FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY FOR 1992

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 current April–May 1992 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.

Hurricane Day - Four 6-hour periods during which a tropical cyclone is observed or estimated to have hurricane intensity winds.

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.

Named Storm Day - Four 6-hour periods during which a tropical cyclone is observed or estimated to have attained tropical storm or hurricane intensity winds.

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.

Intense Hurricane - A hurricane reaching at some point in its lifetime a sustained low level wind of at least 111 mph (96 kt or 50 ms^{-1}). This constitutes a category 3 or higher on the Saffir/Simpson scale.

Intense Hurricane Day - Four 6-hour periods during which a hurricane has intensity of Saffir/Simpson category 3 or higher.

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 Niño - (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 Niño events occur irregularly, about once every 5-6 years or so on average.

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 ranging from 1 to 5 of hurricane wind and ocean surge intensity. One is a weak hurricane whereas 5 is the most intense hurricane.

SLPA - Sea Level Pressure Anomaly. A deviation of Caribbean and Gulf of Mexico sea level pressure from observed long term average conditions.

SST(s) - Sea Surface Temperature(s).

ZWA - Zonal Wind Anomaly. A measure of upper level ($\sim$ 200 mb) west to east wind strength. Positive anomaly 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 forecast for the amount of tropical cyclone activity which might be expected to occur in the Atlantic Ocean region, including the Caribbean Sea and the Gulf of Mexico, during 1992. This forecast is based on the author and his colleague's ongoing research relateing to the amount of seasonal Atlantic tropical cyclone activity that can be specified in early June by four factors: 1) the Quasi-Biennial Oscillation of equatorial stratospheric wind (QBO); 2) the El Niño (EN); 3) West African Rainfall (AR) anomalies of the previous year and 4) West African west to east gradients of surface pressure and surface temperature during February through May (ΔPT).

Information received by the author through 3 June 1992 indicates that the 1992 hurricane season should be below average with about 4 hurricanes, 8 named storms of at least tropical storm intensity, about 15 hurricane days, a total of 35 named storm days and a Hurricane Destruction Potential (HDP) of 35. It is also expected that there should be only one intense hurricane of Saffir/Simpson intensity category 3, 4 or 5 this season and two intense hurricane days. These numbers are identical to those of the author's 26 November 1991 forecast and to his updated assessment as of 6 April 1992. All of these parameter forecasts indicate a below average hurricane season. However, this year should be more active than last year which was a very suppressed season, but substantially less active than the recent hurricane seasons of 1988–90.

Reduced hurricane activity during the (1992) season will be due to: (1) Tropical Pacific Sea Surface Temperature (SST) anomaly patterns. A warm El Niño event is currently in progress but is beginning to weaken. This weakening is not expected to occur fast enough to prevent inhibiting of the hurricane activity for this year; (2) Below average rainfall conditions are expected in the Sahel region of West Africa; and (3) West African west to east pressure and temperature gradients during February to May of this year indicate a weaker than normal summer monsoon trough and consequently, below average hurricane activity.

This forecast will be updated on 5 August, 1992, just before the beginning of the most active part of the hurricane season. The updated 5 August forecast will make use of June and July data and should provide a more reliable forecast, particularly with regard to the African rainfall as it relates to prospects for intense hurricane activity. The updated forecast will also give a better gage on the strength of this year's El Niño through October, 1992.

This seasonal forecast has less skill for hurricane activity in the Gulf of Mexico region wherein hurricane activity is more a result of relatively local meteorological conditions which may be different than the conditions which effect the rest of the Atlantic basin.

1 Introduction

The Atlantic basin (including the Atlantic Ocean, Caribbean Sea and Gulf of Mexico) experiences more seasonal variability of hurricane activity than any other global hurricane basin. The number of hurricanes per season can range as high as 12 (as in 1969), 11 (as in 1950, 1916), 10 (as in 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 recently there has been no objective method for determining whether a forthcoming hurricane season was likely to be active, inactive, or near normal. Recent and ongoing research by the author and his colleagues (Gray, 1984a, 1984b, 1990; Landsea, 1991; Gray *et al.*, 1992) indicates that there are surprisingly skillful 3 to 11 month (in advance) predictive signals for Atlantic basin seasonal hurricane activity.

2 Factors Known to be Associated With Atlantic Seasonal Hurricane Variability

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

a) The direction of the stratospheric Quasi-Biennial Oscillation (QBO) of east–west winds which circle the globe over the equator: On average, there is nearly twice as much intense Atlantic basin 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 to when they are from a relatively easterly direction. During the 1992 season, these QBO winds will be changing from an easterly to a westerly direction and are expected to be neither an enhancing nor an inhibiting influence on this season's hurricane activity.

b) The presence or absence of a moderate or strong El Niño warm water event in the eastern equatorial Pacific: Atlantic hurricane seasons during moderate or strong El Niño events average only about 40 percent as much hurricane activity as during non-El Niño seasons. These differences are 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 Niño seasons. It is expected that the current moderate to strong El Niño event will be undergoing weakening over the next six months but will still be strong enough during Augusut through October so as to cause an inhibiting influence on this season's hurricane activity.

c) African Rainfall (AR). Atlantic intense hurricane activity is typically enhanced in those seasons when the Western Sahel and Gulf of Guinea regions of West Africa (shaded area in Fig. 1) have had above average late summer and fall precipitation during the previous year (i.e., in this case during the fall of 1991). Hurricane activity is typically suppressed if the prior fall rainfall in these two regions has been below average. Last year (1991) conditions were dry. This indicates that West African precipitation will likely again have below normal rainfall for this year. It is expected that precipitation amounts this year will be more in line with the generally suppressed precipitation years of 1970-87 and 1990-91. This implies a likely below average hurricane season of intense hurricane activity.

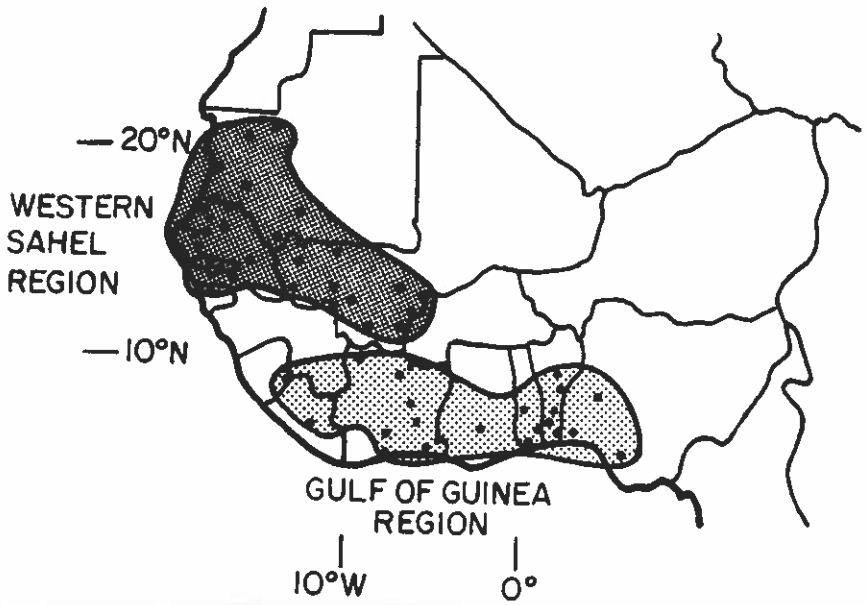

Figure 1: Locations of rainfall stations which make up the 38–station Western Sahel precipitation index and the 24-station Gulf of Guinea precipitation index. August to November rainfall within the Gulf of Guinea region provides a predictive signal for the following years hurricane activity as does prior year August-September rainfall in the Western Sahel (see Landsea, 1991; and Gray *et al.*, 1992).

d) West Africa west to east surface pressure and temperature gradients (Δ PT). Recent research is showing that west to east surface pressure and surface temperature gradients across West Africa from February through May are strongly correlated with the hurricane activity which follows later in the year. We find that Atlantic hurricane activity is enhanced when the east (Region B) minus west (Region A – see Fig. 2) pressure gradient is higher than normal and/or when the east minus west temperature gradient anomaly is below average. Pressure and temperature gradients between February and May of this year were such as to indicate a below average hurricane season.

3 Current Characteristics and Further Discussion of the Four Primary (QBO, ENSO, AR, and Δ PT) Early June Predictors of 1992 Hurricane Season

3.1 QBO

Tables 1 and 2 show the absolute and relative values of the current and extrapolated 30 mb (23 km) and 50 mb (20 km) stratospheric QBO zonal winds near 11 to 13°N for 1992 during the primary hurricane period of August through October. These estimates are based on a combination of the current trends in the relative QBO winds combined with the annual wind cycle variations at the low latitude stations of Curacao (12°N), Trinidad (11°N), and Barbados (13°N). Note that during the primary August through October hurricane season, 30 mb zonal winds are expected to have shifted to an anomalously westerly direction but that 50 mb zonal winds are expected to remain from an easterly direction.

Stratospheric QBO wind conditions for this year are expected to be in an intermediate

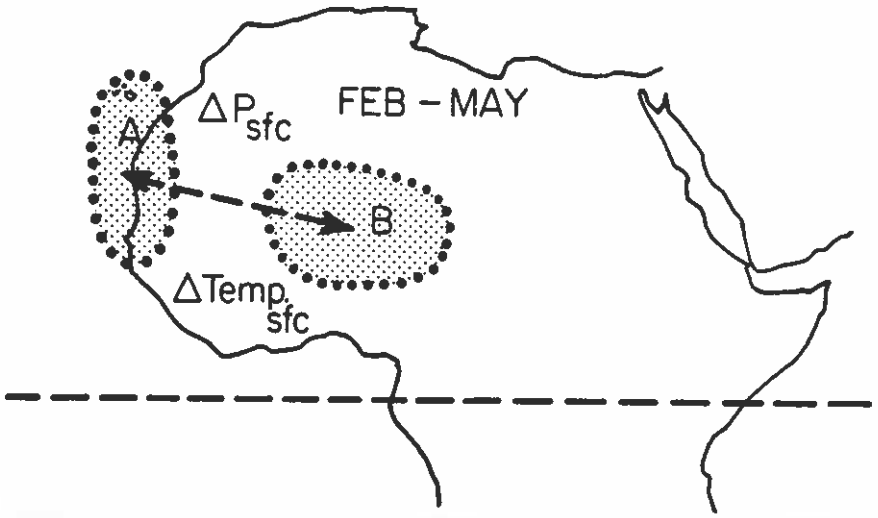

Figure 2: Portrayal of the two West African regions—west (Area A) and east (Area B)—from which the means of multi-station standard deviations of surface pressure and temperature are computed to form combined west-to-east pressure and temperature gradients or Δ PT parameter.

change over stage from easterly to westerly phase conditions. Such change-over conditions are believed to be neutral as regards to deviations of seasonal hurricane activity from average values. Hence, no significant enhancement or reduction of this year's hurricane activity is thus anticipated from the QBO influence.

Table 1: April through October 1992 observed and extrapolated absolute value of stratospheric QBO zonal winds (U) in the critical latitude belts between 11-13°N as obtained from lower Caribbean basin stations of Curacao (12°N), Barbados (13°N), and Trinidad (11°N). Values are in ms^{-1} (as supplied by James Angell and Colin McAdie).

	Observed			Extrapolated				
Level	March	April	May	Jun	Jul	Aug	Sept	Oct
30 mb (23 km)	–15	–18	–21	–23	–21	–15	–9	–4
50 mb (20 km)	–2	–6	–13	–20	–24	–24	–20	–12

3.2 ENSO

El Niño events cause the upper tropospheric westerly winds in the Caribbean basin and easterly tropical Atlantic to be stronger than normal. These upper level westerly winds cause vertical shearing of westward moving Atlantic easterly waves. These shearing influences prevent the easterly waves from developing into named storms or, if they do develop, they prevent them from becoming as intense as they might otherwise be without such shearing influences.

The Central and Eastern tropical Pacific are currently experiencing a moderate to strong El Niño (warm event) that has reached its maximum strength and is now beginning to weaken.

Table 2: Same as Table 1 but for the "relative" (or anomalous) zonal wind where the annual wind cycle has been removed. Values are in ms^{-1}.

	Observed			Extrapolated				
Level	March	April	May	Jun	Jul	Aug	Sept	Oct
30 mb (23 km)	–14	–12	–9	–5	0	+6	+10	+12
50 mb (20 km)	–2	–5	–7	–9	–10	–10	–8	–4

This warming event began last summer. If the present event follows similar warming events of the past (that have begun in the previous year as this event has), the current ENSO event should undergo a steady weakening from now to the end of the hurricane season. For instance, the Southern Oscillation Index (SOI) has already greatly fallen during May (1992) and deep convection near the dateline is beginning to decrease. This warming event is expected to be fully dissipated by late in the year and it is likely that cold SST (or La Niña) condition will occur during the next hurricane season.

Although it is expected to be significantly weaker than at present by September, the current ENSO event is nevertheless anticipated to remain strong enough to pose a suppressing influence on this season's Atlantic seasonal hurricane activity. Historical evidence since 1880 shows that El Niño events in their second year tend to maintain a significant amount of their strength through October, if they have been as strong during the period March through May as the current El Niño event has been.

If the current El Niño is observed to weaken more quickly than presently expected, then the early August forecast will be adjusted to fit this accelerated temperature decrease. Even if the current El Niño should show exceptionally rapid weakening in the next five months, the 1992 hurricane season would still not be expected to have above average hurricane activity. There is often a month or two lag adjustment of the atmosphere circulation to ocean SST changes.

3.3 West African Rainfall (AR)

Substantially more intense Atlantic hurricane activity occurs when June through September West African rainfall is above average as compared to those seasons when rainfall is below average. The long running West African drought of 1970-87 was associated with a great suppression of intense hurricane activity during that 18 year period. A temporary (two year) interruption of African drought conditions occurred in 1988–89 when there was also a substantial increase in intense hurricane activity including five Saffir/Simpson category 4-5 hurricanes. However, drought conditions returned again in 1990 and 1991 (see Fig. 3). The assessment for 1992 (as of the end of May) is that we will again see below average Western Sahel rainfall this year. It is expected that precipitation amounts will be more in line with the reduced precipitation years of 1970-87 and 1990-91. West African rainfall is thus judged to be an inhibiting influence for Atlantic intense hurricane activity for 1992.

The assessment that 1992 will have a below average precipitation year for the Sahel is based upon the following considerations:

- (a) The low values of the Western Sahel August-September precipitation last year (–0.45

standard deviations) and the very low values of Gulf of Guinea region (Fig. 1) rainfall during August through November of last year (-0.96 standard deviation).

- (b) Anticipated continuation of significant El Niño warm water conditions through most of the coming hurricane season. As discussed in the next section, this warm event is consistent with West African below normal rainfall conditions.
- (c) The present arrangement of global and Atlantic SSTA conditions which in past years have been associated with African drought conditions. These SSTA conditions include positive southwest Atlantic SSTA and negative SSTA anomalies off of West Africa. The UK Meteorological Office (1992) is also forecasting dry conditions for this year for the Sahel. Meteorological office forecasts are based on global SSTA patterns through April.
- (d) Negative values of February through May west-to-east gradients of surface pressure and positive gradients of surface temperature (ΔPT) in West Africa. Such conditions are associated with later season dry conditions for the Western Sahel.

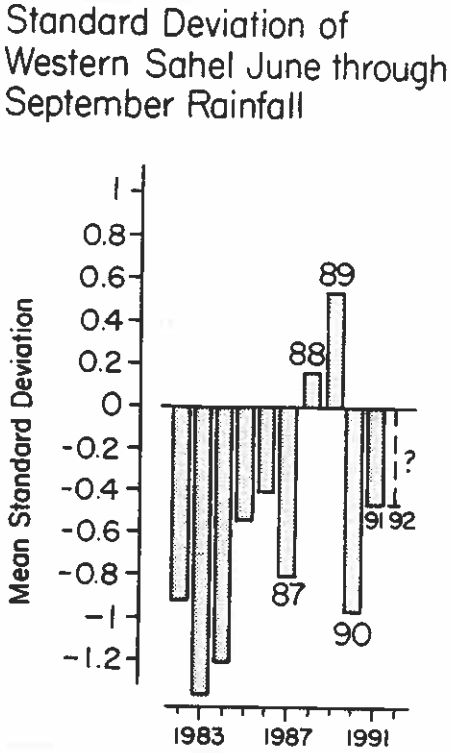

Figure 3: Variations in recent years of the standard deviation of June through September rainfall (right diagram). Note the break in drought conditions during 1988 and 1989.

Interruption of Sahel Drought in 1988 and 1989. These two wet seasons represented a sharp increase in West African rainfall from conditions of the long running drought of 1970–87. More rainfall fell in the Western Sahel region during 1988–89 than during any two consecutive years since 1964–65. The 1988–89 rainfall was more typical of the yearly values during the 1950s and 1960s. And, no less than five category 4-5 hurricanes occurred in 1988–89 (Gilbert, Helene, Joan, Gabrielle, and Hugo) with a total of 18.75 intense hurricane days; well above the annual average of 2.1 intense hurricane days during 1970–87.

Following the 1989 hurricane season it seemed reasonable to surmise that the long running multi-decadal drought might be ending. If true, this would have far reaching implications for the potential of coastal hurricane destruction in subsequent years. In retrospect however, it appears that this long running drought has not yet ended and that the two heavy rainfall years of 1988 and 1989 did not represent the end of the Sahelian drought. Very dry conditions returned again to the West Sahel in 1990 and 1991 and we anticipate generally dry conditions again for 1992. We do not know when this quarter century long drought will end but, if past trends of this sort are an indication of the future, it should likely run its course in the next few years.

Our recent research also indicates that the comparatively heavy West African rainfall of 1988–89 was likely a response to the unusually cold sea surface temperatures which developed throughout the eastern half of the equatorial Pacific Ocean during 1988–89. Similar cold water, or anti-El Niño conditions of this magnitude had not occurred for many years. Teleconnected effects of these cold SSTs acted to suppress upper tropospheric westerly winds within the lower Caribbean Basin and eastern tropical Atlantic. This reduction of upper tropospheric westerly winds over the tropical Atlantic allowed the establishment of stronger upper tropospheric easterly wind anomalies over West Africa with an associated general enhancement of the West African monsoon rainfall. A conceptual illustration of this association is shown in Fig. 4.

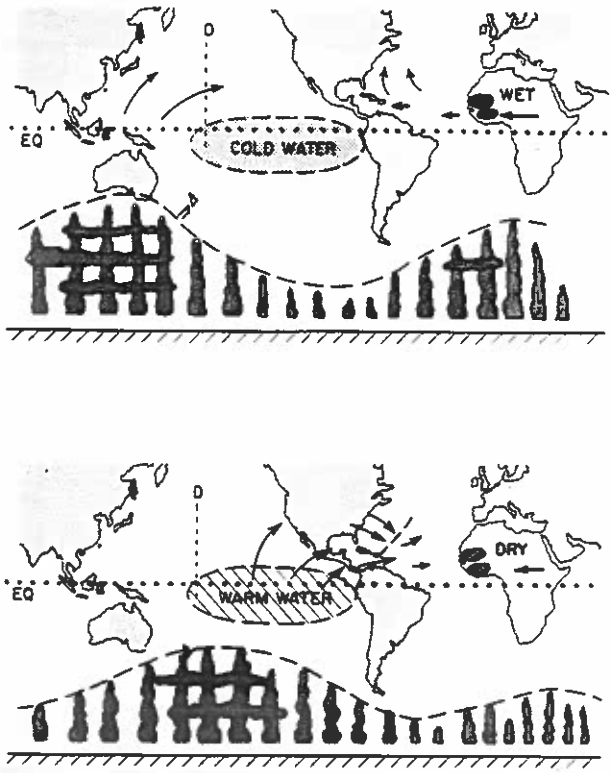

Figure 4: Idealized rendering of the associations between anomalous SST values in the eastern equatorial Pacific and anomalous westerly winds in the upper troposphere over the western tropical Atlantic, as well as the broad features of anomalous equatorial convection around the globe. Cold SST values (top panel) are linked to diminished westerlies and hence enhanced hurricane activity and vice versa for elevated (El Niño) SST values (bottom panel).

If La Niña or cold water conditions occur in the tropical Pacific for 1993 as expected, then it is likely that more normal or possibly above normal Western Sahel rainfall conditions could be experienced for next year.

3.4 Δ PT

New project research by C. Landsea and R. Taft is showing that west-to-east surface pressure and temperature gradients which become established across West Africa during February through May are good indicators of the hurricane activity to be expected in the coming months. Figure 2 shows the west-and-east areas of Africa from which these surface pressure and temperature gradients are taken. Pressure and temperature are expressed as standard deviations (S.D.) from the 1949–1991 average. Hurricane activity is highest when the east (Region B) minus west (Region A) deviational pressure gradients are most positive and/or when the east region minus west region temperature gradients are most negative. Thus, seasonal Atlantic hurricane is a function of Δ *PT or* $(\Delta P_{sfc(B-A)} - \Delta T_{sfc(B-A)}$. It is surprising how well these West African February through May surface pressure and temperature gradients are associated with seasonal hurricane activity in the following months. Pressure and temperature gradients that establish themselves in spring have a conservatism, tending to persist into summer and early fall. The combination of these west to east ΔP and ΔT gradients between 1949-1991 explained 49 percent (r = 0.70) of the variance of seasonal number of intense (category 3-4-5) hurricane days. See Fig. 5.

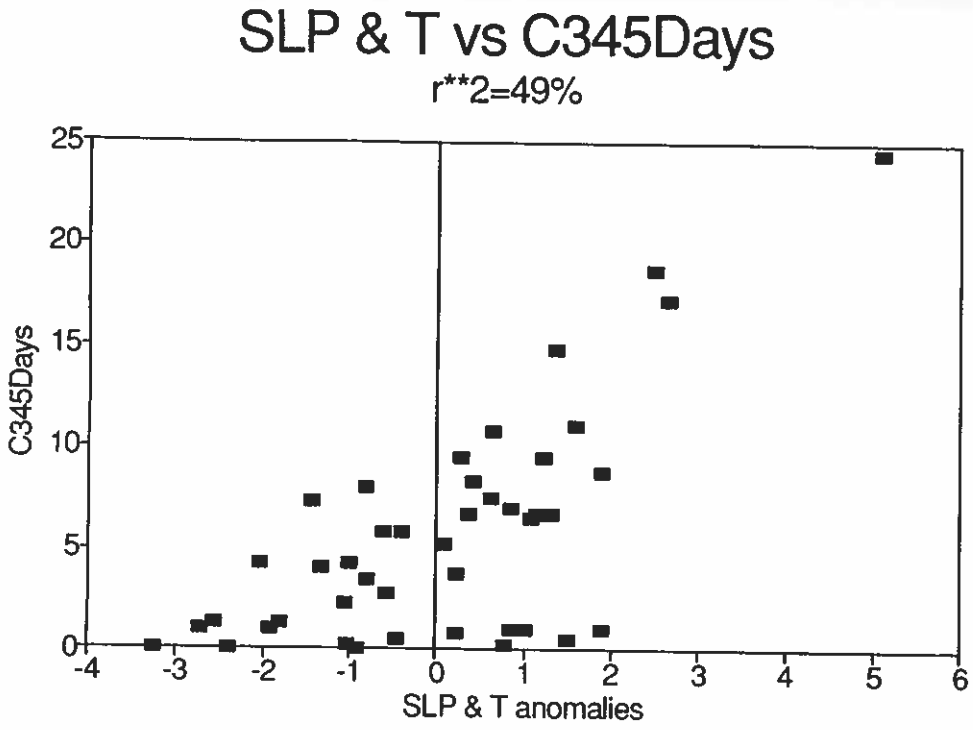

Figure 5: Scatter diagram of the seasonal number of intense hurricane days versus the combined west to east surface pressure and temperature gradient anomalies (ΔPT) during February through May during the years 1949–1991.

Given the typical inverse relationship between land surface temperature and surface pres-

sure, positive west-to-east pressure gradients are typically associated with negative west-to-east temperature gradients and vice versa. A positive value of Δ PT would act to enhance southerly and moist deviational flow over West Africa. More African rain and Atlantic hurricane activity would result. When these two west to east ΔP and ΔT gradients are of opposite sign (negative for ΔP and positive for ΔT) this would cause West Africa to have northerly and dry deviational winds. This is conducive to dry conditions and fewer Atlantic seasonal hurricanes. February through May 1990 Δ PT data for this year was negative (−1.0) indicating a general suppression of hurricane activity.

3.5 SLPA and ZWA

Two parameters which have been used in the past and which are very important for the early August forecast are Caribbean Basin Sea Level Pressure Anomalies and 200 mb (12 km) Zonal Wind Anomalies. New research is showing these parameters to be of only marginal value in comparison with the four other early June predictors. Although April-May 1992 5-station tropical (Trinidad, Barbados, Curacao, San Juan and Cayenne SLPA's were quite low, (-1.1 mb), and the 5-station April-May (Trinidad, Curacao, Barbados, Kingston and Balboa) ZWA value positive was +3.1 m/s. This information is not being used the early June forecast.

4 Author's 1992 Forecast

The early June seasonal forecast has evolved in recent years with the addition of forecast parameters involving West African rainfall during the previous year (AR) and February to May west to east gradients of surface pressure and temperature (or Δ PT).

The author's current early June Atlantic seasonal forecast scheme has the following form:

$$\left(\begin{array}{c}(Predicted\ Amt.\\ of\ Hurricane\\ Activity\\ Per\ Season\end{array}\right) = Ave.\ Season + \underbrace{(QBO + EN + AR + \Delta PT)}_{Adjustment\ Terms}$$

where

QBO = 30 mb and 50 mb Quasi-Biennial Oscillation equatorial zonal wind correction factors; positive hurricane activity enhancement for west phase, negative reduction for east phase.

EN = El Niño influence; warm East Pacific water reduces hurricane activity, cold water enhances it.

AR = Rainfall in the Western Sahel and Gulf of Guinea regions of Africa during the previous year; heavy previous year rainfall is associated with an increase in hurricane activity, reduced rainfall with a decrease in such activity.

Δ PT = West to east positive surface pressure and negative temperature gradients across West Africa during February through May. Positive deviations go with more activity, negative deviations with less.

The author and his research colleagues C. Landsea, P. Mielke and K. Berry are presently performing new statistical tests (jackknife method) to determine the precise hindcast skill of this early June forecast scheme for the period of 1950-1991. It is expected that when statistical tests are completed, that about half of the season to season hurricane activity variance will be independently explained.

A synthesis of these four early June forecast factors leads to the following 1992 seasonal forecasts for the number of hurricanes, named storms, hurricane days, named storm days, Hurricane Destruction Potential (HDP), major hurricanes, and major hurricane days (see Table 5).

TABLE 5
1992 Predicted Seasonal Hurricane Activity

(No. of Hurricanes)	=	(Ave. Season) + QBO + EN + AR + Δ PT	
		5.9 + (0) + (−1.0) + (−0.5) + (−0.5)	≈ 4
(No. of Hurricanes and Tropical Storms)	=	(Ave. Season) + QBO + EN + AR + Δ PT	
		(9.8) + (0) + (−1.0) + (−0.5) - (−0.5)	≈ 8
(No. of Hurricane Days)	=	(Ave. Season) + 5 (QBO + EN + AR + Δ PT)	
		25 + 5 [+ 0 + (−1.0) + (−0.5) + (−0.5)]	≈ 15
(No. of Named Storm Days)	=	2.3 x (No. of Hurricane Days)	≈ 35
(Hurricane Destruction Potential - HDP)[1]	=	(Ave. Season) + 15 (QBO + EN + AR + Δ PT)	
		74 + 15[0 + −1.0 + (−0.8) + (−0.8)]	≈ 35
(No. of Intense [2] Hurricanes)	=	2.5 + 0.7 (QBO + EN + AR + Δ PT)	
		0.7[(0) + (−1.0) + (−0.8) + (−0.8)]	≈ 1
(Intense Hurricane Days)[3]		(No. of Intense Hurricanes) x (2)	≈ 2

Table 6 provides a comparison of this season's Atlantic hurricane forecast with the observed hurricane activity of recent years. Note that the 1992 season is expected to be significantly less active than the three hurricane seasons of 1988–89–90 but more active than 1991. It is expected that the 1992 hurricane season will be more typical of the average hurricane season during 1970–87. This early June forecast is identical to the extended range forecast of seasonal Atlantic hurricane activity issued on 26 November 1991 and the author's updated assessment made on 6 April of this year.

[1]See definition on Page 2.
[2]See definition on Page 2.
[3]See definition on Page 2.

Table 6: Comparison of 1992 Hurricane Activity Forecast With Activity in Previous Years.

	5 June Forecast 1992	Observed 1991	1990	1989	1988	Average Season 1970-87	Average Season 1950-69	42-Year Ave.
Hurricanes	4	4	8	7	5	4.9	6.5	5.9
Named Storms	8	8	14	11	12	8.3	9.8	9.9
Hurricane Days	15	8	28	32	24	15.5	30.7	23.8
Named Storm Days	35	20	68	66	47	37.3	53.4	47.2
Hurr. Dest. Pot. (HDP)	35	23	57	108	81	42.7	100.0	74.5
Major Hurricanes (Cat. 3-4-5)	1	2	1	2	3	1.6	3.4	2.5
Major Hurricane Days	2	1	1	10.75	8	2.1	8.8	5.5

5 Forecast for the Gulf of Mexico

Our studies have shown that Gulf of Mexico hurricane activity seems to be less closely related to the seasonal prediction factors for hurricane activity variations in the Atlantic basin as a whole. Figure 6 shows this separation. The Gulf of Mexico is removed from the tropical Atlantic belt and is further downwind from Africa. Only a small percentage of hurricanes track into the Gulf of Mexico from the open Atlantic. Hurricanes in the Gulf occur earlier in the season and the hurricane season therein typically terminates earlier. Intense hurricanes (category 3-4-5) Alicia (1983), Allen (1980), Celia (1970), and Elena (1985) all made landfall along the Gulf Coast in deficient West African rainfall years. This is atypical of the rest of the Atlantic basin. Thus, a below average season for the Atlantic Basin as a whole does not necessarily imply that hurricane activity within the Gulf will be below average.

6 Verification of Previous Forecasts

Table 7 gives verification data for the author's previous eight years of seasonal forecasts. The late July forecasts have been superior to the early June forecasts and the forecasts of named storm activity have been the most skillful. Last year's forecast went very well. Except for 1989, these forecasts are an improvement over climatology - the only objective seasonal prediction that had previously been available. The lack of accuracy for the 1989 forecast is attributed to heavy rainfall which fell in West Africa. Prior to 1990 this rainfall was not explicitly included in the author's forecast scheme. However, this rainfall is now included and its influence is becoming better understood.

7 Discussion

It is expected that the suppressing effects of the El Niño, Western Sahel drought and negative ΔPT influences will lead to a below normal hurricane season for this year. Although it is expected that hurricane activity during the 1992 season will be below average, there should be more hurricane activity than occurred in 1991, particularly in the tropical regions ($< 25°$N), the Caribbean, and the Gulf of Mexico. These regions were devoid of hurricanes in 1991. It is

Table 7: Verification of the author's previous seasonal predictions of Atlantic tropical cyclone activity for 1984-1991.

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
1990	**Prediction of 5 June**	**Updated Prediction of 3 Aug**	**Observed**
No. of Hurricanes	7	6	8
No. of Named Storms	11	11	14
No. of Hurricane Days	30	25	27
No. of Named Storm Days	55	50	68
Hurr. Destruction Potential(HDP)	90	70	57
Category 3-4-5 Hurricanes (IH)	3	2	1
Category 3-4-5 Hurricane Days (IHD)	Not fcst.	5	1
1991	**Prediction of 5 June**	**Updated Prediction of 2 Aug**	**Observed**
No. of Hurricanes	4	3	4
No. of Named Storms	8	7	8
No. of Hurricane Days	15	10	8
No. of Named Storm Days	35	30	20
Hurr. Destruction Potential(HDP)	40	25	23
Category 3-4-5 Hurricanes (IH)	1	0	2
Category 3-4-5 Hurricane Days (IHD)	2	0	1

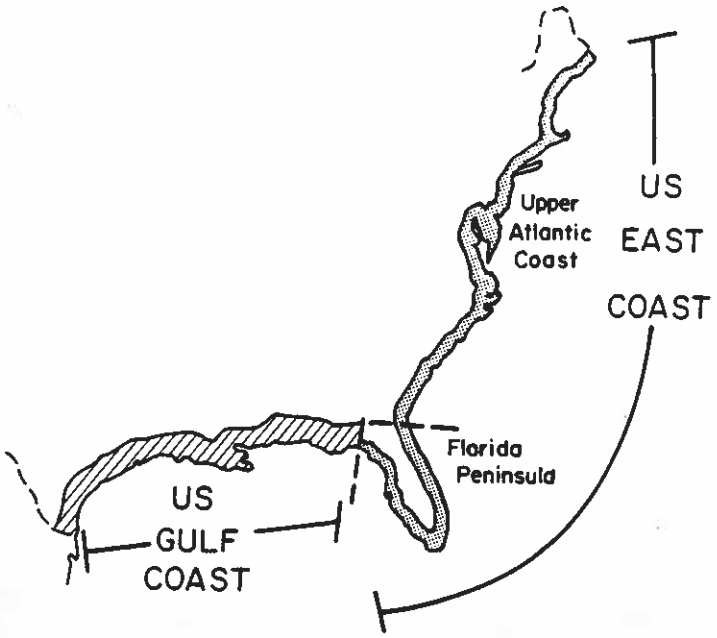

Figure 6: Illustration of the two basic US coastal regions which are observed to have different hurricane destruction responses to varying amounts of seasonal West African precipitation. The approximate separation point is the Apalachee Bay of Florida.

expected that less higher latitude tropical cyclone formation will occur in 1992 in comparison with the large number of tropical cyclone formations of 1990 and 1991.

The projection of drought conditions in the Western Sahel for this year implies that there will likely be a below average amounts of intense hurricane (category 3-4-5) activity. The probability of major hurricane destruction along the US East Coast and over Peninsula Florida will be below that of the last 45 year average and more comparable to the East Coast hurricane threat of the last 20 years [which has been below the longer period (1950-1990) mean]. As hurricane damage along the US Gulf Coast is not much related to West African rainfall amounts, nothing much can be said as to the probability of Gulf Coast intense hurricane related damage for this year.

8 Early August Update of Seasonal Forecast

This forecast will be updated on 5 August 1992. The updated forecast will make use of June–July values for meteorological parameters and should be more accurate. In particular, we will have June–July Western African rainfall information which is a very good predictor of the amount of intense hurricane activity and late information on the El Niño.

9 Outlook for 1993

There is a good possibility that Atlantic basin hurricane activity in 1993 will be considerably greater than last year or as this year is expected to be. This assessment is based on considerations relating to the three primary forecast factors (El Niño, QBO, and African rain)

which indicate a likely above average season. Specifically,

1) There is a high probability that a moderate or strong La Niña (or cold water) event will be in progress in the tropical Pacific during the 1993 season. This should act as an enhancing influence on hurricane activity as the cold La Niña event of 1988-89 was to the very active hurricane season of those two years.

2) It is expected that the stratospheric QBO will be in a westerly and hence hurricane enhancing phase during the main part of next years' hurricane season; and

3) La Niña conditions will favor the lessening of the West African drought conditions.

10 Cautionary Note

It is important that the reader realize that this seasonal forecast is a statistical scheme which will fail in some years. This forecast also does not specifically predict which portion of the hurricane season will be most active or where within the Atlantic basin storms will strike. Even if 1992 should prove to be a below average hurricane season, there are no assurances that several hurricanes will not strike along the US or Caribbean Basin coastline and do much damage.

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