

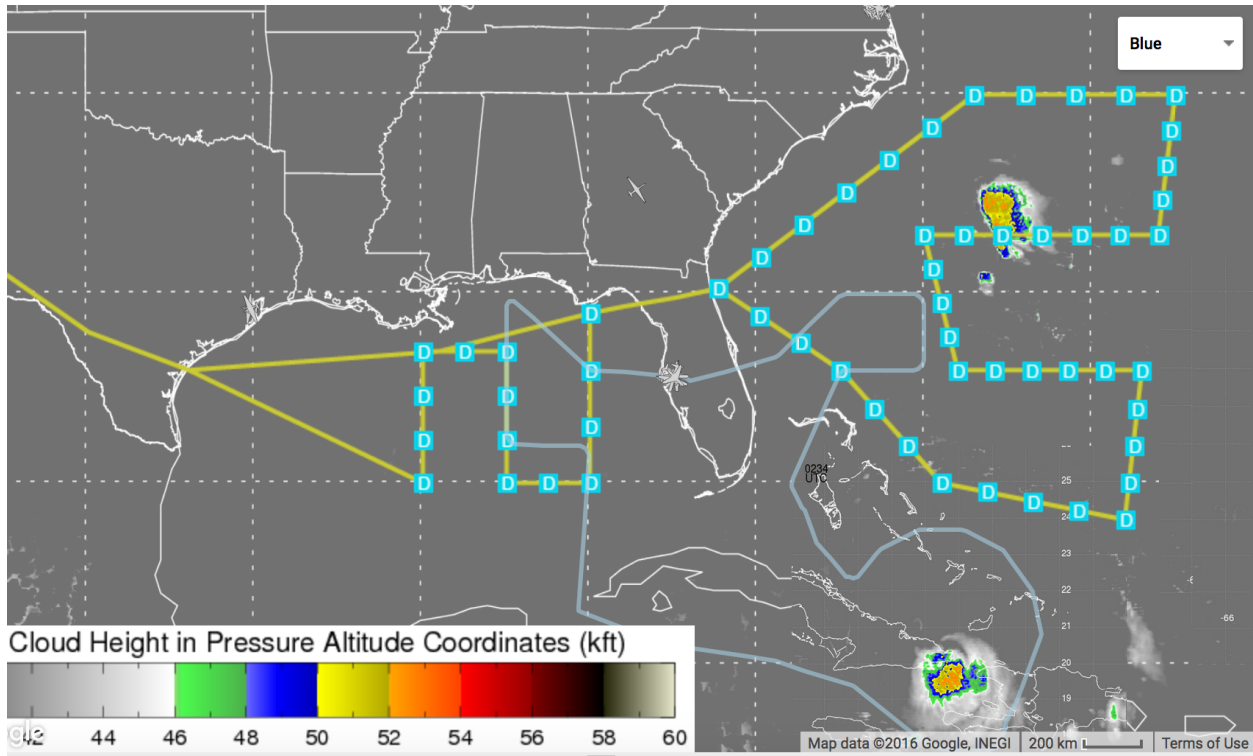
SHOUT Research Flight 7 – 20161005 - Hurricane Matthew

Shift-1 Mission Scientists: Jason Dunion, Trey Alvey , Chris Velden

Shift-2 Mission Scientists: Jon Zawislak, Derrick Herndon, Sarah Griffin

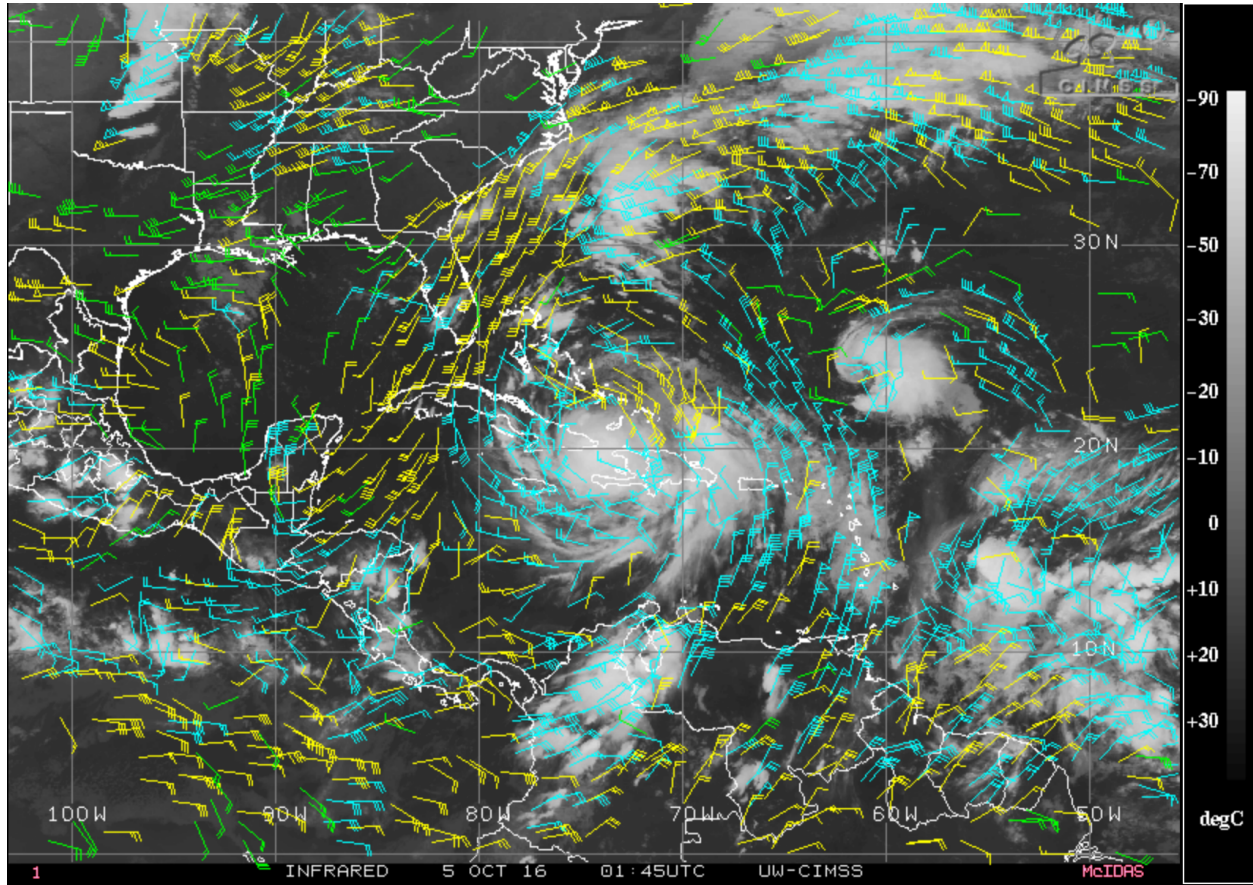
Shift-3 Mission Scientists: Rosimar Rios-Berrios, Peter Black, Tim Olander

Log initiated by J. Dunion

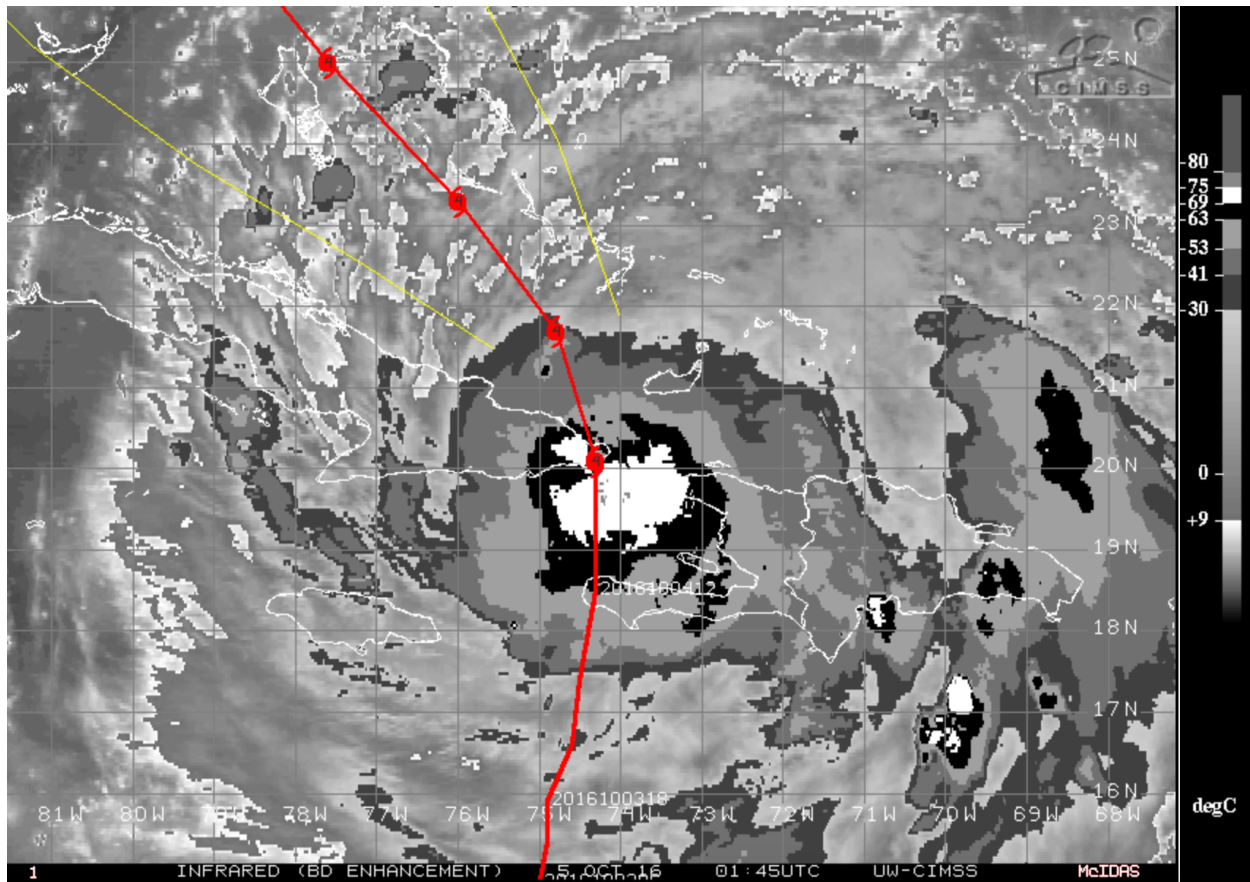


Initial/planned flight track for Hurricane Matthew surveillance mission.

Take-off at 0256 UTC (delayed ~1 hr due to high crosswinds at NASA AFRC)



Plot showing upper level cloud drift winds in the region of Matthew. Trough to the west of Matthew is apparent, as is strong upper level shear to the northwest of the storm. Upper level cyclone and storm outflow to the east and southeast are clearly identified.



Storm currently does not exhibit an eye feature in the IR imagery, although a small, ragged eye was apparent around 21Z for a brief time. The ADT intensity (CI# 5.7... approx 105kts) is 1.2 CI# weaker at the time of the image above (01:45Z) than it was at the same time yesterday (CI# 6.9) as the storm interacts with Cuba and Haiti. Aircraft reconnaissance has indicated the pressure is relatively steady and the surface winds continue to be around 115kts. The storm should continue to hold relatively steady as it moves across and away from Cuba.

HURRICANE MATTHEW DISCUSSION NUMBER 28
 NWS NATIONAL HURRICANE CENTER MIAMI FL AL142016
 1100 PM EDT TUE OCT 04 2016

Hurricane Matthew made landfall along the extreme eastern coast of Cuba near Juaco around 0000 UTC this evening, and the eye is just now moving off of the northeastern coast of Cuba. Some weakening has occurred due to interaction with the mountains of eastern Cuba and western Haiti. However, latest reports from an Air Force Reserve reconnaissance aircraft indicate that the central pressure hasn't risen much and that the maximum winds have only decreased to an estimated 115 kt, keeping Matthew a dangerous category four hurricane.

Radar and recon fixes indicate that Matthew is moving slightly west of due north, or 350/07 kt. Matthew is expected to begin turning toward the north-northwest during the next 12 hours or so, followed by a northwestward motion in 24-48 hours as the large ridge to the north of the powerful hurricane begins to build westward across the southeastern United States in response to a broad trough over the central U.S. weakening and lifting out to the northeast. The next upstream weather system that will affect the steering currents surrounding Matthew is a large trough currently approaching the northwestern U.S. and southwestern Canada. That system is forecast to dig southeastward and amplify over the central U.S. during next several days, resulting in significant ridging downstream over the northeastern United States. As the next ridge builds and lifts northward, Matthew is expected to turn northward as well by 72 hours, and turn northeastward after that as the aforementioned trough moves eastward into the eastern United States by 96-120 hours. The official forecast track remains close to a blend of the GFS and ECMWF models.

The current 10-15 kt of northwesterly vertical wind shear is forecast to weaken to around 5 kt by 36-48 hours while Matthew is moving over the warm waters of the Gulf Stream, where SSTs are expected to be near 30 deg C. That combination, along with high mid-level humidity, should enable Matthew to maintain category four status, although eyewall replacement cycles, which can not be forecast with any skill, could result in fluctuations in the intensity not shown by the official forecast. By 72 hours and beyond, steadily increasing vertical wind shear is expected to induce gradual weakening. The official intensity forecast is close to but slightly above the consensus model IVCN.

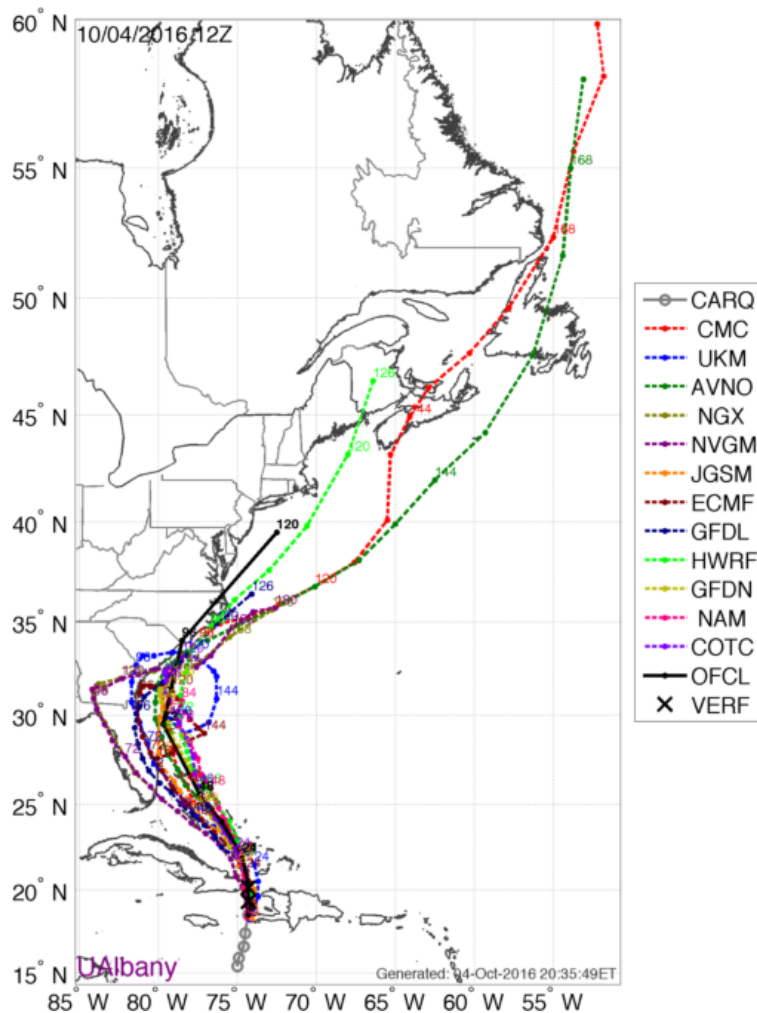
FORECAST POSITIONS AND MAX WINDS

INIT	05/0300Z	20.4N	74.4W	115 KT	130 MPH
12H	05/1200Z	21.7N	74.8W	115 KT	130 MPH
24H	06/0000Z	23.3N	76.0W	115 KT	130 MPH
36H	06/1200Z	25.0N	77.6W	115 KT	130 MPH
48H	07/0000Z	26.7N	79.0W	115 KT	130 MPH
72H	08/0000Z	30.3N	80.8W	100 KT	115 MPH
96H	09/0000Z	33.2N	78.1W	85 KT	100 MPH
120H	10/0000Z	37.0N	72.0W	70 KT	80 MPH

The first part of the mission will sample the Gulf of Mexico environment about 5:30 hours after takeoff. The area is currently devoid of deep convection so the current flight plan should not be affected by any

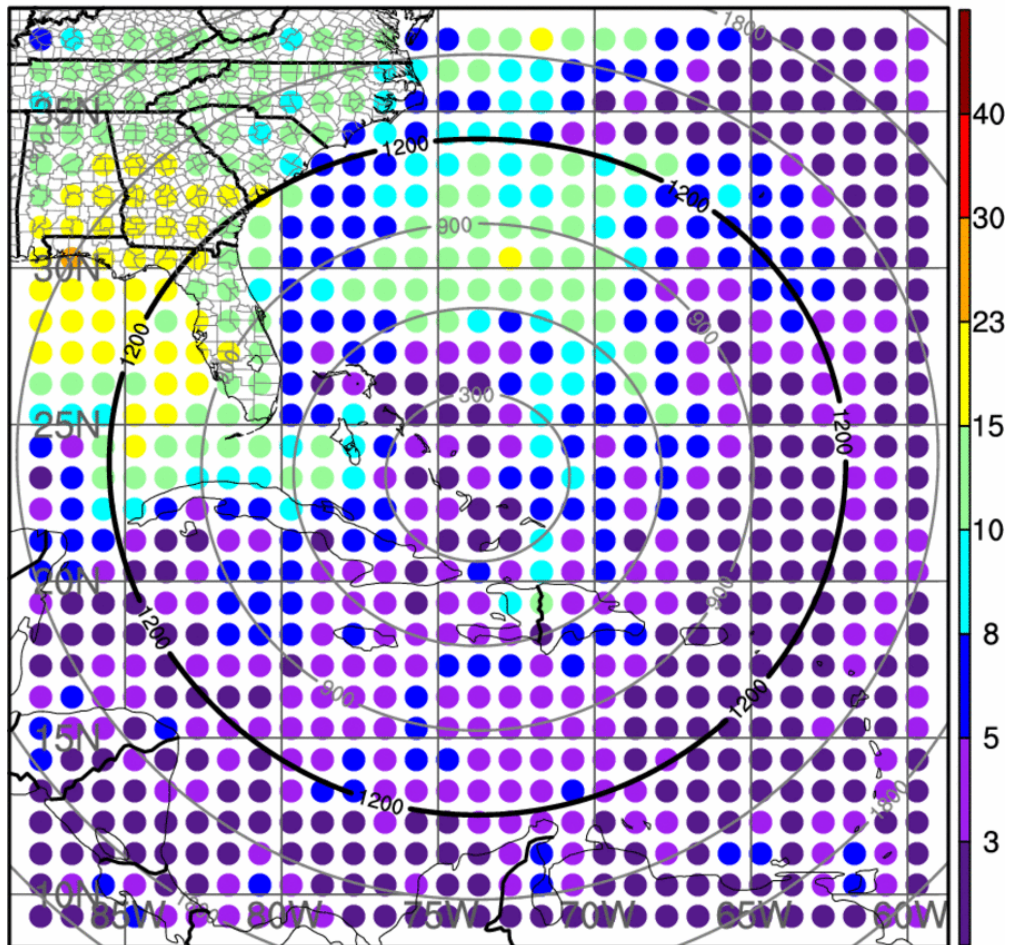
areas of concern to the aircraft. 14 dropsondes are currently scheduled to be dropped by the aircraft over this region. Once the flight track over the Gulf has been completed the aircraft will then move to the open waters to the east of the Florida, Georgia, and Carolina coasts to sample the storm environment north of Matthew. The remainder of the 57 total sondes will be dropped ahead of Matthew.

Track forecasts for Hurricane Matthew are characterized by large uncertainty, especially after the hurricane moves over the Bahamas. Model guidance from 1200 UTC 04 October highlights the widespread of possibilities within the next five days, with some models predicting that Matthew will remain over water and other models predicting landfall anywhere between Florida and North Carolina:



Ensemble sensitivity experiments with the HWRF model suggest that track uncertainty can be reduced with observations over the Gulf of Mexico (related to the upper tropospheric trough) and over western Atlantic (related to the subtropical ridge):

Dropsonde impact at 2016100512 (F060)

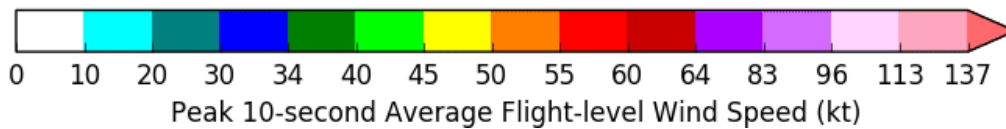
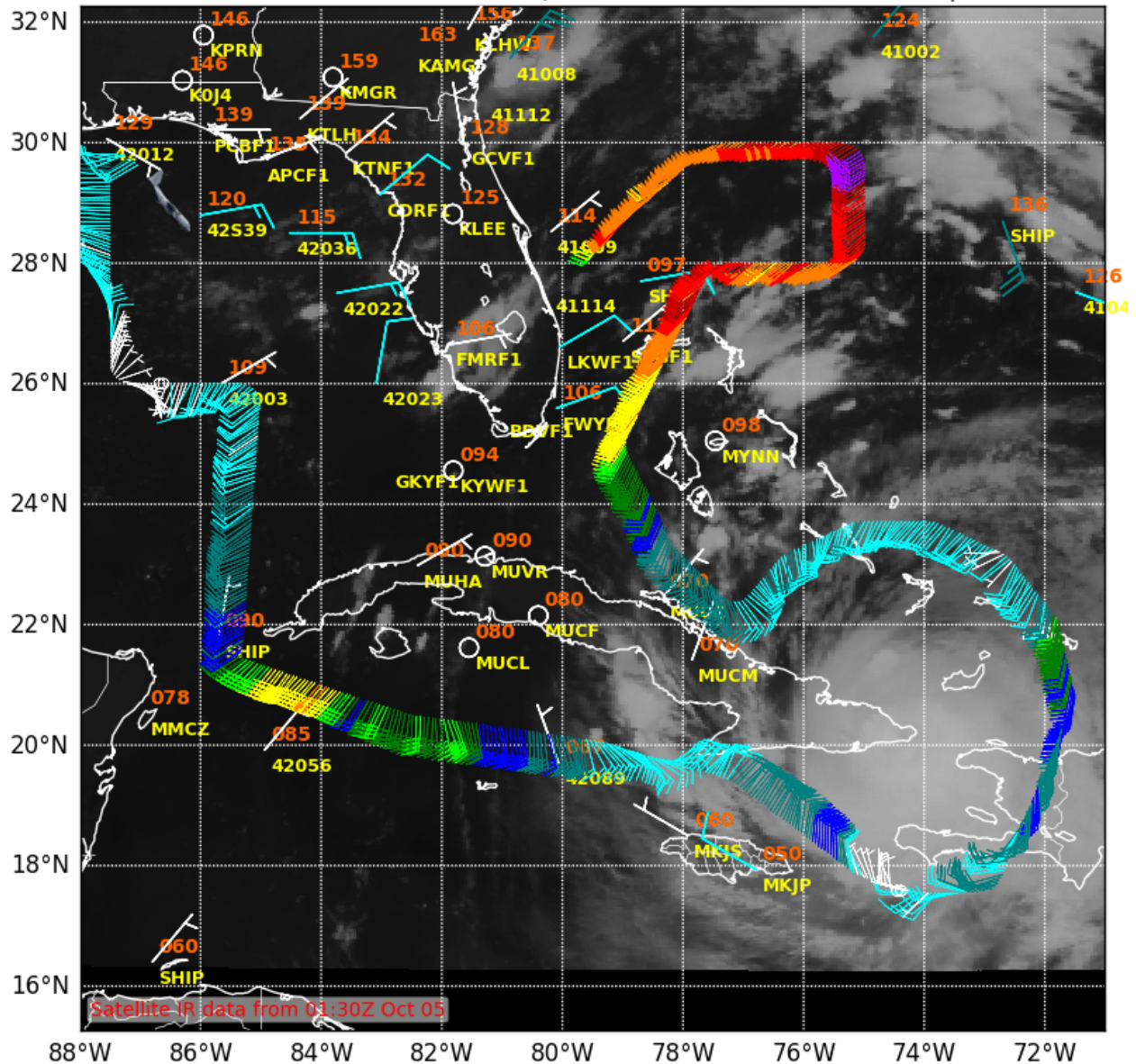


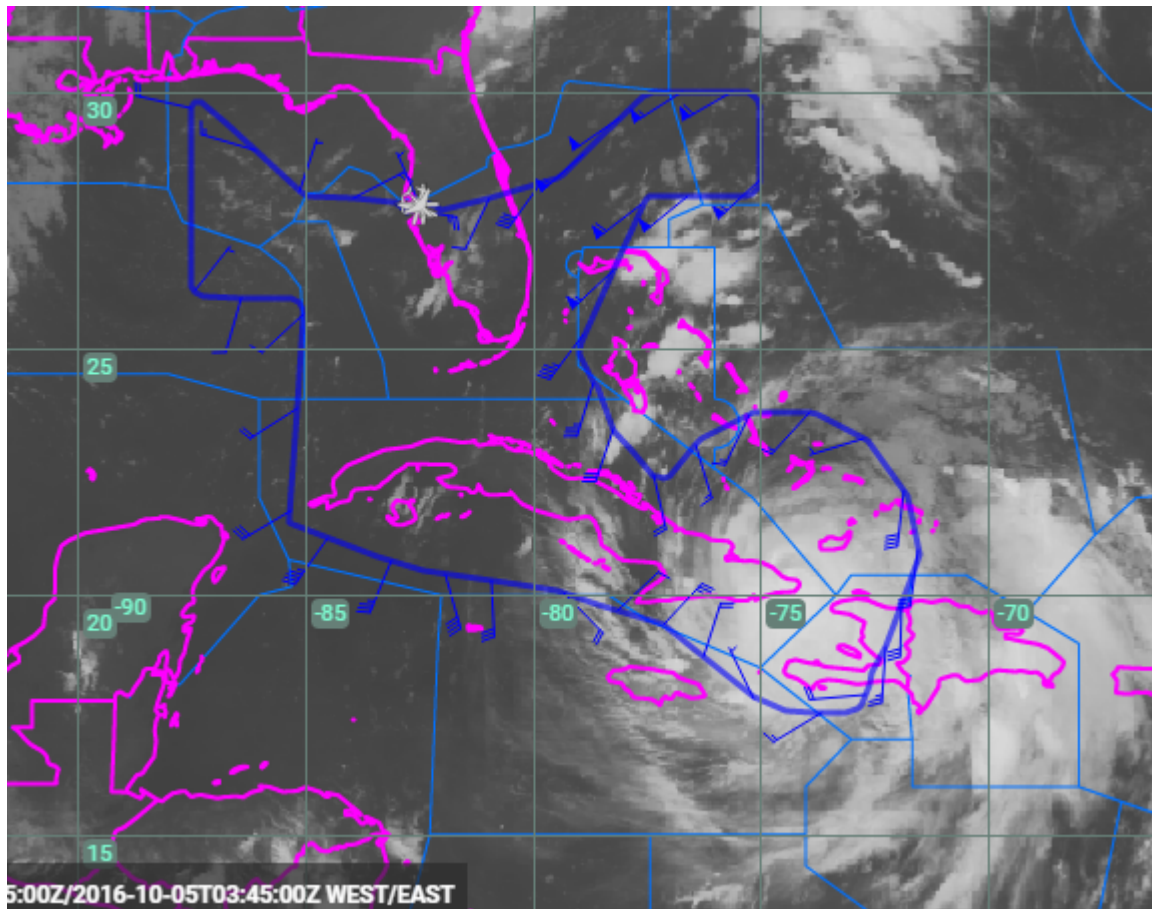
Current flight plan (see above) will cover both regions.

The GIV completed a synoptic surveillance mission earlier in the day, with a focus on the near-storm environment:

NOAA9 Recon Obs as of 01:41Z Oct 05, 2016

Levi Cowan - tropicaltidbits.com





0038 UTC: Take-off has been delayed 1-hr due to high cross winds at EAFB.

0237 UTC: Engine start, payloads powered up -- standing by for pin pull

0244 UTC: Pin pull, standing by for taxi

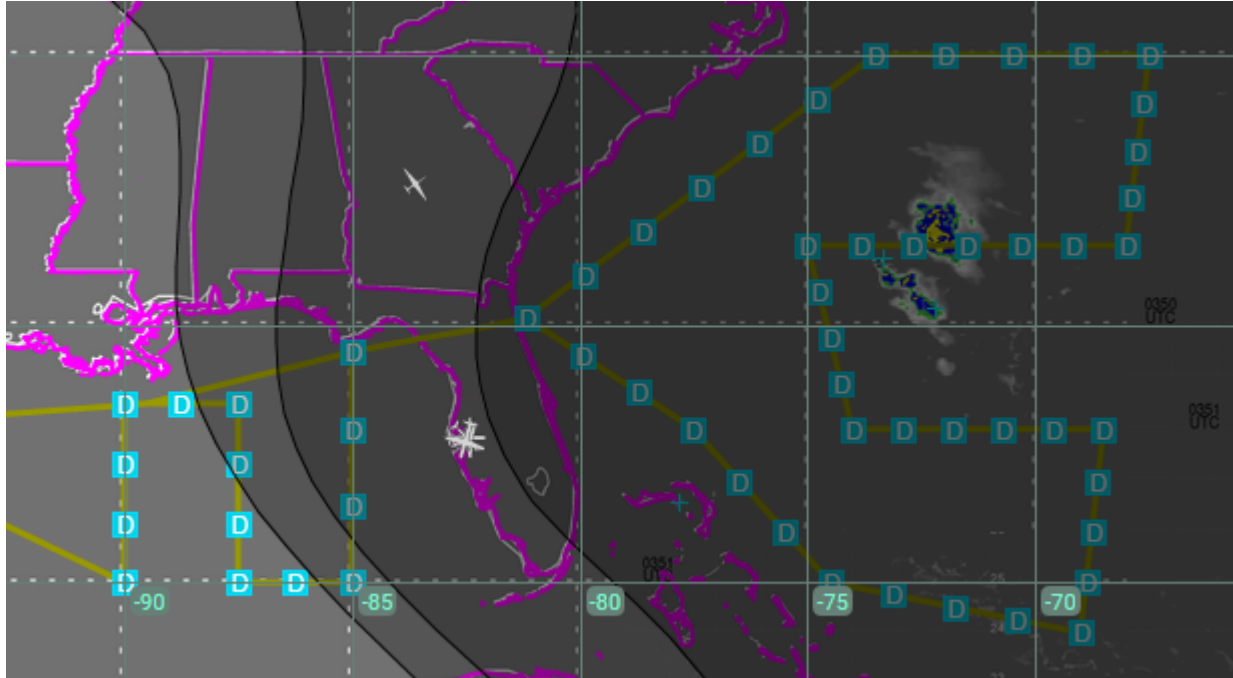
0250 UTC: Taxi

0256 UTC: Take off

0330 UTC: Current Ku satellite coverage does not include drops 24-30 and 43-48. We will need to switch to a different satellite. Data person suggests we do this while we are over the Gulf of Mexico. Planning to switch after dropsonde #5.

Current coverage:

Anticipated coverage by switching to a different satellite:

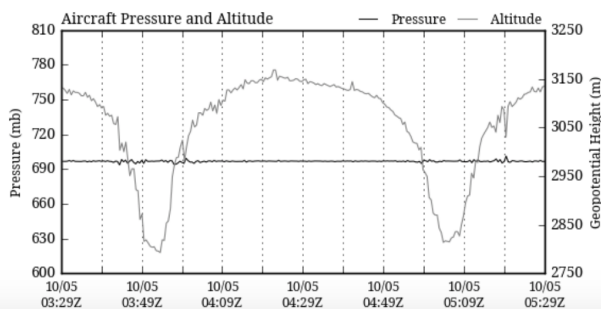
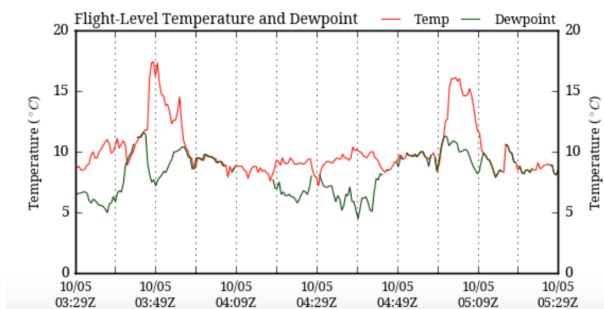
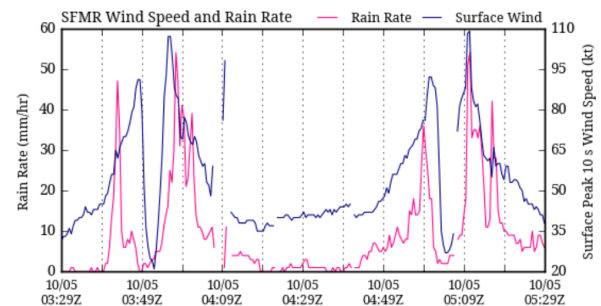
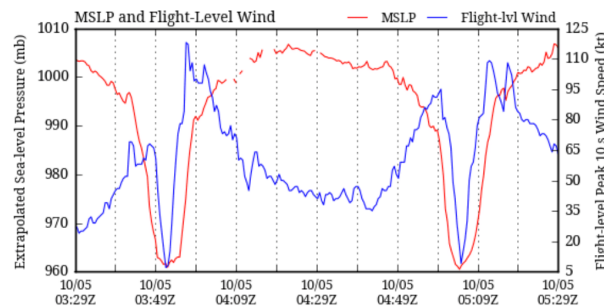


The NOAA-GIV took off about 1:15AM EDT for a reconnaissance flight. AF303 is currently in the storm and has found 115kts/960mb wind/pressure at 700mb flight level.

Recon Aircraft Observations

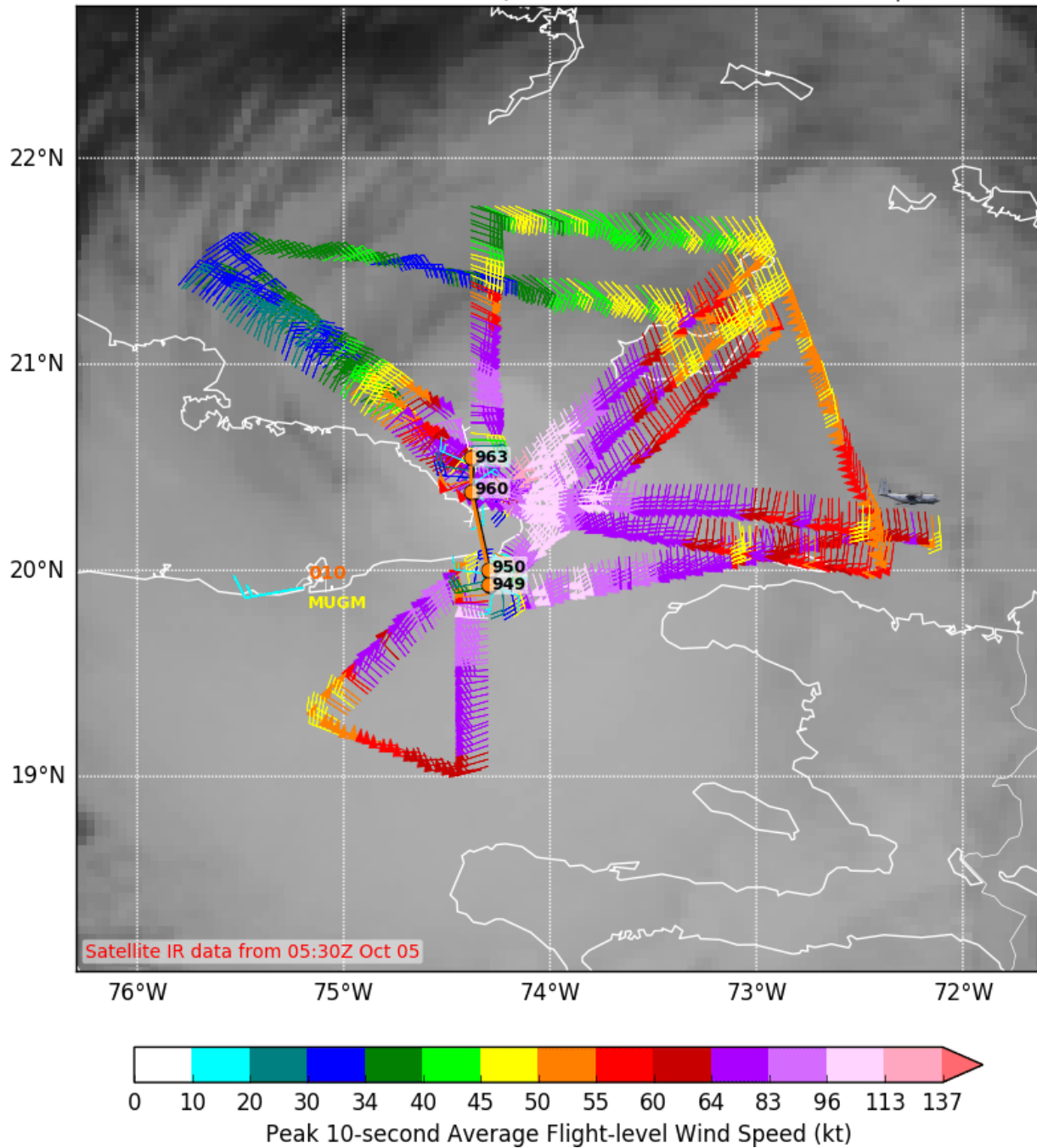
Mission ID: AF303 2114A MATTHEW

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AF303 Recon Obs as of 05:39Z Oct 05, 2016

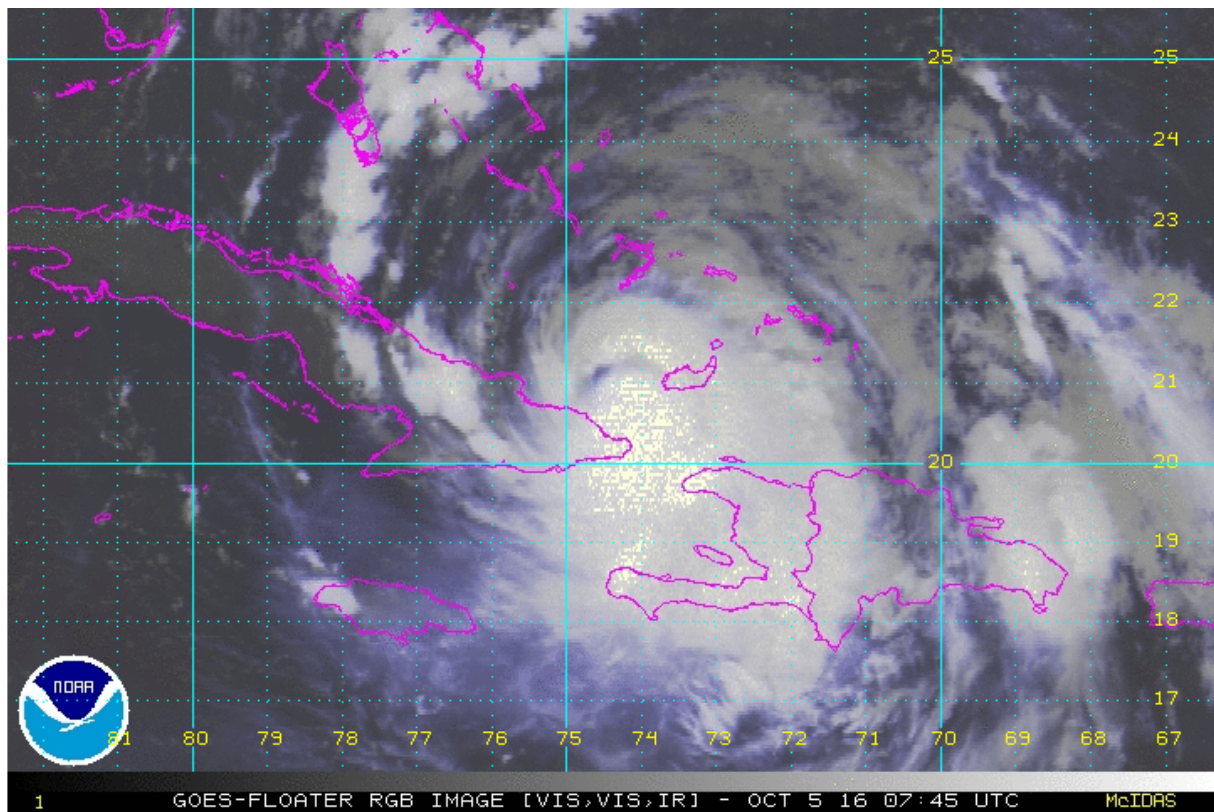
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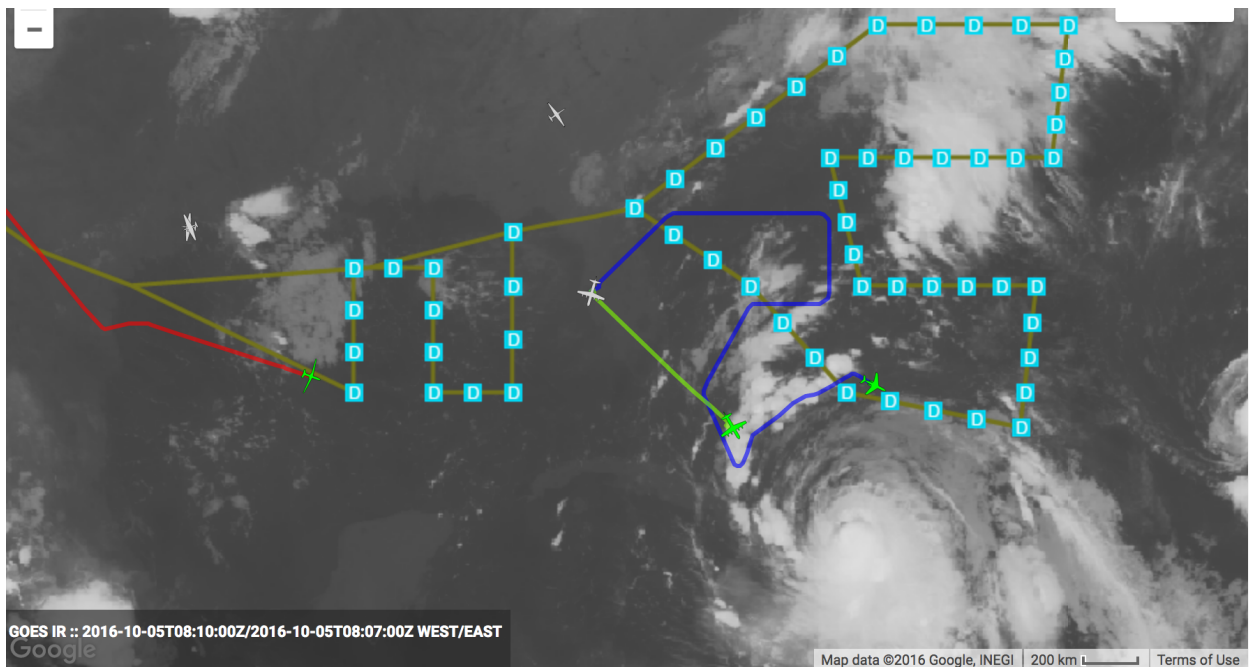
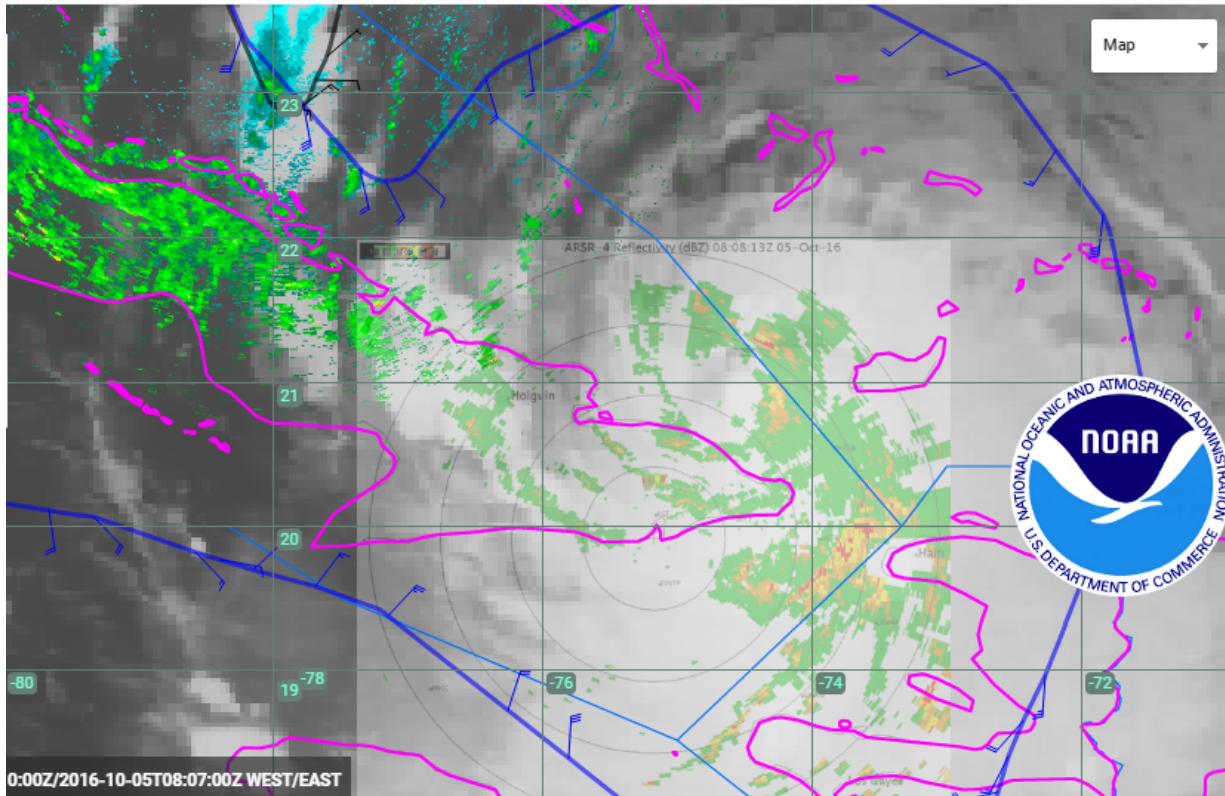


NOAA P-3 just took off around 3:10EDT.

0818 UTC: We are under 30 minutes until the first drop, but we were just notified by the mission director that we may not be able to release sondes anytime soon due to air traffic in the area.

Eye emerging N of eastern tip of Cuba on RGB GOES IR and Guantanamo radar:





Good sampling of the storm about to begin. Global Hawk near first drop site. P-3 (green line) entering outer rainbands, and G-IV sampling around the periphery of the storm. Image grabbed 4:20AM EDT.

0836Z: Sonde #1 released at location 1. Good drop.

0840Z: We will not be able to release at location 2 due to air traffic.

0842Z: Sonde is loaded and ready. Now we just wait for clearance.

0855Z: Sonde #2 released just north of location 2. Good drop. Temperature sensor not working properly.

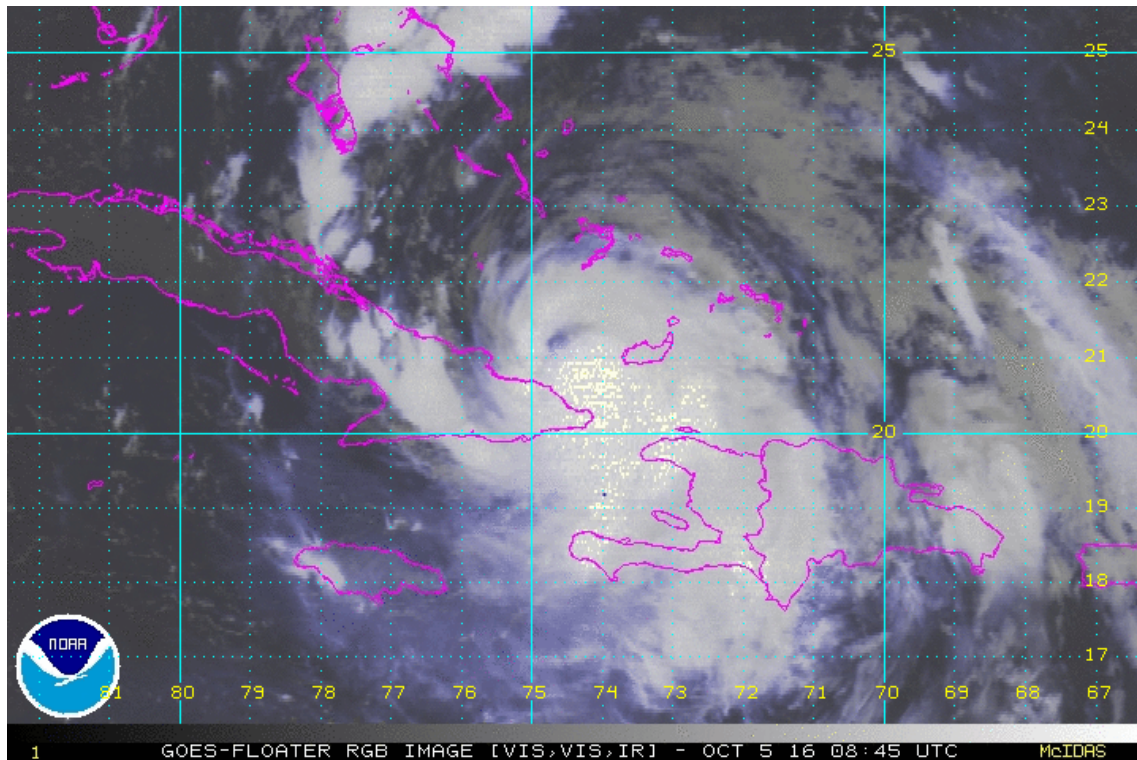
0858Z: Sonde #3 released at location 3. Good drop.

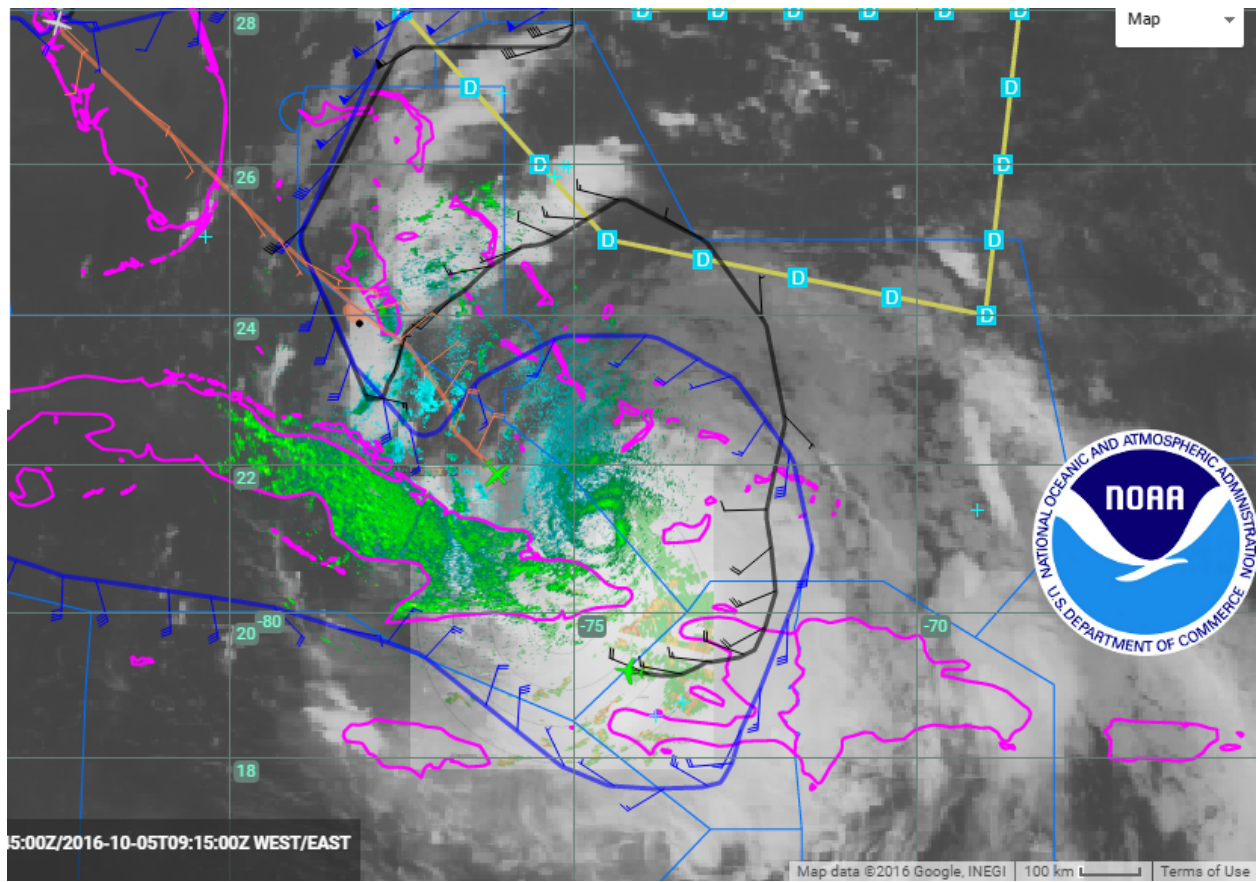
0900Z: Sonde #3a released between location 3 and 4. This is a new, more robust, sonde design with a new temperature sensor. Good drop.

0901Z: Sonde #3b released between location 3 and 4. This sonde is an extra sonde for comparison with the test sonde. Good drop.

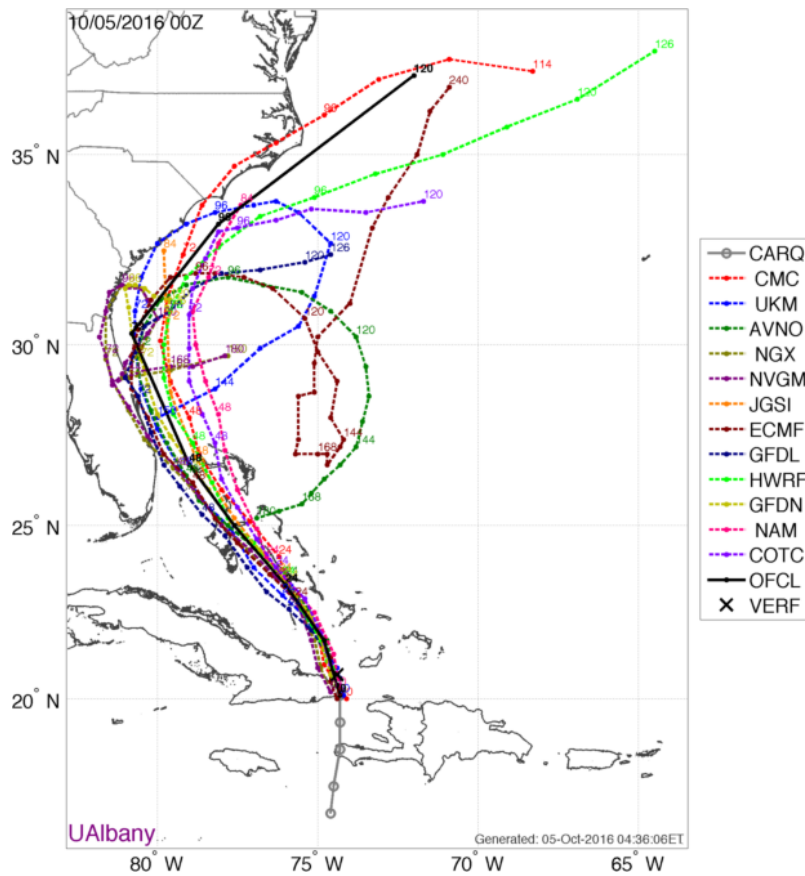
0911Z: Sonde #4 released at location 4. Good drop.

0922Z: Sonde #5 released at location 5, 28.51, -88.69. 57,740 ft. Good drop.

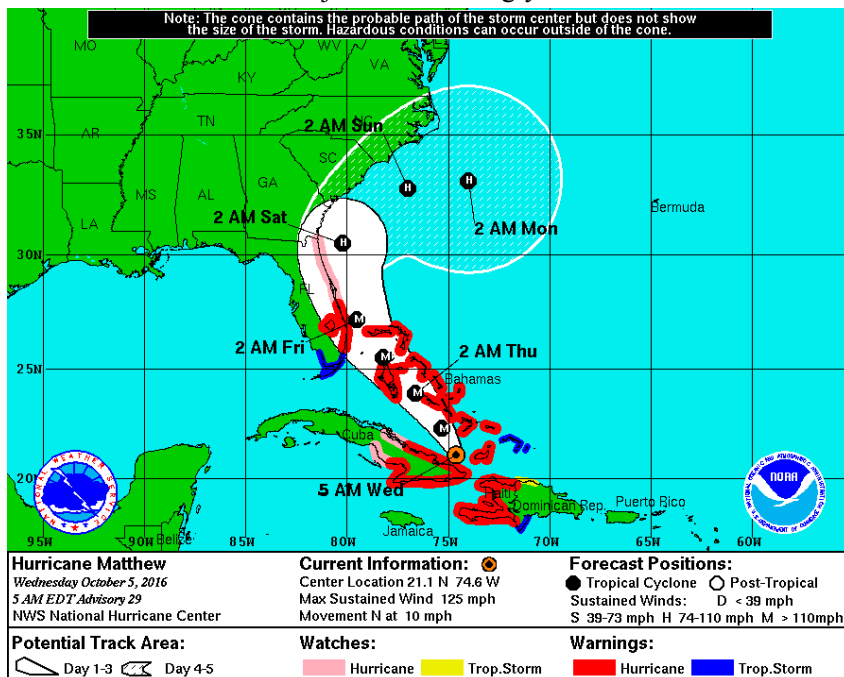


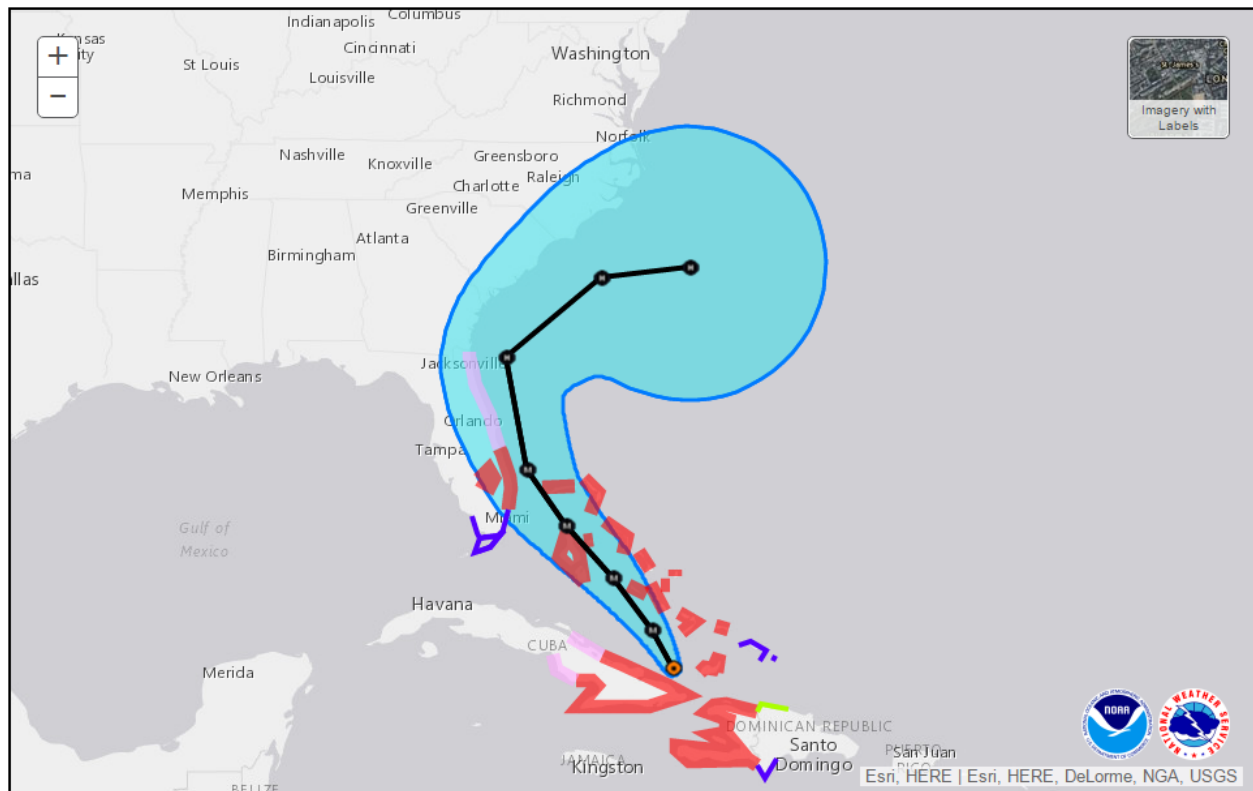


Latest model guidance depicts even higher uncertainty than during the previous cycle.



NHC track forecast was adjusted accordingly:

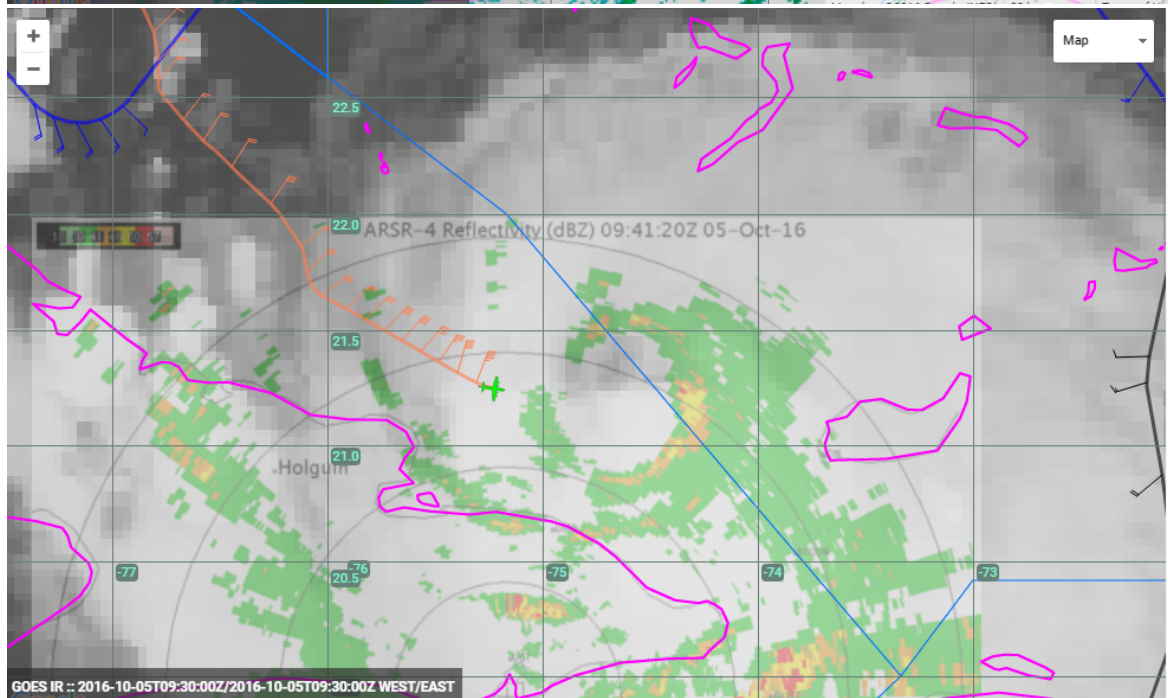
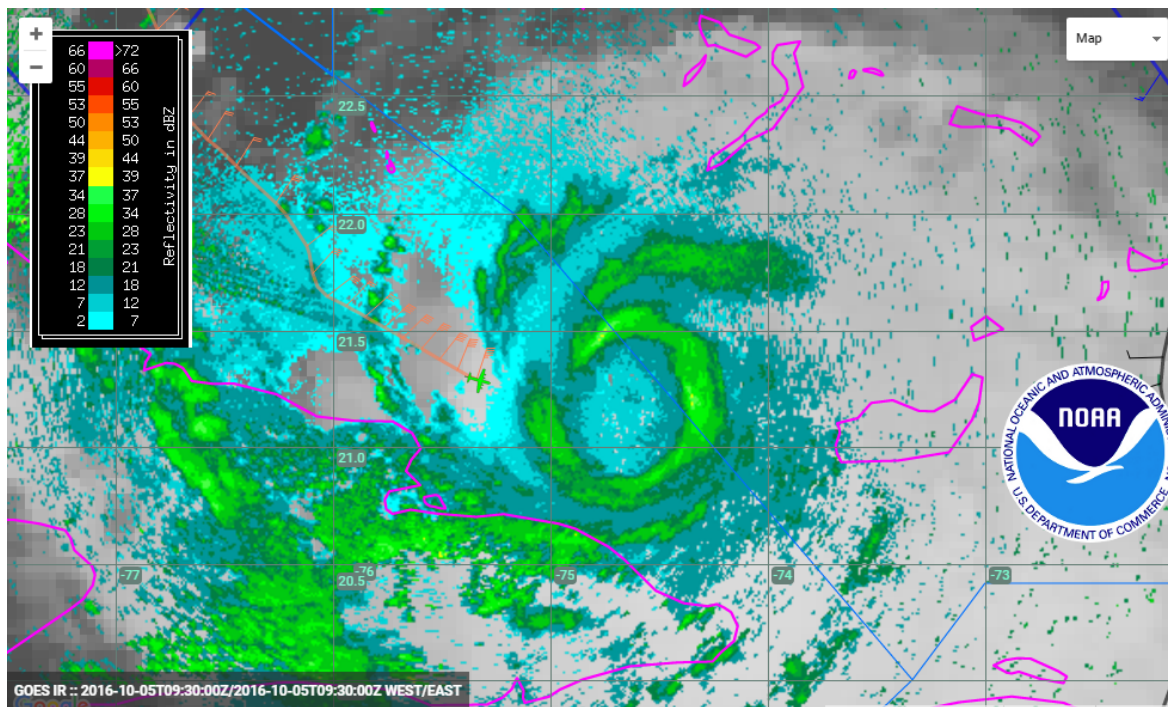


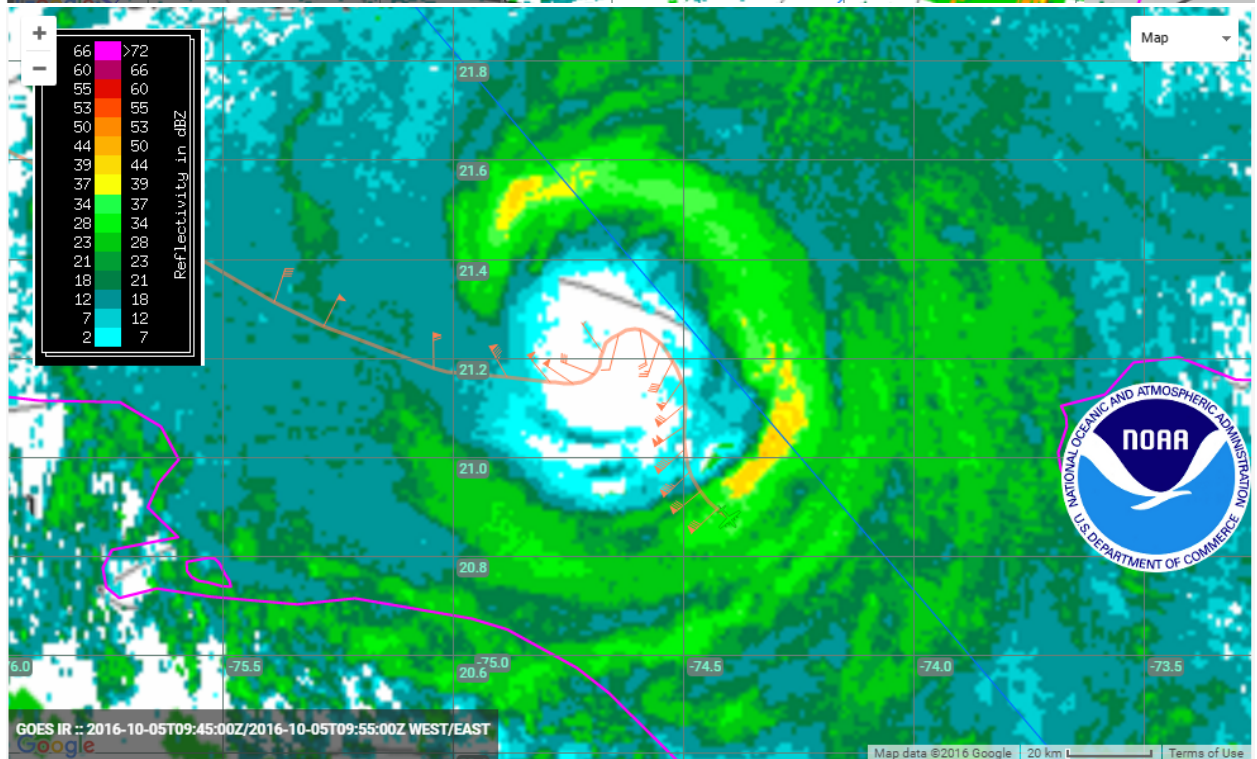
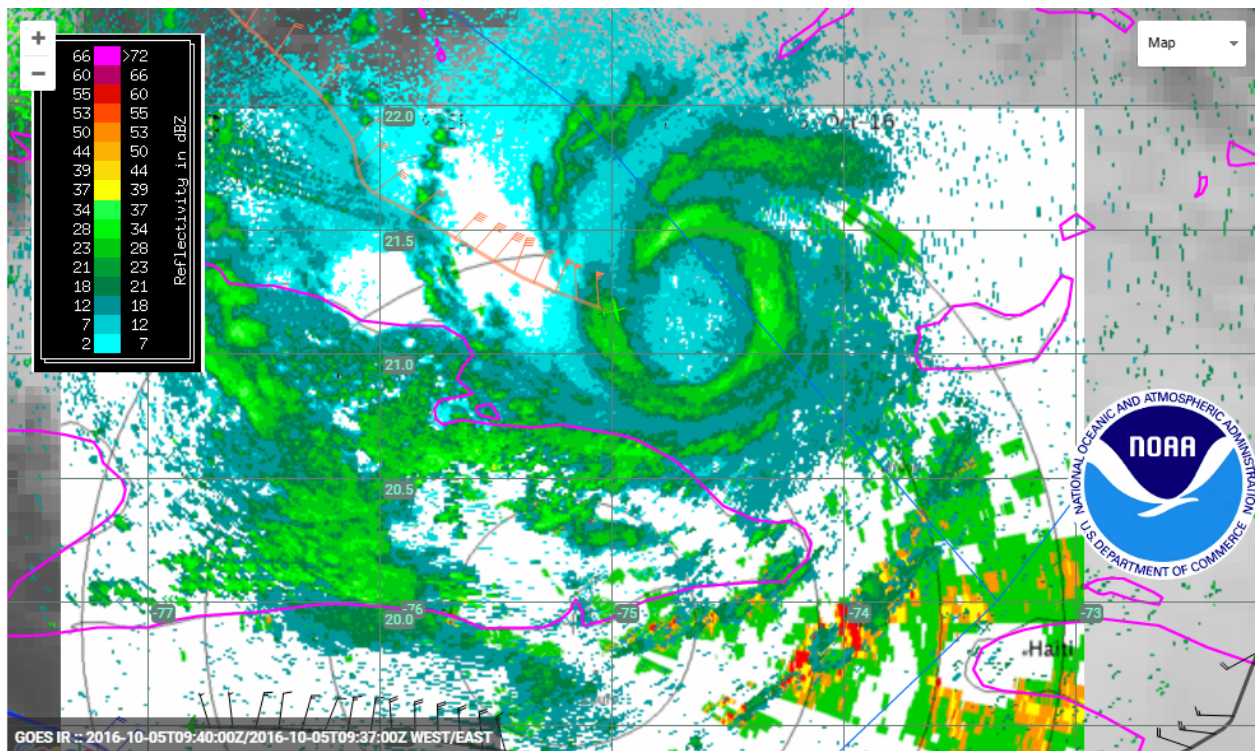


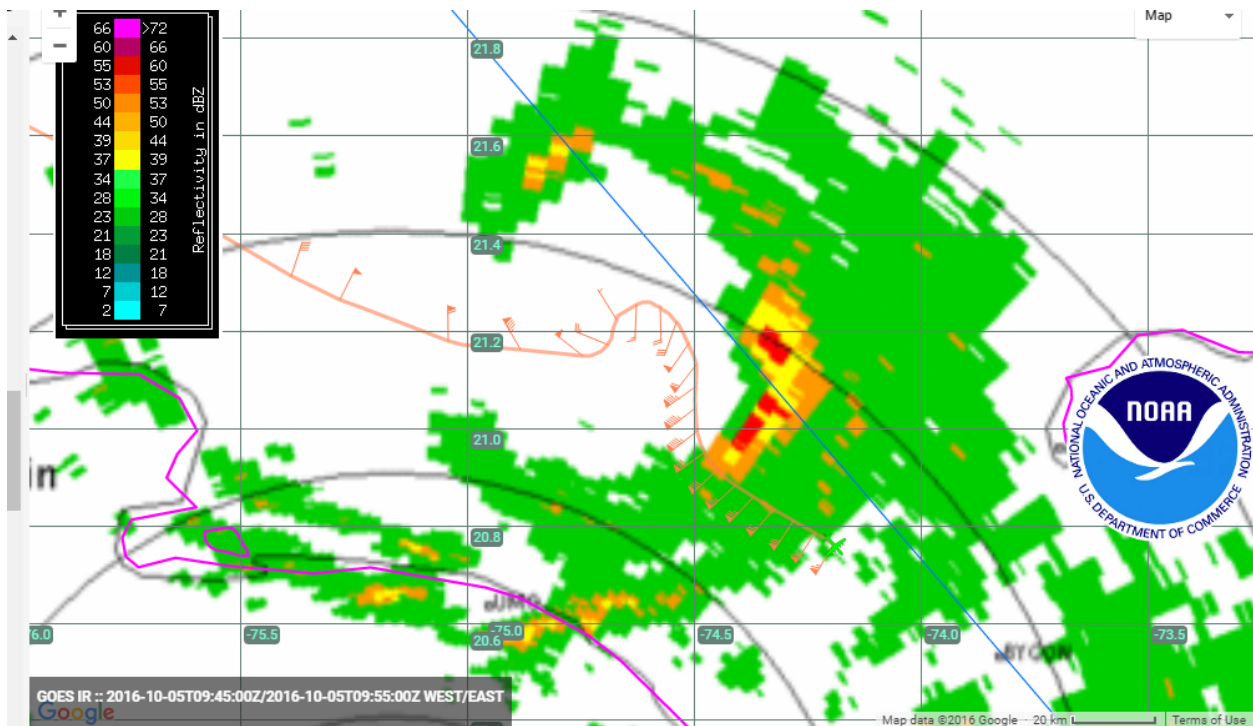
0936Z: We will not be able to release sonde at location 6 because we transitioned between ATCs and we did not get clearance on time from Jacksonville ATC.

ATC being extremely conservative: not letting us drop within 60 nm of other aircraft

1000Z: Update 1 to the flight plan submitted. We added two extra sondes to the last S-N leg just before crossing Florida. The purpose of these two new sondes is to sample the upper tropospheric trough.







Out of 10 sonde locations, only dropped sondes at 4 locations- 6 locations denied by ATC- pattern a shambles in Gulf! We tried to get permission to extend track further south, but we could not do it because we would run into Mexican airspace.

1033Z: We are in the process of switching satellites from CONUS to North Atlantic.

1035Z: Sonde #6 released at location 11. Good drop.

1036Z: Satellite transition could not be completed.

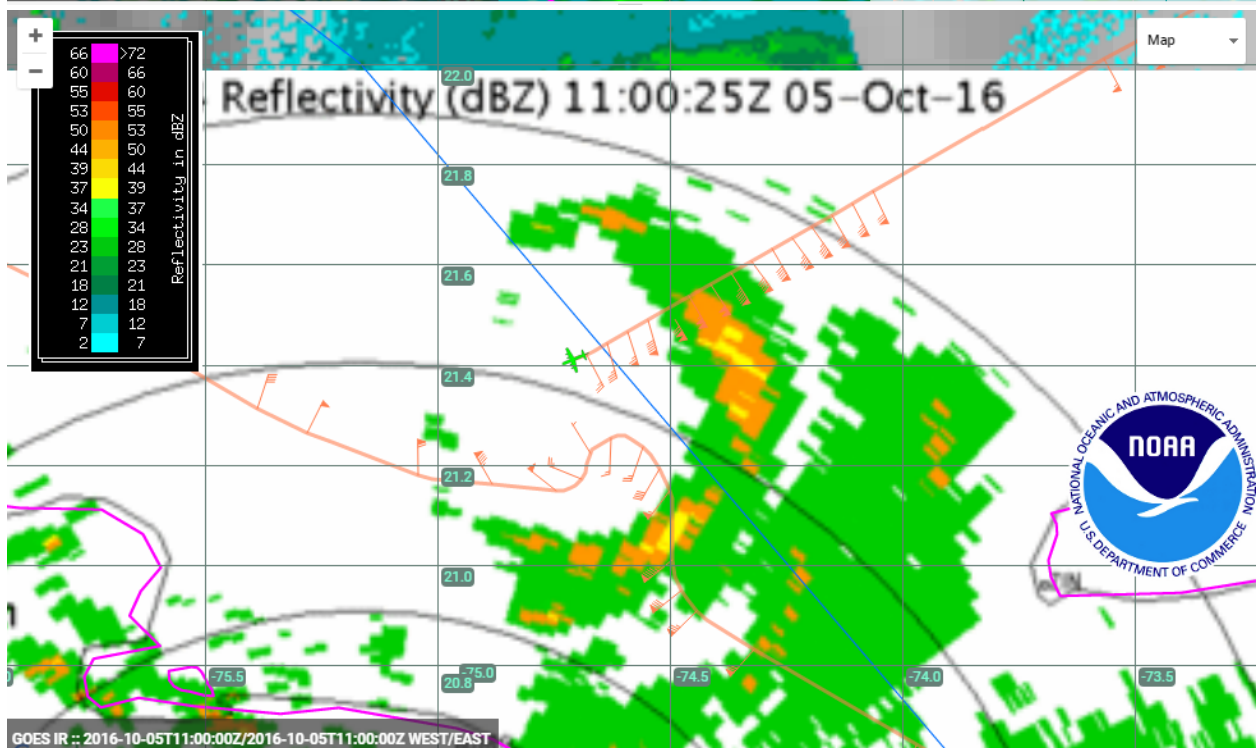
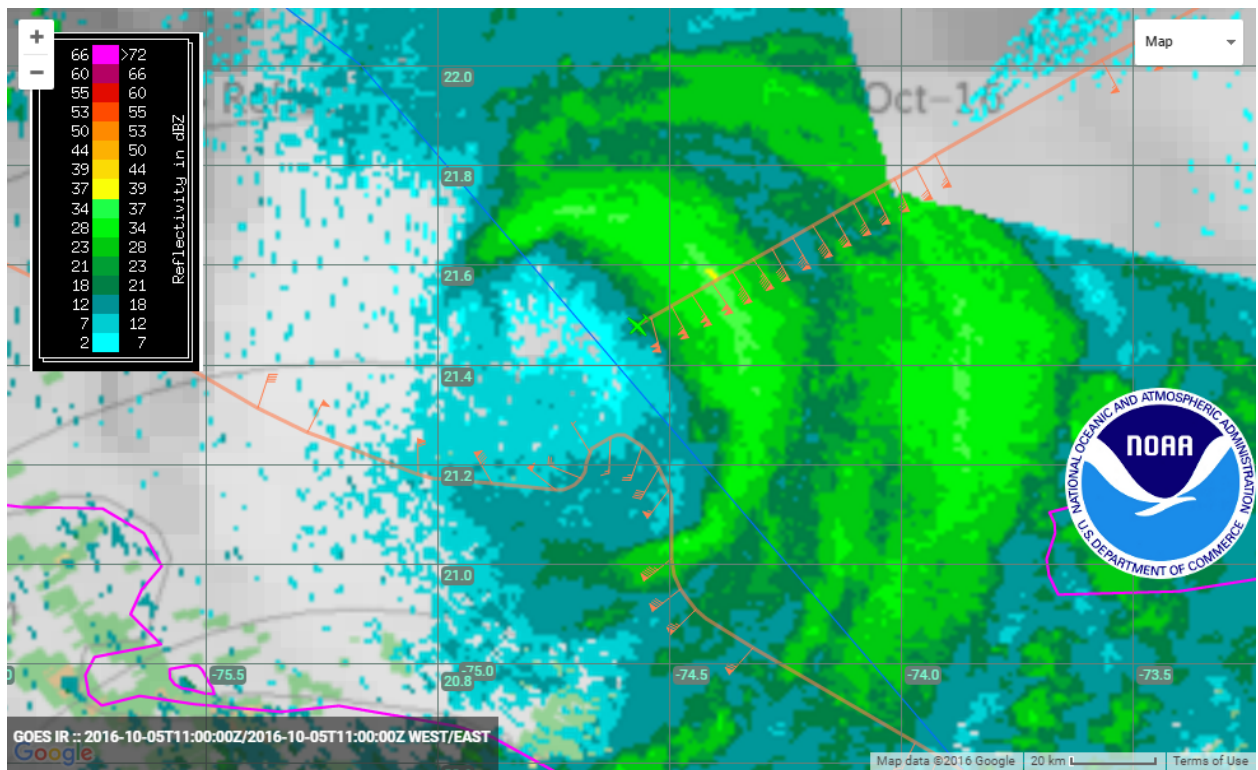
1046Z: Sonde #7 released at location 12. Good drop.

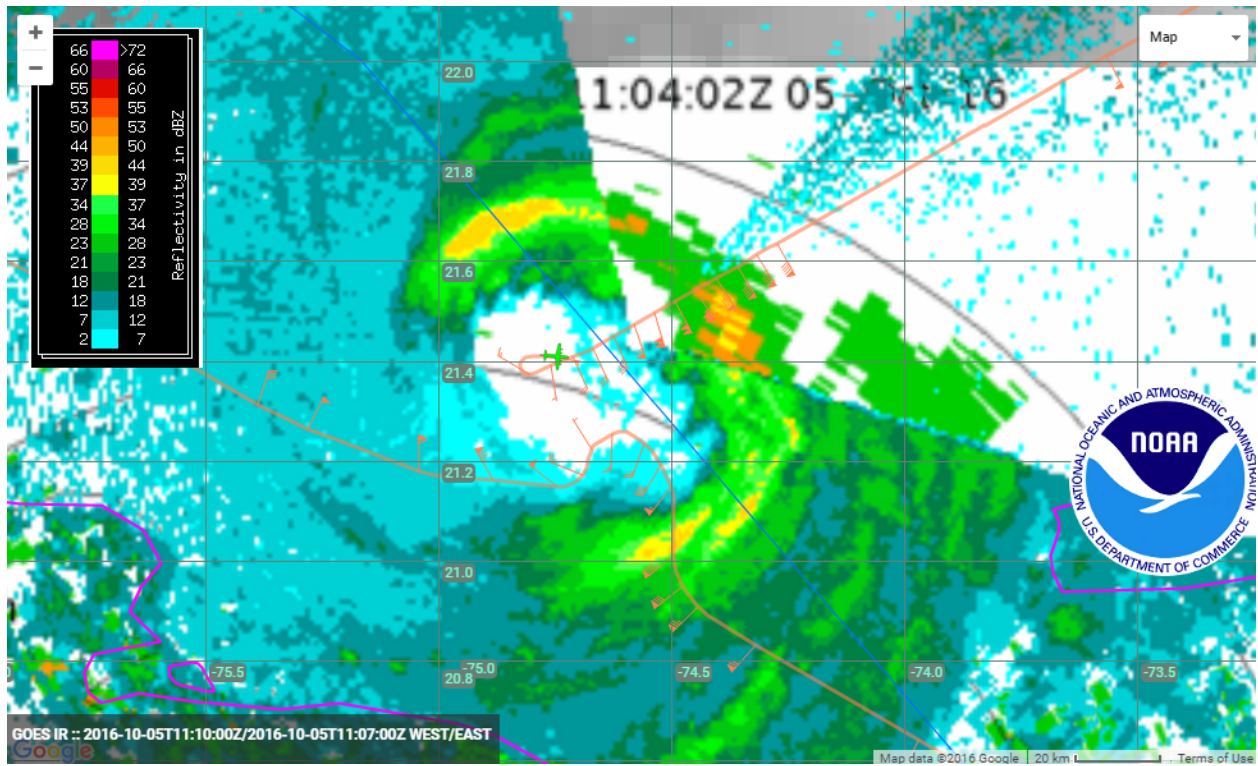
1056Z: Sonde #8 released at location 13. Good drop.

1106Z: Sonde #9 released at location 14. Good drop. (11 drops total include 2 test sondes)

1116Z: Sonde #10 released at location 15. Good drop. (12 drops total include 2 test sondes)

1128Z: Sonde 11 released at location 16. Good drop.





>> Drops are being logged on the HRD drop log from this point on

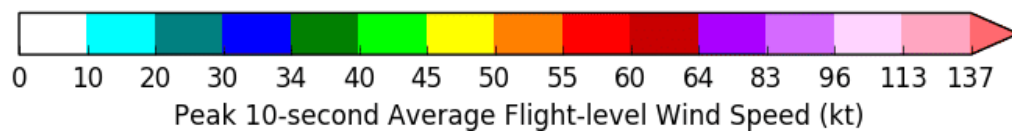
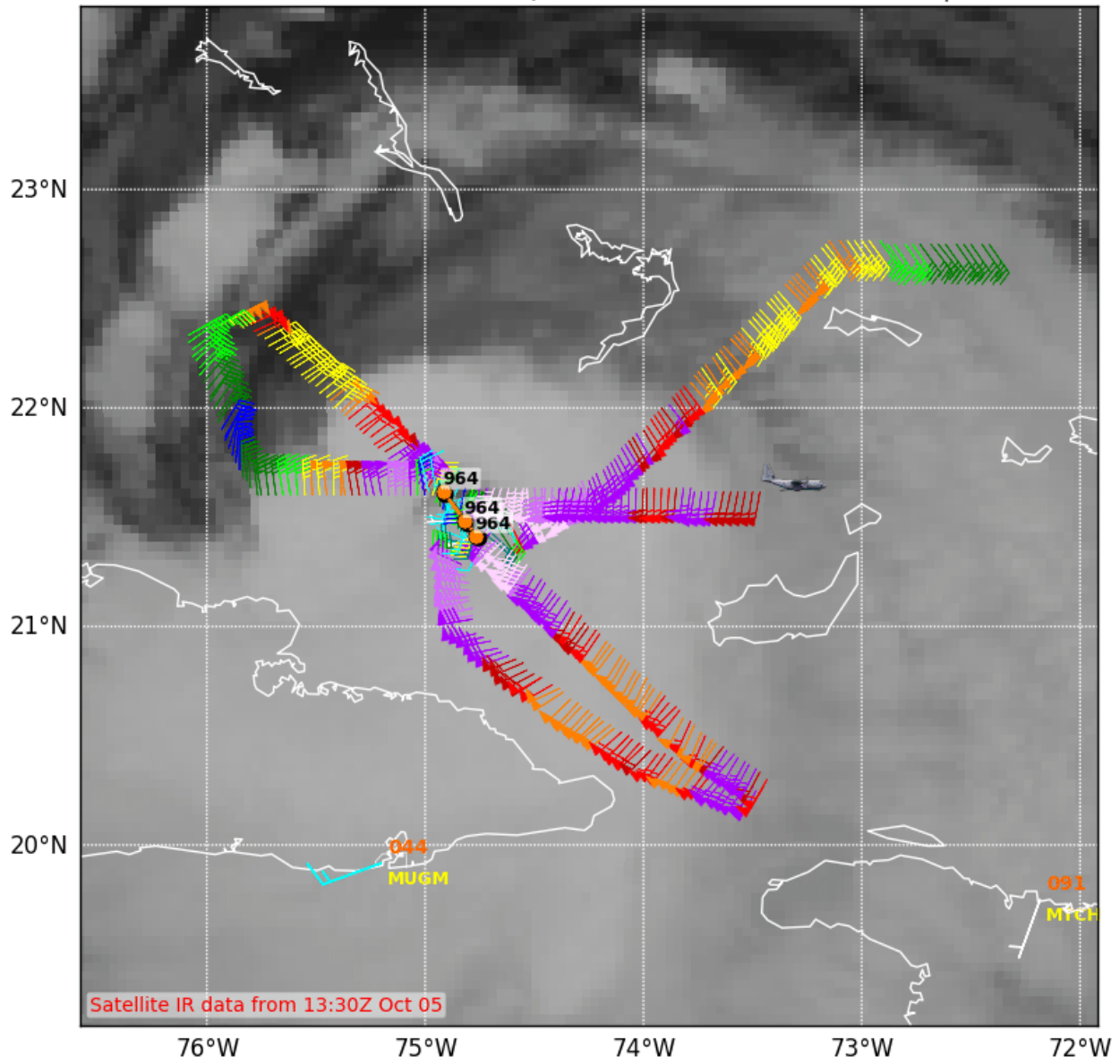


Crossing FL peninsula at sunrise

We considered track alterations to go out and poke TC Nicole, but that would have added ~2 hrs flight time. And cutting some existing track legs would have hindered the ability to define the STR, which right now is a key synoptic player for Matthews future track. So that idea was scrapped.

AF304 Recon Obs as of 13:42Z Oct 05, 2016

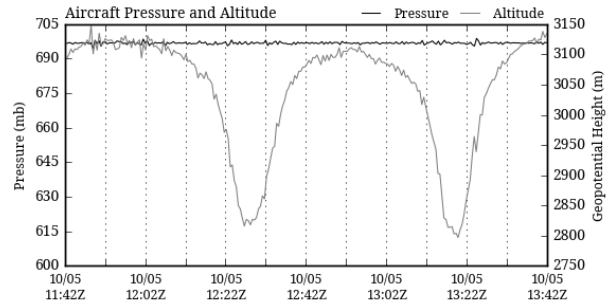
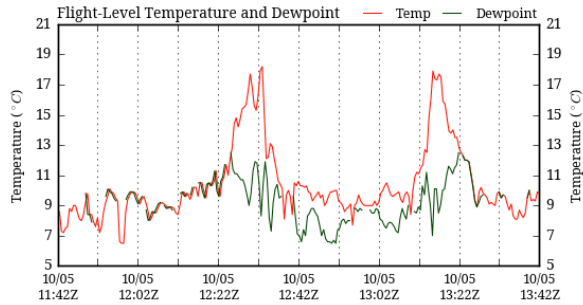
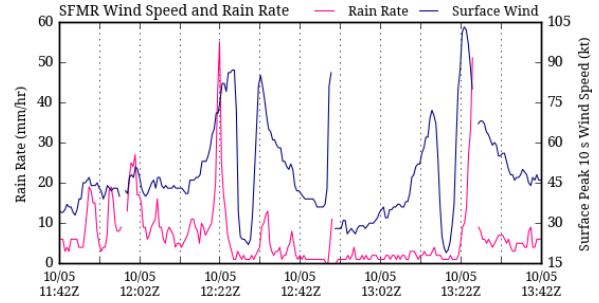
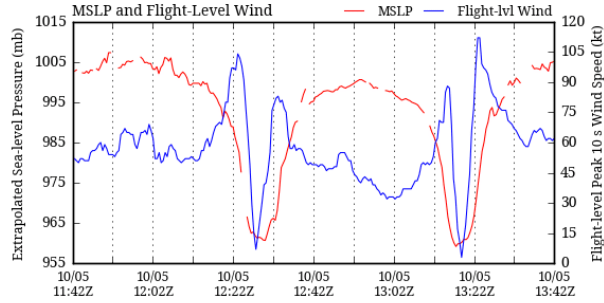
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Recon Aircraft Observations

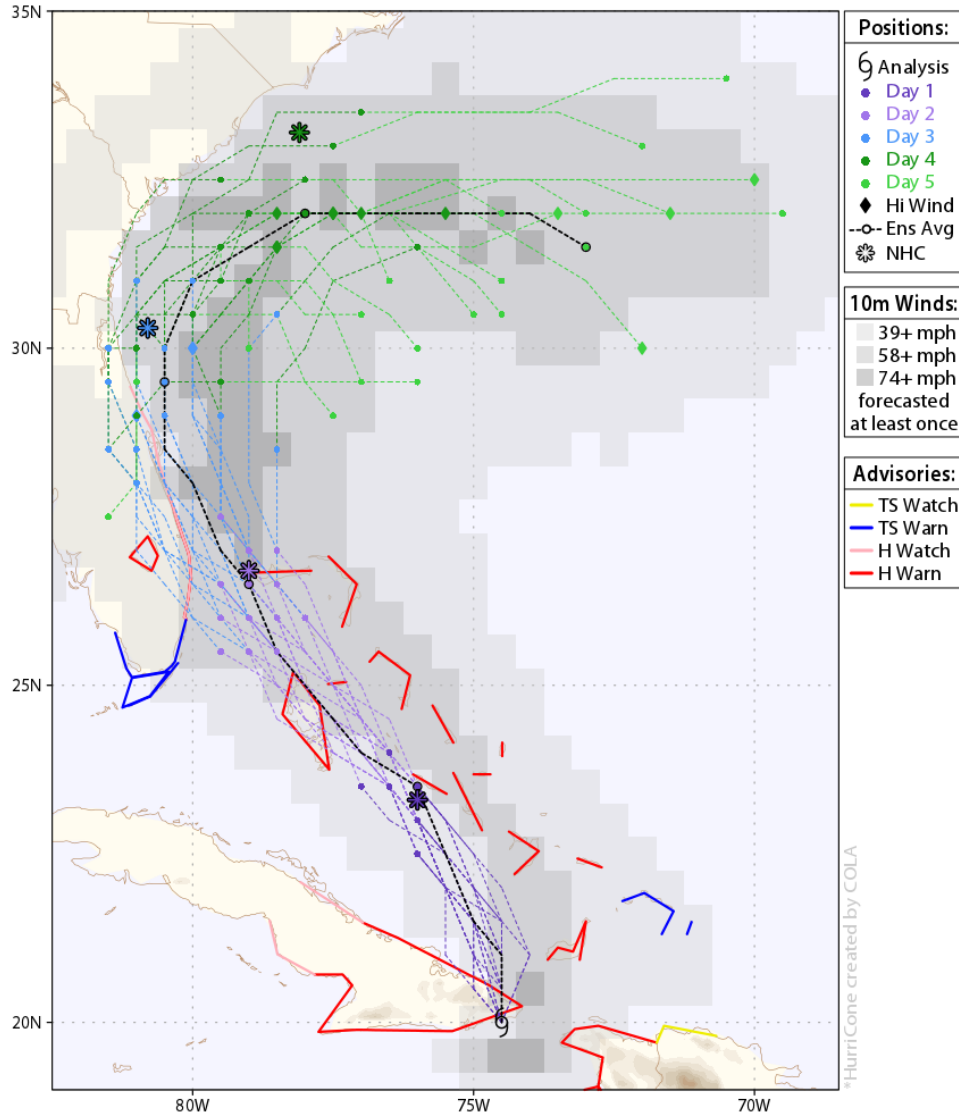
Mission ID: AF304 2314A MATTHEW

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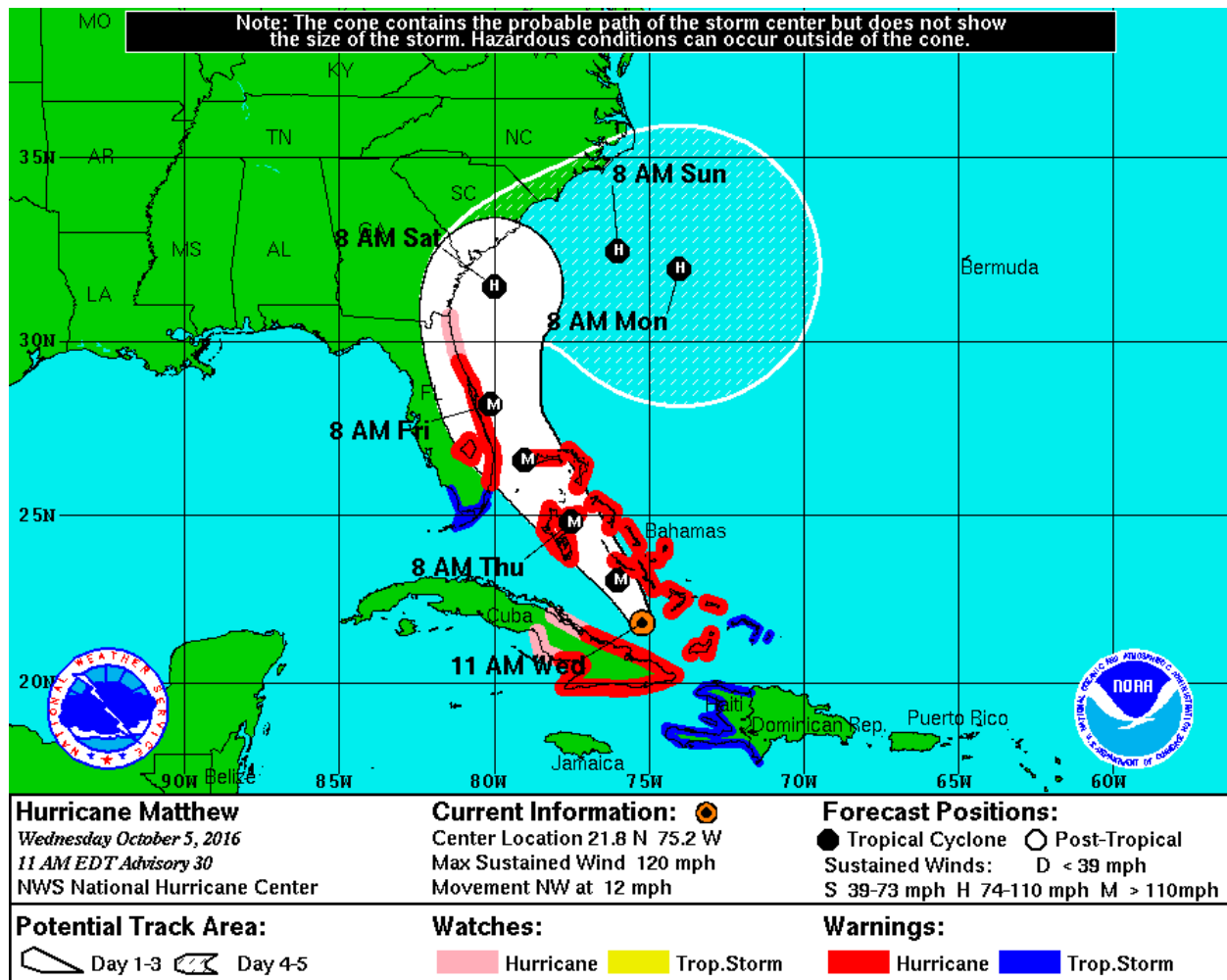
Storm Track and Wind Speed Forecasts for MATTHEW

Based on data from the GEFS model and the National Hurricane Center



GEFS Initialized 00Z 05 OCT 2016
NHC Advisory Issued 03Z 05 OCT 2016

*HurriCone created by COLA



HURRICANE MATTHEW DISCUSSION NUMBER 30
 NWS NATIONAL HURRICANE CENTER MIAMI FL AL142016
 1100 AM EDT WED OCT 05 2016

Both NOAA and Air Force Hurricane Hunter planes have been in the eye of Matthew during the past several hours. Data from those planes indicate that the hurricane is gradually recovering from the passage over the mountains of eastern Cuba and Haiti. The eye is becoming better defined on satellite. Based on SFMR winds of 103 kt and a flight-level peak wind of 118 kt, the initial intensity is 105 kt.

The environment between the Bahamas and Florida is favorable for Matthew to restrengthen some during the next couple of days. After that time, the shear is forecast to increase, resulting in

gradual weakening.

Fixes from the planes indicate that Matthew is moving toward the northwest or 325 degrees at about 8 to 10 kt. The subtropical ridge over the western Atlantic is amplifying as anticipated by the global models. The flow pattern around this ridge should continue to steer the hurricane toward the northwest during the next day or two with no significant change in forward speed. After that time the ridge will move east allowing Matthew to move northward very near or over the Florida east coast and then near or to the east of the Georgia and South Carolina coasts. By the end of the forecast period, models have changed significantly since yesterday. Some track models keep the hurricane moving eastward across the Atlantic while the GFS and the ECMWF reduce the hurricane's forward speed with a southward turn. This change in these two valuable models is reflected in the current NHC forecast.

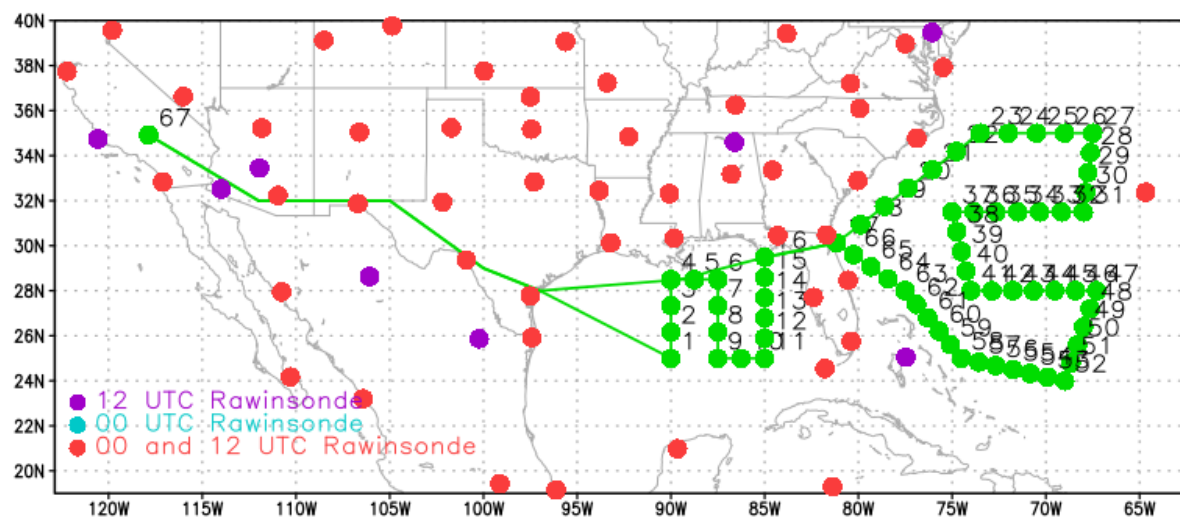
FORECAST POSITIONS AND MAX WINDS

INIT	05/1500Z	21.8N	75.2W	105 KT	120 MPH
12H	06/0000Z	23.1N	76.0W	110 KT	125 MPH
24H	06/1200Z	24.8N	77.5W	115 KT	130 MPH
36H	07/0000Z	26.6N	79.0W	115 KT	130 MPH
48H	07/1200Z	28.2N	80.1W	115 KT	130 MPH
72H	08/1200Z	31.5N	80.0W	95 KT	110 MPH
96H	09/1200Z	32.5N	76.0W	85 KT	100 MPH
120H	10/1200Z	32.0N	74.0W	70 KT	80 MPH

Update 2 to the flight plan has been uploaded to MTS under GH Plan 1 (Active track).

Changes:

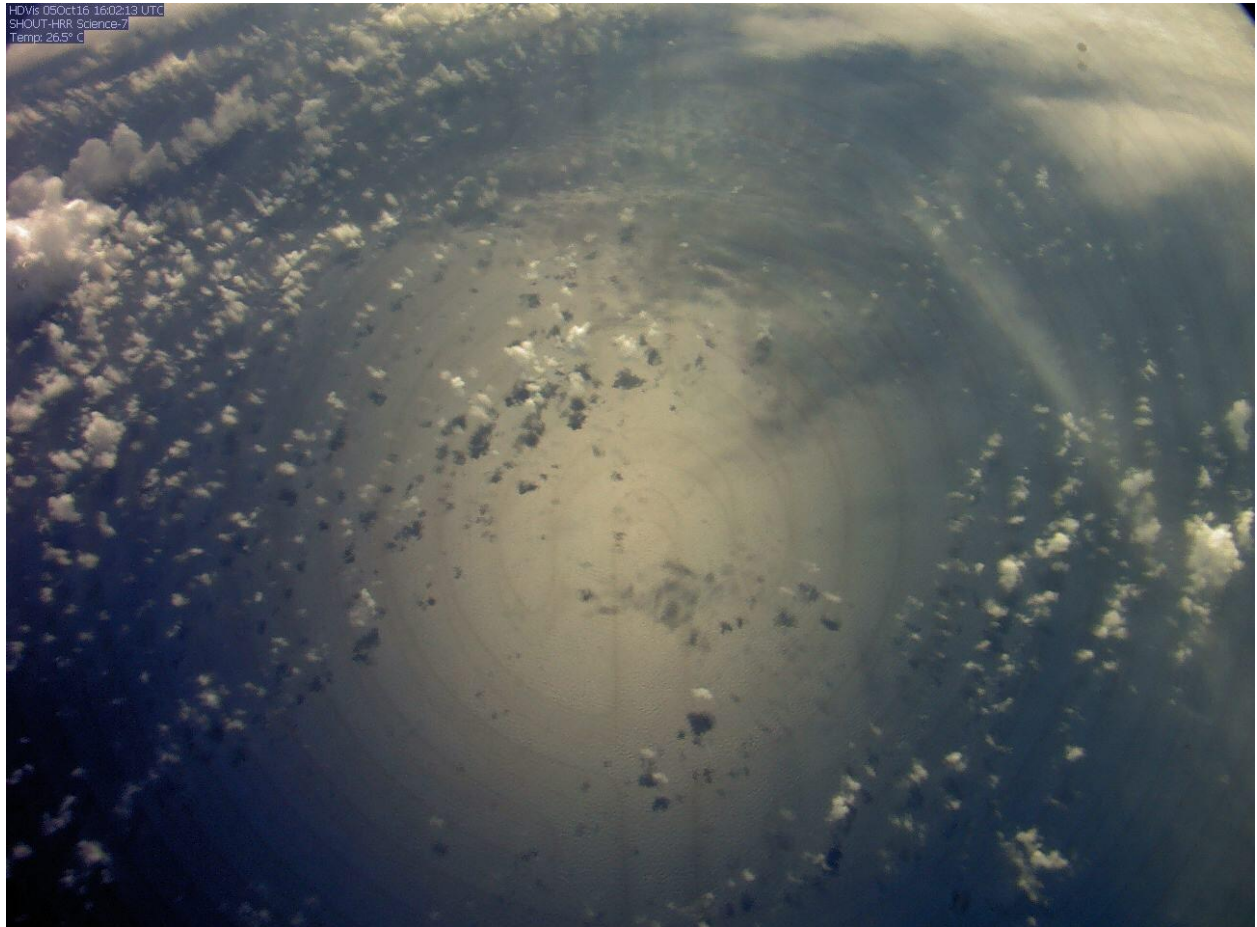
Shifted drop point 46 ~65 nm east and added extra dropsondes along from drop pts 41-59. New track shown below:



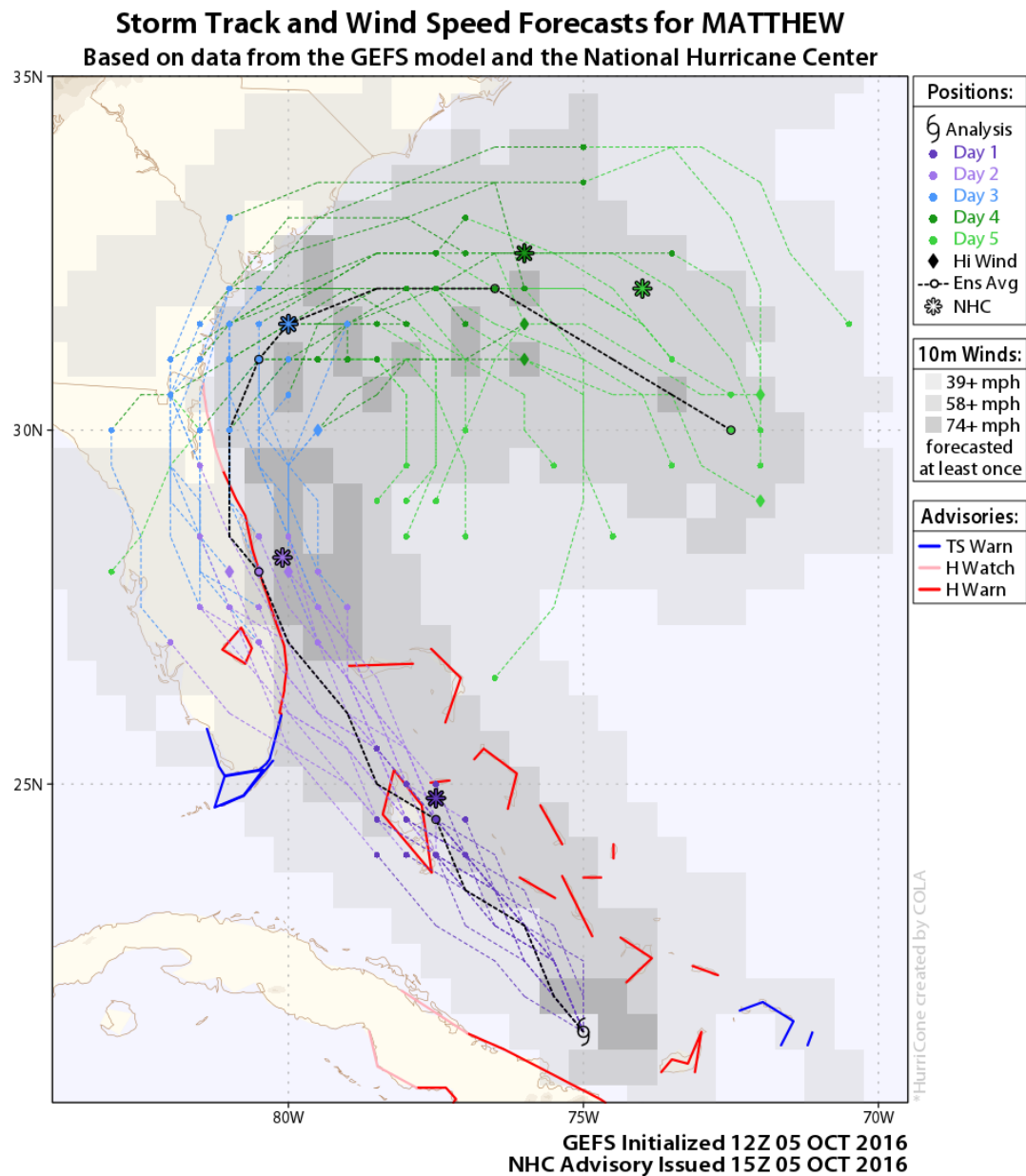
DayLight 05Oct2016 15:58:23 UTC
SHOUT-HRR Science-7
Temp: 17.0° C



At the turn near drop point 37



Near the western nose of the ridge (drop point 38)



Latest GEFS package from 12z has shifted a little further west making landfall on FL more likely.

18:30 GMT: GIV had their Air Data Computer fail, requiring them to abort their mission with last drop at pt3.

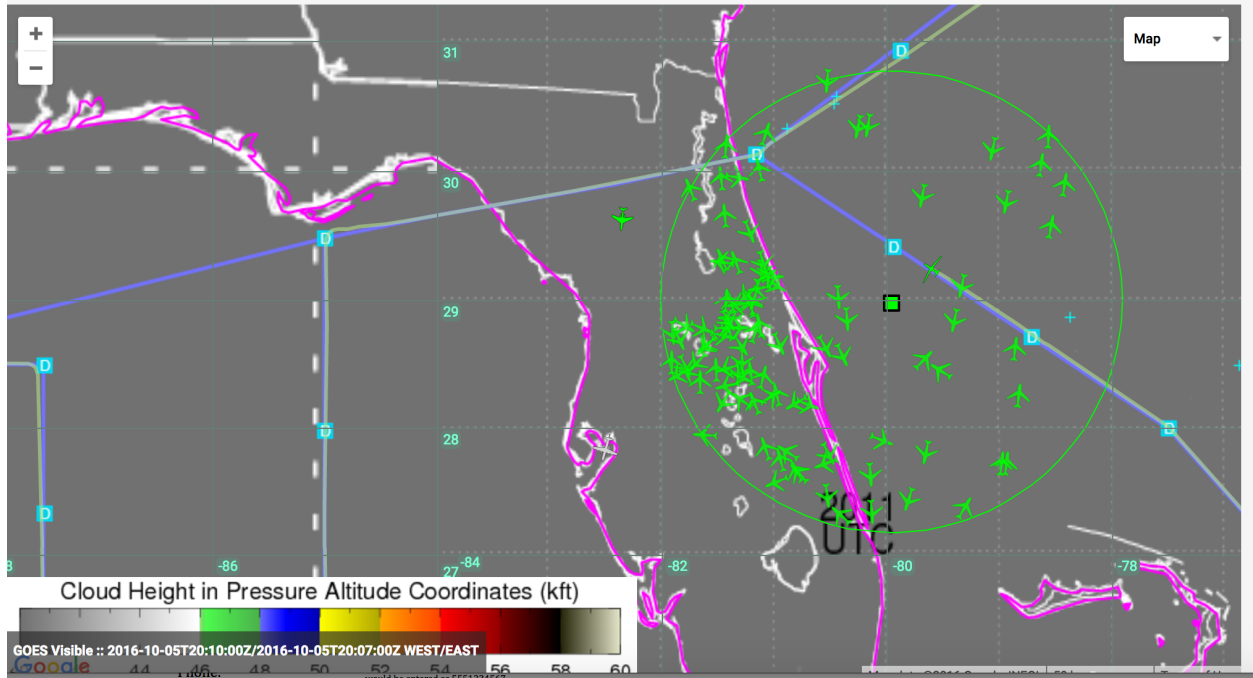
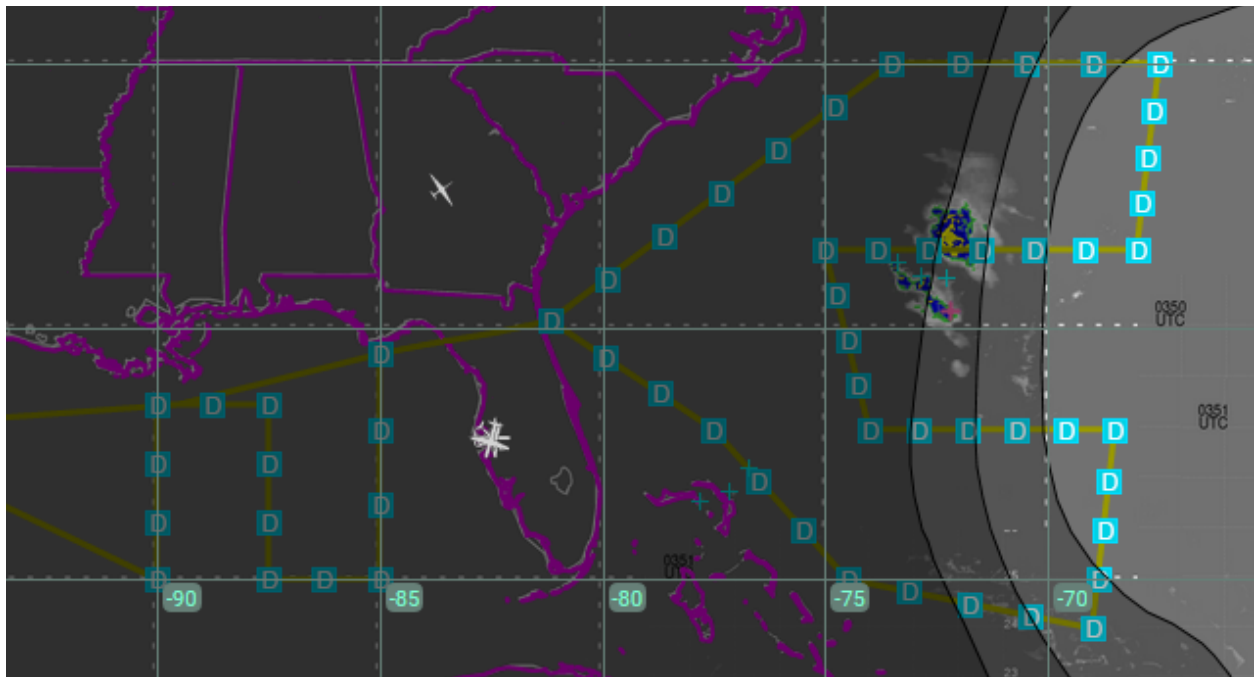
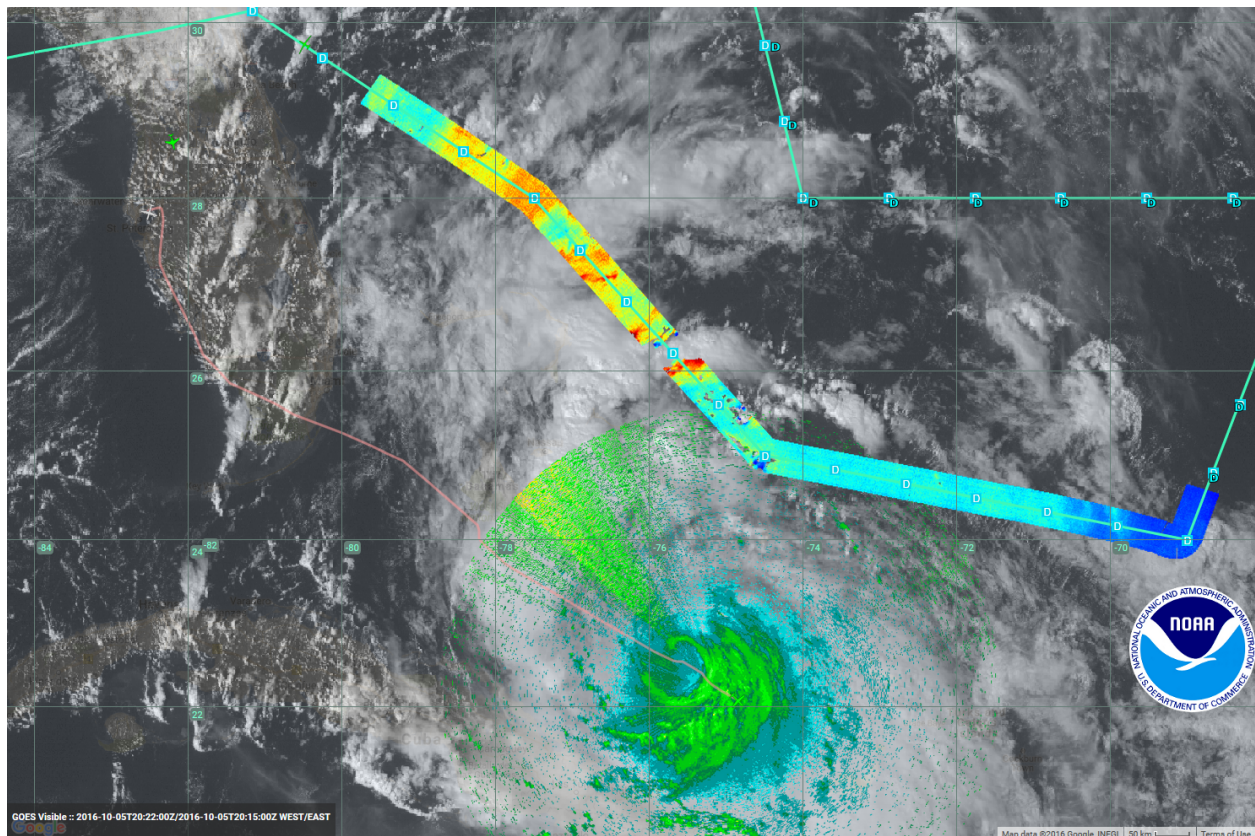


Image showing active traffic in area we are dropping. Trying to enhance drop resolution here as much as possible.



2000Z: After original drop 63, did a 2 min sequence of drops anticipating that drops would cease between MTS drop 64 and 65 due to traffic below. Will pick up high frequency drops after 64. This is within the outflow region extending north from Matthew.



000

WTNT44 KNHC 052040

TCDAT4

HURRICANE MATTHEW DISCUSSION NUMBER 31

NWS NATIONAL HURRICANE CENTER MIAMI FL AL142016

500 PM EDT WED OCT 05 2016

Data from an Air Force Hurricane Hunter plane a couple of hours ago indicated that the structure of Matthew had not changed very much, and the initial intensity remains at 105 kt. Another Hurricane Hunter plane will be in the eye soon. The environment continues to be favorable for Matthew to restrengthen while it approaches the the east coast of Florida during the next day or so. After that time, the shear is forecast to increase significantly, resulting in gradual weakening of the hurricane.

Satellite images indicate that Matthew is moving toward the northwest or 325 degrees at about 10 kt. The subtropical ridge over the western Atlantic is still strong, and the flow pattern around this ridge should continue to steer the hurricane toward the northwest during the next day or two with no significant change in forward speed. After that time, the ridge will shift eastward, allowing Matthew to move northward very near or over the north Florida east coast, and then near or to the east of the Georgia and South Carolina coasts. By the end of the forecast period, models diverge considerably, with the GFS moving the cyclone southwestward toward land, and the ECMWF keeping Matthew over the Atlantic a good distance from

the coast. The NHC forecast keeps Matthew over water in the middle of these two model solutions.

KEY MESSAGES:

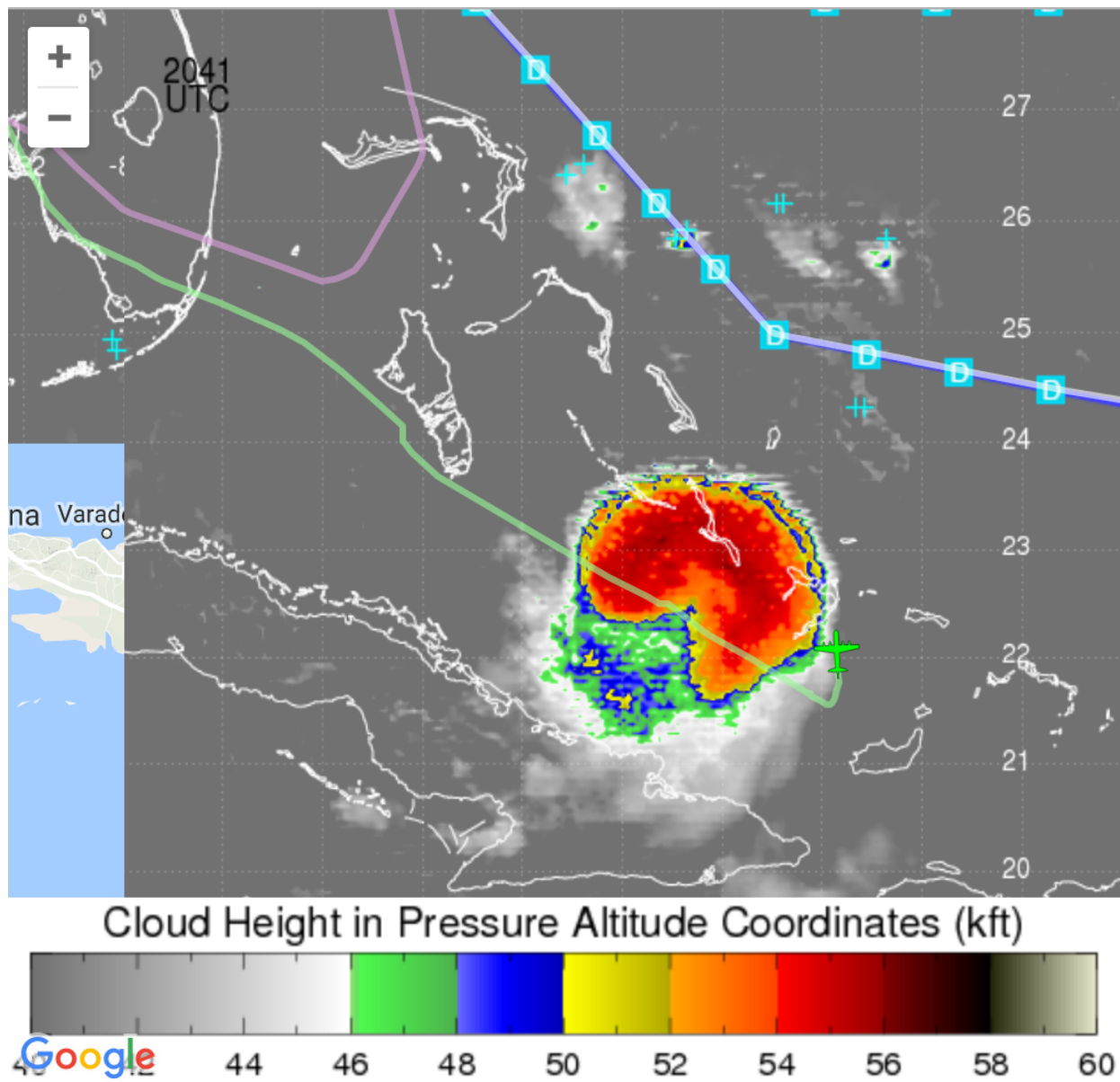
1. Matthew is likely to produce devastating impacts from storm surge, extreme winds, and heavy rains in the Bahamas. Please consult statements from the meteorological service and other government officials in that country.
2. When a hurricane is forecast to take a track roughly parallel to a coastline, as Matthew is forecast to do from Florida through South Carolina, it becomes very difficult to specify impacts at any one location. For example, only a small deviation of the track to the left of the NHC forecast could bring the core of a major hurricane onshore within the hurricane warning area in Florida. However, a small deviation to the right could keep the hurricane-force winds offshore. Similarly large variations in impacts are possible in the hurricane watch area in northern Florida and Georgia.
3. Tropical storm or hurricane conditions could affect South Carolina and North Carolina later this week or this weekend, even if the center of Matthew remains offshore. It is too soon to determine what, if any, land areas might be directly affected by Matthew next week. At a minimum, dangerous beach and boating conditions are likely along much of the U.S. east coast during the next several days.
4. The National Hurricane Center is issuing Potential Storm Surge Flooding Maps, and Prototype Storm Surge Watch/Warning Graphics for Matthew. It is important to remember that the Potential Storm Surge Flooding Map does not represent a forecast of expected inundation, but rather depicts a reasonable worst-case scenario - the amount of inundation that has a 10 percent chance of being exceeded. In addition, because the Flooding Map is based on inputs that extend out only to about 72 hours, it best represents the flooding potential in those locations within the watch and warning areas in Florida and Georgia.

FORECAST POSITIONS AND MAX WINDS

INIT 05/2100Z 22.5N 75.7W 105 KT 120 MPH
12H 06/0600Z 24.0N 76.9W 110 KT 125 MPH
24H 06/1800Z 25.6N 78.5W 115 KT 130 MPH
36H 07/0600Z 27.2N 79.8W 115 KT 130 MPH
48H 07/1800Z 29.0N 80.8W 115 KT 130 MPH
72H 08/1800Z 32.0N 79.5W 90 KT 105 MPH
96H 09/1800Z 32.6N 76.4W 80 KT 90 MPH
120H 10/1800Z 30.0N 74.0W 65 KT 75 MPH

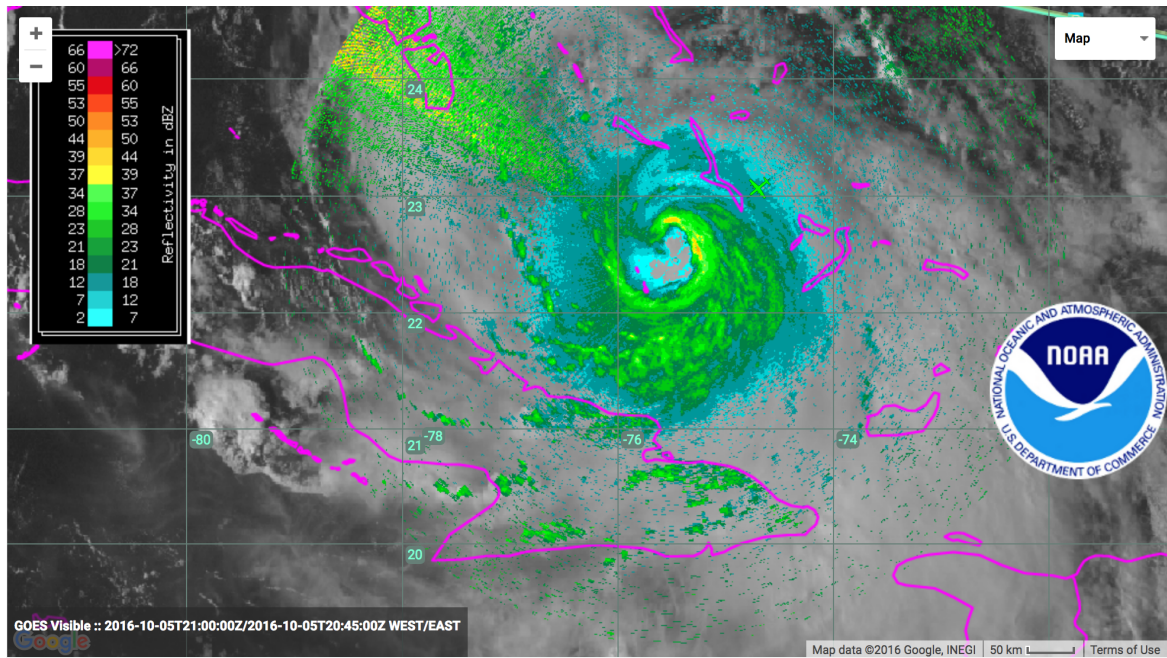
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Forecaster Avila

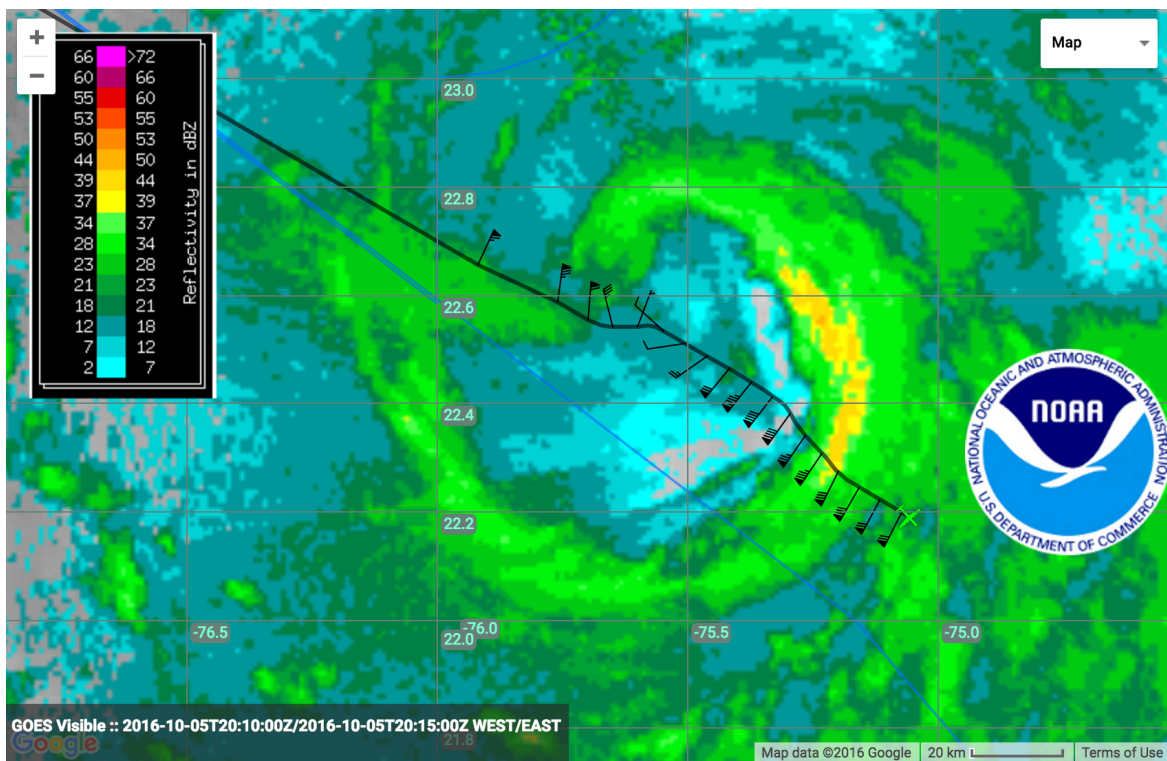


Large convective burst from Matthew evident in the cloud top height product.

Matthew has displayed several convective bursts on the north side of the eye. These have active to cover the earlier visible eye is cirrus. However recent P-3 radar image shows that the eye may be contracting. Pressure is down a few mb from the earlier C-130 flight so perhaps an intensification trend is underway.

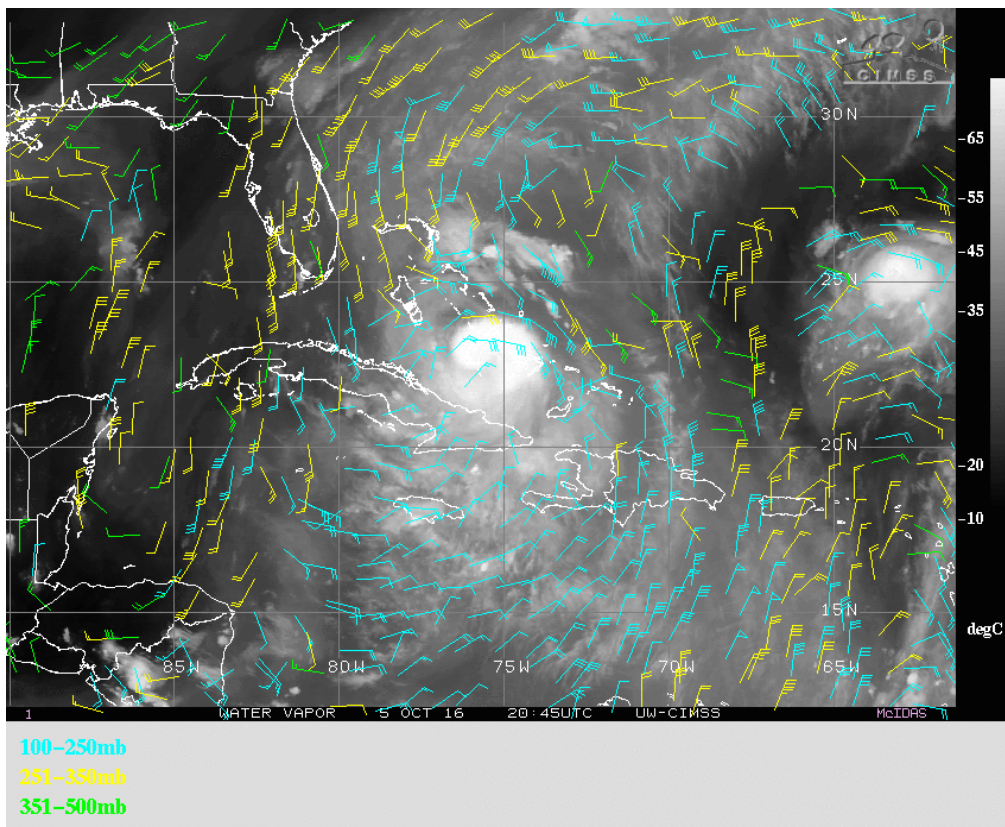
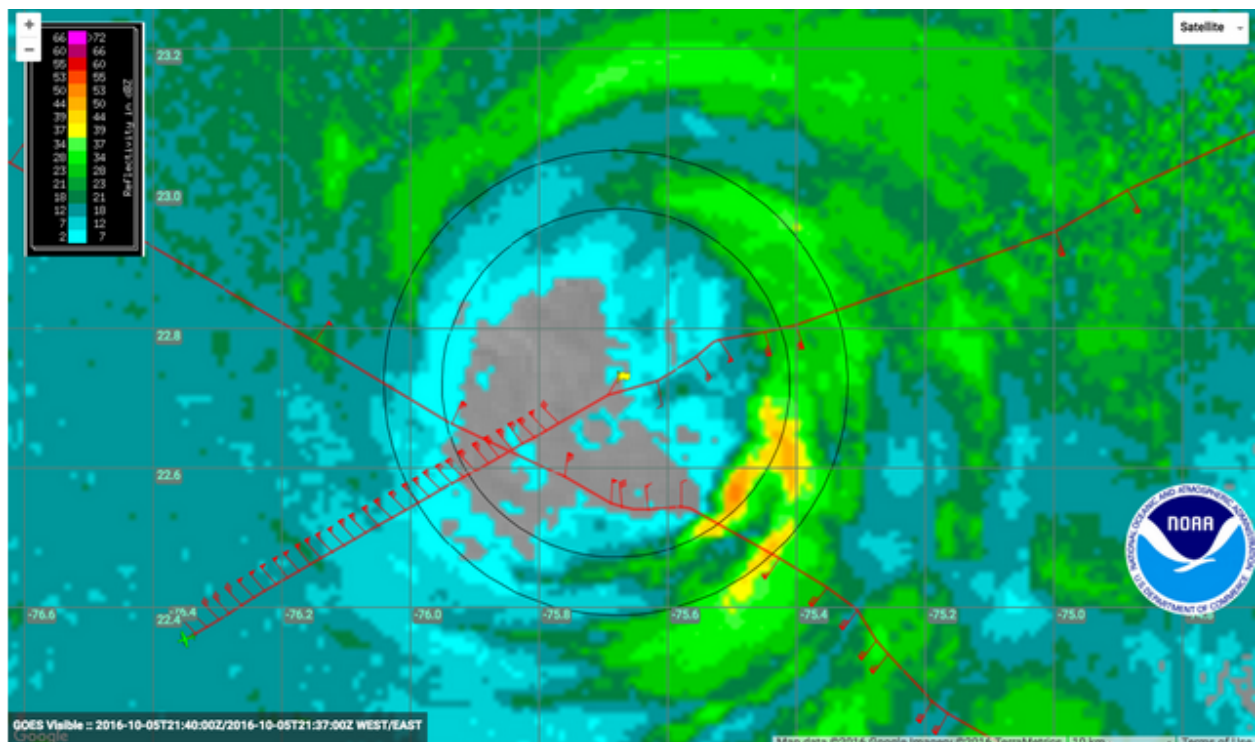


P-3 radar image 1940Z (estimated)



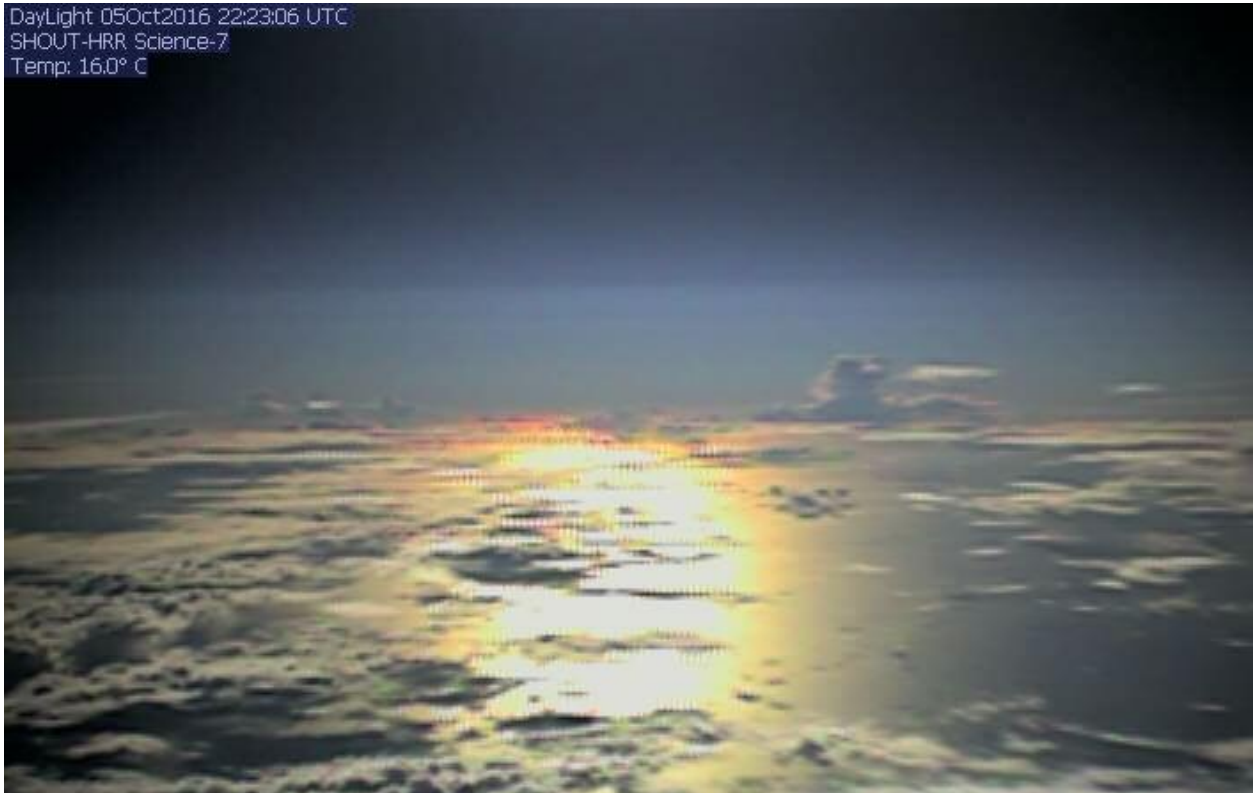
P-3 radar image 2015Z 5 Oct. Center is inside 'eyewall hook' just left of wind minimum. Note 95 kt wind max inside clear eye SE of center.

2155Z: Once again bursts have been initiated downshear right (SE quadrant), and appear to be rotating around to the DSL quadrant, as the previous one did. The image below indicates that they are likely within the RMW, which is estimated to be around 30-40 nmi.



2045Z Water vapor image with mid-upper winds

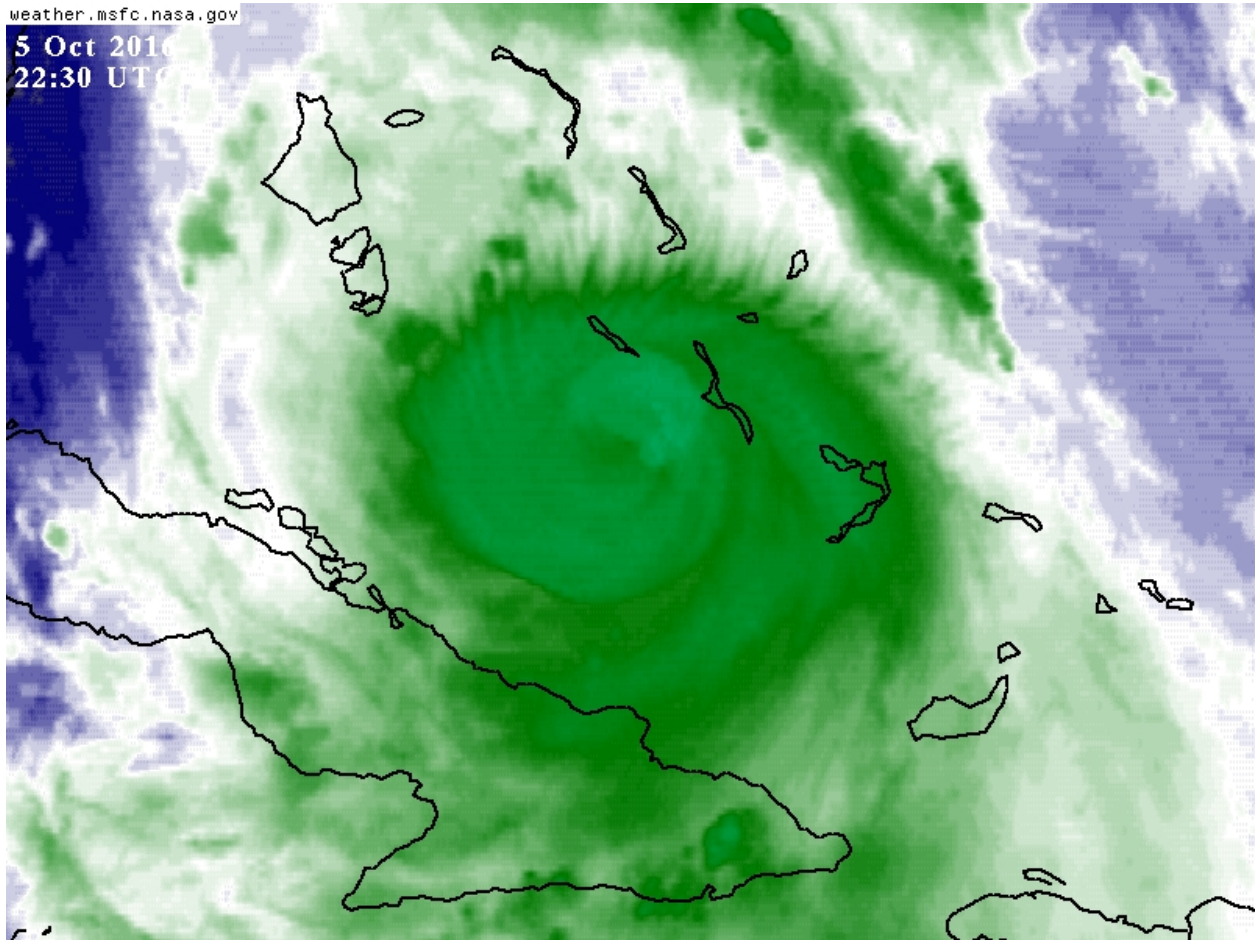
DayLight 05Oct2016 22:23:06 UTC
SHOUT-HRR Science-7
Temp: 16.0° C



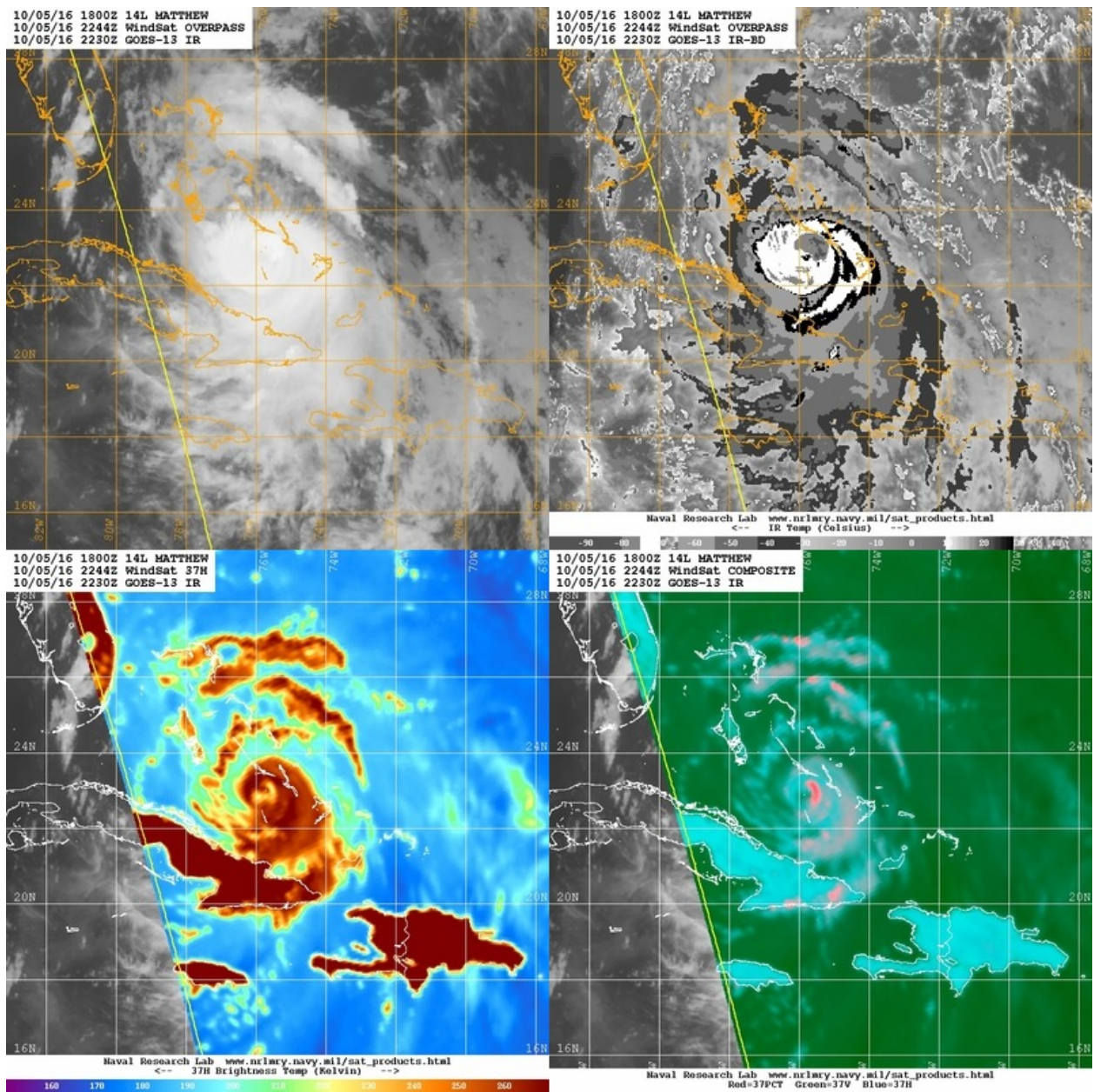
Sunset as the Global Hawk heads back to Armstrong.

weather.msfc.nasa.gov

5 Oct 2016
22:30 UTC



Transverse banding has quickly developed in the outflow cirrus on the north side. 2230Z Water vapor image.

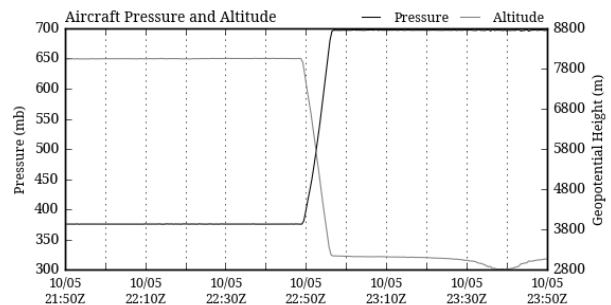
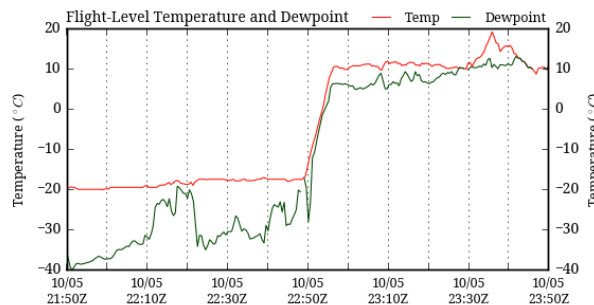
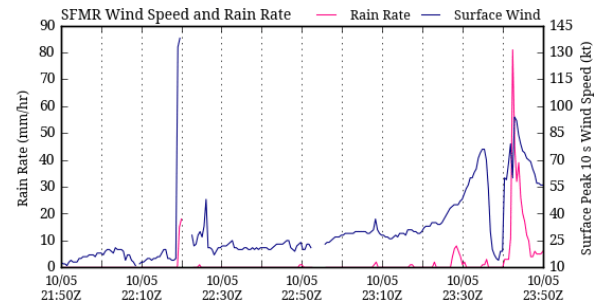
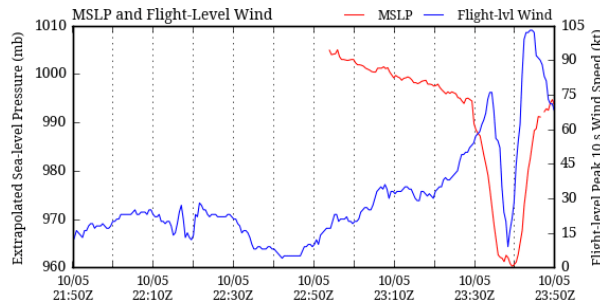


Windsat overpass at 2244Z showing a cyan ring, but little precipitation seems to be associated with that ring.

Recon Aircraft Observations

Mission ID: AF309 2514A MATTHEW

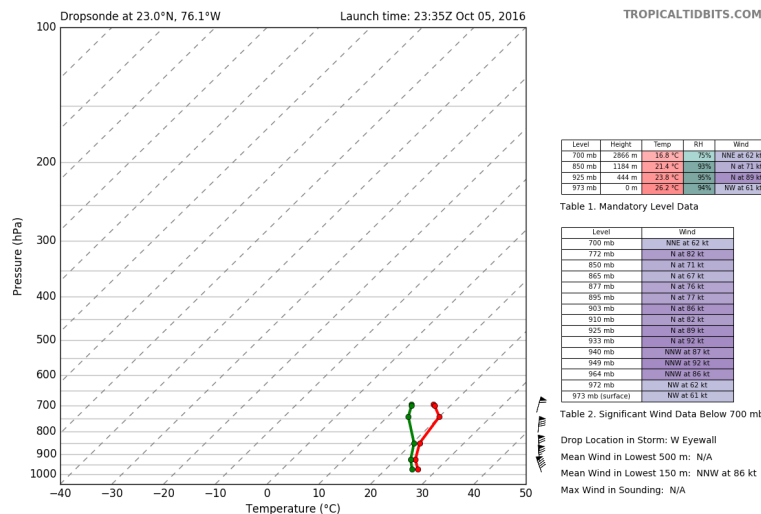
Levi Cowan - tropicaltidbits.com



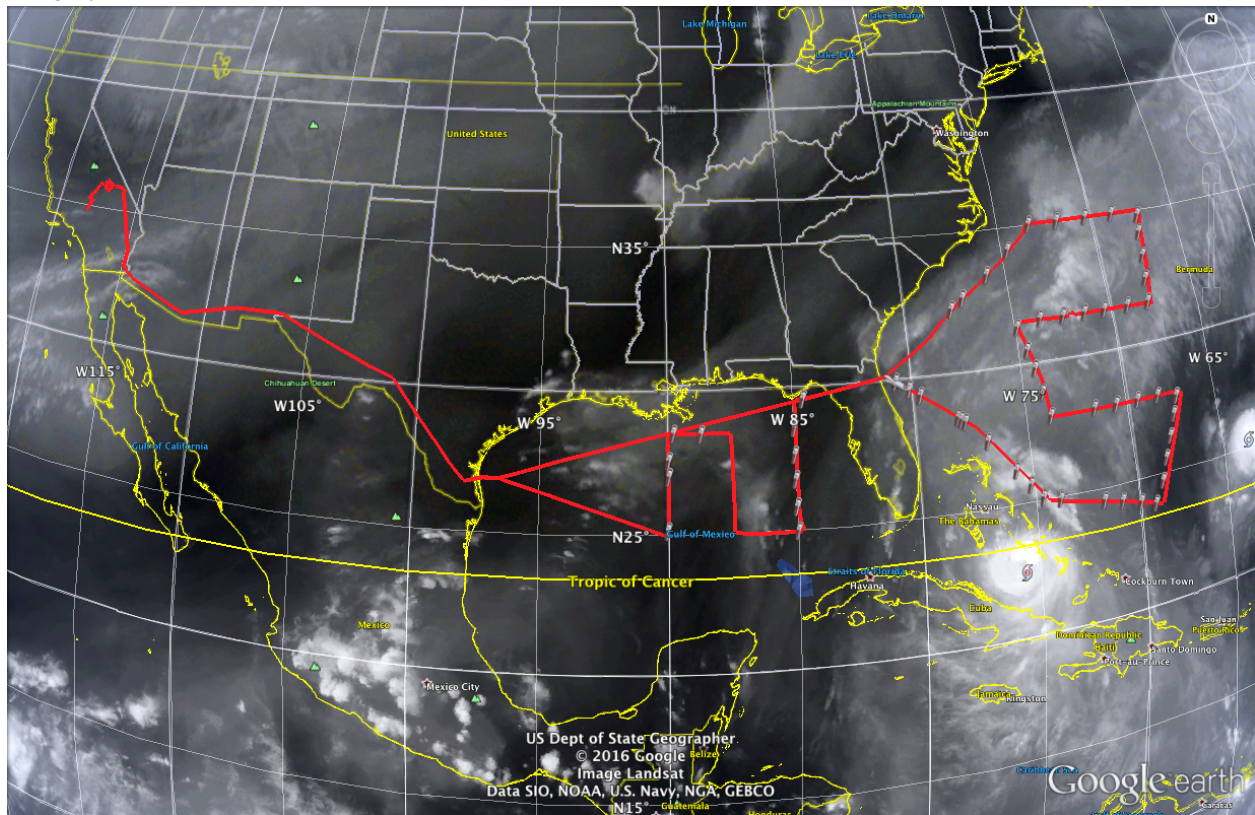
C-130 pass shows rain rate spike on eastern side with pronounced asymmetry. Winds from both aircraft do not support current intensity from NHC at 5 pm of 105 knots. New advisory at 8 pm lowers winds to 100 knots.

Best guess for weakening during the day is dry air near the inner core region seen in imagery earlier this morning on the west side. The bursting convection pattern suggests insufficiently moist environment to maintain convection.

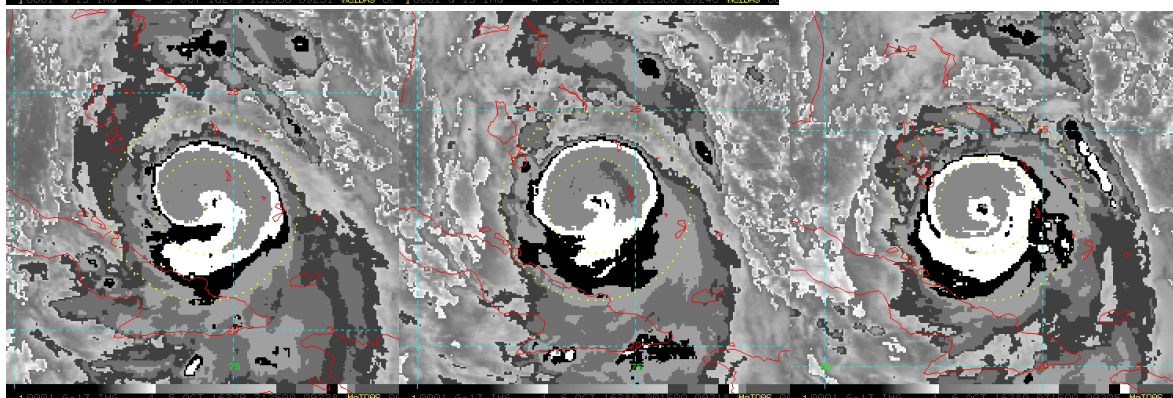
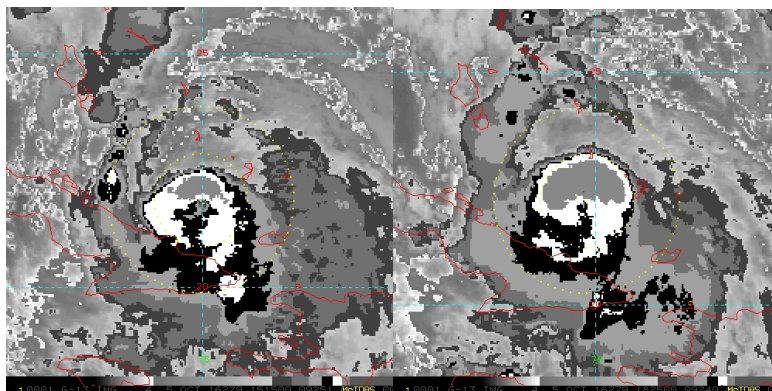
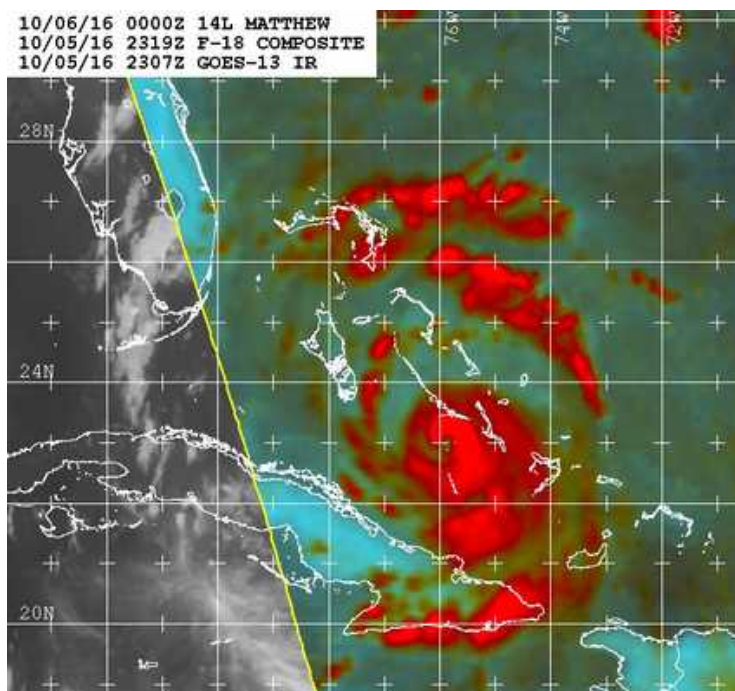
Most recent drop in western eyewall by C-130 shows some mid level drier air.



Mission summary showing final track (red) and sondes released (sonde symbols) overlaid on water vapor imagery: LANDING: 0340Z EDW



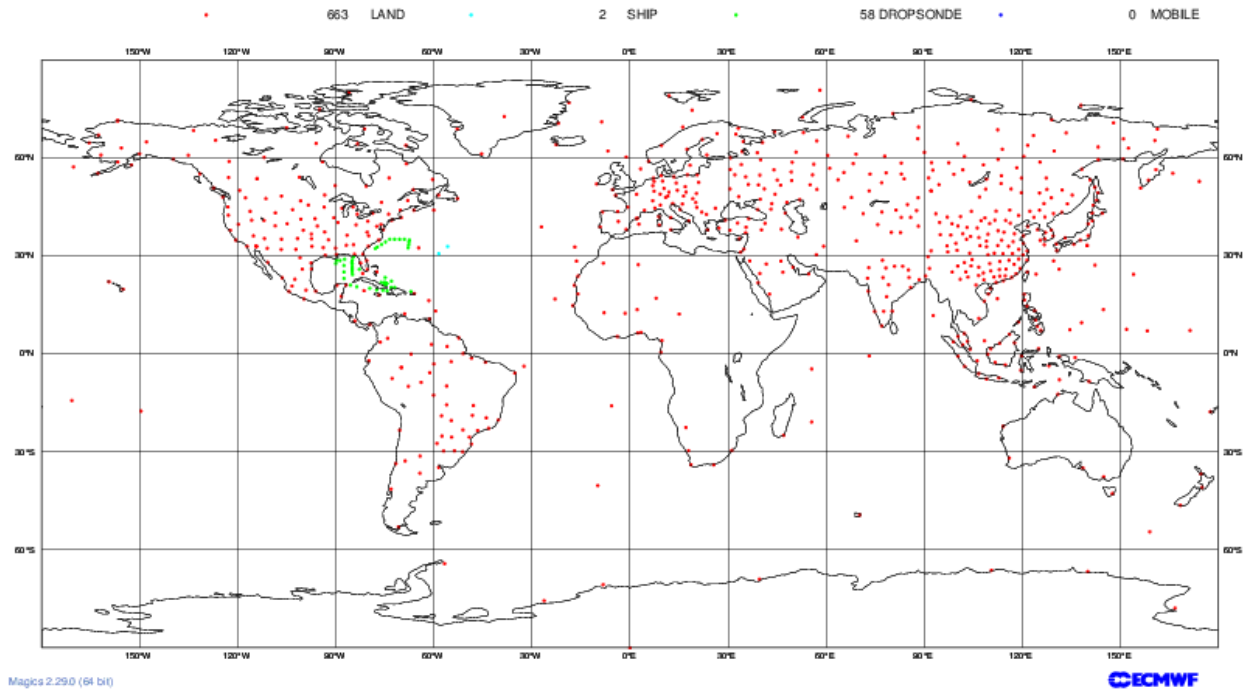
Latest SSMIS pass shows eyewall remains open on sw side but has contracted with an eye diameter of 33 km (2319Z image below)



15Z, 18Z, 21Z, 00Z and 03Z Dvorak IR showing improvement in convective organization of Matthew. The degraded IR presentation brought Dvorak intensity estimates down to as low as 77 knots.

Dropsonde data from this mission were assimilated into the ECMWF 12Z forecasts:

ECMWF Data Coverage (All obs DA) - Temp
05/Oct/2016; 12 UTC
Total number of obs = 723



HURRICANE MATTHEW DISCUSSION NUMBER 32
NWS NATIONAL HURRICANE CENTER MIAMI FL AL142016
1100 PM EDT WED OCT 05 2016

Data from Air Force Reserve and NOAA Hurricane Hunter aircraft showed lower winds in Matthew than seen during the previous mission, with peak 700-mb flight-level winds of 103 kt and estimates near 95 kt from the SFMR instrument. Based on these, the initial intensity is reduced to 100 kt. However, satellite imagery indicates that the hurricane is becoming better organized, with the eye trying to re-appear and cooling cloud tops near the center. In addition, the eye has contracted to 15 n mi wide and the central pressure has fallen to 961 mb. This suggests that the winds are about to increase.

The initial motion is 320/9. There is little change to the synoptic reasoning or the forecast track through 48 hours. Matthew is expected to move around the western side of the subtropical ridge, which should move slowly eastward during the next couple of days. This evolution should steer Matthew generally northwestward for the next 24 hours or so, followed by a turn toward the north-northwest. This forecast track takes the center near Andros Island and New Providence in about 12 hours, and then very near the eastern coast of the the Florida peninsula. This part of the forecast track is west of the various consensus models, but it lies near the GFS, ECMWF, and ECMWF ensemble mean. From 48-72 hours, the cyclone is expected to recurve northeastward along the southern edge of the mid-latitude westerlies. After 72 hours, the track guidance become very divergent, with solutions ranging from a continued eastward motion out to sea to a turn back to the southwest. The new forecast track shows a slow southeastward

motion during this time in best agreement with the ECMWF.

As mentioned above, Matthew is getting better organized, and during the next 36 hours or so it should be moving through an area of light vertical wind shear. This should allow strengthening, and the new intensity forecast calls for the system to reach an intensity near 115 kt in about 36 hours. This is near the upper end of the intensity guidance. After 36 hours, proximity to land and increasing shear should cause weakening, and the cyclone is now expected to be down to tropical storm strength by 120 hours. Overall, the intensity forecast is in best agreement with the SHIPS model.

KEY MESSAGES:

1. Matthew is likely to produce devastating impacts from storm surge, extreme winds, and heavy rains in the Bahamas. Please consult statements from the meteorological service and other government officials in that country.
2. When a hurricane is forecast to take a track roughly parallel to a coastline, as Matthew is forecast to do from Florida through South Carolina, it becomes very difficult to specify impacts at any one location. For example, only a small deviation of the track to the left of the NHC forecast could bring the core of a major hurricane onshore within the hurricane warning area in Florida. However, a small deviation to the right could keep the hurricane- force winds offshore. Similarly large variations in impacts are possible in the hurricane watch area in northern Florida and Georgia.
3. Tropical storm or hurricane conditions could affect South Carolina and North Carolina later this week or this weekend, even if the center of Matthew remains offshore. It is too soon to determine what, if any, land areas might be directly affected by Matthew next week. At a minimum, dangerous beach and boating conditions are likely along much of the U.S. east coast during the next several days.
4. The National Hurricane Center is issuing Potential Storm Surge Flooding Maps, and Prototype Storm Surge Watch/Warning Graphics for Matthew. It is important to remember that the Potential Storm Surge Flooding Map does not represent a forecast of expected inundation, but rather depicts a reasonable worst-case scenario - the amount of inundation that has a 10 percent chance of being exceeded. In addition, because the Flooding Map is based on inputs that extend out only to about 72 hours, it best represents the flooding potential in those locations within the watch and warning areas in Florida and Georgia.

FORECAST POSITIONS AND MAX WINDS

INIT 06/0300Z 23.4N 76.4W 100 KT 115 MPH
12H 06/1200Z 24.6N 77.6W 105 KT 120 MPH
24H 07/0000Z 26.4N 79.2W 115 KT 130 MPH
36H 07/1200Z 28.2N 80.4W 115 KT 130 MPH
48H 08/0000Z 30.1N 81.0W 110 KT 125 MPH
72H 09/0000Z 32.5N 78.5W 90 KT 105 MPH
96H 10/0000Z 32.0N 75.5W 70 KT 80 MPH
120H 11/0000Z 30.5N 73.5W 55 KT 65 MPH

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Forecaster Beven

HIWRAP is down. Repair time unknown. Could impact follow on flight.

Landed 0340Z