Drones are Buzzing Toward Increased Crop Production

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Drivers for Irrigation Management

- Maximize profits (increase food production)
- Water conservation
- Water shortages:
  - Water allocations
  - Limited pumping rate or load control

- Response
  - Increase irrigation water productivity
  - What tools might help?
Variable Rate Irrigation (VRI)
What is VRI?

Sector/speed control:  

Zone control:
Industry Software

Credit: Precision Irrigation, Lindsay Corporation

Disclaimer: UNL doesn’t endorse any particular brand of irrigation equipment.
Potential Benefits of VRI

- Avoid putting chemical/liquid manure on waterways (create an “avoidance area”)
- Reduce pumping
  - Reduce energy costs
  - Reduce nitrate leaching
- Prevent pivot from getting stuck
- Reduce yield losses due to over-irrigation
- Account for topography
- Reduce over-application with corner arms
- More yield with a given water allocation
Management Allowable Depletion

FC

WP

Reservoir Analog

Eisenhauer

P (Root Zone Available Water Capacity)

(Management Allowable Depletion)

MAD
Prescription Maps

\[ N = \left( \frac{\text{MAD}_{\text{max}} - \text{MAD}_{\text{min}}}{I_{\text{max}}} \right) \]

\[ I_{\text{IMZ}} = \frac{1}{N} (\text{MAD}_{\text{max}} - \text{MAD}_{\text{IMZ}}) \]

\[ I_{\text{IMZ, gross}} = \frac{I_{\text{IMZ}}}{E_a} \]

Miller et al. (2018)
Online Map Tool for VRI

- Nebraska website for field-specific pumping reduction and economics

Lo et al. (2016)
http://heeren.unl.edu/map
Net Withdrawal = Pumping – Deep Perc – Runoff = ET
Importance of a System Evaluation

- Pivot orientation off by about 4° at orientation of test
- Especially important for avoidance areas

Barker et al. (2016)
- Variance reduction factor
  - 1.2 m profile, soil water ±2 cm (95% confidence)

- 3 locations for each management zone (impractical)
  - Need combination of soil water sensing and remote sensing

Barker et al. (2017)
Unmanned Aircraft Systems (UAS)
Aircraft

- **Altitude:** 120-240 m
  - 400-800 ft
- **Micasense RedEdge Multi-spectral camera**
  - 5 bands
  - 1280x960
- **Flir Tau 2 thermal infrared camera**
  - 640x512
Post-Processing

- Pix4D
- Stitch images together
Visual Image

- VRI Field
- 60 ha (typical size of a commercial field)
- Corn/maize (north)
- Soybean (south)
Color Infrared

- 8-16 cm resolution
- Multi-spectral
- NIR $\rightarrow$ red
- Red band $\rightarrow$ green
- Green band $\rightarrow$ blue

- Healthy vegetation: red
- Corn has started to senesce

23 August 2017
NDVI

- Normalized Difference Vegetation Index
- Calculated from multispectral data
- Can estimate green leaf area

23 August 2017
Thermal Infrared

- 35 cm resolution
- Canopy temperature
- Identify crop stress
- Soybean (north)
- Corn (south)

28 September 2016
VRI Management with Satellite (Landsat) Data
Remote-Sensing-Based Irrigation Management

- Multispectral & Thermal Imagery
- Soils Map
- Previous Irrigation Maps
- Remote-Sensing-Based Water Balance Model
- Weather Data
- New Irrigation Prescription and Schedule

Barker
Crop Coefficient for ET

- Real-time reflectance-based crop coefficients

Barker et al. (2018a)
Root Zone Water Balance

FAO 56:

\[ D_{r,i} = D_{r,i-1} - (P - RO)_i - I_i - CR_i + ET_i + DP_i \]

Barker et al. (2018a)
Energy Balance for ET

- Simplified Surface Energy Balance
  - \( R_n - G = H + LE \)
  - \( LE = R_n - G + H \)

Barker et al. (2018a)
SETMI Model

- ET from reflectance-based crop coefficients
- ET from two-source energy balance
- Soil water balance (spatial)
- Build prescription maps

Barker et al. (2018a, 2018b)
Field Experiment

• Field Sites:
  • Mead, ARDC (Eastern Nebraska)
  • Brule (Western Nebraska)

Barker et al. (2018b)
Results

• **Total Prescribed Irrigation:**

![Bar chart showing total prescribed irrigation for different locations and years.]

- ARDC Maize 2015
- ARDC Maize 2016
- ARDC Soybean 2016
- Brule Maize 2016

Legend:
- VRI-RS
- VRI-NP
- Uniform

• **Need soil water measurement as well as remote sensing model**

Barker et al. (2018b)
Spatial Variability

<table>
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<tr>
<th>Variable</th>
<th>ARDC</th>
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<th>Brule</th>
<th>Average Coefficient of Variation</th>
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<td></td>
<td>Maize</td>
<td>Soybeans</td>
<td>Maize</td>
<td></td>
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<td>Count</td>
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<td>8</td>
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<td>P-RO+ $I_{\text{net}}+\Delta SW$</td>
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<td>6.6</td>
<td>9.7</td>
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Barker et al. (2018b)
Ongoing Research

• Calibration of UAS data

• Manage VRI with UAS data instead of satellite data

• Incorporate soil water sensor data into SETMI

• Canopy temperature thresholds for irrigation
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