2006 NOAA Hurricane Outlook and Verification

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March 2007

The 2006 North Atlantic Hurricane season featured a total of ten named Tropical Storms (TS), five Hurricanes (H) and two major Hurricanes (MH) [categories 3-5 on the Saffir-Simpson scale]. With an accumulated cyclone energy (ACE) index of 90% of the median (Fig. 1) as defined by National Oceanic and Atmospheric Administration (NOAA), the 2006 hurricane season was classified a near-normal season. This is following the most active (since 1949) North Atlantic hurricane season of 2005 with a record 28 TS, a record 15 H, a record 4 MH and a record ACE index of 285% of the median. After a successful outlook of an extremely active season in 2005, NOAA had again called for another above normal active season in 2006. Unfortunately, it turned out to be an incorrect outlook for 2006. So what happened?

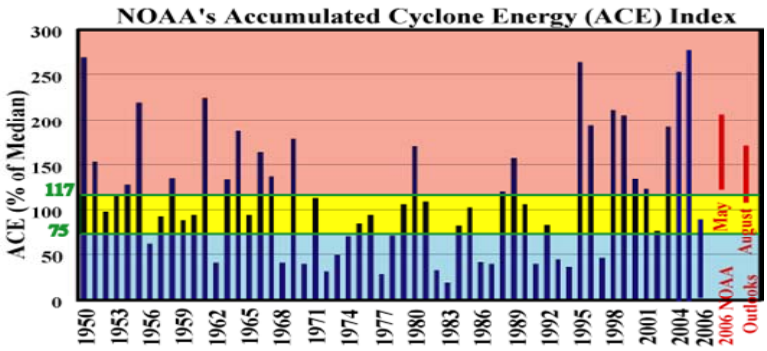

Figure 1 North Atlantic Hurricane Activity as measured by Accumulate Cyclone Energy (ACE) index at NOAA and the May and August 2006 outlooks. The active (orange), normal (yellow) and inactive (blue) ranges of hurricane activity are indicated.

In fact in a three class (above, normal and below) verification system, NOAA's long lead outlooks of North Atlantic hurricane activity had been highly successful since they started issuing the outlooks in 1998. NOAA's long lead hurricane outlook team consists of scientists from NOAA's Climate Prediction Center (lead: Gerry Bell), National Hurricane center (NHC) and the Hurricane Research Division (HRD).

While the local sea surface temperature (SST) in a given ocean basin need to be higher than some minimal value (about 26.5 C) for storms and hurricanes to develop, it does not necessarily always mean that higher the local SST the more will be the overall hurricane activity in that region. Favorable atmospheric conditions such as vertical wind shear and cyclonic vorticity need to be in place as well, which may very well be associated or due to SST and atmospheric conditions elsewhere on the globe. Some could argue that the local SST determines the local atmospheric conditions; but in the true coupled ocean atmosphere system, the ocean in turn is also driven by the atmospheric conditions which are part of a global circulation system. So the observed oceanic and atmospheric conditions and variability that impact the hurricane variability in a given region, say the North Atlantic, is a net result of the local and remote SST and atmospheric conditions and variability. The differing levels of hurricane activity observed in the North Atlantic during 2005 (record active) and 2006 (normal) could very well be a classic illustration of the local versus remote influences even though the SST's in the North Atlantic region in the two years were not much different.

On the decadal and interannual time scales, the two major climate factors that influence the North Atlantic hurricane activity are the low frequency climate variability modes and the El Nino Southern Oscillation (ENSO) phenomenon. The low frequency climate variability modes as used in the NOAA outlooks are the two tropical multidecadal modes TMM1 and TMM2 (Chelliah and Bell, 2004 and Bell and Chelliah 2006). While the TMM1 mode deals with a much larger global scale low frequency tropical convective activity variations involving the African Sahel, South America and the central Pacific and the associated SST, wind shear, and

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multidecadal hurricane activity changes (particularly the drop in hurricane activity in the 70's from the high levels of the 50's and 60's), the TMM2 mode is associated with the recent increase in tropical SST in the Atlantic Ocean basin and related hurricane activity increase in the last decade. On interannual time scales, in general El Nino acts to suppress the North Atlantic Hurricane activity while La Nina acts to enhance the activity (Gray, 1984). Both these TMM modes and the ENSO mode impact the atmospheric circulation (stream function, cyclonic vorticity and vertical wind shear, etc.) and its variability over the North Atlantic thus impacting the hurricane activity there.

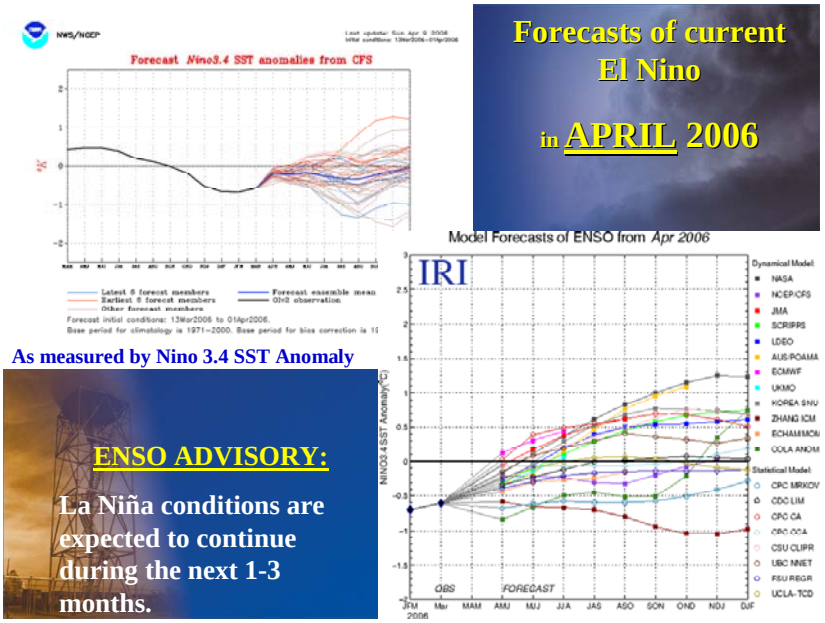

Figure 2 April Forecast of the Fall 2006 El Nino conditions as forecasted by NCEP's CFS Model and several dynamical and statistical models (as reported by IRI).

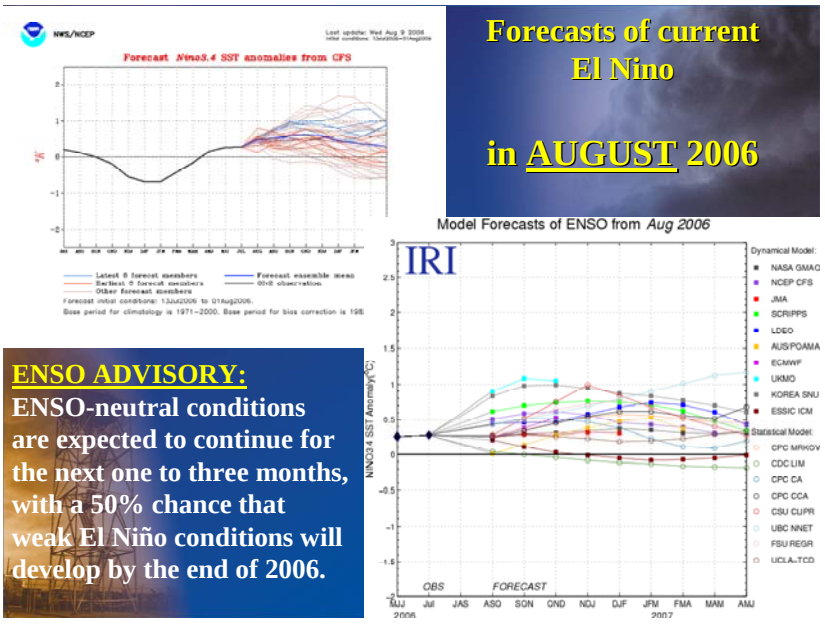

Figure 3 August Forecast of the Fall 2006 El Nino conditions as forecast by NCEP's CFS Model and several dynamical and statistical models (as reported by IRI).

In the North Atlantic during the inactive hurricane period 1971-1994, seasons typically averaged 8.5 TS, 5 H and 1.5 MH and only three (1980, 1988, 1989) out of 24 seasons were classified as above normal. But in the current active hurricane period in the North Atlantic which began in 1995, during the 12-year period 1995-2006, seasons have averaged 14.4 TS, 8.2 H and 3.9 MH with an average ACE value of 171% of the median. By the end of 2005 hurricane season, the only two hurricane seasons (out of 11) that were classified as below normal seasons were the two El Nino years 1997 and 2002. Even during 2004, when weak to moderately strong El Nino conditions prevailed during the entire later half of the year, the seasonal hurricane activity turned out to be at 'hyper active" level with an associated ACE index in excess of 250% of median. As measured by the Nino 3.4 SST Index, the strength of the El Nino during the peak of the 2004 hurricane season (ASO), was only slightly weaker than the 2002 levels. This 'unusually above normal activity' even during the moderate El Nino year (2004) and the other aspects of the hurricane activity since 1995, created a general consensus among the forecasters that unless there is a moderate to strong El Nino during much of the hurricane season (Aug-Sep-Oct), the North Atlantic hurricane activity is unlikely to be either at below or normal levels.

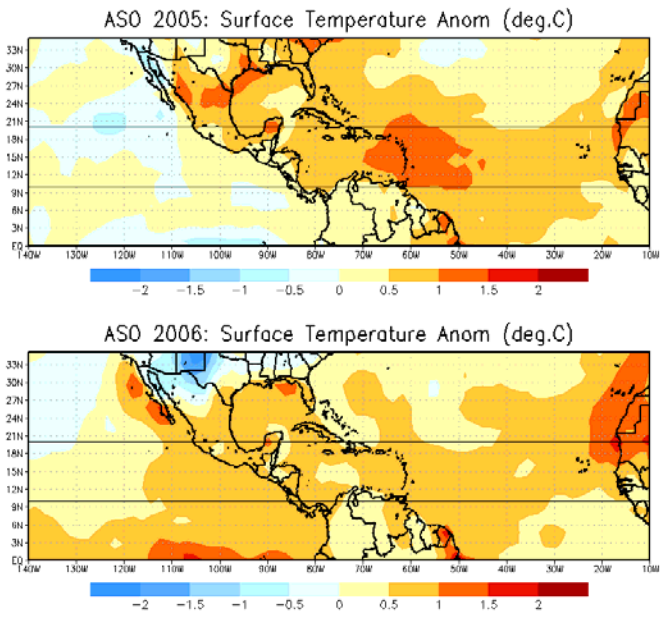

Figure 4 August-September-October mean sea surface temperature anomalies during the peak of the North Atlantic hurricane season in 2006 (bottom) as compared to 2005 (top).

In late April and early May 2006, when the initial hurricane outlook for 2006 was issued by NOAA, none of the dynamical or statistical models (see IRI plumes of Nino 3 or Nino 3.4 Indices for April and May 2006) including the generally and lately best performing Climate Forecast System (CFS) model from the NCEP, did not give any indication of any developing El Nino like conditions during the upcoming hurricane season (Fig. 2). In fact, many models then suggested that the lingering effects of the La Nino (which would favor an active season, Bell and Chelliah, 2006) have not quite yet totally dissipated. Moreover, the Atlantic SST anomalies were above normal, even though they were not as strong as they were in 2005. It would have been too early to get any indication from the stream function or wind shear anomalies in April/May, since they do not begin set up until early to middle summer to be of any use in predicting the seasonal hurricane activity. Nevertheless, the existing conditions were not in any way unfavorable for an active season. Hence the May NOAA hurricane outlook for the 2006 North Atlantic season called for a good chance (see Fig. 1) of an above normal season. Again in early August when the Hurricane outlook update was issued (Fig.1) all dynamical and statistical models still continue to suggest that El Nino will develop only by the end of the year (Fig.3), past the peak (ASO) of the hurricane season. Even though there was very little 'pre peak season' activity in 2006, because the SST stayed fairly warm in the North Atlantic the forecasters tended to lean toward and maintain the 'active season' forecast status issued earlier in May. With NOAA still officially not declaring that El Nino conditions are on the way, the forecasters in late July and in August still continued to interpret the less favorable atmospheric conditions as possibly due to unfavorable intra-seasonal activity - hence the reluctance on the part of forecasters to downgrade the earlier active season forecast.

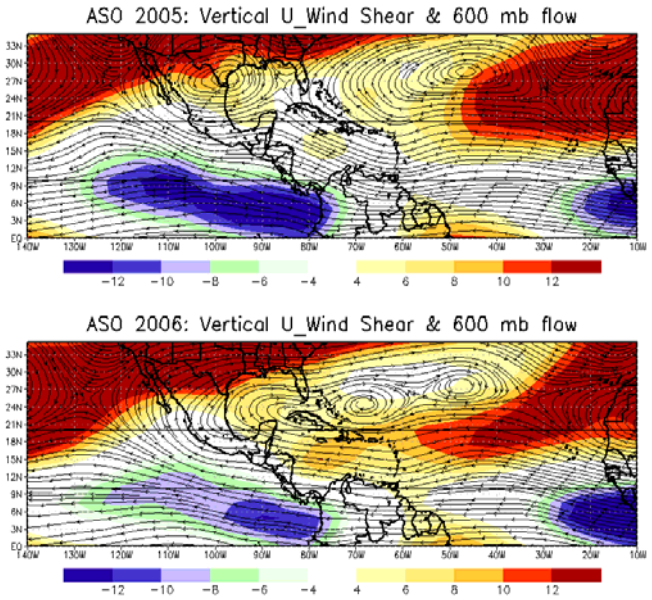

Figure 5 August-September-October mean 600 mb stream flow and vertical wind shear (200-850 mb) during the peak of the North Atlantic hurricane season in 2006 (bottom) as compared to 2005 (top)

After initially announcing in early September that neutral conditions are expected to continue for the next one to two months, NOAA declared in mid September that El Nino conditions have already developed and are likely to continue. These El Nino conditions, which developed very rapidly, further strengthened during the rest of the hurricane season thus suppressing any further storm activity for the season. The 2006 Atlantic hurricane season, as noted earlier, turned out to be a "normal" season. Even though the SST was anomalously warm through much of the season (Fig. 4), the vertical wind shear (Fig. 5) was high (as compared to 2005) over much of the main development region, which did not favor enhanced hurricane activity.

Finally, it appears that the overall behavior of the 2006 Atlantic hurricane activity with respect to the El Nino may still turn out to be rather complex than alluded here, particularly given what happened in 2004. How much of the regional circulation features over the North Atlantic that impacted the hurricane activity to thus reduce it, resulted from El Nino and other attributing factors needs to be studied further. However, it appears that the simple thermodynamic argument that just the warm ocean surface waters alone can contribute to and decide the overall hurricane activity needs to be looked into more carefully. Even though the overall level of enhanced hurricane activity in the North Atlantic that began in 1995 may continue for a decade or more, attributing the causes of the hurricane activity in a given season among the various causal factors such as low frequency modes, the ENSO and the intra-seasonal activity in real time and issuing an successful outlook continues to remain a challenge and further detailed studies are warranted.