MODIS Science Team Meeting, May 18-22, 2015, Silver Spring, MD

Fusing MODIS, Landsat and Geostationary Data for Daily Monitoring of Crop Condition and Water Use at Field Scales

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Background

- Droughts cause reductions in crop yields and impact livestock production
- The impacts from drought can vary widely depending on many factors (e.g., crop type, soil, water management, and crop growth stage)
- Variability in drought resilience across agricultural landscapes is most appropriately investigated at field scales
- In addition, crop phenology has been changed in last several decades. Accurately documenting shifts and variability in phenology require better temporal sampling than can currently be provided by a single high-resolution satellite platform.

Project Objectives

- Map crop progress, water use, and drought impacts at 30-m spatial resolution by fusing MODIS, Landsat and geostationary satellites
- Specifically, we will
  - improve the Spatial and Temporal Adaptive Reflectance Fusion Model (STARFM) algorithm for the complex regions;
  - extend our thermal imagery Data Mining Sharpening (DMS) approach for sharpening Landsat and MODIS thermal imagery using shortwave reflectance bands;
  - improve and evaluate our MODIS reference-based Landsat Leaf Area Index (LAI) retrieval approach over multiple biome types and regions;
  - use dense time-series of fused MODIS-Landsat data, actual Landsat data and Landsat-like resolution data to derive crop phenological metrics at Landsat spatial resolution;
  - fuse retrievals based on Landsat, MODIS and geostationary surface temperature data to map daily evapotranspiration (ET) and an associated Evaporative Stress Index (ESI) at 30-m resolution.
  - study drought impacts on crop yield
- An end-to-end mapping system will be developed, integrating and refining several models/tools developed by the team.

Approach

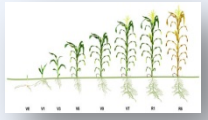
TOOLS

- STARFM — Multi-sensor data fusion
- DMS — Thermal image sharpening
- ALEXI — Multi-scale ET modeling

ASSETS

		SW/TIR
GEO	Hourly	5km/5km
MODIS	Daily	250m/1km
Landsat	16 day	30m/100m
Lsat-like		~20-60m/ --

APPLICATIONS
(daily/30 m)

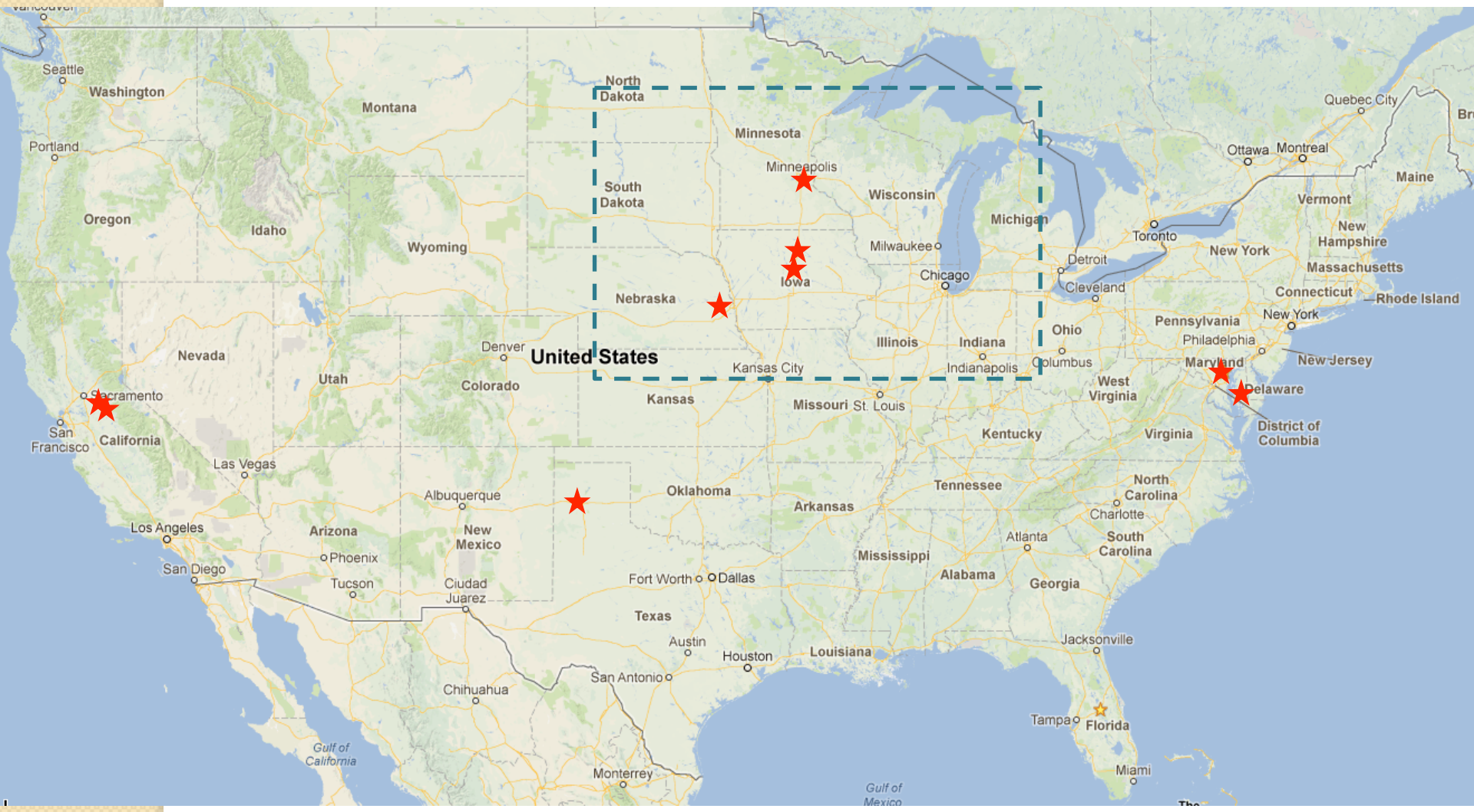

Crop phenology metrics


Crop water use (Evapotranspiration)


Crop stress (drought early warning)


Impact on yield

Study Area


Seattle
Washington
Portland
Oregon
Montana
Idaho
Wyoming
North Dakota
South Dakota
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Chicago
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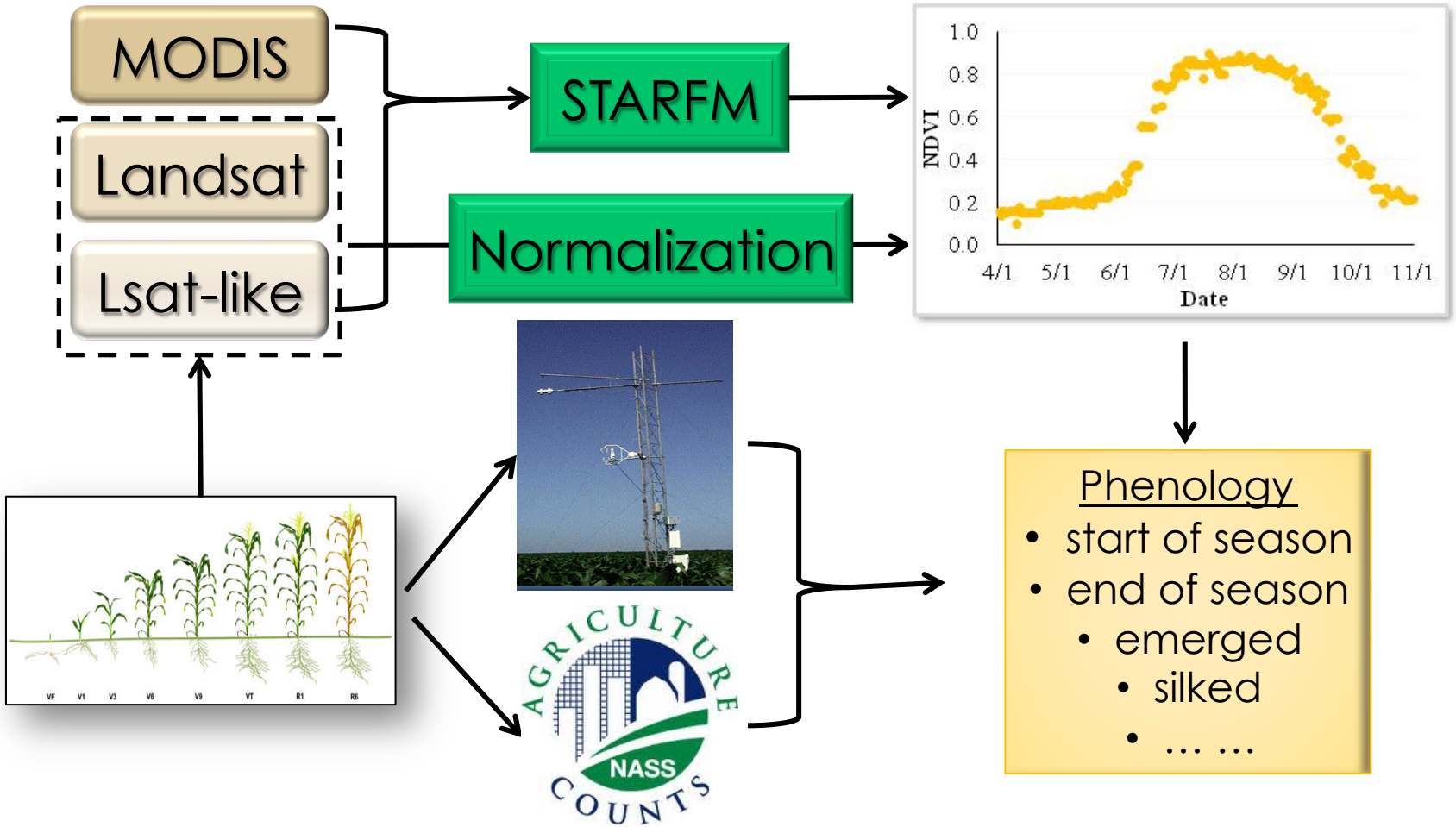
Nebraska
Denver
United States
Kansas City
Illinois
Indiana
Indianapolis
Ohio
Columbus
Pennsylvania
Philadelphia
New York
Maryland
Delaware
New Jersey
District of Columbia
West Virginia
Virginia
Kentucky
Tennessee
North Carolina
Charlotte
South Carolina
Atlanta
Georgia
Alabama
Mississippi
Louisiana
Arkansas
Missouri
St. Louis
Kansas
Oklahoma
Texas
Colorado
Utah
Nevada
Arizona
New Mexico
Albuquerque
Las Vegas
Phoenix
Tucson
Ciudad Juarez
Fort Worth
Dallas
Austin
Houston
San Antonio
Chihuahua
Gulf of California
Monterrey
Gulf of Mexico
Jacksonville
Tampa
Florida
Miami
Los Angeles
San Diego
San Francisco
California
Sacramento
Quebec City
Ottawa
Montreal
Toronto
Detroit
Cleveland
Maine
Vermont
New Hampshire
Massachusetts
Connecticut
Rhode Island
New York

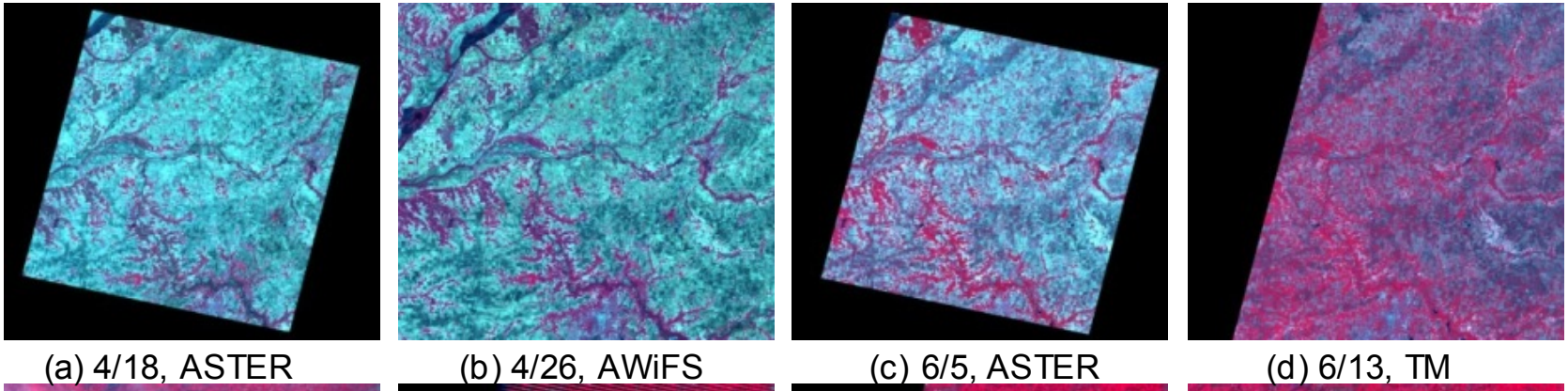
Crop Condition and Water Use Monitoring

Task I. Mapping Crop Phenology at Field Scale

Approach: extract crop phenology and growth stages at field-scale



Method 1: Image Normalization using MODIS

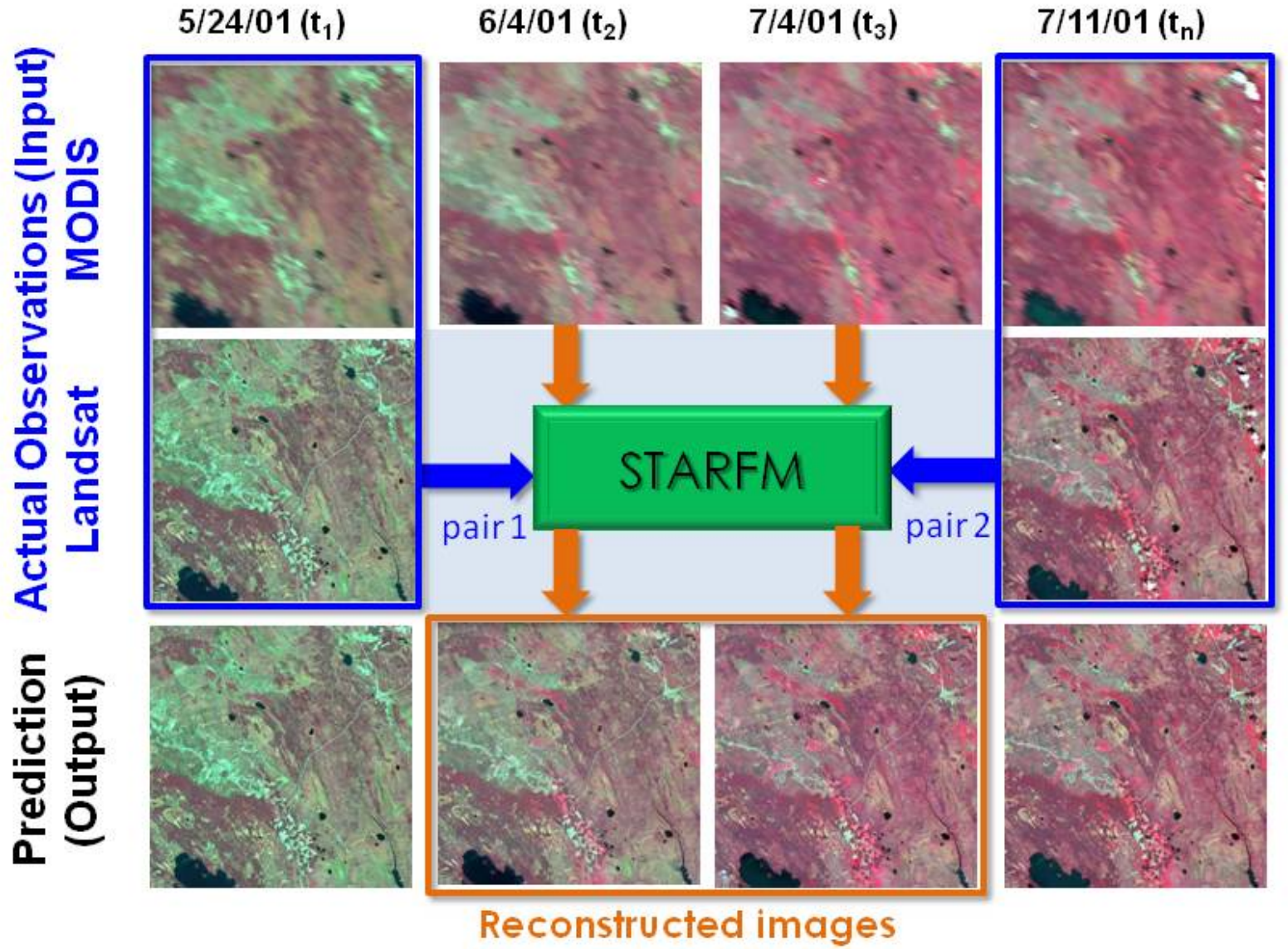


(a) 4/18, ASTER (b) 4/26, AWiFS (c) 6/5, ASTER (d) 6/13, TM

(e) 7/7, AWiFS (f) 7/23, ETM+ (g) 7/31, TM (h) 8/24, AWiFS

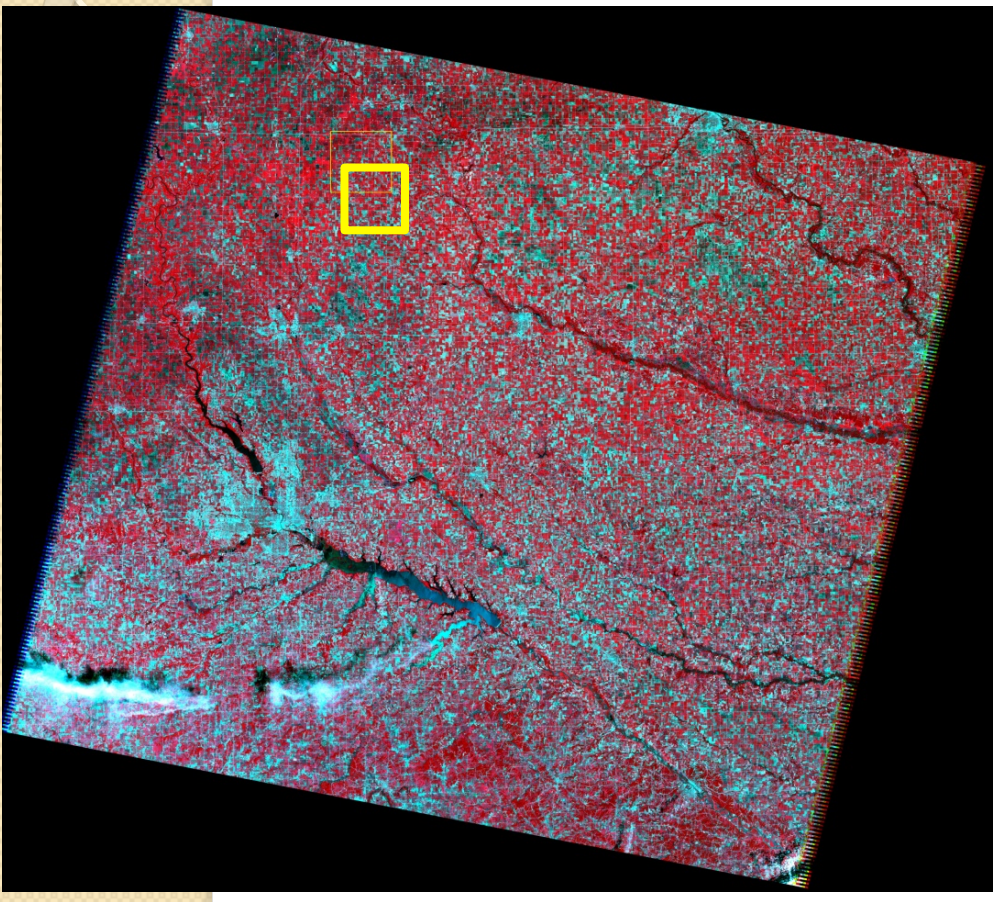
Gao, F., J. Masek, R. Wolfe, C. Huang, Building consistent medium resolution satellite data set using MODIS products as reference, Journal of Applied Remote Sensing, Vol. 4, 043526, doi: 10.1117/1.3430002, 2010

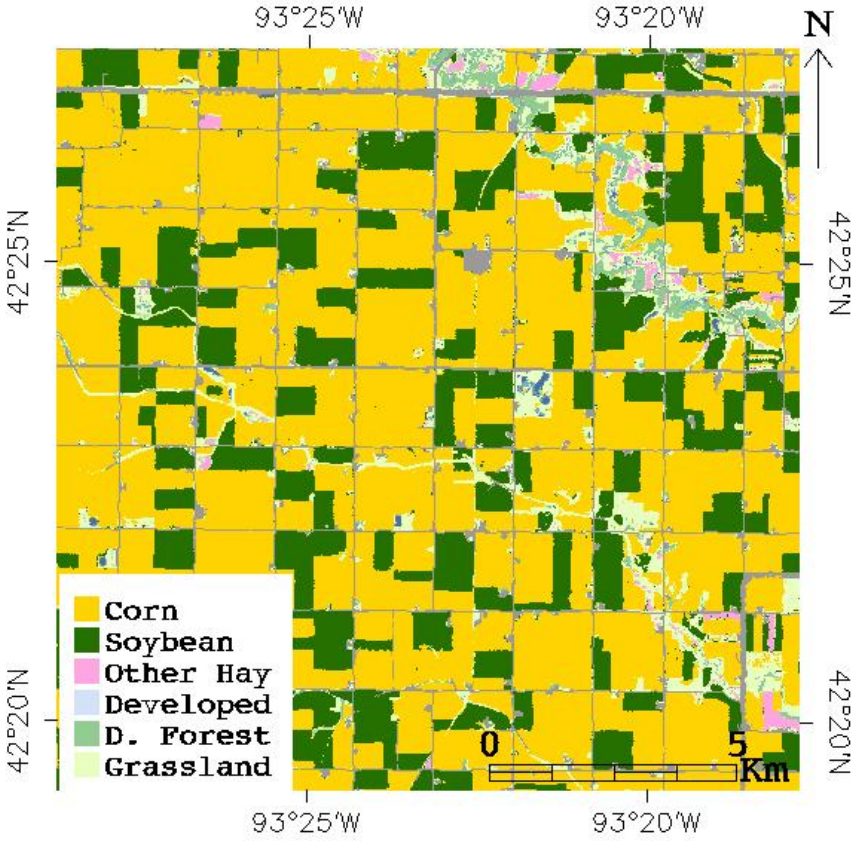
Method 2: STARFM - Fusing MODIS and Landsat



Gao, F., J. Masek, M. Schwaller and F. Hall, On the Blending of the Landsat and MODIS Surface Reflectance: Predict Daily Landsat Surface Reflectance, IEEE Transactions on Geoscience and Remote Sensing, vol. 44, no. 8, pp. 2207-2218, 2006

An Example: South Fork, Iowa

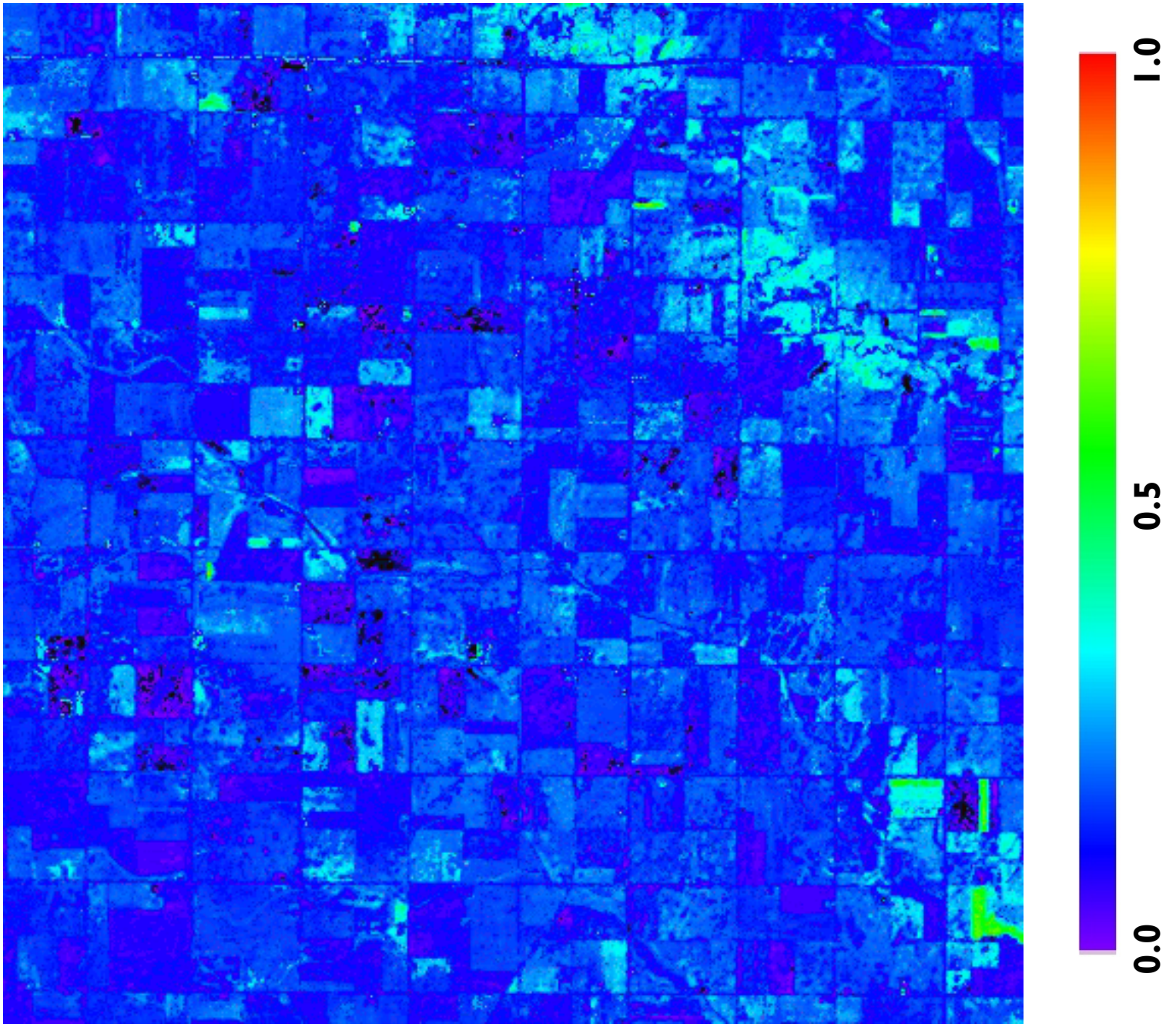




WRS-2 Path 26 Row 31

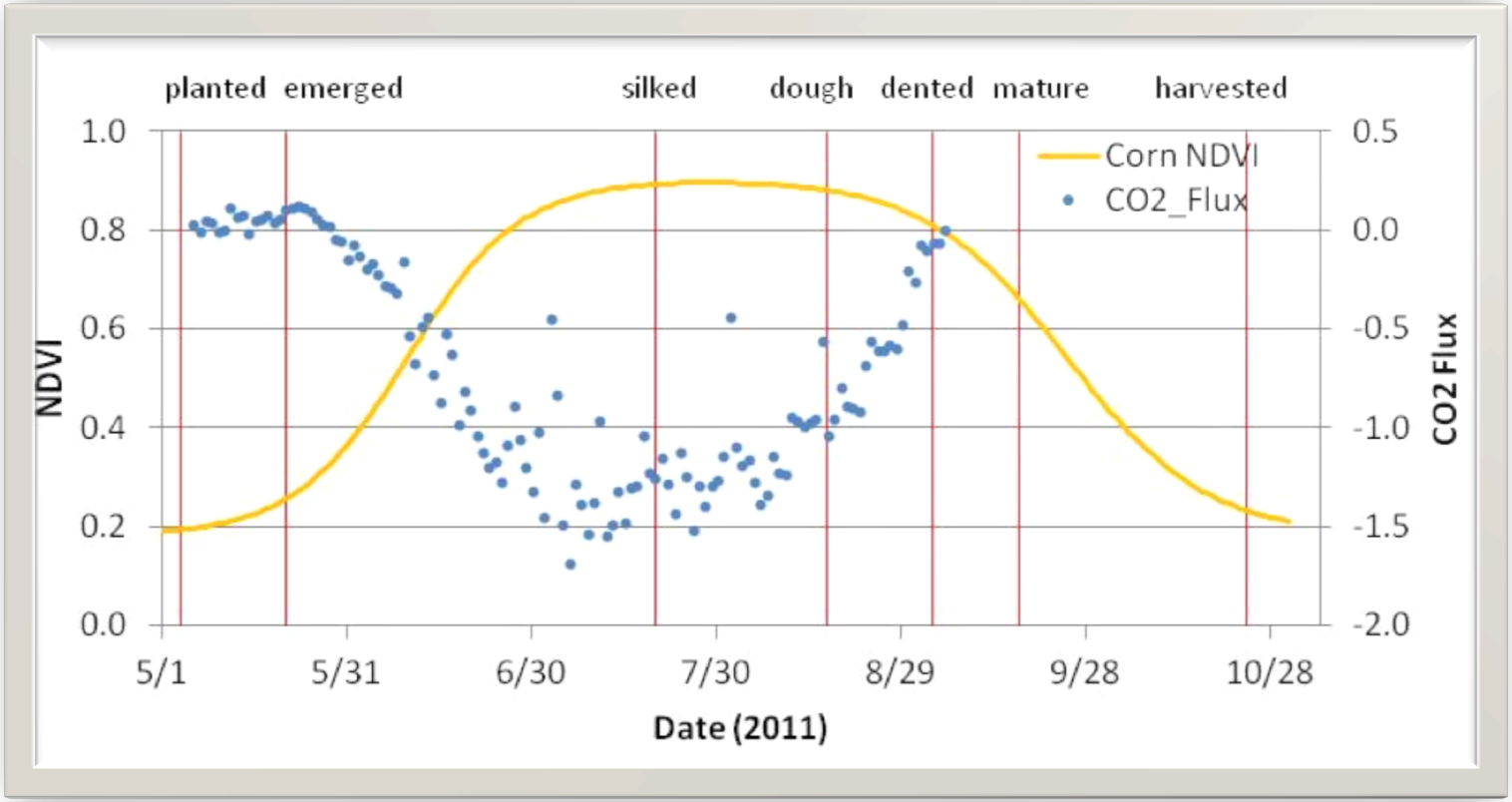
Cropland Data Layer (2011)

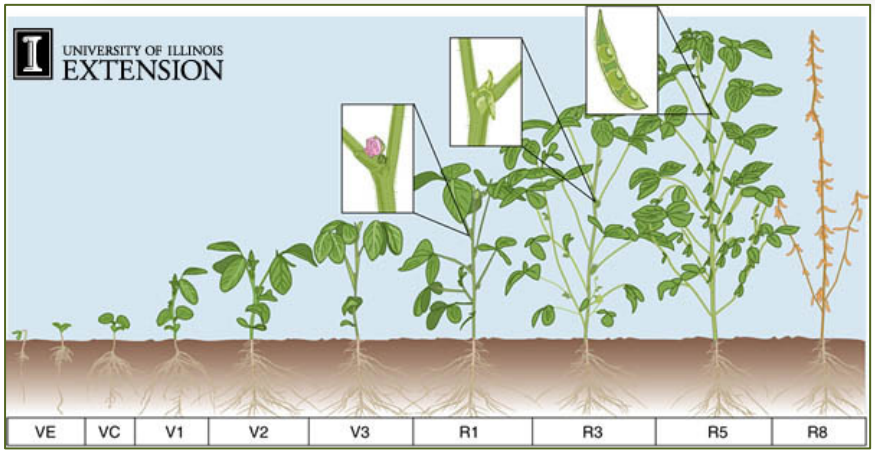
(six pairs of Landsat and MODIS images from July 2 to Nov. 7, 2011)

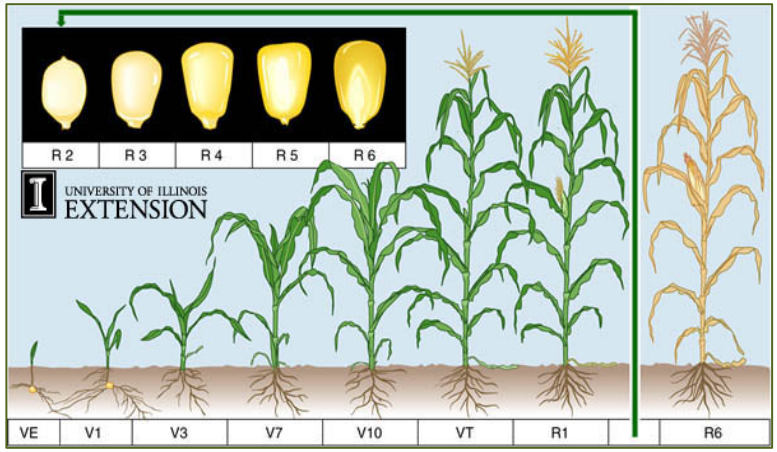


Smoothed Daily NDVI, Apr. 1 – Nov. 1, 2011

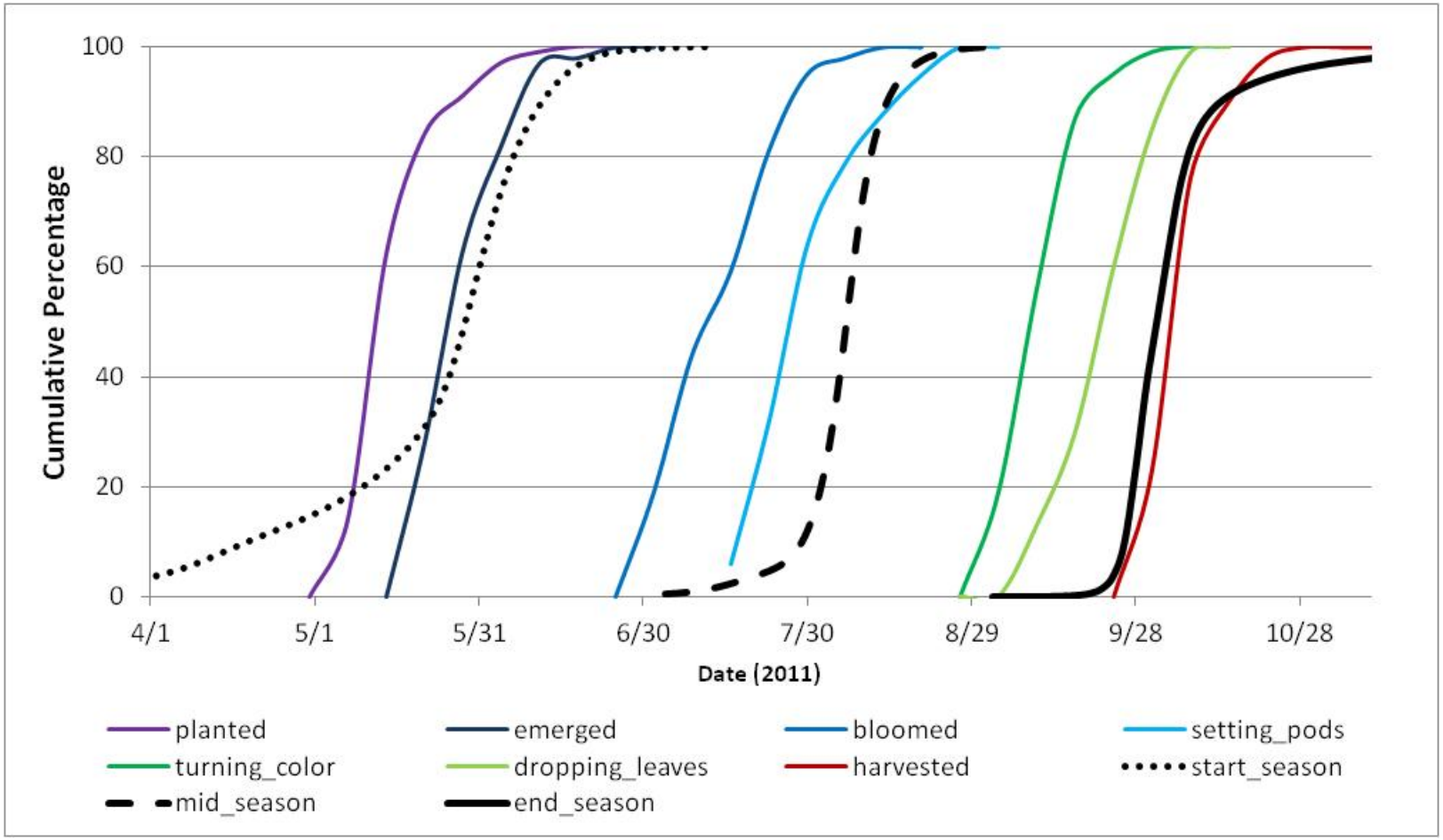
Crop Growth Stages & Remote Sensing Phenology





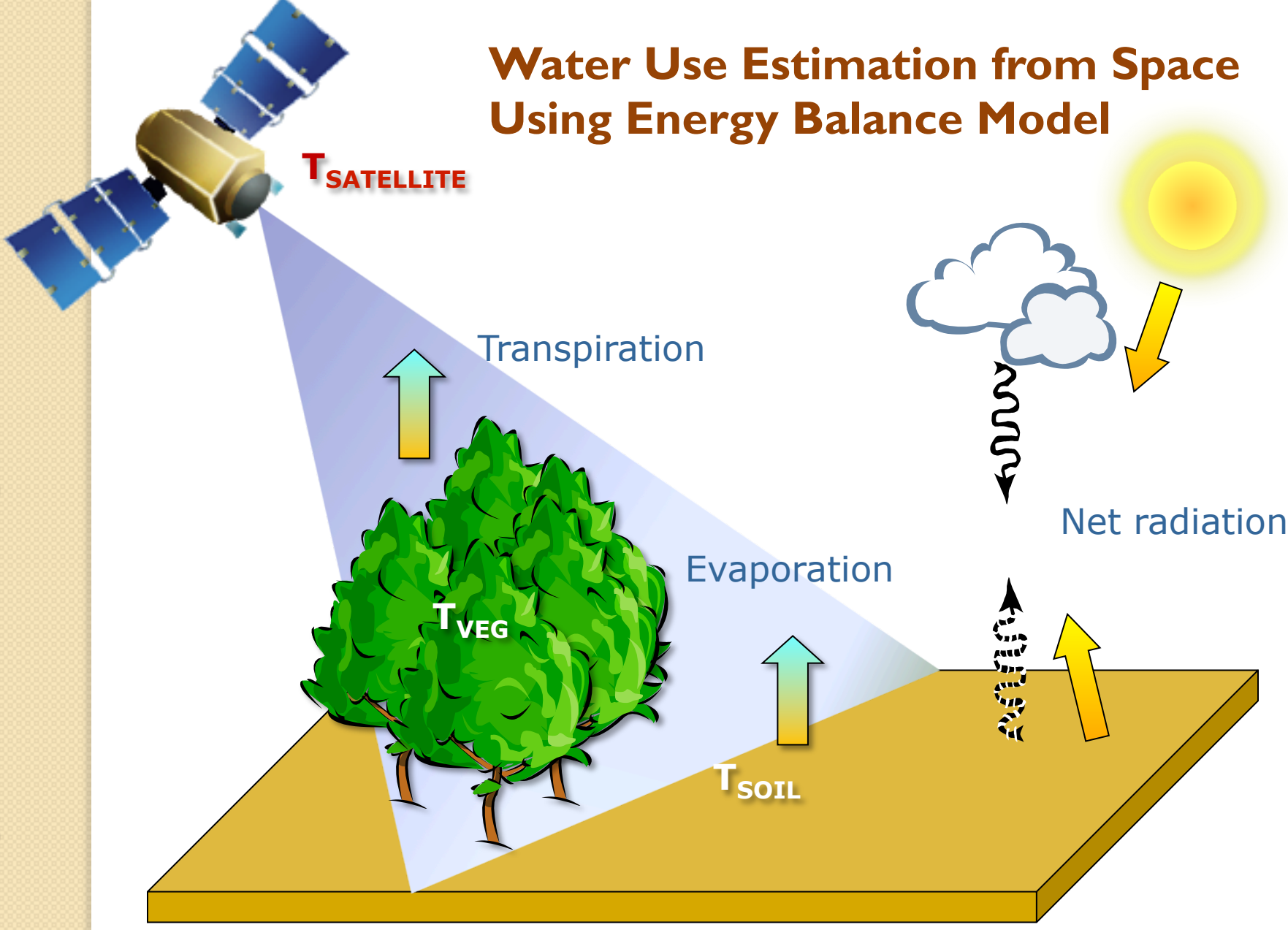


Remote Sensing Phenology vs. NASS Crop Progress Report (Landsat p026r031, central Iowa, soybean)



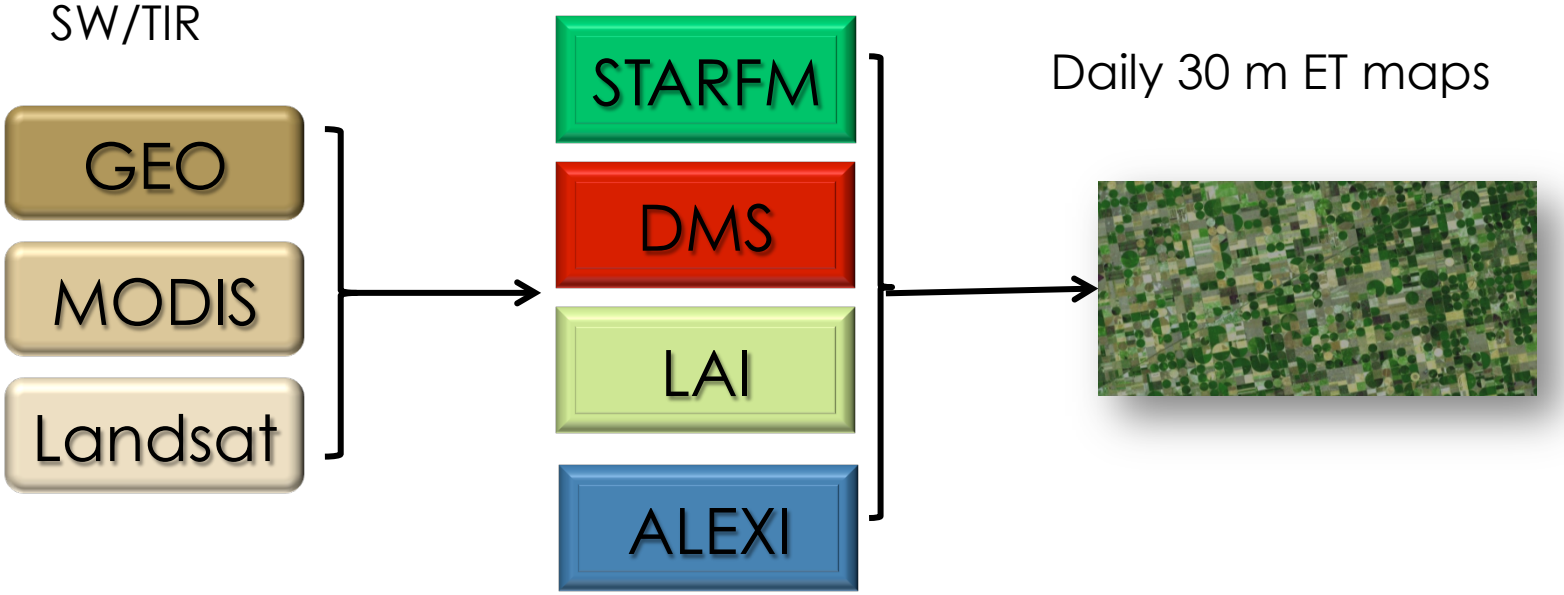
Task II. Mapping Daily Evapotranspiration and Stress at Field Scale

Water Use Estimation from Space Using Energy Balance Model

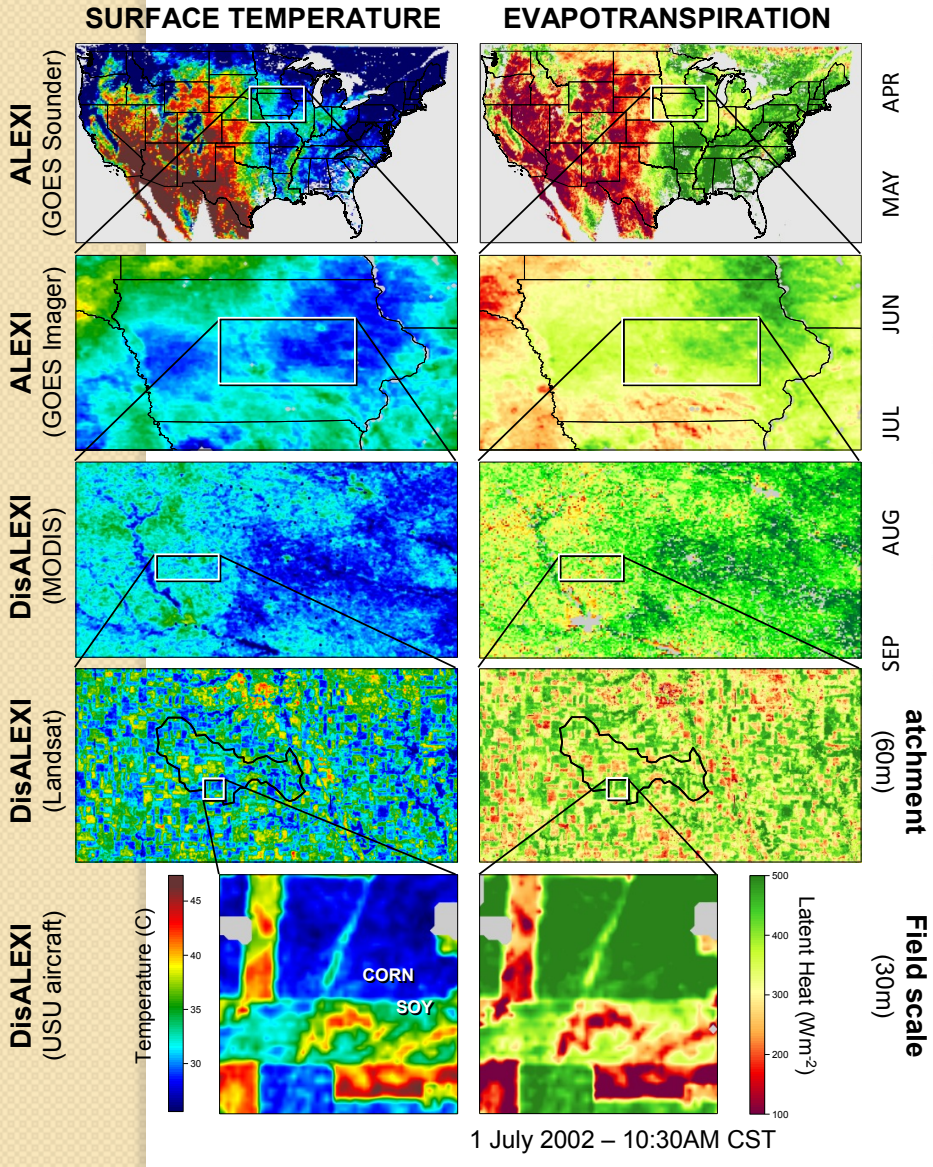


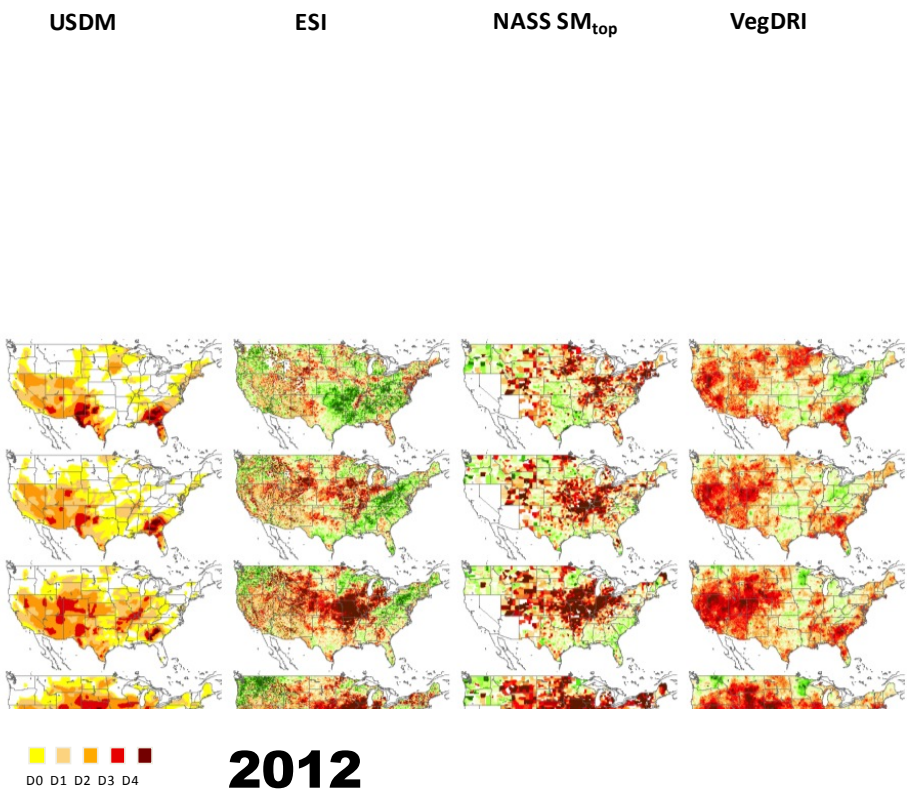
Two-Source Energy Balance (TSEB) and Atmosphere-Land EXchange Inverse (ALEXI) model

FIELD-SCALE DAILY EVAPOTRANSPIRATION



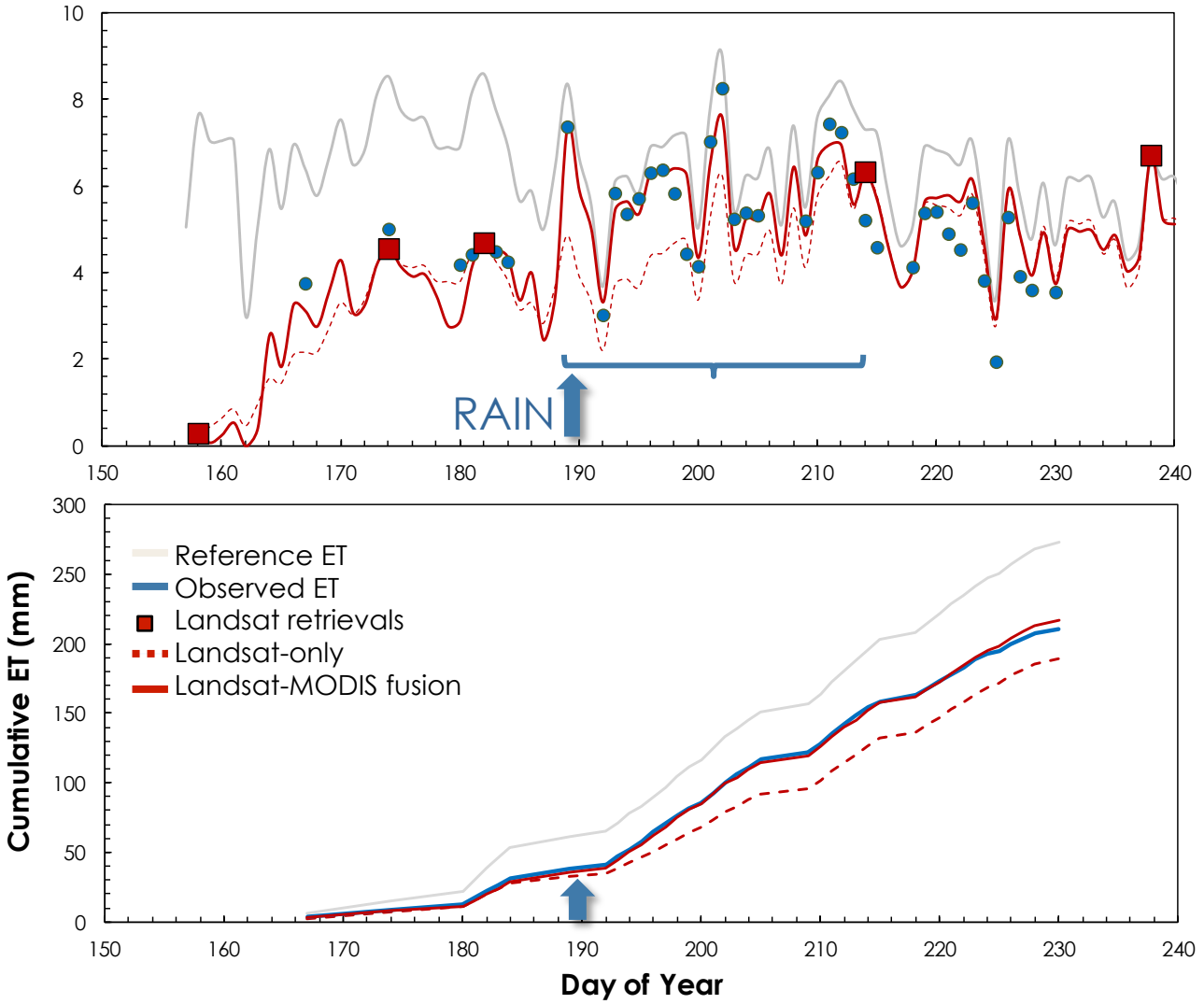
Monitoring Evapotranspiration (ET) and Drought Using Thermal Remote Sensing





Comparison of monthly USDM drought classifications with maps of ESI, anomalies in NASS topsoil moisture data, and with the VegDRI index, primarily reflecting anomalies in NDVI. Also shown are monthly changes in USDM drought class and standardized ESI change anomalies (Anderson et al., 2013). The core of the drought impacted area is clearly delineated in the ESI change indicator in May.

Rainfed soybean – SMEX02 (Iowa)



Results of Landsat-MODIS ET data fusion (red solid line) compared to observations in a rainfed soybean field in Ames, Iowa (blue dots/line) and to a Landsat-only interpolation scheme (red dotted line). The fused MODIS data capture ET enhancements in response to a rainfall event that occurred between Landsat overpasses (red squares)

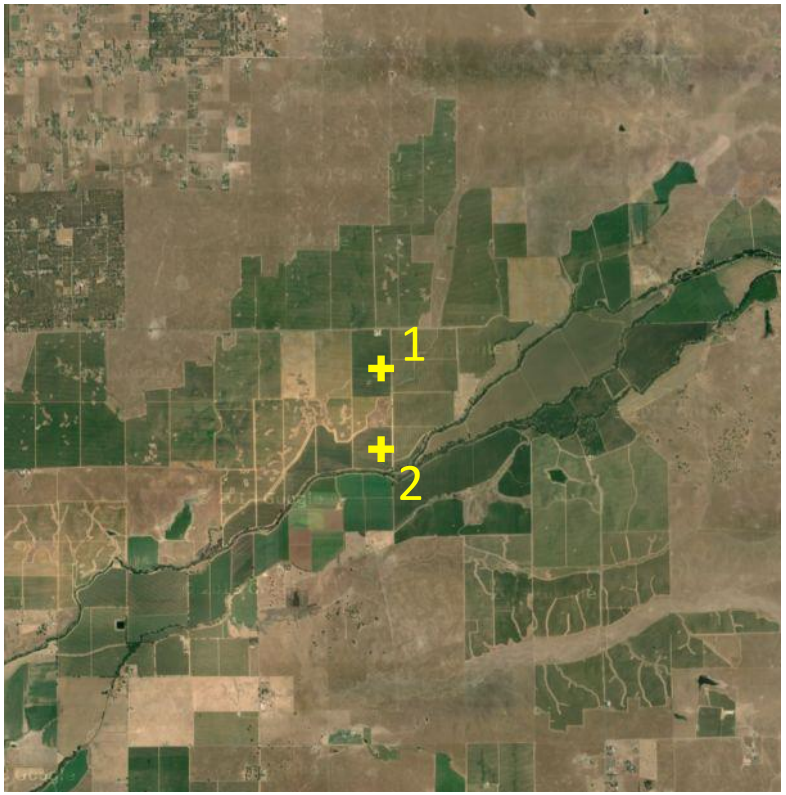
Crop Condition and Water Use Monitoring

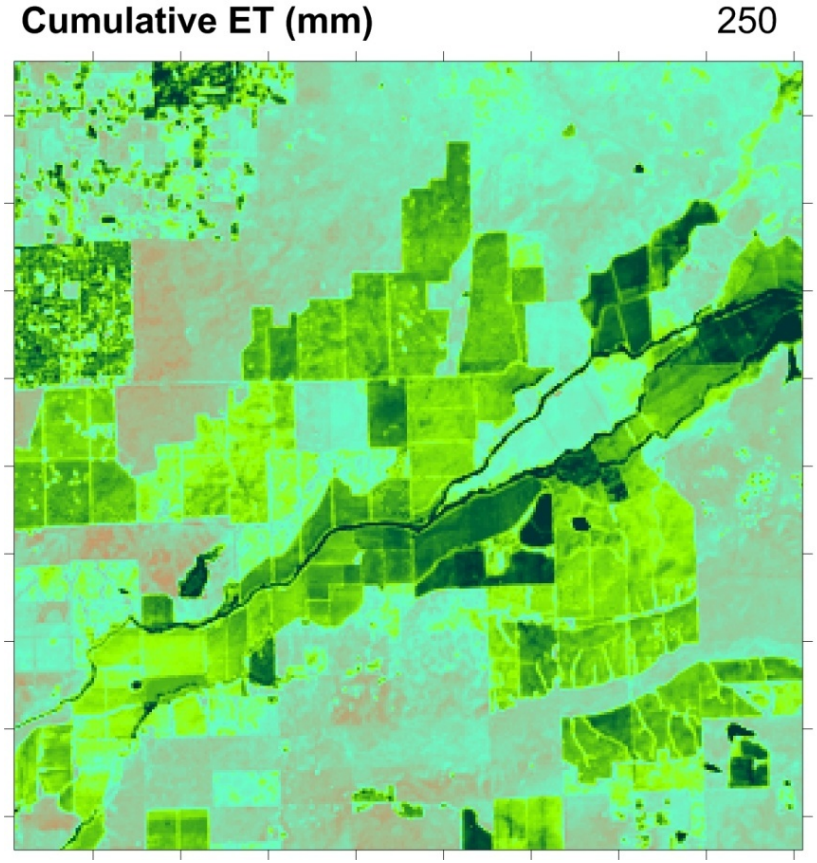
Task III. Evaluating Drought Impacts on Yield

Crop Condition and Water Use Monitoring

Gallo Vineyards, Lodi CA

Gallo Vineyards, Lodi CA



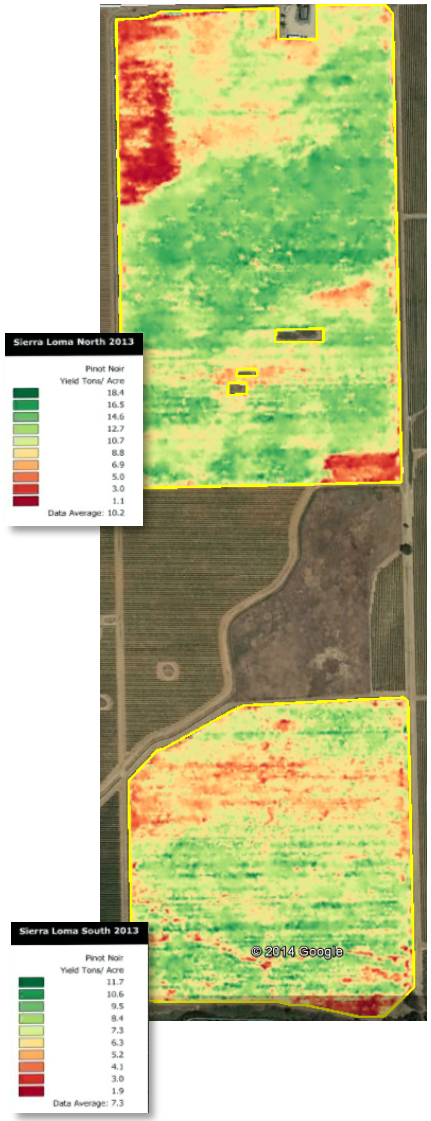


Landsat 8 - 2013

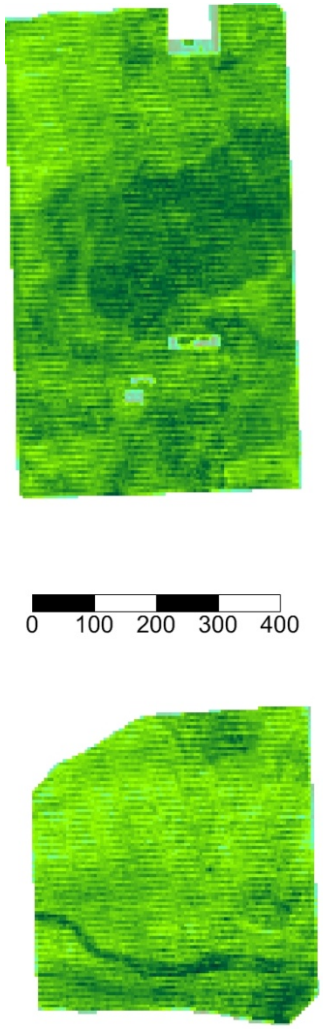
GRAPEX 2013, 2014, 2015

Yield Comparisons

2013 Yield

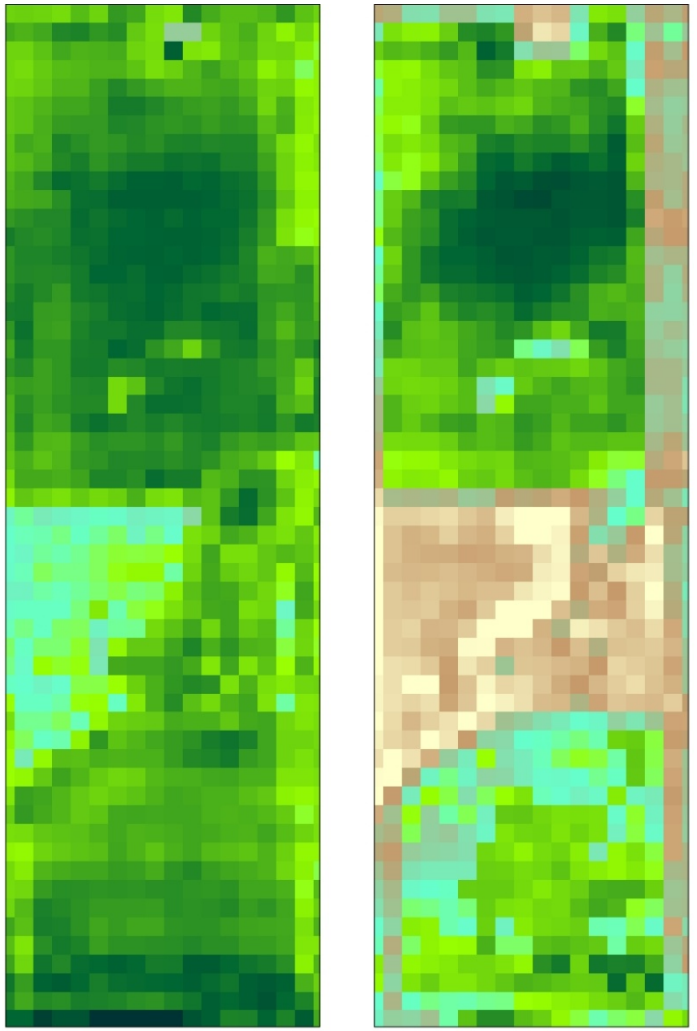


Aircraft ET (5m)



June 12, 2013

Landsat 8 ET (30m)



Cumulative

Summary

TOOLS

- STARFM data fusion
- DMS TIR image sharpener
- ALEXI/DisALEXI ET modeling
- LAI, Phenology …

FIELD-SCALE APPLICATIONS

- Crop phenology
- Daily crop water use and stress
- Drought Impact and early warning