

**EARLY AUGUST
UPDATED FORECAST OF ATLANTIC SEASONAL HURRICANE
ACTIVITY FOR 1995**

(An expected banner year for hurricane activity)

(Next page gives a summary)

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(Various long and short versions of this forecast with figures and tables are available on the
Wide World Web at this URL
<http://typhoon.atmos.colostate.edu/forecasts/index.html>)

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As of 4 August 1995

(A verification of this forecast will be issued in late November)

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Summary of the early August 1995 seasonal hurricane forecast.

Forecast Parameter	Activity up to Early August	Forecast Activity After Early August	Total Seasonal Activity	Last 45-Year Average
Named Storms (NS)	5	11	16	9.3
Named Storm Days (NSD)	16	49	65	46.1
Hurricanes (H)	2	7	9	5.7
Hurricane Days (HD)	3	27	30	23
Intense Hurricanes (IH)	0	3	3	2.1
Intense Hurricane Days (IHD)	0	5	5	4.5
Hurricane Destruction Potential (HDP)	6	84	90	68.1
Net Tropical Cyclone Activity (NTC)	23	107	130	100

DEFINITIONS

Atlantic basin - The area including the entire Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico.

Hurricane - (H) A tropical cyclone with sustained low level winds of 74 miles per hour (33 ms^{-1} or 64 knots) or greater.

Hurricane Day - (HD) 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 - (TS) 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 - (NS) A hurricane or a tropical storm.

Named Storm Day - (NSD) 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 (in 10^4 knots^2) for each 6-hour period of its existence.

Intense Hurricane - (IH) 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 (a "major" hurricane).

Intense Hurricane Day - (IHD) 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 ± 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.

Delta PT - A parameter which measures the anomalous west to east surface pressure (ΔP) and surface temperature (ΔT) gradient across West Africa.

SOI - Southern Oscillation Index - A normalized measure of the surface pressure difference between Tahiti and Darwin.

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 (~ 200 mb) west to east wind strength. Positive anomaly values mean winds are stronger from the west or weaker from the east than normal.

Net Tropical Cyclone Activity (NTC) - Average seasonal percentage sum of NS, NSD, H, HD, IH, IHD. Gives overall indication of Atlantic basin seasonal hurricane activity. (See Appendix A).

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

ABSTRACT

This paper presents details of the authors' early August updated forecast for the amount of tropical cyclone activity that can be expected to occur in the Atlantic Ocean region including the Caribbean Sea and the Gulf of Mexico during the remainder of the 1995 hurricane season. Most Atlantic basin hurricane activity occurs after early August. This forecast is based on the authors' ongoing research relating the amount of seasonal Atlantic tropical cyclone activity to five basic physical parameters. These are: 1) the Quasi-Biennial Oscillation (QBO) of equatorial stratospheric winds; 2) the El Niño-Southern Oscillation (ENSO); 3) West African Rainfall (AR) anomalies during the previous year and June-July of this year, 4) anomalous west to east gradient of surface pressure and temperature (ΔPT) in West Africa during February through May 1995, and 5) Caribbean Basin Sea Level Pressure and Upper Level Zonal Wind Anomalies (SLPA and ZWA, respectively).

Information received by the authors up to 3 August 1995 indicates that the overall 1995 hurricane season should be a very active season with about 9 hurricanes or seven more than we have so far had (total season average is 5.7), 16 named storms or 11 more than we have so far had (total season average is 9.3), a total of about 30 hurricane days (average is 23), 65 named storm days (average is 46) and total Hurricane Destruction Potential (HDP) of 90 (average is 68). It is also expected that there should be 3 intense or major hurricanes of Saffir-Simpson intensity category 3, 4 or 5 (average is 2.1) and about 5 major hurricane days (average is 4.5) are expected. These parameters represent an overall measure of total hurricane and tropical cyclone activity which is about 130 percent of the last 45-year average. This updated forecast is very close to, but more active than, earlier issued 1995 seasonal forecasts on 30 November 1994 and 7 June 1995.

This active season updated forecast is based on the presence of westerly equatorial stratospheric QBO winds, the dissipation of the long running El Niño event, estimates of African Western Sahel rainfall that do not indicate drought conditions for this year, negative values of June-July Caribbean basin surface pressure and 200 mb zonal wind anomalies plus a number of other qualitative factors not explicitly included in our statistical equations. These are warm eastern and central Atlantic sea surface temperatures, stronger than normal African wave activity, a stronger than average 200 mb African tropical easterly jet, etc. All these conditions are favorable for a very active hurricane season. The active early start of the hurricane season plays no role in our analysis of the activity to follow after 4 August.

1 Introduction

The Atlantic basin, including the Atlantic Ocean, Caribbean Sea and Gulf of Mexico, experiences more season-to-season variability of hurricane activity than any other global hurricane basin. The number of hurricanes per season in recent years has ranged as high as 12 (as in 1969), 11 (as in 1950) and 9 (as in 1980, 1955), and as low as 2 (as in 1982) and 3 (1994, 1987, 1983, 1972, 1962, 1957). 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 authors (see Gray, 1984a, 1984b, 1990; Landsea, 1991; Gray et al., 1992, 1993a, 1994) 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

This early August seasonal forecast is based on the current values of indices derived from various global and regional scale predictive factors which the authors have previously shown to be statistically related to seasonal variations of hurricane activity. Figure 1 provides a summary of the locations of the various forecast parameters which go into the forecast. Successive sets of values of these predictive factors are obtained by late November of the previous year, by early June of the concurrent year (the official start of the hurricane season) and by early August (just before the start of the active portion of the hurricane season). These predictive factors include the following:

(a) The stratospheric Quasi-Biennial Oscillation (QBO) influence. The QBO refers to variable east-west oscillating stratospheric winds which circle the globe near the equator. On average, there is nearly twice as much intense (category 3-4-5) Atlantic basin hurricane activity during seasons when equatorial stratospheric winds at 30 mb and 50 mb (23 and 20 km altitude, respectively) are more westerly as compared to when they are from a more easterly direction. During the 1995 season, these QBO winds will be from a relative westerly direction and are expected to be an enhancing influence for this season's hurricane activity.

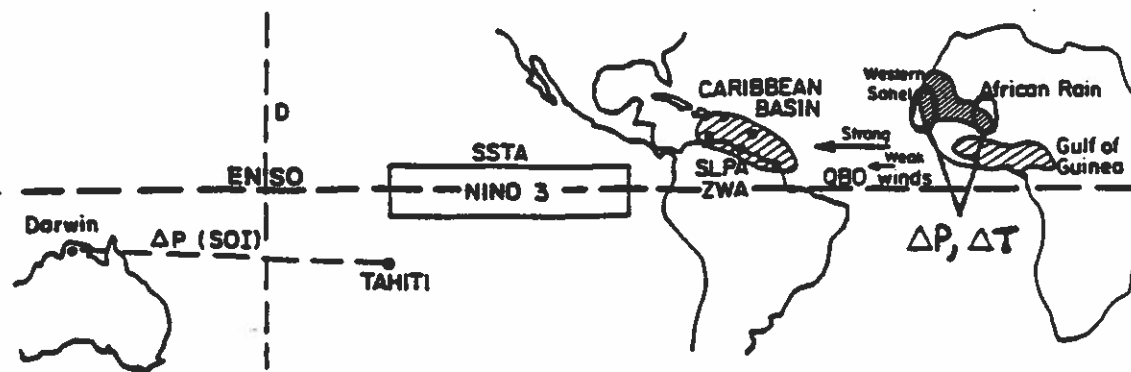


Figure 1: Locations of meteorological parameters used in the seasonal hurricane forecasts.

(b) El Niño-Southern Oscillation (ENSO) influence: ENSO characterizes the sea surface temperature anomalies in the eastern equatorial Pacific and the value of Tahiti minus Darwin (Fig. 1) surface pressure gradient. The effects of a moderate or strong El Niño (warm water and low values of Tahiti minus Darwin sea level pressure difference) event in the eastern equatorial Pacific are to reduce Atlantic basin hurricane activity. By contrast, in those seasons with cold sea surface temperatures, and high values of Tahiti minus Darwin surface pressure occur (La Niña years) there is typically an enhancement of Atlantic basin hurricane activity. These differences are related to alterations of upper tropospheric (200 mb or 12 km) westerly winds and surface pressure over the Caribbean Basin and western Atlantic. Westerly winds are enhanced during El Niño seasons. This condition creates strong vertical wind shear over the Atlantic. This inhibits hurricane activity. During La Niña (or cold) years, westerly winds and the associated vertical wind shear are reduced and hurricane activity is typically greater. The unusually long lasting 1991-94 El Niño has finally run its course and neutral to cold water conditions are beginning to settle in. The gradual establishment of cooler ENSO conditions should be a factor enhancing this year's Atlantic basin hurricane activity.

(c) African Rainfall (AR) influence: The incidence of intense Atlantic hurricane activity is strongly enhanced during those seasons when the June-July Western Sahel and previous year August-November Gulf of Guinea regions of West Africa (shaded area in Fig. 2) had above average precipitation. Hurricane activity is typically suppressed if the rainfall in these two regions was below average. Rainfall amounts for both the Western Sahel (-0.30 S.D.) and the Gulf of Guinea (+0.24 S.D.) were near average conditions. However, we anticipate that the remainder of the Western Sahel rainy season (August and September) will be above the long term average and distinctly above the very low rainfall amounts which has occurred in most of the recent years since 1970 in which extended drought conditions have existed. Western Sahel rainfall is not believed to be a suppressing influence on this season's hurricane activity as it has been during most of the last 25 years.

(d) Influence of West Africa west-to-east surface pressure and temperature gradients (ΔPT) influence. Project research has shown that anomalous west-to-east surface pressure and temperature gradients across West Africa from February through May are well correlated with the hurricane activity which follows later in the year (see Gray et al. 1994). We find that Atlantic hurricane activity is enhanced when the February to May east (Region B - in Fig. 3) minus west (Region A) pressure gradient is higher than normal and/or when the east minus west temperature gradient anomaly is below average. These February through May 1995 pressure and temperature gradients indicated an average North African monsoon and an average amount of seasonal hurricane activity - not distinctly below average conditions as has occurred in recent years.

(e) Caribbean Basin Sea Level Pressure Anomaly (SLPA) and upper tropospheric (12 km) Zonal Wind Anomaly (ZWA) influence. June-July values of SLPA and ZWA have a moderate predictive potential for hurricane activity during the following August through October months. Negative anomalies (i.e., low pressure and easterly zonal wind anomalies) imply enhanced seasonal hurricane activity while positive values imply suppressed hurricane activity. June-July 1995 values of SLPA and ZWA were both below average (SLPA = -0.6 mb, ZWA = -2.5 m/s), indicating an enhancing influence on this season's hurricane activity.

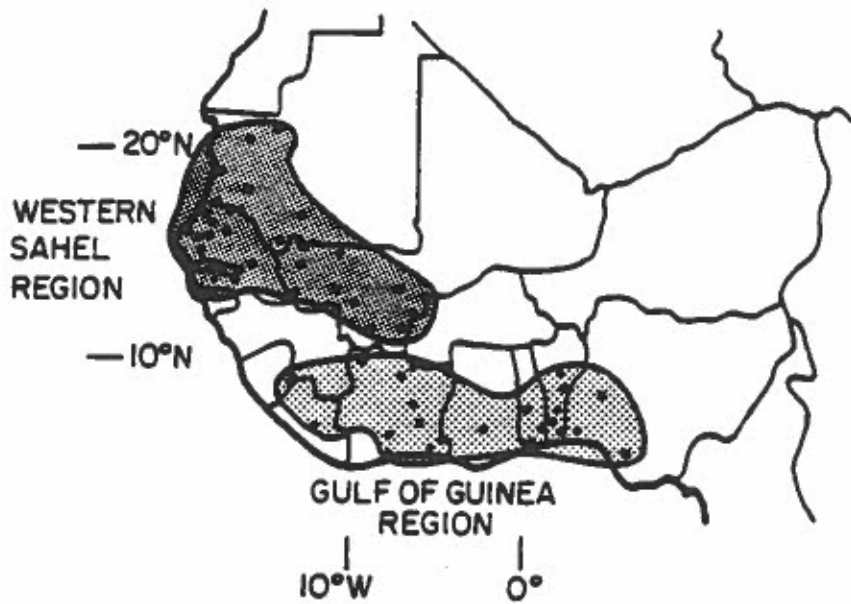


Figure 2: Locations of rainfall stations which make up the 38-station Western Sahel precipitation index and the 24-station Gulf of Guinea precipitation index. August to November rainfall within the Gulf of Guinea region provides a predictive signal for the following years hurricane activity as does prior year August-September rainfall in the Western Sahel (see Landsea 1991; and Gray et al. 1992).

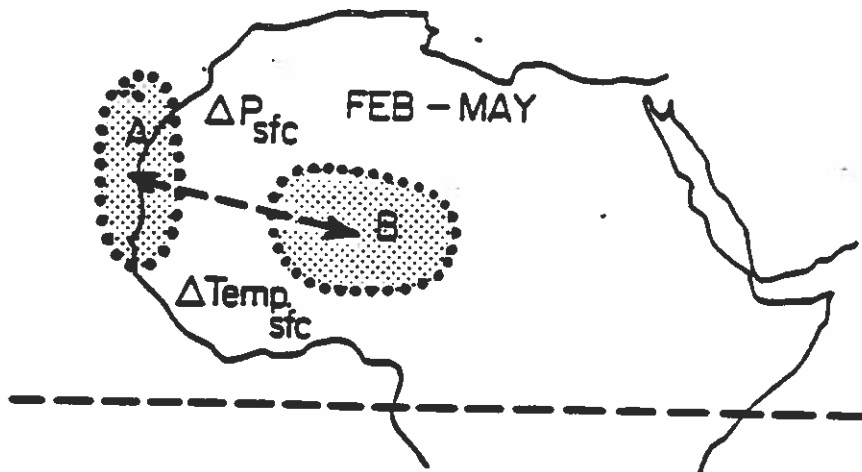


Figure 3: Map showing of the two West African regions—west (Area A) and east (Area B)—from which multi-station surface pressure and temperature values are computed to form combined west-to-east pressure and temperature gradients or ΔPT parameter. (Gray et al. 1994).

Our early August seasonal forecast scheme has the following general form:

$$\begin{array}{l} \text{(Predicted Amount} \\ \text{of TC Activity} \\ \text{Per Season)} \end{array} = \text{Ave. Season} + \text{Adjustment Terms} \quad (1)$$

where

QBO = 30 mb and 50 mb Quasi-Biennial Oscillation zonal winds (U_{30} , U_{50}) and the absolute value of vertical shear between these levels (S_Z). (Increased hurricane activity for westerly (or positive) zonal wind anomalies and weaker shear; reduced hurricane activity for easterly or negative zonal wind anomalies and higher wind shear conditions.)

EN = El Niño influence. (Warm surface water in the equatorial East Pacific reduces hurricane activity, cold water enhances it.) We utilize the June-July Niño-3 Sea Surface Temperature Anomaly (SSTA) in °C and the June-July Southern Oscillation Index (SOI) in standard deviation, two predictors.

AR = Western Sahel rainfall. (Increase activity if wet; reduce activity if dry.) We utilize the August through November 1994 Gulf of Guinea Rainfall (R_G) and the June-July 1995 Western Sahel rainfall in S.D.

$\Delta P T$ = West Africa west-to-east gradients of surface pressure and surface temperature during February through May. (High values of west-to-east pressure gradient and higher values of east-to-west temperature gradient indicate more hurricane activity; less hurricane activity with the opposite gradients).

SLPA = Average Caribbean Sea Level Pressure Anomaly (SLPA) for Spring and early Summer. (Reduce hurricane activity if SLPA is significantly above average; add activity if SLPA is significantly below average.)

ZWA = Zonal Wind Anomaly at 200 mb (12 km) for five low latitude upper air stations in the Caribbean. (Reduce hurricane activity if positive; increase hurricane activity if negative.)

3 Discussion of the Current Characteristics of the Five Primary Early June Predictors (QBO, ENSO, AR, ΔP , and SLPA-ZWA) as Regards the Amount of Anticipated 1995 Seasonal Hurricane Activity

3.1 QBO

Tables 1 and 2 show the absolute and relative anomalous 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 1995 during the primary hurricane period of August through October. These estimates are based on a combination of the current trends in the QBO winds combined with the annual wind cycle variations for low latitude stations at Curacao (12°N), Trinidad (11°N), and Barbados (13°N). Note that during the primary August through October hurricane season that 30 mb and 50 mb zonal winds will be from a relative westerly direction and the value of 30 to 50 mb vertical wind shear is anticipated to be small. This should be an enhancing influence for this year's hurricane activity.

Table 1: March through October 1995 observed and extrapolated absolute values of stratospheric QBO zonal winds (U) in the critical latitude belts between 11-13°N as obtained from Caribbean stations at Curacao (12°N), Barbados (13°N), and Trinidad (11°N). Values are in ms^{-1} (data supplied by James Angell and Colin McAdie).

Level	Observed					Extrapolated		
	March	April	May	Jun	Jul	Aug	Sept	Oct
30 mb (23 km)	+6	+5	0	-6	-7	-7	-6	-4
50 mb (20 km)	+4	+4	+2	-3	-5	-4	-2	+1

Table 2: As in Table 1 but for the “relative” (or anomalous) zonal wind values wherein the annual wind cycle has been removed. Values are in ms^{-1} .

Level	Observed					Extrapolated		
	March	April	May	Jun	Jul	Aug	Sept	Oct
30 mb (23 km)	+10	+13	+14	+11	+12	+11	+10	+8
50 mb (20 km)	+3	+5	+8	+10	+11	+10	+9	+8

3.2 ENSO

The long running four-year El Niño event of 1991-94 has finally dissipated. April through July 1995 SSTA conditions in Nino 1-2 are below average, and Nino-3 SST conditions are right at neutral, $-0.05^{\circ}C$. Similarly, the SOI has gone positive (i.e., toward a cool ENSO phase) after being negative (i.e., warm phase) for nearly four years running. A change over to warm conditions later in the summer, as has occurred the last three summers, is not expected this year. Anticipated August through October ENSO conditions indicate a slow cooling trend. This is indicative of a significant increase in this year’s hurricane activity over what has occurred during the last four seasons.

Sea surface temperature anomaly (SSTA) conditions (in $^{\circ}C$) in Nino-1-2, 3, and 4 as well as the SOI values since January 1995 are shown in Table 3. Note the significant changes since last winter.

Table 3: Various Nino area SSTA in $^{\circ}C$ and Tahiti minus Darwin (SOI) surface pressure difference in S.D.

	Jan	Feb	Mar	Apr	May	June	July
Nino-1-2	0.9	0.6	-0.2	-1.0	-1.0	-0.4	-0.1
Nino-3	1.0	0.7	0.2	-0.2	-0.4	-0.1	0.0
Nino-4	1.1	1.0	0.8	0.5	0.5	0.5	0.3
SOI	-0.6	-0.5	0.2	-1.1	-0.7	-0.2	0.3

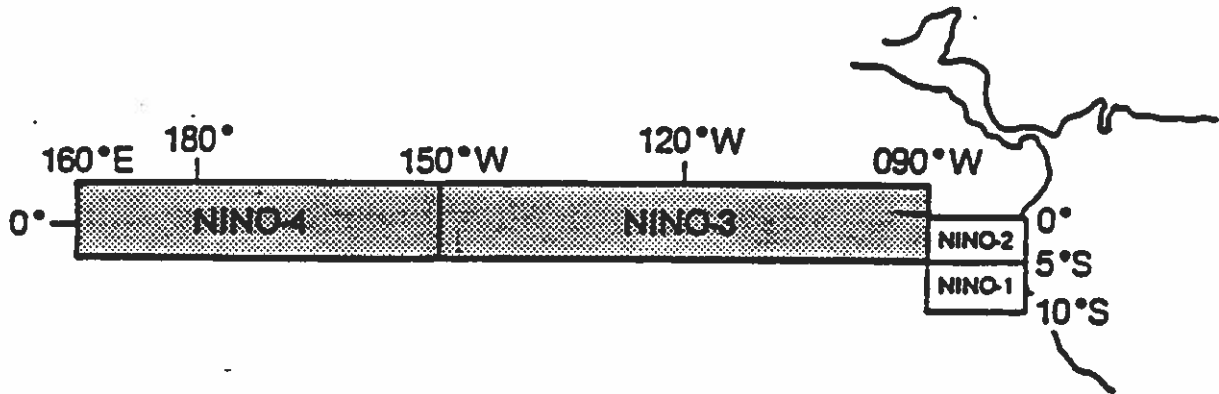


Figure 4: Equatorial Pacific sea surface temperature anomaly indices ($^{\circ}\text{C}$) for the areas indicated.

3.3 West African Rainfall (AR)

Our Western Sahel rainfall forecast (Landsea, et al., 1995) at the end of May of this year for June through September rainfall does not anticipate drought conditions. We forecast Western Sahel rainfall of +0.27 S.D., which is at the high end of the neutral quintile.

This Sahel rainfall forecast is based on many of the same factors as the current seasonal hurricane forecast and indicates that Western Sahel rainfall conditions will be distinctly above the rainfall conditions of the 1990-1993 period. We are in disagreement with the 1995 experimental West African rainfall forecast which was issued by the UK Meteorological Office (1995) which appears to indicate a continuation of general drought conditions.

We thus judge Western Sahel rainfall not to be an inhibiting influence on Atlantic intense hurricane activity during 1995 in comparison to what it has been for most of the last 25 years. June-July 1995 rainfall in the Western Sahel averaged -0.3 S.D. below the 1950-1990 average. Rainfall has started slowly this year but has shown significant increases in the last ten days of July. June-July rainfall represents only 36 percent of the average June-September rainfall which falls in the Western Sahel. We expect Western Sahel rainfall conditions to pick up in the months of August and September and for slightly above average amounts to have occurred by the end of the rainy season.

3.4 West Africa ΔP and ΔT

There has been no change in these conditions since our early June forecast - conditions are as discussed on page 6.

3.5 SLPA and ZWA

Two Caribbean parameters which contribute to the early August hurricane forecast are Caribbean Basin Sea Level Pressure Anomalies (SLPA) and 200 mb (12 km) Zonal Wind Anomalies (ZWA). The June-July 1995 five-station tropical (Trinidad, Barbados, Curacao, San Juan and Cayenne) SLPA's were slightly average (-0.6 mb) and the five-station June-July (Trinidad, Curacao, Barbados, Kingston and Balboa) ZWA values were also negative -2.5 m/s. These two June-July measurements indicate an enhancing influence on this year's hurricane activity. A second six-station surface pressure average made up of Brownsville, Miami, Merida (Yucatan), San Juan, Barbados, and Trinidad gives a pressure anomaly for June-July of -1.1 mb. These measurements are all indicative of an active hurricane season (see Table 4).

Table 4: April through July Sea Level Pressure Anomaly (SLPA) and Zonal Wind Anomaly (ZWA).

	April	May	June	July
5-Station SLPA of Tropical Average (mb)	-0.86	+0.52	-0.20	-1.07
6-Station SLPA of Tropical and Sub- Tropical Average (mb)	-1.40	-0.41	-0.80	-1.40
5-Station Zonal Wind Anomaly (ZWA) (m/s)	-2.5	-0.5	-1.6	-3.4

4 1 August Forecast

We have been performing new research directed to the improvement of our early August forecast skill. One of the new aspects of this research is a thorough study of the anticipated statistical forecast skill reduction which occurs when a dependent data sample such as the historical hurricane information of 1950-1994 is applied to independent data sets such as the coming 1995 season. Anticipated forecast skill reduction (or skill "degradation") from that obtained in the developmental data set is known to be more of a problem when the number of predictors is high and the number of data points available in the developmental sample is small, relatively. There is also additional degradation when the forecast is applied to fully independent data sets. From our 45-year (1950-1994) developmental data set, we have estimated the full forecast skill reduction with 3, 4, 5, 6, etc. up to 10 predictors. This is done for each of our 8 forecast parameters of NS, NSD, H, HD, IH, IHD, HDP and NTC. To maximize forecast skill, we only continue to include predictors in our forecast equations if the last predictor added provides an additional 1 percent increase to our hindcast skill.

We have not previously made enough statistical analysis of the expected degradation with our forecasts. A new paper (Mielke et al. 1995) makes an extensive study of such expected full forecast degradation from an analysis of nearly 4000 cases of tropical cyclone intensity change where the forecast skill was comparable to that of seasonal hurricane forecast skill. This study establishes expected measures of agreement reduction as related to number of predictors and number of years in the developmental data set. We have now applied this analysis of statistical degradation to our earlier 1 August forecast (Gray et al. 1993, 1994a) and to two newly developed 1 August forecast schemes where the number of predictors chosen is allowed to vary.

Our earlier paper (Gray et. al. 1993, 1994a) discusses the 1 August forecast in terms of the 41 years (1950-1990) of developmental data and utilizes nine predictors. Table 5 gives our earlier forecast measure of agreement (ρ) and the expected forecast skill reduction by the "degraded" ρ value specified by the number of predictors (9) and years of dependent data (41). The "degraded" ρ value is defined as how much skill remains when the hindcast equations are applied on completely independent (future) forecasts. This, by necessity, is a rough estimate and may be either an overestimate or an underestimate of what real future skill will occur. Additionally, we believe that qualitative assessments of features not explicitly in the forecast equations (see section 5.1) can improve the skill above that suggested by the degraded measures of agreement.

Note that for named storms days, intense hurricanes, intense hurricane days, and net tropical

Table 5: Skill or measure of agreement (ρ) of our earlier (Gray, et al., 1993a) 1 August forecast scheme with expected measure of skill reduction (or "degradation") due to our sample size (41 years) and number of predictors(9).

	Direct measure of Agreement (ρ)	Fully Degraded measure of agreement (ρ)
Named Storms (NS)	.447	.151
Named Storm Days (NSD)	.608	.418
Hurricanes (H)	.472	.198
Hurricane Days (HD)	.516	.276
Intense Hurricanes (IH)	.598	.404
Intense Hurricane Days (IHD)	.579	.379
Hurricane Destruction Potential (HDP)	.555	.339
Net Tropical Cyclone (NTC) Activity	.598	.404

cyclone activity, the amount of skill remaining in the "degraded" ρ values still account for over 40 percent of the variability. However, some of the other tropical cyclone groupings drop below 20 percent skill level. This highlights the problems inherent with relatively low sample-based agreement values (around 0.4 and 0.5) in combination with a large number (9) of predictors and a small number (41) of years available. Because of the "degradation" found, especially in the named storms, hurricanes, and hurricane days, we have made the following effort to reduce the number of predictors utilized, and thus, reduce the likely "degradation" in future forecasts.

New 1 August Forecast Schemes. We have recently altered our 1 August forecast so that we predict not the whole season of hurricane activity as we have previously done but only the hurricane activity occurring after 1 August. We have also adopted a regression procedure which chooses the best 3, 4, 5, 6, etc. predictors from a total number of 10 predictors shown in Table 6. Table 7 details the various predictors chosen for the different forecast equations. Some predictors (such as Gulf of Guinea rainfall, Western Sahel rainfall and 30 mb zonal winds) are selected for nearly every tropical cyclone grouping, while others (such as ZWA, SSTA, and SOI) are only selected by two or three. The bottom of Table 7 also presents the sample (1950-1994) based agreement values along with the approximate "degraded" agreement values for future forecasts. Note that the optimization in the variable number of predictors has increased the value of the "degraded" agreement values for most of the tropical cyclone categories over what was seen in Table 5 by nearly 0.1 (or an additional 10 percent of the variability).

Table 6: Listing and description of the pool of ten potential 1 August predictors. See Fig. 1 for the location of these predictors.

1 = U_{50}	July to August extrapolated September QBO zonal winds at 50 mb near 10°N in m/s
2 = U_{30}	July to August are extrapolated September QBO zonal winds at 30 mb near 10°N in m/s
3 = AS	absolute value of the extrapolated vertical wind shear between 50 and 30 mb
4 = R_S	Western Sahel June-July precipitation in Standard Deviation (S.D.),
5 = R_G	previous year August to November precipitation in the Gulf of Guinea region,
6 = SSTA	June-July Sea Surface Temperature Anomaly in Nino 3,
7 = ZWA	June-July Zonal Wind Anomaly in the lower Caribbean basin,
8 = SOI	June-July normalized Tahiti minus Darwin Sea Level Pressure differences, or Southern Oscillation Index (SOI) in S.D.
9 = SLPA	June-July Sea Level Pressure Anomaly from five lower Caribbean basin stations,
10 = ΔP	West African anomalous east-west pressure gradient deviation in February through May in S.D.

As an alternative approach, Table 8 shows the sample-based and "fully degraded" agreement

Table 7: New 1 August forecast scheme utilizing a variable number of predictors in order to maximize the forecast skill or measure of agreement (ρ).

Forecast Parameter	No. of Predictors	Predictors						
Named Storms (NS)	5	U ₅₀	AS	R _G	SLPA	ΔP		
Named Storm Days (NSD)	6	U ₃₀	AS	R _s	R _G	SSTA	SOI	
Hurricanes (H)	6	U ₃₀	AS	R _G	ZWA	SLPA	ΔP	
Hurricane Days (HD)	5	U ₃₀	AS	R _s	R _G	SLPA		
Intense Hurricanes (IH)	8	U ₅₀	U ₃₀	AS	R _s	R _G	SSTA	SOI SLPA
Intense Hurricane Days (IHD)	6	U ₅₀	R _s	R _G	SSTA	ZWA	ΔP	
Hurricane Destruction Potential (HDP)	4	U ₃₀	AS	R _s	R _G			
Net Tropical Cyclone Activity (NTC)	6	U ₅₀	U ₃₀	R _s	R _G	SOI	ΔP	

Table 7: Continued.

Forecast Parameter	Direct Measure of Agreement (ρ)	Fully Degraded Measure of Agreement (ρ)
Named Storms (NS)	.484	.275
Named Storm Days (NSD)	.548	.371
Hurricanes (H)	.485	.271
Hurricane Days (HD)	.558	.390
Intense Hurricanes (IH)	.603	.439
Intense Hurricane Days (IHD)	.545	.366
Hurricane Destruction Potential (HDP)	.588	.437
Net Tropical Cyclone Activity (NTC)	.632	.487

values for just the top five predictors for each tropical cyclone grouping. This alternative prediction scheme, while not the optimal combination of predictors as is the variable number scheme, provides another objective tool for use in our forecasting.

Table 8: New 1 August forecast skill or measure of agreement utilizing the best five of the pool of ten predictors.

Forecast Parameter	Direct Measure of Agreement (ρ)	Fully Degraded Measure of Agreement (ρ)
Named Storms (NS)	.484	.275
Named Storm Days (NSD)	.534	.355
Hurricanes (H)	.473	.256
Hurricane Days (HD)	.558	.390
Intense Hurricanes (IH)	.572	.410
Intense Hurricane Days (IHD)	.518	.330
Hurricane Destruction Potential (HDP)	.590	.435
Net Tropical Cyclone Activity (NTC)	.617	.472

5 1995 Early August Forecast

Table 9 lists the values of the pool of ten potential predictors for the amount of after 1 August Atlantic basin hurricane activity. In the average season approximately 85 percent of named storms, 91 percent of hurricanes and 98 percent of intense hurricanes occur after 1 August. Nearly all of these predictors indicate an active hurricane season for 1995.

Table 10 compares the three methods available for seasonal forecasting: the original nine predictor model from Gray et al. (1993), the best five predictor model, and the five predictor model. Tables 11 and 12 give the variable predictor model and the five predictor model together with the additional listing of the tropical activity before 1 August. Note that, because of the large amount of activity which occurred this year before 1 August as well as the large amount of activity forecast after 1 August, that the total seasonal activity is quite a bit above the long term average – especially for named storms and hurricanes.

Table 13 gives our best objective prediction which we take to be our newly developed variable prediction scheme. The column on the right gives our actual forecast which is a qualitative adjustment to the objective forecast.

Note that all forecast parameters are well above the long period average. Table 14 compares this early August forecast to the first author's late November 1994 forecast for 1995 (Gray, 1994)

Table 9: Listing of 1 August 1995 predictors.

U_{50}	-2 m/s
U_{30}	-6 m/s
AS	4 m/s
R_S	-0.30 SD
R_G	0.24 SD
SSTA	-0.05 °C
ZWA	-2.5 m/s
SOI	0.05 SD
SLPA	-0.6 mb
ΔP	-1.0 SD

Table 10: Summary of the whole 1995 seasonal forecast activity of three different 1 August forecast method.

Forecast Parameter	Original (Gray et al. 1993) 9 Predictor Eq. for Entire Hurr. Season Activity Prediction	Best Five Predictor Scheme with Before 1 Aug Activity Added In	Variable Predictor After 1 Aug Scheme with Before 1 Aug Activity Added In
Named Storms (NS)	11.73	16.42	16.42
Named Storm Days (NSD)	64.61	62.79	63.72
Hurricanes (H)	7.74	8.85	10.23
Hurricane Days (HD)	34.07	26.06	26.06
Intense Hurricanes (IH)	2.99	2.64	2.69
Intense Hurricane Days (IHD)	3.96	4.21	3.29
Hurricane Destruction Potential (HDP)	77.69	71.24	70.43
Net Tropical Cyclone Activity (NTC)	120.93	124.13	123.38

Table 11: After 1 August forecast of hurricane activity based on a variable number of predictors (number in parenthesis) with before 1 August and total seasonal hurricane activity.

Forecast Parameter	Activity Before 1 August	After 1 August Variable No. of Predictors	Climatology After 1 August	Total Season Activity
Named Storms (NS)	5	11.42 (5)	7.8	16.42
Named Storm Days (NSD)	16	47.72 (6)	41.4	63.72
Hurricanes (H)	2	8.23 (6)	5.1	10.23
Hurricane Days (HD)	3	23.06 (5)	21.4	26.06
Intense Hurricanes (IH)	0	2.69 (8)	2.0	2.69
Intense Hurricane Days (IHD)	0	3.29 (6)	4.4	3.29
Hurricane Destruction Potential (HDP)	6	64.43 (4)	64.4	70.43
Net Tropical Cyclone Activity (NTC)	23	100.38 (6)	86.0	123.38

Table 12: After 1 August forecast of hurricane activity based on the best five predictors, activity before 1 August and total seasonal hurricane activity.

Forecast Parameter	Activity Before 1 August	5 Best Predictors After 1 August Activity	Climatology After 1 August	Total Season Activity
Named Storms (NS)	5	11.42 (5)	7.8	16.42
Named Storm Days (NSD)	16	46.79 (5)	41.4	52.79
Hurricanes (H)	2	6.85 (5)	5.1	8.85
Hurricane Days (HD)	3	23.06 (5)	21.4	26.06
Intense Hurricanes (IH)	0	2.64 (5)	2.0	2.64
Intense Hurricane Days (IHD)	0	4.21 (5)	4.4	4.21
Hurricane Destruction Potential (HDP)	6	65.24 (5)	64.4	71.24
Net Tropical Cyclone Activity (NTC)	23	101.13 (5)	86.0	124.13

Table 13: The 1995 seasonal forecasts obtained from our best after 1 August forecast objective predictions add to measured activity before 1 August. The authors' actual forecast based upon our objective tools and our subjective adjustments are shown in the right column.

Forecast Parameter	Assumed Best of Objective Predictors	Qualitative Adjustment and Actual Forecast
Named Storms (NS)	16.42	16
Named Storm Days (NSD)	63.72	65
Hurricanes (H)	10.23	9
Hurricane Days (HD)	26.06	30
Intense Hurricanes (IH)	2.69	3
Intense Hurricane Days (IHD)	3.29	5
Hurricane Destruction Potential (HDP)	70.43	90
Net Tropical Cyclone Activity (NTC)	123.38%	130%

and our early 7 June forecast for 1995. Both of our previous forecasts anticipated an active 1995 hurricane season. This table also expresses each parameter in this adjusted forecast as a percentage of the last 45-year average. Table 15 gives a comparison of this year's seasonal activity forecast with the amount of hurricane activity which has occurred during past years. Note that the 1995 season is expected to be much more active than have the last four hurricane seasons and more active than most of the hurricane seasons since the late 1960s.

Table 14: Comparison of the current early August seasonal predictions versus climatology as well as the forecasts for 1995 issued in late November 1994 and early June 1995.

Forecast Parameter	30 Nov. 1994 Fcst	1995 Early 7 June Fcst	Current 1995 Early August Fcst	Current Fcst in % of 1950-1994 Average
Named Storms (NS)	12	12	16	172
Named Storm Days (NSD)	65	65	65	141
Hurricanes (H)	8	8	9	158
Hurricane Days (HD)	35	35	30	130
Intense Hurricanes (IH)	3	3	3	143
Intense Hurricane Days (IHD)	8	6	5	111
Hurricane Destruction Potential (HDP)	100	110	90	132
Net Tropical Cyclone Activity (NTC)	140%	140%	130%	130

5.1 Other Factors Indicating an Active Hurricane Season for 1995

Beside our statistical prediction there are also other factors not explicitly included in our forecast which indicate an active hurricane season. These are:

1. The usually warm SSTa conditions off of the Northwestern African coastline which extend far westward to near Bermuda (Fig. 5). Note how different conditions are from last year at this time.

Table 15: Comparison of early August 1995 seasonal prediction with activity in previous years.

	4 Aug Forecast 1995	Observed				Average Season 1970-87	Average Season 1950-69	45-Year Ave. (1950-94)
		94	93	92	91			
Hurricanes	9	3	4	4	4	4.9	6.5	5.7
Named Storms	16	7	8	6	8	8.3	9.8	9.3
Hurricane Days	30	7	10	16	8	15.5	30.7	23.0
Named Storm Days	65	28	30	38	22	37.3	53.4	46.1
Hurr. Dest. Pot. (HDP)	90	15	23	51	23	42.7	100.0	68.1
Intense Hurricanes (Cat. 3-4-5)	3	0	1	1	2	1.6	3.4	2.1
Intense Hurricane Days	5	0	0.75	3.25	1.25	2.1	8.8	4.5
Net Tropical Cyclone Activity (NTC)	130%	37%	55%	62%	59%	73%	123%	100%

2. Lower Atlantic sub-tropical pressure anomaly and weaker than normal Atlantic tradewind conditions.
3. A stronger than normal 200 mb tropical easterly jet extending westward across the Atlantic from Africa.
4. Stronger than normal wave activity coming out of West Africa at the present time.
5. Higher salinity contents in the polar Atlantic indicating a possible speed-up of the Atlantic thermohaline circulation.
6. High amount of India, Indonesia, and general Asian monsoon rainfall indicating that a return to cooler ENSO conditions is likely progressing.

These additional factors add qualitative support for an active hurricane season.

5.2 Relevance of Early or Before 1 August Tropical Cyclone Activity

We have had an unusually high number of early season named storms (5) and hurricanes (Allison and Erin) reaching named storm status before 1 August 1995. Other years of the century with five named storms (there have never been more than five) include 1966, 1959, 1936, and 1933. There have been ten previous years (1966, 1968, 1959, 1944, 1936, 1934, 1933, 1926, 1916, 1908) when two or more hurricanes formed before 1 August. While many of these years continued having active August through November hurricane seasons, over half actually had August through November activity that was quieter than average conditions. Thus, hurricane activity before 1 August has no correlation with hurricane activity occurring after 1 August. Some of the most active hurricane seasons, such as 1961, didn't experience their second hurricane until September and there have been many active seasons when activity did not begin until after the middle of August.

Our forecast of an active 1995 hurricane season is not based on the amount of early season activity we have already had. It is based on the measured atmospheric and oceanic parameters, which, in the past years have been associated with active hurricane seasons.

6 Analog Years to 1995

Since 1950 there have been five years during which most of these hurricane prediction parameters of our 1 August forecast were similar to the prediction parameters for 1995. These prior early August analog years to 1995 are 1966, 1971, 1978, 1985 and 1990. Each of these five years had nearly identical westerly phase stratospheric QBO wind conditions. Each of these four years had similar June-July Western Sahel rainfall values and other similar forecast

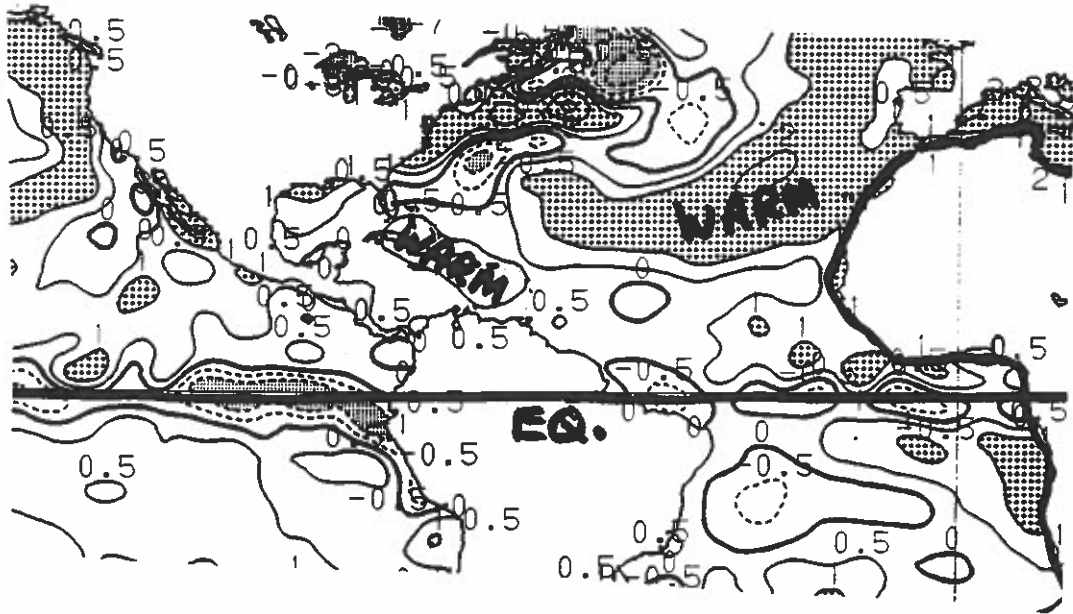
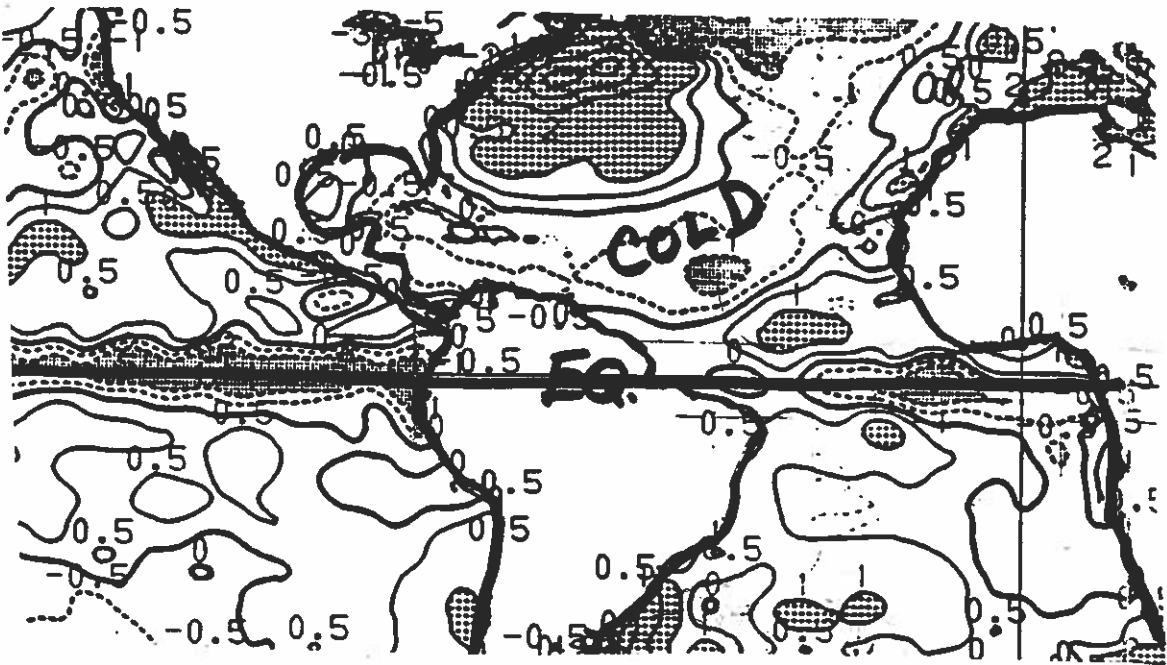


Figure 5: Contrast of Sea Surface Temperature Anomaly (SSTA) for late July in 1994 (above) versus 1995 (below). Note how the tropical Atlantic has become much warmer this year.

predictors. Table 16 shows the nine forecast parameters for these analog years. Note how close their average values are to the nine early August forecast values for 1995. Table 17 shows what the eight 1 August seasonal hurricane parameters were during each of the five analog to 1995 years. Note how the five-year average value of each of these parameters are close to this year's early August forecast. Our forecast for 1995 is higher in some categories than for the five analog years. This is a consequence of the SLPA, ZWA and African rainfall indicating higher activity than that of the average analog years. It is gratifying that these analog years, particularly for the expected activity after 1 August, generally agree with our current forecast. This lends confidence to our after 1 August forecast.

Table 16: Atlantic basin 1 August forecast parameters in four prior years that were similar to the 1 August forecast parameters for 1995.

Year	September (estimated) QBO zonal wind at 10°N - (ms^{-1})			Observed rainfall		Observed Caribbean basin		Observed ENSO	
	1 50 mb	2 30 mb	3 Absolute shear 50-30 mb	4	5	6	7	8	9
				Western Sahelian (std. dev.) Jun-Jul	Gulf of Guinea previous year (std. dev.) Aug-Nov	SLPA (mb) Jun-Jul	ZWA (ms^{-1}) June-July	SOI (std. dev.) Jun-Jul	SSTA ($^{\circ}C$) Jun-Jul
1966	-8	-7	1	-.45	-.17	-1.0	-3.5	0.0	.24
1971	-6	-5	1	-.33	-.23	0.5	1.4	0.2	-.41
1978	-2	-7	5	.16	-.50	0.3	-0.7	0.5	-.29
1985	-3	-3	1	-.27	.04	0.6	2.0	0.6	-.70
1990	-6	-5	1	-.53	.09	0.4	1.0	0.2	.18
Average	-5.0	-5.2	1.8	-.28	-.13	0.1	0.0	0.1	-0.2
1995 Early August Fcst Parameters	-2	-6	4	-0.30	0.24	-0.6	-2.5	0.3	-0.05

Table 17: Atlantic basin tropical cyclone activity which occurred during four previous analog years when end of July forecast parameters were similar to end of July values of these parameters for 1995.

Year	NS	NSD	H	HD	IH	IHD	HDP	NTC
1966	11	62	7	42	3	7.00	121	140
1971	13	63	6	29	1	1.00	65	95
1978	11	40	5	14	2	3.50	40	86
1985	11	51	7	21	3	4.00	61	110
1990	14	68	8	28	1	1.00	57	104
Analog Average	12.0	56.8	6.6	26.8	2.0	3.3	68.8	107
Adjusted 1995 Fcst.	16	65	9	30	3	5	90	130

7 Discussion

Most of those global and regional meteorological features which in the past have been associated with active Atlantic hurricane seasons are coming together this summer. There is a very high statistical probability that 1995 will experience a very active hurricane season. The high amounts of pre-August tropical cyclone activity typically have very little to do with the amount of hurricane activity which occur between the height of the hurricane season, mid-August and mid-October. The development of our new seasonal prediction scheme which forecasts only the amount of expected activity after 1 August has proven very useful this year.

It allows us to combine the observed pre-August activity with that which is forecast after 1 August.

8 Schedule of Forecast Verification and Seasonal Forecasts for 1996

A verification of the 1995 hurricane season and a forecast for the 1996 hurricane season will be issued in late November of this year. In addition seasonal forecasts of late summer and fall 1996 ENSO conditions and the anticipated 1996 Sahel rainfall conditions will also be issued in late November.

9 Cautionary Note

It is important that the reader realize that this seasonal forecast is based on a statistical scheme which will fail in some years. This forecast also does not specifically predict where within the Atlantic basin storms will strike. Even if 1995 should prove to be an average hurricane season, there are no assurances that many hurricanes will strike along the US or Caribbean Basin coastline and do much damage. But the probability of such landfall strikes is higher in 1995 than in recent years.

10 Likely Increase of Landfalling Major Hurricanes in Coming Decades

There has been a great lull in the incidence of intense (category 3-4-5) landfalling hurricanes on US East Coast, Florida and Caribbean Basin during the last 25 years. We see this as a natural consequence of the slowdown in the Atlantic Ocean (thermohaline) Conveyor Belt circulation which has set off a variety of global circulation and rainfall pattern changes such as the Sahel drought, increased El Nino activity, Pacific and Atlantic middle latitude zonal wind increases, etc.

Historical and geological records indicate that this lull in major landfalling hurricane activity will not continue indefinitely. A return of increased major landfalling hurricane activity should be expected within the next decade or two. When this happens, (because of the large coastal development during the last 25-30 years), the US will see hurricane destruction as never before experienced. More research on the causes and the likely timing of this change-over to increased intense hurricane activity is desperately needed. This is a more assured and immediate threat to the US than that of greenhouse gas warming and other environmental problems which are receiving much greater attention in comparison to the hurricane threat.

Changes in the North Atlantic. We may be seeing the early stages of the beginning speed-up of the Atlantic thermohaline (Conveyor Belt) circulation from its three decades long slow down. Aagaard (1995) has recently reported on a large decrease in ice flow through the Fram Strait (the North Atlantic passage between Greenland and Spitzbergen). This decreased ice flow reduces the introduction of fresh water and low salinity values into the North Atlantic. This ice flow reduction is leading to salinity increases in the North Atlantic. Other researchers have also recently reported recent salinity increases in the North Atlantic. Saline water weighs more than fresh water and is able to sink readily to the bottom of the North Atlantic.

These salinity increases that are now being measured in the North Atlantic may result in a speed-up of the Atlantic Ocean thermohaline circulation in the next few years. If this does occur, then we should see a general increase in West African Sahel rainfall, a decrease in Atlantic summertime upper tropospheric westerly winds and an increase of Atlantic basin intense hurricane activity. These new regional Atlantic measurements may be an ominous

sign of future increases in US and Caribbean basin landfalling hurricane activity. The quarter century lull which we have enjoyed cannot be expected to continue indefinitely into the future.

11 Verification of Past Seasonal Forecasts

The first author has now issued seasonal hurricane forecasts for the last eleven years. In most of the prior forecasts, predictions have been superior to climatology, which was previously the only way to estimate future hurricane activity (see Table 18). The seven late May and early June seasonal forecasts for 1985, 1986, 1987, 1988, 1991, 1992 and 1994 were more accurate than climatology. The forecasts for 1984 and 1990 were only marginally successful and the two seasonal forecasts for 1989 and 1993 were failures. The 1989 forecast was a failure because of processes associated with the excessive amounts of rainfall which fell in the Western Sahel that year. Prior to 1990, our seasonal forecast did not include African rainfall as a predictor. We have corrected this important omission and forecasts since 1990 have incorporated Western Sahel rainfall estimates and we have developed a new Sahel rainfall prediction scheme by Landsea et al., 1994. The failure of the 1993 seasonal forecast is attributed to our failure to anticipate the resurgence and continuation of El Niño conditions through the whole of the 1993 hurricane season. In particular, the first author failed to anticipate the re-emergence of stronger El Niño conditions after the middle of August 1993. It is very unusual to have an El Niño last as long as the recent 1991-94 event has. This failure motivated us to develop a new extended range ENSO prediction scheme (Gray et al., 1994b,c).

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Table 18: Verification of the author's previous seasonal predictions of Atlantic tropical cyclone activity for 1984-1994.

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 August	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	75	57
Major Hurricanes (Cat. 3-4-5)	3	2	1
Major Hurr. Days	Not Fcst.	5	1.00

Table 18: Continued.

1991	Prediction of 5 June	Updated Prediction of 2 August	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	22	
Hurr. Destruction Potential(HDP)	40	25	23	
Major Hurricanes (Cat. 3-4-5)	1	0	2	
Major Hurr. Days	2	0	1.25	
1992	Prediction of 26 Nov 1991	Prediction of 5 June	Updated Prediction of 5 August	Observed
No. of Hurricanes	4	4	4	4
No. of Named Storms	8	8	8	6
No. of Hurricane Days	15	15	15	16
No. of Named Storm Days	35	35	35	38
Hurr. Destruction Potential(HDP)	35	35	35	51
Major Hurricanes (Cat. 3-4-5)	1	1	1	1
Major Hurr. Days	2.0	2.0	2.0	3.25
1993	Prediction of 24 Nov 1992	Prediction of 4 June	Updated Prediction of 5 August	Observed
No. of Hurricanes	6	7	6	4
No. of Named Storms	11	11	10	8
No. of Hurricane Days	25	25	25	10
No. of Named Storm Days	55	55	50	30
Hurr. Destruction Potential(HDP)	75	65	55	23
Major Hurricanes (Cat. 3-4-5)	3	2	2	1
Major Hurr. Days	7	3	2	0.75
1994	Prediction of 19 Nov 1993	Prediction of 5 June	Updated Prediction of 4 August	Observed
No. of Hurricanes	6	5	4	3
No. of Named Storms	10	9	7	7
No. of Hurricane Days	25	15	12	7
No. of Named Storm Days	60	35	30	28
Hurr. Destruction Potential(HDP)	85	40	35	15
Major Hurricanes (Cat. 3-4-5)	2	1	1	0
Major Hurr. Days	7	1	1	0
Net Trop. Cyclone Activity	110	70	55	37

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APPENDIX A

Measures of seasonal tropical cyclone activity include the seasonal total number of named storms (NS), hurricanes (H), intense (or major) hurricanes (IH), named storm days (NSD), hurricane days (HD), intense hurricane days (IHD), and hurricane destruction potential (HDP). Definitions of these hurricane indices are given at the beginning of this report. More detailed information is contained in Gray et al. (1992, 1994) and in Landsea (1993). In view of this complexity, it is desirable to define a single number which provides a simple but comprehensive expression of net season tropical cyclone activity in terms of a percentage difference from a long term mean. To this end, we propose a new parameter of seasonal activity termed the "Net Tropical Cyclone activity" (NTC) which is defined as:

$$NTC = (\%NS + \%H + \%IH + \%NSD + \%HD + \%IHD)/6$$

where each of six of the percentage departure values from the long term means are used as measures of seasonal activity. The NTC value is useful as a measure of seasonal tropical cyclone activity because it combines most of the other tropical cyclone parameters of interest into a single index. There are many seasons during which a single parameter, say for example, the number of hurricanes, is not well representative of the actual character of the overall tropical cyclone activity for that year. This single index has the highest forecast skill. Table 19 lists the values of NTC for 1950-1994.

Table 19: Listing of Seasonal Net Tropical Cyclone activity (NTC) values between 1950-1994.

Year	NTC (%)	Year	NTC (%)	Year	NTC (%)
1950	243	1965	86	1980	135
1951	121	1966	140	1981	114
1952	97	1967	97	1982	37
1953	121	1968	41	1983	32
1954	127	1969	157	1984	77
1955	198	1970	65	1985	110
1956	69	1971	95	1986	38
1957	86	1972	28	1987	48
1958	140	1973	52	1988	121
1959	99	1974	76	1989	140
1960	101	1975	92	1990	104
1961	222	1976	85	1991	59
1962	33	1977	46	1992	62
1963	116	1978	86	1993	55
1964	168	1979	96	1994	37