Views of the 2016 Northern Plains Flash Drought: Farmer Perspectives and Remote Sensing Data

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Project Overview

• Summer 2016 flash drought event
• Impacted agriculture across 5-state region centered on Black Hills, SD
• Goal of this project is to compare timing and severity of several drought products (USDM, ESI, GRACE) to agricultural stakeholder’s perception
• My research focus is on GRACE drought products
Agricultural Survey

• Survey sent to 2389 producers in SD, WY, NE, and MT counties that experienced at least abnormally dry (D0) conditions by July 2016

• 348 were returned by agricultural stakeholders

• Survey data grouped by zip code
Agricultural Survey - Results

- Focus on a single, multi-part question regarding:
  - Did certain drought conditions occur?
  - If so, when did it start?
- Date of first occurrence for each condition were average by zip code and plotted

<table>
<thead>
<tr>
<th>Condition</th>
<th>N/A</th>
<th>NO</th>
<th>YES</th>
<th>MEAN DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Decreased topsoil moisture (n=329)</td>
<td>2%</td>
<td>4%</td>
<td>94%</td>
<td>May 14</td>
</tr>
<tr>
<td>B. Decreased subsoil moisture (n=319)</td>
<td>3%</td>
<td>7%</td>
<td>90%</td>
<td>May 21</td>
</tr>
<tr>
<td>C. Delayed or lack of plant emergence (n=317)</td>
<td>9%</td>
<td>26%</td>
<td>65%</td>
<td>May 20</td>
</tr>
<tr>
<td>D. Delayed or lack of plant growth (n=321)</td>
<td>2%</td>
<td>11%</td>
<td>87%</td>
<td>May 31</td>
</tr>
<tr>
<td>E. Plant stress (crop or pasture) (N=318)</td>
<td>2%</td>
<td>6%</td>
<td>92%</td>
<td>Jun 16</td>
</tr>
<tr>
<td>F. Plant death (crop or pasture) (N=302)</td>
<td>9%</td>
<td>40%</td>
<td>51%</td>
<td>June 27</td>
</tr>
<tr>
<td>G. Poor grain fill (n=301)</td>
<td>46%</td>
<td>15%</td>
<td>39%</td>
<td>June 29</td>
</tr>
<tr>
<td>H. Deteriorating range conditions (n=319)</td>
<td>5%</td>
<td>8%</td>
<td>86%</td>
<td>June 17</td>
</tr>
<tr>
<td>I. Decreased forage productivity (n=316)</td>
<td>5%</td>
<td>9%</td>
<td>86%</td>
<td>June 13</td>
</tr>
<tr>
<td>J. Lowered water levels in ponds, streams, or other water sources (n=318)</td>
<td>11%</td>
<td>9%</td>
<td>80%</td>
<td>June 6</td>
</tr>
<tr>
<td>K. Lack of water in ponds, streams, or other water sources (n=317)</td>
<td>13%</td>
<td>16%</td>
<td>70%</td>
<td>June 16</td>
</tr>
<tr>
<td>L. Wells unable to keep up with livestock or irrigation needs (n=307)</td>
<td>28%</td>
<td>56%</td>
<td>16%</td>
<td>June 30</td>
</tr>
<tr>
<td>M. Fire (n=311)</td>
<td>23%</td>
<td>59%</td>
<td>17%</td>
<td>July 6</td>
</tr>
<tr>
<td>N. Infestations of insects or other pests (n=305)</td>
<td>18%</td>
<td>57%</td>
<td>25%</td>
<td>June 15</td>
</tr>
</tbody>
</table>
GRACE

• Gravity Recover and Climate Experiment
  • Sense changes in Earth’s gravity by measuring distance change between the two satellites using a microwave laser
  • Most of the gravity changes are caused by water

• GRACE TWS is assimilated into the Catchment Land Surface Model
  • Each week the assimilated data can be ranked as a percentile of the total historical record
  • Catchment outputs:
    • GWS – Groundwater Storage
    • SWE – Snow Water Equivalent
    • RZMC – Root Zone Moisture Content
Evaporative Stress Index (ESI)

• Standardized anomalies in ratio of actual ET to reference ET

• Actual ET flux estimated from remote sensed land surface temperature*

• Conveys useful information about vegetation health and soil moisture availability

*Anderson et al. 1997, 2007a,b, 2011
Time Series

• Look at survey responses, USDM, ESI, and GRACE RZMC and GWS at monthly intervals

• Blue outlines represent first occurrence of conditions in that month

• Black outlines represent first occurrence of conditions previous to that month
March

QA – Decreased TS Moisture

QB – Decreased SS Moisture

QJ – Lowered Water Levels

4 – Week ESI

GRACE RZMC

GRACE GWS
April

- QA – Decreased TS Moisture
- QB – Decreased SS Moisture
- QJ – Lowered Water Levels

4 – Week ESI
GRACE RZMC
GRACE GWS
May

QA – Decreased TS Moisture
QB – Decreased SS Moisture
QJ – Lowered Water Levels

4 – Week ESI
GRACE RZMC
GRACE GWS
June

QA – Decreased TS Moisture

QB – Decreased SS Moisture

QJ – Lowered Water Levels

4 – Week ESI

GRACE RZMC

GRACE GWS
August

QA – Decreased TS Moisture
QB – Decreased SS Moisture
QJ – Lowered Water Levels

4 – Week ESI
GRACE RZMC
GRACE GWS
Quantitative Results

• USDM, ESI, and GRACE values were over each zip code

• Zip code values were extracted based on each individual reports of first occurrence (348)—then averaged over all reports
  • Temporal trends between 6 weeks prior to 6 weeks after first occurrence were plotted based on these values

• Only use weeks 9 – 39 to avoid winter reports
Conclusion

• Like ESI, GRACE RZMC shows widespread rapid deteriorating conditions after most zip codes first saw decreasing soil moisture
  • Averaged over all zip codes, RZMC showed steady decrease up to six weeks before first occurrence reports
  • Generally good agreement between USDM, RZMC, and ESI

• GRACE GWS showed ~10% decrease over the drought period
  • Flash droughts typically don’t have great effects on long-term groundwater trends

• GRACE products show promise as a standalone drought indicator and as part of a suite of modeled drought tools
Questions?

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Citations


