Atlantic Tropical Systems of 1992

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ABSTRACT

A total of 69 tropical waves (also known as African and easterly waves) were counted in the Atlantic basin during the 1992 hurricane season. As was the case in 1991, the waves were, in general, relatively weak. These waves led to the formation of only four tropical depressions in the Atlantic hurricane basin, of which one intensified into a tropical storm and another intensified into Hurricane Andrew. Andrew was the only 1992 Atlantic hurricane to originate from a tropical wave. There were five additional tropical depressions that were primarily initiated by systems of nontropical origin. These produced three hurricanes and one tropical storm. It appears that tropical waves led to the formation of practically all of the eastern Pacific tropical cyclones in 1992.

1. Introduction

It has been recognized for some time now that westward-propagating disturbances that periodically pass off the west coast of Africa during the summertime can lead to the formation of tropical depressions, tropical storms, and hurricanes over the Atlantic basin (e.g., Dunn 1940). These disturbances have come to be known as tropical waves, or African (or easterly) waves. Normally, the strongest hurricanes of the year originate from tropical waves (e.g., Landsea 1993). This paper is a continuation of a quasi-annual series of articles, begun by Simpson et al. (1968) and revived by Avila and Clark (1989). The primary purpose of this study is to tabulate and summarize certain weaker synoptic-scale systems of 1992—namely, tropical waves and tropical depressions.

As in 1991, the Caribbean Sea and adjacent land areas were not directly affected by a hurricane in 1992. In fact, a rather unusual event, namely, the lack of any hurricane occurrence over the lower latitudes (i.e., south of 25°N) of the Atlantic basin in 1991, was duplicated in 1992. In spite of the continuing quietude over the deep tropics, residents of the northwestern Bahamas, southern Florida, and south-central Louisiana were battered by a major hurricane in 1992 (Mayfield et al., 1994). This hurricane, Andrew, was not an entirely typical "Cape Verde–type" system, since it did not reach hurricane strength until it moved into subtropical latitudes. Nonetheless, Andrew can easily be traced back to a tropical wave that moved off the west coast of Africa near Cape Verde in mid-August.

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Tropical waves were tabulated using satellite imagery as well as surface and upper-air observations across the tropics from Africa to Central America. Tropical waves were identified by analyzing the wind, pressure, and cloud patterns. We acknowledge that some tropical waves have very poor cloud definition. They are difficult to track across the data-sparse tropical Atlantic areas, and there is a certain amount of noise in their identification and positioning. Therefore, when deep convection was minimal or absent and the cloud pattern was not well organized, the position of such waves was estimated by continuity. An example of the wave identification method is shown in Fig. 1. This figure shows a vertical time section of the wind for Dakar, Senegal. Time sections such as these, in conjunction with daily satellite imagery, are used to locate the waves. The presence of a lower-tropospheric cyclonic wind shift and/or the propagation of an organized and distinct cloud mass are the primary parameters used in locating the wave axis. Additional details on the counting method are described by Avila and Clark (1989).

2. Census of the 1992 Atlantic systems

Tropical cyclone activity in the Atlantic continued below normal in 1992. The season featured six tropical storms, four of which became hurricanes. Only Hurricane Andrew and Tropical Storm Earl developed from tropical waves. Tropical waves produced two other tropical depressions, which did not intensify into tropical storms. The remainder of the depressions formed from disturbances of nontropical origin.

a. Tropical depressions

In terms of tropical depression frequency, 1992 was even less active than the previous year. The season fea-

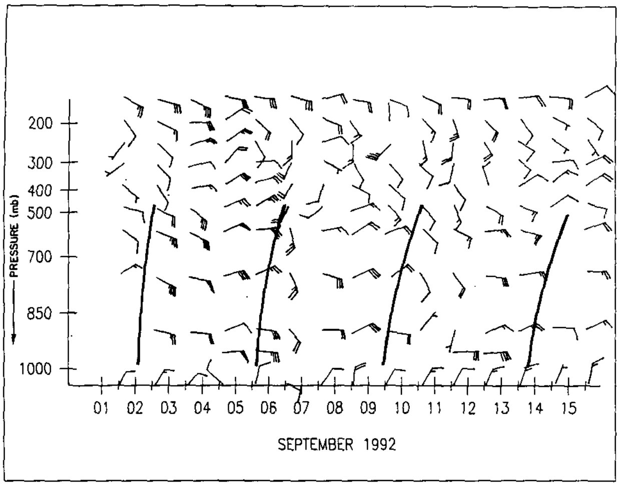

FIG. 1. Vertical time section of the wind at Dakar, Senegal, from 1 to 15 September 1992. Winds plotted every 12 h according to convention with each full barb and half barb denoting 5.1 and 2.6 m s^{-1}, respectively, and the solid flag denoting 25.7 m s^{-1}. The thick lines indicate the positions of the tropical wave axes.

tured a total of just nine tropical depressions. This is the lowest number since 1983, when only six formed. The most active month of 1992 was September, during which five depressions were observed; however, only two of these systems originated from a tropical wave. A single depression was observed in each of the months of June, July, August, and October. Of those, only the June and August depressions formed from tropical waves. No depressions occurred in May or November. Figure 2 shows the Atlantic tropical depression tracks for 1992. The depressions that did not reach tropical storm status are described below. Depressions that reached tropical storm status (as well as subtropical storm status) are described in Mayfield et al. (1994).

1) Tropical Depression One

Tropical Depression One appeared to have its origins in a weak tropical wave that crossed Dakar on 12 June. The wave progressed westward for several days with no significant convection across the Atlantic, the southern Windward Islands, and northern South America. On 20 June, satellite images indicated that convective cloudiness associated with the wave became active to the north of Colombia, over the adjacent Caribbean. Under the influence of mid- to lower-tropospheric southeasterly flow induced by developing Tropical Storm Celia in the eastern Pacific and the south-southwesterly flow associated with a mid- to upper-tropospheric trough over the Gulf of Mexico, the convective system spread over the northwest Caribbean, Cuba, the Yucatan peninsula, and south Florida.

During 23 and 24 June, rawinsonde data from Belize and Merida indicated that a mid- to lower-tropospheric circulation had developed in the vicinity of 20°N, 85°W. Satellite loops during that period showed deep convection with some cyclonic rotation near the extreme western tip of Cuba. However, a reconnaissance plane dispatched to the area on 24 June did not find evidence of a closed low-level circulation over the northwest Caribbean. Satellite images late on 24 June suggested that a low-level circulation began to form over the extreme southeast Gulf of Mexico.

At 1800 UTC 25 June, ship and National Oceanic and Atmospheric Administration buoy data over the eastern Gulf of Mexico confirmed that a closed circulation was at the surface, and tropical depression advisories were initiated. At that time, satellite images showed a shearing pattern, with most of the thunderstorm activity removed to the east and southeast of the broad and poorly defined center of the tropical depression. The outflow from Celia and a deepening trough in the Gulf of Mexico caused the shearing of the system. Figure 3 is a visible satellite picture of the depression over the eastern Gulf, heading toward Florida.

The depression moved northward, then north-northeastward, and dissipated over northern Florida on 26 June, but not without causing gusty winds and coastal flooding along portions of the west Florida shore and the Keys. The remnants of the tropical depression continued northeastward and became absorbed by a large extratropical system that was racing northeastward over the Atlantic.

The tropical depression, in combination with an upper-level trough in the Gulf of Mexico, caused torrential rains over western Cuba and sections of Florida. Rainfall accumulations during the depression's lifetime were as high as 640 mm at San Juan y Martinez in western Cuba and 495 mm at Venice on the west coast of Florida.

2) Tropical Depression Two

Tropical Depression Two was associated with a frontal zone that moved off the coast of New Jersey on 16 July. During the next several days a small concentrated area of clouds could be seen on satellite images moving generally eastward from that area to about longitude 50°W and then southward following a path around the northern and eastern peripheries of an anticyclone centered near Bermuda. By 22 July, the cloud system, located about 1100 km east-southeast of Bermuda, was showing some signs of organization at midlevels of the troposphere as it was traveling westward along the southern periphery of the anticyclone. Figure 4 is a visible satellite picture of the system on 22 July, showing the organizing cloud pattern. The convective cloud mass in this figure is rather small in scale (100–200 km in diameter).

During the following two days, intensity estimates calculated by means of satellite techniques implied that the system was of at least tropical depression strength.

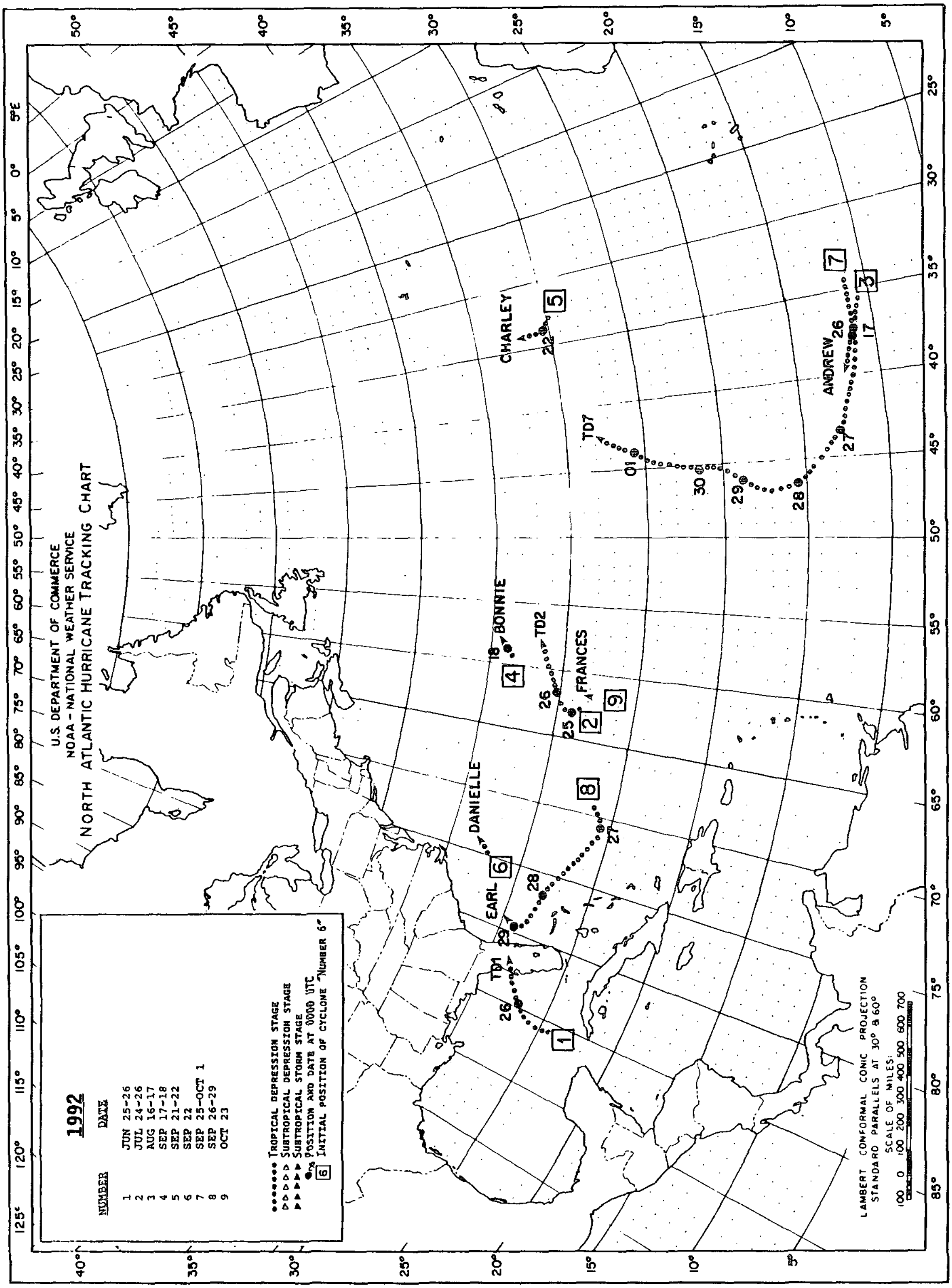

FIG. 2. Tropical depression tracks for 1992.

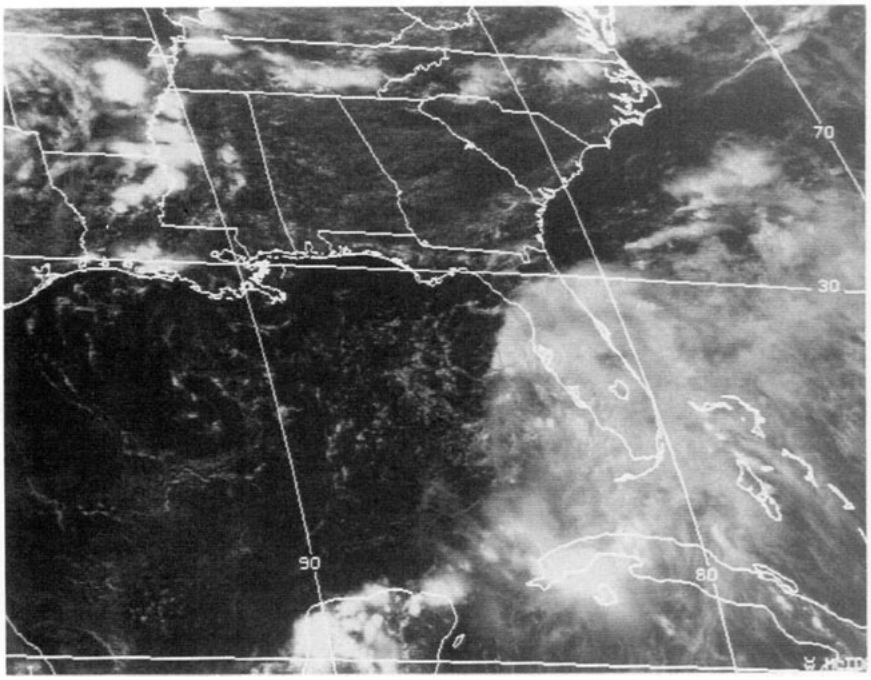

FIG. 3. *GOES-7* visible satellite picture of Tropical Depression One at 2100 UTC 25 June 1992. The poorly defined center is near the northwestern edge of the cloud mass that has spread across Florida.

Even so, observations during that period showed that sea level pressures in the vicinity of the system were unusually high, and ship reports did not confirm that a closed circulation was established at the surface. However, more detailed information received from a reconnaissance aircraft on the afternoon of 24 July indicated that a surface circulation was present, with a minimum central pressure of 1016 mb. Maximum 1-min surface winds were estimated to be near 15 m s^{-1}.

Strong northeasterly shear inhibited further development as the depression drifted northward to within 370 km of Bermuda. The low-level circulation center then accelerated eastward leaving the deep convection behind. The system lost its identity by 1800 UTC 26 July.

3) TROPICAL DEPRESSION SEVEN

The tropical wave that ultimately produced Tropical Depression Seven crossed the coast of Africa on 23 September as a poorly organized area of disturbed weather. The organization improved on 25 September, and based on satellite intensity estimates, a tropical depression centered about 1250 km southwest of the Cape Verde Islands formed in the wave near 1200 UTC 25 September.

The center of the depression moved west-northwestward and became completely exposed from deep convection within 24 h in a southwesterly shearing environment. For the next three days, the system took a gradual turn toward the northwest, then north, and experienced alternating periods of slight strengthening and then weakening in that environment. Figure 5 is a visible satellite picture of Tropical Depression Seven on 26 September, showing the main area of deep convection displaced to the southeast of the center of circulation. Even though shearing continued over the system during the next few days, the convective cloud pattern intermittently showed a fair degree of organization. Therefore, it continued to be tracked as a tropical cyclone for some time. The depression ultimately dissipated around 1800 UTC 1 October approximately 1800 km southwest of the Azores.

b. Tropical waves

Figure 6 shows that, during 1992, 69 tropical waves exited the northwest coast of Africa and moved westward over the tropical Atlantic, the Caribbean, and Central America, and appeared to continue into the eastern Pacific. The average period of the waves was 3.03 days, which is similar to the period that was observed in 1990 and 1991. The first tracked wave exited Africa on 1 May. The last tracked wave crossed Dakar during late November.

For the second consecutive year, tropical waves appeared to be weaker than normal. Most of the waves in 1992 did not have a well-marked lower-tropospheric wind shift in the time sections, and there was not much deep convection accompanying these systems as they

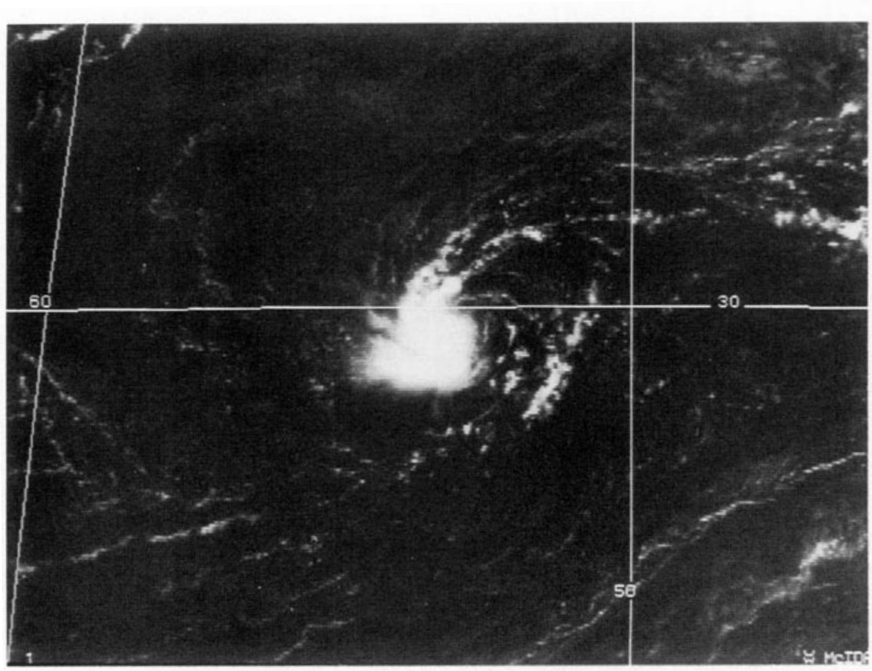

FIG. 4. *Meteosat-3* visible satellite picture at 1400 UTC 22 July 1992 of the system that developed into Tropical Depression Two.

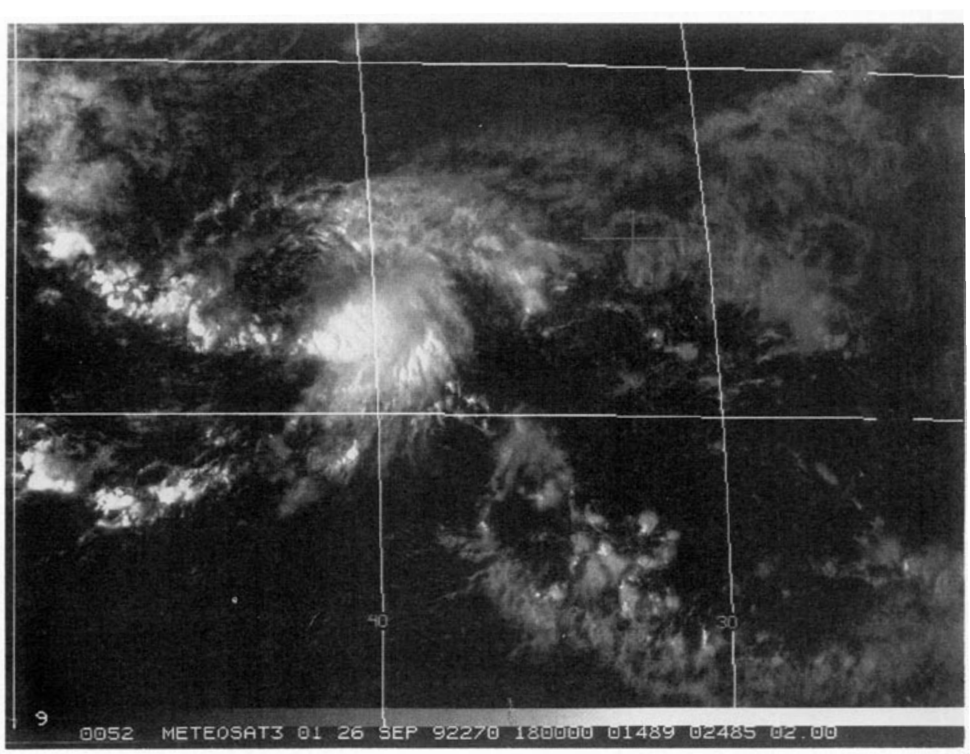

FIG. 5. *Meteosat-3* visible satellite image of Tropical Depression Seven at 1800 UTC 26 September 1992. The center of the depression is located to the northwest of the bright cloud mass (deepest convection) at this time.

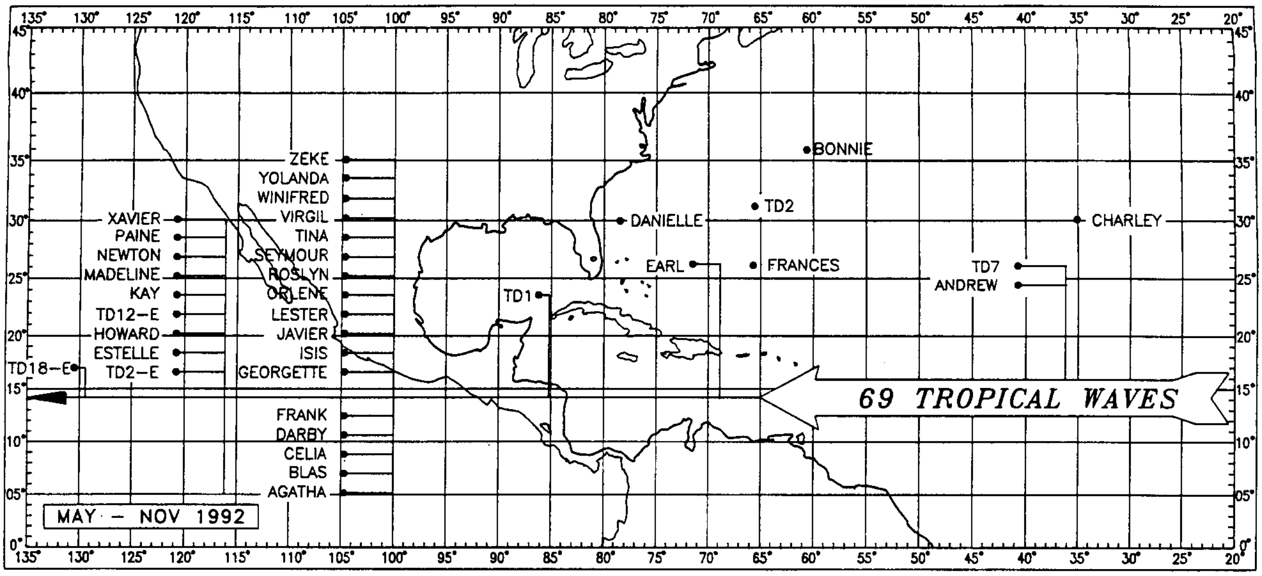

FIG. 6. The total number of waves that maintained their identities while traveling the Atlantic, the Caribbean, the Gulf of Mexico, and the eastern Pacific. The figure highlights the longitude bands in which tropical cyclones developed. Over the Atlantic basin, the separate dots denote the approximate locations of tropical cyclone formation from nontropical disturbances.

emerged from Africa. In most cases, the waves were difficult to track on satellite images over the tropical Atlantic and Caribbean Sea. Some insight into the relative weakness of the waves in 1992 might be gleaned by looking at anomalies of the lower-tropospheric flow. Figure 7 depicts the average low-level (approximately 900 mb) wind anomalies for August through October of 1992. The analogous anomaly chart was also presented for the 1991 hurricane season (Avila and Pasch 1992). There are some remarkable similarities in the anomaly fields for these two years. In 1992, there was an anomalous anticyclone centered near the west coast of Africa and an area of anomalous cyclonic flow near the central subtropical north Atlantic. There is a qualitative resemblance of this anomaly pattern to its 1991 counterpart. As in 1991, the anomalous anticyclonic flow near the west coast of Africa in 1992 could be related to a weaker than normal west African monsoon circulation. A weaker monsoon could, in turn, be related to a weaker intertropical convergence zone over west Africa and weaker disturbances (waves) along this zone, as suggested by Druyan (1989). On the other hand, the anomalous cyclonic flow over the Atlantic is indicative of the relative weakness of the subtropical

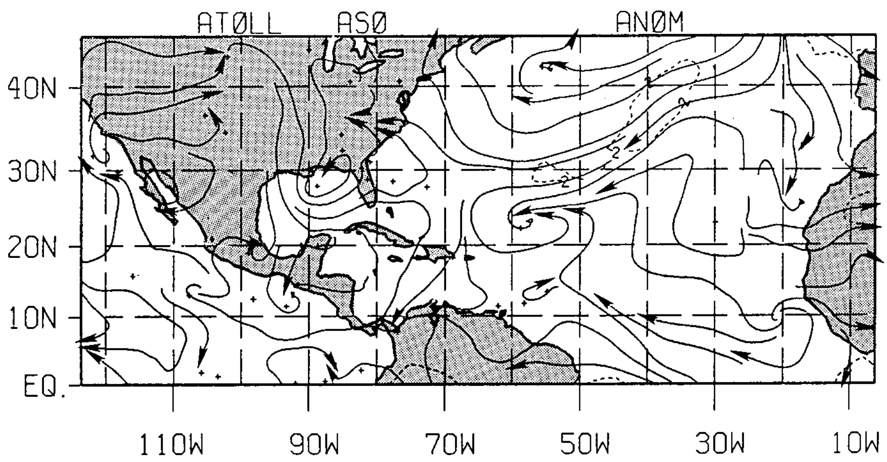

FIG. 7. Average low-level (approximately 900 mb) wind anomalies for August–October 1992. Anomalies are the mean for 1992 minus 1975–92 average. Units are meters per second. The acronym ATOLL refers to "analysis of the tropical oceanic lower layer."

ridge northeast of the Lesser Antilles. This would be reflected by a weaker than normal lower-tropospheric easterly current across the entrance region for the waves into the Caribbean. Lower-tropospheric easterlies increasing toward midlatitudes would likely imply more low-level, large-scale cyclonic vorticity over this tropical belt, which could serve as a source of vorticity for the synoptic-scale (wave) disturbances. Apparently, the larger-scale cyclonic vorticity was less than normal over the lesser Antilles area during the 1992 season.

Historically, the first half of September features the most active tropical waves emerging from the west coast of Africa, with significant potential for development into tropical cyclones. The Dakar time section shown in Fig. 1 covers that typically active period, and it can be seen that the waves exhibited distinct lower-tropospheric wind shifts. However, for one reason or another, none of the waves shown here led to the formation of an Atlantic tropical cyclone. For example, the northern portion of the wave that passed over Dakar on 6 September soon moved to a higher latitude, reducing its likelihood for development. It is also of interest to note that a few days after the ending date of this time section the upper-tropospheric flow over Dakar reversed from an easterly to a westerly component. Climatologically, this event would be expected to occur a few weeks later. The early arrival of upper-tropospheric westerlies over western Africa in 1992 is related to the development of anomalously strong westerly flow around the 200-mb level over the tropical Atlantic during September (Mayfield et al. 1994; see below).

As in 1991, there were no tropical cyclones in the Caribbean in 1992. It was seen in 1991 that most of the tropical waves affected lower latitudes than usual, with their maximum convection over South America. This was in contrast with more active years when maximum cyclonic curvature in the wind field and thunderstorm activity associated with the waves usually extends northward through the Caribbean into the Atlantic. Satellite imagery indicated that, at least occasionally, the waves caused a little more convection over portions of the Caribbean during 1992 than they did during 1991. Nonetheless, this convective activity was in general weaker and farther south than might be expected in an ''active'' season. The relative lack of convection over the Caribbean area was also indicated by the precipitation anomalies over that region during August, September, and October of 1992 (Climate Analysis Center 1992a,b,c).

Most of the 1992 tropical cyclones, like those in 1991, developed at higher latitudes over the subtropical Atlantic. The tropical cyclones of nontropical origin, Tropical Depression Two, Bonnie, Charley, Danielle, and Frances are represented in Fig. 6 by dots detached from the main stream of waves. For the second straight year, relatively few tropical cyclones were spawned by

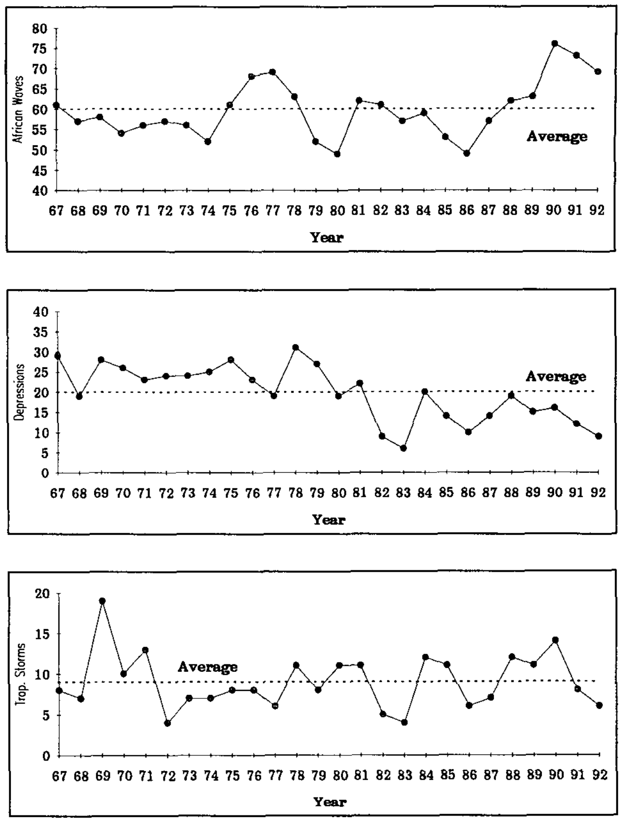

FIG. 8. (a) Total number of tropical waves from 1967 to 1992. The horizontal dashed line represents the average for the 1967–91 period. (b) Total number of tropical depressions from 1967 to 1992. The horizontal dashed line represents the average for the 1967–91 period. (c) Total number of named storms from 1967 to 1992. Horizontal dashed line represents the average for the 1967–91 period.

tropical waves over the Atlantic tropical belt. Mayfield et al. (1994) point out that although the vertical shear of the wind was a little weaker than normal over the tropical Atlantic during August (the month that Hurricane Andrew formed), the shear increased substantially over the deep tropics in September. The increased shear was directly related to an increase in upper-tropospheric westerlies to the east of the Lesser Antilles. Thus, just as in the previous year, low-latitude tropical cyclogenesis from tropical waves was discouraged by conditions in the upper-tropospheric environment during 1992. Other than Andrew, Tropical Depression Seven was the only other tropical cyclone to form over the tropical Atlantic and it was prevented from strengthening significantly by the aforementioned shear. Gray (1992) has related various large-scale atmospheric factors to the small number of low-latitude tropical cyclones during 1992. Among these, in addition to westerly upper-tropospheric wind anomalies over the Caribbean basin (i.e., strong vertical shear), were negative anomalies of precipitation in the western Sahel region of Africa.

TABLE 1. Atlantic tropical system statistics for 1967–92; TD—tropical depression, TS—tropical storm, and H—hurricane.

		Total			African			Ratio		
Year	Waves	TD	TS	H	TD	TS	H	African TD / total TD	African TS / total TS	African H / total H
1967	61	29	8	6	14	5	5	0.48	0.63	0.83
1968	57	19	7	4	8	4	2	0.42	0.57	0.50
1969	58	28	18	12	16	10	8	0.57	0.56	0.66
1970	54	26	10	5	16	7	3	0.82	0.70	0.60
1971	56	23	13	6	12	6	2	0.52	0.56	0.33
1972	57	24	4	3	6	1	1	0.25	0.25	0.33
1973	56	24	7	4	10	4	2	0.42	0.57	0.50
1974	52	25	7	4	12	5	4	0.48	0.71	1.00
1975	61	28	8	6	14	5	5	0.50	0.63	0.83
1976	68	23	8	6	10	5	5	0.43	0.63	0.83
1977	69	19	6	5	7	3	2	0.37	0.50	0.40
1978	63	31	11	5	18	6	4	0.58	0.55	0.80
1979	52	27	8	5	20	8	5	0.74	1.00	1.00
1980	49	19	11	9	14	8	6	0.78	0.73	0.66
1981	62	22	11	7	17	6	6	0.77	0.55	0.85
1982	61	9	5	2	6	3	2	0.67	0.60	1.00
1983	57	6	4	3	3	1	1	0.50	0.25	0.33
1984	59	20	12	5	8	5	1	0.40	0.42	0.20
1985	53	14	11	7	9	8	5	0.64	0.73	0.71
1986	49	10	6	4	6	3	2	0.60	0.50	0.50
1987	57	14	7	3	11	5	2	0.79	0.71	0.66
1988	62	19	12	5	16	9	4	0.84	0.75	0.80
1989	63	15	11	7	14	11	7	0.93	1.00	1.00
1990	76	16	14	8	12	10	5	0.75	0.71	0.62
1991	73	12	8	4	7	3	0	0.58	0.38	0.00
Average	59	20	9	5	11	6	4	0.58	0.59	0.64
1992	69	9	6	4	4	2	1	0.44	0.33	0.25

The development of eastern Pacific tropical cyclones from tropical waves has been suggested previously by Frank and Clark (1980). It has been observed oftentimes that, as they cross Central America, the tropical waves become more convectively active in the eastern Pacific. During the summer months it is typical for weak vertical shear to prevail over the warm Pacific waters to the south of Mexico, and tropical cyclogenesis from the waves is frequently favored. The 1992 season was no exception to this generalization. In fact, a record number of 24 tropical storms formed over the eastern Pacific basin in 1992 (Lawrence and Rappaport 1994). It is likely that tropical waves played a significant role in the formation of the majority of the 1992 eastern Pacific tropical storms. These waves usually take more than a week to traverse the Atlantic basin after emerging from west Africa. Figure 6 shows a longitude band centered along 100°W where the majority of the eastern Pacific tropical cyclones likely formed from the waves. A significant number of storms formed farther to the west, also most likely from tropical waves. In some cases, particularly for those east Pacific tropical cyclones that formed closer to Central America, it is possible that the orographic effects of this mountainous landmass can induce their formation, as theorized by Zehnder (1991).

3. Comparison with other years

Figure 8a and Table 1 show the number of tropical waves from 1967 through 1992. In 1992, as in 1990 and 1991, the number of waves was somewhat higher than the average. However, year-to-year variations in the total number of waves are probably not significant. Since the process of identifying tropical waves has not been uniformly applied over the years, one must be careful in interpreting the total number of such events.

Table 1 indicates that there was a peak in the number of tropical waves as well as in the number of tropical storms in 1990. There was also an above-average number of tropical waves in 1991 and 1992 but, as opposed to 1990, both the 1991 and 1992 seasons had a below-average number of tropical storms. This supports previous findings that the number of waves is not related to the total number of tropical storms (e.g., Frank 1975). It appears that the large-scale environment exercises the largest control on the yearly variation in the number of tropical storms forming from tropical waves.

Table 1 and Figs. 8b,c show the seasonal totals of tropical depressions and storms since 1967. It has been noted that a trend toward fewer tropical depressions per year began around 1980. The average number of tropical depressions for 1980–91 is close to 15. It is speculated that during the 1967–80 period some of the cyclones classified as tropical depressions may have been nontropical systems, such as midlatitude frontal lows. Examples are the depressions of 19–20 June 1970 and 12–13 July 1975 (both over the subtropical Atlantic), where recent analysis of satellite imagery casts some doubt on their tropical characteristics. Therefore, the apparent reduction in the number of tropical depressions over the past decade may be an artifact of the depression classification scheme, which is to some extent a subjective process. The fact that the number of tropical storms per year shows no such long-term trend would seem to partially support that conjecture. In any event, the total of nine depressions in 1992 is well below the more recent 1980–91 average.

Figure 9a displays the ratio of the number of tropical depressions of African origin to the total number of tropical depressions per year (ratio 1). Low values of ratio 1 indicate that a high number of depressions originated from cold lows or along frontal zones—that is, from nontropical "seedling" disturbances (Frank 1975). In 1992, ratio 1 was 0.44, even lower than 1991 (which had the lowest value since 1984) but not as low as the values for the very anomalous years 1972 and 1977.

The ratio between the number of tropical storms of African origin to the total number of tropical storms (ratio 2) has been found to be a useful parameter to describe the overall character of the hurricane season (Avila and Clark 1989). Figure 9b and Table 1 display the values of ratio 2 since 1967. The 25-yr average contribution from tropical waves to the total number of storms was 0.59. In 1992 ratio 2 was 0.33, even a little lower than for 1991; this value has been lower only in 1972 and 1983.

Typically, tropical waves are the main source of hurricanes for the Atlantic basin. There have been exceptions, namely, the 1971, 1972, 1977, 1983, 1984, and 1991 seasons, when tropical waves induced only a few storms. The 1992 season is the second consecutive one to be included in this exceptional group. Table 1 shows that on average, 64% of the hurricanes in the Atlantic develop from tropical waves. Only one 1992 hurricane, Andrew, can be traced back to a tropical wave.

It is of interest to note that 1992 can been designated as a year of generally moderate "El Niño" conditions, based on equatorial Pacific sea surface temperatures and atmospheric indices (Climate Analysis Center 1992). Many of those years when tropical waves induced only a few storms and hurricanes coincided with moderate to strong El Niño events (Gray 1984). Although tropical waves were present during those years, Gray has speculated that a hostile environment, induced by El Niño 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 tropical waves. Years in which ratio 2 is greater than or equal to 0.7 are termed "African" years. "Non-African" years are those for which ratio 2 is less than or equal to 0.5. Intermediate values correspond to "average" years. Clearly, 1992, like 1991, was a non-African year, and its tropical character was totally different from the so-called African years such as 1988 and 1989 when many of the storms and hurricanes developed from tropical waves. The latter two years produced several major hurricanes—for example, Gilbert and Hugo. As noted earlier, it is typical for such strong hurricanes to be spawned by tropical waves. Indeed, intense Hurricane Andrew was of African origin. Even though the year 1992 overall was not an African year by our definition, the single hurricane that was spawned by a tropical wave had disastrous consequences.

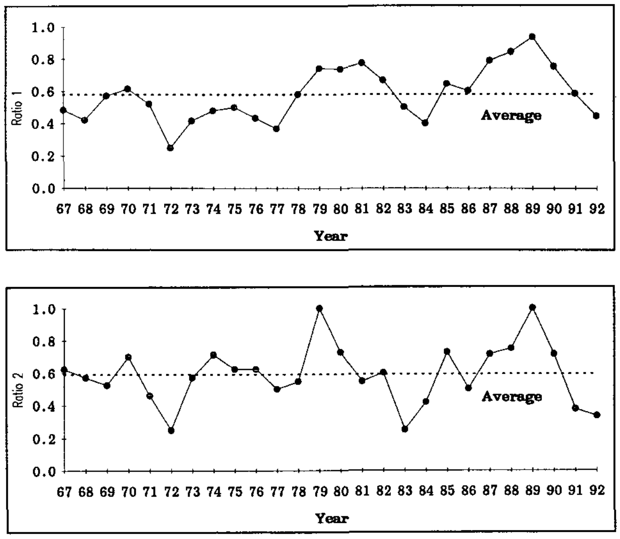

FIG. 9. (a) Ratio of the number of tropical depressions of African origin to the total number of depressions (ratio 1), annually from 1967 to 1992. The horizontal dashed line represents the average for the 1967–91 period. (b) Ratio of the number of named storms of African origin to the total number of named storms (ratio 2), annually from 1967 to 1992. The horizontal dashed line represents the average for the 1967–91 period.

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 et al. 1992). Table 2 summarizes the African, non-African, and average years, including the HDP and the total number of major hurricanes [category 3 or higher on the Saffir–Simpson hurricane scale (Simpson 1974)]. The average HDP of African years for the 1967–92 period was substantially larger than (more than double) the average HDP of the non-African years. The HDP for 1992 is 51, which is somewhat higher than the average for non-African years. Nearly all of this total can be attrib-

TABLE 2. Comparison of African, non-African, and average years with season-averaged hurricane destruction potential (HDP) and major hurricanes (MH). African years: ratio of the number of tropical storms of African origin to the total number of storms is higher than 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 than 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-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	1991	1992		30	7
Average years	1967	1968	1969	1973	1975	1976	1978	1981	1982	55	17

uted to Andrew. The occurrence of such a destructive hurricane is a relatively rare event for any given year, but its occurrence during a year like 1992, in view of the parameters discussed above (ratios 1 and 2 along with Table 1), is considered very exceptional. What is not surprising, however, is that the one category 4 hurricane to have occurred during the past two seasons, Andrew, was of African origin.

Since tropical waves play such a dominant role as the precursors to major hurricanes and the majority of eastern Pacific tropical cyclones can apparently be traced back to these waves, it is important to continue to monitor and to study these systems.

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