EXTENDED RANGE FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY FOR 1992

By
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(This forecast is based on ongoing research by the author and his research colleagues at Colorado State University, together with meteorological information through late November of 1991)

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ABSTRACT

This paper presents details of a 6–11 month extended range seasonal forecast of the tropical cyclone activity that might be expected to occur in the Atlantic Ocean basin during 1992. This forecast is based on new research by the author and his colleagues which allows an estimate of the amount of next season's Atlantic tropical cyclone activity to be made by the end of November of the prior year. The forecast scheme is based upon a 10-month extrapolation of the Quasi-Biennial Oscillation (QBO) of equatorial stratospheric zonal wind and of two measures of West African rainfall through late November.

Information up to late November, 1991, indicates that the 1992 Atlantic hurricane activity will likely be below average with about 4 hurricanes, 8 named storms, 15 hurricane days, and 1 relatively short-lived intense hurricane. Although the 1992 season should be more active than the 1991 season has been, it should be less active than have the recent seasons of 1988-89-90. The probability of hurricane destruction along the US East Coast and within the Caribbean basin for 1992 is projected to be below average.

It is expected that the long running West Sahel drought will continue through next season and that lingering influences of the current (intensifying) El Niño event will both be suppressing influences for next season's activity.

DEFINITIONS AND ABBREVIATIONS

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

Named Storm Day (ND) - Four consecutive 6–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 6-hour periods during which a tropical cyclone is observed or estimated to have hurricane intensity winds.

Intense 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 3 or higher on the Saffir/Simpson scale.

Intense Hurricane Day (HD) - Four 6-hour periods during which a hurricane has Saffir/Simpson category 3 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 for each 6-hour period of its existence. Value is summed for the season.

1 Introduction

A surprisingly strong long range predictive signal exists for Atlantic basin seasonal tropical cyclone activity. This predictive signal is related to two measures of West African rainfall in the prior year and to the phase of the stratospheric Quasi-Biennial Oscillation of zonal winds at 30 mb and 50 mb which can be extrapolated 10 months into the future with reasonable accuracy. These predictors, both of which are available by late November, can be utilized to make surprisingly skillful forecasts of Atlantic tropical cyclone activity in the following year. This apparent skill is based on independent hindcast studies of this lag association for the period of 1950–1990.

Recent research (by the author and Colorado State University research colleagues Chris Landsea, Paul Mielke and Ken Berry) is showing that these QBO and rainfall parameters can be used to forecast between 44 to 51 percent of season-to-season variability of seven indices of Atlantic seasonal tropical cyclone activity as early as late November of the previous year. The recent paper titled "Predicting Atlantic Seasonal Hurricane Activity 6-11 Months in Advance" by the author and colleagues (Gray, *et al.*, 1991) explains this predictive scheme.

a) QBO and Tropical Cyclone Lag Relationship

The easterly and westerly modes of stratospheric QBO zonal winds which circle the globe over the equatorial regions has a substantial influence on Atlantic tropical cyclone activity (Gray, 1984a; Shapiro, 1989). Nearly twice as much intense hurricane activity ($V_{max} \geq 50\ m/s$) occurs during seasons when the stratospheric QBO winds at the 50 mb (20 km) level are in the westerly as opposed to an easterly phase. Figure 1 shows intense hurricane tracks for seasons with foreward extrapolated 30 mb and 50 mb stratospheric QBO zonal winds in contrasting westerly, low shear regimes versus those of easterly, high shear regimes. Note the large differences in the numbers of intense hurricane tracks between these two contrasting 15-year QBO stratifications. This difference represents a 2.8 to 1 modulation in number of intense hurricane days. Our recent paper (Gray *et al.*, 1991) discusses the method of objectively extrapolating QBO winds 10 months into the future.

b) African Rainfall and Tropical Cyclone Lag Relationship

As discussed by Landsea (1991), there are surprising predictive signals in mid-summer to fall West African rainfall amounts for Atlantic hurricane activity in the next year. These include:

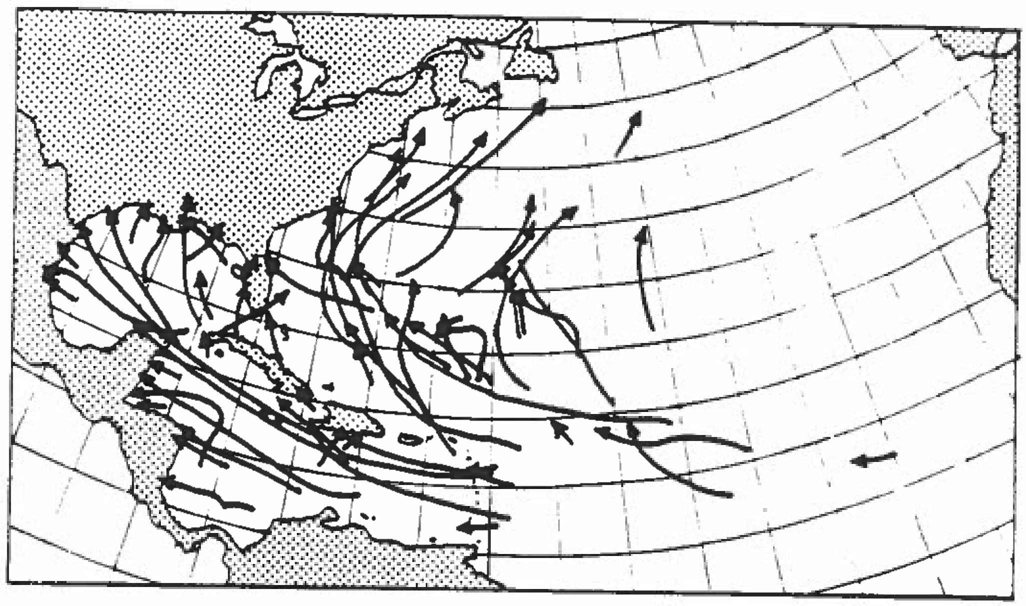
1) August–September Western Sahel Rainfall. During the last four decades, the Western Sahel (Fig. 2) has experienced a large year to year rainfall persistence. In general, wet years have been followed by wet years (e.g., in the 1950s and 1960s) while dry years typically followed dry years (e.g., in the 1970s and 1980s). This persistence provides a moderate amount of skill for forecasting next season's African rainfall and its associated Atlantic hurricane activity.

Figure 3 shows the number of intense hurricane tracks in the years following the 10 wettest and the 10 driest Western Sahel August and September periods between 1950 and 1990. Note the two to one modulation of intense hurricane activity between these two wet and dry periods.

2) August–November Gulf of Guinea Rainfall. Landsea (1991) has documented an even stronger rainfall - intense hurricane lag relationship for August through November rainfall along the Gulf of Guinea (Fig. 2). Figure 4 shows that intense hurricane activity in seasons following the 10 wettest August–November Gulf of Guinea years has <u>four</u> times the amount of activity that occurred during those hurricane seasons following the 10 driest Gulf of Guinea years. This suggests a very strong rainfall modulation.

2 Basis for Extended Range Forecasts

This extended range forecast scheme is based on an optimized combination of these two lag rainfall relationships plus a 10-month extrapolation (November to September) of the absolute value of the QBO zonal winds at 30 mb (U_{30}) and at 50 mb (U_{50}) and the resulting wind shear between these levels at 10° North latitude. Hence, there are five forecast predictors: extrapolated QBO U_{30}, U_{50}, $|U_{30} - U_{50}|$ and August–September Western Sahel (R_s)



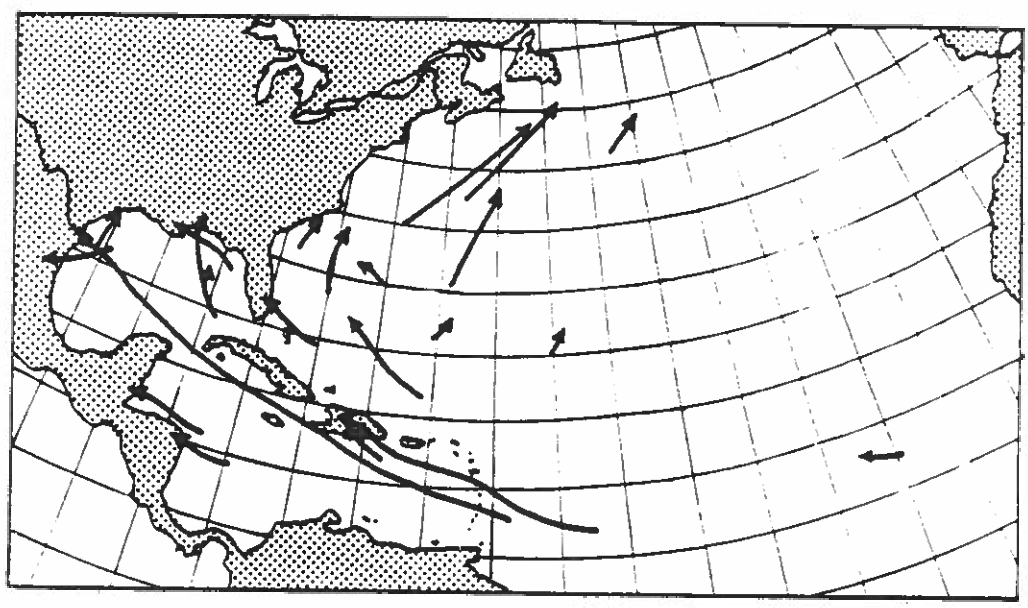


Figure 1: Composite tracks of intense hurricanes during the years (15 out of the last 41 years, 1950–1990) when the sum of the QBO 50 mb zonal winds and the wind shear to 30 mb had the lowest values (top diagram) versus those 15 years when this sum was the largest (bottom diagram).

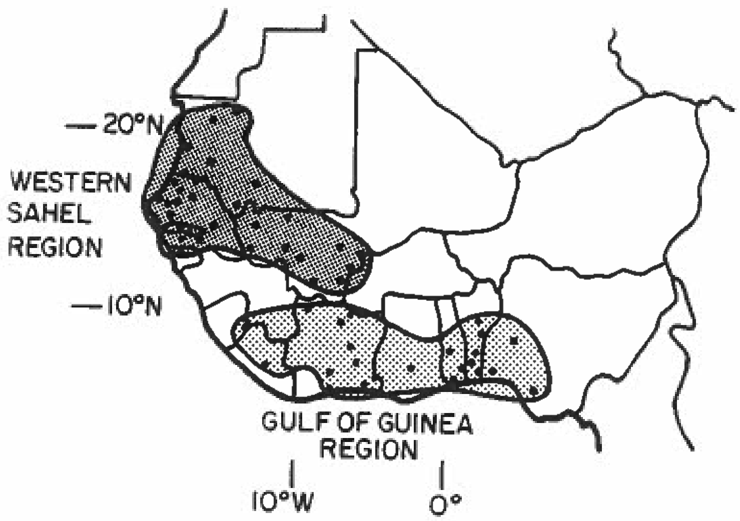


Figure 2: Locations of rainfall stations which make up the 38-station Western Sahel precipitation index and the 24-station Gulf of Guinea precipitation index. August to November rainfall within the Gulf of Guinea region provides a predictive signal for the following year's seasonal Western Sahel rainfall and hurricane activity (from Landsea, 1991).

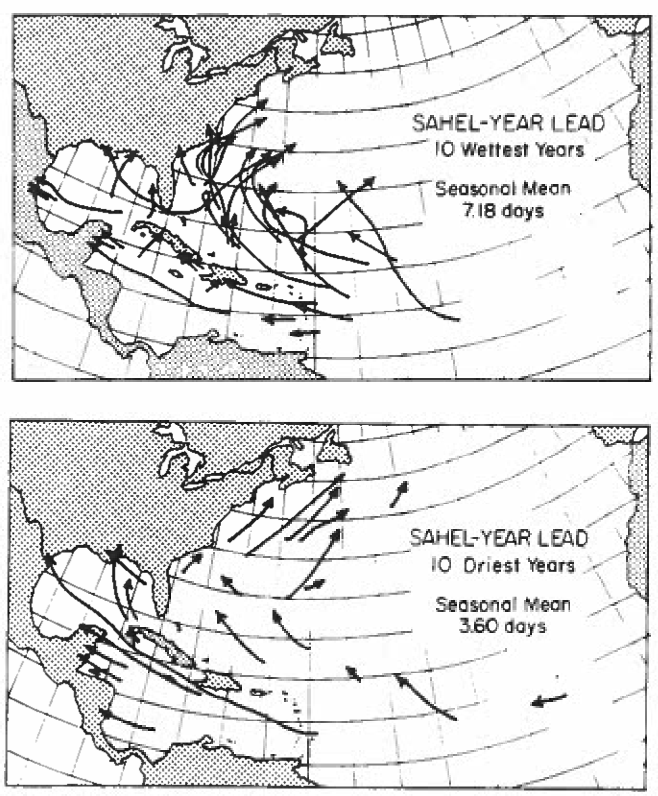


Figure 3: Tracks of intense hurricanes in the years following the 10 wettest (top diagram) August to September Western Sahel years versus those following the 10 driest periods (bottom diagram) for the years 1950 to 1990.

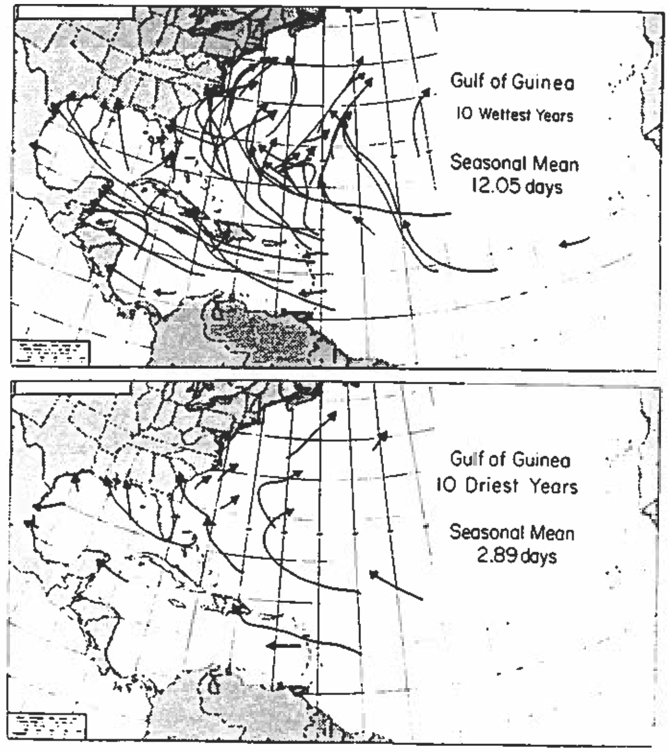


Figure 4: Tracks of intense hurricanes in the years following the 10 wettest (top diagram) August to November Gulf of Guinea years versus the 10 driest periods (bottom diagram) for the years 1950 to 1990.

and August–November Gulf of Guinea (R_G) rainfall. These five forecast parameters specify next year's expected number of named storms (N), named storm days (ND), hurricanes (H), hurricane days (HD), intense hurricanes (IH), intense hurricane days (IHD), and Hurricane Destruction Potential (HDP).

3 Statistical Analysis

Extensive statistical analyses have been made of these five late November predictors and seven following season predictands for the 41-year period of 1950–1990 by Professors Paul Mielke and Ken Berry of the CSU Statistics Department. Their analysis attempts to develop optimized regression equations for the most skillful extended range hindcasts.

The statistical methodology for these analyses consists of four distinct, but interrelated steps: (1) Least-absolute deviation regression provides prediction values for each of the n years. (2) A cross-validation (jackknife) procedure ensures that the prediction for any year is independent of the observations for that year. (3) The predicted values and observed values for all n years are compared by calculating a measure of agreement. (4) The probability of the measure of agreement is obtained under the null hypothesis (Gray, *et al.*, 1991).

The forecast equations take the following form:

$$(Seasonal\ Forecast) = \beta_o + \beta_1[a_1U_{50} + a_2U_{30} + a_3|U_{50} - U_{30}|] + \beta_2[a_4R_s + a_5R_G] \quad (1)$$

where the β's and a's are arbitrarily determined constants. Table 1 lists these coefficients for each forecast parameter.

Table 2 shows the 41-year jackknife measure of agreement coefficient (ρ), hence the percentage of variance explained by the Lease Absolute Deviation (Or LAD analysis) scheme. The

Table 1: Regression weights, from a non-jackknife solution for prediction equations.

Predictants	Term Coefficient			QBO Wind			Rainfall	
	β_0	β_1	β_2	a_1	a_2	a_3	a_4	a_5
(N)	11.732	0.135	0.701	1.000	0.252	-0.640	1.000	2.498
(NS)	64.072	1.031	7.149	1.000	-0.320	-3.384	1.000	2.302
(H)	7.560	0.049	0.759	1.000	-0.320	-3.384	1.000	2.302
(HD)	33.303	0.215	6.645	1.000	1.781	-1.370	1.000	2.144
(IH)	3.571	0.042	0.717	1.000	0.103	-1.415	1.000	2.455
(IHD)	7.605	0.124	2.006	1.000	-0.080	-1.410	1.000	2.292
(HDP)	95.326	0.686	24.747	1.000	1.066	-1.346	1.000	1.700

probability (P) of no relationship is given, and the amount of variance explained had an ordinary least–squares (OLS) type of analysis been performed. Note that LAD analysis demonstrates a significant forecast skill (or explanation of variance) of between 45–50 percent. OLS analysis for the intense cyclone activity exceeds 50 percent of explained variance.

Table 2: Agreement coefficient (ρ), probability (P), and r^2 values, from a jackknife solution.

	ρ	P	r^2
Named Storms	0.440	0.22×10^{-5}	0.395
Named Storm Days	0.514	0.89×10^{-7}	0.488
Hurricanes	0.447	0.15×10^{-5}	0.466
Hurricane Days	0.491	0.46×10^{-6}	0.511
Intense Hurricanes	0.498	0.95×10^{-7}	0.581
Intense Hurricane Days	0.451	0.27×10^{-6}	0.517
Hurricane Destruction Potential	0.447	0.11×10^{-5}	0.527

Figure 5 shows scatter plots of the 41 forecast and verification of the seasonal number of hurricanes and seasonal number of hurricane days.

4 1992 Forecast

Meteorological information as of late November yields the following values for the five predictors:

1. 10 month extrapolated 50 mb September QBO zonal wind near 10°N (U_{50}) = -14 m/s.
2. 10 month extrapolated 30 mb September QBO zonal wind near 10°N (U_{30}) = -3 m/s.

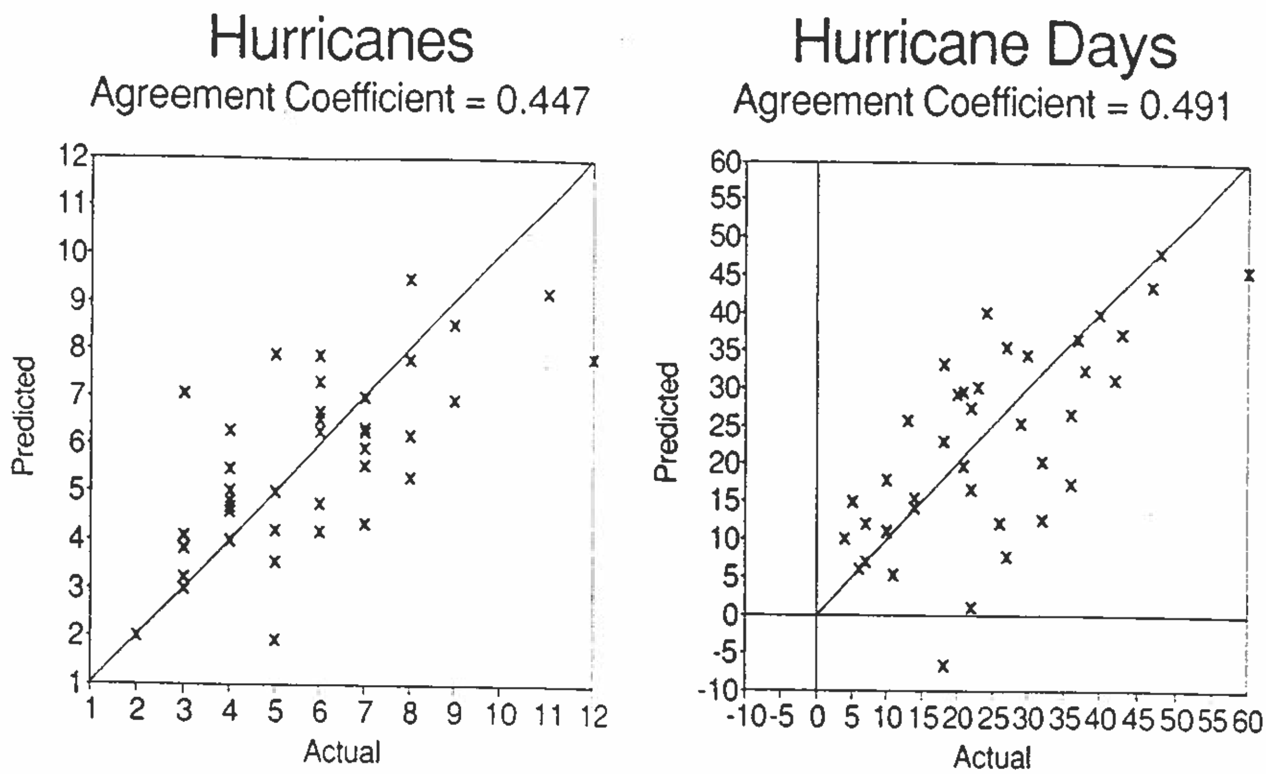


Figure 5: Scatter plots of predicted jackknife versus actual observed seasonal number of hurricanes (above) and hurricane days (below) for hindcast between 1950–1990.

3. 10 month extrapolated 50 mb minus 30 mb September QBO zonal wind shear $|U_{50} - U_{30}|$ = 11 m/s.

4. S. D. of previous year August–September Western Sahel rainfall $\sigma_{RS} = -0.45$.

5. S. D. of previous year August–November Gulf of Guinea $\sigma_{RG} = -0.72$.

Substituting these values into the general forecast Eq. (1) with the appropriate forecast parameter coefficients from Table 1 renders the 1992 forecast statistics as shown in Column A of Table 3. Column B gives the author's qualitative adjustment of the statistical forecast information and my actual 1992 forecast.

Table 3: Raw Atlantic Basin statistical seasonal forecast for 1992 (Column A) and author's adjusted forecast (column B) and comparison (percent) of adjusted forecast for 1992 with the last 41-year average.

Forecast Parameter	A Statistical Prediction for 1992	B Author's Adjusted Forecast for 1992	C 1992 Forecast as a Percent of the last 41 Year Ave.
Named Storms (N)	7.2	8	81
Named Storm Days (NS)	29.2	35	74
Hurricanes (H)	3.5	4	68
Hurricane Days (HD)	12.7	15	63
Intense Hurricanes (IH)	0.73	1	40
Intense Hurricane Days (IHD)	–0.24	2	35
Hurricane Destruction Potential (HDP)	31.94	35	47

It is expected that the 1992 hurricane season will be below normal with typical tropical cyclone parameters about 60% of average of the last 41 years. Intense hurricane activity is expected to be more reduced.

Although next year's hurricane activity is expected to be higher than this year's very suppressed conditions, it should still be considerable less active than were the three recent 1988–1990 seasons.

Predictors of Next Year's Western Sahel Rainfall. We have also developed a prediction scheme for next year's Western Sahel precipitation which utilizes the same QBO and rainfall parameters as does the seasonal hurricane forecast. We find that we can (with jackknife method) predict about 60-65 percent of next season's Western Sahel rainfall from QBO and rainfall data available by late November. This rainfall forecast statistical scheme gives a Western Sahel rainfall prediction for next year (1992) to be one standard deviation below normal.

It is expected that Sahel drought conditions will continue through next year. Thus, there is no evidence of a break in the long running Sahel drought as was thought to be possibly occurring after the wet years of 1988 and 1989. Drought conditions have returned in 1990 and 1991 and continued drought conditions are expected to occur and to be an important factor in helping to keep the lid on next year intense hurricane activity. It is anticipated that the probability of major hurricane spawned destruction along the Florida Peninsula, the US East Coast and within the Caribbean will continue to be significantly below the long term average (see Gray and Landsea, 1991, 1992).

It is also likely that there will be a small lingering and inhibiting influence on cyclone activity due to the expected weakening stage of the current ENSO warming event. This mode of storm suppression occurred in 1983 following the 1982 El Niño and in 1987 following the late arriving El Niño of 1986.

5 Discussion

Why issue such an extended range seasonal hurricane forecast? Answer—because statistical analysis shows that over a number of years, it is possible to improve on climatology based forecasts by an appreciable amount. If there is a significant degree of forecast skill then it should be made available to the broad spectrum of parties who have an interest in the variations of Atlantic tropical cyclones.

It is remarkable that Atlantic seasonal hurricane activity, manifesting itself in many sporadic mesoscale events, would show such a strong and such a long period lag response to forcing functions far removed in space and time. We know of no other climate signals showing this degree of extended range skill. This is further evidence for the primary role of global and regional circulation patterns on seasonal hurricane frequency and intensity. Previously, we had viewed hurricanes and the weaker weather systems which spawned them, more as the product of rapidly varying local circulation characteristics which had a large random component and which were impossible to predict a few days in advance, let alone 10 months in advance. Although this view is still true for individual hurricane systems, it is not for the seasonal aggregate of systems. The climate signal has a strong influence in determining the seasonal number of short lived and transitory events (i.e., hurricanes) which may be activated.

6 Cautionary Note

It is important that the reader realize that this seasonal forecast is a statistical one which will fail in some years. Even though a remarkable degree of 45–50% of independent hindcast skill has been obtained from analysis of the last 41-years of data, there still remains 50–55% of the variance which is not explained. This forecast also does not specifically predict which portion of the hurricane season will be most active or where within the Atlantic basin storms will strike. Even if 1992 should prove to be a below average hurricane season, there are no assurances that one or more hurricanes will not strike along the US or Caribbean coastlines and do much damage.

7 Acknowledgements

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