5.6 EXPERIMENTAL FORECASTING OF DRY SEASON STORMINESS OVER FLORIDA FROM THE ENSO SIGNAL: LATEST RESULTS AND ADVANCEMENTS

Bartlett C. Hagemeyer*
Rebecca A. Almeida
National Weather Service, Melbourne, Florida

1. INTRODUCTION

Hagemeyer and Almeida (2002 - see: http://www.srh.noaa.gov/mlb/enso/mlb-16thstats.html) outlined the evolution of a philosophy and methodology for producing skillful dry season forecasts of rainfall and storminess over Florida from the ENSO signal using the Nino 3.4 index. Their experimental dry season forecast was started on the Internet in the Fall of 2001 after several years of "in-house" forecast simulations (see: http://www.srh.noaa.gov/mlb/enso/mlbnino.html).

This study is a continuation of Hagemeyer and Almeida (2002), hereafter called H&A, and contains preliminary results. This continuing research has four primary goals: 1) develop an improved Florida dry season storm climatology, 2) refine seasonal forecast predictands using the new climatology and stratify prediction equations by storm and associated jet stream tracks, 3) evaluate regions other than Nino 3.4 for improved predictors of storminess and Florida ENSO telleconnections, and 4) implement the improved experimental seasonal forecast on the Web and continue to investigate methods to better communicate the seasonal forecast to decision makers in an ongoing effort to express complicated climate and seasonal forecasting concepts to users via graphical visualizations on the Internet.

The oral presentation at the conference will also recap the 2001-2002 Florida dry season (1 November 2001 to 30 April 2002) and present the results of the first full season of experimental long-lead forecasts of storminess and rainfall and the lessons learned. An update of the 2002-2003 dry season to date, and a forecast for the remainder of the season will also be presented.

This more detailed look at Florida storms and associated jets and their tracks should yield more meaningful information on societal impact and predictability of Florida telleconnections from the ENSO signal. The importance of seasonal forecasts continues to increase as Florida's growing population becomes ever more sensitive to extreme weather events every year. There is a need to understand seasonal variability better, and there should be considerable value in seasonal forecasts of storminess as a proxy for hazardous weather. Improved knowledge of the influence of ENSO on Florida's weather, and a multi-threat consideration of ET cyclones, or the lack of ET cyclones, can only help advance education, preparedness and mitigation efforts.

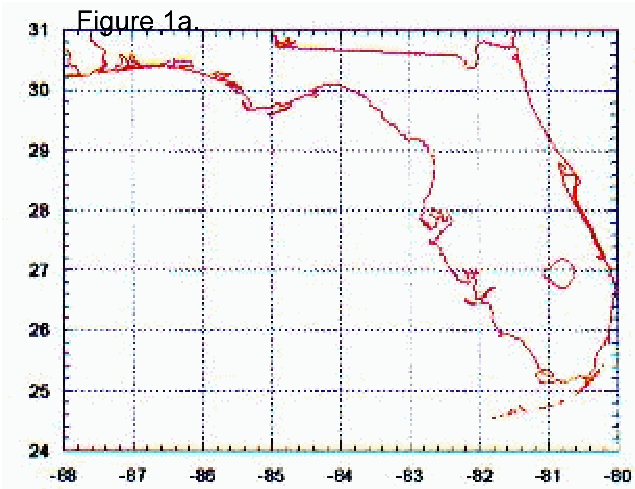
2. IMPROVED FLORIDA STORMINESS CLIMATOLOGY

Hagemeyer and Almeida (2002) developed their conceptual model of Florida dry season storminess and defined a "storm" as a minima in the daily mean sea level pressure (MSLP) #1012 mb averaged over the Florida grid (Figure 1a-b) from 1 November through 30 April. The 1012 mb threshold was developed earlier in Hagemeyer (2000a-b) where a test sample indicated the 1012 mb threshold was highly correlated with significant severe weather and discrimination of more significant extratropical (ET) cyclones. However, the authors expected that this strictly objective statistical search for storms would likely have some limitations and errors. This current study attempts to further refine and improve upon the Florida storm climatology by inspecting each statistically identified candidate storm in the entire population to screen out non-storms, and at the same time assign a storm track and jet stream track to each storm event. The goal is to develop a more accurate and meaningful storm climatology to produce a more accurate and relevant seasonal forecast from the ENSO signal.

For this study the threshold of a storm was raised to include all minima in daily MSLP at or below 1012.5 mb averaged over the Florida grid during the 1960-61 through the 2000-01 dry seasons (same period as H&A 2002) to help assure marginal storms wouldn't be missed. The conceptual model for measuring storminess in this study is adapted from H&A (2002) and shown on Figure 2 where the shaded area below the dashed 1012.5 mb threshold represents the passage of one storm. The original study (H&A 2002) yielded 291 storms. The new criteria yielded 319 potential storms

For each of the 319 candidate storms loops of North American maps of daily MSLP (mb) and 250 mb U (knots) (NCEP/NCAR reanalysis data) were produced to encompass the storm period. The original definition of a storm impacting on Florida from H&A (2002) was retained - that is, some portion of Florida was affected by the warm sector of a passing ET cyclone in the westerlies. The authors then reviewed the animations of each case to determine if it was indeed a true storm, whether the jet

*Corresponding author address: Bartlett C. Hagemeyer, National Weather Service, 421 Croton Rd., Melbourne, FL 32935; e-mail:bart.hagemeyer@noaa.gov.



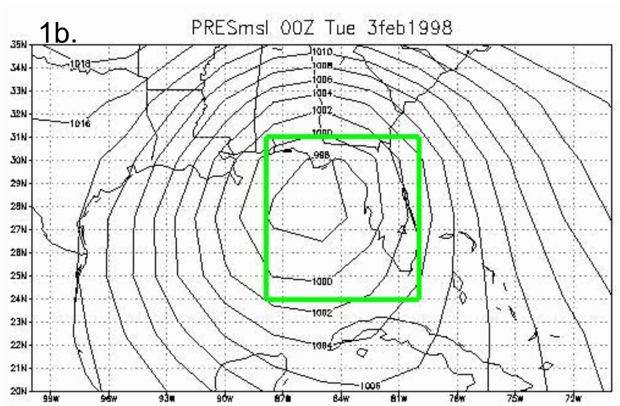


Figure 1a-b. Grid used for computation of Florida storminess (80-88^{E}W, 24-31^{E}N). Figure 1b shows an example of an individual storm passing through the Florida grid.

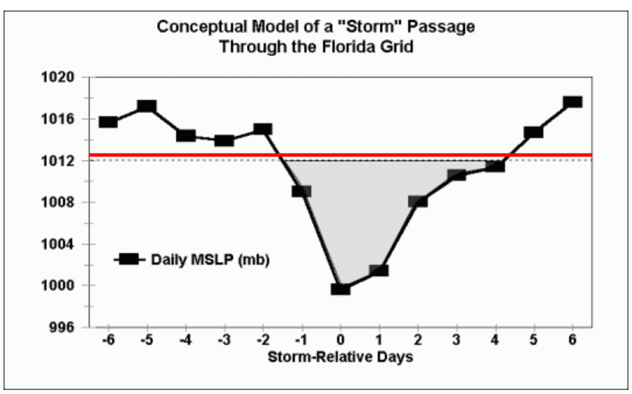


Figure 2. Plot of daily MSLP illustrating the modified conceptual model of the passage of a storm through the Florida grid. MSLP was # the 1012.5 mb threshold on 6 days, but the minima is what is counted as one storm.

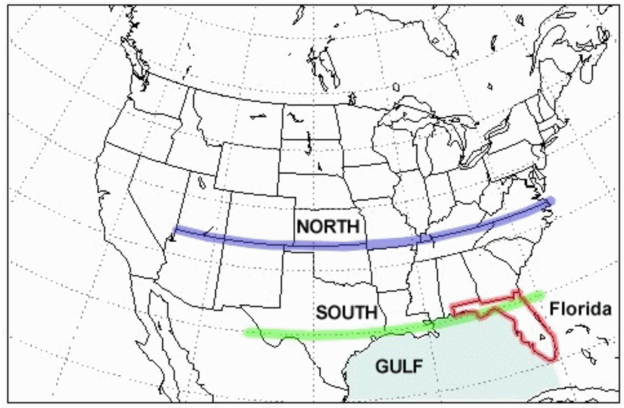


Figure 3. Classification scheme for Florida storm tracks and associated jet stream tracks. Gulf storm and jet tracks, and Florida storm tracks are a subset of the southern tracks.

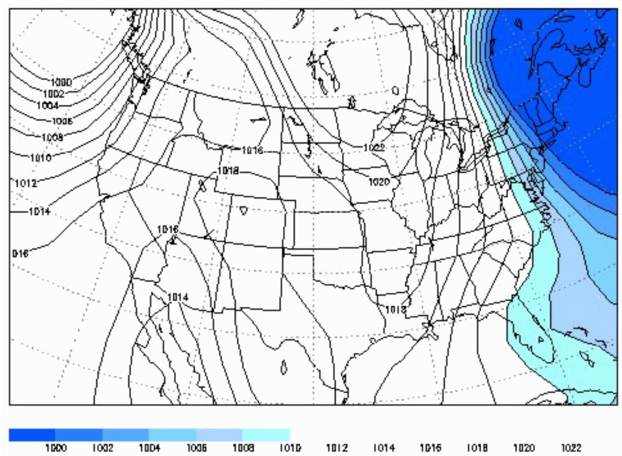


Figure 4. Mean daily MSLP (mb) plot for 16 November, 1999 illustrating the most typical example of a potential storm dropped during the screening process. The MSLP over the Florida grid dropped below 1012.5 mb due to the deepening of a marine cyclone northeast of Florida.

stream was associated with it, and what the tracks of the storm and associated jet stream were. For classification purposes, storm and jet tracks were divided into north and south tracks (blue line on Fig. 3). The south track area was then further subdivided into a Gulf of Mexico (Gulf) storm and jet track area (south of the green line in Fig. 3), and those storms that passed directly over Florida (red outline on Fig. 3) with a plan to identify and define the archetype Florida cyclone.

As each case was examined, it was categorized by both storm track and jet track. For most of the candidate cases only 24 hour resolution maps were available making the determination of storm and jet tracks difficult at times. There were 10 possible combinations assigned: northern track cyclone with north, south, or Gulf jet track, Southern track cyclone with north, south, or Gulf jet track, Gulf cyclone with north, south, or Gulf jet track and an additional category the “Florida Cyclone” with cyclone passing over Florida and a jet track over Florida. At least one of each of the ten possible types was observed. Examples of each of the 10 possible storm/jet combinations are shown as Figures. 5a-j.

Of the 319 initial candidate storms three were found to be part of the same storm system and combined with other storms for 316 candidates. Examination of the animations for each case resulted in 79 potential storms being removed, leaving 237 storms and jet tracks. Candidate storms were screened out primarily because the gridded daily mean MSLP dropped to #1012.5 mb without the direct effect of the warm sector of a specific ET cyclone passing over Florida in the westerlies. The removals resulted from several scenarios: 1) an area of broad low pressure covered the eastern U.S. and was not counted as a storm, 2) named or otherwise officially documented late-season tropical and subtropical cyclones were removed, 3) additional unnamed late season tropical or hybrid lows (Hagemeyer 1998, 1999) moving out of the Carribean or southern Gulf of Mexico and passing near Florida dropping the pressure to below the threshold were removed, 4) marine ET cyclones developing east of Florida dropping the pressure below the threshold were removed, and 5) the most common case, which was “backdoor” storms that were predominantly northern cyclones that deepened significantly after moving offshore over the Atlantic Ocean and dropped the MSLP to below 1012.5 mb in the Florida grid. Figure 4 is an example of this most common “backdoor statistical storm”case that does not constitute the passage of a real storm.

Table 1 shows the classification categories of the 237 storms and their associated jet tracks (the jet stream was present in every case). The most common storm/jet track classification was Gulf/Gulf (49), followed by South/South (44), North/South (41), Gulf/South (39), South/Gulf (34), North/Gulf (24), North/North (4), South/North (1), and Gulf/North (1). It should be noted that most of the northern track storms and jets were relatively near the north/south cutoff.

There were 69 northern track cyclones and 168 southern track cyclones (Gulf + South) and six north track jets and 231 south track jets (Gulf + South). The southern track cyclones with southern track jets (166 of 238 or 70%) were very similar to the conceptual model of an ET cyclone affecting Florida during the dry season first laid out by Hagemeyer in 1997, and further refined in 1998 and 2000a-b. Interestingly, the 69 northern track storms were associated with 65 southern jets despite the fact that neither jet location nor track or gridded 250 mb U were involved in the screening process.

Figure 6 shows a comparison between the 316 1012.5 mb statistically identified dry season storms and the final adjusted 237 storms affecting Florida after the screening process. Of the 79 potential storms dropped, 42 (54%) were northern track storms, 27 were southern track lows, and 10 were undefined due to broad, diffuse low pressure. Figure 7 compares the 237 storms by seasons in this latest study to the previous, less restrictive, study of H&A 2002 with 291 storms based solely on the statistical criteria. This new climatology contains a higher percentage of storms with more significant impact on Florida and should prove to be a more accurate foundation for the dry season forecast effort. For example, the greatest deviation between H&A 2002 and the current study occurred in the 1969/70 season with 16 storms (a significant outlier in previous seasonal forecast results) being reduced to eight storms in the current study. Close inspection revealed eight of the 16 storms were northern storms that dropped MSLP in the Florida grid, but did not meet the spirit of the conceptual model in a manner similar to the case shown on Figure 4. Every season but five had some changes based on careful subjective interpretation. The authors believe that this storminess database will provide more meaningful and useful regression results as well as be an asset in education in its own right.

Figure 8 shows the frequency distribution of the number of storms per dry season from 1960-61 to 2000-01. The mean was 5.8 (previous H&A mean 7.1), median 5 (previous 6), mode 4 (previous 6), standard deviation 3.8 (previous 3.9), and range 18 (previous 17).

It should be noted that these 237 storms are not the only dry season scenarios that can produce a major weather impact, especially on a localized part of Florida due to mesoscale forcing. Our criterion does not catch every storm, or all extreme events, especially from a customer perspective since “all weather is local.” This possibility was recognized early on and in fact is part of the disclaimer for the seasonal forecast on the web which reads in part: *“Extreme weather events can occur within the forecast area and have significant local impacts even though the seasonal measures forecast here are not extreme. For example, record-breaking rainfall could occur over an area of, say, several counties, while the broader forecast area remains in serious long-term drought.”*

An example of this scenario is shown on Figure 9, the MSLP/jet stream chart for 00 UTC 7 March, 1992 at about the time that the most expensive hailstorm in the history of Florida (up to that time) was occurring on the

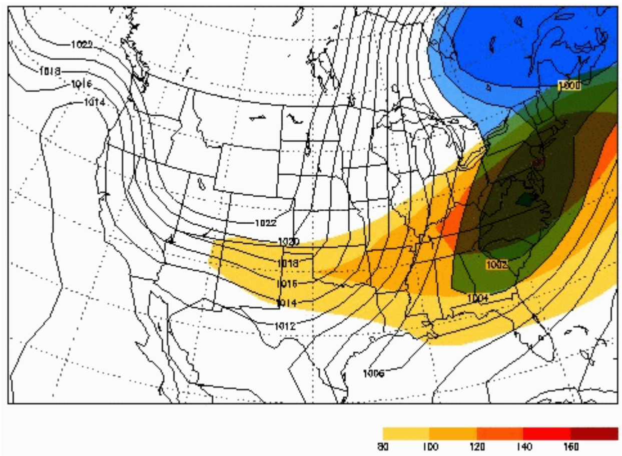


Figure 5a.

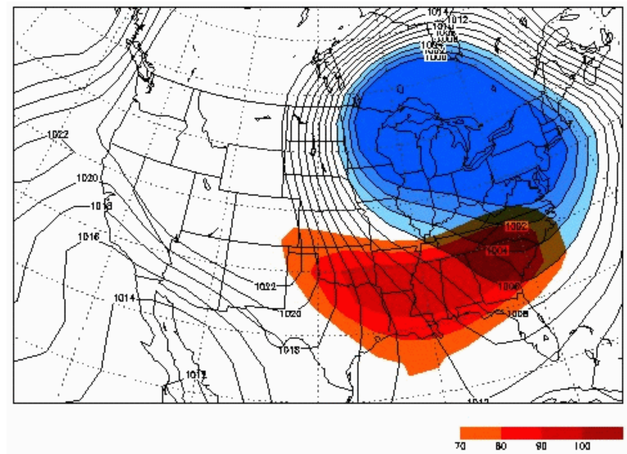


Figure 5b.

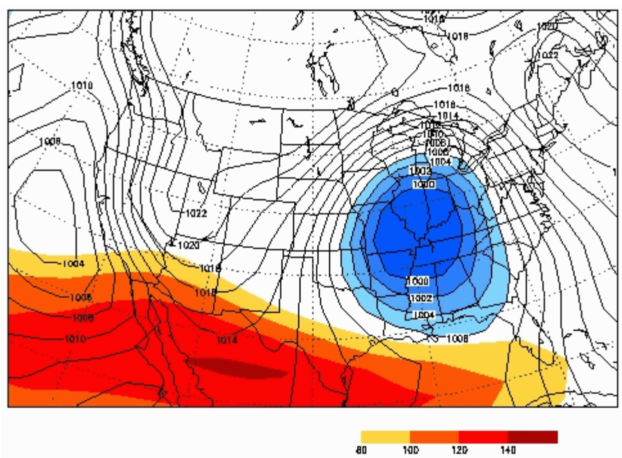
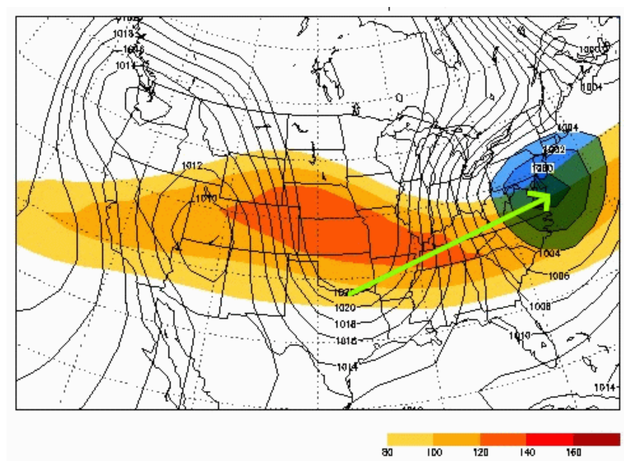


Figure 5c.



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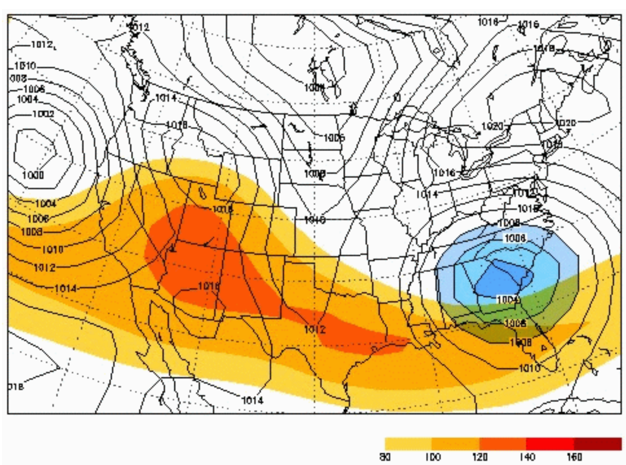

Figure 5e.

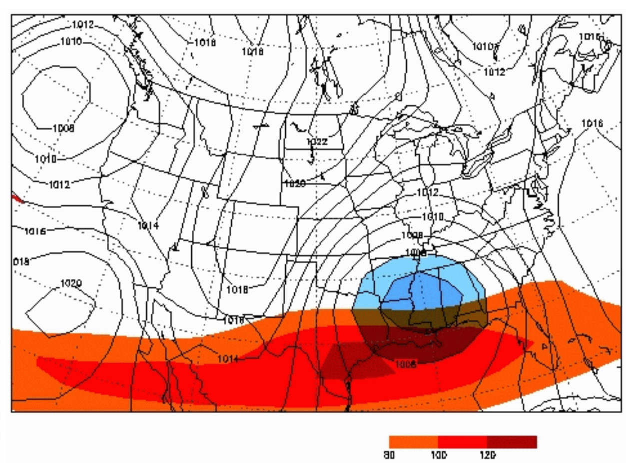

Figure 5f.

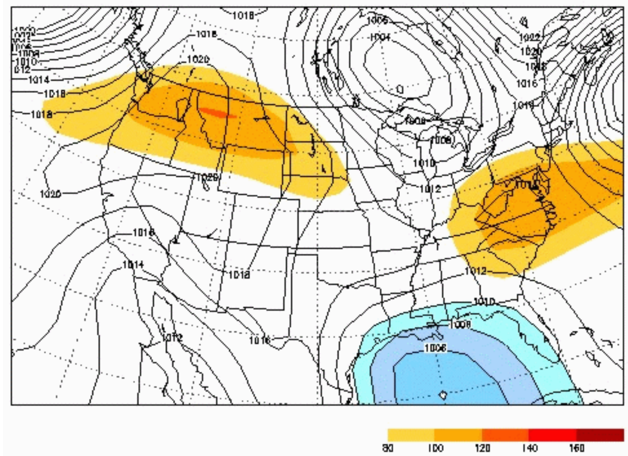

Figure 5g.

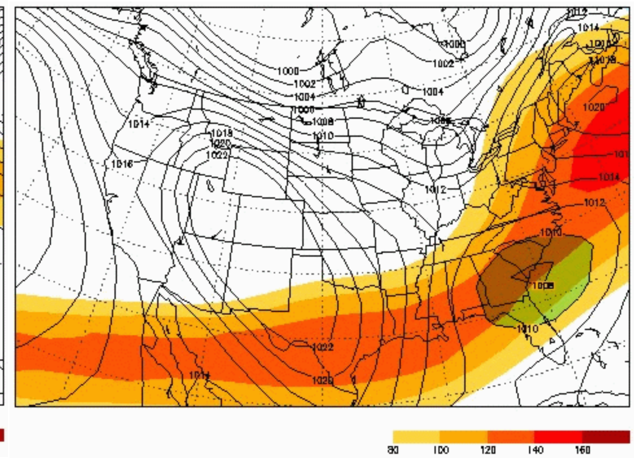

Figure 5h.

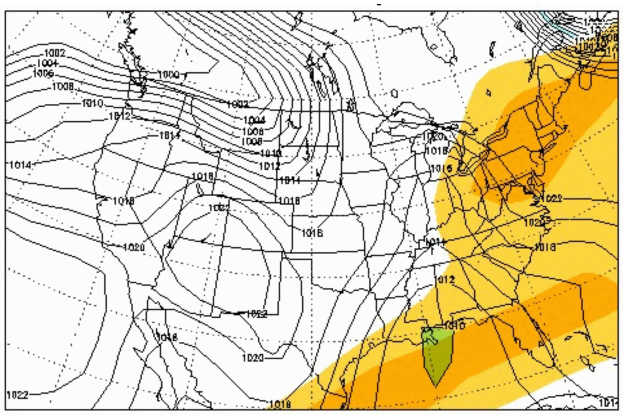

Figure 5i.

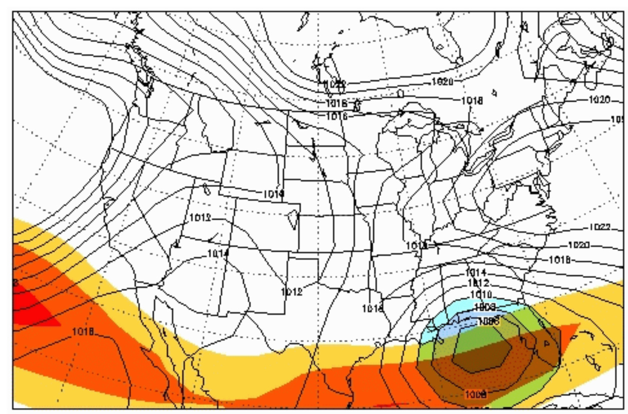

Figure 5j.

Figure 5a-j. Plots of storms (daily mean MSLP in mbs., storms highlighted in shades of blue) and jet streams (daily mean 250 mb U in knots, jet streams highlighted in shades of red) for the 10 possible storm/jet track classifications in the study. 5(a) North storm/north jet - 4 April, 1966, 5(b) North storm/south jet - 2 November, 1997, 5(c) North storm/Gulf jet - 2 February, 1983, 5(d) South storm/north jet (green arrow shows past track of this fast-moving storm) - 6 April, 1982, 5(e) South storm/south jet - 23 February, 1998, 5(f) South storm/Gulf jet - 23 April, 1983, 5(g) Gulf storm/north jet - 10 November, 1963, 5(h) Gulf storm/south jet - 28 February, 1964, 5(i) Gulf storm/Gulf jet - 15 January, 1998, 5(j) Florida Cyclone with associated jet - 28 February, 1983 (a subset of Gulf/Gulf storms/jets).

evening of March 6th. Hail, high winds, excessive rain, and tornadoes raked the Orlando area. But the area was technically not in the warm sector of an ET cyclone, the cyclone developed in the Southern Plains and moved to the upper Midwest and weakened while high pressure built back in over Florida. The outbreak of severe weather was forced by mesoscale circulations (sea breeze/outflow boundaries) in an unseasonable warm, moist, unstable airmass as the right front quadrant of a significant jet maxima approached the area.

Several other well-known severe weather outbreaks that were not truly associated with a surface low and did not make the cut as dry season storms, but that had significant impact on localized areas of Florida were examined. In each case a relatively strong jet maximum was associated with the event. These observations, and the finding of Hagemeyer and Matney (1993) that the mean bulk wind speed through the depth of the troposphere has the greatest correlation to tornado strength, begs the question - which is more important - the cyclone or the energy provided by the jet stream. Clearly in the vast majority of cases the two will be related as in all 237 cases of storms here a jet was in proximity. However, the jet was the major player in some other events (most likely events late in the dry season and nearer the transition to the wet season when proximity to a low is not so critical and mesoscale boundaries can accomplish what a cold front can)

Hagemeyer (2000a-b) did find that the dry season mean 250 mb U was highly correlated with Nino 3.4. It is possible, and indeed likely, that the number of jet maxima in a season is also highly correlated. But Hagemeyer (2000a-b) was concerned about the relevance of the seasonal forecast to users and came to the conclusion that the accumulation of storminess, or lack thereof, was best variable to relate to impact on society. This study only looked at jet streams, given a storm, it did not look at jets in isolation, and it is unknown just how many jet maxima occurred in all the dry seasons of the study period regardless of their association with cyclones. Again, it is significant that of the 69 northern storms - 65 had southern jets. There may be value in calculating the number of jet maxima in each dry season and considering their forecasting.

But for seasonal forecasting of the number of lows, or even of jets, it is the bulk measure we are after. The goal is to forecast the accumulated seasonal impact of storms, or lack thereof. An individual storm setting provides an opportunity for critical elements to come together in space and time to produce hazardous weather. Not all storms reach their potential, and the development of extreme convection can come from lesser storms. This is why the ***number*** of storms in a ***season*** is most important - the more storms/jets the more chances for all elements to come together to negatively impact society, and likewise, fewer storms can also have a negative impact.

3. ADVANCEMENTS IN SEASONAL FORECASTING FROM THE ENSO SIGNAL

This study is a continuation of an investigation by H&A (2002) into how much regional specificity can be achieved in forecasts of dry season storminess from the ENSO signal. They found that there was a significant relationship between dry season storminess and Nino 3.4 over Florida, and a good portion of the Southeast United States. However, they noted there was much more information to be gleaned from multiple linear regression (MLR) and suspected that the location of the SST anomalies might have a significant impact on Florida response.

The preliminary climatology of the 237 storms identified for the 1960-61 to 2000-2001 dry seasons in this study comprises the new database of predictands for seasonal forecasting of dry season storminess. Figure 10a shows the total number of storms (blue line), and the number of north track (red line), south track (green line), and Gulf track (black line) storms for the 1960-61 through 2000-01 dry seasons. Figure 10b shows the total number of jets associated with storms (blue line), and the number of north track (red), south track (green), and Gulf track jet streams for the 1960-61 through 2000-01 dry seasons. Just as was noted in H&A (2002) there is significant season-to-season variability in storminess and an indication of greatly increased storminess during the most recent El Nino's of 1982-83, 1986-87, 1991-92, and 1997-98 and reduced storminess in recent La Nina's such as 1988-89 and 1998-2001. It also appears there is a tendency for more Gulf storms and Gulf jets during the El Nino periods.

Hoerling and Kumar (2000) noted that one of the outstanding problems in seasonal predictability research is determining how nonlinear the relationship between boundary forcing and the climate signal actually is. H&A (2002) stated that the relationship between ENSO and Florida storminess is likely not just a linear one where ENSO controls storminess entirely, but likely a relationship complicated by nonlinear interactions with other systems. However, it is likely that ENSO is the dominant system, especially during extreme phases. Over a restricted range of SST indices and seasonal storminess (for example, -3 to +3 and 0 to .20) a linear model seems reasonable. Figure 11 illustrates the conceptual model of the seasonal forecasting scheme used in H&A (2002). This model is also applied in the current study using all of the commonly available measures of Pacific SST's for ENSO monitoring by the Climate Prediction Center (CPC) as predictors. Figure 12 shows the areas that make up the Nino 1+2, Nino 3.0, Nino 3.4, and Nino 4 indices used in this study.

H&A (2002) found that multicollinearity was a significant issue in multiple linear regression using multiple monthly SST indices as predictors. This study focused on using mean values and two-monthly values because when more than two SST variables were used as predictors in MLR equations, multicollinearity resulted (see H&A 2002 for a more complete discussion).

	Storm Tracks			
Jet Tracks	North	South	Gulf	Total
North	**4**	**1**	**1**	**6**
South	**41**	**44**	**39**	**124**
Gulf	**24**	**34**	**49**	**107**
Total	**69**	**79**	**89**	**237**

Table 1. Classification of the 237 Florida storms by storm track and associated jet stream track. Note that Gulf track storms and jets are a subset of southern track storms and jets, thus total southern storms and jets are obtained by adding the "South" and "Gulf" categories.

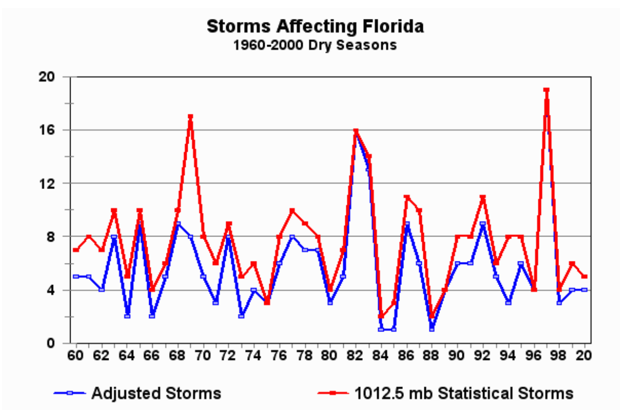

Figure 6. Comparison of the number of dry season candidate "storms" from the initial 1012.5 mb statistical screening process and final number of adjusted storms after detailed inspection of each case.

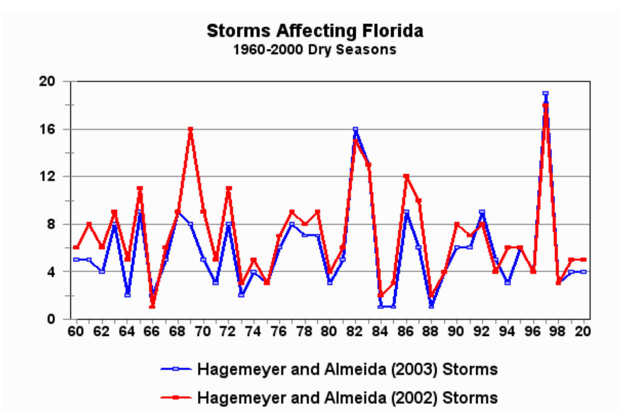

Figure 7. Comparison of seasonal storm counts from Hagemeyer and Almeida (2002) and the results of the current study.

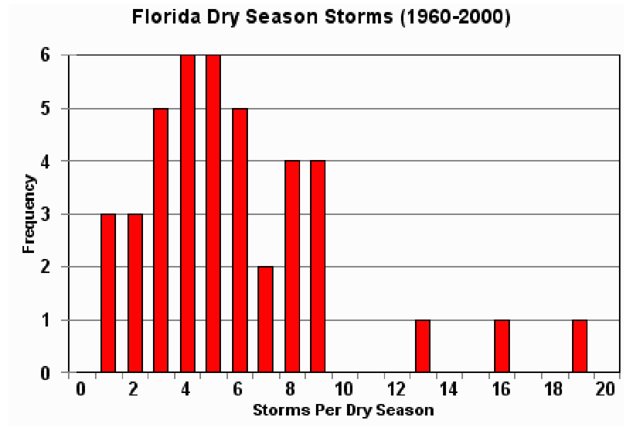

Figure 8. Frequency distribution of number of storms per dry season (1960-61 to 2000-01).

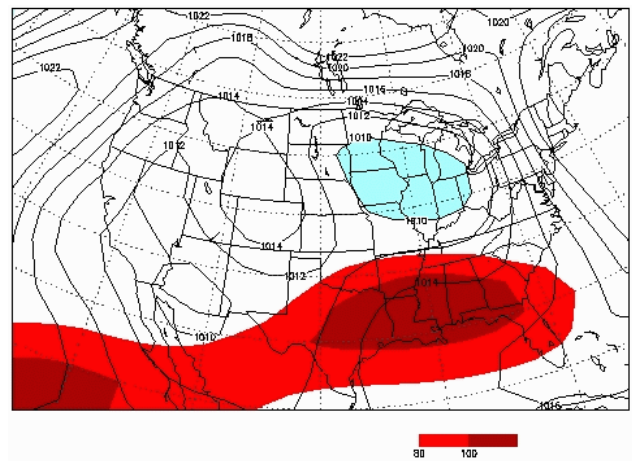

Figure 9. Plot of daily mean MSLP (mb) with relevant low highlighted in light blue and 250 mb U (kts) with jet stream highlighted in shades of red for 00 UTC 7 March, 1992.

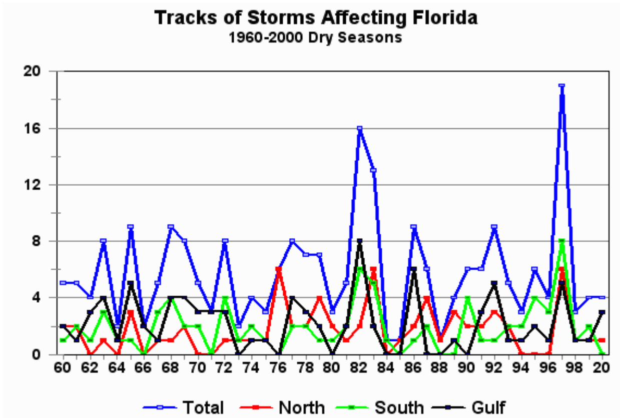

Figure 10a.

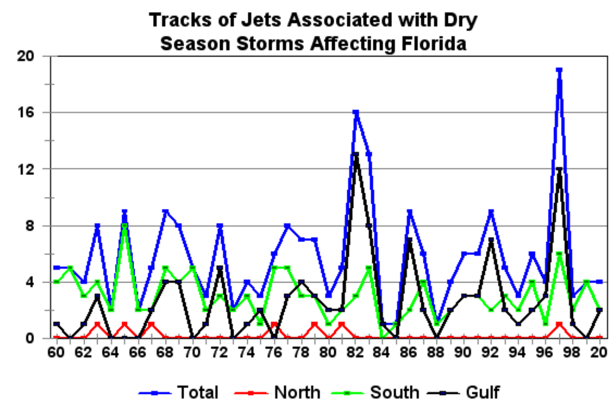

Figure 10a-b. Comparison of dry season storminess (1960-61 to 2000-2001) and storm and jet stream tracks (see Fig. 3). In this case the Gulf and South storm and jet tracks are broken out separately. The sum of the North, South, and Gulf tracks equals the total storms and jets for the season.

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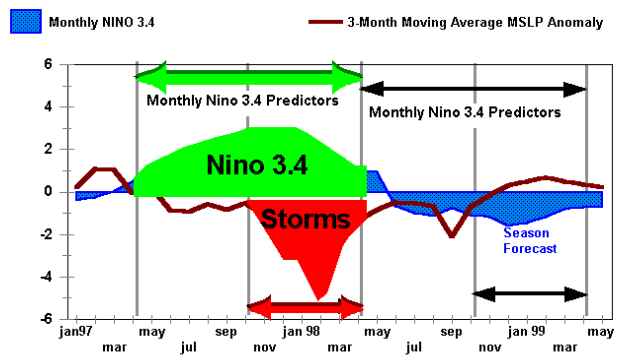


Figure 11. Conceptual model of dry season forecast methodology (from H&A 2002) . For illustration purposes monthly Nino 3.4 and 3-month moving averages of MSLP anomaly for the Florida grid from January 1997 to May 1999 are shown. Nino 3.4 candidate predictors are indicated by the long green horizontal line with arrows. The dry season forecast period is indicated by the short red horizontal line with arrows. Some combination of monthly ENSO predictors will provide the best forecast of dry season storminess over Florida.

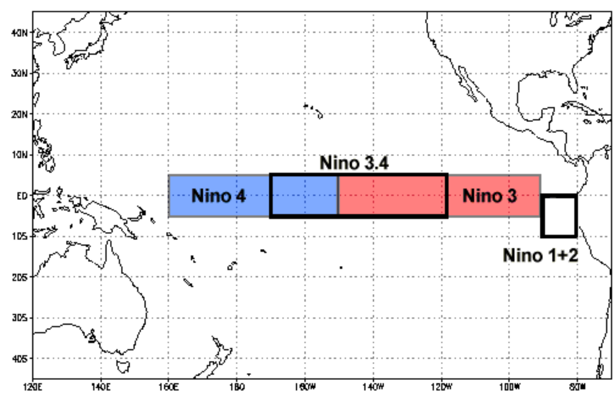


Figure 12. Illustration of sea surface temperature (**SST**) areas used as predictors in this study. The monthly values of Nino 4, Nino 3.4, Nino 3.0, and Nino 1+2 are the area-averaged SST in each of the geographic blocks on the figure.

The authors completed regression analyses on all possible combinations of one-month and two-month values of Nino 1+2, Nino 3.0, Nino 3.4, and Nino 4.0 from May through the following April on dry season storminess and the most common combinations of storm and jet tracks for the 1960-61 through 2000-2001 and the 1980-81 through 2000-2001 dry seasons. Table 2 lists the best results as determined by r-values for each storm and jet track scenario. Information on F-test significance ($F_{.01}$) and t-test significance ($t_{.05}$) is also indicated on Table 2. H&A (2002) found significant relationships between Nino 3.4 and dry season storminess, and that was again the case using the new storminess predictand climatology. The authors believed the location of the warm/cool SST's important, and that Nino 3.0 might prove to be a better predictor. It was expected that Nino 4.0 might give poorer results due to its position in the western equatorial Pacific. It was also expected that Nino 1+2 might give poorer results due to its relatively small geographic area next to the coast of South America.

Perhaps what was most surprising was that Nino 1+2, Nino 3.0 and a combination of both Nino 1+2 and Nino 3.0 all significantly outperformed Nino 3.4. What is abundantly clear, and further confirms the results of H&A (2002), is that there is a strong relationship between equatorial Pacific SST's and Florida dry season weather and that many measures of SST prove to be effective predictors. Clearly the significance of the relationship of equatorial Pacific SST's to Florida storminess decreases from east to west with Nino 1+2 and Nino 3.0 providing nearly equal results, followed by Nino 3.4 and then Nino 4.0 with little useful relative predictive ability.

What was also confirmed from the previous work of H&A (2002) was that the two-month combinations of SST predictors such as June and following February or August and following January, which are appealing conceptually and physically (i.e. the first month marks the ENSO phase and the second month confirms the seasonal trend), do not outperform the most simple measure of SST which is the average SST index from May through following April. Indeed, even when the two-month SST predictors were highly correlated (for example: N. Storms regressed on August and January Nino 1+2), one of the monthly variables occasionally had a negative regression coefficient and failed the t-test indicating some influence of multicollinearity with just two predictor variables. Perhaps the efficacy of the 12-month mean values should not be too surprising since statistical analyses indicate that this average value typically does capture the SST trend which is so important to the teleconnections forecast.

Figures 13 and 14 compare the observed storms for the 1960-2000 dry seasons and for the 1980-2000 dry seasons respectively to those predicted by Nino 1+2 (Equations 1 and 2).

$$\textbf{Storminess}_{\text{(NOV-APR)}} = b + b_{\text{Mean May to April}}(\text{Nino1+2}_{\text{Mean May to Apr}}) \quad \textbf{(1)}$$

$$\textbf{Storminess}_{\text{(NOV-APR)}} = b + b_{\text{Aug}}(\text{Nino1+2}_{\text{Aug}}) + b_{\text{Jan}}(\text{Nino1+2}_{\text{Jan}}) \quad \textbf{(2)}$$

Figures 15 and 16 compare the observed storms for the 1960-2000 dry seasons and for the 1980-2000 dry seasons respectively to those predicted by Nino 3.0 (Equations 3 and 4).

$$\textbf{Storminess}_{\text{(NOV-APR)}} = b + b_{\text{Mean May to April}}(\text{Nino3.0}_{\text{Mean May to Apr}}) \quad \textbf{(3)}$$

$$\textbf{Storminess}_{\text{(NOV-APR)}} = b + b_{\text{Jun}}(\text{Nino3.0}_{\text{Jun}}) + b_{\text{Feb}}(\text{Nino3.0}_{\text{Feb}}) \quad \textbf{(4)}$$

Figures 17 and 18 compare the observed storms for the 1960-2000 dry seasons and for the 1980-2000 dry seasons respectively to those predicted by June Nino 3.0 and January Nino 1+2 (Equation 5).

$$\textbf{Storminess}_{\text{(NOV-APR)}} = b + b_{\text{Jun}}(\text{Nino3.0}_{\text{Jun}}) + b_{\text{Jan}}(\text{Nino1+2}_{\text{Jan}}) \quad \textbf{(5)}$$

Figures 19 and 20 are Taylor-Russell diagrams for Eqs. 1, 3, and 5 for the 1960-2000 and 1980-2000 dry seasons respectively. These results represent a significant improvement over H&A (2002), especially for the period 1960-2000, reflecting both the improved storminess climatology and the use of the new SST variables. The results indicate considerable skill in predicting above/below normal dry season storminess as well as extreme storminess for the Florida grid. Again, the forecasts based on equations using the 1980-2000 data were more accurate. This period was marked by extremes of ENSO, more so than 1960 to 1980 period, again confirming correlations may be stronger during extreme phases of ENSO.

What was most interesting was that for all intents, the results of using average Nino 3.0 and Nino 1+2, and a combination of both were virtually the same and had nearly the same mean absolute errors.

4. CONCLUDING REMARKS

This latest study continues to confirm the importance of the ENSO signal to Florida dry season weather. It also indicates that Nino 3.0 and Nino 1+2, or SST anomalies in the eastern equatorial Pacific Ocean, are better predictors than Nino 3.4, The Climate Prediction Center produces forecasts of Nino 3.0 as well as Nino 3.4 so the author's will incorporate the Nino 3.0 equations into their seasonal forecast scheme. It is clear that many different combinations of Nino 1+2, Nino 3.0 and Nino 3.4 provide significant confidence in predicting above/below normal regional storminess, however, the most important challenge still remains the accurate

Predictors '	Nino 1+2		Nino 3.0		Nino 3.4		Nino 4.0		Nino 3.0 & 1+2
Predictands —	AVG	AUG/ JAN	AVG	JUN/ FEB	AVG	SEP/ JAN	AVG	SEP/ JAN	JUN/JAN
All Storms (60-00)	.68	.69	.68	.68	.55	.53	.33	.32	.70
All Storms (80-00)	.81	.82	.72	.76	.52	.51	.24	.22	.78
North Storms (60-00)	.43	.50	.32	.44	.21	.31	.12	.14	.45
North Storms (80-00)	.51	.68	.36	.57	.22	.31	.10	.10	.57
S. + Gulf Storms (60-00)	.43	.49	.50	.50	.44	.44	.28	.25	.51
S. + Gulf Storms (80-00)	.64	.70	.64	.69	.48	.49	.23	.20	.70
Gulf Storms (60-00)	.26	.37	.36	.45	.44	.42	.23	.20	.37
Gulf Storms (80-00)	.39	.51	.46	.65	.48	.48	.19	.16	.51
Gulf + N. Storms (60-00)	.62	.61	.63	.65	.52	.52	.31	.30	.62
Gulf + N. Storms (80-00)	.72	.71	.66	.72	.49	.47	.23	.20	.67
South + N. Storms (60-00)	.63	.65	.53	.61	.38	.41	.22	.22	.64
South + N. Storms (60-00)	.72	.79	.57	.68	.37	.45	.16	.16	.72
Gulf Jet (60-00)	.59	.56	.54	.57	.42	.40	.27	.26	.56
Gulf Jet (80-00)	.72	.72	.68	.71	.51	.51	.25	.22	.70
Gulf + S. Jet (60-00)	.67	.67	.66	.67	.53	.51	.32	.31	.69
Gulf + S. Jet (80-00)	.80	.80	.72	.76	.52	.50	.24	.22	.78
All Jets	*Same as "All Storms"*								

Table 2. Correlation coefficients (R^2) from regression of ENSO predictors (shaded in light blue) on Florida grid dry season storms and subsets of different storm and jet stream tracks (shaded in light red). Regression equations that passed the F-test at $F_{.01}$ and t-test for each variable at $t_{.05}$ are shaded in light green. Regression equations that passed the F-test at $F_{.01}$, but failed the t-test for one or more variables at $t_{.05}$ are shaded in light yellow. Equations that failed both tests are left unshaded.

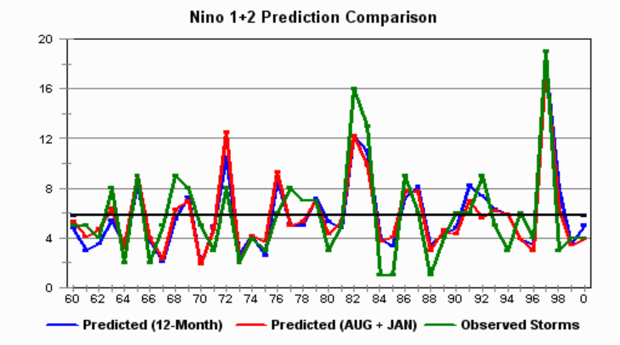


Figure 13. Comparison of observed Florida dry season storms from 1960-61 to 2000-01 (green line) with storms predicted by the average Nino 1+2 from May through following April (blue line) and with storms predicted from August and following January Nino 1+2 (red line).

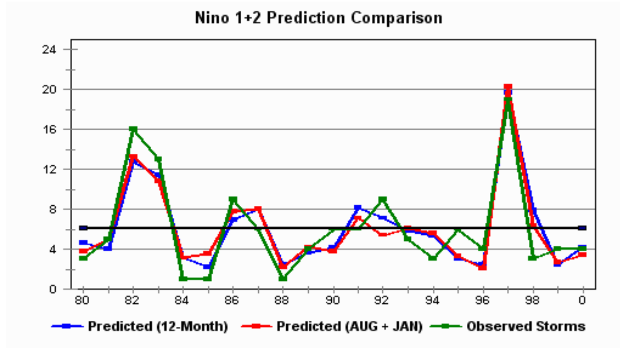


Figure 14. Comparison of observed Florida dry season storms from 1980-81 to 2000-01 (green line) with storms predicted by the average Nino 1+2 from May through following April (blue line) and with storms predicted from August and following January Nino 1+2 (red line).

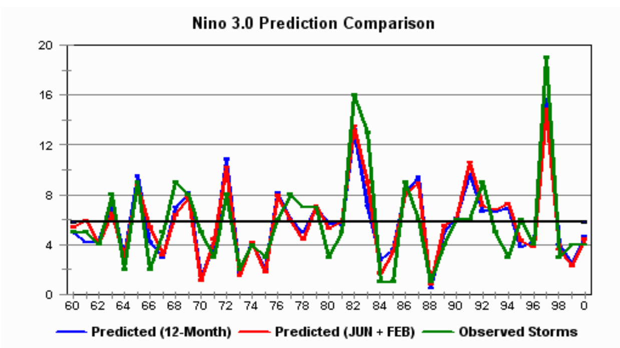


Figure 15. Comparison of observed Florida dry season storms from 1960-61 to 2000-01 (green line) with storms predicted by the average Nino 3.0 from May through following April (blue line) and with storms predicted from June and following February Nino 3.0 (red line).

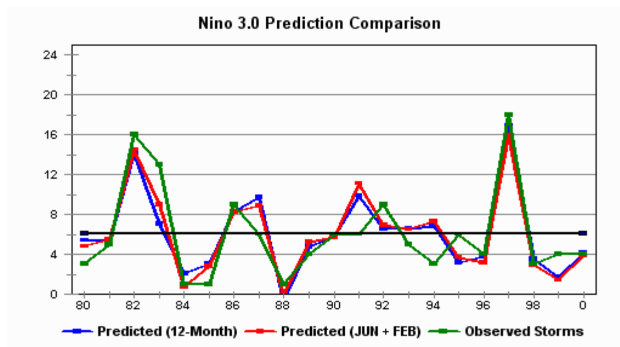


Figure 16. Comparison of observed Florida dry season storms 1980-81 to 2000-01 (green line) with storms predicted by the average Nino 3.0 from May through following April (blue line) and with storms predicted from June and the following February Nino 3.0 (red line).

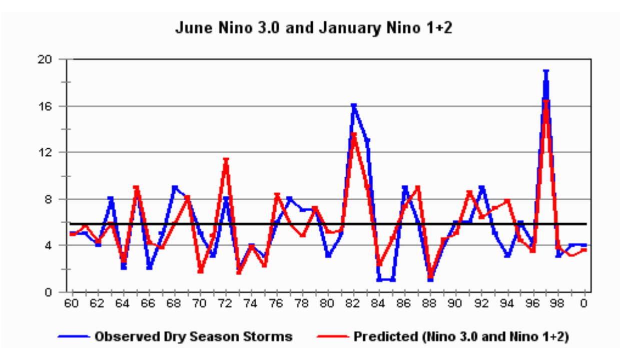


Figure 17. Comparison of observed Florida dry season storms from 1960-61 to 2000-01 (blue line) with storms predicted from June Nino 3.0 and following January Nino 1+2 (red line).

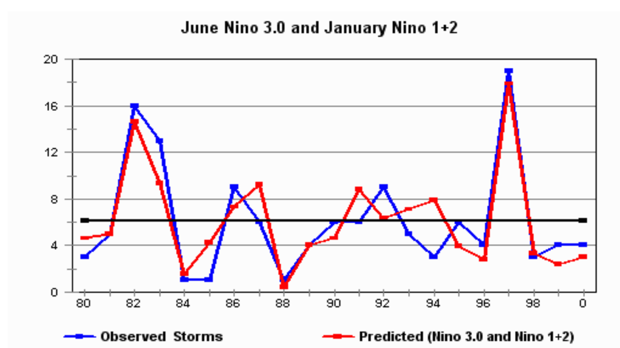
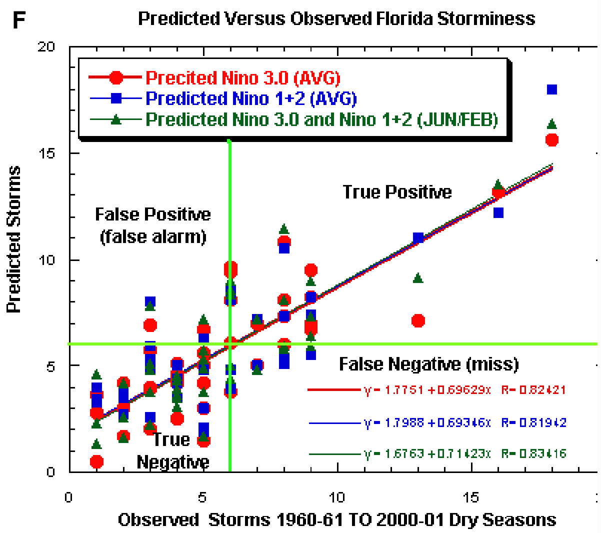


Figure 18. Comparison of observed Florida dry season storms from 1980-81 to 2000-01 (green line) with storms predicted from June Nino 3.0 and following January Nino 1+2 (red line).



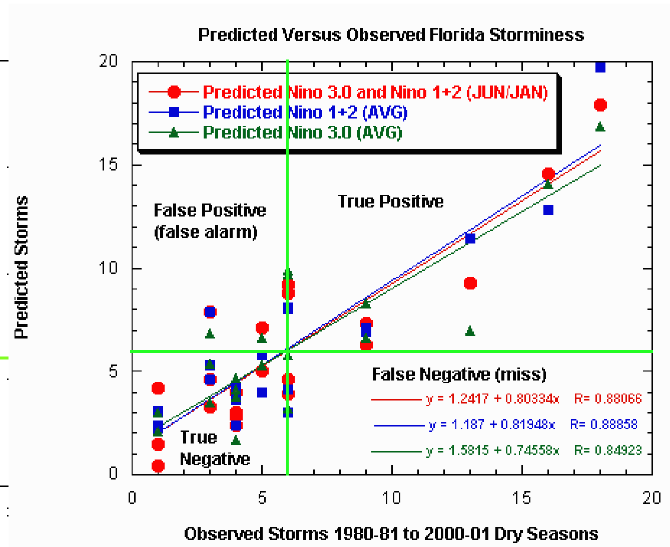


Figure 19. Taylor-Russell diagram plotting observed storms against storms predicted for the 1960-61 to 2000-01 dry seasons from Equations 1, 3, and 5 . Normal storminess is indicated by the green lines (see Stewart, 2000 for a detailed description of the chart).

Figure 20. Taylor-Russell diagram plotting observed storms against storms predicted for the 1980-81 to 2000-01 dry seasons from Equations 1, 3, and 5 . Normal storminess is indicated by the green lines (see Stewart, 2000 for a detailed description of the chart).

prediction of the SST indices on which the telleconnections forecasts depend many months in advance. The author's will experiment using ensembles of the best statistical forecast equations (such as those on Figs. 19 and 20) for the 2002-2003 dry season to determine if they outperform the best single statistical forecast.

The preliminary results presented here have only begun to mine inferences from the huge quantity of information obtained from the regression results (such as indicated on Table 2). Much more work remains to be done in drawing meaningful conclusions regarding the ENSO signal and the frequency and paths of cyclones and jet streams, but the initial results are very encouraging. The authors plan on completing cross validation studies of the most important forecast relationships revealed here. The authors also intend to expand the study to include May storminess that might be related to the ENSO signal, particularly in those years when the transition from the dry to the wet season is delayed beyond April 30.

The author's will also continue the investigation into the significance of the jet stream tracks and plan to develop a climatology of dry season jet maxima passages over the Florida grid and run regressions with the CPC SST indices. As part of the continuing refinement of the Florida storminess climatology the author's will attempt to develop an impact climatology and stratify storminess by primary impact and extent of impact in Florida. The examination of the 319 candidate storms in this study led the author's to tentatively define a subset of storms that they called "Florida Lows" and appear to be the most impactful and potentially dangerous to the citizens of Florida, and often turn into significant storms over the north Atlantic. Detailed study of the 41 identified "Florida Low" candidate cases is planned.

Investigations are planned into other possible Florida telleconnections and how they relate to ENSO and Florida storminess. These possibly nonlinear relationships may well be why the experimental ENSO-based forecasts occasionally fail.

5. REFERENCES

Please see: http://www.srh.noaa.gov/mlb/enso/mlb-14thglobal.html and
http://www.srh.noaa.gov/mlb/research.html.

Hagemeyer, B. C., 1998: Significant Tornado Events Associated with Tropical and Hybrid Cyclones in Florida. **Preprints, 16th Conference on Weather Analysis and Forecasting.** Phoenix, AZ, Amer. Meteor. Soc., 4-6.

Hagemeyer, B. C., 1998: Significant extratropical tornado occurrences in Florida during strong El Nino and strong La Nina events. **Preprints 19th Conference on Severe Local Storms.** Minneapolis, MN., Amer. Meteor. Soc., 412-415.

Hagemeyer, B. C., 1999: El Nino and significant tropical and hybrid cyclone tornado events in Florida. **Preprints, 23rd Conference on Hurricanes and Tropical Meteorology**. Dallas, TX, Amer. Meteor. Soc., 415-418.

Hagemeyer, B. C., 2000a: Development of a low pressure index as a proxy for dry season severe weather in Florida and its relationship with ENSO. **Preprints, 12th Conference on Applied Climatology**. Joint with **15th Conference on Probability and Statistics in the Atmospheric Sciences** Asheville, NC, Amer. Meteor. Soc., J22-25.

Hagemeyer, B. C., 2000b: Development of a low pressure index as a proxy for dry season severe weather in Florida and its relationship with ENSO. Preprints, **20th Conference on Severe Local Storms.** Orlando, FL, Amer. Meteor. Soc., 439-442.

Hagemeyer, B. C., and D. A. Matney, 1993: Relationship of twenty upper air indices to central Florida tornado outbreaks. **Preprints 13th Conference on Weather Analysis and Forecasting**. Vienna, VA, Amer. Meteor. Soc., 574-577.

Hagemeyer, B. C., and R. A. Almeida, 2002: Experimental Forecasting of Dry Season Storminess over Florida and the Southeast United States from the ENSO Signal using Multiple Linear Regression Techniques. **Preprints, 16th Conference on Probability and Statistics in the Atmospheric Sciences.** Joint with **13th Symposium on Global Change and Climate Variations.** Orlando, FL, Amer. Meteor. Soc., J117-124 .

Hoerling, M. P., and A. Kumar, 2000: Understanding and Predicting Extratropical Teleconnections Related to ENSO. **El Nino and the Southern Oscillation: Multiscale variability and global and Regional Impacts.** H. F. Diaz Ed. Cambridge University Press. 54-88.

Stewart, T. R., 2000: Uncertainty, judgment and error in prediction. ***Prediction: science, decision making, and the future of nature.*** Island Press. 41-57. ISBN 1-55963-776-5.