Rocky Mountain National Park Climate Primer

Observed Trends in Temperature and Precipitation

Rocky Mountain National Park (RMNP) is characterized by dramatic vistas and high topographic relief, and the complex interactions of topography and regional-scale air masses create dynamic short-term weather and the long-term climate patterns that characterize RMNP. Elevation strongly influences the amount, seasonality, and form of precipitation. Total precipitation at higher is more than twice that received at the lower elevations in RMNP (Fig. 1). Most high-elevation precipitation occurs as snow in winter, while at lower elevations most precipitation occurs as rain in summer. Major weather events in RMNP and the Southern Rockies are caused by flows of air masses that can originate from any direction, and many notable weather events are the result of collision of air masses from more than one direction. The Front Range location of RMNP makes it particularly susceptible to heavy precipitation events. In the spring, the collision of moist air coming up from the Gulf with colder arctic air can result is intense, very wet snowfalls with total snow depth measured in the feet, containing inches of snow water equivalent. In the summer, moist upslope air masses can lead to intense orographic precipitation (e.g. microbursts) and violent thunder storms. Summer precipitation in the mountains is often a result of convection storms.

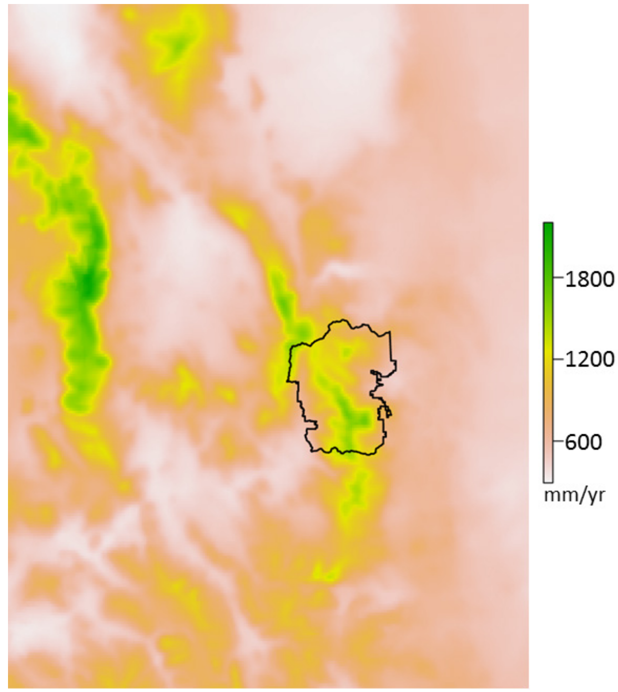


Figure 1. Map of annual precipitation, illustrating steep gradients in precipitation driven by elevation. Higher elevations of RMNP (in green) receive about twice the precipitation of lower elevations, and precipitation at higher elevations falls more consistently throughout the year. RMNP is outlined in black.

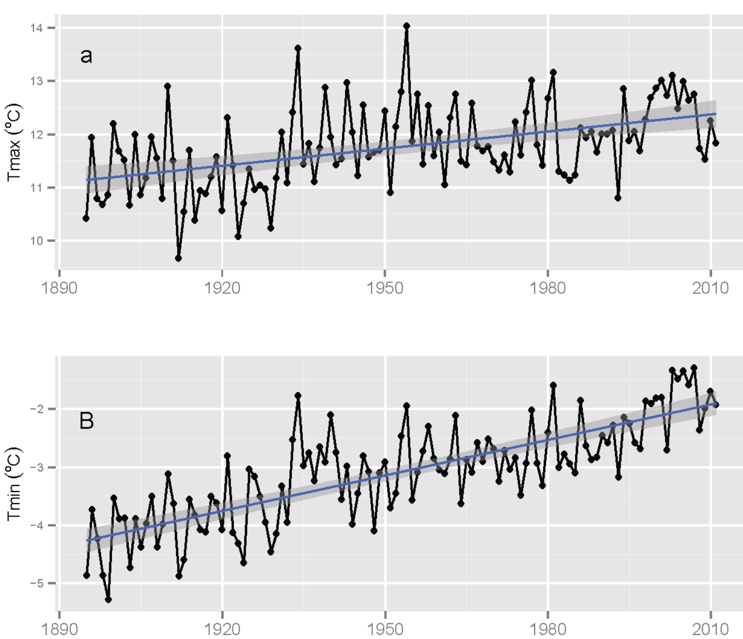


Figure 2. Temperatures have rapidly increased in RMNP over the last century, with minimum temperatures increasing more rapidly than maximum.

Flows of major air masses and other regional influences on RMNP climate and weather have probably not changed much over the past century[i]. Nonetheless, during the past century temperatures have increased about 1.4^{o} C over the past century. Over the past century, average minimum temperature has increased more rapidly than the average maximum (Fig. 2).

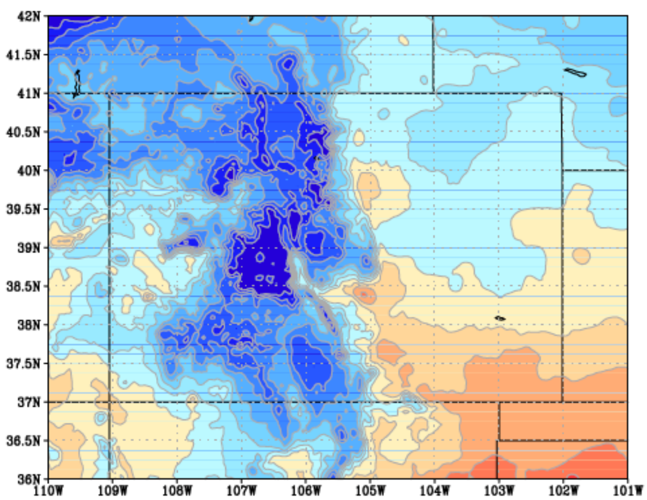
Increases in temperature have been accompanied by changes in the snowpack and runoff. Water content of the spring snow pack has been diminishing, and peak runoff is occurring earlier. One consequence of this is an increasing summer water deficit, which is likely leading to a fire season that begins earlier and ends later.

Projected 21st Century Changes

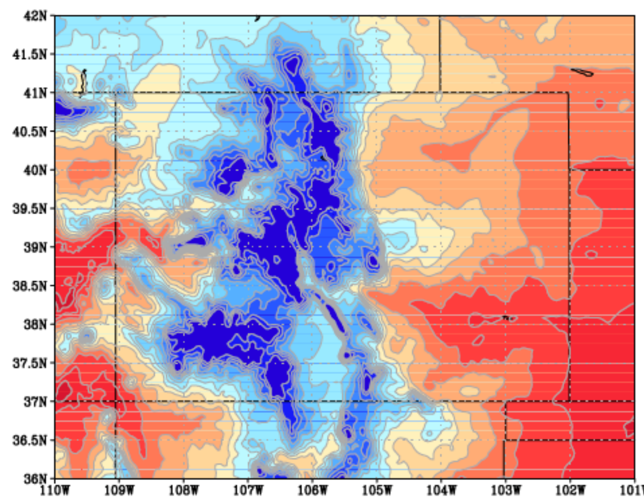
All global climate models (GCMs) are consistent in projecting temperature increases throughout the Rocky Mountains and adjacent areas. Increases in temperatures are projected to lead to an increase in extremely hot weather spells, and a decrease in cold spells (Table below). Projections for changes in precipitation are less certain, with large variations between models and with large year-to-year changes in the amount of rain and snow.

Increasing temperatures will lead to earlier snowmelt, especially at lower elevations, and an earlier runoff. Rain on snow events may be more likely, and most projections include more extreme precipitation events.

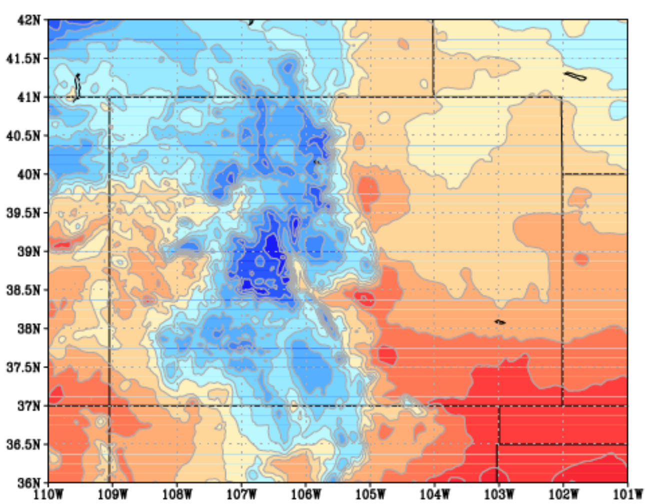
JANUARY CLIMATOLOGICAL TEMPERATURE (1950–99)



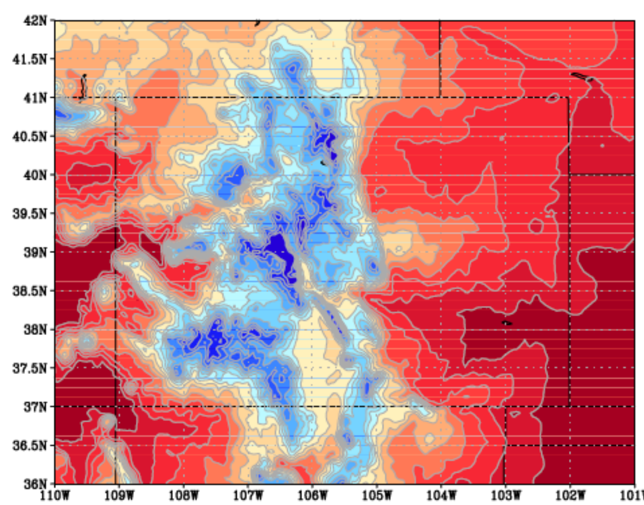
JULY CLIMATOLOGICAL TEMPERATURE (1950–99)

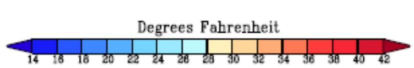


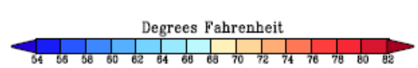
PROJECTED JANUARY CLIMATOLOGICAL TEMPERATURE 2050



PROJECTED JULY CLIMATOLOGICAL TEMPERATURE 2050







Climate Variable	Trend	Relative Change by 2050	Projections for 2050s
Temperature (change from 1960-1990; x + SD)	⇧	Large	2.7 + 0.7 C (4.9 + 1.3 F) Warming greater in summer
Extreme high temperatures	⇧	Large	1-in-20 year mean maximum temperature Likely to increases by 2-3 C (3.6 -5.4 F). 1-in-20 year maximum temperature events Likely to occur 1-in-2 to 1-in-4 years.
Mean precipitation (% change from 1960-1990; x + 1 sd)	⇔	Small	1 + 7.2 %
Evaporation	⇧	Moderate	Increase due to temperature; difficult to quantify
Intense precipitation events	⇧	Moderate	"Marked" increase in 24-hr precipitaton for 2040-2070 period. 50-70% increase in event maxima.
Snowfall (April 1 SWE)	⇩	Moderate	2050: -15 to -30%
Streamflow	⇔	Small	No change to slight decrease
Drought	⇧	Moderate	Difficult to quantify. Likely result of higher temperatures, increased evaporation, and perhaps increased variation in precipitation.
Hail	⇩	Large	Almost complete elimination of surface hail

Impacts of Projected Climate Change

Explosive growth to pine beetles

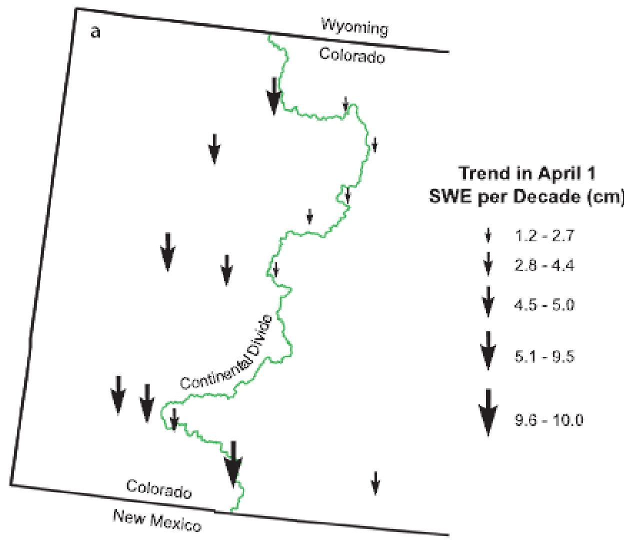
One of the most apparent change in RMNP forests is the result of tree mortality caused by mountain pine beetles (picture at right). Native pine beetles historically produced at a much less rapid rate, and cold winter temperatures limited their distribution and caused extensive winter mortality. The warmer temperatures in the past several decades have allowed pine beetles to complete an entire generation in one year, leading to explosive population growth and massive tree mortality.

Mountain pine beetles have caused extensive mortality of forest trees in RMNP. Pine beetles are native, but temperatures now permit rapid reproduction and explosive population growth.

Projections for RMNP forests are not encouraging. Conifers in RMNP are subject to attack by a variety of forest pathogens and pests, and climate changes may produce additional stressors that make trees more susceptible.

Earlier Runoff

Mountains provide a key service in storing water in the winter and releasing it throughout the summer. Over the past several decades, there has been a significant trend to earlier melt of the snow pack and an earlier peak in snow-fed streams and rivers in Colorado. This trends is most pronounced at lower elevations because these areas are warmer and this a small increase in temperatures melts snow.

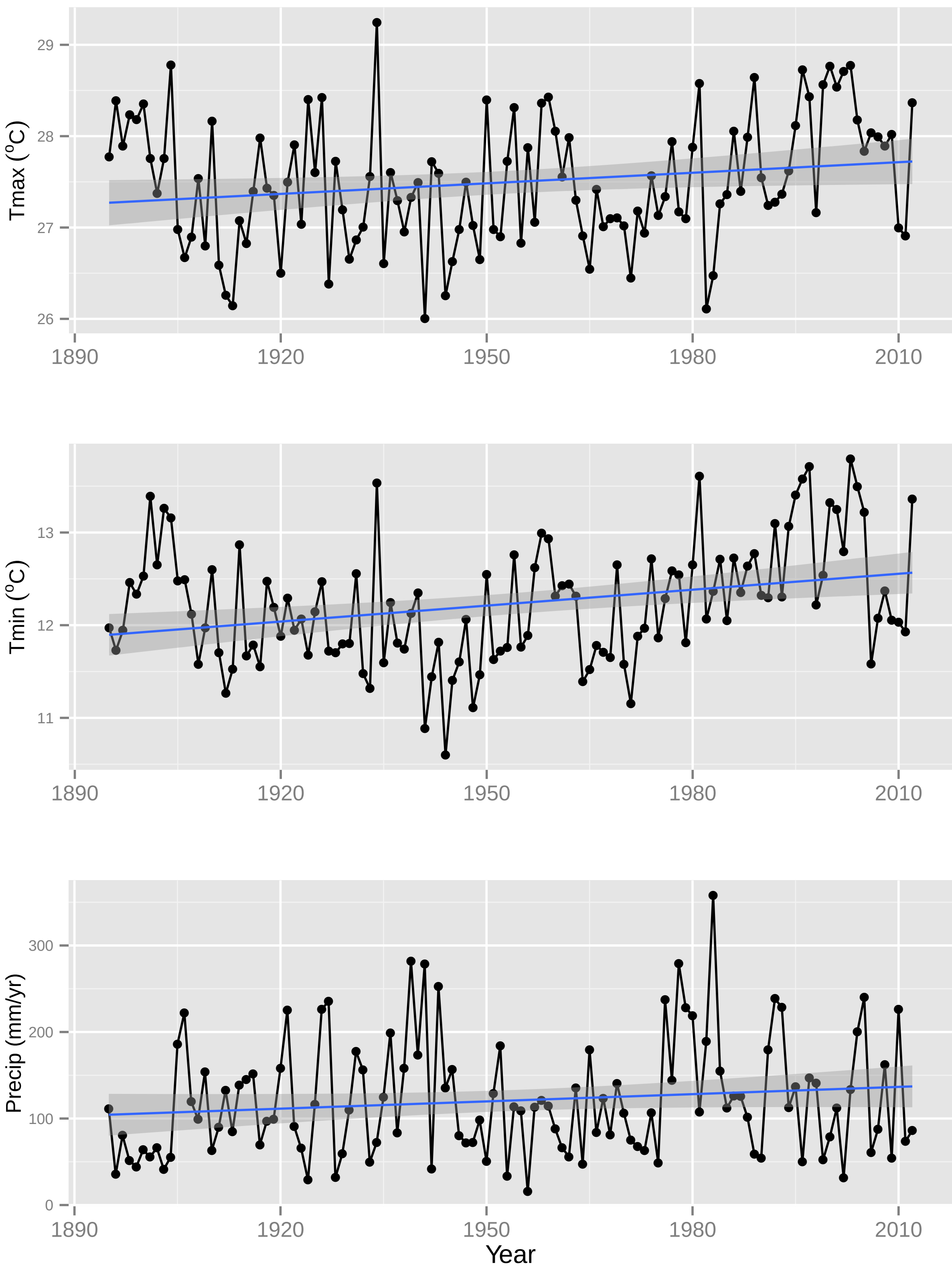


Snow water storage in Colorado has been declining for the past several decades, and all models project the trend to smaller spring snow packs will continue. Figure from Clow 2010)

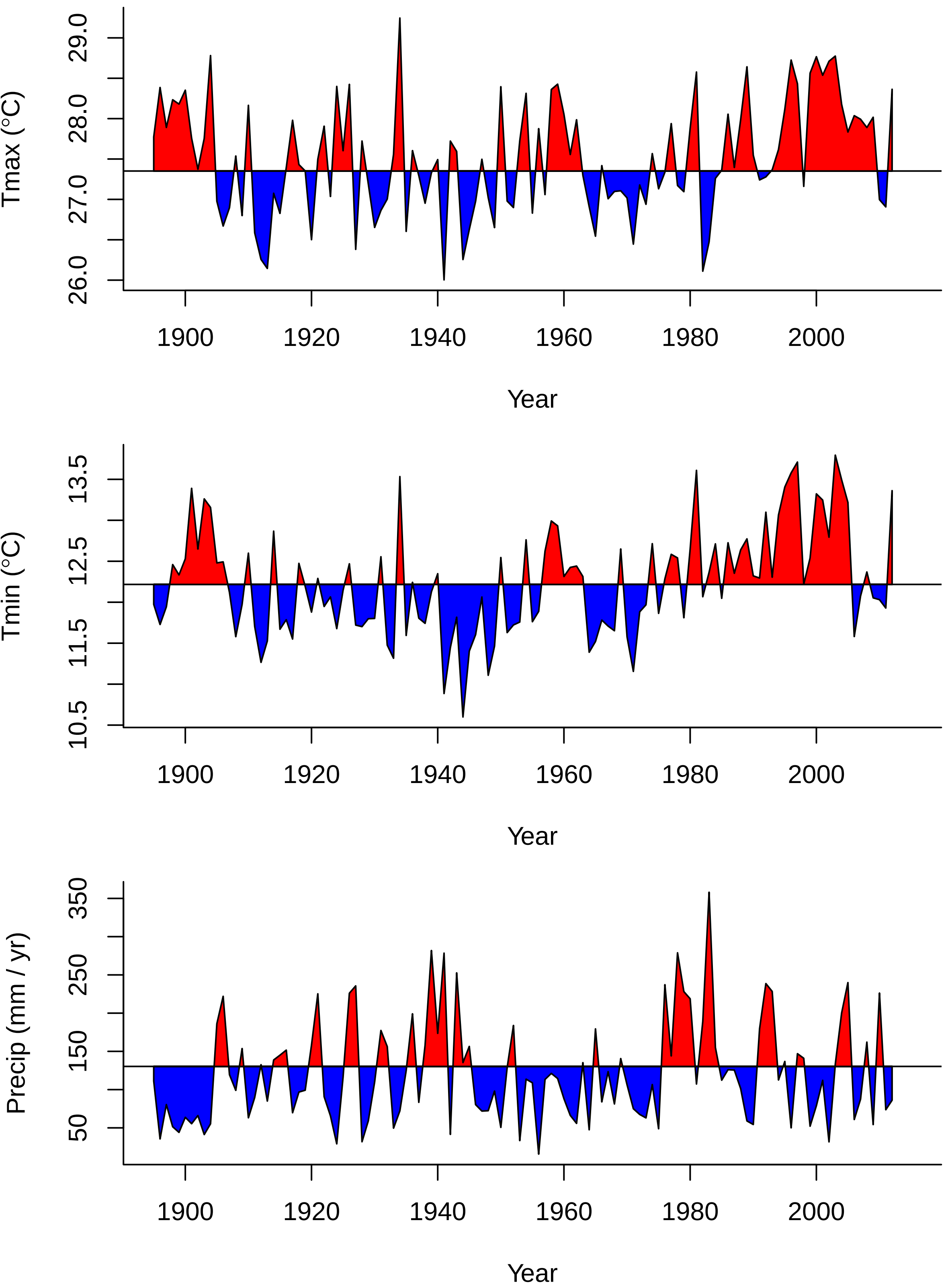
Fire

(text on fire seasonality)

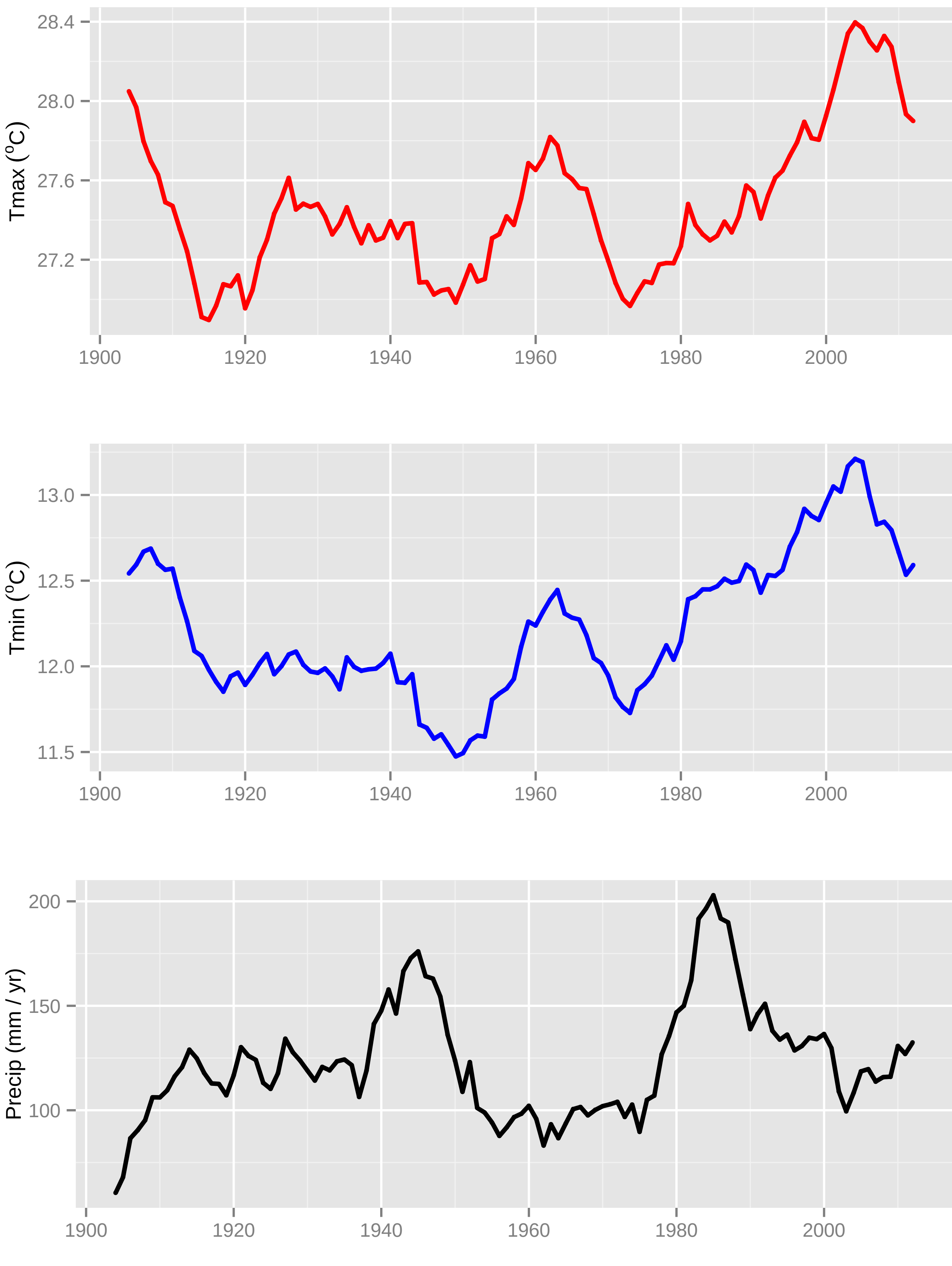
____



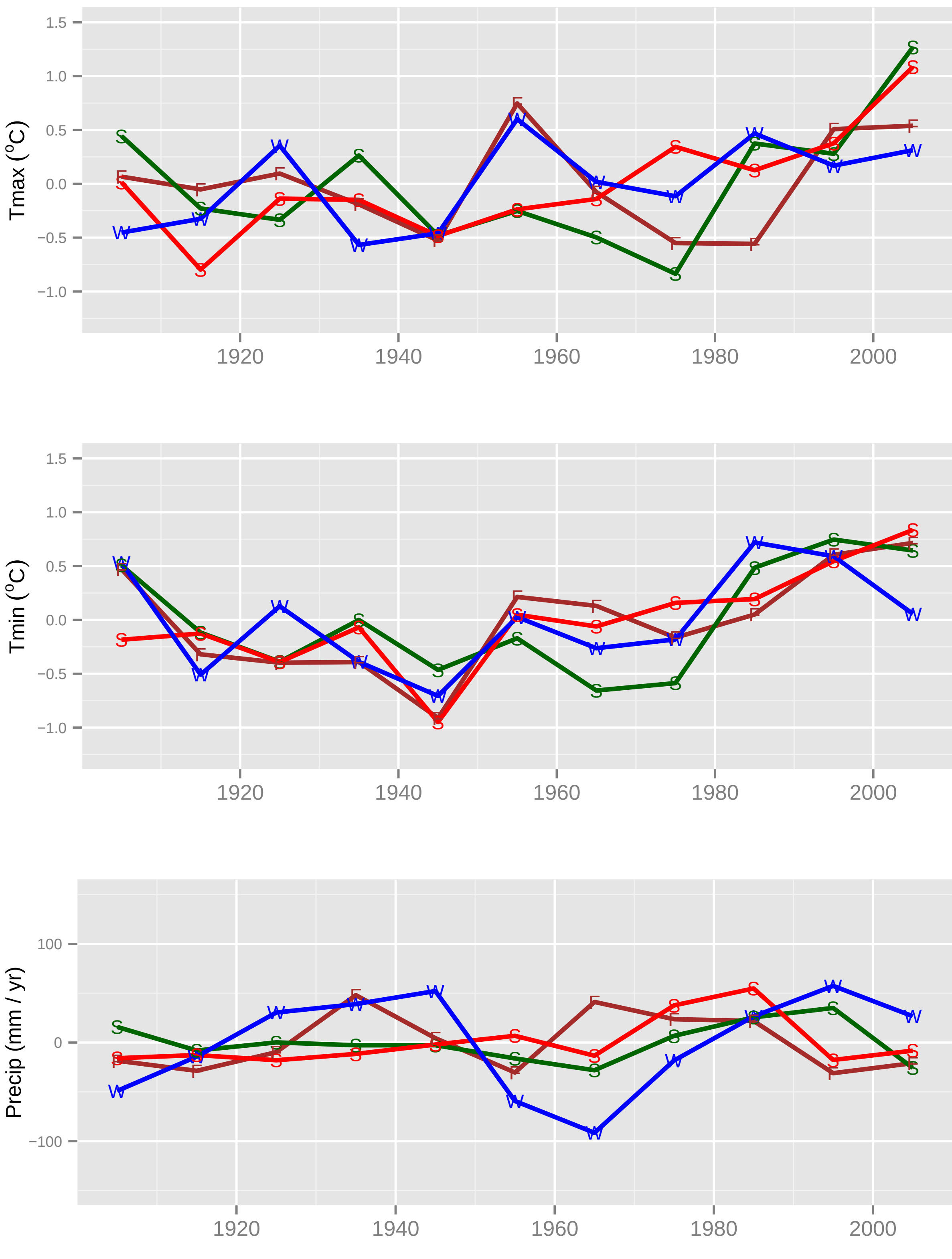
Tmax (°C)
29
28
27
26
1890
1920
1950
1980
2010
Tmin (°C)
13
12
11
1890
1920
1950
1980
2010
Precip (mm/yr)
300
200
100
0
1890
1920
1950
1980
2010
Year



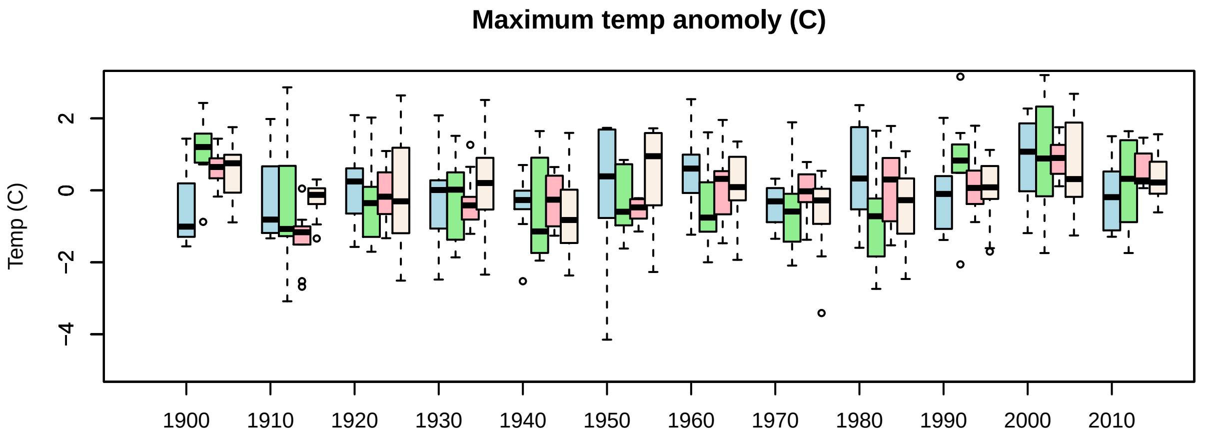
Tmax (°C)
29.0
28.0
27.0
26.0
1900
1920
1940
1960
1980
2000
Year
Tmin (°C)
13.5
12.5
11.5
10.5
1900
1920
1940
1960
1980
2000
Year
Precip (mm / yr)
350
250
150
50
1900
1920
1940
1960
1980
2000
Year

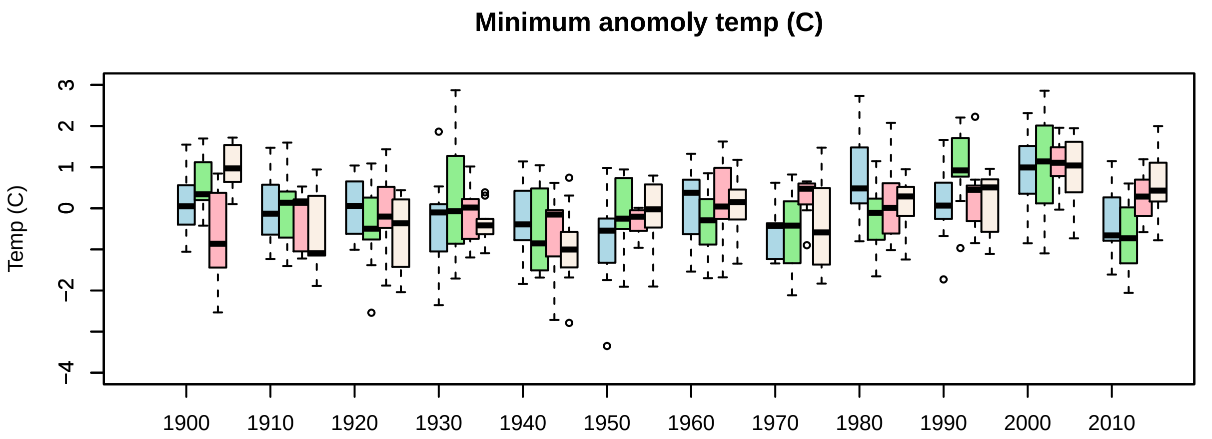


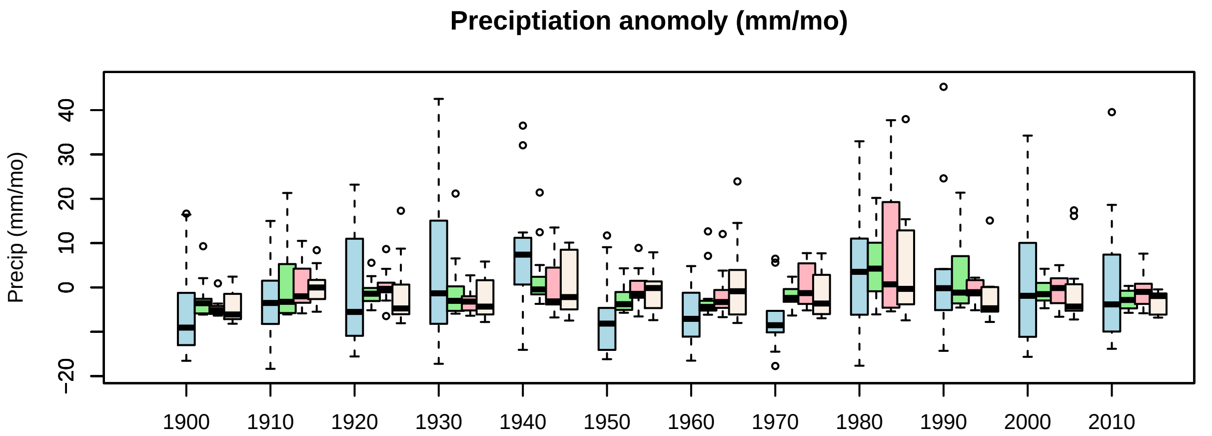
Tmax (ºC)
28.4
28.0
27.6
27.2
Tmin (ºC)
13.0
12.5
12.0
11.5
Precip (mm / yr)
200
150
100
1900
1920
1940
1960
1980
2000

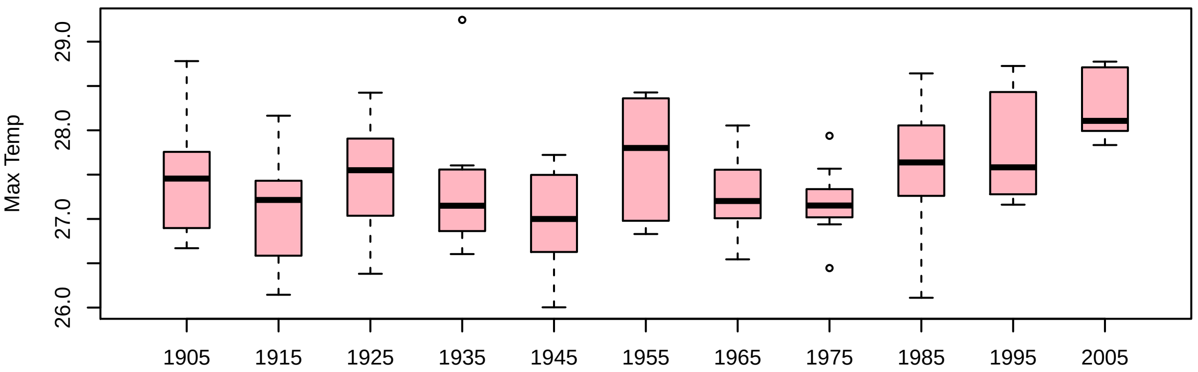


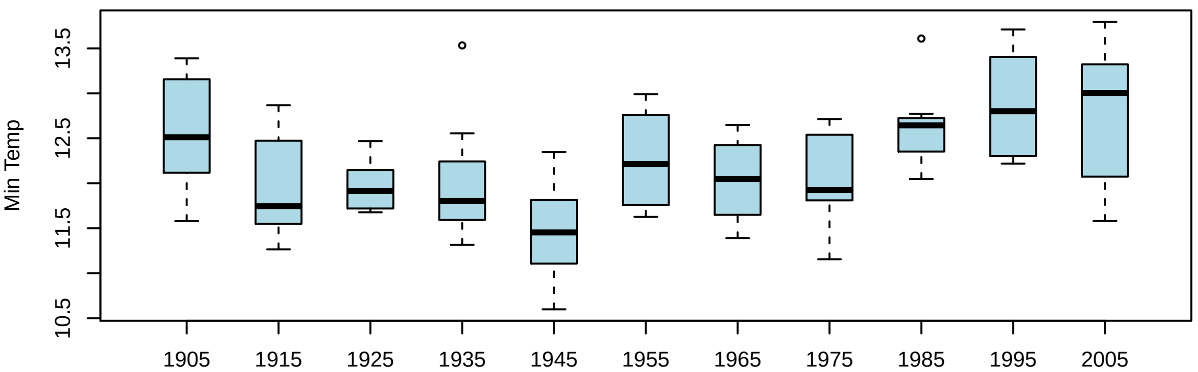
Tmax (ºC)
1.5
1.0
0.5
0.0
−0.5
−1.0
1920
1940
1960
1980
2000
Tmin (ºC)
1.5
1.0
0.5
0.0
−0.5
−1.0
1920
1940
1960
1980
2000
Precip (mm / yr)
100
0
−100
1920
1940
1960
1980
2000

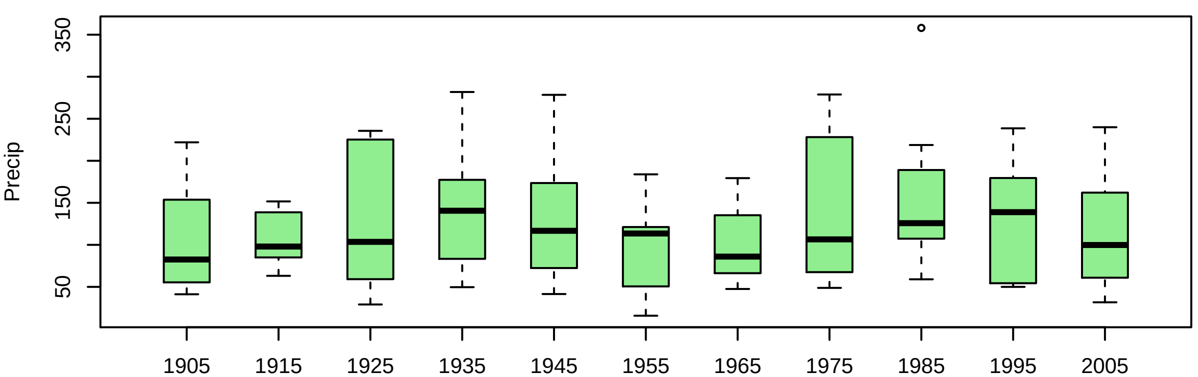

Maximum temp anomoly (C)
Temp (C)
2
0
−2
−4
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

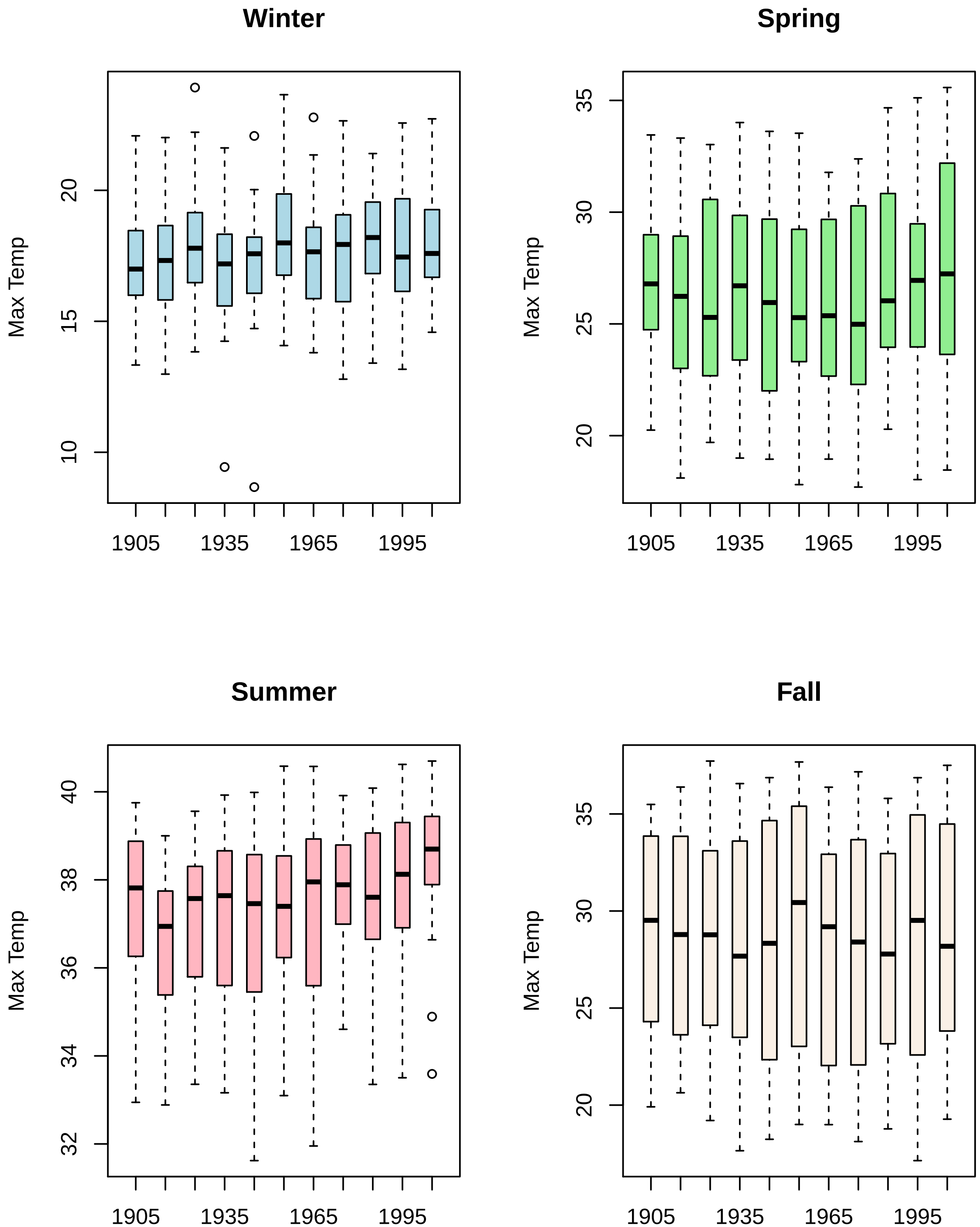

Minimum anomoly temp (C)
Temp (C)
3
2
1
0
−2
−4
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010


Preciptiation anomoly (mm/mo)
Precip (mm/mo)
40
30
20
10
0
−20
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

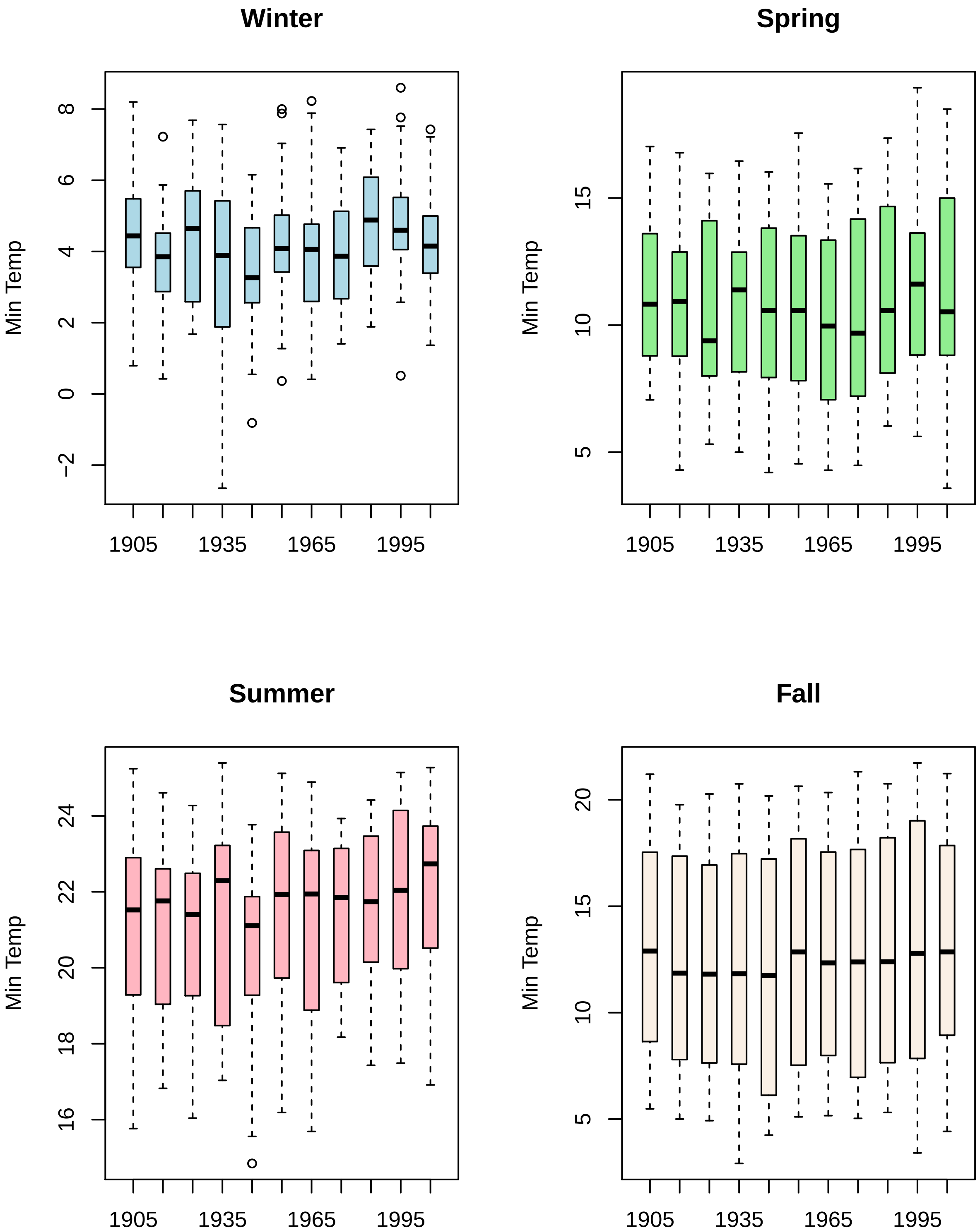

Max Temp
26.0
27.0
28.0
29.0
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005


Min Temp
10.5
11.5
12.5
13.5
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005


Precip
50
150
250
350
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005



Winter
Spring
Summer
Fall
Max Temp
10
15
20
25
30
35
32
34
36
38
40
1905
1935
1965
1995


Winter
Min Temp
−2
0
2
4
6
8
1905
1935
1965
1995
Spring
Min Temp
5
10
15
1905
1935
1965
1995
Summer
Min Temp
16
18
20
22
24
1905
1935
1965
1995
Fall
Min Temp
5
10
15
20
1905
1935
1965
1995