THE EFFECT OF THE NORTH ATLANTIC OSCILLATION ON THE RAINFALL PATTERNS IN GRENADA

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ABSTRACT

The climate of the Eastern Caribbean, including Grenada is tropical, with two distinct seasons; a wet and dry. There are many studies which show that this is because of climate variability of Pacific and Atlantic origin (Giannini et al. 2001), such as the El Nino-Southern Oscillation (ENSO) phenomenon, and the North Atlantic Oscillation (NAO). Hurrell, 1995, identified the North Atlantic Oscillation (NAO) as the dominant mode of winter climate variability in the North Atlantic region, ranging from central North America to Europe and into much of Northern Asia. This study was undertaken to investigate the NAO's influence on the precipitation pattern in Grenada.

INTRODUCTION

The Eastern Caribbean Islands form an archipelago stretching from the US Virgin Islands in the north at approximately 18.34 °N, 64.89 °W, to Trinidad and Tobago in the south at approximately 10.69 °N, 61.22 °W. The tri-island state of Grenada lies to the South of this island chain at approximately 12.11°N, 61.67°W with an area of 133 square miles, which includes Carriacou and Petite Martinique. The islands are characterized by a rainy season which runs from May to November when the ITCZ shifts north of the equator, and a small range in temperature and solar insolation throughout the year. Due to the proximity of the islands to the subtropical ridge, their topography, trade wind subsidence and variations in sea surface temperature (SST), the distribution of the precipitation is rather heterogeneous (Giannini et al. 2000). However, several studies have shown the precipitation is bimodal with an initial maximum which begins in May and extends until June called the early rainfall season (ERS) (Taylor et al. 2002), a relative minimum in June – August called the midsummer dry spell (Gamble et al. 2008), and a second peak in September – October (Giannini et al. 2000).

Figure 1: Location of Grenada

The interannual variability of Caribbean rainfall has been analyzed by several studies and the influence from the North Atlantic and eastern Pacific has been recognized (Jury et al. 2007). According to Dai et al. (1998), the frequency and severity of storms, droughts, and floods in different parts of world have been shown to be related to ENSO through atmospheric and oceanic circulation responses known as teleconnections. The Caribbean is no exception, the relationship between ENSO events and Caribbean rainfall anomalies has been discussed in numerous papers; however, there is another large-scale mode of variability in the climate system known to influence precipitation patterns across the North Atlantic winter, this is the NAO (Hurrell 1995).

The NAO is a dipole pattern of the north-south sea level pressure. One pole is located over Iceland, while the other is positioned approximately over the Azores Islands (Angeles et al. 2010). During a positive NAO phase, below normal pressure appears across Iceland and high latitudes of the North Atlantic, and above normal pressure appears over the Azores Islands, and Central North Atlantic. A positive NAO generates anomalous strong trade winds and cooling of sea surface temperatures (SSTs) in the Tropical North Atlantic (TNA) basin (Giannini et al. 2000). On the other hand, a negative NAO causes the opposite effects (Pozo-Vazquez et al. 2001). The effects of the cooling of the tropical ocean lingers on most noticeably until the start of the Caribbean rainy season, in May-June, when it is associated with deficient rainfall in the basin (Giannini et al. 2000, 2001). Enfield and Alfaro (1999), discussed how the early rainy season appears to be more under the influence of the Tropical North Atlantic Ocean SST. For the late rainy season, the rainfall variability is more related to the east equatorial Pacific SST and concurrent responses to ENSO (Chen and Taylor 2002). The effect on Spring rainfall is particularly evident for the stations on the Caribbean Antilles Islands (Giannini et al. 2001).

METHODOLOGY

Thirty-three years of monthly rainfall data, from January 1986 to December 2018 for Maurice Bishop International Airport, which is located in the most southern part of the island, were available for analysis. The period that was analyzed was December 1986 to February 2018.

Figure 2: Map of Grenada showing location of rainfall station

The standardized anomalies for the rainfall were computed for three-month periods, starting with the winter season; December to February, and lagging by one month, up to the summer season; June to August. These three-month periods were used as the rainfall dataset.

The monthly standardized NAO index was obtained from the website of the International Research Institute Data Library. The period used for analysis was December 1986 to February 2018, consistent with the rainfall dataset. Only the wintertime NAO indices were used, as some researchers (such as Hamilton et al. 2000) have postulated that the wintertime NAO is correlated with spring and early rainy season SST anomalies in the TNA and mid-latitudes. The mean was computed and used as the NAO dataset.

The relationship between the NAO and the rainfall anomalies was observed through graphical representations and a qualitative assessment was made. Further, to test the strength of the relationship between the two variables, the Pearson's Product Moment Correlation was applied.

RESULTS

During the winter, and up to FMA, each three-month period of rainfall was observed to be positively correlated with the NAO index. However, the strongest correlation, based on the Pearson's Product Moment Correlation seems to be when the rainfall lags the NAO by approximately one month, during JFM. Figure3 illustrates this observation and Table 1 provides a summary of the results from the Pearson's Product Moment Correlation.

Beyond spring and up to summer, the rainfall was observed to be negatively correlated with the NAO. The strongest correlation according to the Pearson's Product Moment Correlation was during AMJ as shown in Figure 4.

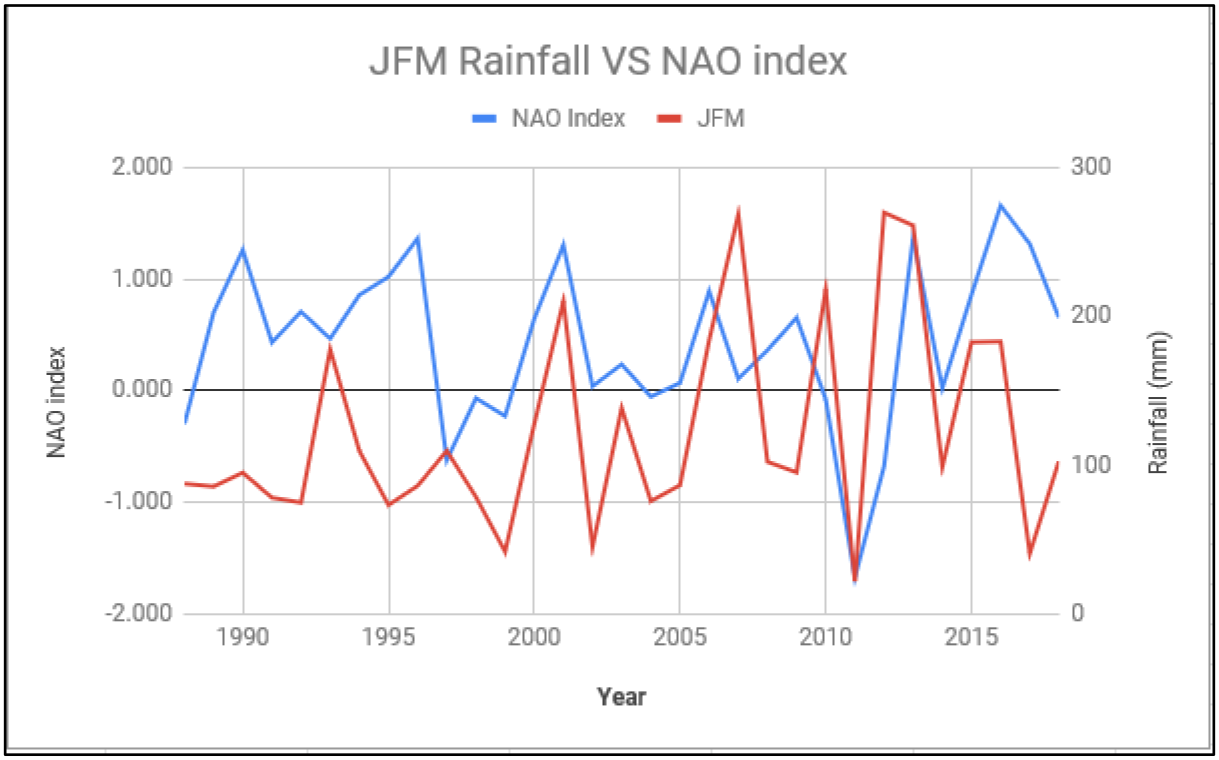

Figure 3: Graph showing the relationship between the NAO and JFM rainfall

Months	Pearson Correlation Coefficient		p-values
DJF	0.1973274		0.279
JFM	0.2399632		0.1859
FMA	0.09572921		0.6022
MAM	-0.06230939		0.7348
AMJ	-0.2934527		0.1031
MJJ	-0.19347081		0.6463
JJA	-0.0843461		0.3881

Table 1. Correlation coefficients for NAO and rainfall

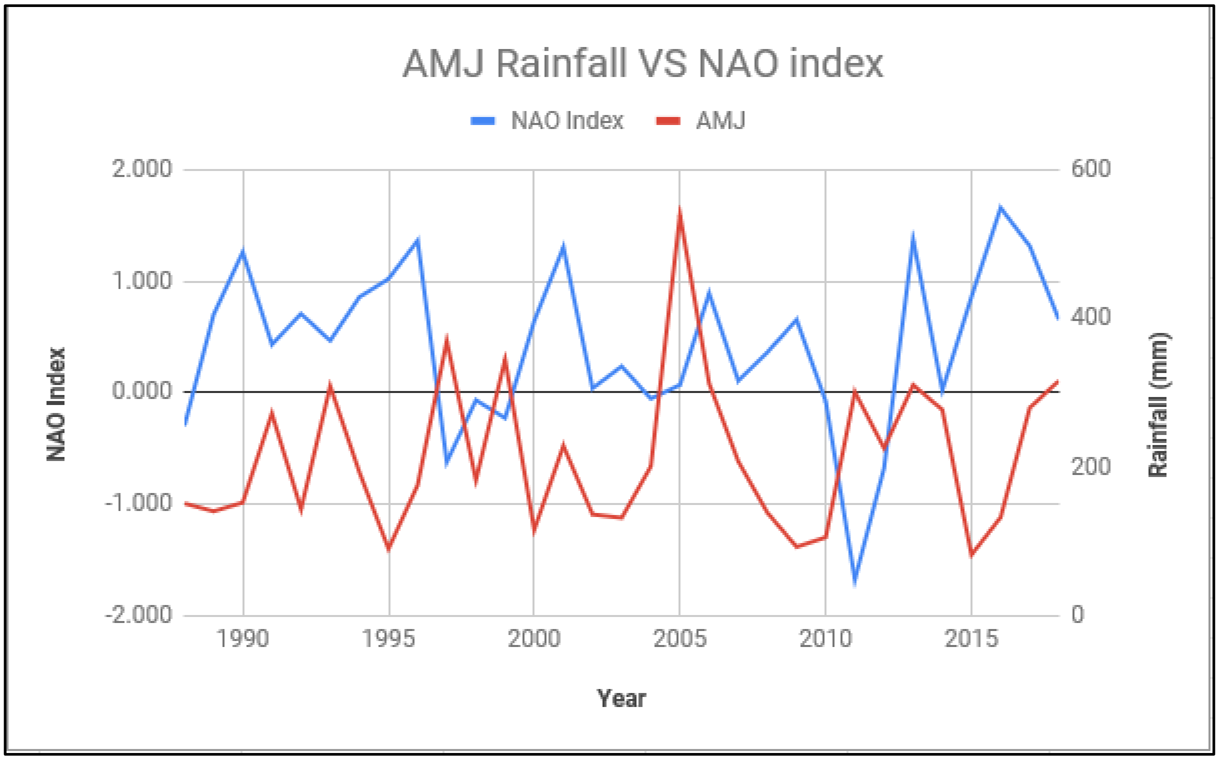

Figure 4: Graph showing the relationship between the NAO and AMJ rainfall

DISCUSSION AND CONCLUSION

There is enough evidence from the observations to conclude that the NAO influences the rainfall pattern of the Grenada. Charlery et al. (2006), concluded that the effects of the NAO are not restricted to temperate latitudes, but also low latitudes as well, after using rainfall data for Barbados to show the very significant influence of the NAO during certain stages of ENSO. These similar results for Grenada support their findings. This is also similar to the conclusions made by Jury et al. (2007), that the NAO exerts some influence on the southeastern Caribbean, with a weak positive value that almost achieves statistical significance at zero lag.

George and Saunders (2001), analyzed the NAO-composited Caribbean rainfall based on contemporaneous, rather than lagged, NAO indices and revealed insignificant differences with

NAO sign. Therefore, the important NAO influence on annual Caribbean precipitation occurred in the preceding winter. Jury et al. (2007), summarized that the NAO is negatively associated with Caribbean rainfall when the preceding winter season is considered in respect to seasonal rainfall. However, a continuous monthly analysis suggests an unstable and generally positive simultaneous association with the Southeastern Caribbean rainfall, particularly in late summer.

Other research reveals that the wintertime NAO is correlated with spring and early SST anomalies in the TNA and mid-latitudes. A positive NAO leads to stronger trade winds, to enhanced wind -induced latent heat flux, to TNA SST cooling, and to lower TNA atmospheric moisture content (Hamilton et al. 2000). The decrease in spring rainfall during positive NAO phases can be explained by a shift in the wind direction impacting the northern Caribbean. Initially, the mean flow comes from the northeast; thus, the northern Caribbean receives increased moisture and rainfall. However, from spring onwards, the wind direction becomes more easterly; hence, reduced evaporation over the cool TNA SST anomaly and reduced rainfall in the Caribbean. The opposite was found during negative NAO phases.

A reasonable assumption can be made that the influence the NAO appears to exert on the rainfall pattern in Grenada, may be fairly representative of the wider subregion.

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