

Should the b-parameter be constant across the U.S. Corn Belt?

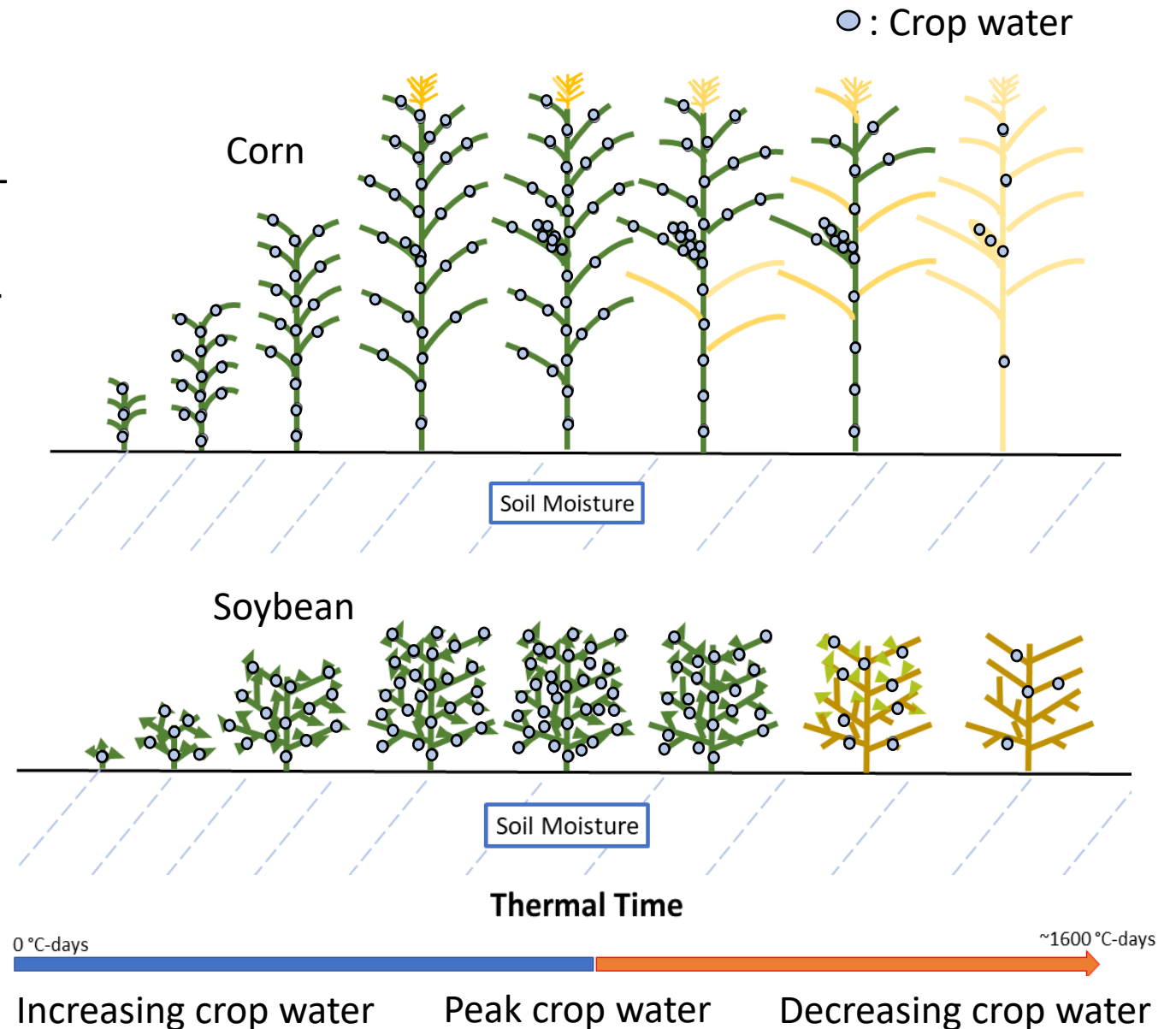
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Crop water

- Vegetation water content (VWC) of crops – Crop water!
- Crops act as temporary reservoirs of water
- Crop water is an important measurement.
 - Vegetation development
 - Drought detection and prediction
 - Improve weather forecasts
- In-situ measurement of crop water is an intensive process.
- Solution: microwave remote sensing measurements!

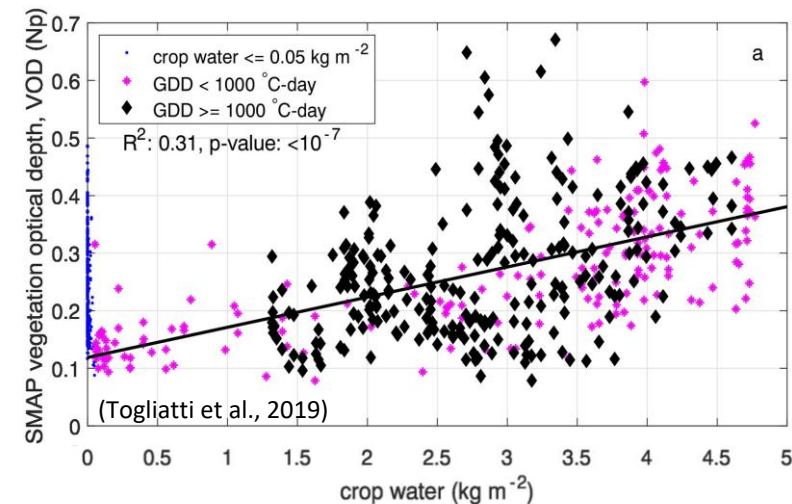


SMAP can provide important measurements of crop water.

- Vegetation optical depth (VOD)
 - VOD is a measurement of the attenuation of microwave radiation due to vegetation.
 - VOD is linearly related to crop water.
 - Relationship between crop water and VOD is dependent on the b-parameter.

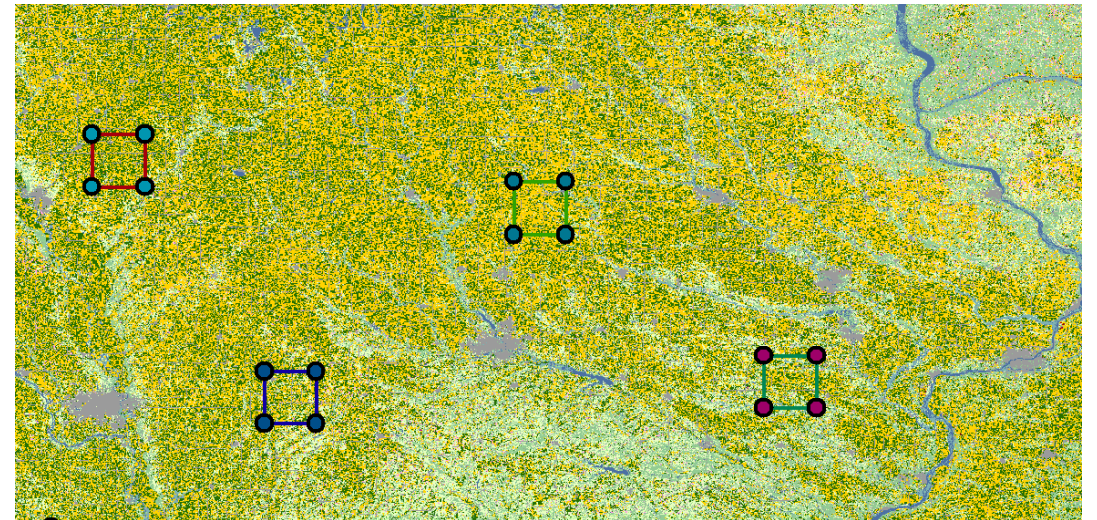
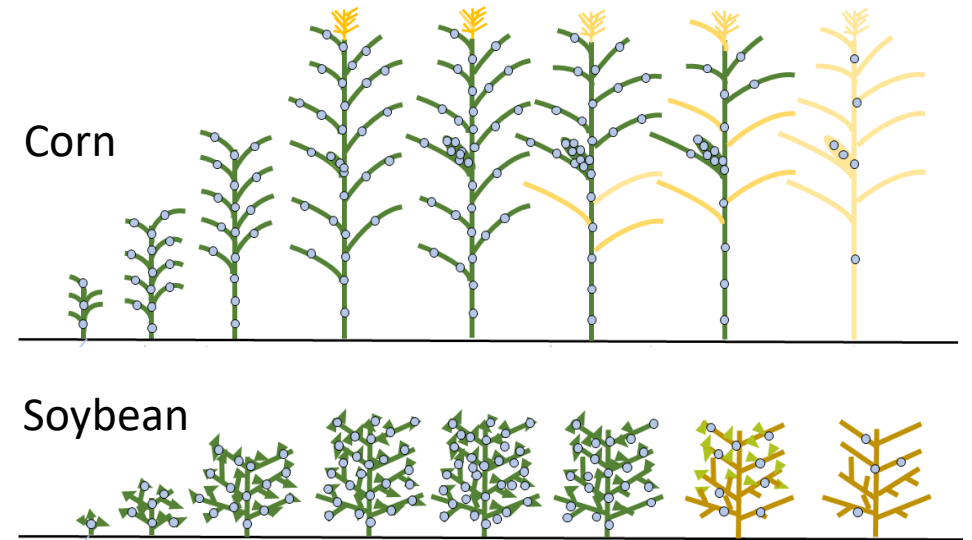
$$\tau = b \times VWC$$

VOD b-parameter crop water



b-parameter depends on the type of vegetation

- b-parameter values for corn and soybean are different! (Jackson and O'Neill (1990))
 - Corn: 0.115
 - Soybean: 0.086
- SMAP cropland b-parameter = 0.11
- Corn and soybean rotations dominate croplands of the U.S. corn belt, but the distribution is heterogeneous
- Variation in the proportion of these crops could cause errors in VOD and soil moisture retrievals.



An aerial photograph of a cornfield, showing a grid of rows of green corn plants. The rows are separated by dark, narrow paths, likely furrows or roads. The overall color palette is dominated by various shades of green, from bright lime to deep forest green, with the dark paths providing a strong contrast.

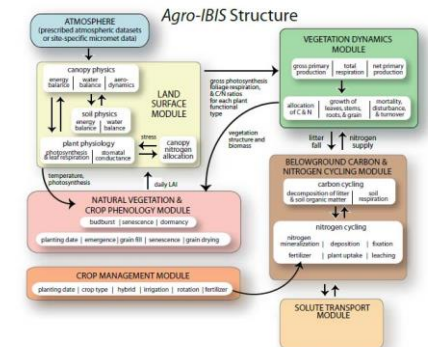
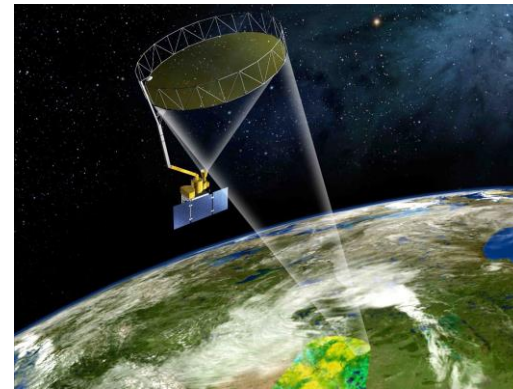
Should the b-parameter be constant across the U.S. Corn belt?

Hypothesis: As relative corn percentage in a SMAP pixel increases, the b-parameter will increase.

Analysis of the b-parameter across the corn belt

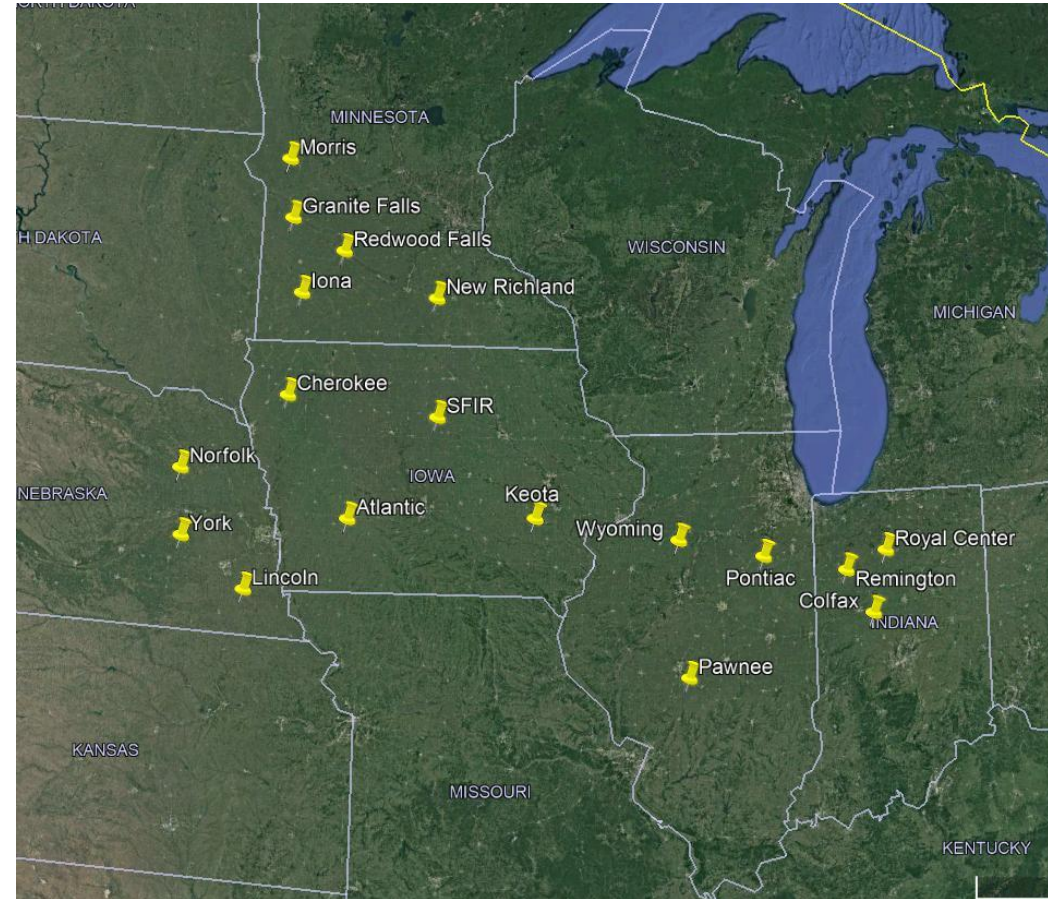
- To calculate the b-parameter we need:
 - VOD
 - Crop water
- SMAP L2 DCA VOD
- Crop water
 - In-situ measurements at satellite scale are too prohibitive
 - We can simulate crop water with a crop model!
- To address hypothesis, compare b-parameters across pixels with a range of crop distributions

$$b = \frac{VOD}{Crop\ Water}$$



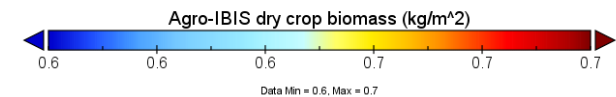
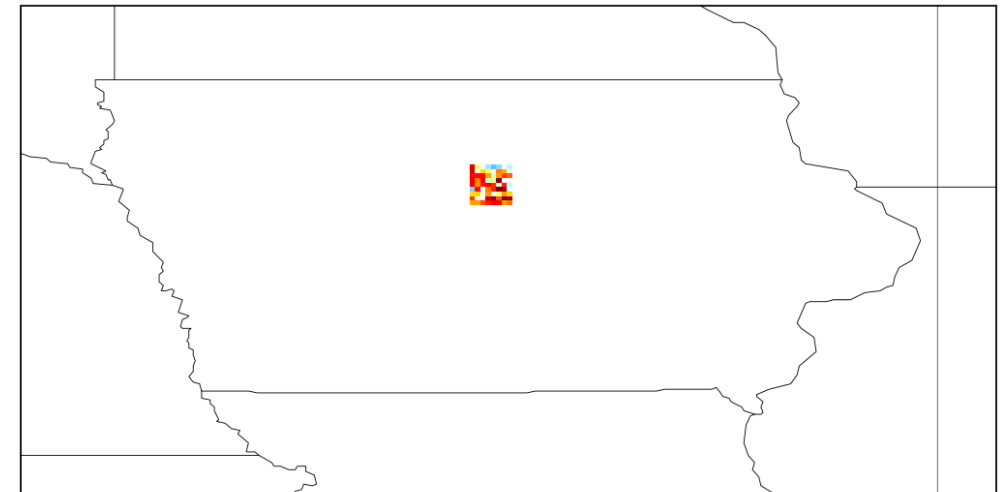
Study locations

- Study site-years
 - 18 sites across 5 states in the U.S. corn belt
 - 2015, 2016, and 2017
 - Total site-years: 54
- Sites chosen are designated by SMAP as 'cropland'
- Sites chosen contain at least 65% corn and soybeans
- Crop percentages calculated using the USDA Cropland Data Layer (CDL).
- Range of crop
 - Soybean – 26%- 45%
 - Corn – 29% - 60%



Agro-IBIS crop model

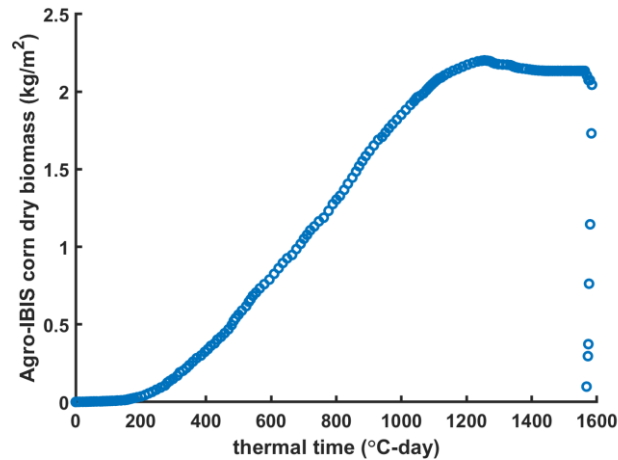
- Agro-IBIS simulations of crop biomass (corn and soybean)
 - 4km gridded simulations
 - ~60 gridpoints for each SMAP pixel
 - Gridpoints averaged together for each SMAP pixel
- Crop planting dates determined using USDA crop progress reports.
 - Crops in model planted at 50% acres reported planted



2015 SFIR example simulation

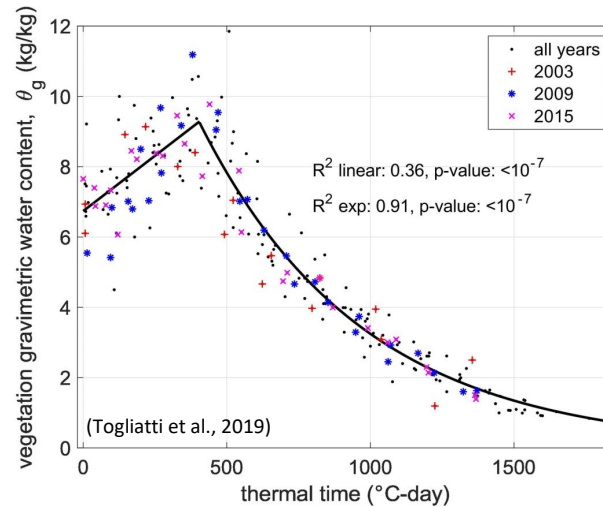
Simulating crop water at SMAP scale

$$\text{dry biomass} \times \theta_g = \text{Crop Water}$$



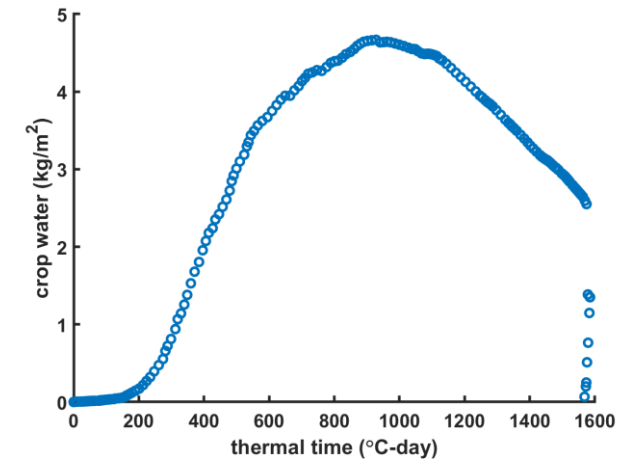
Simulate dry biomass
with Agro-IBIS

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Compute θ_g using model
based on field
measurements

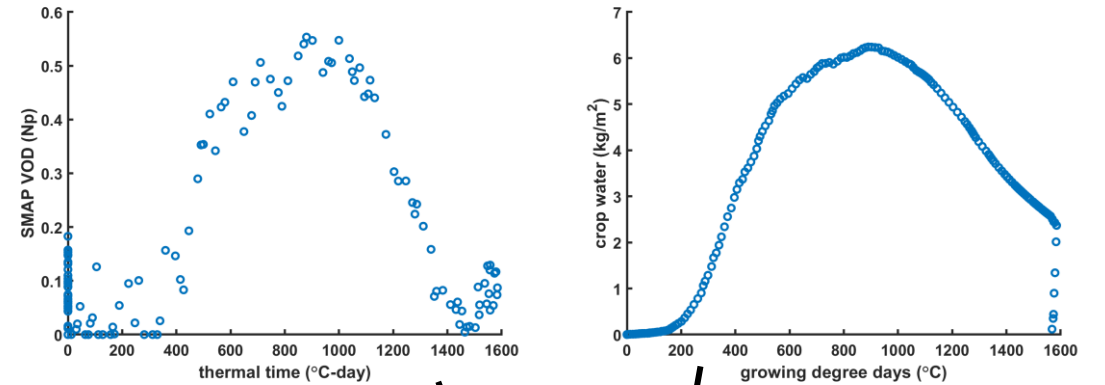
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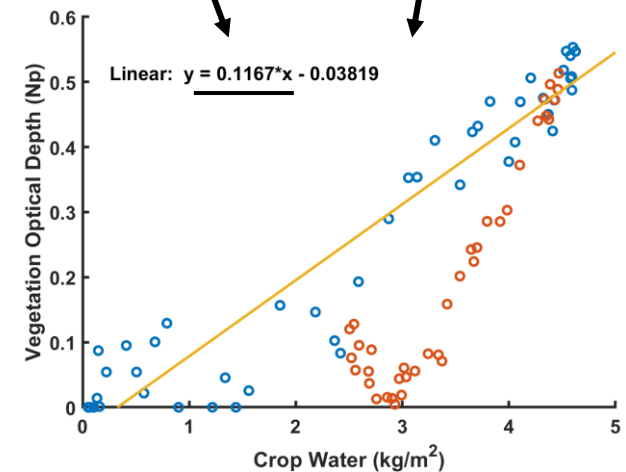
Corn and soybean crop
water weighted
according to CDL
percentages

SMAP VOD & Analysis

- SMAP L2 DCA VOD data was downloaded for each pixel
- A linear regression is drawn from the two data together, and the b-parameter recorded.
- The calculated b-parameters are then analyzed via the relative corn fractions from each site-year.

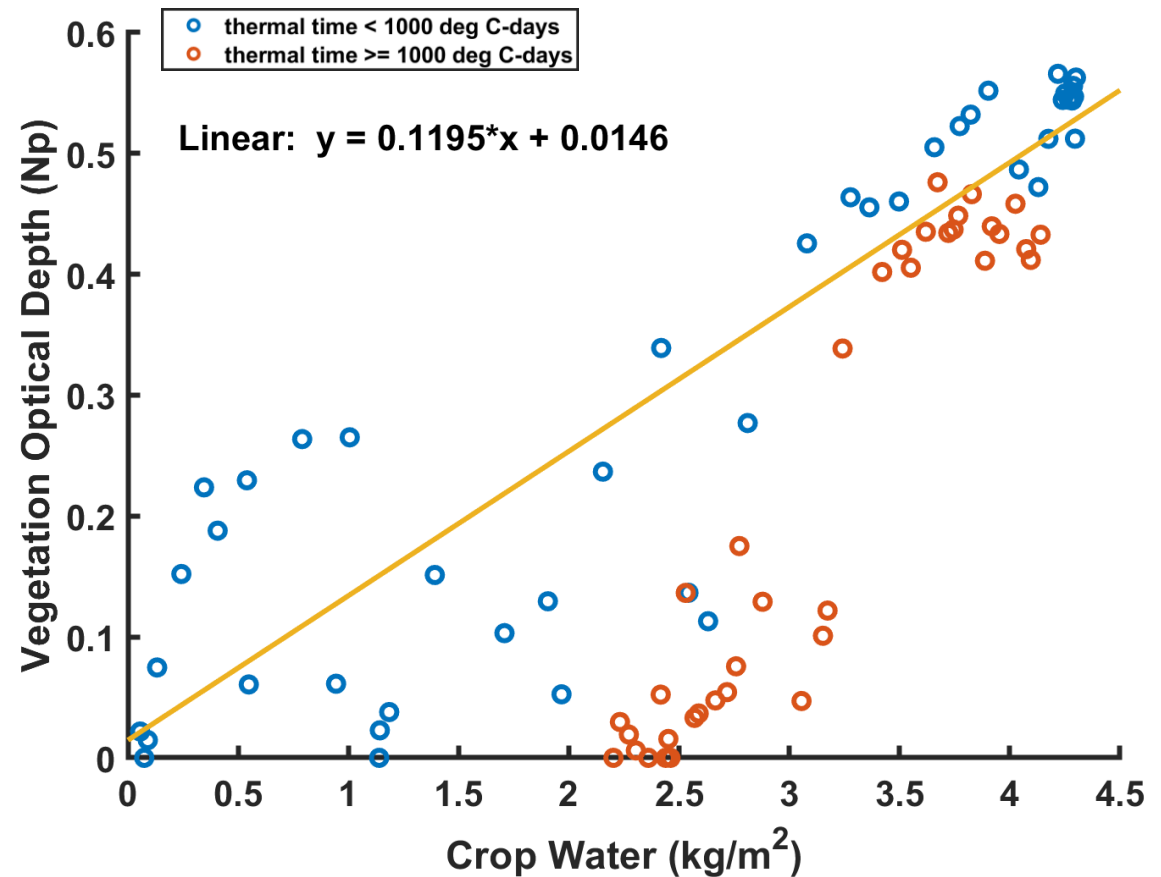


$$b = \frac{VOD}{Crop\ Water}$$



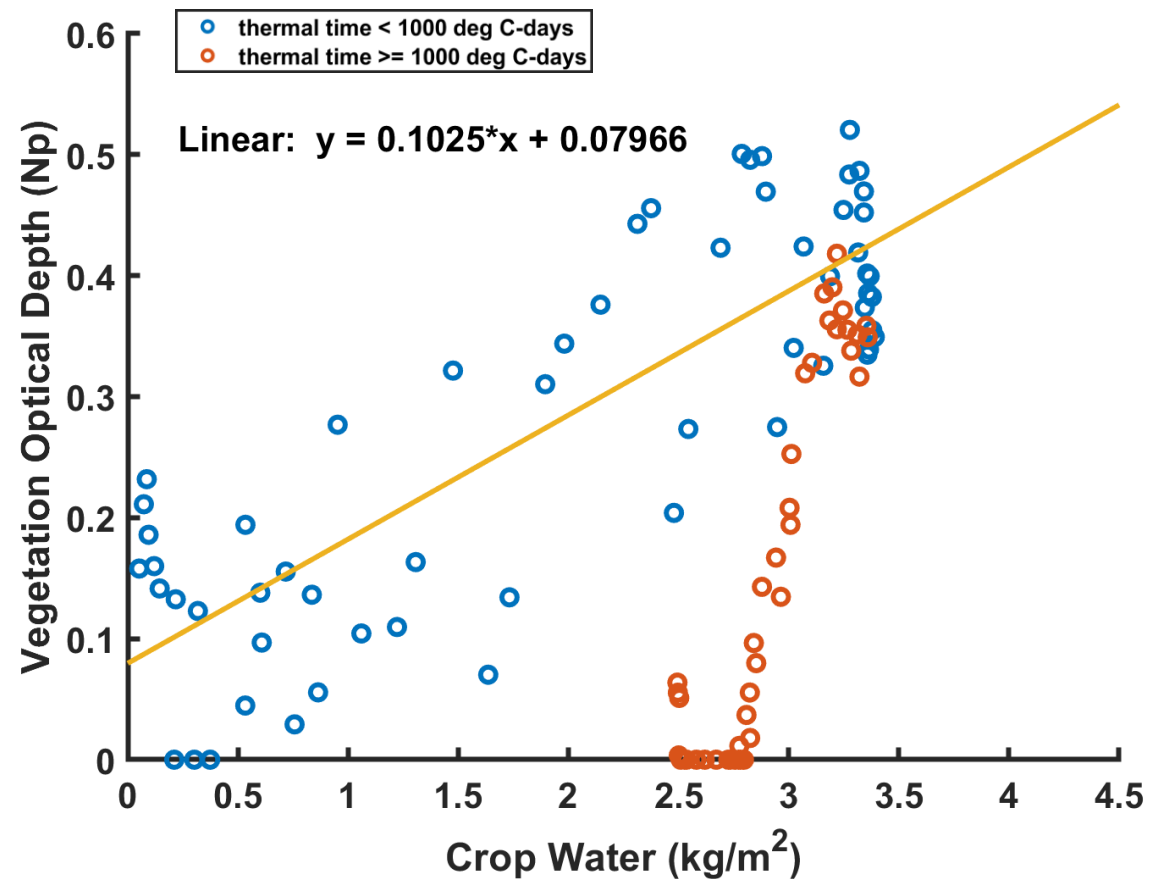
Example analysis: South Fork Iowa River (SFIR)

- Data from the year 2017
- SFIR crop percentage:
 - Corn: 58%
 - Soybean: 26%
- SMAP VOD increases linearly as crop water increases.
- Calculated b-parameter is slope of line from planting to peak water content
 - b-parameter: 0.12

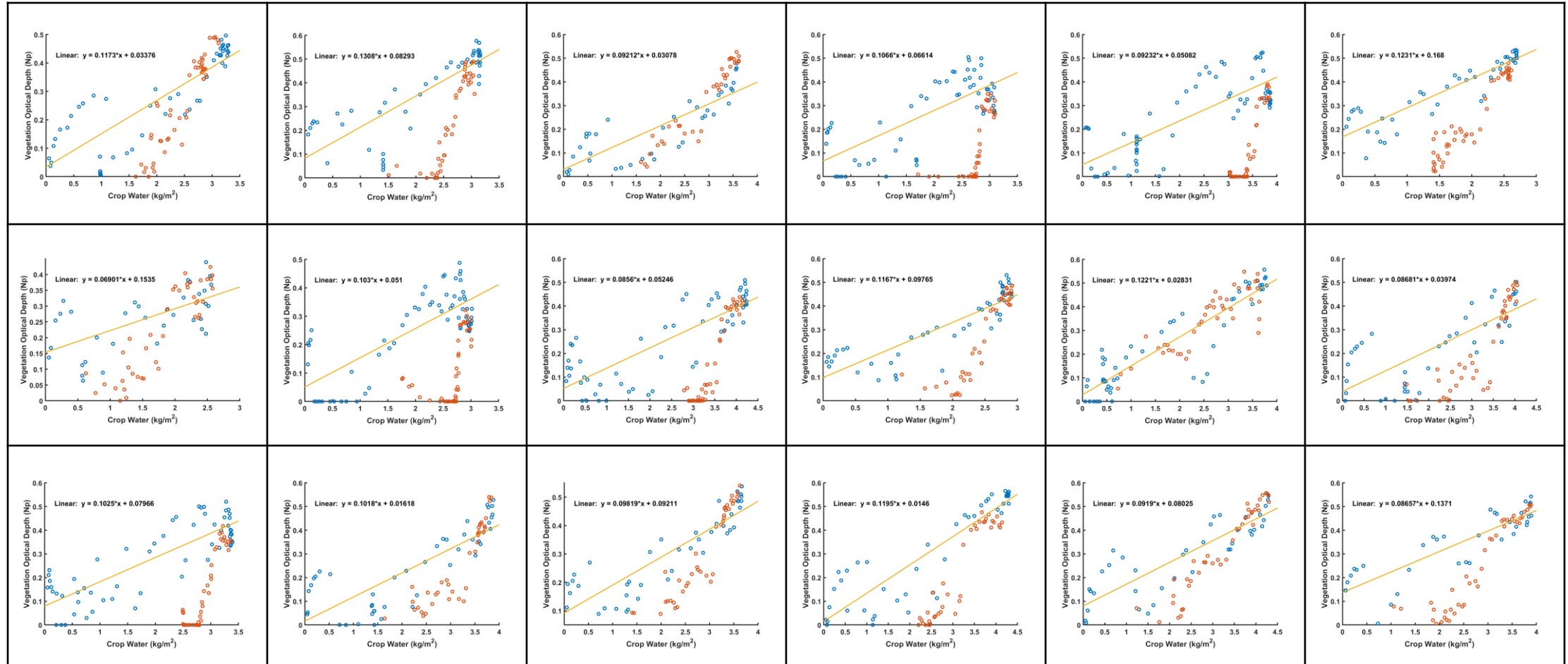


Example analysis: Redwood Falls, MN

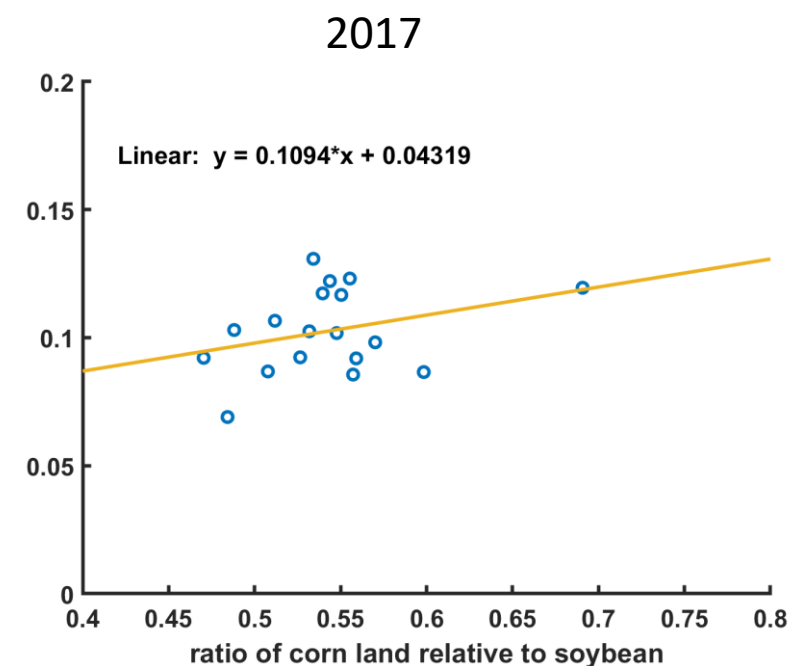
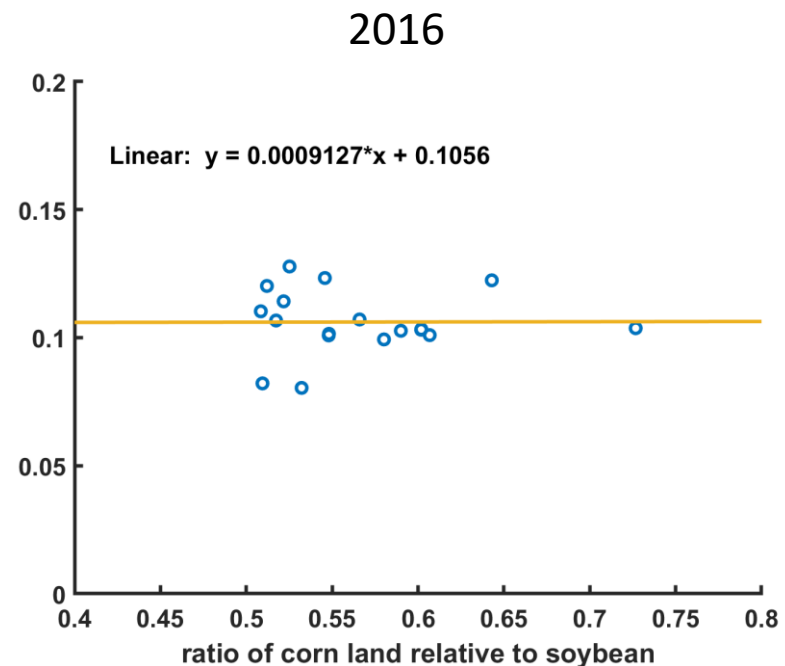
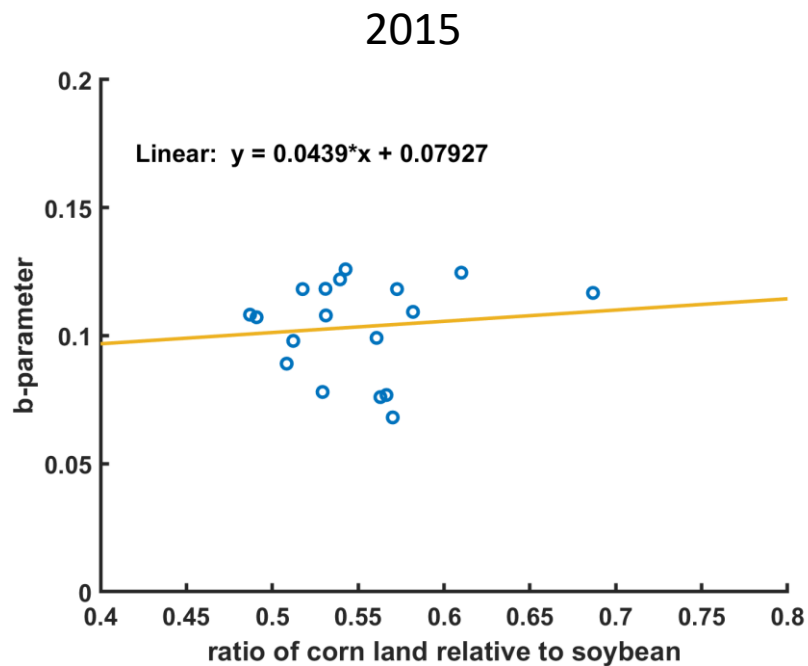
- Data from the year 2017
- Redwood Falls crop percentage:
 - Corn: 40%
 - Soybean: 35%
- SMAP VOD increases linearly as crop water increases.
- Calculated b-parameter is slope of line from planting to peak water content
 - b-parameter: 0.10



Linear relationship between SMAP VOD and crop water holds across the U.S. cornbelt.



SMAP b-parameter and relative corn fraction have a small, positive correlation

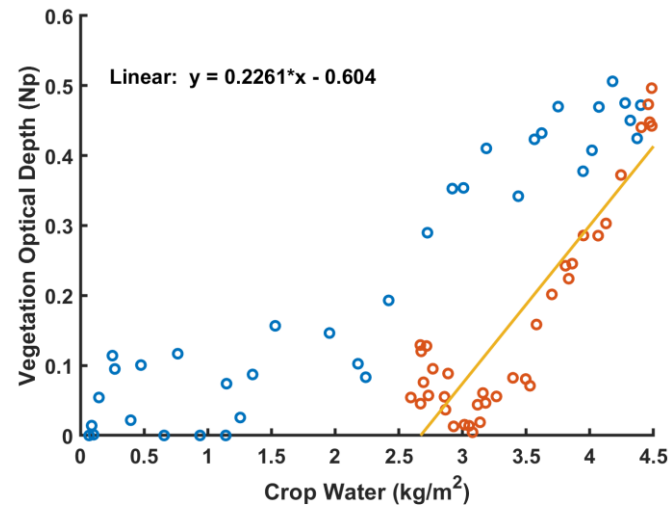
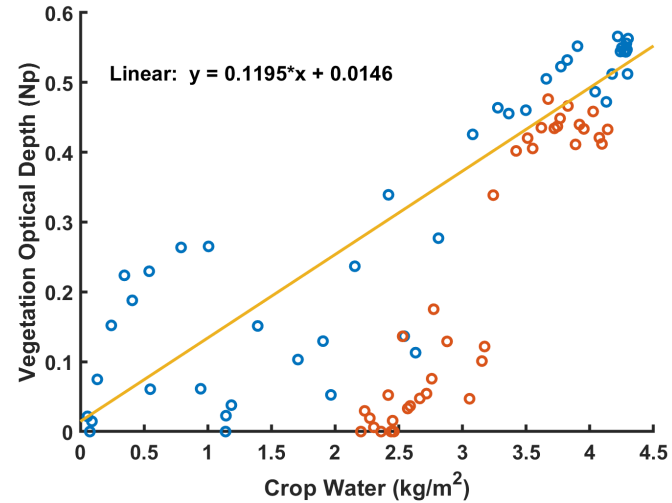


Summary

- Hypothesis: As relative corn percentage in a SMAP pixel increases, the b-parameter will increase.
- This study found:
 - The linear increase between SMAP VOD and crop water holds throughout the U.S. corn belt region.
 - The b-parameters calculated for all site-years were in a range around the SMAP cropland value of 0.11.
 - There is a slight positive correlation between the relative corn percentage and the b-parameter, but not statistically significant.

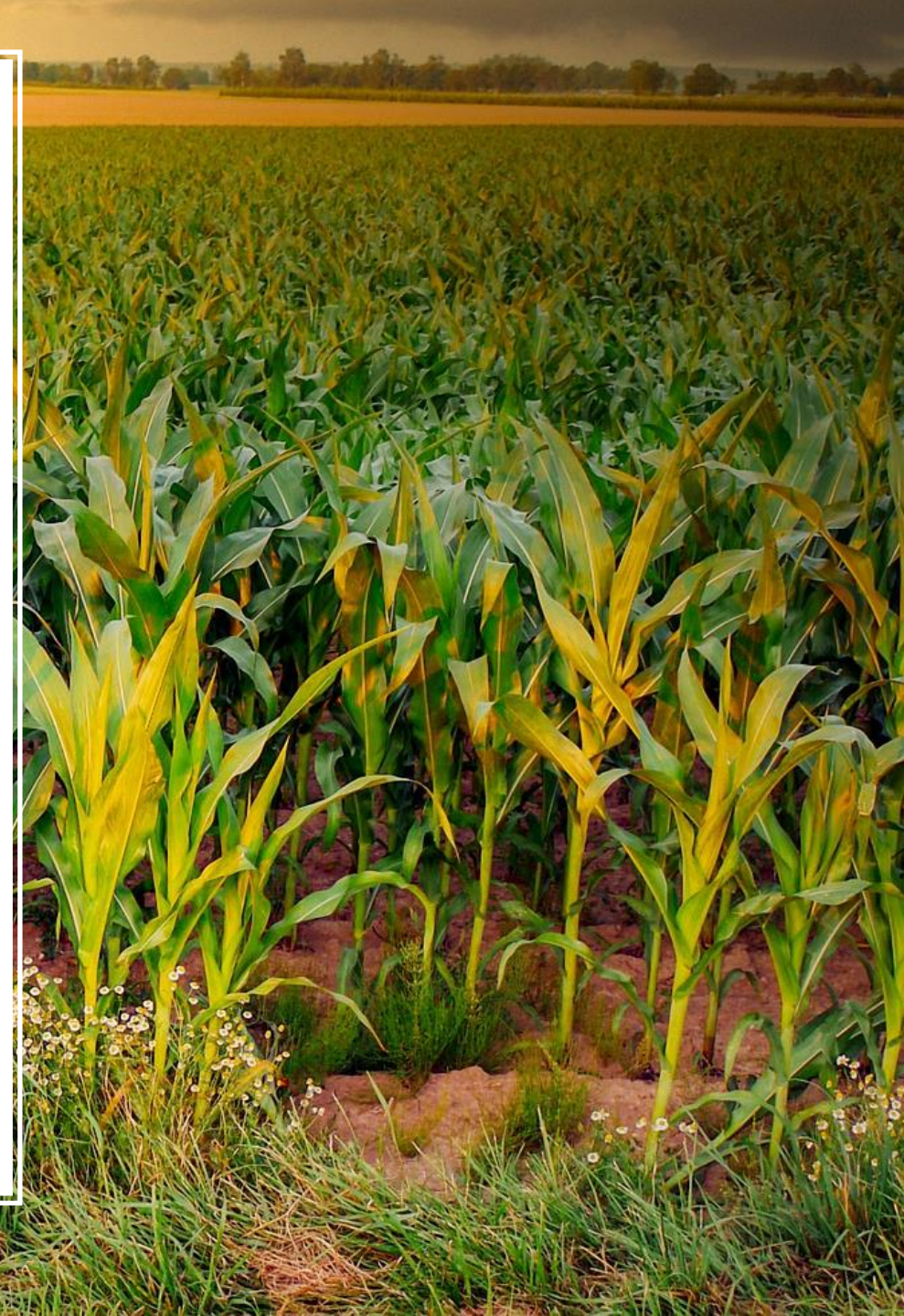
Initial slope vs. dry-down slope

- Two patterns exist in the data from crop water and SMAP VOD.
 - Planting to peak crop water (initial slope)
 - Peak crop water to harvest (dry-down)
- This study focuses on initial slope, but shows that dry-down slope may be important

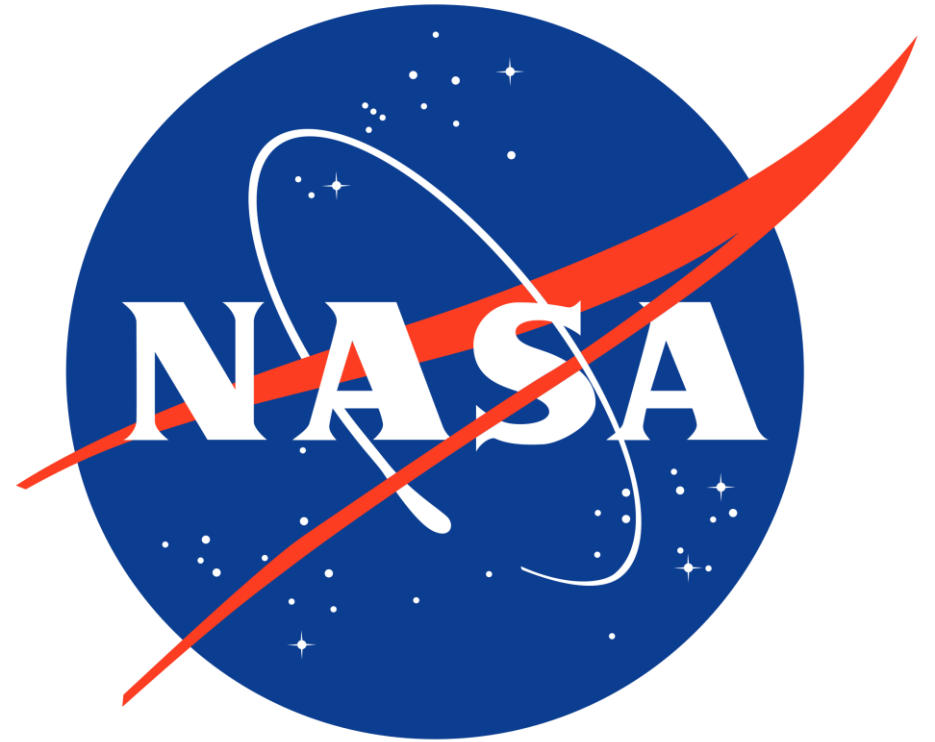


Conclusions

- Potential errors can be introduced into the retrievals from SMAP across the U.S. corn belt
 - However calculated values are centered around current b-parameter value of 0.11
- Plans to extend the study for years after 2017 to understand variability
- Research into the 'dry-down slope' should be done to understand the impact of vegetation canopy structural changes to the b-parameter.



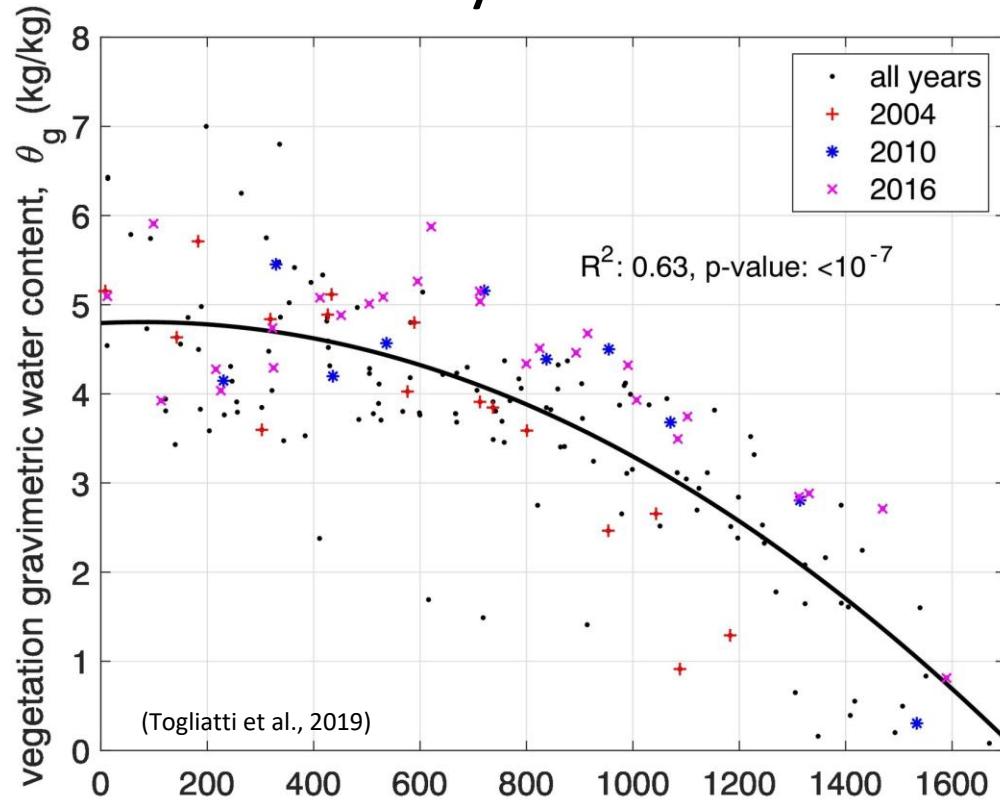
Thank you!



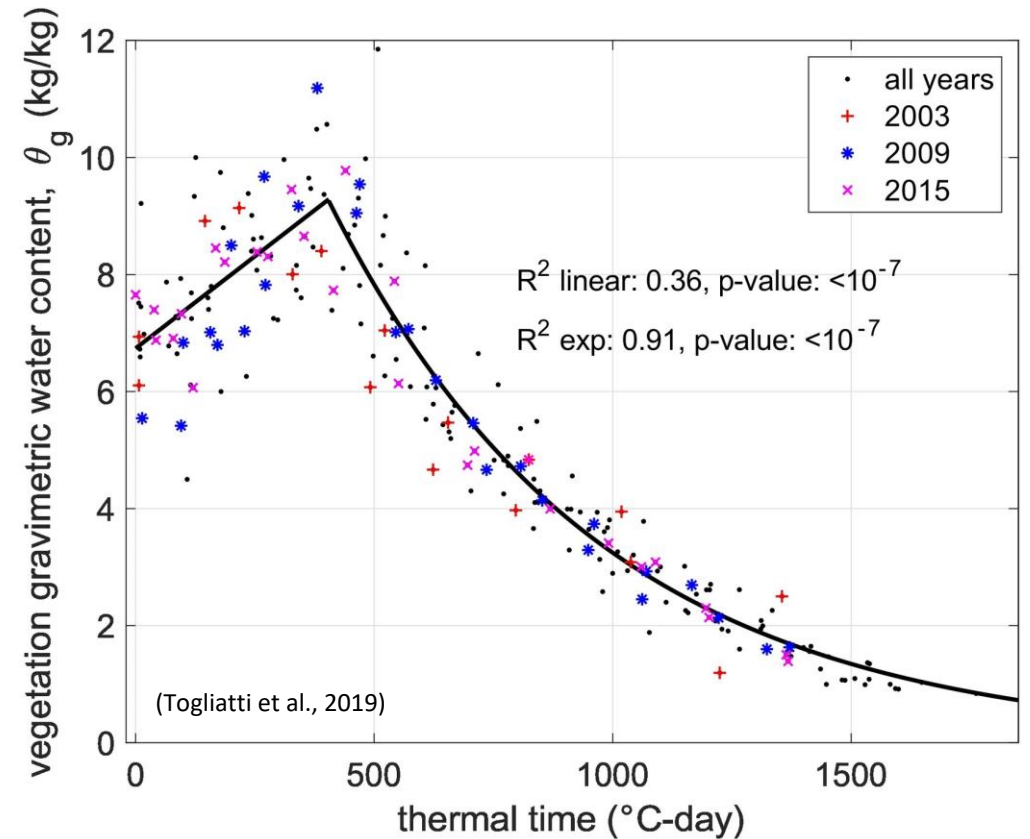
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$$\text{dry biomass} \times \theta_g = \text{Crop Water}$$

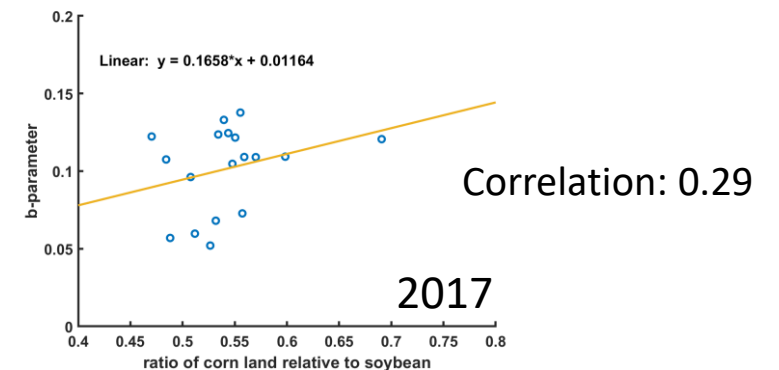
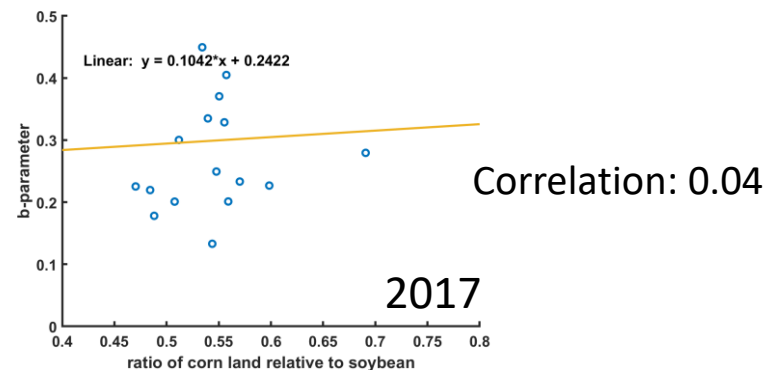
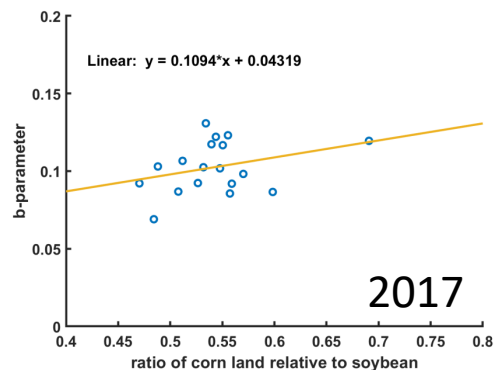
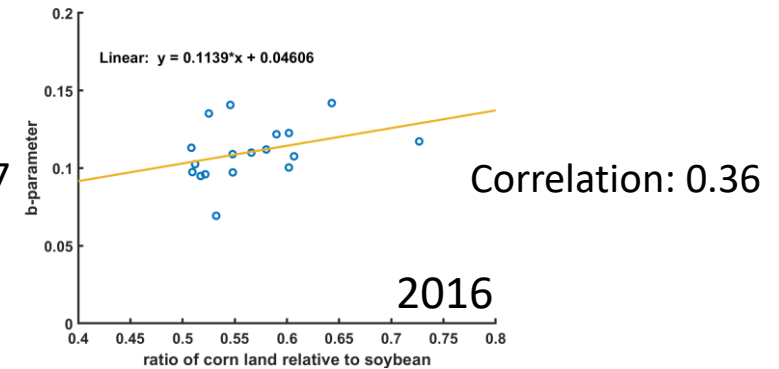
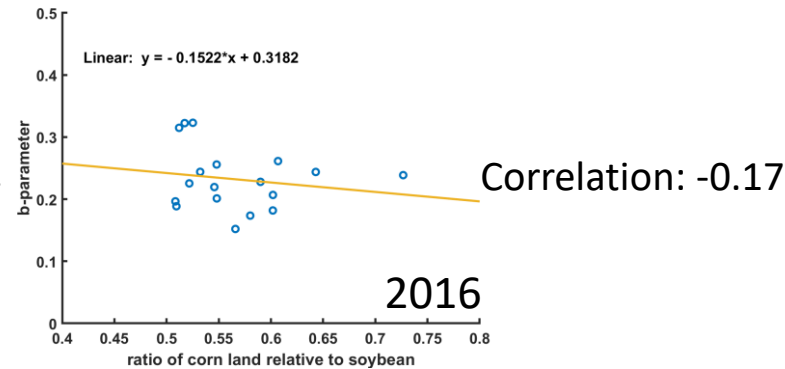
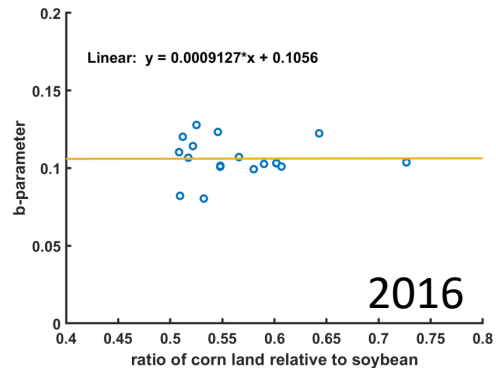
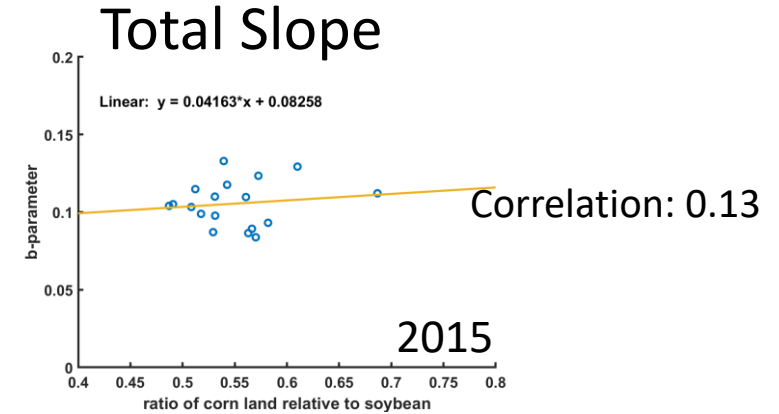
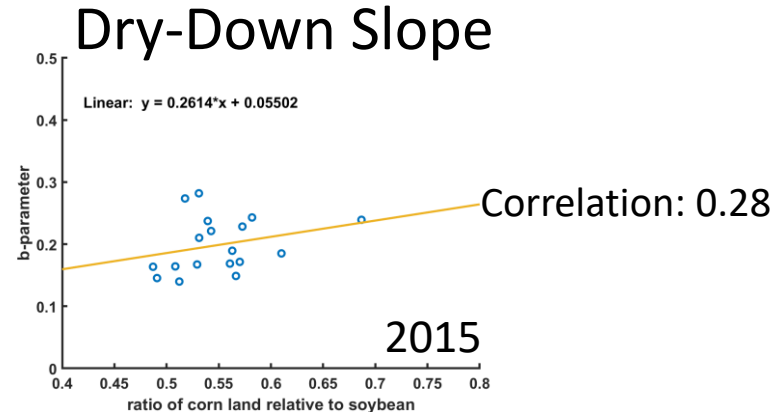
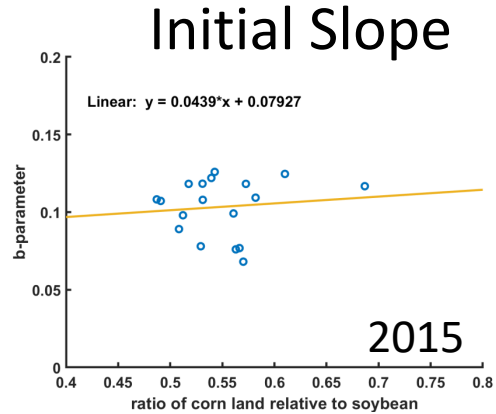
Soybean



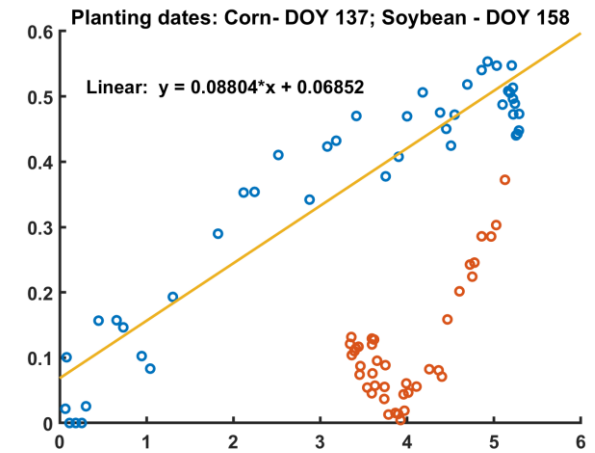
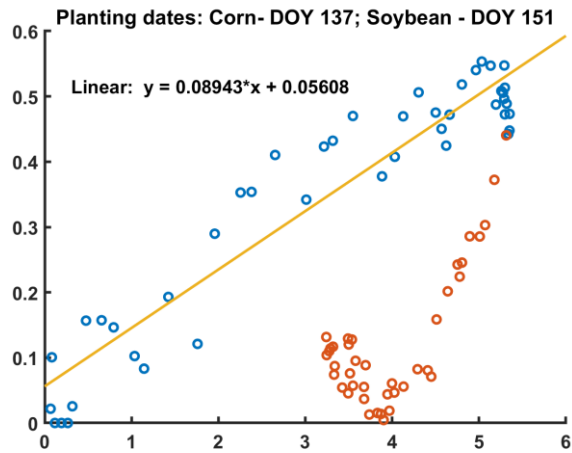
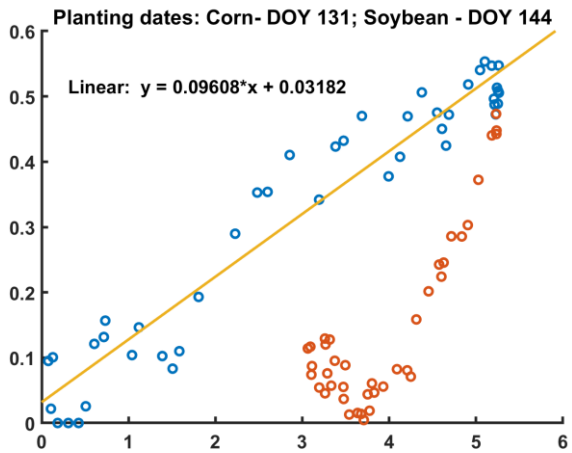
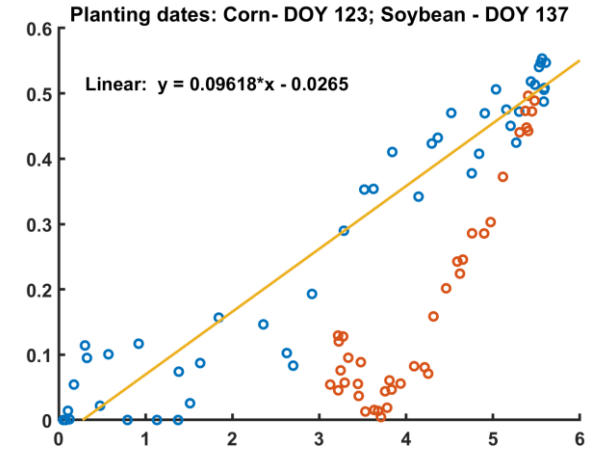
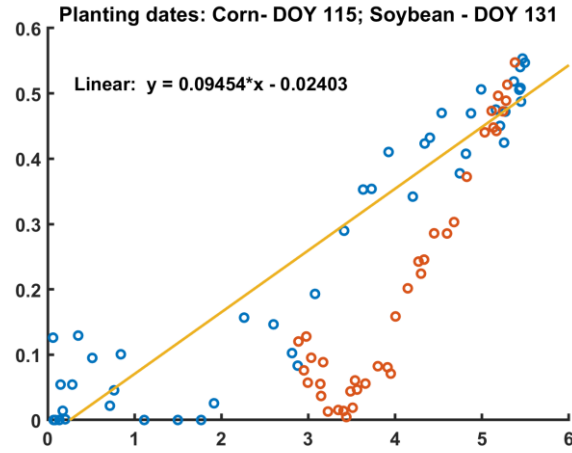
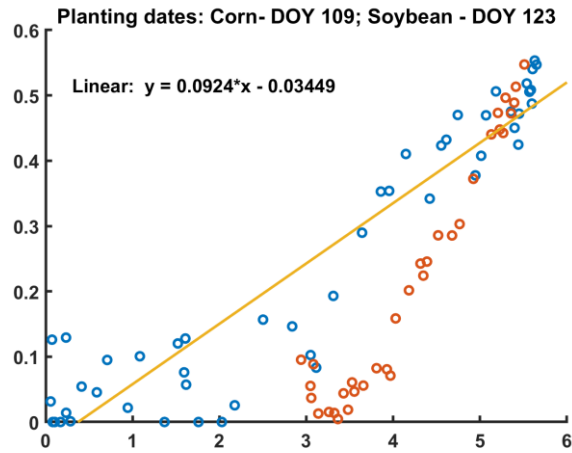
Corn



B-parameter vs. relative corn percentage



SFIR Planting Date Case Study



References

- Jackson, Thomas J., and Peggy E. O'Neill. "Attenuation of soil microwave emission by corn and soybeans at 1.4 and 5 GHz." *IEEE Transactions on Geoscience and Remote Sensing* 28.5 (1990): 978-980.
- Togliatti, Kaitlin, et al. "Satellite L-band vegetation optical depth is directly proportional to crop water in the US Corn Belt." *Remote Sensing of Environment* 233 (2019): 111378.