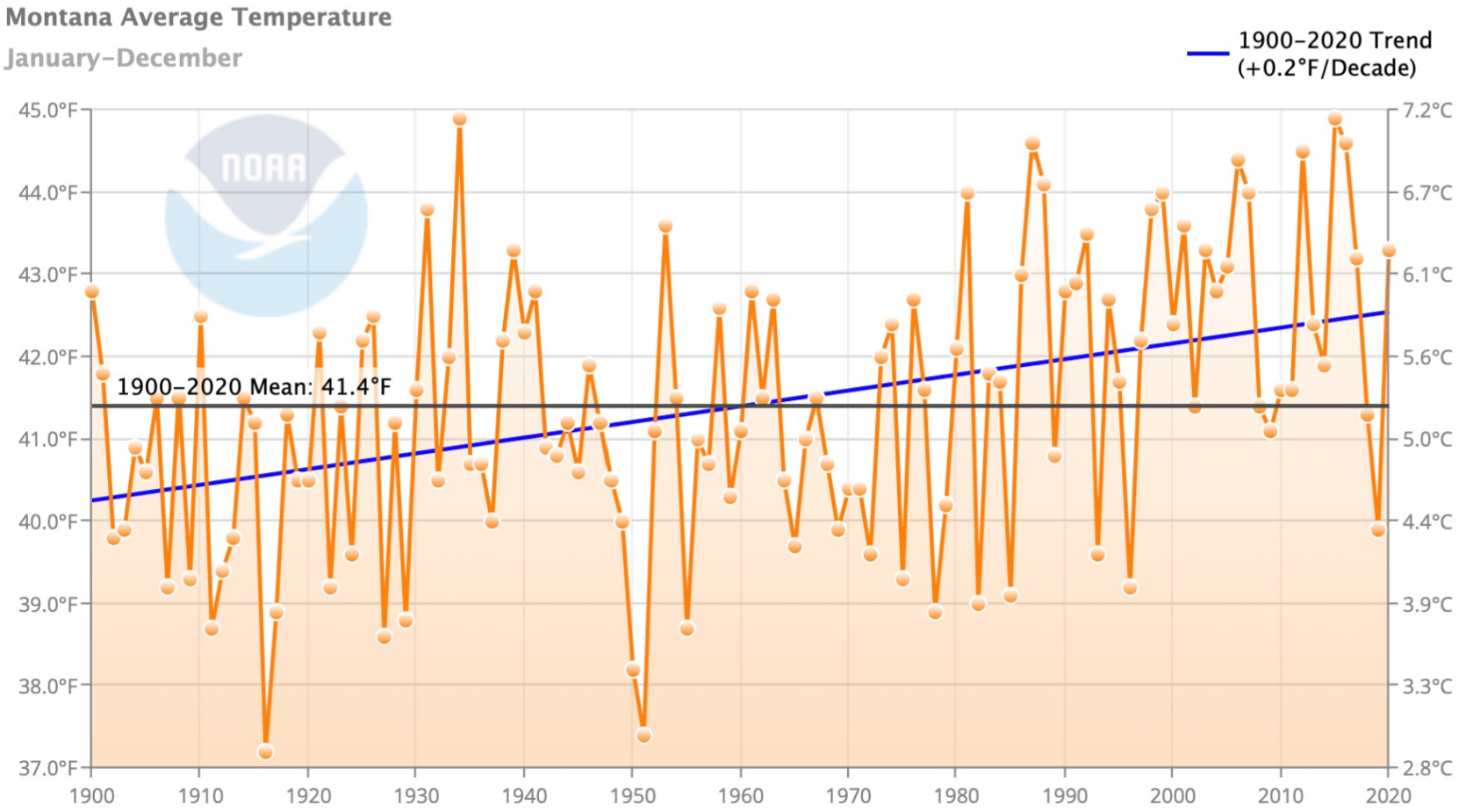
Characterizing Montana's Average Temperature 1900-2020



Trend: 2.4°F (1900-2020)

Warmest years: 1934, 2015

Largest year-to-year change: 6°F (1951-1952)

Multi-decadal regimes

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Extreme weather/climate events versus trends

most records were set in first half of 20th century

- Hottest temperature: 117°F, 1893 and 1937
- Record hottest years: 1934 and 2015
- Record driest year: 1931, 12.62"
- Record wettest year: 1927, avg precipitation 26.15”
- Precipitation record for 24 hours: 11.5”, 1921
- Worst floods: 1908, 1948, 1964, 1978, and 2011
- Worst fire: 1910

The greatest impacts come from extreme events/seasons; these concerns are reflected by Plaintiff’s statements in the complaint

Extremes do NOT scale with the trend in average temperature, with majority of worst events/seasons in 1st half of 20th century

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Frequency of extreme heat in Montana 1970-2019

Plaintiff's Complaint-1970 - 2019

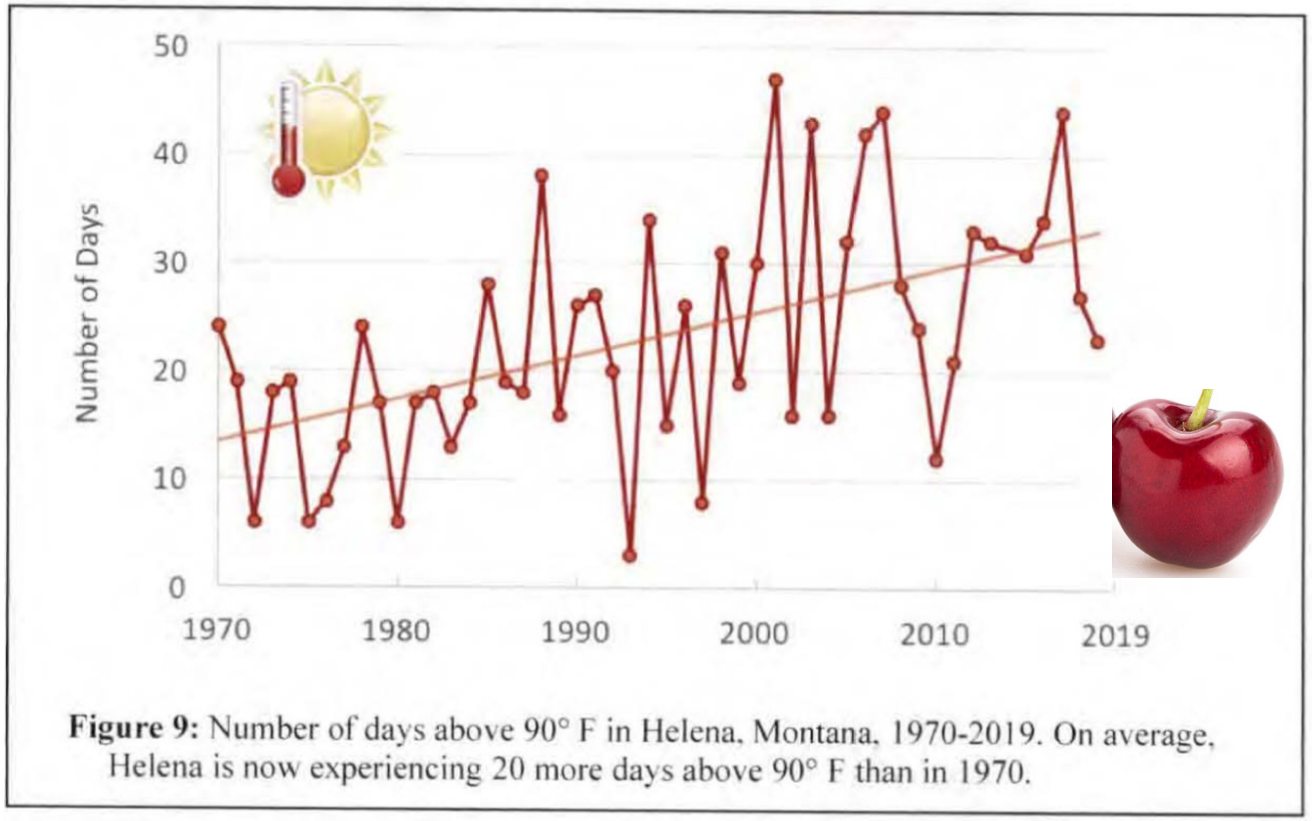
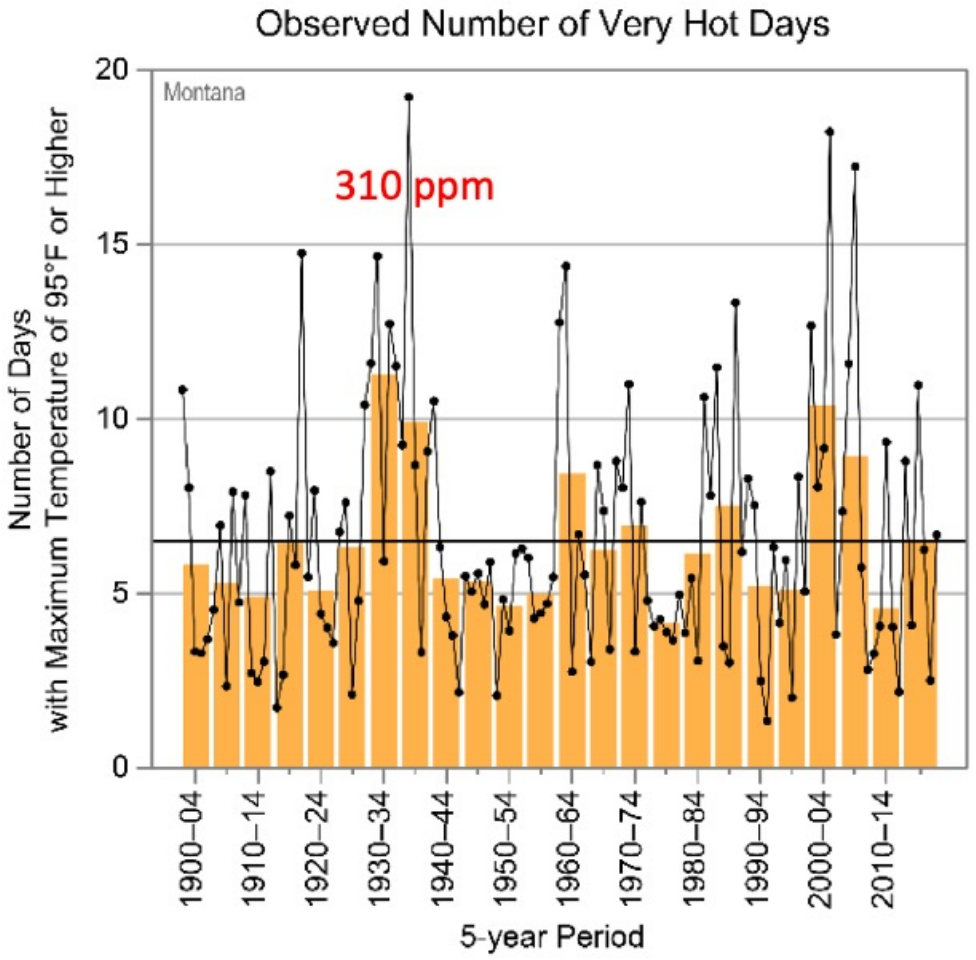


Figure 9: Number of days above 90° F in Helena, Montana, 1970-2019. On average, Helena is now experiencing 20 more days above 90° F than in 1970.

From NOAA 1900 -2022



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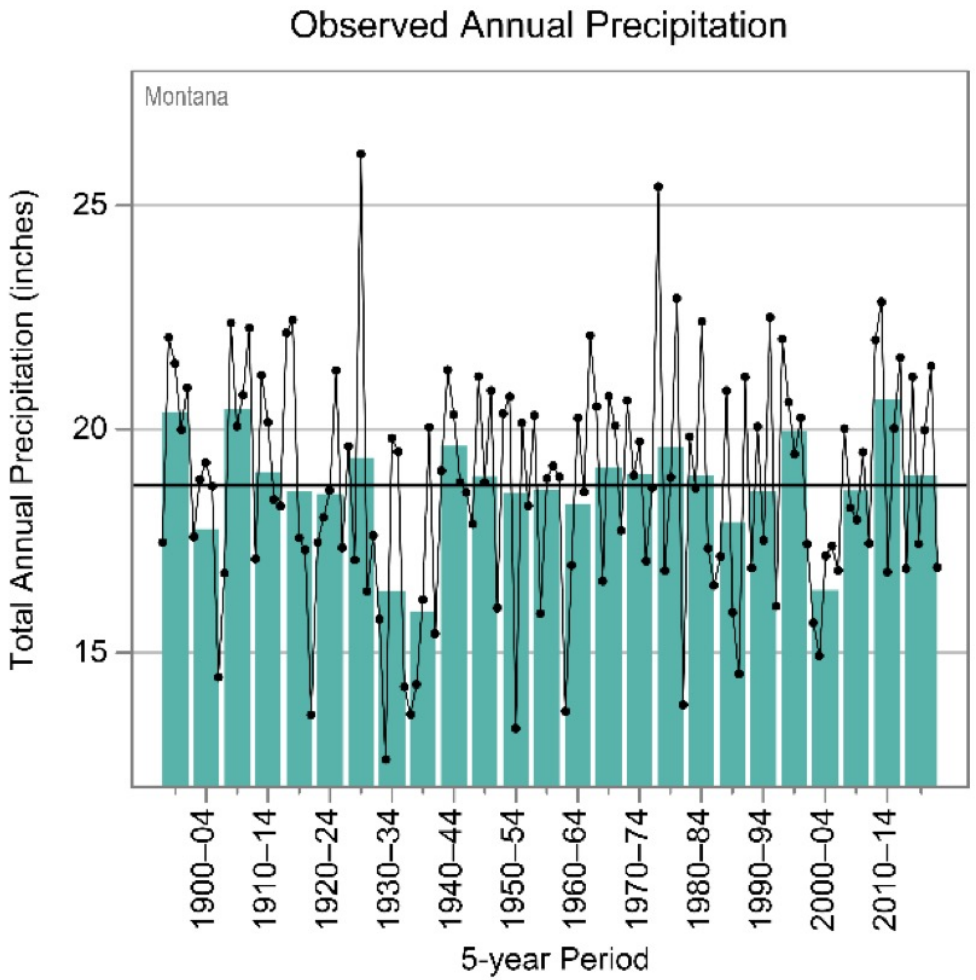
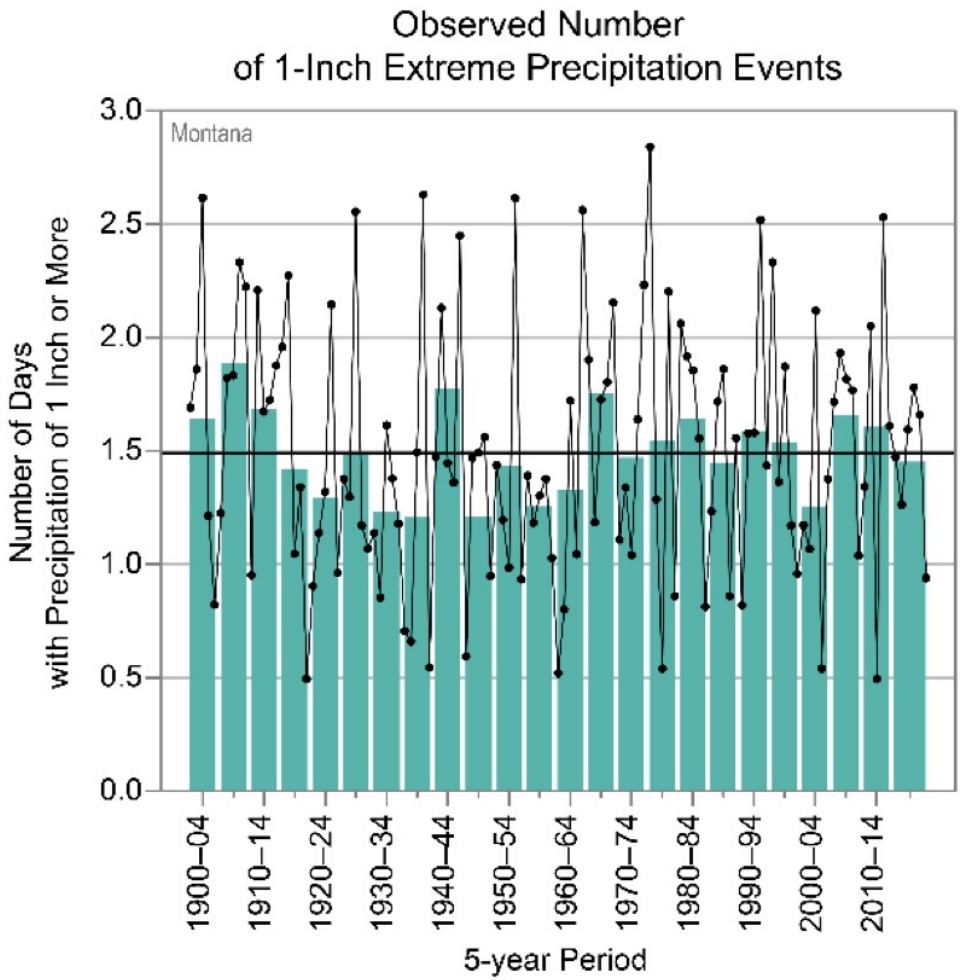
Montana's Precipitation Climatology 1900-2022





From NOAA: no overall trend in precipitation, no trend in droughts, no trend in extreme rainfall events

1955-2016
Plaintiffs

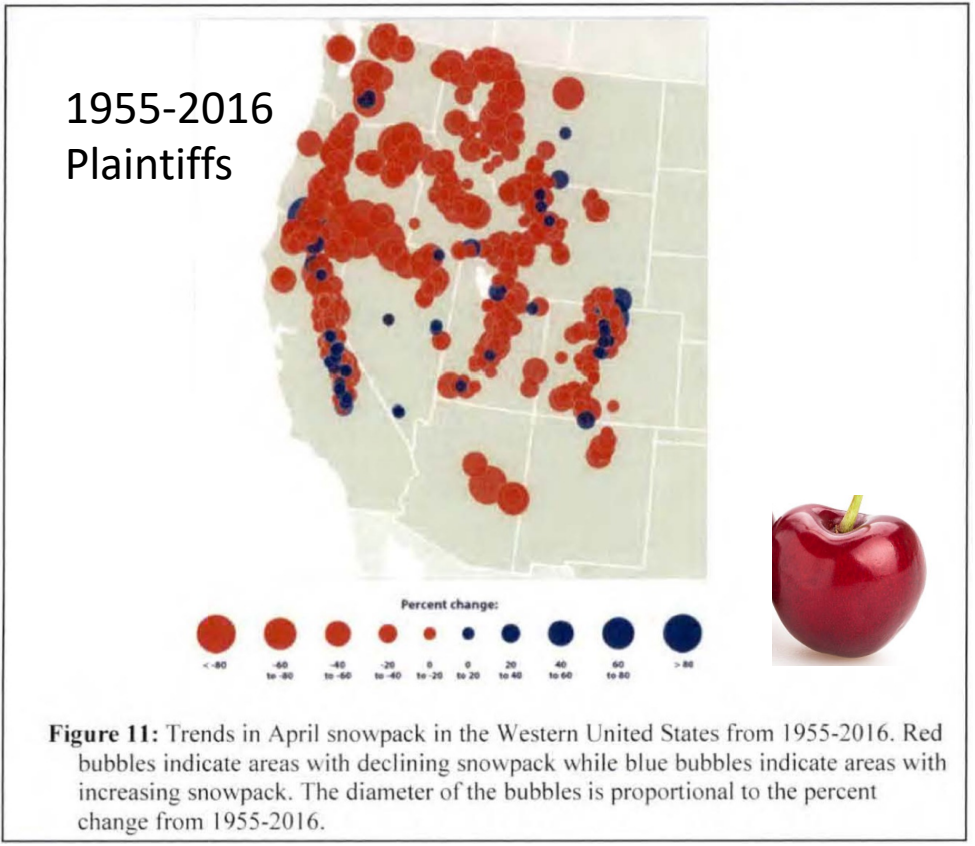
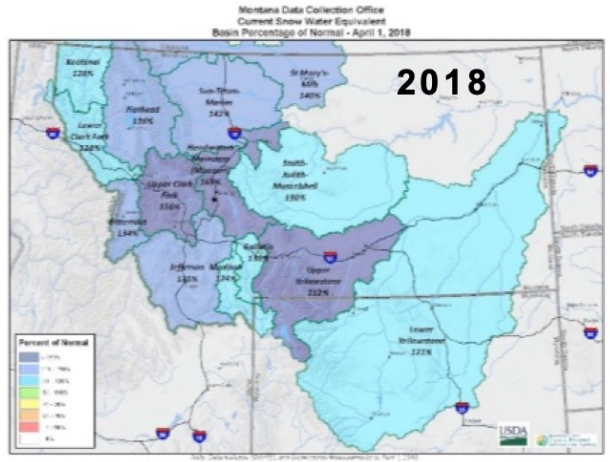
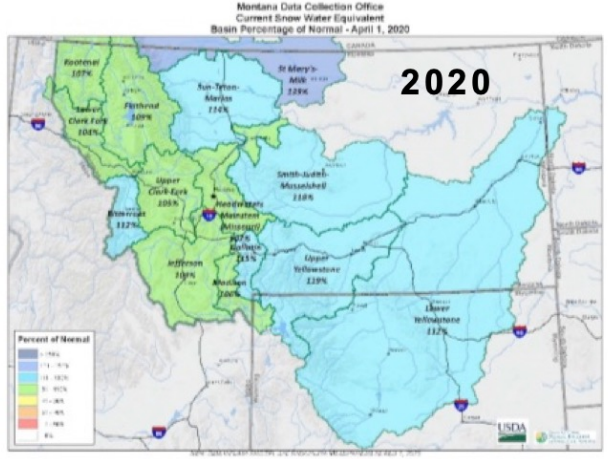


Figure 11: Trends in April snowpack in the Western United States from 1955-2016. Red bubbles indicate areas with declining snowpack while blue bubbles indicate areas with increasing snowpack. The diameter of the bubbles is proportional to the percent change from 1955-2016.

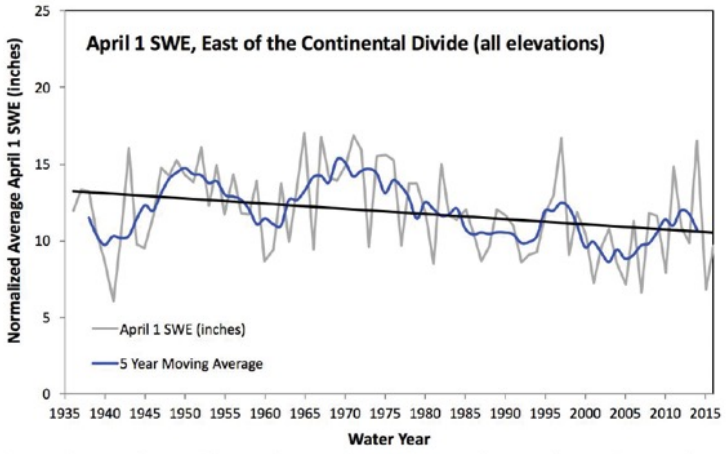
Trends & Variability in Snow Water Equivalent

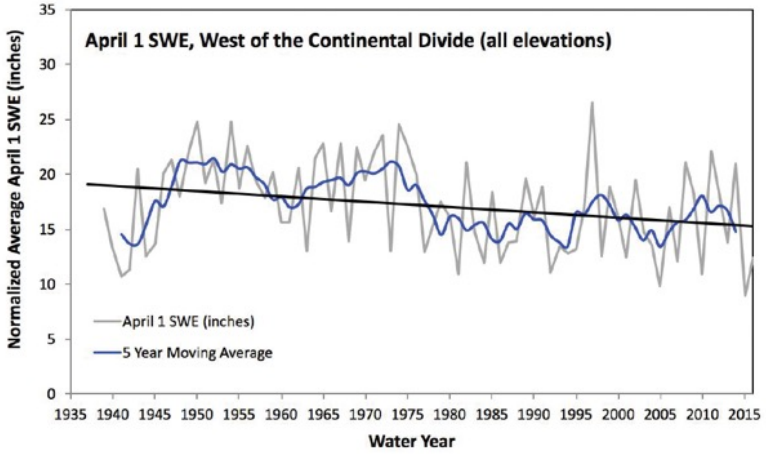
Snowfall since 2016 above average

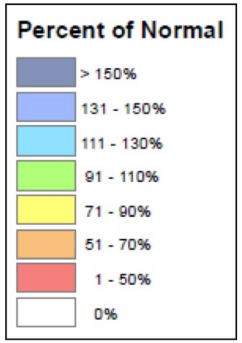


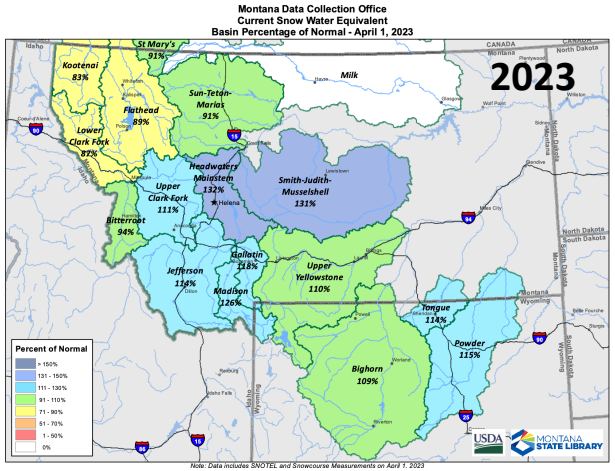


Montana Trends in April 1 SWE from Snow Course Data









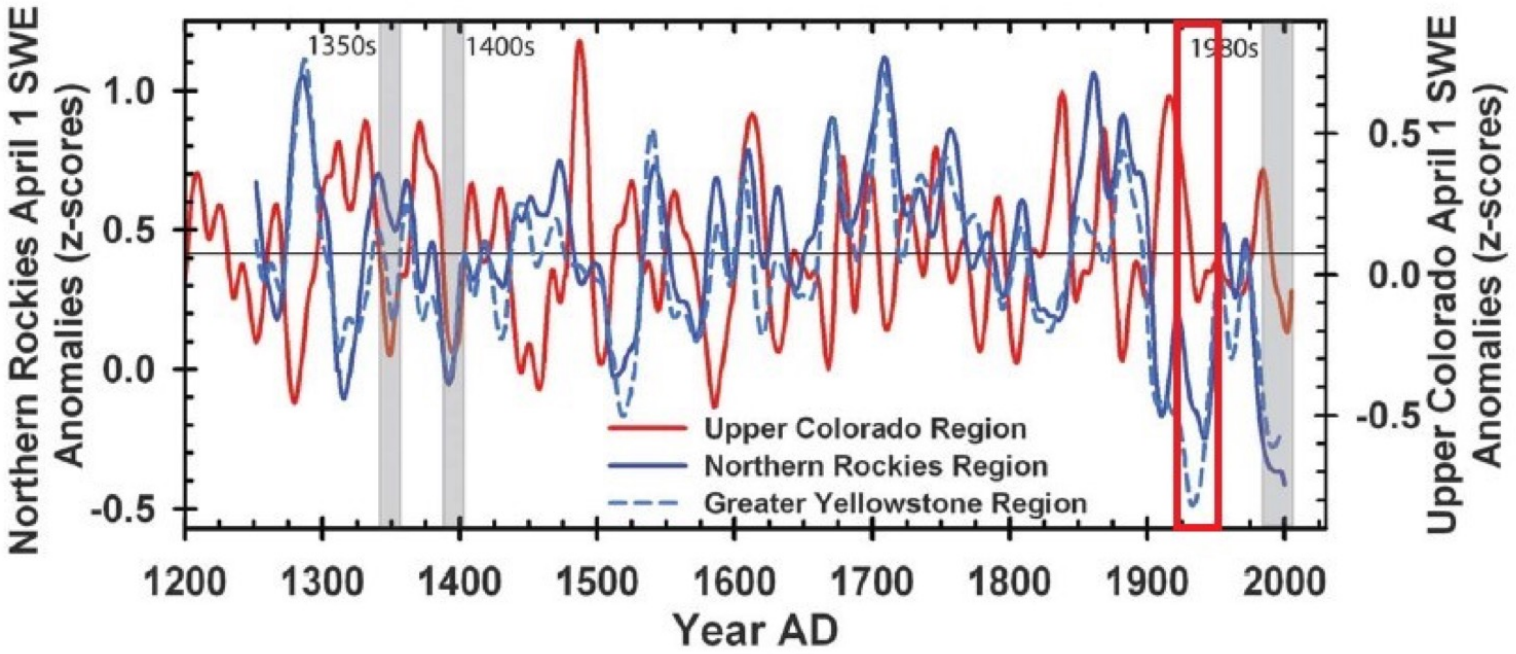


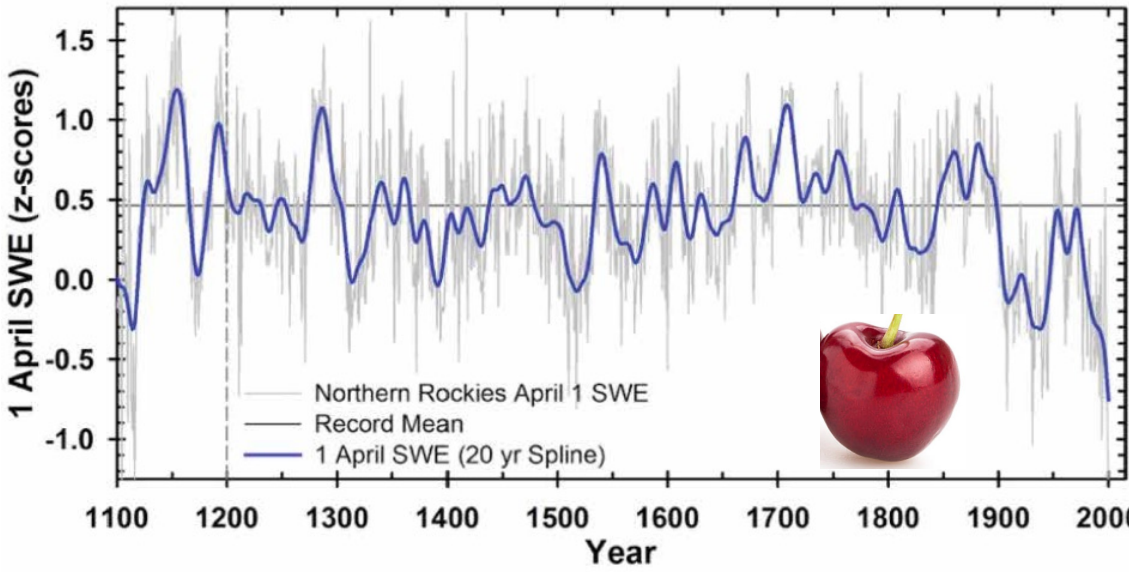
Fig. 3. Decadal-scale antiphasing of the N-S snowpack dipole and periods of synchronous snowpack decline. The 20-year splines of the regional average snowpack anomalies highlight antiphasing and variability at decadal scales. The shaded bars highlight periods of synchronous snowpack declin

April Snow Water Equivalent 1200-2000

Yellowstone
Curry's diagram

Snow drought in Yellowstone was worse in the 1930's

Plaintiff's diagram
Northern Rockies



Wildfire trends

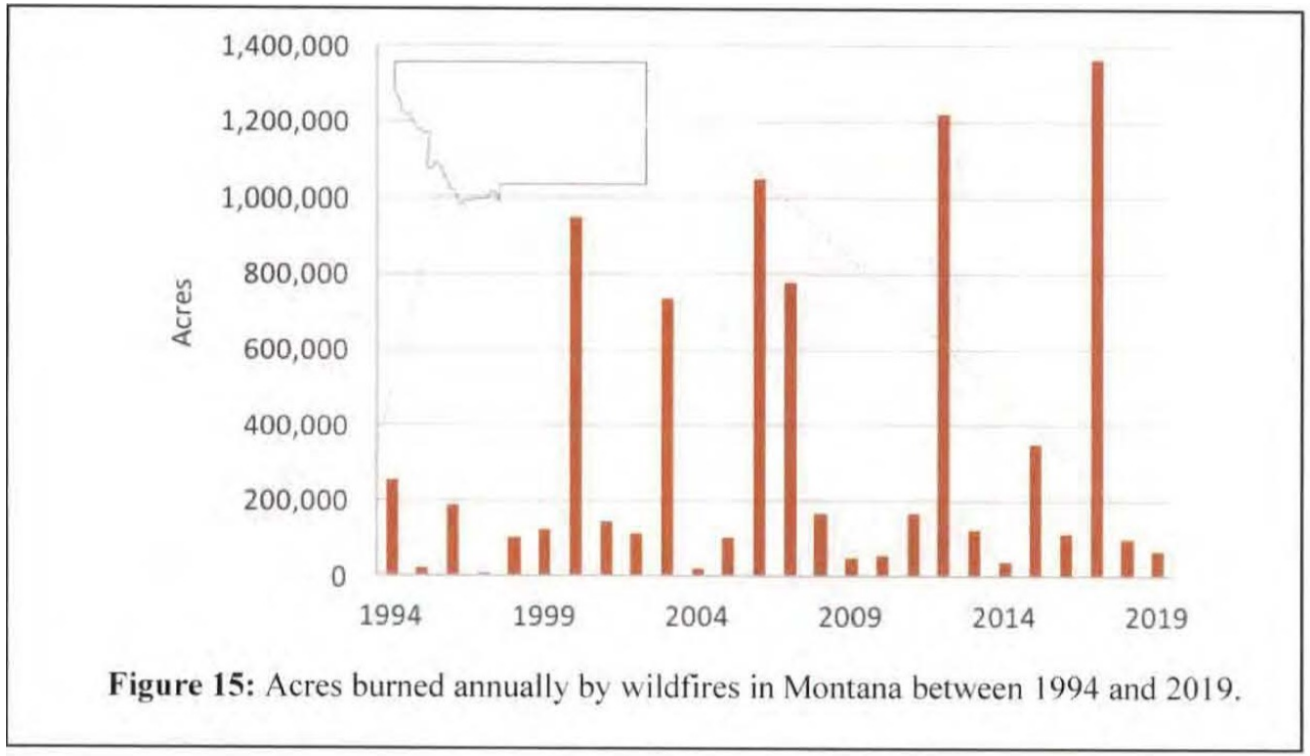
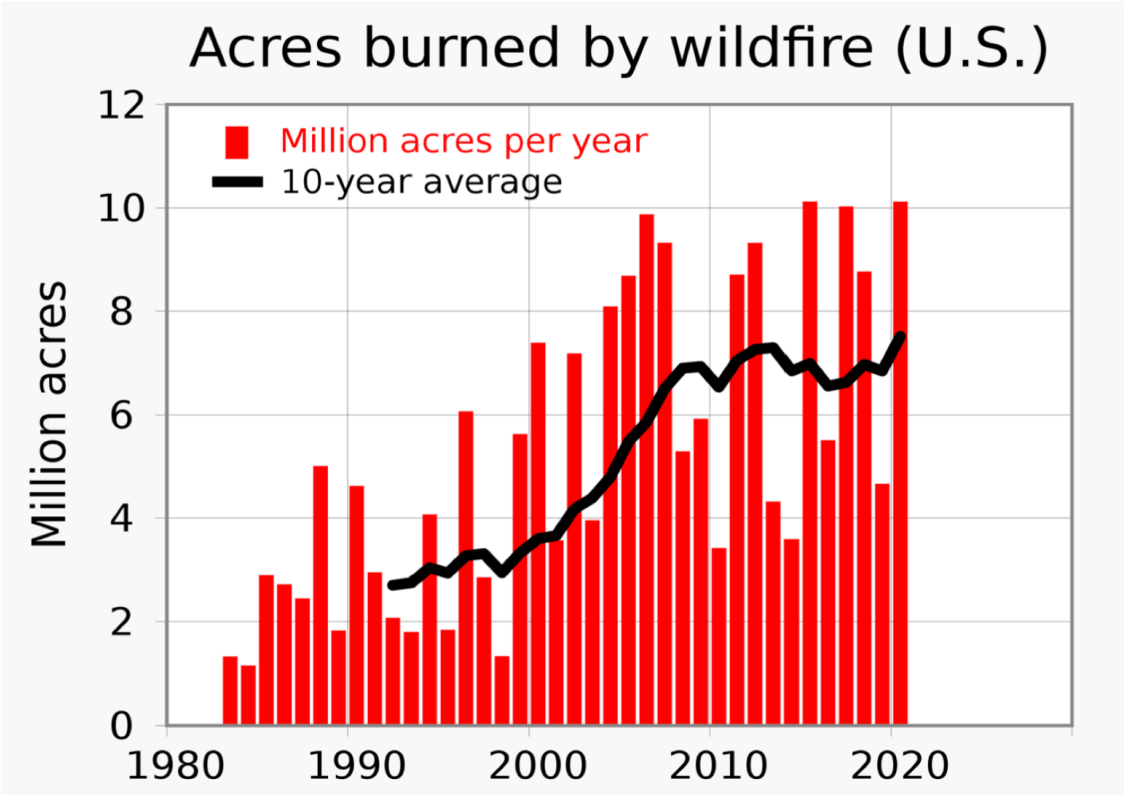
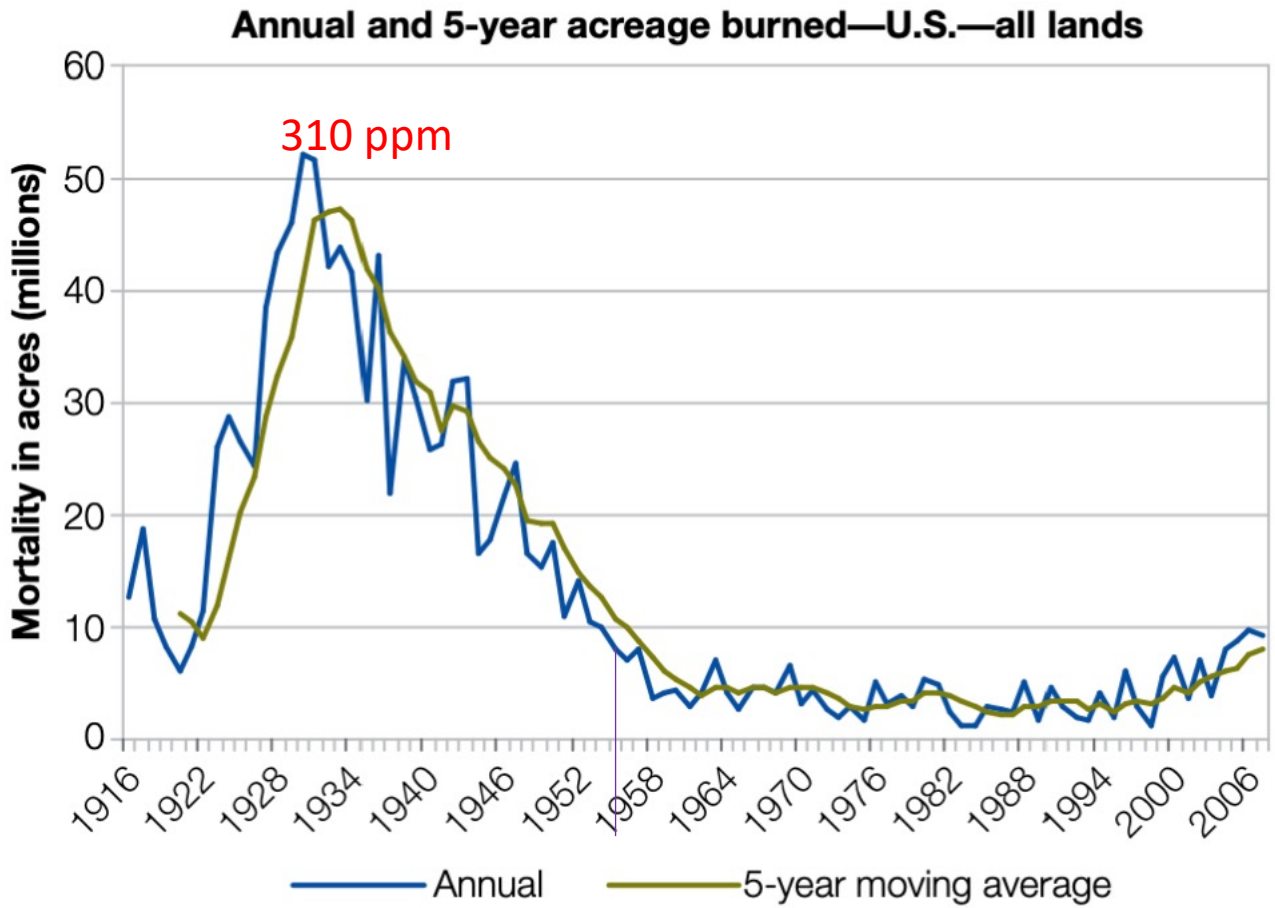


Figure 15: Acres burned annually by wildfires in Montana between 1994 and 2019.



US Total Acreage Burned 1916-2008

Figure 16-1. Total acreage burned.



Source: USDA Forest Service, Forest Health Protection

US wildfires were much worse in first half of 20th century

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Great Montana Fire of 1910 “Big Blowup”

USDA Report:

The Great Fire of 1910
Synopsis

The FIRE

It was one of the largest forest fires in American history.

But 1910 was the driest year in anyone's memory

Loggers, homesteaders and campers started some of the blazes accidentally.

The largest single contributor was the railroads.

For two terrifying days and night's - August 20 and 21, 1910 - the fire raged across three million acres of virgin timberland in northern Idaho and western Montana.

300 ppm

The Great Fire of 1910

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Detection and Attribution of extreme events/seasons

"The fact that abnormally warm temperatures were also experienced in the 1930s does not mean that climate change is not driving warmer temperatures today. The difference today is that we are experiencing a long-term trend of rising temperatures. The annual average temperature in Montana in the last decade has exceeded that of the 1930s." – Running & Whitlock

Detection: identifies a recent change or event that is outside of the bounds of historical natural climate variability

Attribution: why the identified change occurred

- Observations
- Models
- Theory.

<u>1930's (drought, fires, heat):</u>

AMO+

PDO+

La Ninas

<u>Recent:</u>

AMO+ since 1995

PDO+ 1995-1998, 2014-2020

La Nina 2017, 2020, 2021, 2022

2017: Bad wildfires

2022: Low snowfall

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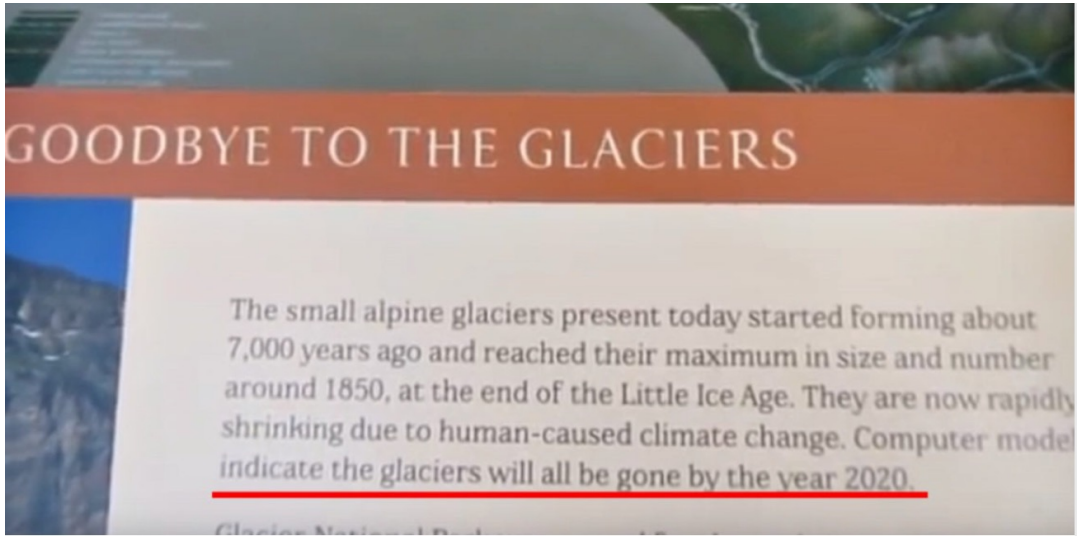
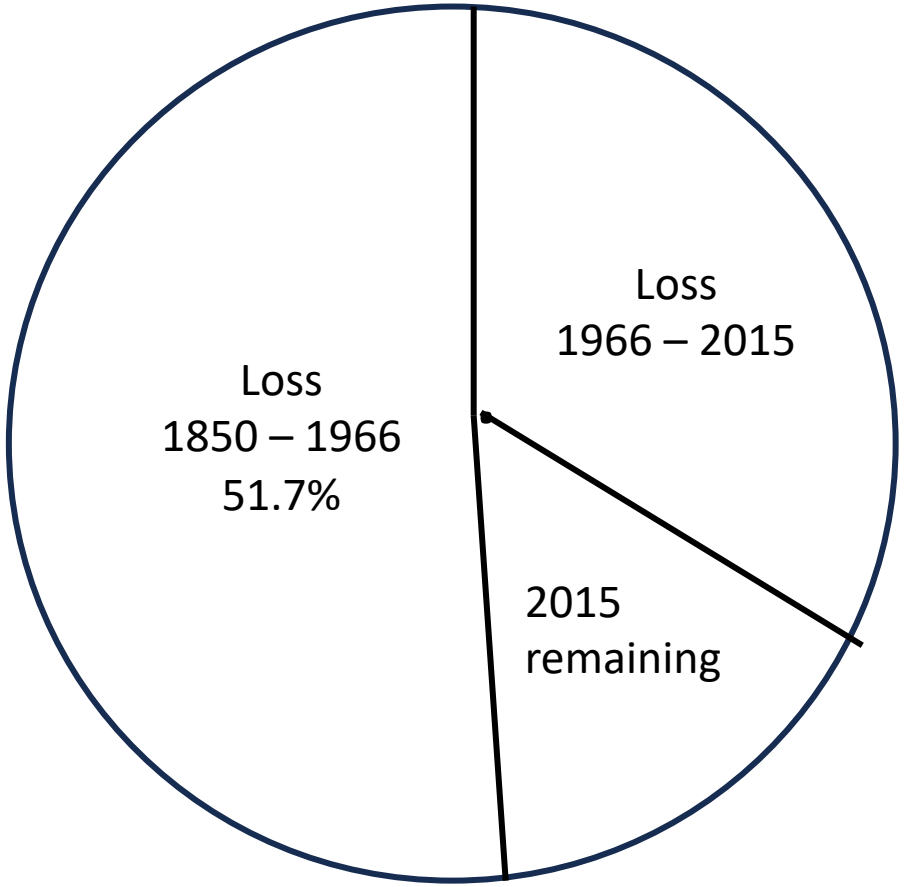
Glacier National Park – Glacier Area Loss since 1850

more than half of the glacier loss occurred before 1966

USGS data:

LIA-1966:	51.7% loss
1966-1998:	24.5% loss
1998-2015:	13.0% loss





Such signs at Glacier National Park have been removed

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IPCC Projections of 21st Century Global Warming

Relative to baseline 1850-1900; 2°F warming has already occurred

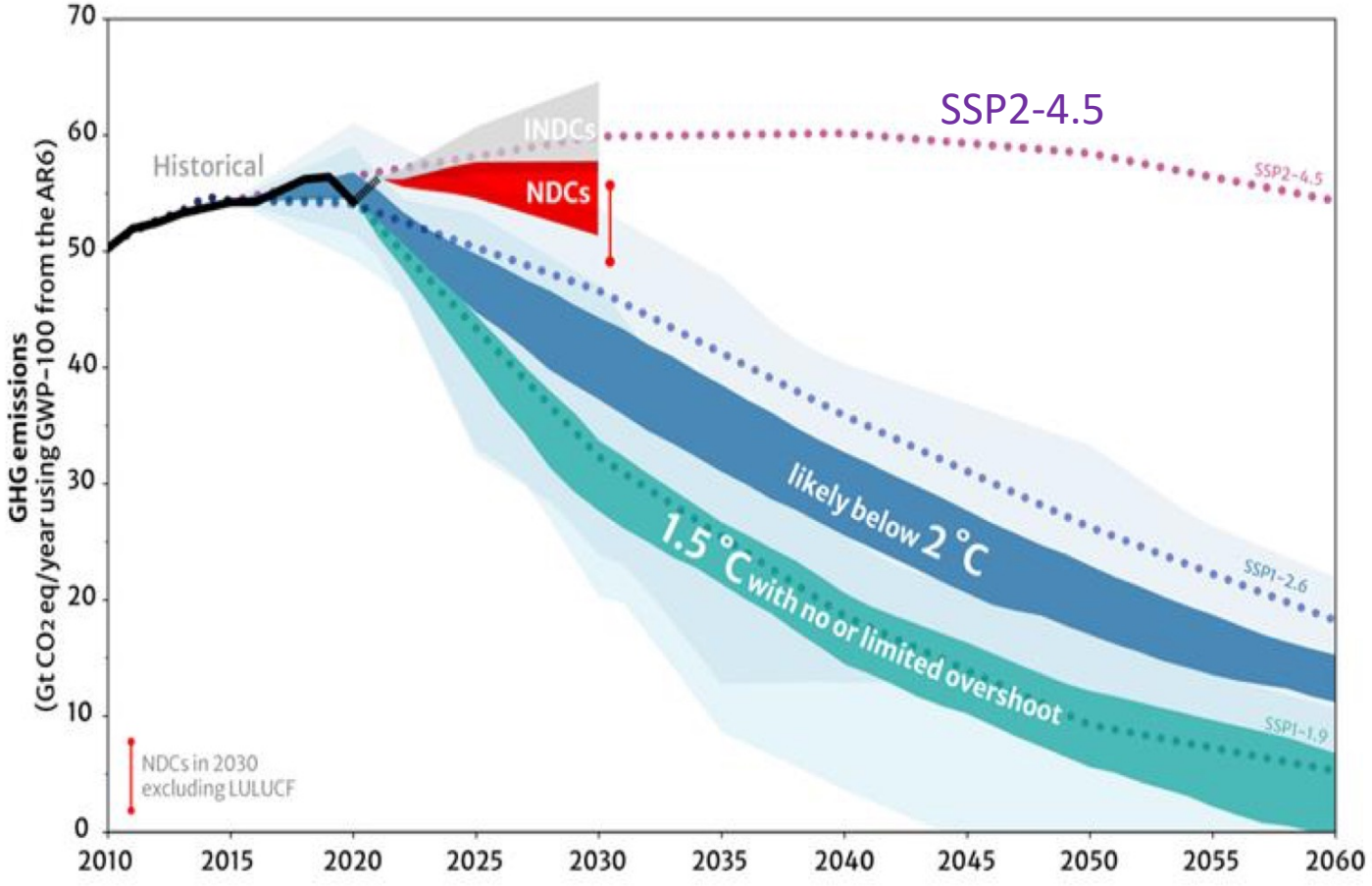
	Near term, 2021–40		Mid-term, 2041–60		Long term, 2081–2100	
Scenario	*Best estimate (°F)*	*Very likely range (°F)*	*Best estimate (°F)*	*Very likely range (°F)*	*Best estimate (°F)*	*Very likely range (°F)*
SSP1–1.9	2.7	2.2 to 3.1	2.9	2.2 to 3.6	2.5	1.8 to 3.2
SSP1–2.6	2.7	2.2 to 3.2	3.1	2.3 to 4.0	3.2	2.3 to 4.3
SSP2–4.5	2.7	2.2 to 3.2	3.6	2.9 to 4.5	4.9	3.8 to 6.3
SSP3–7.0	2.7	2.2 to 3.2	3.8	3.1 to 4.7	6.5	5.0 to 8.3
SSP5–8.5	2.9	2.3 to 3.4	4.3	3.4 to 5.4	7.9	5.9 to 10.3

Plaintiff's complaint: 4.5-6.0 °F by mid-century and 5-10 °F by end of 21st century.

UN COP27: 2.1-2.9 °C (3.7 – 5.2 °F) by end of 21st century

Extreme Emissions Scenario – RCP8.5, SSP5-8.5

UNFCCC COP27:



IPCC AR6:

WGI: “In the scenario literature, the plausibility of the high emissions levels underlying scenarios such as RCP8.5 or SSP5–8.5 has been debated in light of recent developments in the energy sector.”

WGII: “The plausibility of emission levels as high as the emissions scenario conventionally associated with RCP8.5 and SSP5-8.5 concentrations pathways has been called into question since AR5.”

UN Climate Negotiators no longer use the extreme emissions scenario RCP8.5, SSP5-8.5

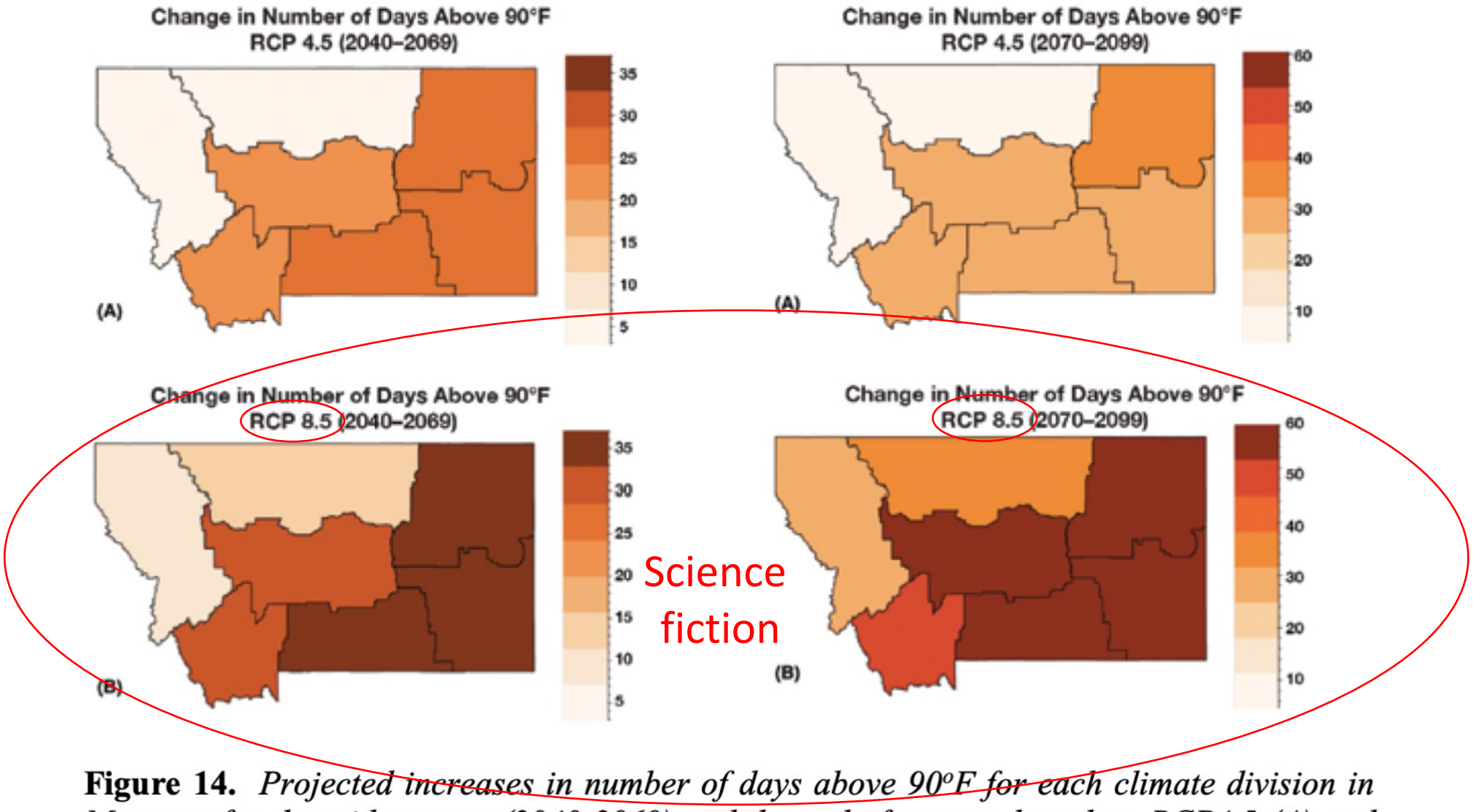


Figure 14. *Projected increases in number of days above 90°F for each climate division in Montana for the mid-century (2040-2069) and the end of century based on RCP4.5 (A) and RCP8.5 (B) (Whitlock et al. 2017).*

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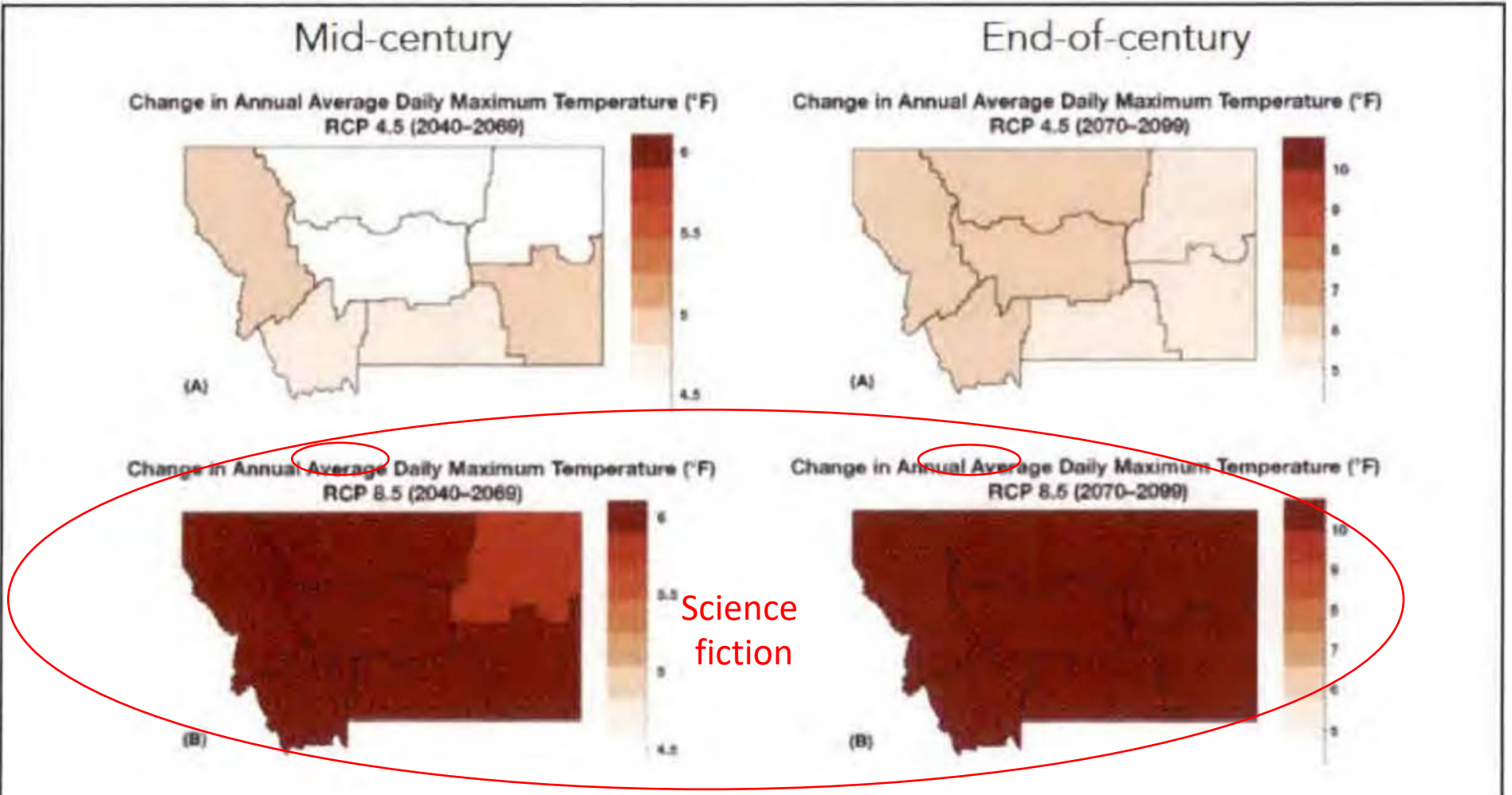

Figure 8: Projected increase in annual average daily maximum temperature (°F) in Montana for mid-century (2049-2069) and end-of-century (2070-2099) under two different GHG emission pathways. Top, the RCP 4.5 is an intermediate pathway that projects global heating is likely to exceed 1.5° C by 2100. While on the bottom, RCP 8.5 is a higher emissions pathway and projects that global heating is likely to exceed 2° C by 2100.[83]

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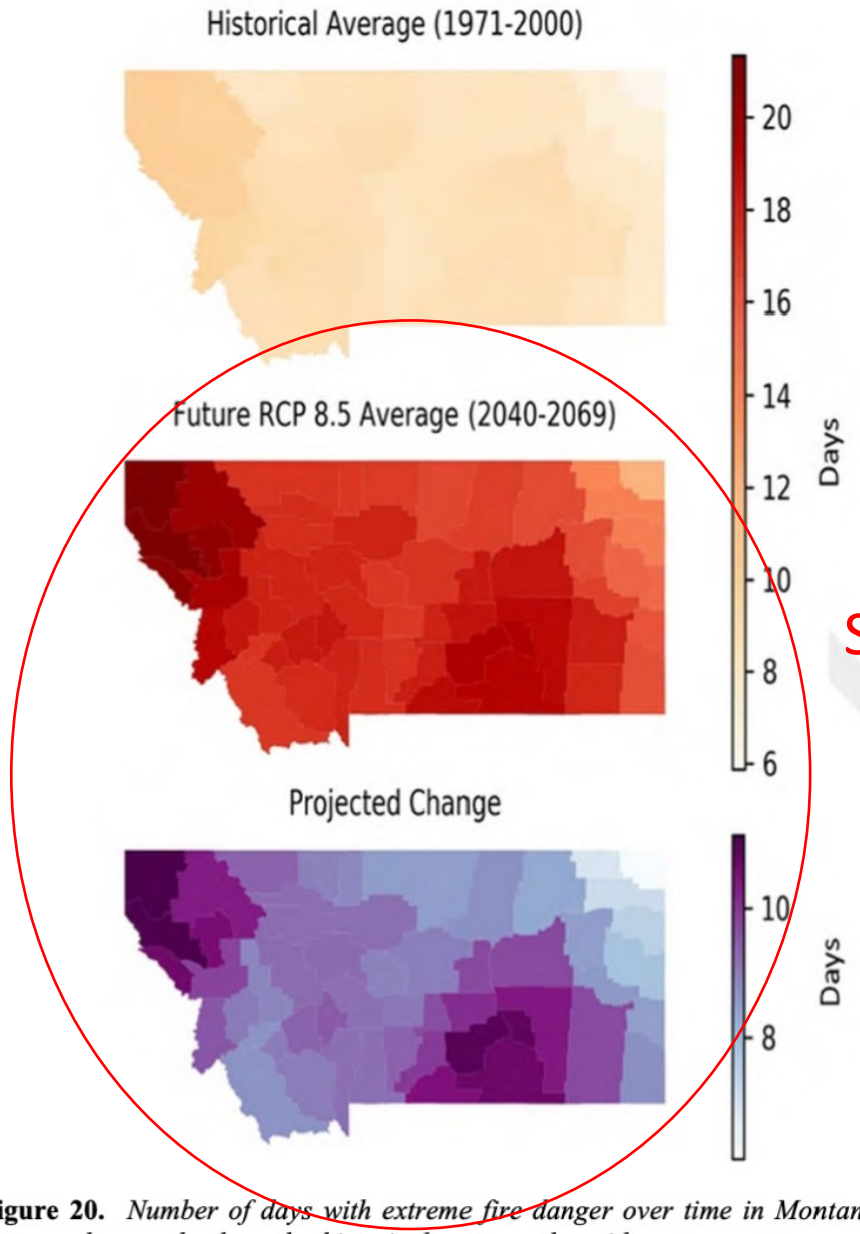

Figure 20. *Number of days with extreme fire danger over time in Montana. From top to bottom, the panels show the historical pattern, the mid-century pattern, and the projected changes in number of extreme fire days from 1971-2000 to mid-century (Adams et al. 2021).*

Projections of fire danger

Montana

Science fiction

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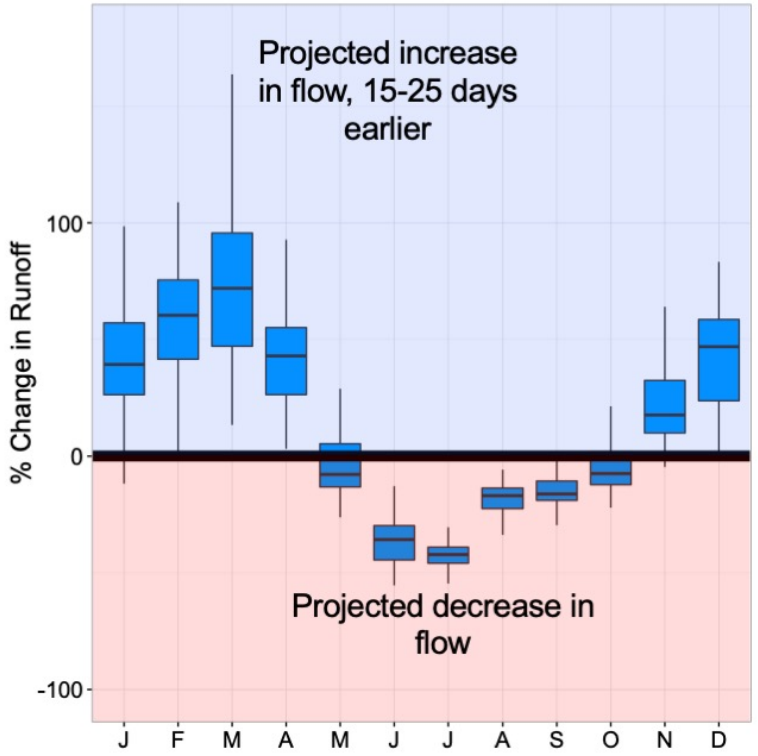
STREAMFLOW PROJECTIONS – CLARK FORK

Snowmelt-dominated rivers in the western & north-central Montana



Science fiction

Figure 17. *Monthly streamflow projections for the Clark Fork River at St. Regis based on RCP8.5 for the mid-century projection (2040-2069). Data are presented as the projected percent change in runoff between 2040-2069 and 1970-2000. Box and whisker plots show variation in the projections among different models, with the line in the middle of the box showing the median value of the model projections (Whitlock et al. 2017).*

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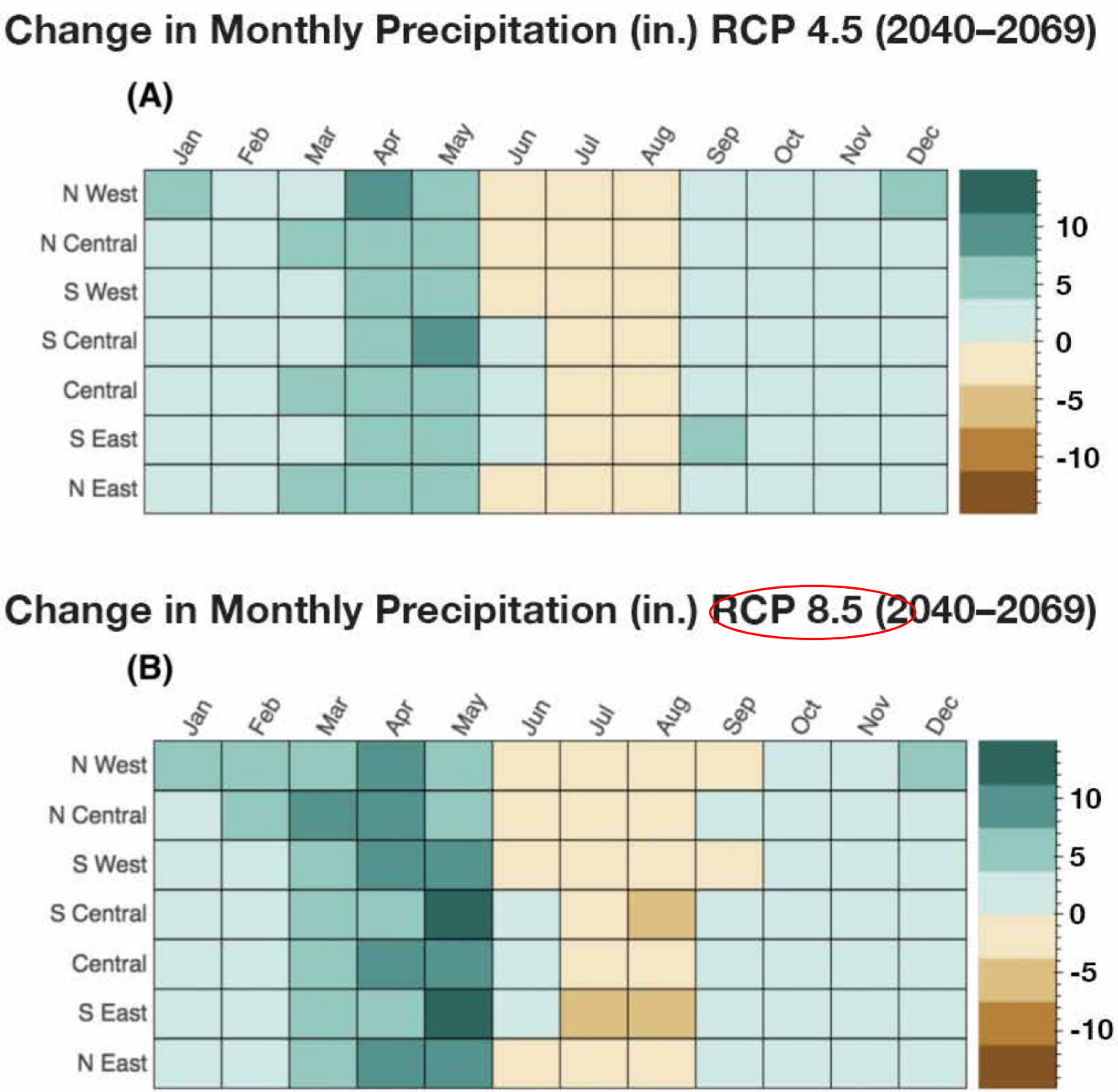
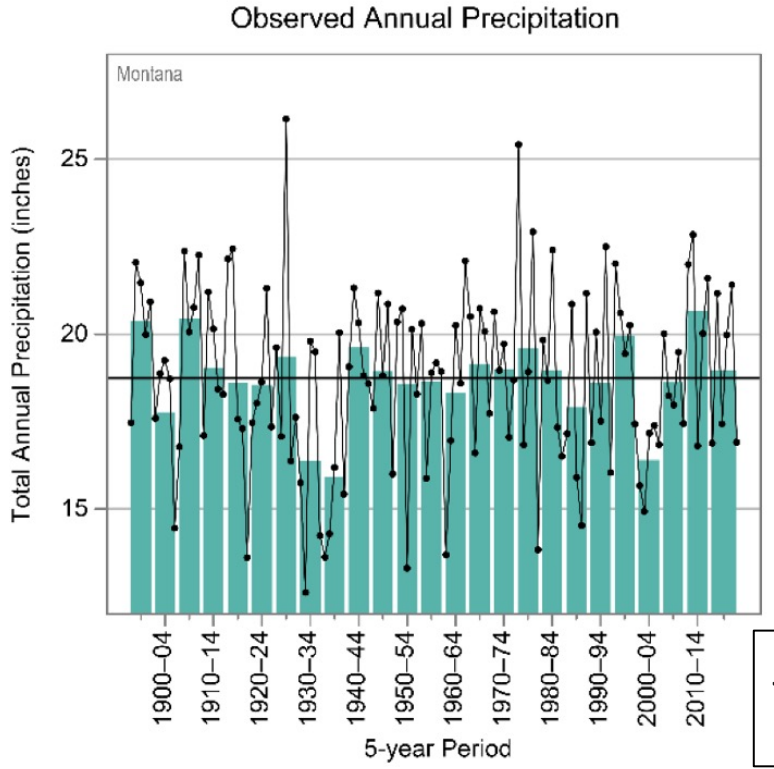


Running & Whitlock rebuttal:

"This lack of trend [in observed precipitation] is largely because **decreases in winter precipitation** have been offset by slight increases in spring and fall precipitation."

The climate model fingerprint shows **increase in winter precipitation**



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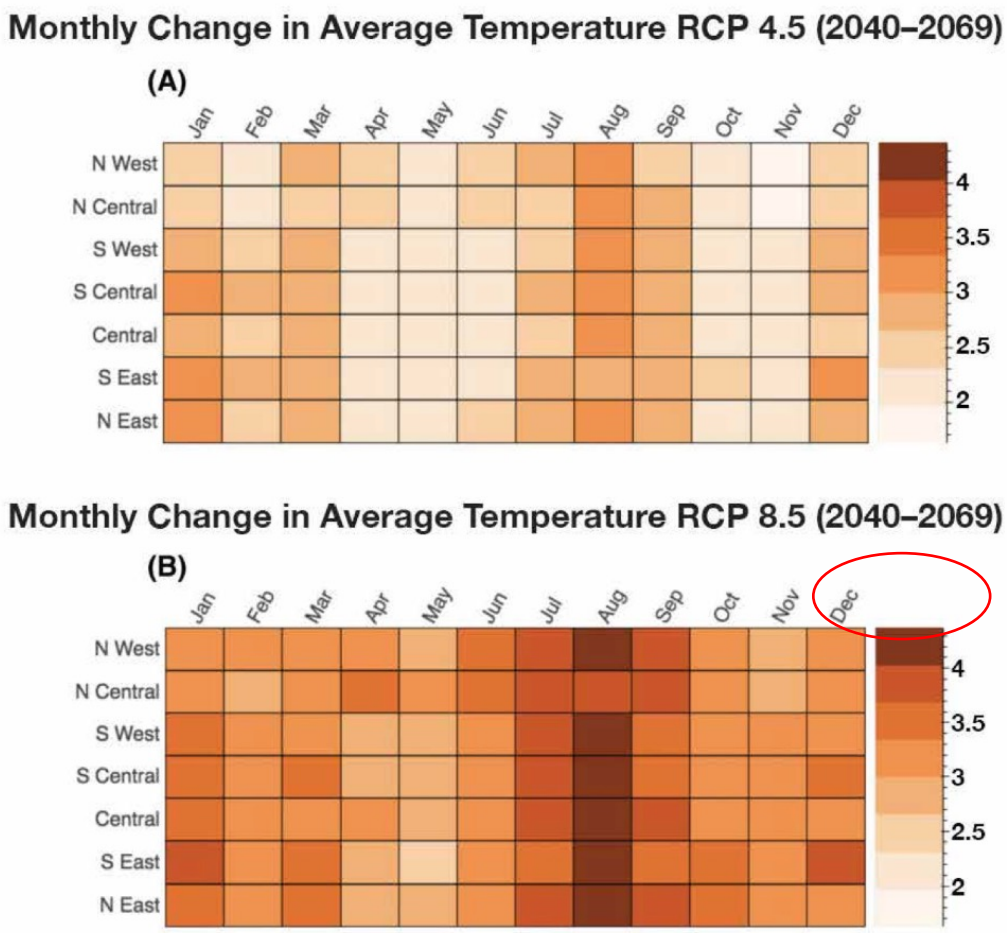
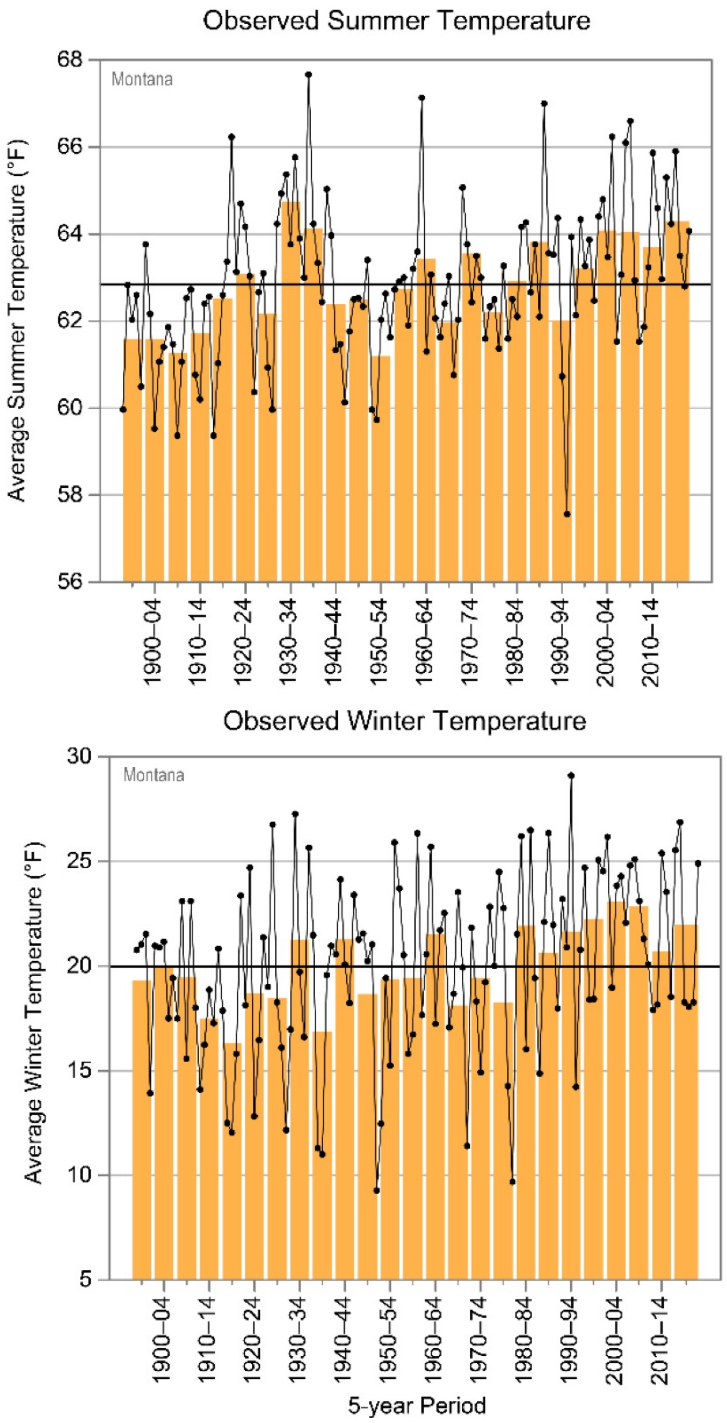


Figure 13. *Projected monthly increase in average temperature (°F) for each climate division in Montana in the mid-century projections (2040-2069) for RCP4.5 (A) and RCP8.5 (B) (Whitlock et al. 2017).*



Climate model fingerprint shows **largest warming in summer**; observations show **largest warming trend in winter**.