UPDATED (as of 28 July 1986)

FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY FOR 1986

By

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This updated forecast uses background material contained in the Colo. State Univ. Dept. of Atmospheric Science forecast report which was issued by the author on 29 May 1986. This report utilizes new June and July 1986 meteorological information and is issued to coincide with the start of the more active part of the hurricane season on 1 August.

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DEFINITIONS

El Nino - (EN) - a 12-18 month period in which anomalously warm sea surface temperatures occur in the eastern half of the equatorial Pacific. Moderate or strong El Nino events occur irregularly. Their average frequency is about once every 5-6 years or so.

QBO - Quasi-Biennial Oscillation. These letters refer to stratospheric (20 to 35 km altitude) equatorial east to west or west to east zonal winds which have a period of about 26 to 30 months or roughly 2 years. They typically blow for 12-16 months from the east and then reverse themselves and blow 12-16 months from the west and then back to the east again.

SLPA - Sea Level Pressure Anomaly. Caribbean and Gulf of Mexico Sea Level Pressure Anomaly in the spring and early summer has an inverse correlation with late summer and early autumn hurricane activity. The lower the pressure the more likely there will be hurricane activity.

Atlantic Basin - The ocean area of the entire Atlantic including the Caribbean Sea and the Gulf of Mexico.

Hurricane - A tropical cyclone with sustained low level winds of 74 miles per hour (32 meters/s) or greater.

Tropical Storm - a tropical cyclone with maximum sustained winds between 39 (17 m/s) and 73 (31 m/s) miles per hour.

Tropical Cyclone - a large-scale circular flow occurring within the tropics and subtropics which has its stronger winds at low levels. This includes tropical storms, hurricanes, and other weaker rotating vortices.

Hurricane Day - any part of a day in which a tropical cyclone is observed or estimated to have hurricane intensity winds.

Millibar - (abbreviated mb). A measure of atmospheric pressure. Often used as a vertical height designator. 200 mb is at a level of about 12 kilometers, 30 mb at about 23 kilometers altitude. Monthly averages of surface pressure in the tropics show maximum seasonal summer variations of about $\pm$ 2 mb. These small pressure variations are associated with variations in seasonal hurricane activity. Average surface pressure is slightly over 1000 mb.

ZWA - Zonal Wind Anomaly. A measure of upper level west to east wind strength. Positive values mean winds are stronger from the west or weaker from the east than normal.

ABSTRACT

This short paper discusses the author's updated forecast of the amount of seasonal hurricane and tropical storm activity which can be expected to occur in the Atlantic basin, Caribbean, and Gulf of Mexico region in 1986. This updated forecast is issued just before the start of the most active part of the hurricane season after 1 August. The author's previous forecast for 1986 was issued on 29 May 1986 (Gray, 1986) and called for 4 hurricanes (2 below average), 8 named tropical storms (2 below average), and 15 hurricane days (10 below average). This updated forecast is based on the author's earlier forecast and more recent June and July meteorological data.

Statistical information received by the author as of 28 July 1986 indicates that the hurricane and tropical storm activity for 1986 can (despite this being a non-El Nino year and the already occurrence of a hurricane and a tropical storm in June) be expected to be an even more suppressed season than anticipated in late May. This revised forecast indicates a probability for 4 hurricanes (6 is average), 7 hurricanes and tropical storms (10 is average), and 10 hurricane days (25 is average). New June and July meteorological information continues to indicate and further reinforces the probability for an inactive Atlantic hurricane season for 1986.

1. INTRODUCTION

The reader should refer to the 24 page paper of 29 May 1986 which was titled, "Forecast of Atlantic Seasonal Hurricane Activity for 1986" for background information on the methodology of the author's Atlantic seasonal forecast for this year. This forecast is based on past and current research on this subject by the author (Gray, 1984a, 1984b, 1985) which relates seasonal amount of Atlantic hurricane activity to: 1) the El Nino (EN); 2) the Quasi-Biennial Oscillation of equatorial stratospheric wind (QBO); 3) the Caribbean Basin and Gulf of Mexico Sea-Level Pressure Anomaly (SLPA); and 4) 200 mb Zonal Wind Anomaly (ZWA) at 5 key low latitude Caribbean Basin stations in the months of June and July.

The hurricane season is now nearly two months old and two June named cyclones (Andrew and Bonnie) have occurred. This should not be taken to indicate that the 1986 will be an active hurricane season since the bulk of the activity historically occurs after 1 August (Fig. 1). Records since 1900 indicate that the occurrence of June tropical storms and hurricanes do not correlate with the later season tropical cyclone activity.

The next four sections discuss how new June and July 1986 meteorological information on the El Nino, the Quasi-Biennial Oscillation (QBO), the Caribbean Basin Sea-Level Pressure Anomaly (SLPA) and low latitude Caribbean Basin 200 mb (12 km) upper level zonal wind information are used to update the author's original 1986 seasonal forecast of late May.

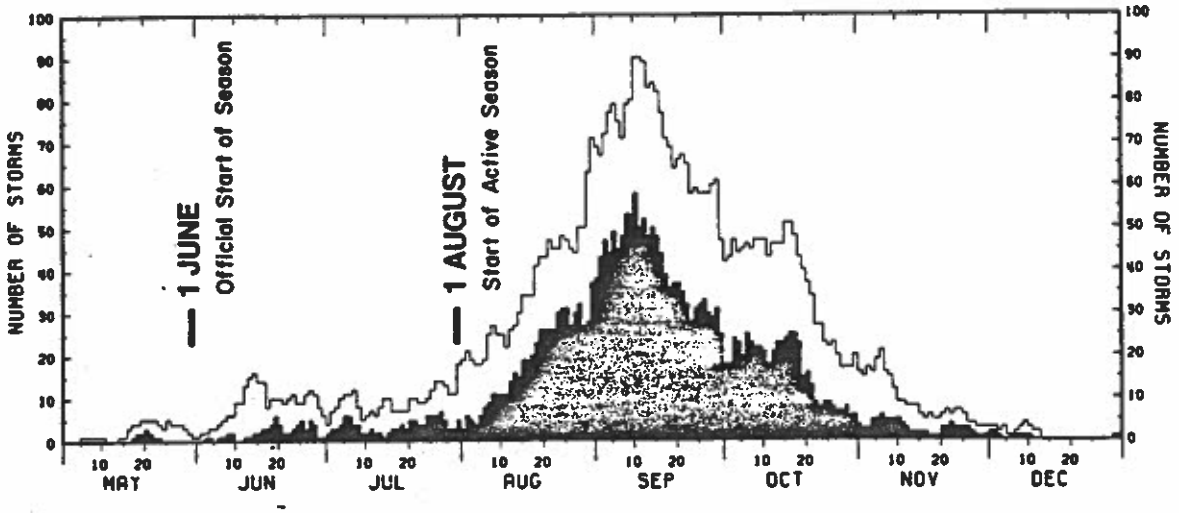

Fig. 1. Number of tropical storms and hurricanes (open curve) and hurricanes (solid curve) observed on each day, May 1, 1886 through December 31, 1980 (from Neumann, et al., 1981).

2. EL NINO INFLUENCES

The best estimates by those who study El Ninos is that there is only the remotest chance that 1986 will experience a strong or moderate El Nino event. The strong inhibiting influences on hurricane activity of a strong or a moderate El Nino event are thus not to be expected in 1986. Just a few months ago indications were that there was a strong possibility of an El Nino event for 1986. The US Climate Analysis Center (NOAA, Washington, DC) issued an El Nino alert on 13 March. A few numerical models and some other El Nino statistical forecast schemes indicated (in February and March) a high probability of an El Nino event for this year. But new data since April and into late July indicates that this possibility has now receded. No inhibiting influence of a strong or moderate El Nino event is thus forecast for 1986.

3. QUASI-BIENNIAL OSCILLATION (QBO) INFLUENCE

Information on the equatorial stratospheric zonal winds from Balboa, C.Z ($9^{o}N$), Ascension Island ($8^{o}S$), and other stations in June and July of 1986 does not cause the author to alter his original assessment made in late May that the 1986 hurricane season will be one in which 30 mb (or 23 km or 75,000 ft altitude) QBO equatorial stratospheric zonal winds (with the annual cycle removed) are easterly and increasing easterly (see Fig. 2). The 30 mb zonal winds (on which this forecast is based) shifted to an easterly direction in May and have been steadily increasing from the east throughout June and July. These easterly wind increases should continue through the 1986 season. Such easterly QBO winds and easterly wind speed increases are typically (as previously discussed in the 29 May 1986 forecast) associated with a reduction of seasonal hurricane activity.

4. CARIBBEAN BASIN SEA-LEVEL PRESSURE ANAMOLY (SLPA) INFLUENCE

Atlantic seasonal hurricane activity is, on a long period statistical basis, inversely related to Caribbean Basin-Gulf of Mexico Sea Level Pressure Anomaly (SLPA) during August-September. In non-El Nino years sea level pressure anomaly in the period of June through July are correlated (~0.6) with later August and September SLPA. The lower the SLPA in June and July, the more likely it is that a hurricane season will be active.

Table 1 gives information on the April-May and the 1 June to 27 July 1986 Caribbean-Gulf of Mexico SLPA in mb. Data are derived from six key stations in this region. SLPA for Trinidad is also shown. Values are averaged over two months to eliminate a suspected 40-60 day oscillation in surface pressure. Such an oscillation reduces the

validity of single month pressure values. The average of these stations was negative (by -0.50 mb) in April-May but is strongly positive by +1.20 mb in the period 1 June to 27 July. June-July values of SLPA correlate somewhat better with hurricane activity than do April-May values. These very high June-July sea level pressure anomalies indicate (other factors remaining neutral) a likely reduction in hurricane activity for 1986.

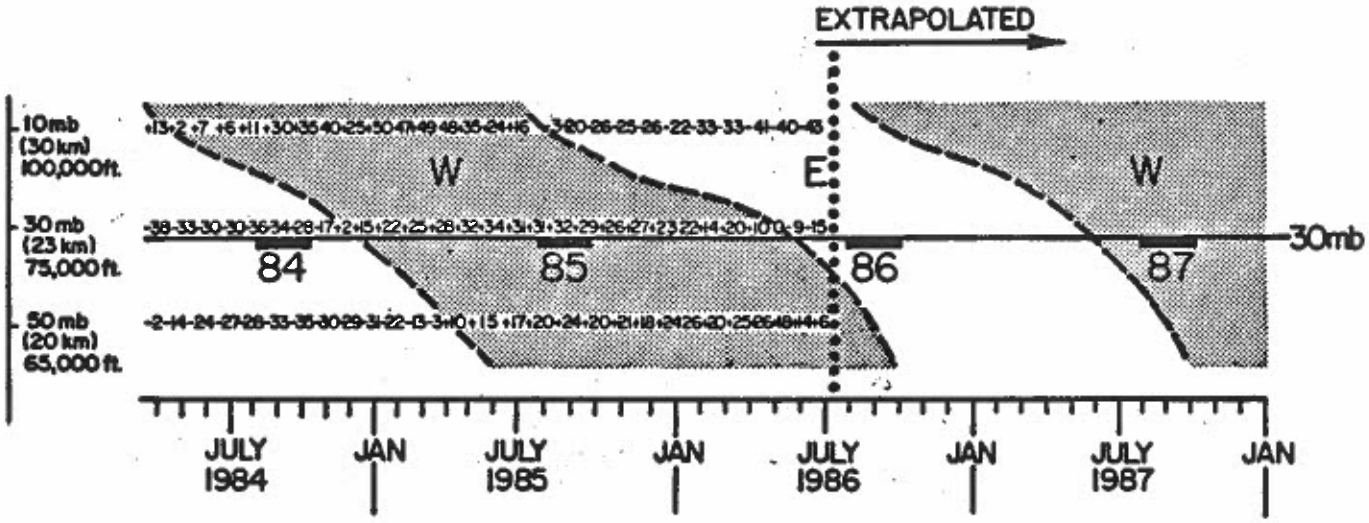

Fig. 2. Vertical cross-section of recent stratosphere monthly average QBO zonal wind (in knots). This figure represents an average of the Balboa, C.Z. ($9^{\circ}N$) and Ascension ($8^{\circ}S$) rawinsondes. The annual cycle has been removed from each sounding before averaging. Winds from a westerly direction have been shaded. Information beyond July 1986 has been extrapolated. Thick horizontal lines show the active portion of each hurricane season for 1984-1987.

TABLE 1

APRIL-MAY AND JUNE-JULY 1986 AVERAGE CARIBBEAN-GULF OF MEXICO SEA-LEVEL PRESSURE ANOMALY (SLPA) - IN MB (FROM DATA SUPPLIED BY A. PIKE OF NHC AND L. AVILA OF THE UNIVERSITY OF MIAMI)

	APRIL-MAY	1 JUNE-27 JULY
BROWNSVILLE	-0.2	+1.4
MERIDA (MEX.)	-0.3	+1.1
MIAMI	+0.0	+1.3
SAN JUAN	-1.4	+0.9
CURACAO	-1.0	+1.0
BARBADOS	-0.1	+1.5
MEAN	-0.5	+1.20
TRINIDAD	-0.2	+1.4

5. 200 MB ZONAL WIND ANOMALY (ZWA) IN NON-EL NINO YEARS

A study of hurricane frequency over the 28-year period of 1957-1984 (when upper level wind data is available from a number of low-latitude stations) shows that Atlantic hurricane activity in non-El Nino years is also related to June and July upper tropospheric (200 mb) zonal or west to east wind anomalies at the low latitude Caribbean Basin stations of Balboa, C.Z. (9°N), San Andres (12.5°N), Curacao (12°N), Trinidad (10.5°N) and Barbados (13°N). Stronger than normal June-July 200 mb (12 km or 40,000 ft level) winds from the west are statistically associated with less hurricane activity. By contrast, hurricane activity is generally more prevalent when early summer 200 mb winds at these stations are weaker than average from the west or stronger than average from the east. It is only the June-July winds which are related to hurricane activity. Wind data from earlier months do not show such a relationship. These winds are thus not used for the late May forecast

but assist with the late July updated forecast. Due to a suspected 40-60 day oscillation in the 200 mb wind reports, it is desirable (as with the surface pressure data) to average zonal wind data over at least a two month period and not make judgements based on individual monthly information.

Table 2 shows 200 mb (~ 12 km height) zonal or west-to-east wind anomaly for these 5 key low latitude Caribbean Basin upper air stations for the period 1 June to 27 July 1986. Values for Kingston are also shown. These positive west wind anomalies at all stations also indicate a probability for reduced Atlantic hurricane activity for the coming 1986 season.

TABLE 2

200 MB (OR 12 KM HEIGHT) ZONAL WIND ANOMALY (IN M/S) FOR 1986 FOR 5 KEY LOW-LATITUDE CARIBBEAN BASIN UPPER AIR STATIONS AND KINGSTON, JAMAICA FOR THE PERIOD OF 1 JUNE THROUGH 27 JULY 1986 AS SUPPLIED THE AUTHOR BY A. PIKE OF NHC AND LIXION AVILA OF THE U. OF MIAMI.

Balboa, C.Z. (9°N)	+1.8
San Andres (12.5°N)	+3.0
Curacao (12°N)	+3.7
Trinidad (10.5°N)	+3.1
Barbados (13°N)	+4.5
Average	+3.2
Kingston (13°N)	+8.4

Discussion. Of the four storm predictors for this updated forecast (QBO, EL, SLPA, and ZWA), all but the El Nino (EL) indicate a reduction in seasonal hurricane and tropical storm activity from average conditions. Of the three predictors available in a non-El Nino year, all indicate a reduction in hurricane activity. That is,

1) Stratospheric equatorial QBO winds will be from the east and will be increasing from the east during the hurricane season - previous seasons in which these conditions have been present have usually been below average hurricane seasons.

2) SLPA for June-July shows large positive values. Higher pressure in these months is, on average, associated with below average seasonal activity.

3) Lower latitude Caribbean basin 200 mb (12 km or 40,000 ft height) zonal winds in June and July are substantially stronger than normal from the west. Such zonal wind anomaly in non-El Nino years is statistically related to below average seasonal storm activity.

The more recent June and July meteorological data generally agrees with and helps to further substantiate the 29 May forecast of a below average 1986 hurricane season. In fact, June and July data indicates a somewhat more suppressed hurricane season than anticipated in late May.

6. UPDATED 1986 SEASONAL PREDICTION

Table 3 combines all four of these influences on seasonal hurricane activity and gives the author's updated numerical estimates of each term of his three prediction equations for the 1986 season. As April-May SLPA values were -0.5 mb, the author is making a SLPA of -1 instead of -2. The high values of June-July pressures would indicate a pressure correction of -2, if these pressure values were used alone without regard for the April-May values.

These updated values give the same forecast for the number of hurricanes (4) but lower for the number of named storms (hurricanes and tropical storms) by 1 and hurricane days by 5. The number of hurricanes, number of hurricanes and tropical storms, and number of

hurricane days are thus forecast to be 4 (2 below average), 7 (3 below average), and 10 (15 below average) respectively. It is estimated that there should be about 25 combined tropical storm and hurricane days.

TABLE 3

INFORMATION USED FOR REVISED 1986 SEASONAL FORECAST

(PREDICTED NO. OF HURRICANES PER SEASON) $= 6 + (QBO_1 + QBO_2) + EN + SLPA + ZWA$

$= 6 + (-1) + (-1) + (0) + (-1) + (-1) = 2$ (4)

The qualitative part of this forecast scheme (see Gray, 1984b) specifies that when this value is less than 4 in a non-El Nino year the value should be raised to a value of 4. In the last 40 years there has been only one non-moderate or strong El Nino year with less than 4 hurricanes. That was 1962 which had 3 hurricanes.

(PREDICTED NO. OF HURRICANES AND TROPICAL STORMS PER SEASON) $= 10 + QBO + EN + SLPA + ZWA$

$= 10 + (-1.6) + (0.7) + (-1) + (-1) = 7$

(PREDICTED NO. OF HURRICANE DAYS PER SEASON) $= 25 + 5\ (QBO_1 + QBO_2) + EN + SLPA + ZWA$

$= 25 + (-5) + (-5) + (0) + (-5) + (-5) = 5$ (10)

The qualitative part of this forecast scheme specifies that if the above formula gives a value less than 10, then the value should be raised to 10. In the last 54 years there have been only 4 non-El Nino years when the number of seasonal hurricane days have been less than 10. These were 1946 (8), 1970 (7), 1973 (9), and 1977 (6).

Comparison with Past Non El Nino Seasons of Easterly QBO Winds. Since stratospheric QBO wind information became available in 1950, there have been 7 previous non-El Nino years (1956, 58, 62, 68, 70, 74, and 81) when QBO winds were from the east and were increasing easterly during the hurricane season. Table 4 shows the number of hurricanes, hurricanes and tropical storms, hurricane and named storm days which occurred during these seasons together with June - July average Sea Level Pressure Anomaly (SLPA) for Caribbean-Gulf of Mexico stations plus the June - July low latitude Caribbean Basin Zonal Wind Anomaly (ZWA). It is seen that hurricane activity is generally lower in these non-El Nino years of QBO easterly winds and increasing easterly winds. SLPA and ZWA data for June and July indicate that 1986 may likely be more suppressed than these other years because of the higher values of SLPA and ZWA. None of the previous seven years of similar easterly QBO winds have had such a suppressing combination of SLPA and ZWA values. Given this combination of easterly QBO wind and increasing easterly QBO winds along with high values of both SLPA and ZWA, statistical odds favor a quite suppressed hurricane season. Particularly so, for a non-El Nino year. Note how 1986 June-July values of SLPA are over 1 mb higher than the long-term average and +.97 mb higher than the seven year average QBO easterly and increasing easterly years. None of these other seven years had as high a SLPA. Note also that 1986 June-July ZWA for the 5 station average is 3.2 m/s when the seven year average is but 0.2 m/s. Only one other previous easterly QBO year (1974) had a value of ZWA as high. None of these other seven previous easterly QBO years had a combination of June-July SLPA and ZWA as high.

TABLE 4

Hurricane and Tropical Storm activity in non-moderate and strong El Nino seasons since 1950 when stratospheric QBO winds have been easterly and increasing easterly during the hurricane season. Values occurring after 1 August are shown in parentheses. June and July SLPA and ZWA for these years and 1986 are also shown.

Year	No. of Hur.	No. of Hur. and Trop. Storms	No. of Hur. Days	Name Storm Days	June-July SLPA mb	June-July ZWA m/s
1956	4(3)	8(6)	12(11)	24(19)	+.60	+0.8
1958	7(7)	10(9)	33(33)	50(49)	-.70	-1.3
1962	3(3)	5(5)	10(10)	18(18)	+.53	-1.7
1968	4(2)	7(4)	9(7)	19(14)	+.67	+0.2
1970	5(4)	10(8)	7(7)	15(13)	+.35	-0.1
1974	4(4)	7(7)	16(16)	25(25)	+.24	+.4.3
1981	7(7)	12(10)	23(23)	50(47)	-.06	-1.1
Average	4.9(4.3)	8.4(7.0)	15.7(15.3)	28.7(26.4)	+.23	+0.2
1986					+1.20	+3.2

Summary

Values in the above predictive equations specify 7 named storms and only 10 hurricane days for this season. The forecast is for a quite suppressed tropical cyclone season. I thus alter my original forecast of 29 May 1986 for 4 hurricanes, 8 named storms, and 15 hurricane days downward to a forecast of 4 hurricanes (2 below average), 7 named storms of hurricane or tropical cyclone intensity (3 below average), and 10 hurricane days (15 below average). This updated forecast implies that (because we have already had 1 hurricane and 1 tropical storm in June) that only 3 additional hurricanes 5 additional named storms (hurricanes

and tropical storms),and 8 additional hurricane days are forecast for the remainder of the 1986 season. The revised forecast, the original forecast of 28 May and average seasonal values are given in Table 5.

TABLE 5

	Original Forecast As of 29 May 86	Revised Forecast As of 28 July 86	Average Year
No. of Hurricanes	4	4	6
No. of Named Storms (Hurricanes and Tropical Storms)	8	7	10
No. of Hurricane Days	15	10	25
Estimated No. of Tropical Storm and Hurricane Days	35	25	45

If 1986 follows a typical pattern, then one might expect to have about 25 named storm days. The seasonal average for the last 35 years is about 45. Last year there were 60 named storm days and the year before that 61.

As easterly QBO winds are typically associated with a suppression of lower latitude hurricane activity statistical odds favor a continuation of the last 4 years of suppressed Caribbean Basin cyclone activity.

For more information on this forecast please see the more detailed earlier forecast paper by the author (1986) which was issued on 29 May 1986.

7. CAUTIONARY NOTE

It is important that the reader realize that the author's forecast scheme, although showing quite promising statistical skill in the typically meteorological sense, can only predict about 50% of the total variability in Atlantic Seasonal hurricane activity over a long period. This is nevertheless a substantial improvement over the previous lack of any very skillful seasonal forecast scheme.

This forecast scheme will likely fail in some years when the other unknown factors (besides the QBO, EN, SLPA and ZWA) which cause storm variability are more dominant.

This forecast scheme cannot be judged in its verification in any one or a few seasons. The author is very confident that this forecast scheme has definite skill over a longer time period of 10-12 seasons. It should only be evaluated on this longer time scale.

This forecast scheme does not specifically predict which portion of the hurricane season will be most active or where within the Atlantic basin the storms will strike. Even if 1986 should numberwise prove to be a suppressed season, much damage and potential loss of life is possible from only one or two storms should they strike along a vulnerable coastline. One should always be alert to such a possibility. 1983 was one of the most inactive seasons on record but Hurricane Alicia caused over a billion dollars of damage to the Houston area. If there remains only one Atlantic hurricane this year, but it happened to go over your house or business, then for you, 1986 will seem to be a very active hurricane season indeed!

8. ACKNOWLEDGEMENTS

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