FINAL

Hurricane Season Outlook 2017

Submitted to:

Water Resources Management Division
Department of Municipal Affairs and Environment

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1.0 2017 ATLANTIC HURRICANE SEASON OUTLOOK

Each year, various agencies issue outlooks for tropical cyclone activity in the Atlantic basin. The most widely followed is likely the Colorado State University (CSU) outlook, followed by the National Oceanic and Atmospheric Administration (NOAA) outlook, and then the University College London's Tropical Storm Risk (TSR) outlook. These are issued to draw attention to the science and to provide users, clients, and insurance agencies with a prediction of the severity of the upcoming hurricane season. NOAA's Atlantic hurricane season outlook (9 August) favors an above-normal season, with the possibility that the season could be extremely active. There is a 70% probability of 14-19 named storms (including the 6 storms named at issue time), 5-9 hurricanes, and 2-5 major hurricanes. The CSU Tropical Meteorology Project forecast from 4 August is calling for 16 named storms (including the 5 storms named at issue time), 8 hurricanes, and 3 major hurricanes. The TSR forecast from 4 August calls for 17 storms (including the 5 storms named at issue time), 7 hurricanes, and 3 major hurricanes. Major hurricanes are defined as reaching Category 3 or higher, with sustained 1-minute winds of 178 km/h. Freshwater flooding, followed by storm surge flooding are the greatest killers in any tropical cyclone so it is important not to focus solely on category, which is only defined by sustained 1-minute wind speeds (Fig. 1). Hurricane Igor in 2010 was a devastating example of this phenomenon. Hurricane remnants can bring tremendous damage and loss of life as was seen in the wake of Hurricane Matthew last season or Hurricane Hazel in 1954 in Toronto.

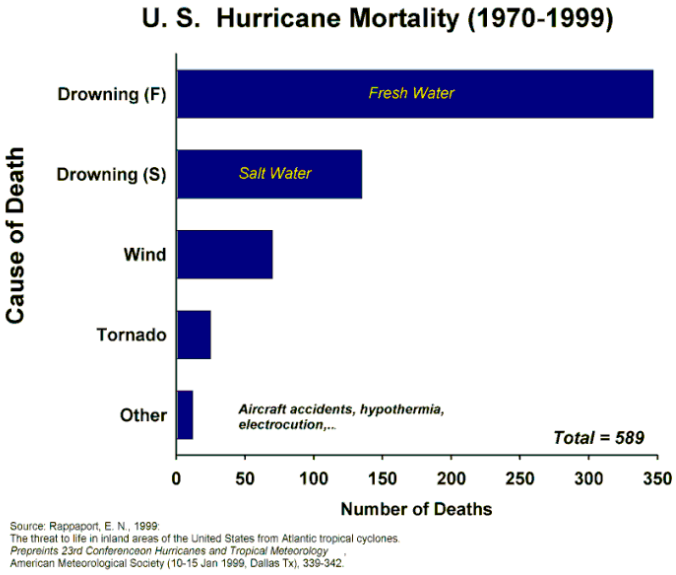

Figure 1. U.S. Hurricane Mortality 1970-1999 (Rappaport et al. 1999)

Hurricane season predictions consider the various and complex interactions of intraseasonal and interseasonal variables such as ENSO, AMO, MJO, the African Easterly Jet, Sahel rainfall, The Atlantic SLP pattern, mid-level relative humidity, and wind shear. The Atlantic Multidecadal Oscillation (AMO) which is defined by the sea surface temperature (SST) patterns of the North Atlantic is considered a major driving force in Atlantic tropical cyclone activity. Positive values yield higher numbers of storms and increased Accumulated Cyclone Energy (ACE).

This report will focus on two major influences, the AMO and ENSO (El Niño-Southern Oscillation). The AMO probably has the most correlation of the main variables for tropical cyclone activity. Positive values tend to coincide with other factors which lead to greater activity, such as warmer SSTs, weaker wind shear, weaker Azores High, and increased Sahel rainfall. The last few years have seen some conflicting data emerge from the AMO index. The Tropical Atlantic is much warmer than normal but the SSTs in the far North Atlantic are cooler than normal, leading to a conflicting signal (Fig. 2 and 3). The classic Earth Science Research Laboratory (ESRL) calculation leads to a positive value, but the more dynamic Klotzbach and Gray (2008) calculation leads to a negative value. This second number takes into greater account the strength of the Bermuda-Azores High and the far North Atlantic SSTs. There is therefore some speculation that the era of very active tropical cyclone activity in the basin since 1995 is ending, to be replaced by a persistent negative AMO state and lower numbers of storms. It is important to note that overall there is little to no correlation between the relative risk of landfall at a given location and how busy the hurricane season is. It only takes one storm to have a devastating impact.

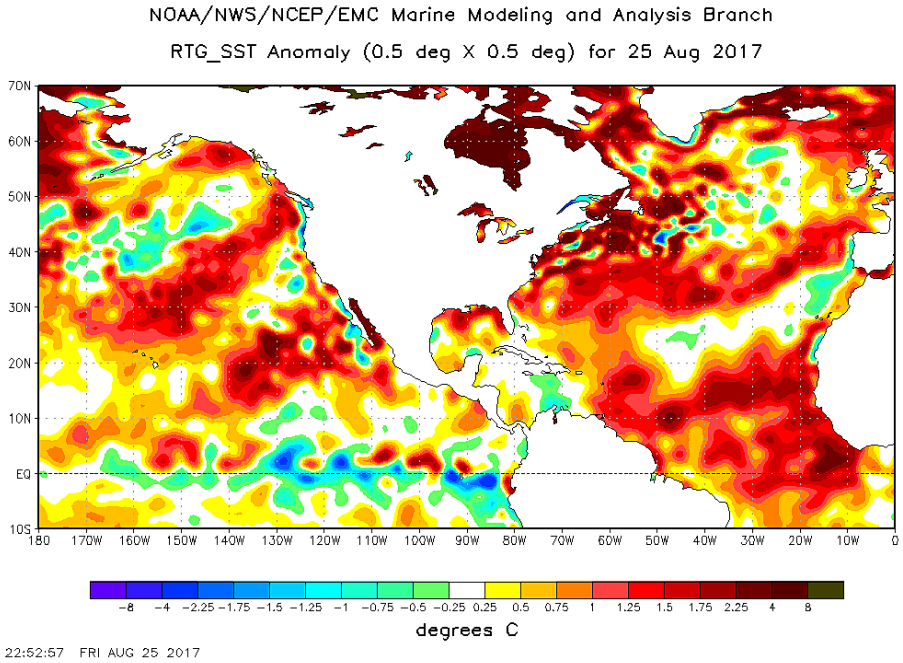

Figure 2. Atlantic Basin SST Anomaly, August 2017

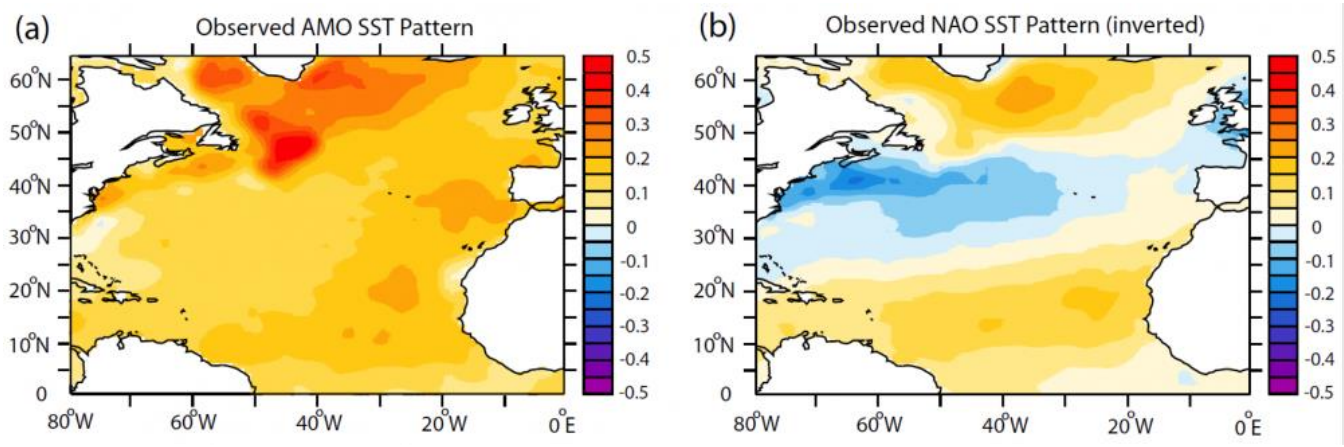

Figure 3. Positive AMO SST Pattern on the left (Trenberth et al. 2017)

El Niño-Southern Oscillation is a measure of the anomaly in SSTs and winds over the tropical eastern Pacific Ocean (Fig. 6). El Niño conditions are reached when the Niño 3.4 region reaches 0.5 ^{0}C or above and remains so for five consecutive three-monthly periods. La Niña conditions are reached when Niño 3.4 reaches -0.5 ^{0}C or below and remains so for five consecutive three-monthly periods. While this is mainly a Pacific SST phenomenon, it affects the whole global circulation. El Niño tends to produce greater values of wind shear across the Atlantic Basin, especially the Caribbean, whereas La Niña produces the opposite effect (Fig. 7). This affects the overall number and intensity of hurricanes (Fig. 8). Strong eastern-based El Niño produce the greatest reduction of hurricanes, while a weaker central-based El Niño produces greater numbers of hurricanes in the Gulf of Mexico and the United States but lesser numbers in the central Atlantic. The current three monthly May-June-July value is 0.3 ^{0}C. This value has tended to fall over the past few weeks, and the latest weekly value is -0.5 ^{0}C (Fig. 4). There is a likelihood of ENSO-neutral conditions persisting through the heart of the hurricane season and into the fall, with the slight possibility of La Niña conditions developing (Fig. 5). This is a large change from spring ENSO predictions which favored an El Niño state to develop in hurricane season. This leads to greater confidence of an above normal hurricane season in the Atlantic.

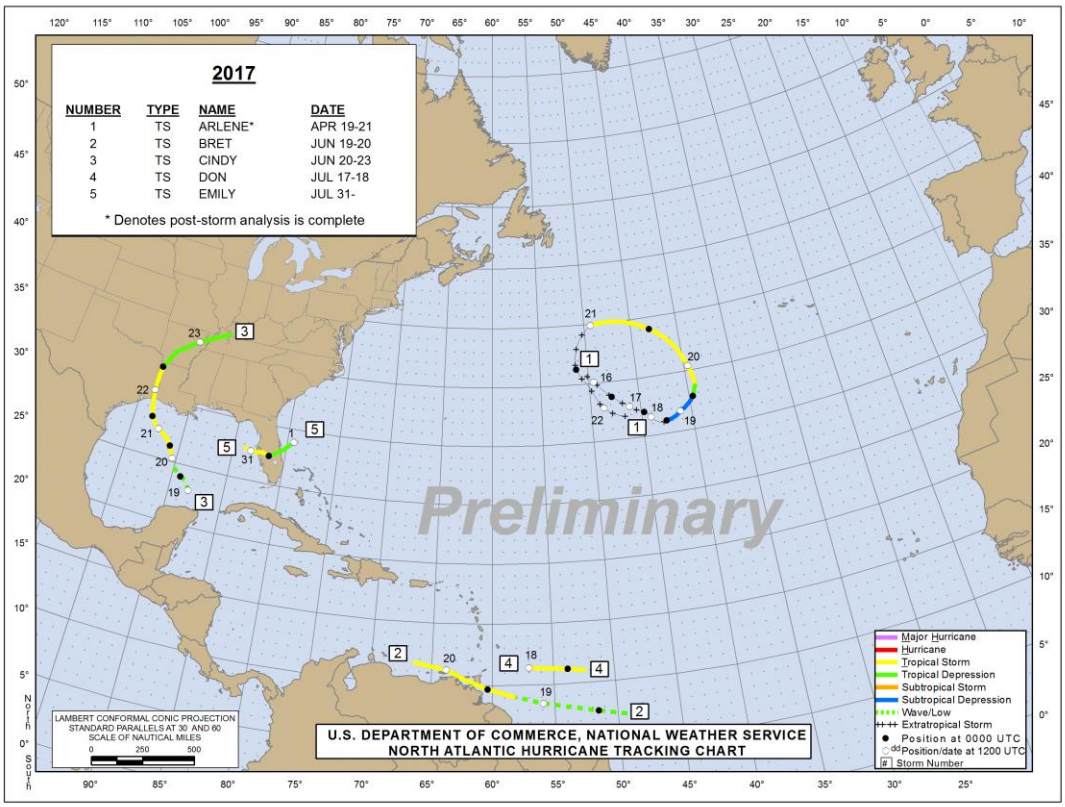

Figure 4. 2017 Atlantic hurricane season tracking, as of July

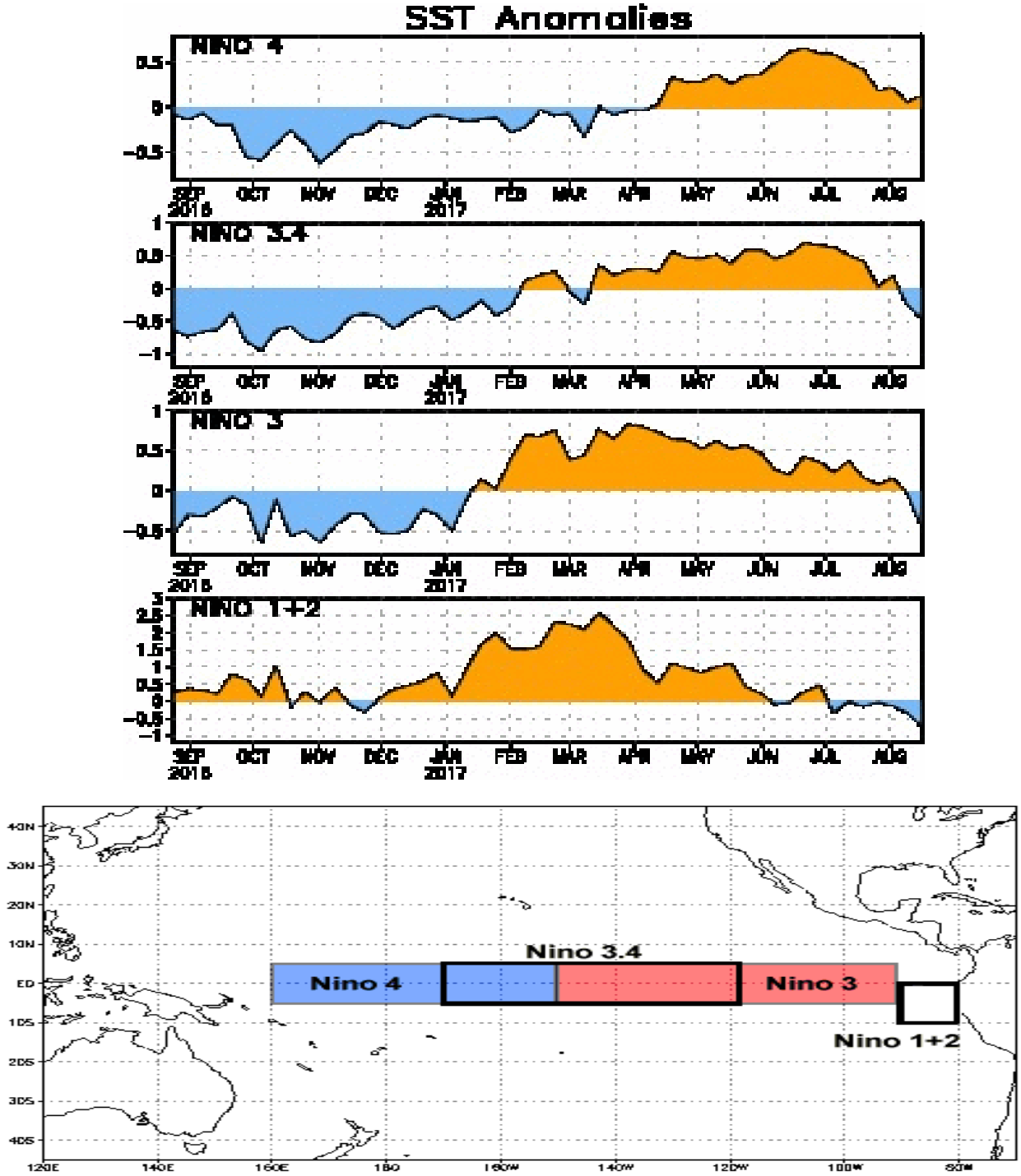

Figure 5. SST Anomaly in the Niño Regions

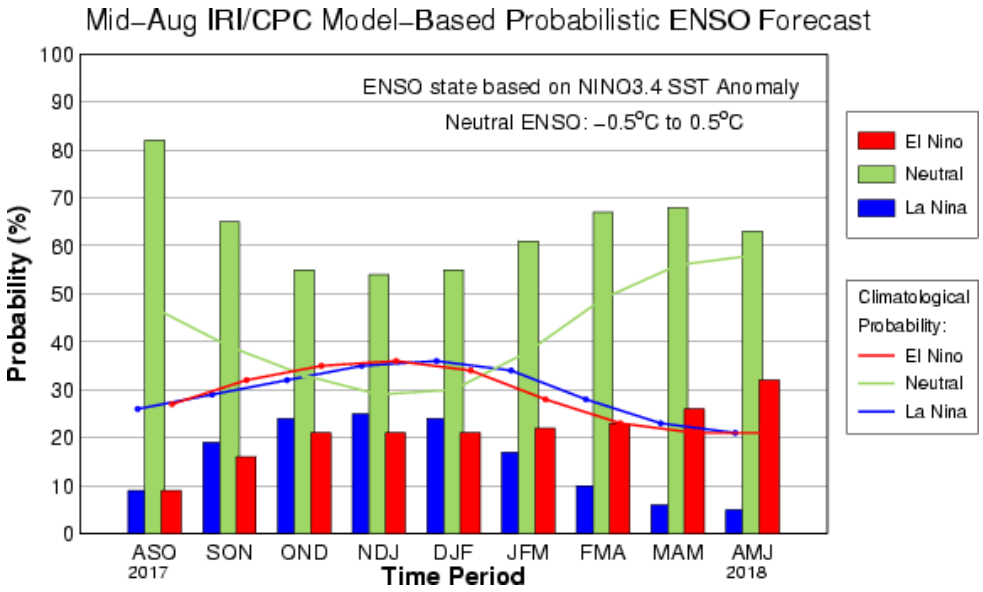

Figure 6. Probabilistic ENSO Forecast

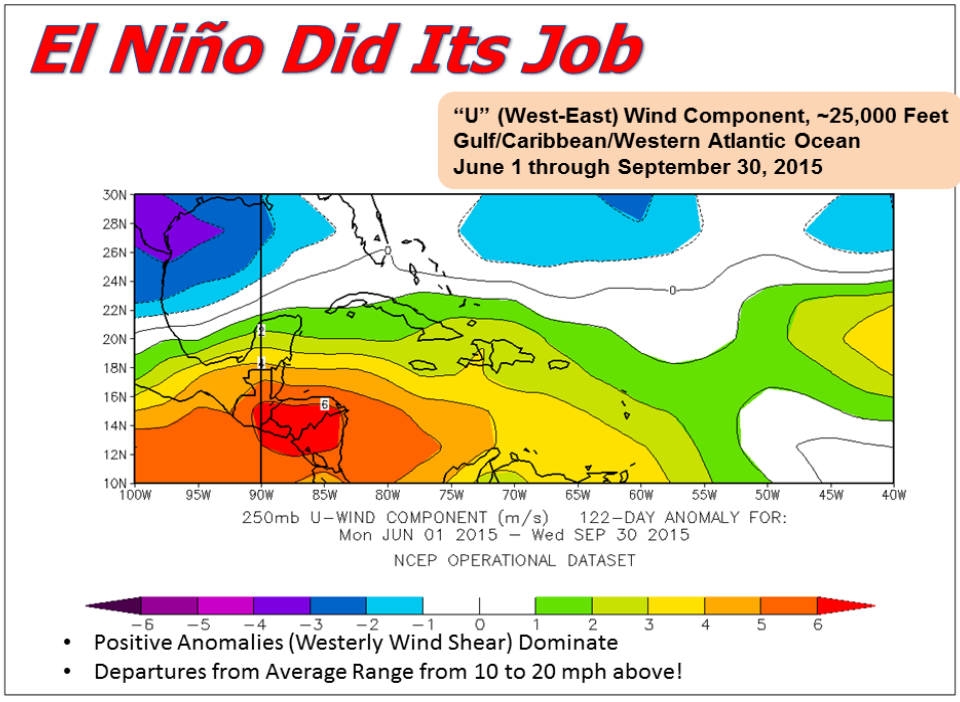

Figure 7. Strong anomaly of westerly wind shear induced by strengthening El Niño, 2015

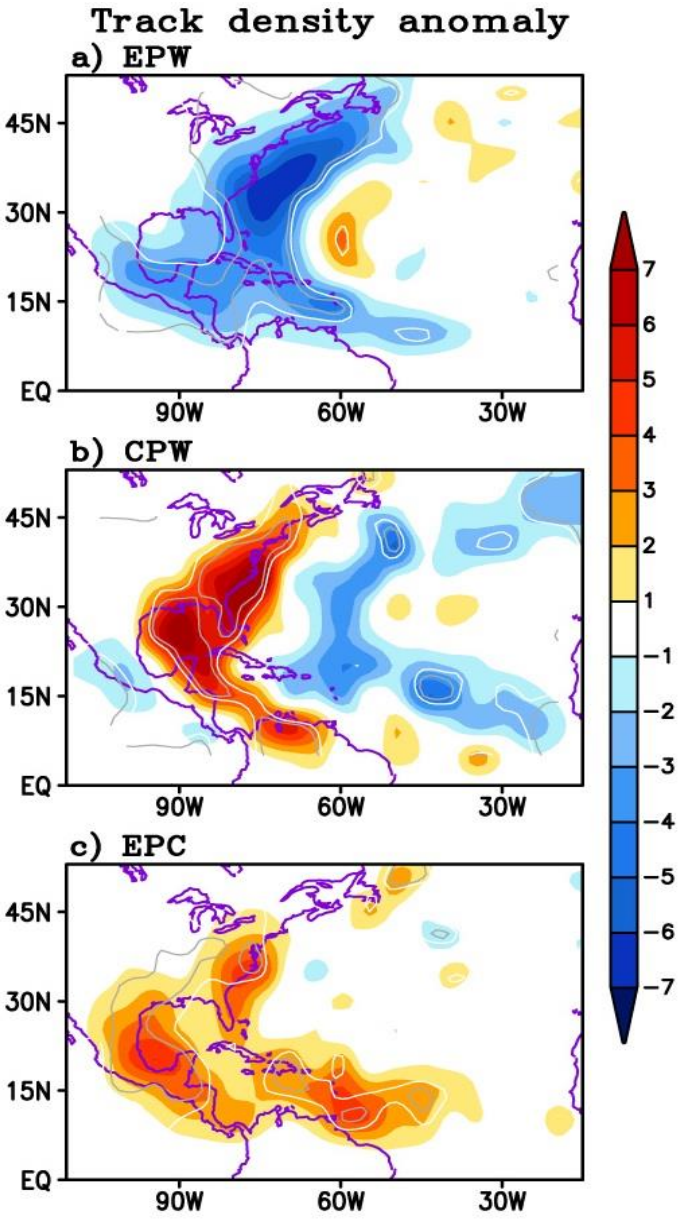

Figure 8. Relative increase/decrease of cyclone tracks in relation to the ENSO state (Kim et al. 2009)

2.0 HISTORICAL AND ANALOG YEARS OF THE HURRICANE SEASONS

Based on Environment Canada and Climate Change (ECCC) records, Newfoundland experiences more tropical storms than Labrador. Figure 9(a-b) shows the frequency of tropical storms by year for both locations between 1901 and 2000.

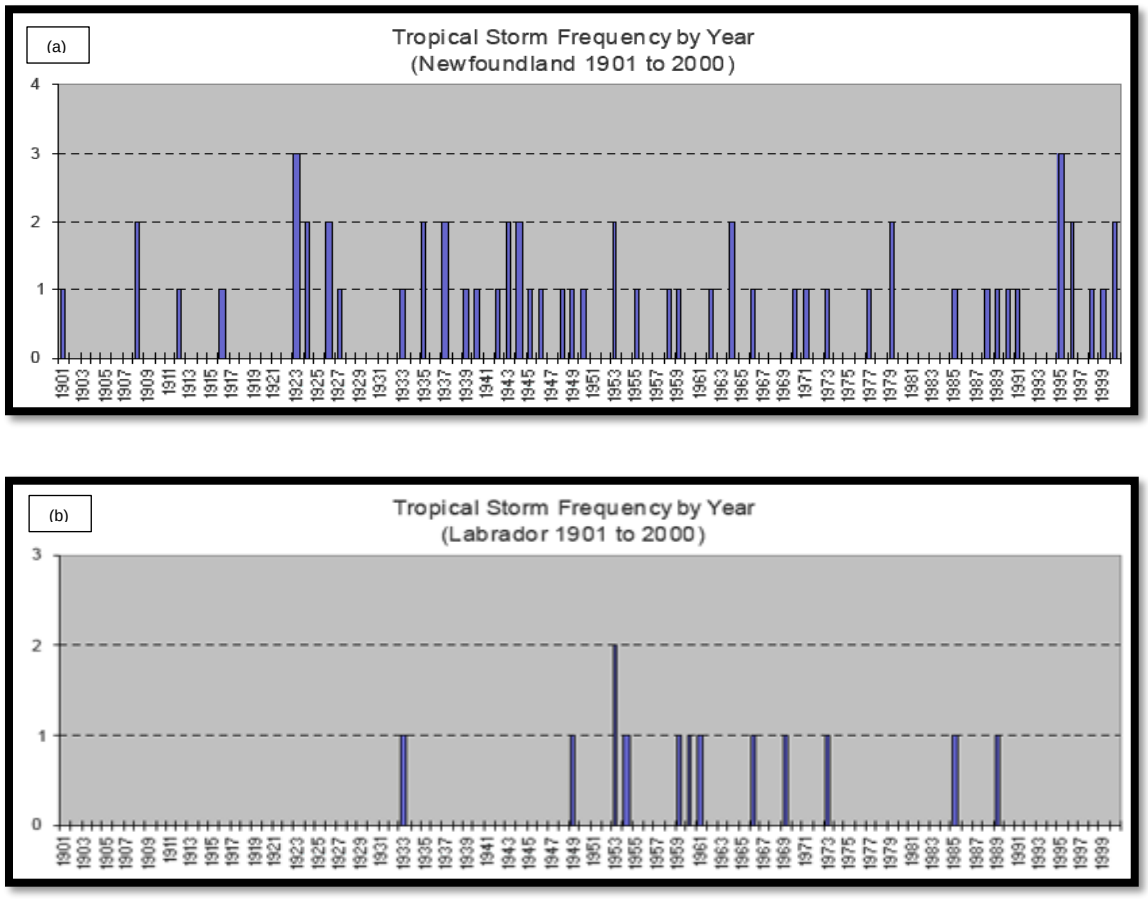

Figure 9. Tropical storm frequency by year for Newfoundland (a) and Labrador (b)

The same records reveal the month of September as having the greatest storm frequency with October being second, as seen in figure 10 (a-b). While Labrador has never received a tropical storm in October it is important to note that the overall lack of storms in Labrador may be skewing the statistic, and October tropical storms could certainly occur in Labrador in October, given a conducive set-up.

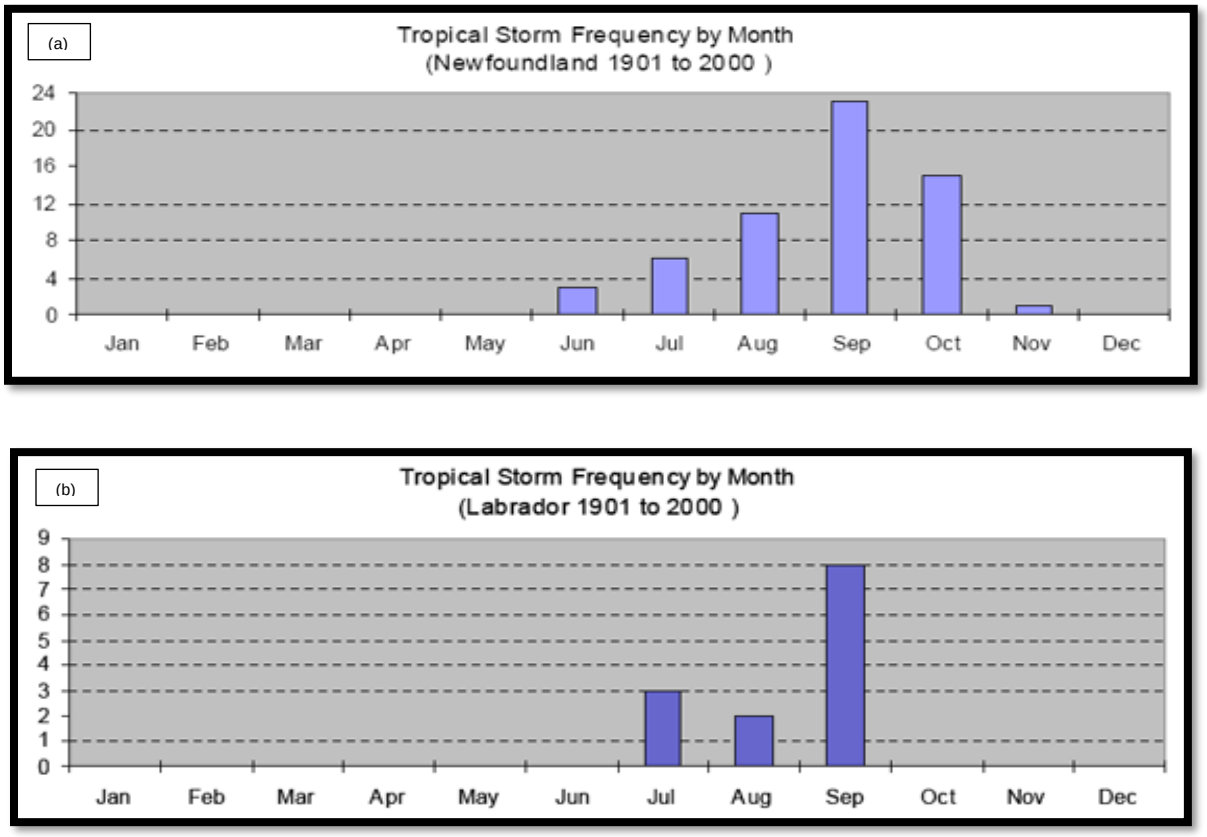

Figure 10. Tropical storm frequency by month for Newfoundland (a) and Labrador (b)

The database of Newfoundland tropical (TC) and post-tropical cyclone (PTC) landfalls was extended to include the 2001-2016 seasons. Since 1950, there have been 49 TC or PTC that have made landfall on the Island of Newfoundland. During the same period, there were 30 neutral ENSO years, 18 La Niña years and 19 El Niño years (Table 2-1). For these purposes, ENSO state was defined by the Oceanic Niño Index (ONI), which was discussed in the first section of this report. The findings are quite robust, showing considerable skill over climatology if the ENSO state is El Niño or La Niña. La Niña is much more active than neutral or El Niño conditions, with a return period of 1 TC or PTC per year. Neutral is very close to the climatological return period of 0.7 per year. El Niño is much less active than neutral or La Niña seasons, with a return period of only 0.53 TC or PTC per year. Similar findings are shown in Figure 8.

This is not meant to be a comprehensive database of all storm that affected Newfoundland, given that there are occasionally significant effects from storms that do not make landfall. Storms which pass east of the Avalon Peninsula can still bring heavy rains to central and eastern Newfoundland as much of the

heavy rain in a transitioning system is located to the left or west of the storm track. Consider, for example, Hurricane Matthew last year, where the low level centre dissipated well south of Nova Scotia, but the injection of tropical moisture into another mid-latitude system caused severe flooding in western and central Newfoundland and eastern Nova Scotia. Storms which affect Newfoundland most regularly approach from the south-southwest and generally pass near Bermuda before arriving on the NL coast (Fig. 18 and 19).

Given that we are currently in a neutral ENSO season, and the ENSO is a robust predictor for Newfoundland storms, it is used as the primary factor for finding analog seasons. AMO, NAO (North Atlantic Oscillation), AO (Arctic Oscillation), and PDO (Pacific Decadal Oscillation) were also considered in defining analogs. AMO does not seem to affect the likelihood of impacts in Newfoundland but it is illustrative, given its effects on the circulation and the number of storms in the Atlantic basin.

Analog years depict similar SST patterns and conditions in addition to similar teleconnection phases, so they often share a comparable hurricane season. For the current SST setup, the years 1961 and 2013 are considered the best analog years, with 2008 following. The current 500mb steering pattern shows a stronger than normal ridge over the central Atlantic (Fig. 11) with a strong trough in Ontario, Quebec, and the Northeast United States. There is also a strong ridge in western Canada and the western US which has plagued interior British Columbia with wild fires. The years 1961 and 2013 matched well with neutral ENSO states, positive NAO and AO, and positive PDO, with Figures 12 and 13 showing a similar 500mb height distribution this year thus far. The year 2008 (Fig. 14) is considered an acceptable match as the indices themselves are the same sign, but the 500mb anomaly presentation is quite different. The tracking charts for all the analog seasons are illustrated in Figures 15, 16, and 17.

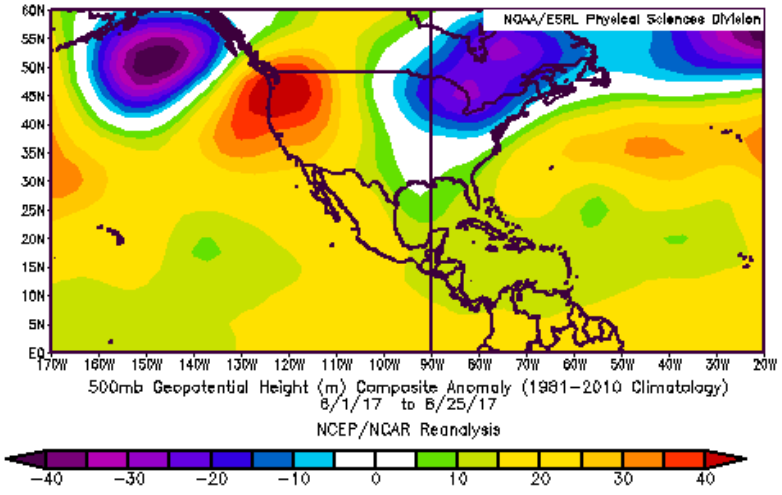

Figure 11. 500mb height anomalies for the current Hurricane Season to date

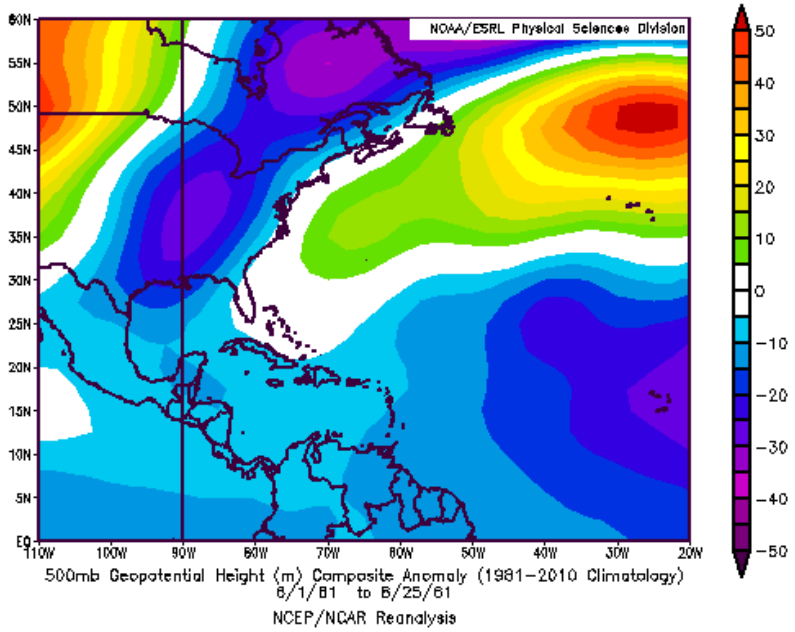

Figure 12. 500mb height anomalies for the 1961 Hurricane Season to date

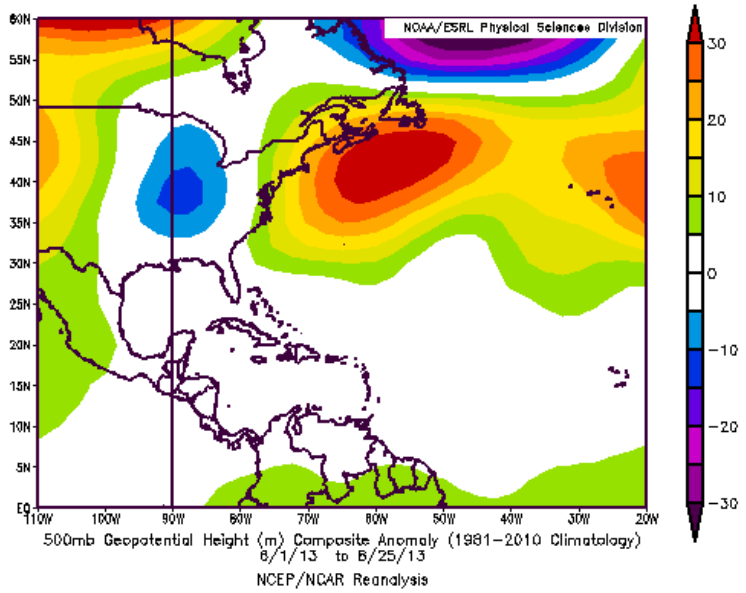

Figure 13. 500mb anomalies from the 2013 Hurricane Season to date

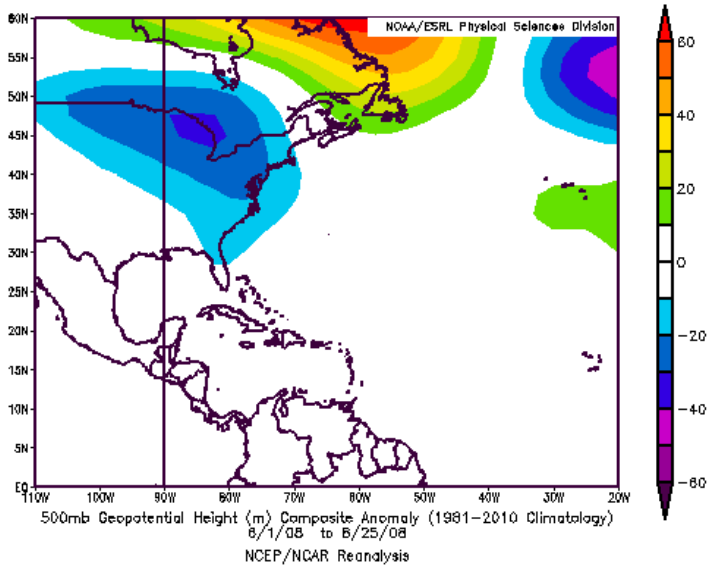

Figure 14. 500mb anomalies from the 2008 Hurricane Season to date

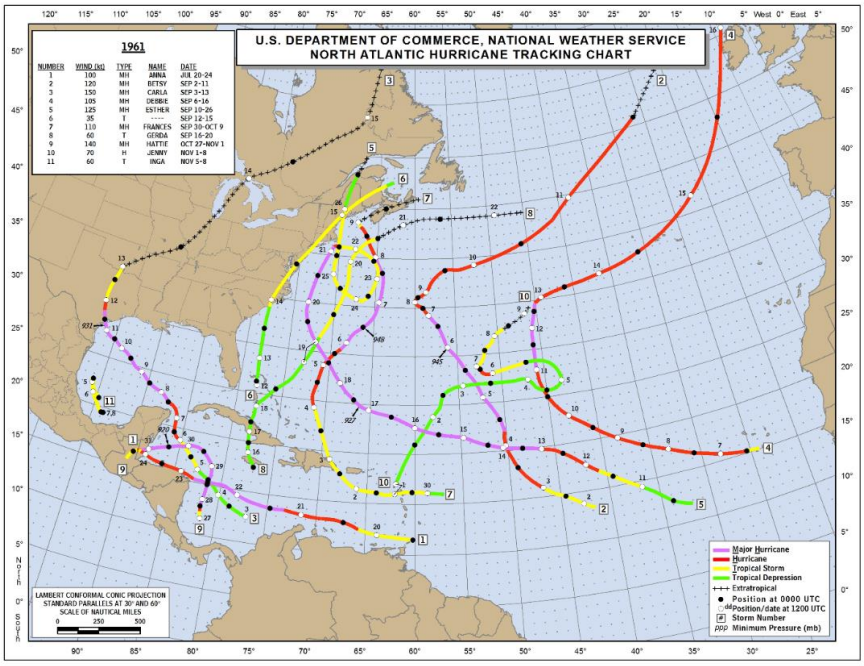

Figure 15. 1961 Atlantic Hurricane Season tracking chart

No significant impacts to Newfoundland.

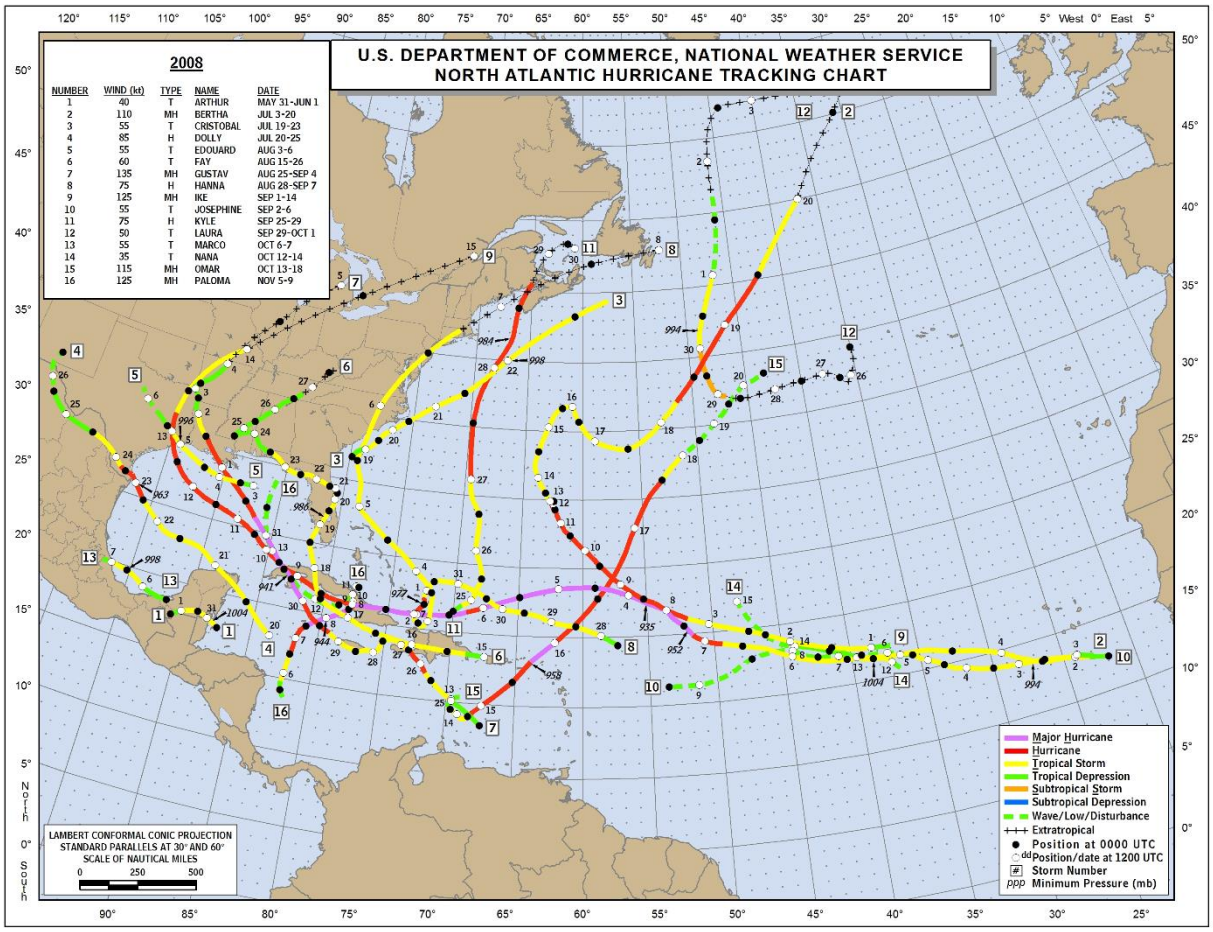

Figure 16. 2008 Atlantic Hurricane Season tracking chart.

Tropical Storm Laura gave the Hibernia Oil Platform tropical storm force winds to 47 knots near midnight October 1st, 2008.

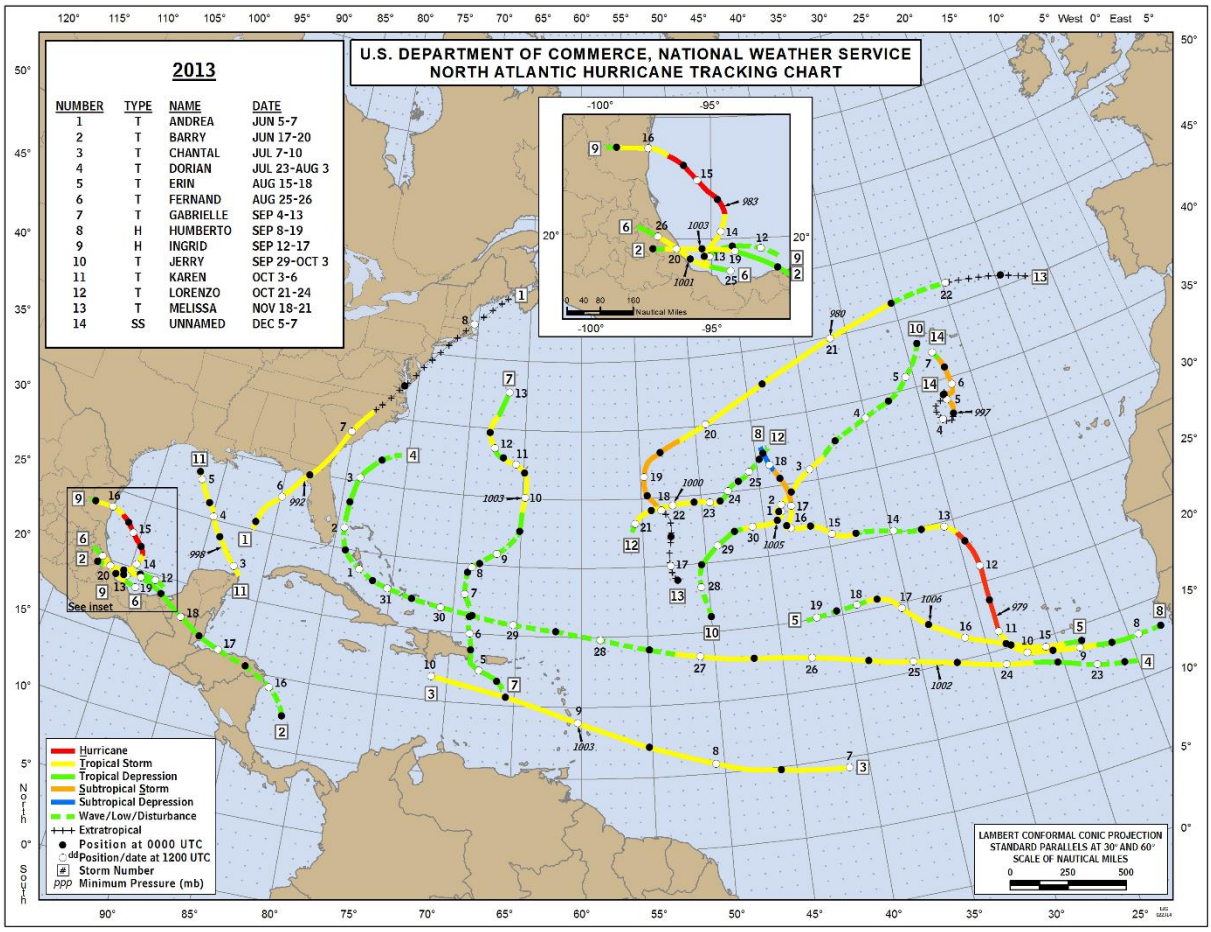

Figure 17. 2013 Atlantic Hurricane Season tracking chart.

No significant impacts to Newfoundland.

Table 2-1: ENSO state, storm return period, and skill over climatology

Storms	Years	ENSO state	Return Period	Skill over Climatology
21	30	Neutral	0.7	4.3%
18	18	**La Nina**	**1.0**	**36.7%**
10	19	**El Nino**	**0.53**	**28.0%**
49	67		0.73	

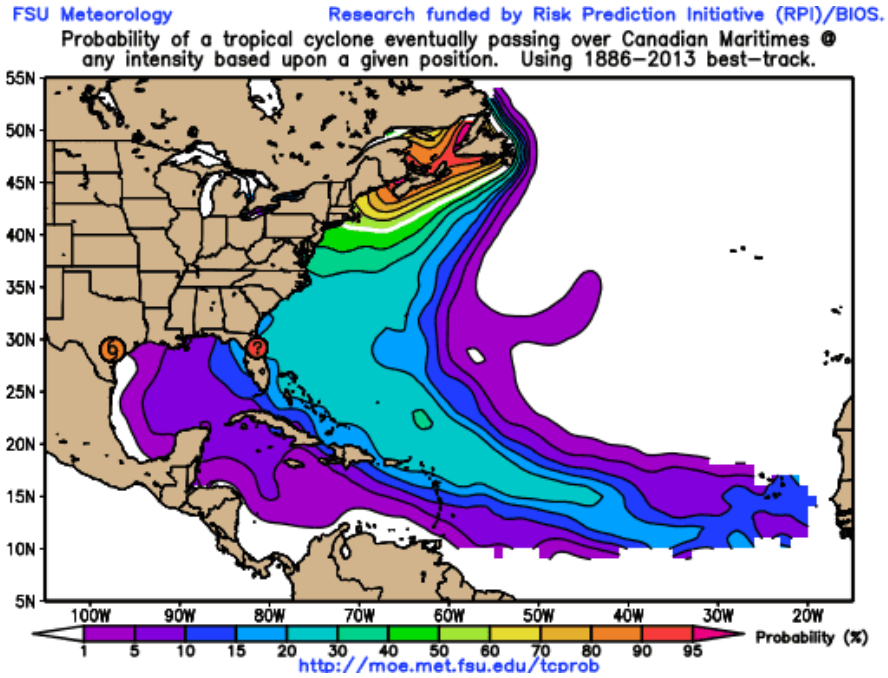

Figure 18. Using historical tracks to estimate likelihood of a tropical cyclone impacting Atlantic Canada

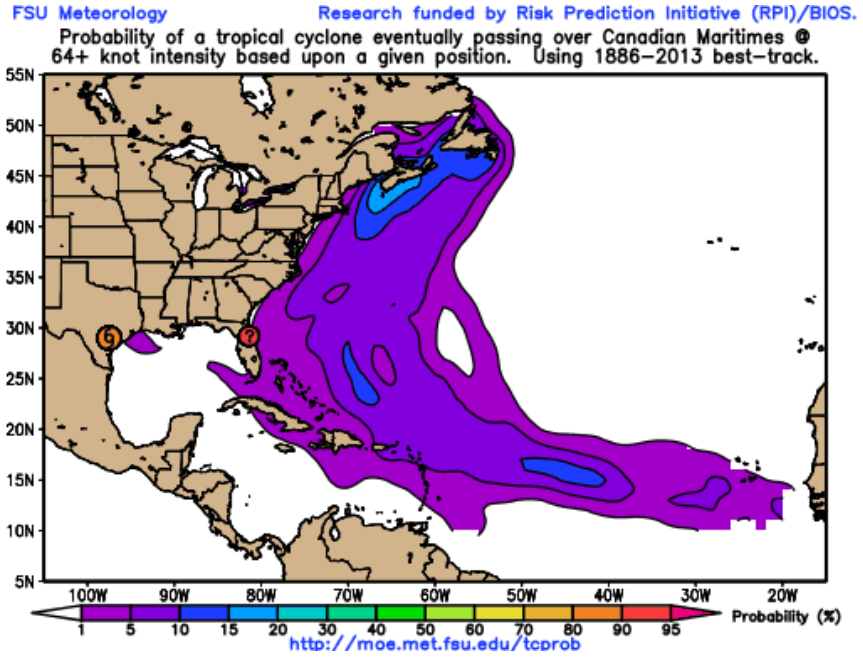

Figure 19. Using historical tracks to estimate likelihood of a hurricane impacting Atlantic Canada

3.0 AVERAGE NEWFOUNDLAND AND LABRADOR HURRICANE SEASON

The Canadian Hurricane Centre's (CHC) records are updated through 2014 and Amec Foster Wheeler has been archiving tropical/post-tropical cyclones since 2014. The 56 year combined records (1960-2016) show 45 tropical/post-tropical cyclones in the Atlantic Ocean have made landfall in or have passed within 100 km of Newfoundland and Labrador. This represents 10% of all tropical/post-tropical cyclones that have formed in the Atlantic Ocean for this period.

For Labrador, hurricane activity is limited by the fact that a hurricane must traverse land or cross over cold ocean water to reach Labrador. As hurricanes move north and pass over the colder waters of the Labrador Current, it dramatically decreases the energy available to fuel the storm. In addition, hurricanes have typically lost strength by the time they reach Labrador because they have made landfall by that point, cutting off the source of warm, moist air that was encouraging storm development.

4.0 2017 NEWFOUNDLAND AND LABRADOR HURRICANE SEASON OUTLOOK

Given the current oceanic and atmospheric conditions in addition to the concurring forecasts of NOAA and CSU discussed earlier, there is a potential of 1 to 2 tropical/extratropical cyclones to affect Newfoundland and Labrador through the rest of this season with the highest impact expected to be along southern Newfoundland and Labrador as shown in figure 11. Historically, September shows the highest impact month for Newfoundland and Labrador with the threat likely to remain through October for the island of Newfoundland. The current normal to below normal SST area south and east of island of Newfoundland is likely to curb further intensification of cyclones tracking through that area. However, weather systems transitioning from being tropical in origin into a strong area of low pressure are likely to produce periods of heavy rainfall and strong sustained winds that can cause significant damage.

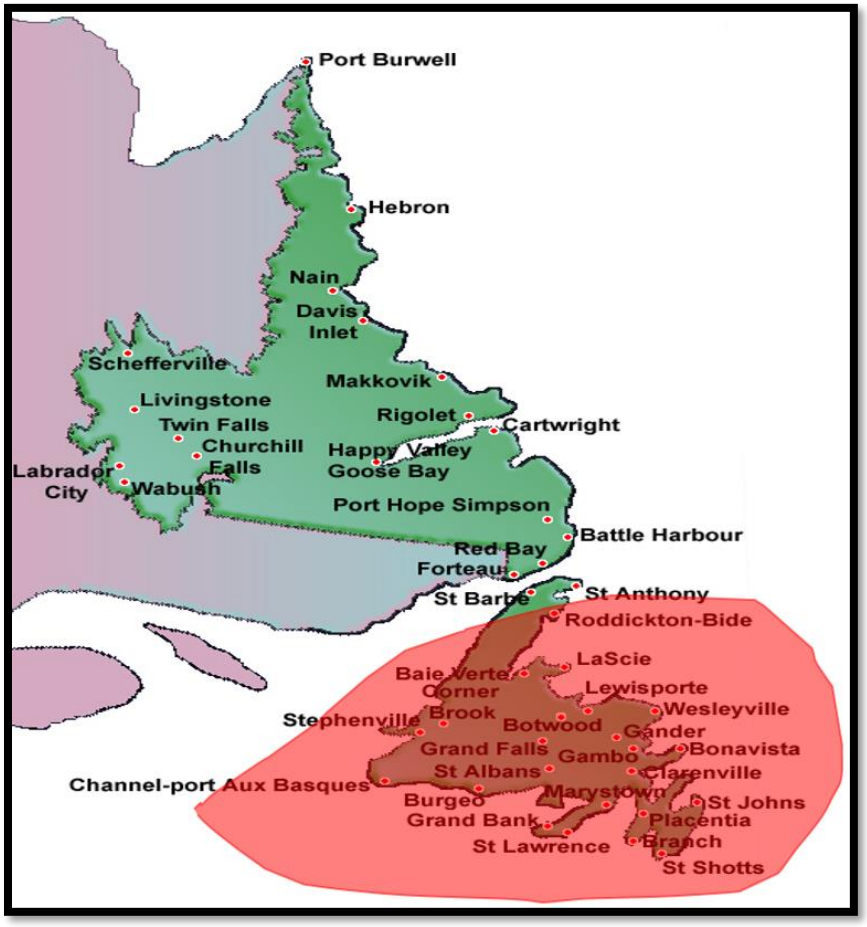

Figure 20. Tropical/extratropical cyclones track high impact risk map for NL and Labrador (WRMD), 2017 Hurricane season

5.0 CLOSURE

We trust that this report meets your needs. Please do not hesitate to contact the undersigned if you have any questions or comments regarding the hurricane season outlook.

Yours sincerely,

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