VRI Irrigation Scheduling

MOISST Workshop

June 6, 2018

Lincoln, Nebraska

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Background

- Variable rate irrigation (VRI)
- Sprinkler and speed control to spatially vary applied irrigation under center pivots
- Remote sensing ET and water balance models to manage VRI

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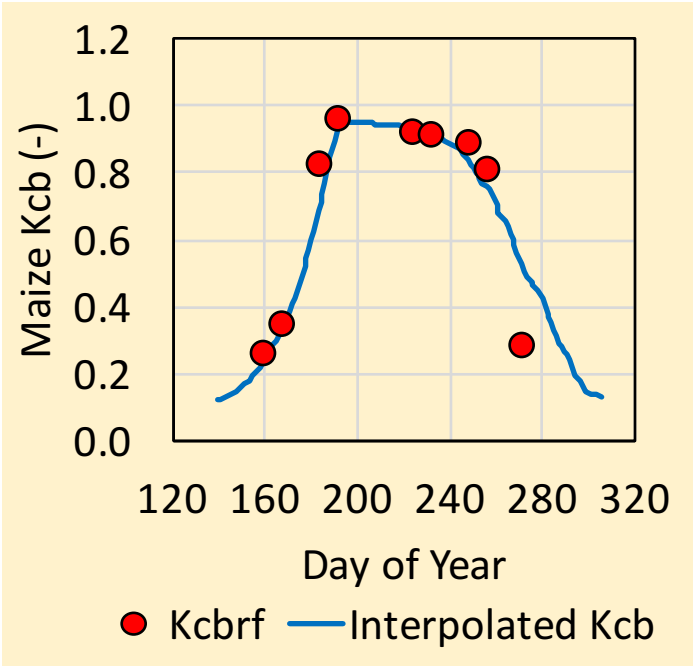
Background

- Little research on applying remote sensing ET (particularly thermal infrared based) in real-time irrigation management
- Results from three-years of research in eastern Nebraska, USA
  - Maize and soybean
  - 2015-2016: **Barker, J.B., D.M. Heeren, C.M.U. Neale, D.R. Rudnick. 2018. "Evaluation of variable rate irrigation using a remote-sensing-based model."** ***Ag. Water Mngt.*** **203: 63-74. DOI: 10.1016/j.agwat.2018.02.022**
  - 2017: Preliminary

Background

- Daily water balance using reflectance based basal crop coefficients (Bausch and Neale, 1987)
- Enables computation of water balance between remote sensing image dates (Campos et al. 2017)
- Two-source Energy Balance (TSEB; Norman et al. 1995) for comparison
- TSEB ET incorporated using statistical interpolation (Neale et al. 2012)



Data from Landsat 7 and 8, U.S. Geological Survey.
Weather data from HPRCC at UNL.

Bausch, W. C., & Neale, C. M. U. (1987). Crop coefficients derived from reflected canopy radiation - A concept. *Transactions of the ASAE,* 30(3), 703-709.

Campos, I., Neale, C.M.U., Suyker, A.E., Arkebauer, T.J., & Goncalves, I.Z. (2017). Reflectance-Based Crop Coefficients REDUX: For Operational Evapotranspiration Estimates in the Age of High Producing Hybrid Varieties. *Ag. Water Mgmt.* 187:140-153. DOI: 10.1016/j.agwat.2017.03.022

Norman, J.M., W.P. Kustas, K.S. Humes. 1995. "Source approach for estimating soil and vegetation energy fluxes in observations of directional radiometric surface temperature." *Ag. and Forest Meteor.* 77(3–4):263-293. DOI: 10.1016/0168-1923(95)02265-Y.

Neale, C.M.U, H.M.E. Geli, W.P. Kustas, J.G. Alfieri, P.H. Gowda, S.R. Evett, J.H. Prueger, L.E. Hipps, W.P. Dulaney, J.L. Chávez, A.N. French, T.A. Howell. 2012. "Soil water content estimation using a remote sensing based hybrid evapotranspiration modeling approach." *Adv. in Water Res.* 50:152-161.DOI: 10.1016/j.adwatres.2012.10.008

Why Modeling?

- Need three neutron probe measurement locations per irrigation management zone > ~1 ha (Barker et al. 2017)
- Assume ~1.2 m root zone and 2 cm total accuracy of mean.

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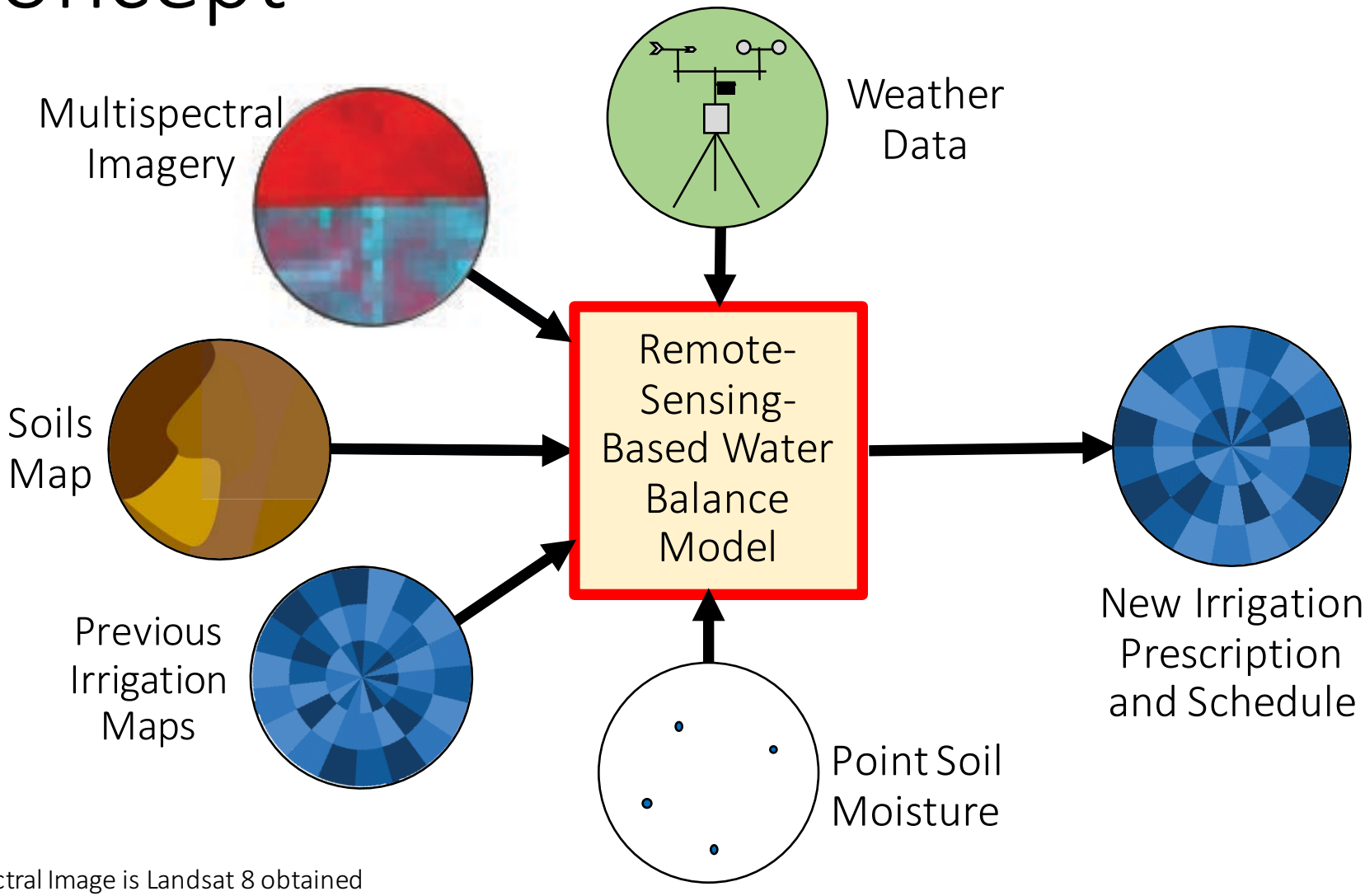
Barker, J.B., T.E. Franz, D.M. Heeren, C.M.U. Neale. 2017. "Soil water content monitoring for irrigation management: A geostatistical analysis." *Ag. Water Mngt.* 188: 36-49. DOI: 10.1016/j.agwat.2017.03.024

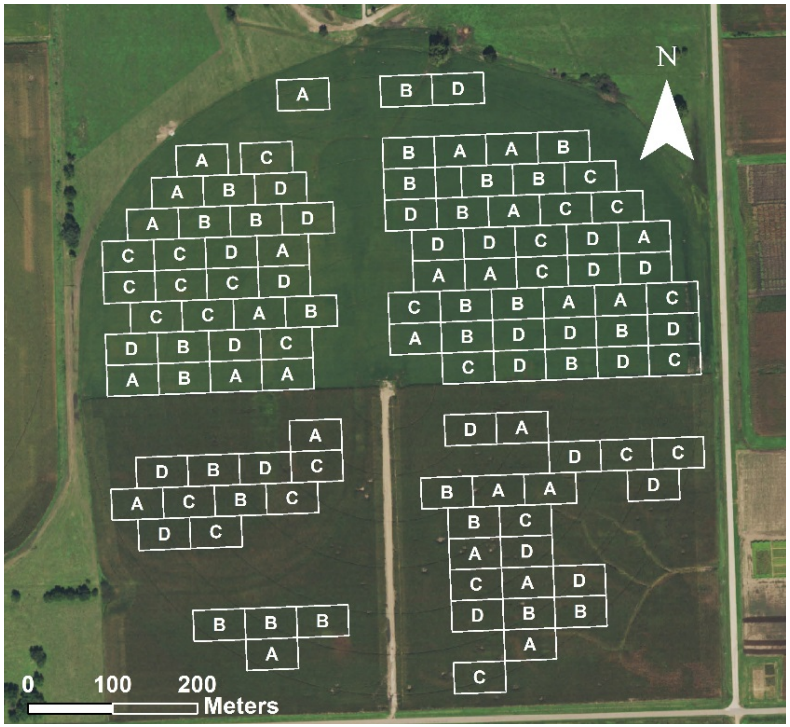
Concept



Multispectral Image is Landsat 8 obtained from the U.S. Geological Survey.

Methods

- Eastern Nebraska Research and Extension Center
- Production scale
- ~53 ha irrigated field
- ½ maize, ½ soybean in annual rotation
- VRI center pivot



Aerial image source: USDA-FSA-APFO. October, 25, 2014. "USDA-FSA-APFO Digital Ortho Mosaic." USDA_FSA_APFO Aerial Photography Field Office, Salt Lake City, Utah, USA. Obtained from the USDA-NRCS Geospatial Datagateway: https://datagateway.nrcs.usda.gov

Methods info: Barker, J.B., D.M. Heeren, C.M.U. Neale, D.R. Rudnick. 2018. "Evaluation of variable rate irrigation using a remote-sensing-based model." *Ag. Water Mngt.* 203: 63-74. DOI: 10.1016/j.agwat.2018.02.022

Methods

- Field capacity from neutron probe
- Wilting point from electrical conductivity survey and benchtop psychrometer measurements

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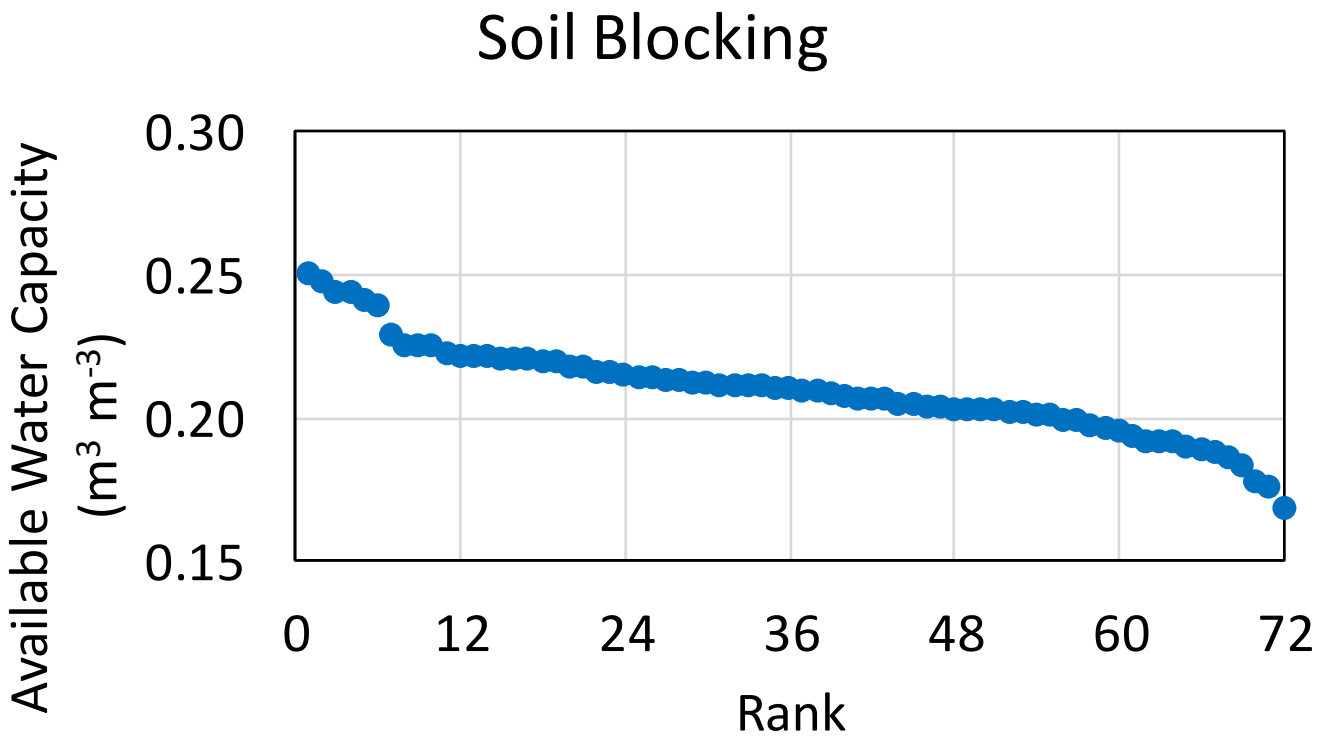
Irrigation Blocks, 2018



Methods

- Four treatments
  - Variable rate irrigation with RS-based ET model – used Landsat 7, 8
  - Variable rate irrigation with neutron-probe-base water balance
  - Uniform with neutron-probe-based water balance
  - Rainfed
- Plot specific available water capacity

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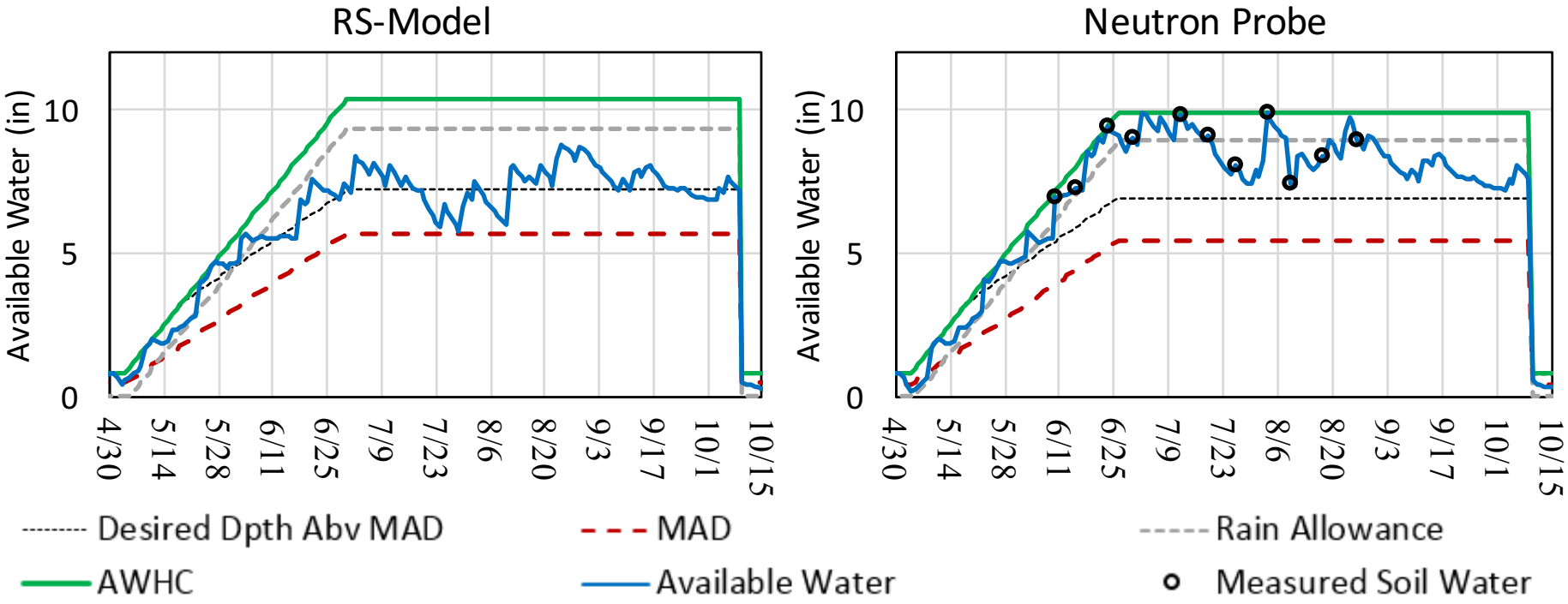
Process

- Schedule to avoid exceeding management allowable depletion (e.g., 50% of root zone available water holding capacity)



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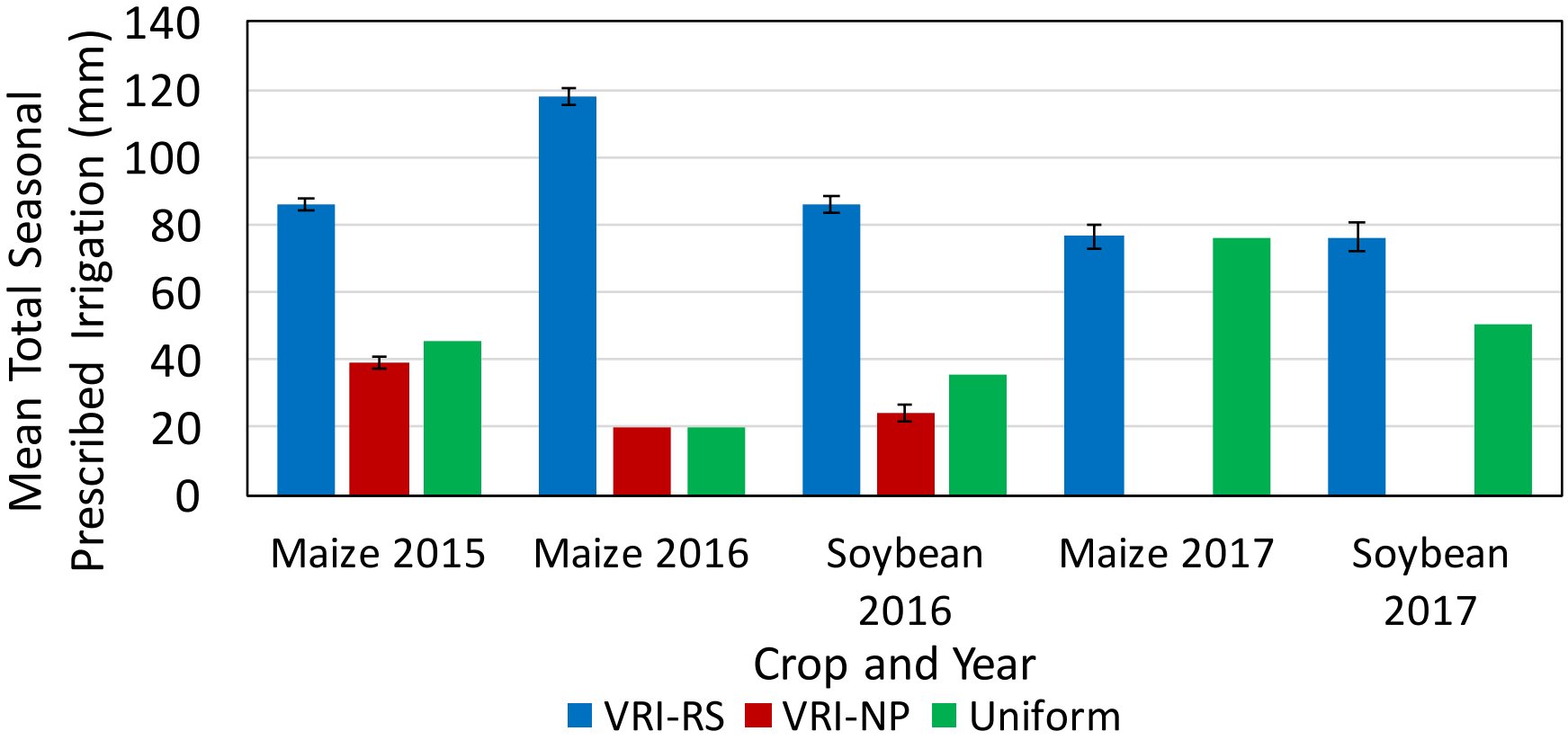
Process

- Individual nozzle control VRI

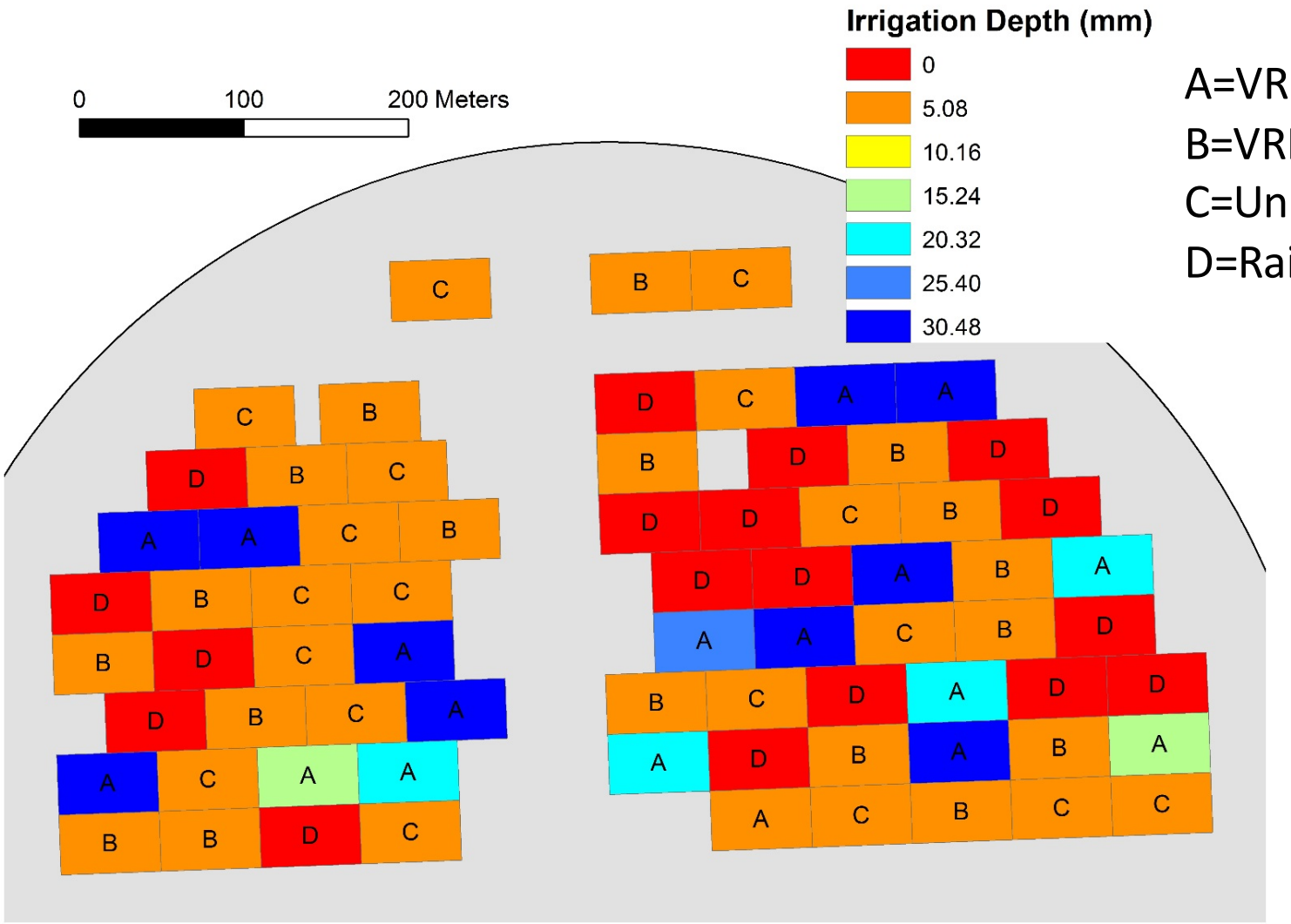
Photo: Derek Heeren? Mention of tradenames does not constitute endorsement by the University of Nebraska

Total Prescribed Irrigation

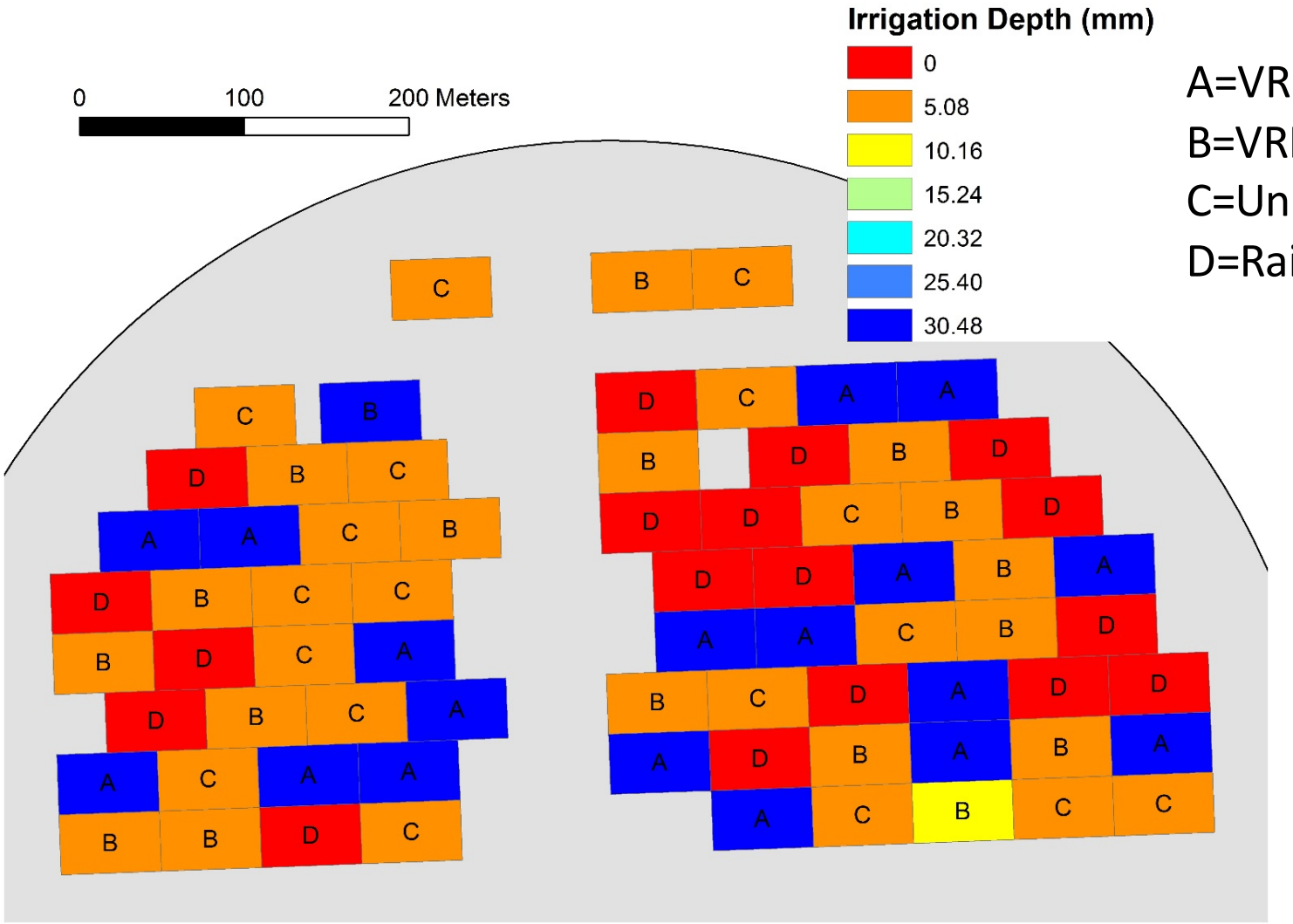


Source of 2015 and 2016 data: Barker, J.B., D.M. Heeren, C.M.U. Neale, D.R. Rudnick. 2018. "Evaluation of variable rate irrigation using a remote-sensing-based model." *Ag. Water Mngt.* 203: 63-74. DOI: 10.1016/j.agwat.2018.02.022

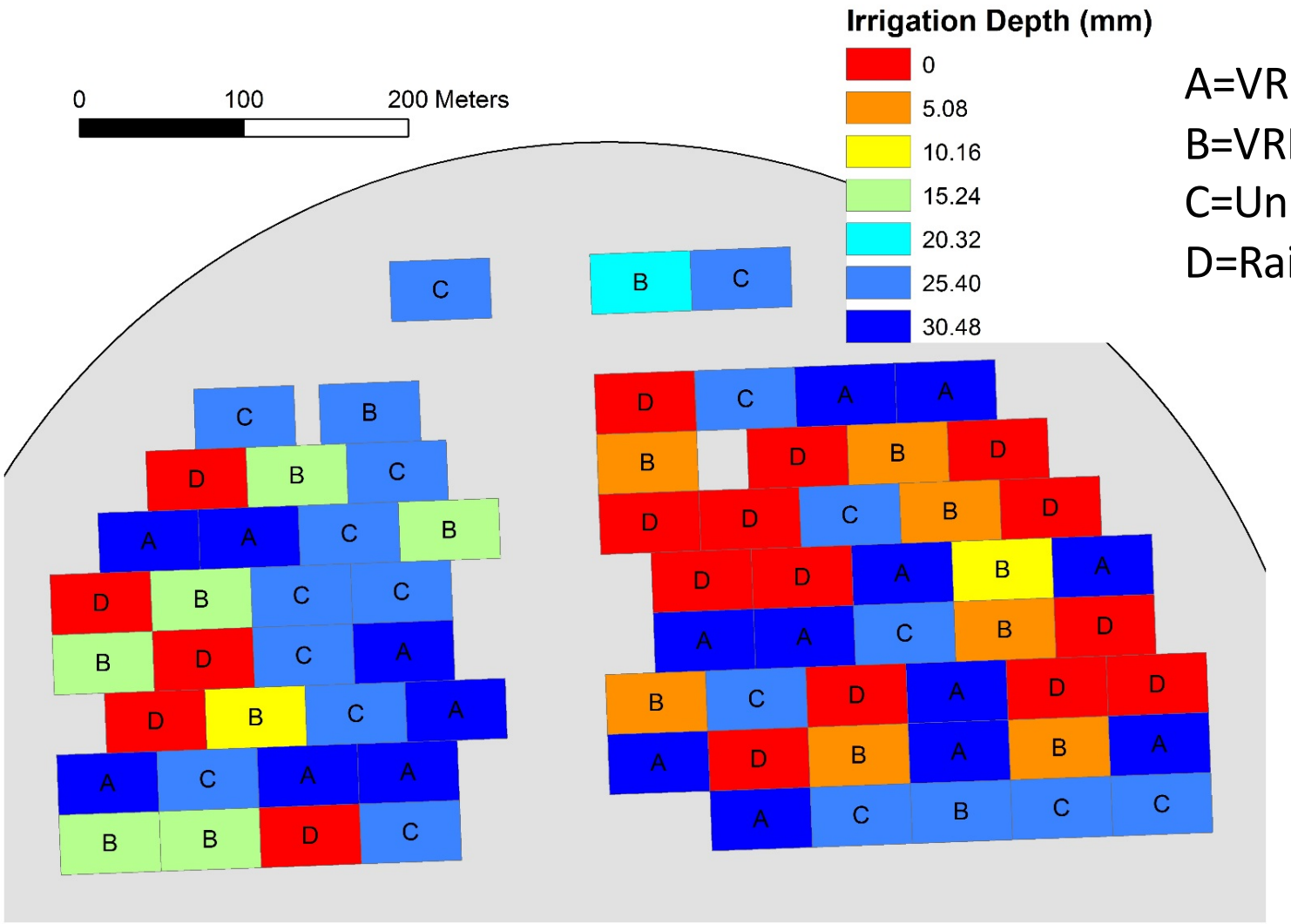
Prescribed Irrigation 2016, Soybean



Prescribed Irrigation 2016, Soybean

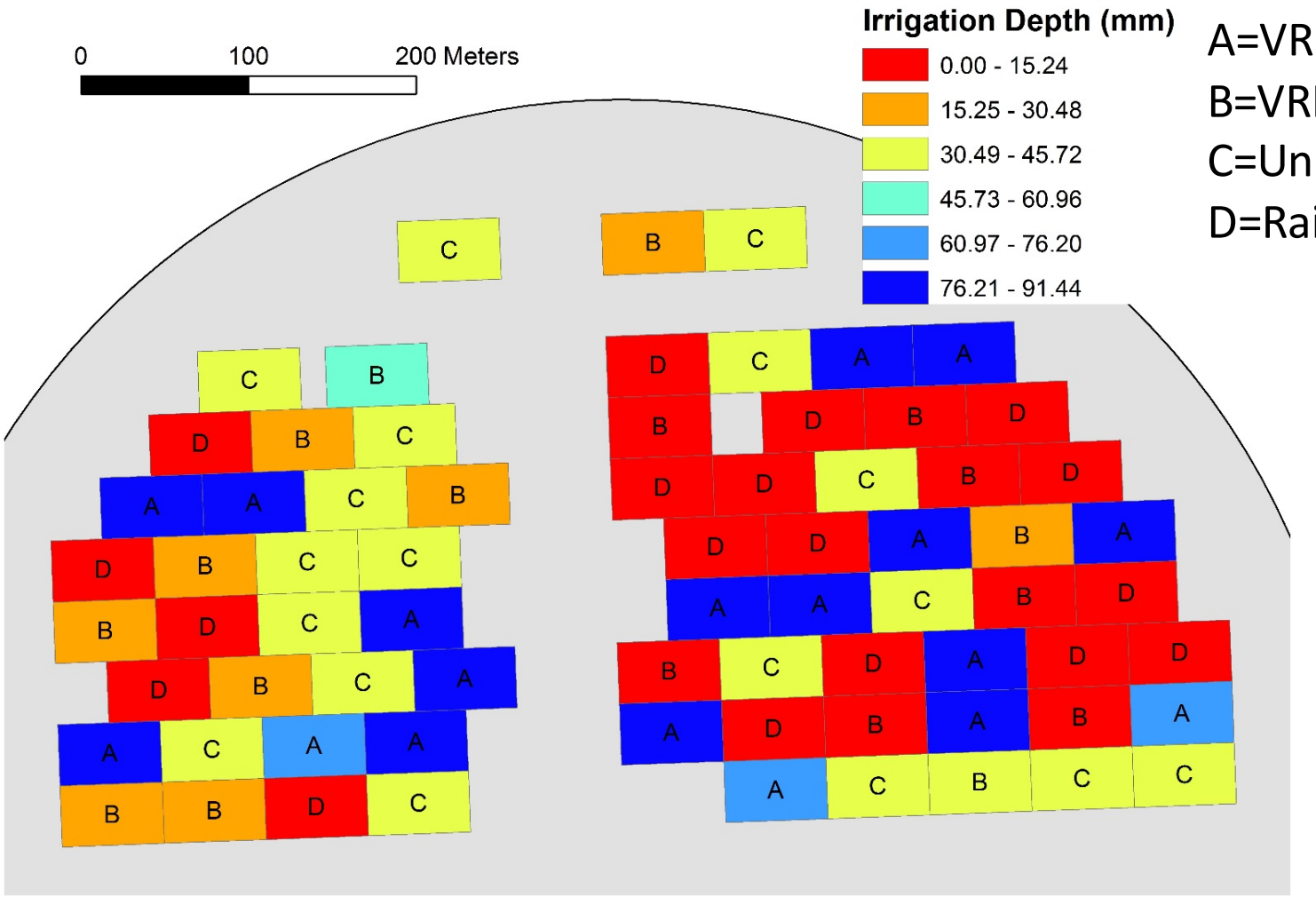


Prescribed Irrigation 2016, Soybean

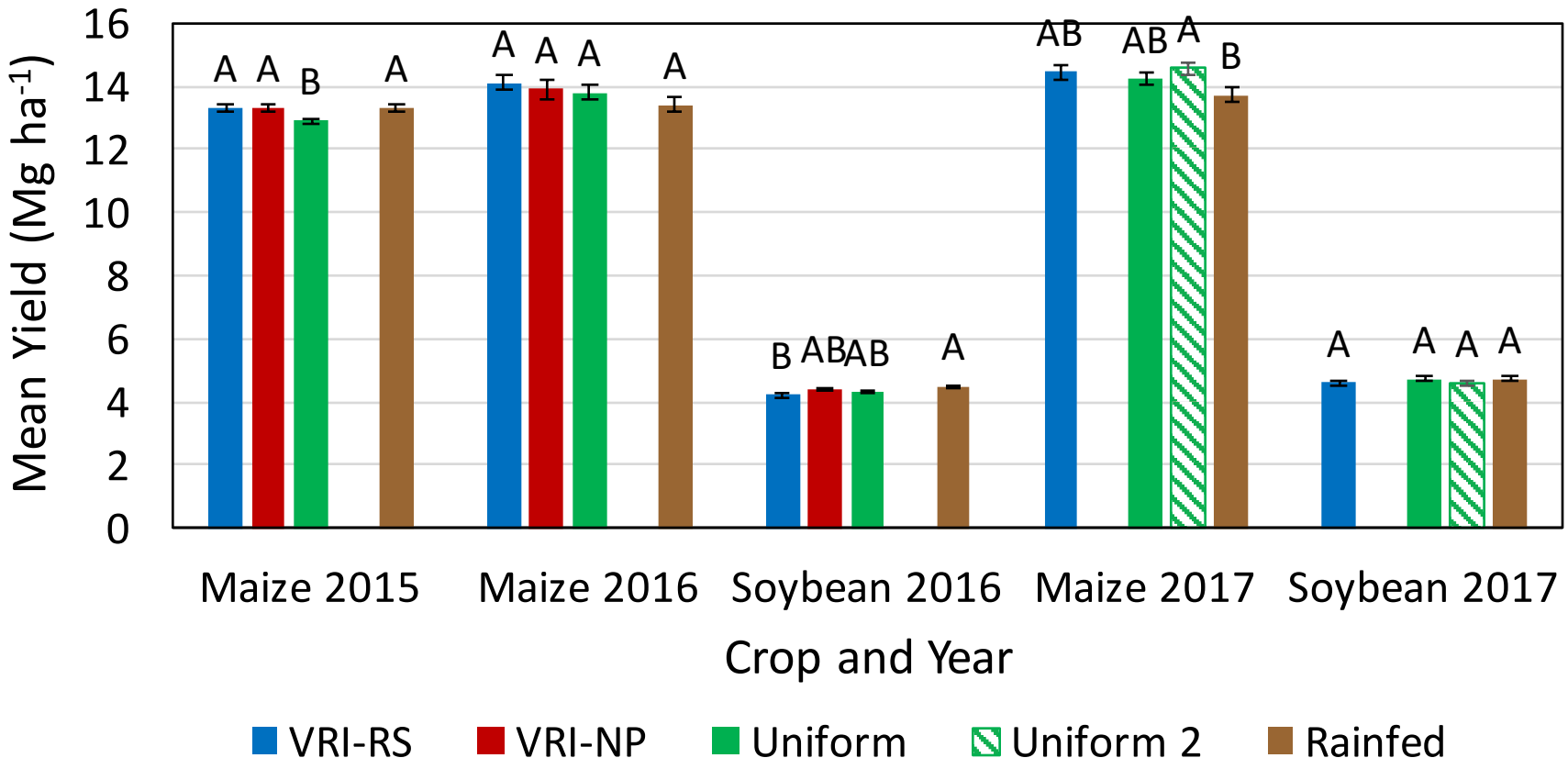


A=VRI-RS
B=VRI-Neutron
C=Uniform
D=Rainfed

Prescribed Irrigation 2016, Soybean



Total Yield



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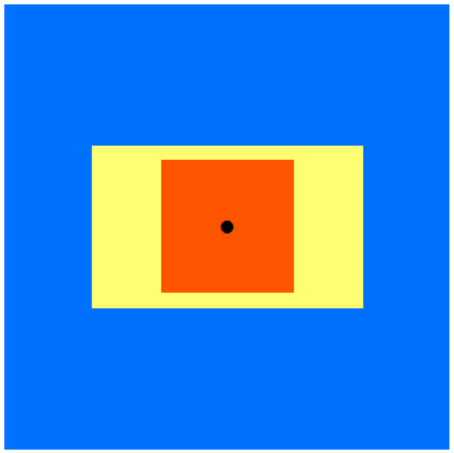
Summary

- VRI-RS treatment resulted in greatest prescribed irrigation because of model drift – possibly drainage related
- Yield effects mostly expected to be random error in maize, except perhaps 2017
- Possible over irrigation in soybeans in 2016
- Satellite image frequency was a challenge

Scale Issues and Adoptability

- Different scales of measurements
  - Landsat thermal measurement resolution (60-100 m; USGS 2018)
  - Plot size (120 ft. × 200 ft.; 37 m × 61 m)
  - Landsat shortwave resolution (30 m; USGS 2018)
  - Neutron probe measurement volume (small)



Blue is 100 m x 100 m
Yellow is plot
Orange is 30 m x 30 m
Black is point

USGS. 2018. https://landsat.usgs.gov/what-are-band-designations-landsat-satellites. Last updated 4/25/2018. Accessed 6/4/2018.

Scale Issues and Adoptability

- Addressing scale and adoptability
  - Unmanned aircraft (finer spatial scale)
  - Electronic soil moisture sensors

Photo courtesy of M. Maguire, UNL.

Sensor station, 2016, photo courtesy of G. Bai.

Acknowledgements

- Drs. Daran Rudnick and Joe Luck
- Many individuals helped with the research
- Weather data from the High Plains Regional Climate Center and Cosmic-ray Soil Moisture Observing System

- Other Funding
  - **USDA-AFRI**
  - USGS
  - Nebraska Engineering Recruitment Fellowship Graduate Recruitment fellowship
  - Milton E. Mohr Graduate Fellowship
  - Elenore Gakemeier Swarts Outstanding Doctoral Student Award
  - University of Nebraska Presidential Fellowship

Questions?

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https://heeren.unl.edu/variable-rate-irrigation