The climate drivers of Florida's hydroclimate variations and change

Vasu Misra, Akhilesh Mishra, Amit Bhardwaj

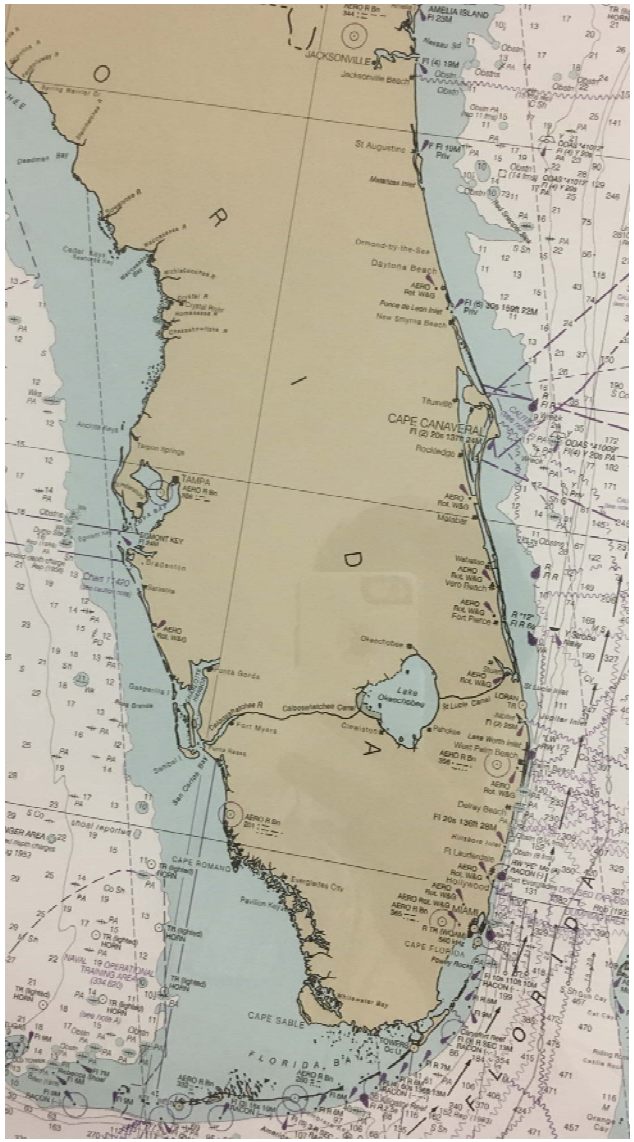
Dept. of Earth, Ocean and Atmospheric Science
Center for Ocean-Atmospheric Prediction Studies
Florida Water and Climate Alliance

June 8, 2016; FLMS

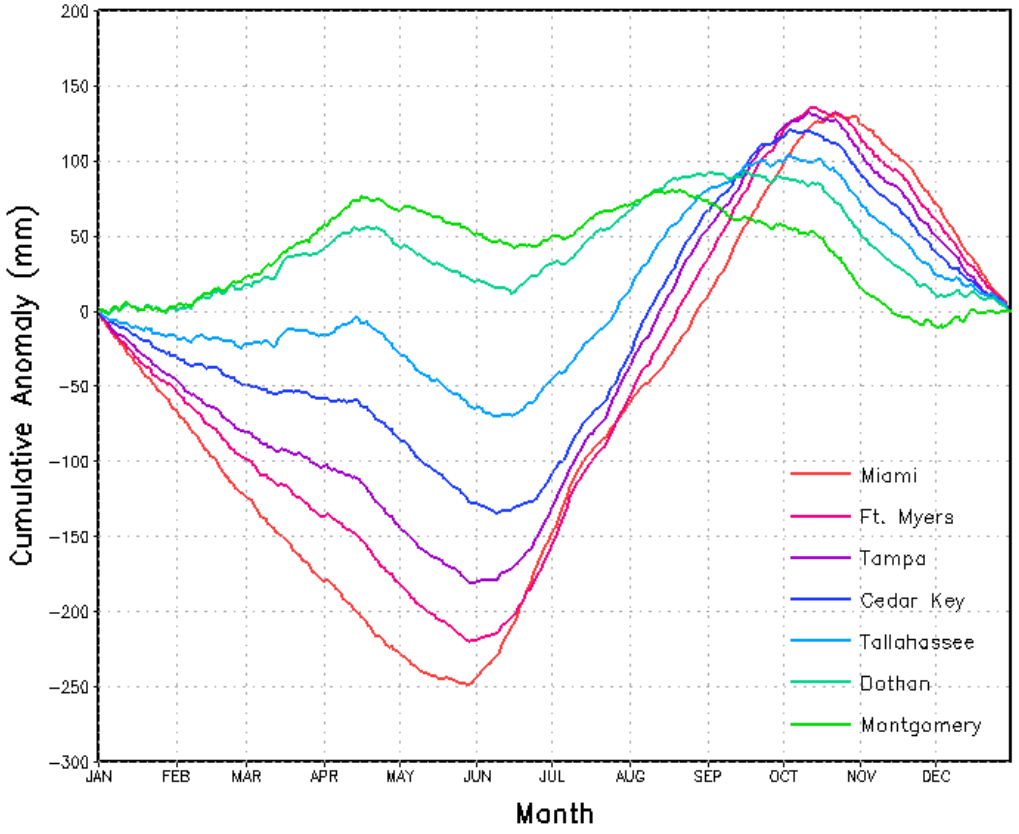
Drivers of Florida's hydro-climate

1. ENSO affects winter season (rain and temperature)
2. ENSO affects hurricane season
3. **But what is the role of the Atlantic, Gulf of Mexico, Caribbean Sea?**
4. Sea level changes is likely to affect
5. Remote changes in the Indo-Pacific Ocean could likely have an effect—Climate does not recognize political boundaries!
6. **Anthropogenic influence: land cover-land use change**, GHG concentration, etc.

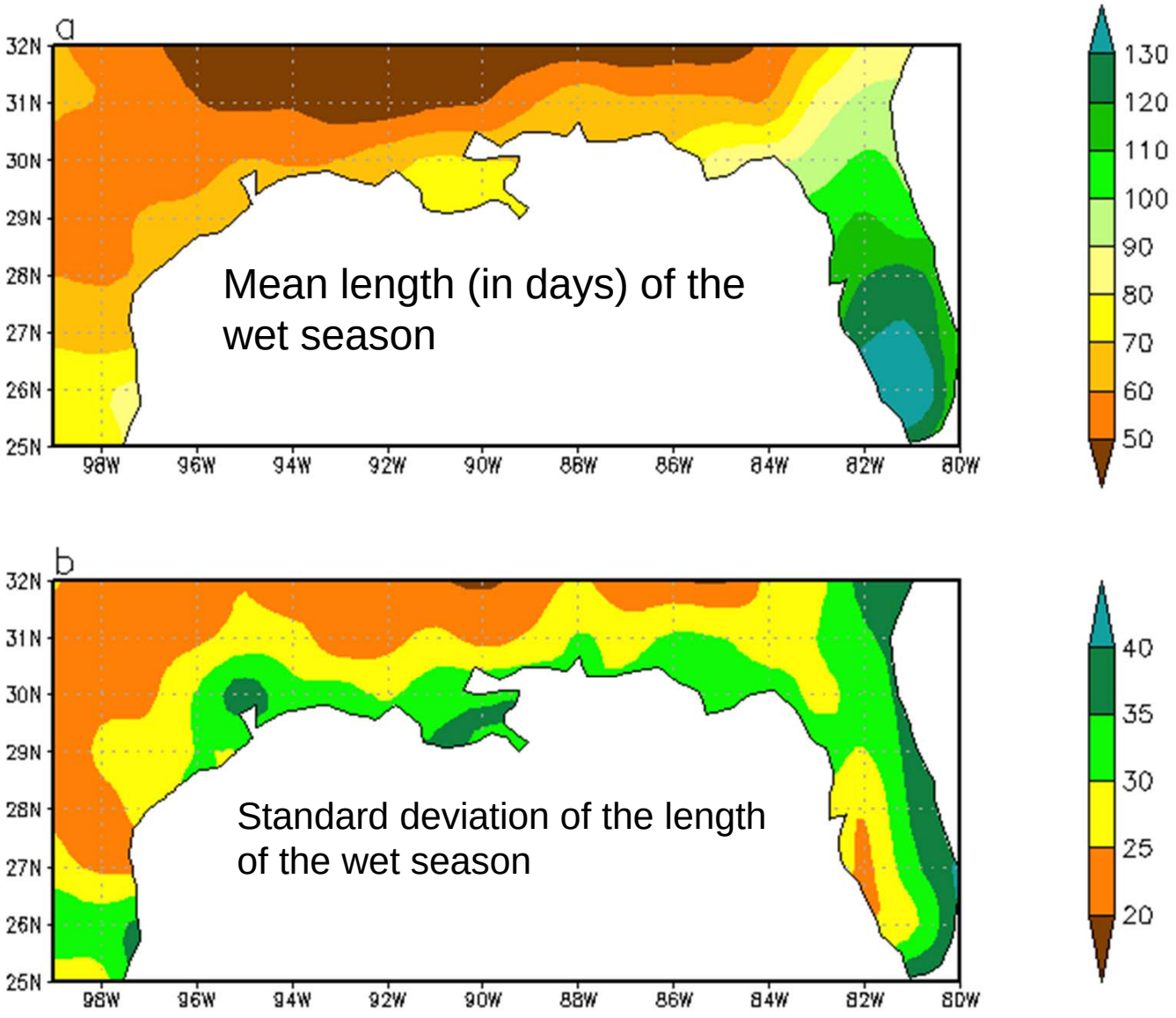
Florida



Florida has Monsoon like wet season

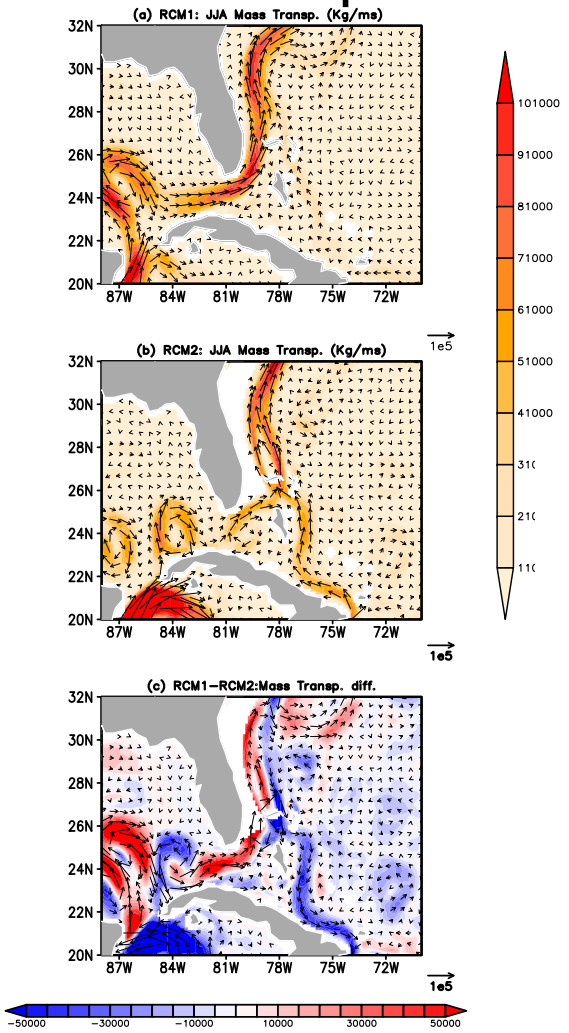


The wet season length

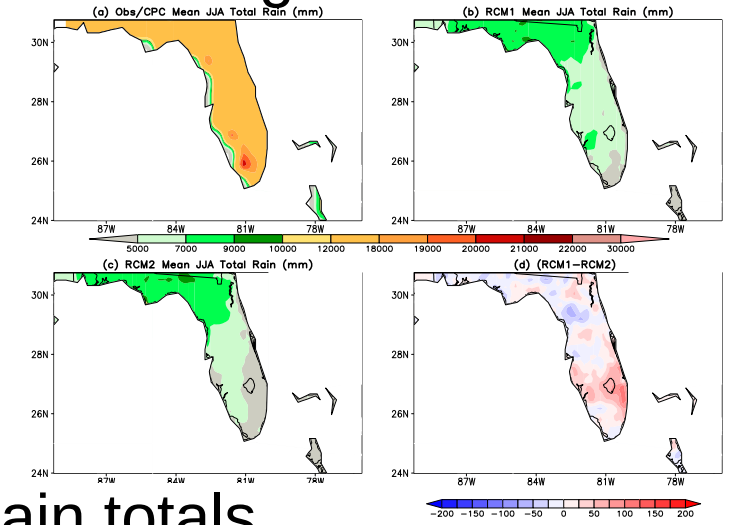


Numerical model experiments

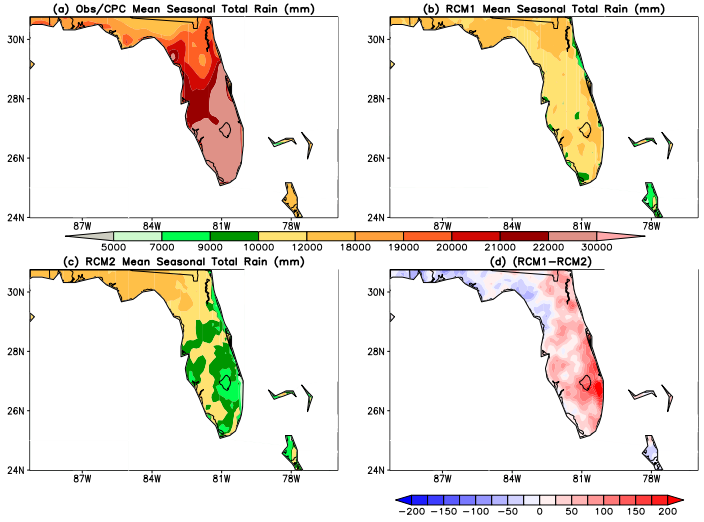
Heat transport



Jun-Aug rain totals

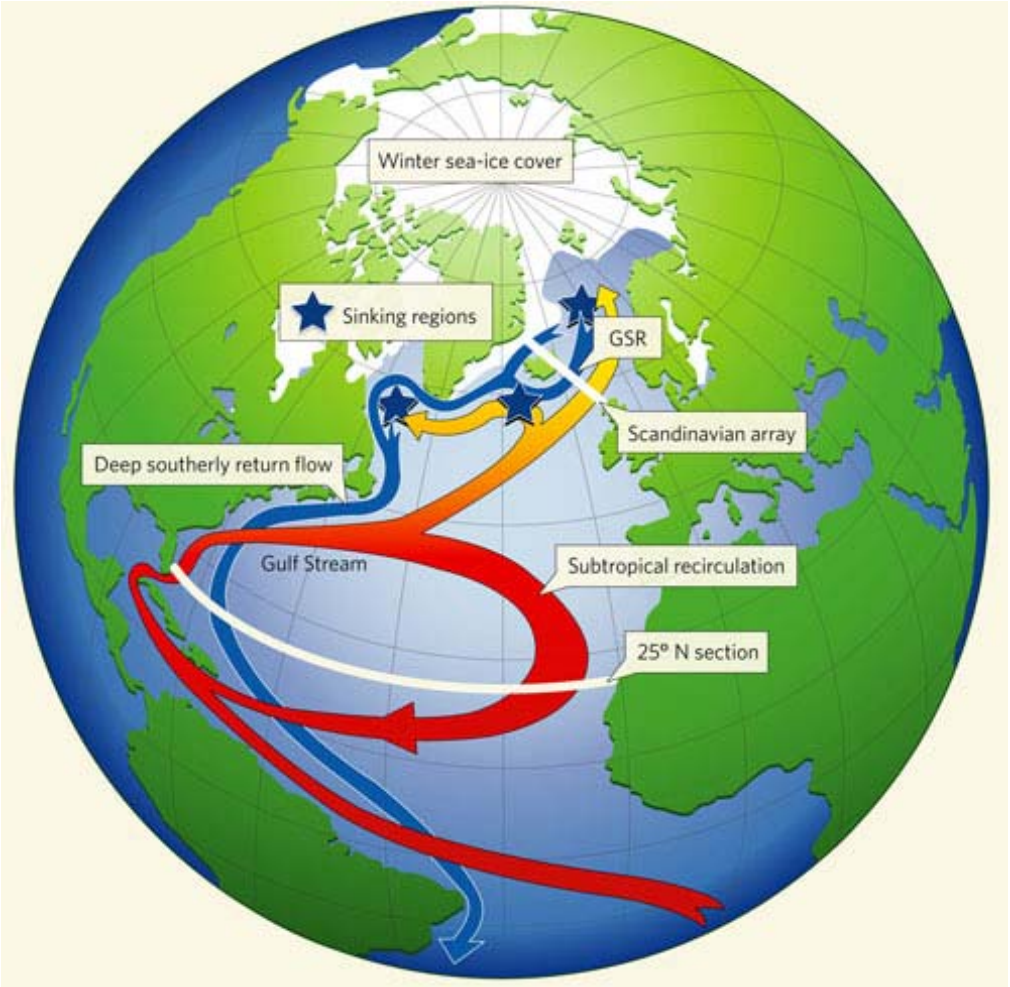


Wet season rain totals



Neighboring ocean heat transport has important bearing on Florida's hydroclimate

Atlantic meridional overturning circulation



Day after tomorrow

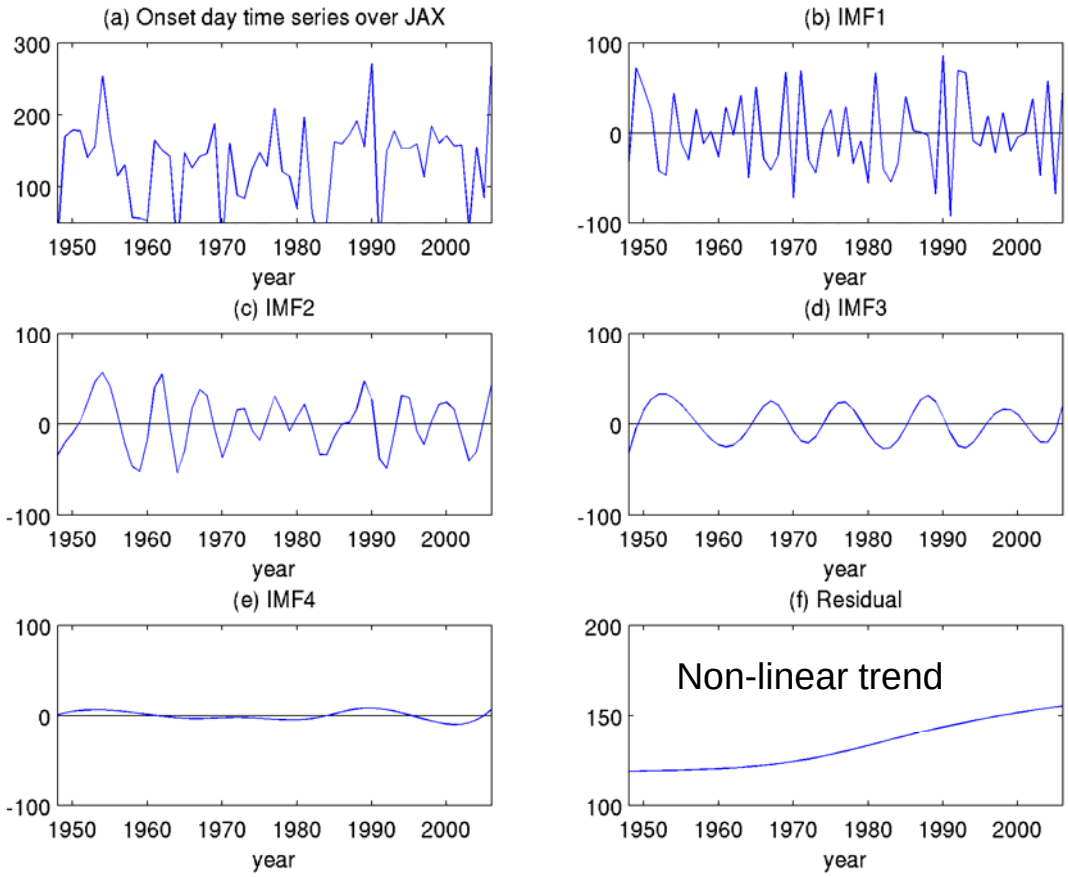
If the higher latitudes were to glaciate then Florida's distinct wet season is likely to disappear!

Summary

Ocean circulation in the neighboring oceans are important for summer season rain over Florida.

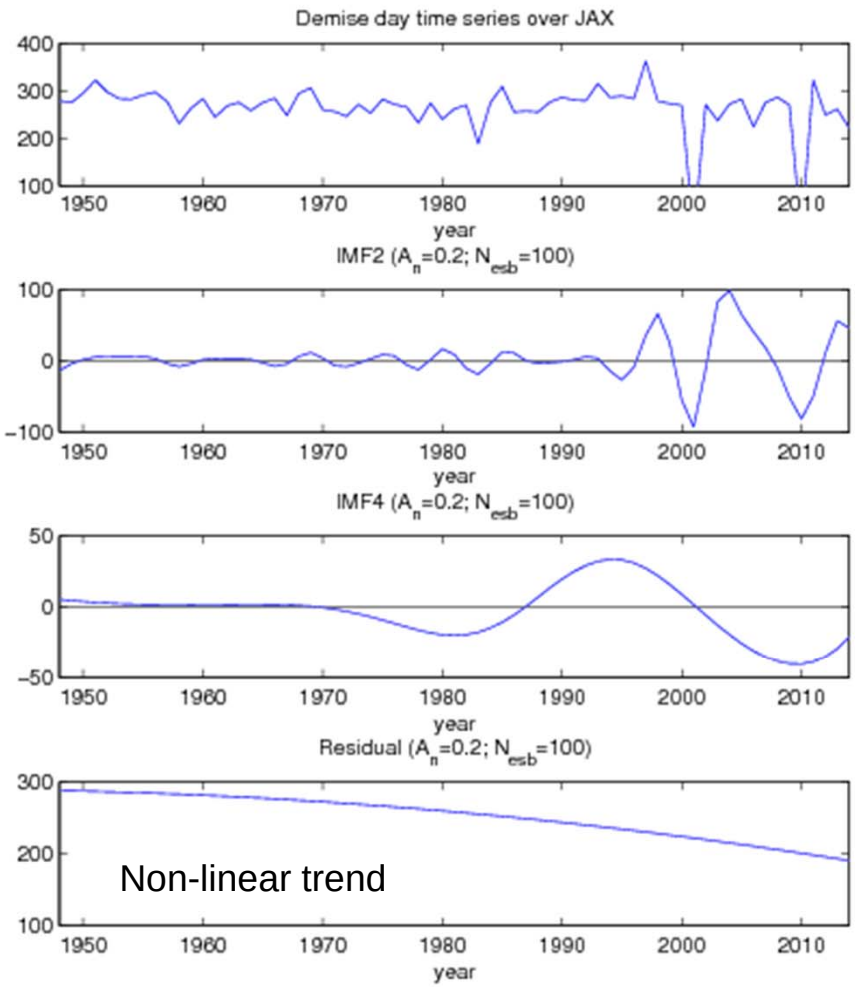
Impact of land cover and land-use changes on Florida's hydroclimate

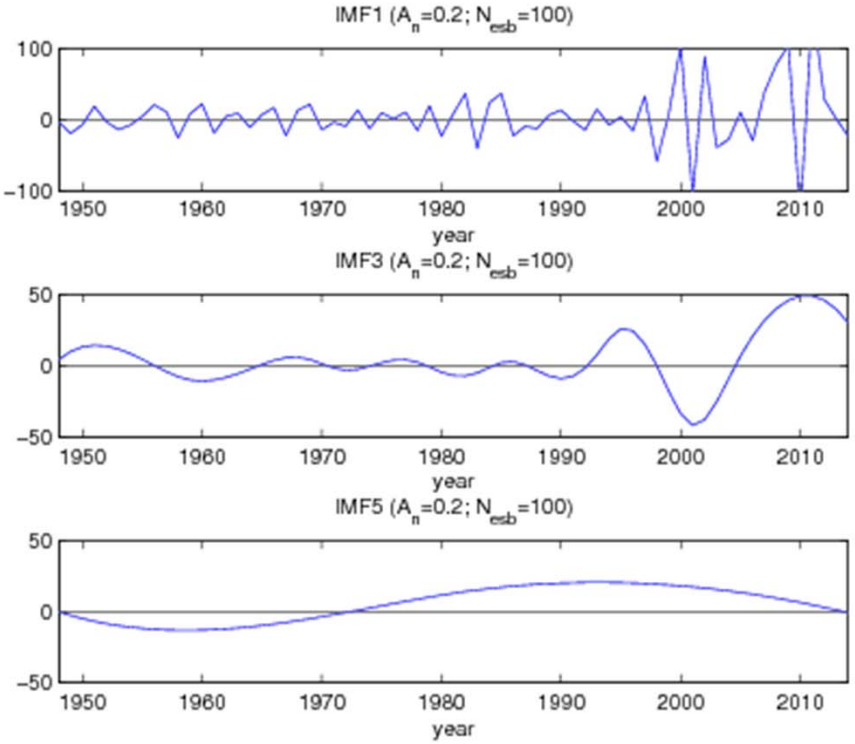
Time series decomposition



Decomposition of the time series of onset date of wet season over Jacksonville

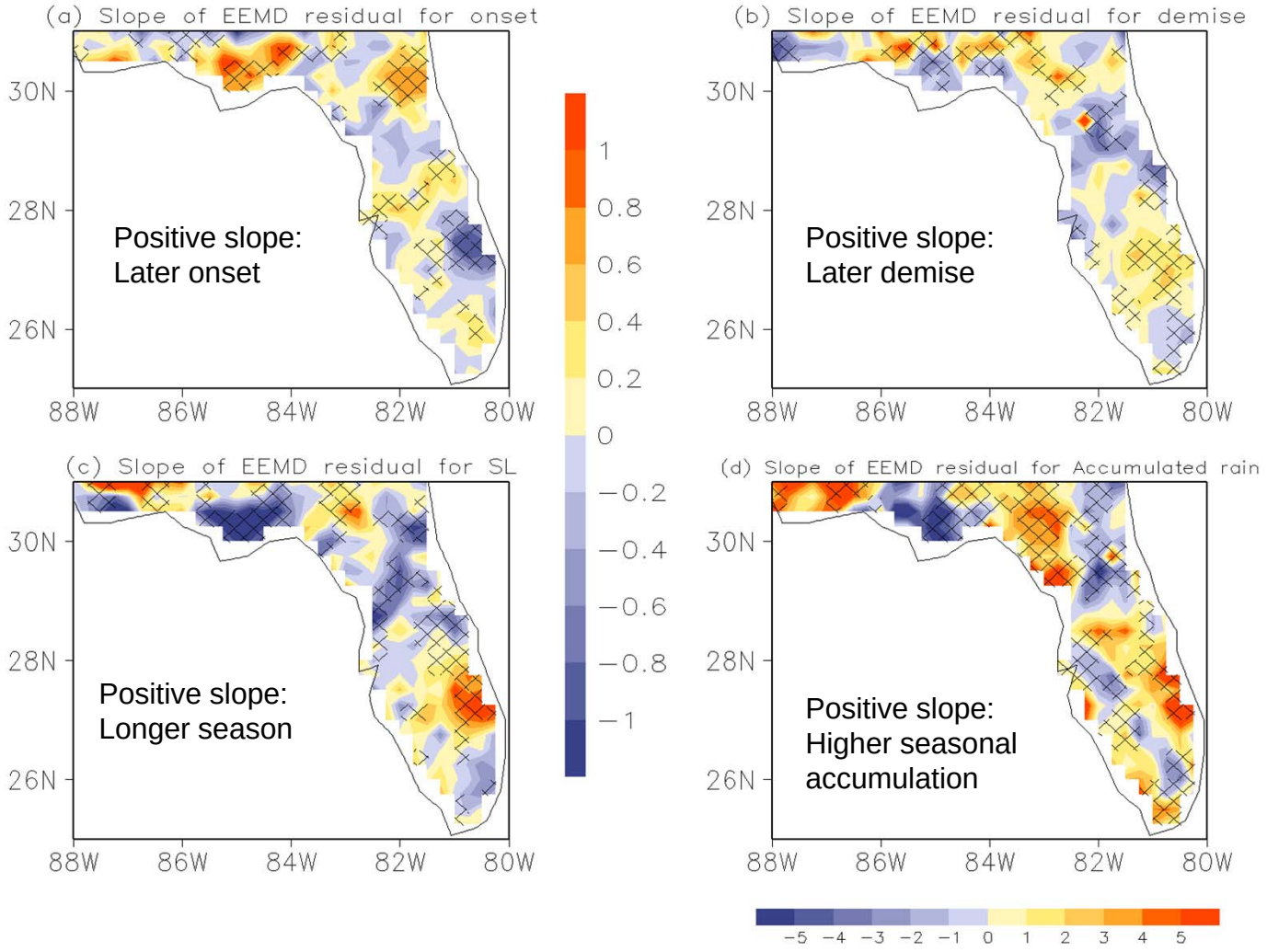
Time series decomposition



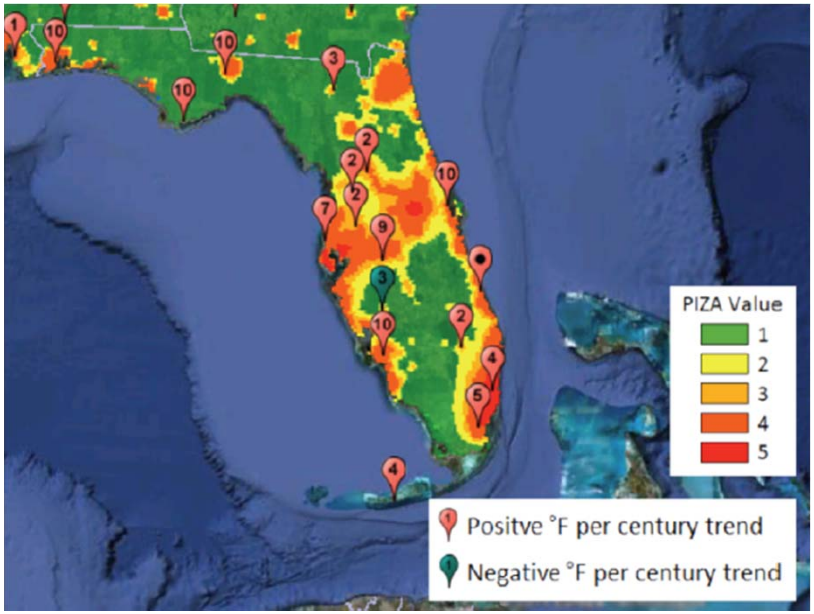


Decomposition of the time series of demise date of wet season over Jacksonville

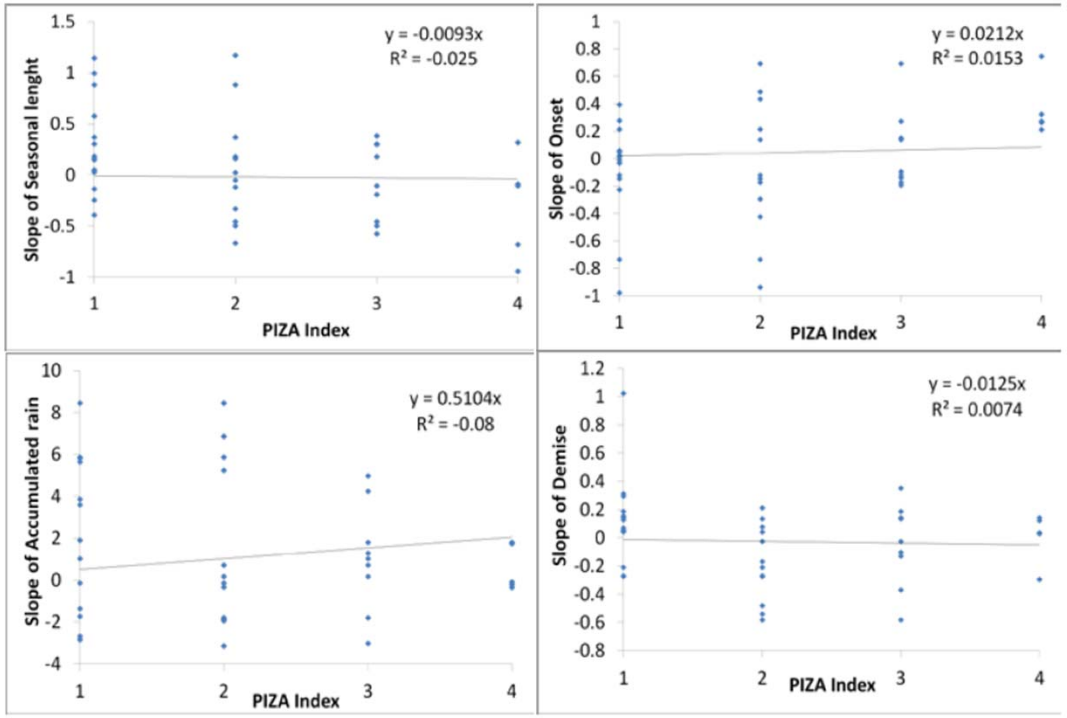
Slope of the linear trend



Relation with urban land cover

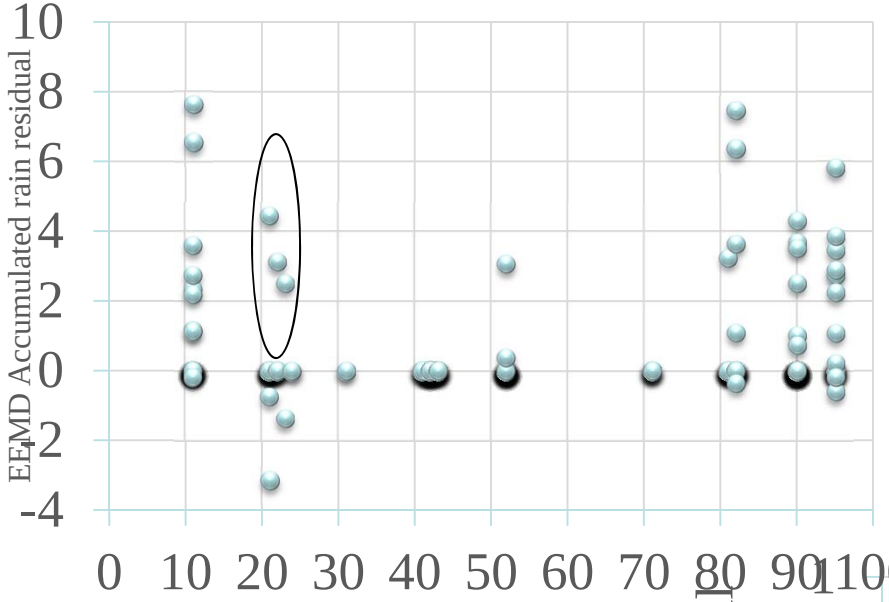


PIZA: Population Interaction Zone with Agriculture

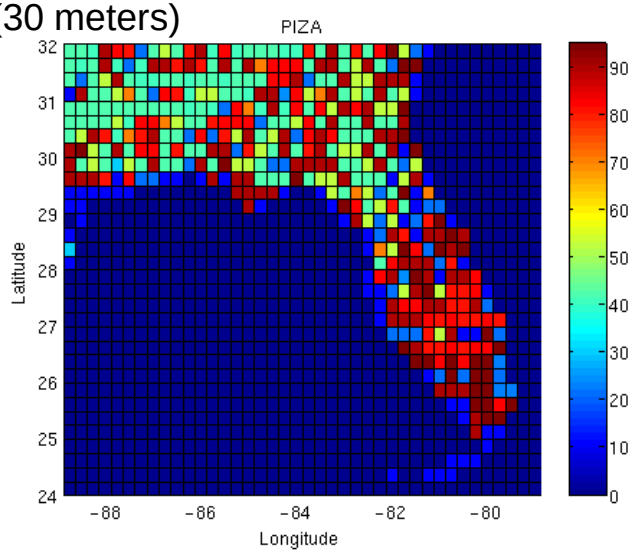


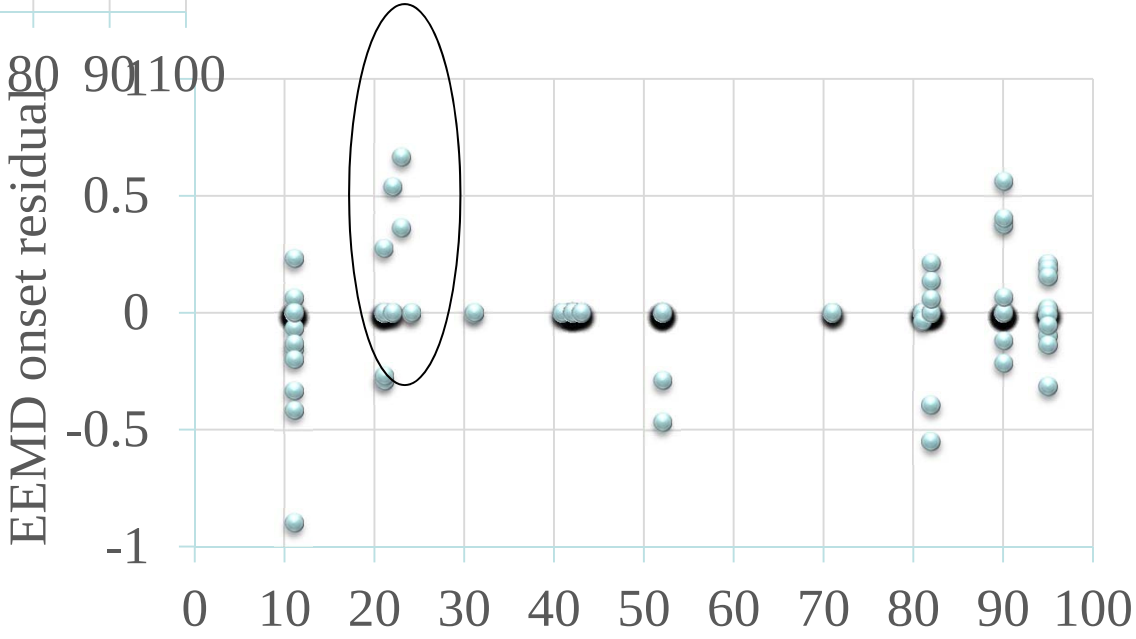
1. Delayed onset in urban areas
2. Increased seasonal accumulation of rainfall

Relation with urban land cover

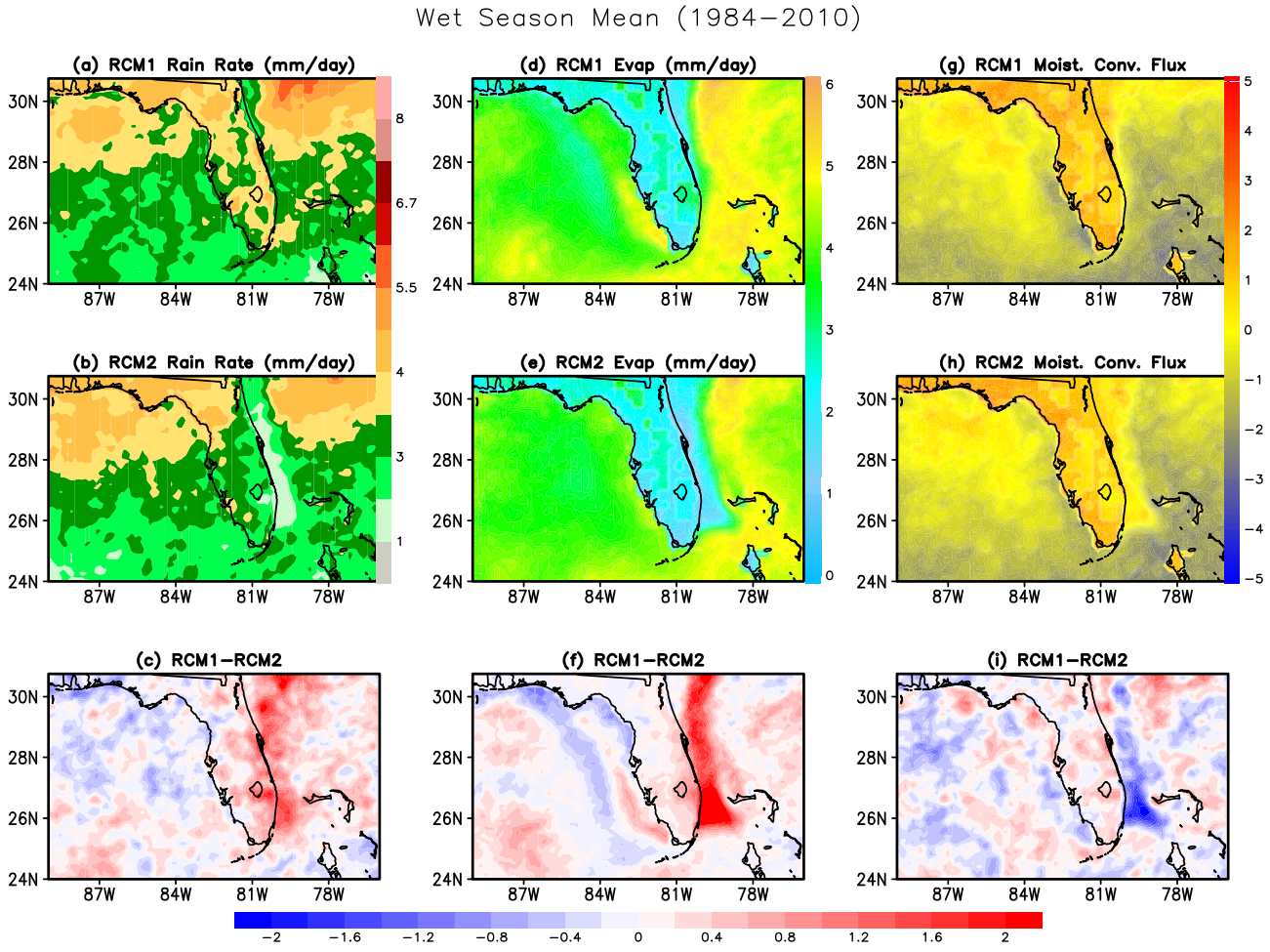


National land cover database from USGS (30 meters)



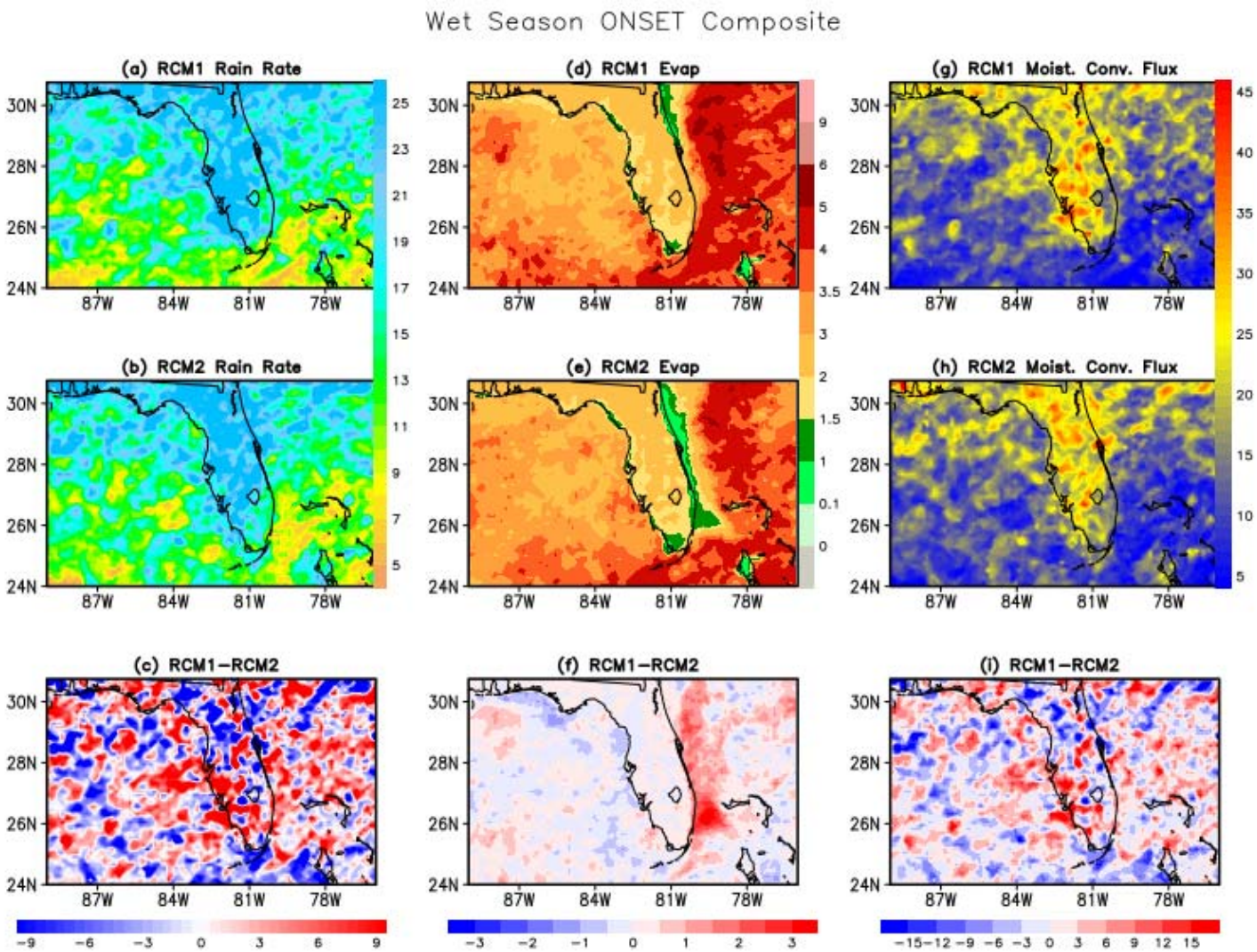


Results from moisture budget for the wet season



Evaporation is about 50% less than moisture flux convergence during the wet season

Results from water budget at onset



Moisture flux convergence dominates at onset. But there is subtle and uniform role of surface evaporation.

Summary

1. There are significant trends in the
   - Onset of the rainy season
   - Demise of the rainy season
   - Seasonal accumulation of the rainy season
2. The onset of the rainy season seems to be delayed in urban areas of Florida.
3. This is likely the result of the relative reduction in local precipitation recycling from the paved surfaces of the urban areas.

Urban heat island effect……

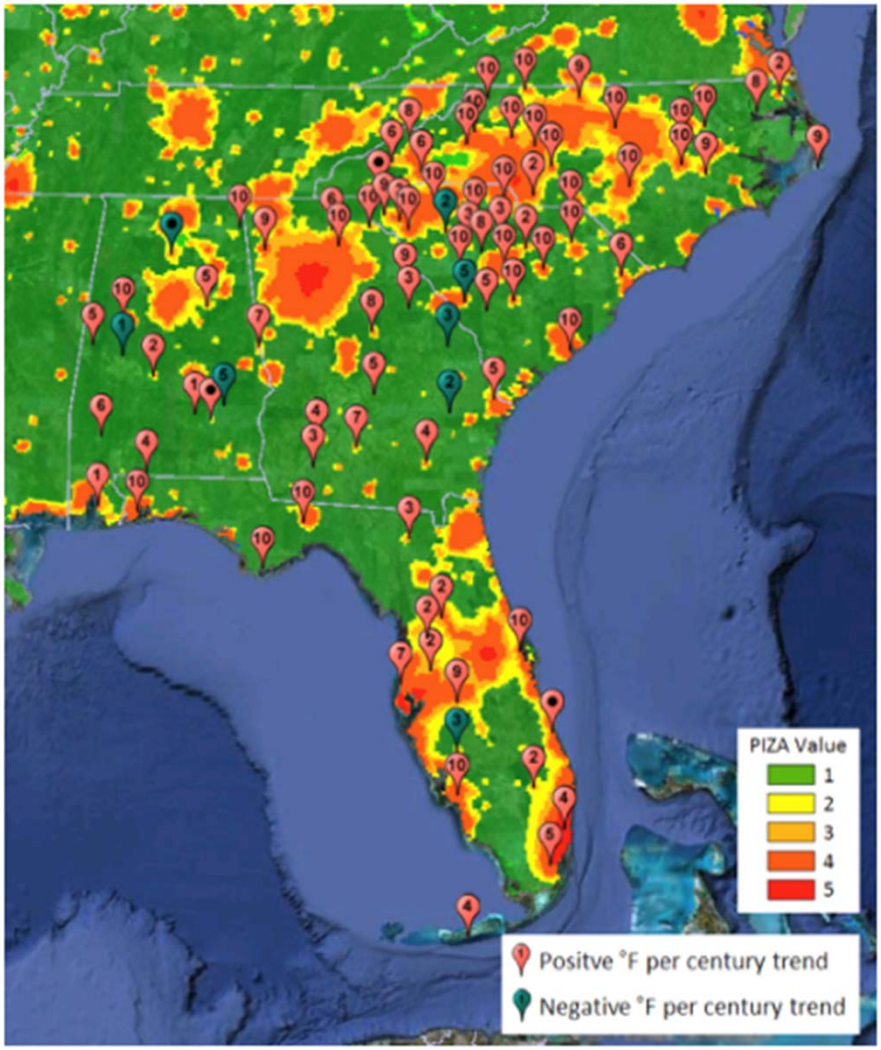
The heat capacity and conductivity of building and paving materials allow for more heat to be absorbed during day in urban areas which then partially compensate for the radiational cooling at night.

Sky view factor: trapping of reflected solar radiation by narrow arrangement of buildings

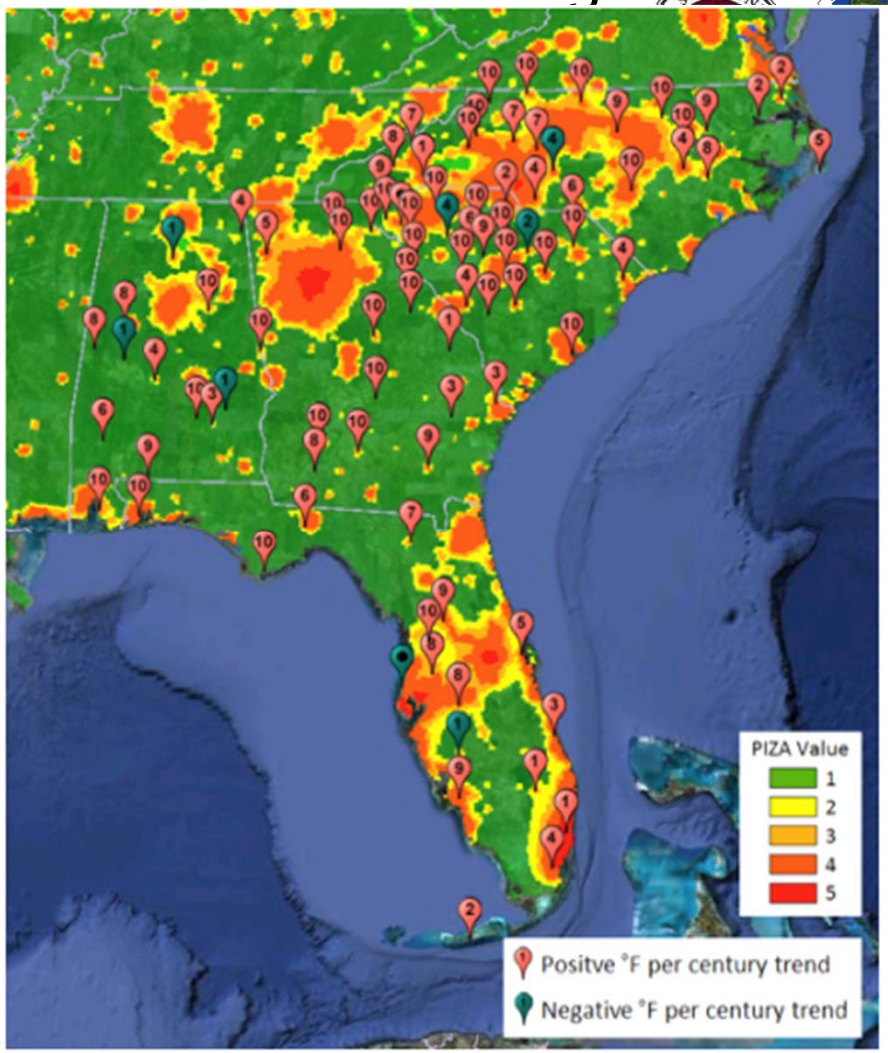
Additional sources: pollutants, heat from refrigeration and air-conditioning systems and obstruction of rural air flows by the windward surface of built up surfaces

Recent past…..

Using USHCN2+



Trends of T_{min} overlaid on PIZA

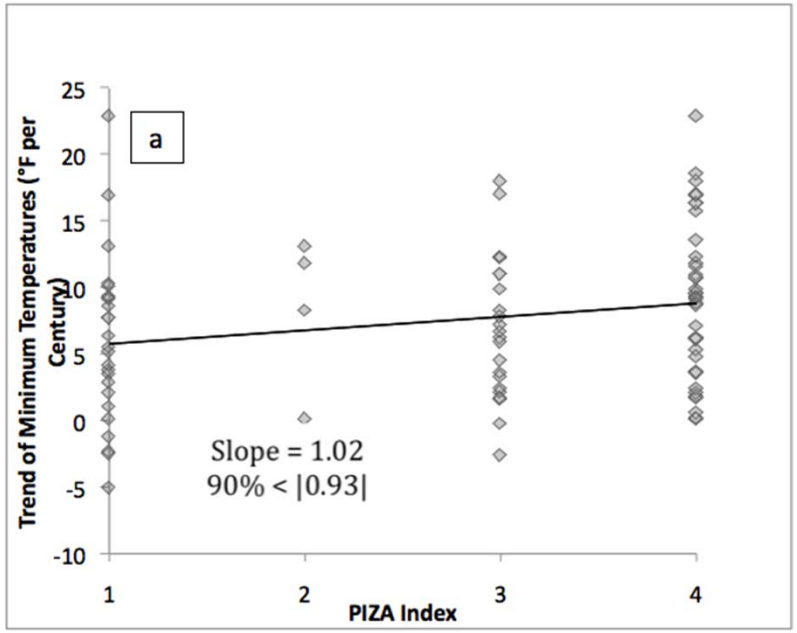


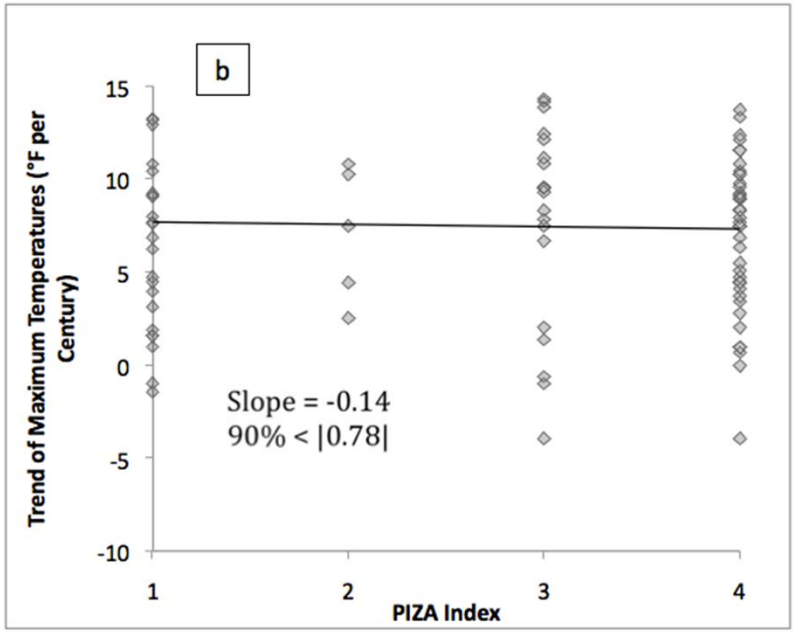
Trends of T_{max} overlaid on PIZA

Population Interaction Zone for Agriculture defined by the USDA ERS which is designed to represent residential, commercial, and industrial urban activities affecting the social and economic environment of agriculture. The data is available at 5km grid resolution.

Recent past (1948-2005)

Using USHCN2+ data





More urban the land surface higher would be its PIZA index

The relatively stronger linear relationship of PIZA index with T_{min} is suggestive of the urban heat island effect.

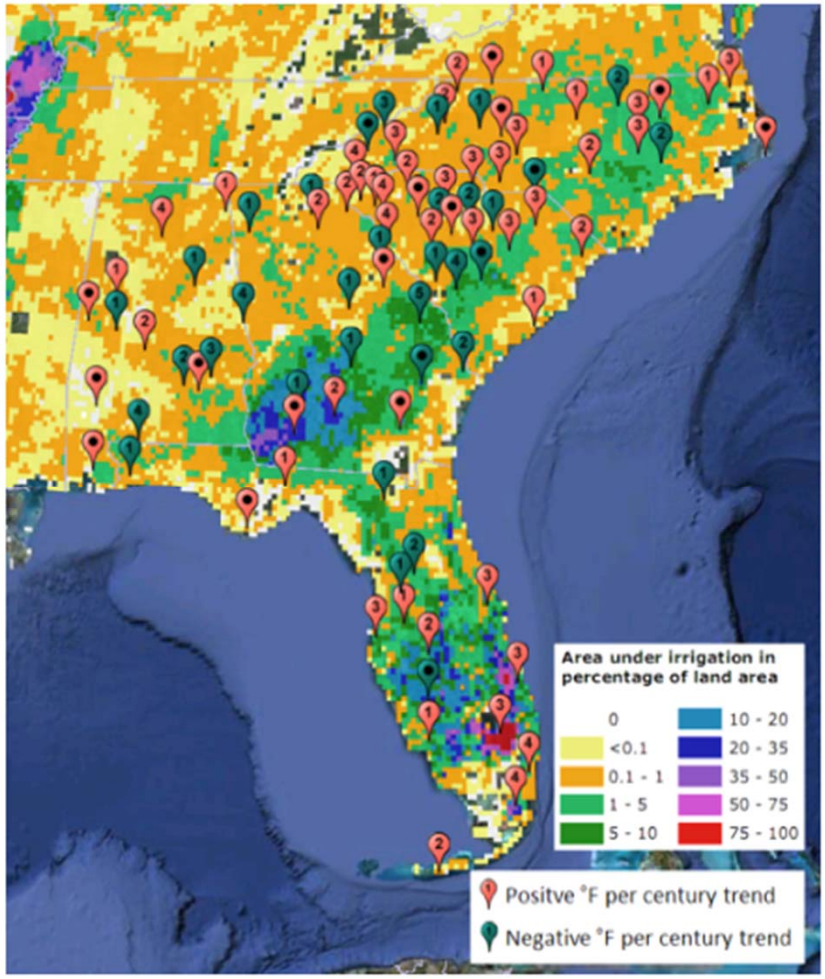
Influence of irrigation…..

Irrigation, by way of wetting the soil, raises evaporation during the day and changes the Bowen ratio, which leads to apparent cooling of the surface temperature

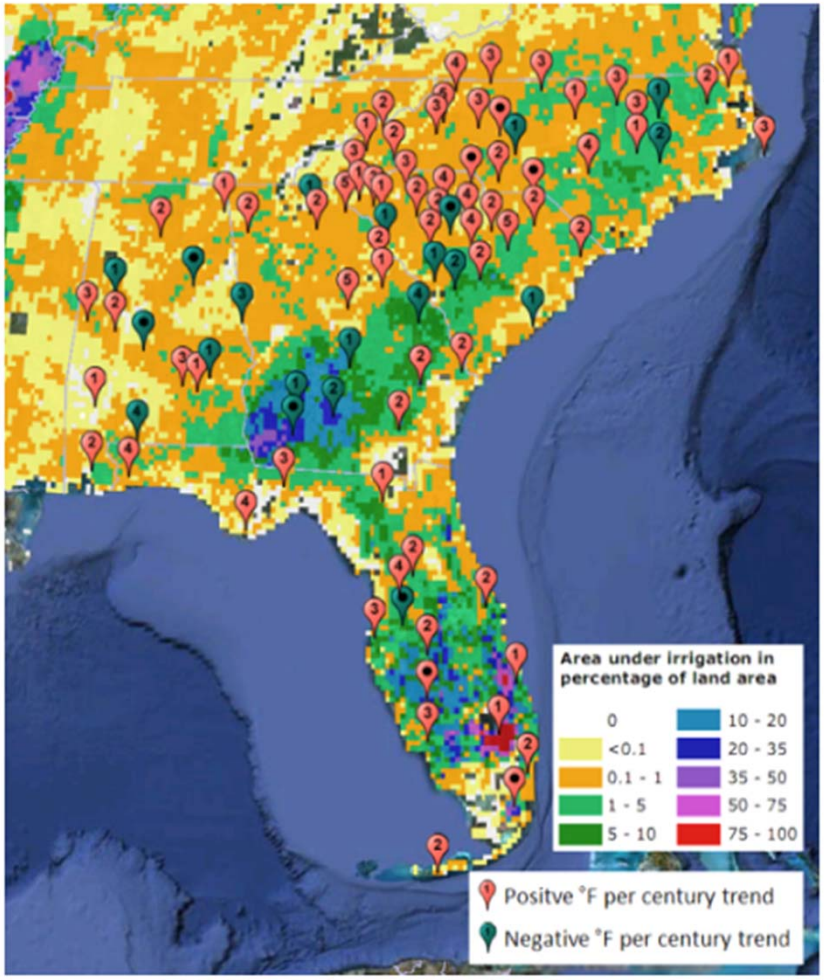
Irrigation raises the heat capacity and conductivity of the soil and, under weak wind conditions (typically at night, when the boundary layer decouples from the rest of the atmosphere), can lead to warming of surface T_{min}

Recent past…..

Using USHCN2+



Trends of **JJA** T_{min} overlaid on irrigation density

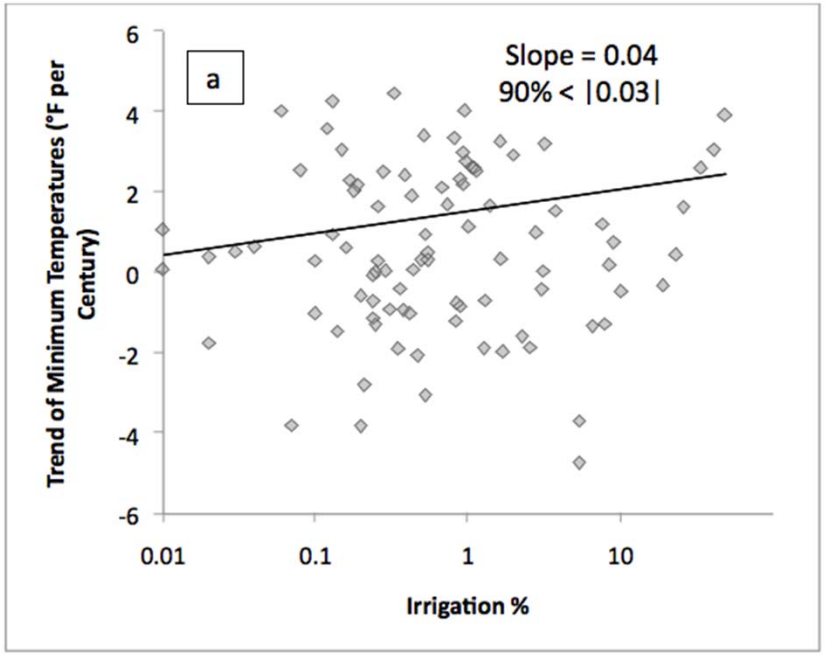


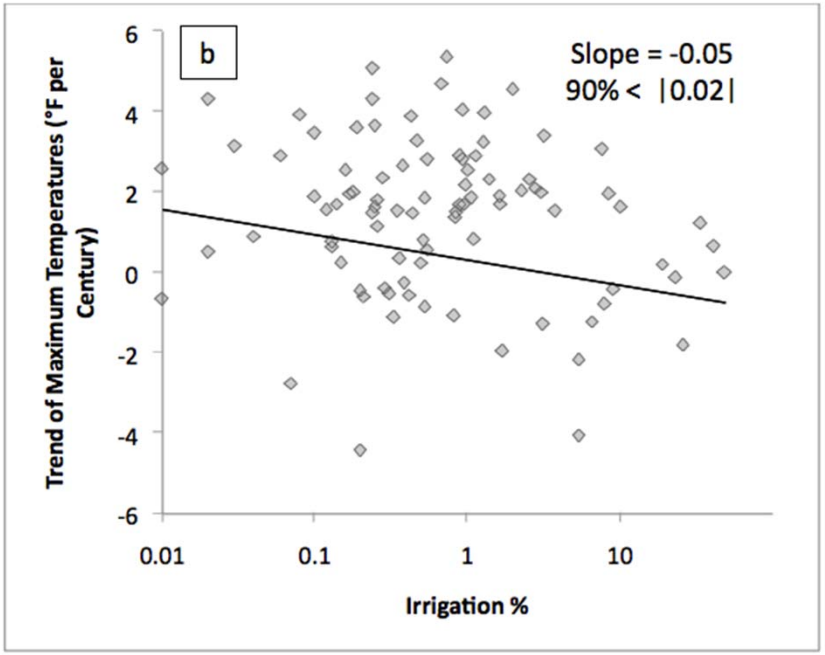
Trends of **JJA** T_{max} overlaid on irrigation density

JJA Surface temperature trends overlaid on irrigation density maps from UN Food and Agriculture Organization available on 5 arc-minute cells. Irrigation density refers to area equipped for irrigation, not amount of irrigation.

Recent past (1948-2000)

Using USHCN2+ data





Trends of **JJA** T_{min} increase with increase in irrigation

Trends of **JJA** T_{max} decrease with increase in irrigation

In summary…..

Urbanization has an influence on the temperature trends of the T_{min} in the southeast US: Rural areas have weaker warming (or larger cooling) trends

Irrigation in the southeast US, especially in summer seems to reduce the warming (or increase the cooling) trends of T_{max}. On the other hand irrigation seems to raise the warming (or reduce the cooling) trends of T_{min}.

Summer season shows the strongest influence of land cover and irrigation (take my word for it!)

Change in land cover and irrigation has secondary effect on surface temperature trends: they explain the spatial distribution of the trends but not the trends in itself.

Conclusion

1. Changes in the Atlantic Meridional Overturning Circulation (AMOC) may have implication on Florida's summer climate.
2. Smart urban planning could possibly reduce the potential changes seen in the rain and temperature, patterns of especially summer season.
3. Knowing local drivers of climate may help in understanding remote influences of climate variations and change.