Tropical Cyclone Report
Tropical Storm Ingrid
(AL082007)
12 – 17 September 2007

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Ingrid was a tropical storm that formed over the central tropical Atlantic Ocean and dissipated as it approached the Leeward Islands.

a. Synoptic History

Ingrid developed from a large tropical wave that exited the coast of Africa on 6 September. At that time, strong easterly shear inhibited development over the eastern Atlantic and it was not until 9 September that a broad area of low pressure developed along the wave axis, about midway between Africa and the Lesser Antilles. The easterly shear gradually diminished over the next several days, which allowed the system to maintain convection near the low center on 11 September, when Dvorak classifications were initiated. By the morning of 12 September, the system acquired sufficient organization to be designated a tropical depression, while centered about 980 n mi east of the Lesser Antilles.

The "best track" chart of the tropical cyclone's path is given in Fig. 1, with the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1. The depression moved on a general west-northwestward track within a weak steering flow south of a mid-tropospheric ridge. Despite moderate westerly shear, the cyclone became a tropical storm around 0600 UTC 13 September, while centered about 730 n mi east of the Lesser Antilles, and reached its maximum intensity of 40 kts 12 h later. Persistent westerly shear, due to a stronger than normal upper-trophospheric mid-oceanic trough located west-northwest of the cyclone, prevented further intensification. During the next 24 hours, the shear increased, which resulted in Ingrid weakening to a tropical depression by 1800 UTC 15 September. Ingrid remained a tropical depression for a day or so before degenerating into a remnant low around 0600 UTC 17 September, while centered about 140 n mi east-northeast of Antigua. The remnants of Ingrid moved slowly northwestward and west-northwestward within the lower-tropospheric steering flow, and the low dissipated on 18 September.

b. Meteorological Statistics

Observations in Ingrid (Figs. 2 and 3) include satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), as well as flight-level and Stepped Frequency Microwave Radiometer (SFMR) surface observations from several flights of the NOAA P-3 research aircraft. Microwave satellite imagery from NOAA polar-orbiting satellites, the NASA Tropical Rainfall Measuring Mission (TRMM), the NASA Aqua, the NASA QuikSCAT, the Department of Defense WindSat, and Defense Meteorological Satellite Program (DMSP) satellites were also useful in tracking Ingrid.

The estimated peak intensity of Ingrid on 14 September represents a blend of the surface-adjusted flight-level winds and SFMR data from the NOAA P-3 aircraft. During the morning flight on 14 September, the SFMR reported a maximum 51 knot wind over the southwestern quadrant of the storm; however, this observation did not appear representative of the strength of the poorly-defined circulation. The minimum pressure of 1002 mb is based on a dropsonde pressure of 1004 mb that was accompanied by a 26-kt surface wind, which indicates that the dropsonde probably did not sample the center of the cyclone and its lowest pressure.

No ship or land station reported sustained winds of at least tropical storm force in association with Ingrid.

c. Casualty and Damage Statistics

There were no reports of damage or casualties associated with Ingrid.

d. Forecast and Warning Critique

The genesis of Ingrid was well anticipated. The tropical wave that eventually spawned Ingrid was first introduced into the Tropical Weather Outlook (TWO) at 0230 UTC 7 September, about five days prior to genesis. At that time, the wave was located a few hundred miles south of the Cape Verde Islands. For the next couple of days, there was continual mention in the TWO that slow development of the system was possible. By late on 9 September, the potential for tropical depression formation was explicitly mentioned in the outlook. It was not until early on 12 September that the system acquired enough organization to be designated as a tropical depression. This resulted in a 54-hour lead time between the first mention of potential tropical depression formation in the TWO and when tropical cyclogenesis actually occurred.

A verification of NHC official and guidance model track forecasts is given in Table 2. Average official track errors for Ingrid were 28, 52, 89, 115, 145, and 154 n mi for the 12, 24, 36, 48, 72, and 96 h forecasts, respectively. These errors are lower than or close to the average long-term official track errors for all forecast periods (Table 2). Both the GFSI and UKMI models performed relatively well in comparison to the other dynamical model guidance. Notably, the UKMI had lower track errors than the official forecasts at all forecast lead times except for 24 h. Both the GFSI and UKMI kept a more westerly track compared to the other dynamical models during the first couple of days. The GFSI and UKMI maintained Ingrid as a weak system and anticipated the ridge to the north of the cyclone to remain intact. On the other hand, the NGPI had the largest errors as it forecasted a stronger Ingrid to take a more northwestward track in response to a weakness in the subtropical ridge. Despite somewhat of a dichotomy in the model guidance, the official track forecasts correctly maintained Ingrid on a more westward track within the low- to mid-level steering flow.

Average NHC official intensity errors were 2, 4, 4, 8, 18, and 28 kt for the 12, 24, 36, 48, 72, and 96 h forecasts, respectively (Table 3). For comparison, the average long-term official intensity errors are 6, 10, 12, 14, 18, and 20 kt, respectively. The official intensity forecast errors were slightly below the average long-term errors through 72 hours; however, they were larger than the average error at 96 h. Even though only three official forecasts verified at 96 h, the

larger than average errors at that forecast time can be attributed to the global models predicting that the shear would lessen, which would allow for gradual strengthening of the cyclone. The GHMI provided the most accurate intensity guidance and did particularly well in the later forecast periods. It is notable that the GFDL Hurricane Model correctly predicted the weakening, in this case, in the sheared environment. In earlier years that model was notorious for over-intensifying tropical cyclones in environments of strong vertical shear. This change could be attributable to recent improvements in the GFDL model physics.

Table 1. Best track for Tropical Storm Ingrid, 12-17 September 2007.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
12 / 0600	13.0	43.6	1009	25	tropical depression
12 / 1200	13.0	44.3	1008	30	"
12 / 1800	13.1	45.1	1007	30	"
13 / 0000	13.4	45.9	1006	30	"
13 / 0600	13.7	46.7	1005	35	tropical storm
13 / 1200	14.1	47.5	1005	35	"
13 / 1800	14.4	48.1	1004	35	"
14 / 0000	14.7	48.6	1002	35	"
14 / 0600	15.0	49.3	1003	35	"
14 / 1200	15.3	49.9	1004	40	"
14 / 1800	15.6	50.5	1004	40	"
15 / 0000	15.9	51.2	1005	35	"
15 / 0600	16.2	52.2	1005	35	"
15 / 1200	16.3	53.3	1005	35	"
15 / 1800	16.5	54.4	1006	30	tropical depression
16 / 0000	16.7	55.4	1006	30	"
16 / 0600	16.9	56.3	1006	30	"
16 / 1200	17.1	57.2	1006	30	"
16 / 1800	17.2	58.1	1007	30	"
17 / 0000	17.3	59.0	1009	25	"
17 / 0600	17.5	59.9	1010	25	remnant low
17 / 1200	18.0	60.6	1010	25	"
17 / 1800	18.4	61.0	1010	25	"
18 / 0000	18.8	61.4	1011	20	"
18 / 0600	19.0	61.7	1011	20	"
18 / 1200	19.1	62.0	1011	20	"
18 / 1800					dissipated
14 / 0000	14.7	48.6	1002	35	minimum pressure
14 / 1200	15.3	49.9	1004	40	maximum wind

Table 2. Preliminary track forecast evaluation (heterogeneous sample) for Tropical Storm Ingrid, 12-17 September 2007. Forecast errors (n mi) are followed by the number of forecasts in parentheses. Errors smaller than the NHC official forecast are shown in bold-face type. Verification includes the depression stage but does not include the remnant low stage.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
CLP5	32 (18)	60 (16)	95 (14)	126 (12)	**143 (8)**	202 (4)	
GFNI	31 (12)	72 (9)	125 (9)	209 (5)	224 (1)		
GFDI	28 (18)	56 (16)	89 (14)	116 (12)	**117 (8)**	**114 (4)**	
HWFI	31 (8)	65 (16)	106 (14)	136 (12)	164 (8)	207 (4)	
GFSI	41 (18)	69 (15)	110 (13)	144 (11)	207 (7)	285 (4)	
AEMI	28 (18)	55 (16)	101 (14)	146 (12)	174 (1)		
NGPI	44 (16)	98 (14)	161 (12)	227 (10)	255 (5)	285 (1)	
UKMI	**26 (16)**	58 (14)	**81 (12)**	**86 (10)**	**77 (6)**	**139 (2)**	
BAMD	52 (18)	101 (16)	148 (14)	184 (12)	254 (8)	377 (4)	
BAMM	28 (18)	58 (16)	100 (14)	141 (12)	211 (8)	299 (4)	
BAMS	**25 (18)**	**48 (16)**	**85 (14)**	117 (12)	179 (8)	234 (4)	
CONU	28 (18)	57 (16)	98 (14)	134 (12)	149 (8)	185 (4)	
GUNA	**27 (16)**	62 (13)	106 (11)	140 (9)	147 (4)	**147 (1)**	
FSSE	37 (6)	84 (6)	141 (4)	174 (4)	186 (1)		
OFCL	28 (17)	52 (15)	89 (13)	115 (11)	145 (7)	154 (3)	
NHC Official (2002-2006 mean)	35 (1852)	61 (1686)	86 (1519)	112 (1362)	162 (1100)	221 (885)	290 (723)

Table 3. Preliminary intensity forecast evaluation (heterogeneous sample) for Tropical Storm Ingrid, 12-17 September 2007. Forecast errors (kt) are followed by the number of forecasts in parentheses. Errors smaller than the NHC official forecast are shown in bold-face type. Verification includes the depression stage but does not include the remnant low stage.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
SHF5	2.7 (18)	6.1 (16)	9.3 (14)	13.8 (12)	19.4 (8)	**26.3 (4)**	
GHMI	3.2 (18)	**3.8 (16)**	6.2 (14)	**6.4 (12)**	**13.0 (8)**	**11.0 (4)**	
HWFI	3.2 (18)	5.1 (16)	5.9 (14)	9.7 (12)	**14.6 (8)**	**21.5 (4)**	
SHIP	2.8 (18)	4.7 (16)	7.8 (14)	13.3 (12)	24.3 (8)	35.5 (4)	
DSHP	2.8 (18)	4.7 (16)	7.8 (14)	13.3 (12)	24.3 (8)	35.5 (4)	
FSSE	2.7 (6)	7.0 (6)	12.3 (4)	11.0 (4)	**12.0 (1)**		
ICON	2.4 (18)	**3.7 (16)**	5.8 (14)	9.1 (12)	**17.6 (8)**	**22.8 (4)**	
OFCL	1.8 (17)	4.0 (15)	4.2 (13)	7.7 (11)	17.9 (7)	28.3 (3)	
NHC Official (2002-2006 mean)	6.4 (1852)	9.8 (1686)	12.0 (1519)	14.1 (1362)	18.3 (1100)	19.8 (885)	21.8 (723)

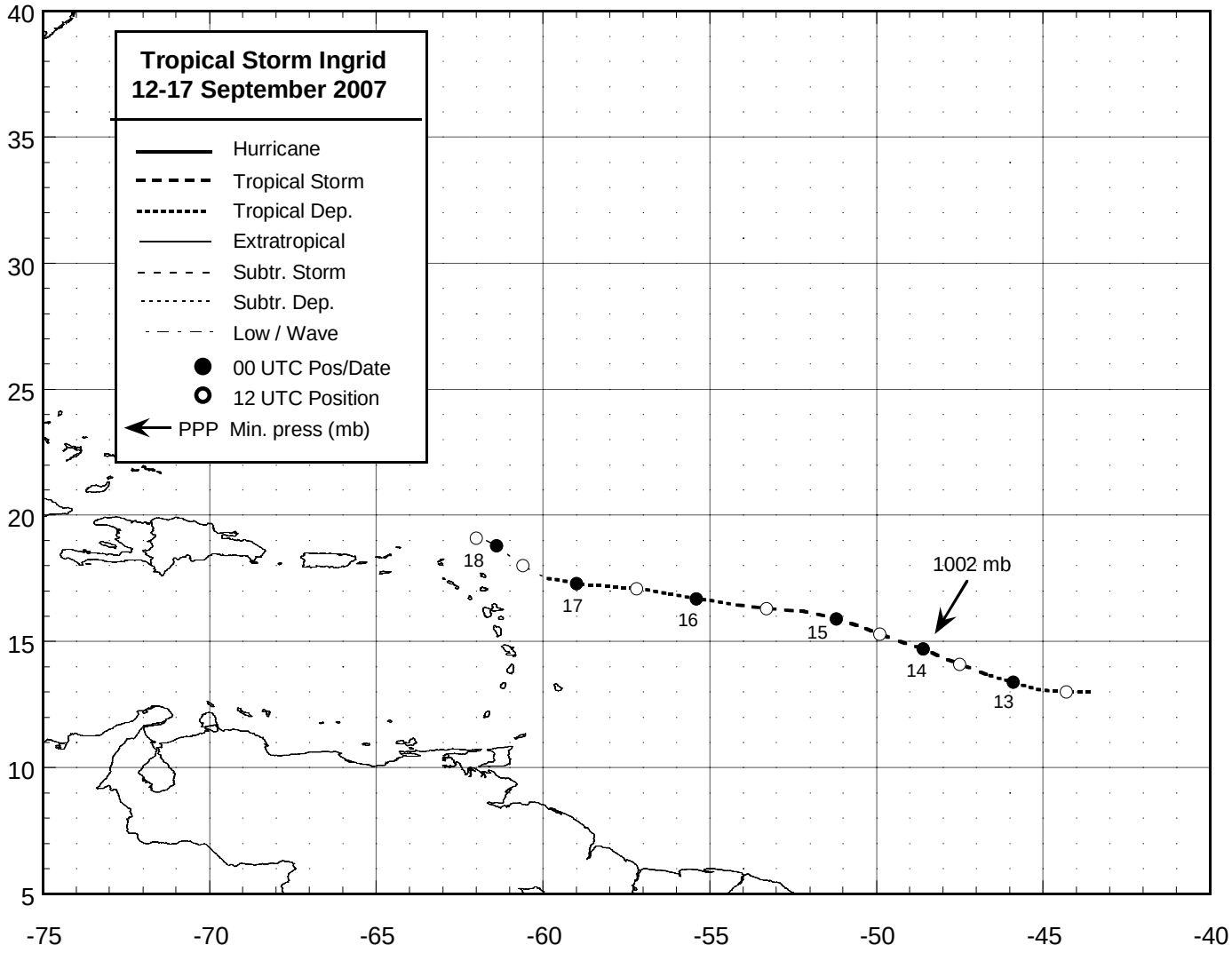

Figure 1. Best track positions for Tropical Storm Ingrid, 12-17 September 2007.

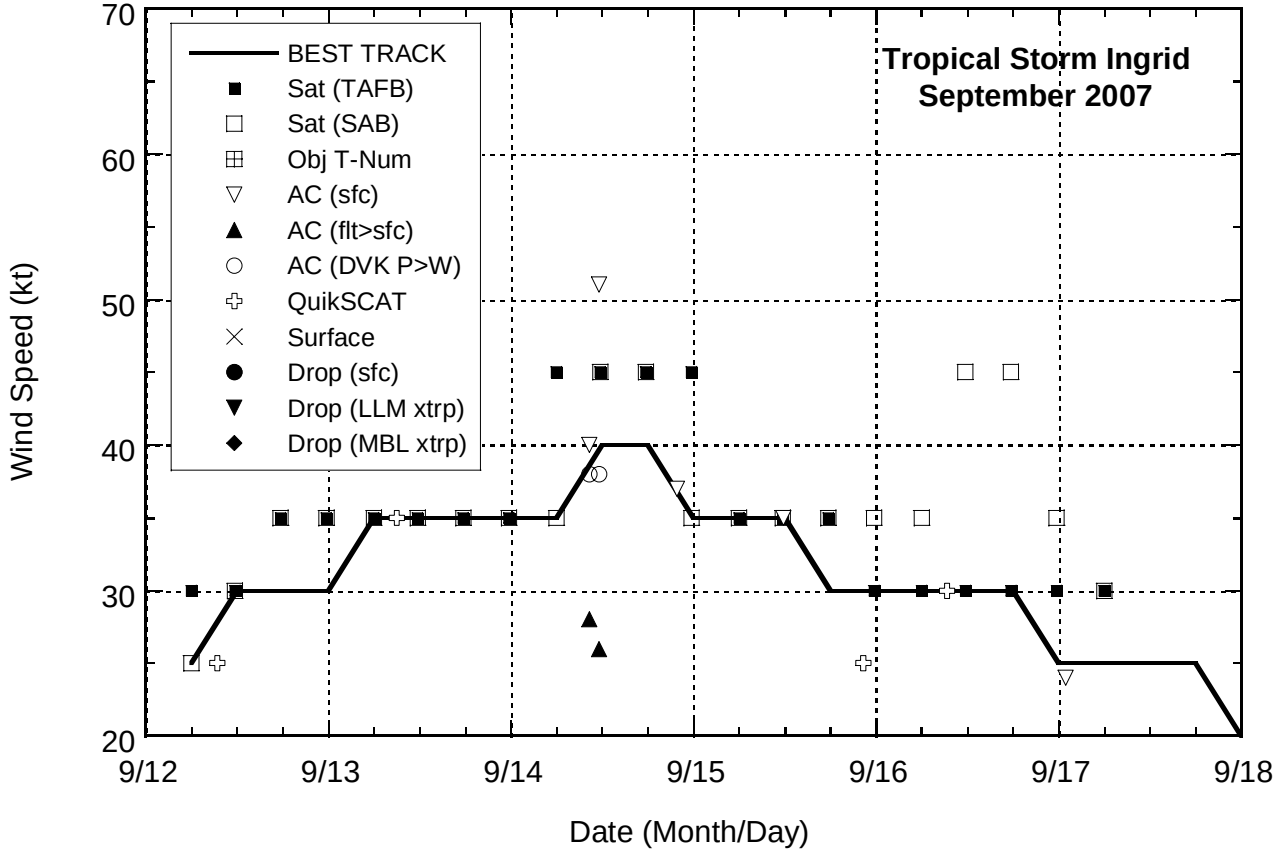

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Ingrid, 12-17 September 2007. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% reduction factors for observations from 700 mb, 850 mb, and 1500 ft, respectively.

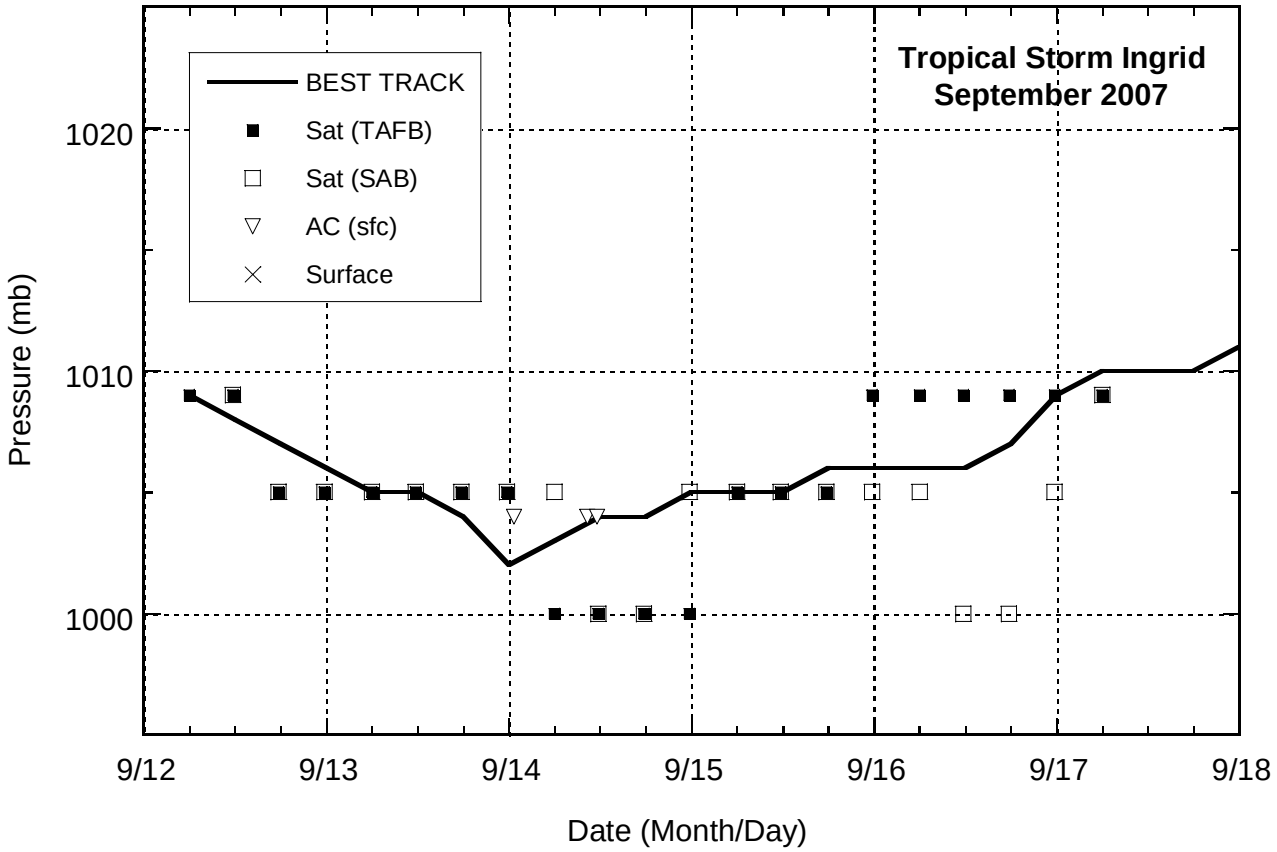

Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Ingrid, 12-17 September 2007.