UPDATED FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY AND US LANDFALL STRIKE PROBABILITIES FOR 2001

Conditions affecting hurricane activity now indicate above average activity during 2001

This forecast is based on ongoing research by the authors along with meteorological information through May 2001

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[Both this and prior forecasts are available at the following World Wide Web address: http://tropical.atmos.colostate.edu/forecasts/index.html] — also you may contact:

David Weymiller and Thomas Milligan, Colorado State University media representatives who are available to answer various questions about this forecast (970-491-6432).

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7 June 2001

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2001 ATLANTIC BASIN SEASONAL HURRICANE FORECAST

Tropical Cyclone Seasonal	7 December 2000 Forecast for 2001	Updated 7 April 2001	Updated 7 June 2001
Named Storms (NS) (9.3)	9	10	12
Named Storm Days (NSD) (46.9)	45	50	60
Hurricanes (H)(5.8)	5	6	7
Hurricane Days (HD)(23.7)	20	25	30
Intense Hurricanes (IH) (2.2)	2	2	3
Intense Hurricane Days (IHD)(4.7)	4	4	5
Hurricane Destruction Potential (HDP) (70.6)	65	65	75
Maximum Potential Destruction (MPD) (61.7)	60	60	70
Net Tropical Cyclone Activity (NTC)(100%)	90	100	120

UPDATED PROBABILITY FORECAST OF LANDFALL BY ONE OR MORE MAJOR (CATEGORY 3-4-5) HURRICANE

1) Probability of landfall somewhere on the U.S. coastline – 69% (average for last century is 52%)

2) For the U.S. East Coast Including Peninsular Florida – 50% (average for last century is 31%)

3) For the Gulf Coast from the Florida Panhandle westward to Brownsville – 39% (average for last century is 30%)

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.

PDO - Pacific Decadal Oscillation

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 two 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 10-22°N, 10-50°W.

ZWA - Zonal Wind Anomaly - A measure of upper level (~ 200 mb) west to east wind strength. Positive anomaly values mean winds are stronger from the west or weaker from the east than normal.

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

ABSTRACT

Information obtained through May indicates that the 2001 Atlantic hurricane season will likely be above average though not so busy as the recent 1995, 1996, 1998, 1999 and 2000 hurricane seasons. However, the 2001 season should be considerably more active than the average for the hurricane seasons during the recently ended multi-decadal period of low activity from 1970 through 1994. Collectively, Atlantic basin Net Tropical Cyclone (NTC) activity during 2001 is expected to be about 20 percent above the average for hurricane seasons during the last 50 years. Predictive signals in the Atlantic basin including Sea Surface Temperature Anomalies (SSTAs) and surface pressure are quite favorable for above average activity. The only suppressing influences for this year's activity are the anticipated development of a weak El Niño this summer and an easterly stratospheric QBO. We estimate that the 2001 season will bring about 7 hurricanes (average is 5.7), 12 named storms (average is 9.3), 60 named storm days (average is 47), 30 hurricane days (average is 24), 3 intense (category 3-4-5) hurricanes (average is 2.2), 5 intense hurricane days (average is 4.7), a Hurricane Destruction Potential (HDP) value of 75 (average is 71) and overall NTC activity of 120 percent of the average year for the period between 1950–1990. U.S. landfall probability is forecast to be 10–20 percent above the long-term value owing to the effects of the anticipated continuation of a strong Atlantic Ocean thermohaline circulation and cool Pacific Decadal Oscillation (PDO) conditions.

1 Introduction

Our evolving forecast techniques are based on a variety of global and regional predictors previously shown to be related to forthcoming seasonal Atlantic tropical cyclone activity and landfall probability. This paper presents details of our observations, as well as the rationale for this 6-month (1 June to 30 November) extended range seasonal forecast for 2001. The forecast is based on both statistical analyses and on prior (analog) hurricane seasons with atmospheric and oceanic conditions analogous to those which we anticipate to be in place during the 2001 hurricane season.

Useful long-range predictive signals exist for seasonal tropical cyclone activity in the Atlantic basin. Our research has shown that a sizeable portion of the season-to-season variability of Atlantic tropical cyclone activity can be forecast with skill exceeding climatology by early December of the prior year. Qualitative adjustments are added to accommodate additional processes that are related to seasonal activity but which are not yet incorporated into our statistical models. The climate influences which will largely determine this year's Atlantic basin hurricane activity are:

1. The status of the El Niño-Southern Oscillation (ENSO),
2. The configuration of Atlantic Sea Surface Temperature Anomaly (SSTA) conditions which provide proxy signals for the strength of the Atlantic Ocean thermohaline circulation,
3. The phase of the stratospheric Quasi-Biennial Oscillation (QBO) of zonal winds at 30 mb and 50 mb which can be easily extrapolated 6 months into the future,
4. Two measures of West African rainfall during the prior year (see Figs. 1 and 2),
5. The East minus West gradient of the temperature and surface pressure over West Africa, and
6. The strength of the Azores High surface pressure anomaly during March through May of the current year and the configuration of the current and forecast future (late summer) broad scale Atlantic sea surface pressure and temperature anomaly patterns (see Fig. 2). A brief summary of these predictor indices and their specific current implications for the 2001 season follows.

See Table 2 for a listing of all of our potential predictors.

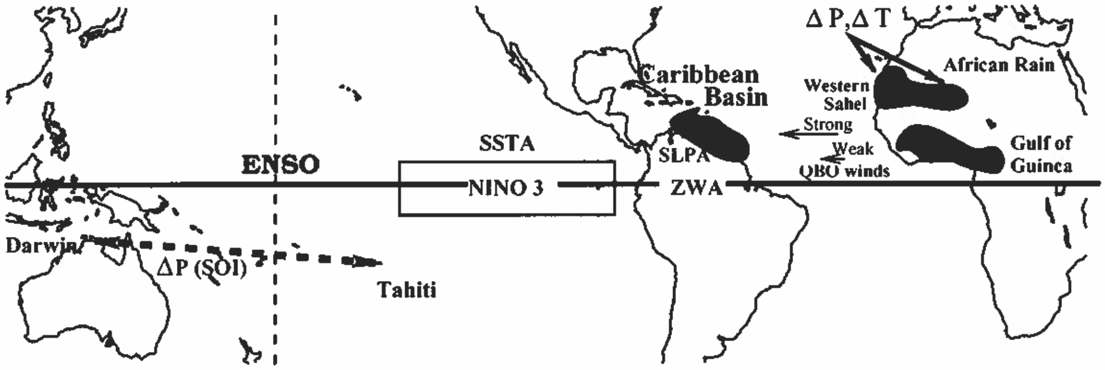

Figure 1: Meteorological parameters used in various prior versions of our early August (Gray et al. 1994a) seasonal forecast.

a) ENSO

ENSO is one of the principal global-scale environmental factors affecting Atlantic seasonal hurricane activity. Hurricane activity is usually suppressed during El Niño events (e.g., 1997 which was the strongest El Niño ever observed for the August to October period was quite suppressed). Conversely, activity tends to be enhanced during seasons with cold (or La Niña) water conditions, as occurred during 1995–1996 and 1998–2000. We expect that the

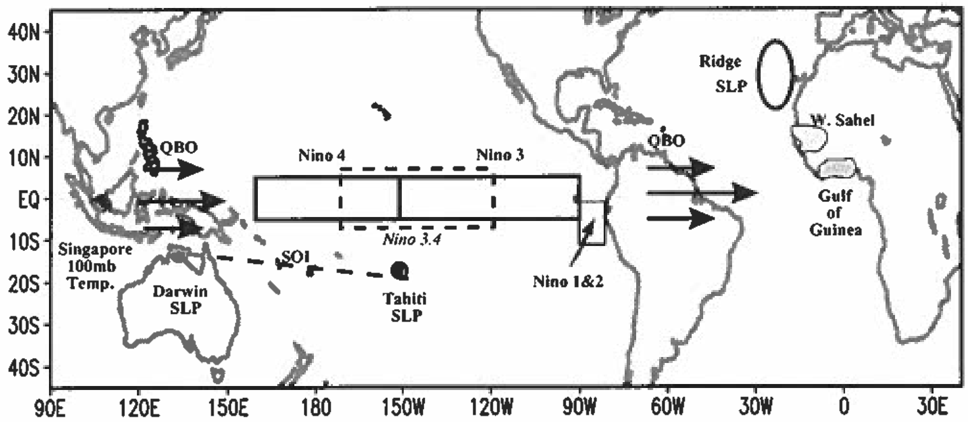

Figure 2: Additional parameters used or consulted in making the actual extended-range forecasts.

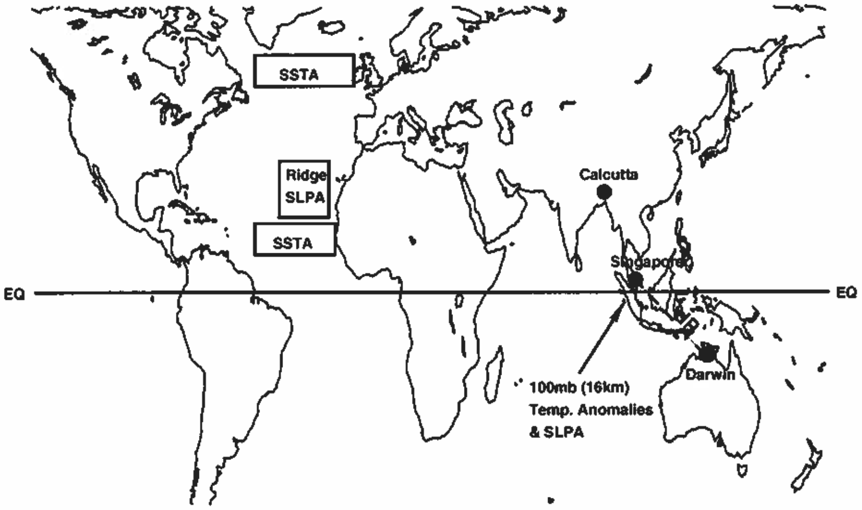

Figure 3: Additional (new) predictors which have recently been noted to be related to the upcoming Atlantic hurricane activity.

recent cool ENSO conditions are now being replaced by warming associated with a weak El Niño which will likely be in place during the 2001 hurricane season. This trend should exercise only a modest suppressing influence on 2001 hurricane activity and be nothing like the powerful suppressing force of the extremely intense El Niño event of 1997.

Warming of the sea surface in the tropical east Pacific Ocean during El Niño events decreases hurricane activity by enhancing deep cumulus convective activity in the East Pacific region. A portion of the increased upper-level wind outflow from this enhanced convection spreads through the tropical Atlantic where it eventually sinks and dries the upper troposphere while also strengthening upper-level ($\sim$ 200 mb) westerly winds. These effects inhibit the intensification of organized westward moving (African) disturbances by enhancing vertical shear in the intensification region. We expect that during 2001, the weak El Niño event we anticipate (particularly in combination with the easterly QBO at 50 mb, as described below) will be a modest constraining influence on Atlantic TC activity. As noted previously, we anticipate that any El Niño influences during 2001 will be typical of the generally more modest three weak El Niño events of the 1950s and 1960s (i.e., 1951-53-63) during which hurricane activity was not greatly suppressed.

ENSO Is Not the Only Consideration

Although ENSO conditions tend to be the single most important parameter dictating Atlantic seasonal hurricane variability, other properties of the atmosphere and ocean can be preeminent in some years. Table 1 shows cases of years wherein active hurricane seasons occurred during El Niño conditions. Note in the lower panel of Table 1, that despite NINO 3.4 SSTA conditions during August through September being, on average, nearly 2°C warmer during the two contrasting 5-season periods, NTC activity was 2.6 times greater during the warm years.

Thus, even if our projection of a weak El Niño event should occur later this summer-fall, this by itself is far from indicative of an inactive hurricane season.

b) 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, 40 to 50 percent more hurricane activity (depending on the specific activity index considered) occurs at low latitudes during those seasons when stratospheric QBO winds between 30 mb and 50 mb are anomalously westerly (hereafter, the "westerly QBO"). Conversely, seasonal hurricane activity is typically reduced during the easterly QBO phase and/or large vertical wind shear conditions exist between 30 and 50 mb. During 2001, we anticipate that the easterly QBO phase will be in place in

Table 1: Unusual years in which warm El Niño and cool La Niña (NINO 3.4) conditions occurred but with TC activity trends opposite to what is typically observed.

Cool (La Niña) Seasons With Below Average NTC Activity

Year	Aug-Oct NINO 3.4 SSTA (°C)	NS	H	NTC
1890	−1.00	1	1	13
1892	−1.07	9	4	78
1956	−0.61	8	4	69
1970	−1.01	10	5	64
1973	−1.56	7	4	51
Average	−1.05	7	3.6	55

Warm (El Niño) Seasons With Above Average NTC Activity

1896	1.22	6	6	141
1899	1.07	6	5	144
1951	0.60	10	8	120
1953	0.64	14	6	120
1969	0.68	17	12	155
Average	0.84	10.6	7.4	136

the lower stratosphere below 30 mb throughout the hurricane season. This should be only a modest inhibiting influence on this year's low latitude hurricane activity since there are many other positive influences.

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. Two such rainfall-linked signals include:

(1) June–September Western Sahel Rainfall. The Western Sahel area (see Fig. 2) experiences large year-to-year persistence of rainfall trends. 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 the first half of the 1990s) and suppressed hurricane activity. Since the rainfall in this region is positively related to Atlantic hurricane activity, year-to-year persistence alone tends to provide a moderate amount of skill for forecasting next season's African rainfall as well as the associated Atlantic hurricane activity. Last year's (2000) rainfall over the Western Sahel during June-September was −0.70 SD below average and thus is a negative factor for 2001 hurricane activity. The SSTA and SLPA patterns of this April-May and the progression of rain up the West African coast so far this year indicate that last year's below average rainfall in the western Sahel is likely

not representative of the TC activity likely to occur this year.

(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). Intense hurricane activity during seasons following the ten wettest August–November Gulf of Guinea years is many times greater than occurs during hurricane seasons following the ten driest August-November periods in the Gulf of Guinea. The 2000 August-November Gulf of Guinea rainfall was below average (–0.50 SD), implying a negative signal regarding next year's hurricane activity. However, since 1994 West Sahel rainfall has been generally higher than it was during the 1970 to 1993 period. It is also notable that the two rainfall relationships described here have not worked well during the active (1995–2000) hurricane seasons. Hence, we presently judge them to be of little relevance to the coming hurricane season's activity.

d) October–November 2000 and March 2001 Atlantic Subtropical Ridge (Azores High) Between 20-30°W

High surface pressure between 20-30°W associated with the Azores High is positively related to stronger east Atlantic trade winds which, in turn, enhance upwelling of cold water off the coast of northwest Africa. Colder sea surface temperatures created by this enhanced ocean upwelling are often associated with higher surface pressures during the following spring which can then create a self-enhancing (positive feedback) process ultimately resulting in higher Caribbean pressures during the subsequent summer (Knaff 1999). By this mechanism, positive ridge index values in the prior fall and during March are thus associated with an enhanced Azores high the following spring, stronger trade winds and thereby generally reduced hurricane activity. The long-term memory and feedback effects of this association make it a useful parameter for predicting next year's seasonal hurricane activity. Although ridge strength during October-November 2000 was high (+1.1 SD above the long-term mean), March 2001 ridge values were very low (–1.6 SD). These March ridge pressure values are more closely associated with TC trends than the October-November values. Hence, the very low March SLPA values and their persistence through recent months (April-May) is indicative of enhanced 2001 hurricane activity.

2 Prediction Methodology

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), 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 15 potential forecast parameters known to be related to tropical cyclone activity. The current set of potential predictors used to develop our early June forecast is shown in Table 2. The specific values of these parameters used for 2001 are shown in the right–hand column.

Table 2: Pool of predictive parameters and their estimated values for the early June 2001 prediction based on meteorological data through May 2001. See Figs. 1 to 3 for the locations of these predictors.

Predictive Parameter	
1 = QBO 50 mb 4-month extrapolation of zonal wind at 12°N to Sept. 2001	–22 ms^{-1}
2 = QBO 30 mb 4-month extrapolation of zonal wind at 12°N to Sept. 2001	–14 ms^{-1}
3 = QBO absolute value of shear between 50 and 30 mb at 12°N to Sept. 2001	+8 ms^{-1}
4 = Rgc AN Gulf of Guinea rainfall anomaly (Aug-Nov of 2000)	–0.50 SD
5 = Rws West Sahel rainfall anomaly (June-Sept 2000)	–0.70 SD
6 = Temp East-West Sahel temperature gradient(Feb-May 2001)	-0.50 SD
7 = SLPA April-May Caribbean basin sea level pressure anomaly	+0.8 mb
8 = ZWA April-May Caribbean basin zonal wind anomaly	+0.6 ms^{-1}
9 = R-ON: Azores surface pressure ridge strength in Oct-Nov 2000	+1.10 SD
10 = R-M: Mar Azores surface pressure ridge strength in Mar 2001	-1.60 SD
11 = SST3.4 Nino 3.4 SSTA in April-May 2001	0°C
12 = D-SST3.4: Nino 3.4 SSTA for April-May minus Feb-Mar 2001	+0.4°C
13 = TATL Tropical Atlantic SSTA anomaly (10-22°N,18-50°W) (Apr-May)	0°C
14 = NATL North Atlantic SSTA anomaly (50-60°N,10-50°W) (Apr-May)	+0.4°C
15 = SATL Mid Atlantic SSTA anomaly (5-18°S,50°W-10°E) (Apr-May)	+0.3°C

A number of statistical forecasts are made for each of several TC activity parameters. Table 3 lists the seasonal hurricane indices that we predict and the number and name of the forecast parameters we use for each forecast. Our hindcast skill (between 50-60 percent) for the 42-year period of 1950–1991 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.

We have also studied a scheme which uses various fixed (maximum) numbers of predictors. Table 3 lists these predictors. This procedure considers how hindcast variance (not neces-

Table 3: Listing of predictors chosen for each parameter that is forecast and the total hindcast variance explained by these predictors for the enclosed updated 1 June forecast.

Forecast Parameter	No. of Predictors	Predictors Chosen from Table 1	Variability Explained by Hindcast (1950-1991)	Likely Independent Forecast Skill
NS	3	1, 3, 9	.498	.322
NSD	6	3, 4, 5, 7, 9, 10	.562	.405
H	6	3, 4, 5, 7, 10, 11	.532	.361
HD	6	2, 4, 5, 6, 9, 14	.544	.379
IH	5	1, 4, 6, 9, 10	.557	.402
IHD	3	4, 6, 11	.443	.230
HDP	5	1, 4, 5, 6, 10	.532	.366
NTC	5	1, 4, 5, 6, 10	.554	.398
MPD	4	3, 4, 9, 14	.591	.453

sarily true skill) increases as the number of predictors increases from 4 to 6 to 8. Although independent forecast skill (i.e., "true skill") typically degrades in approximate proportion to the increased number of predictors, it is of interest to assess the degree of hindcast improvement which occurs with added predictors. Individual year forecast skill degradation from application of hindcast statistics can never be accurately specified. Consequently, as the latter are purely random effects, the hazards of overfitting become obvious. Additional forecast parameters representing conditions in the Atlantic and Pacific Ocean basins and in the Asia-Australia regions (refer to Figs. 1-3) are also consulted for further qualitative inter-relations and possible influences on our final "adjusted" forecast.

Probability dictates that, on average, a net degradation of this hindcast skill of between 10-20 percent of total variability will likely occur. The amount of degradation (if any) for an individual year forecast is a random process. In some years, when conditions include strong trends that are similar to past years, forecasts will do quite well, perhaps better than the skill of the hindcast scheme. In other years, a given forecast can perform quite poorly. This is because our 42-year (1950-1991) predictor database likely does not contain realizations expressing the full range of independent possibilities. Our 1997 forecast is a good example. No year in our 1950 through 1991 developmental data sets had experienced an El Niño event nearly as intense (by a factor of 2) of any other on record.

In Table 4, columns 1-3 lists each of our statistical forecasts, column 4 contains our best qualitatively adjusted "final" forecasts and column 5 provides the climatological mean for each parameter for 1950-1990. Note in column 4 that we have made a large upward adjustment to our statistical forecasts to reflect the expectation of a more active hurricane season.

Table 4: 1 June statistical forecasts which have a variable number of predictors with variable predictors (column 1) along with 4, 6 and 8 fixed predictors forecast (columns 2, 3). Column 4 is our final adjusted early June forecast of 2000 hurricane activity. Column 5 gives climatology.

Full Forecast Parameter	(1) Variable Predictor	(2) Fixed predictors 4 Predictors	(3) 6 Predictors	(4) Adjusted Actual Fcst	(5) 1950-1990 Climatology
Named Storms (NS)	5.2	4.8	4.8	12	9.3
Named Storm Days (NSD)	31.6	43.1	31.6	60	46.9
Hurricanes (H)	3.4	5.8	3.4	7	5.8
Hurricane Days (HD)	19.0	28.0	19.0	30	23.7
Intense Hurricanes (IH)	2.0	2.2	1.8	3	2.2
Intense Hurricane Days (IHD)	4.8	5.0	5.5	5	4.7
Hurricane Destruction Potential (HDP)	32.3	39.6	39.5	75	70.6
Maximum Potential Destruction (MPD)	49.6	49.6	47.0	70	61.7
Net Tropical Cyclone Activity (NTC)	46.7%	113%	93.8%	120%	100%

Three other strong predictors that have not yet been quantitatively incorporated into our 1 June statistical forecast scheme and which indicate 2001 seasonal activity above that indicated by our current statistical schemes include the following:

1. June through September prediction of Caribbean basin Sea Level Pressure Anomaly (SLPA). This has recently been developed by J. Knaff (1998). Lower SLPA forecasts indicate enhanced hurricane activity, while higher SLPA indicates a reduction. August-September SLPA has a very strong association with seasonal hurricane activity. Knaff's 1 April 2001 forecast of June through September SLPA gave a value of -0.79 mb. This adds additional evidence for an active 2001 hurricane season. Table 5 provides details of these Caribbean-West Atlantic SLPA forecasts which are based on anomaly information concerning the March Atlantic subtropical ridge, January through March SSTs in the North Atlantic (50-60°N, 10-50°W) and January through March Niño 3.4 (5°N–5°S, 120°W–170°W) SST anomalies. Using this combination of factors in separate regression equations leads to a forecast of reduced Caribbean-western tropical Atlantic SLPA for the months of August-September, and June through September, respectively. Hindcasts of this predictive signal since 1903 show good skill and a significant association with variations of seasonal hurricane activity. Knaff finds that additional April-May predictors does not improve on this forecast.

2. A realization that both Atlantic and now, global climate have shifted to a new mode favorable to increased Atlantic major hurricane activity, as experienced from the 1930s through the mid-1960s is believed to have occurred. This recent climate shift took

place in the Atlantic in 1995 and appears to have now (2001) extended over most of the globe.

3. New information on the configuration of mid-latitude and tropical East Pacific SSTAs shows cold values. This is indicative of a negative PDO and enhanced hurricane activity. These SSTAs have not yet been incorporated into our statistical forecast model.

Table 5: April 1, 2001 multi-month independent statistical prediction of Caribbean basin and Western tropical Atlantic Sea Level Pressure Anomaly (SLPA) for this summer (Knaff 1998). Separate regression analyses are made for each monthly category. SLPA predictions are given in terms of mb.

	June-July	August-September	June through September
SLPA	−0.35	−0.66	−0.79

These three factors, in conjunction with additional qualitative information, suggest that our statistical forecast is underestimating the amount of hurricane activity likely to occur this season, and we have chosen to make an upward adjustment in our forecast to values more in line with what our analog (discussed next) analysis indicates. Consequently, data through the end of May indicate that 2001 will experience above average hurricane activity and notably more than the average for seasons between 1970–1994 when major hurricane activity was greatly suppressed.

3 Anticipated Weak El Niño Conditions During August-October 2001

We anticipate that only a weak El Niño event will develop in the tropical Pacific this coming summer. Table 6 shows changes in Pacific equatorial SSTA conditions during the last three months. We do not expect this warming trend to become an El Niño of sufficient strength to cause a significant reduction in this season's hurricane activity.

4 Analog-Based Estimates of Hurricane Activity During 2001

Certain years in the historical record have global oceanic and atmospheric trends which are notably analogous to those we expect to see during the 2000/2001 hurricane seasons. These analog years provide useful clues as to likely trends that the forthcoming 2001 hurricane season may bring. For this (1 June) extended range forecast, we project atmospheric and oceanic conditions foreward to the coming August through October 2001 period and assess

Table 6: SSTA in (°C) in the equatorial central and east Pacific during the last three-months. See Figure 2 for the locations of the Nino domains.

Month (2001)	Nino 4	Nino 3.4	Nino 3	Nino 1-2
January	–0.6	–0.7	–0.5	–0.5
February	–0.8	–0.5	–0.2	0.1
March	–0.5	–0.3	0.3	1.3
April	–0.2	0.0	0.3	1.3
May	0.0	0.0	0.1	–0.1
Warming March to May	0.5	0.3	–0.2	–1.4

which prior years in our database have similar environmental conditions and then consider the trends in hurricane activity during those years. In the record since 1949, we find five years wherein April-May conditions appear notably similar to April-May conditions of this year. The important conditions and their projection through the 2001 hurricane season are:

- Persistent North Atlantic (50-60°N, 10-50°W) warm SST anomalies during the prior 6 years are expected to remain warm through the 2001 season. This assumes that a persistent strong decadal thermohaline circulation in the Atlantic this year.
- The current general conditions of the North Atlantic Oscillation (NAO), and Pacific Decadal Oscillation (PDO) will also persist in their present mode through fall 2001 (i.e., in a global atmosphere and ocean circulation regime typical of the 1940s and 1950s).
- QBO 50 mb winds in September 2001 will be from an easterly direction.
- Negative March East Atlantic subtropical SLPA ridge conditions will persist through summer-early autumn 2001; a strong enhancing factor for tropical storm activity.

The analog years that have the best resemblence to 2001 appear to be 1951, 1952, 1960, 1963, and 1996. None of these five 2001 analogs seasons had strongly suppressed hurricane activity (see Table 8). Based on the values in Table 7, we expect the 2001 season to have tropical cyclone activity which is about the average that occurred during these five analogs. This analog technique is a reliable forecast technique for adjusting the generally lower levels of activity predicted by our statistical schemes as discussed previously. Thus, based on this analysis we expect that 2001 to be an above average hurricane year and distinctly more active than the average hurricane seasons during the inactive 1970–1994 period.

Table 7: Best analog years for 2001 with the associated tropical cyclone activity listed for each year.

	NS	NSD	H	HD	IH	IHD	HDP	NTC
1951	10	58	8	36	2	5.00	113	120
1952	7	40	6	23	3	4.00	70	97
1960	7	30	4	18	2	11.00	80	72
1963	9	52	7	37	2	5.50	103	115
1996	13	78	9	45	6	6	135	204
Mean	9.2	52	6.8	32	3.0	6.3	98	122
2001 Forecast	11	60	7	30	3	5	75	120

5 Upward Adjustment of 7 June 2001 Forecast

We have chosen to make an upward adjustment of our 7 April 2001 forecast because we believe that (1) the current incipient El Niño event will not be as strong as we anticipated in early April. We now forsee only a weak event. (2) Regional Atlantic arrangements of SSTA and forecast SLPA are more favorable for cyclone activity in May than they were in March. (3) The Azores High remained very low through May with its consequent weakening of the trade winds and the North Atlantic Oscillation (NAO) remains negative. This favors more hurricane activity. (4) The February through May East-West gradients of surface temperature and surface pressure across the western Sahel are now verified to be favorable for above average hurricane activity. (5) Conditions in early June appear more favorable for western Sahel rainfall.

6 Major Reconfiguration of Atlantic Basin SSTs and Long Term Trends in Hurricane Activity

For years we have been suggesting that the recent (1970–1994) era of reduced Atlantic intense (category 3-4-5) hurricane activity was likely ending and that Atlantic coastal residents should expect an eventual long-term increase of landfalling major hurricanes (eg., Gray 1990, Gray et al. 1996). 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.

Recent observations indicate increased salinity in upper layers of the North Atlantic. Greater salinity increases the density of these surface layers which are then able to more readily sink to greater depths, thereby increasing the compensating northward flow of warm (and salty) replacement water at upper ocean levels. The resulting net enhanced northward transport of upper-layer warm water into the high North Atlantic (and compensating equatorward transport of deep cold water) is the principal manifestation of the Atlantic Ocean thermohaline conveyor circulation. A strong conveyor circulation transports greater quantities of heat to high latitudes. Hence, slowly rising salinity values in the far North Atlantic during recent years indicate the development of a stronger thermohaline circulation and a warmer North Atlantic. The effects of a stronger thermohaline circulation have been evident in the region since the spring of 1995 where, as noted before, the best proxy for this increased circulation has been warm North Atlantic SST anomalies.

Despite El Niño-linked reductions of hurricane activity during 1997, the last six years (1995–2000) have together been the most active six consecutive year period on record. This includes the total number of named storms (79), hurricanes (49), major hurricanes (category 3-4-5) (23), major hurricane days (56.25) and Net Tropical Cyclone Activity (NTC, 976) which occurred during the last six years. Despite the weak 1997 hurricane season, the annual average of NS, H, HD, IH, IHD and NTC during the last six years are 146, 163, 239, 329, 331 and 214 percent (respectively) of the average hurricane activity for the six-year period of 1989–1994. The annual average NS, H, IH, IHD and NTC values during the last six years are 153, 165, 247, 250, 373 and 217 percent respectively of the average for the previous 25-year period (1970-1994). The largest increases have come with IH and IHD activity. See our 21 November 2000 verification of our 2000 forecast (available on the Web) for more documentation and discussion on this topic.

The general warming of the North Atlantic that has taken place during the last six years is in concurrence with increased incidence of major hurricanes, an association similar to what occurred during the most active hurricane seasons of the 1930s to the 1960s. This trend manifests itself primarily in the form of more hurricanes forming at low latitudes, more intense hurricanes, and more major hurricanes landfalling along the US East Coast, Florida, and the Caribbean region. The Gulf Coast is less effected by these changes. We expect that this trend will continue for several decades.

7 Landfall Probabilities for 2001

A significant focus of our recent research involves efforts to develop forecasts of the probability of hurricane landfall along the U.S. coastline. Whereas individual hurricane landfall events cannot be accurately forecast months in advance, the total seasonal probability of landfall can be forecast with statistical skill. With the observation that, statistically, landfall is a function of varying climate conditions, a probability specification has been developed through statistical analyses of all U.S. hurricane and named storm landfall events 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 linked to the overall Atlantic basin Net Tropical Cyclone activity (NTC; see explanation in caption of Table 8) 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*, 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, especially for major hurricanes. Atlantic basin NTC can be skillfully predicted and the strength of the Atlantic Ocean thermohaline circulation can be inferred as SSTA* from North Atlantic SST anomalies from prior years. These relationships are then utilized to make probability estimates for U.S. landfall. The current (May 2001) value of SSTA* is 57. Hence, in combination with a new prediction of NTC of 120 for 2001, a combination of NTC + SSTA* of (120 + 57) yields a value of 177.

As shown in Table 8, NTC is a combined measure of the year-to-year mean of six indices of hurricane activity, each expressed as a percentage difference from the long-term average. Whereas many active Atlantic hurricane seasons feature no landfalling hurricanes, some 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 (1) highest NTC and (2) when above average North Atlantic SSTA* conditions are in place. The 33 years with the combined highest NTC and strongest thermohaline circulation (during the last 100) had 24 category 3-4-5 hurricane strikes along the Florida and East Coast whereas the 33 years with the lowest NTC/weakest thermohaline circulation saw only three such intense hurricane landfall events; a difference of 8 to 1.

Table 8: NTC activity in any year consists of the seasonal total 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 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, divided by six, yielding 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

Tables 9 and 10 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, the U.S. East coast and (NTC only) for the Gulf Coast. Landfall characteristics for the Gulf Coast (Fig. 4) (or regions 1-4) from north of Tampa, FL westwards to Brownsville, TX (36 total category 3-4-5 hurricane landfalls of this century) are different from 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. 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 are shown (Fig. 4).

Table 9: Number of Florida Peninsula and U.S. East Coast (regions 5 through 11) hurricane landfall events by intensity class occurring in the 33 highest versus the 33 lowest values of NTC plus Atlantic thermohaline circulation (SSTA) during 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 10: 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

Figure 5 gives a flow diagram outlining the procedures by which these landfall forecasts are made. 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 the Florida Peninsula and East Coast (regions 5-11). Table 11 lists strike probabilities for different TC categories for the whole U.S. coastline, the Gulf Coast and Florida, and the East Coast for 2001. The mean annual probability of one or more landfalling systems is given in parentheses. Note that although Atlantic basin NTC activity in 2001 is expected to be slightly greater than the long term average (120), U.S. hurricane landfall probability is expected to be above average owing to North Atlantic SSTAs being above average in recent years (Fig. 5). During periods of positive North Atlantic SSTA, a higher

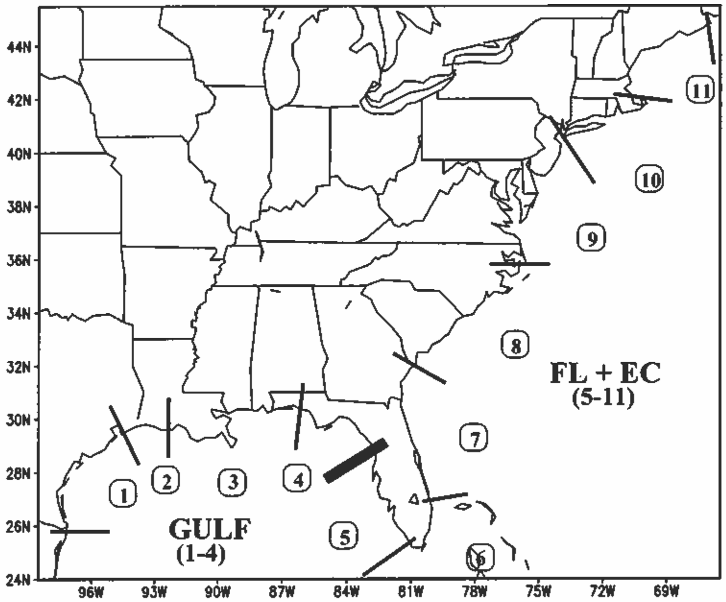

Figure 4: Location of the 11 coastal regions for which separate hurricane landfall probability estimates are made. The heavy bar delineates the boundary between the Gulf (regions 1-4) and the Florida Peninsula and East Coast (regions 5-11).

percentage of Atlantic basin major hurricanes cross the U.S. coastline for a given level of NTC.

Table 11: Estimated probability (expressed in percent) of one or more U.S. landfalling tropical storms (TS), category 1-2 hurricanes (HUR), 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 2001. The long-term mean annual probability 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)	86% (80)	79% (68)	69% (52)	94% (84)	98% (97)
Gulf Coast (Regions 1-4)	67% (59)	52% (42)	39% (30)	71% (61)	90% (83)
Florida plus East Coast (5-11)	57% (51)	58% (45)	50% (31)	78% (62)	91% (81)

8 Unusual Decrease in U.S. Major Hurricane Landfall During the Last Four Decades

Official records indicate that over the last century (1900–2000), 218 major hurricanes developed in the Atlantic basin and of these category 3-4-5 storms, about one-third (73) came ashore along the U.S. coastline. During the last six years (1995–2000), 23 major hurricanes

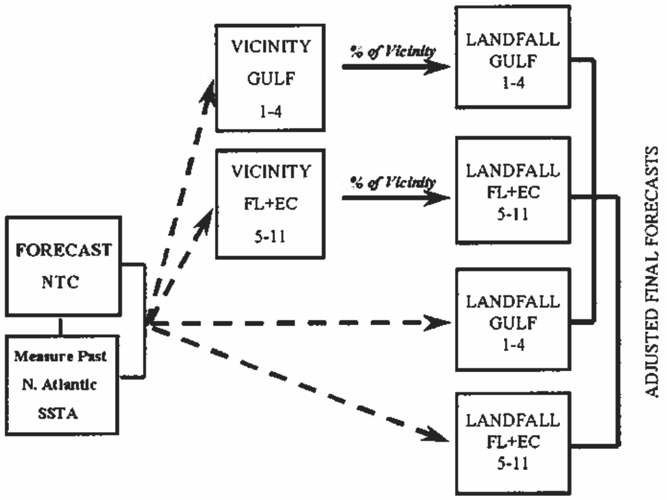

Figure 5: Flow diagram illustrating how forecasts of U.S. hurricane landfall probabilities are made. Forecast NTC values and an observed measure of recent North Atlantic (50-60°N, 10-50°W) SSTA* are used to develop regression equations from U.S. hurricane landfall measurements of the last 100 years. Separate equations are derived for the Gulf and for Florida and the East Coast (FL+EC).

developed in the Atlantic basin but only three (Opal, 1995; Fran, 1996; and Bret, 1999) came ashore. If the typical long-term one-of-three landfalling-to-total events ratio of major hurricanes observed during the last six years had occurred, then we should have experienced 7-8 major hurricane landfall events versus the three that actually came ashore.

We owe our good fortune to a persistent upper-air trough which has been located along the U.S. East Coast during a high percentage of the time during the last six hurricane seasons. This fortuitous trend has caused a large portion of otherwise northwest moving major hurricanes to be recurved to the north before they reached the U.S. coastline. But our good luck cannot be expected to continue forever. Very few residents of the southeastern U.S. coastline are likely aware of how fortunate they have been over the last 3-4 decades.

Given the U.S. major hurricane landfall numbers during the last century, our luck at beating the long term climatological odds has now persisted for about four decades. As for example, during the 30-year period of 1971–2000, the U.S. experienced 15 major landfall events, or 0.50 per year. This rate of incidence is only 62 percent of the annual incidence of major hurricane landfall events which occurred during the previous 72 years, 1900–1971.

Regarding the Florida Peninsula and U.S. East Coast, the situation is even more skewed. In the last 40 years (1961–2000), only six major hurricanes (average 0.15 per year) made landfall on the Florida Peninsula and U.S. East Coast. Between 1900–1960, 31 major landfall events occurred along this same coastline (or 0.51 per year). Thus, the first six decades of the

20th century had 3.4 times the annual average incidence of major hurricane landfall events that occurred during the last four decades. It is highly likely that climatology will eventually right itself, and we must therefore expect a great increase in landfalling major hurricanes in the coming decades. With exploding coastal populations in the southeast U.S., we must also prepare for levels of hurricane damage never before experienced.

9 Forecast Theory and Cautionary Note

Our forecasts are based on the premise that those global environmental conditions which preceed comparatively active or inactive hurricane seasons in the past provide meaningful information about likely similar trends in future seasons as well. Nevertheless, 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 these storms will strike. Landfall probability estimates for 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 probability does not insure that a hurricane will not come ashore. Regardless of how active the 2001 hurricane season is, a finite probability always exists that one or more hurricanes may strike along the US or Caribbean Basin coastline and do much damage.

10 The 1995–2000 Upswing in Atlantic Hurricanes and Global Warming

Some may interpret the recent large upswing in Atlantic hurricane activity (since 1995) as being in some way related to increased man-made greenhouse gases such as carbon dioxide (CO_2). There is no scientifically reasonable way that such an interpretation of this recent upward shift can be made. Anthropogenic greenhouse gas warming, even if a physically valid hypothesis, is a very slow and gradual process that, at best, might be expected to bring about small changes in global circulation over periods of 50 to 100 years and could not cause the abrupt and dramatic upturn in hurricane activity as occurred between 1994 and 1995. Also, the large downturn in Atlantic basin major hurricane activity between 1970–1994 would need to be reconciled with proposed global warming scenarios during this period. Atlantic intense (or category 3-4-5) hurricane activity showed a 40 percent decrease during 1970–1994 versus that which occurred during the 1950–1969 or the 1995–2000 periods. There were 78 Atlantic basin major hurricanes in the 26 years of 1950–1969, 1995–2000 versus 38 in the 25 years of 1970–1994. This is an annual ratio difference of two to one. Even if human–induced greenhouse gas increases were shown to be causing global temperature increases over the last 25 years, there is no way to relate such a small global temperature increase to more hurricane activity.

In contrast with the large increase in Atlantic basin major hurricane activity during the last five years, total hurricane and typhoon activity in the (East and West) North Pacific region during the 1995–2000 period has decreased. When we combine total Atlantic and North Pacific tropical cyclone activity we observe a net downward trend for the recent 1995–2000 period (Table 12). Hence, we should not interpret the recent enhancement of major hurricanes in the Atlantic as indicative of the changes of hurricane activity around the globe. It is only in the Atlantic where hurricane activity has shown a sharp rise, and this rise is in conformity with the changes in Atlantic sea surface temperature patterns and the diagnosed increase in the thermohaline circulation. Such up and down multi-decadal changes in Atlantic sea surface temperature and tropical cyclone activity have been observed to take place many times in the past and are considered to be naturally occurring modes of multi-decadal variability.

Table 12: Comparison of North Pacific and Atlantic tropical cyclone activity during 1989–1994 versus 1995–2000.

(1989–1994)	No. of Systems $\geq$ TS Intensity	No. of Systems $\geq$ HUR. Intensity	No. of Major Hurricane
North Pacific (East and West)	301	230	100
Atlantic	54	30	7
Total	355	250	107
(1995–2000)			
North Pacific (East and West)	252	183	73
Atlantic	79	49	23
Total	331	232	96
Ratio of Total North Pacific + Atlantic 1995–2000/1989–1994	0.93	0.93	0.90

11 Schedule for 2001 Forecast Updates

This 7 June 2001 forecast will be updated on Tuesday 7 August. This is a change from our earlier 3 August release schedule to allow more time to obtain and analyze July data.

Most hurricane activity, particularly major hurricane activity, occurs after mid-August. The 7 August prediction package will also include a separate forecast of August-only hurricane activity. We find that this separate August forecast helps us with our overall seasonal prediction. These updates also allow us to make adjustments as newer information becomes available. A verification of this forecast will be issued in late November 2001 and a seasonal forecast for the 2002 hurricane season will be issued in early December 2001.

12 Acknowledgements

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. John Knaff, John Sheaffer and Todd Kimberlain have made many important contributions to the conceptual and scientific background for these forecasts. We are particularly grateful to Arthur Douglas, Richard Larsen, 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 in-depth discussions with most of the current NHC hurricane forecasters. These include Lixion Avila, Miles Lawrence, Richard Pasch, Jack Beven, James Franklin, and Stacy Stewart. The first author would further like to acknowledge the encouragement he has received for this type of forecasting research application over the last two decades from Neil Frank, Robert Sheets, Robert Burpee, Jerry Jarrell, former directors of the National Hurricane Center (NHC), and from the current director, Max Mayfield. We also thank Bill Bailey of the Insurance Information Institute, Inc. for his sage advice and encouragement.

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 generous contributions to the first author's project. It is the latter support which allows our seasonal predictions to continue.

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APPENDIX A: Verification of Past Seasonal Forecasts

The first author has now issued seasonal hurricane forecasts for 17 consecutive years (1984–2000). In the majority of these forecasts, the predictions were superior to climatology (i.e., long-term averages), particularly for named storms. Figures 6 and 7 offer comparisons of our 1 August forecasts of named storms and hurricanes versus climatology and actual year-to-year variability. Overall, there is predictive skill greater than climatology.

We have issued forecasts for intense or major (category 3-4-5) hurricanes since 1990. The 1 August forecast correlation for these 11 years has been r = .73.

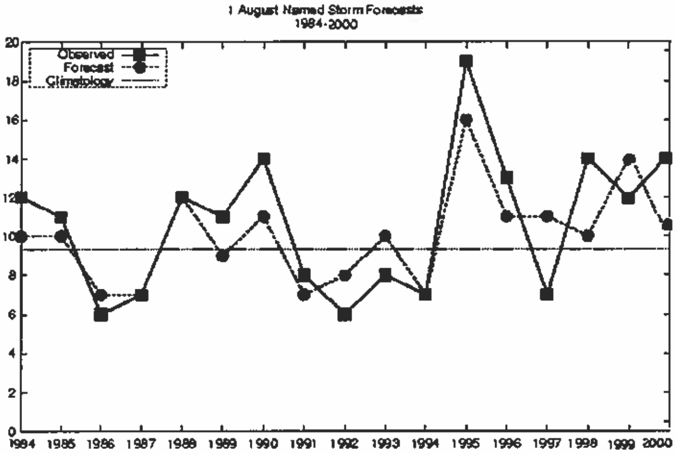

Figure 6: 1 August prediction of total named storms versus the number of actually observed versus long-term climatological mean (r = 0.80) for period 1984–2000.

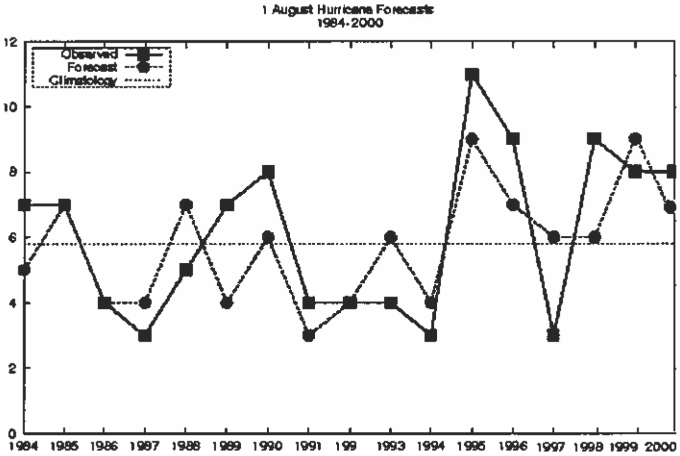

Figure 7: 1 August prediction of total hurricanes versus the number of actually observed versus climatological long-term mean (r = 0.64) for period 1984–2000.

Table 13: Summary verifications of the author's prior seasonal forecasts of Atlantic TC activity between 1984-2000.

	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 4 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

1998	6 Dec 1997	Update 7 April	Update 5 June	Update 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

1999	5 Dec 1998	Update 7 April	Update 4 June	Update 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

2000	8 Dec 1999	Update 7 April	Update 7 June	Update 4 August	Obs.
No. of Hurricanes	7	7	8	7	8
No. of Named Storms	11	11	12	11	14
No. of Hurricane Days	25	25	35	30	32
No. of Named Storm Days	65	65	75	75	77
Hurr. Destruction Potential(HDP)	85	85	100	90	85
Major Hurricanes (Cat. 3-4-5)	3	3	4	3	3
Major Hurr. Days	6	6	8	6	5.25
Net Trop. Cyclone Activity	125	125	160	130	134