Evapotranspiration and Florida Water Sustainability: Insights from a Decade of Research

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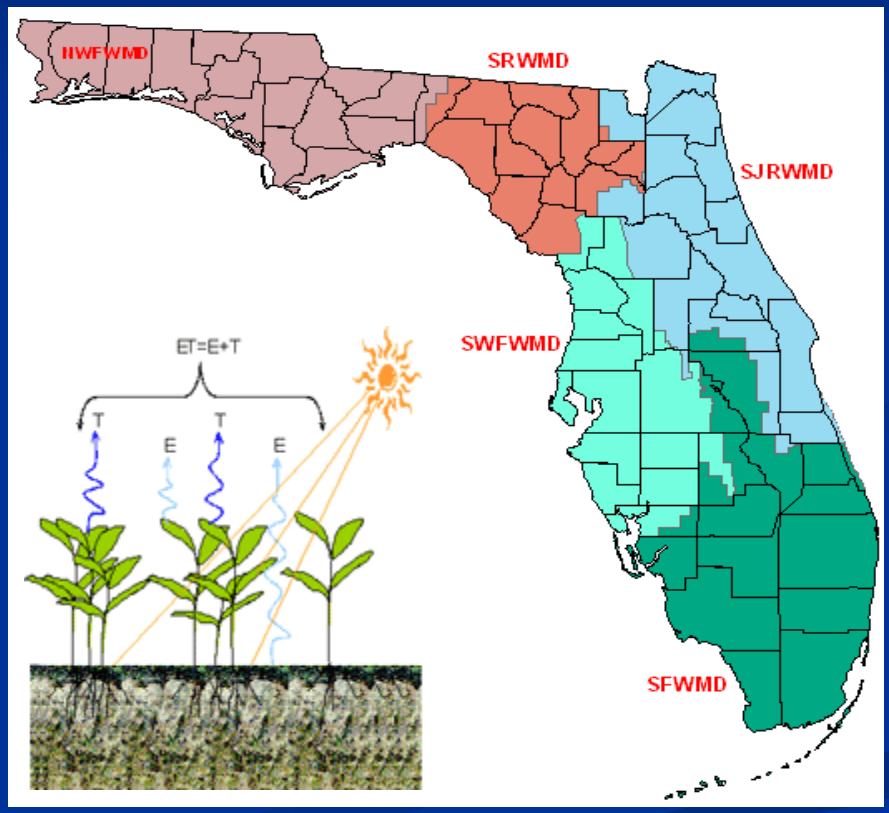
Water Resources Management and Evapotranspiration

- Groundwater Modeling
- Agricultural Water Permitting (Irrigation)
- Water Supply Planning
- Instream Flow Determination
- Everglades Natural System Modeling



Florida Evapotranspiration

Pre-1998

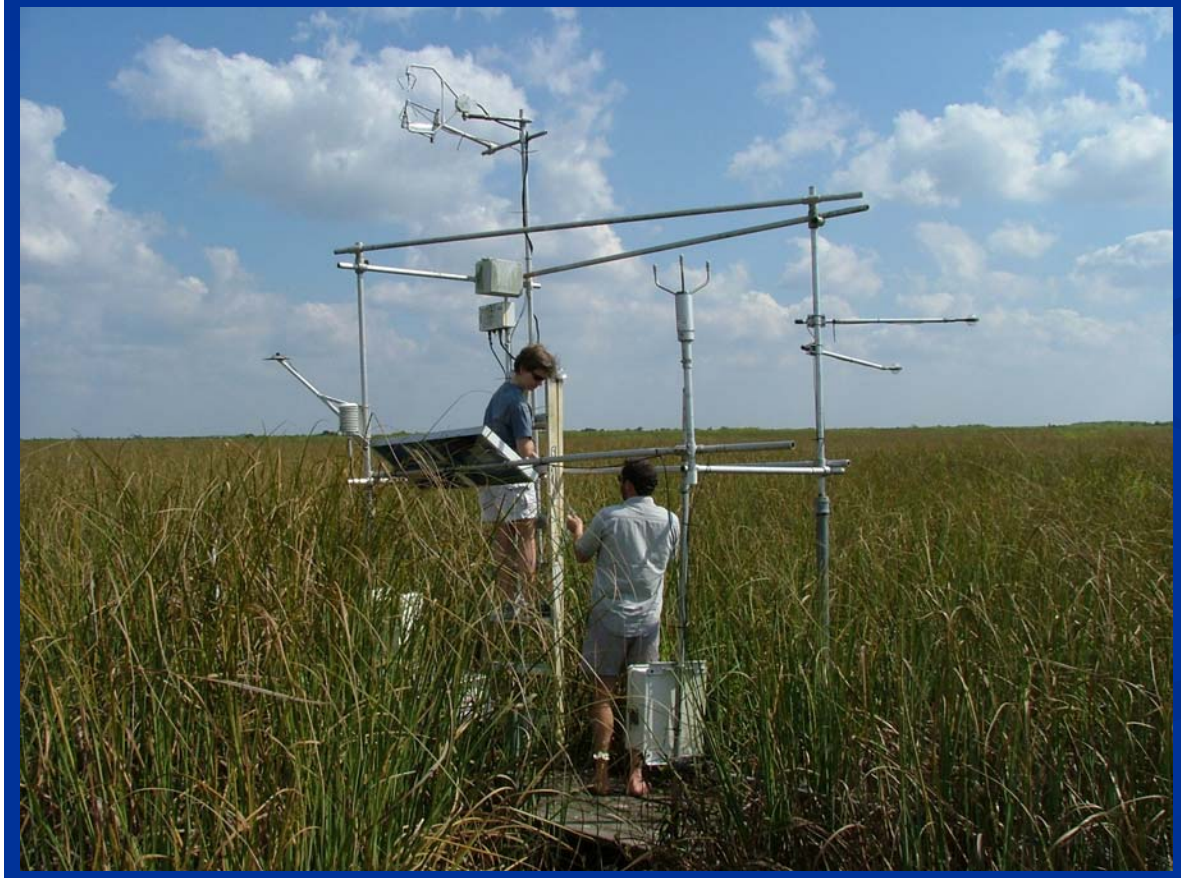
- Florida Water Atlas
- Pan Evaporation
- IFAS (Boman, Haman Smajstrla, Zazueta and others)

1998 to 2007

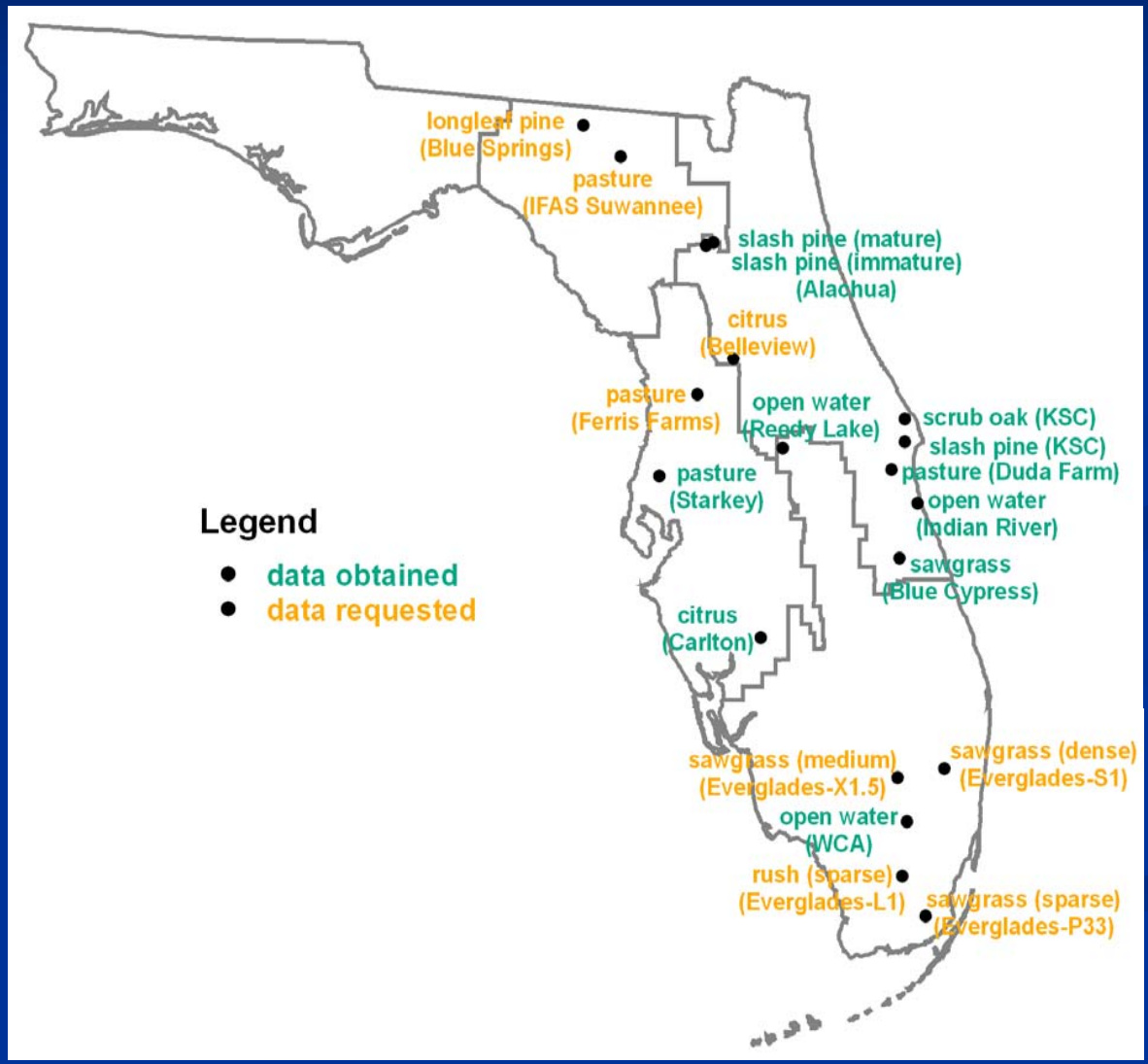
- Measured ET data
- Physical Models
- Water Resource Management

Measurement Technology

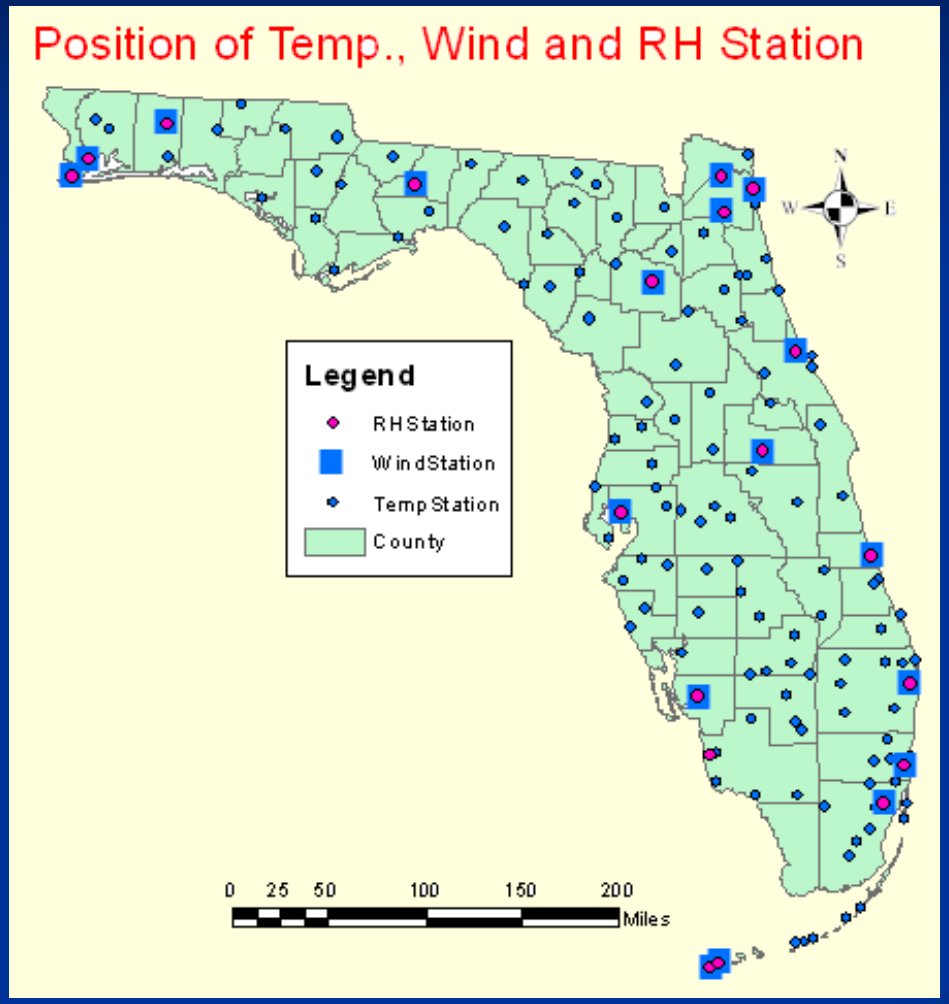
- Eddy Correlation Systems



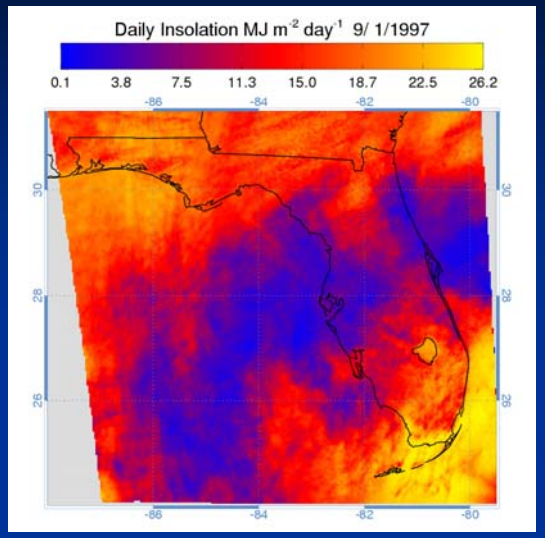
1998-2007: ET Measurements Network

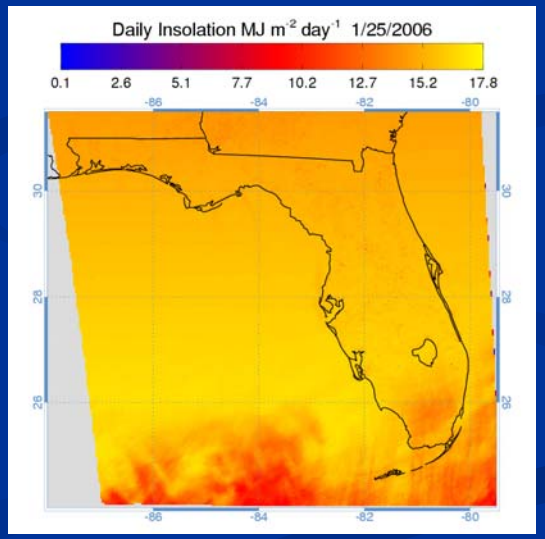


1998-2007: Satellite Measurements



Available climate data from NOAA NCDC





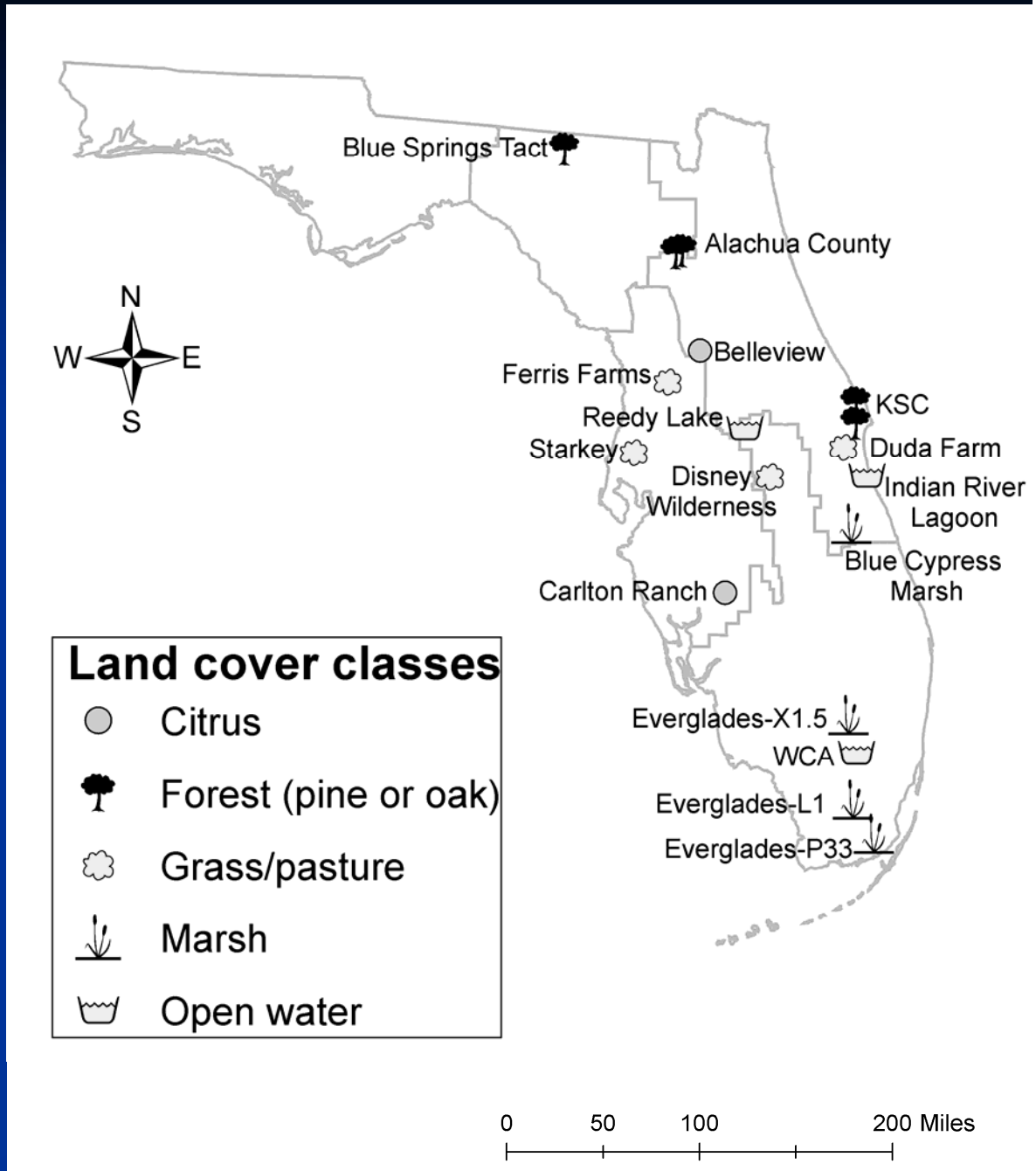
Insolation (MJ/m²) during summer (top) and winter (bottom) estimated from half-hourly GOES-EAST

1a. Measurement Results

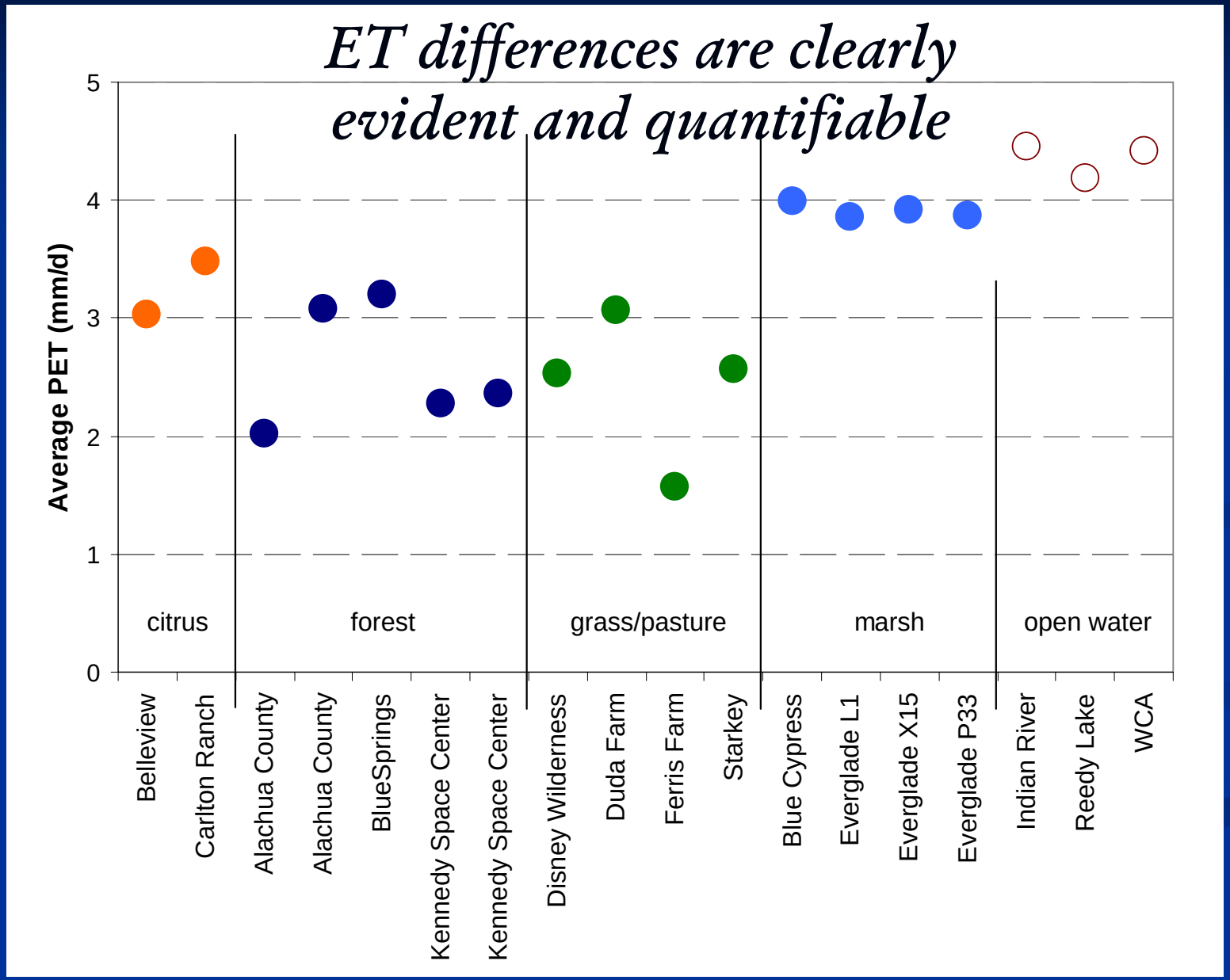
How does ET vary across Florida landuses?

Do we even need to distinguish?

- Florida ET Measurement Sites
- Data duration from 1 to 7 years



Annual ET Differences by Land Use



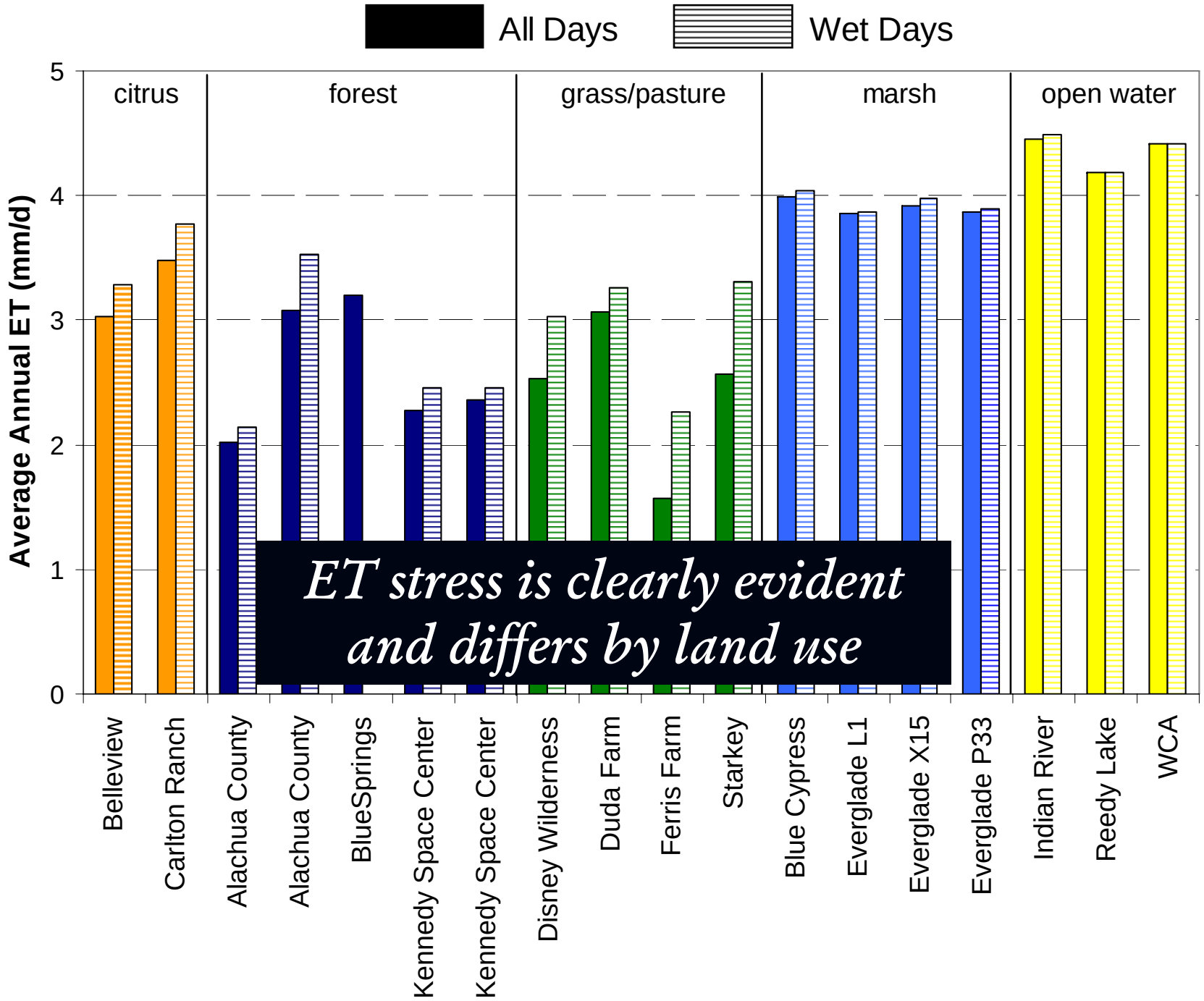
1b. Measurements Results

Can we get a handle on actual ET versus potential ET?

Do we even need to distinguish?

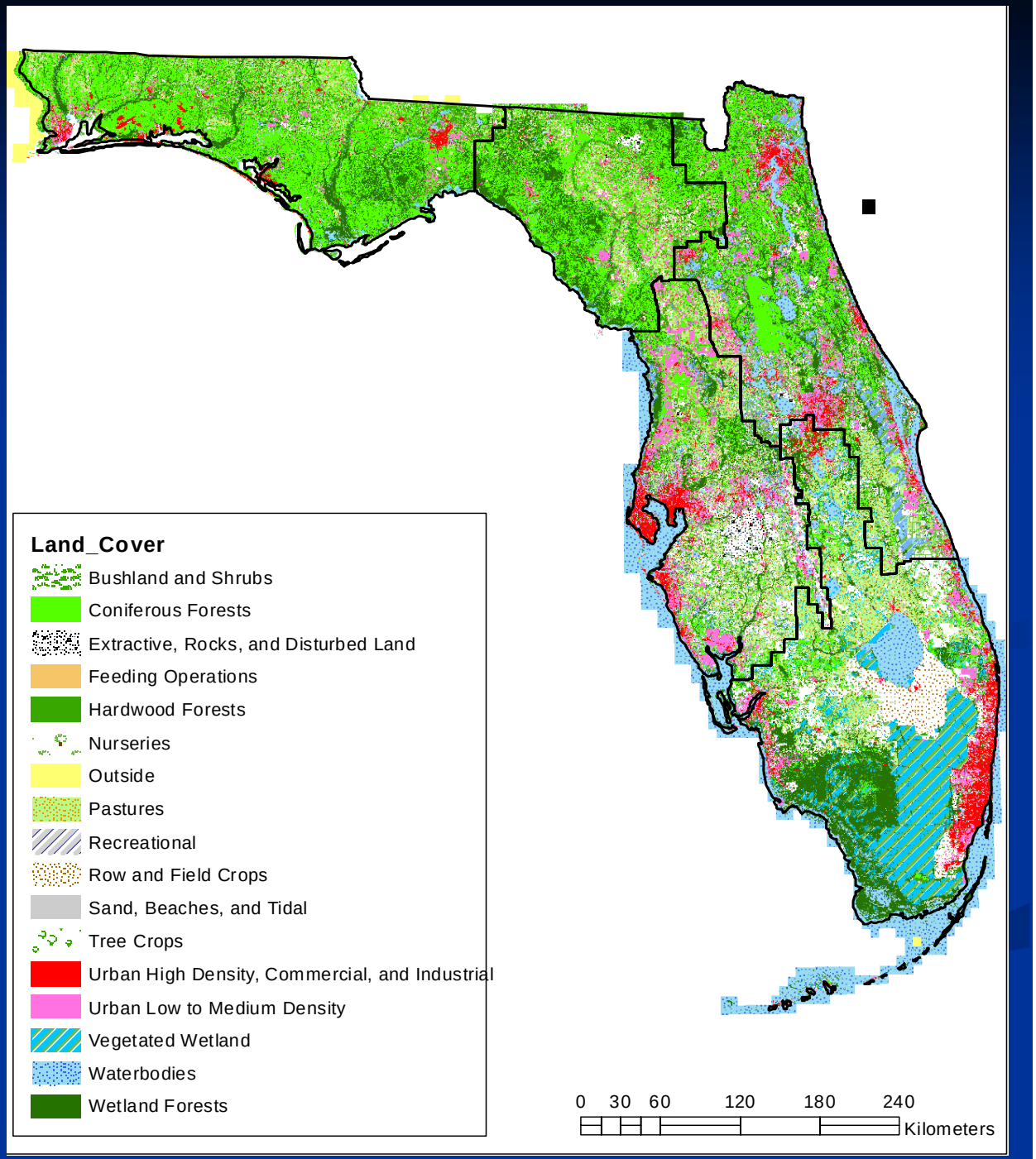
When is ET below potential ET?

- How do we differentiate between potential conditions and stressed conditions?
  - Soil Moisture
  - Bowen Ratio Threshold ($B > 1$)
    where B = Sensible Heat Flux / Latent Heat Flux


All Days
Wet Days
Average Annual ET (mm/d)
0
1
2
3
4
5
citrus
forest
grass/pasture
marsh
open water
Belleview
Carlton Ranch
Alachua County
Alachua County
BlueSprings
Kennedy Space Center
Kennedy Space Center
Disney Wilderness
Duda Farm
Ferris Farm
Starkey
Blue Cypress
Everglade L1
Everglade X15
Everglade P33
Indian River
Reedy Lake
WCA
ET stress is clearly evident and differs by land use

2a. Physical Modeling Results
What is our best option for modeling Florida's Potential ET?

18 Land Use Categories for Evapotranspiration



PET Estimate Methods

1. SFWMD Simple Method

$$\lambda \rho_w ET_0 = K_1 * R_s$$

2. Priestley-Taylor Model

$$\lambda \rho_w ET_0 = \alpha \frac{\Delta}{\Delta + \gamma} (R_n - G)$$

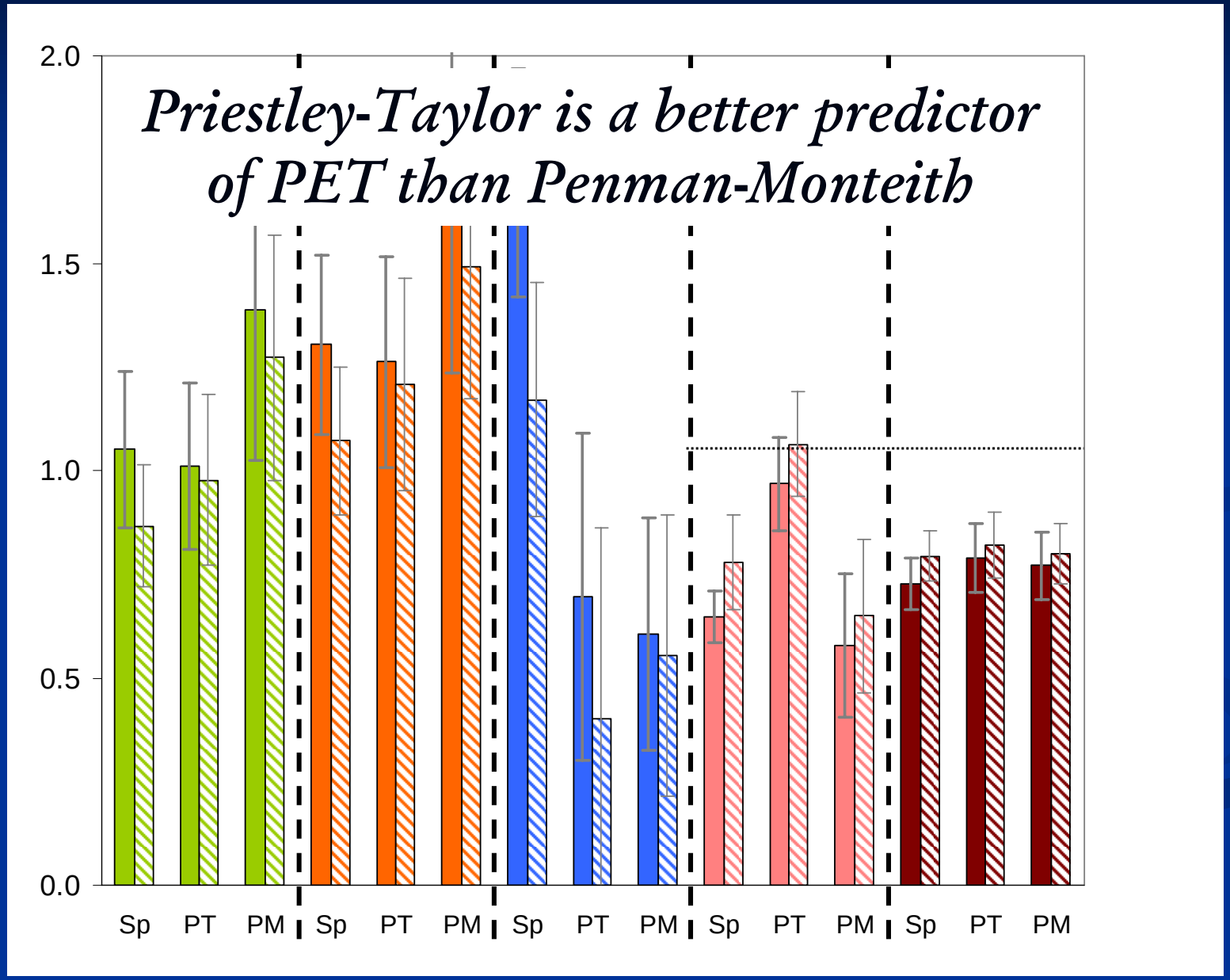
3. Penman-Monteith Model

$$\lambda \rho_w ET_0 = \frac{\Delta (R_n - G) + \rho_a C_p (e_s - e_d) / r_a}{\Delta + \gamma (1 + r_s / r_a)}$$

Modeling PET Surface Characterization by Method

- SFWMD Simple Method
  - None
- Priestley-Taylor Model
  - Surface Albedo
- Penman-Monteith Model
  - Surface Albedo
  - Surface resistance
  - Canopy resistance

Models Versus Measurements



2b. Physical Modeling Results
What are we missing?

$$\lambda \rho_w ET_0 = \alpha \frac{\Delta}{\Delta + \gamma} (R_n - G)$$

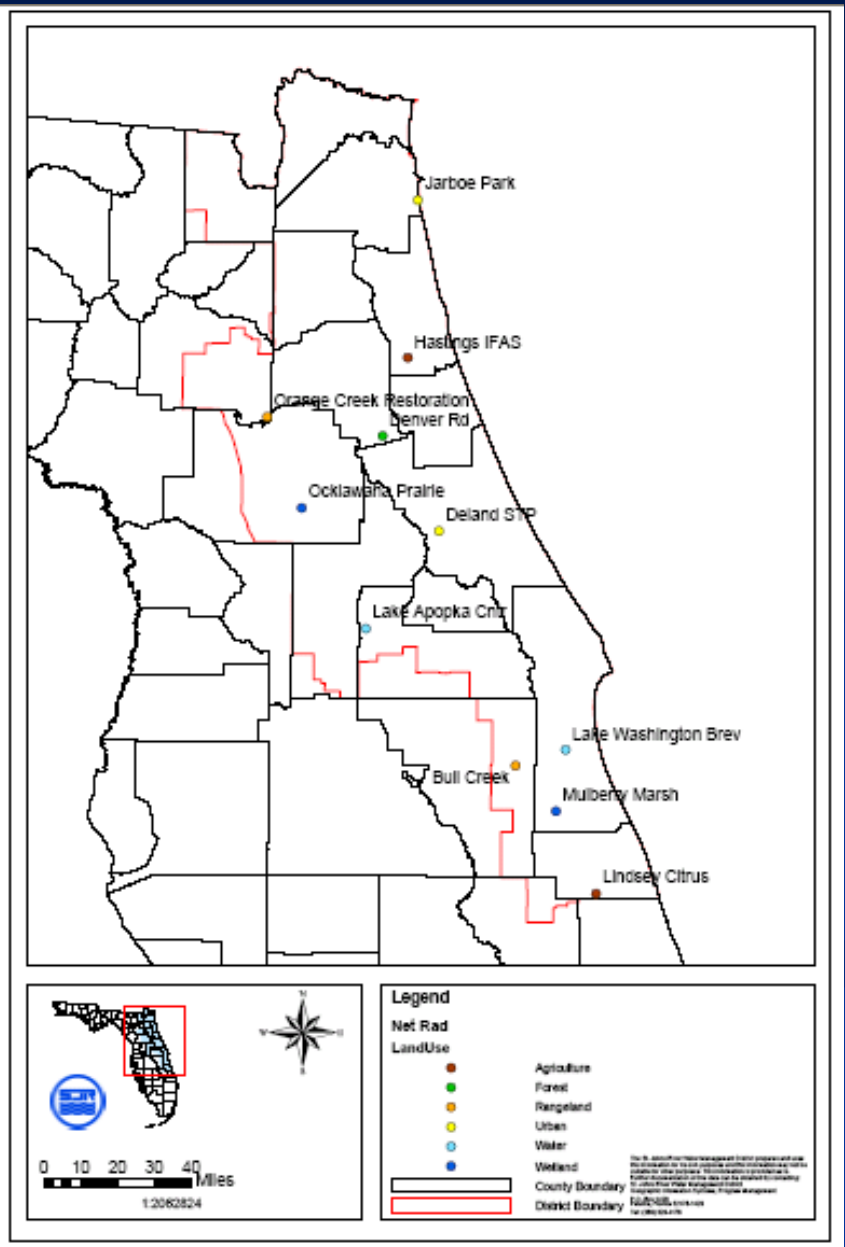
Net Radiation

Florida Net Radiation

$$RN = R_s(1-\alpha) + R_{ld} - R_{lu}$$

Annual average measured albedo values

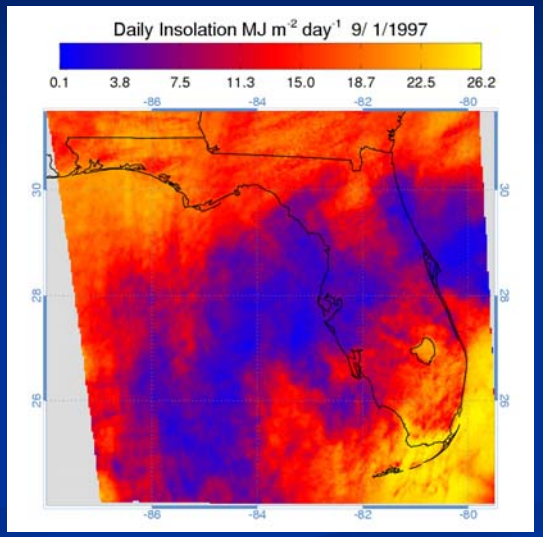
Site	Land Use	Mean Albedo
Lake Apopka K&Z	Water	0.062
Mulberry Marsh	Wetland	0.162
Ocklawaha Prairie	Wetland	0.160
Jarboe Park	Urban	0.144
Deland STP	Urban	0.202
Bull Creek	Rangeland	0.139
Orange Creek Restoration	Rangeland	0.186
Denver Rd	Forest	0.107
Hastings IFAS1	Agriculture	0.122
Lindsey Citrus	Agriculture	0.124
Average with water		0.141
Average without water		0.149

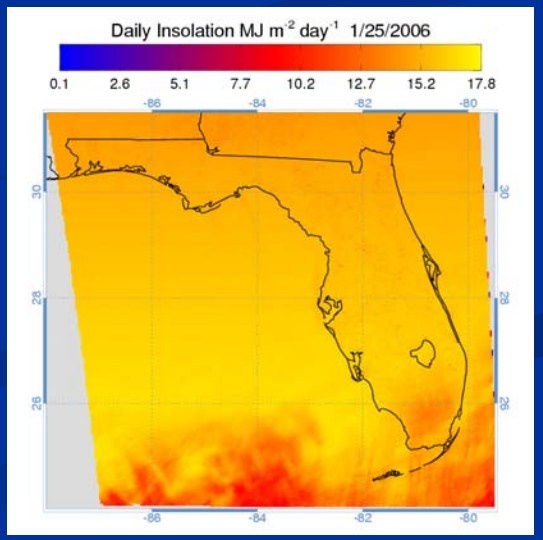


3. ET and Water Resource Managements Results What have we accomplished?

Florida ET Database

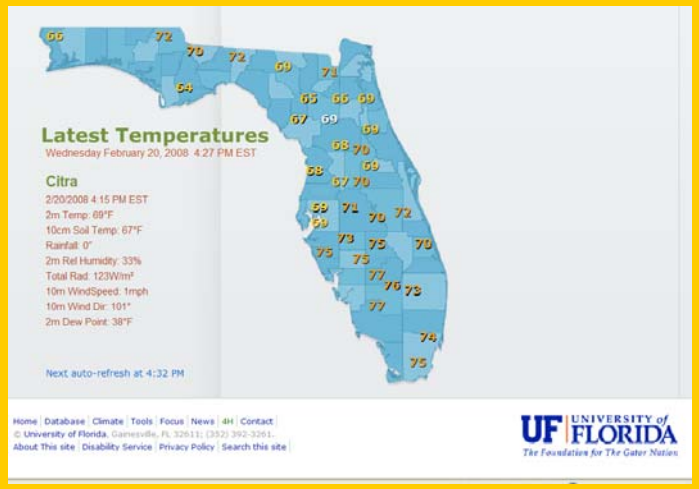
- Developed ET Model Parameters, Forcing Data, and Validation Datasets
- Compared PET Methods
- Created and Validated GOES Satellite Solar Radiation
- Created Daily PET and Reference ET from 1995 to 2004 at a 2 km scale for Florida

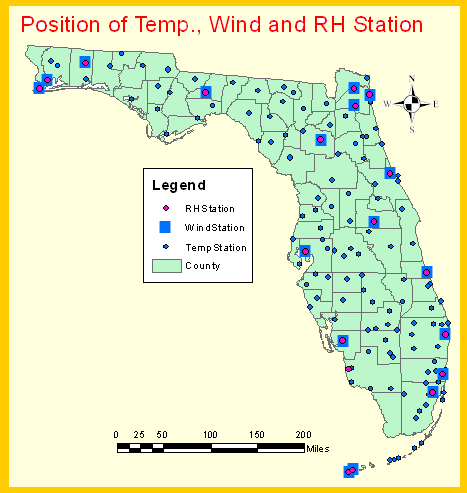




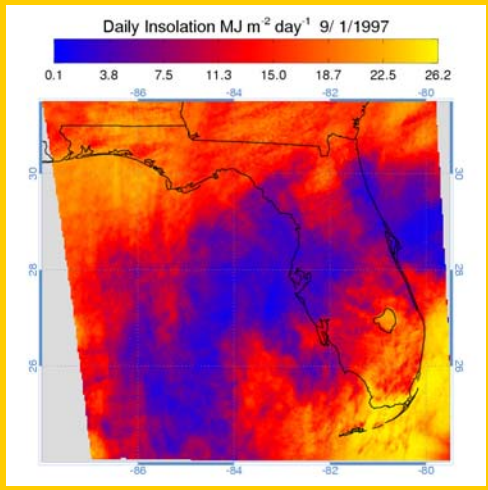
Florida ET Database

Climate data from NOAA NCDC, FAWN, and WMDs





Daily GOES Solar Radiation



Apply to ET Calculations

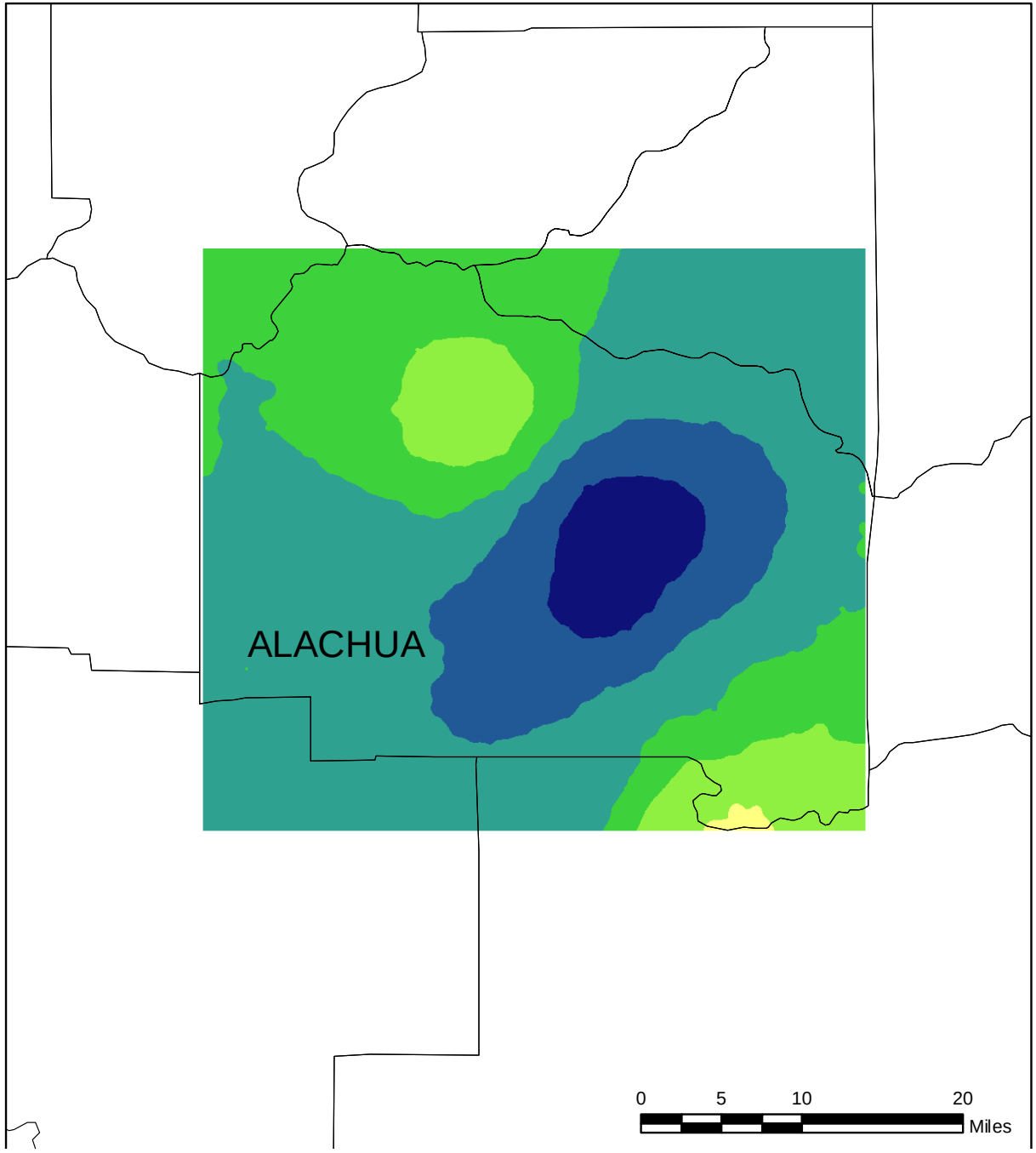
Priestley-Taylor

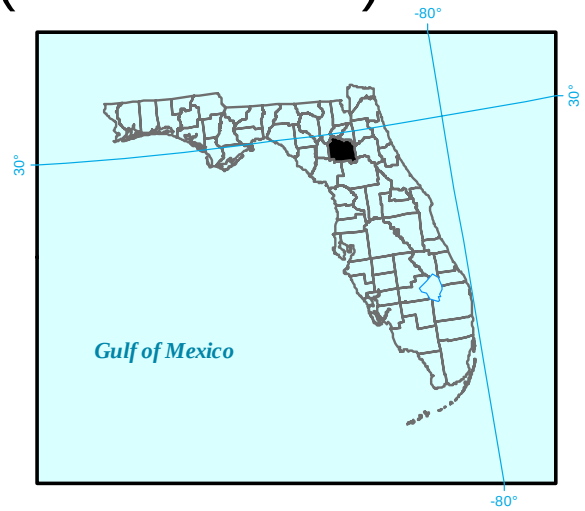
$$\lambda \rho_w ET_0 = \alpha \frac{\Delta}{\Delta + \gamma}(R_n - G)$$

ASCE Reference ET

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{C_n}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + C_d u_2)}$$

Average Annual PET in Alachua County (1995 to 2004)





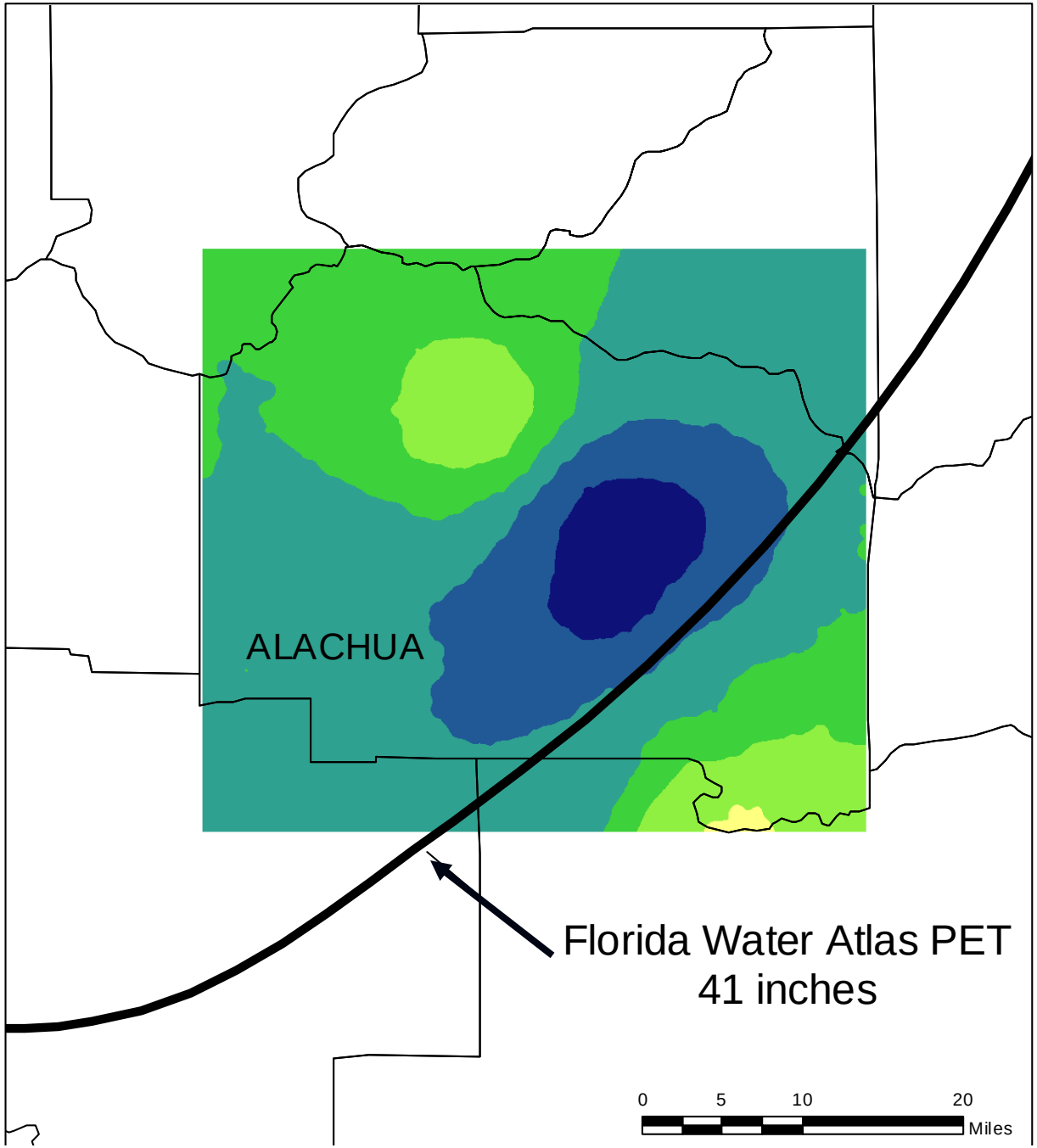
Legend

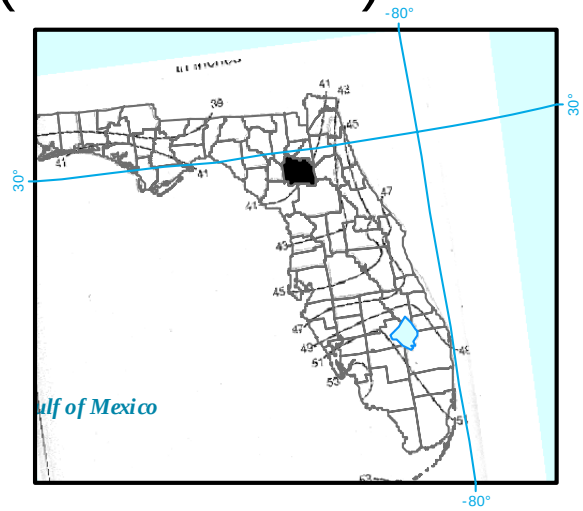
Annual PET (Inches)

- 48.5 - 49.0
- 49.0 - 49.5
- 49.5 - 50.0
- 50.0 - 50.5
- 50.5 - 51.0
- 51.0 - 51.5

3

Average Annual PET in Alachua County (1995 to 2004)





Legend

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- 50.5 - 51.0
- 51.0 - 51.5

3

Florida Integrated Science Center, Tampa, FL

In cooperation with SFWMD, SJRWMD, SWFWMD, SRWMD, NWFWMD

Southwest Florida Water Management District

Hydrologic Data Web Portal

Hydrologic Data Web Portal

Florida Potential and Reference Evapotranspiration 1995-2004

February 20, 2008 4:47 PM

The following datasets are currently under review and should be consided PROVISIONAL.

Please see Notes section at bottom of page.

- Right click on the Download Dataset symbol to select a pre-packaged, compressed data set.

County	Size	Created	County	Size	Created	County	Size	Created
Alachua	59,659,278	1/22/2008	Gulf	34,175,964	1/22/2008	Okaloosa	56,426,419	1/22/2008
Baker	36,876,578	1/22/2008	Hamilton	28,139,233	1/22/2008	Okeechobee	54,647,873	1/22/2008
Bay	44,550,336	1/22/2008	Hardee	39,071,948	1/22/2008	Orange	61,616,245	1/22/2008
Bradford	17,789,268	1/22/2008	Hendry	73,193,029	1/22/2008	PalmBeach	132,535,661	1/22/2008
Brevard	62,115,240	1/22/2008	Hernando	27,302,775	1/22/2008	Pasco	46,039,710	1/22/2008
Broward	75,059,692	1/22/2008	Highlands	69,621,539	1/22/2008	Pinellas	15,787,653	1/22/2008
Calhoun	33,878,088	1/22/2008	Hillsborough	65,362,383	1/22/2008	Polk	120,336,951	1/22/2008
Charlotte	42,149,131	1/22/2008	Holmes	26,719,365	1/22/2008	Putnam	51,979,255	1/22/2008

http://hdwp.er.usgs.gov/et.asp

Concluding Thoughts

- Existing ET Knowledge Gaps
  - Ability to Differentiate by Land Use
  - Characterization of Plant Water Stress and Response
  - Understanding of Biological Controls
  - Forecasting and Hindcasting
- Immediate Action Items
  - Modify Monitoring Approaches
  - Analyze 10-yr PET dataset

Acknowledgements

- Graduate Students: S. Bhat, M. Choi, M. Fischer, A. Guha, E. Hsu, H. Hwan, C. Howerton, R. Ray, S. Satti, L. Wang, and B. Whitfield
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