UPDATED FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY FOR 1990

By

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(This forecast is based on ongoing research by the author and his research colleagues at Colorado State University, together with new June-July 1990 meteorological information)

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DEFINITIONS

Atlantic Basin - The area including the entire Atlantic Ocean, the Caribbean Sea and the Gulf of Mexico.
Hurricane - A tropical cyclone with sustained low level winds of 74 miles per hour (33 ms^{-1} or 64 knots) or greater.
Tropical Cyclone - (TC) - A large-scale circular flow occurring within the tropics and subtropics which has its strongest winds at low levels, including hurricanes, tropical storms and other weaker rotating vortices.
Tropical Storm - A tropical cyclone with maximum sustained winds between 39 (18 ms^{-1} or 34 knots) and 73 (32 ms^{-1} or 63 knots) miles per hour.
Named Storm - A hurricane or a tropical storm.
Hurricane Destruction Potential (HDP) - A measure of a hurricane's potential for wind and storm surge destruction defined as the sum of the square of a hurricane's maximum wind speed for each 6-hour period of its existence.
Hurricane Day - Four consecutive 6-hour periods during which a tropical cyclone is observed or estimated to have hurricane intensity winds.
Named Storm Day - Four consecutive 6-hour periods during which a tropical cyclone is observed or estimated to have attained tropical storm or hurricane intensity winds.
Millibar (mb) - A measure of atmospheric pressure which is often used as a vertical height designator. Average surface values are about 1000 mb; the 200 mb level is about 12 kilometers and the 50 mb is about 20 kilometers altitude. Monthly averages of surface values in the tropics show maximum summertime variations of about $\pm$ 2 mb which are associated with variations in seasonal hurricane activity.
El Nino - (EN) - A 12-18 month period during which anomalously warm sea surface temperatures occur in the eastern half of the equatorial Pacific. Moderate or strong El Nino events occur irregularly, about once every 5-6 years or so on average.
Potential Damage (PD) - Potential damage from a hurricane's wind and ocean surge. Damage is assumed to increase with the square of the Saffir-Simpson 1 to 5 intensity scale.
QBO - Quasi-Biennial Oscillation. A stratospheric (16 to 35 km altitude) oscillation of equatorial east-west winds which vary with a period of about 26 to 30 months or roughly 2 years; typically blowing for 12-16 months from the east, then reverse and blowing 12-16 months from the west, then back to easterly again.
Saffir-Simpson (S-S) Category - A measurement scale (1 to 5) of a hurricane's wind and ocean surge intensity. 1 is the weakest hurricane, 5 the most intense hurricane.
SLPA - Sea Level Pressure Anomaly. Deviation of Caribbean and Gulf of Mexico sea level pressure from long term average conditions.
ZWA - Zonal Wind Anomaly. A measure of upper level ($\sim$ 200 mb) west to east wind strength. Positive values mean winds are stronger from the west or weaker from the east than normal.

1 knot = 1.15 miles per hour = .515 meters per second.

ABSTRACT

This paper presents details of the author's updated forecast of tropical cyclone activity for the Atlantic Ocean region (including the Caribbean Sea and the Gulf of Mexico) during 1990. This forecast is issued to coincide with the start of the more active part of the hurricane season. This forecast is based on the author's and his colleagues ongoing research which relates the amount of seasonal Atlantic tropical cyclone activity to five factors: 1) the El Nino (EN); 2) the Quasi-Biennial Oscillation of equatorial stratospheric wind (QBO); 3) Gulf of Mexico and Caribbean Basin Sea-Level Pressure Anomalies (SLPA); 4) lower latitude Caribbean Basin 200 mb Zonal Wind Anomalies (ZWA) and 5) West African rainfall (AR) amounts.

Information received by the author up to 2 August 1990 indicates that the 1990 hurricane season can be expected to have about 6 hurricanes, 11 total named storms of at least tropical storm intensity, about 25 hurricane days, and a Hurricane Destruction Potential of 75. It is also expected that there should be two major hurricanes of Saffir/Simpson intensity category 3, 4 or 5. This means that the 1990 Atlantic hurricane season will likely be about an average hurricane season based on statistics of the last 40 years, but an above average season as regards to amounts of hurricane activity of the 1970s and 1980s. This updated forecast reduces somewhat the amount of hurricane activity anticipated with the 5 June forecast.

1. Introduction

The Atlantic basin (including the Atlantic Ocean, Caribbean Sea and Gulf of Mexico) experiences a larger seasonal variability of hurricane activity than any other global hurricane basin. The number of hurricanes per season can be as high as 12 (as in 1969), 11 (as in 1950, 1916), 10 (1933), 9 (as in 1980, 1955), or as low as zero (as in 1914, 1907), 1 (as in 1919, 1905), or 2 (as in 1982, 1931, 1930, 1922, 1917, 1904). Until recent years there has been no objective method for indicating whether a coming hurricane season was likely to be an active one or not. Recent and ongoing research by the author and his colleagues (Gray, 1984a,b, 1990a,b; Gray, et al., 1987; Landsea, 1990) indicates that there is a surprising 3-5 month hurricane predictive signal available for the Atlantic basin from global and regional predictors which are generally not operative in the other global hurricane basins or in the middle latitudes.

2. Factors Known to be Associated With Atlantic Seasonal Hurricane Variability

The author's Atlantic seasonal hurricane forecast is based on the current values of indices derived from two global and three regional scale predictive factors which the author and his colleagues have shown to be statistically related to seasonal hurricane variations. Current values of these predictive factors are available either by early June, the official start of the hurricane season, or early August, the start of the more active part of the hurricane season. The five predictive factors are:

a) The presence or absence of a moderate or strong El Nino warm water event in the eastern tropical Pacific. Atlantic hurricane seasons during moderate or strong El Nino events average only about 40 percent as much hurricane activity as occurs during non-El Nino seasons. This difference is related to the stronger upper tropospheric (200 mb or 12 km) westerly winds which typically occur over the Caribbean Basin and western Atlantic during El Nino seasons. These winds shear off the potentially forming cyclone systems and prevent their development. Currently 1990 is not expected to have a strong or moderate El Nino. El Nino activity is thus judged not to be a significant inhibiting influence on this season's hurricane activity.

b) The direction of the stratospheric Quasi-Biennial Oscillation (QBO) which circles the globe over the equator. On average, there is nearly twice as much Atlantic hurricane activity during seasons when equatorial winds at 30 mb and 50 mb (23 and 20 km altitude respectively) blow from a relatively westerly direction as compared when they are from a relatively easterly direction. This season's QBO winds will be from a relatively westerly direction and near ideal for hurricane enhancement.

c) Sea Level Pressure Anomaly (SLPA) in the eastern Caribbean Basin. Other factors aside, negative pressure anomalies in the eastern

Caribbean basin in late spring and early summer are typically associated with active hurricane seasons and vice-versa. Pressure anomalies for April through July this year indicate near normal pressure conditions. This is judged to be a neutral factor in this season's hurricane activity.

d) Lower latitude Caribbean Basin upper tropospheric (~ 200 mb or 12 km altitude) west to east or zonal wind anomaly (ZWA) in non-El Nino seasons. Stronger 200 mb zonal wind anomalies are associated with a suppression of seasonal hurricane activity and vice-versa. Analysis of these winds also help in the monitoring of El Nino type influences on the lower Caribbean basin upper tropospheric winds. June-July 1990 ZWA are near normal. This is judged to be a neutral factor.

e) West African rainfall (AR). There is substantially more Atlantic hurricane activity, particularly intense hurricane activity when June through September West African rainfall is above average as compared to those seasons when it is below average. The long running west African drought of 1970-87 caused a great suppression of intense hurricane activity during that 18 year period. This drought may now be breaking up. During 1988-89 more rain fell during June through September in the west African countries of Gambia, Guinea-Bissau, western Mali, southern Mauritania, and Senegal than in any two consecutive year periods since the middle 1960s. In association with the rain in 1988-89, there was a substantial increase in intense hurricane activity with five Saffir/Simpson category 4-5 hurricanes. African rainfall information from the latter half of 1989 and 1990 data through July plus other related information indicate that we should expect the western Sahel region of West African to experience somewhat below average amounts of precipitation for this season. This should lead to a modest suppression of rainfall related hurricane activity for this season compared to average of the last 40 year. Although rainfall this year is projected to be less than in 1988 and 1989, this year should not be a drought year in the Western Sahel region. Substantially more precipitation should fall than occurred during the typical drought years of 1970-87 and a greater amount of hurricane activity, particularly intense hurricanes should occur over what transpired during the average of the 1970-1987 drought years.

3. Characteristics and Further Discussion of Five (EN, QBO, SLPA, ZWA, AR) Predictors for the 1990 Hurricane Season

a) El Nino. The central Pacific began experiencing an anomalous warming of its sea surface in November 1989. This warming trend continued through March 1990. This was thought by many to be the precursor of a significant El Nino event. But newer April through July data has shown that this warming has much abated and no significant warming event is now expected for this hurricane season. The July Southern Oscillation index is +0.4 mb. Although a weak warm water anomaly presently exists in the central Pacific (+0.6°C in Nino 4 in July) the eastern Pacific (Nino 1,2) had a -0.6°C below average SSTA. Nino 3 SSTA was zero. It is only the strong and moderate El Nino

events which have been observed to give a large suppression to Atlantic hurricane activity. In previous weak warm ENSO events of the last 40 years such as 1951, 1960-61, 1963, 1969, and 1979-80 hurricane activity was generally above average. Weak El Nino events have thus not been an inhibiting influence on Atlantic tropical cyclone activity in the past. The El Nino correction for this season is thus taken to be zero.

b) QBO. Tables 1 and 2 show the absolute and relative value of the current and extrapolated 30 mb (23 km) and 50 mb (20 km) stratospheric QBO zonal winds near 10°N for the 1990 hurricane period. These estimates are based on a combination of the QBO relative wind alteration and annual wind cycle variations at the low latitude stations of Balboa (9°N), Curacoa (12°N), Trinidad (11°N), and Barbados (13°N). Note that during the primary August through October hurricane season that 30 and 50 mb stratospheric winds are expected to be in a strong westerly phase. This results in the absolute values of the QBO winds being only weakly from the east or west and also that 50 to 30 mb zonal wind shears be very small. These are near ideal conditions for enhanced low latitude hurricane formation and for intense hurricane activity when formation occurs. Most intense hurricanes develop at latitudes equatorwards of 20°.

TABLE 1

April through October 1990 observed and extrapolated absolute value of stratospheric QBO zonal winds (U) in the critical latitude belts between 8-12°N as obtained from lower Caribbean basin stations of Curacao, Barbados, Trinidad, and Balboa. Values in m s^{-1} (as supplied by James Angell and Colin McAdie).

	Observed				Extrapolated		
Level	April	May	Jun	Jul	Aug	Sept	Oct
30 mb (23 km)	-3	-9	-6	-7	-8	-2	+4
50 mb (20 km)	-11	-11	-10	-10	-8	-2	+2

TABLE 2

Same as Table 1 but for the relative zonal wind where the annual wind cycle has been removed. Values in m s^{-1}.

	Observed				Extrapolated		
Level	April	May	Jun	Jul	Aug	Sept	Oct
30 mb (23 km)	+5	+5	+11	+12	+14	+16	+14
50 mb (20 km)	-10	-5	0	+4	+6	+8	+10

c) SLPA. Table 3 shows April-May and June-July 1990 Sea Level Pressure Anomaly (SLPA) for the most relevant tropical stations. April through July SLPA was near normal for the special 5-station low latitude average. These SLPA are derivations from the last 40-year average. The low latitude stations are more relevant to the forecast. The high latitude anomalies are of little significance.

TABLE 3

1990 Average Eastern Caribbean Basin Sea-Level Pressure Anomalies (SLPA) - in mb (as kindly supplied by Colin McAdie of NHC).

Low Latitude	SLPA	Apr-May	Jun-Jul	Gulf of Mexico-Caribbean Basin	SLPA	Apr-May	Jun-Jul
San Juan	(19.5°N,66°W)	-0.3	-0.4	Brownsville		-0.1	+1.3
Curacao	(12°N,69°W)	+0.2	+0.2	Merida (Mex.)		+0.7	+1.4
Barbados	(13.5°N,60°W)	-0.5	-0.2	Miami		+0.5	+1.0
Trinidad	(11°N,62°W)	+0.2	+0.3	San Juan		-0.3	-0.4
Cayenne	(5°N,52.5°W)	+0.1	-0.0	Curacao		+0.2	+0.2
				Barbados		-0.5	-0.2
	Average	-0.1	0.0		Average	+0.1	+0.6

d) ZWA. Lower Caribbean Basin 200 mb zonal wind anomaly (ZWA) for June-July 1990 give some indication of future tropospheric wind shear conditions. ZWA conditions also help monitor the possible influences of a Pacific El Nino warm water event on Caribbean Basin upper tropospheric wind conditions. Table 4 shows that the upper tropospheric ZWAs for April-May and June-July. Note that all values are close to zero. These ZWA values indicate a neutral correction for this factor. They also indicate that a possible hurricane inhibiting influence from the weak central Pacific SST warming event now in progress has not shown a typical El Nino influence on Caribbean Basin upper tropospheric winds. In strong and moderate El Nino events 200 mb ZWA anomaly conditions in the lower Caribbean Basin are strongly positive.

TABLE 4

1990 Caribbean Zonal Wind Anomaly (ZWA) in m s^{-1} (as supplied by Colin McAdie of NHC).

Station	April-May	June-July
Balboa (9°N, 80°W)	-2	+3
Kingston (18°N, 77°W)	-2	+2
Curacoa (12°N, 69°W)	+2	-1
Barbados (13.5°N, 60°W)	+2	+1
Trinidad (11°N, 62°W)	0	0
Average	0	+1

e) AR. African Rainfall (AR) is a new forecast parameter that we are including in this year's forecast for the first time. Atlantic intense hurricane activity is much enhanced when the Western Sahel region of West Africa (see Fig. 1) has above average precipitation and much suppressed when precipitation in this region is much below average. The striking differences in Atlantic hurricane activity between wet and dry West African rainfall years is illustrated in Fig. 2. Recent analysis by Landsea (1990) is showing high correlation of year-to-year variance in the number of intense (category 3-4-5) hurricane days over the last 40 years. It is amazing that African rainfall data prior to August would be so highly correlated with hurricane activity during the main August through October period.

Analyses of Western Sahel precipitation through July of this year indicates that western Sahel precipitation will be somewhat below normal. Table 5 compares the sum of rainfall of August through November period of the previous year in the Gulf of Guinea (R1) precipitation - (weight one-third) and June-July Western Sahel (R3) precipitation weighted two-thirds and seasonal number of category 3-4-5 hurricane days. This combination, available on 1 August explains 60% of the 1949-89 seasonal variance in intense hurricane days.

African rainfall information through July 1990 indicates that the Western Sahel region will have less rain during this year than occurred during the seasons of 1988 and 1989. This season's pre-August rainfall amounts are however higher than in 12 of the last 20 hurricane seasons

Fig. 1. Location of rainfall stations which make up the western Sahel precipitation index (R3). The R1 region along the Gulf of Guinea shows a predictive value for hurricanes using the August to November rainfall from the previous year (from Landsea, 1990).

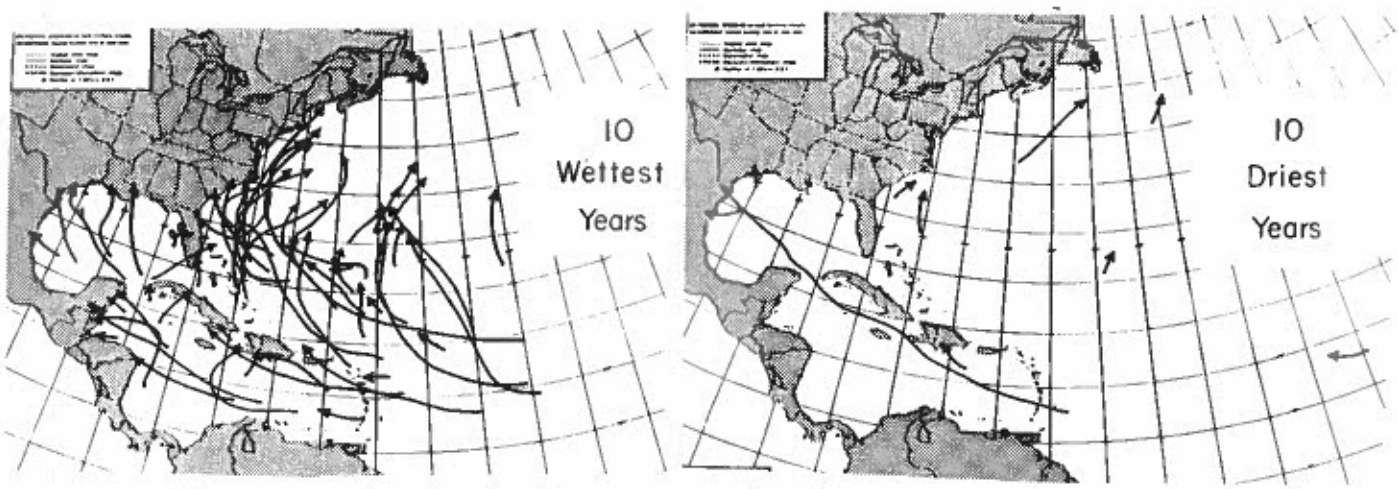

Fig. 2. Contrast of category 3-4-5 hurricane tracks in the 10 wettest years (a) versus the 10 driest years (b) during the 41-year period (1949-1989).

TABLE 5

Previous year period (1949-1989) August-November African rainfall from the Gulf of Guinea region (R1 of Fig. 1) weighted one-third and June-July Western Sahel rainfall (R3 of Fig. 1) weighted two-thirds versus seasonal intense hurricane (category 3-4-5) days. Rainfall is expressed as the standard deviation (σ) from the 41-year mean. These two quantities are correlated at r = .77 and explain about 60% of variance of intense hurricane days.

	Rainfall	Intense Hurricane Days		Rainfall	Intense Hurricane Days
1949	-.16	5.25	1970	-.31	1.00
1950	.55	18.75	1971	-.31	1.00
1951	-.32	8.25	1972	-.66	0.00
1952	.61	6.75	1973	-.62	0.25
1953	.72	6.75	1974	-.20	4.25
1954	.38	9.50	1975	.38	2.25
1955	1.19	17.25	1976	-.50	1.00
1956	.15	2.75	1977	-.73	1.00
1957	-.03	6.50	1978	.01	3.50
1958	.54	9.50	1979	.04	5.75
1959	-.46	4.25			
1960	.53	11.00	1980	-.48	7.25
1961	.92	24.50	1981	.00	3.75
1962	-.32	0.50	1982	-.71	1.25
1963	.19	7.00	1983	-.78	0.25
1964	.98	14.75	1984	-.77	0.75
1965	-.29	7.50	1985	-.27	4.00
1966	-.38	8.75	1986	-.59	0.00
1967	.24	5.75	1987	-.56	0.50
1968	-.37	0.00	1988	.31	8.00
1969	.76	6.75	1989	.70	10.75
			1990	-.28	5.00 Fcst.

and higher than 5 of the 6 seasons between 1982-87. There have been no reports of dust coming out of Africa this year as typically occurs in drought years. The U.K. Meteorological Offices global model has, based on June sea surface temperature data, projected a near normal amount of summer precipitation for the Western Sahel. Their statistical models forecast a below average rainfall season.

Note in Table 1 that 30 and 50 mb zonal winds in September have been extrapolated to be very weak. The vertical shear between these levels is expected to be very small. There have only been 12 other years since 1950 that QBO conditions have been as favorable for activity as this season. These conditions are expected to help overcome some of this year's below average (-0.28 o) values of the West African R1 and R3 pre-August precipitation. In the six previous seasons (1959, 66, 71, 73, 80, 85) in which similar very favorable QBO conditions existed and below normal (-0.42 o average) pre-August precipitation conditions existed average or somewhat above average seasonal hurricane activity occurred. During these 6 seasons the averages of the number of hurricanes, named storms, HDP, number of category 3-4-5 storms, and category 3-4-5 storm days were 6.8, 10.8, 77, 2, and 4.3, respectively.

4. Author's 1990 Forecast

The author's Atlantic seasonal forecast scheme is of the following form:

$$\begin{pmatrix}\text{Predicted Amount}\\ \text{of Hurricane}\\ \text{Activity per Season}\end{pmatrix} = \begin{pmatrix}\text{Average}\\ \text{Season}\end{pmatrix} + \underbrace{(\text{QBO} + \text{EN} + \text{SLPA} + \text{ZWA} + \text{AR})}_{\text{Adjustment Terms}} \quad (1)$$

where

QBO = 30 mb and 50 mb Quasi-Biennial Oscillation equatorial zonal wind corrections, positive for west phase, negative for east phase.

EN = El Nino influence. Warm East Pacific water reduces hurricane activity, cold water enhances it.

SLPA = Average SLPA for June-July from deep tropical and selected Caribbean-Gulf of Mexico stations. Reduce if SLPA is significantly above average, add if significantly below average.

ZWA = Zonal Wind Anomaly at 200 mb (12 km) for five low latitude upper air Caribbean stations. Hurricane activity is inversely correlated with this parameter. Applied only in non-El Nino years.

AR = African rainfall. Heavy summertime West African rainfall is associated with an increase of both the number and the

intensity of Atlantic hurricanes; reduced rainfall with a decrease in hurricane number and intensity.

A synthesis of the five forecast factors as discussed in section 3 leads to the author's updated 1990 seasonal forecasts for the number of hurricanes, named storms, hurricane days, named storm days, Hurricane Destruction Potential (HDP), major hurricanes, and major hurricane days for the coming 1990 hurricane season (see Table 6).

It is anticipated that the upcoming 1990 hurricane season will be somewhat less active than were the 1988 and 1989 seasons. This means that 1990 will be about an average hurricane season based on statistics of the last 40 years but distinctly above average compared to typical conditions of the last 20 years. If this forecast is verified, then this would be the third consecutive year that hurricane conditions have been average or above average. This may be an indication of changing western Sahel rainfall conditions.

Table 7 gives a comparison of this season's Atlantic hurricane forecast with the observed hurricane activity of recent years. This season is forecast to have greater amounts of hurricane activity than occurred during most of the hurricane seasons of 1970s and 1980s except for the seasons of 1979, 80, 88, 89 and in particular more activity than occurred during the 6-year period of 1982-87 when Atlantic hurricane activity was unusually low. As was observed in 1988 and 1989 there is a good probability of the occurrence of at least two Saffir/Simpson category 3, 4, or 5 hurricanes during 1990. Intense hurricanes are much more prevalent in seasons when West Africa is not in drought, when 30 and 50 mb stratospheric QBO winds are from a relatively westerly direction, and where there is no strong or moderate El Nino is present. 1990 will be one of these seasons.

It appears that we may have turned a corner since 1988 and will now see a return to a period of more active and intense hurricane seasons as were experienced in the period of the late 1940s through the 1960s.

Verification of the Author's Six Previous Seasonal Forecasts. Table 8 gives verification data for the author's previous seasonal forecasts. The late July forecasts have been superior to the late May forecasts and the forecasts of named storm activity have been the most successful. Except for last year these forecasts had been a significant improvement over climatology - the only objective seasonal prediction that had previously been available. This lack of accuracy in last year's forecast is attributed to the apparent breaking of the long running African Sahel drought which was not explicitly included in the author's earlier forecast scheme and for which the author did not properly account. A study of the last 40 years of hurricane seasons had shown that those seasons of easterly QBO wind and above average SLPA in April through July (as 1989 was) were usually suppressed hurricane seasons. Last year did not follow this pattern. This was most assuredly due to the very heavy amount of rainfall which fell in the

TABLE 6

UPDATED 1990 PREDICTED SEASONAL HURRICANE ACTIVITY

No. of Hurricanes per Season	= 6 + QBO + EN + SLPA + ZWA + AR		
	5.8 + (1.5) + (0) + (0) + (0) + (-1.5) =	6	
No. of Hurricanes and Tropical Storms	= 9 + QBO + EN + SLPA + ZWA + AR		
	9.8 + (1.5) + (0) + (0) + (0) +(-1.5) =	10	(Raise to 11)
No. of Hurricane Days	= 25 + 5 (QBO + EN + SLPA + ZWA + AR)		
	25 + 5 [(1.5) + (0) + (0) + (0) + (-1.5)] =	25	
No. of Named Storm Days	= 2.0 x (No. of Hurricane Days) =	50	
Hurricane Destruction[1] Potential - HDP	= 75 + 15 (QBO + EN + SLPA + ZWA + AR)		
	75 + 15[(1.5)+(0)+ (0) + (0) + (-1.5)] =	75	
No. of Major[2] Hurricanes	= 2.5 + 0.8 (QBO + EN + AR)		
	2.5 + 0.8 [(1.5) + (0) + (-1.5)] ~	2	
Major Hurricane Days[3]	= 2.50 x (No. of Major Hurricanes) ~	5	

[1] The wind and storm surge destruction of a hurricane is better represented by the square of the storm's maximum winds than by the maximum wind itself. This potential for damage from hurricane winds and storm surge might be termed Hurricane Destruction Potential (HDP). We define Hurricane Destruction Potential (HDP) as the sum or $\Sigma (V_{max})^2$ for V_{max} equal or greater 65 knots (74 mph) for each 6-hour period for all hurricanes that are in existence during a full season. Units are 10^4 knots^2.

[2] Hurricanes of Saffir/Simpson category 3, 4, or 5.

[3] During average and above average hurricane seasons there are about 2.5 major hurricane days for every major hurricane.

TABLE 7

Comparison of 1990 Hurricane Activity Forecast With Previous Years' Activity.

	Updated 3 Aug Forecast 1990	5 June Forecast 1990	1989	1988	Average Season 1982-87	Average Season 1970-87	Average Season 1950-69
Hurricanes	6	7	7	5	4.0	4.9	6.5
Named Storms	11	11	11	12	7.5	8.3	9.8
Hurricane Days	25	30	32	24	10.7	15.5	30.7
Named Storm Days	50	55	66	47	32.0	37.3	53.4
Hurr. Dest. Pot. (HDP)	75	90	108	81	27.0	42.7	100.0
Major Hurricanes (Cat. 3-4-5)	2	3	2	3	1.2	1.6	3.4
Major Hurricane Days	5	-	10.8	8.0	1.1	2.1	8.8

TABLE 8

Verification of the author's previous seasonal predictions of Atlantic tropical cyclone activity for 1984-1989.

1984	Prediction of 24 May and 30 July Update	Observed
No. of Hurricanes	7	5
No. of Named Storms	10	12
No. of Hurricane Days	30	18
No. of Named Storm Days	45	51

1985	Prediction of 28 May	Updated Prediction of 27 July	Observed
No. of Hurricanes	8	7	7
No. of Named Storms	11	10	11
No. of Hurricane Days	35	30	21
No. of Named Storm Days	55	50	51

1986	Prediction of 29 May	Updated Prediction of 28 July	Observed
No. of Hurricanes	4	4	4
No. of Named Storms	8	7	6
No. of Hurricane Days	15	10	10
No. of Named Storm Days	35	25	23

1987	Prediction of 26 May	Updated Prediction of 28 July	Observed
No. of Hurricanes	5	4	3
No. of Named Storms	8	7	7
No. of Hurricane Days	20	15	5
No. of Named Storm Days	40	35	37

1988	Prediction of 26 May and 28 July Update	Observed
No. of Hurricanes	7	5
No. of Named Storms	11	12
No. of Hurricane Days	30	24
No. of Named Storm Days	50	47
Hurr. Destruction Potential (HDP)	75	81

1989	Prediction of 26 May	Updated Prediction of 27 July	Observed
No. of Hurricanes	4	4	7
No. of Named Storms	7	9	11
No. of Hurricane Days	15	15	32
No. of Named Storm Days	30	35	66
Hurr. Destruction Potential (HDP)	40	40	108

western Sahel region of Africa during late July and through mid-September. Most intense hurricanes are spawned from Africa wave systems during periods when Africa rainfall conditions are near or above average. It was impossible to know before last year's forecast was made whether the relatively heavy Sahel rains of 1988 were a one year occurrence or whether 1988 represented the start of a longer term break in the Sahel drought. It is now clear that any Atlantic seasonal forecast scheme which fails to account for western Sahel rainfall will fail in those seasons in which a basic change from drought to wet or from wet to drought occurs. Had the pre-August 1989 rainfall information shown in Table 5 been available last year and had we known then what we know now about the strong Western Sahel-intense hurricane relationship, a much more active 1989 hurricane season forecast would have been made.

5. Cautionary Note

It is important that the reader realize that the author's forecast scheme does not specifically predict which portion of the hurricane season will be most active or where within the Atlantic basin the storm will strike. Even if 1990 should prove to be an active hurricane season, there is no assurance that any of these hurricanes will necessarily strike along vulnerable US or Caribbean basin coastline.

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