CLIMATE IMPACT COMPANY
www.climateimpactco.com

Scott A. Yuknis
High impact weather forecasts, climate assessment and prediction.
14 Boatwright's Loop
Plymouth, MA 02360
Phone/Fax 508.927.4610
Cell: 508.813.3499
ClimateImpact@comcast.net

Climate Impact Company Research

Issued: Friday, December 1, 2017

Using the Accumulated Cyclone Energy (ACE) Index as a Predictor for Hurricane Season Severity in the Atlantic Basin

Tropical Cyclone Seasons and their severity are measured and documented in various forms around the globe. Counts of total named tropical disturbances, tropical depressions, tropical storms, hurricanes, and major hurricanes are the most common metrics that determine the activity and severity of an Atlantic Hurricane Season. A less commonly used index for tracking hurricane season activity and severity is the Accumulated Cyclone Energy (ACE) Index. It is a measured used by the National Oceanic and Atmospheric Administration (NOAA) to quantify the intensity of an individual storm or entire season. ACE *approximates* the total energy used by a storm through its lifetime and is calculated by summing the squares of the estimated maximum sustained wind velocity (speed) every six hours. Because kinetic energy (energy of an object in motion) is proportional to the square of the velocity, adding the energy together at a set unit of time through time provides the accumulated energy of the system. It is important to understand that ACE is not a direct calculation of energy because a direct calculation of energy would require computing the total air moved by the storm, which is dependent on storm size. ACE only considers the storm's sustained winds. Lastly, there is one caveat with ACE. As the duration of the storm increases, so does ACE because it is a summation through time. Thus a longer-lasting storm of weaker intensity may accumulate a higher ACE value than a shorter duration storm of strong intensity (WMO 2017).

ACE can be applied and used in forecasting Hurricane Season Forecasting by reviewing the dynamics that drive atmospheric motion. The simplest explanation is to understand that differences in temperature across Earth's surface results in differences in pressure across Earth's surface and through the depth of the atmosphere. The resulting difference in pressure across Earth's surface leads to wind, an effort of the atmosphere to move warm and cold air masses together to reach a balanced temperature state. Applying to the tropical oceans, as the oceans warm, low-pressure systems develop and intensify. The warmer the oceans are compared to the overlying atmosphere and surrounding atmosphere, the greater the pressure difference, and the stronger the wind speeds.

This research statement briefly reviews annual ACE values of the Atlantic Hurricane Seasons from 1948-2016 (http://www.aoml.noaa.gov/hrd/tcfaq/E11.html). Storms with ACE values 1 standard deviation or higher than the average ACE season value (1968-2016) are classified into one group, and storms with ACE values 1 standard deviation or lower than the average ACE season value are classified into another group. These grouping s are then subjected to visual analysis using NCEP-NCAR Reanalysis data to determine the differences in the atmospheric dynamics between active hurricane seasons and non-active hurricane seasons as defined by ACE.

Years 1 SD Above Mean	**Years 1 SD Below Mean**
1950	1962
1955	1972
1961	1977
1964	1982
1969	1983
1995	1986
1996	1987
1998	1991
1999	1994
2003	2013
2004	
2005	
2010	

Table 1: Very active and inactive tropical cyclone seasons according to ACE index across the North Atlantic basin.

Variables reviewed through reanalysis and presented below include 3 different measurements of sea surface temperatures (SSTs), 1000mb geopotential height, 500mb geopotential height, and Omega at 700mb (vertical velocity or “lift”). Composite anomalies of the values are taken for the months of May through November (1 month prior to the start of hurricane season, through the end of hurricane season).

High ACE Years

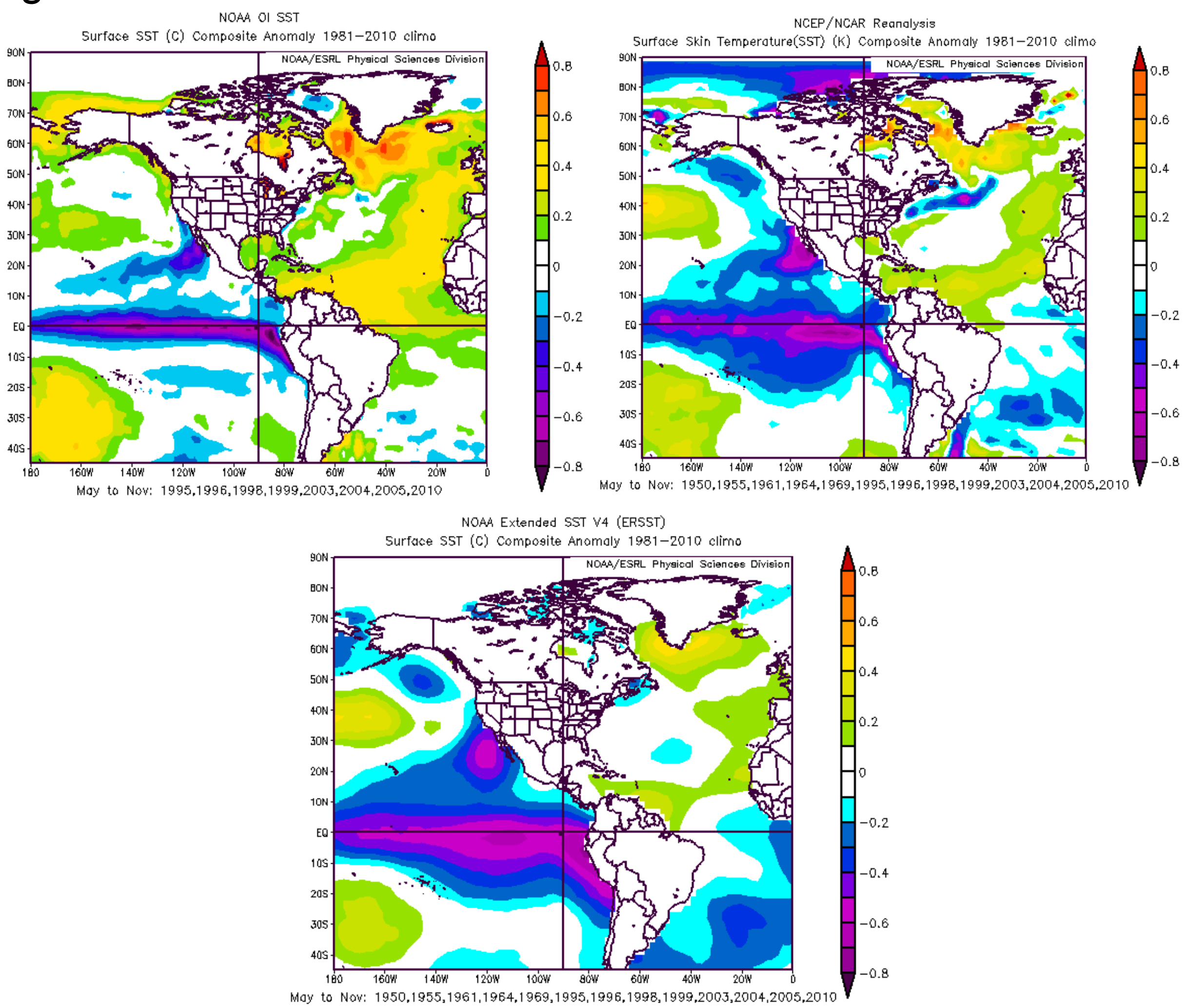

Figure 1: Sea surface temperature anomaleis associated with Atlantic hurricane seasons of high ACE values. The Tropical North Atlantic region is warmer than normal in all three analysis plots, along with warmer than normal temperatures south of Greenland. A La Niña and cool phase Pacific Decadal Oscillation pattern is establish across the Pacific.

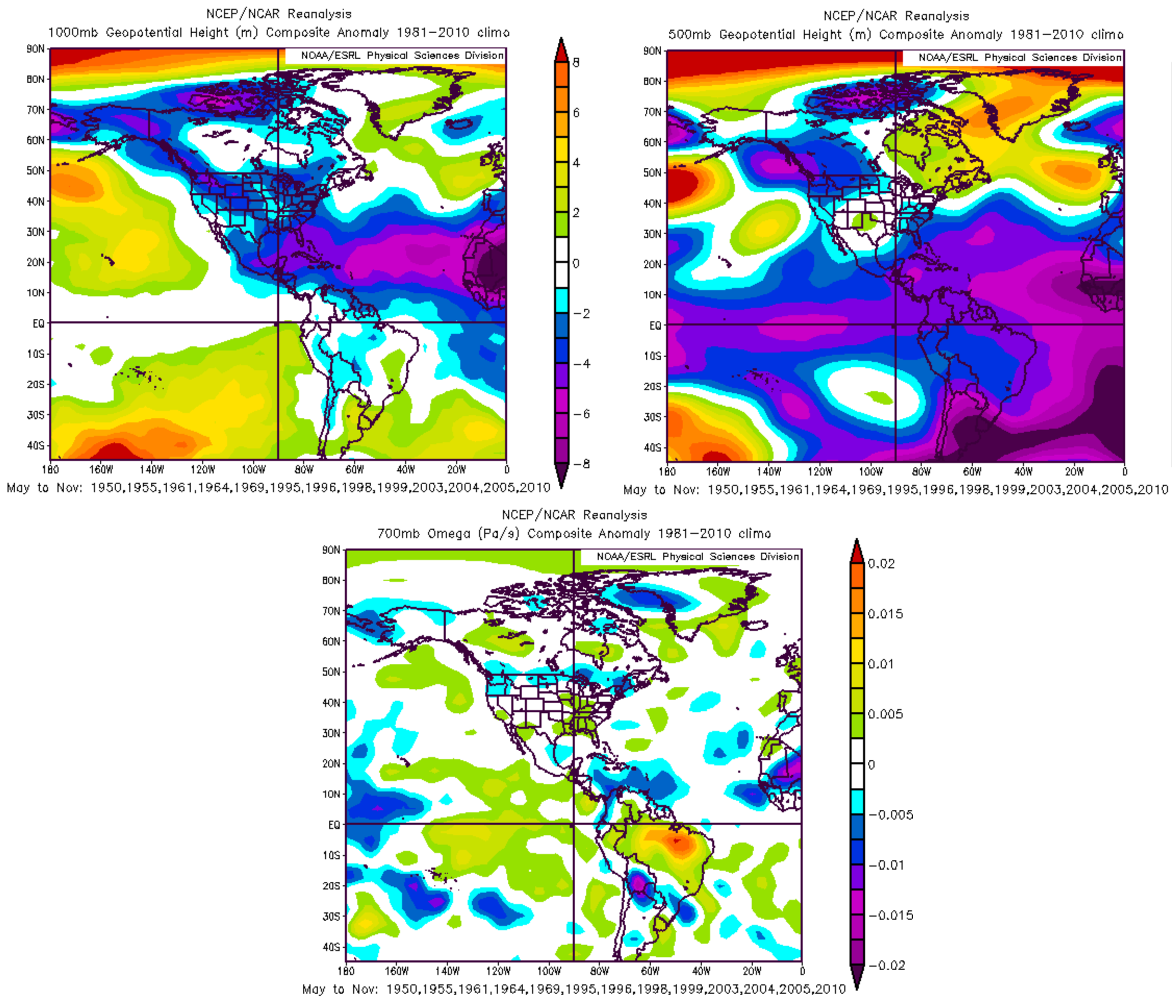

Figure 2: Geopotential height anomalies indicate if the atmosphere is colder or warmer at various levels. Lower heights are indicative of colder layers in the atmosphere and higher heights are indicative of warmer layers in the atmosphere. In the case of high ACE years, heights over the Atlantic are lower than average at the surface and at 500mb. Warmer oceans with a colder atmosphere overlaying the surface water through the depth of the atmosphere that warm core systems form in results in greater instability (so more vigorous updrafts) that result in stronger warm core systems, and thus, higher wind speeds. Increased Omega (measurement of the rate of lift through a layer) can be seen over the Southeast United States extending eastward in to the Atlantic Ocean.

Low ACE Years

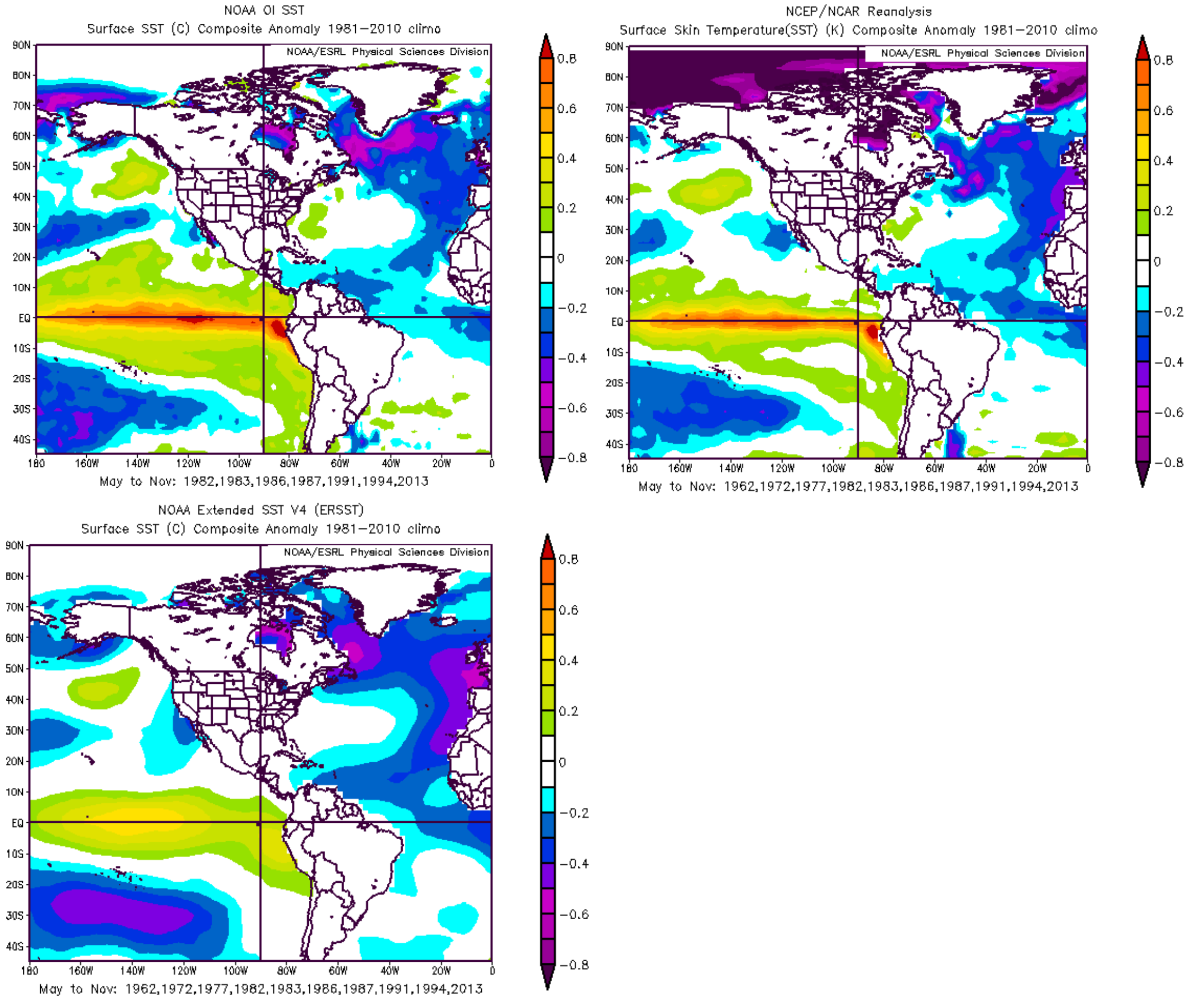

Figure 3: Sea surface temperature anomaleis associated with Atlantic hurricane seasons of low ACE values. The Tropical North Atlantic region is colder than normal in all three analysis plots, along with colder than normal temperatures south of Greenland. An El Niño and a warm phase like Pacific Decadal Oscillation pattern is establish across the Pacific.

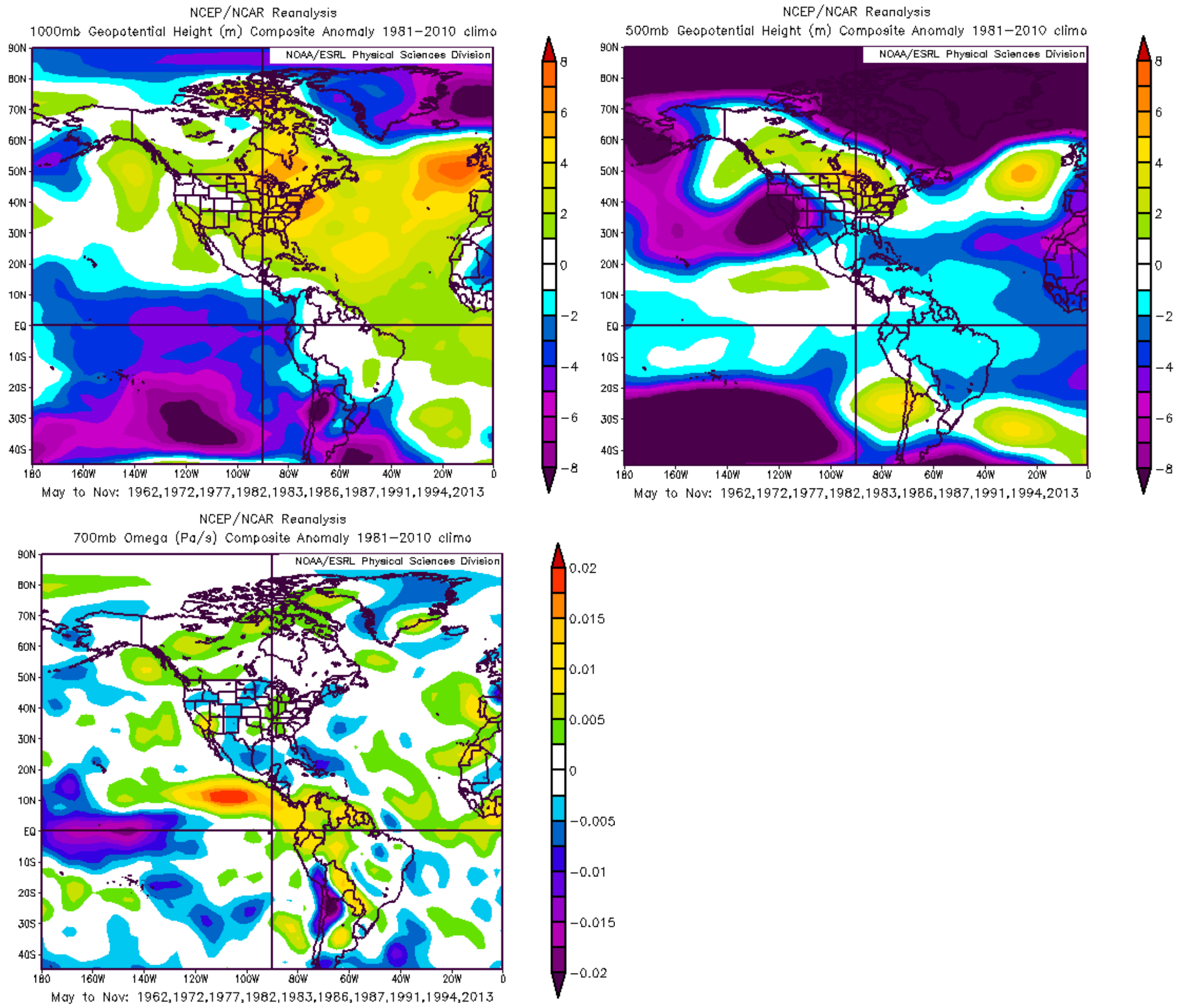

Figure 4: In the case of low ACE years above, heights over the Atlantic are higher than average at the surface but are lower than average at 500mb. This reduces instability and decreases Omega, as seen over the Gulf of Mexico, extending eastward in to the Caribbean and Atlantic Ocean. The reduced instability and weaker lift will result in less intense cyclones (i.e. weaker winds).

The following figures are presented to show how predicting hurricane season based on ACE is a better metric than just providing a prediction of the total number of named storms. The same parameters as presented above are now presented using years where the number of named storms was 1 SD or higher than the seasonal average of named storms. The years include 1969, 1995, 2005, 2008, 2010, 2011, and 2012.

Years with Named Storms 1 SD or Greater

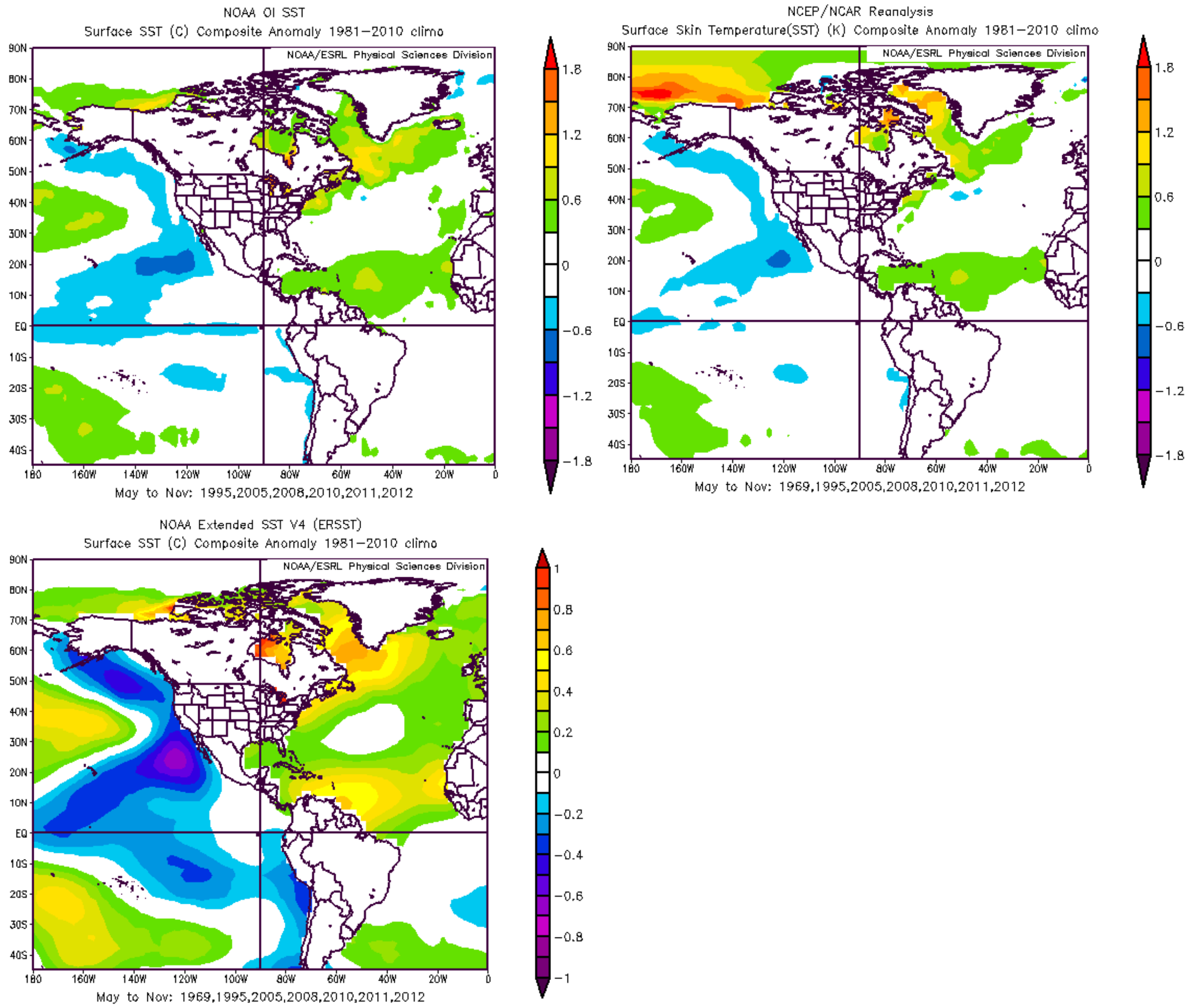

Figure 5: Sea surface temperature anomaleis associated with Atlantic hurricane seasons with 1 SD or greater named storms. Clearly defined SST patterns such as ENSO and the PDO are not as well establied during these years. The warmth in the Atlantic is also not as strong.

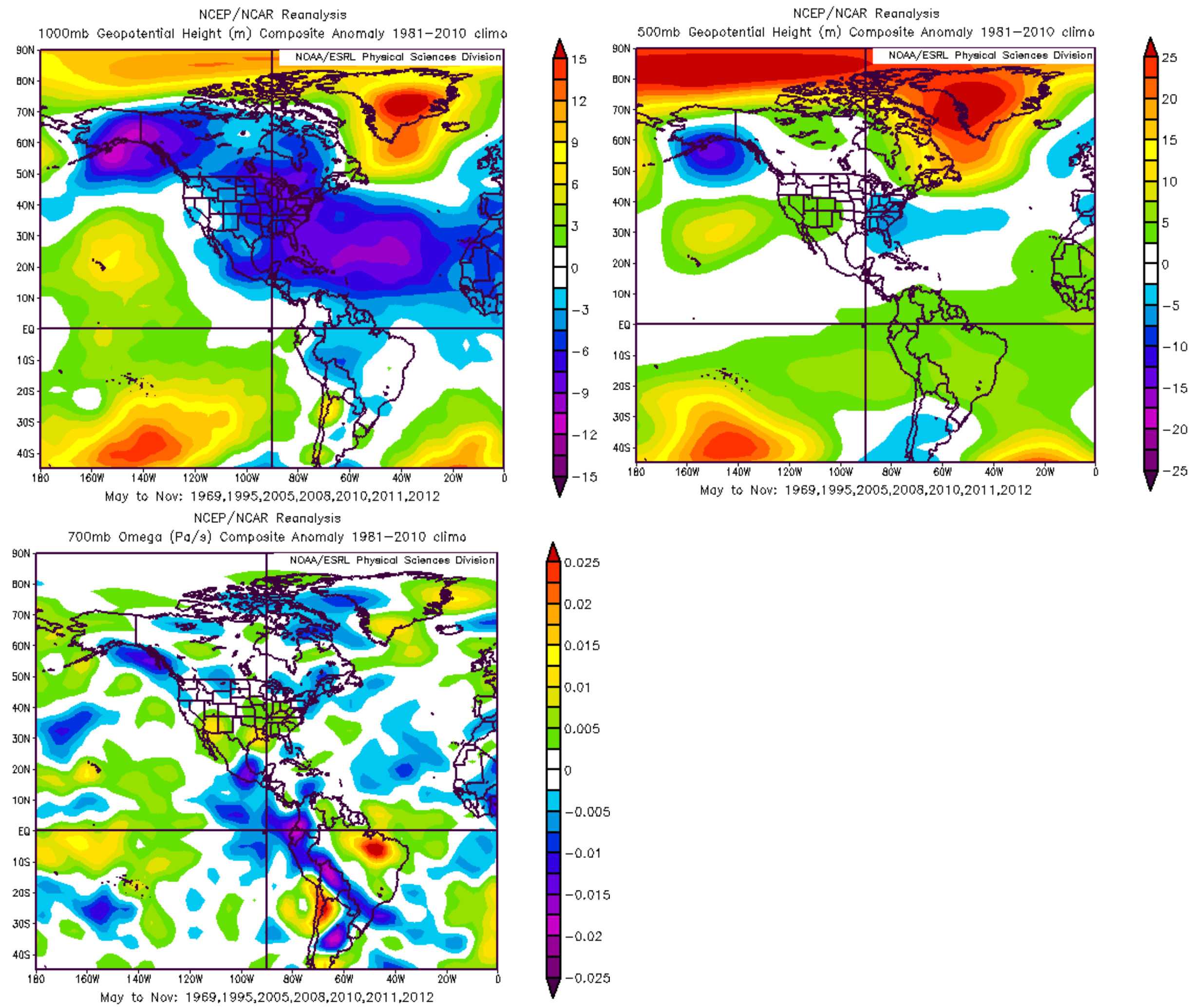

Figure 6: Height anomalies for years with the number of named storms 1 SD or greater show marked differences to the plots for high ACE years and low ACE years. Here, while the 1000mb and 500mb heights resemble the high ACE years, the lower heights at 500mb are displaced northward of the equator and tropics region. This reduces instability and decreases Omega in the region, as seen over Florida and the Tropical North Atlantic where most tropical disturbances begin to form.

Conclusions

The ACE Index, as developed and applied by NOAA is an ideal metric to quantify the potential of an active hurricane season because it best captures the dynamics supportive of stronger, more vigorous tropical systems that result in higher ACE values. When analyzed by high ACE years and low ACE years, clearly defined atmospheric teleconnection patterns that are predictable months in advance are seen, increasing forecast confidence and lead time. It is recommended that ACE be used as a predictor for Atlantic hurricane season potential instead of just providing an estimate of total named storms, hurricanes, and major hurricanes.

References:

World Meteorological Organization (WMO), 2017: Accumulated Cyclone Energy (ACE). *https://www.wmo.int/pages/prog/arep/wwrp/tmr/documents/ACE.doc (Accessed 31 October 2017.)*