EXTENDED RANGE FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY AND US LANDFALL STRIKE PROBABILITY FOR 2005

We foresee a slightly above-average hurricane season for the Atlantic basin in 2005. Also, an above-average probability of U.S. major hurricane landfall is anticipated. We do not, however, expect anything close to the U.S. landfalling hurricane activity of 2004.

(as of 3 December 2004)

This forecast is based on new research by the authors,
along with current meteorological information through November 2004

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[This forecast as well as past forecasts and verifications are available via the World Wide Web: http://hurricane.atmos.colostate.edu/Forecasts] - also,

Brad Bohlander and Thomas Milligan, Colorado State University Media Representatives (970-491-6432) are available to answer various questions about this forecast.

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ATLANTIC BASIN SEASONAL HURRICANE FORECAST FOR 2005

Forecast Parameter and 1950-2000 Climatology (in parentheses)	**3 December 2004 Forecast for 2005**
Named Storms (NS) (9.6)	11
Named Storm Days (NSD) (49.1)	55
Hurricanes (H)(5.9)	6
Hurricane Days (HD)(24.5)	25
Intense Hurricanes (IH) (2.3)	3
Intense Hurricane Days (IHD)(5.0)	6
Net Tropical Cyclone Activity (NTC)(100%)	115

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

1) Entire U.S. coastline - 69% (average for last century is 52%)

2) U.S. East Coast Including Peninsula Florida - 49% (average for last century is 31%)

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

4) Above-average major hurricane landfall risk in the Caribbean

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DEFINITIONS

ABSTRACT

Information obtained through November 2004 indicates that the 2005 Atlantic hurricane season will be slightly more active than the average 1950-2000 season. We estimate that 2005 will have about 6 hurricanes (average is 5.9), 11 named storms (average is 9.6), 55 named storm days (average is 49), 25 hurricane days (average is 24.5), 3 intense (category 3-4-5) hurricanes (average is 2.3), and 6 intense hurricane days (average is 5.0). The probability of U.S. major hurricane landfall is estimated to be 30 percent above the long-period average. We expect Atlantic basin Net Tropical Cyclone (NTC) activity in 2004 to be about 115 percent of the long-term average. This forecast is based on our recently developed 6-11 month extended range statistical forecast procedure which utilizes 52 years of past data. Both statistical and analog predictors have been utilized. These include five selective measures of September-November North Atlantic and Pacific surface pressure and 500 mb height fields and a measure of the stratospheric QBO. The influence of El Niño conditions are implicit in these predictor fields, and therefore we do not utilize a specific ENSO forecast as a predictor. We do not foresee a major El Niño event for the 2005 season.

Acknowledgment

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1 Introduction

This is the 22nd year in which the first author has made forecasts of the upcoming season's Atlantic basin hurricane activity. Our Colorado State University research team has shown that a sizable portion of the year-to-year variability of Atlantic tropical cyclone (TC) activity can be hindcast with skill exceeding climatology. These forecasts are based on a statistical methodology derived from 52 years of past data and a separate study of analog years which have similar precursor circulation features. Qualitative adjustments are added to accommodate additional processes which may not be explicitly represented by our statistical analyses. These evolving forecast techniques are based on a variety of climate-related global and regional predictors previously shown to be related to the forthcoming seasonal Atlantic tropical cyclone activity and landfall probability. We believe that seasonal forecasts must be based on methods showing significant hindcast skill in application to long periods of prior data. It is only through hindcast skill that one can demonstrate that seasonal forecast skill is possible. This is a valid methodology provided the atmosphere continues to behave in the future as it has in the past. We have no reason for thinking that it will not.

2 December Forecast Methodology

Our initial 6-11 month early December seasonal hurricane forecast scheme (Gray et al. 1992) demonstrated hindcast skill for the period of 1950-1990 but did not give skillful results when utilized on a real-time basis for forecasts between 1995-2001. This was due to the discontinuation of the strong relationships we had earlier found between West African rainfall and the stratospheric Quasi-Biennial Oscillation (QBO) with Atlantic basin major hurricane activity 6-11 months in the future. We did not expect these relationships that had worked so well for 41 years to stop working from 1995 onward. We do not yet have a good explanation why these relationships failed. We have discontinued this earlier 1 December forecast scheme and have developed a new 1 December forecast scheme.

Our new, recently developed early December forecast scheme (Klotzbach and Gray 2004) does not utilize West African rainfall and gives less weight to the QBO. This new extended range forecast scheme shows significantly improved hindcast skill and better physical insights into why such precursor relationships have such an extended period memory. The location of each of these new predictors is shown in Fig. 1. The pool of six predictors for the new extended range forecast is given in Table 1. Strong statistical relationships can be extracted via combinations of these predictors (which are available by 1 December) and the Atlantic basin hurricane activity occurring the following year.

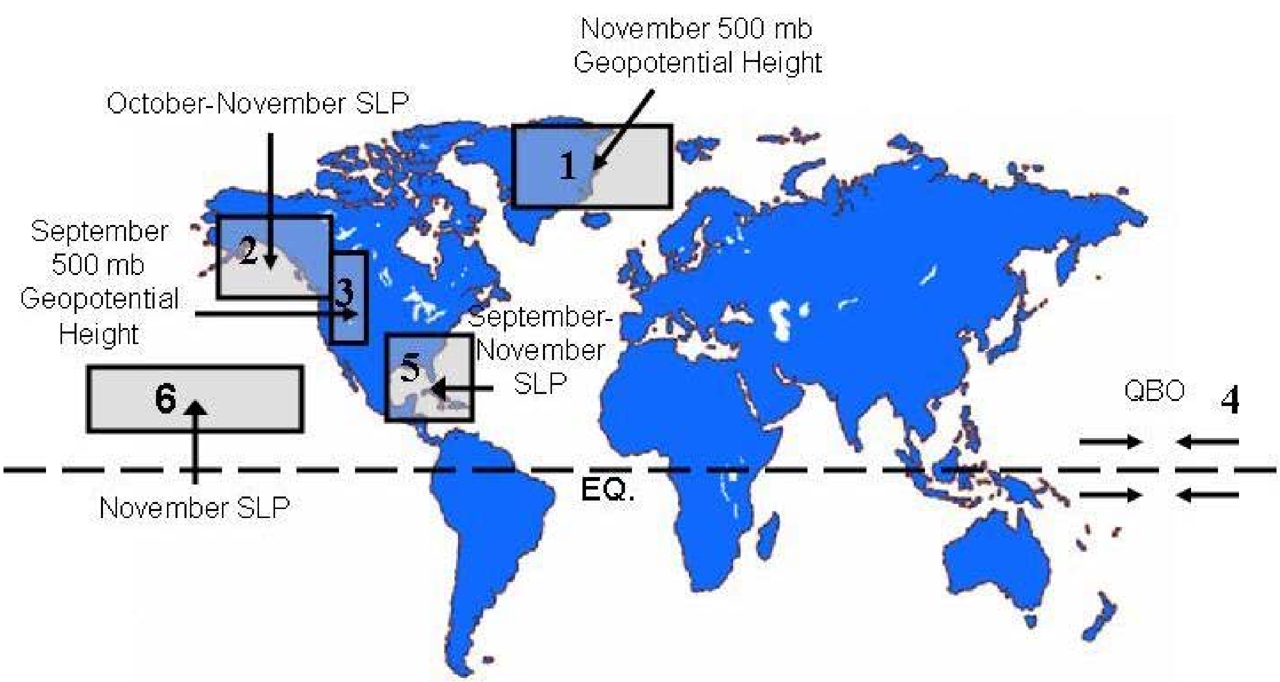

Figure 1: Location of the new predictors for our early December extended range prediction for the 2004 hurricane season.

Table 1: Listing of 1 December 2004 predictors for the 2005 hurricane season. A plus (+) means that positive values of the parameter indicate increased hurricane activity the following year, and a minus

(-) means that positive values of the parameter indicate decreased hurricane activity the following year.

	2004 Values for 2005 Forecast
(1) - November 500 mb geopotential height (67.5-85°N, 10E-50°W) (+)	+0.1 SD
(2) - October-November SLP (45-65°N, 120-160°W) (-)	+0.3 SD
(3) - September 500 mb geopotential height (35-55°N, 100-120°W) (+)	-0.3 SD
(4) - July 50 mb U (5°S-5°N, 0-360) (-)	+1.6 SD
(5) - September-November SLP (15-35°N, 75-95°W) (-)	-0.8 SD
(6) - November SLP (7.5-22.5°N, 125-175°W) (+)	+0.3 SD

2.1 Physical Associations among Predictors Listed in Table 1

The locations and brief descriptions of our 6-11 month predictors are as follows:

Predictor 1. November 500 MB Geopotential Height in the far North Atlantic (+)

(67.5-85°N, 10°E-50°W)

Positive values of this predictor correlate very strongly (r = -0.7) with negative values of the Arctic Oscillation (AO) and the North Atlantic Oscillation (NAO). Negative AO and NAO values imply more ridging in the central Atlantic and a warm North Atlantic Ocean (50-60°N, 10-50°W) due to stronger southerly winds during this period. Also, on decadal timescales, weaker zonal winds in the subpolar areas (40-60°N, 0-60°W) across the Atlantic are indicative of a relatively strong thermohaline circulation. Also, positive values of this November index (higher heights, weaker mid-latitude zonal winds) are correlated with weaker tropical Atlantic 200 mb westerly winds and weaker trade winds the following August-October. The associated reduced tropospheric vertical wind shear enhances TC development. Other following summer-early fall features that are directly correlated with this predictor are low sea level pressure in the Caribbean and a warm North and tropical Atlantic. Both of the latter are hurricane-enhancing factors.

Predictor 2. October-November SLP in the Gulf of Alaska (-)

(45-65°N, 120-160°W)

Negative values of this predictor are strongly correlated with a positive Älaskan pattern" (Renwick and Wallace 1996) as well as a slightly eastward shifted positive "Pacific North American Pattern" (PNA) which implies reduced ridging over the central Pacific with increased heights over the western United States. The negative mode of this predictor is typically associated with warm current eastern Pacific equatorial SST conditions and a mature warm ENSO event. Low sea level pressure is observed to occur in the Gulf of Alaska with a decaying El Niño event, and anomalously high pressure is observed with a weakening La Niña event (Larkin and Harrison 2002). Negative values of this predictor indicate a likely change to cool ENSO conditions the following year. Cool ENSO conditions enhance Atlantic hurricane activity.

Predictor 3. September 500 MB Geopotential Height in Western North America (+)

(35-55°N, 100-120°W)

Positive values of this predictor correlate very strongly (r = 0.8) with positive values of the PNA. PNA values are usually positive in the final year of an El Niño event (Horel and Wallace 1981). Therefore, cooler ENSO conditions are likely during the following year. Significant lag correlations exist between this predictor and enhanced 200 mb geopotential height anomalies in the subtropics during the following summer. Higher heights in the subtropics reduce the height gradient between the deep tropics and subtropics resulting in easterly anomalies at 200 mb throughout the tropical Atlantic during the following summer. Easterly anomalies at 200 mb provide a strong enhancing factor for tropical cyclone activity.

Predictor 4. July 50 MB Equatorial U (-)

(5°S-5°N, 0-360°)

Easterly anomalies of the QBO during the previous July indicate that the QBO will likely be in the west phase during the following year's hurricane season. The west phase of the QBO has been shown to provide favorable conditions for development of tropical cyclones in the deep tropics according to Gray et al. (1992, 1993, 1994) and Shapiro (1989). Hypothetical mechanisms for how the QBO effects hurricanes are as follows: a) Atlantic TC activity is inhibited during easterly phases of the QBO due to enhanced lower stratospheric wind ventilation and increased upper-troposphere-lower-stratosphere wind shear, and b) for slow moving systems, the west phase of the QBO has a slower relative wind (advective wind relative to the moving system) than does the east phase. This allows for greater coupling between the lower stratosphere and the troposphere.

Predictor 5. September-November SLP in the Gulf - SE USA (-)

(15-35°N, 75-95°W)

This feature is strongly related to the following year's August-September sea level pressure in the tropical and subtropical Atlantic. August-September SLP in the tropical Atlantic is one of the most important predictors for seasonal activity, that is, lower-than-normal sea level pressure is favorable for more TC activity. Low pressure in this area during September-November correlates quite strongly with the positive phase of the PNA. In addition, easterlies at 200 mb throughout the tropical Atlantic are typical during the following year's August-September period with low values of this predictor.

Predictor 6. November SLP in the Subtropical NE Pacific (+)

(7.5-22.5°N, 125-175°W)

According to Larkin and Harrison (2002), high pressure in the tropical NE Pacific appears during most winters preceding the development of a La Niña event. High pressure forces stronger trade winds in the East Pacific which increases upwelling and helps initiate La Niña conditions which eventually enhance Atlantic hurricane activity during the following summer. This predictor correlates with low geopotential heights at 500 mb throughout the tropics the following summer, indicative of a weaker Hadley circulation typical of La Niña conditions. Also, high pressure in November in the tropical NE Pacific correlates with low sea level pressure in the tropical Atlantic and easterly anomalies at 200 mb during the following August through October period.

2.2 Hindcast Skill

Table 2 shows the degree of hindcast variance explained by our new 1 December forecast scheme based on our 52-year developmental dataset between 1950-2001. To reduce overfitting, the 1 December forecast picks the best combination of five predictors from a pool of six predictors or until the jackknife variance explained no longer increases.

Table 2: Variance explained based upon 52 years (1950-2001) of hindcasting.

Variables Selected	Variance (r^2) Explained	Jackknife (r^2)
NS - 1, 2, 3	0.40	0.29
NSD - 1, 3, 4, 5, 6	0.45	0.28
H - 1, 2, 3, 4, 5	0.53	0.38
HD - 1, 2, 3, 4, 5	0.53	0.35
IH - 1, 2, 3, 4, 5	0.69	0.57
IHD - 1, 3, 4, 5, 6	0.51	0.41
NTC - 1, 3, 4, 5, 6	0.62	0.46

3 Analog Based Predictors for 2005 Hurricane Activity

Certain years in the historical record have global oceanic and atmospheric trends which are substantially similar to 2004/2005. These years also provide useful clues as to likely trends in activity that the forthcoming 2005 hurricane season may bring. For this (1 December) extended range forecast, we project atmospheric and oceanic conditions for August through October 2005 and determine which of the prior years in our database have distinct trends in key environmental conditions which are similar to current October-November 2004 conditions. Table 3 lists our analog selections.

We select prior hurricane seasons since 1949 which have similar atmospheric/oceanic conditions to those currently being experienced. Analog years for 2005 were selected primarily on how similar they are to conditions currently observed such as anomalously warm tropical and north Atlantic sea surface temperatures and weak El Niño conditions.

There were four hurricane seasons since 1949 with characteristics similar to what we observe in November 2004. The best analog years that we could find for the 2005 hurricane season are 1952, 1958, 1970, and 2003 (Table 3). We anticipate that 2005 seasonal hurricane activity will be about as active as the average values for these four analog years. Thus, based on this analog analysis, we expect 2005 to have slightly above-average activity.

Table 3: Best analog years for 2005 with the associated hurricane activity listed for each year.

	NS	NSD	H	HD	IH	IHD	NTC
1952	7	40	6	23	3	4.00	93
1958	10	56	7	30	4	8.25	133
1970	10	23	5	7	2	1.00	62
2003	16	75	7	33	3	16.75	173
Mean	10.8	48.5	6.3	23.3	3.0	7.5	115.3
2005 Forecast	11	55	6	25	3	6	115

4 ENSO

We do not anticipate a significant El Niño event that would bring about a large reduction in Atlantic basin hurricane activity in 2005. We expect that there will be continued warm water temperatures near the dateline in the equatorial Pacific (Nino 4 region) and some slight warming in the Nino 3.4, Nino 3 and Nino 1-2 regions. Except for very strong El Niño events such as 1957, 1972, 1982-1983, 1986-1987 and 1997, El Niños do not necessarily dominate Atlantic basin hurricane activity. Other global ocean/atmosphere parameters play an important role in regulating Atlantic tropical cyclones. For example, 1953, 1958, 1963, 1969 and 1979 were all weak to moderate El Niño years but had average to above-average hurricane activity. Our 1 December statistical forecast scheme does not contain an explicit El Niño prediction; however, its effects are implicit in several of the predictors. Little skill has been shown in long-range El Niño prediction, and there is a wide range in current El Niño predictions for August-October 2005.

5 Adjusted 2005 Forecast

Table 4 shows our final adjusted 1 December forecast for the 2005 season which is a combination of our derived full 52-year statistical forecast, our analog forecast and qualitative adjustments for other factors not explicitly contained in either scheme. We foresee a slightly above-average 2005 hurricane season. We anticipate that ENSO conditions will not play a strong inhibiting role and that warm sea surface temperatures will continue to be present in the North and tropical Atlantic. We do not expect the 2005 hurricane season to be as active as the 2004 season has been.

Table 4: Summary of our new 1 December statistical forecast, our analog forecast, and our adjusted final forecast for the 2005 hurricane season.

Forecast Parameter and 1950-2000 Climatology (in parentheses)	New Statistical Scheme	Analog Scheme	Adjusted Final Forecast

Named Storms (9.6)	9.5	10.8	11
Named Storm Days (49.1)	45.5	48.5	55
Hurricanes (5.9)	6.0	6.3	6
Hurricane Days (24.5)	23.2	23.3	25
Intense Hurricanes (2.3)	1.5	3.0	3
Intense Hurricane Days (5.1)	4.2	7.5	6
Net Tropical Cyclone Activity (100%)	91.8	115.3	115

6 Skill and Verification of 1 December Forecasts

We define forecast skill as the degree to which we are able to predict the variation of seasonal hurricane activity parameters from their long-term climatology. The latter is expressed as the ratio of our forecast error to the observed difference from climatology or:

Forecast Error/Seasonal Difference from Climatology

For example, if there were a year with five more tropical storms than average and we had predicted two more storms than average, we would give ourselves a skill score of 2 over 5 or 40 percent. By this measure, each of the eight parameters of our seasonal forecasts have shown some degree of forecast skill from 1 December. Table 5 shows our average skill score based on 52 years of hindcasts from 1950-2001, and Table 6 displays our skill score in real-time forecasting for the last six years. All parameters of our real-time forecasts have shown skill from 1 December.

Table 5: Average percent of variation of 1 December hindcasts from climatology (in percent) for the 52-year period 1950-2001. A value of 40 means that we hindcast 40 percent of the variability from climatology or that we were unable to explain 60 percent of the variability from climatology.

Tropical Cyclone Parameter	Early December
NS	31
NSD	29
H	35
HD	37
IH	41
IHD	29
NTC	44

Table 6: Last six years' (1999-2004) average percent of variation of our 'real-time' forecasts issued on 1 December from climatology (in percent). A value of 30 means that we have predicted 30 percent of

the variability from climatology or that we were unable to explain 70 percent of the variability from climatology.

Tropical Cyclone Parameter	Early December
NS	30
NSD	25
H	11
HD	25
IH	18
IHD	20
NTC	27

Another way to consider the skill of our forecasts is to evaluate whether the forecast for each parameter successfully forecast above- or below-average activity. Table 7 displays how frequently our forecasts have been on the right side of climatology in hindcasts from 1950-2001 and in real-time forecasts for the past six years (1999-2004). Note that our forecasts have been successful at determining whether various hurricane parameters will be above- or below-average over 70% of the time at the extended lead time of 1 December in both hindcasts and real-time forecasts.

Table 7: The number of years that our tropical cyclone forecasts issued on 1 December have correctly predicted above- or below-average activity for each predictand in (A) hindcast mode (1950-2001) from Klotzbach and Gray (2004) and in (B) real-time forecast mode (1999-2004).

Tropical Cyclone Parameter	(A) Hindcast	(B) Forecast
NS	39/52	5/6
NSD	42/52	5/6
H	40/52	4/6
HD	37/52	4/6
IH	40/52	4/6
IHD	39/52	4/6
NTC	44/52	4/6
Total	281/364	30/42
Correct Prediction of Above or Below Climatology	77%	71%

Of course there are significant amounts of unexplained variance in a number of the individual parameter forecasts. Even though the skill for some of these parameter forecasts is quite low, there is a great curiosity in having some objective measure as to how active the coming hurricane season is likely to be. Therefore, even a forecast that has shown to be only modestly skillful in past years should be considered worthwhile for application when nothing else is available but climatology.

7 Landfall Probabilities for 2005

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.

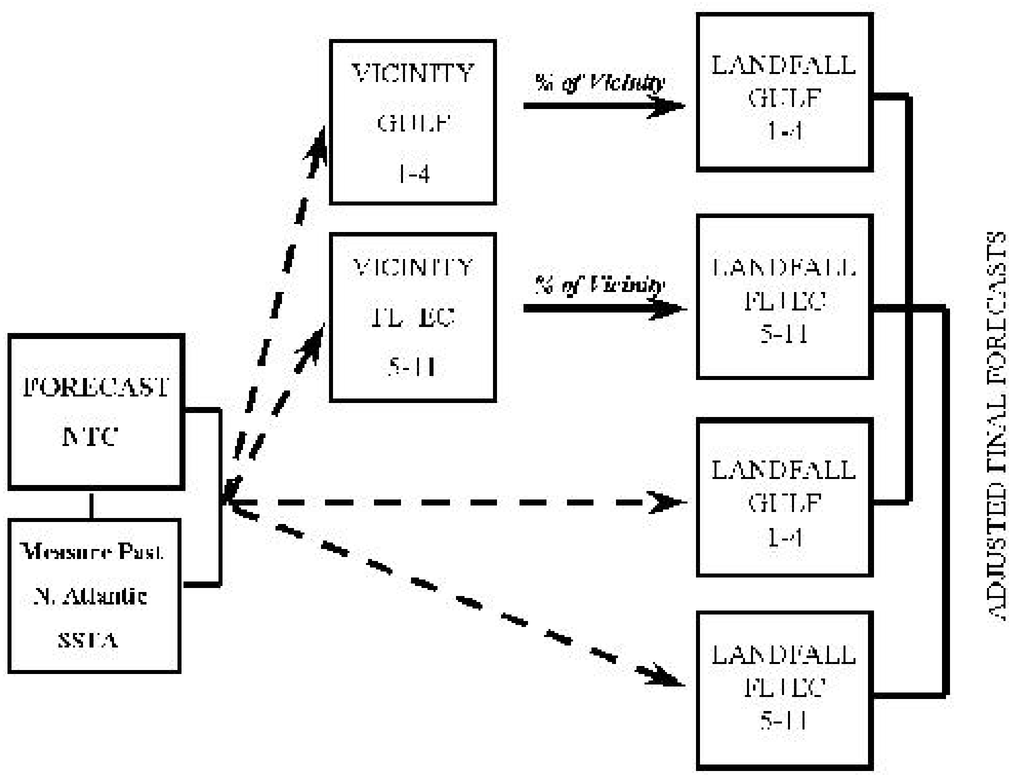

Figure 2: Flow diagram illustrating how forecasts of U.S. hurricane landfall probabilities are made. Forecast NTC values and an observed measure of recent North Atlantic (50-60˚N, 10-50˚W) SSTA*

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).

Figure 2 provides a flow diagram showing how these forecasts are made. Net landfall probability is shown linked to the overall Atlantic basin Net Tropical Cyclone activity (NTC; see Table 8) and to climate trends linked to multi-decadal variations of the Atlantic Ocean thermohaline circulation as inferred from recent past years of North Atlantic SSTA*.

Higher values of SSTA* generally indicate greater Atlantic hurricane activity, especially for intense or major hurricanes. Atlantic basin NTC can be skillfully hindcast, and the strength of the Atlantic Ocean thermohaline circulation can be inferred from the value of SSTA* which is North Atlantic SST anomalies (in the region 50-60°N, 10-50°W) from current and prior years. See our previous papers (located online at http://hurricane.atmos.colostate.edu/Forecasts) for further discussion of SSTA*. The forecast relationship we use to make probability estimates for U.S. landfall is as follows:

Landfall Probability = Forecast NTC + Measured SSTA* **(1)**

The current (November 2004) value of SSTA* is 62. Hence, in combination with a prediction of NTC of 115 for 2005, a combination of NTC + SSTA* of (115 + 62) 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. 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) increased NTC and (2) above-average North Atlantic SSTA* conditions.

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: 10/9.6 = 104, 50/49.1 = 102, 6/5.9 = 102, 25/24.5 = 102, 3/2.3 = 130, 5/5.0 = 100, divided by six, yielding an NTC of 107.

		1950-2000 Average
1)	Named Storms (NS)	9.6
2)	Named Storm Days (NSD)	49.1
3)	Hurricanes (H)	5.9
4)	Hurricane Days (HD)	24.5
5)	Intense Hurricanes (IH)	2.3

6) Intense Hurricane Days (IHD) 5.0

Table 9 lists strike probabilities for the 2005 hurricane season for different TC categories for the entire U.S. coastline, the Gulf Coast and the East Coast including the Florida peninsula. The mean annual probability of one or more landfalling systems is given in parentheses. Note that Atlantic basin NTC activity in 2005 is expected to be greater than the long-term average of 100, and North Atlantic SSTA* values are measured to be well above average (62 units). The long-period SSTA* average is 0. During periods of positive North Atlantic SSTA, a higher percentage of Atlantic basin major hurricanes cross the Florida and eastern U.S. coastline for a given level of NTC. U.S. hurricane landfall probability is thus expected to be above average owing to both above-average NTC and above-average North Atlantic SSTAs.

Please visit our web site at http://www.e-transit.org/hurricane for landfall probabilities for 11 U.S. coastal regions, 96 subregions and 205 coastal and near-coastal counties from Brownsville, Texas to Eastport, Maine.

Table 9: 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 2005. 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)	80% (68)	69% (52)	94% (84)	99% (97)
Gulf Coast (Regions 1-4)	67% (59)	52% (42)	39% (30)	71% (61)	90% (83)
Florida plus East Coast (5-11)	57% (51)	57% (45)	49% (31)	79% (62)	91% (81)

8 Increased Major Hurricane Activity Since 1995

A major reconfiguration of the distribution of Atlantic SST anomalies began in mid-1995 and has largely persisted to the present. North Atlantic SSTs have become about 0.4 to 0.6˚C warmer than normal since 1995, and tropical Atlantic August-October upper tropospheric 200 mb winds have increased from the east. This has brought about a significant decrease in tropospheric vertical wind shear. Low-level horizontal wind shear along the Atlantic equatorial trough (ITCZ) has also increased. It was the strengthening of the Atlantic Ocean thermohaline circulation (THC) which led to these Atlantic basin changes. This interpretation is consistent with changes in a long list of global atmospheric circulation features during the last ten years which conform to a prominent shift into hurricane-enhancing Atlantic circulation patterns, particularly the enhancement of major hurricane activity. Table 10 displays tropical cyclone activity from 1995-2004 compared with climatology and the earlier quarter-century period from 1970-1994. Activity has increased for all tropical cyclone activity parameters and especially for intense hurricanes. Historical and geographic evidence going back thousands of years indicates that shifts in the Atlantic multi-decadal thermohaline circulation tend to occur on periods of about 25-50 years. If the recent ten-year shift follows prior occurrences, it is likely that enhanced Atlantic basin major hurricane activity will persist through the early decades of the 21st century in contrast with the diminished major hurricane activity that was present from 1970-1994. We expect that the hurricane season of 2005 will follow, although with somewhat less intensity, this recent 10-year upswing in hurricane activity. Our recent 2004 forecast verification paper has more discussion on this topic. It is available on our website: http://hurricane.atmos.colostate.edu/Forecasts

Table 10: Comparison of the last ten years of Atlantic basin hurricane activity (1995-2004) with climatology (1950-2000) and with the 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)
1995	19	121	11	60	5	11.75	221
1996	13	79	9	45	6	13.00	192
1997	**7**	**29**	**3**	**10**	**1**	**2.25**	**52**
1998	14	88	10	49	3	9.50	169
1999	12	79	8	41	5	14.25	182
2000	14	68	8	33	3	5.00	131
2001	15	64	9	26	4	4.25	134
2002	**12**	**55**	**4**	**11**	**2**	**3.00**	**80**
2003	16	80	7	33	3	16.75	173
2004	14	89	9	45	6	23.00	231
Ten-Year Average 1995-2004	13.6	75.2	7.8	35.3	3.8	10.3	156.5
Ratio 1995-2004/ Climatology	142	153	132	144	165	206	157
Ratio 1995-2004/ 1970-1994	136	191	132	219	239	346	209

Bold Face denotes El Niño Years

9 The 1995-2004 Upswing in Atlantic Hurricanes and Global Warming

Many individuals have queried whether the unprecedented landfall of four destructive hurricanes in a seven-week period is related in any way to human-induced climate changes. There is no evidence that this is the case. If global warming were the cause of the increase in United States hurricane landfalls in 2004 and the overall increase in Atlantic basin major hurricane activity of the past nine years (1995-2003), one would expect to see an increase in tropical cyclone activity in the other storm basins as well (ie., West Pacific, East Pacific, Indian Ocean, etc.). This has not occurred. When tropical cyclones worldwide are summed, there has actually been a slight decrease since 1995. In addition, it has been well-documented that the measured global warming of about 0.5˚C during the 25 -year period of 1970-1994 was accompanied by a downturn in Atlantic basin hurricane activity.

We attribute the heightened Atlantic major hurricane activity of 2004 season as well as the increased Atlantic major hurricane activity of the previous nine years to be a consequence of the multidecadal fluctuations in the Atlantic Ocean thermohaline circulation (THC) as we have been discussing in our Atlantic basin seasonal hurricane forecasts for several years. Major hurricane activity in the Atlantic has been shown to undergo marked multidecadal fluctuations that are directly related to North Atlantic sea surface temperature anomalies. When the Atlantic Ocean thermohaline circulation is running strong, the central Atlantic equatorial trough (ITCZ) becomes stronger. The stronger the Atlantic equatorial trough becomes, the more favorable are conditions for the development of major hurricanes in the central Atlantic. Since 1995, the THC has been flowing more strongly, and there has been a concomitant increase in Atlantic major hurricanes in the tropical Atlantic. Even though the 2004 hurricane season has been quite active, it is only somewhat more active than seven of the past nine hurricane seasons (1995-1996, 1998-2001, 2003). It was the environmental steering currents that drove four of the six major hurricanes of 2004 on such long, low-latitude westerly tracks that made this season so special. The very damaging Atlantic 2004 hurricane season this year was simply a low probability event resulting from unusual natural variability in the ocean-atmosphere system. Similarly, the ten typhoons that struck Japan this year were also a rare statistical event that was in part a consequence of the anomalously warm tropical central Pacific sea surface temperatures and a weaker-than-normal West Pacific subtropical anticyclone. This caused a high percentage of West Pacific typhoons that formed in the central Pacific to be steered toward the Japanese Islands. Such high U.S. and Japan landfalls events this year should in no way be associated with the human-induced global warming hypothesis.

10 Forecast Theory and Cautionary Note

Our forecasts are based on the premise that those global oceanic and atmospheric conditions which preceded comparatively active or inactive hurricane seasons in the past provide meaningful information about similar trends in future seasons. 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. The probability of landfall for any one location along the coast is very low and reflects 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 landfall probability does not insure that hurricanes will not come ashore. Regardless of how active the 2005 hurricane season is, a finite probability always exists that one or more hurricanes may strike along the US coastline or the Caribbean Basin and do much damage.

11 Forthcoming Update Forecasts of 2005 Hurricane Activity

We will be issuing seasonal updates of our 2005 Atlantic basin hurricane activity forecast on Friday 1 April, Tuesday 31 May (to coincide with the official start of the 2005 hurricane season on 1 June), Friday 5 August, Friday 2 September and Monday 3 October 2005. The 5 August, 2 September and 3 October forecasts will include separate forecasts of August-only, September-only and October-only Atlantic basin tropical cyclone activity. A verification and discussion of all 2005 forecasts will be issued in late November 2005. Our first seasonal hurricane forecast for the 2006 hurricane season will be issued in early December 2005. All these forecasts will be available at our web address given on the front cover:
(http://hurricane.atmos.colostate.edu/Forecasts).

12 Acknowledgments

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13 Citations and Additional Reading

14 Verification of Previous Forecasts

Table 14: Summary verification of the authors' six previous years of seasonal forecasts for Atlantic TC activity between 1999-2004. Verification of our earlier year forecasts for the years 1984-1998 are given in our late November seasonal verifications (on this Web location).

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 (NTC) 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	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 (NTC) Activity	125	125	160	130	134

2001	**7 Dec 2000**	**Update 6 April**	**Update 7 June**	**Update 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	63
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 (NTC) Activity	90	100	120	120	142

2002	**7 Dec 2001**	**Update 5 April**	**Update 31 May**	**Update 7 August**	**Update 2 Sept**	**Obs.**
No. of Hurricanes	8	7	6	4	3	4
No. of Named Storms	13	12	11	9	8	12
No. of Hurricane Days	35	30	25	12	10	11
No. of Named Storm Days	70	65	55	35	25	54
Hurr. Destruction Potential(HDP)	90	85	75	35	25	31
Major Hurricanes (Cat. 3-4-5)	4	3	2	1	1	2
Major Hurr. Days	7	6	5	2	2	2.5
Net Trop. Cyclone (NTC) Activity	140	125	100	60	45	80

2003	6 Dec 2002	Update 4 April	Update 30 May	Update 6 August	Update 3 Sept	Update 2 Oct	Obs.
No. of Hurricanes	8	8	8	8	7	8	7
No. of Named Storms	12	12	14	14	14	14	16
No. of Hurricane Days	35	35	35	25	25	35	33
No. of Named Storm Days	65	65	70	60	55	70	75
Hurr. Destruction Potential(HDP)	100	100	100	80	80	125	131
Major Hurricanes (Cat. 3-4-5)	3	3	3	3	3	2	3
Major Hurr. Days	8	8	8	5	9	15	16.75
Net Trop. Cyclone (NTC) Activity	140	140	145	120	130	155	173

2004	5 Dec 2003	Update 2 April	Update 28 May	Update 6 August	Update 3 Sept	Update 1 Oct	Obs.
No. of Hurricanes	7	8	8	7	8	9	9
No. of Named Storms	13	14	14	13	16	15	15
No. of Hurricane Days	30	35	35	30	40	52	45
No. of Named Storm Days	55	60	60	55	70	96	91
Major Hurricanes (Cat. 3-4-5)	3	3	3	3	5	6	6
Major Hurr. Days	6	8	8	6	15	23	23
Net Trop. Cyclone (NTC) Activity	125	145	145	125	185	240	233

Footnotes:

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