



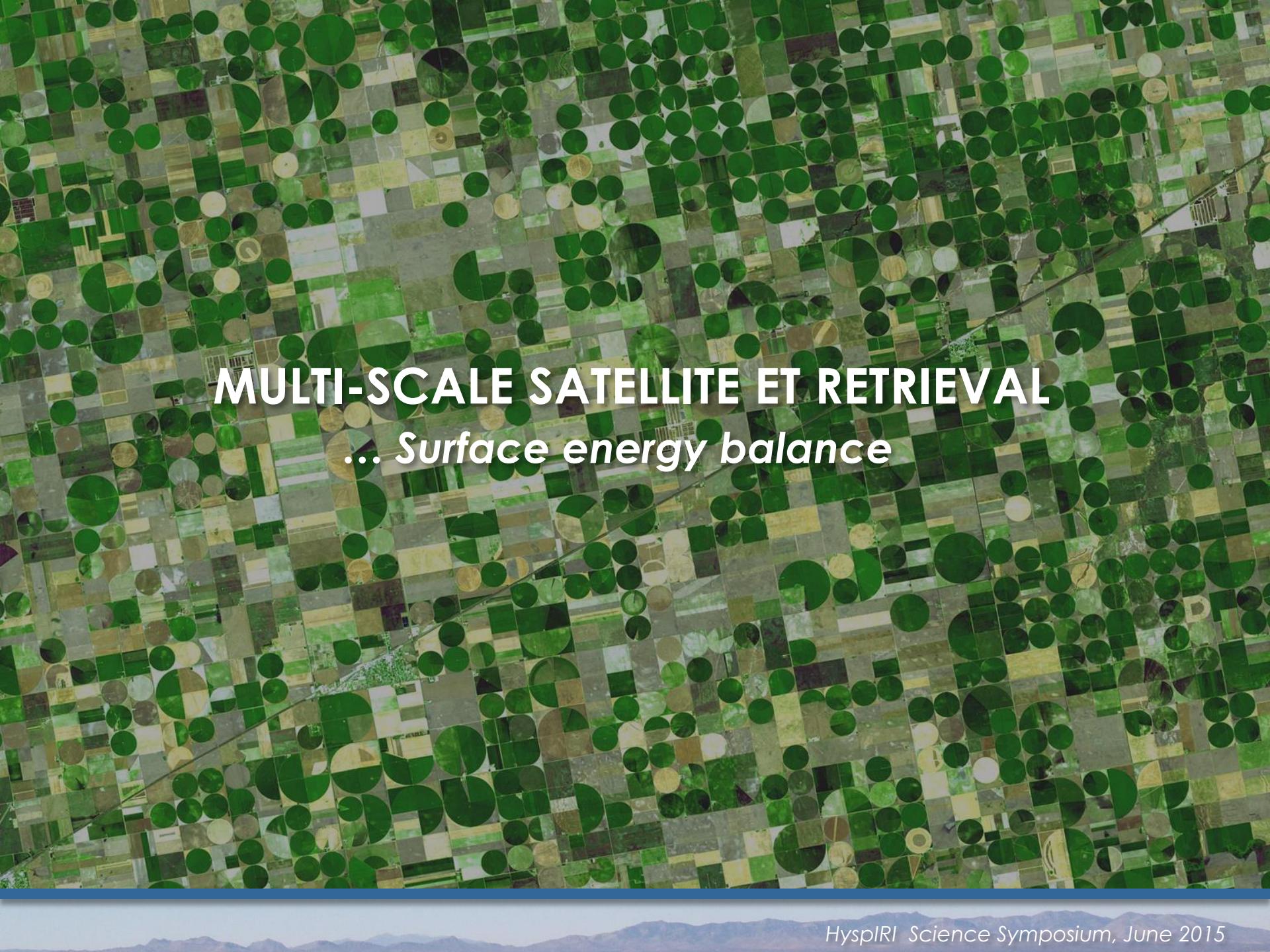
Daily Field-scale ET Estimation Using Data Fusion Techniques

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Hydrology and Remote Sensing Laboratory
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Chris Hain

NOAA-NESDIS

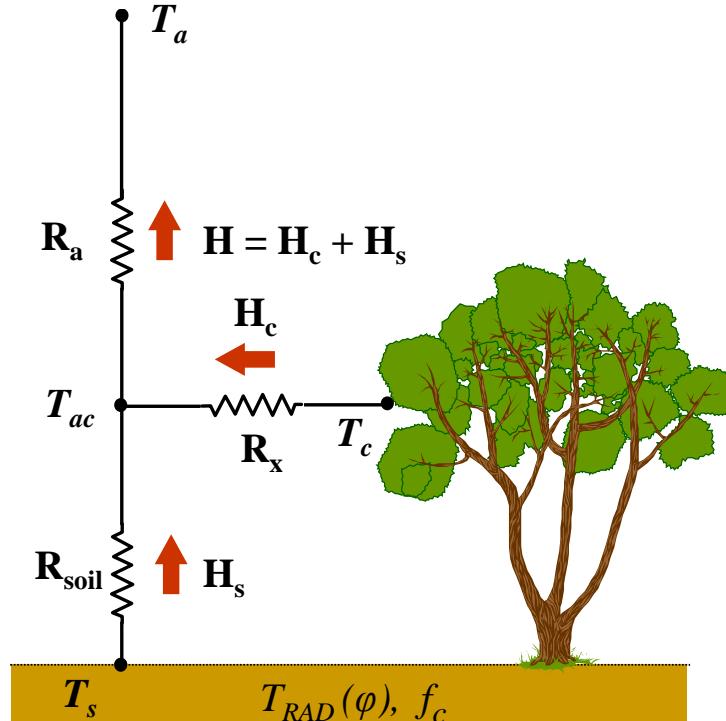


Aerial photograph showing a patchwork of agricultural fields with various crop types and irrigation systems, including large circular pivot irrigation circles.

MULTI-SCALE SATELLITE ET RETRIEVAL

... *Surface energy balance*

Two-Source Energy Balance (TSEB)



Norman and Kustas, et al. (1995)

System, soil, canopy budgets

$$RN = H + LE + G$$

$$RN_S = H_S + LE_S + G$$

$$RN_C = H_C + LE_C$$

Two-source approximation

$$T_{RAD}(\theta)^4 \sim f_C(\theta) T_C^4 + [1-f_C(\theta)] T_S^4$$

Temperature constraint

H_C, H_S, RN_C, RN_S, G

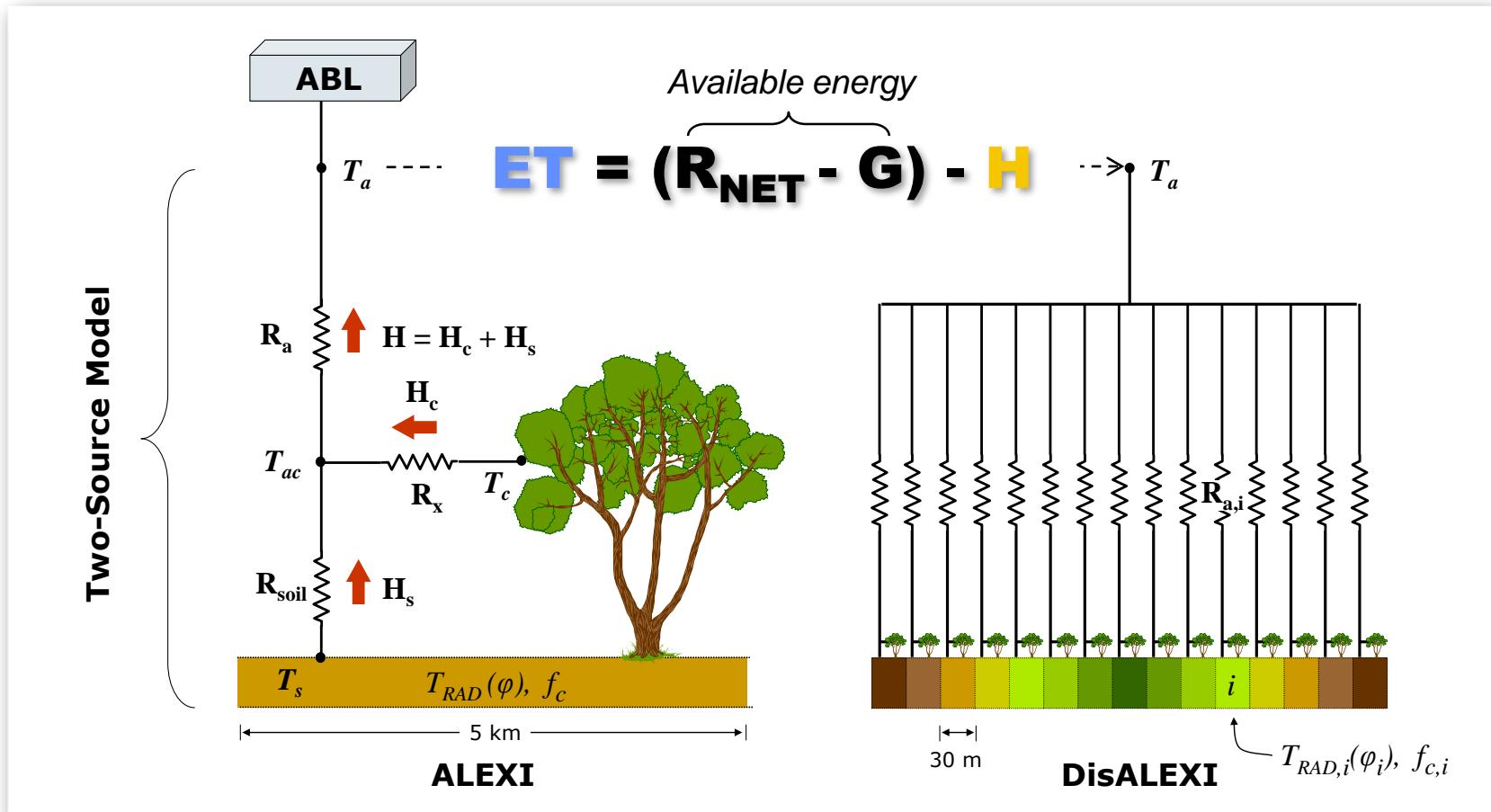
PT, PM or LUE R_c model

LE_c

Residual

$$LE_S = RN - H - G - LE_C$$

Iterative solution



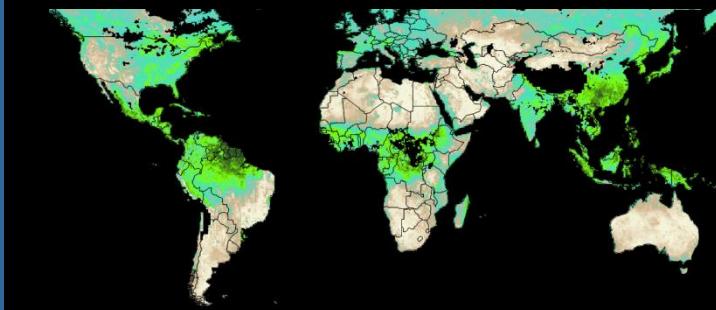
Regional scale

Surface temp: ΔT_{RAD} - Geostationary
 Air temp: T_a - ABL model

Landscape scale

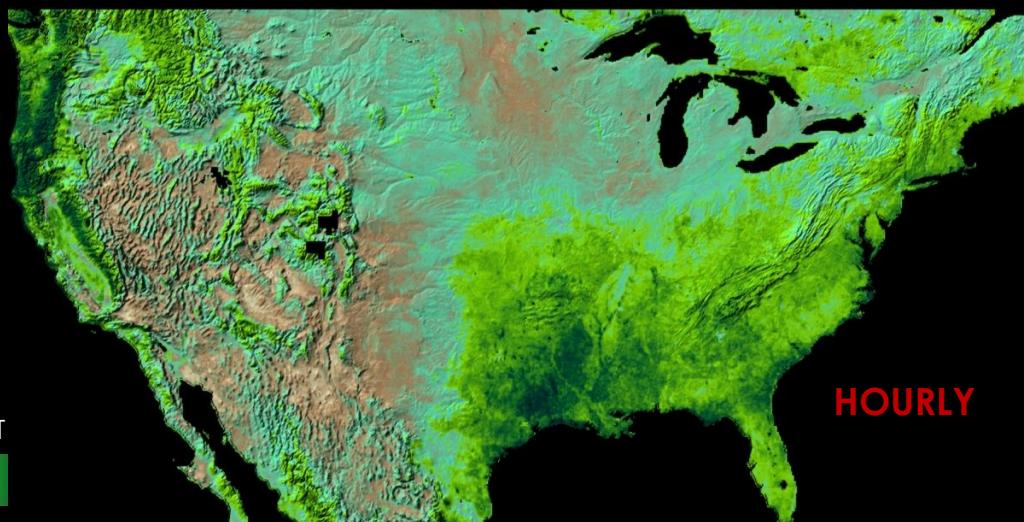
T_{RAD} - Landsat, MODIS
 T_a - ALEXI

Multi-sensor evapotranspiration



International geostationary constellation

NOAA Geostationary Operational Environmental Satellites



GOES - West



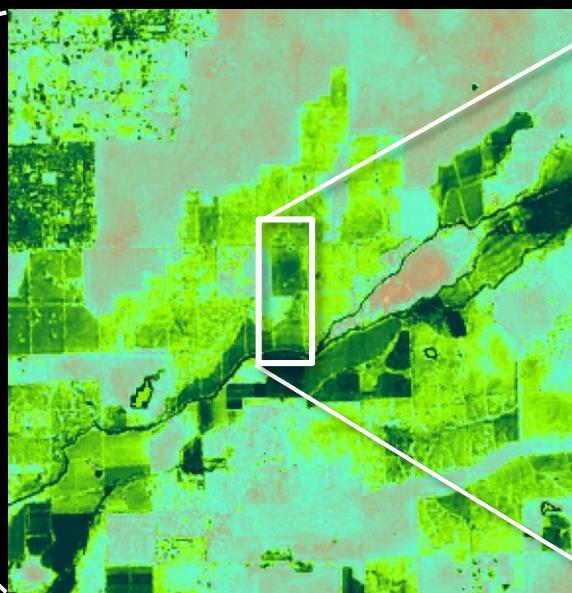
Low ET

High ET

GOES/MODIS/Landsat fusion

Landsat

Aircraft



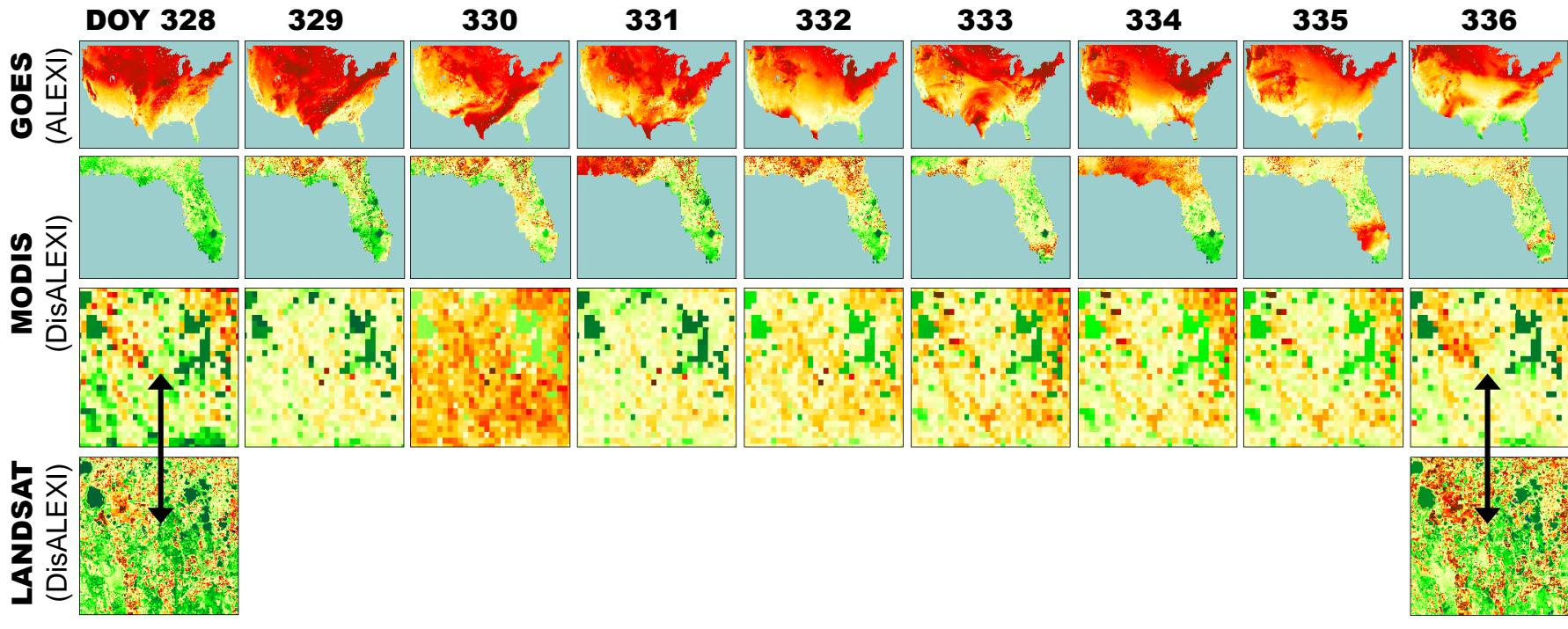
"DAILY"

MONTHLY

June 12, 2013

GOES/MODIS/Landsat FUSION

Daily Evapotranspiration – Orlando, FL, 2002



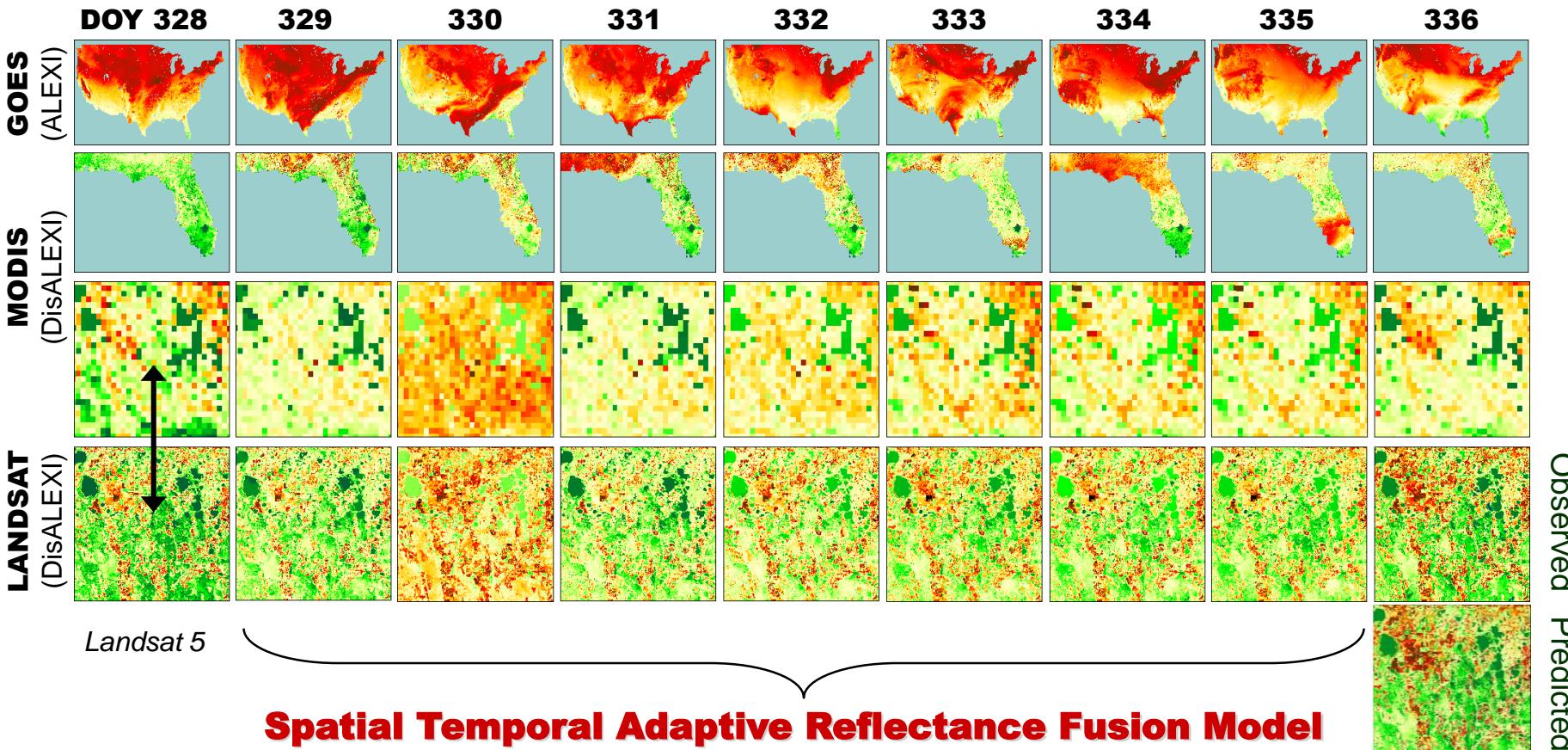
Landsat 5

Landsat 7

**Spatial Temporal Adaptive Reflectance Fusion Model
(STARFM)** *(Gao et al, 2006)*

GOES/MODIS/Landsat FUSION

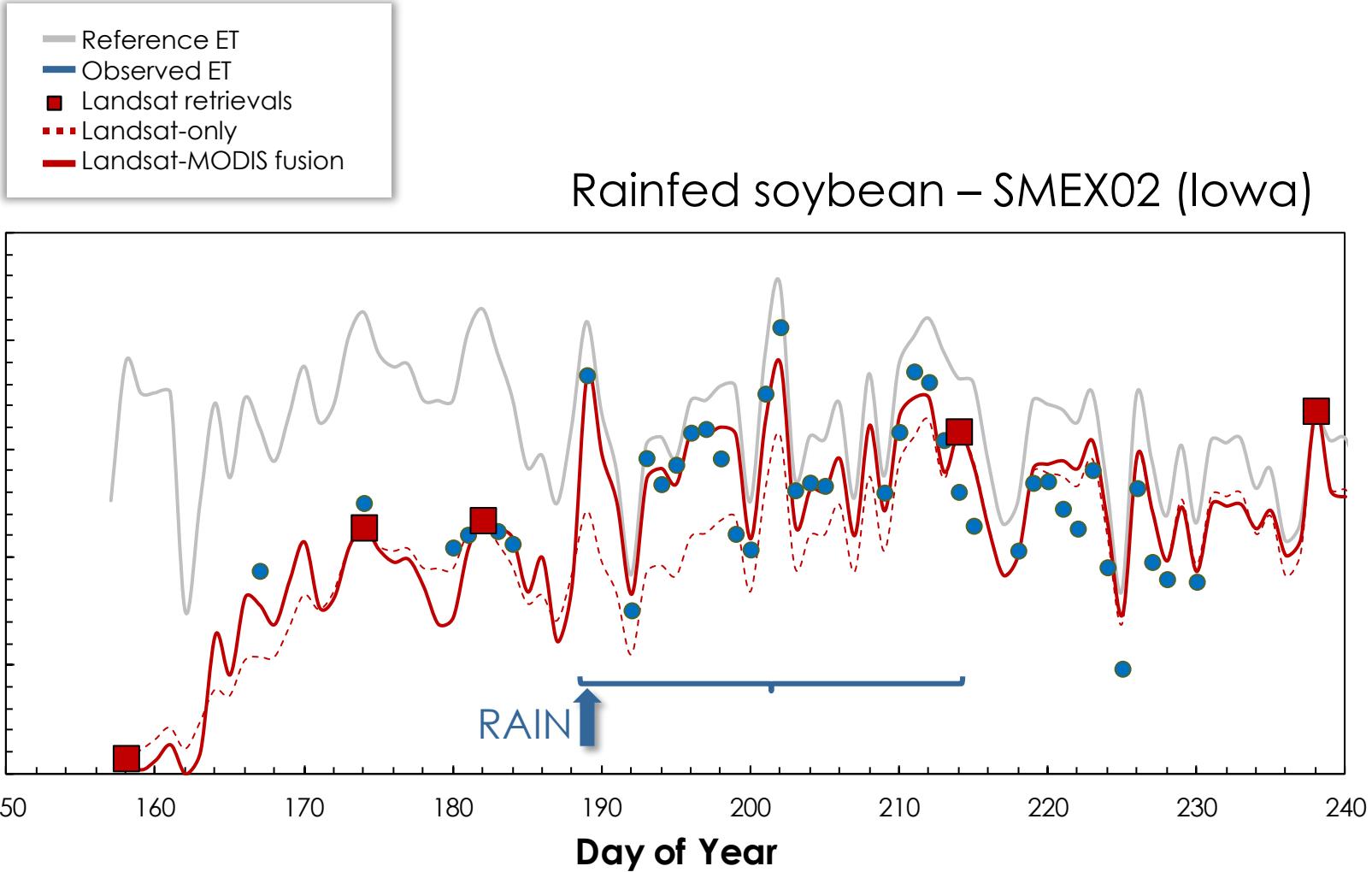
Daily Evapotranspiration – Orlando, FL, 2002



**Spatial Temporal Adaptive Reflectance Fusion Model
(STARFM)** *(Gao et al, 2006)*

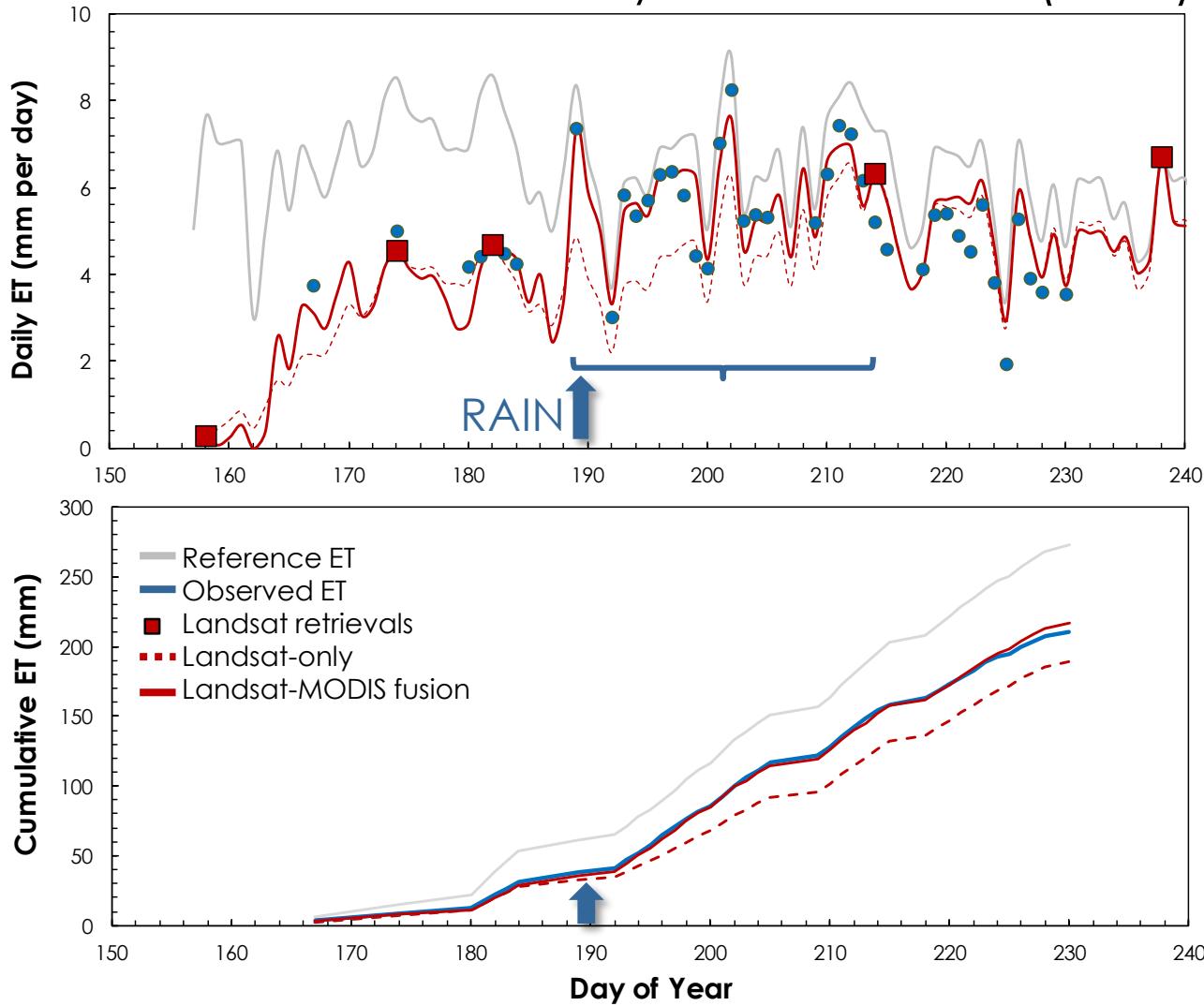
$R^2: 0.83$
(9% error)

Validation using flux tower data



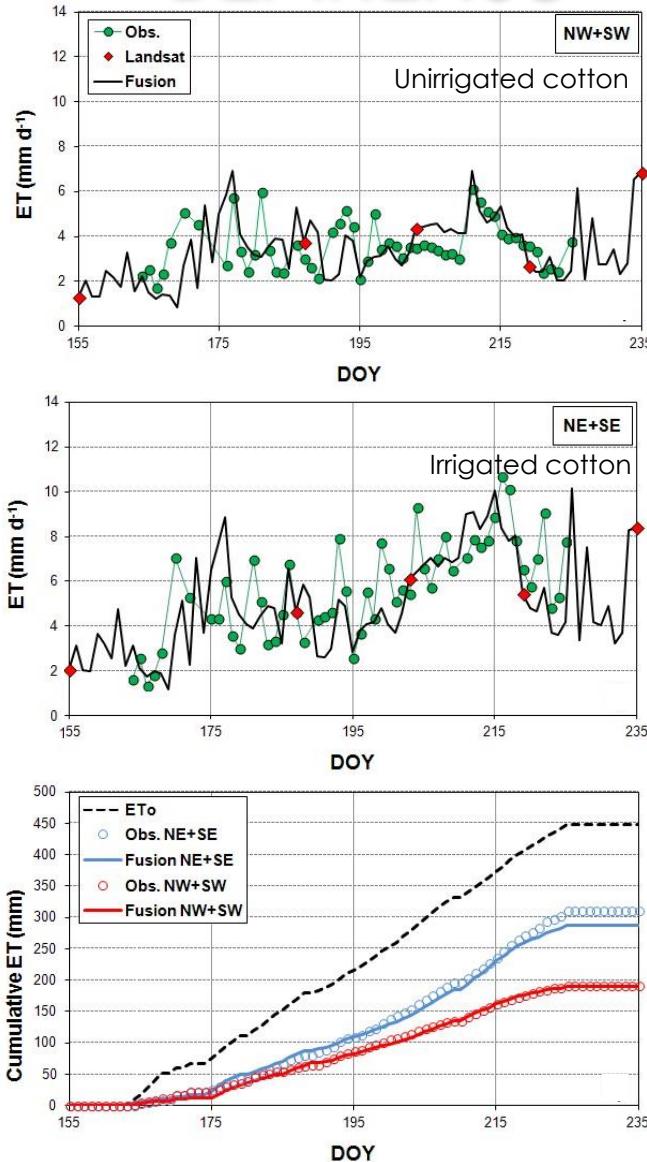
Validation using flux tower data

Rainfed soybean – SMEX02 (Iowa)

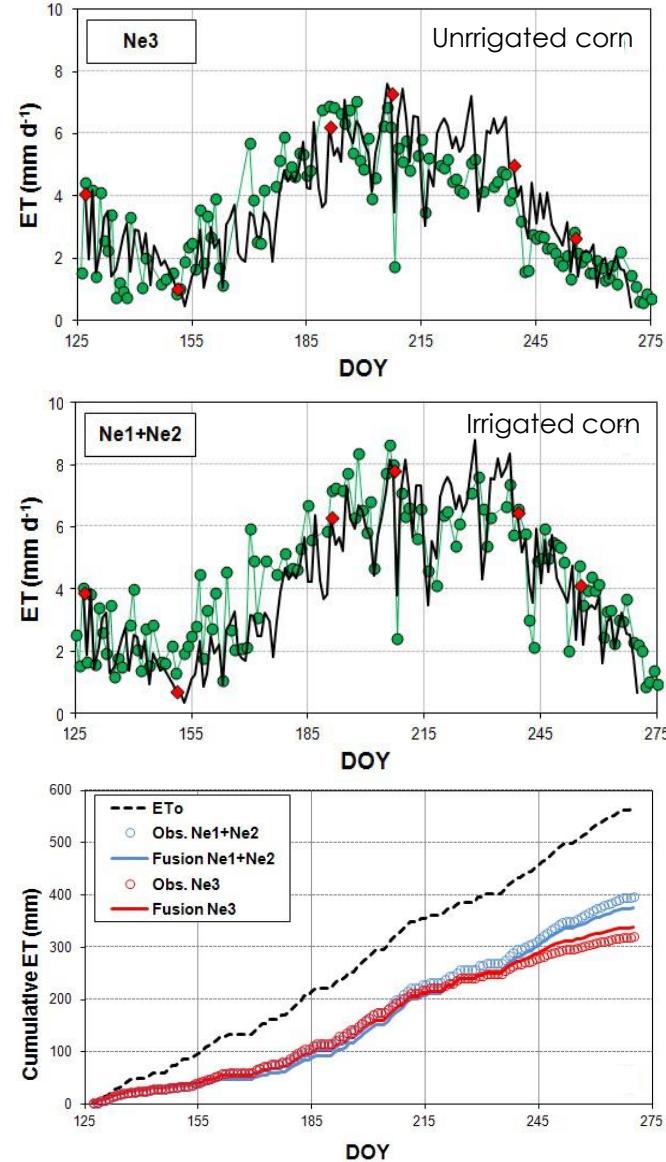


BEAREX08 and MEAD

BEAREX08



MEAD



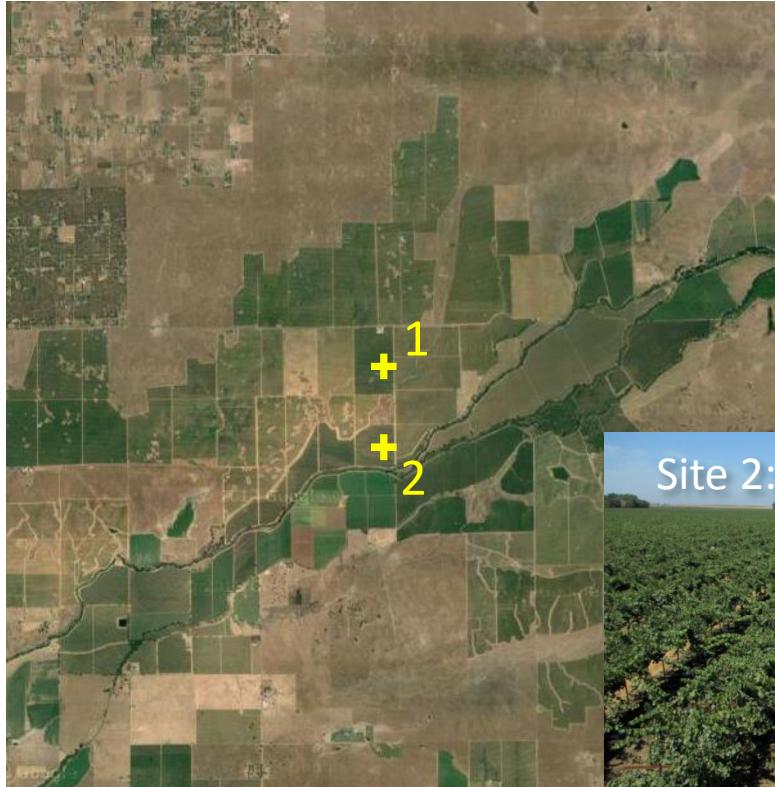


The background of the slide is a high-resolution aerial photograph showing a patchwork of agricultural land. The fields are organized into numerous circular plots, likely due to center pivot irrigation systems. The colors range from deep green to brown and tan, indicating different crops or soil types. A thin diagonal line cuts across the fields from the bottom left towards the top right.

ONGOING FUSION EXPERIMENTS

*... Water use in vineyards and
pine plantations*

Gallo Vineyards, Lodi CA



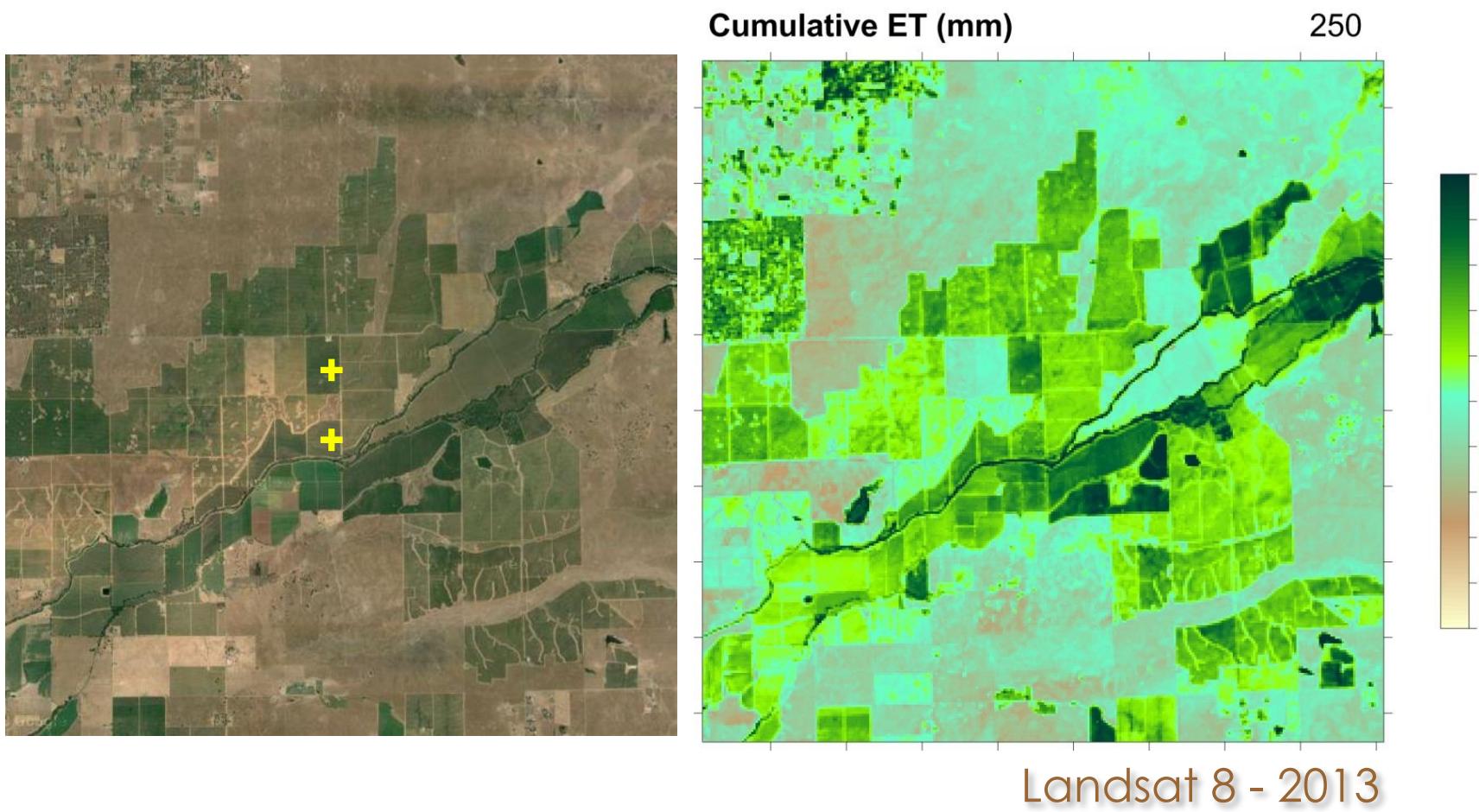
GRAPEX2013, 14, 15



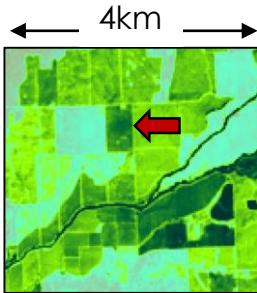
Site 2: 5-year Pinot



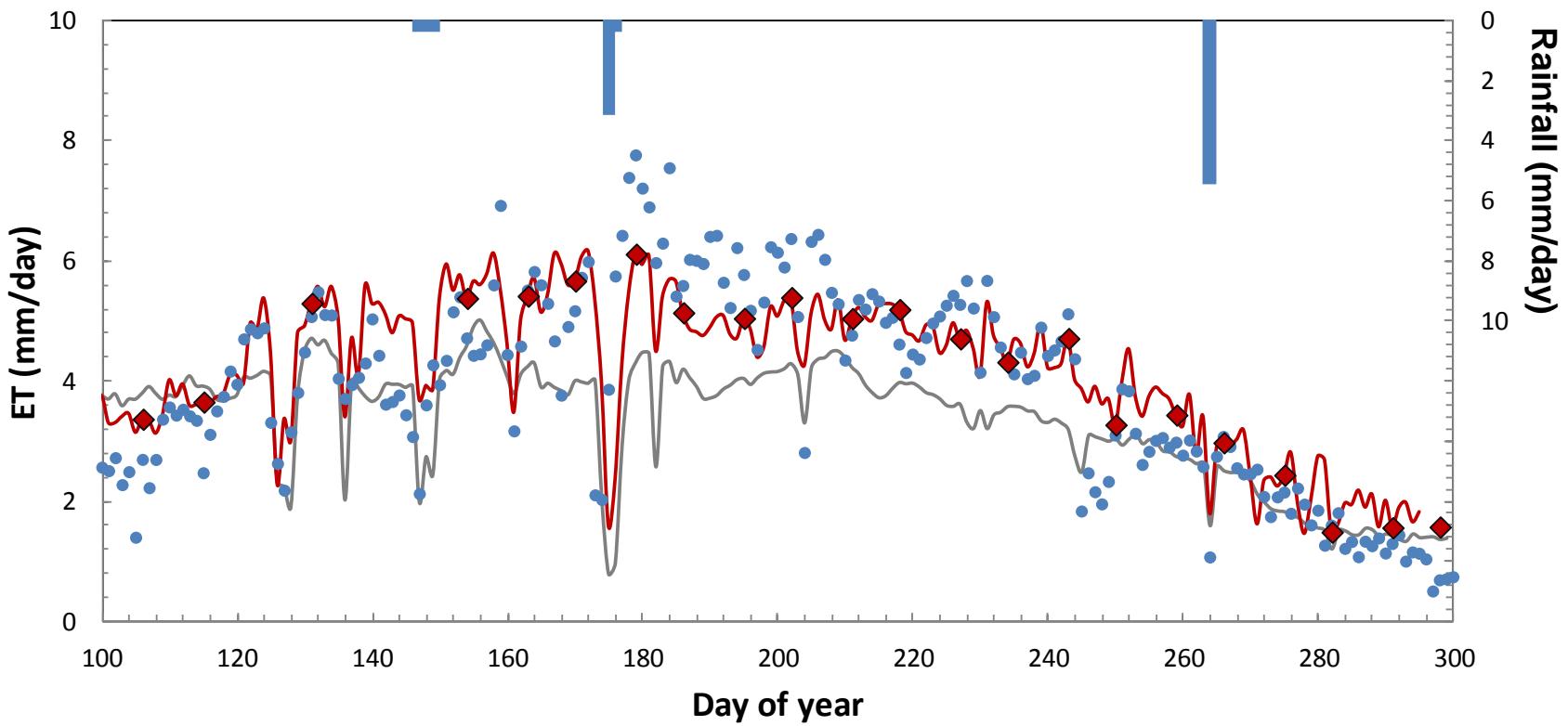
Gallo Vineyards, Lodi CA

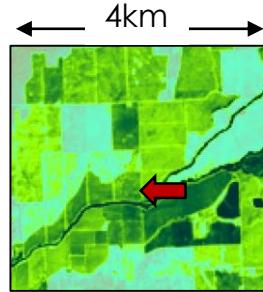


- ALEXI ET (4km)
- Observed ET
- Landsat retrieval
- Landsat-MODIS fusion
- Precipitation

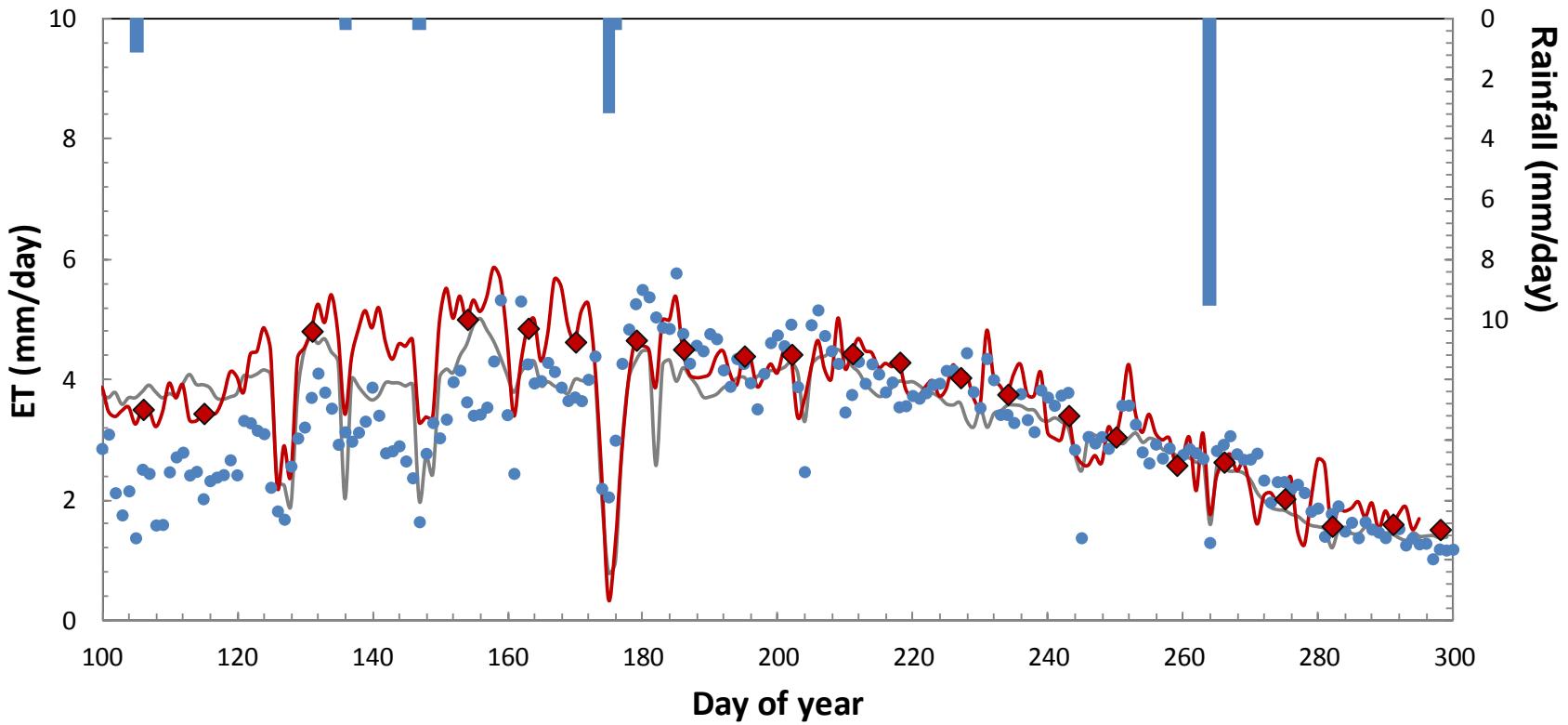


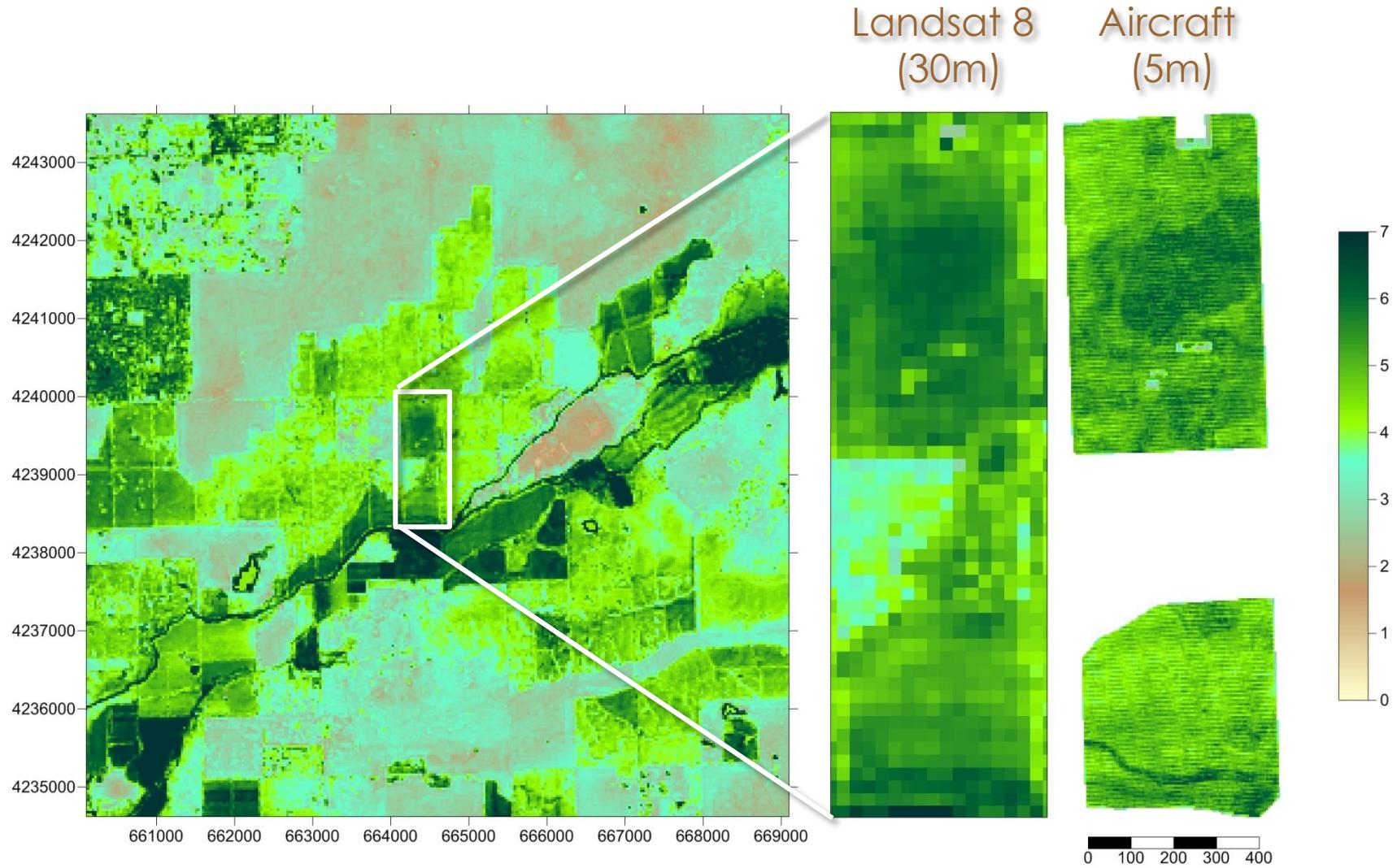
SITE 1:
Pinot Noir – 8 YR (2013)





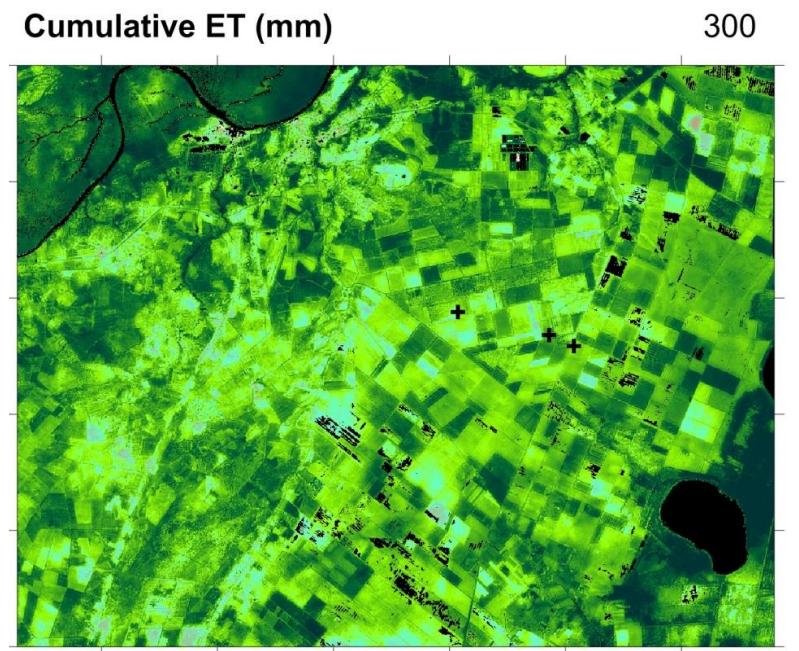
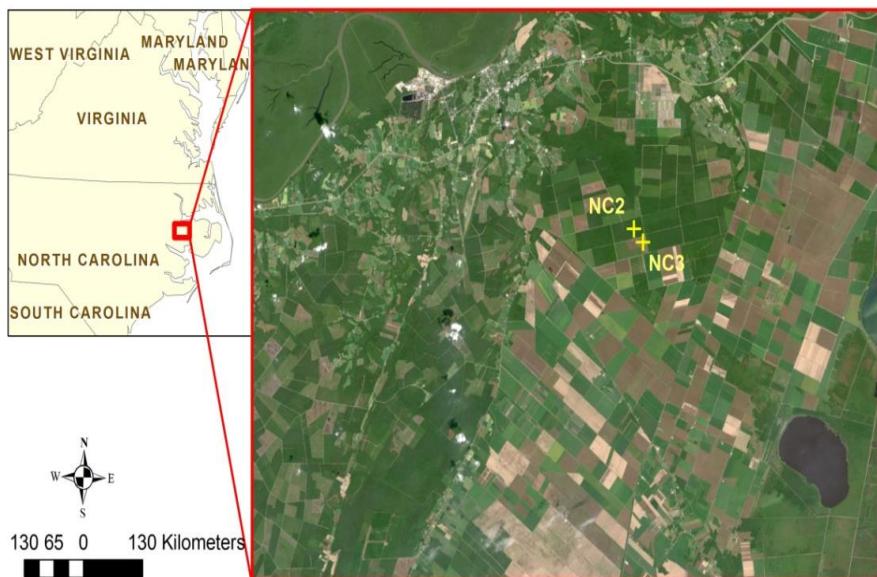
SITE 2:
Pinot Noir – 5 YR (2013)



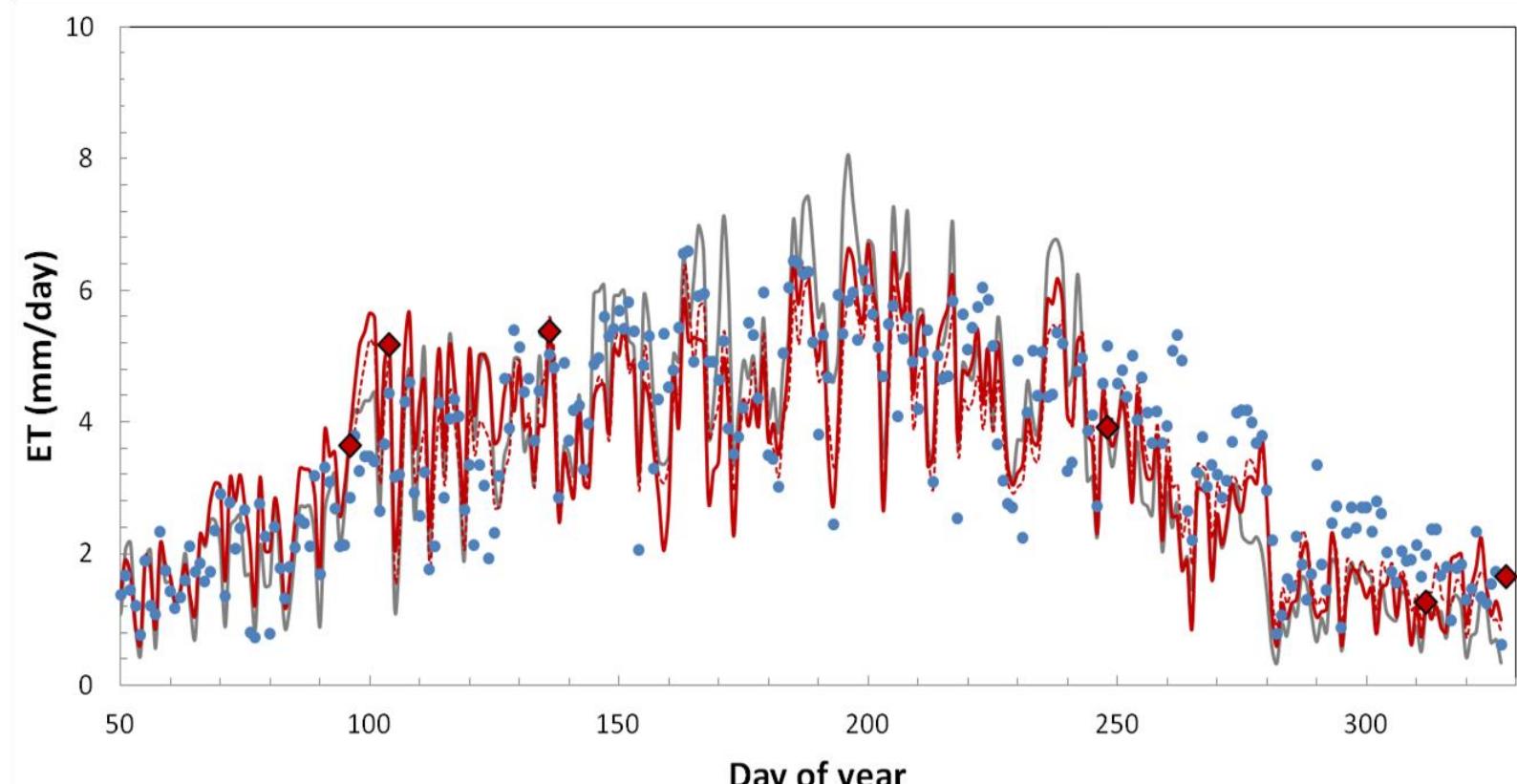


Effect of forest management

Loblolly Pine Plantation, NC



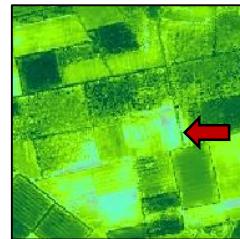
Effect of forest management



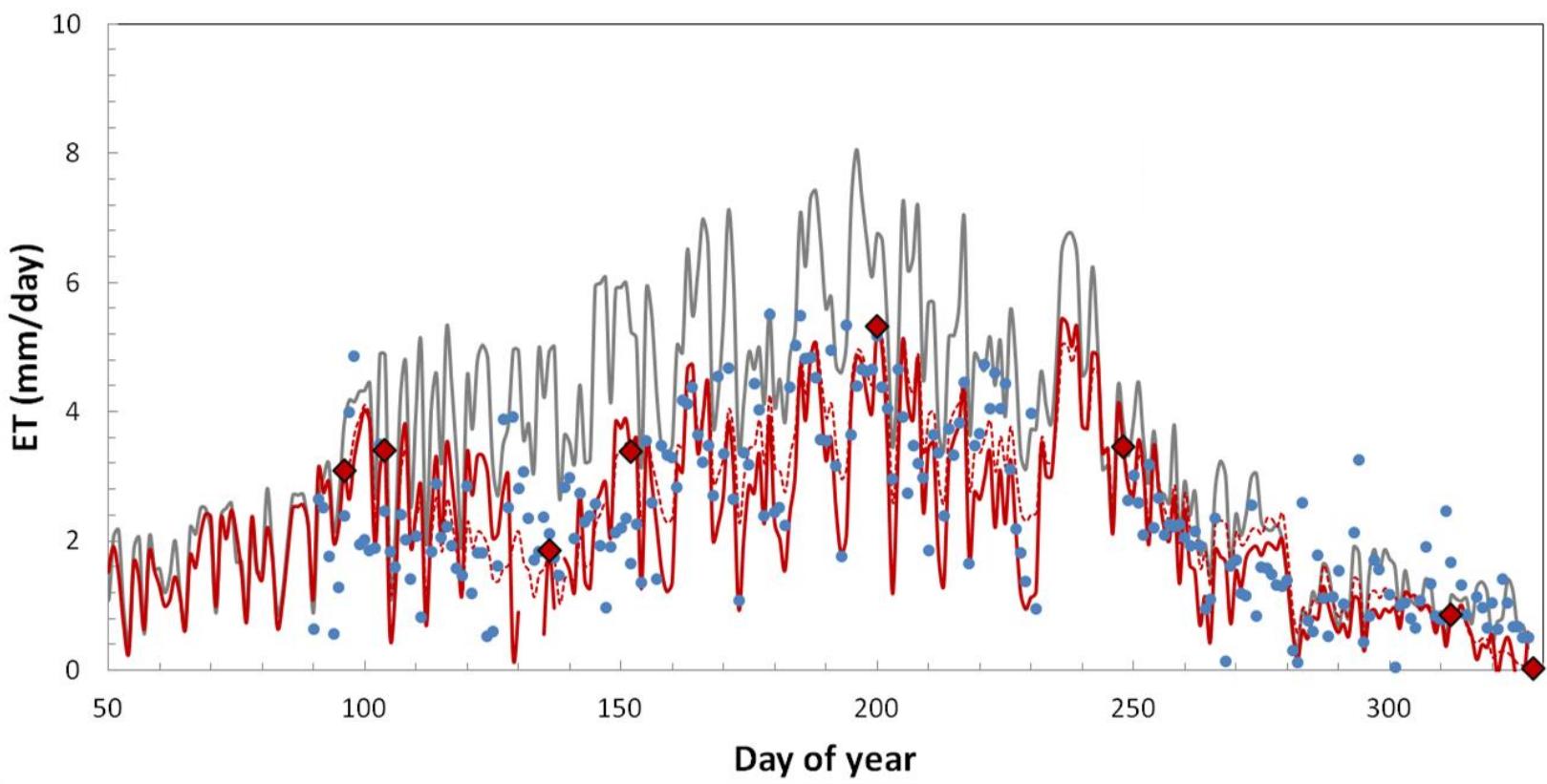
(Yang et al., 2015)

Effect of forest management

- ALEXI ET (4km)
- Observed ET
- Landsat retrieval
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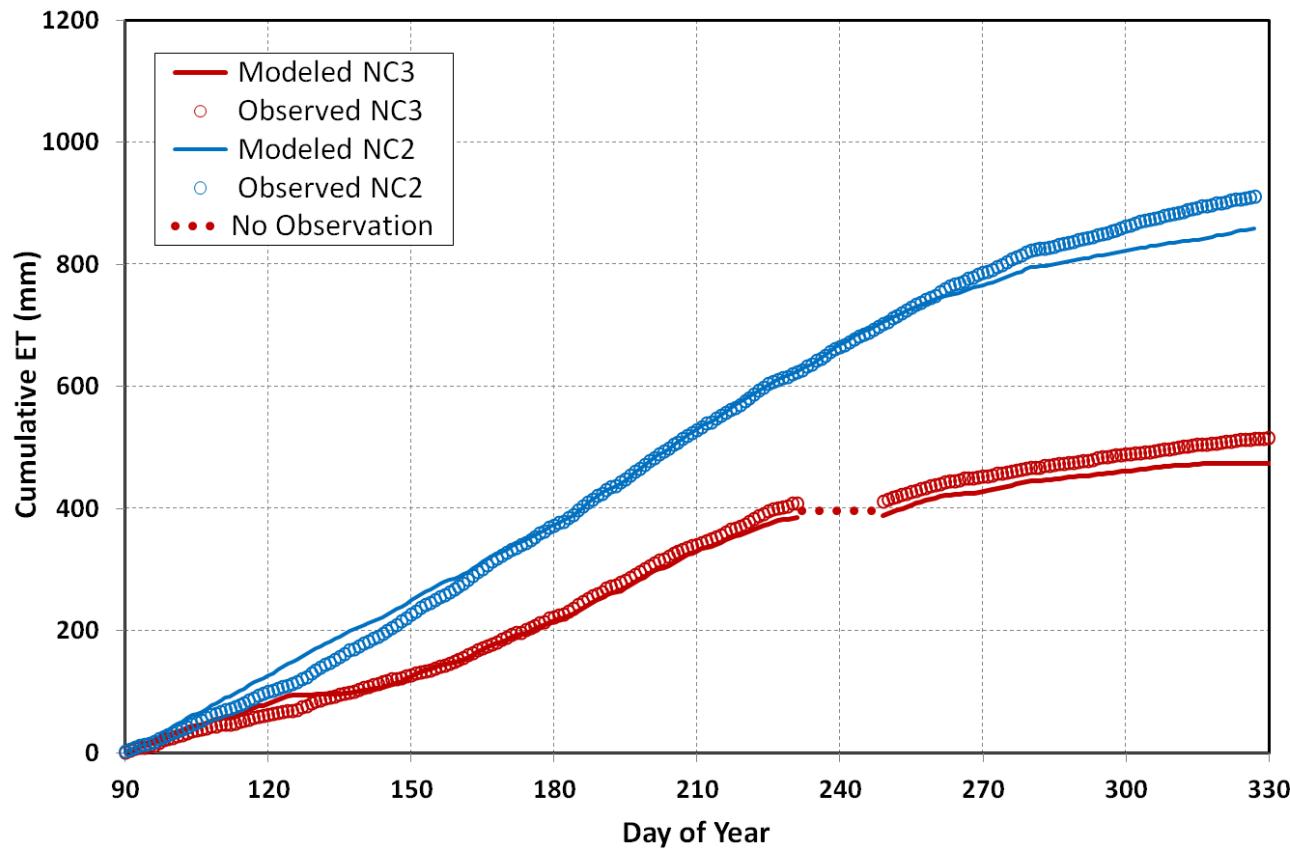
NC3:
Clearcut Pine (2013)



(Yang et al., 2015)

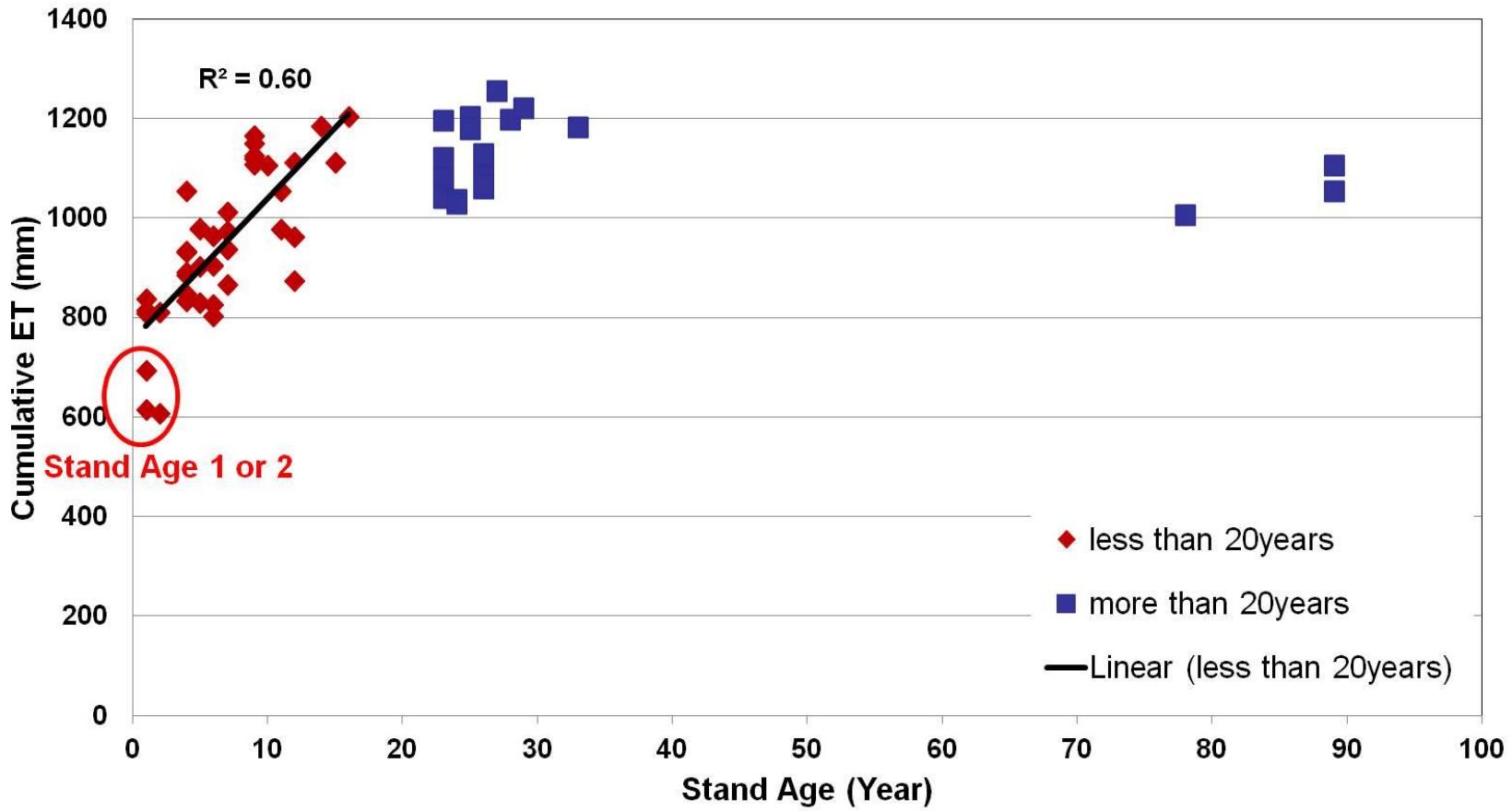
Effect of forest management

Loblolly Pine Plantation



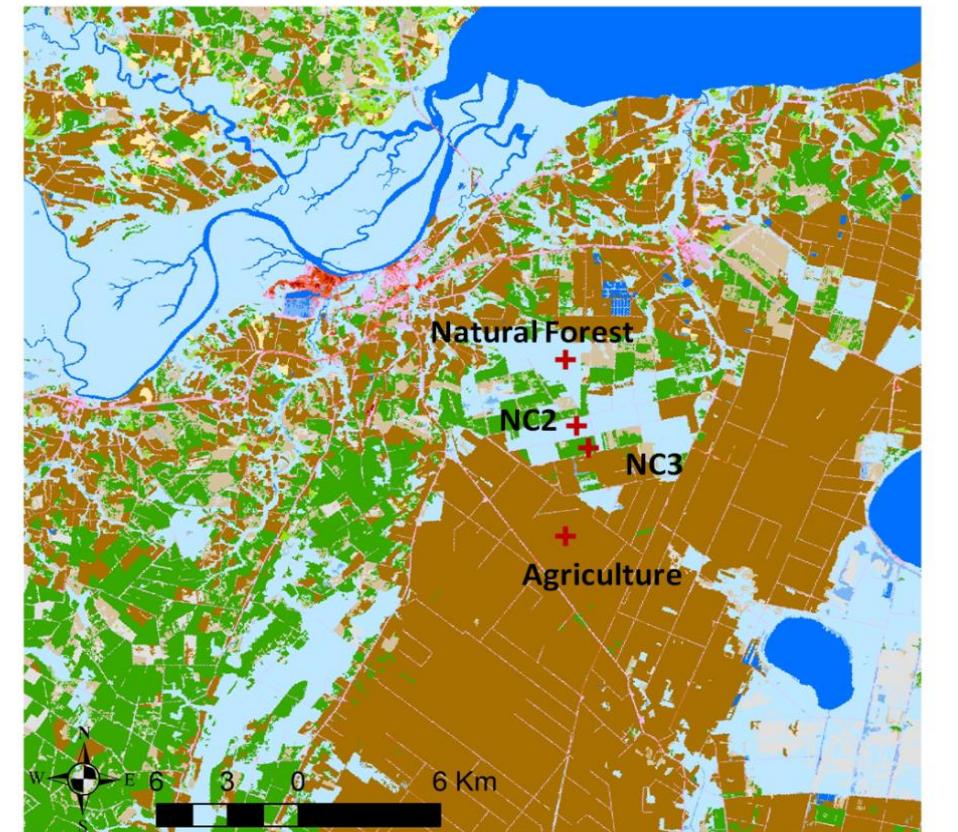
Effect of Stand Age

Pine Plantation Stand Age



Effect of Landcover types

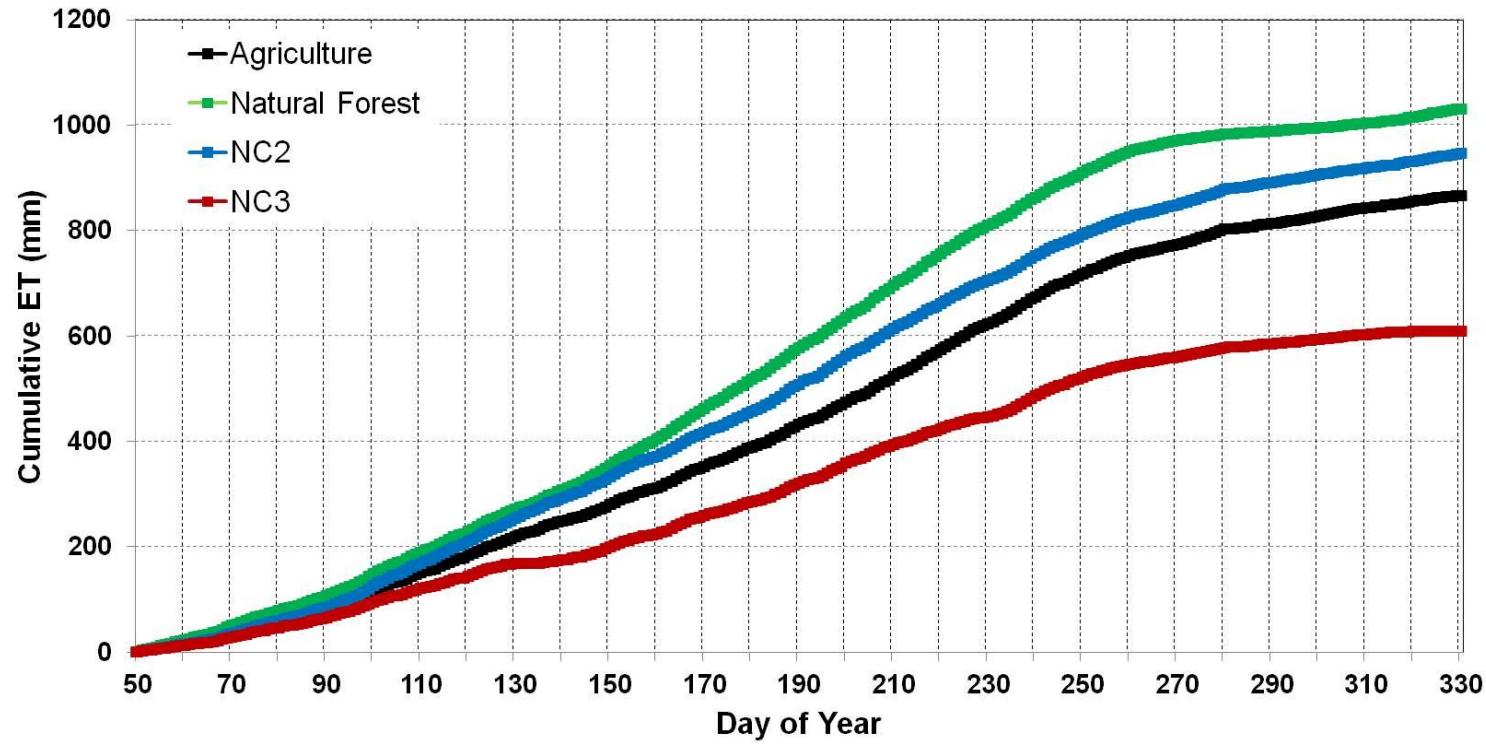
NLCD Landcover



Landcover		
Emergent Herbaceous Wetlands	Grassland/Herbaceous	Developed, High Intensity
Woody Wetlands	Shrub	Developed, Medium Intensity
Cultivated Crops	Mixed Forest	Developed, Low Intensity
Pasture/Hay	Evergreen Forest	Developed, Open Space
	Deciduous Forest	Open Water
	Barren Land	

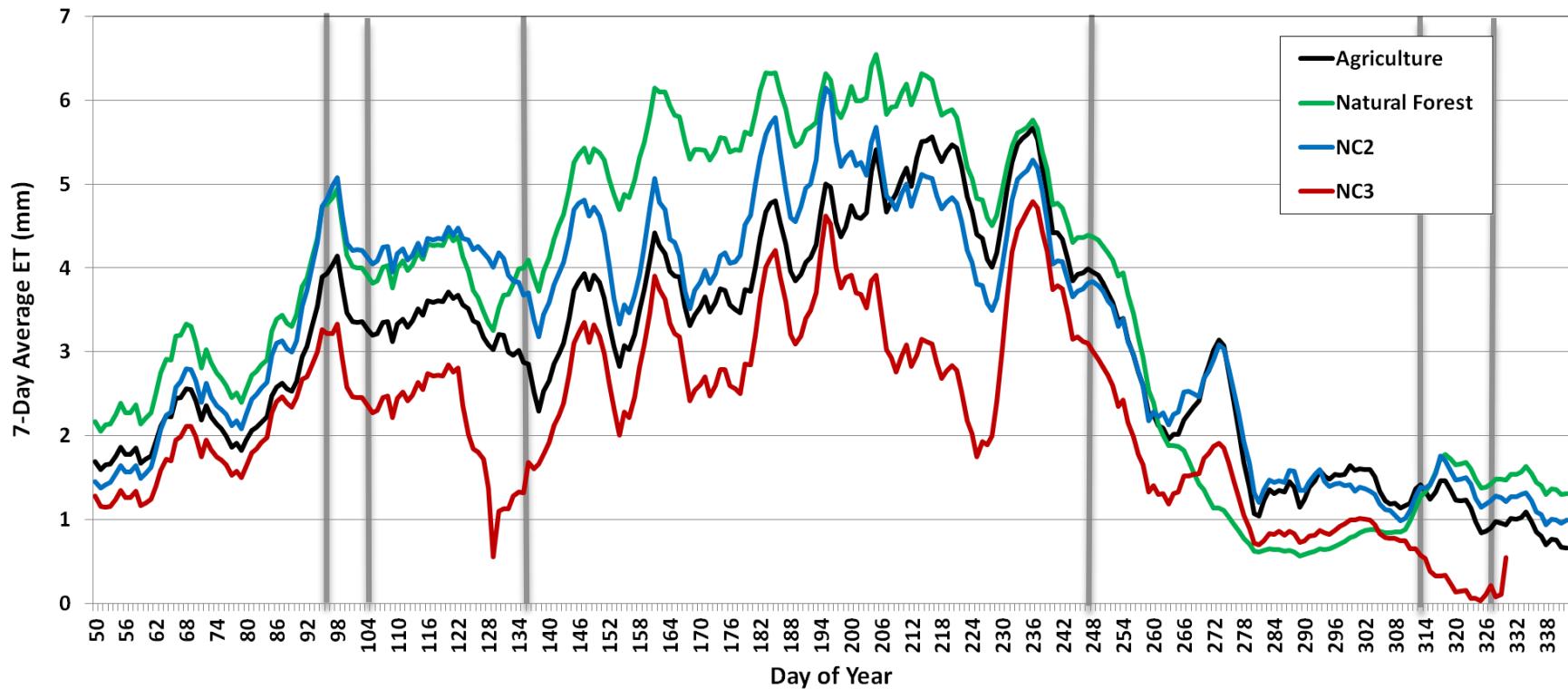
Effect of Landcover types

NLCD Landcover



Effect of Landcover types

NLCD Landcover



Satellite Evapotranspiration

- Using a multisensor and multiresolution technique to produce consistent daily ET maps over a wide range of scales and spatial resolution.
- Monitoring water use at field to continental scales which is of benefit for water management applications
- Applications in global water and food security

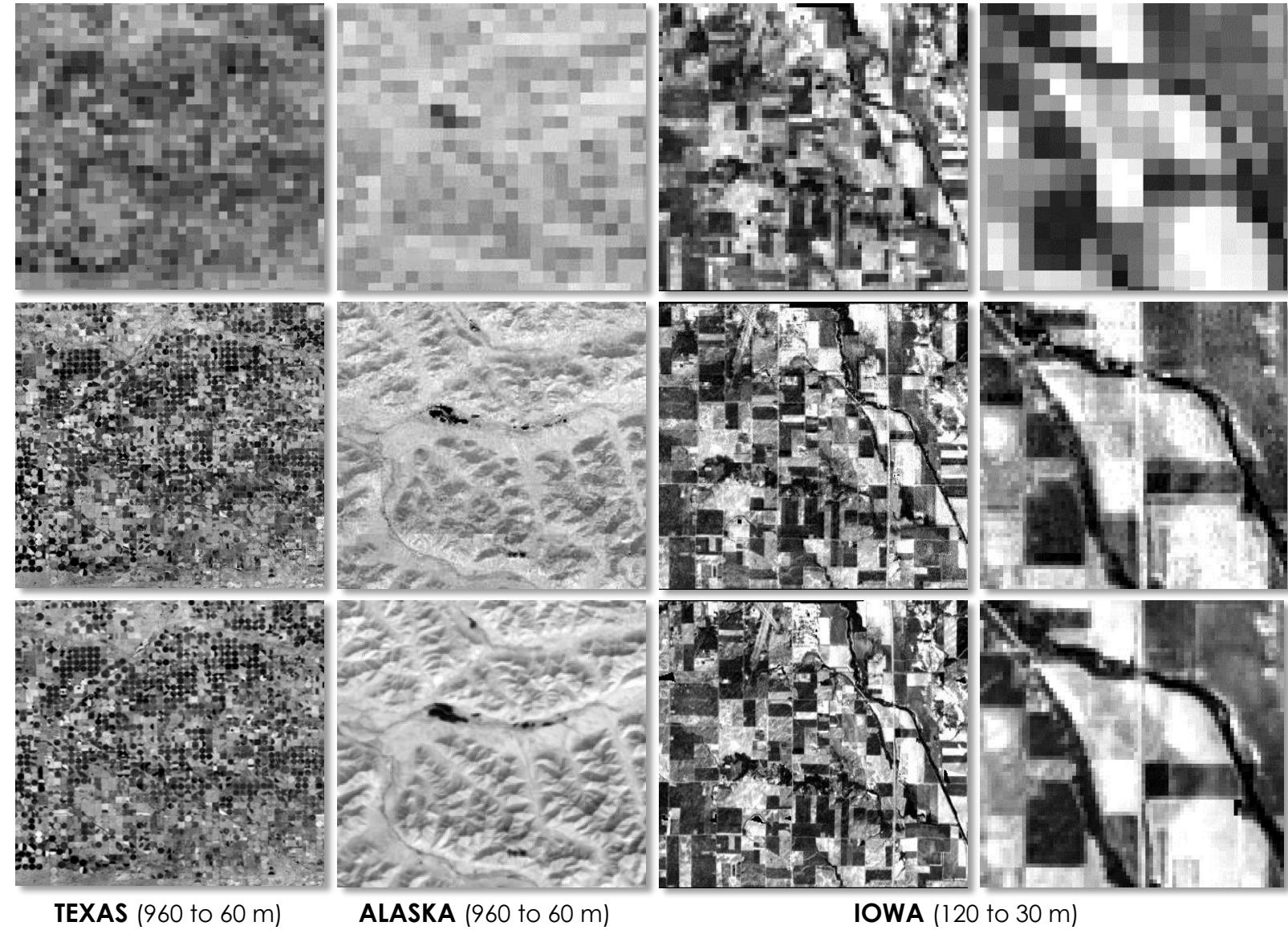
hrsl.arsusda.gov/drought



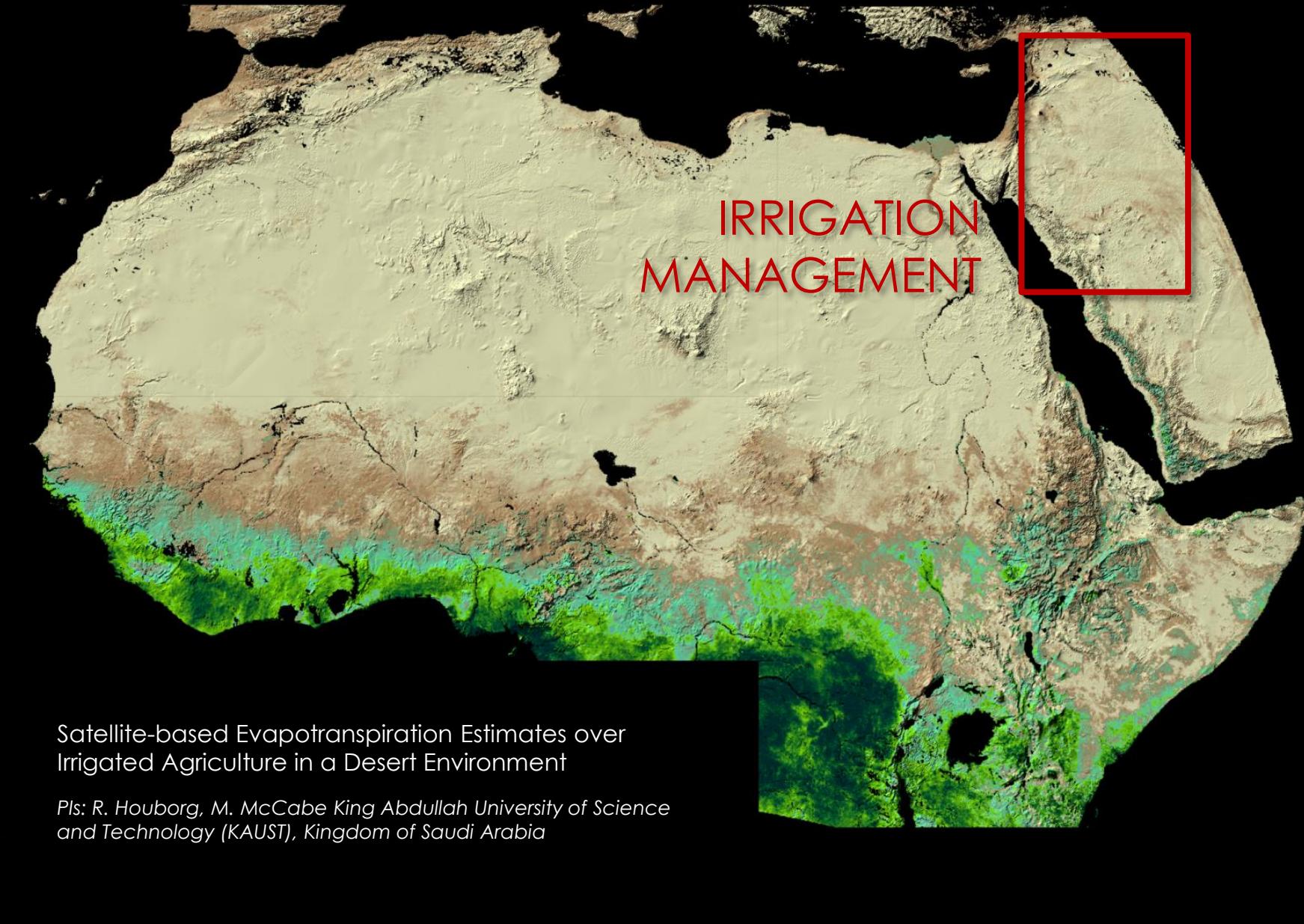
USDA is an equal opportunity provider and employer.

DMS: Thermal image sharpening

Data Mining Sharpener

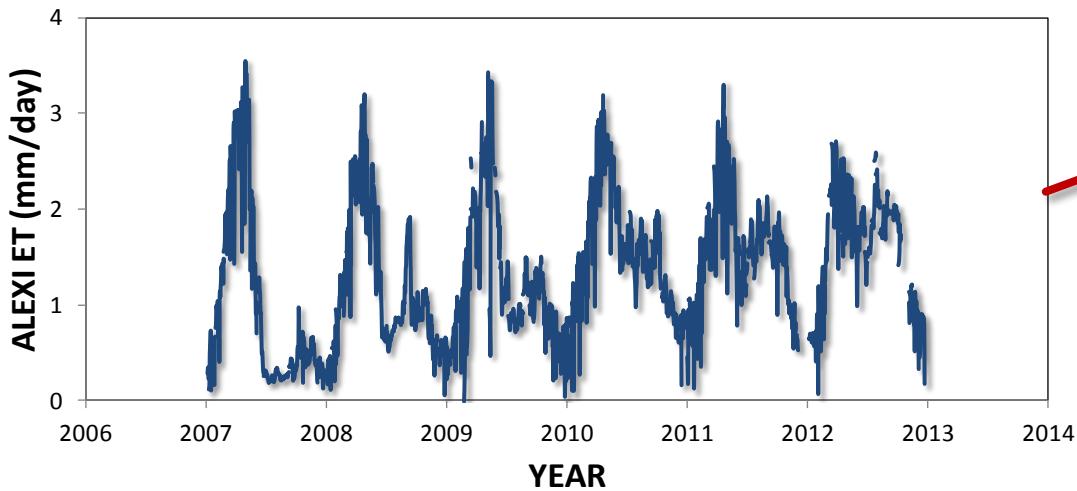


Water use by irrigation

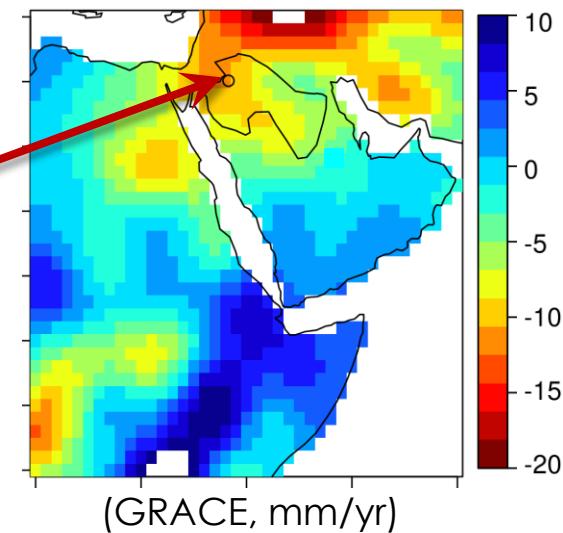


Water use by irrigation

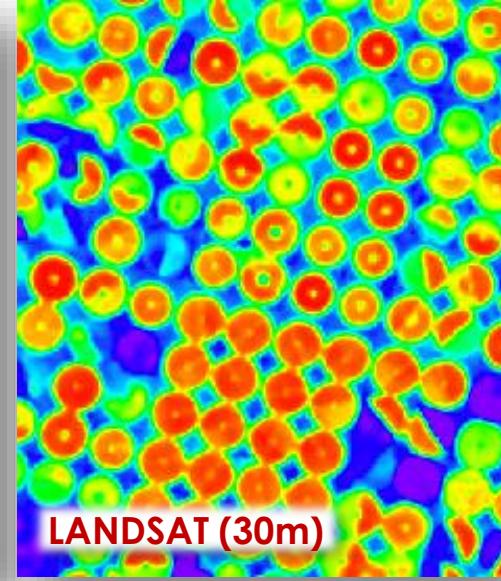
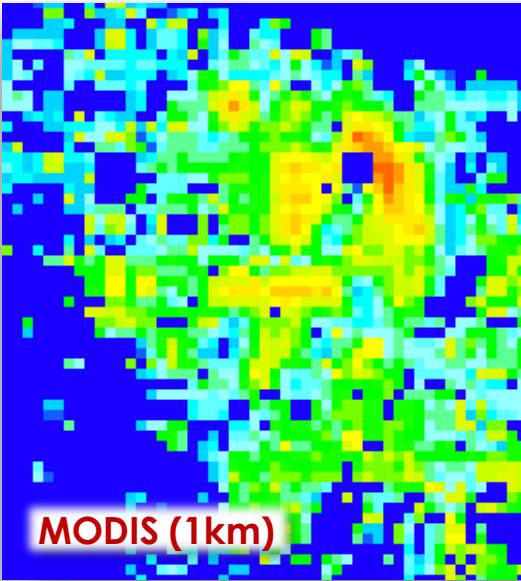
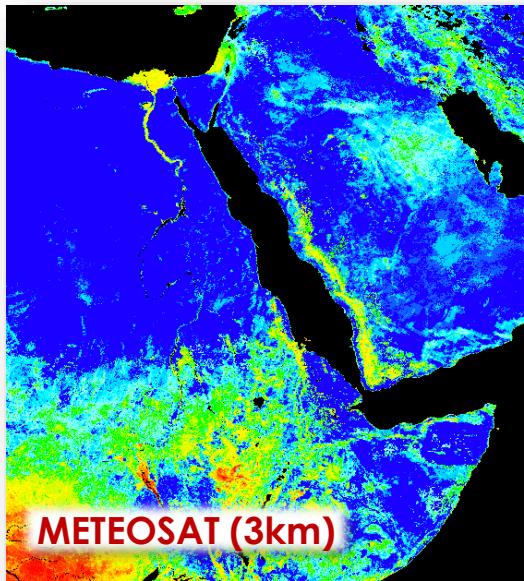
ALEXI ET – AL JOWF IRRIGATION SITE



GROUNDWATER DEPLETION TRENDS



MULTI-SCALE ET MAPPING (mm/day)



Houborg et al., 4th International Symposium of RAQRS, Valencia, Spain, Sept. 2014