The Predictability of Northern Great Plains Precipitation

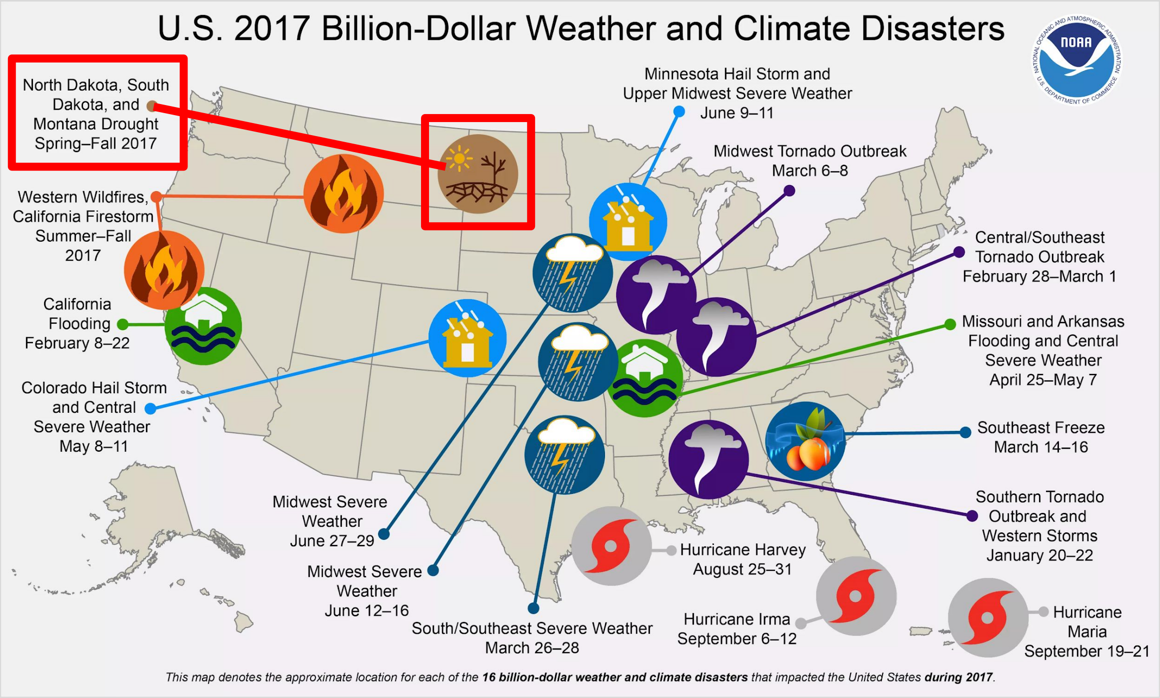
Lessons Learned From the 2017 Billion Dollar Drought

Andy Hoell

NOAA/ESRL Physical Sciences Division

andrew.hoell@noaa.gov

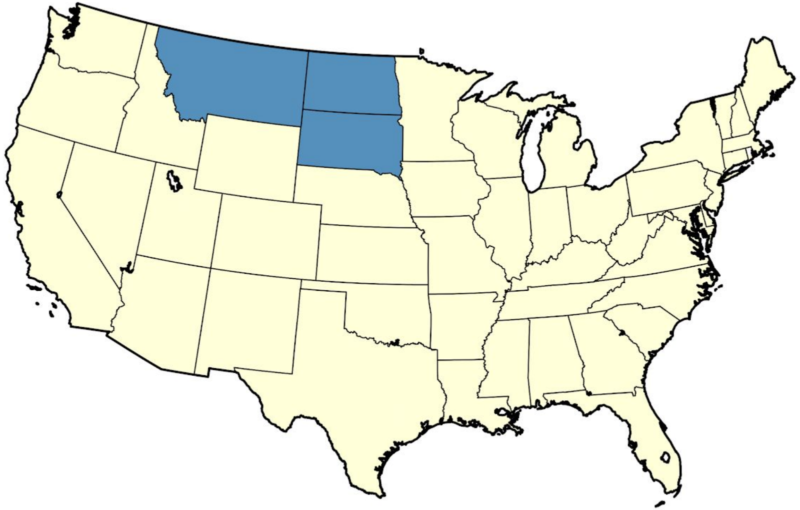
Spring-Fall Drought Over North Dakota, South Dakota and Montana in 2017 Sparked a Billion Dollar Disaster



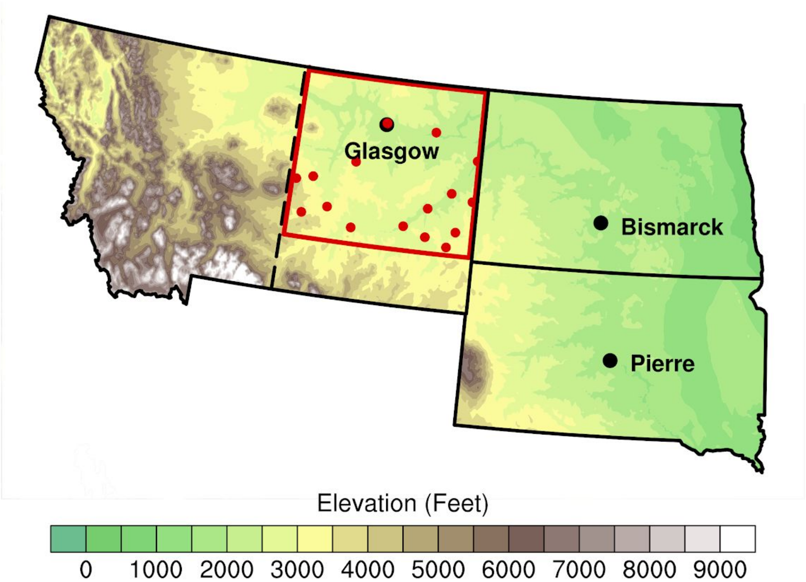
Source: https://www.ncdc.noaa.gov/billions/

Northern Plains Defined As Region East of 109˚W
Northeastern Montana is Also Considered

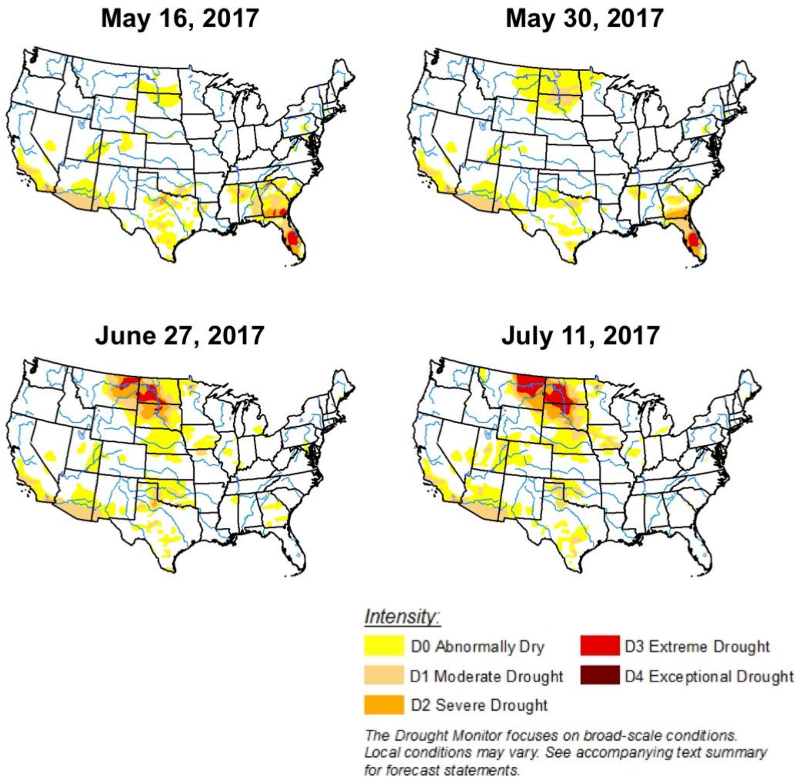
(a) Location of Northern Plains



(b) Northern Plains Region

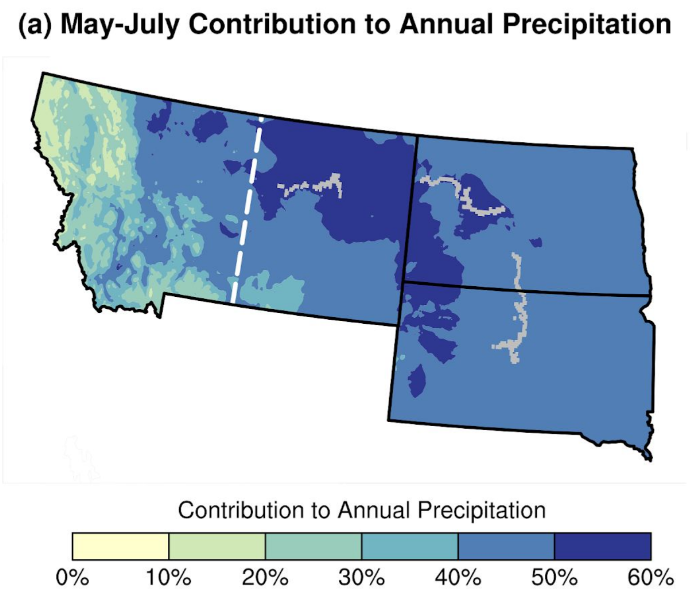


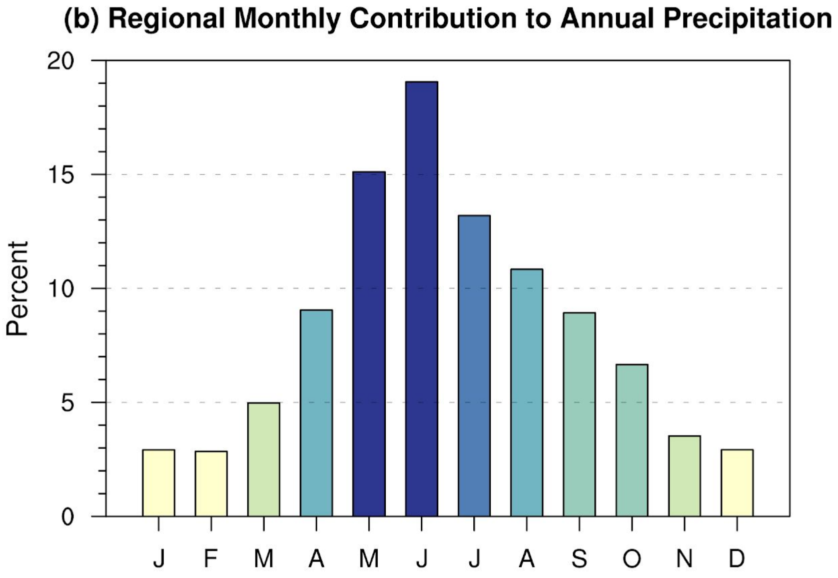
U.S. Drought Monitor:
Drought Evolved Quickly During May-July 2017



Source:
http://droughtmonitor.unl.edu/

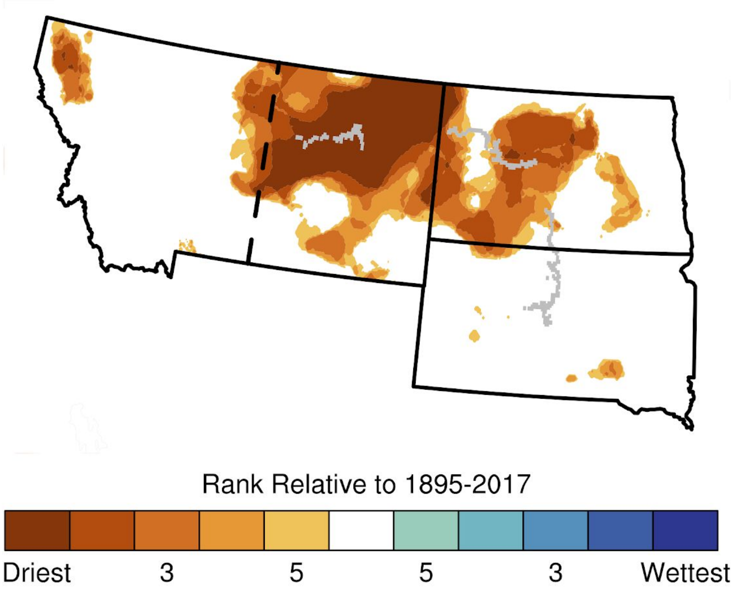
2017 Drought Developed During the Wettest 3-Month Season and the Growing Season



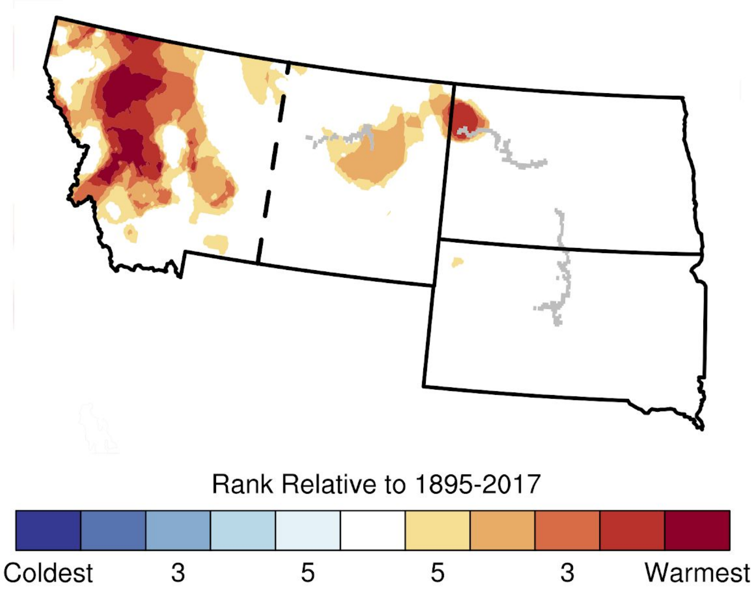


Driest May-July Since At Least 1895 Caused the 2017 Drought

(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?

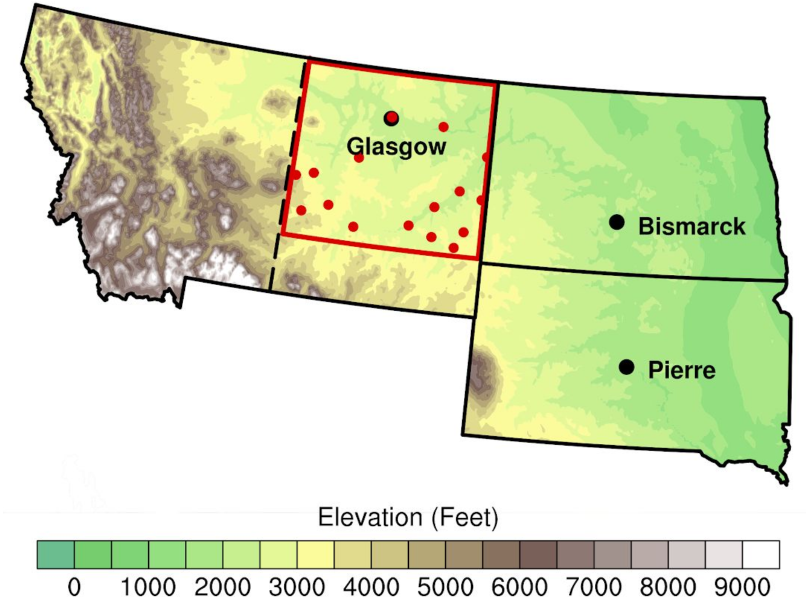
- Could the low May-July 2017 seasonal precipitation have been forecast at any lead time?

- 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

GHCN Stations Considered



Station ID	Station	Latitude (North)	Longitude (West)
USC00241088	Bredette	48.15	105,30
USC00241231	Brusett 3N	47.46	107.31
USC00243013	Flatwillow 4 ENE	47.10	108.37
USC00243581	Glendive	47.10	104.72
USC00243727	Grass Range	47.02	108.80
USC00244358	Hysham	46.29	107.22
USC00245303	Mackenzie	46.14	104.72
USC00245596	Melstone	46.60	107.90
USC00245754	Mizpah 4 NNW	46.28	105.29
USC00246601	Plevna	46.42	104.52
USC00247214	Roundup	46.44	108.54
USC00247560	Sidney	47.72	104.13
USC00248165	Terry	46.79	105.30
USC00248957	Wilbaux 2E	46.99	104.16
USW00024037	Miles City	46.43	105.88
USW00094008	Glasgow Intl AP	48.21	106.62

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
- Data source: https://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/

Model	Members	Reference
EMC: CFSv2	24	Saha et al. (2014)
Env. Canada: CMC2	10	Merryfield et al. (2013)
Env. Canada: CMC1	10	Merryfield et al. (2013)
GFDL: FLORa06	12	No ref, so use model ref: Vecchi et al. (2012)
GFDL: FLORb01	12	No ref, so use model ref: Vecchi et al. (2012)
GFDL: CM2.1	10	Zhang et al. (2007)
NASA: GEOS5	~~12~~ 11, one missing member	Vernieres et al. (2012)
RSMAS: CCSM4	10	No ref, so use model ref: Gent et al. (2011)

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

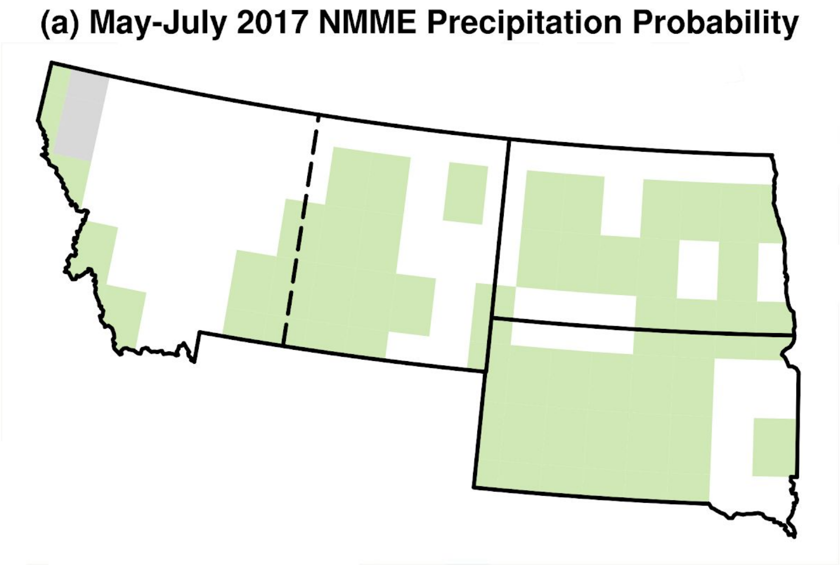
“The ESRL/PSD 2nd-generation Reforecast Project has produced a dataset of historical weather forecasts generated with a fixed numerical model, using the 2012 version of NCEP's Global Ensemble Forecasting System (GEFS, Version 10). This Reforecast V2 dataset consists of an 11-member ensemble of forecasts, 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.”

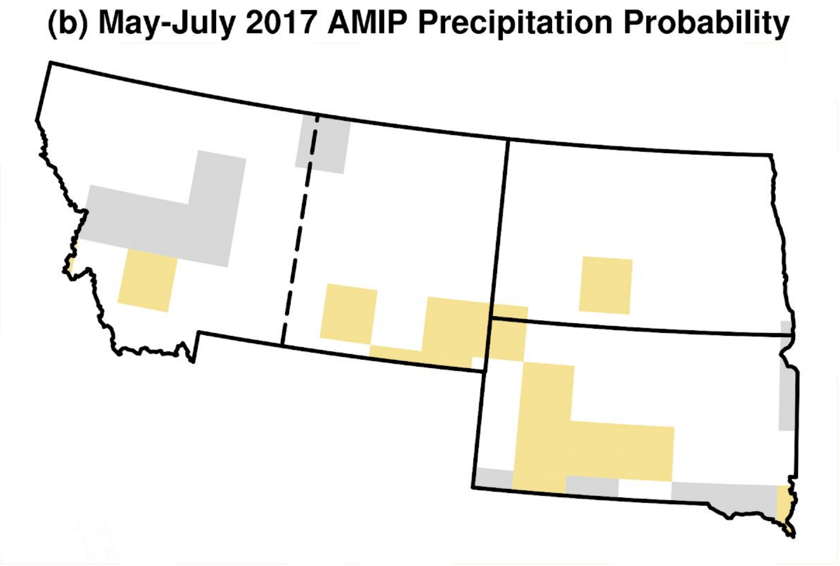
Source: https://www.esrl.noaa.gov/psd/forecasts/reforecast2/

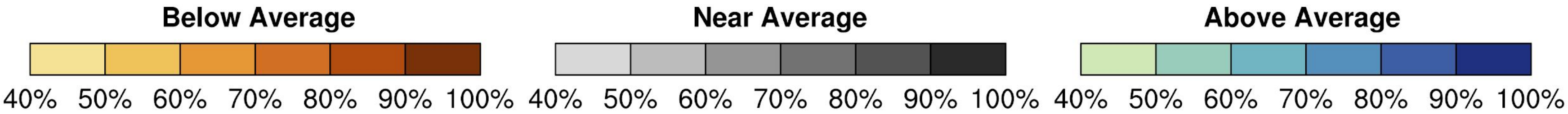
Questions

- 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

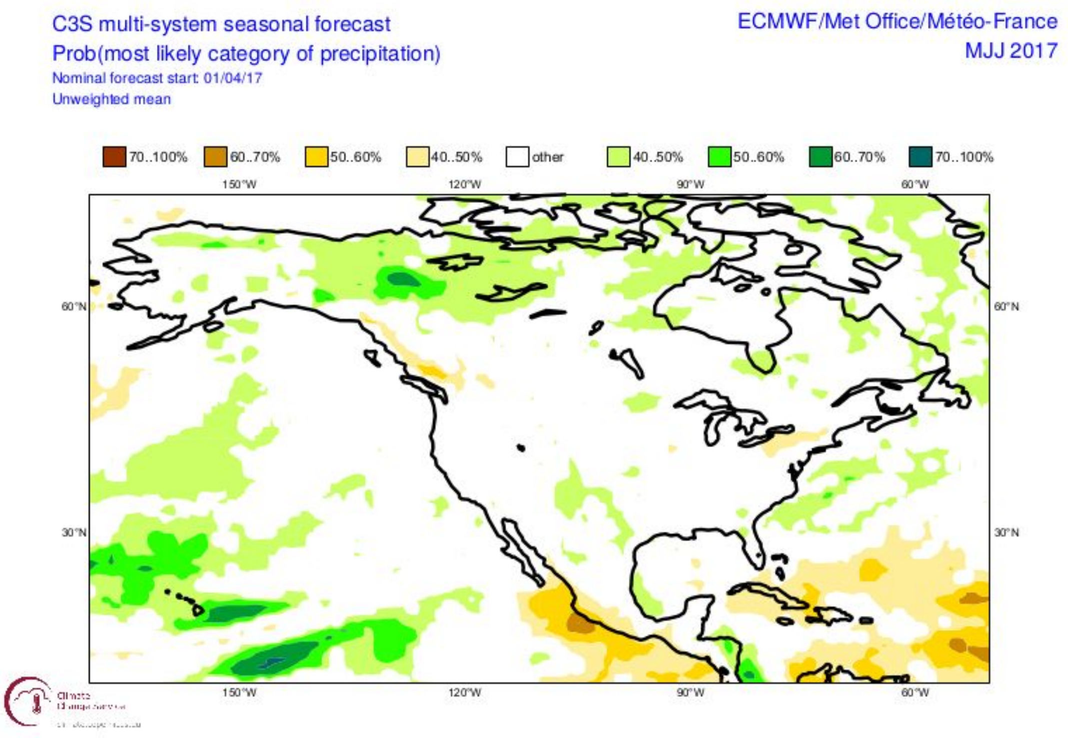






C3S Seasonal Prediction System Initialized in April 2017 Also Did Not Forecast a Shift in Odds to Below Average

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?

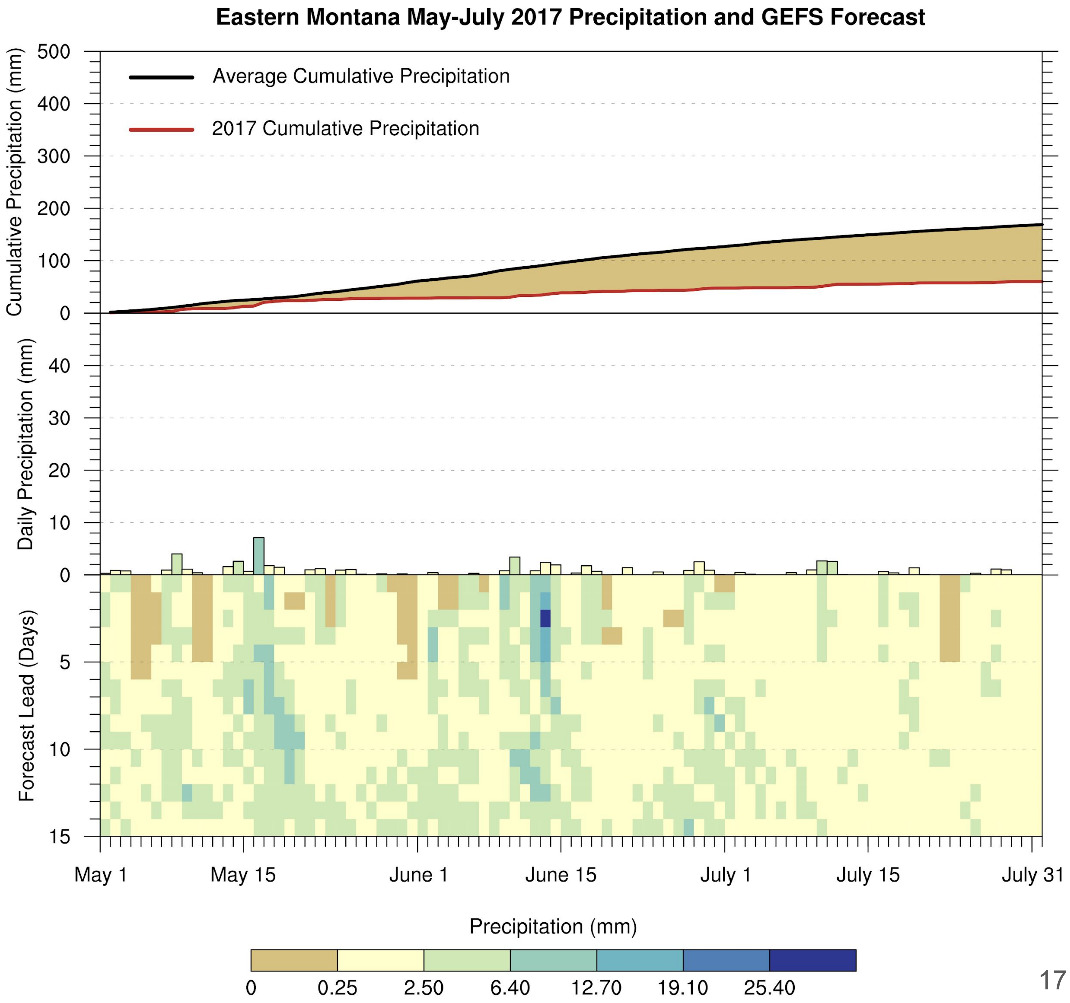
  No

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

- What are the sources of May-July precipitation predictability?

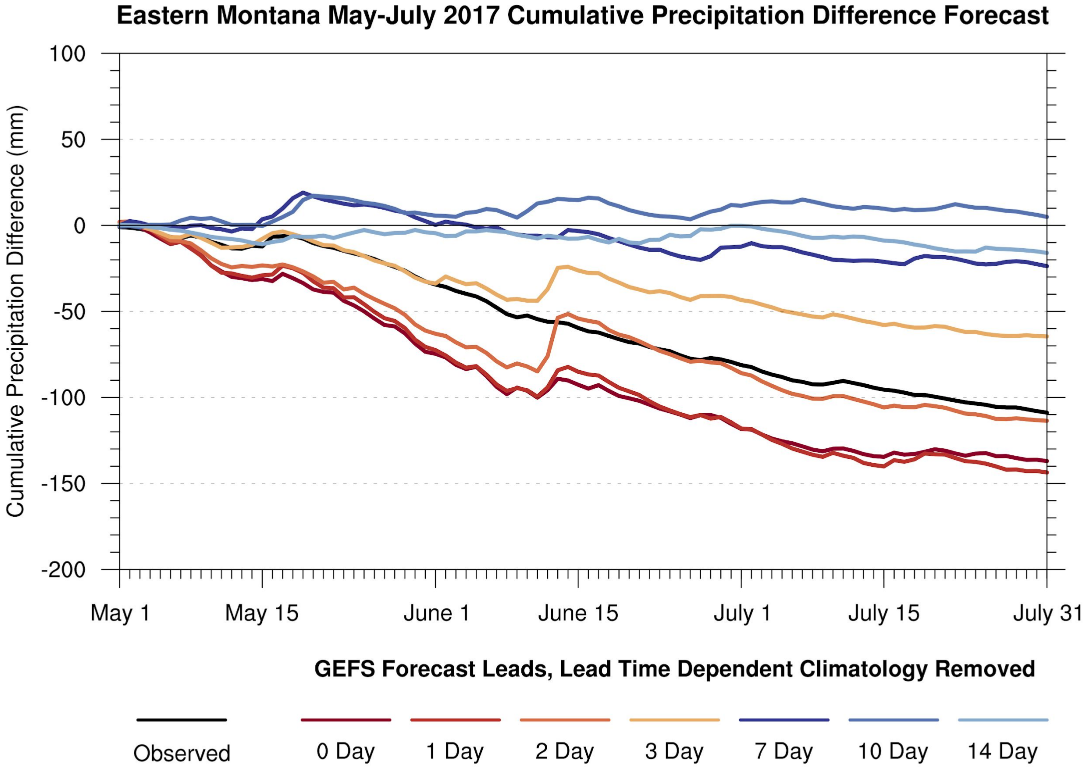
Dry Periods Predictable Up to 5 Days in Advance

- 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?

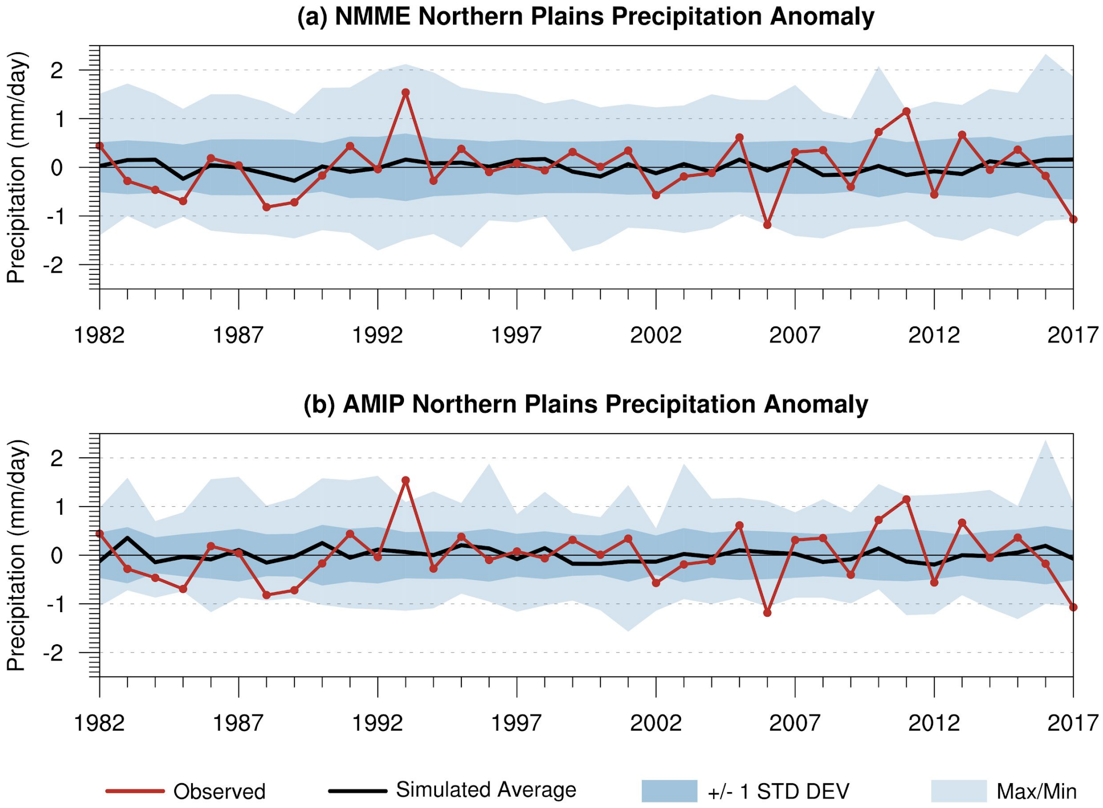
  No

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

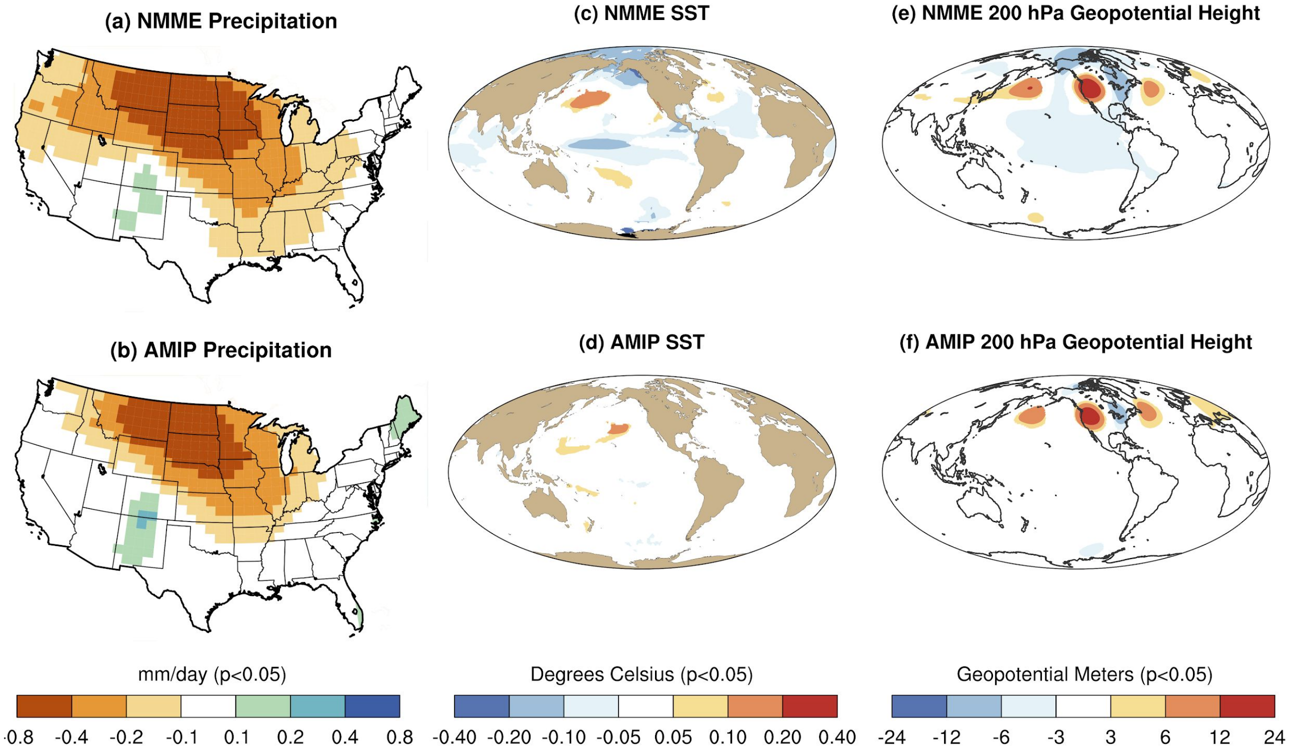
  Yes, through a sequence of up to 5 day forecasts

- 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



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?

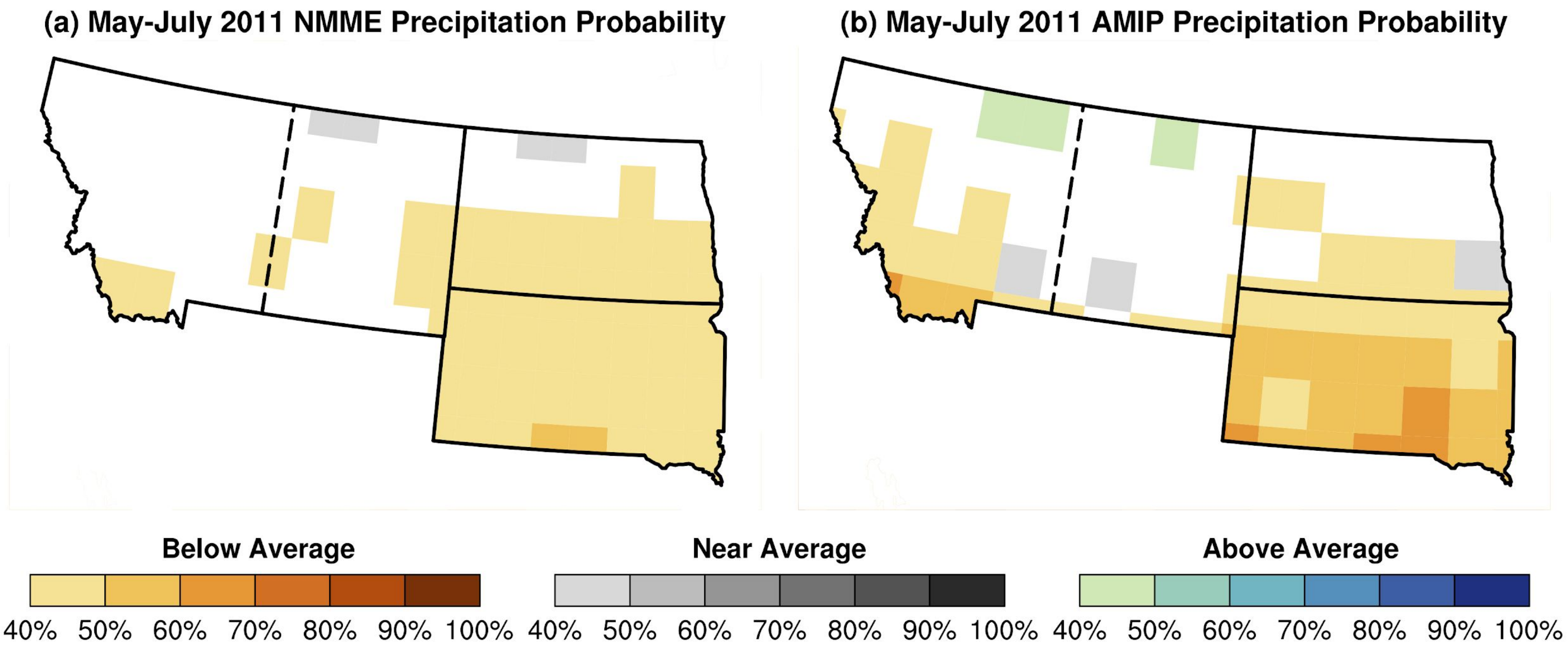
  Yes, through a sequence of up to 5 day forecasts

- What are the sources of May-July precipitation predictability?

  Mostly short lead times with a little long lead help by La Niña

Extra Slides

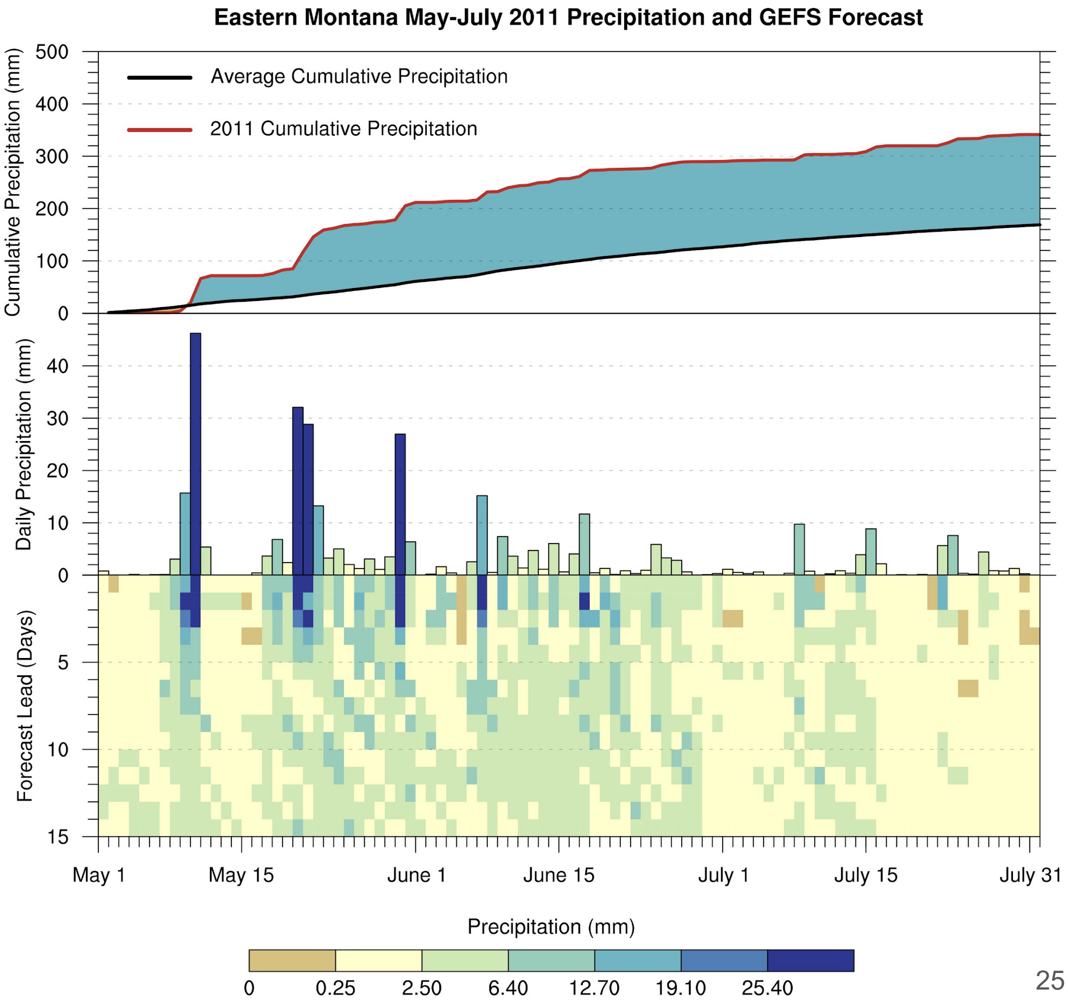
No Tilt in Odds to Above Average Precipitation



Percent of ensemble members that fall into the lower, middle and upper terciles of own model distribution

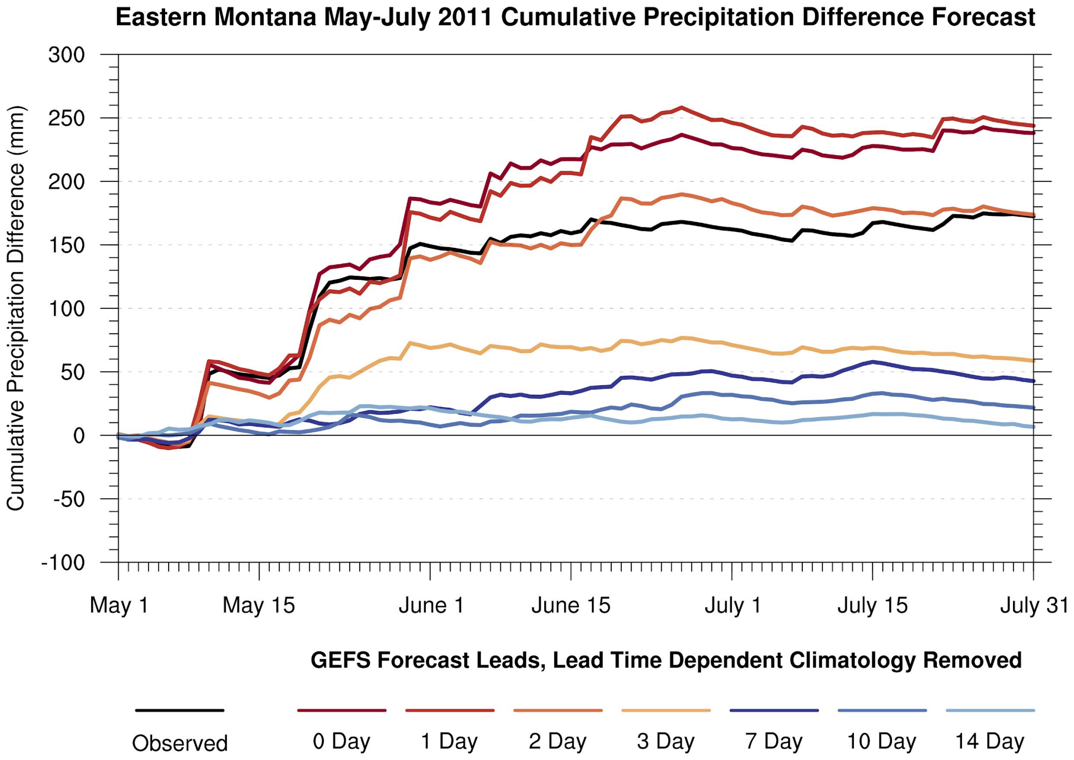
Wet Periods Predictable Up to 5 Days in Advance

- 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