Model Evaluation and Climate Variability Application to the Systems Dynamic STELLA© model of the Apalachicola Chattahoochee Flint (ACF) Basin

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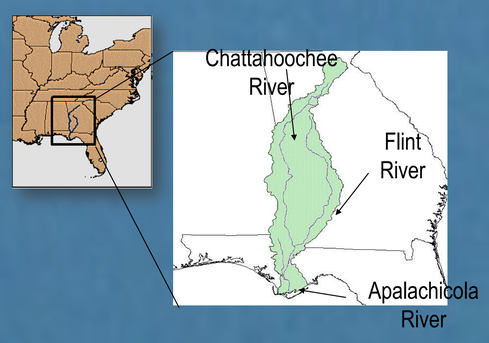
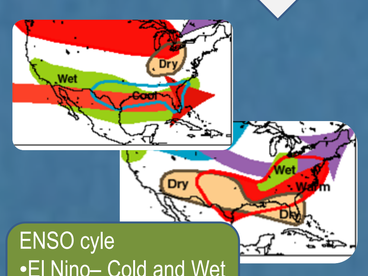
Introduction

Drought 2006-2007
- Increased concern in water allocation

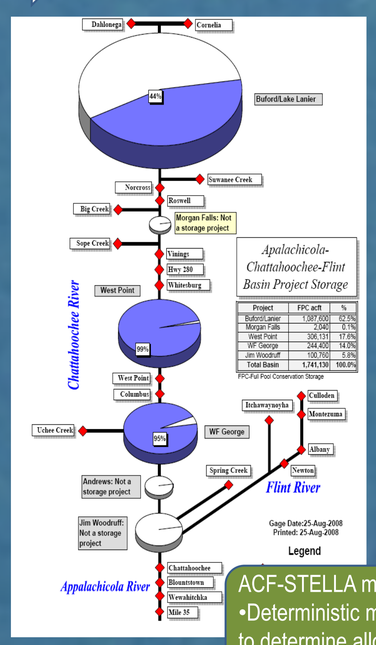


The Apalachicola Chattahoochee Flint Watershed has recently undergone extensive droughts. The recent drought of 2006-2008 caused reduction in hydroelectric power generation, recreation profit losses, and promoted restrictions of water use in the area Moreover, it showed the vulnerability of such large areas of commerce and agriculture throughout the southeast and the utter dependence on accurate water management in times of limited water supplies.

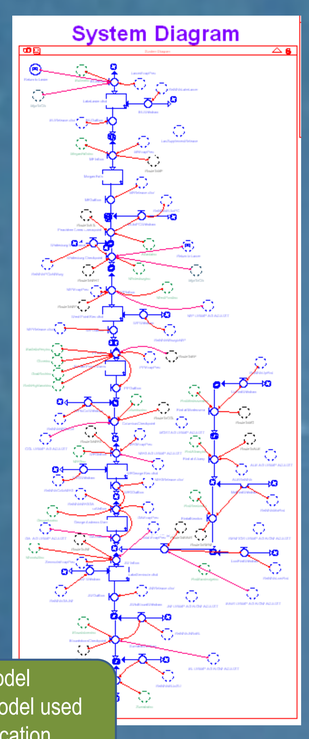


ENSO cyle
- El Nino– Cold and Wet
- La Nina- Hot and Dry

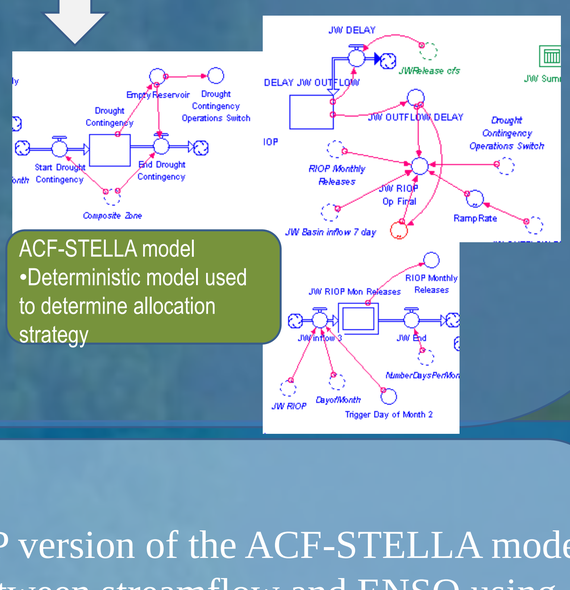
The ACF-STELLA model was created under a shared vision planning process to incorporate multiple stakeholder concerns; however it does not contain critical indices such as climate variability. Climate research has been conducted heavily as the implications and applications are vast. Several areas that climate study has proven useful are in agriculture as well as precipitation and streamflow forecasting.



ACF-STELLA model
- Deterministic model used to determine allocation strategy



ACF-STELLA updated to contain current Revised Interim Operations procedures. Drought Contingency Operations introduced to replace the Exceptional Drought Operations. Created spawning season (March-May), non-spawning season (June-November), and winter (December-February) Composite storage thresholds.



ACF-STELLA model
- Deterministic model used to determine allocation strategy

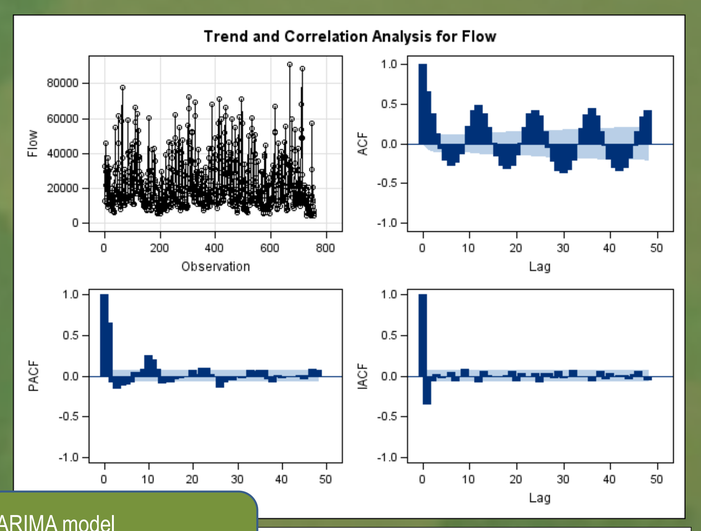
Methods

1. Unimpaired flows can not be validated by conventional means

   Embedded within the model exists a comprehensive dataset of the unimpaired streamflow of the major stems of the ACF. The unimpaired flows are defined as flows that are relatively unaltered by anthropogenic influences. To develop this dataset, the historic observed flows were adjusted for human influence by accounting for reservoirs, municipal, agricultural, industrial, and thermal power influences. This dataset was derived by the United States Army Corps of Engineers (Corps) after extensive investigation of water use and allocation was performed. The ACF-STELLA model essentially adds the demands that were taken out of the observed back into the dataset.

2. Develop time series forecast for Unimpaired flows driving the model.

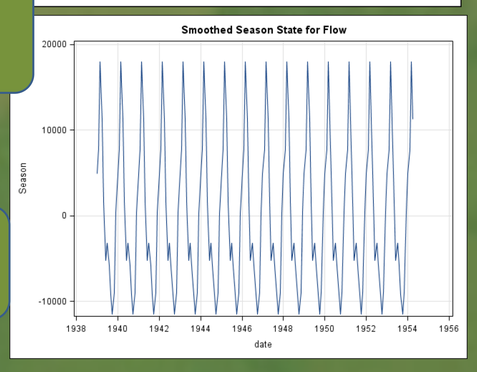
   The ARIMA model analyzes and forecasts equally spaced univariate time series data, transfer function data, and intervention data by using the autoregressive integrated moving-average (ARIMA) or autoregressive moving-average (ARMA) model. An ARIMA model predicts a value in a response time series as a linear combination of its own past values, past errors (also called shocks or innovations), and current and past values of other time series.



ARIMA model
- Forecast future flows
- Disaggregate time series

Moving Average Filter → Stationary Autoregresive Filter → Non-stationary Summation Filter

ARIMA model
- Process for developing ARIMA model



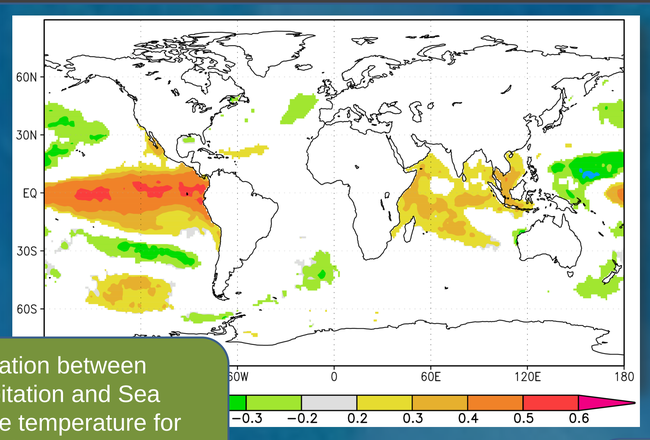
3. Cross-Correlation and other statistical analyses on of unimpaired flow versus recorded HCDN streamflow
4. Correlate streamflow with ENSO phases and incorporate into ACF-STELLA model

   The streamflow values were correlated with the sea surface temperatures to determine which ENSO index would be used to conduct the correlation. Once determined, ENSO phases were separated into La Nina, Neutral, and El Nino. Tests were performed to determine if streamflow are statistically different. The Student t-test and the non-parametric rank sum test were conducted and results varied.

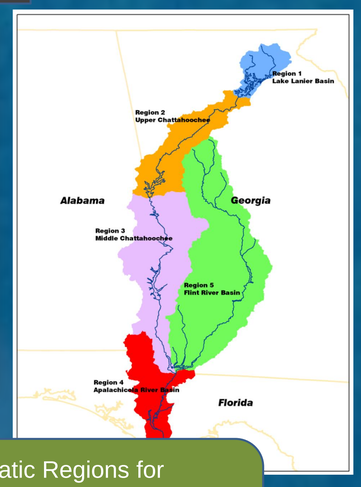
Objectives

1. Test model using current RIOP version of the ACF-STELLA model
2. Show statistical correlation between streamflow and ENSO using Pearson and t-test statistical methods
3. Incorporate climate variability into the ACF-STELLA model using lumped regional streamflow forecasting

Results – ENSO Correlation

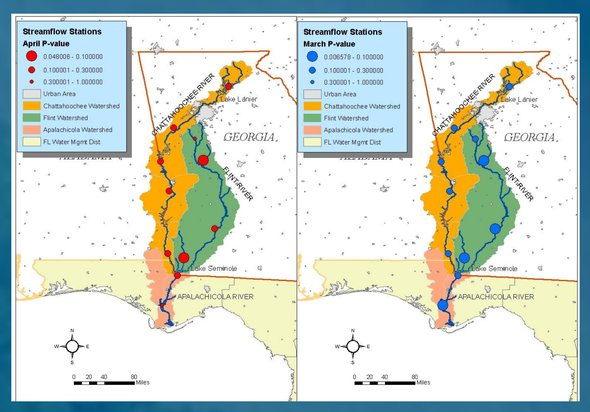


Correlation between Precipitation and Sea surface temperature for Dec-Feb average Apalachicola gauge



Climatic Regions for application to the ACF-STELLA model based on watersheds emptying to different reservoirs

The unimpaired flows are still being tested with using the ARIMA model with no conclusion. Preliminary correlation was determined for many of the unimpaired flow as being most significant for the months of March and April. Climatic regions have been divided to provide for the insertion of the ENSO index into the model at proper locations. Correlation during these months may be helpful in water management for the ACF basin.



Results – ACF STELLA

The ACF-STELLA was updated to contain current Revised Interim Operations procedures. A pre-validation was performed over the time frame from 1979-1983 to determine if the model was in the range of observed values. This model has undergone many changes during the subsequent allocation formula changes with very little peer review. However, imbedded within the model are earlier pre-validation correlating the Blountstown historical flows, Army Corps of Engineers (Corps) HEC-5 Blountstown model flows, and the calibrated model flows using graphical techniques however no statistical evaluation of the results was performed to show correlation. Furthermore the pre-validation tested only the Blountstown location which is on the tail waters of the river system and should show the least correlation.