EXTENDED RANGE FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY, INDIVIDUAL MONTHLY ACTIVITY AND U.S. LANDFALL STRIKE PROBABILITY FOR 2006

We foresee an active Atlantic basin tropical cyclone season in 2006; however, we have reduced our projection for 2006 hurricane activity from our earlier forecasts. Landfall probabilities for the 2006 hurricane season are projected to be above their long-period averages for the East Coast and near their long-period averages for the Gulf Coast.

(as of 3 August 2006)

By Philip J. Klotzbach[1] and William M. Gray[2]

with special assistance from William Thorson[3]

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

Emily Wilmsen, Colorado State University Media Representative, (970-491-6432) is available to answer various questions about this forecast

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ATLANTIC BASIN SEASONAL HURRICANE FORECAST FOR 2006

Forecast Parameter and 1950-2000 Climatology (in parentheses)	Issue Date 6 Dec 2005	Issue Date 4 April 2006	Issue Date 31 May 2006	Observed Activity Through July 2006	Forecast Activity After 1 August	Total Seasonal Forecast
Named Storms (NS) (9.6)	17	17	17	2	13	15
Named Storm Days (NSD) (49.1)	85	85	85	5.5	69.5	75
Hurricanes (H) (5.9)	9	9	9	0	7	7
Hurricane Days (HD) (24.5)	45	45	45	0	35	35
Intense Hurricanes (IH) (2.3)	5	5	5	0	3	3
Intense Hurricane Days (IHD) (5.0)	13	13	13	0	8	8
Net Tropical Cyclone Activity (NTC) (100%)	195	195	195	6	134	140

POST 1-AUGUST PROBABILITIES FOR AT LEAST ONE MAJOR (CATEGORY 3-4-5) HURRICANE LANDFALL ON EACH OF THE FOLLOWING COASTAL AREAS:

1) Entire U.S. coastline - 73% (average for last century is 52%)

2) U.S. East Coast Including Peninsula Florida - 64% (average for last century is 31%)

3) Gulf Coast from the Florida Panhandle westward to Brownsville - 26% (average for last century is 30%)

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

Notice of Author Changes

By William Gray

The order of the authorship of these forecasts has been reversed from Gray and Klotzbach to Klotzbach and Gray. After 22 years (since 1984) of making these forecasts, it is appropriate that I step back and have Phil Klotzbach assume the primary responsibility for our project's seasonal, monthly and landfall probability forecasts. Phil has been a member of my research project for the last five years and has been second author on these forecasts for the last four years. I have greatly profited and enjoyed our close personal and working relationships.

Phil is now devoting more time to the improvement of these forecasts than I am. I am now giving more of my efforts to the global warming issue and in synthesizing my projects' many years of hurricane and typhoon studies.

Phil Klotzbach is an outstanding young scientist with a superb academic record. I have been amazed at how far he has come in his knowledge of hurricane prediction since joining my project five years ago. I foresee an outstanding future for him in the hurricane field. I expect he will make many new forecast innovations and skill improvements in the coming years. I plan to continue to be closely involved in the issuing of these forecasts for the next few years.

ABSTRACT

Information obtained through July 2006 indicates that the 2006 Atlantic hurricane season will be more active than the average 1950-2000 season; however, we have reduced our prediction from our earlier forecasts. We estimate that 2006 will have about 7 hurricanes (average is 5.9), 15 named storms (average is 9.6), 75 named storm days (average is 49.1), 35 hurricane days (average is 24.5), 3 intense (Category 3-4-5) hurricanes (average is 2.3) and 8 intense hurricane days (average is 5.0). The probability of U.S. major hurricane landfall is estimated to be about 40 percent above the long-period average. Landfall probabilities are based upon our expectation for another active season as well as analysis of our new steering current predictors for the East Coast and Gulf Coast of the United States.

We expect Atlantic basin Net Tropical Cyclone (NTC) activity in 2006 to be about 140 percent of the long-term average. This early August forecast is based on a newly devised extended range statistical forecast procedure which utilizes 57 years of past global reanalysis data. Analog predictors are also utilized. This 3 August forecast reduces our forecast from our early December 2005, early April 2006 and late May 2006 predictions due to small changes in June-July atmospheric and oceanic fields that indicate conditions are less favorable for tropical cyclone development in the tropical Atlantic. These changes include above-average tropical Atlantic sea level pressure, above-average tropical Atlantic trade wind strength and a decreasing trend in tropical Atlantic sea surface temperatures. Sea surface temperatures have also risen slightly in the eastern equatorial Pacific. We expect an active hurricane season for the Atlantic basin, but we do not foresee nearly as active a season as was experienced in 2004 and 2005. Seasonal updates of our 2006 forecast will be issued on 1 September and 3 October. A seasonal summary and forecast verification will be issued in late November.

Acknowledgment

We are grateful to the National Science Foundation (NSF) and Lexington Insurance Company (a member of the American International Group (AIG)) for providing partial support for the research necessary to make these forecasts. We also thank the GeoGraphics Laboratory at Bridgewater State College (MA) for their assistance in developing the Landfalling Hurricane Probability Webpage (available online at http://www.e-transit.org/hurricane).

The second author gratefully acknowledges valuable input to his CSU research project over many years by former graduate students and now colleagues Chris Landsea, John Knaff and Eric Blake. We also thank Professors Paul Mielke and Ken Berry of Colorado State University for much statistical analysis and advice over many years.

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 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 sustained low-level winds of at least 111 mph (96 knots 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 an intensity of Saffir/Simpson category 3 or higher.

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.

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.

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

QBO – Quasi-Biennial Oscillation – A stratospheric (16 to 35 km altitude) oscillation of equatorial east-west winds which vary with a period of about 26 to 30 months or roughly 2 years; typically blowing for 12-16 months from the east, then reversing 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, five is the most intense hurricane.

SLPA – Sea Level Pressure Anomaly – The deviation of 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.

ZWA – Zonal Wind Anomaly – A measure of the 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 = 0.515 meters per second

1 Introduction

This is the 23rd year in which the CSU Tropical Meteorology Project has made forecasts of the upcoming season's Atlantic basin hurricane activity. Our forecast 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 57 years of past data and a separate study of analog years which have similar precursor circulation features to the current season. 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 associated with the forthcoming seasonal Atlantic basin tropical cyclone activity and landfall probability. We believe that seasonal forecasts must be based on methods that show 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 that the atmosphere continues to behave in the future as it has in the past.

A variety of atmosphere-ocean conditions interact with each other to cause year-to-year and month-to-month hurricane variability. The interactive physical linkages between these many physical parameters and hurricane variability are complicated and cannot be well elucidated to the satisfaction of the typical forecaster making short range (1-5 days) predictions where changes in the momentum fields are the crucial factors. Seasonal and monthly forecasts, unfortunately, must deal with the much more complicated interaction of the energy-moisture fields with the momentum fields.

We find that there is a rather high (50-60 percent) degree of year-to-year hurricane forecast potential if one combines 4-5 semi-independent atmospheric-oceanic parameters together. The best predictors (out of a group of 4-5) do not necessarily have the best individual correlations with hurricane activity. The best forecast parameters are those that explain the portion of the variance of seasonal hurricane activity that is not associated with the other variables. It is possible for an important hurricane forecast parameter to show little direct relationship to a predictand by itself but to have an important influence when included with a set of 4-5 other predictors.

In a five-predictor empirical forecast model, the contribution of each predictor to the net forecast skill can only be determined by the separate elimination of each parameter from the full five predictor model while noting the hindcast skill degradation. When taken from the full set of predictors, one parameter may degrade the forecast skill by 25-30 percent, while another degrades the forecast skill by only 10-15 percent. An individual parameter that, through elimination from the forecast, degrades a forecast by as much as 25-30 percent may, in fact, by itself, show much less direct correlation with the predictand. A direct correlation of a forecast parameter may not be the best measure of the importance of this predictor to the skill of a 4-5 parameter forecast model. This is the nature of the seasonal or climate forecast problem where one is dealing with a very complicated atmospheric-oceanic system that is highly non-linear. There is a maze of changing physical linkages between the many variables. These linkages can undergo unknown changes from weekly to decadal time scales. It is impossible to understand how all these processes interact with each other. It follows that any seasonal or climate forecast scheme showing significant hindcast skill must be empirically derived. No one can completely understand the full complexity of the atmosphere-ocean system or develop a reliable scheme for forecasting the myriad non-linear interactions in the full-ocean atmosphere system.

2 Newly-Developed 1 August Forecast Scheme

We have recently developed a new 1 August statistical seasonal forecast scheme for prediction of Net Tropical Cyclone (NTC) activity. This scheme was developed on NOAA/NCEP reanalysis data from 1949-1989. It was then tested on independent data from 1990-2005 to insure that the forecast shows similar skill in this later forecast period. As a rule, predictors were only added to the scheme if they explained an additional three percent of the variance of NTC in both the dependent period (1949-1989) and the independent period (1990-2005)

The pool of four predictors for this new extended range forecast is given and defined in Table 1. The location of each of these new predictors is shown in Fig. 1. Strong statistical relationships can be extracted via combinations of these predictive parameters (which are available by the end of July), and quite skillful Atlantic basin forecasts of NTC activity for the season can be made if the atmosphere and ocean continue to behave in the future as they have during the hindcast period of 1949-2005. Sixty percent of the variance in NTC is explained over the 1949-2005 period, and on independent data (1900-1948), using the same equations and predictors, 49 percent of the variance is explained. This is comparable to what would be expected with independent data as a jackknife regression technique on the 1949-2005 period indicated 52 percent of the variance could be explained. This gives us increased confidence that the new statistical scheme should be of considerable value in the future.

Our statistical forecast for the other predictors (i.e., named storms, hurricanes) is then adjusted by the predicted statistical value of NTC. For example, if a typical season has 10 named storms and the predicted NTC value is 120%, the predicted number of named storms for the season would be 12 (10 * 120%).

August Seasonal Forecast Predictors

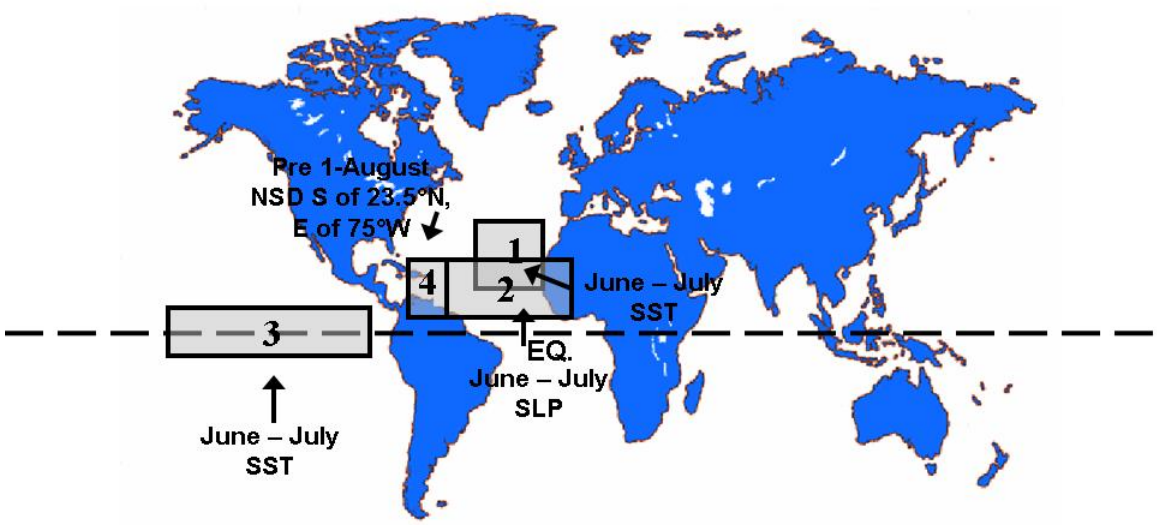

Figure 1: Location of predictors for the 1 August forecast for the 2006 hurricane season.

Table 1: Listing of 1 August 2006 predictors for this year's hurricane activity. A plus (+) means that positive values of the parameter indicate increased hurricane activity this year, and a minus (-) means that positive values of the parameter indicate decreased hurricane activity this year. The combination of these four predictors calls for about an average hurricane season.

Predictor	Values for 2006 Forecast
1) June-July SST (20-40°N, 15-35°W) (+)	+0.8 SD
2) June-July SLP (10-25°N, 10-60°W) (-)	+0.3 SD
3) June-July NINO3 Index (5°S-5°N, 90-150°W) (-)	+0.3 SD
4) Pre-1 August Named Storm Days – South of 23.5°N, East of 75°W	0

Table 2 shows our statistical forecast for the 2006 hurricane season and the comparison of this forecast with climatology (average season between 1950-2000). Our statistical forecast is calling for about average activity this year, which adds additional support for the reduction of our forecast from our previous early-season predictions.

Table 2: 1 August statistical forecast for 2006.

Predictands and Climatology	Statistical Forecast Numbers
Named Storms (NS) – 9.6	10.0
Named Storm Days (NSD) – 49.1	51.1
Hurricanes (H) – 5.9	6.1
Hurricane Days (HD) – 24.5	25.5
Intense Hurricanes (IH) – 2.3	2.4
Intense Hurricane Days (IHD) – 5.0	5.2
Net Tropical Cyclone Activity (NTC) – 100	104

2.1 Physical Associations among Predictors Listed in Table 1

Brief descriptions of our 1 August predictors follow:

Predictor 1. June-July SST in the Northeastern Subtropical Atlantic (+)

(20°-40°N, 15-35°W)

Warm sea surface temperatures in this area in June-July correlate very strongly with anomalously warm sea surface temperatures in the tropical Atlantic throughout the upcoming hurricane season. Anomalously warm sea surface temperatures are important for development and intensification of tropical cyclones by infusing more latent heat into the system (Goldenberg and Shapiro 1998). In addition, associated with anomalously warm June-July SSTS are weaker trade winds. Weaker trade winds cause less evaporation and upwelling of the sea surface which therefore feeds back into keeping the tropical Atlantic warm. In addition, weaker trade winds imply that there is less vertical wind shear across the tropical Atlantic. Weak wind shear is favorable for tropical cyclone development and intensification (Gray 1968, Gray 1984a, Goldenberg and Shapiro 1996, Knaff et al. 2004). Lastly, there is a strong positive correlation (~0.5) between anomalously warm June-July SSTs in the subtropical northeastern Atlantic and low sea level pressures in the tropical Atlantic and Caribbean during the heart of the hurricane season. Low sea level pressures imply decreased subsidence and enhanced mid-level moisture. Both of these conditions are favorable for tropical cyclogenesis and intensification (Knaff 1997).

Predictor 2. June-July SLP in the Tropical Atlantic (-)

(10-25°N, 10-60°W)

Low sea level pressure in the tropical Atlantic in June-July implies that early summer conditions in the tropical Atlantic are favorable for an active tropical cyclone season with increased vertical motion, decreased stability and enhanced mid-level moisture. There is a strong auto-correlation ($r > 0.5$) between June-July sea level pressure anomalies and August-October sea level pressure anomalies in the tropical Atlantic. Low sea level pressure in the tropical Atlantic also correlates quite strongly ($r > 0.5$) with reduced trade winds (weaker easterlies) and anomalously easterly upper-level winds (weaker westerlies). The combination of these two features implies weaker vertical wind shear and therefore more favorable conditions for tropical cyclone development in the Atlantic (Gray 1968, Gray 1984a, Goldenberg and Shapiro 1996).

Predictor 3. June-July Nino3 Index (-)

(5°S-5°N, 90-150°W)

Cool sea surface temperatures in the Nino3 region during June-July imply that a La Niña event is currently present. In general, positive or negative anomalies in the Nino3 region during the early summer persist throughout the remainder of the summer and fall. El Niño conditions shift the center of the Walker Circulation eastward which causes increased convection over the central and eastern tropical Pacific. This increased convection in the central and eastern Pacific manifests itself in anomalous upper-level westerlies across the Caribbean and tropical Atlantic, thereby increasing vertical wind shear and reducing Atlantic basin hurricane activity. The relationship between ENSO and Atlantic hurricane activity has been well-documented in the literature (e.g., Gray 1984a, Goldenberg and Shapiro 1996, Elsner 2003, Bell and Chelliah 2006).

Predictor 4. Named Storm Days South of 23.5°N, East of 75°W (+)

Most years do not have named storm formations in June and July in the tropical Atlantic; however, if deep tropical formations do occur, it indicates that a very active hurricane season is likely. For example, the six years with the most named storm days in the deep tropics in June and July (since 1949) are 1966, 1969, 1995, 1996, 1998 and 2005. All six of these seasons were very active. When storms form in the deep tropics in the early part of the hurricane season, it indicates that conditions are already very favorable for TC development. In general, the start of the hurricane season is restricted by thermodynamics (warm SSTs, unstable lapse rates), and therefore deep tropical activity early in the hurricane season implies that the thermodynamics are already quite favorable for TC development. Also, this predictor's correlation with seasonal NTC is 0.53 over the 1949-2005 period, and when tested on independent data (1900-1948), the correlation actually improves to 0.63, which gives us increased confidence in its use as a seasonal predictor.

2.2 Hindcast Skill

Table 3 shows the degree of hindcast variance (r^2) explained by our new 1 June forecast scheme based on our 41-year developmental dataset (1949-1989), our skill on the independent dataset (1990-2005), and our skill over the entire dataset (1949-2005).

Note that the scheme generally shows improved skill in the independent dataset, which lends increased confidence in its use.

Table 3: Variance (r^2) explained for our new 1 August forecast scheme for NTC in the developmental dataset (1949-1989), in the independent dataset (1990-2005), and over the entire dataset (1949-2005).

Variable	Variance (r^2) Explained Developmental Dataset (1949-1989)	Variance (r^2) Explained Independent Dataset (1990-2005)	Variance (r^2) Explained Entire Dataset (1949-2005)
NTC	0.52	0.76	0.60

3 Predictions of Individual Monthly Atlantic TC Activity for August, September and October

A new aspect of our climate research is the development of TC activity predictions for individual months. There are often monthly periods within active and inactive Atlantic basin hurricane seasons which do not conform to the overall season. For example, 1961 was an active hurricane season (NTC of 222), but there was no TC activity during August; 1995 had 19 named storms, but only one named storm developed during a 30-day period during the peak of the hurricane season between 29 August and 27 September. By contrast, the inactive season of 1941 had only six named storms (average 9.3), but four of them developed during September. During the inactive 1968 hurricane season, three of the eight named storms formed in June (June average is 0.5).

We have conducted new research to see how well various sub-season or individual monthly trends of TC activity can be forecast. This effort has recently been documented in papers by Blake and Gray (2004) for August and Klotzbach and Gray (2003) for September. These reports show that it is possible to develop skillful prediction schemes for August-only and September-only Atlantic basin tropical cyclone activity. We have also developed a separate October forecast scheme. On average, August, September, and October have about 26%, 48%, and 17% or 91% of the Atlantic basin's NTC activity. Initial August-only forecasts have now been made by Blake for the last six years (2000-2005), and the verification of these forecasts looks promising. The verification of the September-only and October-only forecasts also appears to show skill.

3.1 Independent August-Only Statistical Forecast

Figure 2 and Table 4 list the predictors used in the August-only hindcast (Blake and Gray 2004) for each of the seven different forecast parameters. The table also shows hindcast skill for the 51-year period 1950-2000, as well as the independent jackknife hindcast skill over this period. Table 5 gives the predictor values for August 2006. Table 6 gives our independent statistical prediction for August 2006. These predictors indicate well above-average activity for August 2006. The most skillful August predictors, in general, call for a very active month, so we are calling for considerable activity during the month.

Predictor Map

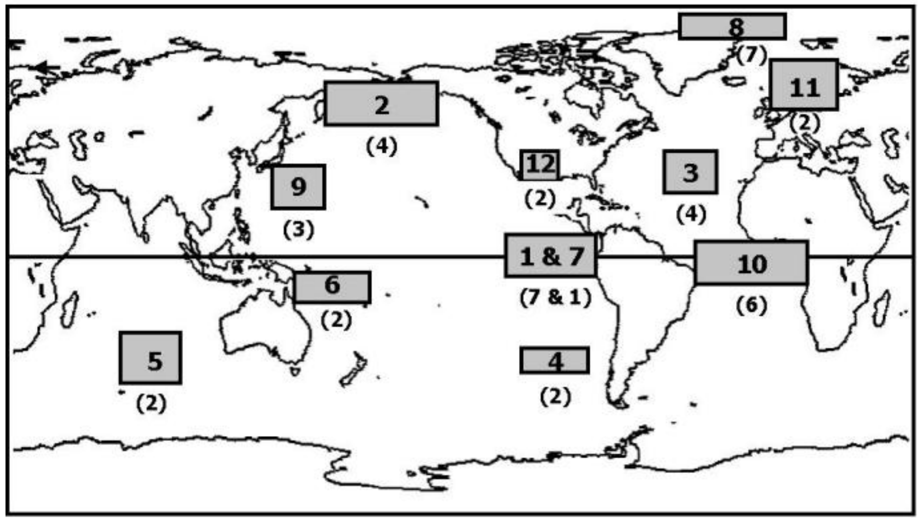

Figure 2: Global map showing locations of August-only TC predictors. Table 4 provides a listing and description of these predictors. The numbers in the boxes are keyed to the descriptions given in Table 4. The numbers in parentheses beneath each box indicate how many individual parameters (NS, NSD, etc.) are obtained from each predictor.

Table 4: Listing of predictors chosen for each forecast parameter and the total hindcast variance explained by these predictors for the August-only forecast. The name and atmospheric parameter utilized in each predictor is given below – where the number is keyed to Fig. 2.

Forecast Parameter	Number of Predictors	Predictors Chosen From Table	Variability Explained by Hindcast (r^2) (1949-1999)	Estimated Independent Forecast Skill (Jackknife)
NS	5	3, 6, 7, 9, 11	0.55	0.41
NSD	5	1, 2, 3, 8, 10	0.71	0.61
H	4	1, 2, 8, 10	0.57	0.47
HD	5	3, 4, 8, 9, 10	0.69	0.59
IH	5	1, 3, 5, 8, 12	0.68	0.59
IHD	5	1, 4, 5, 6, 9	0.78	0.72
NTC	5	1, 2, 8, 10, 12	0.74	0.66

Table 5: August 2006 predictors. The sign of the predictor associated with increased tropical cyclone activity is in parentheses.

Predictors	2006 Observed Values	Effect on 2006 Hurricane Season
Galapagos July 200 mb V (-)	-1.0 SD	**Enhance**
Bering Sea July SLP (-)	-1.0 SD	**Enhance**
Atlantic Ocean July SLP (-)	+0.8 SD	Suppress
SE Pacific July 200 mb U (-)	+0.2 SD	Suppress
S. Indian Ocean July 500 mb Geo Ht. (-)	+1.0 SD	Suppress
Coral Sea July 200 mb U (+)	+0.7 SD	**Enhance**
Galapagos July 200 MB U (-)	-0.5 SD	**Enhance**
North Greenland June 200 MB U (+)	+0.5 SD	**Enhance**
Northwest Pacific June SLP (+)	+1.0 SD	**Enhance**
S. Atlantic Ocean April SLP (-)	-0.6 SD	**Enhance**
Scandinavia February SLP (-)	+0.4 SD	Suppress
SW USA January SLP (-)	-1.0 SD	**Enhance**

Table 6: Independent August-only prediction of 2006 hurricane activity based on Blake and Gray (2004). August climatology is shown in parentheses.

Parameter	Statistical Model	Qualitative Adjustment
NS	3.3 (2.8)	4
NSD	21.1 (11.8)	22
H	2.9 (1.6)	3
HD	8.1 (5.7)	11
IH	0.7 (0.6)	1
IHD	2.0 (1.2)	3
NTC	53.6 (26.1)	50

3.2 Independent September-Only Statistical Forecast

Figure 3 and Table 7 list the predictors used in the September-only hindcast (Klotzbach and Gray 2003) for each of the seven different forecast parameters. The table also shows hindcast skill for the 51-year period 1950-2000, as well as the independent jackknife hindcast skill over this period. Table 8 gives the predictor values for September 2006. Table 9 gives our independent statistical prediction for September 2006. Predictor values for September 2006 are mixed, so our final forecast is calling for slightly above-average activity for the month.

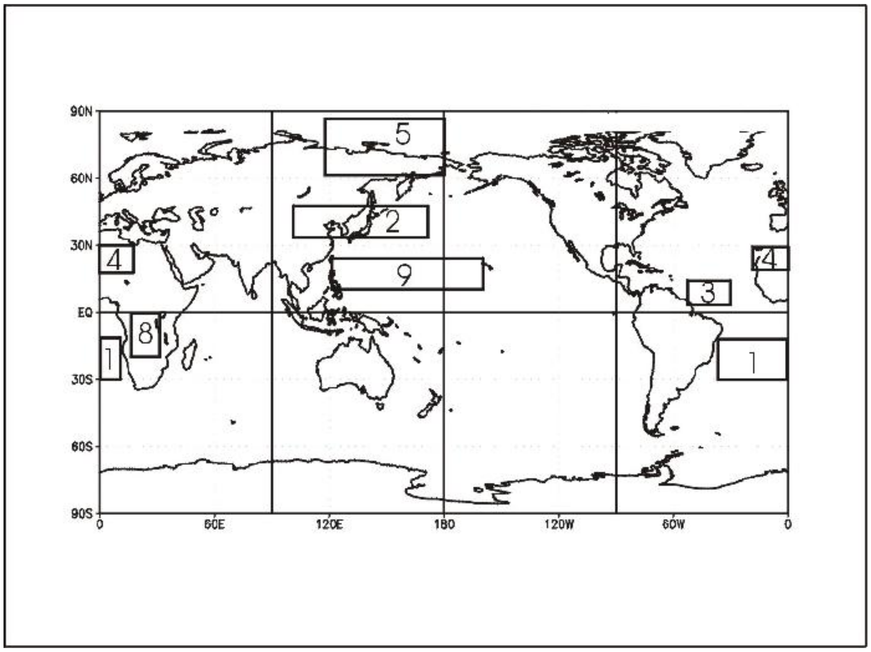

Figure 3: Predictors selected for the end of July forecast of September tropical cyclone activity. The numbers in each area are keyed to the description given in Table 7.

Table 7: Listing of predictors chosen for each forecast parameter and the total hindcast variance explained by these predictors for the September-only forecast. The name and atmospheric parameter utilized in each predictor is given below – where the number is keyed to Fig. 3.

Forecast Parameter	Number of Predictors	Predictors Chosen From Table	Variability Explained by Hindcast (r^2) (1950-2000)	Estimated Independent Forecast Skill (Jackknife)
NS	3	2, 3, 5	0.29	0.19
NSD	5	2, 3, 4, 5, 8	0.54	0.44
H	3	2, 3, 8	0.38	0.28
HD	5	2, 3, 4, 5, 8	0.60	0.51
IH	5	1, 2, 3, 5, 9	0.63	0.53
IHD	4	3, 4, 5, 9	0.63	0.54
NTC	5	2, 3, 4, 5, 9	0.75	0.68

Table 8: September 2006 predictors. The sign of the predictor associated with increased tropical cyclone activity is in parentheses.

Predictors	2006 Observed Values	Effect on 2006 Hurricane Season
South Atlantic April 1000 mb U (-)	-0.6 SD	**Enhance**
Northeast Asia July 200 mb Geo Ht. (+)	+1.3 SD	**Enhance**
Tropical Atlantic July 1000 MB U (+)	-0.8 SD	Suppress
West Africa February 1000 mb U (-)	+0.8 SD	Suppress
Northeast Siberia April 200 mb U (-)	-1.2 SD	**Enhance**
Central Africa May 200 mb V (+)	-1.4 SD	Suppress
West Pacific Jan-Feb 200 mb U (-)	+0.4 SD	Suppress

Table 9: Independent September-only prediction of 2006 hurricane activity based on Klotzbach and Gray (2003). September climatology is shown in parentheses.

Parameter	Statistical Model	Qualitative Adjustment
NS	4.1 (3.4)	5
NSD	20.8 (21.7)	25
H	2.2 (2.4)	3
HD	7.2 (12.3)	12
IH	1.8 (1.3)	2
IHD	1.5 (3.0)	4
NTC	48.3 (48.0)	60

3.3 Independent October-Only Statistical Forecast

Through examination of the NCEP/NCAR reanalysis, we have discovered four predictors that in combination explain about 50 percent of the October cross-validated variance in Net Tropical Cyclone activity for the hindcast period of 1950-2001. We are currently unable to find combinations of predictors that explain large amounts of variance for the individual tropical cyclone parameters (i.e., named storms, hurricane days, etc.). Therefore, our October forecast consists of predicting NTC and consequently increasing or decreasing October's values for the other parameters accordingly. For example, if October NTC was 150 percent of normal and a typical October had two named storms, we would forecast three named storms for October. The predictors utilized in our initial October prediction are displayed graphically in Figure 4. Table 10 gives the predictor values for October 2006. Table 11 gives our independent statistical prediction for October 2006. In general, predictors for October 2006 indicate slightly below-average activity for the month, and our final forecast for October 2006 is in line with our statistical prediction.

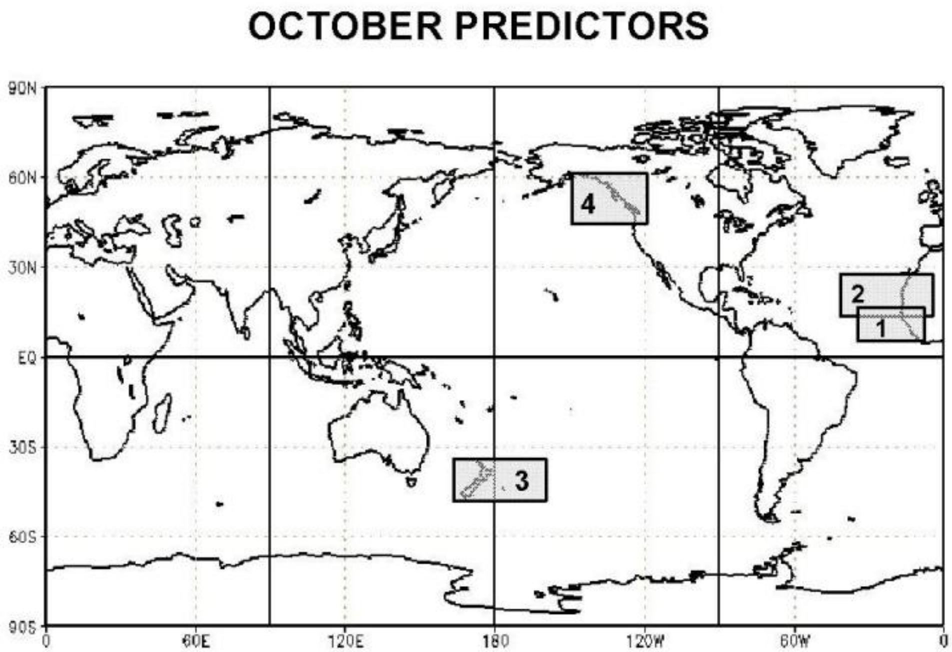

Figure 4: Location of 1 August predictors for October tropical cyclone activity.

Table 10: October 2006 predictors. The sign of the predictor associated with increased tropical cyclone activity is in parentheses.

Predictors	2006 Observed Values	Effect on 2006 Hurricane Season
Tropical Atlantic June-July SLP (-)	+0.5 SD	Suppress
Sub-Tropical Atlantic July 200 MB Ht. (+)	+1.1 SD	**Enhance**
South Pacific July 200 MB U (+)	-0.9 SD	Suppress
NW North America Previous Nov SLP (-)	0.0 SD	Neutral

Table 11: Independent October-only prediction of 2006 hurricane activity. October climatology is shown in parentheses.

Parameter	Statistical Model	Qualitative Adjustment
NS	1.4 (1.7)	2
NSD	7.3 (9.0)	11
H	0.9 (1.1)	1
HD	3.6 (4.4)	4
IH	0.2 (0.3)	0
IHD	0.6 (0.8)	0
NTC	14.6 (18.0)	15

3.4 Monthly Prediction Summary

Table 12 summarizes our individual monthly predictions and our monthly adjustments to these predictions. Based on jackknifed hindcast data from 1950-2000, the sum of the August, September, and October forecasts explains 79% of the variance in seasonal TC activity.

Table 12: August, September and October 2006 individual statistical model predictions and qualitative adjustments. The monthly climatology is given in parentheses.

Forecast Parameter	August Model Prediction	August Adjustment	September Model Prediction	September Adjustment	October Model Prediction	October Adjustment	3- Month Model Sum	3 – Month Adjusted Sum
NS	3.3 (2.8)	4	4.1 (3.4)	5	1.4 (1.7)	2	8.8	11
NSD	21.1 (11.8)	22	20.8 (21.7)	25	7.3 (9.0)	11	49.2	58
H	2.9 (1.6)	3	2.2 (2.4)	3	0.9 (1.1)	1	6.0	7
HD	8.1 (5.7)	11	7.2 (12.3)	12	3.6 (4.4)	4	18.9	27
IH	0.7 (0.6)	1	1.8 (1.3)	2	0.2 (0.3)	0	2.7	3
IHD	2.0 (1.2)	3	1.5 (3.0)	5	0.6 (0.8)	0	4.1	8
NTC	53.6 (26.1)	50	48.3 (48.0)	60	14.6 (18.0)	15	116.5	125

4 Analog-Based Predictors for 2006 Hurricane Activity

Certain years in the historical record have global oceanic and atmospheric trends which are substantially similar to 2006. These years also provide useful clues as to trends in activity that the upcoming 2006 hurricane season may bring. For this early August forecast, we project atmospheric and oceanic conditions for August through October 2006 and determine which of the prior years in our database have distinct trends in key environmental conditions which are similar to current June-July 2006 conditions. Table 13 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 2006 were selected primarily on how similar they are to conditions that are currently observed such as slightly above-average tropical and North Atlantic sea surface temperatures and neutral to slightly warm ENSO conditions.

There were five hurricane seasons since 1949 with characteristics similar to what we observed in June-July and what we project for August-October. The best analog years that we could find for the 2006 hurricane season are 1953, 1958, 1980, 2001 and 2003. We anticipate that 2006 will have comparable seasonal hurricane activity to what was experienced in the average of these five years. We believe that the 2006 Atlantic basin hurricane season will be somewhat above average.

Table 13: Best analog years for 2006 with the associated hurricane activity listed for each year.

Year	NS	NSD	H	HD	IH	IHD	NTC
1953	14	64.50	6	18.00	4	6.75	127
1958	10	55.50	7	30.25	5	9.50	144
1980	11	60.00	9	38.25	2	7.25	130
2001	15	64.25	9	25.50	4	4.25	134
2003	16	79.25	7	32.75	3	16.75	174
Mean	13.2	64.7	7.6	29.0	3.6	8.9	141
2006 Forecast	**15**	**75**	**7**	**35**	**3**	**8**	**140**

5 Comparison of Forecast Techniques

Table 14 provides a comparison of our statistical and analog forecast techniques along with the final adjusted forecast and climatology. Column 1 gives activity prior to 1 August. Column 2 gives the 3-month sum of our monthly forecasts. Column 3 is our adjusted final after 1 August forecast, Column 4 is our analog scheme, column 5 is the total season adjusted forecast and column 6 is the 1950-2000 climatology.

Table 14: Comparison of our post-1 August 2006 statistical and analog forecast techniques along with our final adjusted forecast and the 1950-2000 climatology.

Forecast Parameter	(1) Pre-1 Aug Activity	(2) Sum of 3 Individual Adjusted Monthly Forecasts	(3) After-1 Aug Adjusted Final Forecast	(4) Total Season Analog Forecast	(5) Total Season Adjusted Forecast	(6) 1950-2000 Climatology
NS	2	11	13	13.2	15	9.6
NSD	5.5	58	69.5	64.7	75	49.1
H	0	7	7	7.6	7	5.9
HD	0	27	35	29.0	35	24.5
IH	0	3	3	3.6	3	2.3
IHD	0	8	8	8.9	8	5.0
NTC	6	125	134	141	140	100

6 Discussion

6.1 Reasons for Reduction of the 2006 Hurricane Seasonal Forecast

We have reduced our forecast from our earlier predictions issued in early December, early April and late May. There have been no large changes in any particular atmospheric and oceanic predictor that have caused us to do this. There has, however, been a combination of changes in the ocean/atmosphere system that indicate to us that this season is no longer likely to be as active as our earlier predictions indicated.

Physical features which have become less favorable for an active hurricane season are as follows:

1) An increase in sea level pressure values in the tropical Atlantic. Higher sea level pressure values indicate increased stability in the tropical Atlantic which inhibits tropical cyclogenesis.

2) An increase in strength of the trade winds in the tropical Atlantic. Stronger trade winds drive increased evaporation and upwelling which cools Atlantic sea surface temperatures. In addition, stronger trades usually indicate increased vertical wind shear in the tropical Atlantic.

3) A decrease in tropical Atlantic sea surface temperatures. Cooler Atlantic SSTAs (sea surface temperature anomalies) provide less latent heat (i.e., less fuel) for developing tropical cyclones.

4) An increase in Pacific eastern equatorial SSTAs. Sea surface temperatures have still not reached El Niño levels; however, increased warming implies a shift in tropical convection towards the dateline. This eastward-shifted convection often increases vertical wind shear over the tropical Atlantic.

The fact that we have had only two tropical storms during June-July does not necessarily impact our forecast for the upcoming season. There have been many active hurricane seasons (e.g., 1950, 2004, etc.) that had no activity in June and July. Last year (2005) was an unusually active early season with seven named storms and two major hurricanes before August 1. Last year broke most existing single season hurricane records.

6.2 Brief Comments on the 2005 Hurricane Season

The year of 2005 was a very unusual year, not only for Atlantic hurricanes but also for other global circulation features. We consider 2005 to be within the range of natural variation. For example, 1933 had 21 named storms and would likely have had 4-5 more storms if satellite data had been available. Also, the tremendous economic damage from last year's storms would have been only about 30-50% as much if the levees in New Orleans had not been breached.

7 Post 1-August Landfall Probabilities for 2006

7.1 Introduction

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 20th century (1900-1999). Specific landfall probabilities can be given for all tropical cyclone intensity classes for a set of distinct U.S. coastal regions.

As shown in Table 15, 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 20th century show that a greater number of intense hurricanes strike the United States coastline in years of above-average NTC.

Table 15: 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

7.2 Steering Current Prediction

We have considerably improved the statistical skill of our landfall probability forecasts through the inclusion of three April-May predictors of mid-latitude steering flow for the Florida Peninsula and the East Coast and two predictors of mid-latitude steering flow for the Gulf Coast. Based on data from the NCEP/NCAR reanalysis, using a combination of our NTC forecast and the predictors listed in Tables 16 and 17 and displayed in Figures 5 and 6, we are able to hindcast approximately 30 percent of the variance in hurricane landfall for the Gulf Coast and approximately 50 percent of the variance in hurricane landfall for the Florida Peninsula and the East Coast over the period 1950-2004. As evidenced by hurricane landfall activity in 2004 and 2005 compared with the earlier period of 1995-2003, the strength of midlatitude westerly winds related to the position of the Bermuda High, is vitally important in determining how likely storms are to make landfall along either the East Coast or the Gulf Coast. The predictors listed in Tables 16 and 17 give us some degree of skill in predicting the mid-level steering flow during the hurricane season, and therefore add skill to our landfall probabilities beyond that specified by the combination of NTC and SSTA*. New research is finding that SSTA* does not add much additional skill beyond NTC and the steering current predictors, and therefore we have now discontinued the inclusion of SSTA* in our landfall probability calculations. We are currently unable to find any June-July mid-level steering flow indicators that improve upon our 1 June hindcast skill for landfall probability.

Table 16: Listing of steering current predictors for the East Coast and Florida Peninsula. The sign of the predictor associated with increased landfall is in parentheses.

Predictor	Values for 2006 Forecast
1) April-May 500 MB Ht. (35-50°N, 60-80°W) (+)	+0.1 SD
2) April-May SLP (20-40°S, 70-110°W) (+)	+0.2 SD
3) April-May 500 MB Ht. (70-85°N, 20°W-100°E) (+)	+1.9 SD

Table 17: Listing of steering current predictors for the Gulf Coast. The sign of the predictor associated with increased landfall is in parentheses.

Predictor	Values for 2006 Forecast
1) May 500 MB Ht. (10-25°S, 20-60°W) (+)	-0.8 SD
2) April-May 500 MB Ht. (40-55°S, 120°E-170°W) (+)	+0.1 SD

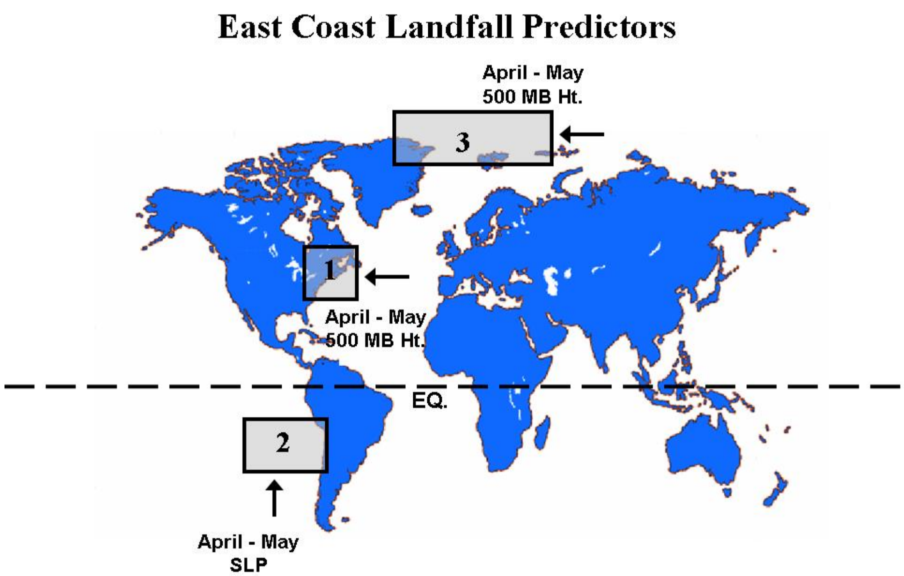

Figure 5: Listing of steering current predictors for the East Coast and Florida Peninsula.

Gulf Coast Landfall Predictors

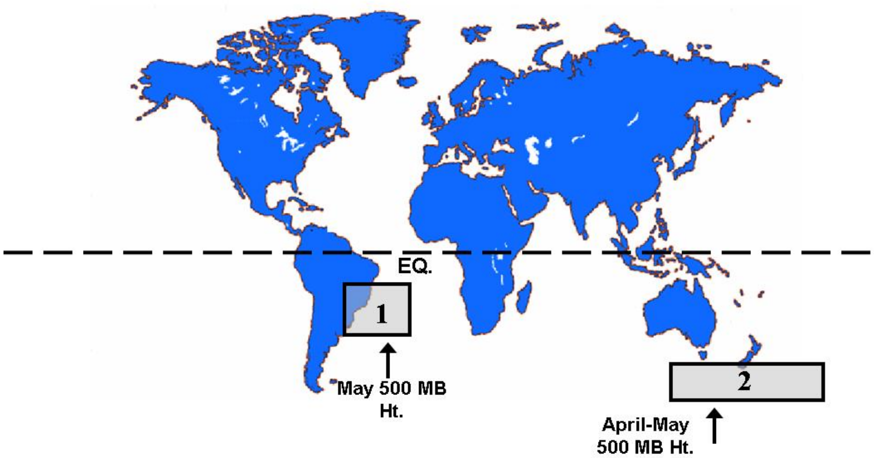

Figure 6: Listing of steering current predictors for the Gulf Coast.

7.3 Steering Current Predictor Physical Relationships

Brief descriptions of how we believe our steering current predictors relate to the steering currents likely to be present during the hurricane season are as follows:

East Coast Predictors:

Predictor 1. April-May 500 MB Geopotential Height in the Northeast United States and Canada (+)

(35-50°N, 60-80°W)

Anomalously high heights in the northeast United States during April-May, i.e., anomalous mid-level ridging, are associated with increased likelihood of hurricane landfalls along the East Coast and Florida Peninsula during the upcoming hurricane season. High heights in April-May tend to persist through August-October with an auto-correlation between the two periods of approximately 0.40. Easterly mid-level zonal wind anomalies associated with this anomalous ridging tend to drive tropical cyclones further west across the East Coast of the United States and inhibit early recurvature into the westerlies.

Predictor 2. April-May 500 MB Geopotential Height off the West Coast of South America (+)

(20-40°S, 70-110°W)

Anomalous ridging off the west coast of South America during April-May is commonly associated with strong equatorial east winds over the eastern Pacific and cold water upwelling. Such cold water upwelling is associated with a positive Southern Oscillation Index (SOI) and hence a La Niña event. La Niña events tend to persist from late May through the summer/fall period. In general, United States hurricane landfalls, especially in the Southeast, are more likely when the SOI is positive (Elsner 2003).

Predictor 3. April-May 500 MB Geopotential Height in the Arctic (+)

(70-85°N, 20°W-100°E)

Anomalously high heights in the Arctic are associated with a negative phase of the Arctic Oscillation (AO) (Thompson and Wallace 2000). A negative phase of the AO is associated with weaker westerlies across the North Atlantic. Stronger westerlies tend to steer storms away from the United States; whereas, weaker westerlies favor landfall along the East Coast of the United States (Xie et al. 2005).

Gulf Coast Predictors:

Predictor 1. May 500 MB Geopotential Height off the East Coast of South America (+)

(10-25°S, 20-60°W)

Anomalously high heights off the east coast of South America in May are strongly correlated with anomalous mid- and upper-level warming throughout the entire tropics during the spring. By the summer/fall period, a strong ridge develops over the southeastern United States with positive values of this predictor in May. This ridging tends to advect storms further west into the Gulf of Mexico and prevent early recurvature into the North Atlantic.

Predictor 2. April-May 500 MB Geopotential Height off the South Coast of New Zealand (+)

(40-55°S, 120°E-170°W)

Anomalous ridging off the south coast of New Zealand is associated with a positive value of the Antarctic Oscillation (AAO) (Thompson and Wallace 2000) and a stronger mid-latitude zonal circulation in the Southern Hemisphere. By August-October, when April-May values of this predictor are positive, La Niña conditions tend to be seen in the tropical Pacific, and there is also anomalous ridging seen over the southeastern United States. Anomalous ridging over the southeastern United States tends to enhance United States Gulf Coast landfall.

7.4 2006 Landfall Probabilities

Landfall probabilities for the 2006 season are calculated based upon values of the steering current predictors listed in the previous section and NTC. Landfall probabilities for the East Coast are quite high this year, due to a combination of predicted above-average NTC values and favorable steering currents for East Coast landfall. In general, a negative North Atlantic Oscillation (NAO) and Arctic Oscillation (AO) increases the likelihood of East Coast landfall, and both of these indices have been predominately negative so far this spring (Xie et al. 2005). Two of the three predictors utilized in our East Coast steering current model relate to the NAO and AO, especially Predictor 3, which as can be seen in Table 16, has very high values this year. The odds of a major hurricane making landfall along the East Coast are more than twice the climatological average value this year.

For the Gulf Coast, landfall probabilities are slightly below the climatological average. Steering current parameters for the Gulf Coast are mixed, with one of the predictors being slightly positive and the other predictor being moderately negative. However, it is to be noted that Gulf Coast landfall probabilities are still near their climatological averages (based on predicted high values of NTC), and therefore, coastal residents should prepare for a 26% probability of a landfalling major hurricane along the Gulf Coast.

Table 18 displays the landfall probabilities for the 2006 season.

Please visit our website at http://www.e-transit.org/hurricane for landfall probabilities for 11 U.S. coastal regions, 55 subregions and 205 coastal and near-coastal counties from Brownsville, Texas to Eastport, Maine.

Table 18: 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, and total hurricanes and named storms along the entire U.S. coastline, along the Gulf Coast (Regions 1-4), and along the Florida Peninsula and the East Coast (Regions 5-11) for 2006. The long-term mean annual probability of one or more landfalling systems during the 20th century 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)	85% (80%)	67% (68%)	73% (52%)	91% (84%)	99% (97%)
Gulf Coast (Regions 1-4)	57% (59%)	33% (42%)	26% (30%)	51% (61%)	79% (83%)
Florida plus East Coast (Regions 5-11)	64% (51%)	47% (45%)	64% (31%)	81% (62%)	93% (81%)

8 Is Global Warming Responsible for the Large Upswing in 2004-2005 US Hurricane Landfalls?

8.1 Background

The U.S. landfall of major hurricanes Dennis, Katrina, Rita and Wilma in 2005 and the four Florida landfalling hurricanes of 2004 (Charley, Frances, Ivan and Jeanne) has raised questions about the possible role that global warming may be playing in these last two unusually destructive seasons.

The global warming arguments have been given much attention by many media references to recent papers claiming to show such a linkage. Despite the global warming of the sea surface of about 0.4°C that has taken place over the last two decades, global numbers of hurricanes and their intensity have not shown increases over the past twenty years (Klotzbach 2006). In addition, we have no valid physical theory as to why small changes of global average sea surface temperature (SST) should bring about increases in Atlantic basin hurricane activity. In the past century, Atlantic basin hurricane activity has been above-average both when global SST has been increasing (from the middle 1920s through the middle 1940s) and when global SST has been decreasing (from the middle 1940s through the middle 1960s).

The Atlantic has seen a very large increase in major hurricanes during the last 11-year period of 1995-2005 (average 4.0 per year) in comparison to the prior 25-year period of 1970-1994 (average 1.5 per year). This large increase in Atlantic major hurricanes is primarily a result of a multi-decadal increase in strength in the Atlantic Ocean thermohaline circulation (THC) which is not directly related to global temperature increase. Changes in ocean salinity are believed to be the driving mechanism. These multi-decadal changes have also been termed the Atlantic Multi-Decadal Oscillation (AMO). It should also be noted that during this same time period, activity in the Northeast Pacific basin has decreased considerably. When activity in these two basins (the North Atlantic and the Northeast Pacific) is summed together, there has been virtually no trend in major hurricanes.

There have been similar past periods (1940s-1950s) when the Atlantic was just as active as in recent years. For instance, when we compare Atlantic basin hurricane numbers of the last 15 years with an earlier 15-year period (1950-1964), we see little difference in hurricane frequency or intensity even though global surface temperatures were cooler and there was a general global cooling during 1950-1964 as compared with global warming during 1990-2004.

8.2 Discussion

There is no physical basis for assuming that global hurricane intensity or frequency is necessarily related to global mean surface temperature changes of less than ± 0.5°C. As the ocean surface warms, global upper air temperatures warm as well to maintain conditionally unstable lapse-rates and global rainfall rates at their climatological values. Seasonal and monthly variations of sea surface temperature (SST) within individual storm basins show only very low correlations with monthly, seasonal, and yearly variations of hurricane activity (Shapiro and Goldenberg 1998, Klotzbach 2006). Other factors such as tropospheric vertical wind shear, surface pressure, low level vorticity, mid-level moisture, etc. play more dominant roles in explaining hurricane variability than do surface temperatures. Although there has been a general global warming over the last 30 years and particularly over the last 10 years, the SST increases in the individual tropical cyclone basins have been smaller than the overall global warming (about half) and, according to the observations, have not brought about any significant increases in global major tropical cyclones except for the Atlantic which, as has been discussed, has multi-decadal oscillations driven primarily by changes in Atlantic salinity. No credible observational evidence is currently available that directly associates global surface temperature change with changes in global hurricane frequency and intensity.

Most Southeast coastal residents probably do not know how fortunate they had been in the prior 38-year period (1966-2003) leading up to 2004-2005 when there were only 17 major hurricanes (0.45/year) that crossed the U.S. coastline. In the prior 40-year period of 1926-1965, there were 36 major hurricanes (0.90/year or twice as many) that made U.S. landfall. It is understandable that coastal residents were not prepared for the great upsurge in landfalling major hurricanes in 2004-2005. For many years, we had been warning that the southeastern United States should expect great increases in hurricane-spawned destruction in future years.

We should interpret the last two years of unusually large numbers of U.S. landfalling hurricanes as natural but very low probability years. During 1966-2003, U.S. hurricane landfall numbers were substantially below the long-term average. In the last two seasons, they have been much above the long-term average. Although the 2004 and 2005 hurricane seasons have had an unusually high number of major landfall events, the overall Atlantic basin hurricane activity has not been much more active than five of the recent hurricane seasons since 1995 (e.g., 1995-1996, 1998-1999, 2003). What has made the 2004-2005 seasons so unusually destructive is the higher percentage of major hurricanes that moved over the U.S. coastline. These landfall events were not primarily a function of the overall Atlantic basin net major hurricane numbers, but rather of the favorable broad-scale Atlantic upper-air steering currents which were present the last two seasons. It was these favorable Atlantic steering currents which caused so many of the major hurricanes which formed to come ashore.

It is rare to have two consecutive years with such a strong simultaneous combination of high amounts of major hurricane activity together with especially favorable steering flow currents. The historical records and the laws of statistics indicate that the probability of seeing another two consecutive hurricane seasons like 2004-2005 is very low. Even though we expect to see the current active period of Atlantic major hurricane activity continue for another 15-20 years, it is statistically unlikely that the coming 2006 and 2007 hurricane seasons, or the seasons which follow, will have the number of U.S. landfalling major hurricane events that we have seen in 2004-2005.

9 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 U.S. 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 2006 hurricane season is, a finite probability always exists that one or more hurricanes may strike along the U.S. coastline or in the Caribbean and do much damage.

10 Forthcoming Updated Forecasts of 2006 Hurricane Activity

We will be issuing seasonal updates of our 2006 Atlantic basin hurricane forecasts on **Friday 1 September** and **Tuesday 3 October 2006**. The 1 September and 3 October forecasts will include separate forecasts and updates of September-only and October-only Atlantic basin tropical cyclone activity. A verification and discussion of all 2006 forecasts will be issued in late November 2006. Table 19 displays our forecast schedule for the remainder of the 2006 hurricane season. Our first seasonal hurricane forecast for the 2007 hurricane season will be issued in early December 2006. All of these forecasts will be made available on the web at: http://hurricane.atmos.colostate.edu/Forecasts.

Table 19: Timetable of upcoming forecasts and updates for the 2006 hurricane season.

Forecast Date	Based on Data Through	Upcoming Forecasts and Updates			
1 September 2006	August 2006	August Verification	Updated September Forecast	Updated October Forecast	Updated Seasonal Forecast
3 October 2006	September 2006		September Verification	Updated October Forecast	Updated Seasonal Forecast
Late November 2006	Verification of all Forecasts				

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13 Verification of Previous Forecasts

Table 20: Summary verification of the authors' six previous years of seasonal forecasts for Atlantic TC activity between 2000-2005.

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	85	85	100	90	85
Intense Hurricanes	3	3	4	3	3
Intense Hurricane Days	6	6	8	6	5.25
Net Tropical Cyclone 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	65	65	75	75	71
Intense Hurricanes	2	2	3	3	4
Intense Hurricane Days	4	4	5	5	5
Net Tropical Cyclone 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	90	85	75	35	25	31
Intense Hurricanes	4	3	2	1	1	2
Intense Hurricane Days	7	6	5	2	2	2.5
Net Tropical Cyclone 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	14
No. of Hurricane Days	35	35	35	25	25	35	32
No. of Named Storm Days	65	65	70	60	55	70	71
Hurr. Destruction Potential	100	100	100	80	80	125	129
Intense Hurricanes	3	3	3	3	3	2	3
Intense Hurricane Days	8	8	8	5	9	15	17
Net Tropical Cyclone 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	14
No. of Hurricane Days	30	35	35	30	40	52	46
No. of Named Storm Days	55	60	60	55	70	96	90
Intense Hurricanes	3	3	3	3	5	6	6
Intense Hurricane Days	6	8	8	6	15	23	22
Net Tropical Cyclone Activity	125	145	145	125	185	240	229

2005	3 Dec. 2004	Update 1 April	Update 31 May	Update 5 August	Update 2 Sept.	Update 3 Oct.	Obs.
No. of Hurricanes	6	7	8	10	10	11	15
No. of Named Storms	11	13	15	20	20	20	27
No. of Hurricane Days	25	35	45	55	45	40	51
No. of Named Storm Days	55	65	75	95	95	100	125
Intense Hurricanes	3	3	4	6	6	6	7
Intense Hurricane Days	6	7	11	18	15	13	16.75
Net Tropical Cyclone Activity	115	135	170	235	220	215	275