Flash Drought in the Great Plains and its Predictability

Credit: Olesia Bilkei, Adobe Stock

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Senior Research Meteorologist

NOAA Physical Sciences Laboratory

Pilot Project: Spring and Summer Precipitation Forecasts

REPORT TO CONGRESS

SUBSEASONAL AND SEASONAL FORECASTING INNOVATION: PLANS FOR THE TWENTY-FIRST CENTURY

Developed pursuant to:
Section 201 of the Weather Research and Forecasting Innovation Act of 2017,
(Public Law 115-25)

Spring and Summer S2S Precipitation Forecasts for Agriculture for the Central U.S.
The dominant share of precipitation in the central U.S. falls during the spring and summer. This rainfall is critical for farmers and ranchers. When drought occurs, it can have devastating consequences as seen with the 2017 flash drought that occurred in South Dakota, Montana, and North Dakota. Key science challenges for improving these forecasts include: lack of observations and inaccurate modelling of the land surface and hydrologic cycle, especially soil moisture and the processes leading to flash drought; improved fidelity in modeling of warm season precipitation processes; and understanding and prediction of large-scale upper-level dynamical flow anomalies that occur in this region at this time of year.

Great Plains Flash Drought

Characteristics

Intensify rapidly, result in drought, and produce impacts.

Causes

Sequences of extreme weather events that last at least several weeks.

Low Predictability

Lack a holistic understanding and forecasts of past events have been poor.

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Flash Droughts Intensify Rapidly, Result in Drought, and Lead to Severe Impacts

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ADVANCED REVIEW

WIREs WATER WILEY

Flash drought: A state of the science review

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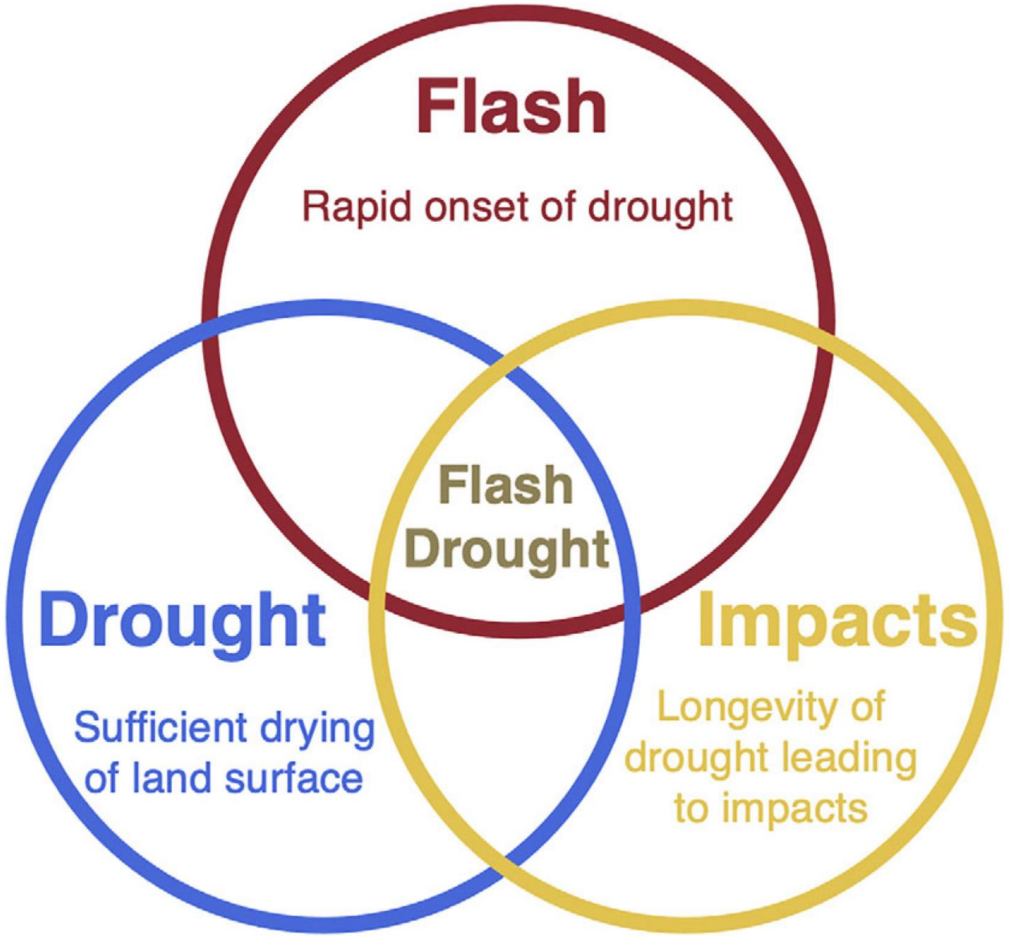
Abstract

In the two decades, since the advent of the term "flash drought," considerable research has been directed toward the topic. Within the scientific community, we have actively forged a new paradigm that has avoided a chaotic evolution of conventional drought but instead recognizes that flash droughts have distinct dynamics and, particularly, impacts. We have moved beyond the initial debate over the definition of flash drought to a centralized focus on the triad of rapid onset, drought development, and associated impacts. The refinement toward this general set of principles has led to significant progress in determining key variables for monitoring flash drought development, identifying notable case studies, and compiling fundamental physical characteristics of flash drought. However, critical focus areas still remain, including advancing our knowledge on the atmospheric and oceanic drivers of flash drought; developing flash drought-specific detection indices and monitoring systems tailored to practitioners; improving subseasonal-to-seasonal prediction of these events; constraining uncertainty in flash drought and impact projections; and using social science to further our understanding of impacts, particularly with regard to sectors that lie outside of our traditional hydroclimatological focus, such as wildfire management and food-security monitoring. Researchers and stakeholders working together on these critical topics will assure society is resilient to flash drought in a changing climate.



Many Flash Droughts Related to Billions in Losses in the Great Plains

BAMS Essay

Getting ahead of Flash Drought:

From Early Warning to Early Action

Jason A. Otkin, Molly Woloszyn, Hailan Wang, Mark Svoboda, Marina Skumanich, Roger Pulwarty, Joel Lisonbee, Andrew Hoell, Mike Hobbins, Tonya Haigh, and Amanda E. Cravens

Flash drought has recently become an active and rapidly evolving area of research within climate, agricultural, and ecological scholarship because of the large environmental and socioeconomic impacts it can cause. The term "flash drought" was coined in the early 2000s to draw attention to a subset of droughts that belie the conventional understanding of drought as a creeping phenomenon that takes months or years to develop (Svoboda et al. 2002). For example, the 2012 flash drought across the central United States developed rapidly over only a few weeks but ultimately affected 80% of U.S. agricultural lands, resulting in $36.9 billion in economic losses (Rippey 2015). The 2017 flash drought across the U.S. northern Great Plains and the Canadian Prairies is another example: in the United States, wildfires burned 4.8 million acres and caused agricultural losses in excess of $2.6 billion (Hoell et al. 2020).

Year	Loss in 2024 USD	U.S. Great Plains Area
1988	55.2B	Central
2012	42.3B	Northern, Central, Southern
1980	41.1B	Northern, Central, Southern
2002	16.2B	Northern, Central
2006	9.7B	Northern, Central, Southern
2003	8.8B	Central
1989	7.9B	Northern, Central
1998	7.0B	Central, Southern
2007	5.6B	Northern, Central
2018	3.9B	Central, Southern
2017	3.3B	Northern

Source: NOAA Billion Dollar Disasters

Rapid Onset Droughts Noted as Early as 1982 Despite Not Being Called 'Flash Drought'

Some Causes of United States Drought[1]

JEROME NAMIAS

University of California, San Diego, Scripps Institution of Oceanography, La Jolla, CA 92093

(Manuscript received 29 August 1982, in final form 27 September 1982)

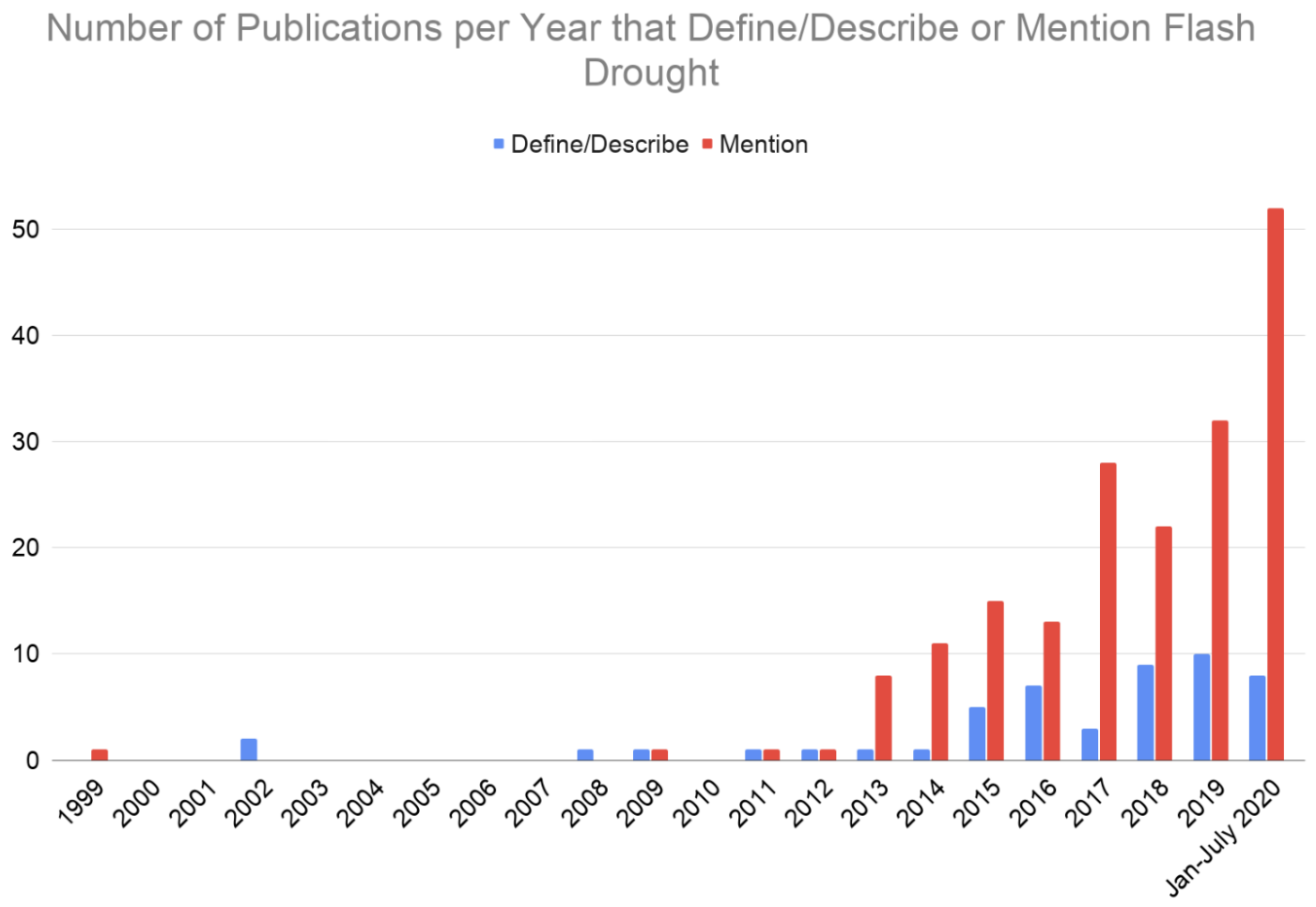
ABSTRACT

Some physical causes of United States drought are outlined. Among the associated factors is subsidence, either in the upper level anticyclones or to the south of strong jets, or sometimes under prevailing northerly components of upper level flow. These conditions are engendered by abnormal forms of the atmosphere's general circulation. Causative factors vary in kind and degree according to area, so that droughts over the Far West differ from those of the Great Plains or the East. Examples of each of these are shown as well as treatment of a rapidly developing drought. It should be obvious from this report that a successful numerical (dynamical) solution of the drought problem should be high on meteorologists' agendas.

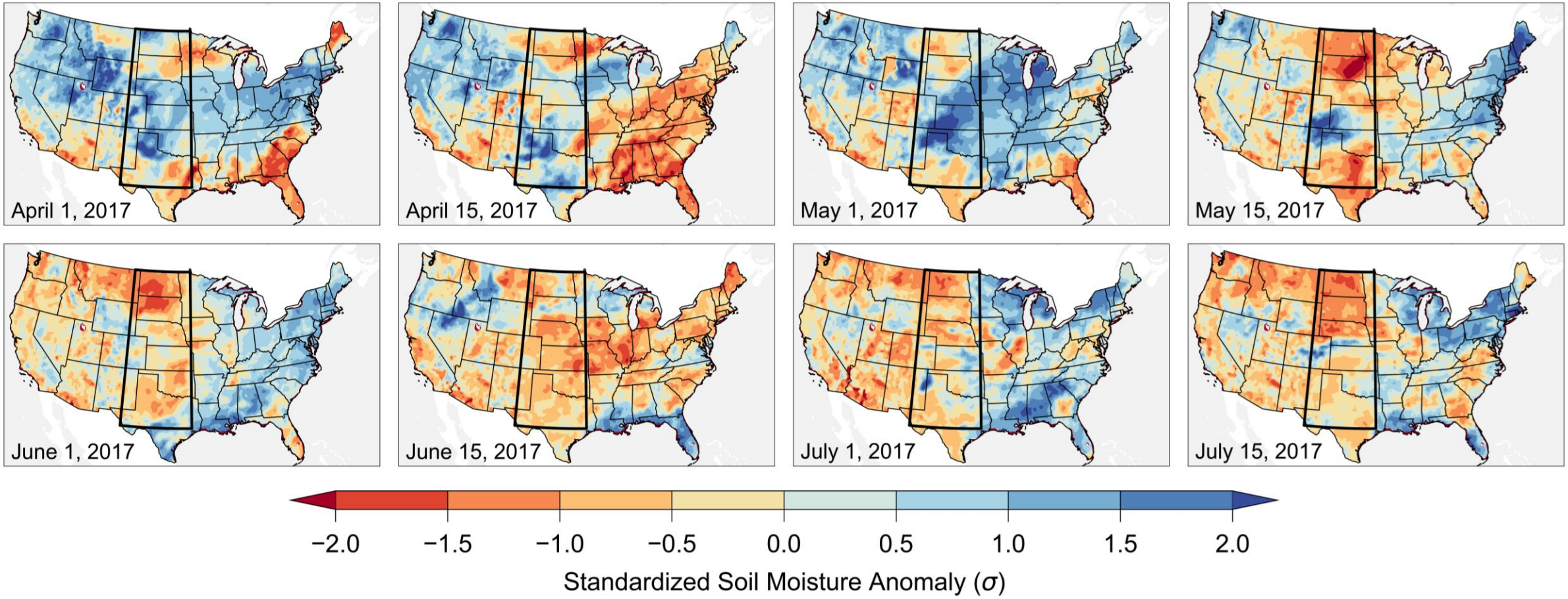
Increased Focus on Flash Drought Since the 2012 Event Alongside the Emergence of Subseasonal-to-Seasonal Forecasting

Making sense of flash drought: definitions, indicators, and where we go from here

Joel Lisonbee[1,3], Molly Woloszyn[1], Marina Skumanich[2]

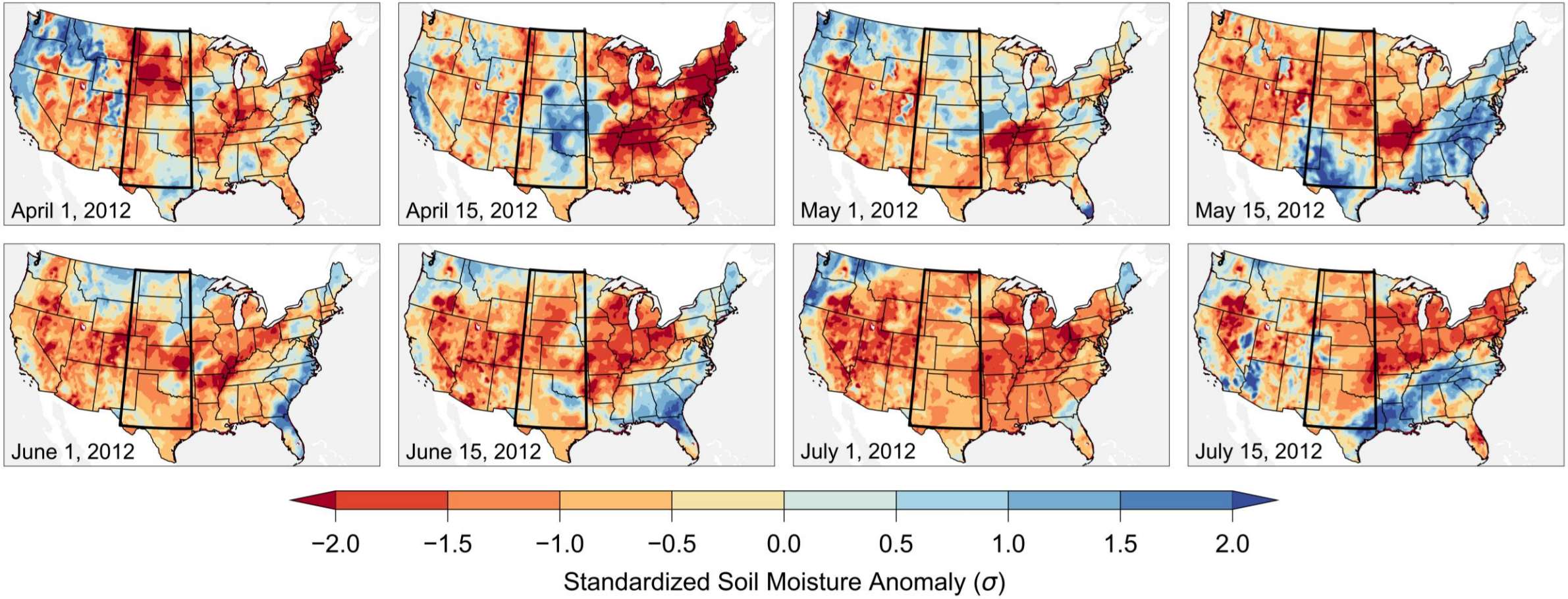


2017 Northern Great Plains Flash Drought Developed in May



Source: ECMWF ERA5

2012 Flash Drought Engulfed the Entire Great Plains and Developed at Different Times in Different Places



Source: ECMWF ERA5

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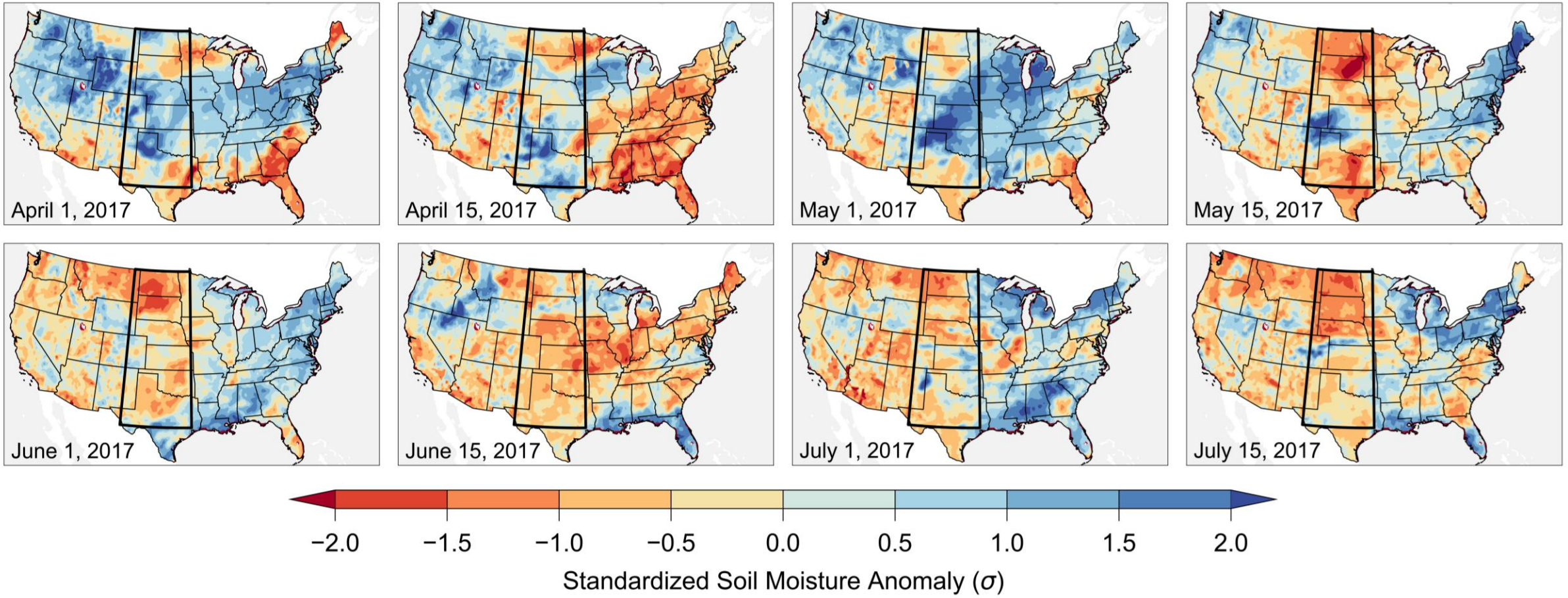
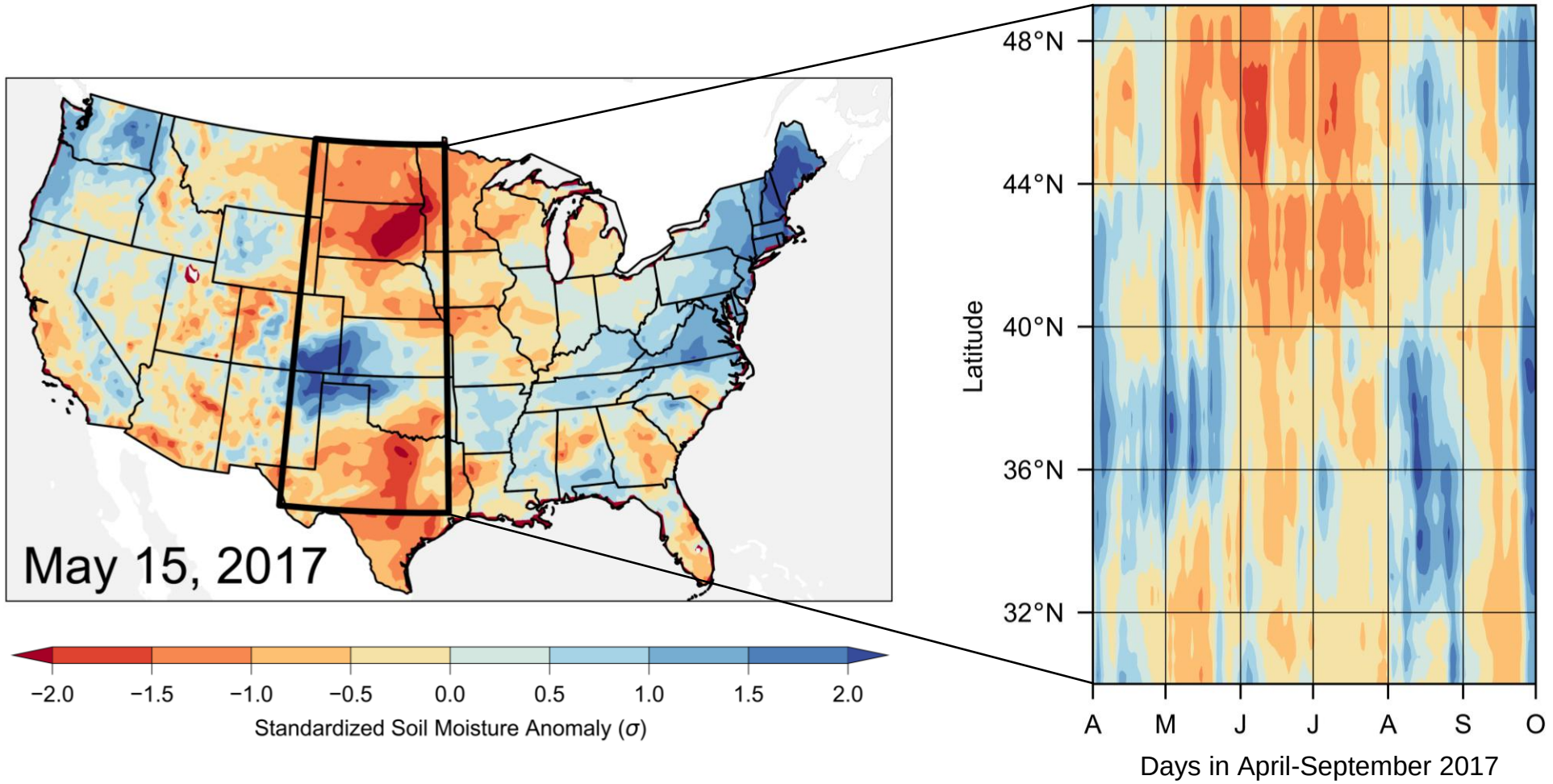
Flash Droughts Require a Multi-Dimensional Perspective



Source: ECMWF ERA5

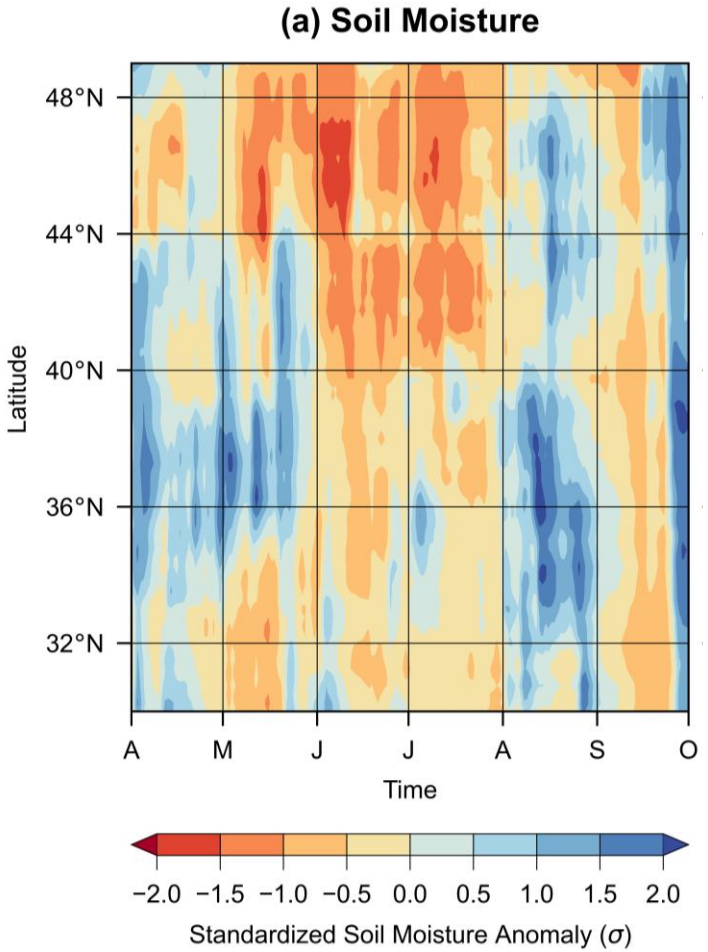
Adopt a Perspective that Includes Space and Time



Average along latitude from 105ºW to 95ºW.

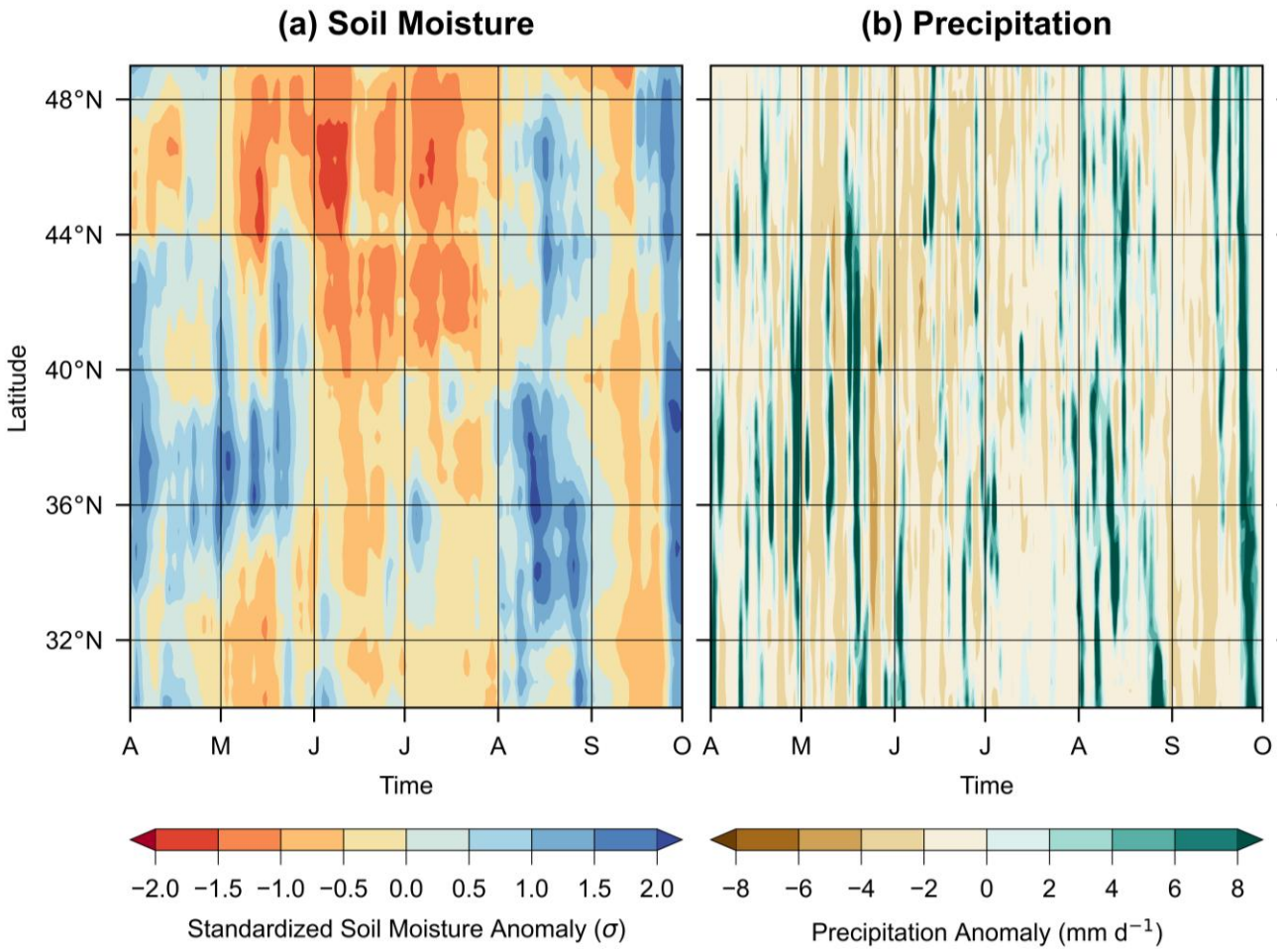
Source: ECMWF ERA5

Rapid Soil Moisture Decline in Northern Plains During May-June 2017



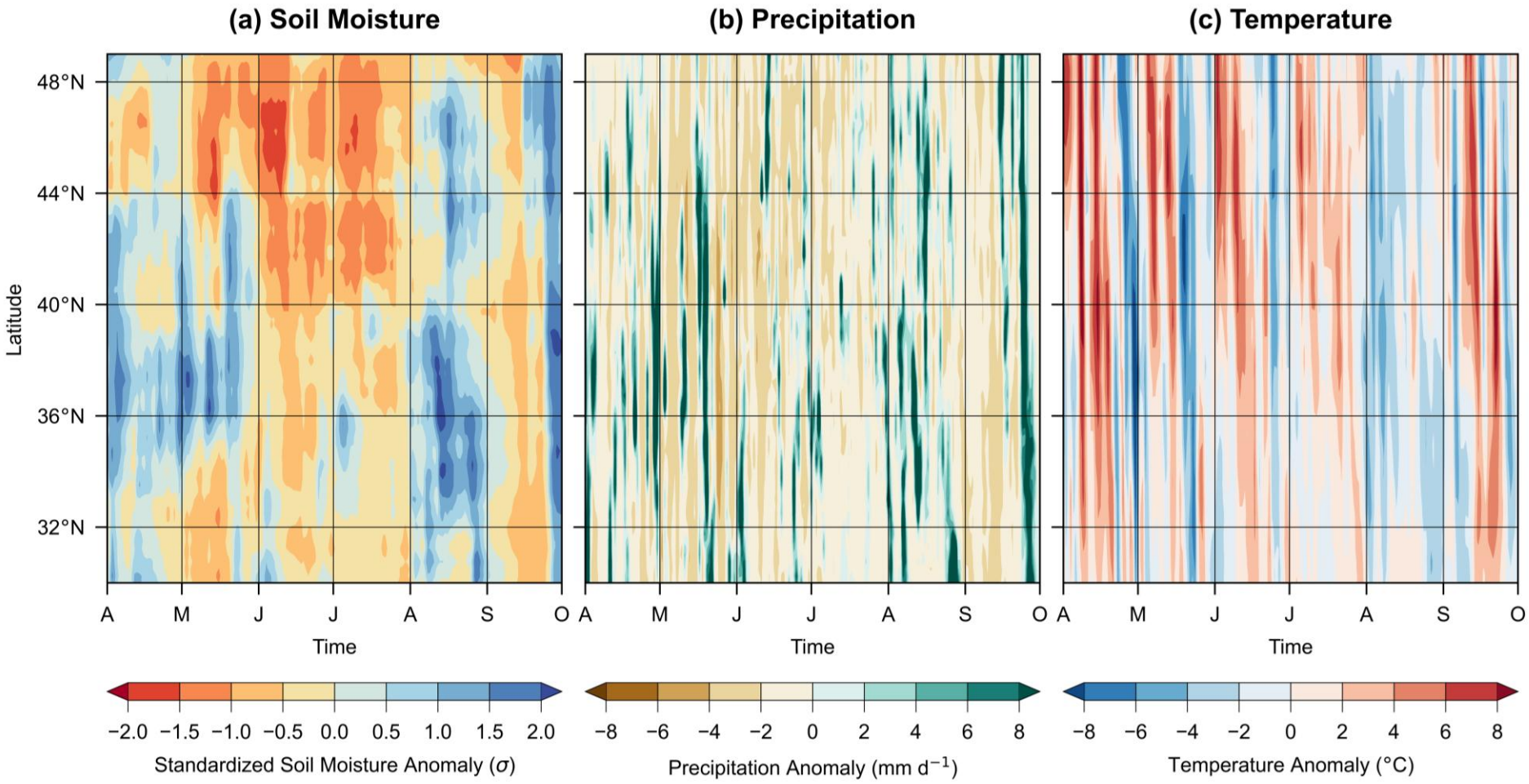
Source: ECMWF ERA5

Rapid Soil Moisture Decline Related to Below-Average Precipitation



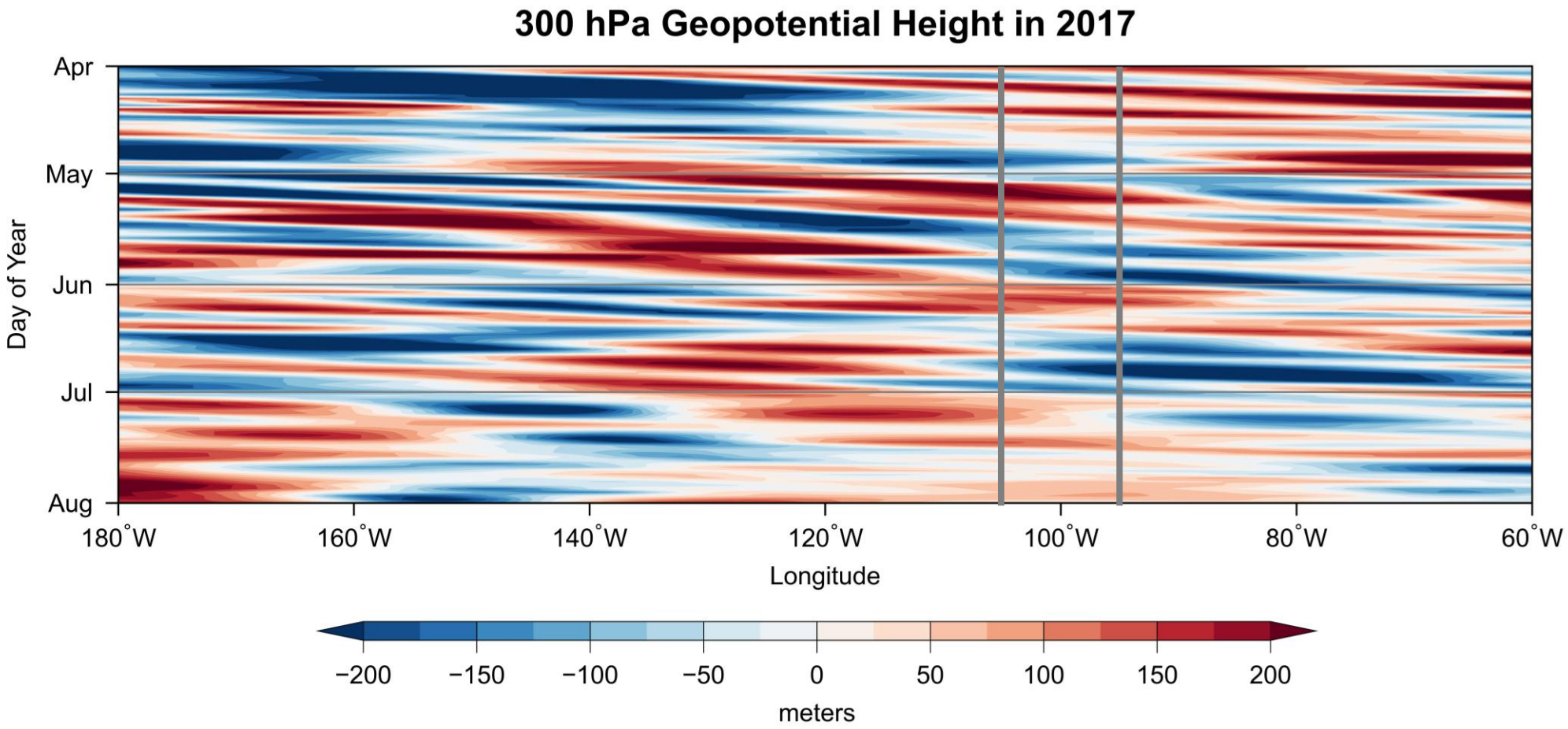
Source: ECMWF ERA5

Rapid Soil Moisture Decline Related to Extreme Temperatures



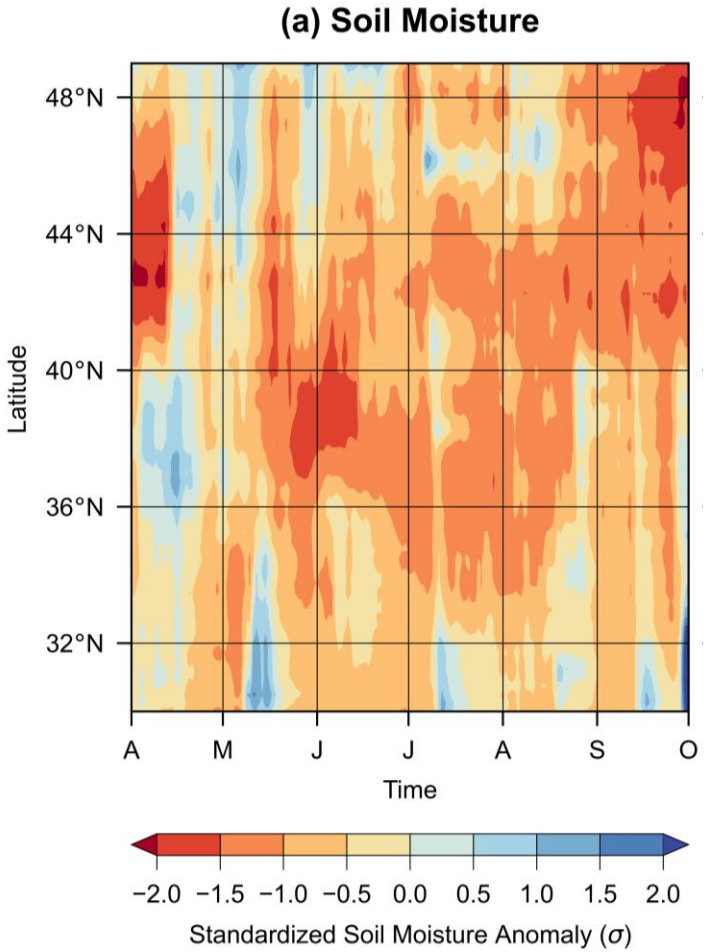
Source: ECMWF ERA5

Persistent Blocking High Pressure to the West of the Northern Great Plains in May-July 2017



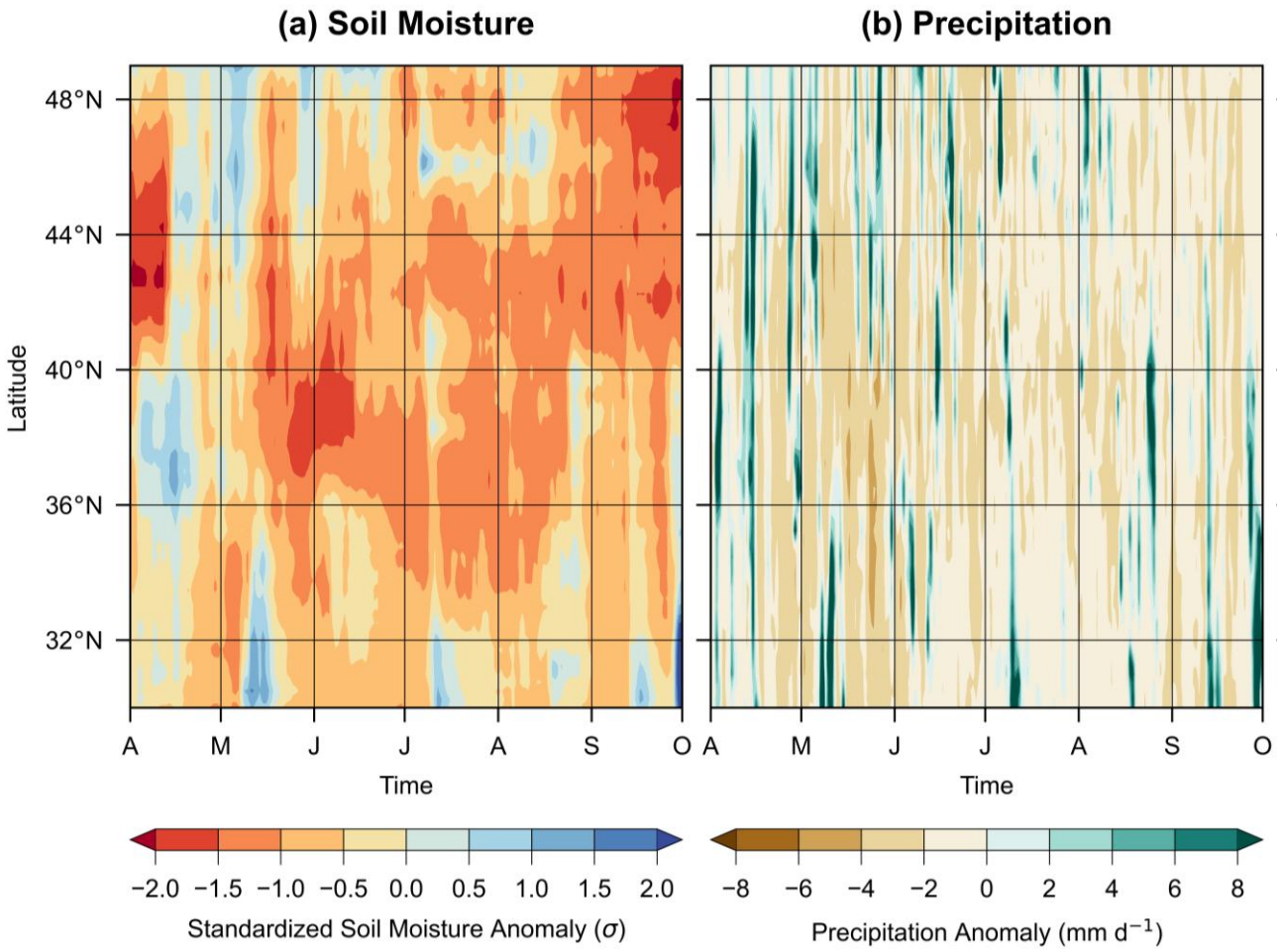
Source: ECMWF ERA5

Rapid Soil Moisture Decline in North-Central Plains During May-June 2012



Source: ECMWF ERA5

Rapid Soil Moisture Decline Related to Below-Average Precipitation



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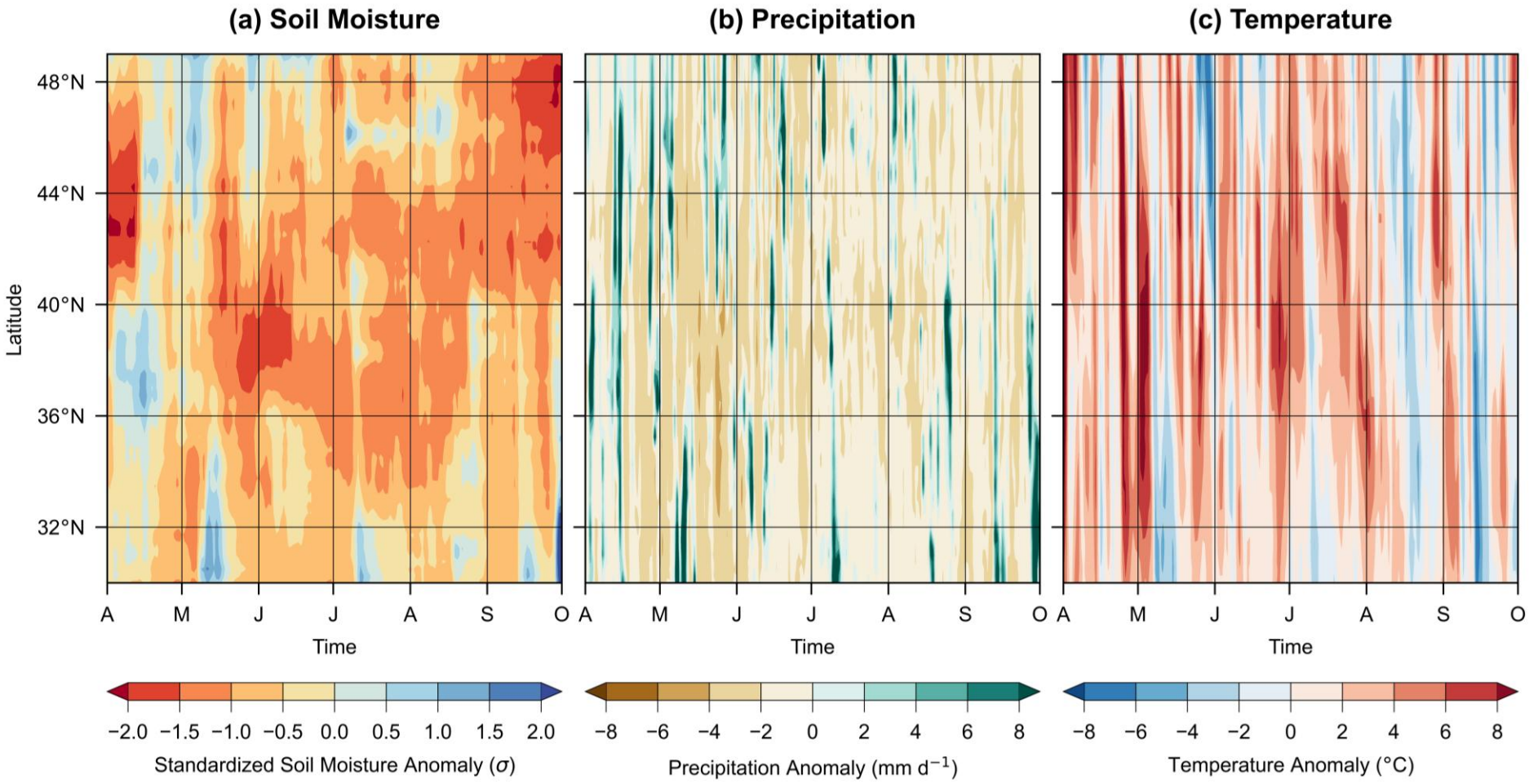
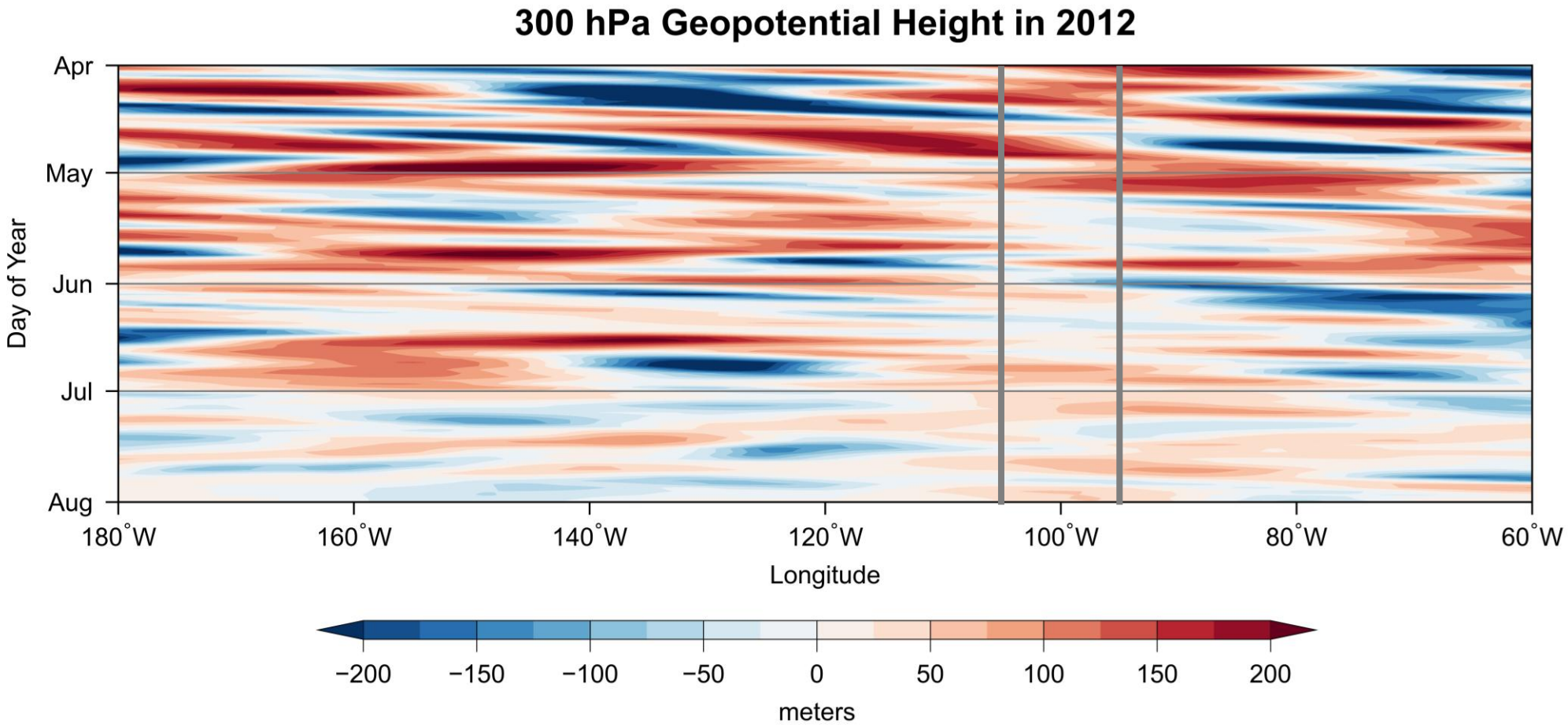


Source: ECMWF ERA5

Persistent Blocking High Pressure to the West of the Great Plains in May-June 2012



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We Lack a Holistic Predictive Understanding of Flash Drought

Rare

Too few events to generalize their characteristics and predictability.

Standardization

All past predictability studies were conducted differently.

Tools

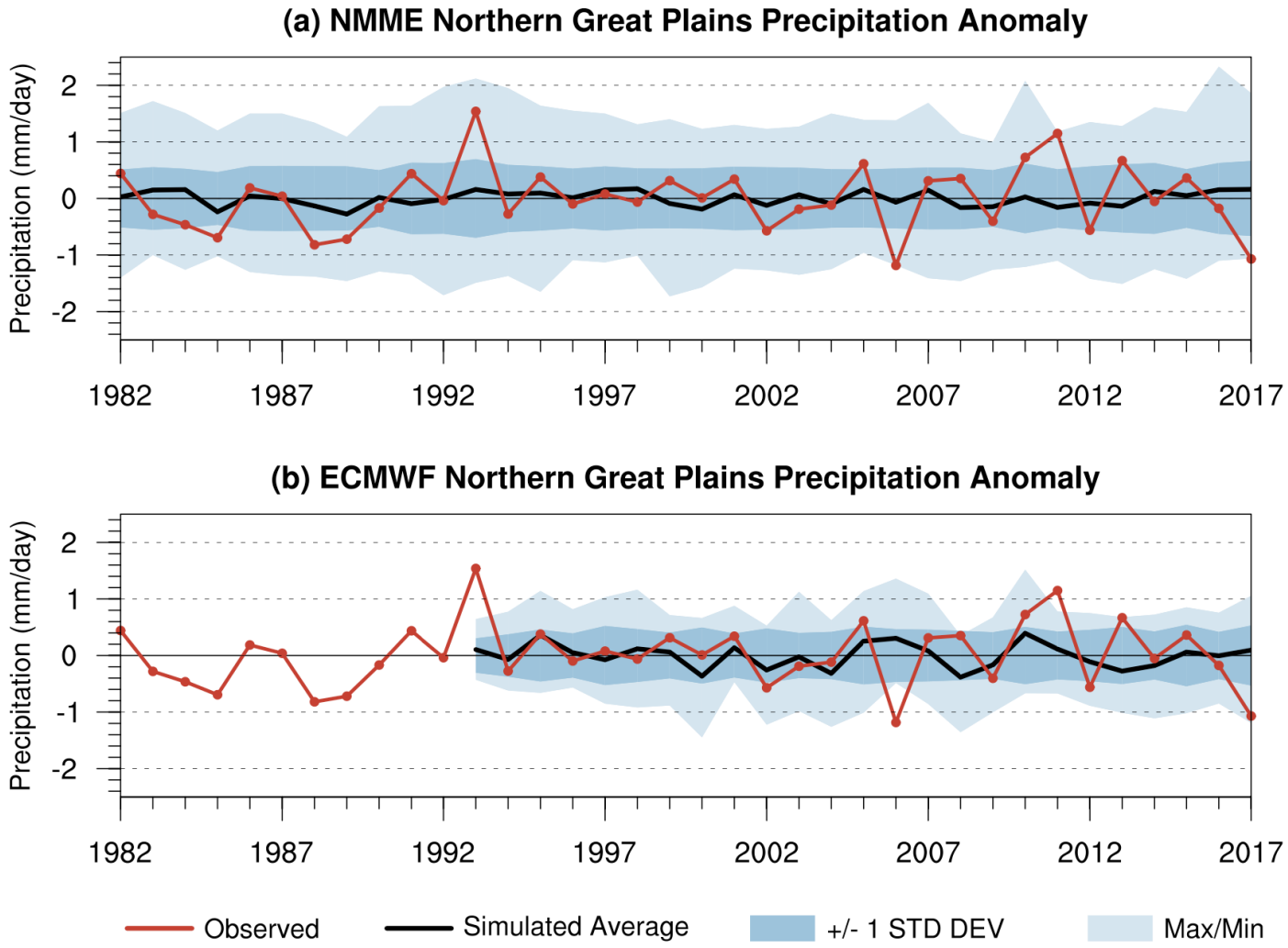
Poor predictions of past events.

May-July 2017 Precipitation Deficits Related to Northern Great Plains Flash Drought Unpredictable Ahead of the Season

BAMS Essay

Lessons Learned from the 2017 Flash Drought across the U.S. Northern Great Plains and Canadian Prairies

Andrew Hoell, Britt-Anne Parker, Michael Downey, Natalie Umphlett, Kelsey Jencso, F. Adnan Akyuz, Dannele Peck, Trevor Hadwen, Brian Fuchs, Doug Kluck, Laura Edwards, Judith Perlwitz, Jon Eischeid, Veva Deheza, Roger Pulwarty, and Kathryn Bevington



May-July 2017 Precipitation Deficits Related to Northern Great Plains Flash Drought Unpredictable More Than 7 Days in Advance

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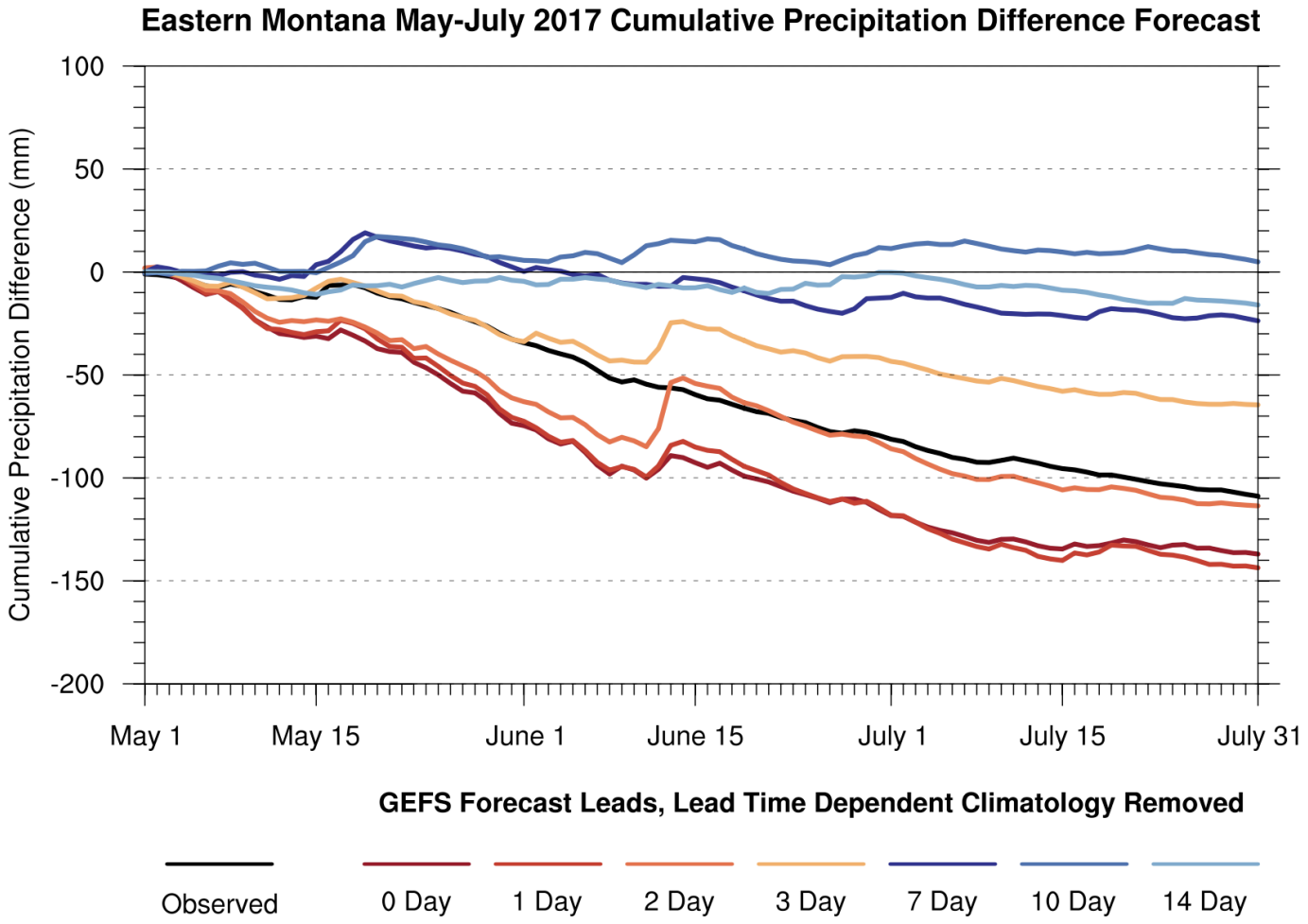
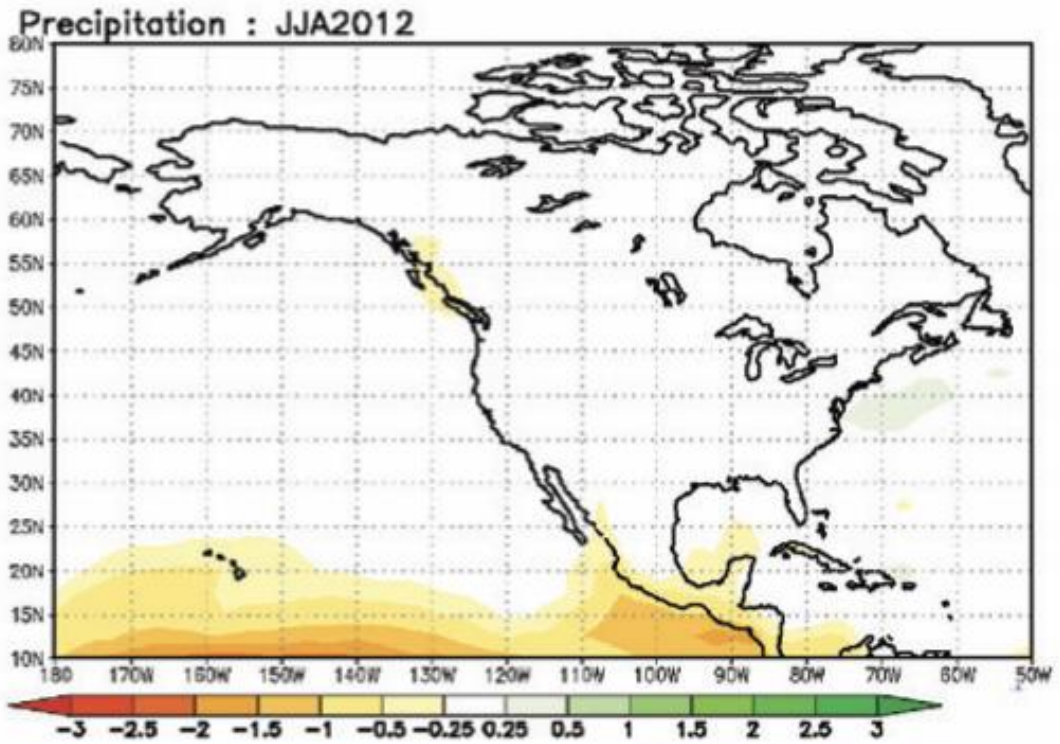
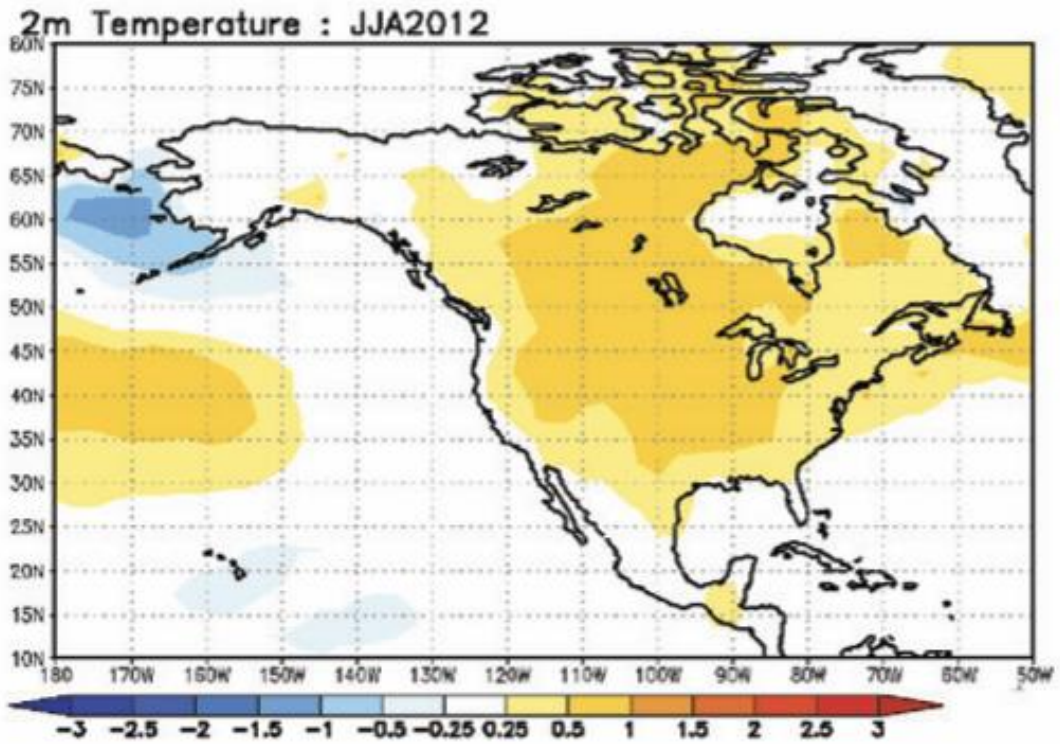


June-August 2012 Precipitation Deficits Related to Central Great Plains Flash Drought Unpredictable Ahead of the Season



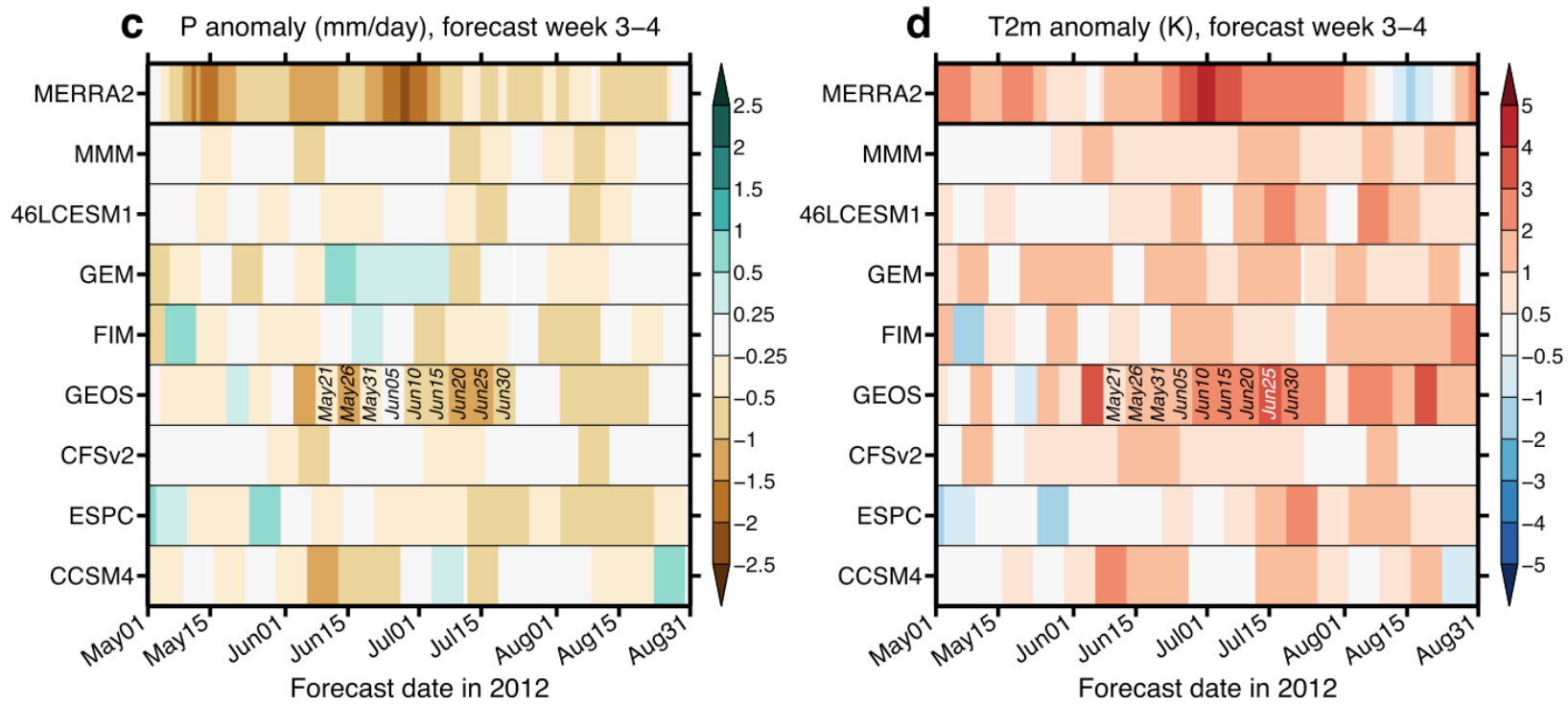


CAUSES AND PREDICTABILITY OF THE 2012 GREAT PLAINS DROUGHT

BY M. HOERLING, J. EISCHEID, A. KUMAR, R. LEUNG, A. MARIOTTI, K. MO, S. SCHUBERT, AND R. SEAGER

AMERICAN METEOROLOGICAL SOCIETY
FEBRUARY 2014 BAMS | 269

June-August 2012 Precipitation Deficits Potentially Predictable up to Three Weeks in Advance According to Just One Forecast Model



Prediction Skill of the 2012 U.S. Great Plains Flash Drought in Subseasonal Experiment (SubX) Models

ANTHONY M. DEANGELIS,[a] HAILAN WANG,[b] RANDAL D. KOSTER,[c] SIEGFRIED D. SCHUBERT,[a,c] YEHUI CHANG,[c,d] AND JELENA MARSHAK[c]

[a] *Science Systems and Applications, Inc., Lanham, Maryland*
[b] *Climate Prediction Center, NOAA/NWS/NCEP, College Park, Maryland*
[c] *Global Modeling and Assimilation Office, NASA GSFC, Greenbelt, Maryland*
[d] *Goddard Earth Sciences Technology and Research, Morgan State University, Baltimore, Maryland*

Great Plains Flash Drought Considerations

Compound Events

Flash drought predictability depends on accurate forecasts of several quantities.

Reassessment

Routine review of physical science and impacts to test the latest advances.

Investment

Tools that improve real-time monitoring and forecasts.

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Credit: Olesia Bilkei, Adobe Stock

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