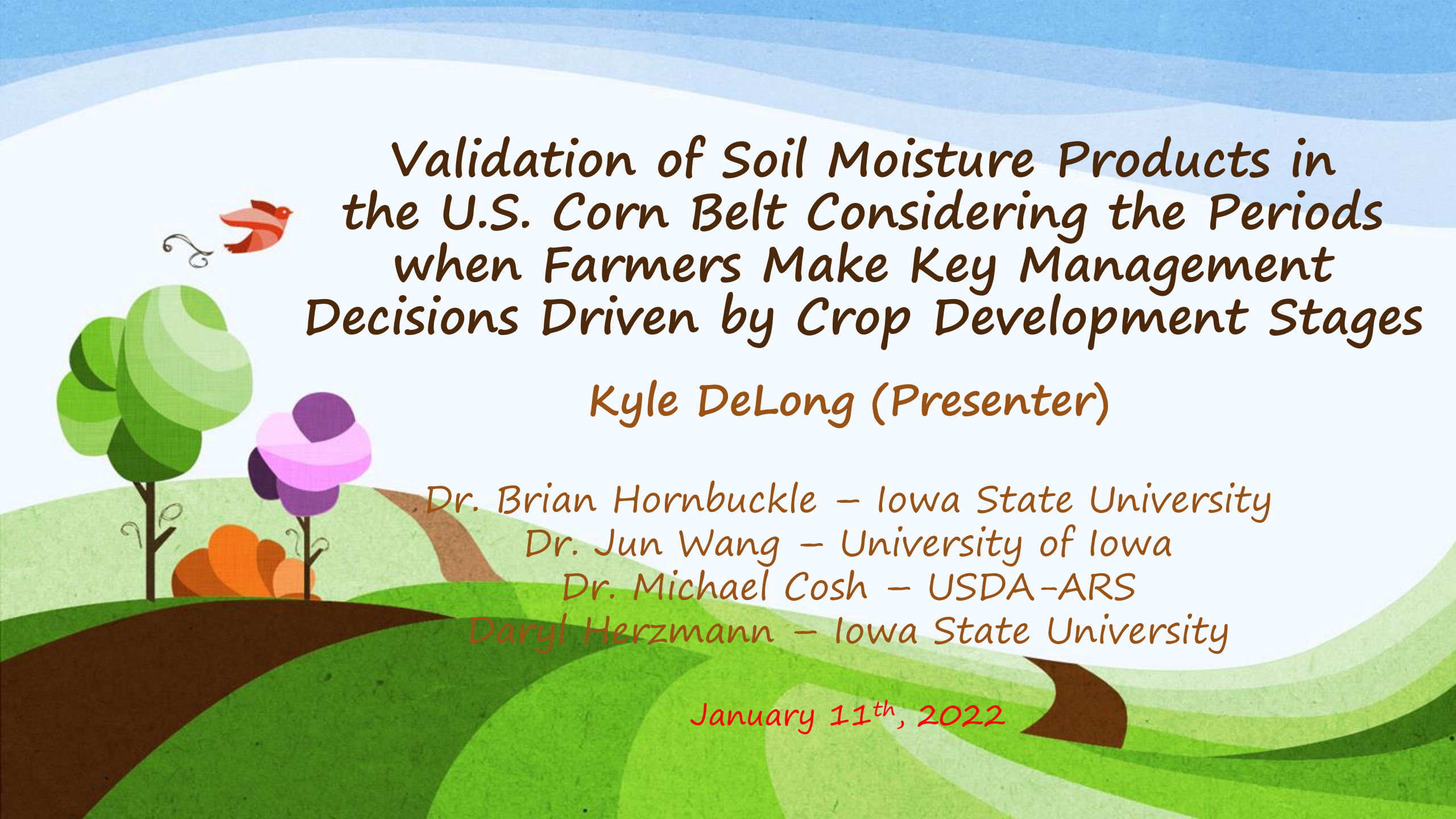

Validation of Soil Moisture Products in the U.S. Corn Belt Considering the Periods when Farmers Make Key Management Decisions Driven by Crop Development Stages

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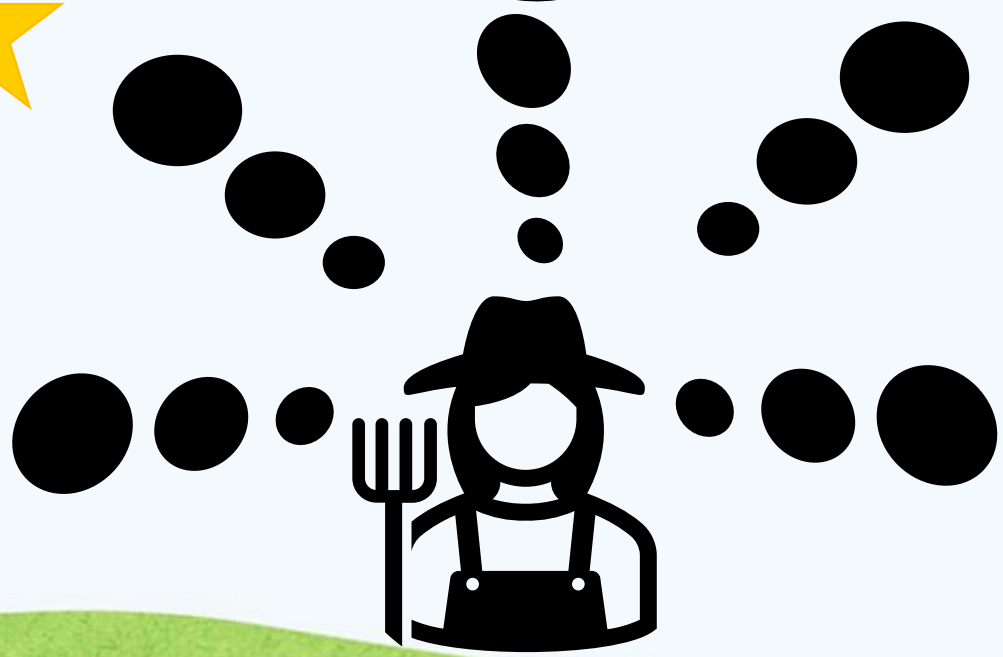
Dr. Brian Hornbuckle – Iowa State University
Dr. Jun Wang – University of Iowa
Dr. Michael Cosh – USDA-ARS
Daryl Herzmann – Iowa State University

January 11th, 2022

Background: Research Topic



Background: Motivation and Metrics

Evaluating soil moisture information should consider when key crop development stages occur and ultimately when decisions based upon soil moisture status must be made by farmers.

METRICS:

$$bias\ [m^3m^{-3}] = \overline{Predicted\ - Actual}$$

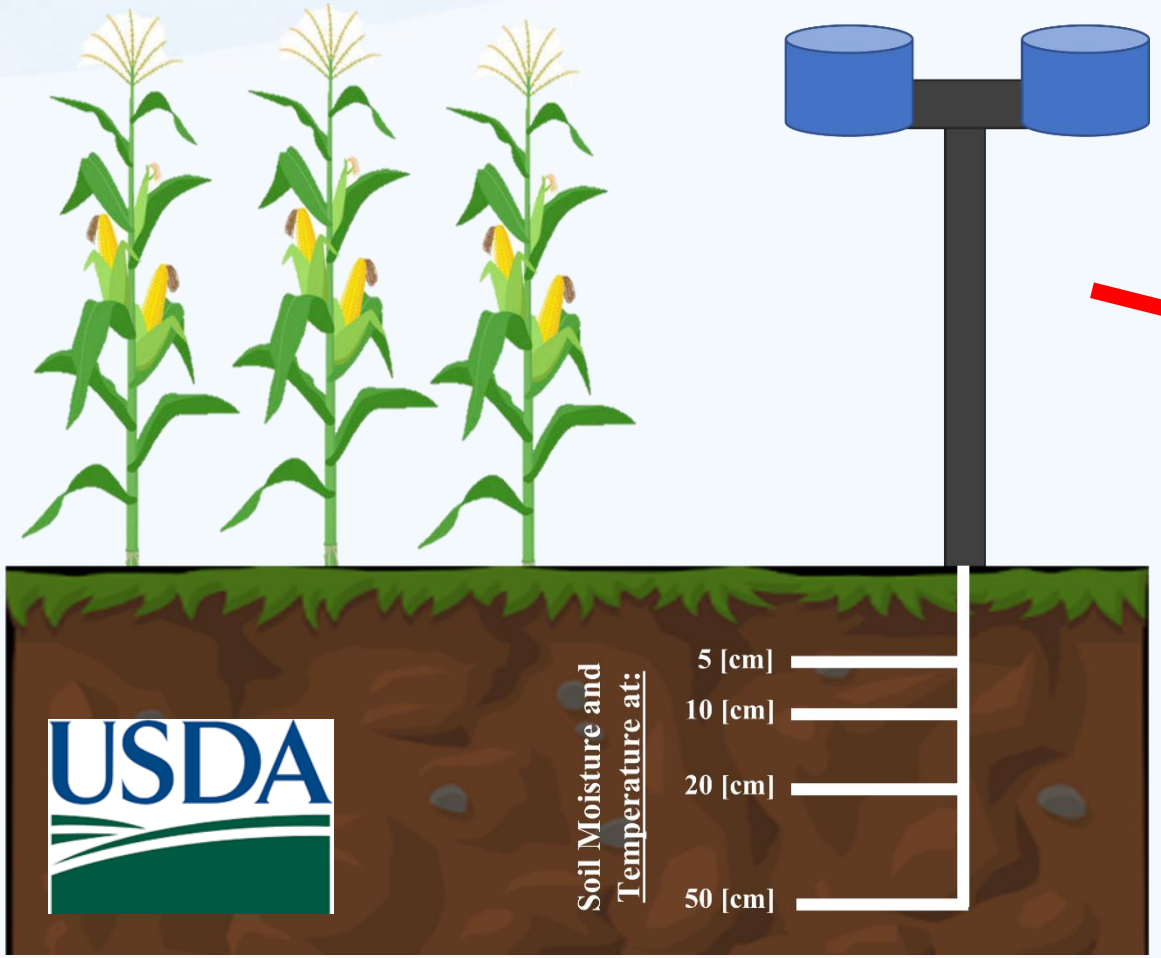
$$unRMSE\ [m^3m^{-3}] = \sqrt{\left(\sqrt{\overline{Predicted\ - Actual^2}}\right)^2 - bias^2}$$

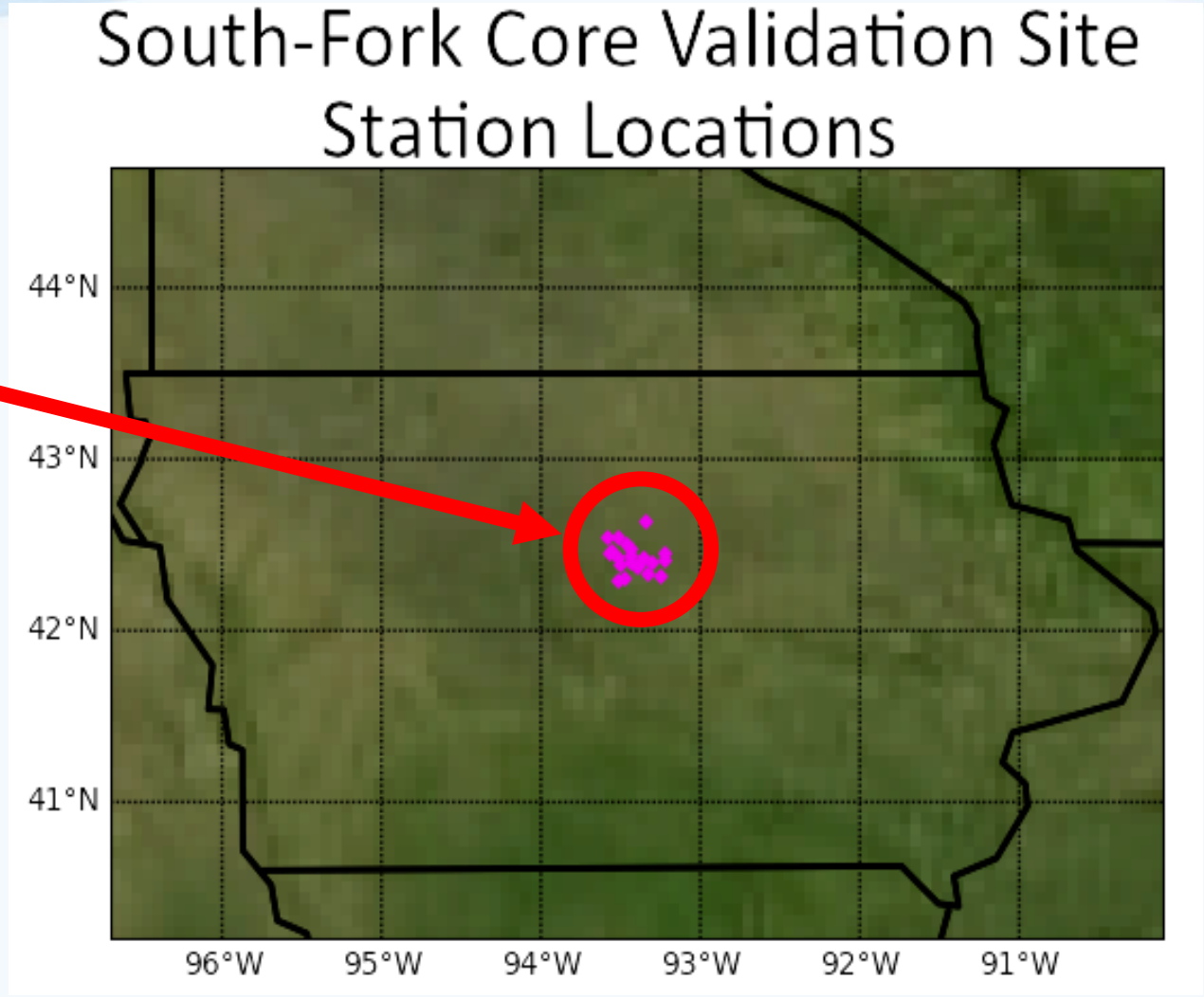
Background: Question

Are there patterns of strong/weak bias within different segments of the growing season?

Do current soil moisture estimators have an Unbiased Root Mean Square Error (unRMSE) at or below $0.04\ [m^3 m^{-3}]$?

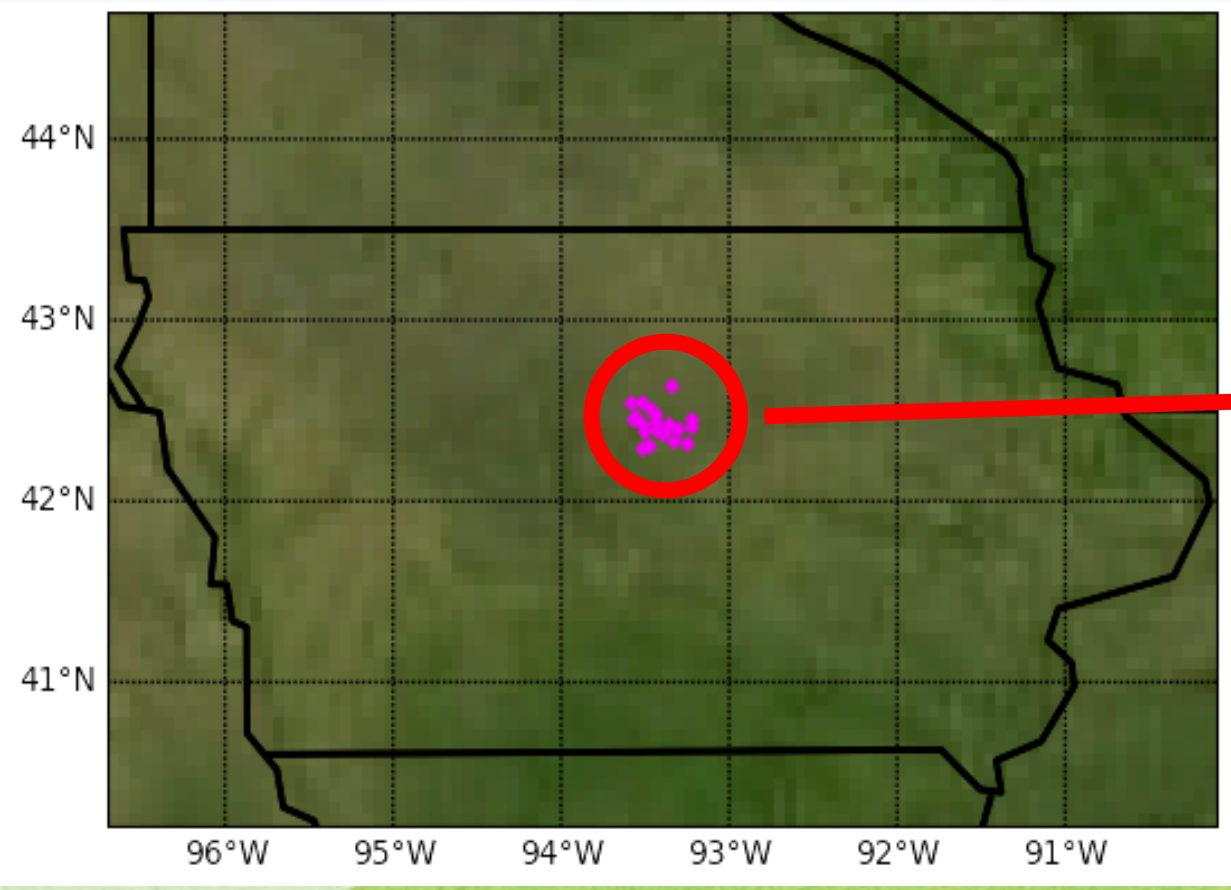
Materials and Methods: In-Situ Site

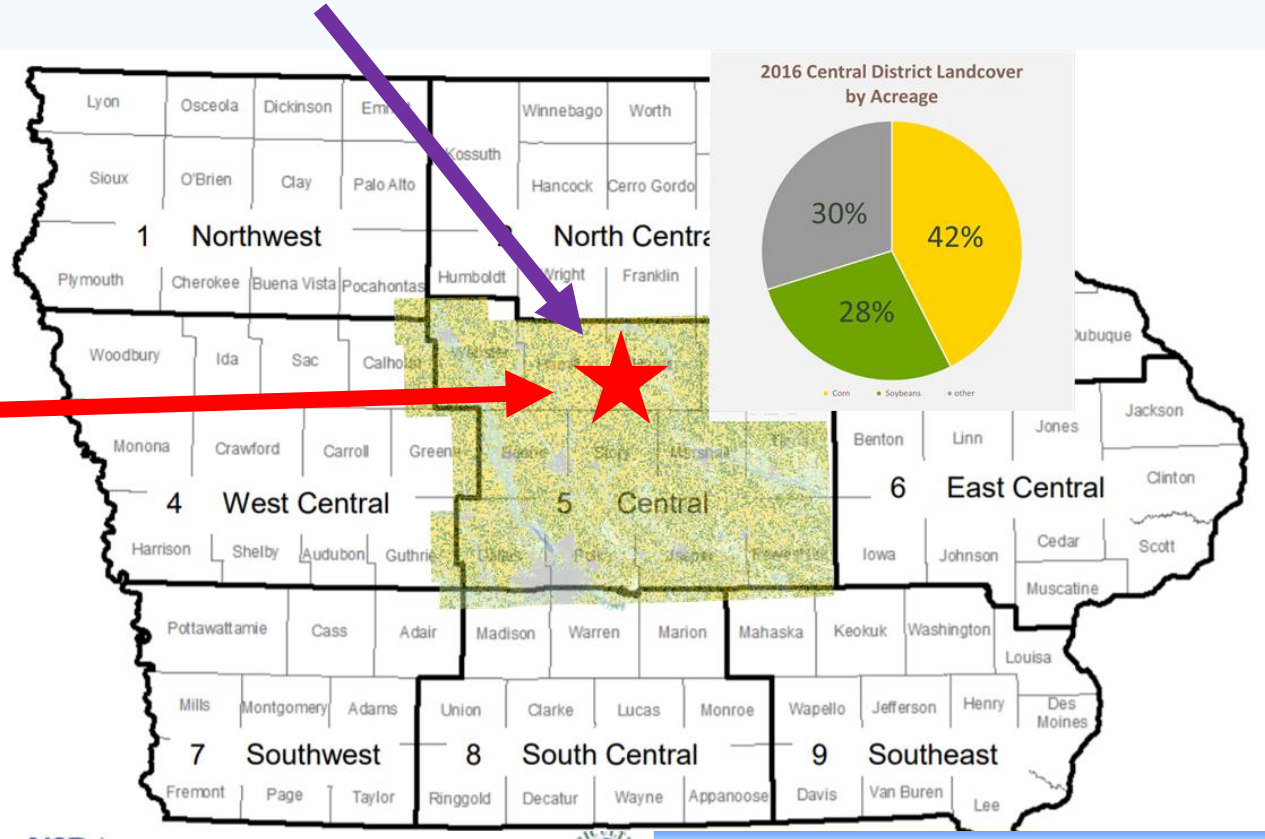




Materials and Methods: USDA-NASS Data

Item	Districts									State	Last week	Last year	5-yr avg
	NW	NC	NE	WC	C	EC	SW	SC	SE				
	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)
Corn dough	80	84	78	77	84	81	81	81	72	80	61	67	57
Corn dented	15	24	21	17	28	30	33	31	23	23	7	11	18

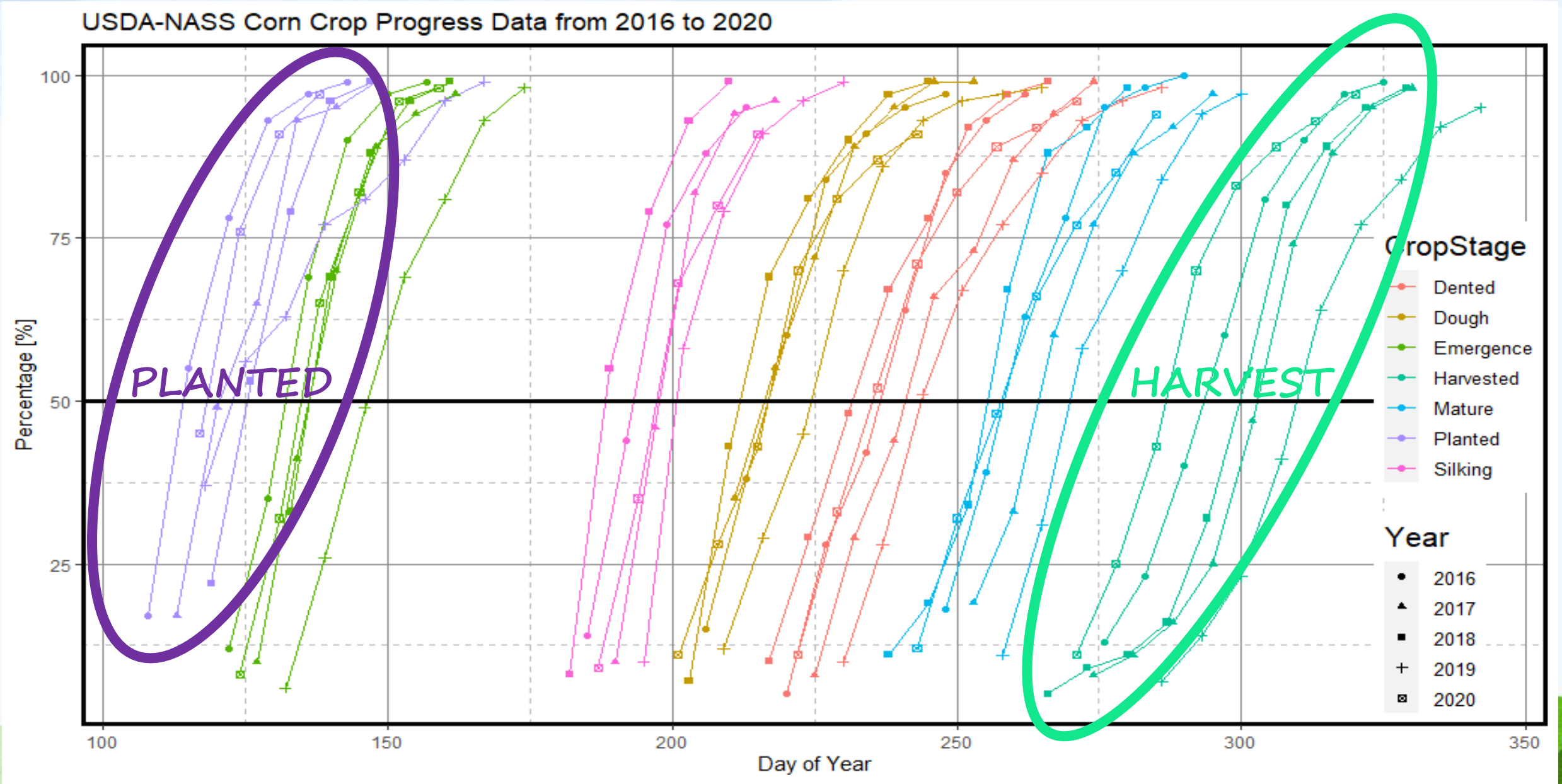




USDA United States Department of Agriculture
National Agricultural Statistics Service

CropScape - Cropland Data Layer

Materials and Methods : USDA-NASS Data



Materials and Methods: Validation Timeline

Why use USDA-NASS Crop Progress data?

1. **Seasons and crops do not obey months and days in the calendar.**
    i. **Farmers must make key management decisions when soil moisture is “just right”.**
2. **Different segments to the growing season could help identify areas of strong bias.**

Materials and Methods: Validation Timeline

March 1st

Pre-Planting

Interpolated 50% Planting Stage

Active-Management

When canopy closure is reached [V8]

Minimal-Management

Interpolated 50% Harvesting Stage

Post-Harvesting

November 30th

Data Collection: Soil Moisture Estimators

Reanalysis Models:

Modern-Era Retrospective Analysis for Research Applications version 2 (MERRA-2)

North American Regional Reanalysis (NARR)

Water Erosion Prediction Project (WEPP)

Satellites:

Soil Moisture Active Passive (SMAP)

Soil Moisture Ocean Salinity (SMOS)

Meteorological Operational/Advanced Scatterometer (Met-Op/ASCAT)

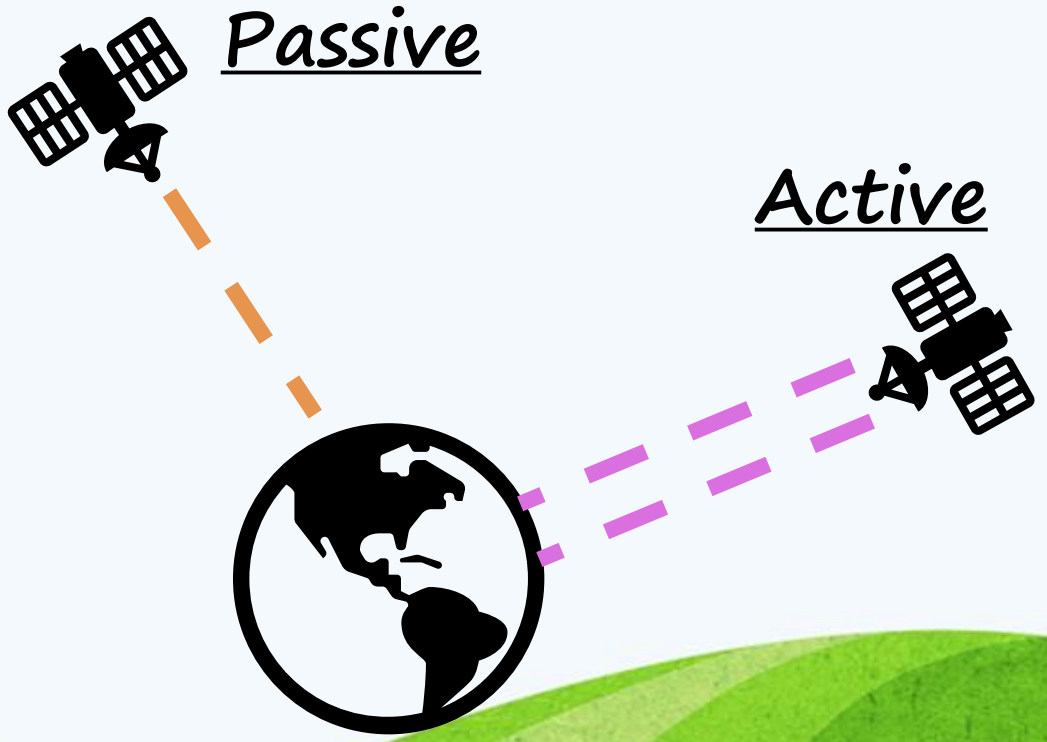
Data Collection: Soil Moisture Estimators

Reanalysis Models:

A model that uses all possible observations and is run back in time (the past, not future forecasting)

Giving what is thought to be the best possible answer

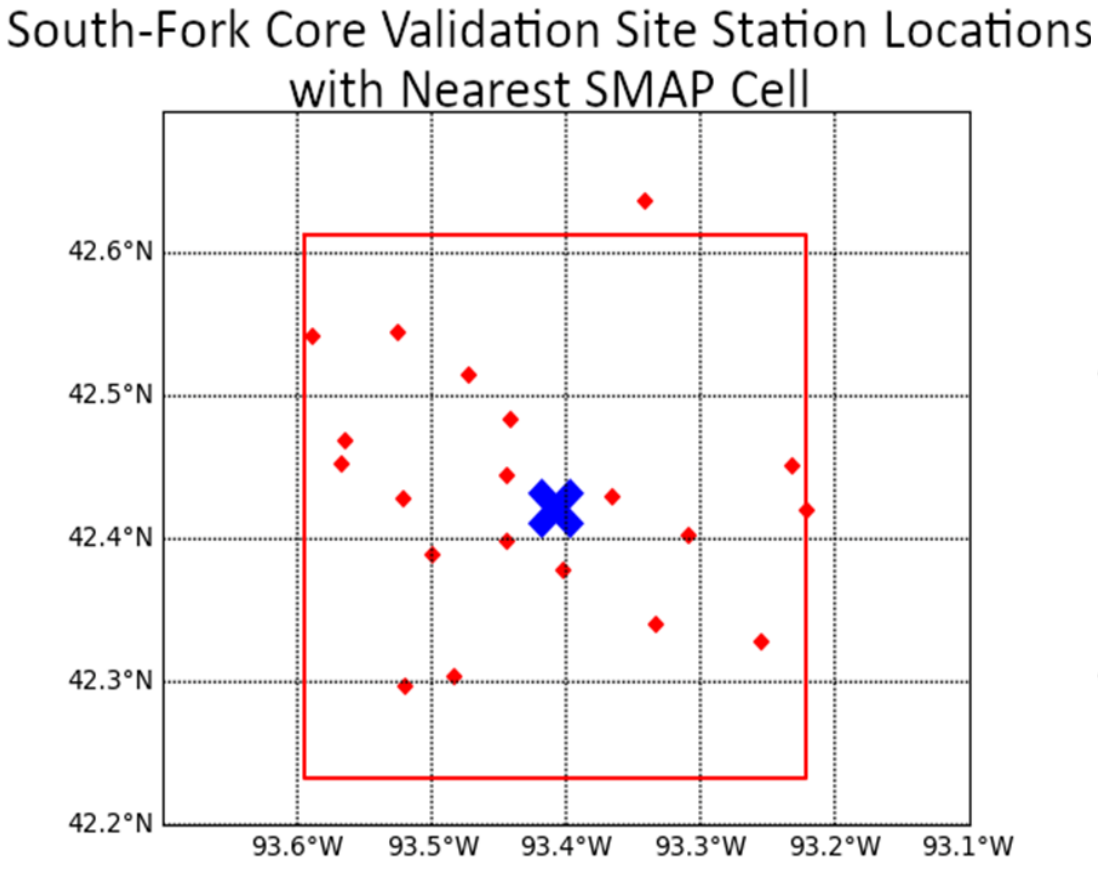
Satellites:

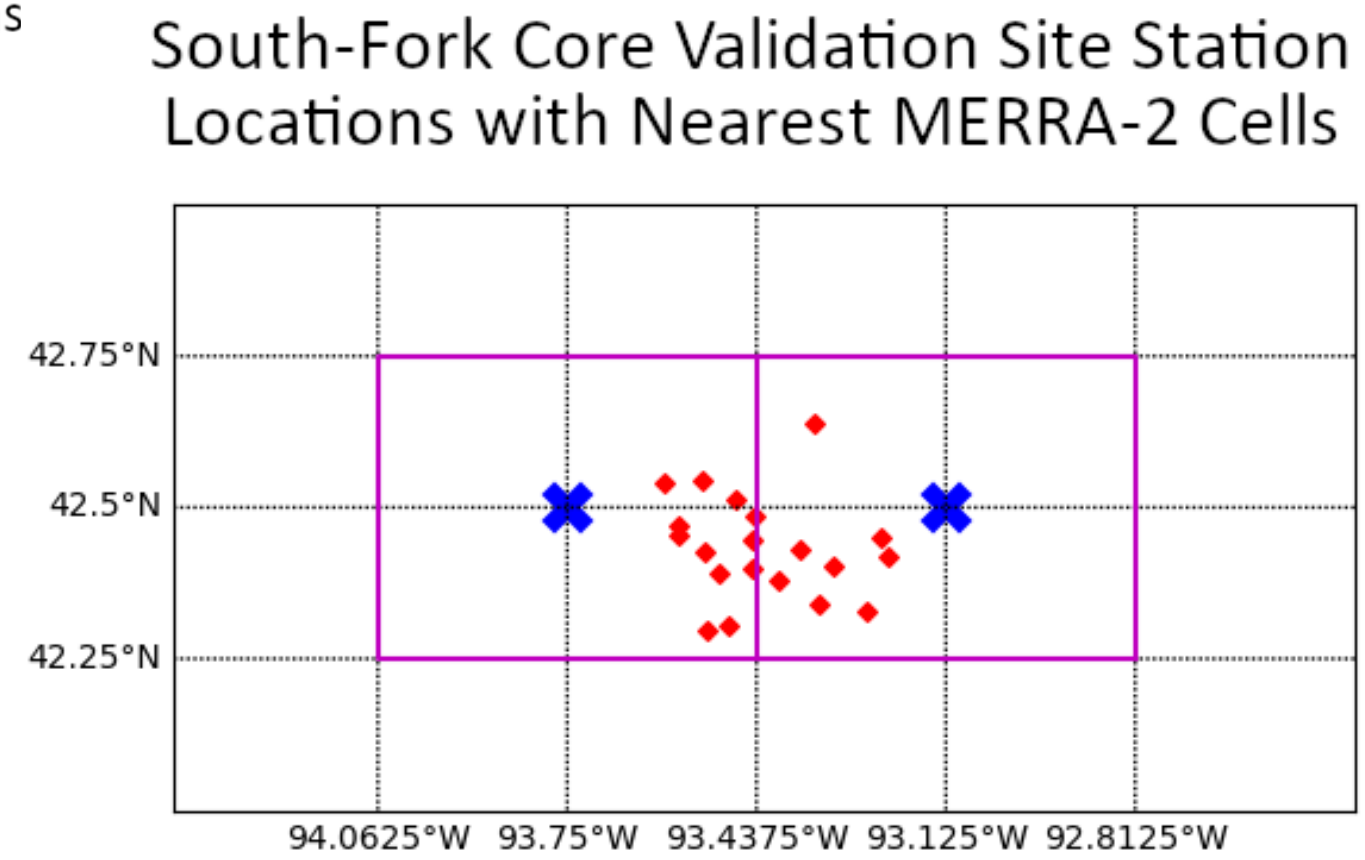


Data Collection: Soil Moisture Estimators

Characteristic	MERRA-2	NARR	WEPP	SMAP	SMOS	MetOp/ ASCAT
Organization	NASA	NCEP	USDA-ARS	NASA	ESA	EUMETSAT
Latency	Monthly	Monthly	-	< 24 hours	8-12 hours	< 36 hours
Measurement Soil Depth (cm)	0-5	0-10	0-10	~5	~5	~1 to 2
Temporal Resolution	Hourly	3-Hourly	Daily	Varies	Varies	Varies
Temporal Domain	1980 to present	1979 to present	-	March 2015 to present	June 2010 to present	Varies to present
Spatial Resolution	0.5° x 0.625°	32 x 32 km	-	33 x 33 km	43 x 43 km	25 x 25 km
Spatial Domain	Global	North America	Sub-watershed	Global	Global	Global

Data Collection: Soil Moisture Footprint/Grid





Materials and Methods: Validation Timeline

March 1st

Pre-Planting

Interpolated 50% Planting Stage

Active-Management

When canopy closure is reached [V8]

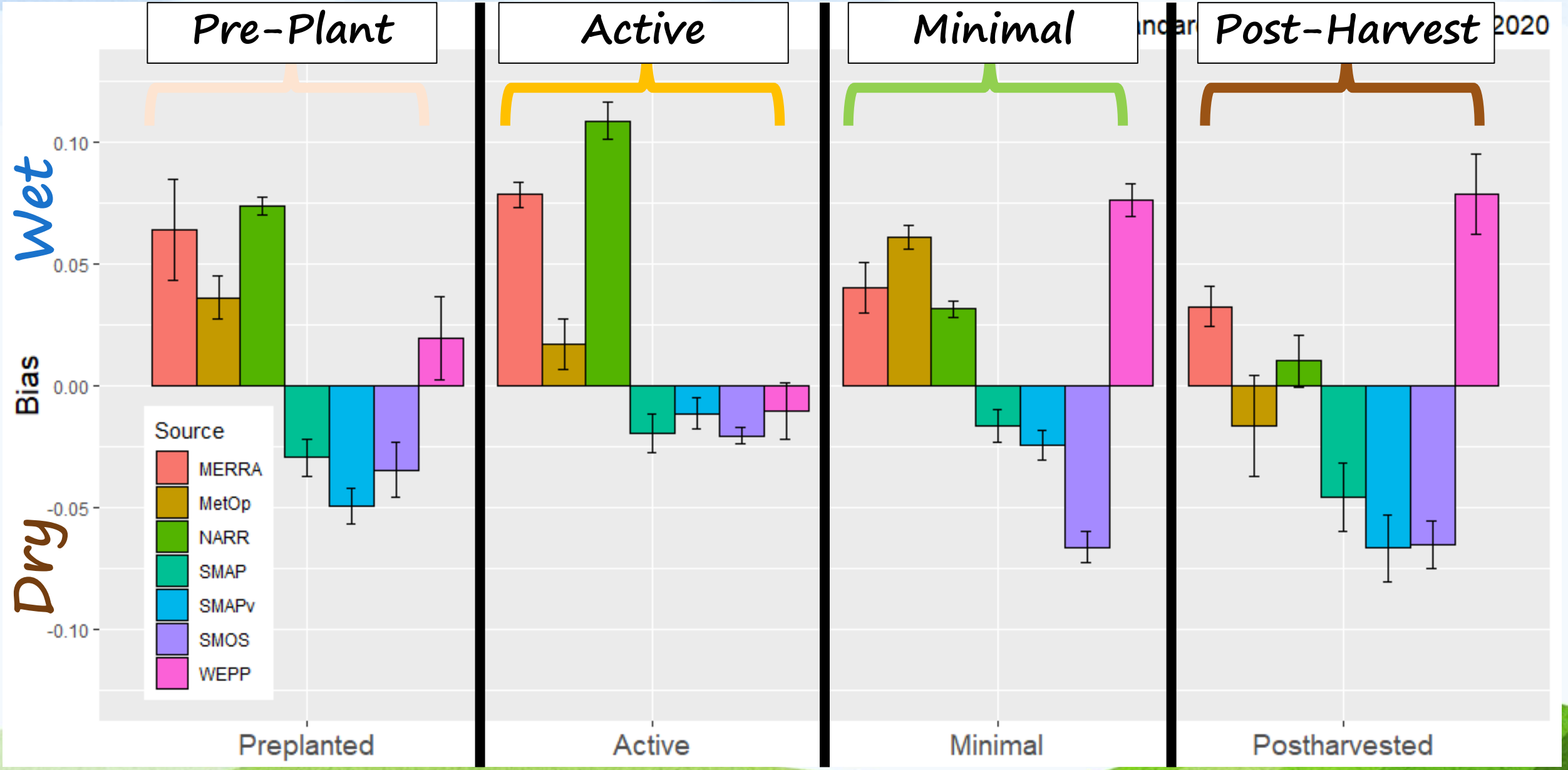
Minimal-Management

Interpolated 50% Harvesting Stage

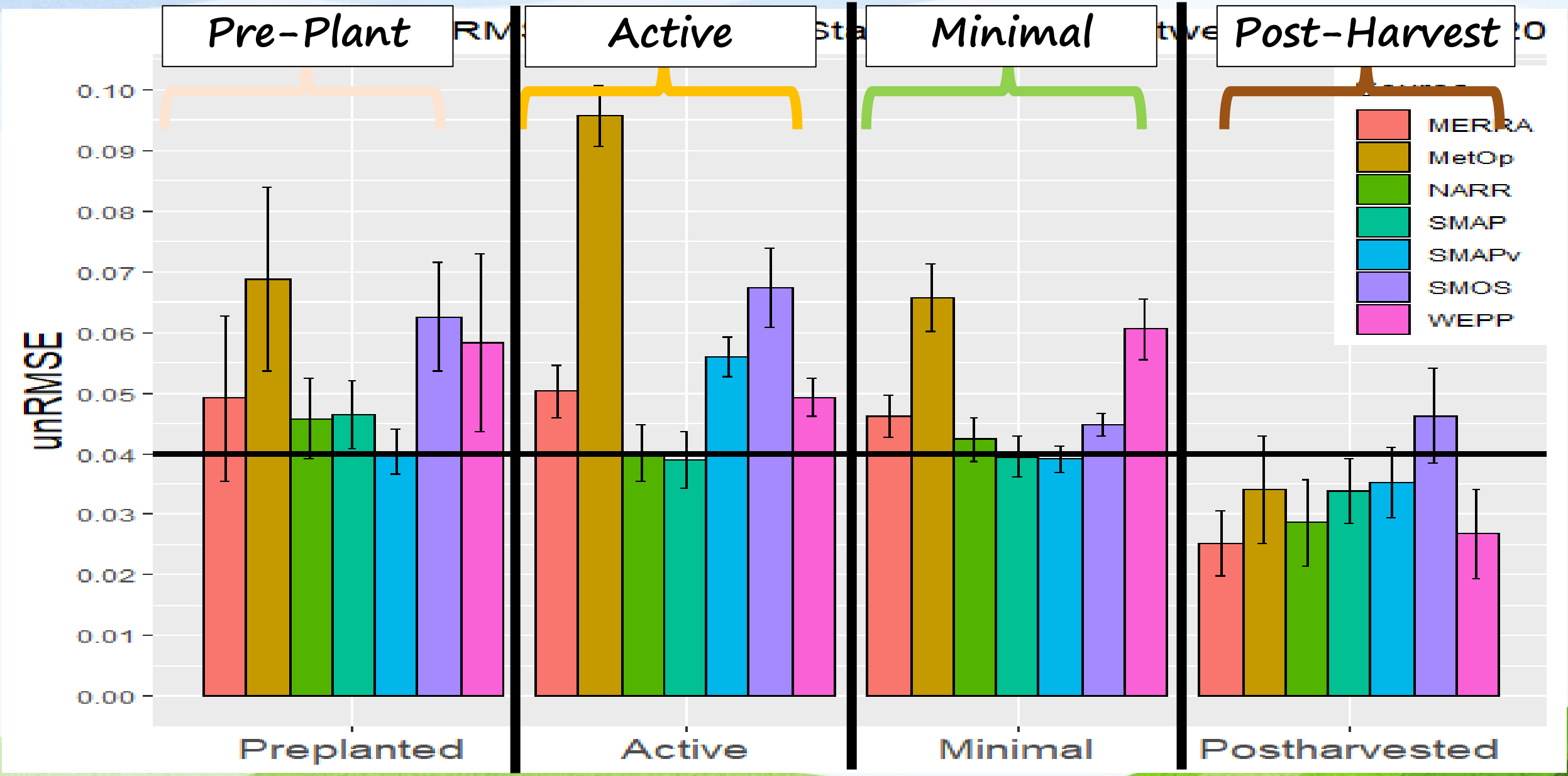
Post-Harvesting

November 30th

Results: Bias



Results: unRMSE



Conclusion:

- On average, there is consistency in bias (dry or wet) throughout the year for a given estimator, but the magnitude changes throughout the growing season.
- On average, there is some consistency in unRMSE at or above the threshold of $0.04\ [\mathrm{m^3 m^{-3}}]$, but the magnitude changes throughout the growing season.
- The crop-based timeline can show bias patterns associated with a growing season that would normally be “hidden” in an annual validation.

Discussion: Other Applications

Other applications for the Validation Timeline:

- Any research that involves increasing the efficiency of farm management.

Other uses for the USDA Data:

- Calibrating spatially large models with parameters like planting and harvesting dates.

Acknowledgements:

Dr. Brian Hornbuckle – Major Professor
Dr. Jun Wang – University of Iowa
Dr. Michael Cosh – USDA-ARS
Daryl Herzmann – Iowa State University

DataFEWSion Graduate Traineeship Program

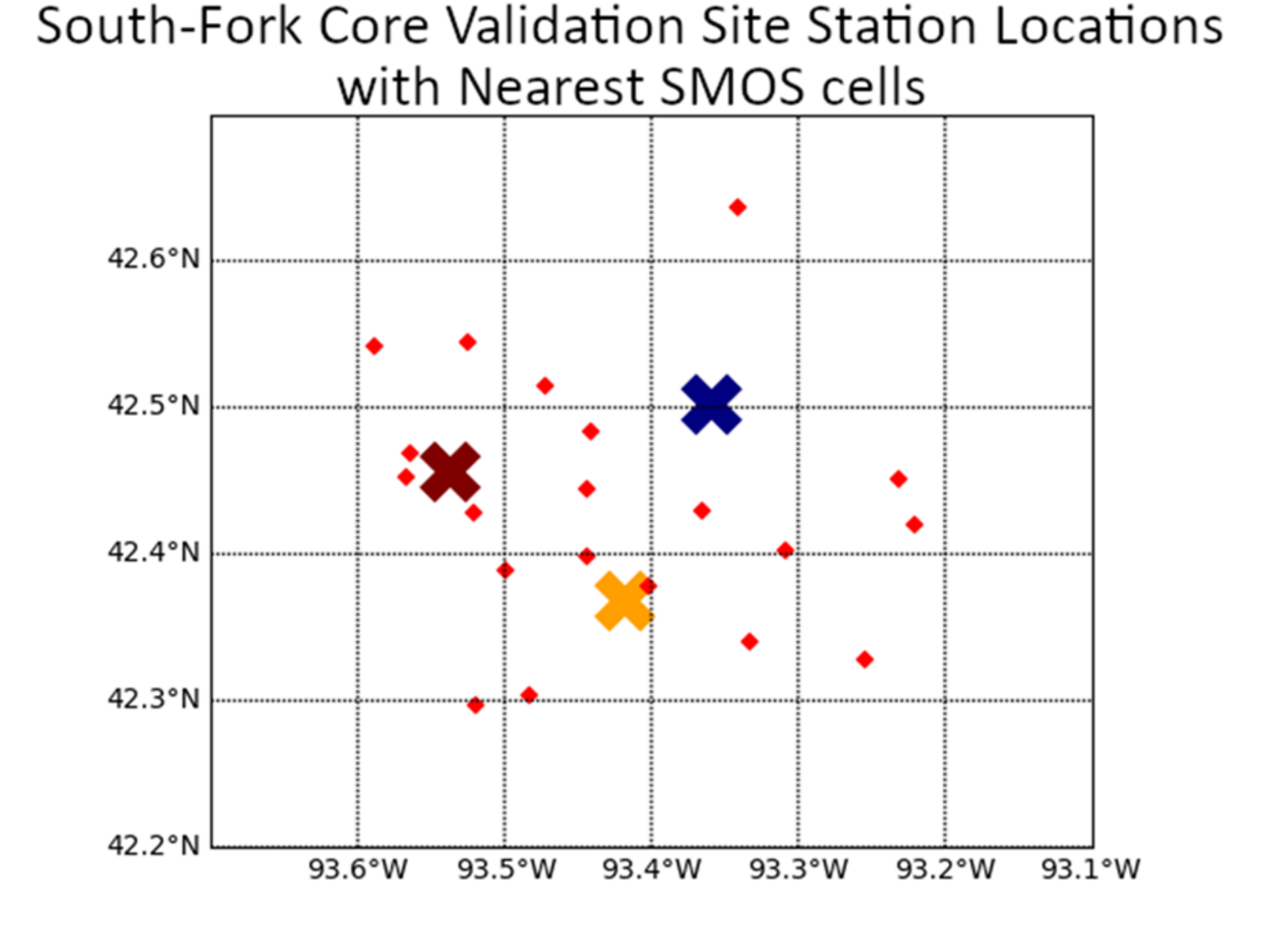
Innovations at the FEWS nexus

Appendix: Dates in Timeline

Table 3.5 Transition periods between the key validation segments. Each column is represented for a date within the year specified in a month/day format.

Year	Start	Planted	Canopy Closure	Harvested	End
2016	03/01	04/23	06/18	10/20	11/30
2017	03/01	04/30	06/21	10/30	11/30
2018	03/01	05/05	06/15	10/27	11/30
2019	03/01	05/03	06/28	11/06	11/30
2020	03/01	04/27	06/20	10/13	11/30

Appendix: SMOS Footprints



Appendix: Effects of Crops and soil in Retrievals

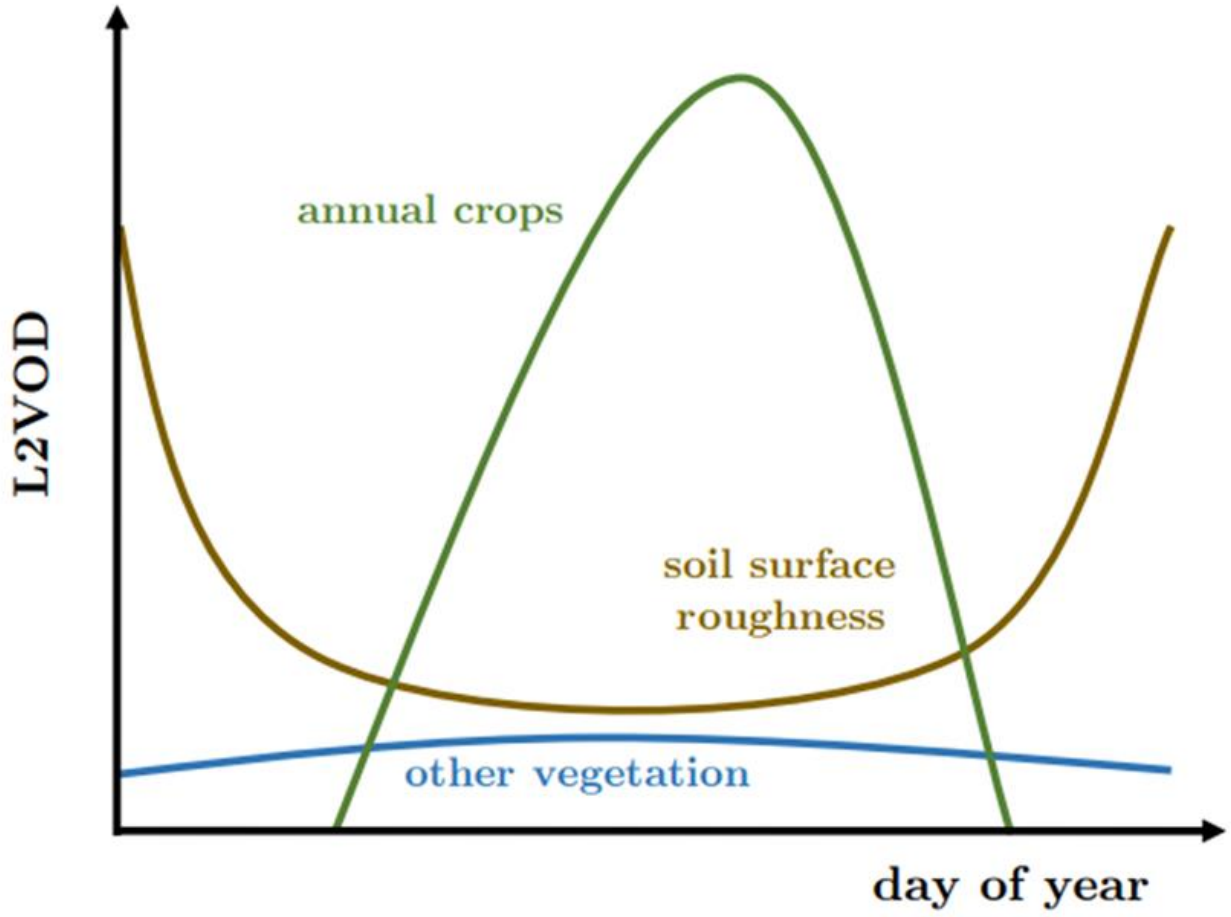
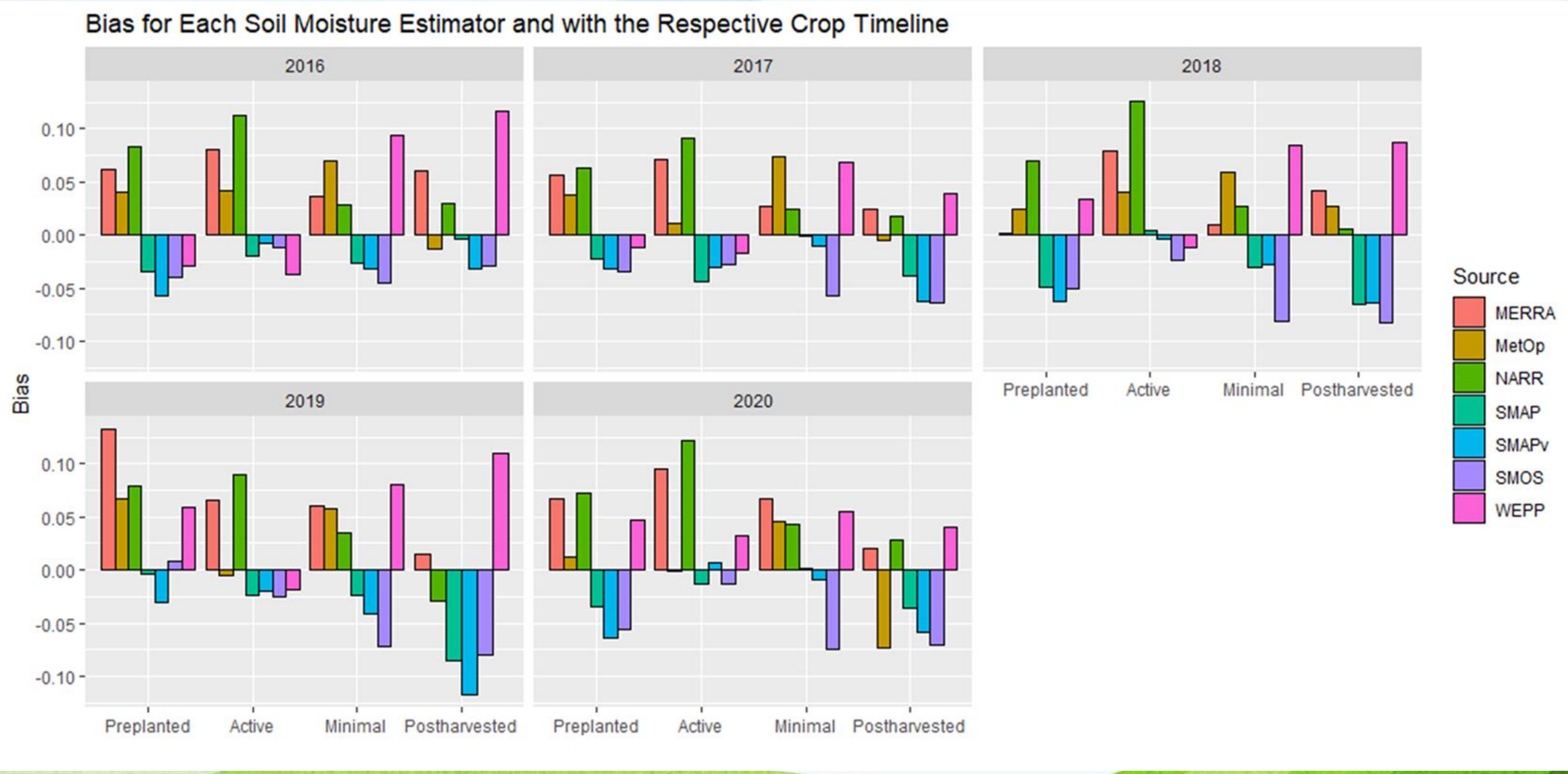
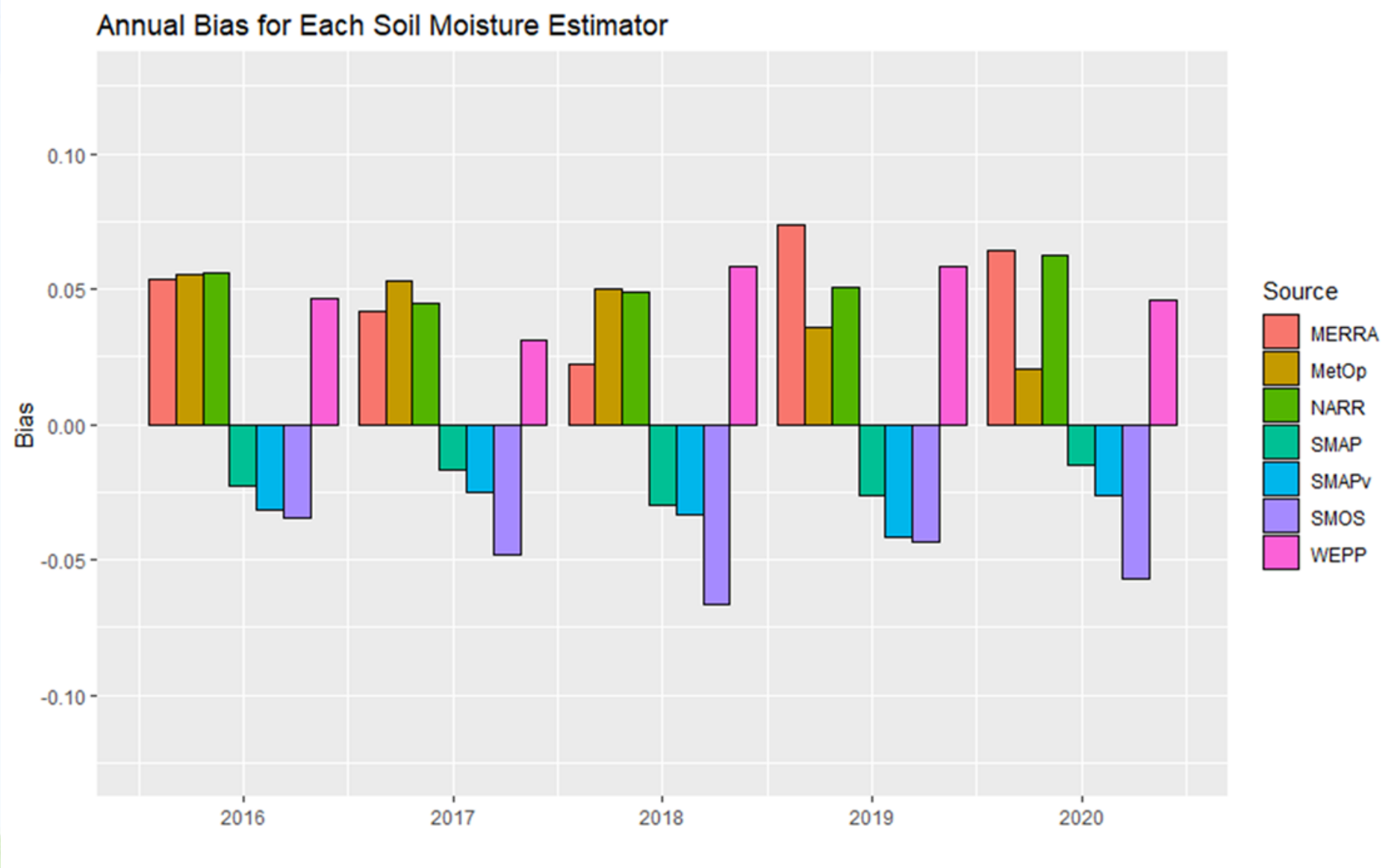


Figure 3.1 Conceptual diagram of retrieved L2VOD in the U.S. Corn Belt.

Appendix: Yearly Breakdown of Analysis



Appendix: Breakdown of a Whole Growing Season



Appendix: Assumptions

1. MetOp Porosity:
   - From SMAP Ancillary EASE-2 grid data assumed to be 0.4928 in SF
   - $\therefore Soil\ Moisture = 0.4928 \times Soil\ Moisture\ Conent$
2. Canopy Closure occurs at V8 using Central Climate Division NWS-COOP temperature data from ISU IEM
3. In-situ site is homogenous and represents every grid/footprint
4. Iowa Central District is representative of south-fork in-situ site