Supertyphoon Forrest (September 1983): The Overlooked Record Holder of Intensification in 24, 36, and 48 h

KARL HOARAU

International Association of Climatology, Cergy Pontoise University, Cergy-Pontoise, France

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ABSTRACT

Reanalysis of aircraft reconnaissance data shows that in September 1983 Supertyphoon Forrest reached a sea level pressure of 876 hPa instead of 883 hPa as previously accepted. It is estimated that at the time, Forrest was the deepest typhoon in the western North Pacific since Tip, 870 hPa in October 1979, and June, 875 hPa in November 1975. Using calculations from 700-hPa aircraft reconnaissance data, it is determined that a surface pressure of 876 hPa was reached at 2030 UTC 22 September 1983, which would constitute an amazing deepening rate of 100 hPa in a little over 23 h. In addition, pressure drops of 101, 111, and 120 hPa in 24, 36, and 48 h respectively, are inferred from these calculations. These figures would set new records previously held by Supertyphoons Ida in September 1958 and Irma in November 1971. The validity of using surface pressures calculated from 700-hPa data is discussed by comparing them with other data gathered in Supertyphoon Forrest as well as with comparisons from other aircraft reconnaissance data in similarly intense typhoons.

1. Exceptionally low pressure values in Supertyphoon Forrest

According to best track data from the Joint Typhoon Warning Center (JTWC), Guam, Annual Tropical Cyclone Report (ATCR) (JTWC 1983), Forrest reached both tropical storm intensity (18 m s^{-1}) and typhoon intensity (33 m s^{-1}) on 21 September 1983 as it moved on a northwestward track in the western North Pacific (Fig. 1). However, its greatest intensification took place between 21 and 22 September when aircraft reconnaissance vortex reports from dropsonde measurements showed central pressure drops from 975 to 926 to 883 hPa in a little under 24 h (see Table 1, column 2). JTWC used this last measured report of 883 hPa at 2307 UTC on 22 September as their basis for Forrest's minimum pressure estimate. However, in addition to the above surface pressure measurements, the ATCR reconnaissance dataset also included several aircraft reconnaissance vortex reports where the central surface pressure was not recorded, but other standard meteorological measurements were made, including the minimum height at the 700-hPa pressure level. The value of the cyclone's minimum height at the 700-hPa flight level was often used by the typhoon forecaster to calculate an equivalent surface pressure in place of a surface measurement during an intermediate, or offtime, center fix or whenever a dropsonde measurement was not available (R. Edson 1999, personal communication). Indeed, the following linear regression equation developed by Jordan (1958) in the 1950s was commonly used by the forecaster:

$$\mathrm{Pc} = 645 + 0.115x,$$

where Pc represents the central atmospheric pressure of the cyclone at sea level (in hPa) and x is the minimum height in meters for the 700-hPa pressure level. Because of hydrostatic balance in the eye, it is possible to get an equivalent surface pressure from this method to within 1 or 2 hPa of the actual surface pressure. Weatherford and Gray (1988) also showed a similar relationship between the central surface pressure and the minimum 700-hPa height in their evaluation of aircraft reconnaissance data in the eye of western North Pacific typhoons. In Supertyphoon Forrest's case, there were eight aircraft reconnaissance vortex reports where a minimum 700-hPa height was provided but no surface pressure recorded. Table 1 shows the minimum height data from the first 11 aircraft reports into Forrest (to cover the intensification period), including five with 700-hPa height measurements but no surface data. Computed equivalent surface pressures using Jordan's equation for the minimum surface pressure are then shown in the adjoining column. As expected, where the surface pressures were actually measured, the calculated values are fairly close to their corresponding measured values. Table 1 shows that the lowest 700-hPa height, 2009 m, occurred in Supertyphoon Forrest at 2030 UTC on 22

Corresponding author address: K. Hoarau, 27 Allee de la Toison d'Or, Appartement 6, Etage 2, 94000 Creteil, France.
E-mail: KHoarau@aol.com

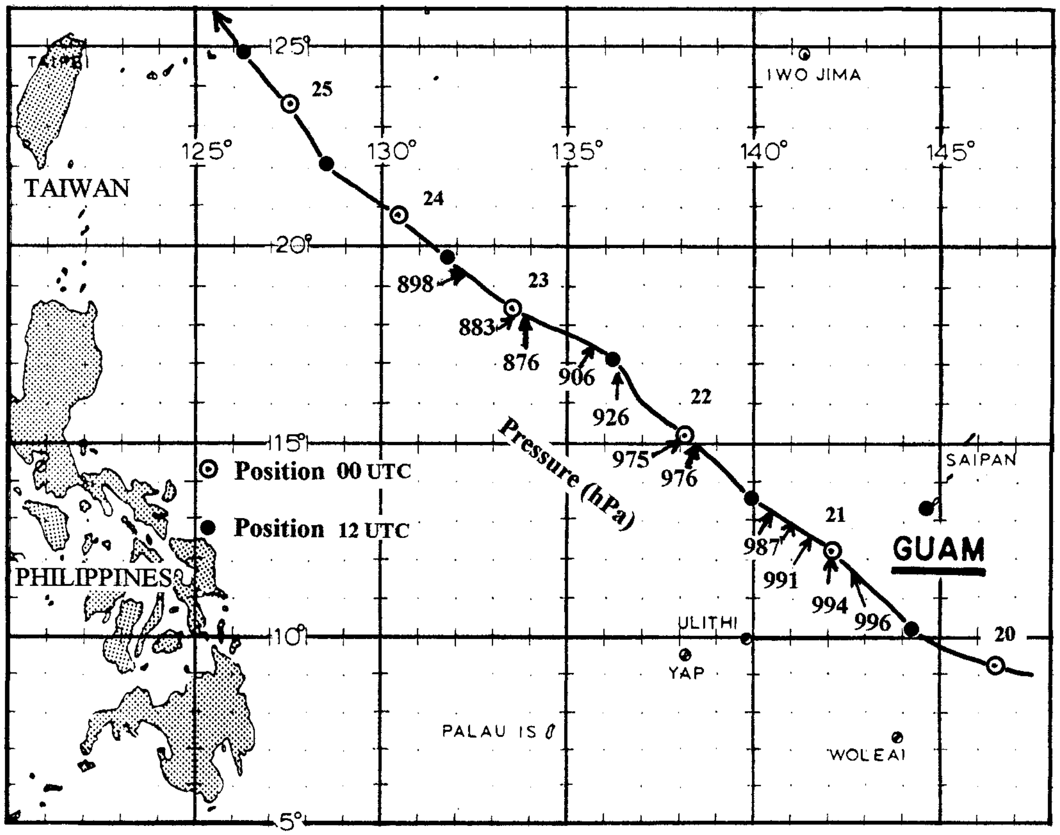

FIG. 1. Track and intensity (hPa) of Supertyphoon Forrest during the period 20–25 Sep 1983. Source: JTWC (1983) and recomputed aircraft reconnaissance data from JTWC.

September. Since no dropsonde measurement was taken during this intermediate fix time, Jordan's formula is used to give an estimated equivalent sea level pressure of 876 hPa—7 hPa lower than the next reported value of 883 hPa at 2307 UTC (2068 m at 700 hPa). This is graphically depicted in Fig. 2 where the combined calculated and measured central sea level pressures are shown for the period 21–23 September. In addition to the 700-hPa height data, the eye characteristics reported from earlier aircraft reconnaissance missions, also supported Forrest's steep pressure drop through 2030 UTC and the higher second report at 2307 UTC. By 1057 UTC 22 September, the weather reconnaissance officer (M. Middlebrooke 1999, personal communication) reported frequent lightning throughout the eye wall and "an impressive" 5 n mi circular eye (down from a 35 n mi × 20 n mi elliptical eye 24 h, previously). This was usually a good indication that the typhoon was in the process of undergoing rapid intensification. By 2030 UTC, the 700-hPa central eye temperature had already

TABLE 1. Calculation and verification of the central sea level pressure in Supertyphoon Forrest from aircraft reconnaissance fixes (Sep 1983). Source: data from JTWC (1983).

Day and time (UTC)	Surface pressure by dropsonde (hPa)	700-hPa-level height (m)	Computed surface pressure from 700-hPa level	Definitive surface pressure (hPa)
20 Sep 2337	994	3032	993.5	994
21 Sep 0252	—	3013	991.5	991
21 Sep 0544	—	2981	988	987
21 Sep 0839	987	2984	988	987
21 Sep 2127	—	2880	976	976
21 Sep 2340	975	2865	974.5	975
22 Sep 1057	926	2468	929	926
22 Sep 1345	—	2285	908	906
22 Sep 2030	—	***2009***	***876***	***876***
22 Sep 2307	883	2068	883	883
23 Sep 0912	898	2189	897	898

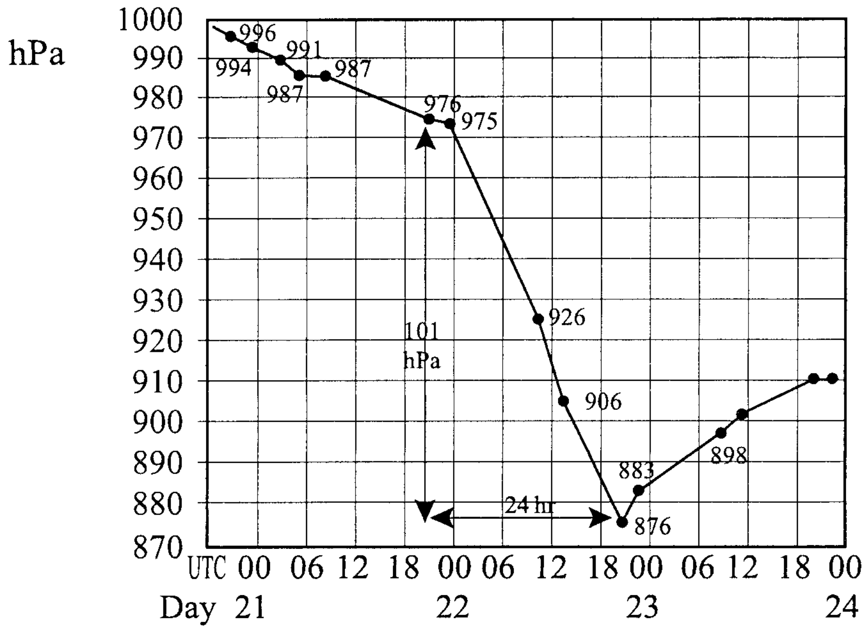

FIG. 2. Central sea level pressure in Supertyphoon Forrest for 21–23 Sep 1983. Source: recomputed aircraft reconnaissance data from JTWC (1983).

reached 27°C, the same temperature reported at the latter 2307 UTC time period (up from 16°C at 2340 UTC 21 September). The lack of any further rising 700-hPa temperature, the higher 700-hPa height, and the fact that the eye had become completely undercast at 2307 UTC (as reported by the weather reconnaissance officer on board that flight) are all indications that Forrest had probably peaked by the earlier 2030 UTC time. Finally, in order to ensure that Jordan's equation is equally reliable for very intense tropical cyclones, comparisons of the 700-hPa height-computed surface pressure and dropsonde-measured surface pressure data for several other similarly intense typhoons are shown in Table 2. The computed surface pressures are all within 1 to 2 hPa of the measured pressures.

2. Record pressure falls in 24, 36, and 48 h

Minimum sea level pressure measurements supplemented with newly calculated 700-hPa-deduced surface pressures are evaluated between 20 and 22 September in order to determine Supertyphoon Forrest's exceptional intensification rate (Fig. 2). The greatest intensification rate took place between 2127 UTC 21 September and 2030 UTC 22 September. Here, an impressive 100-hPa (from 976 to 876 hPa) sea level pressure drop occurred in 23 h 3 min (i.e., an average hourly fall of 4.3 hPa). Assuming 876 hPa was the minimum pressure for the cyclone, an interpolation of the pressure curve for a full 24 h (2030 UTC 21 September to 2030 UTC 22 September) would give an overall drop of 101 hPa (Fig. 2). This figure would constitute a new record, replacing the old record previously held by Supertyphoon Irma with 96 hPa in 24 h (4.0 hPa per hour) recorded in November 1971 (Holliday 1973; Holliday and Thompson 1979). A similar analysis provides interpolated sea level pressure drops of 111 hPa (from 987 to 876 hPa) in 36 h (between 0830 UTC 21 September and 2030 UTC 22 September) and 120 hPa (from 996 to 876 hPa) in 48 h (between 2030 UTC 20 September and 2030 UTC 22 September). The 111-hPa pressure fall in 36 h and the 120-hPa pressure fall in 48 h are equivalent to an average hourly rate of 3.0 and 2.6 hPa, respectively. These figures would also represent

TABLE 2. Surface minimum pressure and 700-hPa-level height in other extreme typhoons in the western North Pacific. Source: data from JTWC (1959–87).

Typhoon name	Date	700-hPa-level height (m)	Computed surface pressure (hPa)	Surface pressure by dropsonde (hPa)
Nora	6 Oct 1973	2010	876	877
June	19 Nov 1975	2000	875	875
Rita	25 Oct 1978	2007	876	878
Tip	12 Oct 1979	1944	868.5	870
Vanessa	26 Oct 1984	2022	877.5	879

new records; the previous records were held by Supertyphoon Ida in September 1958 with pressure falls of 103 hPa in 36 h (2.9 hPa per hour) and 113 hPa in 48 h (2.4 hPa per hour) (JTWC 1958).[1]

3. Summary

An analysis of the 700-hPa height data from JTWC-reported intermediate aircraft reconnaissance vortex reports enables the lowest pressure recorded in Supertyphoon Forrest to be inferred to be 876 hPa at 2030 UTC 22 September 1983, instead of the 883-hPa pressure recorded by dropsonde at 2307 UTC. This would establish a remarkable pressure fall of 100 hPa in a little over 23 h. Supertyphoon Forrest established new records for pressure falls at sea level of 101, 111, and 120 hPa for 24, 36, and 48 h, respectively. This typhoon was the third deepest tropical cyclone recorded in the western North Pacific after Supertyphoon Tip, 870 hPa in October 1979, and Supertyphoon June, 875 hPa in November 1975 (JTWC 1958–1987).

[1] Based on the available reconnaissance data, it is estimated that Supertyphoon Forrest had a 6- and a 12-h pressure drop of 34 hPa (934 to 900 hPa) and 60 hPa (936 to 876 hPa), respectively. This would not surpass the 6- and 12-hour pressure falls of 43 and 75 hPa recorded in Typhoon Opal in September 1967 and Supertyphoon Irma in November 1971, respectively (estimated from JTWC aircraft reconnaissance fixes data, 1958–87).

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