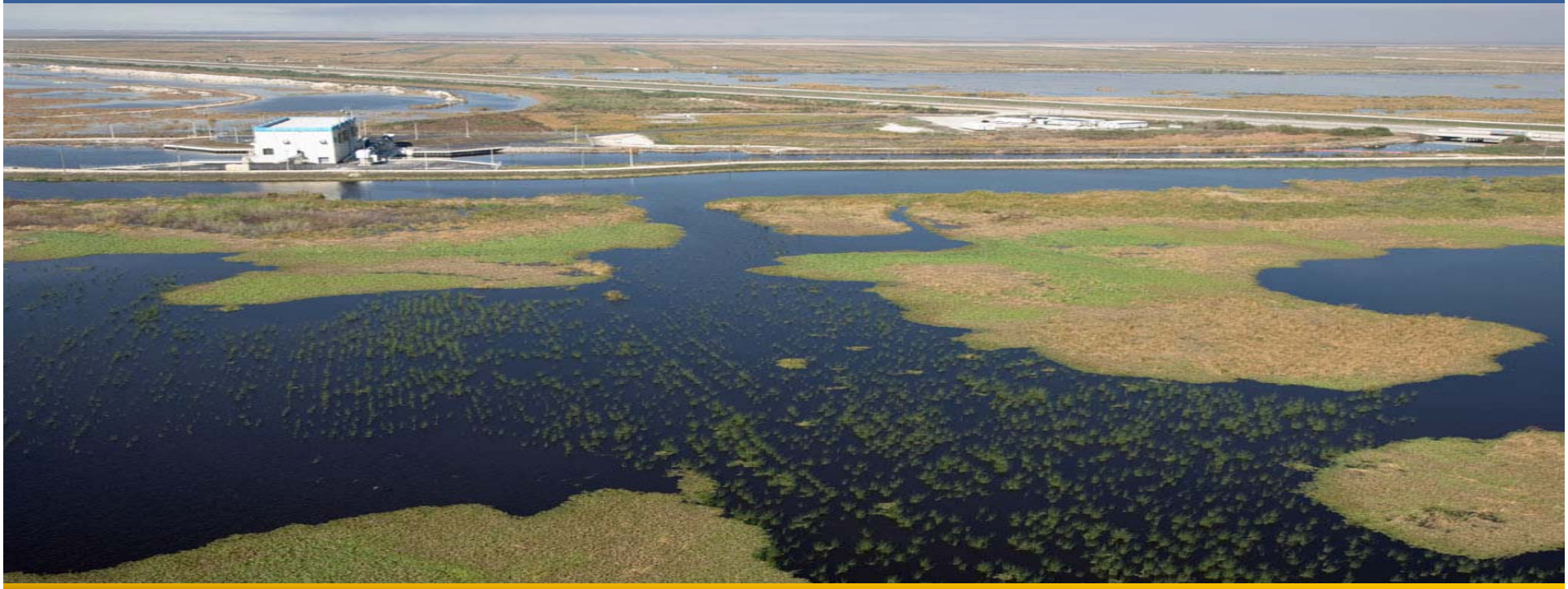
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Evapotranspiration in the Everglades and its Watershed

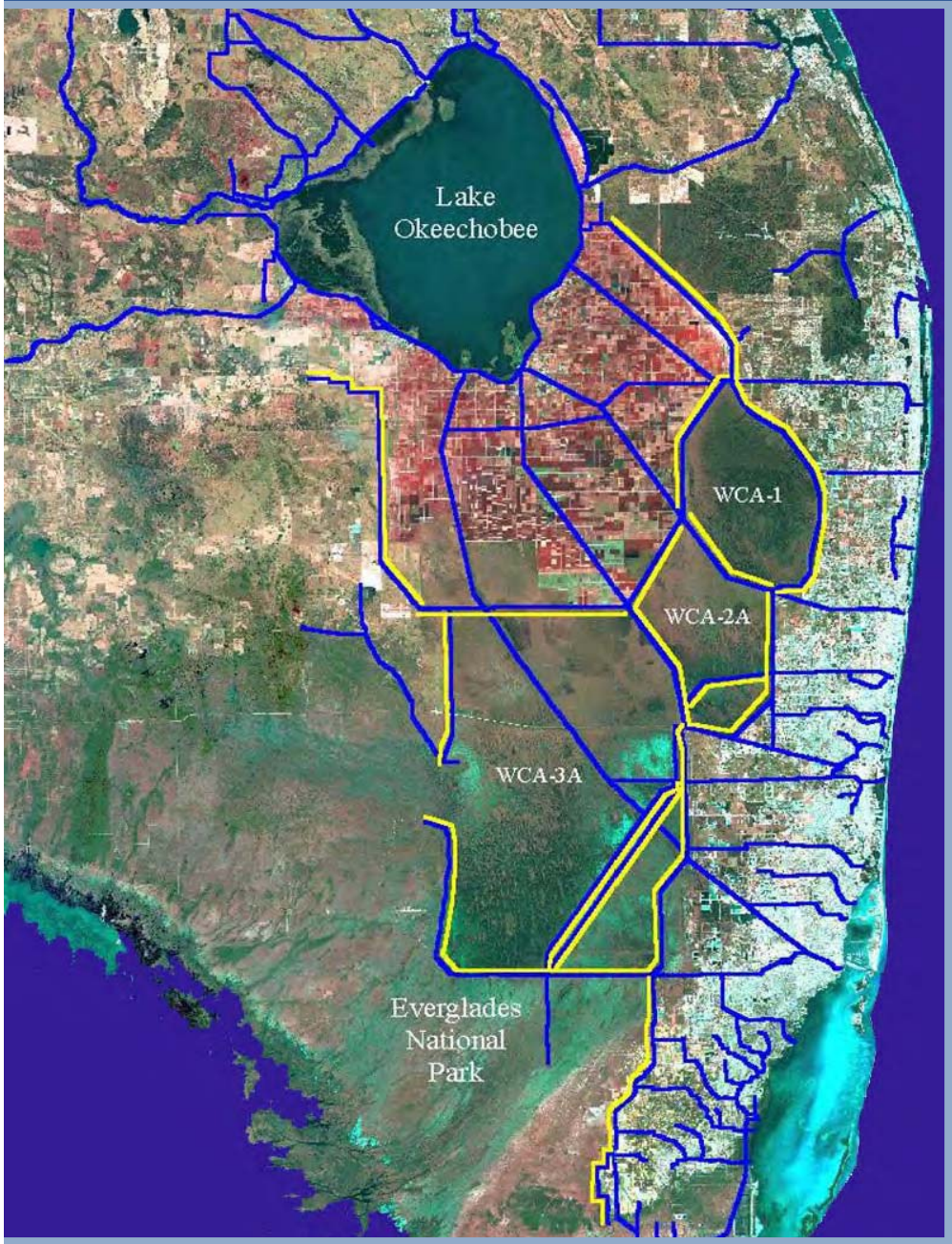
Wossenu Abtew, Ph.D., P.E., D.WRE
Principal Engineer, Water Resources Division, South Florida Water Management District



Hydrology of the Everglades in the Context of Climate Change

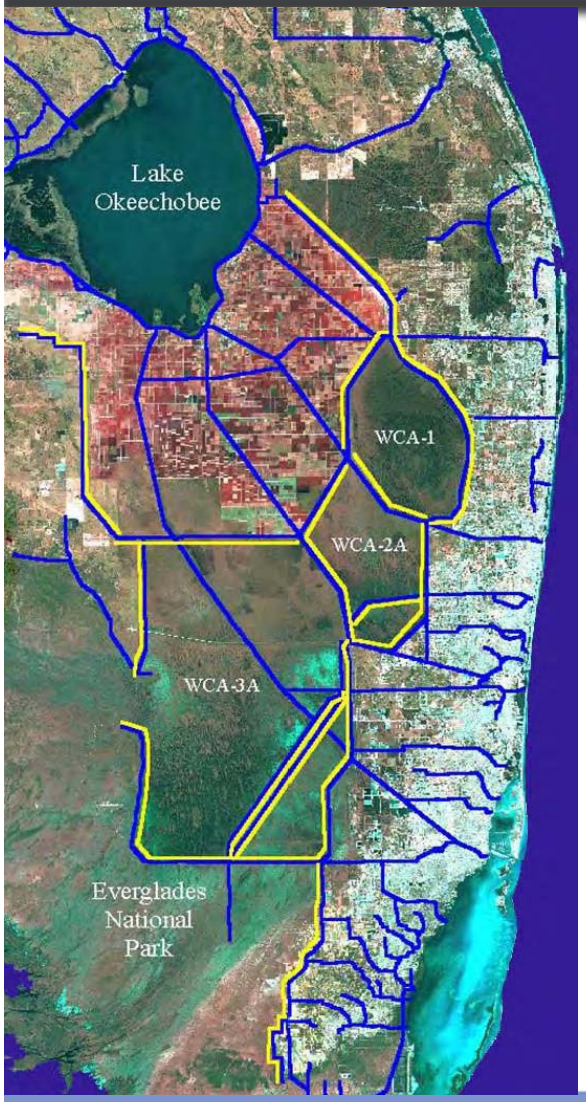
USGS, CES, Sea Grant Sponsored Workshop
Florida Atlantic University - Davie Campus
March 29 & 30, 2012

sfwmd.gov



The Everglades and its Current Watershed

Questions of Interest – 3 Parts



1. What is the rate of evapotranspiration in the Everglades?

2. Is there significant difference between open water evaporation and wetland evapotranspiration?

3. What is the likely trend of evapotranspiration in south Florida?

PART 1

What is the rate of evapotranspiration in the Everglades?

Mean Annual Lake Evaporation

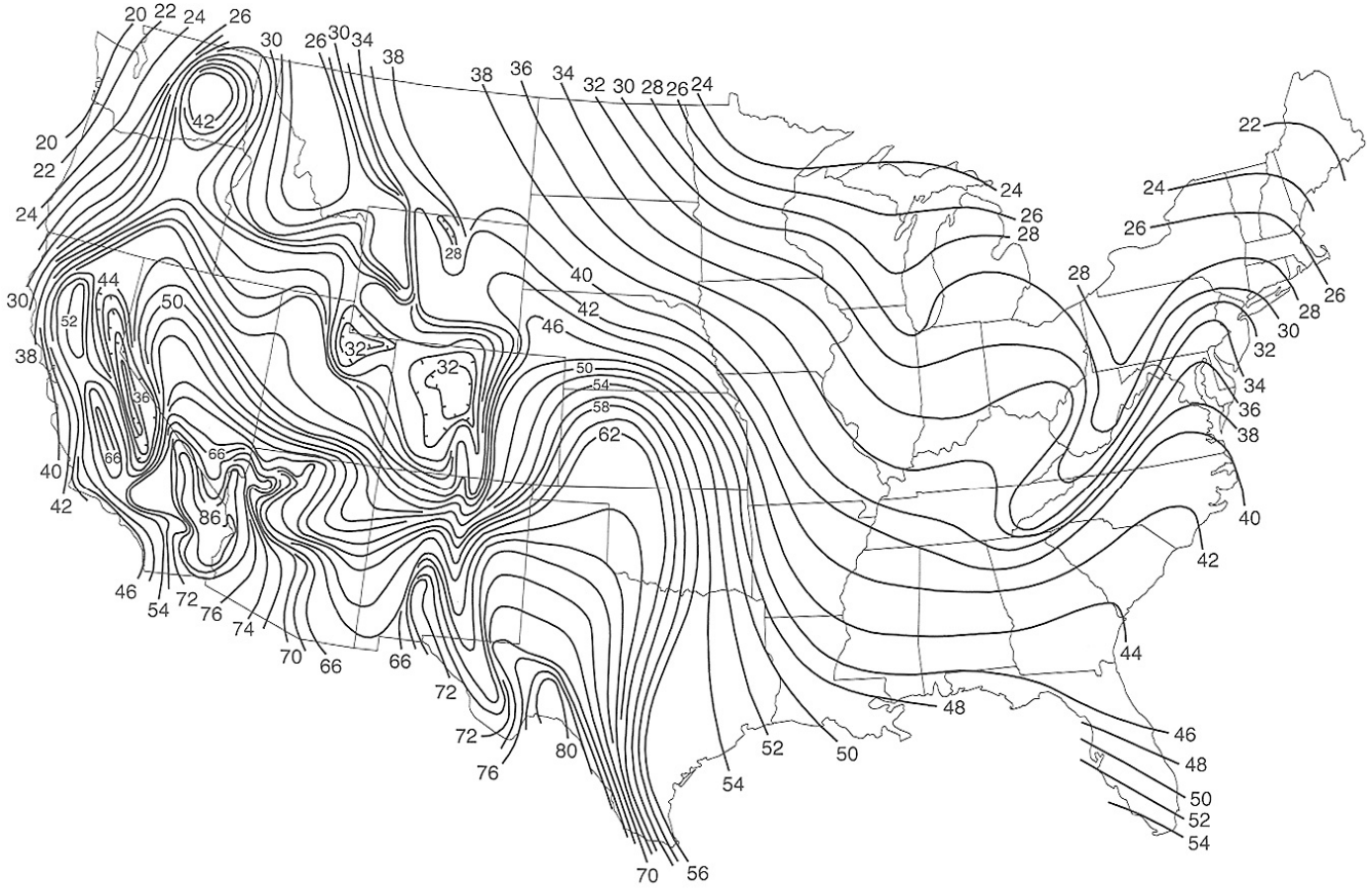
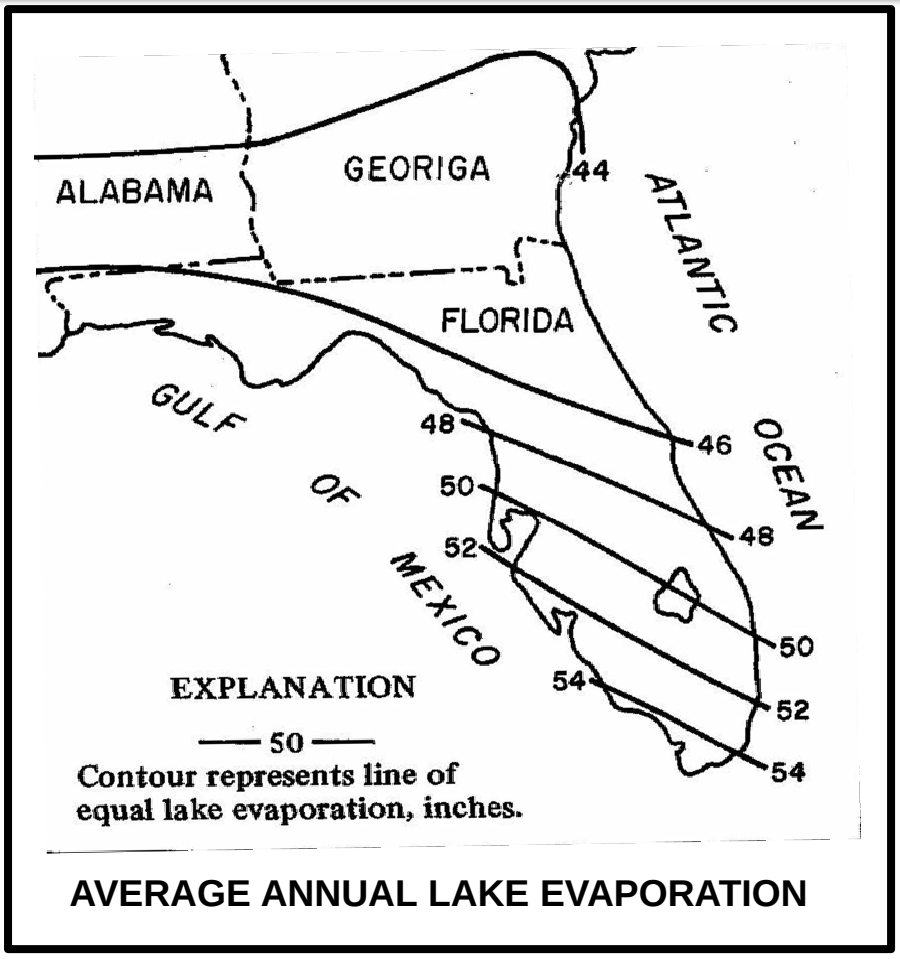


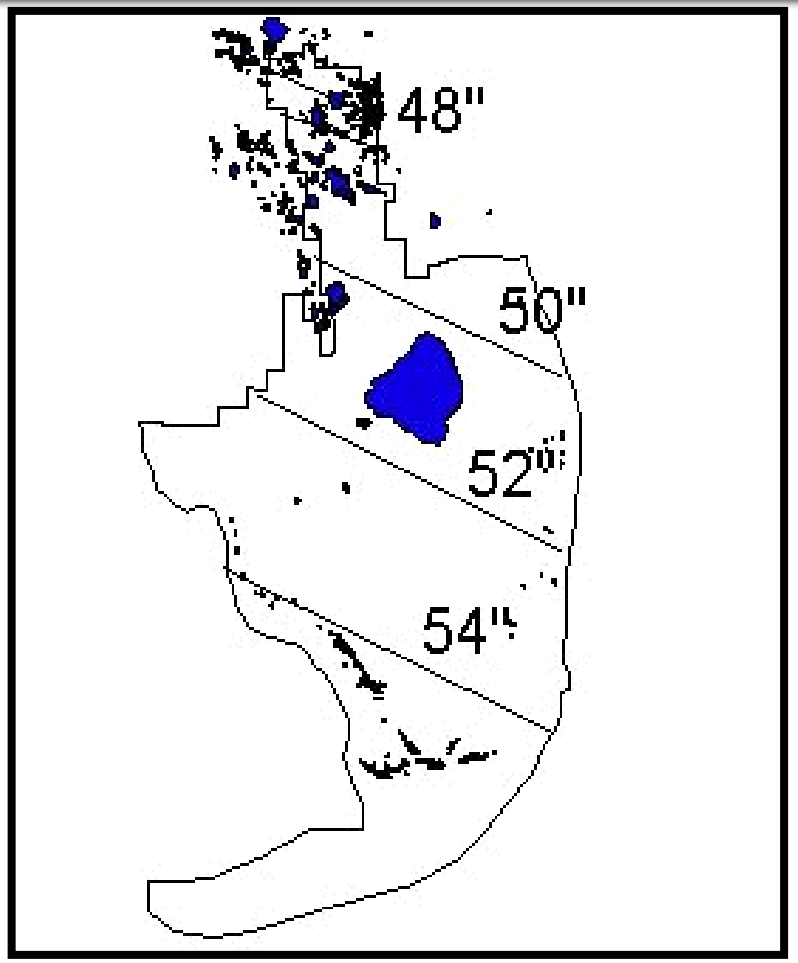
FIGURE 4.16 Mean annual lake evaporation, 1946–1955. (From Kohler, M.A., T. Nordenson, and D. Baker, Evaporation Maps for the United States, U.S. Weather Bureau Technical Paper 37, 1959.)

Abtew and Melesse. 2012. Evaporation and Evapotranspiration: Measurements and Estimations. Springer (in process);

Average Annual Lake Evaporation and Wetland Evapotranspiration



AVERAGE ANNUAL LAKE EVAPORATION



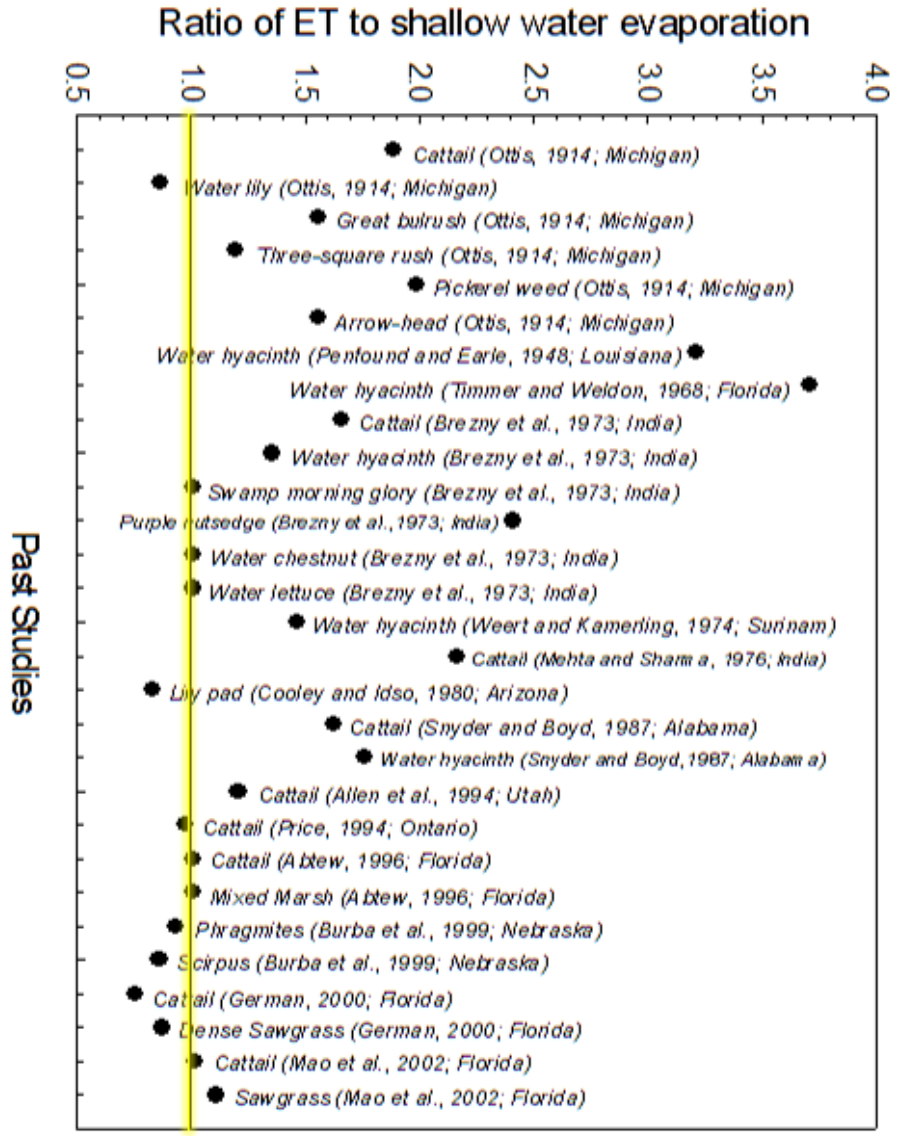
Evaporation (Visher, F.N. and G.H. Hughes, 1969. *The difference between rainfall and potential evaporation in Florida, 2nd Ed. Florida Bureau of Geology Map Series 32,*Tallahassee, FL.; Abtew, W., J. Obeysekera, M. Irizarry-Ortiz, D. Lyons and A. Reardon. 2003. *Evapotranspiration Estimation for South Florida*. P. Bizier and P. DeBarry (Ed.). Proceedings of the World Water and Environmental Resources Congress 2003. ASCE.); Abtew and Melesse. 2012. Evaporation and Evapotranspiration: Measurements and Estimations. Springer (in process);

Evaporation and Wetland Evapotranspiration in South Florida - Annual Rates

- 51.9 inches *(Central FL marsh; Dolan et al., 1984)*
- 53.5 inches *(Belle Glade Sugar Cane; Shih and Gascho, 1980)*
- 52.2 inches *(Lake Okeechobee; Langbein, 1951)*
- 52.0 inches *(Lake Okeechobee; Abtew, 2001)*
- 51.8 inches *(Everglades Nutrient Removal Project; Abtew, 1996)*
- 55.3 inches *(Everglades average; German, 2000)*

PART 2

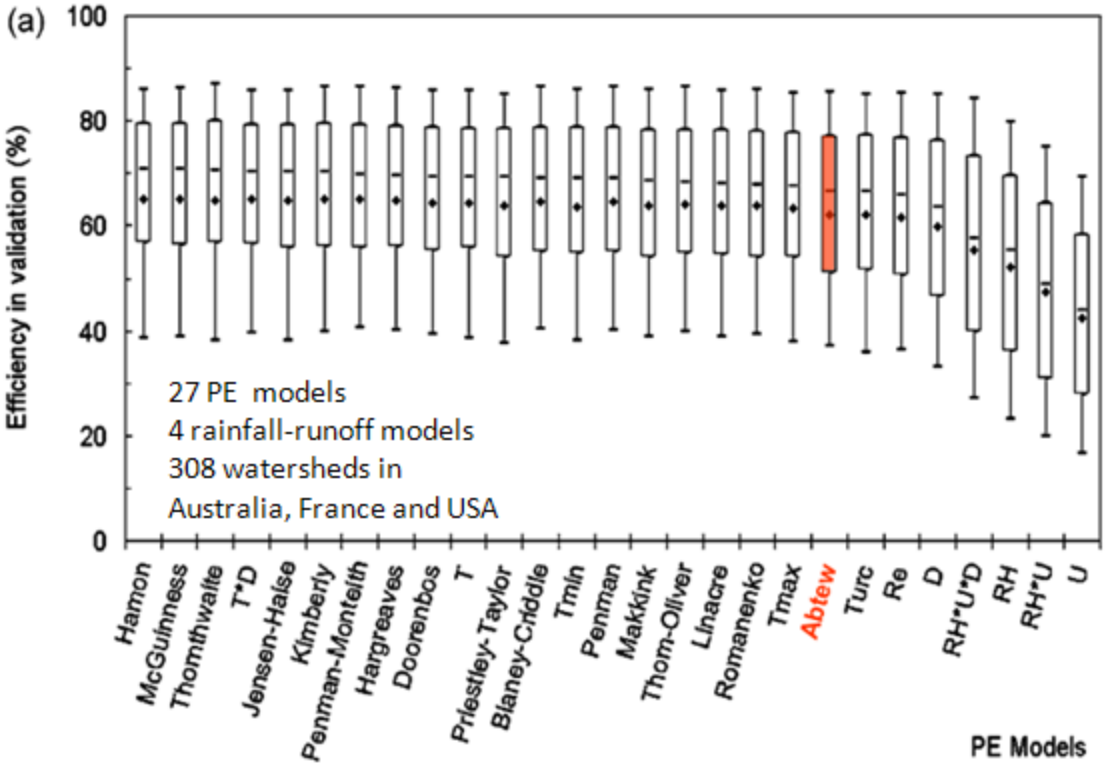
Is there significant difference between open water evaporation and wetland evapotranspiration?

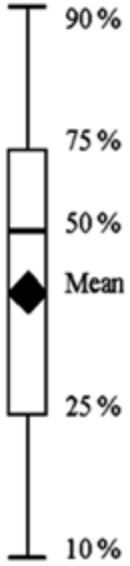


What is the Ratio of Wetland ET to Open Water Evaporation?

Abtew and Melesse. 2012. Evaporation and Evapotranspiration: Measurements and Estimations. Springer (in process); Abtew, W. 2005. Evapotranspiration in the Everglades: Comparison of Bowen Ratio Measurements and Model Estimates. Proceedings of the ASAE Annual International Meeting Technical Papers, July 17-20, 2005, Tampa, Florida. ASAE; 46. Abtew, W. 1996. Lysimeter Study of Evapotranspiration from a Wetland. C. R. Camp, E. J. Sadler and R.E. Yoder (Eds.). Evapotranspiration and Irrigation Scheduling. Proceedings of the International Conference. Nov. 3-6, San Antonio, TX. pp. 54-60. ASAE.

Wetland and Shallow Lake Evapotranspiration:
Potential evapotranspiration data in SFWMD database (DBHYDRO)





$$ET = K_1 \frac{Rs}{\lambda}$$

Oudin, L.; Hervieu, F.; Michel, C.; Perrin, C.; Andreassian, V.; Anctil, F.; Loumagne, C. Which Potential Evapotranspiration Input for a Lumped Model Part 2-Towards a Simple and Efficient Potential Evapotranspiration Model for Rainfall-runoff Modeling. *J. Hydrol. 2005, 303, 290-306.* Melesse, A., W. Abtew and T. Dessalegne. 2009. *Evaporation Estimation of Rift Valley Lakes: Comparison of Models*. Sensors Journal 9:9603-9615; DOI:10.3390/s91209603.

Comparison of Bowen Ratio Measured ET and Simple Method Estimated Everglades ET

Site	No. of Months	r	MSE mm^2	Bowen Ratio Measured ET mmd^{-1}	Model Estimated ET mmd^{-1}	Site Characteristics
1	24	0.90	0.20	3.36	3.54	Cattail
2	13	0.89	0.79	4.19	3.63	Open Water
3	24	0.97	0.99	4.48	3.68	Open Water
4	45	0.69	0.68	3.79	3.97	Dense Sawgrass
5	24	0.83	0.76	3.91	3.77	Medium Sawgrass; dry part of some years
6	32	0.80	0.50	3.63	3.80	Medium Sawgrass
7	58	0.82	0.99	4.19	3.97	Sparse Sawgrass
8	58	0.61	0.63	3.66	3.86	Sparse Rushes; dry part of each year
9	24	0.70	0.72	3.40	3.89	Sparse Sawgrass; dry part of each year

German ER (2000) Regional evaluation of evapotranspiration in the Everglades. USGS Water Resources Investigations Report 00-4217, Tallahassee, FL; Abtew, W. 2005. Evapotranspiration in the Everglades: Comparison of Bowen Ratio Measurements and Model Estimates. Proceedings of the ASAE Annual International Meeting Technical Papers, July 17-20, 2005, Tampa, Florida. ASAE.); Abtew and Melesse. 2012. Evaporation and Evapotranspiration: Measurements and Estimations. Springer (in process)

PART 3

What is the likely trend of evapotranspiration in south Florida?

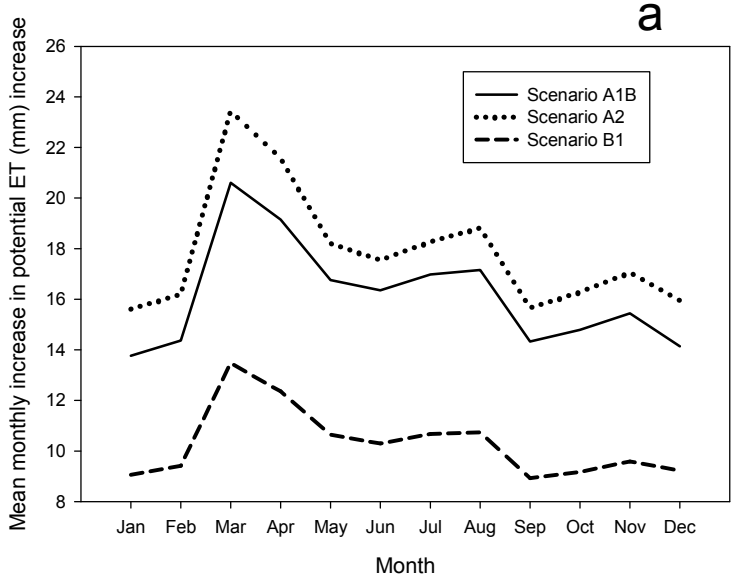
Climate Change and Evapotranspiration

What is the likely trend of evapotranspiration in south Florida?

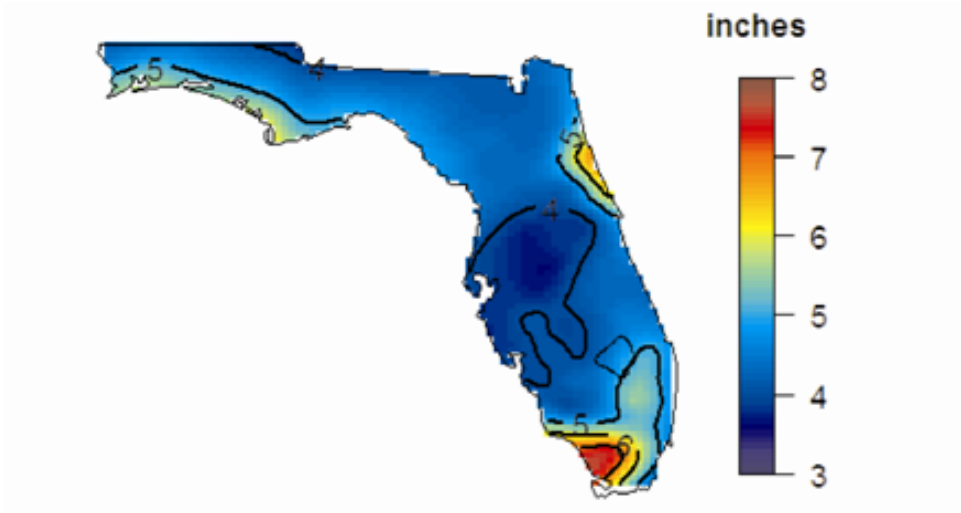
Reference Evapotranspiration in Great River Basin, Jamaica (2080-2100)
(CCCMA, GFDL MPI-M)

Reference Evapotranspiration in Florida by 2050
(Canadian Regional Climate Model output)

a



b



a) Abtew and Melesse. 2012. Evaporation and Evapotranspiration: Measurements and Estimations. Springer (in process); **b)** Obeysekera J, Park J, Ortiz MI, Trimble P, Barnes J, VanArman J, Said W, Gadzinski E (2011) Past and projected trends in climate and sea level for south Florida. Technical Report, South Florida Water Management District. West Palm Beach, FL

Variables that Control ET / Evaporation and Possible Trends

1. Vapor pressure deficit
2. Wind speed
3. Air temperature
4. Solar radiation
5. Atmospheric pressure
6. Heat storage

Abtew and Melesse. 2012. Evaporation and Evapotranspiration: Measurements and Estimations. Springer (in process)

Literature on ET and Related Parameters Trend: Importance of Data Quality

The *Research Highlights* from this paper are:

a) Globally 148 regional studies reviewed; average wind speed trend = ~ −0.014 m s^{-1} a^{-1}

b) Globally 55 pan evaporation studies were reviewed; average trend = −3.19 mm a^{-2}

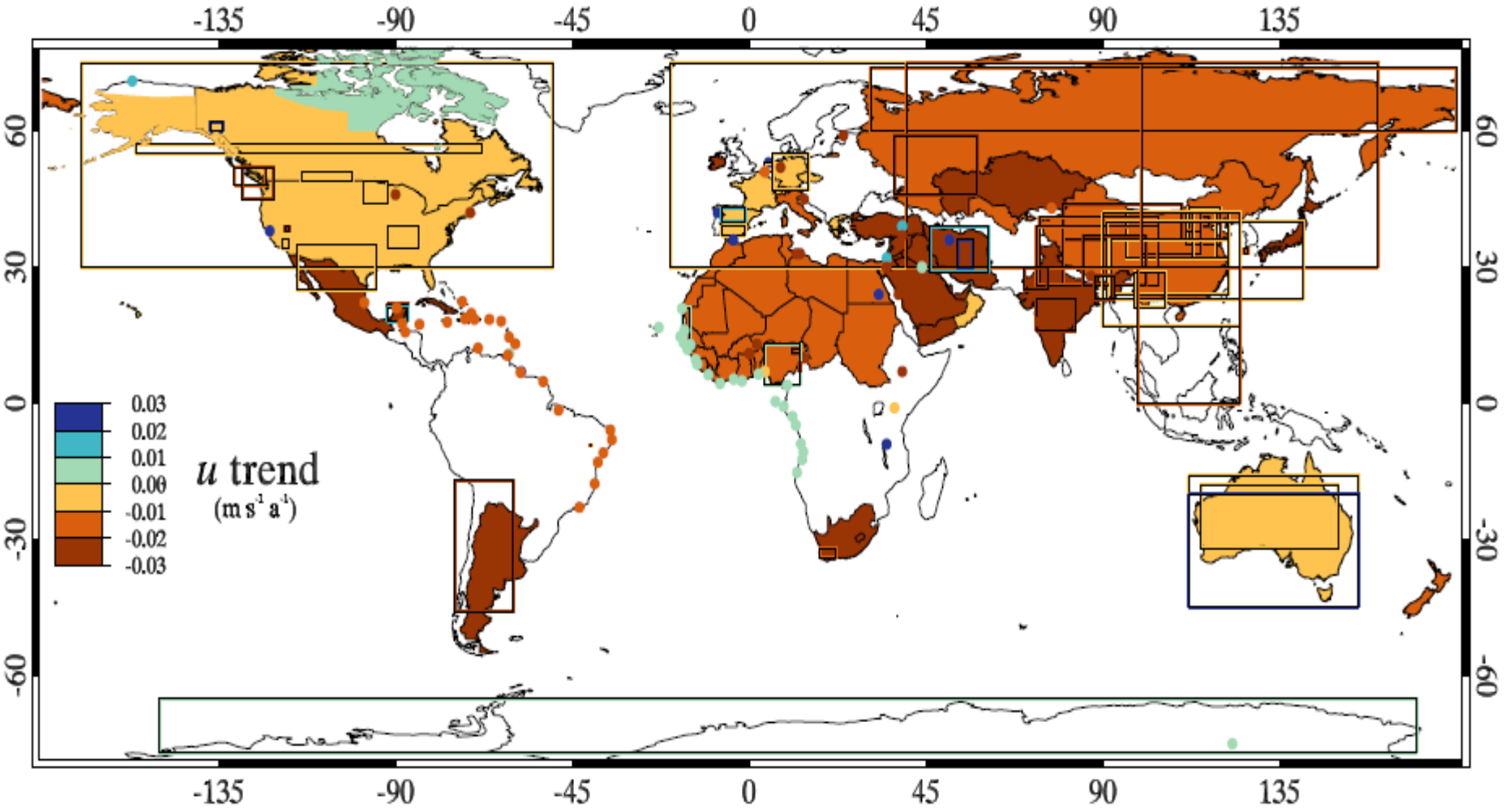
c) Twenty-six crop reference evapotranspiration studies reviewed; average trend = −1.31 mm a^{-2}

d) Globally 36 studies confirmed wind speed importance when assessing evaporation trends

e) Influence of wind speed trends on actual evaporation depends on limiting factor

McVicar, T.R., Roderick, M.L., Donohue, R.J., Li, L.T., Van Niel, T.G., Thomas, A., Grieser, J., Jhajharia, D., Himri, Y., Mahowald, N.M., Mescherskaya, A.V., Kruger, A.C., Rehman, S., and Dinpashoh, Y. (2012) Global review and synthesis of trends in observed terrestrial near-surface wind speeds: Implications for evaporation. *Journal of Hydrology*. 416-417, 182-205, doi:10.1016/j.jhydrol.2011.10.024

Global Wind Speed Trend



T.R. McVicar et al. / Journal of Hydrology 416–417 (2012) 182–205

Pan Evaporation and Potential Evapotranspiration Trends in South Florida

Pan Evaporation and Potential Evapotranspiration Trends in South Florida

Wossenu Abtew, Jayantha Obeysekera and Nenad Iricanin

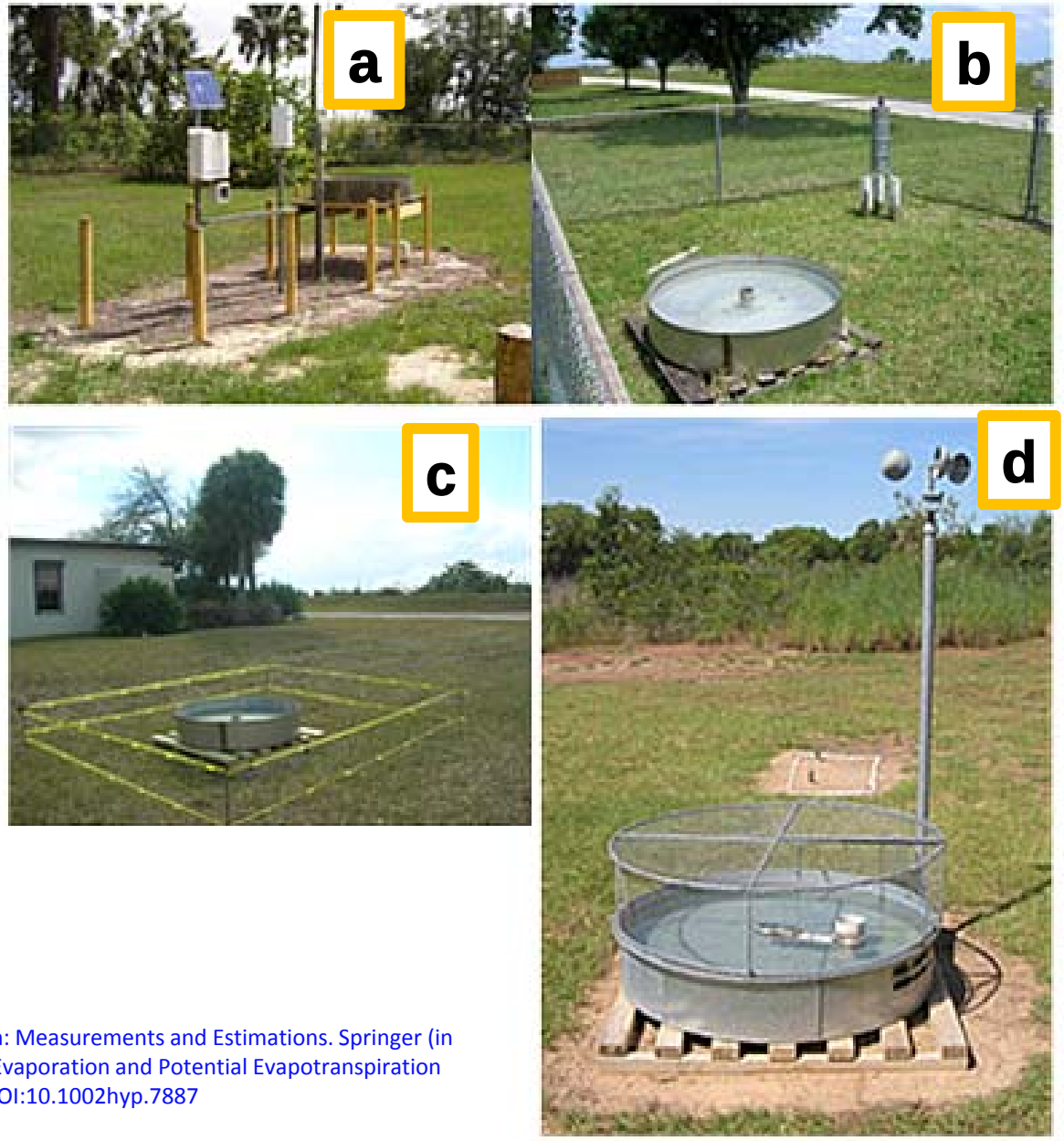
Abstract:

Declining trends in pan and lake evaporation have been reported. It is important to study this trend in every region to evaluate the validity of the trend and water management implications. Data from nine pan evaporation sites in South Florida were evaluated to see if there is a trend and if the quality of the data is sufficient for such analysis. The conclusion is that pan evaporation measurements are prone to too many sources of errors to be used for trend analysis. This condition is demonstrated in South Florida and in other regions by differences in magnitude and direction between spatially related pan stations and unexplainable observations. Also, potential evapotranspiration (ETp) was estimated with the Simple (Abtew equation) and the Penman–Monteith method. Both cases indicated no decline in evapotranspiration for the period of analysis. Based on the decline in humidity and the increasing trend in vapor pressure deficit for the short period of analysis, 1992–2009, it appears that South Florida is experiencing increase in evaporation and evapotranspiration at this time assuming no systematic error in the weather stations' observations.

KEY WORDS evaporation; evapotranspiration; pan evaporation; trends in evaporation

Abtew, W., J. Obeysekera and N. Iricanin. 2011. *Pan Evaporation and Potential Evapotranspiration Trends in South Florida*. Hydrological Processes. 25:958-969. DOI:10.1002hyp.7887

Variations in Evaporation Pan Environment Result in Differences in Observations



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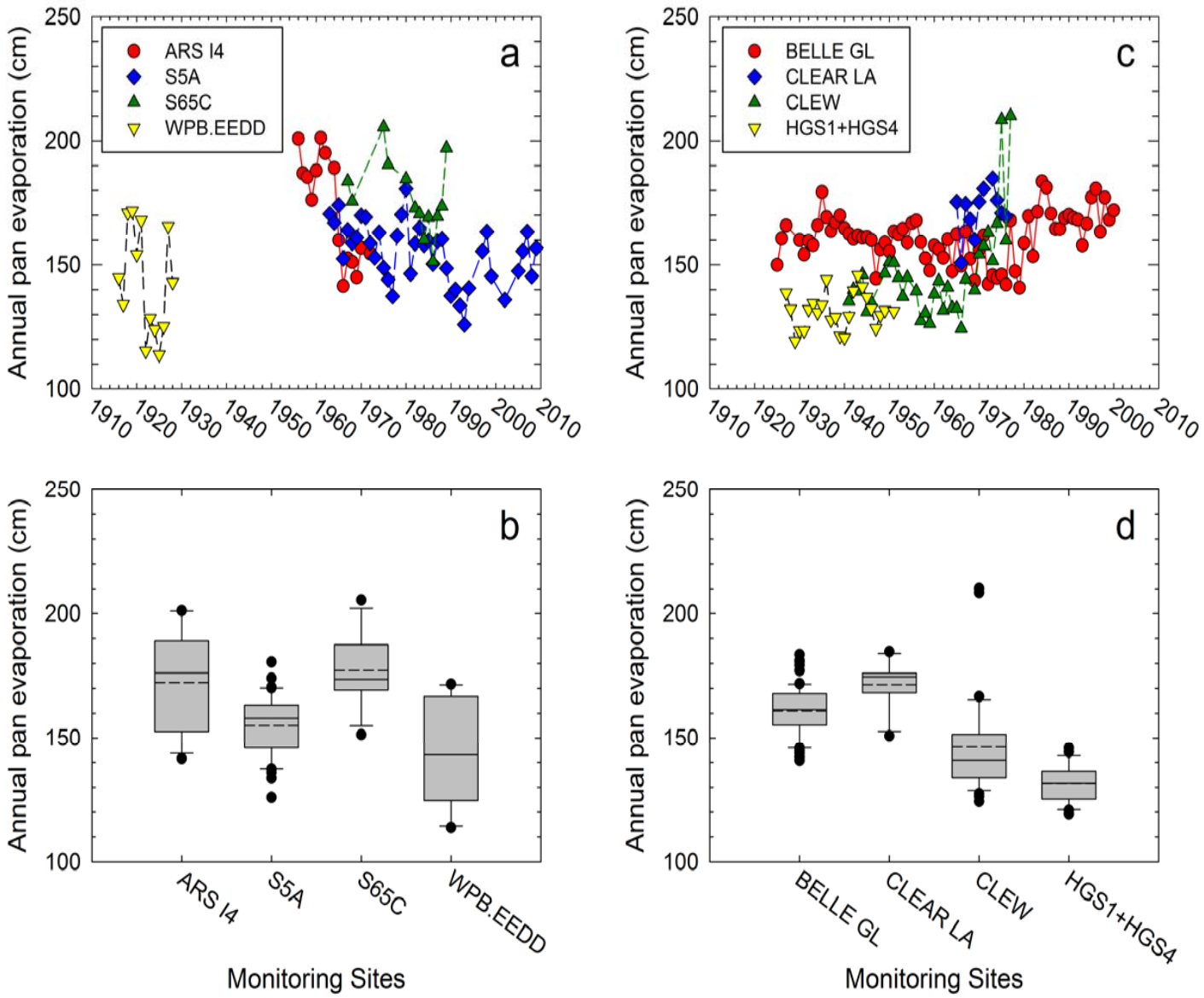
Pan Evaporation in South Florida



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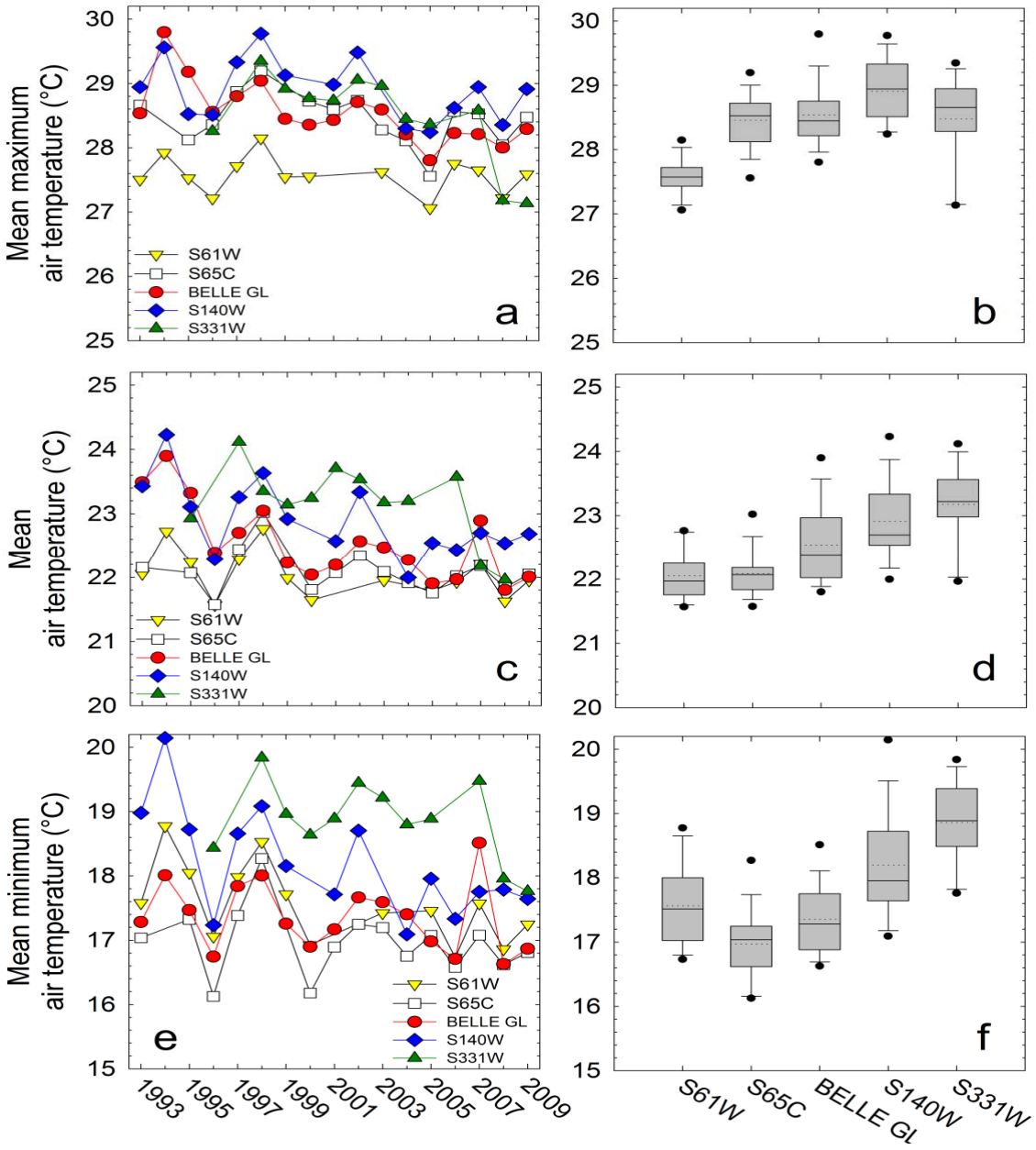

Air Temperature Trends in South Florida

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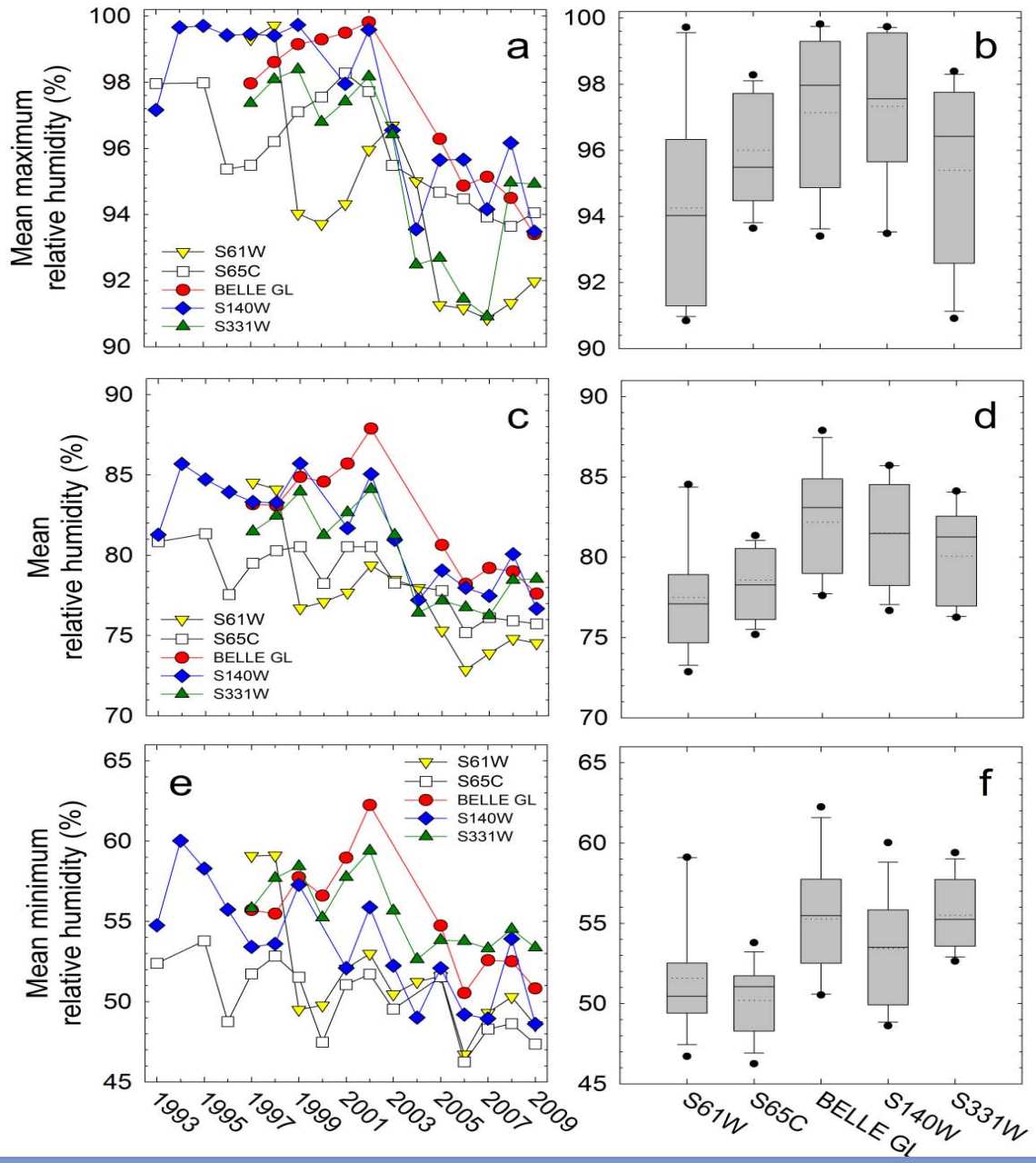
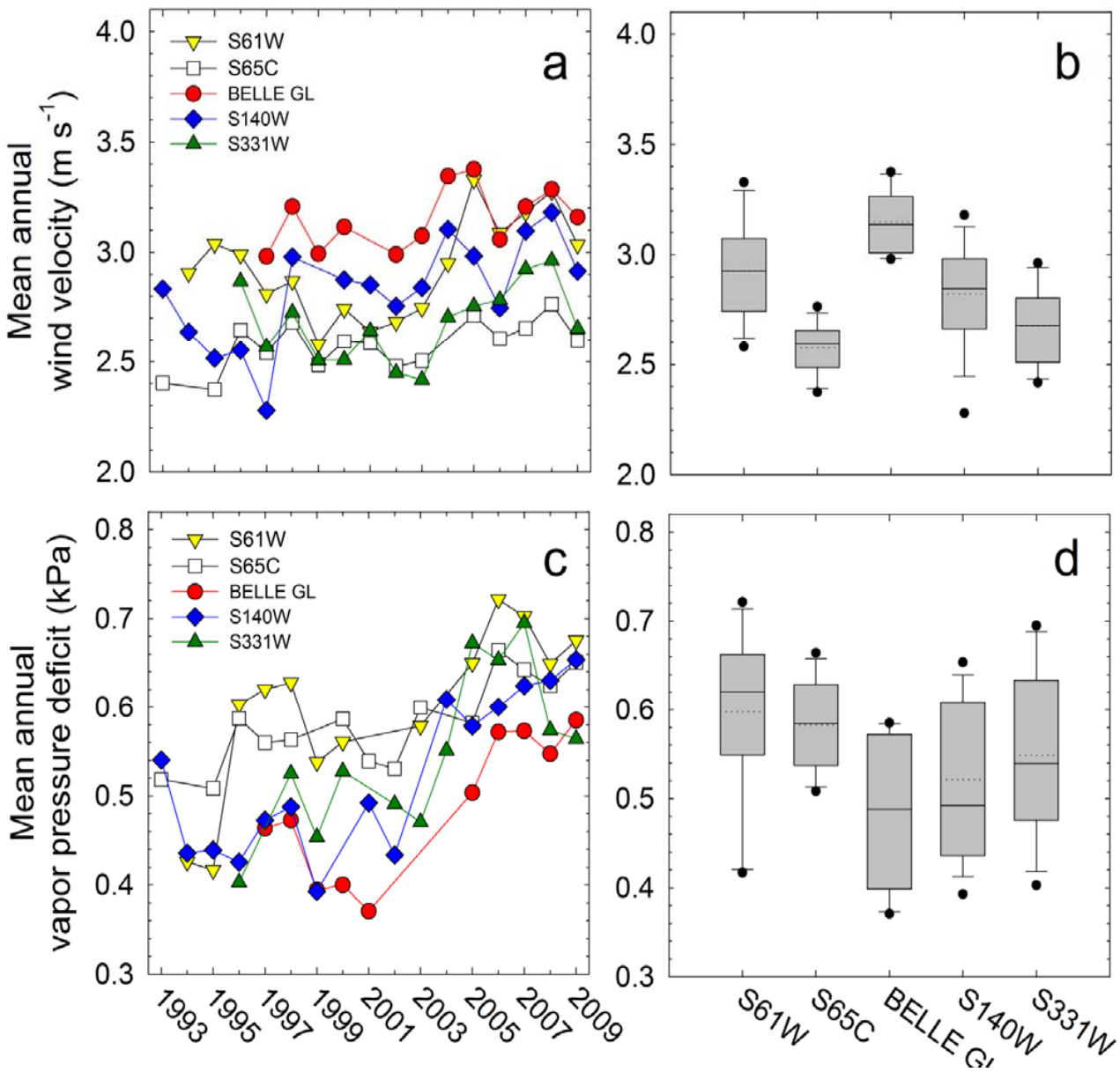


Relative Humidity Trends in South Florida

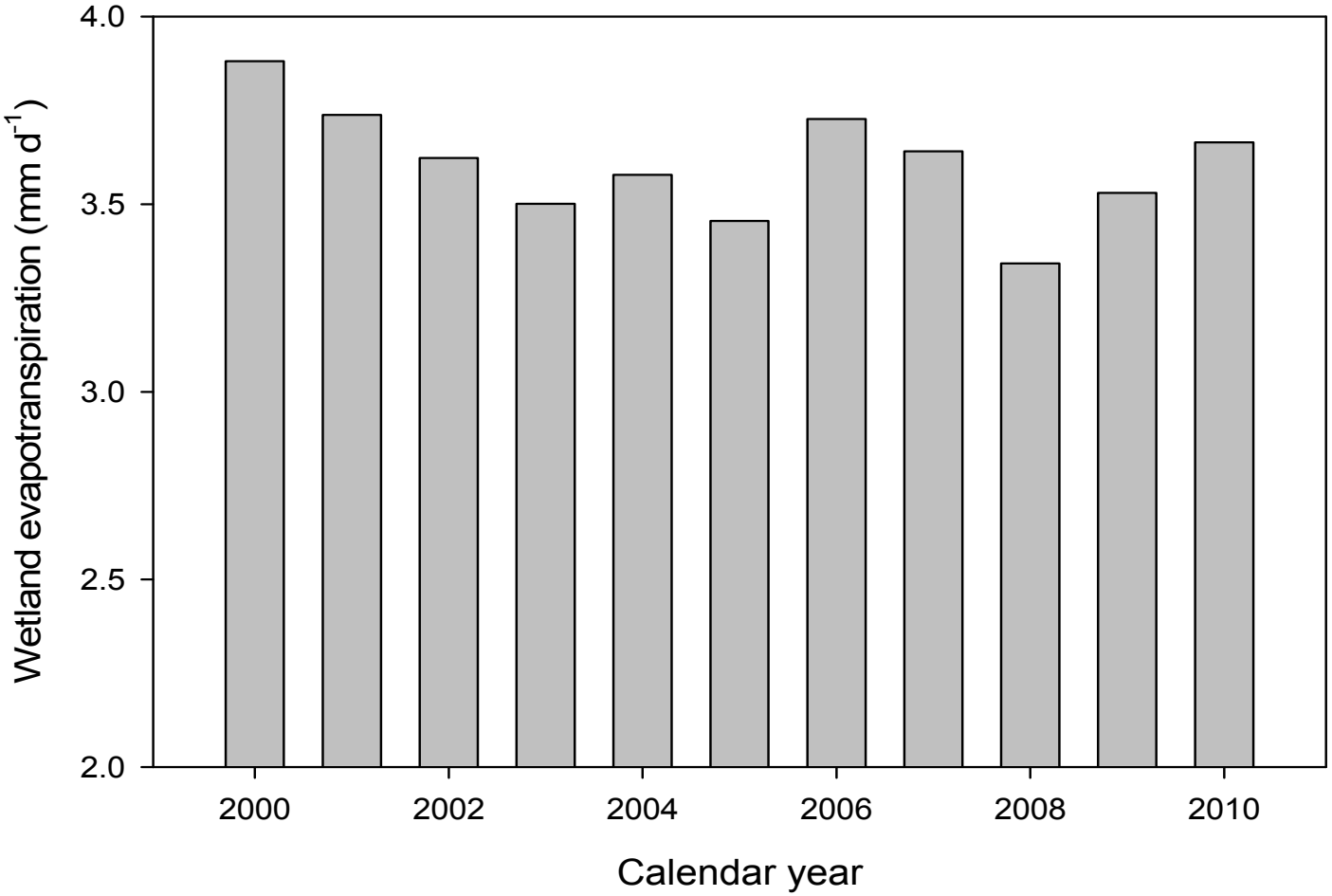
Abtew, W., J. Obeysekera and N. Iricanin. 2011. Pan Evaporation and Potential Evapotranspiration Trends in South Florida. Hydrological Processes. 25:958-969. DOI:10.1002hyp.7887



Wind Speed and Vapor Pressure Trends in South Florida

Abtew, W., J. Obeysekera and N. Iricanin. 2011. Pan Evaporation and Potential Evapotranspiration Trends in South Florida. Hydrological Processes. 25:958-969. DOI:10.1002hyp.7887

Wetland ET in Stormwater Treatment Area 1W



SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Droughts and Wildfire

(2011 La Niña - Water Conservation Area 1, 5/7/11)

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

El Niño-Southern Oscillation (ENSO) and ET

(2011 La Niña - Water Conservation Area 2, 5/7/11)

Is Drought Frequency Increasing?

Hydro-Ecological Importance of ET

Drought years since 2000:
2000, 2001, 2006, 2007, 2008, 2010, 2011 and 2012 so far is a drought year

(red are La Niña years)

Wind Event

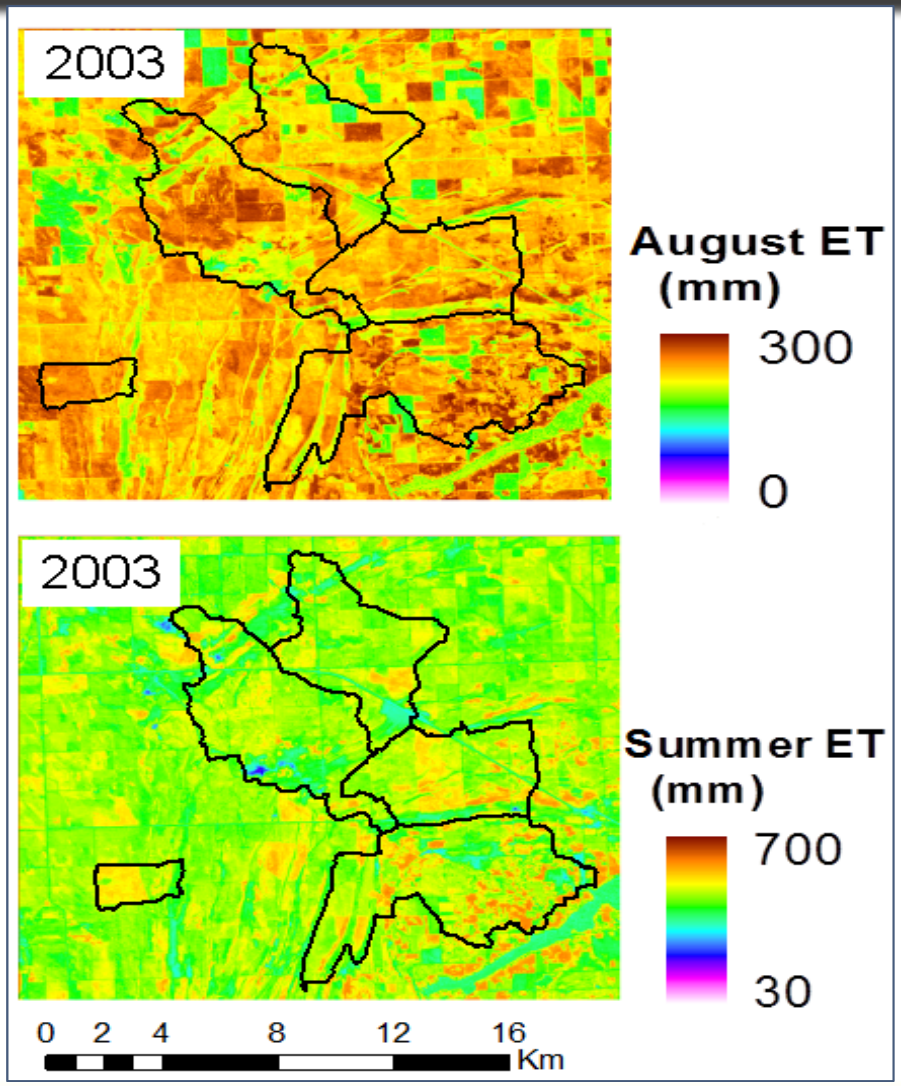
drought

Organic Soil Fire

Wildfire

Remote Sensing Applications to Regional ET Estimation:
Advancements in regional ET estimation using satellite observations

Glacial Ridge Prairie Wetland Restoration Site in Minnesota



Abtew and Melesse. 2012. Evaporation and Evapotranspiration: Measurements and Estimations. Springer (in process)

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Evapotranspiration: a demand that has to be satisfied

Evapotranspiration in the Everglades and its Watershed

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Principal Engineer, Water Resources Division
South Florida Water Management District