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Current and Projected Impacts of Droughts on Water Resources of the Southeast

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Climatology, Climate Variability, and Climate Change

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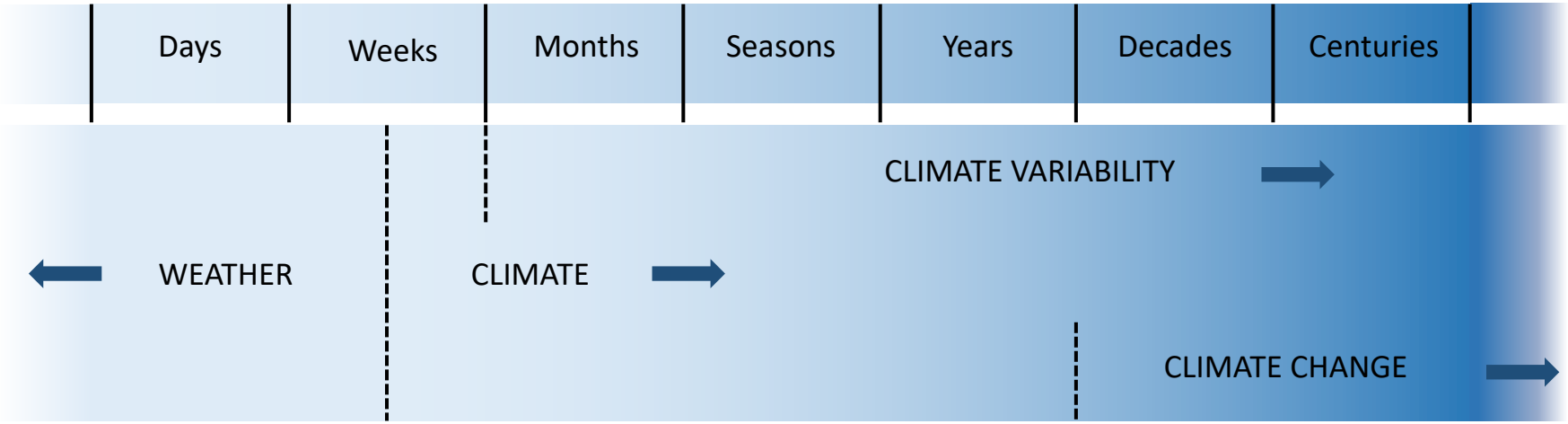
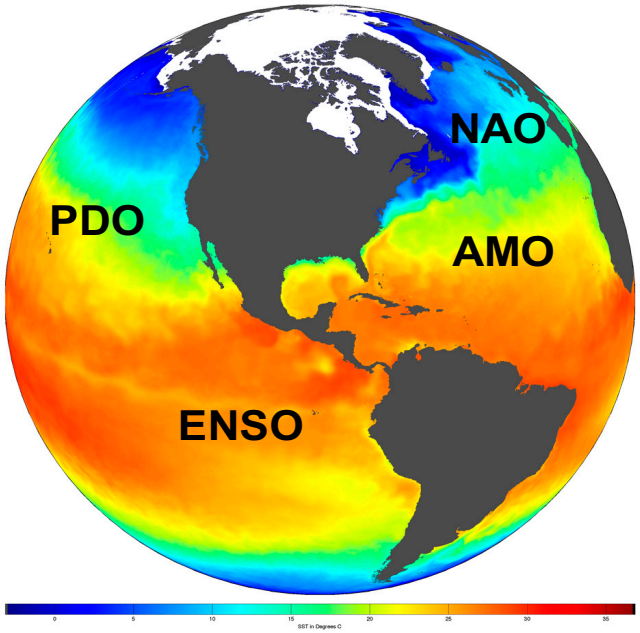
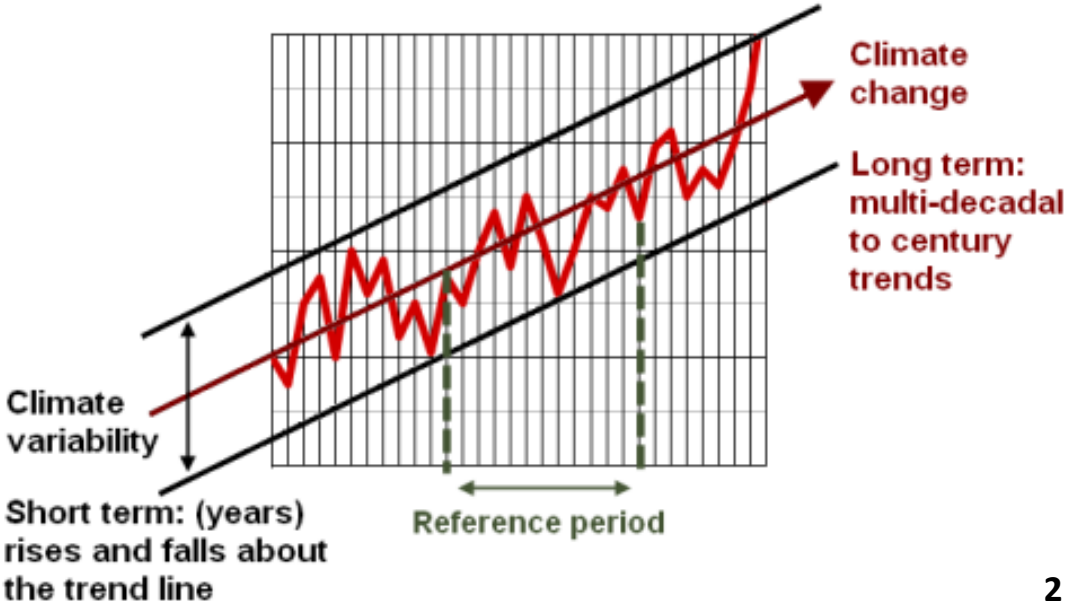
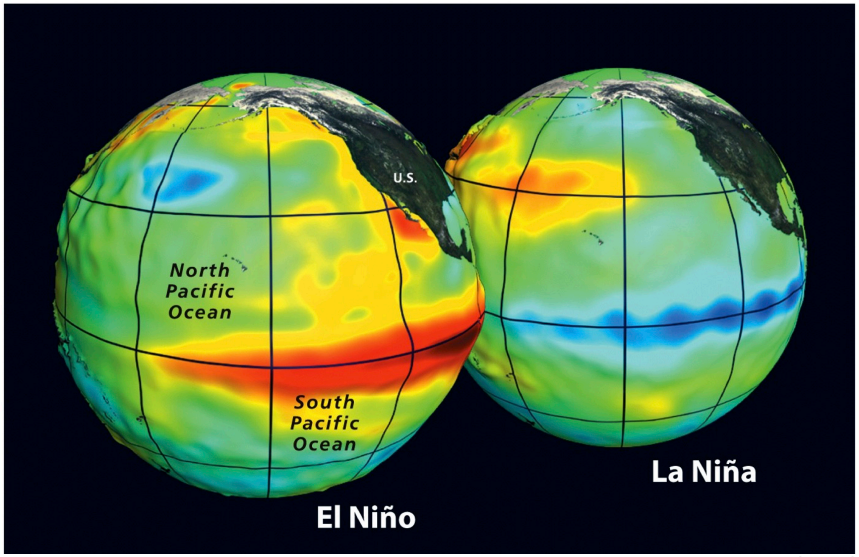
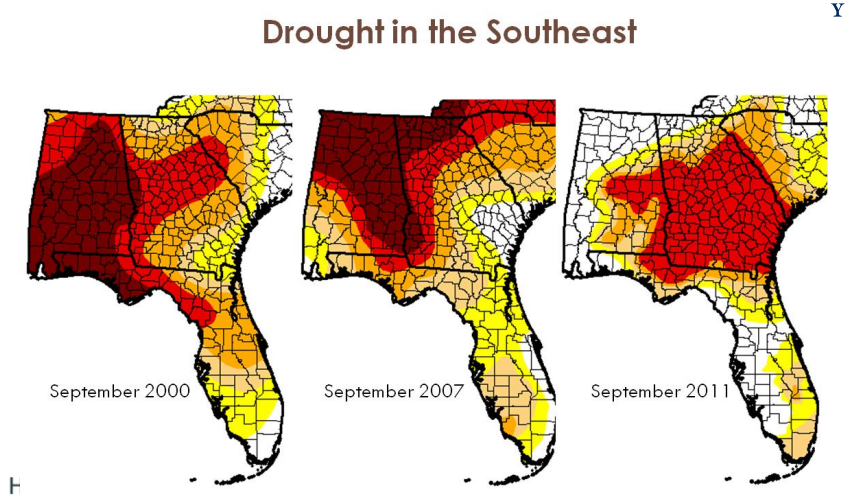




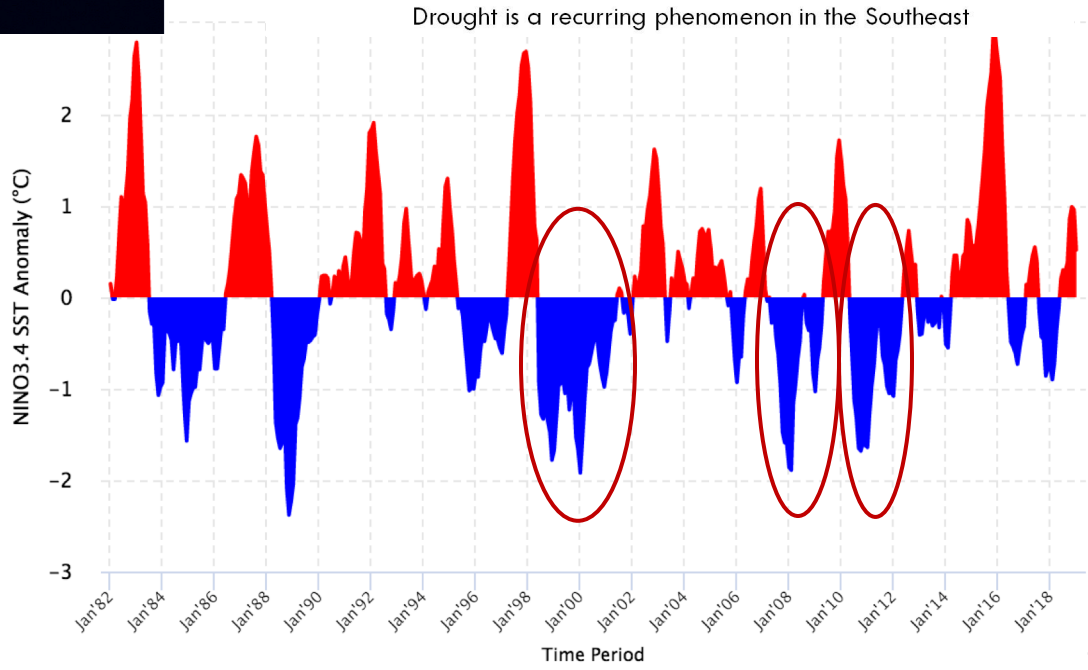


El Niño Southern Oscillation (ENSO)





PDO, AMO, and NAO can exacerbate the impact of ENSO



Examples of Drought Impacts on Water Resources

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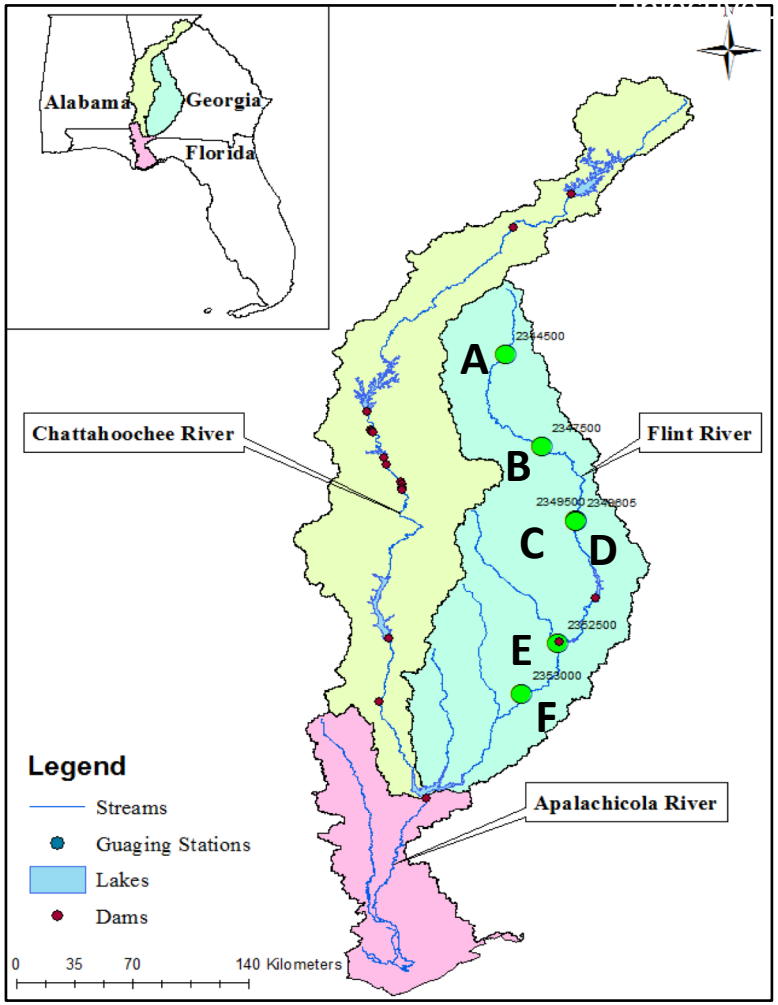
1. Baseflow response to climate variability induced droughts
2. Groundwater response to climate variability induced droughts
3. Drought risks for small- to mid-size communities and how to reduce it
4. Retrospective and Future Droughts in the Southeast (Past Climate and Climate Change)

Baseflow response to climate variability induced droughts

Baseflow Data

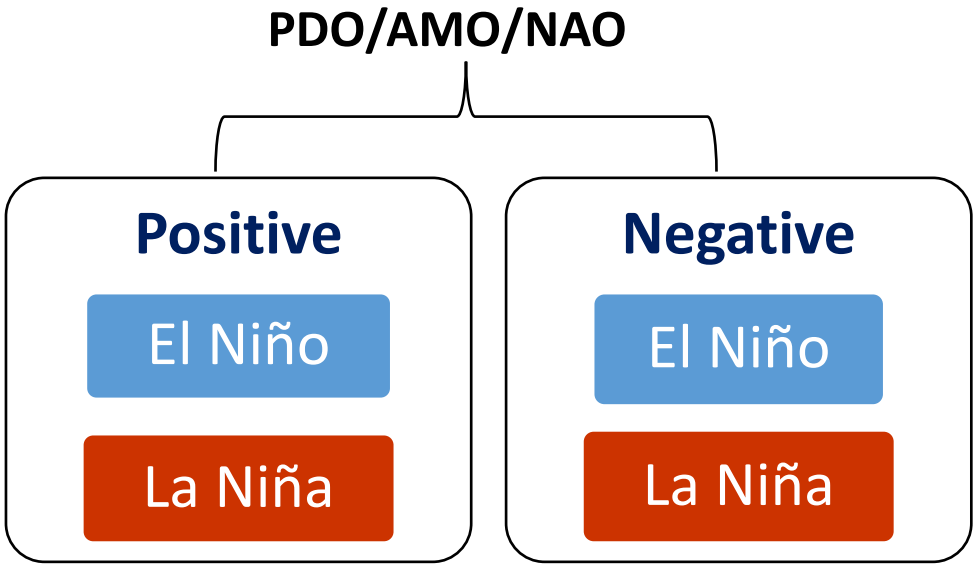
- Six unregulated streamflow gauging stations in the Apalachicola-Chattahoochee-Flint (ACF) River Basin were used

Station ID	Given Name	Data Range (Year)
02344500	A	1950-2008
02347500	B	1950-2008
02349500	C	1950-2003
02349605	D	1950-2008
02352500	E	1950-2008
02353000	F	1957-2008

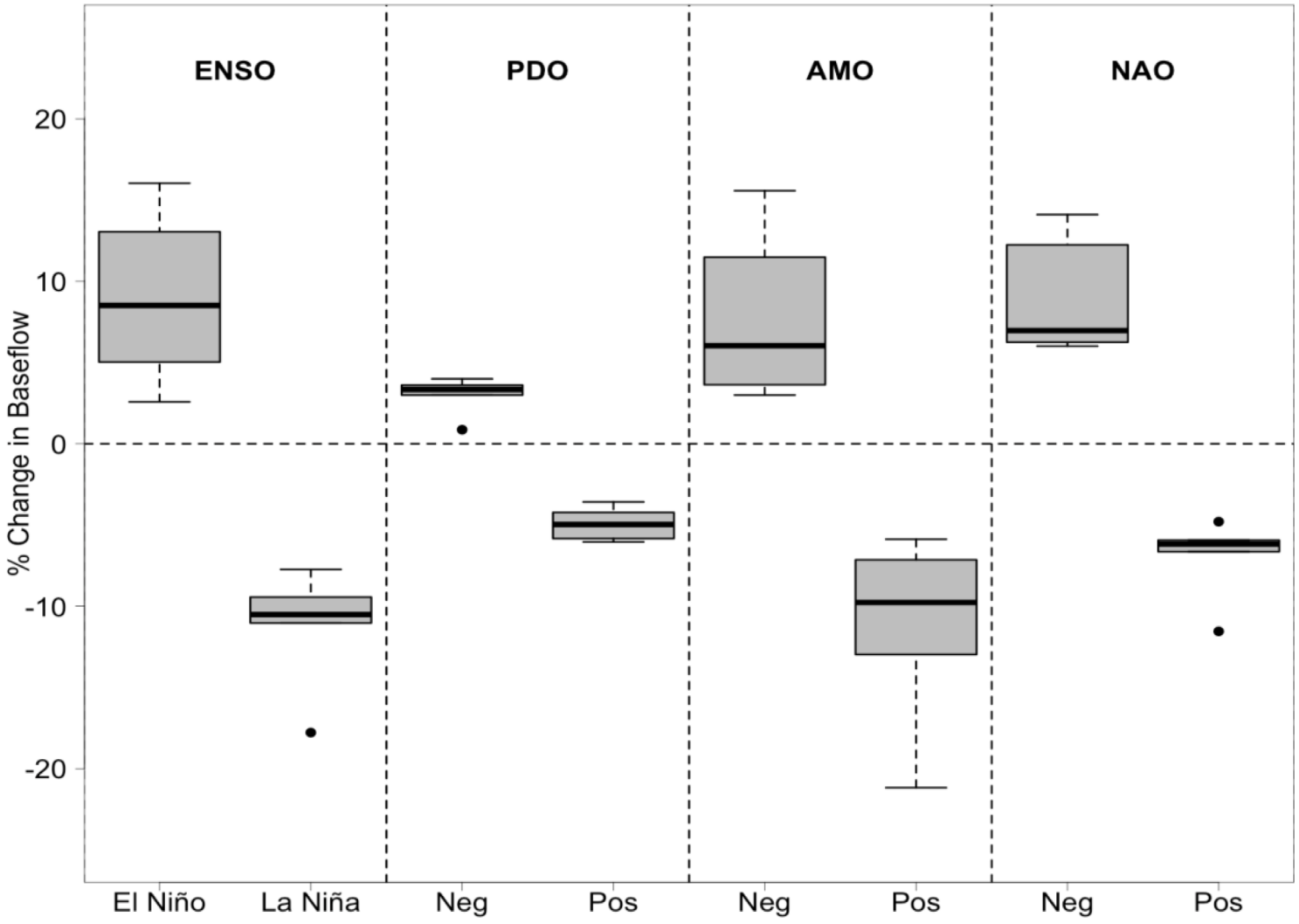


Objectives

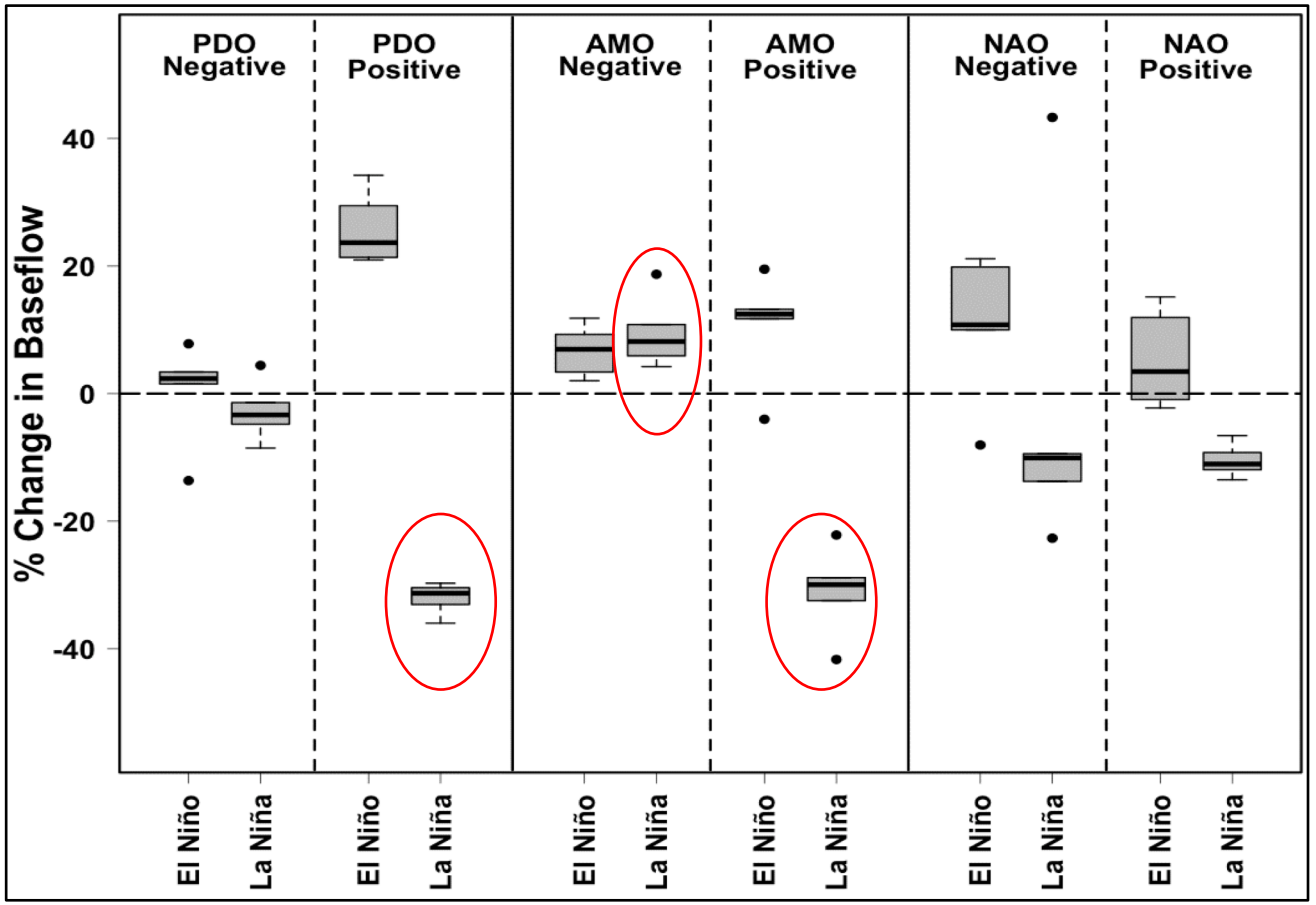
- Quantify individual impacts of climate variability cycles on baseflow (Individual Analysis).
- Quantify influence of PDO, AMO and NAO cycles on baseflows (Coupled Analysis).



Summary of Individual Analysis



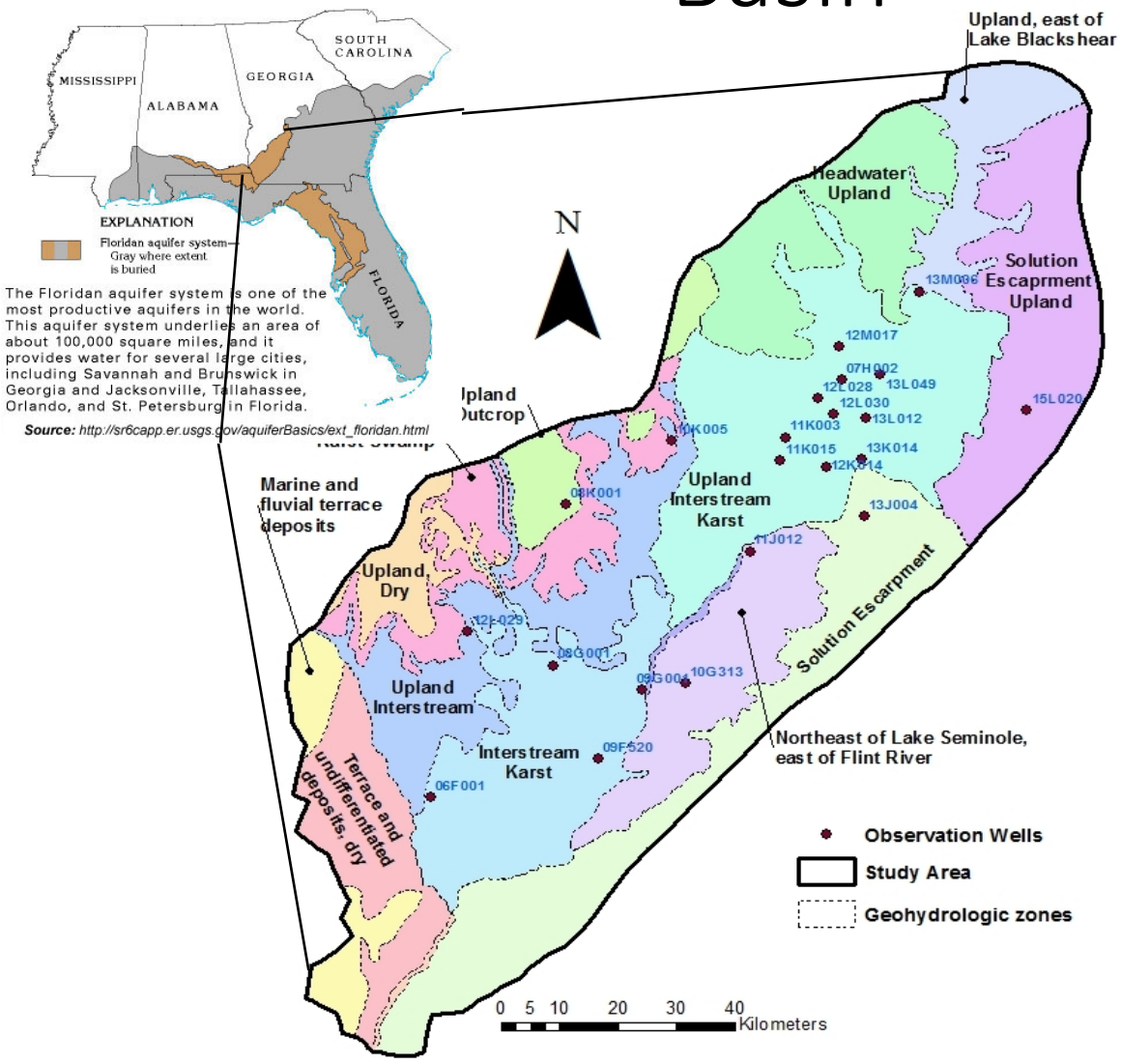
Summary of Coupled Analysis



- La Niña phase associated with positive phases of AMO and PDO are responsible for greater decrease in flow levels in the Flint River.

Groundwater response to climate variability induced droughts

Study Area in the Lower ACF River Basin

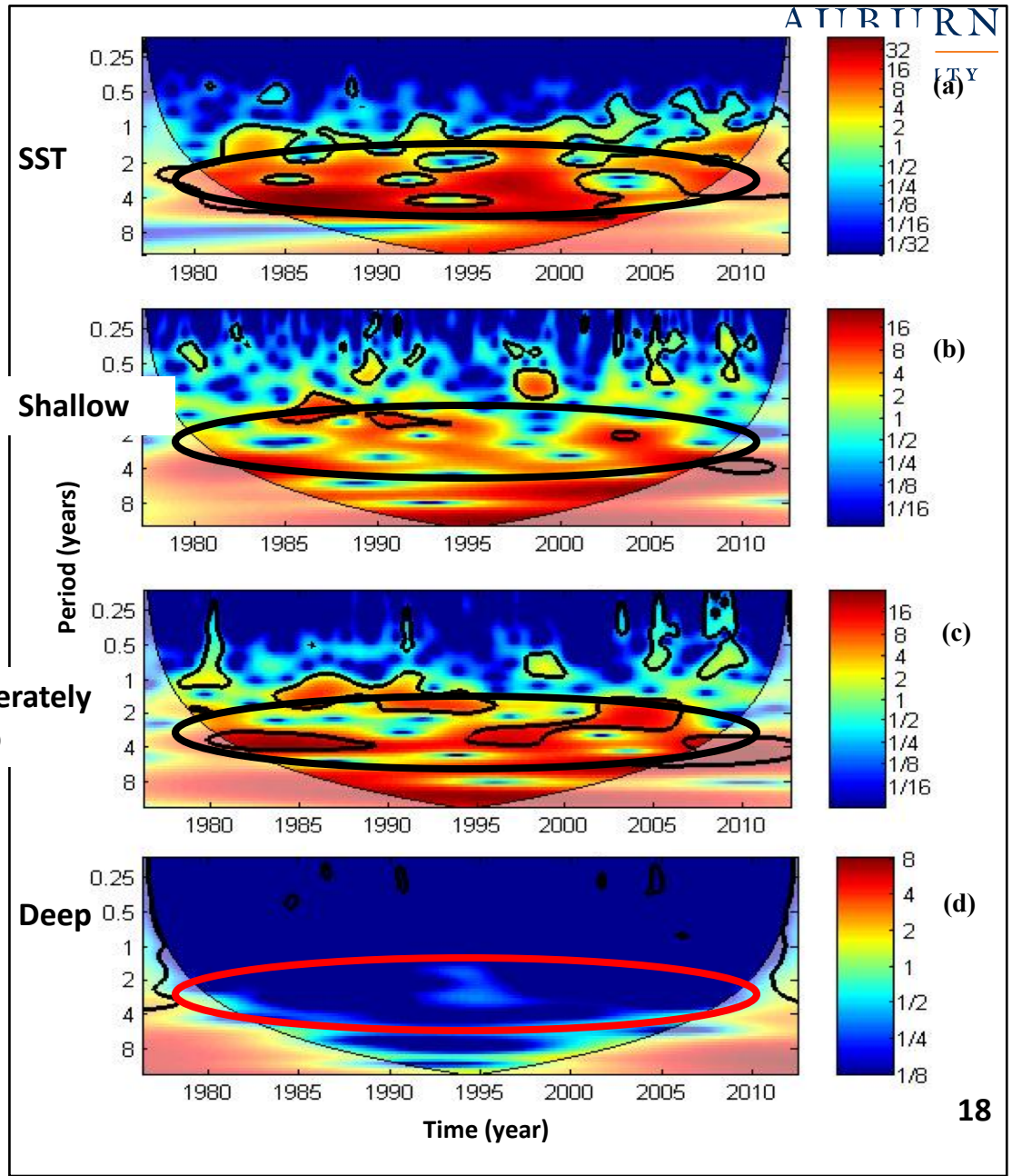


- Water withdrawal for irrigation during droughts threaten stream flows in the Lower Flint and its tributaries (affecting endangered mussel species)
- About 4632 mi^2 of land area contributing surface and groundwater to the Upper Floridan Aquifer (UFA).

Results

Continuous Wavelet Spectra

- Well under shallow and moderately deep overburden conditions showed regions of high power, though not statistically significant, in the ENSO periodicity of 2-7 years
- Well under deep overburden did not exhibit any areas with high power.



Results

Well-ID	El Niño (ft)	La Niña (ft)	Diff (ft)	P (<0.05)
06F001	1.35	-3.96	5.30	0.00
10G313	0.72	-2.82	3.54	0.00
08G001	3.66	-5.50	9.16	0.00
08K001	5.74	-2.42	8.16	0.00
11K003	3.35	-1.52	4.87	0.00
12L030	2.33	-2	4.88	0.00
12L028	1.76		4.96	0.00
13L049	2.89	-3.68	6.57	0.00
13M006	3.24	-1.62	4.86	0.00
07H002	3.79	-2.76	6.56	0.00
12L029	1.82	-2.24	4.07	0.00
11K015	0.36	-2.03	2.39	0.00
15L020	0.60	-1.95	2.56	0.41
Median	**1.36**	**-2.02**	**3.66**	

Influence of La Niña

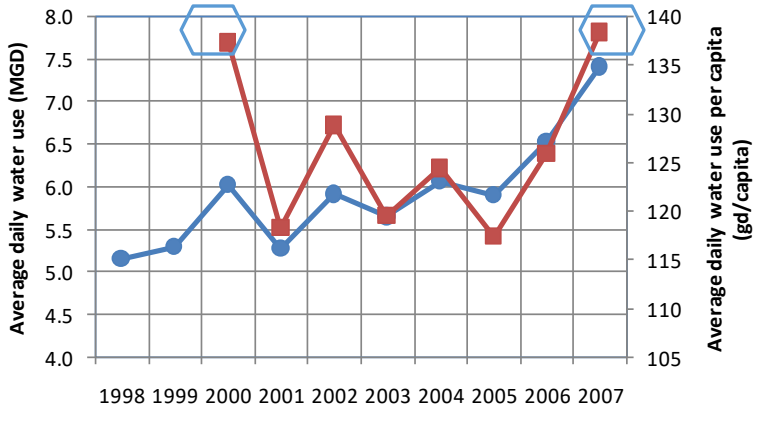
Well-ID	Year 2001	Year 1989
06F001	18	1
10G313	24	8
08G001	18	1
08K001	18	0
11K003	25	2
13L012		0
12L030		2
12L028	26	6
13	26	1
13M006	25	1
12L029	25	1
11K015	25	8
10K005	25	0
Mean	**22**	**2**

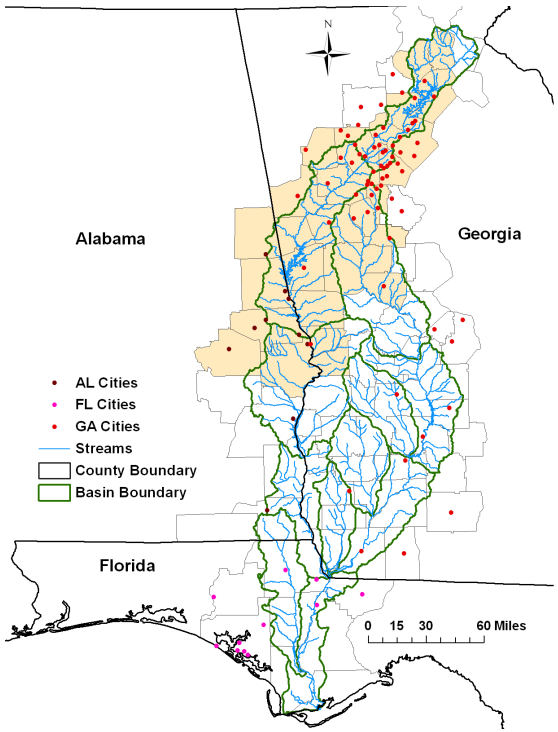
Recovery time (months)

Drought risks for small- to mid-size communities and how to reduce it

Climate Variability/Drought

- Small- to mid-size communities (pop. less than 100,000) are especially vulnerable to drought
- More than 75 such communities in and around the ACF River Basin
- Mainly depend on surface water sources
- Climate forecasts can help with water supply and demand balance
- Climate forecasts are not currently used in water management



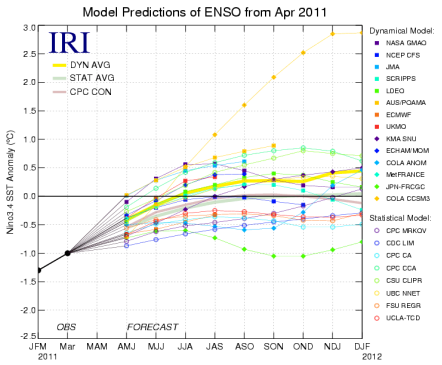


Objectives

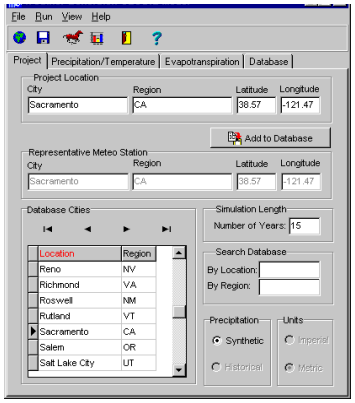
- Develop a drought index (CWDI) for forecasting drought for small- to mid-size communities of the Southeast United States using the ENSO forecast, and

- Evaluate the value of the developed index for water resource managers of the region.

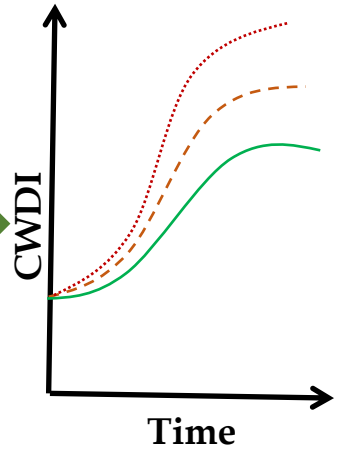
Drought Forecasting



ENSO Outlook and Climate Variables



CWDI Model (STELLA)



Case Study – City of Auburn

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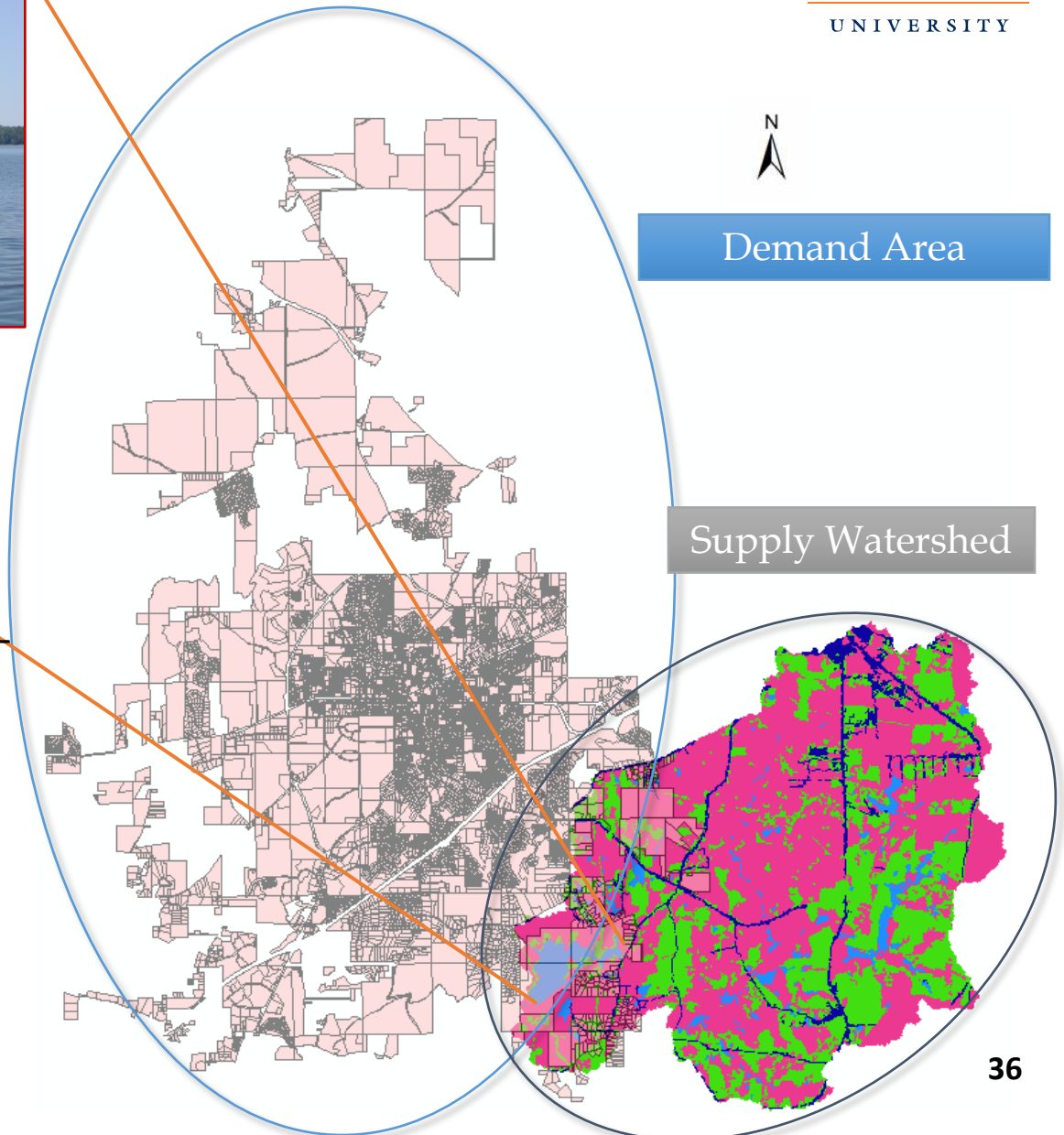
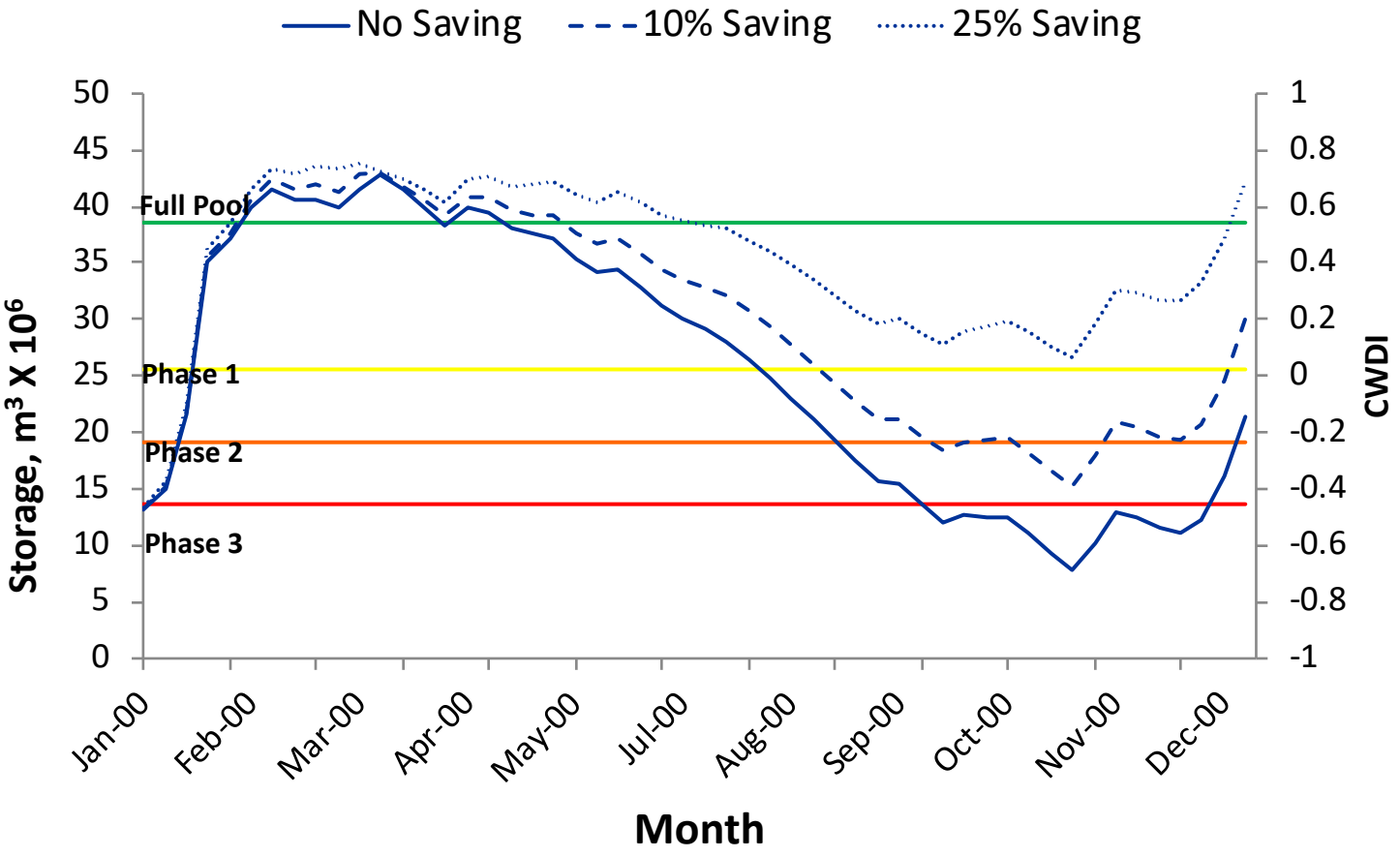
Lake Ogletree



- Current average usage for the water system - 6 MGD
- Current water supply capacity - 11.6 MGD
- Can purchase up to 3.6 MGD from Opelika (used only at certain times during the year)

Scenario Analysis



CWDI – used to plan restrictions/conservation policies

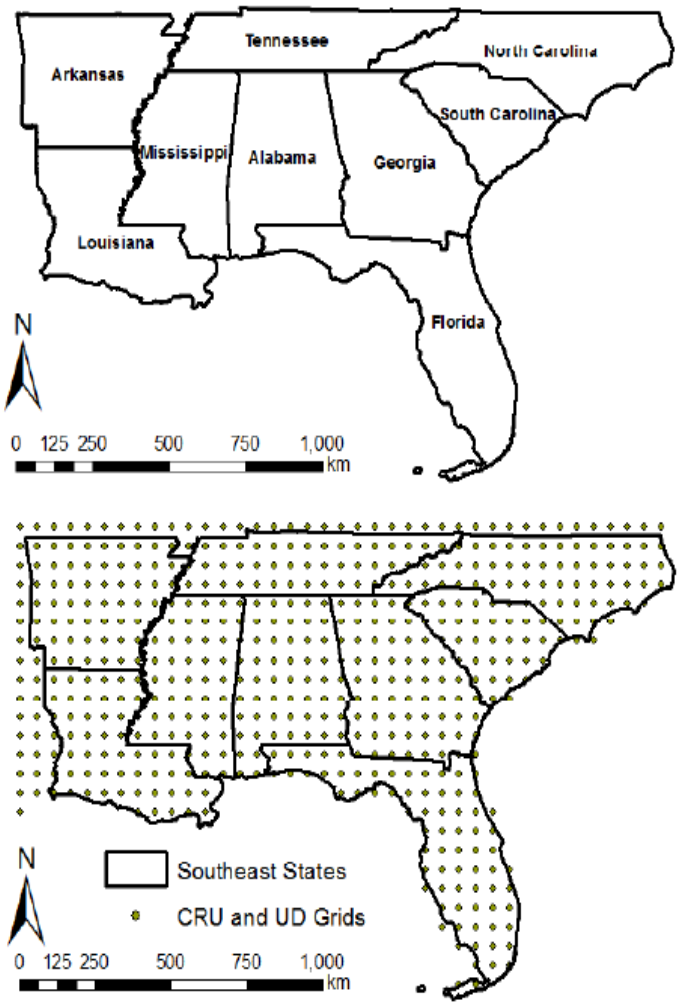
Value of CWDI-forecasted Drought

- Model runs for drought years suggest that CWDI forecasts and subsequently water use restrictions would have
  - helped reduce outdoor water use demand as compared to observed use
  - Auburn would have saved $1.2 million and $0.5 million during winter to summer months in two different drought years
- **Manuscript received Superior Paper Award from the American Society of Agricultural and Biological Engineers (ASABE)**

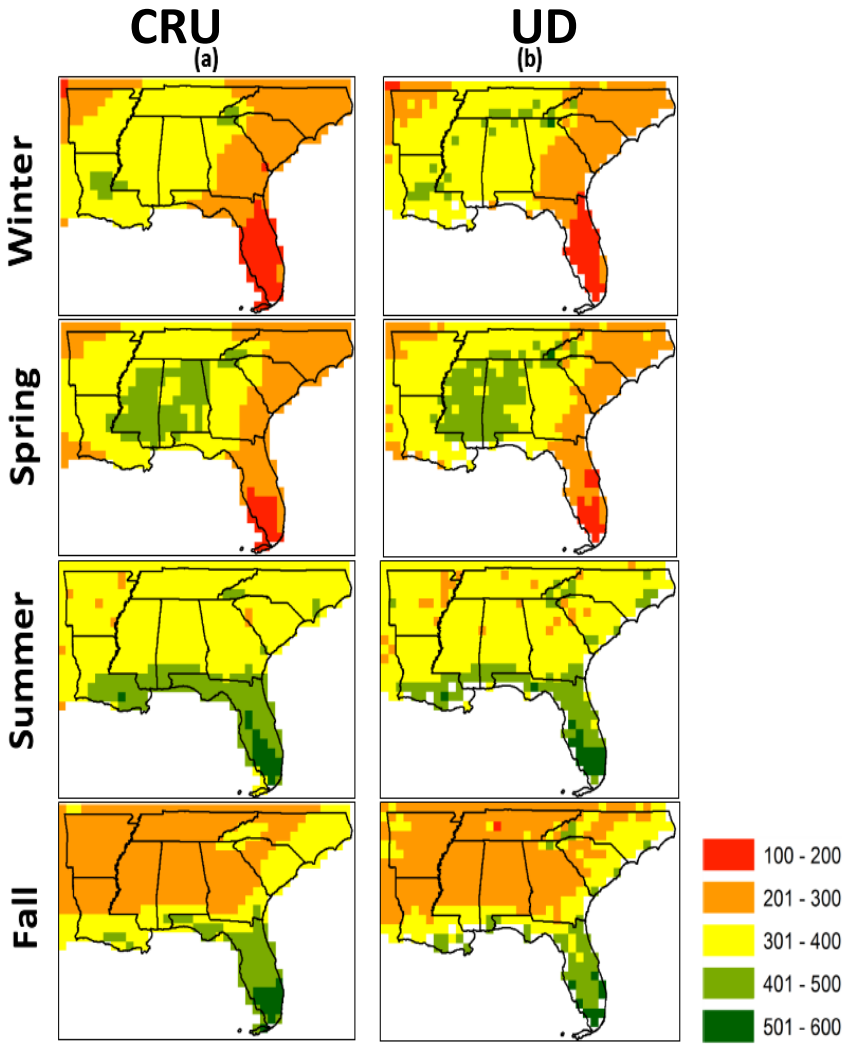
Retrospective and Future Droughts in the Southeast

Climatology

Climatology



Precipitation (mm)



Past Droughts

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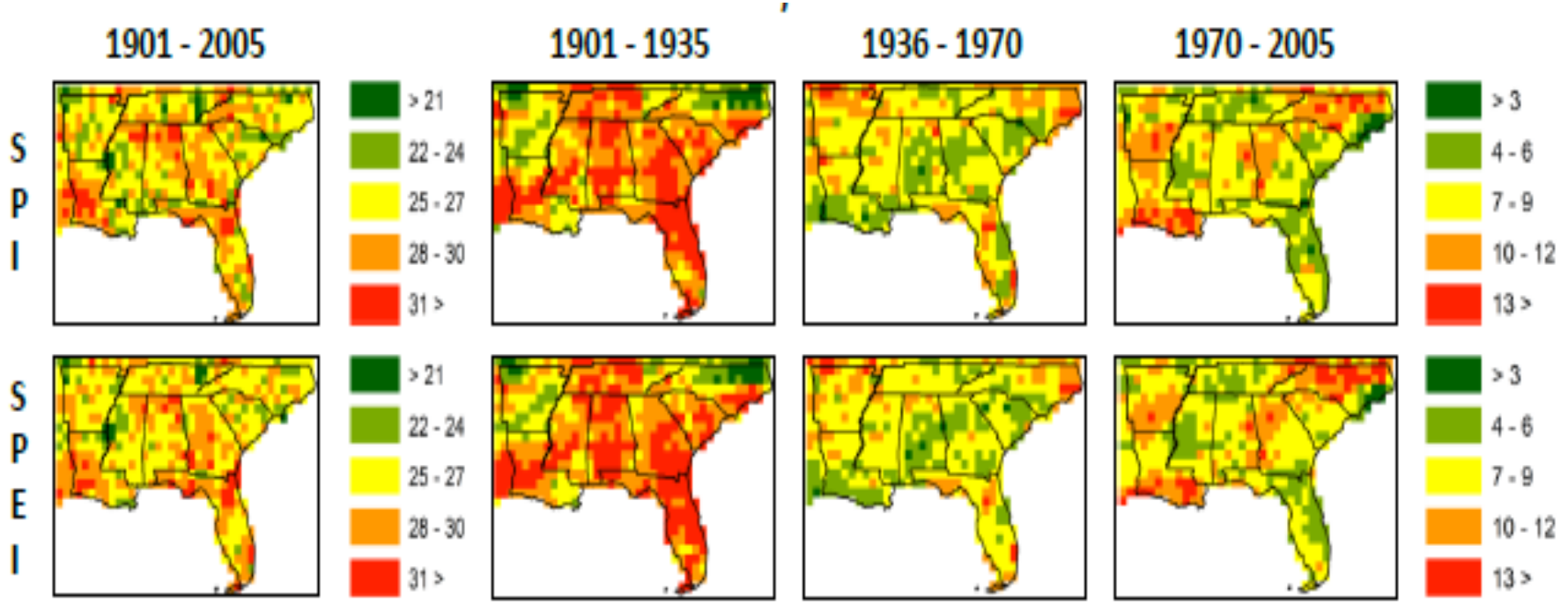
Drought Severity
Winter-Spring Season



Past Droughts

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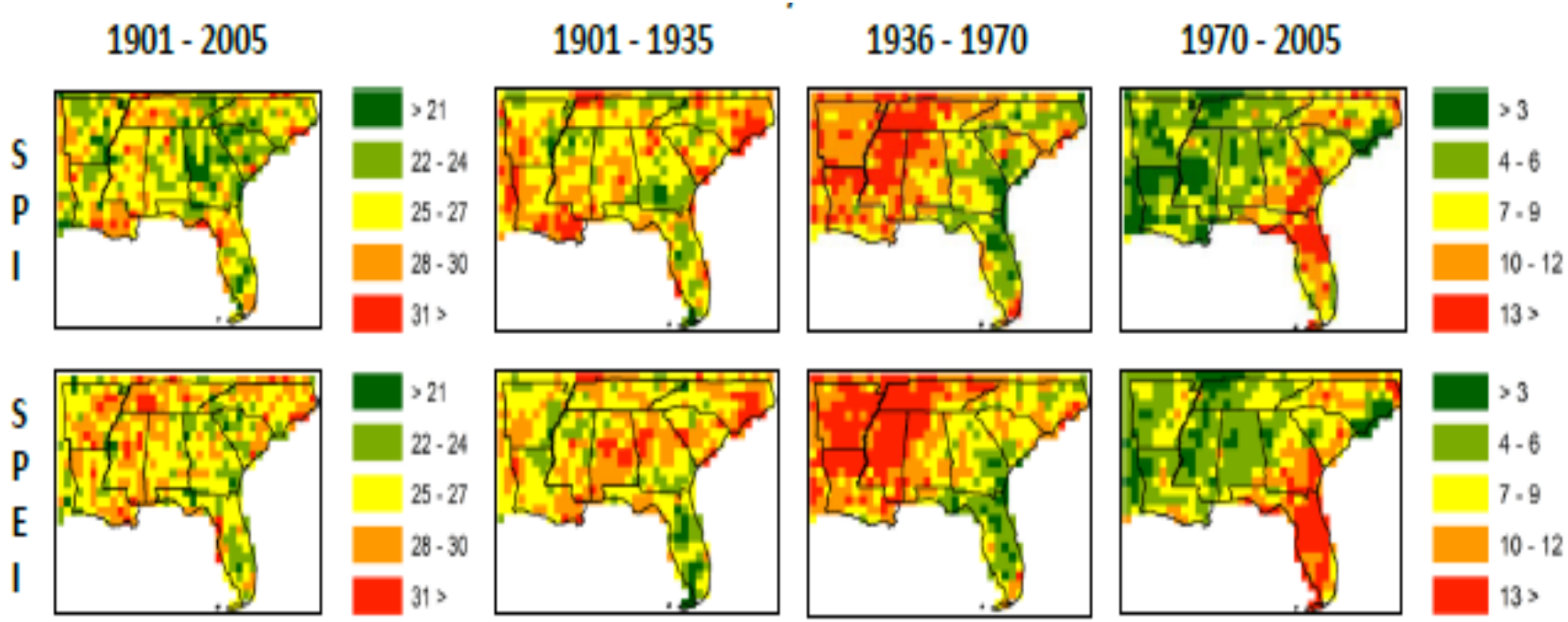
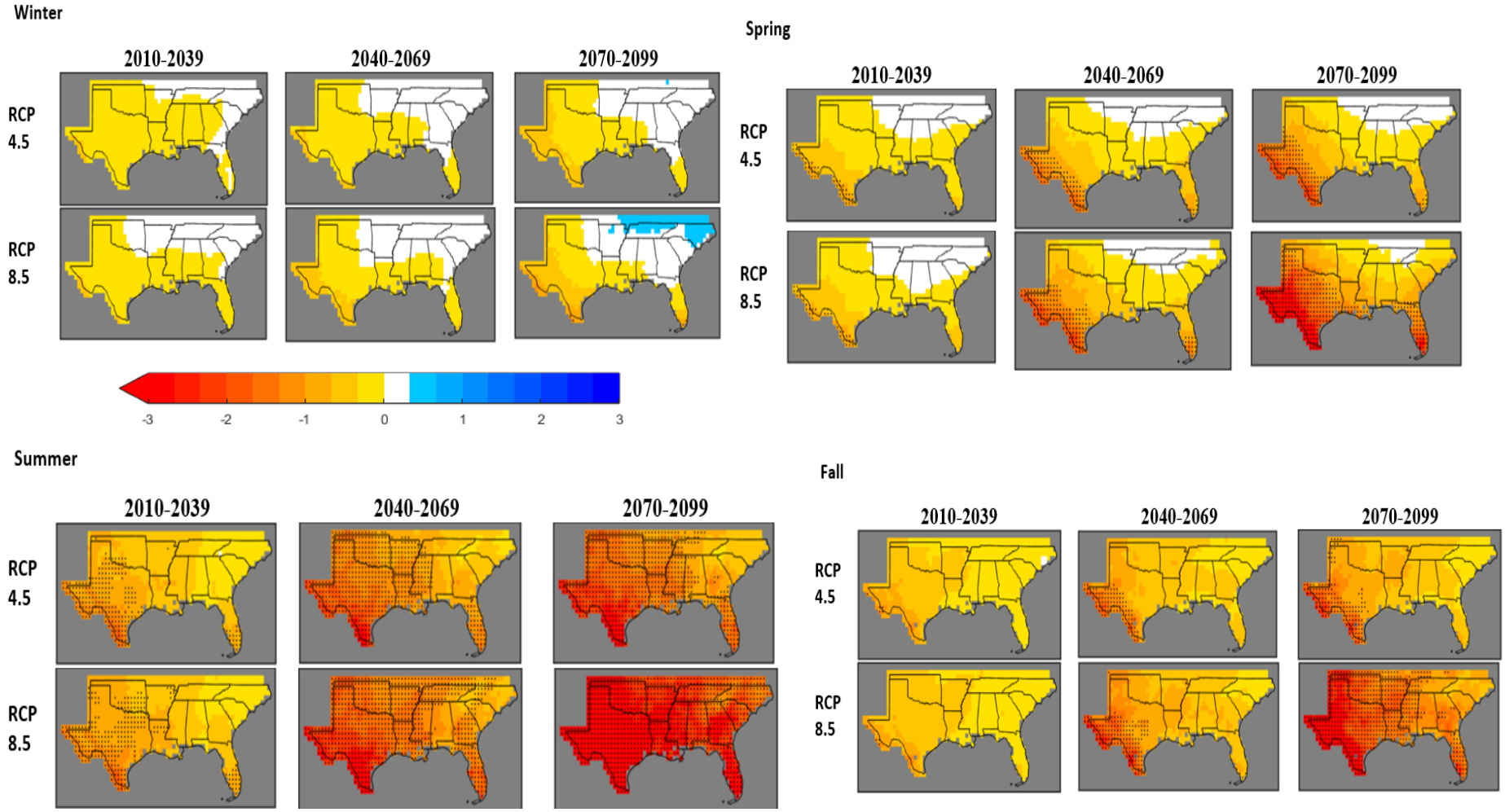
Drought Severity
Summer-Fall Season



Future Droughts

Standardized Precipitation Evapotranspiration Index (SPEI)



Conclusions

Future Droughts

- Future increases in temperature and evapotranspiration will outstrip increases in precipitation and significantly affect future droughts over the study domain.
- Drought risks are higher for this region according to SPEI based analysis which also considers the effects of rising temperatures and evapotranspiration.
- The entire study domain is projected to experience greater drought intensities, frequency and durations based on SPEI.

ACF River Basin Drought Early Warning Webinars

Monthly webinars (bi-weekly during drought) conducted by Auburn/SECC continuously since 2011 (8+ years).

Presenters

- State climatologists (Florida, Georgia, Alabama)
- USGS South Atlantic Water Science Center
- Southeast River Forecast Center
- Army Corps of Engineers
- Apalachicola National Estuarine Research Reserve
- University of Alabama-Huntsville

ACF River Basin Drought Early Warning Webinars

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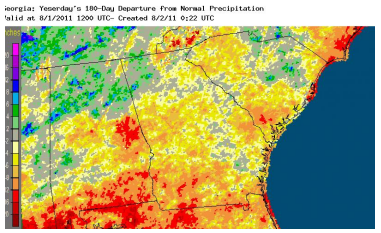
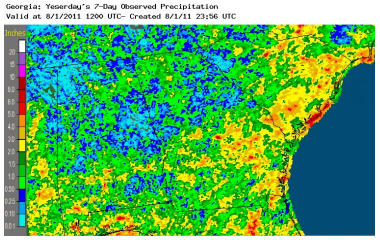
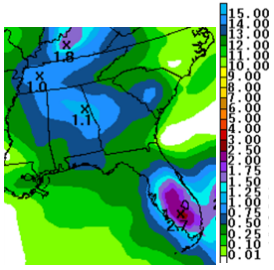


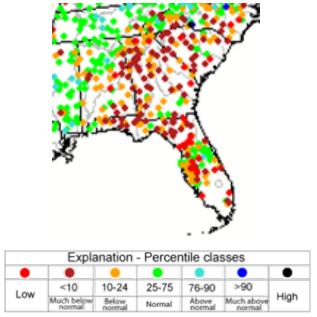
(a) 180-day cumulative rainfall deficit (yellow and red colors show deficit)



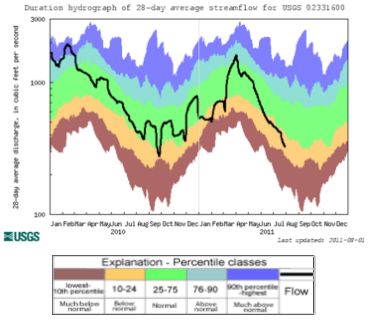
(b) 7-day cumulative rainfall totals



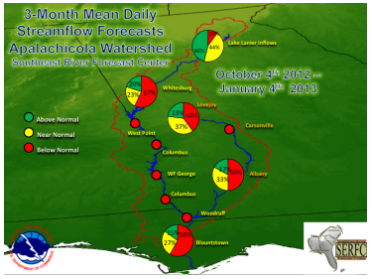
(c) 5-day precipitation forecast



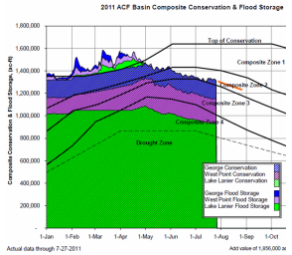
(d) Real-time streamflows compared to historical average



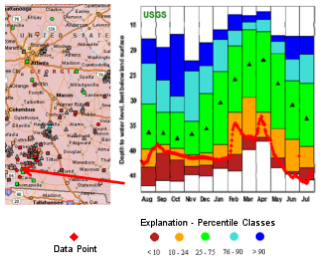
(e) Lake inflows (black line) with percentile classes (colored areas)



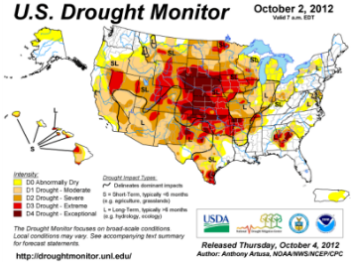
(f) 3-month streamflow forecast (red dots represent below normal streamflows)



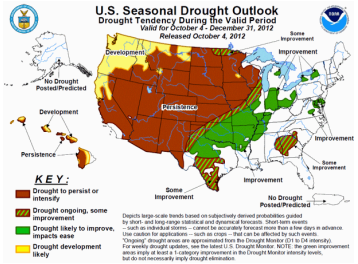
(g) ACF River Basin composite conservation and flood storage (of all major reservoirs)



(h) ACF River Basin groundwater status depicted by one representative groundwater well in southwest Georgia



(i) U.S. drought monitor



(j) U.S. seasonal drought outlook

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