

NOAA / AOML / Hurricane Research Division
Hurricane Field Program
Advancing the Prediction of Hurricanes Experiment (APHEX)

FLIGHT LOG - 20210926H1

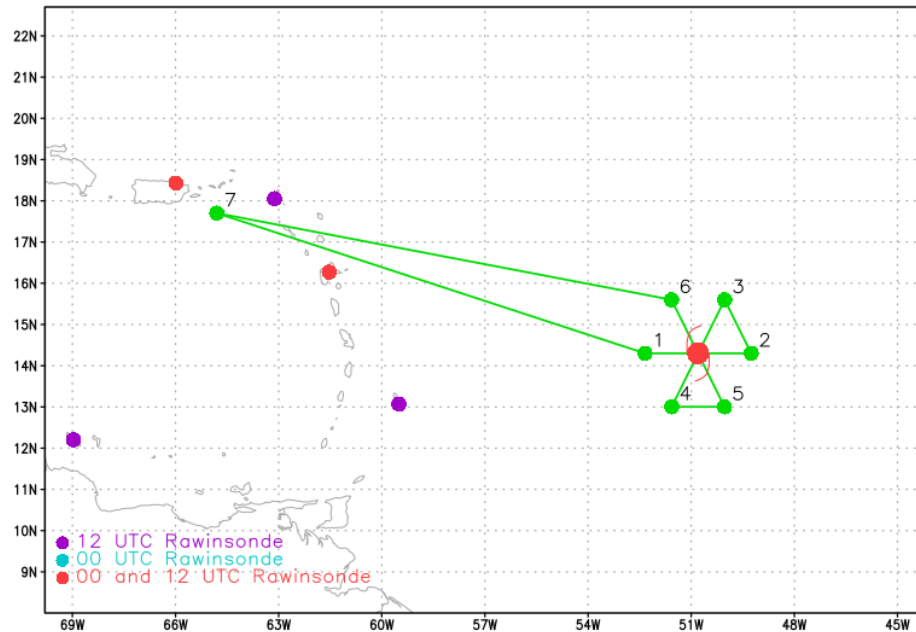
MISSION PLAN			
FLIGHT ID	20210926H1	STORM	AL18 / SAM
MISSION ID	0218A	TAIL NUMBER	NOAA42
TASKING	EMC	PLANNED PATTERN	Butterfly
MISSION SUMMARY			
TAKEOFF [UTC]	1941	LANDING [UTC]	0414
TAKEOFF LOCATION	St. Croix	LANDING LOCATION	St. Croix
FLIGHT TIME	8.5	BLOCK TIME	8.7
TOTAL REAL-TIME RADAR ANALYSES (Transmitted)	3 (3)	TOTAL DROPSONDES (Good/Transmitted)	34 (34/34)
OCEAN EXPENDABLES (Type)	7 (ONR AXBT)	sUAS (Type)	None
APHEX EXPERIMENTS / MODULES	Mature Experiment: Gravity Wave Module		
HRD CREW MANIFEST			
LPS ONBOARD	Bucci	LPS GROUND	Zawislak
TDR ONBOARD	Bucci	TDR GROUND	Gamache
ASPEN ONBOARD	J. Zhang	ASPEN GROUND	None
NESDIS SCIENTISTS	None		
GUESTS (Affiliation)	None		
AOC CREW MANIFEST			
PILOTS	Legidakes, Keith, Rannenberg		
NAVIGATOR	Hough, Utama		
FLIGHT ENGINEERS	Sanchez, Levine		
FLIGHT DIRECTOR	Hathaway, Lundry		
DATA TECHNICIAN	T. Richards		
AVAPS	McAllister		

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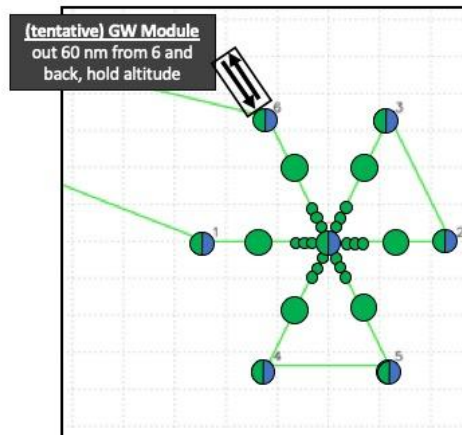
PRE-FLIGHT

Flight Plan



Tasking: EMC

N42 PM flight into Sam: 26 September, 2021



- Flight track
- Regular drop
- Combo drop (Regular + AXBT)
- Eyewall rapid drop sequence

Dropsonde payload: ~33 total (12 ONR, 21 EMC)
 6 turn point drops (EMC)
 6 midpoint drops (EMC)
 3 center drops (EMC)
 ~18 RMW rapid drops (~12 ONR, 6 EMC)

AXBT payload: 7 (NRL/ONR)

center drop guidance: Regular drops in the center on each center pass; attempt combo AXBT drop on 1 center pass.

RMW drop guidance: release at least 3 drops on each pass through eyewall/RMW.

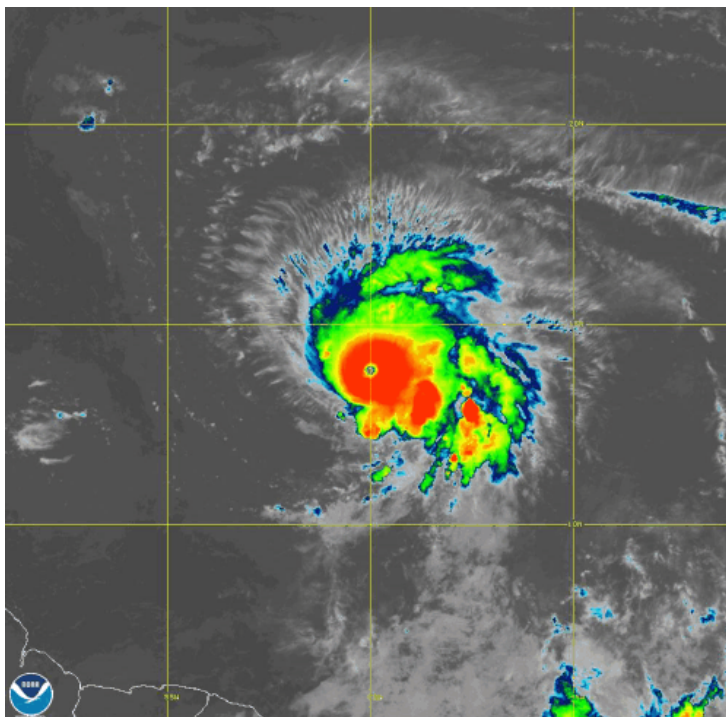
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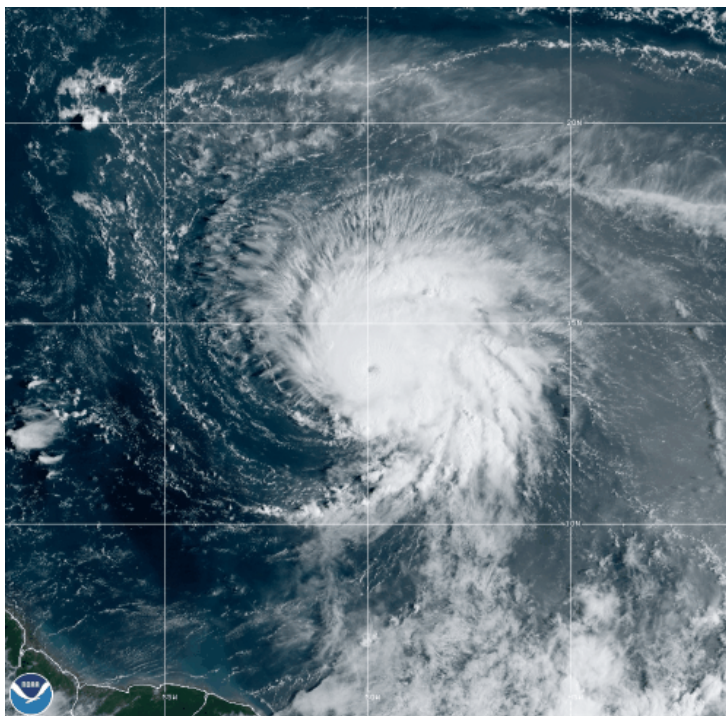
	The planned pattern is for a 90 n mi butterfly with an additional Gravity Wave Module to the NW at the completion of the pattern. Altitude will be 10 kft.
Expendable Distribution	Dropsondes to be released at the endpoints (EMC), midpoints (EMC), center (EMC), and RMWs on each inbound and outbound (6 charged to EMC, the remainder to ONR TCRI). ONR AXBTs will be released at each endpoint, and once in the center (if possible).
Preflight Weather Briefing	As of the 11 AM EDT NHC Advisory, Hurricane Sam was located near 13.9N / 50.2W, had an estimated max wind of 125 kt, MSLP of 943 mb, and was moving west-northwest at 7 kt. Since yesterday, it appears that the storm has more or less been in a steady state, though the inner core continues to exhibit an impressive ring of deep convection and clear eye. The environment continues to be favorable for the storm to maintain its intensity, and perhaps strengthen some (though it is fairly close to its maximum potential intensity), though eyewall replacement cycles are certainly possible and could temporarily weaken the storm. It'll be interesting to see whether this flight observes secondary eyewall formation.

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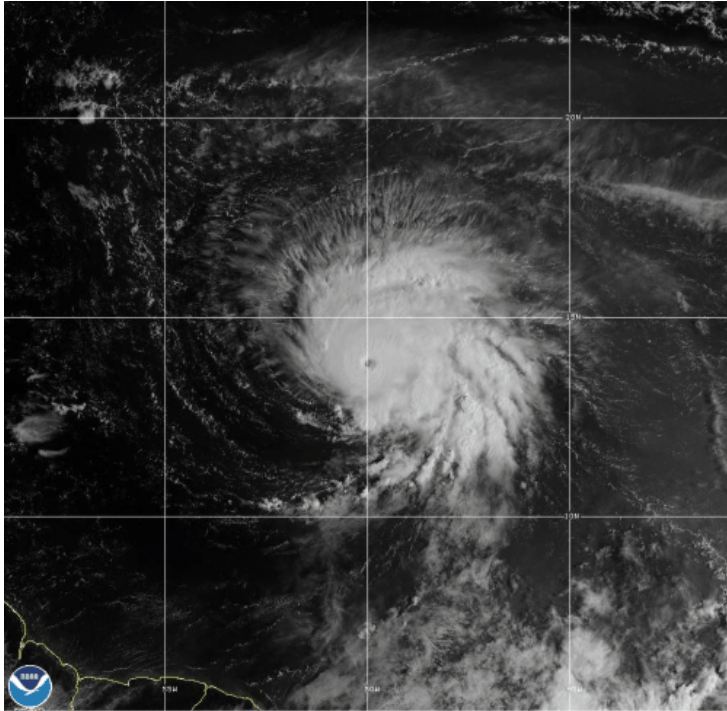
26 Sep 2021 12:00Z NOAA/NESDIS/STAR GOES-East Band 13 HU Sam



26 Sep 2021 11:30Z NOAA/NESDIS/STAR GOES-East GEOCOLOR

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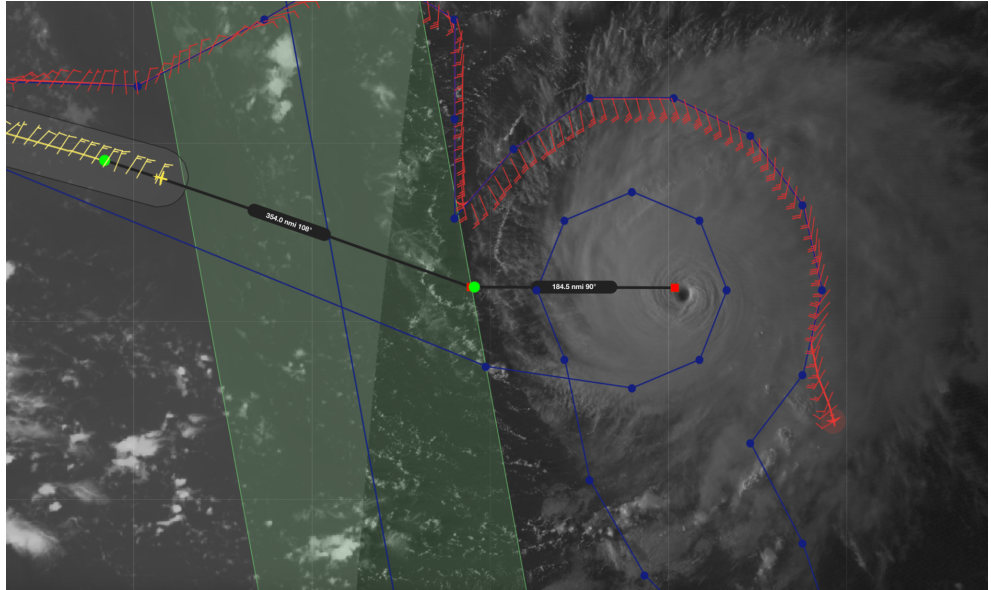
FLIGHT LOG - 20210926H1

	 <p>26 Sep 2021 11:50Z NOAA/NESDIS/STAR GOES-East Band 02 HU Sam</p>
Instrument Notes	All instruments up and functioning. WSRA received a software update to potentially fix a bad data processing from yesterday's flight.

IN-FLIGHT	
Time [UTC]	Event
1941	Take off from STIX / 2 h until begin pattern
2045	<p>5 PM NHC Advisory: 14.2N / 50.5W, 130 kt, 938 mb, moving northwest at 6 kt: "Sam has found a way to strengthen some more today. The ring of intense convection surrounding the 15-n-mi-diameter eye has expanded in size over the past several hours, while cloud tops colder than -70C still completely surround the center. An earlier GMI microwave overpass revealed very strong eyewall convection tightly wrapped around the small eye, a feature oftentimes seen with intense hurricanes. The latest Dvorak intensity estimates from TAFB and SAB remain T6.5/127 kt. However, the UW-CIMSS ADT estimate has recently increased to T6.6/130 kt. Based on the expansion of the ring of convection and a blend of these Dvorak estimates, the initial</p>

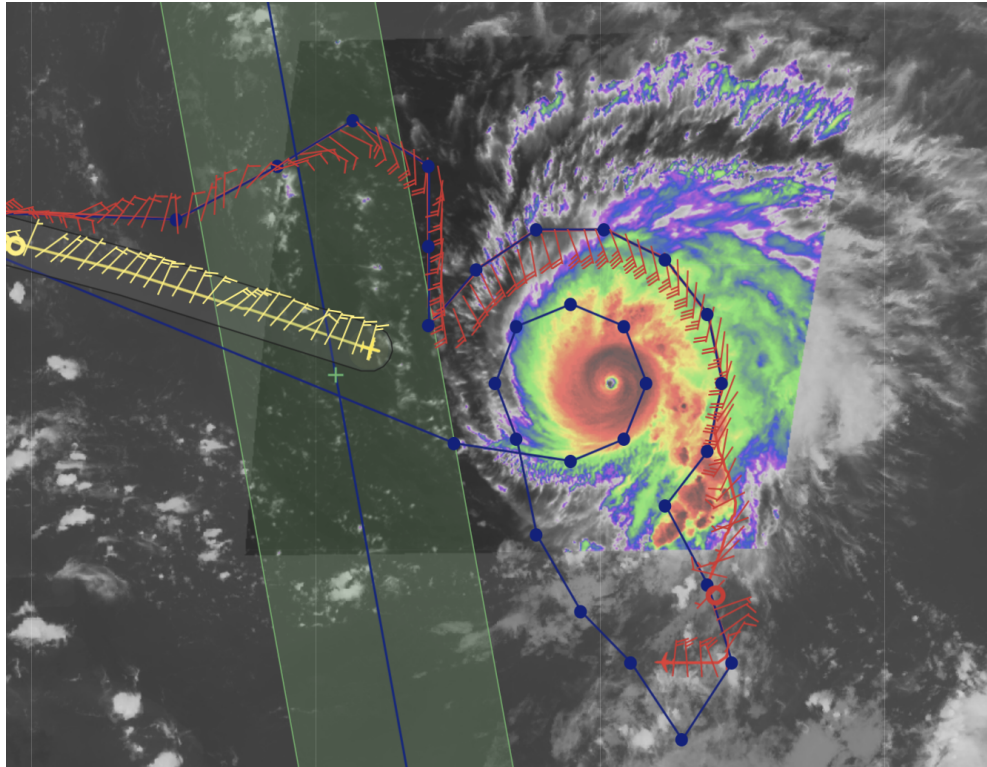
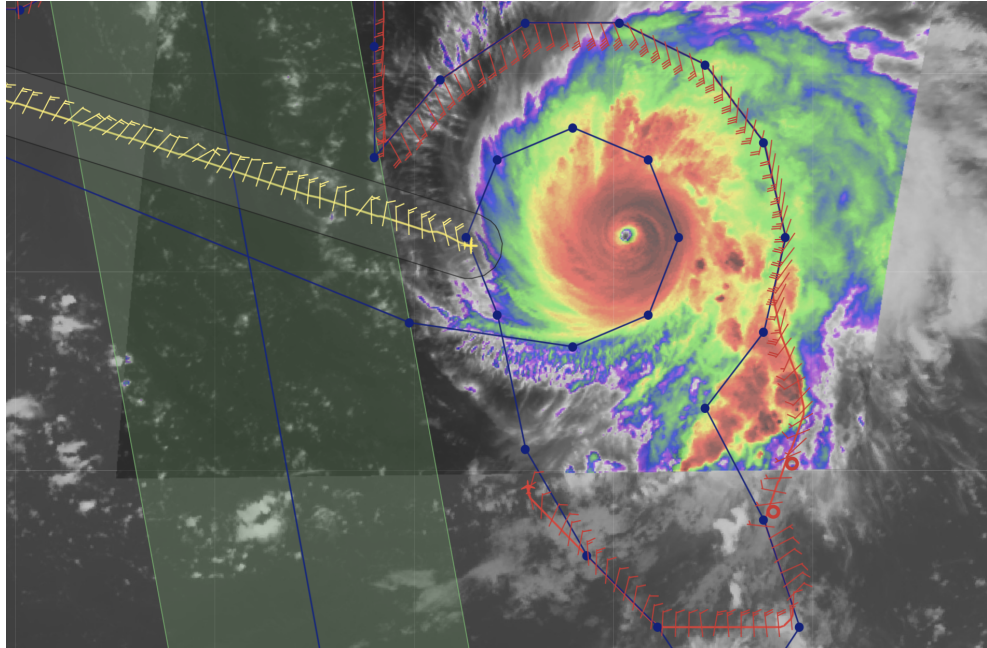
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	<p>intensity is raised to 130 kt for this advisory. Sam remains compact, with winds of tropical storm force extending only 70 n mi from the center. A NOAA Hurricane Hunter aircraft is en route to investigate Sam and will provide more detailed intensity data."</p>
2053	<p>Screenshot below shows the Aeolus track, which will pass by the storm around 2134 UTC. The P-3 will reach the 125 n mi eastern edge about 184 n mi from the center. G-IV has had to deviate around an outer band to target their sondes to the south of the storm.</p> 
2133	<p>Aeolus just passed near the P-3 and just west of the storm.</p>

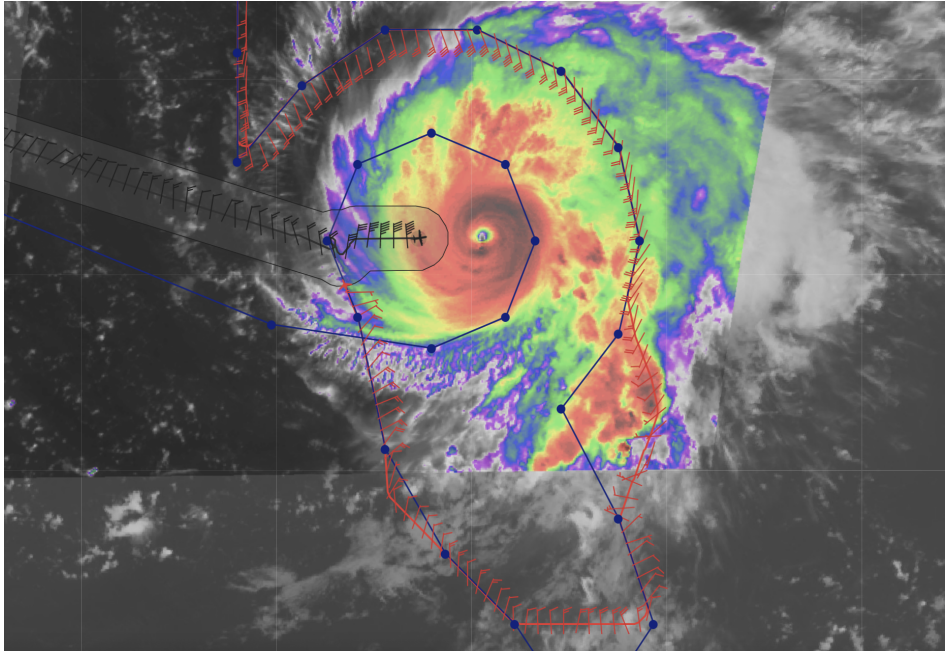
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	 A satellite image of a hurricane with a well-defined eye. Overlaid on the image are several flight paths: a yellow path with cross-ticks on the left, a blue path with dots forming a loop around the eye, and a red path with arrowheads on the right. A green shaded area is visible in the upper left.
2159	<p>Pattern shifted a little east to center it on the eye (from SS mode on MMR)</p>  A satellite image of the same hurricane, showing the flight paths from the previous image shifted slightly to the east. The yellow path is now more centered on the eye, and the blue and red paths are also adjusted accordingly.

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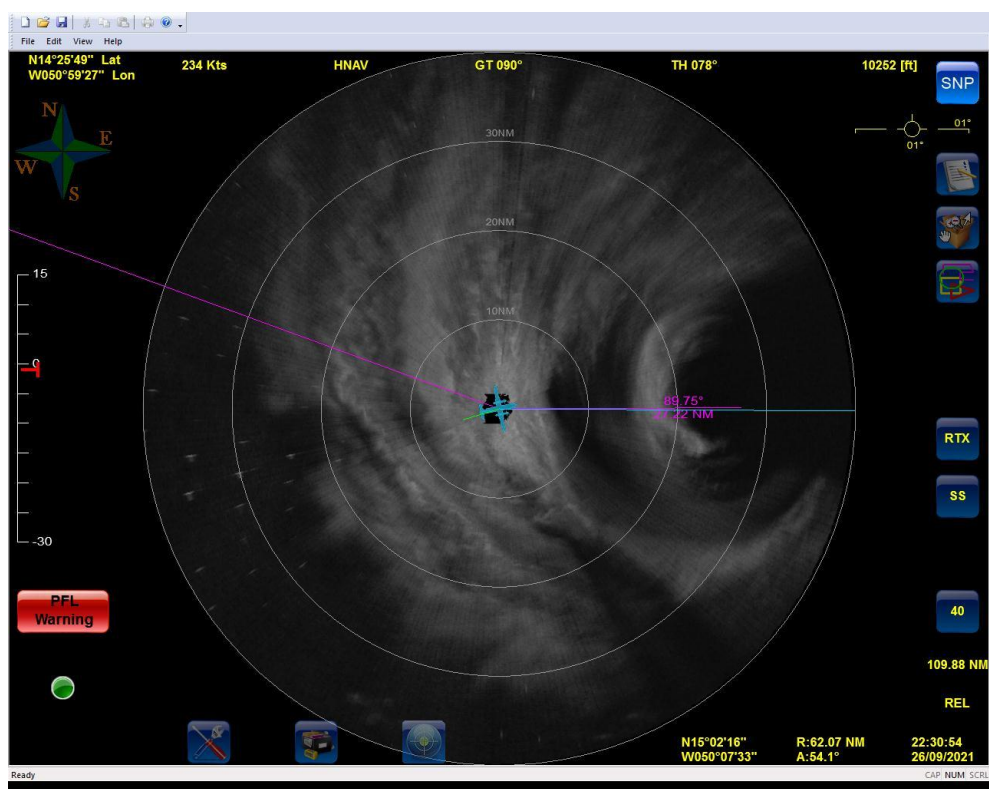
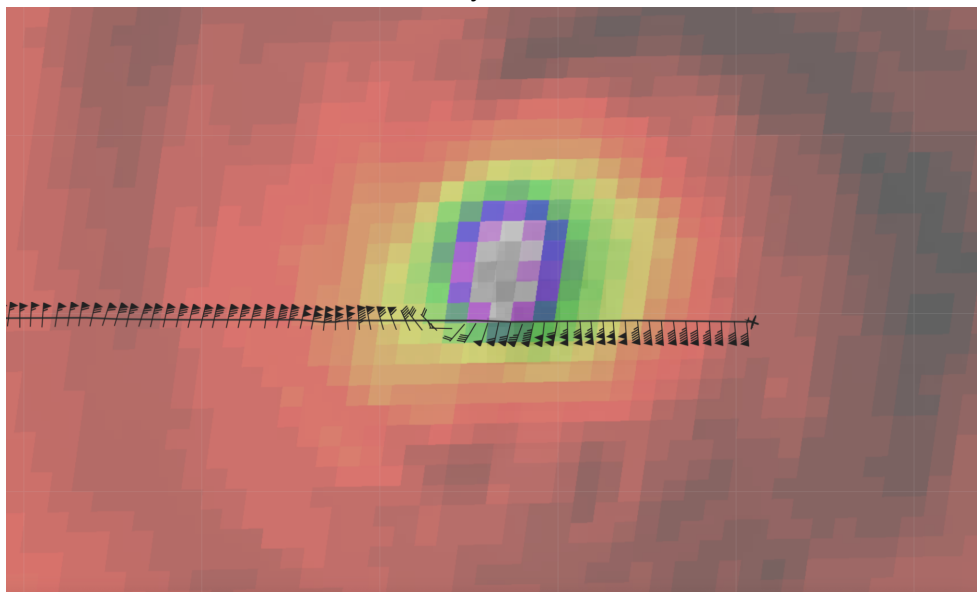
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2215	IP West (Sonde #1 [EMC1]; ONR AXBT #1). SST 28.4°C Sonde incorrectly processed.
2225	<p>G-IV now in the inner circumnav as the P-3 approaches the midpoint of the inbound from the west. Precipitation only extends to about that midpoint on the west side.</p> 
2226	MP West (Sonde #2 [EMC2])
2235	First RMW West (Sonde #3 [EMC3])
2235	Second RMW West (Sonde #4 [ONR1])
2236	Third RMW West (Sonde #5 [ONR2])
2237	Center #1 (Sonde #6 [EMC4]; ONR AXBT #2); 937 mb splash, 110deg./41 kt surface winds
2238	First RMW East (Sonde #7 [EMC5])
2239	Second RMW East (Sonde #8 [ONR3])
2239	Third RMW East (Sonde #9 [ONR4])
2242	A look at the first pass of the center. MSLP was extrapolated to 932 mb,

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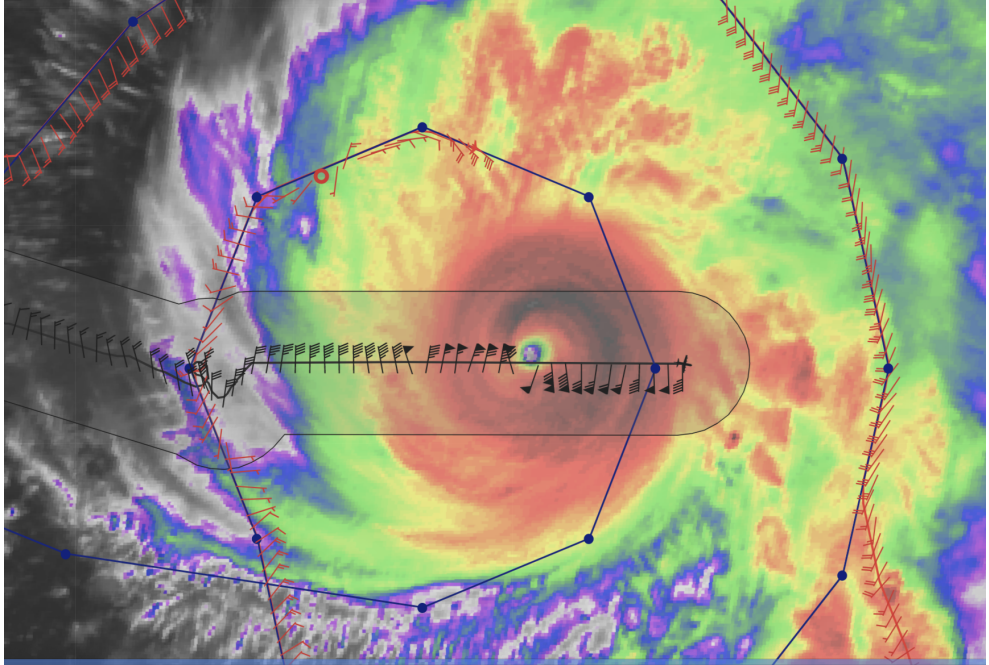
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with 134 kt inbound (west side) maximum surface wind, though oddly the outbound to the east in the VDM only said 98 kt.



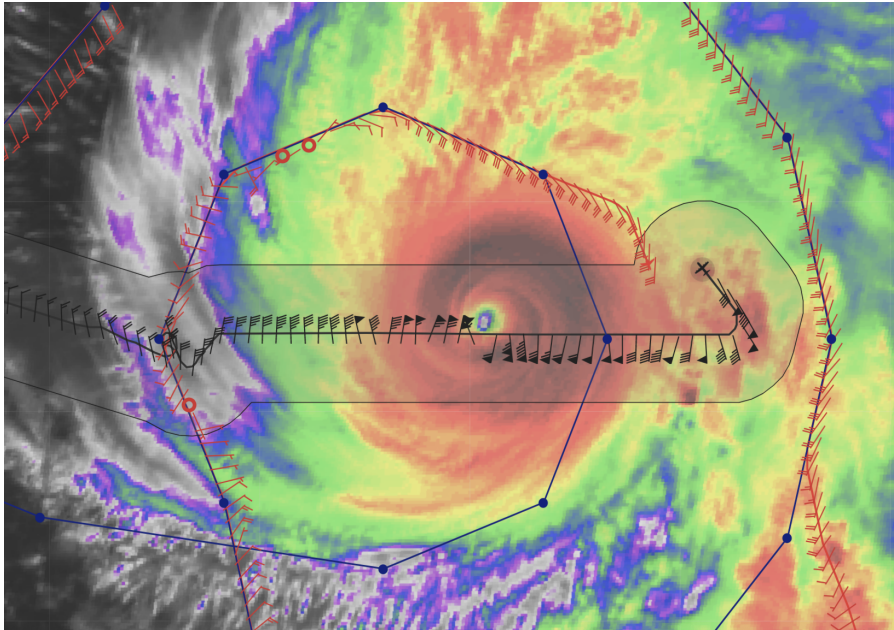
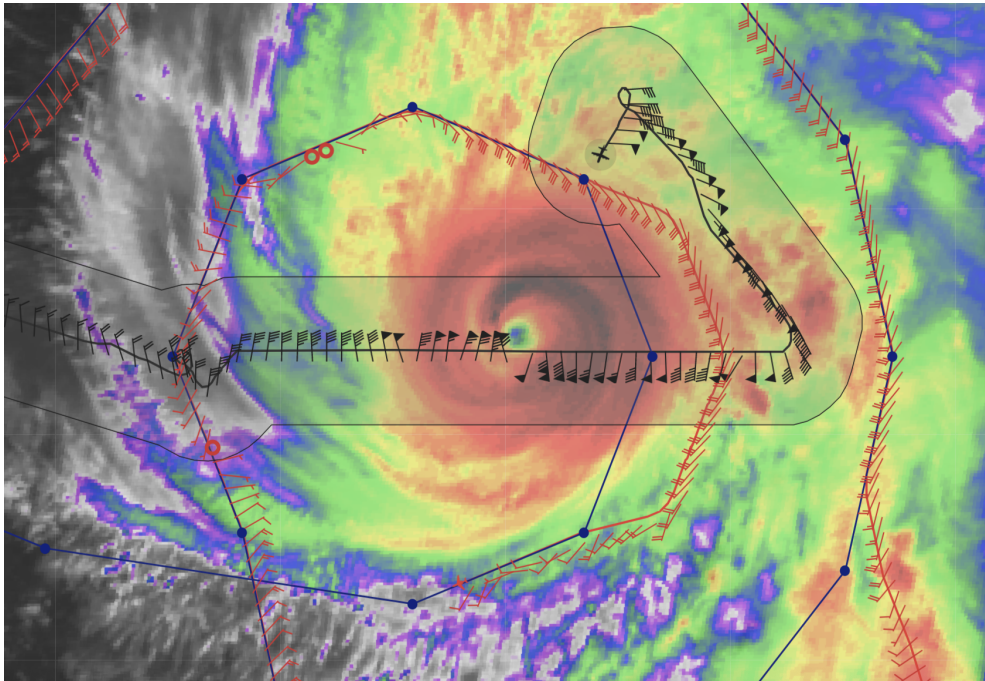
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2249	MP E (Sonde #10 [EMC6])
2252	<p>Looks like secondary eyewall formation is in progress based on MMR imagery! Interestingly the flight level wind speeds are symmetric on the east and west sides, but the surface winds were much higher on the west side than east.</p> 
2259	EP E (Sonde #11 [EMC7]; ONR AXBT #3)
2307	P-3 and G-IV passing next to each other -- opportunity for TDR intercomparison. P-3 showing stratiform on the MMR and TDR returns up to 10 km

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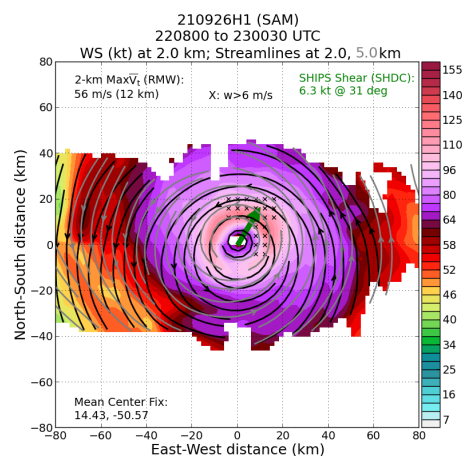
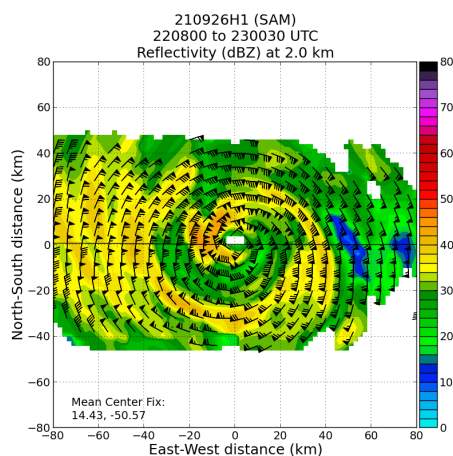
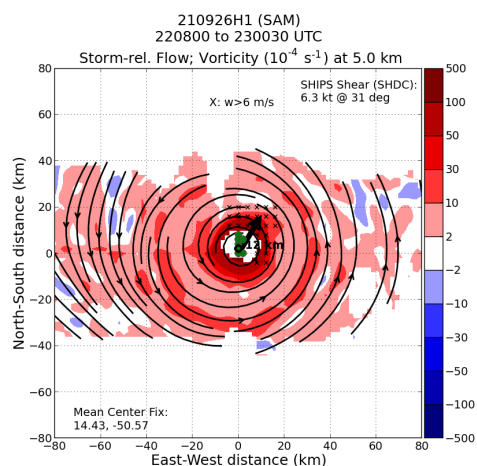
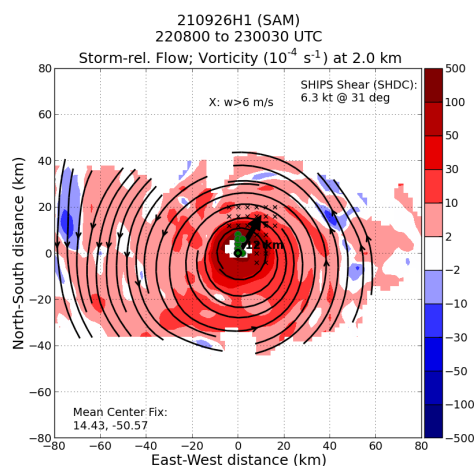
	 A satellite image of a hurricane with a well-defined eye and spiral cloud bands. Overlaid on the image are several flight paths: a red line with circular markers, a blue line with circular markers, and a black line with arrow markers. The hurricane is centered in the upper right quadrant of the image.
2329	<p>IP NE (Sonde #12 [EMC8]; ONR AXBT #4). Now inbound from the NE; G-IV on the southern portion of the inner circumnav.</p>  A satellite image of a hurricane, similar to the one above, showing the same flight paths (red, blue, and black lines with markers) overlaid on the cloud structure. The hurricane's eye is visible in the upper right.
2339	MP NE (Sonde #13 [EMC9])

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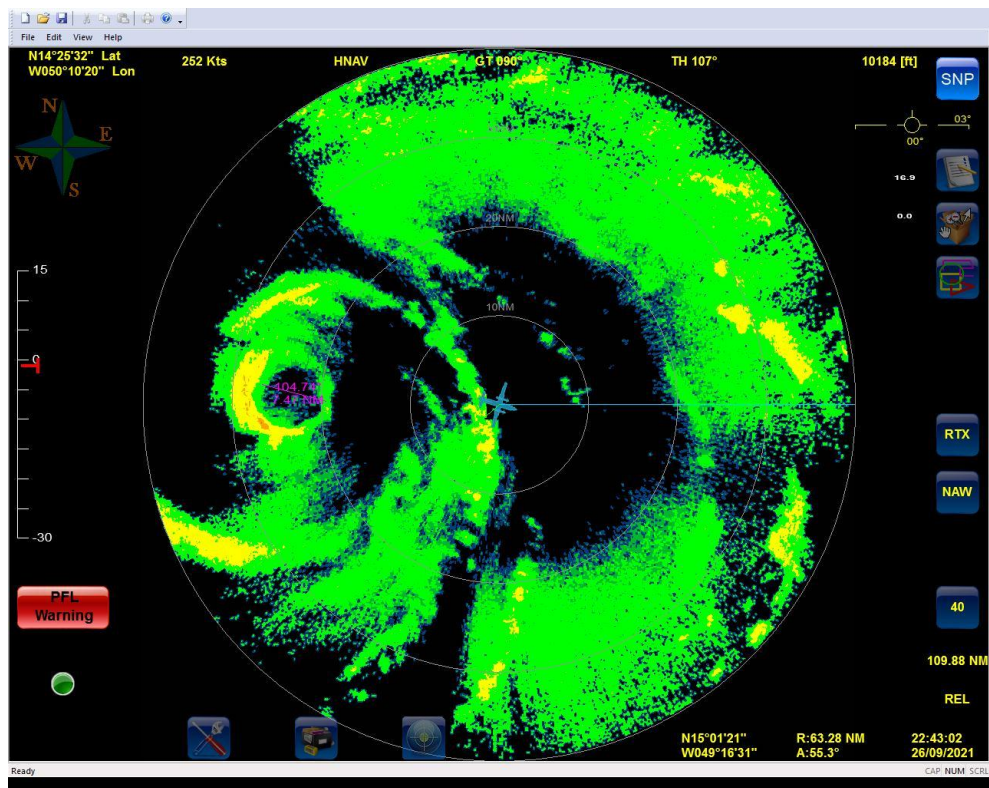
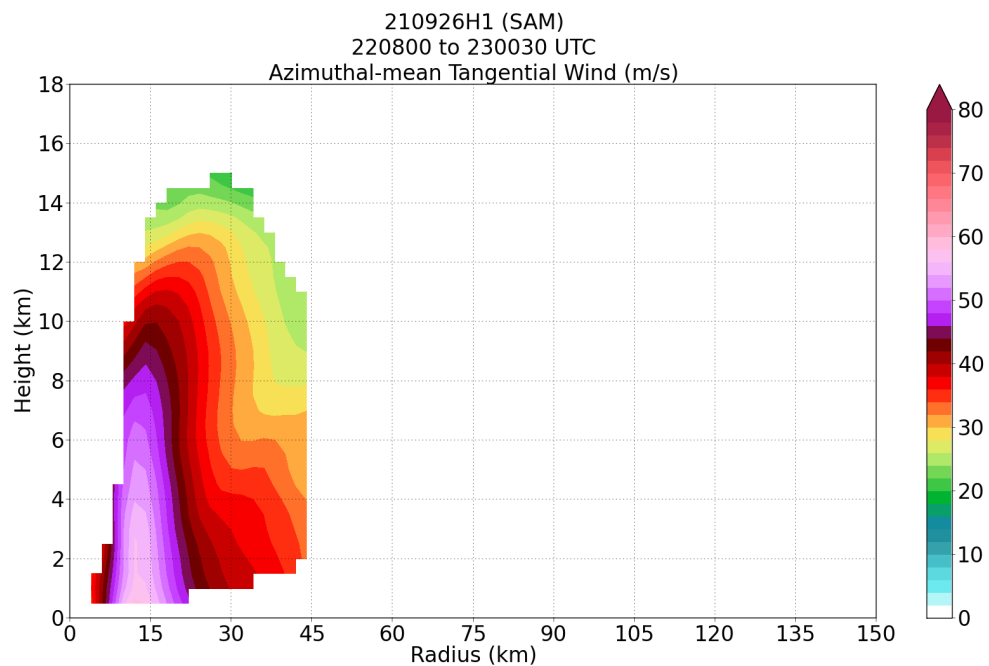
2342

The first TDR analysis (below) shows an outer ring of vorticity at 2 and 5 km at 30 km from the center, suggesting that the SEF is forming. So we decided to drop the first RMW sonde on this inbound from the NE at 15 nmi (where the SEF may be) from the center, then keep the 2 RMW sondes. LPS is reporting an SEF feature on the MMR.



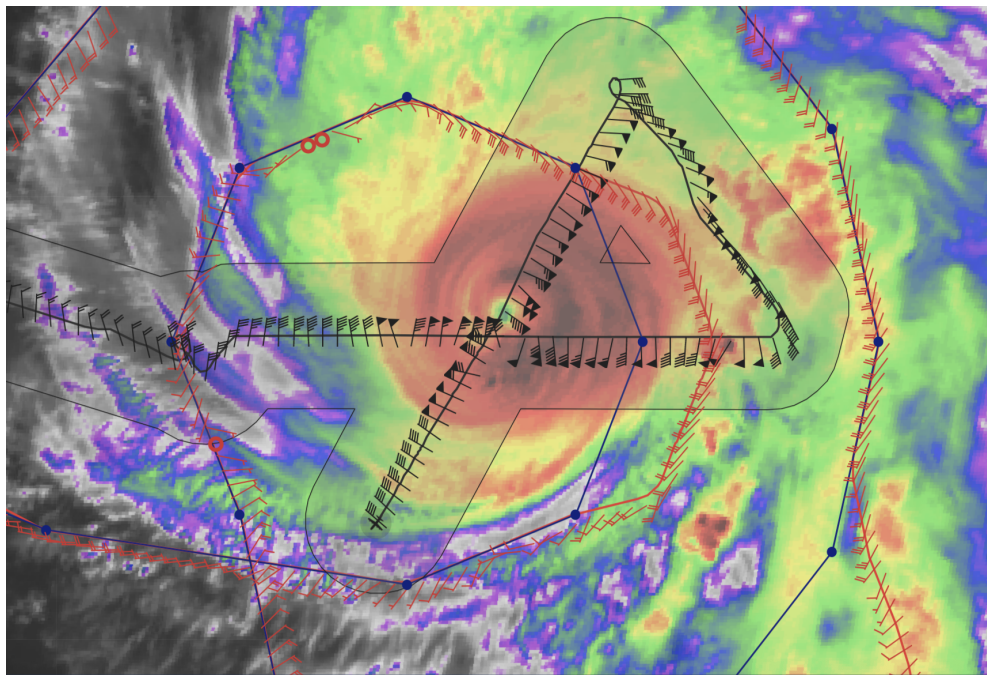
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2347	SEF NE (Sonde #14 [ONR5])
2349	First RMW NE (Sonde #15 [EMC10])
2349	Second RMW NE (Sonde #16 [ONR6])
2351	Center #2 (Sonde #17 [EMC11]); 943 mb splash pressure and 155 deg./23 kt winds
2352	First RMW SW (Sonde #18 [EMC12])
2353	Second RMW SW (Sonde #19 [ONR7])
2353	Third RMW SW (Sonde #20 [ONR8])
0003	MP SW (Sonde #21 [EMC13])
0012	<p>G-IV has completed their inner circumnavigation and the P-3 is nearing the end of its first pass.</p> 
0013	EP SW (Sonde #22 [EMC14]; ONR AXBT #5)
0027	MMR image from the inbound of the previous pass suggesting where the SEF could be. The eyewall is still well defined, but the SEF is showing up in almost all quadrants, even in the surface roughness mode.

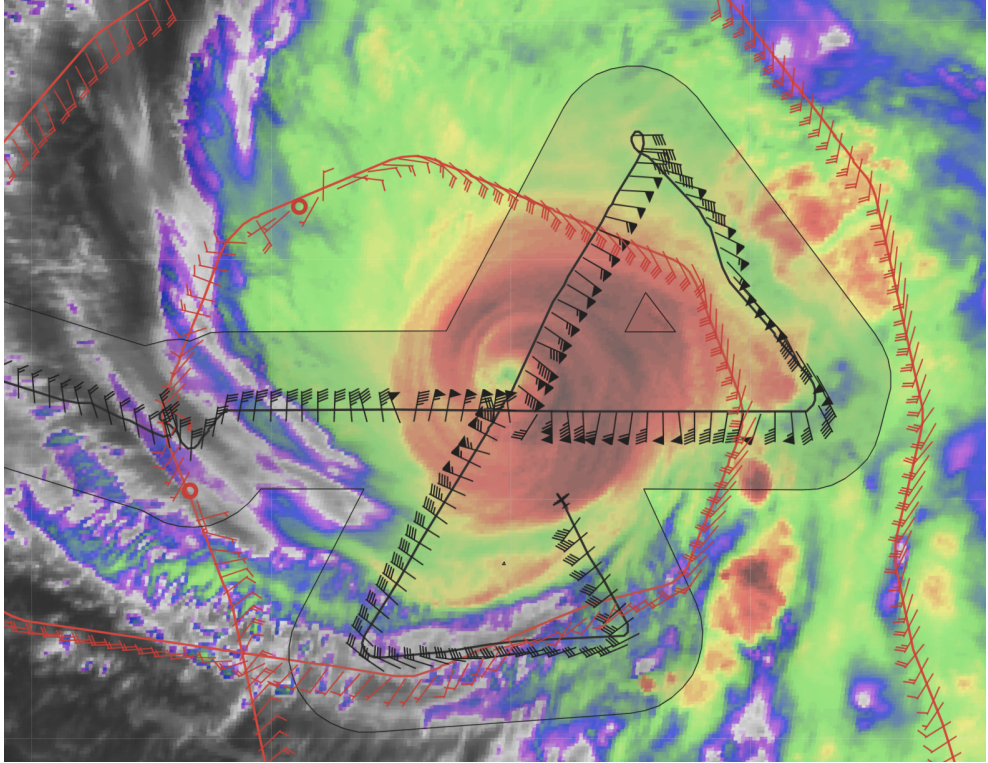
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	<p>The image displays two sequential screenshots of a radar display interface, likely from a flight simulator or a real-time data system. Both screens show a radar plot with concentric range rings (20NM, 40NM, 60NM) and a target marked with a blue 'X' at approximately 20NM. The top screenshot shows a radar plot with a target at 20NM, while the bottom screenshot shows a more complex radar return pattern, possibly indicating a weather system or a different target. Both screens display various data fields including coordinates, speed (Kts), heading (GT), and target height (TH).</p>
0036	IP SE (Sonde #23 [EMC15]; ONR AXBT #6)

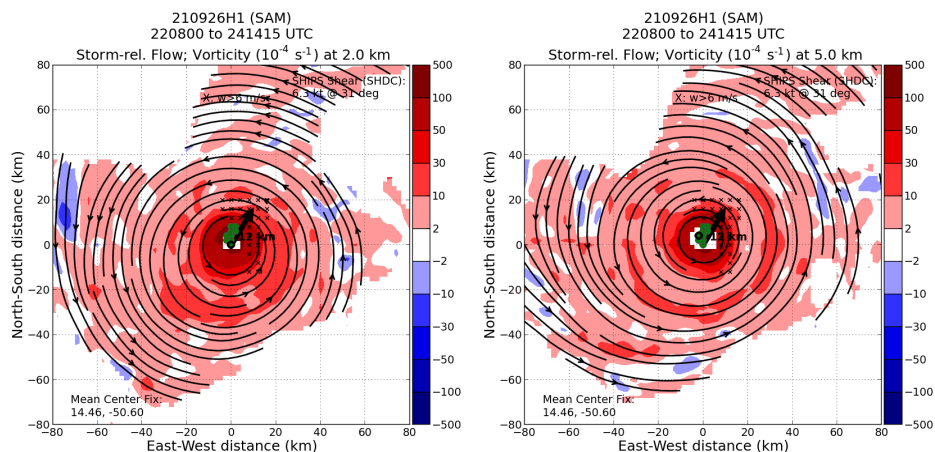
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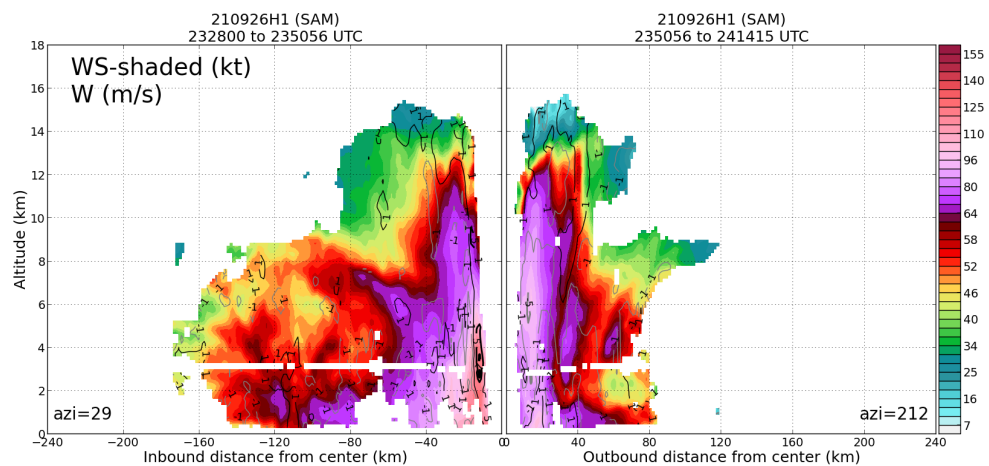
0045	<p>Inbound to the center on the last pass, from the southeast. Sondes on this pass will once again target the SEF location with one of the 3 RMW sondes (the other 2 will still be released in the RMW).</p> 
0047	MP SE (Sonde #24 [EMC16])
0051	<p>A look at the 2nd TDR analyses showing continued SEF development. On the first pass, the low-level reflectivity was more of spiral outer eyewall structure; the 2nd pass shows more of an outer ring: The image below is the composite relative vorticity from the first two passes:</p>

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Then tangential wind profile from the 2nd pass:



The 1st pass at 2 km:

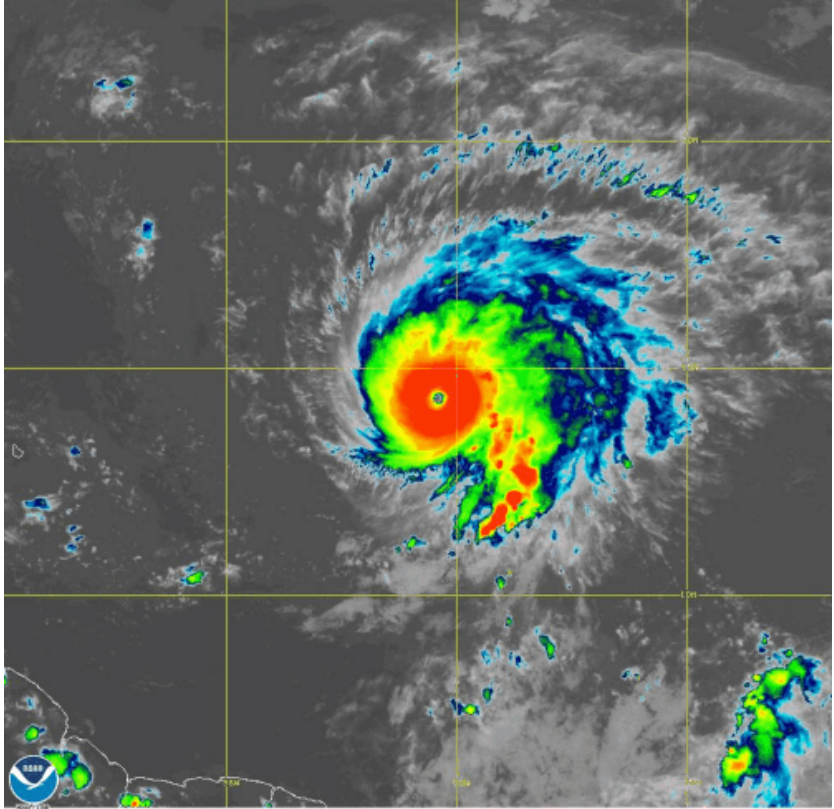
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	<div style="display: flex; justify-content: space-around;"> <div data-bbox="446 380 917 842"> <p>210926H1 (SAM) 220800 to 230030 UTC Reflectivity (dBZ) at 2.0 km</p> </div> <div data-bbox="943 380 1414 842"> <p>210926H1 (SAM) 220800 to 230030 UTC Wind Speed (kt) at 2.0 km</p> </div> </div> <p>The 2nd pass at 2 km:</p> <div style="display: flex; justify-content: space-around;"> <div data-bbox="446 961 917 1423"> <p>210926H1 (SAM) 230030 to 241415 UTC Reflectivity (dBZ) at 2.0 km</p> </div> <div data-bbox="943 961 1414 1423"> <p>210926H1 (SAM) 230030 to 241415 UTC Wind Speed (kt) at 2.0 km</p> </div> </div>
0053	SEF SE (Sonde #25 [ONR9])
0055	First RMW SE (Sonde #26 [EMC17])
0056	Second RMW SE (Sonde #27 [ONR10])
0057	Center #3 (Sonde #28 [EMC18])
0058	First RMW NW (Sonde #29 [ONR11])
0059	Second RMW NW (Sonde #30 [ONR12])

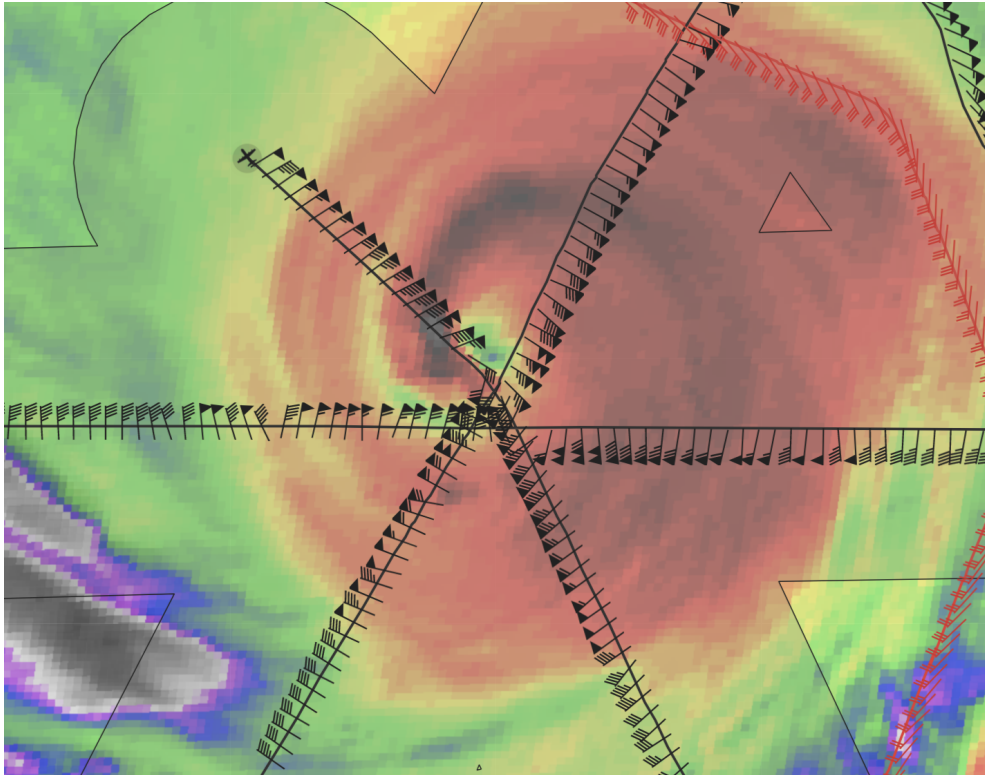
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0059	Third RMW NW (Sonde #31 [EMC19])
0103	<p>SEF NW (Sonde #32 [ONR13]) IR satellite loop shows warming cloud tops and trending towards weakening of the original inner eye.</p>  <p>26 Sep 2021 20:50Z NOAA/NESDIS/STAR GOES-East Band 13 HU Sam</p>

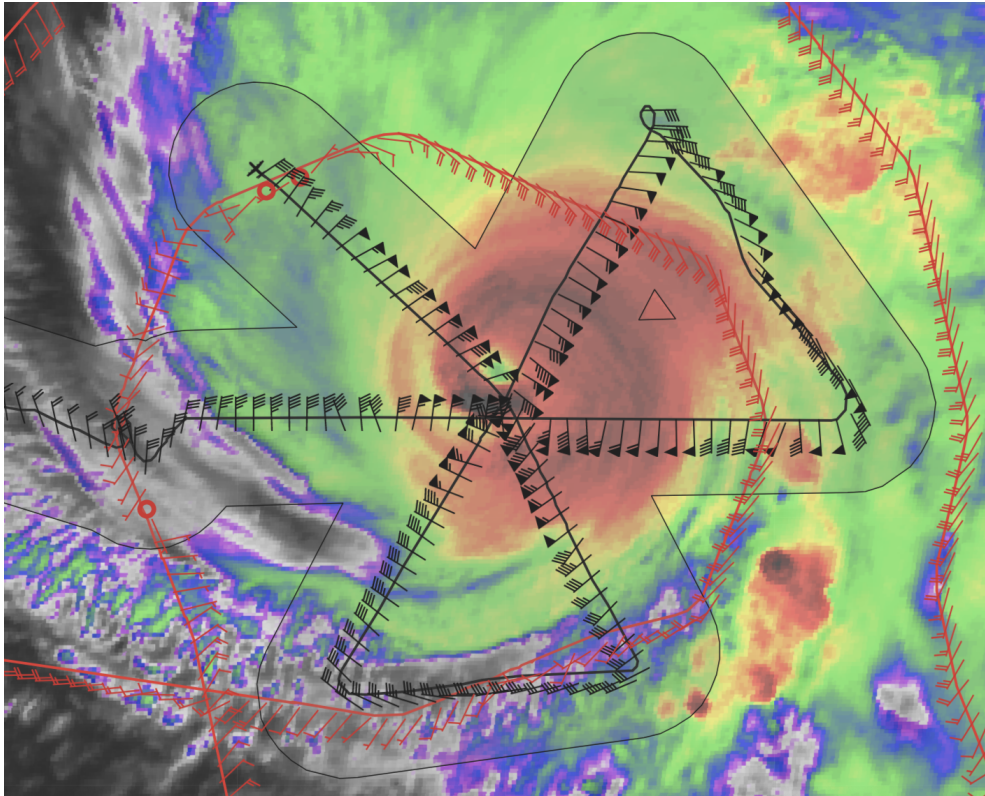
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0111	MP NW (Sonde #33 [EMC20])
0120	Nearing the completion of the butterfly; about time to do the Gravity Wave Module -- looks nice and clear ahead to do the module.

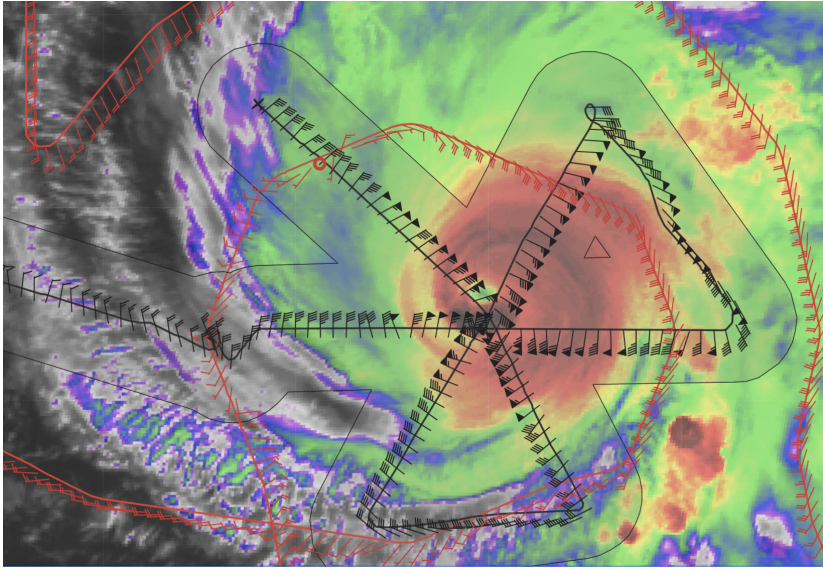
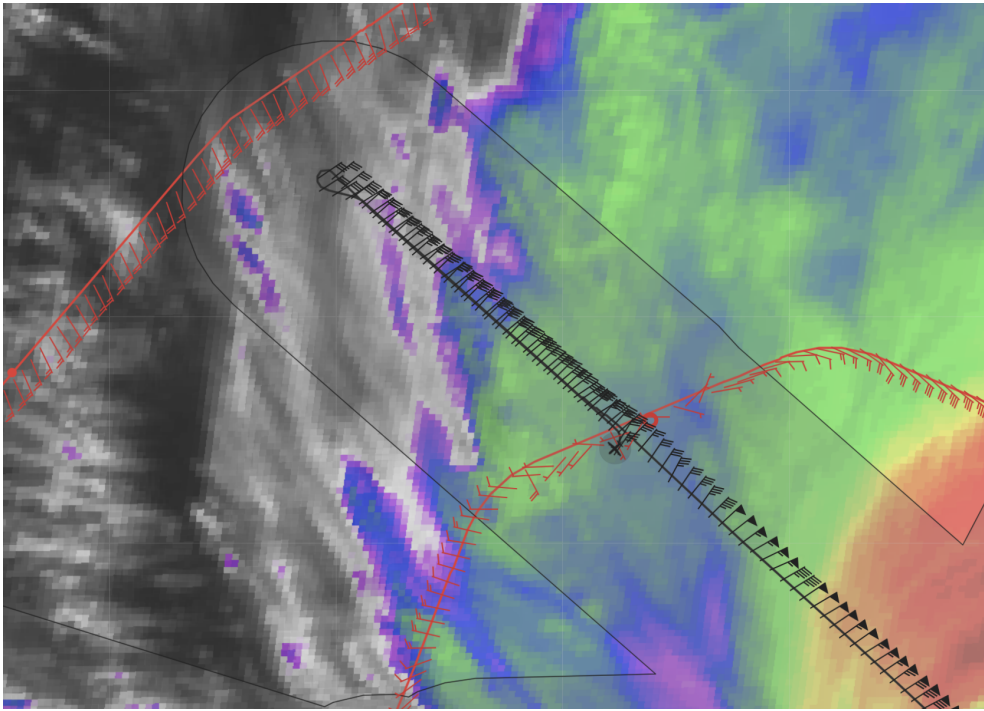
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0119	EP NW (Sonde #34 [EMC21]; ONR AXBT #7)
0119	Start of Gravity Wave Module to the NW; nice and straight and level outbound, which is ideal for the GW module.

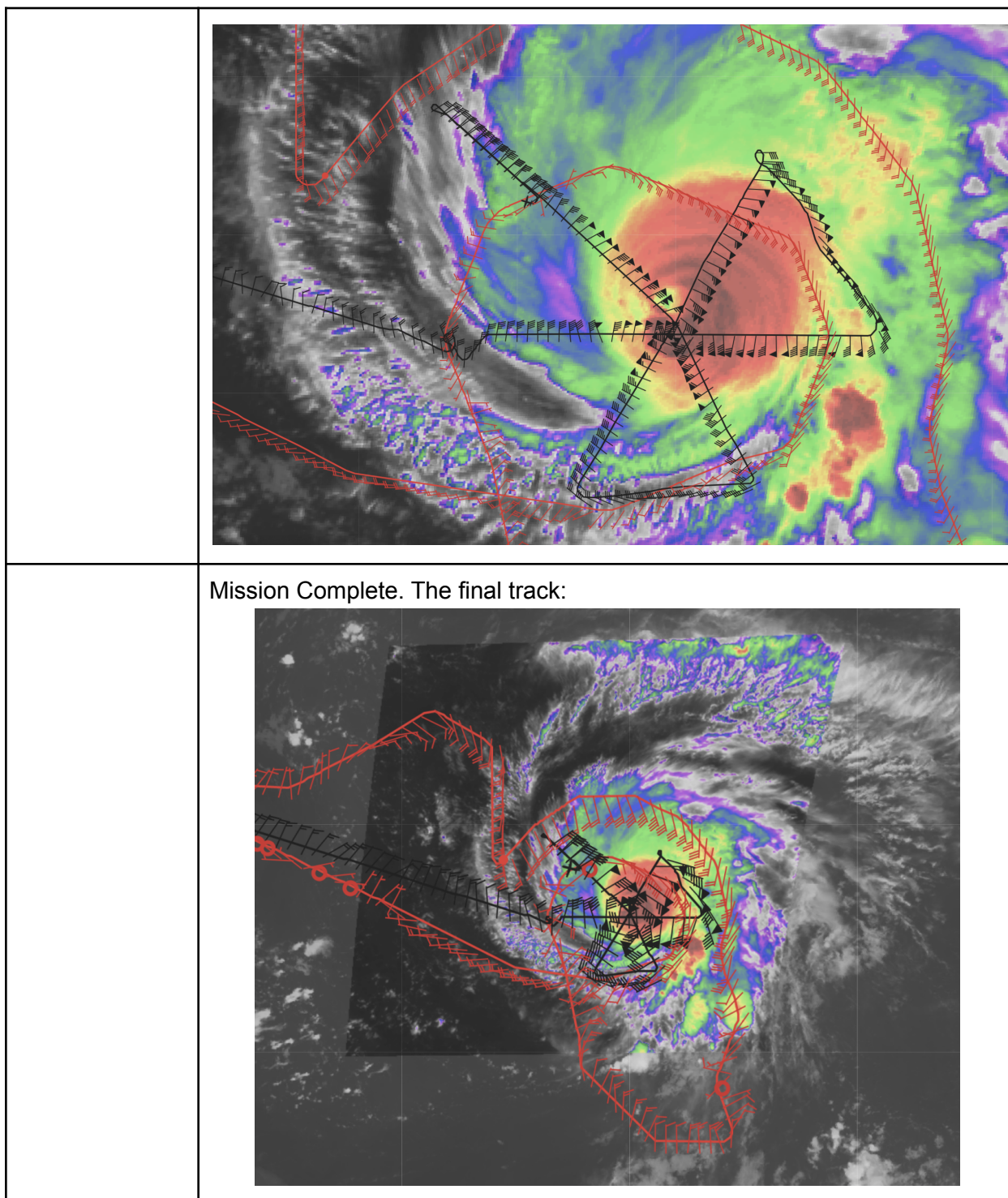
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0133	Turning around for return leg of Gravity Wave Module
0153	Gravity Wave Module completed very successfully. 

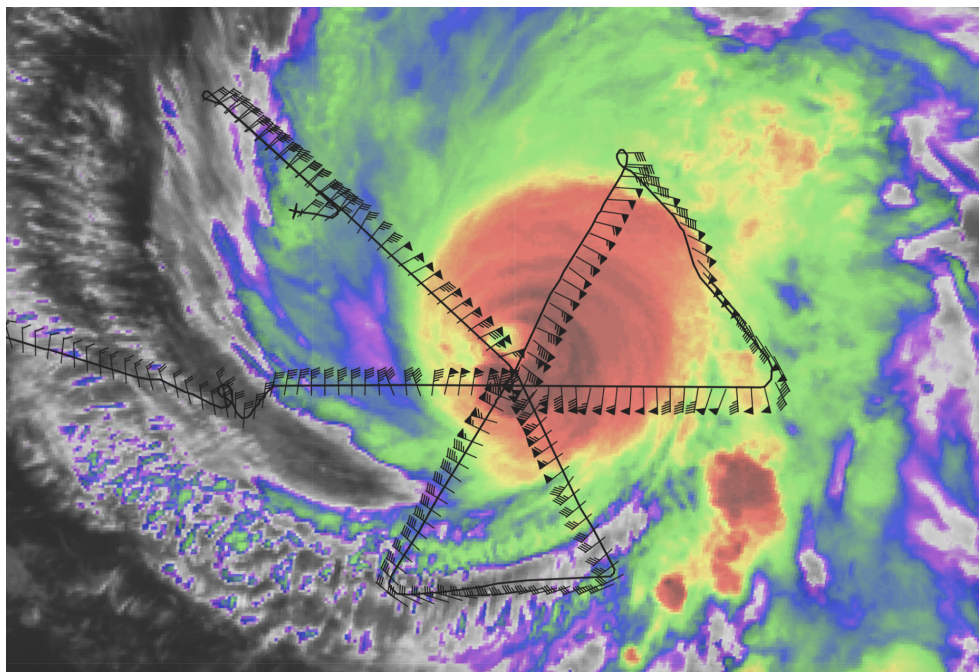
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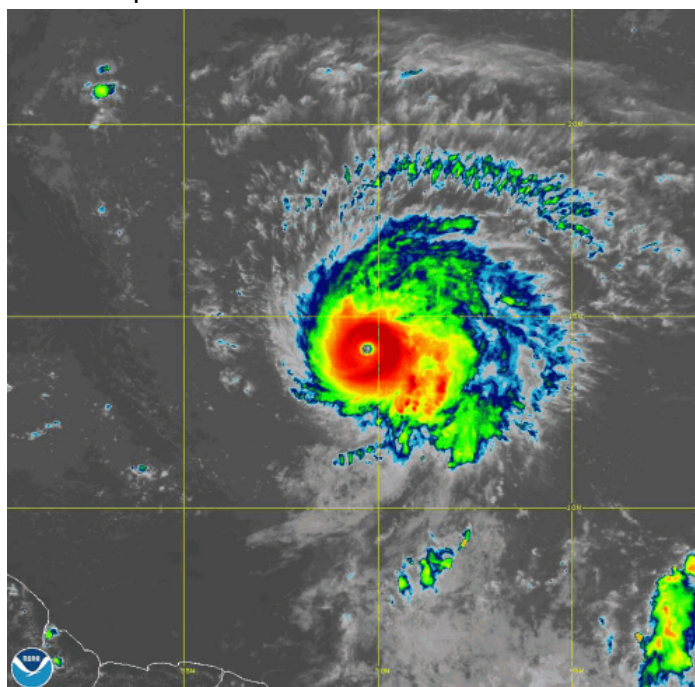


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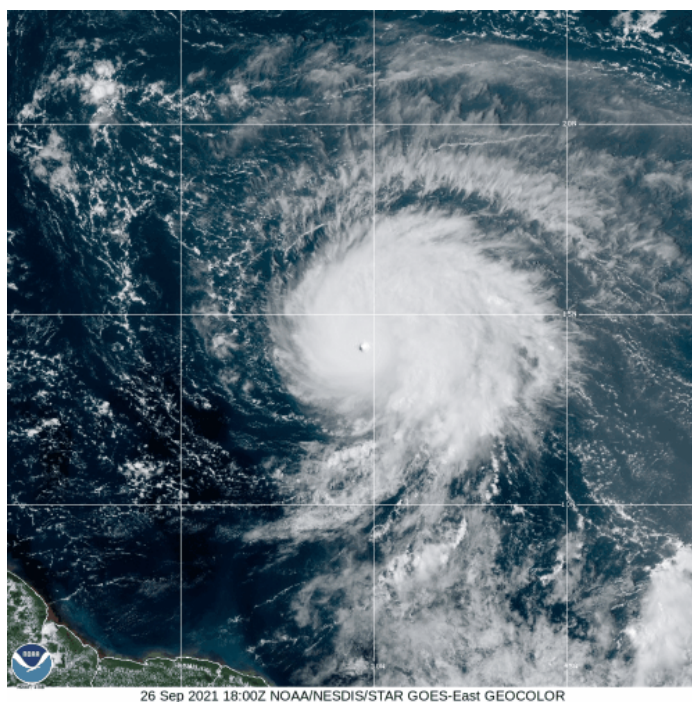
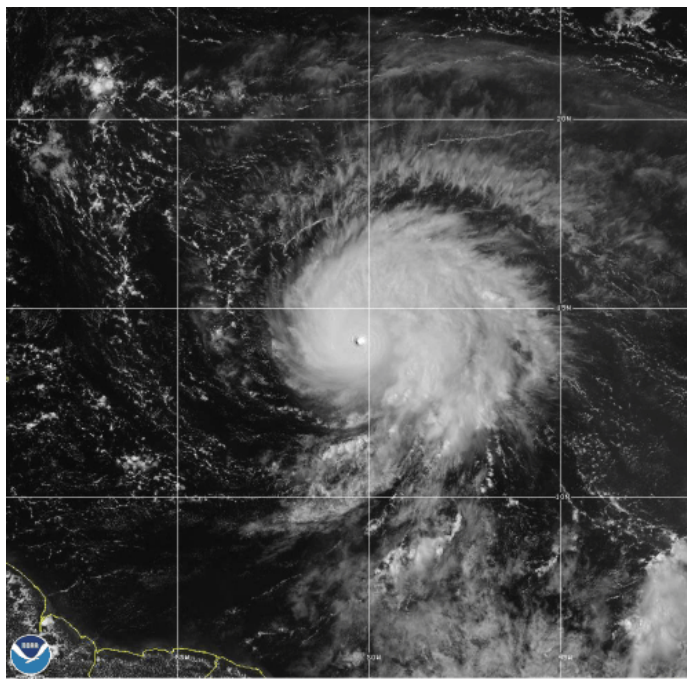
The final satellite loops from the mission:



26 Sep 2021 18:10Z NOAA/NESDIS/STAR GOES-East Band 13 HU Sam

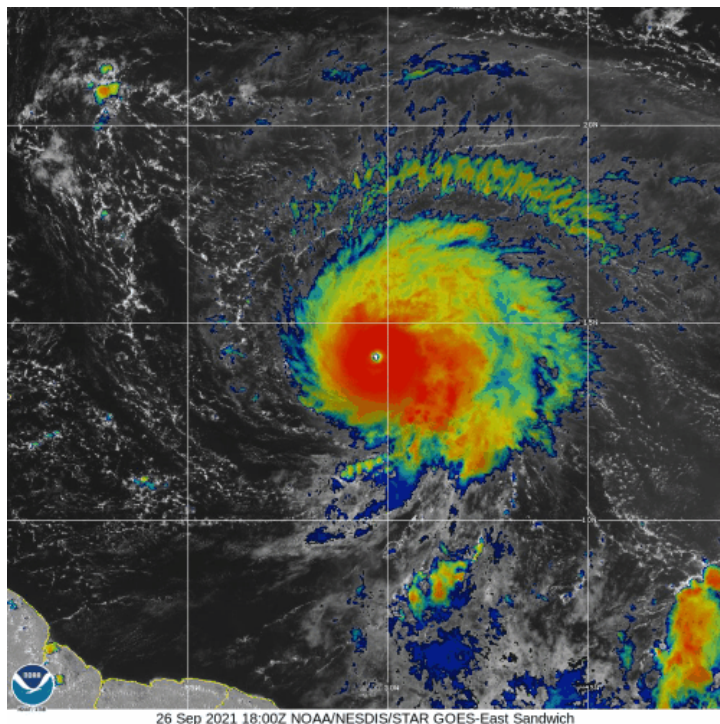
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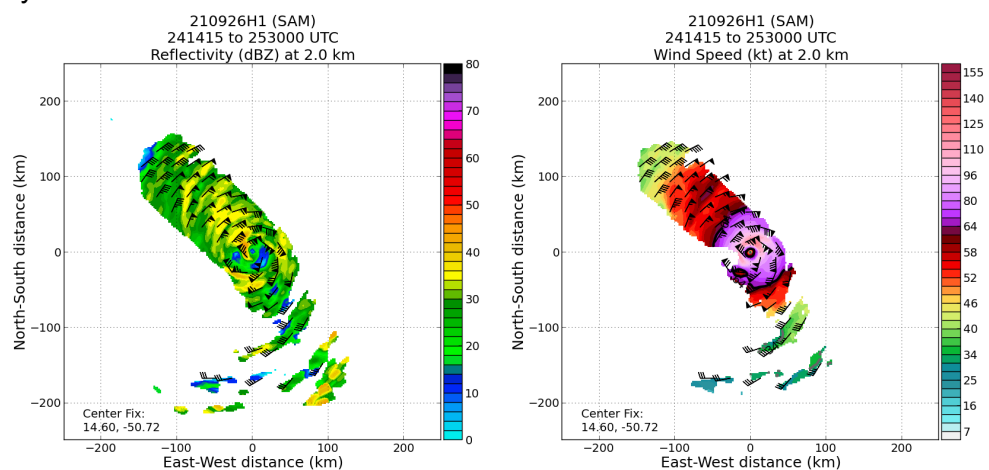


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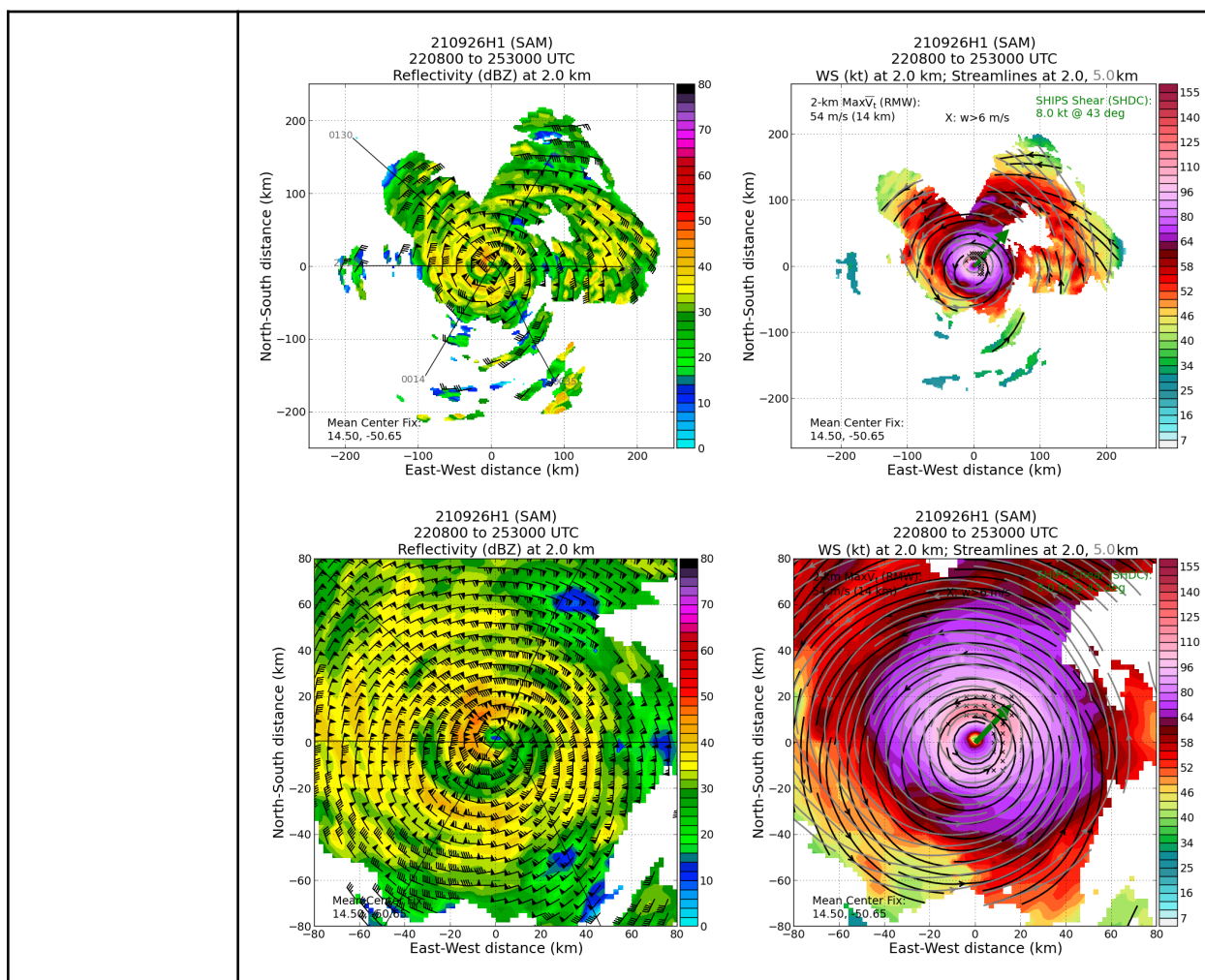
The third TDR analysis at 2 km showing how very little is left of the inner eyewall:



The final TDR composite analyses (keep in mind there is a lot of evolution in these structures being averaged together):

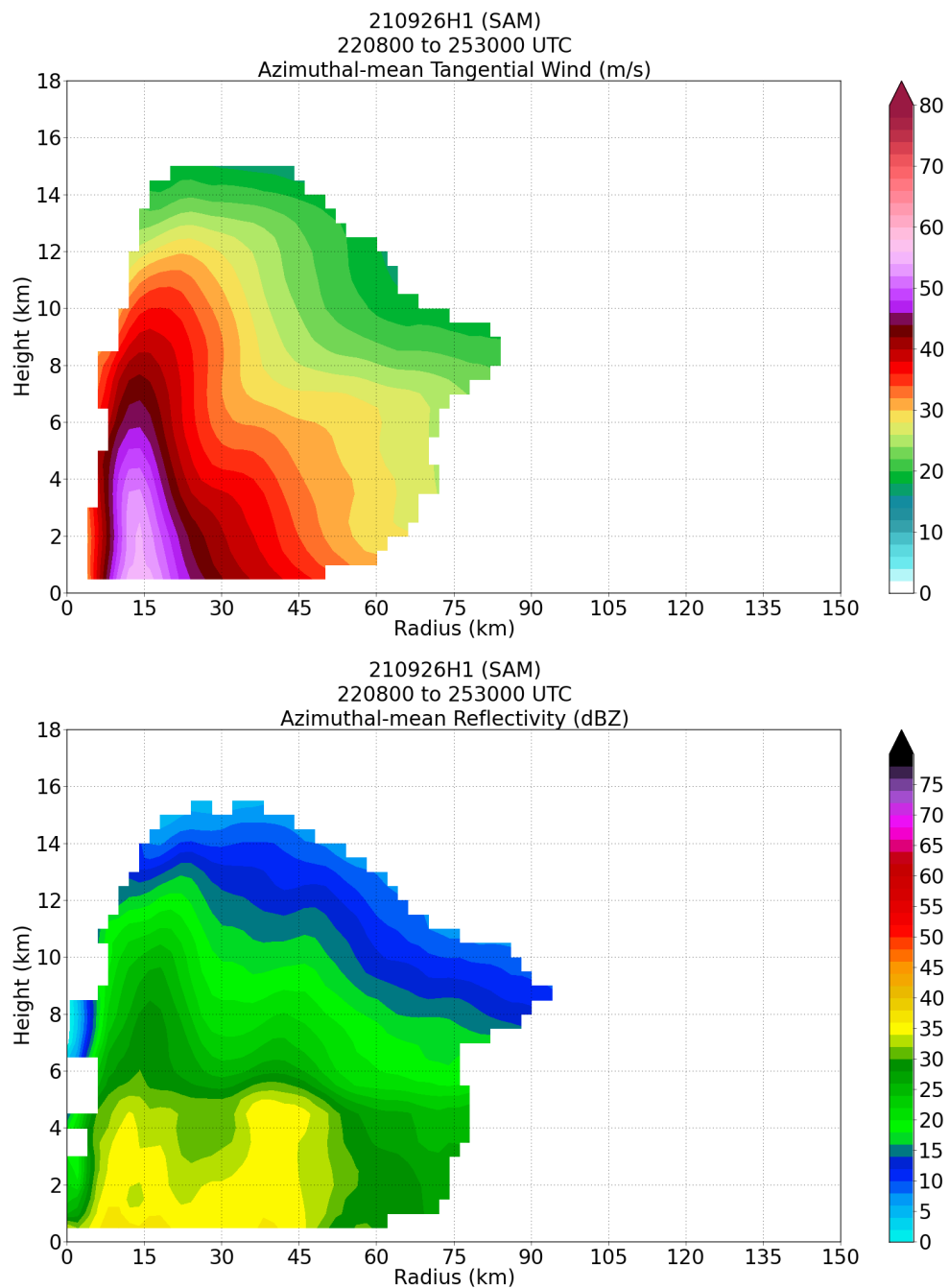
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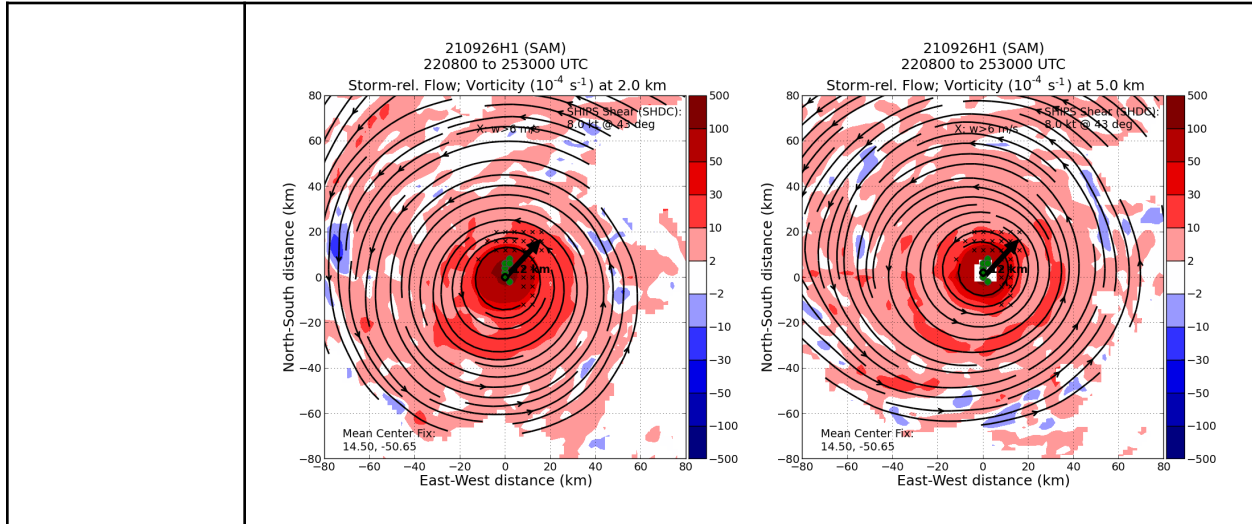
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FLIGHT LOG - 20210926H1



POST-FLIGHT

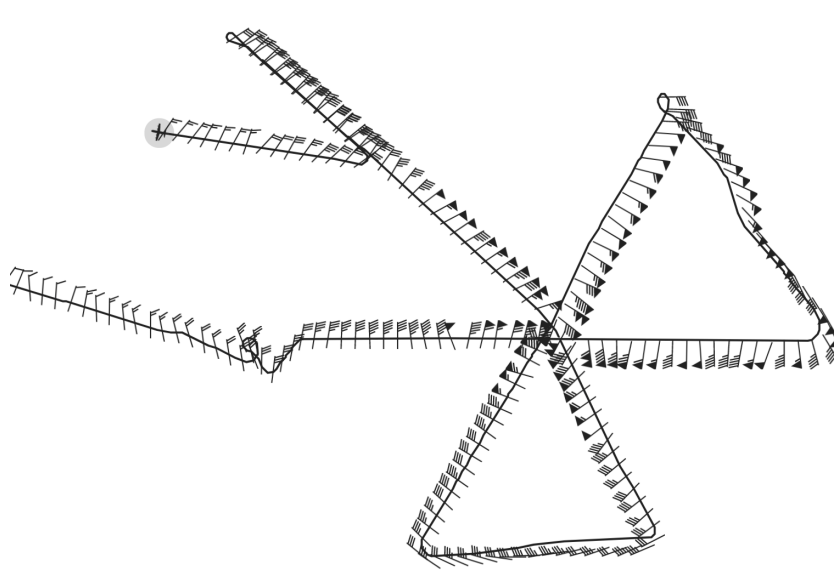
**Mission
Summary**

This mission captured secondary eyewall formation (SEF) as the storm was coming out of peak intensity (the 11 PM EDT NHC forecast discussion suggested an intensity of 135 kt, 929 mb based on the initial data from the first pass of the mission). The observations from the TDR, MMR, and flight level winds clearly indicated SEF formation at about 15-20 n mi from the center (though possibly already had started by the time the P-3 arrived in the storm). The storm is now on a weakening trend (perhaps as much as 14 mb increase in the central pressure, 943 mb by the end). The final satellite loops show the impact of the SEF and pending potential eyewall replacement cycle (ERC). There has been a dramatic warming of the inner central dense overcast (CDO) during the mission, especially on the western side of the inner core, and the eye that was so impressive earlier is filling in. By the second pass, one of the three planned RMW dropsonde releases were changed to be dropped near the radius of the SEF, which was of great interest to the ONR TCRI program, as well. One of the unique aspects of this flight versus other flights that have sampled SEFs is that the inner core was so small that the original eyewall and secondary eyewall were in range of the TDR on each pass; that will allow us to look in detail at the time evolution of the SEF process during the mission. So, overall, excellent data collection and now the question will be: does Sam complete an ERC?

34 dropsondes released (34 transmitted; 21 charged to NWS; 13 charged

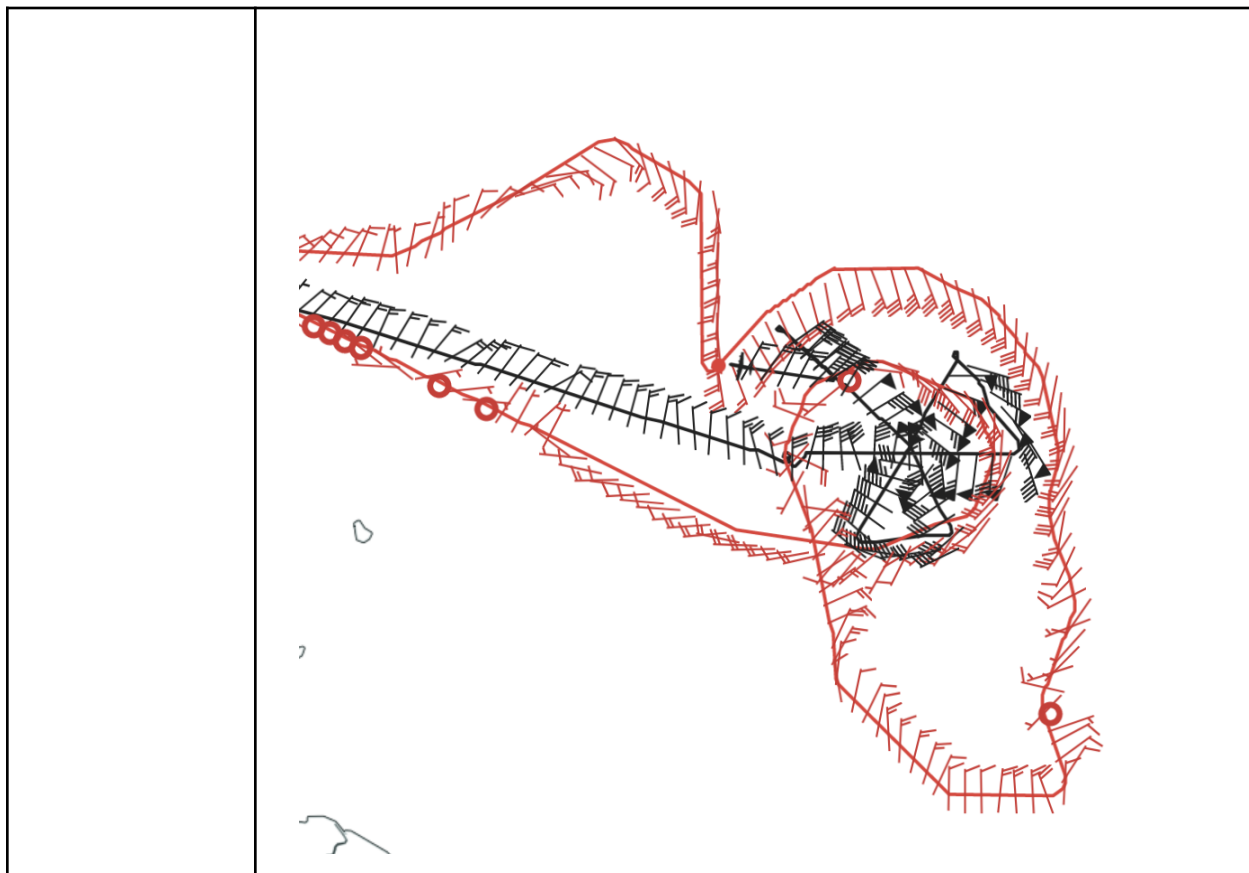
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Advancing the Prediction of Hurricanes Experiment (APHEX)

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	to ONR); 7 ONR AXBTs (all good; SSTs 27-28.5C)
Actual Standard Pattern Flown	Butterfly with 90 n mi radial legs
APHEX Experiments / Modules Flown	<i>Mature Experiment: Gravity Wave Module</i> ; flown in collaboration with ONR TCRI
Plain Language Summary	<ul style="list-style-type: none"> • This mission sampled Sam as it was coming out of its peak intensity and into secondary eyewall formation (SEF). Secondary eyewall formation is a process by which an outer eyewall develops and cuts off the dynamics of the original inner eyewall, leading to a weakening of the eye and inner eyewall. SEF in this case led to a weakening of the strength of the storm. • This mission sampled the small fluctuations in vertical winds (called gravity waves) away from the core of the storm. The science is part of an experiment that seeks to find a link between these waves and the intensity of the hurricane.
Instrument Notes	<ul style="list-style-type: none"> - CRL remained on for the entire flight - WSRA appears to have transmitted good data
Final Mission Track	

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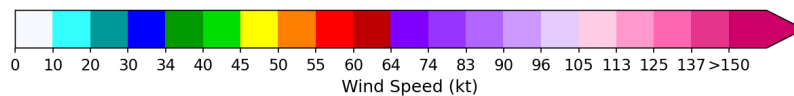
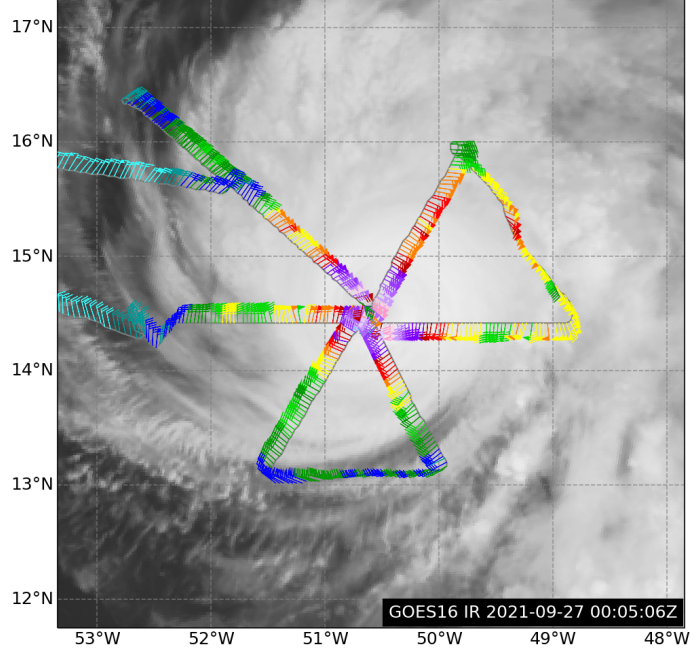
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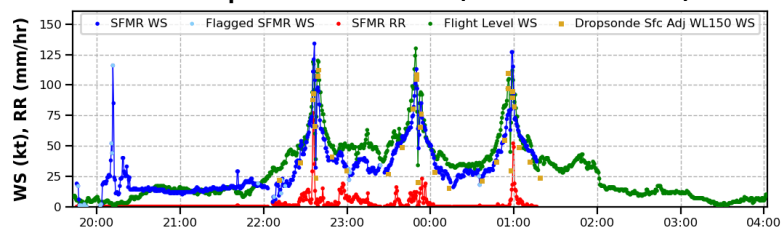
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Flight track + Flight-level Winds: SAM (NOAA 20210926H1)



Wind Speed and Rain Rate (NOAA 20210926H1)



Extrapolated Surface Pressure (mb) and Geopotential Altitude (m)

