Journal of Hydrology 517 (2014) 700–714

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Large scale climate oscillations and mesoscale surface meteorological variability in the Apalachicola-Chattahoochee-Flint River Basin

Kelly A. Stevens [*,1], Paul H. Ruscher [2]

Department of Earth, Ocean and Atmospheric Science, The Florida State University, 1017 Academic Way, P.O. Box 3064520, Tallahassee, FL 32306-4520, United States

ARTICLE INFO

Article history:
Received 9 January 2014
Received in revised form 30 May 2014
Accepted 3 June 2014
Available online 17 June 2014
This manuscript was handled by Andras Bardossy, Editor-in-Chief, with the assistance of Sheng Yue, Associate Editor

Keywords:
ACF
Drought
Climate oscillations
SPI
CCA

SUMMARY

The "water wars" between Alabama, Georgia, and Florida over water restrictions and allocation in the Apalachicola-Chattahoochee-Flint River Basin (ACF) stem, in part, from the occurrence of several droughts in the 1980s, the dramatic increase in water use in the northern basin around Atlanta, and increased agricultural usage in the central basin. This study examines relationships between available surface climatological variables connected to evapotranspiration and climatic oscillations using canonical correlation analysis (CCA).

Canonical loadings and cross loadings from CCA are evaluated in two tests using temperature and precipitation data and four climate oscillations – the Atlantic Multidecadal Oscillation (AMO), North Atlantic Oscillation (NAO), Pacific Decadal Oscillation (PDO), and Southern Oscillation Index (SOI). In the first test, the six-month Standardized Precipitation Index (SPI) and all four seasons of the four climate oscillations from every subbasin in the ACF are evaluated, revealing relationships mostly with the AMO and NAO, and primarily with temperatures. In order to focus more on precipitation and the variance among the different temporal scales of the SPI, Test Two looks at the relationship between all four SPI variations and all four seasons of the climate oscillations from the extreme northern and southern subbasins. Test Two shows the twenty-four month SPI has the largest loadings and variance explained, which may be contributed to the longer frequencies in the AMO and PDO. The southern part of the basin is largely influenced by SOI, while the northern subbasin the AMO and PDO. Concurrent relationships between the same season of the climate oscillation and meteorological variable confirm previously researched directions of the relationships between the oscillation and precipitation or temperature in both Test One and Test Two.

1. Introduction

Water is increasingly recognized as a vital and limited resource in many regions of the world. The "water wars" of the ACF began in the 1980s when a series of droughts in the southeastern United States significantly reduced flows in the three named rivers. Water restrictions and allocation became a source of debate between the states of Alabama, Georgia, and Florida, who share the integral resources provided by the highly managed waters of the ACF.

The ACF river basin originates in northern Georgia with the Chattahoochee River draining from Lake Sidney Lanier near Atlanta, flowing down the Georgia and Alabama border before eventually joining with the Flint River at Lake Seminole at the Georgia/Florida border. From here the Apalachicola River drains from Lake Seminole down to the Gulf of Mexico into Apalachicola Bay (Fig. 1). The ACF is nearly 385 miles (619 km) long and 50 miles (80 km) wide, covering approximately 50,800 km^2. The majority of the basin lies within Georgia (74%), with the remainder

Abbreviations: ACF, Apalachicola-Chattahoochee-Flint River Basin; AMO, Atlantic Multidecadal Oscillation; ASOS, Automated Surface Observing Stations; CCA, canonical correlation analysis; CPC, Climate Prediction Center; ENSO, El Niño Southern Oscillation; FFT, fast Fourier transform; MLR, multiple linear regression; MSLP, mean sea level pressure; NAO, North Atlantic Oscillation; NCDC, National Climatic Data Center; PDO, Pacific Decadal Oscillation; PDSI, Palmer Drought Severity Index; PHDI, Palmer Hydrologic Drought Index; PRISM, Parameter-elevation Regressions on Independent Slopes Model; SOI, Southern Oscillation Index; SPEI, Standardized Precipitation Evapotranspiration Index; SPI, Standardized Precipitation Index; SST, sea surface temperatures.

* Corresponding author. Address: 357 N. Edwards Avenue, Syracuse, NY 13206, United States. Tel.: +1 850 445 6094.

E-mail addresses: kelly_ann_stevens@yahoo.com (K.A. Stevens), pruscher@fsu.edu (P.H. Ruscher).

[1] Present address: Center for Policy Research, Maxwell School, Syracuse University, 426 Eggers Hall, Syracuse, NY 13244-1020, United States.

[2] Present address: Lane Community College, 4000 East 30th Ave., Eugene, OR 97405, United States.

http://dx.doi.org/10.1016/j.jhydrol.2014.06.002
0022-1694/© 2014 Elsevier B.V. All rights reserved.

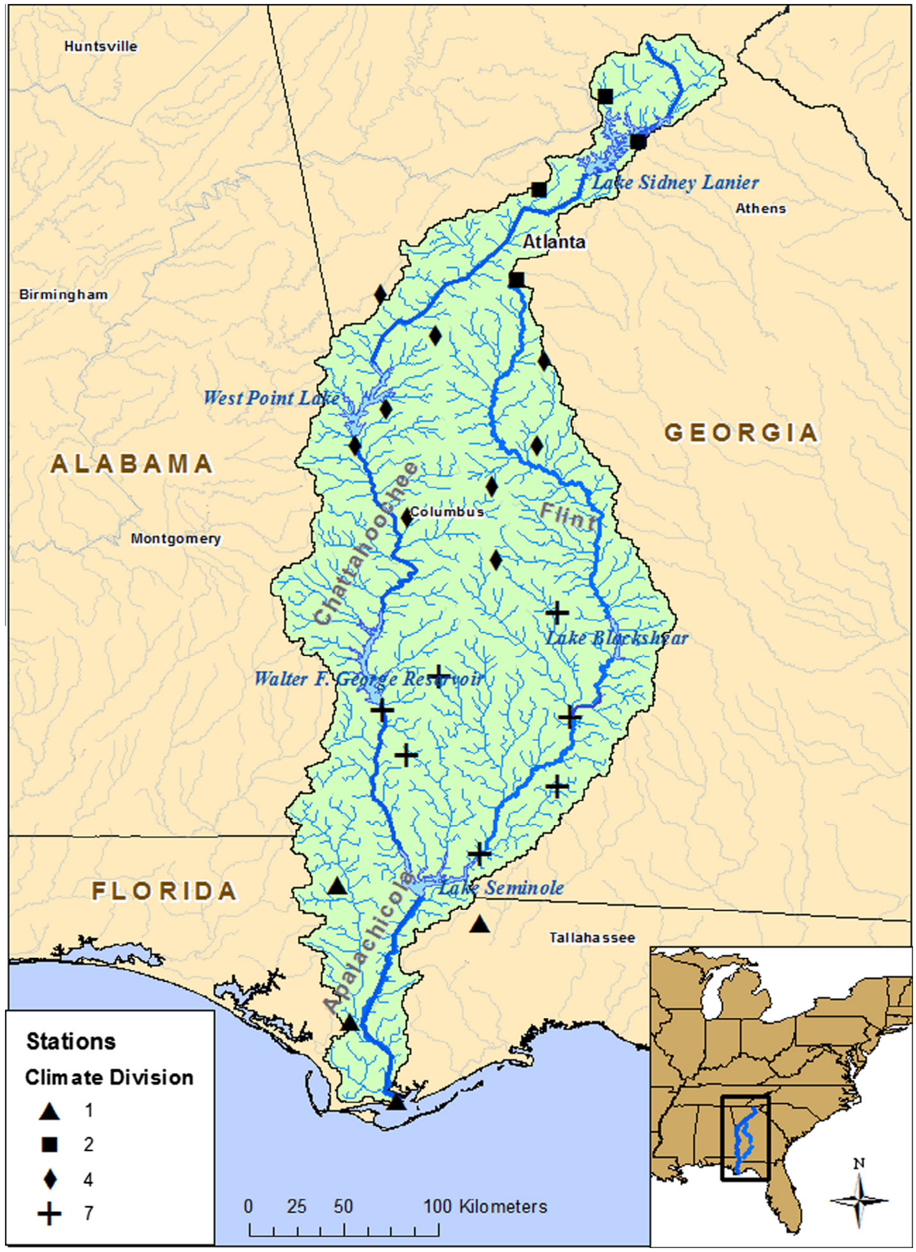

Fig. 1. The Apalachicola-Chattahoochee-Flint River Basin and tributaries encompassed in the basin. Also located on the map are the 24 COOP stations from which temperature and precipitation data were obtained. The station symbols represent the four climate divisions.

in western Alabama (15%) and the western panhandle of Florida (11%) (USACE, 1998). Its annual average discharge ranks it 21st in magnitude among river systems of the conterminous United States (USACE, 1998).

The waters in the basin are heavily managed for a variety of uses including agriculture, recreation, industry, and hydropower production. The ACF currently contains 16 dams and main-stem reservoirs, 14 of which are associated with hydropower operations (Frick et al., 1998). Management introduces water-use agendas and technology that may ultimately generate long-term, unintended consequences for the environment, exacerbating initial conflicts or leading to worse conditions (Carey et al., 2012). The ACF is sensitive to the uses and management of the different sections of the basin, as more drawdown in Atlanta and irrigation along the Flint causes lower flows to the Apalachicola Bay, one of the planet's "biodiversity hotspots" (Ruhl, 2005).

For these reasons, the ACF has a complex legal history. Legal battles flared between Georgia, Alabama, and Florida over water reallocations granted by the United States Army Corps of Engineers (Corps), the responsible water management agency of the ACF. Despite the use of an Interstate Water Compact, protective orders, numerous lawsuits, and court-issued deadlines for agreements, the three states remain in battle over the appropriate water allocation, minimum streamflows, and Atlanta access to drawdown of Lake Lanier. As of January 2014, the Supreme Court is reviewing a request from Florida to hear the most recent lawsuit against Georgia on ACF water use.

High interest in this issue has inspired several other studies to be conducted on the ACF or parts of it, particularly concerning streamflow and drought indicators. One such study by Light et al. (2006) focuses on the water-level decline in the Apalachicola and the associated effects on the floodplain in the last half century. Another study by Steinemann (2003) uses a probabilistic framework to evaluate different drought indicators for the ACF as part of the developed drought plan between the three feuding states. Morey et al. (2009) evaluates variability in the Apalachicola River