Mission Summary
Hurricane Earl
Landfall
980902I1 Aircraft: 43RF

Scientific Crew:		**Aircraft Crew:**	
Chief Scientist	Peter Dodge	Cockpit:	CAPT Jerry McKim
			LCDR Tim O'Mara
Doppler Scientist	John Gamache		CAPT Dave Tennesen
Cloud Physics	Bob Black		Roc Torrey
Dropsonde Scientist	James Franklin	Navigator:	LCDR Dave Rathbun
Workstation/AXBT:	Mike Black	Flight Director:	Stan Czyzyk
Observer	Rob Rogers	Engineers:	Sean McMillan, Jim Barr, Richard McNamara
SRA	Ed Walsh		
		Radio:	Damon SansSouci

Mission Briefing:

At 1 pm EDT, 2 September 1998, we briefed the AOC flight crew for a Tropical Cyclone Windfields at Landfall research flight in Tropical Storm Earl, which at that time was forecast to reach hurricane strength and make landfall between Mobile, Alabama, and Panama City Florida. The goal of the flight was to collect flight-level, radar and GPS dropsonde data to capture the structure of the windfield in a landfalling hurricane. We were especially interested in the onshore flow because of the possibile storm surge in the Florida Panhandle.

Pete Black started the briefing by cautioning the flight crew that there could be severe weather associated with Earl, because of the higher wind shear and the interaction with the coast . I explained our initial pattern, a figure 4 through the storm to be followed by some radial legs toward the Eglin Air Force Base WSR-88D (KEVX). Then we planned, tentatively, to fly a saw-tooth pattern through the main rainabnd east of the center and then to descend to 8000' to fly along the coast, to measure the storm surge in Apalachee Bay with Ed Walsh's surface radar. We planned to drop numerous GPS Sondes and Airborne Expendable BathyThermographs (AXBT's) to map out the onshore and offshore flow, the eye, and the main rainband and/or wind maximum. The AOC crew agreed to this flexible plan. It helped that both Stan Czyzyk and Jerry McKim had been on the Fran and Danny landfall missions in previous years.

Mission Synopsis:

We left MacDill at 1925 UTC, and reached our initial altitude of 14 000' by 1945. This flight was seperated into three modules:

a. ***The initial pattern***: By 2007 we had reached the wind max in the main rainband, ~200 km east of the center of the storm. Sondes and AXBT's were deployed in the band and at buoy 42039. At 2037 Stan fixed the center at 29°04.7′N, 87°09.1′W, and we proceeded west to buoy 42040 where we also dropped sonde and AXBT at 2050. We passed through the center for the second time at 2110 and headed NE to KEVX. This leg was bouncy as we flew through rainbands near the coast. John Gamache reset the LF color scale so we could more easily pick out the 50 dBZ cores; there were several and we managed to avoid them all. At 2129 we turned at the coast dropped some more sondes and AXBT's and passed through the center again at 2150, where we dropped a center sonde. As we headed the south the bouncing subsided and we were in clearer air for a while.

b. ***The rainband sawtooth***: After we had finished the outbound leg from KEVX at 2200 UTC, Mike and Rob designed a sawtooth pattern to measure the inflow into the main convection of the storm. The goal was to drop sondes on either side of the band, as well as in the middle. We had succesful sonde + BT drops at 2240, 2254 and 2305.

c. ***The coastal survey:*** We began our descent to 8000' at 2311 as we headed for Keaton Beach (KTNF1).

At 2320 we started running along the coast We dropped sondes at KTNF1 at 2320, two sondes near St. Marks at 2330, and one at 2334 near Panacea. We had planned to follow the coast on around St Georges Island to sample the coast near Port St Joe and Panama City, but there was some rather strong echo near Cape San Blas (CSBF1), so we headed southeast. In fact, the TLH WSR-88D detected a Tornado Vortex Signature at 2350 in this same area.Mike suggested that we head out to buoy 42039, repeat the figure 4 through the storm and then head for EVX one more time. So thats what we did. Just southeast of Cape San Blas the aircraft flew upwind inot the wind max, just inside the rainband. Mike remarked to Jerry that this was probably the first time he had flown upwind in an "eyewall". The flight crew did an excellent job of steering us around the convection that seemed to be increasing. At 0107 we dropped a sonde just offshore of KEVX, west of Panama City. We paralled the coast for awhile, about 10-20 km offshore, and then we flew right over Gulf Shores into the mouth of Mobile Bay. After dropping a sonde in Mobile Bay, we turned at the Dauphin Island C-Man (DPIA1) and headed SE for our last pass through Earl. At 0204 Stan fixed the center at 29°33.5′N, 86°17.9′W, well east of our previous center. The Air Force remarked that the center seemed stretched out on a N-S axis. Ed Walsh noted 30' waves at 0208. We dropped the last sonde and AXBT at 0238, in the main rainband, and 0242 we climbed and headed back to Tampa. At 0311 we did a radar altimeter calibration pass over the runway for Ed Walsh, and then landed at 0317 UTC.

Evaluation:

The flight went very well. The sonde and AXBT coverage provide good coverage of a rather unusual hurricane. James Franklin noted that the sondes did nott find a surface wind > 50 kts, yet at 7000' the flight-level winds were > 70 kts for much of the latter part of the flight. Mark Powell incorporated some of that flight level data in an analysis centered at 0130 that estimated the maximum surface wind to be 79 kts, 91 nmi east of the center. A preliminary surface analysis of the GPS sonde data shows similarities to a cold front! The portion of the data set that was collected in Apalachee Bay will be supplemented by wind profiler data collected by Kevin Knupp's group from the University of Alabama-Huntsville, and the WSR-88D data collected by the Eglin AFB and Tallahassee WSR-88D radars.

We now have four data sets collected over land in weak to moderate hurricanes. I still think we must be very cautious about flying in stronger hurricanes overland. It is difficult to interpret the LF display when at 14,000' because strong echo can be caused ether by convectiion or bright band echo. The Dopplerized nose radar may help in discriminating the nasty places from the merely bumpy.

Acknowledgements:

The AOC crew were great. Stan Czyzyk and Dave Rathbun agreed to every change in the flight patterns that we requested, and Jerry McKim, Dave Tennesen, and Tim O'Mara moved us through some bumpy flying with a minimum of surprises. Jim Barr kept the radar running, and Sean McMillan and Richard McNamara managed to keep with our evolving plans for GPS sonde and AXBT drops.

Mike Black acted as co-LPS on this mission; he called most of the Sonde and AXBT drops, and also helped design the rainband and second figure-4 patterns. Rob Rogers also helped plan the rainband pattern. James Franklin processed and transmitted most of the GPS data. Bob Black collected some more big raindrop data; NASA will probably be interested in our cloud physics data because they did not fly below 14 000 '. Pete Black helped plan the flight, and reminded us to be careful on this hurricane flight after 21/2 weeks of continuous operation.Steve Feuer and Mark Powell's analyses and comments helped set up the first part of the flight for the briefing.

Problems:

I forgot to request that we record WARDS data, so the WARDS system did not collect Dopplerized Nose radar data. There was a brief probblem with the ASDL system at the beginning of the flight. There may be a problem with the way spectral width is reorded on the data system. We did not send out our LF composites until late in the flight; we should have sent them in a more timely manner. The radar tape has numerous parity errors, which may result in significant data gaps.

Tables:

Table 1. Centers determined by AOC Flight Director and Navigator

Time	Lat	Lon	Comments
2037	29 ° 04′	87° 09′	
2110	29° 04′	87° 08′	
2150	29° 08′	87° 08′	maybe a bit south of center. Sonde dropped here.
0024	29° 19′	86° 45′	
0052	29° 20′	86° 43′	
0204	29° 33′	86° 17′	

Table 2. GPS Sondes

	Serial #	Time	Lat	Lon	Comments
1	974940036	200206	28.5	84.5	With BT
2	974510099	200730	28.6	84.9	Rainband, signal loss
3	974530042	202222	28.8	86.0	with BT
4	981950004	205100	29.2	88.3	"
5	982630002	210243	28.6	87.5	"
6	974740026	212032	29.7	86.6	rainband, no winds
7	974510001	212130	29.7	86.6	rainband
8	973730034	213207	30.3	86.4	rainband
9	974740043	214357	29.5	86.8	rainband
10	981950051	214431	29.5	86.9	rainband
11	981810026	215018	29.1	87.1	eye
12	973730037	222918	27.3	85.8	with BT, sst = 27
13	973840061	223420	27.5	85.4	rainband edge
14	982640245	224005	27.9	85.2	with BT, clipped, 10% diff
15	982710012	224438	28.1	85.4	rainband
16	982630012	225409	28.6	85.4	with BT, no data (late winds?)
17	973840042	225607	28.7	85.2	rainband
18	973730042	230527	28.6	84.5	with BT, over buoy 42036
19	980410074	232205	29.8	83.6	
20	973250047	233020	30.1	84.2	No LD, rainband
21	981750067	233110	30.1	84.2	rainband
22	975020002	233430	29.9	84.4	rainband
23	974530061	233715	29.9	84.6	over land, rapid ws falloff
24	974510040	235130	29.3	85.0	eyewall
25	982630004	001046	28.8	86.0	no winds
26	973730045	001343	28.9	86.2	
27	981810011	010738	30.2	86.3	rainband offshore
28	982430005	012515	30.2	87.8	
29	982010104	023806	28.6	84.5	rainband, failed early

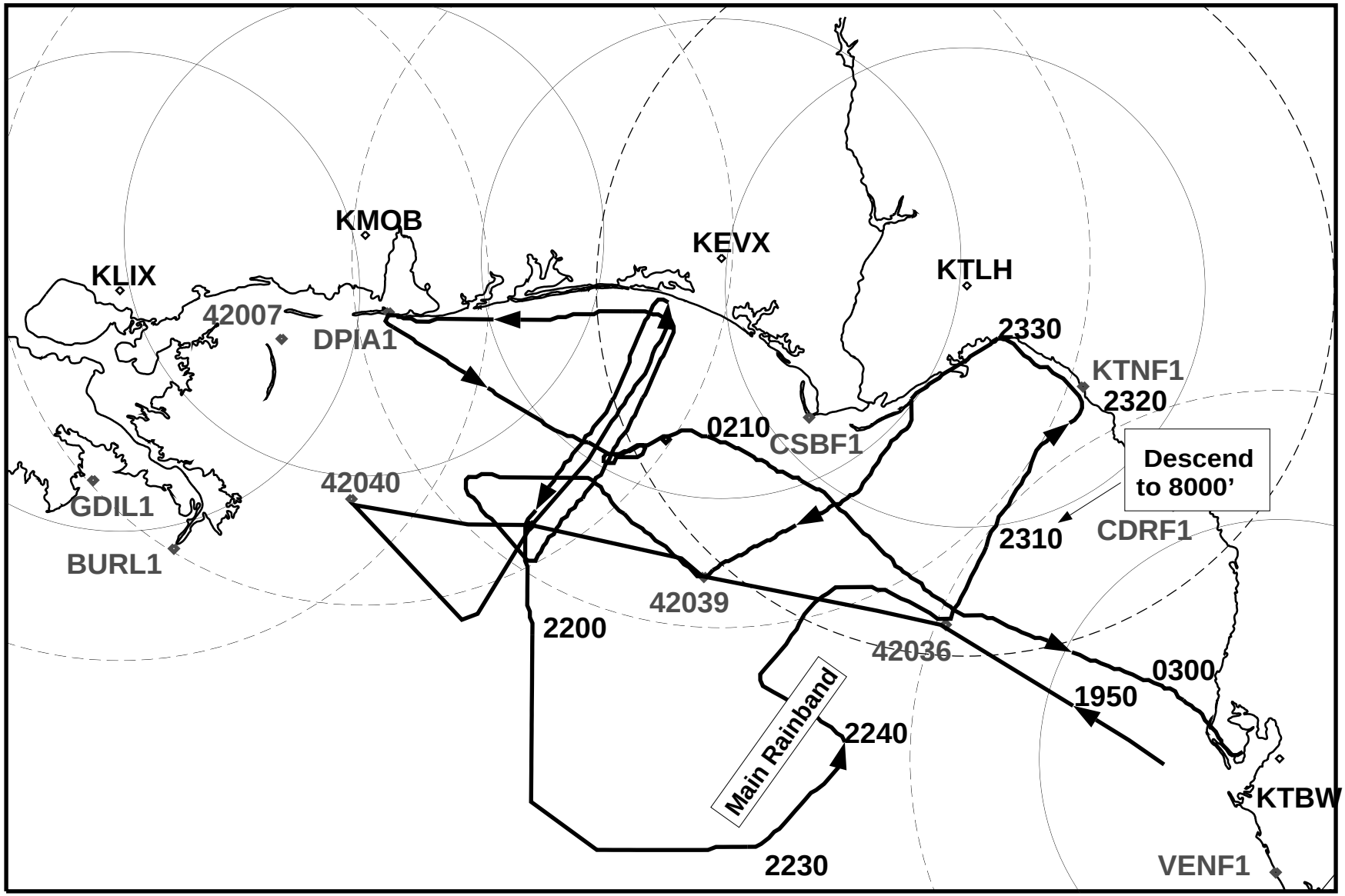
Table 3. AXBT's

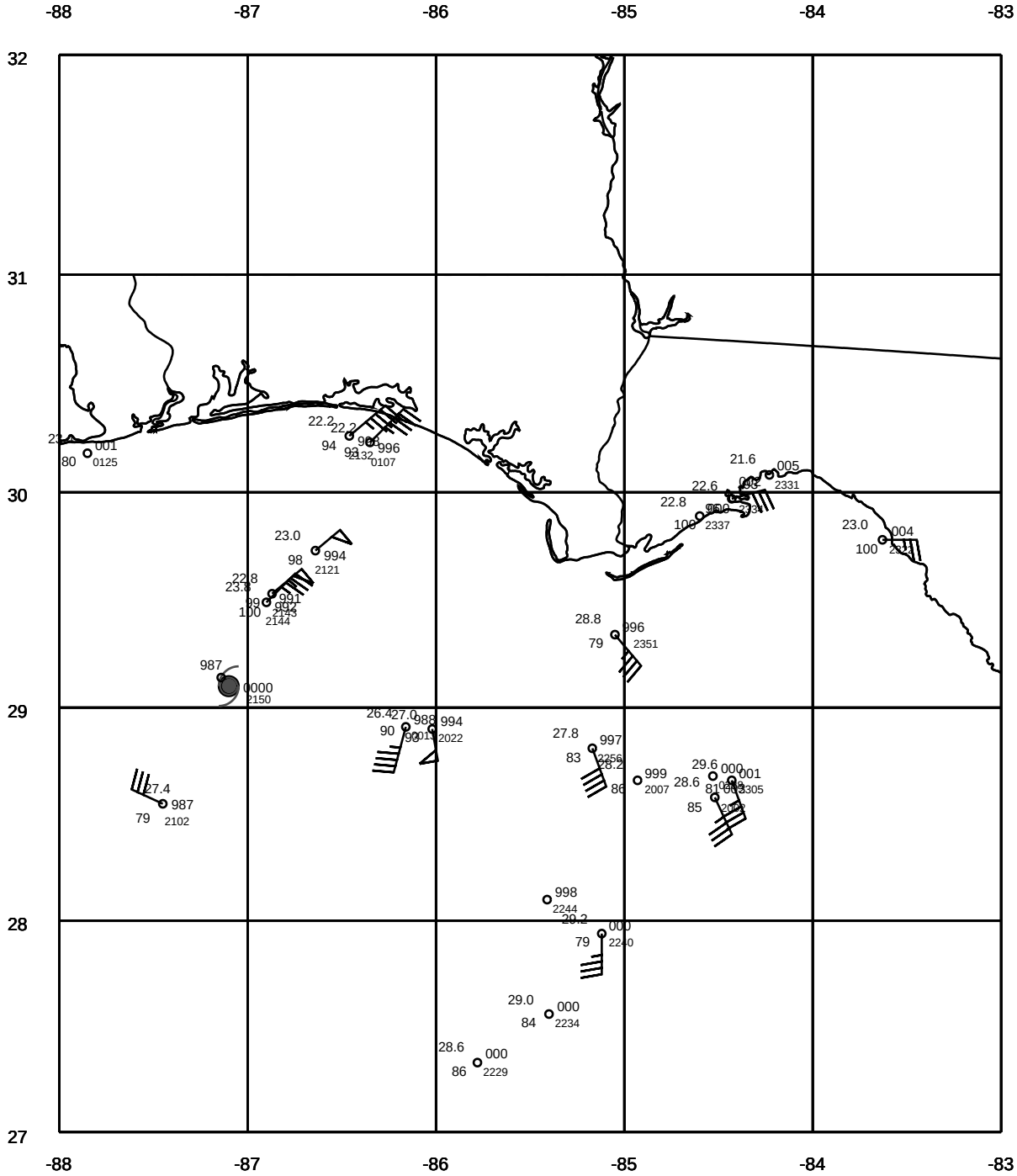
#	Time	Lat	Lon	Comments
1	200219	28° 30'	84° 32'	
2	202300	28° 47'	86° 03'	
3	205100	29° 10'	88° 17'	
4	210248	28° 34'	87° 29'	
5	211657	29° 26'	86° 47'	in rainband, maybe no good
6	214534	29° 25'	86° 55'	
7	222920	27° 15'	85° 49'	
8	224006	27° 52'	85° 09'	
9	225409	28° 36'	85° 21'	
10	230528	28° 35'	84° 26'	
11	001100	28° 47'	86° 01'	near Buoy 42039
12	002400	28° 18'	86° 45'	Dropped in eye
13	004320	28° 52'	87° 07'	
14	010057	29° 51'	86° 23'	
15	014042	29° 48'	87° 22'	
16	021732	29° 36'	85° 54'	
17	023025	28° 56'	84° 55'	
18	024018	28° 34'	84° 24'	

Figures:

1. NOAA 43RF flight track. (on thor in /users/peter/earl_stuff.d/earl_flight_map.draw, *.ps}
2. Surface map from GPS drops. (on thor in /users/peter/earl_stuff.d/ sond_srf_map.ps)

Hurricane Earl NOAA 43RF flight track 2 September 1998





EARL

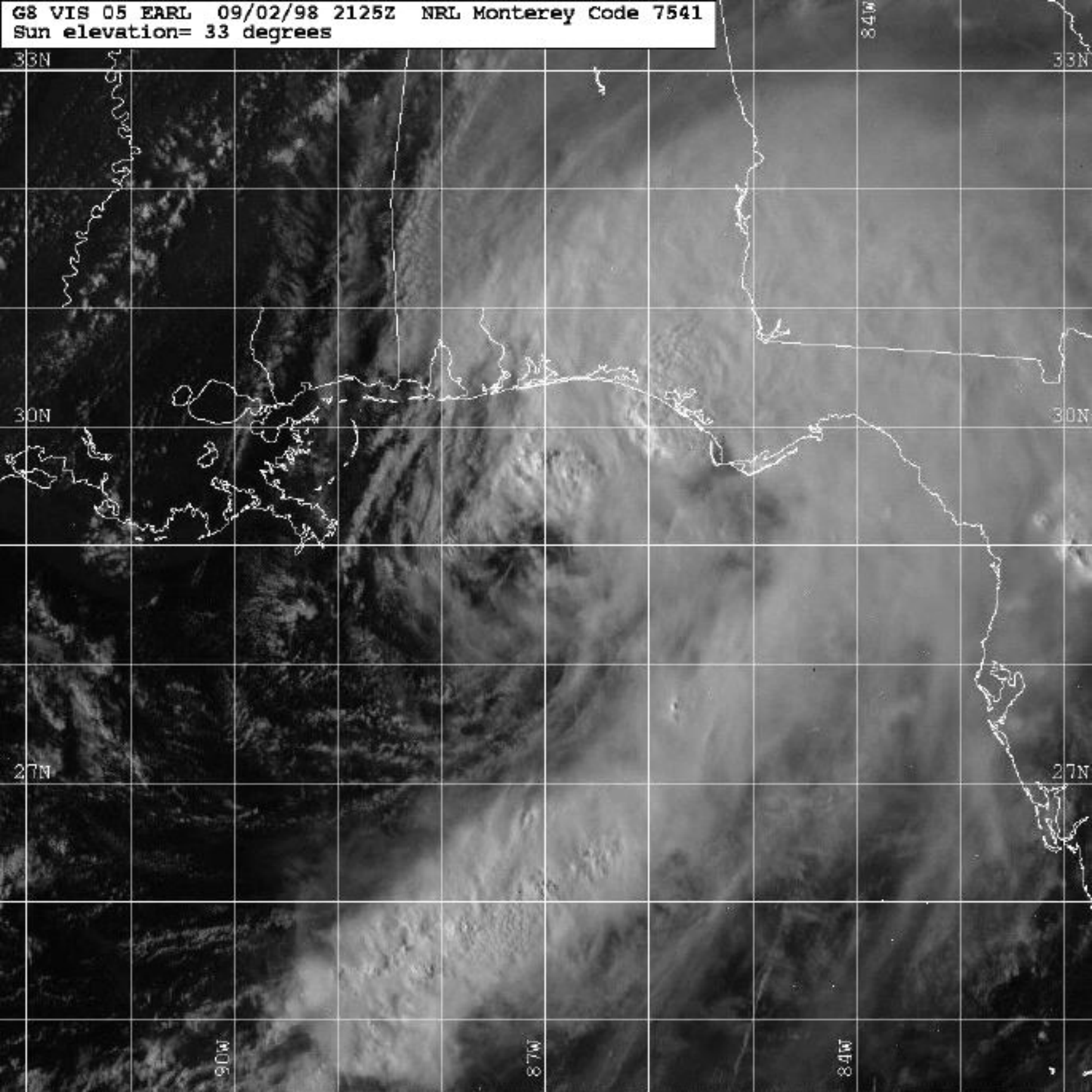
Surface

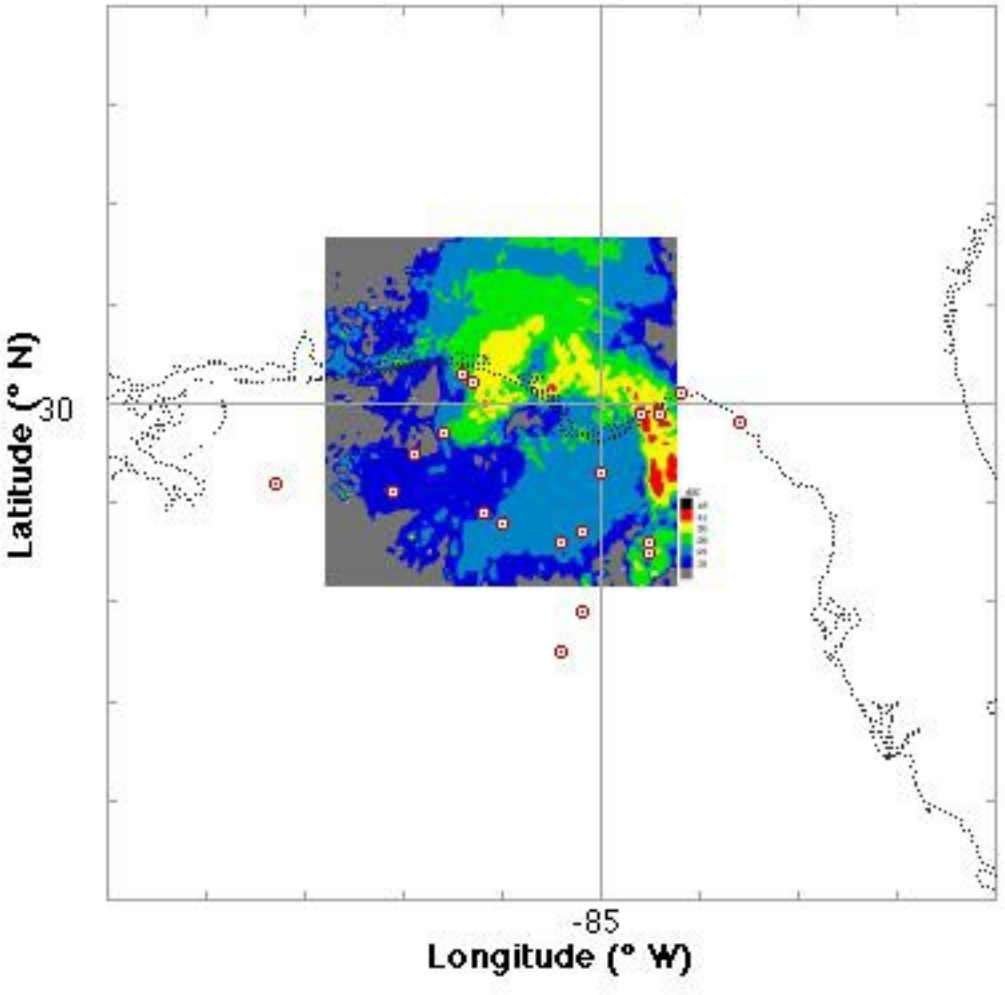
Date: 980902

Time: 18-30 UTC

EARTH RELATIVE

NOAA/ERL/HURRICANE RESEARCH DIVISION


G8 VIS 05 EARL 09/02/98 2125Z NRL Monterey Code 7541
Sun elevation= 33 degrees
33N
30N
27N
90W
87W
84W


Latitude (° N)
30
-85
Longitude (° W)