EXTENDED RANGE FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY AND US LANDFALL STRIKE PROBABILITY FOR 2002

A continuation of the recent seven year upturn in Atlantic basin hurricane activity is expected. We anticipate significantly above average hurricane activity and U.S. hurricane landfall probability.

(as of 7 December 2001)

This forecast is based on new research by the authors,
along with current meteorological information through November 2001

By

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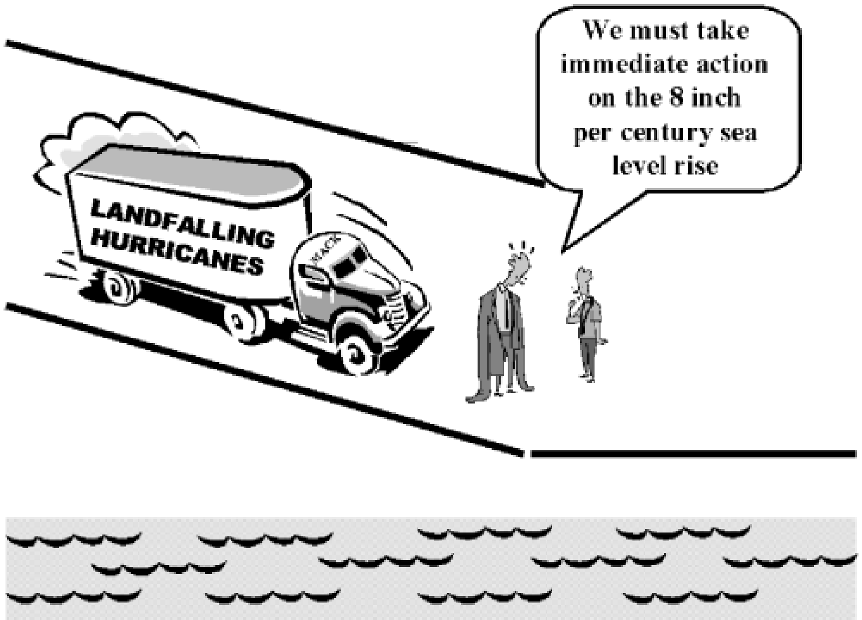

REVISED SUMMARY OF THE 2001 SEASON AND FORECAST VERIFICATION

Our 20 November 2001 seasonal verification requires updating due to the unusual late November formation of Hurricane Olga on the 26th of November after our seasonal verification had been released. The following revised table includes Olga in the verification records.

Tropical Cyclone Seasonal Parameters (1950-90 Ave.)	Sequence of Forecast Updates				
	7 Dec 00 Forecast	6 Apr 01 Forecast	7 Jun 01 Forecast	7 Aug 01 Forecast	Observed* 2001 Totals
Named Storms (NS) (9.3)	9	10	12	12	15
Named Storm Days (NSD) (46.9)	45	50	60	60	63
Hurricanes (H)(5.8)	5	6	7	7	9
Hurricane Days (HD)(23.7)	20	25	30	30	27
Intense Hurricanes (IH) (2.2)	2	2	3	3	4
Intense Hurricane Days (IHD)(4.7)	4	4	5	5	5
Hurricane Destruction Potential (HDP) (70.6)	65	65	75	75	71
Maximum Potential Destruction (MPD) (61.7)	60	60	70	70	87
Net Tropical Cyclone Activity (NTC)(100%)	90	100	120	120	142

*A few of the numbers may change slightly in the National Hurricane Center's final tabulation

New TC activity records set during the 2001 hurricane season revised to include Hurricane Olga.

1. First season with nine hurricanes forming after 8 September.

2. First season with three hurricanes in November and highest November NTC of all time.
3. First time occurrence that there have been 19 consecutive Atlantic basin hurricanes (extending back to Irene of 1999) without a U.S. hurricane landfall. The statistical probability of this is less than one-tenth of one percent.

ATLANTIC BASIN SEASONAL HURRICANE FORECAST FOR 2002

Forecast Parameter and 1950-2000* **Climatology (in parenthesis)**	7 December 2001 Forecast for 2002
Named Storms (NS) (9.6)	13
Named Storm Days (NSD) (49.1)	70
Hurricanes (H)(5.9)	8
Hurricane Days (HD)(24.5)	35
Intense Hurricanes (IH) (2.3)	4
Intense Hurricane Days (IHD)(5.0)	7
Hurricane Destruction Potential (HDP) (72.7)	90
Net Tropical Cyclone Activity (NTC)(100%)	140

*Note we have updated the climatology from 1950-1990 to 1950-2000.
A comparison of the averages are shown in Table 19
This update has slightly decreased the historical NTC values.

PROBABILITITES FOR AT LEAST ONE MAJOR (CATEGORY 3-4-5) HURRICANE LANDFALL ON EACH OF THE FOLLOWING COASTAL AREAS:

1) Entire U.S. coastline - 86% (average for last century is 52%)

2) U.S. East Coast Including Peninsula Florida - 58% (average for last century is 31%)

3) Gulf Coast from the Florida Panhandle westward to Brownsville - 43% (average for last century is 30%)

4) Expected above-average major hurricane landfall risk in the Caribbean.

DEFINITIONS

ABSTRACT

Collectively, Atlantic basin Net Tropical Cyclone (NTC) activity in 2002 is expected to be about 140 percent of the long-term average. This forecast is based on a new, 6-11 month extended range statistical forecast procedure developed recently using 51 years of data. Both statistical and analog predictors have been utilized including selective measures of September-November North Atlantic and Pacific 500 mb/surface pressure fields, a foreward extrapolation of the stratospheric QBO and an estimate of El Niño conditions for next year. Information obtained through November 2001 indicates that the 2002 Atlantic hurricane season will likely be about as busy as the average of the last seven hurricane seasons and much more active than the recent multi-decadal period of low activity (1970-1994). We estimate that 2002 will see 8 hurricanes (average is 5.9), 13 named storms (average is 9.6), 70 named storm days (average is 49), 35 hurricane days (average is 24.5), 4 intense (category 3-4-5) hurricanes (average is 2.3), 7 intense hurricane days (average is 5.0) and a Hurricane Destruction Potential (HDP) of 90 (average is 71). U.S. major hurricane landfall probability is forecast to be 30 percent above the long period average owing to the effects of an ongoing strong Atlantic Ocean thermohaline circulations, a westerly QBO and only weak ENSO warming during August-October 2002.

1 Introduction

Our research has shown that a sizeable portion of the year-to-year variability of Atlantic tropical cyclone (TC) activity can be hindcast with skill greatly exceeding climatology. Qualitative adjustments are added to predictions from our statistical hindcast scheme to accommodate additional processes which are not explicitly accommodated by our statistical model. Our evolving forecast techniques are based on a variety of climate related global and regional predictors previously shown to be related to forthcoming seasonal Atlantic tropical cyclone activity and landfall probability. Hence, the forecast is based on both statistical and analog analyses of prior hurricane seasons with atmospheric and oceanic conditions similar to what is currently observed and what we anticipate to be in place during the 2002 hurricane season. This paper presents the details of our observations as well as the rationale for this 6 to 11-month (December to June-November) extended range seasonal forecast for 2002.

2 December Forecast Problems

We believe that seasonal forecasts must be based on methods showing significant hindcast skill in applications of the proposed scheme over decades of prior data. Hindcast skill demonstrates that future forecast skill is likely provided the atmosphere continues to behave in the future as it has in the recent past. Our initial 6-11 month early December seasonal hurricane forecast scheme (Gray et al. 1992) for June-November activity in the following year demonstrated hindcast skill for the period of 1950-1990. The parameters responsible for these skillful early December hindcasts included two measures of the nine -month extrapolated Quasi-biennial Oscillation (QBO) winds at 30 and 50 mb and two measures of prior season West African rainfall. These measures of West African rainfall were composed of: 1) a 38-station August-September western Sahel collection of standardized rainfall measurements and 2) a similar standardized rainfall dataset for August to November within a 22-station region in the Gulf of Guinea (Fig. 1).

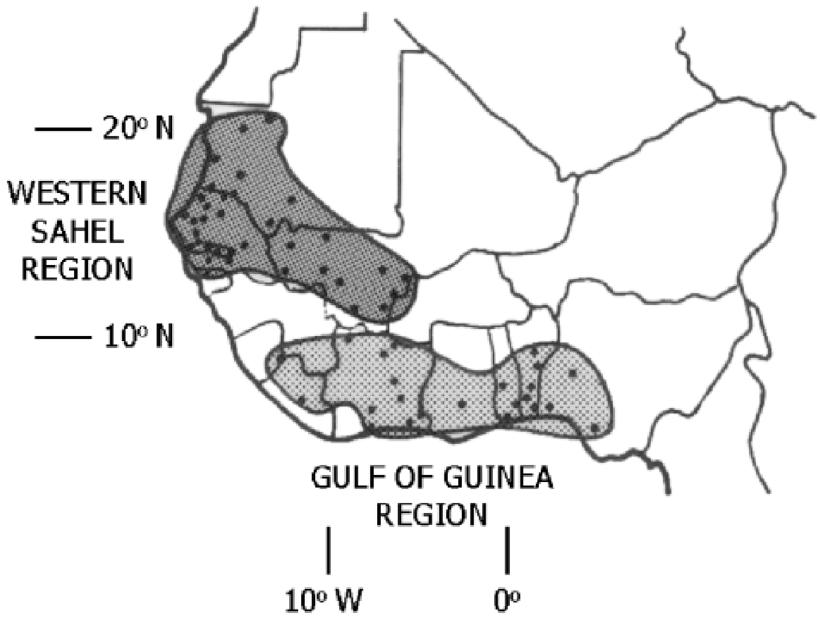

Figure 1: African rainfall predictor regions.

In this prior study (Gray et al. 1992) it was found that we could hindcast up to 45-50 percent of the following year's variance of Atlantic basin hurricane activity. This result had implications for improved understanding and extended range forecasting of global climate. It implied that the earth's climate system had substantial multi-season predictability out 6-11 months into the future. Our first extended range forecast issued on 26 November 1991 for the 1992 season was successful; four hurricanes and one major (cat. 3-4-5) hurricane were both forecast and observed. We next worked on adding more parameters to further improve our earlier hindcast results. New parameters included surface pressure anomalies for the October-November East Atlantic subtropical ridge and various measures of ENSO and its tendencies. The additional parameters improved our early December hindcast predictions as shown in Table 1 which lists the amount of undegraded hindcast variance explained using these two extended range forecasts.

Table 1: Amount of undegraded variance explained by our original 1 December (Gray et al. 1992) hindcast and our improved (unpublished) 1 December hindcast for the following year of Atlantic basin hurricane activity.

Forecast Parameter	**Original 1950-1990 hindcast**	**Improved 1950-1995 hindcast**
Named Storms (NS)	.44	.52
Named Storm Days (NSD)	.51	.55
Hurricanes (H)	.45	.49
Hurricane Days (HD)	.49	.54
Intense Hurricanes (IH)	.47	.44
Intense Hurricane Days (IHD)	.45	.42
Hurricane Destruction Potential (HDP)	.44	.49
Net Tropical Cyclone Activity (NTC)	.53	.53

However, and most importantly, unlike our early June and early August forecasts, these early December forecasts have not shown operational forecast skill. In particular, we have not been able to demonstrate forecast skill for predictions from early December in independent data for the period of 1993-2001, this despite the prior findings of hindcast skill for 1950-1990.

The explanation for this lack of skill appears to reside in a breakdown of the association between African rainfall late in the prior year and hurricane activity in the following year. This rainfall-hurricane relationship has not worked during the last nine years. The large upturn in Atlantic basin hurricane activity since 1995 has not been accompanied by a similar increase in west African rainfall which, instead, has remained well below the long-term averages. Figure 2 illustrates the properties of the breakdown of the African rainfall-NTC relationship between 1995-2001 versus the relationship during 1950-1969 and 1970-1994. This recent trend diverges from the strong positive rainfall to hurricane relationship present during the four decades between 1950 and 1990 as well as during the 91-year period of 1899-1990 (Landsea et al. 1992). Though we cannot explain the recent breakdown of this relationship, we can speculate in offering several possible explanations. These entail either a basic change in the TC-rainfall association in the time since the Atlantic thermohaline circulation has reintensified (i.e., since 1995) or that the African rainfall measuring network may have undergone significant degradation in recent decades (that the rainfall measurements are simply not as accurate as they were before 1990). Economic and human considerations may have led some west African interests benefitting from famine relief to underestimate rainfall amounts. A qualitative evaluation of the recent satellite data suggests that drought conditions are not as severe as indicated by the rain gauge data. Yet another potential cause of this rainfall-hurricane breakdown may be related to human-altered land surfaces, plant ecosystems, soil hydrology and their feedback processes. Because of dramatic population growth and intense grazing deformation and desertification have occurred in the Gulf of Guinea/Sahel regions, a modest net diminished moisture re-circulation may have occurred.

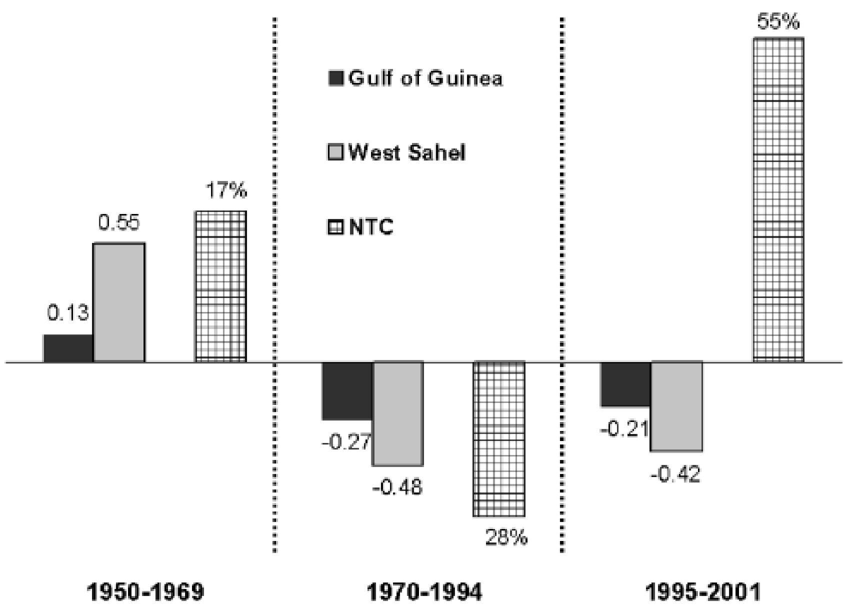

Figure 2: Comparison of Gulf of Guinea (G) August-November and West Sahel (June-September) rainfall with NTC activity for the three periods of 1950-1969, 1970-1994 and 1995-2001.

Whatever the cause or causes, the west African rain data for August-November have not shown a direct association with the following year's hurricane activity over the last seven years. This is the principal cause of our inability to show early December forecast skill since 1993 and we have discontinued this forecast methodology. Our choices regarding December forecasts for the next year were: (1) stop making these forecasts or (2), develop new forecast methods which do not use west African rainfall while showing hindcast skill for the last 50 years (including the last seven years when the previous rainfall-hurricane association has not worked).

Choosing the latter course, we find the new NCEP reanalysis data (available on the web) are most useful for devising a new December forecast scheme which does not utilize west African rainfall data but employs other parameters not previously known to be related to Atlantic hurricane activity 6-11 months in advance. The new five-parameter prediction scheme that has recently been developed shows surprisingly powerful early December extended range hindcast skill. Consequently, we have abandoned our two prior early December forecast schemes and decided to employ this new scheme which shows superior hindcast skill over a longer (50 versus 40 year) period.

We have also gathered information on how statistical climate forecasts can vary sharply with the mode of multi-decadal global climate one is in. In particular, forecast schemes which show substantial hindcast skill for 2-3 decades often fail in following decades. Ramage (1983) referred to the tendency for predictive associations to fail given enough time as ``The Siege of Time''. This sort of change may be partly responsible for the recent seven-year failure of the west African rainfall/hurricane association. Additional examples of multi-decadal change in teleconnection associations during weak versus strong phases of the Atlantic Ocean thermohaline circulation include alterations in the frequency and intensity of El Niño activity which are more frequent and stronger when the Atlantic thermohaline circulation is weaker, trends in the incidence of protracted (several weeks) ``blocking'' events in the boreal winter mid-latitude circulation, seasonal prediction relationships for precipitation in the western U.S., multi-decadal rainfall and temperature associations over much of northwest Europe and North America and reciprocal trends in the incidence of North American cyclogenesis. All of these factors appear to vary with the thermohaline circulation. It is also likely that regardless of reported rainfall trends during the last seven years, long term west African Sahel rainfall tends to increase with a stronger thermohaline - it is possible that this will soon follow with a 5-10 years lag.

Indian Sub-Continent Monsoon Onset - Sea Level Pressure Relationiship. The sea level pressure relationship between the time of onset of the Indian sub-continent monsoon has been observed to shift oppositely in approximate conformity to the changes in the multi-decadal Atlantic thermohaline circulation as judged by North Atlantic SSTAs.

Tornado and ENSO Relationship. It has been observed that springtime U.S. Great Plains F4 and F5 tornado frequency reverses their relationship with the ENSO in approximate conformity with reversals in the Atlantic thermohaline circulation. When the thermohaline circulation is strong as in the period 1926-1969, F4 and F5 tornado events are positively correlated with warm ENSOs. When the thermohaline is judged to be running slowly as in the periods of 1900-1925 and 1970-1994 F4 and F5 frequency is negatively correlated with warm ENSO events (Gray unpublished).

In view of the foregoing it appears that various multi-decadal changes in teleconnection associations are related to variations in the strength of the Atlantic thermohaline circulation. Where the Atlantic thermohaline circulation is strong (as we infer it to have been during 1950-1969 and 1995-2001) we have global atmospheric and oceanic circulation trends which are measurably different from the global circulation modes attending a weak thermohaline circulation as occurred between 1970-1994 and between 1900-1925. Table 2 offers a comparative summary of the typical differences in global circulation patterns for a strong versus weak Atlantic thermohaline circulation.

Table 2: Contrast of typical climate indices when the global atmosphere and ocean circulation patterns which conform with a strong Atlantic thermohaline circulation (as during 1950-1969 and 1995-2001) left column and the typical climate index patterns which occur when the Atlantic thermohaline circulation is

weak (as during 1970-1994) - right column. The (+) sign means above long-term average and the minus (-) sign below the long-period average.

Strong Atlantic Thermohaline		Weak Atlantic Thermohaline
+	North Atlantic Sea Surface Temperature (SSTA)	—
—	Arctic Oscillation (AO)	+
—	North Atlantic Oscillation (NAO)	+
—	Pacific North America (PNA) Oscillation	+
—	Pacific Decadal Oscillation (PDO)	+
—	El Nino Activity	+
—	Symmetry of Southern Hemisphere Polar Vortex	+
—	Longitudinal Symmetry of the Global Hadley Cell	+
+	Indian Monsoon Rainfall	—
+	West Sahel Rain	—
+	Atlantic Hurricane Activity	—
—	Global Surface Temperature	+

3 Basic Climate Features Likely During August-October 2002

Two important climate factors (for enhanced TC activity) which we believe will be present during August-October 2002 are a warm North Atlantic and a westerly QBO. Persistence of recent warm SST conditions in the Atlantic is of some concern, however. In the last 50 years there have been only eight periods when tropical Atlantic SSTA changed from warm (as they were in 2001) to cold the following year. These periods were 1953-1954, 1955-1956, 1958-1959, 1963-1964, 1966-1967, 1969-1970, and 1981-1982. The global atmosphere and ocean features present during October-November 2001 are substantially different from these transitional Atlantic cooling events. In addition, none of these prior transition cases are analog years for 2001 and our best estimates is that an Atlantic Ocean cooling will not occur in 2002.

Another potentially important unknown is the status of ENSO for next August-October. Our current estimate is that a strong El Niño (warming) event will not occur in the tropical east Pacific next summer. Rather, we presently project only a weak to modest El Niño warming which should not cause a significant reduction in next year's Atlantic hurricane activity. Moreover, strong or moderate El Niño events typically do not develop during the westerly QBO onset years as 2002 will be.

Strong Atlantic thermohaline conditions are typically associated with diminished El Niño frequency and intensity which are notably reduced from what occurred during the recent 1970s to mid-1990s. Hence, it is likely that we may go many years before another significant El Niño event develops [as occurred from

1931 to 1964 where only two strong El Niño events (1939-1941 and 1957) developed]. Various extended range El Niño predictions for next summer show a wide variety of anticipated conditions. The ENSO forecast of Knaff and Landsea (1997) which is one of the most accurate models, anticipates near neutral conditions for August-October 2002.

4 New 1 December Extended Range Scheme

As noted elsewhere, we have developed several new and more powerful teleconnection relationships for our new December forecasts. When we separate hindcast multi-decadal periods according to the inferred strength of the Atlantic thermohaline circulation, our hindcast skill is significantly improved. The measurement of the thermohaline circulation is expressed by the North Atlantic (50-60˙N, 10-50˙W) SST anomalies which we take to be a proxy for the strength of the Atlantic thermohaline circulation.

Through extensive analyses of NOAA-NCEP reanalysis products, Phil Klotzbach of our forecast team has developed a new set of 6-11 month extended range predictors which show superior hindcast prediction skill than did our previous pool of previous predictors. The location, height and month of origin for each of these predictors is shown in Fig. 3. The pool of five predictors for our new extended range forecast is shown in Table 3. There are surprisingly strong statistical relationships among combinations of these parameters (which are available by 1 December) and the Atlantic basin hurricane activity occurring the following year. These statistical relationships are illustrated in Table 4 for the 52 year period 1950-2001 during which the thermohaline circulation was variously both weak (1970-1994) and strong (1950-1969, 1995-2001).

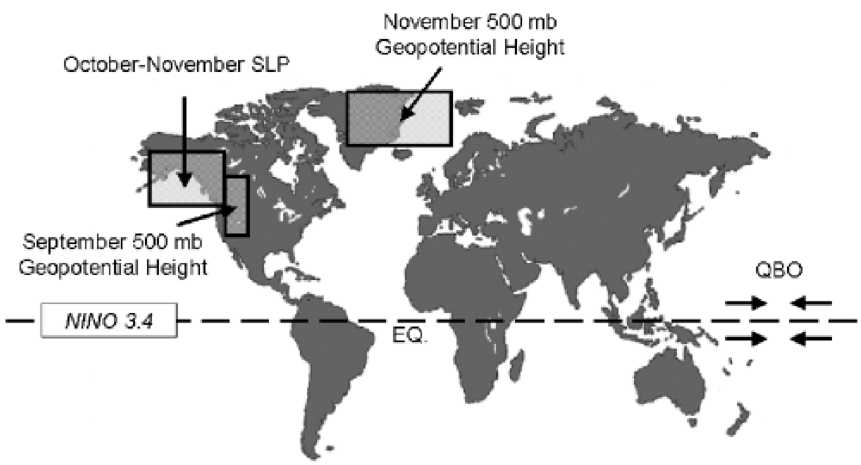

Figure 3: Location of the new predictors for our early December extended range prediction for the 2002 hurricane season.

Table 3: 1 December 2001 predictors for next year's hurricane activity. A plus (+) means that positive values of the parameter indicate increased hurricane activity and a minus (-) means that positive values of the parameter indicate a decrease of activity.

	2001 Values for 2002 Forecast
(1) - November 500 mb geopotential height (67.5-85N, 10E-50W) (+)	-1.5
(2) - October-November SLP (45-65N, 120-160W) (-)	-1.0
(3) - September 500 mb geopotential height (35-55N, 100-120W) (+)	+1.2

(4) - July 50 mb U (5S-5N, 0-360) (-)	-1.1
(5) - September-November ENSO CLIPER forecast for Niño 3.4 (-)	+ 0.1

Table 4: Amount of variance explained (r^2) from the pool of five predictors shown in Table 3 for the 52-year period of 1950-2001. Calculations of the best single predictor is shown in box A, the best two predictors in box B, best three in box C and the best four in box D. The second column gives the amount of variance explained when each of the years being forecast are not in the training data set (jackknife method).

A-Best Single Predictor			**B-Best Two Predictors**		
	Variance Explained	Jackknife		Variance Explained	Jackknife
NS - 1	0.248	0.196	**NS - 1, 2**	0.367	0.304
NSD - 1	0.230	0.179	**NSD - 1, 2**	0.344	0.279
H - 2	0.286	0.237	**H - 1, 2**	0.452	0.389
HD - 1	0.259	0.204	**HD - 1, 2**	0.394	0.326
IH - 1	0.320	0.259	**IH - 1, 3**	0.472	0.401
IHD - 1	0.220	0.152	**IHD - 1, 3**	0.364	0.284
NTC - 1	0.320	0.263	**NTC - 1, 2**	0.473	0.403
C-Best Three Predictors			**D-Best Four Predictors**		
	Variance Explained	Jackknife		Variance Explained	Jackknife
NS - 1, 2, 3	0.403	0.318	**NS - 1, 2, 3, 4**	0.415	0.293
NSD - 1, 2, 3	0.386	0.298	**NSD - 1, 2, 3, 5**	0.406	0.280
H - 1, 2, 3	0.485	0.400	**H - 1, 2 3, 5**	0.488	0.362
HD - 1, 2, 3	0.449	0.357	**HD - 1, 2, 3, 4**	0.466	0.341
IH - 1, 2, 3	0.541	0.455	**IH - 1, 2, 3, 4**	0.544	0.428
IHD - 1, 3, 4	0.410	0.308	**IHD - 1, 2, 3, 4**	0.434	0.312
NTC - 1, 2, 3	0.553	0.477	**NTC - 1, 2, 3, 4**	0.578	0.476

Predictor (1) is related to the Arctic Oscillation (AO). As shown in Table 2 Atlantic hurricane activity is inversely related to the strength of the AO and is proportional to the strength of the thermohaline circulation. Predictor (2) is inversely related to the Pacific North America (PNA) pattern and is also proportional to the thermohaline circulation (Table 2). Predictor (3) is a biennial predictor associated with the year-to-year changes of ENSO. Low 500 mb heights are related to the ENSO warm phase and high heights to the cold phase. The fourth predictor represents the stratospheric QBO and predictor (5) is derived as a combination of climatology and extrapolation (termed as CLIPER) as has been devised by J. Knaff and C. Landsea (former project members) to predict the following year September to November Niño 3.4 conditions. This simple ENSO prediction scheme makes use of climatological seasonal and yearly changes of ENSO as observed in 50 years of prior data. Consideration has also been given to the strength of the Azores subtropical ridge between 20-30˚W. Lower than normal October-November conditions of this ridge indicate more hurricane activity for next year. October-November ridge conditions for 2001 offer a neutral signal for hurricane conditions for 2002 (+0.15 SD).

To optimize true skill in statistical prediction, we utilize the best four of the potential five predictors of Table 3. Of these five potential predictors, Table 4 shows a breakdown of the single best predictor of those listed in Table 3, the best two predictors, the best three predictors, etc. We stop selecting predictors when the jackknife forecast skill no longer increases when additional predictors are included. These predictors encompass the 52-year period of 1950-2001 during which the thermohaline circulation was both weak and strong.

A separate hindcast analysis is made for the aggragate 25 years (1950-1969 and 1995-1999) when the thermohaline circulation was strong. Table 5 shows the substantial improvement obtained when our forecast is limited to the latter 25 years when the thermohaline was likely strong. Note that the combinations of the best four predictors explain two-thirds of the variance in NTC and the incidence of intense (Cat. 3-4-5) hurricanes by the jackknife method. It is remarkable that this high level of variance of next year's hurricane activity can be predicted for the following year with only a three or four predictor model. These results indicate that the global atmosphere has considerable memory extending 6-11 months into the future.

Table 5: Amount of variance explained (r^2) from the pool of five predictors shown in Table 12 for the 25-year period of 1950-1969 and 1995-1999 when the Atlantic thermohaline circulation was judged to be strong. The calculations of the best single predictor is shown in box A, the best two predictors in box B, best three in box C and the best four in box D. The second column gives the amount of variance explained when each of the years being forecast are not in the training data set (jackknife method).

A-Best Single Predictor			**B-Best Two Predictors**		
Pick 1	Variance Exp.	Jackknife	**Pick 2**	Variance Exp.	Jackknife
NS - 2	0.224	0.119	**NS - 1, 3**	0.421	0.302
NSD - 3	0.202	0.075	**NSD - 1, 3**	0.444	0.331
H - 2	0.316	0.206	**H - 1, 2**	0.467	0.345
HD - 2	0.236	0.137	**HD - 2, 5**	0.394	0.240
IH - 1	0.299	0.185	**IH - 1, 3**	0.603	0.520
IHD - 1	0.185	0.072	**IHD - 1, 3**	0.416	0.298
NTC - 1	0.251	0.148	**NTC - 1, 3**	0.556	0.468
C-Best Three Predictors			**D-Best Four Predictors**		
Pick 3	Variance Exp.	Jackknife	**Pick 4**	Variance Exp.	Jackknife
NS - 1, 3, 4	0.510	0.338	**NS - 1, 2, 3, 4**	0.572	0.360
NSD - 3, 4, 5	0.545	0.333	**NSD - 1, 3, 4, 5**	0.694	0.519
H - 1, 2, 3	0.545	0.394	**H - 1, 2 3, 5**	0.588	0.302
HD - 1, 3, 5	0.501	0.327	**HD - 1, 3, 4, 5**	0.618	0.464
IH - 1, 3, 4	0.696	0.592	**IH - 1, 3, 4, 5**	0.798	0.668
IHD - 1, 3, 4	0.468	0.323	**IHD - 1, 3, 4, 5**	0.559	0.370
NTC - 1, 3, 4	0.638	0.533	**NTC - 1, 3, 4, 5**	0.778	0.678

Table 6 gives our new forecast model output for 2002 hurricane activity. Note that our model developed on hurricane activity during a strong Atlantic thermohaline circulation (1950-1969, 1995-1999) predicts greater activity than does the model developed for the full 52-year period.

Table 6: New early December 2001 model output forecast for the 2002 hurricane season.

	Full 52 Years	25 Strong Thermohaline Years
NS	8.8	9.3
NSD	43.6	54.9
H	5.4	5.3
HD	21.1	29.2
IH	1.8	2.0
IHD	5.1	5.6
HDP	72.2	84.5
NTC	90	103

5 Analog Based Predictors for 2002 Hurricane Activity

Certain years in the historical record have global oceanic and atmospheric trends which are substantially similar to 2001/2002. These years also provide useful clues as to likely trends that the forthcoming 2002 hurricane season may bring. Although some of the physical associations manifest in these analog years are presently only partly understood, the inferred analog relationships are useful for extended range prediction. For this (1 December) extended range forecast, we project atmospheric and oceanic conditions into August through October 2002 and determine which of the prior years in our database have distinct trends in key environmental conditions which are similar and then consider the hurricane activity trends that occurred in these analog years. Table 7 lists our analog selection considerations.

Table 7: Criteria for picking the closest analogs to the following August-October period.

Years	Oct-Nov ENSO	Oct-Nov Ridge	PDO State	Warm ATL?	QBO State (all W phase)
Nov 2001	Neutral	+0.15	-	Yes	W coming at 30 mb
Nov 1952 (1953)	Neutral	+0.11	0	Yes	W through 30 mb
Nov 1956 (1957)	Neut-cool	+2.50	-	Yes	W coming at 30 mb
Nov 1960 (1961)	Neutral	-0.53	-	Yes	W coming at 30 mb
Nov 1968 (1969)	Neut-warm	-1.11	0	Yes	W coming at 30 mb
Nov 1979 (1980)	Neutral	-0.07	+	Yes	W coming higher than 30 mb
Nov 1989 (1990)	Neutral	-0.18	0	Yes	W coming higher than 30 mb

Analog Years Selected. We find six prior hurricane seasons since 1949 which were fairly similar to current November 2001 conditions and projected 2002 August-October conditions. Specifically, we expect the North Atlantic (50-60°N, 10-50°W) warm SST anomalies to remain warm for the 2002 hurricane season and hence that the strong Atlantic thermohaline circulation will persist through the next year. Also, it is assumed that the conditions of the Northern Hemisphere NAO, PNA, PDO, and AO of the last year will persist through 2002 with the implication that the recent global atmosphere and ocean circulation regimes which are also typical of the 1930s through the 1950s, will continue to be present. In addition it is almost certain that QBO 30 mb and 50 mb winds in September 2002 will be from a westerly direction. We view the latter as a modest enhancing factor for the formation of low latitude hurricanes to the east of the Antilles.

There were six hurricane seasons since 1949 with characteristics similar to what we anticipate for summer/fall 2002. These analog years include August through October 1953, 1957, 1961, 1969, 1980, and 1990. Only one in six of these analog years had suppressed hurricane activity. Based on the values in Table 7, we expect the 2002 season to approximate the average values for these six analogs. We believe this to be more representative of the level of hurricane activity for next year than the somewhat lower levels of activity indicated by our new statistical schemes. Thus, based on this analysis, we expect 2002 to be nearly as active as the average of the last seven (1995-2001) hurricane seasons and considerably more active than the average for seasons during the inactive 1970-1994 period. Also, these six analog years had above normal activity in both the deep tropics and mid-latitudes. Thus, we also expect more Tropical Only Hurricanes (TOH) formations as well as more middle latitude Baroclinically Initiated Hurricanes (BIH) than climatology based upon this analog analysis (Elsner et al. 1996) (see Table 8). When we apply our new 1 December hindcast scheme to these analog years we obtained the forecast values shown in Table 9.

Table 8: Best analog years for 2002 with the associated hurricane activity listed for each year.

	NS	**NSD**	**H**	**HD**	**IH**	**IHD**	**HDP**	**NTC**	**TOH**	**BIH**
1953	14	65	6	18	3	5.50	59	115	4	0
1957	8	38	3	31	2	5.25	66	81	1	1
1961	11	71	8	48	6	20.75	170	210	6	1
1969	17	83	12	40	3	2.75	110	149	5	4
1980	11	60	9	38	3	7.25	126	129	3	3
1990	14	66	8	27	1	1.00	57	98	4	3
Mean	12.5	63.8	7.7	32.0	3.0	7.1	98.0	130.3	3.8	2
2002 Forecast	13	70	8	35	4	7	90	140	-	-

Table 9: Best forecast analog years for 2002 along with the associated forecast hurricane activity by the 52-year hindcast method listed for each year.

	NS	**NSD**	**H**	**HD**	**IH**	**IHD**	**NTC**
1953 Forecast	11	61	7	32	3	7	134
1957 Forecast	10	49	6	25	2	6	106
1961 Forecast	13	72	9	41	4	10	169

1969 Forecast	15	86	10	47	5	11	196
1980 Forecast	11	56	7	29	3	6	121
1990 Forecast	10	53	8	27	3	6	112
Mean	11.7	62.8	7.8	33.5	3.3	7.7	140
2002 Forecast	13	70	8	35	4	7	140
2002 Forecast as %							
of 1950-2000 Mean Fcst.	135	143	136	143	174	140	140

Table 10 shows our new 1 December statistical forecast for the 2002 season from both our derived full 52 -year data set and the forecast derived from the 25-year period (1950-1969, and 1995-1999) when we judge the thermohaline circulation to have been strong. Also included is the mean of our fix best analog years, and our adjusted final forecast.

Table 10: Our new 1 December statistical forecast.

Forecast Parameter and 1950-2000 Climatology (in parenthesis)	**52 Year Scheme**	**25 Year Scheme**	**Analog Scheme**	**Adjusted Final Forecast**
Named Storms (9.6)	8.8	9.3	12.5	13
Named Storm Days (49.1)	44	55	63.8	70
Hurricanes (5.9)	5.4	5.3	7.7	8
Hurricane Days (24.5)	21.1	29.2	32.0	35
Intense Hurricanes (2.3)	1.8	2.0	3.0	4
Intense Hurricane Days (5.1)	5.1	5.6	7.1	7
Hurricane Destruction Potential (72.7)	72	85	98.0	90
Net Tropical Cyclone Activity (100%)	90	103	130.3	140

6 Qualitative Upward Adjustment of the 2002 Forecast

We have chosen to increase the 2002 forecast from our statistical forecasts for the following reasons:

1. During the last seven years, our statistical schemes have significantly underforecast active years. The last seven years have been the most active seven consecutive hurricane seasons on record and as such are not well represented in the training data sets which were developed on observations extending backward 25 and 52 years. There are no compelling reasons why this active period should not continue through the 2002 season.

2. Our new 1 December 52 and 25 year forecast schemes when using the forecast parameters for the six analog years of 1953, 1957, 1961, 1969, 1980 and 1990 gave a NTC forecast of 40 and 27 percent higher than our two statistical forecasts for 2002.

3. New satellite, aircraft and GPS dropwinsonde technology allow better detection and intensity measurements for tropical cyclones. We believe this new technology causes a small upward shift in Atlantic basin cyclone activity due purely to these better observations, especially for the most intense cyclone activity.

7 Landfall Probabilities for 2002

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 11) 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. SSTA* is an average of North Atlantic SSTA for the last six years, last year and the last six months in comparison with the first half of the year. A decreasing weighting is given to each these three criteria.

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 (November 2001) value of SSTA* is 91. Hence, in combination with a new prediction of NTC of 140 for 2001, a combination of NTC + SSTA* of (140 + 91) yields a value of 231.

As shown in Table 11, 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 exist. 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 resulting in a difference of 8 to 1.

Table 11: 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 12 and 13 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 12: 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*) or NTC + 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 13: 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

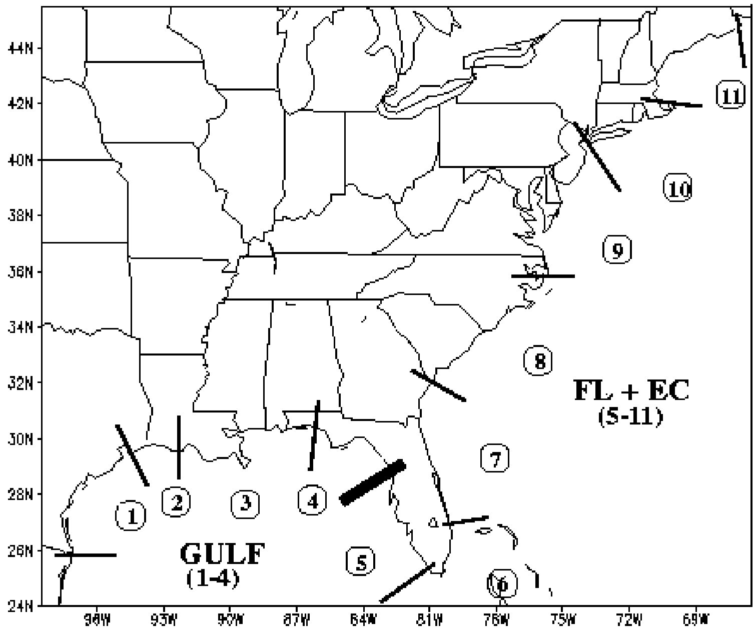

Figure 4: Location of the 11 coastal regions for which separate hurricane landfall probability estimates are made. The heavy bar delineates the boundary between the Gulf (regions 1-4) and the Florida Peninsula and East Coast (regions 5-11).

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 probability 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 14 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 Atlantic basin NTC activity in 2002 is expected to be greater than the long-term average (140), U.S. hurricane landfall probability is expected to be above average owing to North Atlantic SSTAs being above average in recent years. During periods of positive North Atlantic SSTA, a higher percentage of Atlantic basin major hurricanes cross the U.S. coastline for a given level of NTC.

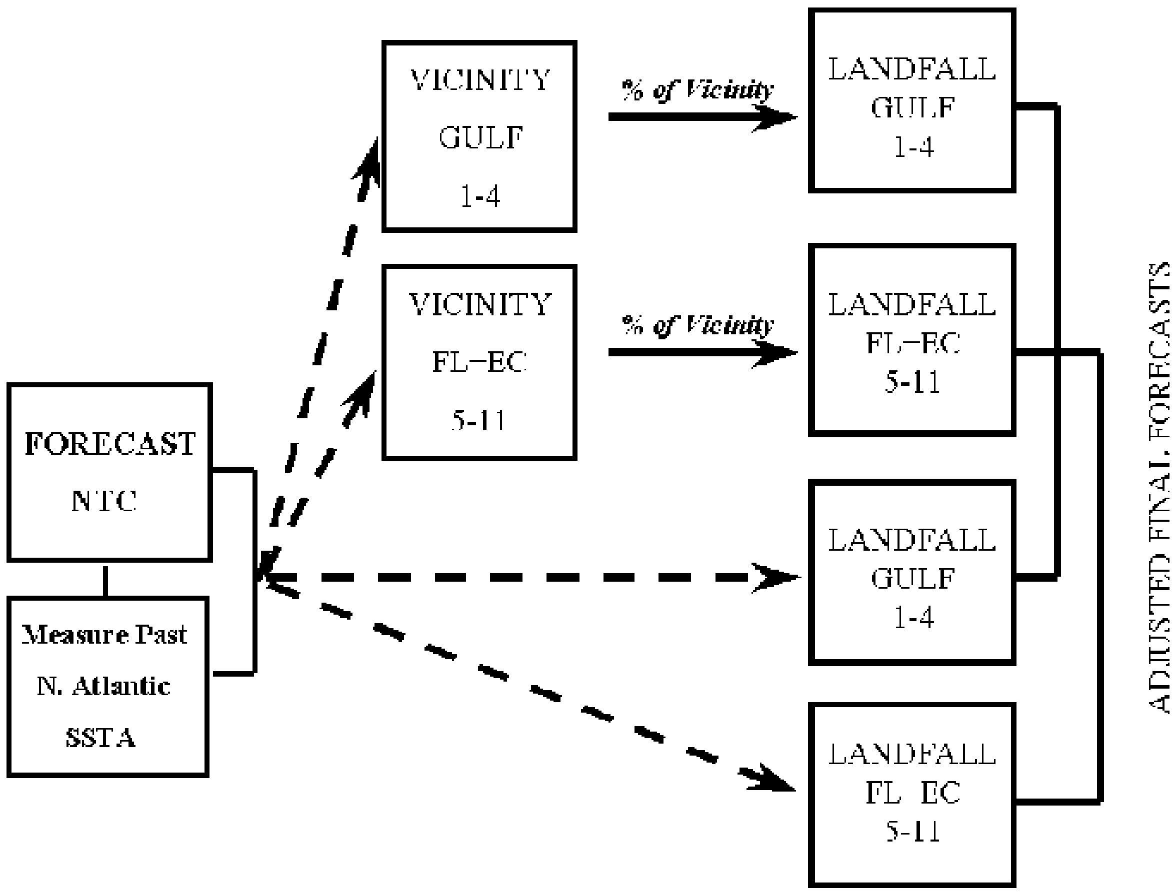

Figure 5: Flow diagram illustrating how forecasts of U.S. hurricane landfall probabilities are made. Forecast NTC values and an observed measure of recent North Atlantic (50-60˚N, 10-50˚W) SSTA* are used to develop regression equations from U.S. hurricane landfall measurements of the last 100 years.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

Table 14: 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 2002. 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)	91% (80)	96% (68)	86% (52)	96% (84)	99% (97)
Gulf Coast (Regions 1-4)	78% (59)	57% (42)	43% (30)	76% (61)	94% (83)
Florida plus East Coast (5-11)	60% (51)	66% (45)	58% (31)	86% (62)	95% (81)

8 Increased Level of Atlantic Basin Hurricane Activity During the Last Seven Years - But Decreased Landfalls

A major reconfiguration of the distribution of Atlantic SST anomalies began in mid-1995 and has persisted through the present. North Atlantic SSTs have become about 0.4 to 0.6˙C warmer than normal. This trend is well associated with increased major hurricane activity in the Atlantic basin during the last seven years. We hypothesize that these strong broadscale SST changes are associated with basic changes in the strength of the Atlantic Ocean thermohaline (``conveyor belt") circulation. This interpretation is consistent with changes in a long list of global atmospheric circulation features during the last seven years which conform to a prominent shift into hurricane-enhancing Atlantic circulation patterns as shown in Table 2. Historic and geographic evidence going back thousands of years indicates that shifts in the Atlantic multi-decadal thermohaline circulation tend to occur on periods of 25-50 years. If the recent 7-year shift follows prior occurrences, then it is likely that enhanced intense Atlantic basin hurricane activity will persist through the early decades of the 21st century. This will be in contrast with the diminished hurricane activity which persisted from 1970-1994 and the first quarter of the 20th century.

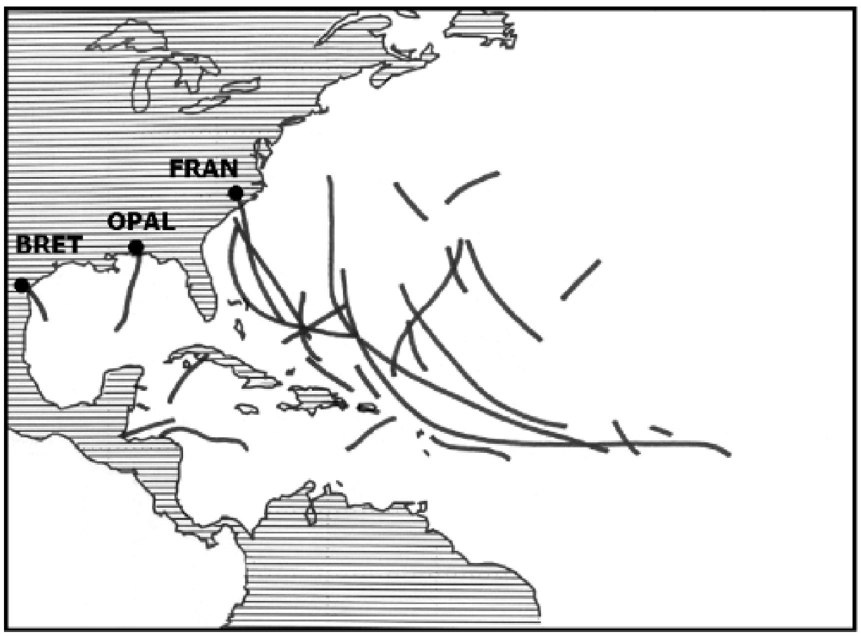

Figure 6: Intense (Cat 3-4-5) hurricane tracks during the period from 1995-2001. Note that despite twenty -seven intense hurricanes during this period that only three (Bret, Opal and Fran) made US landfall. Bret made landfall at the least vulnerable location in the US, and Opal and Fran made landfall in areas that were not densely populated.

Despite El Niño-linked reduction of hurricane activity during 1997, the last seven years (1995-2001) constitute the most active seven consecutive years on record. Table 15 provides a summary of the total number of named storms (94), named storm days (524), hurricanes (58), hurricane days (266), major hurricanes (27), major hurricane days (61.25) and Net Tropical Cyclone activity (1123) which occurred during 1995-2001. Despite the inactive 1997 season the annual average NS, NSD, H, HD, IH, IHD and NTC during these seven years was 144, 198, 143, 235, 254, 347 and 214 percent respectively above the averages of the prior 25-year period of 1970-1994. Note also that NS, NSD, H, HD, IH, IHD and NTC during these seven years are 140, 153, 141, 155, 168, 172 and 154 percent of the climatological average for the period 1950-2000 with the greatest increase occurring for IH and IHD activity. These trends toward increased hurricane activity give strong support to the suggestion that we have entered a new era of greatly increased major hurricane activity. NTC activity during the seven-year period averaged 214 percent of the level observed during the 1970-1994 period. Excluding 1997, average NTC for the other six years from (1995-2001) was 176. There have been as many Atlantic basin intense hurricanes during the seven years between 1995-2001 as there were during the eighteen years between 1977-1994.

Table 15: Comparison of recent seven-year (1995-2001) hurricane activity with climatology and prior quarter century period of 1970-1994.

Year	Named Storms (NS)	Named Storm Days (NSD)	Hurricanes (H)	Hurricane Days (HD)	Cat 3-4-5 Hurricanes (IH)	Cat 3-4-5 Hurricane Days (IHD)	Net Tropical Cyclone Activity (NTC, 1950-2000)
1995	19	121	11	60	5	11.50	221
1996	13	78	9	45	6	13.00	192
1997	7	28	3	10	1	2.25	51
1998	14	80	10	49	3	9.25	168
1999	12	77	8	43	5	15.00	181
2000	14	77	8	32	3	5.25	130
2001	15	63	9	27	4	5.00	142
TOTAL	94	524	58	266	27	61.25	1123
Seven-year Ave. 1995-2001	13.4	74.9	8.3	38.0	3.86	8.75	155
Ratio 1995-01/ climatology (1950-2000) in percent	140	153	141	155	168	172	155
Ratio 1995-01/1970-94 in percent	144	198	143	235	254	347	215

Beginning about 1990, we suggested that the era of greatly reduced intense Atlantic category 3-4-5 hurricane activity that began during the late 1960s was likely coming to an end and that the U.S. and Caribbean coastal regions should expect a long term increase in major landfalling hurricanes (Gray 1990). Such an increase is an ominous prospect considering the strong increases in U.S. and Caribbean coastal population in recent years and that, when hurricane destruction is normalized for coastal population, inflation, and wealth per capita [see Pielke and Landsea (1998)], it is found that major hurricanes cause about 85 percent of all U.S. tropical cyclone-linked destruction.

Good fortune has been manifest during the last seven years as a persistent upper-air trough has been located along the U.S. East Coast much of the time during hurricane season. The presence of this upper-level trough caused a large portion of otherwise northwest moving major hurricanes to recurve to the north before they reached the U.S. coastline. Also, more systems formed at higher latitudes, and these storms tended to move away from the U.S\. Figure 6 provides a summary illustration of these effects showing the tracks of major hurricanes during their intense stages for the last seven years. Note that though many major hurricanes passed close to the U.S. coastline, only three made landfall. This run of good luck cannot be expected to continue.

Table 16 further demonstrates the good luck of the last seven years (1995-2001) expressed in terms of the number of U.S. major hurricane landfalls per year during the 95-year period of 1900-1994. Along the Florida Peninsula and the East Coast, major hurricane landfall per year has been only 38 percent as great as in the average year between 1900-1994 and 58 percent as large for the whole U.S. coastline.

In terms of the ratio of the number of U.S. major hurricane landfalls per number of Atlantic basin major hurricanes, the last seven years have witnessed a very strong downturn. Table 17 shows that the U.S. Gulf in the last seven years has experienced only 46 percent as many major hurricane landfall events per Atlantic basin major hurricanes as during the average of the previous 95 years. The Florida and the East Coast rate of landfalling major hurricanes the last seven years has been only 22 percent as great and the whole U.S. coastline 35 percent as great. This fortuitous landfall downturn is unlikely to persist.

Table 16: The incidence of U.S. average major hurricane landfall per year. Number in parentheses indicate the percentage ratio for 1995-2001 versus 1900-1994).

	Gulf Coast Regions 1-4	**Florida Peninsula and East Coast Regions 5-11**	**Whole U.S. Coast Regions 1-11**
1900-1994	.358	.379	.737
1995-2001	.258(80%)	.143(38%)	.429(58%)

Table 17: The incidence of U.S. average major hurricane landfall per year expressed as percent of Atlantic basin total major hurricanes. Number in parenthesis indicate the annual percentage ratio for 1995 -2001 versus 1900-1994).

	Gulf Coast Regions 1-4	**Florida Peninsula and East Coast Regions 5-11**	**Whole U.S. Coast Regions 1-11**
1900-1994	.162	.172	.321
1995-2001	.074(46%)	.037(22%)	.111(35%)

9 Downturn in the Incidence of U.S. Hurricane Landfall in Recent Decades

During the 102 years between 1900 and 2001, 112 category 1-2 hurricanes and 73 category 3-4-5 hurricanes made landfall on the U.S. coast. However, the annual incidence of landfall in Florida and U.S. East Coast was nearly twice as great during the first 67 years of this century (1900-1966) as it was during the recent 36 year period (1966-2001). Please see pages 26-27 of our recent 20 November 2001 verification report for more discussion on this subject.

[http://tropical.atmos.colostate.edu/forecasts/index.html]

10 The 1995-2001 Upswing in Atlantic Hurricanes and Global Warming

Various groups and individuals have suggested that the recent large upswing in Atlantic hurricane activity (since 1995) may be in some way related to the effects of increased man-made greenhouse gases such as carbon dioxide (CO_2). There is no reasonable scientific way that such an interpretation of this recent upward shift in Atlantic hurricane activity can be made. Please see our recent 20 November 2001 verification report for more discussion on this subject.

http://tropical.atmos.colostate.edu/forecasts/index.html]

11 Forecast Theory and Cautionary Note

Our forecasts are based on the premise that those global oceanic and atmospheric conditions which precede comparatively active or inactive hurricane seasons in the past provide meaningful information about likely similar 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 specifically predict 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. It must also be emphasized that a low landfall probability does not insure that a hurricane will not come ashore. Regardless of how active the 2002 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.

12 Forthcoming Update Forecasts of 2002 Hurricane Activity

We will be issuing seasonal updates of our 2002 Atlantic basin hurricane activity forecast on 5 April, 31 May (to coincide with the official start of the 2002 hurricane season on 1 June) and 7 August 2002. The latter will include separate forecasts for August-only and September-only activity during 2002. All these forecasts will be available at our web address given on the front cover (http://tropical.atmos.colostate.edu/forecasts/index.html).

13 Acknowledgments

John Sheaffer and John Knaff 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, Vern Kousky, Ray Zehr and Mark DeMaria for very valuable climate discussions and input data. We thank Colin McAdie, Jiann-Gwo Jiing, and Gary Padgett who have furnished us with data. Richard Taft has provided help with African rainfall collection. In addition, Barbara Brumit and Amie Hedstrom have provided excellent manuscript, graphical, 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, 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 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 for his sage advice and encouragement.

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13 Citations and Additional Reading

Table 18: Summary verifications of the author's prior seasonal forecasts of Atlantic TC activity between 1999-2001.

		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	140
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

		Update	Update	Update	
2000	8 Dec 1999	7 April	7 June	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	55	55	65	55	66
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

		Update	Update	Update	
2001	7 Dec 2000	6 April	7 June	7 August	Obs.
No. of Hurricanes	5	6	7	7	9
No. of Named Storms	9	10	12	12	15
No. of Hurricane Days	20	25	30	30	27
No. of Named Storm Days	45	50	60	60	62
Hurr. Destruction Potential(HDP)	65	65	75	75	71
Major Hurricanes (Cat. 3-4-5)	2	2	3	3	4
Major Hurr. Days	4	4	5	5	5
Net Trop. Cyclone Activity	90	100	120	120	142

Table 19: Alteration of Atlantic basin tropical cyclone climatology when the base period is increased from 1950-1990 to 1950-2000.

	1950-1990	1950-2000	Difference
No. of Hurricanes	5.8	5.9	0.1
No. of Named Storms	9.3	9.6	0.3
No. of Hurricane Days	23.7	24.5	0.8
No. of Named Storm Days	46.9	49.1	2.2
Hurr. Destruction Potential(HDP)	61.7	72.7	11.0
Major Hurricanes (Cat. 3-4-5)	2.2	2.3	0.1
Major Hurr. Days	4.7	5.0	0.3
Net Trop. Cyclone Activity	100	100	0