Climate Risk Analysis: Alberta

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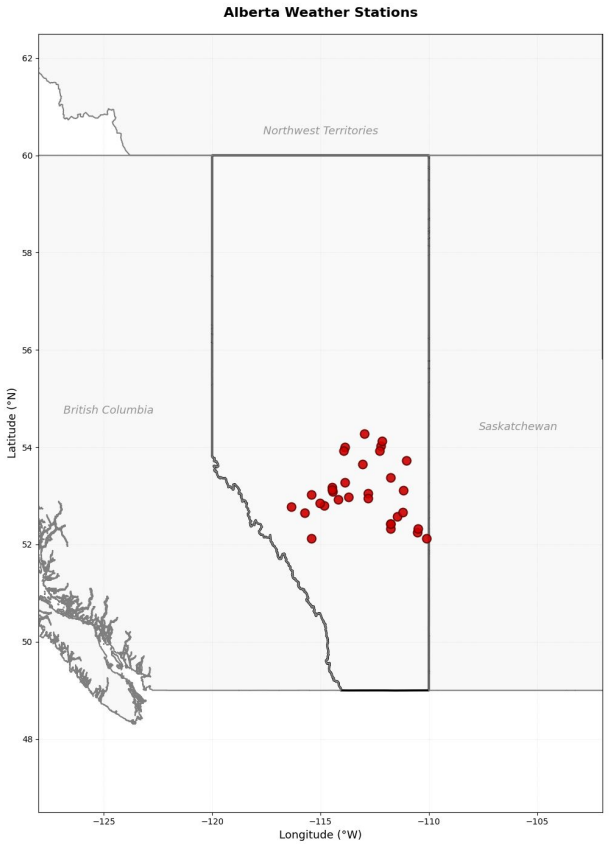
Executive Summary

1. Data Overview
2. Precipitation Decrease
3. Extreme Heat
4. Growing Wildfire Risk
5. High risk region: Southeast Cluster

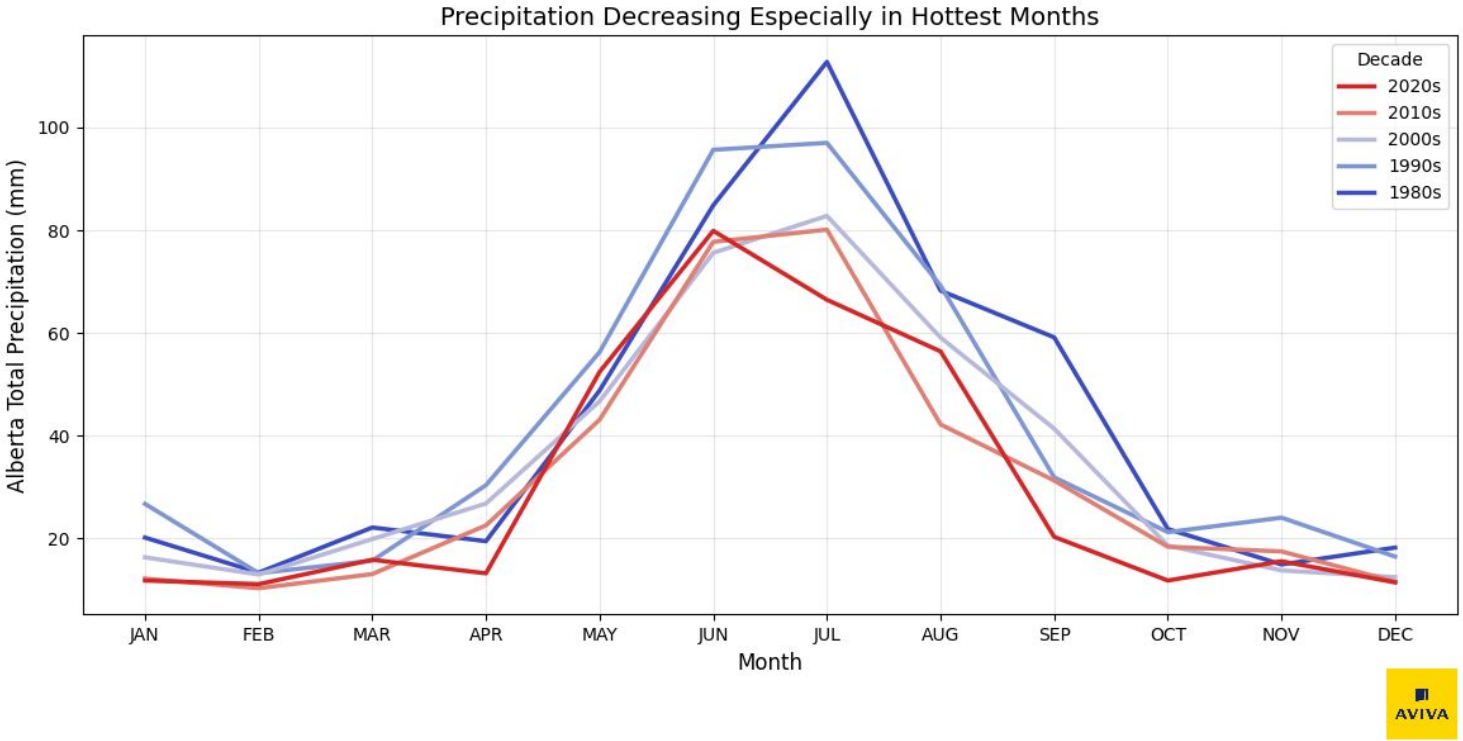
1. Data Overview



Missing data

- All stations are clustered centrally.
- 28 of 29 stations have substantial data gaps.
- Most analysis will focus on averages across all stations for data completeness.
- Regional clustering will facilitate some regional analysis as well in section 5.

2. Precipitation Decrease



Takeaway: precipitation is decreasing decade on decade across this region of Alberta. Summer months in particular show a pronounced decline.

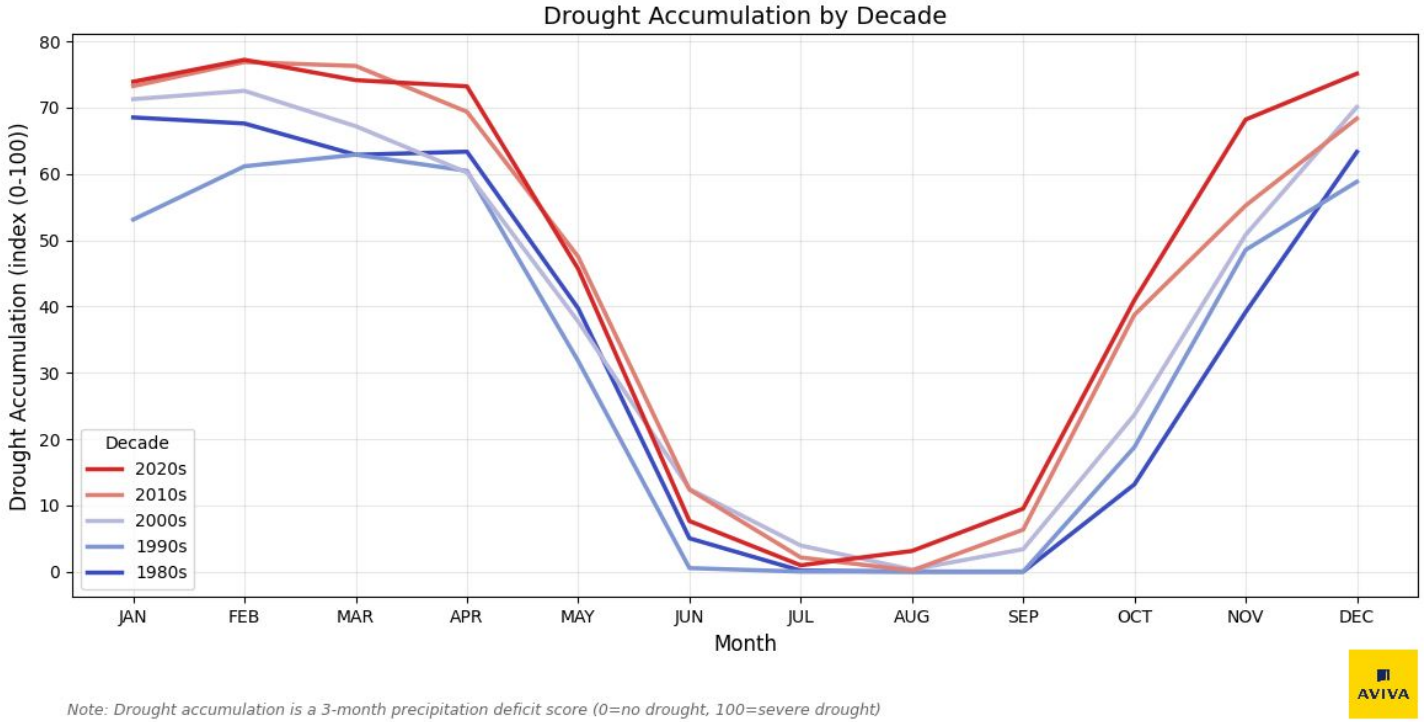
2. Precipitation Decrease: Regime Shift

Detecting regime shifts using Bayesian change point analysis (Ruggieri, 2013)

A significant regime shift in Alberta's precipitation occurred around 2008 ($p < 0.001$) with average monthly precipitation decreasing from 41 mm to 31 mm – **a 25% drop.**

The impacts on agriculture, forest health, and **wildfire risk** will be significant.

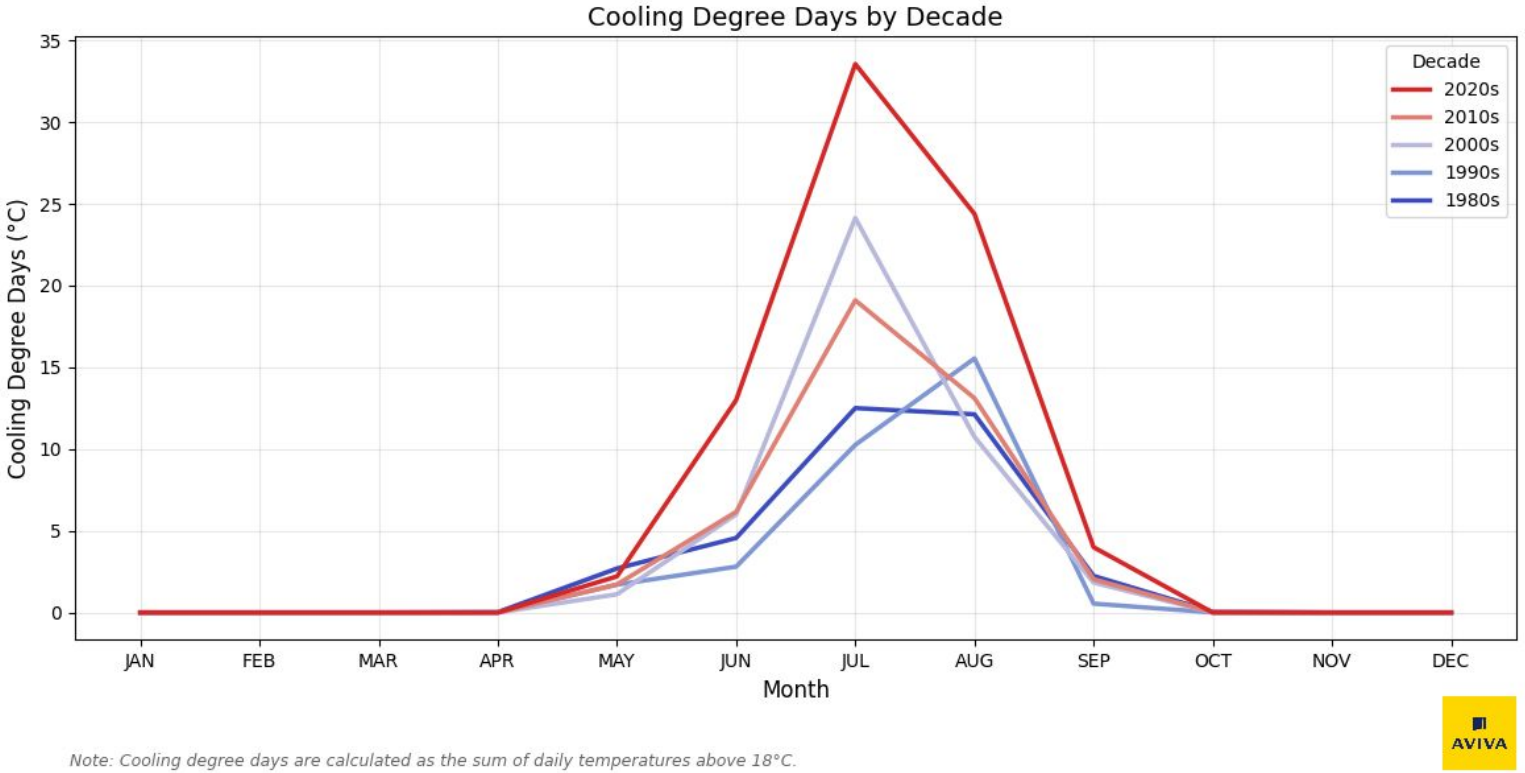
2. Precipitation Decrease



Note: Drought accumulation is a 3-month precipitation deficit score (0=no drought, 100=severe drought)

Takeaway: decreasing precipitation is also leading to longer term drought vulnerability, especially in Summer and Fall months.

3. Extreme Heat



Takeaway: the 2020s have seen dramatically elevated frequency of very hot days especially in summer months (June - August).

3. Extreme Heat

Extreme value analysis modeling annual temperature maxima found that extreme high temperatures in Alberta show a statistically significant increasing trend over time (**p= < 0.001**).

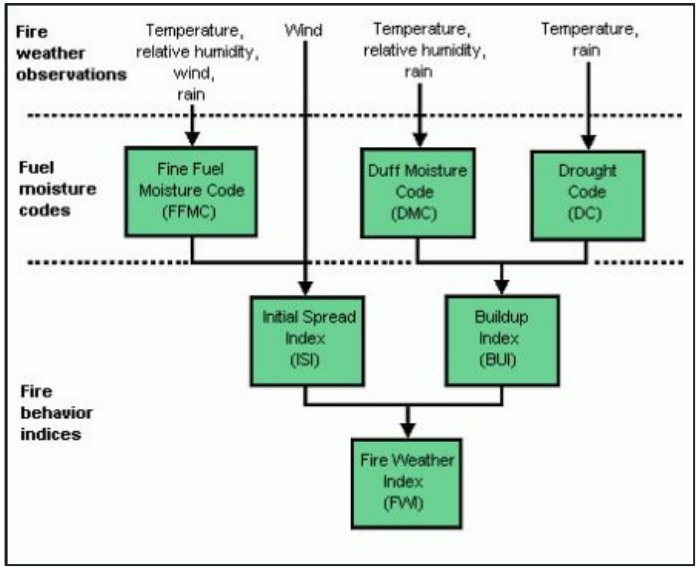
The baseline 100-year heat event now occurs approximately **every 93 years** - a modest but statistically significant increase of the most extreme, dangerous temperatures.

4. Growing Wildfire Risk

“Fire Weather Index” (FWI) is a metric invented by the Canadian Forest Service and used internationally to asses wildfire risk. The metric considers temperature, humidity, windspeed, precipitation, and fuel availability.

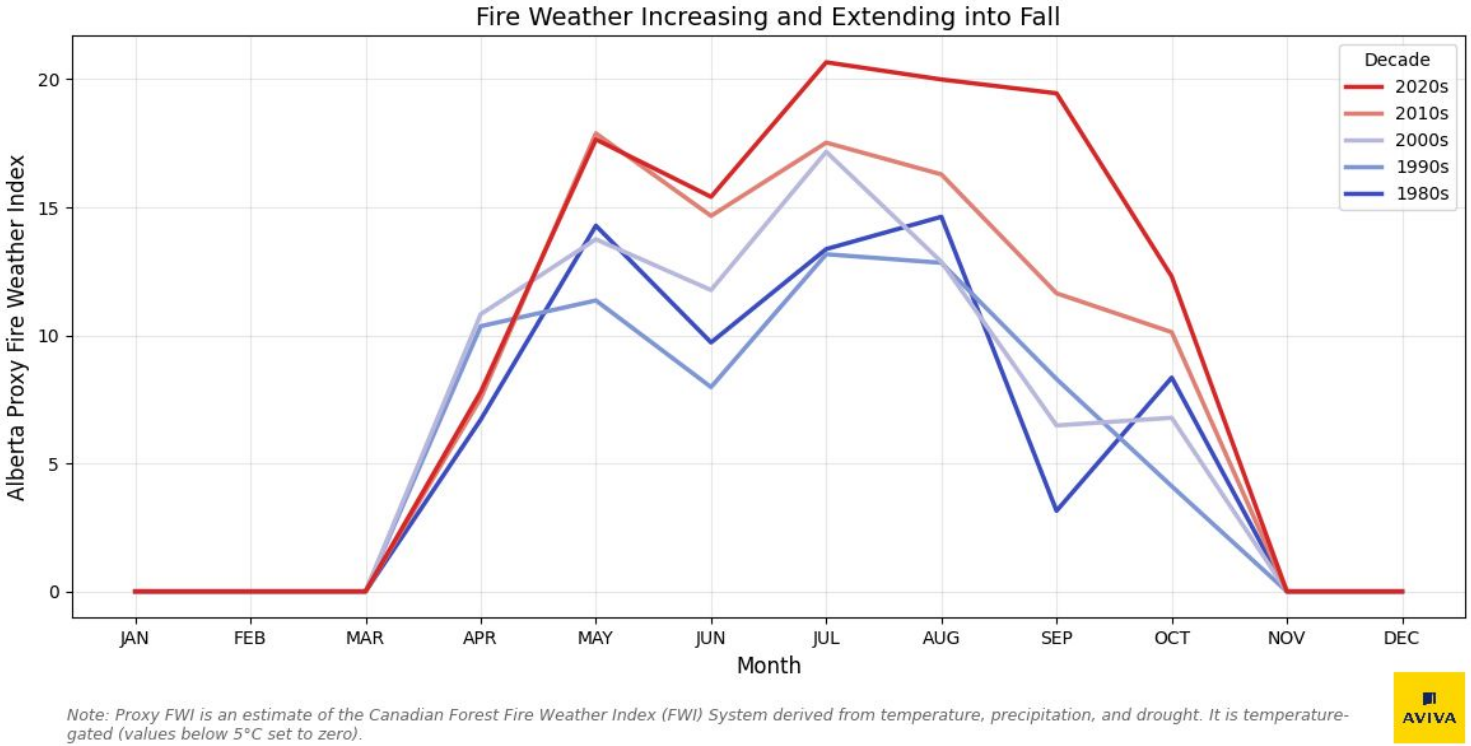
Extreme heat and low levels of precipitation, especially coinciding in Summer months, are driving high wildfire risk in Alberta.

This analysis uses a proxy calculation for FWI using monthly temperature and precipitation data.



https://cwfis.cfs.nrcan.gc.ca/background/summary/fwi

4. Growing Wildfire Risk



Note: Proxy FWI is an estimate of the Canadian Forest Fire Weather Index (FWI) System derived from temperature, precipitation, and drought. It is temperature-gated (values below 5°C set to zero).

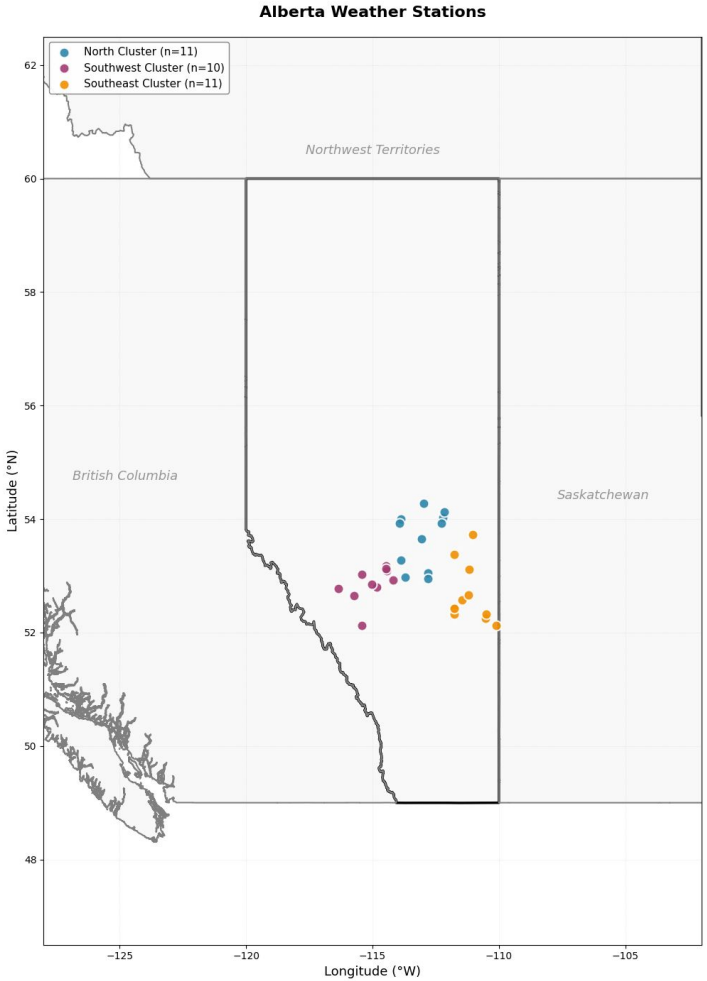
Takeaway: the 2020s in particular have seen elevated risk in late Summer and early Fall months (July-October) revealing a worsening peak wildfire season as well as its extension into Fall.

4. Growing Wildfire Risk

Extreme fire weather is characterized by a dangerous combination of very high temperatures, low humidity, high fuel availability, and high winds. The most destructive wildfires in Alberta have tended to occur during periods of extreme fire weather.

Fire weather extremes in Alberta show a statistically significant increasing trend over time (**p=0.028**).

Fire weather risk that used to only be reached every 100 years now occurs approximately **every 79 years**—a significant jump in frequency of the most dangerous fire weather.



5. High risk region: Southeast Cluster

Geographic clustering allows us to identify regional patterns without sacrificing data robustness.

The Southeast (yellow) cluster has seen particularly pronounced risk increases.

5. High risk region: Southeast Cluster

Less precipitation makes droughts worse and increases wildfire risk. These related risks are especially elevated in the Southeast cluster compared to the other 2 clusters.

A precipitation event that historically occurred once per century (the driest month in 100 years) is now nearly **twice as frequent** - what was a 100-year drought minimum now has approximately a **52-year return period**.

The regime shifts have occurred **first in the Southeast cluster** suggesting the region may be a leading indicator of climate changes in other parts of the province.

Methodology

For details on methodology and statistical results refer to:

- The accompanying notebook.
- Code and results in the GitHub repo.

References:

1. Canadian FWI System: https://cwfis.cfs.nrcan.gc.ca/background/summary/fwi.
2. Ruggieri, Eric. "A Bayesian approach to detecting change points in climatic records." *International Journal of Climatology* 33.2 (2013): 520-528. https://mathcs.holycross.edu/~eruggier/joc3447.pdf.
3. extRemes: Extreme Value Analysis. https://cran.r-project.org/web/packages/extRemes/index.html.
4. Station Inventory. https://collaboration.cmc.ec.gc.ca/cmc/climate/Get_More_Data_Plus_de_donnees/.