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Atlantic Tropical Systems of 1971

NEIL L. FRANK—*National Hurricane Center, NOAA, Miami, Fla.*

ABSTRACT—The 1971 hurricane season featured 103 seedlings, 23 depressions, and 12 named storms. An anomalous circulation pattern developed over the Gulf of Mexico and the southwestern Atlantic Ocean in September and spawned a large number of depressions and storms within the subtropical belt near or north of latitude 25°N.

1. INTRODUCTION

This is the fifth in a continuing series of annual articles whose purpose is to highlight salient features of the previous hurricane season with special emphasis on the weaker synoptic scale systems. Details on the named storms that occurred in 1971 are contained in a companion article by Simpson and Hope (1972).

Terms were defined in two previous papers by Simpson et al. (1968, 1969). The basic purpose of this effort is to identify and document the history of all synoptic scale tropical perturbations that developed during the hurricane season (June 1–November 30). Prior to the satellite era, it was impossible to maintain continuity on tropical systems traversing the Atlantic Ocean, because of data considerations. The satellite has given us the tool to bridge this gap.

The Atlantic disturbances have been divided into two categories based on their cloud distribution. If the stratocumulus field that normally exists over the eastern tropical Atlantic Ocean north of the intertropical convergence zone (ITCZ) is organized into an "inverted V" pattern, the system has been labeled a "tropical wave," suggesting that the region of cyclonic vorticity is within the trade winds belt. A second type of disturbance, which has been labeled "ITCZ disturbance," appears to be directly related to the equatorial trough and is revealed by a concentrated area of convection on the ITCZ. The influence of these ITCZ disturbances generally does not affect the stratocumulus; however, in late August and early September when the ITCZ reaches its northern-most position this is not always true, and it is more difficult to assign a disturbance to one of these two categories. We realize that this arbitrary division is tenuous and may have to be refined when data collected in the Global Atmospheric Research Program (GARP) Atlantic Tropical Experiment (GATE) becomes available. We may find that a greater

TABLE 1.—*Summary of the history of tropical waves and disturbances in 1971*

Dakar passage	Nature	Formed in Atlantic	Weakened in Atlantic	Barbados passage	Nature	Weakened in Caribbean	Formed in Caribbean	San Andrés passage	Nature	Atlantic storm	Pacific storm
							X	June 2	ITCZ		
		X ITCZ	X								
June 3	Wave			June 7	Wave			June 12	Wave		Bridget
								June 7	ITCZ		
June 7	Wave			June 12	Wave			June 15	Wave		
June 11	ITCZ			June 16	ITCZ			June 19	ITCZ		
June 12	Wave			June 17	Wave	X					
June 13	Wave		X								
June 17	Wave			June 23	Wave			June 27	Wave		
		X		June 20	Wave			June 22	Wave		
June 20	Wave			June 27	Wave			July 1	Wave		Eleanor
		X ITCZ	X								
June 22	Wave		X								
June 23	Wave			June 29	Wave			July 3	Wave		
								June 25	Wave		Carlotta
		X ITCZ	X								
June 27	Wave			July 3	Wave			July 7	Wave		
							X	June 28	ITCZ		Denise
							X	June 30	ITCZ		
June 29	Wave			July 5	Wave			July 8	Wave	Dep.	
July 1	Wave			July 8	Wave			July 11	Wave		
							X	July 14	ITCZ	Dep.	
July 4	ITCZ		X								
		X ITCZ	X								
July 6	Wave			July 12	Wave			July 15	Wave		
July 9	ITCZ		X								

Table 1.—*Concluded*

Dakar passage	Nature	Formed in Atlantic	Weakened in Atlantic	Barbados passage	Nature	Weakened in Caribbean	Formed in Caribbean	San Andrés passage	Nature	Atlantic storm	Pacific storm
July 10	Wave			July 16	Wave	X					
							X	July 13	ITCZ		
July 13	Wave			July 18	Wave			July 21	Wave		Hilary
		X		July 17	ITCZ			July 20	ITCZ		
		X ITCZ	X								
July 16	Wave			July 25	Wave			July 30	Wave		
		X ITCZ	X								
July 20	Wave			July 29	Wave			Aug. 2	Wave		Jewel
July 23	Wave			July 30	Wave	X					
							X	July 24	ITCZ		
		X ITCZ	X								
							X	July 28	ITCZ		Ilsa.
July 29	Wave			Aug. 3	Wave			Aug. 6	Wave		Dep.
July 31	Wave			Aug. 5	Wave			Aug. 8	Wave		
Aug. 3	Wave			Aug. 8	Wave			Aug. 11	Wave		
							X	Aug. 5	ITCZ		Katrina
		X ITCZ	X								
Aug. 7	Wave			Aug. 13	Wave			Aug. 17	Wave		
		X		Aug. 12	Wave			Aug. 15	Wave		
Aug. 10	Wave			Aug. 16	Wave			Aug. 19	Wave		
Aug. 11	Wave			Aug. 18	Wave			Aug. 21	Wave		
Aug. 13	ITCZ			Aug. 19	Dep.			Aug. 23	Dep.	Chloe	Monica
Aug. 15	Wave			Aug. 23	Dep.			Aug. 26	Wave	Doria	
Aug. 19	Wave			Aug. 25	Wave			Aug. 28	Wave		
Aug. 21	Wave			Aug. 27	Wave			Aug. 31	Wave		Nanette
Aug. 22	Wave		X								
Aug. 25	Wave			Aug. 30	Wave			Sept. 2	Wave		
Aug. 26	Wave			Sept. 1	Wave			Sept. 4	Wave	Dep.	
Aug. 28	Wave			Sept. 4	Wave	X					
Aug. 31	Wave			Sept. 6	Dep.			Sept. 9	Storm	Edith	
Sept. 3	Dep.			Sept. 11	Wave	X				Dep.	
							X	Sept. 15	ITCZ		
		X		Sept. 10	Wave	X					
Sept. 7	Wave			Sept. 14	Dep.			Sept. 18	Storm	Irene	Olivia
Sept. 10	Dep.			Sept. 17	Wave			Sept. 21	Wave	Dep.	
Sept. 14	Wave			Sept. 22	Wave			Sept. 25	Wave		
		X ITCZ	X								
		X		Sept. 20	ITCZ	X					
Sept. 17	Wave		X								
Sept. 18	Dep.			Sept. 24	Dep.			Sep. 28	Wave	Janice	
Sept. 20	Wave			Sept. 28	Wave	X					
							X	Sept. 23	ITCZ		
		X ITCZ	X								
Sept. 22	Wave			Oct. 1	Wave			Oct. 4	Wave		Priscilla
Sept. 25	Wave			Oct. 2	Wave			Oct. 5	Wave	Dep.	
Sept. 28	Wave			Oct. 7	Wave			Oct. 9	Wave		
							X	Oct. 1	ITCZ		
		X		Oct. 4	ITCZ	X					
Sept. 30	Wave			Oct. 9	Wave			Oct. 12	Wave		
Oct. 2	Wave			Oct. 10	Wave	X					
Oct. 6	Wave			Oct. 12	Wave			Oct. 16	Wave		Dep.
Oct. 8	Wave			Oct. 16	Storm	X				Kristy	
Oct. 12	Wave			Oct. 18	Wave			Oct. 22	Wave		
Oct. 12	Wave			Oct. 18	Wave			Oct. 22	Wave		
		X ITCZ	X								
Oct. 14	Wave			Oct. 23	Wave			Oct. 27	Wave		
Oct. 18	Wave		X								
							X	Oct. 20	ITCZ		Dep.
Oct. 21	Wave			Oct. 26	Wave			Nov. 11	Wave		
		X		Oct. 25	Wave	X					
Oct. 24	Wave		X								
							X	Oct. 24	ITCZ		Ramona
Oct. 26	Wave			Nov. 1	Wave						
Oct. 29	ITCZ		X								
							X	Nov. 4	ITCZ		
							X	Nov. 14	Dep.	Laura	
		X		Nov. 16	ITCZ	X					

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TABLE 2.—*Summary of 1971 tropical systems according to type and geographical area of formation. The numbers in parentheses indicate systems that were counted in a weaker stage.*

	Africa	Tropical Atlantic	Subtropical Atlantic	Caribbean	Gulf of Mexico	Total
Waves	49	4	–	2	–	55
ITCZ	4	15	–	15	–	34
Depressions	3	–(4)	7(1)	–(2)	4(2)	14(9)
Named storms	0	–(1)	–(6)	–(4)	–(1)	–(12)
Totals	56	19(5)	7(7)	17(6)	4(3)	103(21)

number of disturbances emerging from Africa are of the ITCZ type. This should not significantly change the total number of African disturbances because this value is based entirely on pressure and wind indications over western Africa at coastal stations.

2. CENSUS OF 1971 TROPICAL SYSTEMS

The year 1971 featured 103 independent systems, 23 depressions, and 12 named storms. The results of the census are tabulated in tables 1 and 2 and shown schematically in figure 1. Table 1 presents pertinent information describing the history of 92 of the 103 systems, giving the dates when systems passed three key stations—Dakar, Senegal; Barbados; and San Andrés Island. The other 11 systems were either depressions or storms that formed in the Gulf of Mexico or over the waters of the subtropical Atlantic Ocean.

Table 2 summarizes the systems according to type and geographical area of formation. The numbers in parentheses indicates systems that were counted in a weaker stage of development. For example, of the six depressions that formed in the Gulf of Mexico (four plus the two in parentheses), two were spawned from tropical waves whose origin was in Africa. One of the depressions strengthened and became hurricane Fern. This is shown in the table by the number (1) within the parentheses. Over half of the systems originated in Africa and over half were wave type. This observation has been true in every one of the past 5 yr.

Figure 1 gives the number of systems that passed Dakar, Barbados, and San Andrés Island as well as the number that maintained their identity while crossing the Atlantic and Caribbean. Of the 56 African systems, 47 were tracked to the Caribbean and 38, all the way to the Pacific Ocean. Nine weakened in the central Atlantic. Ten disturbances were identified along the ITCZ in the Atlantic and were followed for at least 48 hr before dissipating. Another nine disturbances developed within the Atlantic and moved into the Caribbean. Fifty-six systems passed through the Antilles, 41 of which maintained their status while traversing the Caribbean. These 41 combined with the 17 that developed over the Caribbean resulting in 58 systems moving into Central America.

The depression tracks for the months June through November are shown in figure 2. The first depression of the year did not develop until July 4. Simpson and Hope

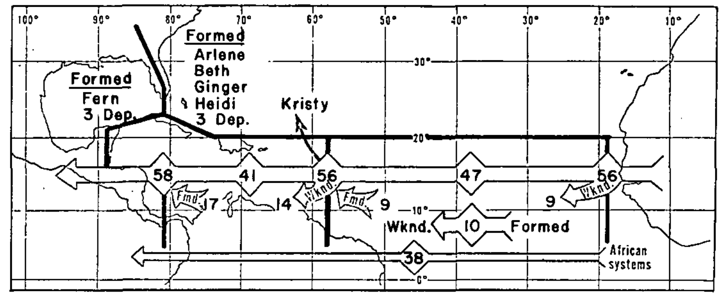

FIGURE 1.—Summary of the tropical systems that passed three key stations (Dakar, Barbados, and San Andrés) in 1971 and those maintaining their identity while crossing the Atlantic and Caribbean.

(1972) attribute the absence of depressions in June to above normal midtropospheric heights over the Gulf of Mexico, the Bahama Islands, and the southwestern Atlantic Ocean. Five depressions and one storm (Fern) formed in the Gulf of Mexico; one depression and four storms (Chloe, Edith, Irene, Laura) in the Caribbean Sea; four depressions and one storm (Janice) in the tropical Atlantic south of latitude 20°N; three depressions and six storms (Arlene, Beth, Doria, Ginger, Heidi, Kristy) in the subtropical Atlantic; and three depressions over Africa.

Even though the heart of the hurricane season (August and September) was unusually active, the geographical area of activity was abnormal. Over half of both the named storms (7 of 12) and depressions (14 of 23) formed in the subtropics near or north of latitude 25°N. We have been in a 4-yr period characterized by a significant decrease in tropical storm activity over the tropical portion of the Atlantic Ocean. The circulation features responsible for this trend are not readily apparent. In 1971, a very anomalous circulation pattern formed over the southwestern Atlantic and Gulf of Mexico during early September producing five depressions, three of which became named storms. The seed of this pattern was in the upper troposphere where a strong east-northeast to west-southwest-oriented trough developed and propagated downward to the surface in the form of an east–west shear line extending from the northern Gulf of Mexico nearly 2000 n./mi. eastward across Florida and the Bahama Islands into the Atlantic Ocean. As new impulses of energy were injected into the upper trough in the form of strong cold lows, depressions would form at the surface.

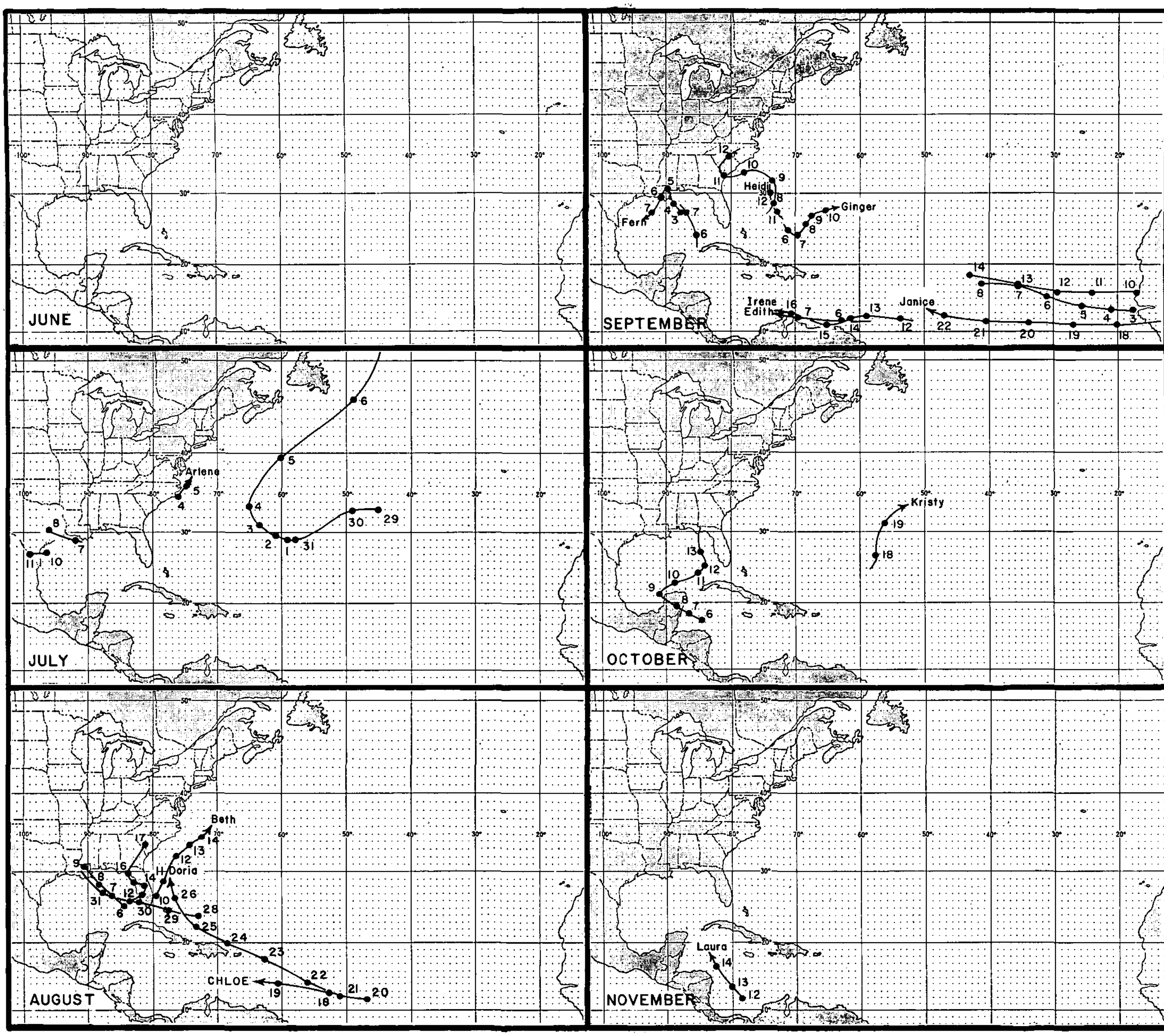

FIGURE 2.—Tracks of tropical depressions in 1971.

The surface map on September 11 (fig. 3) shows two of the depressions (one later became Heidi) and two storms (Fern and Ginger) spawned from this unusual circulation feature. In addition, two other depressions and tropical storm Edith were in existence on this day, marking September 11 as one of the most active days in recent years.

In conjunction with the large number of storms forming at unusually high latitudes, a greater percentage of the depressions and storms were spawned by disturbances of baroclinic origin. These two factors go hand in hand, and summers characterized by intense upper lows in the subtropics generally feature a large number of subtropical depressions and hurricanes.

Table 3 presents a summary of the type of seedlings that grew to depressions and storms in 1971. The seedlings have been grouped into two main categories, "tropical" and "baroclinic," depending on their source of energy; within each category there are two subdivisions. The tropical category includes those seedlings driven by latent heat. African systems have been placed in this group, although it is realized the driving mechanism is not clearly understood. A seedling has been labeled a disturbance if an enhanced area of convection persisted for at least 48 hr. It may or may not have been associated with the ITCZ. Baroclinic seedlings have been divided into two divisions; those which have their roots in the upper troposphere and those forming in conjunction with a baroclinic zone in the lower troposphere. Arlene offered a classical example of the latter process.

A cold front moved off the southeast coast of the United States on July 2, 1971, and became stationary. Overnight minimum temperatures revealed a temperature gradient of 2–3°C across the front. On July 3, satellite pictures (fig. 4) indicated the development of a frontal wave off the South Carolina coast. Figure 5 shows the

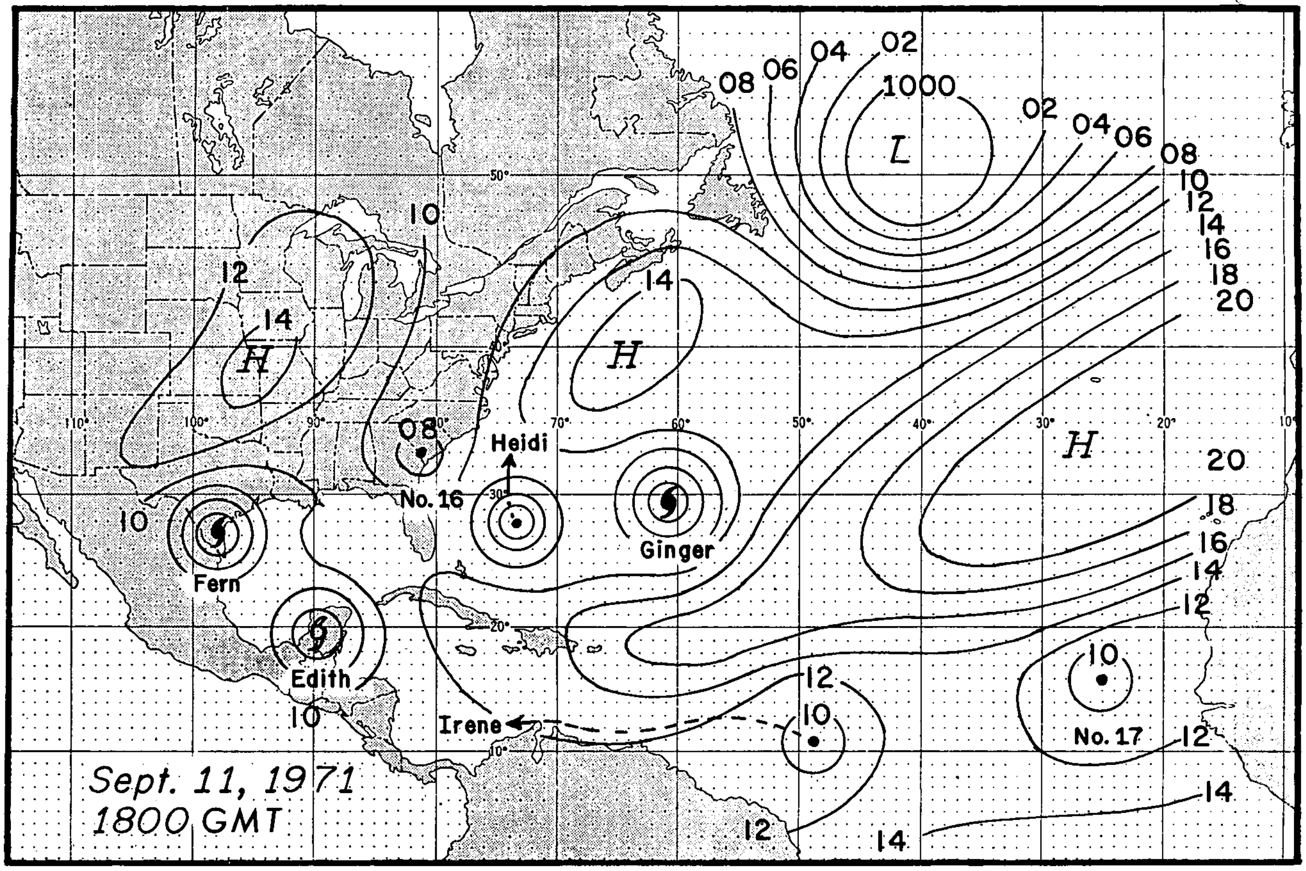

FIGURE 3.—Surface map for 1800 GMT, Sept. 11, 1971, showing four depressions and three named storms.

TABLE 3.—*Summary of the type of seedlings that initiated Atlantic depressions and named storms in 1971. The systems are listed under two main categories depending on their source of energy.*

	Tropical		Baroclinic		
	African systems	Disturbances	Upper troposphere	Lower troposphere	Totals
Named storms	6	1	3	2	12
Depressions	11	1	7	4	23

surface maps for 3 days during the period of development. The wave strengthened and moved toward the northeast, passing very near Cape Hatteras, N.C. The cloud pattern as viewed by the satellite on the 5th (fig. 4) was more circular, suggesting that the system was in a state of transition and becoming more tropical. This was confirmed later in the day when a reconnaissance plane found a warm core and winds in excess of the threshold value for a tropical storm. The suprising element in the development of Arlene was the rapidity of the transformation process.

Table 3 reveals that approximately half of the depressions (11 of 23) and 40 percent of the named storms (5 of 12) grew from baroclinic seedlings. This contrasts to the average for the previous 4 yr, which shows 20 percent of the named storms and 30 percent of the depressions coming from baroclinic systems.

Two of the depressions warrant special comment because they strengthened until they nearly satisfied the requirements for named storms. Each year one or more baroclinically initiated depressions strengthen and begin the metamorphosis process that leads to a warm core structure. During the transition stage, latent heat and baroclinic energies are released, and it is seldom possible to determine which source of energy is dominant because of data limitations. Spiegler (1971) discussed this type of system and Simpson and Pelissier (1971) suggested that they be called "neutercanes." The depression that developed east of Bermuda on July 29 was a hybrid type, and winds may have been near hurricane force when the Low approached the Maritime Provinces of Canada.

A second near-miss occurred in August when a depression began strengthening rapidly as its center approached Cedar Key, Fla. The depression formed southwest of Ft. Myers, Fla., on August 12, moved inland on the 13th, drifted slowly northward up the Florida peninsula on the 14th, and emerged back over the Gulf of Mexico north of Tampa on the 15th. Even though there was no evidence of intensification during the night at coastal stations, reconnaissance aircraft found 30-to 40-kt winds early on the 16th, and Cedar Key reported winds gusting to hurricane force for a brief period. Forecasters are consoled by the fact that advances in observing technology during the past 10–20 yr, including the evolution of radars and, more recently, satellites, eliminate the possibility of a major hurricane reaching the United States coast undetected; however, there is always the frightening chance of having a system intensify near the coast

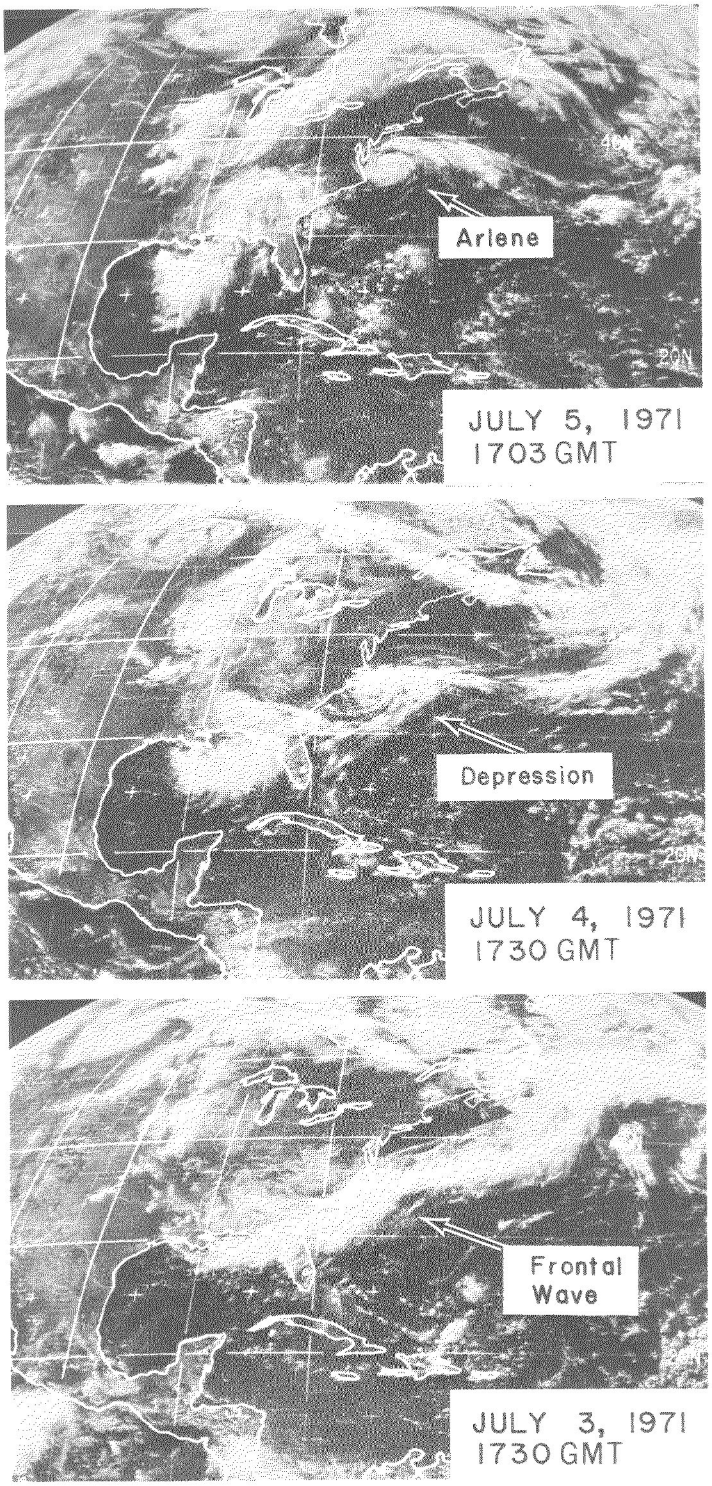

FIGURE 4.—Three-day sequence of Applications Technology Satellite pictures showing the development of Arlene.

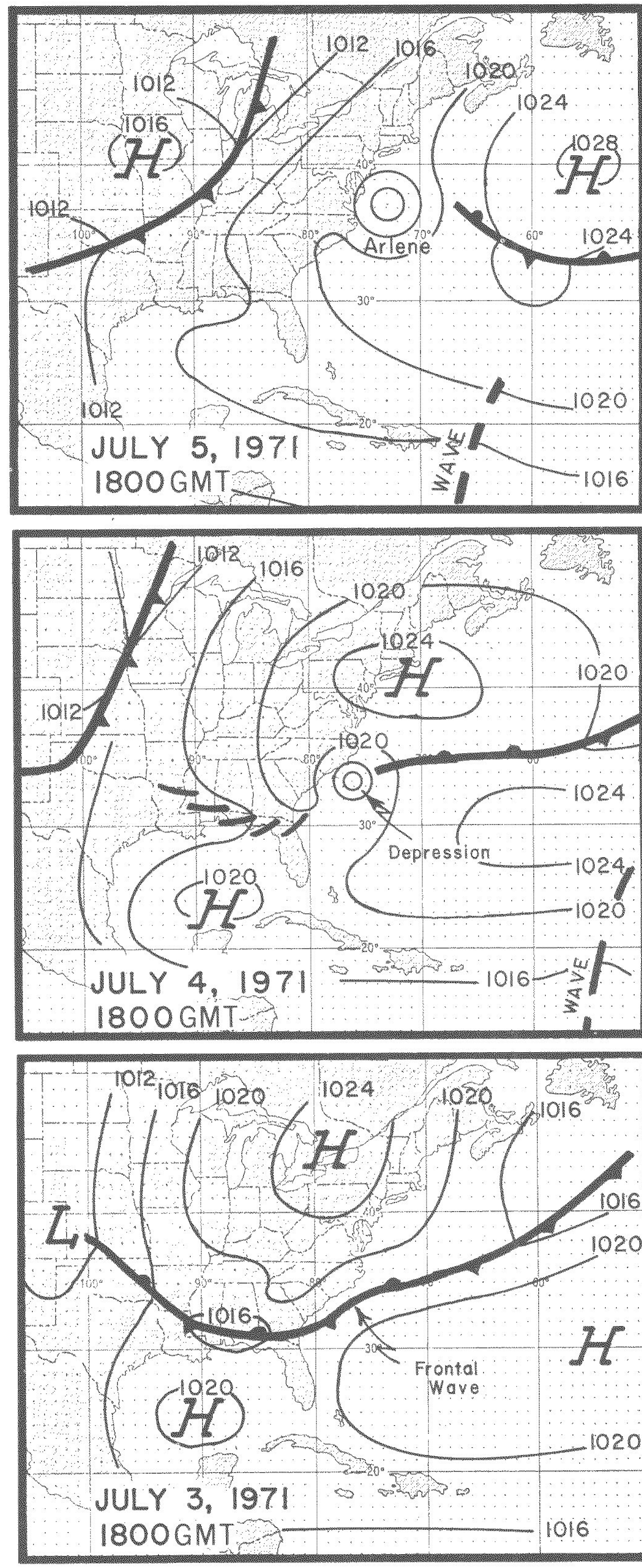

FIGURE 5.—Three-day sequence of surface maps showing the development of Arlene.

during the early hours of the morning when it is impossible to give advanced warning to coastal residents.

During the past 4 yr, we have attempted to relate the development of east Pacific storms to systems of Atlantic origin. Unfortunately, the lack of conventional data prevents a strong definitive position in some cases. San Andrés Island, located in the extreme western Caribbean, is the only reliable upper air reporting station that can be used to investigate this question. This means that unless disturbances are associated with recognizable cloud masses that allow satellites to establish the track, continuity must be maintained by extrapolating systems into the

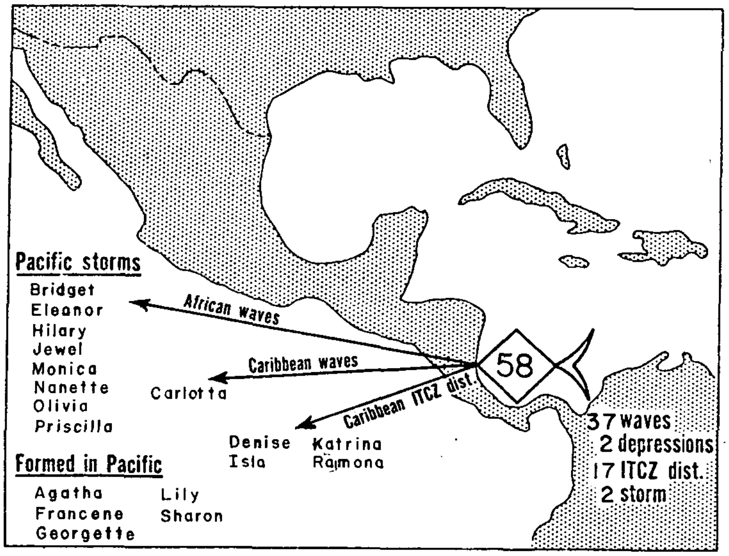

FIGURE 6.—Summary of the type of seedlings that initiated Pacific storms in 1971.

TABLE 4.—*Four-yr summary of the numbers of tropical systems within several categories*

	1968	1969	1970	1971	4-yr average
Total systems (all types)	107	105	85	103	100
Dakar systems	57	58	54	56	56
Barbados systems	59	44	53	56	53
San Andrés systems	40	43	45	58	46
Depressions	19	28	24	23	24
Named storms	7	13	7	12	10

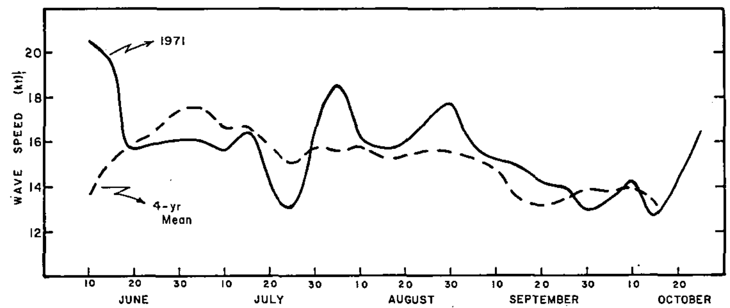

FIGURE 7.—Seasonal plot of the trans-Atlantic tropical wave speed for 1971 compared with the 4-yr mean.

Pacific with the speed that was observed in the western Caribbean. If the extrapolated positions eventually coincided with a developing area of convection on the ITCZ, the Atlantic perturbation was assumed to be the responsible agent. In no case was a disturbance carried on continuity beyond 3 days, and in most cases the extrapolated time period was only 1 or 2 days. The rationale for accepting this premise as a working hypothesis is that it conforms nicely with the Conditional Instability of the Second Kind (CISK) theory. CISK states that the vertical motion at the top of the boundary layer is directly proportional to the magnitude of the relative vorticity. Because wave disturbances are associated with positive vorticity, they provide a mechanism for enhancing convection.

The best example of a system maintaining its identity while crossing Central America in 1971 was the seedling that initiated Olivia. On September 7, a tropical wave emerged from Africa and started its journey across the Atlantic. A depression formed on the 11th near 11°N, 48.5°W and passed just south of Barbados on the 13th. Hugging the coast of South America, the depression experienced no significant change in strength until reaching the western Caribbean Sea, where winds increased and Irene was named. After moving inland, the remnants of Irene were easily followed across Nicaragua. Winds increased rapidly after the center moved into the Pacific Ocean and the system was redesignated by a new name, Olivia. Even though the evidence supporting the alleged continuity between Atlantic seedlings and Pacific storms is not as convincing as this in all cases, there is little doubt that Atlantic systems play an important role in east Pacific storm genesis.

The results for 1971 are shown in figure 6. Approximately two-thirds of the Pacific tropical storms were initiated by seedlings born on the Atlantic side of Central America, of which eight could be traced back to Africa.

3. COMPARISON WITH OTHER YEARS

Table 4 compares the storm totals in several categories for the past 4 yr with the average annual number (last column). Except for San Andrés systems, the storm totals for 1971 were very near the annual averages. However, one must use caution in using these annual averages because they are based on the past 4 yr, which have not been typical years. The reason for the sharp increase in the number of systems over the western Caribbean in 1971 is unknown but may be related to the anomalous circulation pattern that was established near this area in September.

The year 1971 was the fourth in succession that has been marked by a decrease in hurricane activity over the tropical Atlantic. Even though there was an abundant supply of storms and depressions in 1971, an unusually large percentage stemmed from subtropical baroclinic seedlings.

A new parameter is being introduced this year that we hope will eventually give us a better understanding of the hurricane problem as it relates to the large-scale circulation pattern. Historically, it has been difficult to determine anomalies in the broad-scale flow patterns over the tropical portions of the Atlantic Ocean because there have been no data. Inferences are generally based on extrapolation from midlatitude patterns and this is not very satisfactory. One of the parameters that we are able to compute from our data set is the average speed of disturbances as they cross the Atlantic from Africa to the Antilles and, heuristically, we believe this speed is directly related to the strength of the trades. Because the disturbance frequency is normally between 3 and 5 days, there are sufficient data to plot a seasonal curve of the wave speed. The seasonal plot was subjected to a 10-day running smoothing. A mean curve was then determined for the past 4 yr and is shown in figure 7 along with the curve for 1971.

During the first half of the 1971 season, the trade winds were weaker than normal. This was so until early August when the subtropical ridge shifted northward and strengthened, causing the trades to increase. The trades remained stronger than normal during August and September. Because there were very few storms in the Atlantic this year, this implies that the chance for hurricane genesis decreases in those years when the trades are abnormally strong and tropical waves move with an unusually fast forward speed. This also agrees with an old empirical forecast rule that states that fast-moving systems seldom strengthen.

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