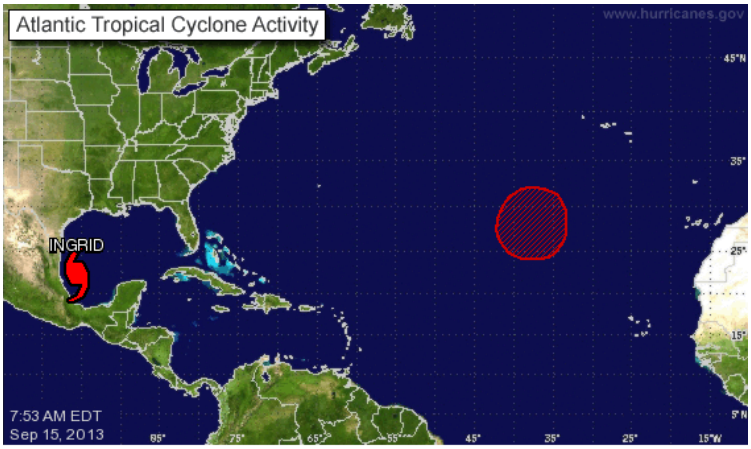
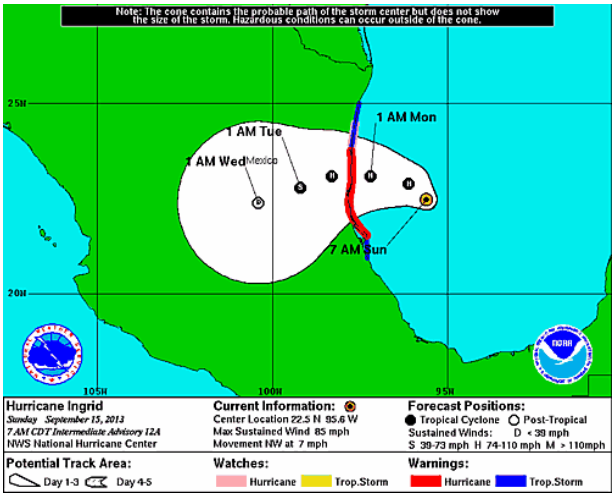
**Hurricane and Severe Storm Sentinel (HS3) Mission**

**HS3 2013.09.15-16 Flight Report: GLOBAL HAWK AV-1 mission to Hurricane Ingrid**

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 the sample the convection in Cat. 1 Hurricane Ingrid. Ingrid's intensity is currently 75 kts, 986 mb, with a northwest motion of 6 kts.




The NHC track forecast shows the storm making landfall Monday morning, show we should have the storm offshore for the entire AV-1 flight.

The NHC discussion at 0800 UTC is shown below:

HURRICANE INGRID DISCUSSION NUMBER 12
NWS NATIONAL HURRICANE CENTER MIAMI FL AL102013
400 AM CDT SUN SEP 15 2013

ALTHOUGH THE CLOUD PATTERN OF INGRID IS SOMEWHAT RAGGED-LOOKING...
THE CYCLONE IS PRODUCING VERY STRONG DEEP CONVECTION WITH NUMEROUS
CLOUD TOPS COLDER THAN -80C. DVORAK INTENSITY ESTIMATES FROM TAFB
AND SAB ARE UNCHANGED FROM THE PREVIOUS CYCLE...AND THE CURRENT
INTENSITY ESTIMATE IS HELD AT 75 KT. A NOAA HURRICANE HUNTER
AIRCRAFT IS INVESTIGATING INGRID AND WILL SOON PROVIDE MORE PRECISE
INFORMATION ABOUT THE INTENSITY...BUT PRELIMINARY OBSERVATIONS FROM
THAT AIRCRAFT SUGGEST THAT THERE HAS BEEN NO RECENT INCREASE IN THE
WINDS. INGRID WAS ABLE TO STRENGTHEN DESPITE THE PRESENCE OF
MODERATE TO STRONG WESTERLY SHEAR. GLOBAL MODELS INDICATE SOME
RELAXATION OF THE SHEAR IN A DAY OR SO...SO SOME ADDITIONAL
STRENGTHENING SEEMS LIKELY PRIOR TO LANDFALL. THE OFFICIAL WIND
SPEED FORECAST IS SIMILAR TO THE PREVIOUS ONE AND IS CLOSE TO THE
STATISTICAL-DYNAMICAL LGEM GUIDANCE.

ALTHOUGH THE CENTER IS DIFFICULT TO LOCATE WITH INFRARED SATELLITE
IMAGERY...A VERY RECENT CENTER FIX FROM THE NOAA PLANE INDICATES
THAT INGRID HAS TURNED TOWARD THE NORTHWEST...WITH A MOTION
ESTIMATE OF 315/6. FOLLOWING THE FLOW ON THE SOUTH SIDE OF A
MID-LEVEL RIDGE...THE HURRICANE IS EXPECTED TO TURN TOWARD THE WEST
AS IT APPROACHES THE COAST. NO IMPORTANT CHANGES HAVE BEEN MADE TO
THE TRACK FORECAST OR REASONING FROM THE PREVIOUS ADVISORY PACKAGE.
THE OFFICIAL FORECAST LIES IN BETWEEN THE ECMWF AND GFS SOLUTIONS
AND IS CLOSE TO THE LATEST HWRF MODEL FORECAST.

IN ADDITION TO THE WIND AND STORM SURGE THREATS...THE MOIST FLOW
RESULTING FROM THE COMBINATION OF INGRID AND TROPICAL STORM MANUEL
IN THE EASTERN PACIFIC WILL CONTINUE TO PRODUCE TORRENTIAL RAINS.
LIFE-THREATENING FLOODING OVER EASTERN MEXICO WILL REMAIN A

SIGNIFICANT HAZARD OVER THE NEXT COUPLE OF DAYS.

FORECAST POSITIONS AND MAX WINDS

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INIT  15/0900Z 22.4N  95.4W   75 KT  85 MPH
 12H  15/1800Z 22.9N  96.1W   80 KT  90 MPH
 24H  16/0600Z 23.1N  97.2W   85 KT 100 MPH
 36H  16/1800Z 23.1N  98.3W   70 KT  80 MPH...INLAND
 48H  17/0600Z 22.8N  99.2W   35 KT  40 MPH...INLAND
 72H  18/0600Z 22.4N 100.4W   20 KT  25 MPH...POST-TROP/REMNT
LOW
 96H  19/0600Z...DISSIPATED

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FORECASTER PASCH
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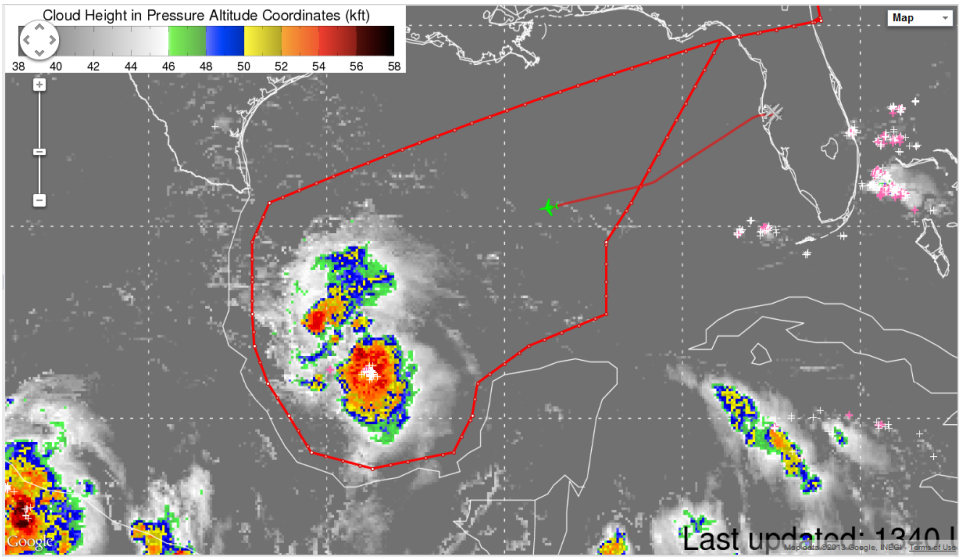
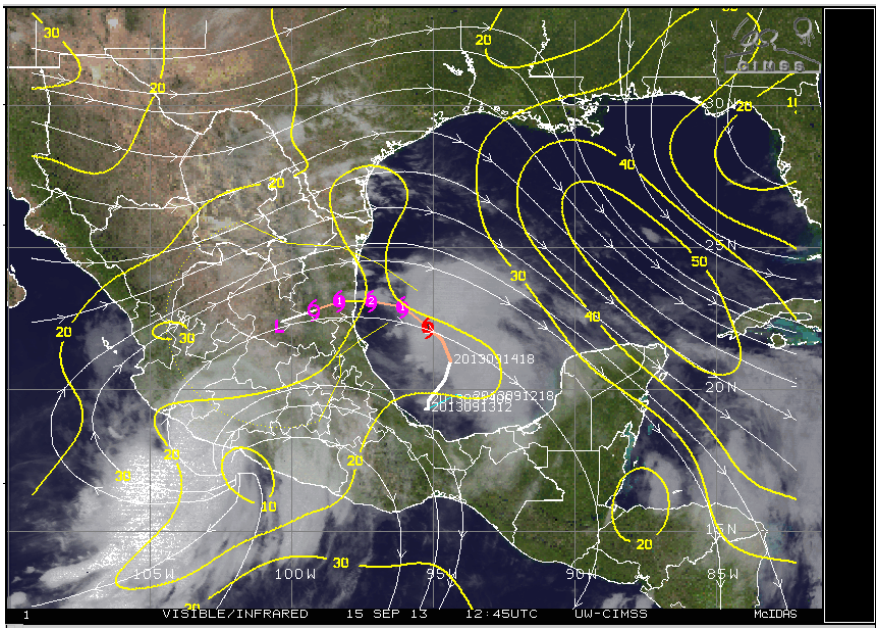
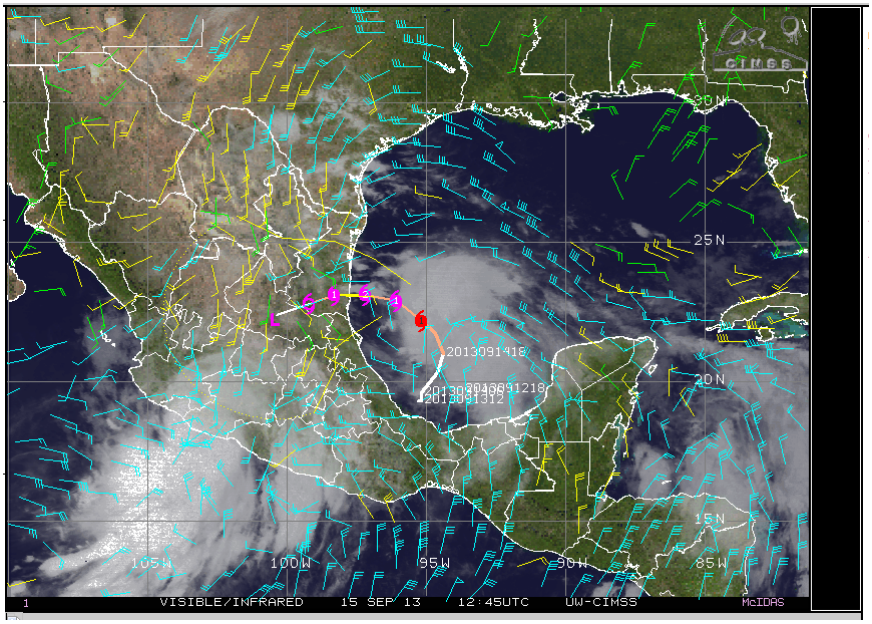


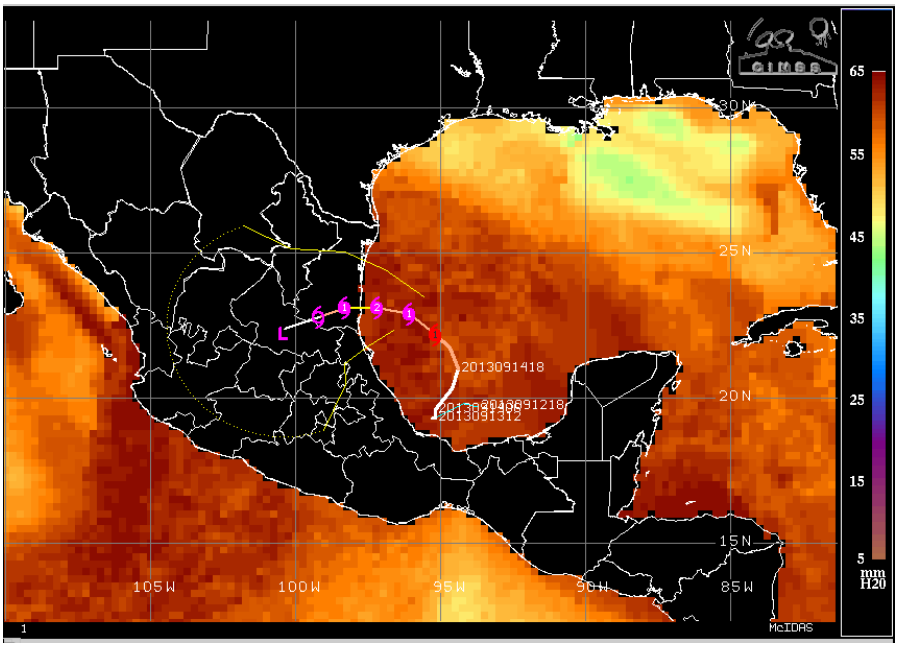

Convection in Ingrid is currently quite intense with tops up to 56 kft and lots of lightning southeast of the center (currently at 22.5N, 95.6W). The cloud system to the northwest of the center had been lowering (warming) earlier but now looks like a new cell is pushing up to 54-56 kft. The NOAA G-IV can be seen heading out to Ingrid as well. NOAA 43 is also expected to get in the storm later in the afternoon.




CIMSS shear product show moderate (20+ kts) westerly shear near the storm. Convection is largely downshear to downshear-left.




Upper-level outflow from Tropical Storm Manuel may be contributing some to the shear over Ingrid. Ingrid's outflow is primarily to the east and south.

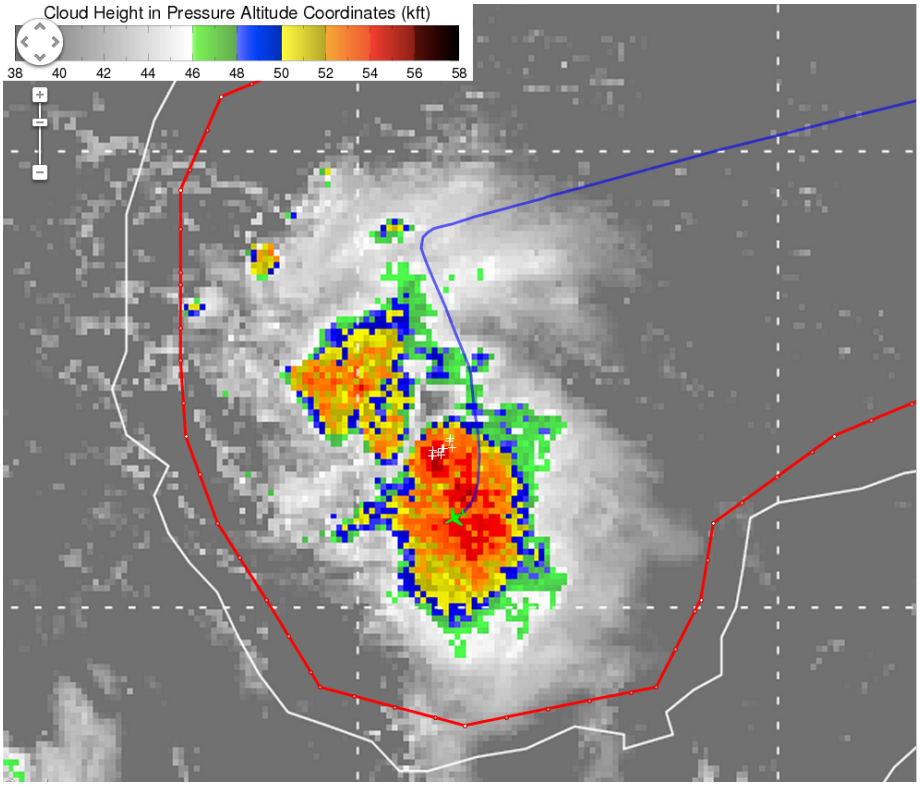



TPW values in the region are high, so moisture availability is good.

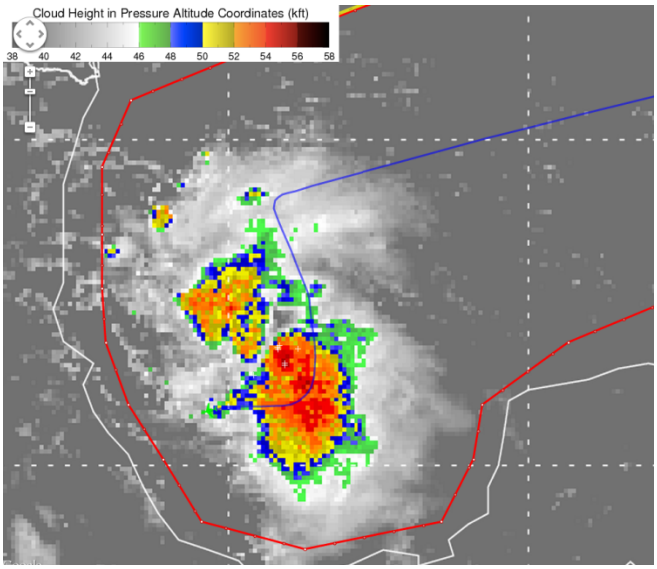
1302 UTC Engine start

1338 Takeoff

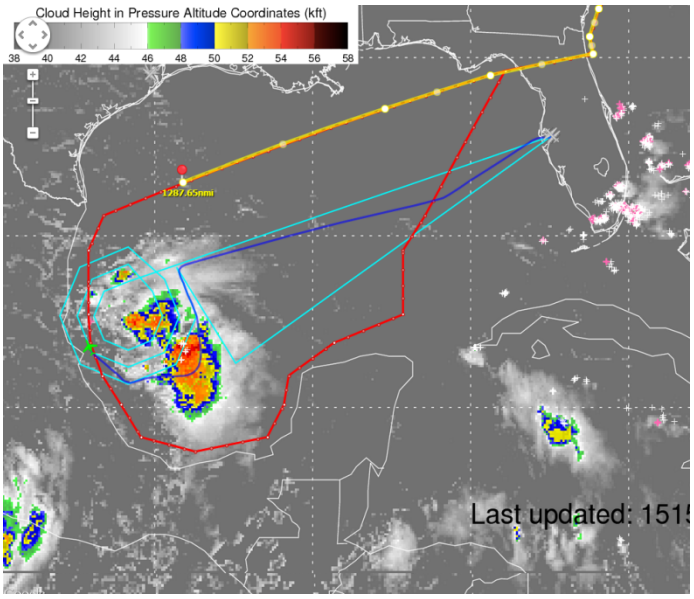
1420 Now heading south.




1507 Screen grab from MTS showing cloud top height and position of NOAA G-IV, flying below the anvil cloud tops on south lobe of system (aircraft altitude 41878 ft).

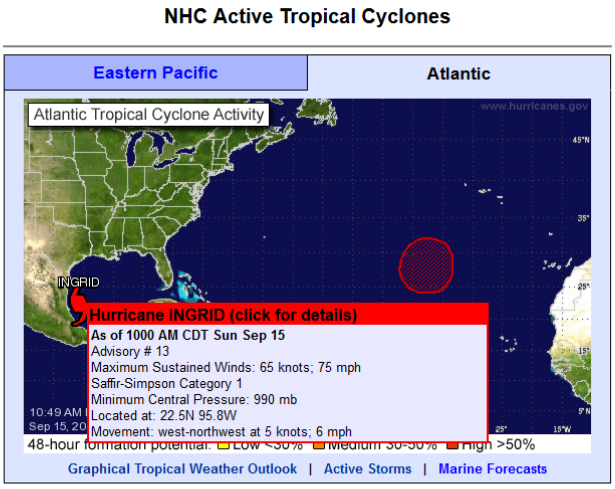



1518 Here the G-IV comes out of the system, turning toward south.

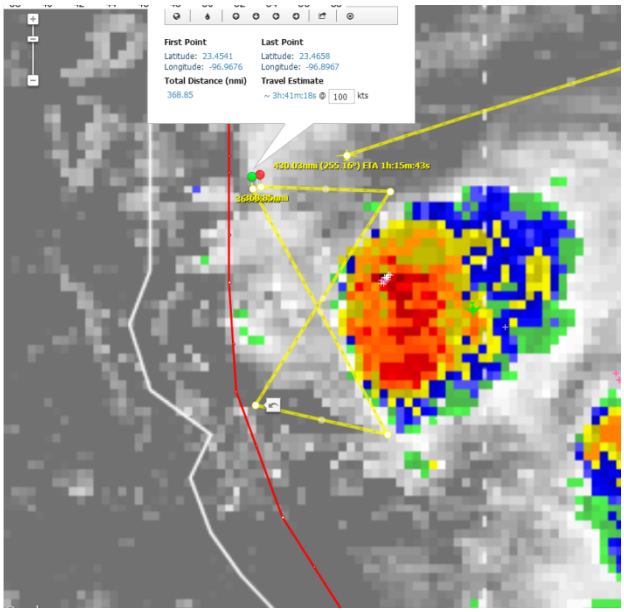



1536 And now can see G-IV flight track (cyan line) and them beginning spiral pattern. Seems maybe flying backwards of flight track.

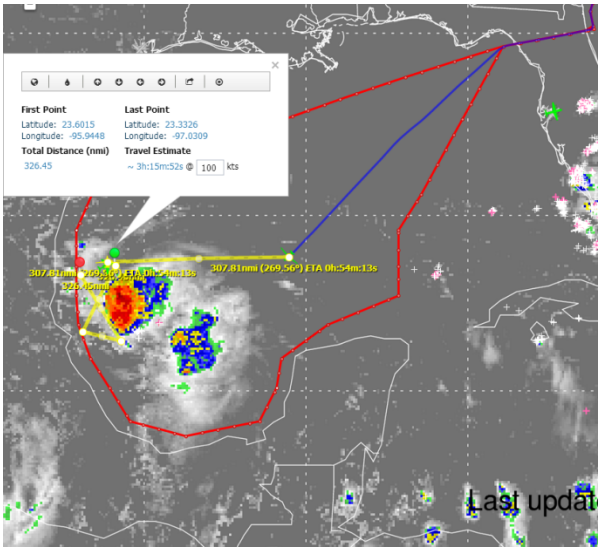
1549 HIWRAP indicates flying over some precip.



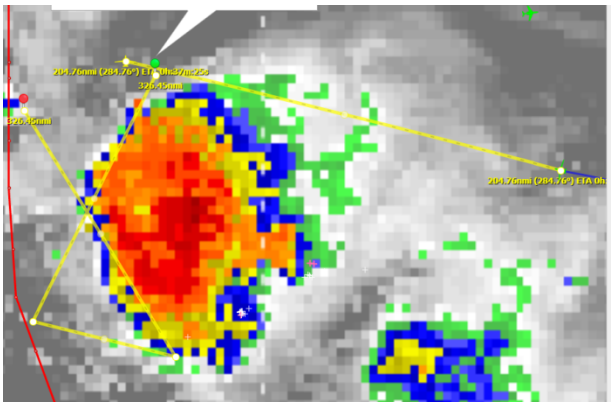

1601 Latest update from NHC shows max sustained winds decreasing, suggesting storm getting sheared apart.



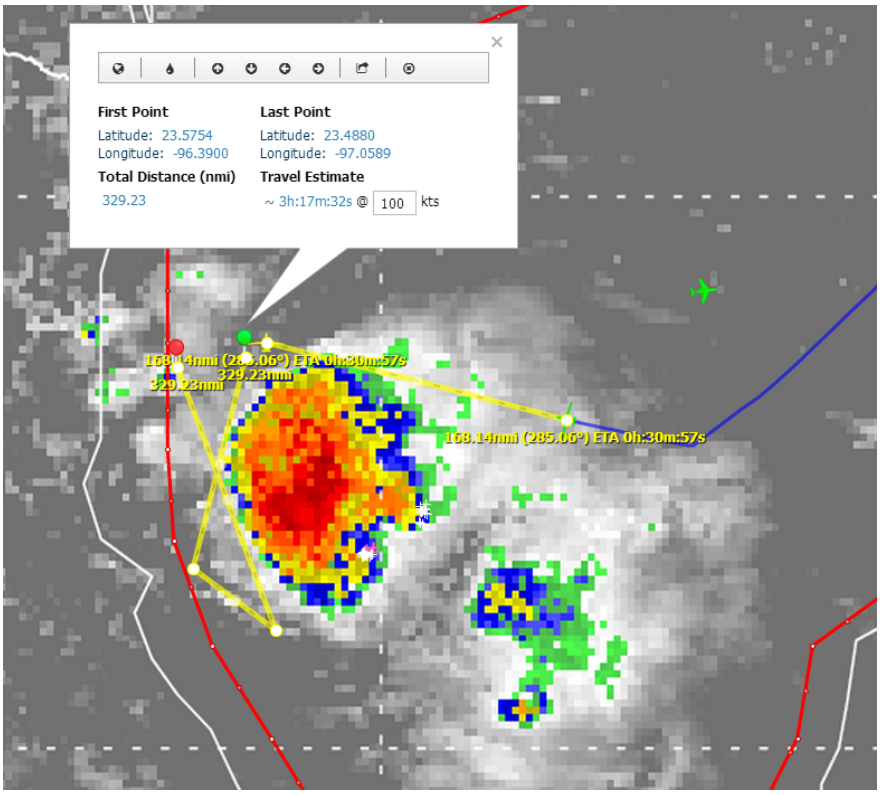

Above: 1738 Cloud tops



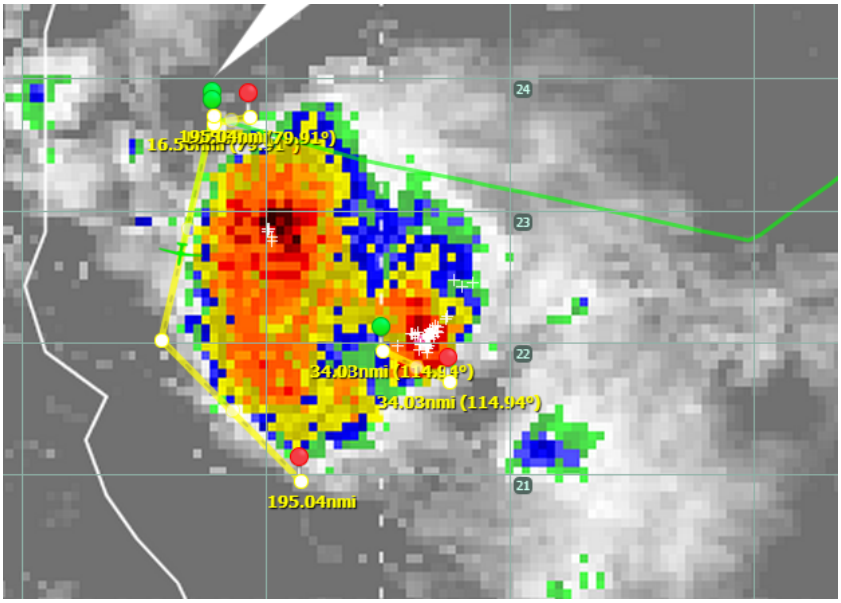

Above: 1805 aircraft position, starting to head westward



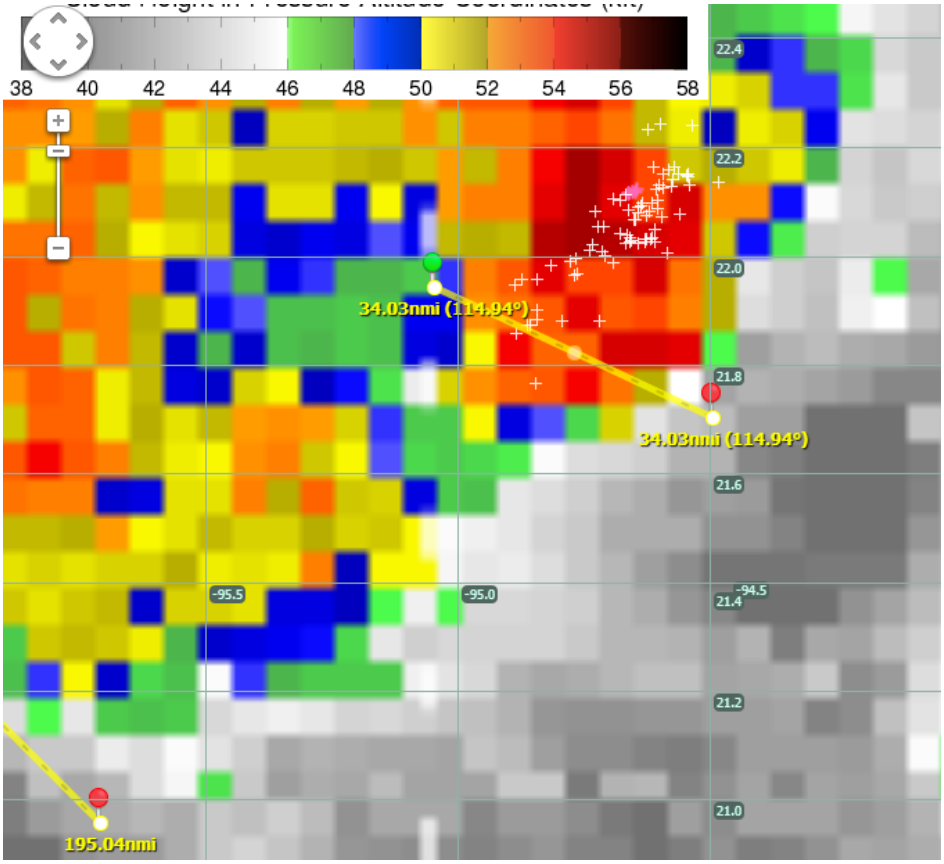
1829 A/C location. Note lightning on SE side of main convection. Plan is not current. See next entry for latest plan.



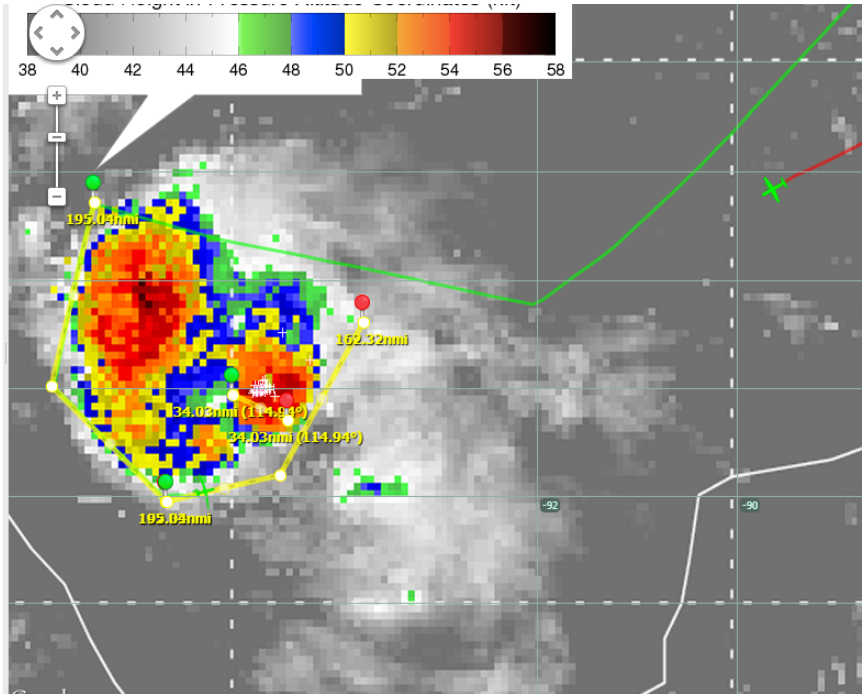

1835 A/C location & current plan. Note lightning on SE side of main convection.



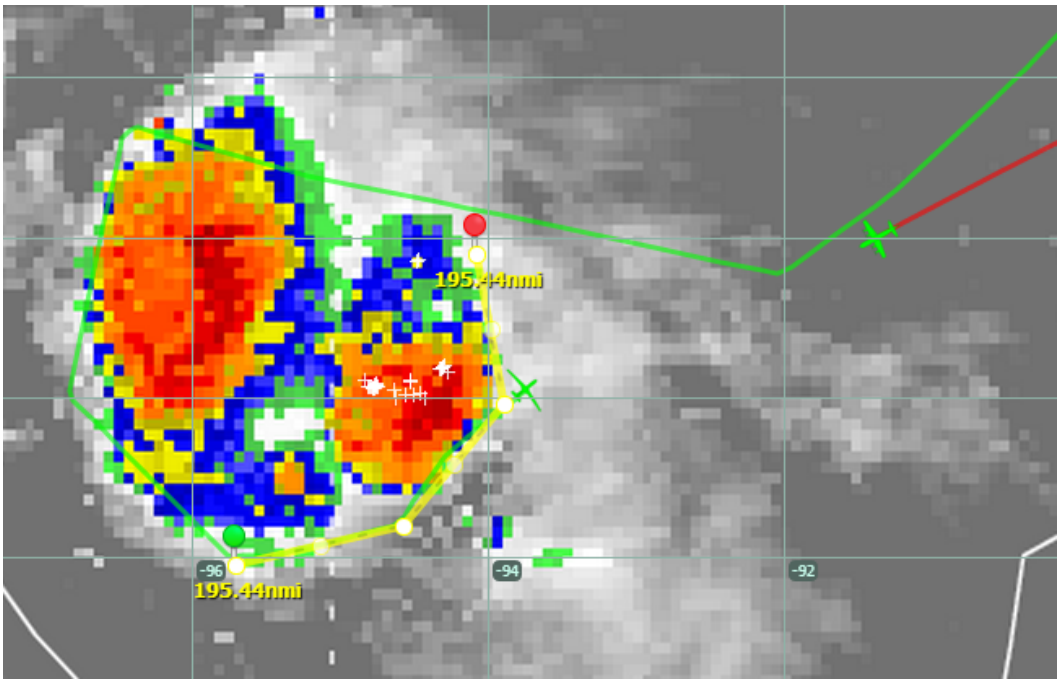

1920 A/C location & current plan.



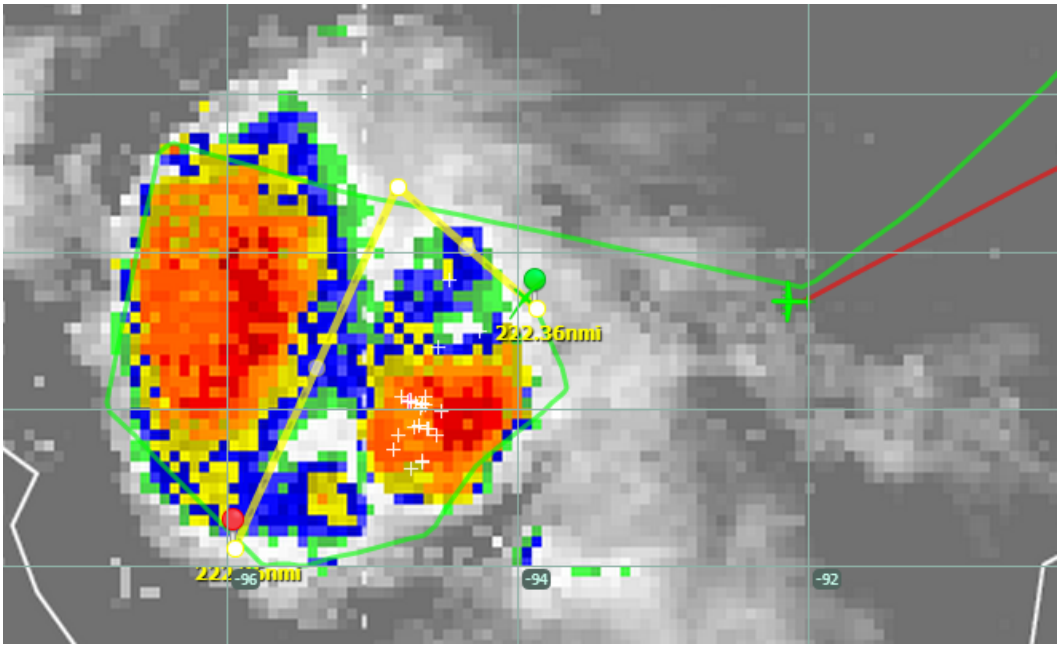
1929 lightning on SE side.



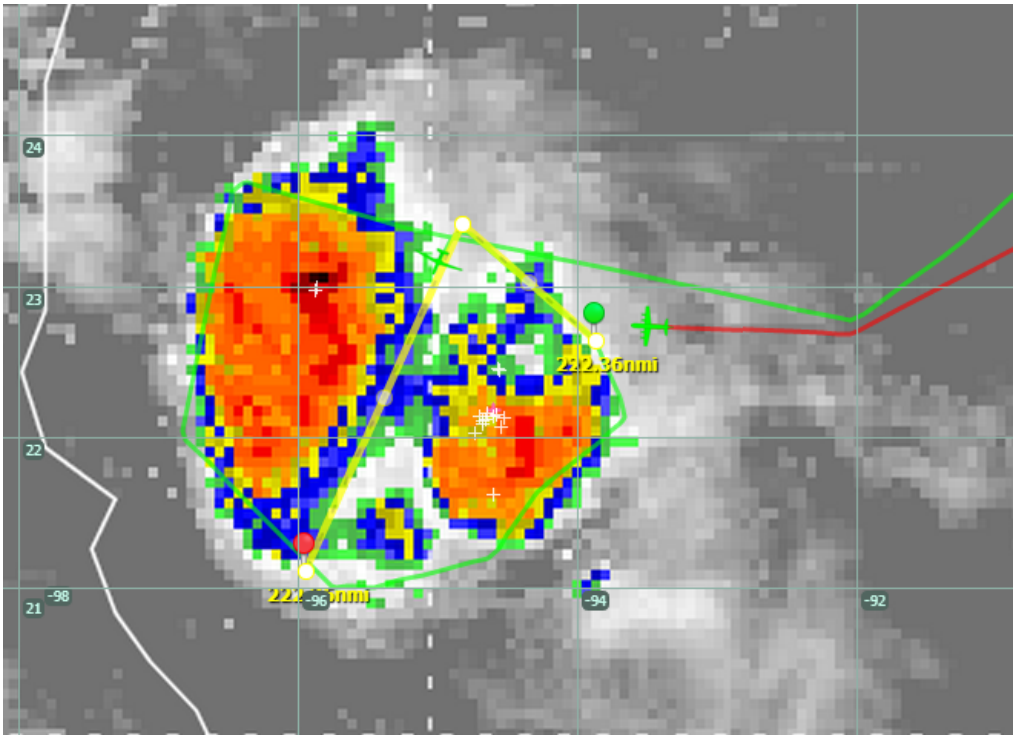

1949 NOAA43 approaching from NE



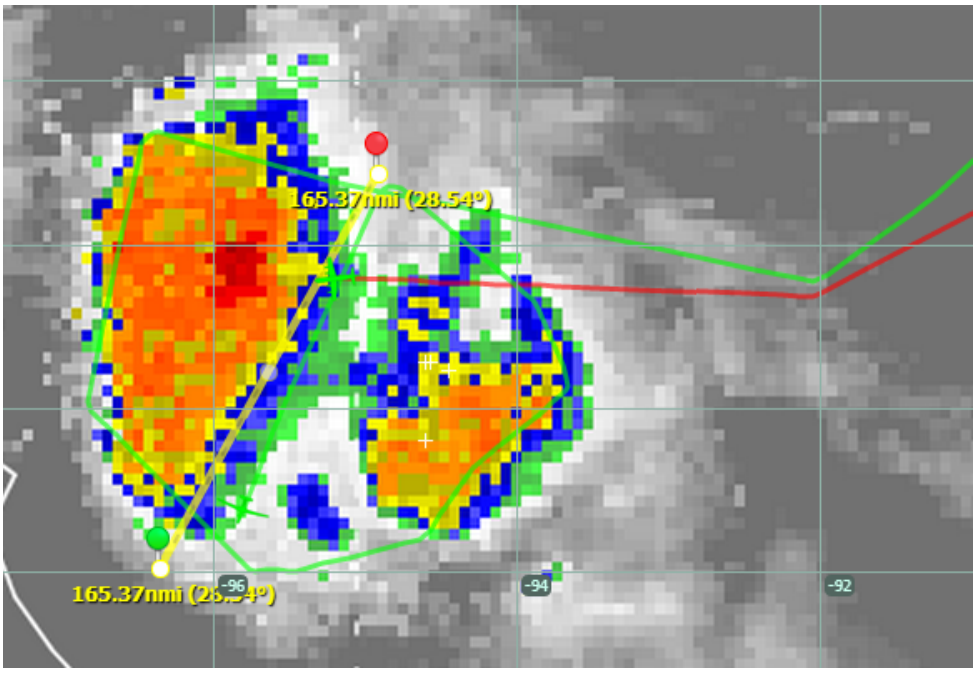

2009 Latest track revision (to avoid lightning)



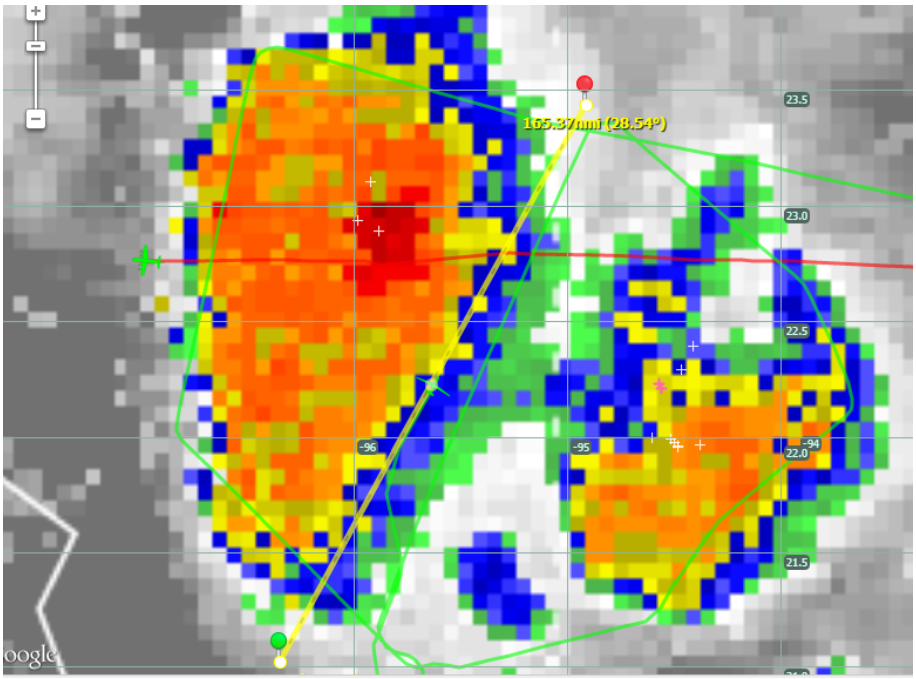

2016 Latest track revision



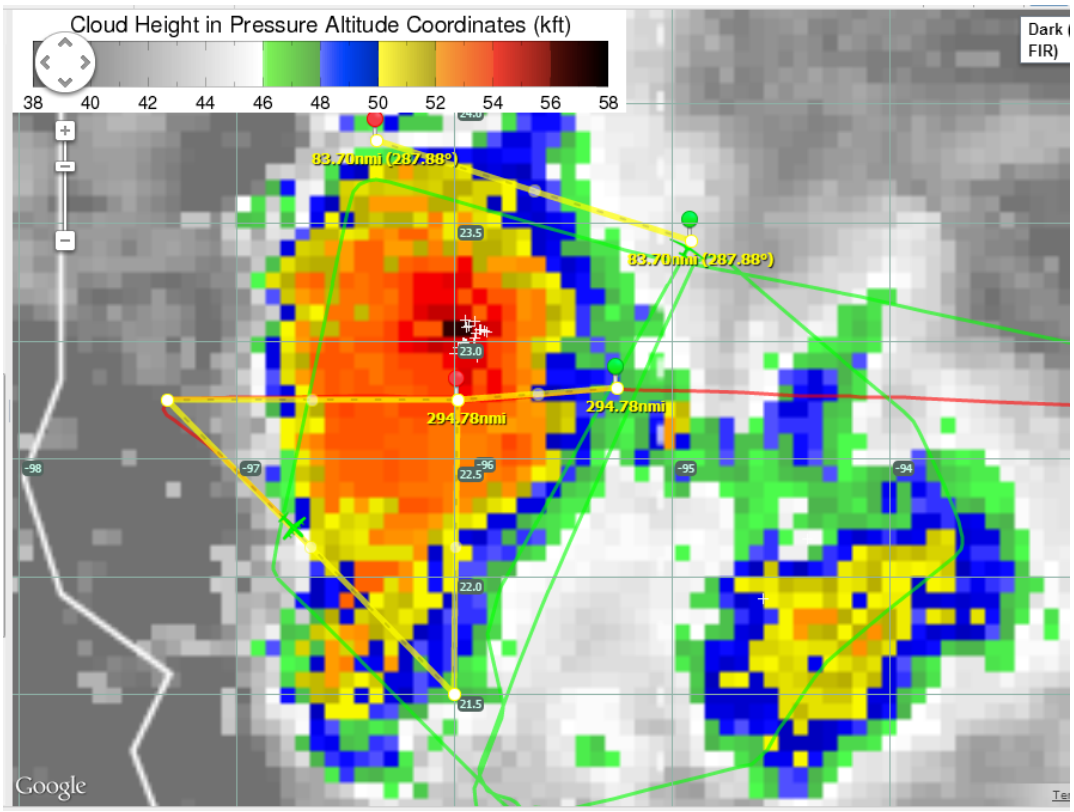

2032 A little bit of lightning in the high top to the west of the track.



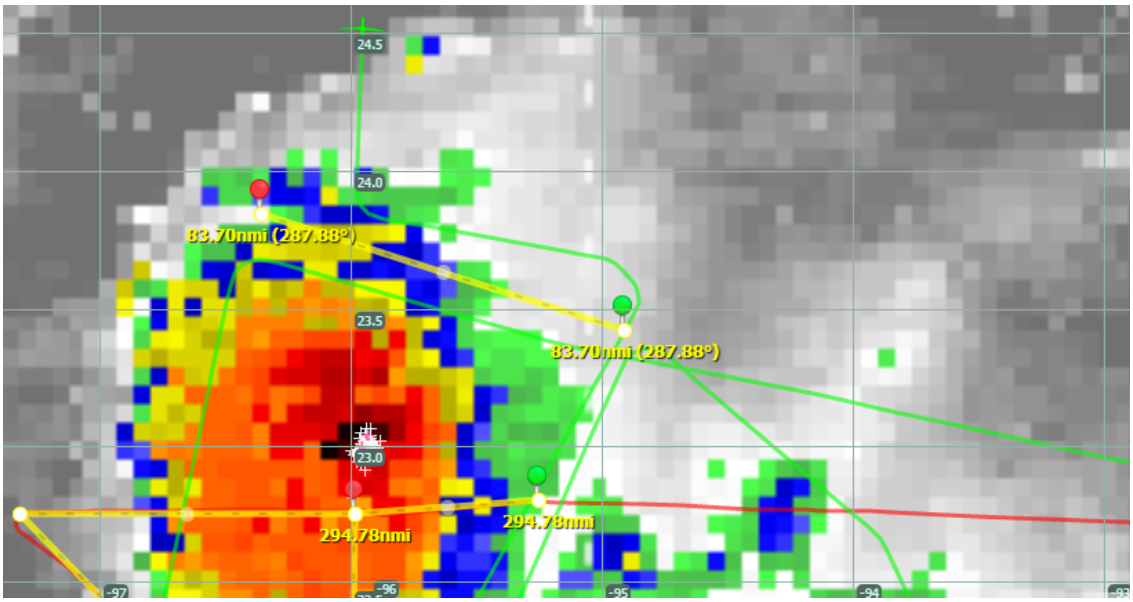

2054 latest track for AV1. P3 near middle of pattern



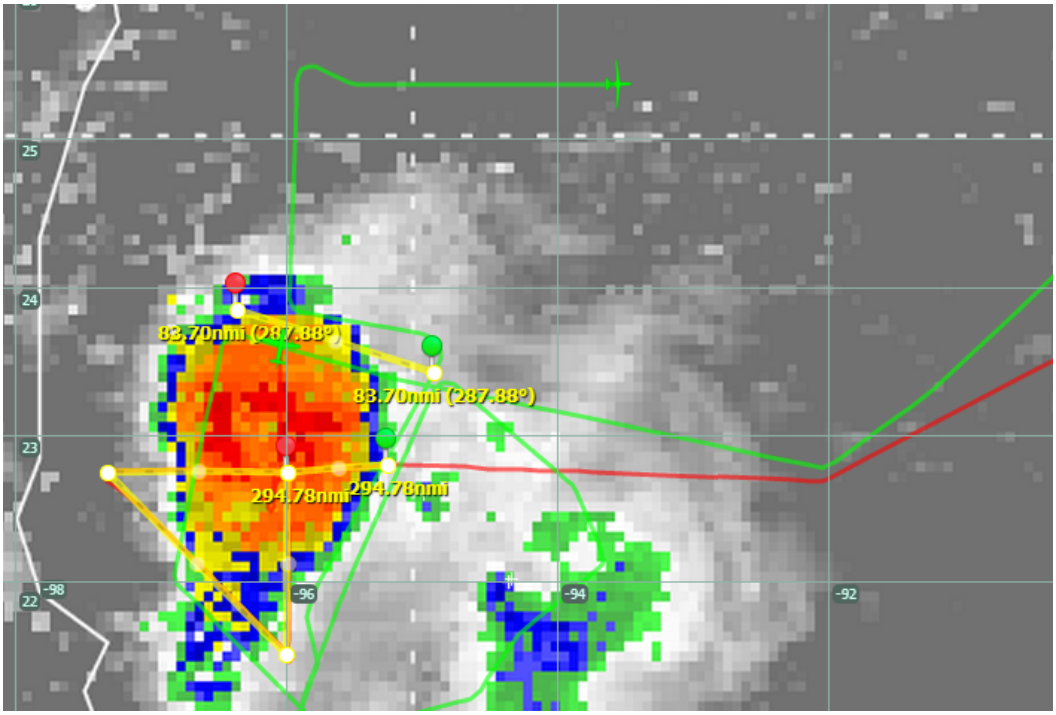

2119




2134 P3 Figure 4 pattern and AV1 leg plan on N side. We were requested to keep the plane to the north for warmer conditions at flight level. P3 found center near the middle of their Figure 4.

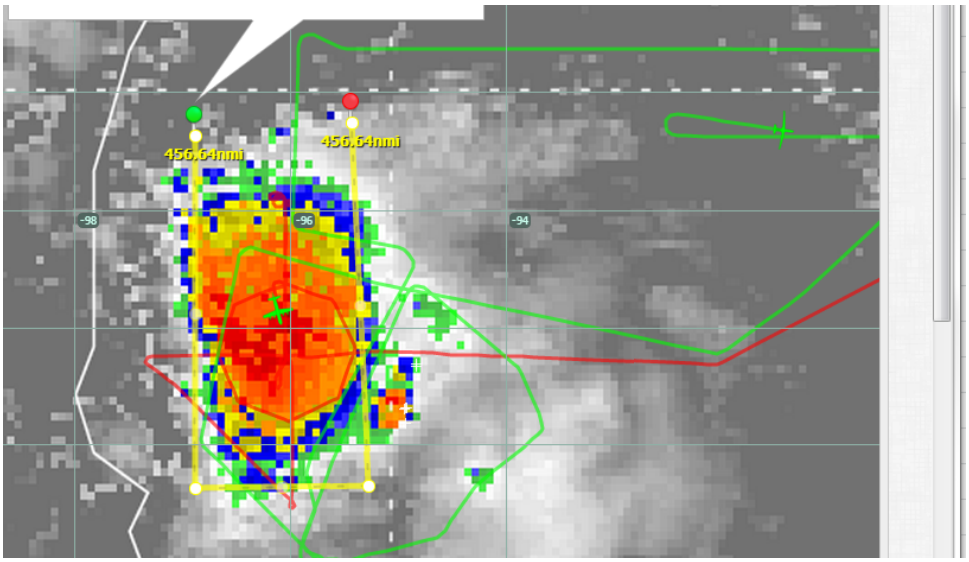



2155 AV1 headed north to get into warmer air; fuel too cold. Lightning increasing. Fuel is at -38degC, which is within 2 degrees of a “red line” fault. They want to avoid an RTB scenario. Their heater is on.

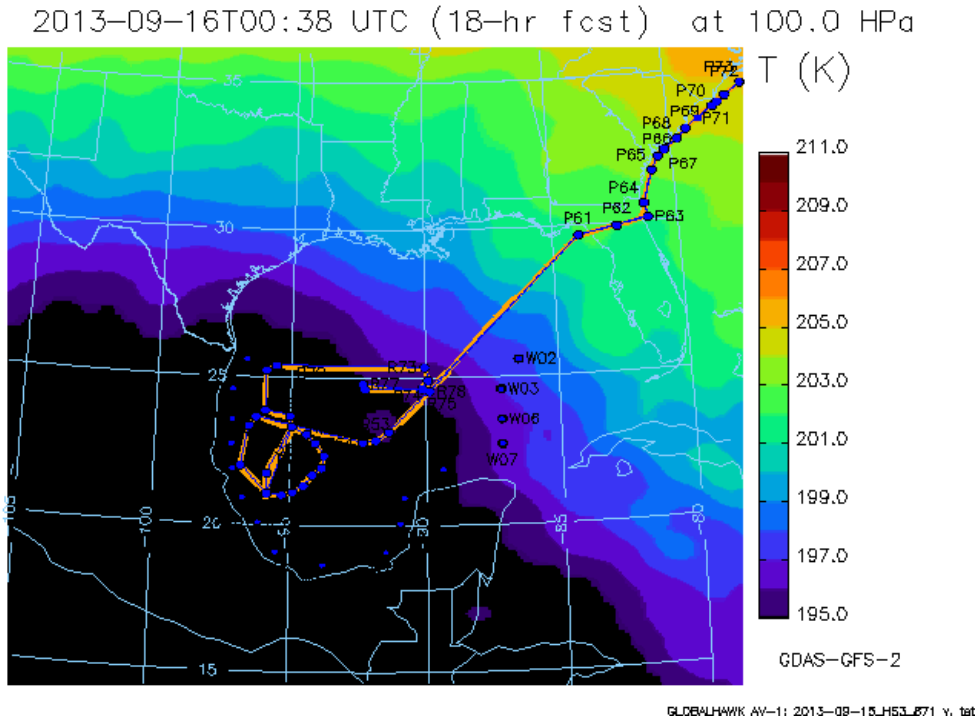



2230 AV1 still heading east in search of warm air. Fuel has not warmed up. If it warms up by the time they get to their original outbound track they will head back to the storm; if not, they will RTB.

2233 pilot says fuel starting to warm up. Fuel in wings was colder. They are burning it off. Whatever.



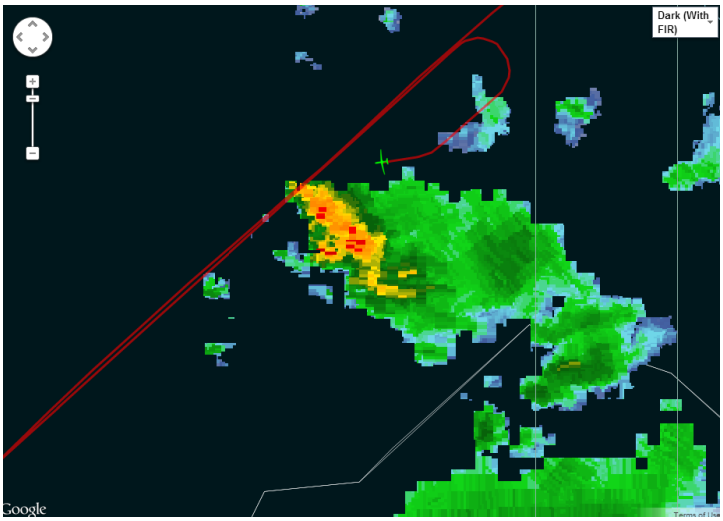
2350 The box around the storm was the planned AV1 track, but the pilots aborted the mission. They are turning back to base. The fuel temperature hit a “red line fault” the temperature gradient at 100 hPa is SW-NE with a minimum over the storm and warmer air to the NE. When they got back to the region of lower temperature, the fault occurred. SEE NEXT FIGURE.



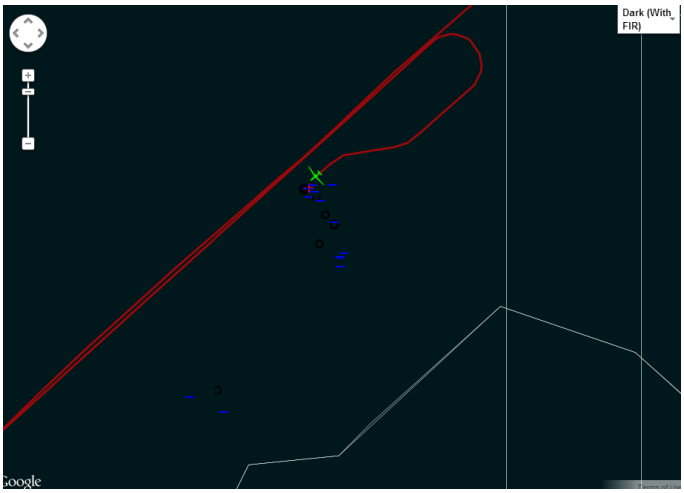

This is this AV1 track superposed on the 100 hPa temperature pattern

Mission Scientists – Paul Newman and Chris Thorncroft

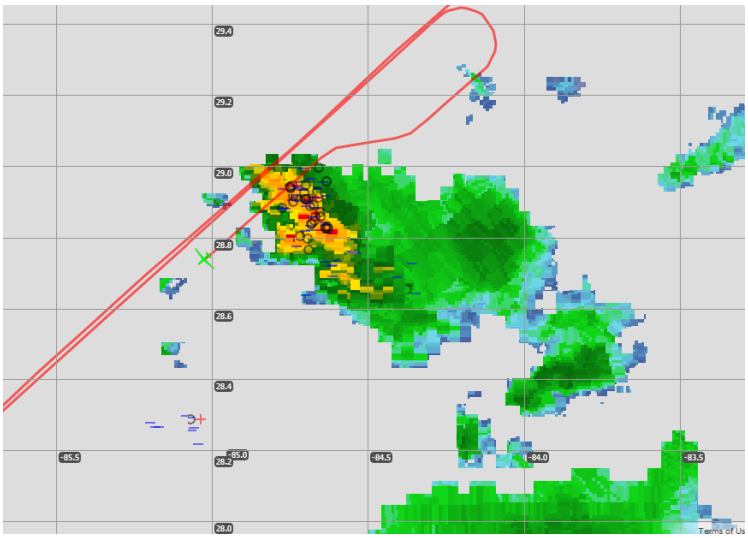
21.29 We have been given permission to deviate from flight track to fly around organized convective system off West coast of Florida.




Last 10 minutes lighting:

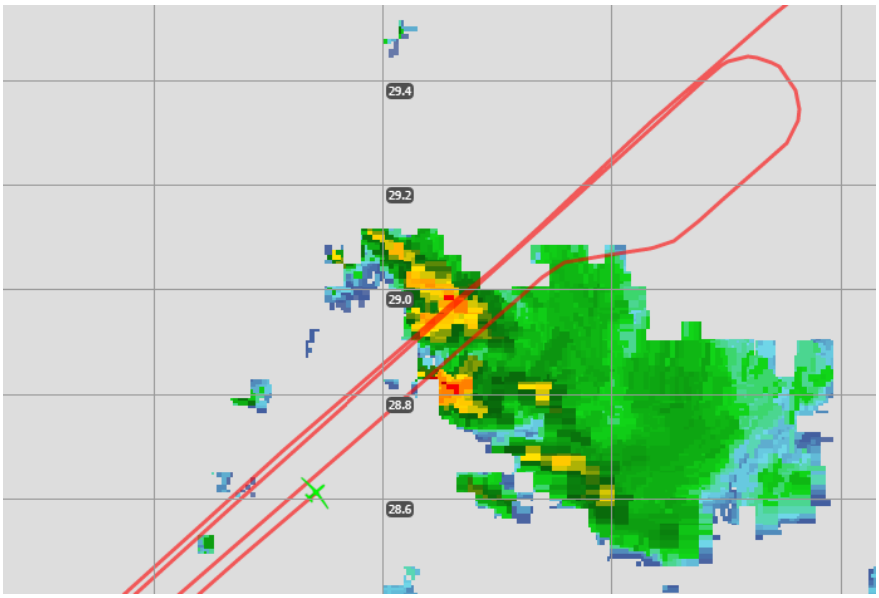



21.43 EDT: Last 10 minutes lightning and radar:

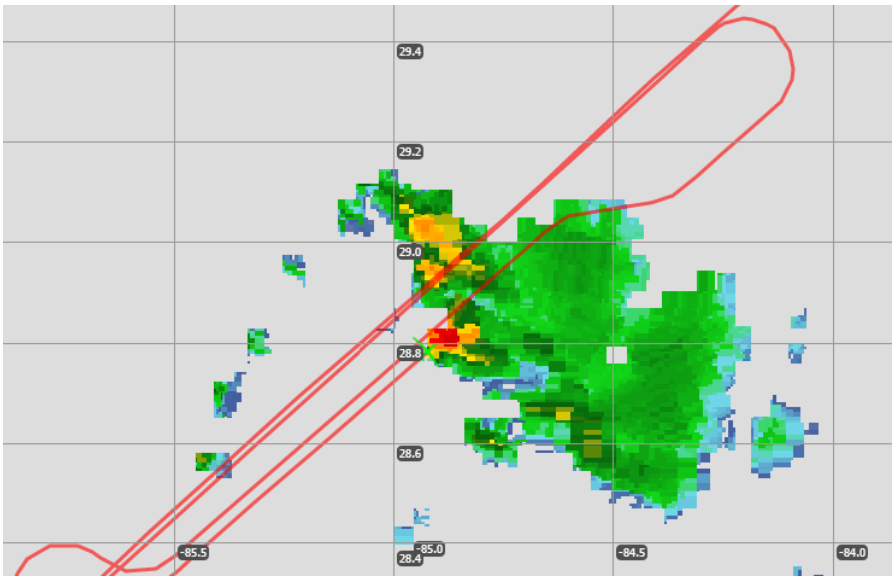


21.51EDT planning to turn and fly through the line again aiming to hit most intense cell SE of original cell.

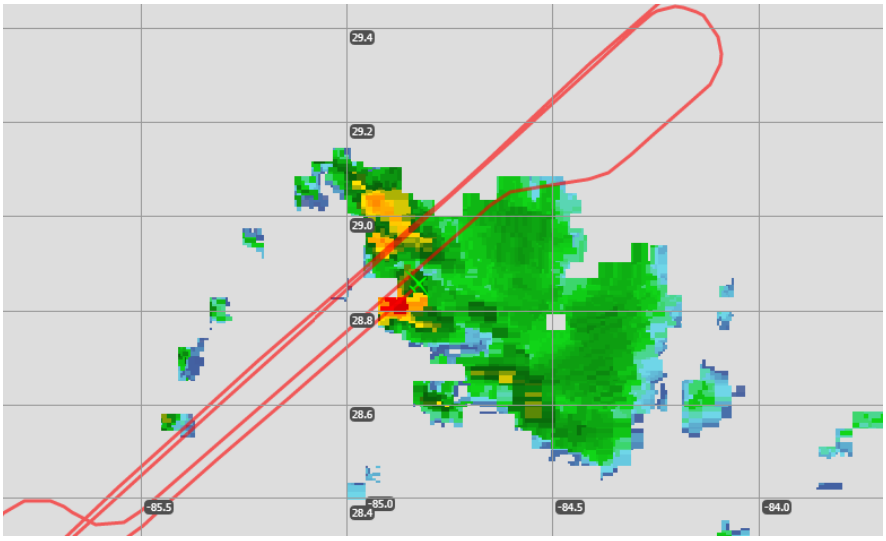
22.01EDT Approaching line, cloud tops near 44kft (Figure shows radar)



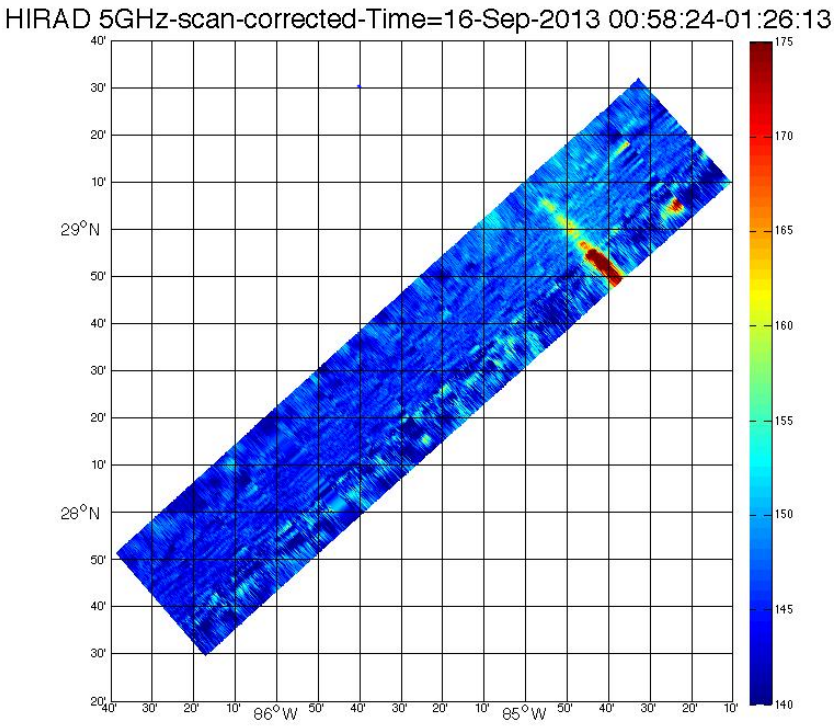

22.04 EDT:

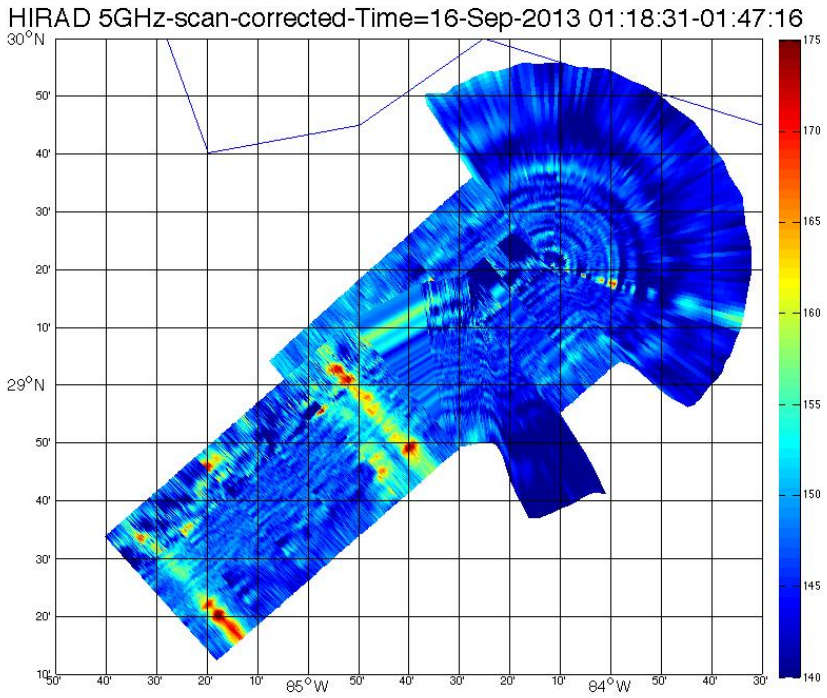


22.05 EDT:

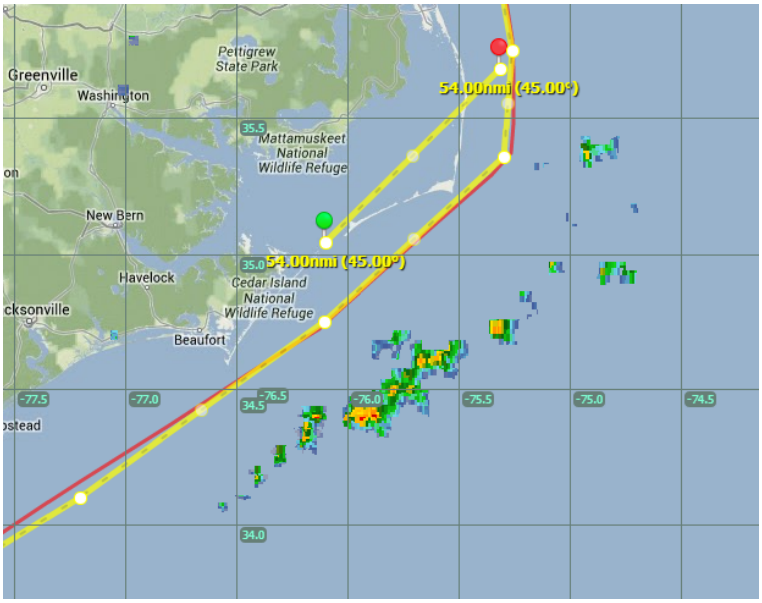



HIRAD images for overpass:



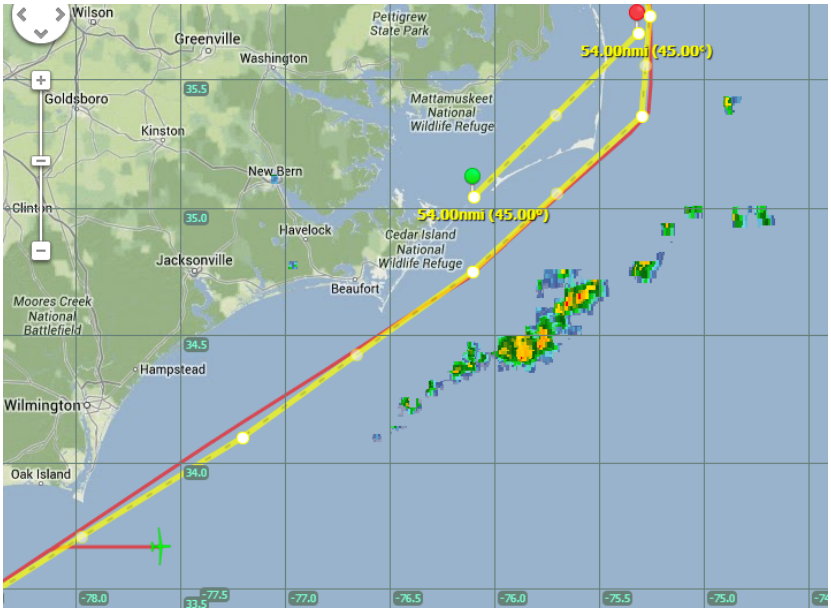



23.16EDT Discussing request to fly along line of convective cells SE of Outer Banks.




23.36EDT Clearance given to fly along convective line

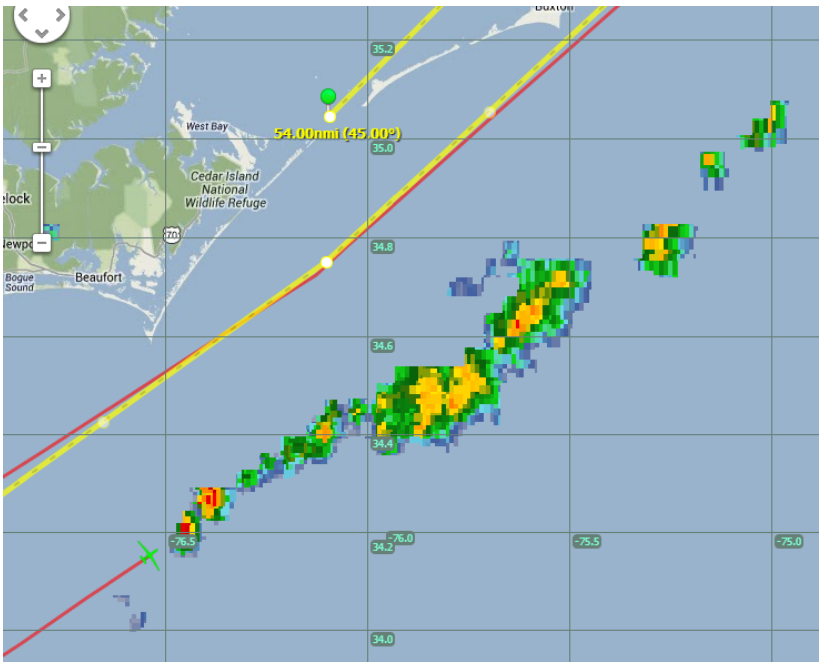
23.43EDT:



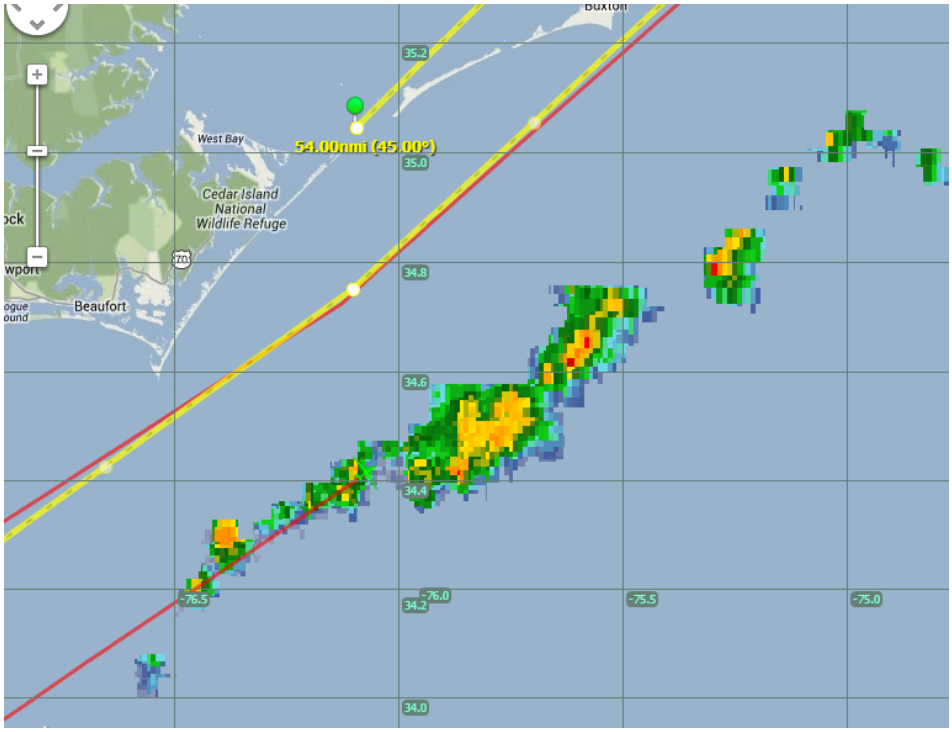

23.49EDT We now plan to do 3 legs through the convective line!

23.52EDT FTC agreed to do the 3 legs!

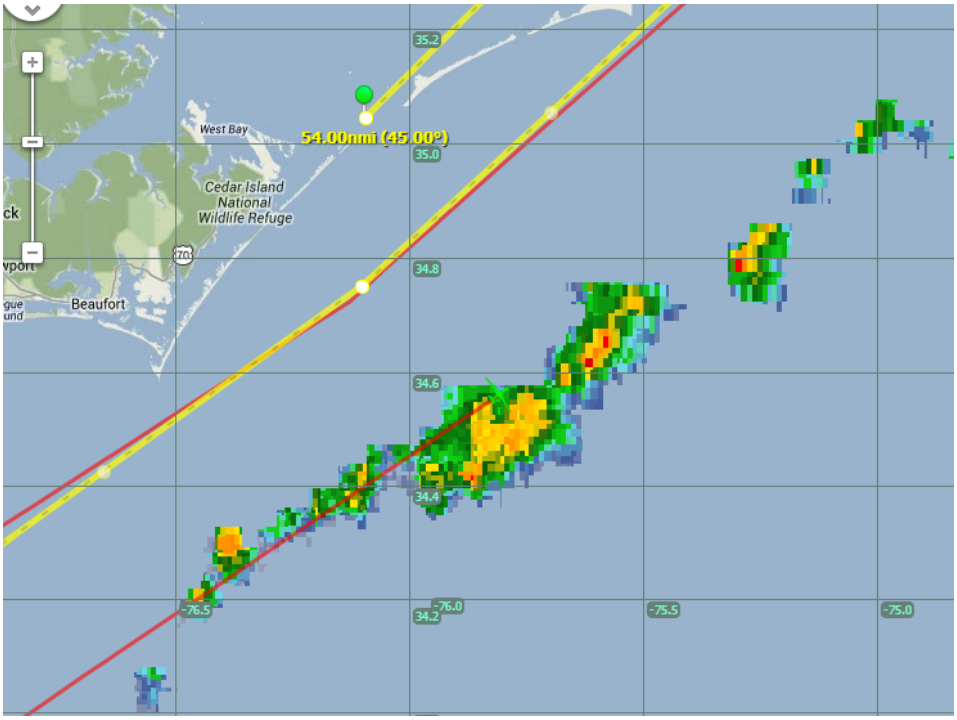
23:53EDT:



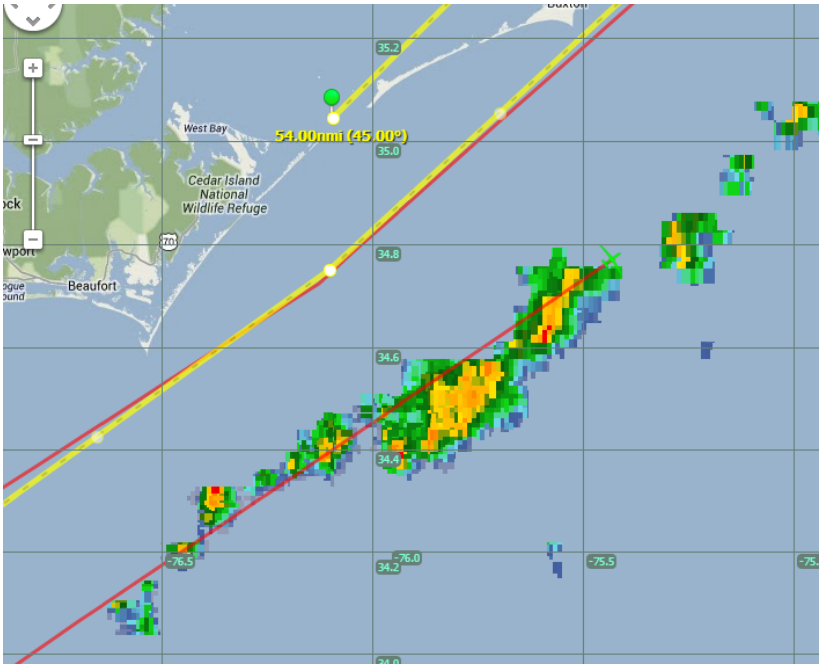
23.58EDT:



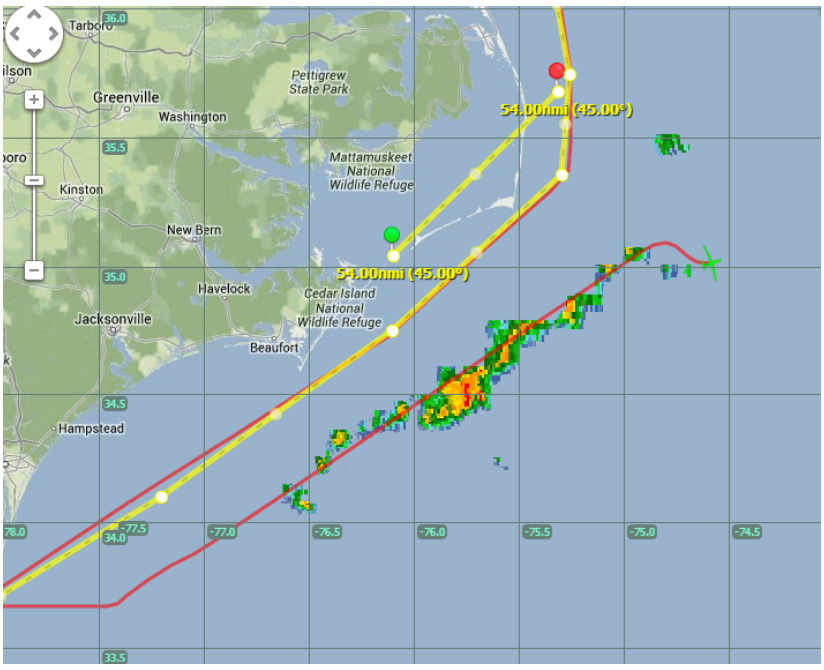

00.01EDT:



00.04EDT:

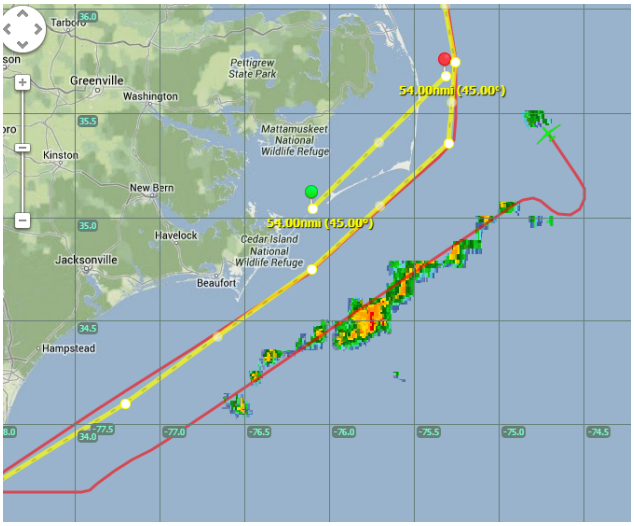



00.13EDT:




00.15EDT: Return leg will be offset by 15 nautical miles towards the land for calibration of HIRAD.

00.19EDT:

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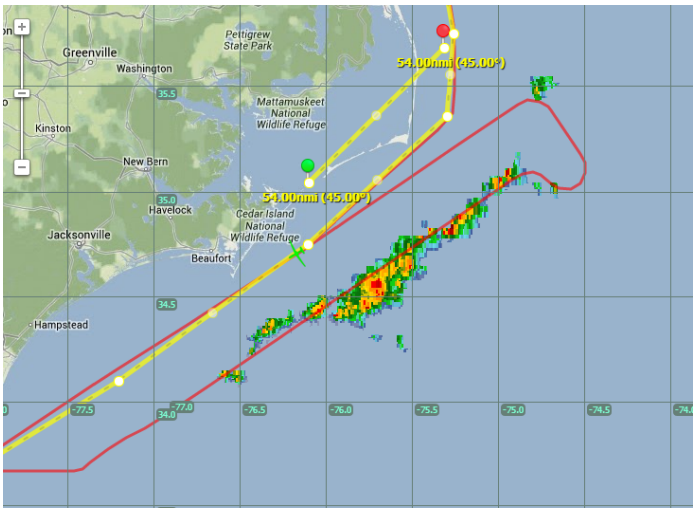
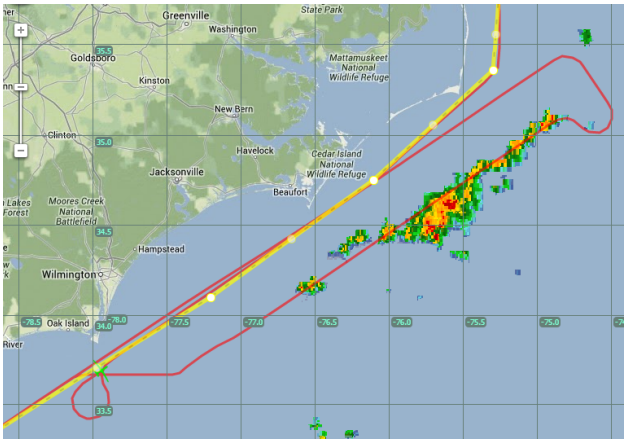
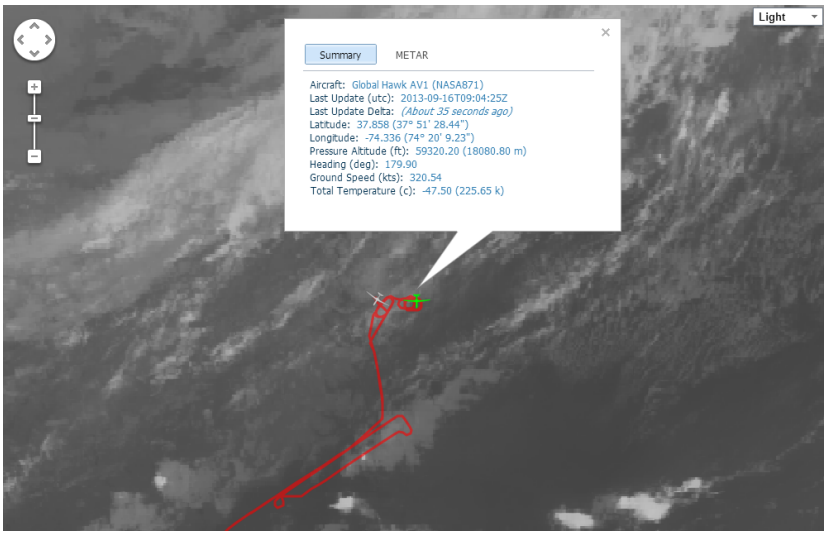



01.01EDT: On our way back!

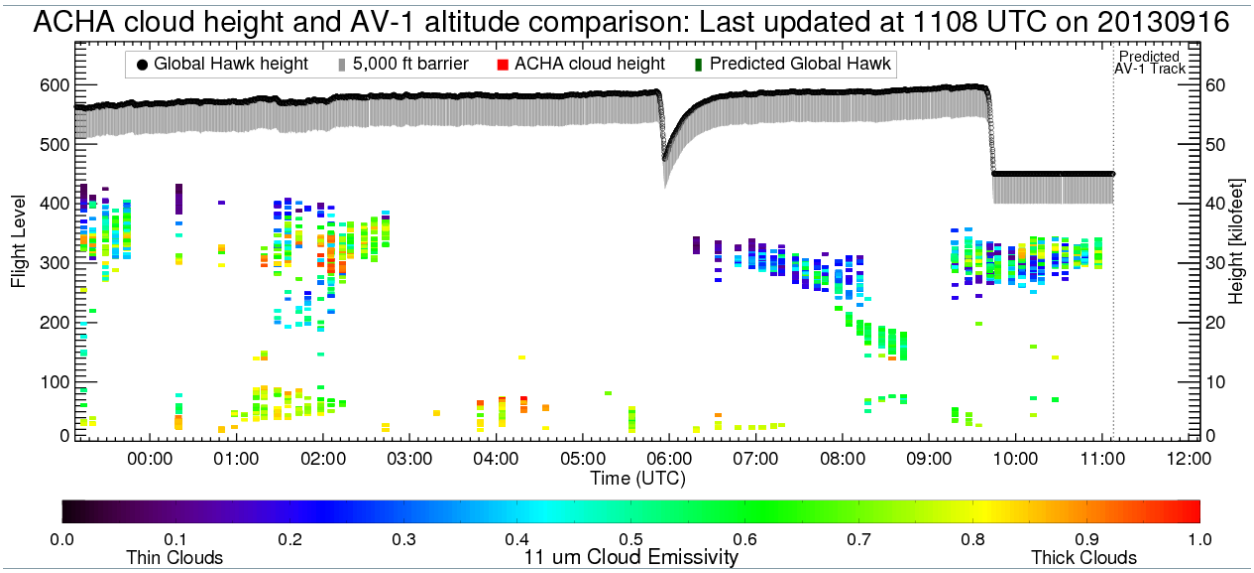


0555 Arrived VACAPES. Plan is to orbit in the VACAPES track at altitude and keep the instruments warm.

0702 Still orbiting off shore.




0905 Loitering




1110 Plane flew to 45kft altitude about 0930 but has otherwise just been loitering. Landing at about 1145.

1139 Just got word that Chase is only just now setting up. So we're looking at a landing at about 1230.

1155 Chase is now airborne!

1204 Powering off instruments

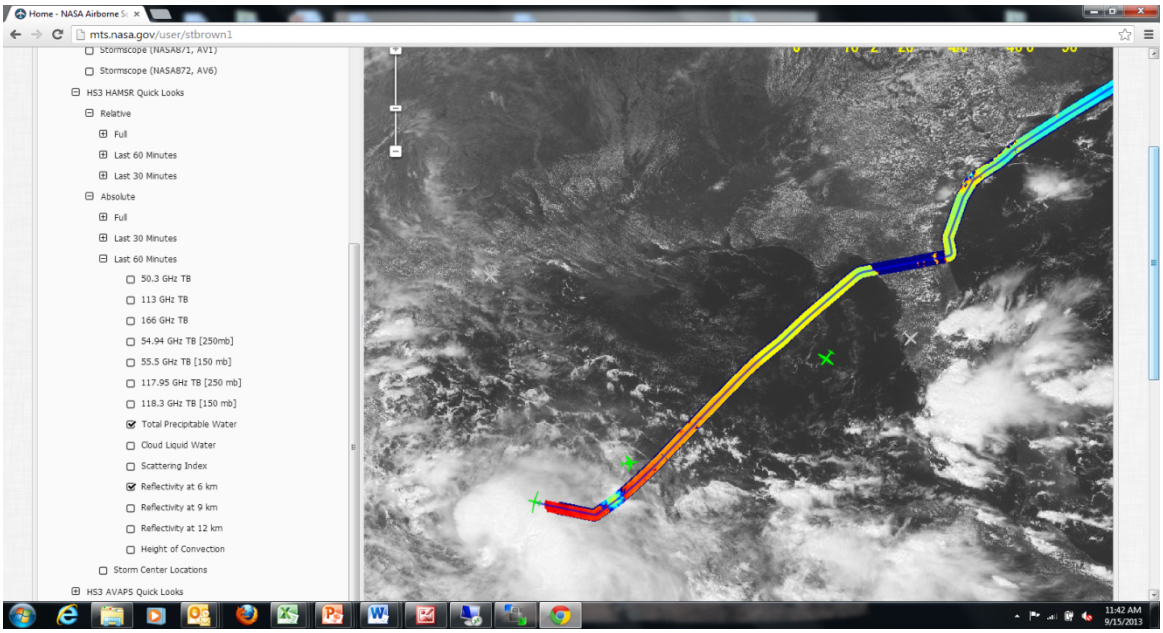
1230 Landing

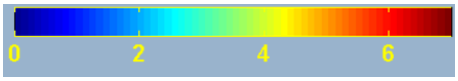
Instrument reports

HAMSR

HAMSR performed well during the 9/15/2013 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. The real-time processing code was updated prior to the flight and run for the first time during this flight. The code worked well and the latency of the quick-look imagery was significantly reduced from the ~15-30 minute latency experience during the 9/3 flight. The typical latency was 1-5 minutes with the new code. Note, only the "past 60 minute" fields are currently available with the 1-5 minute latency. The others (Full and past 30 minute) were not yet included in the updated code. The code was also updated so that the colorbar for the imagery would display in MTS.

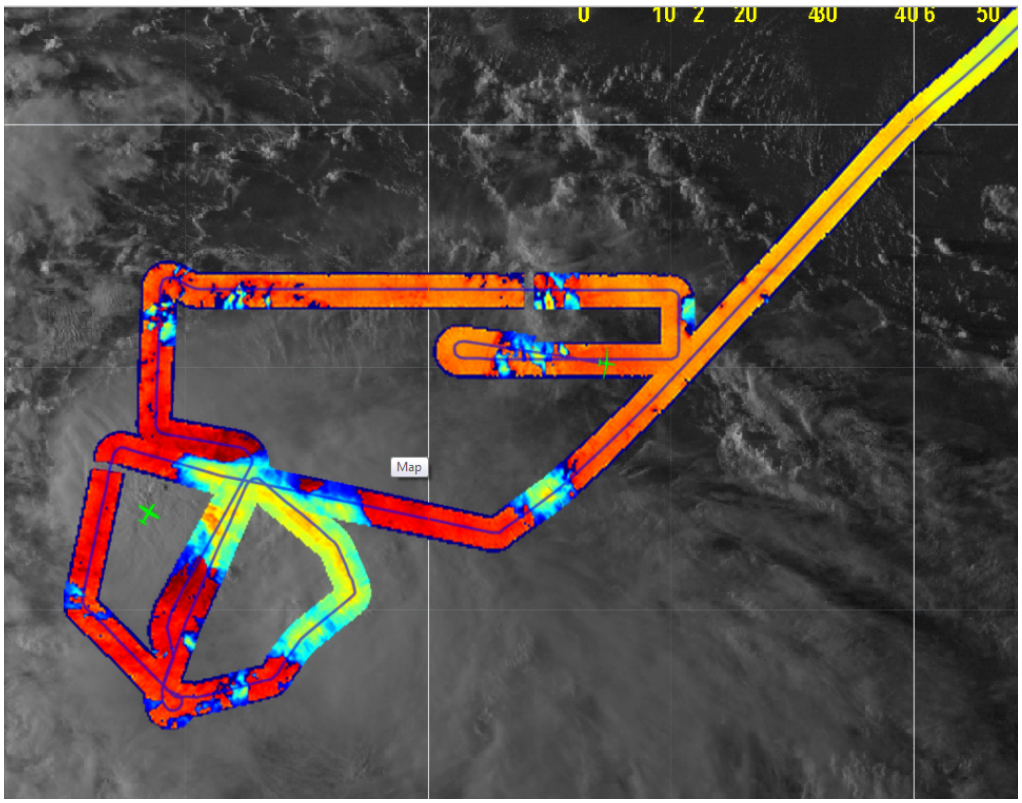
A few observations of note during the flight are shown in the following figures. The first figure shows the HAMSR total precipitable water vapor along the flight path. The figure also illustrates the reduced latency with the new code (e.g. the proximity of the data to the plane icon). The atmosphere was fairly moist in and around the storm (TPW > 5cm), but slightly drier in the rest of the Gulf (TPW ~4cm). The next plot shows the HAMSR derived reflectivity overlaid with the TPW. The storm didn't exhibit widespread precipitation. Most of the precipitation was observed on the north east side of the storm with some isolated convective cells to the north and south of the storm center. The strongest convection was observed just north of the estimated circulation center with ~35dBZ reflectivities. The final plot illustrates some convection that was observed off the coast of Florida on the transit back. The 166 GHz TB is shown overlaid with NEXRAD reflectivity. The strong scattering signature (~100K) from the convection is clearly evident.

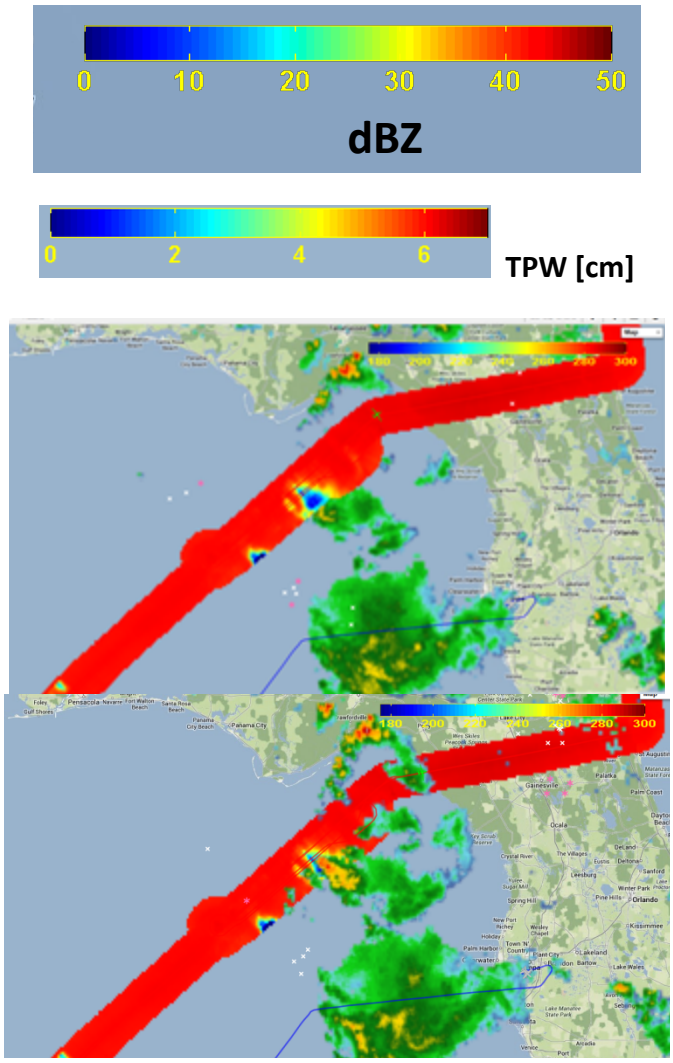



**TPW [cm]**

**Figure 1. Example of HAMSR real-time data in MTS with reduced latency.**



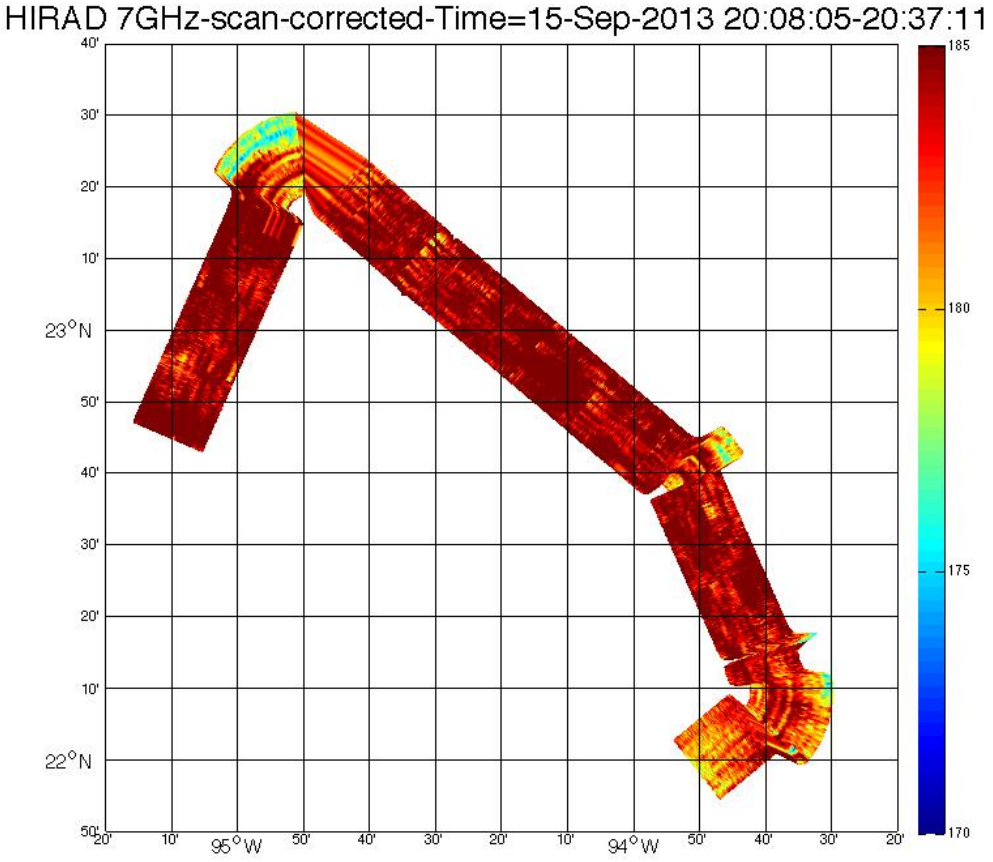


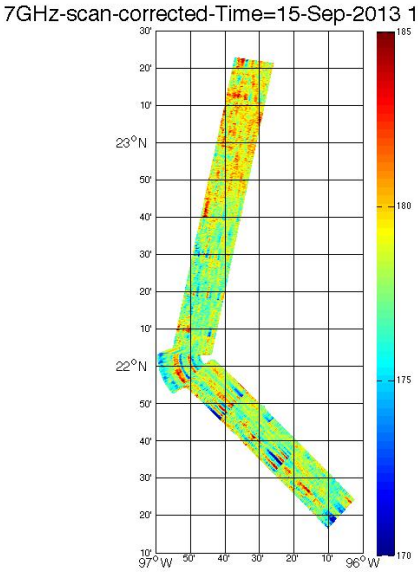

**166 GHz TB [K] with NEXRAD reflectivity**

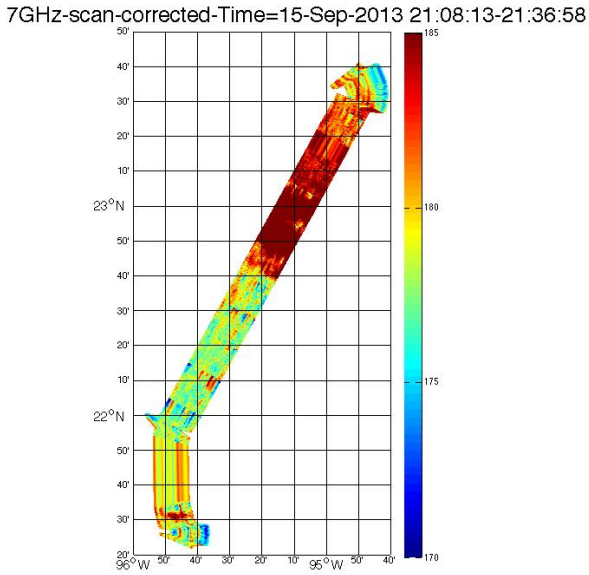
## HIRAD

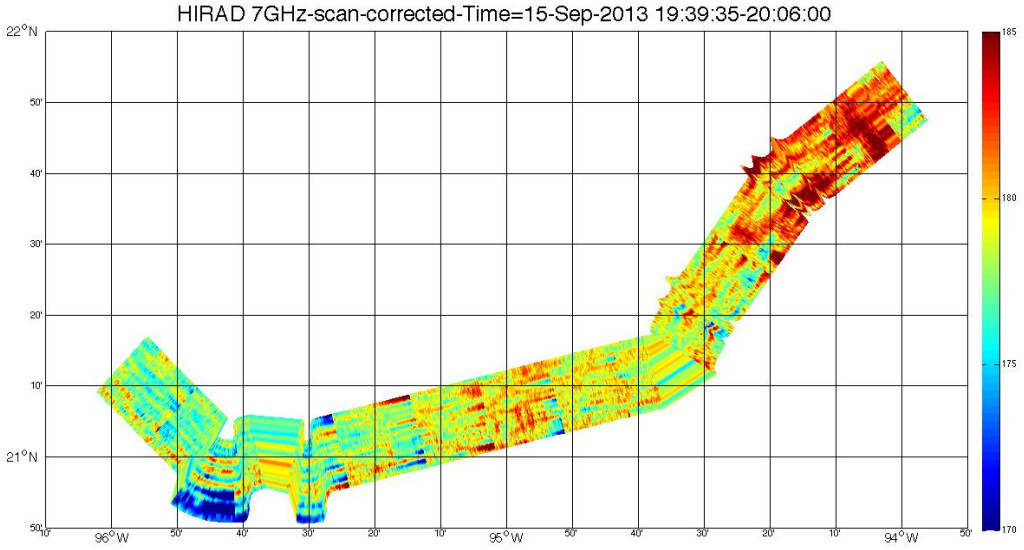
HIRAD performed nominally, collecting data from Hurricane Ingrid and from convective targets along the transit path (particularly off the west coast of Florida. After an adjustment to the positioning of the thermal blanket while HIRAD was down from the airplane Friday, the receiver temperatures remained stable for longer this time than in the 3 September science flight. Most were stable for about 8 hours, and rose steadily thereafter. The rising temperatures can be accounted for in post-processing.

In the pattern around Hurricane Ingrid, our strongest signals were generally on the northern legs:



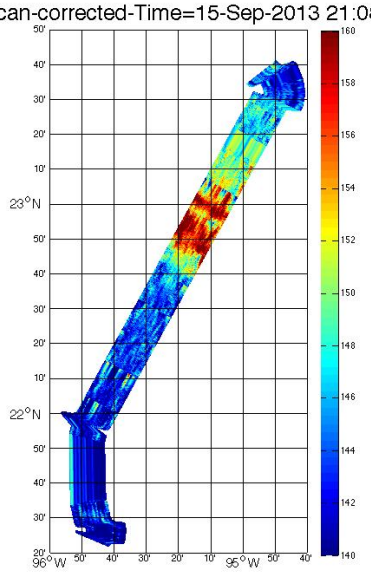


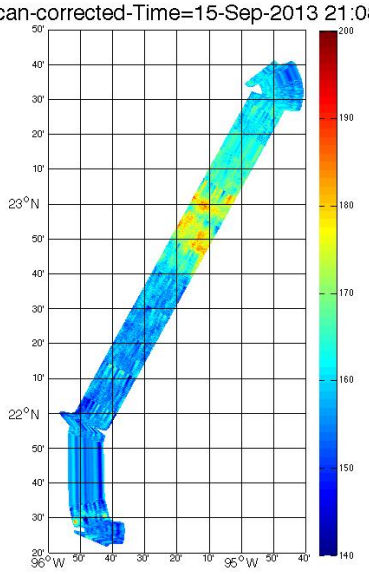




The most prominent feature noticed in the near realtime quicklooks was near 22.9 N, 95.1 W near 2034 and 2128 UTC:

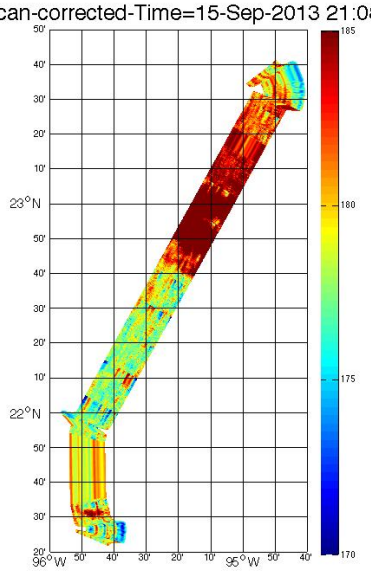
5GHz-scan-corrected-Time=15-Sep-2013 21:08:13-21:36:58




6GHz-scan-corrected-Time=15-Sep-2013 21:08:13-21:36:58




7GHz-scan-corrected-Time=15-Sep-2013 21:08:13-21:36:58




Calibration targets were also obtained by overflying convective rain near Florida and flying back and forth along the North Carolina coast (allowing us to see the coast first on the right side of our swath, then on the left side of our swath).

## HIWRAP

HIWRAP operated throughout the 15-16 September 2013 flight, collecting Doppler and reflectivity data from all channels and beams. An initial real-time display was completed during this flight, showing reduced-quality uncalibrated reflectivity at the lower elevations. Temperatures swung significantly in the radar due to the combination of external temperatures and thermal requirements of the plane. This caused some problems, but postflight maintenance on the radar improved system resistance to these effects.

An intermittent antenna problem caused occasional loss of data for gaps ranging from 30 seconds to 5 minutes during the flight. These problems were caused by an unusual problem with the antenna positioner data (likely aggravated by temperature swings) that was fixed during postflight. The radar operated correctly for the vast majority of the flight.

Below is an image of the real-time data during this flight. The top subplot is a vertical curtain view of reflectivity below the aircraft. The bottom two subplots are horizontal reflectivity corresponding to the elevations indicated by the horizontal lines in the top subplot. This real-time data snapshot is of significantly reduced quality, as it only includes a single Ka-band channel, does not cover the full range in data, and has errors in the positioner data used. These problems will not be present in the data processed for science, but were a product of the experimental nature of this real-time processing. The gap in this image was caused by dropouts in the aircraft network link.