Mission Summary
Tropical Storm Gabrielle
20010915H Aircraft: N42RF

Scientific Crew:

Lead Project Scientist	Frank Marks
Radar Scientist	John Gamache
Workstation Scientist	Peter Dodge
Dropsonde Scientist	Mike Black
CN/CCN scientist	Jim Hudson (DRI)
BL Scientist	Gary Barnes (U Hawaii)/Matt Eastin (CSU)

Aircraft Crew:

Pilots	Tennesen, Taggert
Flight Engineer	Bast
Navigators	Newman
Flight Director	Shepherd
Engineers	McMillan, Delgado, Lynch

MISSION BRIEF:

HRD scheduled an extended cyclone dynamics experiment (XCDX) mission into Tropical Storm Gabrielle with N42RF and the NASA DC-8 and ER-2 aircraft for 15 September 2001. N42RF would take off at 1600 UTC from MacDill AFB and recover at MacDill. The NASA aircraft would take off from Jacksonville 45 minutes after N42RF in order to coordinate our pattern. If the ER-2 couldn't take off because of cross winds N42RF and the NASA DC-8 would fly at coordinated pattern. N42RF and the DC-8 would fly an XCDX pattern with six radials around the storm at radii 150 nm from the center for N42RF and 250 nm for the DC-8 (see Fig. 1). All legs would be coordinated to attempt to cross the center at the same time. The DC-8 would drop GPS sondes in the eye and at the end points of each of the six radial legs. The radial legs to the west and southwest would be truncated to stay off the coast. N42RF would drop GPS sondes at the end points of each leg, and at 25 nm equally spaced locations within the inner 75 nm of the center of the storm to map the boundary layer structure. The inner drops would have coincident AXBTs to map the air-sea fluxes as the storm moved over the Gulf Stream.

MISSION SYNOPSIS:

At the 1200 UTC conference call with NASA we decided to slip the aircraft take off by 2 h to see if the DC-8 and ER-2 could take off as Gabrielle was still close to the east coast of Florida. At the pilot briefing it was clear that the ER-2 would not be able to participate, as the winds had not abated enough at Jacksonville. N42RF departed MacDill AFB at 1758 UTC, passing through bands of convection as we transited over Florida and just off the east coast of Florida. Along our transit to the storm we realized the storm was further north and east than we planned for. So we shifted our and the DC-8 pattern to account for the new center position (1900 UTC).

The first run into the center from the WSW was very difficult, as the center at flight level (14000 ft) and that at the surface (based on fixes from the AFRES) were roughly 25 nm (40 km)

apart. Tom Shepard followed the flight-level winds, but they were very light and variable. I attempted to assist by looking at the structure in the low cloud field (there were was very little deep convection south and west of the center). We fixed what we thought was the surface center (south and east of the flight-level center) at 1900 UTC and started tracking east to a point 150 nm (230 km) from the center. At the center we aligned with the DC-8 directly overhead (visual siting) and tried to maintain close coordination on the rest of the legs. As we tracked east, dropping GPS sondes and AXBTs every 25 nm out to 75 nm (Fig. 2), we noted that the surface circulation as indicated from the sonde surface winds was actually east and a little north of the center we fixed. So we started trying to estimate where the center would be for the next leg to pass up to the DC-8. We reached the end of the first leg (**2**) at 1928 UTC. During the leg we heard from N49RF as they continued their surveillance pattern dropping GPS sondes within 150 nm north and east of our new center.

We tracked northwest to a point 150 nm north of our estimated center position (**3**) for the next leg. We dropped 3 equally spaced AXBTs along this diagonal leg 150-190 nm northeast of the center, roughly along the intended track. The SST was between 28.0 and 28.5 C along the leg as we passed over the Gulf Stream axis. We also passed across the major rainband just inside the major convective feature with tops to near 15 km and reflectivity near 50 dBZ (Fig. 3). We reached (**3**) at 2008 UTC and noted the center appeared to be 20 nm further east than we anticipated. So we adjusted the DC-8 and our north to south track further east.

Tracking south to the center we entered the major rainband north of the center at 75 nm radius. This rainband was mainly stratiform in nature, but the bright band was relatively strong, with reflectivity of 40-45 dBZ. The GPS sondes showed that the wind turned considerable with height in this rainband from near easterly at flight level to northeast at lower levels, with peak velocities over 25 m s^{-1}. We passed through the inside edge of the rainband 25 nm north of the center and fixed a flight level center at 2036 UTC. We proceeded south 150 nm in relatively clear air noting a low-level swirl in the clouds which were likely at the surface center (Fig. 4). The only other remarkable sight was a band of high surface winds (evidenced by white caps and streaks on the surface) over a very broad area starting about 25 nm south of the center almost to the end of our leg 150 nm south of the center (**4**) (Fig. 5). The GPS sondes indicated that the surface winds had peaks near 18-20 m s^{-1}. We reached (**4**) at 2100 UTC and turned northeast to a point 150 nm southeast of the center (**5**).

Along the short leg to (**5**) we estimated a new center location for the next coordinated leg with the DC-8. We reached (**5**) at 2123 UTC and turned tracking northwest to the center. Jim Hudson reported some very interesting CN/CCN observations in the clear slot southeast of the center, with interesting radial gradient of CN in an area devoid of deep convection. Once again we passed over the broad area of surface winds visible in the sea state from flight level. The GPS sondes once again showed increased surface winds near 20 m s^{-1}. We hit the center at 2148 UTC and tracked across the major rainband 30 nm northwest of the center. It was pretty clear the center was tracking northeast (50°) at 7 m s^{-1}. We reached (**6**), 150 nm northwest of the center, at 2213 UTC. (**6**) was only 25 nm south of Charleston, SC (Fig. 2) (the DC-8 point was near Columbia, SC) and GPS sondes showed that the surface temperatures were near 24 C.

Once again we estimated the position of the center for the next coordinated leg to pass to the DC-8. We tracked southwest to a point 150 nm west of the estimated center for the next leg (**7**). We reached (**7**) at 2227 UTC and turned east to the center. This leg passed south of the rainband as it didn't wrap around the west side of the center. We did encounter strong surface winds once more from the GPS sondes as well as in the sea state. The center wasn't as far east as we

anticipated so we did not drop a sonde 25 nm W of the center. We reached the center at 2259 UTC and proceeded to (**2**) 150 nm east of the center. We didn't drop any GPS sondes on this leg because we had already dropped them east of the center. We reached (**2**) at 2324 UTC and turned north to (**8**) 150 nm northeast of the center which was in the middle of the deep convection which was closer to the center than the first time we passed it. We also learned that the DC-8 had cut the pattern and had proceeded from the center directly to their (**8**) missing a pass through the major convection.

We proceeded to (**8**) along the convective feature and proceeded to pick our way through the strong cells (2328 UTC). We had to make a choice of passing through the band and then turning further east to get to (**8**), or we could pick up the radial 90 nm from the center. When we found out that the DC-8 had cut their pattern short we opted to start at 90 nm to try to stay coordinated on the final leg. We started the leg at 2344 UTC in the rainband. On our inbound leg we made contact with the next AFRES aircraft entering the storm from the west passing them our estimated center position for this leg. Unfortunatley, the radar went down for about 5 min at 2356 UTC, while we were in stratiform rain and convective cells. Luckily it came back up about 25 nm from the center at 0001 UTC. We hit the flight level center at 0005 UTC, which turned out to be 28 nm north of the AFRES fix at 1500 ft. We proceeded southwest to (**9**) 150 nm southwest of the center dropping GPS sondes 25, 50, 75, and 150 nm radius. We reached (**9**) at 0031 UTC and then proceeded back to MacDill. landing at 0118 UTC (7.9 h mission).

Penetrations: 6 (no hurricane)
Expendables: 34 GPS-sondes, 18 AXBTs/2 bad
4 video tapes, 1 flight level DAT, 1 radar DAT and 1 Cloud Physics DAT

SUMMARY

A very good mission! Good coordination with the DC-8 by the N42RF crew (primarily Carl Newman and Tom Shepherd). We completed the pattern as briefed with a few wrinkles for flight safety. On the first inbound leg from the west we moved the whole pattern to the northeast when we realized the center was much further north and off the coast.

The storm structure was very interesting, with only one large rainband wrapping around the north and east side of the center. East of the center the band was 150-200 nm from the center to about 30-40 nm north of the center (Fig. 3). The surface circulation was well south and east of the flight-level center (20-25 nm). The region south and east of the center was very dry with only small convective clouds. However, the sea state south and east of the center indicated a region of strong surface winds 18-25 m s^{-1} surrounding a broad center 50 nm across. During the mission the only deep convective features were to the northeast of the center (Fig. 3) about 120 nm from the center where the cloud tops were near 15 km and the reflectivity was near 50 dBZ.

Jim Hudson noted some very interesting radial gradients of CN/CCN surrounding the center. He noted differences in the aerosol concentrations between the clear air southeast of the center and that near the convection to the north. The AXBTs revealed that the SST was running between 28.5-29.0 C over a large domain that the storm was over. It appeared the storm was moving right over the Gulf Stream axis. By the time we left the storm the convection was getting more vigorous and it appeared the storm was much better organized than when we arrived, certainly deserving tropical storm status.

I think the analysis of this flight will prove very useful in diagnosing how a storm gets better organized out over open water with relatively high SSTs. I suspect with the phenomenal GSP sonde coverage over such a large area from N42RF, DC-8, and G-IV (which apparently passed within the DC-8 pattern on the east side of the storm), combined with the AXBT coverage will provide a great data set for air-sea interaction and trough interaction studies of a slowly intensifying storm. Combined with the data set from the next day when Gabrielle returned to hurricane status it will be even more valuable.

PROBLEMS:

1) The HVPS worked on the bench before take off, but wouldn't work when it was mounted on the aircraft. AOC engineers recognized the problem but could not repair it or come up with a solution before the flight. They are looking into a solution.

2) The radar system crashed at 2356 UTC during the leg from the NE. Sean McMillan restarted the system and it was back up by 0001 UTC. There was another short restart between 2113-2114 UTC. It worked perfectly the rest of the flight until the end when the transmitter had a component burn up at landing.

Frank Marks
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19 September 2001

TABLES:

Table 1. GPS dropsondes.

#	Sonde Id	Time (UTC)	Lat.	Lon.	150-m wind	DLM wind	MBL wind	SST	comments
1	003338014	15:18:59:00	29.81	-79.20	01013	34016	1015		Center
2	003155019	15:19:08:00	29.84	-78.71	33507	29008	33506	28.5	
3	003155017	15:19:13:00	29.87	-78.22	23511	21514	24011	28.5	
4	003438008	15:19:18:00	29.91	-77.73	18528	19532	19030	28.0	
5	003135113	15:19:27:00	29.93	-76.87	18535	20046	18538	28.2	
6	003248075	15:20:08:00	32.26	-79.05	03046	05534	3548	27.5	RAINBAND
7	003338080	15:20:21:00	31.49	-78.92	03541	04538	04045	28.0	RAINBAND
8	003135351	15:20:27:00	31.08	-78.87	03044	05043	02549	28.0	LST WND 011 RAINBAND
9	003155016	15:20:36:00	30.47	-78.93	03525	03518	03028	28.4	
10	003115222	15:20:33:00	30.69	-78.95	02034	03527	02533		
11	003115212	15:20:40:00	30.14	-78.89	01516	00514	02018		
12	003155021	15:20:45:00	29.73	-78.87	32013	30516	32513		
13	003135041	15:20:50:00	29.32	-78.85	28020	28523	28019		
14	003135006	15:21:00:00	28.59	-78.86	27022	27526	27522	29.0	
15	003338066	15:21:23:00	29.49	-76.73	21043	21545	20543		
16	003135344	15:21:33:00	29.97	-77.31	21524	22033	21527	28.0	
17	003135112	15:21:38:00	30.23	-77.74	23013	22516	23014		
18	003438011	15:21:42:00	30.45	-77.98	03515	03503	03013		
19	003115248	15:21:48:00	30.60	-78.38	03525	03518	03525		
20	003135102	15:21:52:00	30.80	-78.71	02538	03531	02538		
21	993925312	15:21:58:00	31.07	-79.11	03544	03040	03547		LST WND 024
22	990148032	15:22:13:00	31.80	-80.14	02040	04033	01541		LST WND 011
23	994335232	15:22:27:00	30.72	-80.63	01046	02533	01546		
24	994015040	15:22:40:00	30.71	-79.57	02042	02038	02046		
25	990435520	15:22:47:00	30.43	-79.04	02045	02541	02046		
26	993915072	15:22:58:00	30.66	-78.20	04037	05018	04038		
27	994325184	15:23:49:00	31.80	-77.15	05049	07530	05050		
28	994015040	15:23:54:00	31.45	-77.47	03552	06532	04052		
29	011218036	16:00:00:00	31.06	-77.63	02530	05014	03530	28.0	
30	993925184	16:00:11:00	30.49	-78.20	02539	02529	03041		
31	990845120	16:00:16:00	30.25	-78.53	01533	01029	01036		
32	993925184	16:00:21:00	29.98	-78.88	00538	36047	00544		
33	992515712	16:00:31:00	29.55	-79.55	36035	35532	00536		

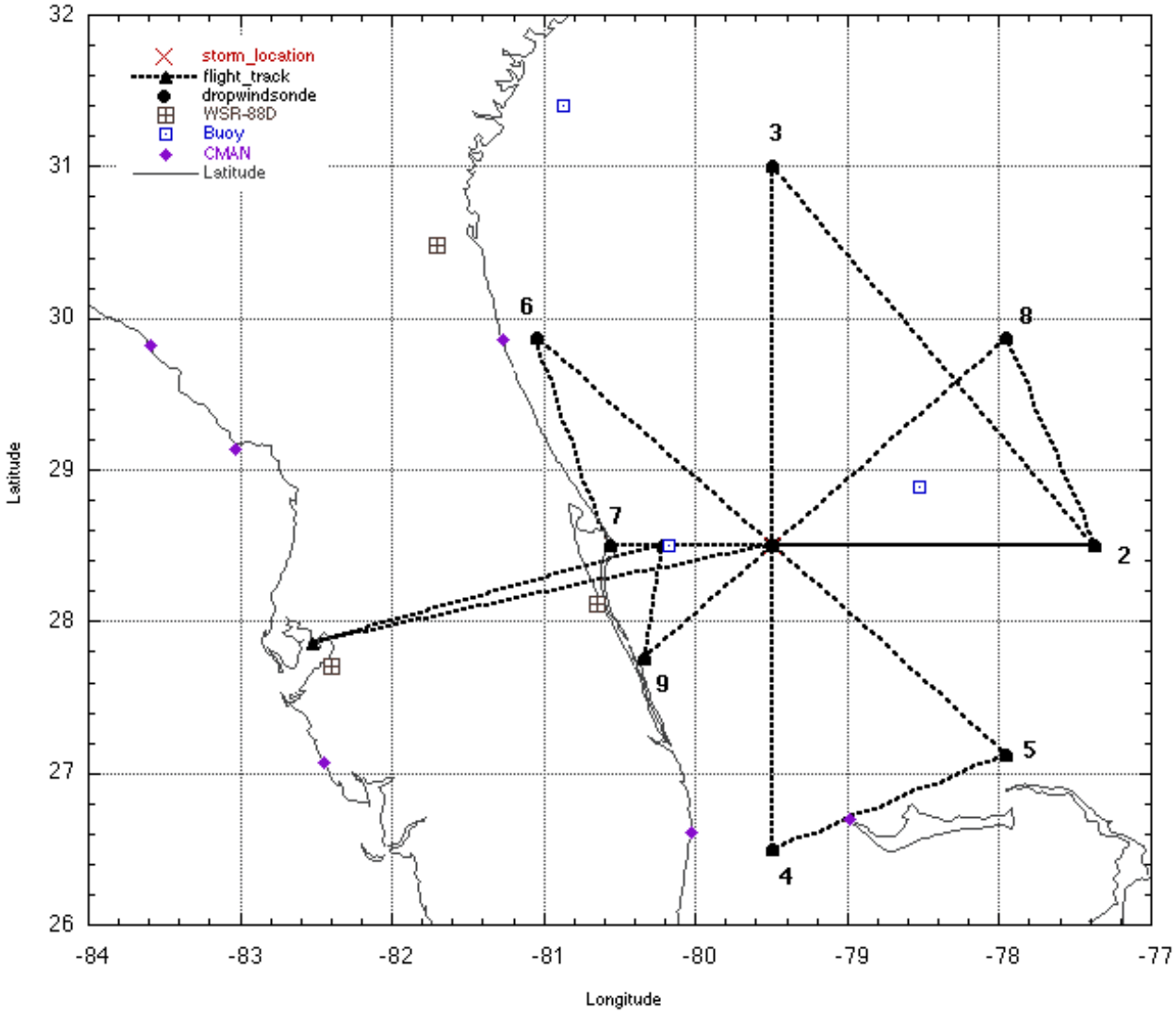

Fig. 1. Planned flight track for N42RF

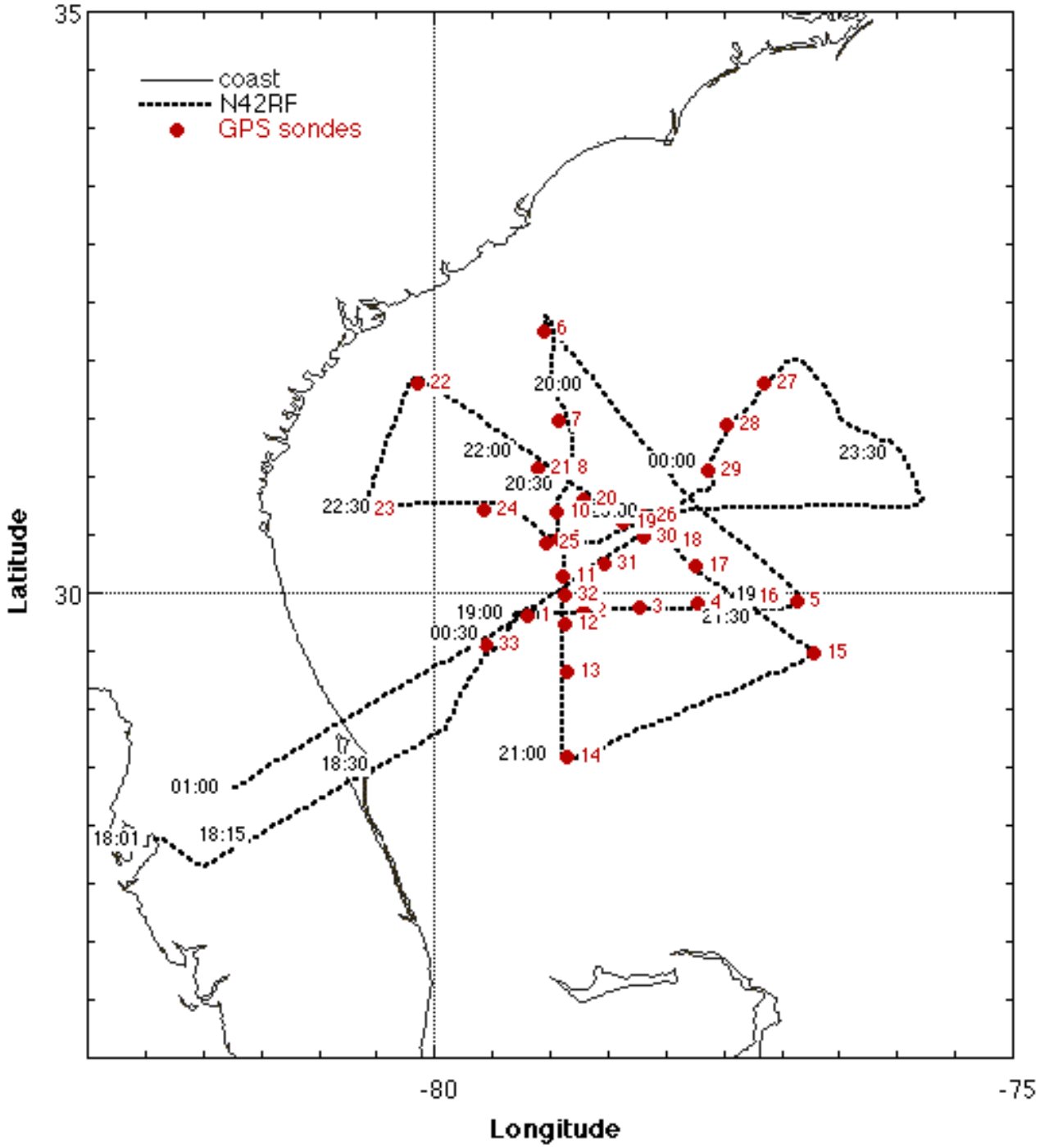

Fig. 2 N42RF flight track on 15 September 2001.

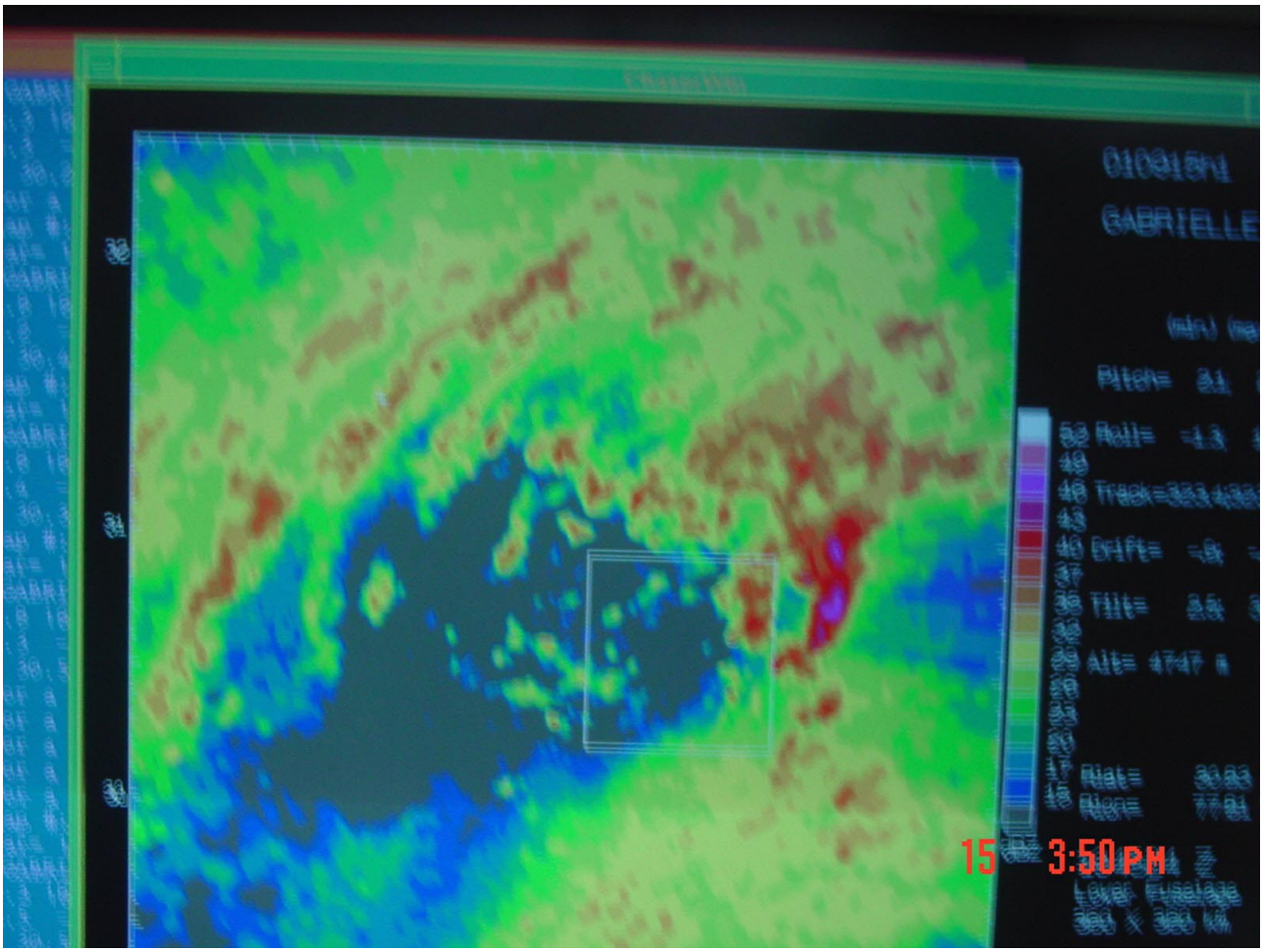

Fig. 3. Photograph taken of LF radar showing heavy rain cells 120 nm east-northeast of the circulation center (photo credit Mike Black, NOAA/AOML/HRD).

Fig. 4. Photograph taken from N49RF in the eye around 1917 UTC showing low-level circulation center (photo credit Sim Aberson, NOAA/AOML/HRD).

Fig. 5. Photograph taken from N49Rfsouth of the center showing sea state south of the surface center (photo credit Sim Aberson, NOAA/AOML/HRD).