2018 Atlantic Hurricane Seasonal Outlook

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Figure 1. NOAA GOES-16 true color visible satellite loop of Hurricanes Irma, Jose, and Katia on September 8, 2017.

Subtropical Storm Alberto

A broad area of low pressure developed over the southwestern Caribbean Sea on May 21 as a result of a weak surface trough interacting with an upper-level low. The system slowly moved northwestward into the northwestern Caribbean Sea and over the Yucatan Peninsula as it gradually became better organized during the following days. On May 25 at 1500 UTC, the heavily sheared low was considered sufficiently organized to be classified as Subtropical Storm Alberto just south of Cozumel, Mexico marking the fourth consecutive year to have a named storm form prior to the official start of hurricane season. The bare circulation of Alberto drifted eastward during the next 12 hours as its main convective activity remained well to the northeast. The next day, Air Force reconnaissance found that a more dominant center had reformed closer to this area of convection as Alberto lifted north into the Gulf of Mexico. Despite becoming more consolidated than the day prior, the system was still not considered fully tropical citing that the warm core was too shallow. The subtropical storm turned north-northeastward on May 27 and began to strengthen further as wind shear began to decrease. Contrary to the improving upper level wind environment for the system, significant dry air entrainment deterred deep convective activity near the system's center. Early May 28, Alberto reached its peak intensity with sustained winds of 65 mph before beginning to gradually weaken as the system made landfall near Laguna Beach, Florida around 2100 UTC. Alberto remained well intact even after being downgraded to a depression by the NHC and actually became organized enough to be considered fully tropical by the WPC after advisories were handed off to them as the system continued inland over Alabama and Tennessee on May 29. The next day the tropical depression was still remarkably well-organized with notable banding and a central pressure of 996 hPa reported as it moved through central Indiana.

Alberto's structure finally began to degrade that evening with the system becoming a post-tropical cyclone over northeastern Michigan at 0900 UTC on May 31.

Introduction

The North Atlantic hurricane season occurs from June 1st to November 30th and averages around twelve named storms, six hurricanes, and three major hurricanes based on the 1981-2010 mean. Despite most tropical cyclones occurring during this six month time period, there are occasions in which tropical cyclones do form prior to or after the season. These tropical cyclones typically form in regions of copious moisture, strong instability, light upper level winds, and sea surface temperatures near or above 26.5 degrees Celsius. This hurricane outlook will discuss the multitude of variables that can influence tropical cyclone activity in the Atlantic basin as well as illustrate a general idea of what could be expected from this hurricane season given these variables.

Analysis

I. Atlantic Multidecadal Oscillation

The Atlantic Multidecadal Oscillation (AMO) refers to the variance of sea surface temperatures (SST) compared to average across the North Atlantic Ocean. The AMO follows a general 65-80 year period that has an amplitude close to 0.4 ^{o}C that has been observed for about 160 years. A warm AMO phase has been associated with above average tropical cyclone activity due to the above normal warmth observed in the Atlantic's Main Development Region (MDR) where a majority of Atlantic tropical cyclones form. The cool phase is associated with below average tropical cyclone activity in the North Atlantic due to the MDR being cooler than normal.

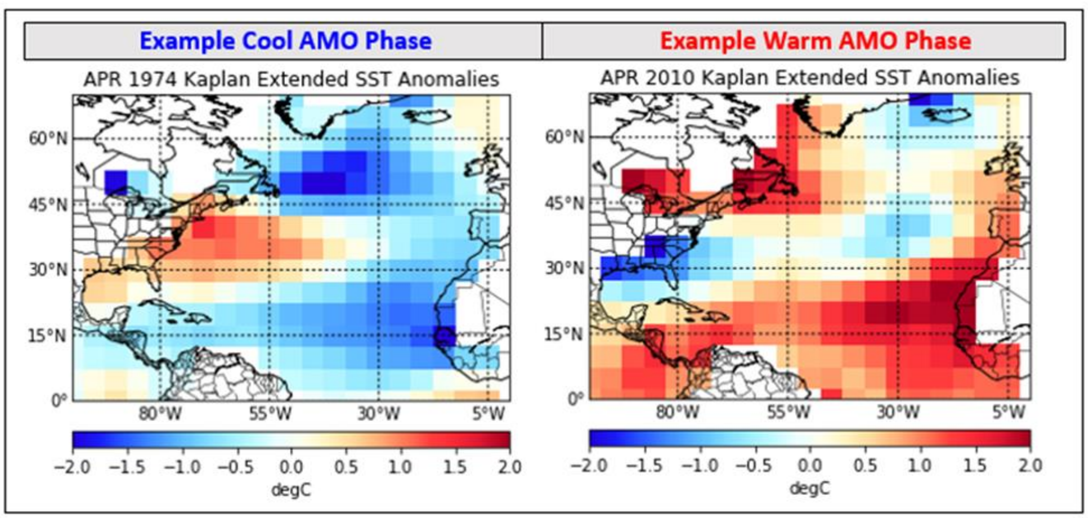


Figure 2. Kaplan Extended SST anomalies for April 1974 and April 2010 depicting the cool and warm phases of the AMO.

In 1995, the Atlantic Multidecadal Oscillation made a notable transition from a cool phase to a warm phase which is believed to have been the spark that started an active period in Atlantic tropical cyclones. The AMO remained largely in the warm phase throughout the remainder of the 1990s and through the 2000s which coincided with copious above normal hurricane seasons such as the record-breaking 2005 season. However, this changed in 2014 and 2015 with the onslaught of a warm ENSO event and a persistent positive North Atlantic Oscillation (NAO) winter pattern which caused the tropical Atlantic to cool significantly. The strong cool signal that occurred over this time period began speculation that it could be the beginning of a more permanent shift of the AMO to a cool phase, however, it was noteworthy that the MDR warmed during the summer to near average. 2016 served to quiet down some of this speculation as the tropical Atlantic warmed through the summer giving way to a warm AMO and the first above average hurricane season since 2012. This warm state continued in 2017 as the tropical Atlantic warmed to record temperatures through the late spring and summer which fueled the hyperactive season during that year. However, when comparing these two years to other warm AMO years, it was apparent that the subtropical Atlantic warm pool present during this period was anomalous to the traditional warm AMO SST profile.

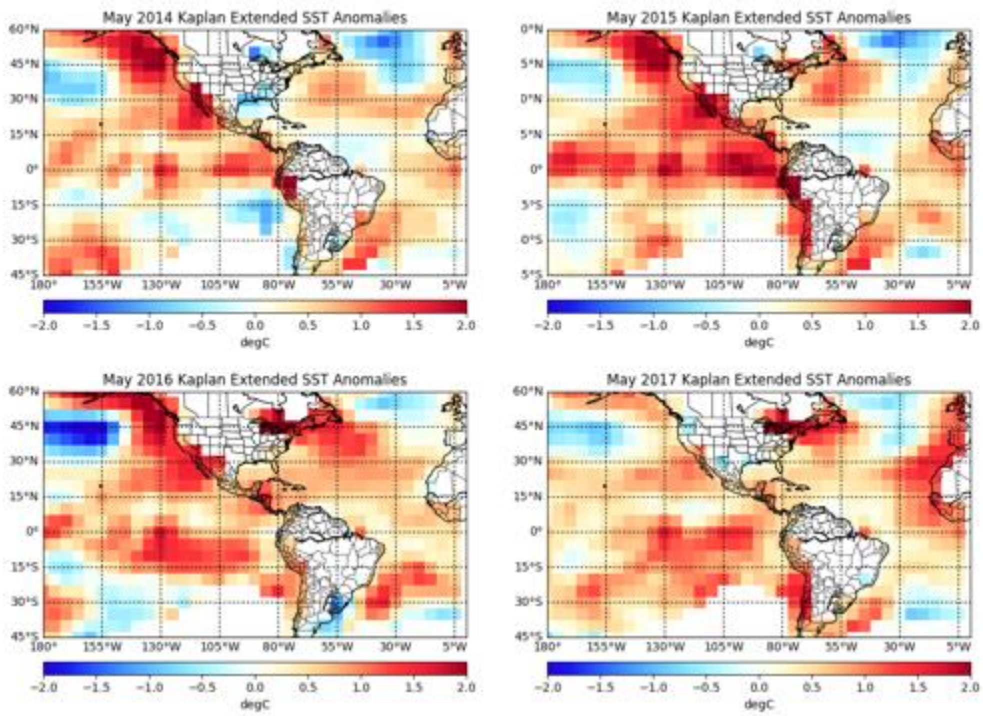


Figure 3. Kaplan Extended SST anomalies for May 2014, 2015, 2016, and 2017.

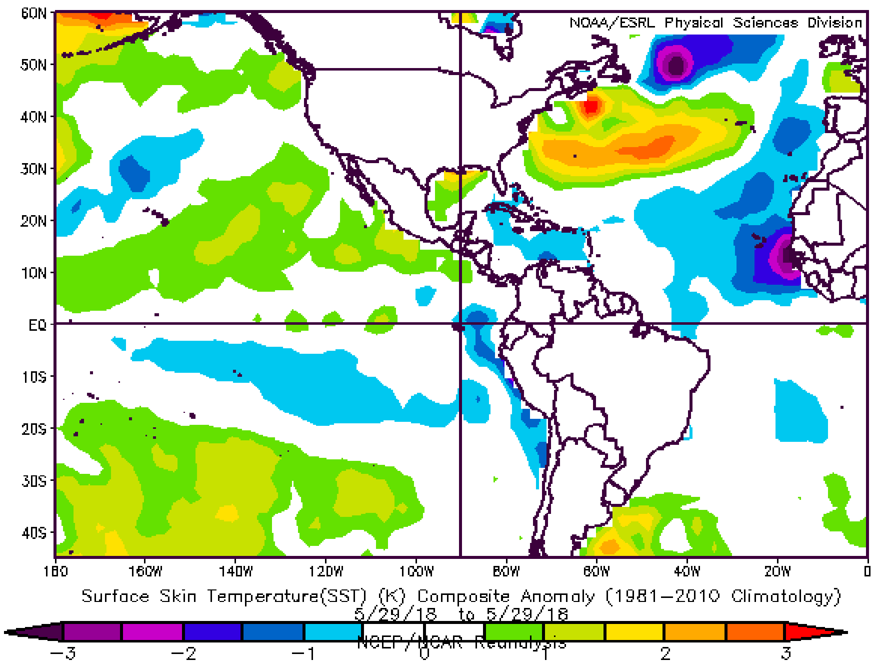


Figure 4. NOAA ESRL composite of NCEP/NCAR Reanalysis SST anomalies for May 29, 2018.

In the first five months of 2018, persistent ridging has caused significant upwelling across the tropical Atlantic leaving behind a “horseshoe” of cool anomalies that extends from the arctic down across the northeastern Atlantic and into the deep tropics. This background has shaped May 2018 to be the coldest AMO measured in the active era (1995-Current), and would be an inhibiting factor for tropical cyclone activity if this SST profile were to remain during the peak of hurricane season. Another component of the cool AMO phase that is worth talking about is the subtropical Atlantic warm pool that has been rather persistent in the basin since the end of 2013. This warm pool is exceptionally potent currently, and due to the cooler anomalies in the deep tropics, could be problematic as it would serve to create a much larger field of warm sea surface temperatures. Enlarging the area of warmest temperatures away from the deep tropics would thus expand the Hadley Cell in the Atlantic basin which could cause largescale sinking motion in the basin and therefore lowering vertical instability across the Main Development Region (MDR). Despite this, there is a clear possibility that the tropical Atlantic could recover during the summer months with the right trade wind pattern. One trait that assisted 2017 in warming up significantly through the early season was the anomalously slow easterly trade winds and northerly displaced ridging that caused the trade belt to remain well north of the deep tropics. This scenario leaves room for some error in the hurricane outlook because of the possibility of the MDR warming which could assist in negating some of the inhibiting factors noted above.

II. El Niño Southern Oscillation

The El Niño Southern Oscillation (ENSO) is defined as the variance of the SSTs in the eastern Equatorial Pacific Ocean. The period for ENSO is two to seven years and can vary upwards of 2 to 3 ^{o}C in amplitude. This climate oscillation is one of the most influential in overall global climate and is associated with significant variations in precipitation in the continents neighboring the Pacific Ocean. ENSO is categorized by three different phases: La Niña, neutral, and El Niño. A La Niña event is considered the cool phase of the ENSO and is associated with weaker upper level winds across the tropical Atlantic due to the lack of convective enhancement of the Subtropical Jetstream (STJ) in the lower latitudes during the summer months. El Niño is known as the warm phase of the ENSO and typically favors upward motion across the eastern pacific and American continents. This upward motion not only enhances convection across the eastern Pacific which promotes a more active summer STJ, but also generally promotes downward motion across surrounding basins like the North Atlantic and western Pacific.

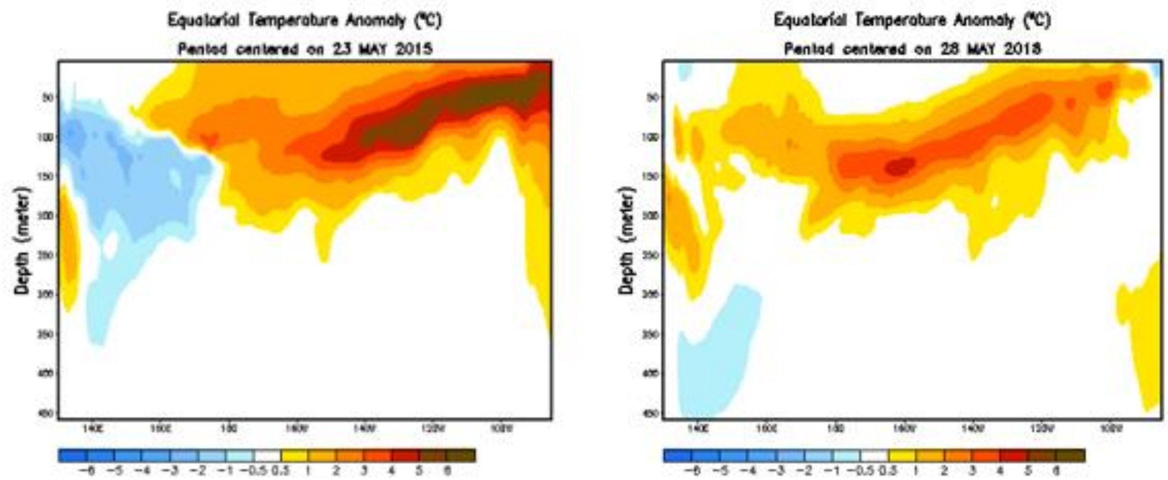
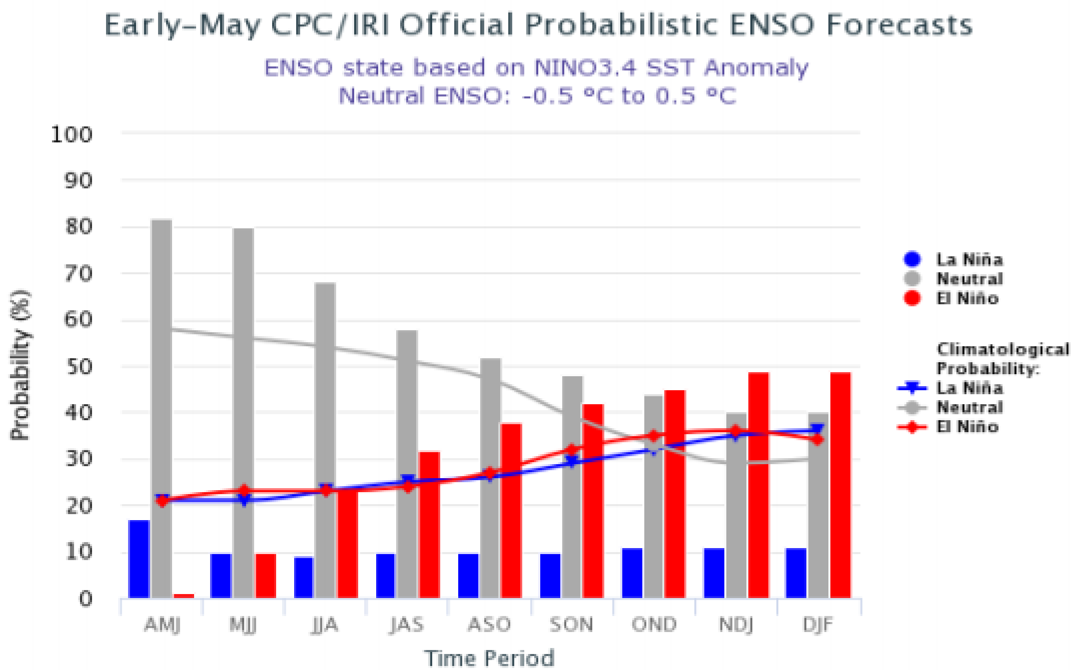


Figure 5. NOAA/PMEL TAO depth-longitude SST anomalies of the equatorial Pacific for May 23, 2015 and May 28, 2018 comparing a traditional El Niño subsurface profile to current.

In the fall and winter months of 2017, a moderate La Niña event emerged after a brief period of ENSO neutral during the first half of the year. This cool ENSO event marked the second consecutive year of La Niña conditions in the eastern Pacific during the fall and winter months which aided Atlantic hurricane activity during that time period. Since then, the La Niña event has slowly decayed with the Climate Prediction Center issuing their final La Niña advisory on May 29, 2018 which means the eastern Pacific has returned to ENSO neutral. Currently, there is some speculation that ENSO could continue to warm through the second half of the year resulting in the beginning of an El Niño event as indicated by the climate model consensus. This anticipated warming shown by the climate models is back by the notable downwelling oceanic kelvin wave, or subsurface warm pool, that currently resides in the central Pacific. This warm pool will tend to favor a warming of the equatorial waters east of the international dateline when the trade wind regime is favorable. However, the atmosphere is still generally slanted toward La Niña at the moment which would infer that for any warm ENSO event to prosper it will need to have a strong, consistent force behind it to help the event mature and reverse this atmospheric background. A potential force that could supply this favorable environment for El Niño is the breaking down of the Walker Circulation which would serve to slow, or reverse, equatorial easterly trade winds. Once sufficient warmth manifests over the eastern Pacific, this can serve as a positive feedback loop by enhancing upward motion over the region causing a localized area of lower pressures to develop and therefore causing the equatorial trade winds to decrease further and enhance ongoing warming in the region.



Although there is a warm pool capable of warming the eastern Pacific further, currently there is no evident forcing that will cause the ENSO regions to warm significantly enough to give a high probability of an El Niño by the fall of 2018. However, the gradual warming of the ENSO regions through the summer could give a sufficient base state for ENSO to favor El Niño going into the winter months. The increasing likelihood of an El Niño by this time is noted by the Climate Prediction Center in which they give about a 50% chance of an El Niño developing. This solution is supported by a vast majority of the climate forecast models, however, forecast skill for ENSO is lowest in spring when climatological variability is highest. This was proven once again to be true in 2017 when many climate forecasts predicted an El Niño to develop in the fall/winter when ultimately a La Niña event was what actually developed in this timeframe. Regardless, ENSO neutral is the favored mode during the peak of the Atlantic hurricane season which would largely have mute effects on the overall landscape of the Atlantic hurricane season this year.

III. Pacific Decadal Oscillation & Tropical Pacific

Another aspect of the Pacific's impacts on Atlantic tropical cyclone activity is the Pacific Decadal Oscillation (PDO). The PDO refers to the variation in SSTs in the subtropical Eastern Pacific. In the positive phase of the PDO, waters are warmer than normal across the eastern part of the subtropical Pacific near the west coast of the United States with cooler waters to the west. In a negative PDO, the SST profile is the opposite with cooler than normal waters off the US west coast.

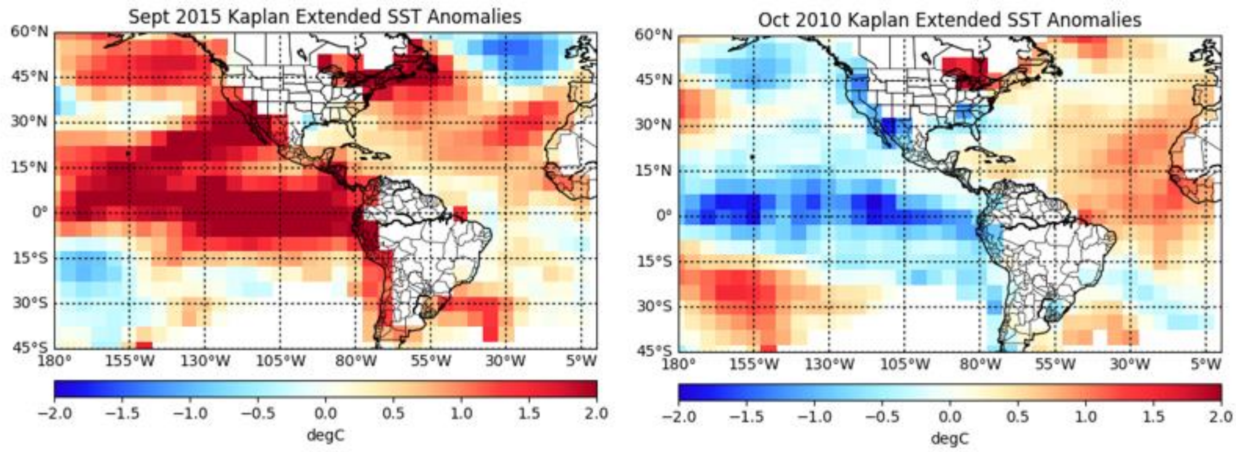


Figure 6. Kaplan Extended SST anomalies for September 2015 (positive PDO) and October 2010 (negative PDO).

For the past few years, the PDO has been positive with an anomalous area of warmer water off the western US coast. In 2018, these waters grew warmer with record warmth noted across the subtropical and tropical Pacific east of Hawaii. With significant warmth in this region contrasting against well below normal SSTs in the tropical Atlantic, upward motion would be favored to stay in the Pacific resulting in sinking motion across Africa and the Atlantic. With enhanced upward motion over the Pacific basin, much like you would see in a warm ENSO event, this would tend to favor an invigorated and further south oriented Subtropical Jetstream (STJ). With the STJ amplified over the MDR, this could seriously inhibit tropical cyclone formation and subsequently lead to a below normal season. However, another possibility is that the large expanse of warmth in the eastern Pacific could lead to more convective activity and tropical cyclones in the western portion of the eastern Pacific basin and central Pacific. When warmth is focused more in the western portion of ENSO regions and the subtropical Pacific we tend to call this a Modoki El Niño. In Modoki years, convective activity is most vigorous near the international dateline and thus tends to amplify the STJ more through the eastern Pacific tropics. These warm ENSO events tend to not have as large of an impact on Atlantic tropical cyclone activity and have actually in some cases enhanced activity such as in 2004.

IV. African Easterly Jet & Sahel

The African Easterly Jet (AEJ) refers to the region where easterly trade winds are enhanced due to the contrast in temperatures between the Sahel and the Gulf of Guinea during the summer. This Jetstream is known for transporting tropical waves across the African continent and into the Atlantic Ocean. Tropical waves that emerge into the Atlantic account for the majority of tropical cyclone genesis that occurs in the basin. The differences in placement of the AEJ can have significant effects on the overall capabilities tropical waves will have in the basin. When the placement of the AEJ is further north, tropical waves are enhanced due to the increased latitudinal distance from the equator that allows for greater vorticity. Contrarily, a southerly displaced AEJ is associated with the suppression of tropical waves which inhibits further development once the waves have emerged into the Atlantic. Good indicators on the favored placement of the AEJ as we approach summer are differences in western African rainfall and SSTs in the Gulf of Guinea. In years like 2017, the African Sahel was much wetter than normal which enhanced AEWs and in-turn tropical cyclone activity in the basin.

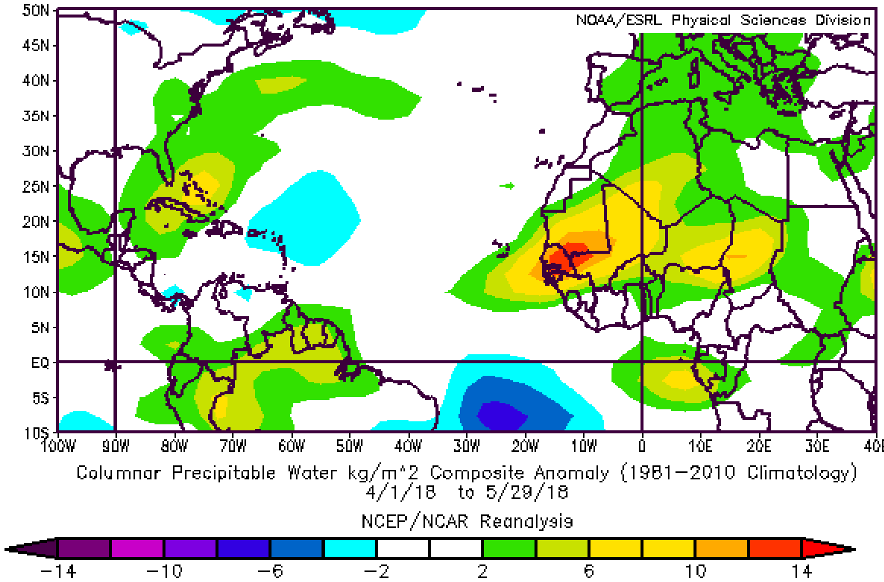
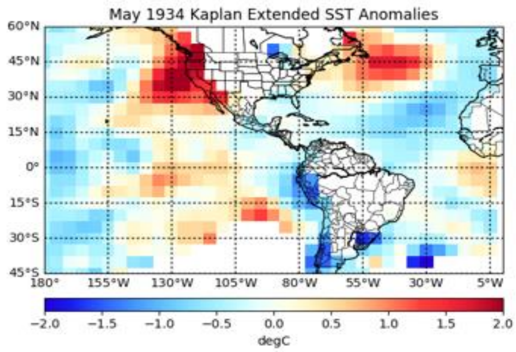


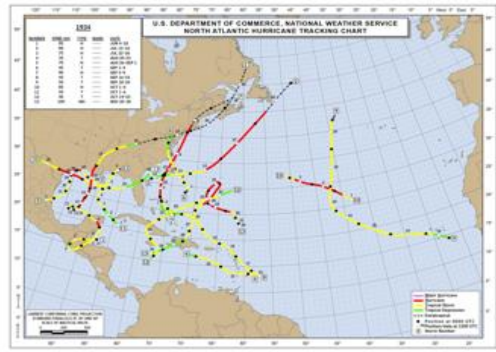
Figure 7. NCEP/NCAR Reanalysis data of Columnar Precipitable Water from April 1, 2018 to May 29, 2018 between 100W - 40E and 10S - 50N.

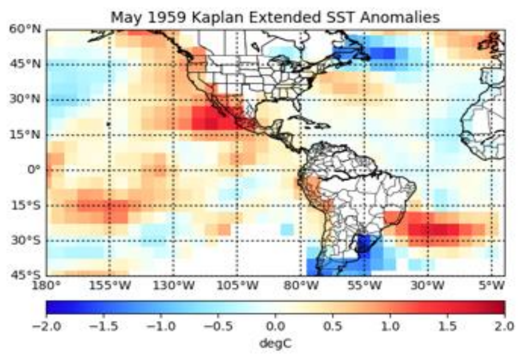
In 2018, the African Sahel is once again wetter than normal. This has enhanced the AEJ and would favor stronger AEWs. With that being said, the negative AMO and warm Gulf of Guinea has caused the Intertropical Convergence Zone (ITCZ) to remain further south compared to the climatological norm which could negate some of the positive effects from having a strong AEJ due to the loss of latitude and corresponding Coriolis force after exiting Africa.

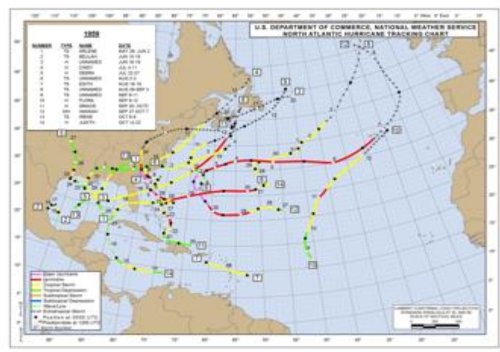
V. Seasonal Analogs

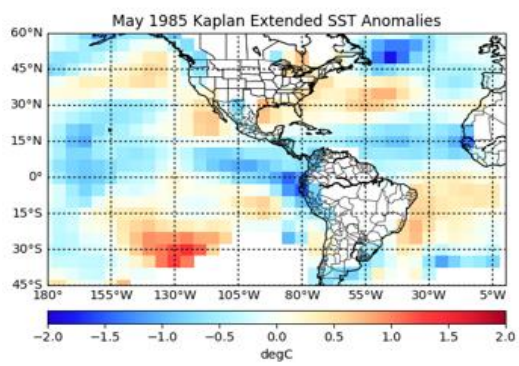
The main features as noted above in searching for seasonal analogs for the upcoming hurricane season were a warming ENSO background, preferably a dissipating La Niña, a strong negative AMO SST profile in the Atlantic, and a positive PDO and tropical eastern Pacific. The years that fit this profile the best are 1934, 1959, 1985, 1986, and 1994. The average activity of these five analogs is 10.2 named storms, 5.6 hurricanes, and 1.2 major hurricanes with a total seasonal Accumulated Cyclone Energy (ACE) of about 69% of normal. The most notable observations from these seasons were their lack of activity in the Main Development Region. The lack of activity in this region was hampered largely by the same conditions that were noted as inhibiting factors for the upcoming season above. Despite all of these seasons being near normal to below normal seasons, there were still notable impacts to land in almost all of them. Storms such as Hurricane Gracie (1959), Elena and Gloria (1985) as well as many other landfalling hurricanes during these analog years illustrate that the threat to land does not diminish entirely in less active seasons. In fact, seasons in which more system form in the subtropics and further west, also known as “homegrown” storms, are more likely to strike land than seasons where storms more often form in the far eastern Atlantic. But it is, however, worth noting that it is much harder to have above average hurricane seasons when the Main Development Region is less favorable like most of these analogs have. Tropical cyclone activity that occurs in the subtropical Atlantic is much more pattern dependent and less about climatological cues like Cabo Verde hurricanes forming in the eastern Atlantic. When TC activity becomes pattern dependent, it can create a larger margin for error in terms of numerical forecasts as well and thus we see the difference between a season like 1986 and 1959. Although overall activity is more varied in this case, the main takeaway from these analogs is that we could see more “homegrown” storms that are more immediate threats to land.

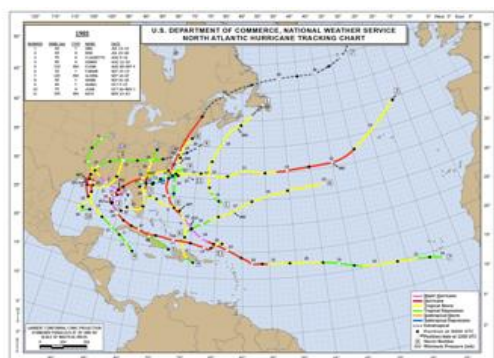


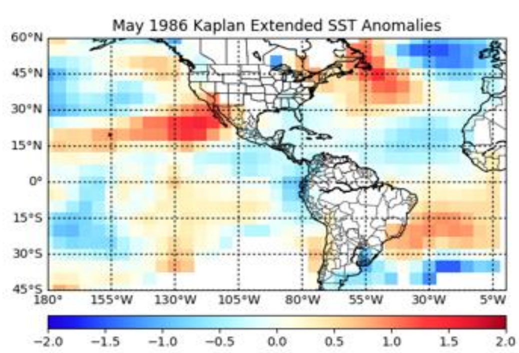


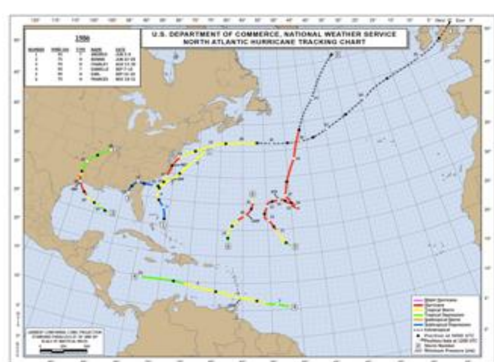












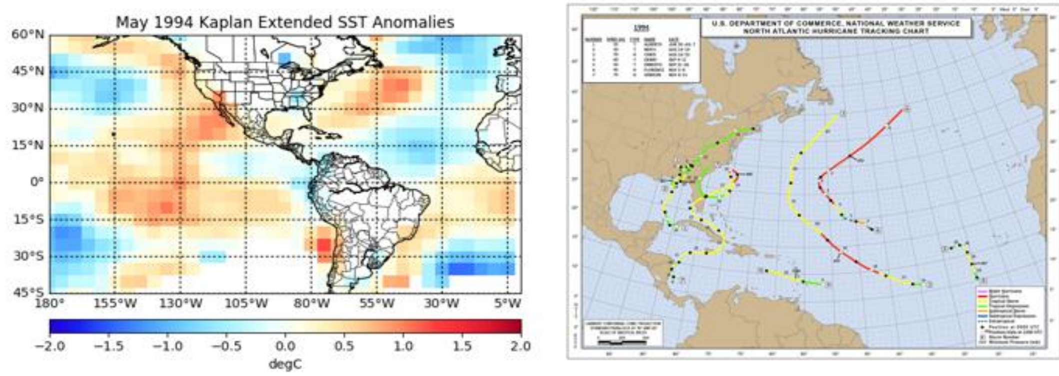


Figure 8. Kaplan Extended SST Anomalies for May 1934, 1959, 1985, 1986, and 1994 and HURDAT2 hurricane tracking chart for the corresponding analog years.

VI. Summary & Seasonal Outlook

The negative AMO signature with anomalously cold MDR will be an inhibitor to tropical cyclone formation in this region where African Easterly Waves emerge. Additionally, the collapse of the La Niña state in the eastern pacific this spring as well as the anomalously warm subtropical Pacific will play a role in focusing upward motion over this region where waters are comparatively warmer than the Atlantic basin. These SST profiles will likely change some, and thus there is a margin of error with this forecast, however, what is being currently observed is much more representative of below normal Atlantic hurricane seasons. One factor at play that could serve to boost Atlantic activity is the wetter than normal Sahel and subsequent active African Easterly Jet (AEJ) that has already become apparent over the African continent this spring. The increased activity of the AEJ will likely enhance easterly waves as they emerge off of Africa and into the Atlantic which could lead to quick developing tropical cyclones in the eastern Atlantic that feed off the African monsoon trough before dissipating over the open Atlantic much like we saw in years like 2015. However, there are still drawbacks to this given that the Intertropical Convergence Zone (ITCZ) remains below its climatological latitude for this time of year which could cause waves to struggle due to less Coriolis influence with regards to vorticity. Overall, the seasonal analogs selected were varied from below normal hurricane seasons to near normal and therefore my range forecast reflects this. As mentioned prior, one thing the majority of these analogs does not align with 2018 on is the wetter than normal Sahel which could serve to edge 2018 higher in terms of total number of storms which is why my seasonal forecast portrays a slightly higher number of named storms relative to climatology.

June Hurricane Outlook

2018 Hurricane Season

Most Likely Scenarios

ENSO Neutral w/ Negative AMO (55%)
10 Named Storms
6 Hurricanes
2 Major Hurricane
ACE 77% of Normal

ENSO Neutral w/ Positive AMO (20%)
14 Named Storms
7 Hurricanes
3 Major Hurricane
ACE 124% of Normal

El Niño Event w/ Negative AMO (20%)
7 Named Storms
3 Hurricanes
1 Major Hurricanes
ACE 31% of Normal

El Niño Event w/ Positive AMO (5%)
10 Named Storms
4 Hurricanes
2 Major Hurricanes
ACE 52% of Normal

Forecast Mean
10.2 Named Storms
5.5 Hurricanes
2.0 Major Hurricanes
ACE 76.0% of Normal

My Forecast
13 Named Storms
6 Hurricanes
2 Major Hurricanes
ACE 80% of Normal

Range Forecast
10-14 Named Storms
4-7 Hurricanes
1-3 Major Hurricanes
ACE 60-90% of Normal

***Forecast includes Alberto**

The forecast mean was derived through determining the most likely scenarios that could occur during this hurricane season, using an average of other seasons that fell into these categories from 1950-2017, and using percentile of probability that this scenario would occur.

The 2018 Atlantic hurricane season is expected to be near average with weight added on the lower side of the scale to display that the potential is higher for tropical cyclone activity to be below average than above average. Given all of the variables addressed above, it appears that there will be more inhibiting factors than enhancing factors to tropical cyclone development this season. With that being said, it is important to note that tropical cyclone activity as a whole does not give any region any less or more chance for a hurricane strike in a given year and it is important to be prepared and go over all hurricane safety procedures in order to protect yourself and your property this hurricane season. For more information on hurricane preparedness as well as the latest outlooks on all tropical cyclone activity in the Atlantic and Eastern Pacific basins please consult the National Hurricane Center (nhc.noaa.gov) and your national weather service office.