Atlantic Tropical Systems of 1988

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ABSTRACT

The 1988 season produced 62 tropical waves, 19 tropical depressions and 12 tropical storms, 5 of which became hurricanes. Eighty-three percent of the tropical storms developed from African waves. A comparison with the past 21 years is included.

1. Introduction

This paper is a revival of an annual series of articles published from 1968 to 1980 (see Frank and Clark 1980). Its main purpose is to tabulate and summarize all synoptic-scale Atlantic tropical weather systems that developed from May through November 1988. This helps to gain a better understanding of the climatology of tropical systems.

Tropical waves are defined as a trough or cyclonic curvature in the trade-wind easterlies which may reach maximum amplitude in the lower to middle troposphere. Waves may be the reflection of an upper-tropospheric cold low or an equatorial extension of a midlatitude trough (Simpson et al. 1968). Careful analysis for the past ten years indicates that most of the tropical waves in the Atlantic originated in Africa. Since only systems that emerged off Africa were considered, the terms "African waves" and "tropical waves" are interchangeable in this article.

The data used for the tabulation consist of daily upper-air soundings from Africa, the Caribbean and Central America displayed in time-section form. Low-level cloud vectors calculated with satellite image animation devices were also used. African waves were recognized in the wind, pressure and cloud patterns, and there were no attempts to eliminate weaker systems as long as they were identifiable for a few days. During the period when convection was minimal or absent, the position of the wave was estimated by continuity and extrapolation.

These waves are very persistent features. They maintained their identity and westward progression in spite of any hostile large-scale environment they might encounter. In many cases, after a few days void of thunderstorm activity, convection indeed rejuvenates.

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2. Census of 1988 systems

The 1988 Atlantic hurricane season had 12 tropical storms, 5 of which acquired hurricane intensity. This compares to the past 50-year average of 9.4 tropical storms, of which 5.5 became hurricanes. The 1988 season produced one category 5 (Gilbert), and two category 4 (Helene and Joan) hurricanes according to the Saffir–Simpson scale (Simpson 1974). Gilbert's central pressure reached 888 mb, the lowest ever recorded in the Atlantic basin. Most of the 1988 systems developed within the deep tropics.

Figure 1 shows the total number of waves that emerged off the coast of Africa and maintained their identities while traveling over the tropical Atlantic, the Caribbean Sea and the Gulf of Mexico. The 62 African waves as indicated by the large arrow in Fig. 1 gives an average of one wave crossing a particular longitude every 3.4 days. The first wave passed Dakar on 1 May and the last one on 27 November. Figure 1 also highlights the approximate longitudes over which depressions and storms formed. There were no preferred longitude bands for development in the Atlantic basin. All of the 1988 systems were initiated from African seedlings with the exception of Alberto, Beryl and Florence. Note that those three systems were not attached to the main stream of waves on Fig. 1. African waves were the main contributor to East Pacific events.

One interesting aspect of 1988 was that most of the African waves were distinct and quite vigorous during the entire period. During the first half of the season from June to late August, however, a rather strong easterly upper-tropospheric flow sheared much of the convection, so that by the time the waves reached the western Atlantic the convection had ceased. This is reflected in Fig. 2, which clearly indicates the lack of tropical depressions during the early part of the season. Except for one depression in May, no other depressions formed until August. Weaker upper-level easterlies from late August to November allowed some of these

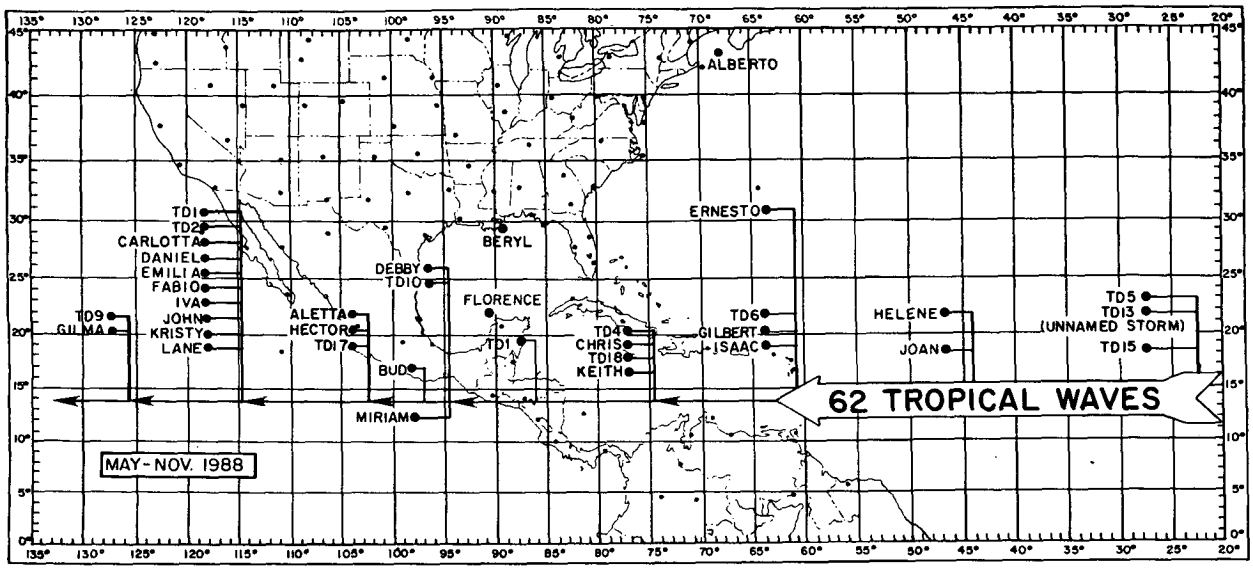

FIG. 1. Total number of waves that maintained their identities while traveling the Atlantic, Caribbean, the Gulf of Mexico and the Eastern Pacific. The figure highlights the longitude band in which tropical cyclones developed.

vigorous waves to develop into tropical storms and hurricanes. Figure 2 also shows that six depressions developed in August, nine in September, two in October and one in November. There were cases when the same wave was able to produce more than one system. For example, the southern portion of the wave that spawned Tropical Storm Chris continued westward and developed into Hurricane Debby in the Gulf of Mexico.

3. Description of tropical depressions that did not strengthen to named storms

The depression tracks for 1988 are shown in Fig. 3. Only the depressions that did not reach tropical storm status are described. The first depression formed over the northwest Caribbean on 30 May and dissipated on 2 June in the Florida Straits. Even though the depression was weak, rainfall totals of 600 mm were recorded in central Cuba. Resulting floods killed 21 people in Cuba and destroyed thousands of homes.

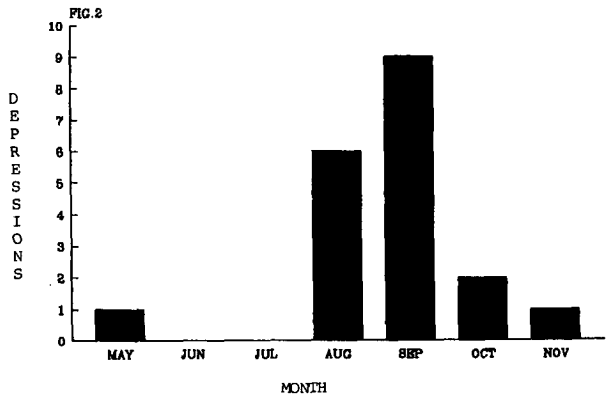

FIG. 2. Number of tropical depressions per month during 1988.

Depression Four developed in the southern Bahamas on 12 August, moved west-northwest, reached the Florida/Georgia border on 13 August and dissipated near New Orleans on 15 August. The depression produced heavy showers along the coastal sections of the northeast Gulf of Mexico.

Depression Five developed near the Cape Verde Islands on 20 August and produced heavy rains and winds up to 15 m s^{-1}. The depression weakened but continued west-northwest as a disturbance to near 34°N, 73°W where it redeveloped. The Washington Weather Service Forecast Office carried the system as a gale center until it merged with a frontal zone on 1 September.

Tropical Depression Six formed on 20 August while approaching the Windward Islands. It moved westward through the Caribbean and was downgraded to a wave along 80°W on 23 August. The wave moved over Central America and eventually developed into Hurricane Kristy in the eastern Pacific. The depression produced squally weather in the Windward Islands.

Tropical Depression Seven developed near the Texas/Louisiana coast on 3 September but lasted only for a few hours. The system moved rapidly northeastward and merged with a frontal zone the same day. Tropical storm warnings were posted from Cameron, Louisiana to Apalachicola, Florida. Oil rigs along the Gulf of Mexico coast reported winds gusting to 18 m s^{-1} and moderate to heavy rains affected a large portion of southern Texas and Louisiana.

Tropical Depression Thirteen formed near the Cape

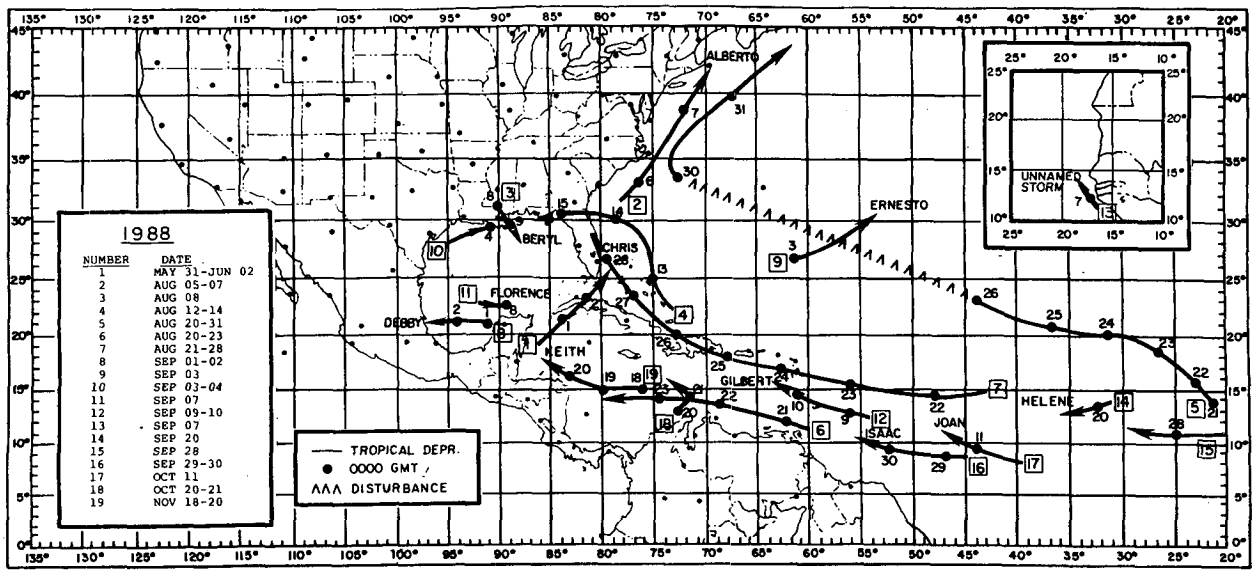

FIG. 3. Tropical depression tracks of 1988.

Verde Islands on 7 September and rapidly reached tropical storm strength. This unnamed storm was added to the list of 1988 named tropical systems.

Tropical Depression Fifteen also developed near the Cape Verde Islands on 27 September. The system weakened rapidly and was downgraded to a wave on 28 September.

Tropical Depression Eighteen developed and became well organized in the south-central Caribbean on 19 October, but, the outflow from powerful Hurricane

TABLE 1. Atlantic tropical system statistics for 1967–88.

Year	African waves	Total: Tropical depressions	Total: Tropical storms	Total: Hurricanes	African: depressions	African: storms	Ratio: African depressions / Total depressions	Ratio: African storms / Total storms
1967	61	29	8	6	14	5	.48	.65
1968	57	19	7	4	8	4	.42	.57
1969	58	28	18	12	16	10	.57	.56
1970	54	26	10	4	16	7	.62	.70
1971	56	23	13	6	12	6	.52	.56
1972	57	24	4	3	6	1	.25	.25
1973	56	24	7	4	10	4	.42	.57
1974	52	25	7	4	12	5	.48	.71
1975	61	28	8	6	14	5	.50	.63
1976	68	23	8	6	10	5	.43	.63
1977	69	19	6	5	7	3	.37	.50
1978	63	31	11	5	18	6	.58	.55
1979	52	27	8	5	20	8	.74	1.00
1980	49	18	11	9	14	8	.78	.73
1981	62	22	11	7	17	6	.77	.55
1982	61	9	5	2	6	3	.67	.60
1983	57	6	4	3	3	1	.50	.25
1984	59	20	12	5	8	5	.40	.42
1985	53	14	11	7	9	8	.64	.73
1986	49	10	6	4	6	3	.60	.50
1987	57	14	7	3	11	5	.79	.71
Average	57.6	20.9	8.5	5.2	11.3	5.1	.55	.59
1988	62	19	12	5	16	9	.84	.75

FIG. 4a

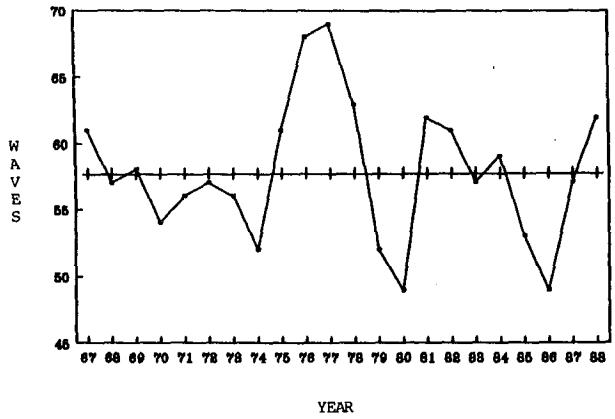

FIG. 4b

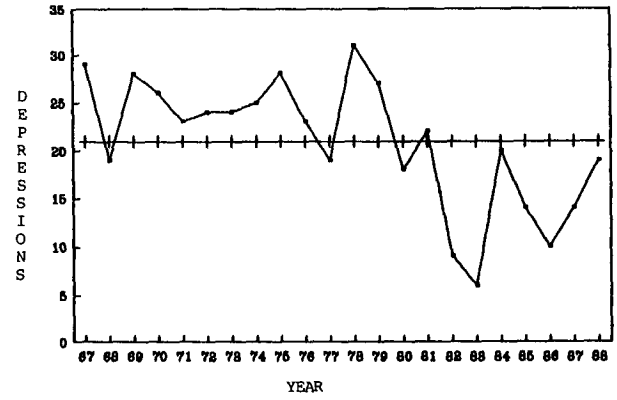

FIG. 4c

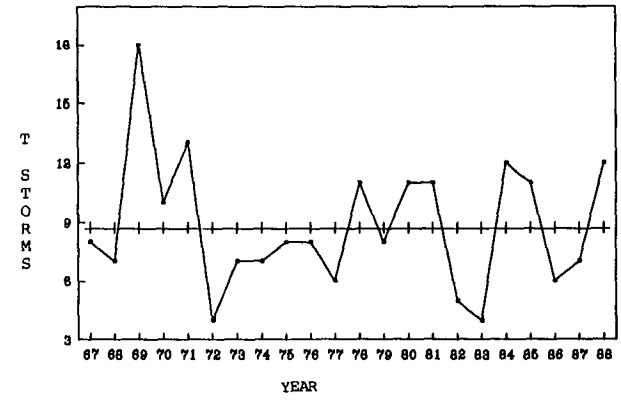

FIG. 4. (a) Total number of African waves from 1967 to 1988. Horizontal line indicates the average for the period. (b) Total number of tropical depressions from 1967 to 1988. Horizontal line indicates the average for the period. (c) Total number of tropical storms from 1967 to 1988. Horizontal line indicates the average for the period.

Joan, located not far to the west, increased the shear over the depression, resulting in gradual weakening. The system dissipated on 21 October. Heavy rains were felt in the Netherlands Antilles. News reports indicated a locust outbreak related to this system which had originated in Africa and reached Trinidad on 17 October.

4. Comparison with other years

Figure 4a and Table 1 show the number of waves from 1967 to 1988. There were 62 tropical waves during 1988. This number is slightly higher than the previous 21-year average, which is given in Table 1. There are variations from year to year in the total number of waves as seen in Table 1. However, these variations could be related to observational methods. It is extremely difficult to draw conclusions from such a short record.

Figures 4b, c and Table 1 show the number of tropical depressions and storms for the same period. There were 19 tropical depressions, 12 of which became trop-

FIG. 5A

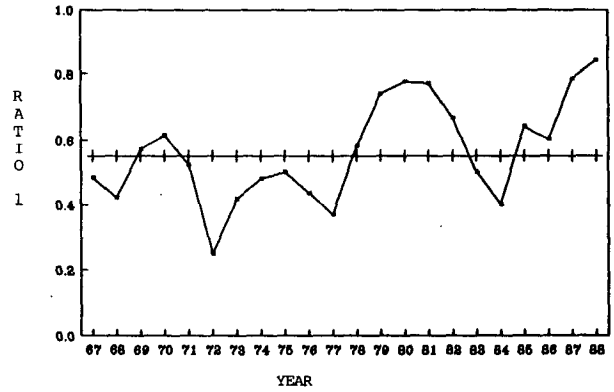

FIG. 5B

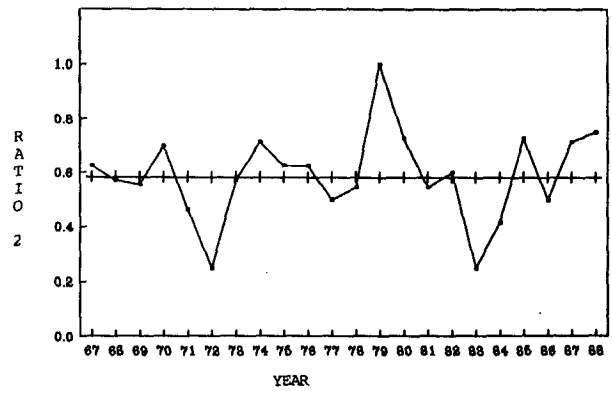

FIG. 5. (a) Ratio of the number of tropical depressions of African origin to the total number of depressions from 1967 to 1988. Horizontal line represents the average for the period. (b) Ratio of the number of tropical storms of African origin to the total number of storms. Horizontal line represents the average for the period.

TABLE 2. Comparison of African, non-African and average years with season averaged Hurricane Destruction Potential (HDP). African years: Ratio of the number of tropical storms of African origin to the total number of tropical storms is higher or equal to 0.70. Non-African years: Ratio of the number of tropical storms of African origin to the total number of tropical storms is lower or equal to 0.50. Average years: Ratio of number of tropical storms of African origin to the total number of tropical storms is less than 0.70 and higher than 0.50. HDP: Sum of the square of each hurricane's maximum wind for each 6-hour period of its existence (Gray 1988).

										HDP
African years	1970	1974	1979	1980	1985	1987	1988			59
Non-African years	1971	1972	1977	1983	1984	1986				28
Average years	1967	1968	1969	1973	1975	1976	1978	1981	1988	55

ical storms in 1988. The number of depressions was slightly below normal if compared with an average of 21 depressions from 1967 to 1987. Figure 4b suggests a decrease of the number of depressions since 1980. The same is not true for tropical storms. This decrease in the number of depressions could be interpreted as a real trend; however, organized clusters of heavy convection over the oceans or some midlatitude frontal lows may have been classified as tropical depressions during the earlier years.

In spite of an almost constant number of African waves per year, the number of systems that develop into depressions or storms from such waves shows large variations from year to year. This can be seen by inspecting the yearly totals of African depressions and storms in Table 1 (i.e., depressions and storms originated from African waves). One can conclude that the number of waves is unrelated to the number of depressions each year and that the nature of the wave and the large-scale environment play the most important role for storm development. On the other hand, the environment apparently exerts very little influence on the number of waves.

Frank (1974) introduced a parameter that seemed to be useful in describing the overall character of the hurricane season. This is computed by forming the ratio of the number of depressions of African origin to the total number of depressions. Low numbers of this value suggest a high number of depressions of extratropical origin.

In 1988 the ratio was 0.84. This is the highest value observed over the 1967–88 period. Figure 5a shows the variability of this parameter for the past 22 years. In the inactive years of 1972 and 1977, the values were well below the 0.55 mean. The ratio increased from 1978 to 1981, reaching a peak during 1979–80, the period in which David, Frederic and Allen developed. A sharp decrease occurred from 1982 to a minimum in 1984, a year that was characterized by a large number of systems that were triggered by extratropical forcing. Nonetheless, there appears to be a trend towards larger values of this parameter in recent years.

The increase of the ratio of African depressions to the total number of depressions after 1978 is partially related to the decrease in the total number of tropical depressions discussed above. This ratio therefore may not be a very representative parameter. A new parameter, given by the ratio of the number of storms of African origin to the total number of storms, is probably more representative of the overall character of the season. Note that there is no apparent trend in the annual number of storms during the past 21 years in Fig. 4c.

The ratio of the number of storms of African origin to the total is given in Fig. 5b. The 21-year average African contribution to the total number of storms was 59 percent compared to 55 percent for the number of depressions (Fig. 5a). Africa contributed 75 percent to the total number of storms during 1988. This is the highest number since 1979 and the second highest for the 1967–88 period. During 1971, 1972, 1983 and 1984, the African contribution was low (less than 50 percent). On the contrary, Africa produced 100 percent of the named storms in 1979. Given this information, "African years" can be separated from "non-African years" by considering relative contribution to tropical storm development by African waves in a given year.

Figure 5b shows that, typically, Africa is the main source for storms for the Atlantic basin. Africa produced a small number of storms in 1972, 1977, 1983 and 1986; however, those years coincided with moderate to strong El Niño episodes (Gray 1988). Although the African impulses were clearly present during those years, the hostile large-scale environment induced by those episodes did not permit disturbances to grow (Gray 1988).

Table 2 summarizes the African, non-African and average years. We arbitrarily defined African years by those in which the ratio is greater than or equal to 0.70 and non-African years by those whose ratio is less than or equal to 0.50. This definition is strictly based on the type of formation; in other words, from African waves or from extratropical sources. The last column on the table is the Hurricane Destruction Potential (HDP) defined by Gray (1988) and is proportional to the averaged intensity of storms in a given year. The average HDP during the African years of the 1967–1988 period was larger than the HDP of the non-African years. This

lends credence to the notion that the more intense hurricane usually develops from African waves.

Acknowledgments. Many thanks to the Hurricane Specialist Unit and Dr. Richard J. Pasch of the National Hurricane Center for their valuable assistance in the preparation of this manuscript and to David Petrovich for his expertise in the preparation of the computer graphics. Special thanks also are extended to Joan David for the drafting of the figures and to Sandra Potter for the skillful preparation of the manuscript.

REFERENCES

Frank, N. L., 1974: Atlantic tropical systems of 1974. *Mon. Wea. Rev.*, **103,** 294–300.

———, and G. B. Clark, 1980: Atlantic tropical systems of 1979. *Mon. Wea. Rev.*, **108,** 966–972.

Gray, W. M., 1988: Summary of 1988 Atlantic tropical cyclone activity and verification of author's seasonal forecast, 49 pp. [Available from Colorado State University, Dept. of Atmospheric Science, Ft. Collins, CO, 80523.]

Simpson, R. H., 1974: The Hurricane Disaster Potential Scale. *Weatherwise,* **27,** 169–186.

———, N. L. Frank, D. Shideler and H. M. Johnson, 1968: Atlantic tropical disturbances of 1967. *Mon. Wea. Rev.*, **96,** 251–259.