The Combined and Individual Effects of the North Atlantic Oscillation and the Atlantic Meridional Mode on Early Rainfall Season Precipitation in the Insular Caribbean

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Abstract

The insular Caribbean is a region influenced by Atlantic Ocean climate variability. Effects of low-frequency atmospheric circulation patterns on the precipitation of the Caribbean have been well documented. However, individual modes of variability are usually only considered in isolation. Here we analyse the combined and individual effects of the North Atlantic Oscillation (NAO) and the Atlantic Meridional Mode (AMM) on insular Caribbean precipitation. This work focuses on the Early Rainfall Season (ERS, April-July), which explains much of the interannual variability in precipitation for this region, from 1960-2016. Correlation analysis compare monthly NAO and AMM indices from the National Oceanic and Atmospheric Administration (NOAA) against monthly Caribbean precipitation from the Climate Research Unit (CRU) year-by-year climate variables by country. Sea surface temperature (SST) and sea level pressure (SLP) composites using NOAA data were also created to analyse regional patterns. Analysis of the results show that the NAO and AMM presented a correlation of opposite signs and affected the Eastern Caribbean (from Dominican Republic to Grenada) during ERS, resulting in precipitation anomalies above/below ± 10%. The combined and individual effects of NAO and AMM indicate that Feb-Mar NAO and AMM are significant correlated to May-Jun Eastern Caribbean precipitation anomalies. More frequent and consistent regional effects on precipitation anomalies, and more regionally spread and persistent SLP and SST were registered when both NAO and AMM occurred together in the previous winter. These results could be helpful in seasonal forecasting, by indicating whether a wetter or drier ERS would be expected based on the previous season NAO and AMM activity.

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Introduction

The insular Caribbean is a region influenced by North Atlantic climate variability. Effects of low-frequency atmospheric circulation patterns on the precipitation of the Caribbean have been well documented. However, individual modes of variability are usually only considered in isolation. Here we **analyse the combined and individual effects of the North Atlantic Oscillation (NAO) and the Atlantic Meridional Mode (AMM) on insular Caribbean precipitation**. This work focuses on the Early Rainfall Season (ERS, April-July), which explains much of the interannual variability in precipitation for this region, from 1960-2016.

Data and Methods

- Used Climate Research Unit (CRU, V4.1) precipitation dataset to calculate monthly precipitation anomaly (%), from 1960-2016.
- Correlated monthly precipitation anomaly (%) from each country (19) with monthly NAO and AMM indices (NOAA Earth System Research Laboratory).
- Analyzed which months presented more spatially distributed and statistically significant correlation (p-value <0.05) between NAO/AMM and precipitation anomalies (%) (**Figure 1**).

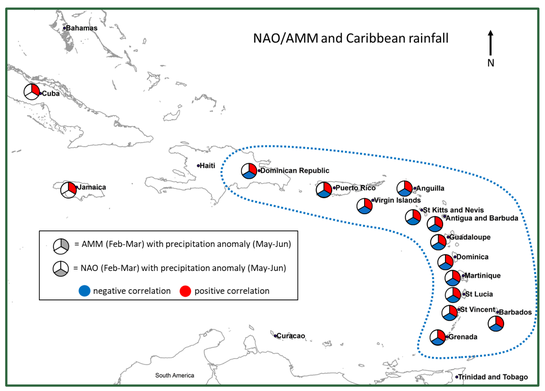

Figure 1. Correlation between NAO/AMM and the insular Caribbean precipitation anomalies. Each relationship is represented by one circle sector and colored in red (positive) or blue (negative).

This indicated the Eastern Caribbean islands (from Dominican Republic to Grenada) as the region where **NAO and AMM (Feb-Mar)** were correlated with **precipitation anomalies (May-Jun).**

- Created sea surface temperature (SST) and sea level pressure (SLP) anomalies composites based on the same statistically significant correlated months (NOAA Monthly Climate Composites).

Results

The NAO and AMM (Feb-Mar) presented a **correlation of opposite signs** and affected the Eastern Caribbean during the ERS months of May-Jun, resulting in precipitation anomalies of at least ±10%. For both **positive and negative precipitation anomalies distribution**, the more frequent (19 years) and consistent regional effects were registered over the **Eastern Caribbean** when **NAO and AMM occurred together** in the previous winter (**Figure 2,a**). However, greater values of precipitation anomalies(+) were related to wintertime NAO(-) alone, while lower values of precipitation anomalies(-) were related to wintertime AMM(-) alone (**Figure 2,b**).

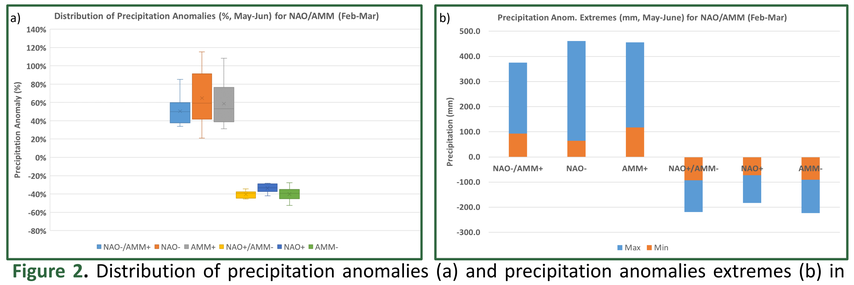

Figure 2. Distribution of precipitation anomalies (a) and precipitation anomalies extremes (b) in the Eastern Caribbean (May-Jun) when NAO and AMM occurred together or isolated (Feb-Mar).

The consistent regional effect on precipitation anomalies during ERS related to the combination of wintertime NAO/AMM was evident during the **severe drought of 2015** (**Figure 3**), when the Eastern Caribbean registered between -15% and -30% of annual precipitation anomaly compared to 1979-2014 (Mote et al. 2017).

Figure 3. Reservoir in Toa Alta (right) and dry banks of La Plata River in Comerio (left), Puerto Rico.

SST and SLP anomalies composites indicated that when wintertime NAO and AMM are combined, both SST and SLP anomalies persist over the Eastern Caribbean during the months of May-Jun (**Figure 4**). The persistent anomalies in SST and SLP do not happen over the entire Eastern Caribbean when NAO or AMM occurred alone in the previous winter (not shown).

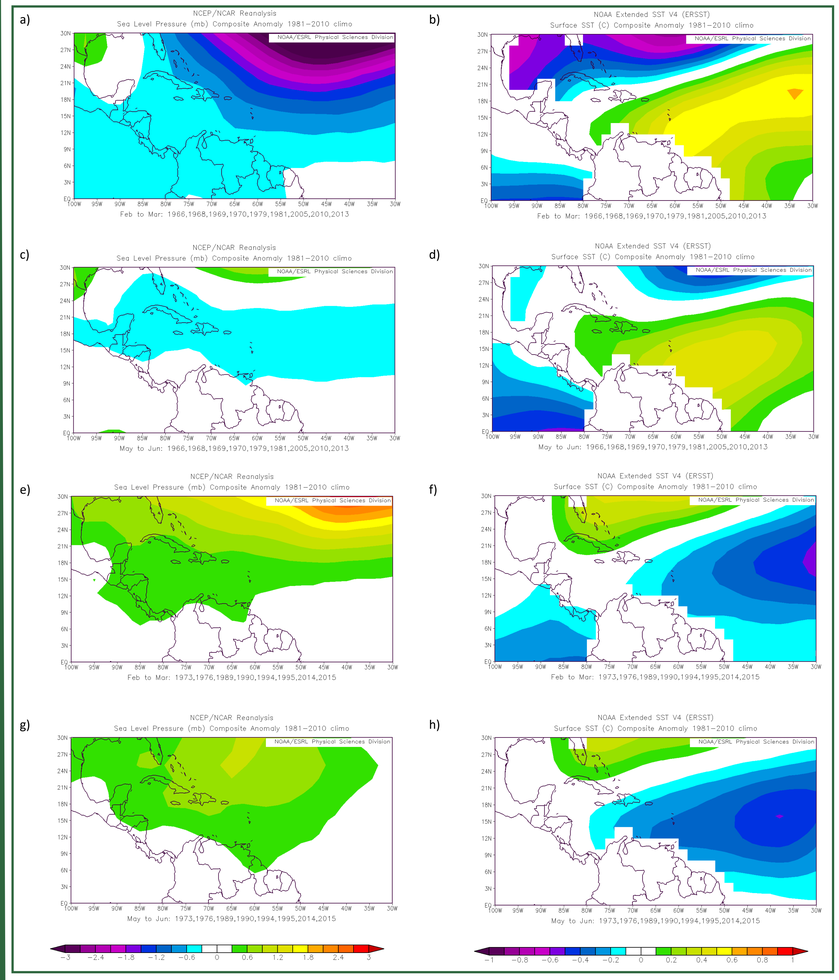

Figure 4. SST and SLP anomalies composites during Feb-Mar and May-Jun when NAO(-) and AMM(+) are combined and precipitation anomaly(+) is registered in Eastern Caribbean (a-d), and when NAO(+) and AMM(-) are combined and precipitation anomaly(-) is registered in Eastern Caribbean (e-h).

Conclusions

The combined and individual effects of NAO and AMM indicate that the **Eastern Caribbean** is where precipitation anomalies (May-Jun) and NAO/AMM (Feb-Mar) are correlated. More frequent and consistent **regional effects on precipitation anomalies**, and more regionally spread and persistent SLP and SST were registered when **both NAO and AMM occurred together in the previous winter**. These results could help in seasonal forecasting, for regional drought or precipitation prediction.

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