Atmospheric Blocking & Drought Patterns: An In-Depth Analysis & Comparison of the Dry Summer of 2022 in the Midwest USA

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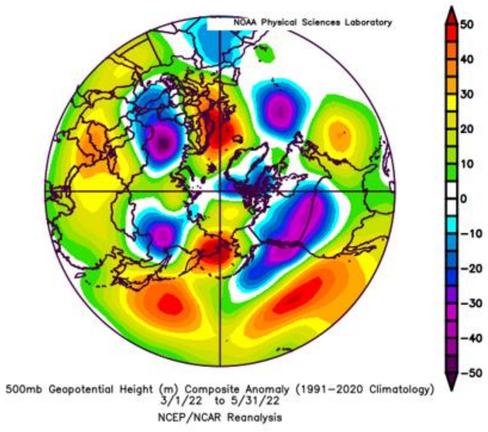
Introduction

- Severe droughts occur across the world, but this study focuses on the United States.
- Teleconnections have been linked to droughts in previous studies (e.g., Lupo et al. 2022).
- Typically, when there is a dry year there is more ridging.
- During the summer, droughts form below a blocking anticyclone resulting in a sky that which is cloud free, thus, equating to drier soil and more shortwave radiative warming at the surface.

Motivation/Objective/Goal

- The summer of 2022 was very dry across the Mid-West including the Missouri Region and the southern plains in the United States.
- 2022 had more blocking during the spring months which is consistent with the wetter spring, shown in Table 1.
- A comparison was carried out involving the 2022 summer season to the very dry seasons of 2012, 2018, and the relatively wet summer of 2021. This was carried out using the National Centers for Environmental Prediction / National Centers for Atmospheric Research reanalysis, the Climate Prediction Center teleconnection indexes, and the blocking archive at the University of Missouri.



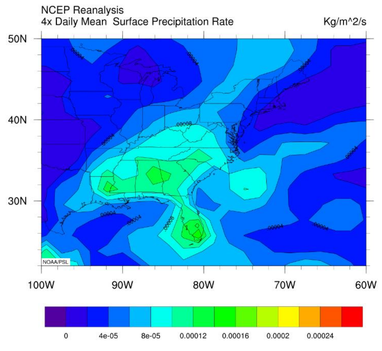


Figure 1. The 500 hPa heights (m) for 00Z 1 March 2022 through 31 May 2022 indicating blocking along the west coast and the east coast (top) and the 4x daily mean Surface Precipitation Rate (kg/m^2/s) indicating the wet summer months 1 June 2022 through 31 August 2022 (bottom).

BLOCKING FOR THE SPRING MONTHS (MARCH 1 – MAY 31) IN THE UNITED STATES

Year	Number of Blocks	Days	Blocking Index (BI)
2012	0	0	NA
2018	1	9	4.24
2021	4	34.5	2.78
2022	6	52.5	3.00

BLOCKING FOR THE SUMMER MONTHS (JUNE 1 – AUGUST 31) IN THE UNITED STATES

Year	Number of Blocks	Days	Blocking Index (BI)
2012	0	0	NA
2018	2	14	2.69
2021	3	24.5	2.28
2022	1	20.5	2.13

Table 1. Blocking for both the spring and summer months for 2012, 2018, 2021, and 2022 for the United States.

Data and Methods

- The 500 hPa anomaly height fields (m) at 00Z for the summer months (1 June through 31 August) for the years 2012, 2018, 2021, and 2022 were used to show areas of anomalous ridging and troughing. Surface potential evaporation (W/m^2) and surface precipitation rate (mm/day) were both analyzed in determining months with associated years that received precipitation and those that endured drought conditions.
- Climatological Data were provided by the USA's National Weather Service (NWS). Teleconnection data were obtained from the Climate prediction center.
- The University of Missouri Blocking Archive provided the information for the blocking events http://weather.missouri.edu/gcc/ Blocking events and characteristics are evaluated following Wiedenmann et al. (2002) (J. Climate). These included onset, duration and Block Intensity (BI).

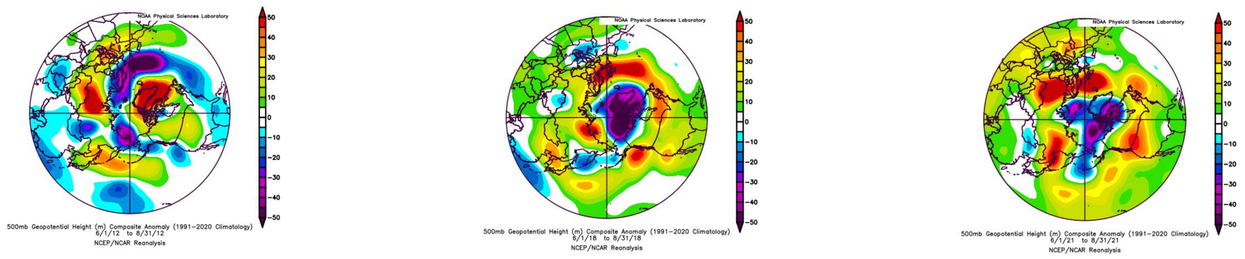


Figure 2. The observed 500 hPa anomaly height fields (m) for 1 June – 31 August 2012 (left), 1 June – 31 August 2018 (middle), and 1 June – 31 August (2021) (right).

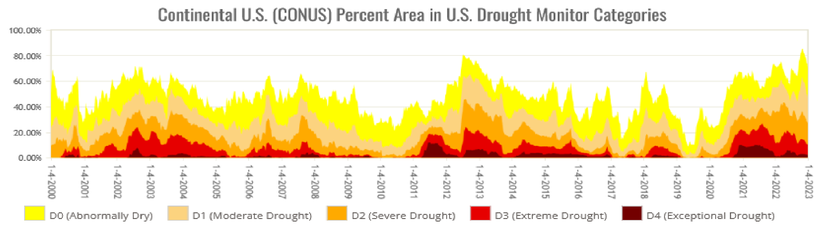


Figure 4. For the year of 2012, there was a higher percentage for an exceptional drought (D4). For 2022, there were percentages of an exceptional drought, but was not as much as seen in 2012.

Comments

- The surface potential evaporation (Figure 4: A – D) shows that the summers of 2012 (A) and 2022 (D) had areas of higher values indicating areas of evaporation or droughts. The summers of 2018 (B) and 2021 (C) had negative values indicating non-drought conditions or areas that do not indicate evaporation.
- The surface precipitation rate (Figure 4: E – H) shows negative values for both the years of 2012 (E) and 2022 (H) which would be a strong indicator of an ongoing drought.

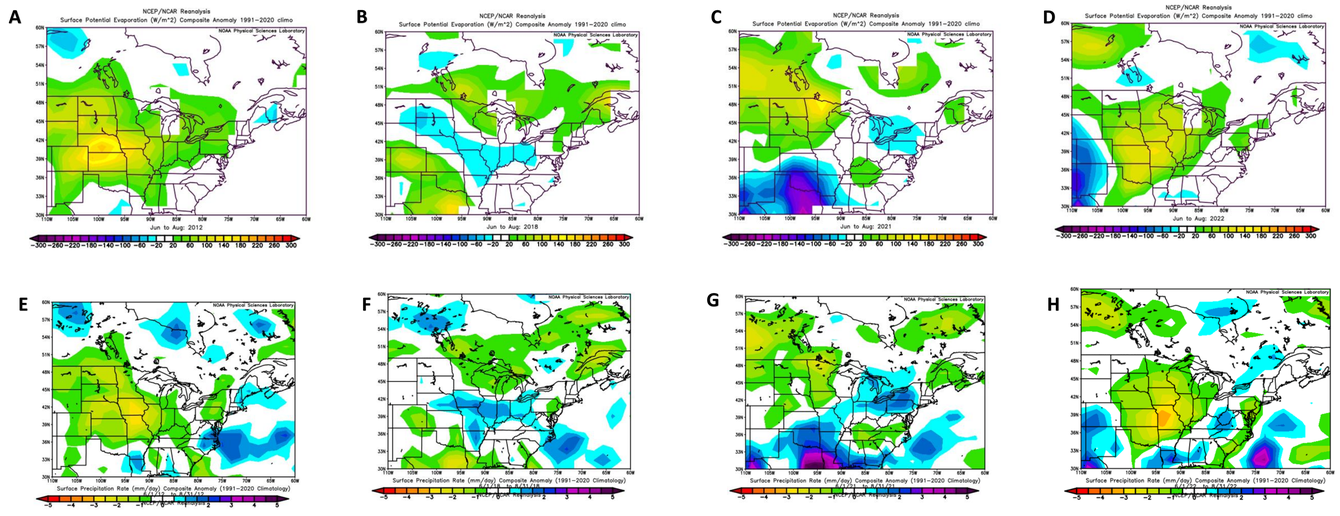


Figure 5. Images A – D (top) indicate Surface Potential Evaporation (W/m^2) for the summer months of 2012, 2018, 2021, and 2022. Images E – H (bottom) indicate Surface Precipitation Rate (mm/day) for the summer months of 2012, 2018, 2021, and 2022.

What is Drought?

- A drought occurs when there is a prolonged deficiency of precipitation relative to evaporation over an extended time which is typically a season or more and results in a water shortage.
- There are 5 types of droughts: 1) Meteorological, 2) Hydrological, 3) Agricultural, 4) Socioeconomic, and 5) Ecological. Each drought has a common denominator that which is the lack of water.
- Droughts can affect agriculture, transportation, public health, ecosystems, water quality, and can create wildfires.

Figure 3. A map of the eastern half of the United States with the Missouri Region and southern plains as focal areas.

Summary and Conclusions

- This study compared dry summers of 2012, 2018, and 2021 to the drought of 2022.
- Drought years were determined to be 2012 and 2022. A non-drought year was determined to be 2021. A marginal year was determined to be 2018; neither drought nor wet.
- Ridging typically is associated with years that endured a drought. This study showed that this is mostly true, but not always.
- The summer of 2021 was wet and considered a non-drought year as there was a ridge located over the western portion of the United States; blocking event was located in the eastern Pacific.
- The ample amount of precipitation that occurred during the spring months of 2021 could have been the reasoning as to why summer 2021 was a non-drought season.
- The summer of 2022 was similar to the summer of 2012 in that there were strong anomalies over the plains with little blocking events occurring in the eastern Pacific.
- Generally, AO and NAO will have similar teleconnection values, with PNA being opposite (Lebedeva et al. 2019). But during these summers, NAO and PNA have similar teleconnection values.
- During the spring months, the teleconnections AO and NAO had almost all positive values as shown in Table 2 for the focal years; PNA had negative values.
- During the summer months when drought occurs, the NAO and PNA become positively correlated. In the case of 2012, the AO also had the same sign as the NAO and PNA. Additionally, the anomalous ridging over North America was similar for 2012 and 2022.

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