# Atlantic Tropical Systems of 1990

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ABSTRACT

The 1991 hurricane season produced 76 tropical waves of which 12 became tropical depressions. African seedlings initiated 10 of the 14 named Atlantic storms and all of the eastern Pacific tropical cyclones. A comparison with previous years is presented.

## 1. Introduction

This paper is a continuation of a series of articles whose purpose is to tabulate and highlight features of the previous hurricane season with emphasis on the weaker synoptic-scale systems. The data used for this tabulation consisted of satellite imagery as well as surface and upper-air observations across the tropics from Africa to Central America. African waves were recognized in the wind, pressure, and cloud patterns; and during the period when convection was minimal or absent, the position of the wave was estimated by continuity. Details on the counting method are described in previous articles by Avila and Clark (1989) and by Avila (1990).

## 2. Census of the 1990 Atlantic systems

The 1990 season had 14 named storms, 8 of which attained hurricane intensity. These totals exceed the past 50-yr annual averages of 9.6 tropical storms and 5.6 hurricanes. In spite of the large number of tropical cyclones during 1990, there were no landfalling hurricanes in the United States. Tropical Storm Marco was the only tropical cyclone to affect the United States coast and is blamed for 7 deaths and $57 million in damage. Hurricane Lili threatened the east coast of the United States but veered seaward before reaching land. Hurricane Diana reportedly killed 96 people in the state of Veracruz, Mexico. Gustav was the strongest hurricane, reaching category 3 on the Saffir–Simpson scale (Simpson 1974) while over open waters of the north Atlantic. Additional details on the named storms and hurricanes are contained in an article by Mayfield and Lawrence (1991).

The monthly distribution of tropical depressions for the Atlantic basin is illustrated in Fig. 1. The maximum activity occurred during August with five systems. Four of these developed from African waves and one developed from an old frontal zone. A second maximum occurred in October with four tropical cyclones, but only two of these formed from African waves.

The Atlantic tropical depression tracks for 1990 are shown in Fig. 2. The following descriptions apply only to tropical depressions that did not reach tropical storm status. Tropical Depression One formed on 24 May before the official hurricane season began. It developed over the western Caribbean and later moved northward over Cuba and the Florida Straits, causing heavy rains and gusty winds primarily to the east of the poorly defined center. The depression was absorbed by a frontal zone on 26 May over the Florida Keys. Figure 3 shows Tropical Depression One located south of Cuba. Note the extensive area of cloudiness and thunderstorms associated with the depression at that time.

Tropical Depression Eleven developed from an African wave on 18 September, midway between Africa and the Lesser Antilles. Ship and reconnaissance aircraft observations indicated that the depression approached tropical storm strength. However, strong upper-level winds sheared the system. The center of the depression became ill-defined and drifted west-north-

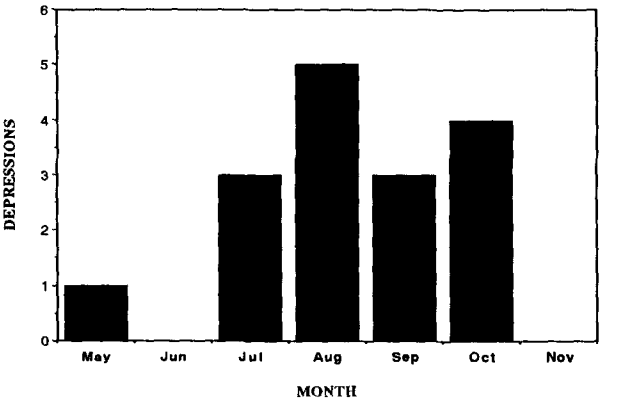


FIG. 1. Number of tropical depressions per month during 1990.

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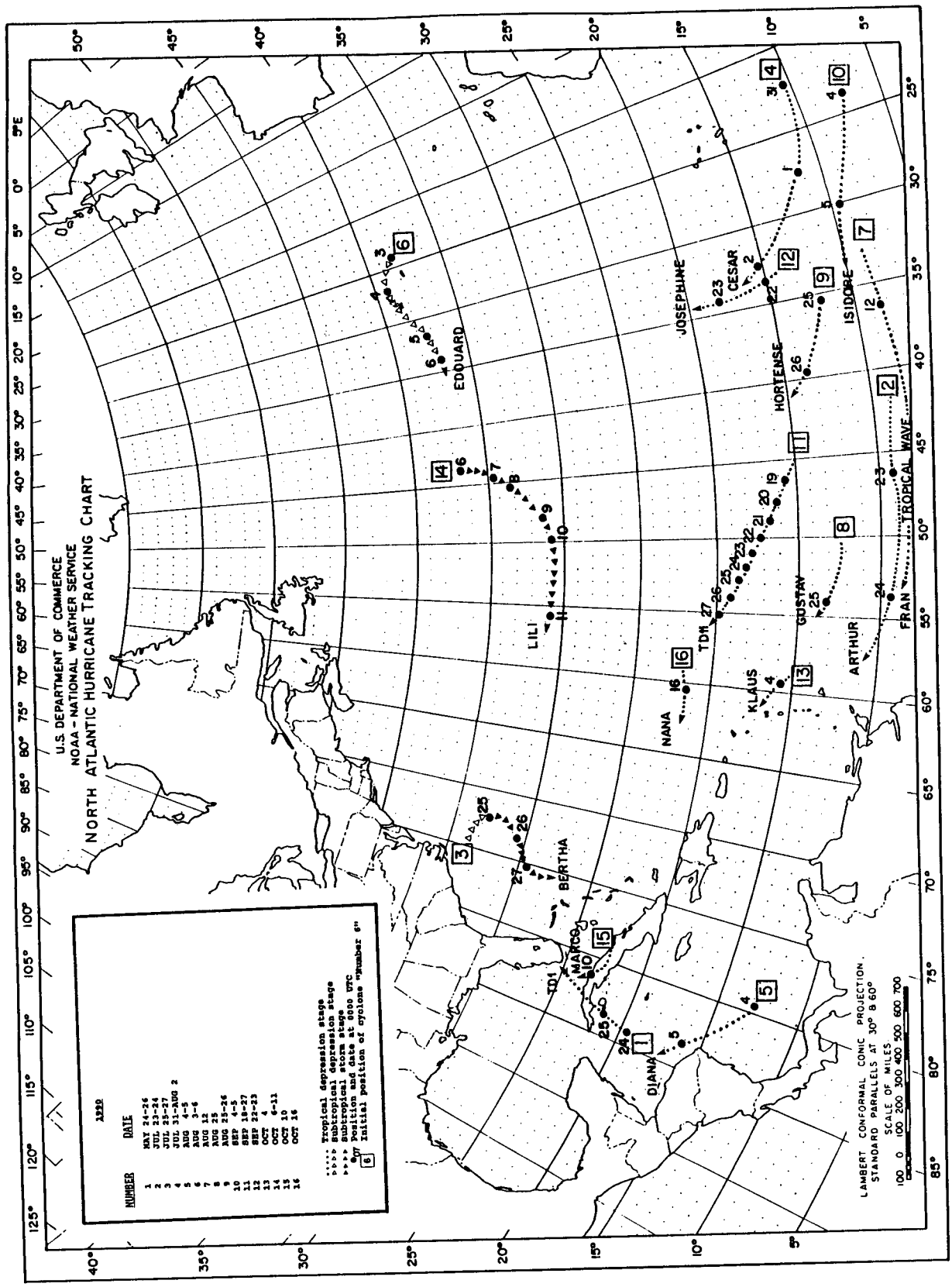


FIG. 2. Tropical depression tracks of 1990.

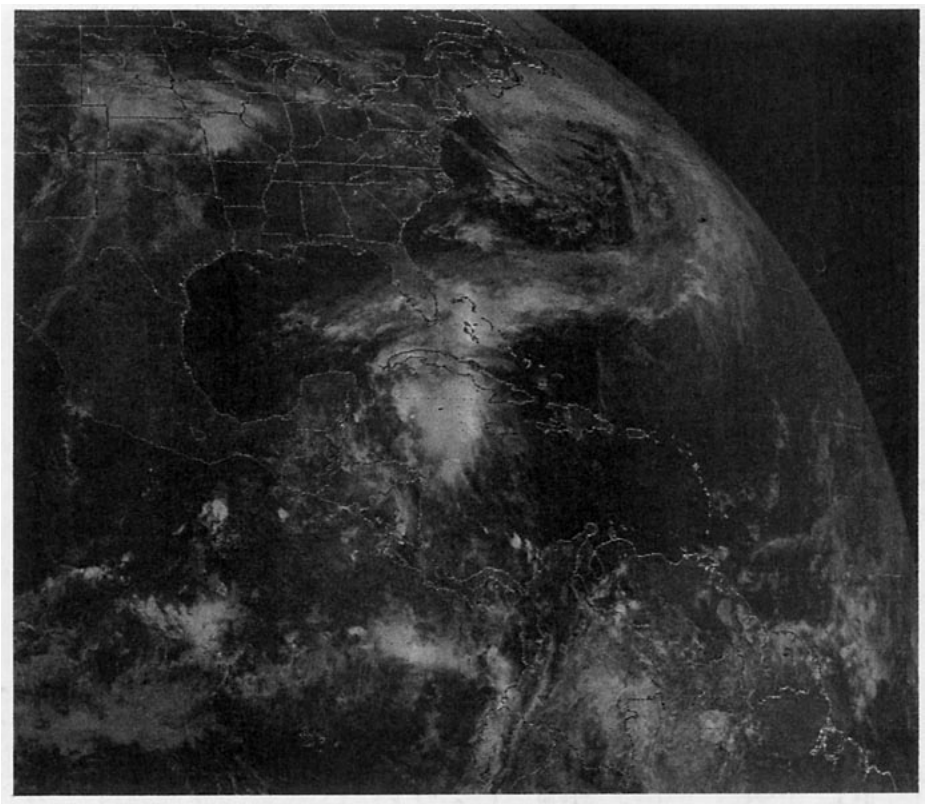

FIG. 3. GOES visible satellite image of Tropical Depression One at 1601 UTC 24 May 1990.

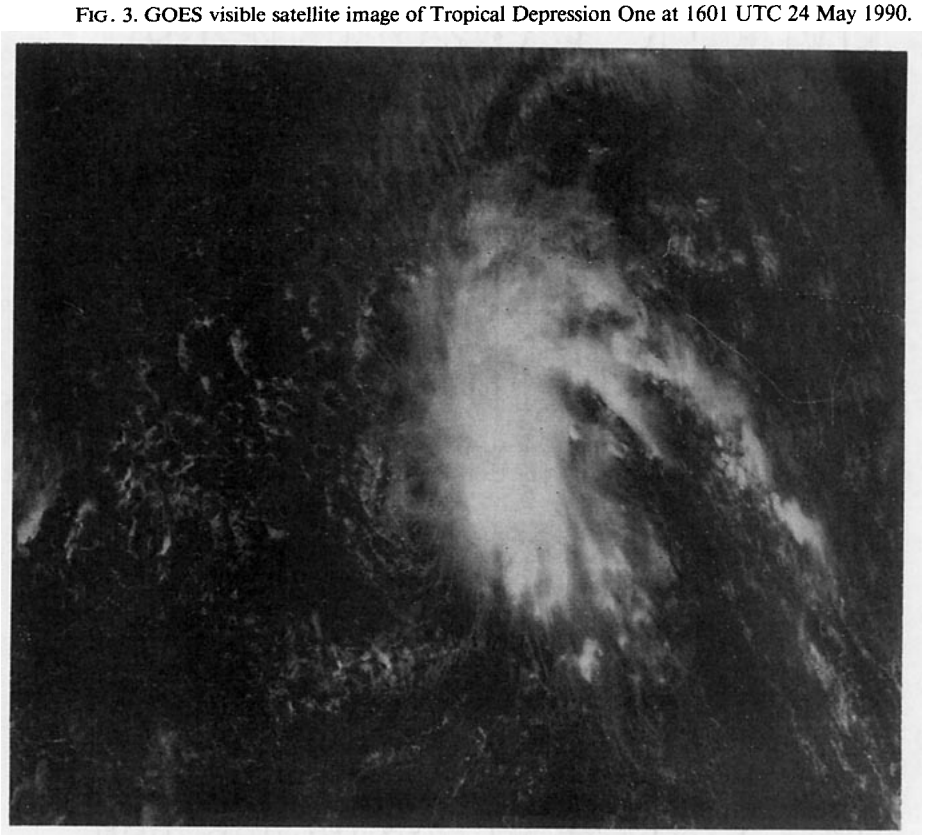

FIG. 4. GOES visible satellite image of Tropical Depression Eleven at 1331 UTC 19 September.

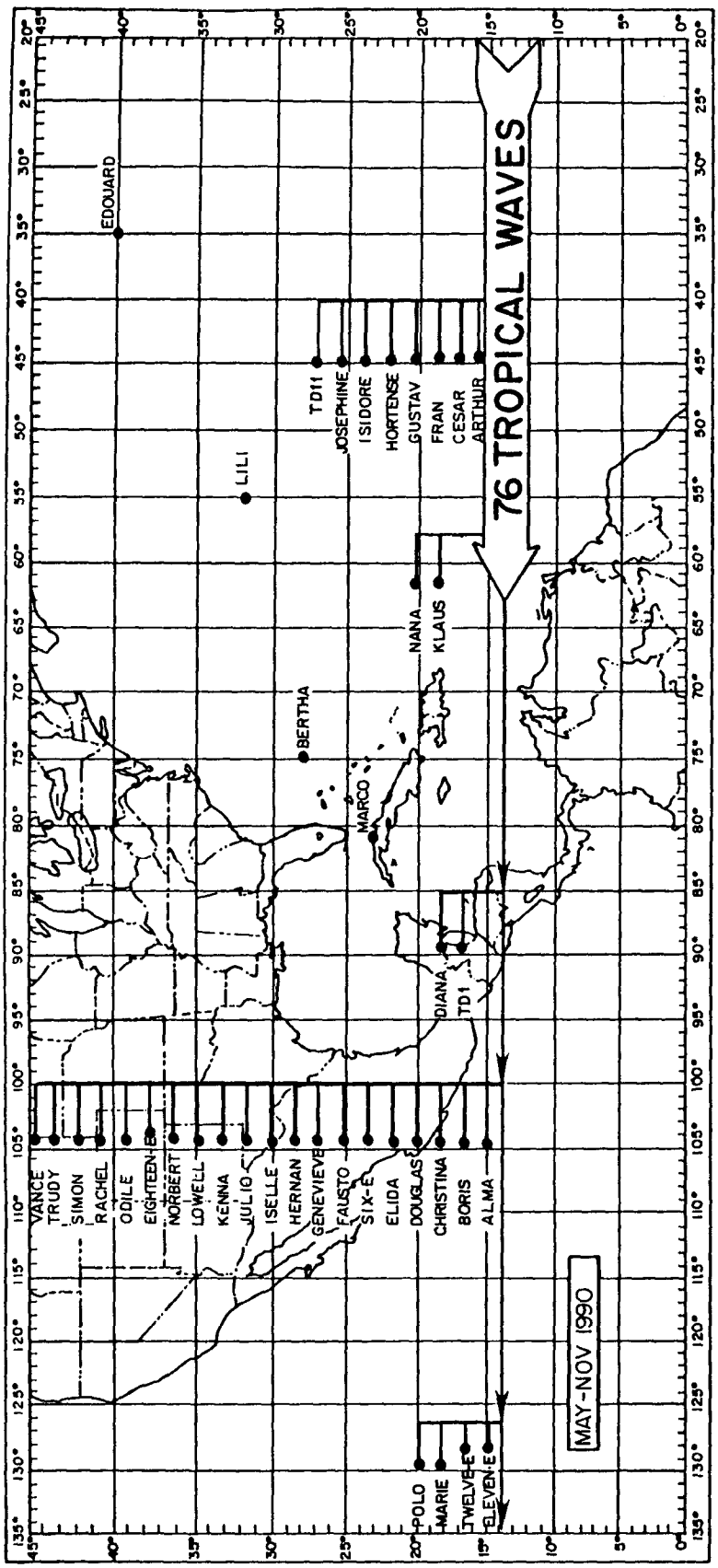


FIG. 5. Total number of waves that maintained their identities while traveling the Atlantic, Caribbean, the Gulf of Mexico, and the eastern Pacific. The figure highlights the longitude bands in which tropical cyclones developed.

westward for several days until it dissipated on 27 September. Figure 4 is a satellite image of Tropical Depression Eleven when located east of the Lesser Antilles. At that time, the low-level center of the depression began to separate from the main convective region.

Of the 14 tropical storms during the 1990 season, 10 formed from African waves. The first wave moved off Africa on 28 April and became Tropical Storm Alma in the eastern Pacific in mid-May. The last wave crossed Dakar, Africa, on 29 November. Figure 5 shows that 76 tropical waves emerged from the coast of Africa and traveled westward over the tropical Atlantic, the Caribbean, and Central America into the eastern Pacific. This gives an average of one wave crossing a particular longitude every 2.9 days, for a frequency somewhat higher than observed in the past (Avila 1990).

The waves were generally distinct on satellite images near the coast of Africa and over the eastern Atlantic throughout the season. Many waves began developing into tropical depressions near 40°W, as highlighted in Fig. 5. However, convection associated with other waves was often suppressed passage over the Caribbean making the waves difficult to follow.

A large number of waves became active again in the eastern Pacific, triggering all of the 1990 tropical cyclones there. Note in Fig. 5 a second longitude band along 100°W, where most of the 1990 eastern Pacific tropical cyclones formed. There were cases when the same wave produced more than one system. For example, the wave that spawned Tropical Storm Fran in the Atlantic triggered Hurricane Kenna in the eastern Pacific.

Satellite imagery in the past has shown large dust outbreaks associated with some tropical waves during consecutive years of drought over the tropical Africa. During 1990, in spite of the below normal rainfall over the western Sahel region (Gray 1990), satellite images suggested that the amount of dust accompanying the tropical waves appeared to be small. This was confirmed by observations of dust concentration taken at Barbados. Those measurements indicate that the dust concentration in 1990 (as in 1988 and 1989) was substantially low, compared with most of the other years of the past decade (Prospero and Savoi, personal communication).

The four remaining named Atlantic tropical cyclones, Bertha, Edouard, Lili, and Marco, were spawned by disturbances of baroclinic origin. They are represented in Fig. 5 by dots detached from the mainstream of waves.

### 3. Comparison with other years

Figure 6a and Table 1 show the number of African waves from 1967 through 1990. There were 76 waves

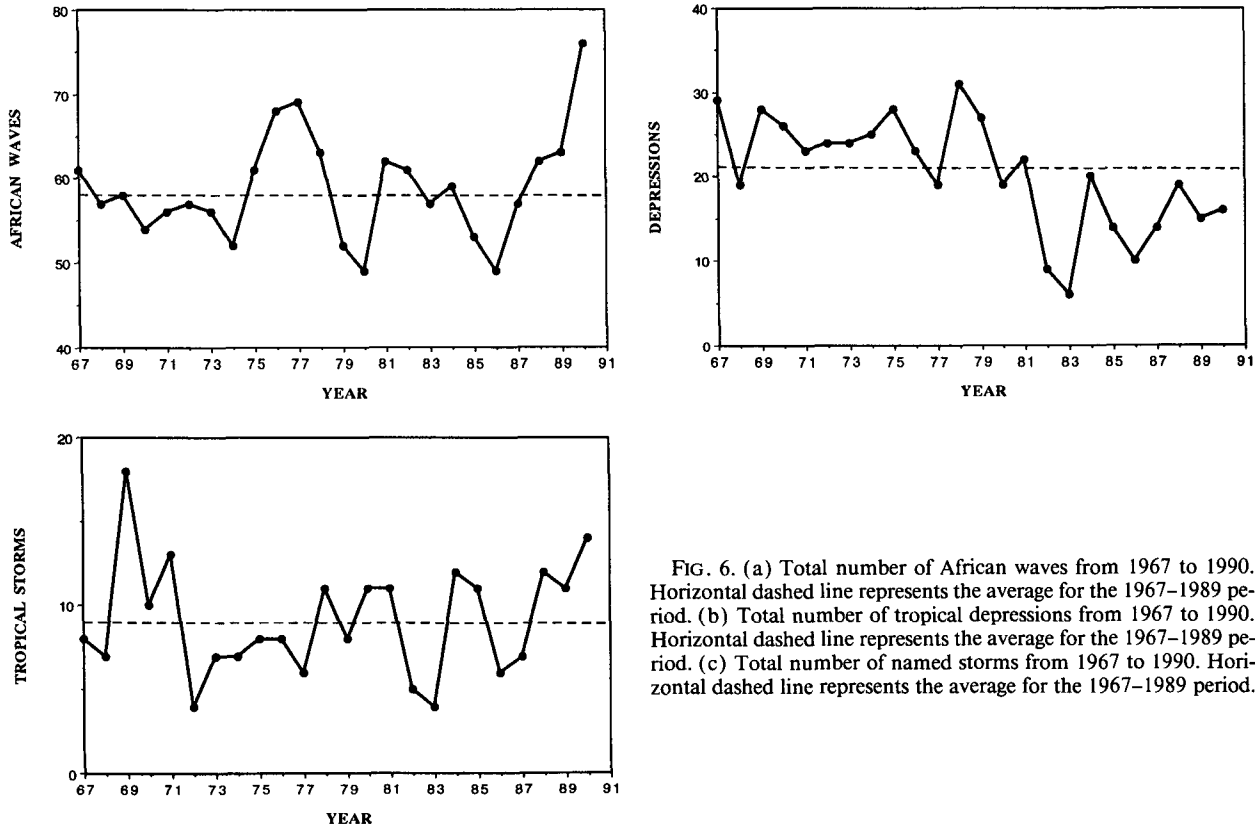


FIG. 6. (a) Total number of African waves from 1967 to 1990. Horizontal dashed line represents the average for the 1967–1989 period. (b) Total number of tropical depressions from 1967 to 1990. Horizontal dashed line represents the average for the 1967–1989 period. (c) Total number of named storms from 1967 to 1990. Horizontal dashed line represents the average for the 1967–1989 period.

TABLE 1. Atlantic tropical system statistics for 1967–1990.

| Year | Waves | Total | | | African | | Ratio | |
|---|---|---|---|---|---|---|---|---|
| | | Tropical depressions | Tropical storms | Hurricanes | Depressions | Storms | African depressions / Total depressions | African storms / Total storms |
| 1967 | 61 | 29 | 8 | 6 | 14 | 5 | 0.48 | 0.65 |
| 1968 | 57 | 19 | 7 | 4 | 8 | 4 | 0.42 | 0.57 |
| 1969 | 58 | 28 | 18 | 12 | 16 | 10 | 0.57 | 0.56 |
| 1970 | 54 | 26 | 10 | 4 | 16 | 7 | 0.82 | 0.70 |
| 1971 | 56 | 23 | 13 | 6 | 12 | 6 | 0.52 | 0.56 |
| 1972 | 57 | 24 | 4 | 3 | 6 | 1 | 0.25 | 0.25 |
| 1973 | 56 | 24 | 7 | 4 | 10 | 4 | 0.42 | 0.57 |
| 1974 | 52 | 25 | 7 | 4 | 12 | 5 | 0.48 | 0.71 |
| 1975 | 61 | 28 | 8 | 6 | 14 | 5 | 0.50 | 0.63 |
| 1976 | 68 | 23 | 8 | 6 | 10 | 5 | 0.43 | 0.63 |
| 1977 | 69 | 19 | 6 | 5 | 7 | 3 | 0.37 | 0.50 |
| 1978 | 63 | 31 | 11 | 5 | 18 | 6 | 0.58 | 0.55 |
| 1979 | 52 | 27 | 8 | 5 | 20 | 8 | 0.74 | 1.00 |
| 1980 | 49 | 19 | 11 | 9 | 14 | 8 | 0.78 | 0.73 |
| 1981 | 62 | 22 | 11 | 7 | 17 | 6 | 0.77 | 0.55 |
| 1982 | 61 | 9 | 5 | 2 | 6 | 3 | 0.67 | 0.60 |
| 1983 | 57 | 6 | 4 | 3 | 3 | 1 | 0.50 | 0.25 |
| 1984 | 59 | 20 | 12 | 5 | 8 | 5 | 0.40 | 0.42 |
| 1985 | 53 | 14 | 11 | 7 | 9 | 8 | 0.64 | 0.73 |
| 1986 | 49 | 10 | 6 | 4 | 6 | 3 | 0.60 | 0.50 |
| 1987 | 57 | 14 | 7 | 3 | 11 | 5 | 0.79 | 0.71 |
| 1988 | 62 | 19 | 12 | 5 | 16 | 9 | 0.84 | 0.75 |
| 1989 | 63 | 15 | 11 | 7 | 14 | 11 | 0.93 | 1.00 |
| Average | 58.0 | 20.6 | 8.9 | 5.3 | 11.6 | 5.9 | 0.59 | 0.61 |
| 1990 | 76 | 16 | 14 | 8 | 12 | 10 | 0.75 | 0.71 |

during 1990; the largest number observed since wave count records began in 1967. This large number may be attributed to improved analysis procedures and observing systems, such as the inclusion of additional African rawinsonde stations and greater use of the Meteosat data.

The wave maximum in 1990 coincided with a peak in the number of Atlantic tropical storms in 1990 as shown in Table 1. However, an inspection of Figs. 6a–c and the yearly totals in Table 1 for the Atlantic indicates that the number of waves is poorly related to the total number of depressions or storms each year. The cause of the annual variability of tropical waves is unknown.

Table 1 and Figs. 6b,c show the seasonal totals of tropical depressions and storms since 1967. There were

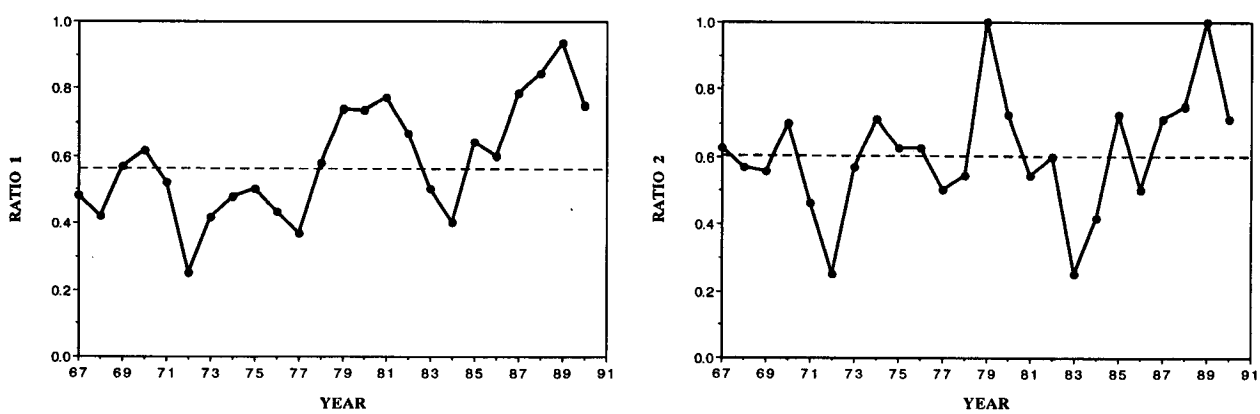


FIG. 7. (a) Ratio of the number of tropical depressions of African origin to the total number of depressions (ratio 1) from 1967 to 1990. Horizontal dashed line represents the average for the 1967–1989 period. (b) Ratio of the number of named storms of African origin to the total number of named storms (ratio 2) from 1967 to 1990. Horizontal dashed line represents the average for the 1967–1989 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 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 storms is lower or equal 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-h period of its existence (Gray 1988) scaled by $10^{-4}$. MH: total number of major hurricanes (category 3 or higher on the Saffir–Simpson scale, Simpson 1974) during those years.

| | | | | | | | | | | HDP | MH |
|---|---|---|---|---|---|---|---|---|---|---|---|
| African years | 1970 | 1974 | 1979 | 1980 | 1985 | 1987 | 1988 | 1989 | 1990 | 62 | 18 |
| Non-African years | 1971 | 1972 | 1977 | 1983 | 1984 | 1986 | | | | 28 | 4 |
| Average years | 1967 | 1968 | 1969 | 1973 | 1975 | 1976 | 1978 | 1981 | 1982 | 55 | 17 |

16 tropical depressions in 1990. Figure 6b shows that 1990 continued the trend started in 1980 of having fewer tropical depressions than the 1967–1989 average of 21. It is speculated that the 1967–1989 average may have been contaminated by midlatitude frontal lows improperly classified as tropical depressions during early years.

Figure 7a displays the ratio of the sum of tropical depressions of African origin to the total number of depressions per year (ratio 1). Low values of ratio 1 indicate that a high number of depressions originated from cold lows or frontal zones (Frank 1975). In 1990, the ratio 1 was 0.75, the lowest since 1986, but still higher than the 1967–1989 average.

The ratio between the number of tropical storms of African origin and the total number of storms (ratio 2) has been found to be a more useful parameter to describe the tropical character of the hurricane season (Avila and Clark 1989). Figure 7b and Table 1 display the values of ratio 2 since 1967. The 23-yr average contribution from African waves to the total amount of storms was 61%. In 1990, the ratio 2 was 0.71.

Typically, Africa is the main source of storms for the Atlantic basin. Some exceptions occurred (e.g., 1972, 1977, 1983, and 1986) when African waves induced only a few storms. Those years coincided with moderate to strong El Niño episodes (Gray 1988), and although African impulses were present during those years, the hostile environment induced by those episodes prevented many of the waves from developing in the Atlantic basin.

Avila and Clark (1989) arbitrarily used ratio 2 to quantify the relative contribution to tropical storm development by African waves. Years in which ratio 2 is greater or equal to 0.7 are termed "African years." "Non-African years" are when ratio 2 is less than or equal to 0.5. Intermediate values are "average years." Since some of the systems were initiated by baroclinic seedlings, the 1990 season did not have the strong "tropical character" of the 1989 season when all storms originated from African waves. Four tropical storms were induced by extratropical forcing; the largest quantity since 1984. However, there were enough tropical storms of African origin (ratio 2 = 0.71) to include 1990 in the group of African years.

Ratio 2 has not previously been calculated for the eastern Pacific. Seasonal summaries for that basin indicate that since 1988, only Hurricane Kiko did not originate from an African wave. Hence, virtually all eastern Pacific tropical cyclones apparently form from African waves.

While ratio 2 provides information about tropical cyclone origin, the hurricane destruction potential (HDP) measures a hurricane's potential for wind and storm surge destruction. The HDP is defined as the sum of the square of each hurricane's maximum wind speed for each 6-h period of its existence (Gray 1988). Table 2 summarizes the African, non-African, and average years including the hurricane destruction potential and the total number of major hurricanes (category 3 or higher on the Saffir–Simpson scale, Simpson 1974). The average HDP of African years for the 1967–1990 period was larger than the average HDP of the non-African years. Also, the total number of major hurricanes during African years is much larger than the number of major hurricanes during the non-African years. This implies that usually the most intense hurricanes are spawned by African waves and, for that reason, it is important to monitor those waves.

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