Benchmarking irrigation water use in producer fields in US central Great Plains*

Patricio Grassini [1], Katherine Gibson [2], Justin Gibson [2]

[1] UNL Department of Agronomy and Horticulture
[2] Water For Food Global Institute, University of Nebraska-Lincoln

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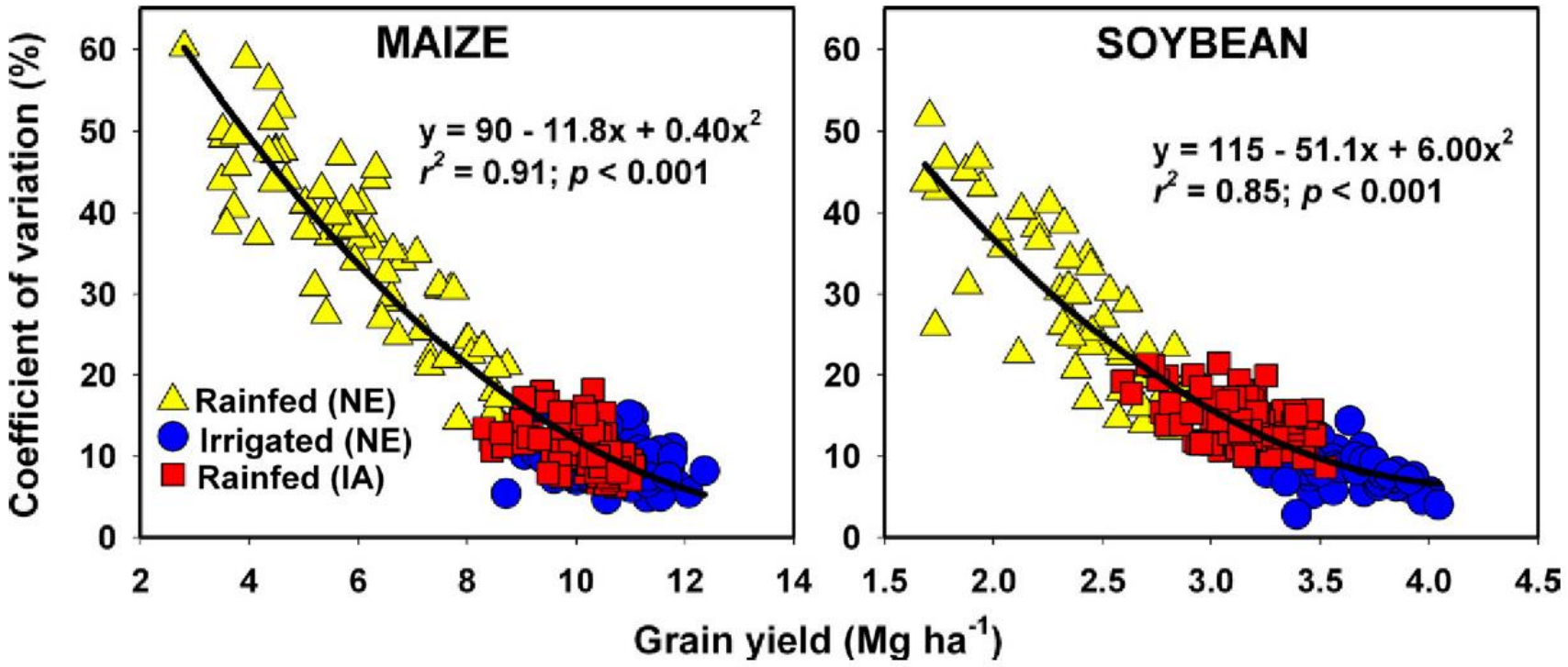
IRRIGATION INCREASES YIELD AND REDUCES VARIABILITY

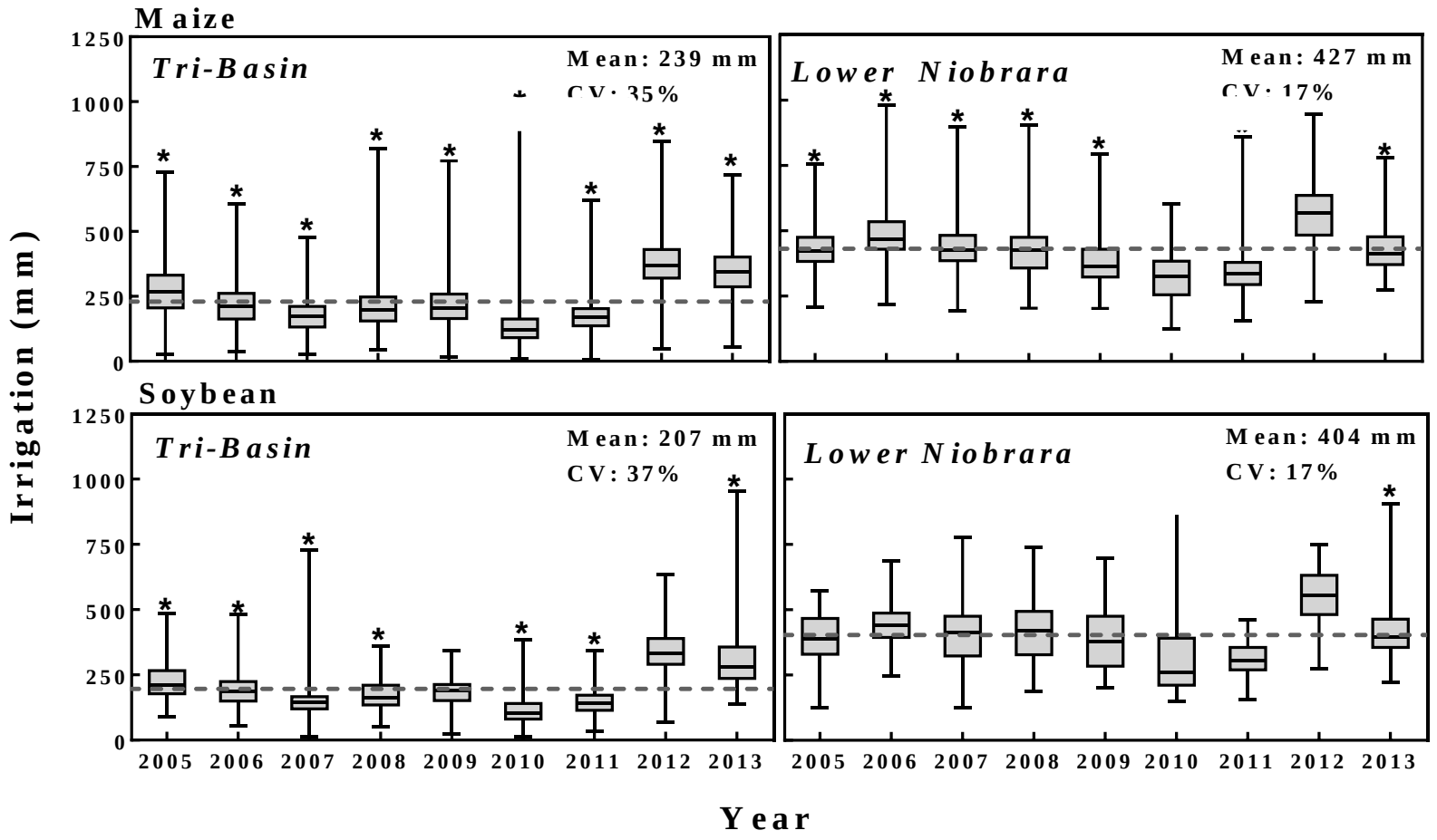
Each point represents a 10-y county average yield and its coefficient of variation for rainfed crops in Iowa (IA) and irrigated and rainfed crops in Nebraska (NE). Source: USDA-NASS



Source: Grassini *et al.* 2015; Crop Physiology-Applications for Genetic Improvement and Agronomy (2nd Ed)

Variation in irrigation across producer fields

- Huge field-to-field variability in irrigation for any given region and year
- 70% of region-year field irrigation distributions are skewed (*) towards high values



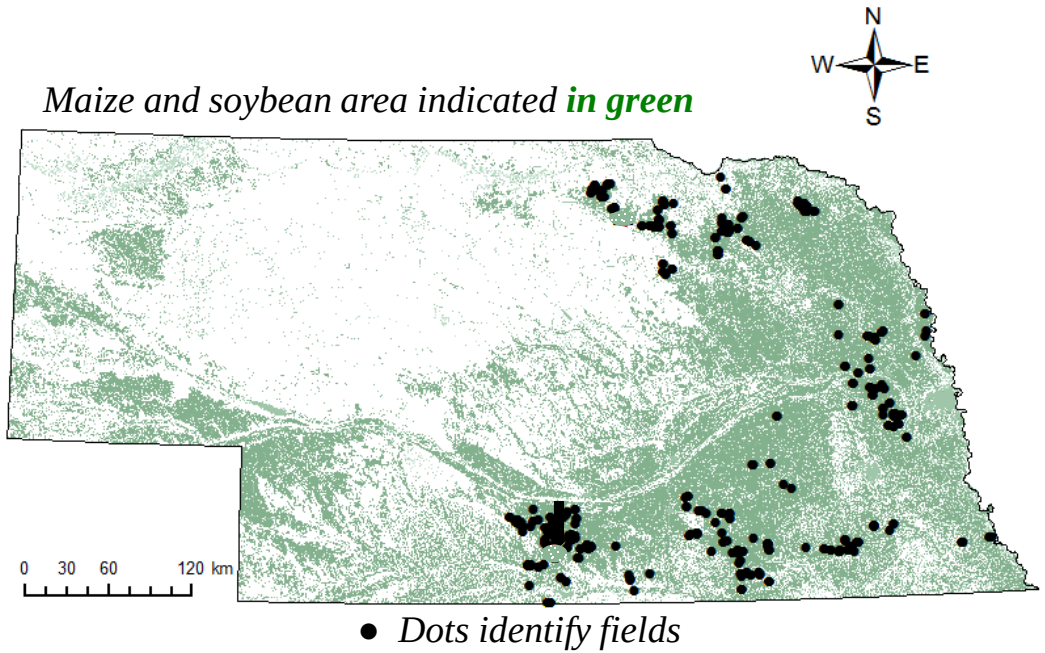
Objectives

- Develop a framework to benchmark on-farm irrigation
- Identify opportunities to improve field-level irrigation management without hurting crop yields

http://il5.picdn.net/shutterstock/videos/768742/thumb/1.jpg

Producer field data collection

- 534 maize and soybean, center-pivot irrigated fields over three years – 2010, 2011, 2012
- Fields covered variety of management, soils, and weather, including wet (2010) and drought years (2012)
- High-quality field data on:
  - Irrigation (flowmeters)
  - Yield
  - Management practices
  - Soil
  - Weather



Irrigation water surplus and relative yield

Irrigation water surplus: difference between producer irrigation and irrigation water requirements

- Small water surplus: producer irrigation ≈ irrigation requirement
- Large water surplus: producer irrigation exceeds irrigation requirement by a large margin.
- We used 50 mm as a threshold to differentiate large *versus* small water surplus as it represents two irrigation events in a pivot-irrigated field.

Relative yield: ratio (as a %) between producer yield and yield potential

- Yield potential is defined as the yield of a well-adapted cultivar when grown without water and nutrient limitation and kept free of biotic stresses such as weeds, diseases, and insect pests (Evans 1993).
- A relative yield close to 100% indicates that producer yield is similar to yield potential
- Low relative yield indicates suboptimal management leading to a 'yield gap'
- In irrigated crop systems where producers have access to markets, inputs, and extension services, reaching 80% of yield potential is a reasonable goal.

Estimation of yield potential and irrigation requirement for each producer field

Well-validated crop models to simulate *irrigation requirement* and *yield potential* for each field based on site-specific weather, soil, and management (e.g., planting date, relative maturity).

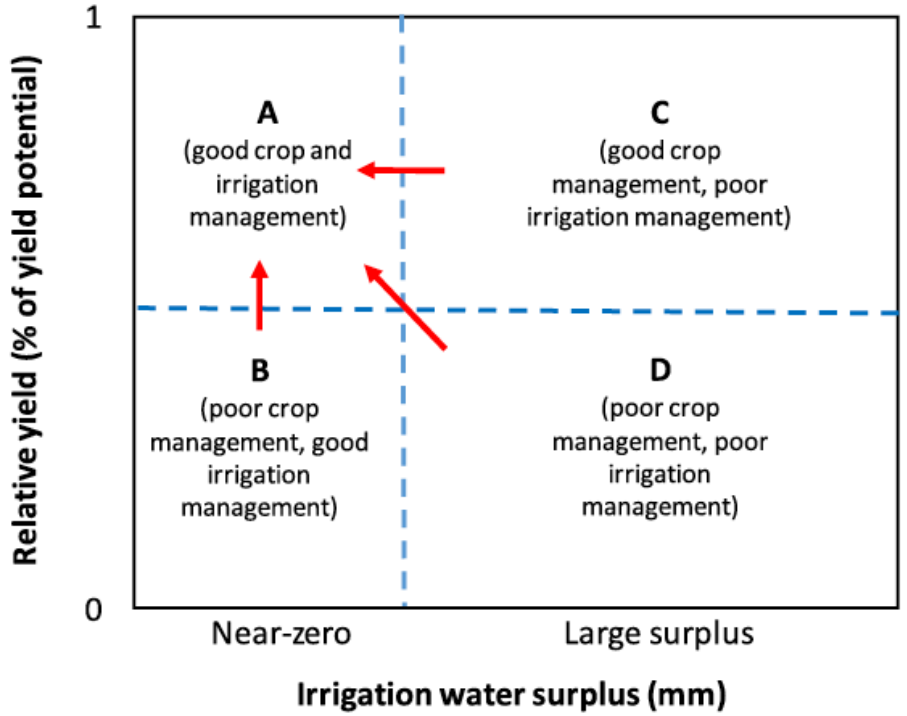
- ***HybridMaize*** **to simulate maize yield potential and irrigation water requirements (Yang *et al* 2004, 2017)**

- ***SoySim*** **to simulate soybean yield potential, *SoyWater* (http://hprcc-agron0.unl.edu/soywater/index.html) to simuate soybean irrigation requirements (Setiyono et al 2010, Specht et al. 2010)**

Conceptual framework

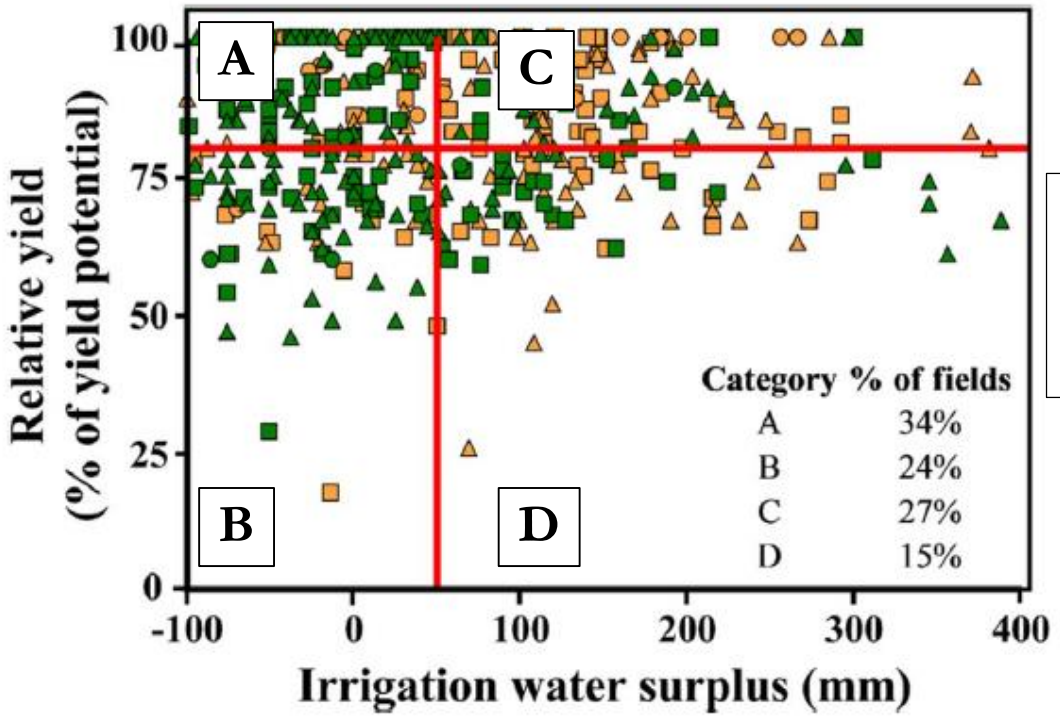
- Four categories based on irrigation water surplus & relative yield :

(A) Small water surplus, high relative yield
(B) Small water surplus, low relative yield
(C) Large water surplus, high relative yield
(D) Large water surplus, low relative yield



Where do producers' yields and irrigation fall?

- One third of producers achieved high yields with small water surplus (A)
- Large room for improvement as one third of the fields exhibited low yields (B & D) and 40% exhibited large water surplus (C & D).

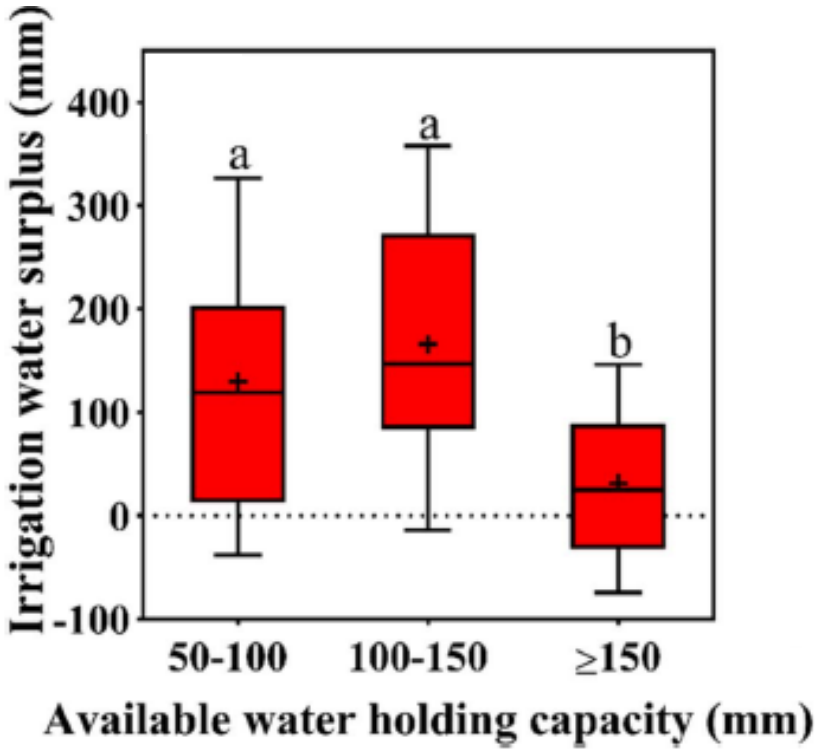


Each datapoint represents a field sown with maize (red) or soybean (green) in 2010 (squares), 2011 (triangles), or 2012 (circles)

1 inch = 25 mm

Irrigation, soil type, and risk perception

Magnitude of irrigation surplus increased with decreasing soil water holding capacity, despite the latter was taken into account to simulate water requirements

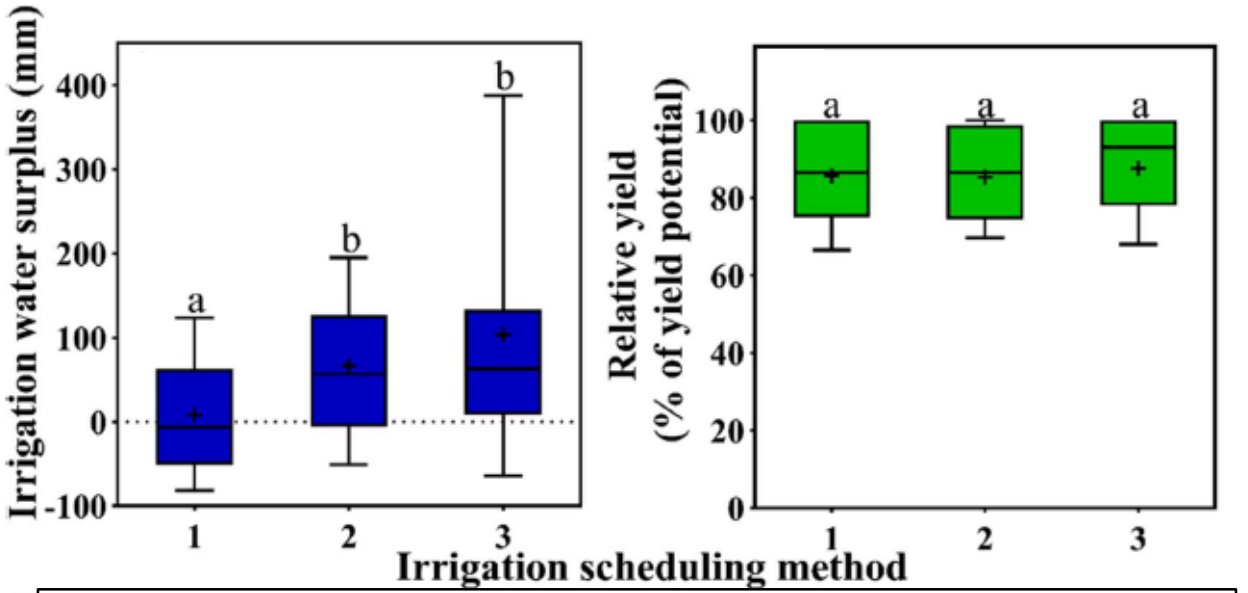


1 inch = 25 mm

Irrigation scheduling

- Empirical, generic scheduling methods resulted in large irrigation water surplus
- No difference in yield between scheduling methods (P = 0.54)
- Large room to reduce water surplus without hurting yield through better scheduling

1 inch = 25 mm



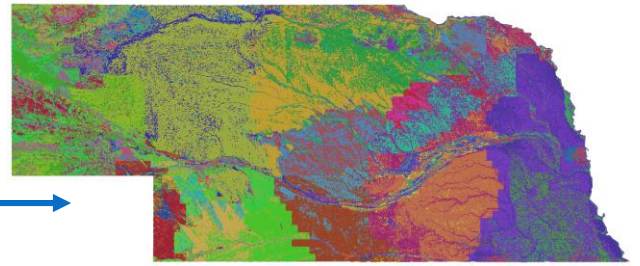
(1) soil water sensors and/or soil water balance (22% of fields)
(2) examination of soil samples – 'feel the soil' (64% of fields)
(3) rudimentary methods: fixed schedule, visual inspection of the crop, follow neighbor's schedule (14% of fields)

Estimating regional irrigation savings

Technology Extrapolation Domains (TEDs)* basis for up-scaling

TEDs: spatial unit, specific combination of climate & soil

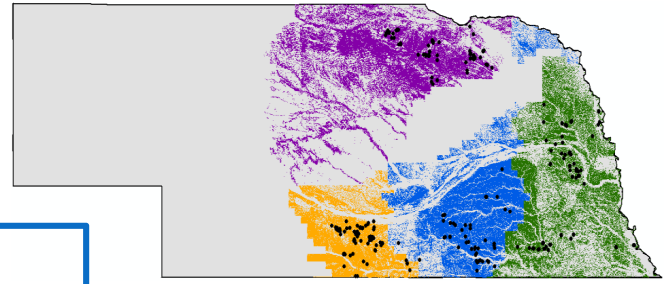
Soil and weather considered relatively homogeneous within a TED



*Rattalino Edreira et al. (ERL 2018)

4 TEDs to represent study area

Covers 43% of irrigated maize area and 52% of irrigated soybean area in Nebraska

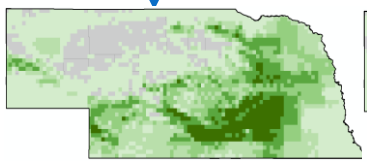


TEDs with irrigated crop area

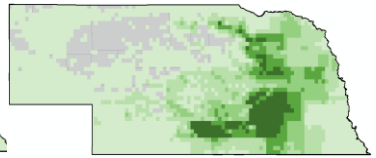
From Spatial Production Allocation Model (SPAM)

Actual irrigation water volume for each crop, region, year†

(Reported irrigation for [Zone], [Year], [Crop]) **x** (Area of [Crop] in [Zone]) = Average water volume used



SPAM Maize Area
http://mapspam.info/



SPAM Soybean Area
http://mapspam.info/

<u>Adjusted</u> irrigation water volume for each crop, region, year

(Adjusted irrigation for Zone], [Year], [Crop]) **x** (Area of [Crop] in [Zone]) = Average adjusted water volume

Actual water vol. – Adjusted water vol. = Possible water savings

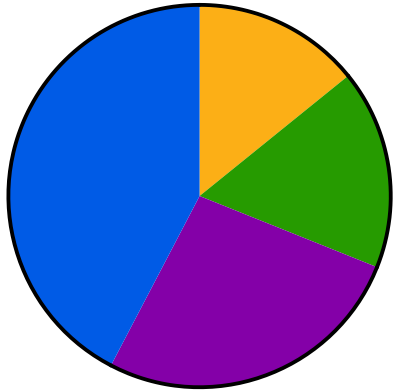
Per a given crop, region, and year

Estimating regional irrigation savings

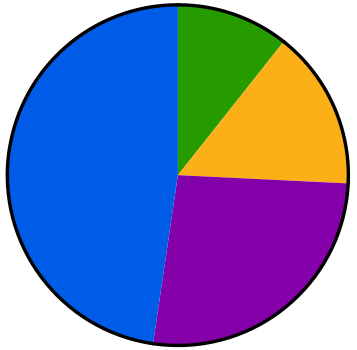
If fields with irrigation surplus would reduce current irrigation so that it does NOT exceed the irrigation water requirements by more than 50 mm, the resulting potential water savings would represent:

- **25-40% of total irrigation volume in NE in years with near or above-average rain**
- **<10% in drought years**

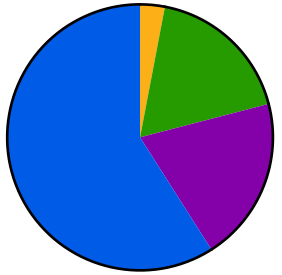
2010
407 million m^3

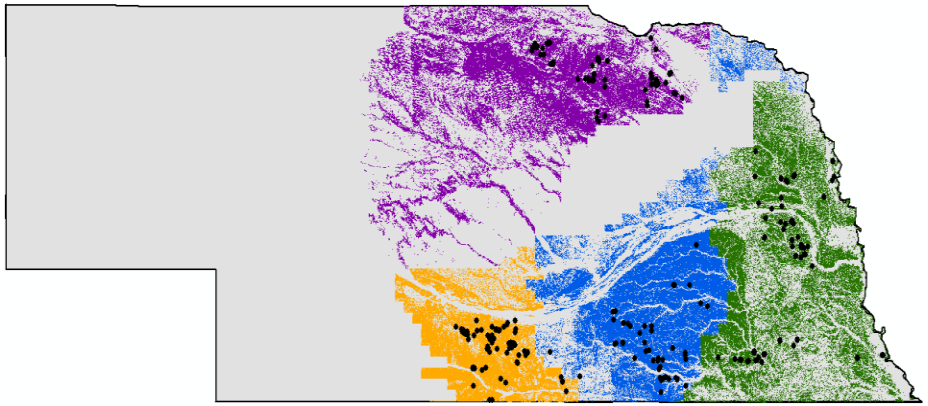


2011
268 million m^3



2012
192 million m^3





Conclusions

- Novel framework to benchmark irrigation water use and yield, identify opportunities for improvements in crop and irrigation management
- In the case of Nebraska, there is large room to reduce irrigation water surplus in producer fields without hurting yield
    - Irrigation scheduling, risk management.
- The framework can be used at local and regional levels by NRD managers/boards, policy makers, and government agencies to:
    - prioritize investments on research & extension programs
    - inform policy
    - monitor impact

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