The Predictability of Northern Great Plains Precipitation

Lessons Learned From the 2017 Billion Dollar Drought

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Spring-Fall Drought Over North Dakota, South Dakota and Montana in 2017 Sparked a Billion Dollar Disaster

Source: https://www.ncdc.noaa.gov/billions/
Northern Plains Defined As Region East of 109°W
Northeastern Montana is Also Considered

(a) Location of Northern Plains

(b) Northern Plains Region

Elevation (Feet)

0 1000 2000 3000 4000 5000 6000 7000 8000 9000

Glasgow

Bismarck

Pierre
U.S. Drought Monitor: Drought Evolved Quickly During May-July 2017

Source: http://droughtmonitor.unl.edu/
2017 Drought Developed During the Wettest 3-Month Season and the Growing Season

(a) May-July Contribution to Annual Precipitation

(b) Regional Monthly Contribution to Annual Precipitation
Driest May-July Since At Least 1895 Caused the 2017 Drought

(a) May-July 2017 Precipitation Rank

(b) May-July 2017 Average Temperature Rank
Questions

● Was the low May-July 2017 seasonal precipitation predictable in advance of the season?

● Could the low May-July 2017 seasonal precipitation have been forecast at any lead time?

● What are the sources of May-July precipitation predictability?
Tools: Observed Estimates

● Precipitation
  ○ NCEI GHCN gridded 5km precipitation version 1 (Vose et al. 2014)
  ○ Daily precipitation from NCEI GHCN-daily version 3 (Menne et al. 2012)

● Sea Surface Temperatures
  ○ Based on the Hurrell et al. (2008) analysis, which combines HadiSST with NOAA OI on a 1°x1° grid. Also forces the AMIP simulations
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Tools: North American Multi-Model Ensemble

- Include models that were operational in 2017 whose hindcast and forecasts of precipitation span 1982-2017
- Focus on April-initialized forecasts
- Anomalies and terciles relative to own model

<table>
<thead>
<tr>
<th>Model</th>
<th>Members</th>
<th>Reference</th>
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<td>Zhang et al. (2007)</td>
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<td>NASA: GEOS5</td>
<td>42, 11, one missing member</td>
<td>Vernieres et al. (2012)</td>
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Tools: AMIP Simulations

- 60-member ensemble of atmospheric model simulations forced by prescribed boundary conditions for 1982-2017
  - 30 members from the CAM5 model
  - 30 members from the ECHAM5 model
- Models interpolated to the CAM5 grid
- Anomalies and terciles relative to own model
Tools: GEFS Forecasts

“The ESRL/PSD 2nd-generation Reforecast Project has produced a dataset of historical weather forecasts generated with a fixed numerical model, using the 2012 version of NCEP's Global Ensemble Forecasting System (GEFS, Version 10). This Reforecast V2 dataset consists of an 11-member ensemble of forecasts, produced every day from 00 UTC initial conditions from Dec 1984 to present. The horizontal resolution of GEFS is T254 (about 50 km) out to 8 days, and T190 (about 70 km) from 8-16 days. Real-time forecasts are ongoing.”

Source: https://www.esrl.noaa.gov/psd/forecasts/reforecast2/
Questions

- Was the low May-July 2017 seasonal precipitation predictable in advance of the season?

- Could the low May-July 2017 seasonal precipitation have been forecast at any lead time?

- What are the sources of May-July precipitation predictability?
Little to No Tilt in Odds to Below Average Precipitation

(a) May-July 2017 NMME Precipitation Probability

(b) May-July 2017 AMIP Precipitation Probability

Legend:
- Below Average: 40% to 60%
- Near Average: 70% to 90%
- Above Average: 90% to 100%
C3S Seasonal Prediction System Initialized in April 2017
Also Did Not Forecast a Shift in Odds to Below Average

C3S is a multi-model ensemble comprised of ECMWF, Met Office and Meteo-France models
Questions

● Was the low May-July 2017 seasonal precipitation predictable in advance of the season?

  No

● Could the low May-July 2017 seasonal precipitation have been forecast at any lead time?

● What are the sources of May-July precipitation predictability?
Dry Periods Predictable Up to 5 Days in Advance

- Dry periods forecast at short leads then model returns to its climatology
- One noteworthy daily miss in mid-June. Precipitation was over forecast.
Dry Periods Predictable Up to 5 Days in Advance

- A sequence of 0-5 day predictions would allow one to forecast the dry evolution of the season.
- Beyond 1 week there is little indication of a dry seasonal evolution.
Questions

- Was the low May-July 2017 seasonal precipitation predictable in advance of the season?
  
  **No**

- Could the low May-July 2017 seasonal precipitation have been forecast at any lead time?
  
  **Yes, through a sequence of up to 5 day forecasts**

- What are the sources of May-July precipitation predictability?
Large Simulated Spread During All Years Compared to Mean Anomaly (Low Signal-to-Noise Ratio) Suggests Low Predictability Overall

(a) NMME Northern Plains Precipitation Anomaly

(b) AMIP Northern Plains Precipitation Anomaly
Low Precipitation (Weakly) Related with La Niña

Composites conditioned upon below average Northern Plains precipitation
Questions

- Was the low May-July 2017 seasonal precipitation predictable in advance of the season?
  
  No

- Could the low May-July 2017 seasonal precipitation have been forecast at any lead time?
  
  Yes, through a sequence of up to 5 day forecasts

- What are the sources of May-July precipitation predictability?
  
  Mostly short lead times with a little long lead help by La Niña
Extra Slides
No Tilt in Odds to Above Average Precipitation

Percent of ensemble members that fall into the lower, middle and upper terciles of own model distribution
Wet Periods Predictable Up to 5 Days in Advance

- Wet/dry periods forecast at short leads then model returns to its climatology
Dry Periods Predictable Up to 5 Days in Advance

- A sequence of 0-5 day predictions would allow one to forecast the wet evolution of the season.
- Beyond 1 week there is little indication of a wet seasonal evolution.
Northern Plains 20th and 21st Century Changes