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EXTENDED RANGE FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY FOR 1995

By
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(This forecast is based on ongoing research by the author and his Colorado State University research colleagues, together with meteorological information through late-November of 1994)

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ARAGO'S ADMONITION

"NEVER, NO MATTER WHAT MAY BE THE PROGRESS OF SCIENCE, WILL HONEST SCIENTIFIC MEN WHO HAVE REGARD FOR THEIR REPUTATIONS VENTURE TO PREDICT THE WEATHER"

ABSTRACT

This paper presents details of a 6–11 month extended range seasonal forecast of the tropical cyclone activity likely to occur in the Atlantic Ocean basin during 1995. This forecast is based on new research by the author and his colleagues which allows estimates of next season's Atlantic tropical cyclone activity to be made by late November of the prior year. The forecast scheme is based on a 10-month forward extrapolation of the Quasi-Biennial Oscillation (QBO) of equatorial stratospheric zonal winds, two measures of Western Sahel rainfall through mid-November 1994, an extended range forecast of El Niño conditions for August to October 1995 and an extended range forecast of Western Sahel rainfall amount for next season.

Information through mid-November 1994 indicates that 1995 Atlantic hurricane activity is likely to be above average with 8 hurricanes (average 5.7), 12 named storms (average 9.3), 65 named storm days, 35 hurricane days (average 23), 3 intense (category 3-4-5) hurricanes (average 2.1), 8 intense hurricane days and a hurricane destruction potential (HDP) of 100 (average 68). Collectively, net tropical cyclone activity is expected to be 140 percent of the long period average. The 1995 season should be much more active than the four recent 1991 through 1994 hurricane seasons, and especially in the tropical regions at latitudes south of 25°N where only two short lived hurricane have occurred during the last four years. The character of 1995 season should tend toward that of the two recent hurricane seasons of 1988 and 1989 which produced a total of five intense or major hurricanes and 19 intense hurricane days. The probability of hurricane destruction along the US coastline and within the Caribbean basin for 1995 is projected to be higher than the mean probability for the last 45 years and distinctly higher than the probabilities for the last four years.

It is expected that the long running 1990-1994 El Niño-like equatorial Pacific warm water conditions will finally dissipate by next summer and that comparatively cool surface water conditions will return to the east and central equatorial Pacific during next season's hurricane season. This trend should enhance hurricane activity over that of the last four years. It is also expected that the Western Sahel region of Africa will experience somewhat above average rainfall with total amounts ranking among the fourth or fifth highest since 1970. This upward trend in rainfall should also enhance the probability of intense hurricane activity for next year.

DEFINITIONS AND ABBREVIATIONS

Named Storm (NS) - A hurricane or tropical storm.

Named Storm Day (NSD) - Four consecutive six–hour periods during which a tropical cyclone is observed or estimated to have attained tropical storm or hurricane intensity winds.

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) - Four six-hour periods during which a tropical cyclone is observed or estimated to have hurricane intensity winds.

Intense or Major Hurricane (IH) - A hurricane reaching sustained low level winds of at least 111 mph (96 kt or $50ms^{-1}$) at some point in its lifetime. This constitutes a category three or higher storm intensity rating on the Saffir/Simpson scale.

Intense or Major Hurricane Day (IHD) - Four six-hour periods during which a hurricane has Saffir/Simpson category three intensity or higher.

Hurricane Destruction Potential (HDP) - A measure of a hurricane's potential for wind and storm surge destruction. HDP is defined as the sum of the square of a hurricane's maximum wind speed during each six-hour period of its existence. This value is summed for the season.

Net Tropical Cyclone Activity (NTC) - A combined measure of the average seasonal percentage of NS, NSD, H, HD, IH, and IHD to their long term mean.

1 Introduction

Surprisingly strong long range predictive signals exist for Atlantic basin seasonal tropical cyclone activity. Recent research by the author and colleagues Chris Landsea, Paul Mielke and Ken Berry indicates that a sizeable portion of the season-to-season variability of eight indices of Atlantic tropical cyclone activity can be independently hindcast in 42 years of past data (1950-1991) by as early as late November of the prior year. These predictive signals include two measures of Western Sahel rainfall during the prior year, the phase of the stratospheric Quasi-Biennial Oscillation of zonal winds at 30 mb and 50 mb (which can be extrapolated ten months into the future) and similar extended range predictions for El Niño-Southern Oscillation (ENSO) and Western Sahel rainfall for the following summer. A brief summary of these predictor indices is as follows:

a) QBO–Tropical Cyclone Lag Relationship

The easterly and westerly modes of stratospheric QBO zonal winds which circle the globe over the equatorial regions have a substantial influence on Atlantic tropical cyclone activity (Gray, 1984a; Shapiro, 1989). Typically, there is 50 to 75 percent more hurricane activity (depending on the specific activity index considered) during those seasons when stratospheric QBO winds between 30 and 50 mb are from a westerly phase (direction) and, consequently, when the vertical wind shear (ie., the variation of wind speed with height) between these two levels is small. Conversely, seasonal hurricane activity is typically reduced when stratospheric winds are in the easterly phase and the wind shear between 30 and 50 mb is large. We project that 50 and 30 mb winds will be strongly from the west next year. This should be an enhancing influence on next year's hurricane activity.

b) African Rainfall and Tropical Cyclone Lag Relationship

As discussed by Landsea (1991), Gray and Landsea (1992) and Gray et al. 1992, surprising strong predictive signals for seasonal hurricane activity can be obtained from the mid-summer to fall rainfall data for Western Sahel during the prior year. These include:

(1) August–September Western Sahel Rainfall. During the last four decades, the Western Sahel area (see Fig. 1) has experienced large year to year persistence of rainfall trends; that is, wet years tend to be followed by wet years (e.g., in the 1950s and 1960s) while dry years are typically followed by dry years (e.g., in the 1970s, 1980s and 1990s). This persistence alone tends to provide a moderate amount of skill for forecasting next season's African rainfall and the associated Atlantic hurricane activity. But, there are other non-persistent features which make this a useful forecast parameter.

(2) August–November Rainfall in the Gulf of Guinea. Landsea (1991) and Gray and Landsea (1992) have documented an even stronger African rainfall - intense hurricane lag relationship using August through November rainfall along the Gulf of Guinea (see Fig. 1). Intense hurricane activity during seasons following the ten wettest August–November Gulf of Guinea years was four times greater than that which occurred during those hurricane seasons following the ten driest August-November periods in the Gulf of Guinea. This association suggests a very strong modulation of the following season's hurricane activity by rainfall during the prior year. This year's rainfall for the West Sahel during August-September 1994 was not dry at all. In fact, it was above average for the last 45 years (1950-1994) average (+0.08 SD). And the Gulf of Guinea August-November rainfall has also been above average (+0.22 SD). These trends indicate the likelihood of a break in the long running Western Sahel drought conditions for next year. Rainfall values are projected to be the fourth or fifth highest of any year since 1970. It appears that we will likely see a temporary break in drought conditions as was experienced during the 1988 and 1989 seasons. This should be an enhancing influence on next year's hurricane activity

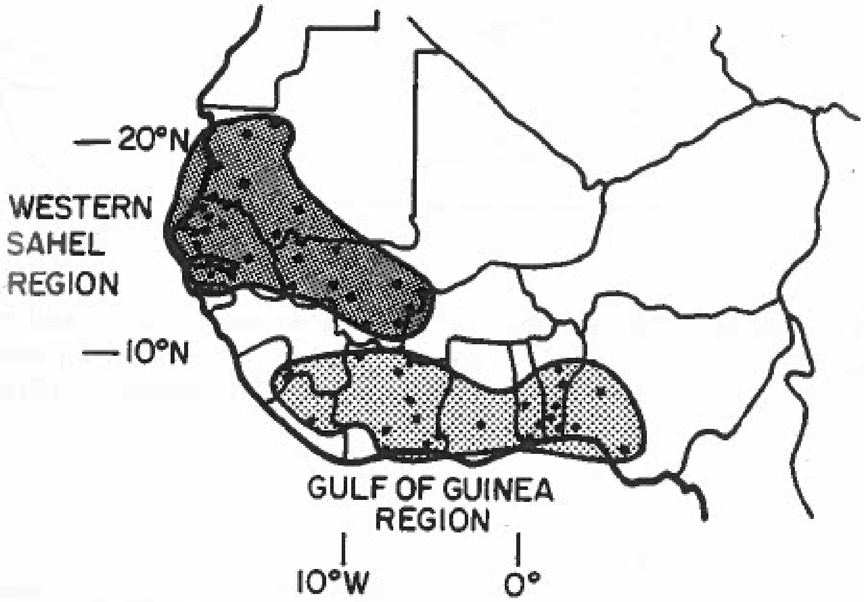

Figure 1: Locations of meteorological parameters used in early August Atlantic basin seasonal forecast.

c) The El Niño-Southern Oscillation (ENSO) Relationship

ENSO is one of the principal global scale environmental factors affecting Atlantic seasonal hurricane activity. Hurricane activity is usually much suppressed during those seasons when anomalously warm water temperatures are present in the equatorial eastern and central Pacific. And, activity is usually enhanced during seasons with cold (or La Niña) water conditions. Hurricane activity during the last four seasons (1991-1994) has been much suppressed because of the persistent, continuous warm water conditions which have been present in the NINO-3 and NINO-4 regions of the equatorial Pacific and the associated negative values of the Southern Oscillation Index (SOI or Tahiti minus Darwin surface pressure).

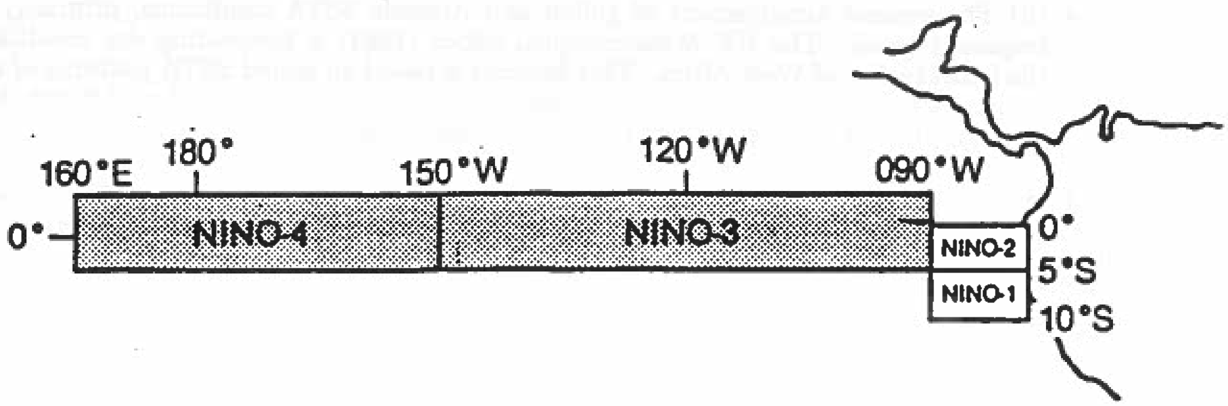

Figure 2: Equatorial Pacific sea surface temperature anomaly indices (°C) for the areas indicated.

We have recently devised a scheme for making extended range predictions of next summer's NINO-3 sea surface temperature anomaly (SSTA) conditions. This new ENSO prediction scheme (Gray et al. 1993) adds qualitative improvement to the extended range seasonal hurricane forecasts which Gray et al. (1992) developed previously but which lacked an ENSO prediction component.

Our NINO-3 forecast for SSTA conditions for August through October 1995 is for cool water conditions; we forecast an anomaly of –0.74°C. It appears that the 4-year warm water event will finally come to an end by the summer of 1995 (see attached report) detailing this forecast. This should be a factor enhancing next year's hurricane activity.

2 Basis for Extended Range Forecasts

This extended range forecast scheme is based on an optimized combination of multiple lag relationships observed between Atlantic hurricane activity and the climate indices described in the prior section. There are three forecast predictors for the QBO [extrapolated U_{30}, U_{50}, $|U_{30} - U_{50}|$], and two predictors for African rain [August–September Western Sahel rainfall (R_s) and August–November Gulf of Guinea (R_G) rainfall]. We also have a six parameter model which makes a late November prediction for the following August-October of NINO-3 Sea Surface Temperature Anomaly (SSTA) and a 5-term prediction from late November of the following Western Sahel Jun-September summer rainfall. These latter two predictions are not yet explicitly included in our hurricane forecast but offer important additional qualitative input to our late November hurricane forecast. By next year we hope to have both our ENSO and Western Sahel rainfall forecasts explicitly incorporated into the extended range hurricane prediction. Our forecast specifies the likely number 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 activity (NTC) for next year.

3 Statistical Forecast

Our forecast equation takes the following form (see Gray et al, 1992):

$$(Seasonal\ Forecast) = \beta_o + \beta_1[a_1 U_{50} + a_2 U_{30} + a_3|U_{50} - U_{30}|] + \beta_2[a_4 R_s + a_5 R_G] \quad (1)$$

where

1. U_{50} = 10 month extrapolated 50 mb September QBO zonal wind near 10°N
2. U_{30} = 10 month extrapolated 30 mb September QBO zonal wind near 10°N
3. $|U_{50} - U_{30}|$ =10 month extrapolated 50 mb minus 30 mb September QBO zonal wind shear
4. R_s = Measured standard deviation of previous year August-September Western Sahel rainfall
5. R_G = Measured standard deviation of previous year August-November Gulf of Guinea rainfall

The β_o and "a" coefficients are determined to maximize the hindcast predictive signals (last page). β_o and "a" coefficients are determined for each predictor. These equations were developed on data from the 41 years of 1950-1990. They explain about 40-50 percent of the variance of each parameter.

Values of the forecast parameters used in next year's prediction of Atlantic hurricane activity are given in Table 2. Substitution of the forecast predictors in Table 2 into Eq. 1 gives our statistical assessment and our qualitative adjustment based on our separate and independent extended range ENSO and Sahel prediction. We consider the values in the second column of Table 2 to be the best estimates that can be made of next year's Atlantic hurricane activity at this time. Through qualitative assessment of future Sahel rainfall and ENSO predictors, we believe that we are able to obtain a higher level of predictive skill than was possible with our extended range hurricane forecast scheme alone (Gray et al., 1992) which did not include extended range forecasts of ENSO or Sahel rainfall. The percentage, expressed in terms of the long term mean, is given in the right column of this table.

Table 1: Values of the five (input) parameters for 1995 forecast are as follows:

1. $U_{50} = 0$ m/s
2. $U_{30} = -4$ m/s
3. $|U_{50} - U_{30}| = 4$ m/s
4. Sahel (R_s) = +0.08 S.D.
5. Gulf of Guinea (R_G) = + 0.22 S.D.

Table 2: Statistical prediction for the 1995 season as obtained with Eq. 1 and the final adjusted forecast which qualitatively takes into account our independent forecast of 1995 ENSO and the consistency of the forecast of Western Sahel drought conditions.

Forecast Parameter	Gray et al. 1992 Statistical Forecast	Qualitative Adjusted Actual Forecast	Forecast in Percentage of 1950-1993 Mean
Named Storms (NS)	11.69	12	127
Named Storm Days (NSD)	65.35	65	142
Hurricanes (H)	7.40	8	140
Hurricane Days (HD)	34.26	35	153
Intense Hurricanes (IH)	2.94	3	144
Intense Hurricane Days (IHD)	6.62	8	178
Hurricane Destruction Potential (HDP)	91.42	100	138
Net Tropical Cyclone Activity (NTC)	128.41	140	140

Figure 3 is a graphical portrayal of our 1995 seasonal forecast in comparison with the 1950-1993 climatology and with the hurricane activity of 1994. Note the large increase in expected 1995 hurricane activity from what occurred in 1994.

4 Discussion

Implicit in this forecast is the anticipated dissipation of the long running equatorial Pacific warm water event which has now persisted for over four consecutive years. Historical records going back to the 1850s (see Wright, 1989) indicate that above average water temperatures and negative values of the Southern Oscillation Index (SOI) have never lasted for more than four consecutive years and that such three and four year consecutive warm events are very rare. Most El Niños last only a year or two. The departure of the current warm event is long overdue. Our extended range ENSO prediction scheme forecasts a NINO-3 sea surface temperature anomaly of −0.74°C for

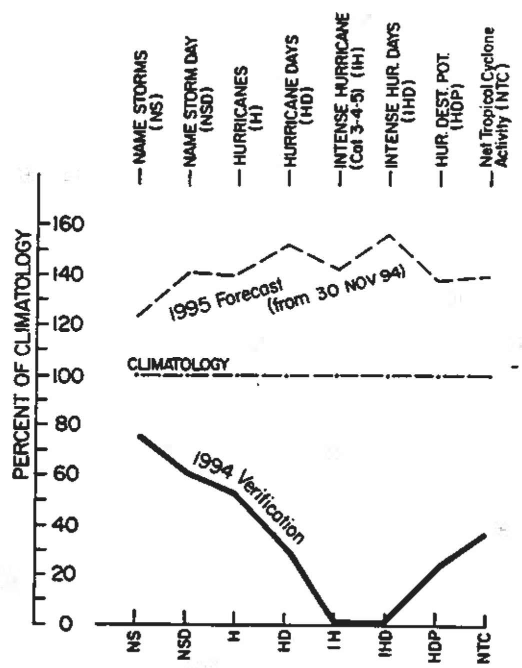

Figure 3: Comparison of the amount of hurricane activity which occurred in 1994 versus the long term means and the activity expected in 1995. All values are expressed in terms of percentages of the long term mean.

the August-October 1995 period. The inhibiting influence on hurricane activity of warm equatorial Pacific water temperatures for next year is thus felt to be very low. Consequently, hurricane activity should be higher.

In addition, our extended range estimate of Western Sahel precipitation for next year give positive precipitation values (+0.38 S.D.). This indicates that we should likely see a temporary break in the long running Western Sahel drought for next year. Rainfall amounts should be higher than have occurred during most of the last 25 years. Recent August to mid-November 1994 Gulf of Guinea rainfall are above average (+0.22 S.D.) for the first time since 1988. This is another indication that next year's seasonal hurricane activity is consistent with what has been observed during the last four years. Thus, all three of our primary extended range predictors (ENSO, QBO and Western Sahel rainfall), appear to be consistent and to favor a strong enhancement of next year's hurricane activity. Hurricane activity in 1995 should definitely be above that of the last four years.

5 Early April Update

The foregoing hurricane, African rainfall and ENSO predictions are all consistent with one another, indicating a major shift in global circulation patterns by the summer of 1995 with the return of an active hurricane season for the first time in 5 years. These conditions will be carefully monitored. A short update assessment of the likelihood as these forecasts working out will be made in early April and widely distributed. A better evaluation of conditions will be possible at that time. Should it look like El Niño conditions will persist for yet another year, then this forecast would have to be revised downward.

6 Cautionary Note

It is important for the reader to realize that this seasonal forecast is a statistical procedure which will fail in some years. This forecast does not specifically predict where within the Atlantic basin storms will strike. Even if 1995 should prove to be an active hurricane season, there are no assurances that hurricanes will strike along the US or Caribbean coastlines or do much damage. However, we reiterate that the probability of damage for 1995 is higher than the average for the last 40 years and is especially higher than it has been during the last four years (despite Andrew) and higher than the average of the last 25 years. The last 25-year intense hurricane activity has been greatly suppressed compared with average intense hurricane activity of the 1940s through the 1960s.

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December 1 forecasts

	B0	B1	a1	a2	a3	B2	a4	a5
NS	11.732	0.135	1	0.252	-0.64	0.701	1	2.498
NSD	64.072	1.031	1	0.424	-0.316	7.149	1	2.39
H	7.56	0.049	1	-0.32	-3.384	0.759	1	2.302
HD	33.303	0.215	1	1.781	-1.37	6.645	1	2.144
IH*	2.759	0.0316	1	-0.0146	-1.1649	0.3592	1	3.7987
IHD*	6.4086	0.0381	1	-1.9858	-7.4296	1.1286	1	3.8304
HDP*	86.6214	0.4572	1	1.778	-1.26	18.9744	1	2.118
NTC*	123.6108	0.4534	1	1.8	-2.499	17.7062	1	2.869