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The A. & M. College of Texas
DEPARTMENT OF OCEANOGRAPHY

MARINE METEOROLOGY OF THE GULF OF MEXICO, A BRIEF REVIEW

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Dale F. Leipper

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Texas A.&M. Research Foundation
COLLEGE STATION, TEXAS

THE AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
Department of Oceanography
College Station, Texas

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MARINE METEOROLOGY OF THE GULF OF MEXICO, A BRIEF REVIEW*

Dale F. Leipper

INTRODUCTION

The best general summary of the weather over the Gulf of Mexico in non-technical language is probably that prepared by the United States Weather Bureau for the United States Coast Pilot** (1939). There are a number of articles on the general circulation of the atmosphere and on meteorological processes without specific reference to the Gulf of Mexico, which, nevertheless, pertain to this region as well as to all similar regions. It will not be attempted to review such articles in the present summary. Two references of this type are Holmboe, Forsythe, and Gustin (1945) and Byers (1947). In addition, there are some publications such as Riehl (1947) which deal with the general weather in the low latitudes and are helpful in understanding the Gulf of Mexico weather more completely.

EXTRA TROPICAL CYCLONES

Saucier (1949) has analyzed the frequency and behavior of extra tropical cyclones originating on or near the northwestern coast of the Gulf of Mexico over a forty-year period. These cyclones have marked effect upon the weather of the Gulf as well as upon that of much of the eastern United States. They occur on the average about ten times per year with a maximum number of nineteen occurring in 1899 and a minimum of two in 1916. The high frequency of these storms is indicated to result from the influence on the general circulation of the warm moist surface provided by the Gulf of Mexico, the cold continental air to the north and the mountains to the west. It was found that the cyclones seldom occurred immediately after a deep cold air mass penetrated

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* Contribution from the Department of Oceanography of the Agricultural and Mechanical College of Texas, Oceanographic Series, No. 20. Based in part upon work done under the sponsorship of the Office of Naval Research and the Air Force Cambridge Research Center.

** References are listed at the end of the review.

the entire Gulf of Mexico, but were most common when it remained north of the Gulf coast. The storms may begin as early as October. The maximum occurs in January. Very few occur later in the spring than April. The regions of formation, directions of motion, and the characteristics of the intensification of the 388 cyclones studied are discussed.

THE GENERAL AIR CIRCULATION AND SOME OF ITS CONSEQUENCES

The Bermuda atmospheric high pressure cell dominates the circulation over the Gulf, particularly during the spring and summer months. In the late summer there is a general northward shift of the circulation and, as shown in Figure 1, the Gulf comes under the more direct influence of the equatorial low pressure belt. The constancy of the Bermuda high tends to maintain steady circulation and to govern the climate during the summer. Summer conditions are illustrated in Figure 2. No isotherms appear for average water temperature (sea surface temperature) since the waters are nearly uniform at about 84° F as illustrated in Technical Report No. 4 of this project, Physical Oceanography of the Gulf of Mexico. The air temperatures on the average are also quite uniform and high. The southerly position of the Bermuda cell brings about the southeast-northwest orientation of isobars across the Gulf and leads to a predominance of southeasterly winds, as shown by the barbs on the wind arrows. The winds tend to become more southerly in the northern part of the Gulf. In this region there are practically no northerly winds in summer and only a relatively few from the east or the west. In the more southern parts of the area the predominance of the easterly and southeasterly flow is even more marked.

With a typical summer circulation over the Gulf (see Figure 2) and the uniform average sea surface temperature, there would be expected only a minimum number of local weather features over the water which are the type caused within the Gulf by air flow toward successively warmer or cooler water surfaces. However, on a larger scale the relatively high temperature of the Gulf of Mexico waters compared to those of other water surfaces in the same latitudes brings about such a great warming and increase in the moisture content of the overlying air masses that weather patterns of the area are markedly affected. (The mean annual surface temperature of the Gulf is 78° F while that of a comparable region at the same latitude in the western Atlantic is 76°, in the eastern Atlantic 73° and in the eastern Pacific 68°.)

Typical features of the winter circulation are shown in Figure 3. Here the winds are more from the easterly directions with fewer southerlies but more northerlies. There are very few winds from the west or the southwest. The sea surface temperature pattern shows a variation from more than 75° F in the southeastern portion to less than 65° in the northwest. Southeasterly winds bring warm, moist air from lower latitudes and carry it from warmer toward colder water in the Gulf. When this flow is slow and sustained, the cooling by the ocean surface leads to condensation and fog and stratus formation in the northern Gulf.

A discussion of the upper air circulation for the Gulf and Caribbean area is given by Erna and Rudolf Penndorf (1944).

AVERAGE CONDITIONS

Average sea level atmospheric pressures in the Gulf vary from 30.00 to 30.15 inches of mercury. There are wide deviations from these averages in individual synoptic situations. Worthy of note is the diurnal pressure variation with a lesser early morning minimum followed by a greater late morning maximum and evening minimum and a lesser nocturnal maximum.

The "Atlas of Climatic Charts of the Oceans" and the "Pilot Chart of Central American Waters", issued monthly, give further information about the winds, pressures, temperatures, and other weather features of the Gulf of Mexico. The average wind velocity varies from 6 to 8 knots in the summer, with the stronger winds in the southeast portion, to 10 to 12 knots with considerable variability in the winter, the higher averages being in the northeastern portions.

Fog is most frequent in midwinter when as high as 10% of all observations record light or dense fog in the north central part of the Gulf. In this season fogs occur less than 1% of the time in the southeastern portion.

For the year around the average cloud cover over the Gulf is 4/10 to 6/10 of the sky obscured. In winter and spring the areas most obscured are in the north and northwest, while in the summer and fall the southern and southwest portions have the highest average cloud cover. The most commonly reported low type clouds are cumulus, which have the greatest frequency - greater than 30% of all observations - in the summer and fall in a band extending from the Yucatan channel northwestward across the Gulf. Altostratus and altocumulus are common the year around, their average frequency being from 10 to 20% throughout the Gulf. In the summer and fall cumulonimbus are observed about 10% of the time in the western and northwestern regions.

The period of lowest occurrence of rainfall over the open water is in the spring when less than 5% of the observations show rain according to the "Atlas of Climatic Charts of the Oceans". The remainder of the year the frequency is 5 to 10% over most of the Gulf, except for an area around the Yucatan peninsula where frequencies drop below 5% in the winter and summer. A study by Kloster reported in the Coast Pilot shows rain in from 13 to 21% of the hourly observations available for all months of the year between 22 1/2 to 27 1/2° N. latitude and 80 to 90° W. longitude. Rainfall was most frequently reported in the mid afternoon - 19% versus 15 to 17% at other times of the day.

The average depression of the wet bulb is 3° F for the fall quarter, September, October and November. During the remainder of the year it is 2° for the western Gulf and 3° for the eastern.

In the summertime the air and the sea surface differ in temperature by less than 1° F. the sea temperature being higher according to the "Atlas of Climatic Charts of the Oceans". In the fall and winter, differences increase, with the sea temperature being as much as 5°F higher than the air temperature in the area just west of the Florida peninsula. This leads to heating from below on the average and explains the high frequency of cumulus type clouds over the Gulf. Monthly average sea surface and air temperatures are tabulated in Technical Report No. 4.

WEATHER OBSERVING STATIONS

It is the purpose of this summary to discuss weather over the water in the Gulf. Since the observations here are sparse, some of the conclusions are drawn from observations made on the surrounding land areas. The weather observing stations in these areas are shown in Figure 4. Those on the coast are listed in Table I. A particularly interesting feature of the Gulf is that although it covers some 700,000 square miles, it is more than 90% enclosed by land. The rather complete coverage of weather information around its perimeter makes it an unusual natural laboratory in which to study changes in the character of air masses as they pass across the large body of water.

TYPICAL UPPER AIR SOUNDINGS

A comparison of the upper air soundings from Swan Island, south of the Gulf, with those of New Orleans and Brownsville, on the north and northwestern coasts, illustrates the modifying effects of the water surface. Monthly average radiosonde observations for a summer month and a winter month at each of these stations are shown in Figure 5. It will be noted that the annual change in structure at Swan Island, which is almost completely controlled by oceanic factors, is very small, the most noticeable change being the higher relative humidities in the summer. At Brownsville and New Orleans the sea surface is cooler in winter but also the continental influence tends to make winter temperatures definitely lower than those in summer and leads to relatively low humidities below about 6,000 feet elevation (800 millibars).

TABLE I

WEATHER OBSERVING STATIONS ALONG THE

COAST OF THE GULF OF MEXICO

(201)	Key West, Florida (NAS)	(642)	Nautla, Veracruz
(211)	Tampa, Florida (International Airport)	(692)	Veracruz, Veracruz
(214)	Tallahassee, Florida (Dale Mabry Field)	(741)	Coatzacoalcos, Veracruz
(220)	Apalachicola, Florida	(743)	Villa Hermosa, Tabasco
(222)	Pensacola, Florida	(746)	Ciudad Obregon, Tabasco
(223)	Mobile, Alabama	(749)	Ciudad del Carmen, Campeche
(231)	New Orleans, Louisiana	(695)	Campeche, Campeche
(232)	Burrwood, Louisiana	(643)	Merida, Yucatan
(240)	Lake Charles, Louisiana	(648)	Cozumel, Quintana Roo
(241)	Port Arthur, Texas	(751)	Chetumal, Quintana Roo
(242)	Galveston, Texas	(501)	Swan Island, West Indies
(243)	Houston, Texas	(395)	Vernam Field, Jamaica
(255)	Victoria, Texas	(397)	Kingston, Jamaica
(251)	Corpus Christi, Texas	(325)	Havana, Havana (Casa Blanca)
(250)	Brownsville, Texas	(244)	Cienfuegos, Santa Clara
(491)	Ciudad Victoria, Tamaulipas	(355)	Camaguey, Camaguey
(349)	Ciudad Camargo, Tamaulipas	(367)	Guantanamo, Oriente
(639)	Tuxpan, Veracruz	(265)	Antilla, Oriente

A rather complete discussion of the tropical Gulf air mass is given by Willett (1943). He states that the uniformity of the water temperature in the source regions of tropical maritime air masses has proved to be of more importance in fixing the properties of the masses at all levels than has the previous life history of the individual air masses. Evidence is given demonstrating that the structure of the lower stratum of the air mass results from the turbulent mixing of saturated air. The air masses are characterized by marked potential instability, implying that all convective or mechanical turbulence up to at least 5 kilometers elevation must affect an upward transport of latent heat. The high relative humidities indicate that active convection extending above this level can be initiated by very little vertical displacement. Summer thunderstorms are more likely along the eastern part of the northern Gulf coast than along the western because of the higher relative humidities in the eastern area.

Using a series of atmospheric temperature and moisture soundings between the sea surface and 45 feet elevation made at four hour intervals in March 1949 from an oil platform in the northwestern Gulf, Gerhardt (1951) demonstrated the modifying effects of the sea surface. He was able to support the usually assumed logarithmic distribution of water vapor with height, the variation of the evaporation coefficient with wind speed and the essential similarity of the heat and moisture transfer processes.

A discussion of the extent to which the sea surface affects the overlying atmosphere is given by Jacobs (1951). He computes the average winter evaporation in the Gulf to be of the order of 0.40 gms. per cm^2/day and compares this with the other ocean areas of the world. Similar comparisons are made for the other energy exchange processes operating between the sea and the atmosphere.

NORTHERS

A period of north winds lasting from 1 to 3 or 4 days and having speeds greater than approximately 20 knots is known to seamen as a "Norther". Each year 15 or 20 northers are observed in the Gulf, usually between November and March. Many of them reach as far south as Key West, Florida and Techuantepec, Mexico. The low temperatures of the polar air masses which move in and the large waves built up in the open Gulf have considerable effect upon shipping and work at sea. Also the water level is often lowered in the shipping canal and in harbors along the north coast markedly affecting ship transportation in the area. According to the Coast Pilot a veering of the north winds into the east and southeast brings a resumption of fair weather while a backing toward northwest means more foul weather.

METEOROLOGICAL TIDES

Water levels along the coasts of the Gulf change noticeably with changes in wind speed and direction. Two extreme conditions are the change associated with a norther, mentioned above, and the storm tide associated with a hurricane to be discussed later. However, the stress of the wind acting upon the sea surface at times other than times of northers or hurricanes may also be sufficient to bring about a water level change of the same order of magnitude as that resulting from the periodic tide producing forces. This leads to considerable deviation of the observed water levels from those published in the tide prediction manuals. It does not mean that the manuals are in error but rather means that a non-periodic, usually short term wind effect must be superimposed upon the published predictions. One of the most challenging problems facing the meteorologist-oceanographer is that of finding a way to calculate these wind effects for different situations. Some work has been done by Dietrich (1937).

HURRICANES

The Galveston flood tide of 1900 in which 6,000 persons lost their lives emphasizes the impact of the Gulf coast hurricane upon this region. Much has been written on this and similar storms. Some references are the Coast Pilot, Tannehill (1944), Cline (1926) and (1933), Riehl and Burgner (1950), and Shisler (1949).

Nearly 80% of the hurricanes appearing in the Gulf form outside and enter moving northwestward across the Yucatan Channel and Florida Peninsula area. Approximately 15% form in the northern Gulf and most of the remainder form in the southwestern Gulf. They travel at an average speed of 10 to 13 knots. The most common path is westward becoming northwestward and northeastward. Some, however, do not turn northward. The months of greatest frequency and intensity are August, September and October. There are an average of about 9 hurricanes each year in the western North Atlantic and many of these enter the Gulf.

Hurricanes are 100 to 500 miles in diameter. In the eye of the storm is a region of calm where the water level rises in a "hurricane wave" which may be 20 feet or more in height. Around the storm center, high wind waves develop. Passing out of the wind area these waves become swell and often provide the first indication that a hurricane is approaching.

Much of the damage caused by hurricanes in coastal areas is due to the fact that the wind-driven storm tide raises the water level sufficiently that the high breaking wind waves are carried across breakwaters and retaining walls into unprotected inshore areas. The tracks of the centers of hurricanes which caused the highest tides of record on the Gulf coast are shown in Figure 6. A detailed discussion of such meteorological tides is given by Cline (1933)

In recent years much has been learned about the formation and motion of hurricanes from the weather flights into the centers of the storms made by the U. S. Navy and other flights made by the Air Force. In addition the storms have been followed by radar sets, since they make a distinctive pattern on the radar screen.

APPLICATIONS OF MARINE METECROLOGY IN THE GULF

The heavy investments by the petroleum industry in the shallow waters of the Gulf (some $250,000,000) are greatly affected by meteorological conditions as evidenced for example by a symposium on this and related subjects appearing in the February 23, 1950 issue of the "Oil and Gas Journal". Glenn (1950) discusses the part that meterorologists can play in improving the safety and efficiency of offshore petroleum operations.

The many large industrial organizations on the coast need information about offshore weather for use in conducting their operations. Several organizations have established weather observation stations including radar facilities, such as those described by Jorgensen (1951).

Fishing here as elsewhere is successful or not depending to a large extent upon the weather. Navigation, protection of beaches, construction along the coast, and recreation all furnish applications for knowledge gained in the study of marine meteorology.

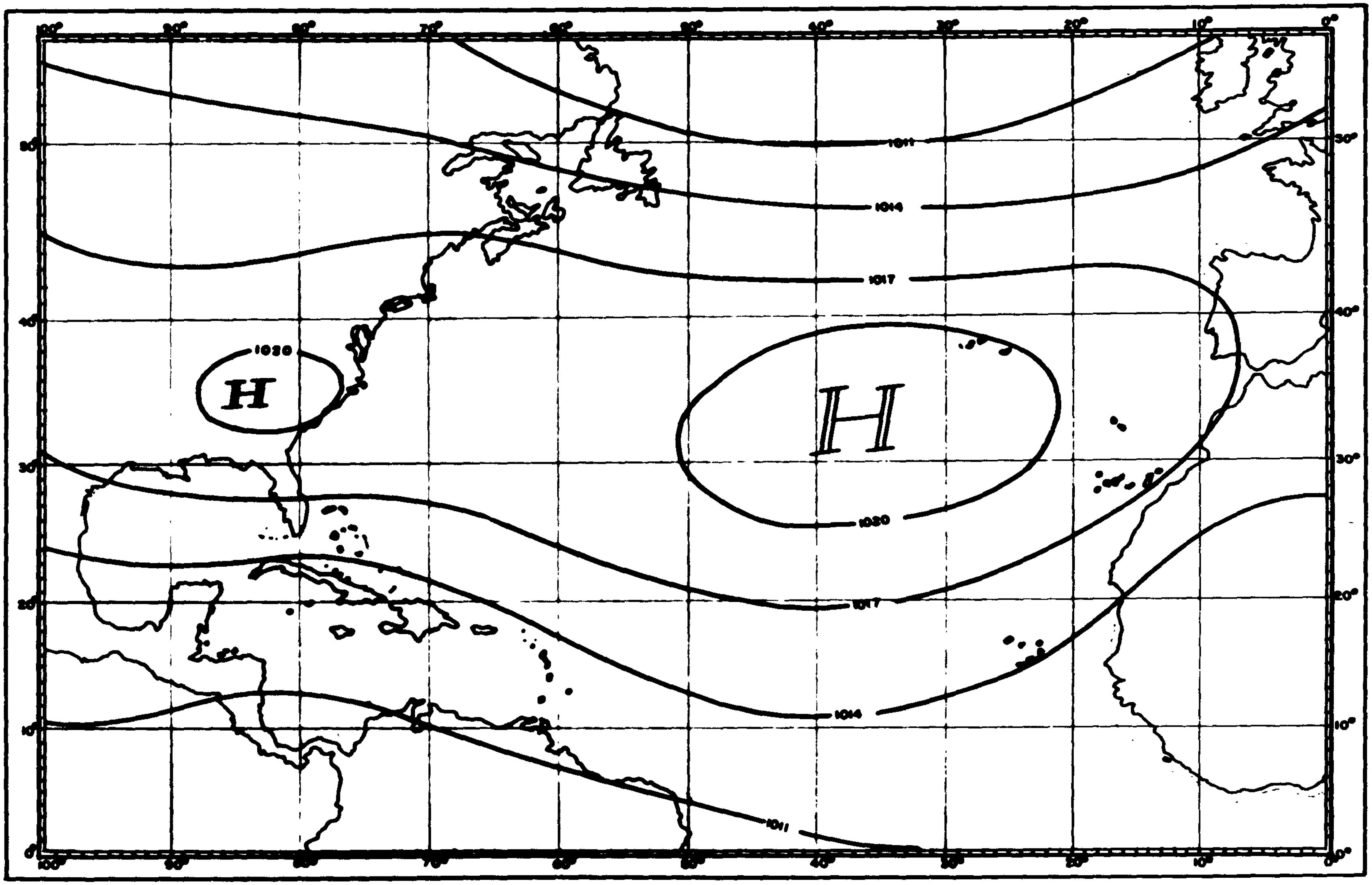
FURTHER SOURCES OF INFORMATION

Many pertinent articles on marine meteorology are reproduced on the back of the Pilot Charts. An index to those between January 1946 and September 1950 inclusive appears on the chart for November 1951. Some examples are: Cyclonic storms - October 1949, Fog - September 1946, Hurricanes and Tropical Disturbances - August 1946, 47 and 48, Northers - September 1949, 50 and 51, Line squalls - March 1948, Northers - September 1947 and November 1948, Waterspouts - December 1948 and the Gulf Stream - August 1950. These charts may be obtained for 30 cents each by addressing a request to the U. S. Navy Hydrographic Office, Washington 25, D. C.

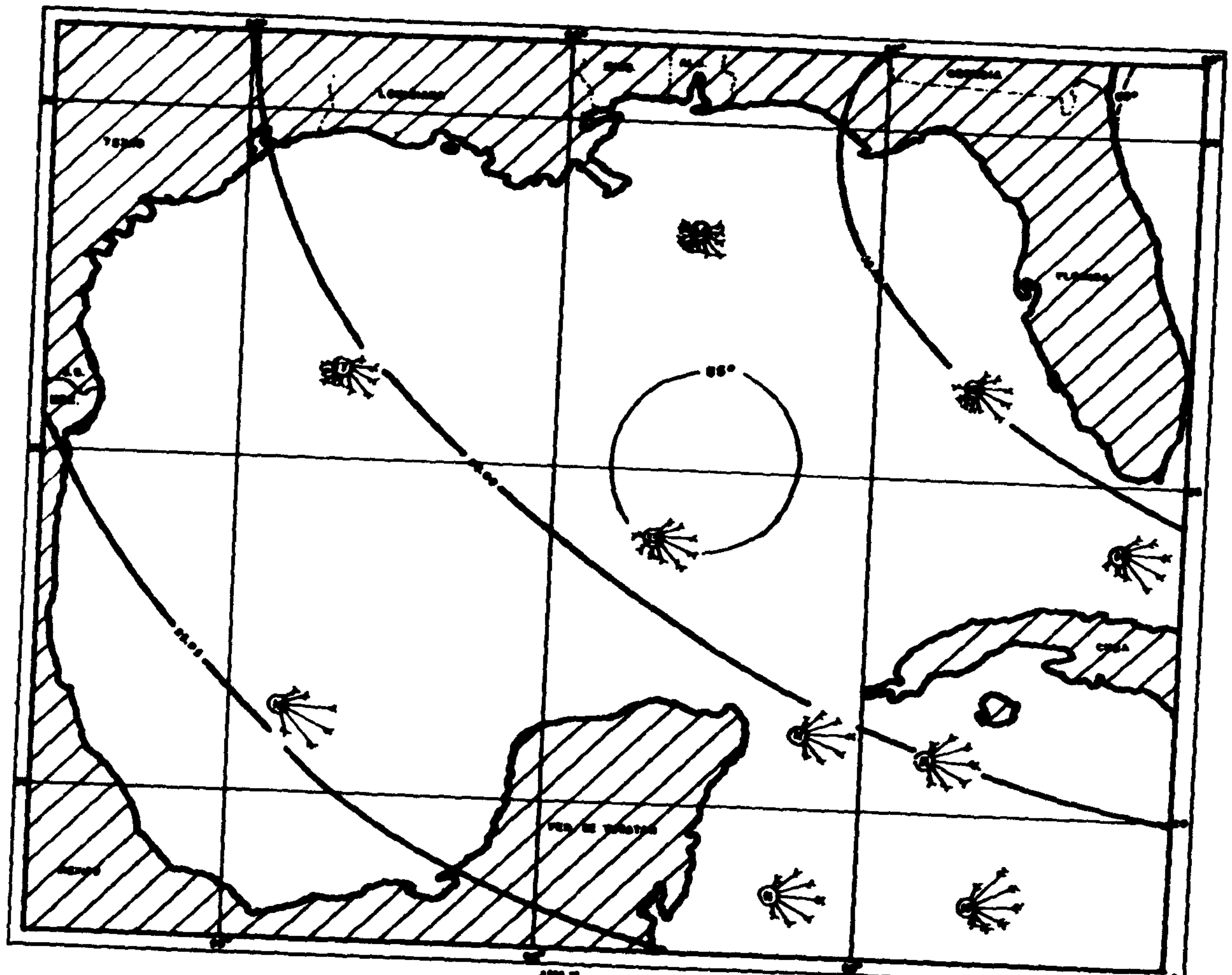
Geyer (1950) includes a number of references to the marine meteorology of the Gulf.

CONCLUSION

The development of marine meteorology in the Gulf of Mexico and other ocean areas has been delayed by the lack of sufficient information about the underlying water surface which exerts a dominating influence upon the atmosphere. Only recently has there been increased emphasis upon the collection of this information and upon the analysis of the data in such a manner as to lead to more complete understanding of the processes of interaction between the sea and the atmosphere and their effect upon the weather. It is common knowledge that the climate of coastal areas is to a large extent determined by the nature of the adjacent sea. However, much remains to be learned about the mechanisms by which these controls are exerted.

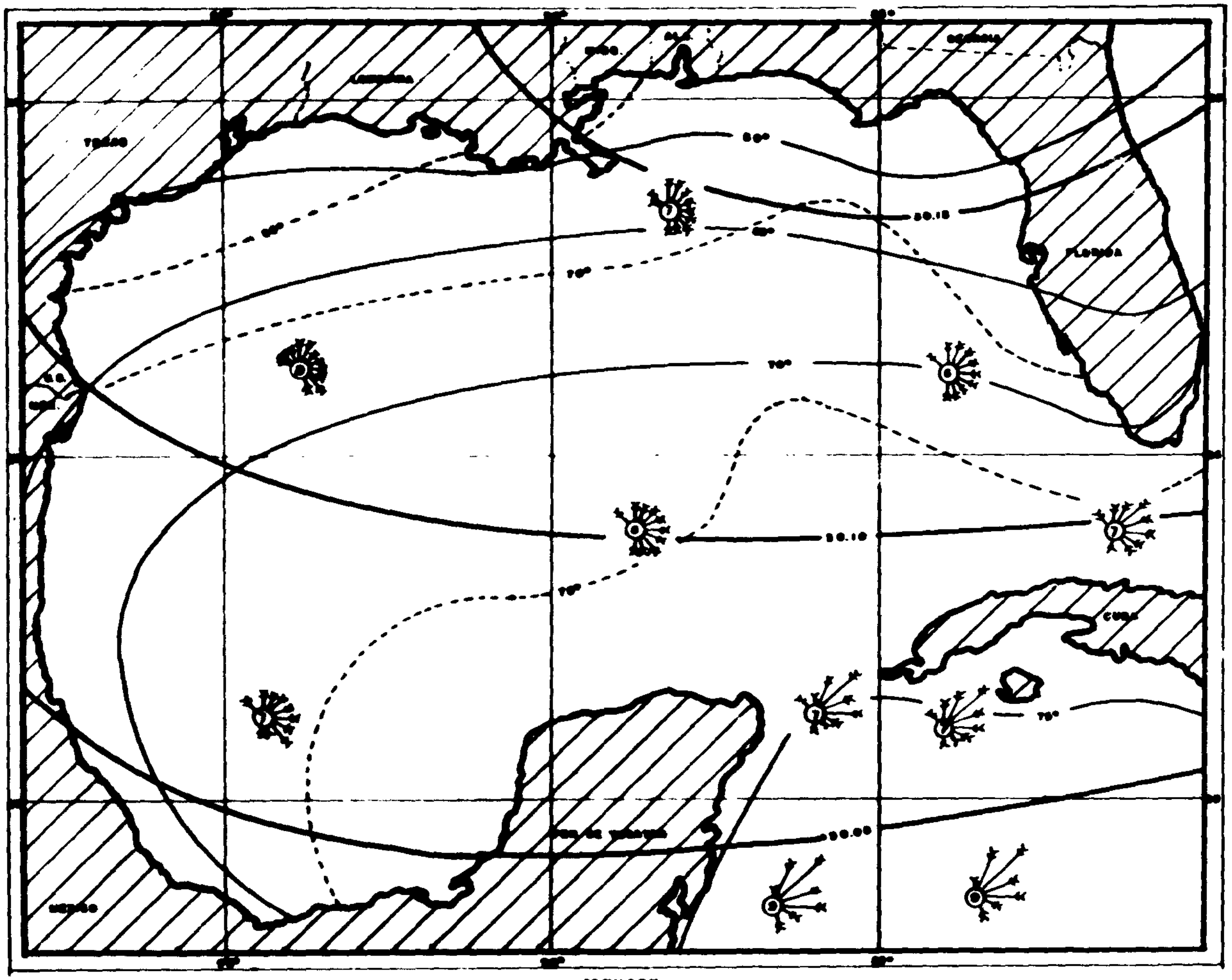


NORMAL SEALEVEL PRESSURE
OCTOBER
FIGURE 1



AVERAGE SEA LEVEL PRESSURE (INCHES)
AVERAGE AIR TEMPERATURE (°F)
AVERAGE WATER TEMPERATURE (°F)

FIGURE 2



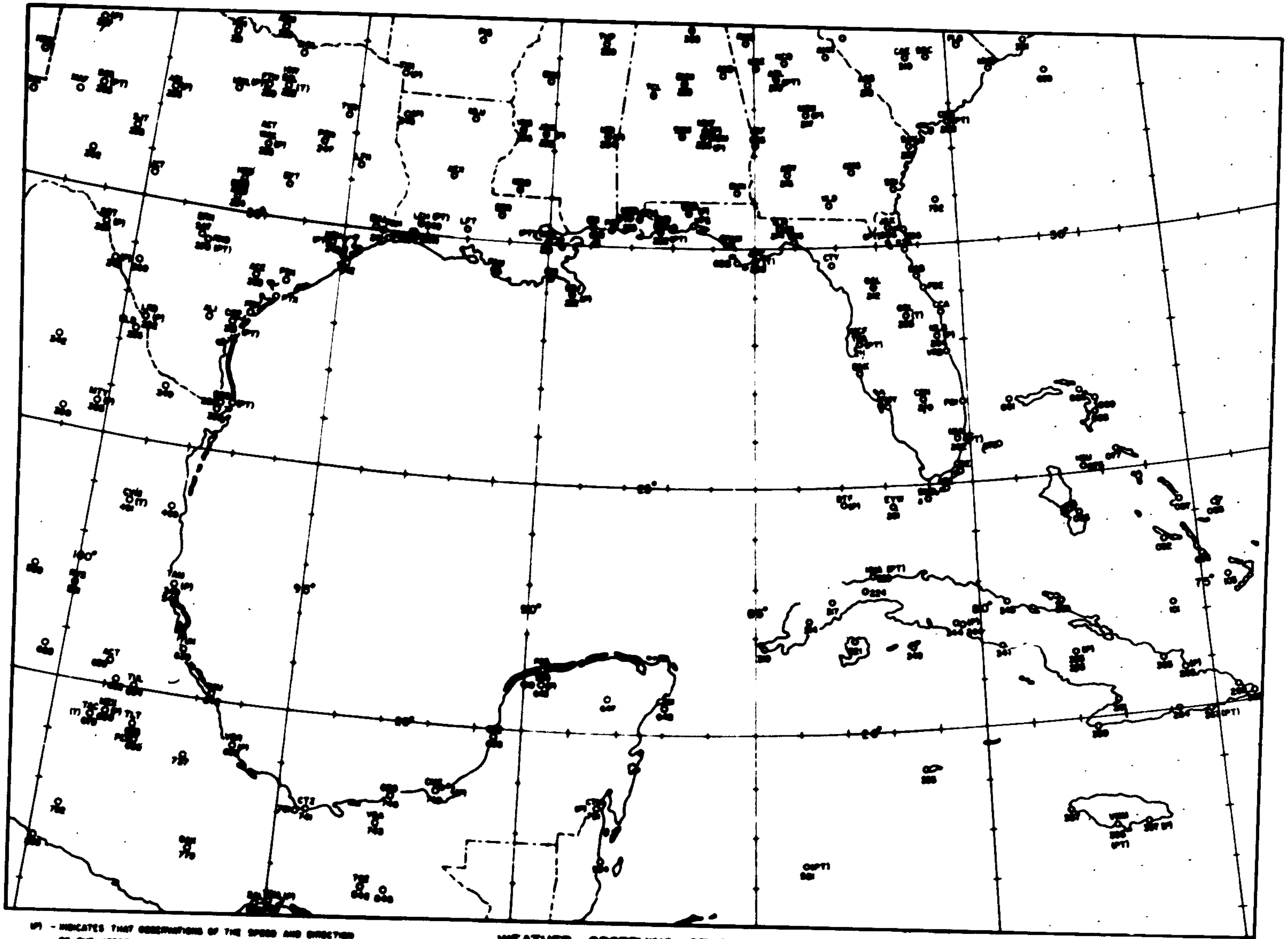
JANUARY

—— AVERAGE SEA LEVEL PRESSURE (INCHES)
—— AVERAGE AIR TEMPERATURE (°F)
- - - - AVERAGE WATER TEMPERATURE (°F)

WIND: Arrows fly with the wind. Length of arrow gives percent of total observations to sixteen points of the compass. Barbs show force on Beaufort scale. Figure in center of circle gives percentage of light, variable winds.

Scale of Wind Percentages

FIGURE 3



(P) - INDICATES THAT OBSERVATIONS OF THE SPEED AND DIRECTION OF THE UPPER AIR ARE TAKEN

WEATHER OBSERVING STATIONS
GULF OF MEXICO AREA
FIGURE 4

(T) - INDICATES THAT UPPER AIR SOUNDINGS OF TEMPERATURE, PRESSURE, AND MOISTURE CONTENT ARE TAKEN.

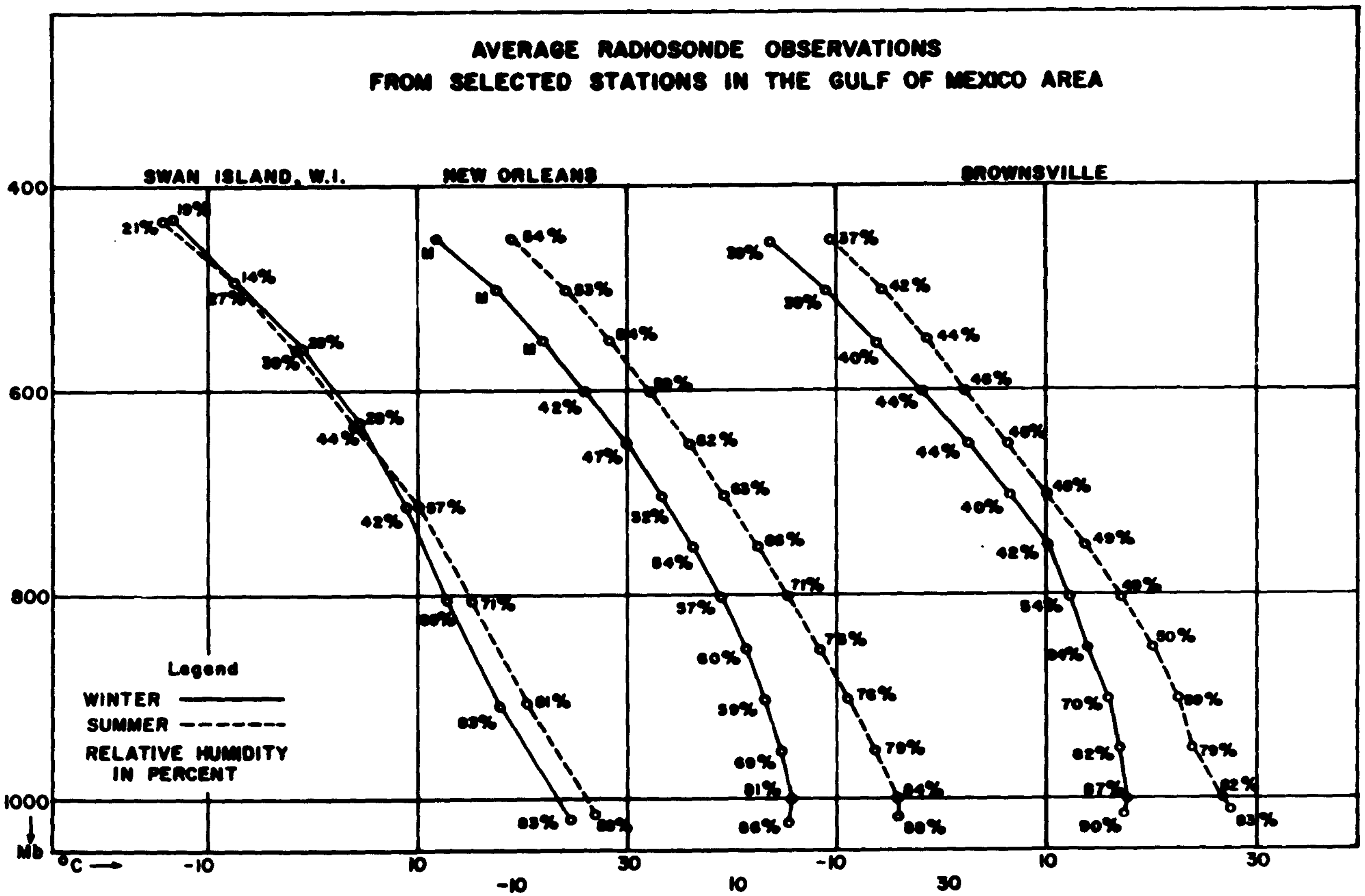

AVERAGE RADIOSONDE OBSERVATIONS
FROM SELECTED STATIONS IN THE GULF OF MEXICO AREA
SWAN ISLAND, W.I.
NEW ORLEANS
BROWNSVILLE
Legend
WINTER
SUMMER
RELATIVE HUMIDITY IN PERCENT
400
600
800
1000
Mb
°C
-10
10
30

FIGURE 5

HURRICANE TRACKS

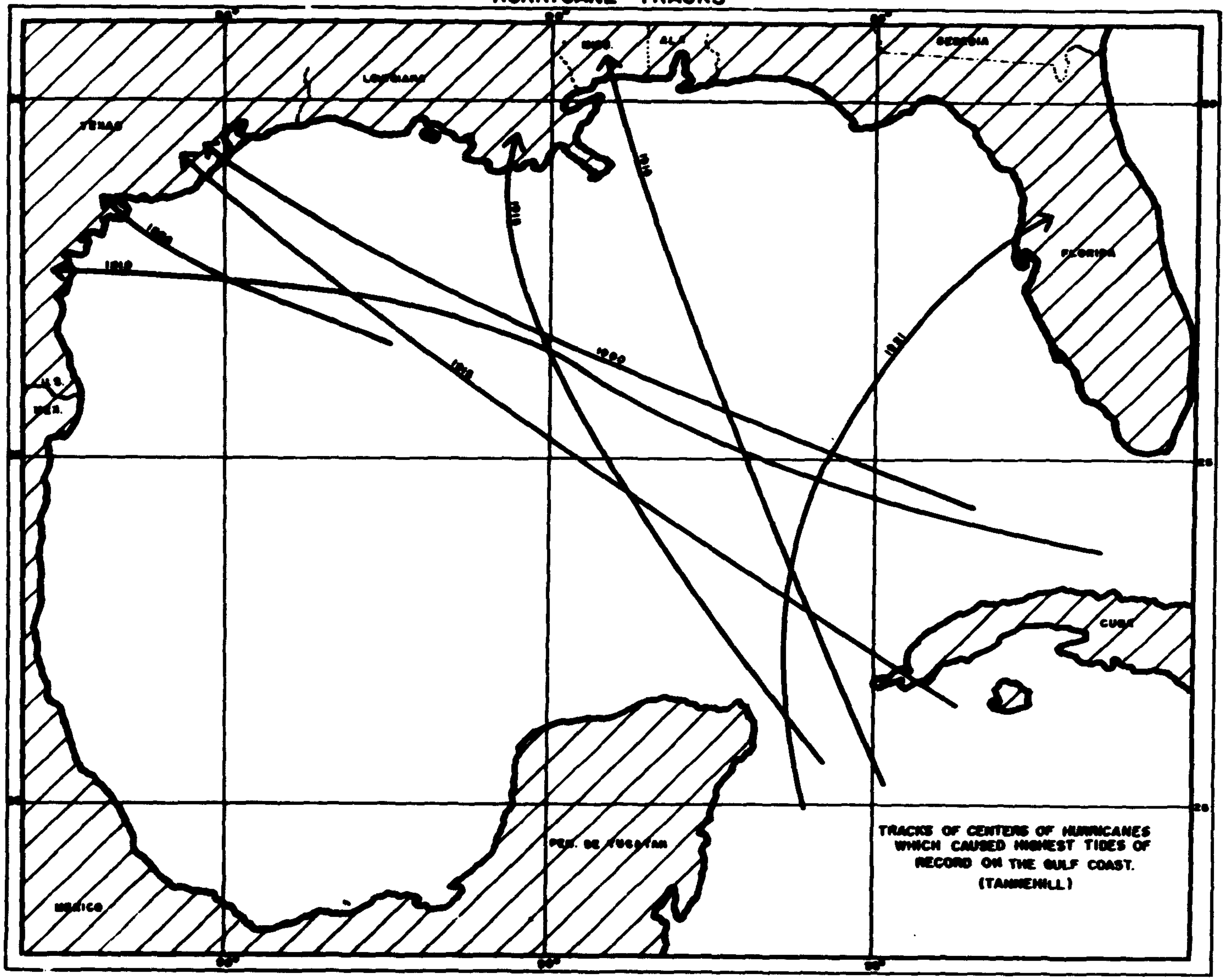


FIGURE 6

BIBLIOGRAPHY

"Atlas of Climatic Charts of the Oceans" (1938), Department of Agriculture, Weather Bureau, Washington, D. C., W. B. No. 1247.

Byers, H. R. (1944), "General Meteorology", McGraw-Hill Book Company, Inc., New York, 645 pp.

Cline, I. M. (1933), "Tides and Coastal Currents Developed by Tropical Cyclones", Monthly Weather Review, 61:36-38.

Cline, I. M. (1926), "Tropical Cyclones", Macmillan Company, New York.

Dietrich, Gunter (1937), I. "Die Lage der Meeresoberfläche im Druckfeld von Ozean und Atmosphäre", mit Besonderer Berücksichtigung des Westlichen Nordatlantischen Ozeans und des Golfs Von Mexiko, Veröffentlichungen des Instituts fur Meereskunde an der Universitat Berlin, Neue Folge A. Heft 33, 91 pp., January.

Gerhardt, John R. (1951), "Temperature and Moisture Soundings Over the Gulf of Mexico for March, 1949", Trans. American Geophysical Union, Vol. 32, No. 1, pp. 15-25, February.

Geyer, R. A. (1950), "A Bibliography on the Gulf of Mexico", The Texas Journal of Science, Vol. II, No. 1, pp. 71-76, March 31.

Glenn, A. H. (1950), "Wave, Tide, Current, and Hurricane Problems in Coastal Operations", Oil and Gas Journal, June 22.

Holmboe, Jorgen, George E. Forsythe and William Gustin (1945), "Dynamic Meteorology", John Wiley and Sons, Inc., New York, 363 pp.

Jacobs, Woodrow C. (1951), "The Energy Exchange Between Sea and Atmosphere and Some of its Consequences", Bulletin of the Scripps Institution of Oceanography of the University of California, Vol. 6, No. 2, pp. 27-122.

Jorgensen, R. C. and W. F. Gerdes (1951), "The Dow Chemical Company Leads Industry in Using Radar for Hurricane Detection", Bulletin of the American Meteorological Society, Vol. 32, No. 6, pp. 221-225, June.

BIBLIOGRAPHY
(continued)

Penndorf, Erna und Rudolf Penndorf (1944), "Aerologische studien nr. 7. Die strömungsverhaltniss in der freien atmosphäre - besonders die des passates - über dem Karibischen Meer und dem Golf von Mexiko", Ann. hydrogr., Berlin, 72:107-116.

"Pilot Chart of the Central American Waters", issued monthly, Hydrographic Office, Navy Department, Washington, D. C., H. O. No. 3500.

Riehl, Herbert and Newton M. Burgner (1950), "Further Studies of the Movement and Formation of Hurricanes and Their Forecasting", Bulletin American Meteorological Society, Vol. 31, No. 7, pp. 244-253, September.

Riehl, Herbert (1947), "Subtropical Flow Patterns in Summer", Miscellaneous Report No. 22, Department of Meteorology, University of Chicago.

Saucier, Walter J. (1949), "Texas - West Gulf Cyclones", Monthly Weather Review, Vol. 77, pp. 219-231, August.

Shisler, Karl (1949), "Maintenance of Safety and Efficiency in Offshore Operations During Periods of Hurricanes", The Oil and Gas Journal, June 30.

Tannehill, Ivan Roy (1944), "Hurricanes", Princeton University Press, 269 pp.

"United States Coast Pilot, Gulf Coast, Key West to Rio Grande", 3rd edition, (1949) U. S. Coast and Geodetic Survey, U. S. Department of Commerce, Serial No. 725, pp. 50-83, U. S. Printing Office, April 2.

Willett, H. C. (1943), "American Air Mass Properties", Massachusetts Institute of Technology and Woods Hole Oceanographic Institution, Papers in Physical Oceanography and Meteorology, Vol. II, No. 2, 116 pp., January.

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