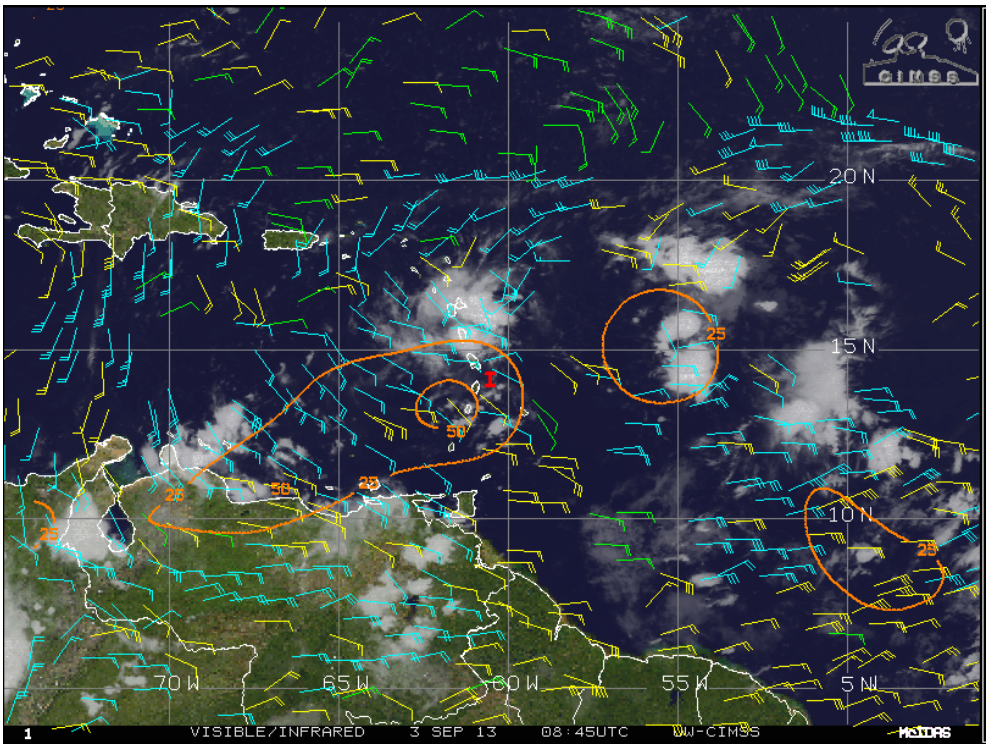
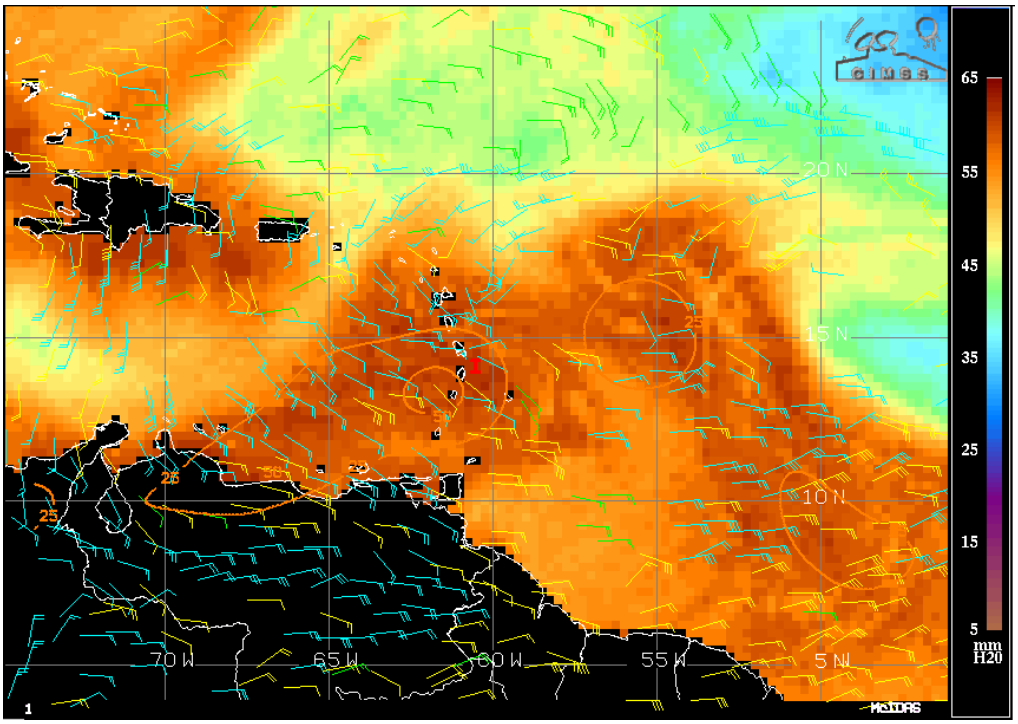
Hurricane and Severe Storm Sentinel (HS3) Mission

HS3 2013.09.03-04 Flight Report: GLOBAL HAWK AV-1 mission to P25L and P30L

Mission Scientists:
Shift 1 (0800-1700 UT): Scott Braun/Pete Black
Shift 2 (1600-0100 UT): Jason Sippel/Deanna Hence/Ed Zipser
Shift 3 (0000-0900 UT): Steve Guimond/ Jon Zawislak/Gerry Heymsfield
Shift 4 (0800-1200 UT): Scott Braun/ Pete Black

Mission goal: This mission is a follow on to an AV-6 flight over P25L on Aug. 29-30. The NOAA G-IV flew the storm on Aug. 31. Earlier attempts at an AV-1 flight had been cancelled due to aircraft issues. The goal of this mission is to either revisit the P25L disturbance (seen near 62W in the image below) or to sample what appears to be a more promising system in P30(the vorticity maximum near 55W. The TPW data shows that both disturbances or pouches are in high TPW regions and appear to have sufficient protection from dry air. SSTs are near 29-30C. Ocean heat contents (OHC) is higher for P25L, lower for P30L. If P30L tracks northwestward, it will move roughly along the eastern edge of the higher OHC values.

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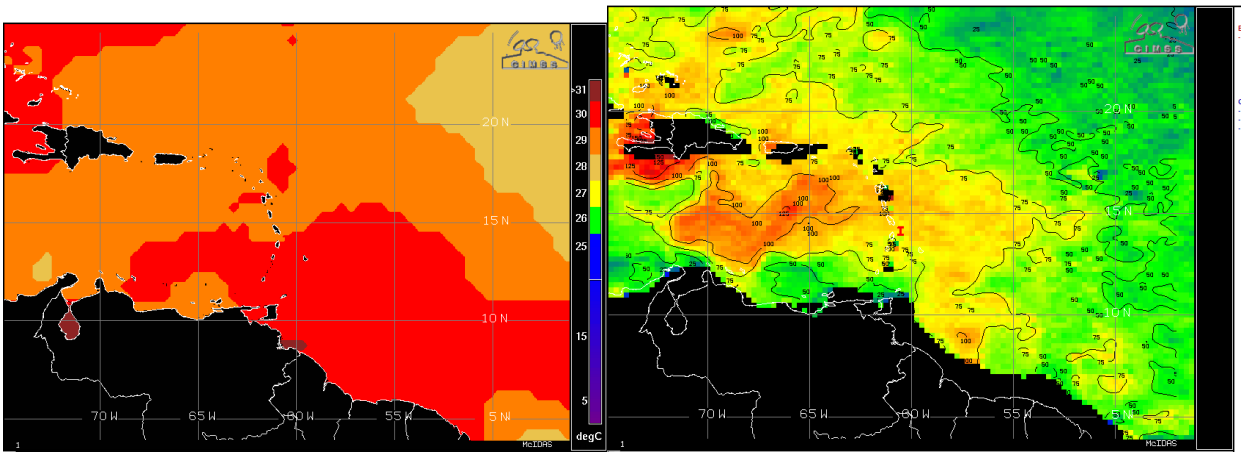
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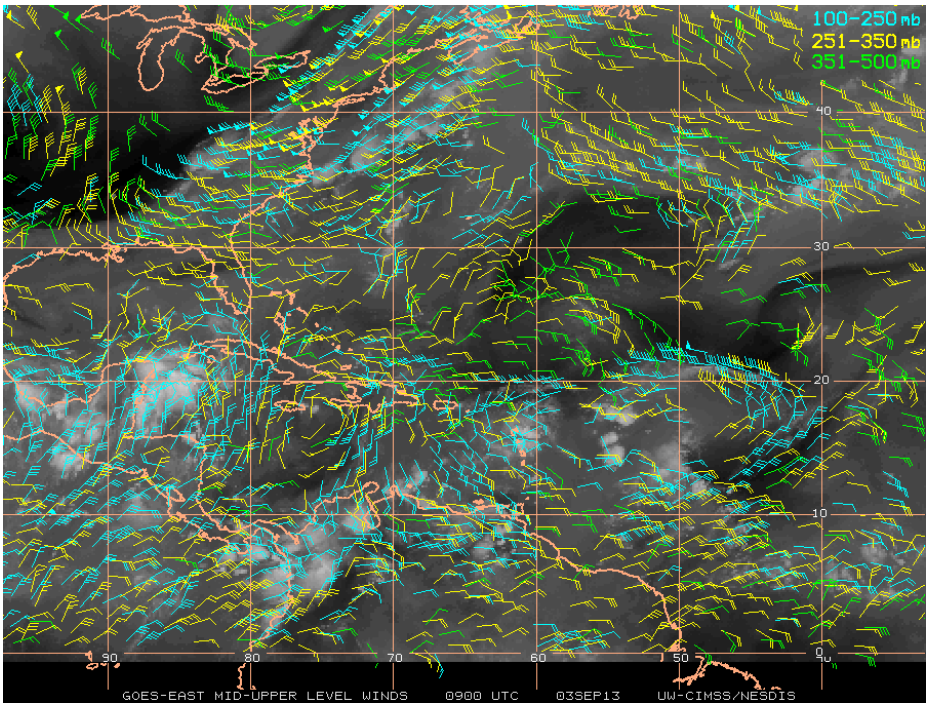
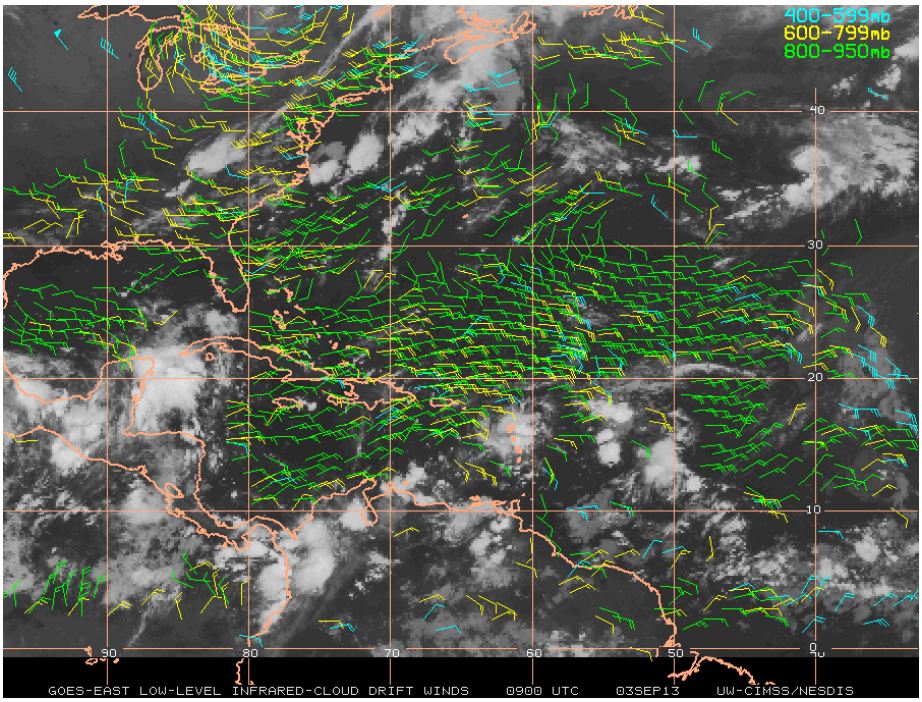
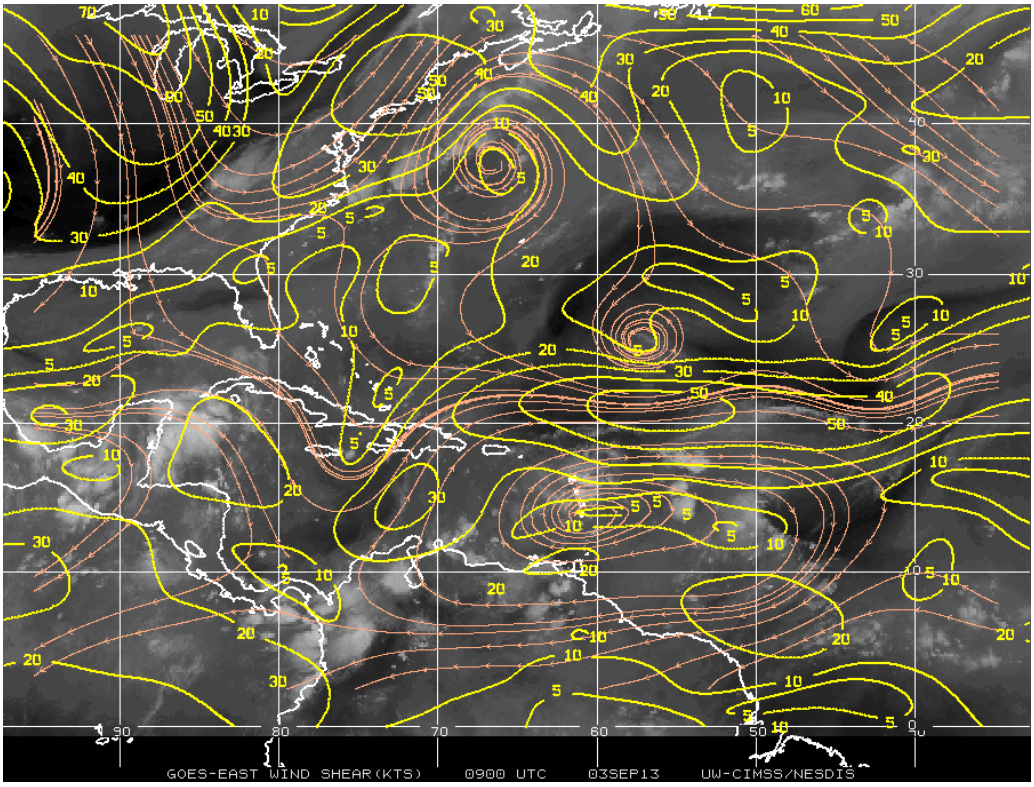
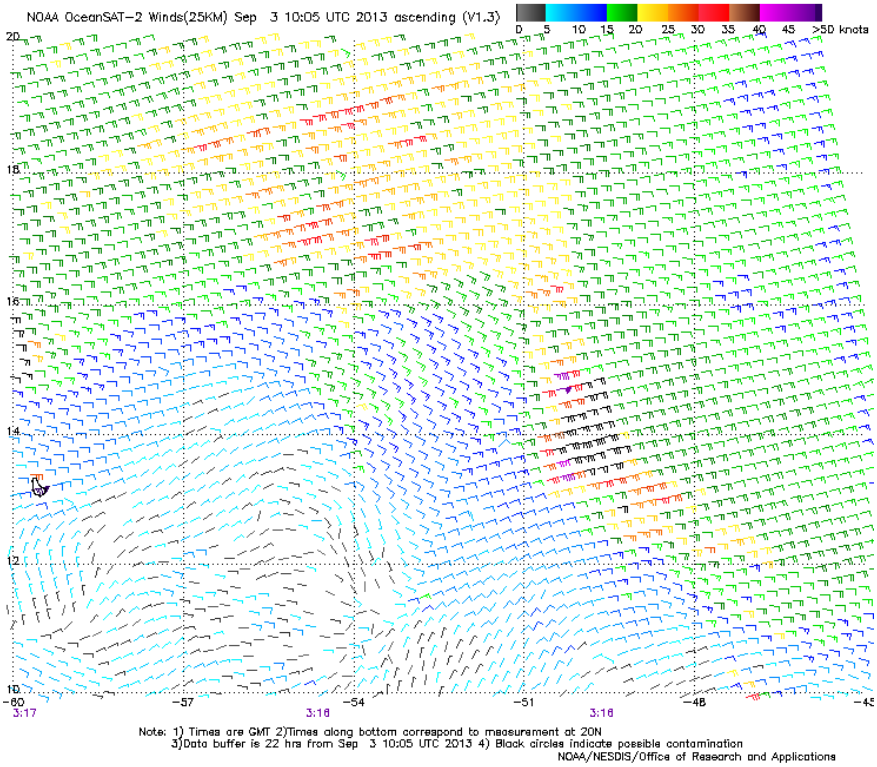


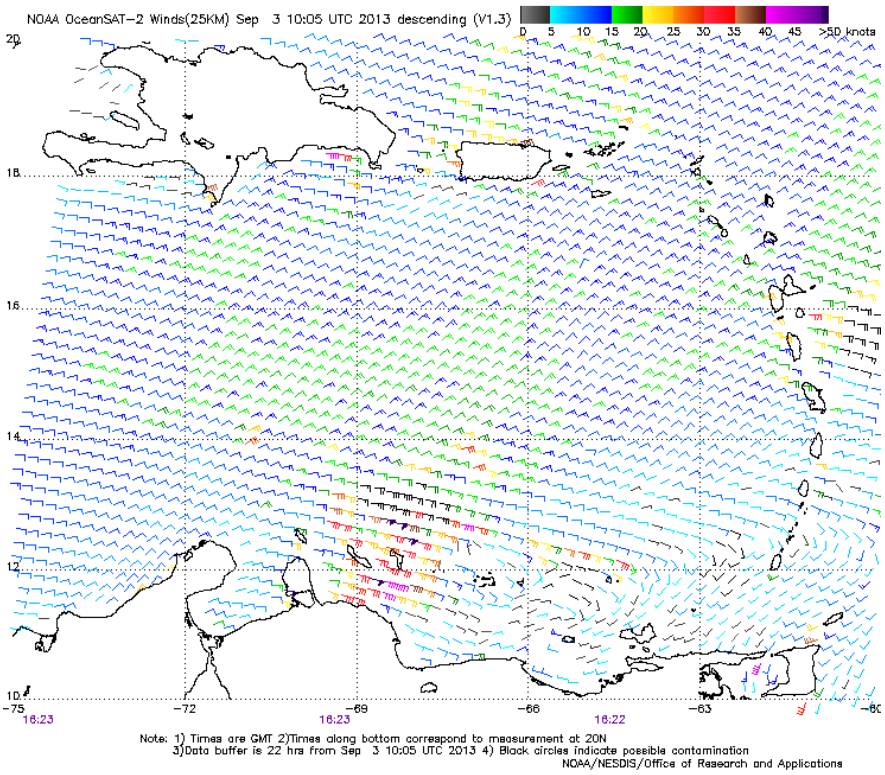


GOES winds above show an above anticyclone above the two systems while lower level winds show easterlies of about 20knots north of P25L, 25 knots north of P30L.

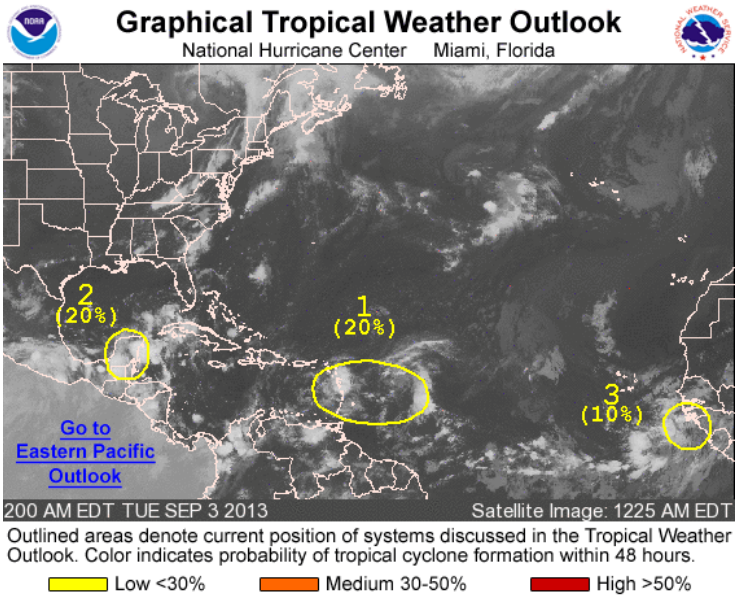


The CIMSS shear product shows strong shear on the north sides of both systems, but weaker shear over the pouch centers.





OSCAT imagery for 1005 UTC 3 Sept (above) shows a region of higher wind speed on the north side of the CIMSS derived vorticity maximum, but no closed circulation at this point. Another OSCAT pass over P25L also shows no closed circulation at the surface, a change from the day before when a clear circulation was seen.

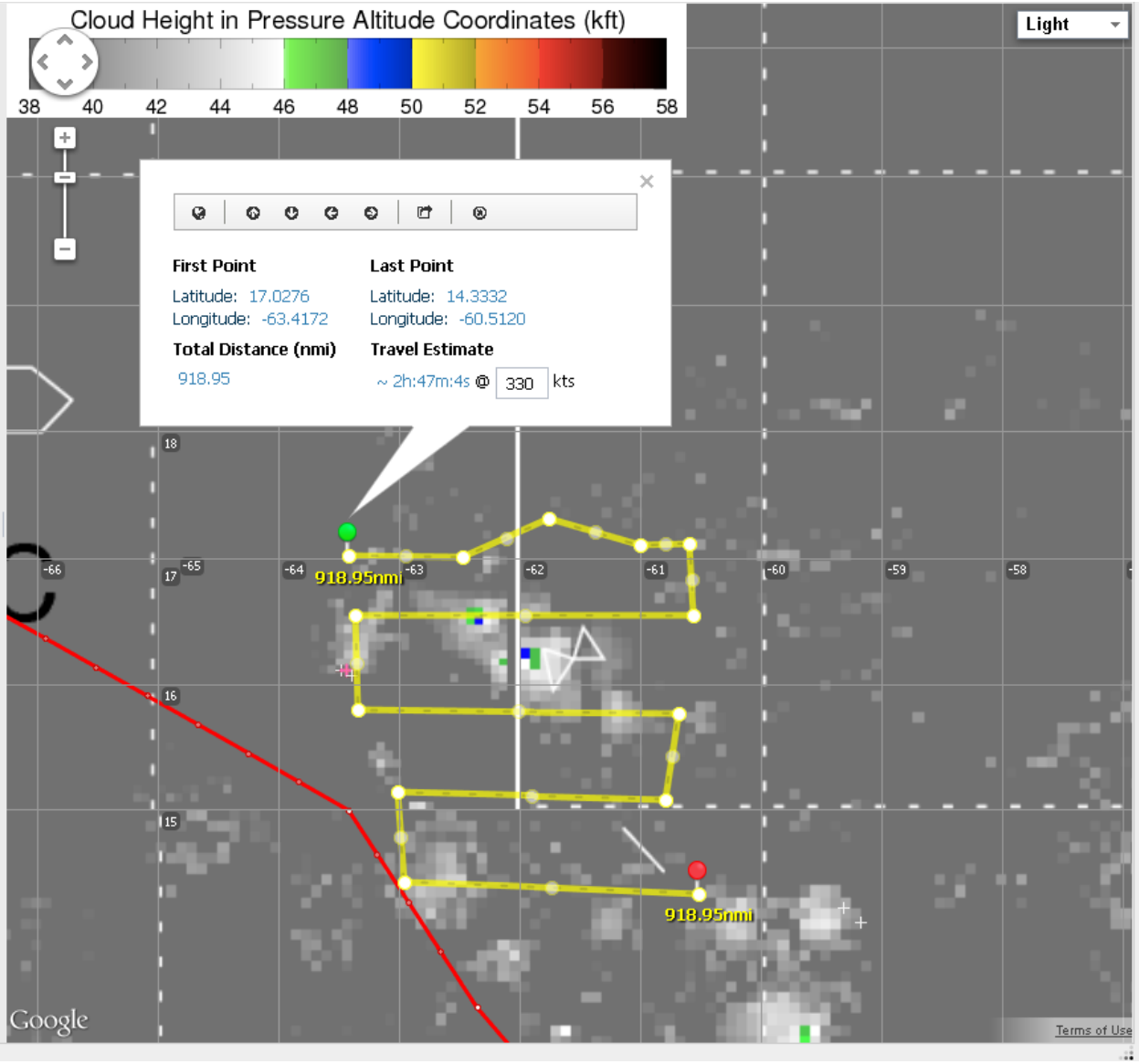


NHC gives is giving an estimate of a 20% chance of formation in the P25-P30L region. Two other regions of possible formation are also seen, one currently over the Yucatan and the other system just coming off of Africa.

Engine start: 1003 UTC

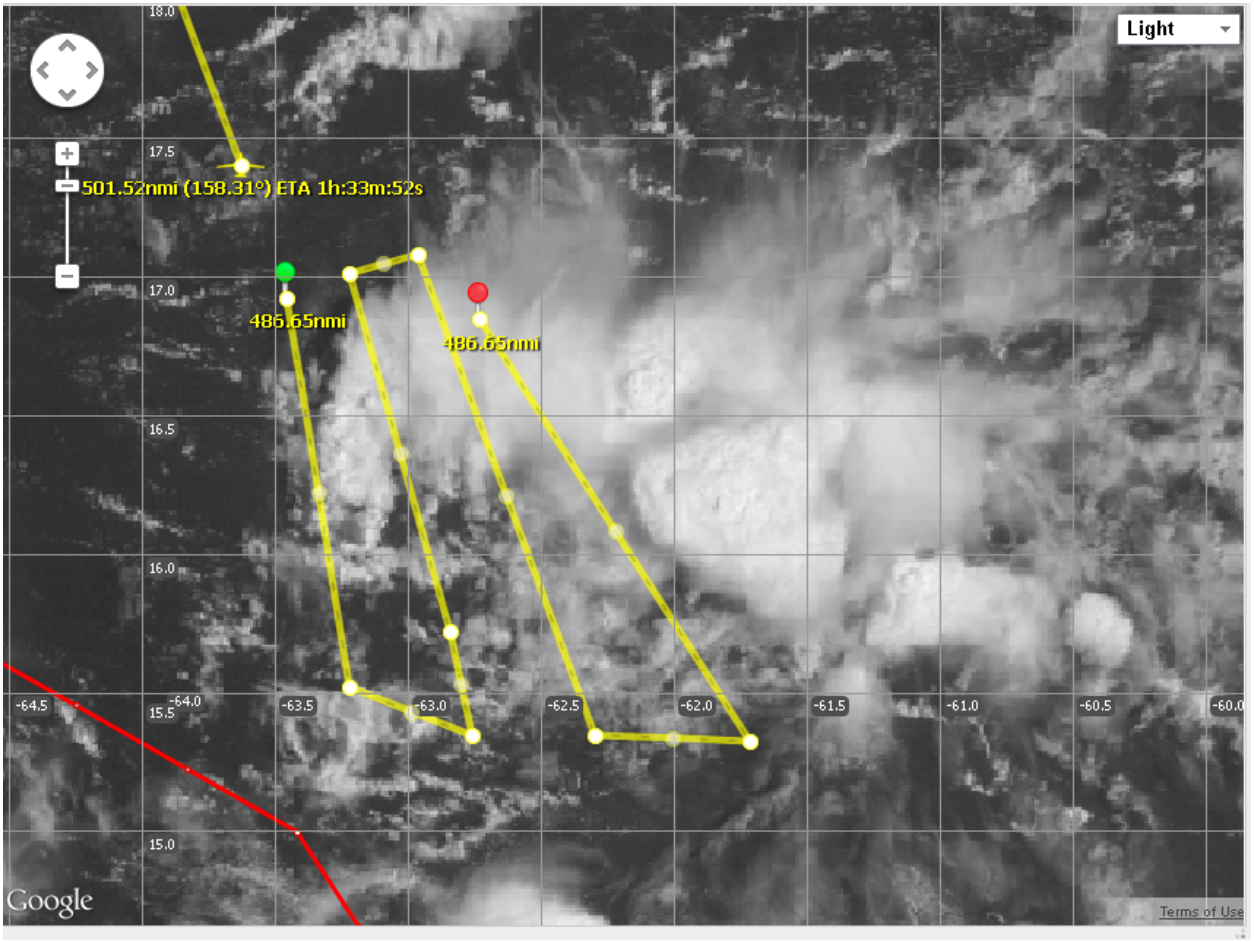
We have been having issues with MPCS and Ku this morning. Behind schedule for takeoff.

1129 Takeoff

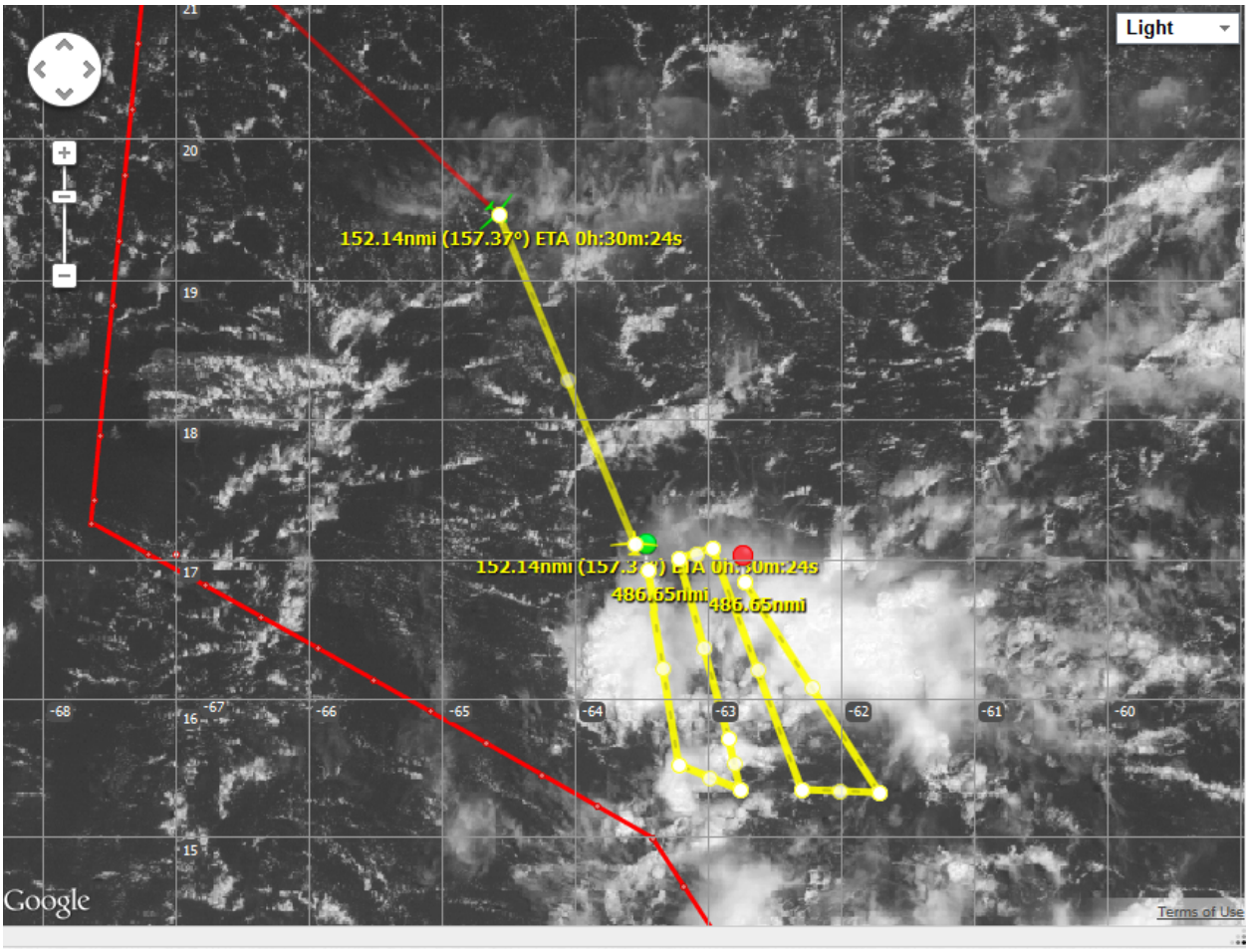


1410 Sent the pilots the waypoints for the initial convective module. The difficulty is that the convection is over or very near the islands, so a route was developed the go between the islands.

1430 Change in plans. Can't be within 15 nmi of land, so have to replan.



New plan is to do a lawnmower west of the islands to catch the convection near the estimated center. Because of the delay in getting the pattern to the pilots, we have moved farther southward along the mission plan before heading toward the initial point.



1615 About a half hour out from the start of the module. Pilots still doing handover.

1630 Mission Science handover—Jason Sippel (flight planning/situational awareness), Deanna Hence (writing), Ed Zipser on shift

1639 Working on shifting the start of the first legt more westward to cover blowup of convection. Needs negotiation with ATC.

1650 Heading towards new initial leg farther to the west. Rest of pattern consistent with original plan.

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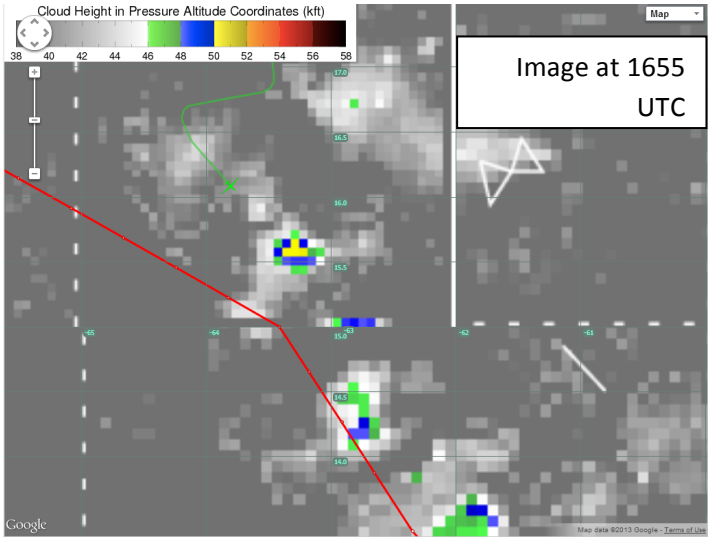
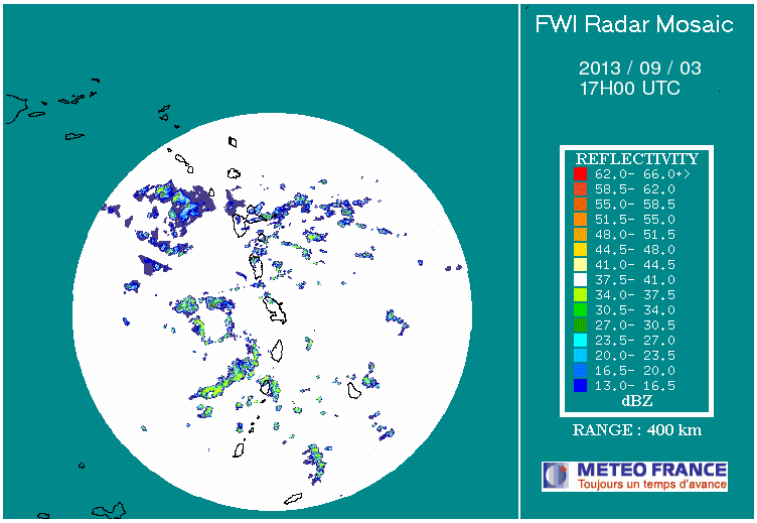
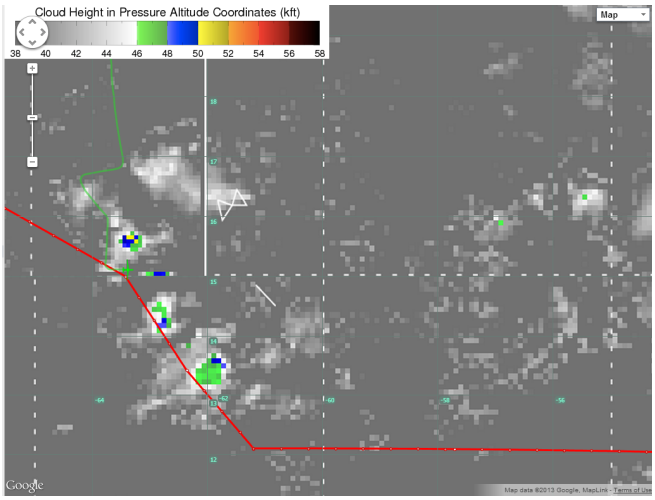
1700 Convection firing actively in southern part of 25L, diverting waypoints away from overshooting tops in cell because at flight altitude 53462.9.



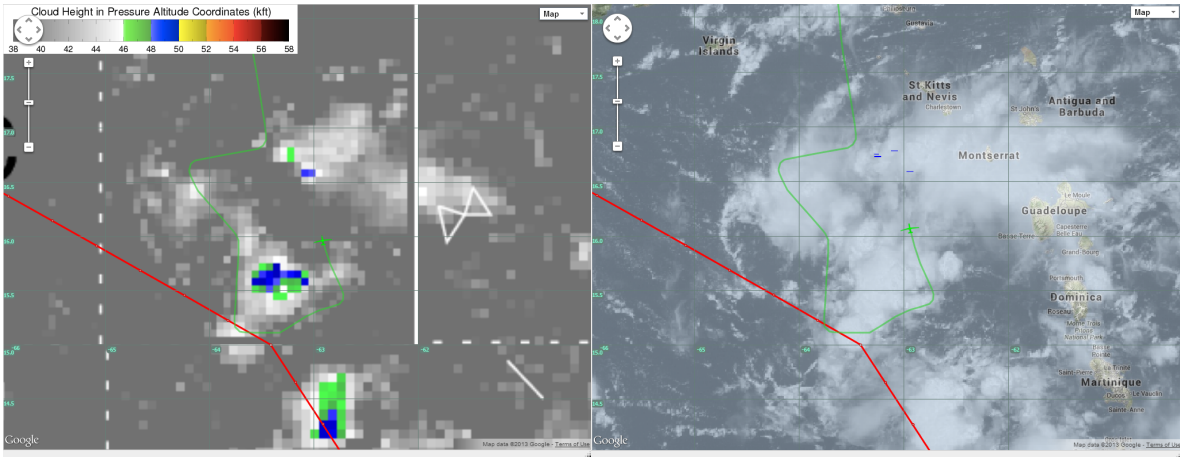
1710 Convective cells on Martinique radar. 40+ dBZ cores evident around plane diversion, although much more intense band further south.



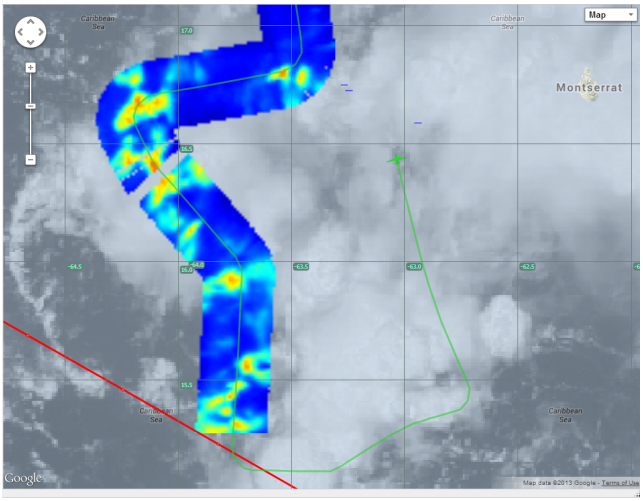
1717 Shooting between cells



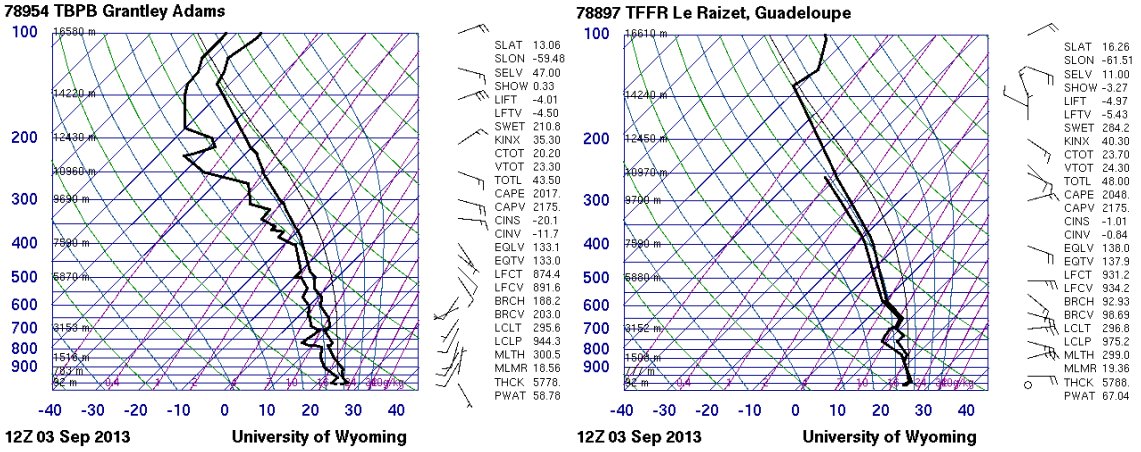
1733 More diversions to avoid convection and lightning ahead.



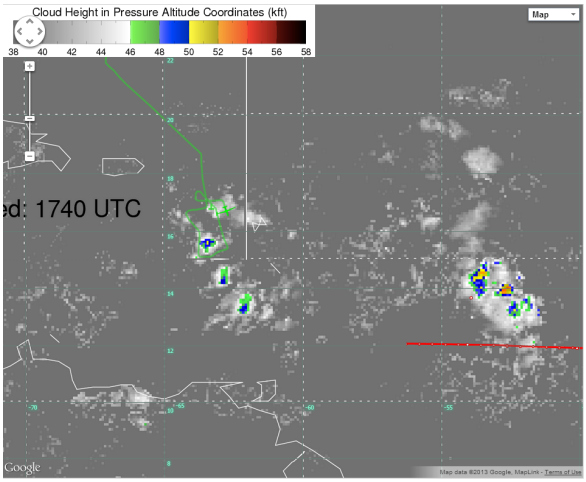
1738 HAMSR Quicklook Cloud Liquid Water



1800 Pretty stunning differences in the 12Z soundings between Barbados and Guadaloupe, with the Guadaloupe sounding indicating near saturated conditions and mostly due easterly winds. The Barbados sounding indicates low-level southwesterly winds up to mid levels, with mostly easterly winds aloft. Possible indication of some sort of broad circulation or a northern shear zone?

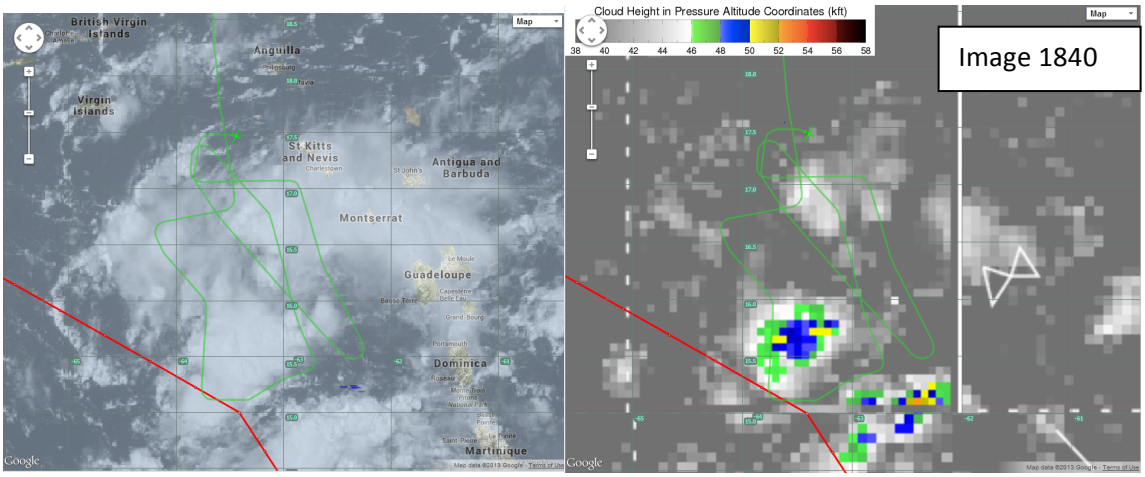


1810 General agreement that the amount of time and clear air coverage to get to convection associated with P30L far to the east may not be worth the ferry at this time. Will consider heading over to that region if convection in current area peters out. Discussing heading further south to hit up convection closer to Martinique and St. Vincent.

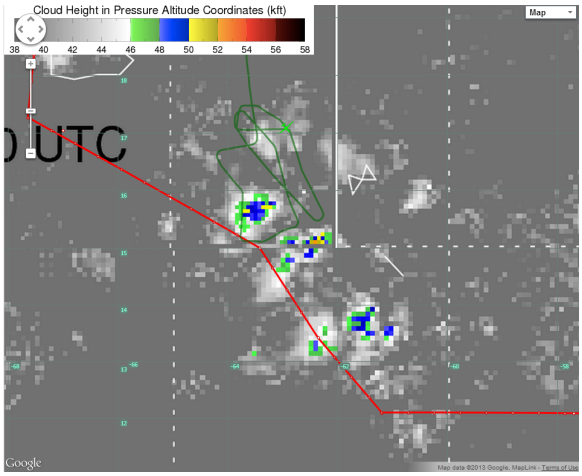


1826 Fuel burn rate much higher than expected, AV-1 is turning around to return to base, to make it back before dark and avoid an emergency alternate landing elsewhere. Forecasters examining local weather to determine ability to land this evening.

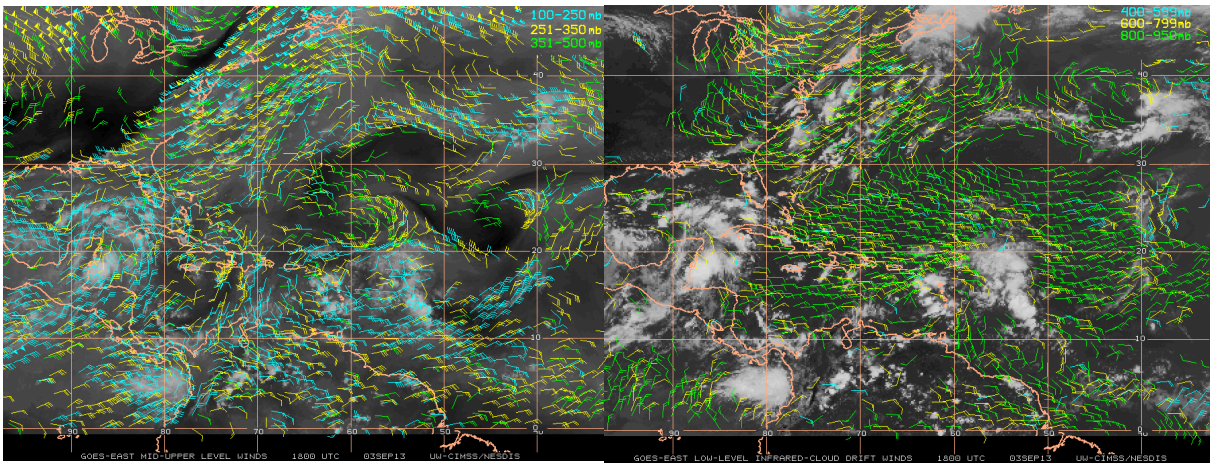
1853 Ok, nevermind….going to continue to do science, doing an emergency landing at 3am local due to no crew and no chase. Drawing up new flight plan now. Currently at 55733.8, lightning in cell with 54k cloud tops.

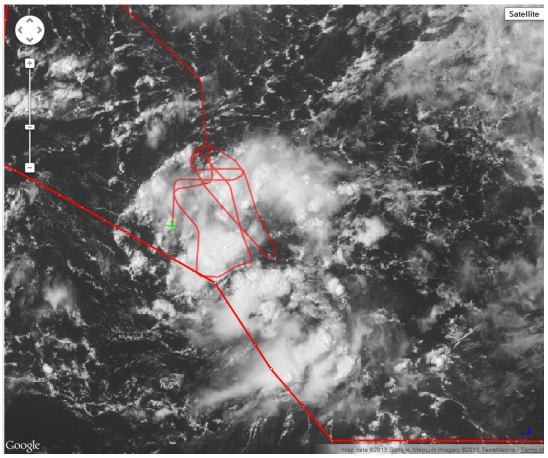


1901 New plan to skirt west along flight boundary box towards cell to the southeast.

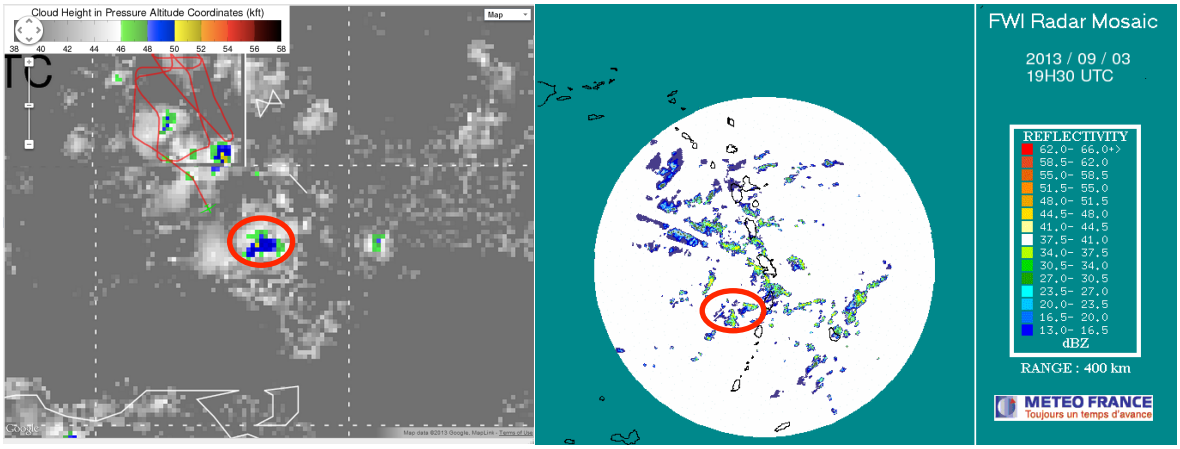


1928 Loop of visible satellite and radar imagery indicates possible strengthening low- or mid-level circulation being overridden by strong easterly winds.

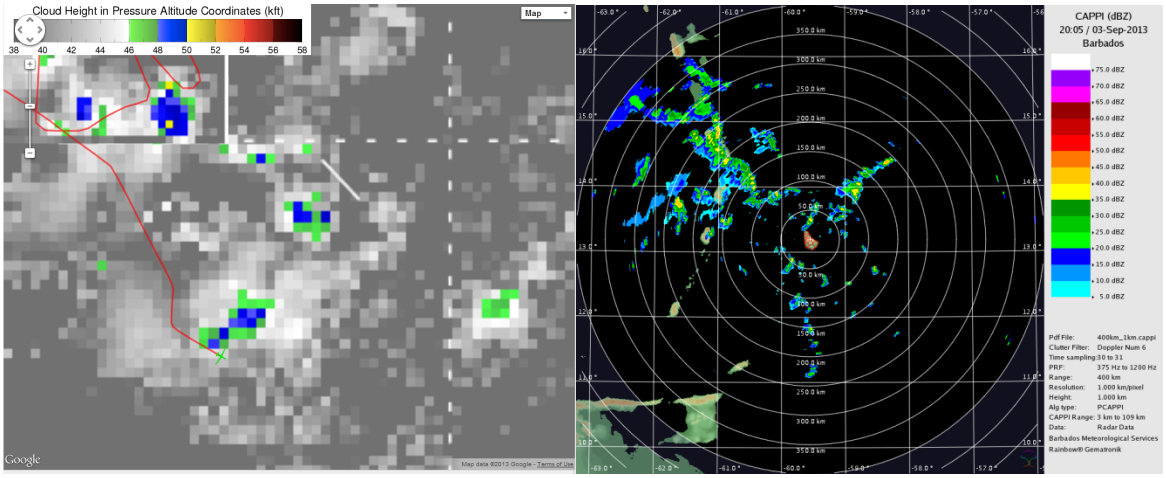




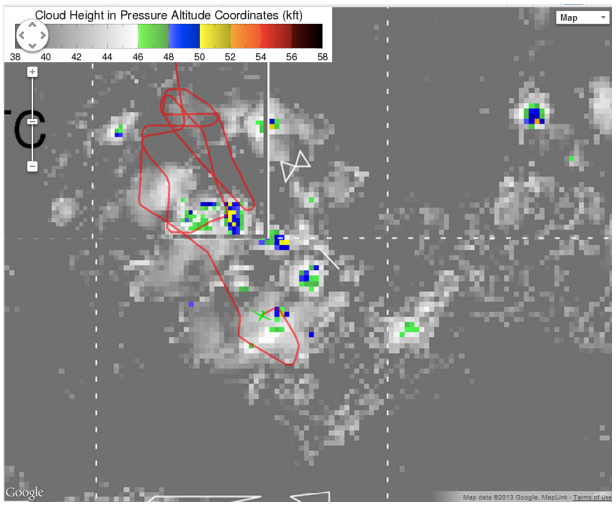
1953 New flight plan to do a small double racetrack over cell with cloud tops 48-50 kft.



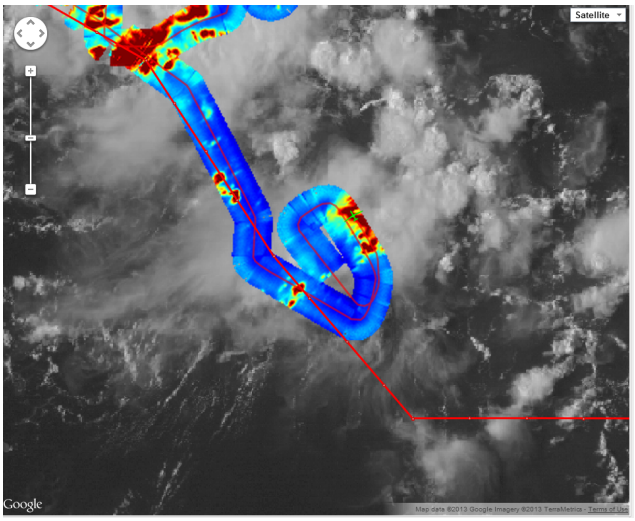
2010 Cell appears to be collapsing, with cloud tops beginning to drop below 48 kft. Barbados radar indicating transition from convective to stratiform precipitation.



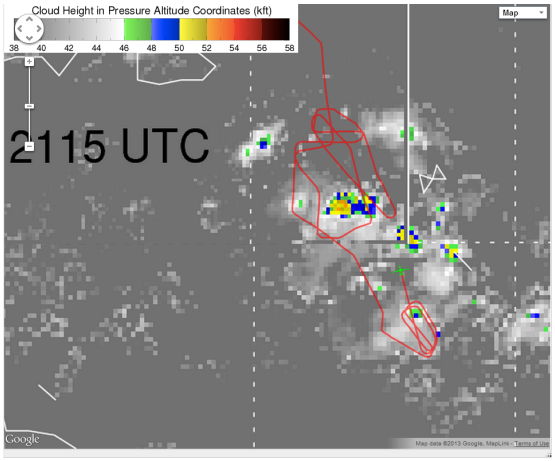
2025 Considering new target along convective line west of Dominica. Minimal lightning detected with cloud tops mostly below 50 kft but some popping above. Convection in that area has been fairly persistent for the past several hours.



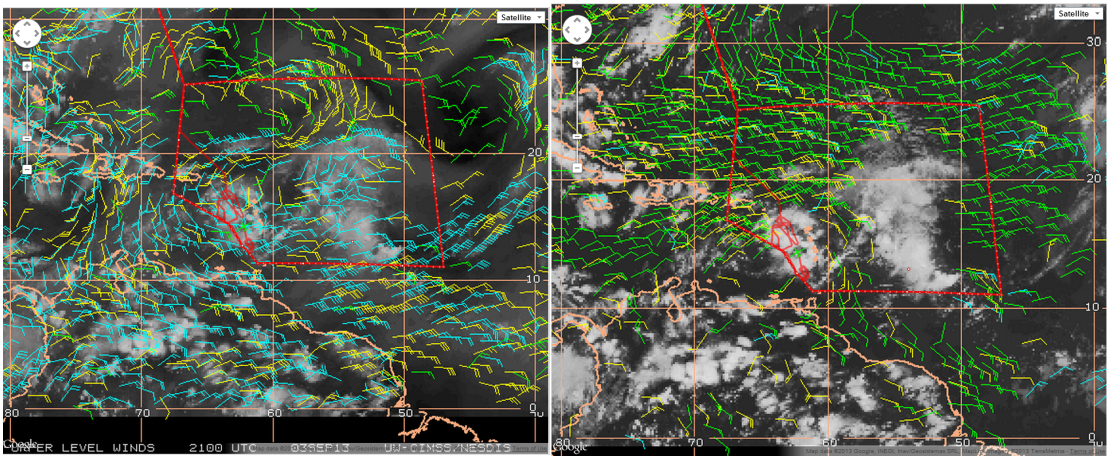
2053 HAMSR indicating the high cloud liquid water in the collapsing cell.



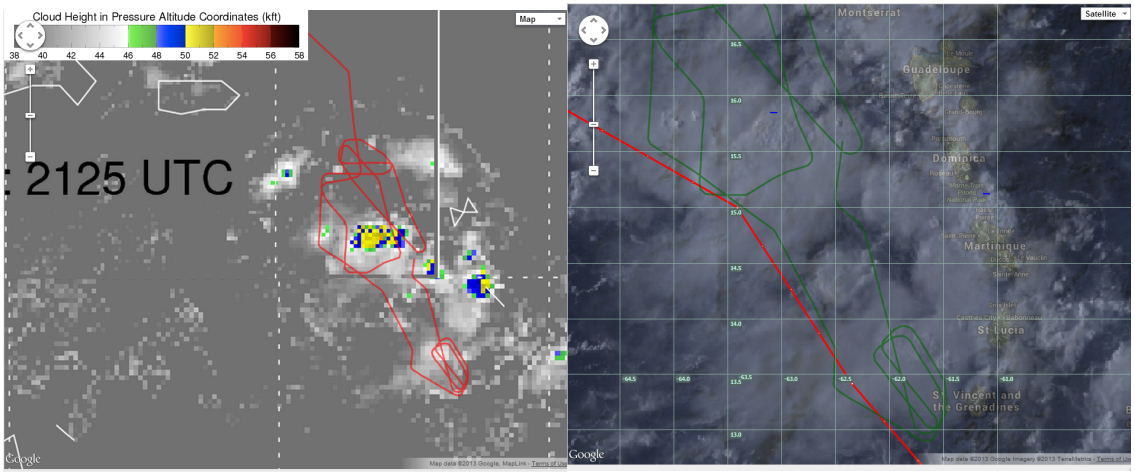
2129 Heading back north to cover line of convection west/southwest of Guadaloupe, west of Martinique. Convection above 52 kft popping up but is currently 50 nm from waypoint.



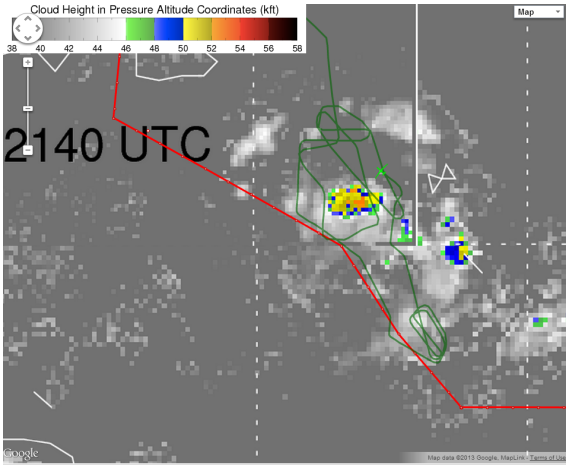
2132 Satellite wind data indicateing nice upper-level anticyclone with possible outflow to the north. Low-level circulation still indicating possible closed circulation around 25L.



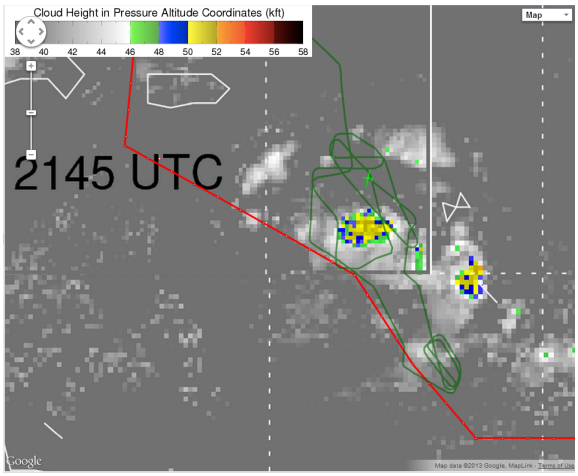
2136 Difficult overflying convection due to conservative pilot diversions. Although a few cloud tops appear marginal, vast majority are below threshold and extremely little to no lightning indicated.



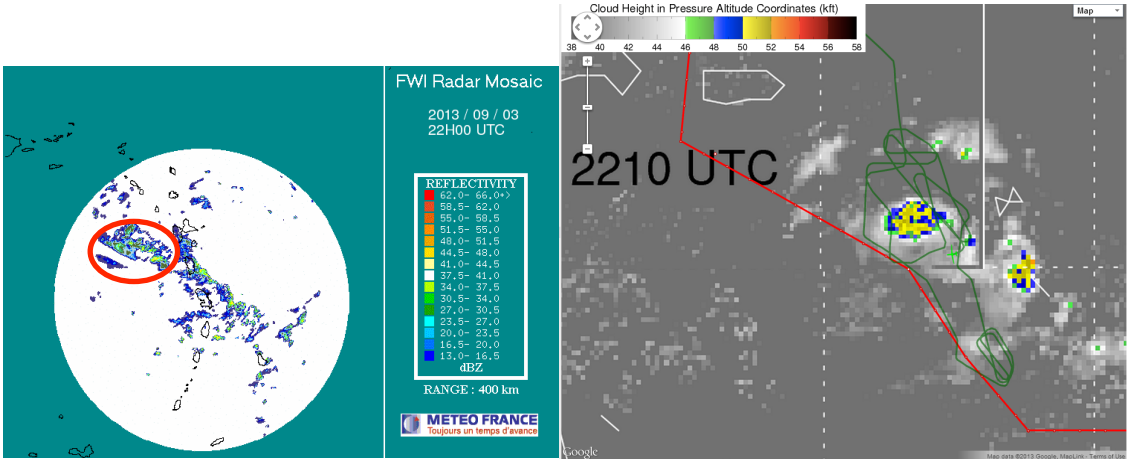
2147 Naturally, old products prevail…cloud tops are becoming more marginal. Going to inform pilots to do lawnmower as possible but deviate as necessary. Minimal to no lightning still present.



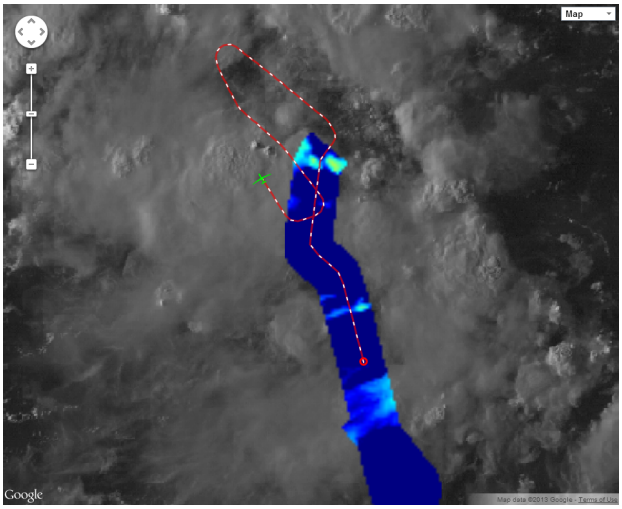
2158 Overtopping clouds dissipating, going for the middle.



2218 Martinique radar indicating relatively large cell currently being sampled (with beam blockage or bad ray or other artifact). Flying in good position between the border of the box and the islands.



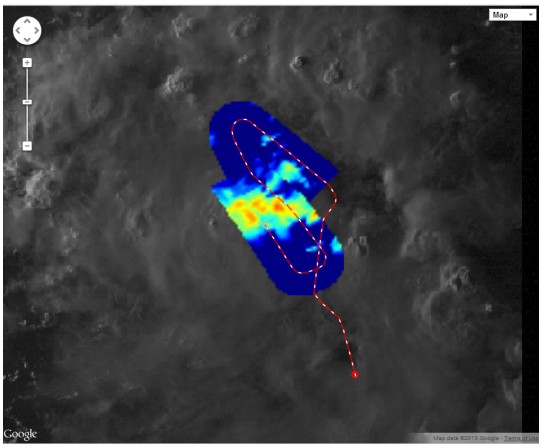
2225 HAMSR indicating 20-25 dBZ reflectivities in the cells to the east of the large convective cell currently being flown. Nice set of overshooting tops being highlighted by the setting sun.



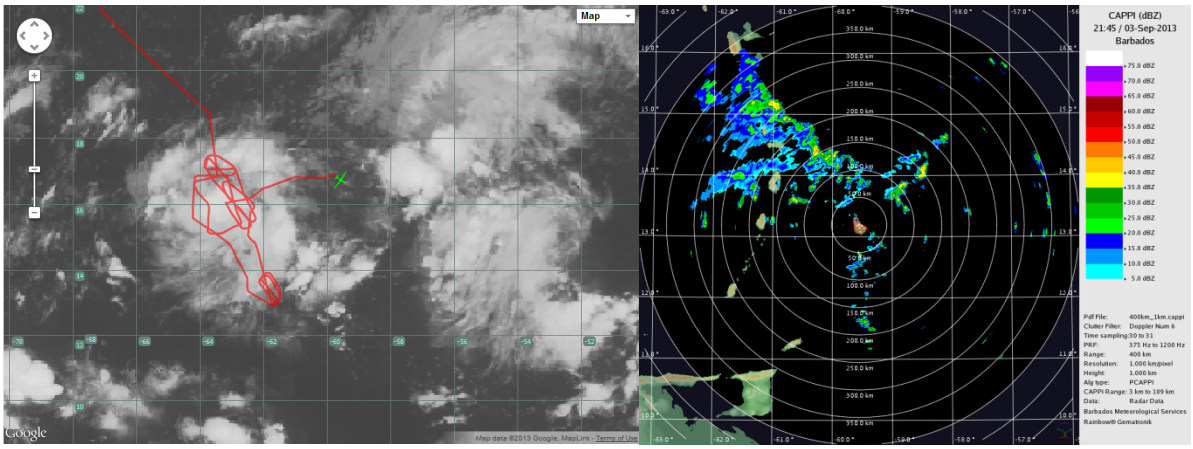
2304 Currently having trouble with MTS updating aircraft position. As of right now the position hasn't updated in 38 minutes.

2308 Decision made to head east to get clear air sampling and thermodynamic information on the system to the east.

2310 HAMSR indicates that the convective cell had ~35 dBZ reflectivity cores at 6 km. Flight position still not updated in MTS.

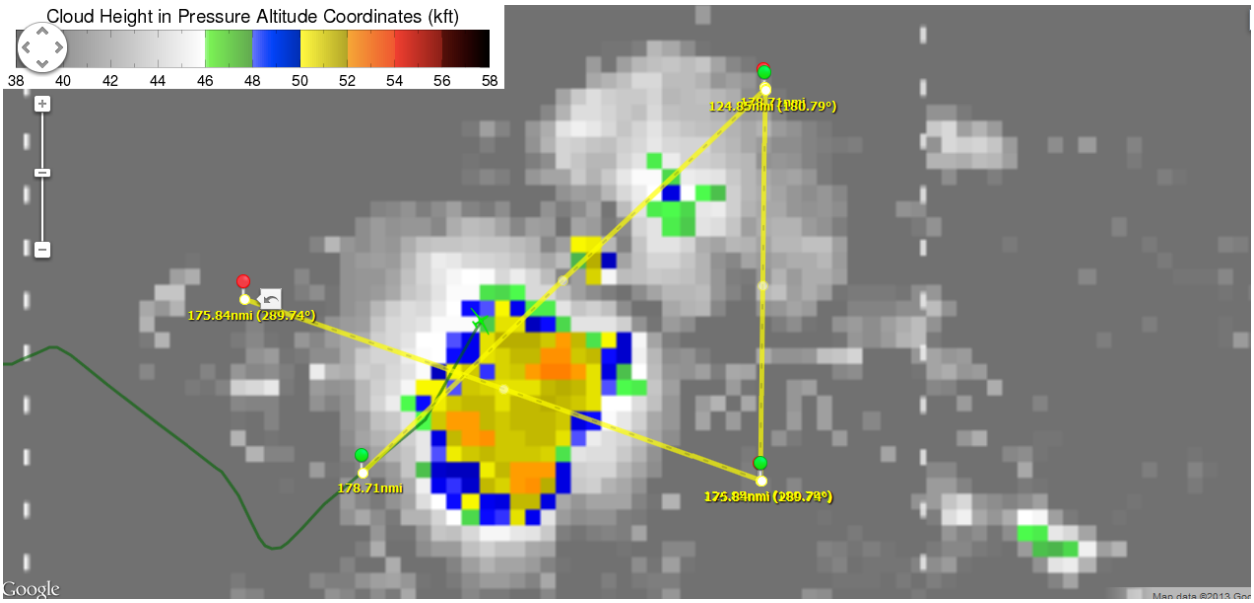


2356 Confusion amongst pilots re: which waypoints to go towards. Now redirecting to the waypoint SW of the convective area in 30L. Barbados radar and satellite imagery indicate that convective band is beginning to extend towards the NE from Barbados, possibly will close the gap between the convection around 25L and the convective area with 30L.



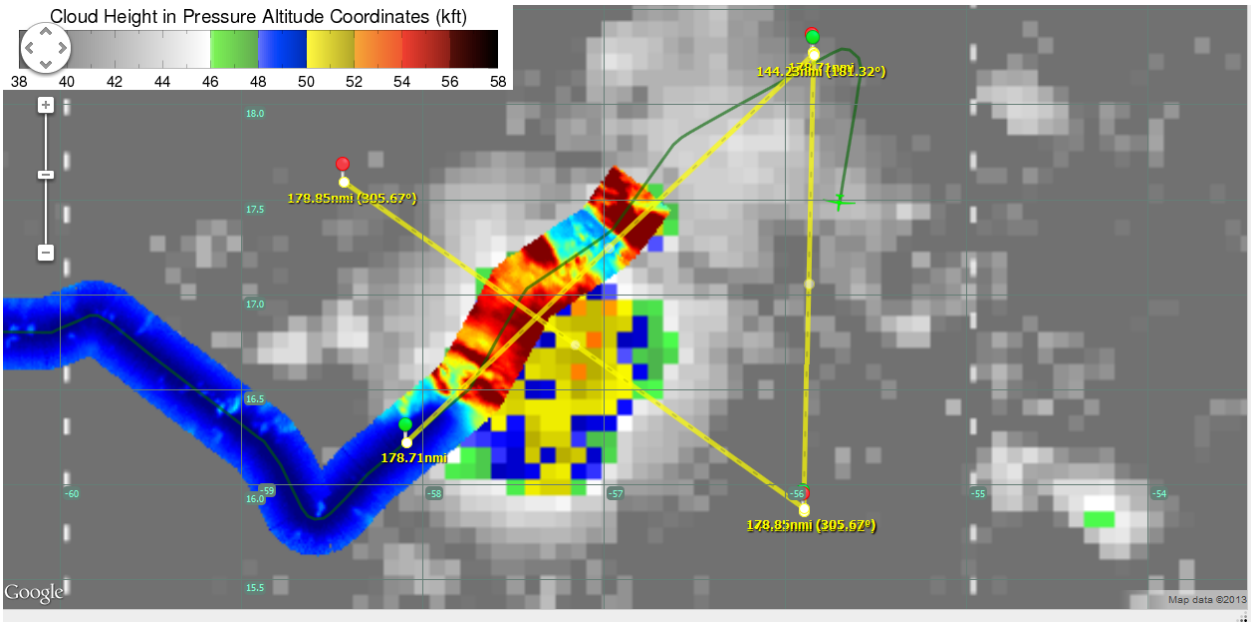
0030 UTC Steve Guimond and Jon Zawislak have taken over for Deanna Hence and Jason Sippel as mission scientists.

0015 UTC Cloud height product showing the upcoming flight pattern. We had a delay in satellite coverage, which led to a small deviation in the flight track, but the satellite image came back at 0015 UTC (see below). There were a few vertical accelerations of 1.20 G noted by the aircraft, which is not concerning.

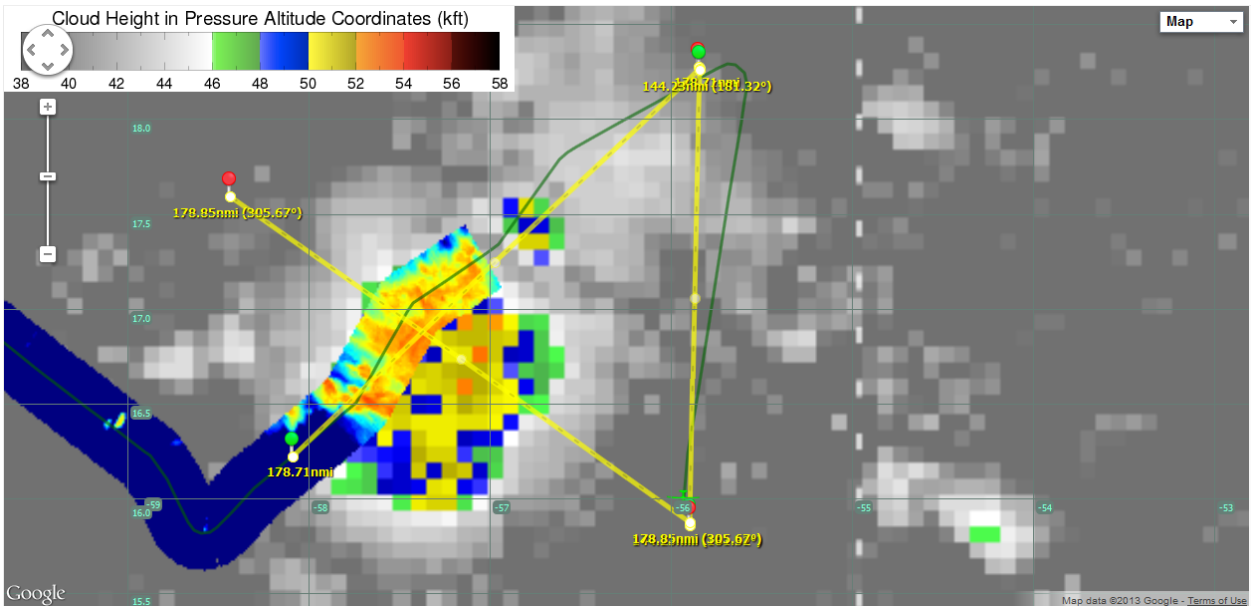


0100 UTC GH has turned the corner and we are heading South, will then go straight over the convective mass. Shown in the image below are HAMSR scattering index and the cloud heights.

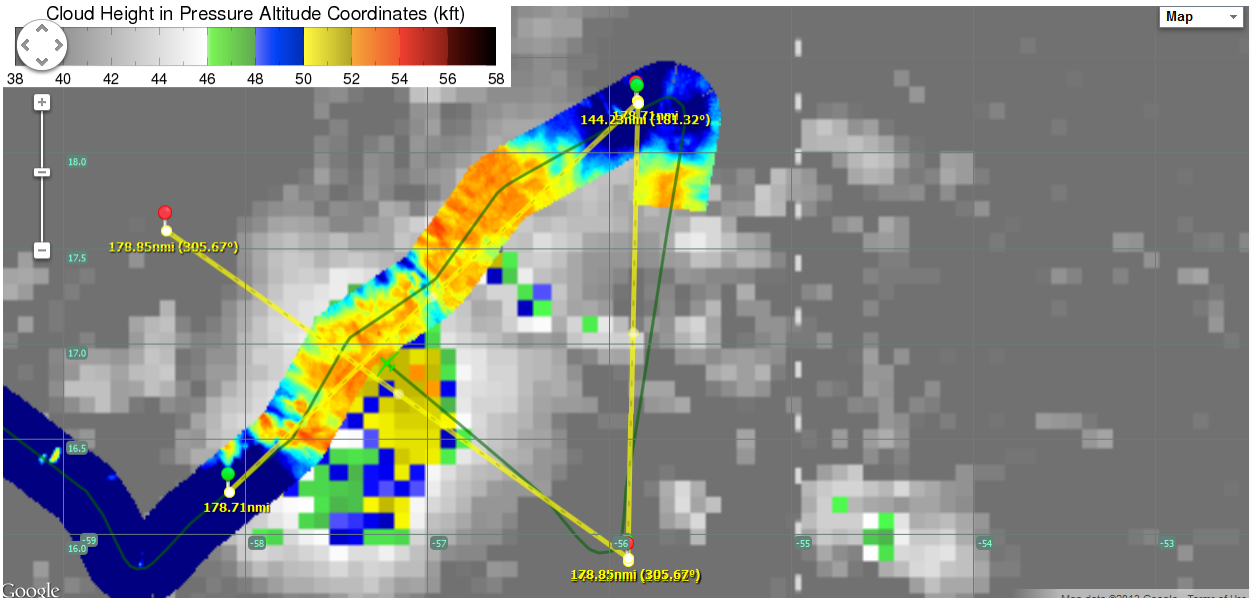
Good data was gathered over the convective mass, but some deviations in the flight track were needed due to developing convection. Satellite data is too coarse in time to coordinate science objectives with safety.



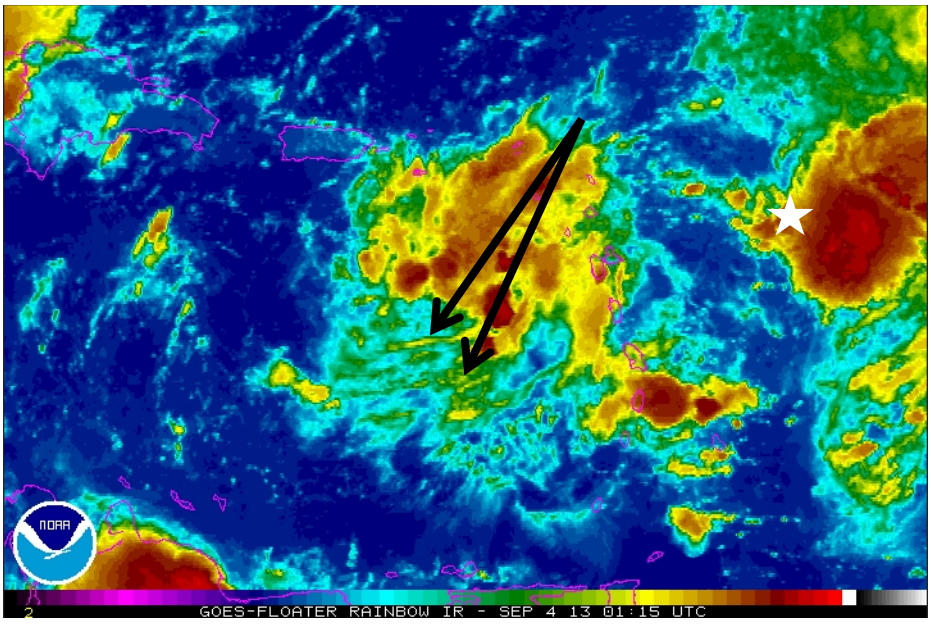
0122 UTC Here is the HAMSR derived reflectivity at 6 km height for the same area as above. We are planning on heading straight through the center of the convective mass as shown below. We just got word from the mission director that we have ~ 2 hours more time on station to execute a pattern. We are working up another pass through the convective mass.



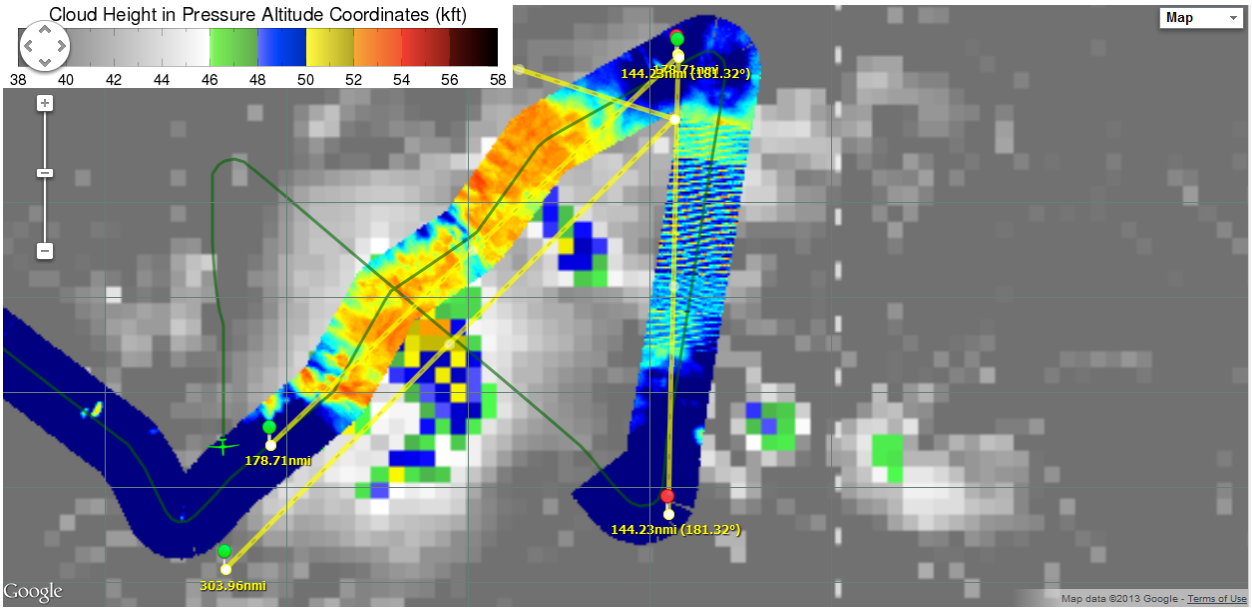
0140 UTC Heading through the convective mass where HAMSR derived reflectivity showed 30 – 35 dBZ at 6 km height. Will get an update on how the reflectivity has changed in a few minutes. We have updated the flight plan to add another pass through the convective cell. This will be shown soon. Cloud top heights in this region where the plan is currently are 50 – 52 kft. Good level pass for instruments.



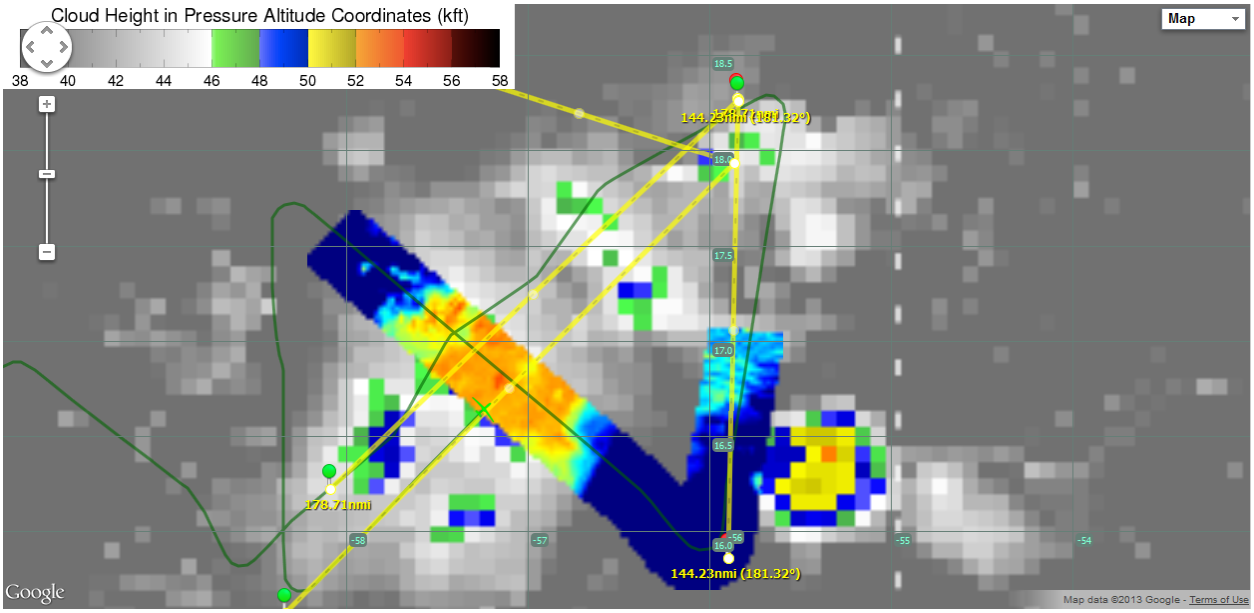
0115 UTC Large scale infrared satellite image of 97L (on left) and P30 (on right). There are curved bands (shown by the black arrows) in 97L indicative of a low-mid level circulation. Currently the GH is flying in P30 at the location shown by the white star.



0210 UTC Satellite cloud height image below is from 0155 UTC with HAMSR derived reflectivity at 6 km height overlaid. We are heading down to the southernmost point (green balloon) and will follow the yellow flight track for another pass through the convective system. After that, we may have to head home, but will check with pilots on fuel issue.

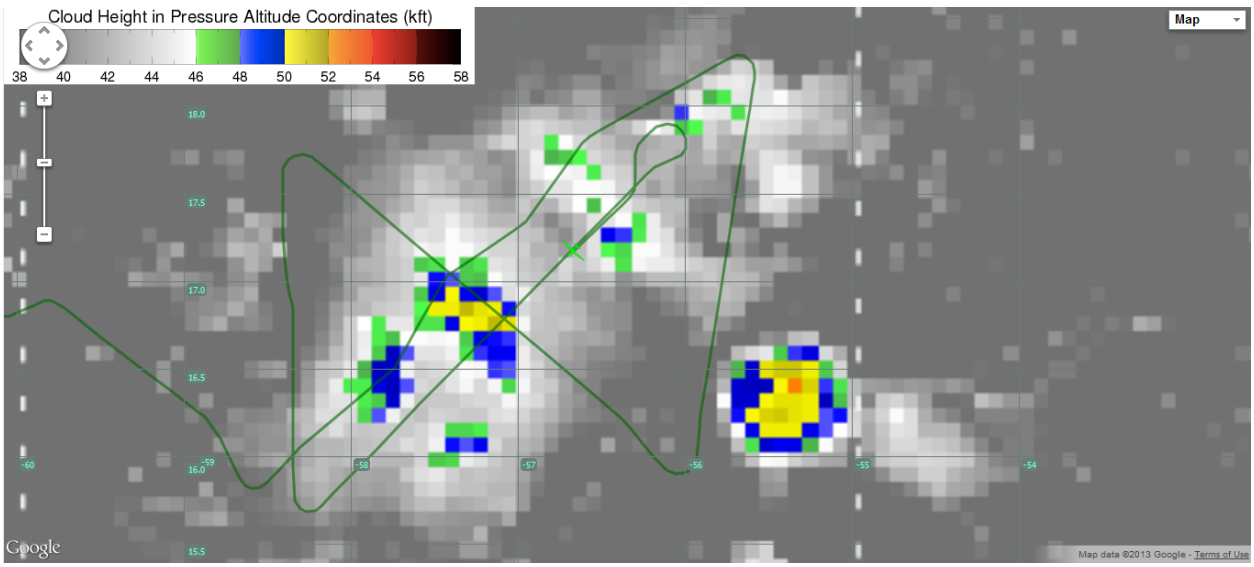


0233 UTC Below is the HAMSR derived reflectivity at 6 km height for the last pass over the convective cell. The values are ~ 35 dBZ with some indications of 40 dBZ in the red colors. The reflectivity has gotten stronger since the last pass with a revisit time of ~ 1 hour.

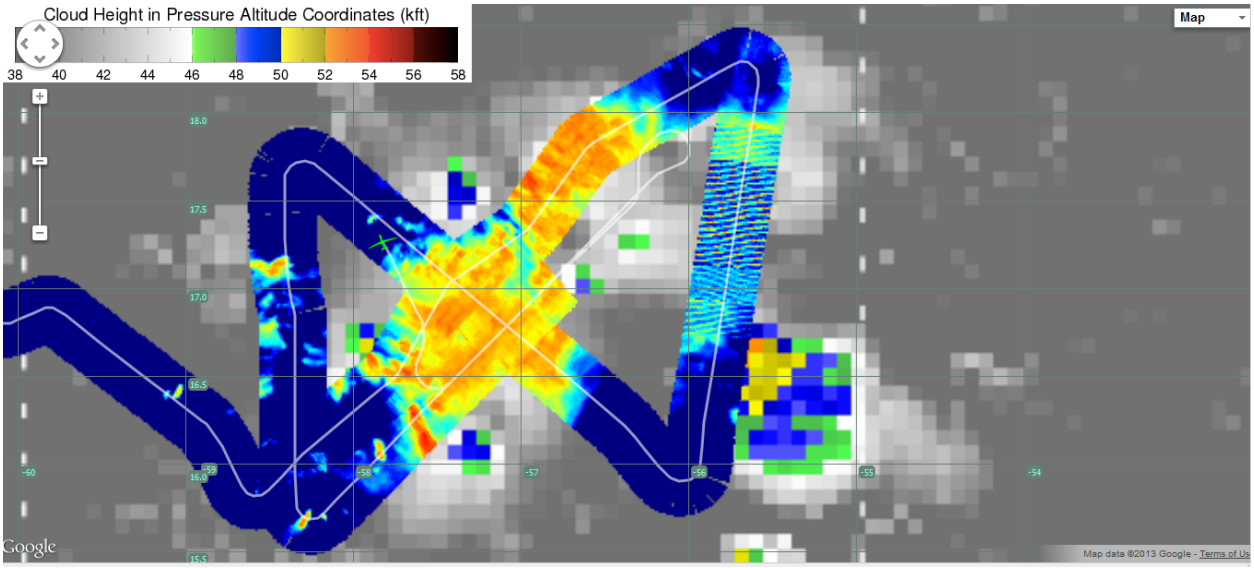


0248 UTC Discussion with pilots on fuel indicates that they can do a turnaround and come back across the convection before heading home. They don't know how far into the convective cell they can penetrate before turning back, but we will update when we know.

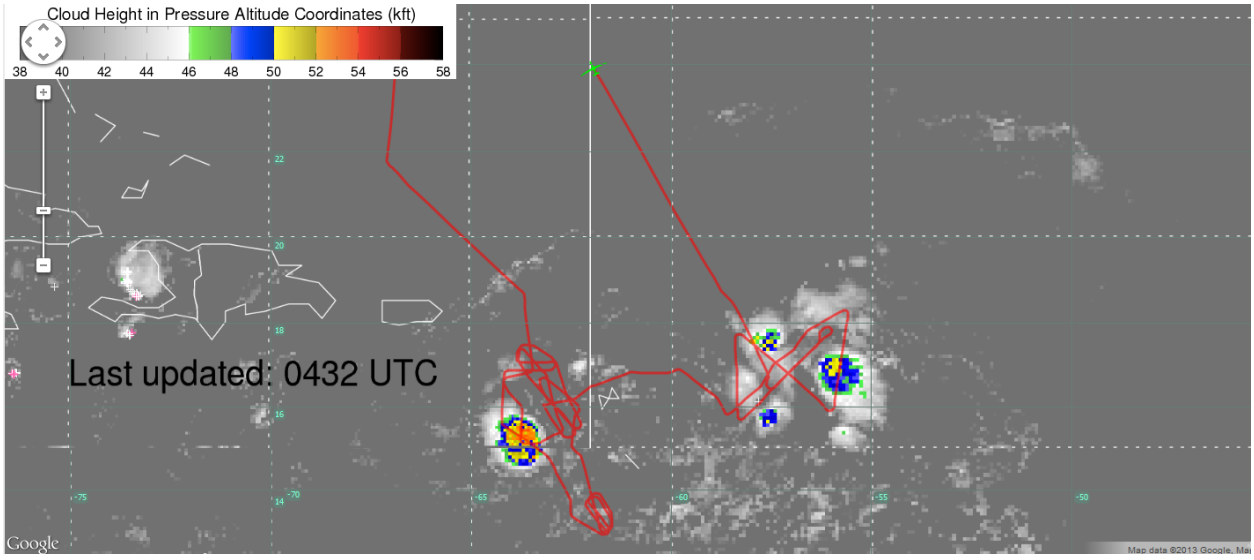
0300 UTC The GH did a 360 turn and is heading back through the convective cell. The cell is quieting down a bit with only a small patch of cloud tops around 50 kft. The revisit time on this portion of the cell is around 30 minutes so we should be able to capture some of the convective evolution. Overall this large cell has looked impressive tonight and it will be interesting to see if a circulation exists once HIWRAP data can be analyzed.



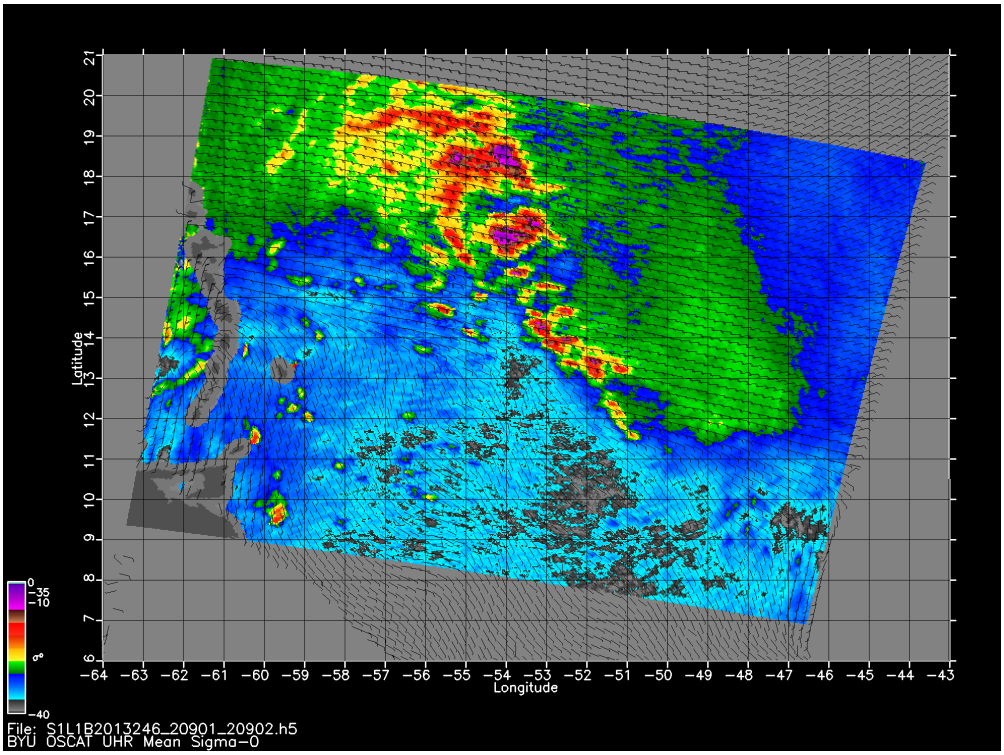
0326 UTC Snapshot of HAMSR derived reflectivity at 6 km height for the entire on station time of P30. The pilots indicated that they needed to head home, but we got most of the way through the final pass through the cell. We started heading home at 0314 UTC and we are estimating around 5 h to get home. The HAMSR data shows that we got good sampling of the convective mass at different stages in its lifecycle.



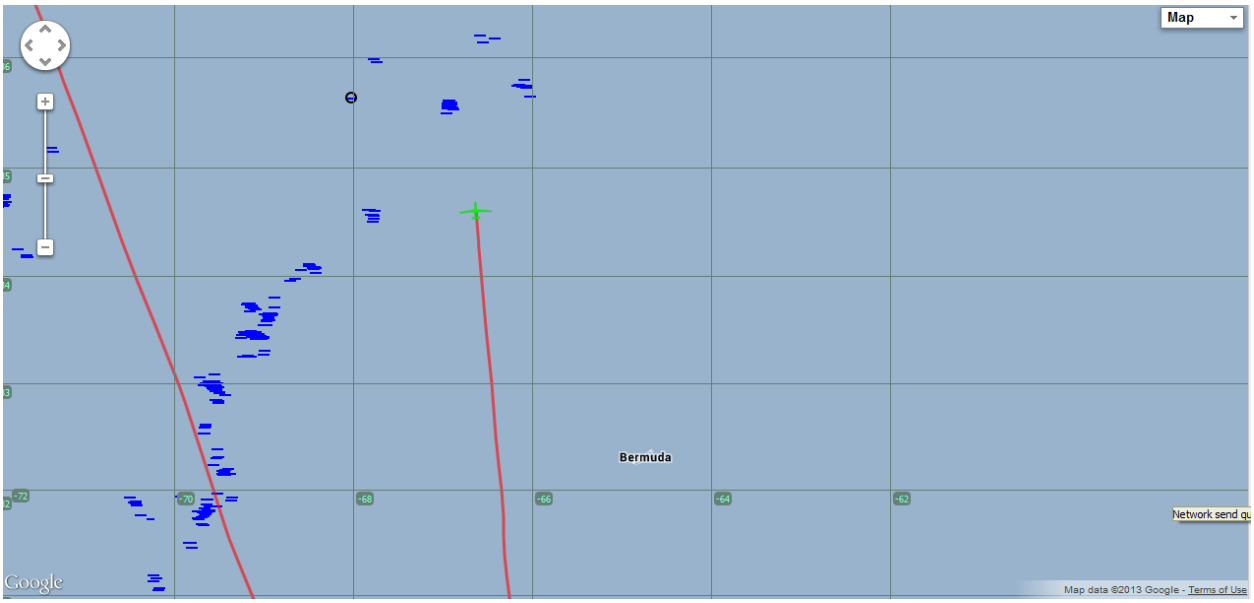
0448 New convection is developing on the southeastern side of the patterns that sampled P30. As convection has waned in this system, the cloud tops have warmed and the precipitation areas that were sampled presumably have been reduced to stratiform. An IR loops does not (yet?) indicate any left over MCV from this convective system. In P25L, a new burst has developed south of the apparent center.



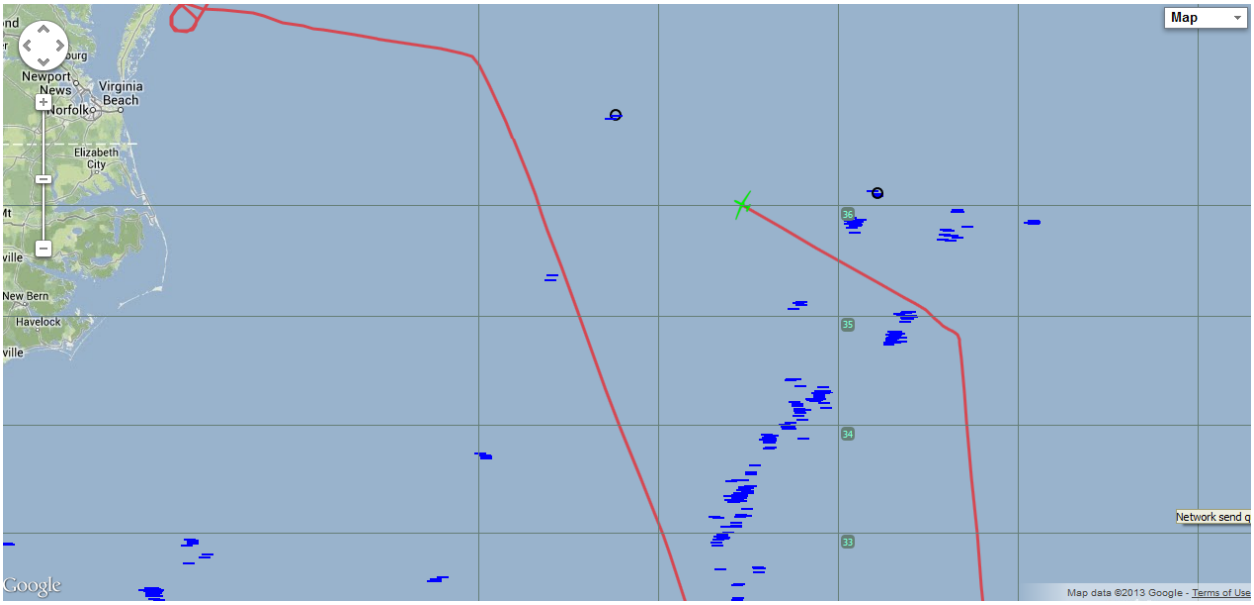
Just for reference, the OSCAT composite of P25-P30L at ~2100 3 September is below.



0645 UTC On way back home and approaching a frontal system. The system is producing a good bit of lightning, but cloud tops are not a problem. We communicated this to the GH mission director, but he indicated the pilots wanted to go around the system so they are heading to 35N and will then head towards WFF for landing. The frontal system is pushing towards the NE and thus, they may still run into the lightning. We communicated this to the GH mission director and he said they had already filed their flight plan with ATC. We will monitor the situation and suggest areas they can go if things get difficult.



0720 UTC Pilots moved through the front and avoided the lightning…



0800- ETA WFF now 1000 UTC. More fuel than expected. Why?

0930- 30L centered under upper anticyclone. 55 kt outflow jet 550 km NE of 30L

1038- landing

HIWRAP report

HIWRAP took data throughout the flight. This data is being saved to disk, and will look at data after this. The radar transmitted and took data continuously through the flight. There was however an intermittent problem with the antenna data caused occasional short 30-second drop-outs. This was managed and minimized during the flight, and the HIWRAP team has implemented a software change for future flights to minimize this problem. Also, the heat load caused problems with the experimental real-time processing, however was managed sufficiently for the science data. We're still looking into temperature data measured during the flight. The GPS battery worked correctly for the first time during this flight.

HAMSR Report: Shannon Brown, Boon Lim, Sidharth Misra

HAMSR performed well during the 9/3/2013 science flight. The instrument landed with the radome intact. The networking at WFF worked as expected and the real-time ground data processing system worked for the flight duration. Several code updates were made during the flight to reduce the latency of the real time product and several more will be implemented prior to the next science flight. The processing of the real-time data occurred at WFF and was displayed on the Mission Tools Suite and the JPL HS3 Portal during the flight. An example of the MTS display is shown in Figure 1. The HAMSR products available are window channel TBs (50.3, 113 and 166 GHz), upper level temperature channels (54.94, 55.5, 117.95 and 118.3 GHz), precipitable water vapor, cloud liquid water, HAMSR derived reflectivity at 6km, 9km and 12km and the height of the precipitation (defined as the maximum height of precipitation with at least 10dBZ reflectivity). The products are available for the full flight and the past 30 or 60 minutes of the flight. There are also two options to display the data with an absolute or relative color scale. The colorbar was not available in MTS during the flight, but was in the JPL portal. A small modification to the code will be made to ensure that the MTS display contains the colorbar.

A few observations of note during the flight are shown in the following figures. The first figure shows the HAMSR total precipitable water vapor. The atmosphere was fairly moist in and around the two storm systems that were sampled (TPW > 5cm). Drier conditions were observed several hundred kilometers north of the storm with typical TPW values in the range of 3-4 cm. The following plots show the HAMSR derived reflectivity and height of precipitation. The western system exhibited less areas of strong convection. The eastern system exhibited more widespread and stronger precipitation with convection reaching up to ~14km. HAMSR quick-look temperature and relative humidity profiles are shown for the entire flight in the final figures. The profiles are shown as a function of an along track index, the positions of which are

shown in the accompanying map. The profiles in and around the storm systems were observed to be nearly saturated up to about 400 mb and about 3 degrees warmer at low and mid-levels than the surrounding environment to the north. The mid-level air (300 - 800mb) to the north of the storms was also significantly drier.

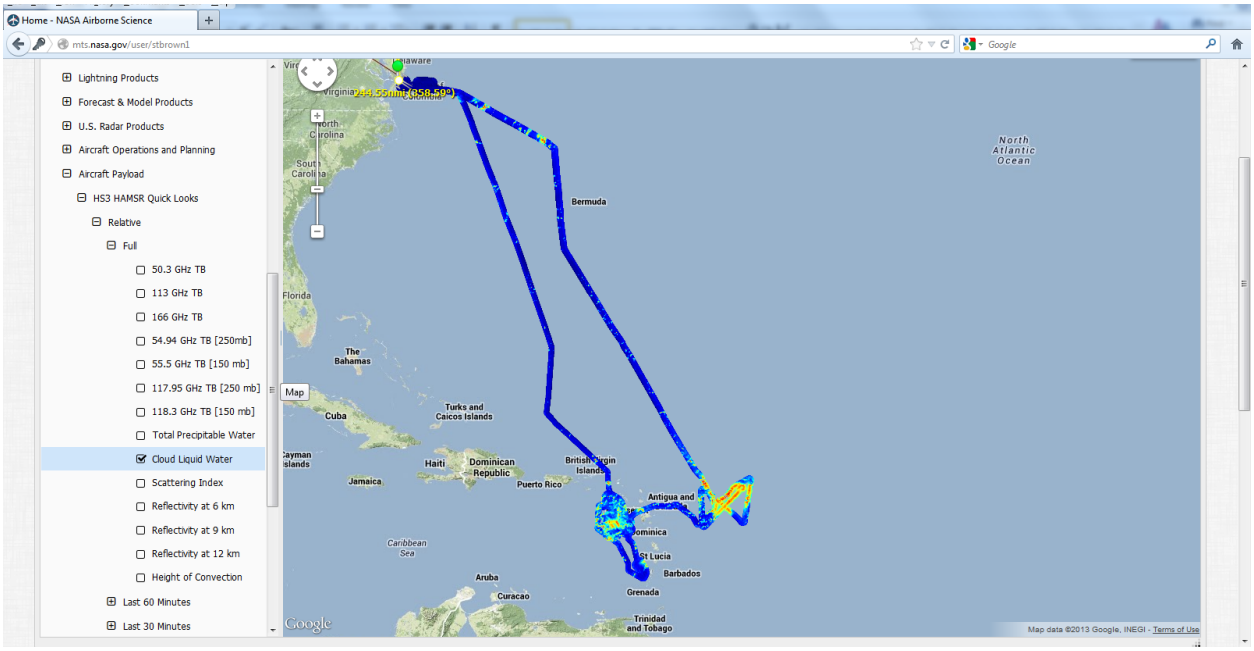


Figure 1. Example of HAMSR real-time data in MTS.

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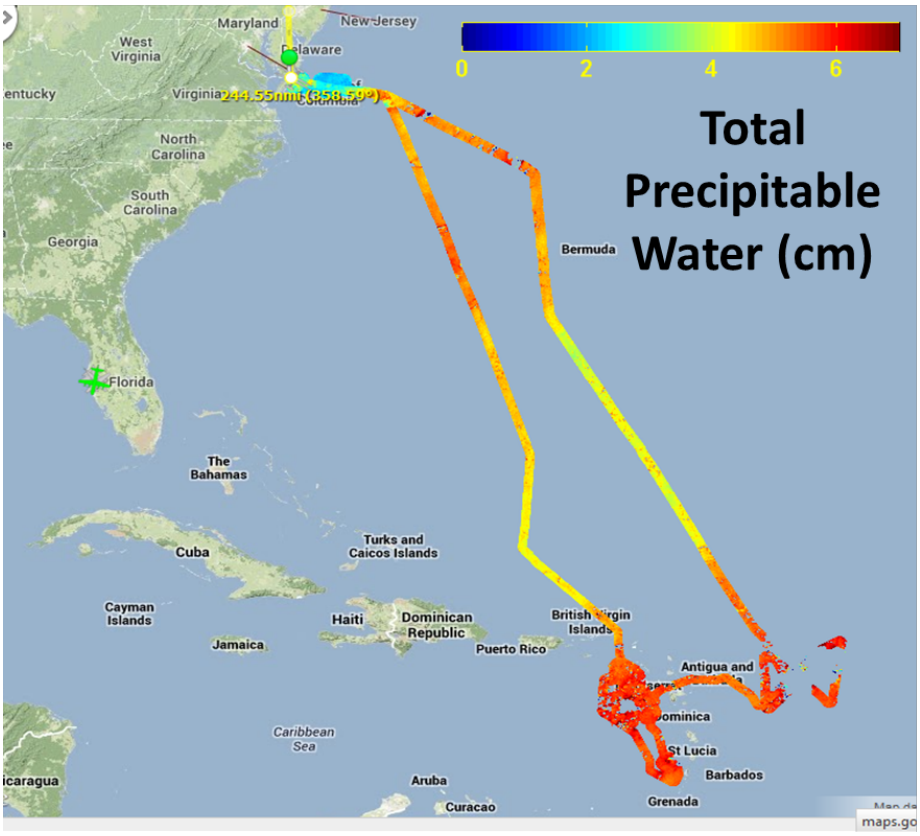
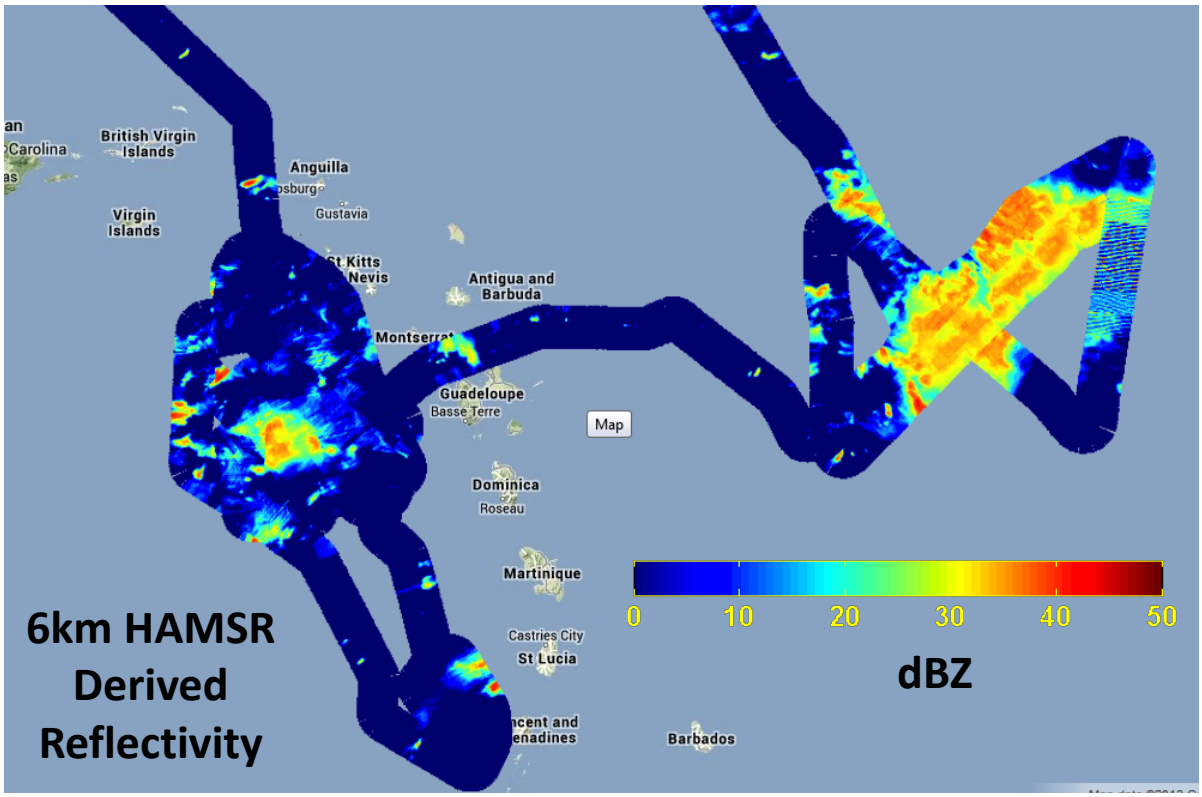
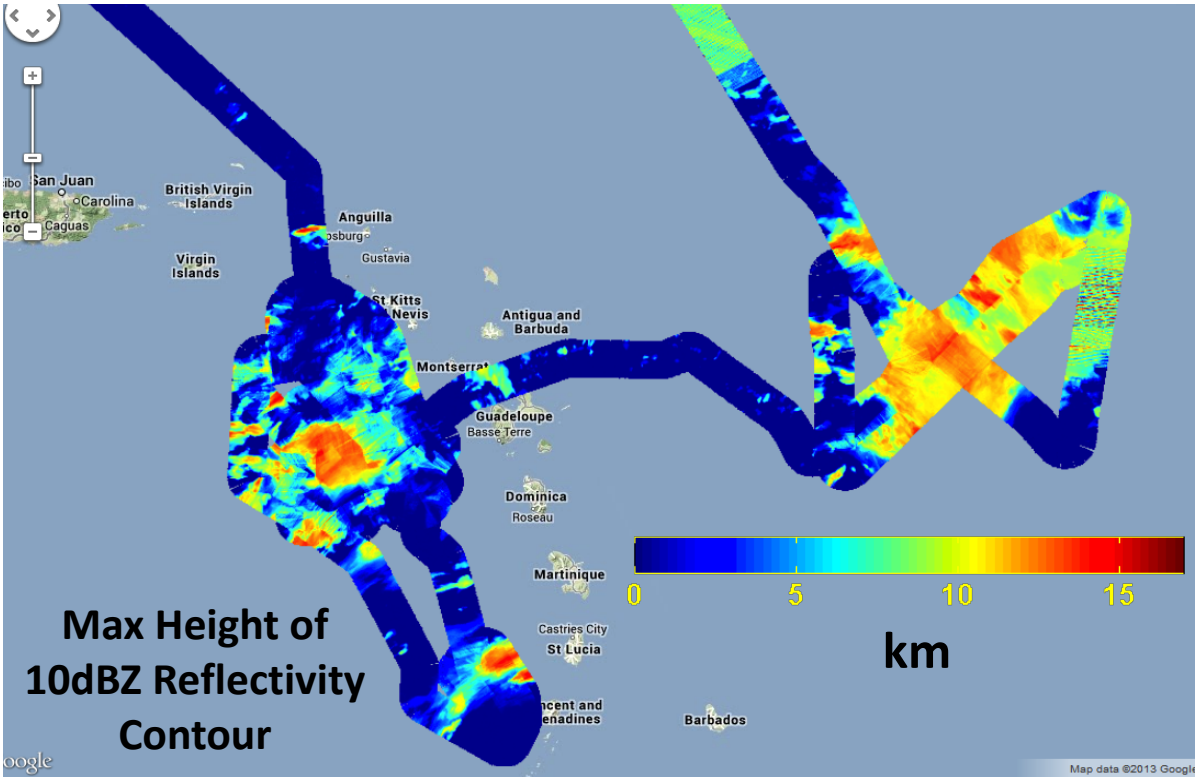

Total Precipitable Water (cm)
0
2
4
6
Maryland
New Jersey
West Virginia
Delaware
Virginia
North Carolina
South Carolina
Georgia
Florida
Bermuda
The Bahamas
Cuba
Turks and Caicos Islands
Cayman Islands
Haiti
Dominican Republic
Jamaica
Puerto Rico
British Virgin Islands
Antigua and
Dominica
St Lucia
Barbados
Grenada
Caribbean Sea
Aruba
Curacao


British Virgin Islands
Anguilla
Gustavia
Virgin Islands
Antigua and Barbuda
Guadeloupe
Basse Terre
Map
Dominica
Roseau
Martinique
Castries City
St Lucia
Barbados
0
10
20
30
40
50
dBZ
6km HAMSR Derived Reflectivity


San Juan
Carolina
Caguas
British Virgin Islands
Anguilla
Gustavia
Virgin Islands
Antigua and Barbuda
Guadeloupe
Basse Terre
Dominica
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Castries City
St Lucia
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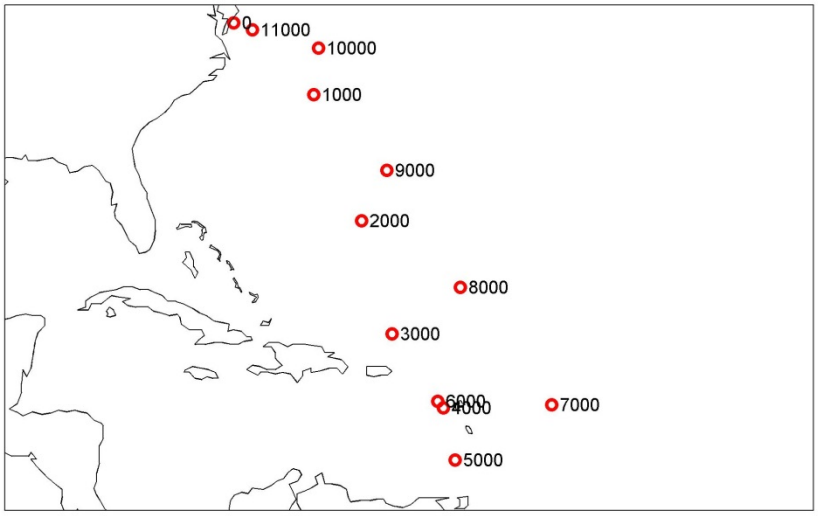
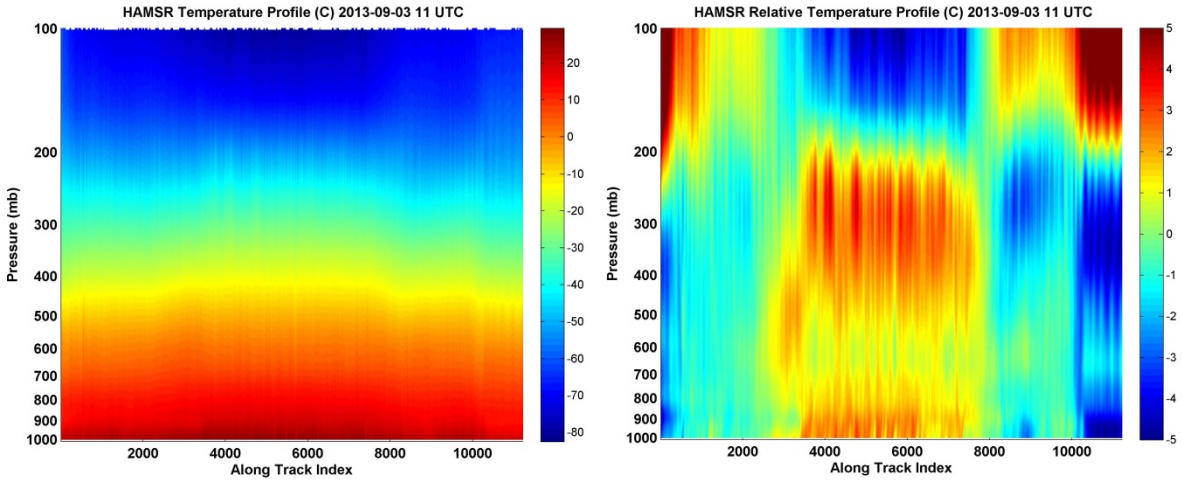
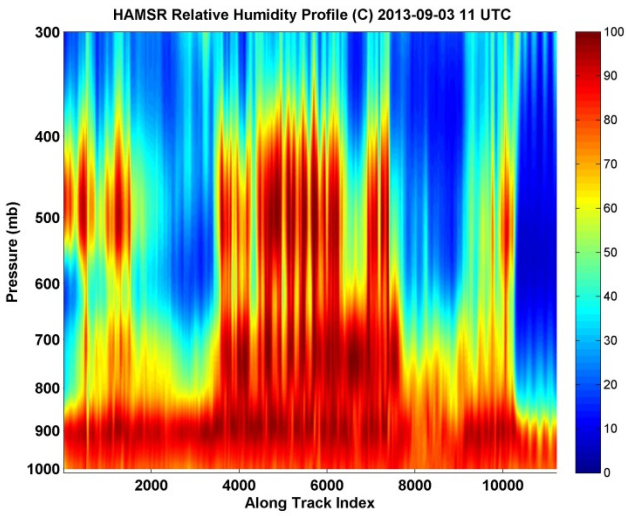
0
5
10
15
km
Max Height of 10dBZ Reflectivity Contour
Map data ©2013 Google



Lat/Lon locations corresponding to the along track index in the profile plots.



Temperature profile (left) and temperature differenced from the mean for the entire flight (right) showing relative temperature differences at each level.



Relative humidity profile for the flight

HIRAD Summary

HIRAD collected data throughout the flight, with real-time imagery generated at NSSTC. This imagery only has rough initial calibrations, and is primarily for monitoring by the HIRAD team. Antenna pattern corrections were applied from clear, calm ocean scenes before and after the weather portions of the flight. The target was not suitable for HIRAD, because of its weak winds below HIRAD's retrieval limits. HIRAD could see that there was wind and rain in both of the targets (generally west of Antigua and east of Antigua). The stronger HIRAD signal was from the eastern of the two targets (Figure 1-2).

HIRAD generated more heat than it could dissipate. The receivers initially cooled to the point that the heaters came on, holding receiver temperatures stable near the set-points from about 1600-2200 UTC (some remained stable longer). Afterwards, receiver temperatures steadily rose until near the end of the flight. The instrument's FPGA temperature reached 80 C near the end of the flight, the temperature at which we begin looking to power down as a precaution. In subsequent flights, we will consider changing the heater set-points in order to maintain stability longer, and consider powering down the instrument for a short period(s) outside the science portion of the flight.

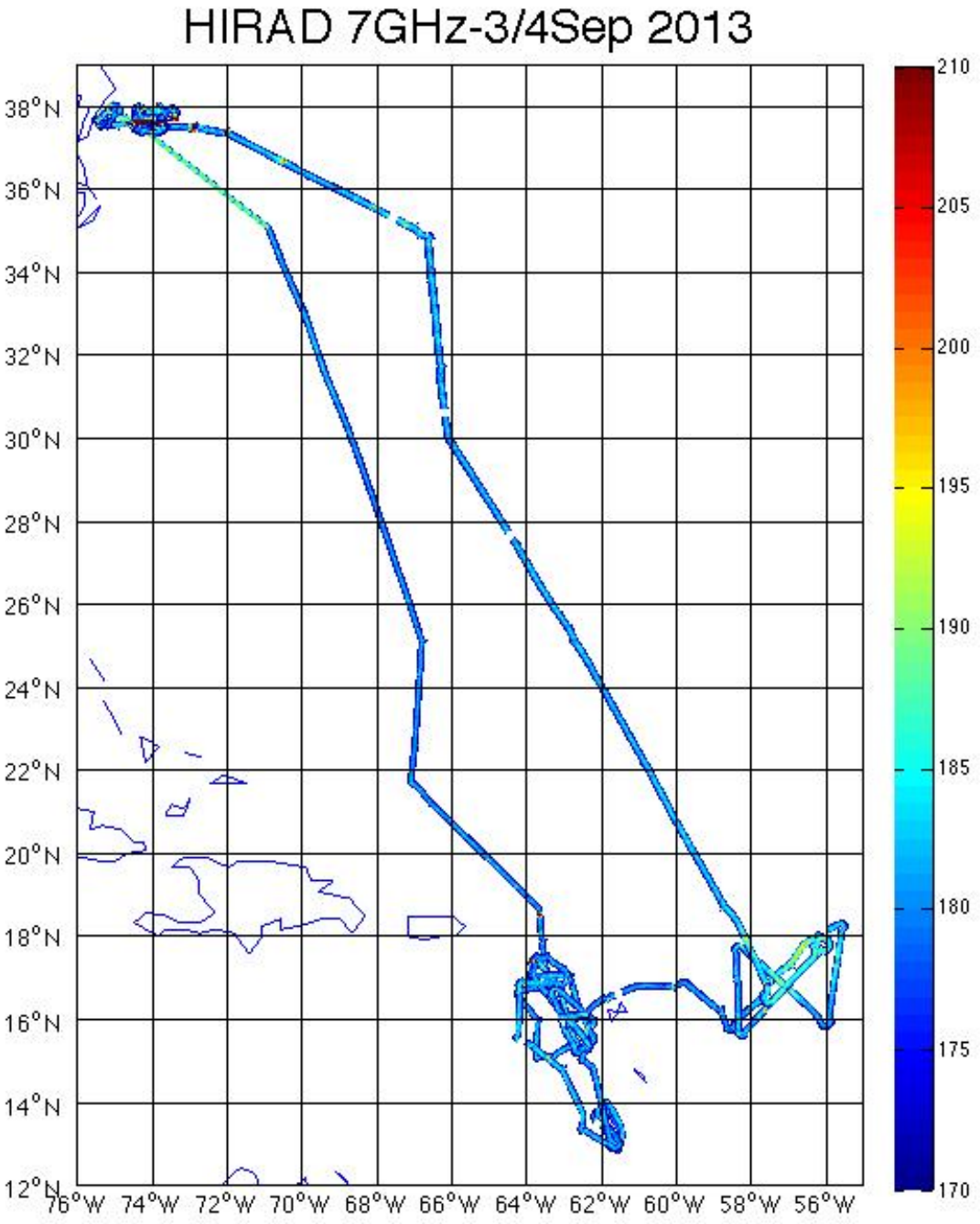


Figure 1. HIRAD 7 GHz brightness temperatures for 3-4 September science flight, using an early calibration of the real-time data stream.

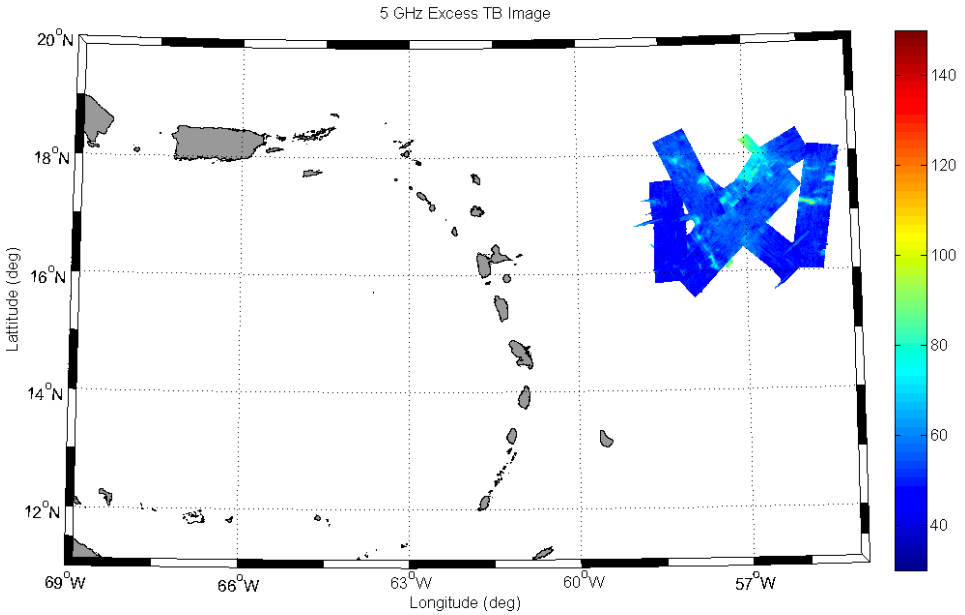


Figure 2. Initial excess brightness temperature (excess from that predicted for a clear, calm ocean scene) for the eastern target in the 3-4 Sep. science flight. Image generated from the full data (post-flight), with an early calibration.