Use Satellite Imagery to Calibrate Crop Coefficient Kc for Irrigation

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Objectives

• Challenges and opportunities
• Vegetation indices based crop coefficient
• Crop coefficient on irrigation management
Challenges

• Conventional irrigation decision making:
  - Real-time field observation (e.g. hand feel soil),
  - Soil moisture probe,
  - Virtual weather

• Satellite imagery:
  - Minimum one day delay, usually several days behind
## Challenges

### Imagery sources

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Resolution</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat 8</td>
<td>30 meters</td>
<td>16 days*</td>
</tr>
<tr>
<td>Sentinel 2A/2B</td>
<td>10 meters</td>
<td>5 days*</td>
</tr>
<tr>
<td>High resolution</td>
<td>3 meters</td>
<td>1 day (multiple)</td>
</tr>
</tbody>
</table>

*Frequency may vary depending on the location of the field
Opportunities:

Use satellite imagery to facilitate irrigation

\[ ET_c = ETo \times Kc \]
Vegetation indices based crop coefficient
An example:
Materials and Methods

**Data source:** Two years

**Crop type:** Corn and Soybean

**Location:** O’Neil, Oakland, NE

**Methods:** 3-4 fields for each crop type, collection imageries for season

**Results:** Vegetation indices include EVI, EVI2, NDVI $\rightarrow$ Crop Coefficient (Kc)
Adjusted VI based Kc vs. reference Kc
2016 corn field vegetation indices

EVI > NDVI > EVI2
2016 corn field crop coefficient

EVI_Kc > EVI2_Kc > NDVI_Kc
2016 soybean field vegetation indices

Site 2 (Soybean; 2016-05-15/2016-09-17)

Site 5 (Soybean; 2016-05-05/2016-09-14)

Site 7 (Soybean; 2016-05-06/2016-09-23)

EVI > NDVI >= EVI2
2016 soybean field crop coefficient

Site 2 (Soybean; 2016-05-15/2016-09-17)

Site 5 (Soybean; 2016-05-05/2016-09-14)

Site 7 (Soybean; 2016-05-06/2016-09-23)

EVI_Kc > EVI2_Kc = NDVI_Kc
2019 corn field vegetation indices

EVI > NDVI > EVI2
2019 corn field crop coefficient

EVI > NDVI > EVI2
2019 soybean field vegetation indices

EVI = NDVI > EVI2
2019 soybean field crop coefficient

EVI > NDVI >= EVI2
Vegetation indices

- EVI > NDVI > EVI2
- EVI tends to have the greatest value

Crop coefficient Kc

- EVI > NDVI > EVI2
- EVI based Kc has the greatest value while NDVI and EVI2 are similar

The vegetation index and crop coefficient pattern are not limited by a crop type
Calculate the “actual ET” value from soil moisture sensor to compare with the predict ET values from the model to evaluate the adjusted crop coefficient

\[ \text{ET}_{\text{today}} = (\text{WC}_{\text{yesterday}} + \text{Irrigation}_{\text{today}} + \text{Rainfall}_{\text{today}}) - \text{WC}_{\text{today}} \]
Comparison of ET

ET calculated from granular matrix sensor
Reference ET

ET calculated from capacitance sensor
Reference ET
Vegetation indices based crop coefficient

• EVI based crop coefficient has the greatest value
• Kc driven by EVI has the greatest value, the pattern of EVI driven Kc is consistent
• The calculated ET based on adjusted Kc has a large variation, and it depends on the type of soil moisture sensor been used
Crop coefficient on irrigation management
Use vegetation index based adjusted Kc for irrigation

First, the vegetation index based Kc, is close to the Kc value from FAO 56 for a given day.
Adjusted Kc_initial from 0.3 to 0.4 by imagery

After adjust Kc
Before vs. after adjusting Kc on irrigation recommendation

**Before adjust Kc**
- Total irrigation forecast: **6 inches**
- Total Crop ET: **14.9 inches**
- Irrigation rounds: **6**

**After adjust Kc**
- Total irrigation forecast: **6 inches**
- Total Crop ET: **15.7 inches**
- Irrigation rounds: **7**

After adjusting Kc value based on imagery derived vegetation index, the irrigation recommendation increase 1 more round, with 0.8 inches.
Take home messages:

• Satellite imagery has potential for using on adjustment of irrigation forecasting/recommendation

• The application effectiveness of using satellite imageries may depend on which vegetation index is used and the Kc adjustment timing and magnitude

• Solely depends on satellite imageries for irrigation recommendation is not mature yet. The quality of imageries will affect accuracy (e.g. cloud cover)

• Kc is still the most effective parameter for irrigation scheduling.
Questions?