2010 Atlantic Tropical Cyclone Outlook

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Summary of 2010 Forecast Results

The 2010 Atlantic hurricane season is forecast to be above normal. The expected number of named storms developing in the Atlantic basin is significantly higher than the climatologies of the last two decades; however, the number of landfalling hurricanes and tropical storms along the US Gulf and Atlantic coasts are not significantly different[a] from the climatologies of the last two decades. From June 1 to November 30, 2010, we expect[b] 14-19 named storms to be formed in the Atlantic basin (Fig.1), which is higher that climatologies of the past 20 years and that of the past fifty years (9-11 storms). 7-11 storms are expected to become hurricanes (Fig.2). There is an approximate 80 percent chance that at least one tropical cyclone will hit the U.S. Southeast Coast (Fig.3), and an approximate 70 percent chance that it will be of hurricane status (Fig.4). For the Gulf of Mexico, we expect 4-7 named storms to be formed (Fig.5), of which 2-4 become hurricanes (Fig.6). 3-6 named storms (Fig.7) are expected to make landfall along the Gulf Coast. There is an approximate 80 percent chance at least 1 of the landfalling storms will be of hurricane status (Fig.8). The chance for at least 1 major hurricane to hit the U.S. Gulf Coast is approximately 55 percent (Fig.9).

[a] Significance based upon a 95 percent prediction interval of the expected number of storms.
[b] Range of expected values obtained using a 95 percent prediction interval for the number of counts.

1 Data

In the creation of our forecast, the response value was the counts of storms that either formed in a particular area of the Atlantic Basin or made landfall to a particular area of the US coastline. These counts were generated using information from the Tropical Prediction Center Best Track Reanalysis found at http://weather.unisys.com/hurricane/atlantic/index.html. This site lists tropical systems in the Atlantic since 1851. With our response variable created, we try to locate weather indices that we can utilize to assist in the prediction of the counts for an upcoming hurricane season. To obtain these indices, we imported data from http://www.cdc.noaa.gov/data/climateindices/. The indices used in this year's forecast can be seen in Table 1. Atlantic Meridional Mode(AMM) is calculated from SST datasets over the region between 21S to 32N and 74W to 15E. Atlantic Multidecadal Oscillation(AMO) is a timeseries calculated from the Kaplan SST dataset that is an index on North Atlantic temperatures. This detrended timeseries is a weighted average of sea-surface temperatures between latitudes 0 and 70N. The Atlantic Warm Pool(AWP) is a weighted average of sea-surface temperatures between latitudes 6 and 30N and longitudes 10 and 100W. Dipole Mode(DM) is the difference in average sea-surface temperature over two locations in the Atlantic. Box 1 is the area within latitude 4 to 24N and longitude 16 to 60W. Box 2 is the area within latitude 4 to 24S and longitude 30W to 12E. Tropical Northern Atlantic(TNA) is the anomaly of the average of the monthly SST from 5.5N to 23.5N and 15W to 57.5W. Tropical Southern Atlantic(TSA) is the anomaly of the average of the monthly SST from Equator to 20S and 10E to 30W. Western Hemisphere warm pool(WHWP) is the monthly anomaly of the ocean surface area warmer than 28.5C in the Atlantic and eastern North Pacific. The final index used in our model is a representation of the nino value from the Pacific. This is the only data value that is not a previously known value. Using www.cpc.ncep.noaa.gov/products/people/wwang/cfs_fcst/images3/nino12SSTMonE120.gif, seen in Figure 10, provides a forecasted value of the nino values for seasonal blocks of time. Of the multiple versions of the nino values, the extreme eastern value (0-10S, 90W-80W) was seen to carry the most influence on storm counts in the Atlantic. For each climate index, a monthly value is given. Research from Elinor Keith showed which months perform better in our model. Once the months for each index are selected, the average of the values are calculated to create a single representative value from each index. Before the regression was executed, these values were checked for correlation. All values, except TSA and NINO12, showed strong correlation to each other. To alleviate this issue, we perform a principle component analysis on the remaining indices. A principle component analysis takes many correlated values and reduces them into fewer uncorrelated values. These values are organized by the amount of variability explained in the data. We incorporate the first principle component, TSA, and NINO12 into our regression statement.

2 Method

Our goal is to arrive at an estimate for our parameter λ. λ is the average storm count expected to make landfall or to form in a particular area. Sometimes referred to as a log-linear regression, the log of the parameter λ is assumed to be linearly related to our selected climate indices.

$$\log(\lambda) = \beta_0 + \beta_1(PC1) + \beta_2(TSA) + \beta_3(NINO12) + \varepsilon$$

Table 1: *Values of climate indices used in forecast.*

Index Name	Index Value	Index Name	Index Value
AMM January	1.980	AMM February	3.960
AMO January	0.090	AMM February	0.222
DM January	-0.0491	DM February	0.3712
Nino12 July	-1.15	Nino12 August	-0.85
Nino12 September	-0.45	TNA January	0.80
TNA February	1.10	TSA November	0.30
TSA December	0.70	TSA January	0.79
WHWP August	4.09	WHWP September	3.77
WHWP October	4.87	WHWP November	3.17

Using the data from previous years, the coeffcients for each index is estimated by maximum likelihood calculations. With these estimates, we then predict the value of log(λ) for the current hurricane season as well as a standard error for this prediction. Under the assumption of normality, we create 95 percent confidence intervals for the log(λ) values. Exponentiating these confidence limits will result in non-symmetric confidence limits for λ because the limits must account for λ's lower bound of zero. The interval is still at 95 percent due to the monotonicity of the exponential function (Table 3). These confidence limits are our forecast values for each model.

Once the values of λ have been calculated for our forecast, we compare these to the values estimated by climatology. To calculate the climatology values, we average the counts for each year over set blocks of time. In our comparison, we use three climatology values: since 1950 (50 year average), since 1990 (20 year average), and since 1994 (15 year average). In each of figures 1 through 9, we present the 2010 forecast compared to each of these three climatology values. Significant differences between climatology and the forecast values are validated through the 95 percent confidence intervals created for the forecast. If a climatology value falls within this interval, we say that the forecast is not significantly different from the climatology (Table 4). This statement is capable of being extended to saying that the distributions of the forecast and the climatology are the same. Since the distribution is Poisson and explicitly described by the one value λ, which is both its mean and variance, the statement of the distributions being the same is valid. There are other means of testing that the two distributions, climatology and forecast, are the same but are not needed here.

Table 2: *2010 Forecast Variable Matrix:*

Gulf Coast landfall TCs	Atlantic basin TCs
Gulf Coast landfall hurricanes	Atlantic basin hurricanes
Gulf Coast landfall major hurricanes	Atlantic basin major hurricanes
Southeast landfall TCs	Caribbean basin TCs
Southeast landfall hurricanes	Caribbean basin hurricanes
Southeast landfall major hurricanes	Caribbean basin major hurricanes
Northeast landfall TCs	Gulf of Mexico basin TCs
Northeast landfall hurricanes	Gulf of Mexico basin hurricanes
Northeast landfall major hurricanes	Gulf of Mexico basin major hurricanes

Note: *TC=tropical storm + hurricane; Major Hurricane=Category 3-5 hurricane; Atlantic basin=Atlantic + Gulf of Mexico + Caribbean; Southeast=East coast of Florida to North Carolina; Northeast=Virginia to Maine*

Table 3: *95 percent confidence intervals for expected counts in each category.*

Category	Lower Limit	Mean	Upper Limit
Gulf Coast TC Landfalls	2.729	3.990	5.835
Gulf Coast H Landfalls	0.883	1.585	2.843
Gulf Coast MH Landfalls	0.332	0.804	1.947
Southeast TC Landfalls	1.201	1.786	2.656
Southeast H Landfalls	0.598	1.003	1.683
Southeast MH Landfalls	0.106	0.270	0.685
Northeast TC Landfalls	0.183	0.391	0.834
Northeast H Landfalls	0.032	0.117	0.424
Northeast MH Landfalls	0.003	0.028	0.280
Atlantic TC Observe	13.421	16.142	19.413
Atlantic H Observe	6.834	8.727	11.145
Atlantic MH Observe	3.540	5.037	7.167
Caribbean TC Observe	3.139	4.575	6.669
Caribbean H Observe	2.079	3.360	5.430
Caribbean MH Observe	1.204	2.206	4.042
Gulf of Mexico TC Observe	3.863	5.362	7.443
Gulf of Mexico H Observe	1.561	2.498	3.999
Gulf of Mexico MH Observe	0.572	1.177	2.421

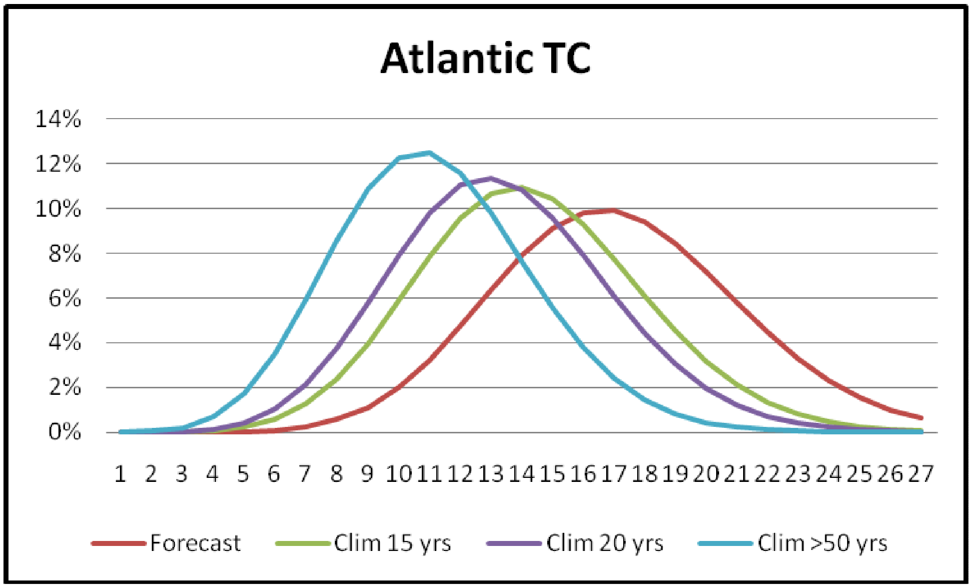

Figure 1: Count probabilities for named storms in the Atlantic basin: past 50 years climatology (blue), past 20 years climatology (purple), past 15 years climatology (green), and forecast (red).

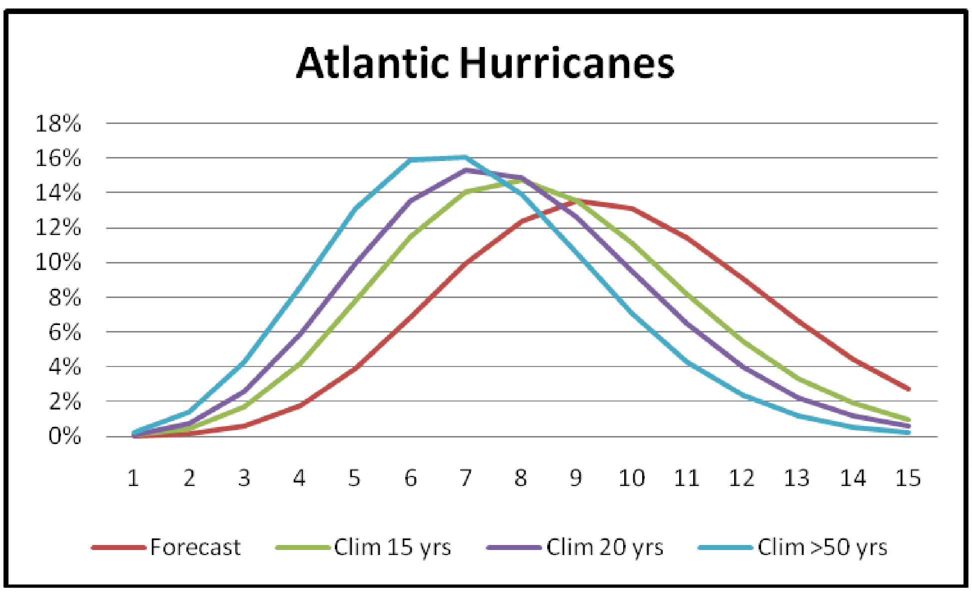

Figure 2: Count probabilities for hurricanes in the Atlantic basin: past 50 years climatology (blue), past 20 years climatology (purple), past 15 years climatology (green), forecast (red).

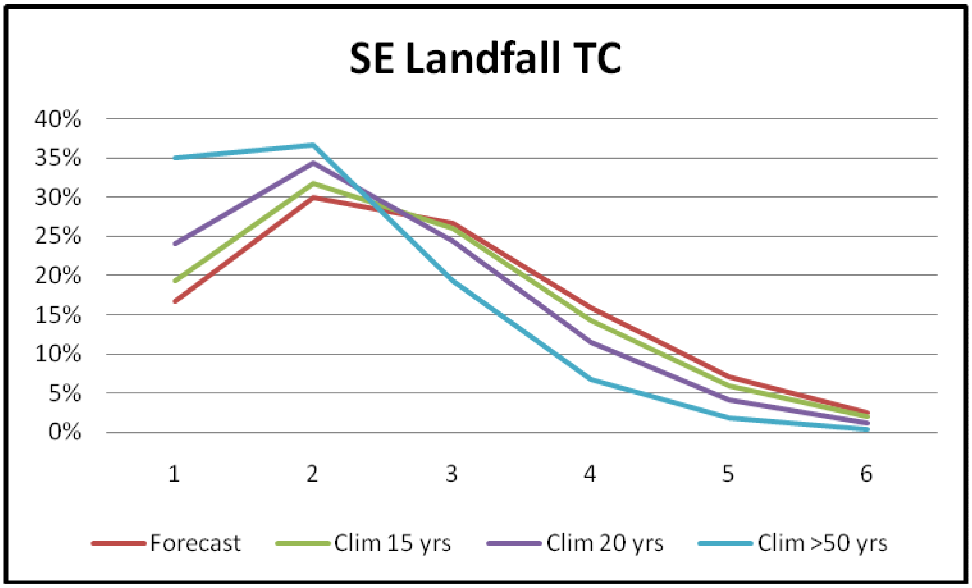

Figure 3: Landfalling count probabilities for named storms to hit the U.S. Southeast: past 50 years climatology (blue), past 20 years climatology (purple), past 15 years climatology (green), forecast (red).

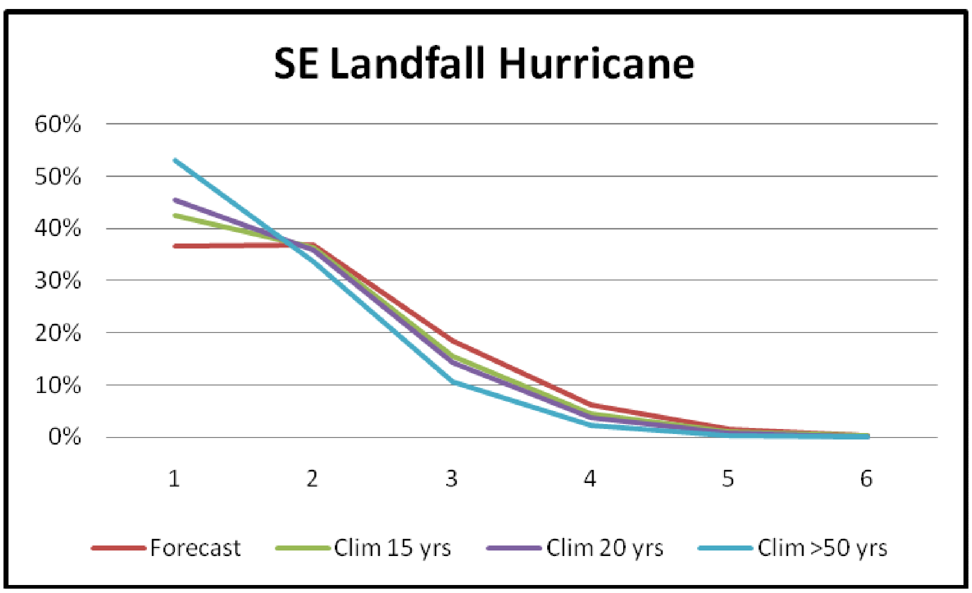

Figure 4: Landfalling count probabilities for hurricanes to hit the U.S. Southeast: past 50 years climatology (blue), past 20 years climatology (purple), past 15 years climatology (green), forecast (red).

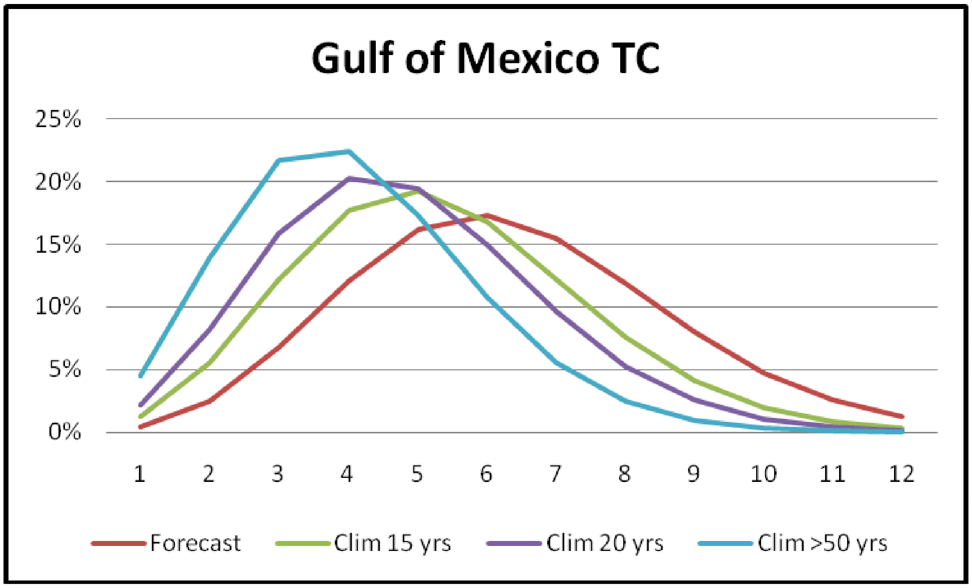

Figure 5: Count probabilites for named storm in the Gulf of Mexico: past 50 years climatology (blue), past 20 years climatology (purple), past 15 years climatology (green), forecast (red).

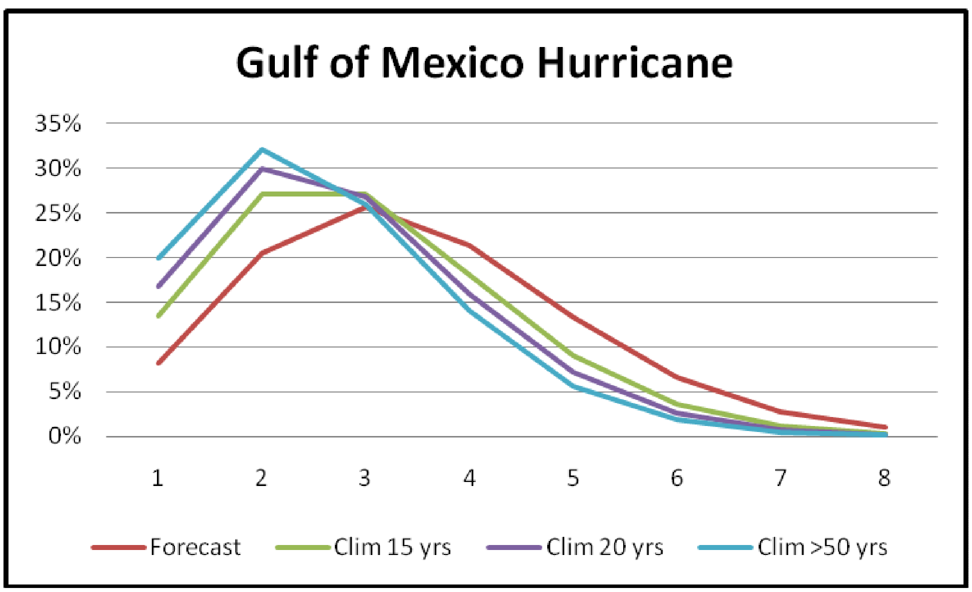

Figure 6: Count probabilites for hurricanes in the Gulf of Mexico: past 50 years climatology (blue), past 20 years climatology (purple), past 15 years climatology (green), forecast (red).

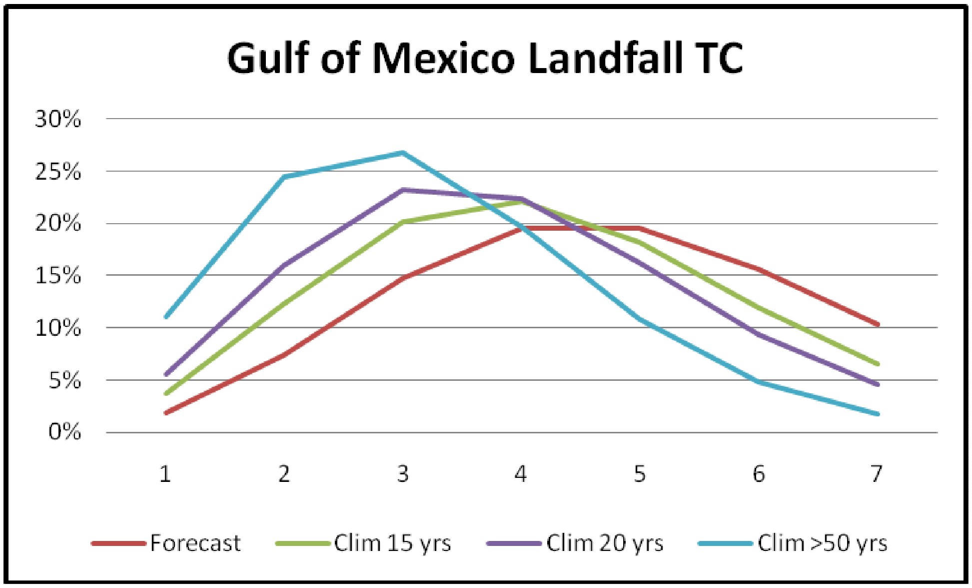

Figure 7: Landfalling count probabilities for named storms to hit the Gulf Coast: past 50 years climatology (blue), past 20 years climatology (purple), past 15 years climatology (green), forecast (red).

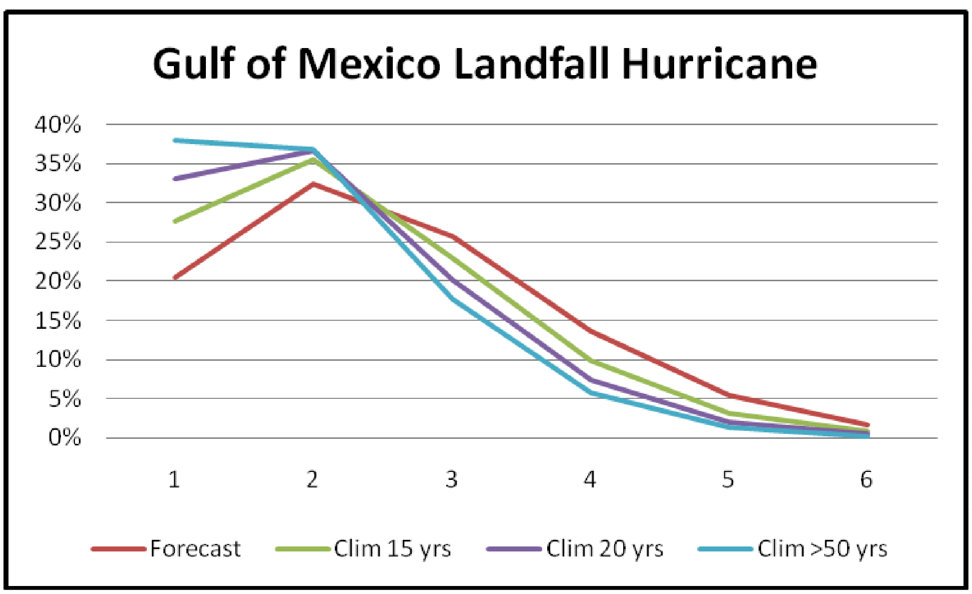

Figure 8: Landfalling count probabilites for hurricanes to hit the Gulf Coast: past 50 years climatology (blue), past 20 years climatology (purple), past 15 years climatology (green), forecast (red).

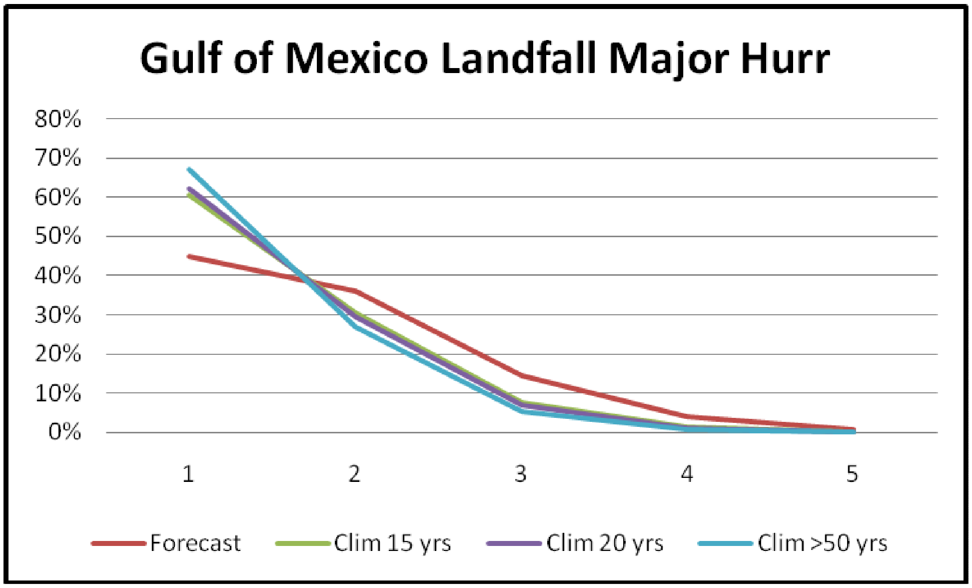

Figure 9: Landfalling count probabilities for major hurricanes to hit the Gulf Coast: past 50 years climatology (blue), past 20 years climatology (purple), past 15 years climatology (green), forecast (red).

Table 4: *Expected counts for each climatology type.*

Category	50 Yr Clim.	20 Yr Clim.	15 Yr Clim.
Gulf Coast TC Landfalls	**2.200**	2.895	3.286
Gulf Coast H Landfalls	0.967	1.105	1.286
Gulf Coast MH Landfalls	0.400	0.474	0.500
Southeast TC Landfalls	**1.050**	1.421	1.643
Southeast H Landfalls	0.633	0.789	0.857
Southeast MH Landfalls	0.233	0.211	0.143
Northeast TC Landfalls	0.383	0.316	0.286
Northeast H Landfalls	0.150	0.053	**0**
Northeast MH Landfalls	0.050	**0**	**0**
Atlantic TC Observe	**10.167**	**12.368**	**13.357**
Atlantic H Observe	**6.067**	**6.789**	7.357
Atlantic MH Observe	**2.667**	**3.158**	3.643
Caribbean TC Observe	**2.317**	**3.000**	3.429
Caribbean H Observe	**1.283**	**1.789**	2.286
Caribbean MH Observe	**0.750**	**0.947**	1.214
Gulf of Mexico TC Observe	**3.100**	**3.842**	4.357
Gulf of Mexico H Observe	1.617	1.789	2.000
Gulf of Mexico MH Observe	0.667	0.684	0.786

NOTE: *Those outside the bounds of the 95 percent confidence intervals for our forecast are in boldface.*

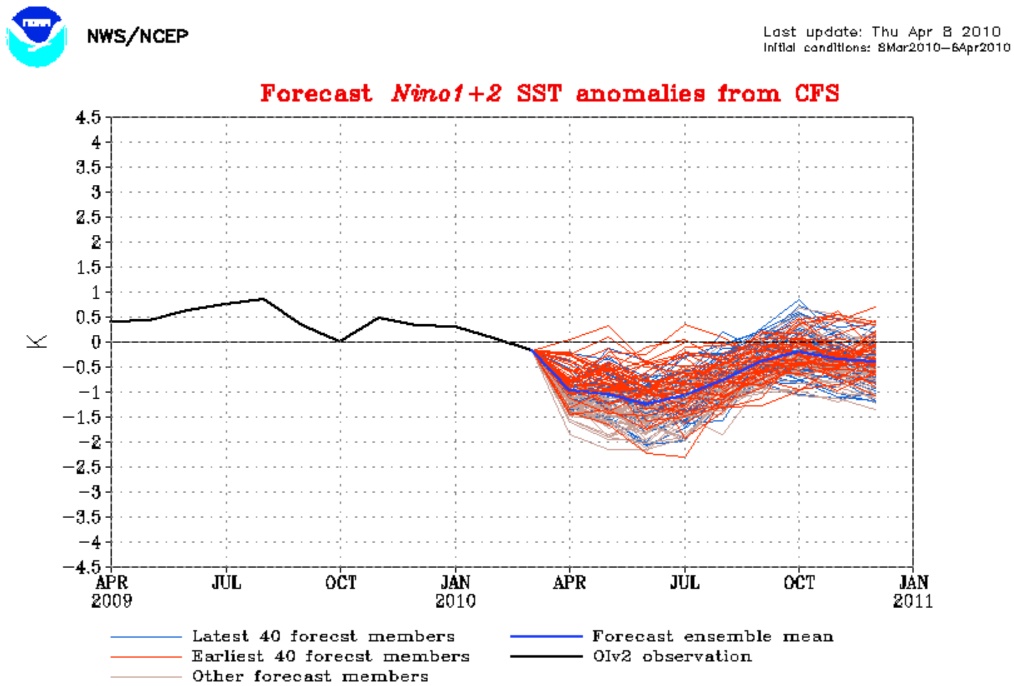

Figure 10: Nino12 forecast graph used in equation for creating the hurricane forecast.