Physical Mechanisms Driving Central Great Plains Extreme Precipitation Increases During Winter

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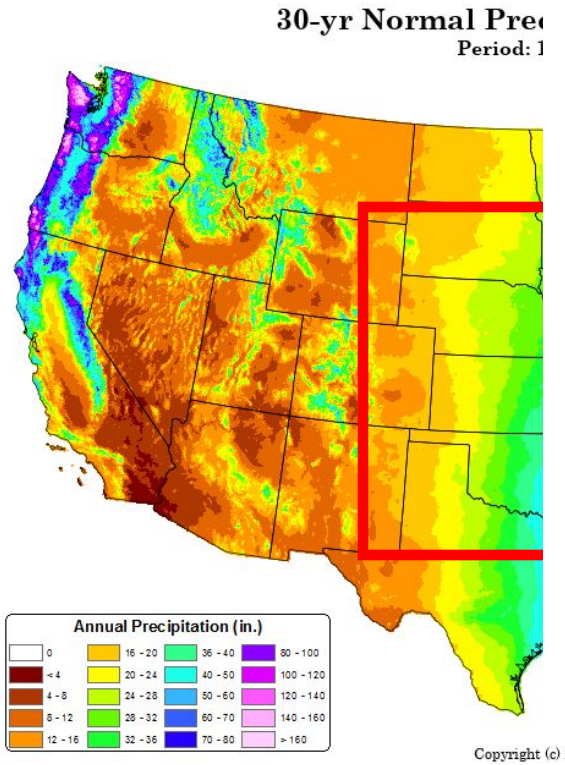
Introduction

Great Plains Hydroclimate



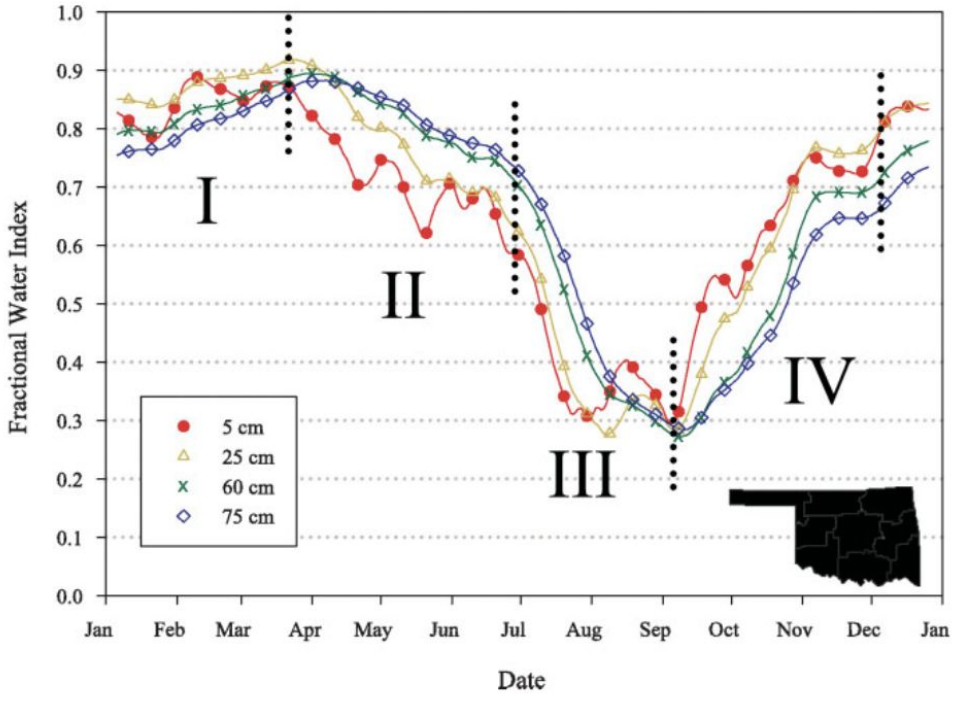
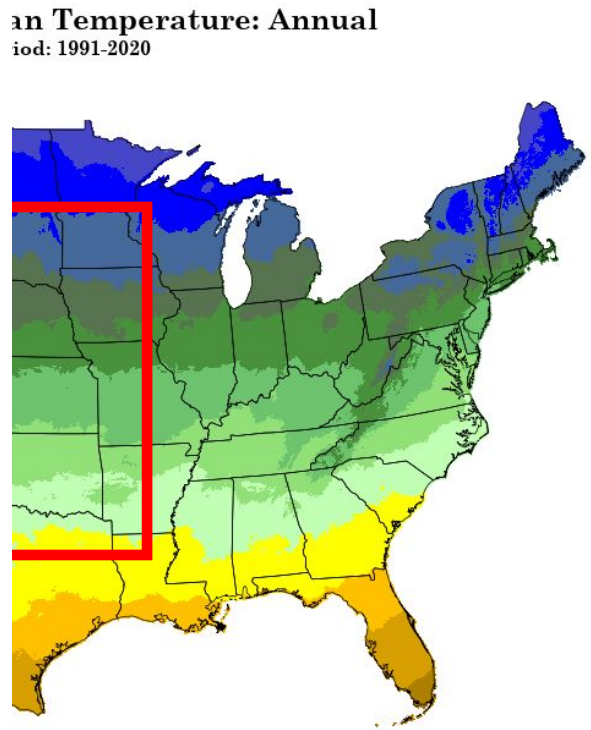
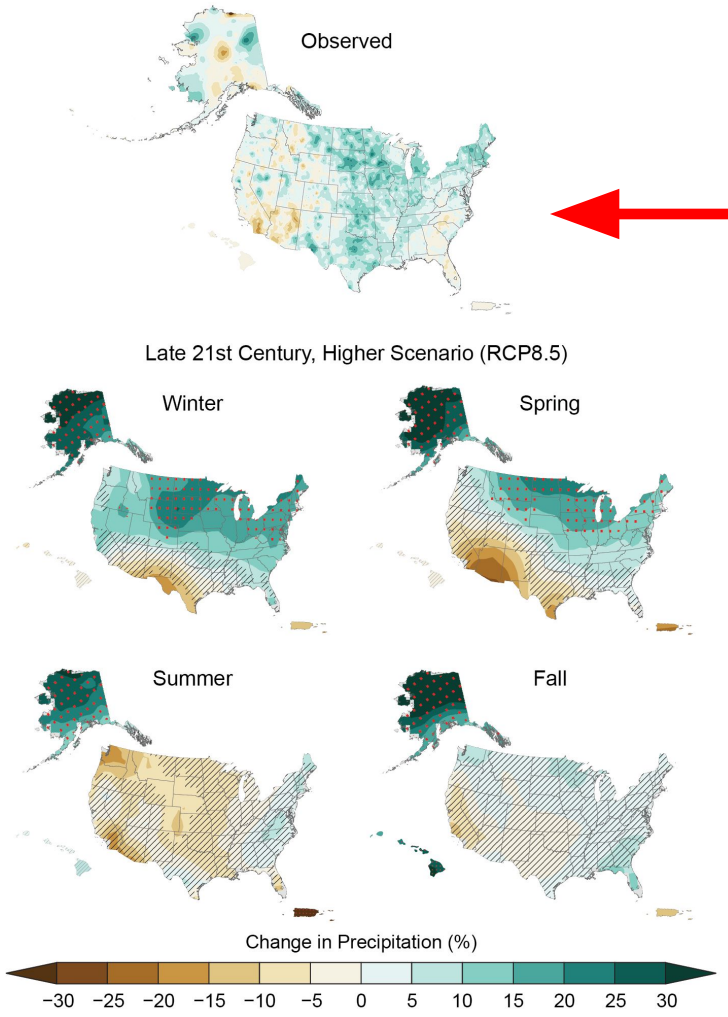


Figure 2. The annual cycle of FWI averaged across Oklahoma and illustrating four soil moisture phases (I–IV)



From Illston et al. 2004

Introduction and Motivation

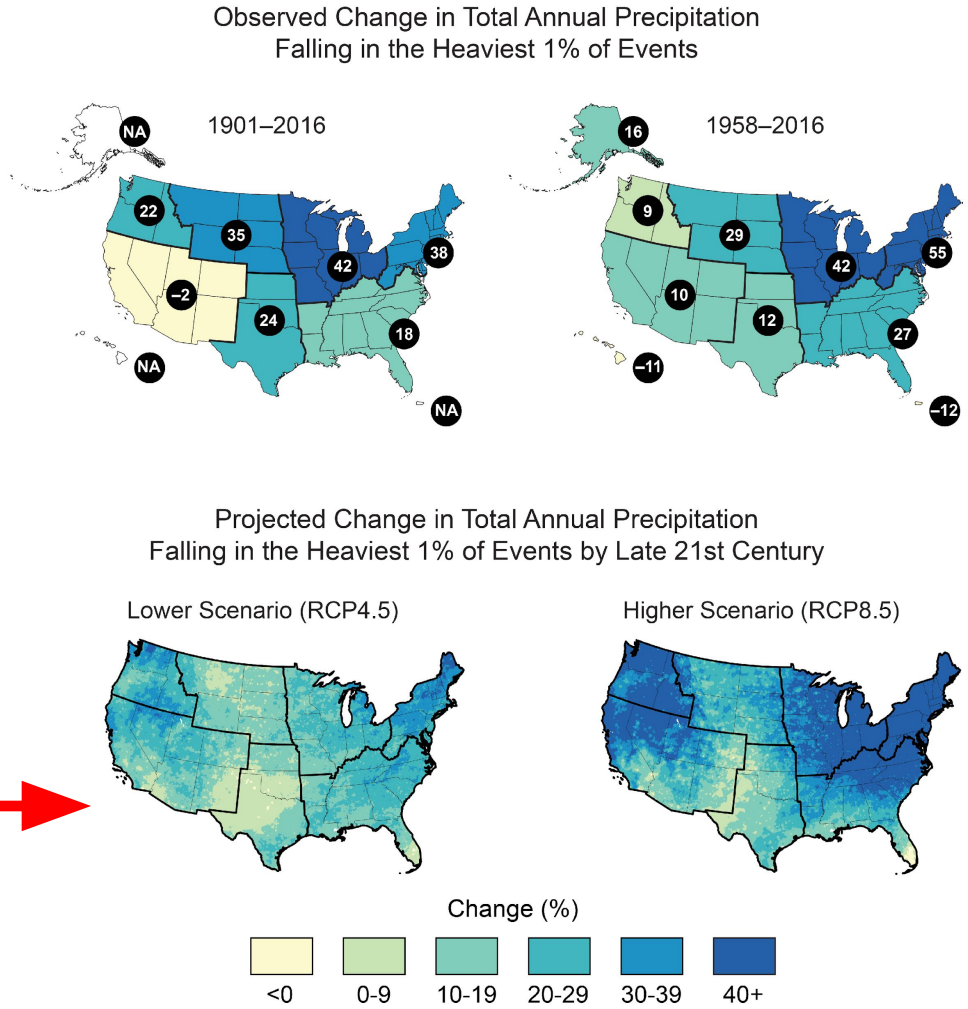


Left: Adapted from Easterling et al. 2017 in the 4th National Climate Assessment.

Depicts the observed and projected changes in precipitation

Right: (top) adapted from Easterling et al. 2017; (bottom) NOAA NCEI, CICS-NC, and NEMAC in the 4th National Climate Assessment.

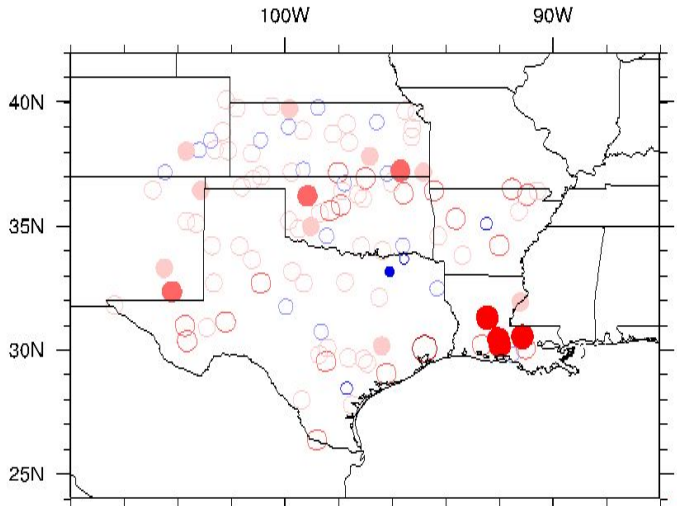
Depicts the observed and projected changes in 99th percentile events across the United States



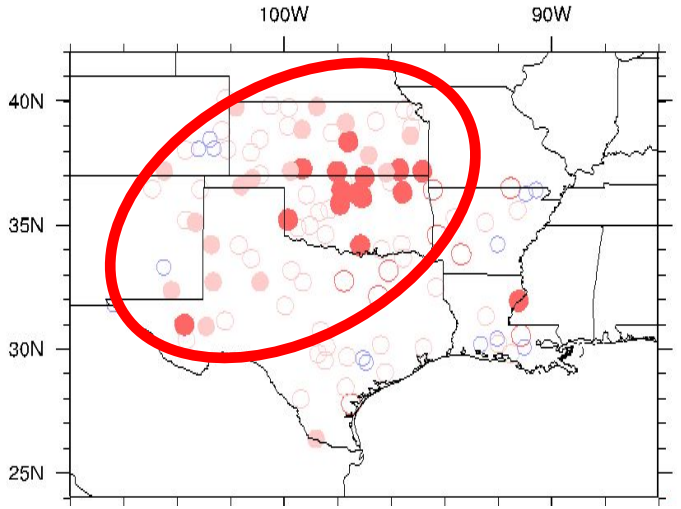
Previous SGP Extreme Precipitation Study - Trends

From Flanagan and Mahmood 2023

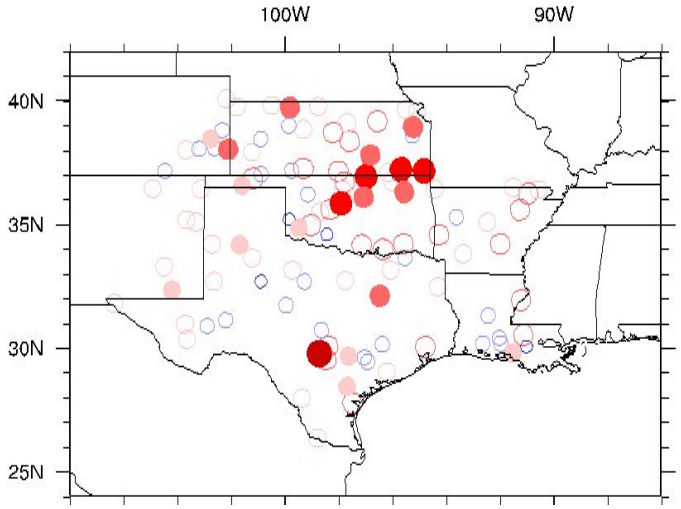
SON



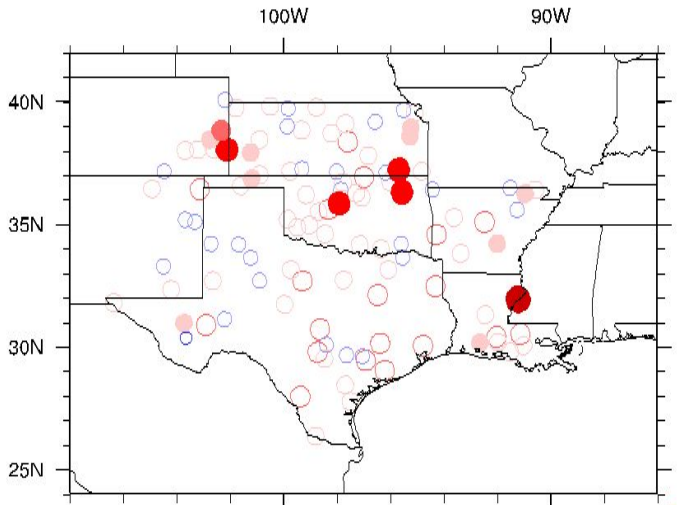
DJF



MAM

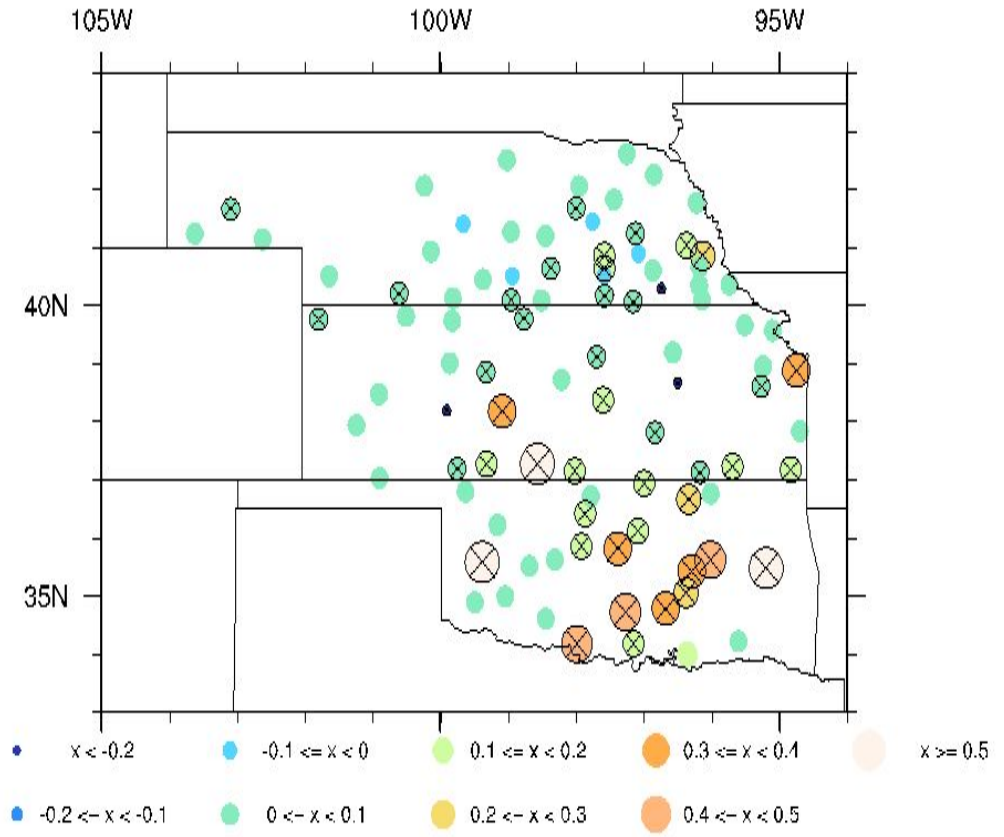


JJA



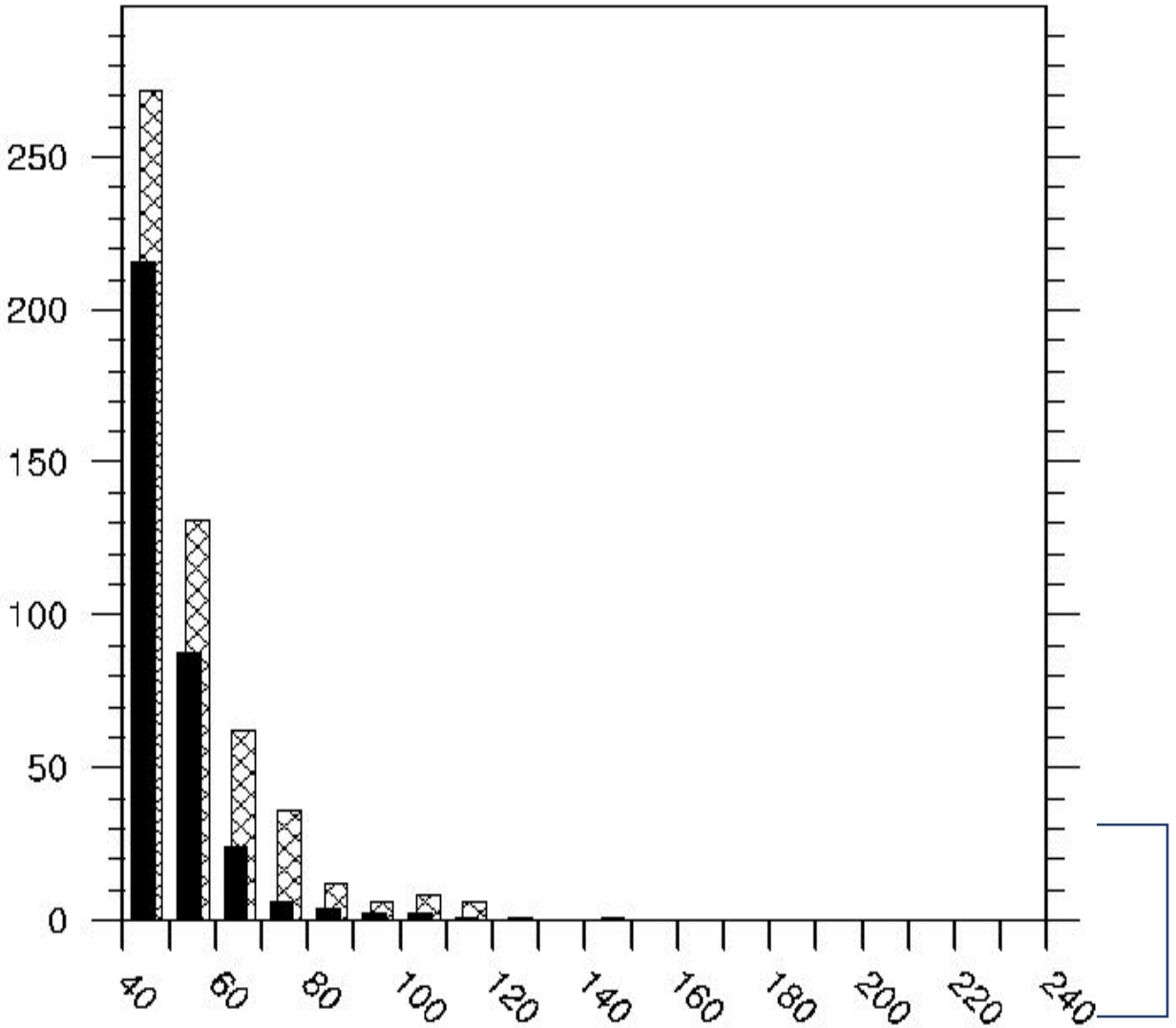
USHCN Data Methodology

- Stations were required to have less than 10% missing precipitation, minimum temperature, and maximum temperature data to be used.
  - **95** stations from Oklahoma, Kansas, and Nebraska met the 10% or less missing data requirement for all 3 variables.
- Extreme precipitation events were identified using each stations 99th percentile threshold computed from all precipitation events (> 0.0 mm).
- The day, month, and year information from all precipitation extremes were then used to pull out the required temperature data for all analyses.
  - If no temperature data was available then that precipitation extreme was not considered within the analyses.



Distribution of **all** precipitation events above 0.0 mm during DJF

Black– Before 1985
Hatched – After 1985

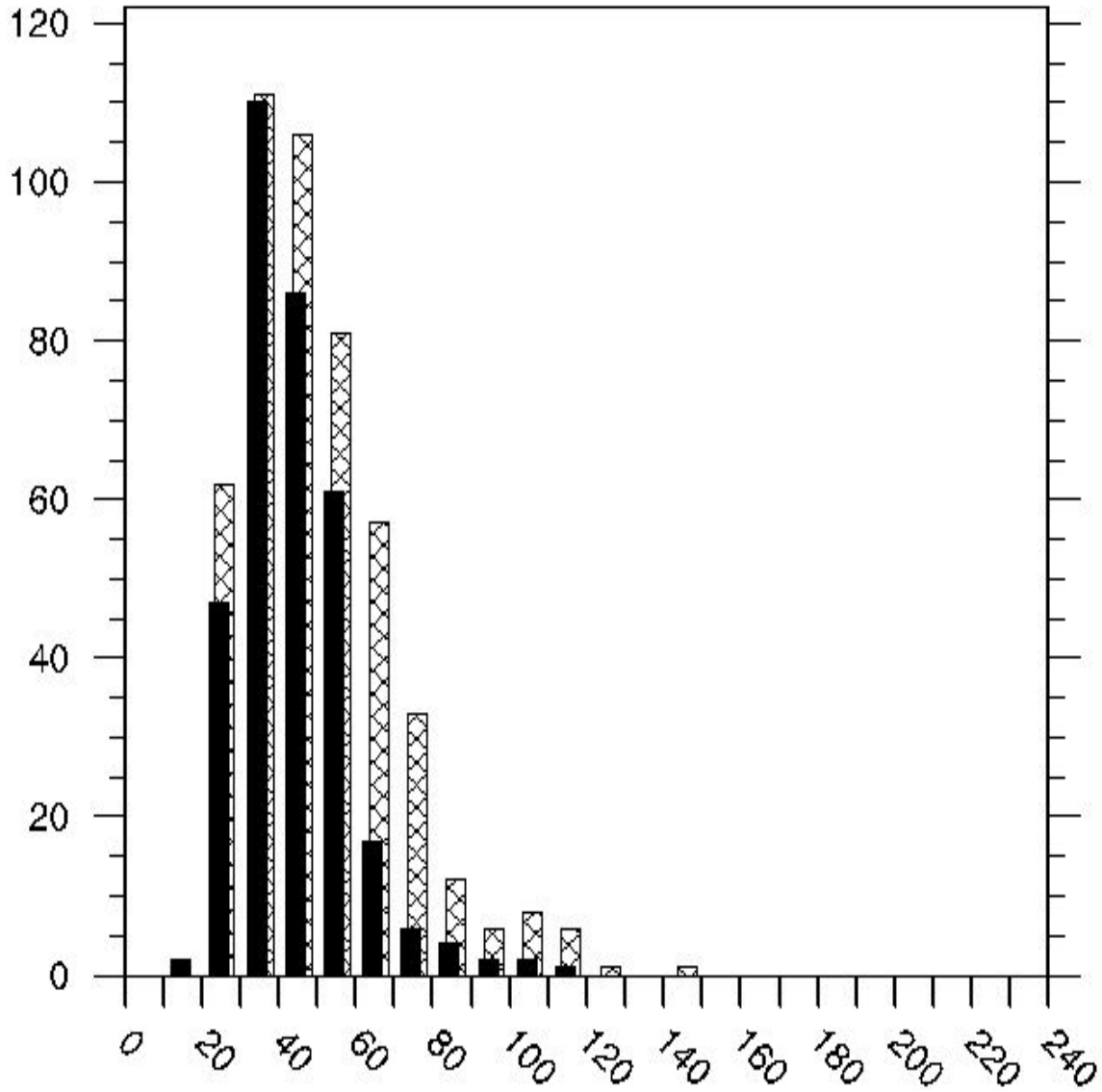


Count of **all*** daily precipitation totals above the 99th percentile threshold defined at all DJF stations

*Multiple events were counted for each day

Black– Before 1985
Hatched – After 1985

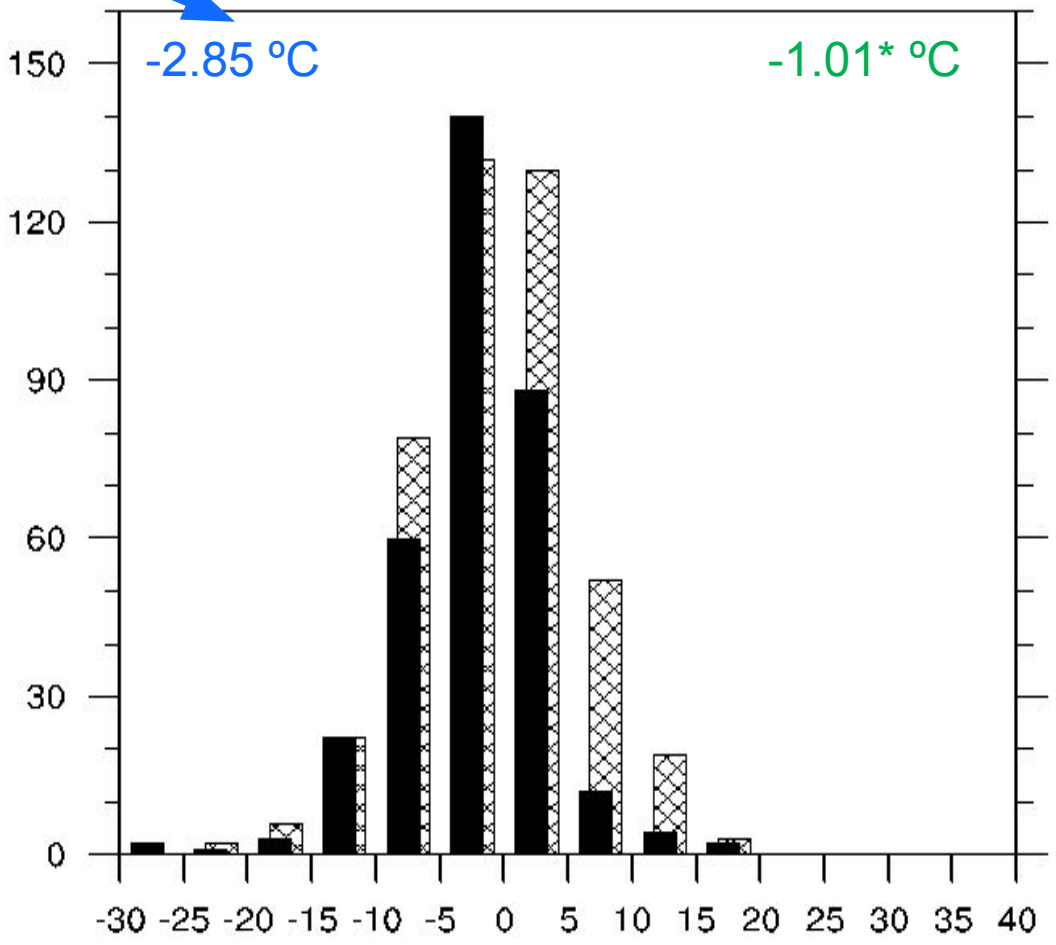
Number of events before 1985 – **338** (**97** unique events)
Number of events after 1985 – **484** (**162** unique events)



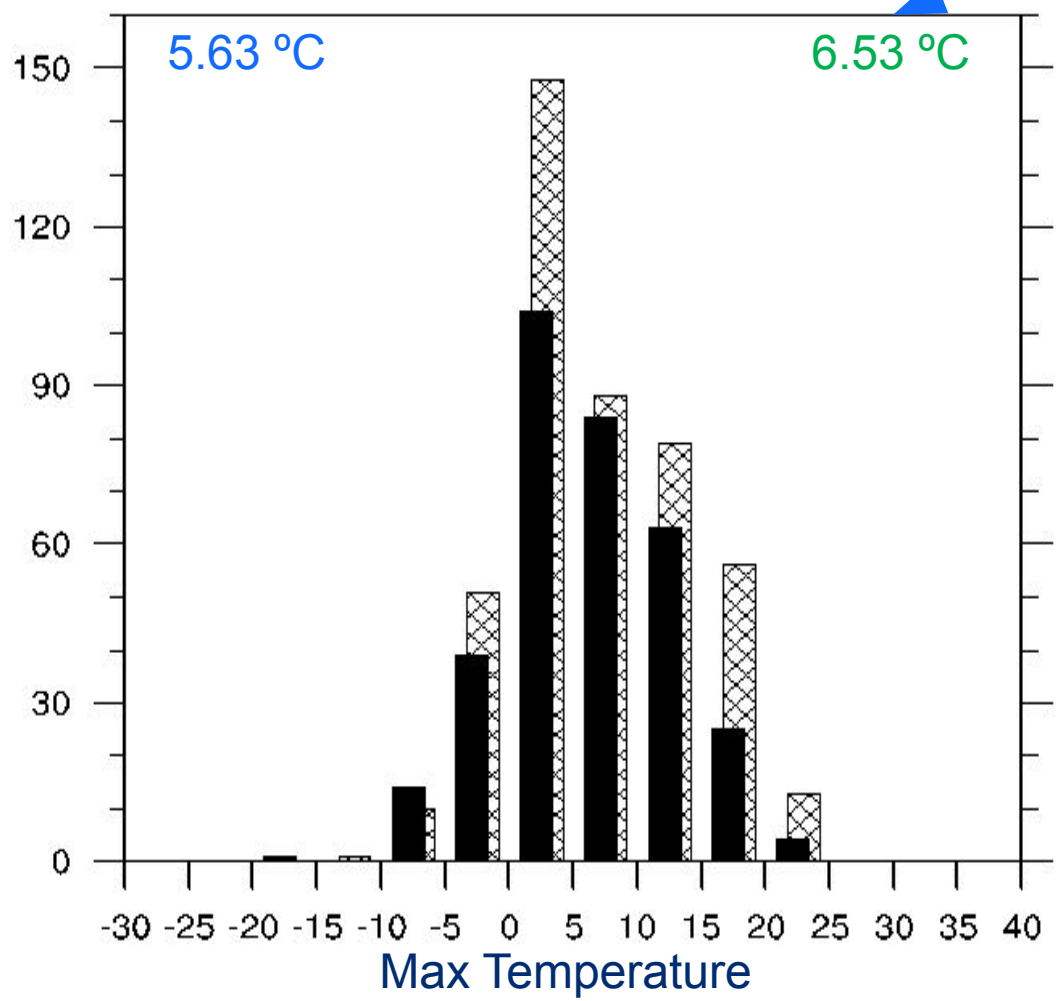
Distribution of DJF Maximum and Minimum temperatures on **all** days with a noted 99th percentile daily precipitation total

Day of extreme precipitation event

Before 1985



After 1985

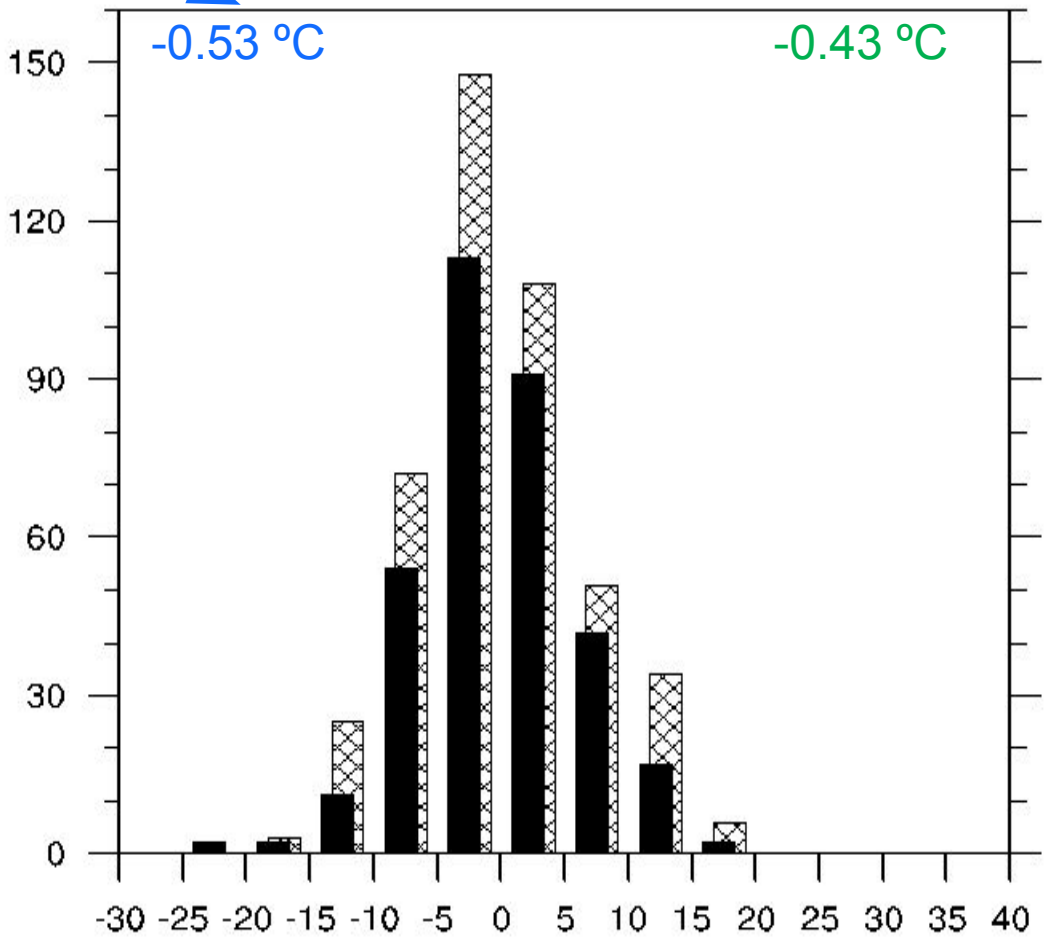


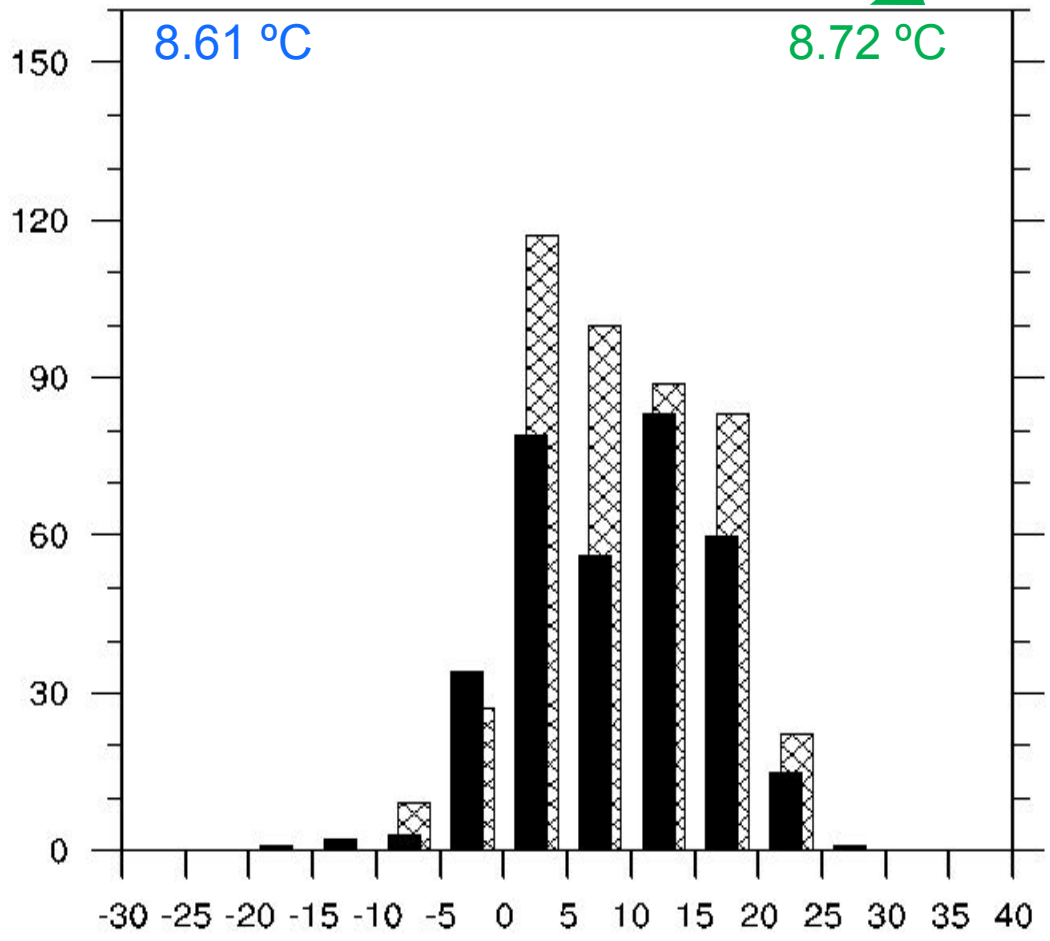
Distribution of DJF Maximum and Minimum temperatures on **all** days with a noted 99th percentile daily precipitation total

Day before extreme precipitation event

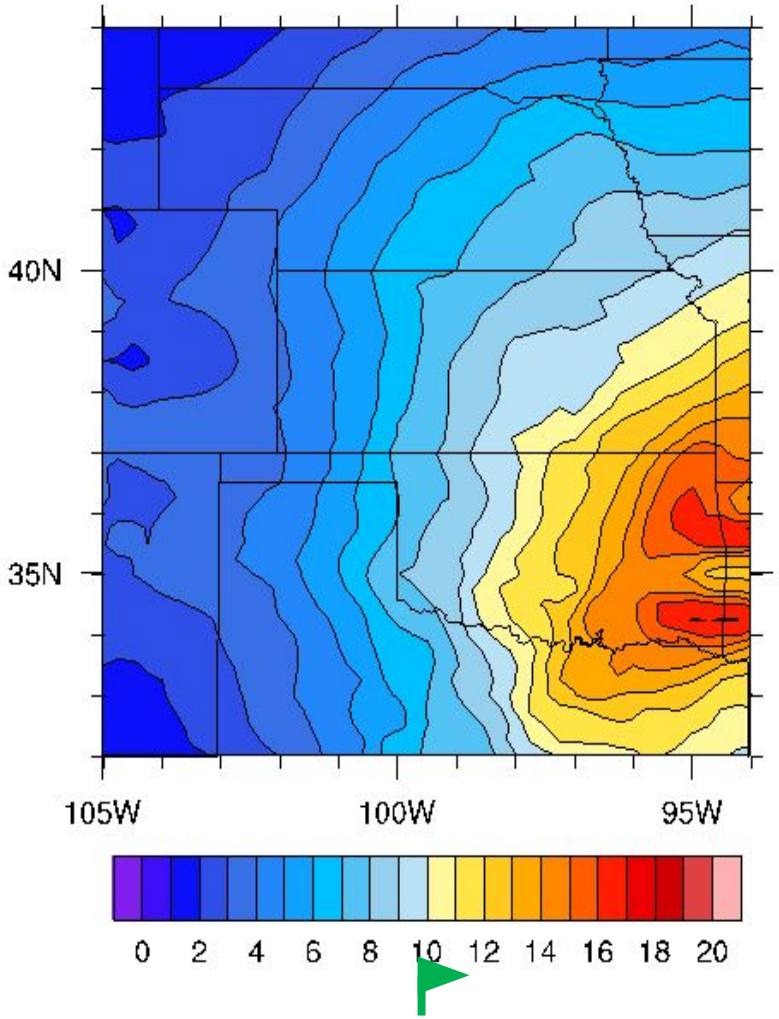
Before 1985

After 1985





Preliminary ECWMF Reanalysis 5 (ERA-5) Analysis

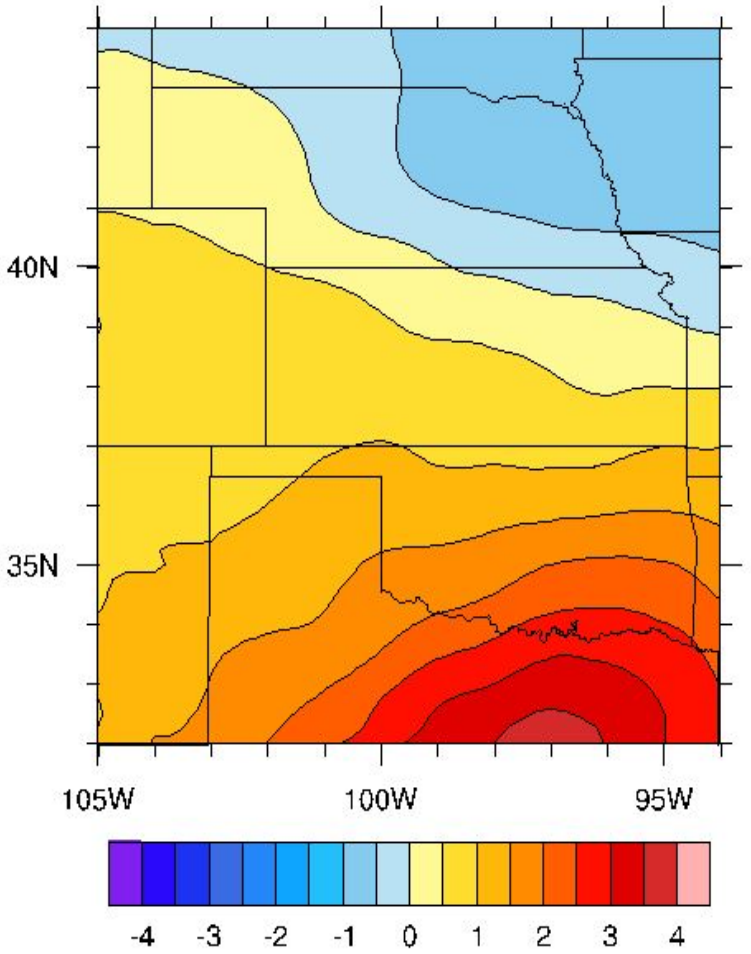


Average ERA-5 Precipitation Totals (mm) for all USHCN 99th percentile Events

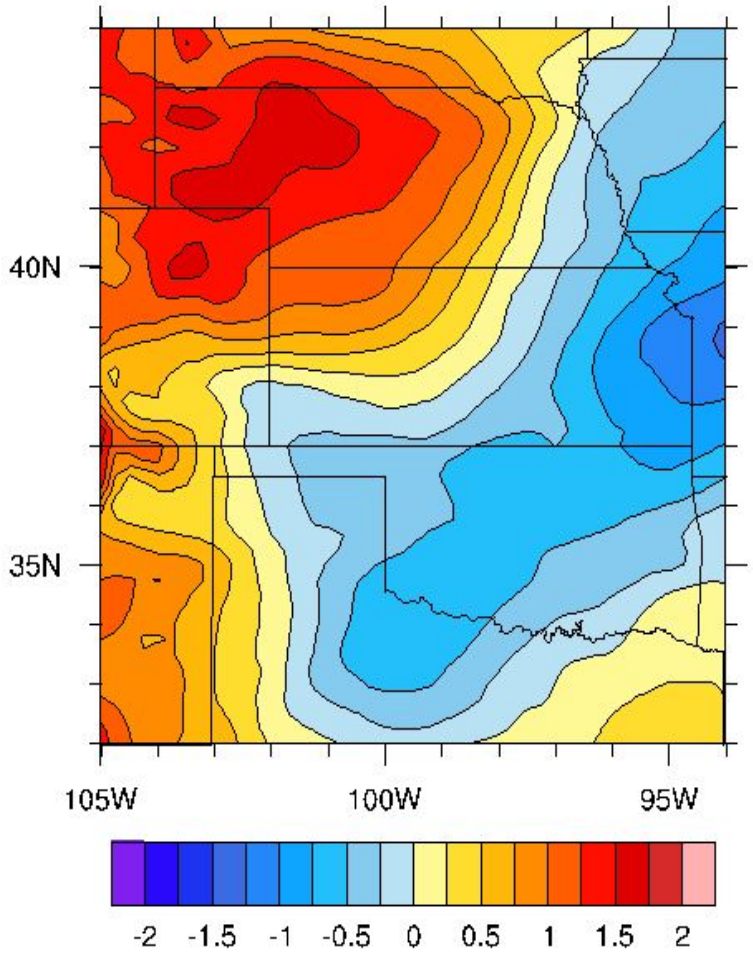
- ERA-5 data was downloaded from the ECMWF Climate Data Store (https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-complete?tab=overview)
- Data from 1950 to 2020 was used.
- Primary data used for this study was precipitation amounts, 2m temperature, total column (precipitable) water, mean sea level pressure, 500 mb u and v wind components and 500 mb geopotential heights.
- 99th percentile precipitation dates identified from all 95 USHCN stations were used to subset the hourly ERA-5 data into **Before** (97 dates) and **After** (162 dates) ***1985*** composites.
- Difference plots were created by subtracting the After 1985 averages from the Before 1985 averages.

ERA-5 Precipitable Water (left) and 2m Temperature (right) differences.

Differences are defined as
After 1985 – Before 1985

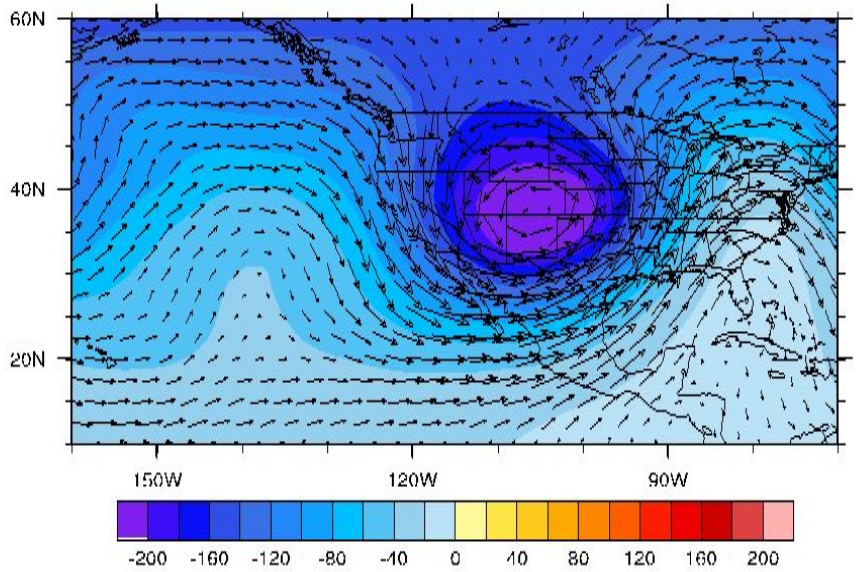


Precipitable Water (mm) Difference

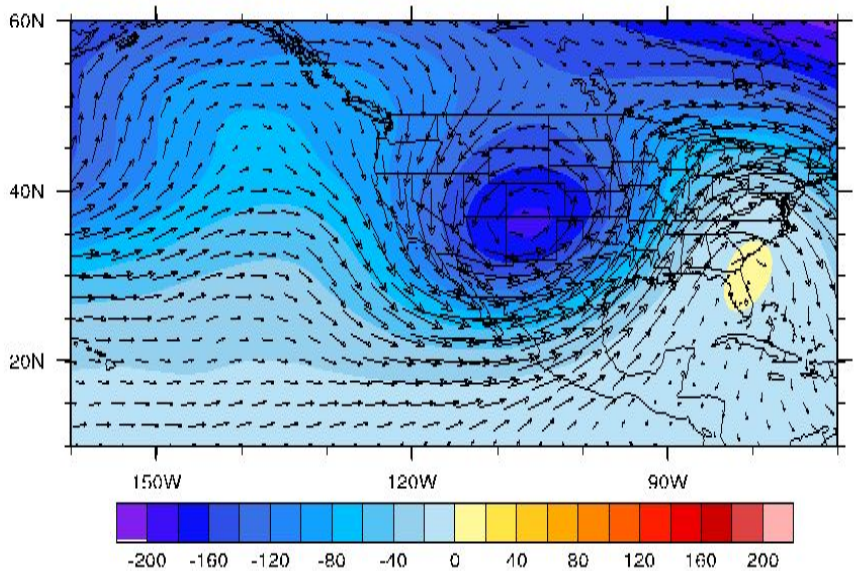


2m Temperature (ºC) Difference

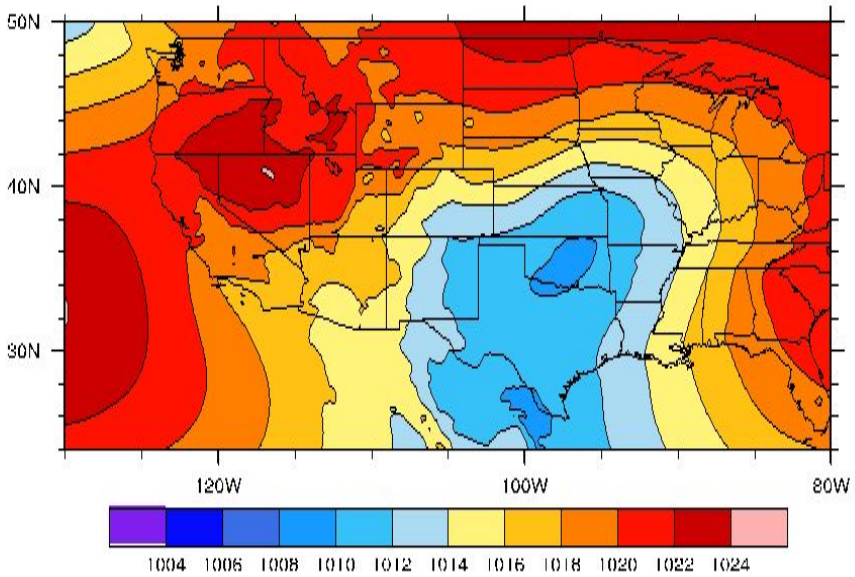
Before 1985



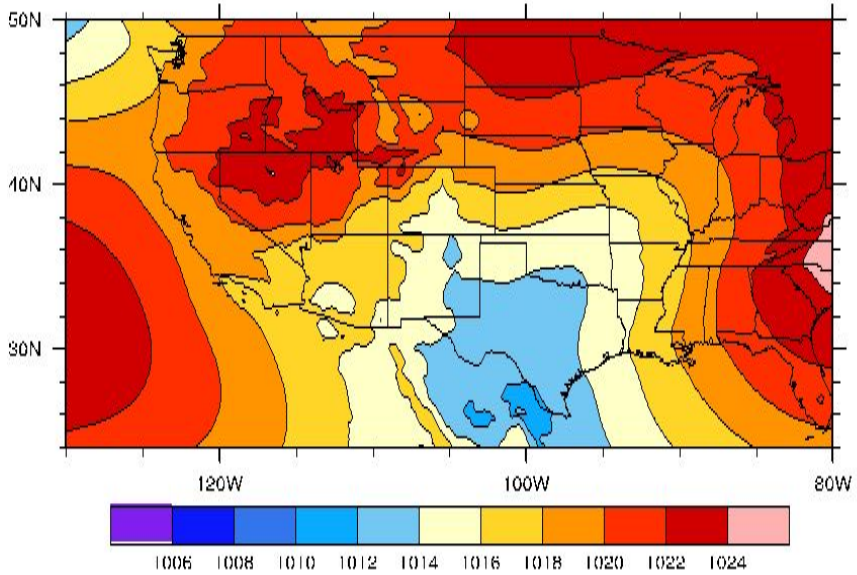
500 mb GPH and Wind vector anomalies



After 1985



Average MSLP



Conclusions

- Goal of this study was to use station and atmospheric reanalysis data to diagnose the drivers behind the widespread statistically significant increase (95 stations throughout the Central Great Plains) in extreme precipitation in the CGP in the winter.

- Frequency of precipitation appears to be increasing throughout the entire distribution of precipitation, however percent differences are much higher at the higher end of the distribution.

- More 99th percentile events (when 99th percentile is defined with each stations distribution) occurred in the last 35 years (1985 – 2020) compared to the first 35 years (1950 – 1984)

- Minimum temperatures on the day of the extreme precipitation totals are increasing
  - No definable increase seen in the day of maximum temperatures or in the minimum/maximum the day before the extreme precipitation event.

- Preliminary analysis of ERA-5 data shows that changes in extreme precipitation events before and after 1985 are linked to enhanced atmospheric moisture even with a decrease in the south to north temperature gradient (cooling in the south and warming in the north), along with increases in geopotential height and decreased southerly flow.

Thank you for listening!

Feel free to reach out with any other questions!

Email: Paul.Flanagan2@usda.gov

Picture 1: Chickasaw Country website (https://chickasawcountry.com/outdoors/turner-falls-park)

Picture 2: Steve Sisney/The Oklahoman via AP (https://www.savannahnow.com/story/news/2015/06/19/bills-remnants-flood-oklahoma-along-path-us-midsection/13579701007/)