

# HYDROLOGIC RESPONSE OF THE SUWANNEE RIVER BASIN IN FLORIDA TO CLIMATE VARIABILITY

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## INTRODUCTION

The assessment of water resources of the Suwannee River Basin (SRB) in north Florida is important because water demands within the basin are increasing (Katz and Raabe 2005). The basin's water availability is highly affected by population and climate variability. Florida has more available ground water in aquifers than any other state in the United States (McGuinness 1963; Purdum 2002). However, the state's natural hydrology systems must meet its water needs for increasing human demands. These systems have specific water requirements in terms of quantity, quality, seasonal variations and geographical locations in the state (Department of Environmental Protection [DEP] 2001).

The state's abundant precipitation is characterized by spatial and temporal variability, which have significant effects on water availability in various parts of the state at different times of the year. The issue of moving water from water-rich areas in north Florida to densely populated south Florida heated up in late 2003 and became known as the "north-south water transfer debate" or "water wars" (Gainesville Sun August 17, 2003). In 1996, the Army Corps of Engineers proposed a pipeline to move water from the Suwannee River to the Tampa area (Gainesville Sun May 19, 2003). The proposal was not approved. Towards the end of 2004 the need for linking growth to availability of local water resources was identified as an alternative to long-distance water transfer (Gainesville Sun Nov 5, 2004). Recently, it has been speculated that north Florida could become a future development hub because of its abundant water resources (Gainesville Sun April 17, 2005). Therefore sustainable planning of water resources in the SRB is required, which calls for information on spatial and temporal variability of inflows and outflows to the basin.

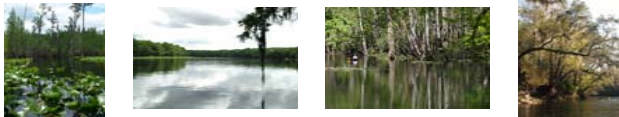
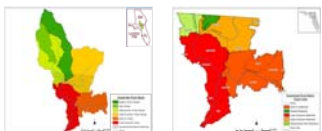
The most important issue that led to this research was demand and broadly recognized need for better water resources management in the state (Florida Council of 100) and in the SRB (Katz and Raabe 2005). It was hypothesized that supply and uses of water resources in the SRB are affected by ENSO phases during different times of the year.

## OBJECTIVE

The objective of this research was to characterize the behavior of monthly, seasonal, and annual water balances relative to ENSO phases in the SRB.

## STUDY AREA

- The study area is part of the Suwannee River Basin (SRB) that falls within Florida (Figure). It covers about 7% of the total landmass of the state
- The SRB is 11,020 sq. miles with 4,230 sq miles area within Florida. (38 % of the total SRB)
- The SRB is drained by four rivers – The Alapaha, Withlacoochee, Suwannee and Santa Fe
- The Florida part of the SRB is divided into five watersheds – Alapaha, Withlacoochee, Upper Suwannee, Lower Suwannee and Santa Fe and covers, partially or totally, a total of thirteen counties



## METHODS

### Water Balance Equation

$$\Delta S_i = \left( \sum_{i=1}^n P_i^* A_i \right) - \left( \sum_{i=1}^n Q_i^* A_i \right) - \sum_{i=1}^7 [K C_i^* \left( \sum_{i=1}^n E T_{p_i}^* A_i \right)] - \sum_{c=1}^6 \sum_{i=1}^m W U_i^* F - A_c^* F - C W U_i$$

where  
 $P_i$  = precipitation falling on polygon  $i$  (m);  
 $A_i$  = area of polygon  $i$  (m<sup>2</sup>);  
 $i$  = polygons with precipitation,  $i = 1, n$ ;  
 $n$  = total number of polygons;  
 $Q_i$  = streamflow generated from polygon  $i$  (m);  
 $E T_{p_i}$  = potential evapotranspiration loss from polygon  $i$  (m);  
 $K C$  = crop coefficient;  $n$  = number of LC classes,  $i = 1, 7$ ;  
 $i$  = number of polygons,  $i = 1, n$ ;  
 $c$  = counties in a watershed,  $c = 1, m$ ;  
 $m$  = total number of counties in a watershed;  $u$  = USGS individual water use categories,  $u = 1, 6$ ;  
 $F$  = fraction area of the county in a watershed;  
 $F \cdot C W U_u$  = CWU fraction of individual water use category

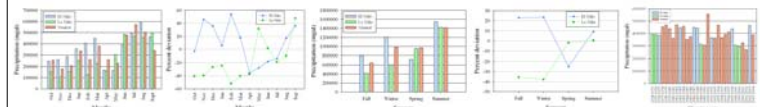
### Methods for ENSO-based Analysis

- The water balance was calculated for a period of 30 (1974/75-2003/04) climate years (October 1974 - September 2004) at a monthly time step.
- The Japan Meteorological Agency (JMA) index (COAPS 2006) was used for defining three ENSO phases: El Niño, La Niña and Neutral.
- Seasons were defined as: fall (Oct. - Dec.), winter (Jan. - Mar.), spring (Apr. - Jun.) and summer (Jul. - Sept.).
- ANOVA (Steel and Torrie 1980) was used to test the influences of ENSO phases on the hydrologic components

## RESULTS

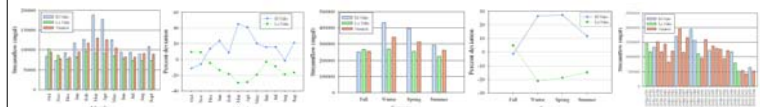
### Precipitation

- November and February and Fall and Winter showed significant responses to ENSO (P<0.05).
- Deviations between ENSO phases were greatest in February and least in April.
- Variation in seasonal precipitation between ENSO (El Niño vs. La Niña) phases was greatest in winter followed by fall. Variation during summer (rainiest season) was the least.



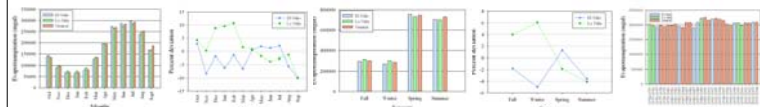
### Streamflow

- ENSO effects were significant during March (P<0.05) and nearly so during April (P= 0.0574).
- ENSO effects on seasonal streamflow were not significant though streamflow in El Niño spring was higher than in La Niña and Neutral years.
- Streamflow was highly variable during El Niño years in the spring season.
- Variation in streamflow between ENSO phases was greatest in March (the month with maximum streamflow) followed by April. The least variation was in October.
- Seasonally, variations between the ENSO phases were highest in winter followed by spring.



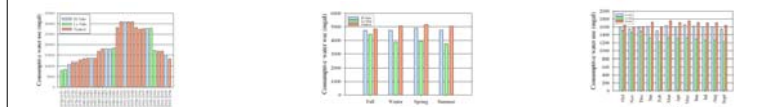
### Evapotranspiration

- ENSO did not affect ET significantly.
- Variation in ET between ENSO phases was greatest during January (least ET) followed by February and December and was least in April and September with no difference in monthly ET. Variation in July (greatest ET) was small.
- Variations in ET among ENSO phases and across seasons were small and insignificant.



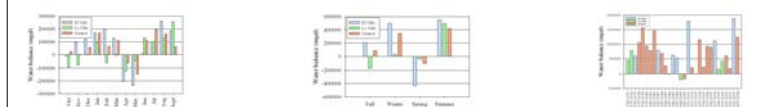
### Consumptive Water Use

- CWU did not vary significantly with month or season.
- CWU was not significantly different among the ENSO phases.



### Water Balance

- Based on a 30-year annual average (1974/75 to 2003/04) WB in the basin was estimated to be about 700 billion gallons.
- Mean WB was about 822, 319 and 755 billion gallons in El Niño, La Niña, and Neutral years, respectively. WB was 61% higher in El Niño than in La Niña
- In both November and February, WB was significantly higher in El Niño than in Neutral or La Niña years (P<0.05)
- Winter and spring WB showed significant responses to ENSO phase (P<0.05) with La Niña WB significantly less than in El Niño or Neutral years. Effects of ENSO phase during the fall season were weaker (P=0.069).



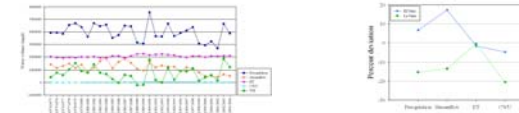
### 30-Year Water Balance

#### 30-Year Water Balance Trend

- WB was highest and lowest in 2002/03 (El Niño) and 1988/89 (La Niña), respectively.
- WB was negative during three of the 30 years (1985/1986-Neutral, 1988/1989-La Niña and 1989/1990-Neutral)

#### Deviation in hydrologic components between ENSO phases

- Mean El Niño precipitation, streamflow and WB were higher than in Neutral years, ET and CWU were lower.
- Mean La Niña precipitation, streamflow, ET, CWU and WB were all lower than Neutral year values (Figure)



## DISCUSSION

### Partitioning of precipitation relative to ENSO

#### Based on 30-year annual average

	Streamflow	Evapotranspiration	Consumptive water use	Water balance
30-year average	30%	52%	0.5%	17%
7-year El Niño average	32%	47%	0.45%	19%
5-year La Niña average	30%	60%	0.47%	9%

#### Based on seasonal average

	Streamflow	Evapotranspiration	Water Balance
30-year average	40% (greatest) in Fall (lowest precipitation) 18% (least) in Summer (rainiest season)	82% (greatest) in Spring 29% (least) in Winter	34% (greatest) in Winter -18% (least) in Spring
7-year El Niño average	55% (greatest) in Spring 19% (least) in Summer	4% (greatest) higher than precipitation in Spring 67% (least) less than precipitation	41% (greatest) in Winter -59% (least) in Spring
5-year La Niña average	64% (greatest) in Fall (lowest precipitation) 16% (least) in Summer (rainiest season)	76% (greatest) in Fall (rainiest season) 49% (least) in Summer (rainiest season)	35% (greatest) in Summer -41% (least) in Fall

## CONCLUSIONS

- Precipitation was higher during El Niño fall, winter and summer compared to La Niña and Neutral year estimates. Higher precipitation in El Niño summers is a new finding.
- Streamflow values were higher during El Niño winter, spring, and summer. Streamflow values were also higher in La Niña fall.
- ET losses were highest in July in El Niño years compared to La Niña and Neutral years. On a seasonal scale, ET was highest in El Niño spring and in La Niña and Neutral fall, winter and summer seasons.
- The WB was higher during El Niño fall, winter and summer seasons, similar to that of precipitation.

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