Introduction

Much of the Caribbean experienced back-to-back extreme drought conditions during the summer of 2014 and 2015. Impacts in our study area of St. Elizabeth, Jamaica included hundreds of acres of farmland destroyed by fire, increased prices of produce, and water restrictions. June and July 2014 were particularly hard hit as indicated by our assessment of rain gauge data in Table 1 compared to a local climatology, and the GPCP v2.2 product for the grid box covering western Jamaica (Figure 1) and Figure 4a for location). Consistent with this pattern, the IPCC 5th Assessment Report suggests that droughts will be more common in the future. The objectives of this study are (i) present results from a multi-linear regression equation of July 2014 rainfall based on ENSO and NAO (and make a preliminary assessment for 2015), (ii) examine atmospheric anomalies accompanying extremely dry July's that may help explain the connections with the climate anomalies and (iii) offer a hypothesis from the literature.

Hypothesis

Lin et al. (2009) and Frederiksen and Lin (2013; using theory and observations) show that the MJO exerts an atmospheric influence as the MJO moves through the Maritime Continent. As shown below, it begins as a Pacific-North American-like pattern in 500 hPa streamfunction followed by an NAO-like pattern. Note the similarities between Frederiksen and Lin's Figures 10c and our Figure 4c.

Below are two phase space plots of the MJO rotary activity and strength (from December to March 2006-07 (lef) and 2013-14 (right). In these and the other three dry years (Table 2) the MJO was located in the Maritime Continent (phase 3-5) during December and January, March and Schumacher (2011) also note that the annual mean precipitation decreases when the MJO is in phases 3 and 4 and they attribute it to an increase in the low-level jet.

Thus, MJO activity over the Maritime Continent in the winter season prior to drought in the winter (and may be stronger than and earlier than) the separate NAO and ENSO predictors. In addition to the MJO-NAO relationship described here, it has been shown that MJO activity can lead to the development of El Nino, but not always, as was the case in 2007-2008. Future work will include examining the MJO-NAO relationship directly.

By the summer season, the streamfunction anomaly over the Caribbean may be explained by intraseasonal variability. The patterns in July (Fig 4f and 4a) are very similar to the percent of explained variance of the SA 200 hPa streamfunction and zonal wind, respectively, associated with the intraseasonal (ENSO) EOF of 100 hPa velocity potential (Chelliah and Bell 2004).

Western Jamaica precipitation related to ENSO and NAO

GPCP [July precipitation in western Jamaica (18.15 N, 73.25 W; box in Fig. 6a) was found to be related to the preceding March NAO$^+$ value and the subsequent January Nino 3.4 value according to the following formula (Pome et al. in press) developed from 1979 to 2013:

\[
\text{July rainfall (mm)} = -22.517 + 0.803 \text{NAO} - 0.04 \text{ENSO} = 134.435
\]

Accordingly, when the NAO is positive and there is a developing El Nino then rainfall is predicted to decrease. Years with the first dry June's were identified in Table 2. NAIO+Nino 4, and GPCP precipitation are given for March, June and the following year's January ["January" $^+$]. For all years except 1991, a positive NAO occurred in March. For all years except 2007, a weak to strong El Nino occurred in January. July 2014 (not included in the generating statistical relationships) was the second driest July in the record. The GPCP and Nino 4 data in Table 2, the multi-linear equation above would predict a value of 139 mm (or an anomaly of 4.98 mm day$^{-1}$). Thus, the model underestimated the severity of the drought in July 2014. The March 2015 NAO value was comparable to 1997. Also, similar to 1997, the July 2015 Nino 3.4 anomaly was high signaling a strong El Nino event. Therefore, it is expected that GPCP rainfall in July 2015 will be low which is consistent with real-time drought monitoring products and media reports from Jamaica and elsewhere in the Caribbean.

Atmospheric Patterns Leading to Extreme Dryness in July

GPCP precipitation and NCEP/NCAR reanalysis data were averaged for March (Figure 2) to July (Figure 5) of the years with the driest Junes (see Table 2), including 2014:

- The composite maps suggest that for these years, the drying began in June.
- The positive phase of the NAO is clearly seen in March with a southeast extension of the low pressure anomaly into April. A wave-train pattern emerges in June and July.
- A negative upper-tropospheric streamfunction anomaly establishes itself in the Caribbean in May and atmosphere in the western trust into July. Streamfunction is related to vorticity, except the sign is reversed (negative = cyclonic motion) and the field is spatially smoother.
- The lower-tropospheric streamfunction anomaly is of opposite sign in the Caribbean (not shown).
- Centers of anomalous anticyclonic rotation in the lower-troposphere and cyclonic rotation in the upper-troposphere over the western Caribbean are found, with the strongest subsidence at the anticyclone (see Fig. 7), coincident with the GPCP grid box location.

References:


