

Atlantic Hurricane Season of 1973

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ABSTRACT

The general overview of the 1973 hurricane season in the North Atlantic is presented together with detailed accounts of all named tropical storms.

1. General summary

The tropical Atlantic remained relatively quiet in 1973 as hostile atmospheric conditions continued to discourage storm development. The current lull in storm activity began in 1970 with the development of strong upper-tropospheric westerlies over the Caribbean and the appearance of abnormally cool sea-surface temperatures between Africa and the Antilles. For the third time in the past four years both the number and intensity of tropical cyclones in the Atlantic were below normal. Seven tropical cyclones were given names and four attained hurricane strength. The past 30-year averages are nine and six respectively.

This was the first year since 1962 that a hurricane did not cross the United States coastline; therefore, damages and loss of life in the United States were the lowest since 1963 and 1968, respectively. Delia claimed 5 lives and caused \$18 million in damages in Texas and Louisiana. For all areas of the Atlantic, Caribbean, and Gulf of Mexico, 16 lives were lost and damage estimates were less than \$20 million. Statistics for the 1973 season are presented in Table 1.

The tracks of the 1973 named storms are shown in Fig. 1. During the past few years the National Hurricane Center has attempted to differentiate between pure tropical storms and those of mixed character,

which have been designated subtropical cyclones (Simpson, 1973). Fran and Gilda both possessed subtropical features during a portion of their existence and one other small subtropical cyclone developed and was labeled Alfa. The tracks of the subtropical portions of these storms are shown in Fig. 2.

One of the most significant characteristics of the last three hurricane seasons has been the lack of storm development in the central and eastern Atlantic. Apparently, this is not because of a reduction in the number of opportunities. Frank and Hebert (1973) found that the number of disturbances emerging from Africa was exactly normal, and that 1973 produced an abundance of hurricane seedlings. Why the lack in storm activity? Even though the exact reason cannot be specified, it is possible to look at anomalies of several environmental parameters that are at least consistent with inactivity.

In 1972 the large-scale flow over the tropical Atlantic was more baroclinic than normal. This pattern persisted in 1973. One way of measuring the magnitude of this effect is to examine the vertical shear of the horizontal wind from the upper to the lower troposphere. Fig. 3 shows the mean vertical shear (Simpson, 1970) over the primary development areas during the peak of the 1973 hurricane season, and Fig. 4 depicts the changes

TABLE 1. Summary of North Atlantic tropical cyclone statistics, 1973. (H) indicates hurricane and T, tropical storm.

No.	Name	Dates	Maximum sustained wind (kt)	Lowest Pressure (mb)	U. S. damage (\$ millions)	Deaths
1)	Alice (H)	July 1-6	80	986		
2)	Brenda (H)	Aug. 18-22	70	977		
3)	Christine (T)	Aug. 25-Sep. 4	62	996		
4)	Delia (T)	Sep. 1-7	60	986	18.0*	Mexico, 10 Puerto Rico, 1 U. S., 5
5)	Ellen (H)	Sep. 14-23	120	962		
6)	Fran (H)	Oct. 8-13	70	978		
7)	Gilda (T)	Oct. 16-29	50	994	†	

* 15 million dollars of this amount was crop damage resulting from heavy rains with Delia and a tropical depression which affected the same area five days later.

† An undetermined amount of beach erosion was caused mainly by the subtropical storm which developed from Gilda.

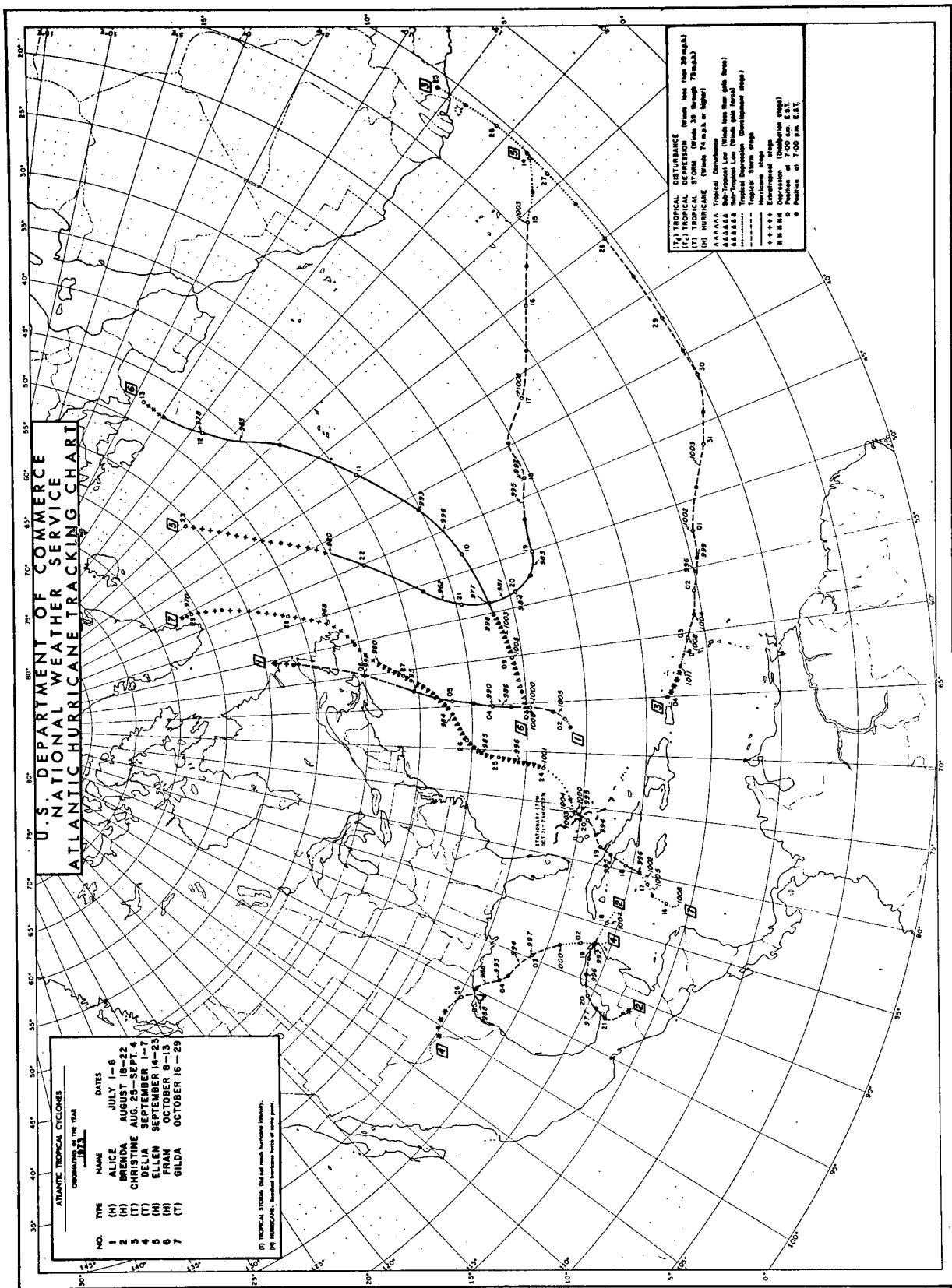


FIG. 1. Tracks of Atlantic tropical storms and hurricanes of 1973.

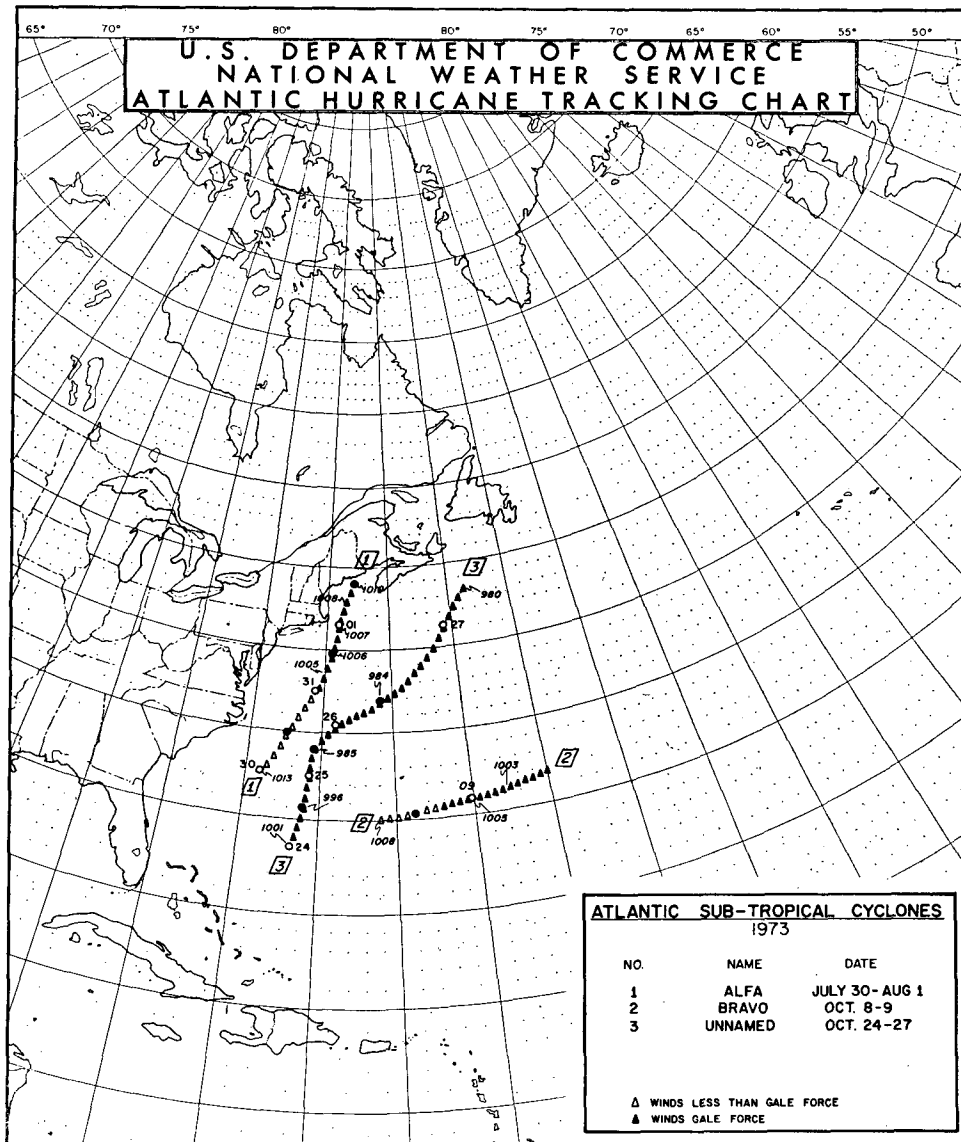


FIG. 2. Tracks of Atlantic subtropical storms of 1973.

from 1972. Little change is noted in the magnitude of the shear except over the western Caribbean where two storms and one strong depression developed during this period in 1973. The stronger than normal shears indicated unusually cool temperatures aloft continuing over the tropics.

Another parameter that is important is the temperature of the sea. Fig. 5 shows the mean sea-surface temperature anomalies for the period from 15 August to 15 September, and Fig. 6 shows the changes from 1972. The anomalously low sea-surface temperatures (SST) of 1972, which extended from the Lesser Antilles to Africa, gave some indications of returning to normal in 1973, but remained marginally near Palmén's threshold value for development (Palmén, 1948).

In spite of the fact that storm development was

below normal, several noteworthy firsts were observed during the 1973 hurricane season. Alice was the first July hurricane to threaten Bermuda, and Brenda was the first hurricane of record to affect the southeastern coastal sections of Campeche Bay while moving onshore. Delia was the first storm to make two landfalls over the same coastal location, and the evolution of Gilda from a tropical storm to a severe subtropical cyclone was the first such event documented.

Detailed accounts of individual storms follow.

2. Individual storms

a. Hurricane Alice, 1-6 July

Alice was the first hurricane or tropical storm of record to ever develop or pass near Bermuda in July.

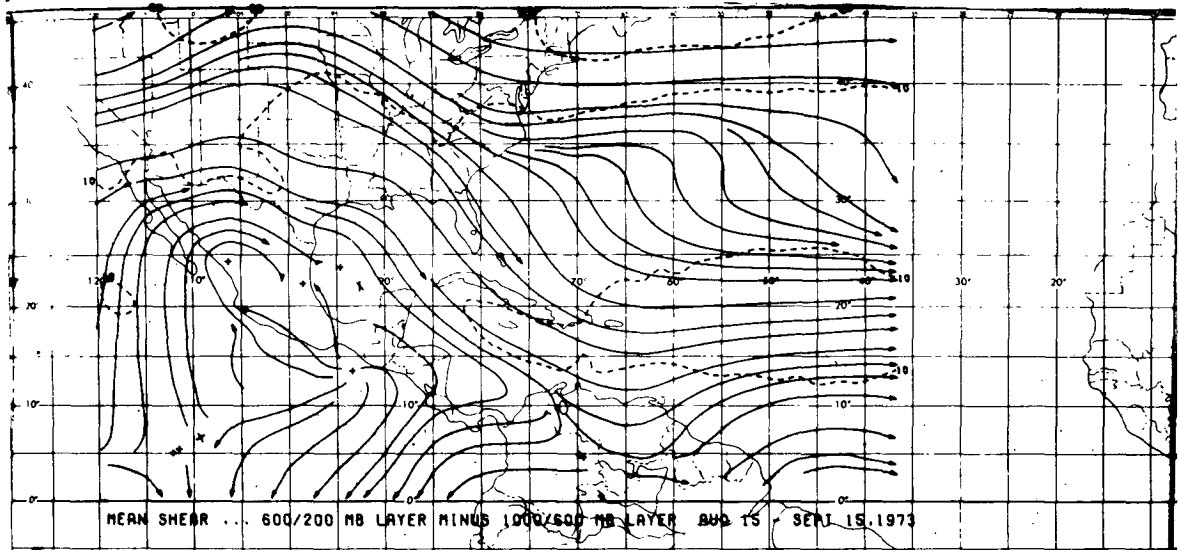


FIG. 3. NHC tropospheric mean wind shear field (600-200 mb upper mean minus the 1000-600 mb lower mean) for the period 15 August-15 September 1973.

The interaction of merging convective cloud systems of an easterly wave and a weak middle-tropospheric trough moving eastward from Florida produced a weak circulation northeast of the central Bahamas late on 28 June, but the first evidence of a well-defined circulation came on the 30th when ship reports located a low near 26N, 69W.

The development process during the initial stages appeared to be drawing more on baroclinic energy than on the latent heat releases of the convection. Satellite pictures showed the low-level cyclonic cloud banding separated from the dense, convective cloudiness to the east. This type of cloud presentation is usually associ-

ated with strong upper westerlies and this impedes tropical storm development. Environmental conditions surrounding the depression gradually became more favorable, as vertical shears over and near the depression slowly decreased, allowing the low-level cyclonic circulation to gradually merge with the convective energy source to the east.

Winds approached gale force on 1 July and reconnaissance aircraft consistently reported winds in excess of tropical storm force on the 2nd, when the system was named. A persistent ridge of high pressure to the east steered Alice on a northward course at 10 kt during the next 48 hours. As the high level flow pattern

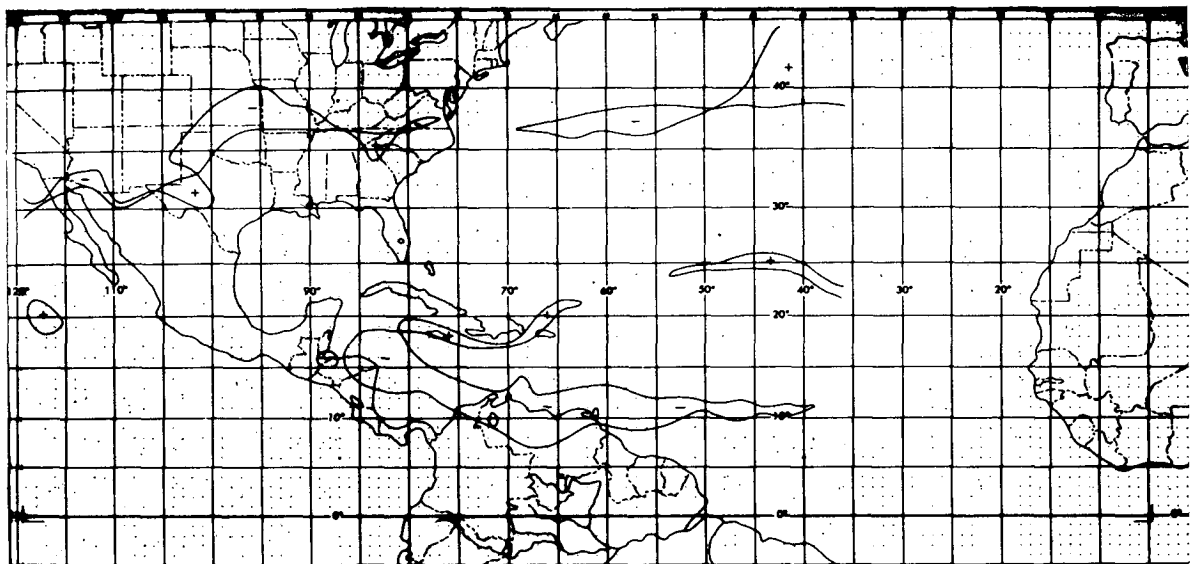


FIG. 4. Change of the 10-kt mean wind shear isotach of Fig. 3 from the same period in 1972.

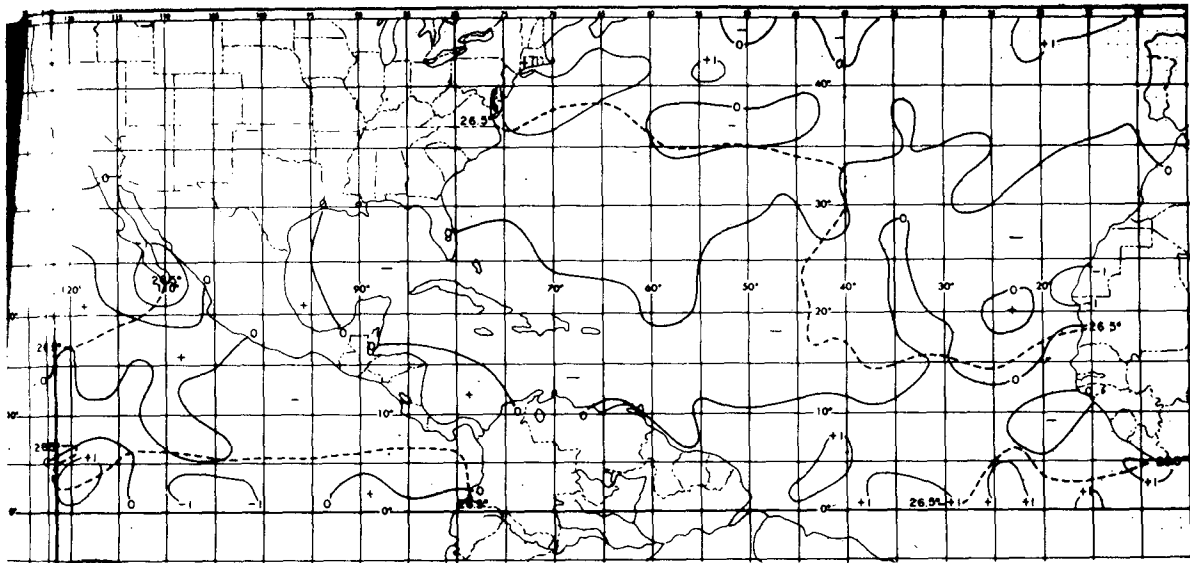


FIG. 5. Sea surface temperature (SST) anomalies ($^{\circ}\text{C}$) for the period 15 August–15 September 1973. The 26.5C isotherm (dashed line) indicates the Palmén threshold for hurricane development (Palmén, 1948).

became more favorable for outflow the storm continued to deepen and Alice became a hurricane on the morning of the 3rd. Reconnaissance aircraft found sustained 700-mb flight level winds of 70 kt and satellite pictures revealed a well-defined eye. Eighteen hours later the lowest central pressure of 986 mb was recorded by a reconnaissance aircraft as the radar set at Bermuda indicated the eyewall of the hurricane was brushing the western tip of the island.

The lowest pressure reported from Bermuda was 995 mb at 0630 GMT 4 July. The maximum sustained surface wind was 43 kt, while gusts reached 57 kt.

Sustained winds reached 65 kt with gusts to 77 kt atop a 100-ft tower on the island. Rainfall from the hurricane totalled 4.54 inches.

Alice accelerated northward when a middle tropospheric trough moved into the North Atlantic States. Winds decreased to less than hurricane force late on the 5th, and the system was in the process of losing its tropical character as it crossed the southwest coast of Newfoundland around 1700 GMT 6 July.

Sable Island, near 44N, 60W, measured surface winds of 40 kt with gusts to 57 kt as the center passed 20 mi to the west about 1000 GMT 6 July, but winds of gale force were not observed over Newfoundland.

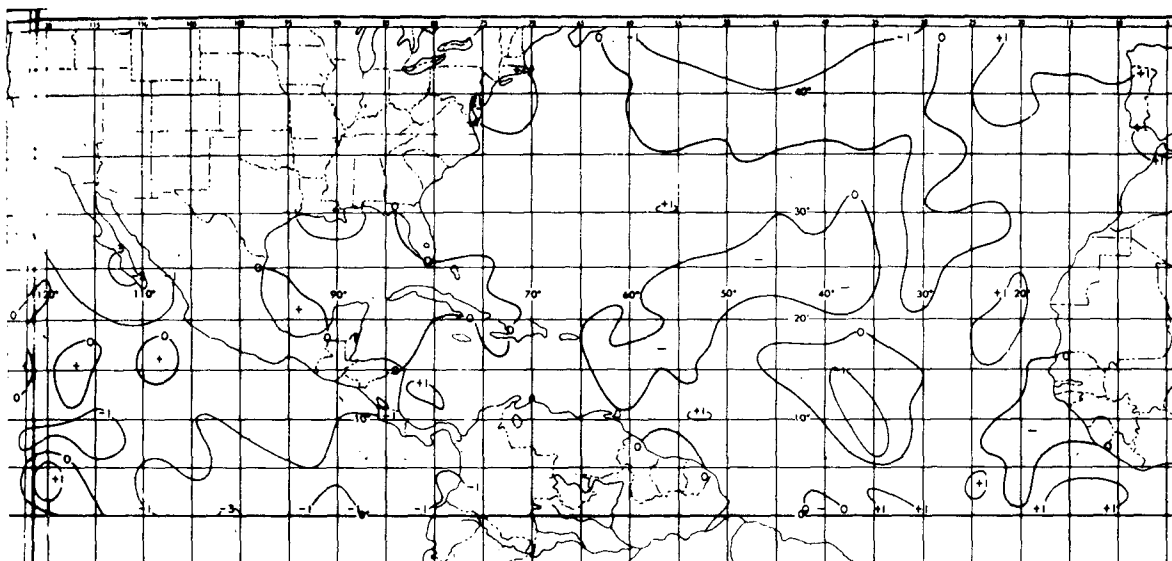


FIG. 6. Changes in the SST anomalies of Fig. 5 from the same period in 1972.

No casualties or significant damage have been attributed to Alice.

b. Hurricane Brenda, 18–22 August

The disturbance which eventually developed into Brenda moved westward off the African coast south of Dakar, Senegal, on 9 August. The disturbance weakened after leaving the coast, moving across the Atlantic as an inverted-V tropical wave. The first signs of development occurred on the 13th when a large area of showers and thunderstorms developed over the Lesser Antilles. This area of disturbed weather became more concentrated as the system moved to the western Caribbean during the next three days. A sharp amplitude upper and middle tropospheric trough had preceded the convection by about 300 mi. East-northeast winds of 40 to 60 kt at middle tropospheric levels were reported by several stations in advance of the trough. Satellite pictures on the 17th revealed the convection had consolidated into a concentrated, nearly circular pattern, and the 850-mb wind at Kingston, Jamaica, shifted to southeasterly 55 kt at 1200 GMT. Thickness values indicated the system was quite warm, and Grand Cayman gave evidence of strong convection by recording over four inches of rain on the 17th.

A ship near 21N, 84W reported 45 kt southeast winds and 18-ft seas that evening, suggesting that a low center was developing. A NOAA-2 infrared satellite photograph at 0117 GMT 18 August also suggested formation of a low center. The next morning a ship just south of Cape San Antonio, Cuba, reported winds shifting from northeasterly 50 to 60 kt to southeasterly 45 kt accompanied by 20-ft seas. A reconnaissance aircraft reported winds nearing hurricane force during the afternoon, and the central pressure dropped to 992 mb shortly before the center moved inland 30 mi north of Cozumel, Mexico, during the early evening.

The center passed directly over Merida 24 hours later, and was turned southwestward into the Bay of Campeche on the 20th by a strong ridge of high pressure building over Texas and Mexico. Rapid intensification occurred after the center moved offshore. ATS-3 satellite pictures revealed an eye at midday, and a reconnaissance aircraft reported a central pressure of 977 mb and maximum sustained winds of 70 kt about 0000 GMT 21 August. At the same time an unidentified ship north of the center reported hurricane force winds of 65 kt from the northeast, one of two ship observations of hurricane force winds during the 1973 hurricane season. It is likely that further intensification took place prior to landfall 30 mi west of Carmen early on the morning of the 21st. Rapid weakening occurred over land, and the system was downgraded to a depression by 0000 GMT 22 August.

The turn of Brenda to the southwest and south was very unusual for an August storm. Brenda was the first hurricane of record to affect the southeast coastal

sections of Campeche Bay by moving onshore from the Gulf of Mexico. The only other tropical cyclones of storm intensity to move ashore in the Carmen-Campeche area occurred in May 1933, and October 1922 and 1936.

Carmen reported the highest sustained wind by a land station—45 kt with gusts to 50 kt, but hurricane force winds undoubtedly occurred near the center. Gusts to gale force were observed as far west as Vera Cruz. Earlier, Cozumel and Merida had experienced winds of minimal gale force.

Ten persons were killed in coastal towns as widespread tidal flooding occurred from Vera Cruz to Campeche. The town of Campeche was 80% flooded, the worst in 25 years. The hurricane destroyed 50% of the houses in coastal municipalities of the state of Tabasco, leaving 2000 persons homeless. Another 2000 persons lost their homes in Carmen.

The press mistakenly associated widespread damage over large portions of Mexico with Brenda. Prior to the arrival of this storm, a prolonged three-month rainy period had caused considerable flooding damage over central Mexico, and this damage was enhanced by an earthquake along the southeast Mexican coast west of Brenda's landfall.

The Greek freighter *Yucatan* was crippled by Brenda when caught by the unexpected turn to the south. In addition, Brenda terminated the almost-completed Acali Raft Experiment of human endurance, which had departed from the Canary Islands on 12 May.

c. Tropical storm Christine, 25 August–4 September

The disturbance which produced Christine left the west African coast as a strong depression on 25 August. Unlike many African disturbances which produce tropical storms, its passage 300 mi to the south of Dakar, Senegal, was barely reflected in the latter's upper air soundings.

Satellite pictures on the morning of the 28th indicated the system was probably of minimal tropical storm strength and later that day the German cargo ship *Steinfels* reported winds of 30 to 35 kt veering from NE to S, while passing some distance east of the center. Except for the ephemeral Ginger of 1967, Christine became the first tropical storm since 1966 to form as far east as longitude 30W. The first advisory on Christine was not issued until late on the 30th when a reconnaissance flight found a surface pressure of 1007 mb and sustained surface winds of 45 kt about 1000 miles east of Trinidad.

The storm reached maximum strength on 2 September when reconnaissance aircraft obtained the lowest central pressure of 996-mb and 700-mb maximum sustained winds of 62 kt from the east. With the storm located 300 mi east of Guadeloupe, gale warnings and a hurricane watch were issued at noon AST on the 2nd for the northern Leeward Islands of Guadeloupe,

Desirade, Antigua, and Barbuda. Later in the day, gale warnings were extended southward to Dominica.

As has been the case several times in recent years, the storm began to weaken steadily as it approached the Leeward Islands, and was of less than tropical storm strength when it reached Antigua at midday on the 3rd. Satellite pictures that day indicated a strong vertical shear of the horizontal wind over the storm, and as a consequence the low-level circulation separated from the convective system of the storm. The depression degenerated into an easterly wave while approaching Puerto Rico and finally lost its identity under an upper cold low north of Hispaniola on the 6th.

Heavy thundersqualls moved into the Leeward Islands early on the 4th and spread westward to Puerto Rico later that day. Wind gusts to 49 kt occurred at San Juan during the late morning, causing minor damage over eastern Puerto Rico. One person died when electrocuted by a fallen power line. Heavy rains up to $9\frac{1}{2}$ inches in southeastern Puerto Rico caused minor flooding. Similar conditions likely prevailed over the Virgin and northern Leeward Islands, but detailed information is lacking.

d. Tropical storm Delia, 1-7 September

Delia was the only tropical storm or hurricane of 1973 to cross the U. S. coastline, but it did so twice. The storm made a loop back over the water shortly after moving ashore in the Galveston-Freeport area during the evening of the 4th, and moved onshore again in the same area 24 hours later. The Galveston-Freeport area thus becomes the first coastal section of the United States ever to have two landfalls with the same storm. The two landfalls of hurricane Easy in the Cedar Key-Tampa area in 1950 were somewhat further apart.

Delia was triggered by a tropical wave that developed over the central Caribbean on 27 August. This disturbance moved west-northwest during the next three days, and phased with an upper tropospheric cold low which had moved from north of Hispaniola to the eastern Gulf of Mexico.

ATS-3 satellite pictures on the 30th and 31st showed a gradual increase in convection with evidence of cyclonic banding. Surface observations on the 31st indicated a weak cyclonic circulation over the Gulf of Honduras. The depression drifted northward along the east coast of the Yucatan Peninsula on 1 September with satellite pictures showing the convective area becoming more concentrated and circular. The depression moved northwest into the Gulf of Mexico during the night and by the afternoon of the 2nd, a reconnaissance aircraft found a central pressure of 1000 mb and 45 kt winds about 150 mi north of the Yucatan Peninsula, promulgating the first advisory on Delia.

Slow intensification took place during the next 24 hours as Delia continued northwest at 13 kt. How-

ever, large scale baroclinic changes hostile to hurricane development began to dominate the Gulf of Mexico. A large scale cyclonic circulation developed in the middle troposphere, and there was evidence of a surface low in the Bay of Campeche to the south of Delia on the 3rd. These changes reduced the low level mass inflow and restricted significant strengthening of the tropical circulation. Together with passing anticyclones to the north they also contributed to two tight loops in the northwestern Gulf of Mexico before the storm moved inland on the 6th and weakened rapidly. The remains of the storm turned west-southwest and dissipated over the mountains of northern Mexico on the 7th.

Reconnaissance aircraft measured maximum sustained winds of 60 kt on the 3rd and 4th, and reported squalls well above hurricane strength on the 4th and 5th. However, Delia never developed the classic wall cloud of a hurricane, and sustained winds remained just below hurricane force. The lowest pressure of 986 mb was reported by reconnaissance aircraft just prior to the first landfall on the 4th.

Gales of 40 to 45 kt occurred from Freeport to Galveston with gusts of 50 to 60 kt. The maximum recorded sustained wind of 40 kt and gusts to 59 kt occurred at Galveston on the 4th. The lowest pressure recorded by a land station was 992 mb at Freeport early on the 6th. At least 8 tornadoes were reported in Louisiana and Mississippi on the 4th and 5th, causing 4 injuries but no significant damage. Additional meteorological data is given in Table 2.

Tides of 4 to 6 ft MSL in Galveston Bay caused flooding of the Baytown area and an estimated \$3 million in losses for homeowners. Coastal industrial and marine interests suffered only minor losses from Delia.

Significant damage to crops estimated at \$3 million resulted from 8- to 10-inch rains over southeastern Texas and southwestern Louisiana. These losses were augmented when a strong tropical depression moved into the same area five days later and became nearly stationary, producing up to 15 inches of additional rainfall along the Texas coast. The destruction of the rice crop blown down earlier by Delia raised total crop losses to an estimated \$15 million. The crop was ready for harvest and salvageable prior to the rains associated with the second depression. However, there was considerable benefit to inland agricultural interests, as the weakening storm brought needed moisture to pasturelands.

There were 5 deaths associated with Delia in the Houston-Galveston area—two drownings in flooded culverts, one heart attack while boarding up, and two automobile fatalities on rain-slicked streets.

Gale warnings and a hurricane watch were issued at 11 a.m. CDT 3 September for the Louisiana coast east of Lake Charles to the mouth of the Mississippi River. They were extended westward to Palacios, Texas, at 5 p.m. CDT as the storm turned more to the west,

TABLE 2. Tropical storm Delia, 1-7 September 1973, meteorological data.

Station	Date	Pressure (mb)		Fastest mile	Wind (kt)				Tide (ft)		Rainfall (inches)		
		Low	Time†		Time†	Gusts	Time†	Highest MSL	Time†	Storm total	Dates		
Louisiana													
Cameron CG	5			NE	30	4/1000	NE	40	4/1000	5.2‡	0220		
Lake Charles WSO	4	1001.0	1550	E	26	1645	E	35	4/1530			9.99	3-6
Southwest Pass	5			SE	40	0300							
Texas													
Austin WSO	6	995.3	0930	NW	32	5/2013	NW	43	5/2013				
Baytown	6									5.6	0400		
Corpus Christi WSO	5	1001.4	0357	NW	36	1427	NW	41	1404	2.6	4/1100		
Freeport CG	6	992.2	0000	NNE	35	4/1500	NNE	56	4/1500	4.5	5/0000	4.07	
Galveston WSO	4	994.2	1700 and 6/0000	NE	40	1256	NE	59	1300			2.60	
Galveston Oil Rig 25 SSE	4			NE	45	1200	SE	48	5/2200				
Houston WSO	6	993.9	0253	E	30	0355	E	48	0402			5.04	4-6
Matagorda	5	993.6	0100				NW	43*	0130	3.6		7.40	
Palacios	5	993.9	0100	NW	40					4.0		6.04	
Port Aransas CG	5			WNW	32	0600							
Port O'Connor CG	5			NNW	38	0300							
Sabine CG	5			SE	45	2200	SE	50	2200	4.3	4/1500		
Sargent	5	993.9	0000				NW	35*		4.5		10.93	

† Central Standard Time.

‡ Above mean low water.

* Estimated.

and discontinued east of Morgan City at 11 p.m. CDT as the threat diminished. Gale warnings had to be extended to Baffin Bay south of Corpus Christi at 8 a.m. CDT on the 5th as Delia looped southwestward. Observed winds along the coast indicate that warnings were adequate.

e. Hurricane Ellen, 14-23 September

Ellen was the second tropical cyclone of the 1973 season to reach storm intensity in the far eastern Atlantic and eventually became the most intense hurricane of the season. NOAA's Research Flight Facility reconnaissance aircraft measured a minimum central pressure of 962 mb and maximum sustained winds of 120 kt at 1500 ft on the 21st.

Ellen formed from an African disturbance. The cloud system moved off the coast on 13 September and formed a depression about 300 mi south of the Cape Verde Islands on the 14th. Twenty-four hours later the French naval vessel *Garonne* passed through the system and reported a minimum pressure of 1003 mb with 40 kt southerly squalls. Because of the sparsity of conclusive data, the first advisory on Ellen was not issued until the 17th. On that day reconnaissance aircraft found a minimum pressure of 1008 mb and 50-kt surface winds near 22N, 36W.

The storm had moved steadily northwestward at 17 kt after leaving the Cape Verdes. During that time satellite pictures showed the convective cloud mass becoming progressively elongated north-northwest to south-southeast, suggesting that the storm was being

influenced by a weak trough of low pressure between two high pressure cells within the Azores-Bermuda ridge. This trough interacted with a trough passing in the westerlies on the 17th. As the latter continued eastward the westernmost high pressure cell near 30N, 50W strengthened, turning Ellen westward.

Satellite pictures on the morning of the 18th showed a more circular convective cloud system and a diffuse eye, and by late afternoon reconnaissance aircraft found a central pressure of 995 mb and 700-mb flight-level winds of 60 kt. Ellen strengthened to hurricane force that evening and on the 19th a reconnaissance aircraft measured a 985-mb central pressure, 700-mb flight level winds of 75 kt, and a temperature rise of 8C in the eye. The hurricane turned sharply towards the northwest late on the 19th in response to a weak trough moving northeastward from the Bahamas. Rapid intensification to maximum strength took place on the 21st as the hurricane accelerated northeastward ahead of a deepening upper trough moving off the east coast of the U. S. Ellen reached a forward speed of 50 kt on the 22nd before becoming extratropical when the hurricane merged with a frontal zone about 650 mi east of Newfoundland.

No casualties or major damage to shipping has been attributed to Ellen.

f. Hurricane Fran, 8-13 October

A convective cloud system located north of Hispaniola on 1 October gave birth to subtropical cyclone Bravo, which in turn matured and transformed into

hurricane Fran. The shower activity was associated with a midtropospheric trough which had been moving westward across the Atlantic during the preceding week, and may have originated in Africa. The system interacted with a weak mid-tropospheric trough near the U. S. coast, producing a surface trough from south-eastern Florida northeastward on the 4th.

Ship reports of light west winds just east of Florida on the 5th suggested that a weak circulation was developing. Satellite pictures showed increasing organization of the convective pattern during the next 3 days as the system drifted eastward. Ship reports indicated a 1008-mb low pressure center near 30N, 67W on the morning of the 8th and a reconnaissance aircraft found 35-kt surface winds during the late afternoon.

In the meantime, a cold front had moved southward over the western Atlantic and merged with the developing depression. Ship reports indicated that non-tropical air was entering the depression's circulation from the north, and when winds attained storm strength the low was designated subtropical cyclone Bravo. On the next day, however, a reconnaissance flight found hurricane force winds 15 mi from the center and a warm core at 700 mb; thus Bravo was re-classified as hurricane Fran.

Under the influence of a deep surface low in the westerlies, the hurricane accelerated to a forward speed reaching 35 kt by the 11th, passing about 30 mi north of the islands of Flores and Corvo in the Azores. Ship reports and satellite pictures indicated that Fran maintained tropical character until merging with a cold front and becoming extratropical about 300 mi off the French coast late on the 12th.

Southerly surface winds of 35 to 45 kt were reported at 1200 and 1800 GMT on the 11th in the Azores but the maximum winds experienced in the Islands are not known. One of the two ship observations of hurricane force winds during 1973 had been received from the Belgian cargo ship *Fruhel Oceania* 24 hours earlier, when it was buffeted by 65-kt southwest winds near 32N, 49W. The maximum sustained wind measured by reconnaissance aircraft during the storm was 70 kt on the 11th at 1500 ft.

The lowest central pressure measured by reconnaissance aircraft was 993 mb on the 10th, when the hurricane was midway between Bermuda and the Azores. The central pressure in Fran continued to fall after the storm passed the Azores. The French cargo ship *Cetra Columba* reported 981 mb and southerly winds of 35 kt 30 mi east of the center on the 12th. At the same time the German cargo ship *Stephanitor* reported 982 mb and westerly gales to 60 kt 125 mi southwest of the center. From these two ship reports the lowest central pressure during Fran's life was calculated to be 978 mb.

Thus far, no casualties or significant damage has been attributed to Fran.

g. Tropical storm Gilda, 16-29 October

The development of Gilda seemed to be at least partially influenced by a disturbance which left the African coast on 3 October. It reached the eastern Caribbean on the 10th, and developed a large convective system from Hispaniola southwestward to Panama by the 13th. The convection became better organized and more concentrated over the northwestern Caribbean on the 15th, as a large 200 mb anticyclone developed just south of Jamaica, changing to anticyclonic the rather strong, cyclonic vertical shears which had persisted over that area during the preceding week.

A diffuse tropical depression finally formed northeast of Cape Gracias, Nicaragua, late on the 15th. The depression drifted northeastward and continued to strengthen, and late on the 17th a reconnaissance flight found a central pressure of 996 mb. The depression developed into tropical storm Gilda just 60 mi east of Grand Cayman.

Initially, Gilda appeared to present the first serious threat of a hurricane to southeast Florida since Gladys of 1968. National Meteorological Center (NMC) prognostic charts for the next 72 hours indicated lower and higher level steering currents would become rather delicately balanced, leaving indeterminate whether the net effect would be to steer Gilda slightly west or slightly east of due north.

Middle and upper level steering currents prevailed, and the storm moved north-northeast at 6 kt for 48 hours and even more slowly northeast during the next 24 hours. The storm showed little change in strength during this time. Reconnaissance aircraft found the lowest central pressure of 994 mb and the maximum sustained winds of 50 kt during the tropical portion of Gilda's life when the storm was centered off the southern tip of Andros Island on the 19th.

The high level anticyclone remained south of Jamaica as the storm moved northward and came under the negative influence of increasing vertical shears. Satellite pictures on the morning of the 19th showed the convective cloud system separating from the low level circulation, and by the 21st the two were almost completely detached. Slow weakening took place until Gilda was downgraded to a depression at noon EDT on the 22nd. As the storm weakened, low-level steering forces became more dominant, and rising surface pressures around the center stalled it about 60 mi east of Harbour Island late on the 21st.

The storm did not affect Cuba significantly. The lowest sea level pressure reported over the island was 995 mb in Camaguey Province, while the mountain station of Gran Piedra, located well east of the center in Oriente Province, reported the highest sustained wind of 50 kt. Moron, near the north coast just east of the storm's path, reported a six-hourly rainfall of 6.13 inches before the center passed.

While total monetary losses in the central Bahamas were small, the storm proved to be a personal disaster

for most of the farmers on Exuma, Eleuthera, Cat, Long, south Andros, and Harbour Islands and adjacent cays. Most of the losses were caused by the prolonged high tides and heavy rains. Several U. S. Navy automatic weather stations on the east coast of Andros Island reported wind gusts in excess of 50 kt on 19 October. The highest gust was 65 kt at Golden Cay around midday.

After remaining stationary for 36 hours, tropical depression Gilda came under the influence of a cold, upper trough digging southward over the Carolinas on the 23rd, and began moving northeastward and deepening. Synoptic and reconnaissance reports on the morning of the 24th indicated the depression was being transformed into a large, vigorous subtropical cyclone, as the cold air associated with the Carolinas trough provided a baroclinic acceleration of Gilda's circulation. The transformation was completed by the afternoon of the 25th when the huge, severe storm packing sustained winds near 60 kt and a central pressure of 985 mb passed midway between Hatteras and Bermuda. Thus, Gilda became the first tropical storm of record to pass through a subtropical stage en route to becoming extratropical. At one time the circulation of the storm covered the western Atlantic from New England to the Bahamas and eastward beyond Bermuda.

The storm turned northeastward away from the U. S. on the 26th and became extratropical just southeast of Sable Island, Nova Scotia, on the 27th. The central pressure dropped to 968 mb as the low passed just east of Cape Race, Newfoundland, on the 28th, but the stabilizing influence of the colder waters prevented any further increase in surface wind strength. The system that was once Gilda became quasi-stationary off the southeast coast of Greenland on the 29th and gradually filled.

The U. S. Coast Guard Cutter *Taney* (Ocean Station Vessel "H"), located near 38N, 71W, endured gales for 54 hours and 50-kt winds for 24 hours. Seas rose to a peak of 28 ft during the evening of the 25th and early morning of the 26th. Several other ships reported 50 kt gales and seas 20 ft or more on the 25-26th. Sable Island reported northerly gusts to 64 kt on the 27th as polar surface air was drawn into the storm's circulation.

The pounding surf combined with normal high tides for this period to produce minor beach erosion, and caused beachfront property damage from Hatteras to Palm Beach. The most notable damage was along the Florida east coast from Daytona Beach to Hollywood, where rough seas persisted for more than 72 hours.

While such a major storm must have caused some marine losses by damaging cargo, total monetary losses during Gilda's life appear to be small. No casualties have been reported.

Gale warnings were issued from Fort Lauderdale to North Key Largo at 6 a.m. EDT on the 19th, when it appeared Gilda would move close to the southeast Florida coast. Gale warnings were also issued from

Cape Hatteras, N. C., to Manasquan, N. J., at noon EDT and extended to Merrimac River, Mass., at 6 p.m. EDT on the 25th during the subtropical portion of Gilda. Gales were observed from Cape Hatteras to New Jersey.

Tropical storm advisories were issued on Gilda during the subtropical stage, even though forecasters recognized the inconsistency at the time. There were two factors pertinent to the decision—first, the wish to avoid confusion by maintaining continuity with previous forecast releases; and second, the possibility that the storm would again become more tropical in nature.

h. Other strong systems.

In addition to the named tropical cyclones there were three other significant systems during 1973.

A weak subtropical cyclone developed about 200 mi southeast of Cape Hatteras on 30 July. It was designated subtropical cyclone Alfa on the 31st when reconnaissance aircraft found sustained 40-kt surface winds and a central pressure of 1005 mb. This system weakened on 1 August before reaching the east coast of Maine.

The depression that developed in the northwestern Caribbean Sea on 6 September within a low pressure trough extending south and southeast from Delia was of little consequence until it became stationary in the Freeport, Texas, area on the 10th. The heavy rains associated with it caused most of the losses attributed to Delia. The depression strengthened to near storm strength on the 12th as it moved briefly over the coastal waters south of Galveston, but weakened as it moved east northeast through southern Louisiana.

A strong depression developed in the southwestern Caribbean Sea on 17 November, and may have briefly attained tropical storm strength on the 18th before weakening under the influence of increasing westerly shears which destroyed the convective system.

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REFERENCES

- Frank, Neil L., and Paul J. Hebert, 1974: Atlantic tropical systems of 1973. *Mon. Wea. Rev.*, **102**, 290-295.
- Palmén, Erik H., 1948: On the formation and structure of tropical hurricanes. *Geophysica*, **3**, 26-38.
- Simpson, R. H., 1973: The neutercane—Small hybrid cyclone. Paper presented at the Eighth Technical Conference on Hurricanes and Tropical Meteorology, Key Biscayne, Miami, Fla.
- , 1970: A reassessment of the hurricane prediction problem. ESSA Tech. Memo, WBTM SR-50, 16 pp.