



# Multi-scale Remote Assessment of Land-surface Hydrologic Response to Stress

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*USDA-ARS, HRSL*

**T.P. Meyers**

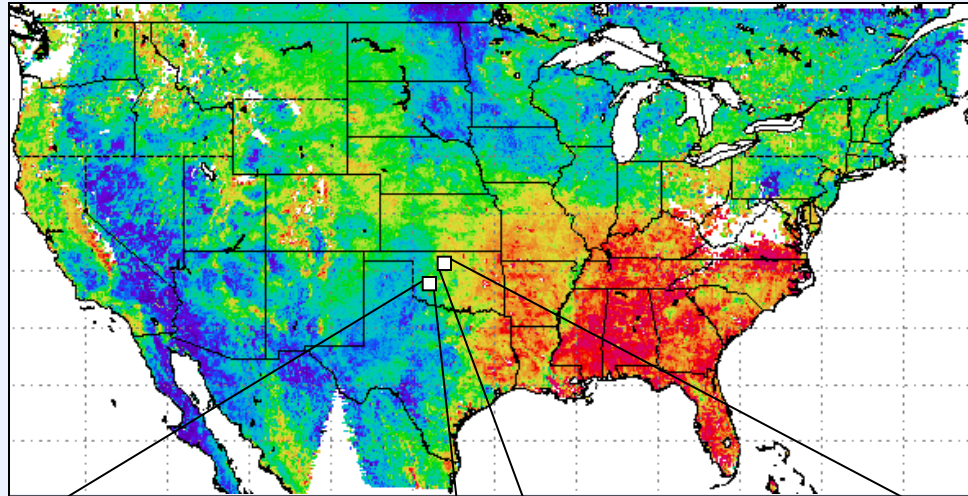
*NOAA-ATDD*

**J.M. Jacobs**

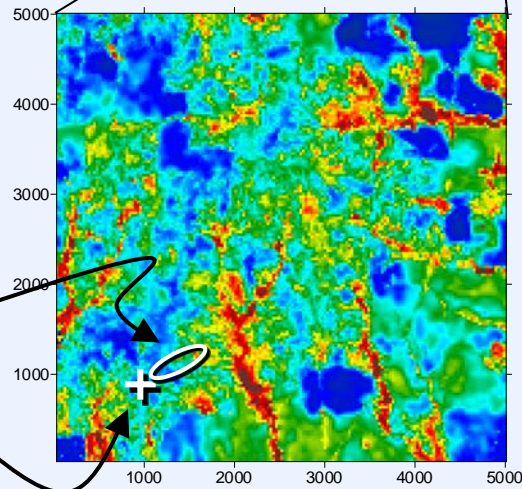
*U New Hampshire*

# Multi-scale flux modeling strategy

GOES-DERIVED FLUXES (10 km)

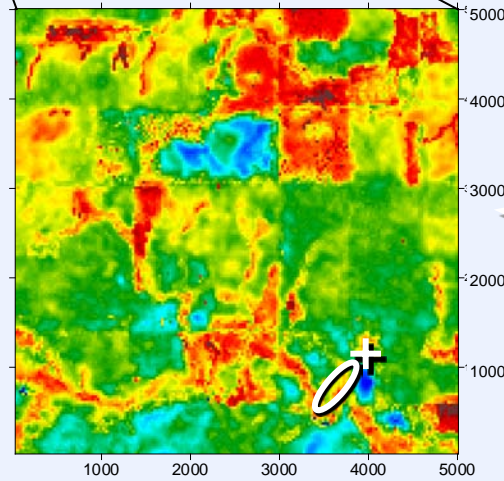


**Hourly**



source footprint

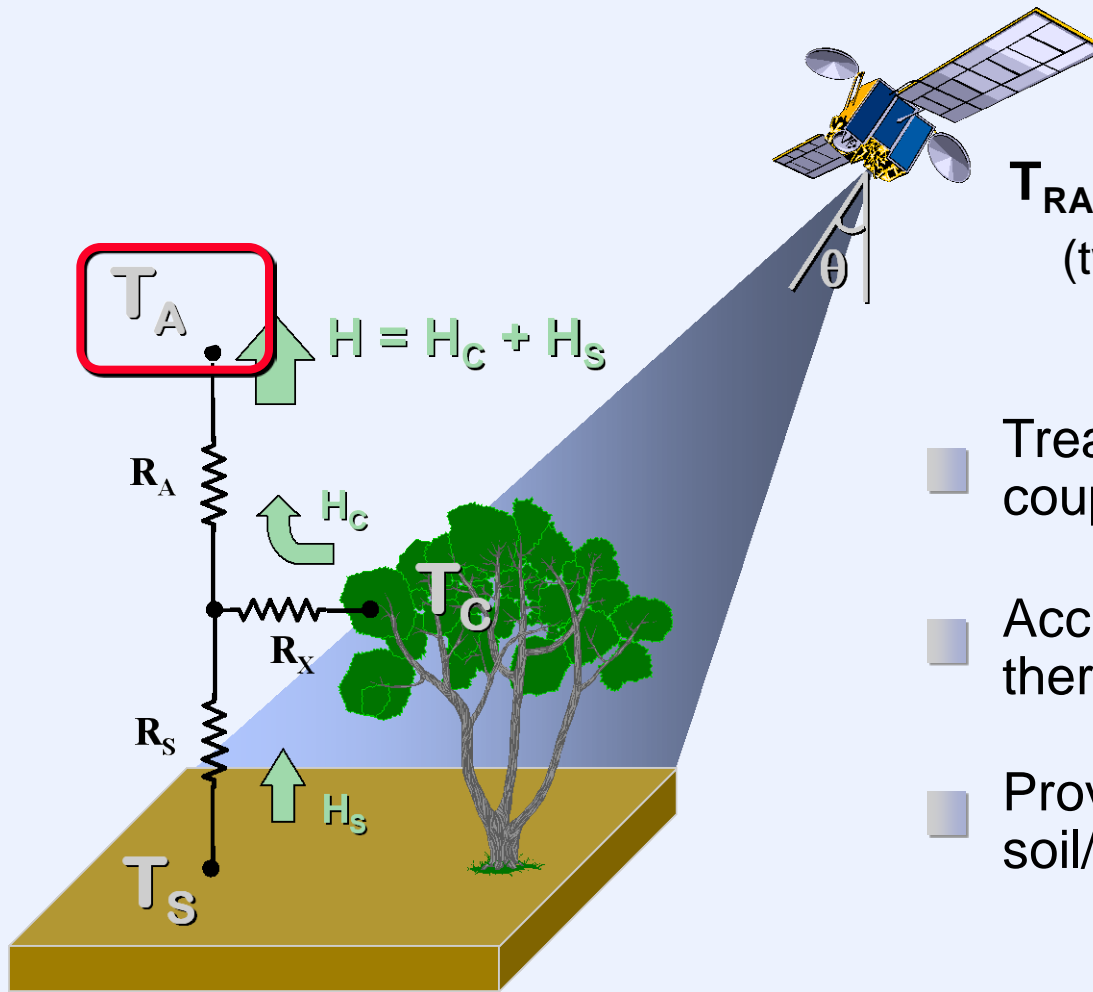
tower



**When available**

LANDSAT-DISAGGREGATED FLUXES (30 m)

# Two-Source Energy Balance Model (TSEB)



$$T_{\text{RAD}}(\theta) \sim f_c(\theta)T_c + [1-f_c(\theta)]T_s$$

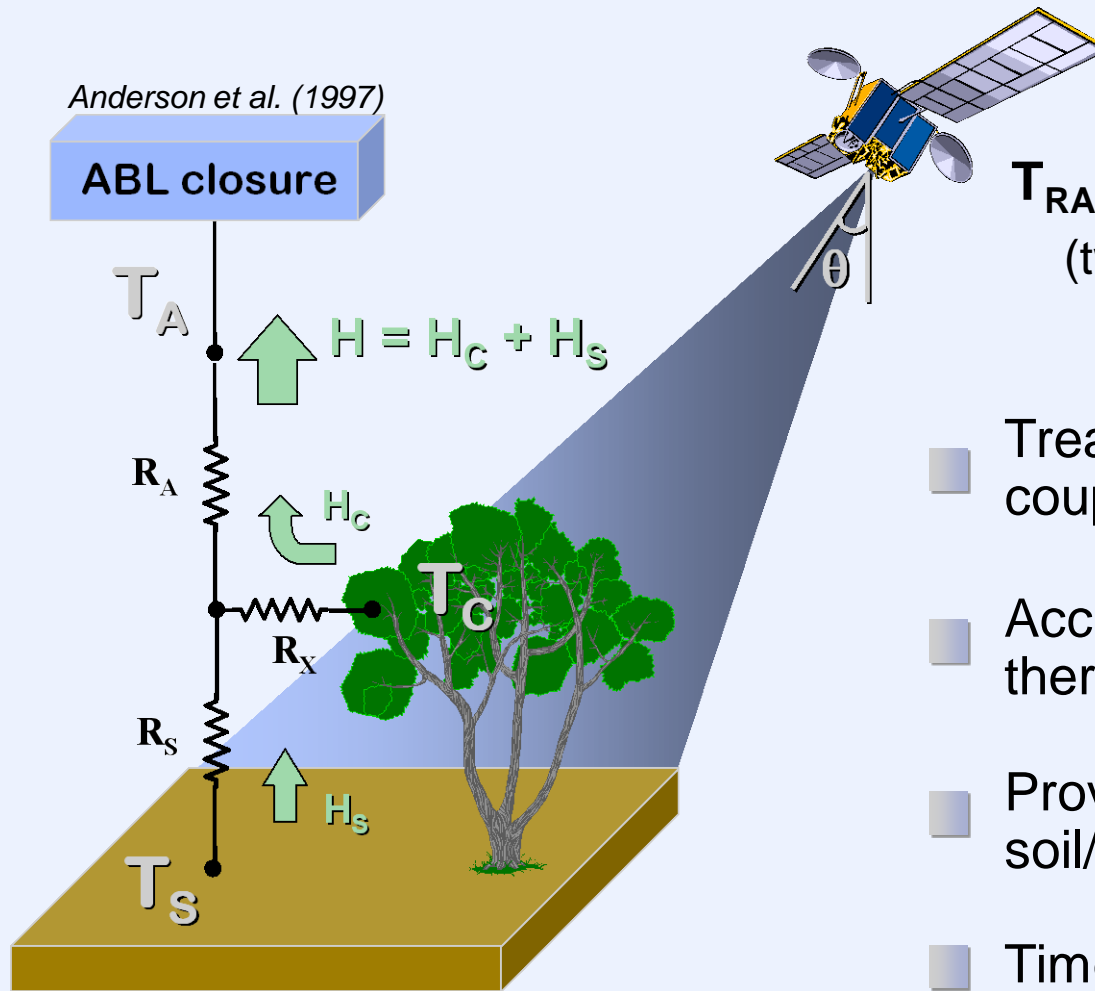
(two-source approximation)

*Norman, Kustas et al. (1995)*

- Treats soil/plant-atmosphere coupling differences explicitly
- Accommodates off-nadir thermal sensor view angles
- Provides information on soil/plant fluxes and stress



# Atmosphere-Land Exchange Inverse Model (ALEXI)



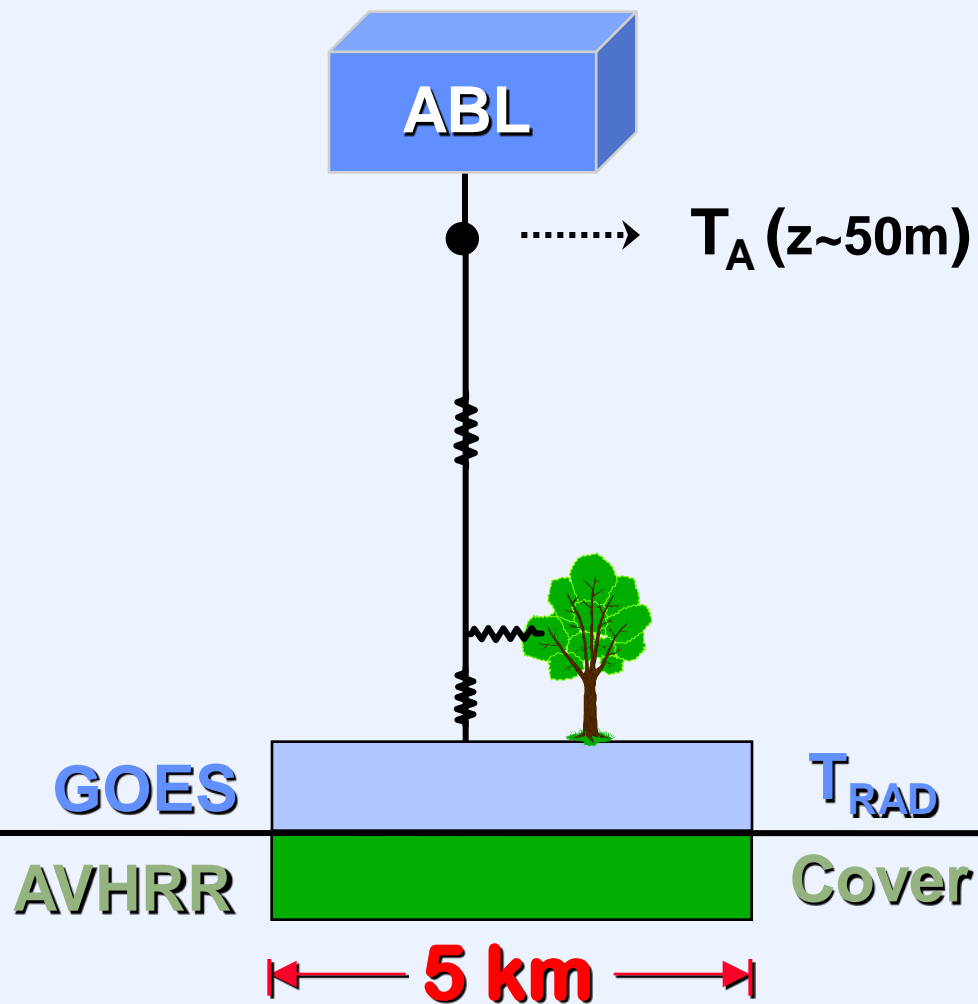
$$T_{\text{RAD}}(\theta) \sim f_c(\theta)T_c + [1-f_c(\theta)]T_s$$

(two-source approximation)

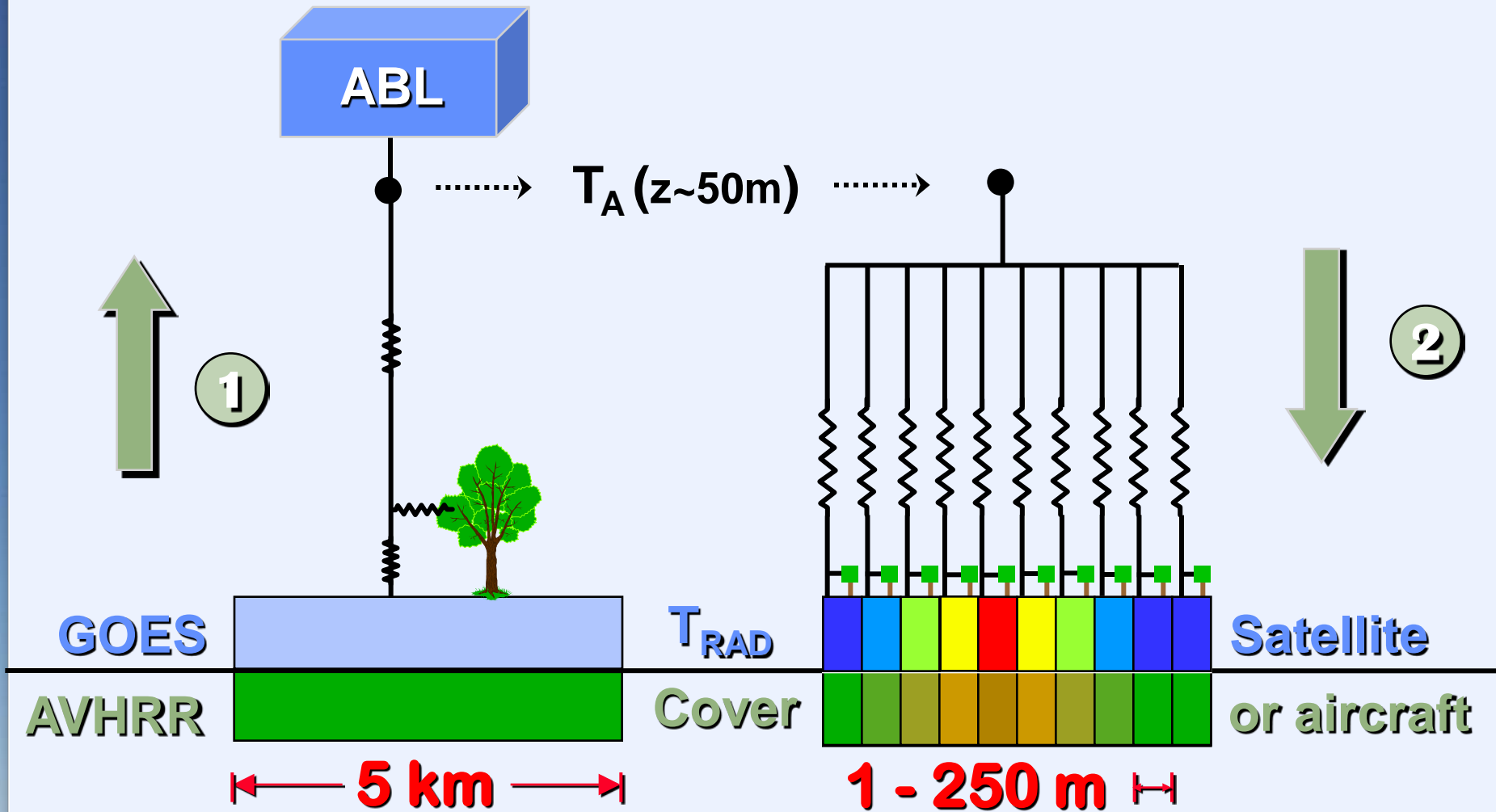
Norman, Kustas et al. (1995)

- Treats soil/plant-atmosphere coupling differences explicitly
- Accommodates off-nadir thermal sensor view angles
- Provides information on soil/plant fluxes and stress
- Time-differential ABL closure

# Atmosphere-Land Exchange Inverse Model (ALEXI)

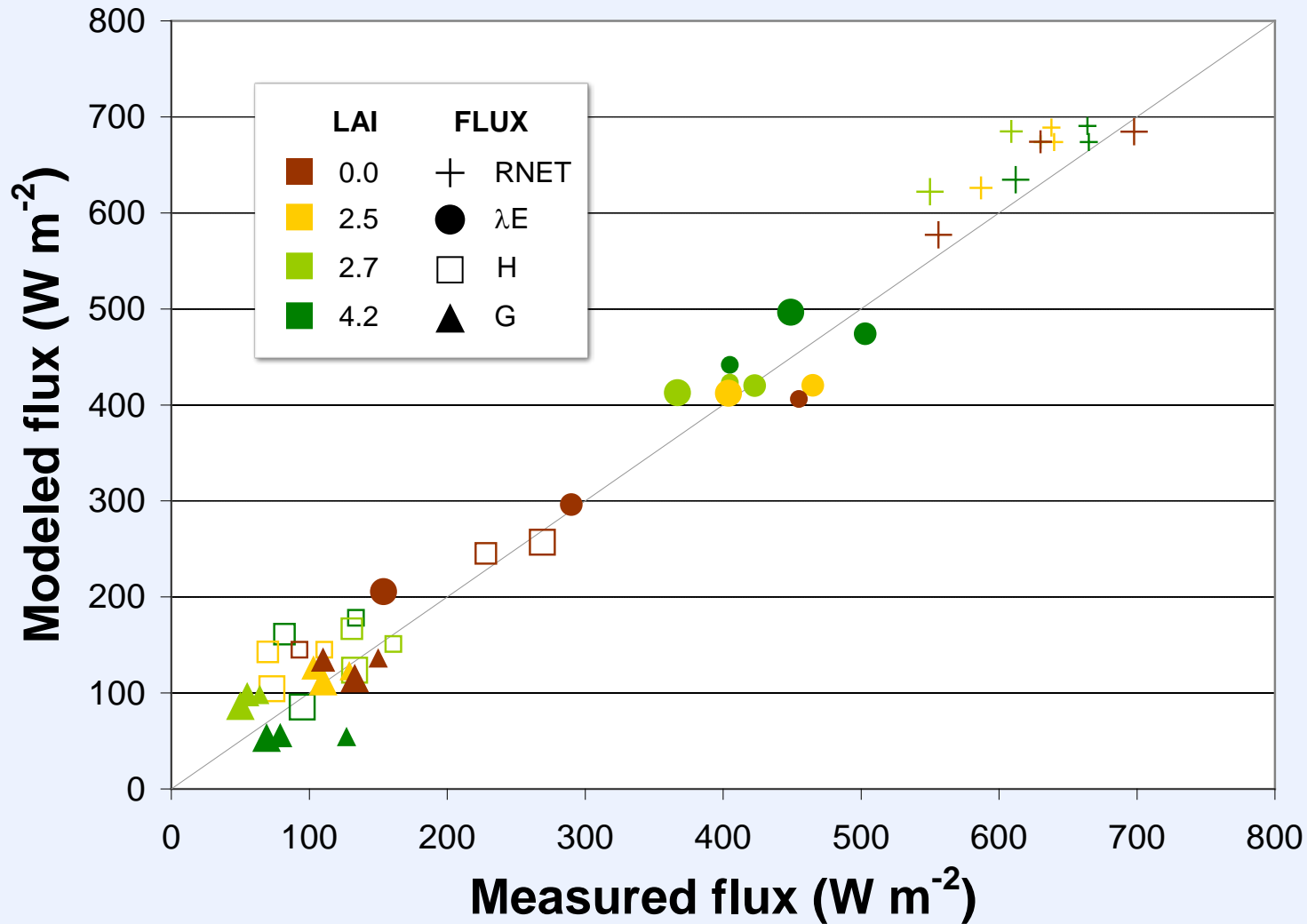


# Disaggregated ALEXI model (DisALEXI)



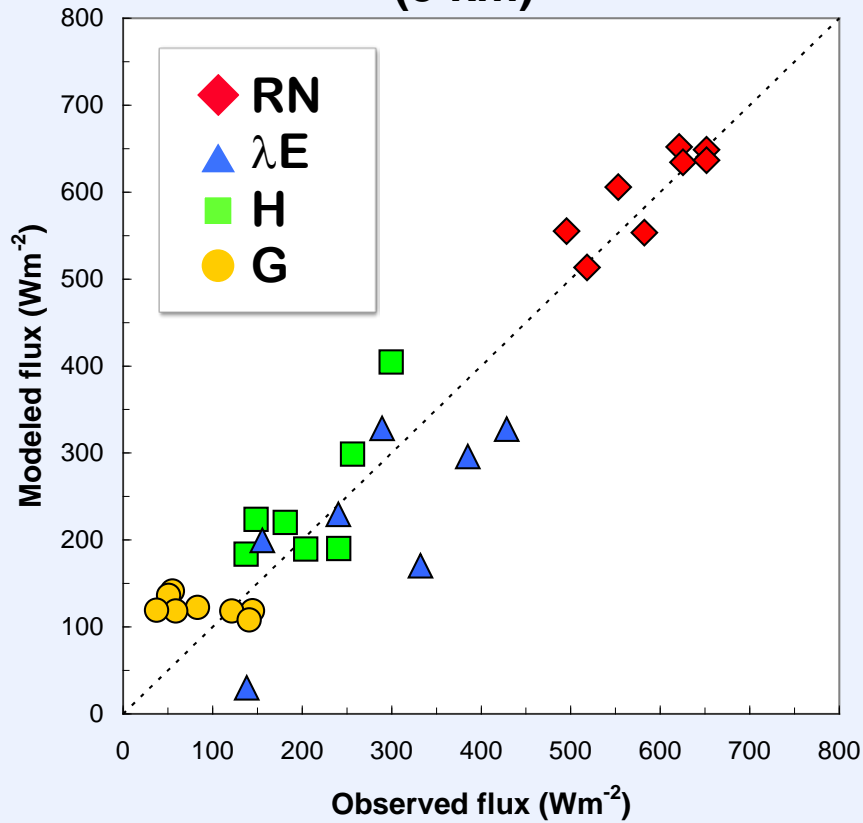
The image is a composite. The top half shows two aircraft flying against a clear blue sky. On the left is a white twin-engine turboprop aircraft with a yellow cabin and a blue and white striped tail. On the right is a smaller, white single-engine propeller aircraft. The bottom half of the image shows a field of solar panels and weather stations. The solar panels are mounted on metal frames and are tilted towards the sun. The weather stations are tall poles with various instruments at the top. The field is filled with green and yellow vegetation. The text "LOCAL VALIDATION" is overlaid in the center of the image in a bold, white, sans-serif font with a black outline.

# LOCAL VALIDATION

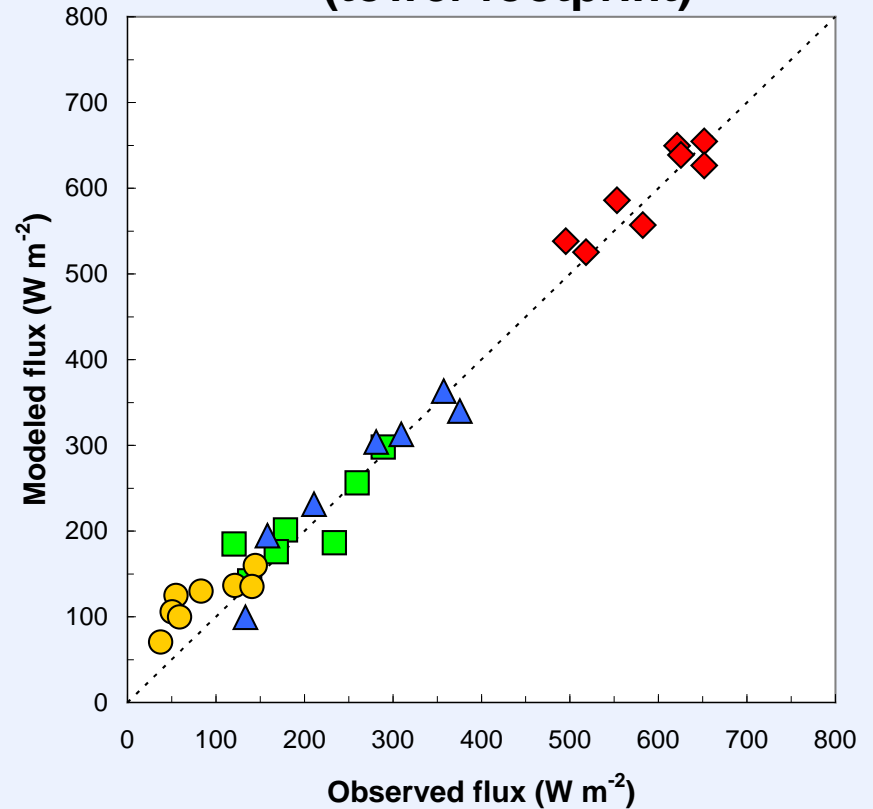




## ALEXI (5 km)



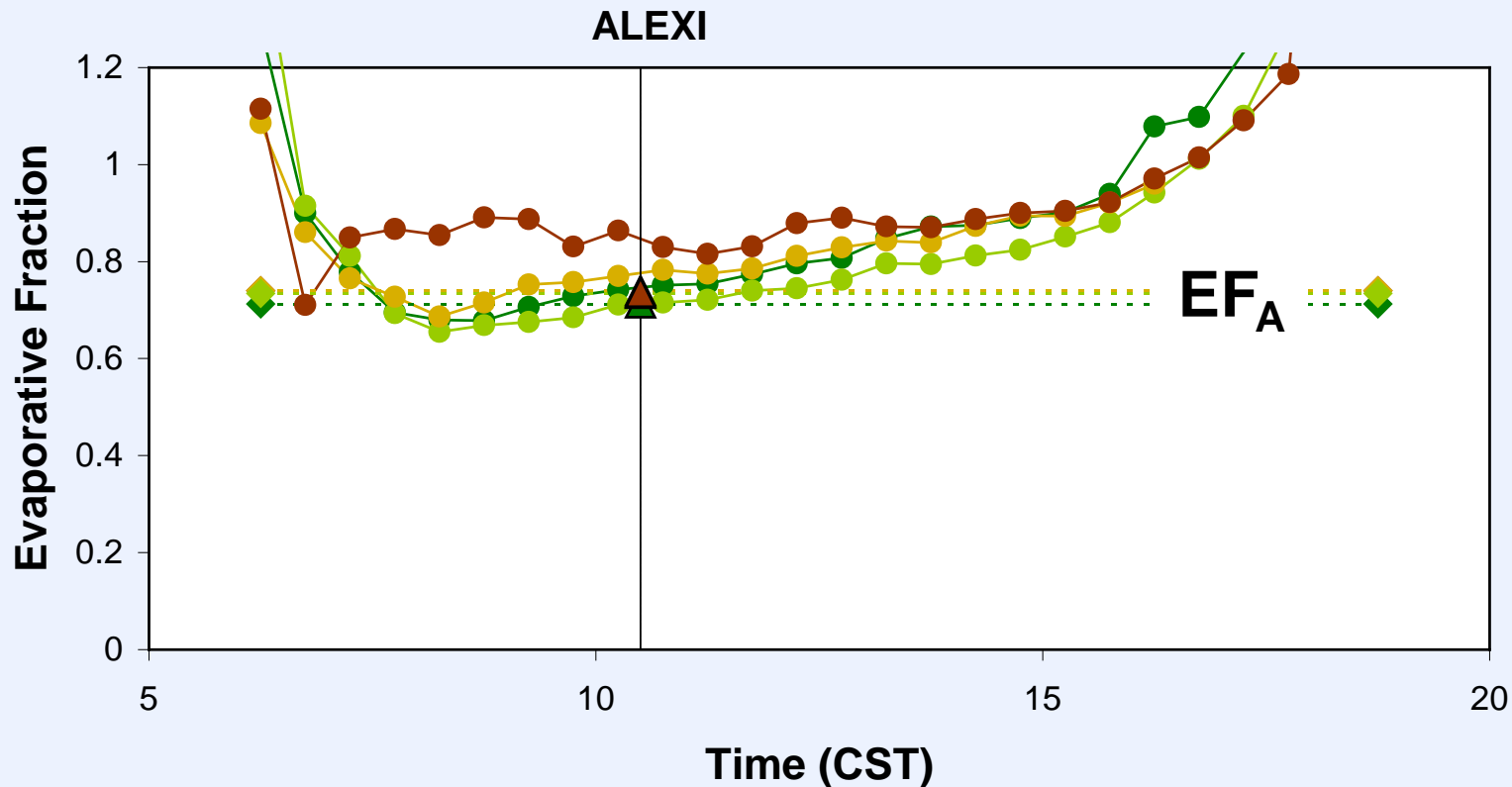
## DisALEXI (tower footprint)



A satellite-style map of North America, showing the United States, Mexico, and parts of Canada. The map is overlaid with a grid of green lines representing state and provincial boundaries. The terrain is visible in shades of brown, tan, and green, with blue representing water bodies like the Great Lakes and the Gulf of Mexico. The text "REGIONAL VALIDATION" is centered in the middle of the map in a bold, white, sans-serif font. Below it, the text "... gap filling" is written in a smaller, italicized, white, sans-serif font.

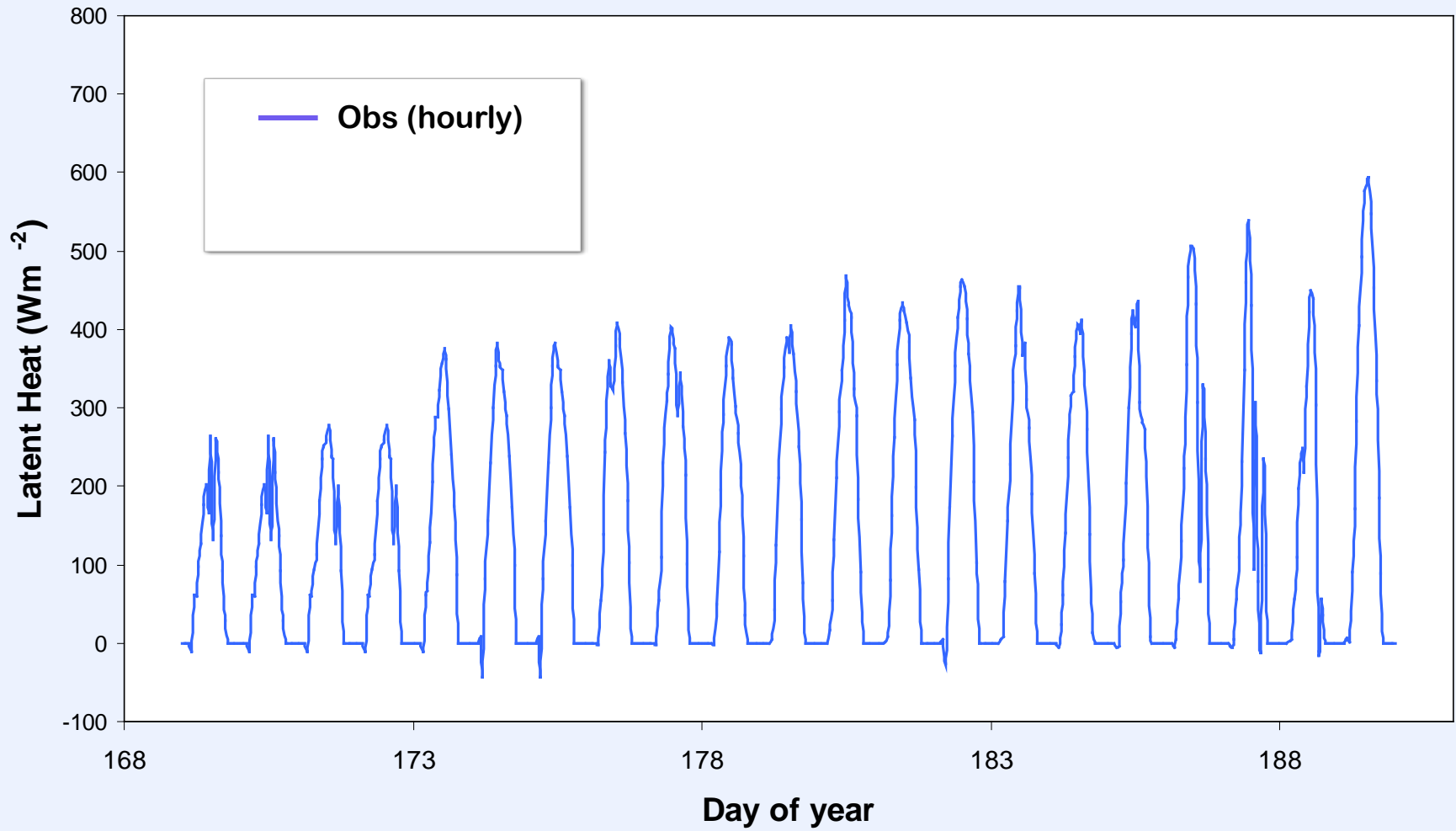
**REGIONAL VALIDATION**  
*... gap filling*

# Daily extrapolation assuming constant EF

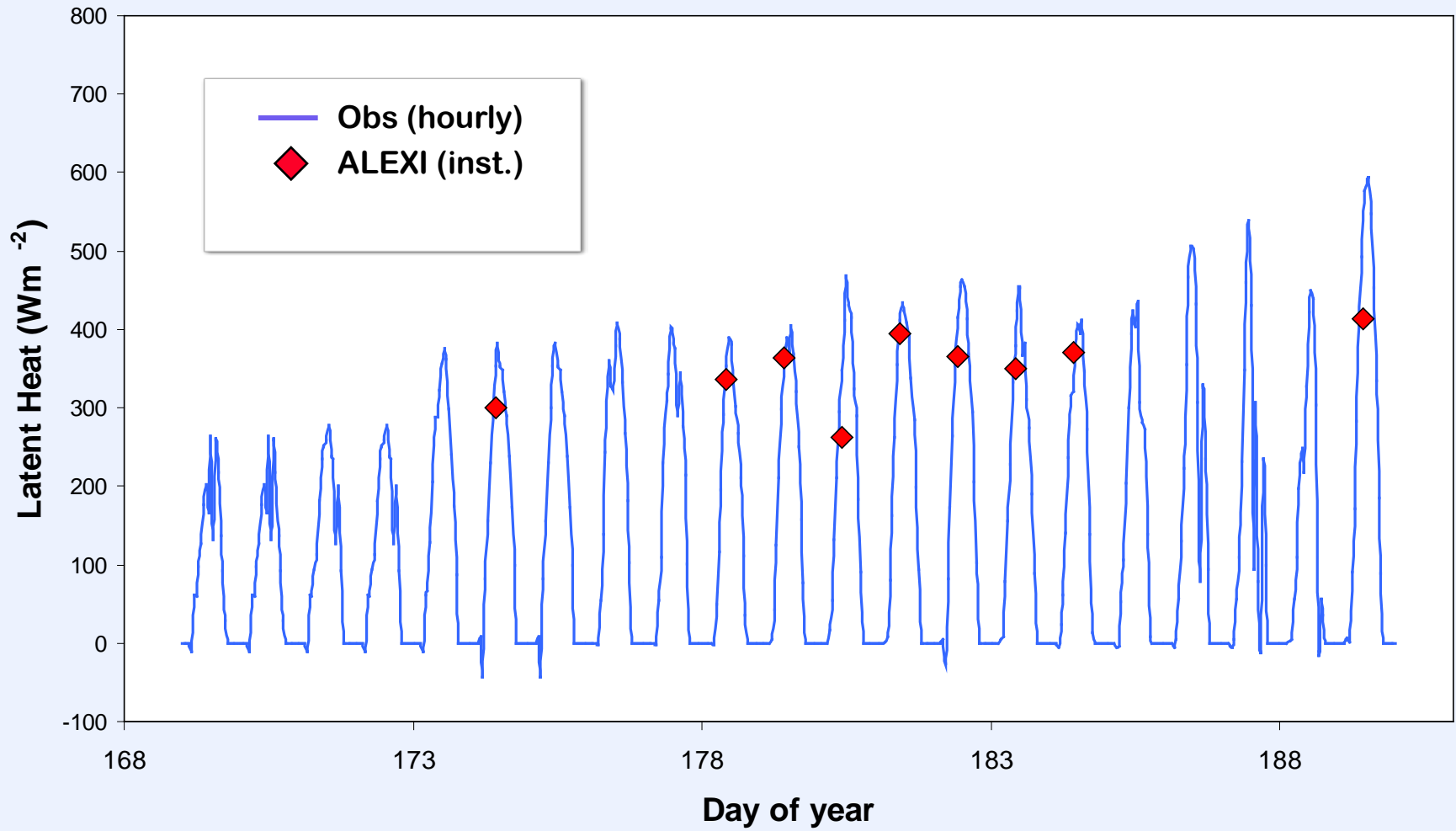


$$EF_A = \frac{\lambda E_A}{RN_A - G_A} \quad \Rightarrow \quad \lambda E(t_i) = EF_A * \underbrace{[ RN(t_i) - G(t_i) ]}_{\text{from GOES}}$$

# Gap-filling algorithm

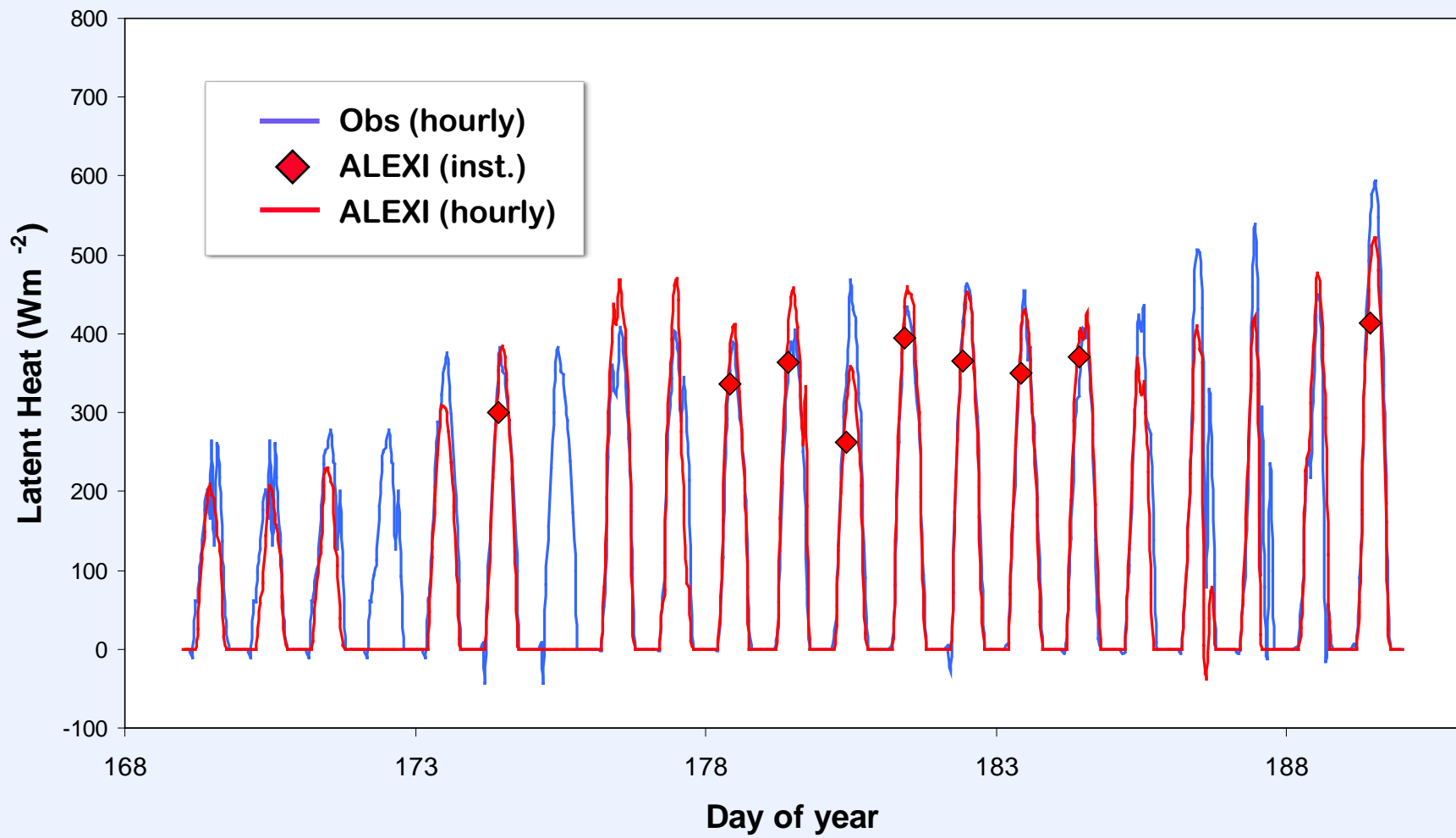


# Gap-filling algorithm





# Gap-filling algorithm



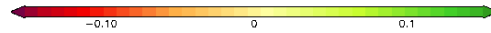
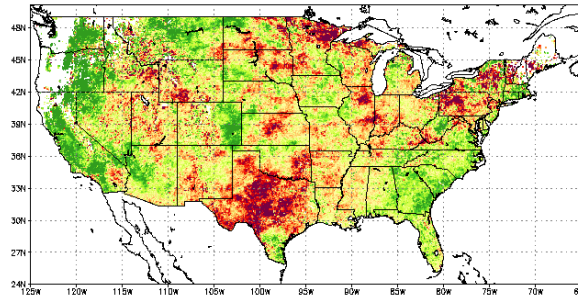
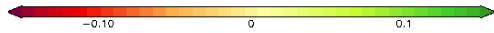
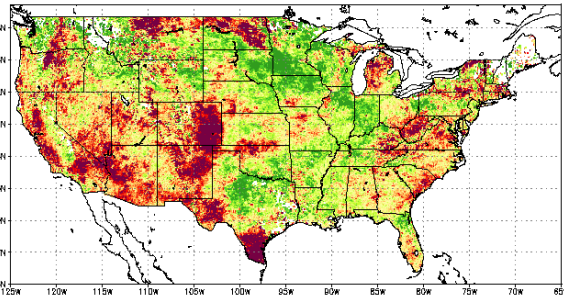
A satellite-style map of North America, showing the United States, southern Canada, and northern Mexico. The map is overlaid with a network of thin green lines that delineate various regional boundaries, likely for hydrological or administrative purposes. The Great Lakes basin is clearly visible in the central-northern part of the continent. The text "REGIONAL VALIDATION" is centered in the middle of the map in a bold, white, sans-serif font. Below it, the text "... stress detection" is written in a smaller, white, italicized serif font.

**REGIONAL VALIDATION**  
*... stress detection*

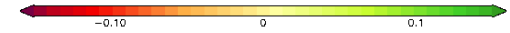
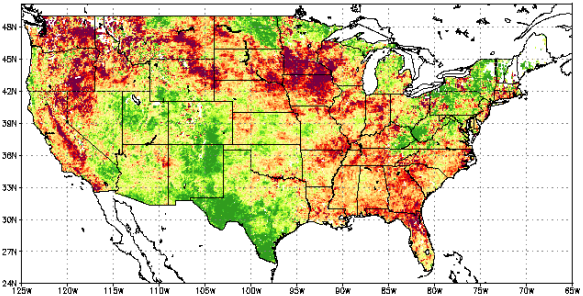
# APRIL

“Climatological” deviation in  $f_{PET}$

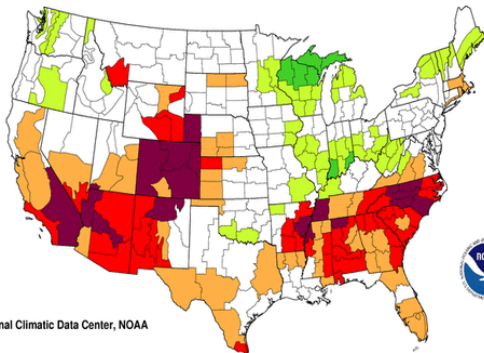
## 28-day ALEXI composite



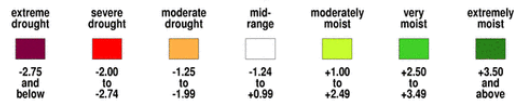
**Drought** **Moist**



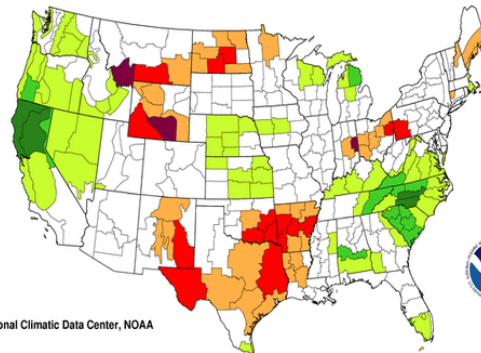
## Palmer Drought Index



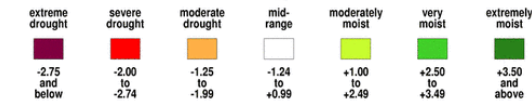
National Climatic Data Center, NOAA



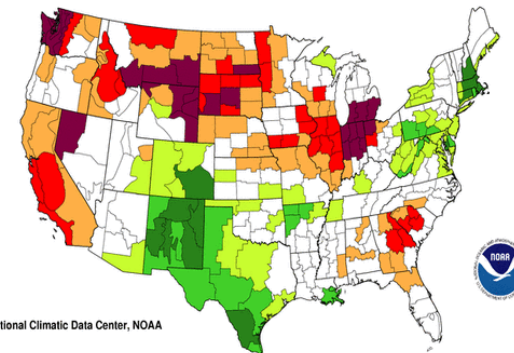
2002



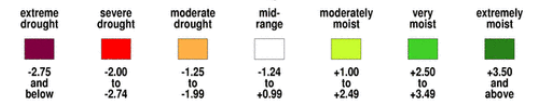
National Climatic Data Center, NOAA



2003



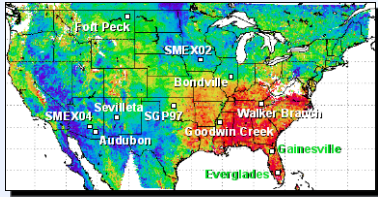
National Climatic Data Center, NOAA



2004



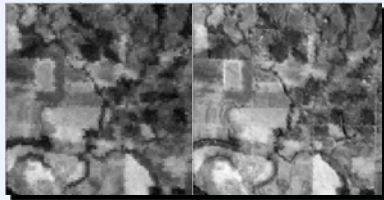
# Project Objectives



## Validation

*Target multiple biomes and climates*

Ameriflux and EOS validation sites



## Algorithm Enhancement

*Improve spatial and temporal coverage*

Thermal sharpening and daily extrapolation



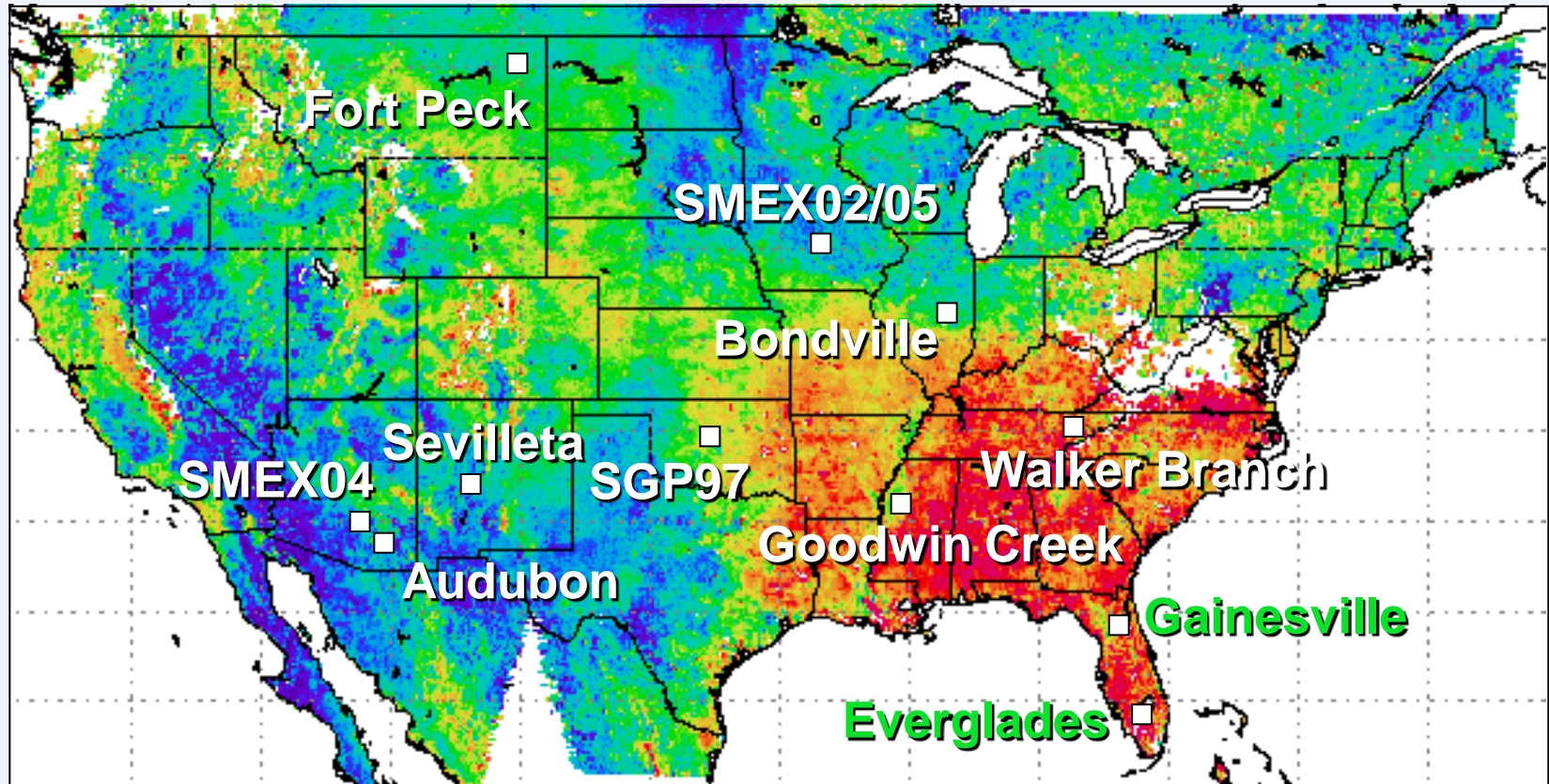
## Case Study Application

*Identify stress detection capabilities*

Florida Everglades

# ALEXI validation sites

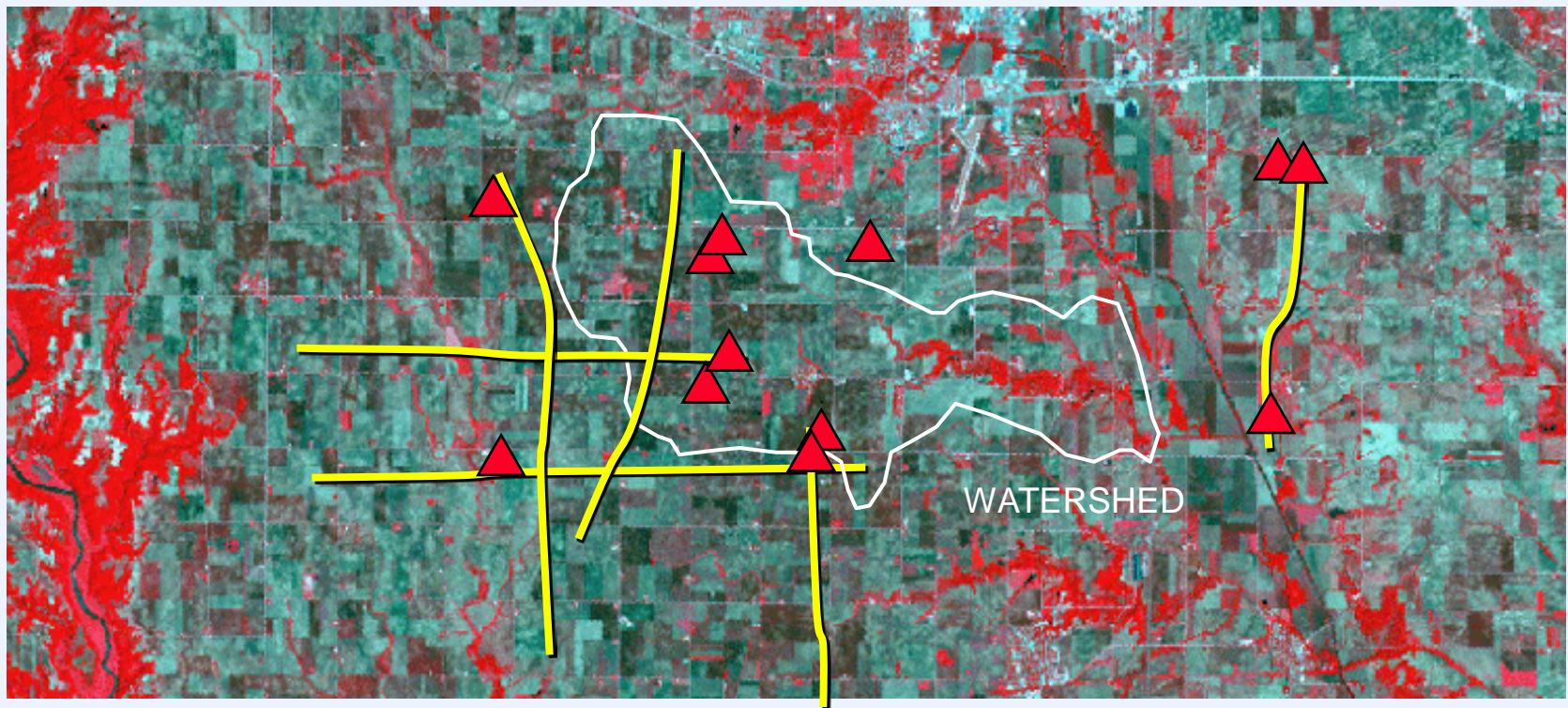
ALEXI LATENT HEAT FLUX – June 2003





# SMEX02 flux measurements

SOIL MOISTURE EXPERIMENT 2002 (SMEX02) – WALNUT CREEK WATERSHED, IA



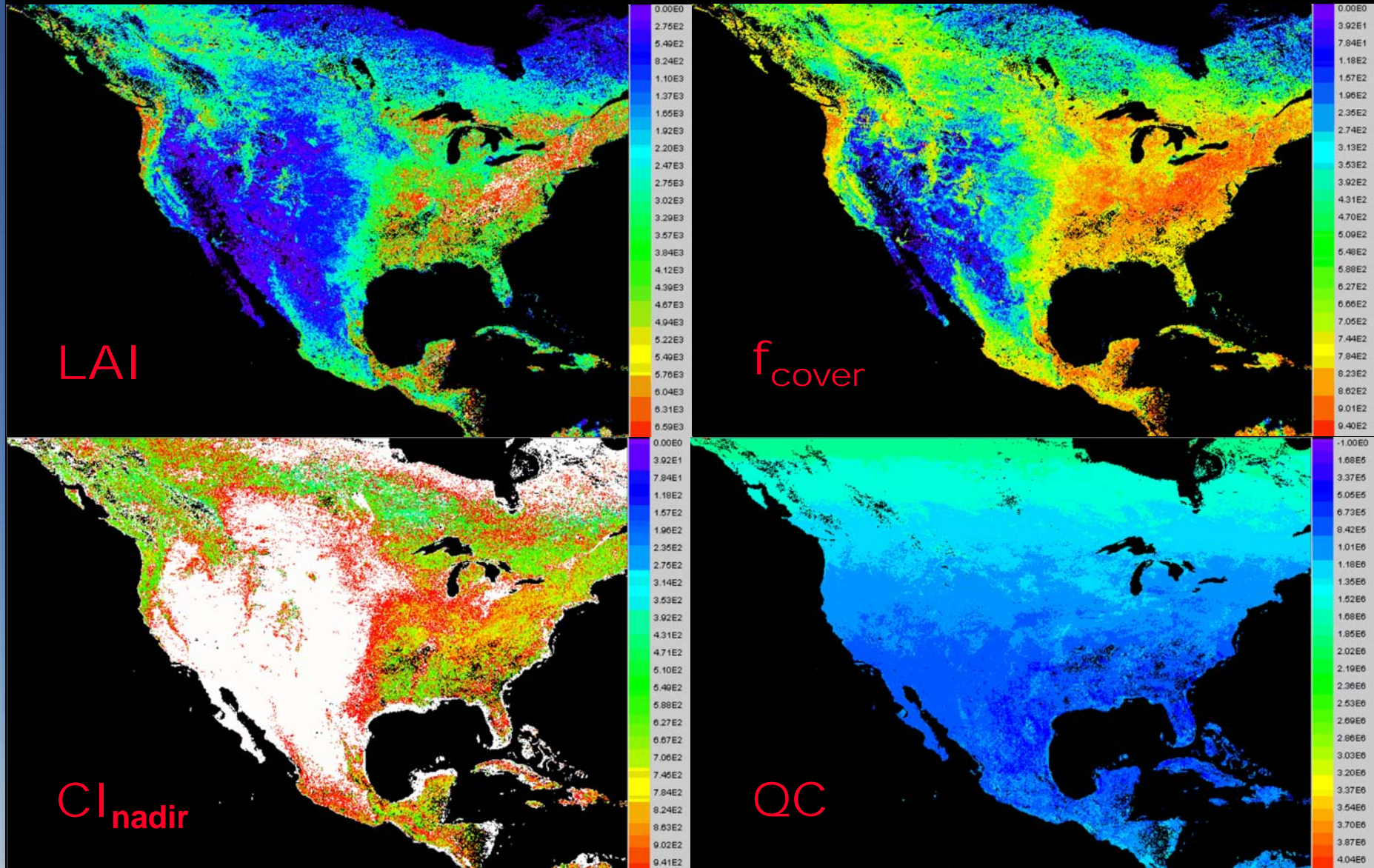
▲ Flux towers

— Twin Otter transects



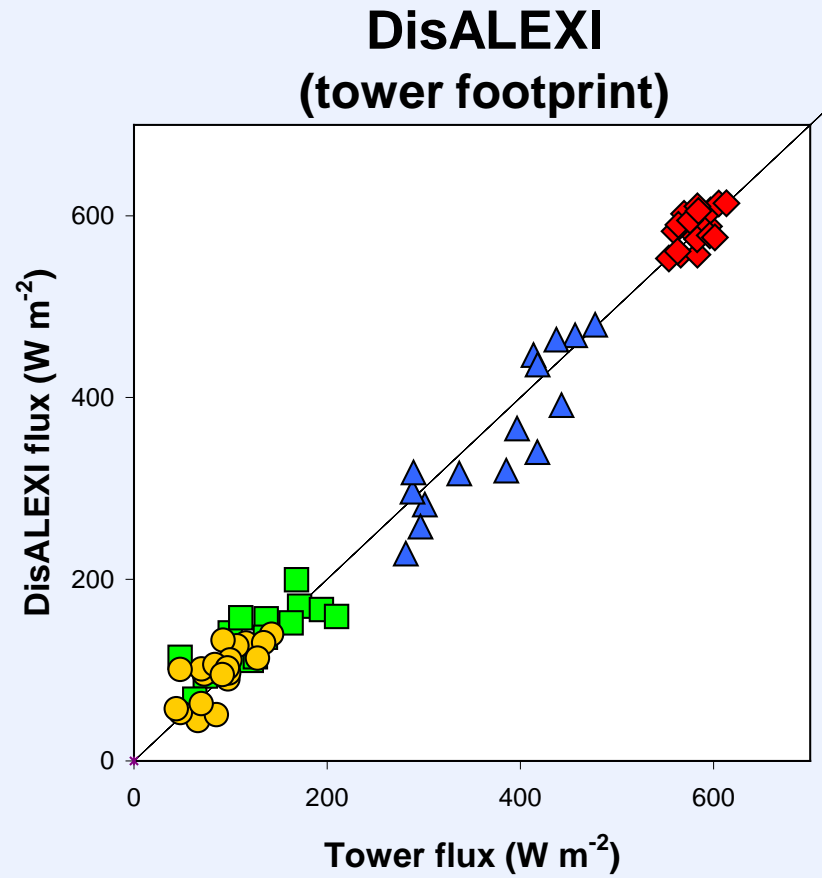
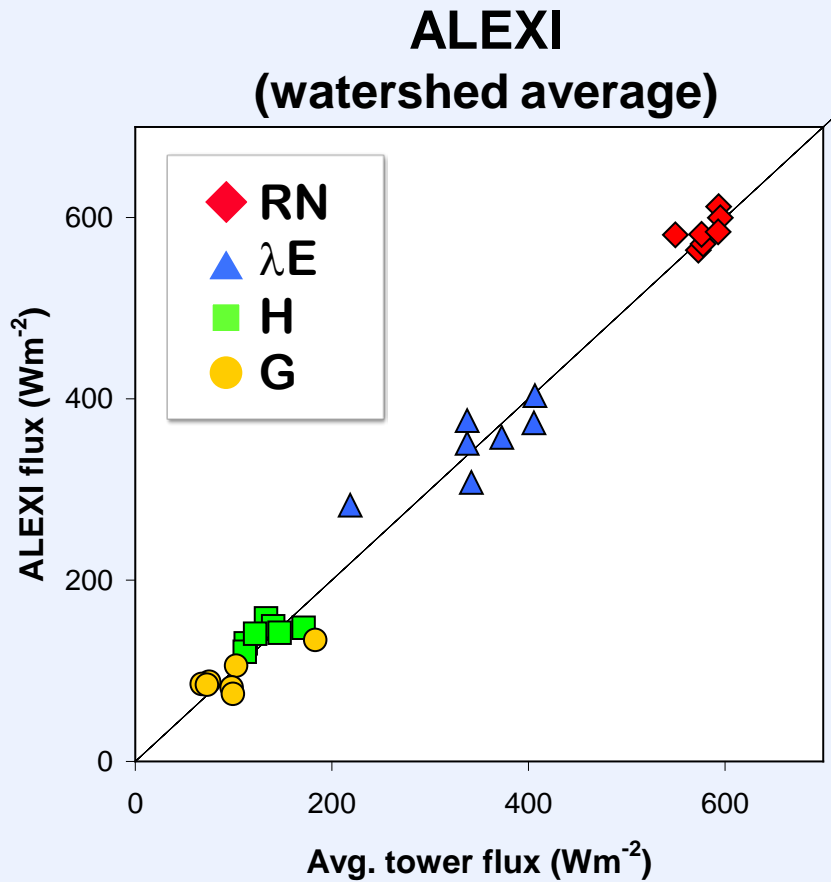
# MODIS-based vegetation clumping index

June 2004



Courtesy of J.-L. Roujean

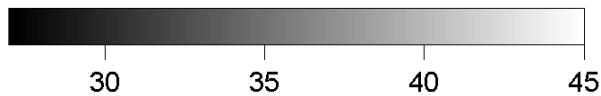
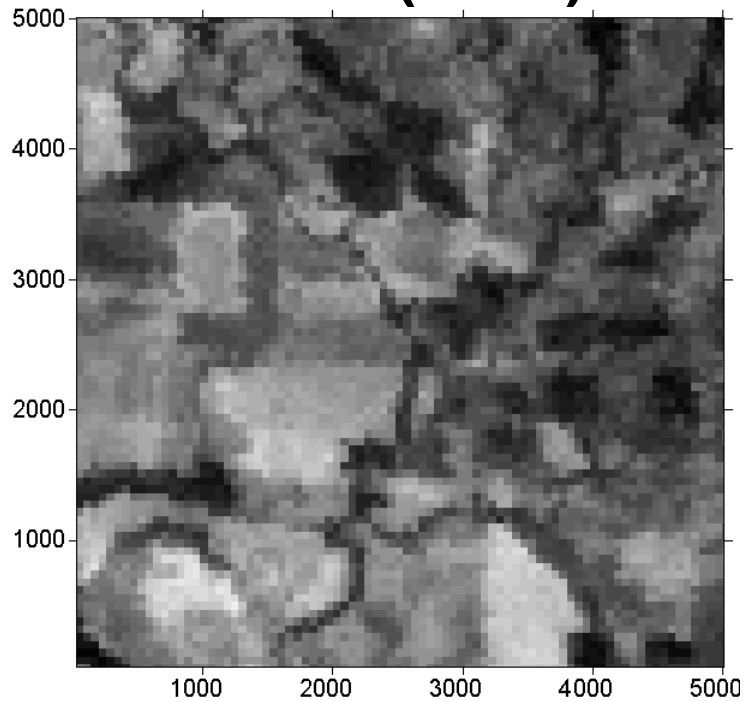
# (Dis)ALEXI vs. tower fluxes



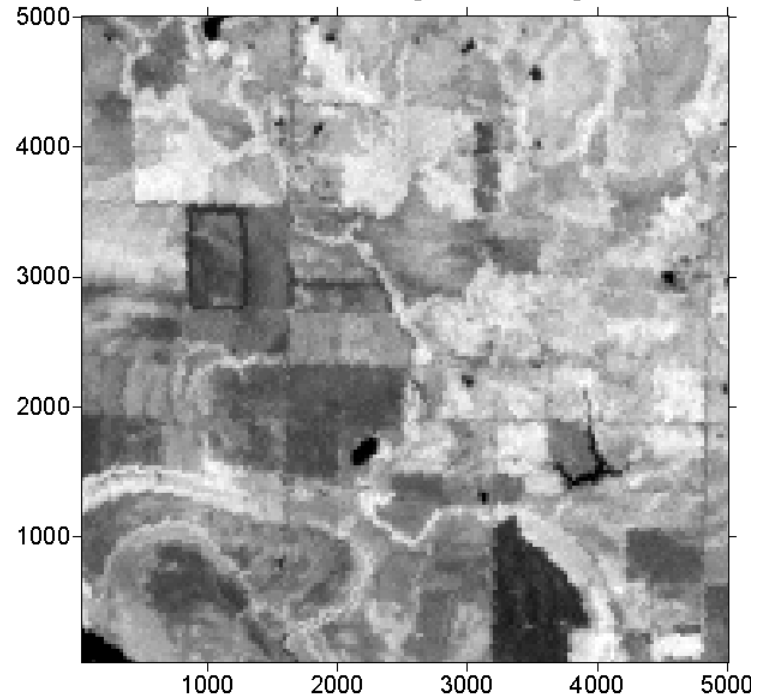
# Landsat-7 thermal/shortwave imagery

Idabel, OK

**TRAD (60-m)**



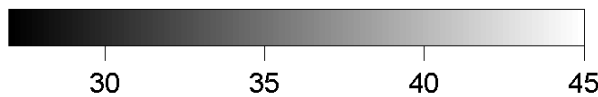
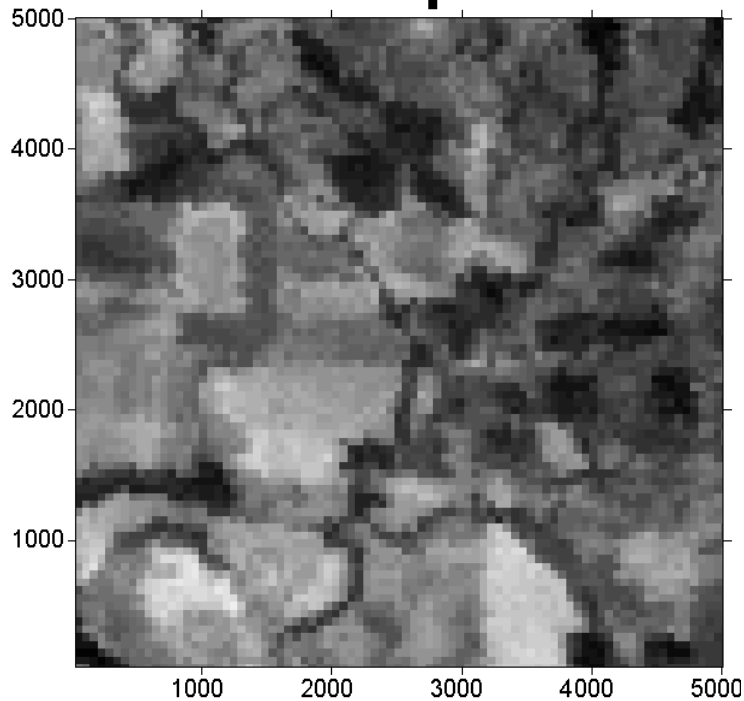
**NDVI (30-m)**



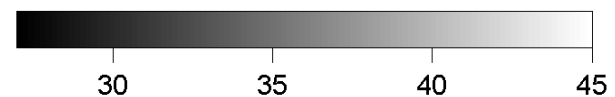
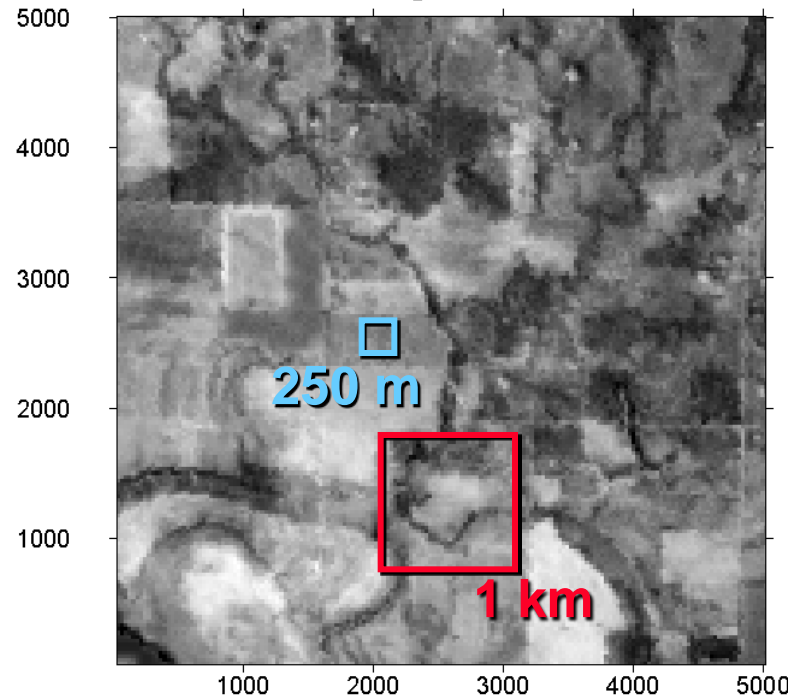
# Thermal sharpening

Idabel, OK

Unsharpened

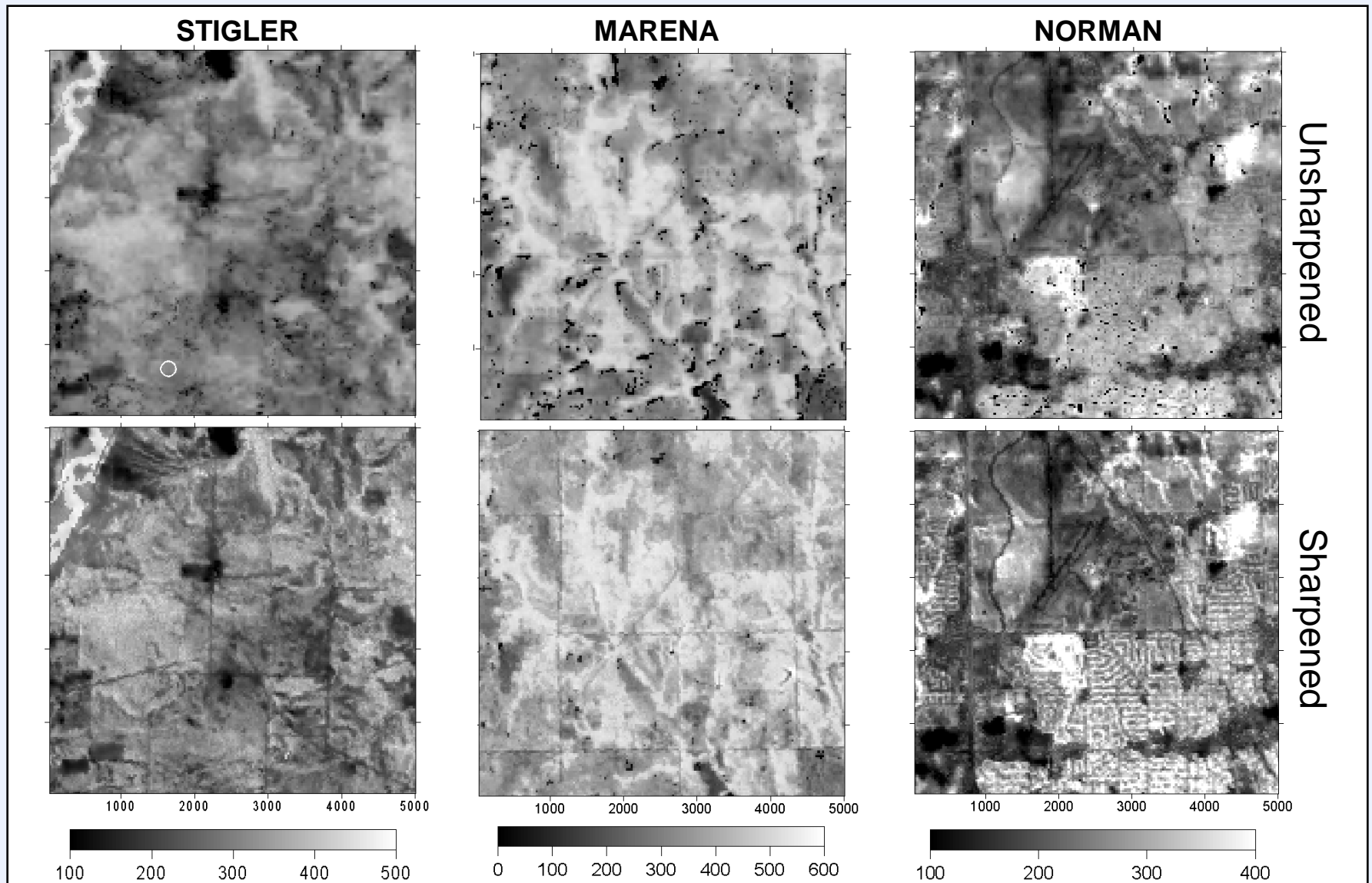


Sharpened

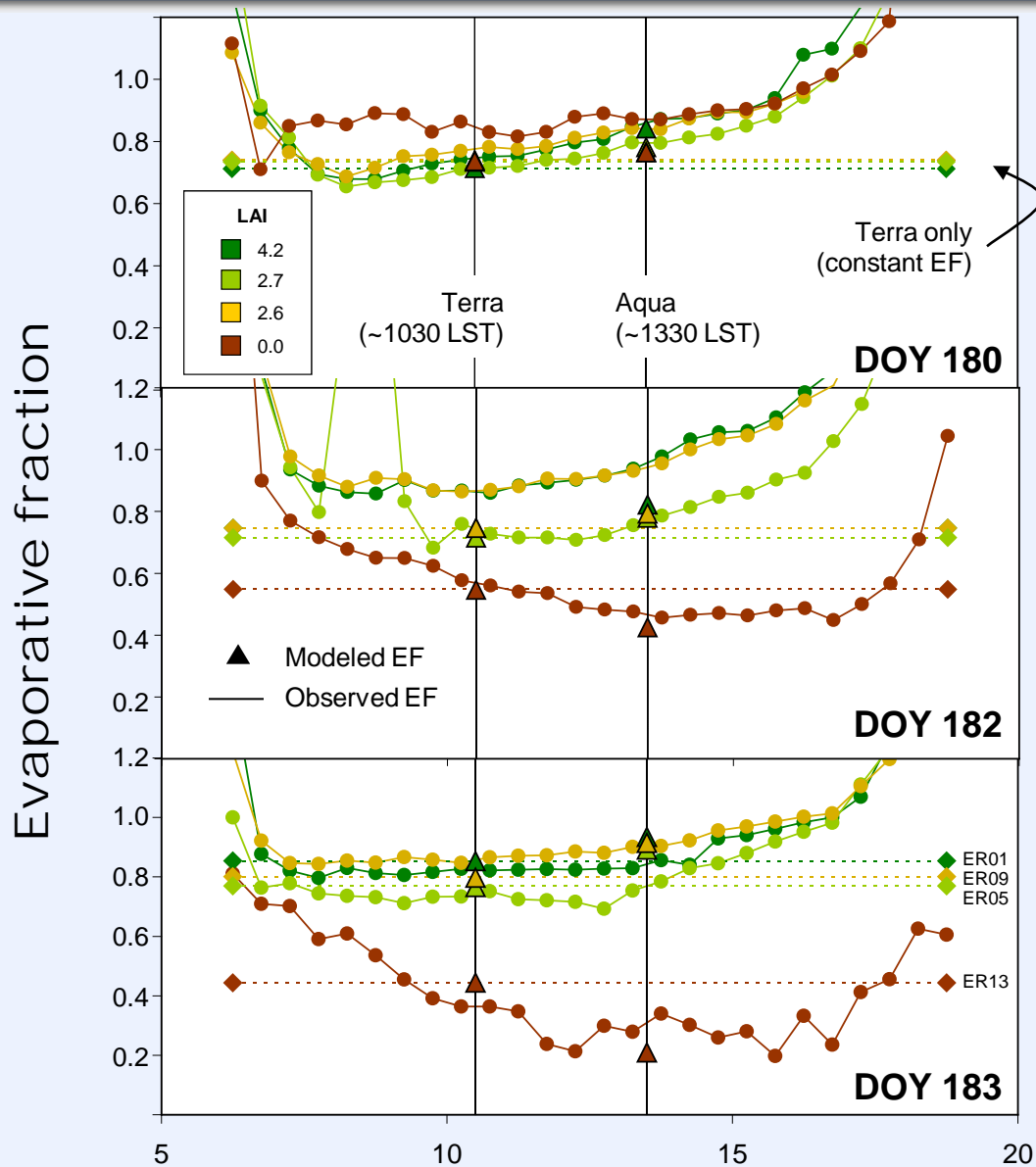




# Latent heat with thermal sharpening



# Daily extrapolation



$$EF = \frac{\lambda E}{RN-G}$$

Time (CST)

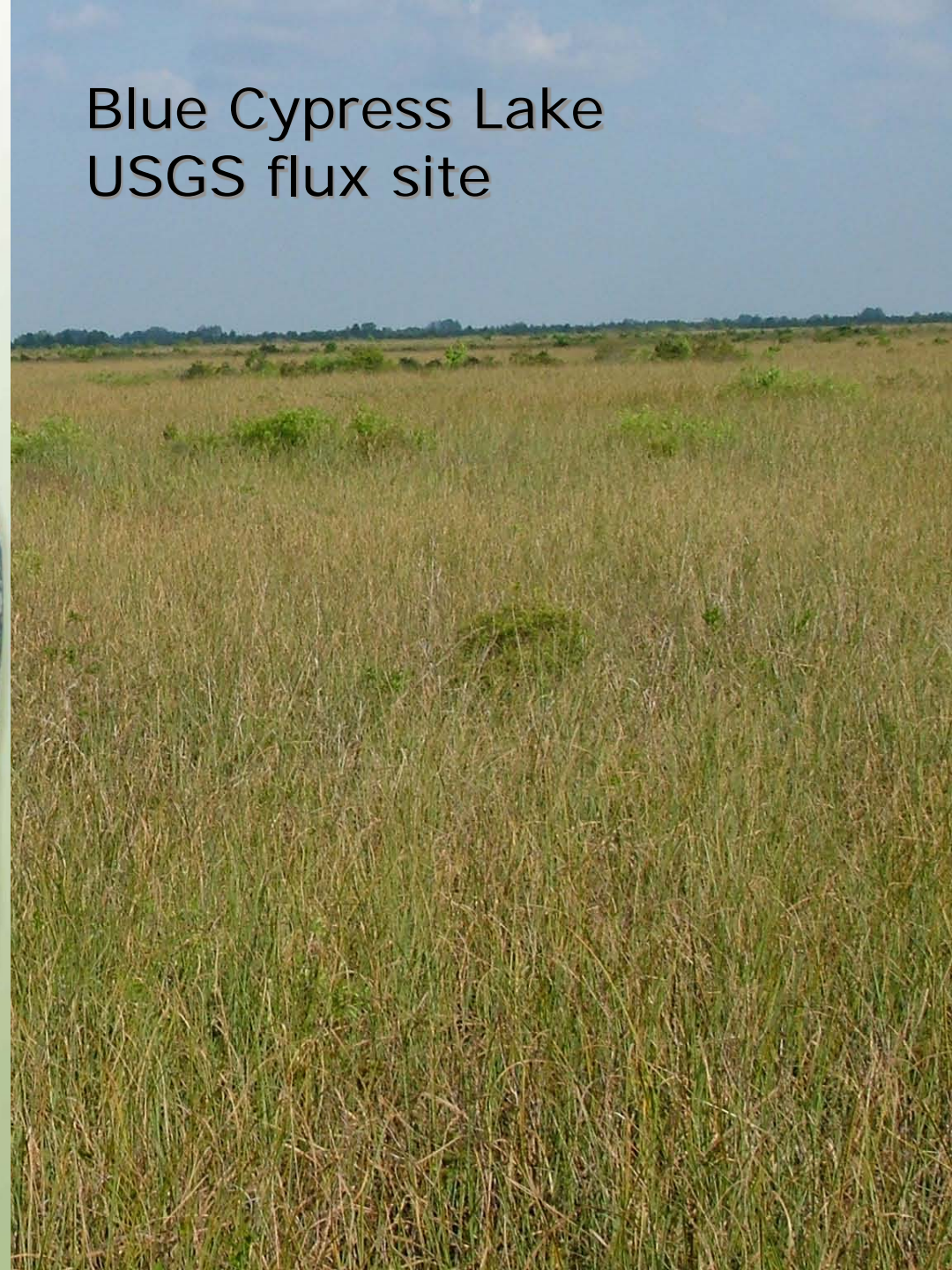




Landsat  
2/13/02



# Blue Cypress Lake USGS flux site

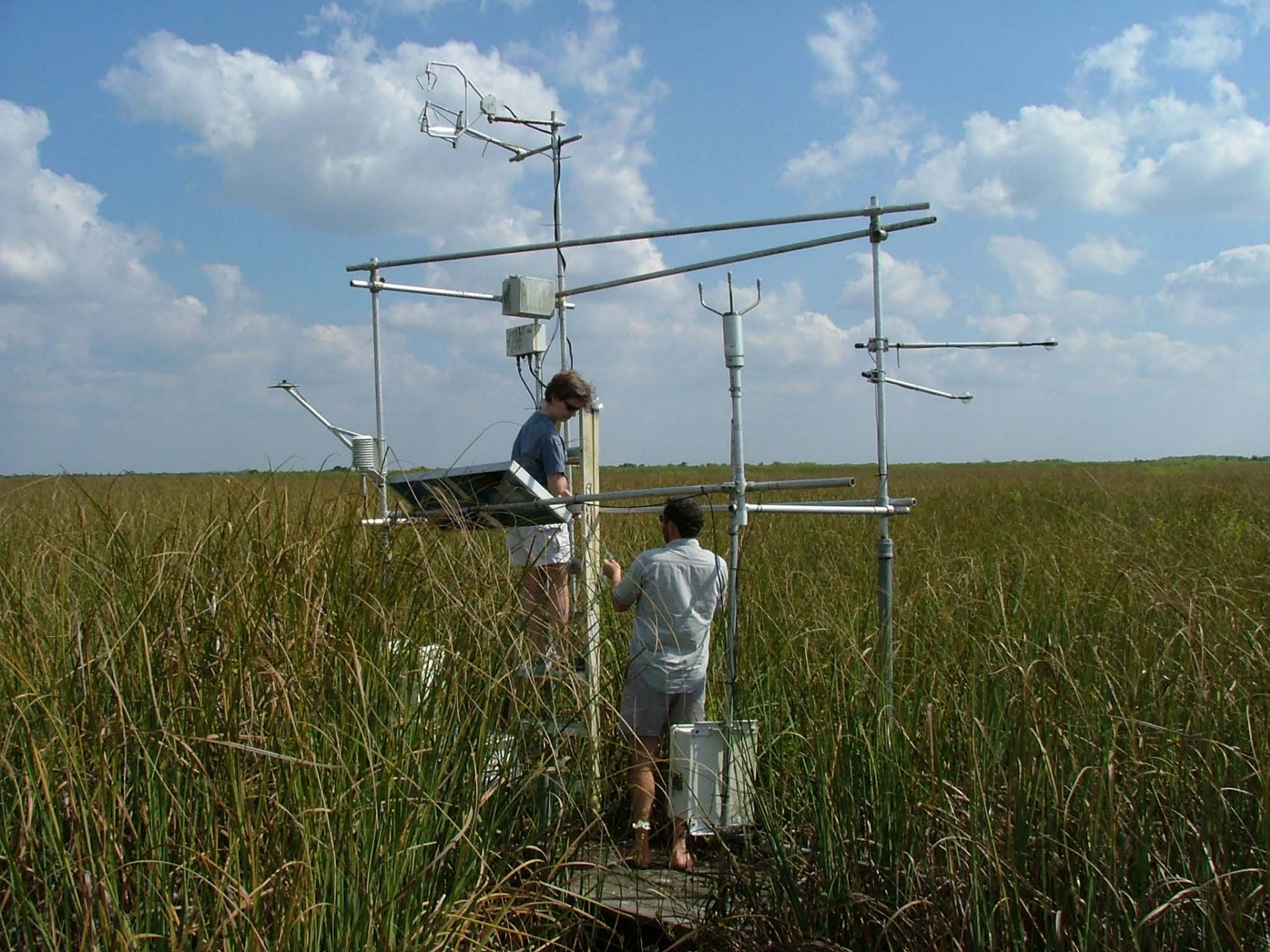




# Broward County USGS flux site



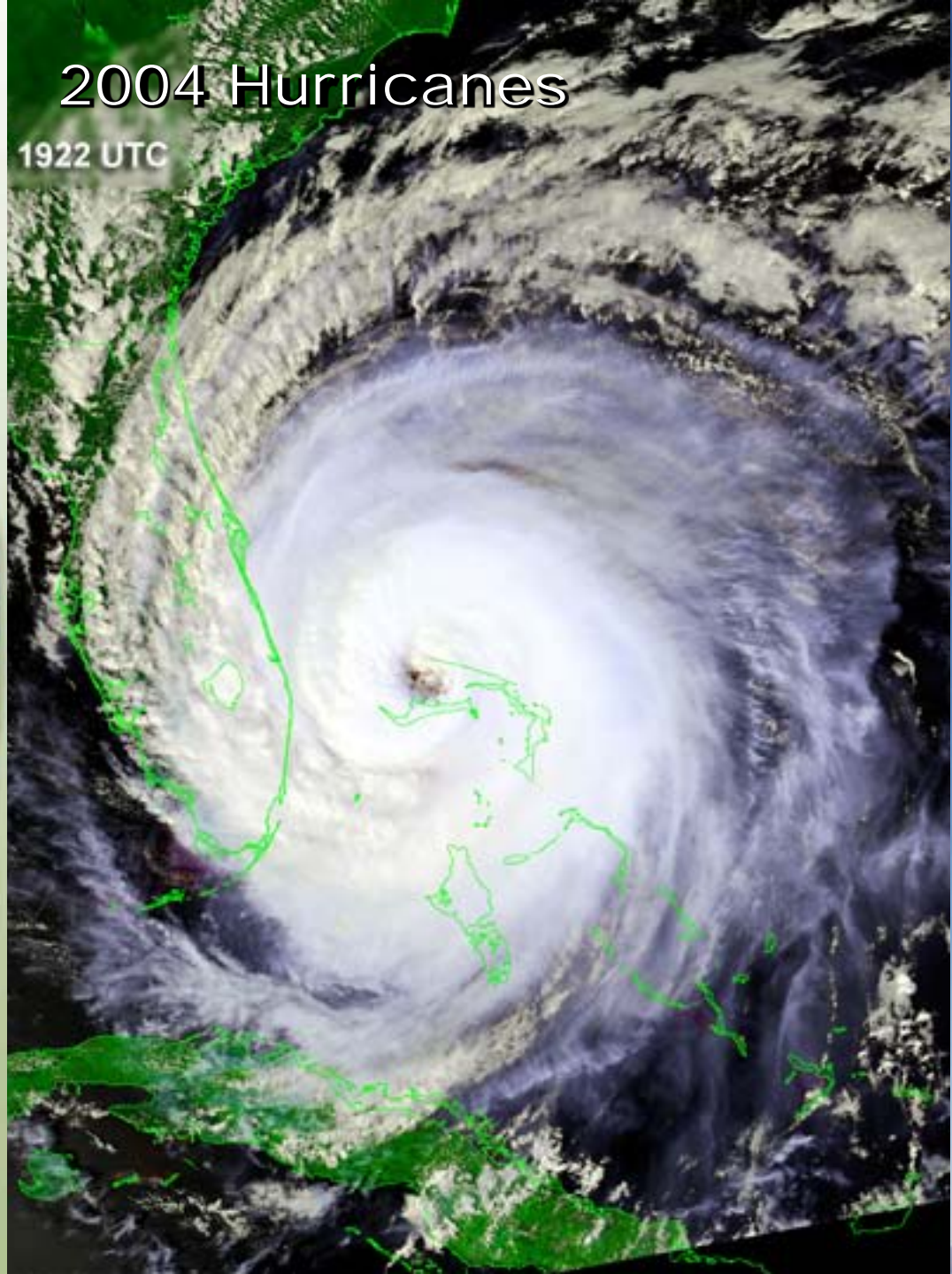




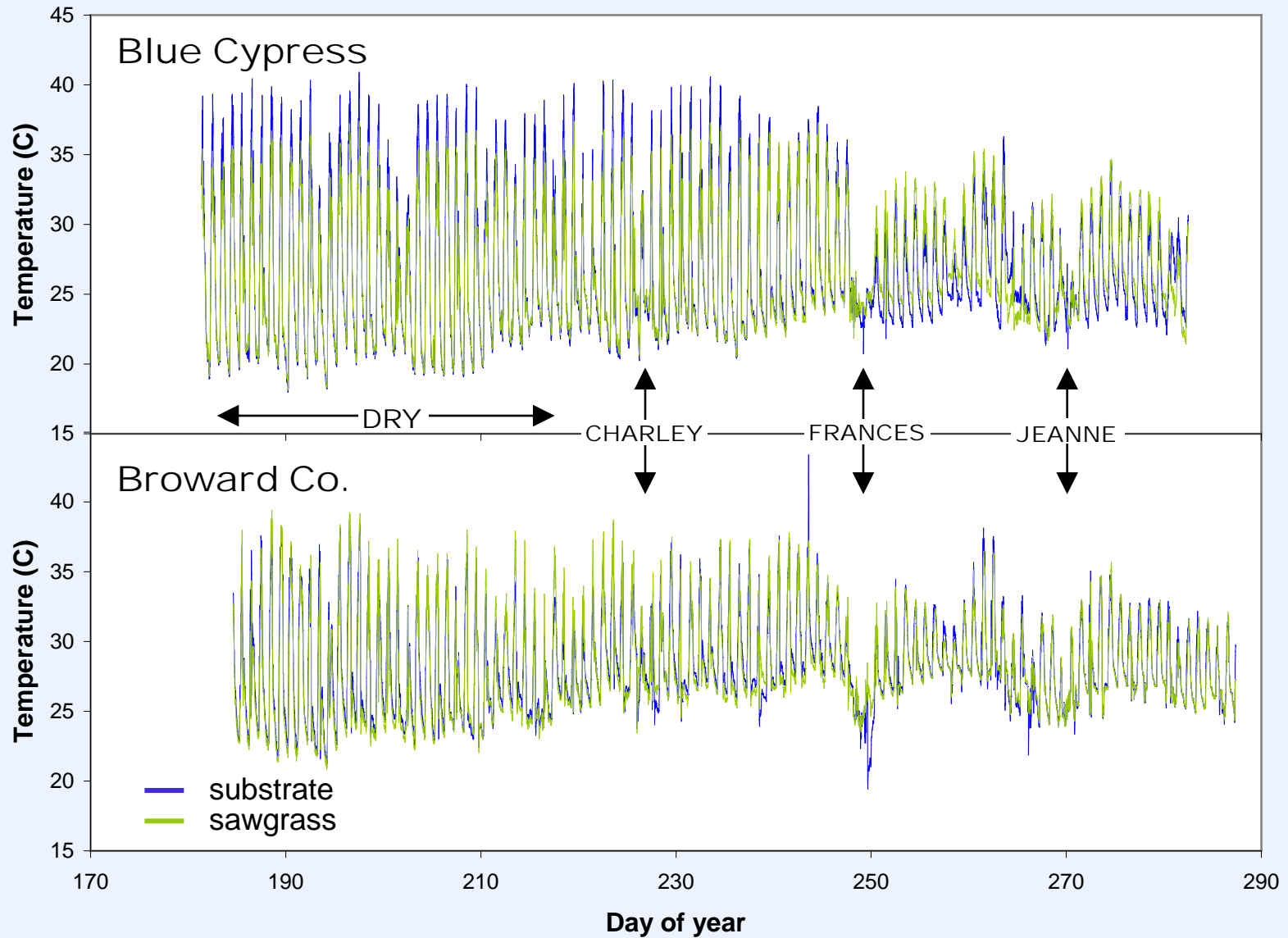








# IRT data at USGS stations





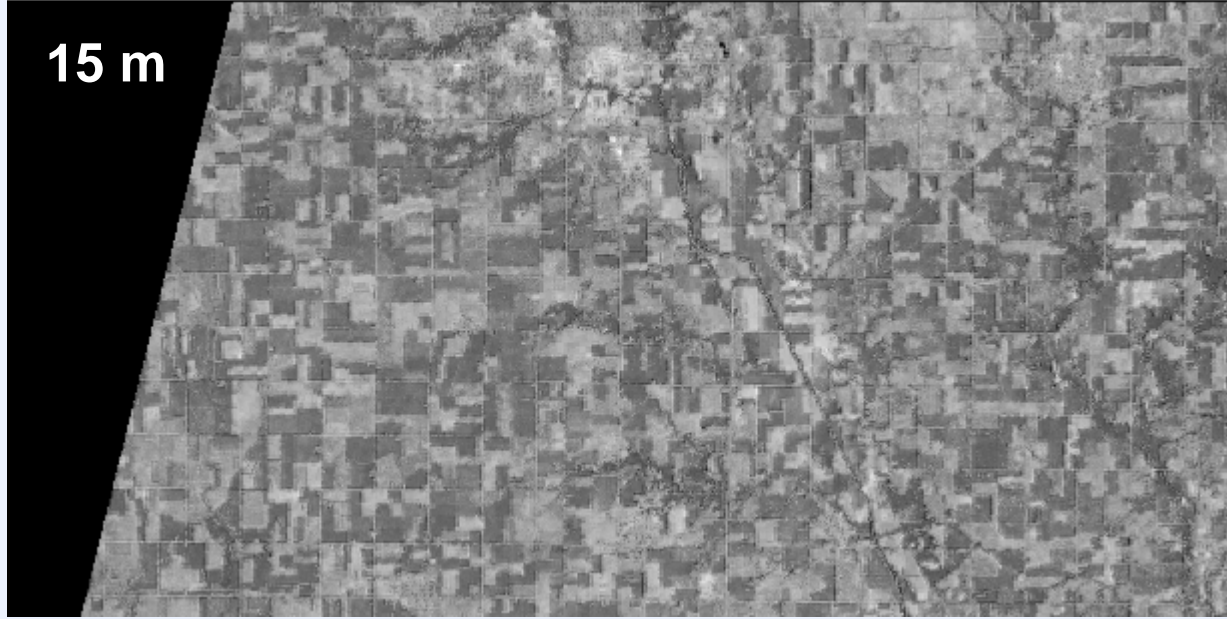
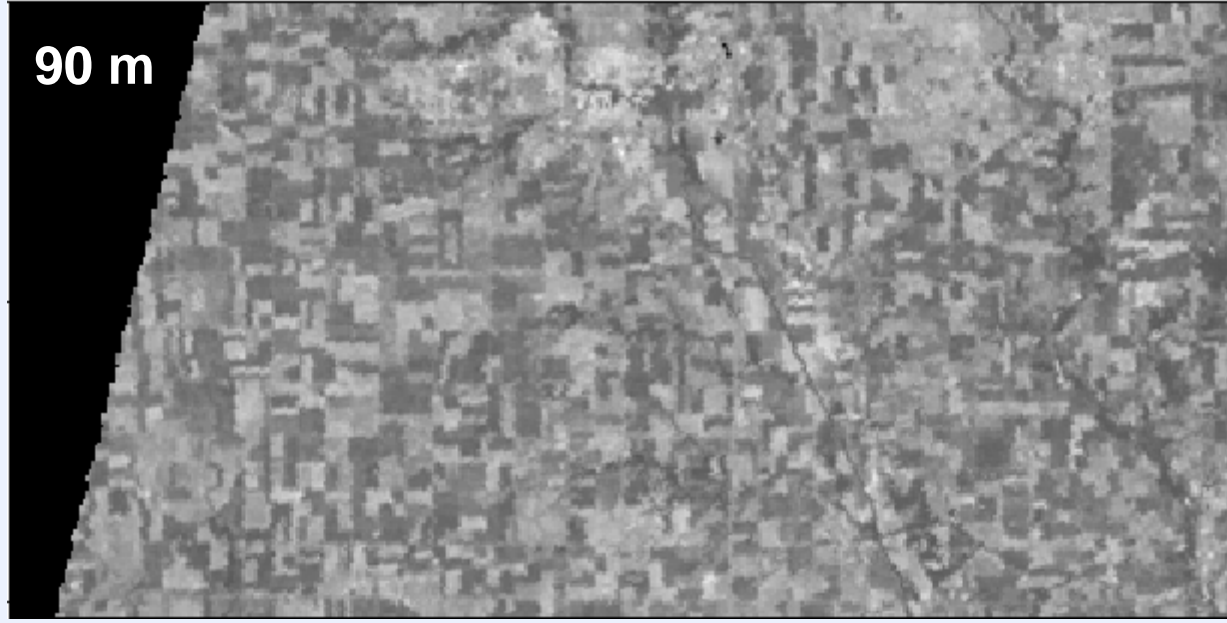
*High-resolution thermal is a valuable asset ...*

[www.soils.wisc.edu/alexi](http://www.soils.wisc.edu/alexi)

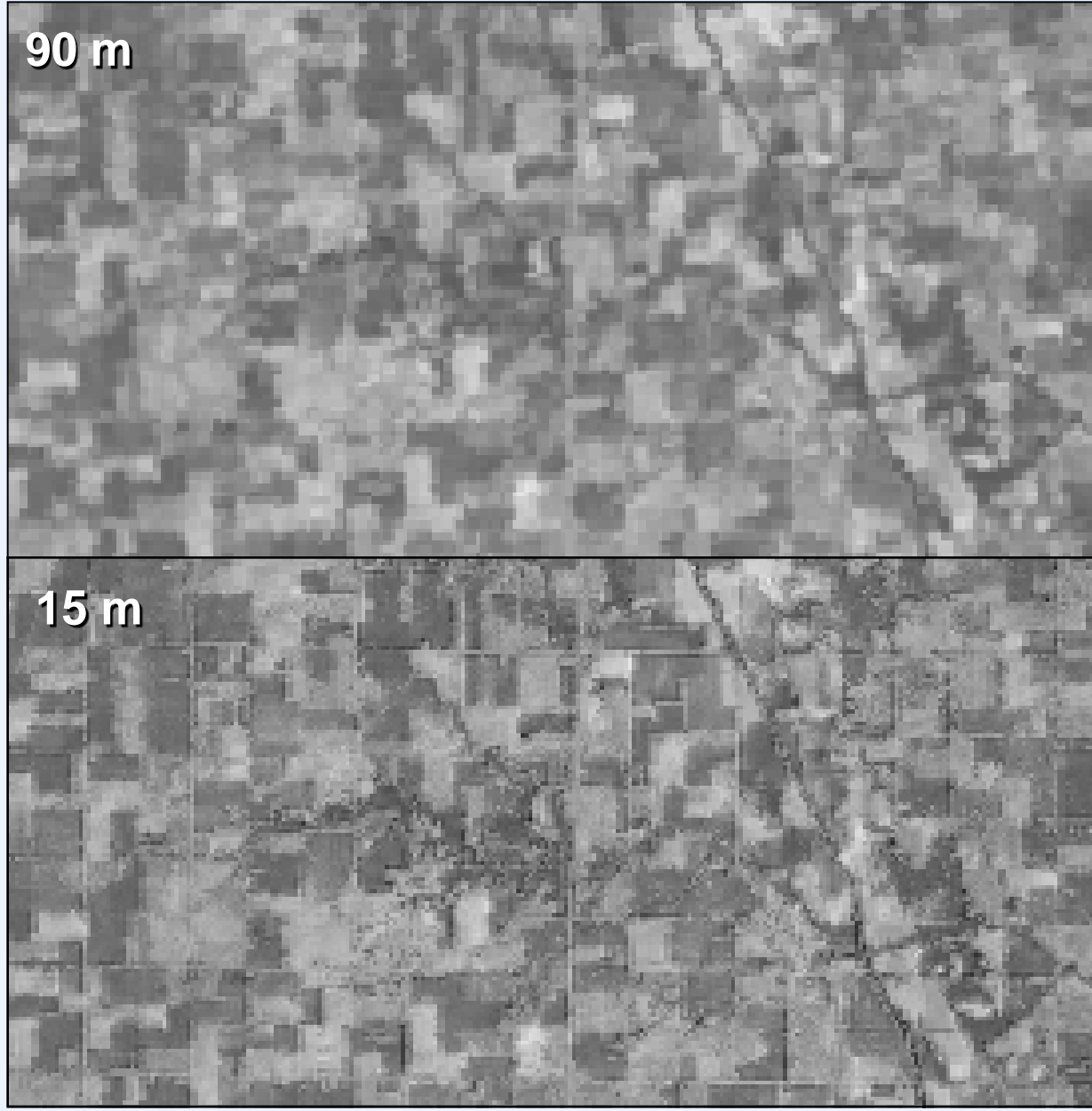
*mcanders@wisc.edu*



# Sharpened ASTER thermal imagery



# Sharpened ASTER thermal imagery

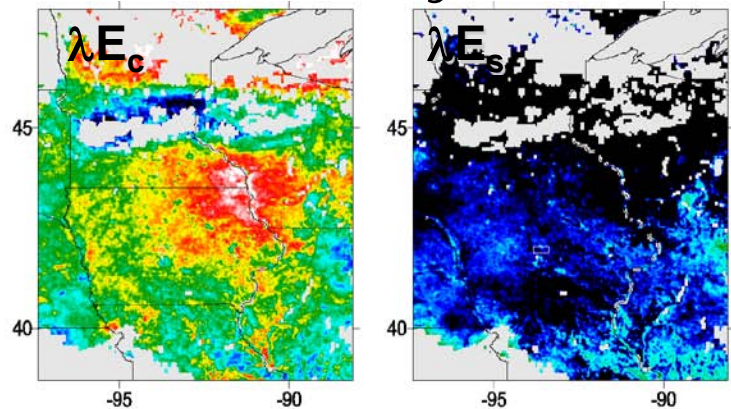
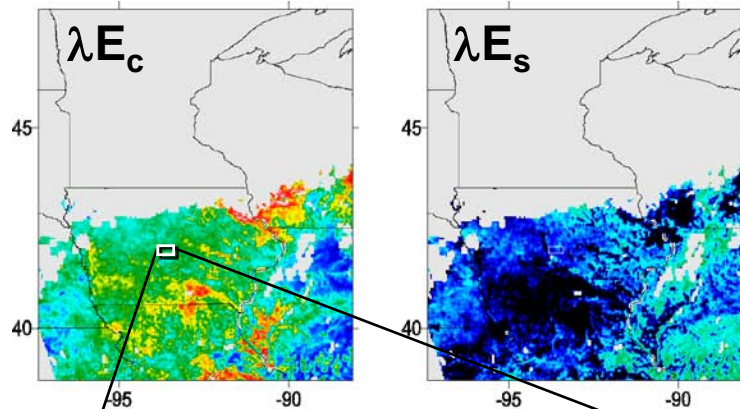




23 June

1 July

ALEXI (5 km)



DisALEXI (60m)

