Predicting Growing Season Grassland Production in the Spring using Sea Surface Temperatures, NDVI, and Grass-Cast

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Outline

- Correlation of annual aboveground plant production (ANPP) to Rainfall Variables and AVHRR NDVI data (1982 to 2014)
  - Long term annual ANPP data from Cheyenne (1940 to 2014)
  - Site-level AVHRR NDVI and ANPP
  - Regional Great Plains simulated AET using the DayCent ecosystem model
- Using Grass-Cast to simulate seasonal forecast of ANPP for the Great Plains
- Conclusions
### Cheyenne Correlation of ANPP to Rainfall Variables

<table>
<thead>
<tr>
<th>Site</th>
<th>Apr - May</th>
<th>Apr - Jun</th>
<th>Apr - Jul</th>
<th>Apr - Aug</th>
<th>Apr - Sep</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheyenne Precipitation</td>
<td>0.4053</td>
<td>0.5685</td>
<td>0.5966</td>
<td>0.361</td>
<td>0.2003</td>
<td>0.2111</td>
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<tr>
<td>Transpiration</td>
<td>0.0648</td>
<td>0.3428</td>
<td>0.5838</td>
<td>0.4882</td>
<td>0.4612</td>
<td>0.4609</td>
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<tr>
<td>AET</td>
<td>0.2275</td>
<td>0.4527</td>
<td>0.6478</td>
<td>0.5152</td>
<td>0.4711</td>
<td>0.4082</td>
</tr>
</tbody>
</table>
Correlation of April to July Cumulative Actual Evapotranspiration (iAET) to Grassland Plant production (ANPP)

**CPER**

\[ y = 5.7671x - 27.47 \]
\[ R^2 = 0.4589 \]
\[ y = 3.5525x - 20.078 \]
\[ R^2 = 0.5726 \]

**Cheyenne**

\[ y = 7.0406x - 41.454 \]
\[ R^2 = 0.6287 \]
Site-level AVHRR NDVI vs. ANPP (1982-2016)

AVHRR - Section 24

\[ y = 0.011x + 1.4634 \]
\[ R^2 = 0.6493 \]

\[ y = 24.037x^2 - 24.357x + 16.243 \]
\[ R^2 = 0.8474 \]
Difference in $R^2$ when AET (April-July) is correlated to cumulative (May-September) NDVI vs when Precipitation (April-July) is correlated to cumulative NDVI.
Grass-Cast Project Goals

- Predict total growing season above-ground grassland plant production (ANPP) for all Great Plains counties in the Spring as function of the April to July cumulative actual evapotranspiration water loss (iAET)
- Starting in April, update ANPP forecasts every two weeks based on current weather data and new precipitation forecasts (monthly basis).
Forecast Procedure

1. Use DayCent model to simulate 2018 county-level iAET (36 model runs per county) where the remainder of 2018 is replaced by analog weather data that was observed from 1982-2017. Weather is ranked by May-July precipitation.

2. For each model run, make prediction of growing season cumulative NDVI (iNDVI) based on county-level correlation of iAET to iNDVI.

3. For each iNDVI prediction, use the Great Plains correlation of iNDVI to ANPP to predict annual ANPP for each county.

4. Three forecasts: below-normal, normal, and above normal MJJ precipitation using the results from the 12 driest, 12 moderate, and 12 wettest years from 1982-2017.
Grass-Cast 2017 Growing Season ANPP Forecasts
(Percent change compared to 30-yr mean predicted ANPP)
2002 (Dry Year) Actual NDVI compared to Predicted ANPP
Percent change compared to 1982-2011 means

78% accurate
2009 (Wet Year) Actual NDVI compared to Predicted ANPP
Percent change compared to 1982-2011 means

76% accurate
GrassCast ANPP forecasts for May 1, 2018

Percent Change in 2018 Predicted NPP compared to 1982-2017 mean NPP
Assuming Below Normal May-July Precipitation (%)

Percent Difference

Data are from 5/1/2018

Percent Change in 2018 Predicted NPP compared to 1982-2017 mean NPP
Assuming Normal May-July Precipitation (%)

Percent Difference

Data are from 5/1/2018

Percent Change in 2018 Predicted NPP compared to 1982-2017 mean NPP
Assuming Above Normal May-July Precipitation (%)

Percent Difference

Data are from 5/1/2018
GrassCast ANPP forecasts for May 8, 2018

Percent Change in 2018 Predicted NPP compared to 1982-2017 mean NPP
Assuming Below Normal May-July Precipitation (%)

Data are from 5/8/2018

Percent Change in 2018 Predicted NPP compared to 1982-2017 mean NPP
Assuming Normal May-July Precipitation (%)

Data are from 5/8/2018

Percent Change in 2018 Predicted NPP compared to 1982-2017 mean NPP
Assuming Above Normal May-July Precipitation (%)

Data are from 5/8/2018
Conclusions

- ANPP in the Great Plains is correlated to AMO, PDO and ENSO sea surface temperature anomalies.
- Plant productivity is correlated to NDVI. Both NDVI and NPP are correlated to AET.
- Grass-Cast has the potential to predict regional patterns of ANPP for the Great Plains given the observed weather data and seasonal forecasts of precipitation.
  - ANPP forecasts greatly improve after May 15.
  - Grass-Cast forecast of ANPP are very similar to growing season observed NDVI data sets.
PDO and ENSO both negative

PDO = Pacific Decadal Oscillation  ENSO = El Niño Southern Oscillation

PDO/ENSO -/-  Driest Conditions for the Southern Great Plains

PDO/ENSO +/-  Wettest Conditions for the Southern Great Plains

Use of April Sea Surface Temperature (SST) anomalies to predict iAET for the Great Plains

PDO/ENSO extremes
Use of April Sea Surface Temperature (SST) anomalies to predict iAET for the Great Plains

PDO and AMO both negative

PDO and AMO both positive

PDO = Pacific Decadal Oscillation  
AMO = Atlantic Multidecadal Oscillation

PDO/AMO extremes
Spring NDVI (May 4-12) correlates to growing season production. (NDVI can be measured by drones as well as satellites.)