How the Great Plains Dust Bowl Drought of the 1930s affected heat extremes over North America and elsewhere in the Northern Hemisphere

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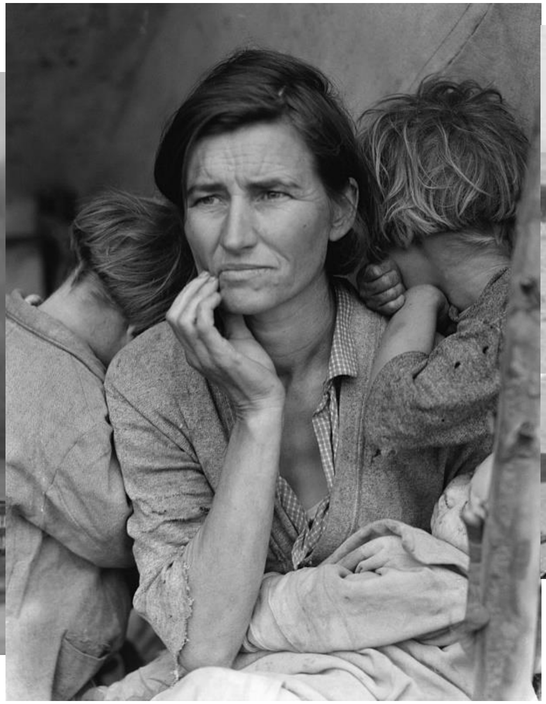
The Dust Bowl Drought of the 1930s (1932-39) was one of the worst natural disasters of the 20th century

A dust storm approaching Rolla, Kansas, May 6, 1935. (Image: Franklin D. Roosevelt Library Digital Archives)



Dorothea Lange’s Migrant Mother, March 1936

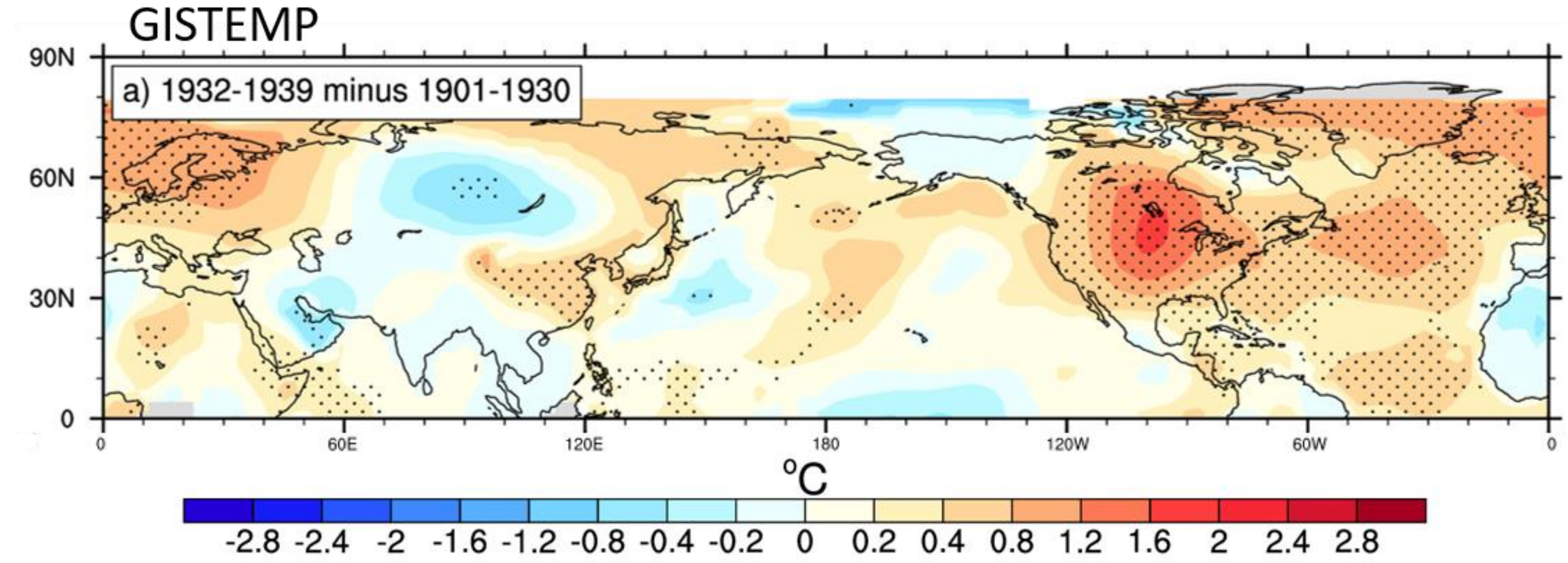
A Dust Bowl farmer digs out a fence post to keep it from being buried under drifting sand in Cimarron County, Okla., in 1936.
(Arthur Rothstein/Library of Congress)

The Dust Bowl drought is thought to have been caused by a combination of negative IPO in the tropical Pacific and positive AMO in the Atlantic that forced an anomalous Rossby wave train over North America to produce a naturally-occurring drought (Schubert et al., 2004, Science; 2009; Herweijer and Seager, 2008) along with associated heat extremes (Cowan et al., 2017, J. Clim.)

It was **made much worse by disastrous land use practices** where the Great Plains were essentially plowed up and then dried up to produce tremendous dust storms; the dryness and dust are thought to have intensified the drought and heat extremes (Cook et al., 2009, PNAS; Cook et al., 2011, Cli. Dyn., Cowan et al., 2017, J. Clim.)

But it was not just the Great Plains that were hot during the 1930s

Anomalous heat extended over much of North America, northeastern Europe and northeastern Asia



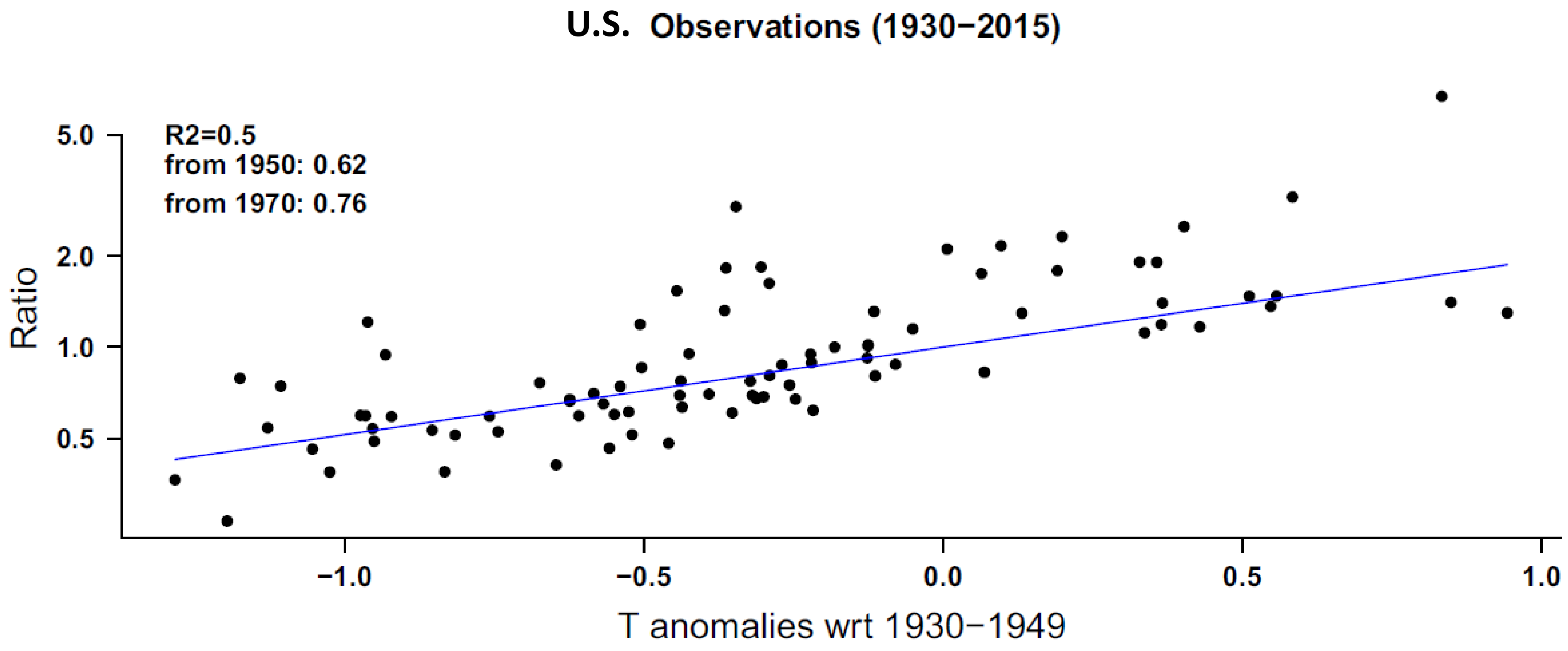
What about heat extremes?

Think of temperature extremes in terms of daily records at a weather station

In a stationary climate, ratio of record high maxima to record low minima at a given location should be roughly 1.0 (equal chances of setting a daily record high maximum or daily record low minimum)

However, average climate has been warming, and the ratio averaged over the U.S. is now about 2 to 1; we are now twice as likely to set a record high maximum at a given location than a record low minimum

(Meehl, Tebaldi, Walton, Easterling and McDaniel., 2009, *GRL*)



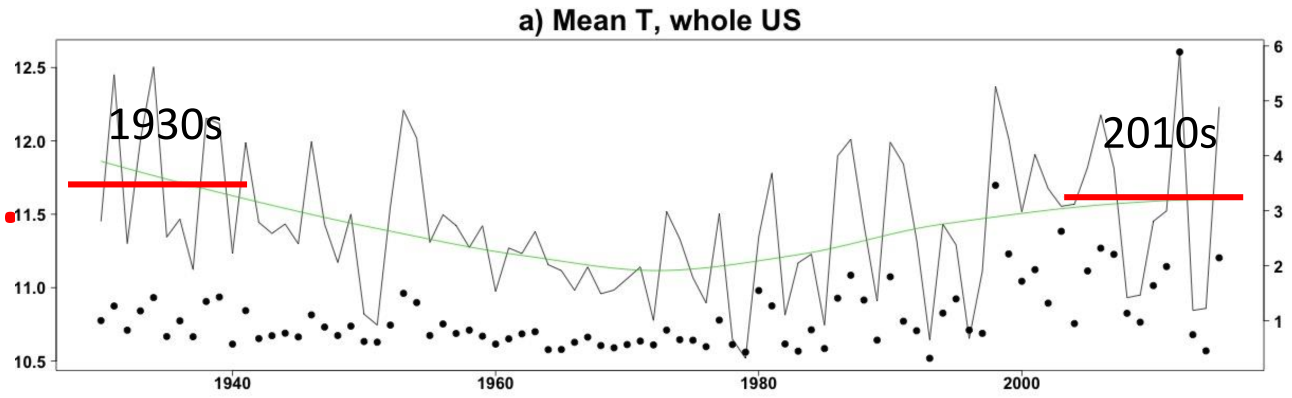
Greater warming means larger records ratio

with projected future warming, the ratio will continue to increase (ever more increasing numbers of daily record high maxima and less daily record low minima)

(Meehl, Tebaldi, and Adams-Smith, 2016, *PNAS*)

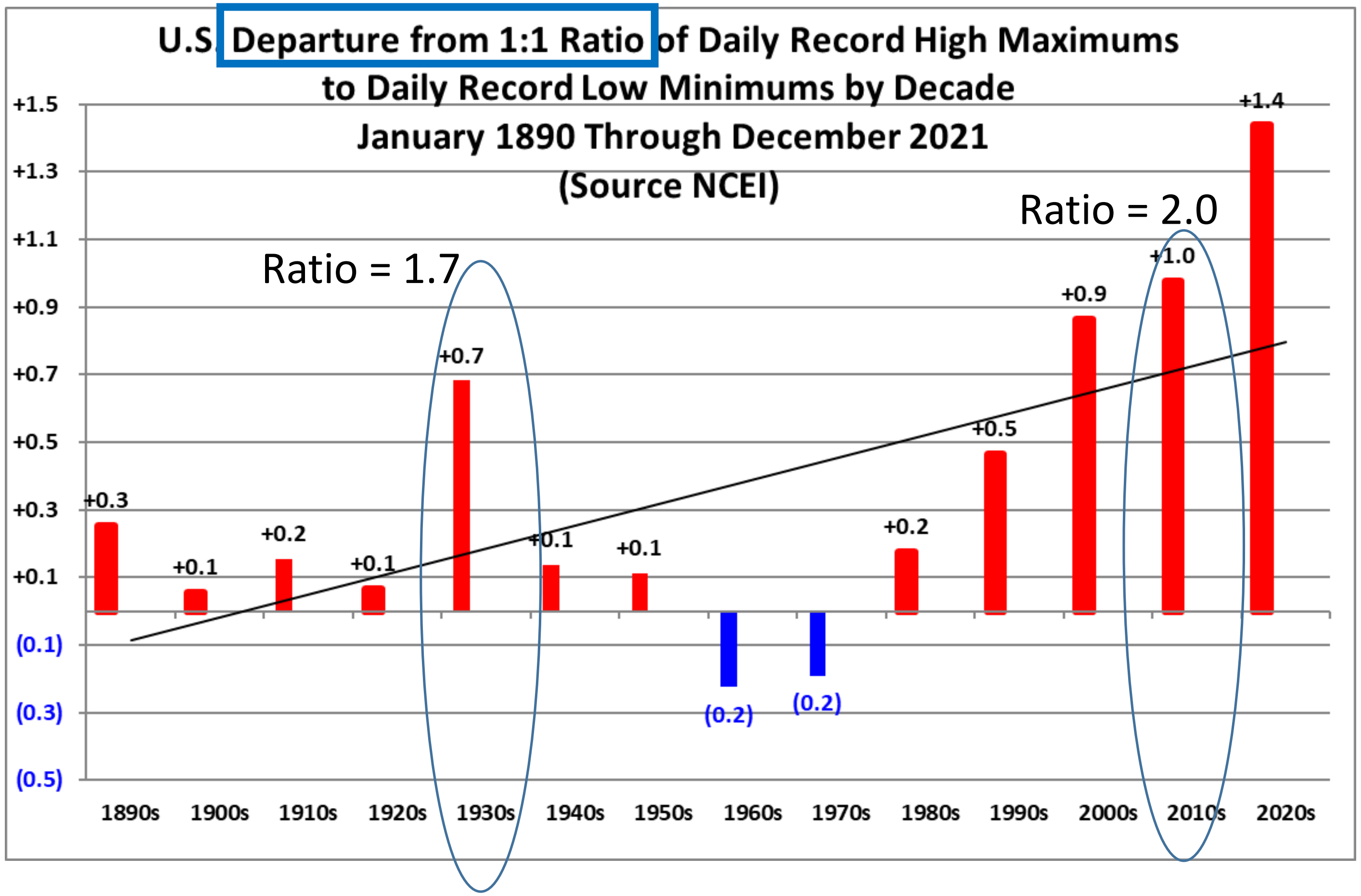
The 1930s Dust Bowl era was exceptionally warm over the U.S.

It has been only in the last two decades that U.S. mean temperatures have approached the warmth of the 1930s, and many heat records set during the 1930s have stood until recently



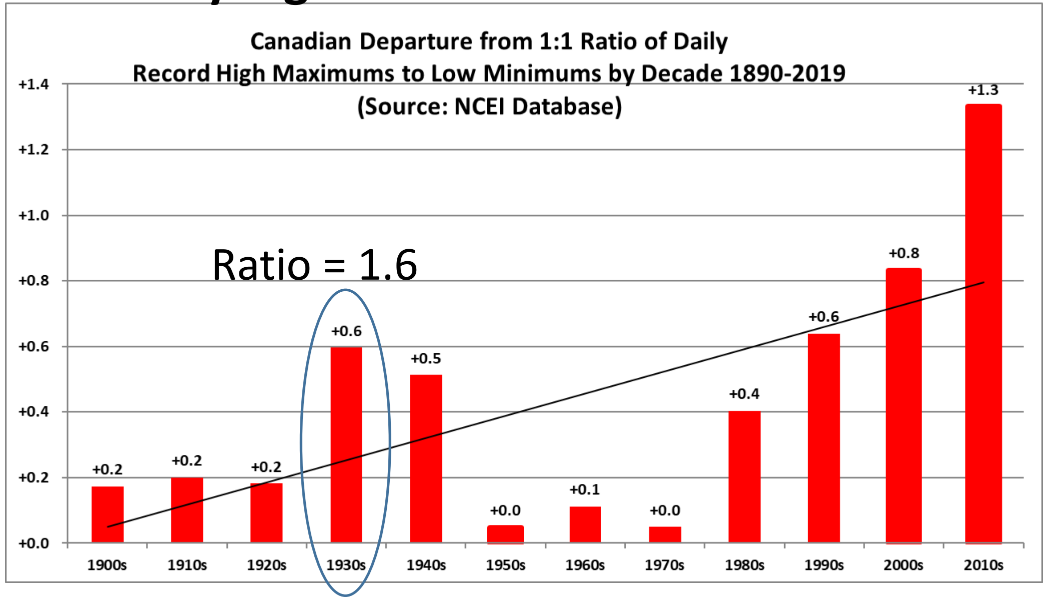
(Meehl, Tebaldi, Adams-Smith, *PNAS*, 2016)

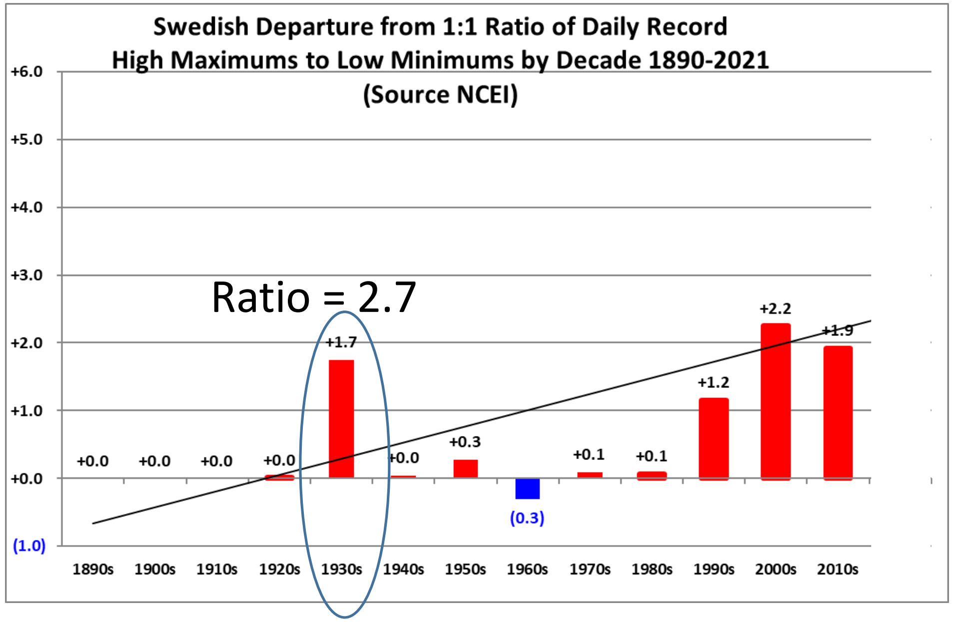
Given the warmth of the 1930s that approaches recent warming, we would expect greater heat extremes represented by large amplitude records ratios in the 1930s and more recently

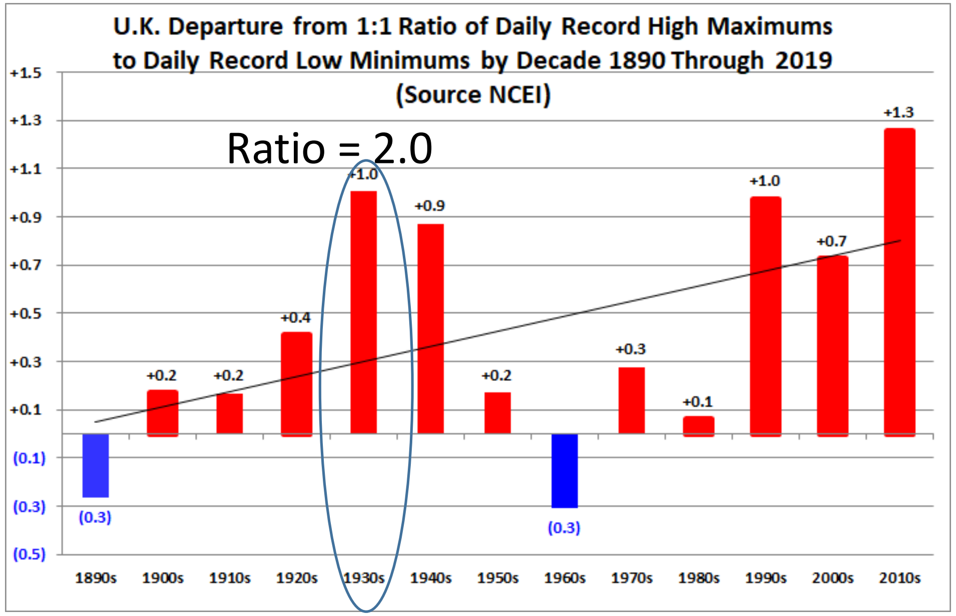


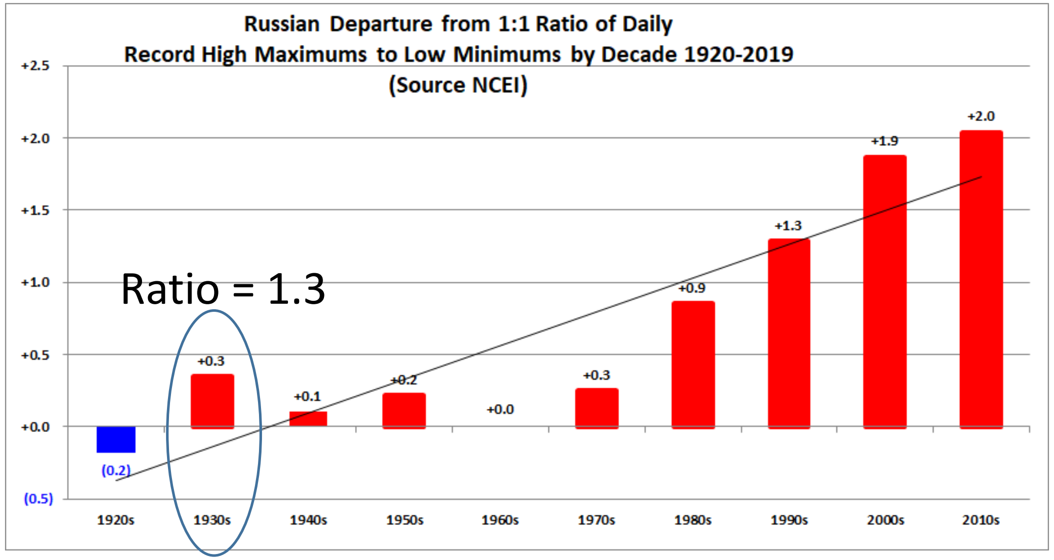
[Records data from NOAA National Centers for Environmental Information (NCEI)](https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.ncdc:C00781)
https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.ncdc:C00781

Other areas in the Northern Hemisphere that were anomalously warm during the 1930s also had relatively high records ratios indicative of extreme heat









Though tropical Pacific and Atlantic SSTs likely caused the Dust Bowl drought with disastrous land use and consequent dust aerosols intensifying it, could the resulting extreme land surface conditions themselves affect total U.S. mean temperature and heat extremes?

Could the drought by itself have affected mean warming, dry conditions, and heat extremes over other areas of the Northern Hemisphere?

Analyze a climate model sensitivity experiment:

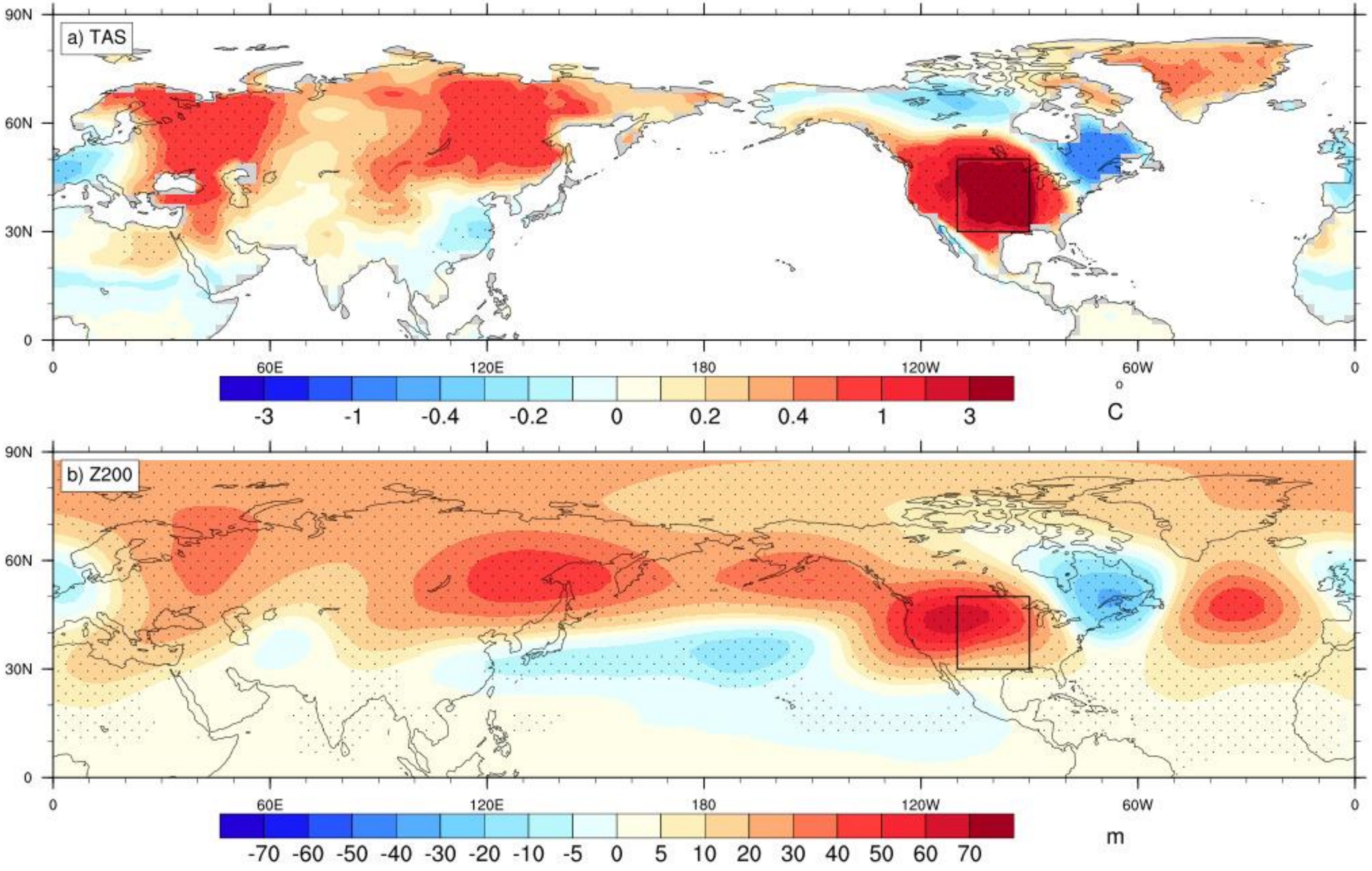
Set soil moisture over the Great Plains to zero in atmosphere-only CAM5

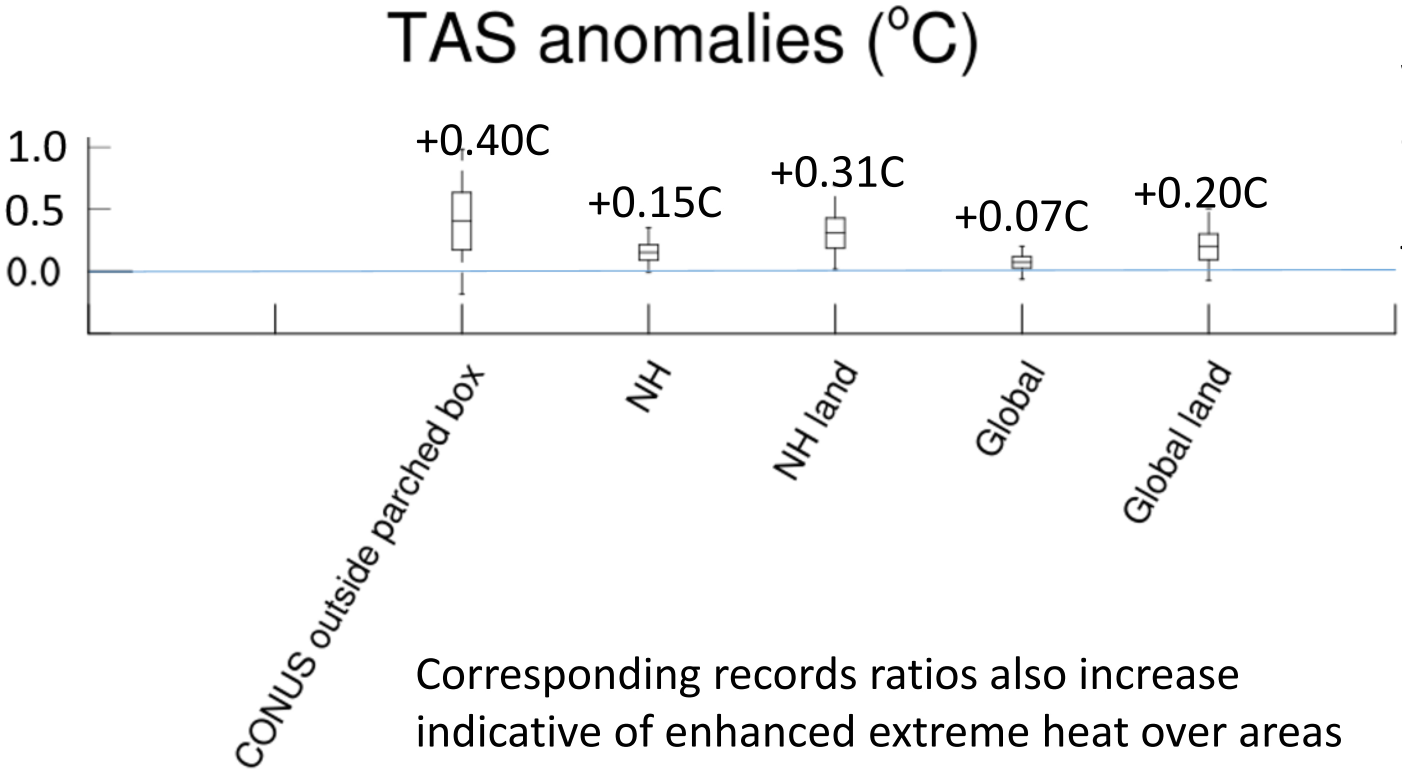
Land surface fully coupled outside the Great Plains; climo SSTs specified

Run 100 ensemble members May through August
Compare to long control run;
averages shown for May-June-July-August season

(Teng et al., 2019, J. Climate)

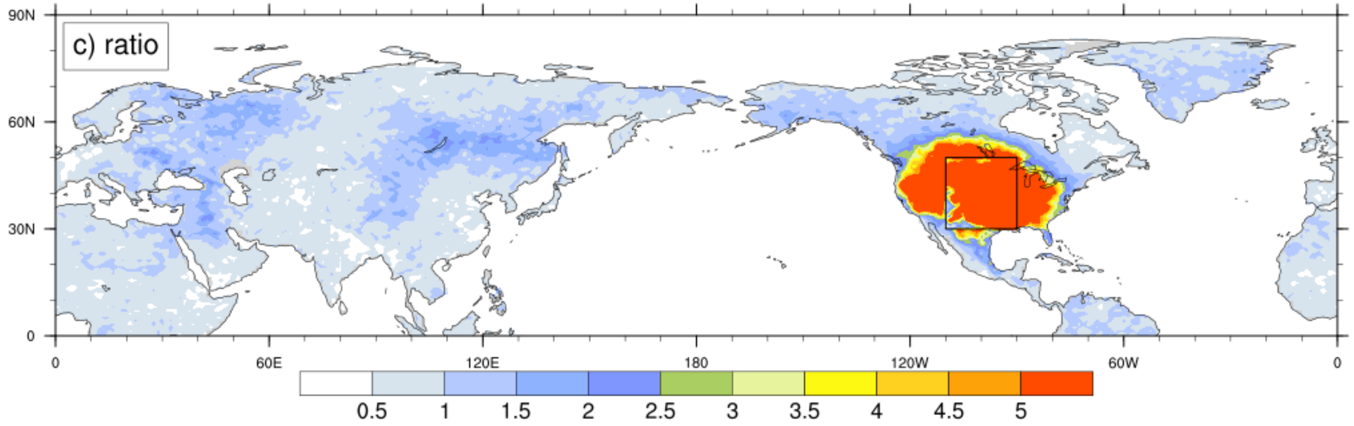
Great Plains drought in the sensitivity experiment produces warming outside the Great Plains box over much of North America, northeastern Europe and northeastern Asia with a wave-5 anomalous upper level response at 200 hPa; this hemispheric-scale response is forced by the anomalous lower tropospheric heating over the Great Plains (Teng et al., 2019, J. Clim.)

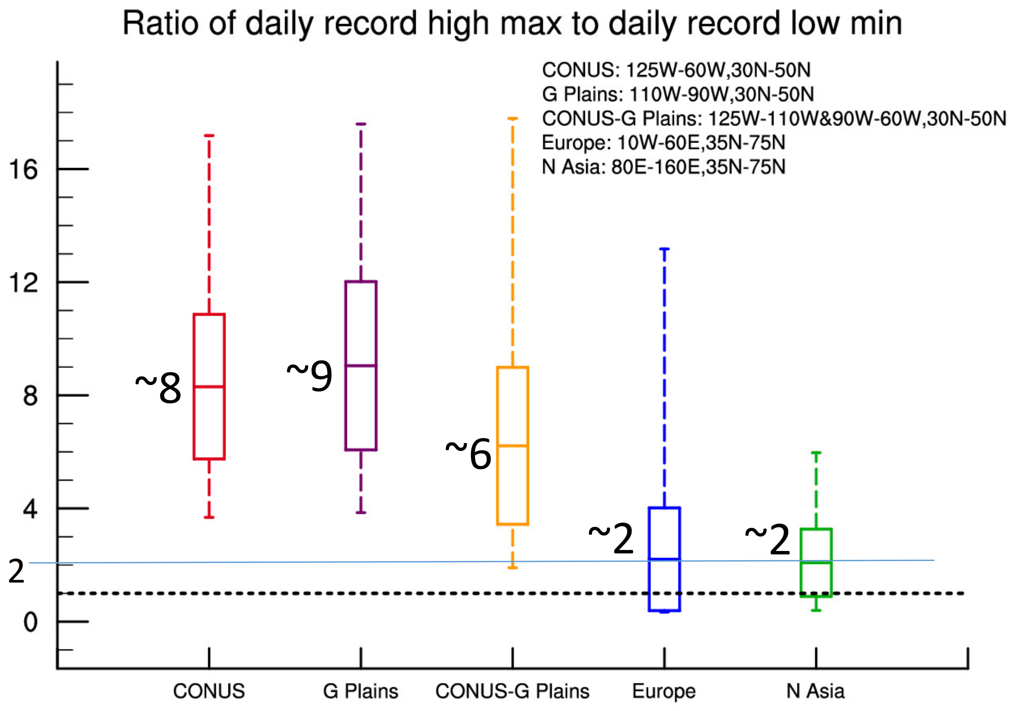




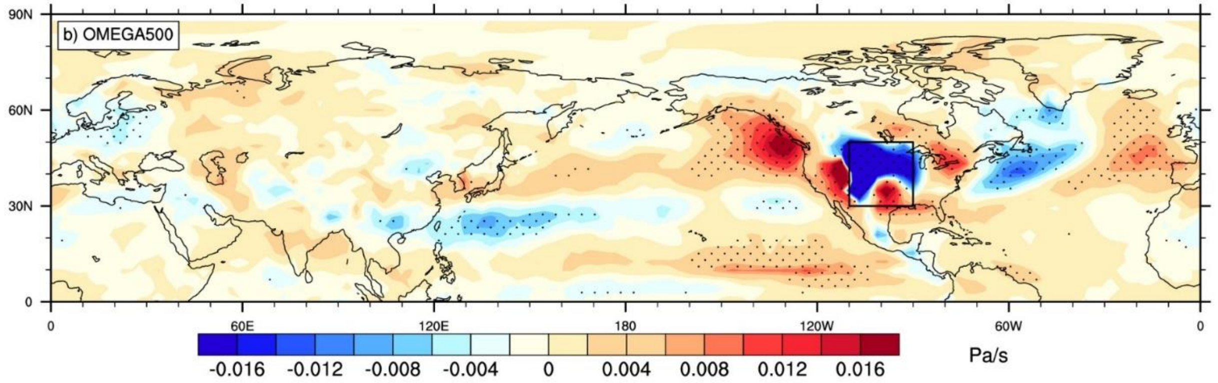
Warming over the Great Plains box in the sensitivity experiment is 4.4°C, but extends outside the Great Plains box with significant warming over the rest of the Northern Hemisphere and globally

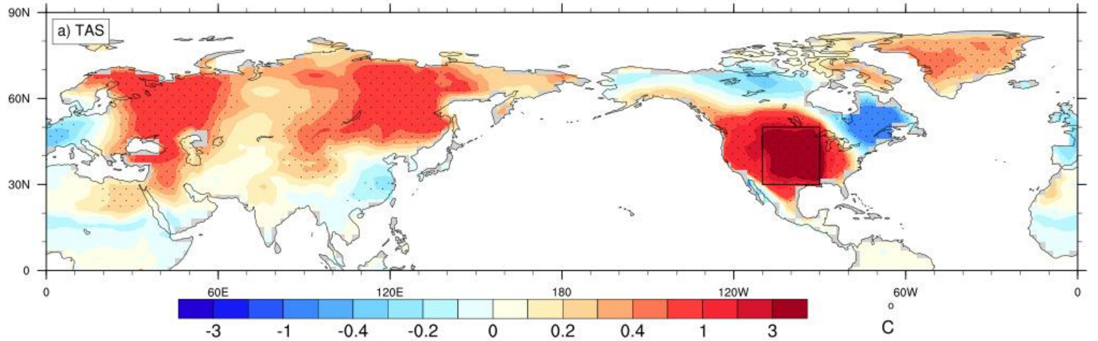
Corresponding records ratios also increase indicative of enhanced extreme heat over areas that warm

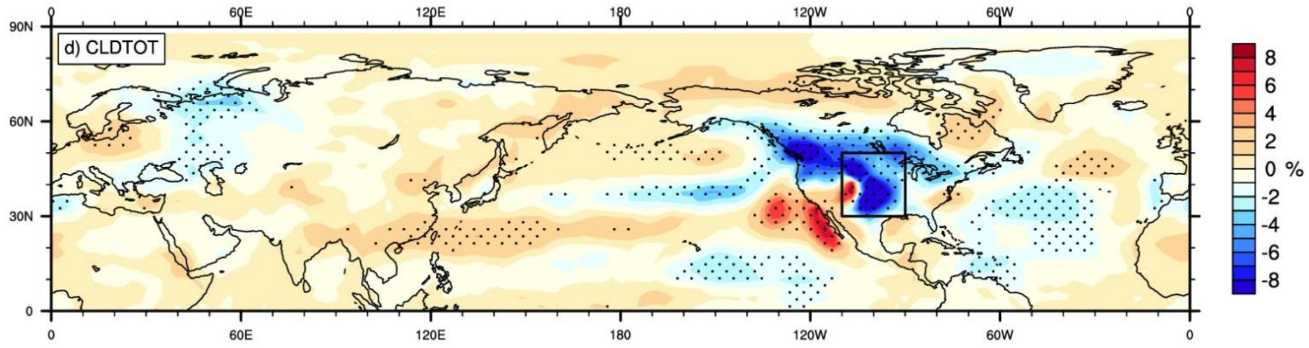


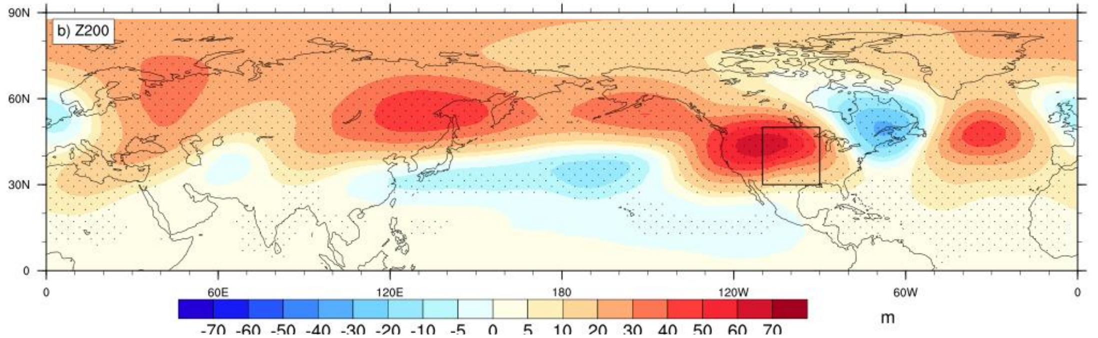


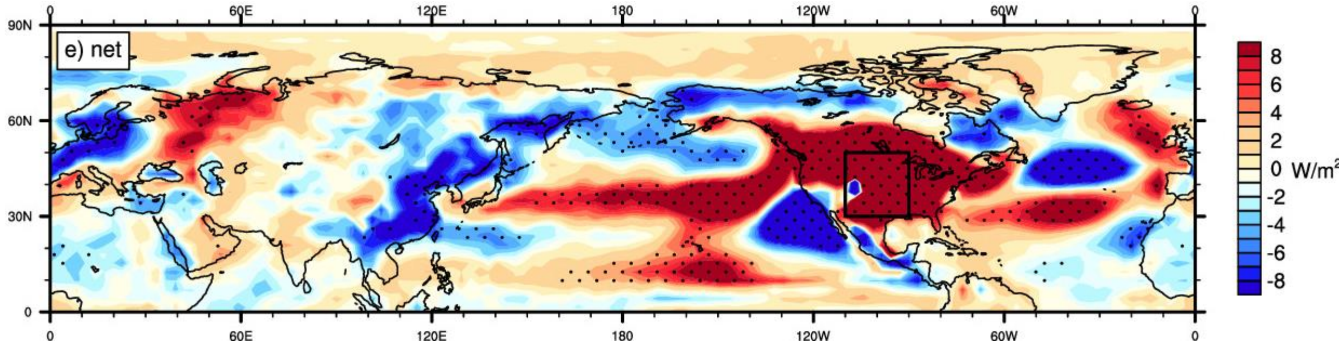
How does the influence of extreme drought over Great Plains spread outside of that area?











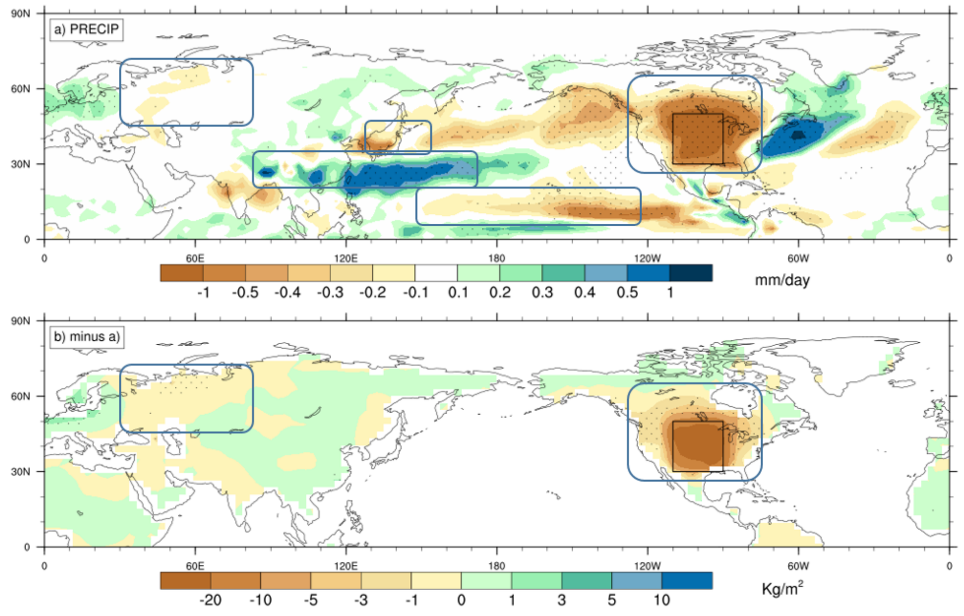
Enhanced lower tropospheric heating → wave-5 hemispheric response → upward motion over Great Plains box → enhanced downward motion outside box over the rest of North America and northwester Europe → decreased clouds in those regions → increased net surface heat flux → warmer surface temperatures → drier soils

Summary

The 1930s Dust Bowl drought over the Great Plains was likely initiated by atmospheric teleconnections from the tropical Pacific and Atlantic and intensified by dust aerosols rising from the bare soils caused by disastrous land use practices

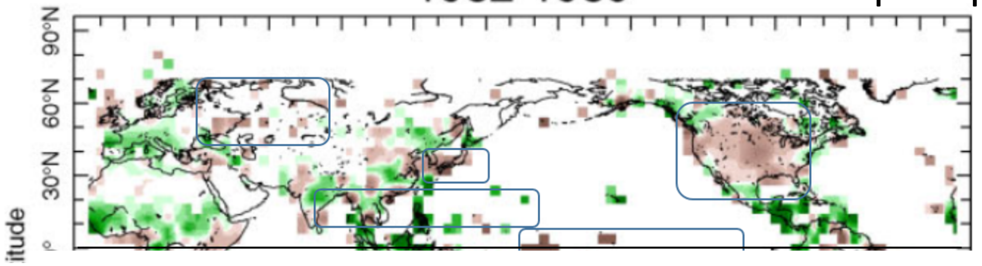
A climate model sensitivity experiment indicates that those Dust Bowl drought conditions themselves could then produce lower tropospheric heating over the Great Plains, an anomalous wave-5 circulation pattern at 200 hPa, and hemisphere-wide teleconnections

Thus, the drought itself can produce heat extremes (indicated by large amplitude ratios of daily record high maxima to daily record low minima) over the Great Plains that extend those heat extremes over most of North America and other regions of the Northern Hemisphere including northeastern Europe and northeastern Asia



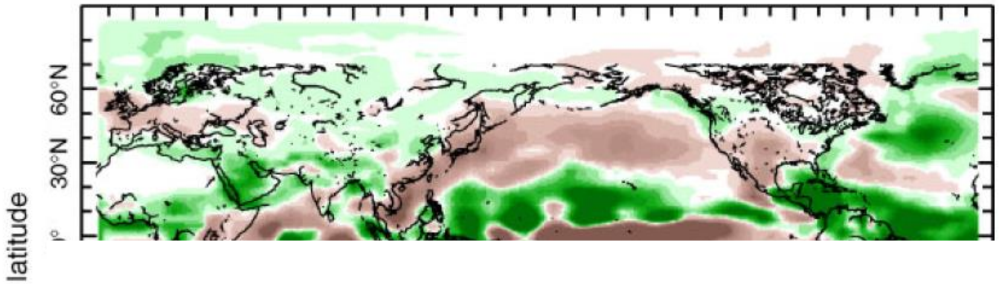
Atmospheric teleconnections also produce changes in precipitation and soil moisture outside the Great Plains box in the model experiment

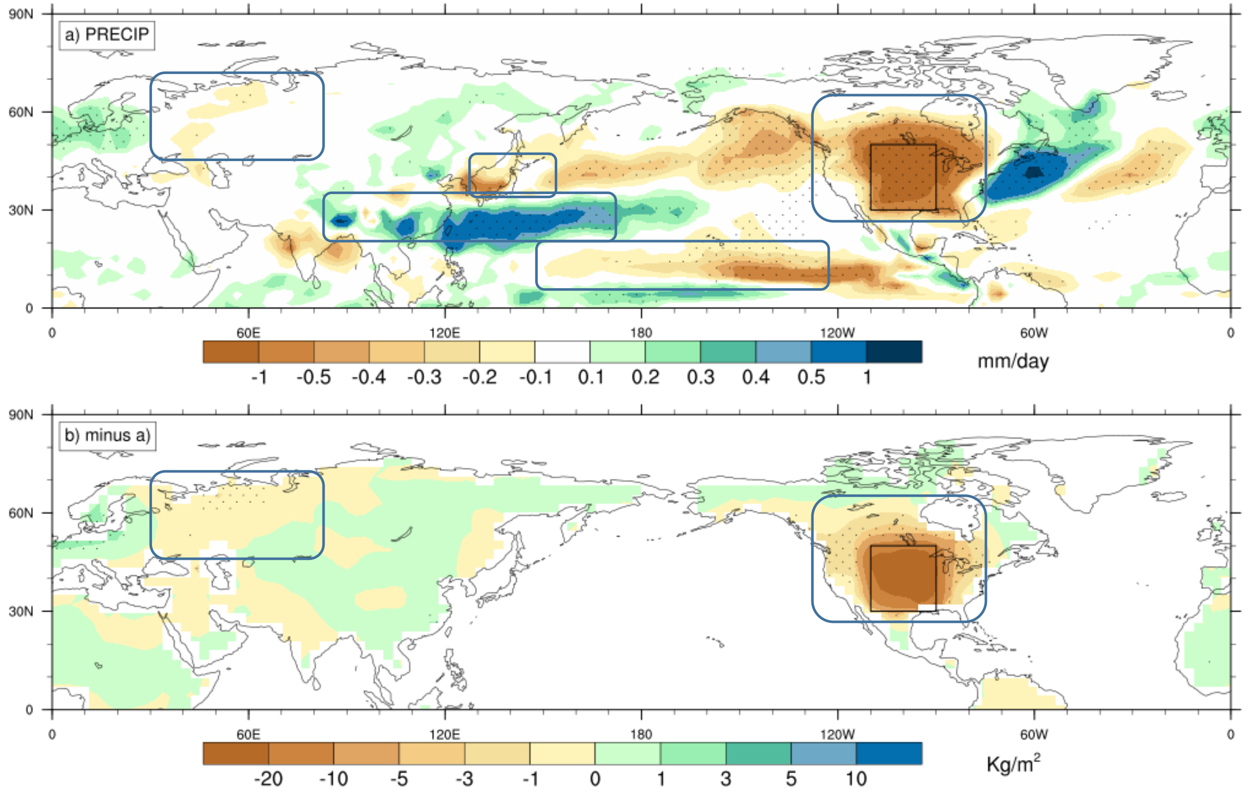
1932-1939 Observed precip anoms



These correspond to observed dry areas during the 1930s

1932-1939 GOGA model exp precip anoms





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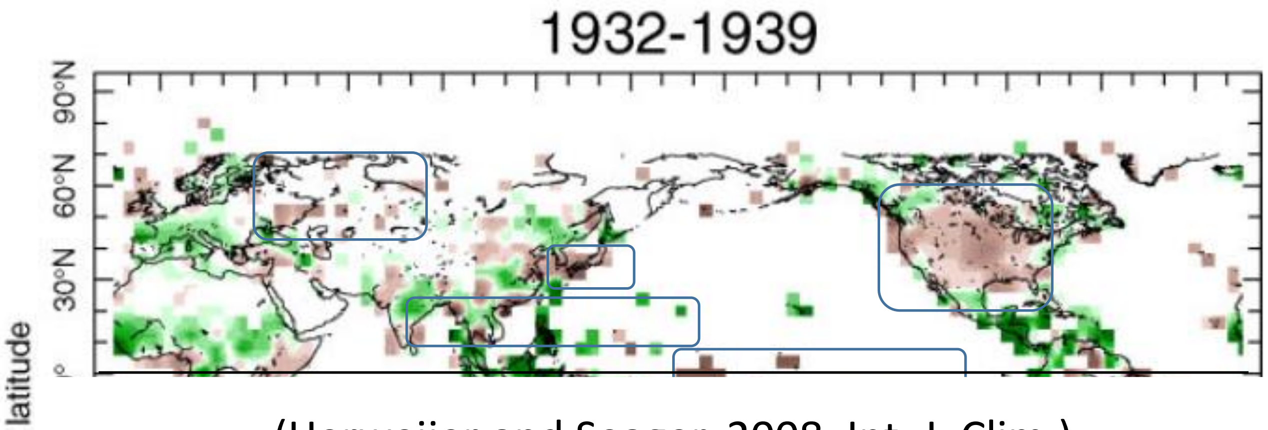

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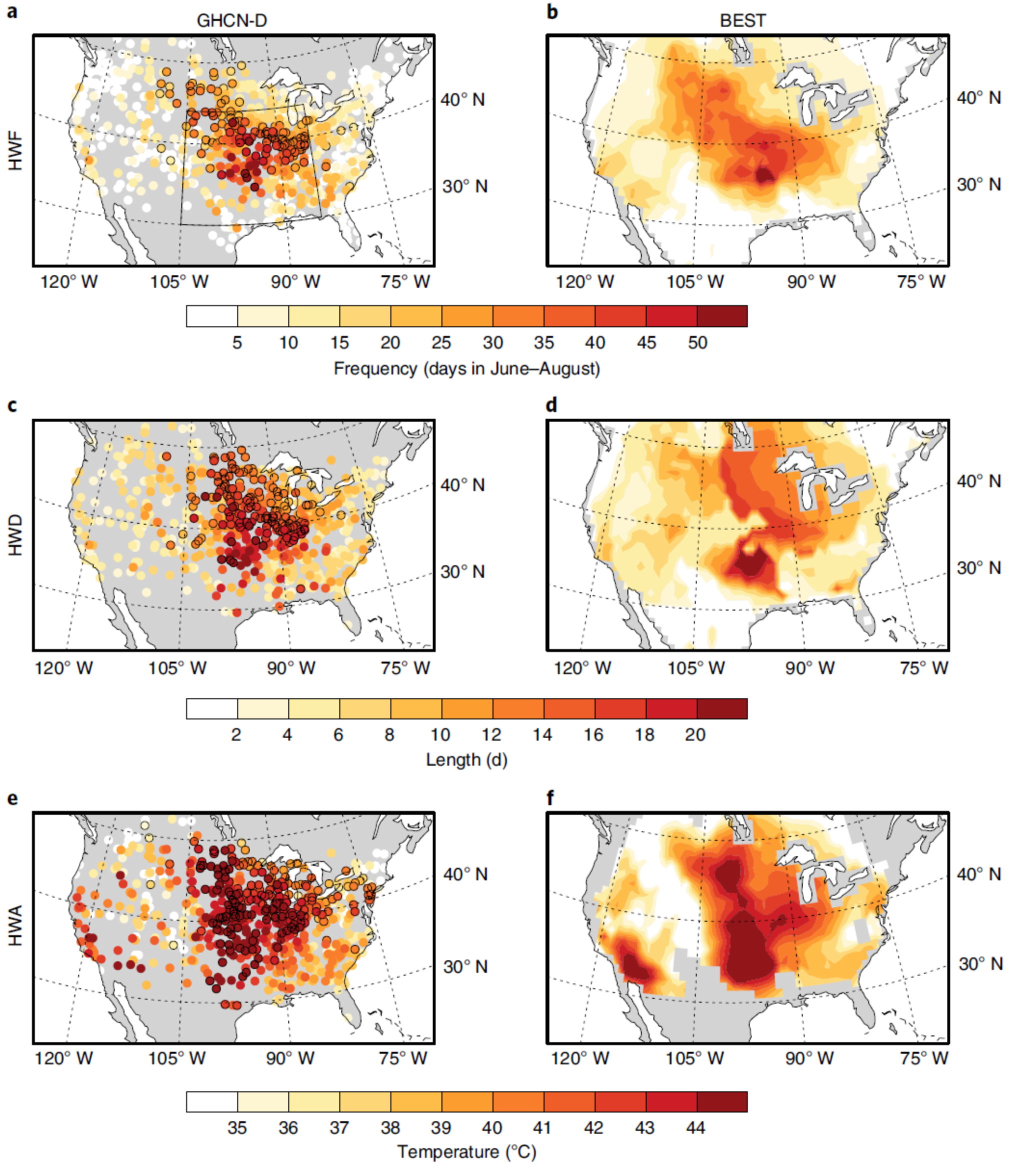
(Herweijer and Seager, 2008, Int. J. Clim.)



(Cowan et al 2020, Nat Clim Chg)

Fig. 1 | Observed Dust Bowl heatwave conditions in 1936. a–f, Comparison between observations from GHCN-D stations (**a**,**c**,**e**) and BEST (**b**,**d**,**f**) for summer heatwave conditions averaged over 1936. **a–f**, Observations include HWF (**a**,**b**), HWD (**c**,**d**) and HWA (**e**,**f**). The heatwave metrics are calculated against a 1920–2012 reference period. The outlined GHCN-D stations are those where 1936 was the year with the most heatwave days and the longest and hottest events of any year up to 2012. The conditions for 1934 are shown in Extended Data Fig. 1.