EXTENDED RANGE FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY AND U.S. LANDFALL STRIKE PROBABILITY FOR 2007

We foresee an above-average Atlantic basin tropical cyclone season in 2007. We anticipate an above-average probability of United States major hurricane landfall.

(as of 8 December 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

Department of Atmospheric Science
Colorado State University
Fort Collins, CO 80523
Email: amie@atmos.colostate.edu

[1] Research Associate
[2] Professor Emeritus of Atmospheric Science
[3] Research Associate

ATLANTIC BASIN SEASONAL HURRICANE FORECAST FOR 2007

Forecast Parameter and 1950-2000 Climatology (in parentheses)	8 December 2006 Forecast for 2007
Named Storms (NS) (9.6)	14
Named Storm Days (NSD) (49.1)	70
Hurricanes (H) (5.9)	7
Hurricane Days (HD) (24.5)	35
Intense Hurricanes (IH) (2.3)	3
Intense Hurricane Days (IHD) (5.0)	8
Accumulated Cyclone Energy (ACE)[4] (96.1)	130
Net Tropical Cyclone Activity (NTC) (100%)	140

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

1) Entire U.S. coastline - 64% (average for last century is 52%)

2) U.S. East Coast Including Peninsula Florida - 40% (average for last century is 31%)

3) Gulf Coast from the Florida Panhandle westward to Brownsville - 40% (average for last century is 30%)

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

[4] In order to facilitate easier comparison with other seasonal forecasting groups (e.g., NOAA, Tropical Storm Risk, etc.), we have decided to start predicting an Accumulated Cyclone Energy (ACE) index as part of our seasonal forecasts. ACE is defined to be a measure of a named storm's potential for wind and storm surge destruction defined as the sum of the square of a named storm's maximum wind speed (in 10^4 $knots^2$) for each 6-hour period of its existence. ACE is similar to the Hurricane Destruction Potential (HDP) index that we forecast for a number of years.

ABSTRACT

Information obtained through November 2006 indicates that the 2007 Atlantic hurricane season will be more active than the average 1950-2000 season. We estimate that 2007 will have about 7 hurricanes (average is 5.9), 14 named storms (average is 9.6), 70 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 125 percent of the long-period average. We expect Atlantic basin Net Tropical Cyclone (NTC) activity in 2007 to be about 140 percent of the long-term average. This forecast is based on a recently-developed 6-11 month extended range statistical forecast procedure which utilizes 52 years of past data and began being utilized operationally in 2002. Predictors in this scheme include five selective measures of September-November North Atlantic and Pacific surface pressure and 500 mb height fields and a measure of the stratospheric quasi-biennial oscillation (QBO). A second new extended-range early December experimental statistical prediction scheme is also consulted. Analog predictors have also been utilized. The influences of El Niño conditions are implicit in these predictor fields, and therefore we do not utilize a specific ENSO forecast as a predictor. We expect current El Niño conditions to dissipate by the active part of the 2007 Atlantic basin hurricane season.

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 six years and has been second author on these forecasts for the last five 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 six 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.

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

Accumulated Cyclone Energy – (ACE) A measure of a named storm's potential for wind and storm surge destruction defined as the sum of the square of a named storm's maximum wind speed (in 10^4 $knots^2$) for each 6-hour period of its existence.

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.

Intense Hurricane - (IH) A hurricane which reaches a sustained low-level wind 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 Caribbean and Gulf of Mexico sea level pressure from observed long-term average conditions.

SOI – Southern Oscillation Index – A normalized measure of the surface pressure difference between Tahiti and Darwin.

SST(s) – Sea Surface Temperature(s)

SSTA(s) – Sea Surface Temperature(s) Anomalies

Tropical Cyclone – (TC) A large-scale circular flow occurring within the tropics and subtropics which has its strongest winds at low levels; including hurricanes, tropical storms and other weaker rotating vortices.

Tropical Storm – (TS) A tropical cyclone with maximum sustained winds between 39 (18 ms^{-1} or 34 knots) and 73 (32 ms^{-1} or 63 knots) miles per hour.

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 24th year in which the CSU Tropical Meteorology Project has made forecasts of the upcoming season's Atlantic basin hurricane activity. Our 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 statistical methodologies derived from 50-55 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 related to 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 Early 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 as to why these relationships have failed. We have discontinued this earlier 1 December forecast scheme and have developed a new 1 December forecast scheme.

Beginning with the 2002 December forecast for the 2003 season, we have relied on a new early December forecast scheme (Klotzbach and Gray 2004) which does not utilize West African rainfall and gives less weight to the QBO. This newer extended range forecast scheme shows significantly improved hindcast skill compared with our earlier December forecast scheme. The location of each of these predictors is shown in Figure 1. The pool of six predictors for the 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.

Several of these predictors are related to a positive Pacific-North American (PNA) pattern which is typically correlated with warm ENSO conditions. However, this year, the PNA was mostly negative through the fall, and therefore, several of our predictors came in much less favorable for hurricane activity than is typically expected when ENSO conditions are present. This year's ENSO event came in 2-3 months later than the typical warm event, and we believe that the atmosphere may not have fully responded to the tropical oceanic forcing yet. In addition, years with warm Atlantic sea surface temperatures in the North Atlantic tend to have weaker zonal winds across the North Atlantic (e.g., a weak NAO); however, this year, this has not been the case.

We are inclined to put less stock in this early December statistical forecast this year due to the above-mentioned conditions. We have decided to develop a new scheme that uses even fewer predictors that we feel have stronger physical links with the following year's hurricane activity. In addition, in an effort to design forecast schemes that will be more stable with time, we are now developing forecasts over a portion of the reliable record and testing it on the remainder of the record.

We have recently developed an even simpler, three-predictor model that we are consulting for the first time this year. This scheme shows comparable hindcast skill to the six-predictor scheme that we have been using over the past few years. We feel that the relationships between individual predictors and seasonal tropical cyclone activity occurring the following year are somewhat better understood using this new prediction scheme. Similar to our newly-developed August seasonal forecast scheme, this scheme only predicts Net Tropical Cyclone (NTC) activity, and the other predictors are then derived from this NTC prediction. 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%).

The location of the three predictors is shown in Figure 2, and a description of each of these predictors is given in Table 2. Predictors for this revised scheme were selected based on their hindcast skill over the 1950-1989 period, and the predictors were tested on independent data from 1990-2004. The combination of these three predictors explains 51 percent of the variance for Net Tropical Cyclone (NTC) activity on the dependent data (1950-1989), and using the equations developed over the 1950-1989 period, it explains 49 percent of the variance for NTC activity on the independent data (1990-2004).

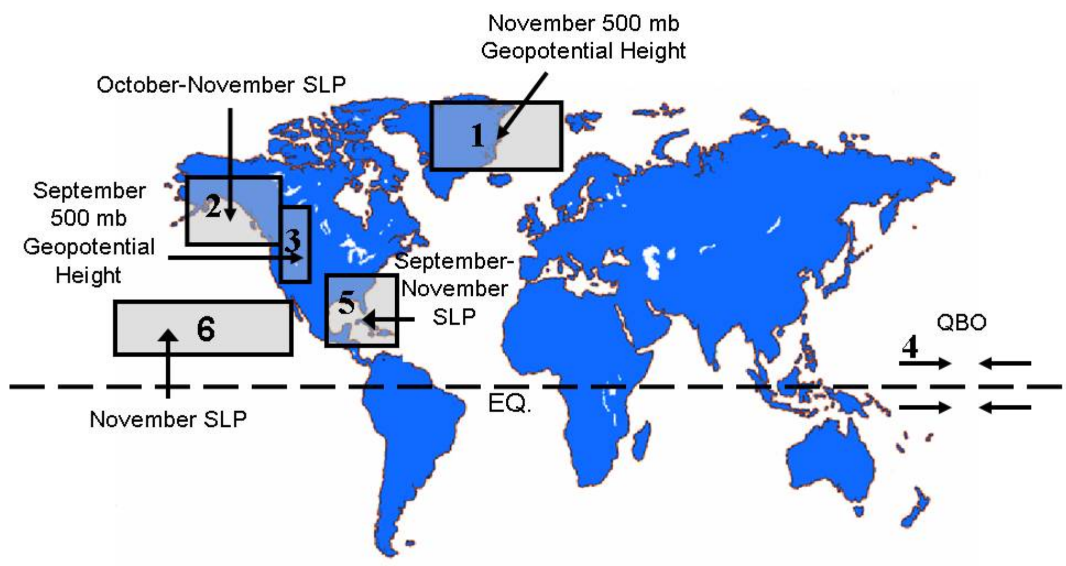

Figure 1: Location of predictors for our early December extended range statistical prediction (developed in 2002) for the 2007 hurricane season.

Table 1: Listing of 1 December 2006 predictors for the 2007 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.

Predictor	2006 Values for 2007 Forecast
1) November 500 mb geopotential height (67.5-85°N, 10°E-50°W) (+)	-1.1 SD
2) October-November SLP (45-65°N, 120-160°W) (-)	+1.4 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°) (-)	+1.2 SD
5) September-November SLP (15-35°N, 75-95°W) (-)	-1.1 SD
6) November SLP (7.5-22.5°N, 125-175°W) (+)	-0.6 SD

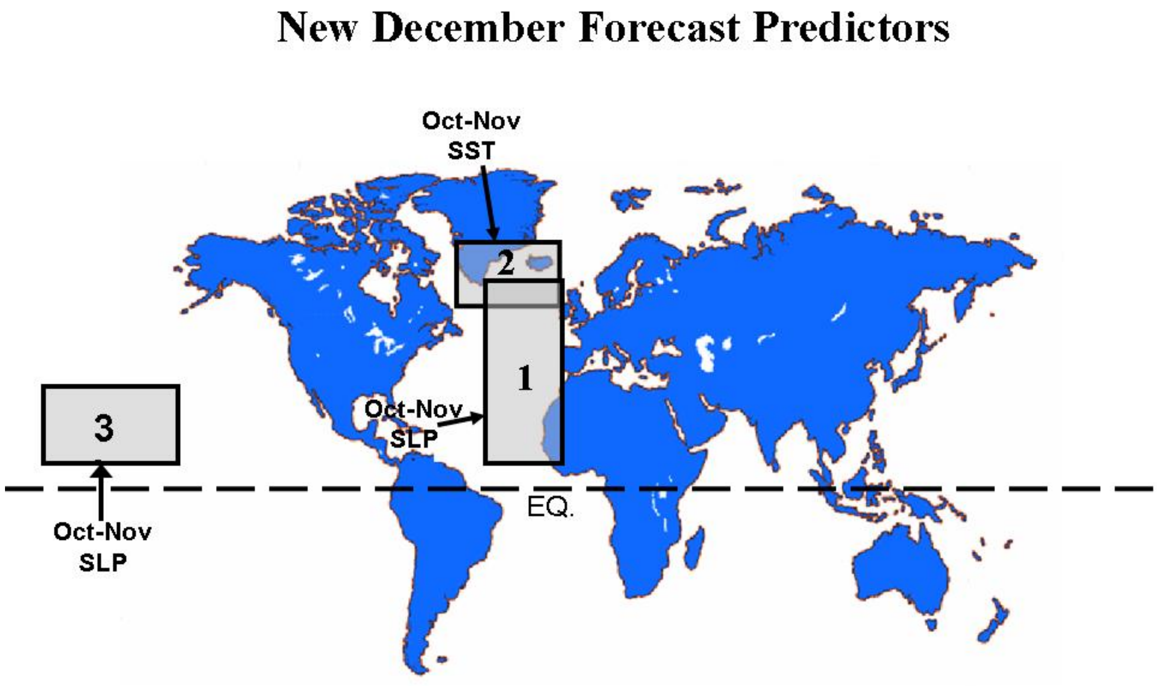

Figure 2: Location of predictors for our experimental December extended range statistical prediction (developed in 2006) for the 2007 hurricane season.

Table 2: Listing of 1 December 2006 predictors using the experimental forecast for the 2007 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.

Predictor	2006 Values for 2007 Forecast
1) October-November SLP (10-60°N, 10-30°W) (-)	-1.7 SD
2) October-November SST (55-65°N, 10-60°W) (+)	+1.6 SD
3) October-November SLP (5-25°N, 150-180°W) (+)	-1.6 SD

2.1 Physical Associations among Predictors Listed in Table 1 for our Forecast Scheme Developed in 2002

The locations and brief descriptions of our 6-11 month predictors follow:

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. 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 also 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 "Alaskan 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 weakening El Niño 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 Physical Associations among Predictors Listed in Table 2 (Experimental Forecast Scheme)

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

<u>Predictor 1. October-November SLP in the North Atlantic (-)</u>

(10-60°N, 10-30°W)

Low pressure in the North Atlantic in October-November SLP is generally related to weaker trade winds during the late fall/early winter which drives less evaporation and upwelling during the winter and spring in the tropical and subtropical Atlantic. Reduced upwelling and evaporation during the previous fall tends to relate to a warmer tropical North Atlantic the following summer and fall.

<u>Predictor 2. October-November SST in the North Atlantic (+)</u>

(55-65°N, 10-60°W)

Warm North Atlantic sea surface temperatures in the fall are indicative of an active phase of the Atlantic Multidecadal Oscillation (AMO) and a likely strong thermohaline circulation. An active AMO is associated with anomalously low vertical wind shear, warm tropical Atlantic sea surface temperatures and anomalously low sea level pressures during the hurricane season, all of which are favorable for an active Atlantic basin hurricane season.

<u>Predictor 3. October-November SLP in the Subtropical NE Pacific (+)</u>

(35-55°N, 100-120°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 October-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.

3 Analog-Based Predictors for 2007 Hurricane Activity

Certain years in the historical record have global oceanic and atmospheric trends which are substantially similar to 2006/2007. These years also provide useful clues as to likely trends in activity that the forthcoming 2007 hurricane season may bring. For this early December extended range forecast, we project atmospheric and oceanic conditions for August through October 2007 and determine which of the prior years in our database have distinct trends in key environmental conditions which are similar to current October-November 2006 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 2007 were selected primarily on how similar they are to conditions that are currently observed. We searched for years that had warm ENSO conditions, warm North Atlantic sea surface temperatures, and a weaker-than-normal Azores high.

There were four hurricane seasons since 1949 with characteristics most similar to what we observe in October-November 2006. The best analog years that we could find for the 2007 hurricane season are 1952, 1958, 1966, and 2003. We anticipate that 2007 seasonal hurricane activity will have activity in line with what was experienced in the average of these four years. We believe that 2007 will be an active season in the Atlantic basin.

Table 3: Best analog years for 2007 with the associated hurricane activity listed for each year.

Year	NS	NSD	H	HD	IH	IHD	ACE	NTC
1952	7	39.75	6	22.75	3	4.00	87	93
1958	10	55.50	7	30.25	4	8.50	121	134
1966	11	64.00	7	41.75	3	7.75	145	137
2003	16	79.25	7	32.75	3	16.75	175	174
Mean	11.0	59.6	6.8	31.8	3.3	9.3	132	134.5
2007 Forecast	14	70	7	35	3	8	130	140

4 ENSO

We are currently in the middle of a moderate El Niño event which developed unexpectedly during the late summer of 2006. Currently, observed sea surface temperatures anomalies in the eastern and central Pacific are approximately 1.0 – 1.5°C above the long-period average. One of the important questions for the upcoming hurricane season is whether or not these warm ENSO conditions will continue through the 2007 Atlantic basin hurricane season. Table 4 shows the eight warmest observed October-November Nino 3.4 anomalies in active multi-decadal periods (1950-1969, 1995-present) and evaluates the following year's August-September-October Nino 3.4 anomalies. The final column in Table 4 displays the NTC that was observed the following year in the Atlantic basin. Seven out of the eight seasons following El Niño years were active Atlantic hurricane seasons, and all of these years witnessed either neutral or La Niña conditions. From this analysis, we believe that we will likely see cooling ENSO conditions next spring/summer, and therefore we do not foresee ENSO to be a strong inhibiting factor for next year's hurricane season.

Table 4: Observed October-November (ON) Nino 3.4 conditions for the eight warmest observed October-November periods in an active Atlantic multi-decadal period, observed August-September-October (ASO) Nino 3.4 anomalies the following year and observed NTC the following year in the Atlantic basin.

Year	First Year Oct-Nov Nino 3.4 Anomaly (°C)	Second Year Aug-Sep-Oct Nino 3.4 Anomaly (°C)	Second Year Atlantic Basin NTC
1997-1998	2.7	-1.2	169
2002-2003	1.6	0.4	174
1965-1966	1.6	-0.1	137
1994-1995	1.1	-0.7	221
1957-1958	1.1	0.0	134
1963-1964	1.0	-0.9	160
1951-1952	0.8	0.0	93
2004-2005	0.8	0.1	277
Mean	1.3	-0.3	171
2006	**1.1**		

5 Adjusted 2007 Forecast

Table 5 shows our final adjusted early December forecast for the 2007 season which is a combination of our statistical scheme developed in 2002, our new experimental statistical forecast, our analog forecast and qualitative adjustments for other factors not explicitly contained in any of these schemes. Our December forecast developed in 2002 indicates somewhat below-average activity. As noted earlier, the PNA pattern was mostly negative through this fall, which is quite unusual for years with warm ENSO conditions. Both our new experimental forecast and our analog forecast indicate activity at above-average levels. We foresee an active Atlantic basin hurricane season.

We anticipate that current warm ENSO conditions will transition to neutral by next summer. Warm sea surface temperatures are likely to continue being present in the tropical and North Atlantic during 2007, due to the fact that we are in a positive phase of the Atlantic Multidecadal Oscillation (AMO) (e.g., a strong phase of the Atlantic thermohaline circulation). In addition, there tends to be a warming of the tropical Atlantic following a warm ENSO event through a weakening of the trade winds associated with the "atmospheric bridge" mechanism (Klein et al. 1999).

Table 5: Summary of our early December statistical forecast, our new statistical scheme, our analog forecast and our adjusted final forecast for the 2007 hurricane season.

Forecast Parameter and 1950-2000 Climatology (in parentheses)	Statistical Scheme (Developed in 2002)	New Statistical Scheme (Developed in 2006)	Analog Scheme	Adjusted Final Forecast
Named Storms (9.6)	7.2	12.9	11.0	14
Named Storm Days (49.1)	36.1	65.6	59.6	70
Hurricanes (5.9)	4.5	7.9	6.8	7
Hurricane Days (24.5)	17.0	32.8	31.8	35
Intense Hurricanes (2.3)	0.9	3.1	3.3	3
Intense Hurricane Days (5.0)	2.9	6.7	9.3	8
Accumulated Cyclone Energy Index (94.7)	68	127	132	130
Net Tropical Cyclone Activity (100%)	72	134	135	140

6 Landfall Probabilities for 2007

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.

Net landfall probability is shown linked to the overall Atlantic basin Net Tropical Cyclone activity (NTC; see Table 6). Upon further study, as first mentioned in our early August forecast, SSTA* does not appear to add additional skill to landfall probabilities beyond that provided by NTC, and therefore, we are now basing our landfall probabilities on predicted NTC only.

As shown in Table 6, 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.

Table 6: 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 7 lists strike probabilities for the 2007 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 2007 is expected to be above its long-term average of 100, and therefore, United States landfall probabilities are above average.

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 7: 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 Peninsula and the East Coast (Regions 5-11) for 2007. 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)	89% (79%)	79% (68%)	64% (52%)	93% (84%)	99% (97%)
Gulf Coast (Regions 1-4)	71% (59%)	54% (42%)	40% (30%)	72% (60%)	92% (83%)
Florida plus East Coast (Regions 5-11)	62% (50%)	56% (44%)	40% (31%)	74% (61%)	90% (81%)

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

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) raised questions about the possible role that global warming played in these 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 that has taken place over the last 3 decades, the global numbers of hurricanes and their intensity have not shown increases in recent years except for the Atlantic (Klotzbach 2006).

The Atlantic has seen a very large increase in major hurricanes during the 12-year period of 1995-2006 (average 3.9 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 the multi-decadal increase in the Atlantic Ocean thermohaline circulation (THC) that 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 Multidecadal Oscillation (AMO).

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 over the 15-year period (1990-2004) with an earlier 15-year period (1950-1964), we see no difference in hurricane frequency or intensity even though the global surface temperatures were cooler and there was a general global cooling during 1950-1964 as compared with global warming during 1990-2004.

Although global surface temperatures have increased over the last century and over the last 30 years, there is no reliable data available to indicate increased hurricane frequency or intensity in any of the globe's seven tropical cyclone basins. Meteorologists who study tropical cyclones have no valid physical theory as to why hurricane frequency or intensity would necessarily be altered significantly by small amounts ($< \pm 1^{o}C$) of global mean temperature change.

In a global warming or global cooling world, the atmosphere's upper air temperatures will warm or cool in unison with the sea surface temperatures. Vertical lapse-rates will not be significantly altered. We have no plausible physical reasons for believing that Atlantic hurricane frequency or intensity will change significantly if global ocean temperatures continue to rise. For instance, in the quarter-century period from 1945-1969 when the globe was undergoing a weak cooling trend, the Atlantic basin experienced 80 major (Cat 3-4-5) hurricanes and 201 major hurricane days. By contrast, in a similar 25-year period of 1970-1994 when the globe was undergoing a general warming trend, there were only 38 major hurricanes (48% as many) and 63 major hurricane days (31% as many) in the Atlantic basin. Atlantic sea-surface temperatures and hurricane activity do not necessarily follow global mean temperature trends.

The most reliable long-period hurricane records we have are the measurements of US landfalling tropical cyclones since 1900 (Table 8). Although global mean ocean and Atlantic surface temperatures have increased by about $0.4^{o}C$ between these two 50-year periods (1900-1949 compared with 1956-2005), the frequency of US landfall numbers actually shows a slight downward trend for the later period. If we chose to make a similar comparison between US landfall from the earlier 30-year period of 1900-1929 when global mean surface temperatures were estimated to be about 0.5°C colder than they were during the 30-year period from 1976-2005, we find exactly the same US hurricane landfall numbers (54 to 54) and major hurricane landfall numbers (21 to 21).

We should not read too much into the two hurricane seasons of 2004-2005. The activity of these two years was unusual but well within natural bounds of hurricane variation. In addition, following the two very active seasons of 2004 and 2005, 2006 had slightly below-average activity, and no hurricanes made landfall in the United States. This was only the 11th year since 1945 (67 total years) that the United States had no landfalling hurricanes.

Between 1966 and 2003, US major hurricane landfall numbers were below the long-term average. Of the 79 major hurricanes which formed in the Atlantic basin from 1966-2003 only 19 (24 percent) of them made US landfall. During the two seasons of 2004-2005, seven of 13 (54 percent) came ashore. Zero of the two major hurricanes that formed in 2006 made US landfall. This is how nature sometimes works.

What made the 2004-2005 seasons so unusually destructive was not the high frequency of major hurricanes but the high percentage of major hurricanes which were steered over the US coastline. The major US hurricane landfall events of 2004-2005 were primarily a result of the favorable, upper-air steering currents present during these two years.

Table 8: U.S. landfalling tropical cyclones by intensity during two 50-year periods.

YEARS	***Named Storms***	***Hurricanes***	***Intense Hurricanes (Cat 3-4-5)***	***Global Temperature Increase***
1900-1949 (50 years)	189	101	39	
1956-2005 (50 years)	165	83	34	+0.4°C

Although 2005 had a record number of tropical cyclones (27 named storms, 15 hurricanes and 7 major hurricanes), this should not be taken as an indication of something beyond natural processes. There have been several other years with comparable hurricane activity to 2005. For instance, 1933 had 21 named storms in a year when there was no satellite or aircraft data. Records of 1933 show all 21 named storm had tracks west of 60°W where surface observations were more plentiful. If we eliminate all the named storms of 2005 whose tracks were entirely east of 60°W and therefore may have been missed given the technology available in 1933, we reduce the 2005 named storms by seven (to 20) – about the same number as was observed to occur in 1933.

Utilizing the National Hurricanes Center's best track database of hurricane records back to 1875, six previous seasons had more hurricane days than the 2005 season. These years were 1878, 1893, 1926, 1933, 1950 and 1995. Also five prior seasons (1893, 1926, 1950, 1961 and 2004) had more major hurricane days. Finally, five previous seasons (1893, 1926, 1950, 1961 and 2004) had greater Hurricane Destruction Potential (HDP) values than 2005. HDP is the sum of the squares of all hurricane-force maximum winds and provides a cumulative measure of the net wind force generated by a season's hurricanes. Although the 2005 hurricane season was certainly one of the most active on record, it is not as much of an outlier as many have indicated.

Despite a fairly inactive 2006 hurricane season, we believe that the Atlantic basin is currently in an active hurricane cycle associated with a strong thermohaline circulation and an active phase of the Atlantic Multidecadal Oscillation (AMO). This active cycle is expected to continue for another decade or two at which time we should enter a quieter Atlantic major hurricane period like we experienced during the quarter century periods of 1970-1994 and 1901-1925. Atlantic hurricanes go through multi-decadal cycles. Cycles in Atlantic major hurricanes have been observationally traced back to the mid-19th century, and changes in the AMO have been inferred from Greenland paleo ice-core temperature measurements going back thousand of years.

8 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 2007 hurricane season is, a finite probability always exists that one or more hurricanes may strike along the U.S. coastline or in the Caribbean Basin and do much damage.

9 Forthcoming Updated Forecasts of 2007 Hurricane Activity

We will be issuing seasonal updates of our 2007 Atlantic basin hurricane forecasts on **Tuesday April 3**, **Thursday 31 May** (to coincide with the official start of the 2007 hurricane season on 1 June), **Friday 3 August**, **Tuesday 4 September** and **Tuesday 2**

October 2007. The 3 August, 4 September and 2 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 2007 forecasts will be issued in late November 2007. Our first seasonal hurricane forecast for the 2008 hurricane season will be issued in early December 2007. All of these forecasts will be available on the web at: http://hurricane.atmos.colostate.edu/Forecasts.

10 Acknowledgments

Besides the individuals named on page 2, there have been a number of other meteorologists that have furnished us with data and given valuable assessments of the current state of global atmospheric and oceanic conditions. These include Arthur Douglas, Richard Larsen, Todd Kimberlain, Ray Zehr, and Mark DeMaria. In addition, Barbara Brumit and Amie Hedstrom have provided excellent manuscript, graphical and data analysis and assistance over a number of years. We have profited over the years from many in-depth discussions with most of the current and past NHC hurricane forecasters. The second author would further like to acknowledge the encouragement he has received for this type of forecasting research application from Neil Frank, Robert Sheets, Robert Burpee, Jerry Jarrell, former directors of the National Hurricane Center (NHC), and from the current director, Max Mayfield and their forecast staffs. Uma Shama and Larry Harman of Bridgewater State College, MA have provided assistance and technical support in the development of our Landfalling Hurricane Probability Webpage. We also thank Bill Bailey of the Insurance Information Institute for his sage advice and encouragement.

The financial backing for the issuing and verification of these forecasts has in part been supported by the National Science Foundation and by the Research Foundation of Lexington Insurance Company (a member of the American International Group). We also thank the GeoGraphics Laboratory at Bridgewater State College for their assistance in developing the Landfalling Hurricane Probability Webpage.

11 Citations and Additional Reading

Blake, E. S., 2002: Prediction of August Atlantic basin hurricane activity. Dept. of Atmos. Sci. Paper No. 719, Colo. State Univ., Ft. Collins, CO, 80 pp.

Blake, E. S. and W. M. Gray, 2004: Prediction of August Atlantic basin hurricane activity. *Wea. Forecasting*, 19, 1044-1060.

DeMaria, M., J. A. Knaff and B. H. Connell, 2001: A tropical cyclone genesis parameter for the tropical Atlantic. *Wea. Forecasting*, 16, 219-233.

Elsner, J. B., G. S. Lehmiller, and T. B. Kimberlain, 1996: Objective classification of Atlantic hurricanes. *J. Climate*, 9, 2880-2889.

Goldenberg, S. B., C. W. Landsea, A. M. Mestas-Nunez, W. M. Gray, 2001: The recent increase in Atlantic hurricane activity: Causes and Implications. *Science*, 293, 474-479.

Goldenberg, S. B. and L. J. Shapiro, 1996: Physical mechanisms for the association of El Niño and West African rainfall with Atlantic major hurricane activity. *J. Climate*, 1169-1187.

Gray, W. M., 1984a: Atlantic seasonal hurricane frequency: Part I: El Niño and 30 mb quasi-biennial oscillation influences. *Mon. Wea. Rev.*, 112, 1649-1668.

Gray, W. M., 1984b: Atlantic seasonal hurricane frequency: Part II: Forecasting its variability. *Mon. Wea. Rev.*, 112, 1669-1683.

Gray, W. M., 1990: Strong association between West African rainfall and US landfall of intense hurricanes. *Science*, 249, 1251-1256.

Gray, W. M., and P. J. Klotzbach, 2003 and 2004: Forecasts of Atlantic seasonal and monthly hurricane activity and US landfall strike probability. Available online at http://hurricane.atmos.colostate.edu

Gray, W. M., C. W. Landsea, P. W. Mielke, Jr., and K. J. Berry, 1992: Predicting Atlantic seasonal hurricane activity 6-11 months in advance. *Wea. Forecasting*, 7, 440-455.

Gray, W. M., C. W. Landsea, P. W. Mielke, Jr., and K. J. Berry, 1993: Predicting Atlantic basin seasonal tropical cyclone activity by 1 August. *Wea. Forecasting*, 8, 73-86.

Gray, W. M., C. W. Landsea, P. W. Mielke, Jr., and K. J. Berry, 1994a: Predicting Atlantic basin seasonal tropical cyclone activity by 1 June. *Wea. Forecasting*, 9, 103-115.

Gray, W. M., J. D. Sheaffer and C. W. Landsea, 1996: Climate trends associated with multi-decadal variability of intense Atlantic hurricane activity. Chapter 2 in "Hurricanes, Climatic Change and Socioeconomic Impacts: A Current Perspective", H. F. Diaz and R. S. Pulwarty, Eds., Westview Press, 49 pp.

Gray, W. M., 1998: Atlantic ocean influences on multi-decadal variations in El Niño frequency and intensity. Ninth Conference on Interaction of the Sea and Atmosphere, 78th AMS Annual Meeting, 11-16 January, Phoenix, AZ, 5 pp.

Henderson-Sellers, A., H. Zhang, G. Berz, K. Emanuel, W. Gray, C. Landsea, G. Holland, J. Lighthill, S-L. Shieh, P. Webster, K. McGuffie, 1998: Tropical cyclones and global climate change: A post-IPCC assessment. *Bull. Amer. Meteor. Soc.*, 79, 19-38.

Klein, S. A., B. J. Soden, and N-C Lau, 1999: Remote sea surface temperature variations during ENSO: Evidence for a tropical atmospheric bridge. *J. Climate*, 12, 917-932.

Klotzbach, P. J., 2002: Forecasting September Atlantic basin tropical cyclone activity at zero and one-month lead times. Dept. of Atmos. Sci. Paper No. 723, Colo. State Univ., Ft. Collins, CO, 91 pp.

Klotzbach, P. J. and W. M. Gray, 2003: Forecasting September Atlantic basin tropical cyclone activity. *Wea. and Forecasting*, 18, 1109-1128.

Klotzbach, P. J. and W. M. Gray, 2004: Updated 6-11 month prediction of Atlantic basin seasonal hurricane activity. *Wea. and Forecasting*, 19, 917-934.

Knaff, J. A., 1997: Implications of summertime sea level pressure anomalies. *J. Climate*, 10, 789-804.

Knaff, J. A., 1998: Predicting summertime Caribbean sea level pressure. *Wea. and Forecasting*, 13, 740-752.

Landsea, C. W., 1991: West African monsoonal rainfall and intense hurricane associations. Dept. of Atmos. Sci. Paper, Colo. State Univ., Ft. Collins, CO, 272 pp.

Landsea, C. W., 1993: A climatology of intense (or major) Atlantic hurricanes. *Mon. Wea. Rev.,* 121, 1703-1713.

Landsea, C. W. and W. M. Gray, 1992: The strong association between Western Sahel monsoon rainfall and intense Atlantic hurricanes. *J. Climate,* 5, 435-453.

Landsea, C. W., W. M. Gray, P. W. Mielke, Jr., and K. J. Berry, 1992: Long-term variations of Western Sahelian monsoon rainfall and intense U.S. landfalling hurricanes. *J. Climate,* 5, 1528-1534.

Landsea, C. W., W. M. Gray, K. J. Berry and P. W. Mielke, Jr., 1996: June to September rainfall in the African Sahel: A seasonal forecast for 1996. 4 pp.

Landsea, C. W., N. Nicholls, W.M. Gray, and L.A. Avila, 1996: Downward trends in the frequency of intense Atlantic hurricanes during the past five decades. *Geo. Res. Letters,* 23, 1697-1700.

Landsea, C. W., R. A. Pielke, Jr., A. M. Mestas-Nunez, and J. A. Knaff, 1999: Atlantic basin hurricanes: Indices of climatic changes. *Climatic Changes,* 42, 89-129.

Landsea, C.W. et al., 2005: Atlantic hurricane database re-analysis project. Available online at http://www.aoml.noaa.gov/hrd/data_sub/re_anal.html

Mielke, P. W., K. J. Berry, C. W. Landsea and W. M. Gray, 1996: Artificial skill and validation in meteorological forecasting. *Wea. Forecasting,* 11, 153-169.

Mielke, P. W., K. J. Berry, C. W. Landsea and W. M. Gray, 1997: A single sample estimate of shrinkage in meteorological forecasting. *Wea. Forecasting,* 12, 847-858.

Pielke, Jr. R. A., and C. W. Landsea, 1998: Normalized Atlantic hurricane damage, 1925-1995. *Wea. Forecasting,* 13, 621-631.

Rasmusson, E. M. and T. H. Carpenter, 1982: Variations in tropical sea-surface temperature and surface wind fields associated with the Southern Oscillation/El Niño. *Mon. Wea. Rev.,* 110, 354-384.

Seseske, S. A., 2004: Forecasting summer/fall El Niño-Southern Oscillation events at 6-11 month lead times. Dept. of Atmos. Sci. Paper No. 749, Colo. State Univ., Ft. Collins, CO, 104 pp.

12 Verification of Previous Forecasts

Table 9: Summary verification of the authors' six previous years of seasonal forecasts for Atlantic TC activity between 2001-2006.

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	14
No. of Named Storms	11	13	15	20	20	20	26
No. of Hurricane Days	25	35	45	55	45	40	48
No. of Named Storm Days	55	65	75	95	95	100	116
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	263

2006	6 Dec. 2005	Update 4 April	Update 31 May	Update 3 August	Update 1 Sept.	Update 3 Oct.	Obs.
No. of Hurricanes	9	9	9	7	5	6	5
No. of Named Storms	17	17	17	15	13	11	9
No. of Hurricane Days	45	45	45	35	13	23	20
No. of Named Storm Days	85	85	85	75	50	58	50
Intense Hurricanes	5	5	5	3	2	2	2
Intense Hurricane Days	13	13	13	8	4	3	3
Net Tropical Cyclone Activity	195	195	195	140	90	95	85