



# Characterizing Field-scale Crop ET, Phenology and Productivity

**Martha C. Anderson, Feng Gao, Jie Xue, Yun Yang, Yang Yang, Kyle Knipper**

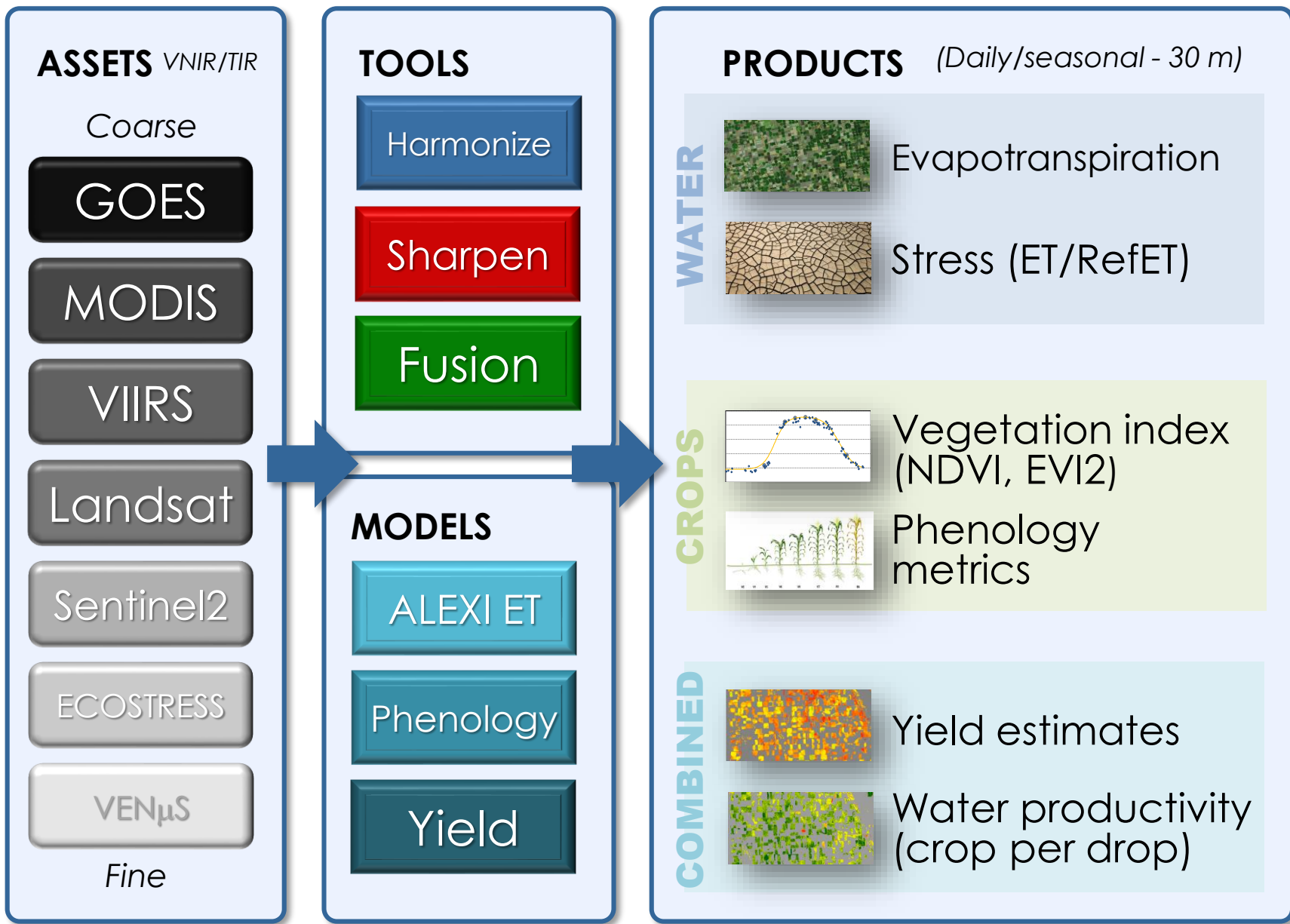
*USDA-Agricultural Research Service  
Hydrology and Remote Sensing Laboratory  
Beltsville, MD*

**Chris Hain** *NASA - MSFC*

**Jason Otkin** *U Wisconsin-Madison*

**Hadi Jaafar** *American U of Beirut*

**Arnon Karnieli** *Ben Gurion U of Negev*





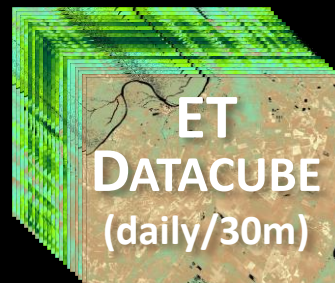


# Landsat 8

Launch 2/11/2013

Polar Orbit (16 day)  
2 TIR bands (100 m)

VNIR from HLS-Landsat (30 m)



# ECOSTRESS

Launch 6/29/2018

ISS Orbit (~4 day)  
5 TIR bands (38x69 m)

VNIR from HLS (30 m)



# VIIRS

Launch 8/28/2011

Polar Orbit (~1 day)  
15 band (375 m)

VNIR from HLS-Sentinel 2 (30 m)



LAND-SURFACE TEMPERATURE

LANDSAT

ECOSTRESS

VIIRS

Native

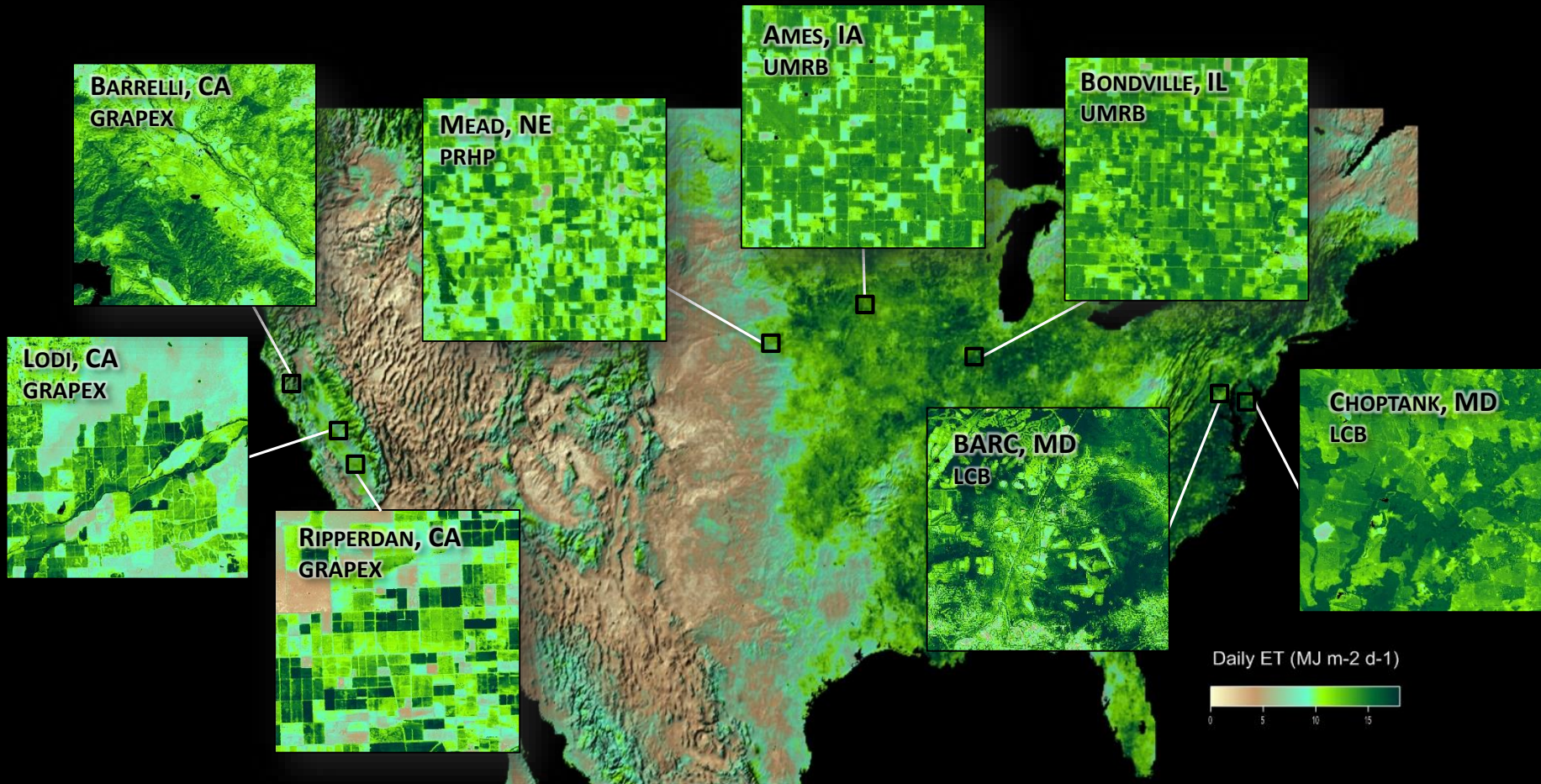


Sharpened





# U.S. ET DATACUBE DEVELOPMENT SITES



## USDA-ARS Long-Term Agroecosystem Research (LTAR) Sites

PRHP

Platte River-High Plains

LCB

Lower Chesapeake Bay

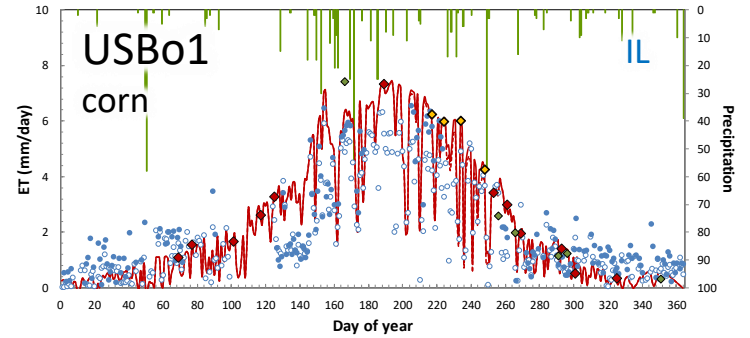
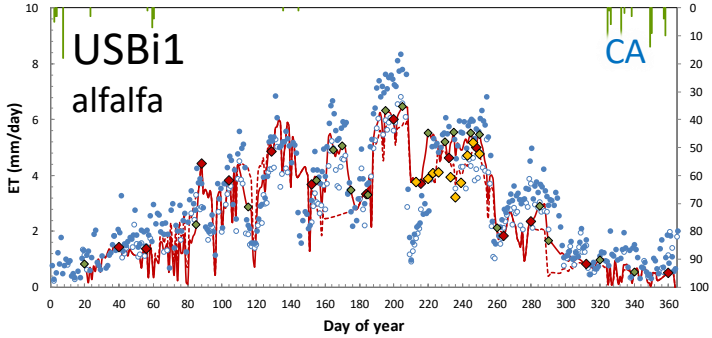
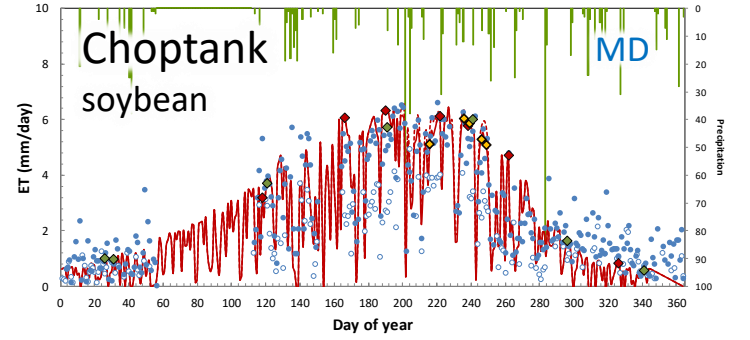
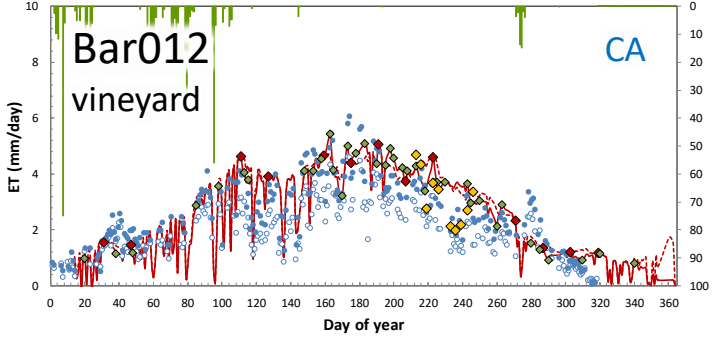
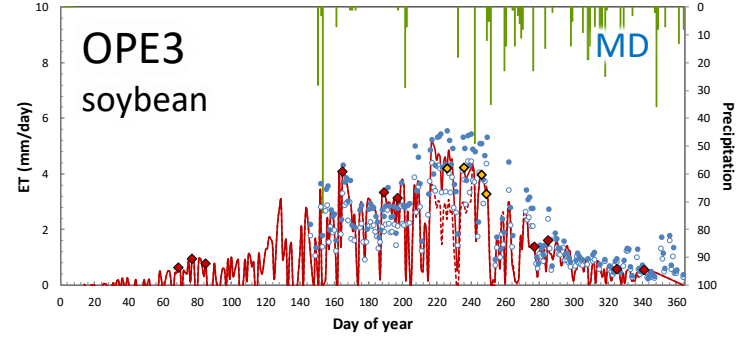
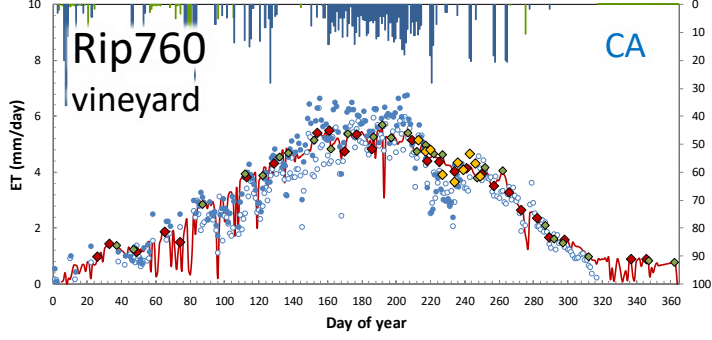
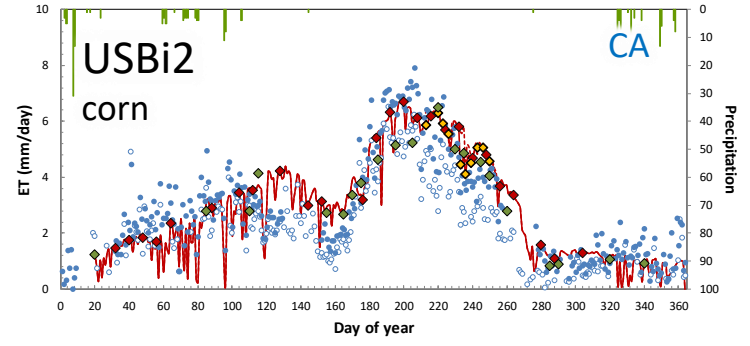
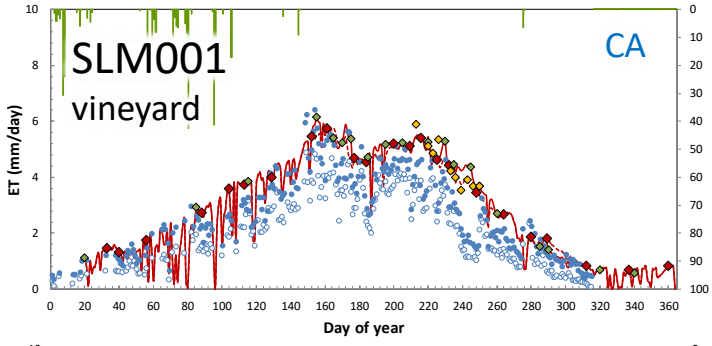
UMRB

Upper Mississippi River Basin

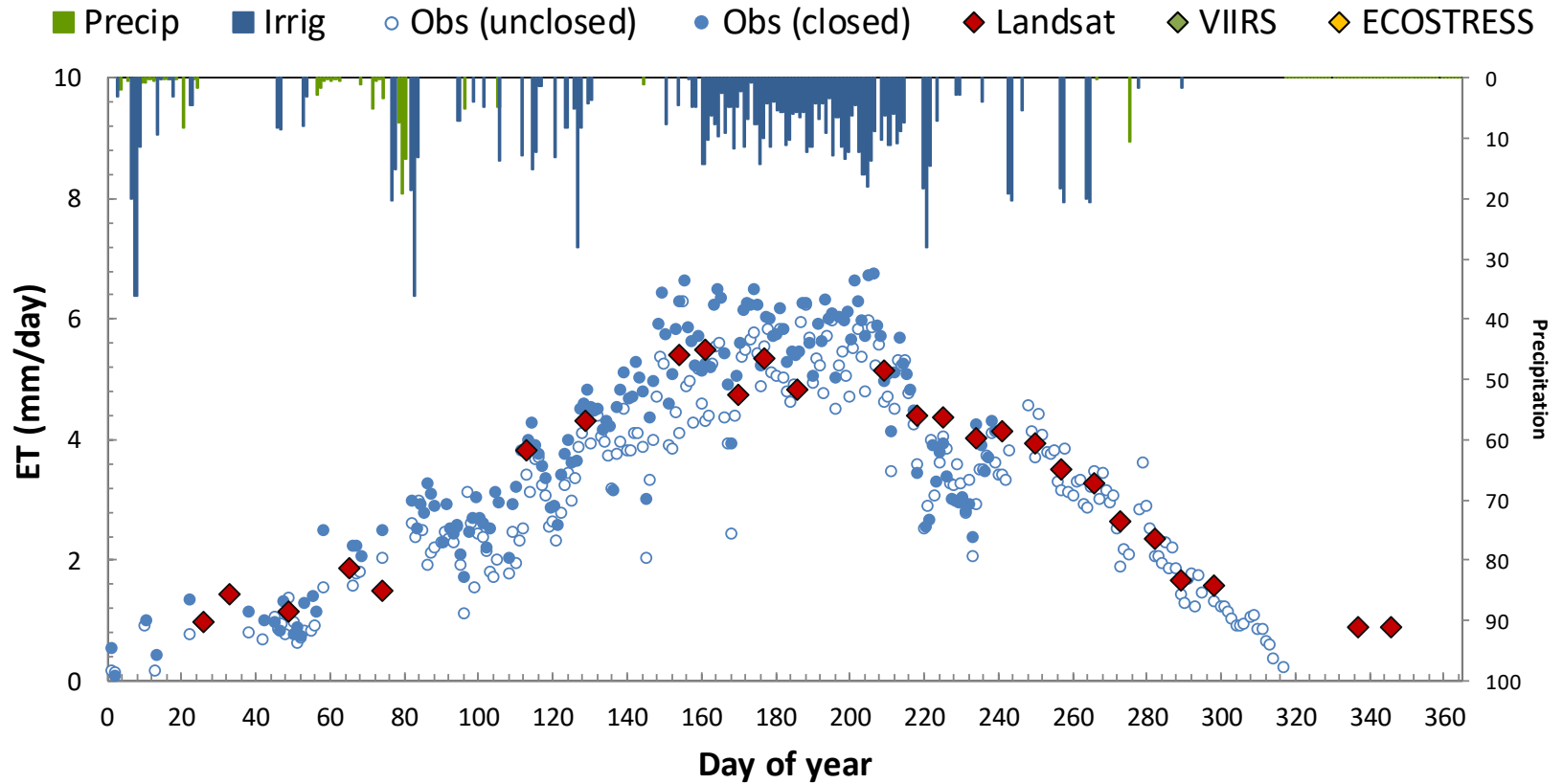
CA

Proposed site

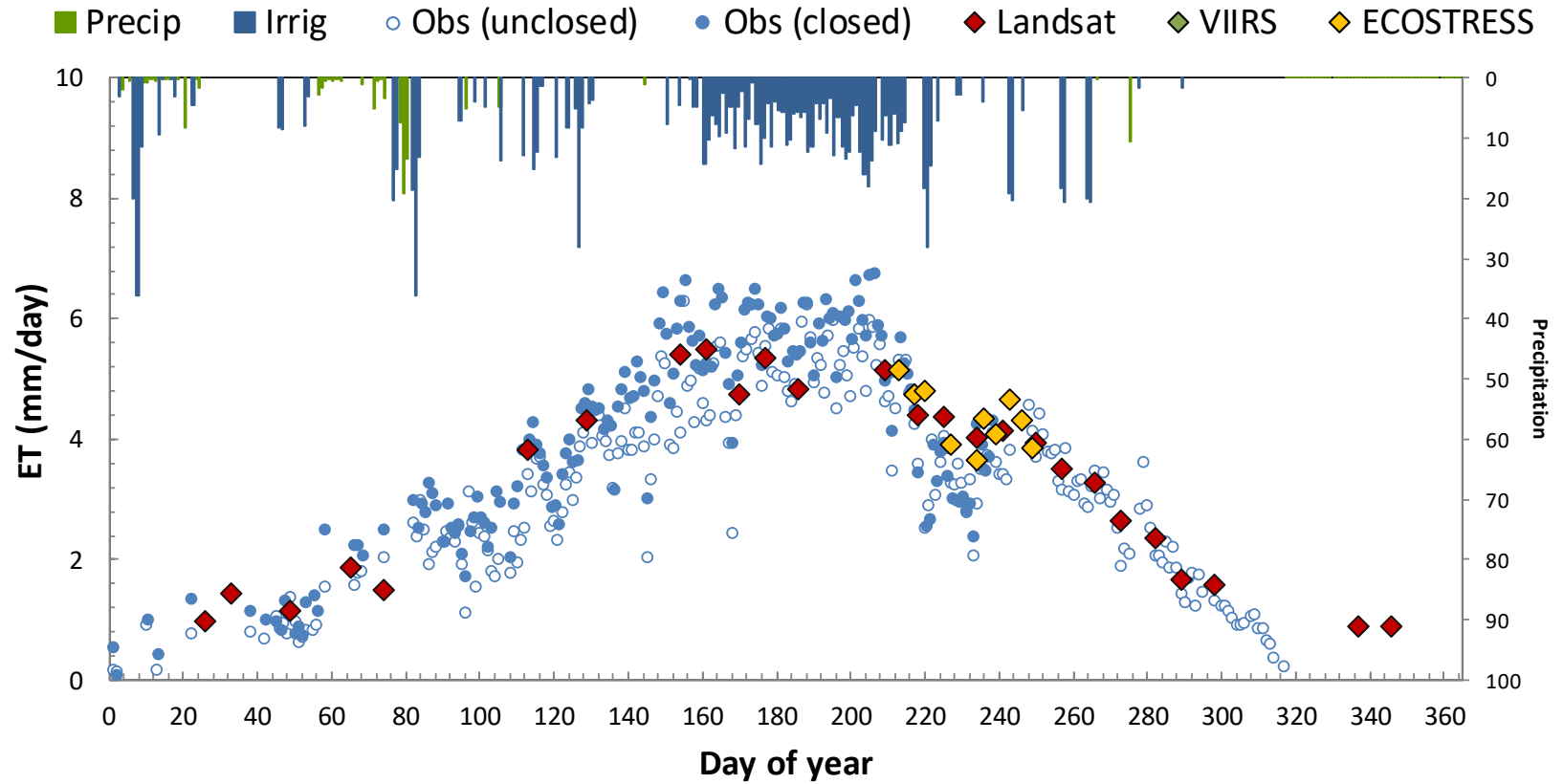
■ Precip ■ Irrig ○ Obs (unclosed) ● Obs (closed) ◆ Landsat ◆ VIIRS ◆ ECOSTRESS — STARFM



# Rip760 - vineyard GRAPEX SITE

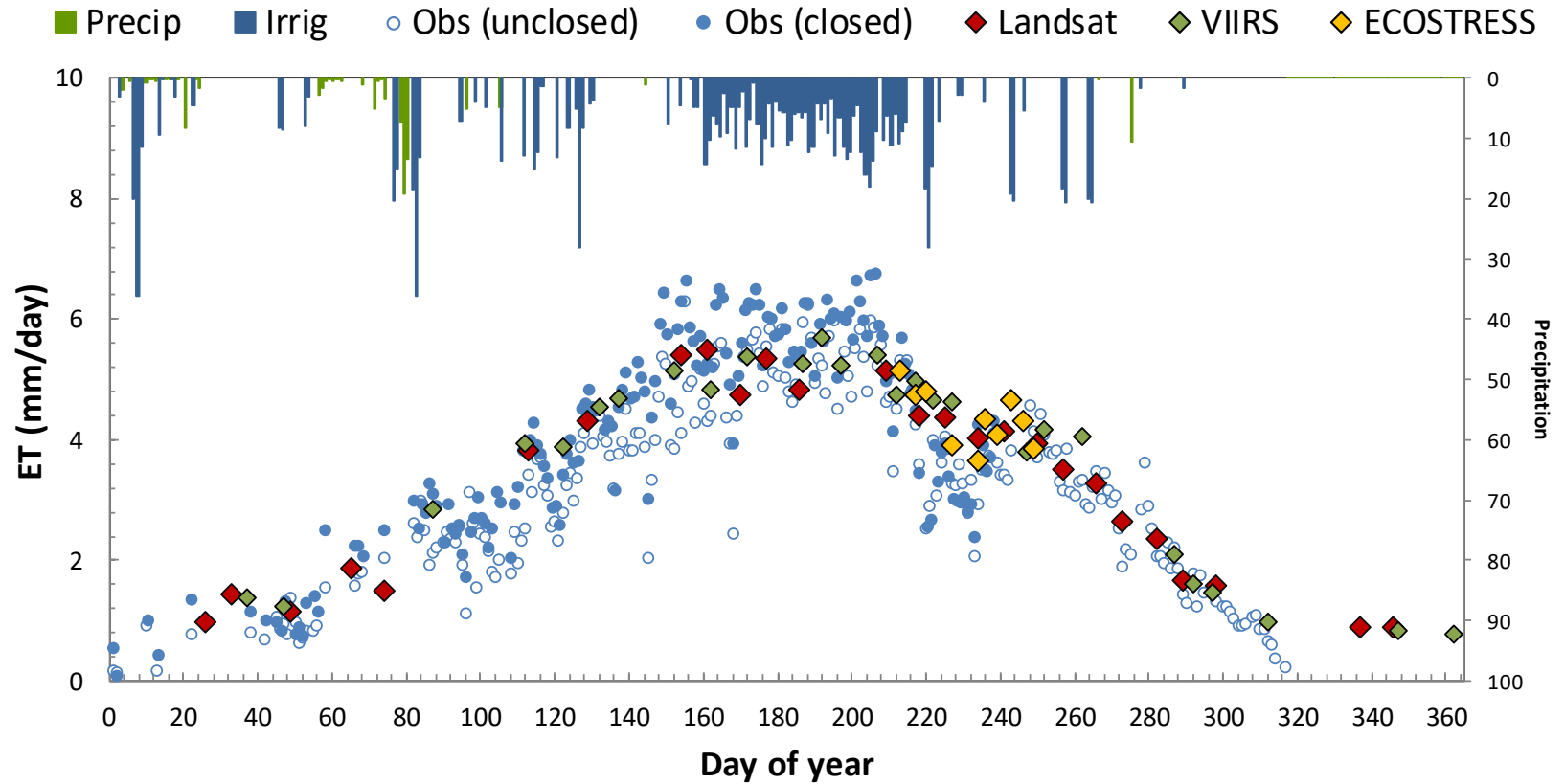


# Rip760 - vineyard GRAPEX SITE

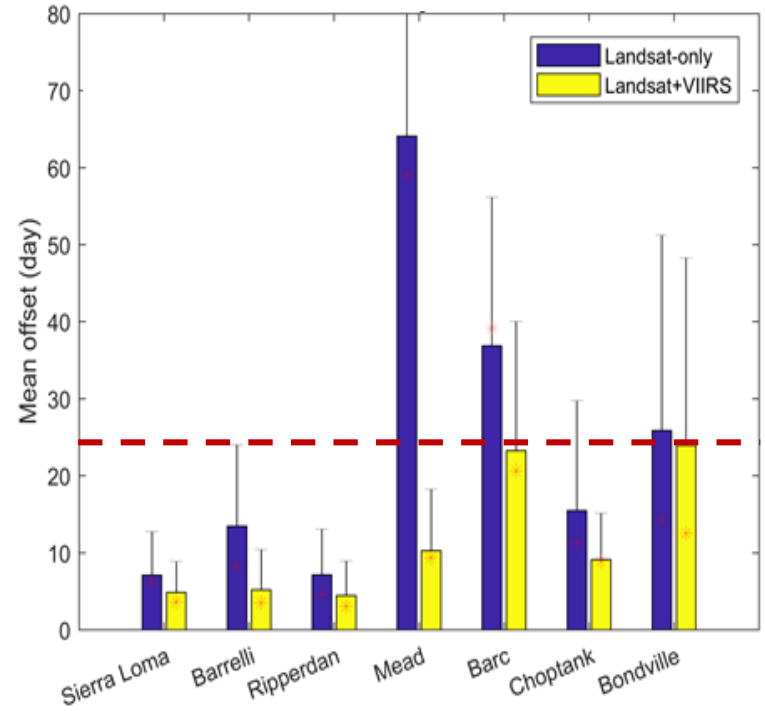
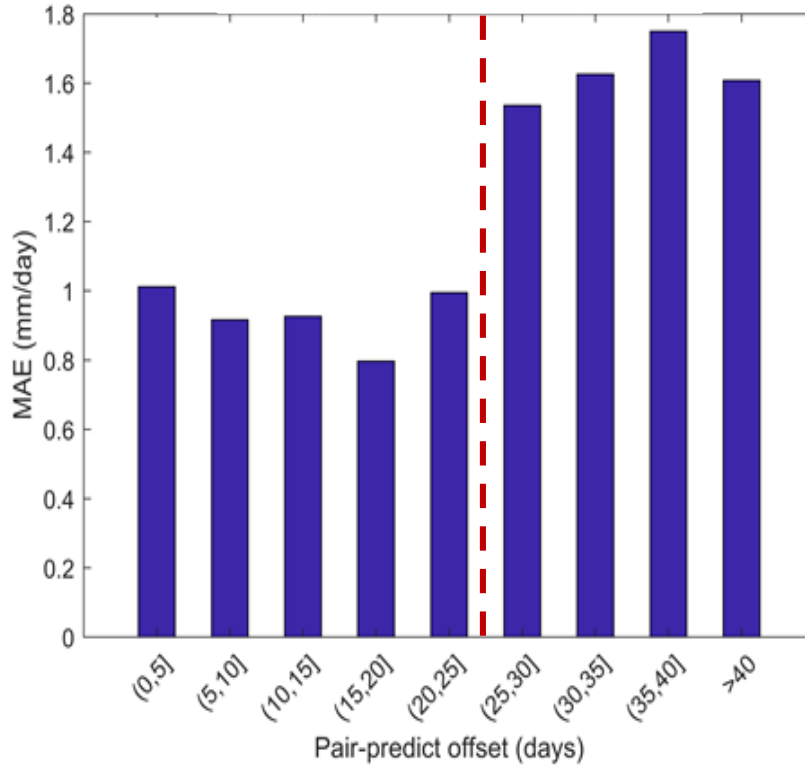




# Rip760 - vineyard GRAPEX SITE



### Growing Season

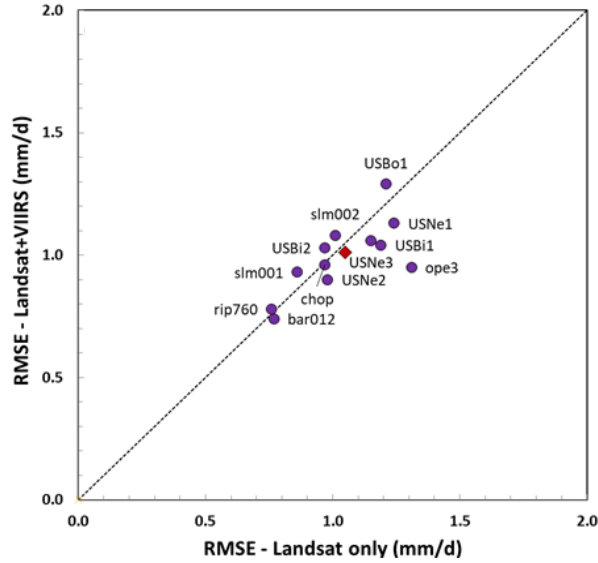


Xue, J. et al. (2020). Evaluation of added value by Sentinel-2 and VIIRS data in mapping daily evapotranspiration at field scales, In prep.

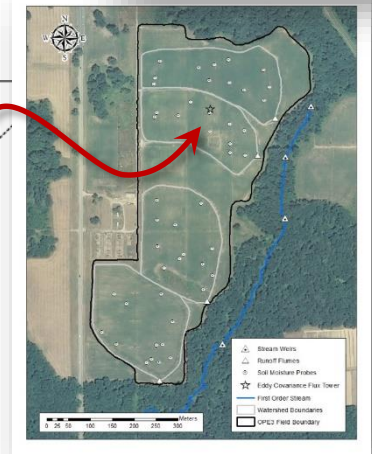
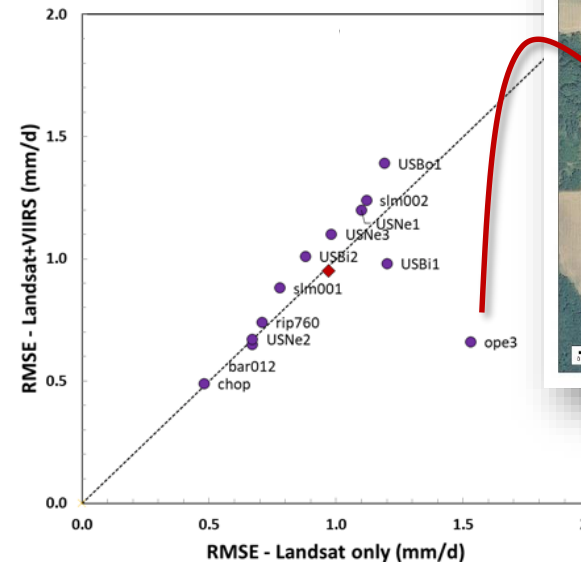
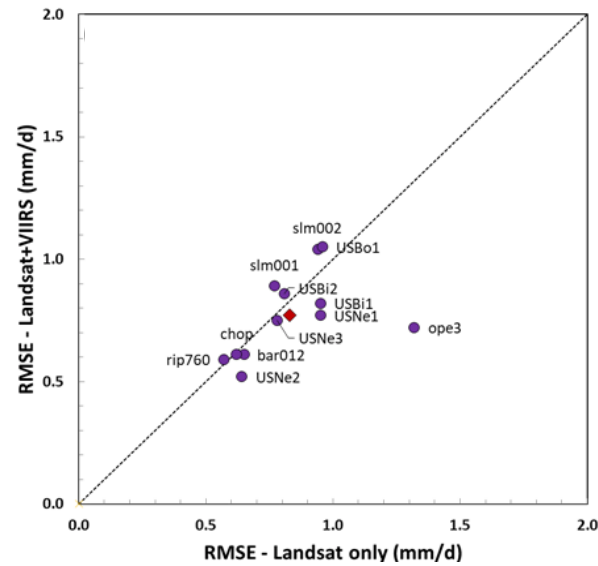
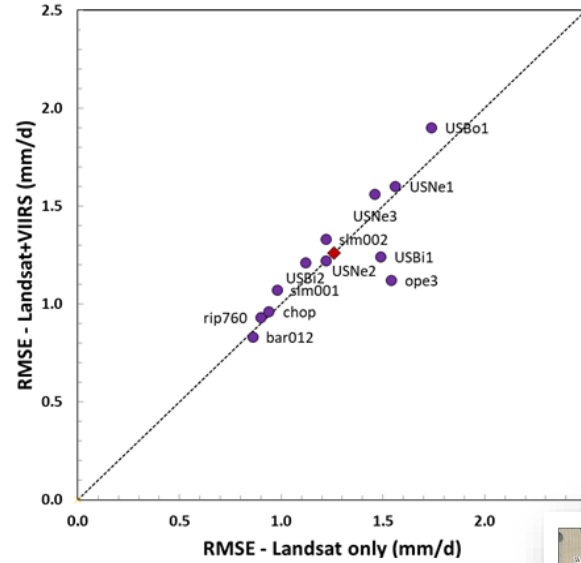
Daily ET

Weekly ET

Full year



Growing season (140-240)

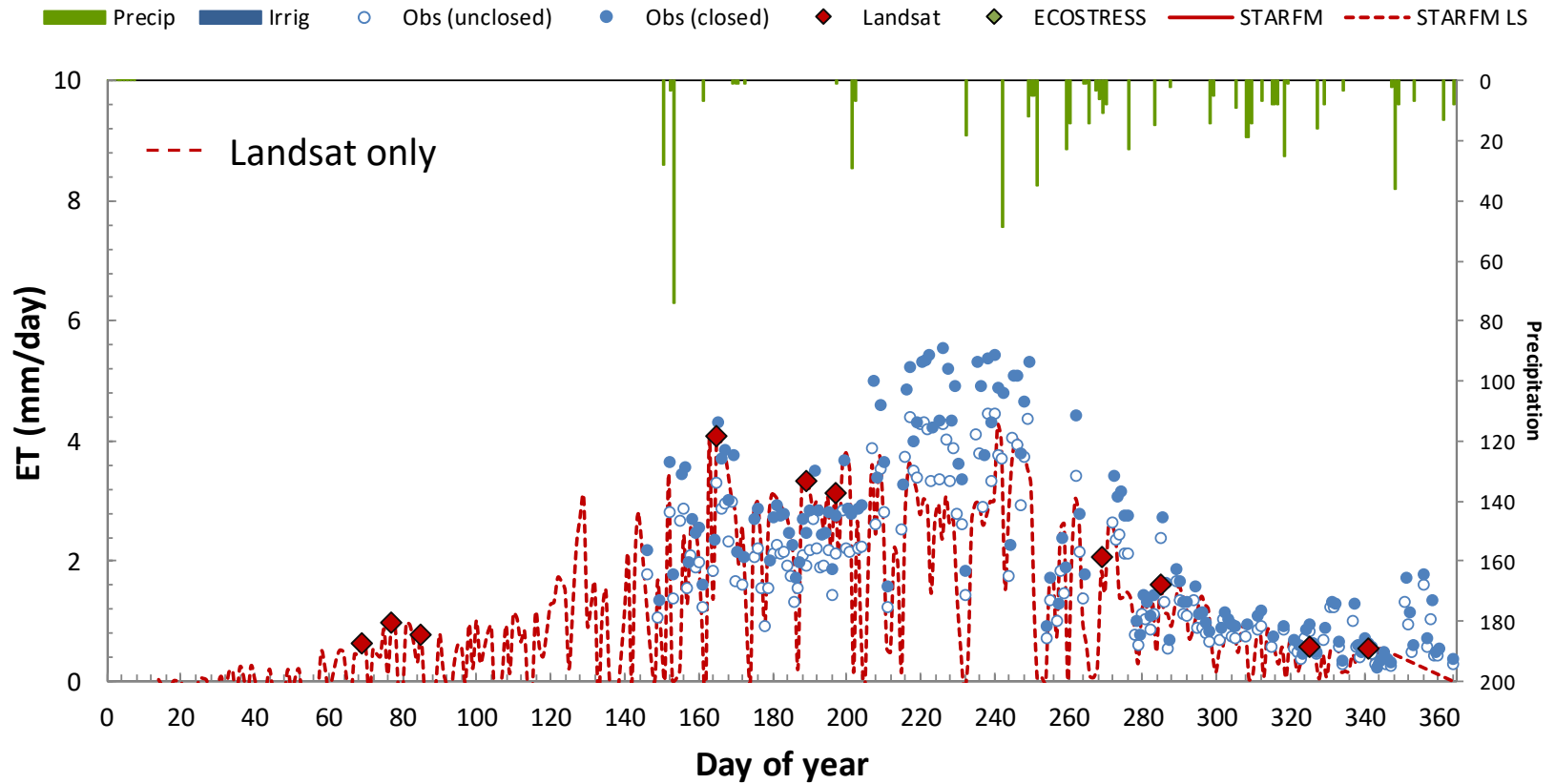




Anderson, M.C., et al. (2020). Interoperability of ECOSTRESS and Landsat for mapping evapotranspiration time series at sub-field scales. *Remote Sensing of Environment*, in review.

# OPE3 - soybean

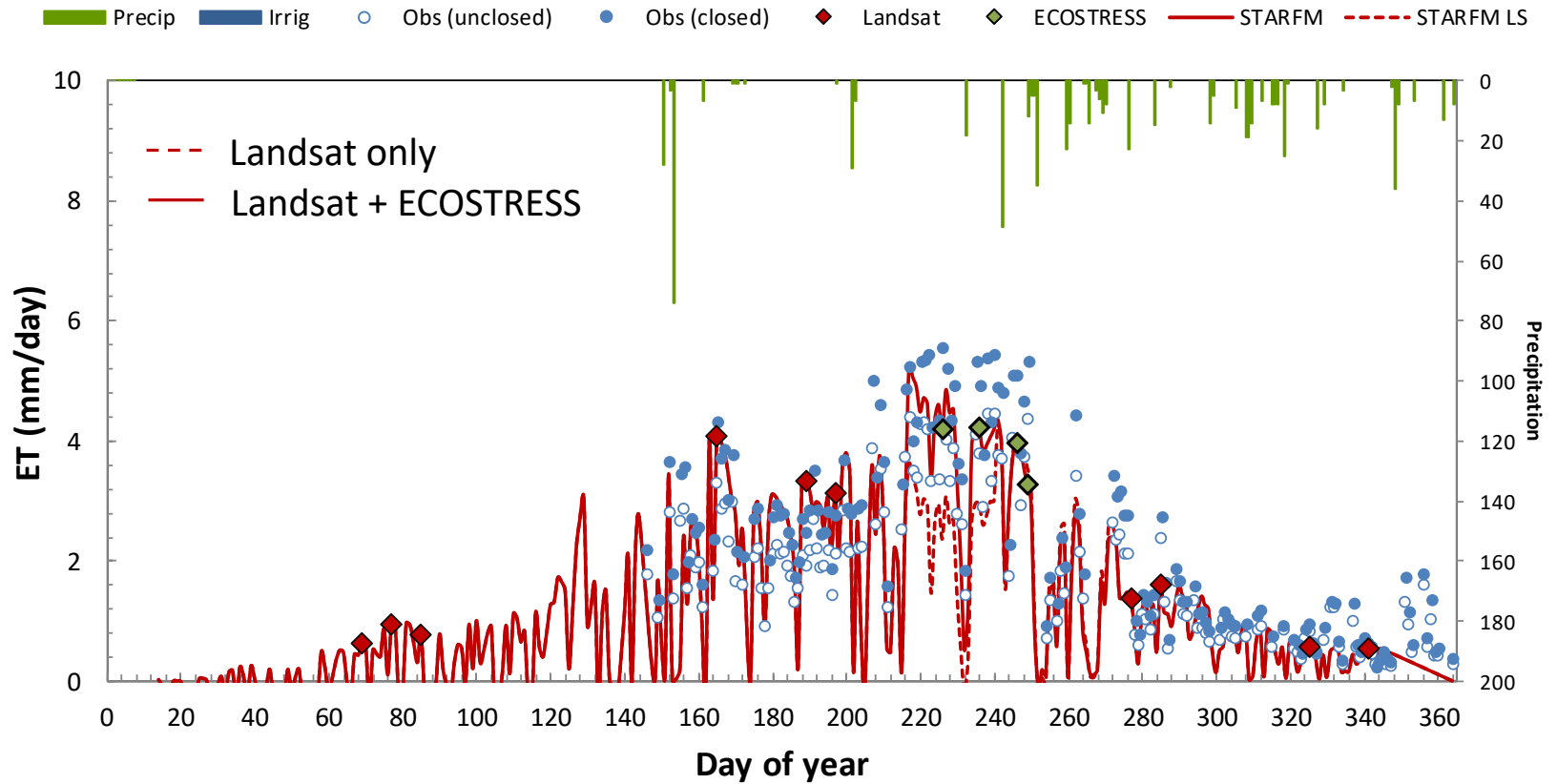
## Beltsville Agricultural Research Center



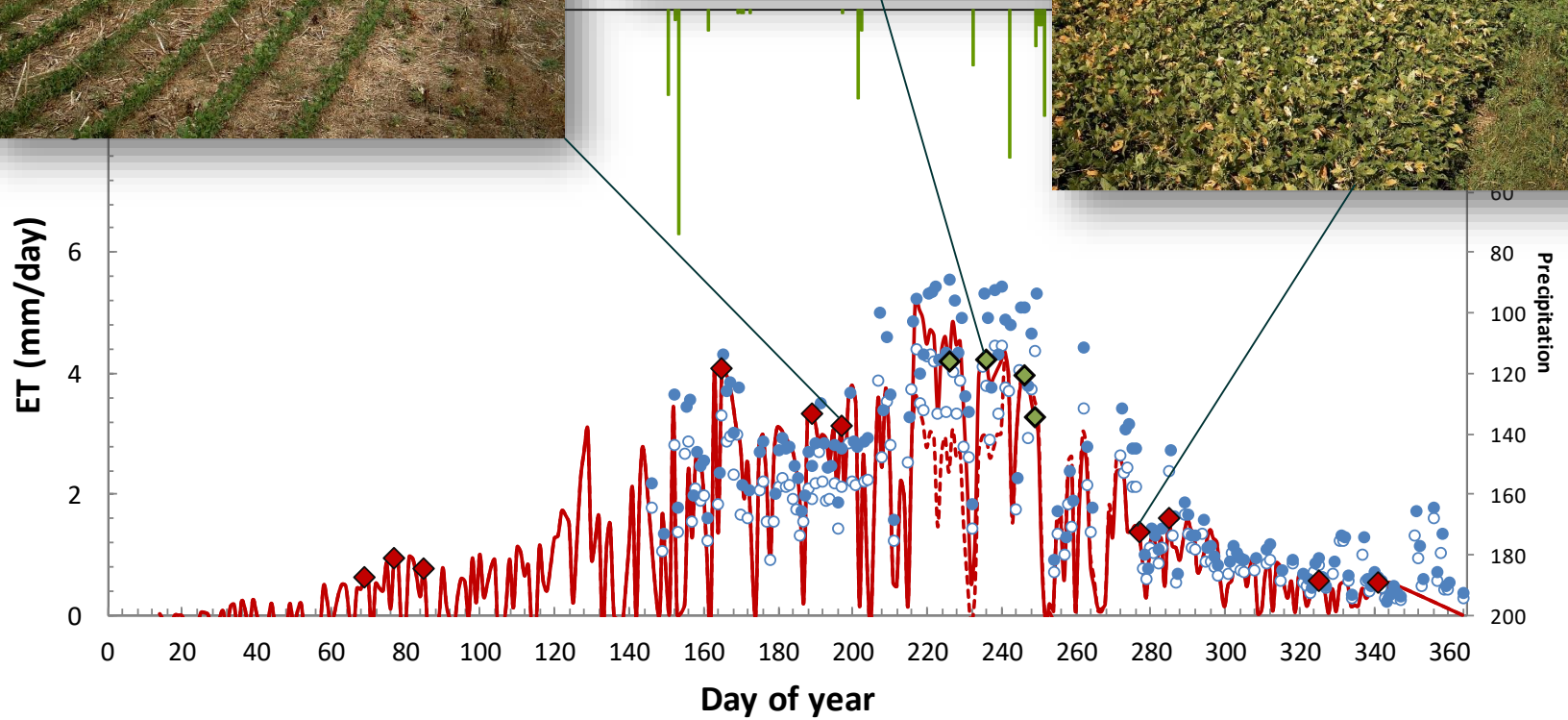
Impacts of enhanced frequency

# OPE3 - soybean

## Beltsville Agricultural Research Center



# Impacts of enhanced frequency



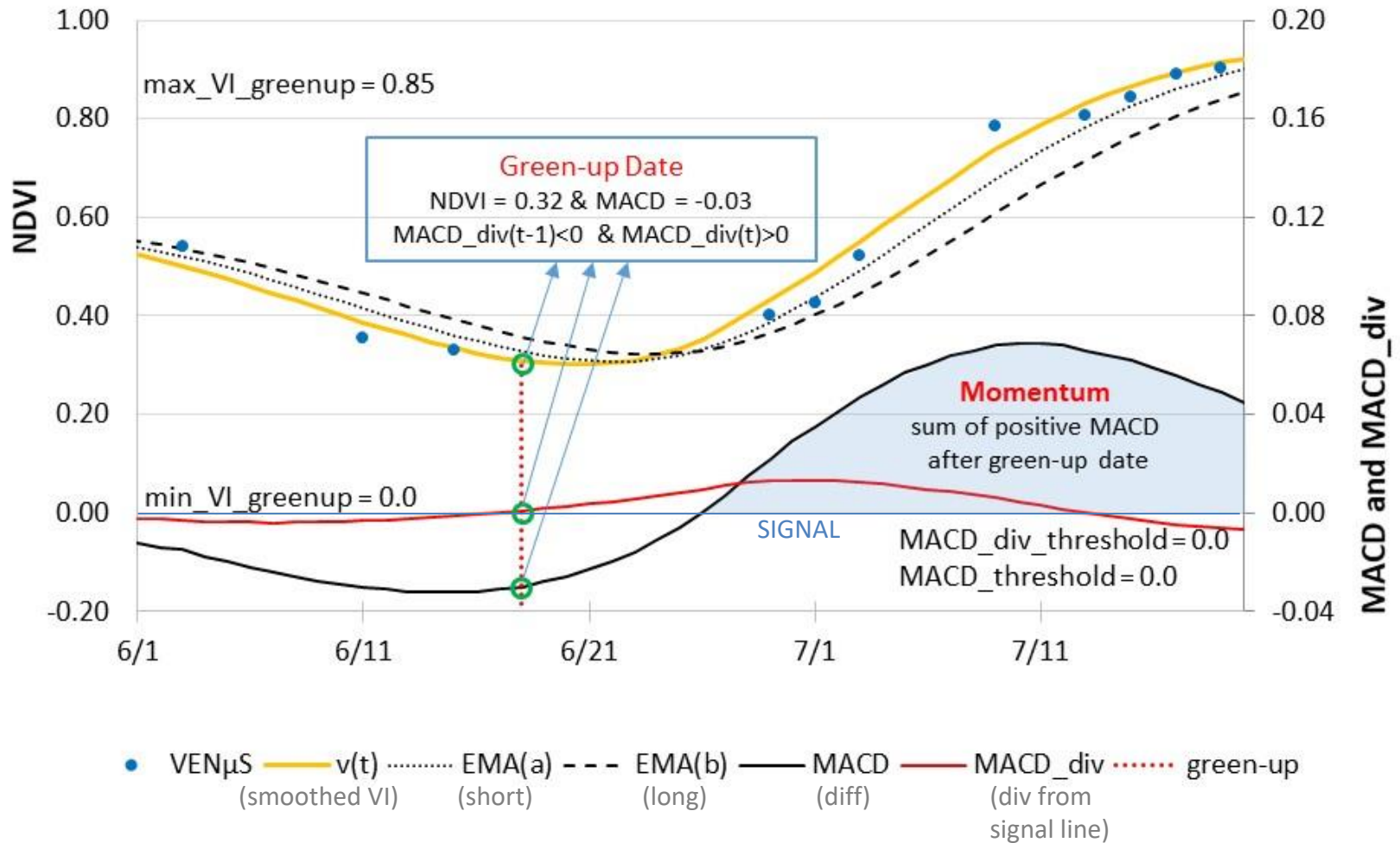


# MULTI-SENSOR PHENOLOGY MAPPING

*... for application within-season*

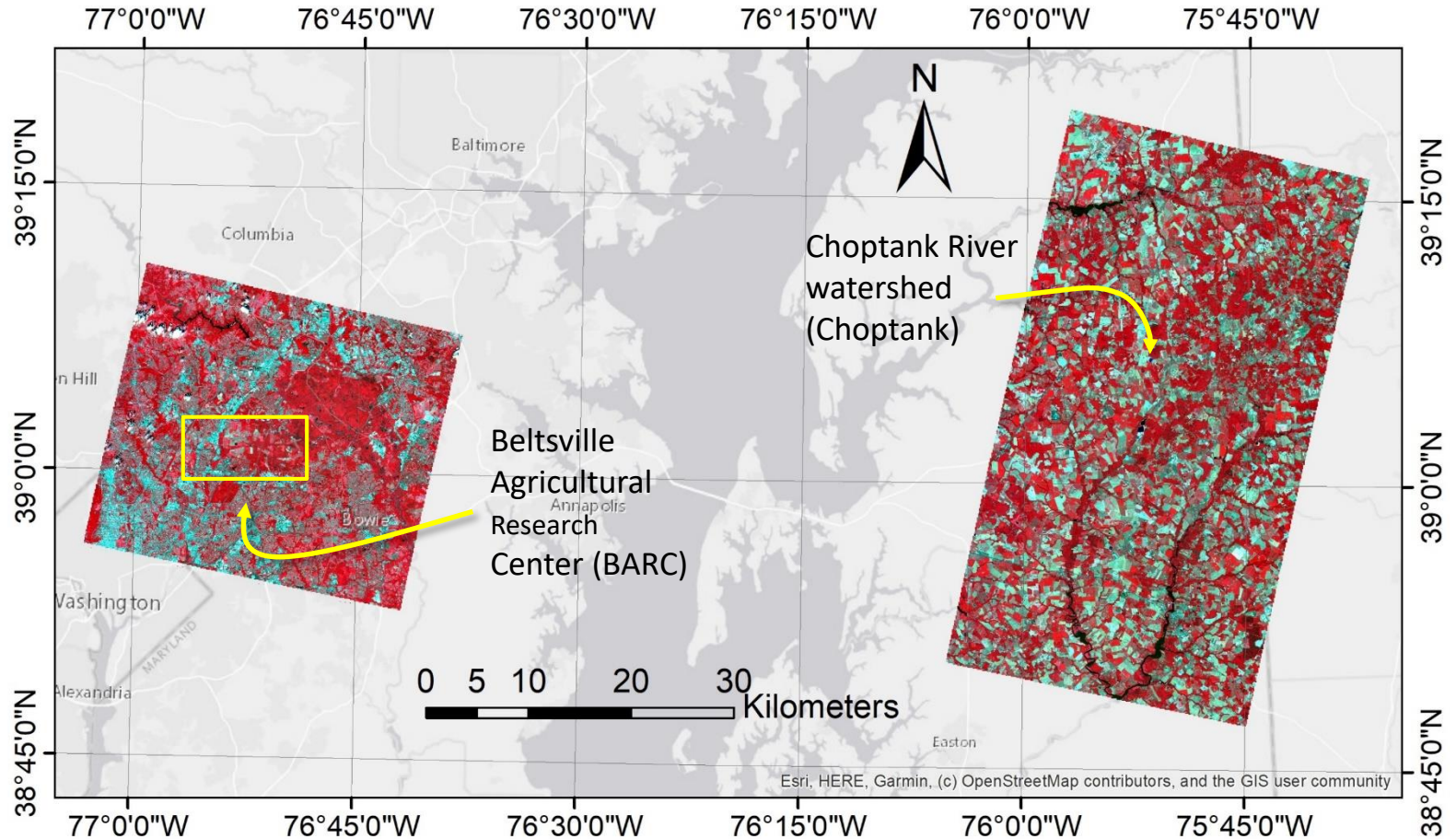


**Step 1: Gap-filling and Smoothing:** Modified Savitzky–Golay  
**Step 2: Extracting Transition Points:** Moving Average Convergence Divergence (MACD) & VI-test



# VENμS and Study Sites

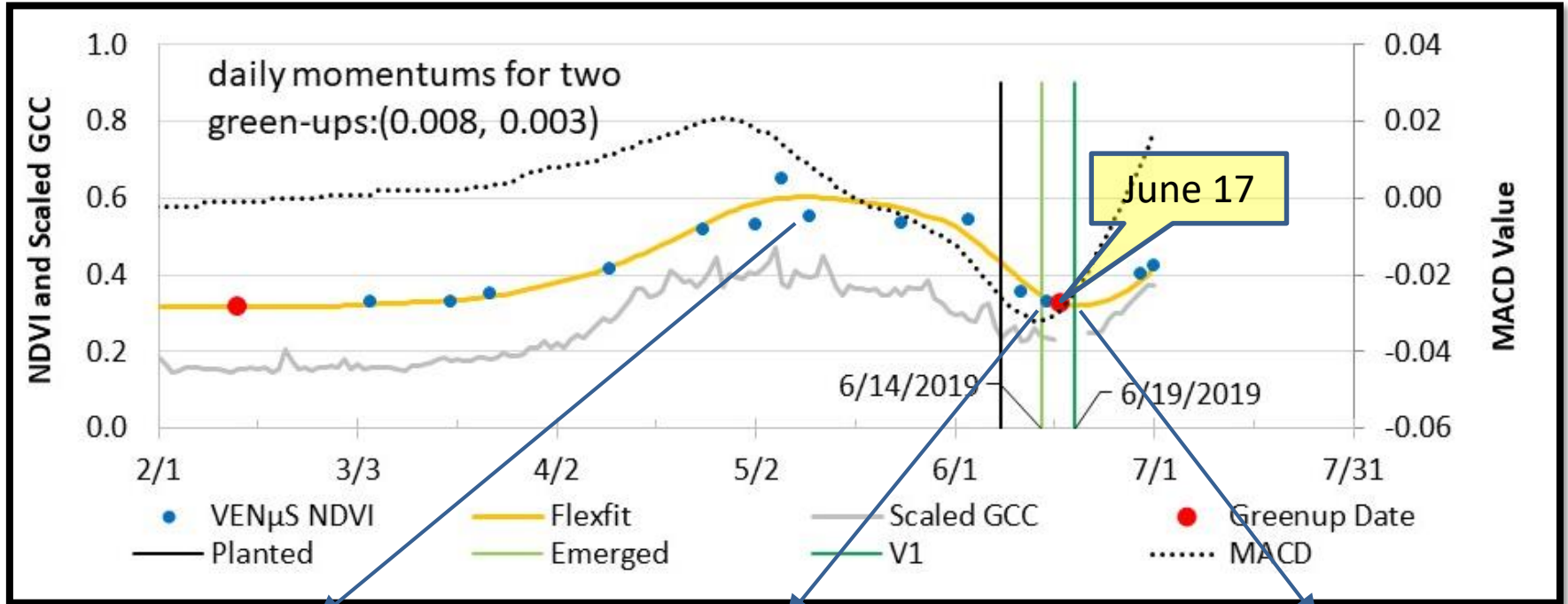
Launch August 2, 2017; Israeli Space Agency & CNES  
Polar Orbit (2-day samples); 12 VNIR bands (5-10 m)



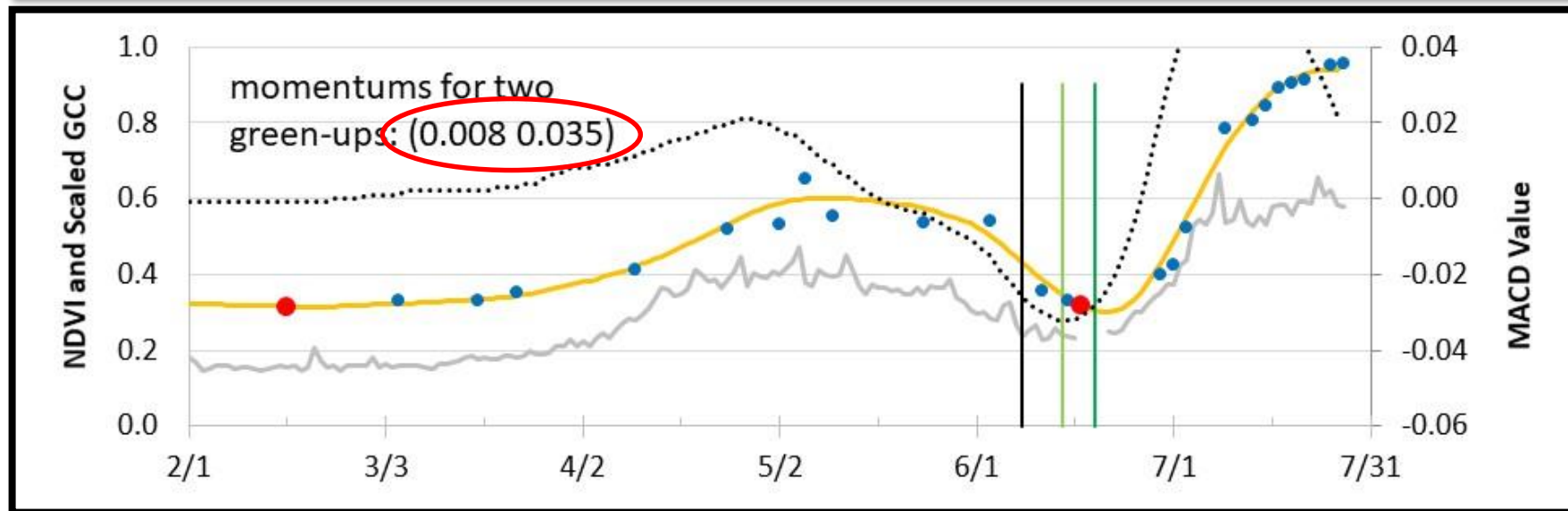
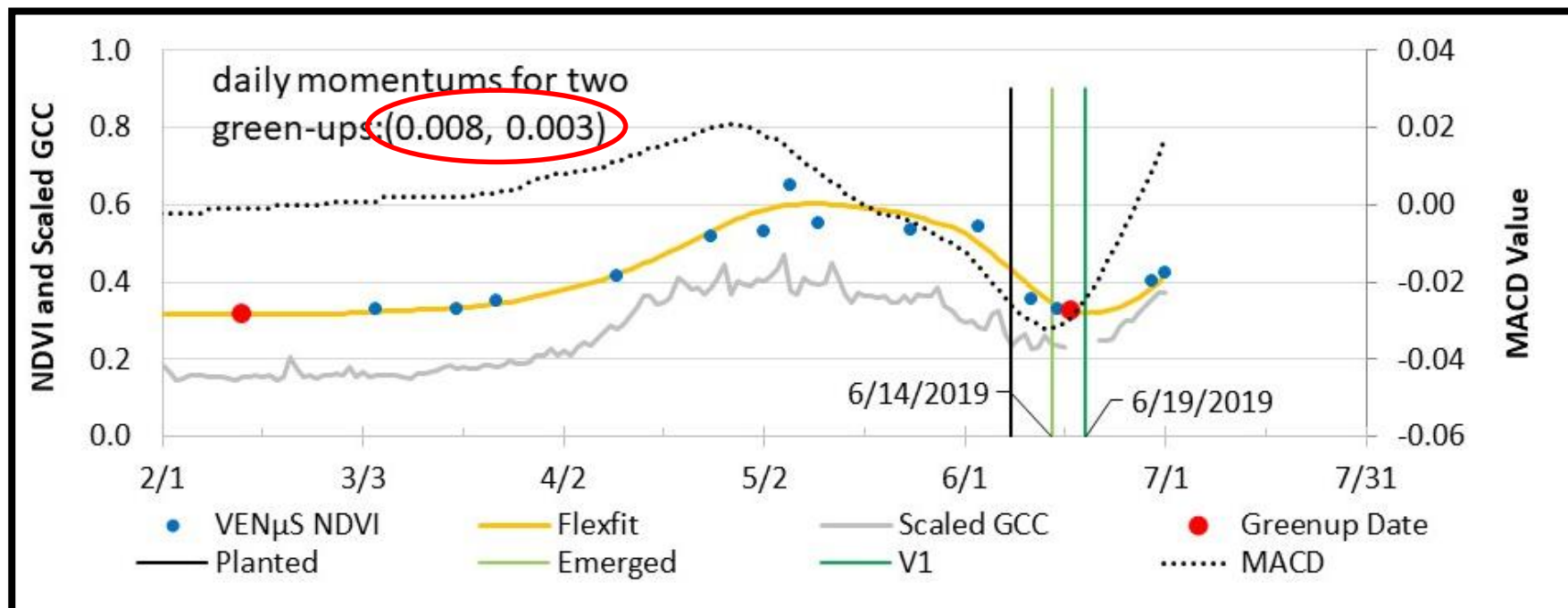
Gao, F., et al. (2020). A within-season approach for detecting early growth stages in corn and soybean using high temporal and spatial resolution imagery. *Remote Sensing of Environment*, 242



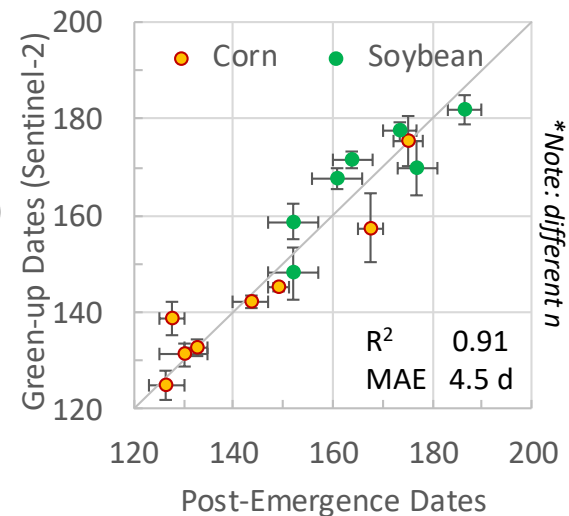
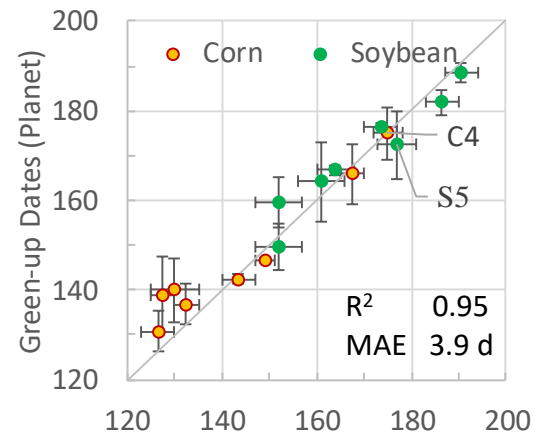
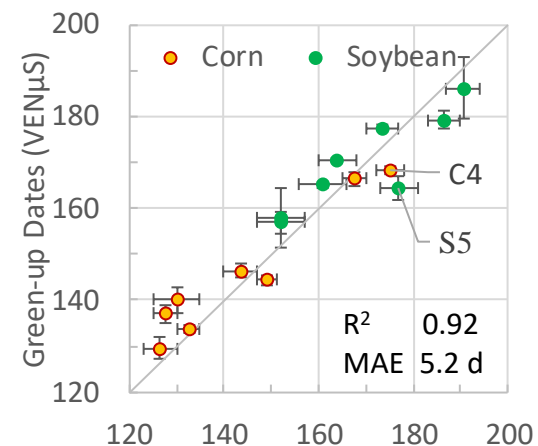
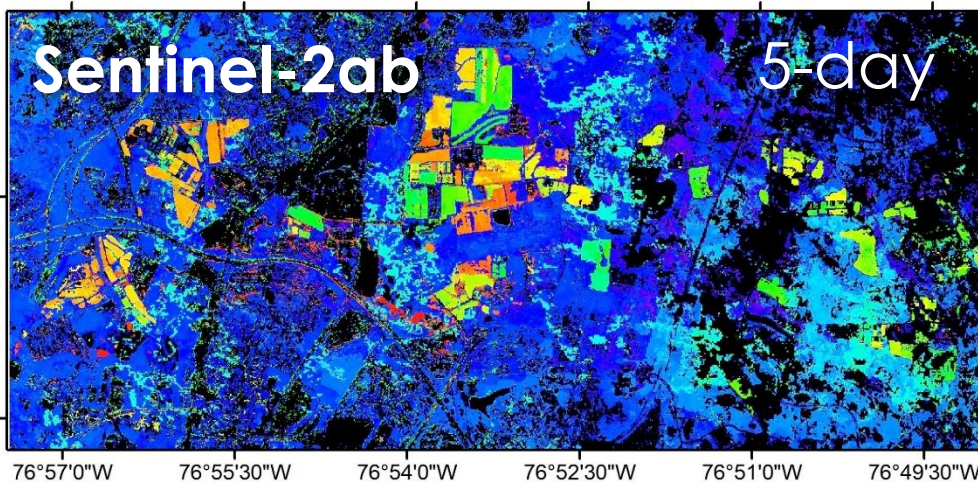
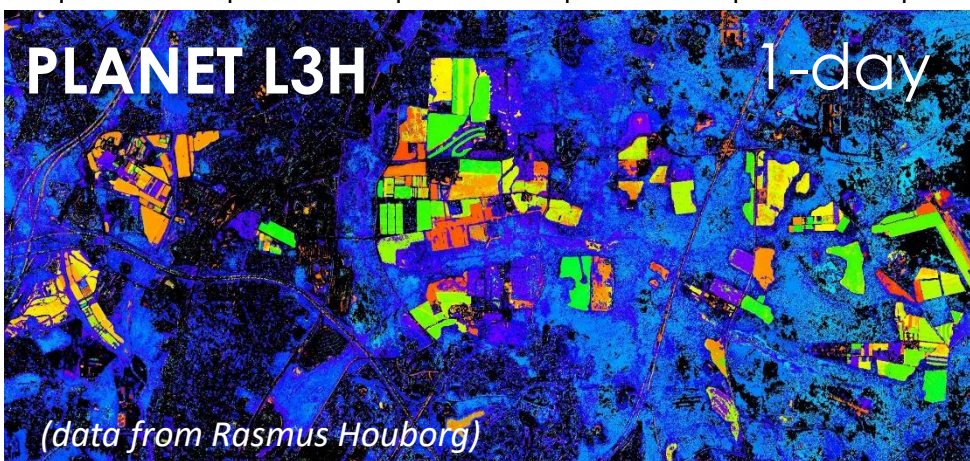
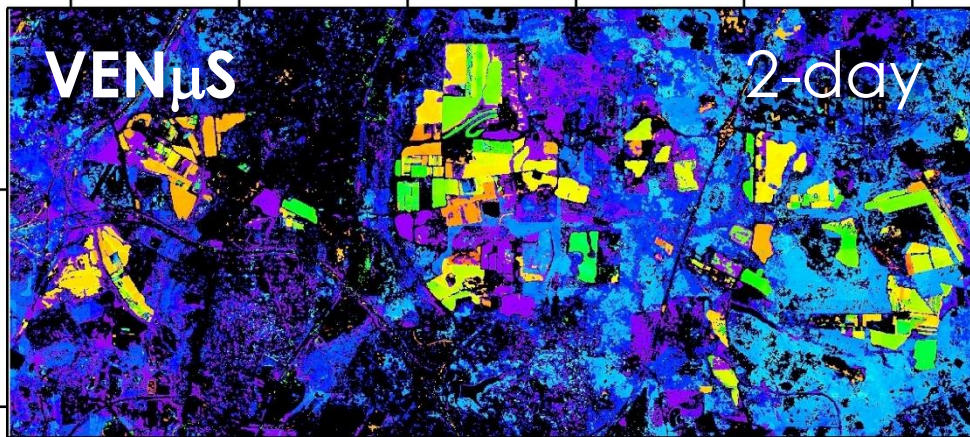
# A corn pixel near the BARC OPE3 Tower Site



# Observations and Green-up Momentum

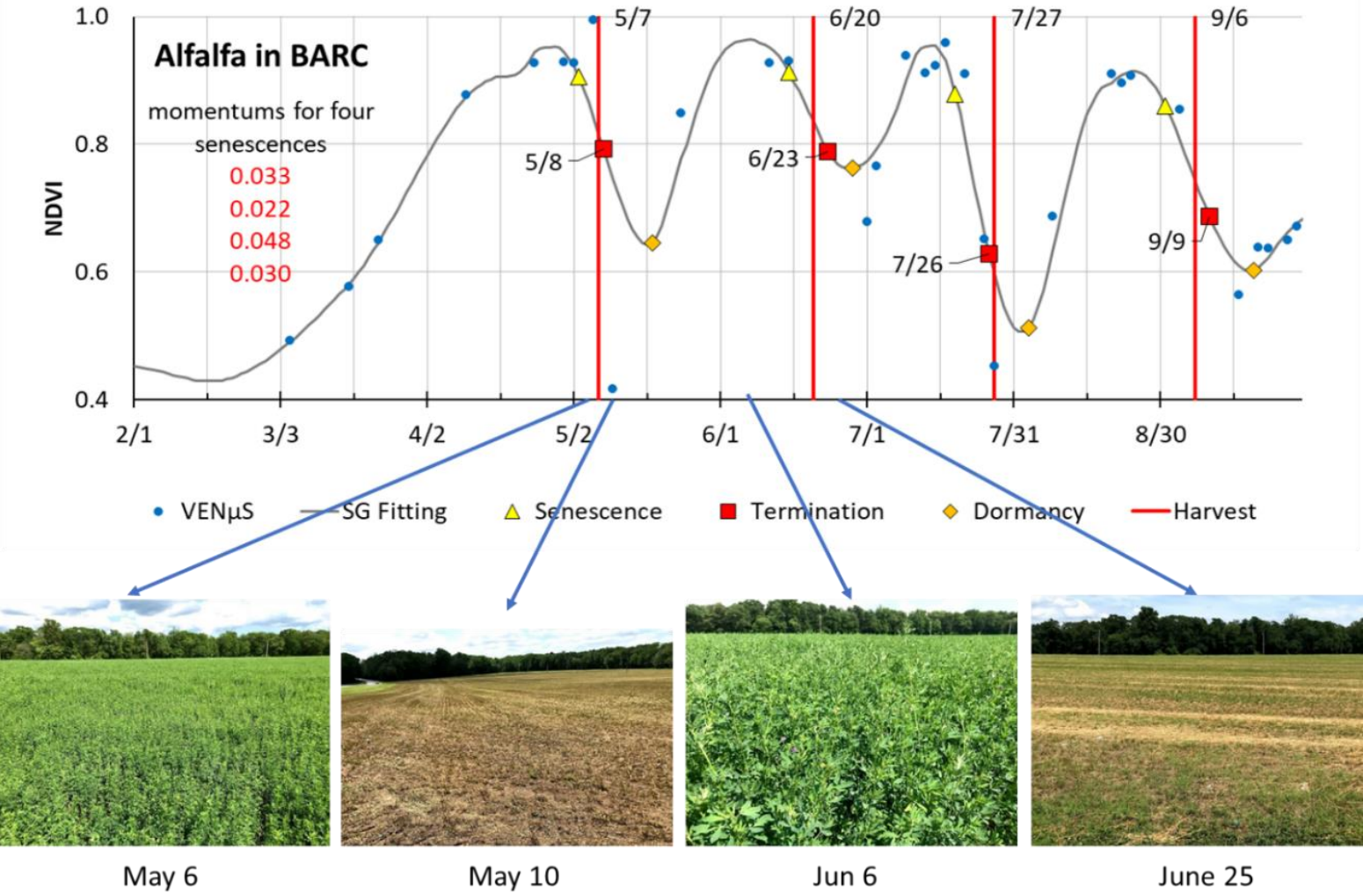






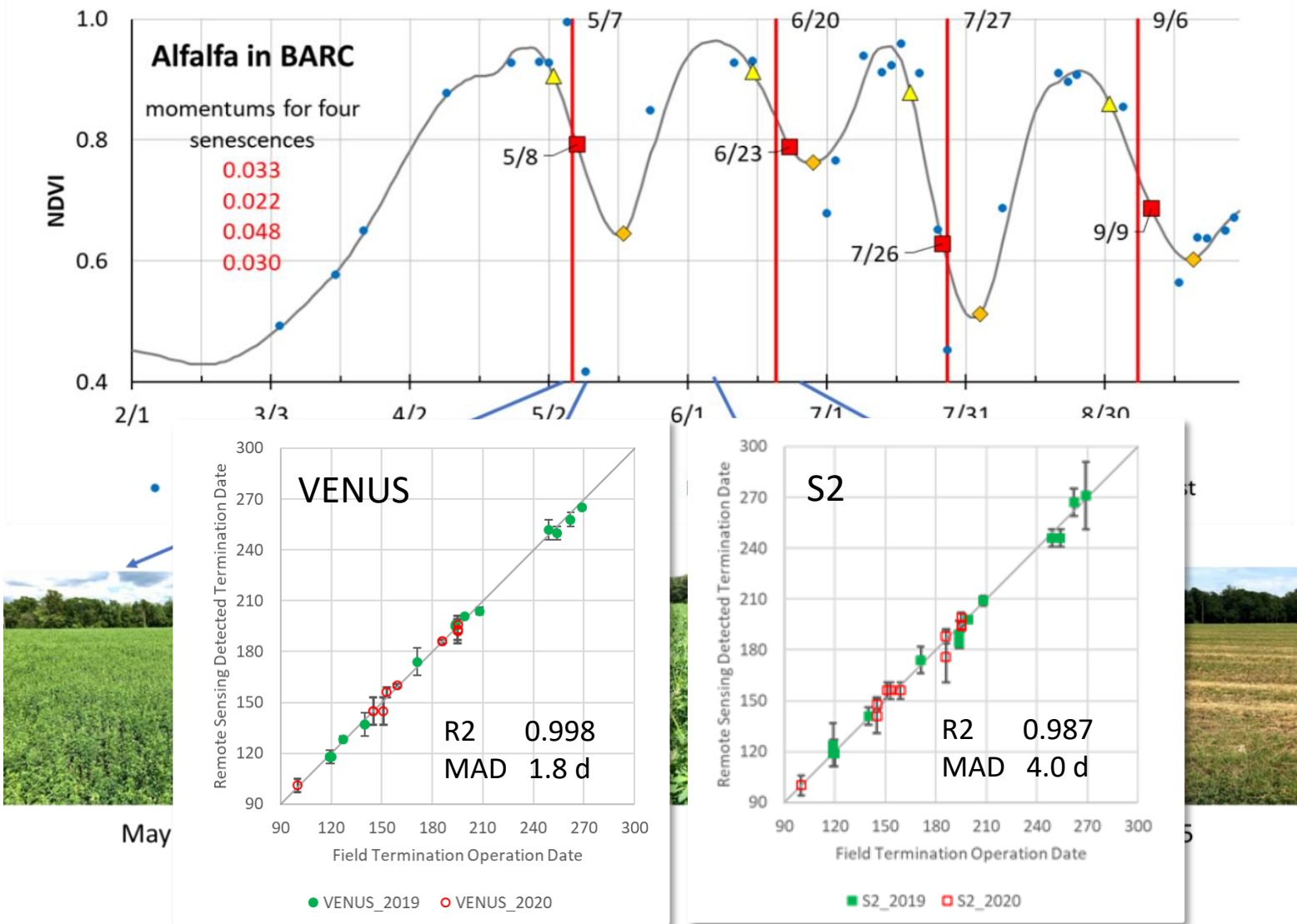


# Alfalfa field in BARC – HARVEST/TERMINATION



Gao, F., Anderson, M.C., & Hively, D. (2020). Detecting crop cover termination within the season using VENμS and Sentinel-2. Remote Sens., in review.

# Alfalfa field in BARC – HARVEST/TERMINATION



Gao, F., Anderson, M.C., & Hively, D. (2020). Detecting crop cover termination within the season using VEN $\mu$ S and Sentinel-2. *Remote Sens.*, in review.

## ***For operational ET monitoring***

- clear value in increased overpass frequency
- consistent resolution/registration over image
  - ➔ ECOSTRESS view angle  $< 20^\circ$ , VIIRS  $< 50^\circ$
- near-simultaneous TIR and VSWIR acquisition
- robust cloud/cloud shadow mask is critical

## ***For operational phenology mapping***

- high frequency (S2a+b may not be enough)
- good consistency/harmonization critical
- 10m captures more fields than 30m