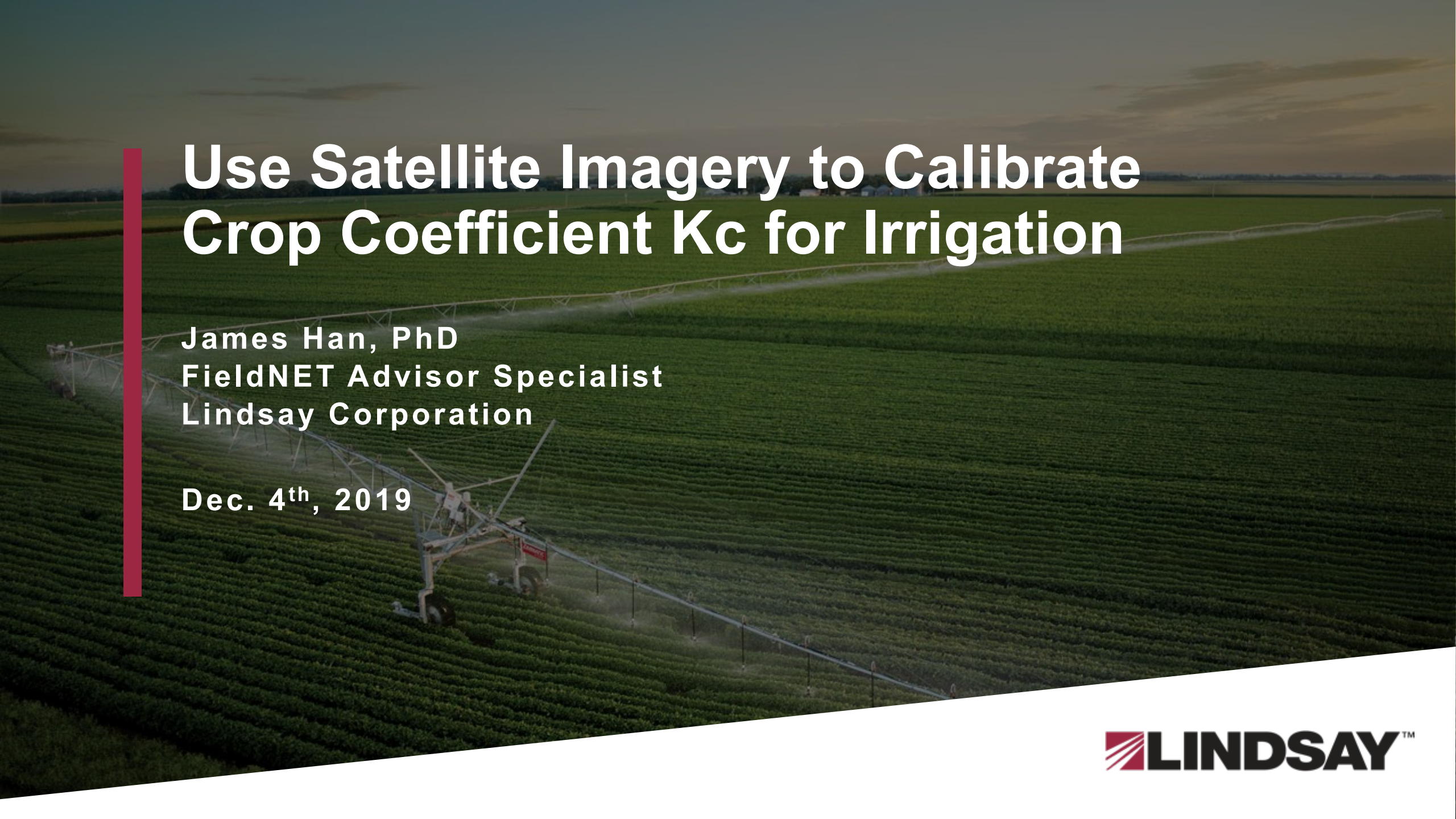

Use Satellite Imagery to Calibrate Crop Coefficient Kc for Irrigation

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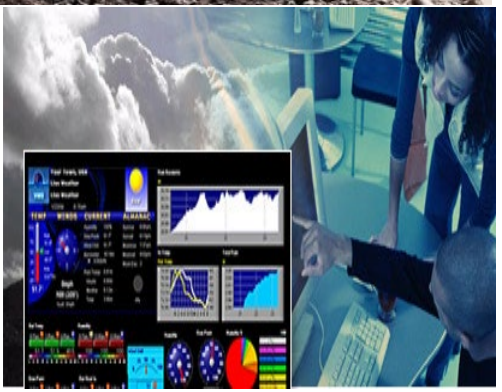
Dec. 4th, 2019

LINDSAY™

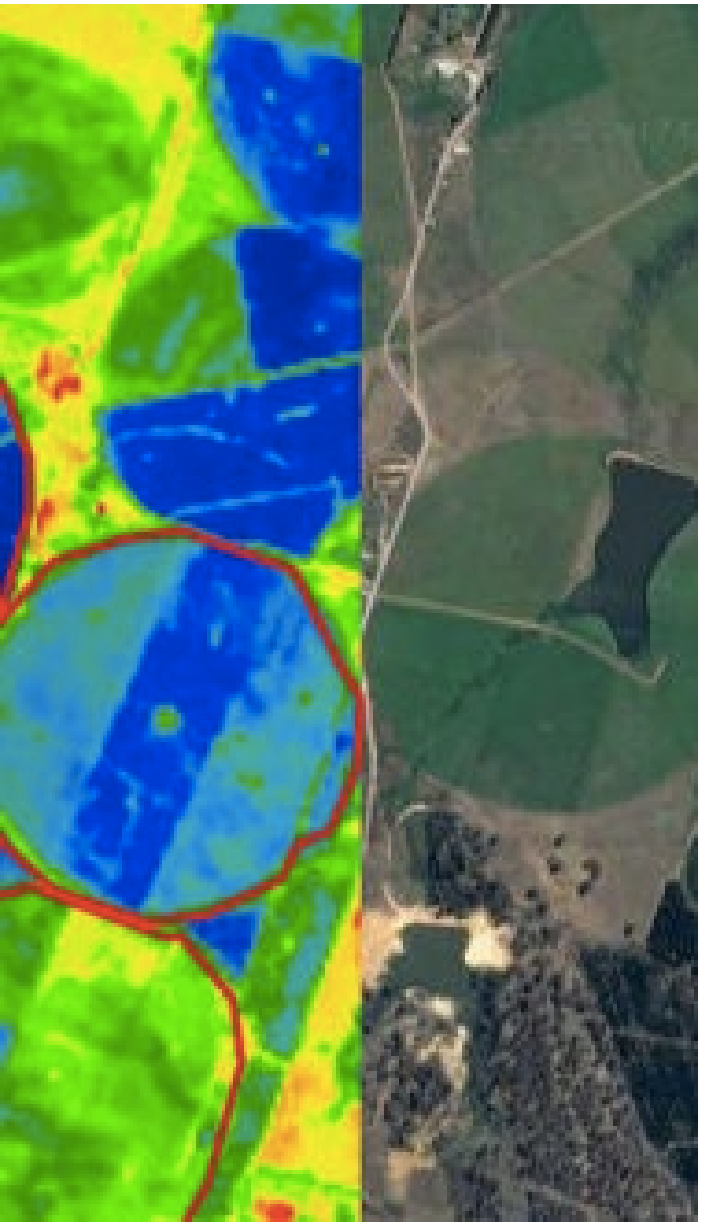
Objectives

- Challenges and opportunities
- Vegetation indices based crop coefficient
- Crop coefficient on irrigation management



Challenges

- **Conventional irrigation decision making:**
  - Real-time field observation (e.g. hand feel soil),
  - Soil moisture probe,
  - Virtual weather
- **Satellite imagery**:
  - Minimum one day delay, usually several days behind



Challenges

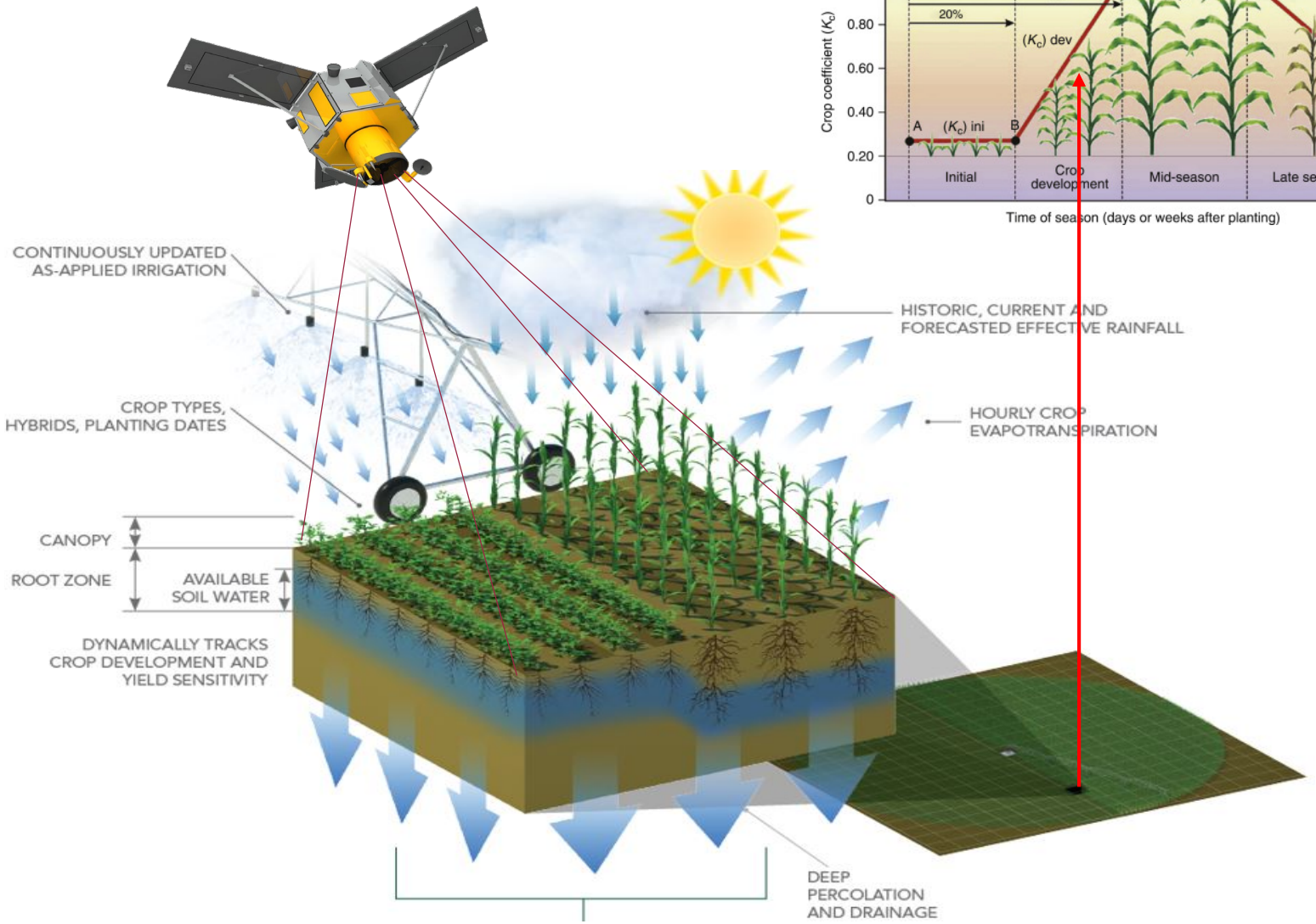
Imagery sources

Satellite	Resolution	Frequency
Landsat 8	30 meters	16 days*
Sentinel 2A/2B	10 meters	5 days*
High resolution	3 meters	1 day (multiple)

*Frequency may vary depending on the location of the field

Opportunities:

Use satellite imagery to facilitate irrigation

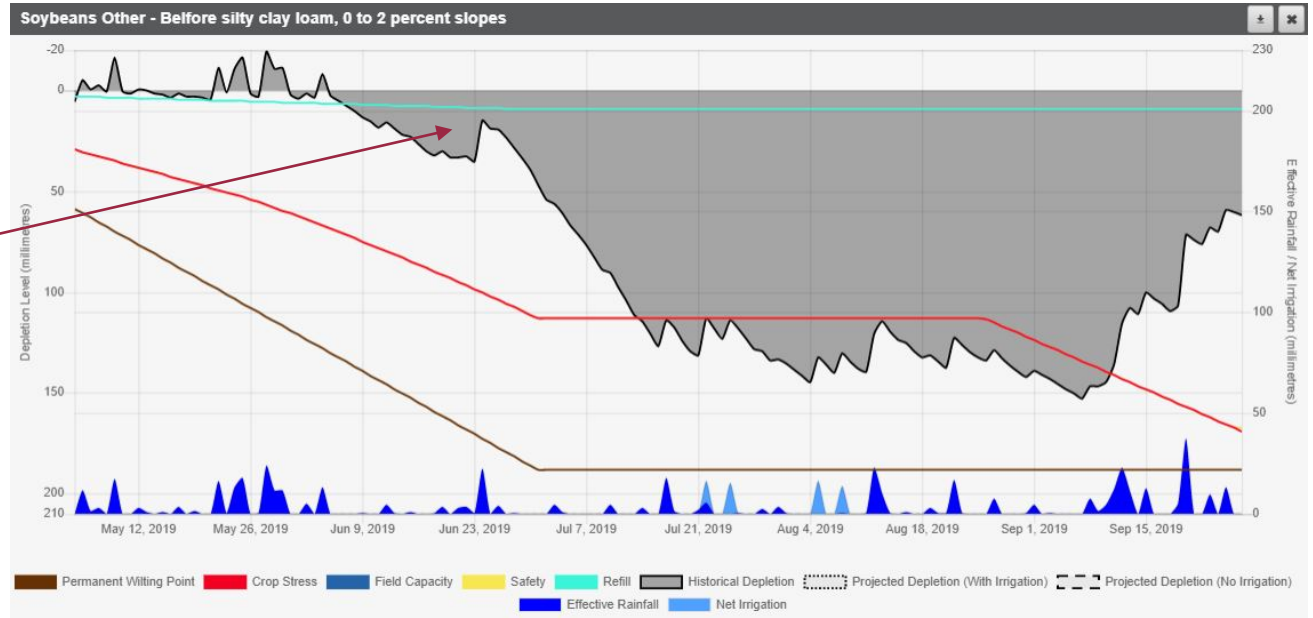


$$ET_c = ETo \times Kc$$

Vegetation indices based crop coefficient

An example:


The enhanced vegetation index (EVI) is an optimized vegetation index that is designed to be more responsive to crop canopy variations and leaf area index (LAI), which play an important role in irrigation management and crop water usage.
County Road 13


Soybeans Other - Belfore silty clay loam, 0 to 2 percent slopes
Depletion Level (millimetres)
Effective Rainfall / Net Irrigation (millimetres)
-20
0
50
100
150
200
210
230
200
150
100
50
0
May 12, 2019
May 26, 2019
Jun 9, 2019
Jun 23, 2019
Jul 7, 2019
Jul 21, 2019
Aug 4, 2019
Aug 18, 2019
Sep 1, 2019
Sep 15, 2019
Permanent Wilting Point
Crop Stress
Field Capacity
Safety
Refill
Historical Depletion
Projected Depletion (With Irrigation)
Projected Depletion (No Irrigation)
Effective Rainfall
Net Irrigation

Materials and Methods

Data source: Two years

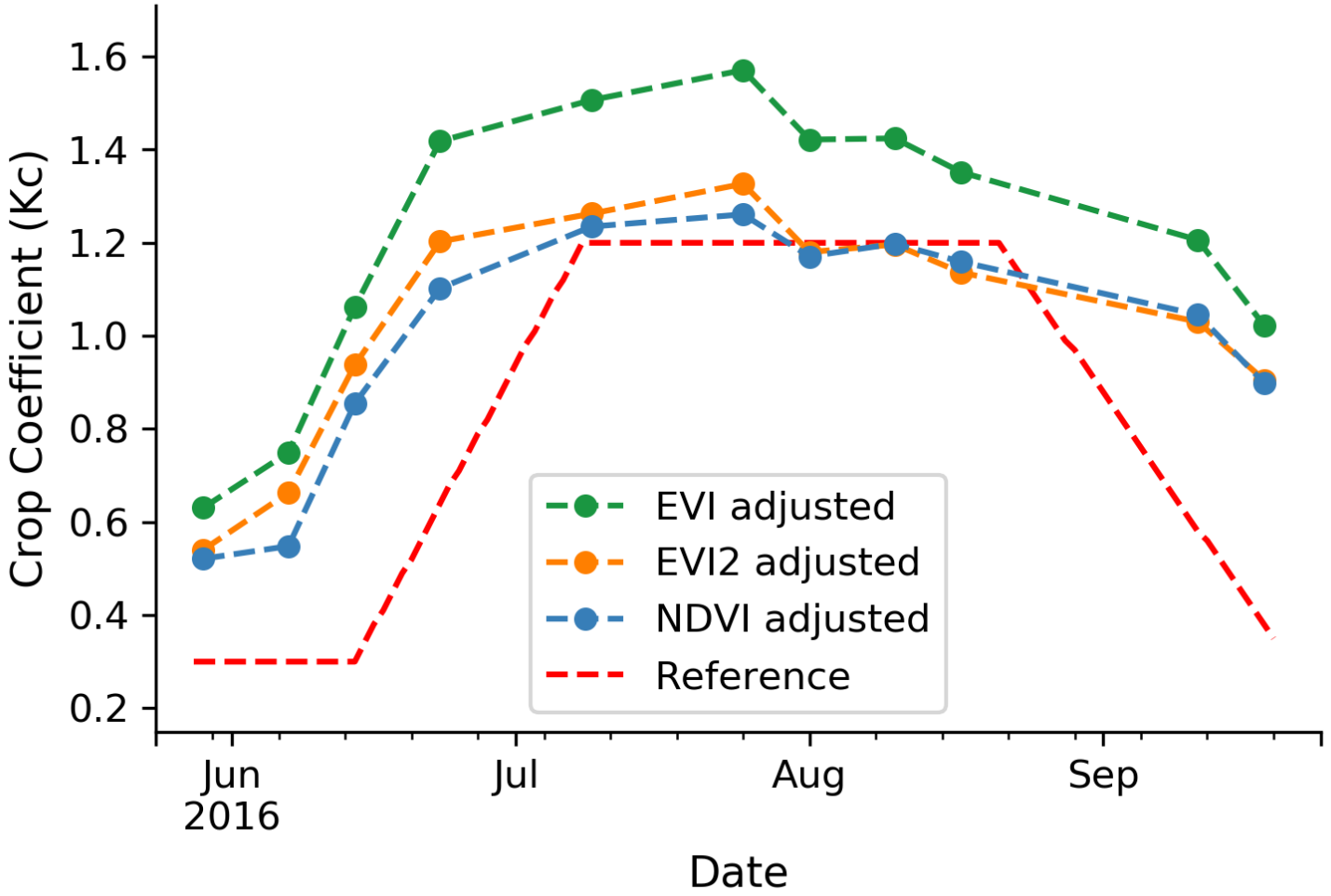
Crop type: Corn and Soybean

Location: O'Neil, Oakland, NE

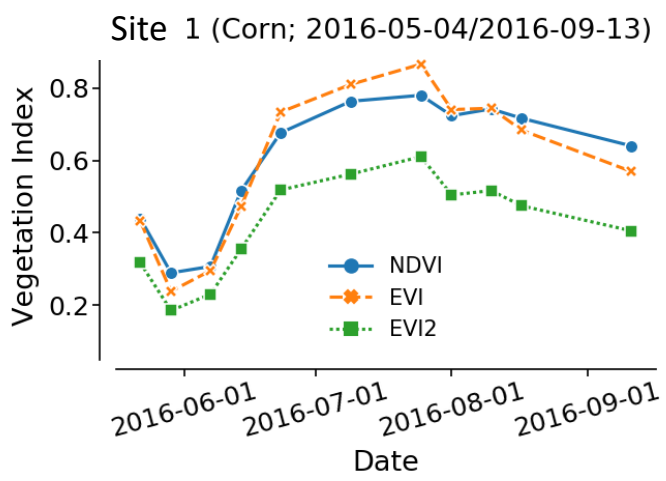
Methods: 3-4 fields for each crop type, collection imageries for season

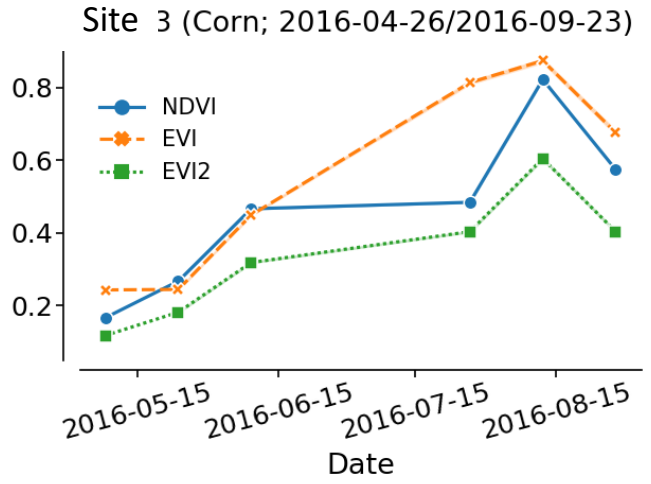
Results: Vegetation indices include EVI, EVI2, NDVI → Crop Coefficient (Kc)

Adjusted VI based Kc vs. reference Kc

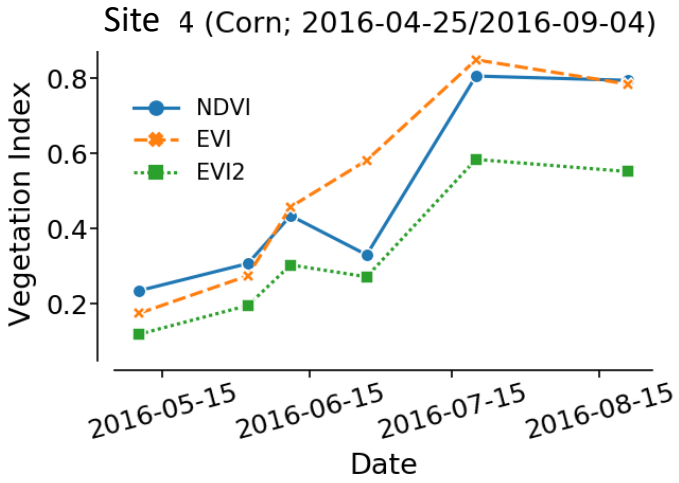


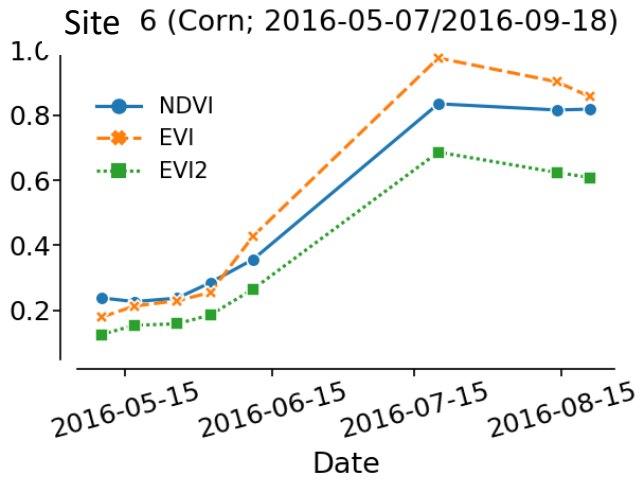
2016 corn field vegetation indices



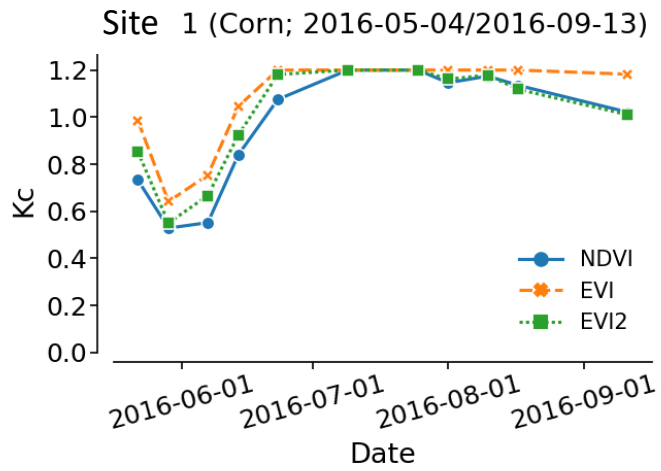


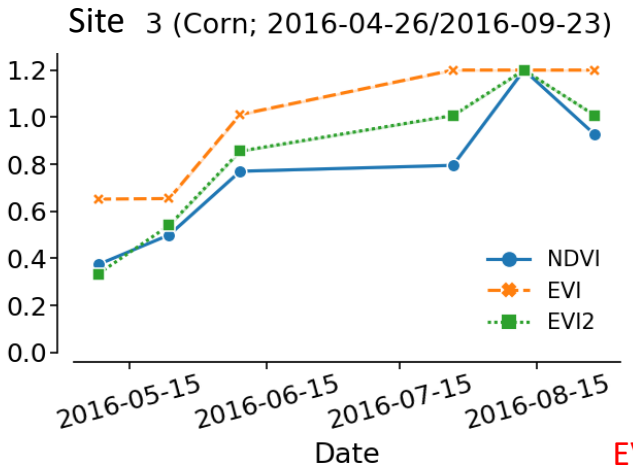
EVI > NDVI > EVI2



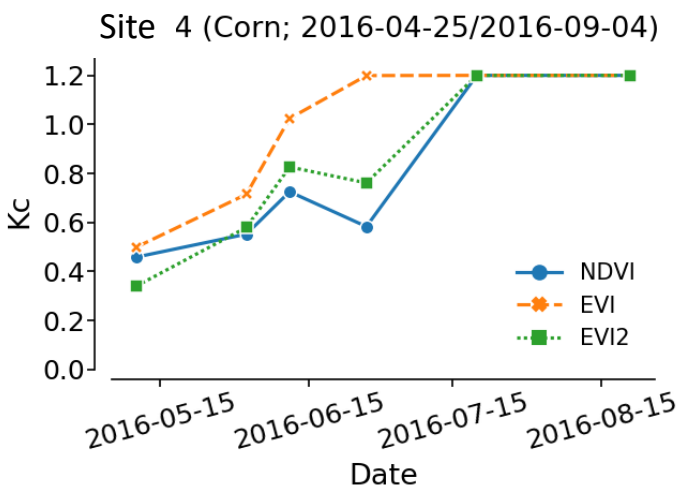


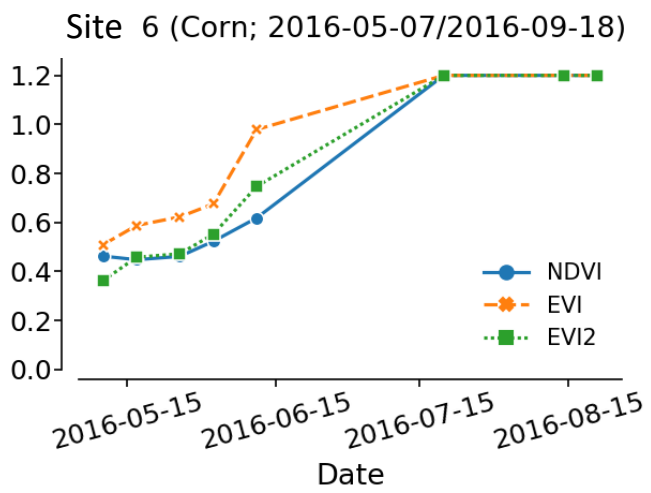
2016 corn field crop coefficient



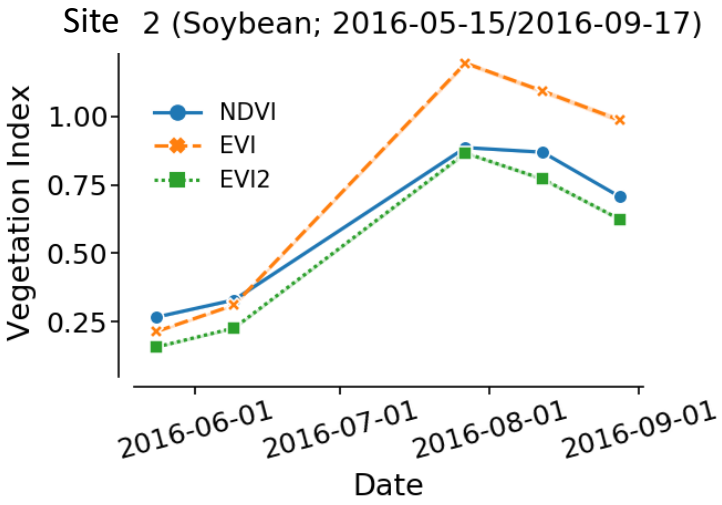


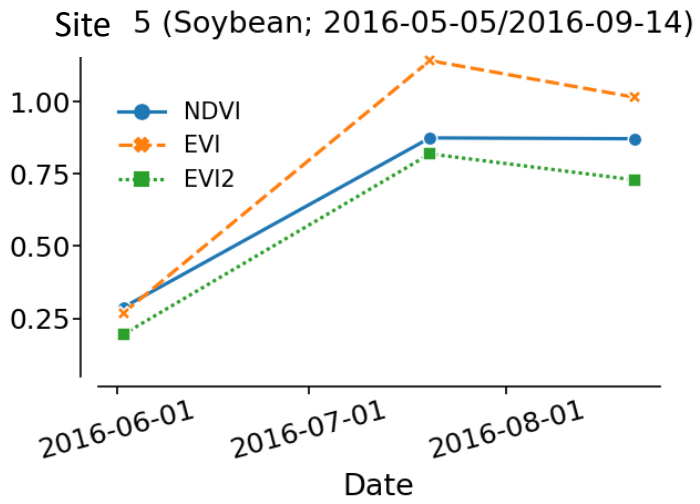
EVI_Kc > EVI2_Kc > NDVI_Kc

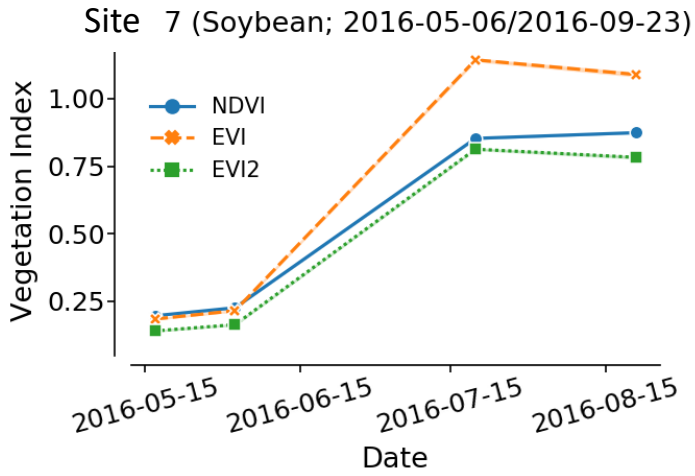




2016 soybean field vegetation indices

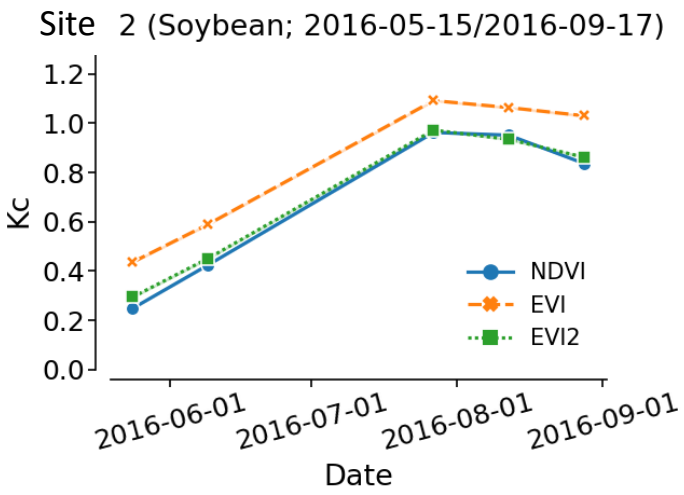


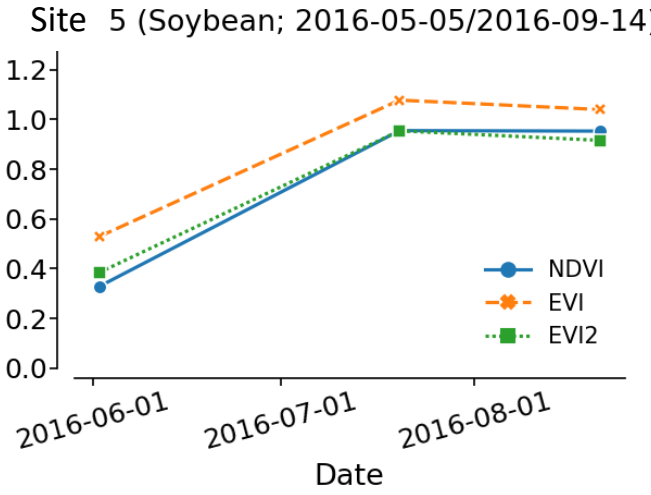


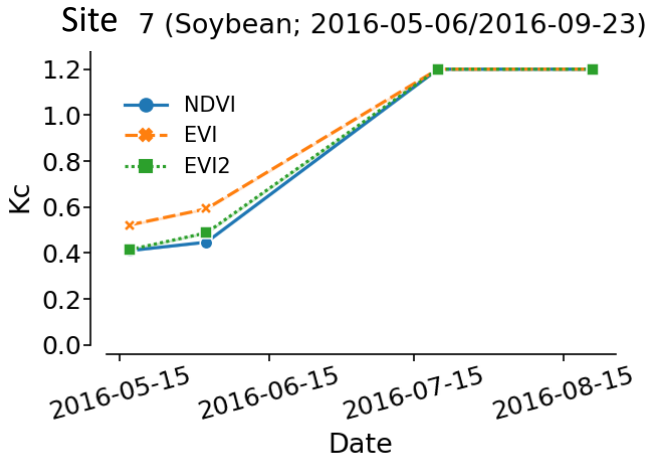


EVI > NDVI >= EVI2

2016 soybean field crop coefficient

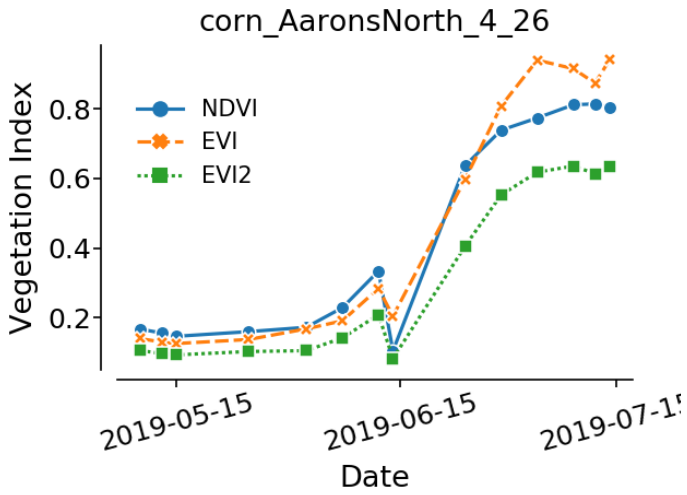


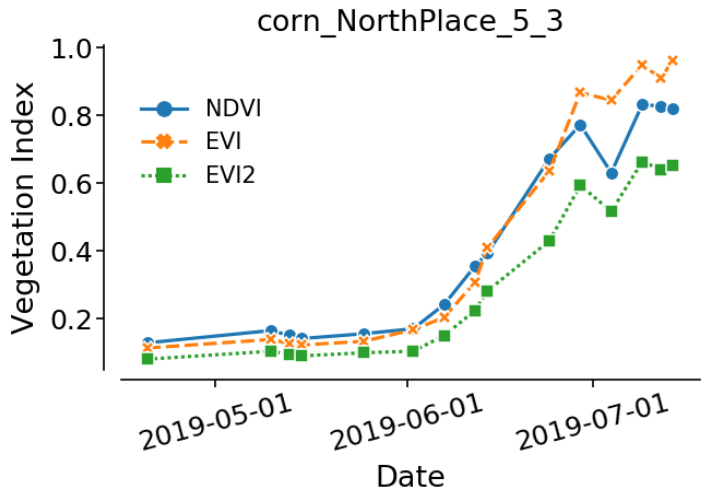


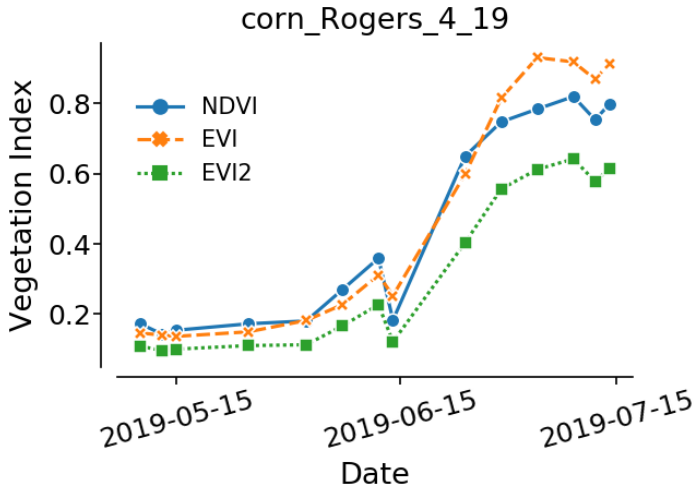


EVI_Kc > EVI2_Kc = NDVI_Kc

2019 corn field vegetation indices

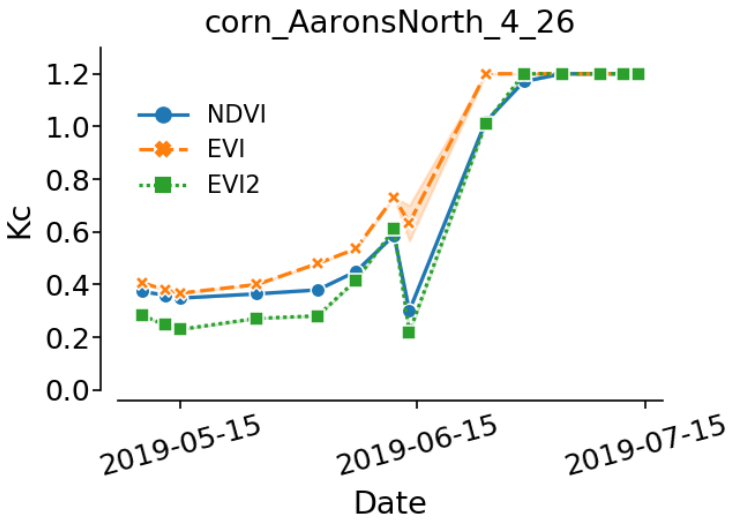


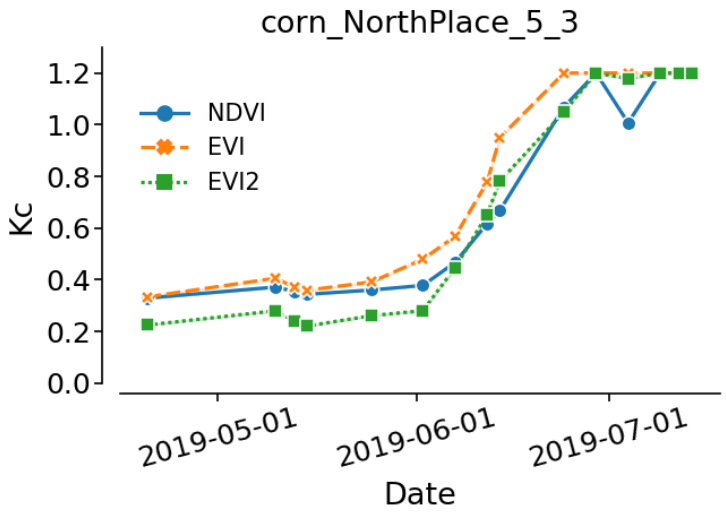


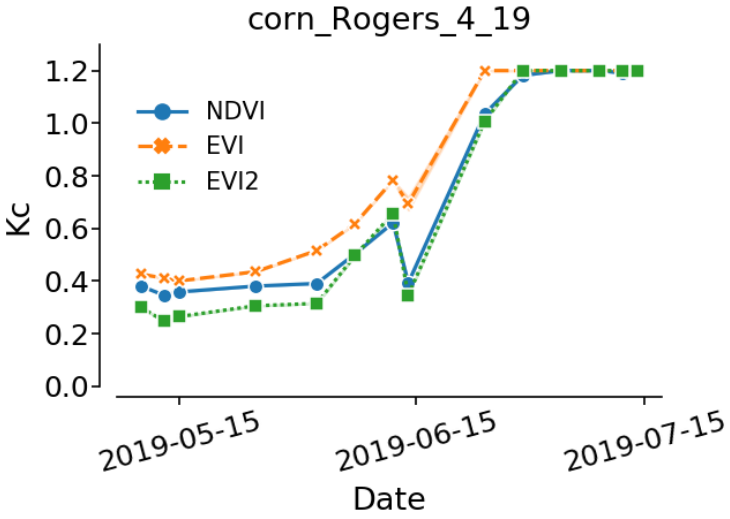


EVI > NDVI > EVI2

2019 corn field crop coefficient

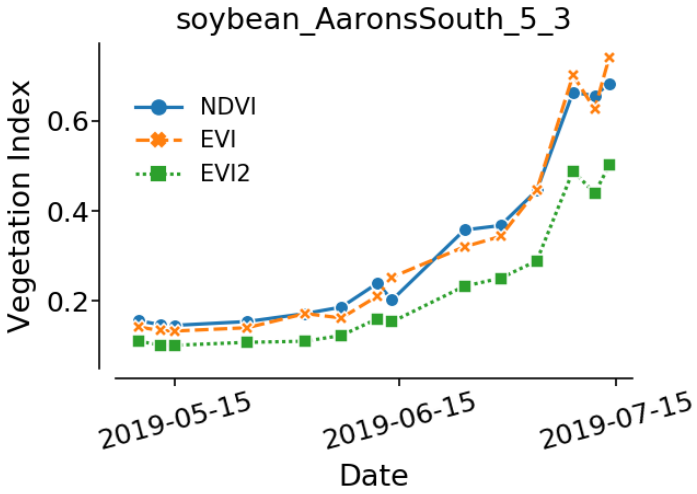


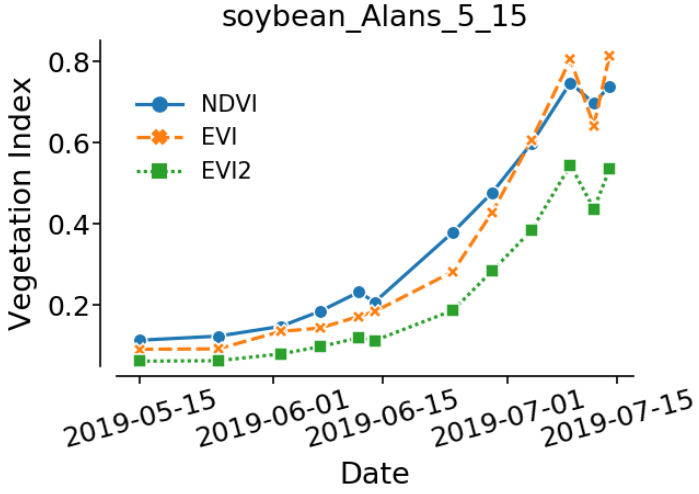


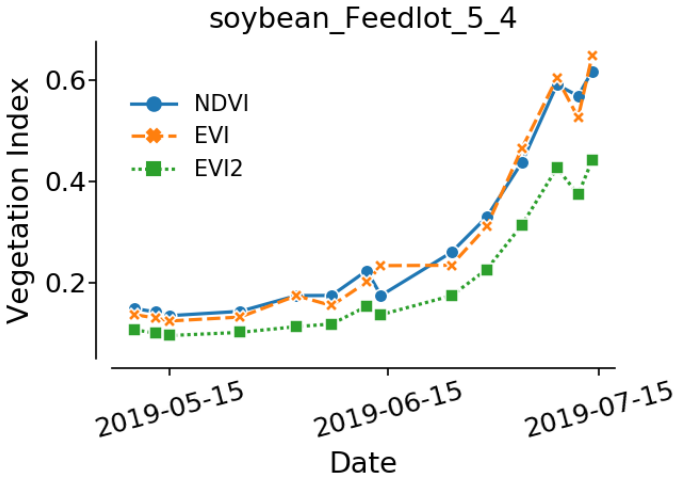


EVI > NDVI > EVI2

2019 soybean field vegetation indices

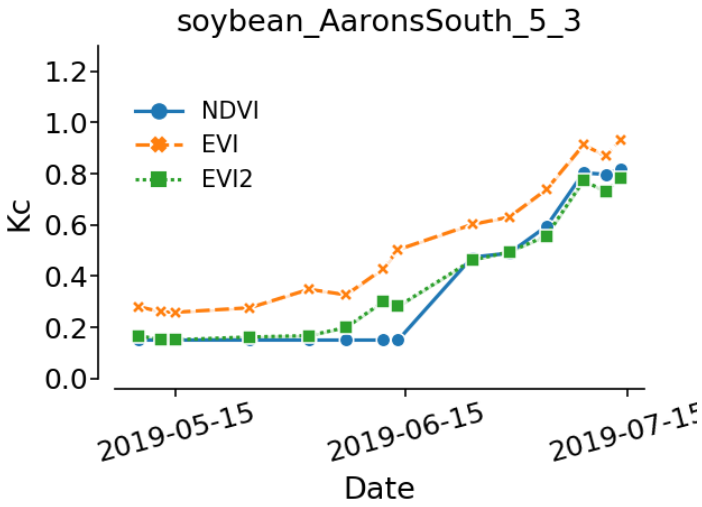


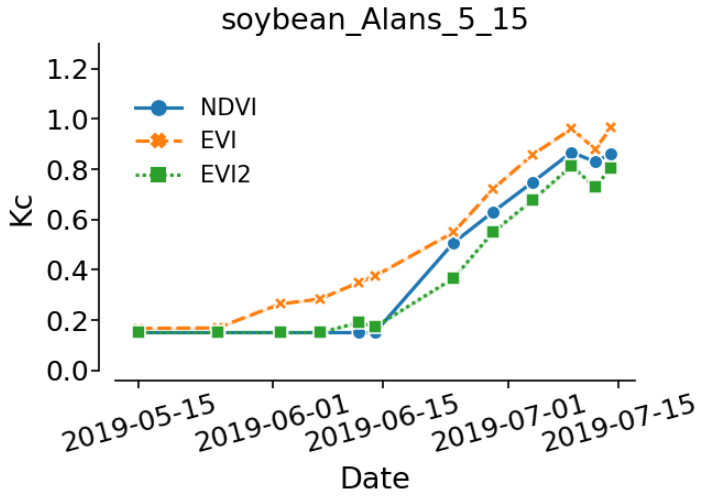


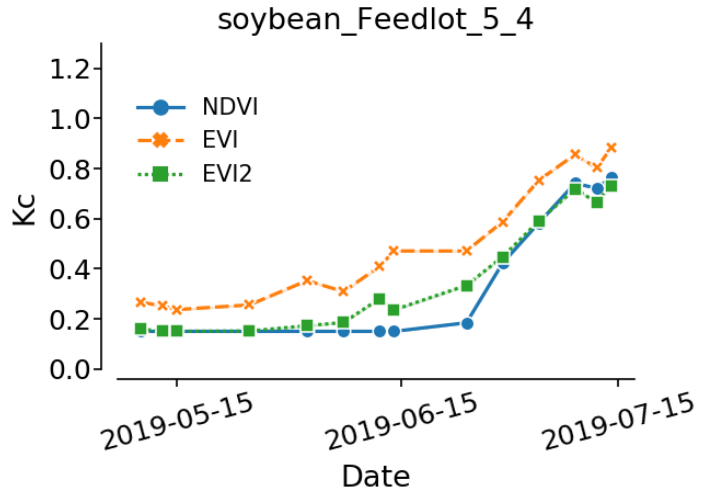


EVI = NDVI > EVI2

2019 soybean field crop coefficient







EVI > NDVI >= EVI2

Vegetation indices and crop coefficient pattern

Vegetation indices

- EVI > NDVI > EVI2
- EVI tends to have the greatest value

Crop coefficient Kc

- EVI > NDVI > EVI2
- EVI based Kc has the greatest value while NDVI and EVI2 are similar

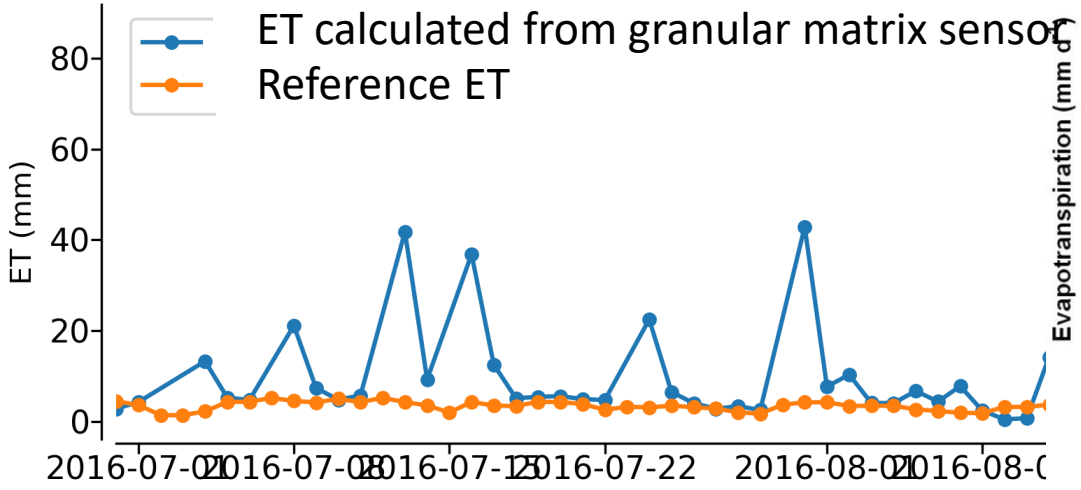
The vegetation index and crop coefficient pattern are not limited by a crop type

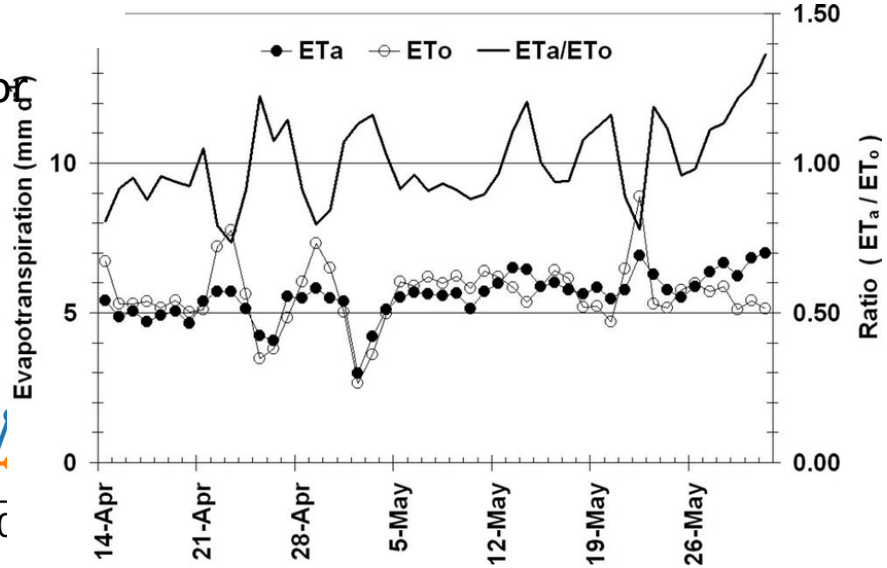
Comparison of ET

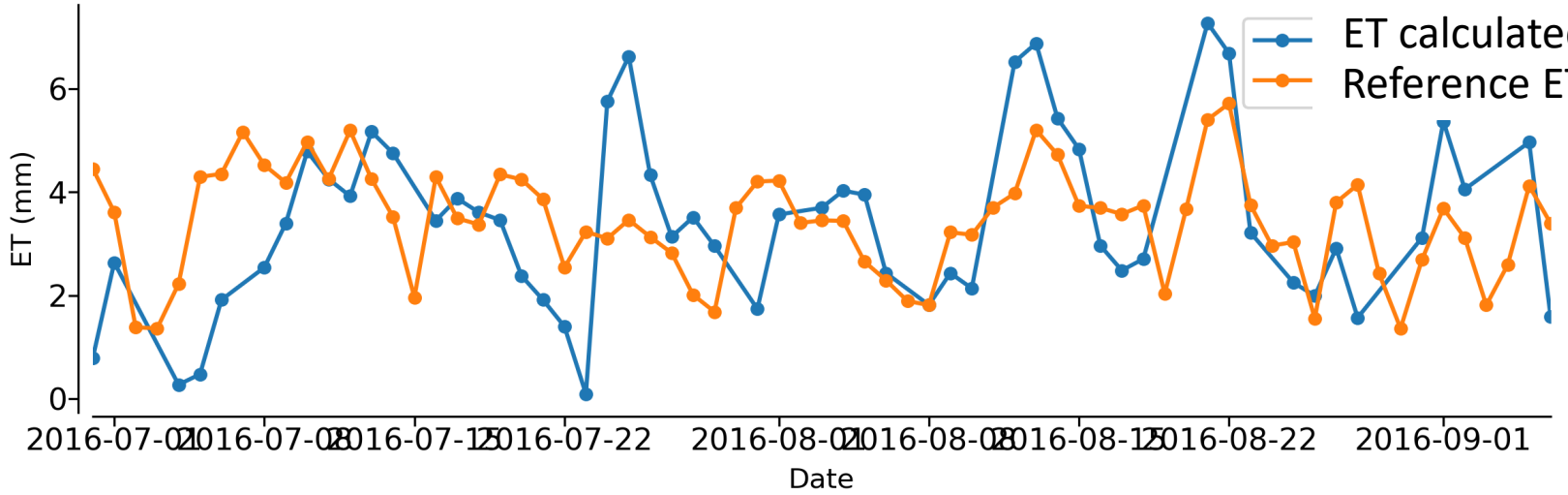
Calculate the “actual ET” value from soil moisture sensor to compare with the predict ET values from the model to evaluate the adjusted crop coefficient

$$ET_{today} = (WC_{yesterday} + Irrigation_{today} + Rainfall_{today}) - WC_{today}$$

Comparison of ET





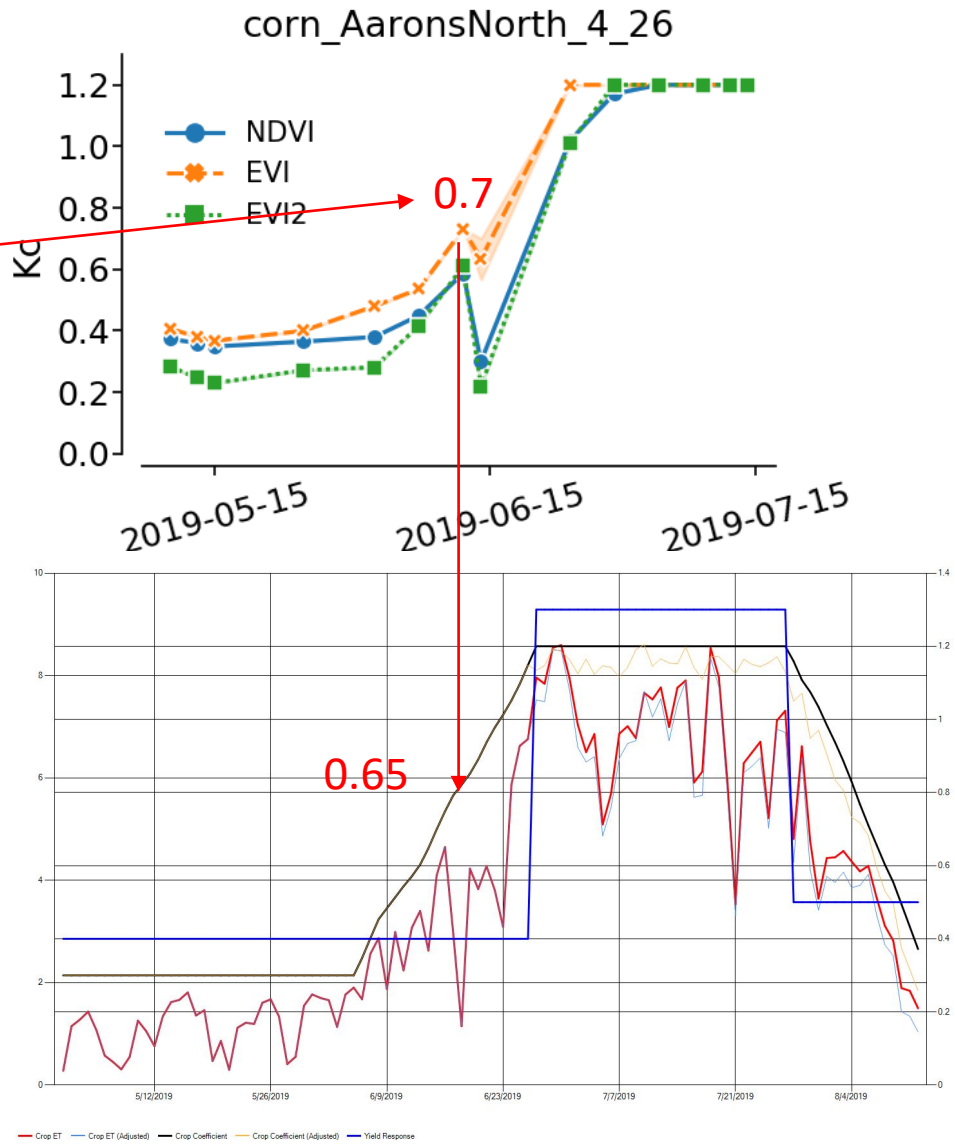


Vegetation indices based crop coefficient

- EVI based crop coefficient has the greatest value
- Kc driven by EVI has the greatest value, the pattern of EVI driven Kc is consistent
- The calculated ET based on adjusted Kc has a large variation, and it depends on the type of soil moisture sensor been used

Crop coefficient on irrigation management

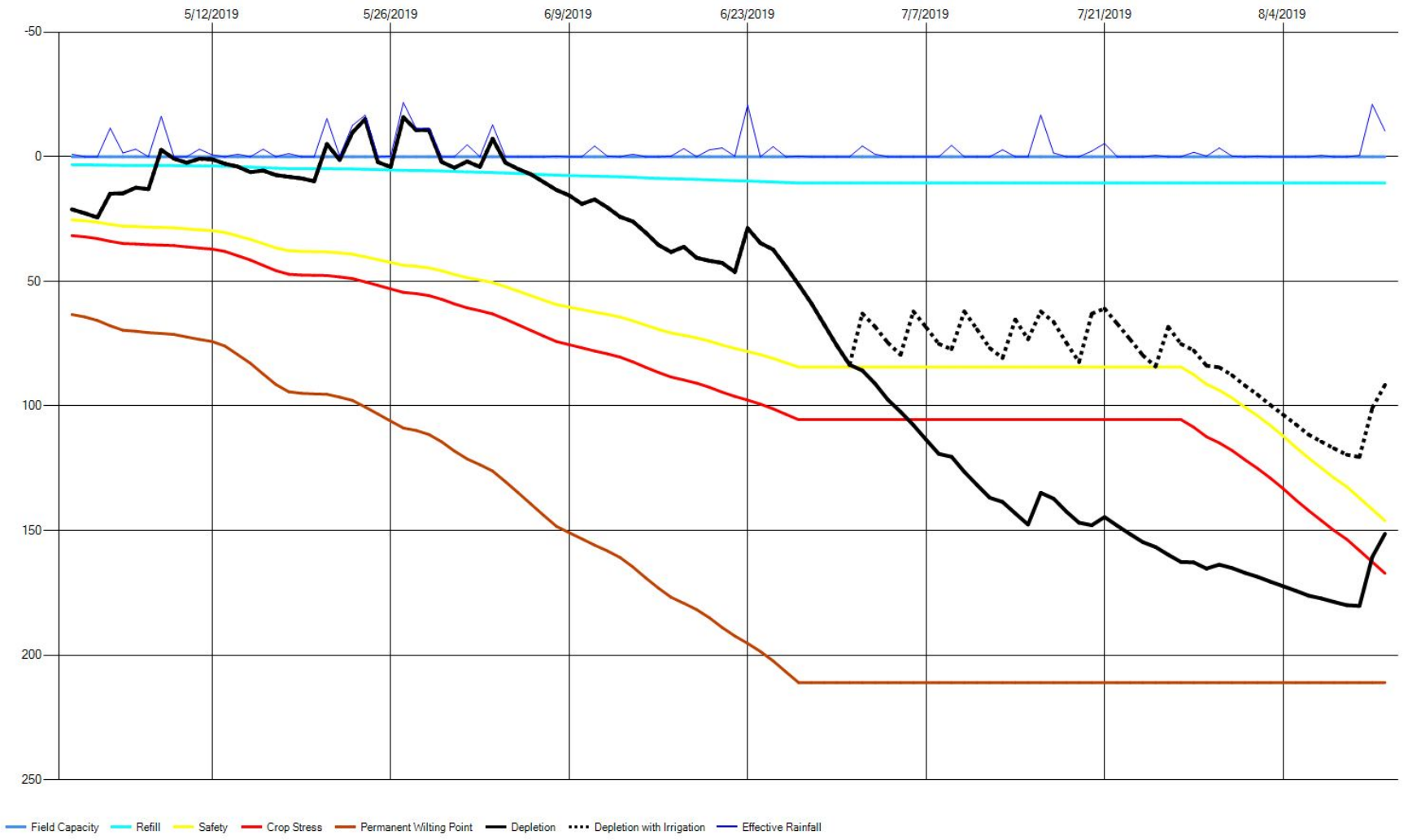
Use vegetation index based adjusted Kc for irrigation



First, the vegetation index based Kc, is close to the Kc value from FAO 56 for a given day.

Adjusted Kc_initial from 0.3 to 0.4 by imagery

After adjust Kc



Before vs. after adjusting Kc on irrigation recommendation

Before adjust Kc

- Total irrigation forecast: **6 inches**
- Total Crop ET: **14.9 inches**
- Irrigation rounds: **6**

After adjust Kc

- Total irrigation forecast: **6 inches**
- Total Crop ET: **15.7 inches**
- Irrigation rounds: **7**

After adjusting Kc value based on imagery derived vegetation index, the irrigation recommendation increase 1 more round, with 0.8 inches.

Take home messages:

- Satellite imagery has potential for using on adjustment of irrigation forecasting/recommendation
- The application effectiveness of using satellite imageries may depend on which vegetation index is used and the Kc adjustment timing and magnitude
- Solely depends on satellite imageries for irrigation recommendation is not mature yet. The quality of imageries will affect accuracy (e.g. cloud cover)
- Kc is still the most effective parameter for irrigation scheduling.

Questions?