FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY FOR 1997

(Another year expected to have above average hurricane activity)

(as of 6 June 1997)

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(This forecast is based on ongoing research by the authors, along with meteorological information through May 1997)

[This and past forecasts are available via the World Wide Web: http://tropical.atmos.colostate.edu/forecasts/index.html] — also,

Thomas Milligan and Carrie Schafer, Colorado State University, Media Representatives (970-491-6432) are available to answer various questions about this forecast. A taped interview with William Gray can be obtained by calling 970-491-1525.

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Summary of 6 June 1997 forecast of seasonal Atlantic hurricane activity.

Forecast Parameter	Forecast 1997 Seasonal Activity	Long-term (1950-1990) Average
Named Storms (NS)	11	9.3
Named Storm Days (NSD)	55	46.9
Hurricanes (H)	7	5.8
Hurricane Days (HD)	25	23.7
Intense Hurricanes (IH)	3	2.2
Intense Hurricane Days (IHD)	5	4.7
Hurricane Destruction Potential (HDP)	75	70.6
Net Tropical Cyclone Activity (NTC)	110%	100%
Maximum Potential Destruction (MPD)	70	61.7

DEFINITIONS

Atlantic Basin - The area including the entire Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico.

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 makes up four 6-hour periods during which a tropical cyclone is observed or estimated to have hurricane intensity winds.

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.

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.

Hurricane Destruction Potential - (HDP) A measure of a hurricane's potential for wind and storm surge destruction defined as the sum of the square of a hurricane's maximum wind speed (in 10^4 knots^2)for each 6-hour period of its existence.

Intense Hurricane - (IH) A hurricane which reaches a sustained low level wind of at least 111 mph (96 kt 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 intensity of Saffir/Simpson category 3 or higher.

Millibar - (mb) A measure of atmospheric pressure which is often used as a vertical height designator. Average surface values are about 1000 mb; the 200 mb level is about 12 kilometers and the 50 mb is about 20 kilometers altitude. Monthly averages of surface values in the tropics show maximum summertime variations of about $\pm$ 2 mb which are associated with variations in seasonal hurricane activity.

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 5-6 years or so on average.

Delta PT - A parameter which measures anomalous east to west surface pressure (ΔP) and west to east surface temperature (ΔT) gradients across West Africa.

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

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 reverse 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 5 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.

SST(s) - Sea Surface Temperature(s).

ZWA - Zonal Wind Anomaly - A measure of upper level ($\sim$ 200 mb) west to east wind strength. Positive anomaly values mean winds are stronger from the west or weaker from the east than normal.

Net Tropical Cyclone Activity (NTC) - Average seasonal percentage sum of NS, NSD, H, HD, IH, IHD. Gives overall indication of Atlantic basin seasonal hurricane activity (see Appendix B).

Maximum Potential Destruction - (MPD) - A measure of the net maximum destruction potential during the season compiled as the sum of the square of the maximum wind observed for each named storm (see Appendix A for a listing of values for 1950-1995).

1 knot = 1.15 miles per hour = .515 meters per second.

ABSTRACT

Information obtained through May 1997 indicates that, as during the previous two seasons the 1997 Atlantic hurricane season is again likely to have greater-than-average activity. We project that total season activity will include 11 named storms (average is 9.3), 55 named storm days (average 47), 7 hurricanes (average 5.8), 25 hurricane days (average 24), 3 intense (category 3-4-5) hurricanes (average 2.2), 5 intense hurricane days (average is 4.7) and a hurricane destruction potential (HDP) of 75 (average 71). Whereas net 1997 tropical cyclone activity is expected to be 110 percent of the long term average, this year's activity should be appreciably less than the unusually active 1995 and 1996 seasons. Still, 1997 should be significantly more active than the average of the generally suppressed hurricane seasons during the last 25 years and especially in comparison to the particularly quiet seasons of 1991–1994. This early June updated forecast is the same as projected in our early December (1996) and early April 1997 forecasts. An important element entering this updated forecast is the belief that the recently formed warm ENSO event will not overly disrupt this year's Atlantic activity. If this 1997 hurricane forecast is approximately correct, then the 3-year period of 1995-1997 will have been the most active consecutive three years of hurricane activity on record. This suggests that we are entering a new era of generally greater Atlantic basin hurricane activity. A final updated forecast for 1997 will be issued on 6 August 1997. A verification of this year's forecast will be made in late November 1997.

1. Introduction

Surprisingly strong long range predictive signals exist for Atlantic basin seasonal tropical cyclone activity. Our recent research indicates that a sizeable portion of the year-to-year variability of Atlantic tropical cyclone activity can be skillfully hindcast as early as late November of the prior year. This late fall forecast can then be updated in early April, early June and early August. In this paper we present an early June update of the coming season's Atlantic basin tropical cyclone activity. This forecast is based on meteorological data available through the end of May 1997.

Forecasts equations were developed using 47 years (1950-1996) of historical data. We have studied these years of historical data to develop the best possible forecast from a variety of global wind, temperature, pressure, rainfall and ocean features. Figures 1 and 2 show the various factors which are used in our statistical models.

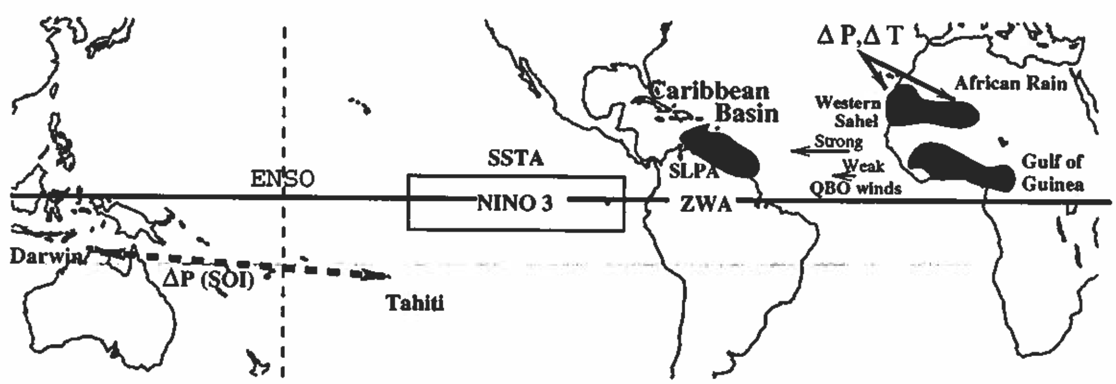

Figure 1: Meteorological parameters used in our old early June (Gray et al. 1994a) seasonal forecast.

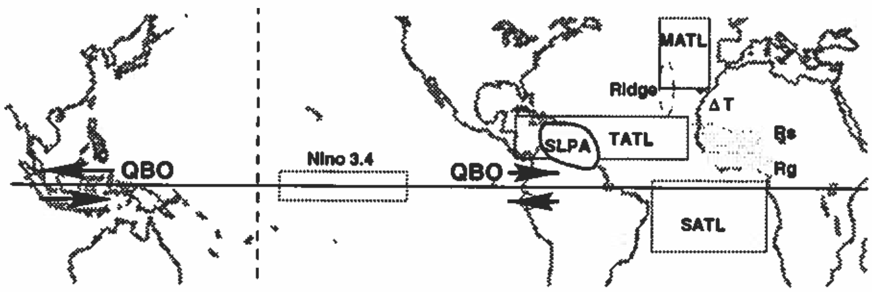

Figure 2: Some additional meteorological parameters used in our new formulation of the June forecast (Gray et al. 1997).

These seasonal hurricane forecasts are based on the premise that the behavior of the atmosphere during the coming year will closely follow that of similar years in the past. In other words, we assume that those global environmental conditions which preceded active or inactive hurricane seasons in the past will be similarly related to future seasonal trends in hurricane activity. Allowing that the global atmosphere operates as a single entity, past observations provide insight on how the atmosphere-ocean-land system will likely operate in future months and seasons. Our forecast methodology and skill continues to evolve as we study new data and ideas to improve both our physical understanding and forecast skill.

2. Prediction Methodology

We prepare forecasts for nine measures of seasonal Atlantic basin tropical cyclone activity including the following: Number of Named Storms (NS), Number of Named Storm Days (NSD), Hurricanes (H), Hurricane Days (HD), Intense Hurricanes (IH), Intense Hurricane Days (IHD), Hurricane Destruction Potential (HDP), Net Tropical cyclone Activity (NTC), and Maximum Potential Destruction (MPD) (Definitions for these indices are given on page 2). For each of these activity parameters we choose the best combination of predictors (i.e., those resulting in optimum prediction skill) from a field of 17 possible forecast parameters. The set of potential predictors currently in our early June forecast are shown in Table 1. The specific values of these parameters used in this early June forecast are shown in the right column. Additional forecast parameters representing conditions in the Pacific Ocean basin and the Asia-Australia regions (Figs. 1 and 2) are also consulted for further qualitative forecast adjustments. In this way, we use both quantitative and qualitative information to produce the final "adjusted" forecast.

Our predictions, developed from the 47-year data period of 1950–1996, explain 47 to 66 percent of the past variance. Table 2 lists the predictions selected for each forecast parameter and gives their hindcast skill for the 47-year period of 1950–1996. In application to independent data (i.e., real forecast situations), we expect a net degradation of this hindcast skill of about 10-25 percent. Obviously, and by definition, it is impossible to specify the amount of degradation (if any) in an individual year. In most years, the forecast will show skill while in other years it will perform poorly.

Table 3 lists two different early June statistical forecasts for the 1997 hurricane season and summarizes our final adjusted early June forecast. Column 1 gives our older statistical model (Gray et al. 1993, 1996) while Column 2 gives our newest statistical model which includes new forecast parameters (Gray et al. 1997); Column 3 gives our adjusted and final early June forecast.

Table 1: Pool of predictive parameters and their estimated values for the early June 1997 prediction. This is based on meteorological data through May 1997. See Figs. 1 and 2 for the locations of these predictors.

Predictive Parameter	
1 = QBO 50 mb 4-month extrapolation of zonal wind at 12°N to Sept. 1997	$-1\ ms^{-1}$
2 = QBO 30 mb 4-month extrapolation of zonal wind at 12°N to Sept. 1997	$-3\ ms^{-1}$
3 = QBO absolute value of shear between 50 and 30 mb at 12°N to Sept. 1997	$2\ ms^{-1}$
4 = Rgc AN Gulf of Guinea rainfall anomaly (Aug-Nov of 1996)	-0.41 SD
5 = Rws West Sahel rainfall anomaly (June-Sept 1996)	-0.16 SD
8 = Temp East-West Sahel temperature gradient(Feb-May 1997)	0.6 SD
9 = SLPA April-May Caribbean basin sea level pressure anomaly	+1.1 mb
10 = ZWA April-May Caribbean basin zonal wind anomaly	+1.0 m/s
11 = ONR:O-N Azore surface pressure ridge strength in Oct-Nov 1996	+1.45 SD
12 = MR:Mar Azore surface pressure ridge strength in Mar 1997	-0.85 SD
13 = SST3.4 Nino 3.4 SSTA ion April-May	+0.8°C
14 = D-SST3.4 Delta Nino 3.4 SSTA for April-May minus Feb-Mar 1997	+1.1°C
15 = SATL South Atlantic SSTA anomaly (March-April)	-0.53°C
16 = TATL Tropical Atlantic SSTA anomaly (March-April)	+0.08°C
17 = MATL Mid Atlantic SSTA anomaly(March-April)	+0.88°C

Table 2: Listing of predictors chosen for each parameter forecast and the amount of hindcast variance explained by these predictors for our newest updated 1 June forecast.

Forecast Parameter	No. of Predictors	Predictors Chosen from Table 1 in Order of Variance Explained	Variance Explained by Hindcast (1950-1995)
N	4	1, 3, 11, 17	.542
NSD	5	3, 4, 13, 16, 17	.580
H	6	1, 3, 4, 5, 11, 17	.532
HD	6	1, 3, 4, 5, 11, 14	.599
IH	7	1, 4, 5, 9, 14, 15, 17	.631
IHD	5	1, 4, 8, 13, 17	.628
HDP	4	1, 4, 13, 17	.580
NTC	5	1, 4, 8, 13, 17	.648
MPD	6	1, 3, 4, 11, 13, 17	.675

Table 3: Full 1 June statistical forecast (column 1) along with our final adjusted early June forecast.

Forecast Parameter	(1) Older Statistical Forecast (Gray et al. 1994)	(2) Newest Statistical Forecast Developed This Year	(3) Final Adjusted 6 June 1997 Forecast
Named Storms (NS)	10.43	10.66	11
Named Storm Days (NSD)	58.76	43.59	55
Hurricanes (H)	8.19	6.47	7
Hurricane Days (HD)	29.25	34.00	25
Intense Hurricanes (IH)	1.69	5.97	3
Intense Hurricane Days (IHD)	7.10	8.78	5
Hurricane Destruction Potential (HDP)	87.23	116.34	75
Net Tropical Cyclone Activity (NTC)	155.23	128.74	110
Maximum Potential Destruction (MPD)	Not made	68.68	70

3. Early June Atlantic Basin Hurricane Forecast for 1997

Table 4 summarizes all 1997 hurricane season forecast values including the results obtained from our 6 December 1996 and 4 April 1997 forecasts and the current early June forecast. Of primary interest is column 4 which gives our 6 June 1997 adjusted, "actual" forecast for 1997. This early June forecast is identical to our earlier 6 December and 4 April forecasts.

Status of the Early June Predictors

The forecast signals for 1997 are somewhat mixed. Of the 17 potential predictors listed in Table 1, eight factors indicate an above average season whereas five predictors (Guinea and Sahel rainfall during 1996, Atlantic Oct-Nov ridge, ENSO and ENSO change) indicate below average activity in 1997. Reflecting on the prior discussions, we believe that the predictors indicating an above average hurricane season (i.e., the Atlantic Ocean and QBO factors) outweigh those indicating a below average season (ENSO related factors). Those that are suggestive of an above average season are as follows:

1. A large weakening of the Atlantic subtropical ridge since the October-November period of +1.45 SD to a March value of –0.85 SD. This change suggests a reduced trend in ocean upwelling along Western Africa and South America, resulting in warmer tropical waters and lower sea level pressure in the tropical Atlantic for this summer.

2. Equatorial (Atlantic) SST anomalies in the area to the south of the West Africa bulge have become cold while the tropical Atlantic to the west of Africa (i.e., off the coast of Mauritania and Senegal) have become warm. If these SSTA patterns hold (as we expect them to), this should be an enhancing influence for both West African rainfall and (associated) hurricane activity this summer.

3. Broad scale North Atlantic SSTA patterns are warm, implying a multidecadal shift in North Atlantic SSTs which we believe are related to changes in the Atlantic Ocean thermohaline or "conveyor" circulation. This condition indicates presence of a stronger Atlantic Ocean thermohaline circulation.

Table 4: Updated statistical and adjusted Atlantic basin hurricane forecasts for 1997. The same forecast has been issued at each time period.

Forecast Parameter	(1) 1950-90 Average	(2) 6 Dec 96 Adjusted Forecast	(3) 4 April 1997 Adjusted Forecast	(4) 6 June 1997 Adjusted Forecast
Named Storms	9.3	11	11	11
Named Storm Days	46.9	55	55	55
Hurricanes	5.8	7	7	7
Hurricane Days	23.7	25	25	25
Intense Hurricanes	2.2	3	3	3
Intense Hurricane Days	4.7	5	5	5
Hurricane Destruction Potential	70.6	75	75	75
Net Tropical Cyclone Activity	100.0	110	110	110
Maximum Potential Destruction	61.7	70	70	70

4. More evidence (and hence, greater confidence) that drought conditions will not occur in the Western Sahel region this coming summer. A separate forecast of 1997 West Sahel rainfall (Landsea et al. 1997) indicates that normal to above average rainfall conditions should prevail this coming summer.

5. Middle latitude Atlantic wind patterns during the winter of 1997 have been more typical of the blocking conditions which were more prevalent during the late 1940s through the late 1960s; a time when the far North Atlantic also had similar warm SSTA conditions and intense Atlantic hurricane activity was more prevalent.

6. Low pressure anomalies in the Caribbean and weaker than normal Atlantic trade wind conditions are expected this summer. These inferences are based on recent work of co-author Knaff (1997b) who has developed a separate forecast of summertime Caribbean basin Sea Level Pressure Anomalies (SLPA). This forecast is based upon the strength of the March Atlantic subtropical ridge, January through March SSTs in the North Atlantic (50-60°N, 10-50°W), and January through March Niño 3.4 (5°N–5°S, 120°W–170°W) SST anomalies. These factors forecast Caribbean SLP anomalies to be -0.1, -0.5, and -0.3 in June through July, June through September, and August through September, respectively. Lower than normal SLP in this region are related to increased hurricane activity (Shapiro 1982, Gray 1984, Knaff 1997a). These numbers are nearly identical to the pressure anomalies forecast for last year's very active hurricane season.

In summary, data through the end of May indicates that 1997 will experience hurricane activity below the level of 1995 and 1996 but still above the average for the last 47 years and distinctly more active than the recent inactive 1991-1994 and (longer) 1970–1994 periods.

4. Early June ENSO Outlook

A warm El Niño is already in place. A dramatic and sudden warming in the eastern and central equatorial Pacific the last three months has signaled the onset of warm ENSO conditions during the past several months. In fact, the warming has been most noticeable in Nino region

3.4 where March SST anomalies were neutral (0.0°C) and May values are reported to be nearly 1.0°C; likewise Nino region 1-2 the warming is significant with a May 1997 SST anomaly of 2.9°C. In addition, the latest SOI values indicate that a fairly rapid change has occurred in the tropical Pacific during the past several months and, in particular, in the month of May to -2.2 SD. Such a decrease signals the advent of warm ENSO conditions. We do not, however, foresee this El Niño warming event to progress to the point where it will greatly disrupt the coming hurricane season. We believed that conditions in the tropical Atlantic will significantly offset the increases of vertical wind shear related to ENSO. In addition, we expect the current El Niño conditions to level off as Northern Hemisphere summer monsoon conditions become established because:

1. QBO westerly wind this summer at both 50 and 30 mb levels. El Niños typically do not intensify and tend to weaken with the onset of the westerly QBO in the lower stratosphere. This onset is presently taking place.

2. Atlantic Ocean surface temperatures and pressure are very conducive for hurricane activity this year. These favorable Atlantic factors are expected to counteract the strong hurricane inhibiting factors related to warm ENSO in the Atlantic basin.

3. The lack of strong positive 100 mb temperature anomalies at Singapore during the last three years. In the historic record (since 1957) all strong El Niños have been preceded by a notable, sustained-100 mb warming at Singapore. Strong 100 mb warming at Singapore occur as a combined effect of the West phase of the QBO and a well established (cold SST) La Niña; these two conditions at times interact to strengthen the processes in the tropical Pacific that govern the ocean heat storage and released during the development of a strong El Niño event. Hence, the lack of a strong 100 mb warming (since late 1993) is unfavorable for a moderate or strong 1997 El Niño event (see Sheaffer 1994, 1995a,b).

9. Hurricane Activity During ENSO Years (As 1997 is expected to be)

Most strong and moderate El Niño years which occurred since 1950 are associated with notably suppressed Atlantic basin hurricane activity. But somewhat weaker events are not. The five weaker eastern Pacific El Niño events occurring in 1951, 1953, 1958, 1969, and 1979 experienced at or above average hurricane activity. August through October NINO-3 SSTA anomalies during these years were 1951 (0.95), 1953 (0.45), 1958 (0.30), 1969 (0.80), and 1979 (0.50)); an average of +0.6°C. Meanwhile, net tropical cyclone (NTC) activity during these years was 120, 120, 139, 155, and 95 percent of average (five-year mean is 126). Our 6 June 1997 NTC forecast value is 110. Thus, even though a moderate warming event of 0.5 to 0.8°C anomaly should remain in place in the NINO-3 and NINO-3.4 regions this year, there is good evidence that this warm event will not be very effective in causing a large suppression of this year's hurricane activity. With the exception of 1979 the above ENSO years had favorable Atlantic conditions which acted to counteract ENSO suppressing tendencies. In short, we believe that Atlantic regional factors are presently too favorable for the current ENSO warming to cause a large suppression of this year's Atlantic basin hurricane activity. Of course, within this current El Niño our forecast for 1997 would have been increased from the current amount.

10. Prior Three-Year Periods of Above Normal Activity

If the actual 1997 hurricane activity turns out to be only average (or greater), then the three seasons of 1995–1997 will represent the most active three consecutive hurricane seasons since records have been kept. But how frequently do runs of three consecutive active hurricane seasons occur? The historical hurricane record shows several such consecutive three-year periods. These include 1886–1888, 1891–1893, 1932–1934, 1943-1945, 1949–1951, 1953–1955, and 1988–1990. A climatology of these three-year periods (noting that the hurricane data prior to aircraft observations are less reliable), is given in Table 5. Average values for measures of tropical cyclone activity during these three year periods are shown along with averages for the third year (only). Note that the third year of these three-year periods is typically as active as the previous two years and notably more active than the 1950–1990 average. Our 1997 forecast, shown on the bottom line of Table 5, is consistent with the average level of hurricane activity occurring during the third year of a three-year active cycle.

Table 5: Average seasonal totals of named storms (NS), named storm days (NSD), Hurricanes (H), Hurricane Days (HD), Intense Hurricanes (IH), Intense Hurricane Days (IHD), Hurricane Destruction Potential (HDP), and Net Tropical Cyclone (NTC) activity during the seven previous three year active hurricane periods during the last 125 years (top line) versus the same average seasonal totals during the third year of these three year periods (line 2). The 1950–1990 average is shown in the third line for comparison.

	NS	NSD	H	HD	IH	IHD	HDP	NTC
Ave. of Seven Most Active 3 Year Periods	12.1	72	7.3	34	2.3	6.6	104	132
Ave. of Third Year of These Active Periods	11.3	69	7.3	34	1.9	6.9	98	128
1950–1990 Average	9.3	47	5.8	24	2.3	4.7	71	100
1997 Forecast	11	55	7	25	3	5	75	110

The occurrence of consecutive three-year periods of above average activity was more common during the 1930 through 1950 period and during the 1880s and 1890s. What else was different during these periods? Figure 3 shows time series of North Atlantic (50-60°N, 10-50°W) SST anomalies and the June to September rainfall in the Sahel in relation to these three-year periods of above normal hurricane activity. In general, the active three-year periods occurred in association with near or greater-than-normal West Sahel June to September rainfall and warmer-than-normal SST conditions in the North Atlantic. We believe the latter (SST conditions) are related to multi-decadal variations in the North Atlantic thermohaline circulation. We presently feel that we have Atlantic Ocean region conditions similar to those of the 1930s through 1960s and are thus in an active period despite the recent development of the current warm ENSO event.

11. The 1995 and 1996 Hurricane Seasons and Global Warming

Some individuals will, no doubt, interpret the recent upswing in hurricane activity during 1995 and 1996 and the expected above normal activity in 1997 as evidence of climate changes due to increased man-made greenhouse gases such as carbon dioxide (CO_2). This may be a logical interpretation, especially given all the media attention to this topic. But this speculation cannot be accepted. Anthropogenic greenhouse gas warming, even if a physically valid hypothesis, is a very slow and gradual process that, at best would only be expected to bring

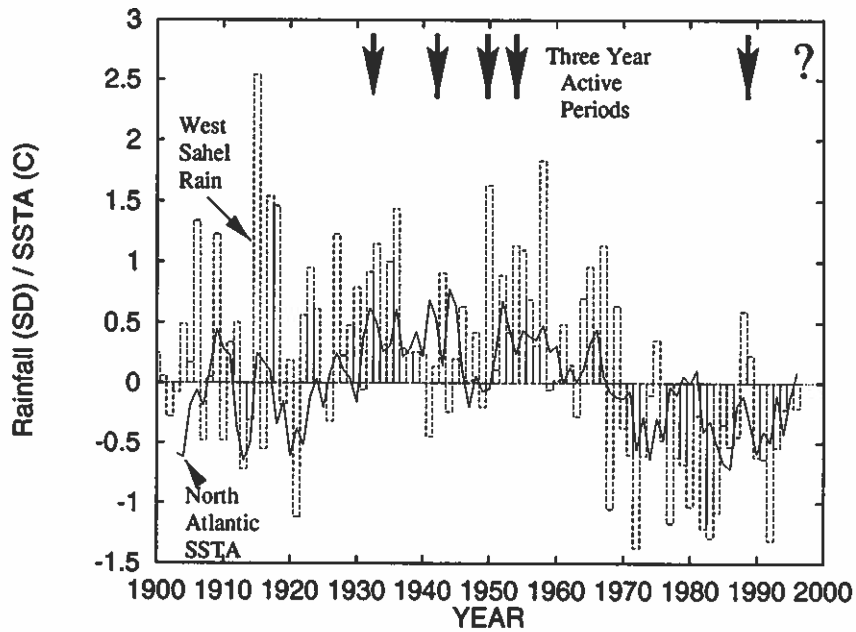

Figure 3: Time series of the North Atlantic SST anomalies (solid line) and the standardized amount of West Sahel June to September rainfall. In the upper portion of this figure are arrows depicting the seven three year periods of increased Atlantic hurricane activity.

about small changes in global circulation over periods of 50 to 100 years. This would not result in the abrupt and dramatic one year upturn in hurricane activity as occurred between the early 1990s and the 1995–1996 time period. And, if man-induced greenhouse increases were to be interpreted as causing global mean temperature increase over the last 25 years, there is no way to relate such a small global temperature increases to more intense Atlantic basin hurricane activity during this same period. Intense Atlantic category 3-4-5 hurricane activity experienced a substantial decrease over the period of 1970–1994. Hence, this sharp downturn in intense hurricane activity occurred while global surface temperatures were increasing. It is the climatology of the Atlantic region that is likely the cause of these abrupt changes. The Atlantic thermohaline circulation may now be recovering from an inferred three-decade-long slowing. Evidence of such a strengthening includes recent reports of decreased ice flow (hence fresh water) through the Fram Strait between Greenland and Spitsbergen, as well as increased water salinity in the deep water formation areas of the North Atlantic during the last three years. Chilling of this comparatively dense, high salinity surface water creates very dense water which can sink to great depth and move south, out of the basin. This engenders a northward flow of warm near surface replacement water; this process is often termed "Atlantic (Ocean) Conveyor". ~~Among other considerations, a strong conveyor, as hypothesized,~~ increases North Atlantic SST anomalies which are useful as a proxy for the strength of the conveyor belt and are an indication of enhanced Atlantic basin hurricane activity.

12. Likely Increase of Landfalling Major Hurricanes in Coming Decades

Excepting the last two (1995 and 1996) seasons, there has been a marked decrease in the incidence of intense category 3-4-5 hurricanes striking the US East Coast, Florida and Caribbean region during the last 25 years. This quarter-century lull is likely a consequence of alterations in the Atlantic Ocean's thermohaline circulation which appears to be responsible for a long list of concurrent global climate trends including the Sahel drought, increased El Niño activity and stronger Pacific and Atlantic middle-latitude zonal winds among numerous others.

Recent data and historical and geological (proxy) records indicate that this extended lull in major hurricane activity is unlikely to continue. A new era of major hurricane activity appears to have begun with the usually active 1995 and 1996 seasons. How long this period will last is still in question however as a consequence of the exploding US and Caribbean coastal development during the last 25-30 years, we will begin to see a large upturn in hurricane spawned destruction – likely higher than anything previously experienced.

13. Forthcoming Forecast Updates

This 6 June 1997 forecast will be updated again on

- Wednesday 6 August 1997, just prior to the most active portion of the hurricane season.

The early August forecast will utilize data which are closer in time to the peak of the hurricane season and therefore, should be somewhat more reliable than this and our earlier forecasts. Verification of all our forecasts will be issued in late November 1997.

14. Cautionary Note

It is important that the reader appreciate that these seasonal forecasts are based on statistical schemes and forecasting judgments which will fail in some years. These forecasts also do not specifically predict where within the Atlantic basin storms will strike. Even if 1997 should prove to be an above average hurricane season, there are no assurances that any hurricanes will strike along the US or Caribbean Basin coastline.

15. Acknowledgments

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17. Additional Reading

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APPENDIX: Verification of All Past Seasonal Forecasts

The first author has now issued seasonal hurricane forecasts for the last 13 years. In most of the prior forecasts, predictions have been superior to climatology, which was previously the only way to estimate future hurricane activity (see Table 6). The seven late May and early

June seasonal forecasts for 1985, 1986, 1987, 1988, 1991, 1992 and 1994 were more accurate than climatology. The forecasts for 1984 and 1990 were only marginally successful and the two seasonal forecasts for 1989 and 1993 were failures. The 1989 forecast was a failure because of processes associated with the excessive amounts of rainfall which fell in the Western Sahel that year. Prior to 1990, our seasonal forecast did not include African rainfall as a predictor. We have corrected this important omission and forecasts since 1990 have incorporated Western Sahel rainfall estimates and we have developed a new Sahel rainfall prediction scheme. The failure of the 1993 seasonal forecast is attributed to our failure to anticipate the resurgence of El Niño conditions. In particular, the first author failed to anticipate the re-emergence of stronger El Niño conditions after the middle of August 1993. It is very unusual to have an El Niño last so long as the recent 1991-94 event. This failure motivated us to develop a new extended range ENSO prediction scheme, which is used as a quantitative first guess as to upcoming El Niño conditions. We have no explanation for my large underprediction of the 1996 hurricane activity.

Table 6: Verification of the authors' previous seasonal predictions of Atlantic tropical cyclone activity for 1984-1995.

1984	Prediction of 24 May and 30 July Update		Observed
No. of Hurricanes	7		5
No. of Named Storms	10		12
No. of Hurricane Days	30		18
No. of Named Storm Days	45		51
1985	**Prediction of 28 May**	**Updated Prediction of 27 July**	**Observed**
No. of Hurricanes	8	7	7
No. of Named Storms	11	10	11
No. of Hurricane Days	35	30	21
No. of Named Storm Days	55	50	51
1986	**Prediction of 29 May**	**Updated Prediction of 28 July**	**Observed**
No. of Hurricanes	4	4	4
No. of Named Storms	8	7	6
No. of Hurricane Days	15	10	11
No. of Named Storm Days	35	25	23
1987	**Prediction of 26 May**	**Updated Prediction of 28 July**	**Observed**
No. of Hurricanes	5	4	3
No. of Named Storms	8	7	7
No. of Hurricane Days	20	15	5
No. of Named Storm Days	40	35	37
1988	**Prediction of 26 May and 28 July Update**		**Observed**
No. of Hurricanes	7		5
No. of Named Storms	11		12
No. of Hurricane Days	30		21
No. of Named Storm Days	50		47
Hurr. Destruction Potential(HDP)	75		81
1989	**Prediction of 26 May**	**Updated Prediction of 27 July**	**Observed**
No. of Hurricanes	4	4	7
No. of Named Storms	7	9	11
No. of Hurricane Days	15	15	32
No. of Named Storm Days	30	35	66
Hurr. Destruction Potential(HDP)	40	40	108
1990	**Prediction of 5 June**	**Updated Prediction of 3 August**	**Observed**
No. of Hurricanes	7	6	8
No. of Named Storms	11	11	14
No. of Hurricane Days	30	25	27
No. of Named Storm Days	55	50	66
Hurr. Destruction Potential(HDP)	90	75	57
Major Hurricanes (Cat. 3-4-5)	3	2	1
Major Hurr. Days	Not Fcst.	5	1.00

1991	Prediction of 5 June	Updated Prediction of 2 August	Observed
No. of Hurricanes	4	3	4
No. of Named Storms	8	7	8
No. of Hurricane Days	15	10	8
No. of Named Storm Days	35	30	22
Hurr. Destruction Potential(HDP)	40	25	22
Major Hurricanes (Cat. 3-4-5)	1	0	2
Major Hurr. Days	2	0	1.25

1992	Prediction of 26 Nov 1991	Updated Prediction of 5 June	Updated Prediction of 5 August	Observed
No. of Hurricanes	4	4	4	4
No. of Named Storms	8	8	8	6
No. of Hurricane Days	15	15	15	16
No. of Named Storm Days	35	35	35	39
Hurr. Destruction Potential(HDP)	35	35	35	51
Major Hurricanes (Cat. 3-4-5)	1	1	1	1
Major Hurr. Days	2	2	2	3.25

1993	Prediction of 24 Nov 1992	Updated Prediction of 4 June	Updated Prediction of 5 August	Observed
No. of Hurricanes	6	7	6	4
No. of Named Storms	11	11	10	8
No. of Hurricane Days	25	25	25	10
No. of Named Storm Days	55	55	50	30
Hurr. Destruction Potential(HDP)	75	65	55	23
Major Hurricanes (Cat. 3-4-5)	3	2	2	1
Major Hurr. Days	7	3	2	0.75

1994	Prediction of 19 Nov 1993	Updated Prediction of 5 June	Updated Prediction of 4 August	Observed
No. of Hurricanes	6	5	4	3
No. of Named Storms	10	9	7	7
No. of Hurricane Days	25	15	12	7
No. of Named Storm Days	60	35	30	28
Hurr. Destruction Potential(HDP)	85	40	35	15
Major Hurricanes (Cat. 3-4-5)	2	1	1	0
Major Hurr. Days	7	1	1	0
Net Trop. Cyclone Activity	110	70	55	36

1995	Prediction of 30 Nov 1994	14 April Qualit. Adjust.	Updated Prediction of 7 June	Updated Prediction 4 August	Obs.
No. of Hurricanes	8	6	8	9	11
No. of Named Storms	12	10	12	16	19
No. of Hurricane Days	35	25	35	30	62
No. of Named Storm Days	65	50	65	65	121
Hurr. Destruction Potential(HDP)	100	75	110	90	173
Major Hurricanes (Cat. 3-4-5)	3	2	3	3	5
Major Hurr. Days	8	5	6	5	11.5
Net Trop. Cyclone Activity	140	100	140	130	229

1996	Prediction of 30 Nov 1995	Updated 14 April	Updated Prediction of 7 June	Updated Prediction 4 August	Obs.
No. of Hurricanes	5	7	6	7	9
No. of Named Storms	8	11	10	11	13
No. of Hurricane Days	20	25	20	25	45
No. of Named Storm Days	40	55	45	50	78
Hurr. Destruction Potential(HDP)	50	75	60	70	135
Major Hurricanes (Cat. 3-4-5)	2	2	2	3	6
Major Hurr. Days	5	5	5	4	13
Net Trop. Cyclone Activity	85	105	95	105	198