

Tropical Cyclone Report  
Tropical Storm Otto  
29 November – 3 December 2004

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Otto was a tropical storm that originated from a mid-latitude baroclinic system. The cyclone remained over the open Atlantic Ocean about midway between Bermuda and the Azores Islands.

a. Synoptic History

A cold front emerged off the east coast of the United States on 21 November and moved slowly eastward before stalling about midway between Bermuda and the Azores Islands early on 25 November. Later that day, a strong upper-level trough to the north dug southward and initiated the development of an extratropical low along the front about 1000 n mi southwest of the Azores Islands by 0000 UTC 26 November. Due to the strong baroclinic effects of the upper-low, the occluded surface low pressure system quickly deepened and became a large gale area later that day. The upper-level trough continued to dig southward and eventually developed a cutoff low to the south of the occluded surface low on 26 November.

The surface and upper-level lows moved generally southwestward at 5-10 kt in tandem for the next three days. Late on 28 November, weak ridging to the north of the upper-low formed over the surface low and convective banding features began to develop near the low-level center. In addition, surface data and analyses from the Tropical Prediction Center's Tropical Analysis and Forecast Branch (TAFB) indicated that the frontal structure associated with the cyclone had dissipated. Dvorak satellite classifications from the various satellite agencies at that time suggest that a subtropical storm formed about 1000 n mi east-southeast of Bermuda around 1200 UTC 29 November. The "best track" chart of the cyclone's path is given in Fig. 1, while the best track positions and intensities are listed in Table 1. Wind and pressure plots are shown in Figs. 2 and 3, respectively.

After Otto acquired subtropical characteristics, the cyclone moved northwestward through a weakness in the mid-level subtropical ridge located to its north. Convection continued to increase over the low-level center and Advanced Microwave Sounding Unit (AMSU) satellite-derived temperature data indicate the system acquired enough warm-core characteristics to be considered a tropical storm at 1200 UTC 30 November about 700 n mi east of Bermuda. For the next 2 days, the cyclone meandered over relatively cool water (sea-surface temperatures of 21-23° C) and beneath a region of relatively weak vertical shear between the upper-low located to its south and another weaker upper-low situated to its northeast. The marginally favorable upper-level flow pattern allowed Otto to maintain some central deep convection. The tropical storm turned slowly southeastward on 1 December as north to northwesterly mid- to upper-level flow increased on the east side of an amplifying ridge off the U.S. east coast. However, the vertical shear also increased causing the deep convection to become displaced to the southeast of the center, which induced a slow weakening trend. Otto weakened into a tropical depression on 2

December. Mid-level dry air entrainment, coupled with the increasing vertical shear, eventually eroded the convection and Otto degenerated into a non-convective remnant low pressure system on 3 December about 800 n mi southeast of Bermuda. For the next 2 days, the broad remnant drifted slowly southward and southwestward before dissipating around 1200 UTC 5 December about 800 n mi northeast of the northern Leeward Islands.

b. Meteorological Statistics

Observations in Otto (Figs. 2 and 3) include satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB), and the U. S. Air Force Weather Agency (AFWA), as well as microwave satellite imagery from NOAA polar-orbiting satellites, the NASA Tropical Rainfall Measuring Mission (TRMM), the NASA QuikSCAT, and Defense Meteorological Satellite Program (DMSP) satellites.

Ship reports of tropical storm force winds associated with Otto are given in Table 2.

Otto's peak intensity of 45 kt during the subtropical storm stage (Fig. 4) is based on a blend of ship reports and Dvorak satellite intensity estimates. Ship LAXP4 (**Star Hansa**) reported a sustained wind of 51 kt at 1800 UTC 29 November about 190 n mi northeast of the center. However, quality control checks by the NOAA Ocean Prediction Center indicate that the wind speeds had a slight high bias. In addition, Ship V7BI3 (**Sabine**) reported a sustained wind of 52 kt at 0900 UTC and 51 kt at 0600 UTC 1 December about 200 n mi northwest of the center. Quality control checks revealed that those reports had a severe high bias, and were also considerably higher than the 30- to 35-kt wind reports from nearby ships. Therefore, the wind reports from ship V7BI3 were not used in determining the 'best track' intensity estimates, nor were they included in Table 2. It is also interesting to note that during Otto's weakening period, several normally reliable Objective Dvorak (ODT) satellite intensity estimates (Fig. 2) were much higher than nearby ship and QuikSCAT wind data were indicating. This may be due to the relatively shallow nature of Otto (convective cloud top temperatures were rarely observed below  $-50^{\circ}\text{C}$ ) and its possibly possessing more subtropical than tropical characteristics.

It is difficult to ascertain exactly when an extratropical low acquires enough warm-core characteristics to be classified as a subtropical low, or when a subtropical low becomes a tropical cyclone. Therefore, it is possible that Otto may have become a tropical cyclone earlier on 29 November.

c. Casualty and Damage Statistics

There were no reports of damages or casualties associated with Tropical Storm Otto.

d. Forecast and Warning Critique

No meaningful forecast verification statistics are available due to Otto's short lifetime. However, the few cases that made up the 12-, 24-, 36-, and 48-h average errors of 34, 71, 103, and 159 n mi, respectively, were better than the 10-yr average of 44, 78, 112, 146 n mi through 36 h. The larger track error at 48 h was due to the first two official forecasts, which called for

Otto to move eastward, as suggested by the various NHC consensus models. Average official intensity errors were 3, 3, 5, and 5 kt for the 12, 24, 36, and 48 h forecasts, respectively. These errors were exceptionally good as compared to the average official intensity errors over the 10-yr period 1994-2003 of 6, 10, 12, and 15 kt, respectively.

No tropical cyclone watches or warnings were required for Tropical Storm Otto. However, the NOAA Ocean Prediction Center and the TPC's Tropical Analysis and Forecast Branch issued marine gale warnings for their respective Atlantic High Seas Forecast areas of responsibility about 18 h before the development of the pre-Otto extratropical low.

Table 1. Best track for Tropical Storm Otto, 29 November – December 2004.

Date/Time (UTC)	Latitude (EN)	Longitude (EW)	Pressure (mb)	Wind Speed (kt)	Stage
26 / 0000	28.0	40.0	1009	30	extratropical
26 / 0600	27.3	41.0	1006	35	"
26 / 1200	26.5	41.9	1002	35	"
26 / 1800	26.8	42.5	1000	35	"
27 / 0000	26.8	43.2	1000	35	"
27 / 0600	26.7	43.8	1000	35	"
27 / 1200	26.4	44.3	1000	35	"
27 / 1800	26.2	44.4	1000	35	"
28 / 0000	26.3	44.1	1000	35	"
28 / 0600	27.4	43.9	1000	35	"
28 / 1200	28.2	44.0	1000	35	"
28 / 1800	28.7	45.1	999	35	"
29 / 0000	28.8	46.5	998	35	"
29 / 0600	29.0	47.8	998	40	"
29 / 1200	29.6	47.9	998	40	subtropical storm
29 / 1800	30.2	48.8	998	45	"
30 / 0000	30.7	49.7	997	45	"
30 / 0600	30.9	50.5	997	45	"
30 / 1200	31.3	51.0	997	40	tropical storm
30 / 1800	31.7	51.0	997	40	"
01 / 0000	31.8	50.9	997	40	"
01 / 0600	31.9	50.8	997	40	"
01 / 1200	31.6	50.4	997	40	"
01 / 1800	31.0	50.1	997	35	"
02 / 0000	30.5	49.9	997	35	"
02 / 0600	29.9	50.1	996	35	"
02 / 1200	29.1	50.4	995	30	tropical depression
02 / 1800	28.5	50.1	996	30	"
03 / 0000	27.9	50.1	997	30	"
03 / 0600	27.2	50.2	998	30	remnant low
03 / 1200	26.5	50.3	1000	30	"
03 / 1800	26.2	50.6	1002	25	"
04 / 0000	25.8	50.2	1005	25	"
04 / 0600	25.4	50.1	1008	25	"
04 / 1200	25.0	50.4	1010	25	"
04 / 1800	25.1	50.9	1011	25	"
05 / 0000	25.5	51.1	1012	20	"
05 / 0600	25.9	51.1	1013	20	"
05 / 1200	26.1	51.4	1014	20	"
05 / 1800					dissipated
02 / 1200	29.1	50.4	995	30	minimum pressure

Table 2. Selected ship reports with winds of at least 34 kt for Tropical Storm Otto, 29 November – 3 December 2004.

Date/Time (UTC)	Ship call sign	Latitude (EN)	Longitude (EW)	Wind dir/speed (kt)	Pressure (mb)
26 / 0000	V2007	33.0	41.1	070 / 37	1015.0
26 / 1800	V2007	33.1	37.4	070 / 37	1017.0
28 / 1800	V3WY2	32.1	44.9	070 / 35	1011.7
29 / 0000	LAXP4	32.6	51.3	060 / 35	1014.0
29 / 0000	V3WY2	31.5	46.4	070 / 35	1006.6
29 / 0600	V3WY2	31.0	48.0	070 / 39	1005.0
29 / 1200	LAXP4	33.0	48.9	060 / 40	1010.0
29 / 1200	V3WY2	30.3	49.6	070 / 35	1001.3
29 / 1200	WAUW	33.5	42.8	090 / 35	1018.0
29 / 1800	LAXP4	33.5	48.1	060 / 51	1008.8
29 / 1800	PCGQ	35.7	50.3	070 / 37	1014.1
29 / 1800	WAUW	33.3	44.7	090 / 37	1013.5
30 / 0000	LAXP4	33.8	47.8	070 / 41	1009.2
30 / 0600	LAXP4	34.4	46.7	080 / 37	1010.2
30 / 1200	LAXP4	35.1	45.7	080 / 37	1012.2

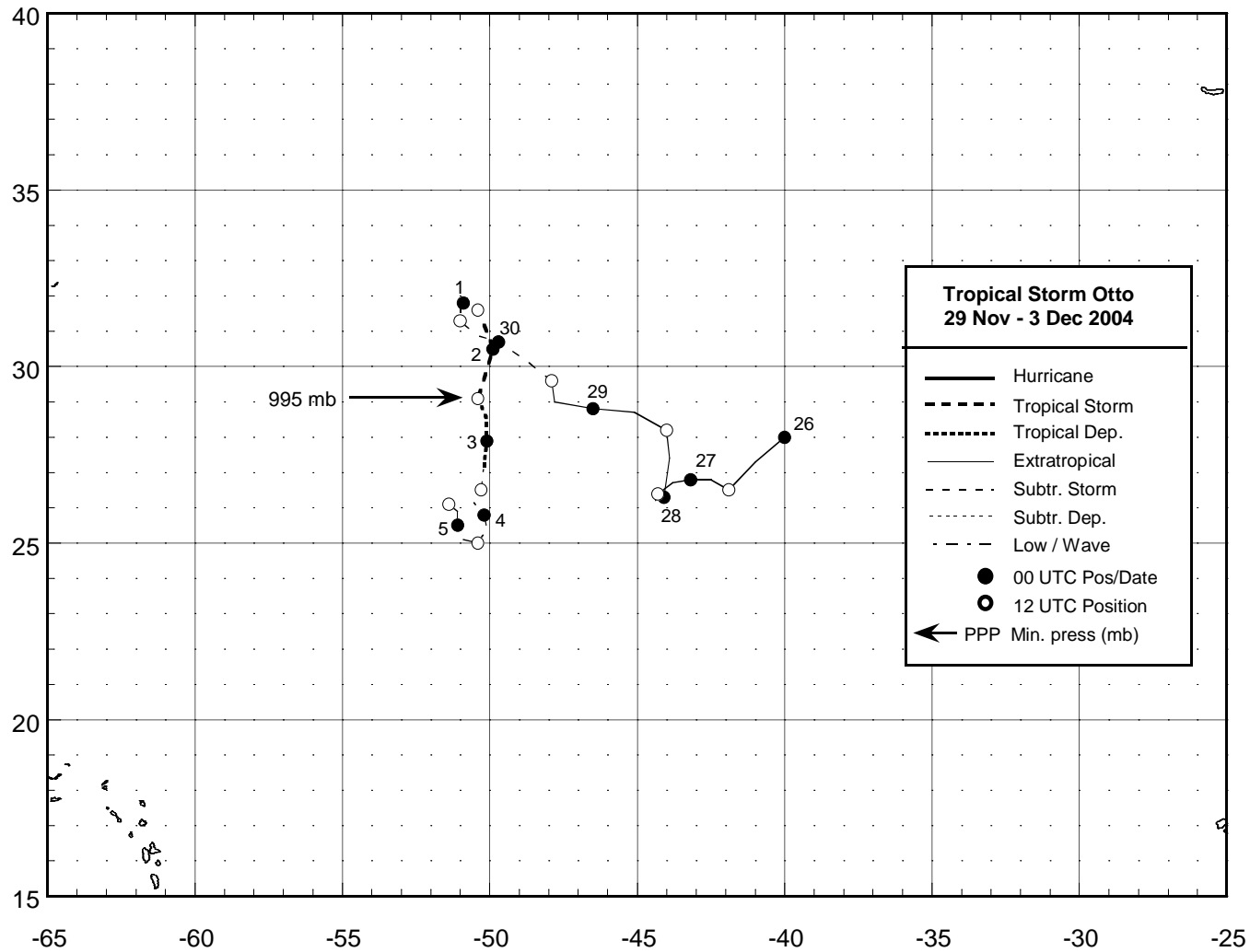


Figure 1. Best track positions for Tropical Storm Otto, 29 November – 3 December 2004.

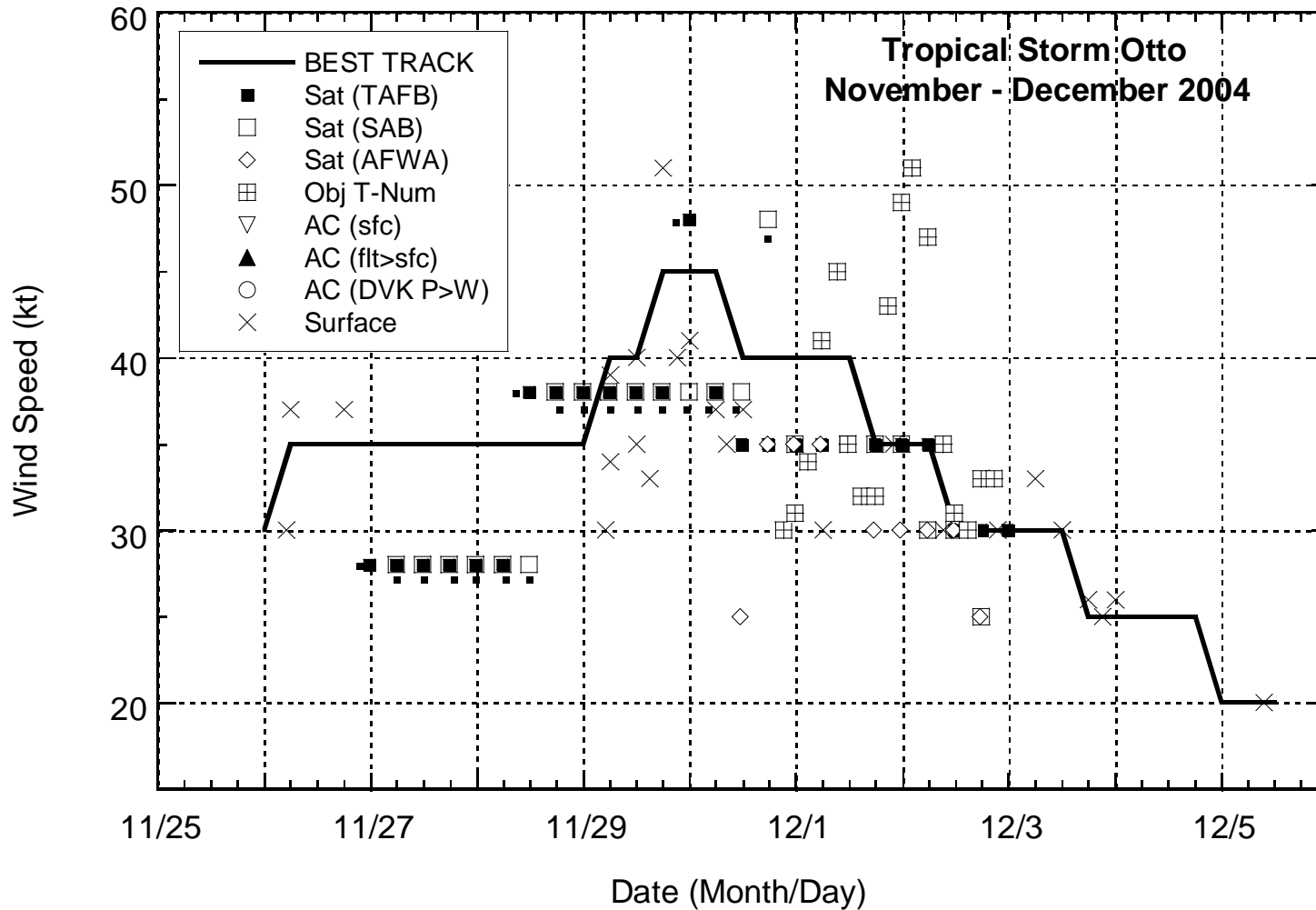


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Otto, 29 November – 3 December 2004. Objective Dvorak estimates represent linear averages over a three-hour period centered on the nominal observation time. Surface plots include ship reports and non-rainflagged QuikSCAT wind vector data. Subtropical Dvorak satellite classifications are denoted by a small dot plotted to the left of or below the data symbol.

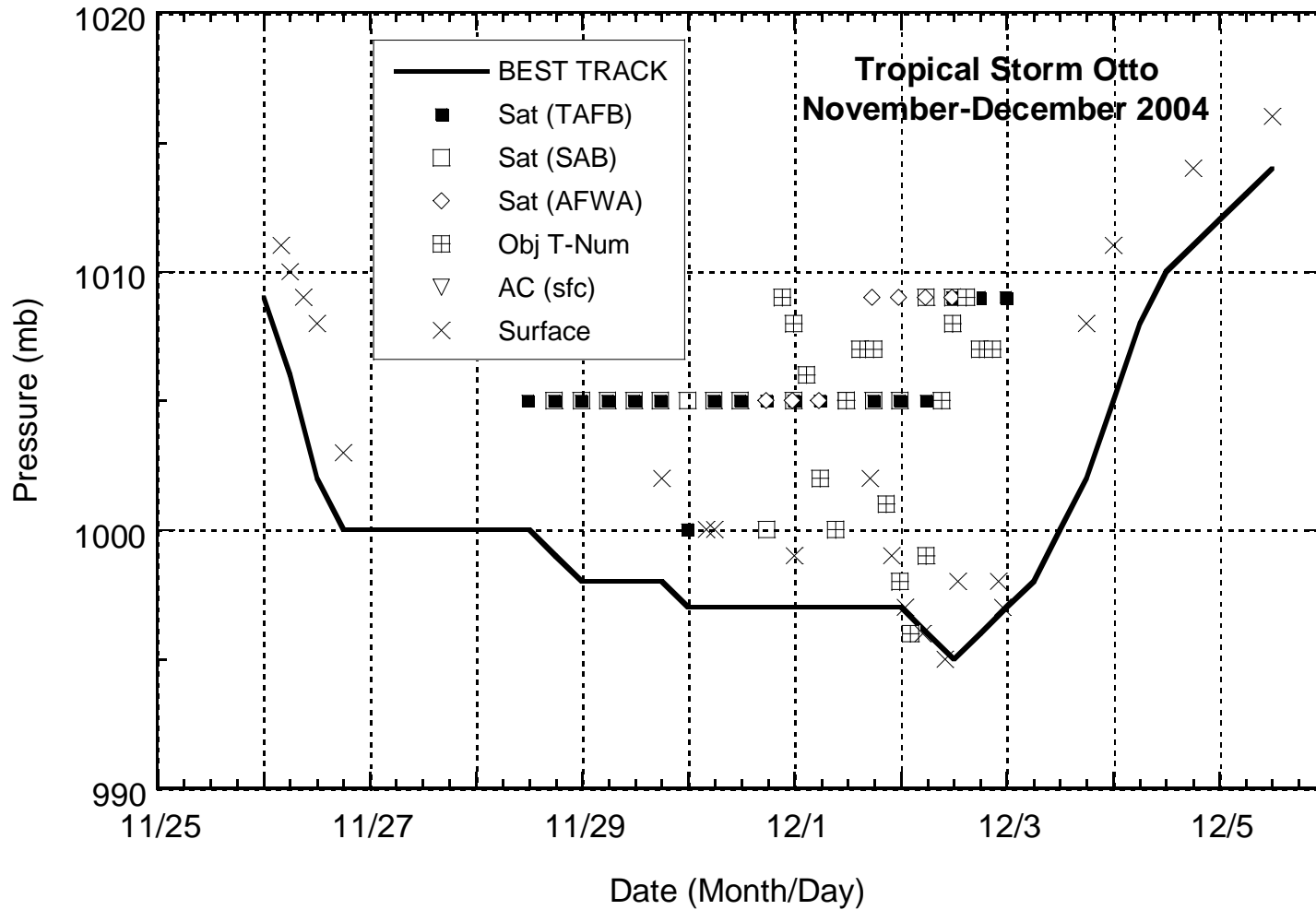


Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Otto, 29 November – 3 December 2004. Objective Dvorak estimates represent linear averages over a three-hour period centered on the nominal observation time. Surface pressure data plots were obtained from ship and buoy observations within 120 n mi of the center.



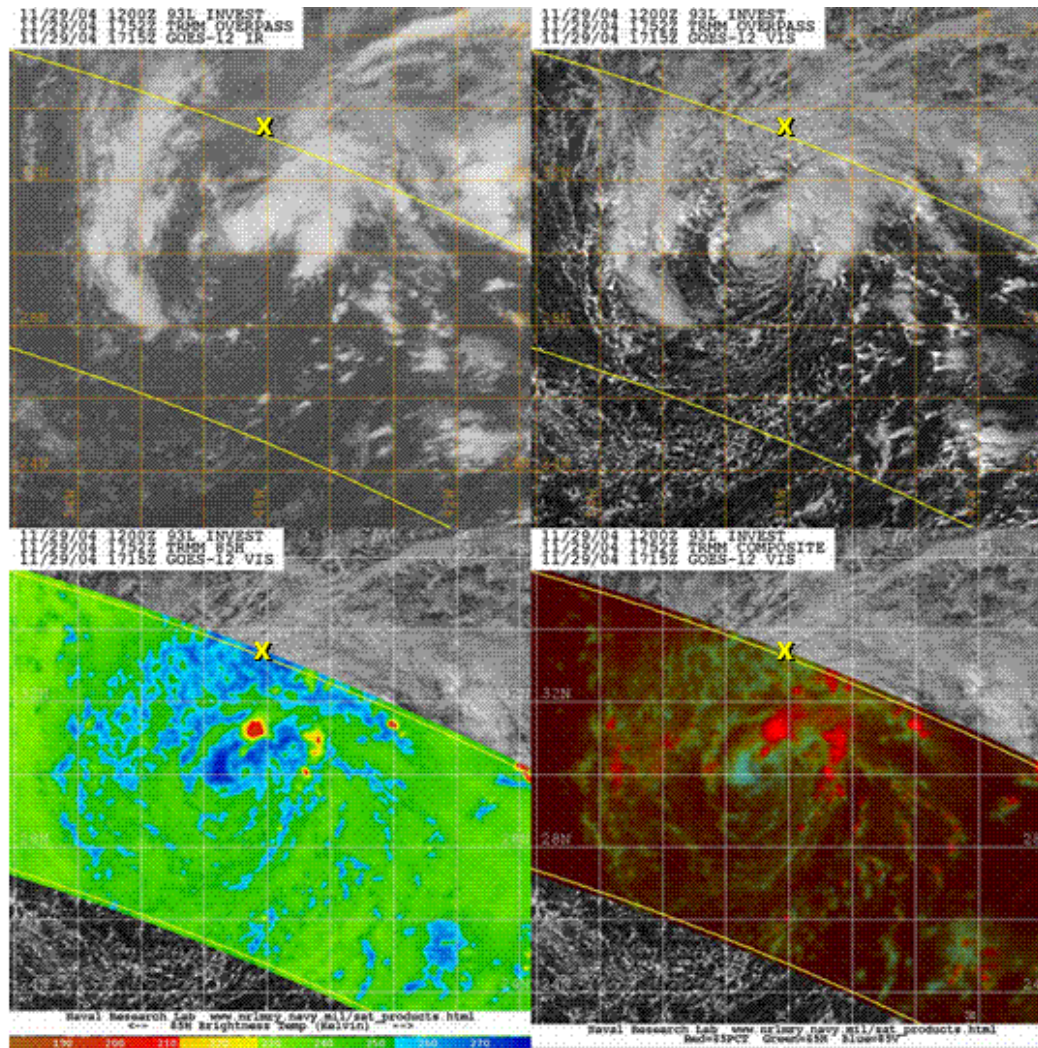


Figure 4. TRMM microwave satellite image at 1752 UTC 29 November 2004, near Otto's peak intensity of 45 kt as a subtropical storm. The yellow "X" denotes the location of ship **LAXP4** at 1800 UTC when it reported a sustained wind of 51 kt. Quality control checks indicate the wind report was about 4-6 kt high (image courtesy of the Naval Research Laboratory, Monterey, CA).