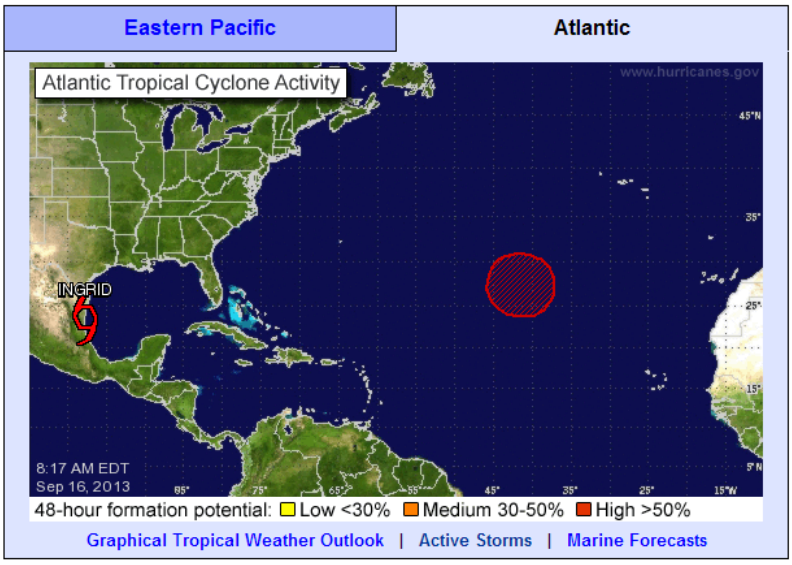
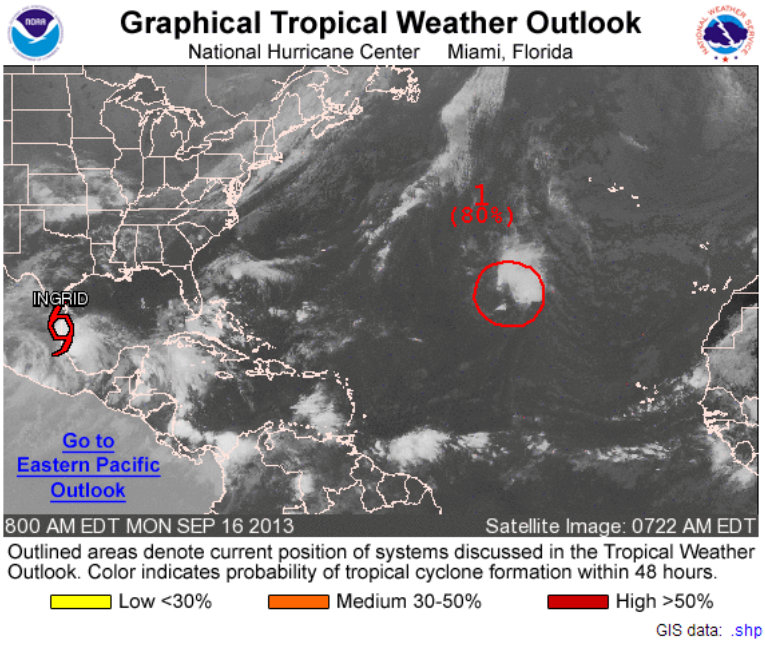
Hurricane and Severe Storm Sentinel (HS3) Mission

HS3 2013.09.16-17 Flight Report: GLOBAL HAWK AV-6 mission to Post/Pre-Re-Humberto

Mission Scientists:
Shift 1 (0800-1700 UT): Scott Braun/Pete Black /Pete Colarco
Shift 2 (1600-0100 UT): Deanna Hence/Bob Houze
Shift 3 (0000-0900 UT): Paul Newman/Mike Montgomery/Chris Thorncroft
Shift 4 (0800-1200 UT): Scott Braun/ Pete Black/Pete Colarco

Mission goal: The goal of this flight is to sample the environment around post-hurricane Humberto. Humberto has 80% likelihood of redeveloping over next 2 days, 90% over next 5 days.





The NHC discussion at 0800 UTC is shown below:

ZCZC MIATWOAT ALL
TTAA00 KNHC DDHHMM

TROPICAL WEATHER OUTLOOK
NWS NATIONAL HURRICANE CENTER MIAMI FL
800 AM EDT MON SEP 16 2013

FOR THE NORTH ATLANTIC...CARIBBEAN SEA AND THE GULF OF MEXICO...

THE NATIONAL HURRICANE CENTER IS ISSUING ADVISORIES ON HURRICANE INGRID...LOCATED OVER THE SOUTHWESTERN GULF OF MEXICO.

1. POST-TROPICAL CYCLONE HUMBERTO IS LOCATED ABOUT 1075 MILES SOUTHWEST OF THE AZORES ISLANDS AND IS MOVING WEST-NORTHWESTWARD AT 10 TO 15 MPH. SHOWER AND THUNDERSTORM ACTIVITY ASSOCIATED WITH THIS SYSTEM HAS CHANGED LITTLE DURING THE PAST SEVERAL HOURS...BUT ENVIRONMENTAL CONDITIONS ARE EXPECTED TO BECOME MORE FAVORABLE FOR REGENERATION INTO A TROPICAL CYCLONE OVER THE NEXT DAY OR SO. THIS SYSTEM HAS A HIGH CHANCE...80 PERCENT...OF BECOMING A TROPICAL CYCLONE AGAIN DURING THE NEXT 48 HOURS...AND A HIGH CHANCE...90 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT FIVE DAYS AS IT TURNS NORTHWARD AND NORTHEASTWARD OVER THE OPEN ATLANTIC. ADDITIONAL INFORMATION ON THE POST-TROPICAL CYCLONE CAN BE FOUND IN HIGH SEAS FORECASTS ISSUED BY THE NATIONAL WEATHER SERVICE.

OTHER SYSTEMS WITH FORMATION POTENTIAL BEYOND 48 HOURS...

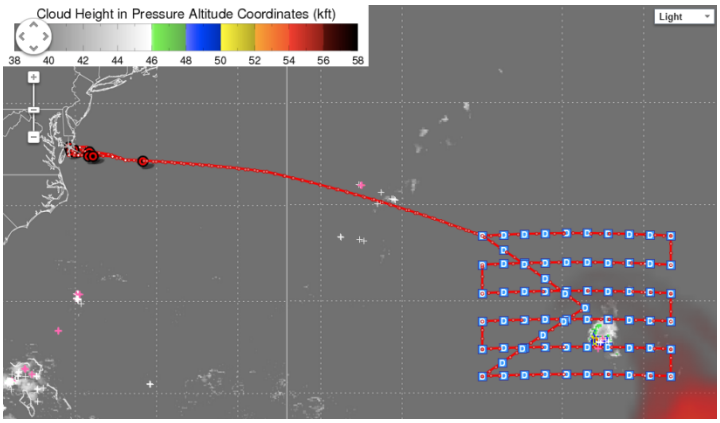
AN AREA OF DISTURBED WEATHER IS LOCATED OVER THE NORTHWESTERN CARIBBEAN SEA. THIS DISTURBANCE IS EXPECTED TO MOVE WESTWARD OR WEST-NORTHWESTWARD ACROSS THE YUCATAN PENINSULA AND INTO THE SOUTHWESTERN GULF OF MEXICO OVER THE NEXT FEW DAYS...WHERE A BROAD AREA OF LOW PRESSURE COULD FORM. ENVIRONMENTAL CONDITIONS ARE FORECAST TO BE CONDUCIVE FOR SOME GRADUAL DEVELOPMENT OF THIS LOW...AND THIS SYSTEM HAS A LOW CHANCE...NEAR 0 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A LOW CHANCE...20 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS.

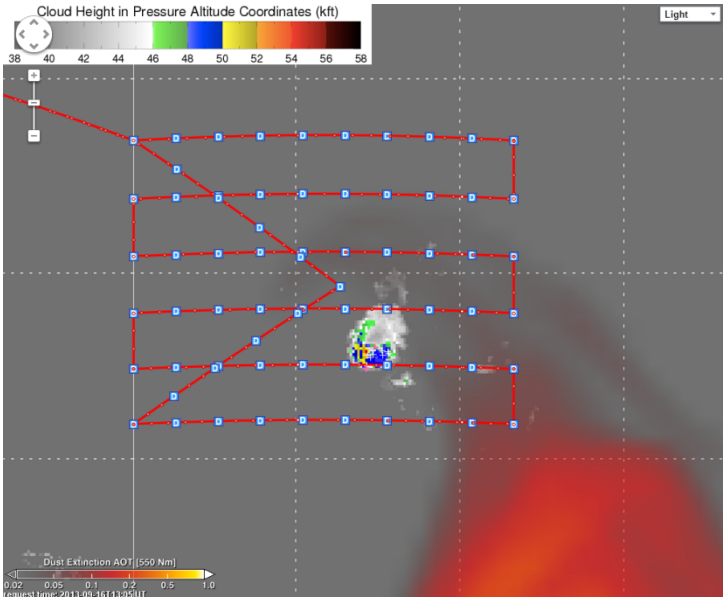
HIGH SEAS FORECASTS ISSUED BY THE NATIONAL WEATHER SERVICE CAN BE FOUND UNDER AWIPS HEADER NFDHSFAT1 AND WMO HEADER FZNT01 KWBC.

FIVE-DAY FORMATION PROBABILITIES ARE EXPERIMENTAL IN 2013. COMMENTS ON THE EXPERIMENTAL FORECASTS CAN BE PROVIDED AT...

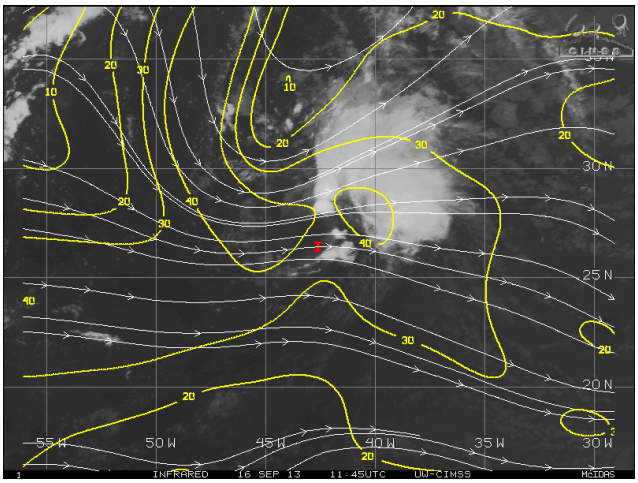
HTTP://WWW.NWS.NOAA.GOV/SURVEY/NWS-SURVEY.PHP?CODE=ETWO

FORECASTER BROWN





Most of Humberto area below 50kft, with high altitude cloud tops to about 56kft only over the SW quadrant of the system. Lower level circulation is somewhat SW of upper levels clouds from latest GOES loop. Shear is pretty strong (40 kts) and convective development on the south side of storm is being sheared off to the east. Latest image loop (goes to 1245) shows cells blowing up on north side.

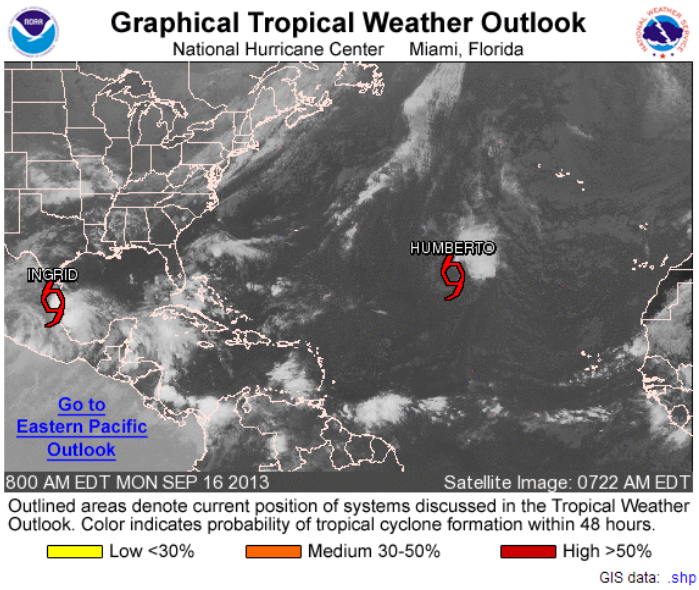


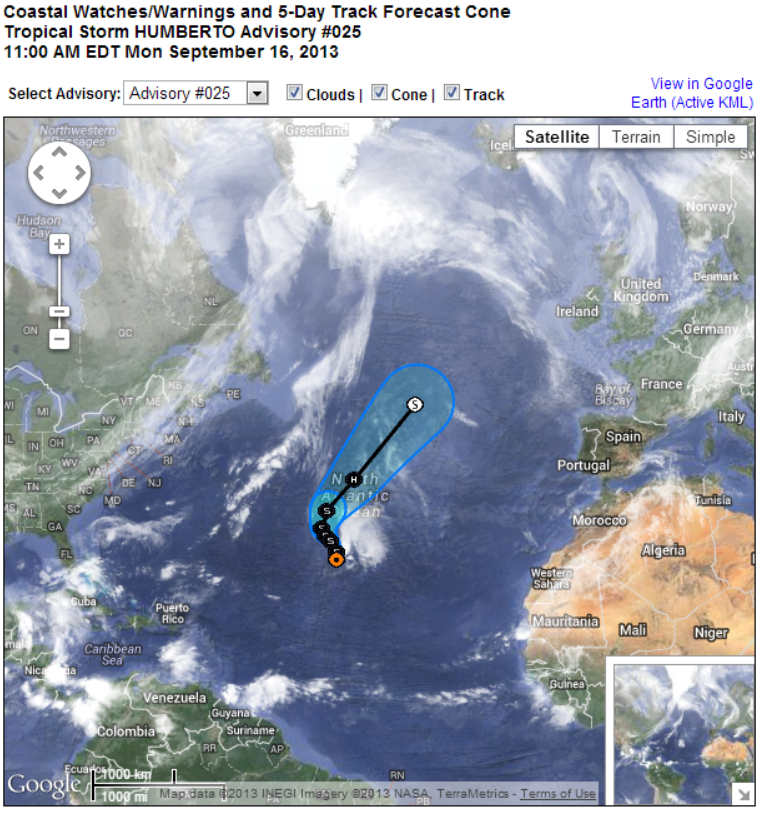
1417 Interesting spin up on this. MPCS was down, delaying takeoff. Now up and going through power up. We have VCAPES until 11 EDT, so need to get off in next 30 minutes or so.

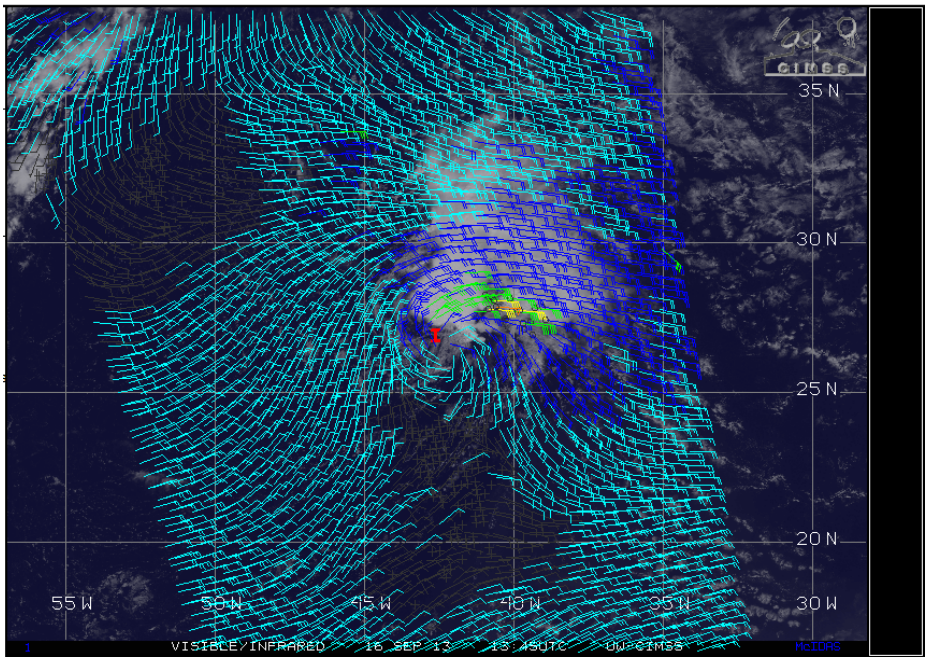
1438 Aircraft is taxiing on runway 22

1441 Taking off!

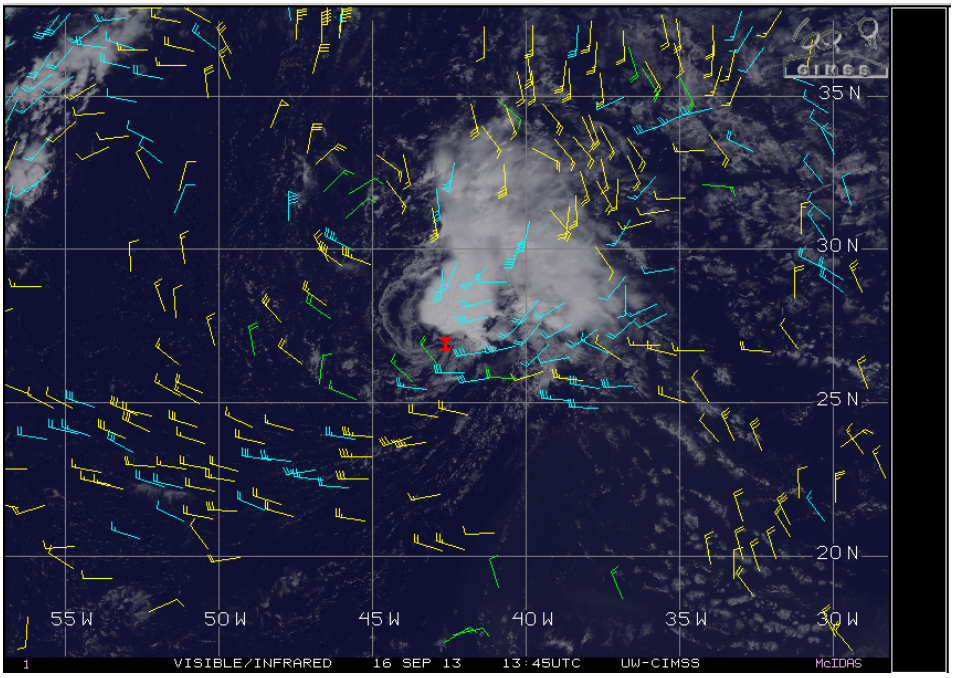
1442 We are airborne.



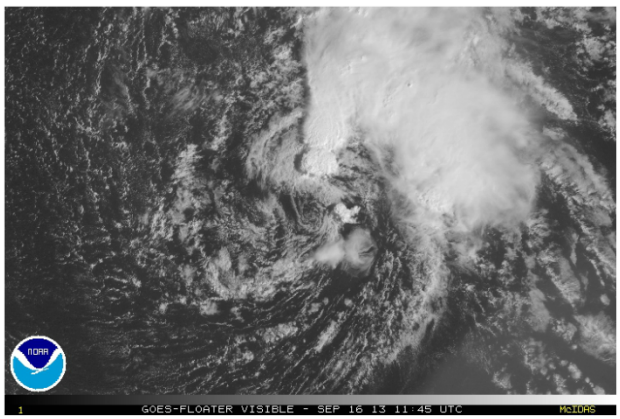


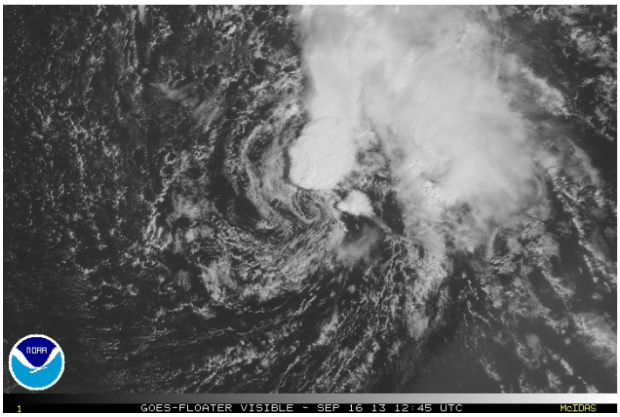


An OSCAT pass this morning shows the closed circulation. Most wind barbs north of the center suggest ~30 kt winds.



1345 Upper level winds suggest an upper trough or low over or just west of the low-level center.


GOES-FLOATER VISIBLE - SEP 16 13 11:45 UTC
McIDAS


GOES-FLOATER VISIBLE - SEP 16 13 12:45 UTC
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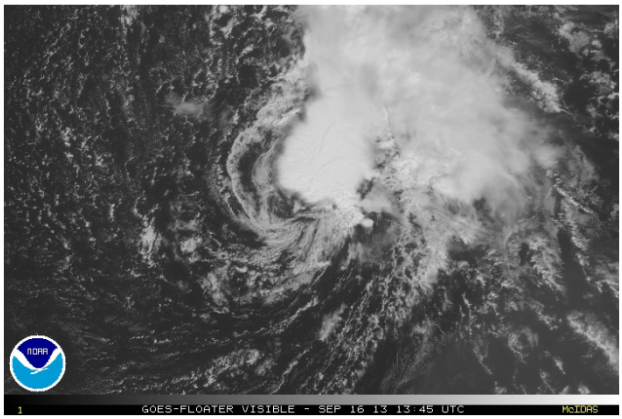
GOES-FLOATER VISIBLE - SEP 16 13 13:45 UTC
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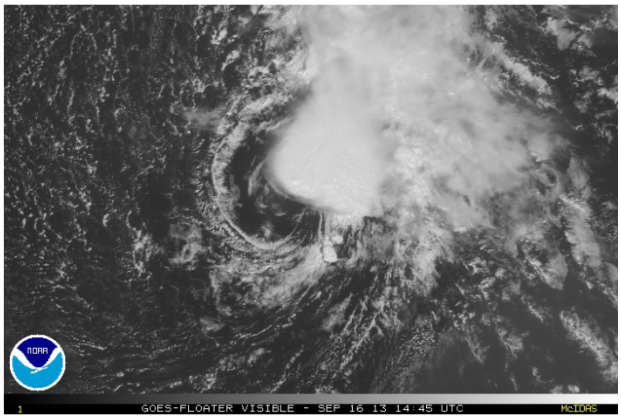
GOES-FLOATER VISIBLE - SEP 16 13 14:45 UTC
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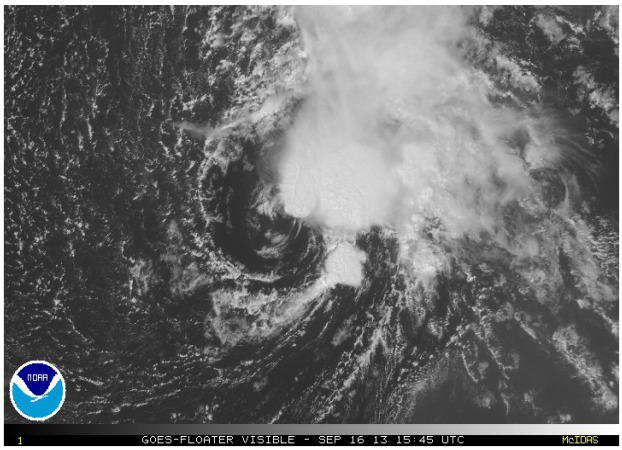
GOES-FLOATER VISIBLE - SEP 16 13 15:45 UTC
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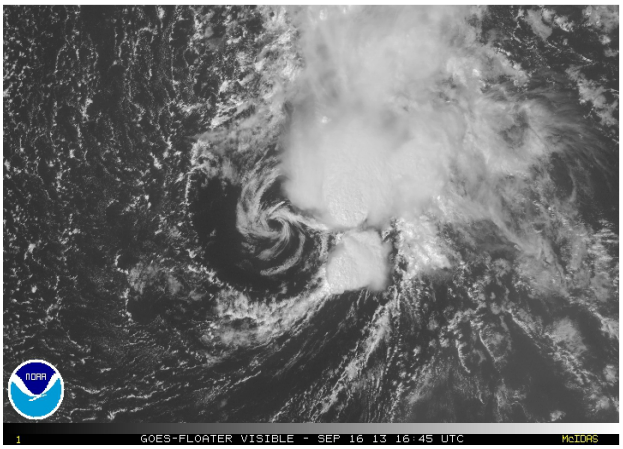
GOES-FLOATER VISIBLE - SEP 16 13 16:45 UTC
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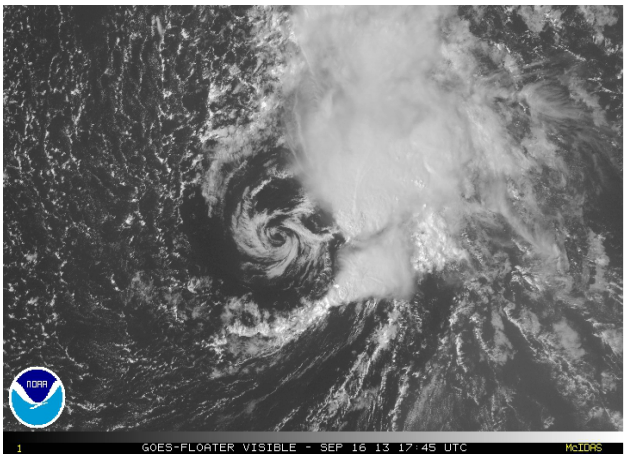
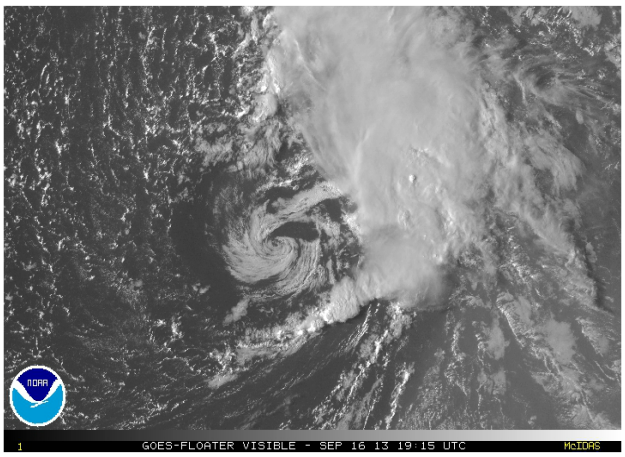
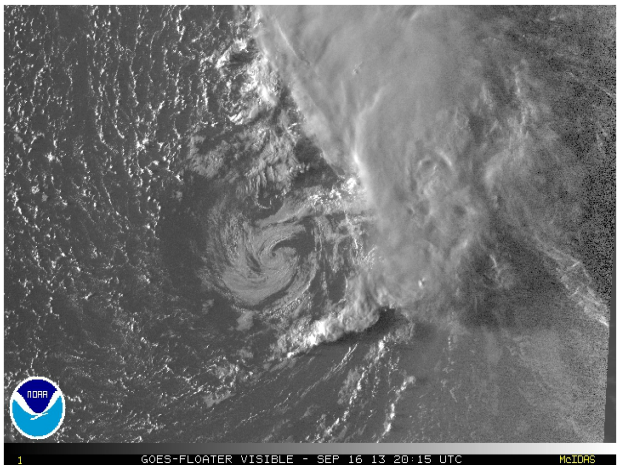
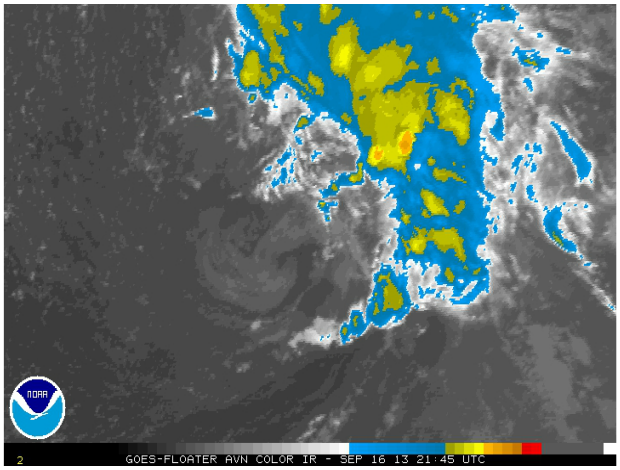
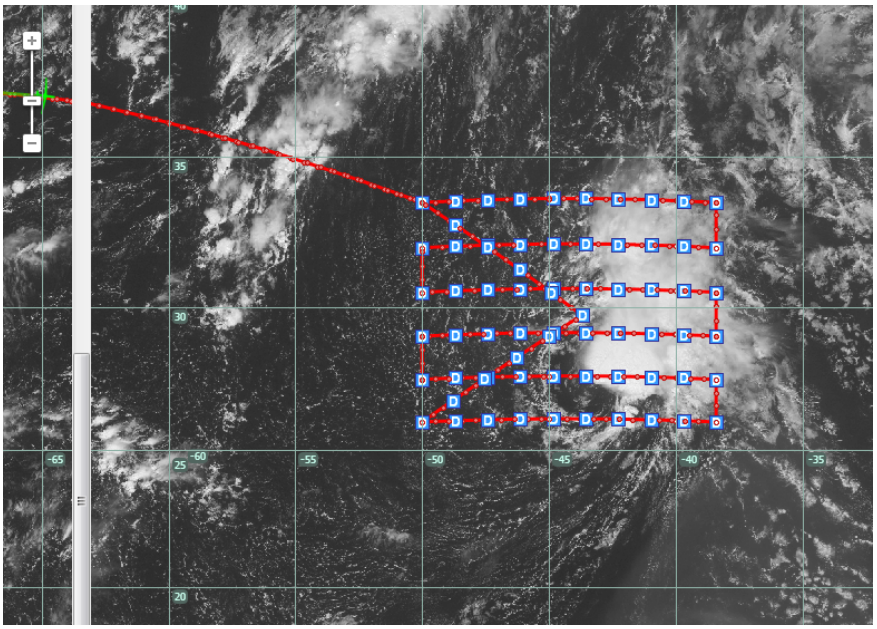




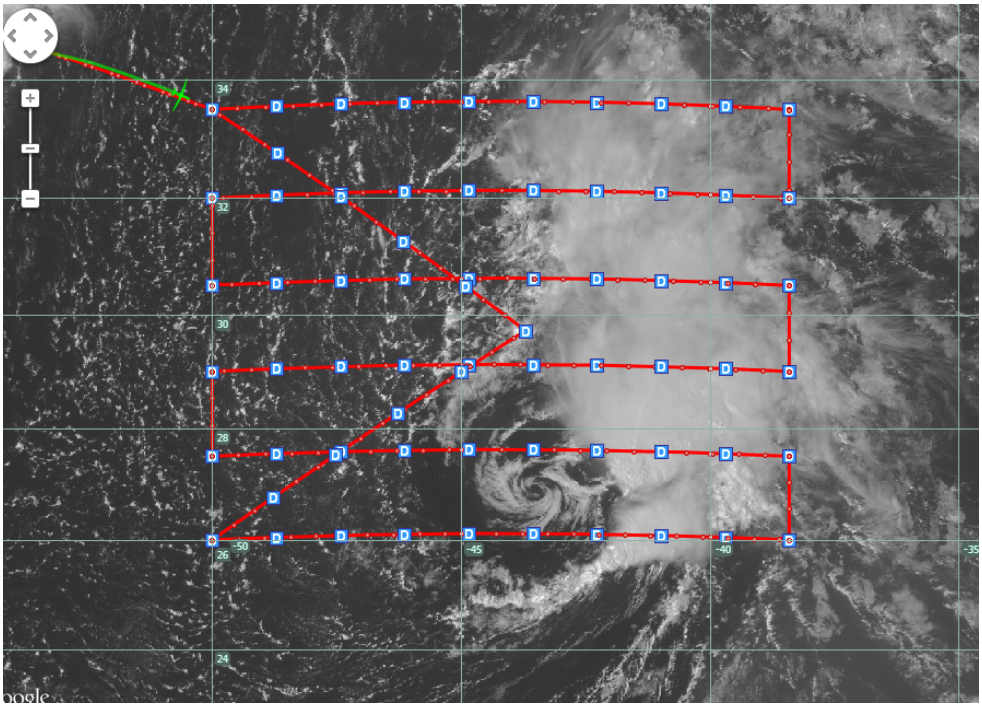




1544 Humberto is re-upped to tropical storm by NHC, and we a track for its continued motion. Maximum sustained winds 35 kts, central pressure 1007 hPa located at 27.2N 43.2W, moving west-northwest at 7 kts.



1629 AV6 on its way to planned pattern. Humberto in SE sector of plan.

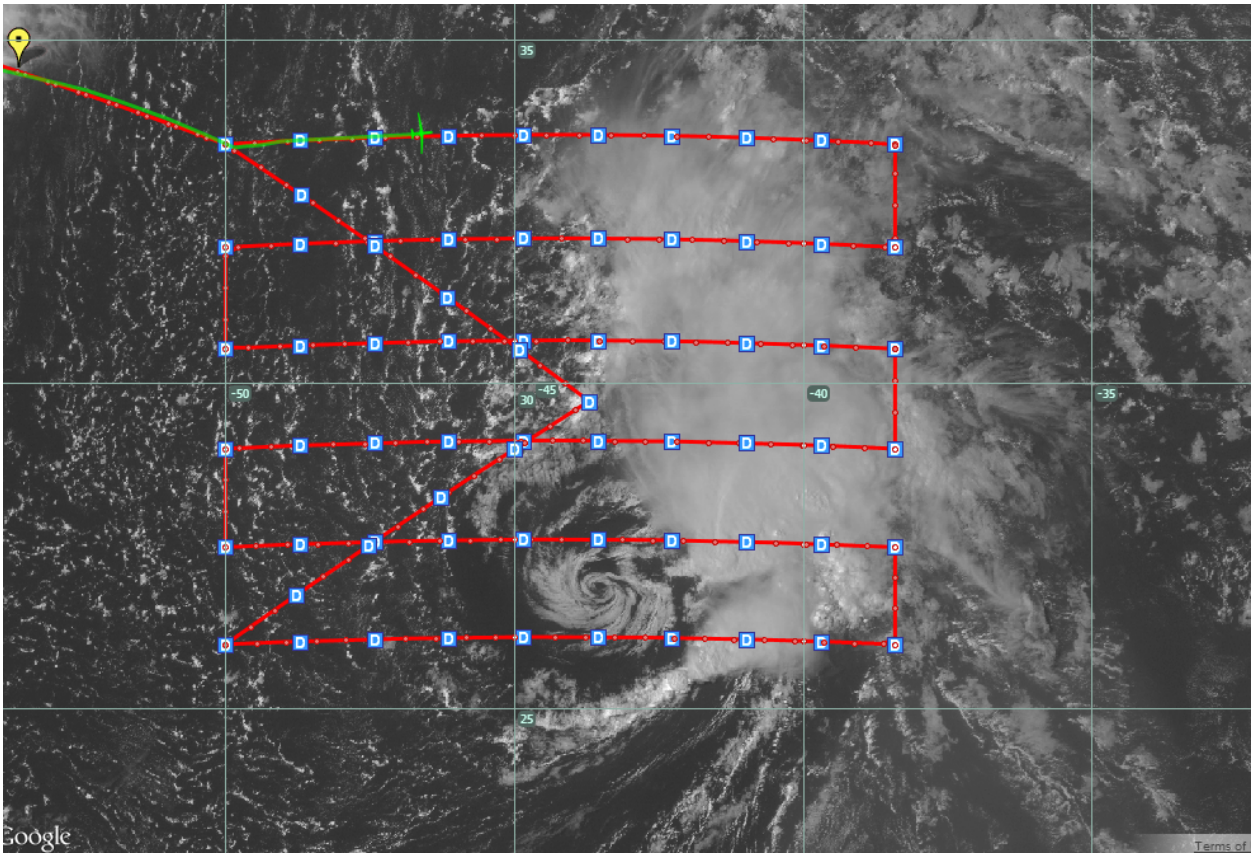


1830 Approaching 1st drop.

1839 D01 sonde launched

1847 D02 sonde launched

1859 D03 ok

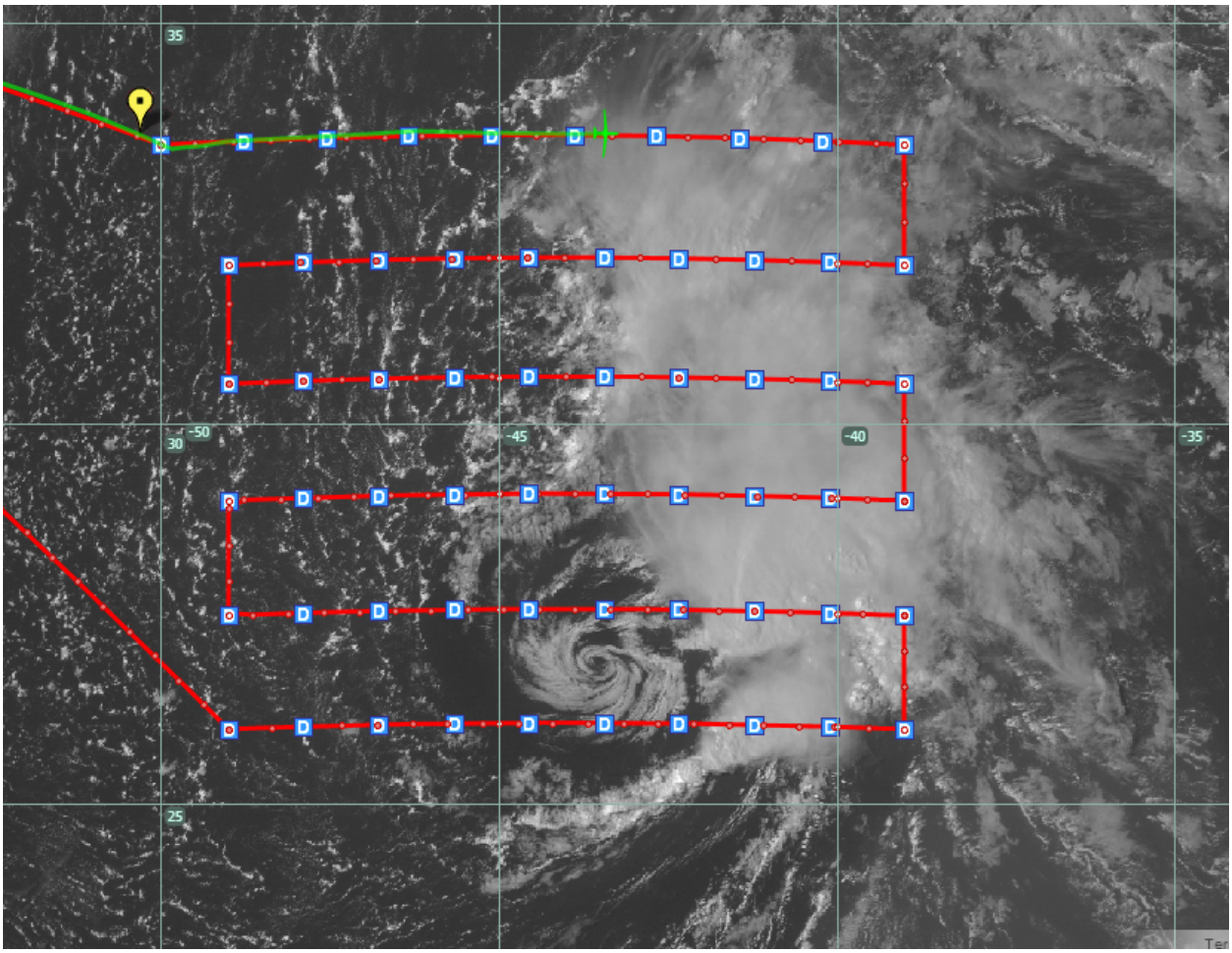


1908 above

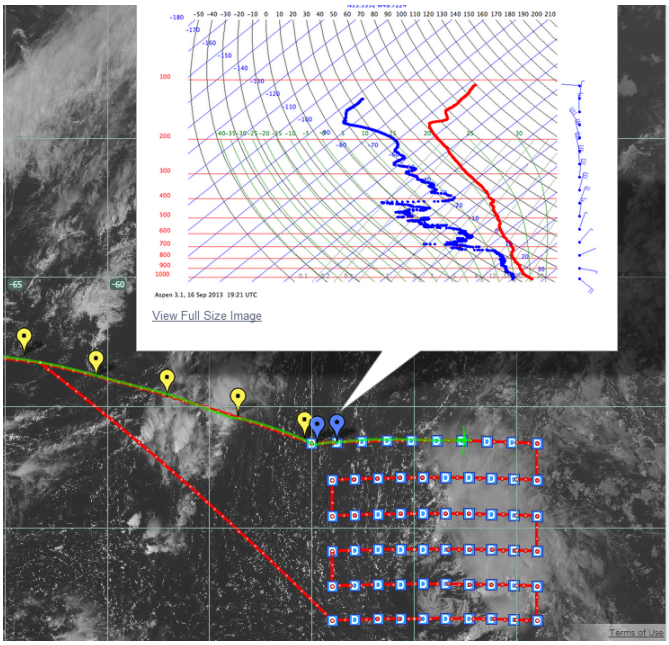
1911 D04

1923 D05

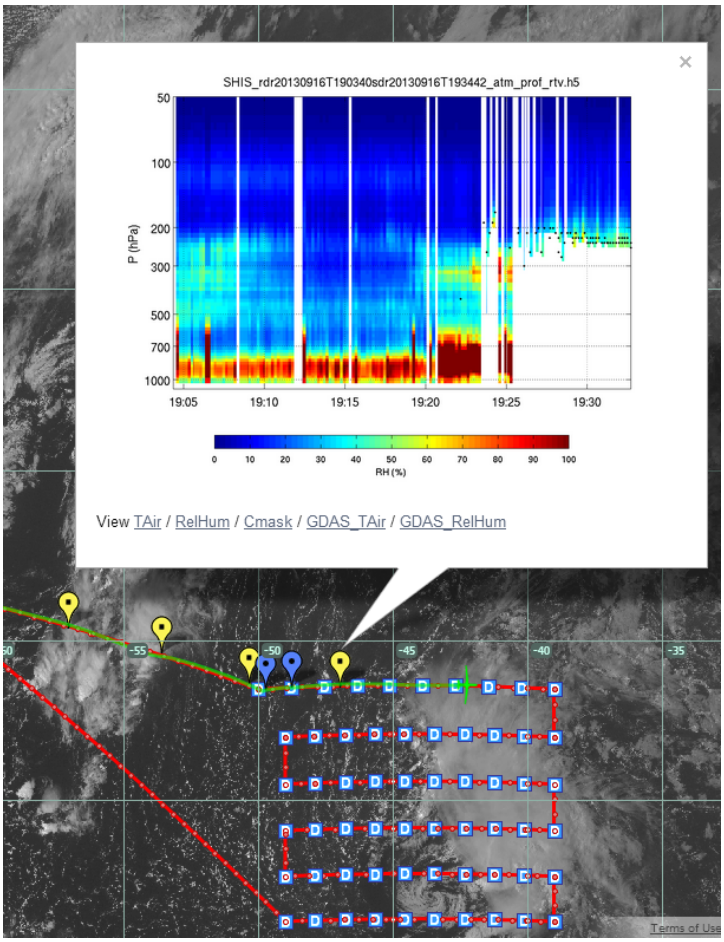
1933 D06



1936 (above) New flight plan to shorten the duration of the mission to accommodate AV1 takeoff tomorrow.

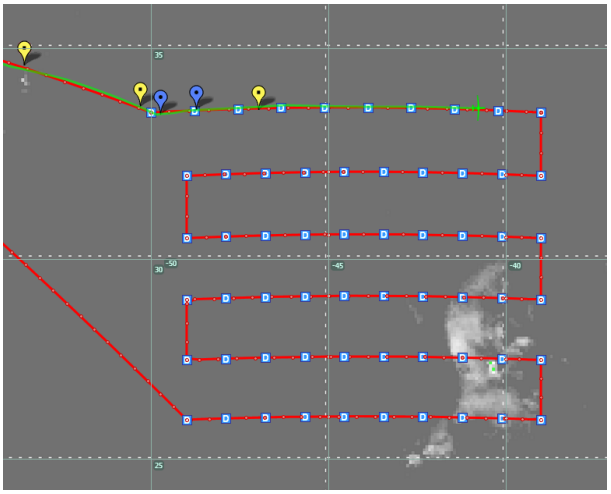


Sounding NW corner



D07

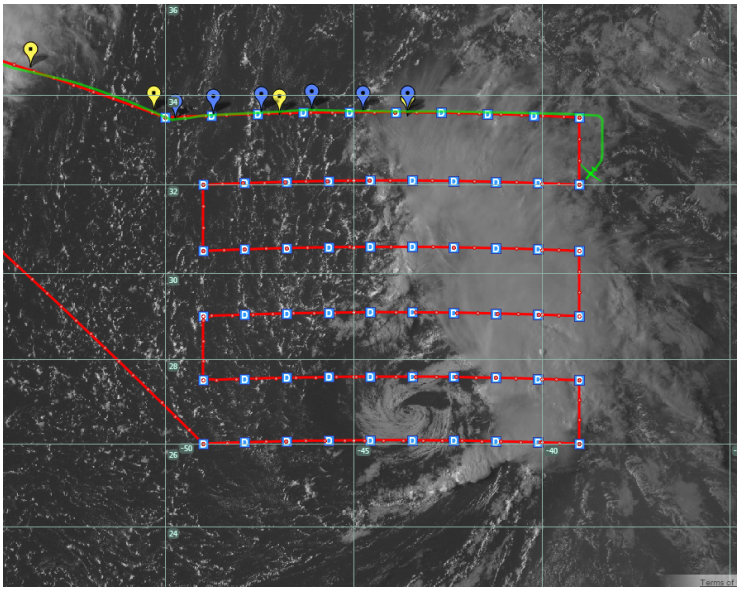
1956 DO8



1959 IR cloud tops (above)

2005 D09

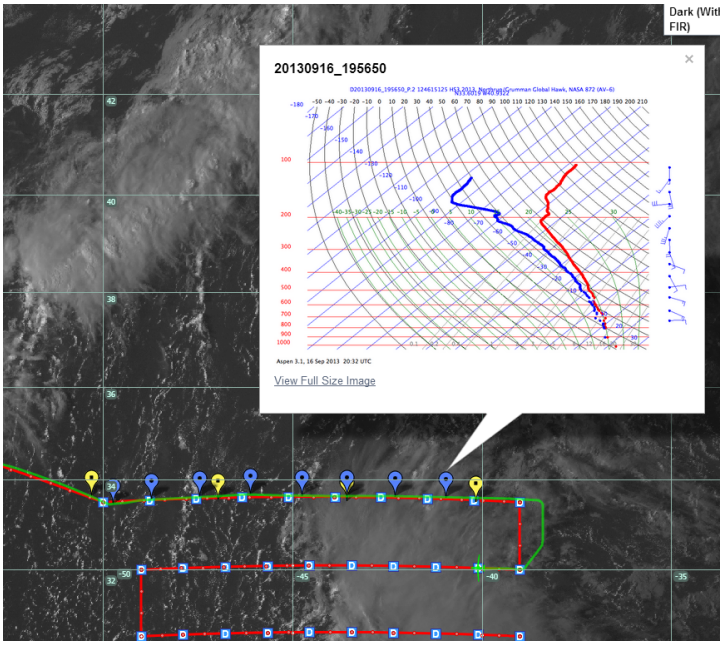
2020 D10



2034 Drop 10 was made according to the original plan. Drop 11 will be made according to the new plan. The plane turned SW to get to the new location of Drop 11.

2037 D11

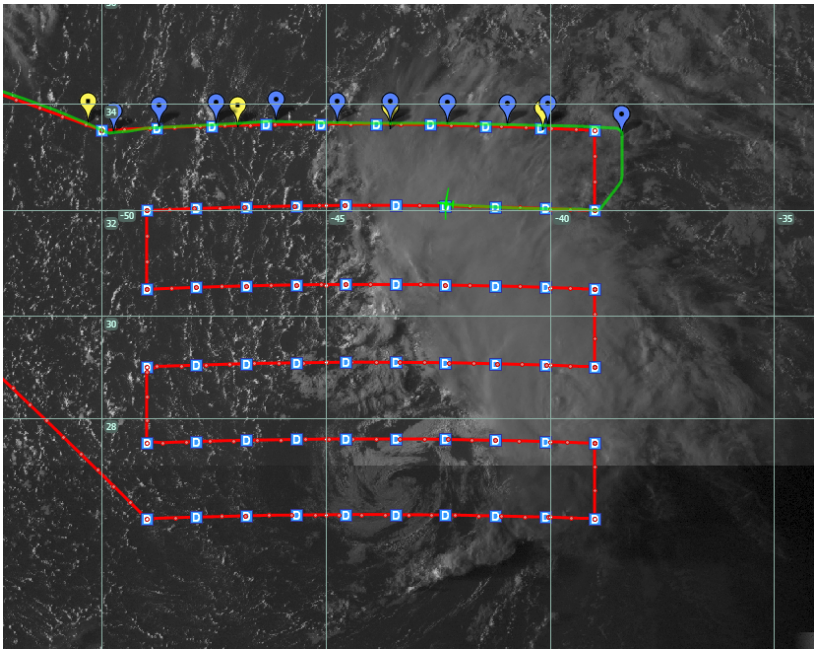
2047 D12



Sounding NE sector (above)

2057 D13

2107 D14



Above: 2107

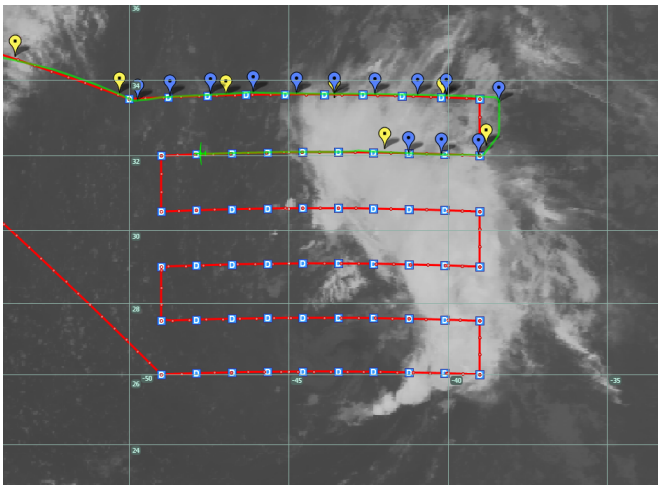
D15

D16 2126

D17

D18

D19 2157



2158 (above)

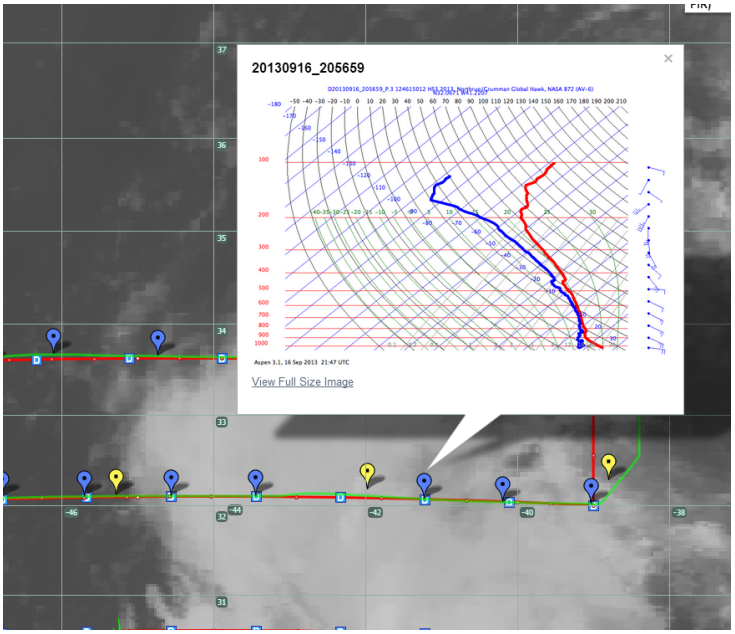
2208 D20

2223 D21

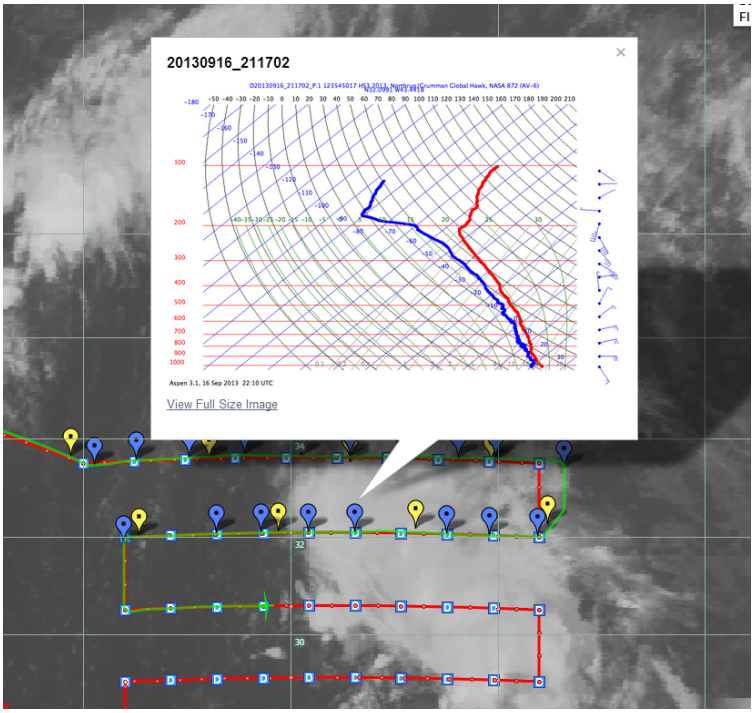
2232 D22

2242 D23

2252 D24

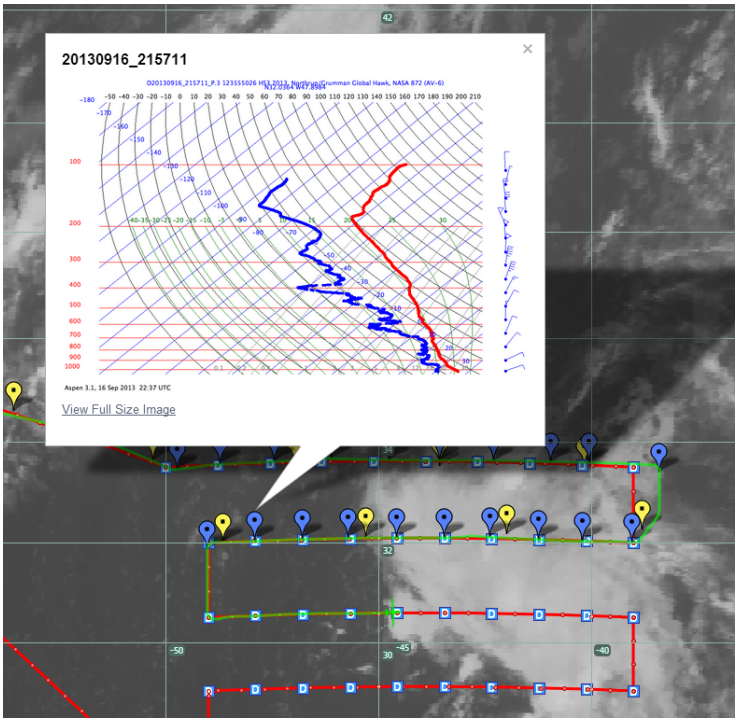


Sounding north-central-east (above)

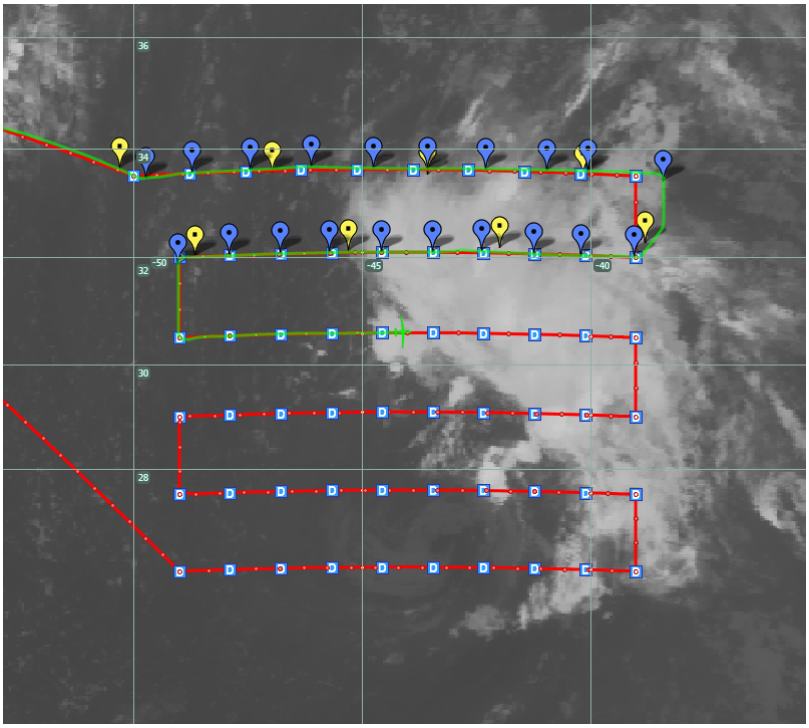


Sounding north-central sector (above)

2302 D25



Sounding north-central-west (above)



2310 plane at center of storm, more or less

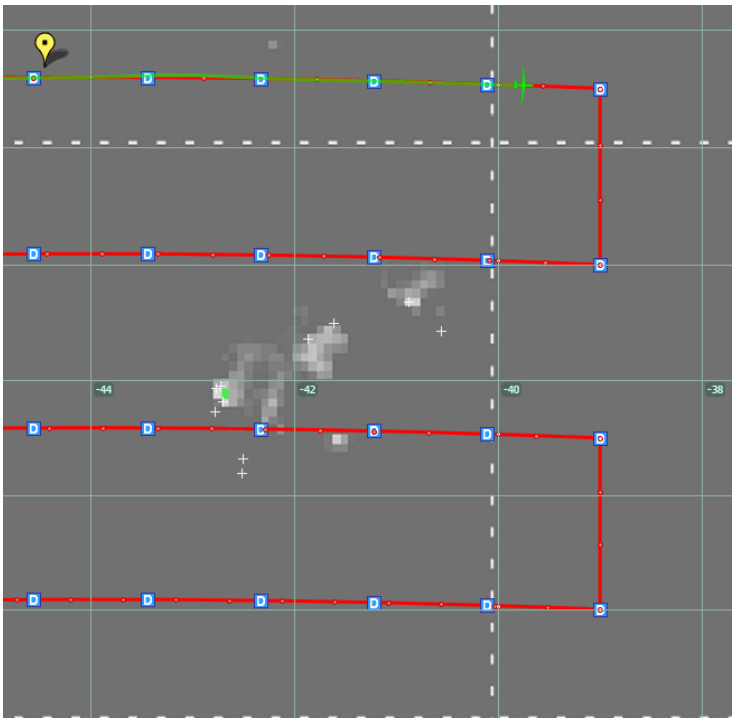
(??MTM/CT not so sure plane is really at center based on our look at dropsonde data -0220 UTC. There appears to be multiple centers of circulation evident after inspecting prior visible and brightness temperature imagery.)

2313 D26

D27

2334 D28

D29



2348 lightning in SE sector (above) Aircraft notified.

2356 D30 Good data

0011 D31 Good data

0020 D32 Good data

0030 D33 Good data

0040 D34 Good data

0050 D35 Good data

0100 D36 Good data

0110 D37 Good data

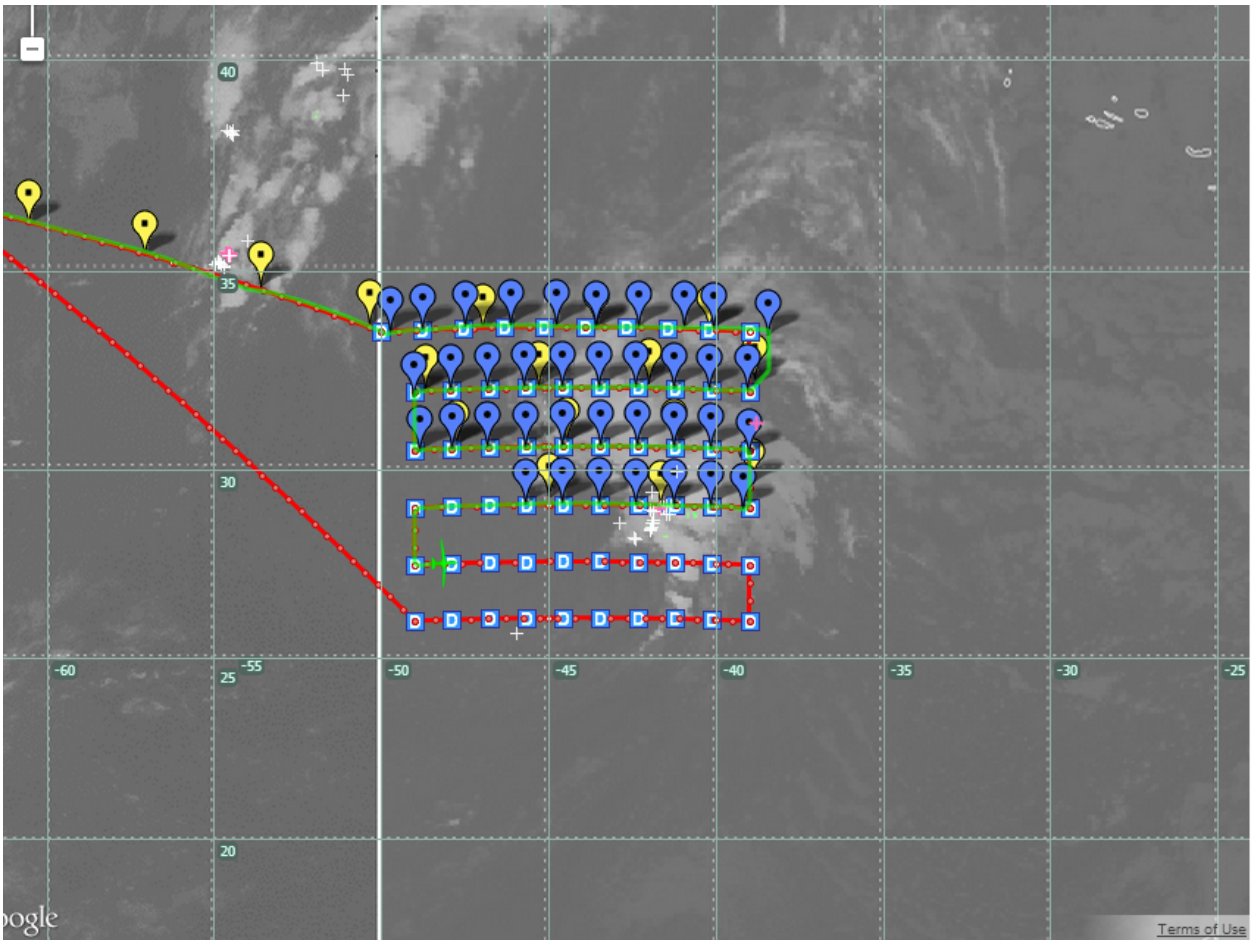
0120 D38 Good data

0130 D39 Good data

0141 D40 Good data

0201 D41 (drop delayed 10 minutes at southwest corner b/c of air traffic) Good data

0207 D42 Good data



Brightness temperature image at 0207 UTC Drop #41 (near southwest corner). Convective on eastern side of circulation appears to have all but disappeared compared to earlier this evening/afternoon.

Center of low-level circulation appears east-southeast of current location (plane marker above). Dropsonde data does not yet show westerly wind component in earth-relative frame of reference. (However, need to revisit with westward translation accounted for.)

0217 D43 Good data

0227 D44 Good data

0238 D45 Good data

0249 D46 Good data

Dropsonde data suggests air is quite dry west of center in comparison to dropsondes analyzed on southeast side of pattern (see below for more).

To sample the filament of low-level dry air that appears to be intruding into the southeastern portion of Humberto evident in the animated TPW loop, we have decided to deploy extra sondes between drops 47 - 48; 48 - 49; 52 - 53 and 53 - 54. These drops are labeled 47a, 48a, etc.

(drop 47a) N 2733 W 04146

(drop 48a) N 2732 W 04040

(drop 52a) N 2620 W 04040

(drop 53a) N 2604 W 04146

0259 D47 Good data

We have now decided to deploy 3 more sondes with a 5 minute interval. All of the new drops will be at the midpoint of dops 47-48, … and 53-54 so as to better sample the identified dry air filament near the southeast corner of the invest region.

Starting drops every 5 minutes now, until the originally planned drop 54.

0305 D47a Good data

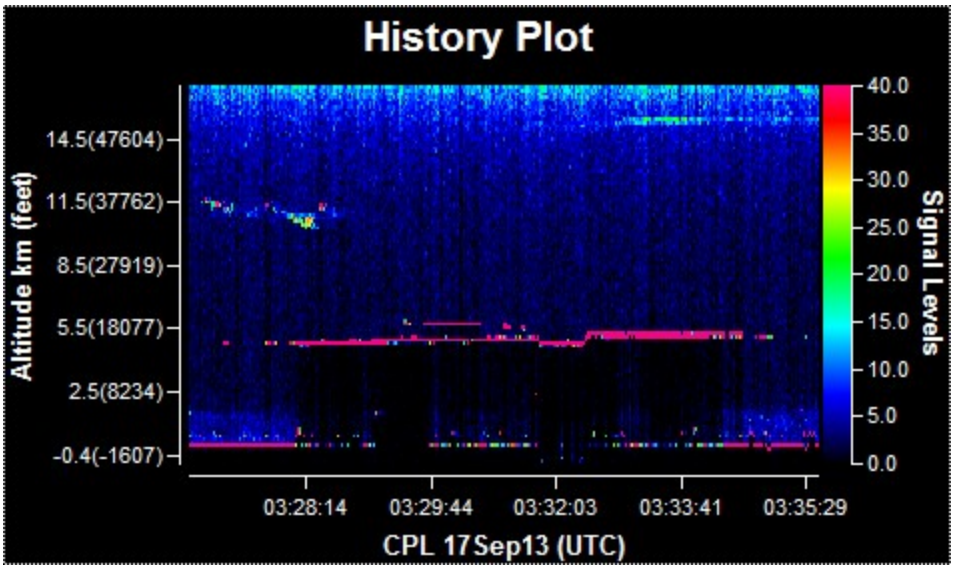
0311 D48 Good data

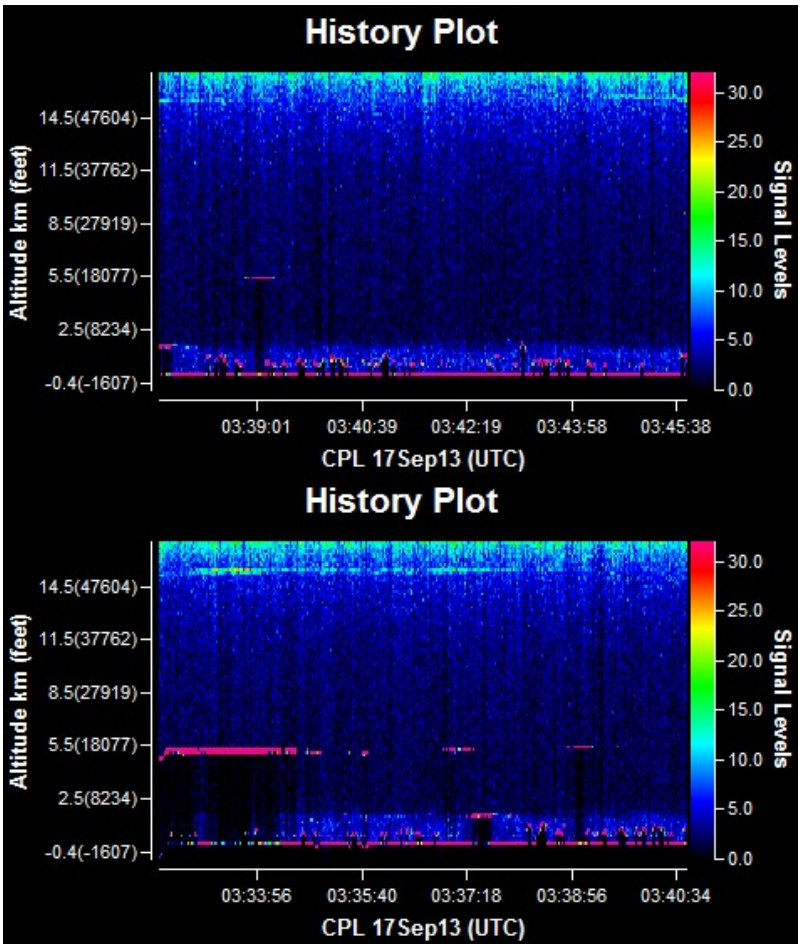
0317 D48a Good data

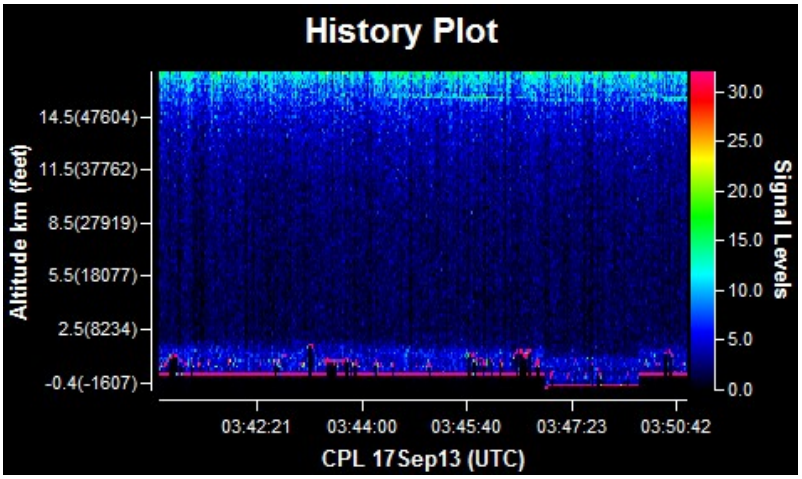
0321 D49 Good data

0326 D49a Good data

CPL time-height profiles near southeast corner.




History Plot
14.5(47604)
11.5(37762)
8.5(27919)
5.5(18077)
2.5(8234)
-0.4(-1607)
Altitude km (feet)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Signal Levels
03:39:01
03:40:39
03:42:19
03:43:58
03:45:38
CPL 17Sep13 (UTC)
History Plot
14.5(47604)
11.5(37762)
8.5(27919)
5.5(18077)
2.5(8234)
-0.4(-1607)
Altitude km (feet)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Signal Levels
03:33:56
03:35:40
03:37:18
03:38:56
03:40:34
CPL 17Sep13 (UTC)


History Plot
14.5(47604)
11.5(37762)
8.5(27919)
5.5(18077)
2.5(8234)
-0.4(-1607)
Altitude km (feet)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Signal Levels
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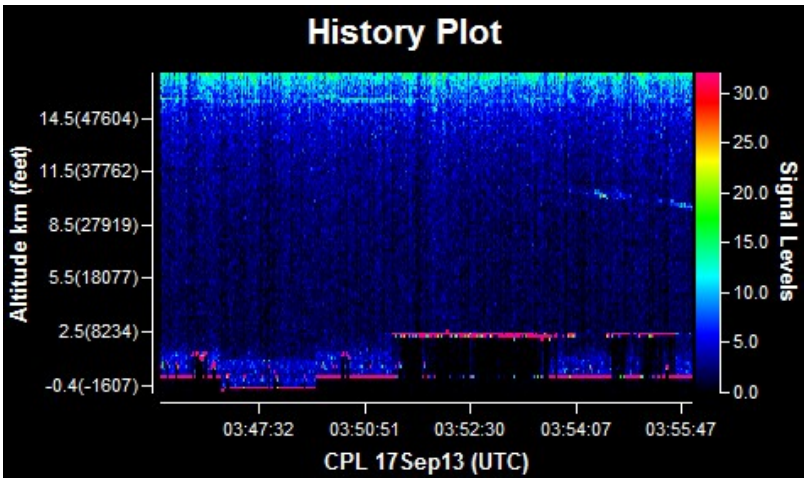
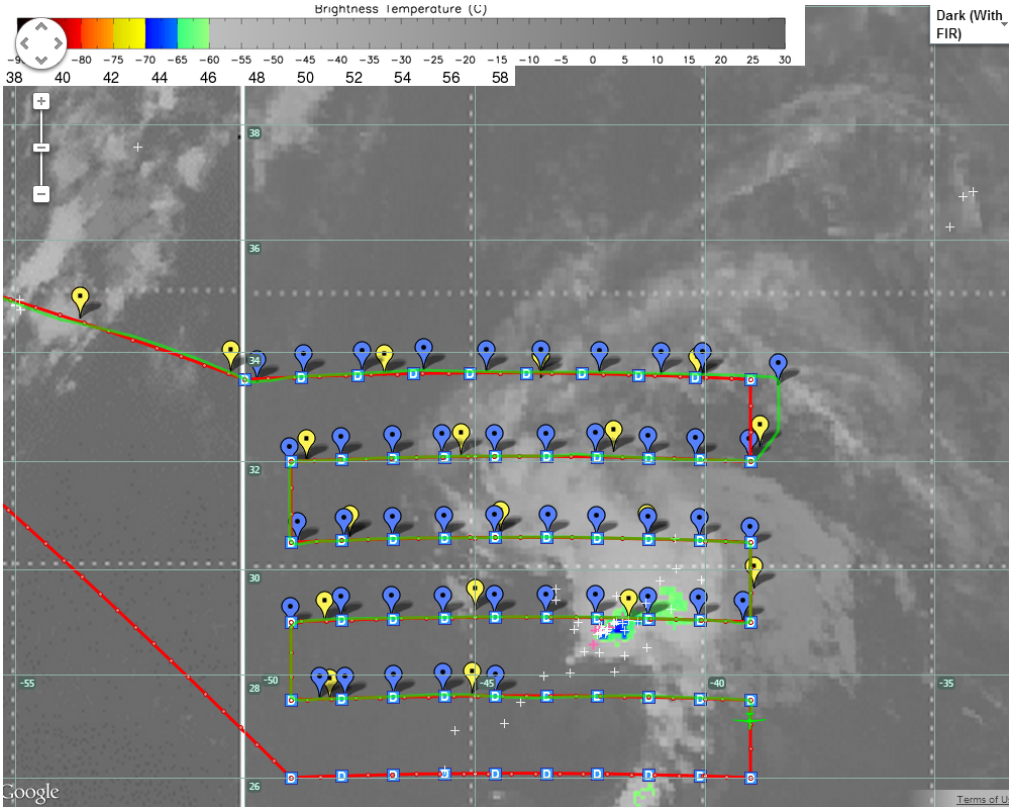
03:44:00
03:45:40
03:47:23
03:50:42
CPL 17Sep13 (UTC)



The CPL data and dropsonde data suggests that the some of the targeted air mass on the southeast sector of Humberto is moist up to approx. 700 mb, while other portions are dry above approx. 1.5 km. The observed structure does not resemble SAL air. The dry soundings resemble dry air laminae and not SAL air.

0331 D50 Good data (However, plotted drop data shows no horizontal winds for this drop. (AVAPS just confirmed with me that this is one of the two "fast fall" dropsondes during tonight's flight.)

0339 D50a Good data



This image shows brightness temperature at 0339 UTC (time of release for dropsonde 50a, near plane marker above), and AVAPS markers for processed dropsonde and SHIS data.

0348 D51 Good data

0353 D51a Good data

0357 D52 Good data

0403 D52a Good data

0408 D53 Good data

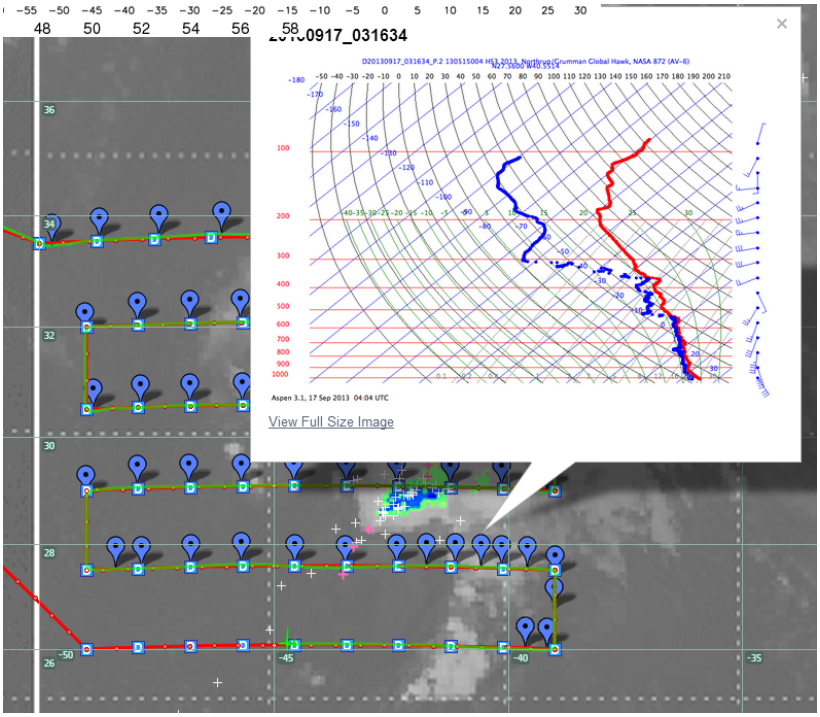
0413 D53a Good data

0418 D54 Good data

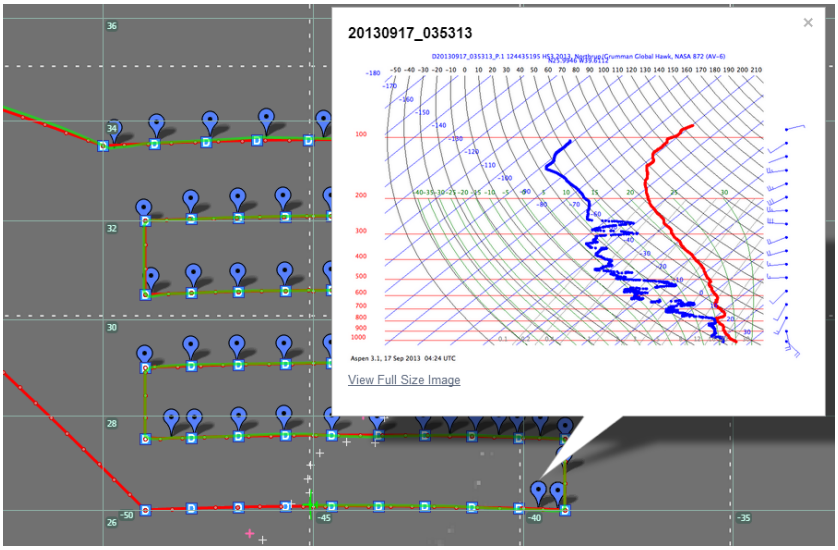
0429 D55 Good data

0440 D56 Good data

A few examples of the processes dropsonde profiles are given below (courtesy of Jason Dunion and Michael Black at NOAA/AOML-HRD and AVAPS team).



Drop 48a: Sounding through a cyclonically curved region of cloudiness in the southeastern sector. Moist adiabatic structure up to approx. 500 mb, a 125 mb layer of reduced moisture (500 – 375 mb), and a very dry layer with a substantial dew point depression (300 – 100 mb).



Drop 51a: Sounding through what appears to be a portion of the dry air filament near the southeastern corner. This filament was the target of our improvised 5 minute sonde-deployment sequence. This sounding is moist up to approx. 800 mb, has a temperature inversion just above 800 mb and a substantial dew point depression above this level with variability (moisture laminae) on finer scales.

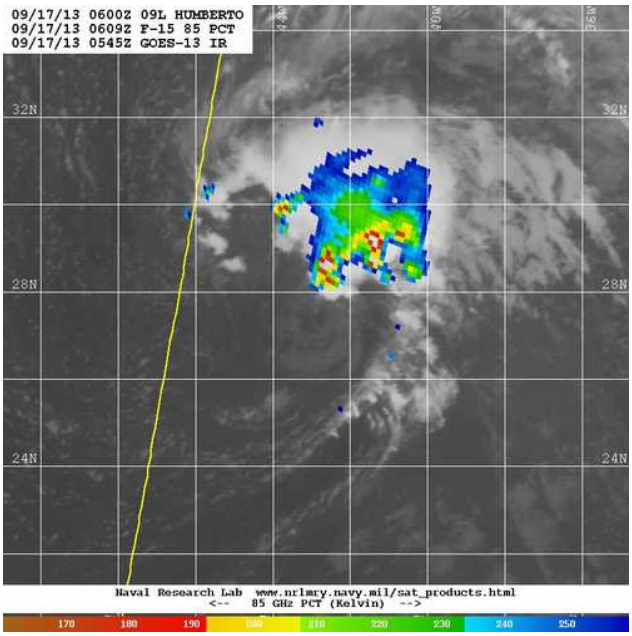
0450 D57 Good data

0501 D58 Good data

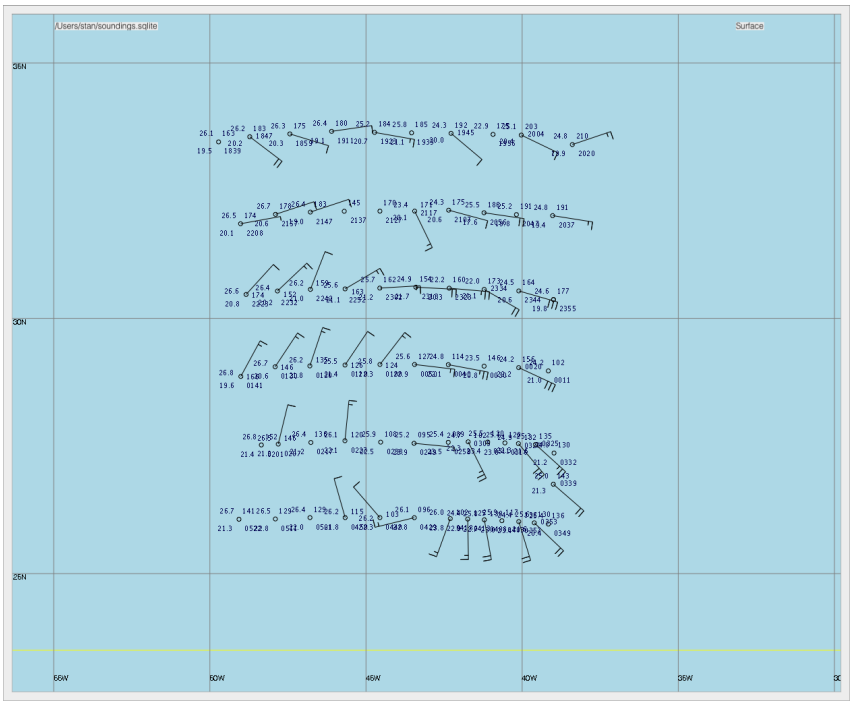
0511 D59 Good data

0522 D60 Good data

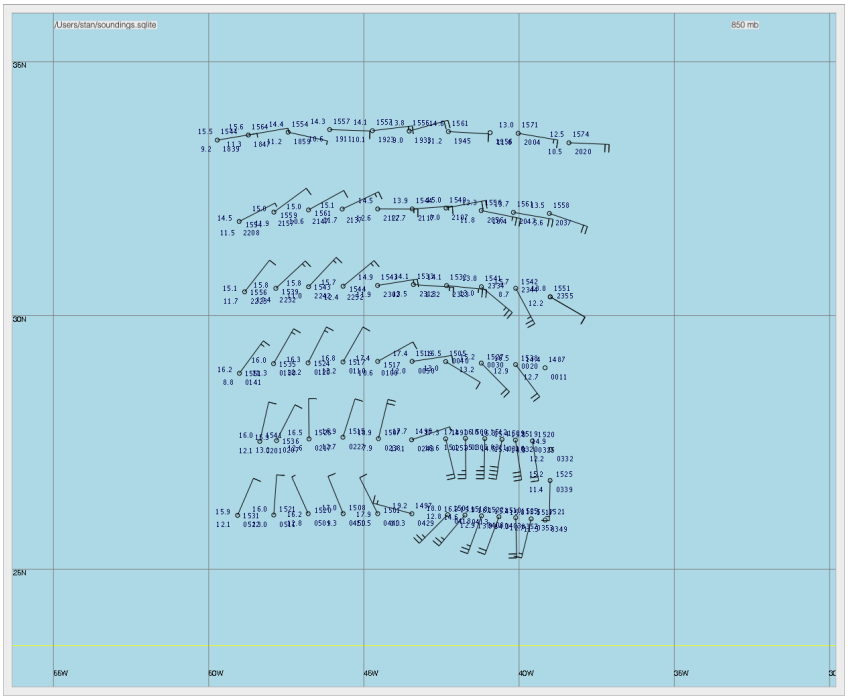
Total of 67 dropsondes released on this mission with only two "fast falls".



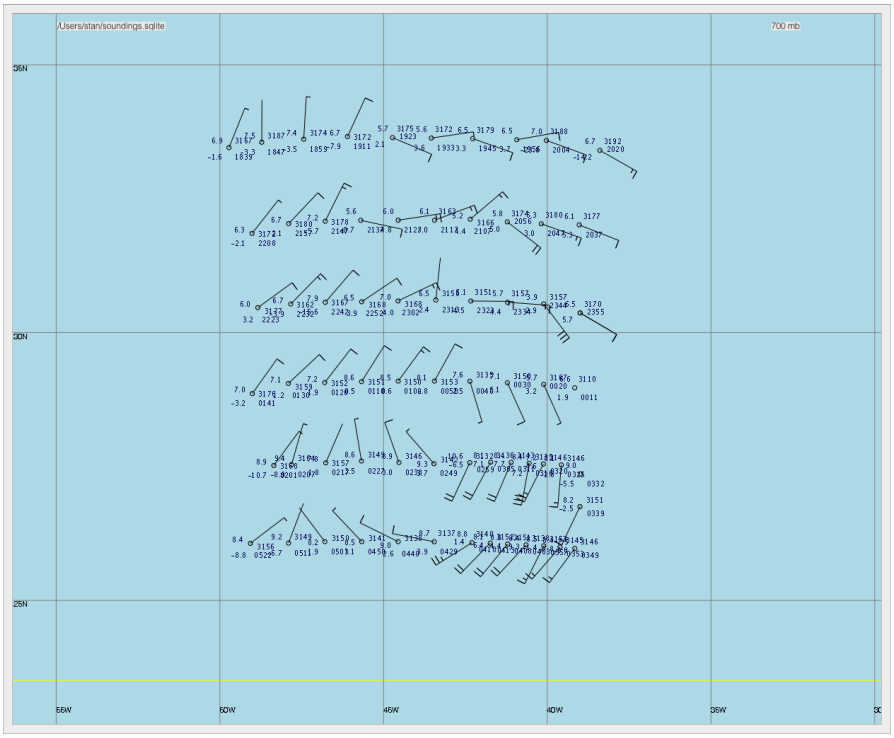
SSMI image at 0609 UTC showing the 85 GHz PCT with convection well northeast of the low level center.



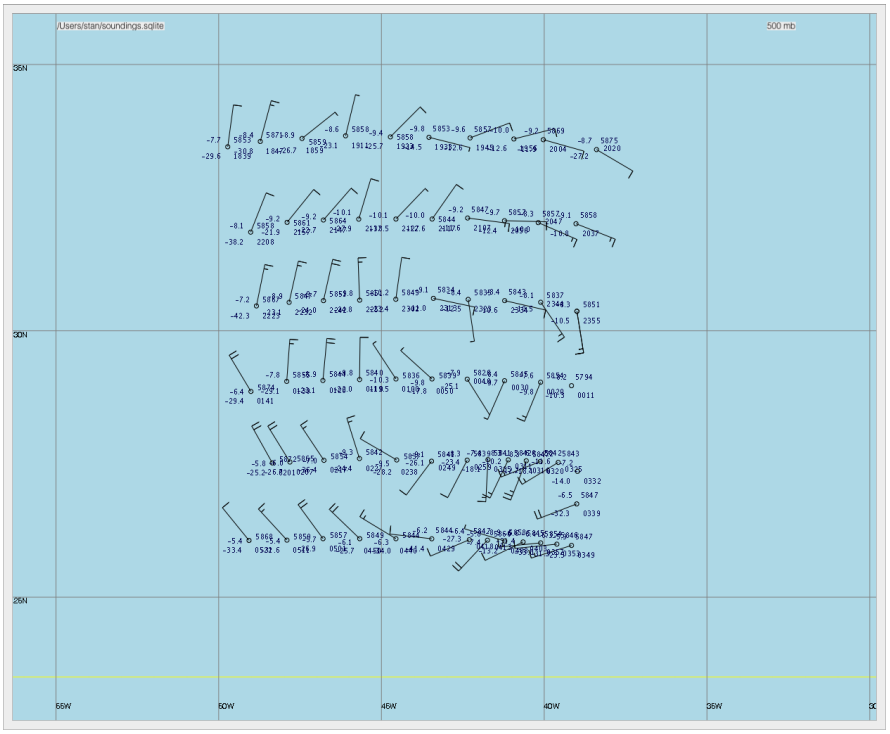
Surface winds from dropsondes shows sfc center south of the second leg near the bottom of the pattern, around 27.5N, 43.5W.



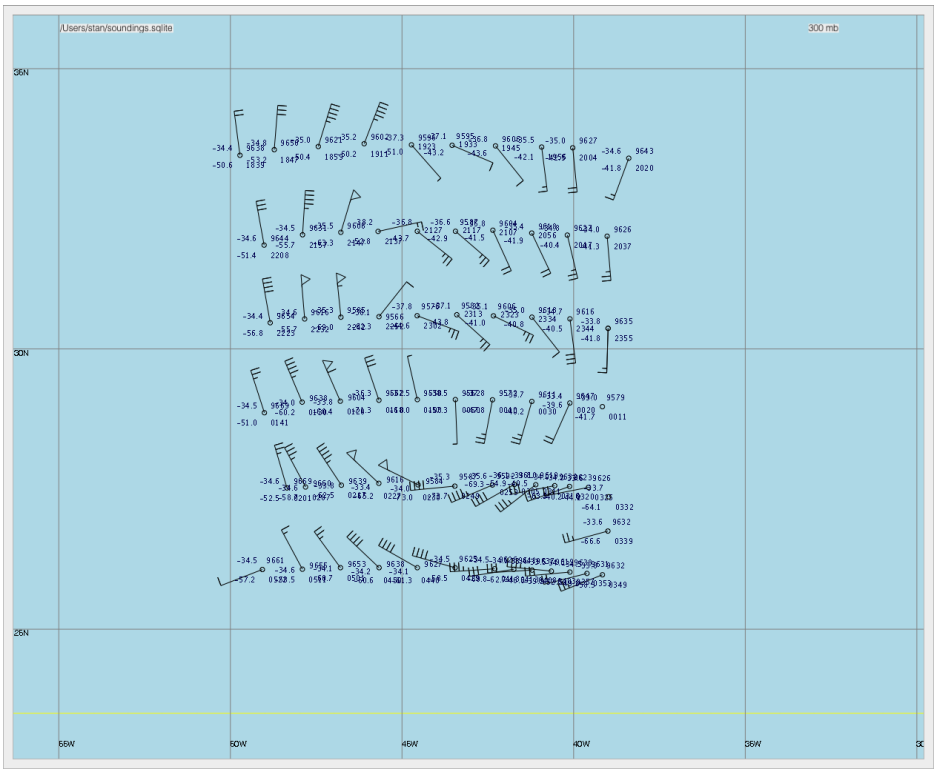
850 mb flow with up to 40 kt winds on the eastern side.



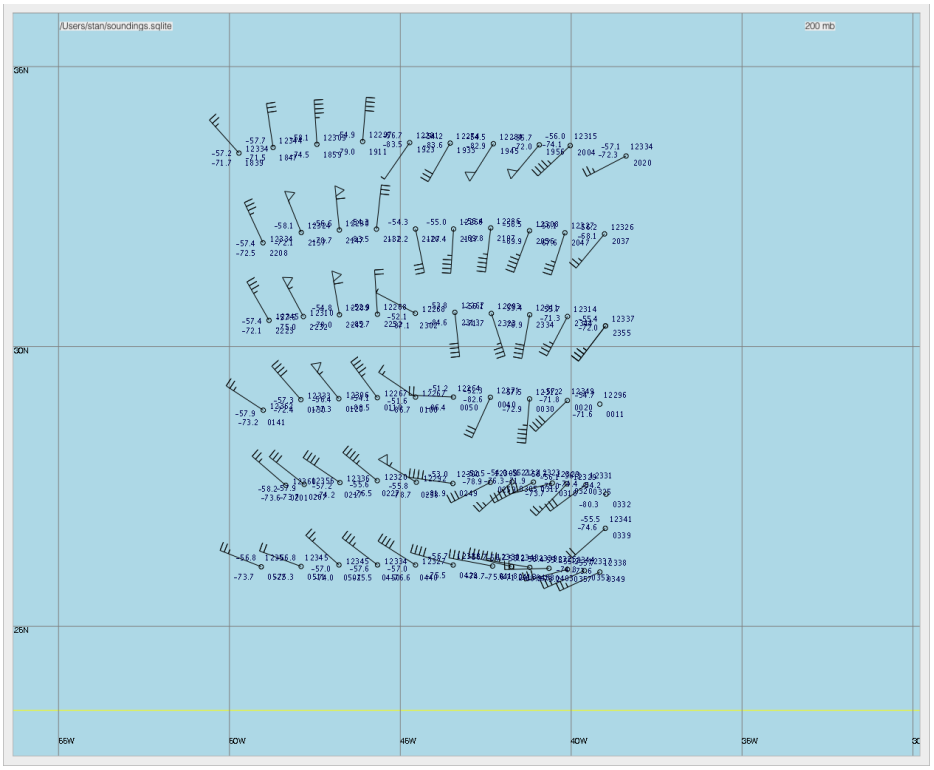
700 mb flow. Center farther to the north near 28.7N, 43W.



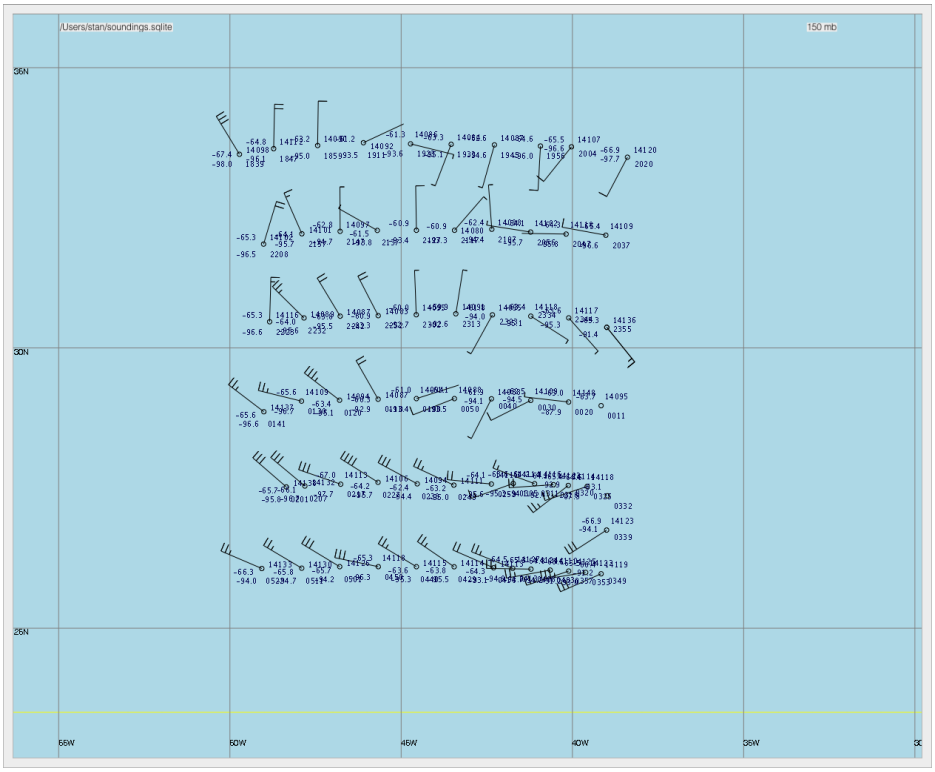
500 mb flow. Center now closer to 30N, 43W, so strong northward tilt of the storm.



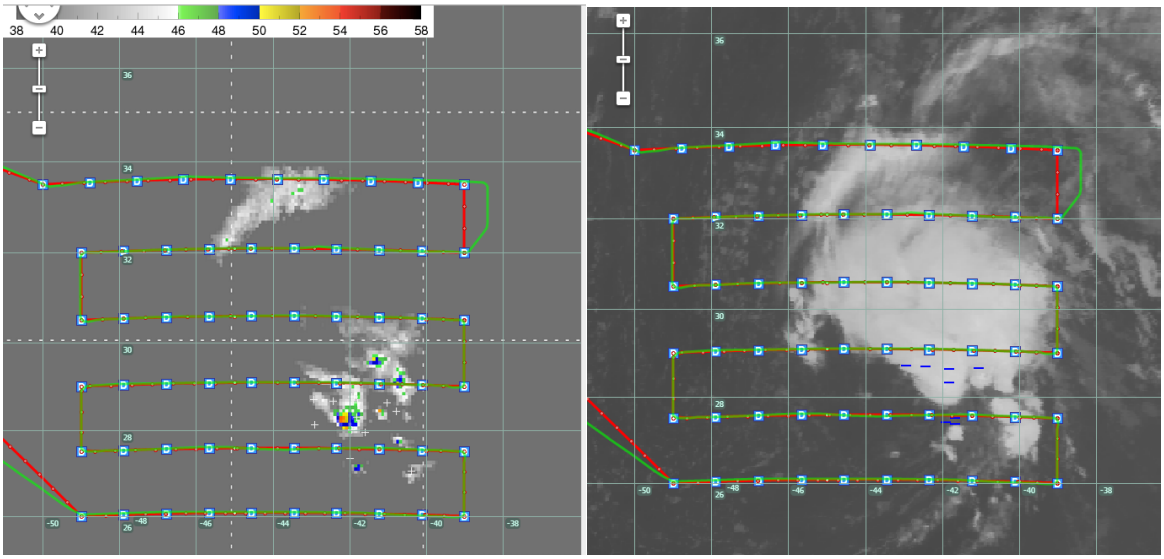
At 300 mb, strong winds are seen on the western side of the storm and strong westerlies lie above the sfc center.



At 200 mb, a similar pattern is present, with the upper low near 30N, 44.5W.



At 150 mb, the winds on the western side weaken, so we are above the upper jet on the west side.



0815 Cloud top heights now reaching to 52 kft with lightning in the area.

The NHC forecast discussion now only calls for weaker intensification, up to only 55 kts in 4 days:

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TROPICAL STORM HUMBERTO DISCUSSION NUMBER  28
NWS NATIONAL HURRICANE CENTER MIAMI FL       AL092013
500 AM AST TUE SEP 17 2013

HUMBERTO CONTINUES TO GO THROUGH CYCLES OF HAVING DEEP CONVECTION
NEAR ITS CENTER TO BEING SHEARED WITH ALL THE CONVECTION DISPLACED
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WELL TO THE NORTHEAST OF THE CENTER. AS OF RIGHT NOW...CONVECTION HAS RE-DEVELOPED NEAR THE CENTER...AND THERE ARE SIGNS THAT THE SHEAR MAY BE RELAXING. THE INITIAL INTENSITY IS HELD AT 35 KT FOR THIS ADVISORY BASED ON A CURRENT INTENSITY ESTIMATE OF 2.5 FROM TAFB AND EARLIER ASCAT DATA. **THE LOWEST PRESSURE MEASURED BY A DROPSONDE FROM A RECENT NASA GLOBAL HAWK MISSION WAS 1009 MB WITH A SURFACE WIND OF 15 KT...**INDICATING THAT THE MINIMUM PRESSURE IS PROBABLY A LITTLE HIGHER THAN PREVIOUSLY ESTIMATED.

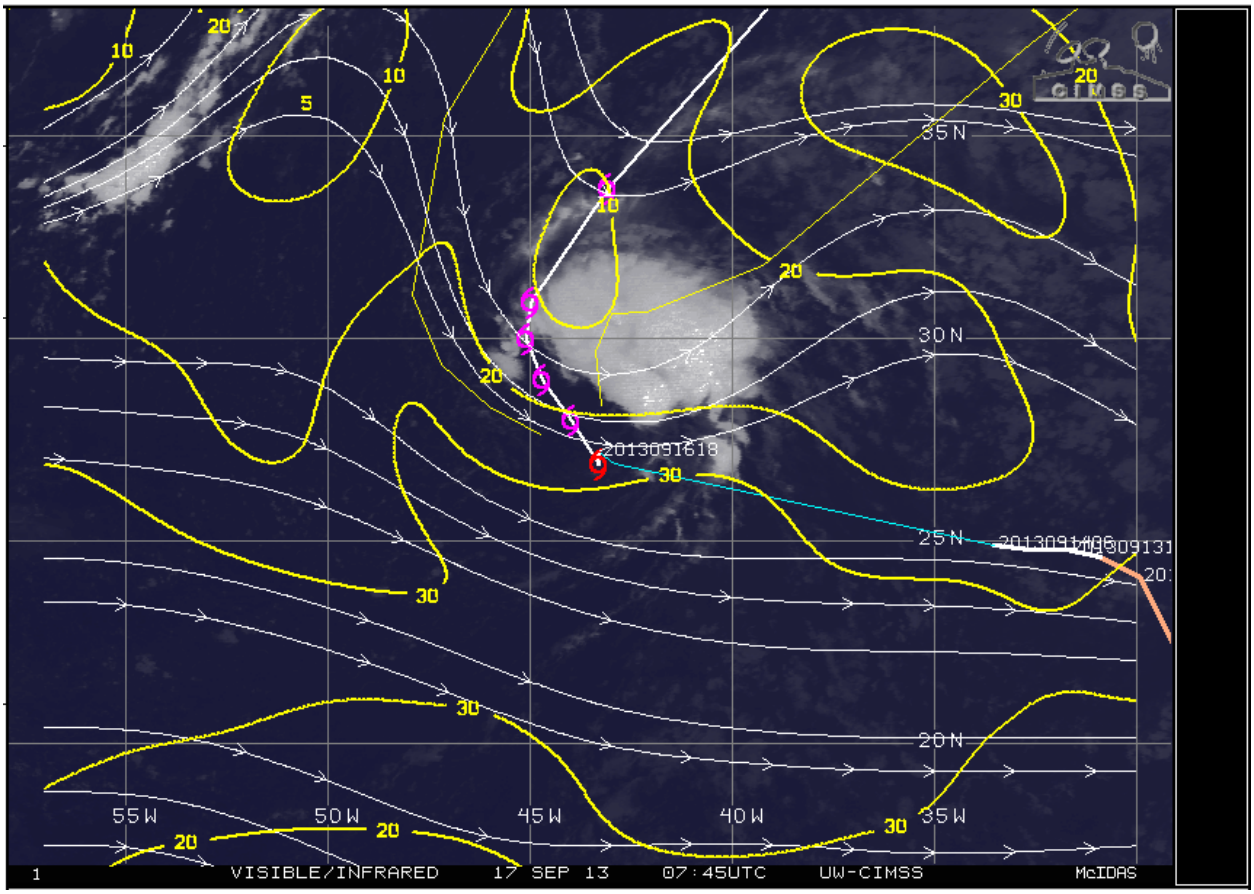
THE WAXING AND WANING OF CONVECTION HAS CAUSED THE SURFACE CENTER TO JUMP AND MEANDER FOR THE PAST 12 TO 24 HOURS. HOWEVER...IT APPEARS THAT HUMBERTO IS NOW MOVING AGAIN...AND A LONGER-TERM AVERAGE YIELDS AN ESTIMATED MOTION OF 020/4 KT. THE STORM IS LOCATED TO THE SOUTHWEST OF A MID-LEVEL ANTICYCLONE CENTERED NEAR THE AZORES AND TO THE SOUTHEAST OF A HIGH-AMPLITUDE MID-LATITUDE TROUGH MOVING OFF THE EAST COAST OF NORTH AMERICA. THE RESULTANT STEERING FLOW IS FORECAST TO PUSH HUMBERTO GENERALLY TO THE NORTH DURING THE NEXT 48 HOURS OR SO...AND THEN THE CYCLONE WILL ACCELERATE TOWARD THE NORTHEAST BEGINNING ON DAY 3 AS THE TROUGH GETS CLOSER. THE HWRF IS THE MAIN OUTLIER IN THE GUIDANCE SUITE...SHOWING A MUCH SLOWER MOTION AND A TRACK TO THE EAST BY DAY 5. THE REST OF THE TRACK MODELS ARE IN REASONABLE AGREEMENT...AND THE OFFICIAL TRACK FORECAST IS FASTER THAN THE MULTI-MODEL CONSENSUS TVCA TO DOWNPLAY THE INFLUENCE OF THE HWRF SOLUTION.

THE CIRCULATIONS OF HUMBERTO AND A NEARBY MID-/UPPER-LEVEL LOW ARE BECOMING COLLOCATED...WHICH SHOULD ALLOW THE VERTICAL SHEAR NEAR THE CYCLONE TO DECREASE DURING THE NEXT DAY OR SO. THEREFORE... GRADUAL STRENGTHENING IS INDICATED IN THE OFFICIAL FORECAST DURING THE NEXT SEVERAL DAYS...MORE OR LESS IN LINE WITH THE INTENSITY CONSENSUS. HUMBERTO IS NOW FORECAST TO BECOME AN EXTRATROPICAL CYCLONE BY DAY 4...AND EVEN THOUGH THE CYCLONE WILL BE MOVING OVER MUCH COLDER WATER BY THAT TIME...BAROCLINIC INFLUENCES COULD ALLOW STRENGTHENING TO CONTINUE A BIT LONGER. A 5-DAY POSITION IS STILL SHOWN FOR CONTINUITY...BUT IT IS POSSIBLE THAT HUMBERTO COULD BE ABSORBED BY ANOTHER LARGER EXTRATROPICAL CYCLONE BY THAT TIME.

FORECAST POSITIONS AND MAX WINDS

INIT	17/0900Z	27.8N	42.7W	35 KT	40 MPH
12H	17/1800Z	28.9N	43.5W	35 KT	40 MPH
24H	18/0600Z	29.8N	44.0W	35 KT	40 MPH
36H	18/1800Z	30.7N	43.9W	40 KT	45 MPH
48H	19/0600Z	31.9N	43.5W	40 KT	45 MPH
72H	20/0600Z	35.5N	40.5W	45 KT	50 MPH
96H	21/0600Z	45.0N	33.0W	55 KT	65 MPH...POST-TROP/EXTRATROP
120H	22/0600Z	54.0N	26.5W	50 KT	60 MPH...POST-TROP/EXTRATROP

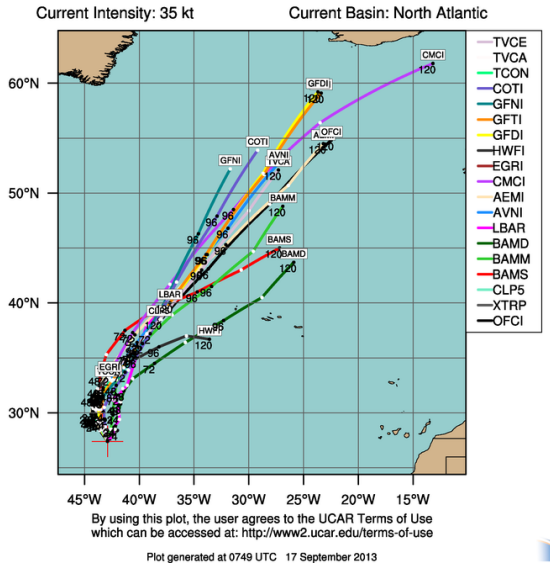
$$
FORECASTER BERG



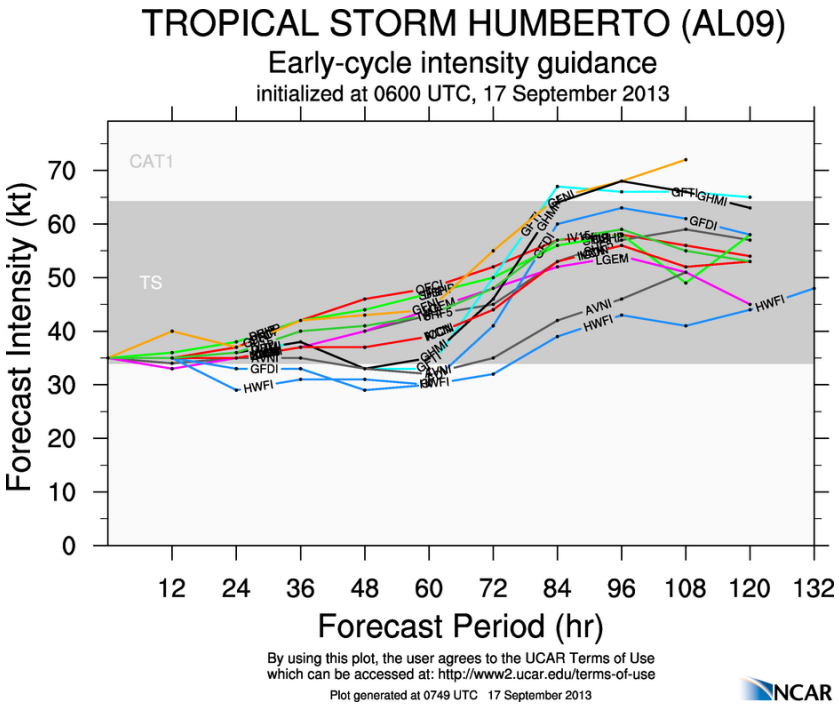
The CIMSS shear product suggests that Humberto may be moving into a region of weaker shear, with the strongest shear now to the south of the system. Shear is currently around 20 kts, but may decrease to 10 kts in the future.

TROPICAL STORM HUMBERTO (AL09)

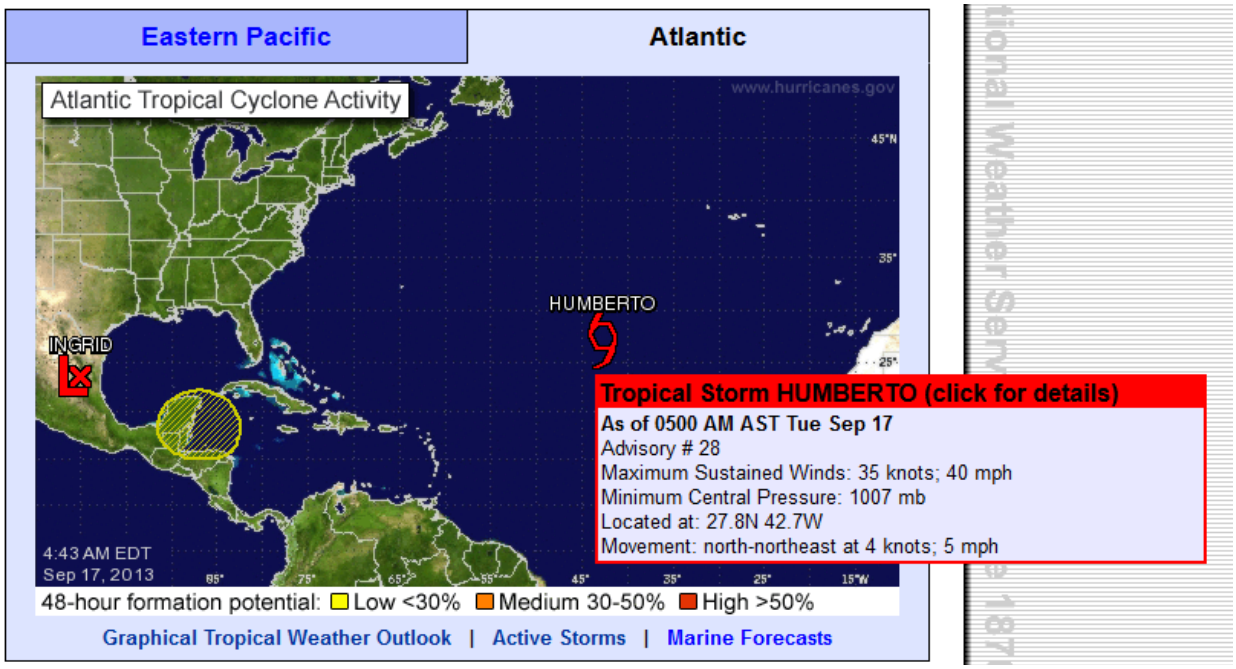
Early-cycle track guidance initialized at 0600 UTC, 17 September 2013



RAL track ensemble forecasts show a northward movement for 2 days followed by northeastward turn.



Most models show only a slow intensification through 72 h followed by a small jump in intensity after 72 h, likely in combination with extratropical transition.



NHC still has Humberto at 35 kts as of 0900 UTC.

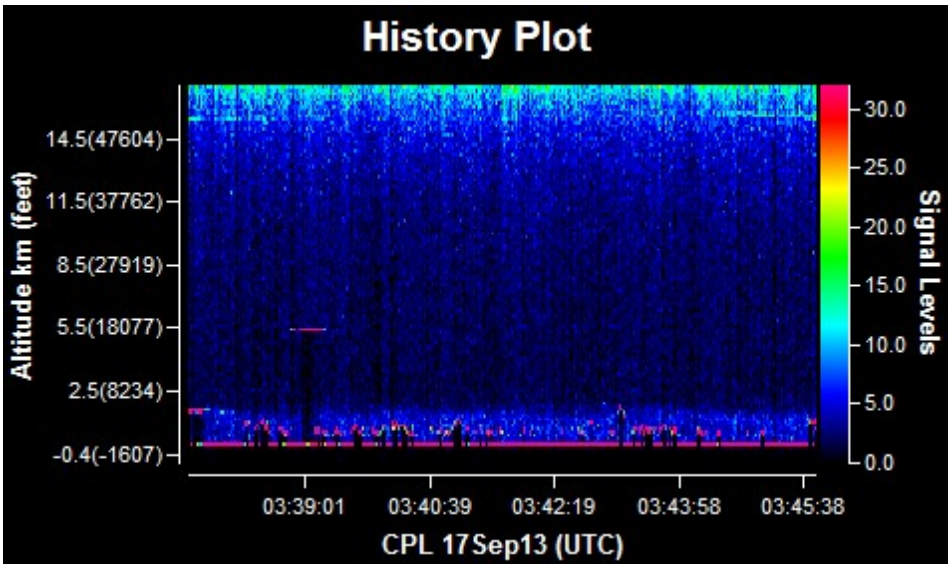
1033 Beginning descent from 45kft in VACAPES

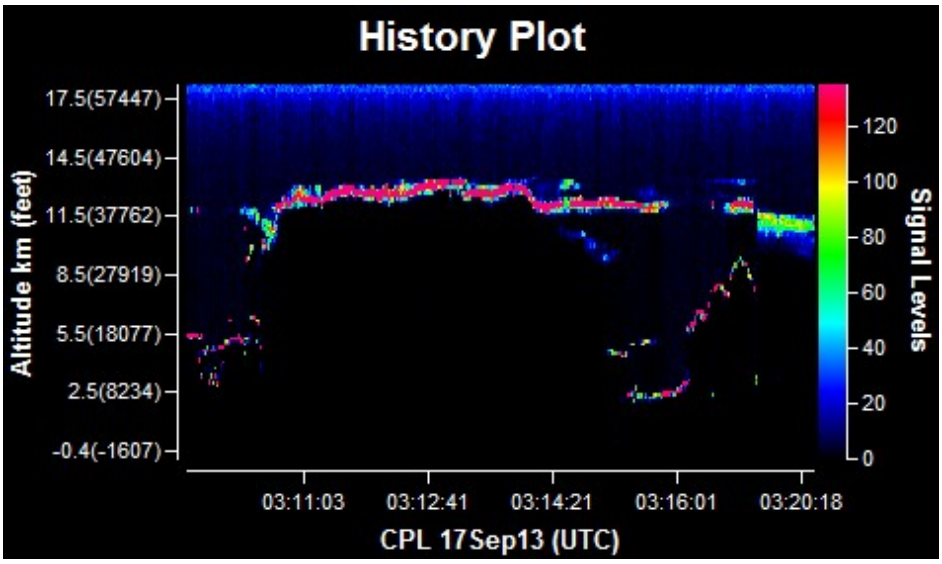
1114 landing

Instrument summaries

CPL

CPL performed nominally during the 16-17Sep13 Science flight. Laser energies, laser 532 signal strength, and temperatures were all very good. We did sense a possible dust layer in the SE corner, but it did not extend above 1.5 km. Attached are two real time images showing the possible dust layer and convective clouds. Hopefully by using our depolarization ratio, we will later determine whether that PBL layer was dust. That PBL layer was absent west of the convective clouds





AVAPS

AVAPS successfully launched 67 sondes during the flight of 20130916 and data quality was generally very good. AVAPS was loaded with the 70 sondes and the modified plan (executed during the first couple hours of flight) called for 60 planned drops at ~10 min spacing on the E-W legs. Later in the flight, 7 additional drops were inserted into the flight plan equidistant between the planned drops D47-

D53 and were labeled D47a-D53a. The higher density drops were ~5 min apart over the the east side of the center of the circulation to characterize dry air intrusion into Humberto.

All sondes were processed in near real-time by the NOAA HRD remote team and posted in MTS. The major data anomalies consisted of two fast falls (D31, D50) and an apparent telemetry gap on D8. The wind measurements were considered suspect for both fast falls and not reported. It is also worth noting that both fast falls occurred upon launching immediately after a right turn and going wings level. Although there is no reason to believe the turn would have an impact, it will be further investigated in the context of the other fast fall data from the overall mission. The telemetry gap on D8 resulted in some data loss in parts of the lower and middle troposphere and may be associated with the banking of the aircraft but needs to be scrutinized more carefully.

Lastly, following up on a flight computer boot anomaly from the last AV-6 flight (RF06), some changes were made to the power up sequence protocol and also to the AVAPS flight software. A 30 s delay was added between turning turning 6-2 ON and turning 5-2 ON. AVAPS started normally in ~2:35 after 5-2 was turned ON.

Sondes Dropped

Qty	Date	Flight
6	8-01-13	Range Flight
15	8-20-13	RF01
54	8-24-13	RF02
72	8-29-13	RF03
80	9-04-13	RF04
57	9-07-13	RF05
67	9-16-13	RF06

351 Total Deployed as of 9-16-2013

As of 9-17-2013
Total Sondes available: 199 (550-351=199

S-HIS

Several multilayered clouds were observed during flight giving a nice comparison between the realtime products and quicklooks of S-HIS and CPL. Additionally, the S-HIS realtime retrievals had good agreement with major features of the AVAPS dropsondes during the flight. SAL air was indicated in the SE corner of the flight pattern.

The S-HIS operated nominally throughout the science flight. The detector cooler stayed around 77 K for the duration of the mission.

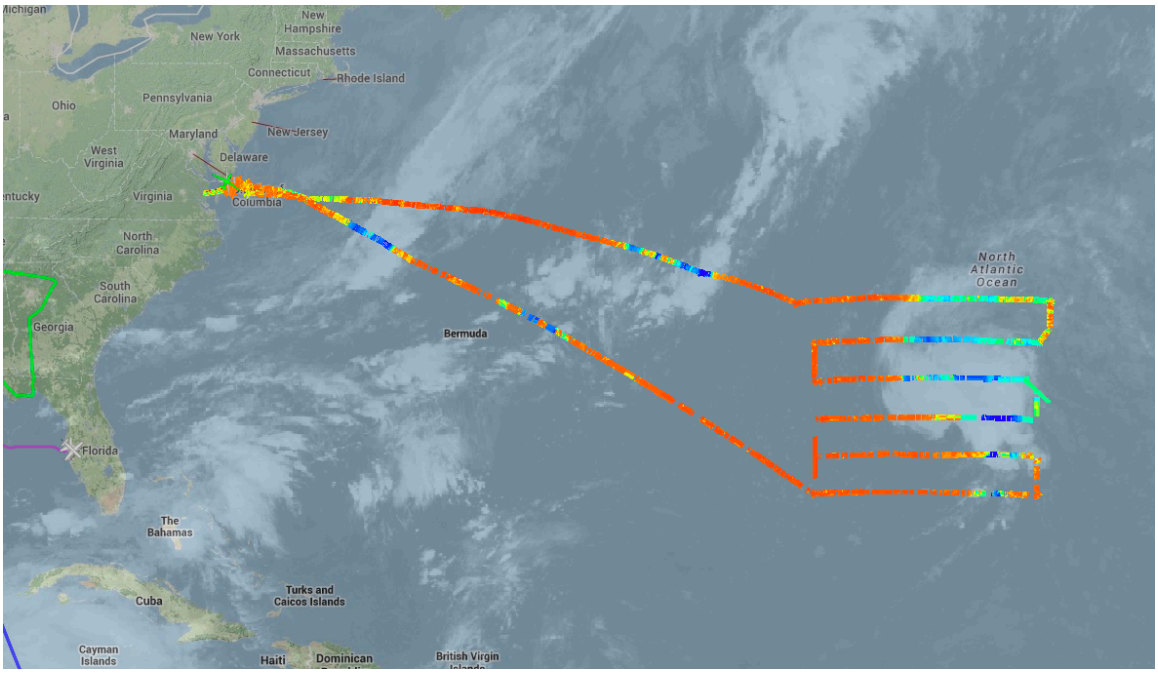


Figure 1. Flight overview, overflight of tropical storm Humberto.

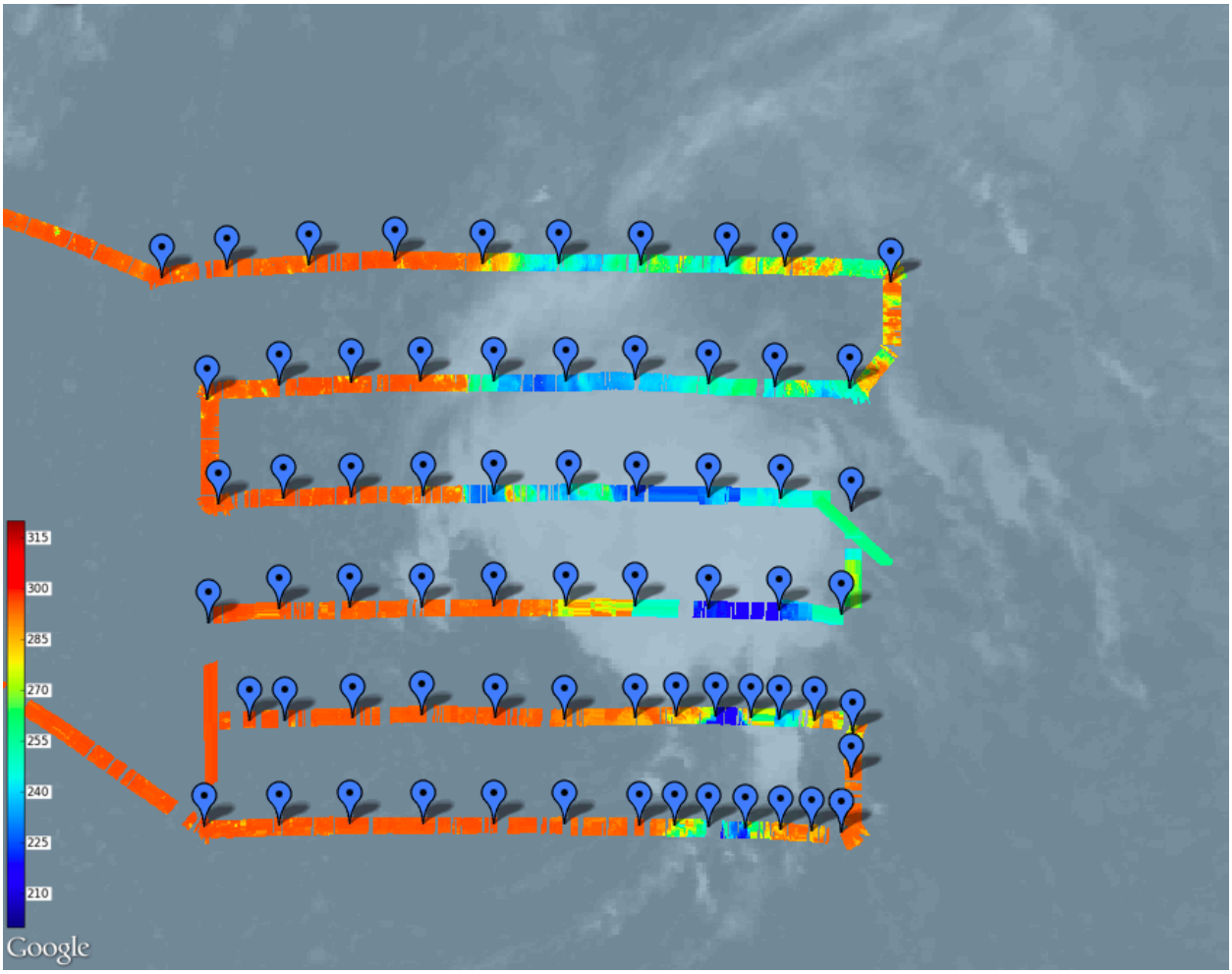


Figure 2. S -HIS realtime brightness temperature data in the 895–905 cm^{-1} channel for the entire science segment of the flight, superimposed on the current GOES IR image. Dropsonde locations are indicated in blue.

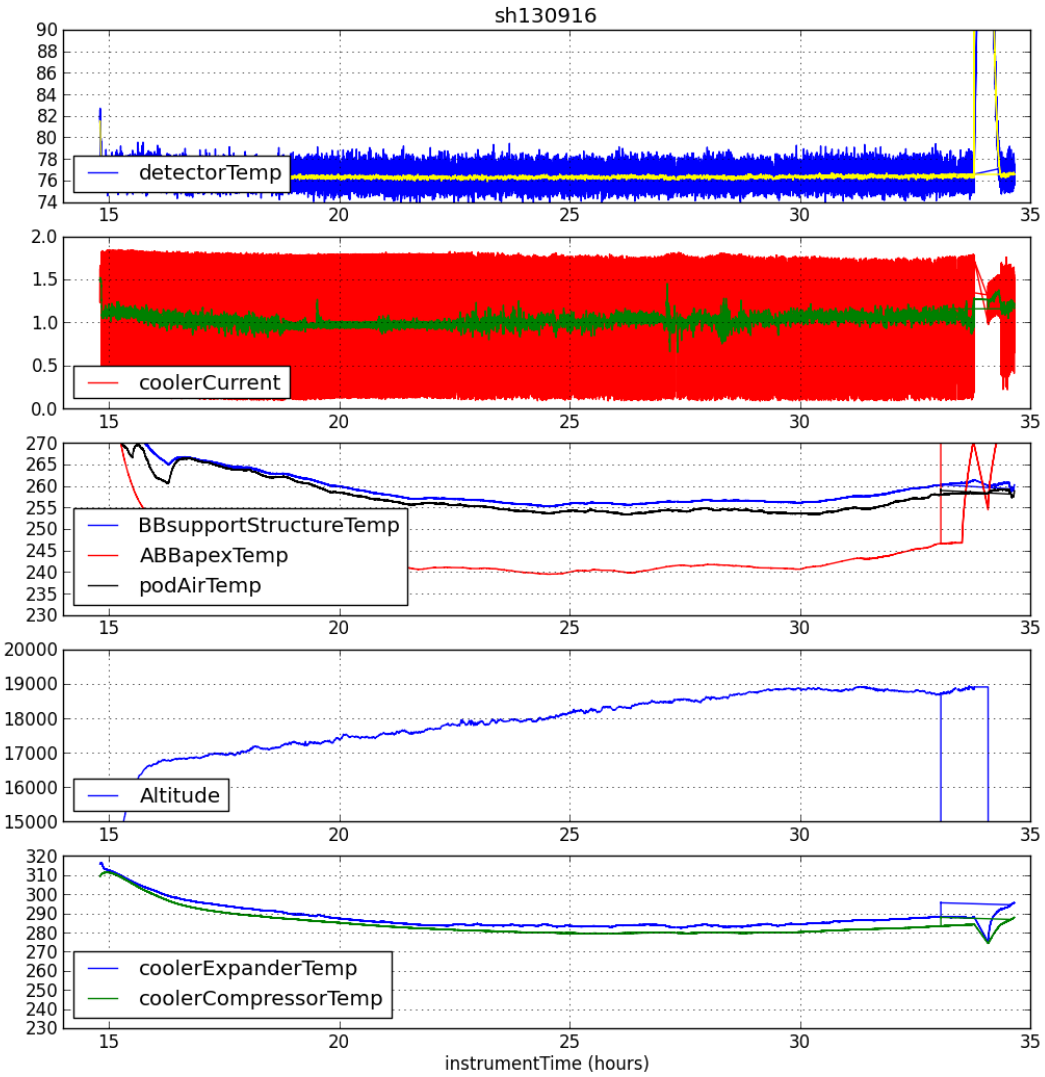


Figure 3. The detector cooler operated nominally during the science flight. Detector temperature was at around 77 K throughout the flight. Cooler current was around 1 Amp throughout the flight.

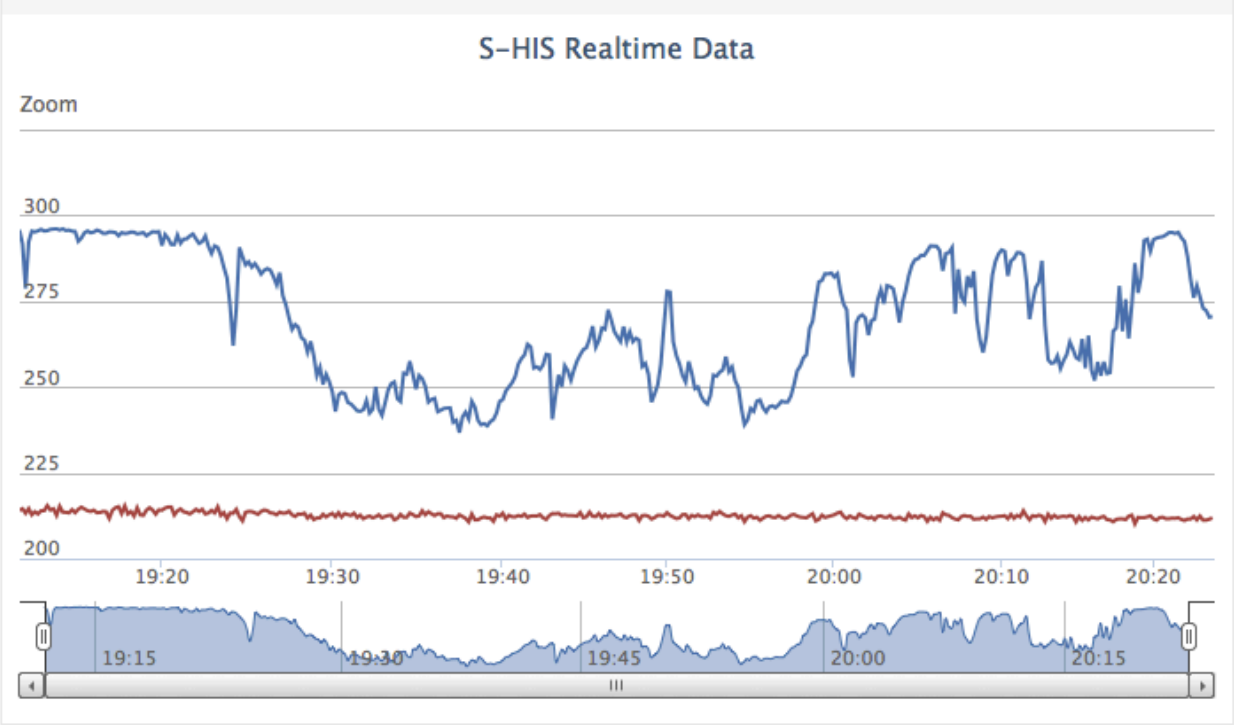


Figure 4. A new data display showing time series of realtime S-HIS brightness temperatures is being tested. 895-905 cm^{-1} (blue) and 690-700 cm^{-1} (red) channels are shown above.

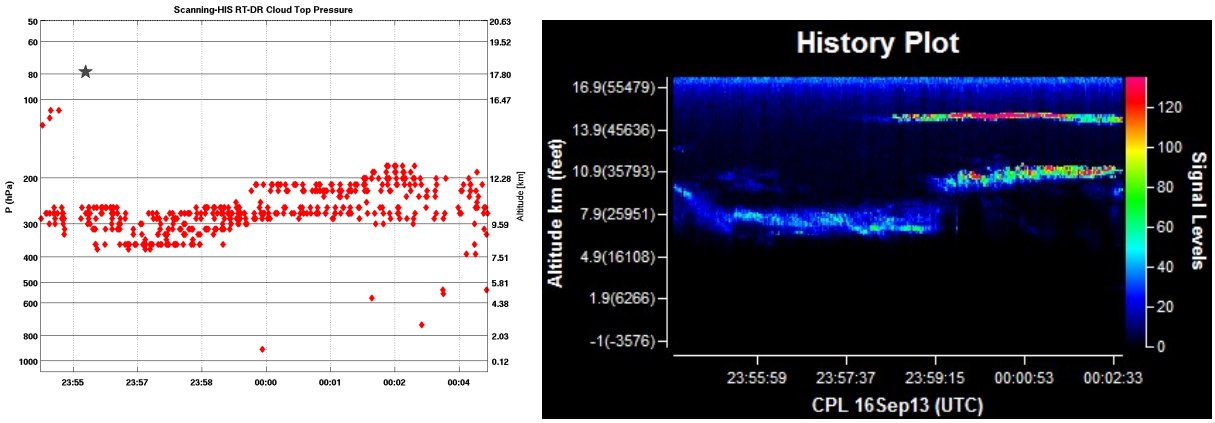


Figure 5. Comparison between S-HIS RT-DR quicklook time series (left) and CPL quicklook time series (right) showing some interesting cloud layers. The RT-DR plot shows both pressure altitude and altitude in km as the y-axes. The star indicates the aircaft altitude. The RT-DR shows similar cloud heights as the CPL for the two lower cloud layers, but is not seeing the higher (most likely thinner) layer at ~15 km.

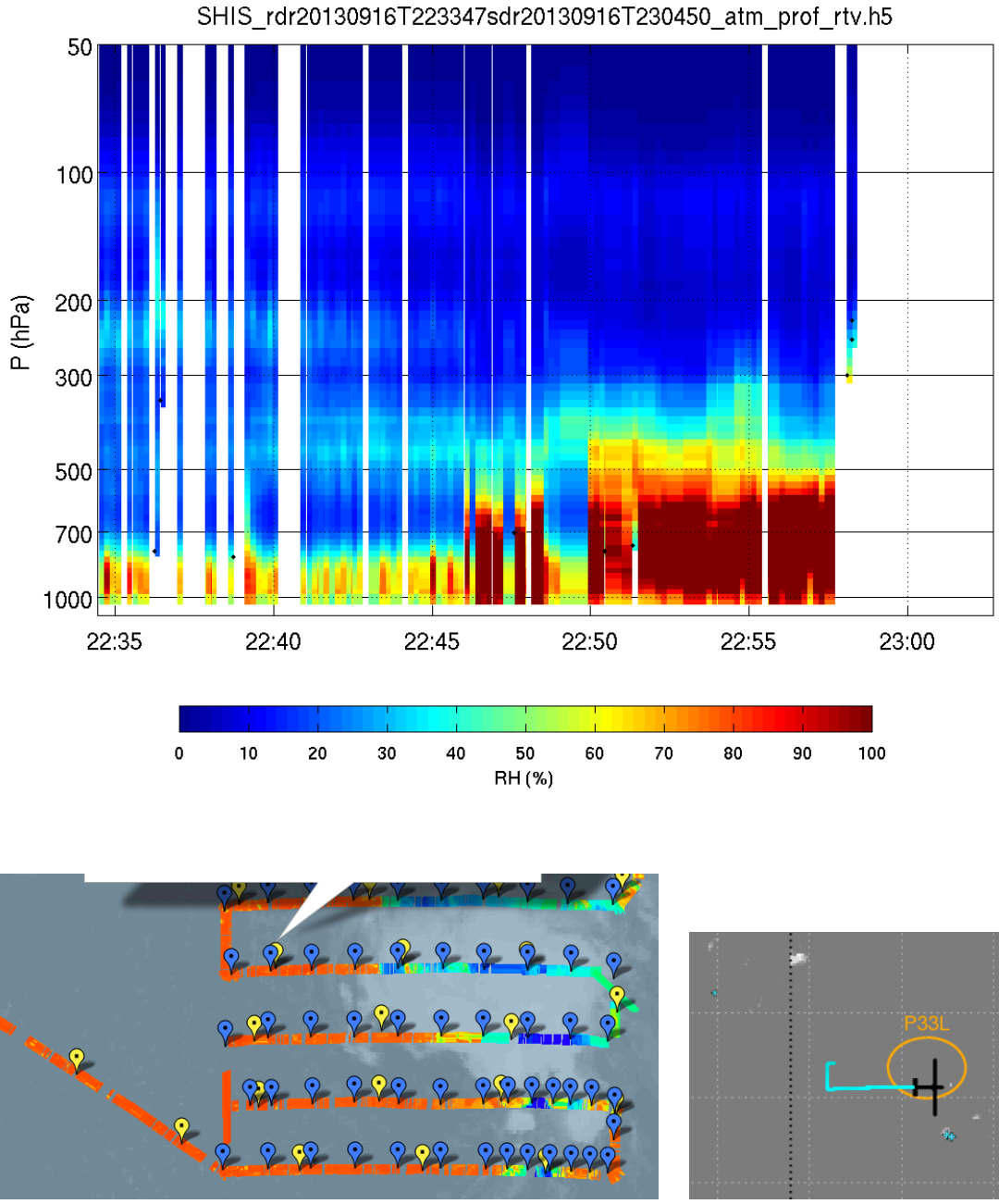


Figure 6. S-HIS RH cross seciton going west to east across Pouch 33L, showing lower levels much moister within the pouch, and a very definite RH change at the pouch boundary. Further east it gets much cloudier and S-HIS does not see through the clouds.

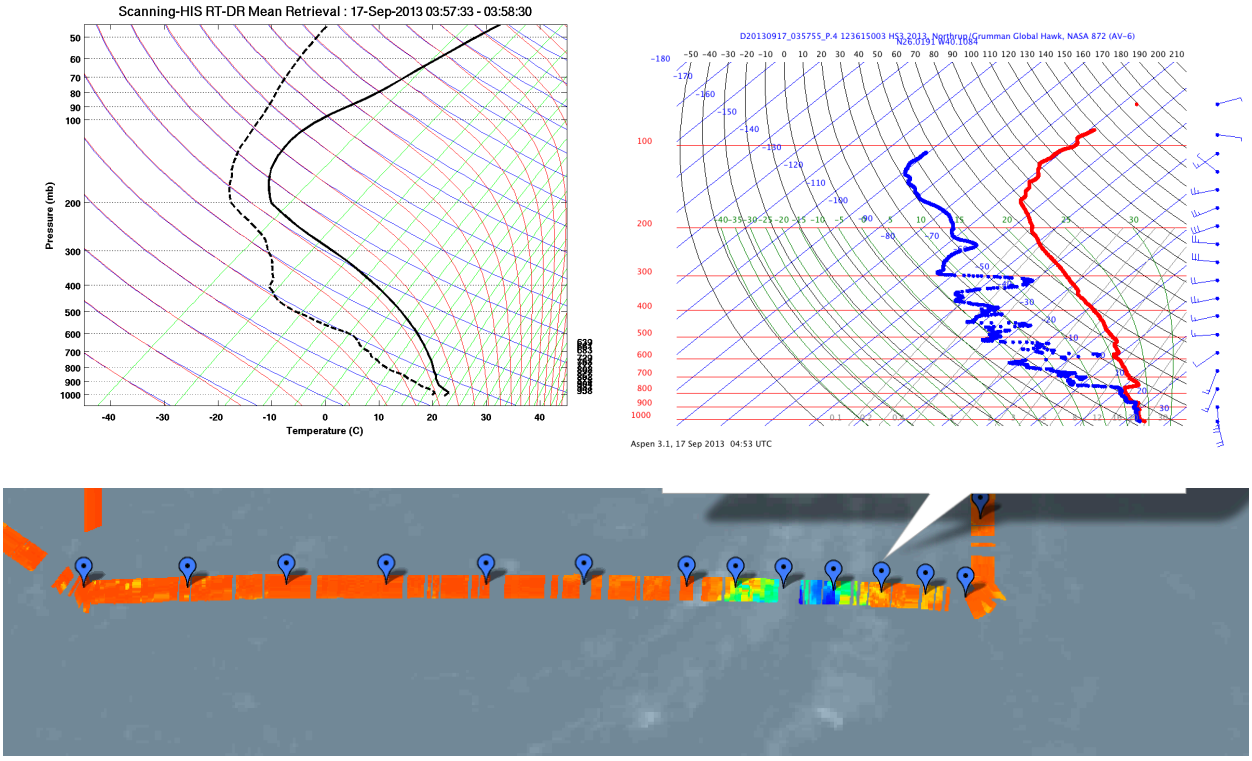


Figure 7. Relatively good agreement between SHIS temperature and moisture structure (left) with the dropsonde profiles (right). This comparison is in the SE corner of the flight where the SAL was encountered.