure from Will Jeffries

Fast-fall and slow-fall sondes

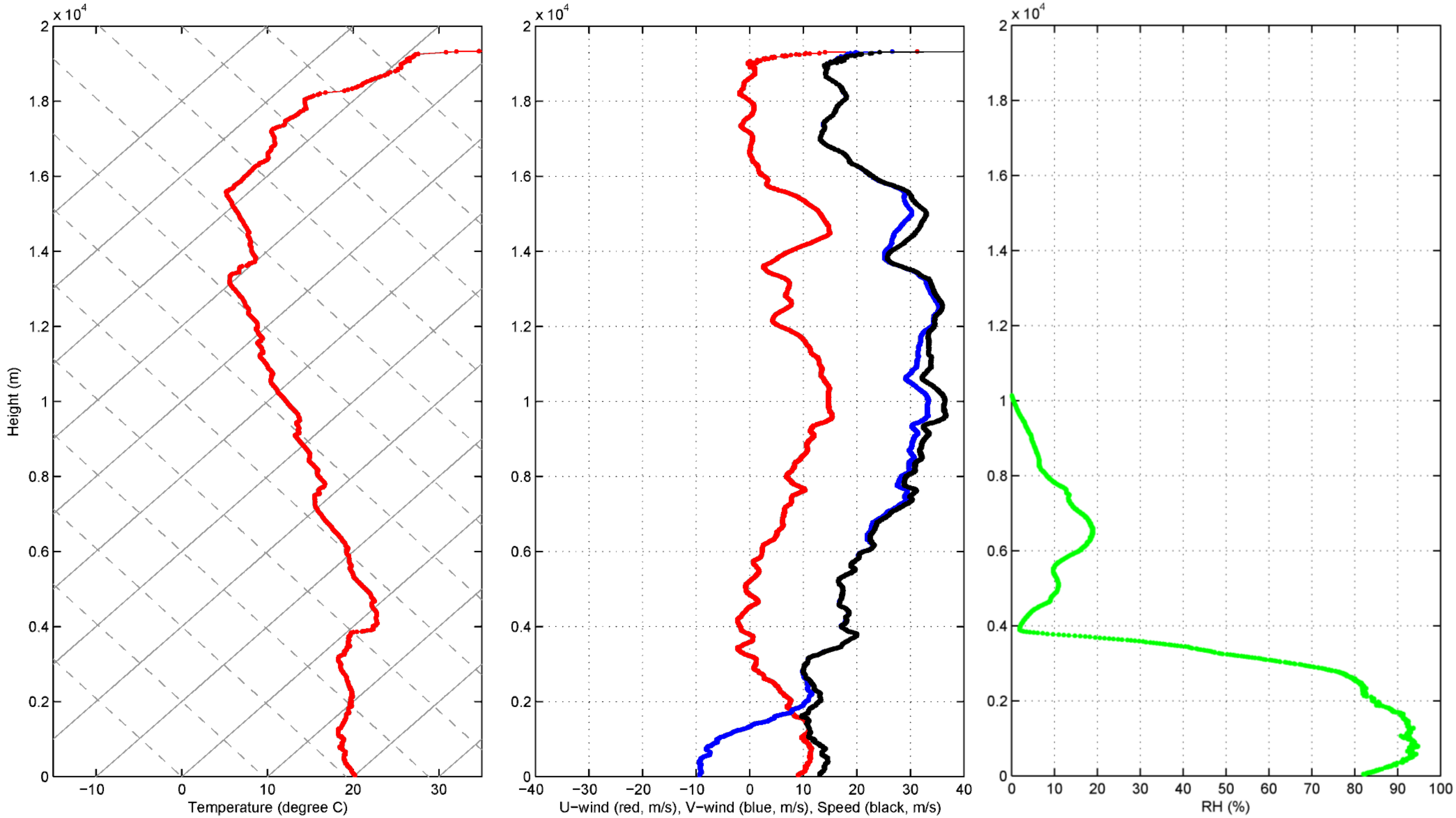
Figure and text from Lee Harrison



As expected for XDD sondes the fraction of the sounding data successfully telemetered depends strongly on the sonde's fall mode. The ballistic-fall sondes and the one experimental sonde with a streamer returned over 95% of records. This is primarily due to transmit antenna orientation: the slow-mode sondes tumble and often the nulls of the antenna pattern are toward the aircraft, resulting in loss of telemetry. The experimental streamer kept its sonde well oriented vertically and slowed it, also demonstrating that the telemetry fraction is not strongly affected by the increased range (due to the slower fall speed).

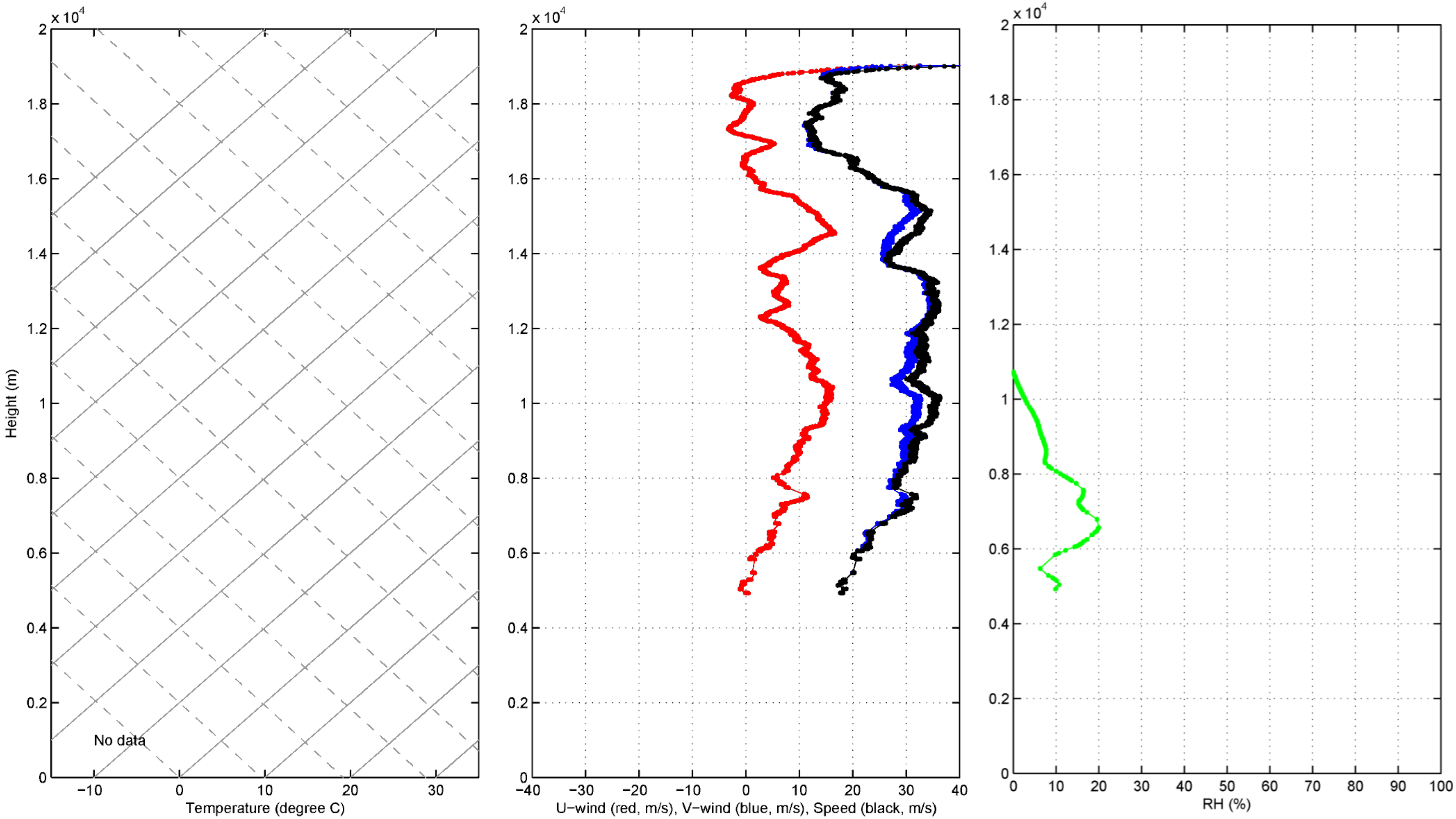
The data fractions returned by some of the sondes (both fast and slow) are impacted by aircraft maneuvering and also aircraft VHF microphone keying (the 3[d] harmonic hits the 400-406 band powerfully). This is more apparent for the fast sondes. The sonde with the streamer was the very last launched, and benefitted from the straight trajectory home, and relative radio quiet when no longer authorizing launches.

Example of good sonde profile



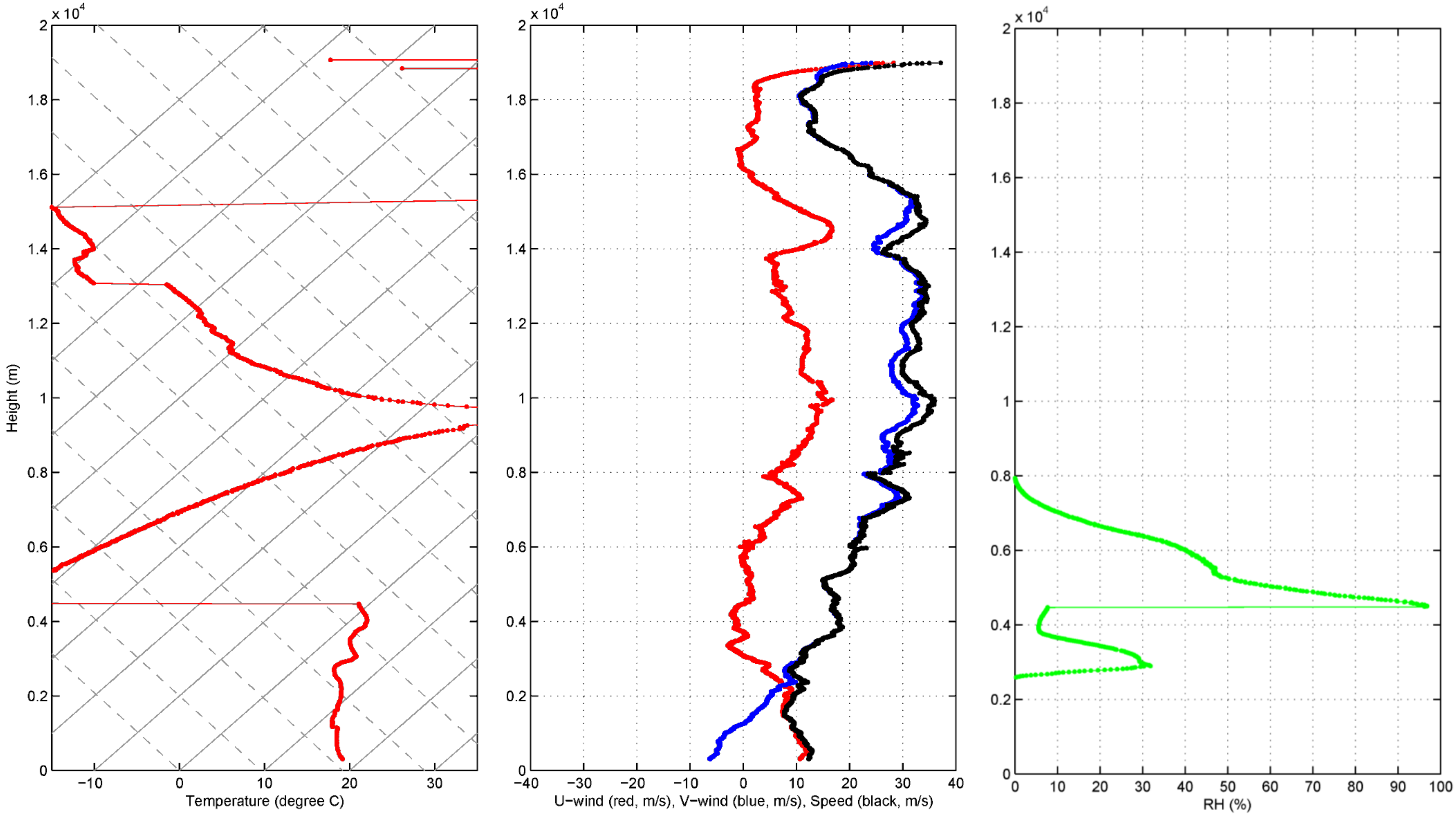
- Example from fast fall sonde with very little noise in wind profile and data all the way to the surface
- In terms of data recovery, only 4 of 21 sondes have a segment of missing data (for all variables) of over ~0.5 km depth. Most sondes sent data back until they splashed.

Some trouble spots



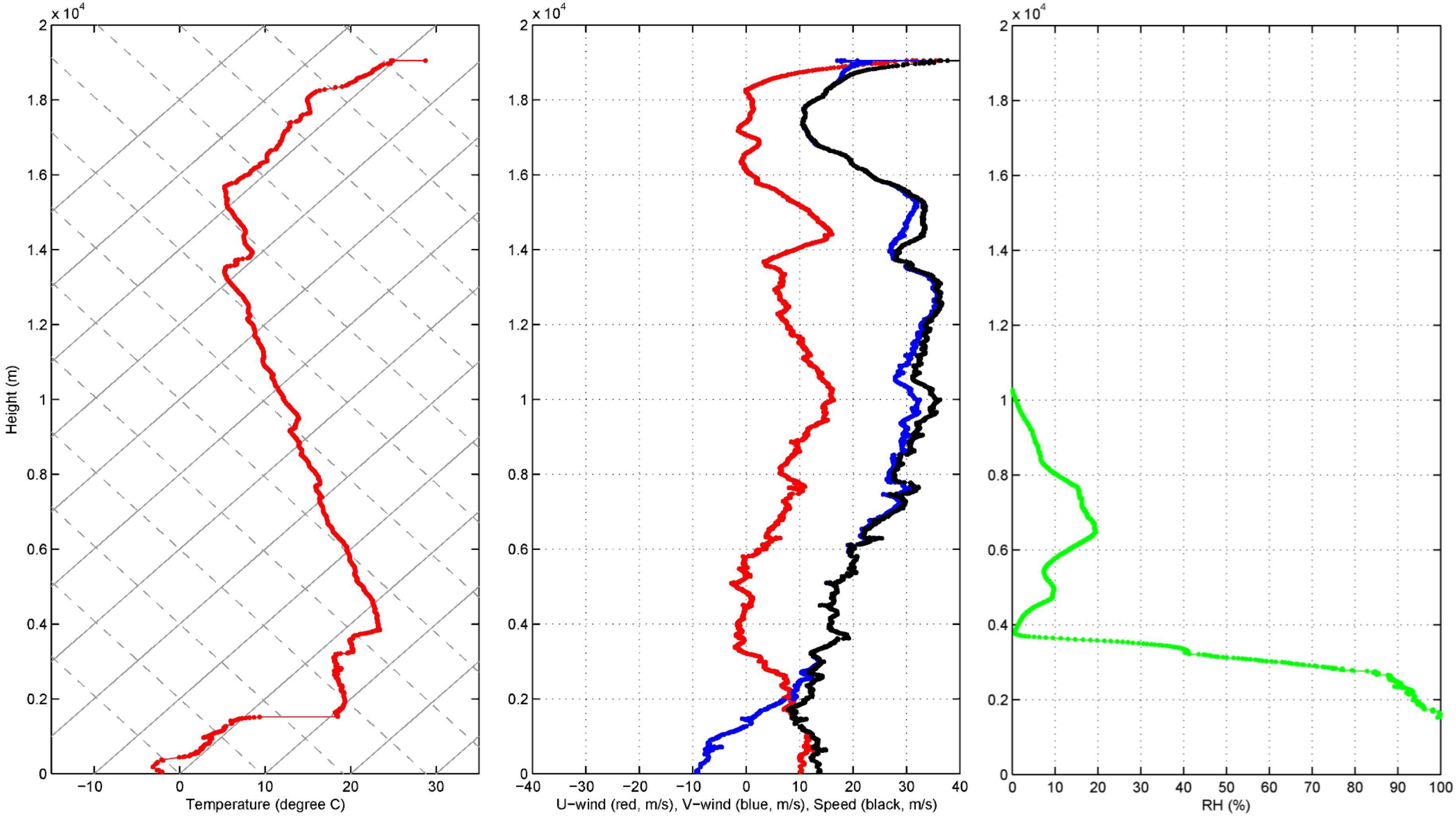
- The 12th sonde launched returned no temperature data. This was also one of the 4 sondes mentioned on the previous slide that had more than ~0.5 km of data missing for all variables.

Some trouble spots



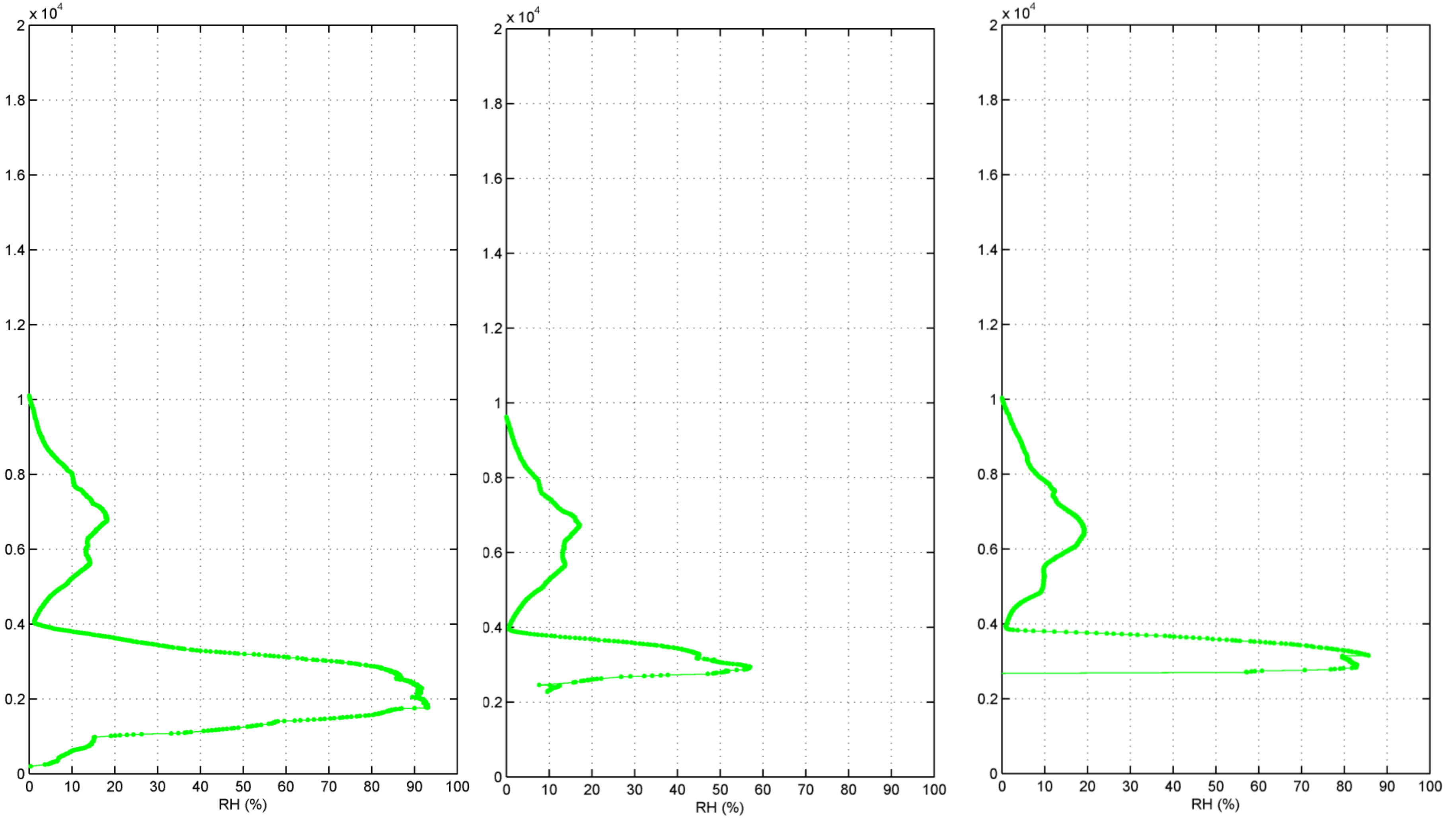
- The 8th sonde launched has good-looing wind data, but bad temperature and RH data

Some trouble spots



- 3 sondes (the 2nd, 10th, and 11th launches) have unrealistically cold temperatures in the lower troposphere below a certain height (which is different for each case). However, the winds look fine.
- In total, 5 of the 21 sondes have problems with temperature that appear unrelated to data recovery issues (that impact all variables)

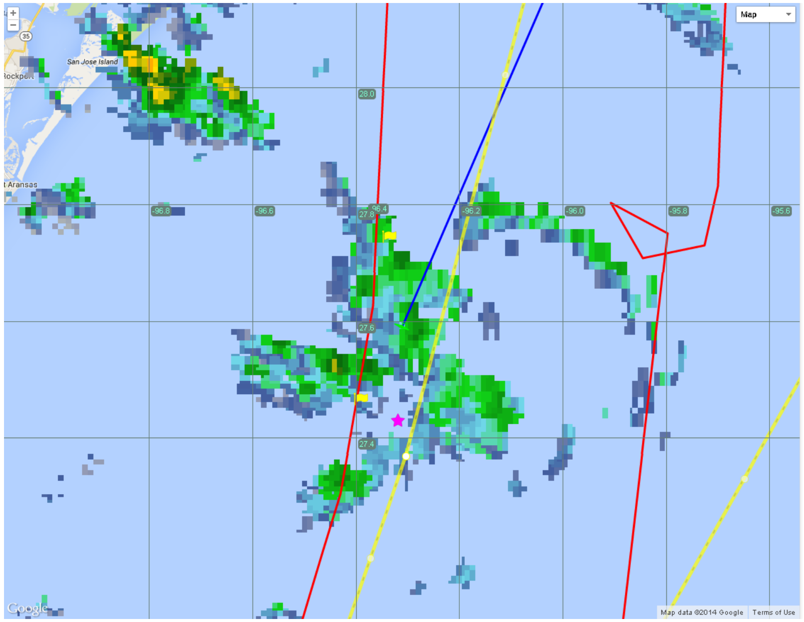
Some trouble spots



- For the 3 sondes mentioned on the previous page, the RH goes bad at the same height as temperature
- For 4 additional sondes (3 examples shown above), the temperature profile looks fine, but the RH suddenly decreases and/or data cuts off in the lower troposphere
- In total, there are 8 sondes with RH problems in the lower troposphere

11/20 Test flight summary

- **Overall HDSS performance was far better than for the Gonzalo science flights**
- Only 4 of 21 sondes had missing data for all variables in a segment of over ~0.5 km
- 75% of the sondes (not counting the streamer sonde) fell in fast-mode, which generally have data recovery rates of >95% and are less susceptible to noisy winds
- 2 sondes had no data or bad data for temperature over the entire profile
- 3 sondes had bad temperature data only in the lower troposphere, and 8 sondes had bad RH data only in the lower troposphere. Rain showers wetting the instrument could be the culprit (speculation)
- Instrument is not sensitive to RH above about 10 km



Rain along flight track

Part 3: Quality control of HDSS Data

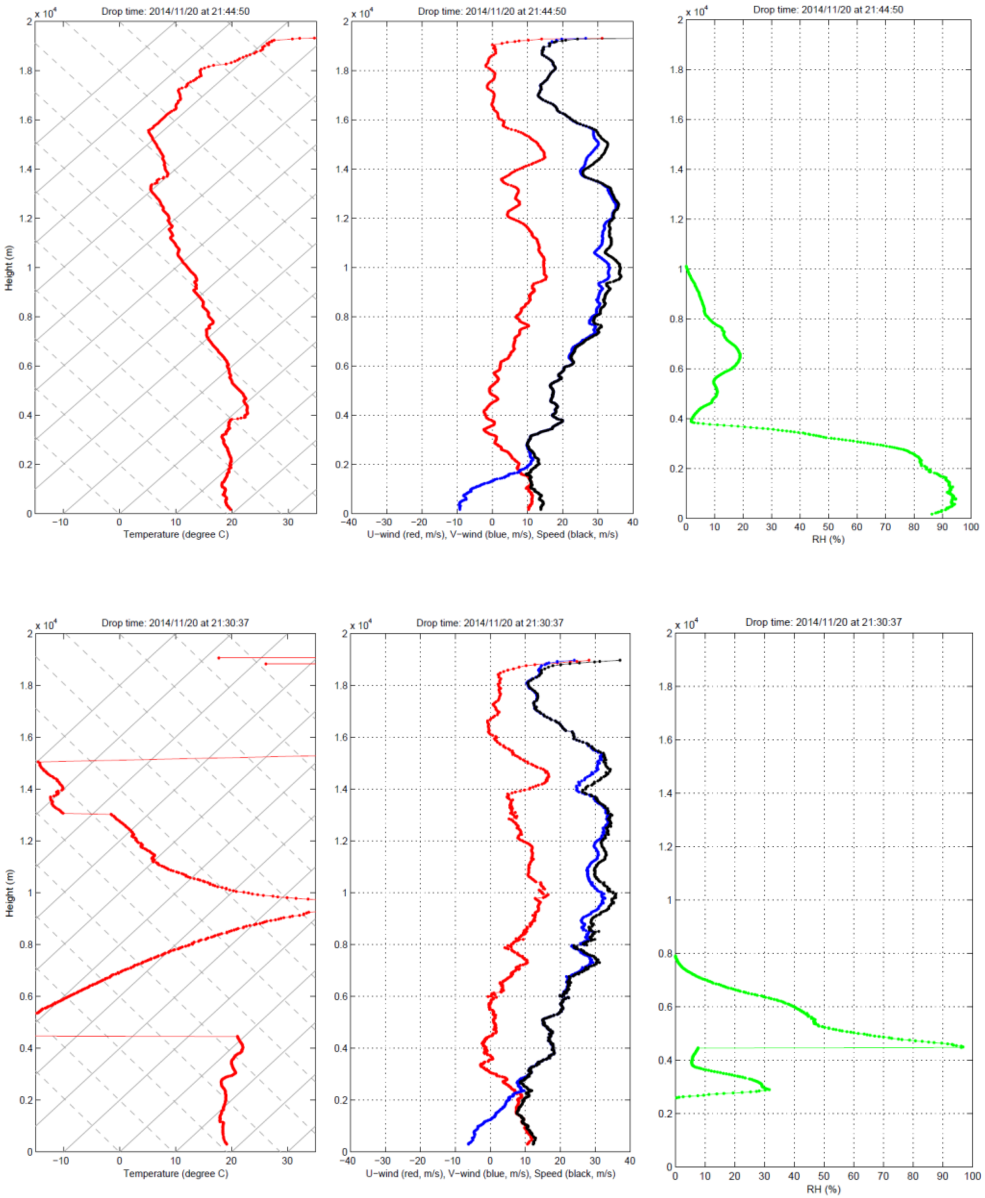
The Nov. 20 test flight HDSS data was able to be quality controlled through the Atmospheric Sounding Processing Environment (ASPEN). ASPEN is developed by NCAR EOL, passes the sondes through several QC checks, removes egregious data, filters the winds, computes geopotential height, and writes out the processed QC'ed sondes in EOL format. The final data is considered a Level 2 product.

Michael Bell was able to produce a script that converts HDSS data to a format that can be ingested in ASPEN for processing. The processing was found to work, producing the Level 2 EOL files.

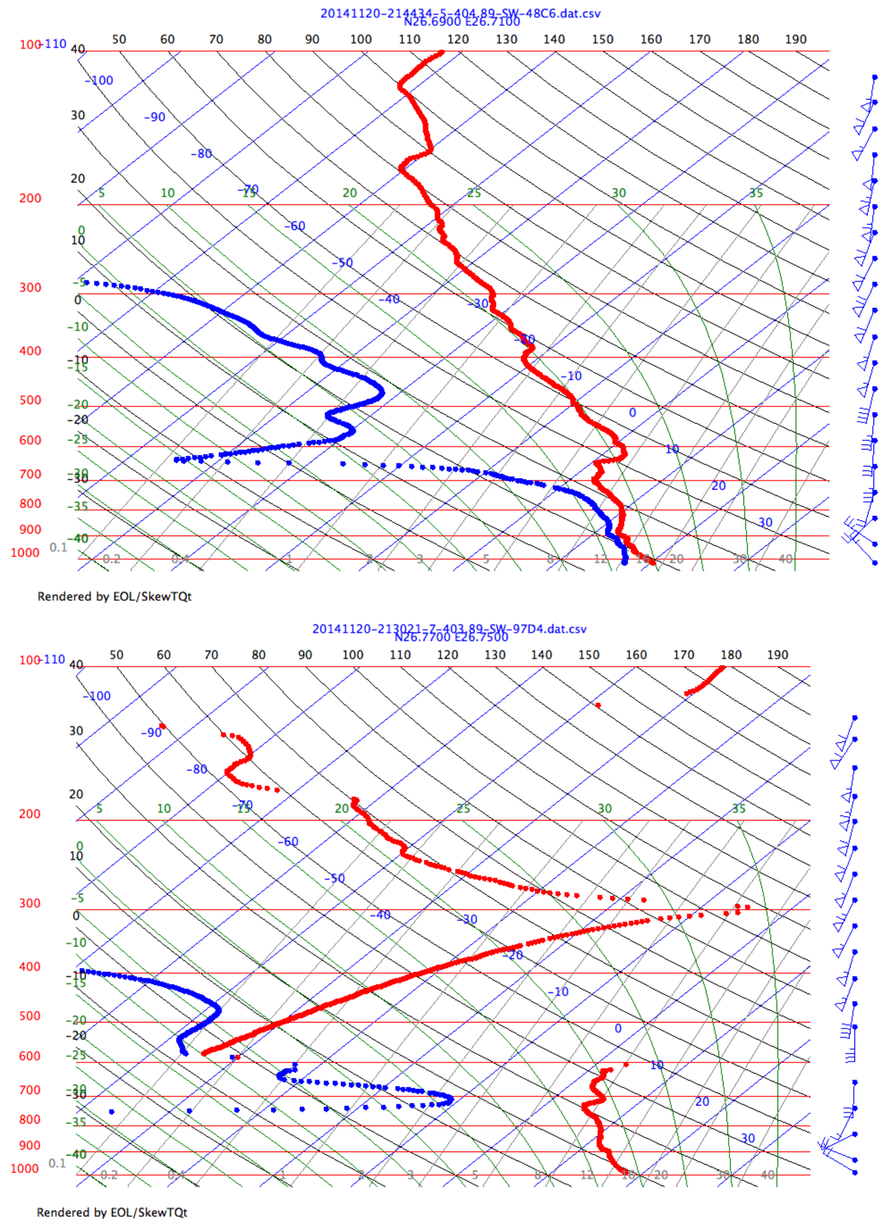
In the next slide, comparisons of the raw HDSS data with the ASPEN QC’ed data is shown for the four examples soundings in the previous section. Work is also underway to process the HDSS data from Gonzalo. From a quick look, the ASPEN QC’ed data are similar in structure to the raw data, and are smoother, indicating ASPEN is broadly functioning properly with the HDSS data. However, a more rigorous examination should be conducted in the future to ensure that ASPEN is processing the HDSS data correctly.

Comparison of raw HDSS to QC'ed HDSS

RAW HDSS

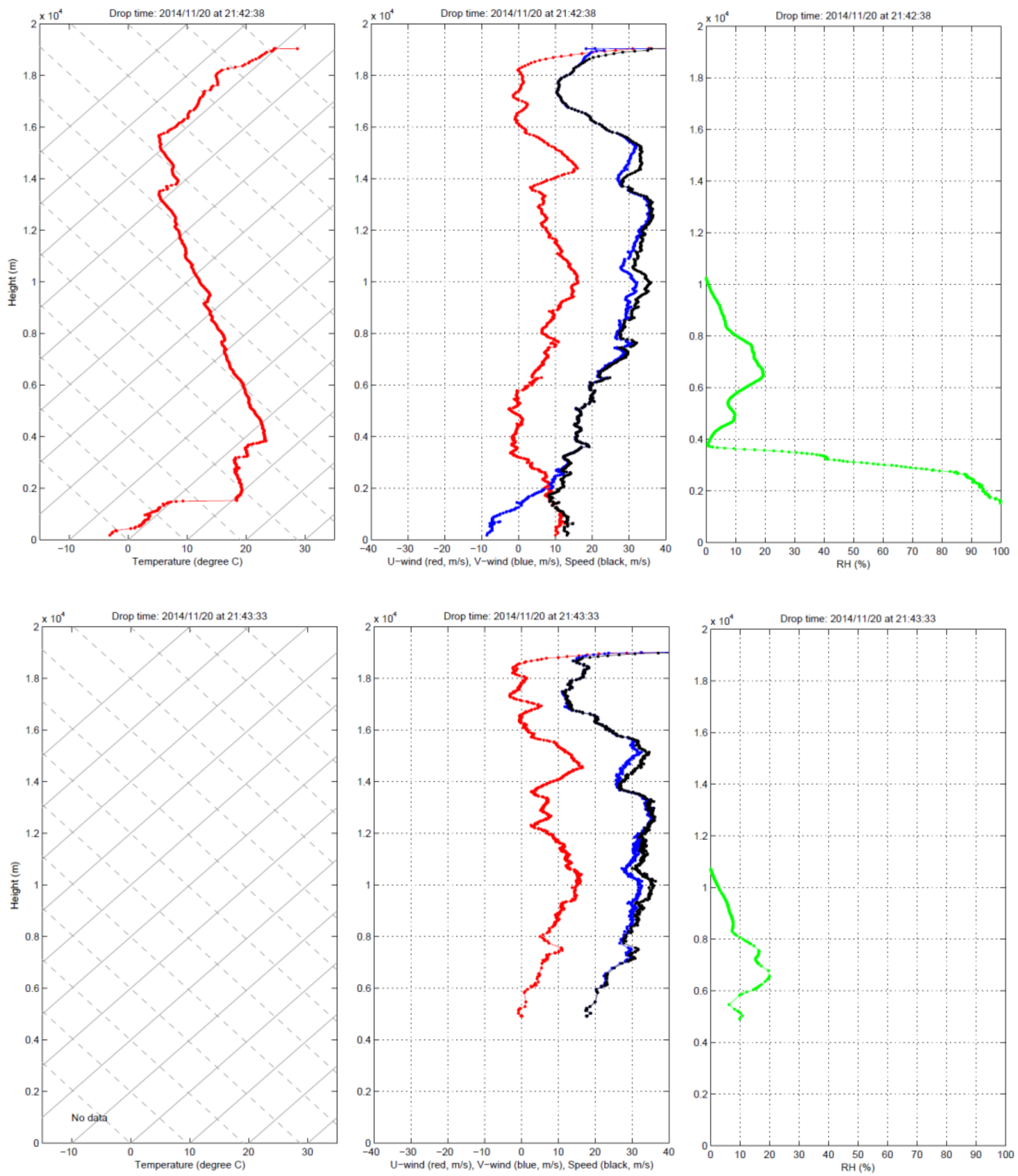


HDSS QC USING ASPEN

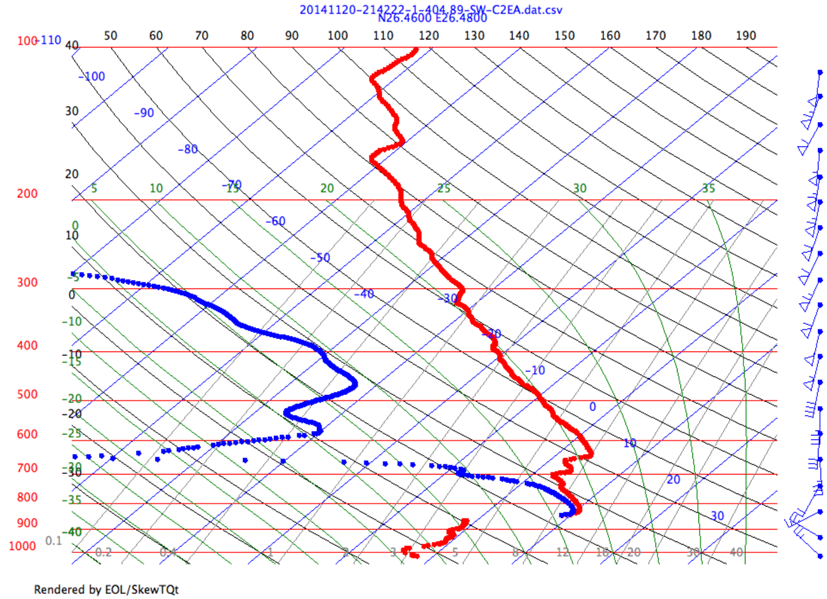


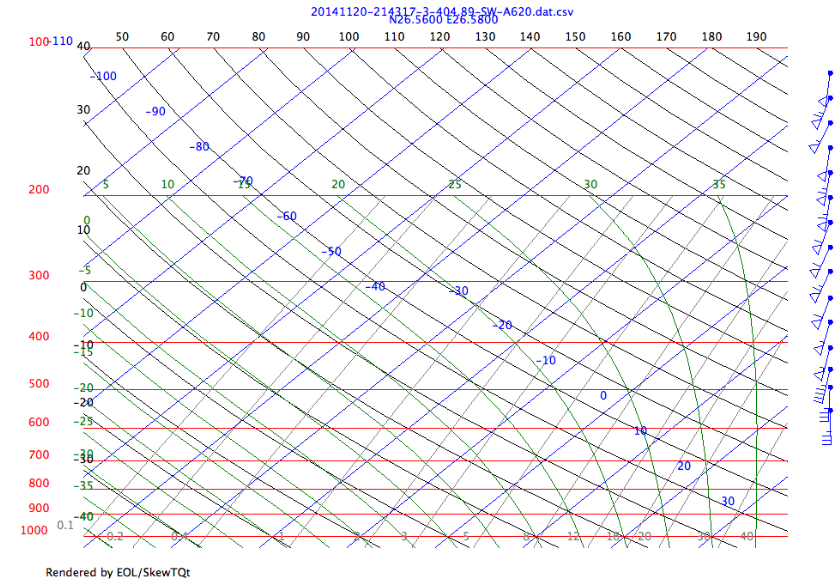
Comparison of raw HDSS to QC'ed HDSS

RAW HDSS



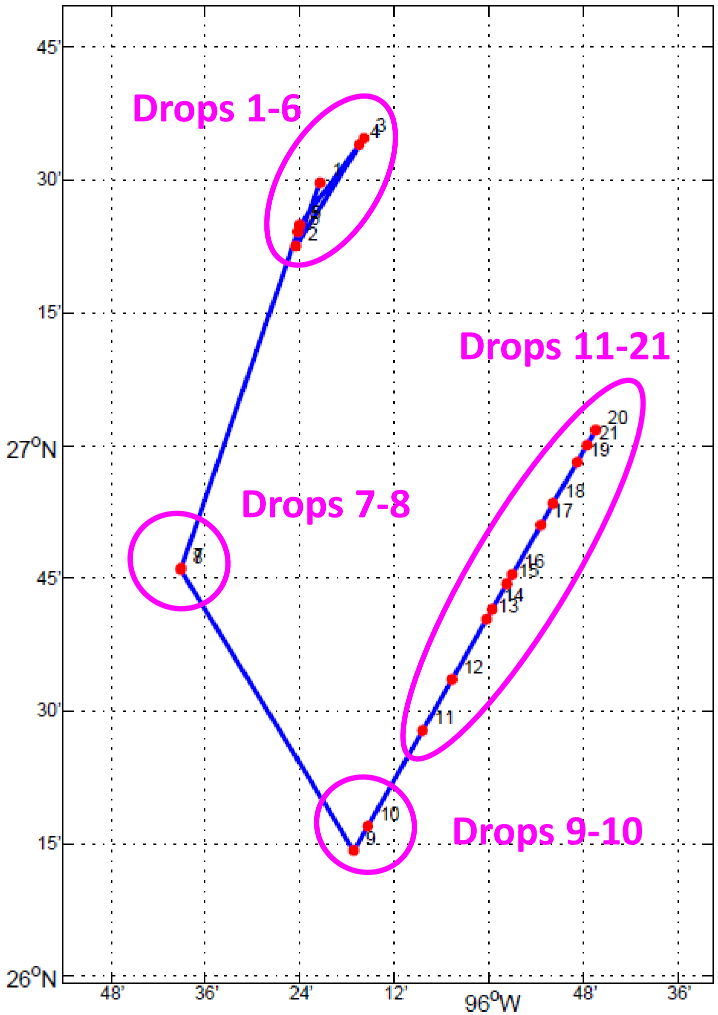
HDSS QC USING ASPEN

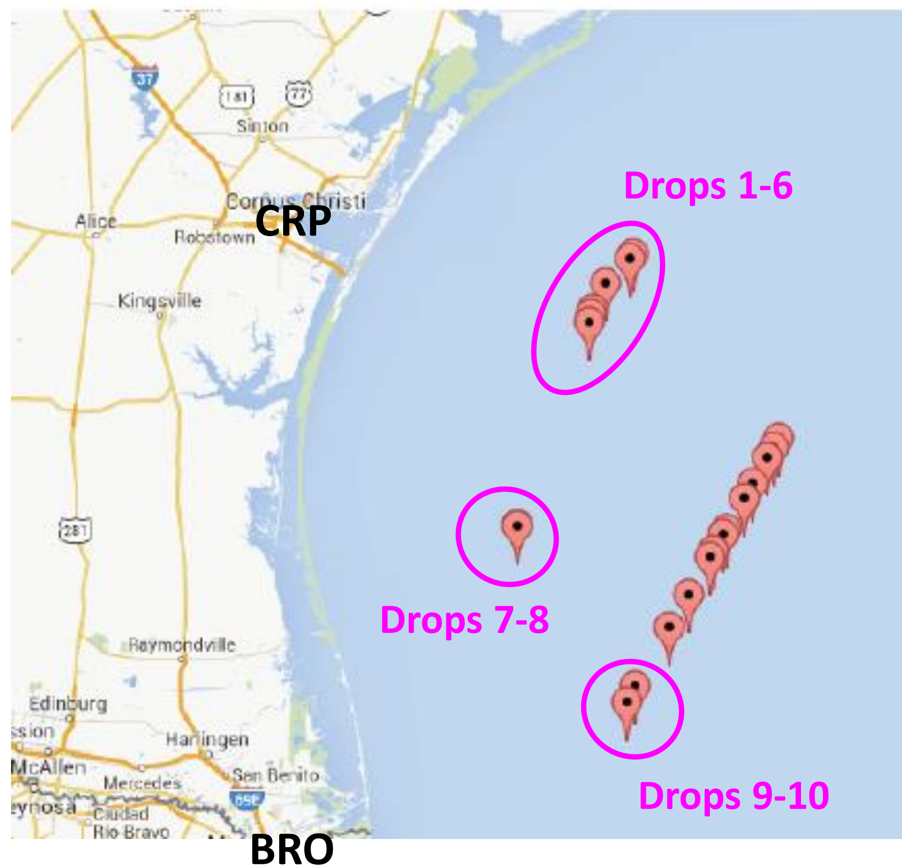


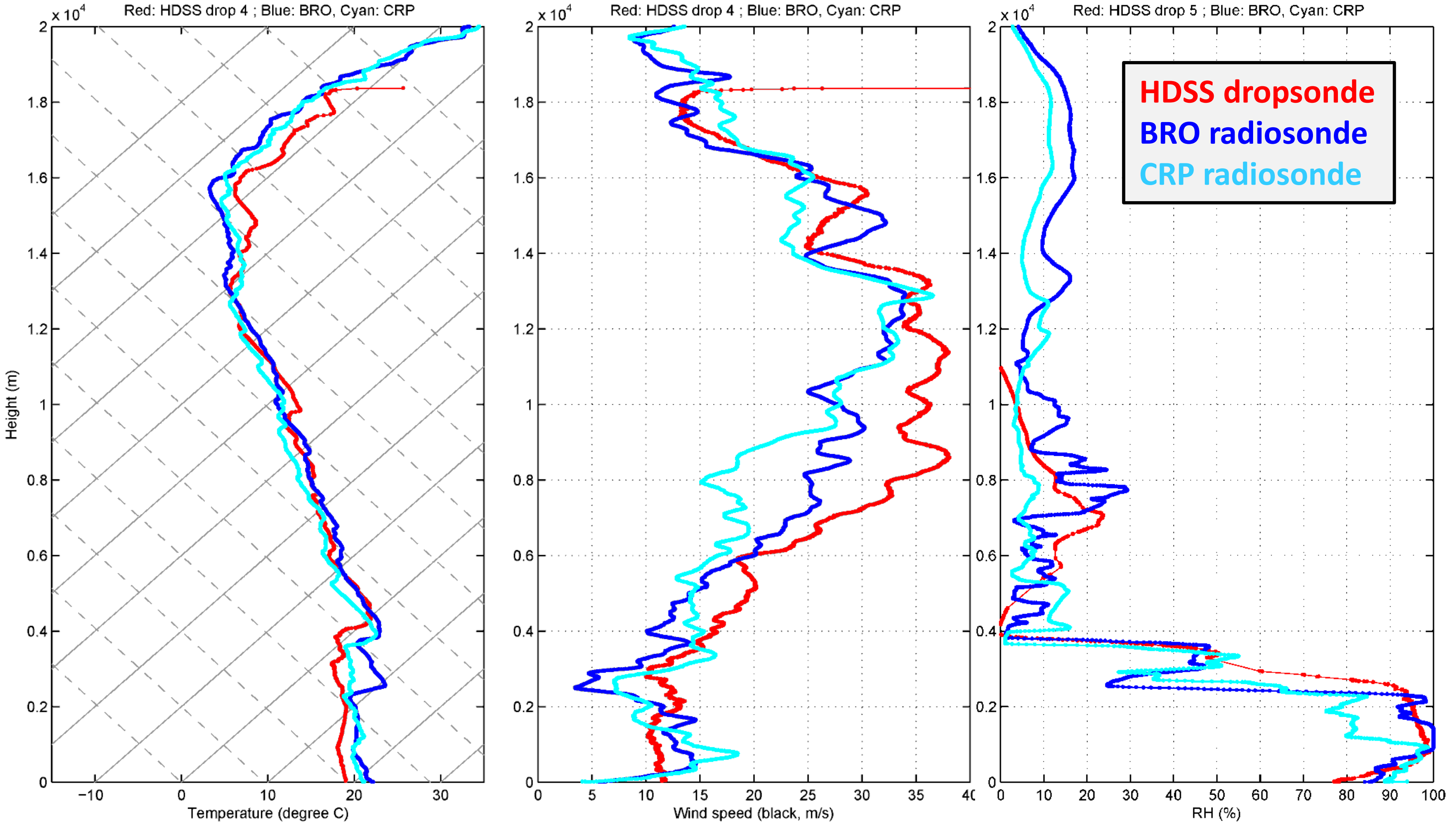


11/20 test flight: Comparison of HDSS to radiosondes

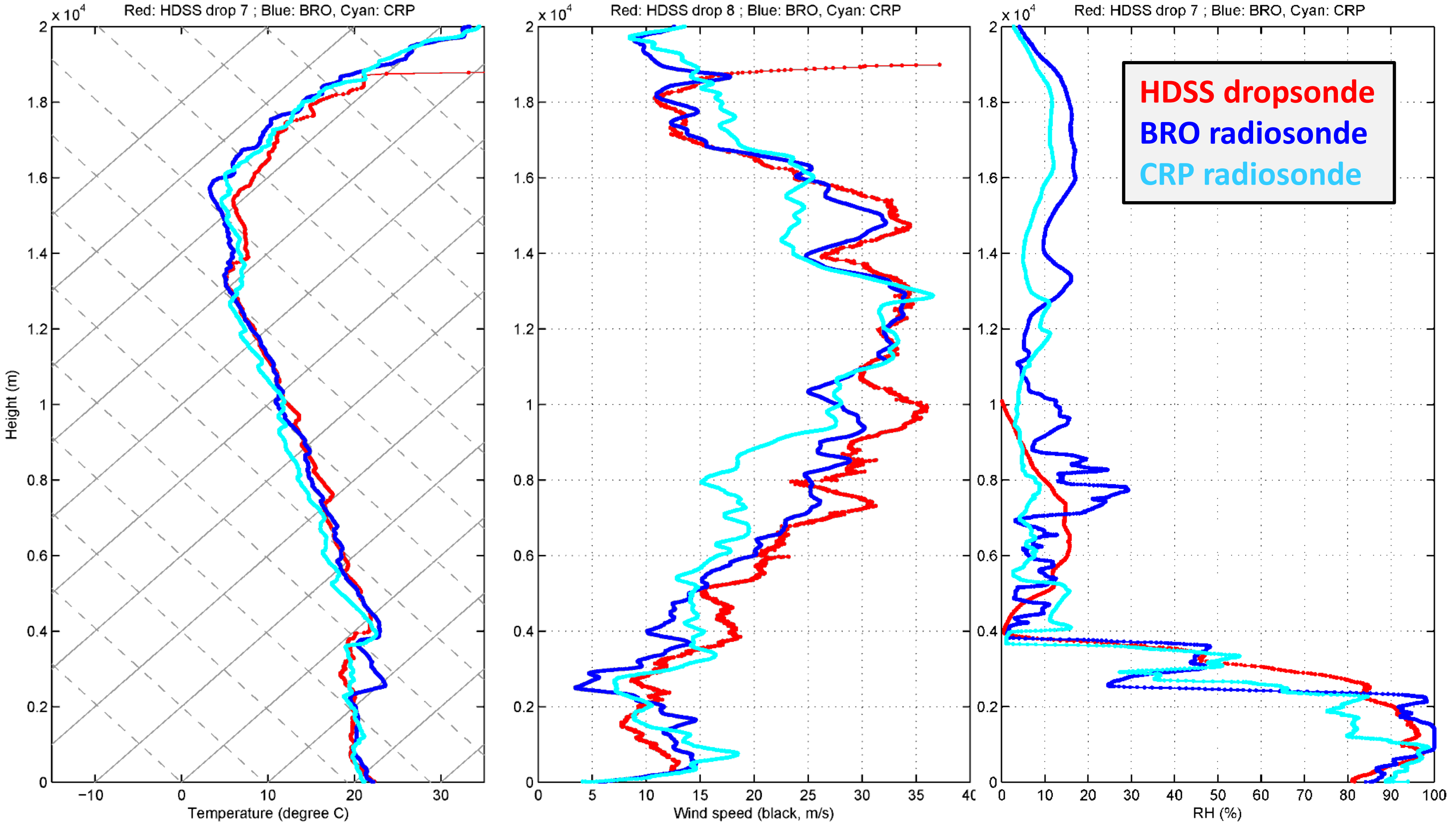
- The HDSS sondes were dropped between 2045z and 2145z on 11/20. Here we will compare the HDSS results with those of the Brownsville (BRO) and Corpus Christi (CRP) radiosondes from 00z 11/21. The maps below show the dropsonde groupings and their locations.



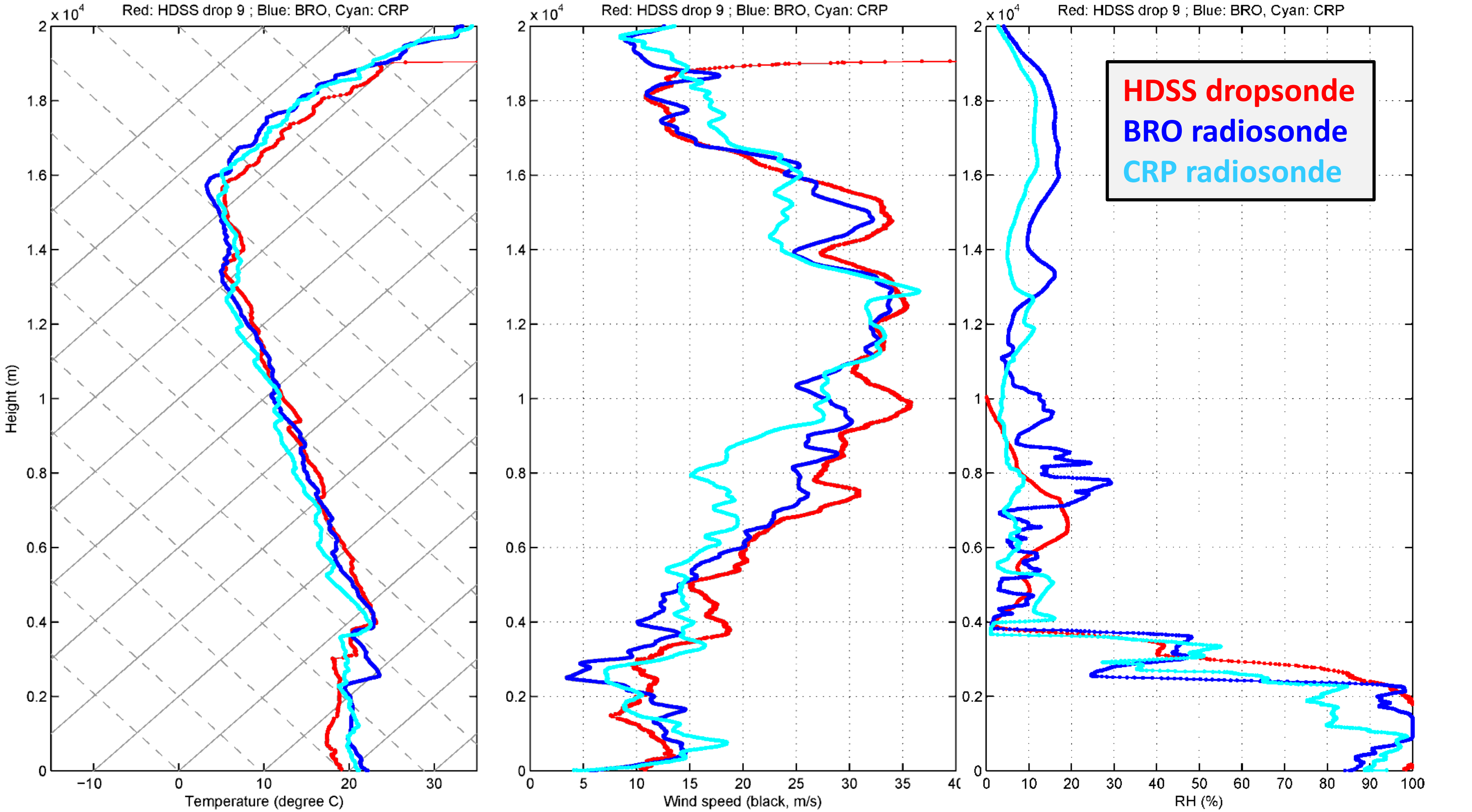




- Plots show temperature (left), wind speed (middle), and RH (right) comparisons for **HDSS dropsondes** from the **drop #1-6 grouping**, which was closest to the **Corpus Christi radiosonde (CRP)**
- For this slides and the ones that follow, I am choosing the "best-looking" HDSS data from each sonde grouping. This mean no obvious problems with low-level temperature or RH, relatively noise-free winds, and no missing data. The purposes of this is to exclude known issues from the comparison and focus on the remaining differences between the dropsondes and the radiosondes.

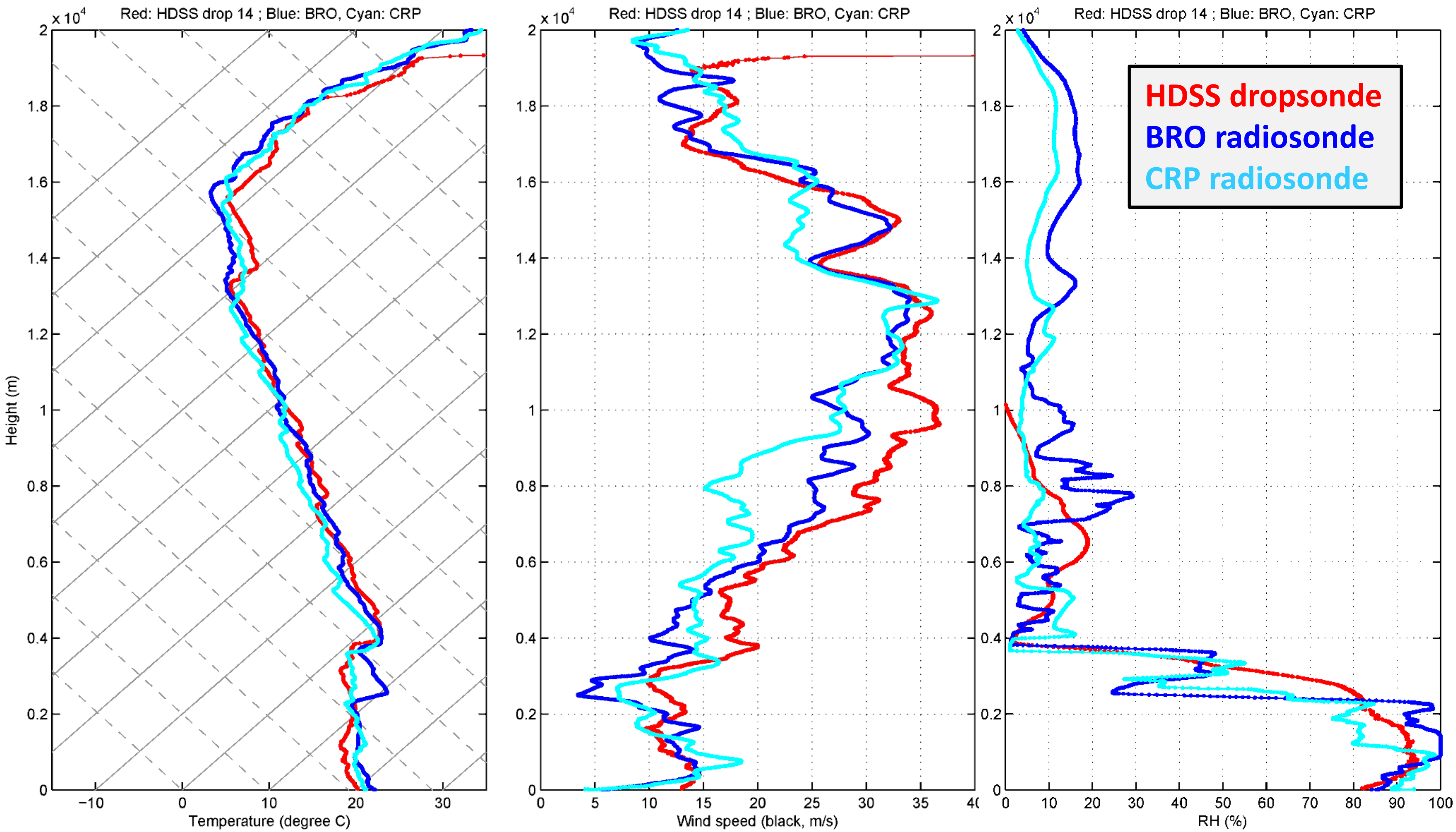


- Plots show temperature (left), wind speed (middle), and RH (right) comparisons for **HDSS dropsondes** from the **drop #7-8 grouping**, which was furthest west and a bit closer to the **Brownsville radiosonde (BRO)** than the **Corpus Christi radiosonde (CRP)**
- The radiosonde data is at 1Hz, while 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. The HDSS data is 'raw' while I'm not sure what kind of post-processing has been applied to the radiosonde data.

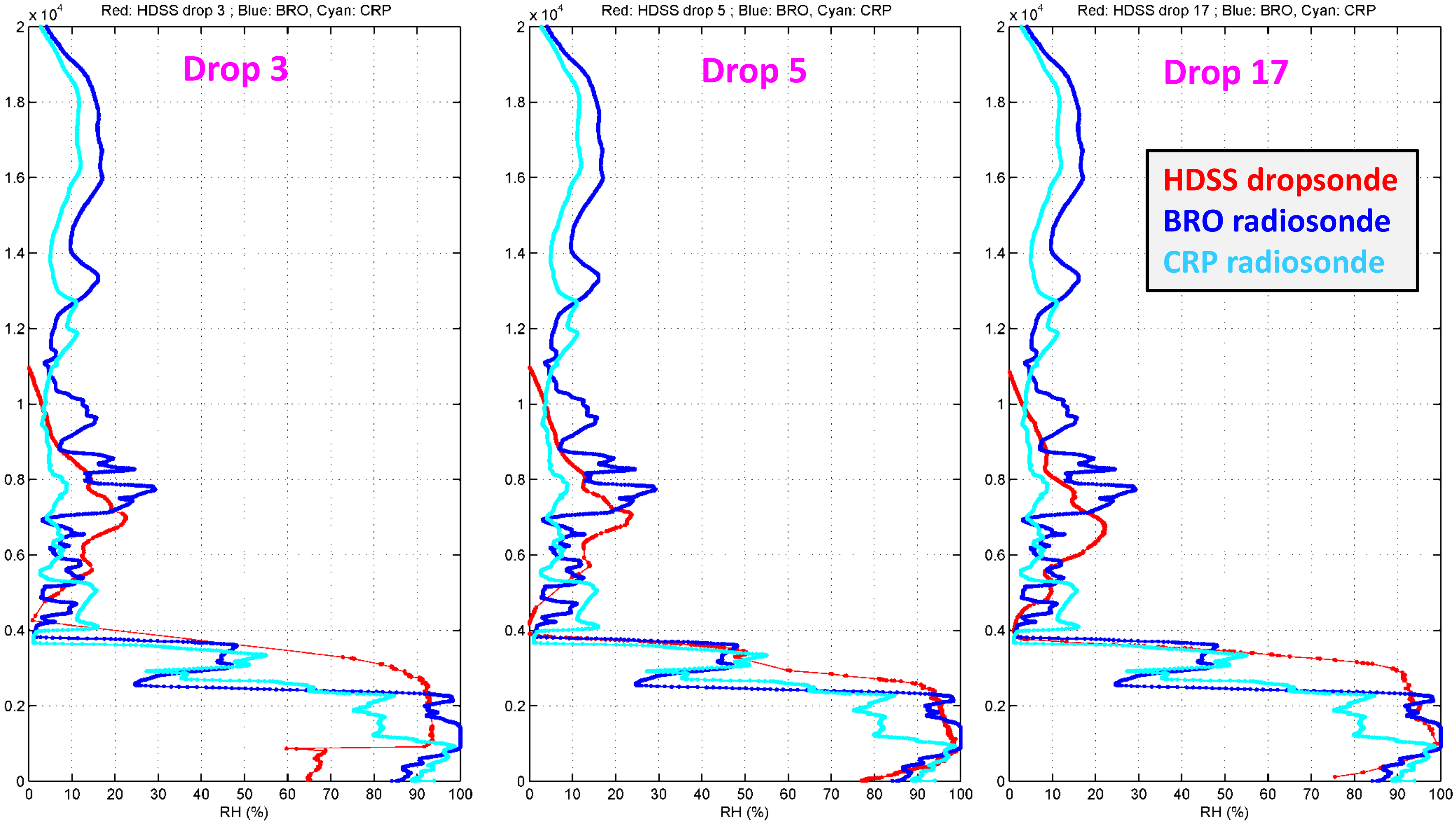


- Plots show temperature (left), wind speed (middle), and RH (right) comparisons for **HDSS dropsondes** from the **drop #9-10 grouping**, which was furthest south

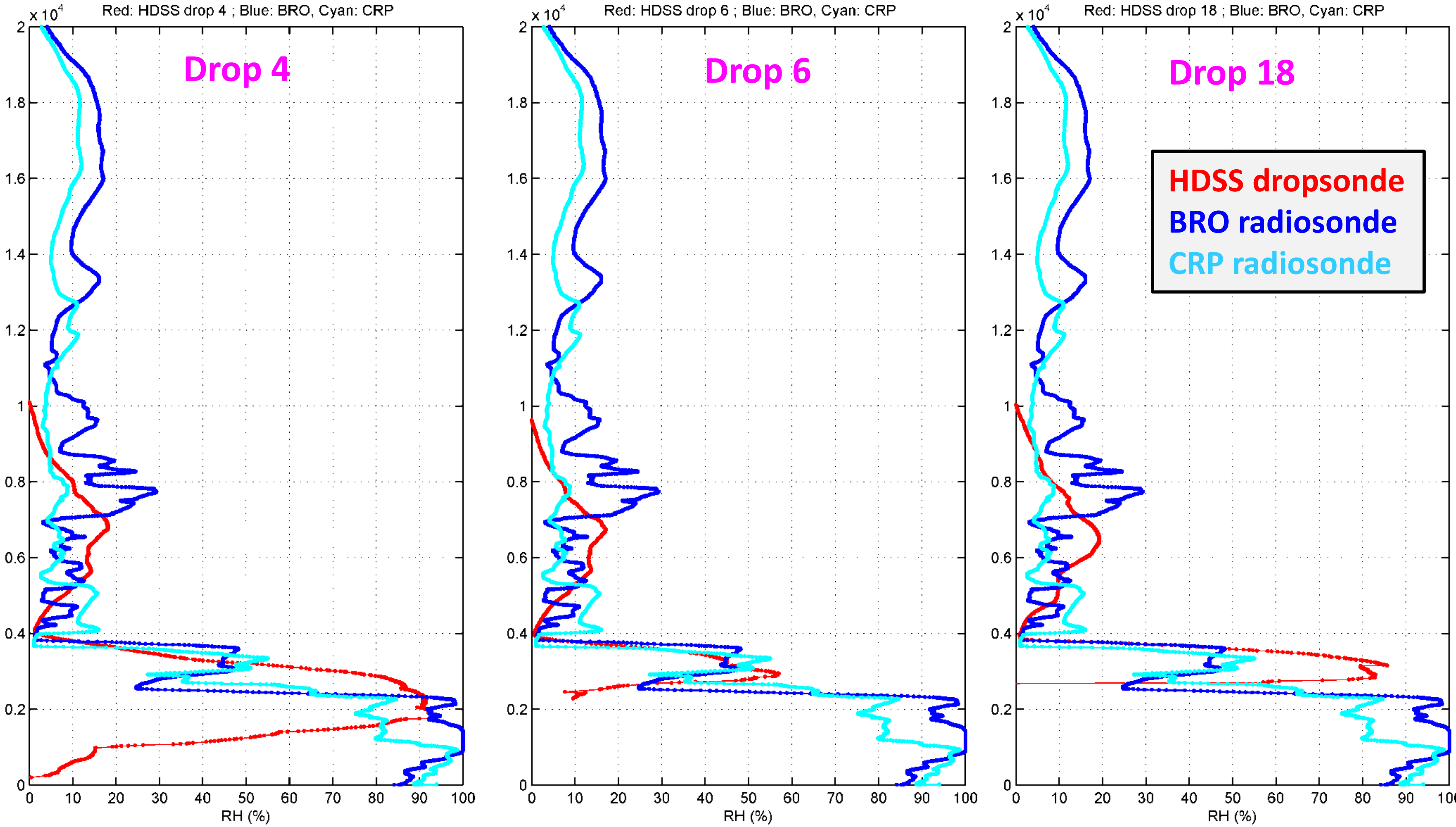
- Because the HDSS dropsondes and the radiosondes are not coincident spacially (2 hr difference in time), it is
- difficult to attribute differences between the profiles to differences in the capabilities of the observing platforms, rather than differences in the meteorological conditions.



- Plots show temperature (left), wind speed (middle), and RH (right) comparisons for **HDSS dropsondes** from the **drop #11-21 grouping**, which was furthest from the radiosonde sites



- Here, there are RH profiles shown from 3 slow-fall sondes. These 3 sondes all had fast-fall sondes that are nearly collocated in space and time; the corresponding fast-fall sondes are shown on the next page.
- Flipping back and forth between this page and the next, it is clear that the slow fall sonde begin reacting to the presence of humidity higher in the atmosphere than fast fall sondes. The peak value in HDSS RH in the middle troposphere is also somewhat higher up and somewhat larger in the slow-fall sondes relative to the fast fall sondes. However, if the BRO radiosonde is representative of the RH, even the slow fall sondes do not react fast enough to the RH maximum near 8 km.



Red: HDSS drop 4 ; Blue: BRO, Cyan: CRP
Drop 4
Red: HDSS drop 6 ; Blue: BRO, Cyan: CRP
Drop 6
Red: HDSS drop 18 ; Blue: BRO, Cyan: CRP
Drop 18
HDSS dropsonde
BRO radiosonde
CRP radiosonde
x 10^4
RH (%)

Summary

- Because the HDSS sondes and radiosondes are not coincident in space and time, it is difficult to draw conclusions about the reason for differences between the profiles.

- Despite the aforementioned, the comparison of the RH profiles with the Brownsville sounding suggests the HDSS RH measurements lag reality as they fall through the middle troposphere. The lag is worse for the fast-fall than the slow-fall sondes. And, as we knew already, the HDSS is not sensitive to RH in the upper-troposphere and lower stratosphere.