EARLY AUGUST UPDATED FORECAST OF ATLANTIC BASIN SEASONAL HURRICANE ACTIVITY AND LANDFALL PROBABILITIES FOR 2000

(A year of above average hurricane activity and landfall probability as anticipated in our 8 December and 7 April forecasts- though somewhat less active than anticipated in our 6 June forecast)

This forecast is based on ongoing research by the authors and their colleagues, together with meteorological information available through July 2000

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SYNOPSIS OF 2000 ATLANTIC BASIN SEASONAL HURRICANE FORECAST

Tropical Cyclone Seasonal	8 Dec 1999 Forecast	Updated 7 April Forecast	Updated 7 June Forecast	Updated 4 August Forecast
Named Storms (NS) (9.3)	11	11	12	11
Named Storm Days (NSD) (46.9)	55	55	65	55
Hurricanes (H)(5.8)	7	7	8	7
Hurricane Days (HD)(23.7)	25	25	35	30
Intense Hurricanes (IH) (2.2)	3	3	4	3
Intense Hurricane Days (IHD)(4.7)	6	6	8	6
Hurricane Destruction Potential (HDP) (70.6)	85	85	100	90
Maximum Potential Destruction (MPD) (61.7)	70	70	75	70
Net Tropical Cyclone Activity (NTC)(100%)	125	125	150	130

Forecast for August 2000 alone: 3 Named Storms, 2 Hurricanes, 1 Major Hurricane

(See discussion in Section 7 - page 14)

PROBABILITY OF ONE OR MORE MAJOR (CATEGORY 3-4-5) HURRICANE LANDFALL IN THE FOLLOWING COASTAL AREAS:

1) Entire U.S. coastline - 60% (average for last century is 52%)
2) U.S. East Coast Including Peninsula Florida - 39% (average for last century is 31%)
3) Gulf Coast from the Florida Panhandle westward to Brownsville - 34% (average for last century is 30%)
4) Caribbean basin (about 10% above the last century average).

(A full report on the methodology involved with these landfall probabilities being prepared and will be listed on this Web site).

DEFINITIONS

ABSTRACT

Information obtained through July 2000 indicates that the Atlantic hurricane season in 2000 is likely to be less active than the four recent very busy years of 1995, 1996, 1998 and 1999. However, total activity is expected to exceed the long term average and is anticipated to be considerably more active than the mean for the recent period of 1970 through 1994. We estimate that the 2000 season will have 7 hurricanes (average is 5.7), 11 named storms (average is 9.3), 55 named storm days (average is 47), 30 hurricane days (average is 24), 3 intense (category 3-4-5) hurricanes (average is 2.2), 6 intense hurricane days (average is 4.7) and a Hurricane Destruction Potential (HDP) of 90 (average is 71). Collectively, net tropical cyclone activity in year 2000 is expected to be about 130 percent of the long term average. This early August forecast update is in close agreement to our prior (8 December 1999) and 7 April forecasts, but somewhat lower than our recent 7 June forecasts. The forecast has been lowered slightly. June-July global circulation conditions have not progressed quite as favorably for hurricane enhancement than as we anticipated in our early June forecast.

1 Introduction

Useful long-range predictive signals exist for seasonal tropical cyclone activity in the Atlantic basin. Our research with prior data has shown that a sizeable portion of the season-to-season variability of nine indices of Atlantic tropical cyclone activity can be skillfully (i.e., with skill as defined as improvement on climatology) estimated many months prior to the active portion of the hurricane season. Forecast techniques are based on precursor atmospheric and oceanic signals observed (in historical data) to contain predictive skill. Qualitative adjustments are added to accommodate additional processes which are not yet incorporated into our statistical models. Predictors include two measures of Western Sahel rainfall during the prior year (Figs. 1 and 2), the phase of the stratospheric Quasi-Biennial Oscillation (QBO) of zonal winds at 30 mb and 50 mb (which can be readily extrapolated many months into the future), extended range estimates of El Niño

-Southern Oscillation (ENSO) variability (Fig. 2), the October-November and March strength of the Azores high surface pressure and the configuration of broad scale Atlantic sea surface temperature anomaly patterns (see Fig. 3). A brief summary of these predictor indices and their specific implications for the 2000 season is as follows:

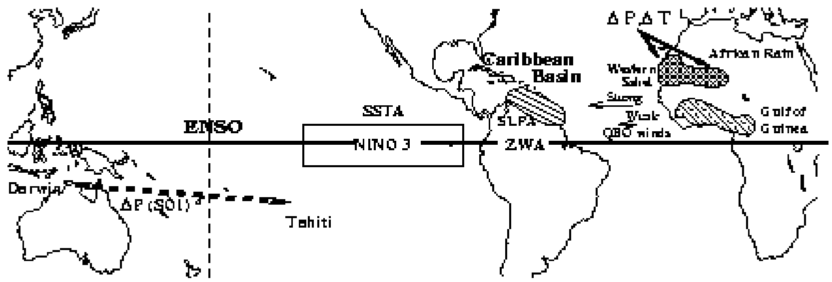

Figure 1: Meteorological parameters used in various versions of our older early August (Gray et al. 1994a) seasonal forecast.

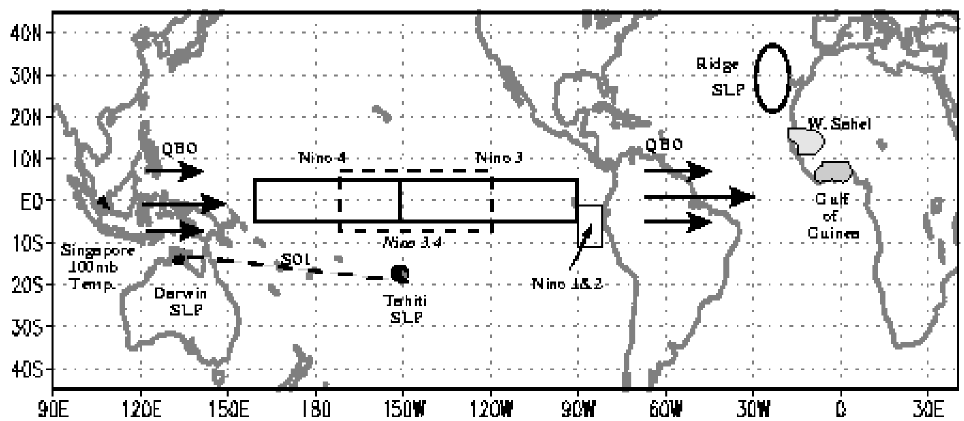

Figure 2: Additional parameters used or consulted in our extended-range forecasts.

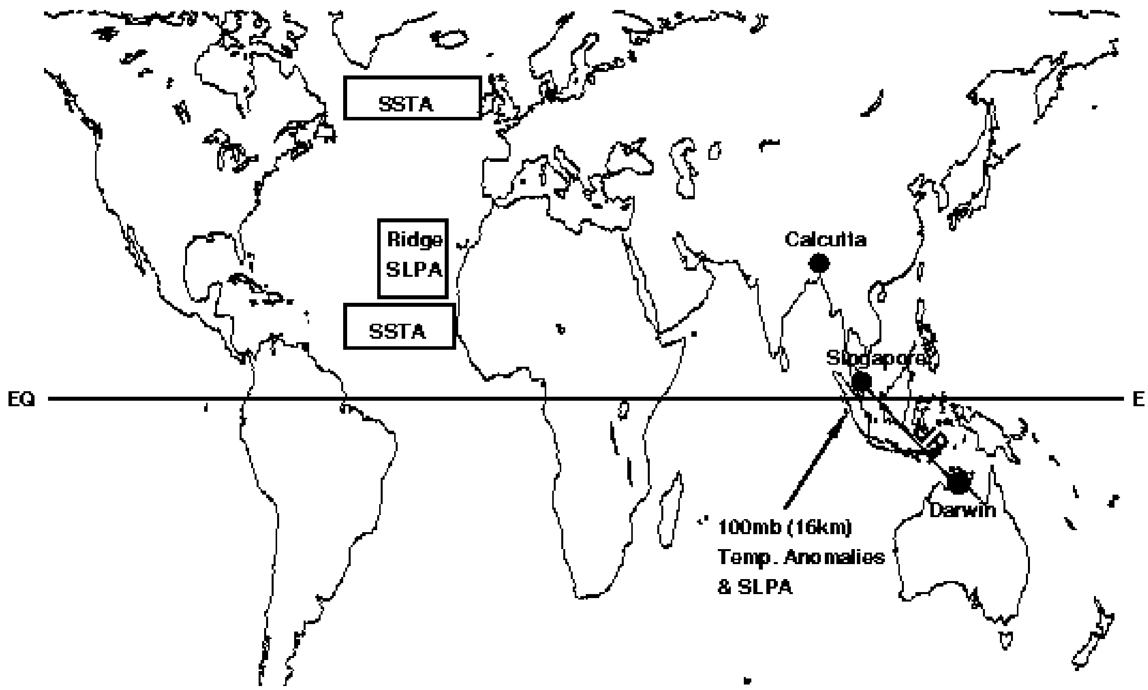

Figure 3: Additional (new) predictors which have recently been noted to be related to upcoming Atlantic hurricane activity.

a) QBO-Tropical Cyclone Lag Relationship

The easterly and westerly modes of stratospheric QBO zonal winds which encircle the globe over the equatorial regions have a substantial influence on Atlantic tropical cyclone activity (Gray, 1984a; Shapiro, 1989). Typically, 50 to 75 percent more hurricane activity [depending on the specific activity index considered] occurs during those seasons when stratospheric QBO winds between 30 mb and 50 mb are anomalously westerly and, when the vertical wind shear (ie., the variation of wind speed with height) between these two levels is comparatively small. Conversely, seasonal hurricane activity is typically reduced when the stratospheric QBO is in the easterly phase and the wind shear between 30- and 50 mb is large. During September 2000, QBO winds are projected to be from an easterly direction with rather large vertical wind shear between these two levels. This should be a suppressing influence on next year's hurricane activity.

b) The El Niño-Southern Oscillation (ENSO) relationship

ENSO is one of the principal global-scale environmental factors affecting Atlantic seasonal hurricane activity. Hurricane activity is usually suppressed during El Niño seasons (e.g., 1997) when anomalously warm surface water is present in the equatorial eastern and central Pacific. Conversely, activity tends to be enhanced during seasons with cold (or La Niña) water conditions as occurred during 1998 and 1999. Cool water conditions have relaxed but are expected to continue through the key months of August through October 2000 and remain an enhancing influence for 2000 hurricane activity.

c) African Rainfall-Tropical Cyclone Lag Relationship

As discussed by Landsea (1991), Gray and Landsea (1992) and Gray et al. (1992), predictive signals for seasonal hurricane activity occur in West African rainfall data during the mid-summer to fall period of the prior year. These rainfall-linked signals include the following:

(1) June-September Western Sahel Rainfall: The Western Sahel area (see Fig. 2) experiences large year-to-year persistence in rainfall. Wet years tend to be followed by wet years (e.g., in the 1950s and 1960s) with enhanced hurricane activity, while dry years are typically followed by dry years (e.g., during the 1970s, 1980s and first half 1990s) and suppressed hurricane activity. Since the rainfall in this region is positively related to concurrent Atlantic hurricane activity, year-to-year persistence (associated with long-term trends) provides a moderate amount of skill for forecasting the following season's African rainfall as well as the associated Atlantic hurricane activity. Last year's (1999) rainfall over the Western Sahel during August-September was +0.15 SD above average and thus is a modest positive factor for 2000 hurricane activity. June-July 2000 rainfall is average (-0.05 SD) and increasing. Within the past two weeks, however, rainfall over this region has greatly increased. June-July rainfall values are higher than any year since 1988. This implies that Sahel rainfall will be an enhancing influence on the season's hurricane activity.

(2) August-November Rainfall in the Gulf of Guinea. Landsea (1991) and Gray and Landsea (1992) documented a strong African rainfall - intense hurricane lag relationship using August through November rainfall along the Gulf of Guinea (see Fig. 2). In historical data, intense hurricane activity during seasons in the years following the wettest August-November Gulf of Guinea months is typically much greater than the hurricane activity that occurs during hurricane seasons following the driest August-November periods in the Gulf of Guinea. As this rainfall relationship has not held well during the last few years (1995-1999), it is being given less qualitative weight in the 2000 forecast. The 1999 August-November Gulf of Guinea rainfall was below average (-0.60 SD), implying a slight negative influence on next year's hurricane activity.

d) Strength of the October-November (1999) and March (2000) Atlantic Subtropical Ridge (Azores High) Between 20-30°W

Higher than normal surface pressure associated with this atmospheric ridge feature is positively related to stronger east Atlantic trade winds which, in turn, enhance upwelling of cold water off the northwest African coast. Colder sea surface temperatures created by enhanced ocean upwelling can cause higher surface pressures during spring which can then create a self-enhancing (positive feedback) response resulting in higher Caribbean pressures during the summer (Knaff 1999). The long-term memory and the feedbacks in this association make it a useful parameter for predicting seasonal hurricane activity. Higher-than-normal surface pressure during the prior fall and spring periods portends reduced hurricane activity and vice versa. Negative ridge index values are associated with a reduced Azores high, weaker trade winds and, thereby, generally enhanced hurricane activity. Ridge strength during October-November 1999 and March 2000 was somewhat below the long-term mean (-0.14 SD and -0.10 SD respectively). Consequently, this factor is presently judged to be a slight positive influence for 2000 hurricane activity.

e) Other Global Predictors

Our more recent work has identified additional global scale parameters which are of value in assessing and adjusting the output of our statistical scheme. These include:

- The broadscale configuration of SST anomaly patterns over much of the high (50-60°N, 10-50°W) and low latitude (10-22°N, 18-50°W) Atlantic: Warm SST anomalies in these regions in the prior 12-18 months are associated with an enhancement of this coming season's hurricane activity and similarly, cold SST anomaly patterns indicate a reduction of hurricane activity. North Atlantic 2000 SST anomaly patterns have been warm while in the tropical Atlantic they are slightly cool implying a mixed or neutral signal for this year's hurricane activity. But SST anomalies have been warming in July and we expect this warming to continue.

- The arrangement of SST anomaly patterns in the Pacific and the Indian Oceans. During the last few years these SST anomalies have taken on configurations which historically have been associated with an enhancement of Atlantic hurricane activity. This configuration of global SSTs includes the recently delineated Pacific Decadal Oscillation (PDO) and the development of cooler ocean temperature patterns in tropical portions of the Indian and western Pacific Oceans. These Pacific and Indian Ocean SST anomaly patterns, along with the new Atlantic Ocean SST anomaly changes (since late 1995) indicate that there is a global scale reconfiguration of ocean SSTA patterns which are more typical of a stronger global conveyor belt (or thermohaline) circulation as suggested by Gray (1998), Gray et al. (1997), and others. Similar global SSTA patterns existed during the 1930s to the 1960s. These changes should be a general enhancing influence on this season's hurricane activity.

2 Prediction Methodology for Early August Forecast

We forecast nine measures of seasonal Atlantic basin tropical cyclone activity including seasonal numbers of the following: Named Storms (NS), Named Storm Days (NSD), Hurricanes (H), Hurricane Days (HD), Intense Hurricanes (IH), Intense Hurricane Days (IHD), the Hurricane Destruction Potential (HDP), Net Tropical Cyclone activity (NTC), and Maximum Potential Destruction (MPD). Definitions for these indices are given on page 3. For each of these measures, we choose the best three to six predictors (i.e., those resulting in optimum prediction skill) from a group of 16 potential forecast parameters known to be related to tropical cyclone activity. The current set of potential predictors used to develop our early August forecast and their specific values are shown in Table 1.

A number of statistical forecasts are made for each activity parameter. Table 2 lists the seasonal hurricane indices that we predict, the number of forecast parameters we use in each forecast and which forecast parameters these are. Our hindcast skill (between 50-60 percent) for the 48-year period of 1950-97 is shown in the right column. These prediction equations are established for our variable parameter forecast model. This represents our best statistical forecast where, so as to minimize the skill degradation of these equations when making independent forecasts via statistical ``overfitting", we include the least number of predictors for the highest amount of hindcast variance. We stop adding predictors when the hindcast improvement of the next best predictor adds less than a 0.025 improvement to the total variance explained. These equations are also constrained to have regression coefficients whose sign match those when analyzed in isolation.

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

Adjustment Terms

(Predicted Amount
of TC Activity = Ave. Season + (QBO + EN + AR + ONR + MATL , TATL etc.) (1)
Per Season)

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 retains greater 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 1: Listing of the pool of predictive parameters and their estimated values for the early August 2000 prediction based on meteorological data available through July 2000. See Figs. 1 and 3 for the locations of the sources of these predictor data.

Predictive Parameter	
1 = QBO 50 mb 4-month extrapolation of zonal wind	
at 12°N to Sept. 2000	-12 $m\ s^{-1}$
2 = QBO 30 mb 4-month extrapolation of zonal wind	
at 12°N to Sept. 2000	-28 $m\ s^{-1}$
3 = QBO absolute value of shear between 50 and 30 mb	
at 12°N to Sept. 2000	16 $m\ s^{-1}$
4 = Rgc AN Gulf of Guinea rainfall anomaly (Aug-Nov of 1999)	-0.6 SD
5 = Rws West Sahel rainfall anomaly (June-July 2000)	-0.05 SD
6 = SST3.4 Nino 3.4 SSTA in June-July 2000	-0.36°C
7 = ZWA June-July 2000 Caribbean basin zonal wind anomaly	-0.2 m/s
8 = SLPA June-July 2000 Caribbean basin sea level pressure anomaly	-0.1 mb
9 = Temp West-East Sahel temperature gradient(Feb-May 2000)	0.5 SD
10 = NATL North Atlantic SSTA anomaly (50-60°N,10-50°W) (June-July)	0.4°C
11 = SATL South Atlantic SSTA anomaly (5-18°S,50°W-10°E) (June-July)	0.3°C
12 = TATL Tropical Atlantic SSTA anomaly (10-22°N,18-50°W) (June-July)	-0.2°C
13 = R-M: Mar Azores surface pressure ridge strength in Mar 2000	-0.10 SD
14 = R-ON: Azores surface pressure ridge strength in Oct-Nov 1999	-0.14 SD
15 = D-SST3.4: Nino 3.4 SSTA for June-July minus April-May 2000	0.17°C

16 = NSD-S: Named storm days south of 23.5°N and east of 75°W before 1 August	0

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 GT) are selected by only one or two of our forecast equations. Table 2a also lists the hindcast measure of agreement or amount of variance explained. Note that for HDP, NTC and MPD we explain nearly two-thirds of the hindcast variance. Table 2b refers to our separate after 1 August forecast. Note that all parameter values are above climatology averages.

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 to minimize artificial skill. See Figs. 1-3 for the locations of the predictors. Data for 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 - U_{30}, Shear, Rg, NSD-S
NSD	.539	.376	5 - U_{30}, Rg, R-M, R-ON, NSD-S
H	.522	.351	5 - U_{30}, Rg, DT, R-M, R-ON
HD	.461	.262	3 - U_{30}, Rg, NATL
IH	.572	.423	5 - U_{50}, Rs, Rg, DT, R-M
IHD	.556	.405	4 - U_{50}, Rg, DT, NSD-S
HDP	.452	.246	3 - Rg, DT, R-ON
NTC	.593	.452	5 - U_{30}, Rg, R-M, R-ON, NSD-S
MPD	.620	.490	4 - U_{30}, Rg, R-M, R-ON

Table 2b also presents a summary of expected forecast skill degradation for application to independent data. As we gain more years of developmental data (now 48) and, as we reduce the number of variables, the amount of estimated real forecast skill, although impossible to determine for an individual year, should not significantly degrade.

3 Forecast Parameters for Early August 2000 Prediction

The following parameter values go into our new 1 August forecast scheme. They are derived from meteorological data available through July, 2000.

3.1 QBO - A Suppressing Influence

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 2000 have an influence on the seasonal hurricane activity equatorward of 25˙N; westerly wind anomalies typically enhance hurricane activity while easterly wind anomalies tend to suppress activity. 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 2000 hurricane season, 30 mb and 50 mb zonal winds will be from a relative easterly direction and, hence, are anticipated to be a suppressing influence for this year's hurricane forecast. We project that 50 mb and 30 mb actual zonal winds for September 2000 will have values of -28 and -12 m/s respectively.

3.2 ENSO - Enhancing Influence for 2000

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 2000 are shown in Table 3. Cooler water conditions are in all Nino areas. These negative SSTA anomalies should act as a weak enhancement on this season's hurricane activity. These cool water conditions should also lead to more low-latitude and longer-lived hurricane activity. Much of this influence, however, will be counteracted by the easterly QBO.

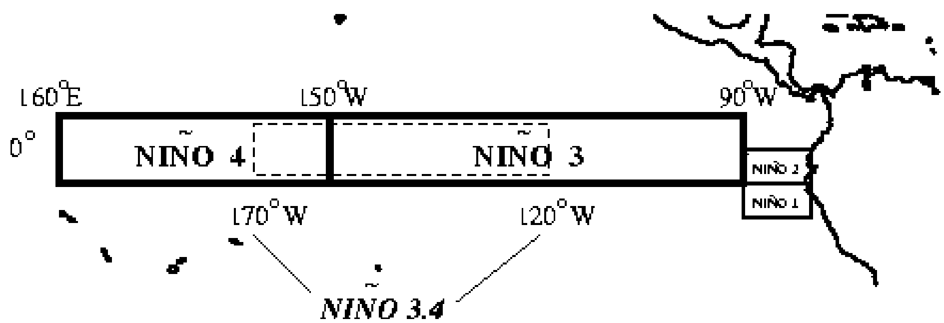

Figure 4: Equatorial Pacific sea surface temperature anomaly indices (˙C) represent the areas indicated. The dashed area is the (newer) Nino 3.4 index.

Table 3: Values for various April through July 2000 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	0.6	0.1	-0.5	-0.9
Nino-3	0.2	0.0	-0.4	-0.2
Nino-3.4	-0.6	-0.5	-0.4	-0.3
Nino-4	-1.0	-0.8	-0.5	-0.4
SOI	1.2	0.2	-0.6	-0.4

3.3 West African Rainfall (AR) - A Slightly Positive Influence

Western Sahel June-July 2000 rainfall data indicate that average rainfall has occurred (-0.05 SD) so far this season. We expect rainfall in August and September to pick up and seasonal rainfall totals for the Western Sahel to be somewhat above average. This is expected to be an enhancing influence for this year's forecast of intense hurricane activity.

3.4 West African GT - Enhancing 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 was anomalously high (+0.50 SD). A positive value for this index cause West African winds to be more out of the South than the North and is an enhancing influence for this season's hurricane activity.

3.5 June-July SLPA and ZWA - Combined Enhancing 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 2000 five-station tropical (Trinidad, Barbados, Curacao, San Juan and Cayenne) SLPA was near neutral. June SLPA was +0.5 mb above average and July SLPA was minus 0.5 mb below. This 1 mb SLPA drop is a good indication that August-October 2000 period will be below average. A second six-station higher latitude surface pressure average, made up of Brownsville, Miami, Merida (Yucatan), San Juan, Barbados, and Trinidad, yielded a surface pressure anomaly for June-July of also slightly negative (-0.2 mb). We anticipate SLPA being below average during the August-September period.

The mean five-station June-July (Trinidad, Curacao, Barbados, Kingston and Balboa) ZWA value gave a value of near zero (-0.2 m/s). We anticipate an increase to more negative ZWA and SLPA values as the season progresses. The combined influence should be an enhancing influence on this season's hurricane activity.

3.6 Summary of 1 August Predictors

Table 1 provided information on the current values of the pool of sixteen 1 August precursor signals that we consult. We choose the best 3-6 predictors for each of our nine measures of seasonal hurricane activity. The majority of these precursor signals are positive and indicate that this year's Atlantic basin hurricane activity will be above average.

4 Statistical Forecast For 2000

Table 4 lists both our original and revised quantitative forecasts for the post-1 August hurricane activity. Our forecast for the remainder of the hurricane season (i.e., August through November) is for much above average tropical storm and hurricane activity. Note that our revised post 1 August forecast (last column) is one cyclone less in most categories than our 6 June forecast but still greater hurricane activity than that specified by climatology (Column 2).

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.

Foercast Parameter	(1) New Variable Predictor for Post 1 Aug Activity	(2) After 1 Aug Climatology	(3) Qualitative Adjusted After 1 Aug Activity	(4) Full Hurricane Season Average 1950-1990
(NS)	6.6	7.8	11	9.3
(NSD)	32.3	41.1	55	46.9
(H)	4.1	5.1	7	5.8
(HD)	14.4	21.4	30	23.7
(IH)	1.8	2.0	3	2.2
(IHD)	2.6	4.4	6	4.7
(HDP)	35.4	64.4	90	70.6
(MPD)	48.6	67	70	61.7
(NTC)	59.6	97	130	100

Table 5 gives all of our 2000 seasonal forecasts. Note that we anticipate about the same numbers as we predicted in early December 1999 and early April 2000, but one cyclone fewer than forecast in early June.

Table 5: Comparison of the current early August 2000 predictions of total seasonal activity versus our three prior forecasts/updates for 2000. The latter were issued on 6 December 1999, 7 April 2000 and 7 June 2000.

	Earlier Forecasts			Current Total Season
Forecast Parameter	8 Dec 99 Fcst	7 Apr 00 Fcst	7 Jun 00 Fcst	4 Aug 00 Fcst
Named Storms (NS)	11	11	12	11
Named Storm Days (NSD)	55	55	65	60
Hurricanes (H)	7	7	8	7
Hurricane Days (HD)	25	25	35	30
Intense Hurricanes (IH)	3	3	4	3
Intense Hurricane Days (IHD)	6	6	8	6
Hurricane Destruction Potential (HDP)	85	85	100	90
Maximum Potential Destruction (MPD)	70	70	75	70
Net Tropical Cyclone Activity (NTC)	125%	125%	150%	130%

5 Reasons for Upward Adjustments of 2000 Statistical Forecast

We believe that the 2000 hurricane season will be more active than is indicated by our statistical schemes owing to several new and likely hurricane enhancing features not fully incorporated in our statistical forecasts. These include the persistence of warm north and tropical Atlantic SSTA patterns (associated with an enhanced Atlantic thermohaline circulation) which are expected to continue as well as other newly found global predictor signals not yet incorporated.

This new information is expected to act to enhance 2000 hurricane activity to higher levels than is indicated by our statistical scheme. It appears that the training data sets for our statistical schemes, developed for periods of 1950-1990 and 1950-1995 did not contain the unusually enhancing hurricane activity of the last five years. Our statistical schemes have underestimated the seasonal hurricane activity in four of the last five seasons (likely owing to the proxy association of strength of the Atlantic thermohaline circulation). This and the results of our analysis of analog years (to be discussed) has lead us to increase our 2000 forecast over that specified by our statistical scheme.

6 2000 Hurricane Activity Inferred from Analog Years

We find that certain years in the historical records have similar global oceanic and atmospheric conditions which provide useful clues to the amount of hurricane activity likely to occur in a given year. Although the physical associations involved with these analog relationships are not completely understood, they are useful for additional guidance in extended range prediction. We look for atmospheric and oceanic conditions resembling current July 2000 conditions starting from 1950 (when direct stratospheric QBO wind data were available).

There are five July analogs which are fairly similar to this year wherein

- the North Atlantic (50-60˙N, 10-50˙W) had persistent warm SST anomalies during the prior year period,
- La Niña conditions were present and persisted (as we expect this year),
- easterly QBO winds were present at 30 and 50 mb during the following September as will occur this year.
- Pacific SST anomaly patterns were similar to this year.

The closest analog years to 2000 wherein the above conditions are generally present include 1949, 1956, 1981, 1989, and 1996. Table 6 lists the hurricane activity which occurred in these five seasons. The 1956 season was suppressed while 1949, 1981, 1989 and 1996 had above average activity despite easterly stratospheric QBO winds. Our actual forecast represents a compromise closer to our analog analysis than our statistical forecast models. These analogs thus indicate that 2000 will experience above average Atlantic basin hurricane activity and much more activity than that which occurred during the generally suppressed hurricane seasons of 1970-1994.

7 Reasons for Decreasing Our 4 August Forecast From Our 7 June 2000 Forecast Activity Values

1. Tropical SSTA: Recent analyses of SSTA across the Atlantic reveal a slight cooling over subtropical and tropical waters across the eastern and central Atlantic. We had assumed that in late May warmer temperature anomaly patterns would be present at this time.
2. The state of ENSO: Although the current La Niña episode is still present, it is a little weaker than anticipated in late May.
3. The ZWA values not quite as favorable as expected at this time of our early June forecast.

Table 6: Atlantic basin tropical cyclone activity (during analog seasons for the year 2000).

Year	NS	NSD	H	HD	IH	IHD	HDP	NTC
1949	13	62	7	22	3	3	64	115
1956	8	30	4	13	2	2.25	39	69
1981	11	60	7	22	3	3.75	63	114
1989	11	66	7	32	2	9.75	108	135
1996	13	78	9	45	6	6.00	135	204
Average	11.2	59	6.8	27	3.2	5.5	82	127
2000 Forecast	11	60	7	30	3	6	90	130

8 Predictions for Individual Months

There are often periods within active and inactive Atlantic basin hurricane seasons which do not conform to the overall trend of the season as a whole. For example, 1961 was a very active hurricane season (NTC of 222) but there was no tropical cyclone activity during August; 1995 had 19 named storms but only one new named storm developed during the 30-day period at the statistical long-term peak of the hurricane season between 27 August and 26 September. By contrast, the inactive season of 1941 had only six named storms (average 9.3) but four of them developed during September (average 3.4). During the inactive hurricane season of 1968, three of the eight named storms that year formed in June (average 0.5).

We have started new research to see how well various sub-season or individual monthly trends can be forecast. This effort is being spearheaded by Eric Blake, a graduate student in the first author's project. Blake has been working to develop a scheme to skillfully predict August only Atlantic basin tropical cyclone activity. On average, August has about 26 percent of the total season activity.

It is, in general, more difficult to predict shorter periods of hurricane activity than to predict the entire yearly activity. Despite the inherent difficulties of a shorter period forecast, Blake has, nevertheless, come up with a quite skillful (as determined by 51 years of hindcast testing using a seasonal independent jackknife approach) forecast scheme for the prediction of August activity alone. He uses June and July NOAA global reanalysis data to find new global hindcast predictors that are not explicitly part of our total season predictions. He predicts the same NS, NSD, H, HD, etc. activity parameters as our seasonal scheme. This forecast methodology will be fully documented in his forthcoming MS thesis within the next few months. Table 7 lists Blake's prediction for August 2000 along with his jackknife determined hindcast skill for the 51 -year period of 1949-1999, the long period August mean, and his final adjusted August 2000 forecast numbers.

Table 7: Prediction of August 2000 Atlantic basin seasonal hurricane activity.

		Jackknife		
Forecast	**Statistical**	**Hindcast**	**August**	**Final Adjusted**
Parameter	**Forecast**	**Skill**	**Climatology**	**Forecast Numbers**
NS	2.29	.49	2.76	3
NSD	14.21	.61	11.80	14.25
H	1.77	.53	1.55	2
HD	8.27	.62	5.67	8.25
IH	1.13	.58	0.57	1
IHD	1.04	.70	1.18	1.25
NTC	32.2	.73	26.1	33

Table 8 shows the best prior July analog years to 2000 that were used as an aid to the August 2000 forecast. These six analog years averaged a little less than the current forecast.

Table 8: Best analog years for August 2000 forecast, or the prior years with the most similar June and July (mainly) global climate signals to June and July 2000.

Year	NS	NSD	H	HD	IH	IHD	NTC
1949	3	15	2	7.5	1	.75	31.9
1951	3	10.75	1	7.25	1	1.75	30.9
1954	2	7.75	1	5	0	0	12.3
1963	2	13.75	2	10.5	1	0.5	30.9
1980	3	19.50	3	13	1	6.5	60.6
1981	2	11	1	0.5	0	0	10.7
Average	2.5	13	1.7	7.25	0.5	1.5	29.6
2000 August Forecast	3	14.25	2	8.25	1	1.25	33

Summary. We expect August to have hurricane activity above (about 33/26.1 or 126 percent) of the long period August mean. In round numbers the August forecast is for three named storms, two hurricanes, and one intense or major hurricane.

9 Suppressed Early Tropical Cyclone Activity

The observation of no named storm through the 4th of August 2000 is judged to have little or no bearing on whether we will have an overall active or inactive hurricane season. A number of active hurricane seasons have experienced little hurricane activity prior to mid or late August. This season will be primarily specified by the activity during the 60-day period between 20 August and 20 October.

10 Landfall Probabilities for 2000

A new aspect of our research involves efforts to develop forecasts of the probability of hurricane landfall along the U.S. coastline. Whereas individual hurricane landfall events can not be accurately forecast for an individual year, the net yearly probability of landfall can be forecast with statistical skill. With the premise that landfall is a function of varying climate signals, a probability specification has been accomplished through a statistical analysis of all U.S. hurricane landfalls of named storms during the last 100 years (1900-1999). Specific landfall probabilities can be given for all cyclone intensity classes for a set of distinct U.S. coastal regions. Net landfall probability is statistically related to the overall Atlantic basin Net Tropical Cyclone Activity (NTC) and to climate trends linked to multi-decadal variations of the Atlantic Ocean thermohaline circulation (as measured by recent past years of North Atlantic SSTA*). The current value of SSTA* is 37. With a new prediction of NTC of 130, this yields a combination of NTC+SSTA* of (130 + 37) = 167. SSTA* is an index of recent year North Atlantic SSTA in the area between 50-60°N, 10-50°W. Higher values of SSTA* generally indicate greater Atlantic hurricane activity, particularly major hurricane activity.

As shown in Table 9, NTC is a combined measure of the year-to-year mean of six indices of hurricane activity, each expressed as a percentage differences from the long-term average. Whereas many active Atlantic hurricane seasons feature no landfalling hurricanes, a number of inactive years have experienced one or more landfalling hurricanes. Long term statistics show that, on average, the more active the overall Atlantic basin hurricane season is, the greater the probability of U.S. hurricane landfall. For example, landfall observations during the last 100 years show that a greater number of intense (Saffir-Simpson category 3-4-5) hurricanes strike the Florida and U.S. East Coast during years of highest NTC and when above average North Atlantic SSTA* conditions are in place. The 33 years (during the last 100) with the combined highest NTC and strongest thermohaline circulation experienced 24 category 3-4-5 hurricane strikes along the Florida and East Coast whereas the 33 years with the lowest NTC and the weakest thermohaline circulation saw only three such intense hurricane hits, a difference ratio of 8 to 1. Tables 10 and 11 summarize the links between hurricane and tropical storm landfall and the combined influences of NTC and thermohaline circulation (i.e., North Atlantic SSTA* effects) for Florida and the U.S. East coast and also for NTC only for the Gulf Coast. Atlantic basin NTC can be skillfully predicted and the strength of the Atlantic Ocean thermohaline circulation can be inferred from North Atlantic Sea Surface Temperature (SST) anomalies from the prior year. These predictive relationships can therefore be utilized to make probability estimates of U.S. landfall .

Table 9: NTC activity in any year consists of the seasonal average of the following six parameters expressed in terms of their long-term averages. A season with 10 NS, 50 NSD, 6 H, 25 HD, 3 IH, and 5 IHD, would then be one-sixth of the percentage of the sum of the following ratios: 10/9.3 = 108, 50/46.6 = 107, 6/5.8 = 103, 25/23.9 = 105, 3/2.3 = 130, 5/4.7 = 106, or an NTC of 110.

		1950-1990 Average
1)	Named Storms (NS)	9.3
2)	Named Storm Days (NSD)	46.6
3)	Hurricanes (H)	5.8
4)	Hurricane Days (HD)	23.9
5)	Intense Hurricanes (IH)	2.3
6)	Intense Hurricane Days (IHD)	4.7

Table 10: Number of Florida Peninsula and U.S. East Coast (regions 5 through 11) hurricane landfall events by intensity class during the 33 highest versus the 33 lowest values of NTC plus Atlantic thermohaline circulation (SSTA) of the last century.

Intensity Category	Sum of Highest 33 Years	Sum of Lowest 33 Years	Ratio of Highest/Lowest 33 Years
IH (Category 3-4-5)	24	3	8.0
H (Category 1-2)	29	12	2.4
NS	24	17	1.4

Table 11: Number of Gulf (regions 1 through 4) hurricane landfall events by intensity class during the seasons with the 33 highest and 33 lowest NTC values during this century.

Intensity Category	Sum of Highest 33 Years	Sum of Lowest 33 Years	Ratio of Highest/Lowest 33 Years
IH (Category 3-4-5)	18	5	3.6
H (Category 1-2)	22	11	2.0
NS	28	27	1.0

Landfall characteristics for the Gulf Coast or (regions 1-4) from north of Tampa, FL and westwards to Brownsville, TX (36 total category 3-4-5 hurricane landfalls of this century) and the rest of the U.S. coast from north of Tampa, FL to Eastport, ME (37 landfalls in regions 5-11).

These differences are due primarily to the varying incidence of category 3-4-5 hurricanes in each of these areas. Figure 4 shows the locations of these 11 coastal zones for which regression equations have been developed relating forecasts of NTC (NTC_f) and measured values of SSTA* to landfall probability in these 11 regions. Figure 5 gives a flow diagram outlining the procedures by which these forecasts are made.

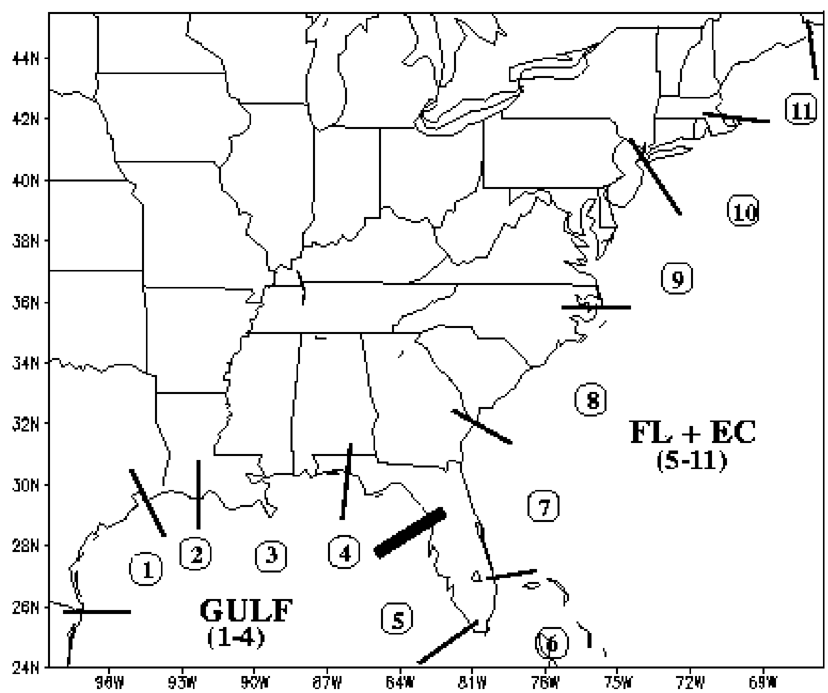

Figure 5: Location of the 11 coastal regions for which separate hurricane landfall probability estimates are made.

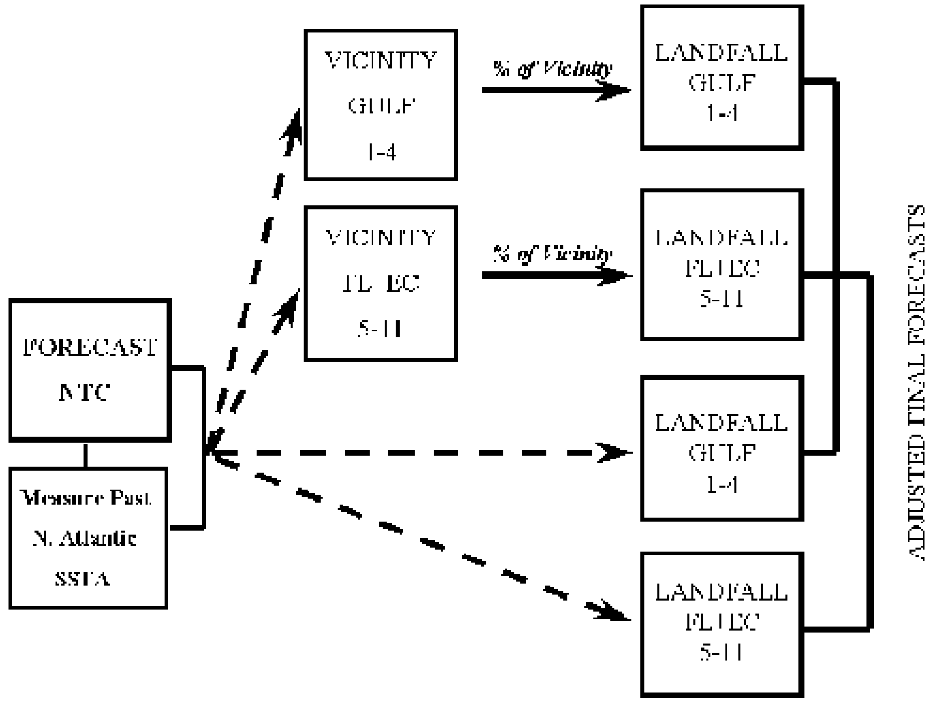

Figure 6: General flow diagram illustrating how forecasts of U.S. hurricane landfall probabilities are made. We forecast NTC and use an observed measure of the last few years of North Atlantic (50-60°N, 10-50°W) SSTA*. Regression equations are then developed from the combinations of forecast NTC and measured SSTA* values. A regression is then developed from U.S. hurricane landfall measurements of the last 100 years and separate equations are derived for the Gulf and for Florida and the East Coast (FL+EC).

Using NTC alone, a similar set of regression relationships has been developed for the landfall probabilities of category 1-2 hurricanes and TSs along the Gulf Coast (regions 1-4) and along Peninsula Florida and East Coastlines (regions 5-11). Research is now directed to making landfall probabilities available for 11 distinct Gulf Coast and U.S. East Coast regions extending from Brownsville, TX to Eastport, ME. Table 12 lists strike probabilities for different TC categories for the whole U.S. coastline, the Gulf Coast and Florida and the East Coast for 2000. The mean annual number of landfalling systems is given in parentheses.

Table 12: Estimated probability (percent) of one or more U.S. landfalling Tropical Storms (TS), category 1-2 hurricanes, and category 3-4-5 hurricanes, total hurricanes and named storms along the entire U.S. coastline, along the Gulf Coast (region 1-4), and along the Florida and the East coastline (Regions 5-11) for 2000. The mean annual number of one or more landfalling systems during the last 100 years is given in parentheses.

Coastal Region	**TS**	**Category 1-2 HUR**	**Category 3-4-5 HUR**	**All HUR**	**Named Storms**
Entire U.S. (Regions 1-11)	82% (80)	73% (68)	60% (52)	89% (84)	98% (97)
Gulf Coast (Regions 1-4)	67% (59)	46% (42)	34% (30)	62% (61)	87% (83)
Florida plus East Coast (5-11)	47% (51)	52% (45)	39% (31)	72% (62)	86% (81)

Although not explicitly determined for this report, intense hurricane (category 3-4-5) frequency in the Caribbean area during 2000 should be approximately that for Florida and the U.S. East Coast; the latter being somewhat greater than the long-term average and distinctly higher than during the recent downturn period between 1970-1994.

11 Technique for the Prediction of U.S. Hurricane Landfall Probability

Full documentation of the methodology for estimating hurricane landfall probability study is being prepared and will, hopefully, be available in the next few months. Landfall probabilities include specific forecast of the probability for landfalling tropical storms (TS) and hurricanes of category 1, 2, 3, and 4-5 is being developed for each of 11 units of the U.S. coastline (Fig. 5). These 11 units are further being subdivided by coastal population into 96 regions based on coastal population. Statistics are being developed for each 100 km (65 mile) segment of the entire U.S. coastline.

These forecast probabilities will be supplemented with probability values for each 100 km coastal segment receiving gale force winds (,40 mph), sustained hurricane force winds (,75 mph), and major hurricane (category 3-4-5) winds (,115 mph). There will also be a discussion of potential tropical cyclone spawned hurricane destruction within each of the 96 different U.S. coastal locations.

12 Evidence of Persistent Multi-Decade Enhancement of Atlantic Hurricane Activity Associated With a Major Reconfiguration of Global Ocean Surface Temperature Patterns

Recent observations indicate increased salinity in upper layers of the North Atlantic Ocean. Higher salinity increases the density of water in the upper ocean layers which is then more able to sink to great depth, thereby increasing compensating northward flow of Atlantic warm (and salty) replacement water in upper ocean levels. The resulting net northward transport of warm upper-layer water into the far North Atlantic (and compensating equatorward transport of deep cold water) is the principal manifestation of the Atlantic Ocean thermohaline (or ``Conveyor Belt") circulation. A strong conveyor circulation increases ocean surface temperatures in the high latitude Atlantic areas by transporting more heat to high latitudes. Hence, slowly rising salinity values in the far North Atlantic during recent years suggest the development of conditions favorable for a stronger Atlantic thermohaline circulation. The effects of a stronger thermohaline circulation have been evident in the Atlantic since the spring of 1995.

The best proxy signal for this enhanced circulation condition is the North Atlantic SST anomalies. Three decades have passed since the SST anomaly patterns of the Atlantic Ocean have been so warm. Figure 6 shows the change of the mean SST anomalies for 1990 through 1999 versus the mean for 1995 to 1999. SSTA values in the North Atlantic (50-60˙N, 10-50˙W) for June through September 1999 were nearly 1˙C warmer than the earlier five-year (1990-1994) period. These warmer SSTAs are a direct result of a stronger Atlantic Ocean thermohaline circulation. And this stronger thermohaline circulation has also led to a warming of the tropical Atlantic (8-22˙N, 10-50˙W) ocean SSTAs. Figures 7 and 8 show time changes of SST changes during two recent five-year periods and the time series of SSTA in the North Atlantic (50-60˙N, 10-50˙W) since 1900. It is assumed that these warm conditions will persist through 2000. Note that the general warming of the North Atlantic that has taken place during the last five years when the incidence of major hurricanes also increased is similar to that which occurred during active hurricane seasons in the period from the 1930s to the 1960s. This trend is hypothesized to manifest itself through alterations of many global climate parameters as seen in Fig. 9. This includes more hurricanes forming at low latitudes, more intense hurricanes, and more major hurricanes landfalling along the US East Coast, Florida, and in the Caribbean Sea. The Gulf Coast seems less affected by these changes. This trend may continue for several decades.

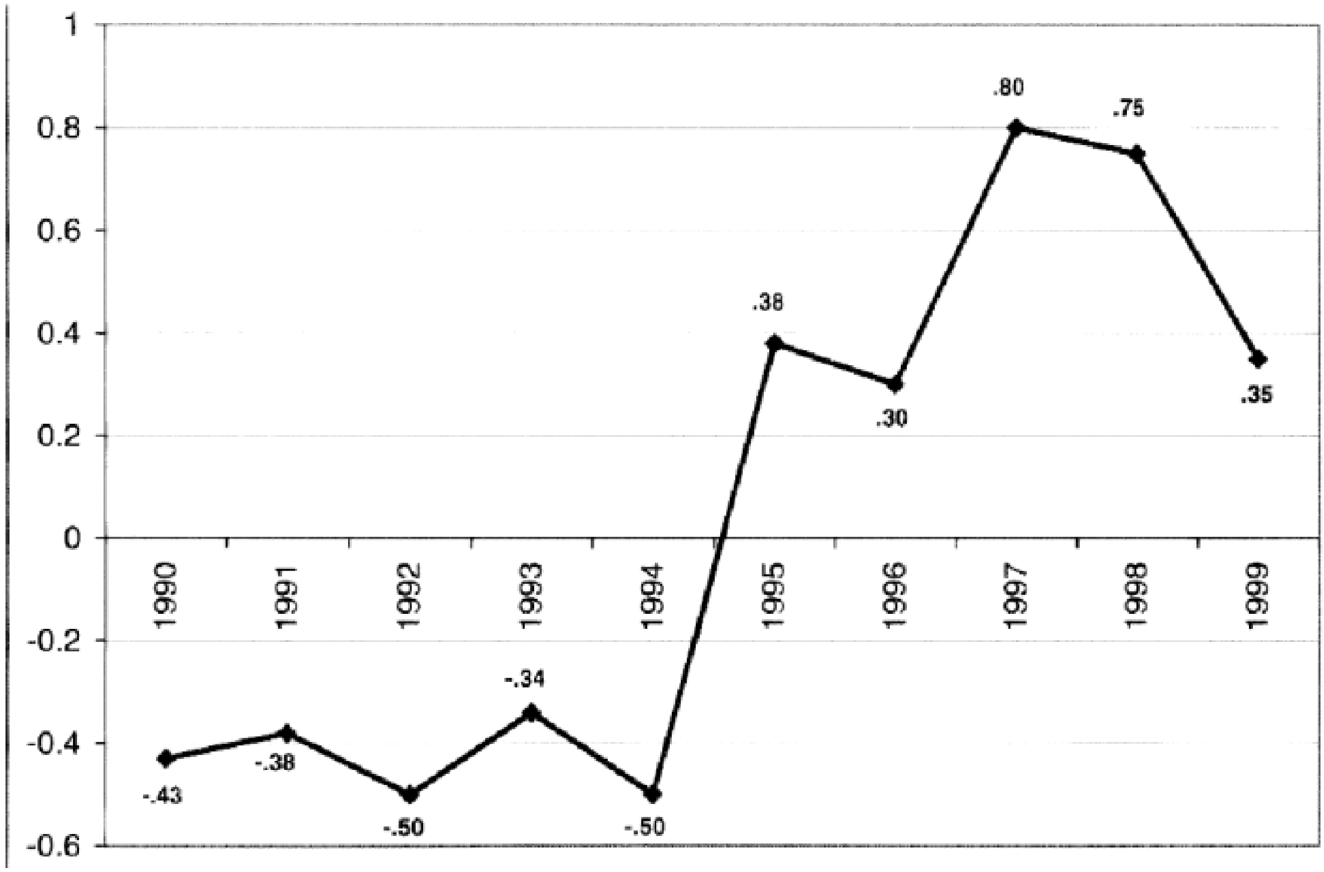

Figure 7: Time series of North Atlantic annual average SST (in ˙C) anomalies in the area between 50-60˙N, 10-50˙W for 1990 to 1999.

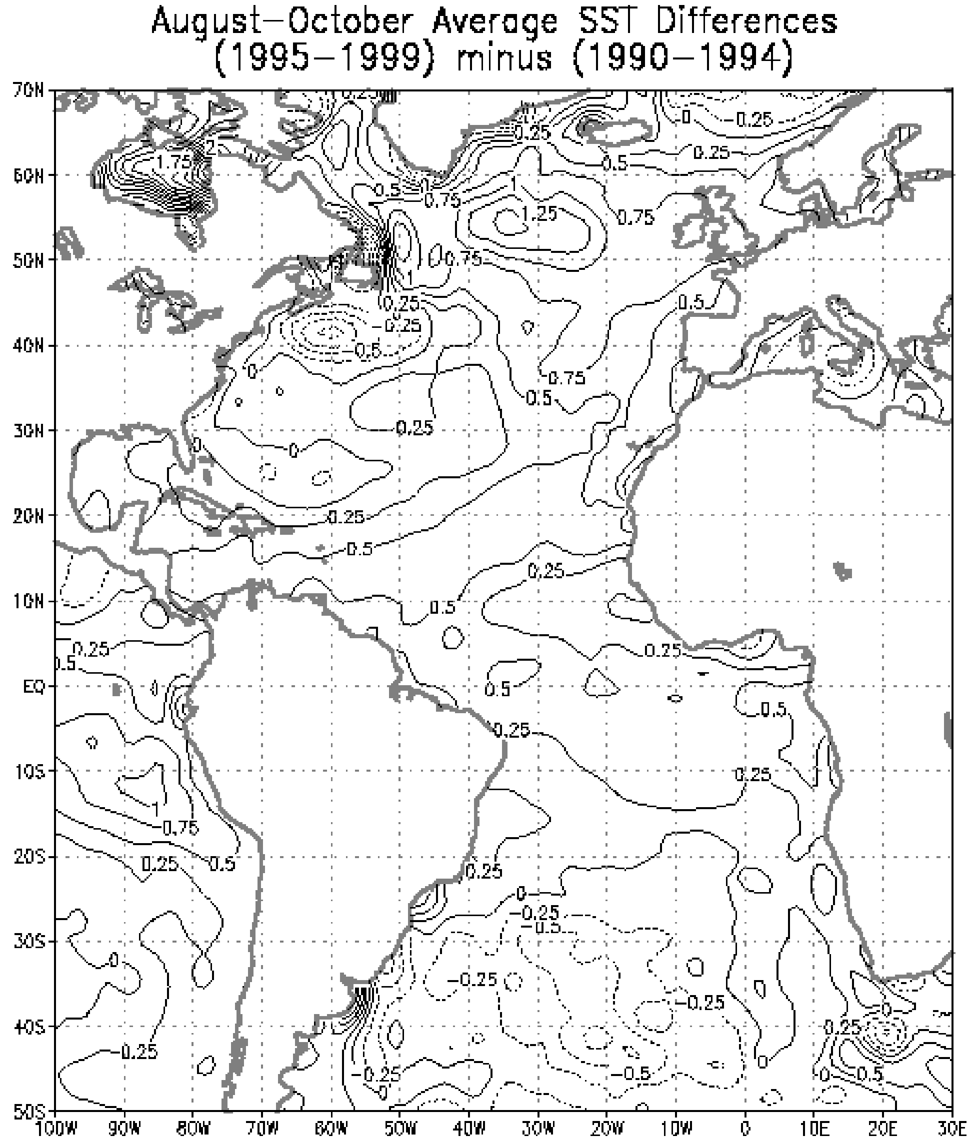

Figure 8: Average August through October SST differences (in ˙C) between two recent five-year periods: i.e., 1995 to 1999 minus 1990 to 1994.

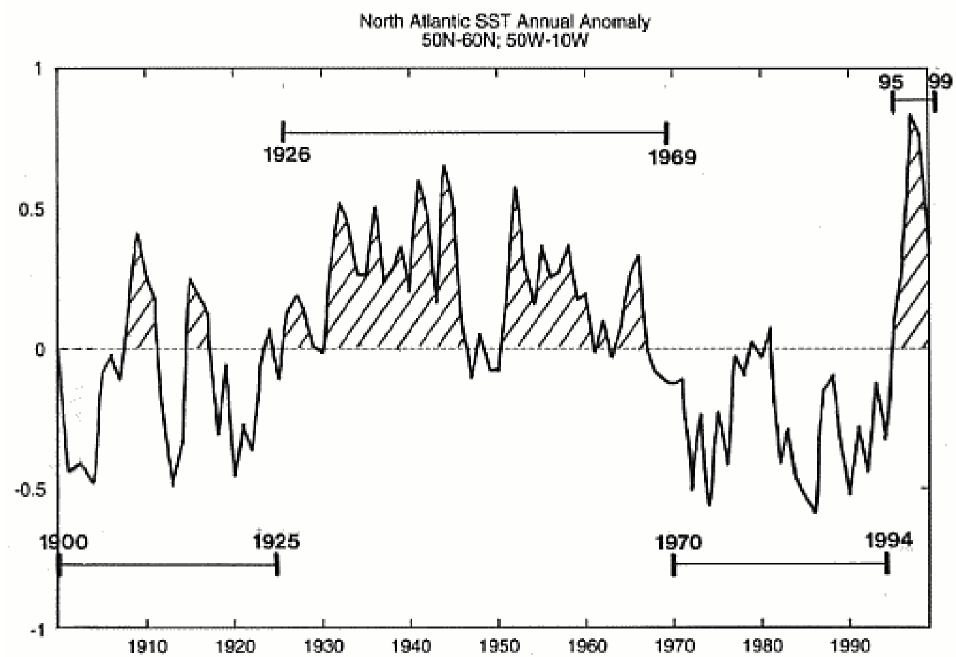

Figure 9: Time series of North Atlantic annual average SST anomalies (in ˚C) in the area between 50-60˚N, 10-50˚W for 1900 to 1999. Periods of positive SST anomalies are hatched.

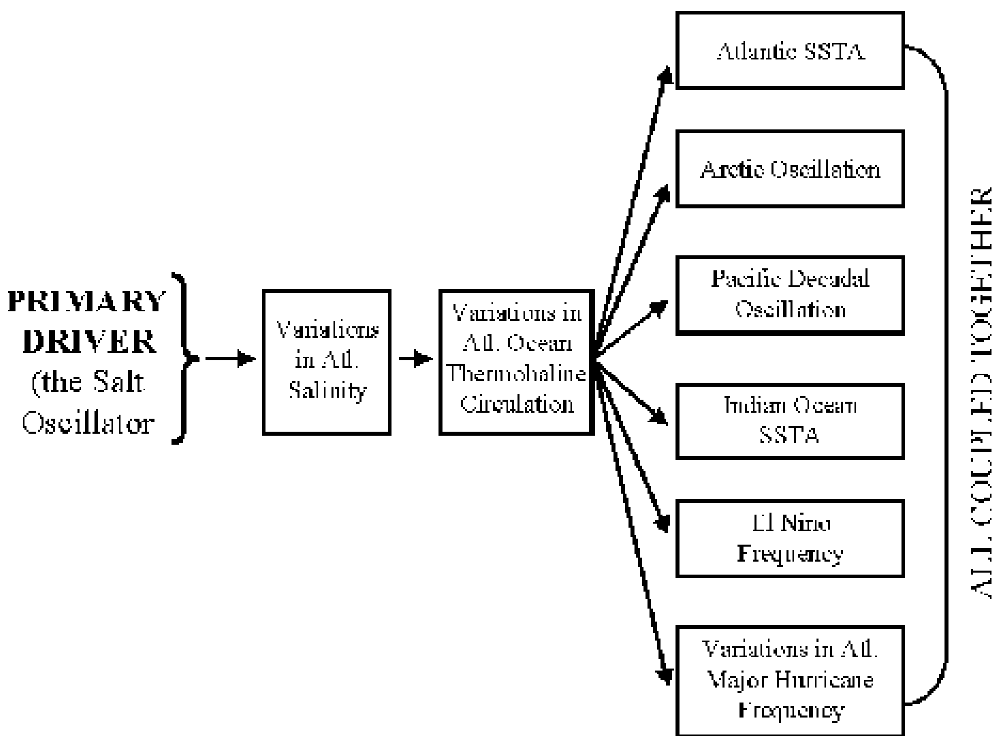

Figure 10: Conceptual outline of the first author's theory on the primary cause of multi-decadal climate change. We look to long period ocean salinity changes (primarily in the Atlantic). These salinity changes cause Atlantic Ocean thermohaline changes which, with time lags of 4-6 years, manifest themselves throughout the global oceans and then the atmosphere.

For years now, we have been suggesting (eg., Gray 1990, Gray et al. 1996) that the recent era of reduced Atlantic intense (category 3-4-5) hurricane activity (which occurred between 1970-1994) was likely ending and that Atlantic coastal residents should expect an eventual long-term increase of landfalling major hurricanes. This outlook is especially ominous because, when normalized by increased coastal population, inflation, and wealth per capita, [see Pielke and Landsea (1999) and Gray (1999)] major hurricanes are observed to cause 80 to 85 percent of all US tropical cyclone linked destruction.

Despite El Niño-linked reductions of hurricane activity during 1997, the last five years (1995-1999) are the most active five (consecutive) year period on record. This activity includes the total number of named storms (65), hurricanes (41), major hurricanes (category 3-4-5) (20), major hurricane days (51) and Net Tropical Cyclone activity (842) which occurred during the last five years. Even with the inclusion of the weak 1997 hurricane season, the annual average of NS, H, IH, IHD and NTC during the last five years are 155, 178, 400, 816 and 311 percent (respectively) of the average hurricane activity for 1990-1994. And, the annual average NS, H, IH, IHD and NTC during the last five years has been 151, 165, 257, 263, 405 and 224 percent of the average for the previous 25-year period (1970-1994). The largest increases have come in IH and IHD activity.

13 Forecast Theory and Cautionary Note

Our forecasts are based on the premise that those global environmental conditions which proceed comparatively active or inactive hurricane seasons in the past provide meaningful information about trends in future seasons as well. 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 explicitly predict specifically where within the Atlantic basin storms will strike. Landfall probability estimates at any one location along the coast are very low and reflect the fact that in any one season, most US coastal areas will not feel the effects of a hurricane no matter how active the individual season is. However, it must also be emphasized that a low strike probability does not insure that a hurricane will not come ashore. Regardless of how active 2000 hurricane season should be, a finite probability always exists that one or more hurricanes may strike along the US or Caribbean Basin coastline and do much damage.

14 The 1995-1999 Active Hurricane Period and Global Warming

Some readers may interpret the recent large upswing in Atlantic hurricane activity as being in some way related to increased human-induced greenhouse gases such as carbon dioxide (CO_2). Such an interpretation of the recent sharp upward Atlantic hurricane activity since 1995 is not plausible. It should be noted that tropical cyclone activity in the other global basins has shown a downward trend since 1995. See our 24 November 1999 verification on this Web site for a more detailed discussion of this issue.

15 Verification of 2000 Forecast and Outlook for 2001

A verification of this forecast will be issued in late November 2000 and a seasonal forecast for the 2001 hurricane season will be issued in early December 2000. As there is a good probability that we will have El Niño in the tropical Pacific next year, it is likely that we will see a below average hurricane season in 2001.

16 Acknowledgements

John Knaff, John Sheaffer, Todd Kimberlain, Eric Blake, and William Thorson have made many important contributions to the conceptual and scientific background for these forecasts. The authors are indebted to a number of meteorological experts who have furnished us with the data necessary to make this forecast or who have given us valuable assessments of the current state of global atmospheric and oceanic conditions. We are particularly grateful to Arthur Douglas, Richard Larsen, David Masonis, Vern Kousky, Ray Zehr and Mark DeMaria for very valuable climate discussions and input data. We thank Colin McAdie and Jiann-Gwo Jiing who have furnished data necessary to make this forecast and to Gerry Bell, James Angell, and Stan Goldenberg for input data and helpful discussions. Richard Taft has provided valuable data development and computer assistance. We wish to thank Tom Ross of NCDC and Wassila Thiao of the African Desk of CPC who provided us with West African and other meteorological information. In addition, Barbara Brumit and Amie Hedstrom have provided excellent manuscript and data analysis assistance. We have profited over the years from many indepth discussions with most of the current NHC hurricane forecasters. These include Lixion Avila, Miles Lawrence, Richard Pasch, Edward Rappaport, Jack Beven and James Franklin. The first author would further like to acknowledge the encouragement he has received for this type of forecasting research applications from Neil Frank, Robert Sheets, Robert Burpee, Jerry Jarrell, former directors of the National Hurricane Center (NHC) and from the current director, Max Mayfield.

The financial backing for the issuing and verification of these forecasts has, in part, been supported by the National Science Foundation. But this NSF support is insufficient. Recently, the Research Foundation of the United Services Automobile Association (USAA) and State Farm insurance companies have made contributions to the first author's project. It is this support which is allowing our seasonal predictions to continue.

17 Additional Reading

APPENDIX - Post-Season Reviews of All Prior Seasonal Forecasts

The first author has now issued seasonal hurricane forecasts for 16 consecutive years (1984-1999). 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 (underestimated), 1993 (overestimated), 1996 (underestimated), and 1997 (overestimated) were quite poor, they were also quite instructive in that each of these failures has led to important new insight and forecast model improvements. Figures 11 and 12 offer a comparison of our 1 August forecasts of named storms and hurricanes versus climatology and actual year-by -year variability.

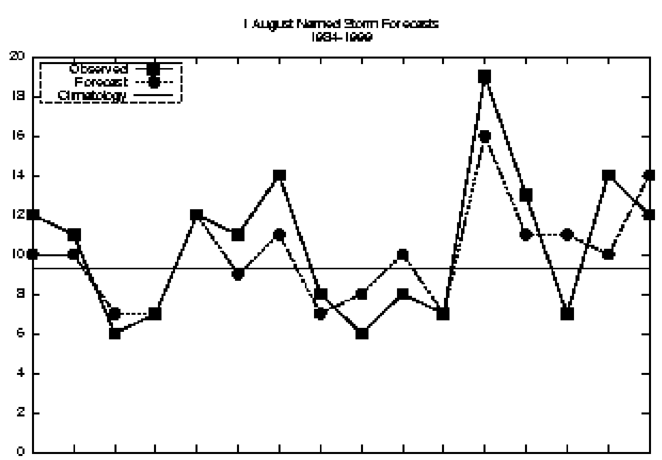

Figure 11: 1 August prediction of total named storms versus the number of actually observed versus long-term climatological mean for period 1984-1999. The correlation (r) is 0.81

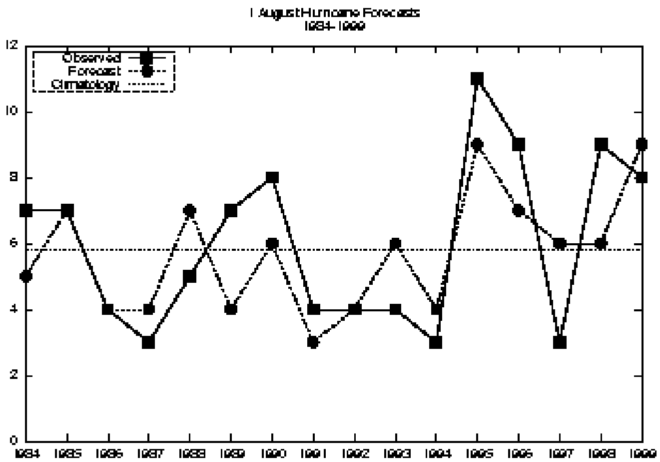

Figure 12: 1 August prediction of total hurricanes versus the number of actually observed versus climatological long-term mean. The correlation (r) is 0.64

Table 13: Summary verifications of the author's prior seasonal forecasts of Atlantic TC activity between 1984-1999.

	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

		Update	Update	Update	
1996	30 Nov 1995	4 April	7 June	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

		Update	Update	Update	
1997	30 Nov 1996	4 April	6 June	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

		Update	Update	Update	
1998	6 Dec 1997	7 April	5 June	6 August	Obs.
No. of Hurricanes	5	6	6	6	10
No. of Named Storms	9	10	10	10	14
No. of Hurricane Days	20	20	25	25	49
No. of Named Storm Days	40	50	50	50	80
Hurr. Destruction Potential(HDP)	50	65	70	75	145
Major Hurricanes (Cat. 3-4-5)	2	2	2	2	3
Major Hurr. Days	4	4	5	5	9.2
Net Trop. Cyclone Activity	90	95	100	110	173

		Update	Update	Update	
1999	5 Dec 1998	7 April	4 June	6 August	Obs.
No. of Hurricanes	9	9	9	9	8
No. of Named Storms	14	14	14	14	12
No. of Hurricane Days	40	40	40	40	43
No. of Named Storm Days	65	65	75	75	77
Hurr. Destruction Potential(HDP)	130	130	130	130	145
Major Hurricanes (Cat. 3-4-5)	4	4	4	4	5
Major Hurr. Days	10	10	10	10	15
Net Trop. Cyclone Activity	160	160	160	160	193