Abstract

This project focuses on climate extremes in North Central Texas. Coupled Model Intercomparison Project Phase 6 (CMIP6) by the end of this century project that heat waves will occur with greater frequency, longer duration, and greater intensity due to anthropogenic-induced climate change. Here we test the hypothesis whether occurrence of these heat waves are highly correlated with severe droughts. The number of days with temperatures over 38˚C (~100 °F) increases approximately 5 times until the end of the century compared to 1991-2020. Heat wave occurrence increases as temperature increases, while the first and last occurance of 38˚C days expand into May and September by the end of the century. However, the Standardized Precipitation Index indicates a multi-decadal drought occurs from 2025 to 2070, with drought becoming less severe after 2050, and finally returns to late 20th century conditions around 2080, thus indicating that correlation between heat waves and droughts under future climate change appears to be more complex and thus requires further investigations.

1. Background

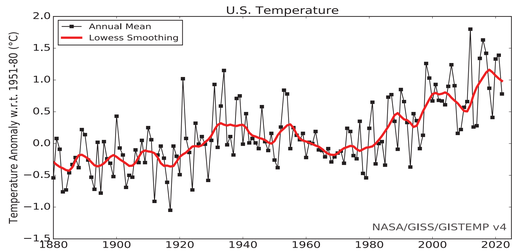


Figure 1. Surface air temperature averaged over contiguous 48 states relative to the 1951-1980 mean (GISS 2021)

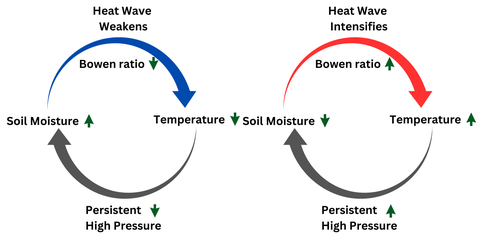
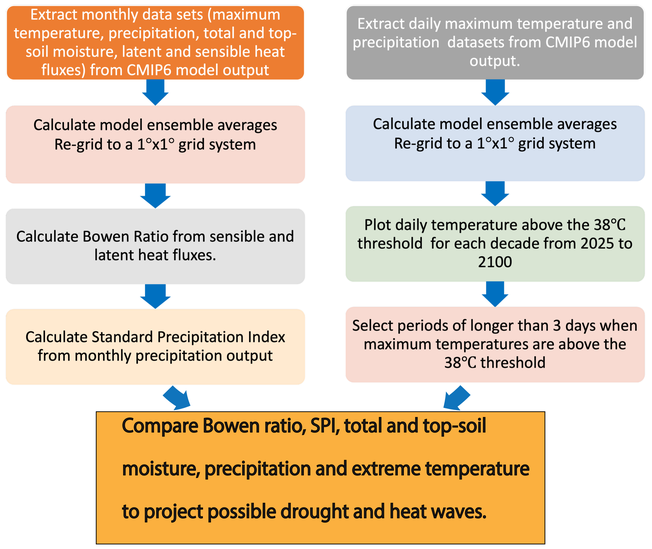


Figure 2. Relationship between Bowen Ratio, soil moisture, temperature, pressure, and heat waves. (After Erdenebat and Sato 2018)

Objective

Estimate the probable frequency of drought and heat waves in North Central Texas through the end of the 21st century using CMIP6 model output.

2. Methodology



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North Central Texas Heat Waves and Drought in Response to Antropogenic-induced Climate Change

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3. Top 10-cm Soil Moisture, Bowen Ratio, and 38˚C Days

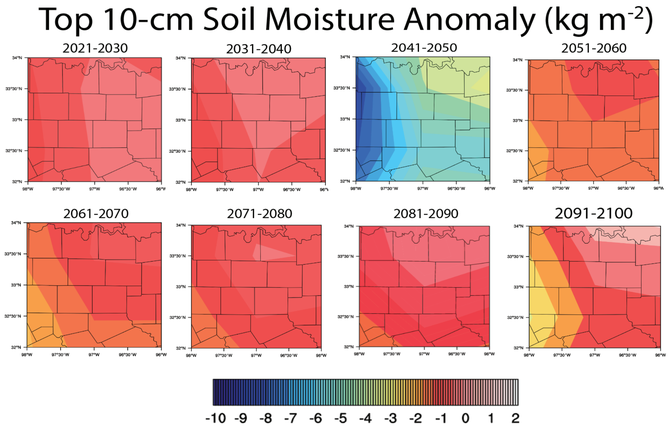

Figure 3. Seasonal average (JJA) 10-cm top soil moisture anomaly (compared to 1991-2000) for North Central Texas from five CMIP6 model simulations.
Top soil moisture decreases throughout the 21st century, but the period from 2041 to 2050 appear the driest decade due to decadal variablity.

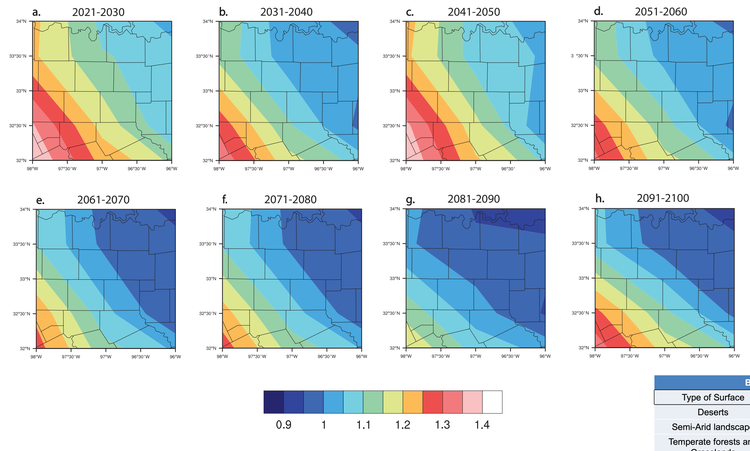

Figure 4. The Bowen Ratio is the ratio of sensible heat flux to latent heat flux. In a transition to to a drought the Bowen ratio increases because the sensible heat flux by far exceeds the latent heat flux.

Bowen Ratio	
Type of Surface	Range of Bowen Ratios
Deserts	> 10.0
Semi-Arid landscape	2 – 5
Temperate forests and Grasslands	0.4 – 0.8
Tropical rainforests	0.1 – 0.3
Tropical oceans	< 0.1

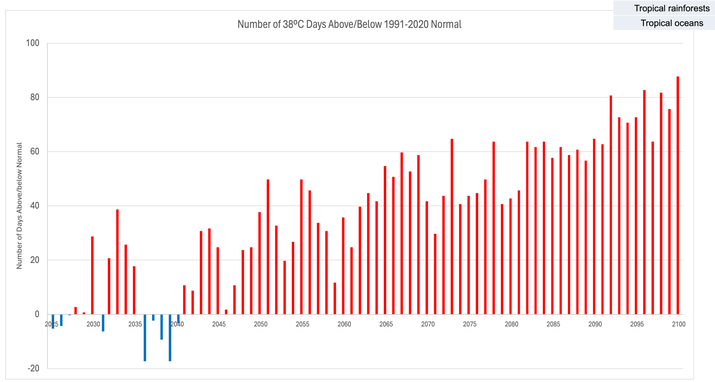

Figure 5. Number of days above 38˚C compared to 1991-2020 (20 days). The threshold for a heat wave is three or more days above 38˚C. As the number of days increase, the first and last occurrence dates of 38˚C days has expands into May and September.

4. STANDARDIZED PRECIPITATION INDEX

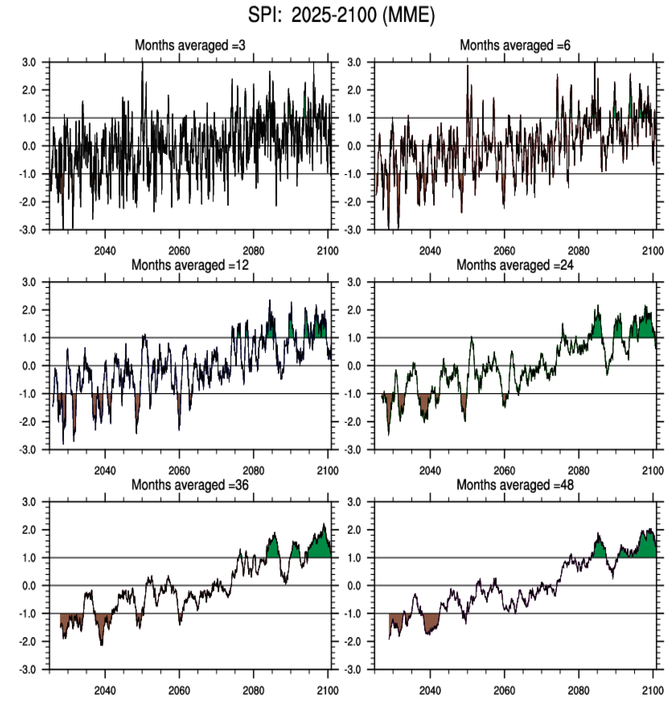

Figure 6. Standard Precipiation Index (SPI) for North Central Texas from CMIP6 . In these plots SPI, a meterological drought indicator, shows a trend toward increased precipitation toward the end of the century. Brown indicates drought, green indicates termination of drought conditions.

5. Conclusions and references

•Heat waves in North Central Texas, with temperatures above 38˚C (~100 °F), increase by the end of the century relative to the end of the 20th century by 80 days. First occurrence of heat waves in 2100 is projected to be in May and last occurrence in September thus resulting in an increase of more frequent, and longer, heat waves.

•Droughts in North Central Texas reach maximum duration during the next two decades)2025-2045) but their length appears to decline due to increase in precipition as inferred the Standardized Precipitation Index as calculated from monthly CMIP6 precipitation. Thus, it appears that the correlation between heat waves and drought are highly complex in this region and need to be further investigated.

References

•Erdenebat, E., and T. Sato, 2018: Role of soil moisture-atmosphere feedback during high temperature events in 2002 over Northeast Eurasia. Progress in Earth and Planetary Science, 5:37. https://doi.org/10.1186/s40645-018-0195-4
•GISS, 2021: GISS surface temperature analysis (v4). Accessed 17 March 2021, https://data.nasa.gov/gistemp/graphs/.

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