FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY FOR 1998

(A year of expected near average hurricane activity)

(as of 6 August 1998)

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(This forecast is based on ongoing research by the authors, along with meteorological information through July 1998)

[This and past forecasts are available via the World Wide Web: http://tropical.atmos.colostate.edu/forecasts/index.html] — also,

David Weymiller and Thomas Milligan, Colorado State University, Media Representatives (970-491-6432) are available to answer various questions about this forecast. A taped interview with William Gray can be obtained by calling 970-491-1525.

(A new forecast of the statistical probability of U.S. coastal hurricane landfall probability for 1998 will be issued on the above Web Site on Friday August 7, 1998).

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Summary of the early August 1998 forecast for seasonal Atlantic hurricane activity.

Forecast Parameter	Observed to 1 Aug	Forecast Activity After 1 Aug	Total Seasonal Activity	Total Season 1950-1990 Average
Named Storms (NS)	1	9	10	9.3
Named Storm Days (NSD)	3	47	50	46.9
Hurricanes (H)	0	6	6	5.8
Hurricane Days (HD)	0	25	25	24
Intense Hurricanes (IH)	0	2	2	2.2
Intense Hurricane Days (IHD)	0	5	5	4.7
Hurricane Destruction Potential (HDP)	0	75	75	70.6
Net Tropical Cyclone Activity (NTC)	3	107	110	100
Maximum Potential Destruction (MPD)	3	67	70	61.7

Colorado State University Hurricane Forecast Team

Front Row - left to right: John Knaff, Bill Gray, Paul Mielke, Rick Taft. Back Row - left to right: Bill Thorson, Chris Landsea, John Sheaffer and Ken Berry, Todd Kimberlain (missing from photo).

DEFINITIONS

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

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 3-7 years or so on average.

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) A measure of hurricane activity, one unit of which occurs as four 6-hour periods during which a tropical cyclone is observed or estimated to have 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 which reaches a sustained low level wind of at least 111 mph (96 kt or 50 ms^{-1}) at some point in its lifetime. This constitutes a category 3 or higher on the Saffir/Simpson scale (also termed a "major" hurricane).

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

MATL - Sea surface temperature anomaly in the sub-tropical Atlantic between 30-50°N, 10-30°W

MPD - Maximum Potential Destruction - A measure of the net maximum destruction potential during the season compiled as the sum of the square of the maximum wind observed (in knots) for each named storm. Values expressed in 10^3kt.

Named Storm - (NS) A hurricane or a tropical storm.

Named Storm Day - (NSD) As in HD but for four 6-hour periods during which a tropical cyclone is observed (or is estimated) to have attained tropical storm intensity winds.

NATL - Sea surface temperature anomaly in the Atlantic between 50-60°N, 10-50°W

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

ONR - previous year October-November SLPA of subtropical Ridge in eastern Atlantic between 20-30°W.

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 - The deviation of Caribbean and Gulf of Mexico sea level pressure from observed long term average conditions.

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

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

SSTA(s) - Sea Surface Temperature(s) Anomalies.

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.

TATL - Sea surface temperature anomaly in Atlantic between 6-22°N, 18-80°W.

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

Information obtained through July 1998 indicates that the 1998 Atlantic hurricane season is likely to have near average hurricane activity. We project that total season activity will include 10 named storms (average is 9.3), 50 named storm days (average 47), 6 hurricanes (average 5.8), 25 hurricane days (average 24), 2 intense (category 3-4-5) hurricanes (average 2.2), 5 intense hurricane days (average is 4.7) and a hurricane destruction potential (HDP) of 75 (average 71). Net 1998 tropical cyclone activity is expected to be about 110 percent of the long term average, which is appreciably more active than 1997 but much less active than the 1995 and 1996 seasons. The 1998 season should also be significantly more active than the average of the recent 25 years (1970-1994) of generally suppressed hurricane seasons, especially in comparison to the very quiet 1991–1994 period. An important element entering this updated forecast is the recent rapid dissipation of the strong El Niño, the very warm Atlantic Sea Surface Temperature (SSTs) and the supposition that we have now entered a new multi-decadal era of increased intense hurricane activity. A verification of this forecast will be made in late November 1998.

1 Introduction

Surprisingly strong long range predictive signals exist for seasonal tropical cyclone activity in the Atlantic basin. Our recent research indicates that a sizeable portion of this year-to-year variability can be skillfully forecast as early as late November of the prior year. This "late fall" forecast is subsequently updated with new information in early April, early June and early August. In this paper we present an early August forecast update of the likely coming season Atlantic basin tropical cyclone activity. This forecast is based on meteorological data available through the end of July 1998.

Forecasts equations have been developed using 48 years (1950-1997) of historical data. We carefully study activity in these prior years to develop the best possible seasonal hurricane forecast from a variety of global wind, temperature, pressure, rainfall and ocean features. Figures 1 through 3 show the various factors which are used in our statistical models.

2 Forecast Methodology

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

$$\begin{array}{l} (\textit{Predicted Amount} \\ \textit{of TC Activity} \\ \textit{Per Season}) \end{array} = \textit{Ave. Season} + \overbrace{(QBO + EN + AR + ONR + MATL,\ TATL\ \textit{etc.})}^{\textit{Adjustment Terms}} \quad (1)$$

Each adjustment term has a weighted coefficient associated with it. We statistically test for the best individual predictor, the best two-predictor combination, the best three-predictor combinations, etc. For each predictor added, we require that the predictor improve the hindcast by at least 2 1/2 percent. Unless such an improvement occurs, we stop adding new predictors. The number of predictors accepted under this criterion typically ranges from four to seven.

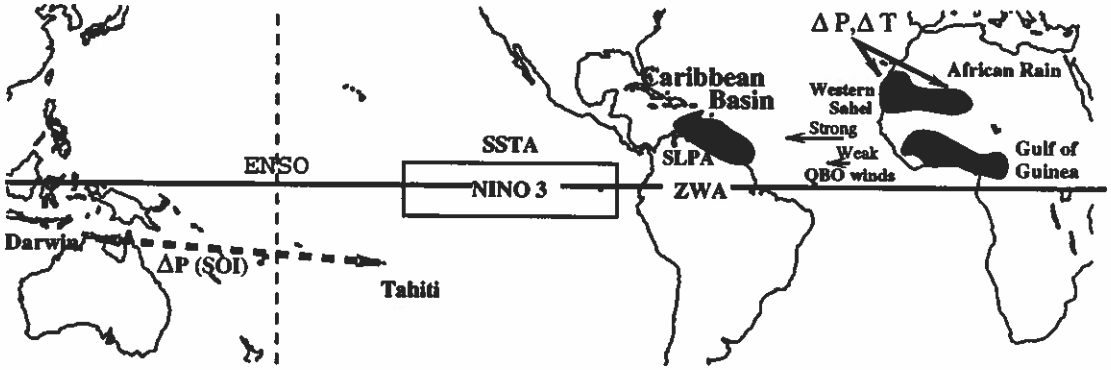

Figure 1: Meteorological parameters used in a prior version of our older early August (Gray et al. 1994a) seasonal forecast.

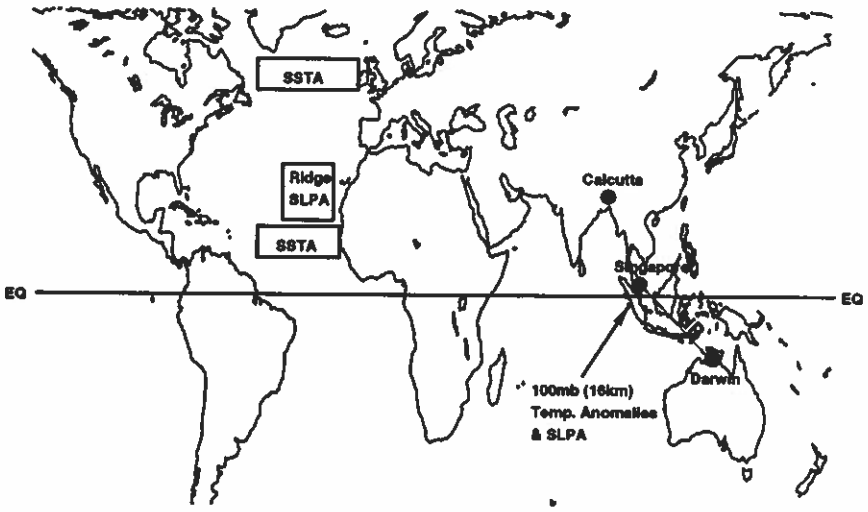

Figure 2: Additional (new) predictors which have recently been noted to be related to the upcoming Atlantic hurricane activity.

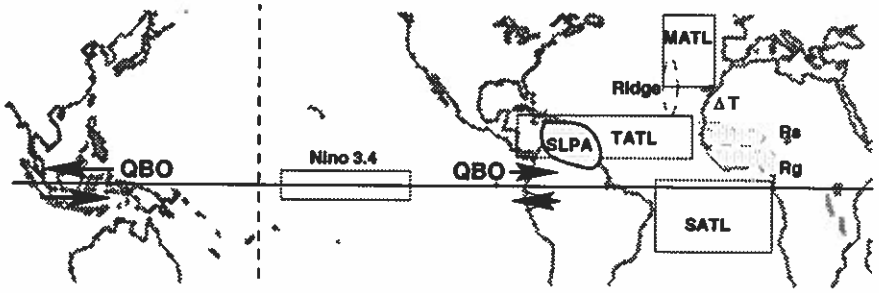

Figure 3: Some additional meteorological parameters that are now used in our new formulation of the early August forecast.

We use the above predictors to make seasonal forecasts for nine separate measures of seasonal hurricane activity. These include separate predictions of the seasonal number of Named Storms (NS), Named Storm Days (NSD), Hurricanes (H), Hurricane Days (HD), Intense Hurricanes, (IH), Intense Hurricane Days (IHD), Hurricane Destruction Potential (HDP), Net Tropical Cyclone Activity (NTC) and Maximum Potential Destruction (MPD). Definitions are given on Page 3.

Research has shown that pre-season atmospheric and oceanic conditions associated with active hurricane seasons differ from those associated with inactive seasons. Moreover, hurricanes forming from African waves typically have longer tracks and more days of activity than do hurricanes forming at higher latitudes. Hence, a tendency for more low latitude storms carries specific forecast implications. As hurricane damage typically increases as the square (or higher power) of wind speed, we have developed specific parameters such as HDP and MPD to better reflect this relationship.

Recent research has been directed towards improving our 1 August forecast methodology. This work has involved adding new predictors and altering statistical procedures. A prior version of our 1 August forecast scheme (Gray et al. 1993) was developed on hindcast information for the 41-year period of 1950-1990. It used the same nine predictors for each forecast parameter, did not distinguish between hurricane activity occurring before and after 1 August, and did not predict Maximum Potential Destruction (MPD). We have recently developed a second (and improved) 1 August forecast scheme which includes three new predictors. This scheme also distinguishes between hurricane activity before and after 1 August and includes forecasts of MPD. This new 1 August forecast scheme also employs an improved statistical approach which chooses the best of 16 potential predictors (see Table 1) from a pool of known precursor signals. The predictors are ordered by the amount of added forecast skill which each contributes. This new prediction scheme allows us to reduce the number of predictors from a fixed set of nine to a variable selection of four to seven. This procedure reduces the shrinkage of true skill when applied to independent data. Other improvements involve optimizing our forecasts to include only hurricane activity occurring after 1 August and using 48 rather than 41 years in the developmental data set. This newer prediction scheme is superior to our earlier scheme of five years ago.

Table 2a provides details of the predictors chosen for each of the different forecast measures of activity (NS, NSD, H, etc.) for the whole seasonal forecast. Some predictors (such as Gulf of Guinea rainfall or 30 mb zonal winds) are selected for nearly every measure of activity, while other predictors (such as SLPA or ΔT) are selected by only one or two of our forecast equations. Table 3 also lists the hindcast measure of agreement or amount of variance explained. Note that for HDP, NTC and MPD we are able to explain nearly as much as two-thirds of the hindcast variance. Table 2b refers to our separate after 1 August forecast. Note that all parameters are above the climatology average.

The documentation of this new forecast scheme is being written up and will soon be sent for publication and distribution on the World Wide Web.

Table 2 also presents a summary listing of the expected forecast skill degradation due to the application of our new scheme to independent data. As we gain more years of developmental data sets (now 48) and, as we reduce the number of variables, the amount of estimated real forecast skill, although impossible to determine in an individual year, should likely not undergo undue degradation.

3 Forecast Parameters for August 1, 1998 Prediction

The following are the parameter values which go into our new 1 August forecast scheme. These are derived from meteorological data available through July, 1998.

Table 1: Listing of the pool of predictive parameters and their estimated values for the early June 1998 prediction based on meteorological data available through May 1998. See Figs. 1 and 3 for the locations of these predictor data.

Predictive Parameter	
1 = QBO 50 mb 4-month extrapolation of zonal wind at 12°N to Sept. 1998	$-14\ ms^{-1}$
2 = QBO 30 mb 4-month extrapolation of zonal wind at 12°N to Sept. 1998	$-31\ ms^{-1}$
3 = QBO absolute value of shear between 50 and 30 mb at 12°N to Sept. 1998	$17\ ms^{-1}$
4 = Rgc AN Gulf of Guinea rainfall anomaly (Aug-Nov of 1997)	–0.43 SD
5 = Rws West Sahel rainfall anomaly (June-July 1998)	–0.80 SD
6 = SST3.4 Nino 3.4 SSTA in June-July 1998	–0.80°C
7 = ZWA June-July Caribbean basin zonal wind anomaly	+0.8 m/s
8 = SLPA June-July Caribbean basin sea level pressure anomaly	+0.3 mb
9 = Temp West-East Sahel temperature gradient(Feb-May 1998)	+0.7 SD
10 = NATL North Atlantic SSTA anomaly (50-60°N,10-50°W) (Apr-May)	+0.73°C
11 = SATL Mid Atlantic SSTA anomaly (5-18°S,50°W-10°E) (Apr-May)	+0.68°C
12 = TATL Tropical Atlantic SSTA anomaly (10-22°N,18-50°W) (Apr-May)	+0.77°C
13 = R-M: Mar Azores surface pressure ridge strength in Mar 1998	–0.91 SD
14 = R-ON: Azores surface pressure ridge strength in Oct-Nov 1997	–1.37 SD
15 = D-SST3.4: Nino 3.4 SSTA for June-July minus April-May 1998	–1.75°C
16 = NSD-S: Named storm days south of 23.5°N and east of 75°W before 1 August	3

Table 2: a: Details of our new 1 August forecast scheme which utilizes a variable selection of predictors so as to maximize forecast skill (hindcast variance explained) while limiting the number of predictors. See Figs. 1-3 for the locations of the predictors. The period 1950–1997 was used to develop these equations.

Forecast Parameter	No. of Predictors	Hindcast Measure of Agreement	Expected Independent Fcst Skill	Predictors
(NS)	5	.602	.463	U_{50}, Shear, R_g, R-ON, NSD-S
(NSD)	3	.518	.363	U_{50}, R_g, NSD-S
(H)	5	.560	.406	U_{30}, R_g, R-M, R-ON, NSD-S
(HD)	4	.513	.341	U_{30}, R_g NATL, NSD-S
(IH)	5	.574	.425	U_{50}, R_s, R_g, D–T, R-M
(IHD)	5	.573	.424	U_{50}, R_g, D–T, R-M, NSD-S
(HDP)	4	.507	.332	U_{30}, R_g, NATL, NSD-S
(NTC)	5	.628	.497	U_{30}, R_g, R-M, R-ON, NSD-S
(MPD)	6	.672	.548	U_{30}, R_g, NATL, R-M, R-ON, NSD-S

Table 2: b: 1 August Results - Remainder of Season Forecast

	hindcast skill	expected skill	Predictors
NS	.543	.386	4 - U30, Shear, Rg, NSD-S
NSD	.539	.376	5 - U30, Rg, R-M, R-ON, NSD-S
H	.522	.351	5 - U30, Rg, DT, R-M, R-ON
HD	.461	.262	3 - U30, Rg, NATL
IH	.572	.423	5 - U50, Rs, Rg, DT, R-M
IHD	.556	.405	4 - U50, Rg, DT, NSD-S
HDP	.452	.246	3 - Rg, DT, R-ON
NTC	.593	.452	5 - U30, Rg, R-M, R-ON, NSD-S
MPD	.620	.490	4 - U30, Rg, R-M, R-ON

3.1 QBO – A Suppressing Influence for 1998 Forecast Hurricane Activity

On a statistical basis, the absolute and relative (i.e., anomalous) values of the current and extrapolated 30 mb (23 km) and 50 mb (20 km) stratospheric QBO zonal winds near 12°N latitude during August through October 1998 have an influence on the seasonal hurricane activity equatorwards of 25°N; westerly wind anomalies typically enhance hurricane activity while easterly wind anomalies usually suppress it. Estimates of these winds are based on a combination of the current trends plus the annual cycle of wind variations for low latitude stations at Curacao (12°N), Trinidad (11°N), and Barbados (13°N). During the August through October 1998 hurricane season, 30 mb and 50 mb zonal winds will be from a relative easterly direction and, hence, are a suppressing influence for this year's hurricane forecast. We project that 50 mb and 30 mb winds for September 1998 will have values of 14 and 31 m/s respectively.

3.2 ENSO – A Positive Influence for 1998 Hurricane Activity

Sea surface temperature anomaly conditions (in °C) in Nino-1-2, 3, 3.4 and 4 (see Fig. 4), as well as the SOI values since April 1998 are shown in Table 3. Very warm water El Niño conditions have been replaced by cooler water conditions in the Nino 3.4 and 4 regions. This cooling trend, which is an enhancing influence for this year's hurricane activity, should continue.

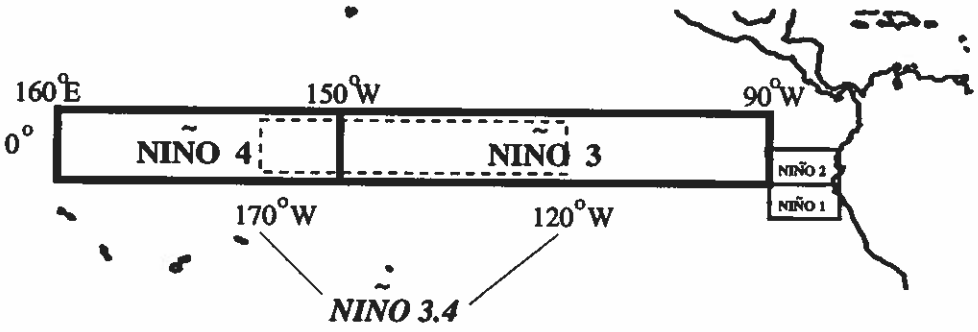

Figure 4: Equatorial Pacific sea surface temperature anomaly indices (°C) represent the areas indicated. The dashed area is the (newer) Nino 3.4 index.

3.3 West African Rainfall (AR) – A Negative Influence

Western Sahel June-July 1998 rainfall data (as available) indicate strong drought conditions (–0.80 SD) so far this season. Although we expect rainfall in August and September to

Table 3: Values for April through July various Niño sea surface temperature anomaly indices (in °C) and for Tahiti minus Darwin (SOI) surface pressure difference (in S.D.)

	Apr	May	June	July
Nino-1-2	3.3	3.8	2.6	2.1
Nino-3	1.8	1.4	-0.2	0.0
Nino-3.4	1.0	0.9	-0.7	–0.9
Nino-4	-0.2	0.1	0.1	–0.3
SOI	–1.9	–0.1	0.6	1.3

pick up significantly, it is likely that seasonal totals will be below average. This is an inhibiting influence for this year's forecast of intense hurricane activity.

3.4 West African ΔT – Positive Influence

There has been no change in these conditions since our early June forecast wherein the value of the west minus east Sahel temperature gradient anomaly was +0.70 SD. A positive value for this index is a enhancing influence for hurricane activity.

3.5 SLPA and ZWA – Neutral Influence

Two Caribbean basin parameters which contribute to the early August hurricane forecast are the Caribbean Basin Sea Level Pressure Anomalies (SLPA) and 200 mb (12 km) Zonal Wind Anomalies (ZWA). The mean June-July 1998 five-station tropical (Trinidad, Barbados, Curacao, San Juan and Cayenne) SLPA was slightly above the 1950–1995 average, yielding a SLPA value of +0.3 mb. A second six-station surface pressure average, made up of Brownsville, Miami, Merida (Yucatan), San Juan, Barbados, and Trinidad, also yield a surface pressure anomaly for June-July of +0.3 mb. The mean five-station June-July (Trinidad, Curacao, Barbados, Kingston and Balboa) ZWA value is also positive, +0.8 m/s. Both of these parameters are expected to go down in the coming months. These June-July SLP measurements are considered a neutral influence for this year's hurricane activity forecast.

3.6 Atlantic Ocean Predictors – Very Strong Positive Influence

Excepting for SATL (Fig. 3) all Atlantic Ocean predictors indicate a very strong enhancement of this year's hurricane activity.

The March 1998 SLPA between 20-30°W of the northeast Atlantic subtropical anticyclonic March Ridge (MR) (see Fig. 2) was low, –0.91 S.D. These lower ridge pressures are indicative of enhanced activity. The October-November 1997 SLPA between 20-30°W in the northeast Atlantic subtropical anticyclonic Ridge (ON-R) was also low (–1.37 SD). As with the March ridge, this condition also indicates an enhancement of 1998 hurricane activity.

May through June 1998 SSTA for the North ATLantic SSTA (NATL – 50-60°N, 10-50°W) was +0.73°C (a very high reading). This measurement also indicates an enhancement of this season's hurricane activity. May through June 1997 SSTA for this Tropical ATLantic SSTA (TATL – 10-22°N, 18-50°W) area (see Fig. 3) was +0.77°C (a very high value). This also indicates an enhancing influence for this season's activity. May through June 1997 SSTA for this South ATLantic SSTA (SATL – 5-18°S, 10°E to 50°W) area (see Fig. 3) was +0.68°C, indicating a weak suppressing influence for this season's activity. Overall the Atlantic Ocean predictors indicate a very strong signal for enhanced season hurricane activity.

3.7 Summary of 1 August Predictors

Table 1 provides information on the current values of the pool of sixteen 1 August predictors from which we choose the best predictors for each of our nine measures of seasonal hurricane activity. These forecast parameters exhibit mixed signals for of this year's Atlantic basin hurricane activity. Seven parameters – SST3.4, NATL, TATL, R-M, R-ON, D-SST of 3.4, and NSD-S indicate an enhancement of hurricane activity. Another six terms including three QBO parameters, two West African rainfall parameters and the SSTA of the South Atlantic (SATL) indicate a general suppression. We believe that, overall, forecast signals indicate a slight enhancement of this year's hurricane activity.

4 Forecast of 1998 Total Hurricane Activity and Activity Likely to Occur After 1 August

Table 4 lists both our original and revised quantitative forecasts for post 1 August hurricane activity. Our forecast for the remainder of the hurricane season (i.e., August through November) is for somewhat above average tropical storm and hurricane activity. During June and July 1998, the Atlantic basin experienced generally favorable conditions for hurricane development. Note that our revised post 1 August forecast (next to last column) is greater than that specified by climatology (Column 3). Our prior 1 August forecast scheme (Gray et al. 1993) did not include three predictors which utilize SSTA at various locations in the Atlantic plus March surface pressure anomalies in the eastern Atlantic subtropical ridge. We have also made recent improvements to our early December, early April and early June forecasts.

Table 4: Summary of forecasts for the entire season (column 1) using prior methodology and for activity after August 1 (columns 2-5) using a new scheme.

Forecast Parameter	New Variable Predictor Scheme All Season	New Variable Predictor for Post 1 Aug Activity	After 1 Aug Climatology	Qualitative Adjusted After 1 Aug Activity
(NS)	9.73	6.79	7.8	9
(NSD)	47.58	44.40	41.1	47
(H)	7.89	6.31	5.1	6
(HD)	31.80	22.04	21.4	25
(IH)	1.98	1.99	2.0	2
(IHD)	8.18	7.37	4.4	5
(HDP)	87.76	84.17	64.4	75
(NTC)	133.48	115.71	97	107
(MPD)	82.44	65.48	67	70

Table 5 shows pre-August 1 1998 activity and our forecast of post-August 1 forecast. The last column in Table 6 gives our total seasonal forecast values which are somewhat above climatology given in the second column of Table 5.

We foresee a somewhat above average Atlantic basin hurricane season despite easterly QBO wind conditions and very dry June-July Western Sahel rainfall values. These negative influences, we believe, will be more than compensated for by the rapid evolution of cold Eastern Pacific SST or "La Niña" conditions and unusually warm Atlantic SST conditions (which are indicative of a new multi-decadal new era of greater intense hurricane activity) and the prior favorable precursor Northeast Atlantic low values of surface pressure in October-November 1997 and

Table 5: Summary of 1998 activity which occurred before 1 August, early August forecast of hurricane activity based on variable number of predictors and total seasonal hurricane activity we expect in 1998.

Forecast Parameter	Activity Before 1 August	After 1 August Adjusted Forecast	1998 Total Seasonal Forecast	Seasonal Average 1950–1990
Named Storms (NS)	1	9	10	9.3
Named Storm Days (NSD)	3	47	50	46.9
Hurricanes (H)	0	6	6	5.8
Hurricane Days (HD)	0	25	25	23.7
Intense Hurricanes (IH)	0	2	2	2.2
Intense Hurricane Days (IHD)	0	5	5	4.7
Hurricane Destruction Potential (HDP)	0	75	75	70.6
Net Tropical Cyclone Activity (NTC)	3	107	110	100%
Maximum Potential Destruction (MPD)	3	67	70	61.7

March 1998. We also anticipate a modest reduction in West Atlantic equatorial 200 mb ZWA and tropical Atlantic SLPA conditions, both of which are positive influences for total hurricane activity. Table 6 compares this 6 August 1998 forecast with our earlier 5 December 1997, 7 April 1998 and 5 June 1998 forecasts. All three of our previous forecasts anticipated about a near average 1998 hurricane season. This early August is based on more recent evolving June-July data and rises our earlier forecast numbers somewhat. A second (complimentary to this) will utilize this forecast and 1998 year landfall information to give 1998 hurricane landfall probabilities for eleven U.S. coastal zones from Brownsville, Texas to Eastport, Maine. This information will shortly be promulgated on the WEB at the site address given on the cover.

Table 6: Comparison of the current early August predictions of total seasonal activity versus our three prior forecasts made for 1998. The latter were issued on 5 December 1997, 7 April 1998 and 5 June 1998.

	Earlier Forecasts			Current Total Season
Forecast Parameter	5 Dec 97 Fcst	7 Apr 98 Fcst	5 Jun 98 Fcst	6 Aug 1998 Fcst
Named Storms (NS)	9	10	10	10
Named Storm Days (NSD)	40	50	50	50
Hurricanes (H)	5	6	6	6
Hurricane Days (HD)	20	20	25	25
Intense Hurricanes (IH)	2	2	2	2
Intense Hurricane Days (IHD)	3	4	4	5
Hurricane Destruction Potential (HDP)	50	65	70	75
Net Tropical Cyclone Activity (NTC)	90%	95%	100%	110%
Maximum Potential Destruction (MPD)	55	65	65	70

5 Analog Years

There are no prior years with global circulation conditions identical to this year. But there are years of somewhat similar global circulation features as 1998. We judge the best 1 August analog years to be 1960, 1965, 1979, 1981, 1995, and 1996. The average hurricane conditions in these years were NS (10.7), NSD (58.8), H (6.7), HD (32.3), IH (3.2), IHD (8.3), HDP (98.2), NTC (139), and MPD (73.7). These analog years may over-represent the annual hurricane activity that we expect in 1998.

6 Theory Behind Forecasts and Cautionary Note

It is important that the reader appreciate that these seasonal forecasts are based on statistical schemes which, owing to their intrinsically probabilistic nature, will fail in some years. Moreover, these forecasts do not predict specifically where within the Atlantic basin storms will strike. It is impossible to predict when and where a hurricane might strike. But the changes in hurricane landfall probability from year to year and decade to decade can be reliably reported on. We have taken on the task of making new studies which allow us to issue the probability of hurricane landfall along the U.S. coastline. Regardless of whether 1998 is an above or below average hurricane season, the probability always exists that one or more hurricanes may strike along the US or Caribbean Basin coastline and do much damage. But the odds of this happening go way down when overall Atlantic activity is predicted to be low.

7 Anticipated Hurricane Activity for Next Year (1999)

The ensemble of slowly evolving climatic conditions suggests that a more active hurricane season is likely during the summer of 1999. This speculation is based on expectations that (1) cool SST anomaly conditions will be present during 1999 in the eastern equatorial Pacific, (2) relatively warm tropical North Atlantic SST anomaly conditions and a strong thermohaline circulation will persist, and (3) stratospheric QBO conditions during 1999 will be from the more favorable westerly direction.

We will be issuing our first forecast for 1999 in early December. In addition to predictions of overall 1999 Atlantic basin hurricane activity, we will also be issuing new U.S. coastal landfall probability forecasts of Saffir/Simpson category 4-5, 3, 2, 1 hurricanes and tropical storms for eleven U.S. coastal zones. A paper now being completed describes the methodology for making these forecasts. This report will be circulated on the World Wide Web.

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Post-Season Reviews (Verifications) of All Prior Seasonal Forecasts

The first author has now issued seasonal hurricane forecasts for 15 consecutive years (1984–1998). In most of these prior forecasts, predictions have been superior to climatology (i.e., long-term averages), particularly for named storms. Whereas the forecasts for 1989 (underestimate), 1993 (overestimate), 1996 (underestimate), and 1997 (overestimate) were well off the mark, they were also quite instructive in that each of these failures led to new insight and forecast model improvements. Figures 5 and 6 offer comparisons of our 1 August forecasts of named storms and hurricanes versus climatology and observed year-by-year variability.

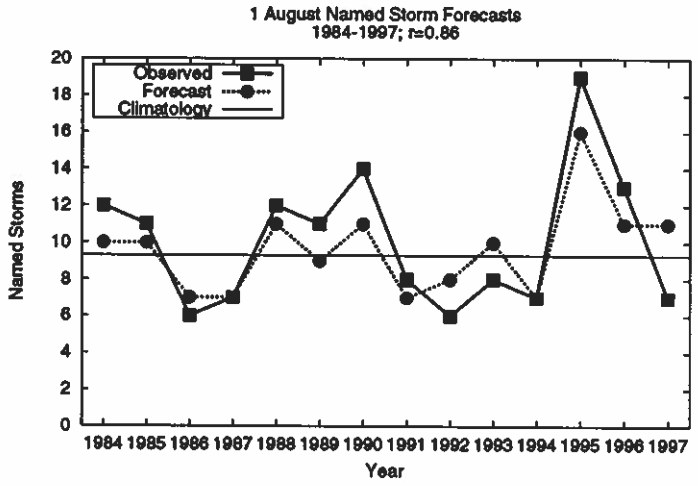

Figure 5: August 1 prediction of total named storms versus the number of actually observed versus long-term climatological mean (r = 0.86) for period 1984–1997.

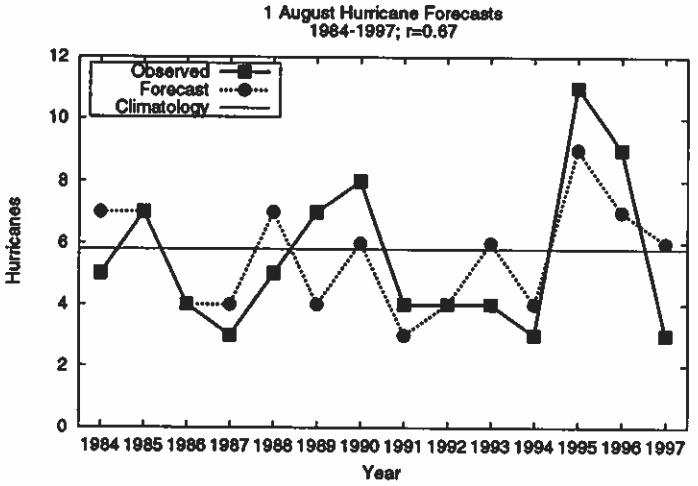

Figure 6: August 1 prediction of total hurricanes versus the number actually observed versus climatological long-term mean (r = 0.67).

Table 7: Verification of the authors' previous seasonal predictions of Atlantic tropical cyclone activity for 1984-1996.

	Prediction Dates		
1984	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	of 28 May	Update 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	29 May	Update 28 July	Observed
No. of Hurricanes	4	4	4
No. of Named Storms	8	7	6
No. of Hurricane Days	15	10	11
No. of Named Storm Days	35	25	23
1987	26 May	Update 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	26 May and 28 July Update		Observed
No. of Hurricanes	7		5
No. of Named Storms	11		12
No. of Hurricane Days	30		21
No. of Named Storm Days	50		47
Hurr. Destruction Potential(HDP)	75		81
1989	26 May	Update 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	5 June	Update 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	66
Hurr. Destruction Potential(HDP)	90	75	57
Major Hurricanes (Cat. 3-4-5)	3	2	1
Major Hurr. Days	Not Fcst.	5	1.00

1991		5 June	Update 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	22
Major Hurricanes (Cat. 3-4-5)		1	0	2
Major Hurr. Days		2	0	1.25
1992	26 Nov 1991	Update 5 June	Update 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	39
Hurr. Destruction Potential(HDP)	35	35	35	51
Major Hurricanes (Cat. 3-4-5)	1	1	1	1
Major Hurr. Days	2	2	2	3.25
1993	24 Nov 1992	Update 4 June	Update 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	19 Nov 1993	Update 5 June	Update 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	36

1995	30 Nov 1994	Update 14 April	Update 7 June	Update 4 August	Obs.
No. of Hurricanes	8	6	8	9	11
No. of Named Storms	12	10	12	16	19
No. of Hurricane Days	35	25	35	30	62
No. of Named Storm Days	65	50	65	65	121
Hurr. Destruction Potential(HDP)	100	75	110	90	173
Major Hurricanes (Cat. 3-4-5)	3	2	3	3	5
Major Hurr. Days	8	5	6	5	11.5
Net Trop. Cyclone Activity	140	100	140	130	229

1996	30 Nov 1995	Update 14 April	Update 7 June	Update 4 August	Obs.
No. of Hurricanes	5	7	6	7	9
No. of Named Storms	8	11	10	11	13
No. of Hurricane Days	20	25	20	25	45
No. of Named Storm Days	40	55	45	50	78
Hurr. Destruction Potential(HDP)	50	75	60	70	135
Major Hurricanes (Cat. 3-4-5)	2	2	2	3	6
Major Hurr. Days	5	5	5	4	13
Net Trop. Cyclone Activity	85	105	95	105	198

1997	30 Nov 1996	Update 4 April	Update 6 June	Update 5 August	Obs.
No. of Hurricanes	7	7	7	6	3
No. of Named Storms	11	11	11	11	7
No. of Hurricane Days	25	25	25	20	10
No. of Named Storm Days	55	55	55	45	28
Hurr. Destruction Potential(HDP)	75	75	75	60	26
Major Hurricanes (Cat. 3-4-5)	3	3	3	2	1
Major Hurr. Days	5	5	5	4	2.2
Net Trop. Cyclone Activity	110	110	110	100	54