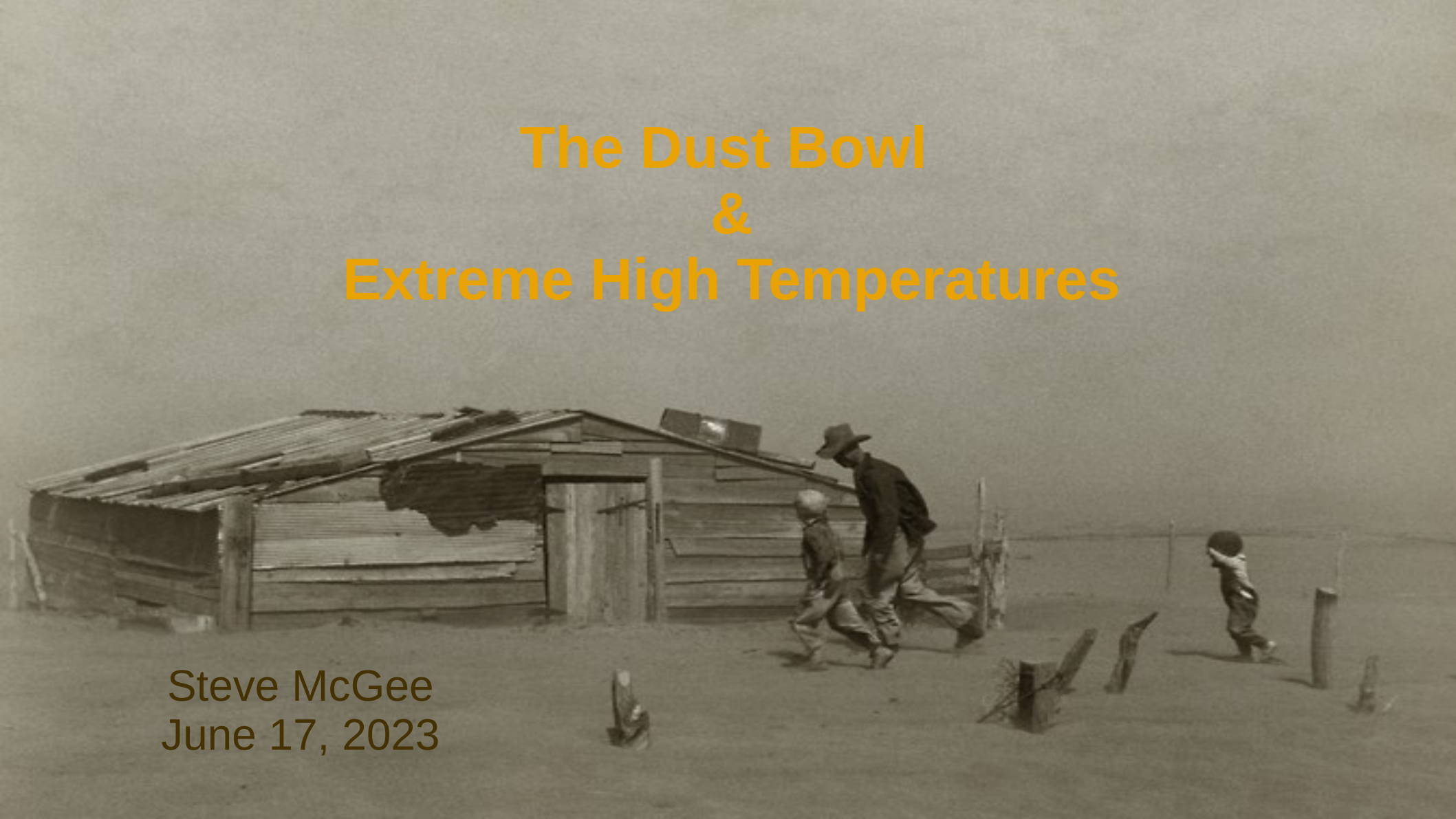
The Dust Bowl
&
Extreme High Temperatures



Steve McGee
June 17, 2023

A Request For Patience
Cautions:

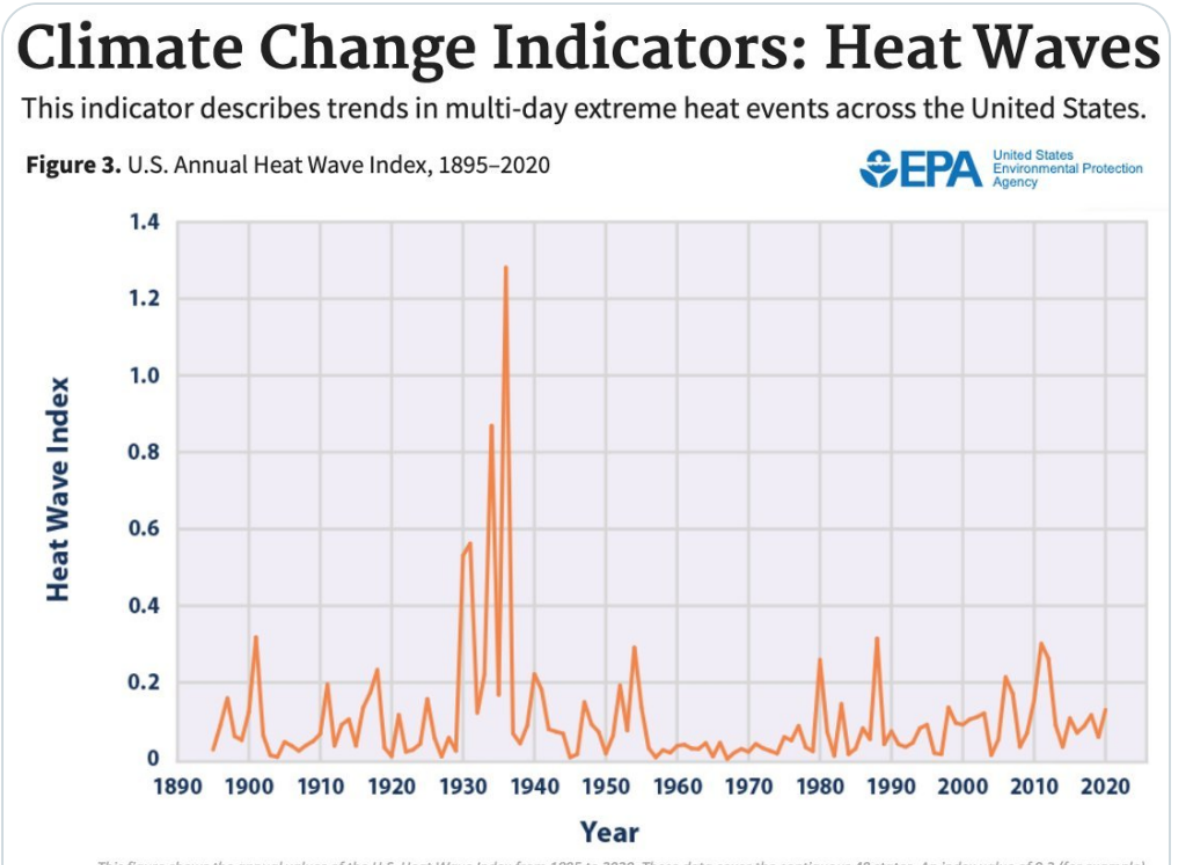
- Not At All Exhaustive Description of Dust Bowl
- Contains Mixed Units
- Sometimes Eye Chart Graphics
- Lengthy & Cumbersome Detail Descriptions
- Mixed descriptions of ‘Summer’ == ‘JJA’ == ‘June-July-August’
- ‘Hottest Day Of Summer’ == Highest Tmax temperature during JJA for a given station

Motivations

- Anger & Defiance? (can lead to bias)
- Ego (tying ego to position → biased defense of position)
- ***Curiosity***
  - Least susceptible to bias
  - *Soldier versus Scout (The Scout Mindset by Julia Galef)*
    - Soldier’s priority is cohesion to accomplish a mission
    - Scout works individually and is accountable for (in)accuracy

Andrew Dessler @AndrewDessler · Aug 21, 2021

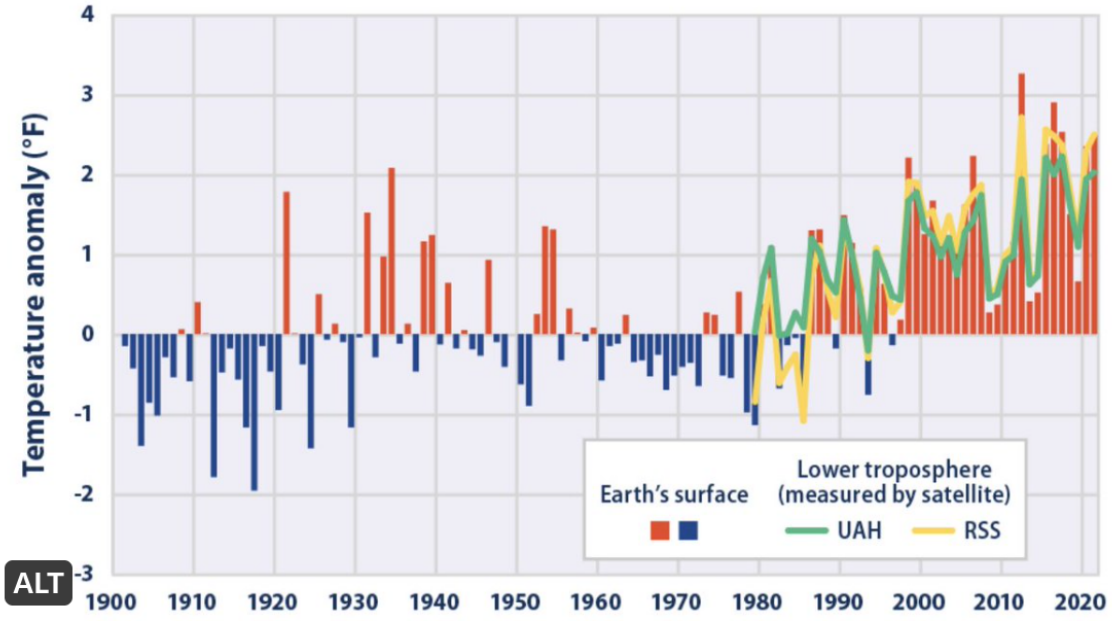
One of the things you learn as a scientist is the ability to look at a plot and think, "that just doesn't look right." That's the feeling I got when I saw this plot that Lomborg is currently pushing.



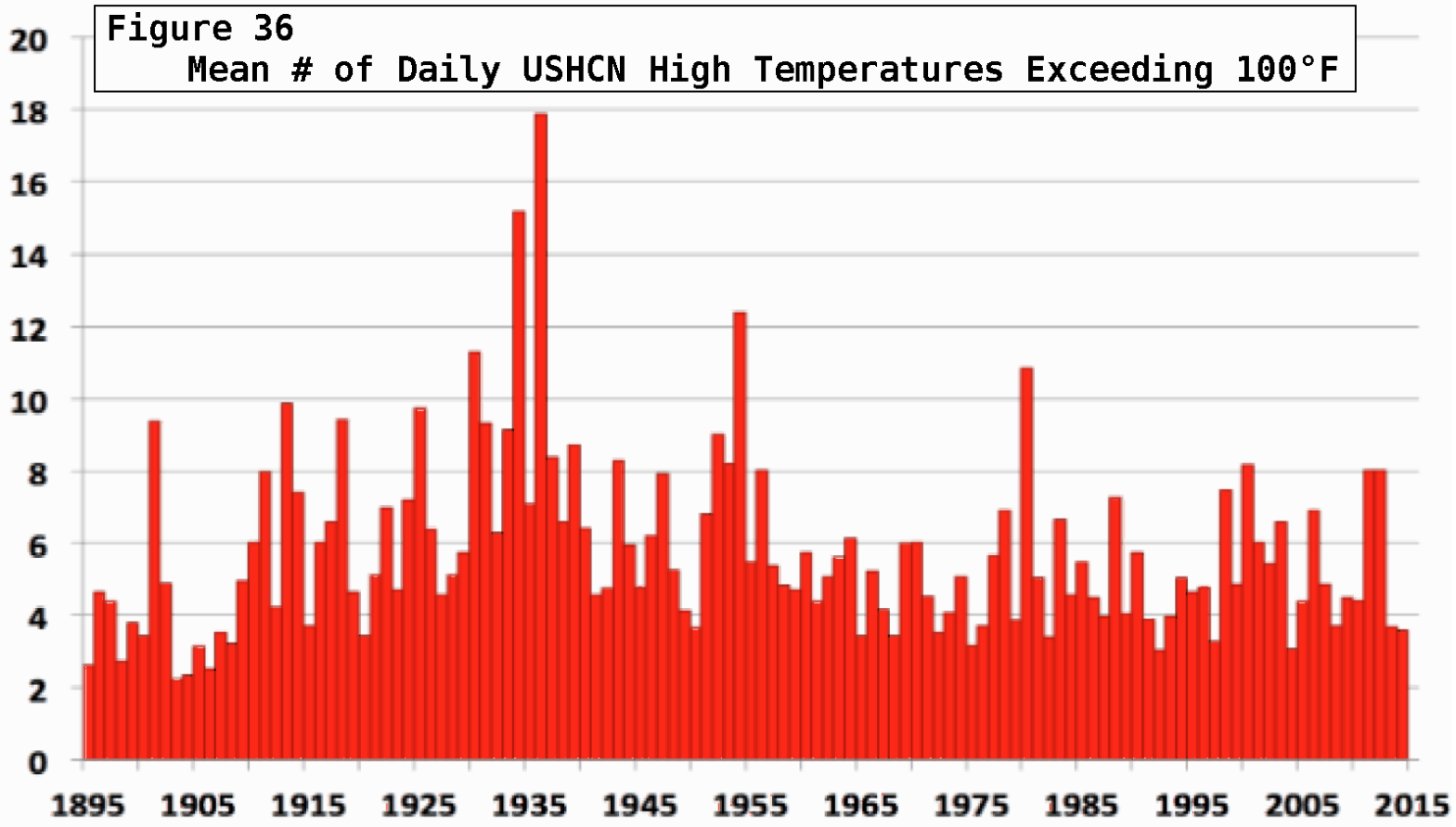
The Real Prof. Katharine Hayhoe
@KHayhoe

"Why was 1934 the warmest year in the US?" I was asked today. Climate scientists often get strawman questions. so my response is, "It wasn't." But then ask, "Why do you think it is?" to turn the conversation to the motivation--which is what really matters! epa.gov/climate-indica...

Figure 1. Temperatures in the Contiguous 48 States, 1901–2021



Dr. John Christy, Testimony To Congress



Questions

- What happened during the Dust Bowl?
- How did temperatures vary during the Dust Bowl?
- What was the role of drought?
- What *caused* the Dust Bowl? (unsatisfactory)

Popular Focus on the Visible: The Dust Storms (Most Dust Storms Were In March & April)

Amarillo 1936

Eckhart KS, 1937

Baca Co. CO, 1936

Less Photographed Was Visible Evidence Of The Droughts

Idaho, May 1936

South Dakota, May 1936

Still Less Visible Evidence Of Dust Bowl Heat

July 25, 1936
Lawn of the
Nebraska
State Capitol
In Lincoln.

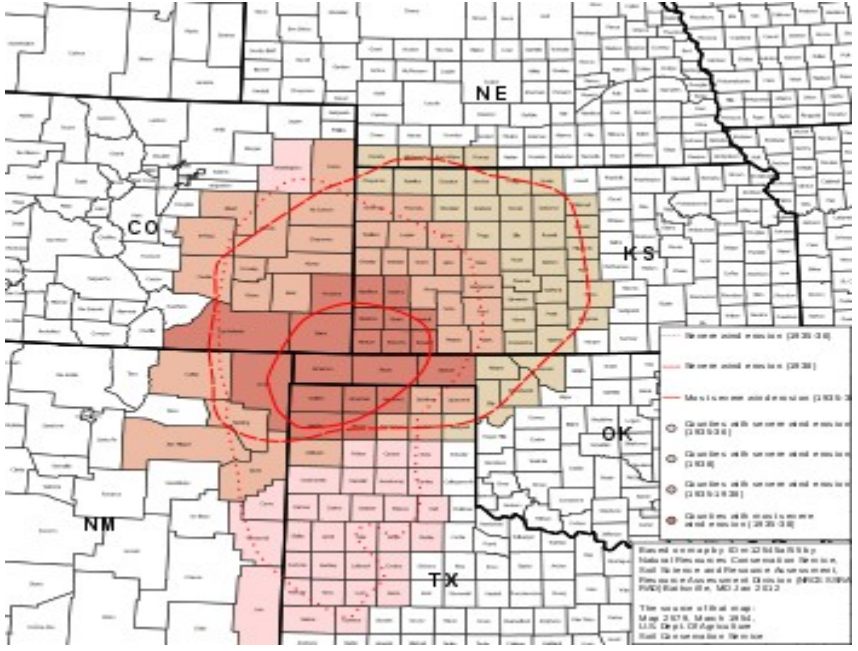
Low Temperature
91F

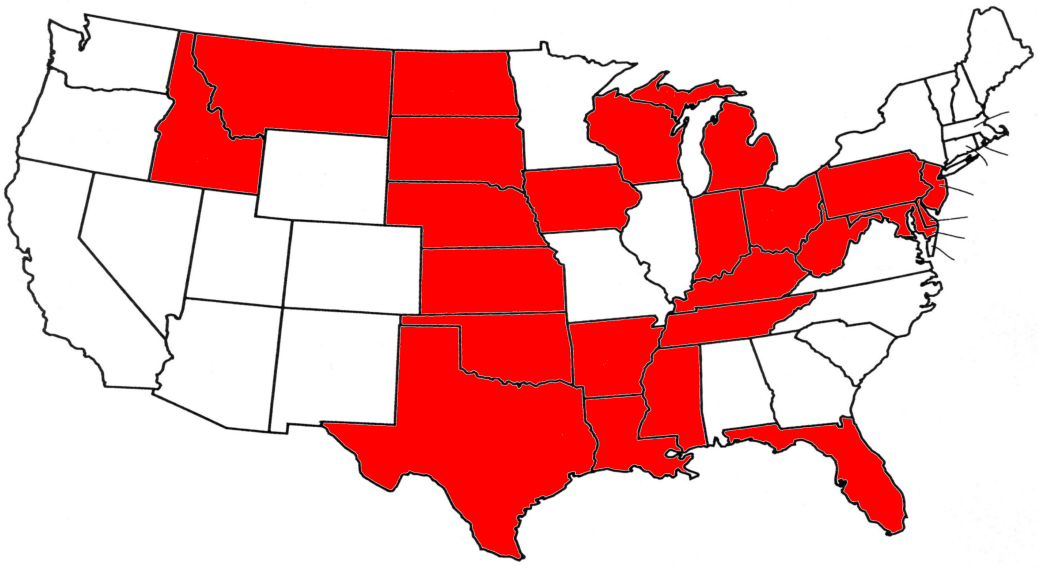
Nebraska State
Record High
Tmax of 118F
Set the day prior.

Focus On Dust & Ascribed Causes

- “The Dust Bowl was caused by several economic and agricultural factors, including **federal land policies**, changes in *regional weather*, **farm economics** and other **cultural factors**.” (history.com)

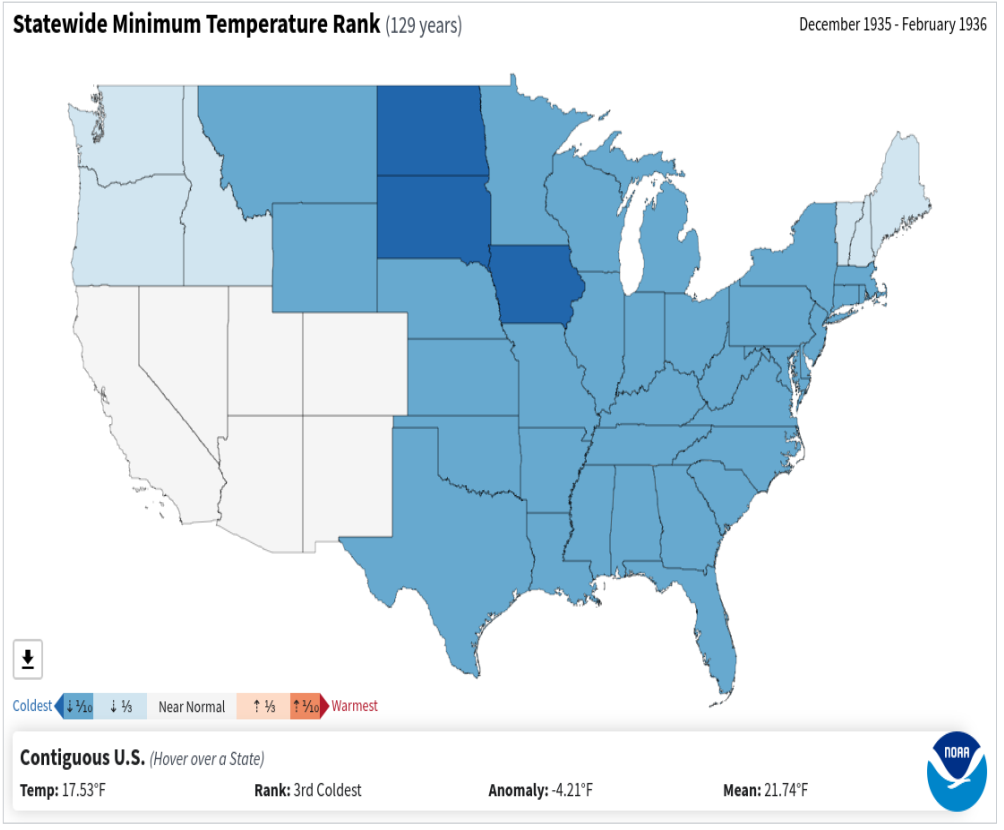
Dust Bowl Thought Of As Area Of Worst Dust but: All-Time Max Temp. Records in half of states (1930-1939)

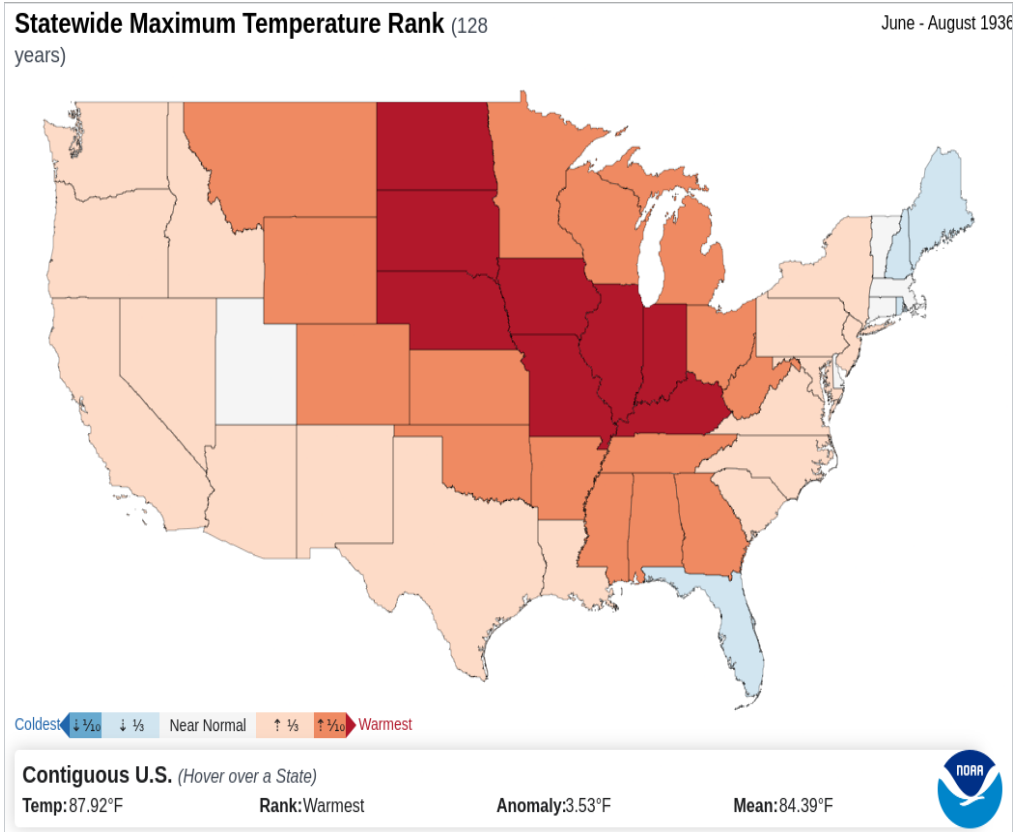




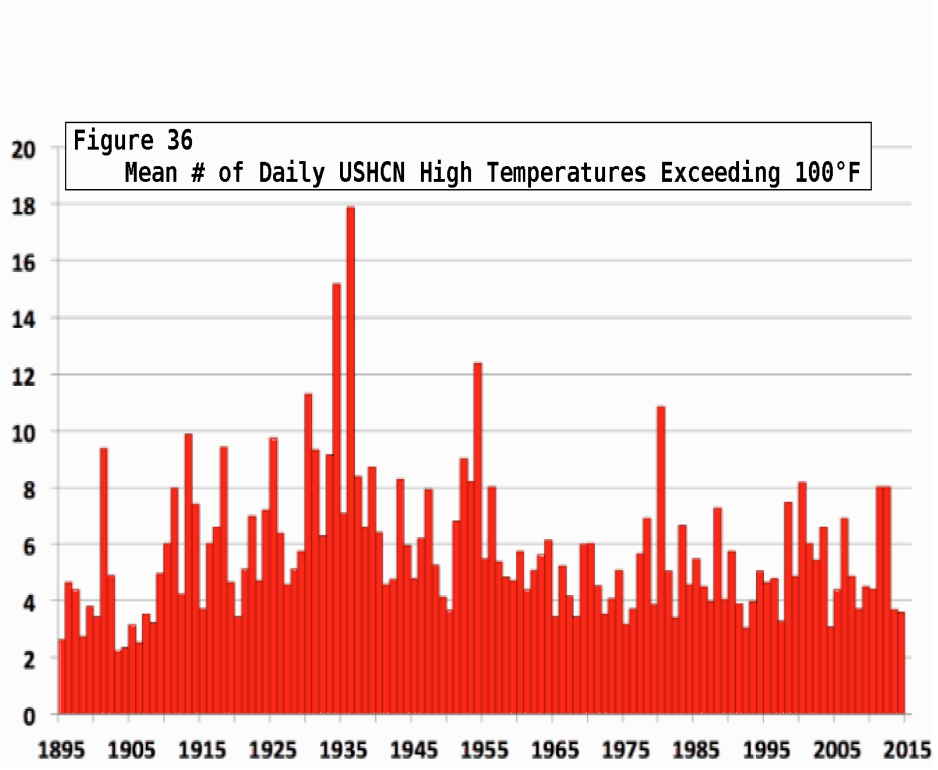
All Time State Tmax Records During Dust Bowl

Not Constant Heat Year to Year or Winter To Summer (1936 below)



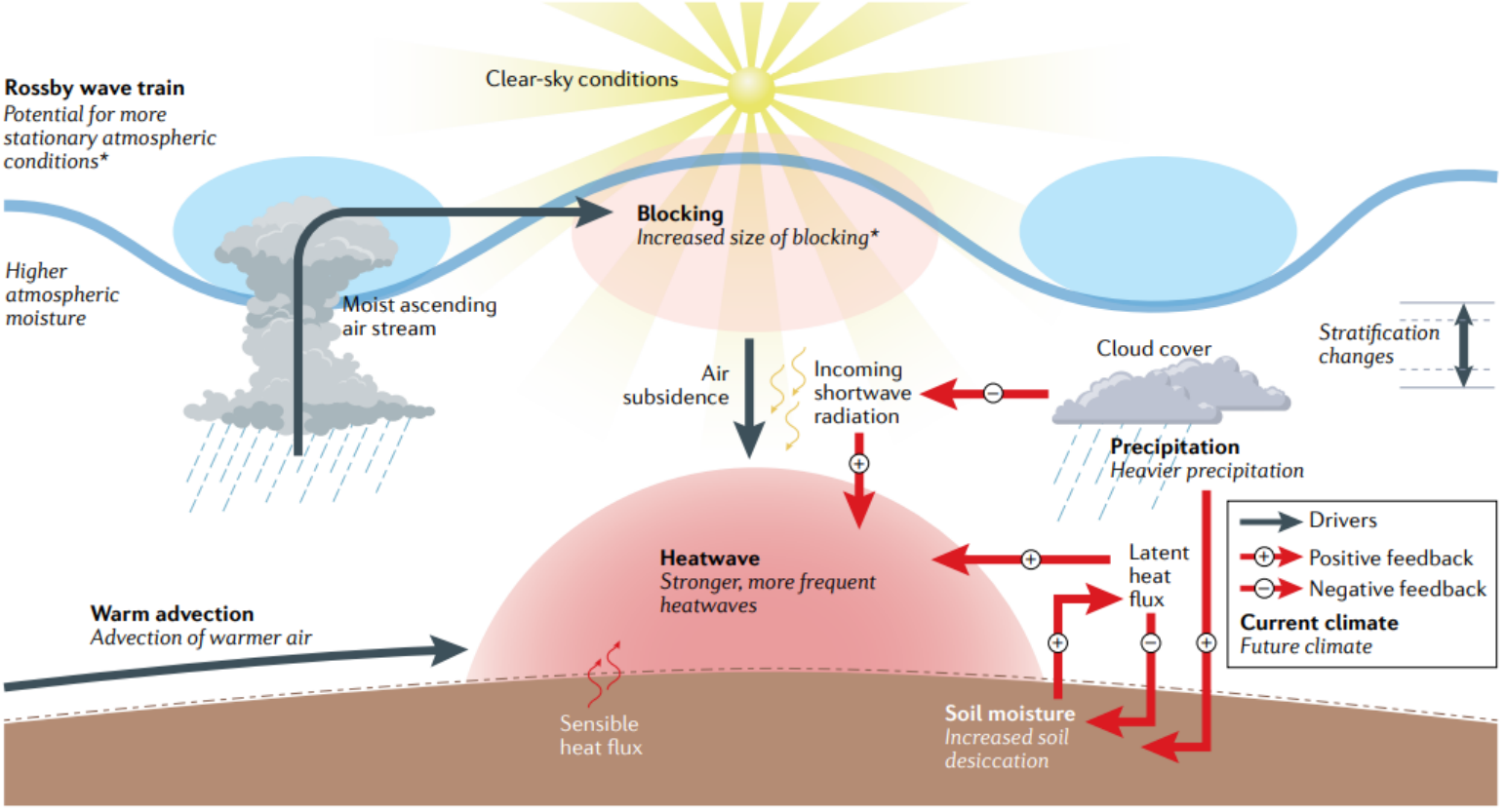


Questions And Problems About High Daily Temps

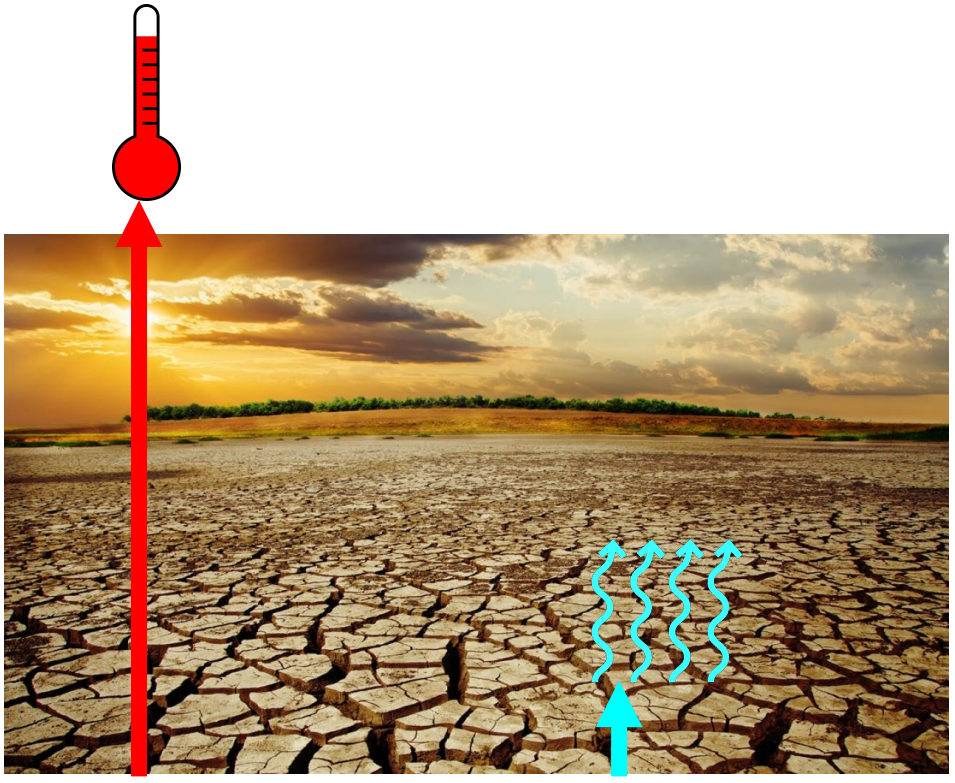


- What is the relationship between daily, monthly seasonal, annual T?
- Stations came and went
- Early stations concentrated in Great Plains & Midwest
- What was the effect of TOBS?
- What was the effect of equipment changes?

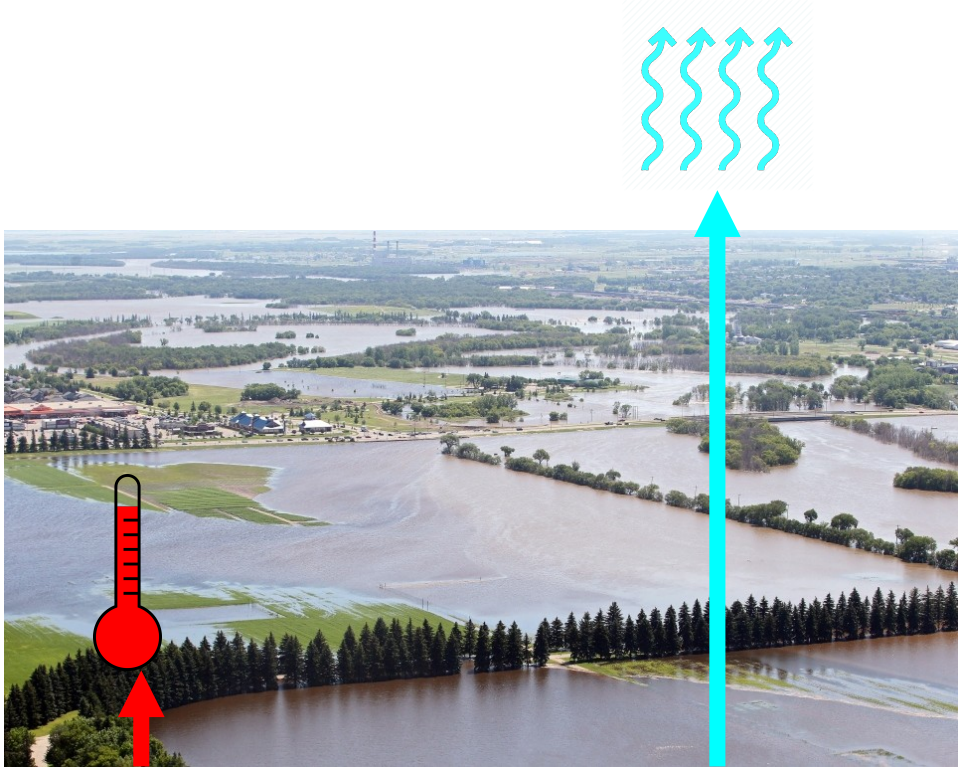
What Causes Heatwaves? (Domeisen, Nature Reviews, 2022)



Low Moisture:
High Sensible Heat
Low Latent Heat



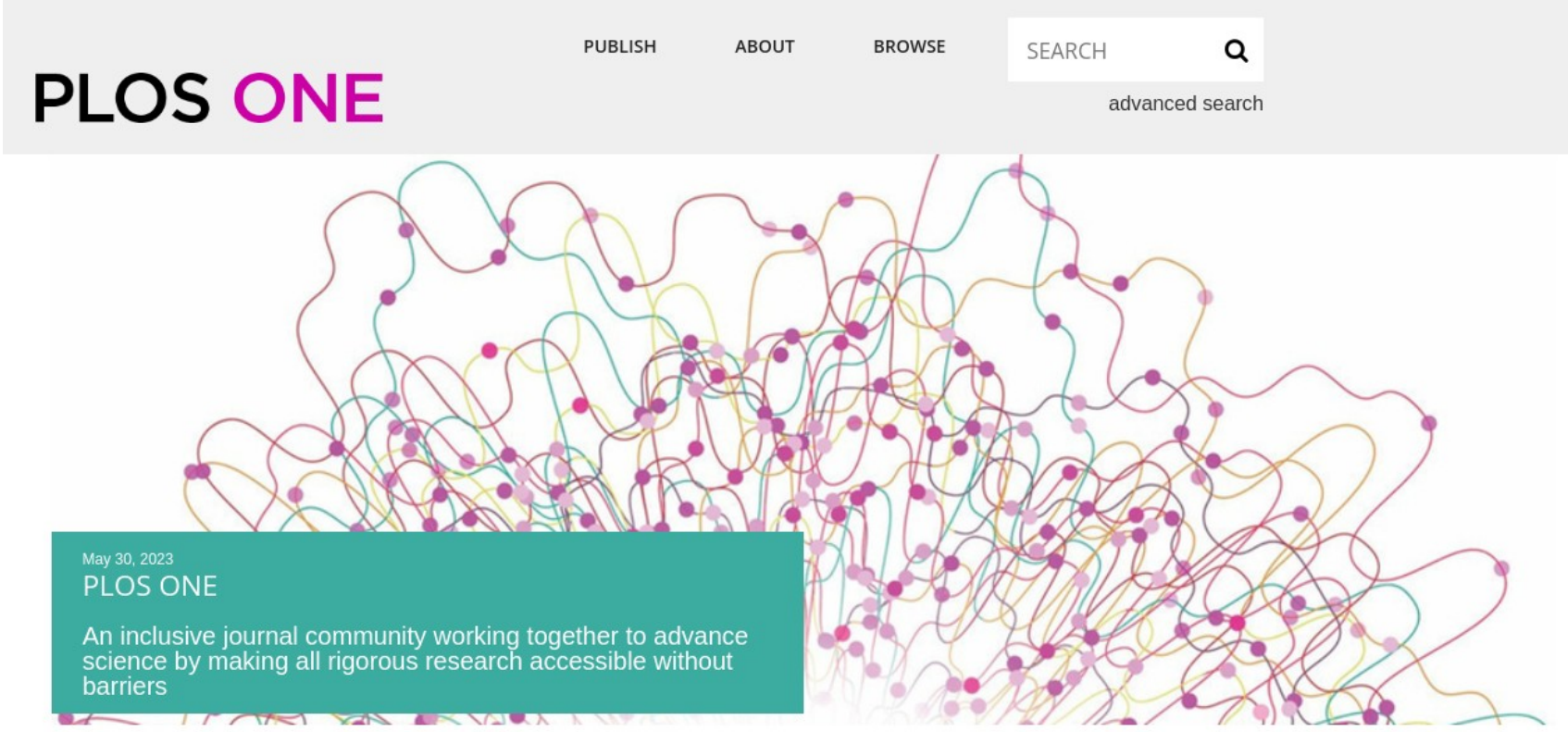
High Moisture:
Low Sensible Heat
High Latent Heat



Dust Bowl Marked By Drought, Heat & Springtime Blowing Dust

- *How did meteorological drought (low precipitation) relate to temperature during the dust bowl?*
- *How do meteorological drought and temperature correlate during all years of observation?*

After Examining USHCN Data Determined To Write Up Results in PLOS ONE



PLOS

- Public Library Of Science (peer reviewd online journal)
- *“PLOS One is built on several conceptually different ideas compared to traditional peer-reviewed scientific publishing in that* ***it does not use the perceived importance of a paper as a criterion*** *for acceptance or rejection.”*
- Submitted to PLOS ONE instead of PLOS Climate

Submitted:

Highest daily maximum surface temperature and precipitation during summer in the contiguous United States from 1930 through 2022

- Rejected for lack of novel finding
- Though rejected, experience provided a focus
- Undaunted, findings from this effort follow

Relationship Between Precipitation & Temperature During Summer

- *Madden & Williams(1978)*: Inverse **seasonal** relationship.
- *Zhao & Khalil(1993)*: Inverse relationship in **CONUS homogenized monthly means.**
- *Durre, Wallace & Lettenmaier(2000)*: "Dependence of Extreme Daily Maximum Temperatures on Antecedent Soil Moisture in the Contiguous United States during Summer." Inverse relationship, based on simple daily soil moisture **model, for 1948-1995**.
- *Trenberth & Shea (2005)*: Inverse relationship during summer for most land areas, using ERA-40 **monthly** reanalyses (**1979-2002**).
- *Mueller & Seneviratne (2012):* Inverse relationship between extreme maximum temperature during hottest month in global reanalysis (**1979-2010**).

GHNC (Global Historical Climate Network) Raw And Homogenized

- RAW Daily Observations
- Precipitation & Tmin/Tmax
- MaxMin sometimes invokes TOBS error
- Shelter/Instrument changes thought to have introduced biases
- Quality Control(flags)

- Monthly Means
- Raw or ‘Adjusted’
- Quality Control(flags)
- ‘Pairwise Homogenization’ based on trends of neighboring station
- Not falsifiable and changes with every analysis

‘Hottest Day Of Summer’

- Frequency of 100F Days (Christy above)
- Statewide All Time Records (NOAA above)
- Correlation of Extremes and Drought (*Durre, Wallace & Lettenmaier)*
- All Indicate Significance of **DAILY observations**
- Observation of highest daily maximum Tmax during June-July-August is the **‘Hottest Day Of Summer’**
- Temperature of the **‘Hottest Day Of Summer’** is not subject to the TOBS bias

Instruments & Shelters (Kunkel, AMS 2017)
Max/Min Hazen or CRS Shelters to XXX

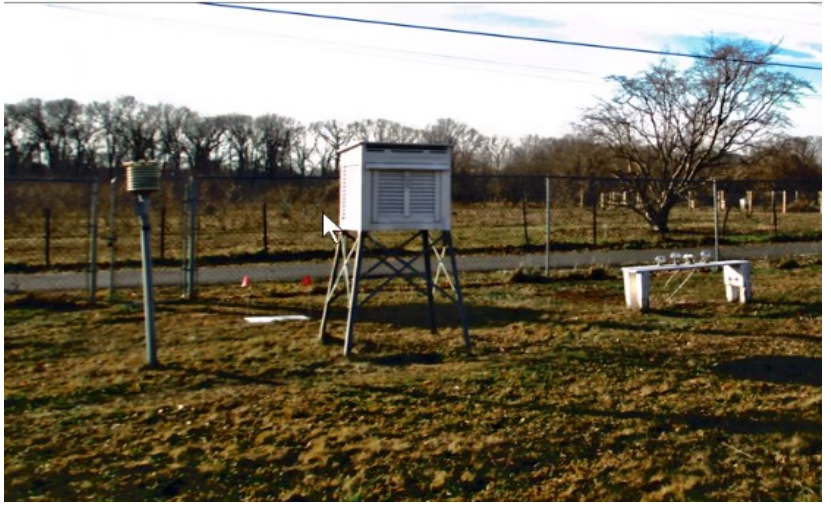
Experimental Data

- Side-by-side observations of MMTS and LIG/CRS or Hazen shelter
- Fort Collins, CO COOP site operated by Colorado State University
  - 28 years of data (Jan 1988 – Dec 2015)
- New Brunswick, NJ COOP site operated by Rutgers University
  - 20 years of data (Aug 1995 – July 2015)

Ft. Collins(Hazen) & New Brunswick (CRS)

Fort Collins site

New Brunswick site



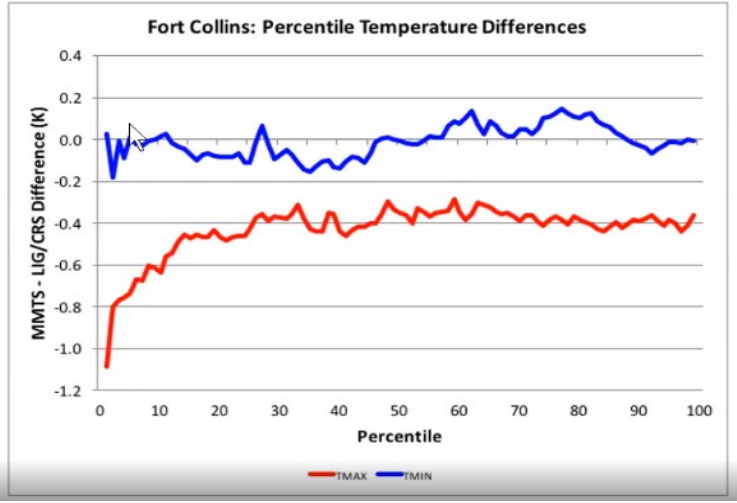
Open Slats At The Bottom Of Shelter Reflected Sunlight, IR Incident On Thermometers

~20y Side By Side Tmin(blue) & Tmax(red) MMTS Adjustment (Menne et al., 2008): HCN, After 1984, Tmax(+0.52°C), Tmin(-0.37°C)

Fort Collins Temperature Differences

Tmax: 0.43K cooler
Tmin: no difference

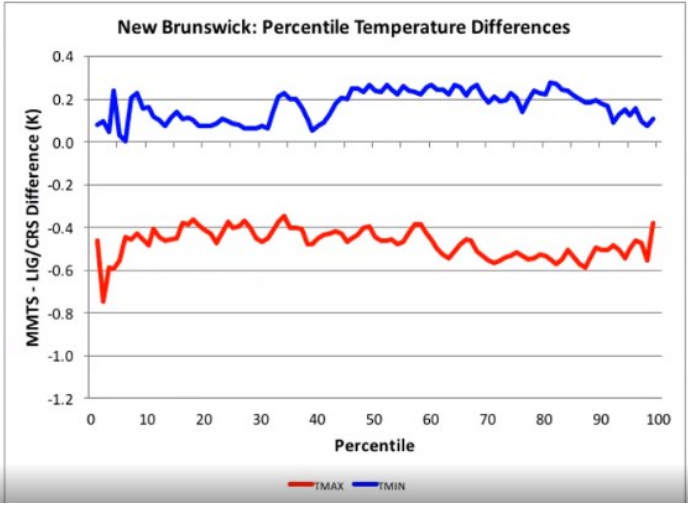
Tmax differences much larger at low percentile values



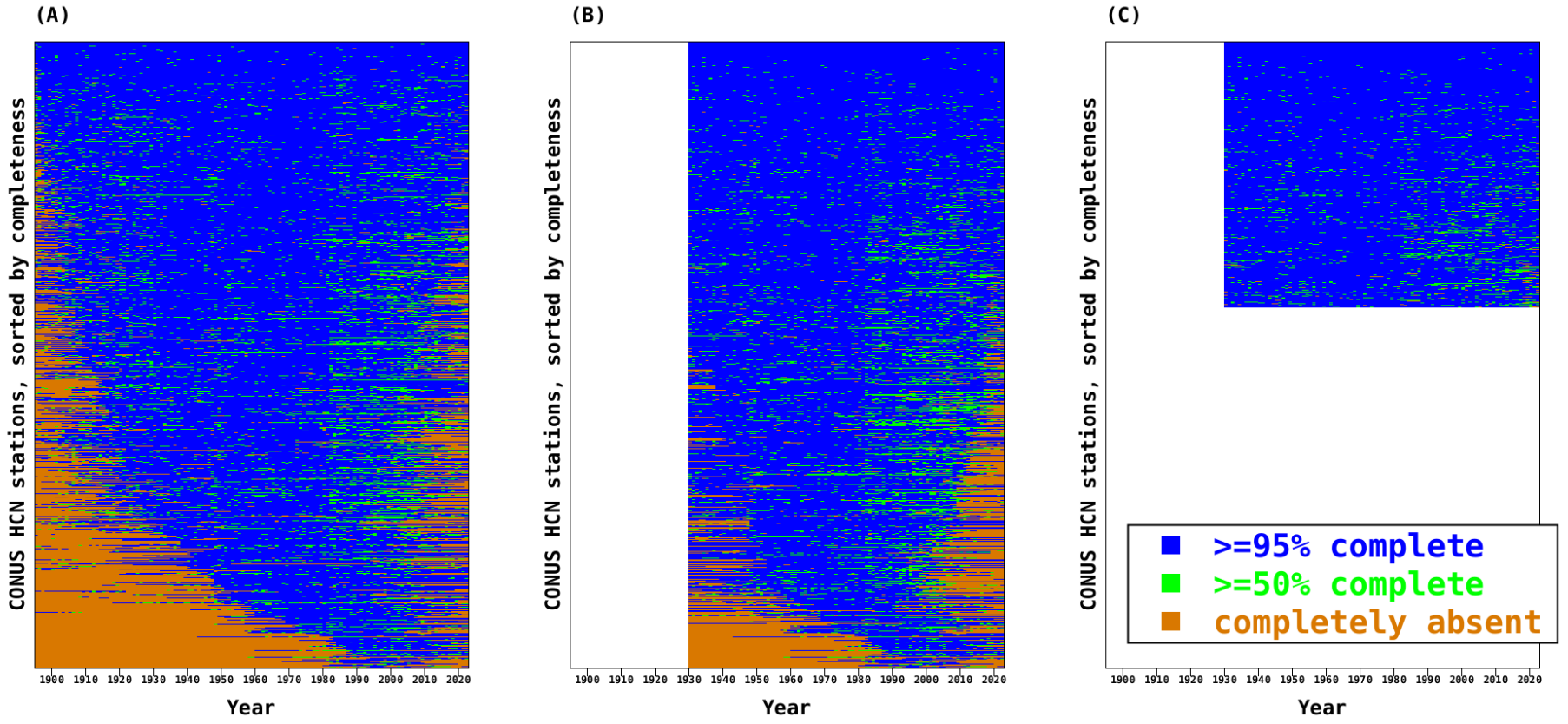
New Brunswick Temperature Diff

Tmax: 0.47 cooler
Tmin: 0.17K warmer

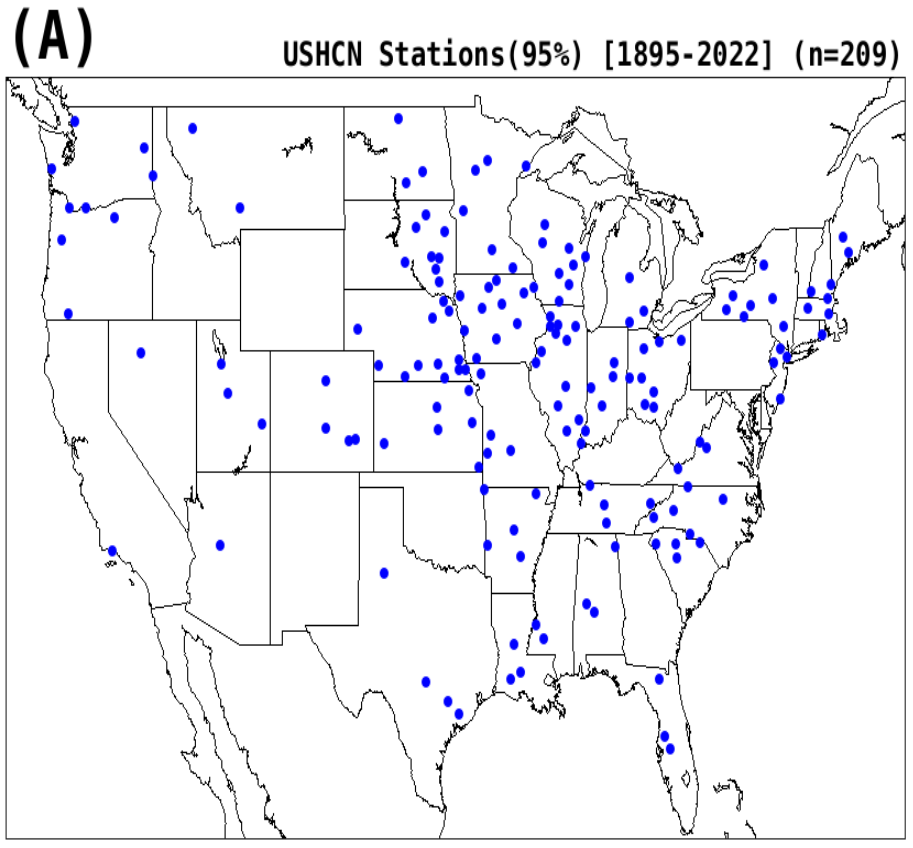
Tmax differences slightly larger at lower percentiles

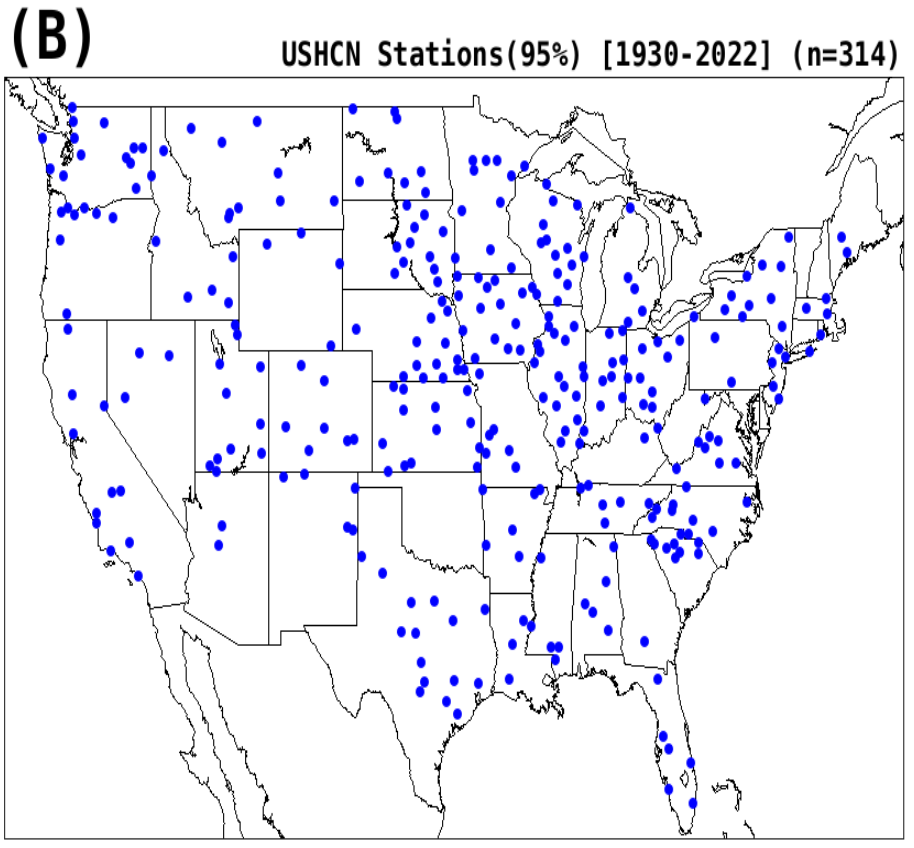


USHCN Records Are Fragmentary
Selecting For Completness Reduces Instability



Station Distribution Improves By Shortening To The Period Of Interest

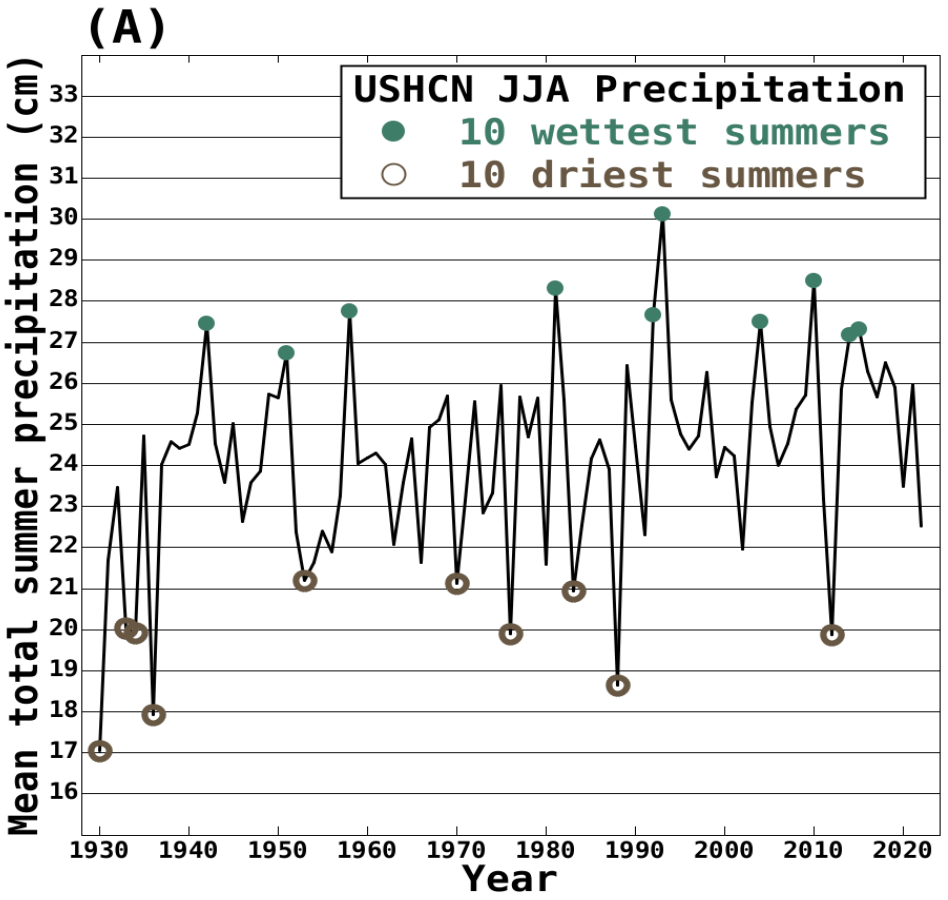


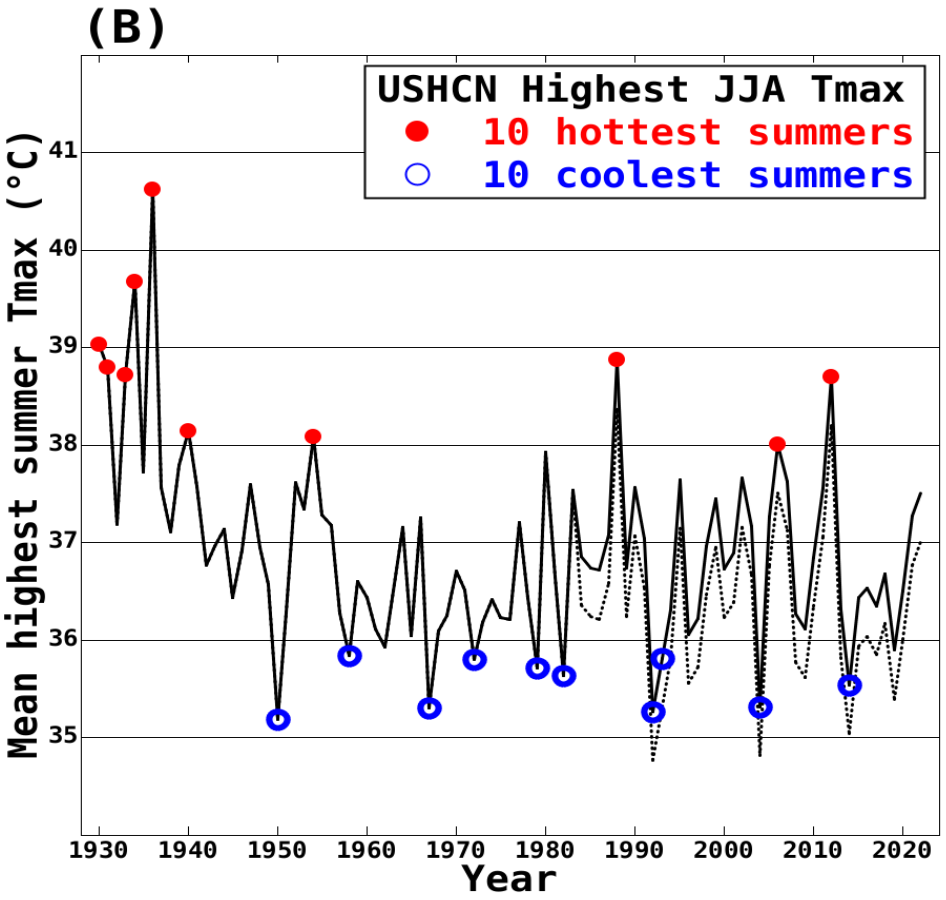


Processing

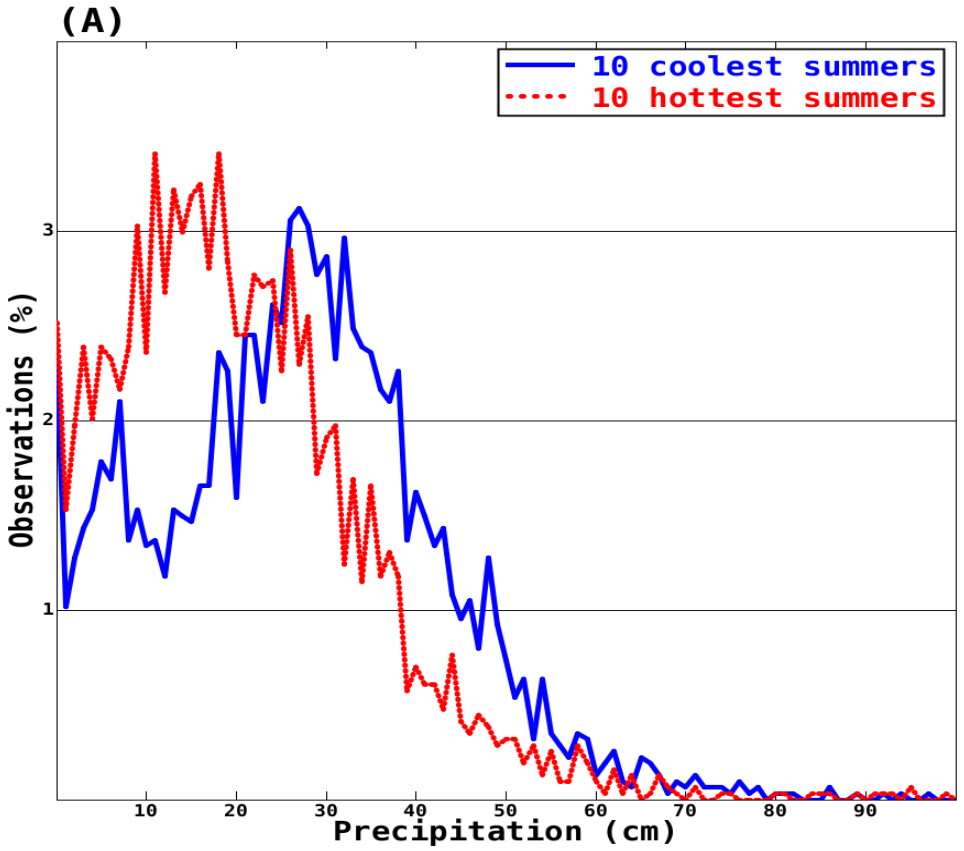
- Many stations ‘composites’- Select only **unmingled** stations (no moves > 40km)
- Read observations and exclude all observations flagged for QC
- Exclude stations < 95% complete for daily Tmax & Precip from 1930-2022
- For each station, for each year Tmax 95% complete, find highest Tmax June-July-August
- Single day Tmax is not subject to TOBS
- Adjust Tmax upward by 0.52C for obs after 1984
- For each station, for each year Precip 95% complete, find previous 10 day total precip for each day. Also sum the total JJA precip
- Exclude any 10 day precip period if missing data

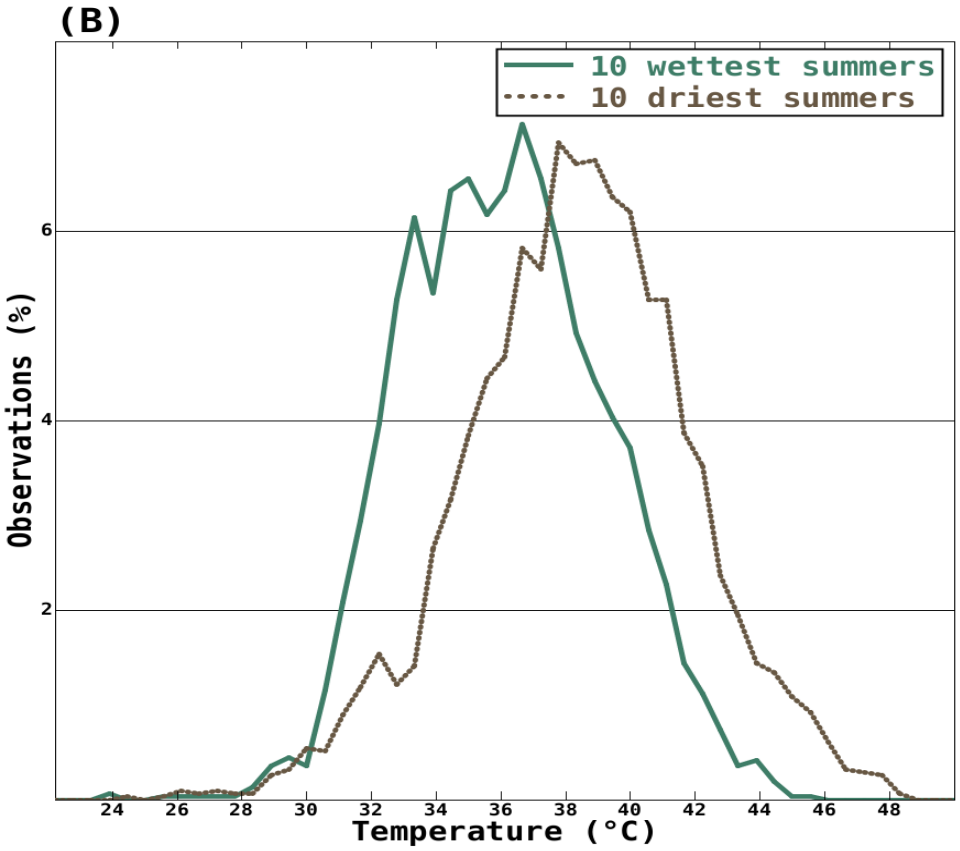
4 Of 10 Driest Summers & 5 Of 10 Hottest Summers Were During The Dust Bowl



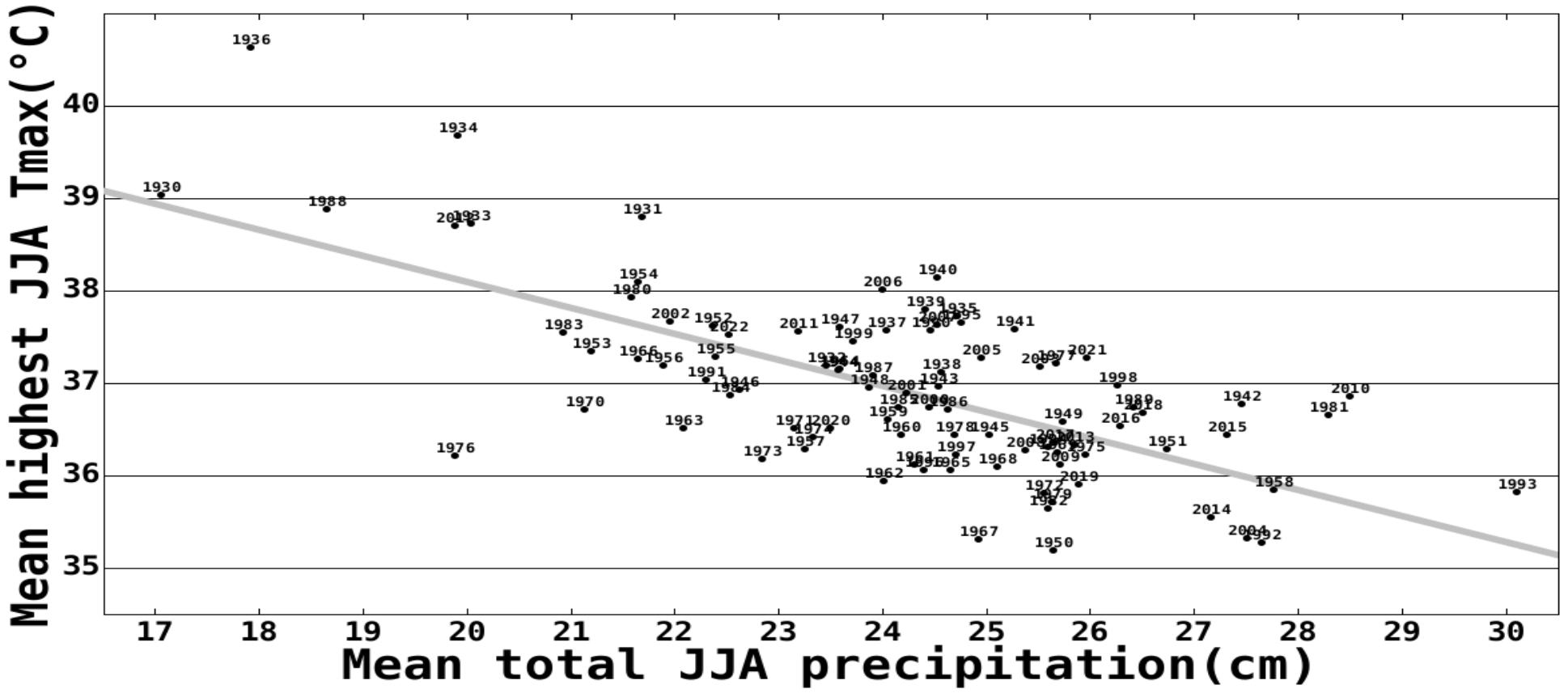


Differences Between Hottest/Coolest & Wettest/Driest Summers

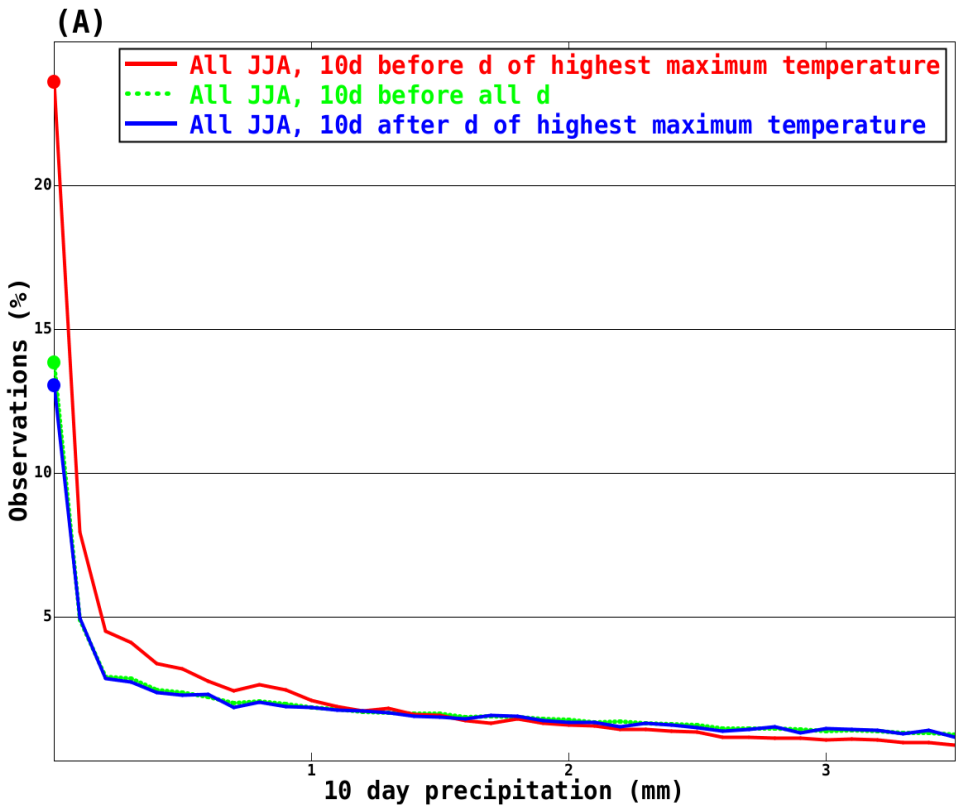


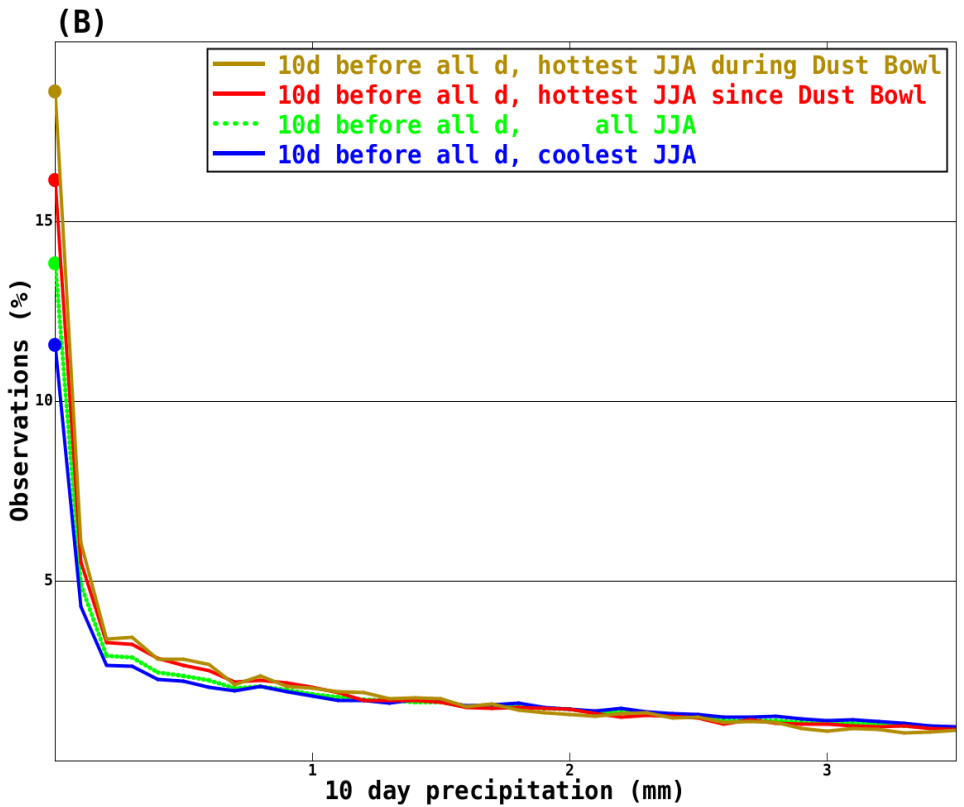


JJA Max Tmax Inversely Correlated w/ JJA Precip
-.28 °C/cm, r^2=.46, p<.0001****

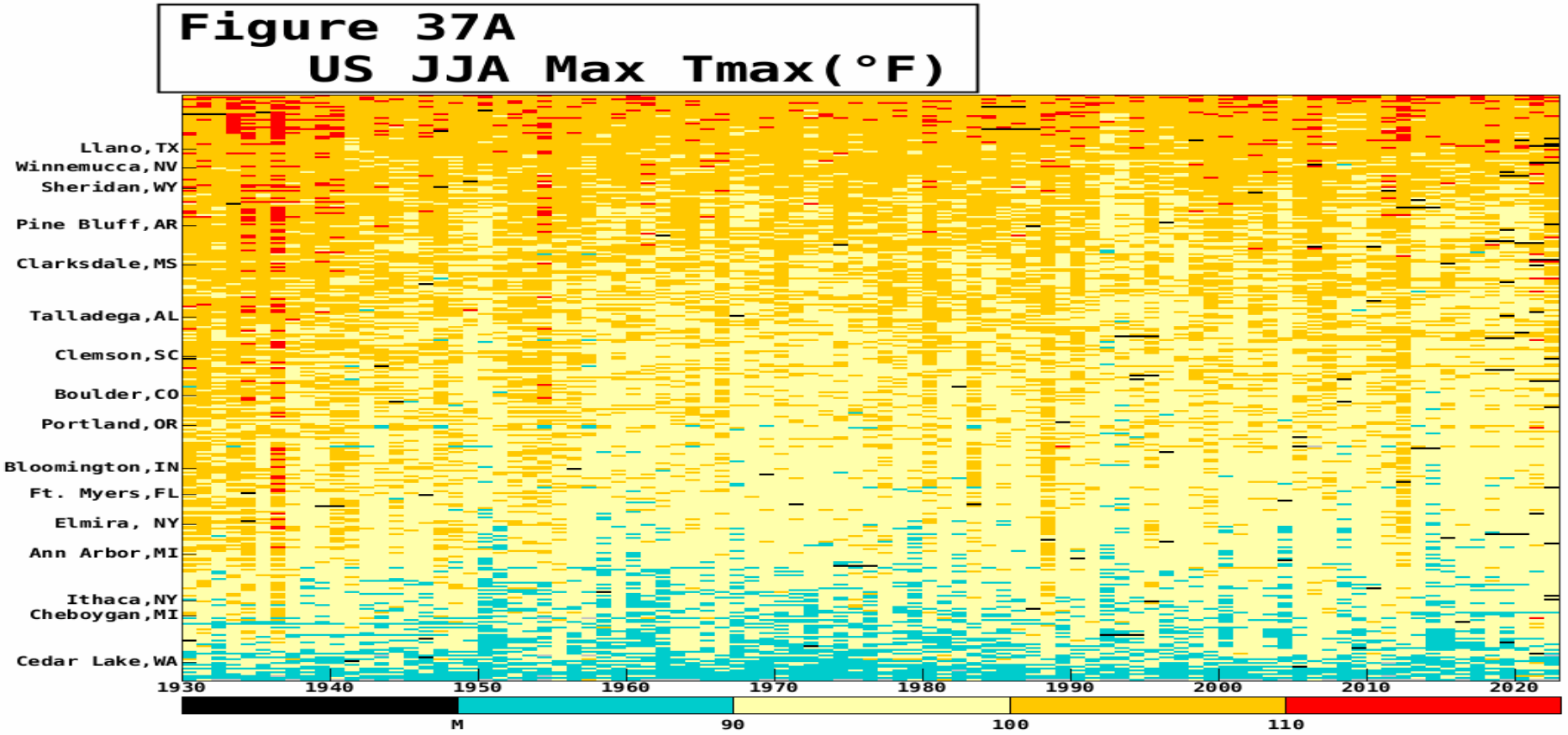


Precipitation Frequency Distributions
(A) All Summers & (B) Categorical Summers

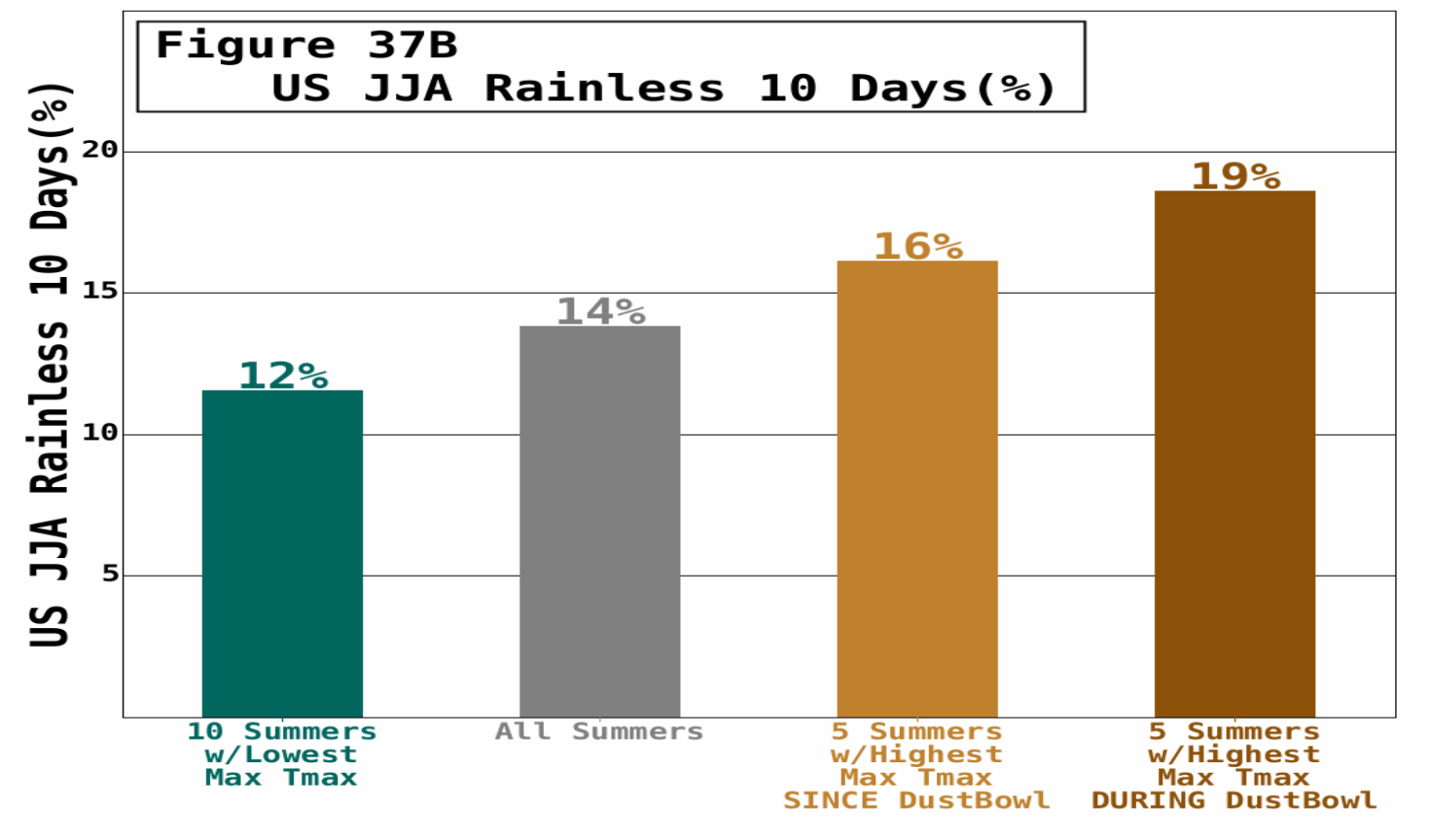




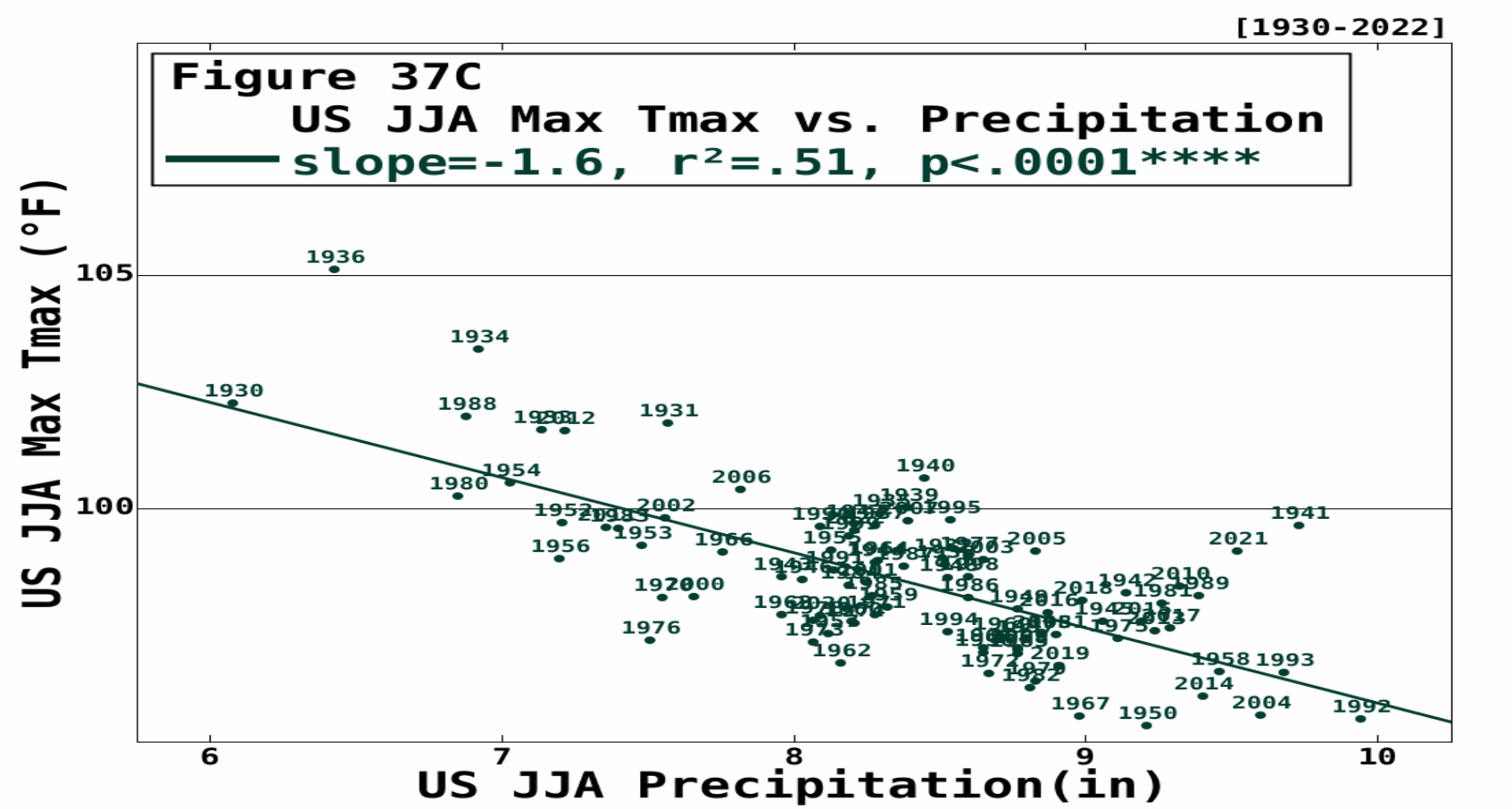
Hottest Days Of Summer [1930-2022]



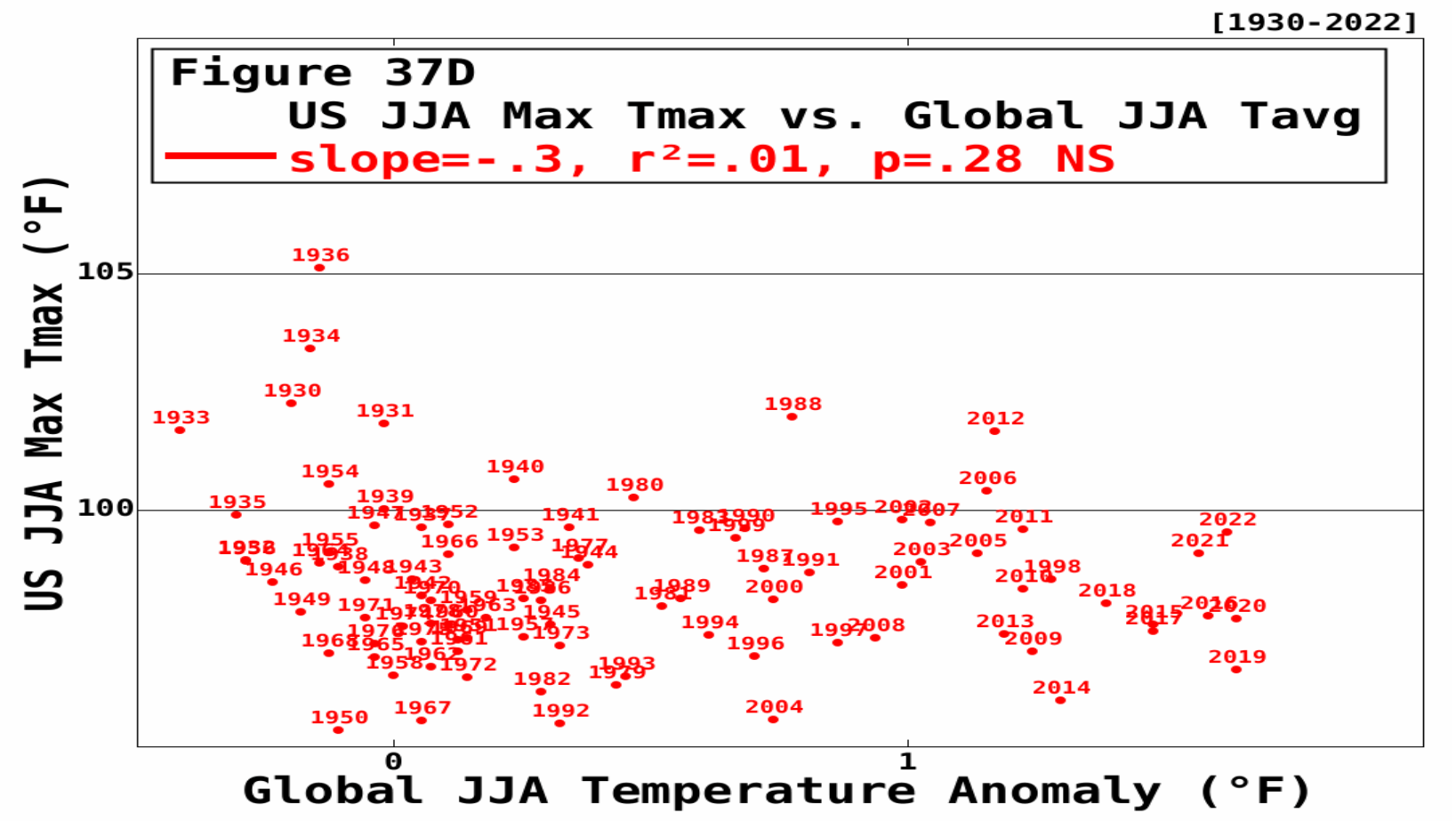
% Rainless 10d Periods Of CONUS Stations During Categorical Summers



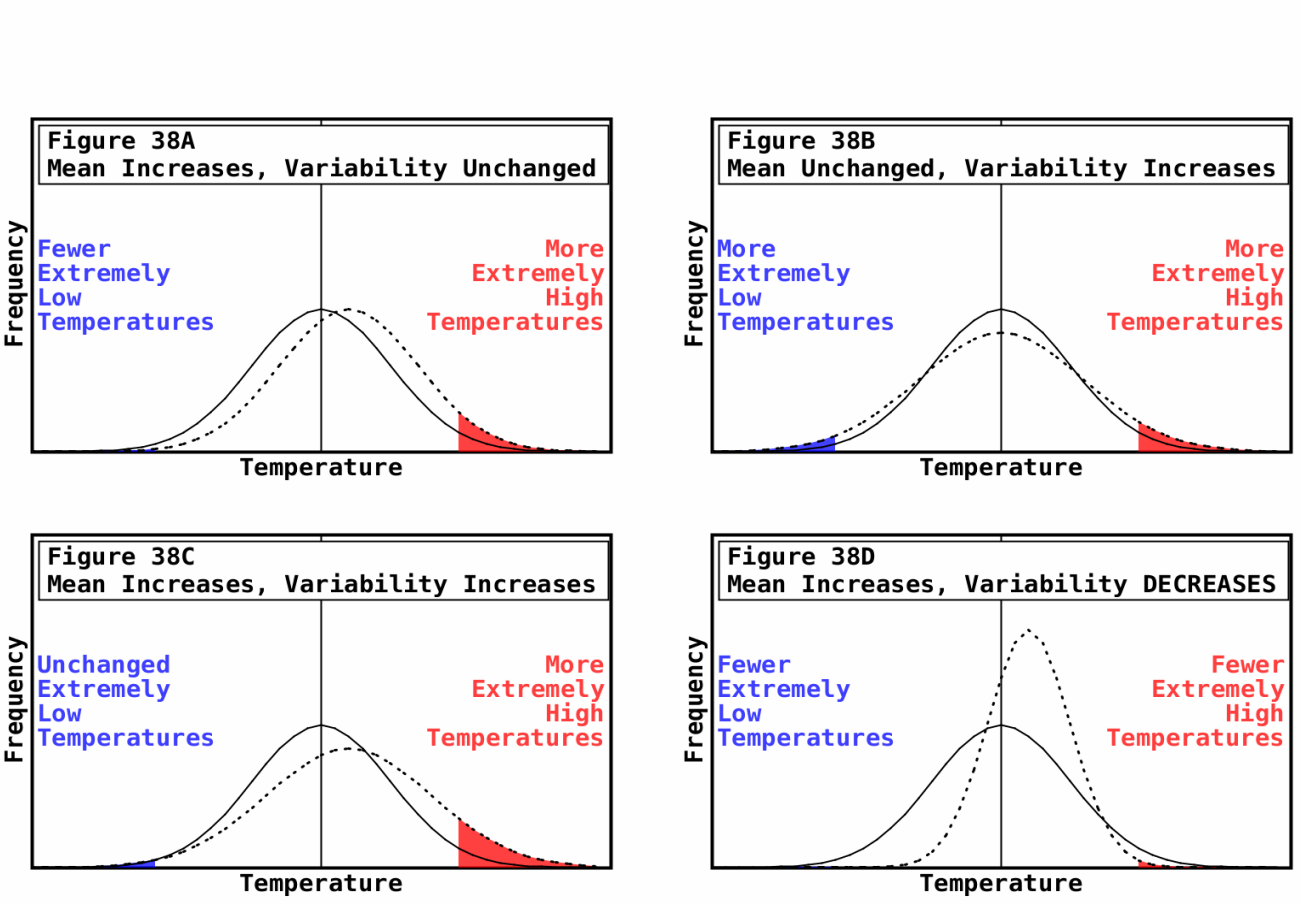
Temperatures of CONUS Hottest Days of Summer versus NCDC SW CONUS Precipitation



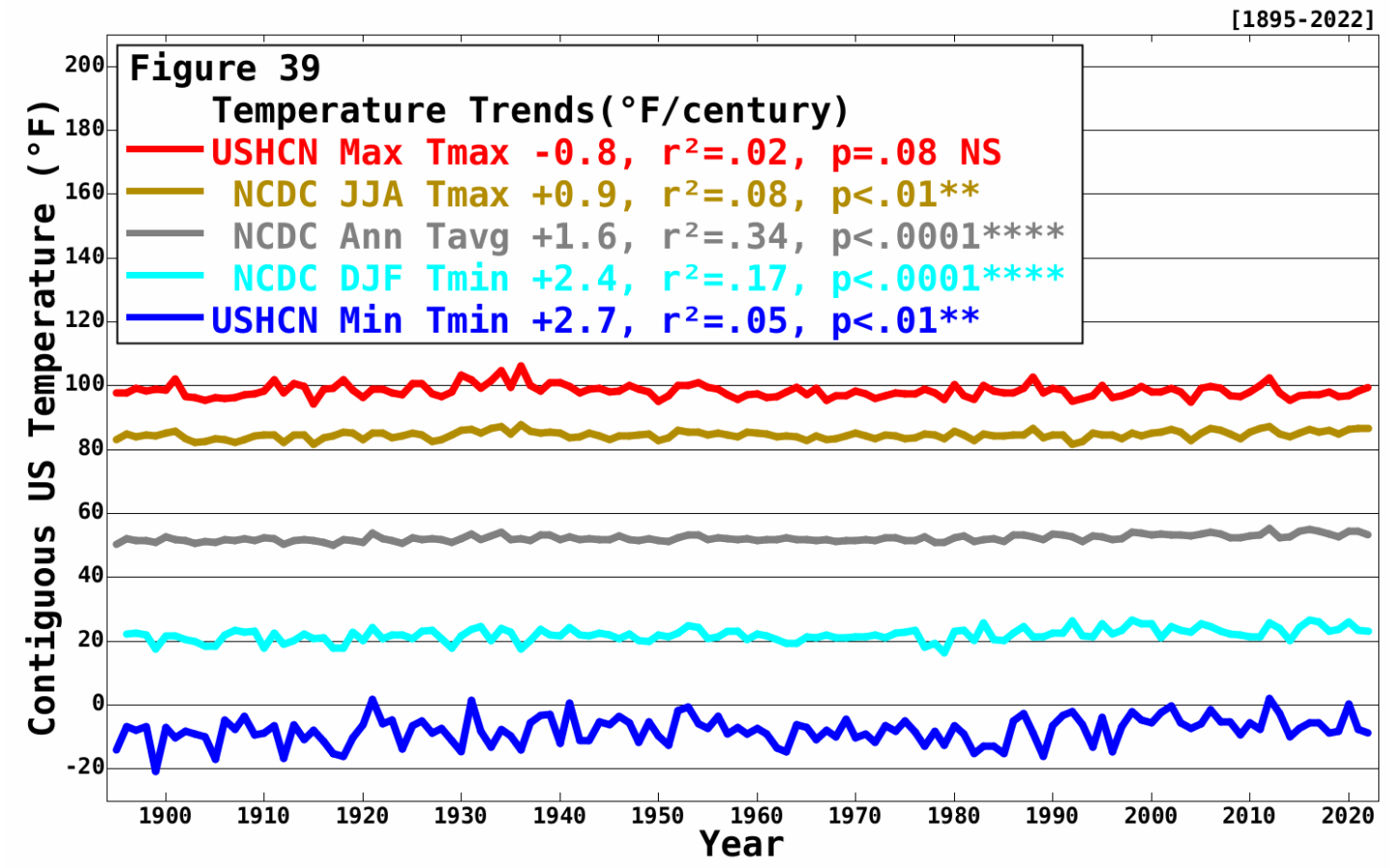
Temperatures of CONUS Hottest Days of Summer versus NCDC Global Mean JJA Temperature



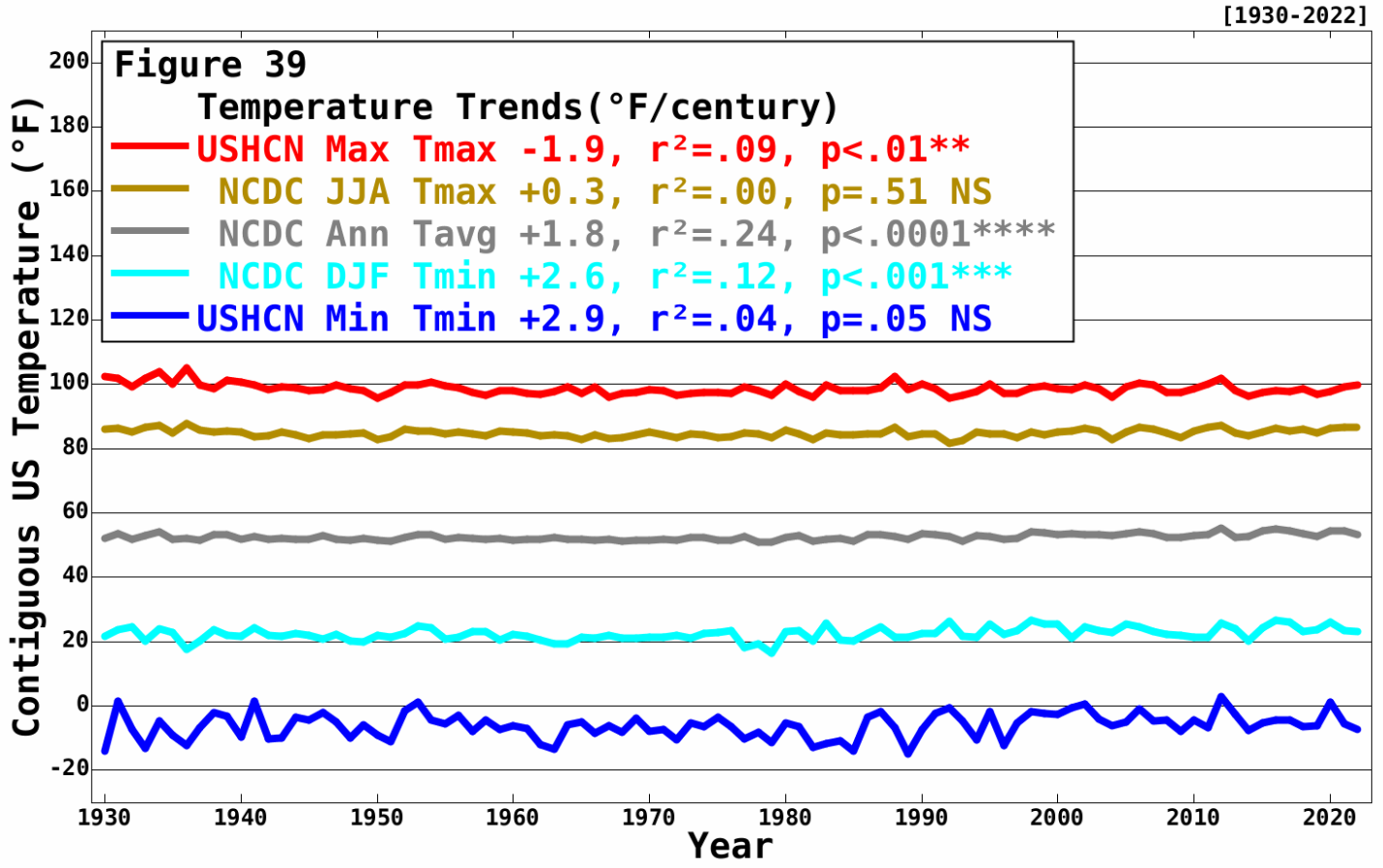
Could Global Warming Lead To a ***Less Extreme Climate?***



Annual Temperature Ranges Over CONUS



Annual Temperature Ranges Over CONUS



Conclusions

- In CONUS, four of the driest summers and five of the summers with the hottest days occurred during the Dust Bowl.
- For highly complete CONUS HCN stations, extreme high temperatures and precipitation are strongly and inversely related.

Conclusions (continued)

- For highly complete CONUS HCN stations, for all summers, the ten days preceding the hottest day of summer experienced significantly less precipitation than did the ten days preceding all days of summer.

Conclusions (continued)

- For highly complete CONUS HCN stations, for all summers, the ten days ***following*** the hottest day of summer experienced precipitation which did not differ significantly from the average day of summer.

Conclusions (continued)

- The five hottest Dust Bowl summers were more likely than the five hottest summers since the Dust Bowl to exhibit no precipitation for ten days.
- The ten coolest summers were less likely than average to experience no precipitation for ten days.

Conclusions (continued)

- Over CONUS, since 1895, the temperatures of the hottest days of summer are significantly and strongly anti-correlated with NCDC spatially weighted total summer precipitation
- Over CONUS, since 1895, the temperatures of the hottest days of summer are not statistically related to the *global* mean temperature during June-July-August.

Conclusions (continued)

- Over CONUS, for highly complete stations since 1895, the temperature trend of the hottest days of summer is not significantly different from zero.
- Over CONUS, for highly complete stations since 1930, temperatures of the hottest days of summer indicate a significant negative trend.
- Over CONUS, for highly complete stations since 1895, the difference of temperatures between the ***hottest days of summer*** and the ***coldest nights of winter*** appears to have decreased, that is, **temperatures have become less extreme**.

Conclusions (continued)

- Over CONUS, for highly complete stations since 1895, temperature trends are greatest for
  - The Single Coldest Night Of Winter, followed by
  - All Nights Of Winter, followed by
  - Mean Temperature Of All Days of the Year, followed by
  - All Days Of Summer, followed by
  - The Single Hottest Day Of Summer
- These trends are consistent with decreased temperature variability

- **References and Further Reading**

- Madden RA, Williams J (1978) The Correlation between Temperature and Precipitation in the United States and Europe. Monthly Weather Review 106: 142-147.
- Zhao W, Khalil MAK (1993) The Relationship between Precipitation and Temperature over the Contiguous United States. J Clim 6: 1232-1236.
- Durre I, Wallace JM, Lettenmaier DP (2000) Dependence of Extreme Daily Maximum Temperatures on Antecedent Soil Moisture in the Contiguous United States during Summer. J Clim 13: 2641-2651.
- Trenberth KE, Shea DJ (2005) Relationships between precipitation and surface temperature. Geophys Res Lett 32: L14703
- Mueller B, Seneviratne S (2012) Hot days induced by precipitation deficits at the global scale. Proc Natl Acad Sci USA 109: 12398-12403.
- Stephens PH, (1937) Why the Dust Bowl? Journal of Farm Economics 19: 750–57.
- Lee JA and Gill TE, (2015) Multiple causes of wind erosion in the Dust Bowl. Aeolian Research 19: 15-36.
- Geiger R (1935) If it Rains.... The Evening Star, Washington D.C. April 15, 1935, p. A-2.
- NOAA National Centers for Environmental Information, Climate Monitoring - Extremes (2023). Available from: https://www.ncei.noaa.gov/access/monitoring/scec/records/all/tmax
- Lawrimore J (2018) Thomas Jefferson and the telegraph: highlights of the U.S. weather observer program.
- National Oceanic and Atmospheric Administration, National Weather Service (2023) Cooperative Observer Program (COOP). https://www.weather.gov/coop/overview.
- Menne MJ, Durre I, Vose RS, Gleason BE, Houston TG (2012) An Overview of the Global Historical Climatology Network-Daily Database. J Atmos Ocean Technol 29:7 897–910.
- Menne MJ, Durre I, Korzeniewski B, McNeill S, Thomas K, Yin X, Anthony S, Ray r, Vose RS, Gleason BE, and Houston TG (2012) Global Historical Climatology Network - Daily (GHCN-Daily), Version 3.29 NOAA National Climatic Data Center. Accessed February 2, 2023. Available from: http://doi.org/10.7289/V5D21VHZ
- Global Historical Climatology Network daily (GHCNd). National Centers for Environmental Information, National Oceanic and Atmospheric Administration. Available from: https://www.ncei.noaa.gov/products/land-based-station/global-historical-climatology-network-daily#tab-298
- Austin JF and McConnell A (1980) James Six F.R.S.. Two Hundred Years of the Six’s Self-Registering Thermometer. Notes and Records of the Royal Society of London 35:1 49–65.
- Doesken NJ (2005) The National Weather Service MMTS (Maximum-Minimum Temperature System) -- 20 years after. Am Meteorol Soc, 15th Conference on Applied Climatology and 13th Symposium on Meteorological Observations and Instrumentation.
- Kunkel KE, Doesken NJ, Robinson DA, Gerbush MR, Ryan WA (2017) The Switch to MMTS Has Changed Extreme Temperature Trends. Am Meteorol Soc 23rd Conference on Applied Climatology. Available from: https://ams.confex.com/ams/23Applied/videogateway.cgi/id/38442?recordingid=38442&uniqueid=Paper318878&entry_password=303942
- Menne MJ, Williams CN, Vose RS (2009) The U.S. Historical Climatology Network monthly temperature data, version 2. Bull Am Meteorol Soc 90: 993-1007.
- Domeisen DIV, Eltahir EAB, Fischer EM, et al (2023) Prediction and projection of heatwaves. Nat Rev Earth Environ 4: 36–50