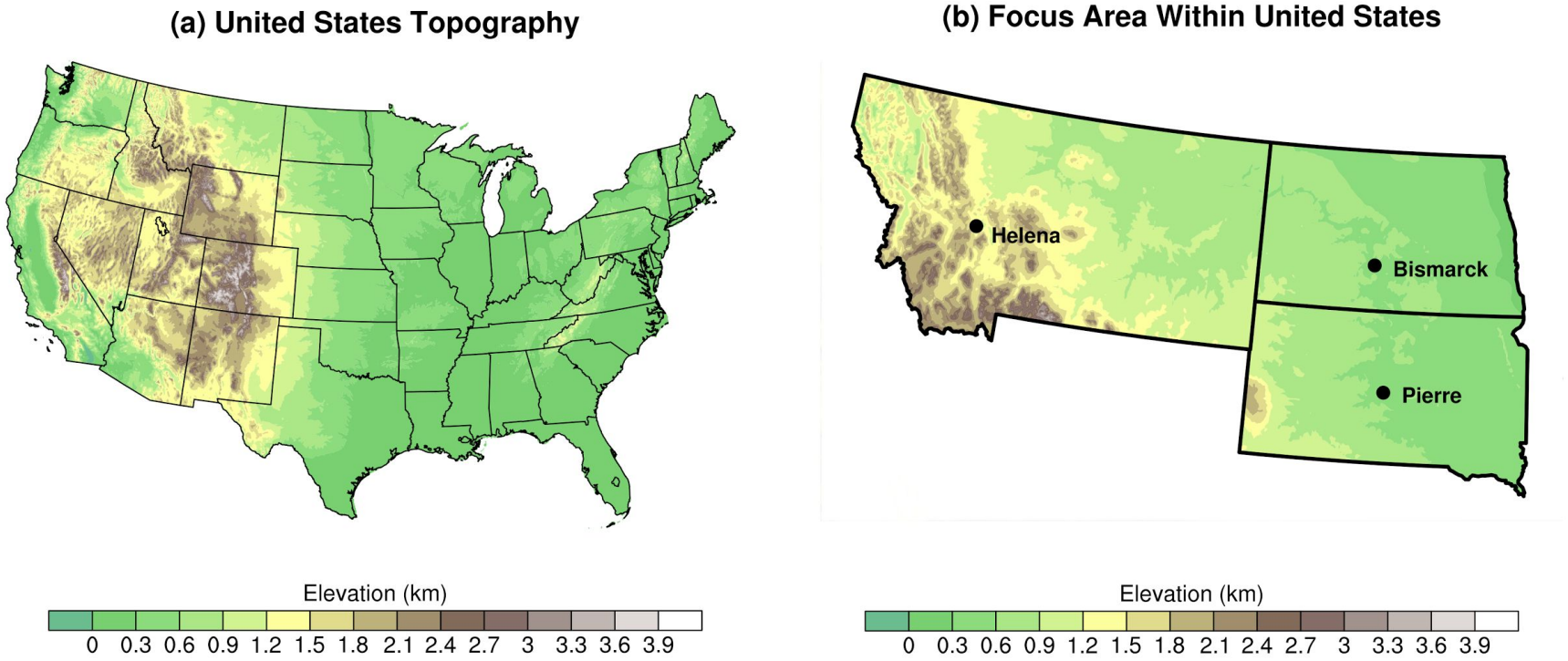
Oceanic and Atmospheric Research · Physical Sciences Division

Historical Context of the 2017-18 U.S. Northern Plains Drought

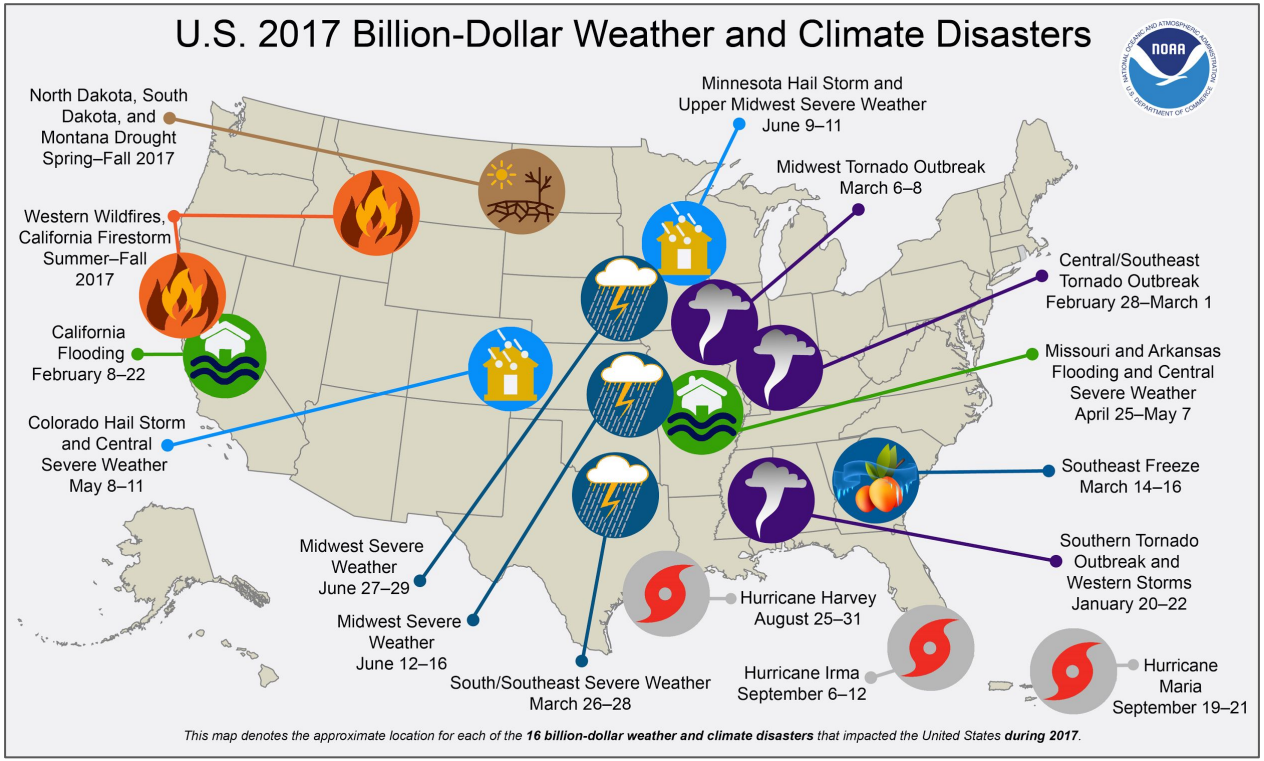
Andy Hoell and Klaus Wolter

Focus: United States Northern Plains



Focus region and elevation

2017-18 N. Plains Drought a ‘Billion Dollar Disaster’



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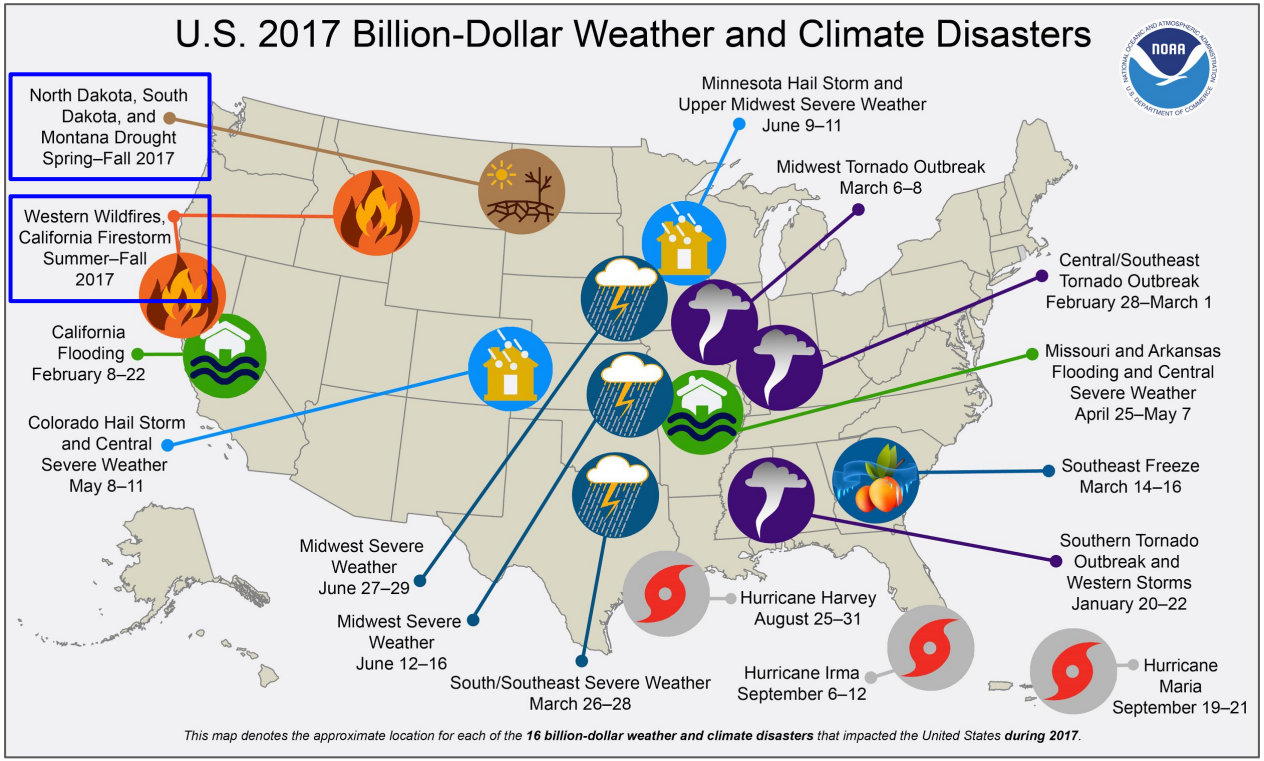
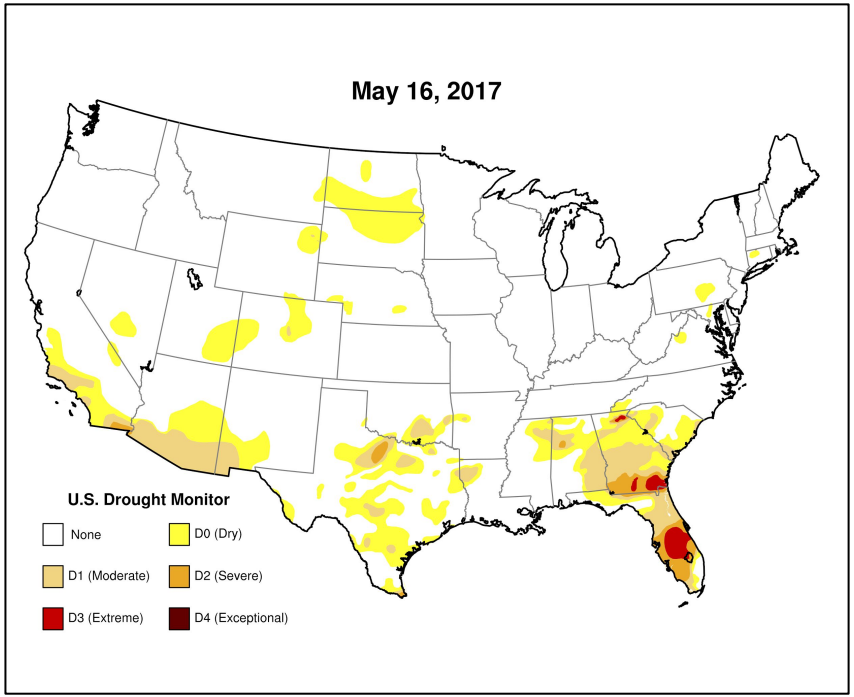
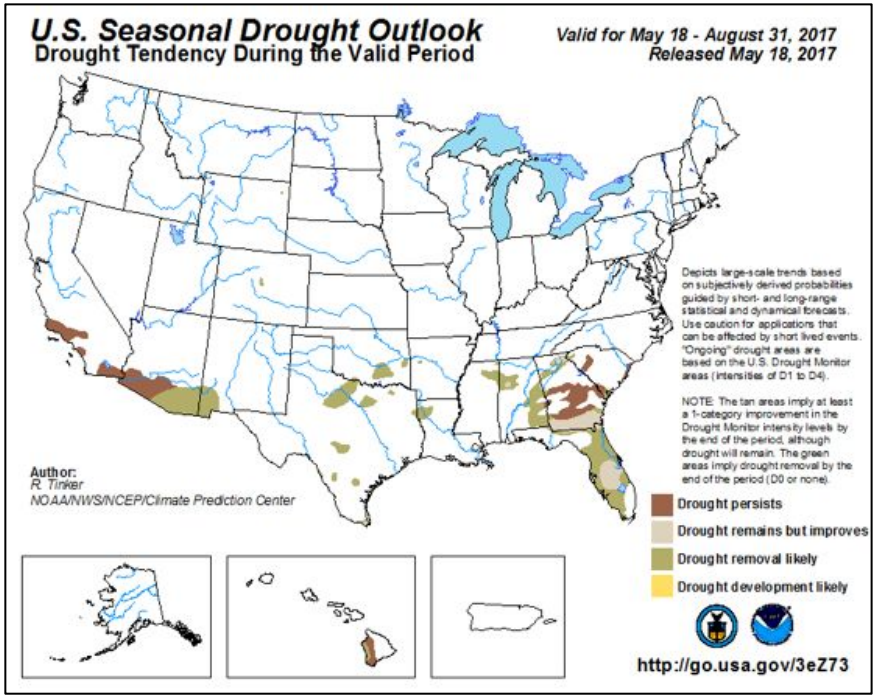


Unforeseen Rapid & Severe Onset

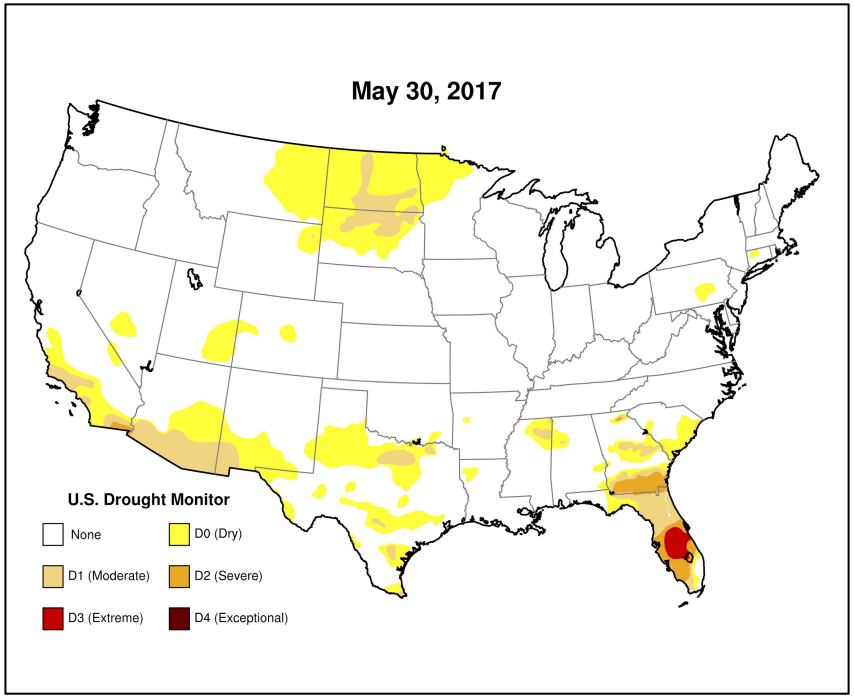


U.S. Drought Monitor - May 16, 2017

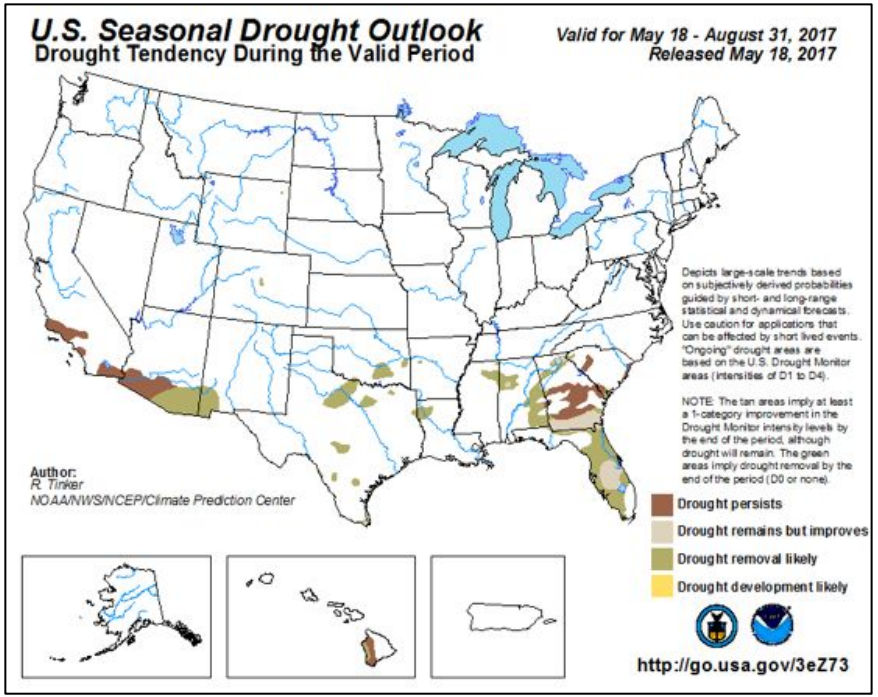


CPC U.S. Seasonal Drought Outlook - May 18, 2017

Unforeseen Rapid & Severe Onset



U.S. Drought Monitor - May 30, 2017



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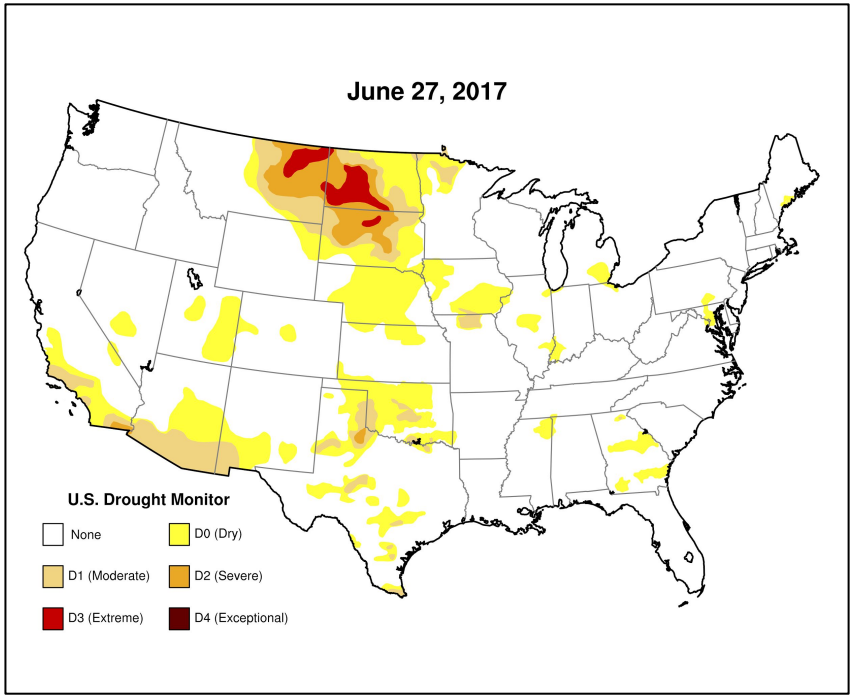
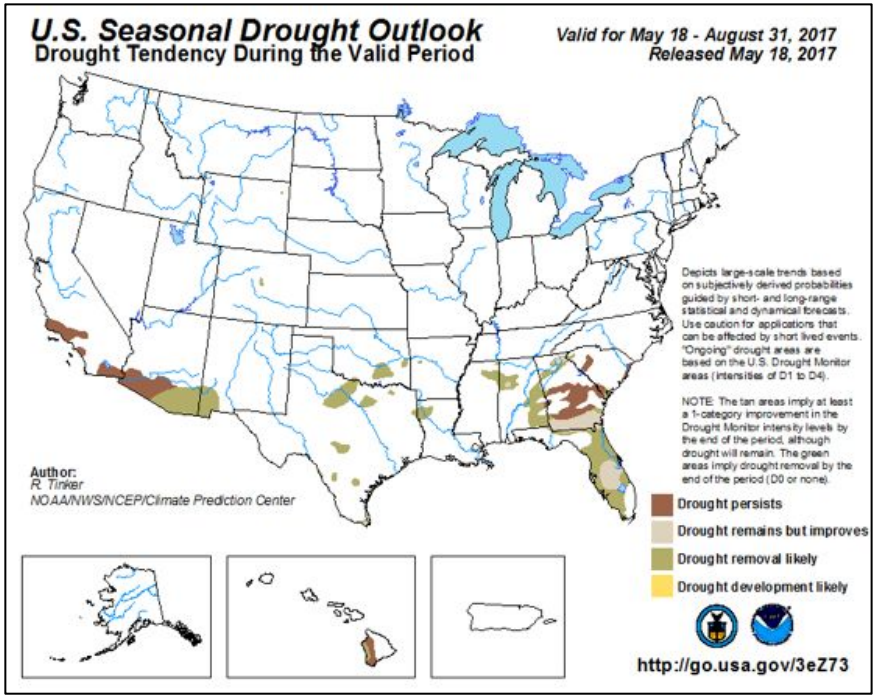


U.S. Drought Monitor - June 27, 2017



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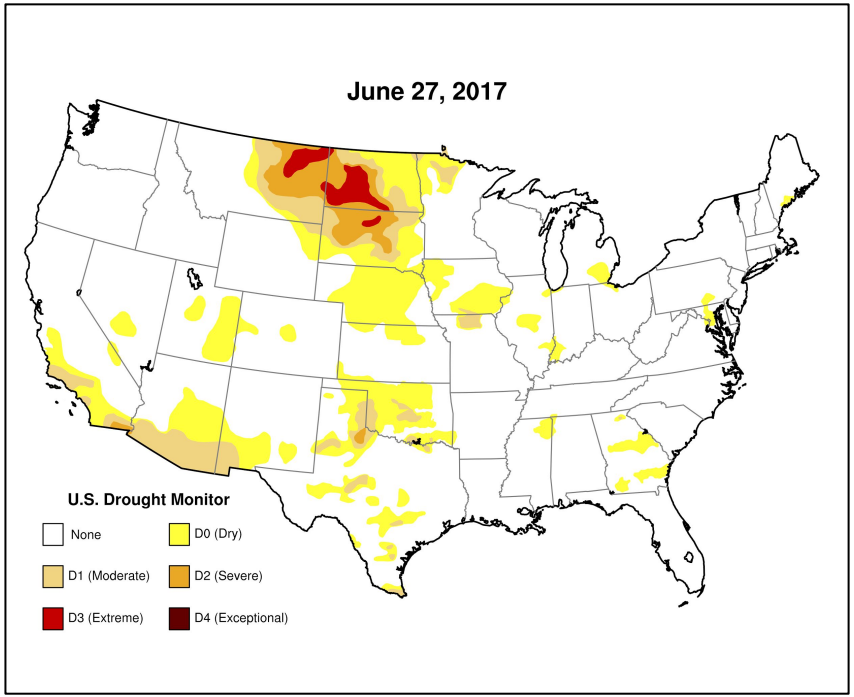

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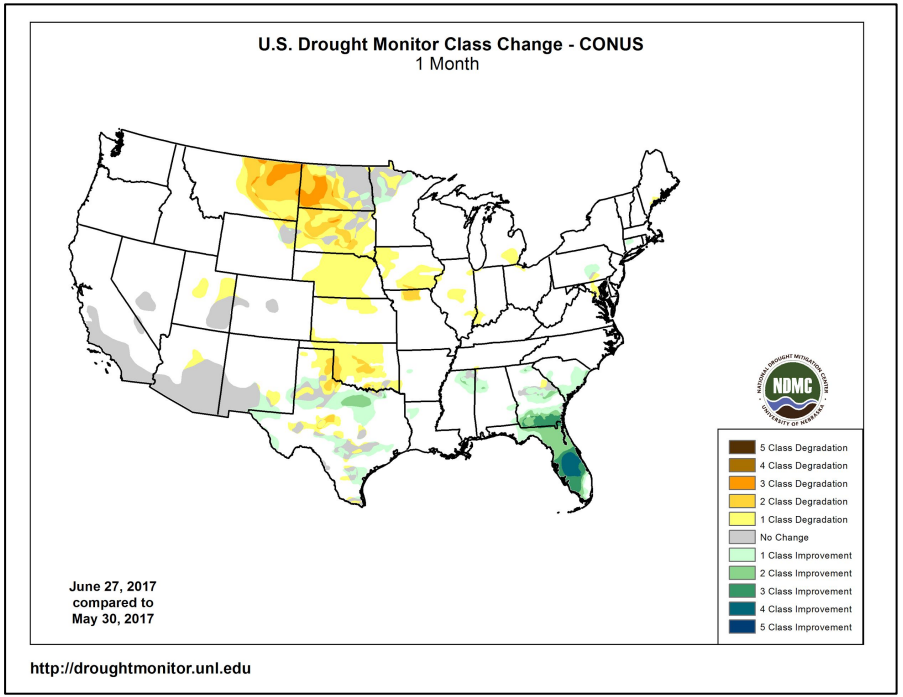
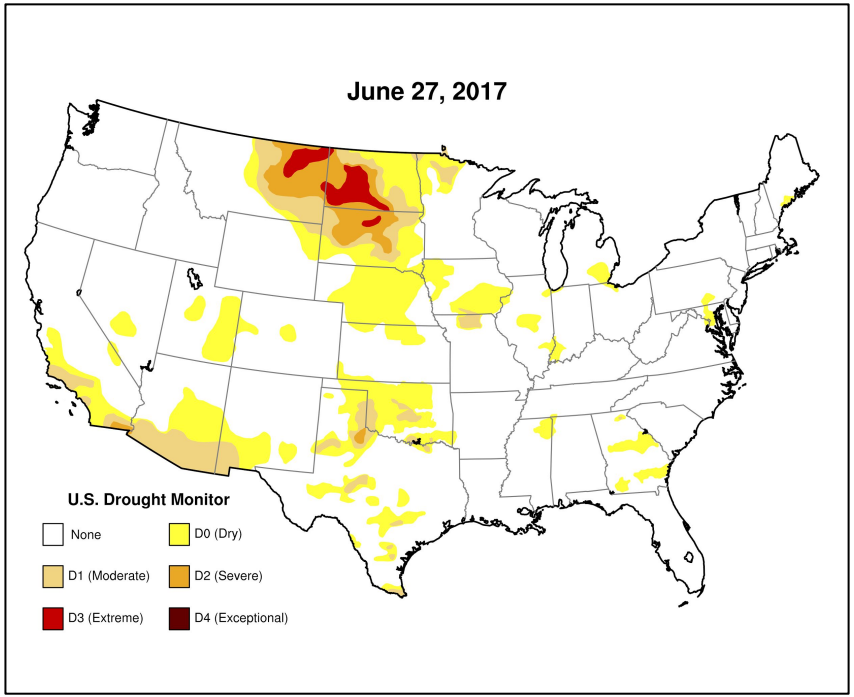


U.S. Drought Monitor 4-Week Change - June 27, 2017

Questions in the Context of Rapid & Severe Drought Onset



U.S. Drought Monitor - June 27, 2017

- When do droughts typically begin and end?
- How likely/unlikely are rapid drought intensifications given onset month?
- How long do droughts last?
- What is the probability of drought onset/demise from given months?
- When will the next drought occur?

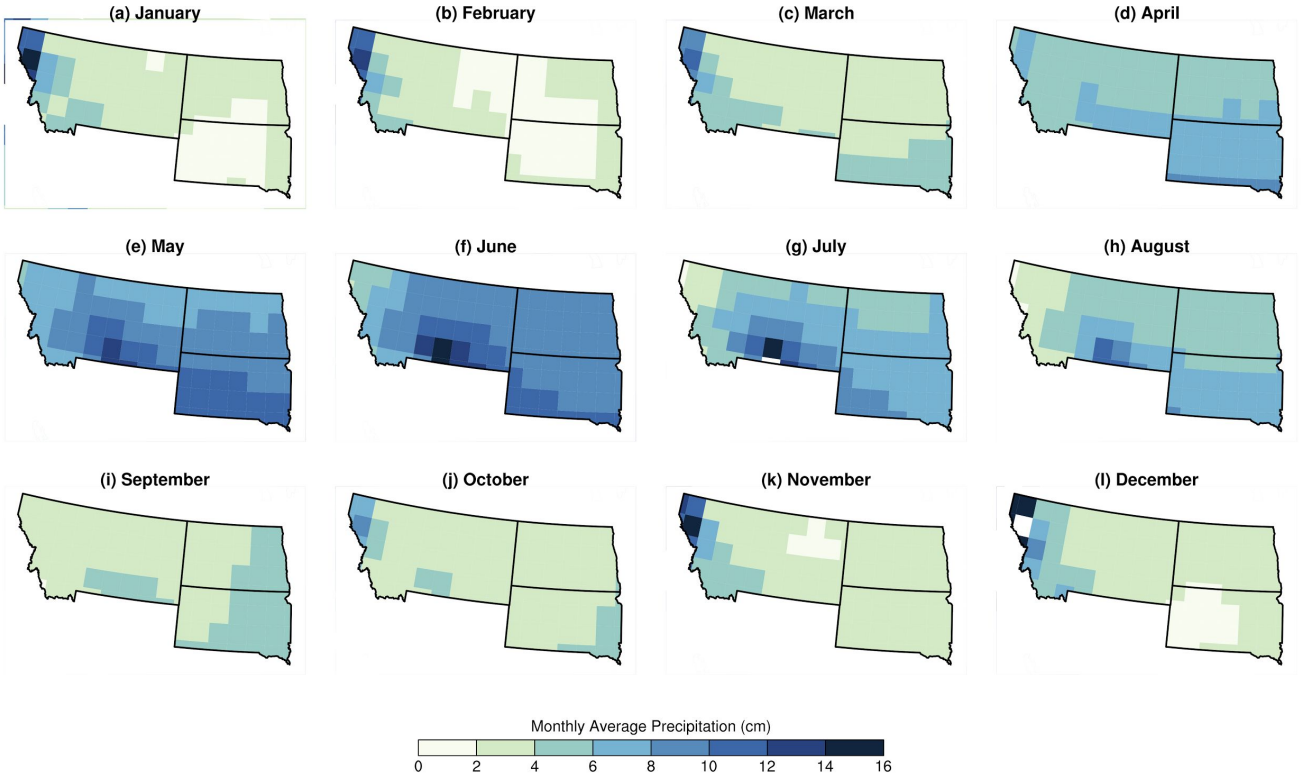
Tools

- Monthly simulated historical land surface estimates for 1916-2015
  - Drawn from an ensemble comprised of five separate models driven by the same time-evolving meteorology all on a 0.5˚x0.5˚ (116x49) grid over the U.S.
    - NOAH, VIC, Sacramento, Catchment and CLM
    - Provided by University of Washington Surface Water Group
- Monthly simulated land surface conditions for 1916-2015
  - Drawn from a 30-member CAM5-CLM4 ensemble driven by an estimate of the observed time-evolving boundary conditions on a ~1˚x1˚ (288x192) global grid

UW Forcing Mean Precipitation

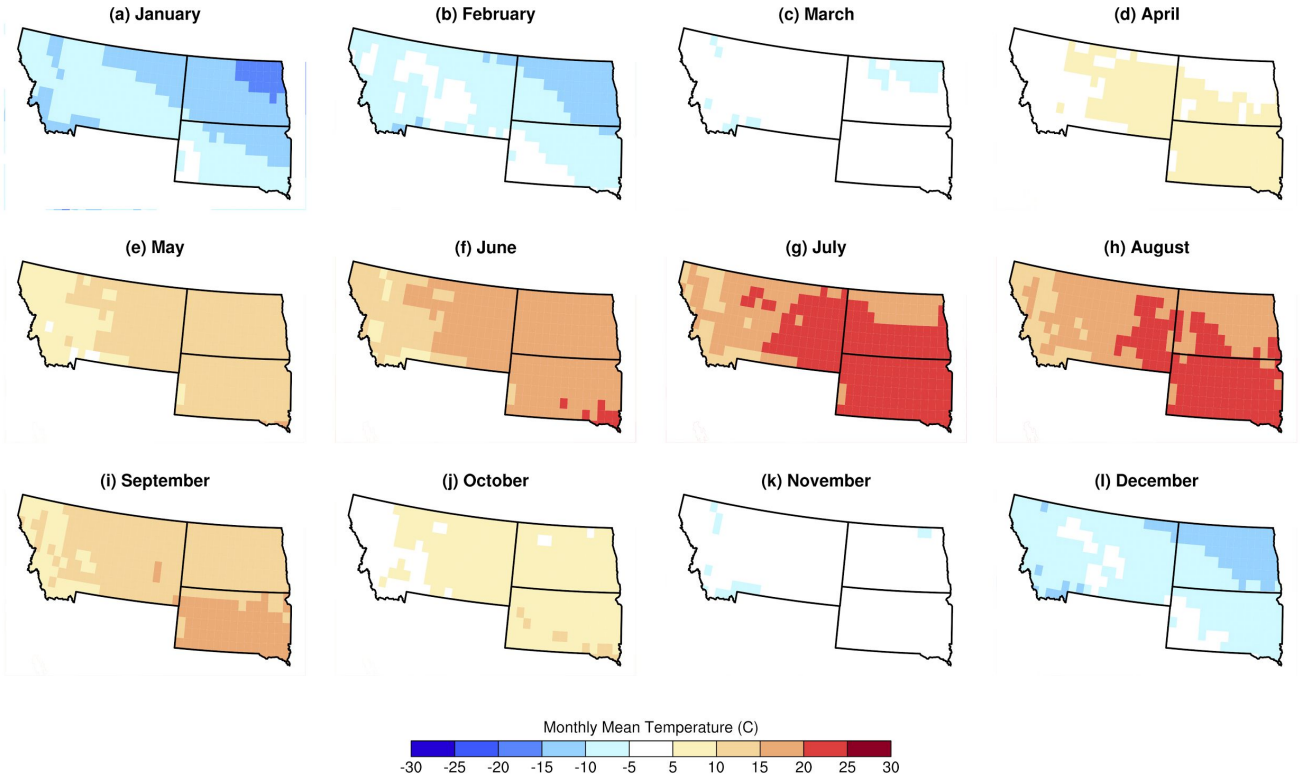
1916-2015 UW Mean Precipitation Forcing

CAM5-CLM Mean Precipitation



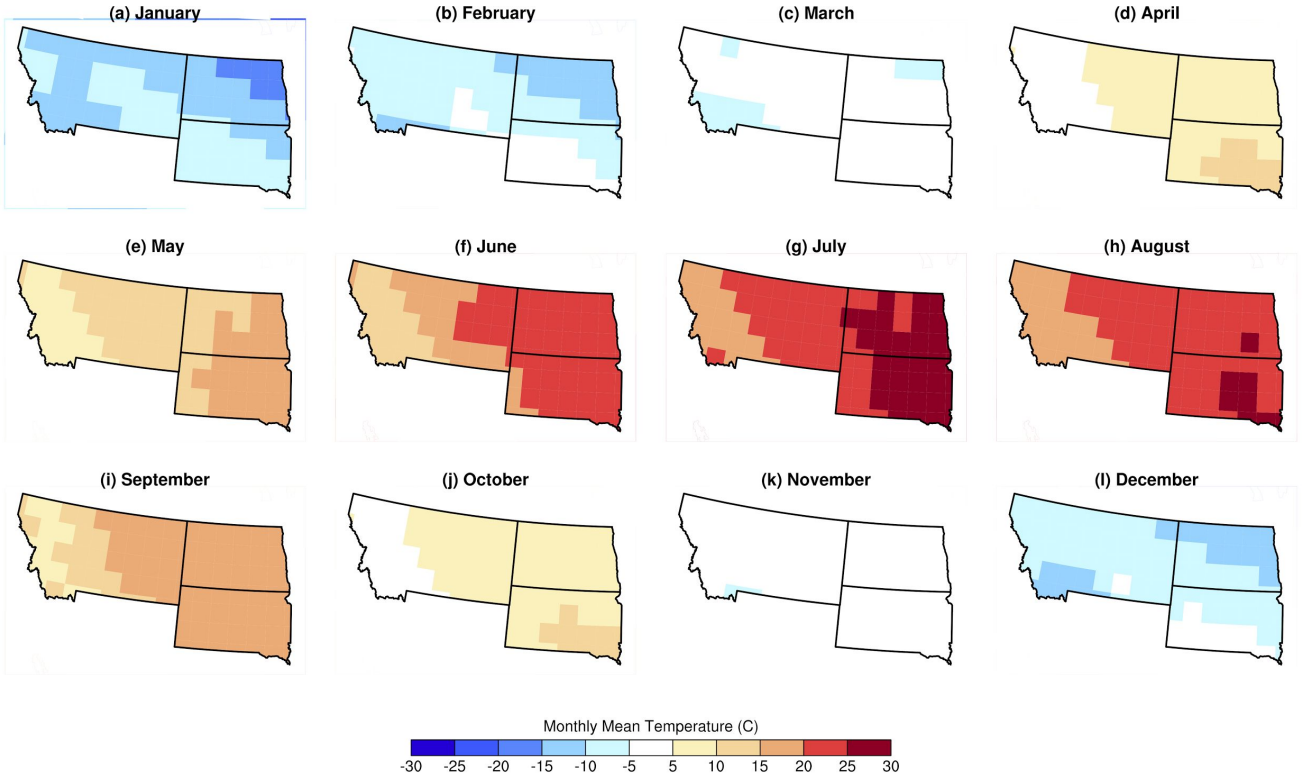
1916-2015 CAM5 Ensemble Member 1 Mean Precipitation

UW Forcing Mean Temperature



1916-2015 UW Mean Temperature Forcing (C)

CAM-CLM Mean Temperature



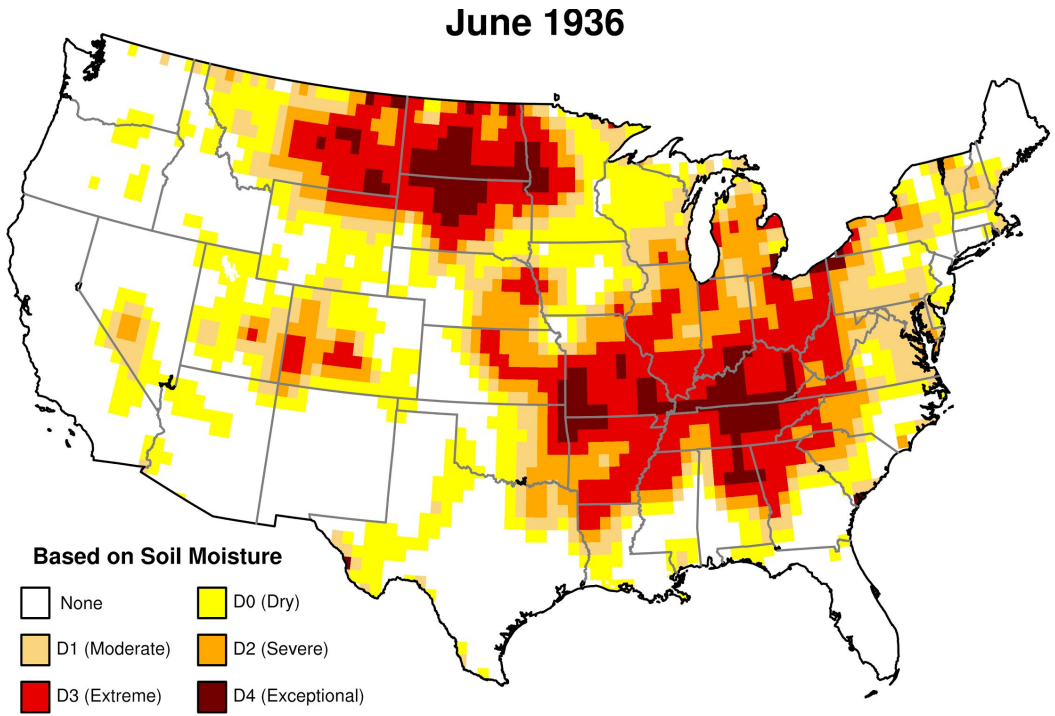
1916-2015 CAM5 Ensemble Member 1 Mean Temperature (C)

Methodology: Local Drought Severity

- Define local drought severity based upon top 1-m soil moisture exceedances at the grid point scale, given the importance of agriculture to the region and that soil moisture integrates effects of both precipitation and evaporation on drought
- Adopt a soil moisture percentile-based drought definition similar to the U.S. Drought Monitor

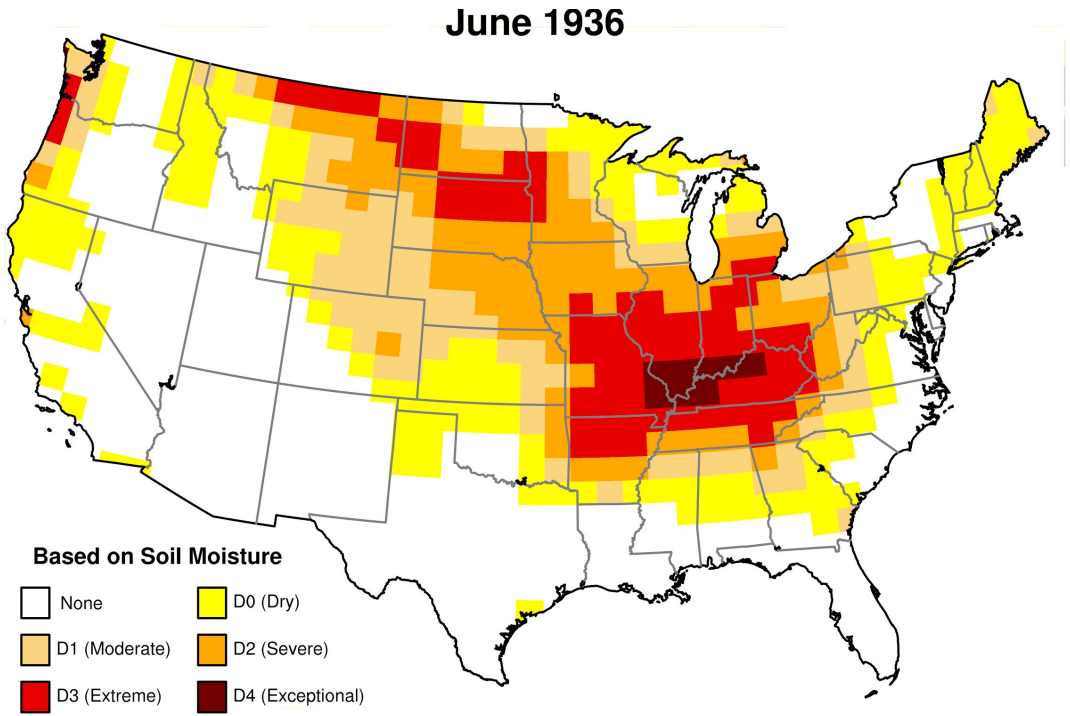
			Ranges				
Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: • short-term dryness slowing planting, growth of crops or pastures Coming out of drought: • some lingering water deficits • pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	• Some damage to crops, pastures • Streams, reservoirs, or wells low, some water shortages developing or imminent • Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	• Crop or pasture losses likely • Water shortages common • Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	• Major crop/pasture losses • Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	• Exceptional and widespread crop/pasture losses • Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

UW-CLM Example of Estimated Drought Severity



Soil moisture-based estimate of observed drought categories from UW-CLM

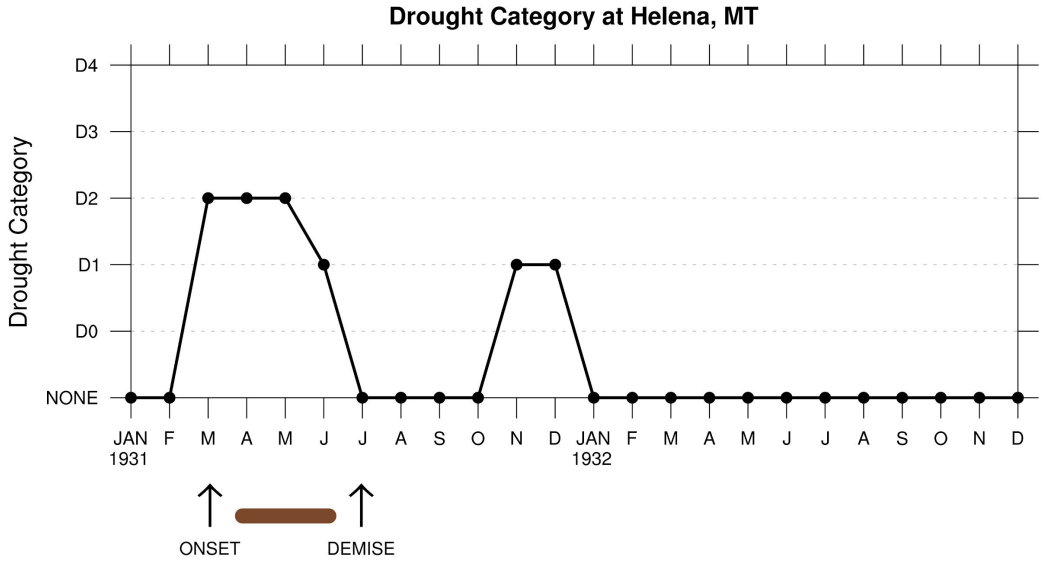
CAM5-CLM4 Example of Drought Severity



Soil moisture-based drought categories from CAM5-CLM4 ensemble member 1

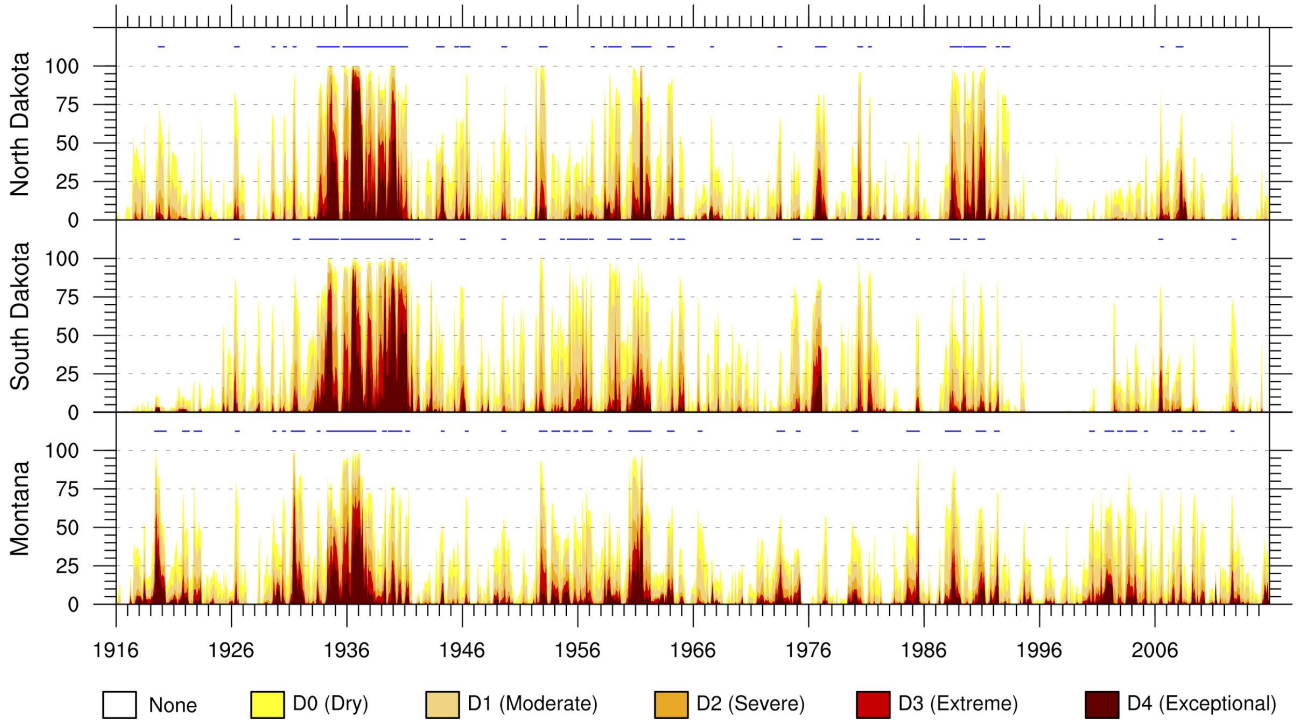
Define Droughts at Each Grid Point Due to Regional Variability

- Drought occurs when D1-D4 for 3 months or more
- Drought recovery occurs when no drought for at least 3 consecutive months



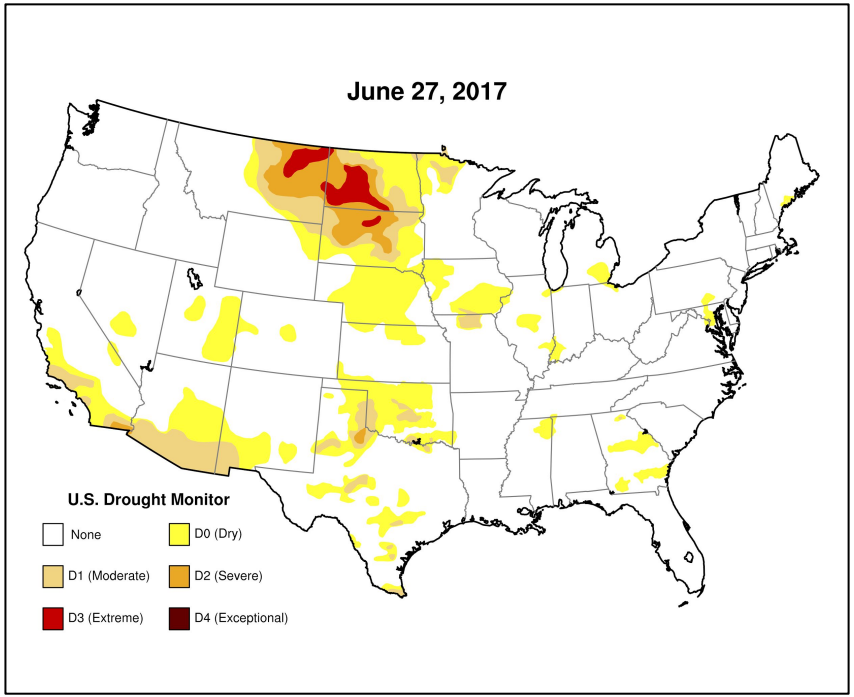
1931-1932 drought category at grid point containing Helena, MT

Area in Drought Does Not Vary Uniformly Between States



Soil moisture-based estimate of observed percent of area covered in drought for each state using UW-CLM

Questions in the Context of Rapid & Severe Drought Onset



U.S. Drought Monitor - June 27, 2017

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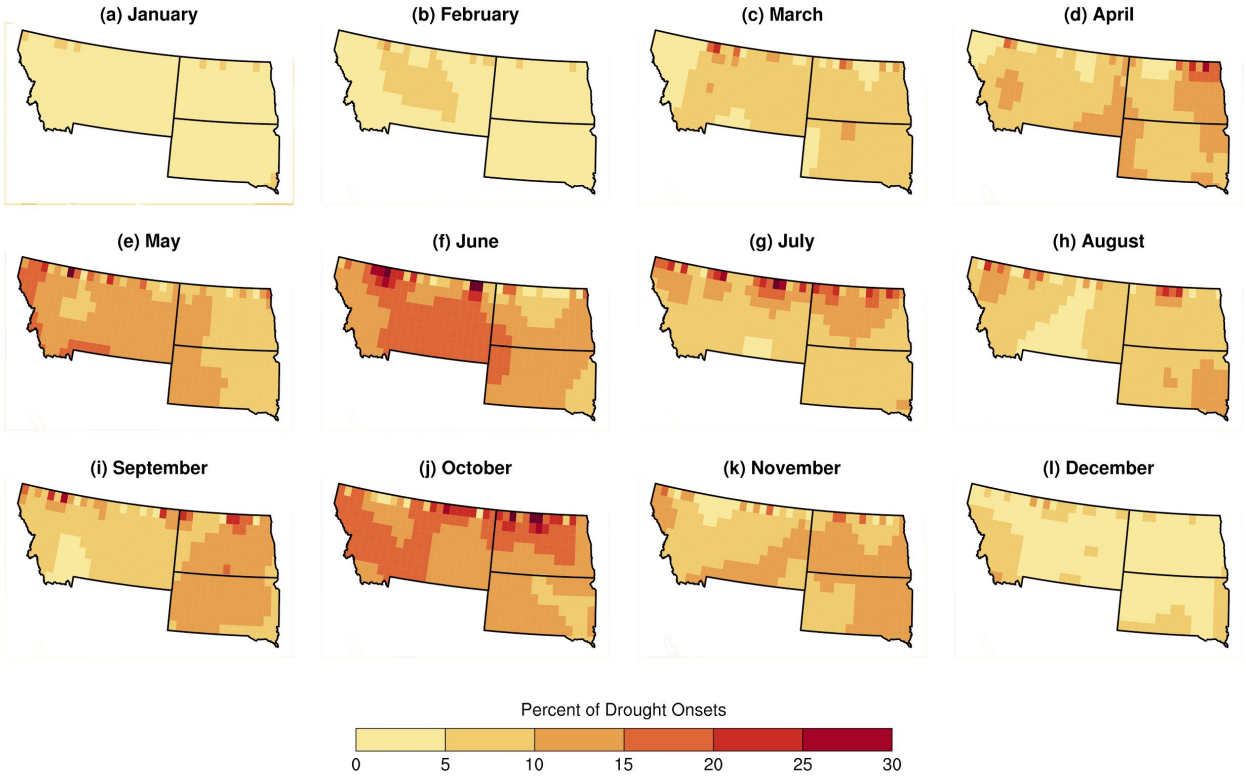
OBS: Warm Season Onsets w/ Late Spring & Fall Maximum

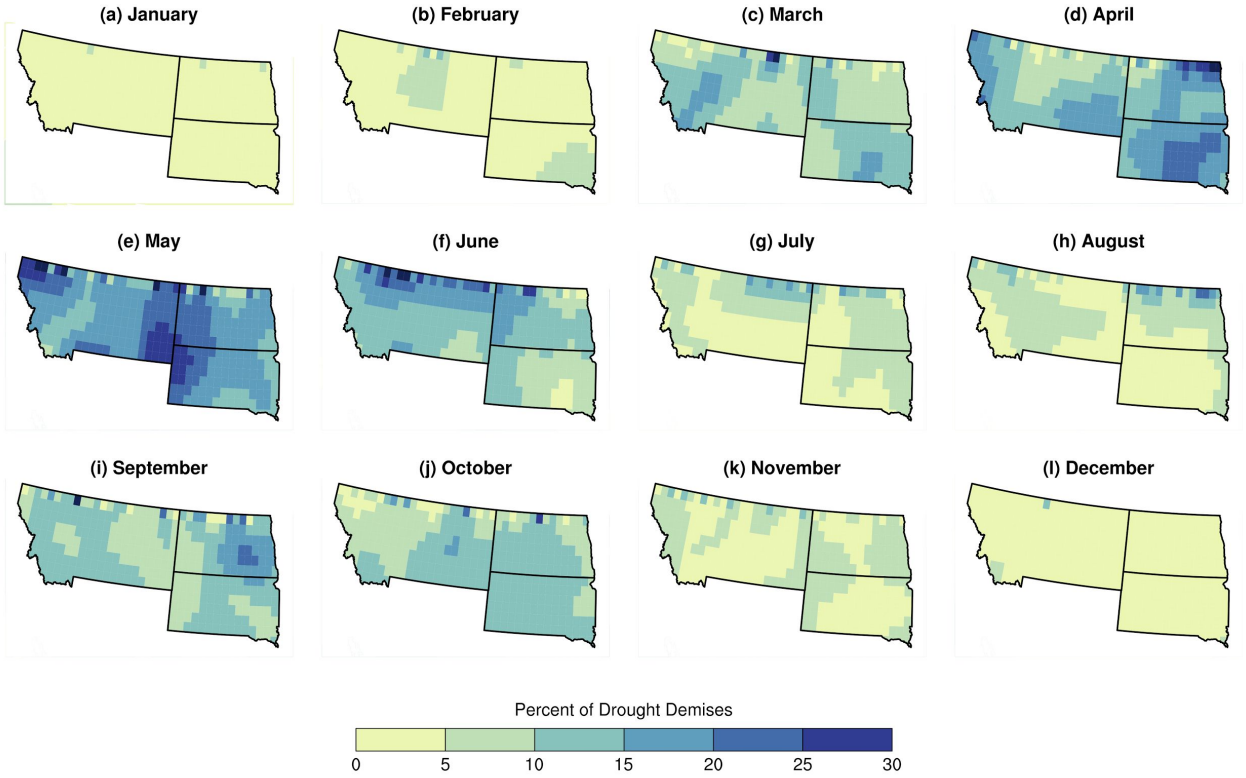


UW-CLM 1916-2015 percent of drought onsets

SIM: Warm Season Onsets w/ Late Spring & Fall Maximum

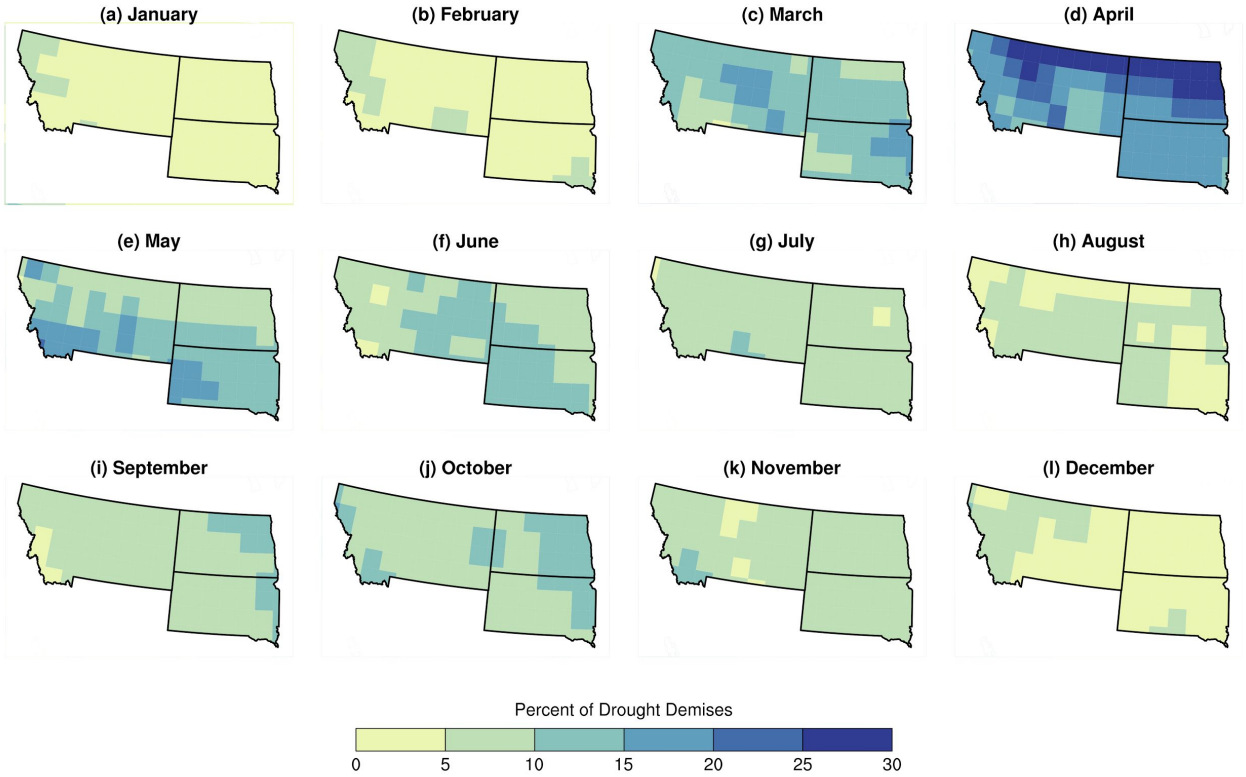
CAM5-CLM4 ensemble 1916-2015 percent of drought onsets

OBS: Spring & Fall Demise



UW-CLM 1916-2015 percent of drought demises

SIM: Spring & Fall Demise



CAM5-CLM4 ensemble 1916-2015 percent of drought demises

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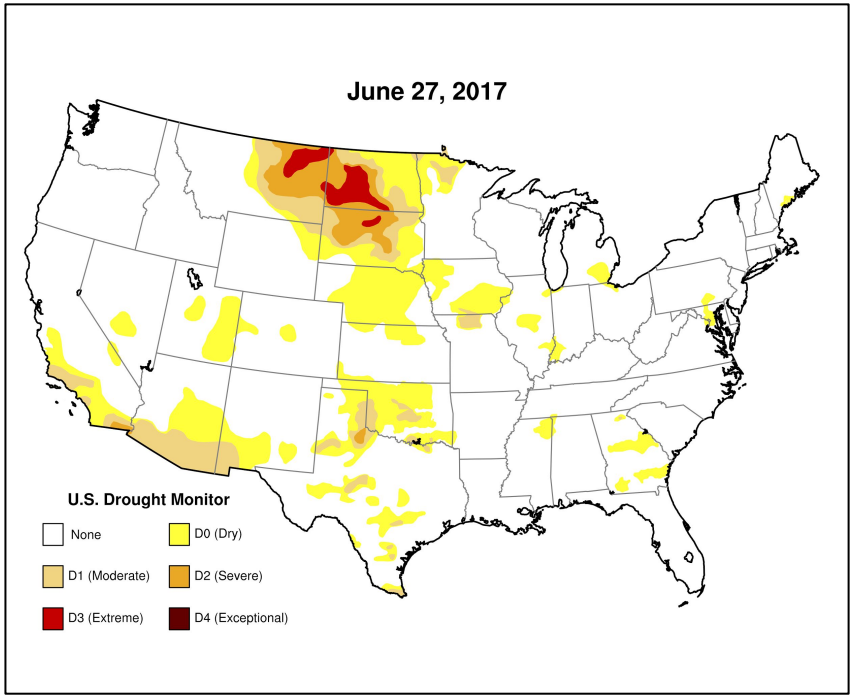

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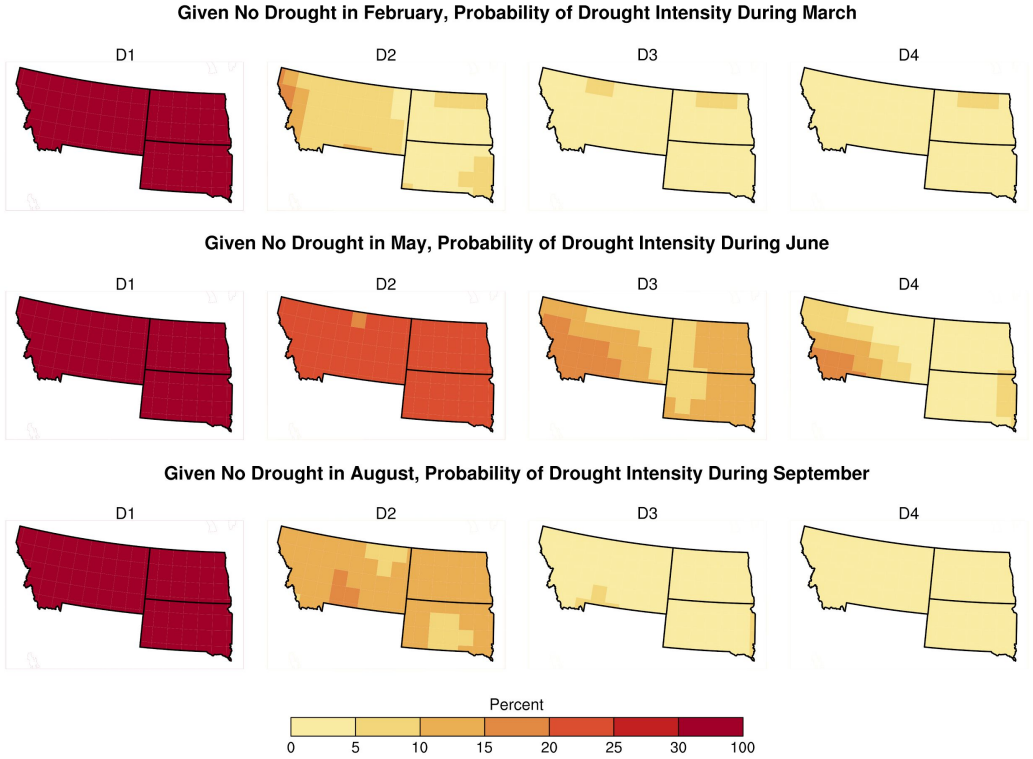
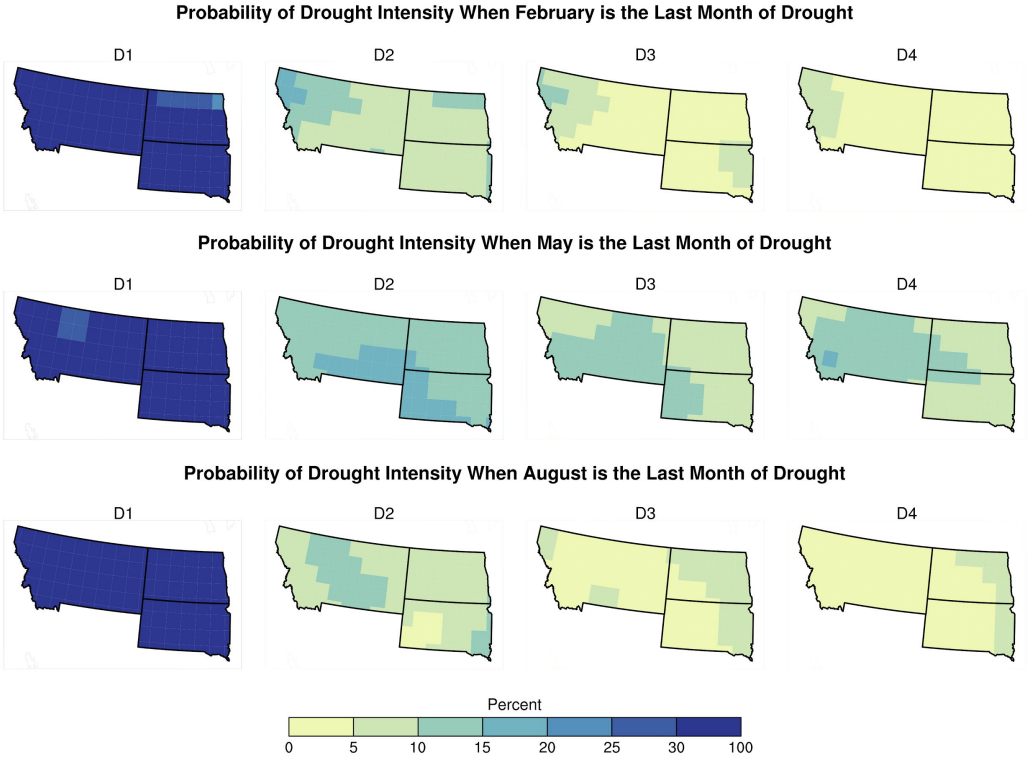
Drought Intensity During Onset Month



CAM5-CLM4 ensemble 1916-2015 probability of drought intensity during first month of drought

Drought Intensity During Last Drought Month



CAM5-CLM4 ensemble 1916-2015 probability of drought intensity during last month of drought

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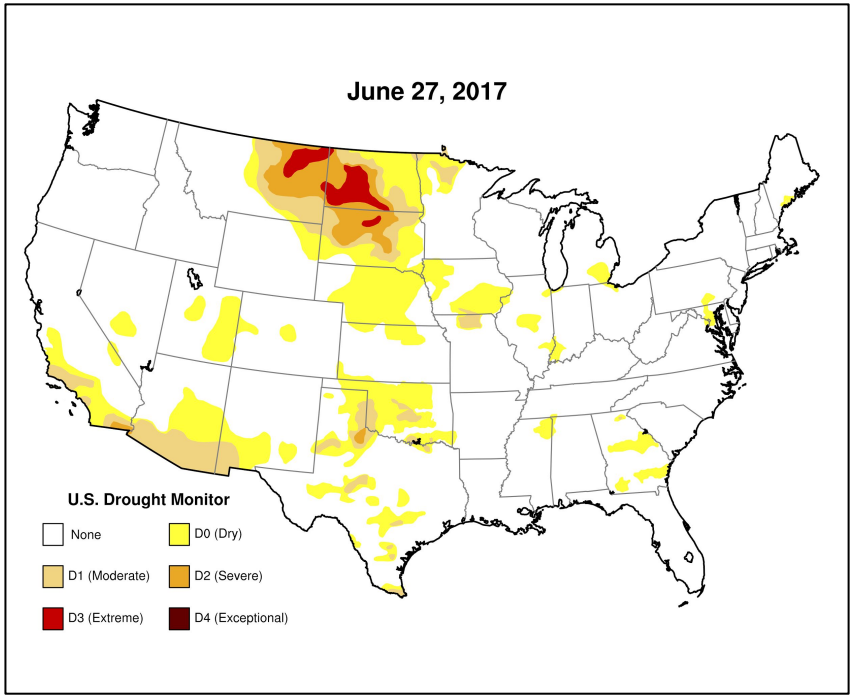

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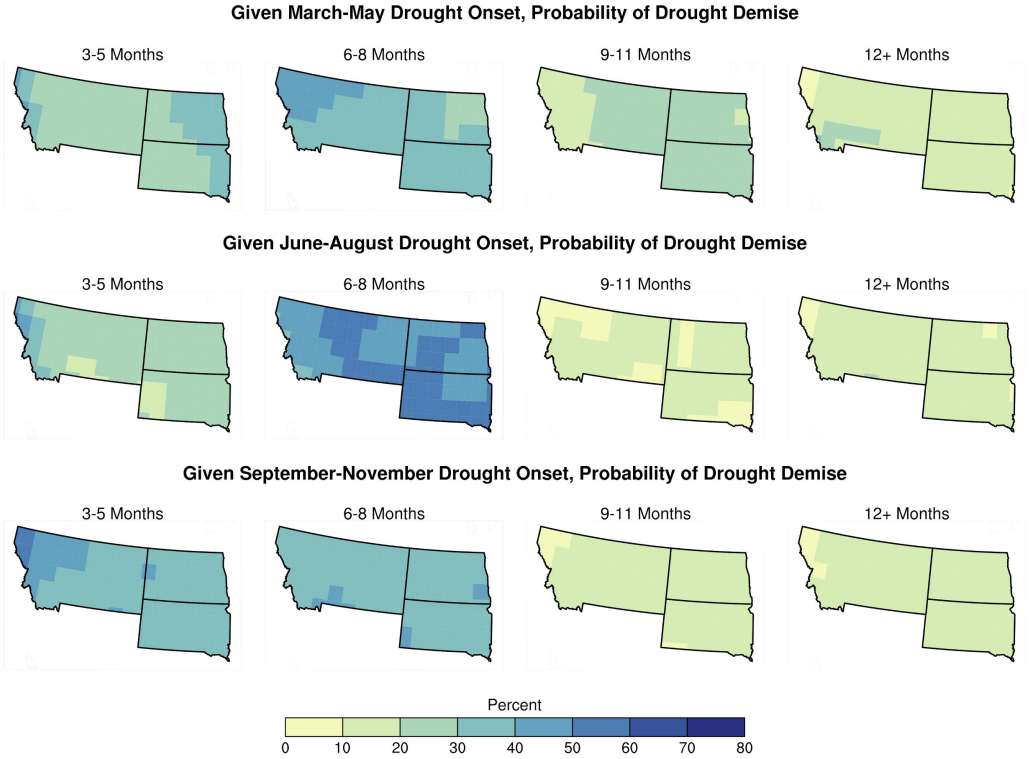
Drought Length Conditioned Upon Onset Season



CAM5-CLM4 ensemble 1916-2015 probability of drought demise as a function of onset season

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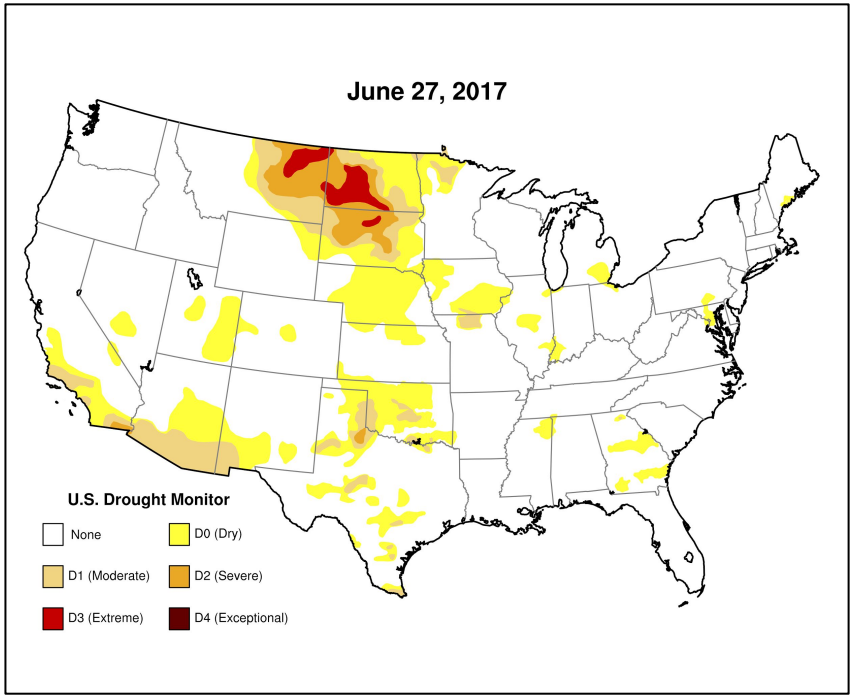

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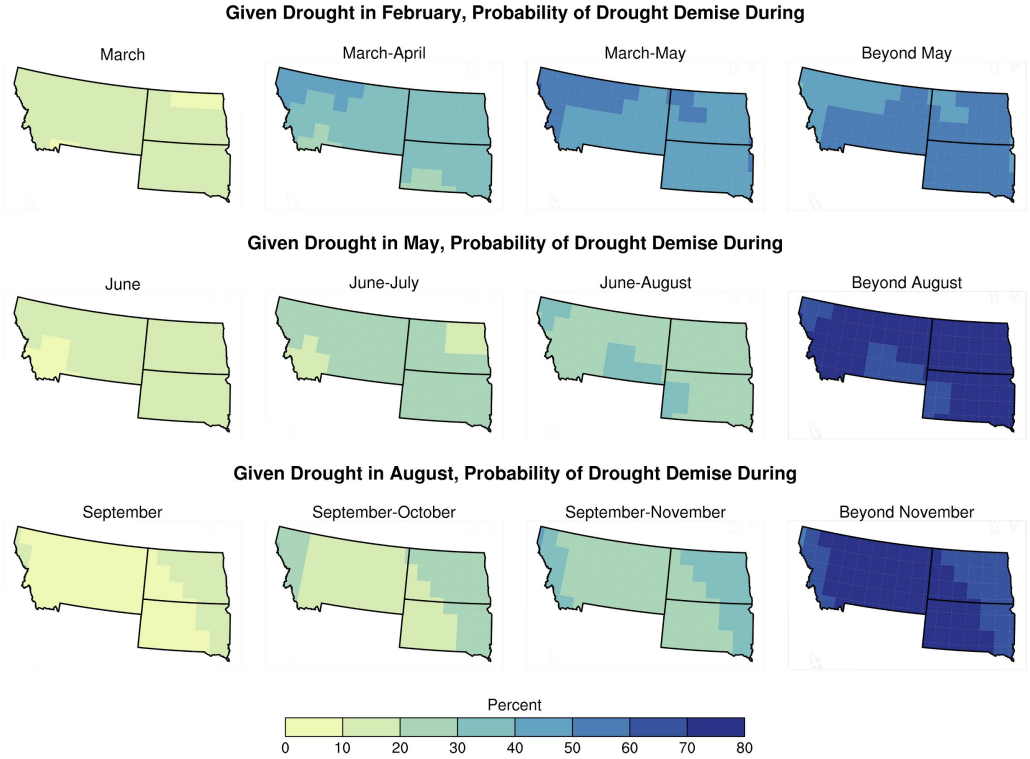
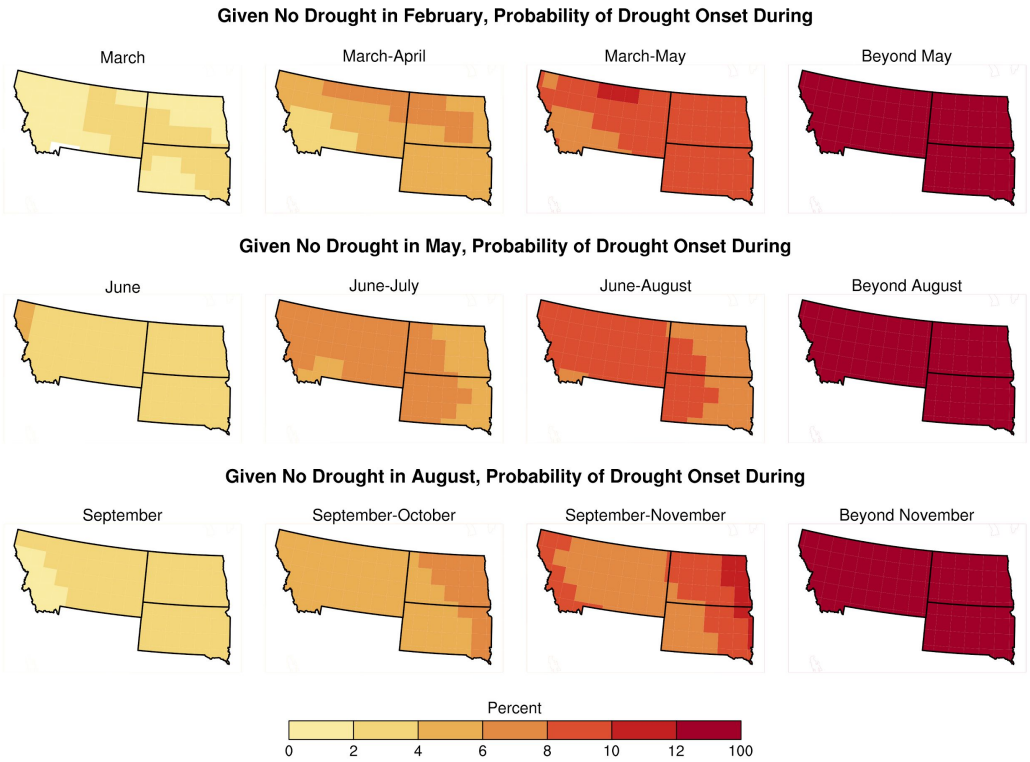
Drought Demise Conditioned Upon Month



CAM5-CLM4 ensemble 1916-2015 probability of drought demise from a given month

Drought Onset Conditioned Upon Month



CAM5-CLM4 ensemble 1916-2015 probability of drought onset from a given month

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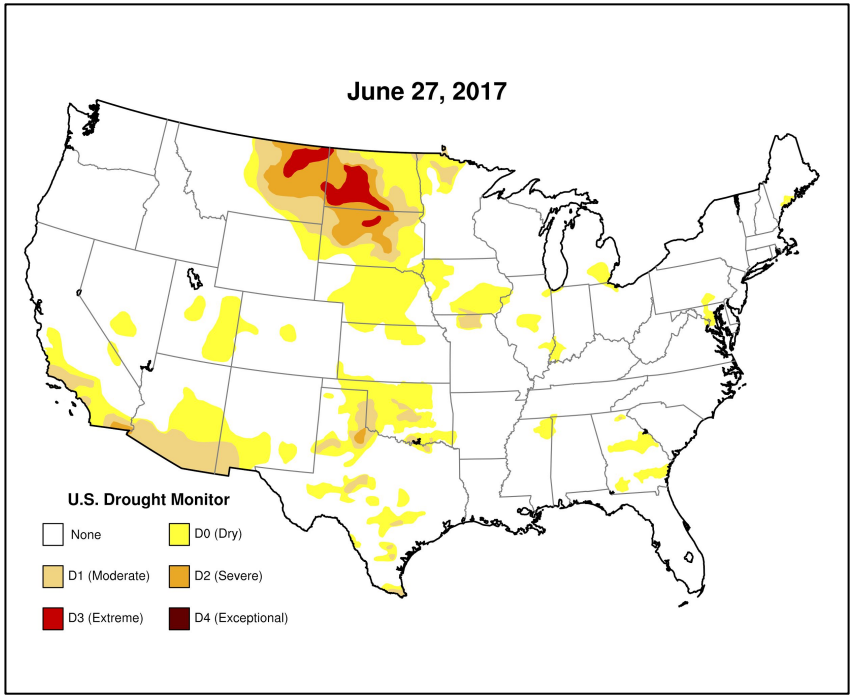

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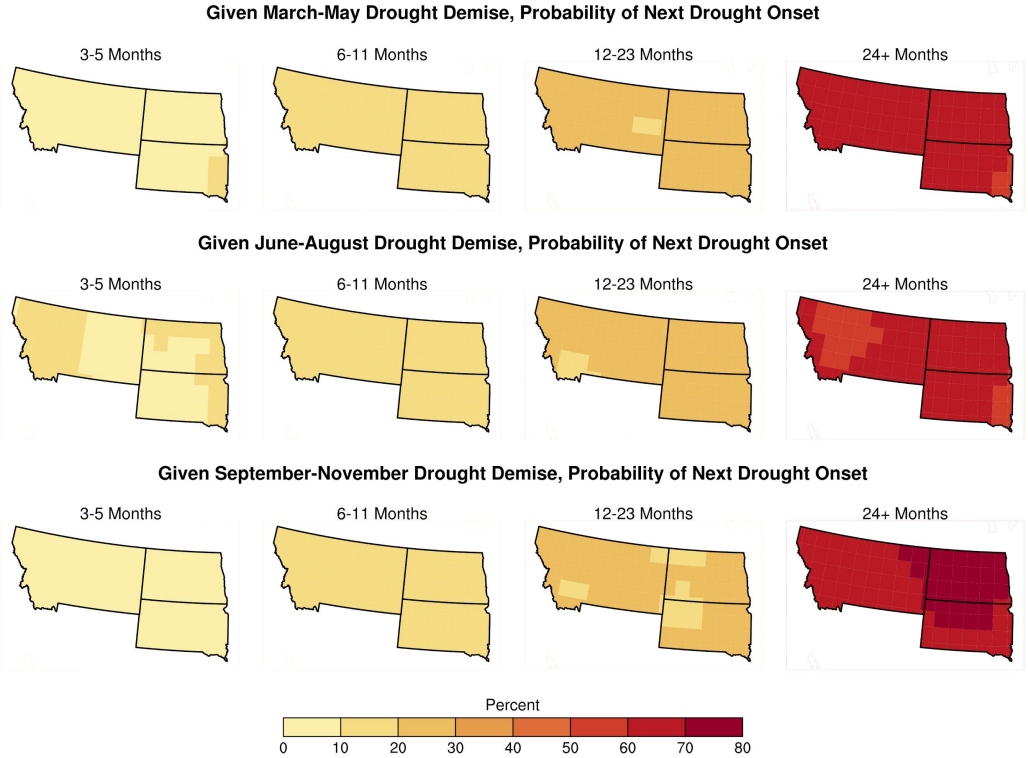
Drought Onset Conditioned Upon Last Drought Month



CAM5-CLM4 ensemble 1916-2015 probability of next drought onset as a function of drought demise

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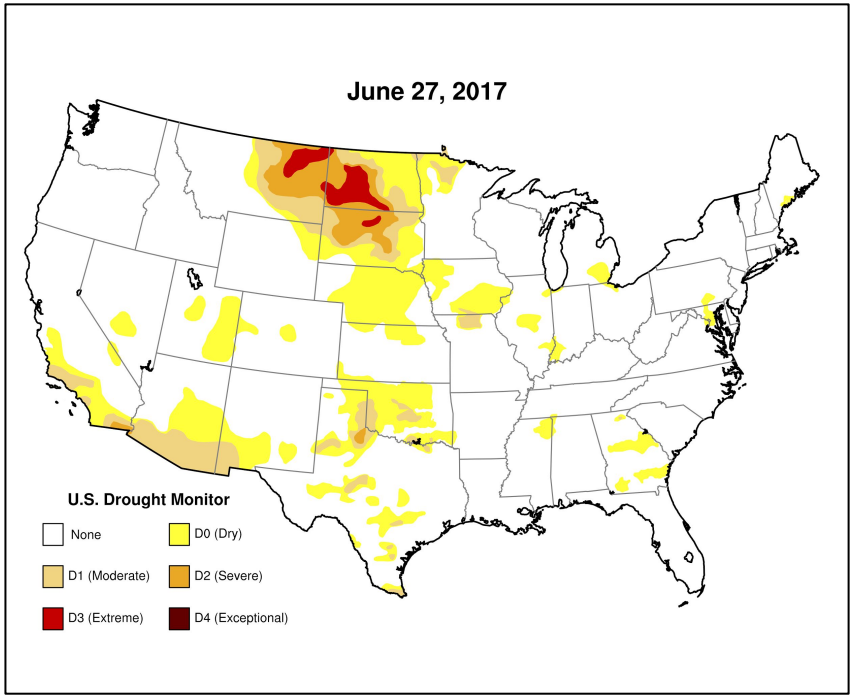

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