

Development of Satellite-Based Evapotranspiration (ET) Historical Data Over Florida

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SFWMD/USGS Coop Program
Annual 2008 - Data Meeting
SFWMD B-1 Auditorium
West Palm Beach, FL



sfwmd.gov

March 7, 2008

Presentation will include following topics.

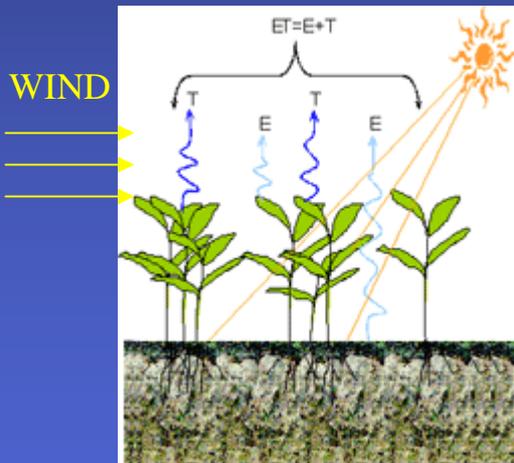
- What are the **benefits** of the project ?
- What was the **objective** of the project ?
- What was the **scope** of the project?
- Which **ET methods** were investigated?
- Which **ET method recommended** and used?
- When and where the **datasets are available** ?

This project, first in the US, developed historical daily ET estimates that will be used in a varieties of water resources projects.

- ◆ used in **Hydrologic Models**.
- ◆ used in the development of **Water Supply Plans**.
- ◆ used for **Regulation and Permitting**
- ◆ used for **Water Budgets**.

Evapotranspiration (ET)

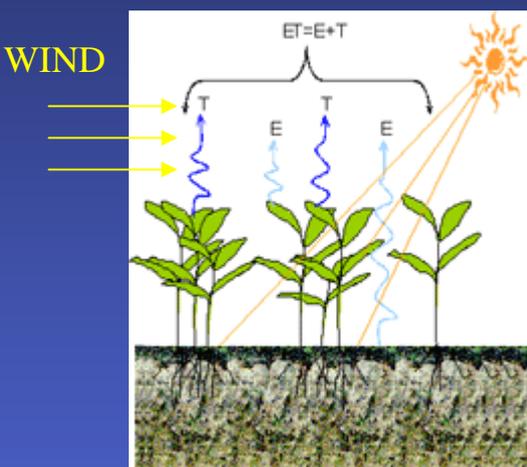
$$ET = f [\{ \text{Land (Soil, Cover, SM)} \}; \{ \text{Air (Radiation, Temp, RH, Wind)} \}]$$



Energy Transfer Between Land and Air

$$ET = f (R_n, \text{Albedo}, G, T_a, T_s, RH, \text{Canopy height, Canopy Resistance, Wind, Latent heat flux, Vapor pressure,})$$

Evapotranspiration (ET)



- Potential Evapotranspiration (PET)
 - Land Cover
 - Sufficient Water/Moisture Available
- Reference Evapotranspiration (RET)
 - Tall Grasses/Alfa-alfa
- Actual Evapotranspiration (AET)
 - $AET = K_t \times PET$
 - $AET = K_c \times RET$

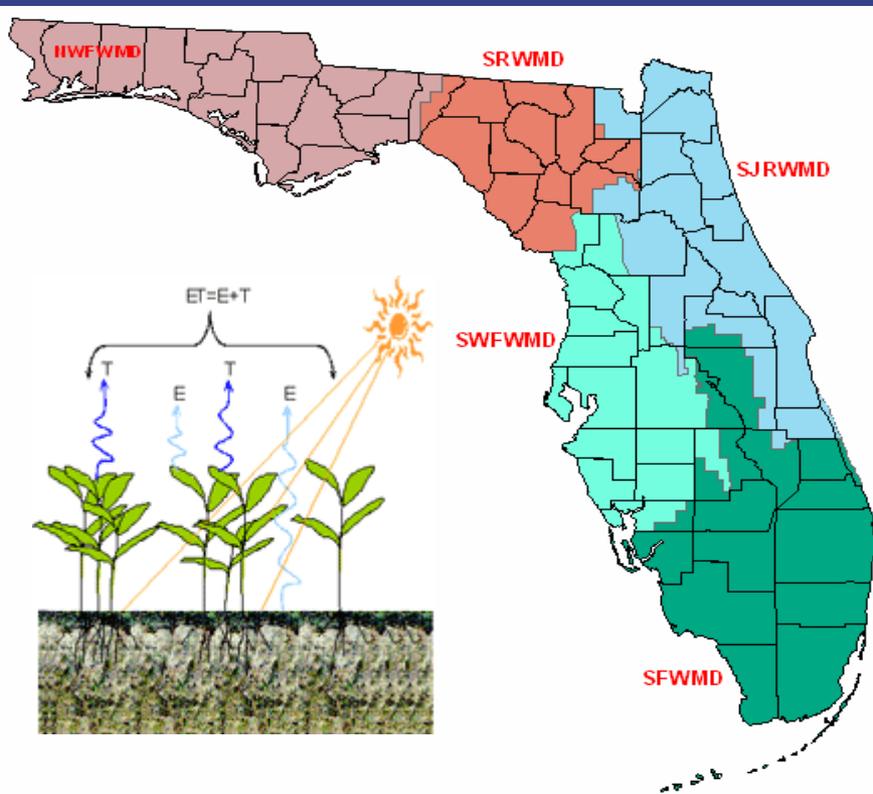
The project's objective was to develop spatially distributed daily ET estimates.

- Potential Evapotranspiration (PET)
- Reference Evapotranspiration (RET)
- Daily estimates from 1995 to 2004
- Spatially distributed at 2km x 2km grid

Satellite-based PET and RET estimates over Florida were developed in this project.

- Project was performed under **USGS contract.**
- Project duration was ~ **36 months.**
- Three WMDs and USGS funded approximately \$400k for this work effort.

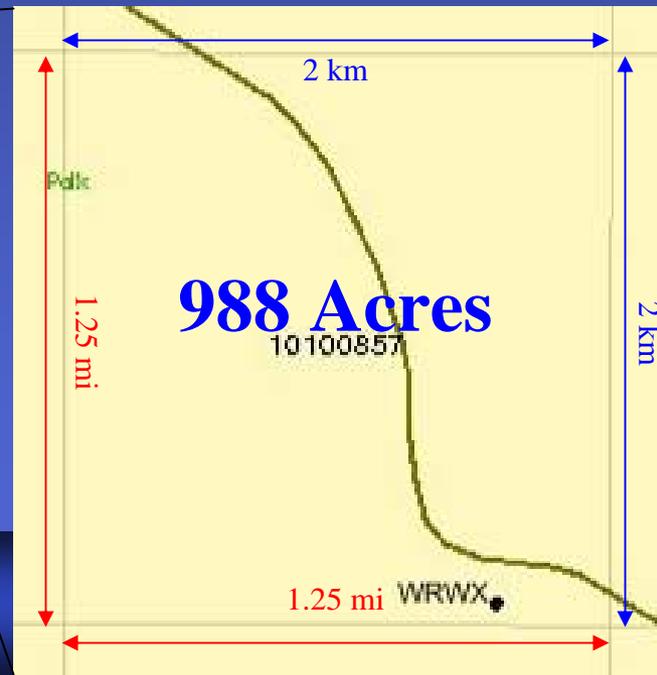
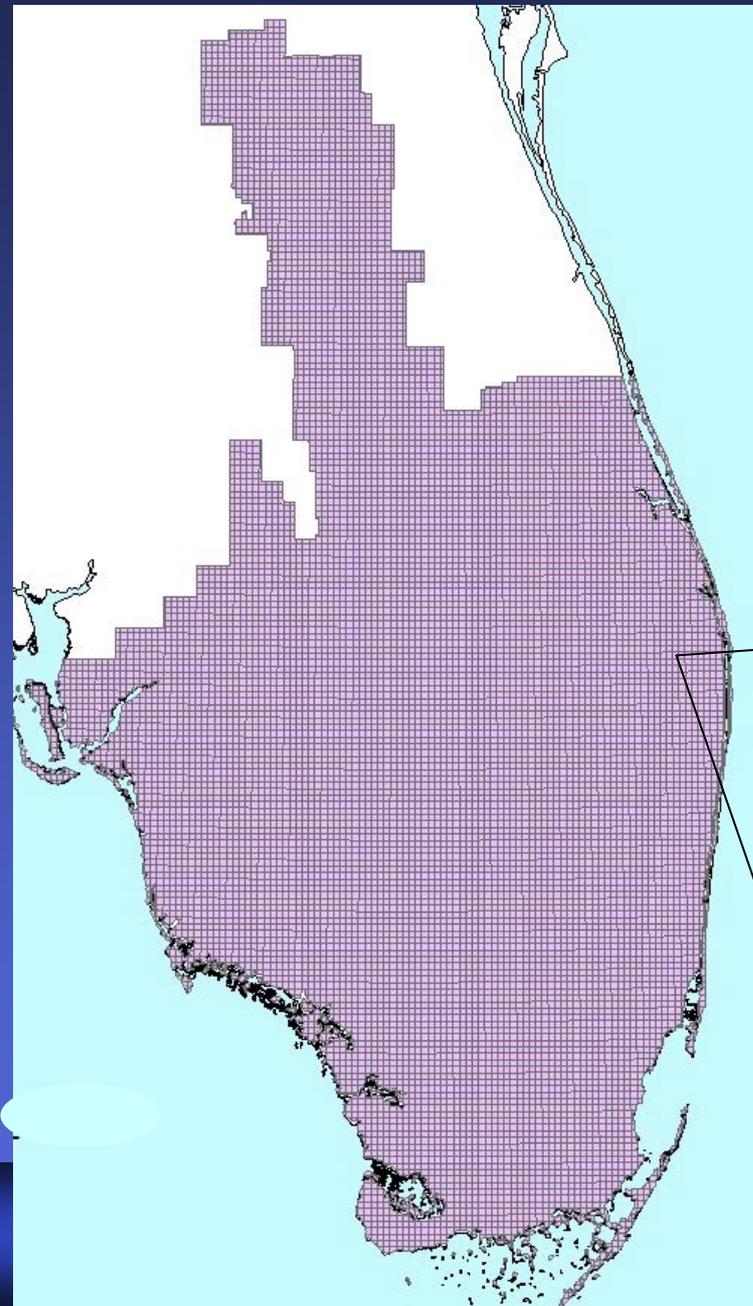
The project developed spatially distributed daily PET and RET estimation over Florida.



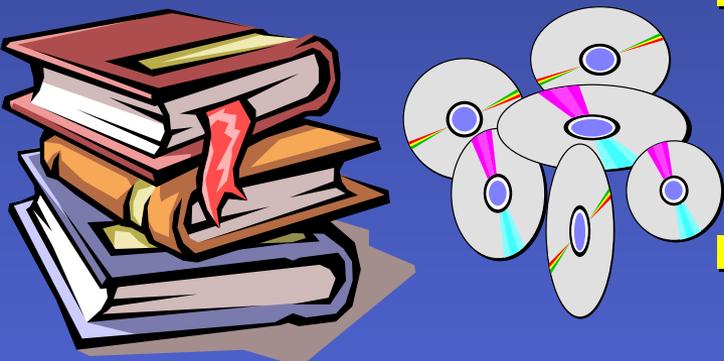
- The project domain included **FIVE (5) Water Management Districts**
- Daily estimates from 1995 to 2004
- Spatially distributed at 2km x 2km grid

GRID Attributes

- 2 km X 2 km grid (= 1 pixel)
- Same as NEXRAD Rainfall GRID
- Total of 12,000 pixels within District boundaries
- Unique pixel id - 8 digit integer

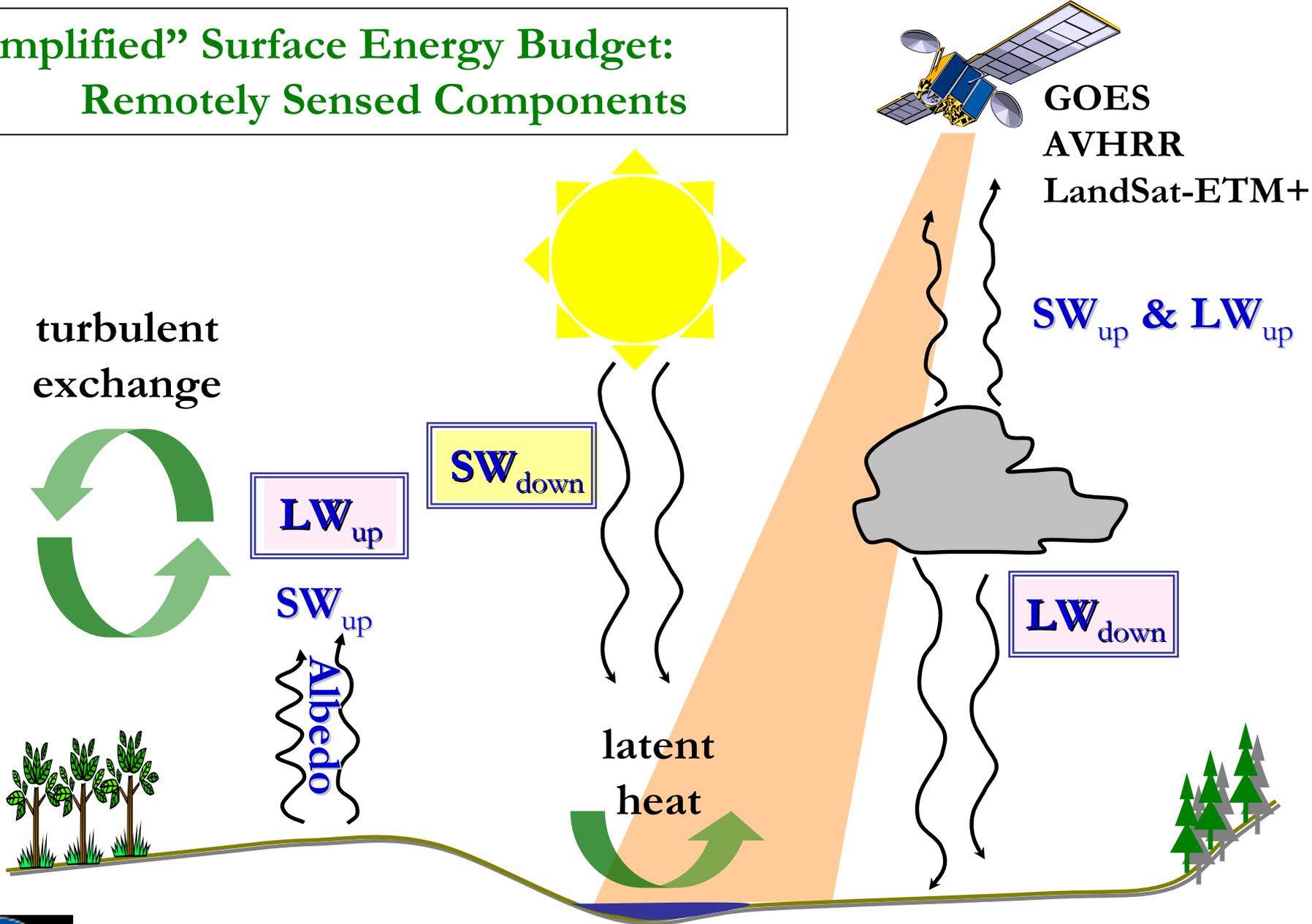


Solar radiation flux is the largest determinant of evapotranspiration (ET) flux.



- Solar radiation explain about 70 percent of the variation.
- Solar radiation is measured by a ground-based pyranometer network.
- Net radiation data are collected at all ET Measured Sites
- $R_{net} = SW_{down/up} + LW_{down/up}$

“Simplified” Surface Energy Budget: Remotely Sensed Components

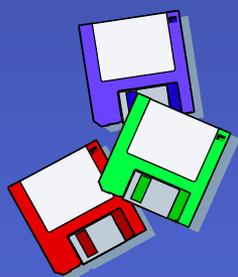
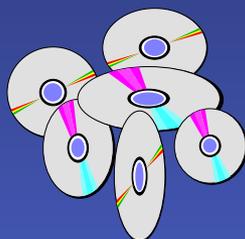


$$R_{net} = SW_{down/up} + LW_{down/up}$$

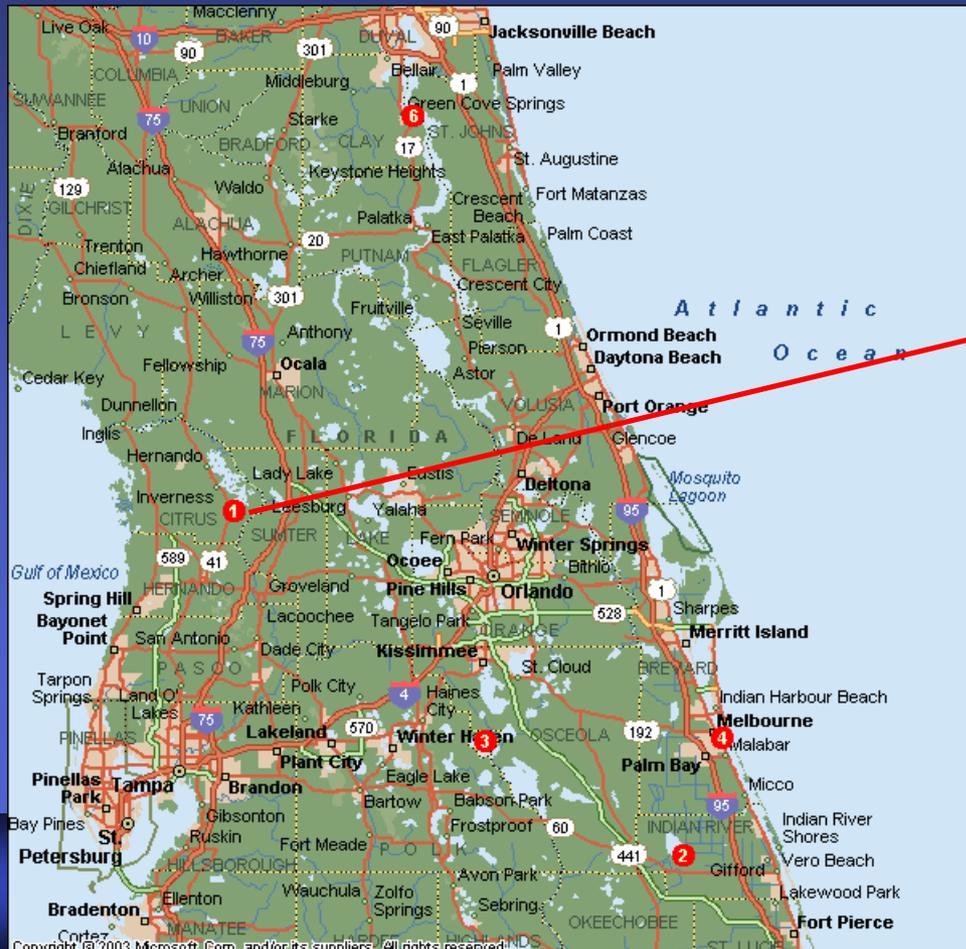


Developed GOES satellite derived solar radiation dataset

- Retrieved and processed GOES satellite datasets from 1995 to 2004
- Developed daily solar radiation data from half-hour solar radiation estimates from GOES datasets
- Calibrated GOES datasets with ground sensors and developed daily solar radiation data for 2kmx 2km grid.



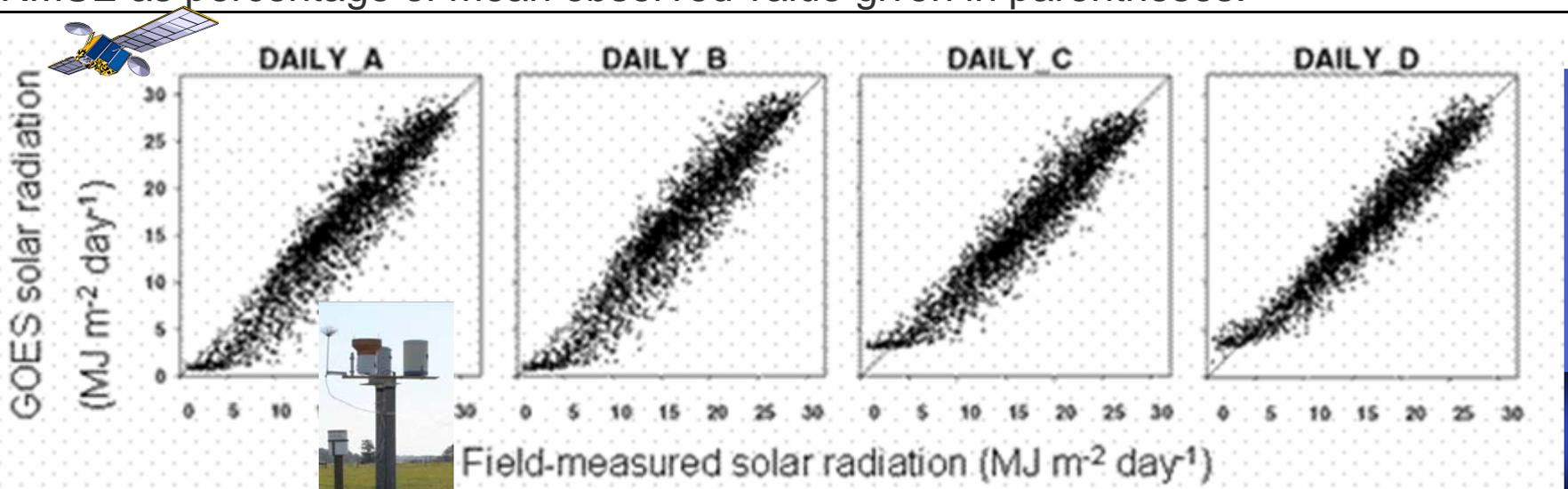
Pyranometer-measured daily solar radiation for Floral City site



Comparison of satellite-estimated and pyranometer-measured daily solar radiation for Floral City site

	DAILY_A	DAILY_B	DAILY_C	DAILY_D
RMSE MJ m ⁻² day ⁻¹ (percent)	2.2 (13 percent)	2.2 (13 percent)	1.9 (11 percent)	1.7 (10 percent)
MBE MJ m ⁻² day ⁻¹	-0.7	-0.2	-0.8	-0.5
r ²	0.90	0.91	0.92	0.93

RMSE as percentage of mean observed value given in parentheses.



PET model comparisons

- Simple method (Sp)

$$\lambda \rho_w ET_o = K_l * R_s$$

- Priestley-Taylor (PT)

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

- Penman-Monteith (PM)

$$\lambda \rho_w ET_o = \frac{\Delta(R_n - G) + \rho_a c_p D / r_a}{\Delta + \gamma(1 + r_s / r_a)}$$

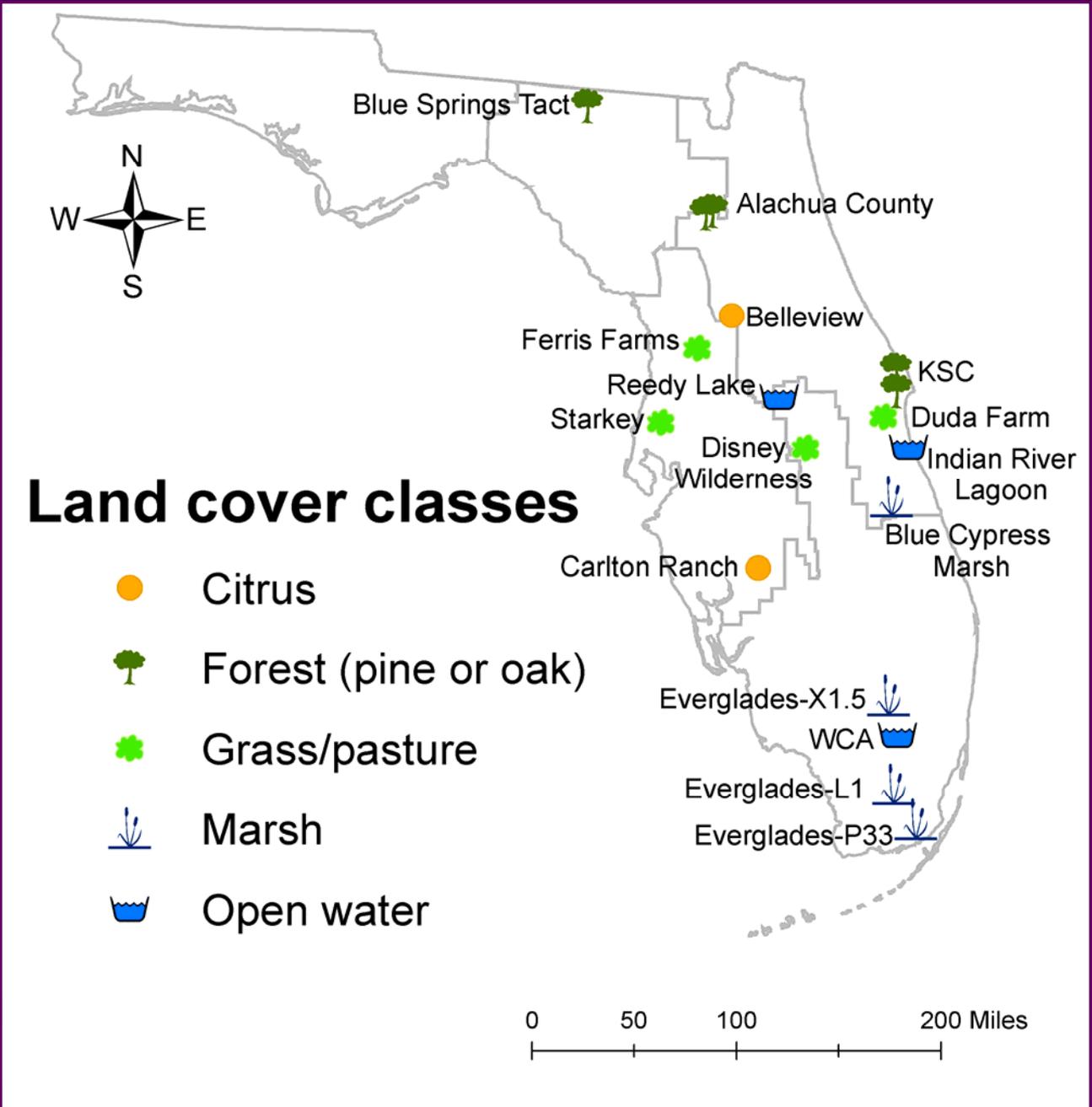
Comparison of Three PET Models

- Computed ET using data collected at sites in sites in different locations and with differing land covers.
- Compared performance of three models with actual ET observations.
- Recommended the “**best**” model for computing ET across Florida.

Validation sites

- **Goal: Good coverage in space and over land cover type**
 - **A minimum of two sites per WMD**
 - **A minimum of two sites per land cover type**

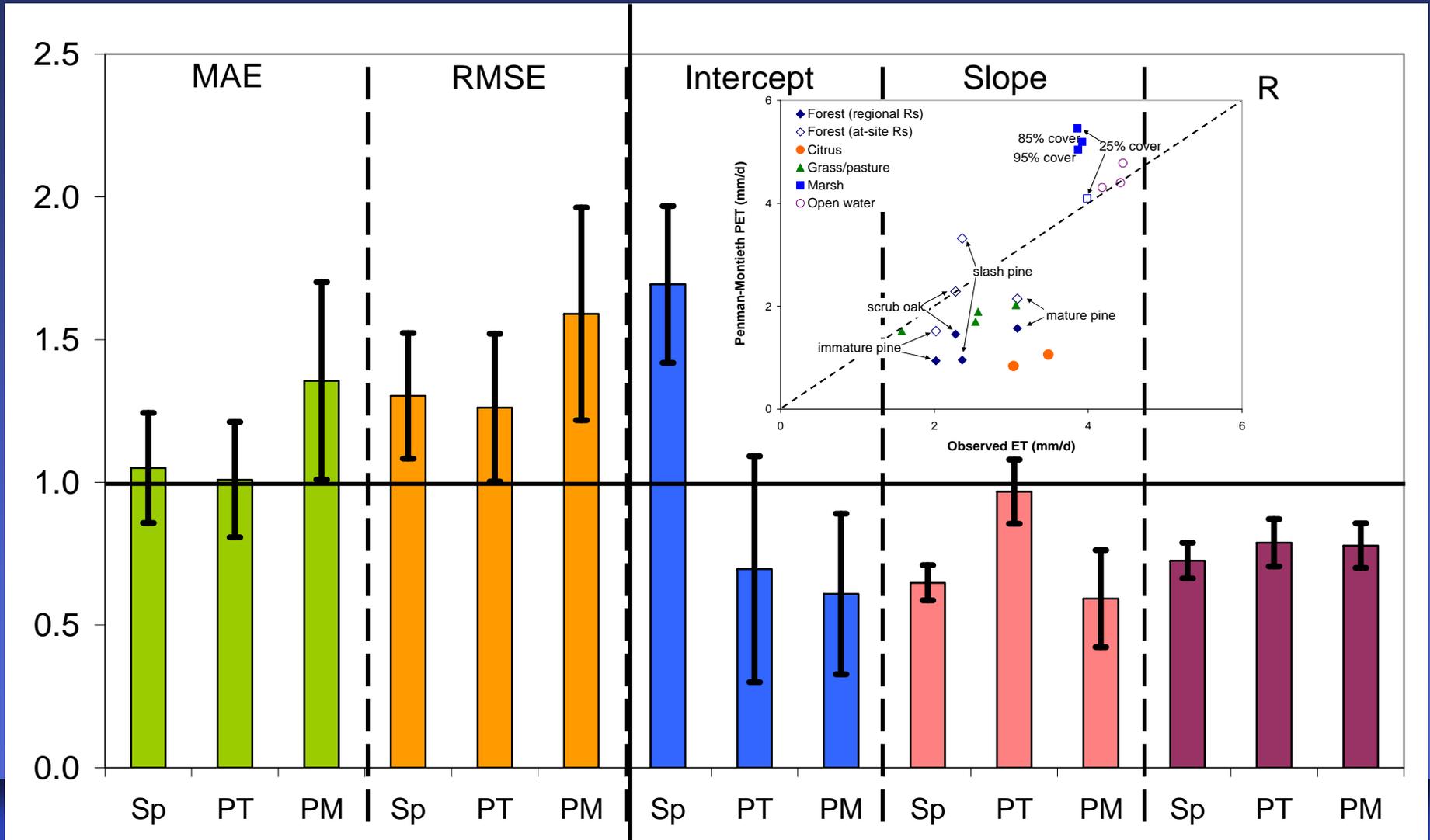
District	marsh	grass/ pasture	citrus	forest	open water
SRWMD	--	--	--	Blue Springs	--
SJRWMD	Blue Cypress	Duda Farm	Belleview	KSC (2) Alachua (2)	Indian River
SFWMD	Everglades (3)	Disney	--	--	WCA Reedy Lake
SWFWMD	--	Starkey Ferris Farms	Carlton ranch	--	--



Observed Actual ET

- Observations data at 30-min increments.
- Daily ET computed as average over 24 hrs.
- Gap-filled when 30-min observations were unavailable.
- “Good” daily ET observation when $\geq 80\%$ of 30-min observations available.
 - Relaxed to $\geq 60\%$ in a few cases (Disney, Everglades)
- Selected observed datasets for PET conditions.

Comparison of model performance



PET model recommendation

- Each method has strengths and weaknesses.
 - PM could be more accurate with better parameters estimates, but these are difficult to measure and regionalize.
 - PT can be computed with readily available data and is comparable in accuracy to PM.
- **RECOMMEND USE OF PT model**

Daily PET and RET Datasets

- **PET** dataset developed using:
 - **Priestley-Taylor Model**
 - Spatially distributed at 2km x 2km grid
 - Daily data from 1995 to 2004
- **RET** dataset developed using:
 - ASCE 2000 reference ET method – **PM Model.**
 - Spatially distributed at 2km x 2km grid
 - Daily data from 1995 to 2004

Availability of Datasets

- **Rs, PET, RET datasets available :**
 - From USGS beginning **Jan 22, 2008**
 - Spatially distributed at **2km x 2km grid**
 - **Daily data from 1995 to 2004**
- **Updated datasets will be available:**
 - **September 30, 2008**
 - Data for years **2005, 2006 and 2007**
- **Updated datasets are planed:**
 - **Annually** for data from year **2008** onwards

Availability of Datasets

<http://hdwp.er.usgs.gov/>

Hydrologic Data Web Portal

The U. S. Geological Survey's Florida Integrated Science Center, located in Tampa, Florida, operates and maintains a comprehensive network of surface water, ground water and water quality monitoring stations throughout southwest Florida. The Hydrologic Data Web Portal combines information collected by differing methods and stored in a variety of formats from wells, lakes, springs and streams and analyzes, displays and serves the information in tables, graphs, statistics, maps and compressed data sets.

 [Register](#) to receive notification when new data or features are available

Database last updated: **1/29/2008 1:00:34 AM**, **6,957,841** Data Values in **1,552** Parameters for **1,817** sites.

Locate & Retrieve Data	Supporting Information	Questions?	
<p>Data</p> <ul style="list-style-type: none"> • Site Finder • Site Inventory • Data Inventory • Database Query • Data Quick Stop 	<p>Resources</p> <ul style="list-style-type: none"> • NWISWeb - Realtime Data for Florida • NWIS - Instantaneous Data Archive for Florida • Annual Data Reports • Surface Water Duration Charts • Ground Water Comparison Graphs • Florida Evapotranspiration Measurement Sites • Florida Potential and Reference Evapotranspiration 1995-2004 • Orlando Hydrologic Data Web Portal 	<p>Help</p> <ul style="list-style-type: none"> • FAQ 	<p>Information</p> <ul style="list-style-type: none"> • CCWS Tampa Staff Directory



Availability of Datasets



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

Florida Integrated Science Center, Tampa, FL

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

Southwest Florida Water Management District

Hydrologic Data Web Portal

Florida Potential and Reference Evapotranspiration 1995-2004

January 29, 2008 11:24 AM

Options Available

- 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	54,611,873	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

Availability of Datasets

Each compressed archive file contains one data file having tab delimited columns of data, which include the following fields:

Column	Column Definition
-----	-----
date	Date data representation
latitude	Latitude of Pixel value
longitude	Longitude of Pixel value
pixel	Pixel ID number
RET	Reference ET(mm/day)
PET	Potential ET(mm/day)
solar	Solar Radiation - Daily Insolation (MegaJoules/sq meter/day)
RHmax	Maximum Relative Humidity for day (%)
RHmin	Minimum Relative Humidity for day (%)
Tmax	Maximum Temperature for day (C)
Tmin	Minimum Temperature for day (C)
Wind	Wind Speed (meters/second)

19950601	27.787	-82.648	93682	8.106	7.299	31.130	91.262	42.466	32.829	24.946	2.535
19950601	27.805	-82.801	94148	7.422	6.891	28.630	91.992	43.998	33.470	23.666	2.557
19950601	27.805	-82.744	94151	7.280	6.816	28.060	91.644	43.265	33.253	24.118	2.546
19950601	27.805	-82.725	94152	7.333	6.845	28.250	91.530	43.029	33.166	24.292	2.543
19950601	27.805	-82.706	94153	7.829	7.122	30.140	91.421	42.802	33.078	24.467	2.540
19950601	27.805	-82.686	94154	8.054	7.275	30.990	91.310	42.575	32.990	24.638	2.536
19950601	27.805	-82.667	94155	7.679	7.037	29.540	91.213	42.375	32.922	24.770	2.533
19950601	27.805	-82.648	94156	7.385	6.874	28.410	91.123	42.192	32.879	24.852	2.531

NEXT STEPS

- **Rs, PET, RET datasets :**
 - Store and retrieve data from DBHYDRO
 - Use ArcMap based data extraction
 - Develop (similar to NEXRAD rainfall) data extraction application
 - Data spatially integrated and at **2km x 2km** grid
 - Data temporally integrated and at **Daily data**
 - Complete by **June 2008**

Rs, PET and RET Datasets

Default Map Hide Navigation Panel

Active Data Layer:

- Entire District
- Entire District
- LOSA Water Basins
- AHED WC Catchments
- AHED Watersheds
- NEXRAD Rain Grid
- Rain Areas
- Basins
- County

Display Layers:

- Entire District
- LOSA Water Basins
- AHED WC Catchments
- AHED Watersheds
- Rain Areas
- Basins
- County

Refresh Map/Reset

Time Specific Data Near Real Time Data

Map Text Get Data!

Start Date: 01 January 2008 00 00

End Date: 01 January 2008 00 00

Time Interval: 15 min

Output Destination: 15 min

Include Zeros (W generate a large file)

Include Pixels in Polygons generate a large file

Batch Mode Batch Email

In summary, the ET datasets will benefit to various existing and future projects.

- **These ET datasets will benefit by providing improved daily ET estimates from 1995 to 2004 that are spatially distributed over the domain of existing and future projects including CERP projects.**

Questions and Answers



Thank you

