Predictions and Predictability of Northern Great Plains Summertime Precipitation Extremes

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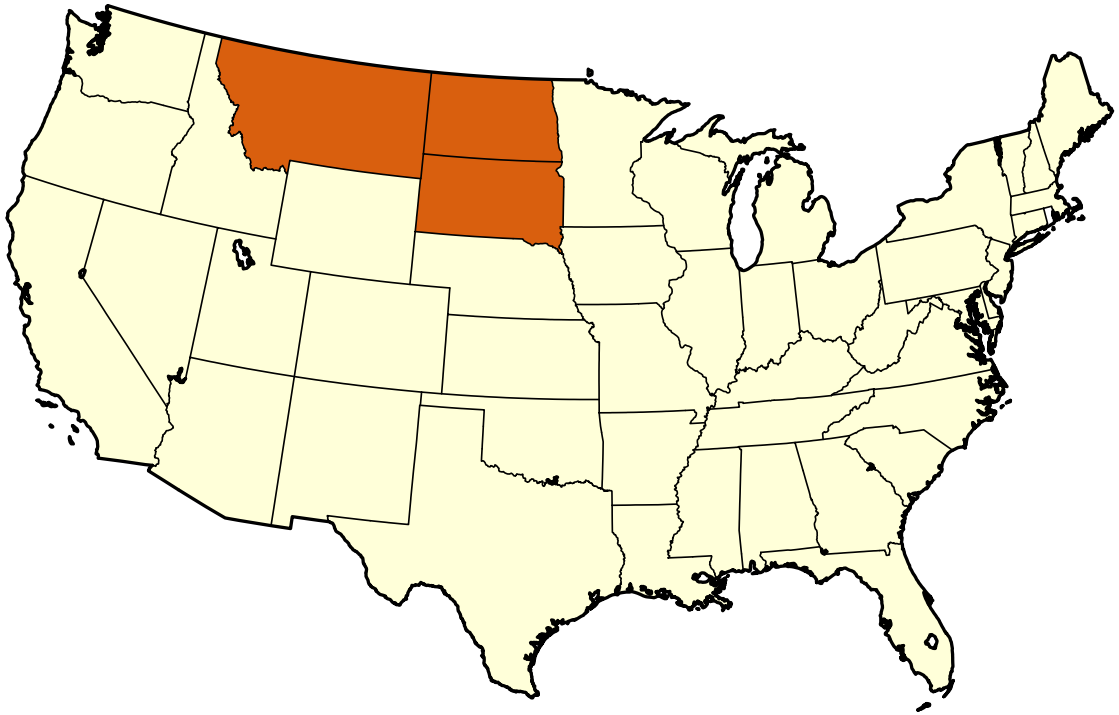
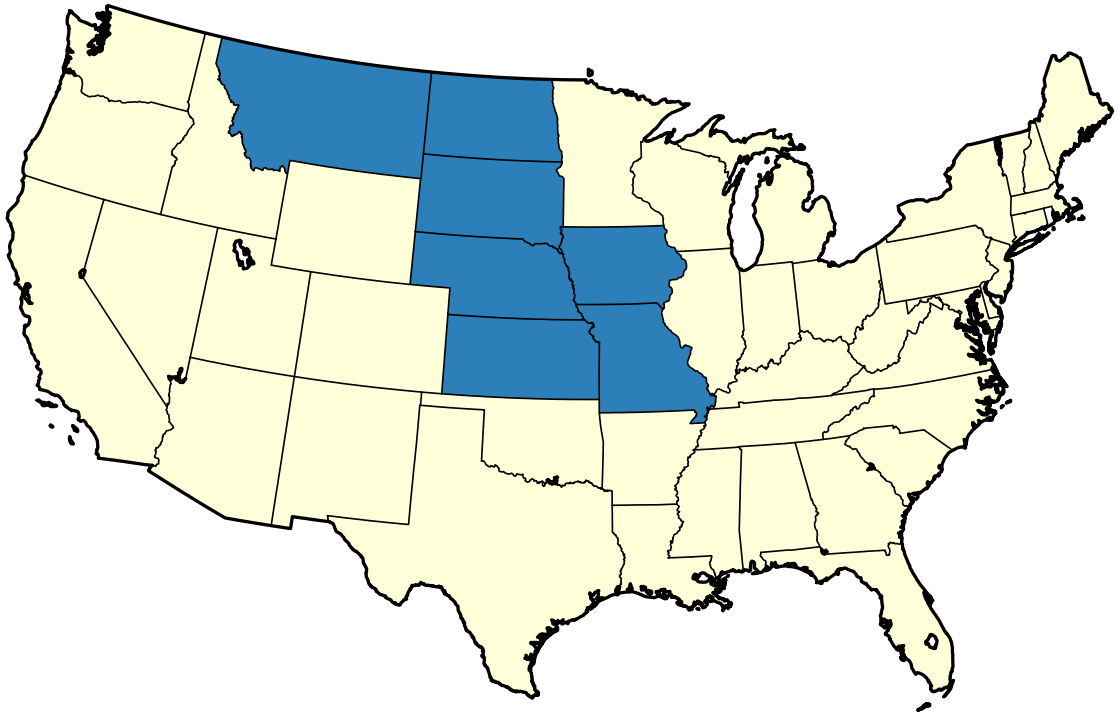
Northern Great Plains Has Experienced Two ‘Billion Dollar Disasters’ Since 2011

(a) Extent of 2017 Billion Dollar Drought

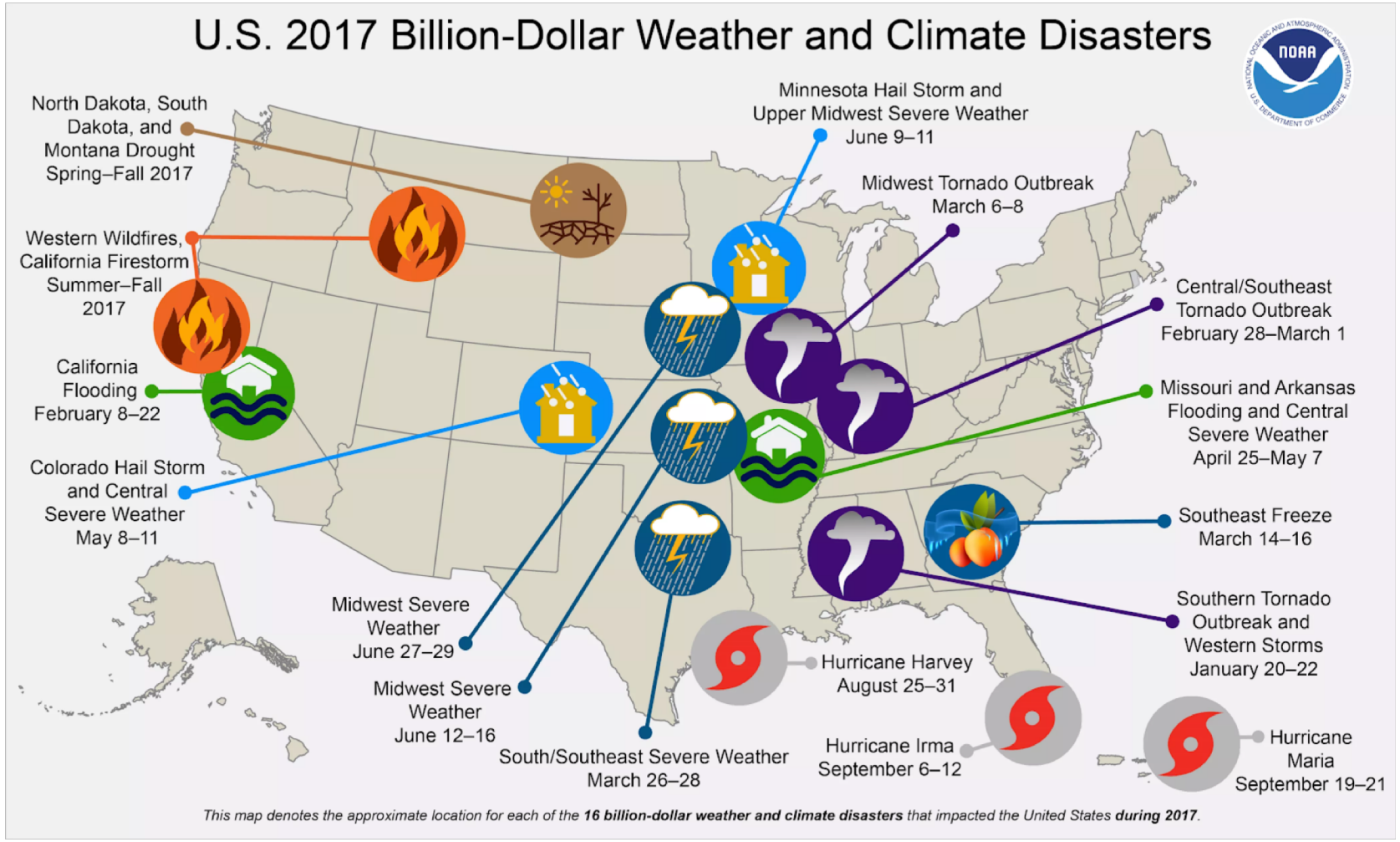


(b) Extent of 2011 Billion Dollar Flood

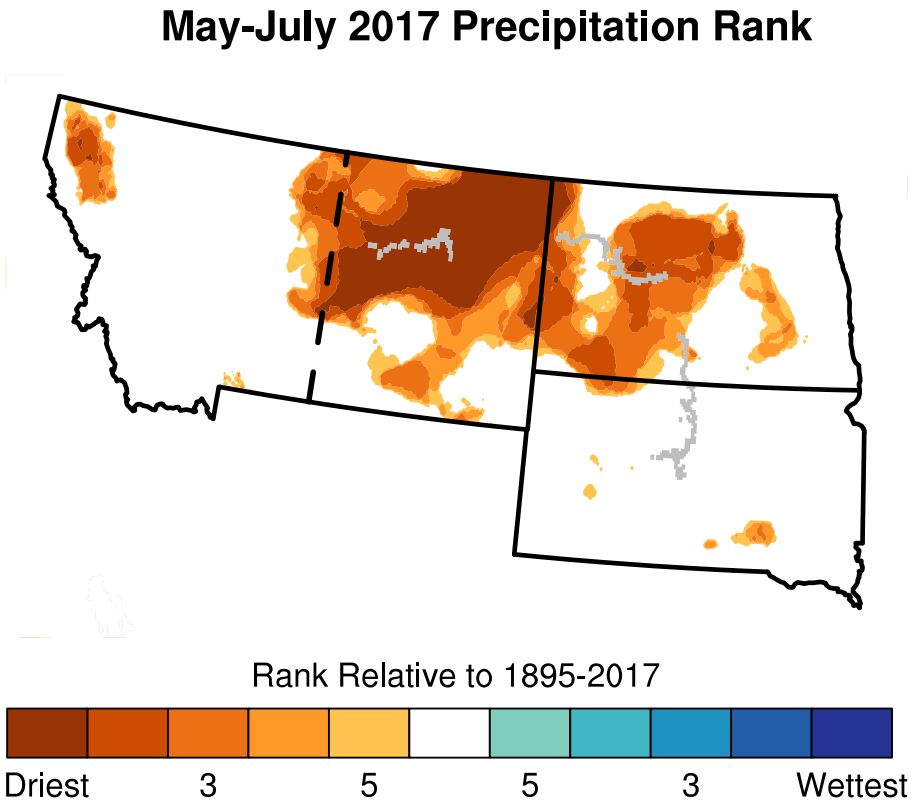


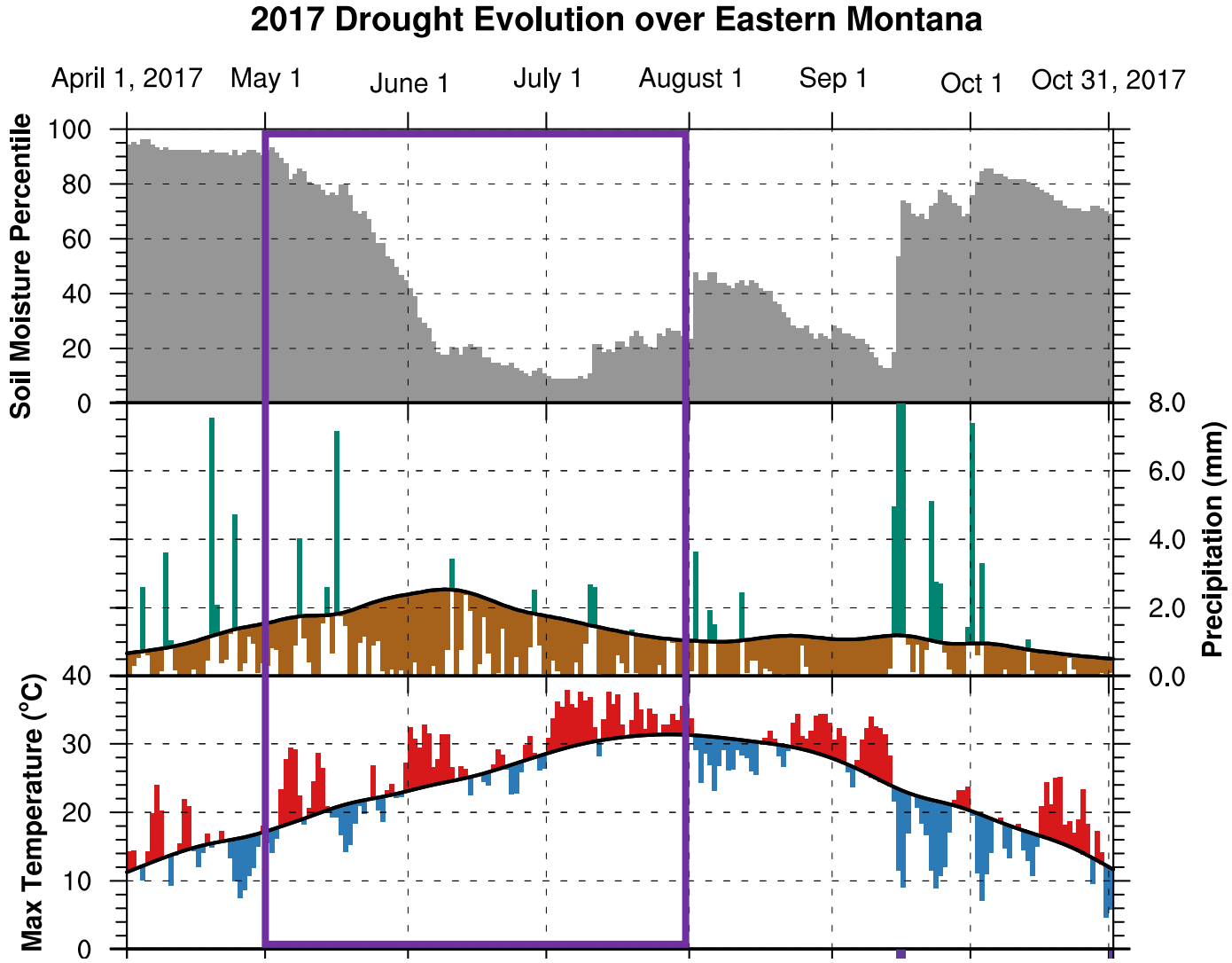
Adapted from https://www.ncdc.noaa.gov/billions/

2017 Drought Caused Wildfires and Crop Losses



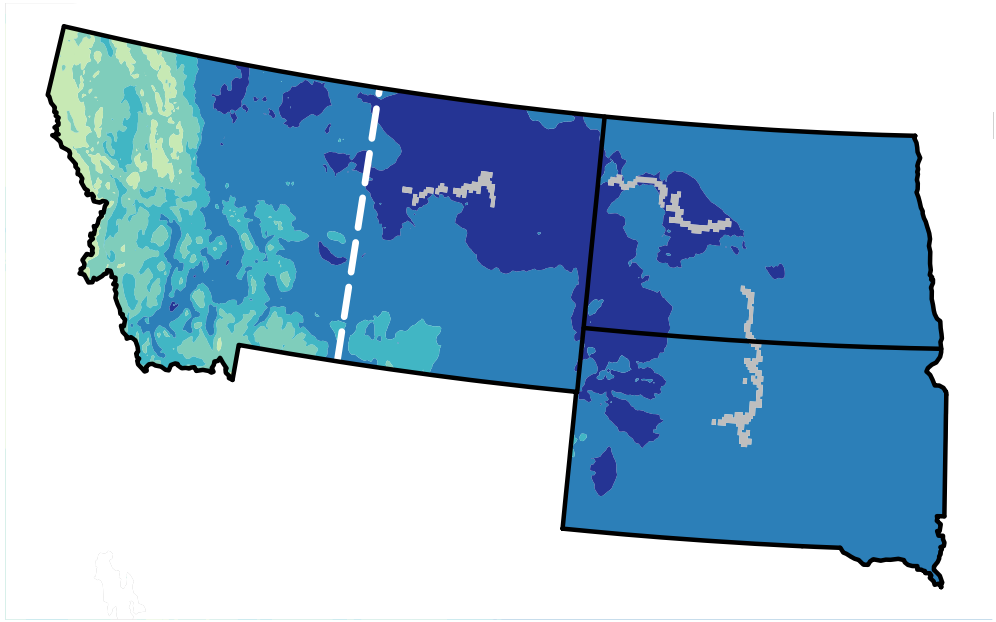
Record Low May-July 2017 Precipitation Drives Rapid Onset Drought



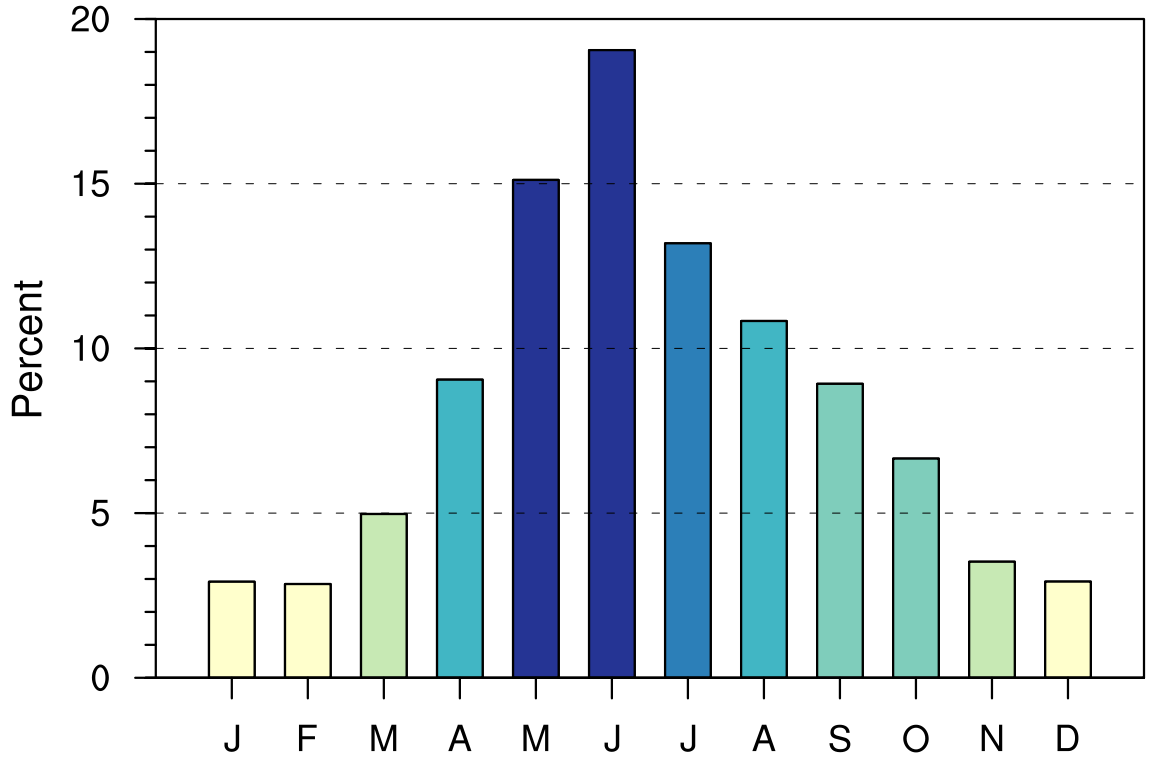


‘Billion Dollar Disasters’ Occurred During the Wettest 3-Month Season & Growing Season

(a) May-July Contribution to Annual Precipitation



(b) Regional Monthly Contribution to Annual Precipitation



Questions

1. Was below average precipitation during May-July 2017 forecast in advance of the season?

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

3. Was the evolution of the May-July 2017 precipitation forecast at any lead time?

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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 atmospheric model simulations

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
- 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	Vecchi et al. (2012)
GFDL: FLORb01	12	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	Gent et al. (2011)

Tools: ECMWF SEAS5

- Focus on April-initialized predictions
- Hindcast period: 1993-2016, 25 members
- Forecast period: 2017-present, 50 members
- Source: https://cds.climate.copernicus.eu/#!/home

Tools: Atmospheric Models Exposed to Observed Boundary Conditions

- 60-member ensemble for 1982-2017
  - 30 members from the CAM5 model (Neale et al.)
  - 30 members from the ECHAM5 model (Roeckner et al. 2006)
- Models interpolated to the CAM5 grid
- Anomalies and terciles relative to own model
- Source: https://www.esrl.noaa.gov/psd/repository/alias/facts/

Questions

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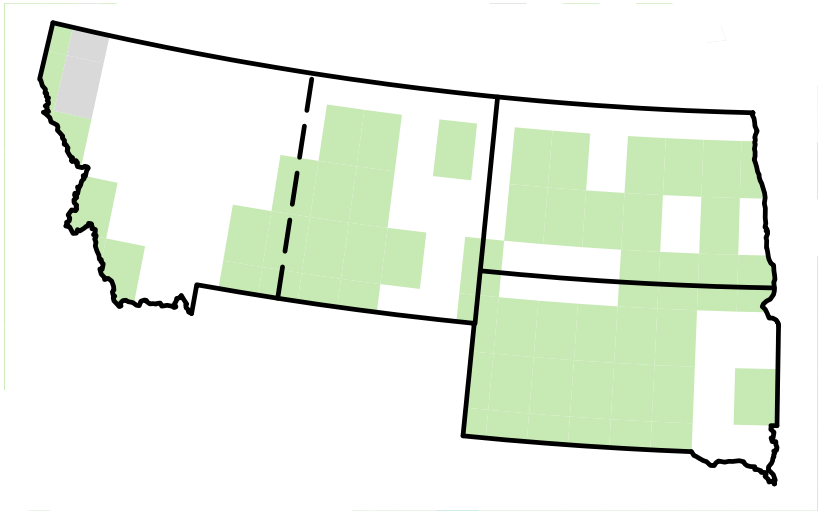
2. What are the sources of May-July precipitation predictability?

3. Was the evolution of the May-July 2017 precipitation forecast at any lead time?

2017: No Tilt in Odds to Below Average Precipitation

(a) May-July 2017 NMME Precipitation



(b) May-July 2017 ECMWF Precipitation

(c) May-July 2017 AMIP Precipitation

Below Average Probability

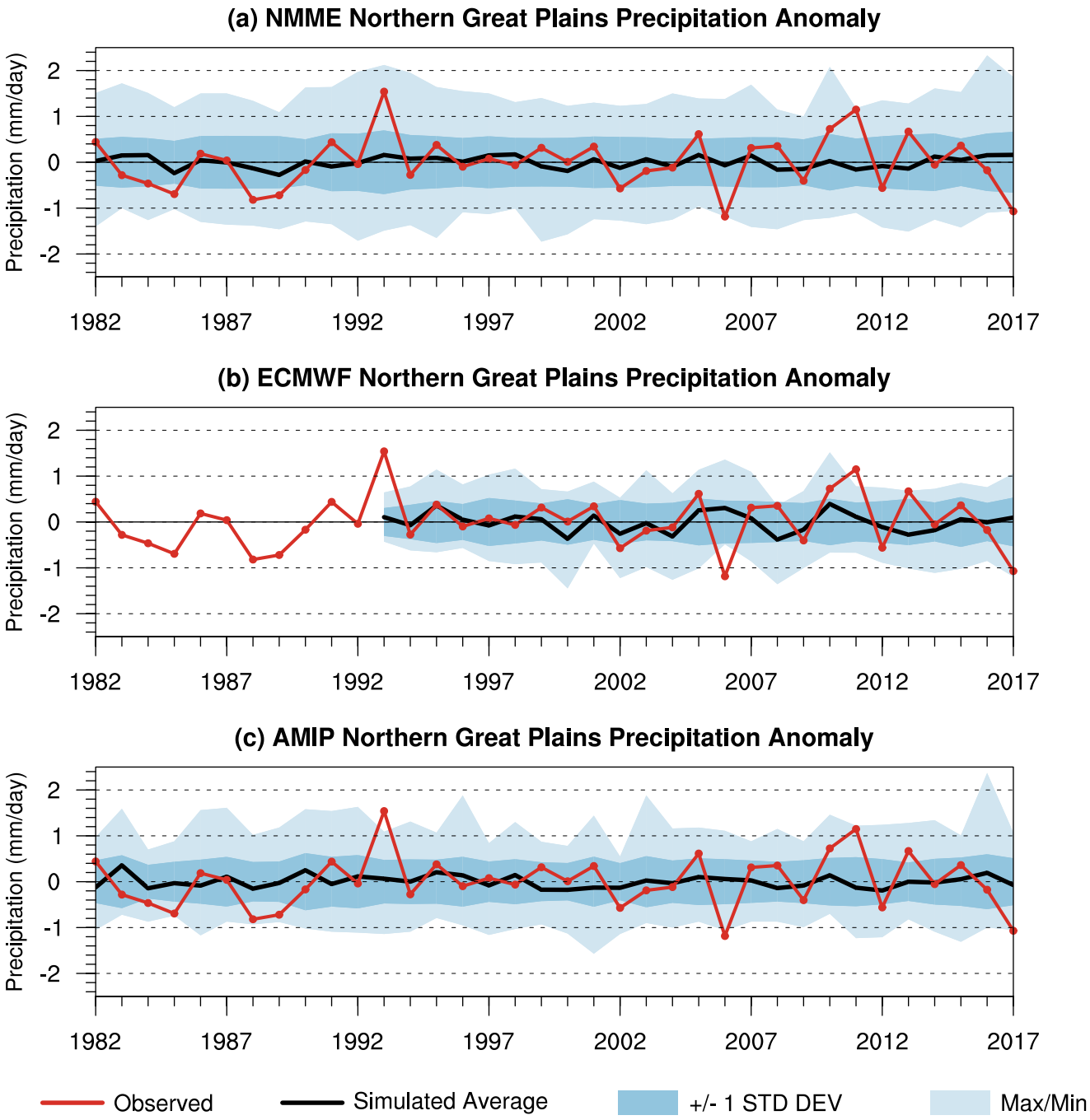
Near Average Probability

Above Average Probability

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

Low Signal-to-Noise Ratio Suggest Limited Predictability

Ensemble spread (noise) is large compared to the ensemble average anomaly (signal)



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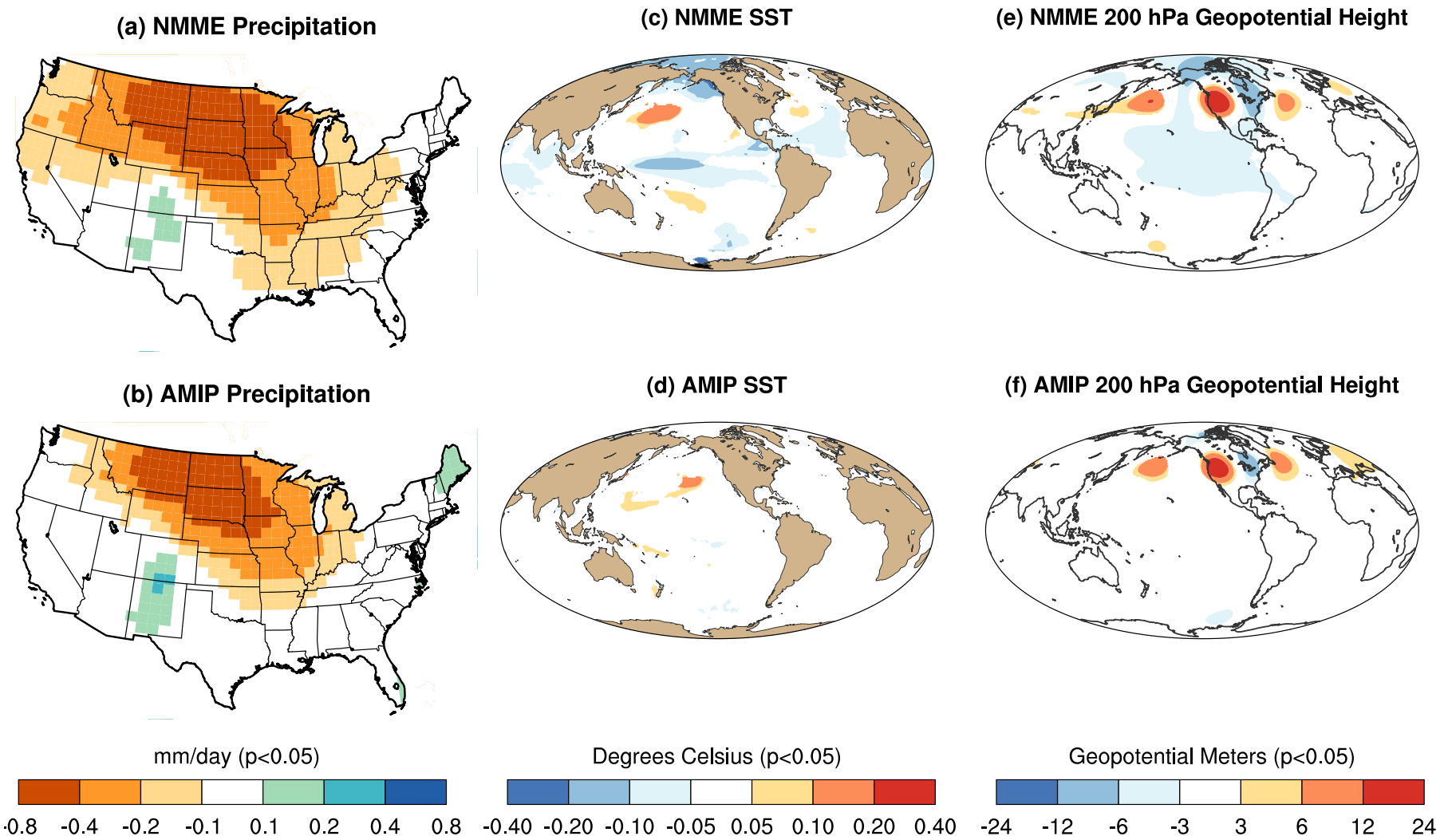
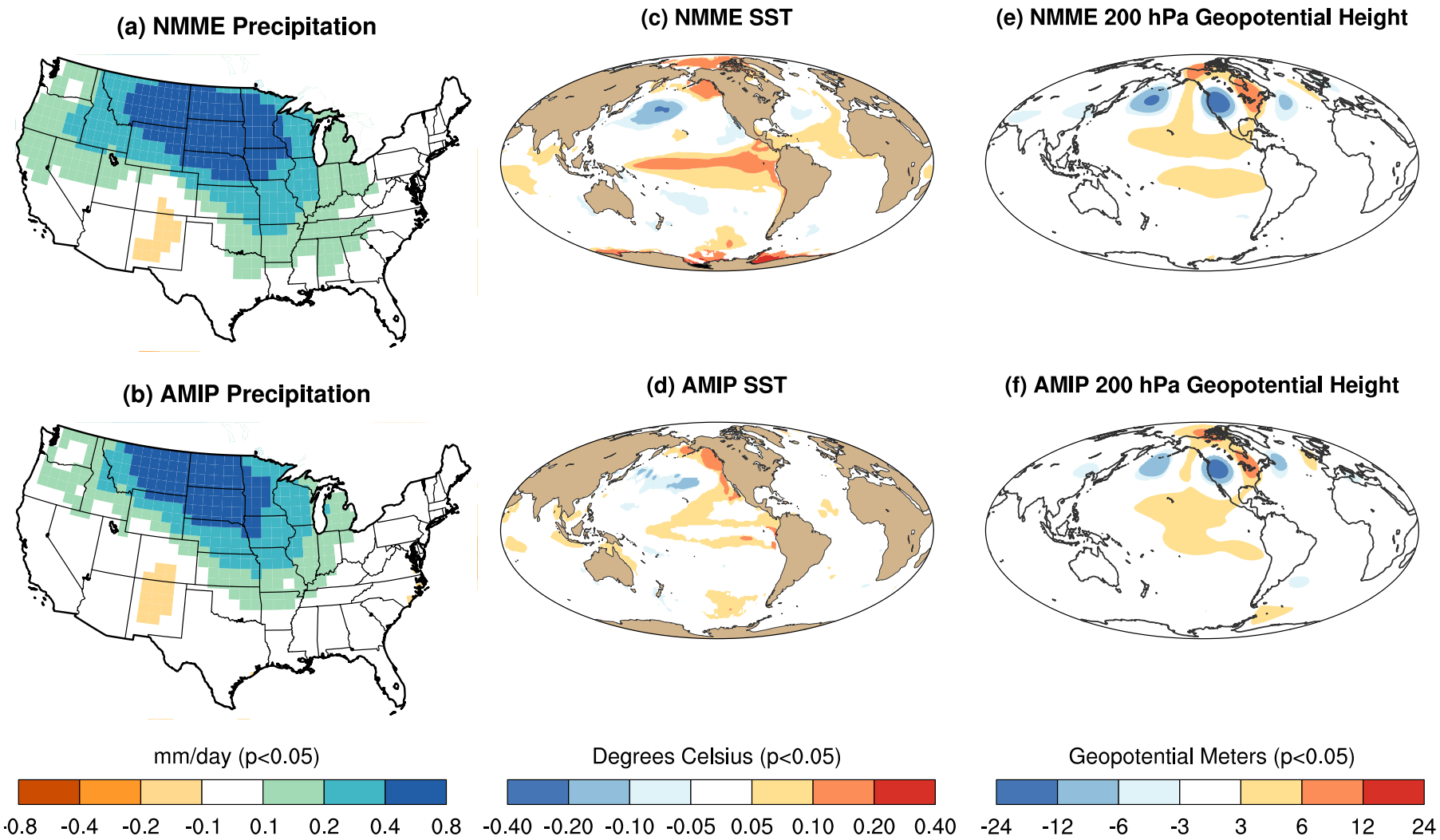
Below Average Precipitation Weakly Related With La Niña



Above Average Precipitation Weakly Related With El Niño



Questions

1. Was below average precipitation during May-July 2017 forecast in advance of the season?

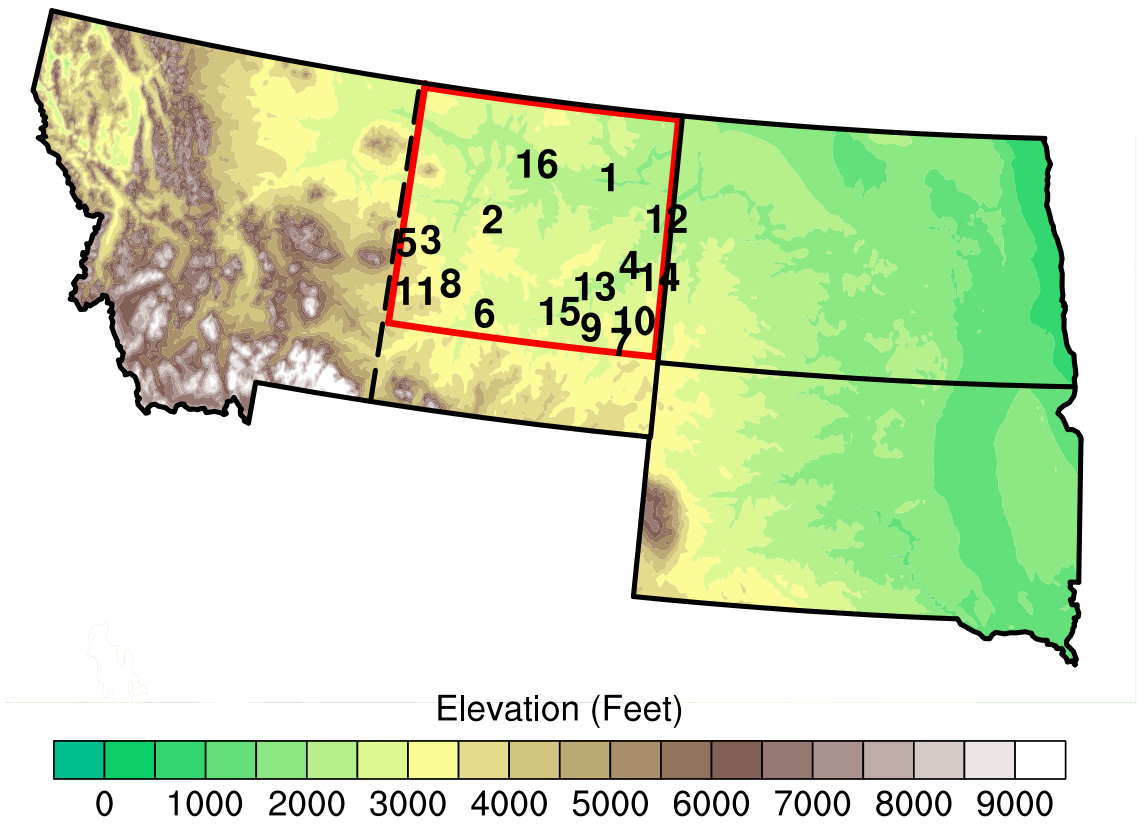
   No

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

   ENSO, but the relationship is not strong

3. Was the evolution of the May-July 2017 precipitation forecast at any lead time?

Tools: GHCN Stations



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

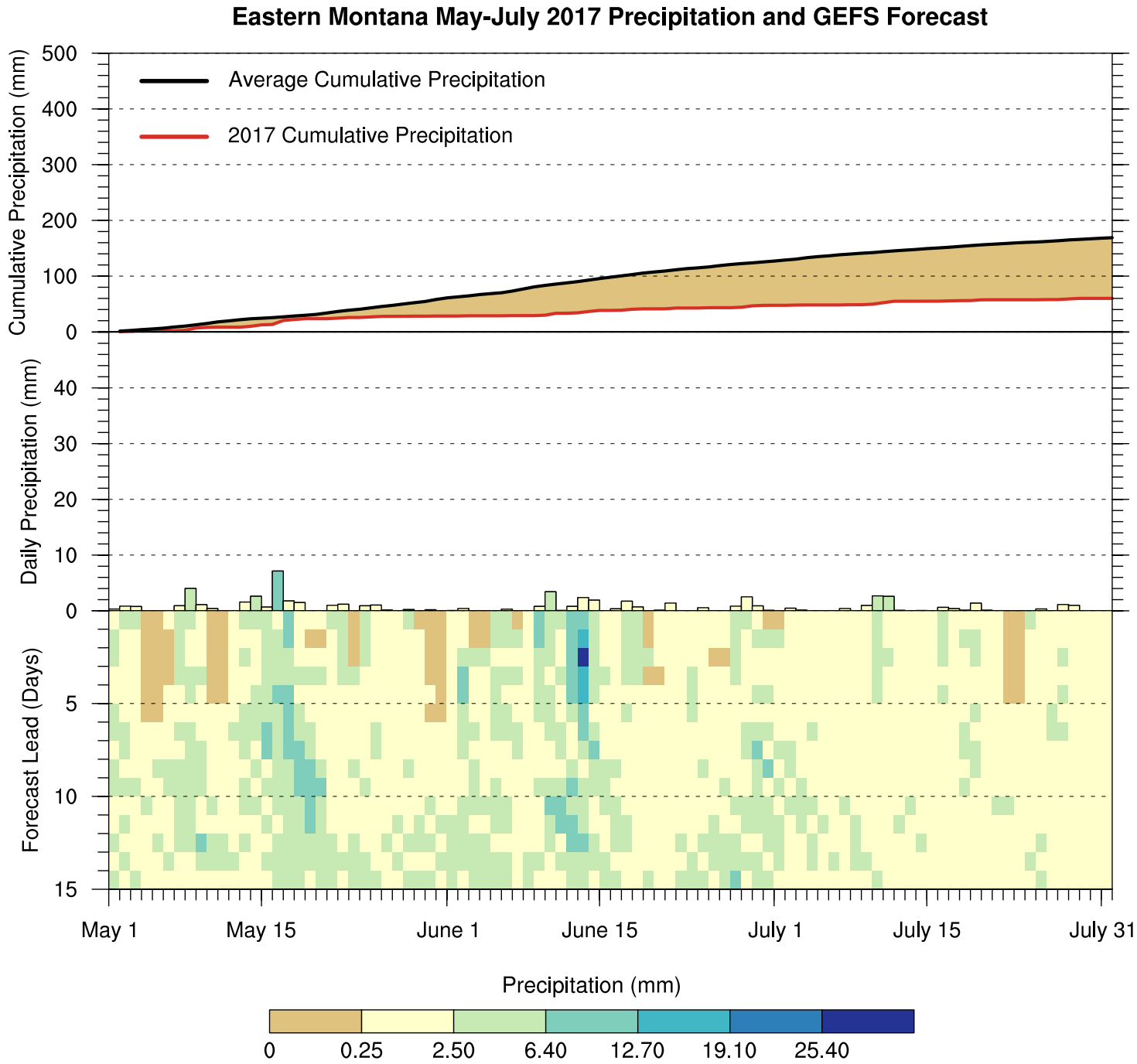
Tools: GEFS Reforecasts

“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/

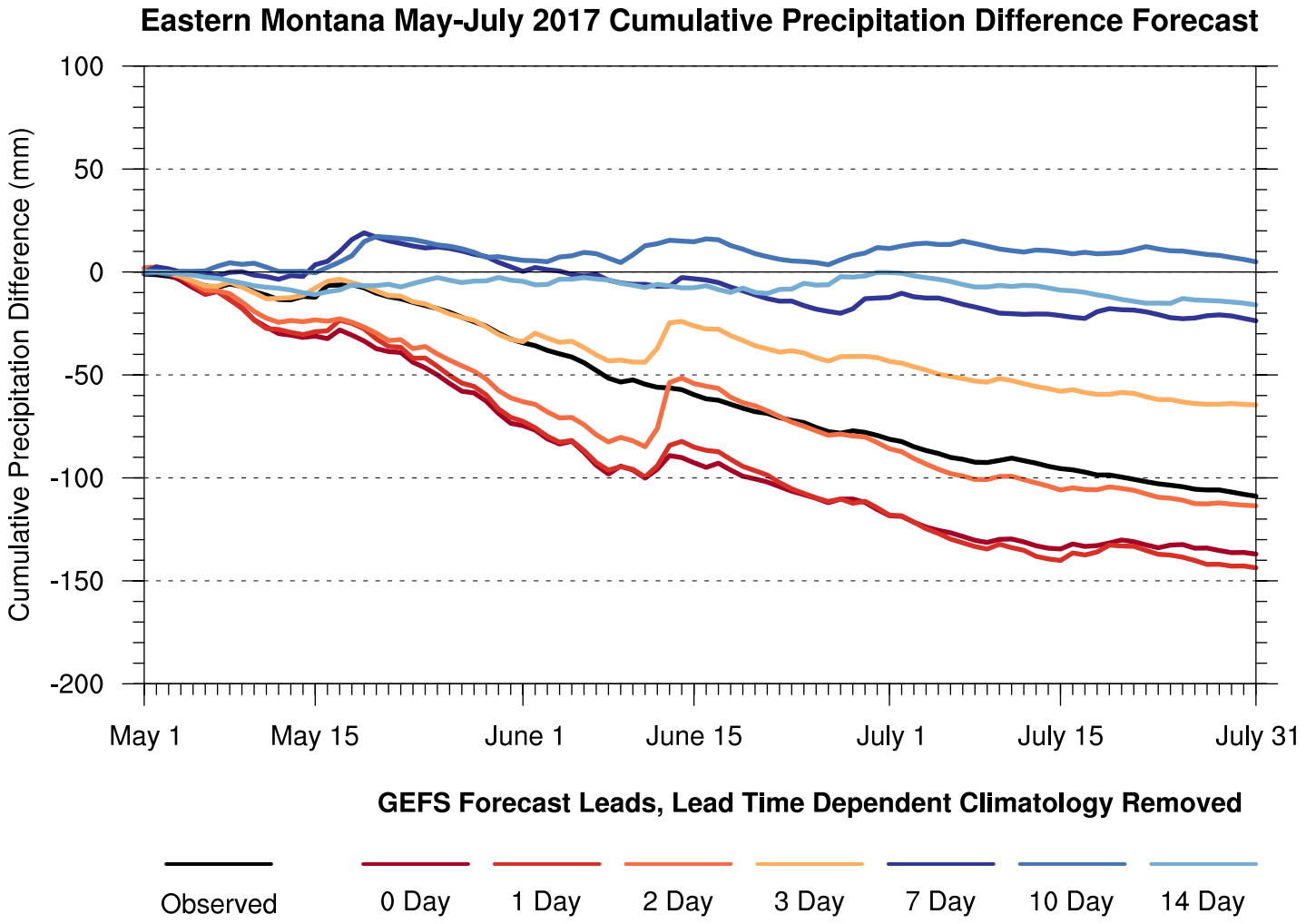
Dry Periods Predictable Up to Three Days In Advance

- Dry periods forecast at short leads then model returns to its climatology
- One noteworthy daily miss in mid-June. Model missed the spatial features of storms on that day.



Dry Periods Predictable Up to Three Days In Advance

- A sequence of 0-3 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

1. Was below average precipitation during May-July 2017 correctly forecast in advance of the season?

   No

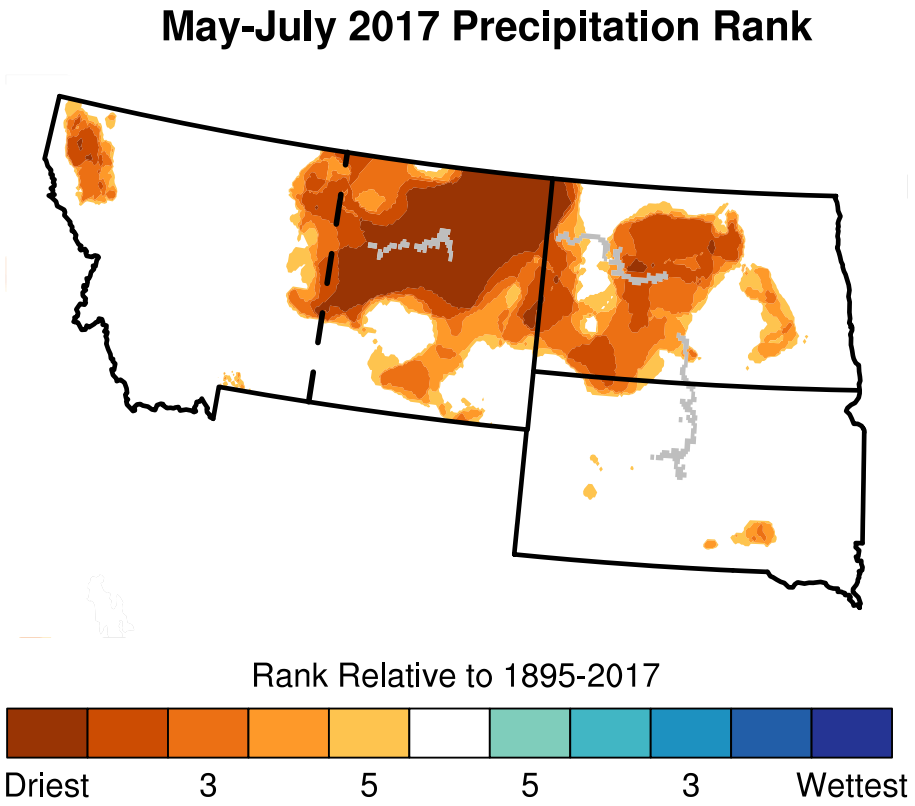
2. What are the sources of May-July precipitation predictability?

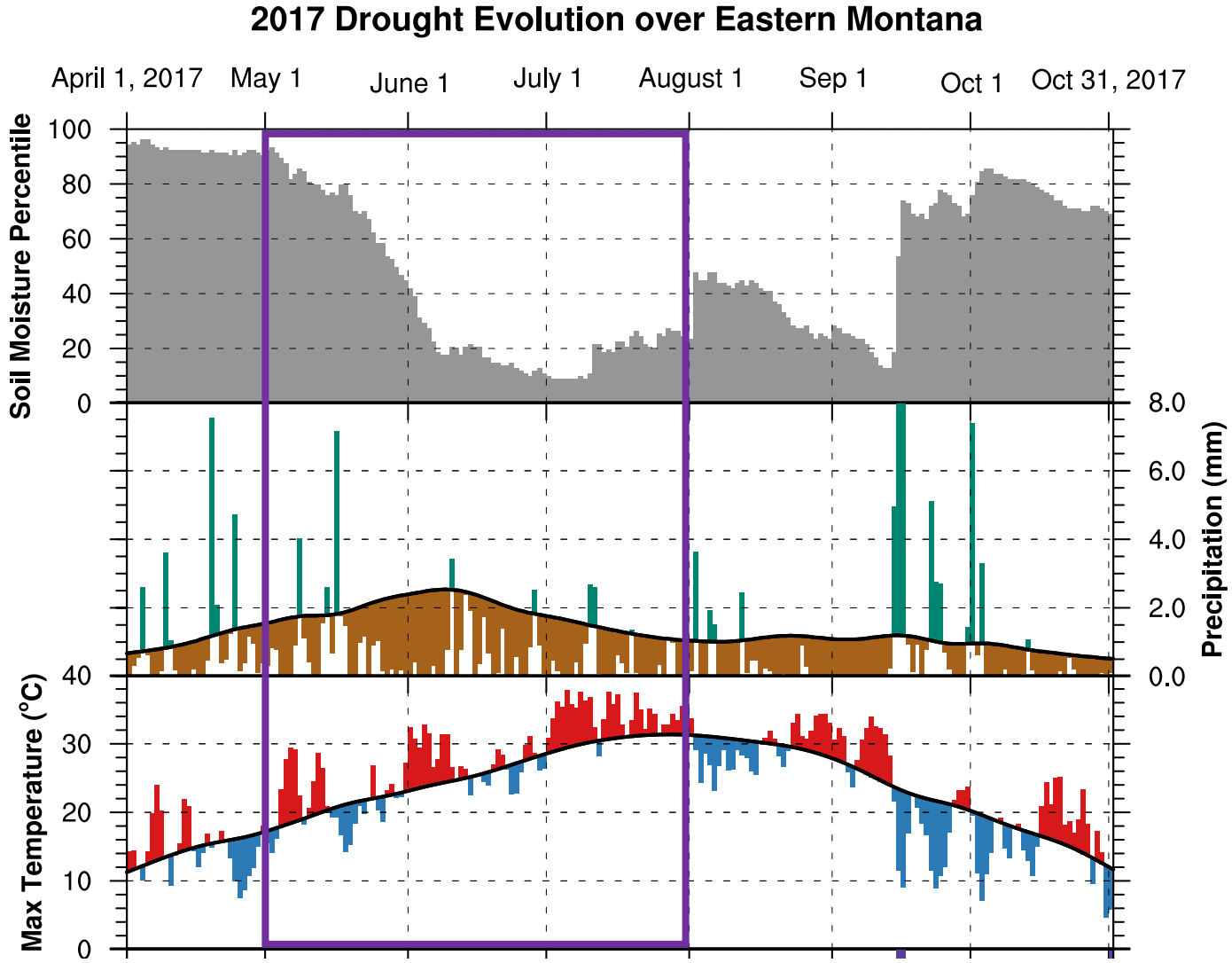
   ENSO, but the relationship is not strong

3. Was the evolution of the May-July 2017 precipitation forecast correctly at any lead time?

   Yes, through a sequence of 3 day forecasts

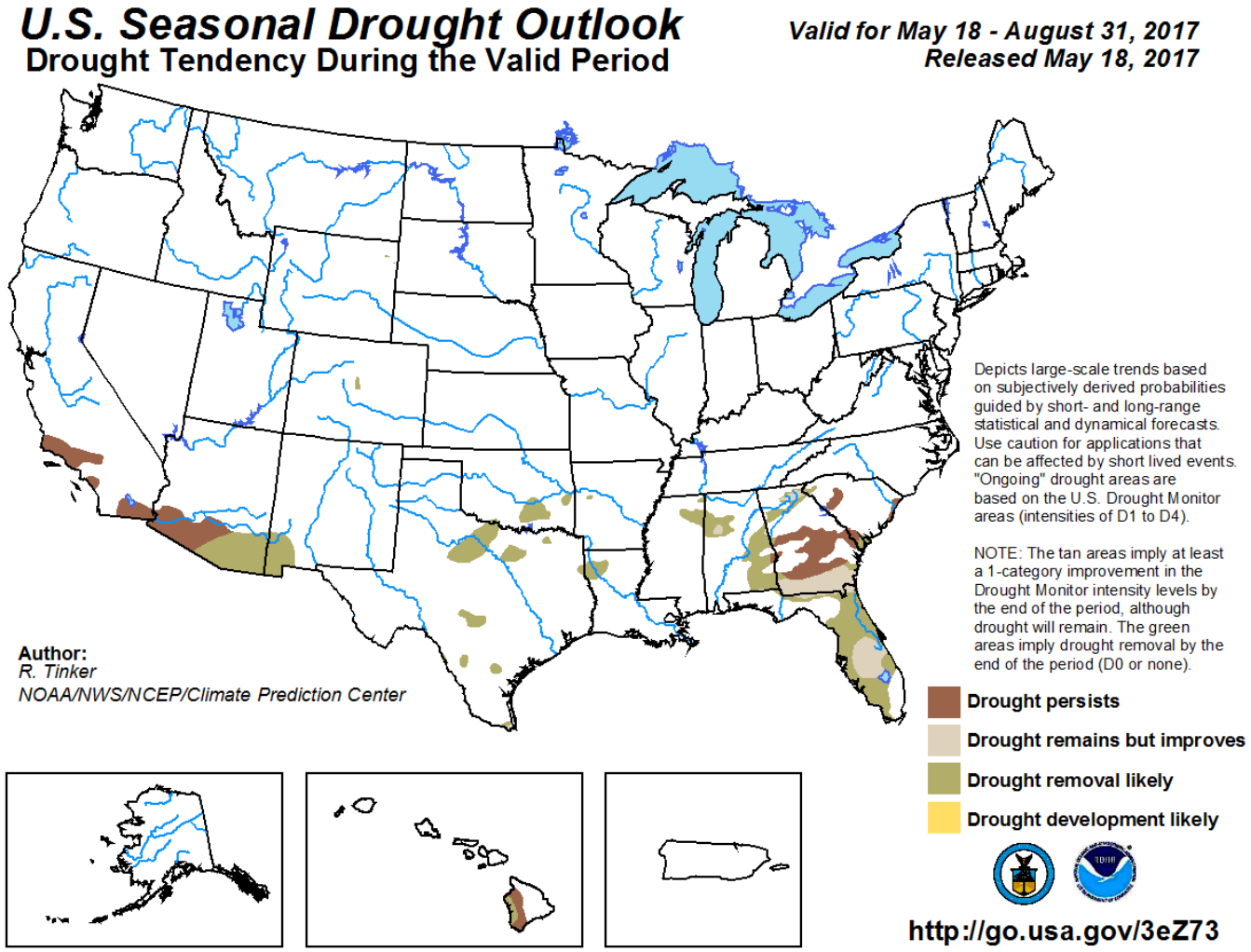
Forecast Models Not Helpful Toward Providing Early Warning of Record Low May-July 2017 Precipitation





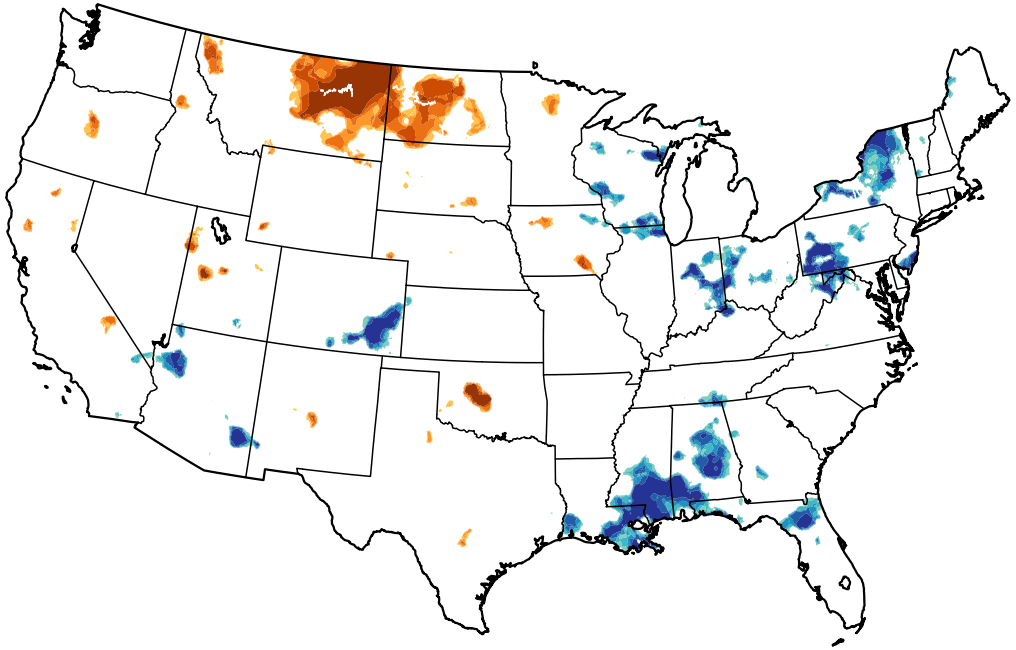
Extra Slides

Drought Onset Unforeseen

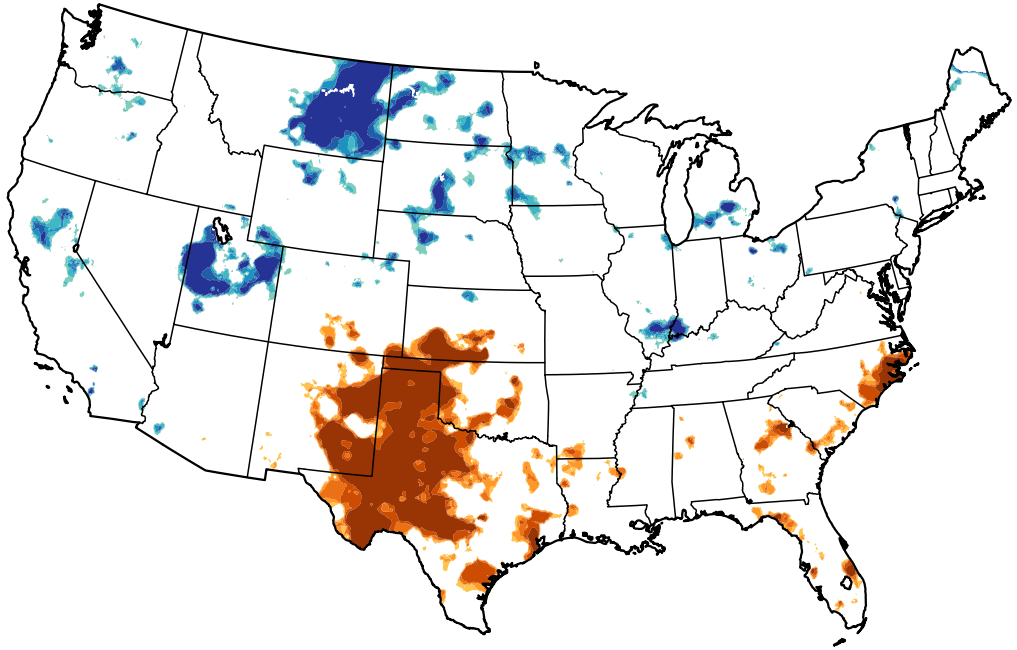


‘Billion Dollar Disasters’ Related With Extreme May-July Northern Great Plains Precipitation

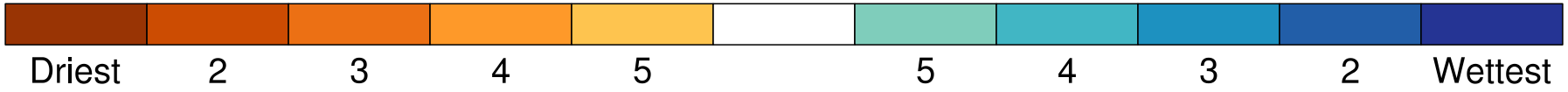
(a) May-July 2017 Precipitation Rank



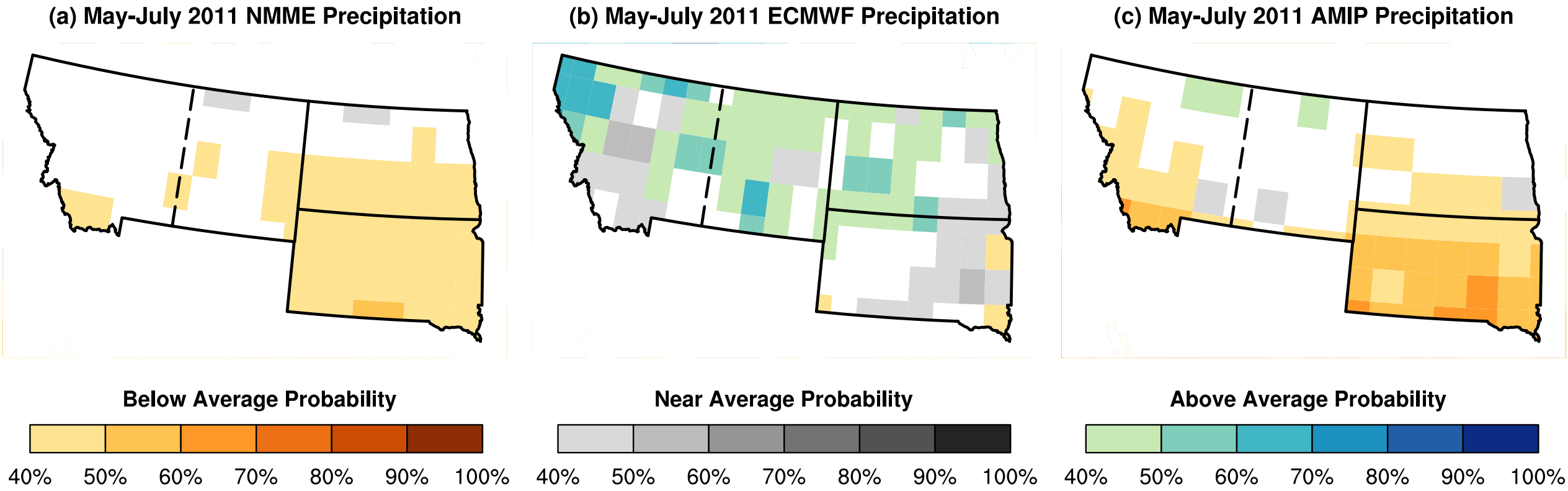
(b) May-July 2011 Precipitation Rank



Rank Relative to 1895-2017



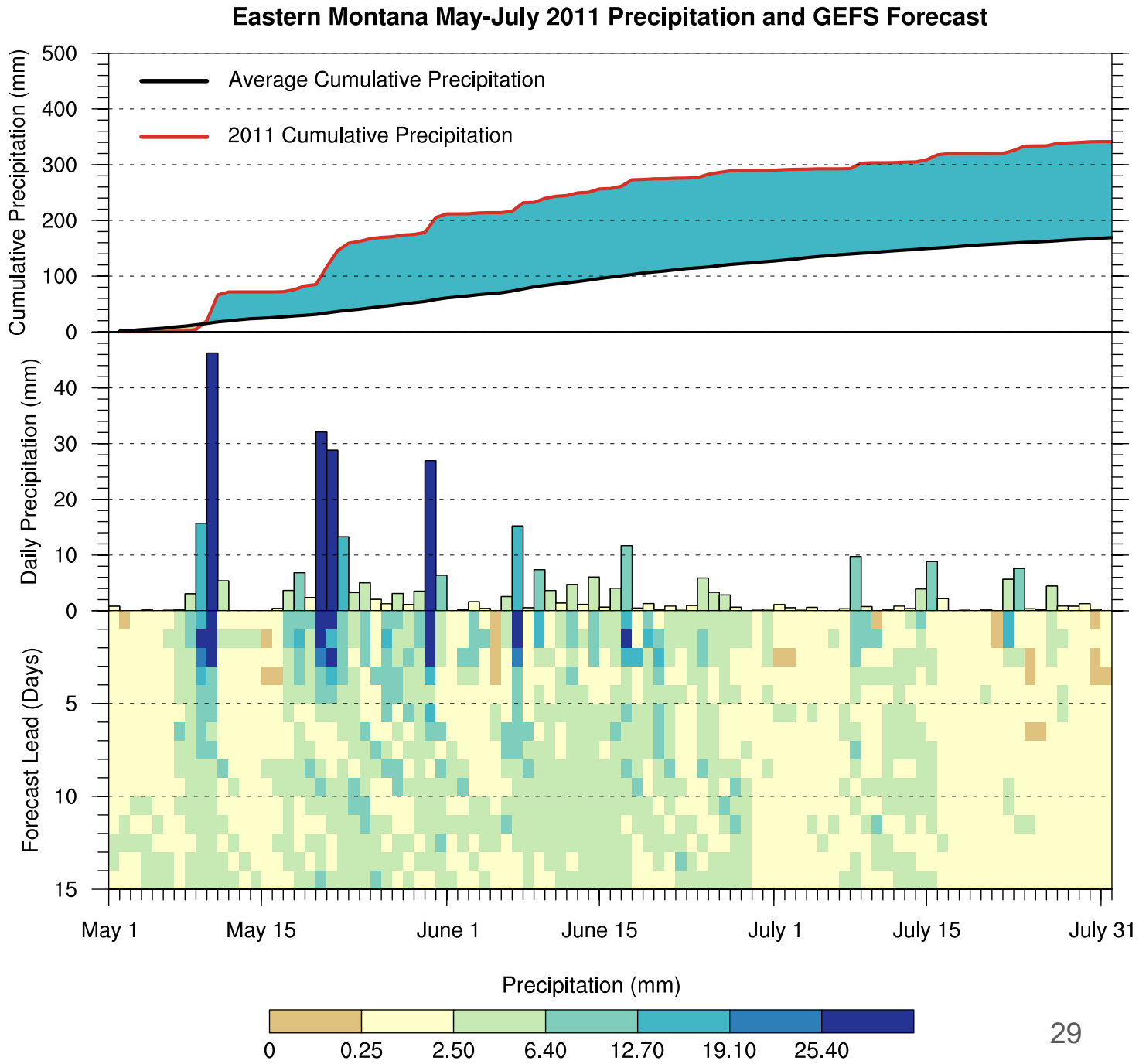
2011: Mixed Tilt in Odds to Above Average Precipitation



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

Wet Periods Predictable Up to Five Days In Advance

- Wet/dry periods forecast at short leads then model returns to its climatology



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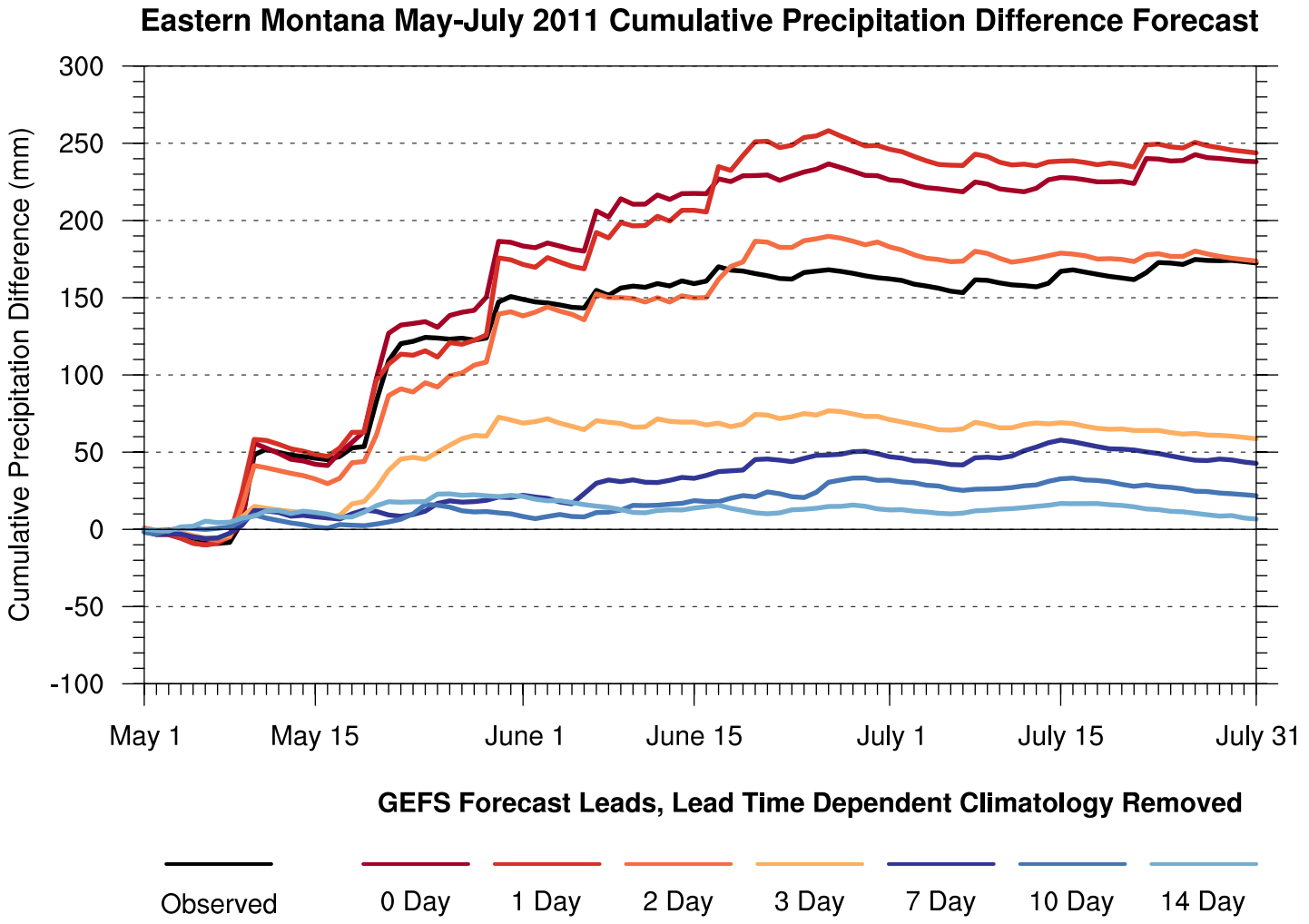
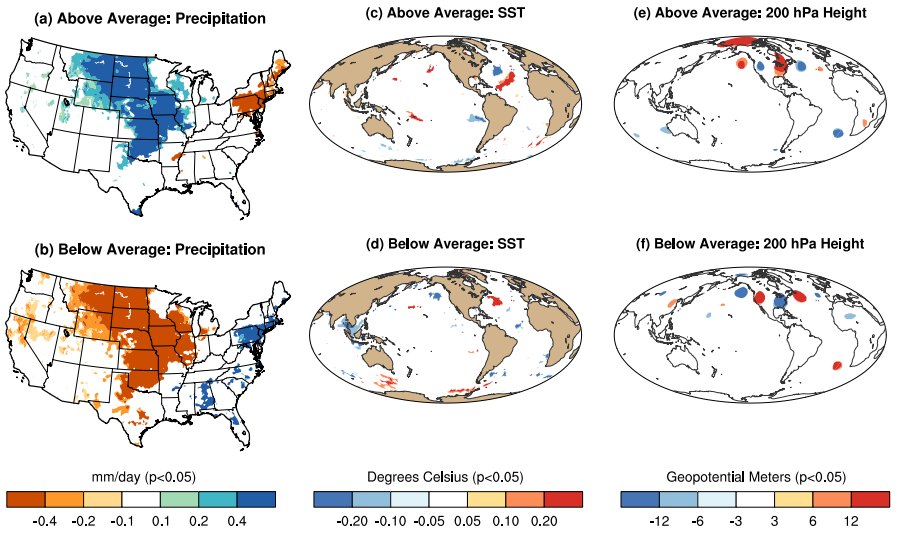
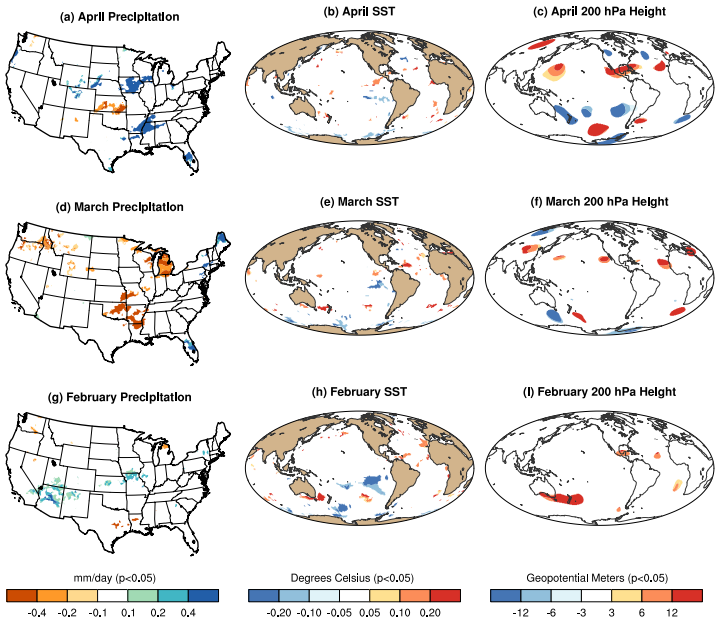
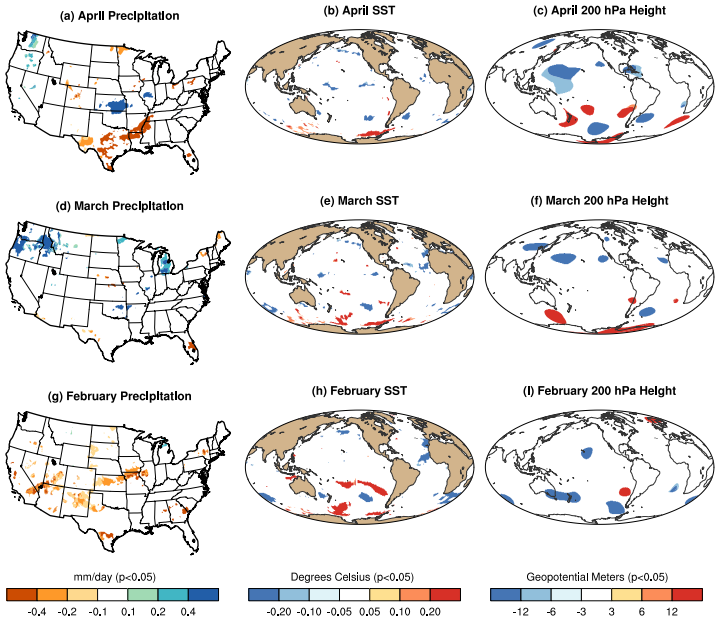



(a) Above Average: Precipitation
(c) Above Average: SST
(e) Above Average: 200 hPa Height
(b) Below Average: Precipitation
(d) Below Average: SST
(f) Below Average: 200 hPa Height
mm/day (p<0.05)
-0.4 -0.2 -0.1 0.1 0.2 0.4
Degrees Celsius (p<0.05)
-0.20 -0.10 -0.05 0.05 0.10 0.20
Geopotential Meters (p<0.05)
-12 -6 -3 3 6 12


(a) April Precipitation
(b) April SST
(c) April 200 hPa Height
(d) March Precipitation
(e) March SST
(f) March 200 hPa Height
(g) February Precipitation
(h) February SST
(i) February 200 hPa Height
mm/day (p<0.05)
-0.4 -0.2 -0.1 0.1 0.2 0.4
Degrees Celsius (p<0.05)
-0.20 -0.10 -0.05 0.05 0.10 0.20
Geopotential Meters (p<0.05)
-12 -6 -3 3 6 12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