Historical drought variability in Southeast Florida and teleconnections to ENSO, PDO, and AMO

Anteneh Abiy, Advisor: Assefa Melesse
Department of Earth and Environmental, Florida International University
aabiy001@fiu.edu

FIU Center for Aquatic Chemistry and Environment
NSF Center of Research Excellence in Science and Technology

Introduction

In Southeast Florida, the incidence of hydrological drought is threatening freshwater availability for differed uses. The declined rainfall attributed to meteorological drought drives hydrological drought. In a regional scale, drought variability is associated with global ocean-atmospheric interaction mode—the Pacific Decadal Oscillation (PDO) and Atlantic Multidecadal Oscillation (AMO), and El Niño–Southern Oscillation (ENSO). However, the tele-connectivity between local drought and these drivers are not well assessed at the local scale. Therefore, water resource planning for local hydrological management lacks a sound knowledge base.

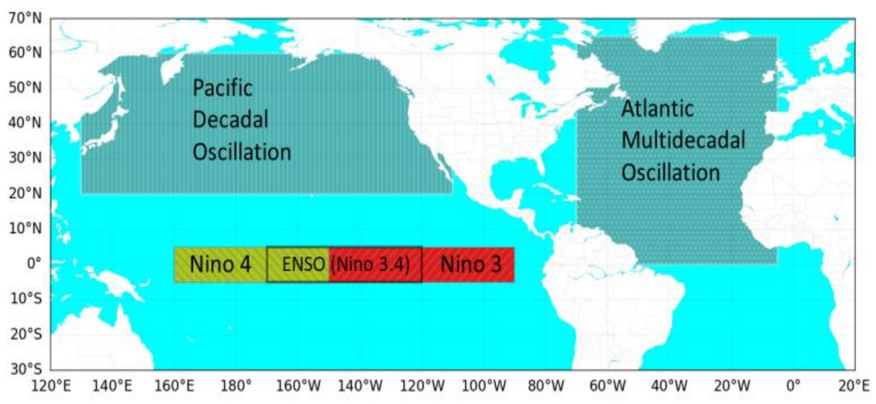

Figure 1. Location of the differed Ocean atmospheric interaction modes.

For a long term sustainable freshwater management planning a detailed evaluation, understanding, and association of local drought with ENSO, PDO, and AMO fluctuations are necessary. Such an understanding is vital to define scenarios and priorities to a sustainable water resources management strategy.

Objectives

The objectives are to:

- evaluate the long-term hydrological drought fluctuation in Southeast Florida and,
- define the tele-connectivity of local drought with ENO, AMO, and PDO.

Data:

- 110 years of monthly rainfall data
- Nino 3.4 , AMO, and PDO data from 1996 to 2016

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Methodology

Correspondence of the rainfall deviation with ENSO, AMO and PDO is evaluated by pairwise quadrant based analysis. The significance of the correspondence between each of the drivers and the rainfall anomaly is evaluated by binomial proportions chi square test given by:

$$\chi^2 = \frac{\sum (f - F)^2}{F} = \frac{(h - n\,p)^2}{n\,p} + \frac{(h - n\,p)^2}{n\,q}$$

Historical Drought is evaluated by using the Standardized Precipitation Index (SPI), calculated at 3, 6, 12, 24, 36, 48, and 60-month time windows. These SPI indices are used to define drought frequency by Fourier Transform. Further, the SPI indices as depended variable were used to assess the combined effects of ENSO, AMO, and PDO on local drought by using multiple regression analysis. The student's t-test appraised the statistical significance of the multiple regression.

Results and Discussions

In general the local rainfall variability is directly proportional to ENSO and PDO, but weakly related to AMO indices.

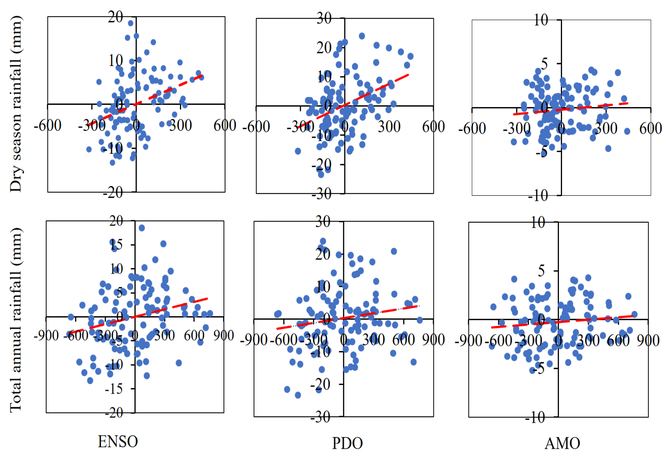

Figure 2. Scattered plot (quadrant based) of rainfall anomaly and each of the divers.

- ENSO index represents 63.1% of annual rainfall variability is and 66.4% of the dry season variability.
- The total annual and dry season rainfall have shown an overlap with PDO index by 40.0% and 42.0%, respectively.
- AMO shows only 50.5% and 43.6% synchronicity between the total annual and dry season rainfall anomaly, respectively.
- SPI indices present the short and long-term wet and dry fluctuations.
- Besides season and inter annual variabilities, long held wet and dry phase were observed in the area.

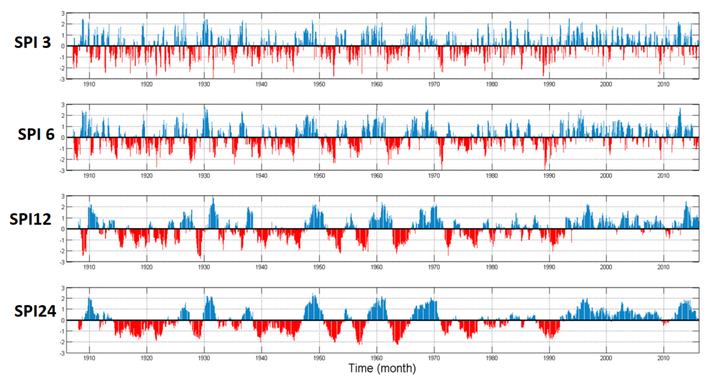

Figure 3. SPI calculated in differed time windows

- Despite the observation n of dry spells, since 1994/95 are is in prologue wet phases of the variabilities.
- SPI indices indicated that the local drought has 2 to 3, 5 to 6, 9 to 10 and 10 to 20 years cycle. Such cyclist coincides with the known cycles of ENSO, AMO, and PDO.
- Multiple regression of SPI indices against ENSO, AMO, and PDO show that the short-term variabilities are significantly correlated with ENSO variabilities. Year to year variabilities has a statistically significant relationship with all the drivers.

Long-term fluctuations (> = 2 years) are correlated with AMO fluctuation. Positive (negative) AMO phases promote wetness(dryness) in SE Florida.

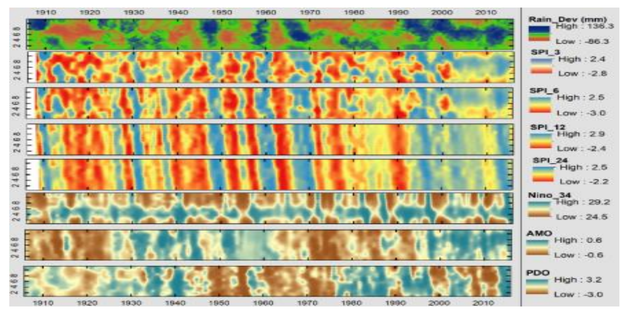

Figure 4. Chart of SPI indices, ENSO, AMO and PDO

Conclusion and Recommendation

While AMO fluctuations drive the rainfall and drought viability in SE Florida, ENSO fluctuations modulate the net hydrological effect. The emergence of negative AMO index is reported. Hence, it is highly likely that the current stated of long-held wetness in the area will change to the dry phase any time soon. This can cause a prolonged small scale drought in the area.

A prolonged drought could result in limited freshwater available due to declined precipitation input and saltwater intrusion. Hence, recharge deficit management due to drought should be considered to enhance the sustainability of freshwater availability in the area.

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Anteneh Abiy
Department of Earth and Environment, Florida International University, Miami, FL, USA