EXTENDED RANGE FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY AND U.S. LANDFALL STRIKE PROBABILITY FOR 2008

We foresee a well above-average Atlantic basin tropical cyclone season in 2008. We have increased our seasonal forecast from our initial early December prediction. We anticipate an above-average probability of United States major hurricane landfall.

(as of 9 April 2008)

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

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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Why issue extended-range forecasts for seasonal hurricane activity?

We are frequently asked this question. Our answer is that it is possible to say something about the probability of this year's hurricane activity being above- or below-average several months before the start of the hurricane season. The Atlantic basin has the largest year-to-year variability of any of the global tropical cyclone basins. People are curious to know how active this year is likely to be, particularly if you can show hindcast skill improvement over climatology during many past years.

Everyone should realize that it is impossible to precisely predict this season's hurricane activity in early April. There is, however, much curiosity as to how global ocean and atmosphere features are presently arranged as regards to the probability of an active or inactive hurricane season for the coming season. Our new early April statistical forecast methodology shows strong evidence over 58 past years that significant improvement over climatology can be attained. We would never issue a seasonal hurricane forecast unless we had a statistical model developed over a long hindcast period which showed significant skill over climatology.

We issue these forecasts to satisfy the curiosity of the general public and to bring attention to the hurricane problem. There is a general interest in knowing what the odds are for an active or inactive season. One must remember that 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. This is not always true for individual seasons. It is also 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.

The methodology of this year's extended-range forecast is based on a recently-developed 1 April statistical technique built on 58 years (1950-2007) of data. This forecast is expressed in units of Net Tropical Cyclone (NTC) activity as discussed in Table 11. Table 2 lists and Figure 1 shows our 58 years of hindcasts compared with observations. We have gone the right way (correctly predicted an above- or below-average season) in 45 out of these 58 hindcast years. This new scheme also shows 1 April hindcast skill over the last 13-year period where our real-time 1 April forecasts failed to show statistical improvement over climatology. See Section 2 for a full explanation of this new forecast methodology.

ATLANTIC BASIN SEASONAL HURRICANE FORECAST FOR 2008

Forecast Parameter and 1950-2000 Climatology (in parentheses)	Issue Date 7 December 2007	Issue Date 9 April 2008
Named Storms (NS) (9.6)	13	15
Named Storm Days (NSD) (49.1)	60	80
Hurricanes (H) (5.9)	7	8
Hurricane Days (HD) (24.5)	30	40
Intense Hurricanes (IH) (2.3)	3	4
Intense Hurricane Days (IHD) (5.0)	6	9
Accumulated Cyclone Energy (ACE) (96.1)	115	150
Net Tropical Cyclone Activity (NTC) (100%)	125	160

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

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

2) U.S. East Coast Including Peninsula Florida - 45% (average for last century is 31%)

3) Gulf Coast from the Florida Panhandle westward to Brownsville - 44% (average for last century is 30%)

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

ABSTRACT

Information obtained through March 2008 indicates that the 2008 Atlantic hurricane season will be much more active than the average 1950-2000 season. We estimate that 2008 will have about 8 hurricanes (average is 5.9), 15 named storms (average is 9.6), 80 named storm days (average is 49.1), 40 hurricane days (average is 24.5), 4 intense (Category 3-4-5) hurricanes (average is 2.3) and 9 intense hurricane days (average is 5.0). The probability of U.S. major hurricane landfall is estimated to be about 135 percent of the long-period average. We expect Atlantic basin Net Tropical Cyclone (NTC) activity in 2008 to be approximately 160 percent of the long-term average. We have increased our seasonal forecast from early December.

This forecast is based on a new extended-range early April statistical prediction scheme that utilizes 58 years of past data. Analog predictors are also 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 La Niña conditions to continue to weaken by the start of the 2008 Atlantic basin hurricane season.

This forecast also contains an analysis of all of our extended-range forecasts that have been issued for the last 13 years (1995-2007). These real-time operational early April forecasts have not shown forecast skill over climatology during this 13-year period. This has occurred despite the fact that the skill over the hindcast period (varying from 40-55 years) showed appreciable skill (approximately 40-50% of the variance explained). This last 13-year failure of our 1 April scheme has led us to perform new research which has led to the development of this new, more skillful, 1 April hindcast scheme.

The current early April forecast consists of a new set of two predictors along with an adjustment based on our early December forecast. This new forecast approach has shown appreciable hindcast skill ($r^2 = 0.64$) over the last 58 years (1950-2007). It is surprising that the global atmosphere-ocean system has such a strong extended-range predictive signal. This scheme also shows appreciable hindcast skill over the more recent 13-year period from 1995-2007 ($r^2 = 0.57$) for which our previous early April schemes have not been able to show real-time forecast skill over climatology.

Notice of Author Changes

By William Gray

The order of the authorship of these forecasts was reversed in 2006 from Gray and Klotzbach to Klotzbach and Gray. After 22 years (since 1984) of making these forecasts, it was 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 seven years and was second author on these forecasts from 2001-2005. 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 in 2000. 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. He was recently awarded his Ph.D. degree.

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 United States 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 project members 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. We also thank Bill Thorson for technical advice and assistance.

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. The 1950-2000 average value of this parameter is 96.

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. The 1950-2000 average value of this parameter is 100.

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.

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 25th 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 a statistical methodology derived from 58 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.

The best predictors 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 forecast 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 2-3 other predictors. 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. No one can completely understand the full complexity of the atmosphere-ocean system. But, it is still possible to develop a reliable statistical forecast scheme which incorporates a number of the climate system's non-linear interactions. Any seasonal or climate forecast scheme must show significant hindcast skill before it is used in real-time forecasts.

2 New Early April Forecast Methodology

Although our seasonal hurricane forecast scheme has shown significant real time skill for our early June and early August predictions, we have yet to demonstrate real-time forecast skill for our early April forecasts that have been issued for the last 13 years (1995-2007).

Our initial early April seasonal hurricane forecast scheme (Scheme A) (Gray et al. 2002), although demonstrating appreciable hindcast skill for the period from 1950-1994, did not give skillful results when utilized in real-time forecasts for 1995-2002. This was largely 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. We did not expect these African rainfall and QBO predictive relationships that had worked so well for 45 years to stop working. We do not yet have a good explanation as to why these relationships have failed. We have discontinued this earlier 1 April forecast scheme and have developed several new 1 April forecast schemes since that time.

Beginning with the 2003 April forecast, we relied on a new early April forecast scheme. This scheme was revised slightly from 2003 to 2004. The same statistical forecast scheme was utilized from 2004-2006. This forecast scheme (Scheme B) (Gray and Klotzbach 2004) did not utilize West African rainfall or the QBO. This newer statistical scheme, although showing improved hindcast skill, did not demonstrate real-time forecast skill for the four years from 2003-2006. See Table 1 for more information on all of our early April extended-range forecast schemes.

We recently developed an even simpler, three-predictor model that we used for our early April prediction for the 2007 season (Scheme C). This scheme showed comparable hindcast skill to the six-predictor scheme (Scheme B) that we used over the previous few years. The relationships between individual predictors and seasonal tropical cyclone activity occurring the following year were better understood using this new and simpler three-predictor scheme. Having only three predictors also eliminates over-fitting of the hindcast which can occur when the scheme uses 4-6 variables. Similar to the newly-developed August seasonal forecast scheme (Klotzbach 2007), this scheme only predicted Net Tropical Cyclone (NTC) activity, and the other predictors were then derived from this NTC prediction. For example, if a typical season predicted an NTC value of 120%, the predicted number of named storms for the season would be 1.2 times 10 (the 1950-2000 annual average for named storms) or 12. Table 1 summarizes the characteristics of each of our previous 1 April forecast schemes, along with the new forecast scheme that we are using for the first time in April 2008.

Table 1: Listing of all previous and our current April extended-range prediction schemes.

	Scheme A Gray et al. (1992)	Scheme B Klotzbach and Gray (2004)	Scheme C Klotzbach and Gray (2007)	Scheme D Klotzbach and Gray (2008)
Years Used in Real-Time Forecasting	1995-2002 (8Yrs.)	2003-2006 (4 Yrs.)	2007 (1 Yr.)	2008 (1 Yr.)
Number of Predictors	13	6	3	3
Hindcast Period	1950-1994 (45 Yrs.)	1950-2001 (52 Yrs.)	1950-2004 (55 Yrs.)	1950-2007 (58 Yrs.)
Hindcast Skill for NTC (r)	0.75	0.84	0.74	0.80
Actual Skill for NTC (r)	-0.07 (1995-2002)	0.05 (2003-2006)	n/a – Only used for 1 year	n/a – First year used
Reason for lack of Skill	QBO and West African rainfall stopped working	Some physical relationships not well understood	n/a – Only used for 1 year	n/a

2.1 April Statistical Forecast Scheme

Neither Scheme B nor Scheme C have shown strong real-time forecast skill for the last six years (2002-2007). We are working to try to better understand why schemes that have shown good hindcast skill over extended past periods should fail when being used in real-time. We have found that using two late-winter predictors and our early December hindcast, we can obtain early April hindcasts that show considerable skill over the period from 1950-2007. This new scheme also retains good skill over the recent period from 2002-2007 (see Table 5 for an evaluation of all three schemes over the past six years).

This new scheme was created by evaluating the two late-winter predictors using least-squared regression. The resulting hindcasts were then ranked in order from 1 (the highest value) to 58 (the lowest value). Then the resulting preliminary April NTC hindcast rank was adjusted to the final April NTC hindcast by using the following method. We ranked the December NTC hindcasts in a similar manner as was done with early April (i.e., from 1 to 58). Then the final April NTC hindcast rank was derived by computing the following equation:

Final April NTC Hindcast Rank = 0.5 * (Preliminary April NTC Hindcast Rank) + 0.5 * (Final December NTC Hindcast Rank).

The final NTC hindcast was obtained by taking the final April NTC hindcast rank and assigning the observed NTC value for that rank. For example, if the final April NTC hindcast rank was 10 (the 10th highest rank), the NTC value assigned for the prediction would be the 10th highest observed rank, which in this case would be 166 NTC units. Since there is considerable uncertainty at this extended lead time as to final forecast values, final hindcast values are constrained to be between 40 and 200 NTC units.

Using the ranking method to arrive at our final forecast values is a new statistical forecasting approach for us. We find that using this method improves the hindcast skill of our forecasts somewhat (approximately 4-10%) and also allows for improved predictability of outliers. For example, simply by ranking our December hindcasts and assigning observed NTC values to those ranks improves our hindcast skill in early December from 45% to 49%.

While statistical prediction schemes A and B showed small or no forecast correlation over their periods of real-time forecasting, the new scheme (Scheme D) detailed below correlates at 0.80 for the years from 1995-2007 and 0.85 for the years from 2002-2007. We believe that we have solid physical links between these predictors and the upcoming Atlantic basin hurricane season.

Table 2 displays hindcasts for 1950-2007 using Scheme D, while Figure 1 displays observations versus NTC hindcasts. We have correctly predicted above- or below-average seasons in 45 out of 58 hindcast years (78%). Our predictions have had a smaller error than climatology in 37 out of 58 years (64%). Our average hindcast error is 26 NTC units, compared with 44 NTC units for climatology. This scheme also shows considerable stability when broken in half, explaining 59 percent of the variance from 1950-1978 and 72 percent of the variance from 1979-2007. This new scheme is also well-tuned to the multi-decadal active hurricane periods from 1950-1969 and 1995-2007 versus the inactive hurricane period from 1970-1994 (Table 3). Figure 2 displays the locations of the two new late-winter predictors used in this scheme in map form. Please refer to Figure 1 of our early December forecast for locations of predictors used in our early December prediction scheme. Table 4 lists the three (two new late-winter predictors and our early December prediction) that are utilized for this year’s April forecast. A more extensive discussion of current conditions in the Atlantic and Pacific basins is provided in Sections 4 and 5. Table 5 displays the forecasts from statistical models B, C, and D for 2002-2007 along with the correlations between each scheme and observations over this period.

Table 2: Observed versus hindcast NTC for 1950-2007 using Scheme D. Average errors for hindcast NTC and climatological NTC predictions are given without respect to sign. Red bold-faced years in the "Hindcast NTC" column are years that we did not go the right way, while red bold-faced years in the "Hindcast improvement over Climatology" column are years that we did not beat climatology. The hindcast went the right way with regards to an above- or below-average season in 45 out of 58 years (78%), while hindcast improvement over climatology occurred in 37 out of 58 years (64%).

Year	Observed NTC	Hindcast NTC	Observed minus Hindcast	Observed minus Climatology	Hindcast improvement over Climatology
1950	230	200	30	130	100
1951	115	**97**	18	15	**-3**
1952	93	**150**	-57	-7	**-50**
1953	116	188	-72	16	**-56**
1954	124	**92**	32	24	**-8**
1955	188	166	22	88	66
1956	66	**129**	-63	-34	**-29**
1957	82	**109**	-27	-18	**-9**
1958	133	134	-1	33	32
1959	94	89	5	-6	1
1960	92	**133**	-41	-8	**-33**
1961	211	200	11	111	100
1962	32	**106**	-74	-68	**-6**
1963	111	**94**	17	11	**-6**
1964	160	116	44	60	16
1965	82	**115**	-33	-18	**-15**
1966	134	130	4	34	30
1967	93	82	11	-7	**-4**
1968	39	66	-27	-61	34
1969	150	200	-50	50	0
1970	62	52	10	-38	28
1971	91	85	6	-9	3
1972	27	40	-13	-73	60
1973	50	64	-14	-50	36
1974	72	50	22	-28	6
1975	89	74	15	-11	**-4**
1976	82	82	0	-18	18
1977	45	40	5	-55	50
1978	83	45	38	-17	**-21**
1979	92	40	52	-8	**-44**
1980	129	**57**	72	29	**-43**
1981	109	**93**	16	9	**-7**
1982	35	62	-27	-65	38
1983	31	40	-9	-69	60
1984	74	93	-19	-26	7
1985	106	111	-5	6	1
1986	37	40	-3	-63	60
1987	46	80	-34	-54	20
1988	118	**83**	35	18	**-17**
1989	130	129	1	30	29
1990	98	82	16	-2	**-14**
1991	57	40	17	-43	26
1992	64	40	24	-36	12
1993	52	72	-20	-48	28
1994	35	46	-11	-65	54
1995	222	160	62	122	60
1996	192	134	58	92	34
1997	51	51	0	-49	49
1998	166	200	-34	66	32
1999	185	192	-7	85	78
2000	134	118	16	34	18
2001	129	**98**	31	29	**-2**
2002	80	91	-11	-20	9
2003	173	185	-12	73	61
2004	228	200	28	128	100
2005	273	173	100	173	73
2006	85	124	-39	-15	**-24**
2007	97	92	5	-3	**-2**
Average	**106**	**104**	**26**	**44**	**+18**

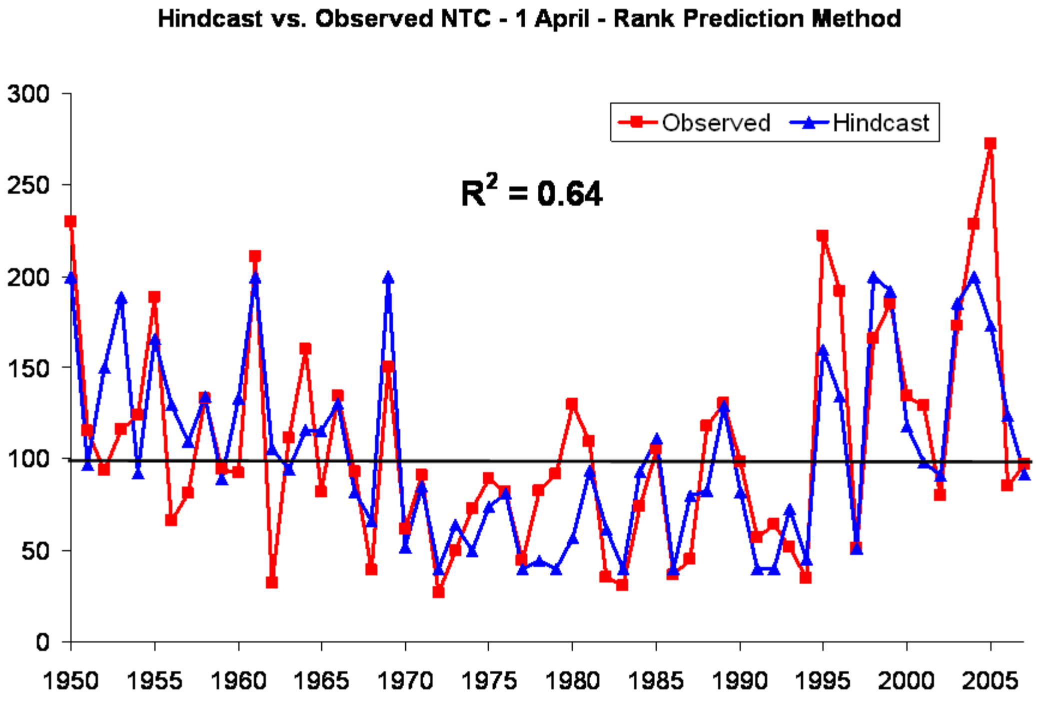

Figure 1: Observed versus hindcast values of NTC for 1950-2007.

Table 3: Hindcast versus observed average NTC for active vs. inactive multi-decadal periods.

Years	***Average Hindcast NTC***	***Average Observed NTC***
1950-1969 (Active)	130	117
1970-1994 (Inactive)	66	72
1995-2007 (Active)	140	155

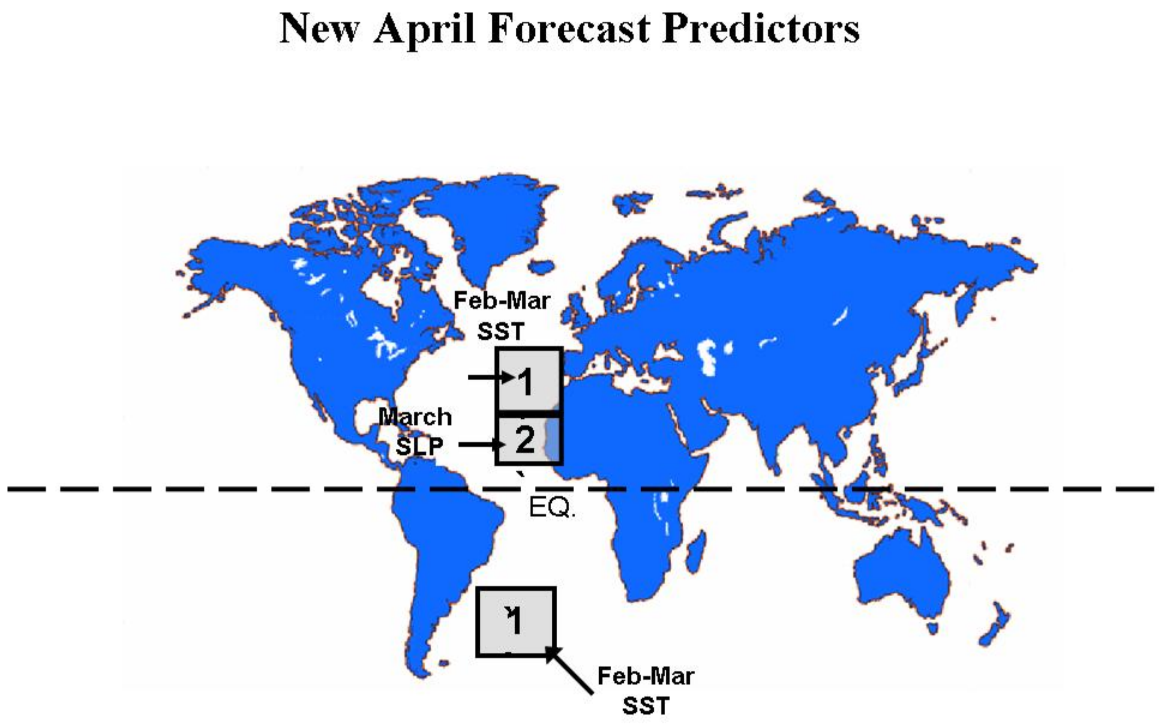

Figure 2: Location of new late-winter predictors for our April extended-range statistical prediction for the 2008 hurricane season.

Table 4: Listing of 1 April 2008 predictors using the new statistical forecast for the 2008 hurricane season. A plus (+) means that positive values of the parameter indicate increased hurricane activity during the following year.

Predictor	2008 Forecast Values
1) February-March SST Gradient (30-45°N, 10-30°W) – (30-45°S, 20-45°W) (+)	+2.3 SD
2) March SLP (10-30°N, 10-30°W) (-)	-1.3 SD
3) Early December Hindcast (+)	125 NTC

Table 5. Statistical forecasts from schemes B, C, and D along with observations of Net Tropical Cyclone Activity from 2002-2007. Note that scheme D does the best at predicting year-to-year variations in NTC activity. A value of 100 represents the average hurricane season.

Years	***Scheme B Forecast***	***Scheme C Forecast***	***Scheme D Forecast***	***Observation***
2002	101	95	91	80
2003	137	118	185	173
2004	149	164	200	228
2005	107	90	173	273
2006	124	111	124	85
2007	88	142	92	97
Correlation (2002-2007)	**0.42**	**0.07**	**0.85**	
Hindcast Correlation	1950-2001 0.84	1950-2004 0.74	1950-2007 0.80	

There is also extended-range forecast skill from 1 April for United States hurricane landfall probabilities. In the 15 out of 58 years where our newest hindcast scheme (Scheme D) forecast NTC values above 133, we had approximately twice as many hurricane (40 versus 17) and major hurricane (18 versus 7) landfalls along the U.S. coastline when compared with the 15 out of 58 years where our newest hindcast scheme gave NTC values below 64. For the Florida Peninsula and the U.S. East Coast, the ratio between NTC hindcast values greater than 133 and below 64 are 25 to 6 for hurricanes and 10 to 1 for major hurricanes.

There have been several hindcast years which were very successful. Table 6 displays the 10 years that our extended-range hindcasts were closest to actual observations. The average hindcast minus observed NTC difference in these years was 3. The average difference between the observed NTC and climatological NTC of 100 in these 10 years was 30.

Table 6: The 10 years that our hindcasts were closest to observations.

Years	***Hindcast NTC***	***Observed NTC***
1958	134	133
1959	89	94
1966	130	134
1976	82	82
1977	40	45
1985	111	106
1986	40	37
1989	129	130
1997	51	51
2007	92	97

There have also been several years where the hindcast was a failure. Table 7 displays the 10 years that our extended-range hindcasts deviated the most from actual observations. For our 10 worst hindcast years, our average NTC error was 66, while the error using climatology was 60. For the 38 of 58 intermediate years between our 10 best and 10 worst NTC forecasts, our average NTC error was 22 while the average NTC error using climatology was 44. The average hindcast error we would have had using climatology for all forecasts was 44.

Over the entire 58-year period, our average hindcast error is 26 NTC units, compared with 44 NTC units using climatology. Our average hindcast error is approximately 41% less than the climatological error.

Table 7: The 10 years that our hindcasts deviated the most from observations.

Years	***Hindcast NTC***	***Observed NTC***
1952	150	93
1953	188	116
1956	129	66
1962	106	32
1969	200	150
1979	40	92
1980	57	129
1995	160	222
1996	134	192
2005	173	273

Table 8 displays how forecasts issued with our new hindcast scheme would have compared with our actual real-time forecasts issued in early April since 1995. All hindcast values have been rounded to the nearest five NTC units. Our actual 1 April real-time forecasts from 1995-2007 have not been successful. These forecasts have correlated at -0.19 with observations from 1995-2007. In contrast, the new hindcast scheme correlates at 0.80 with observations.

Another way of evaluating model skill is examining errors compared with climatology. Our real-time April NTC predictions and a climatological prediction both have errors of 69 NTC units when examined over the 1995-2007 period. Our new April hindcast has an error of 31 NTC units, an improvement of approximately 55% compared with either our earlier April forecast or a climatological NTC forecast.

Our new hindcast scheme had a smaller NTC error than our real-time April NTC prediction in 11 out of 13 years. Our error would have been the same as our real-time forecast in one additional year. Only once in the past thirteen years would our new hindcast scheme not have improved upon our real-time forecasts.

Table 8: Real-time early April forecasts, hindcasts based on our new early April scheme and observed NTC since 1995.

Years	***Real-Time April NTC Forecasts***	***New April NTC Hindcasts***	***Observed NTC***
1995	100	160	222
1996	105	135	192
1997	110	50	51
1998	95	200	166
1999	160	190	185
2000	125	120	134
2001	100	100	129
2002	125	90	80
2003	140	185	173
2004	145	200	228
2005	135	175	273
2006	195	125	85
2007	185	90	97
Verification Correlation	**-0.19**	**0.80**	

2.2 Physical Associations among Predictors Listed in Table 4

The locations and brief descriptions of our two new late-winter predictors for our April statistical forecast are now discussed. It should be noted that both forecast parameters correlate significantly with physical features during August through October that are known to be favorable for elevated levels of hurricane activity. For each of these predictors, we display a four-panel figure showing linear correlations between values of each predictor and August-October values of sea surface temperature, sea level pressure, 200 mb zonal wind, and 925 mb zonal wind, respectively. For more information about the predictors utilized in our early December statistical forecast (used as 50% of our early April forecast), please refer to our early December 2007 forecast: http://tropical.atmos.colostate.edu/Forecasts/2007/dec2007/dec2007.pdf

Predictor 1. February-March SST Gradient between the Subtropical Eastern Atlantic and the South Atlantic (+)

(30-45°N, 10-30°W) - (30-45°S, 20-45°W)

A combination of above-normal sea surface temperatures (SSTs) in the eastern subtropical Atlantic and cooler-than-normal SSTs in the South Atlantic are associated with a weaker-than-normal Azores high and reduced trade wind strength during the boreal spring (Knaff 1997). This heightened SST gradient in February-March is strongly correlated with weaker trade winds, lower-than-normal sea level pressures and above-normal SSTs in the tropical Atlantic during the following August-October period (Figure 3). All three of these August-October features are commonly associated with active Atlantic basin hurricane seasons, through reductions in vertical wind shear, increased vertical instability and increased surface latent and sensible heat fluxes, respectively. A stronger-than-normal temperature gradient between the North Atlantic and South Atlantic correlates quite strongly (~0.6) with active Atlantic basin tropical cyclone seasons. Based on data from the NCEP reanalysis, SSTs in the South Atlantic have been warming faster than SSTs in the North Atlantic over the period from 1950-2007, and therefore, the SST gradient calculation for Predictor 1 has been de-trended. February-March values of this de-trended SST gradient correlate at 0.54 with August-October values of the Atlantic Meridional Mode (AMM) (Kossin and Vimont 2007) over the period from 1950-2007. The AMM has been shown to impact Atlantic hurricane activity through alterations in the position and intensity of the Atlantic Inter-Tropical Convergence Zone (ITCZ). Changes in the Atlantic ITCZ bring about changes in tropical Atlantic vertical and horizontal wind shear patterns and in tropical Atlantic sea surface temperature patterns.

Predictor 2. March SLP in the Subtropical Atlantic (-)

(10-30°N, 10-30°W)

Our April statistical scheme in the late 1990s used a similar predictor when evaluating the strength of the March Atlantic sub-tropical ridge (Azores High). If the pressure in this area is higher-than-normal, it correlates strongly with enhanced Atlantic trade winds. These stronger trades enhance mixing and upwelling, driving cooler tropical Atlantic sea surface temperatures. These cooler SSTs are associated with higher-than-normal sea level pressures which can create a self-enhancing feedback that relates to higher pressure, stronger trades and cooler SSTs during the hurricane season (Figure 4) (Knaff 1998). All three of these factors are associated with inactive hurricane seasons. Sea level pressure values in this region have been trending slightly upward since the 1950s. We have removed half of the trend in the SLP values for our predictor calculations to avoid a potentially non-physical lowering of forecast values.

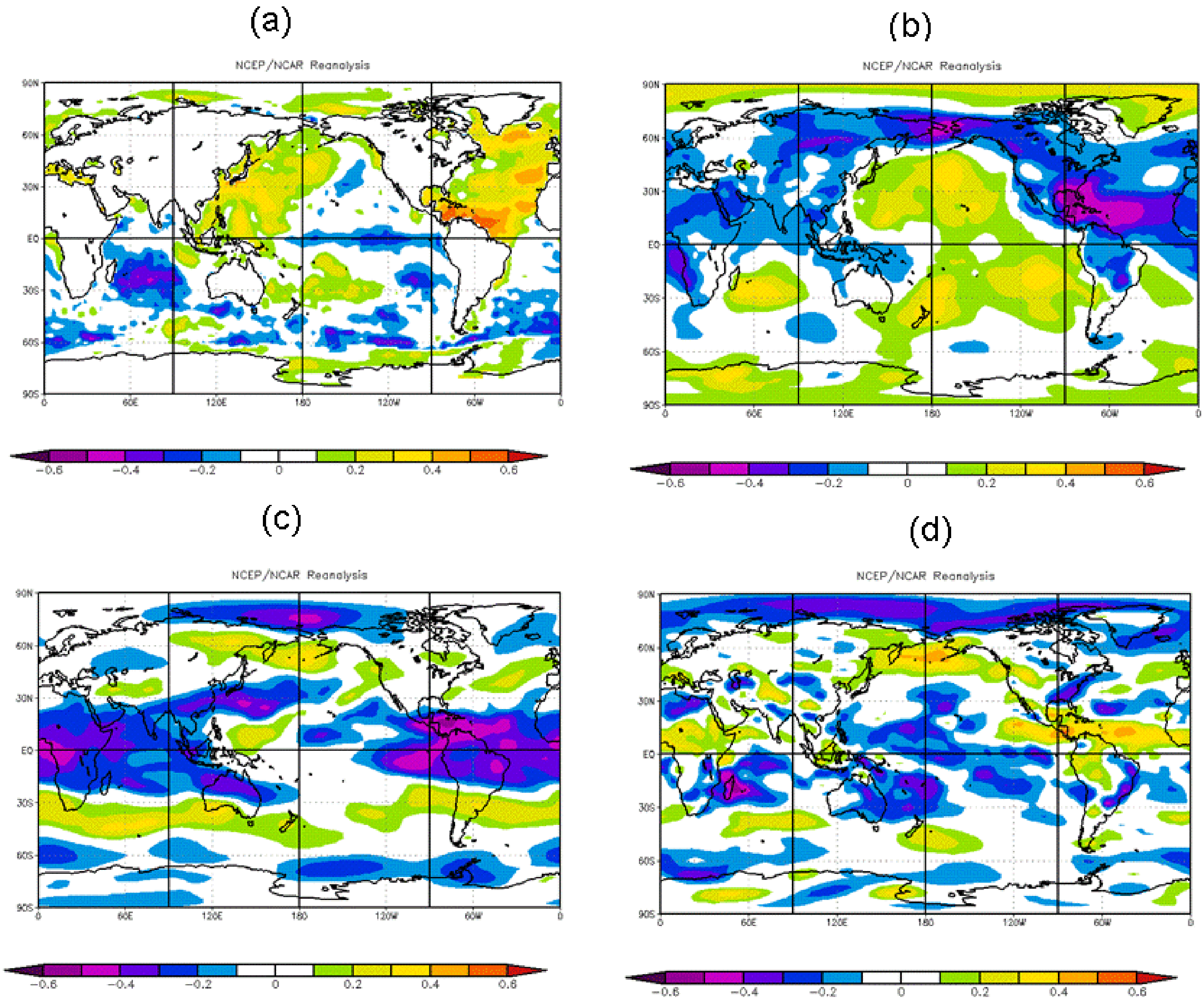

Figure 3: Linear correlations between the February-March SST gradient between the subtropical eastern Atlantic and the South Atlantic (Predictor 1) and August-October sea surface temperature (panel a), August-October sea level pressure (panel b), August-October 200 mb zonal wind (panel c) and August-October 925 mb zonal wind (panel d). All four of these parameter deviations are known to be favorable for enhanced hurricane activity.

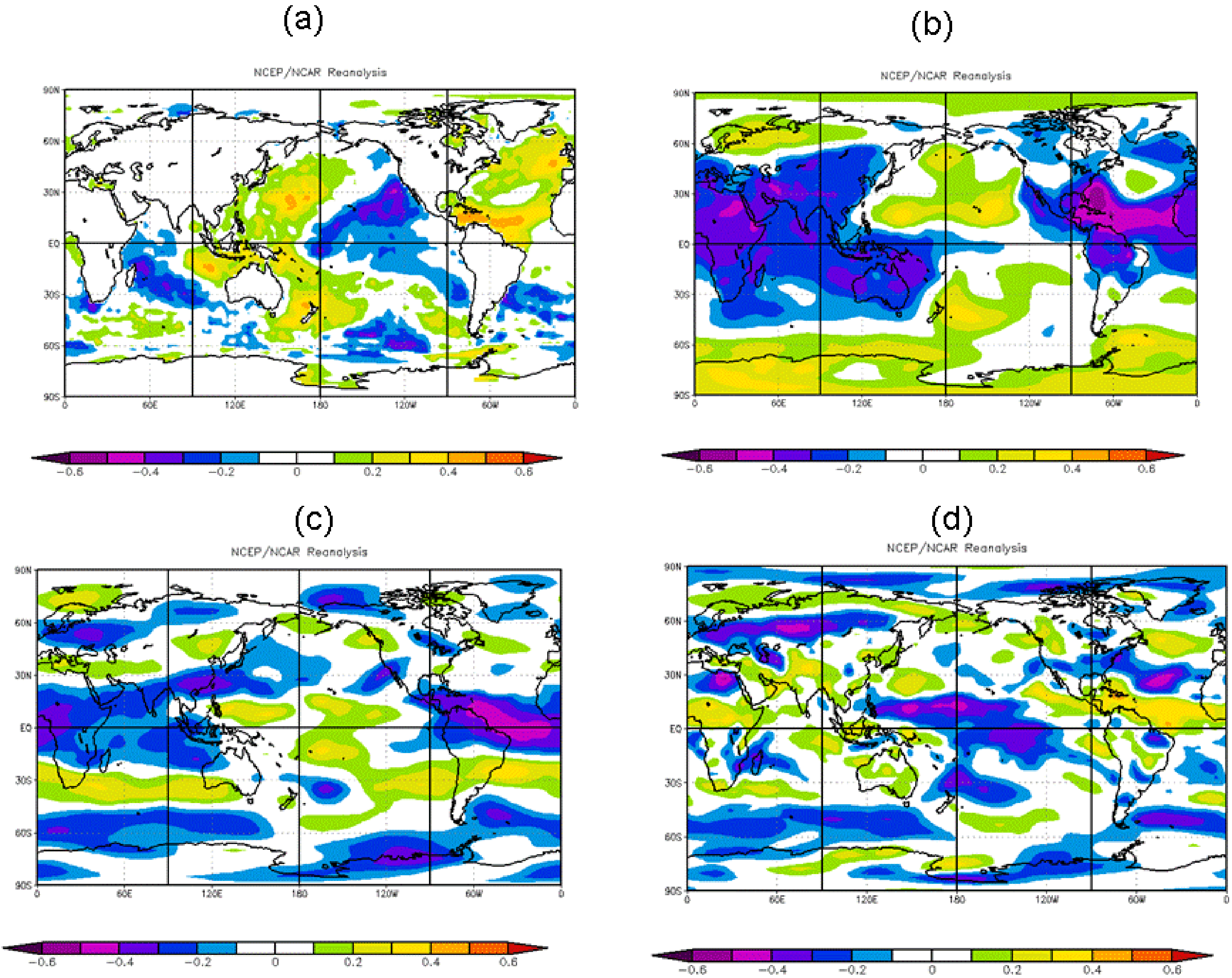

Figure 4: Linear correlations between March SLP in the subtropical Atlantic (Predictor 2) and August-October sea surface temperature (panel a), August-October sea level pressure (panel b), August-October 200 mb zonal wind (panel c) and August-October 925 mb zonal wind (panel d). All four of these parameter deviations are known to be favorable for enhanced hurricane activity. Sea level pressure values have been multiplied by -1 to allow for easy comparison with Figure 3.

3 Analog-Based Predictors for 2008 Hurricane Activity

Certain years in the historical record have global oceanic and atmospheric trends which are substantially similar to 2008. These years also provide useful clues as to likely trends in activity that the forthcoming 2008 hurricane season may bring. For this early April extended range forecast, we determine which of the prior years in our database have distinct trends in key environmental conditions which are similar to current February-March 2008 conditions. Table 8 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 2008 were selected primarily on how similar they are to conditions that are currently observed. We searched for years that had La Niña conditions and above-average tropical Atlantic and far North Atlantic sea surface temperatures during February-March.

There were four hurricane seasons since 1949 with characteristics most similar to what we observed in February-March 2008. The best analog years that we could find for the 2008 hurricane season were 1950, 1989, 1999, and 2000. We anticipate that 2008 seasonal hurricane activity will have activity in line with what was experienced in the average of these four years. We believe that 2008 will have above-average activity in the Atlantic basin.

Table 8: Best analog years for 2008 with the associated hurricane activity listed for each year.

Year	NS	NSD	H	HD	IH	IHD	ACE	NTC
1950	13	98.00	11	59.50	8	18.50	243	247
1989	11	66.00	7	31.75	2	9.75	135	130
1999	12	78.50	8	41.00	5	14.25	177	182
2000	14	67.00	8	32.75	3	5.00	116	130
Mean	12.3	77.4	8.5	41.3	4.5	11.9	168	172
2008 Forecast	15	80	8	40	4	9	150	160

4 ENSO

A moderate to strong La Niña event occurred during the winter of 2007-2008. However, this event has weakened considerably over the past few weeks. Fairly strong cold anomalies still exist in the central tropical Pacific, while warm anomalies are now present in the eastern tropical Pacific. Table 9 displays January and March SST anomalies for several Nino regions. Note that all four regions have experienced warming since January, although most of the warming has occurred in the eastern Pacific. The Nino 4 region has only warmed slightly since January.

Table 9: January and March SST anomalies for Nino 1+2, Nino 3, Nino 3.4, and Nino 4, respectively. March-January SST anomaly differences are also provided.

Region	January SST Anomaly (°C)	March SST Anomaly (°C)	March – January SST Anomaly (°C)
Nino 1+2	-0.7	1.0	1.7
Nino 3	-1.5	-0.4	1.1
Nino 3.4	-1.8	-1.1	0.7
Nino 4	-1.5	-1.3	0.2

The big question is whether this current observed warming will continue through this year's hurricane season. The spring months are known as the ENSO predictability barrier time period, as this is when both statistical and dynamical models show their least amount of skill. This is likely due to the fact that from a climatological perspective, trade winds across the Pacific are weakest during the spring months, and therefore, changes in phase of ENSO are often observed to occur during the April-June period. With that being said, none of the available statistical or dynamical ENSO models are predicting a warm ENSO event during this August-October period (Figure 5).

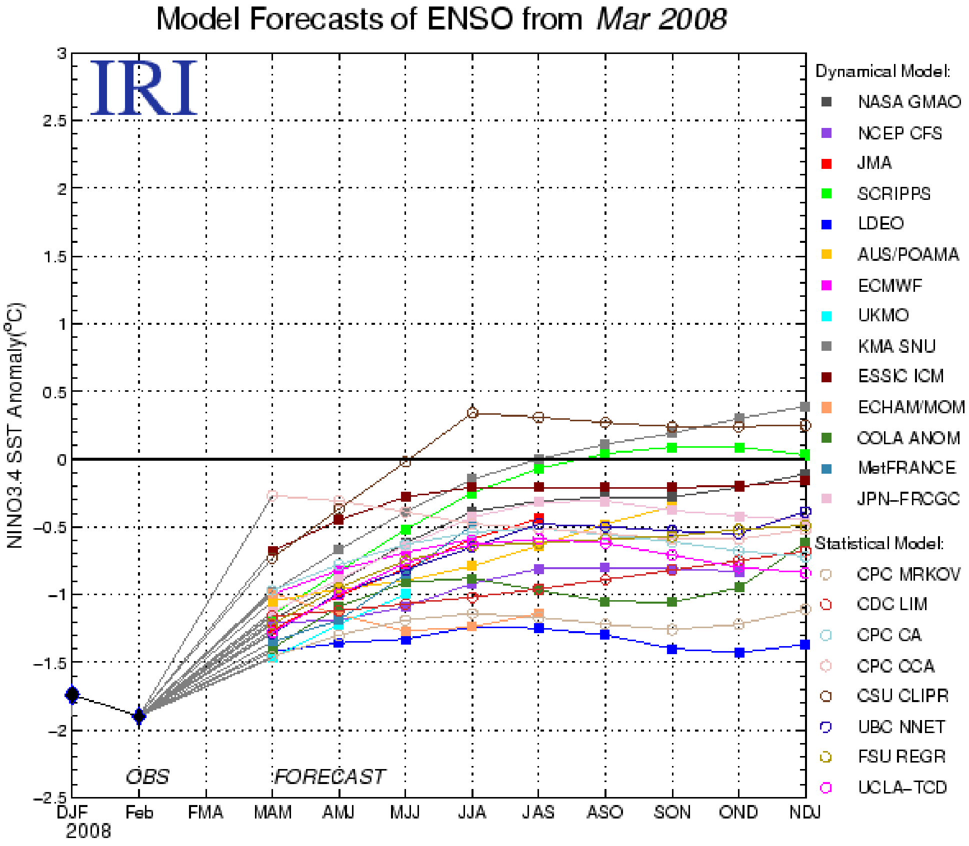

Figure 5: ENSO forecasts from various statistical and dynamical models. Figure courtesy of the International Research Institute (IRI).

Based on this information, we believe that this La Niña event will likely continue to moderate over the next couple of months. However, we do not foresee a transition to warm ENSO conditions during the 2008 hurricane season at this time. We should have more confidence in anticipating 2008 ENSO conditions during the hurricane season by our early June prediction.

5 Current Atlantic Basin Conditions

Current conditions in the Atlantic basin are quite favorable for an active hurricane season. Both of our early April predictors call for a very active hurricane season in 2008. The current sea surface temperature pattern in the Atlantic is a pattern typically observed before very active seasons. Waters off the coast of Iberia as well as the eastern tropical Atlantic are very warm right now (Figure 6). The Azores High has also been quite weak during the month of March. Typically, a weakened Azores High leads to weaker trade winds that enhance warm SST anomalies due to reduced levels of evaporation, mixing and upwelling in the eastern tropical Atlantic.

Our final April statistical model calls for a hyper-active season with an NTC of 190 (Table 10). Due to the uncertainty with current ENSO conditions, we do not feel confident enough to raise our forecast that high at this point, however, if current trends in the Atlantic persist, there is a possibility that the forecast could be increased more in early June.

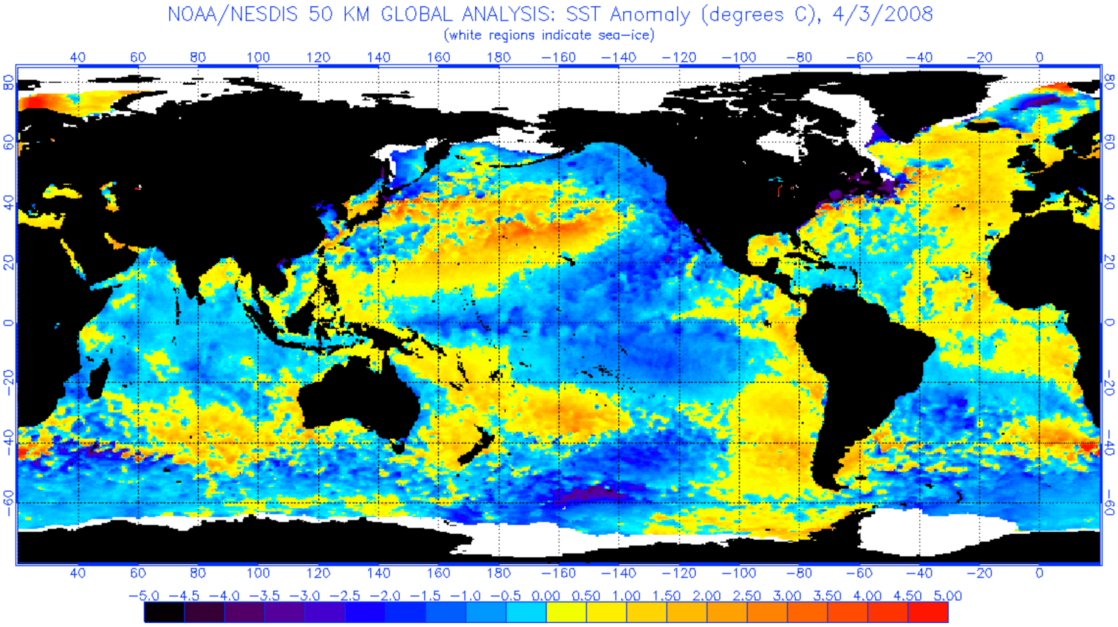

Figure 6: Current SST anomaly pattern as estimated from satellite. Note the warm anomalies in the eastern tropical and subtropical Atlantic. Figure courtesy of NOAA/NESDIS.

6 Adjusted 2008 Forecast

Table 10 shows our final adjusted early April forecast for the 2008 season which is a combination of our statistical scheme, our analog forecast and qualitative adjustments for other factors not explicitly contained in any of these schemes. Our statistical forecast and our analog forecast indicate activity at well above-average levels. We foresee an active Atlantic basin hurricane season. We continue to anticipate that cool ENSO conditions will moderate somewhat by next summer, but a transition to El Niño seems unlikely.

Warm sea surface temperatures are likely to continue being present in the tropical and North Atlantic during 2008, 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). Also, the currently-observed weak Azores High will likely promote weaker-than-normal trade winds over the next few months enhancing warm SST anomalies in the tropical and subtropical Atlantic.

Table 10: Summary of our early April statistical forecast, our analog forecast and our adjusted final forecast for the 2008 hurricane season.

Forecast Parameter and 1950-2000 Climatology (in parentheses)	Statistical Scheme	Analog Scheme	Adjusted Final Forecast
Named Storms (9.6)	18.2	12.3	15
Named Storm Days (49.1)	93.2	77.4	80
Hurricanes (5.9)	11.2	8.5	8
Hurricane Days (24.5)	46.6	41.3	40
Intense Hurricanes (2.3)	4.4	4.5	4
Intense Hurricane Days (5.0)	9.5	11.9	9
Accumulated Cyclone Energy Index (96.1)	183	168	150
Net Tropical Cyclone Activity (100%)	190	172	160

7 Discussion of 2008 Forecast

In the 25 years since our CSU forecast team began issuing seasonal hurricane forecasts, we have always tried to make our forecasts as transparent as possible. We have attempted to fully explain just how we made these forecasts and the physical reasons for why we proceeded as we did. When the season was over, we have gone through considerable effort to fully document all the tropical cyclones that occurred and to explain the broader-scale climate features with which they were associated. We have tried to be as honest as we could in discussing our forecast successes and our inevitable forecast failures. We have not been ashamed of our forecast failures. It is the nature of seasonal forecasting to sometimes be wrong. Our only regret would be if we had not given our best effort and turned over every stone in the quest for the best possible forecast. Anyone who wants to duplicate this early April forecast for the 2008 season or the hindcast statistics for the 1950-2007 seasons can do so through using the NCEP/NCAR reanalysis data which are readily available on the web.

It is surprising that such extended-range hindcasts are able to show statistical skill over long periods. This suggests that there are long-period memory signals within the global climate system. These long-period signals are certainly worthy of much further study. There are likely many new future extended-range forecast signals yet to be uncovered.

One learns more about how the global climate system functions by making real-time public forecasts that have your name on them. This demonstrates your personal commitment to your seasonal forecast methodology and your belief that your current forecast is able to beat climatology. You always learn more when your seasonal forecast busts than when it verifies. Busted forecasts drive us to explain the reasons for the failure and likely lead to enhanced skill in future years.

8 Landfall Probabilities for 2008

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 11). NTC is a combined measure of the year-to-year mean of six indices of hurricane activity, each expressed as a percentage difference from the long-term average. 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 11: NTC activity in any year consists of the seasonal total of the following six parameters expressed in terms of their long-term averages. A season with 10 NS, 50 NSD, 6 H, 25 HD, 3 IH, and 5 IHD would then be the sum of the following ratios: 10/9.6 = 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 12 lists strike probabilities for the 2008 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 2008 is expected to be above its long-term average of 100, and therefore, United States landfall probabilities are above average.

Please visit the United States Landfalling Probability Webpage 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. Work is underway to improve the webpage interface and add additional functionality. More information will be available in the next couple of months.

Table 12: 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 2008. 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)	92% (79%)	84% (68%)	69% (52%)	95% (84%)	99% (97%)
Gulf Coast (Regions 1-4)	76% (59%)	59% (42%)	44% (30%)	77% (60%)	94% (83%)
Florida plus East Coast (Regions 5-11)	67% (50%)	60% (44%)	45% (31%)	78% (61%)	93% (81%)

9 Was 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 Southeast 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 13-year period of 1995-2007 (average 3.8 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 from 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 other tropical cyclone basins besides the Atlantic. 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 from 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). 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 13). Although global mean ocean and Atlantic sea surface temperatures have increased by about $0.4^{o}C$ between these two 50-year periods (1900-1949 compared with 1958-2007), 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, both 2006 and 2007 had slightly below-average and average activity, respectively, and only one Category 1 hurricane (Humberto) made United States landfall.

Between 1966 and 2003, US major hurricane landfall numbers were below the long-term average. Of the 79 major hurricanes that formed in the Atlantic basin from 1966-2003, only 19 (24 percent) made US landfall. During the two seasons of 2004-2005, seven of 13 (54 percent) came ashore. Zero of the four major hurricanes that formed in 2006 and 2007 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 that 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 13: 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	+0.4°C
1958-2007 (50 years)	165	82	33	

Although 2005 had a record number of tropical cyclones (28 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 21) – 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 slightly below-average season in 2006 and average activity in 2007, 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.

9 Forthcoming Updated Forecasts of 2008 Hurricane Activity

We will be issuing seasonal updates of our 2008 Atlantic basin hurricane forecasts on **Tuesday 3 June**, **Tuesday 5 August**, **Tuesday 2 September** and **Wednesday 1 October 2008 –** note date change for October update. The 5 August, 2 September and 1 October forecasts will include separate forecasts of August-only, September-only and October-November Atlantic basin tropical cyclone activity. A verification and discussion of all 2008 forecasts will be issued in late November 2008. Our first seasonal hurricane forecast for the 2009 hurricane season will be issued in early December 2008. All of these forecasts will be available on the web at: http://hurricane.atmos.colostate.edu/Forecasts.

10 Acknowledgments

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12 Verification of Previous Forecasts

Table 14: Summary verification of the authors' six previous years of seasonal forecasts for Atlantic TC activity between 2002-2007.

2002	7 Dec. 2001	Update 5 April	Update 31 May	Update 7 August	Update 2 Sept.	Obs.
Hurricanes	8	7	6	4	3	4
Named Storms	13	12	11	9	8	12
Hurricane Days	35	30	25	12	10	11
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.
Hurricanes	8	8	8	8	7	8	7
Named Storms	12	12	14	14	14	14	14
Hurricane Days	35	35	35	25	25	35	32
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.
Hurricanes	7	8	8	7	8	9	9
Named Storms	13	14	14	13	16	15	14
Hurricane Days	30	35	35	30	40	52	46
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.
Hurricanes	6	7	8	10	10	11	14
Named Storms	11	13	15	20	20	20	26
Hurricane Days	25	35	45	55	45	40	48
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.
Hurricanes	9	9	9	7	5	6	5
Named Storms	17	17	17	15	13	11	9
Hurricane Days	45	45	45	35	13	23	20
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

2007	8 Dec. 2006	Update 3 April	Update 31 May	Update 3 Aug	Update 4 Sep	Update 2 Oct	Obs.
Hurricanes	7	9	9	8	7	7	6
Named Storms	14	17	17	15	15	17	15
Hurricane Days	35	40	40	35	35.50	20	11.25
Named Storm Days	70	85	85	75	71.75	53	34.50
Intense Hurricanes	3	5	5	4	4	3	2
Intense Hurricane Days	8	11	11	10	12.25	8	5.75
Accumulated Cyclone Energy	130	170	170	150	148	100	68
Net Tropical Cyclone Activity	140	185	185	160	162	127	97