Mapping Drought and Evapotranspiration at High Resolution using Landsat/GOES Thermal Imagery

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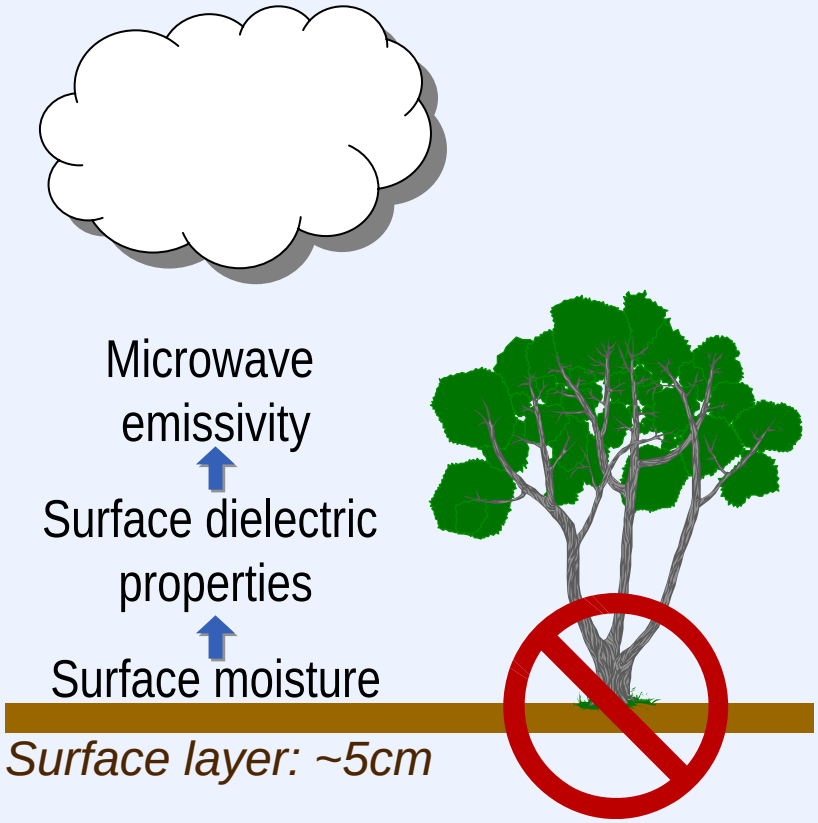
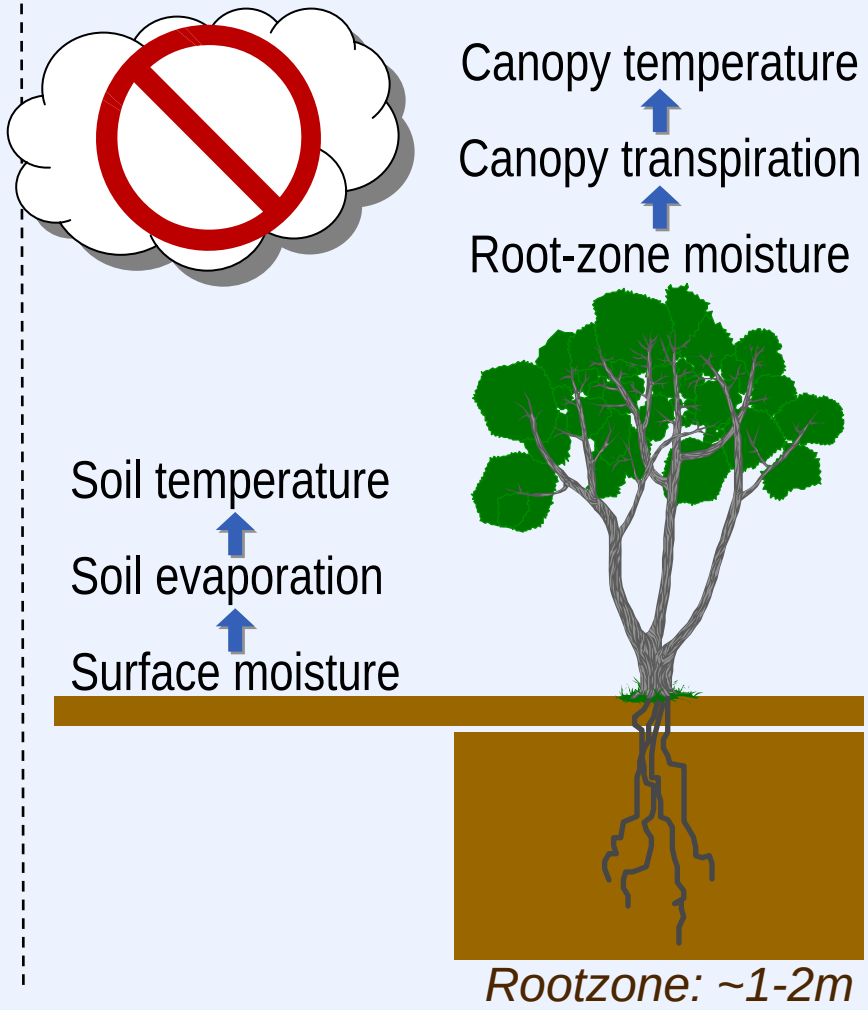
Remote Sensing of Surface Moisture

MICROWAVE
(10-50 km resolution)



THERMAL
(60m – 10km resolution)



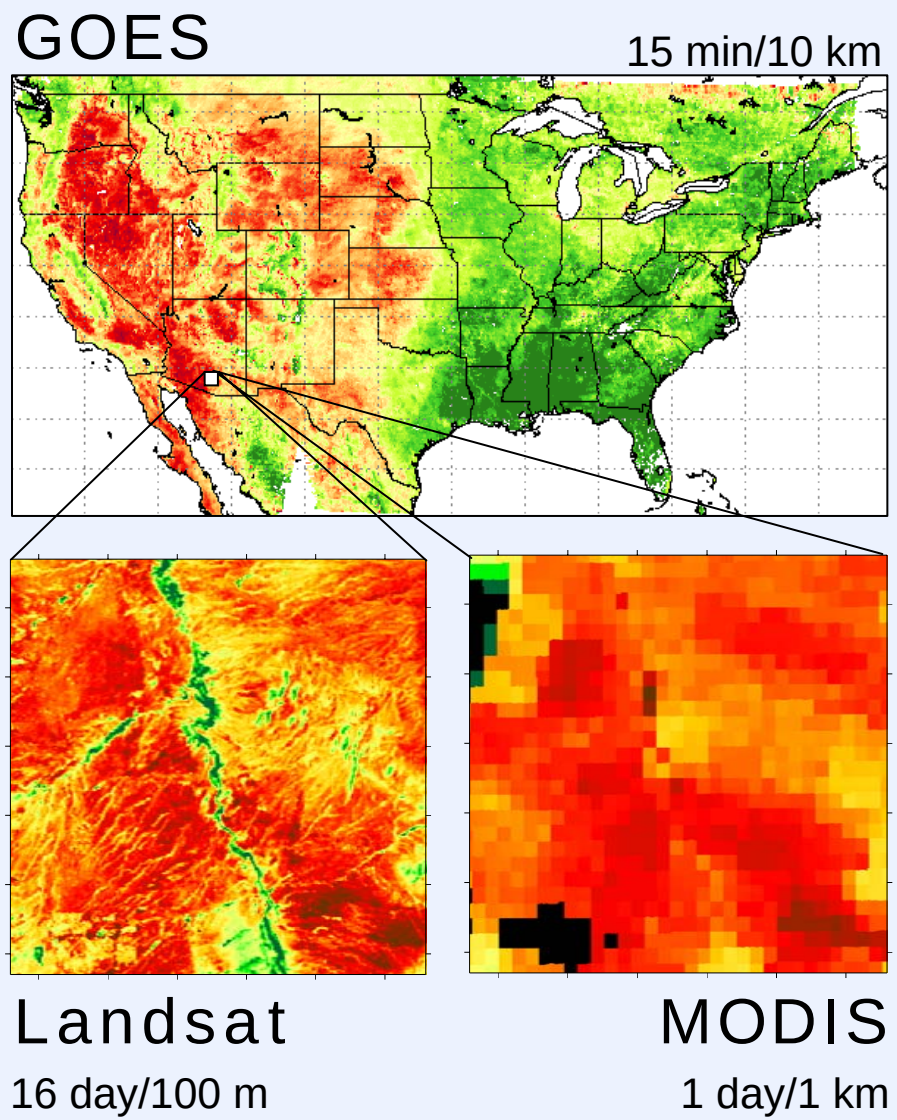
Satellite Thermal Imaging Systems

Pixel Scale	Spatial Resolution	Temporal Resolution	Current Sources	Future Sources
Coarse	5-20 km	15 min	AIRS GOES MSG	CrIS GOES MSG
Moderate	1 km	2-4 times daily	MODIS AVHRR ATSR	VIIRS AVHRR ATSR
Fine	90–120 m	Once every 8-16 days	ASTER Landsat	

Table from S. Hook

PROJECT OBJECTIVES

- Fuse Landsat/GOES to create high spatiotemporal resolution ET/moisture stress products
- Assess Landsat vs. MODIS scale TIR for utility in
  - validating regional products
  - operational applications
- Motivate need for restoring TIR on Landsat 9



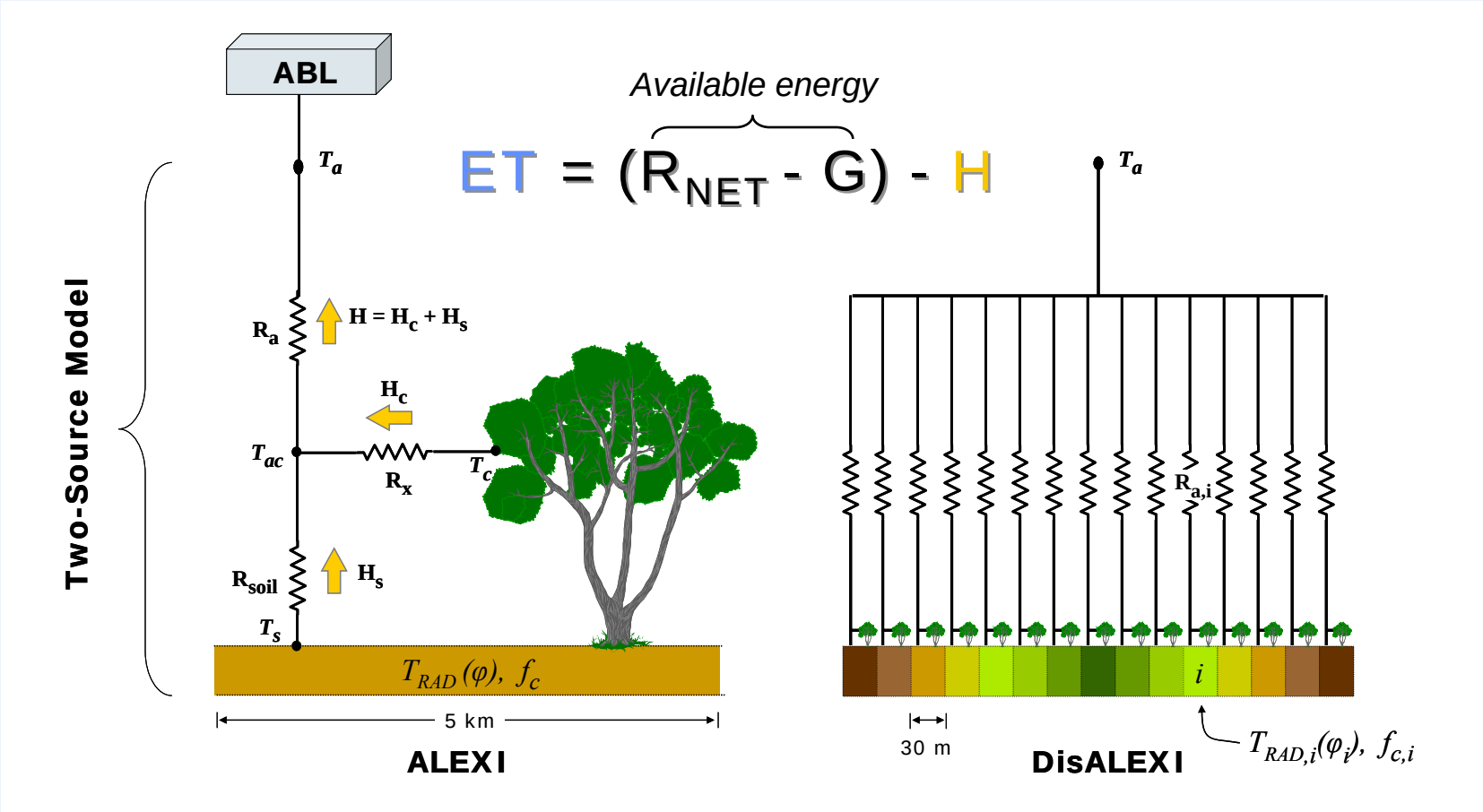
APPLICATIONS

... evapotranspiration

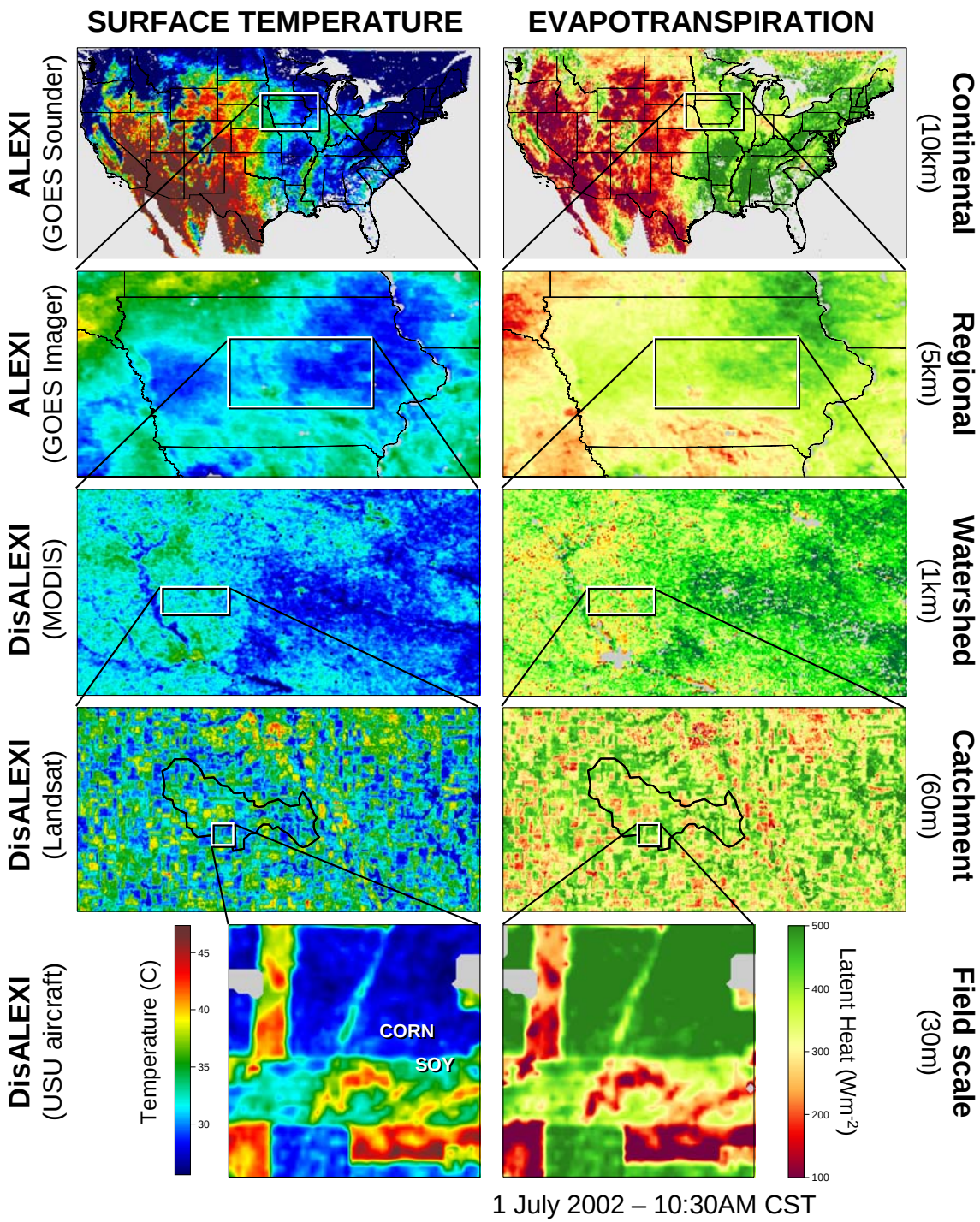
ALEXI – Atmosphere-Land Exchange Inverse Model

(Anderson et al, 1997)

Atmosphere-Land Exchange Inverse (ALEXI)

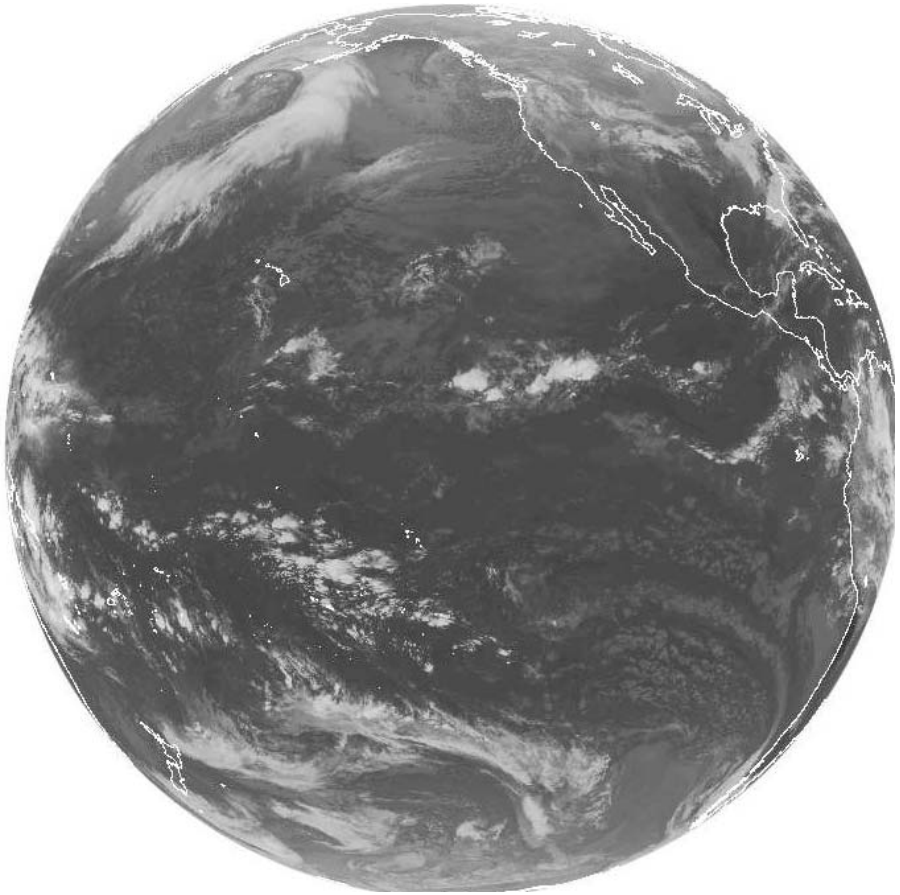


	Regional scale	Landscape scale
Surface temp:	ΔT_{RAD} - GOES	T_{RAD} - TM, ASTER, MODIS
Cover fraction:	f_c - MODIS	f_c - TM, ASTER, MODIS

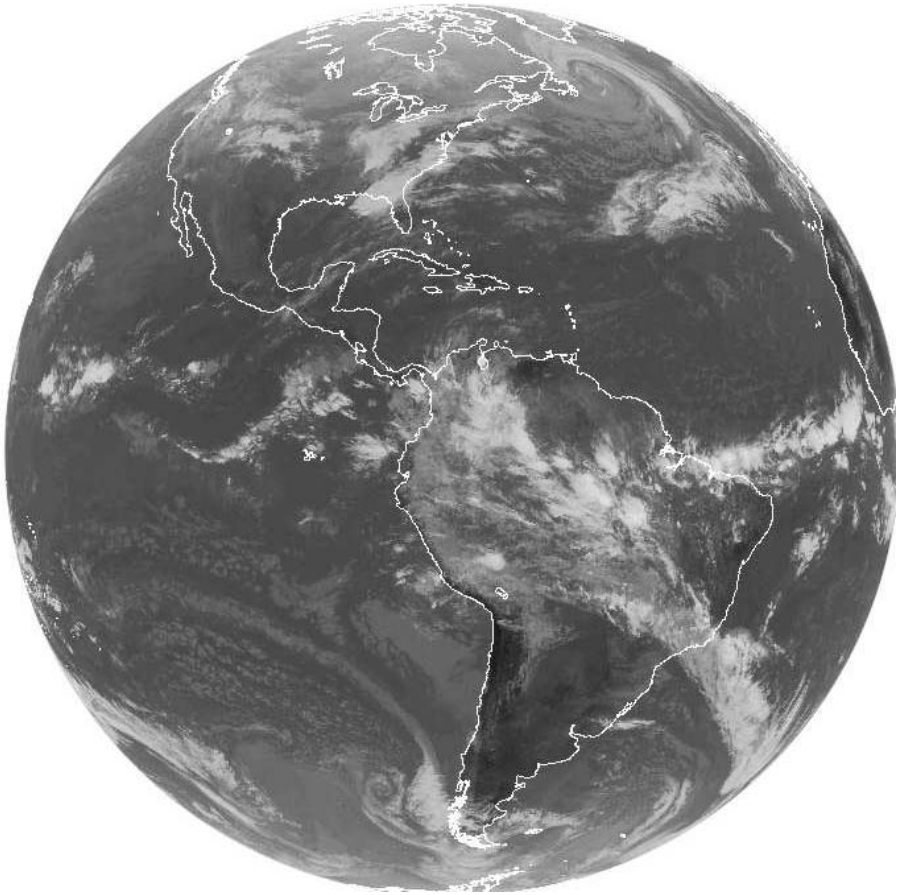

SURFACE TEMPERATURE
EVAPOTRANSPIRATION
ALEXI (GOES Sounder)
ALEXI (GOES Imager)
DisALEXI (MODIS)
DisALEXI (Landsat)
DisALEXI (USU aircraft)
Continental (10km)
Regional (5km)
Watershed (1km)
Catchment (60m)
Field scale (30m)
Temperature (C)
45
40
35
30
CORN
SOY
Latent Heat (Wm-2)
500
400
300
200
100
1 July 2002 – 10:30AM CST

GOES Coverage

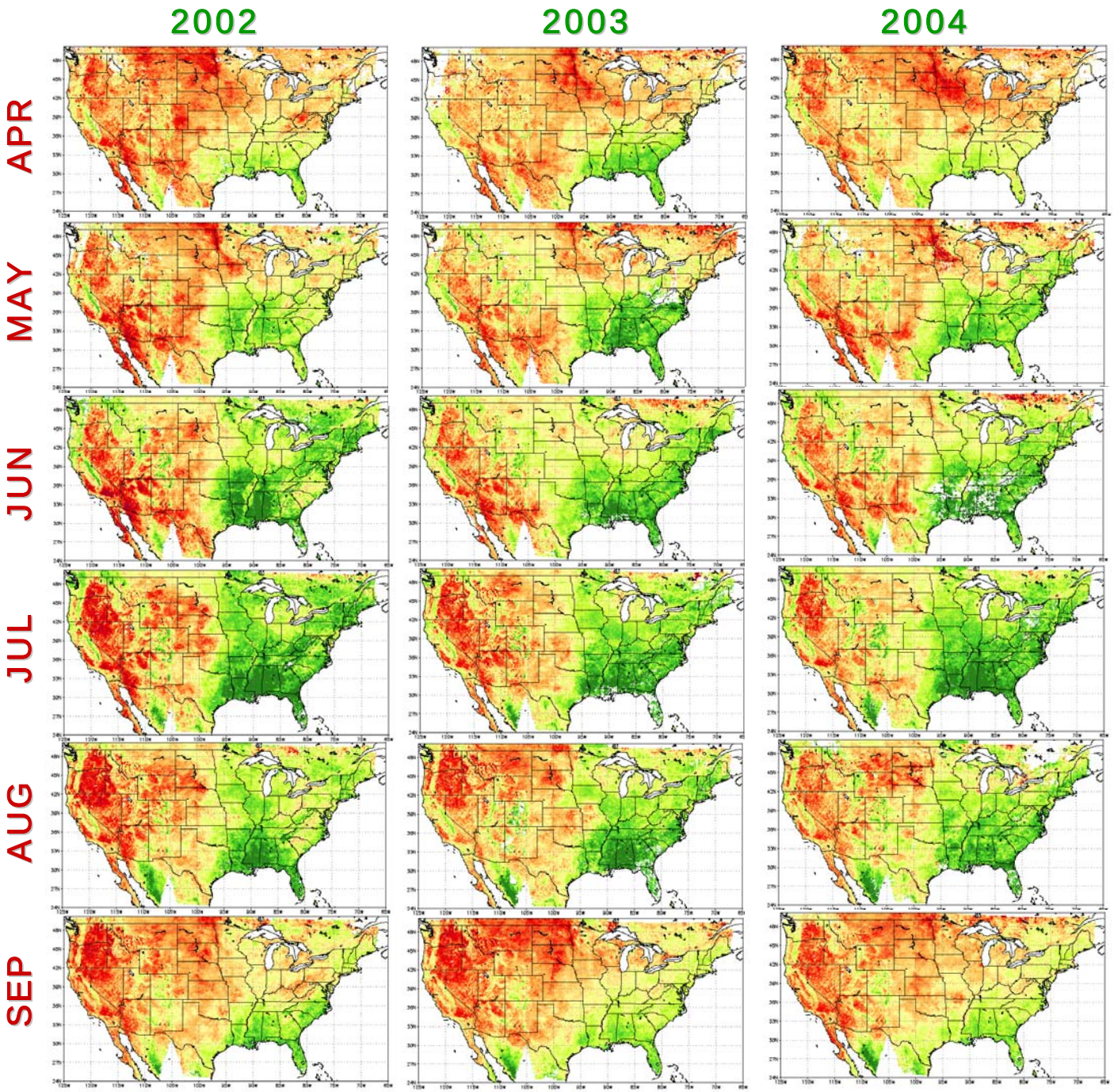
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

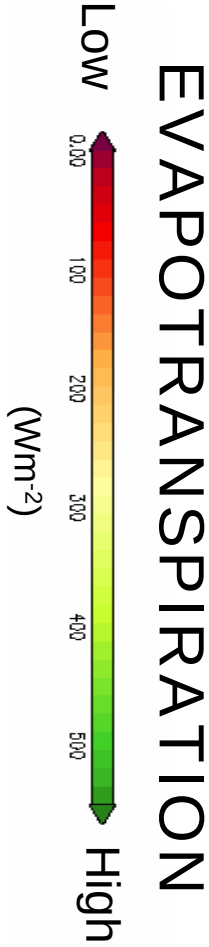


GOES – West (Pacific)



GOES - East

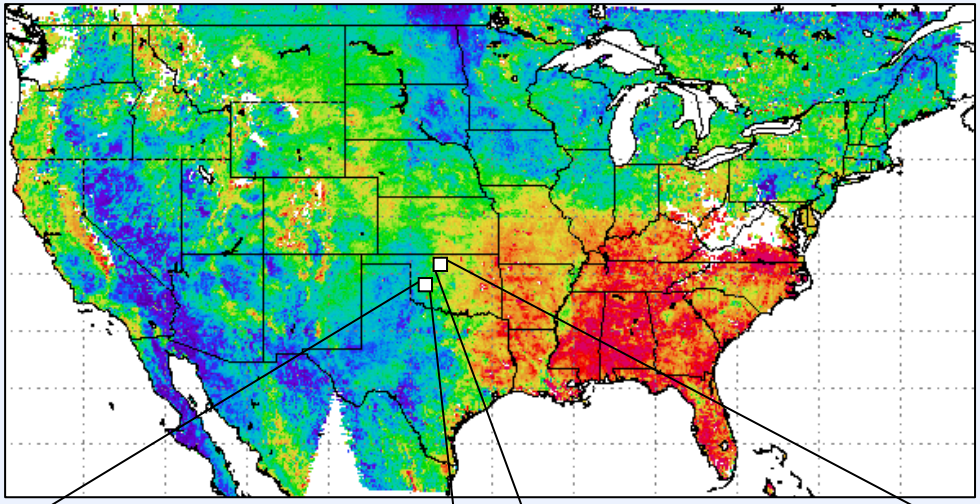




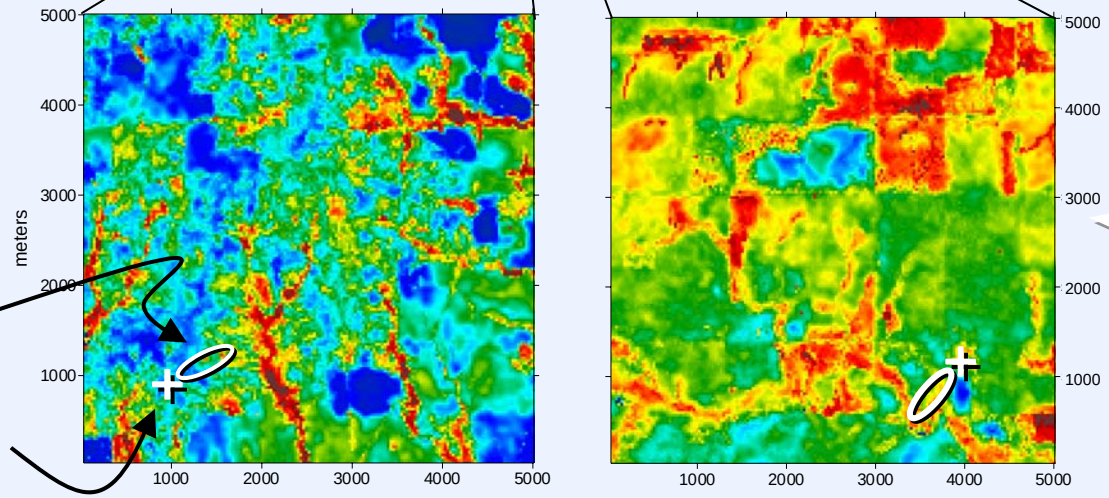
(Anderson et al, 2007)

Validation through disaggregation

GOES-DERIVED FLUXES (5-10 km)



ALEXI



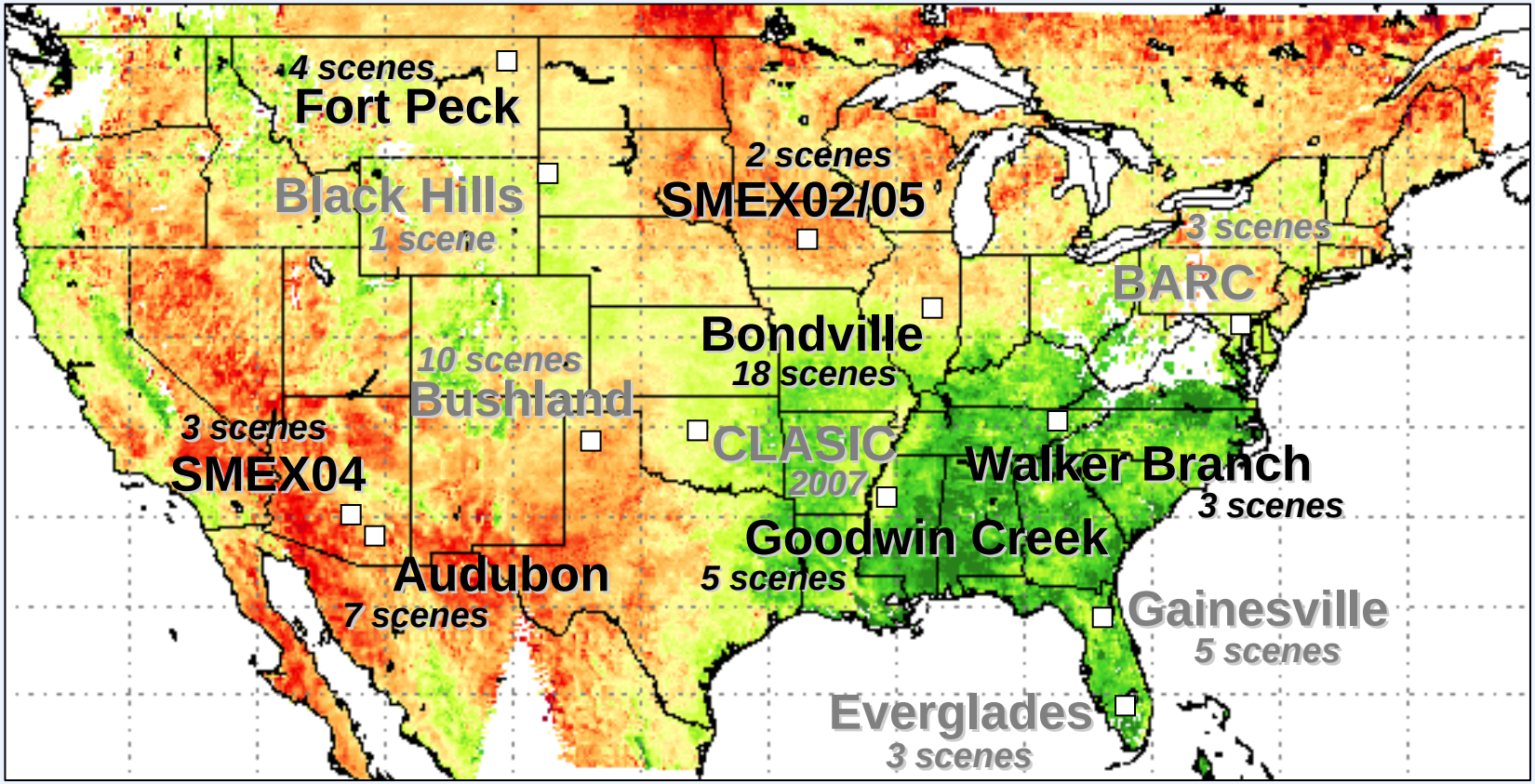
source footprint

tower

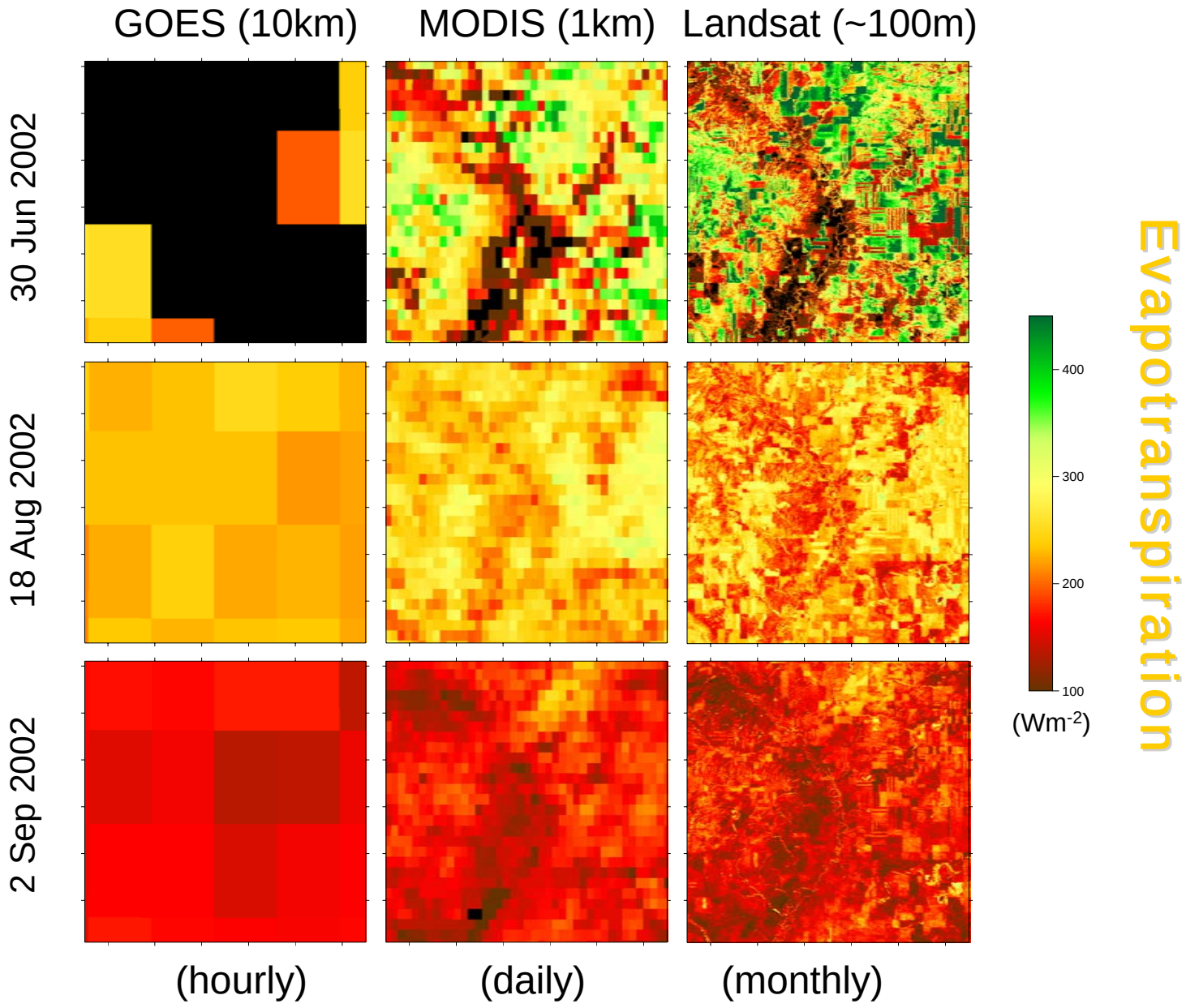
DisALEXI

LANDSAT-DISAGGREGATED FLUXES

ALEXI validation sites

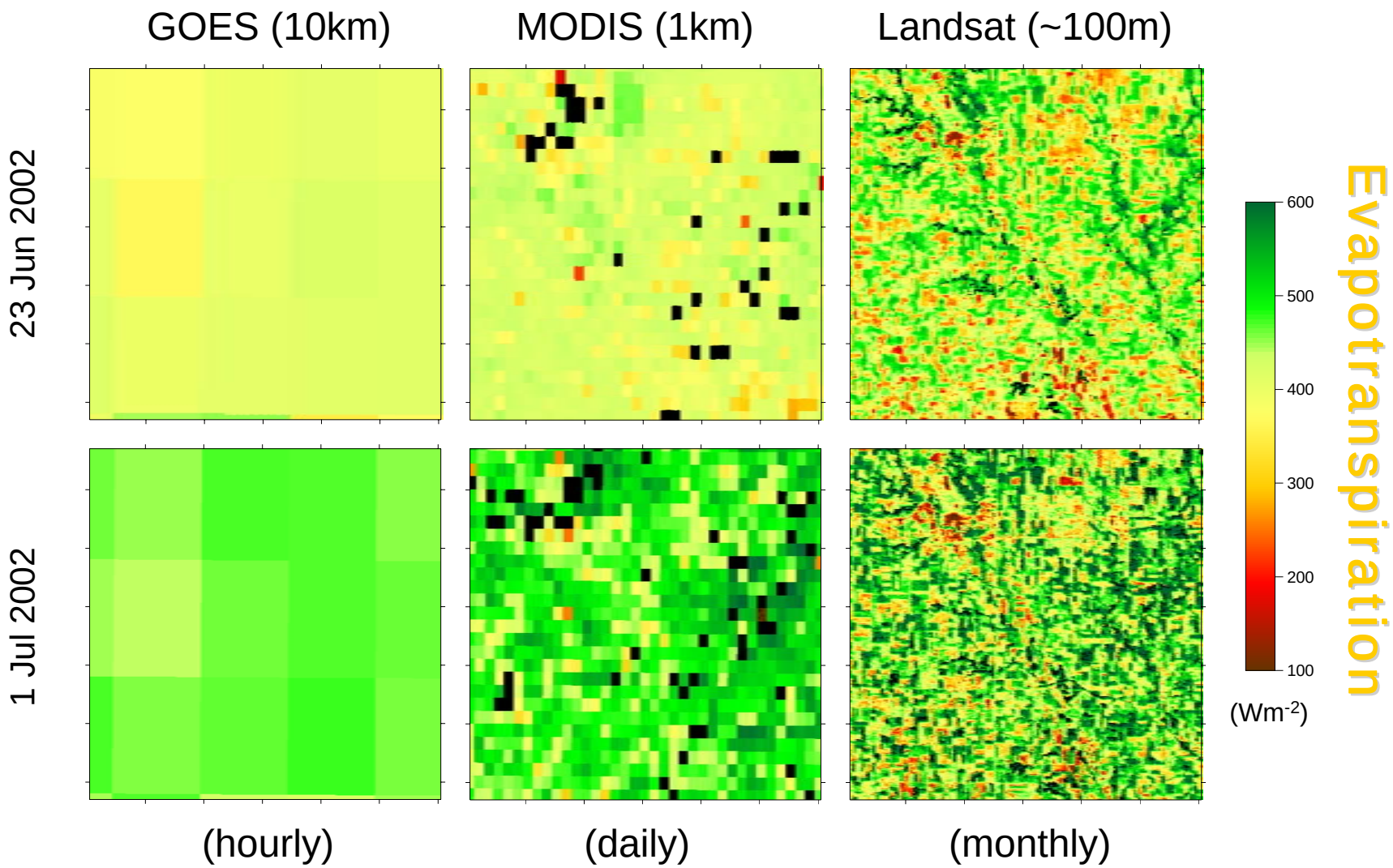


FORT PECK, MONTANA

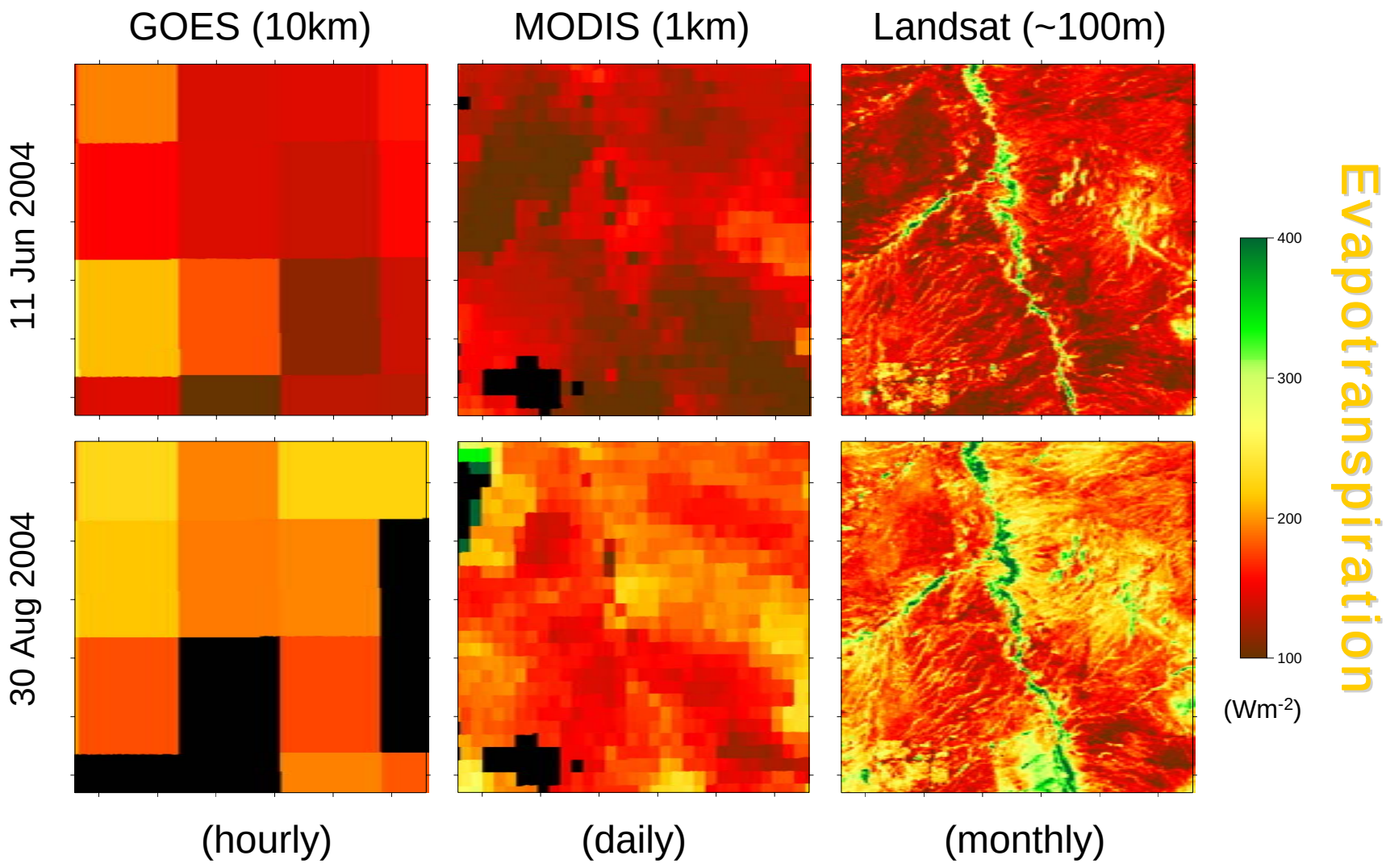


Evapotranspiration

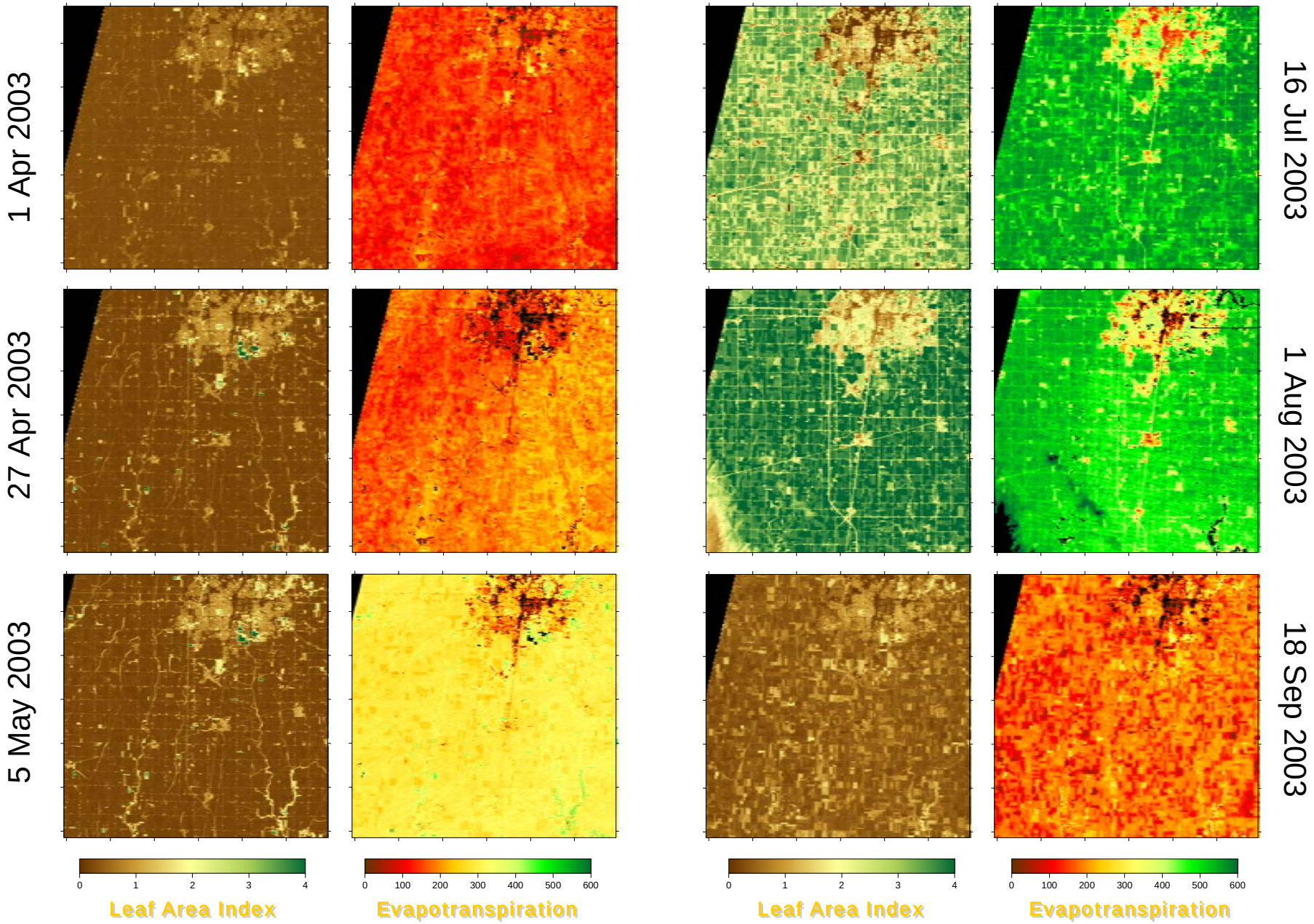
AMES, IOWA


GOES (10km)
MODIS (1km)
Landsat (~100m)
23 Jun 2002
1 Jul 2002
(hourly)
(daily)
(monthly)
600
500
400
300
200
100
(Wm-2)
Evapotranspiration

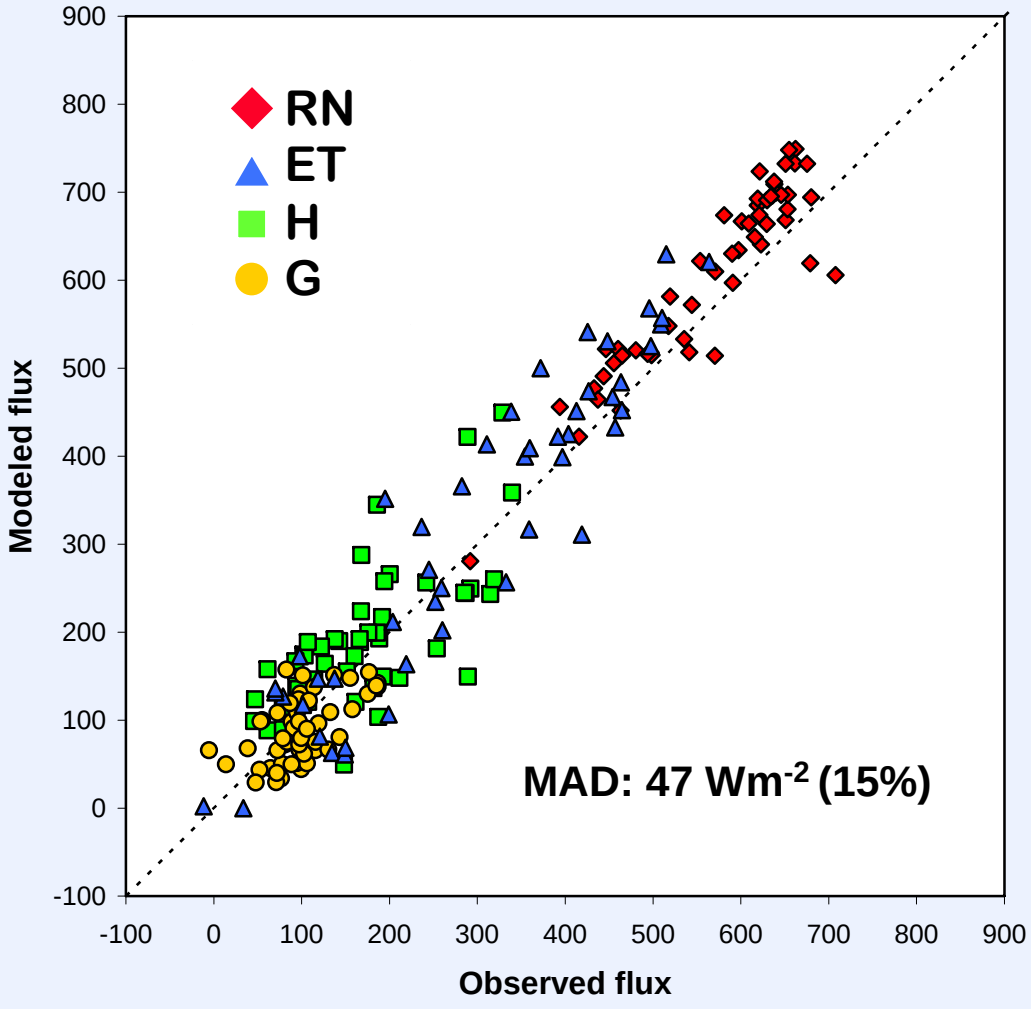
SAN PEDRO RIVER, ARIZONA



BONDVILLE, ILLINOIS

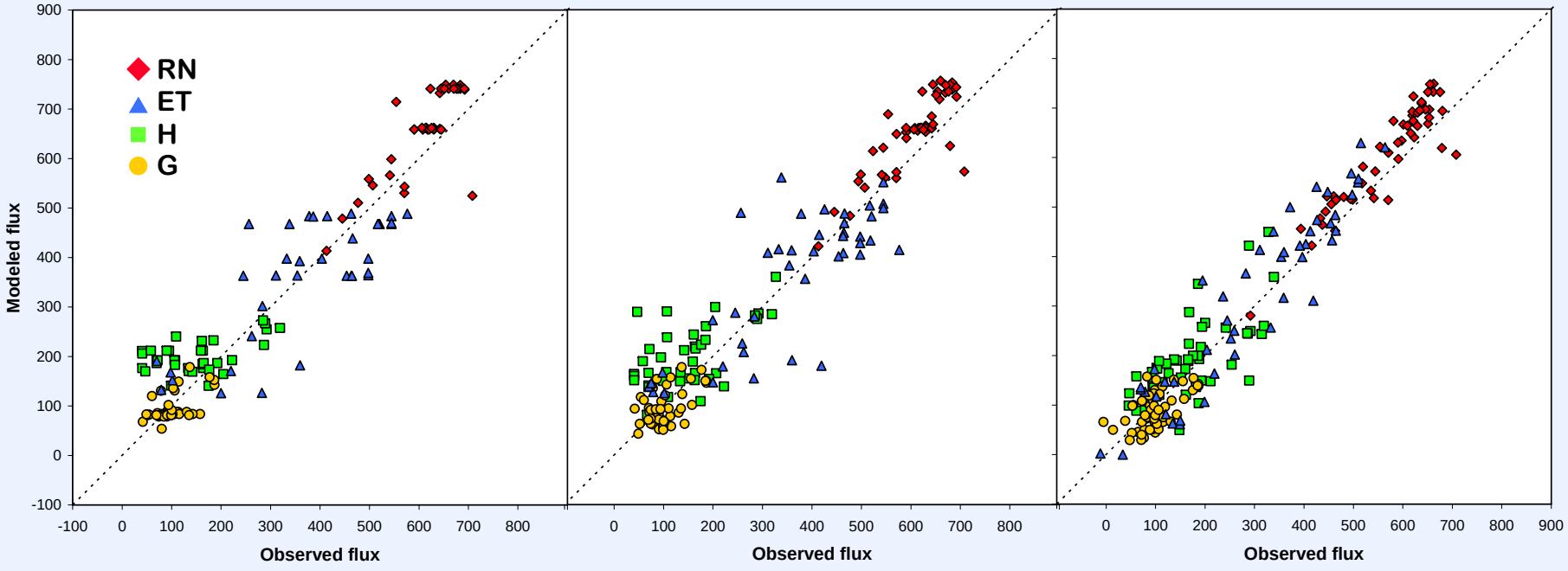


Clear-sky fluxes using Landsat TIR (~100m)

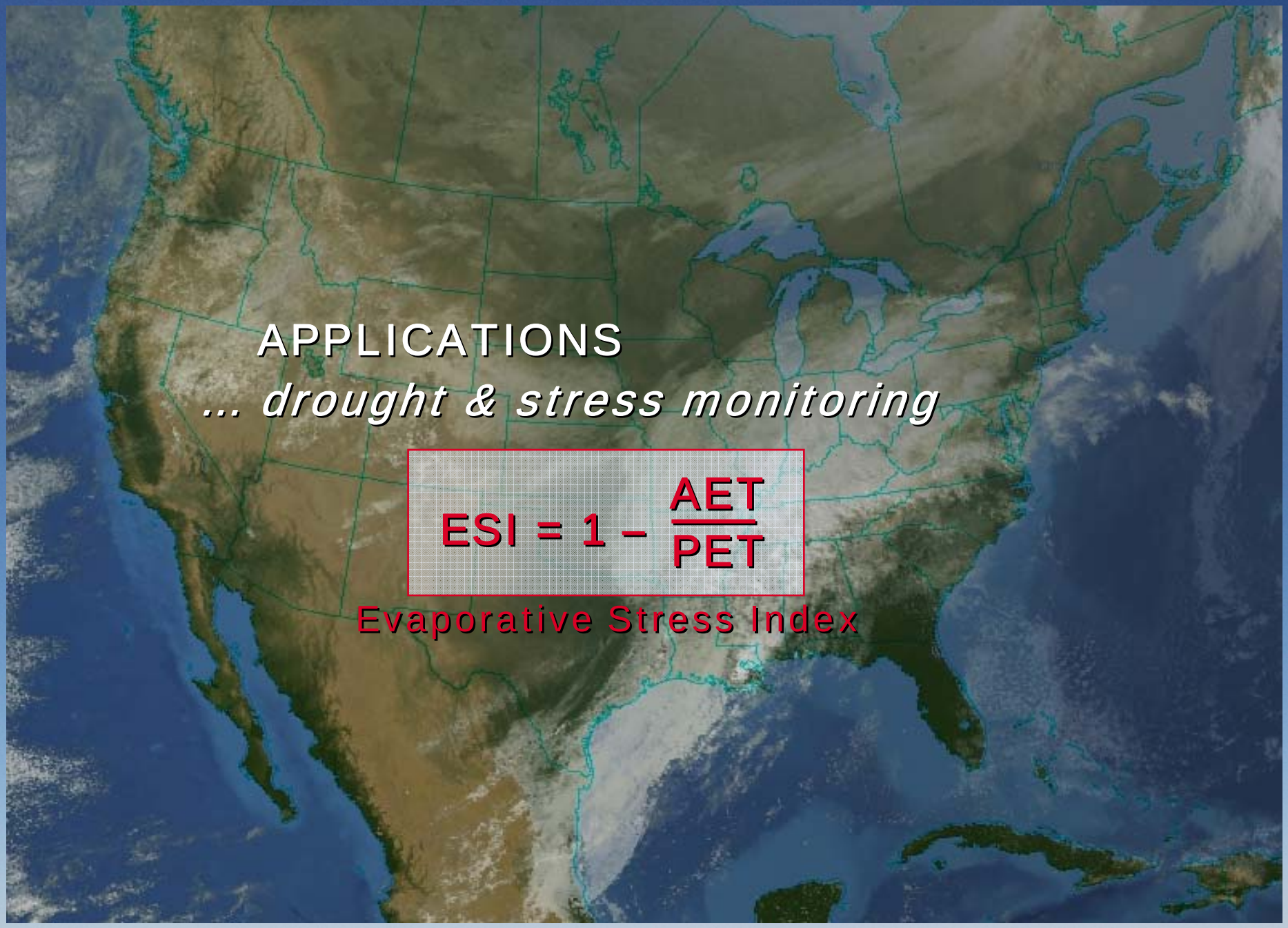


Effect of TIR resolution on validation

GOES (10 km) MODIS (1 km) Landsat (~100 m)



MAD: 75 Wm^{-2} (25%) **MAD: 63 Wm^{-2} (20%)** **MAD: 47 Wm^{-2} (15%)**

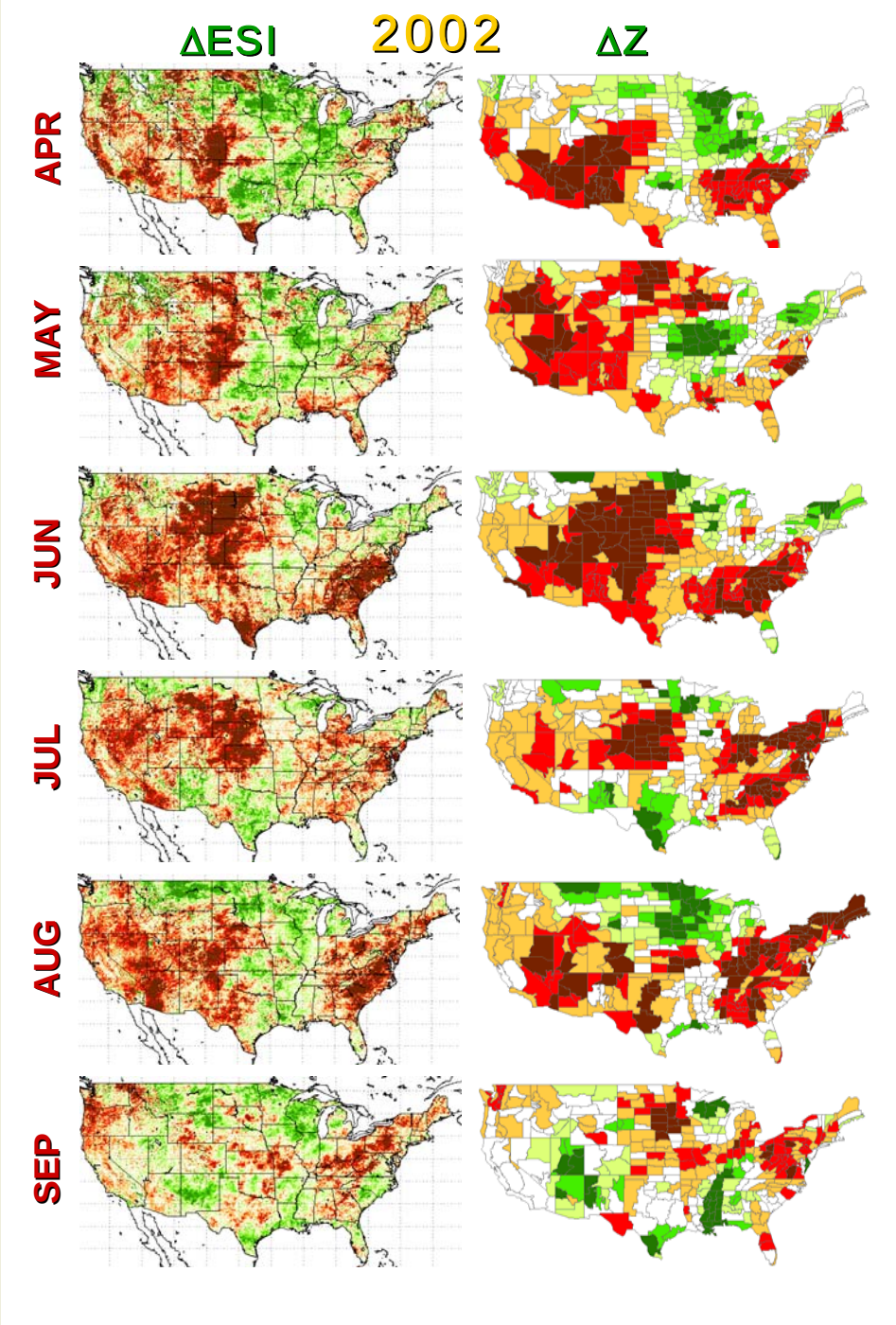


APPLICATIONS

... drought & stress monitoring

$$ESI = 1 - \frac{AET}{PET}$$

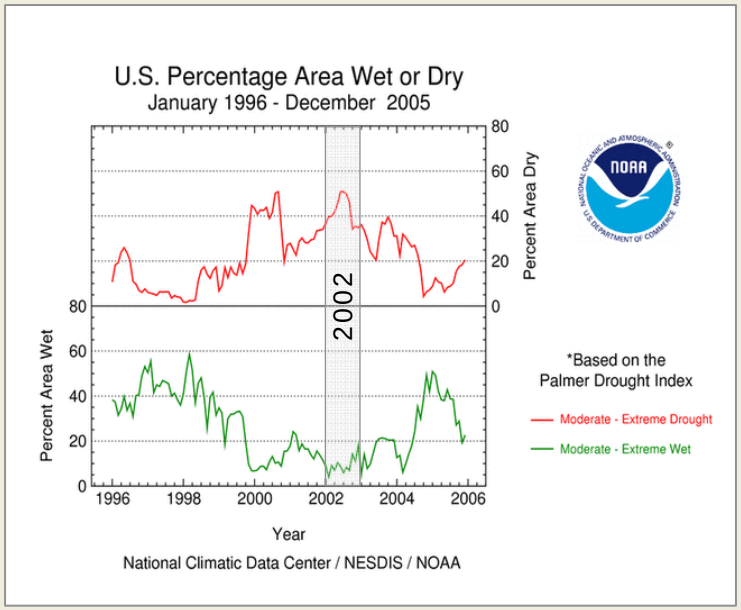
Evaporative Stress Index



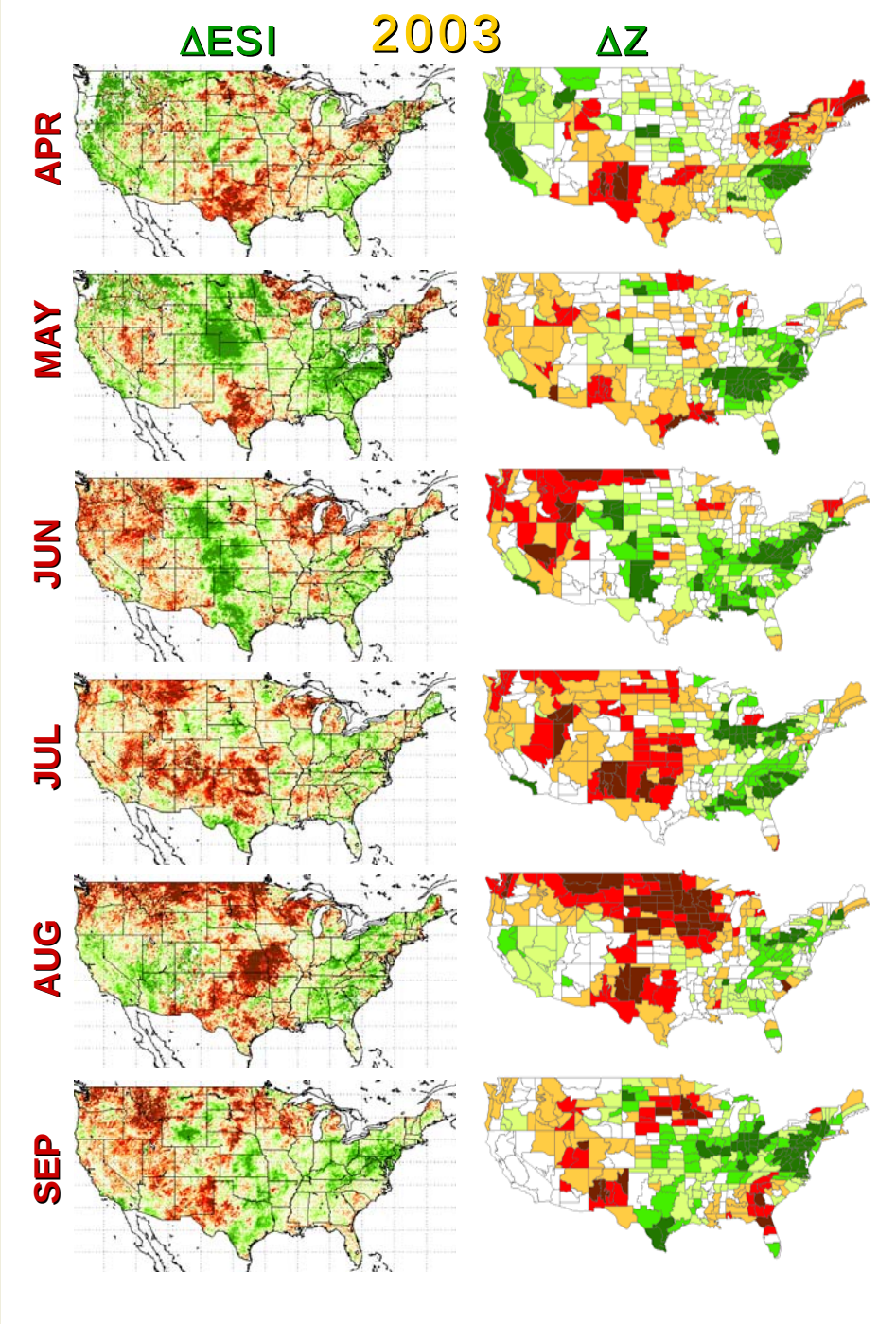
Evaporative Stress Index

2002

Dry — Wet

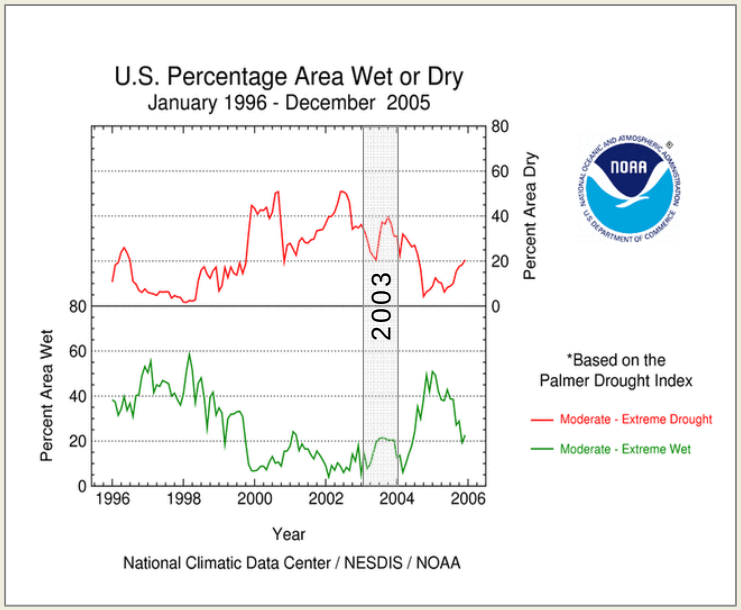


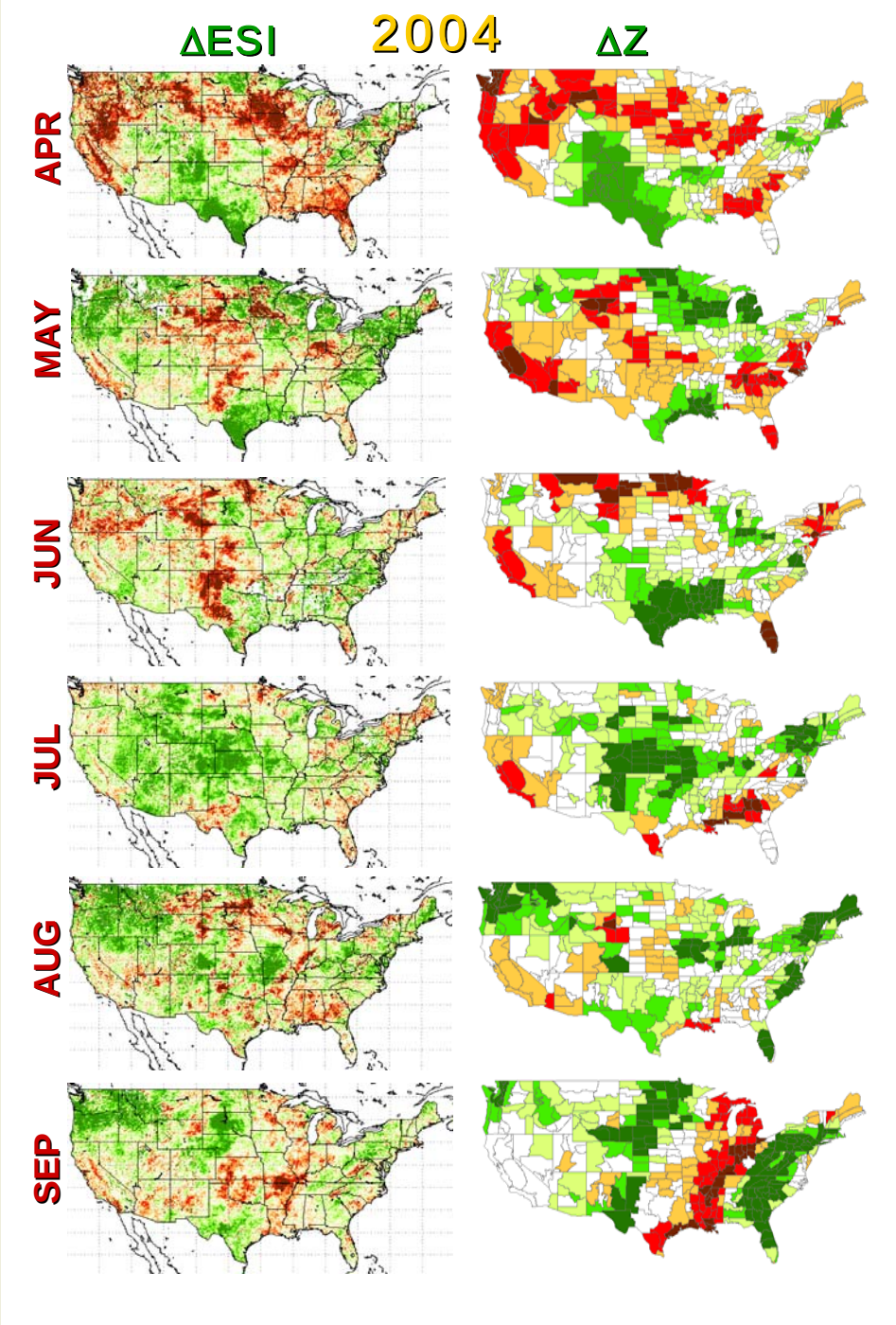
Evaporative Stress Index



2003

Dry — Wet

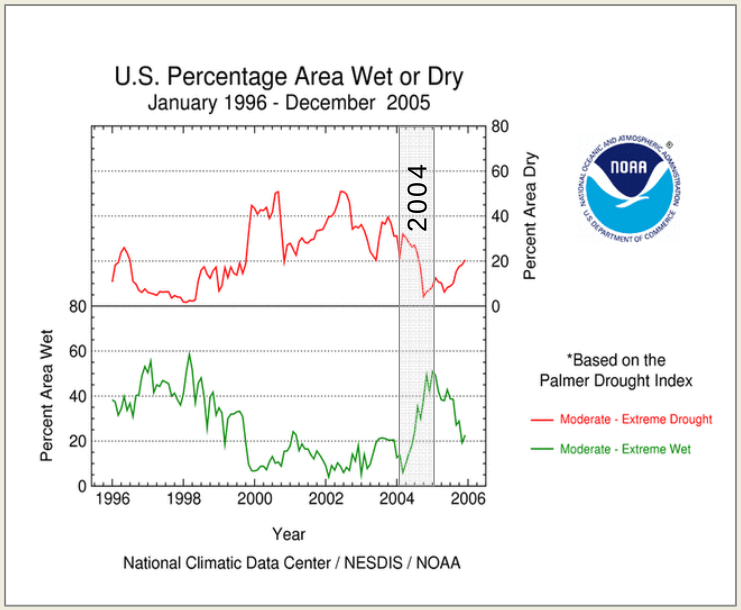


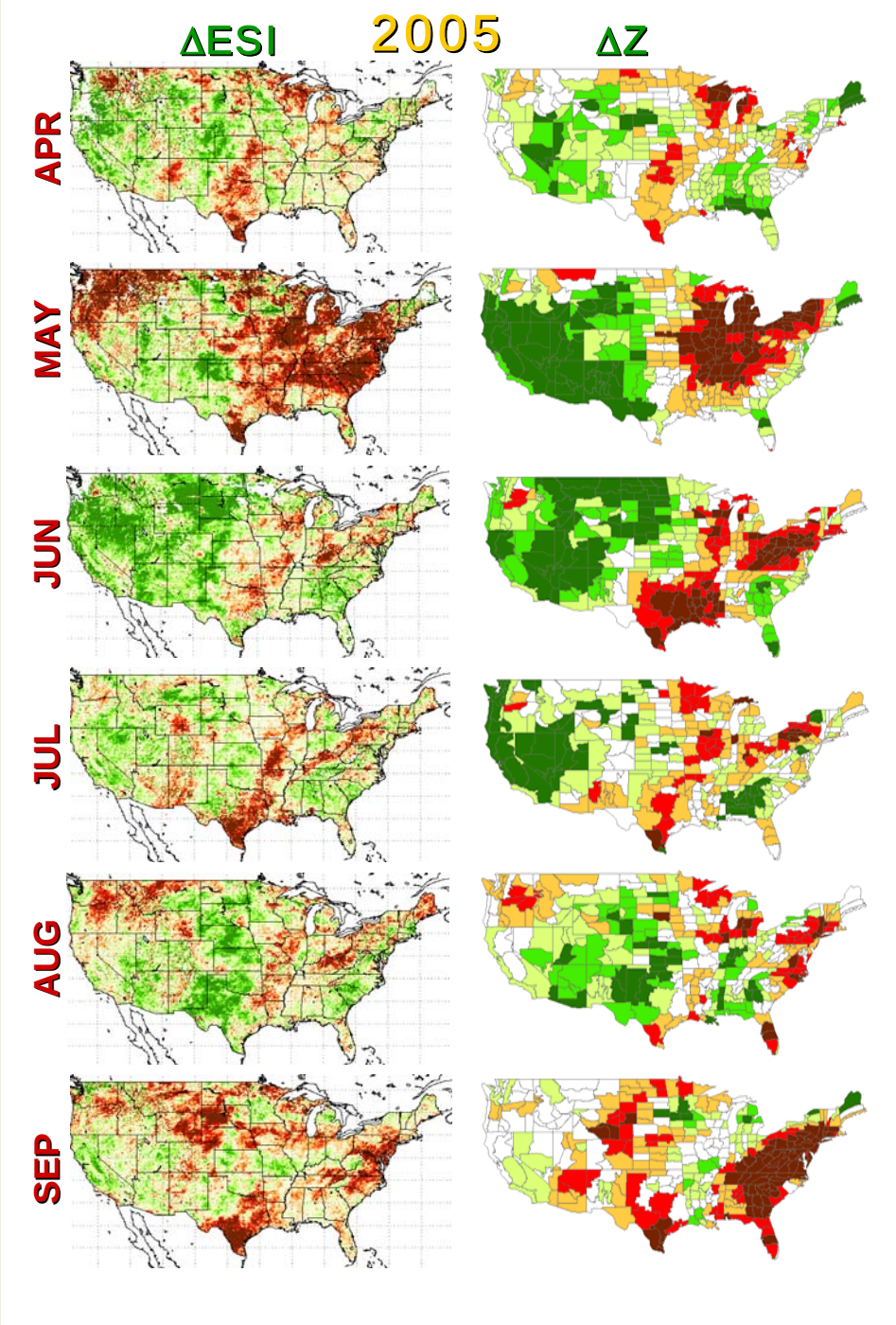


Evaporative Stress Index

2004

Dry — Wet

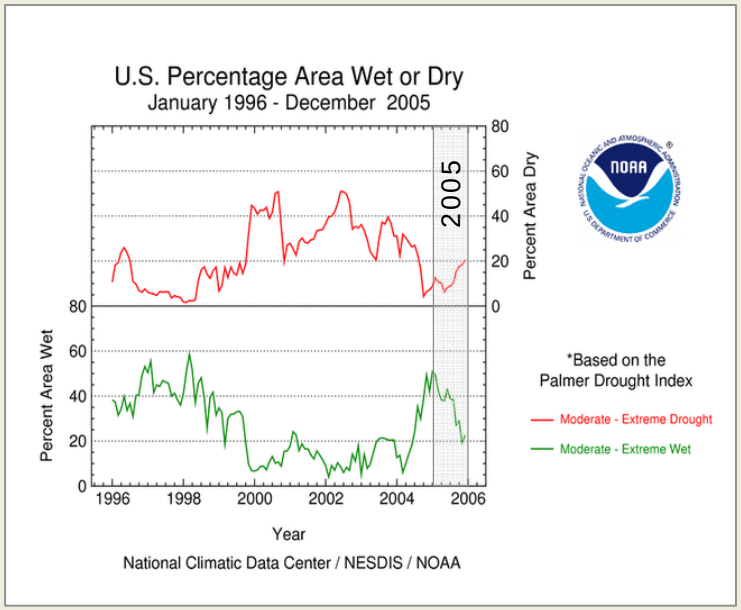




Evaporative Stress Index

2005

Dry — Wet



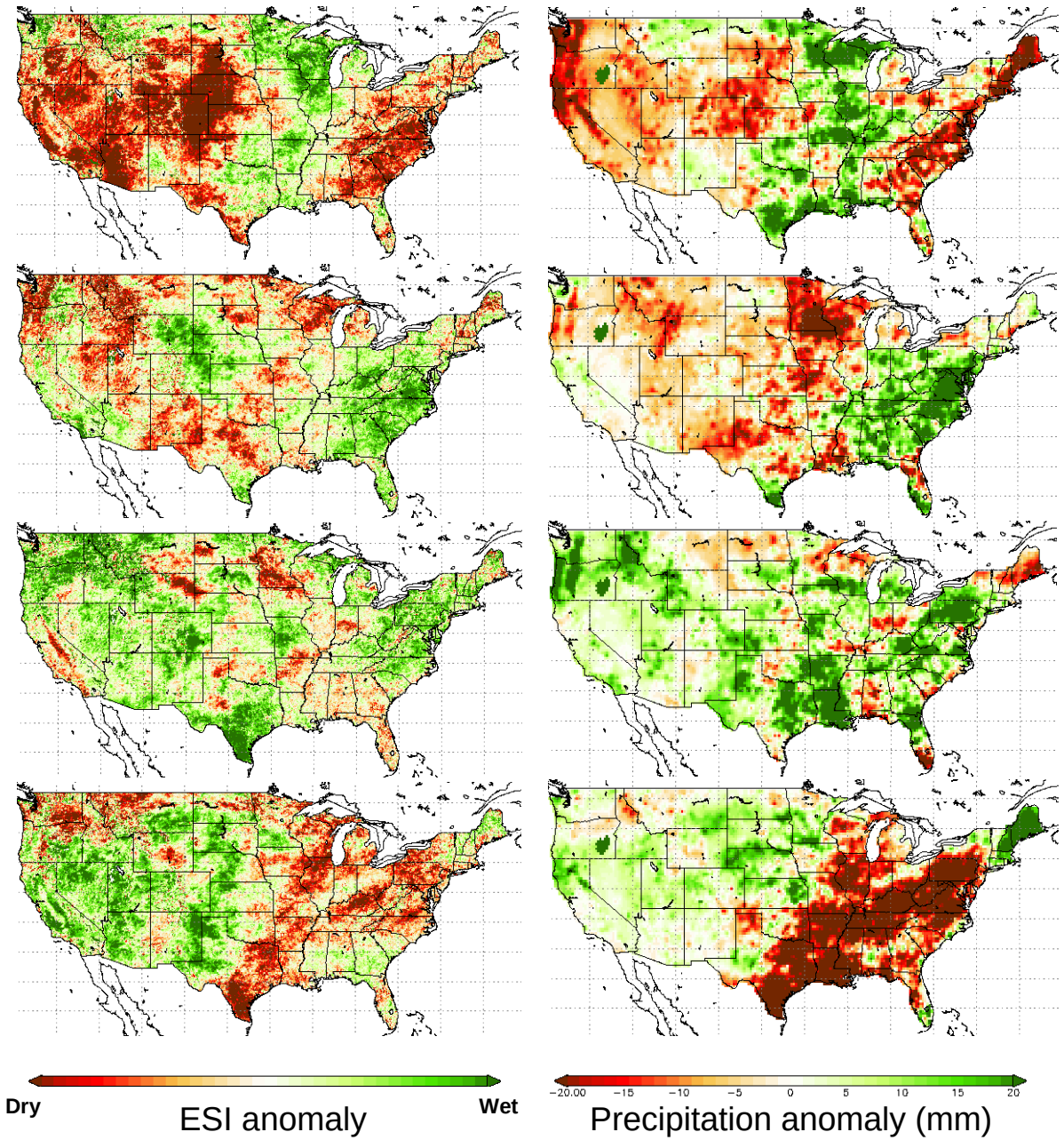
ALEXI Precipitation

2002

2003

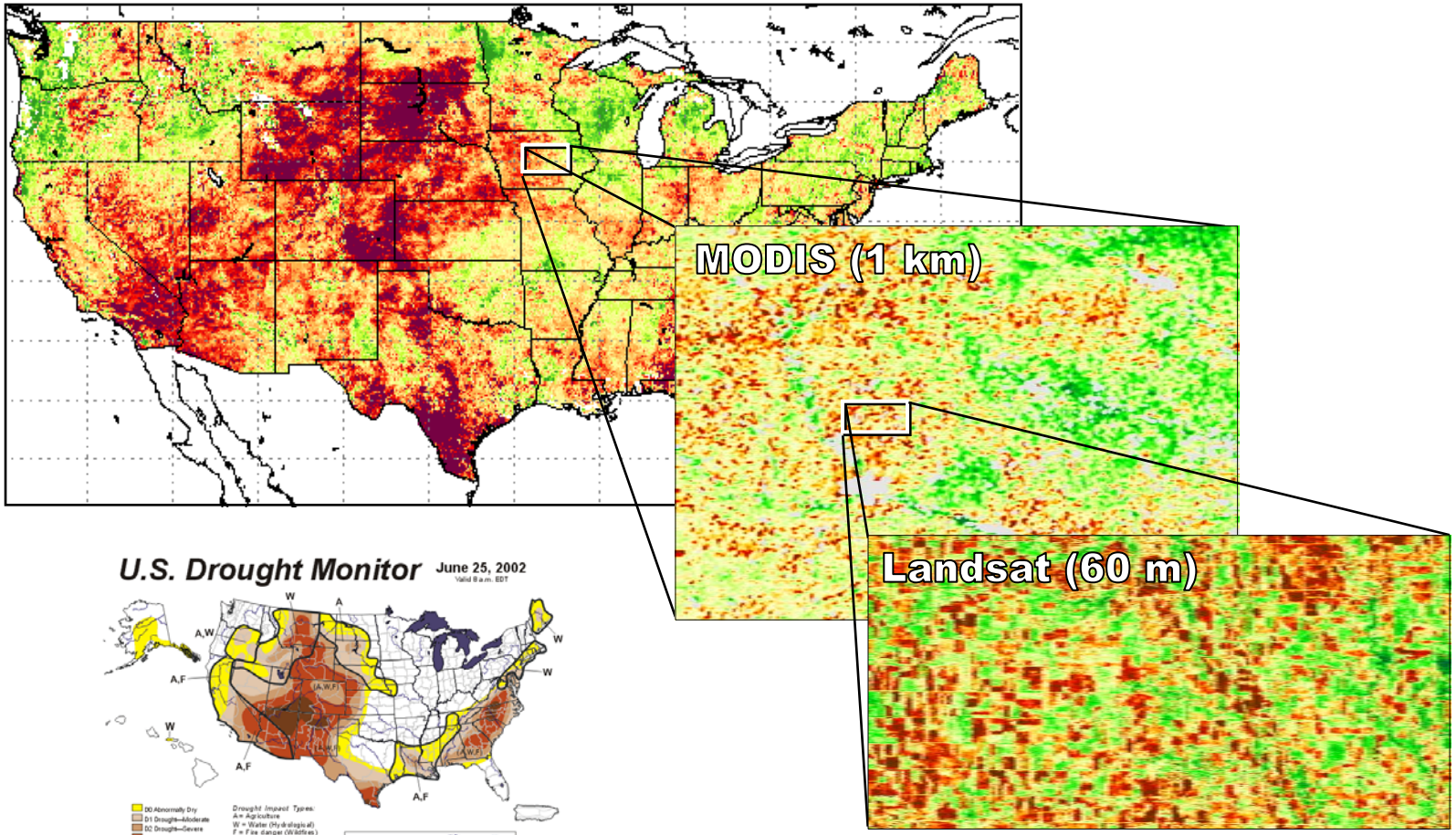
2004

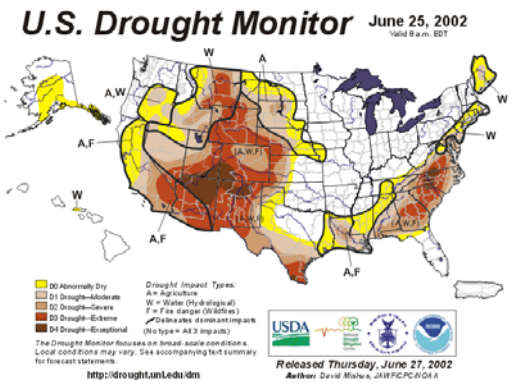
2005

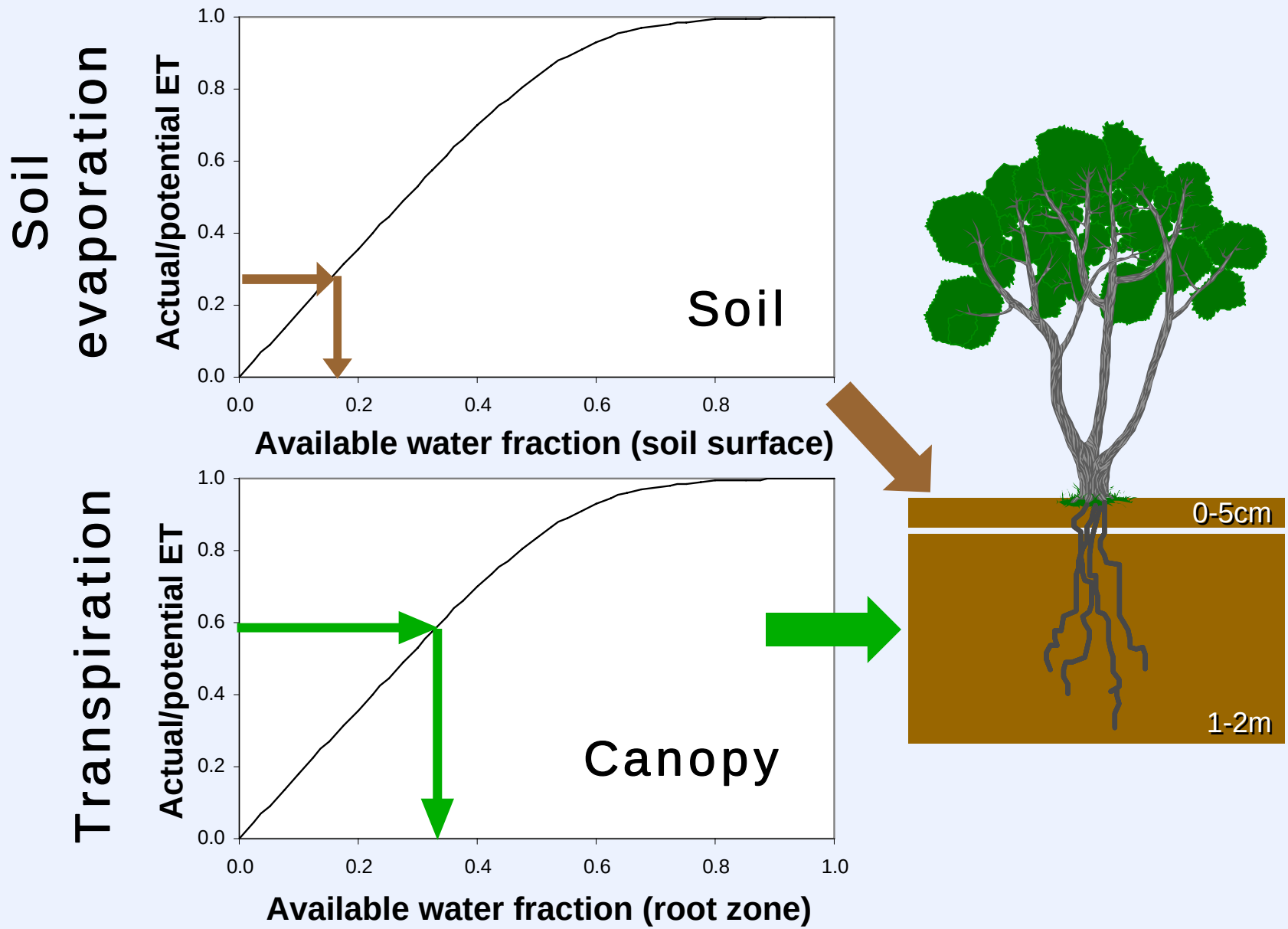


Multi-scale Drought Monitoring

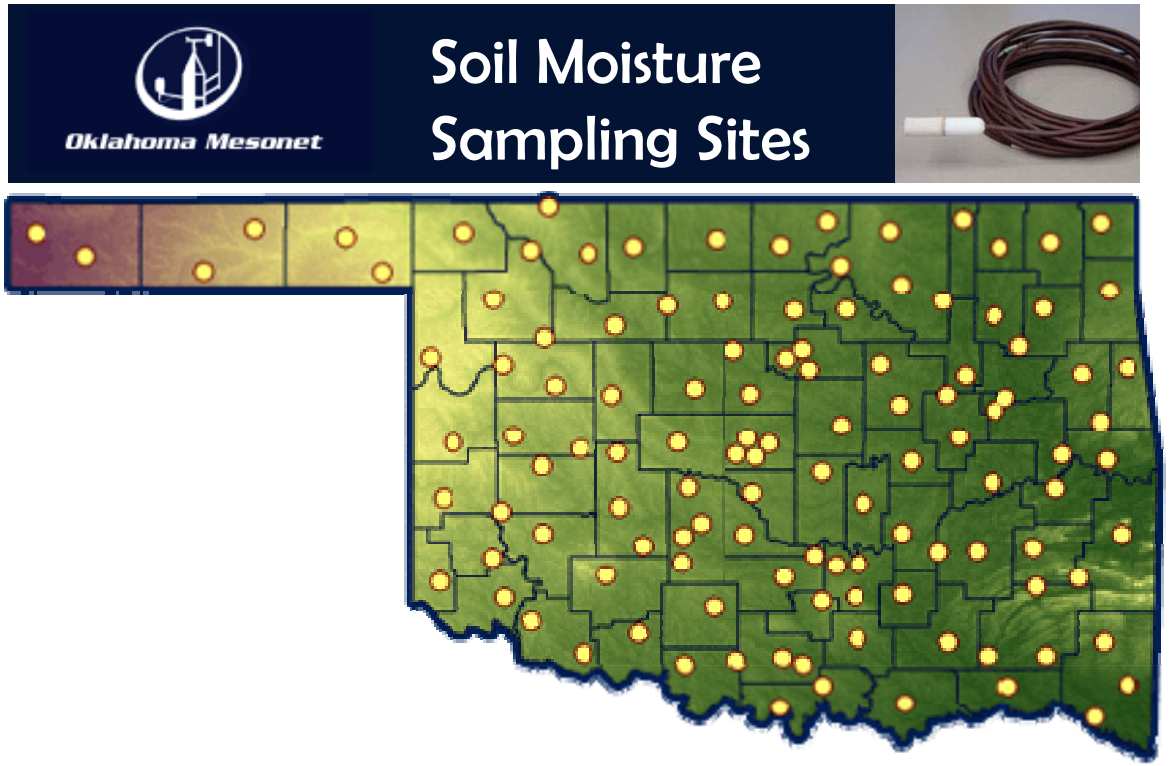
GOES Evaporative Stress Index **JUNE 2002**



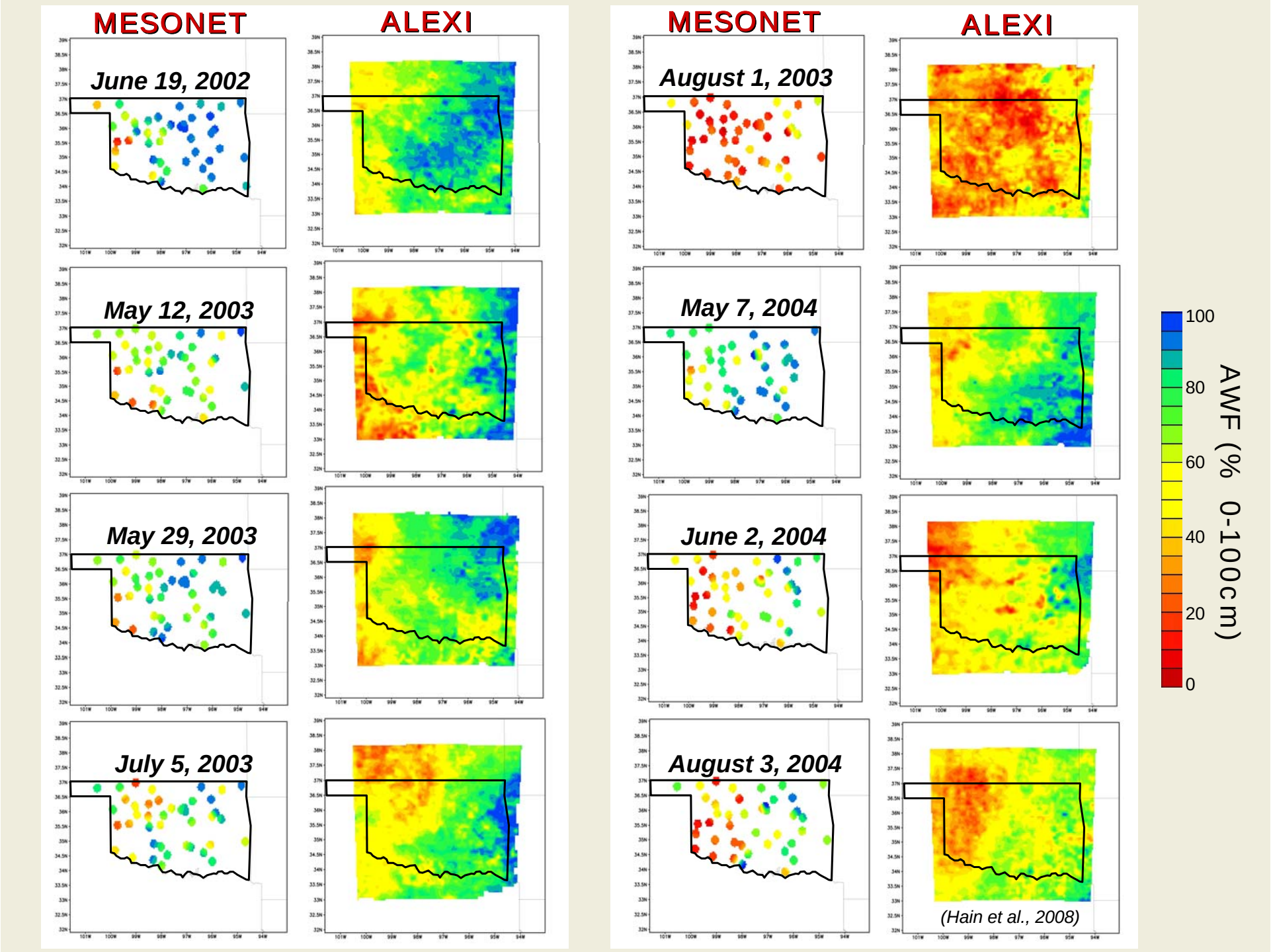



Soil evaporation
Actual/potential ET
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
Soil
Available water fraction (soil surface)
Transpiration
Actual/potential ET
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Canopy
Available water fraction (root zone)
0-5cm
1-2m

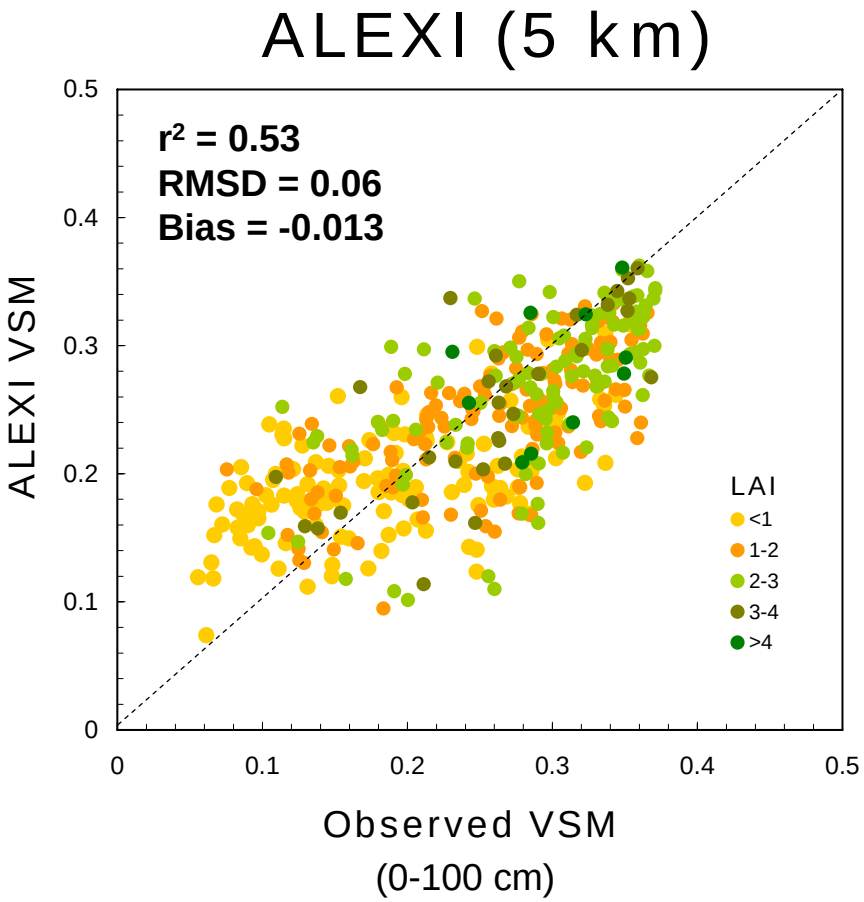
Validation – Oklahoma Mesonet



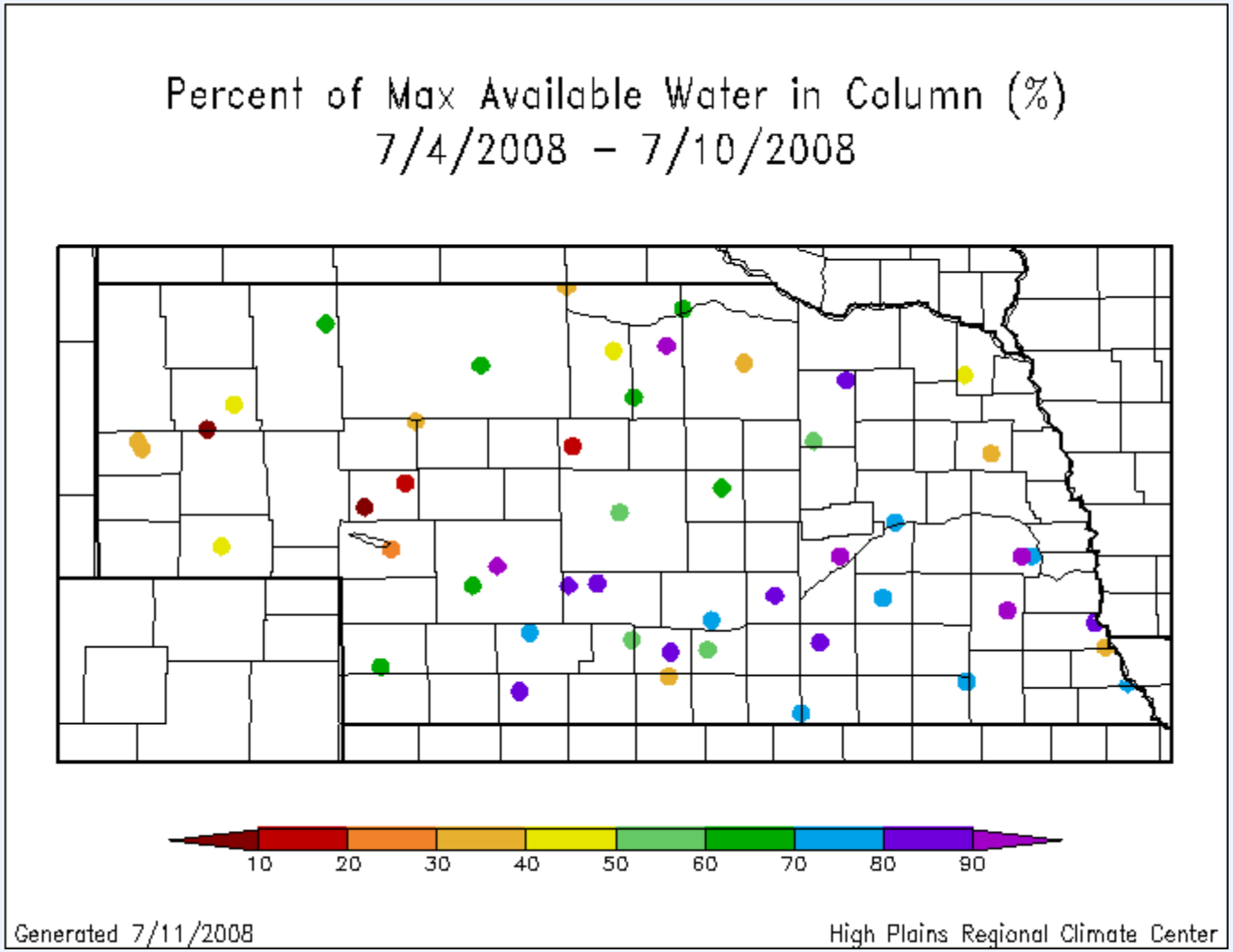
http://okmesonet.ocs.ou.edu/


MESONET
ALEXI
June 19, 2002
May 12, 2003
May 29, 2003
July 5, 2003
MESONET
ALEXI
August 1, 2003
May 7, 2004
June 2, 2004
August 3, 2004
(Hain et al., 2008)
AWF (% 0-100cm)
100
80
60
40
20
0

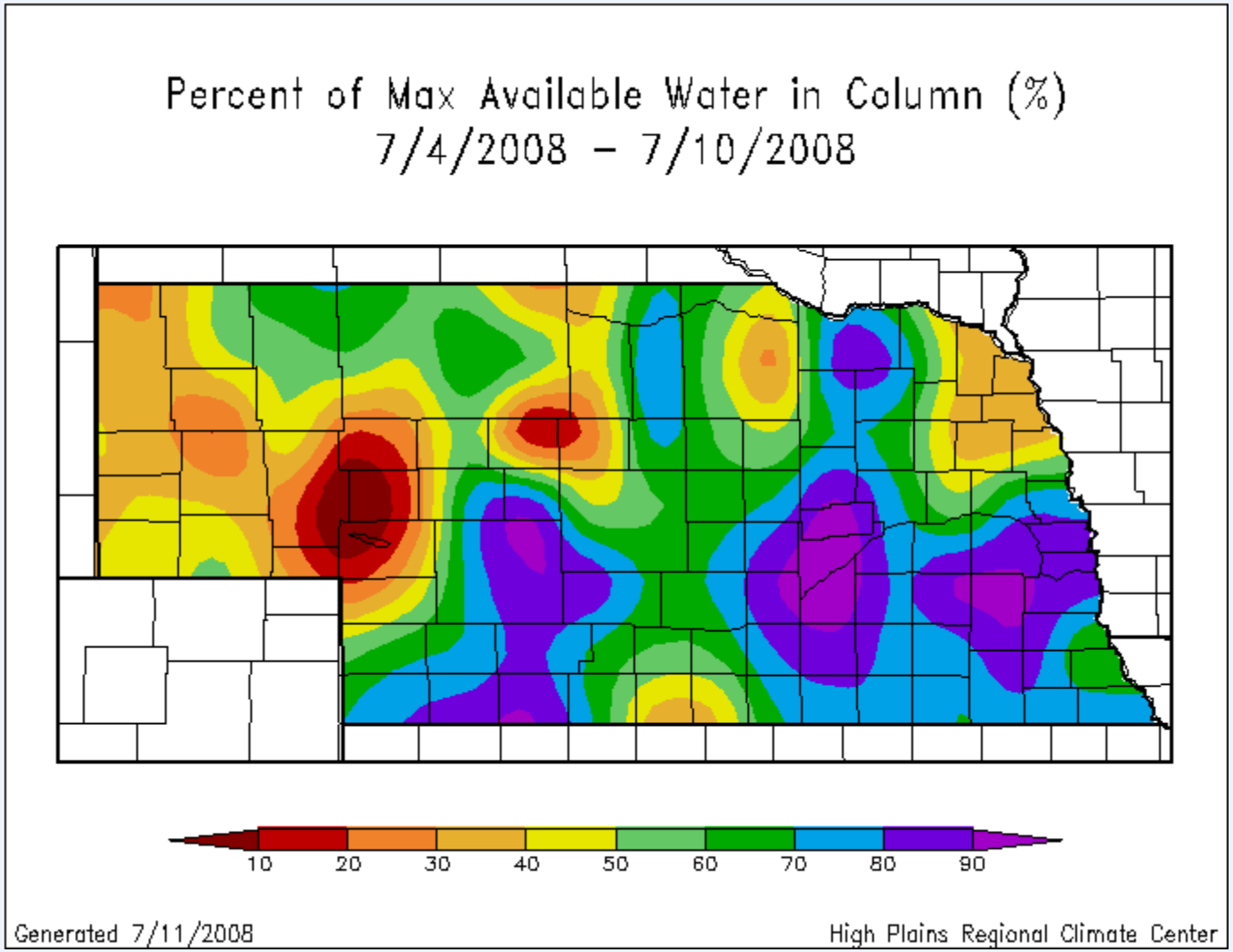
Volumetric Soil Moisture Retrievals



Validation through disaggregation



Validation through disaggregation



SEBASTIAN HENDRICKX-RODRIGUEZ

CONCLUSIONS

- THERMAL REMOTE SENSING DATA HAVE GREAT UTILITY:
  - *... ET mapping*
  - *... drought monitoring*
  - *... soil moisture mapping*

NEED TO MAINTAIN MULTI-SCALE THERMAL DATA SOURCES

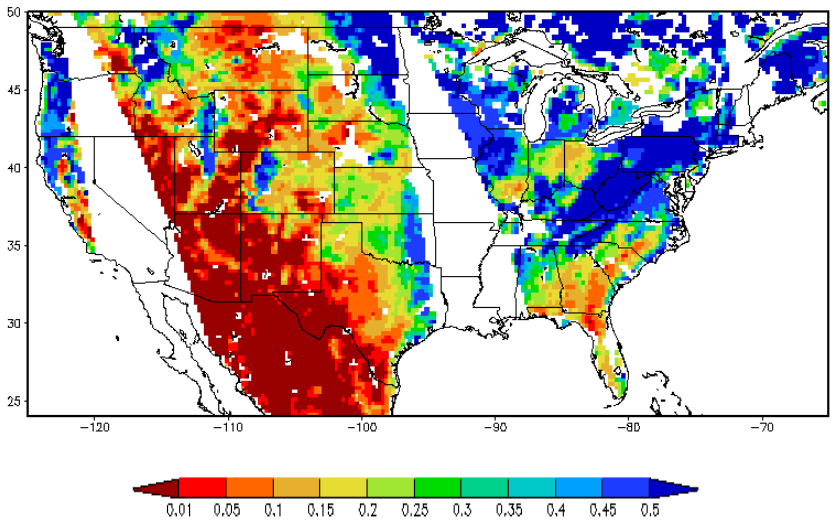
http://www.idwr.idaho.gov/gisdata/landsat-thermal-band.htm

Martha.Anderson@ars.usda.gov

Remote Sensing of Surface Moisture

USDA AMSR-E MICROWAVE SOIL MOISTURE

1 July 2004



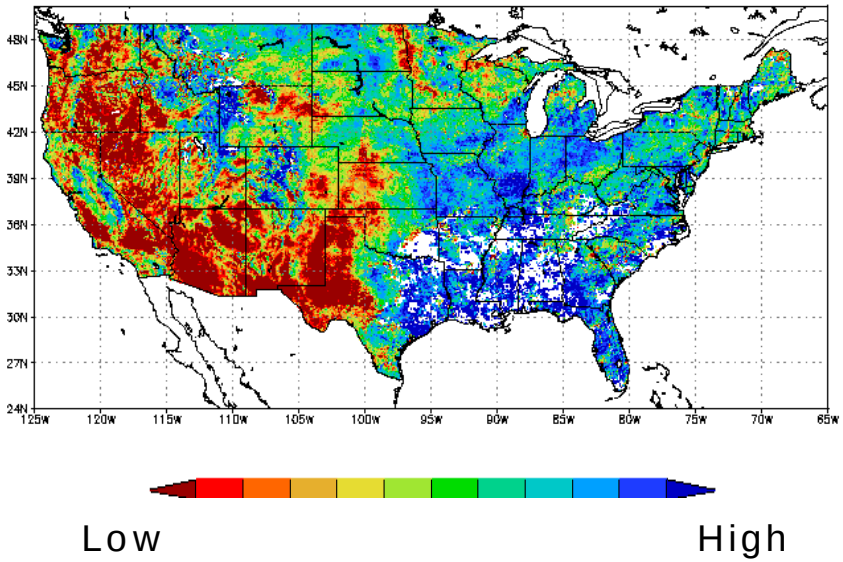
(cm^3/cm^3)

- **samples 5cm layer**
- **50km pixels (AMSR)**
- **~2-day coverage**
- **light vegetation cover**

AMSR: Advanced Microwave Scanning Radiometer

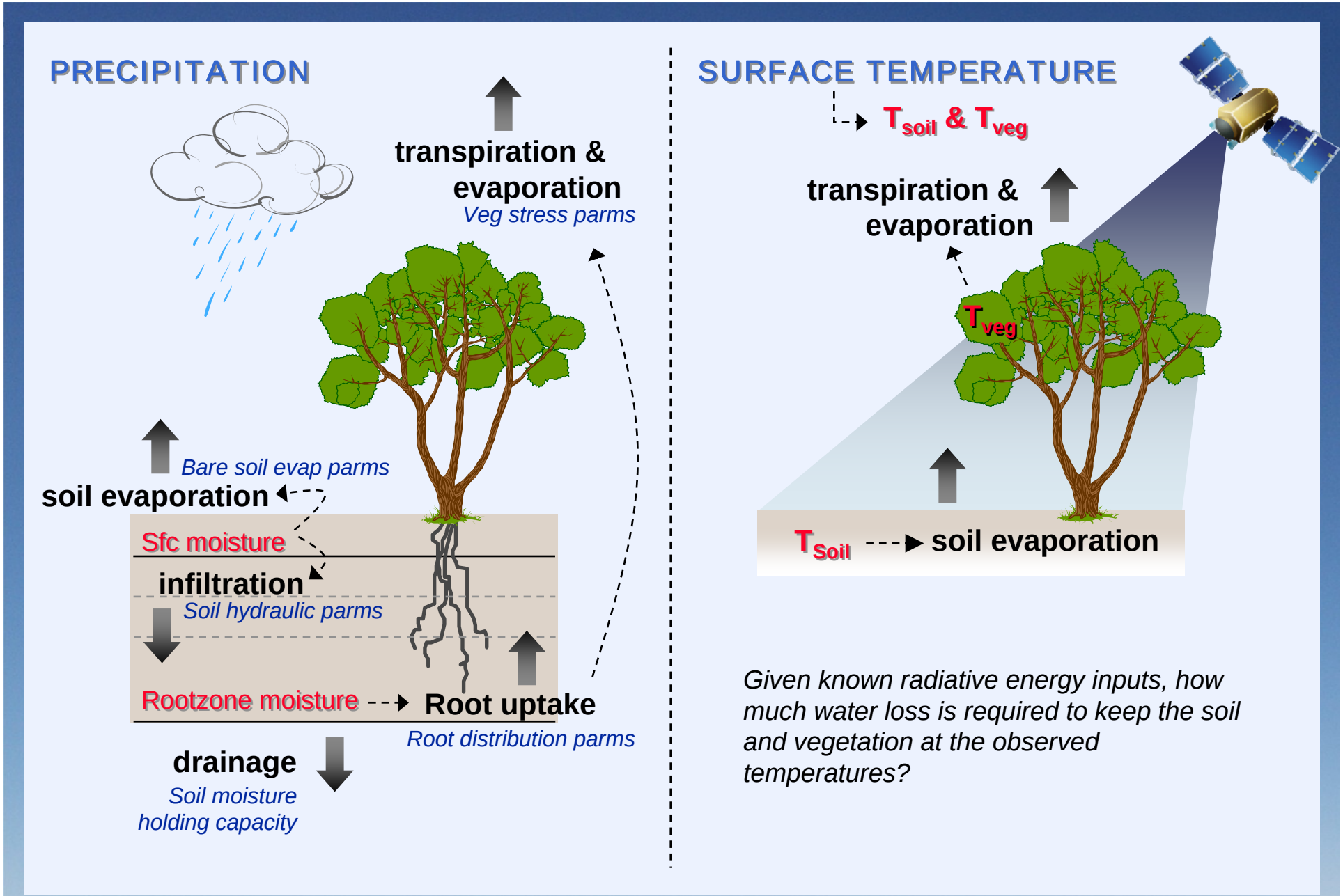
ALEXI GOES THERMAL SOIL MOISTURE

28-day composite ending 1 July 2004



- **samples ~1-2m layer**
- **60m - 5km pixels (L7, GOES)**
- **~15-day coverage (90%)**
- **low to high vegetation cover**

GOES: Geostationary Operational Environmental Satellite
L7: Landsat 7



WATER BALANCE APPROACH
("forward modeling")

REMOTE SENSING APPROACH
("inverse modeling")