ON THE FREQUENCY OF HURRICANES IN THE VICINITY OF PORTO RICO[1]

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How often may we expect a hurricane in the vicinity of Porto Rico?

(1) Of great intensity, such as the storm of August 8, 1899 (San Ciriaco)[2] or of September 13, 1928 (San Felipe.)[2]
(2) Of the second order of intensity, such as the storm of August 22, 1916, or of July 23, 1926.
(3) Of a mild type, such as the storm of September 10, 1921, or of August 29, 1924.

On first thought an answer to these questions may seem to be simply a matter of searching the annals of Porto Rico and noting the frequency of occurrence of storms of great violence. The problem is not so simple, however. References to storms in available historic records are often very fragmentary and very misleading. Estimates of loss of life and extent of property destroyed are contradictory, even in the case of storms of such recent occurrence as 1899 and 1928. Official records of wind velocity and of barometer readings are entirely lacking, prior to 1875.

Bulletin No. 32[3] of the United States Weather Bureau contains a list of 44 hurricanes of more or less violence occurring in the vicinity of Porto Rico from 1515 to 1899. In most cases cited there is not sufficient evidence to classify the storm on a basis of intensity.

It is only since 1898, when the United States Weather Bureau established a series of storm-warning stations in the West Indies, that we have sufficiently detailed information available about these storms to enable us to arrange them satisfactorily, in accordance with their extent and intensity.

Incomplete as the list of storms prior to 1898 is, we may safely use it to determine the distribution of storms through the year. Combining the two periods we find that hurricanes occurred in the vicinity of Porto Rico during the period from 1515 to 1929 with the following monthly frequencies:

Storm frequencies by month

June	1	September	25
July	9	October	6
August	23		

The only June hurricane recorded in a period of 400 years in the vicinity of Porto Rico occurred in 1780, and the meager description leaves us in doubt as to the character of the storm. Hence we may safely disregard June as a hurricane month. July, August, September, and October constitute the hurricane season for Porto Rico. July and October storms are of infrequent occurrence. Since 1899 we have had but two July storms (1901 and 1906) and but one in October (1916). August and September storms were of nearly equal frequency, there being 23 and 25, respectively, based upon the records for the entire period. The August and September storms as recorded in the recent period 1899–1929 show a greater divergence (6 of the former and 11 of the latter), due undoubtedly to the fact that the earlier records probably do not include storms of a milder type.

Distribution by centuries

1515–1599	10	1800–1898	21
1600–1699	1	1899–1929	20
1700–1799	12		

The frequencies for the different centuries show too great a variation to permit us to place much reliance upon the accuracy or completeness of the records. The record for the seventeenth century is obviously incorrect with only one storm. The inclusion of minor disturbances in the list for later periods will explain the great increase in the number of storms recorded in the past 31 years.

A safer basis for determining the frequency of hurricanes is to examine closely the records since 1898. For this period we have accurate official accounts of weather conditions not only in Porto Rico but in many of the islands of the Caribbean. While a period of 31 years is not as long as it should be for safety in discussing the question of the probability of occurrence of storms we may draw certain interesting conclusions even from this short period.

When it comes to the discussions of the relative violence of hurricanes it is necessary to confine our attention almost entirely to the period from 1899 to date.

CLASSIFICATION OF HURRICANES

Before attempting a classification of the storms of Porto Rico it may be well to refer to some of their characteristics. Practically all storms affecting Porto Rico have their origin at a considerable distance to the east of the Windward Islands, probably not far from Cape Verde Islands, near the African coast; with rare exceptions they enter the eastern Caribbean area fully developed. Their course varies generally between east-west and southeast-northwest.

Porto Rico is exposed only to the first or westward moving branch of the usual parabolic path of the storms. The rate of progress of the storm as a whole varies from 10 to 15 miles per hour, depending upon the rate of free movement of the trade winds which carry these storms in a westerly direction.

The island lies between latitudes 18 and 19 N. and between longitudes 66 and 67 W. and hence is in the center of the hurricane belt with its width of 40 miles exposed to the westward moving storms. The area of great devastation within a hurricane seldom extends beyond a distance of 50 miles from the center of the storm. In any well developed storm, winds of 75 miles per hour or more occur near the center. Beyond a radius of 50 miles however, the winds rapidly decrease in force. The rainfall attending these storms may extend to 150 to 200 miles from the center.

As we are considering the frequency and intensity of hurricanes in the vicinity of Porto Rico only, the classification is based upon the extent of the island covered by the central area of hurricane winds.

Class A.—Storms in which the entire Island is swept by winds exceeding 75 miles an hour.
Class B.—Storms in which hurricane winds occur over a portion of the island only.
Class C.—When the winds do not reach full hurricane force over any portion of the island.

All storms considered are assumed to be real hurricanes, but classification into groups A, B, and C depends on the distance of the center of the storm from Porto Rico. In storms of class A the center passed directly over Porto Rico attended by hurricane winds over the

[1] Reprinted with slight changes from the Porto Rico Journal of Public Health and Tropical Medicine Vol. V, No. 2, December, 1929.
[2] The Saints Days upon which the storms passed over Porto Rico.
[3] Alexander, W. H.: Hurricanes. U. S. Weather Bureau. Bul. 32, 1902.

entire island. In class B the center was not more than 50 miles distant, while in class C the center was more than 50 miles distant. Hence the importance of anticipating the exact distance of the center from any portion of the island on the approach of a hurricane.

With this statement of the basis of hurricane classification we may examine the list of storms recorded in the vicinity of Porto Rico since the historic storm of August 8, 1899.

TABLE I.—*List of hurricanes in the vicinity of Porto Rico (1899–1929)*

	Class		Class
1899: Aug. 8 (San Ciriaco)	A	1916: Aug. 22	B
Sept. 9	C	Aug. 29	C
1900, Sept 1	C	Oct. 10	B
1901, July 7	C	1917, Sept. 21	C
1906, Sept 3	C	1919, Sept. 3	C
1908, Sept. 10	C	1921, Sept. 10	C
Sept. 27	C	1922, Sept. 17	C
1909, Aug. 22	B	1924, Aug. 29	C
1910, Sept. 6	B	1926, July 23	B
1915, Aug. 11	B	1928, Sept. 13 (San Felipe)	A

On examination of the official records we may place the storms of this period in the following groups:

Class	Number of storms	Percentage	Dates
A	2	10	Aug. 8, 1899 (San Ciriaco); Sept. 13, 1928 (San Felipe).
B	6	30	July, 1926; August, 1909, 1915, 1916; September, 1910; October, 1916.
C	12	60	July, 1901; August, 1916, 1924; September, 1899, 1900, 1906, (2) 1908, 1917, 1919, 1922, 1921.

The total number of storms recorded in Porto Rico for the 31 years from 1899 to date is 20. As already shown in the list of storms prior to 1899 the hurricane months are July, August, September, and October. Class A shows only two hurricanes in 31 years with an interval of 30 years; class B shows 6, with an average interval of 5 years, and class C shows 12, with an average interval of 2½ years. The distribution of the storms through the period is not at all even, however, as there are 2 periods of 4 consecutive years and 6 periods of 1 year without a storm of any class. There was but 1 storm in the month of October and only 2 in the month of July, confirming the common impression that the months of August and September constitute the real hurricane season in the vicinity of Porto Rico. Six storms are credited to August and 11 to September, but 9 of the 11 September storms were of the mild type, or class C.

As storms of class A were of such infrequent occurrence from 1899 to 1929 an effort was made to extend the period for this class backward to the beginning of the nineteenth century. This may safely be done as storms of such violence would certainly be noted in any local chronicle of hurricanes. In looking over Alexander's list of hurricanes from 1800 to 1899 we find only two additional storms which seem to merit a place with San Ciriaco and San Felipe II, namely, Santa Ana (July 26, 1825) and San Narciso (October 29, 1867). Incidentally, San Narciso is the only storm recorded after the middle of October in a period of over 400 years. Los Angeles (August 2, 1837), Santa Elena (August 18, 1851), and San Felipe I (September 13, 1876), which are frequently quoted as historic storms, seem rather to have been of class B, so far as extent of damage in Porto Rico is concerned. The addition of these two storms of the nineteenth century will give us four storms of class A in a period of 130 years, with an average interval of 31 years.

As storms of class C are on the whole beneficial, owing to the value of the rains which they bring and the comparatively small property losses, we may disregard this class as a source of personal danger, eliminating the element of fear from 60 per cent of the total number of Porto Rican hurricanes.

Storms of class B are likewise attended by beneficial rains; but such benefits may or may not be overshadowed by heavy local property losses.

Storms of class A are a calamity and are responsible for the universal dread which seems to be inseparably connected with the word hurricane throughout the world. Hurricanes of the severest type, if their centers are more than 50 miles distant, are more likely to be beneficial than harmful, as winds exceeding 75 miles an hour seldom extend beyond this distance from the center.

Reviewing the statistics in the above tables and including class A hurricanes of the nineteenth century, we have the following hurricane frequencies for Porto Rico and vicinity:

Class	Number of storms	Period of years
A	4	130
B	6	31
C	12	31

While we may not be justified in concluding that these frequencies and proportions will hold good in the future we may say that the probabilities are in favor of the occurrence of 1 storm of class A, 6 storms of class B, and 12 storms of class C in the next generation. Even this broad statement may have some practical value in estimating probable losses to property and crops and in determining insurance rates.

THUNDER AND LIGHTNING IN THE SOUTH PACIFIC OCEAN

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In the South Seas and Southern Pacific Ocean violent thunderstorms are not of frequent occurrence. In my nine years' residence in Samoa I have only experienced 2 electrical storms which compared in intensity with 5 or 6 per annum in southern Ontario and New England. Lightning, however, often occurs on the open ocean, but is probably most frequent in the vicinity of the island groups which dot the western half of the South Pacific. The research yacht *Carnegie* observed thunder or lightning on 27 of the 139 days she has spent during her fourth, fifth, and sixth cruises (**1**) within the Tropics of the South Pacific Ocean.

Continuous records of thunderstorms are available from Apia, Samoa; Suva, Fiji; Nauru; and Rarotonga. Other records with less sharp distinctions drawn between thunder and lightning have been obtained from Papeete, Tahiti; Nassau; and Niue Islands. Discrepancies in the records show that observers used widely differing ideas of a thunderstorm, the occurrence of lightning being frequently not recorded.

In Table 1 is given the number of days thunder was recorded at the most reliable stations.