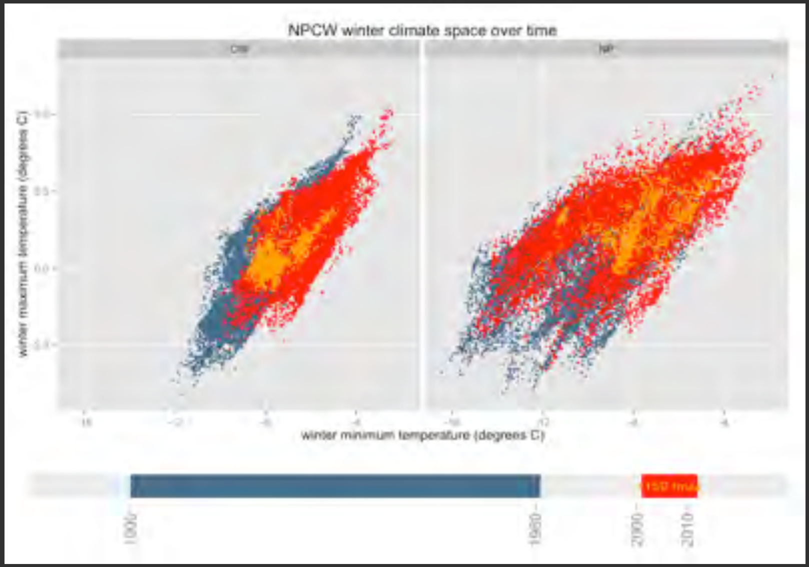
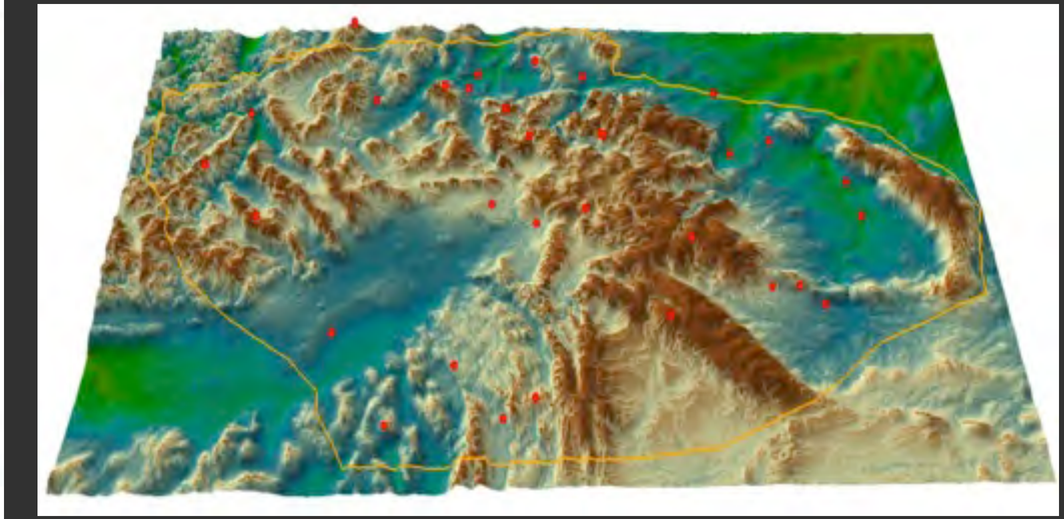
# Current and future trends in climate space in the Nez-Perce & Clearwater National Forests





**Healy Hamilton**

**Stephanie Auer**

**Matt Kling**

# Objective: To support climate change adaptation planning in NPCWNF by analysis and visualization of current and projected trends in seasonal climate variables

Types of questions to address:

Is a signal of climate change already observable?

If so, what is the spatial and temporal nature of change?

How does current change compare to modeled future projections?

How do current and projected trends compare to historic climatic variability to which current NPCWNF resource management is already adapted?

Where are the areas currently demonstrating climatic stability, and where is climate changing most?

# PRISM Spatial Climate Datasets

PRISM
CLIMATE GROUP
PRISM CLIMATE GROUP
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PROJECTS
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HELP ▾
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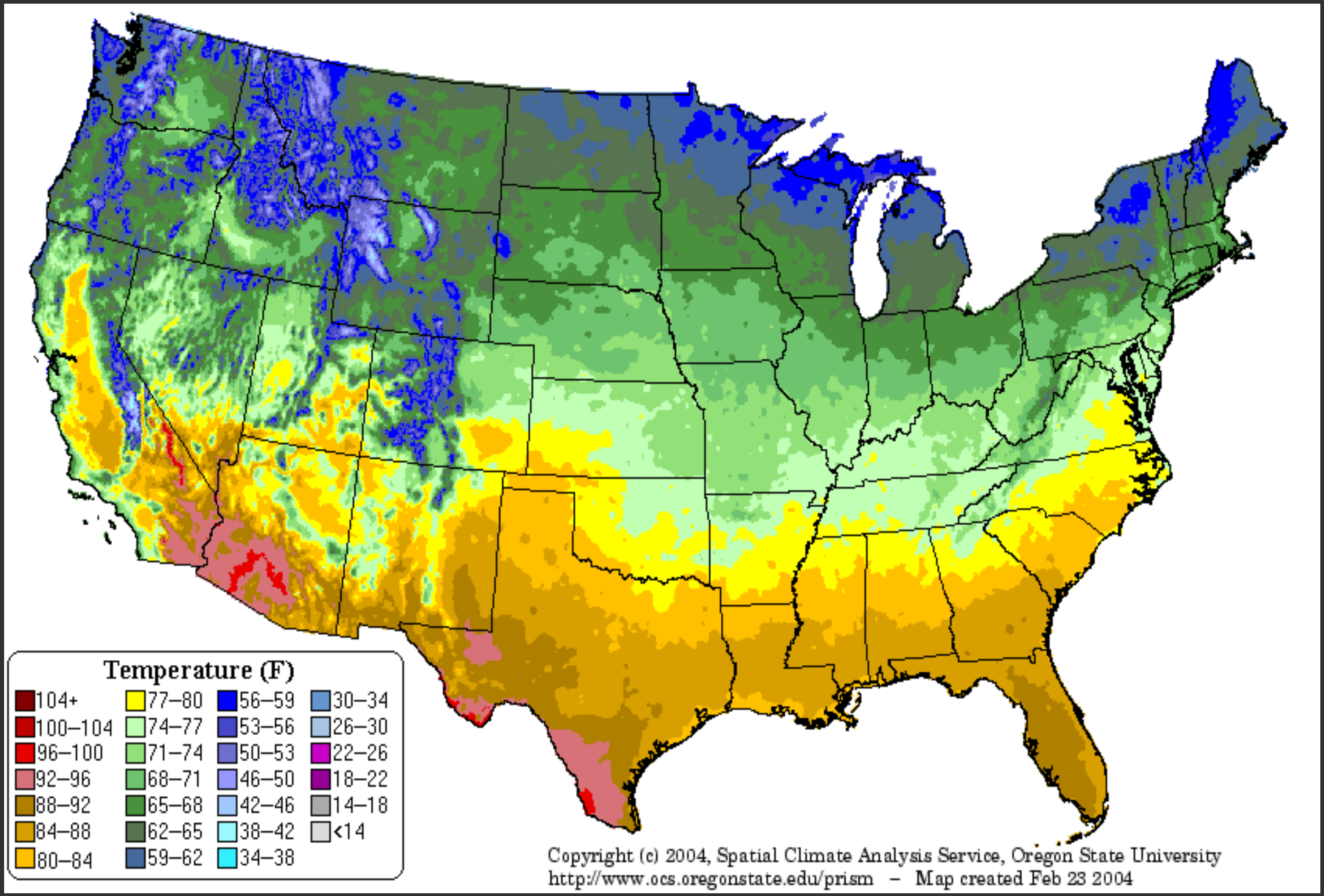
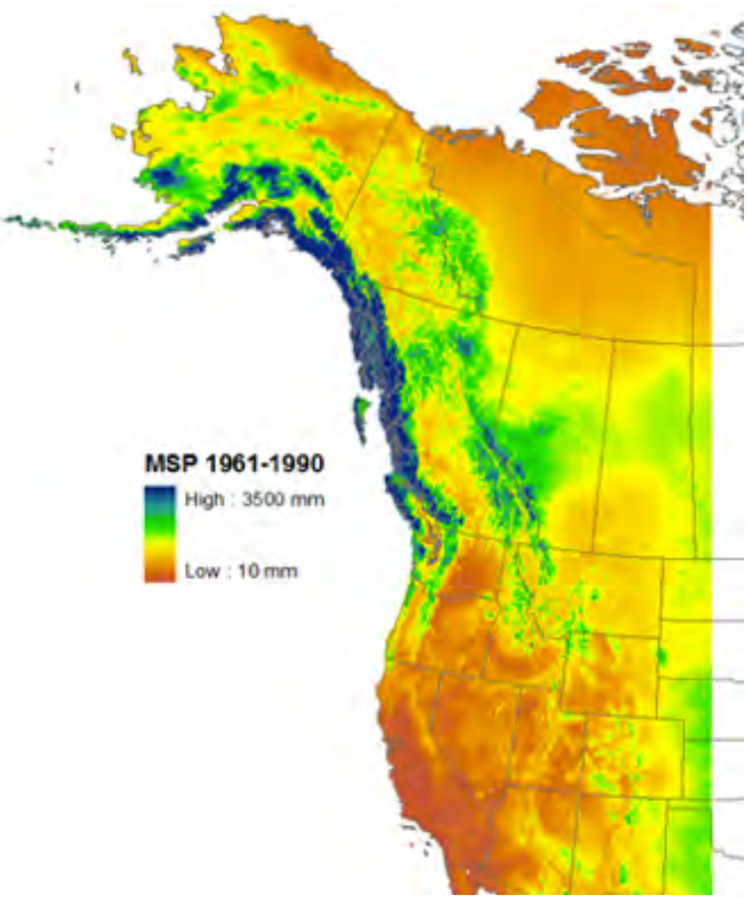
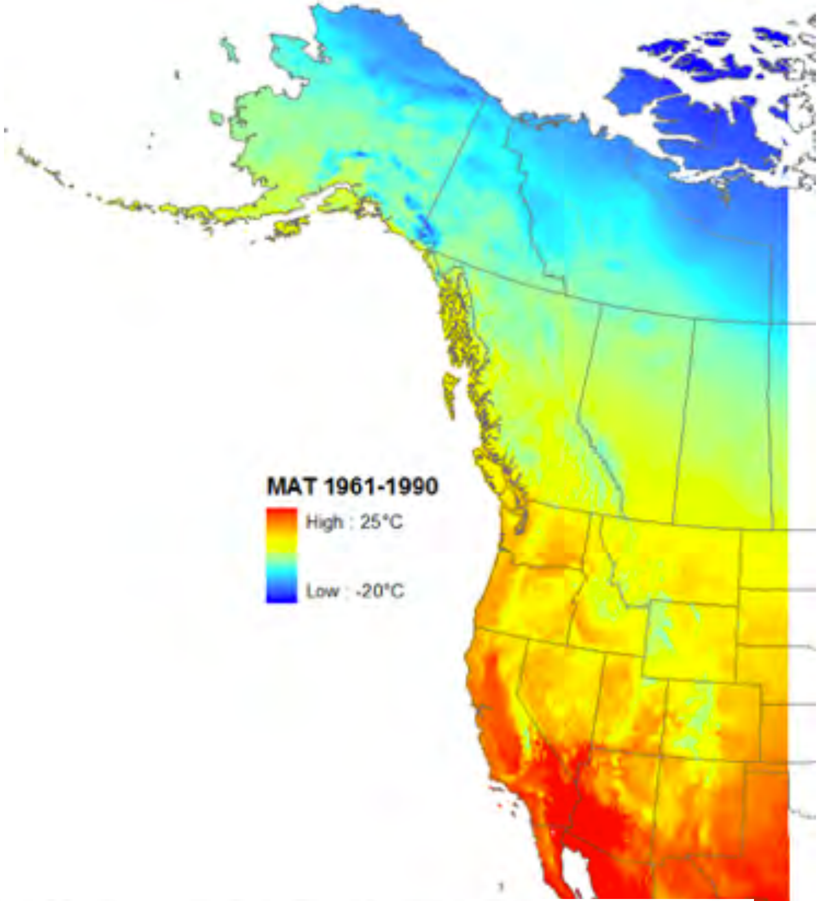
- Physiographically sensitive mapping
- Official climate datasets of the USDA
- 800-m and 4-km resolutions
- Monthly tmin, tmax, precip
- Widely used 30 yr climatologies (1971-2000, 1981-2010)

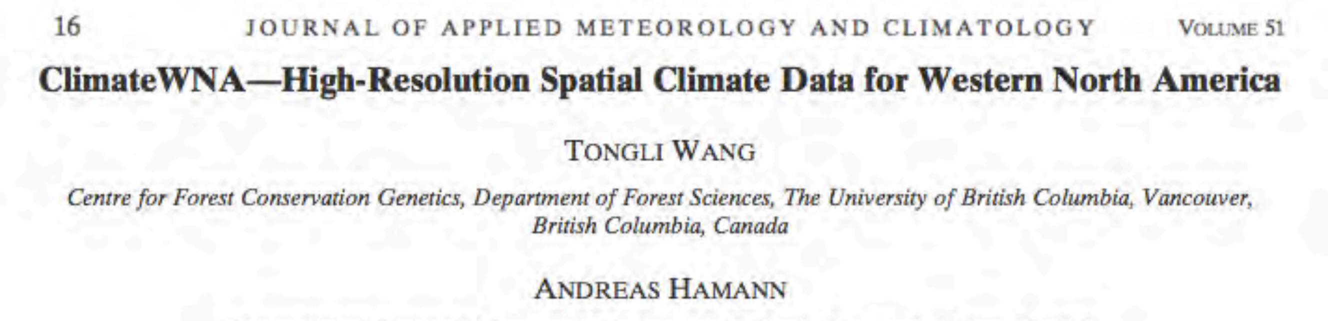

Temperature (F)
104+
100–104
96–100
92–96
88–92
84–88
80–84
77–80
74–77
71–74
68–71
65–68
62–65
59–62
56–59
53–56
50–53
46–50
42–46
38–42
34–38
30–34
26–30
22–26
18–22
14–18
<14

Copyright (c) 2004, Spatial Climate Analysis Service, Oregon State University
http://www.ocs.oregonstate.edu/prism – Map created Feb 23 2004

# Spatial Climate Datasets – "Climate Western North America"
# Wang et al 2012


MSP 1961-1990
High : 3500 mm
Low : 10 mm


MAT 1961-1990
High : 25°C
Low : -20°C



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**ClimateWNA—High-Resolution Spatial Climate Data for Western North America**

TONGLI WANG

*Centre for Forest Conservation Genetics, Department of Forest Sciences, The University of British Columbia, Vancouver, British Columbia, Canada*

ANDREAS HAMANN

# *Current trends in climate space*

Dataset: PRISM, 800m resolution

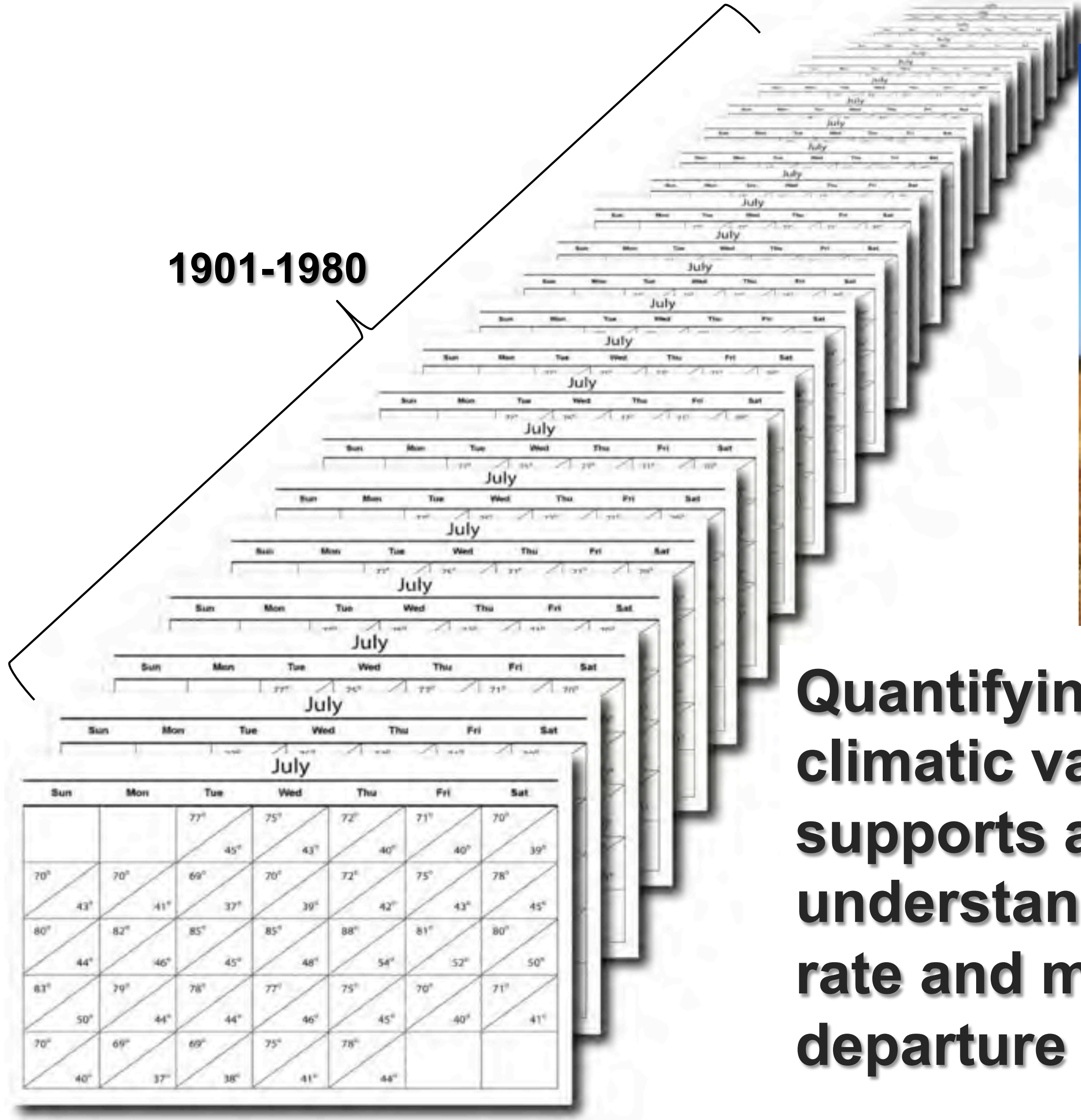
Variables: Seasonal tmin, tmax, precip

Time slices:

- Baseline = 1901-1980
- Current = 1981-2011, 1991-2011, 2001-2011

Analyses:

- Per pixel deltas between current and baseline
- Per pixel departures from range of historic variability

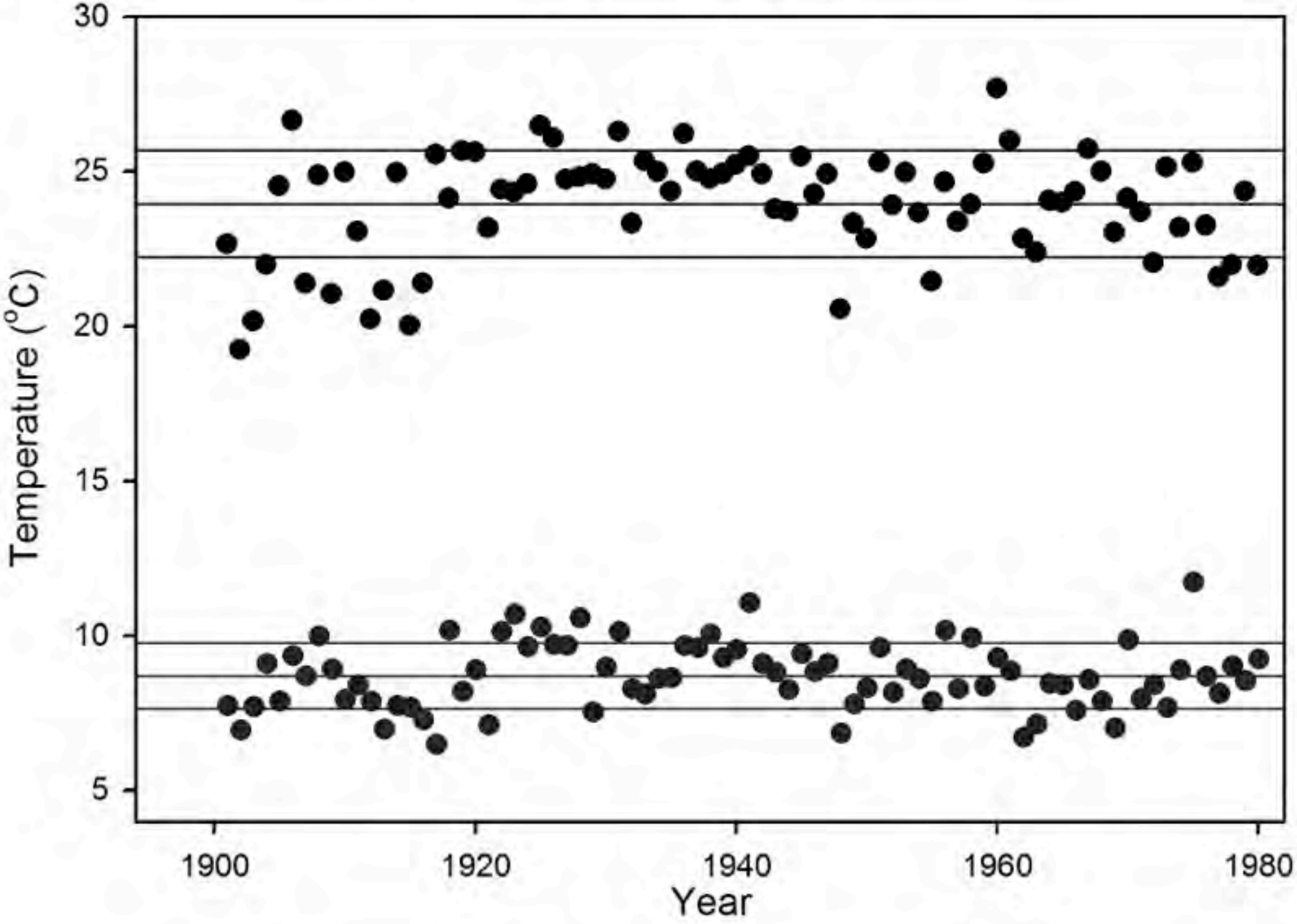


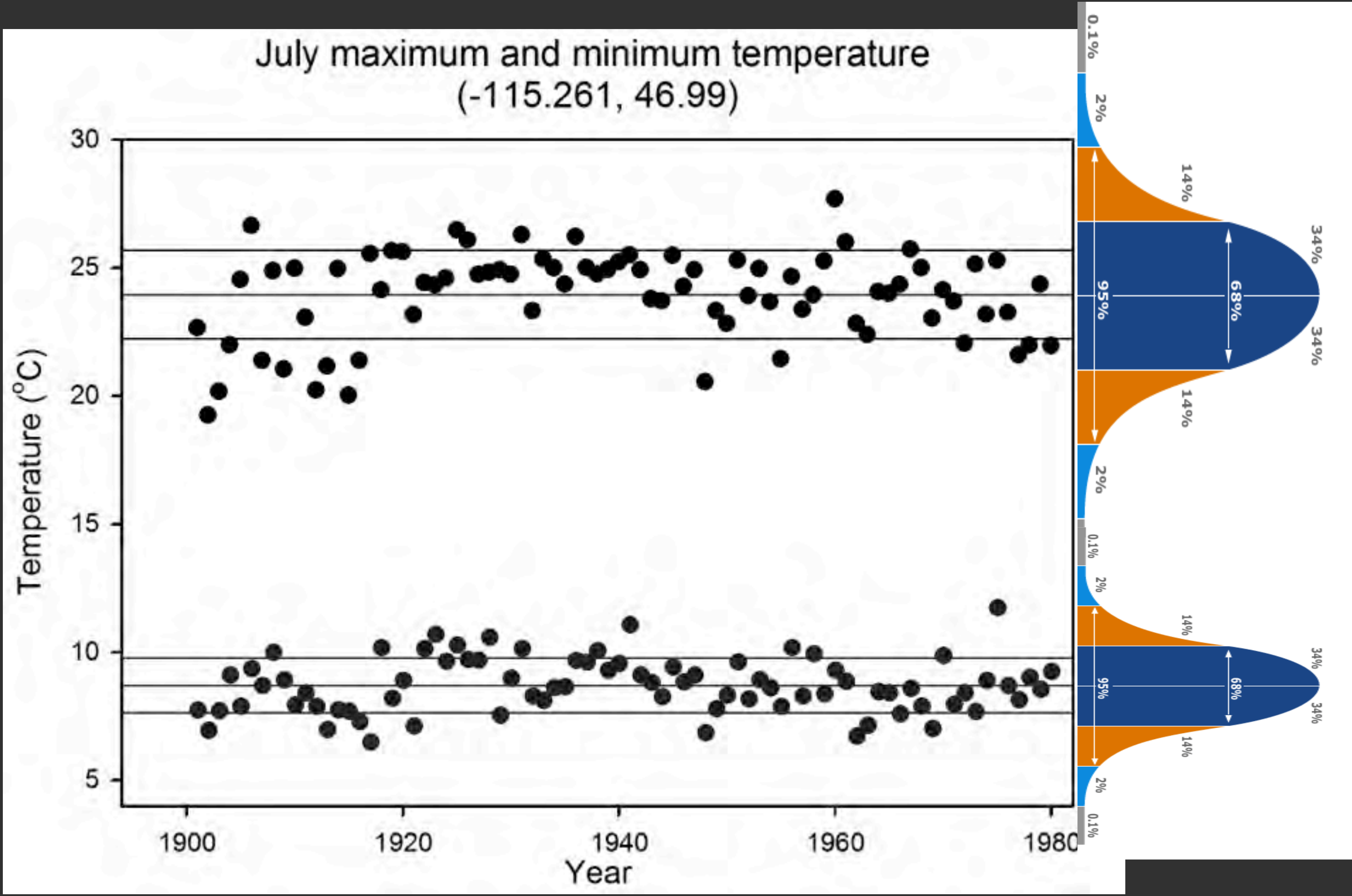
July

| Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|---|---|---|---|---|---|---|
|  |  | 77°<br>45° | 75°<br>43° | 72°<br>40° | 71°<br>40° | 70°<br>39° |
| 70°<br>43° | 70°<br>41° | 69°<br>37° | 70°<br>39° | 72°<br>42° | 75°<br>43° | 78°<br>45° |
| 80°<br>44° | 82°<br>46° | 85°<br>45° | 85°<br>48° | 88°<br>54° | 81°<br>52° | 80°<br>50° |
| 83°<br>50° | 79°<br>44° | 78°<br>44° | 77°<br>46° | 75°<br>45° | 70°<br>40° | 71°<br>41° |
| 70°<br>40° | 69°<br>37° | 69°<br>38° | 75°<br>41° | 78°<br>44° |  |  |

**Quantifying historical climatic variability supports an understanding of the rate and magnitude of departure from “normal”**

# July maximum and minimum temperature
(-115.261, 46.99)





July maximum and minimum temperature
(-115.261, 46.99)

# *Future trends in climate space*

Dataset: Climate Western North America, 4km resolution

Variables: Seasonal tmin, tmax, precip, annual tmean, annual climatic moisture deficit (CMD)

Time slices:

Baseline = 1961-1990

Future = 2041-2070

GCMs – 7 GCM average for tmean & precip
3 GCM average for tmin, tmax, and CMD

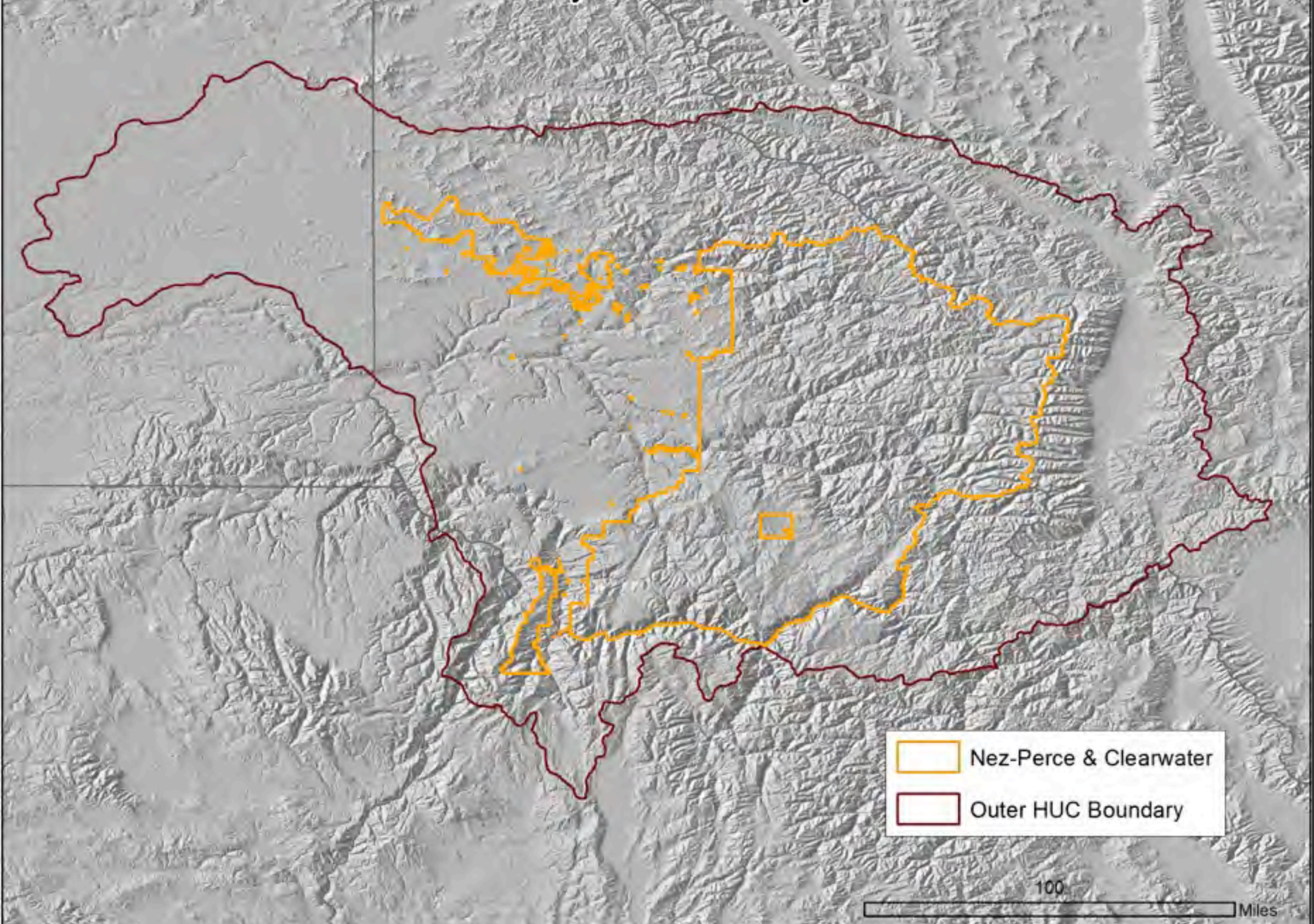
Emission scenario = A1B

Analyses:

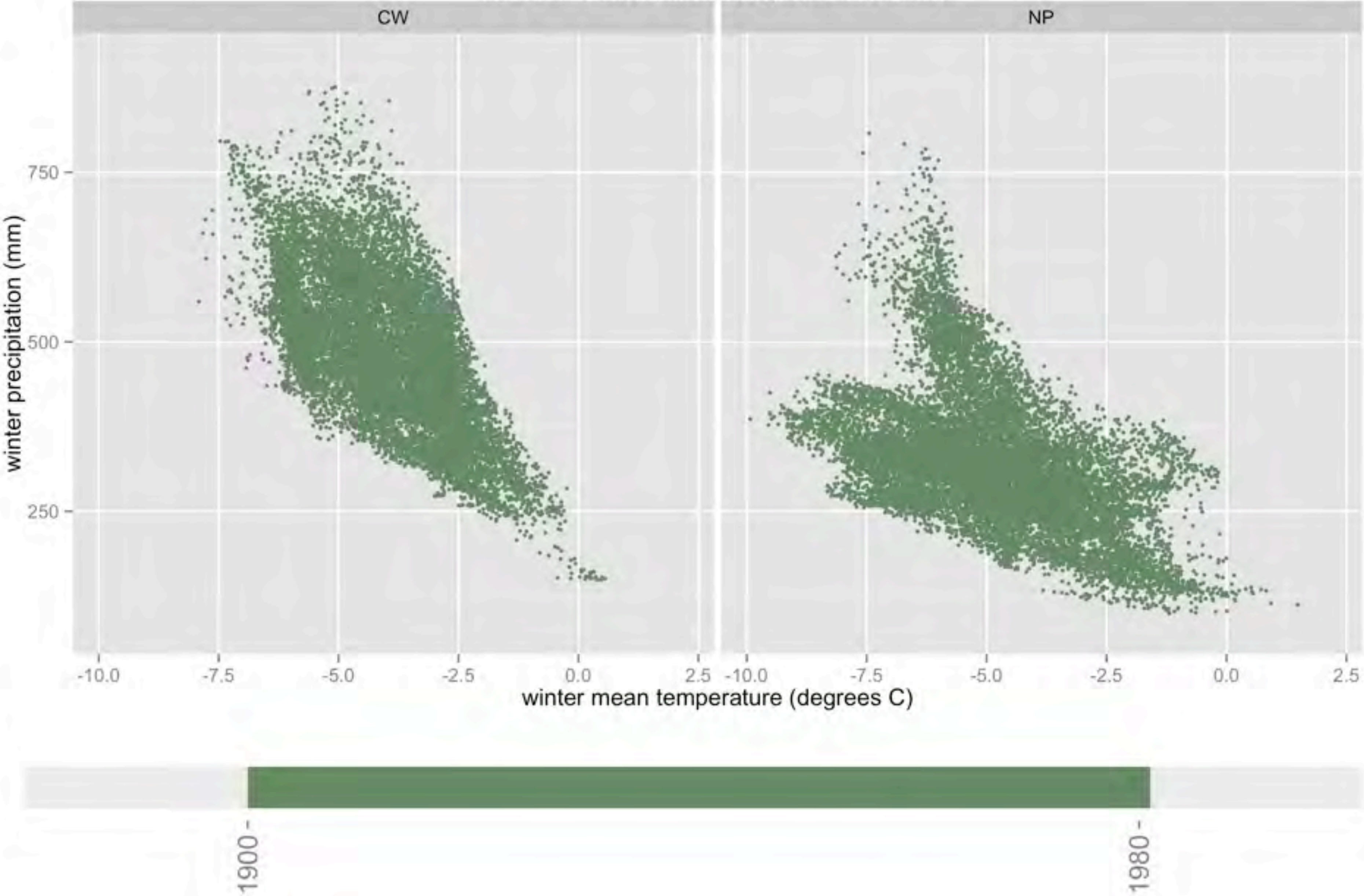
Per pixel deltas between baseline and midcentury future

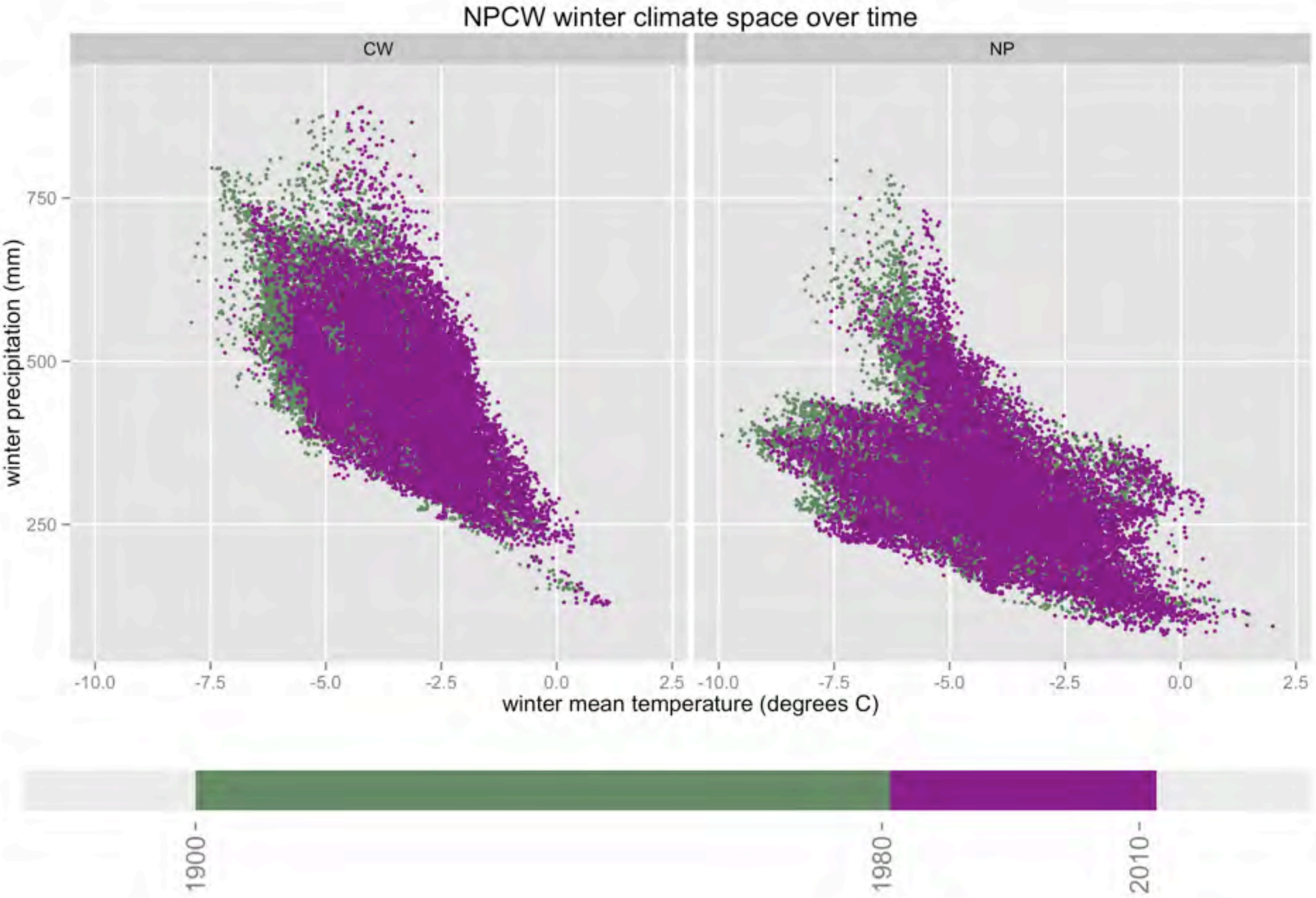
Per pixel departures from range of historic variability

# Analysis Boundary

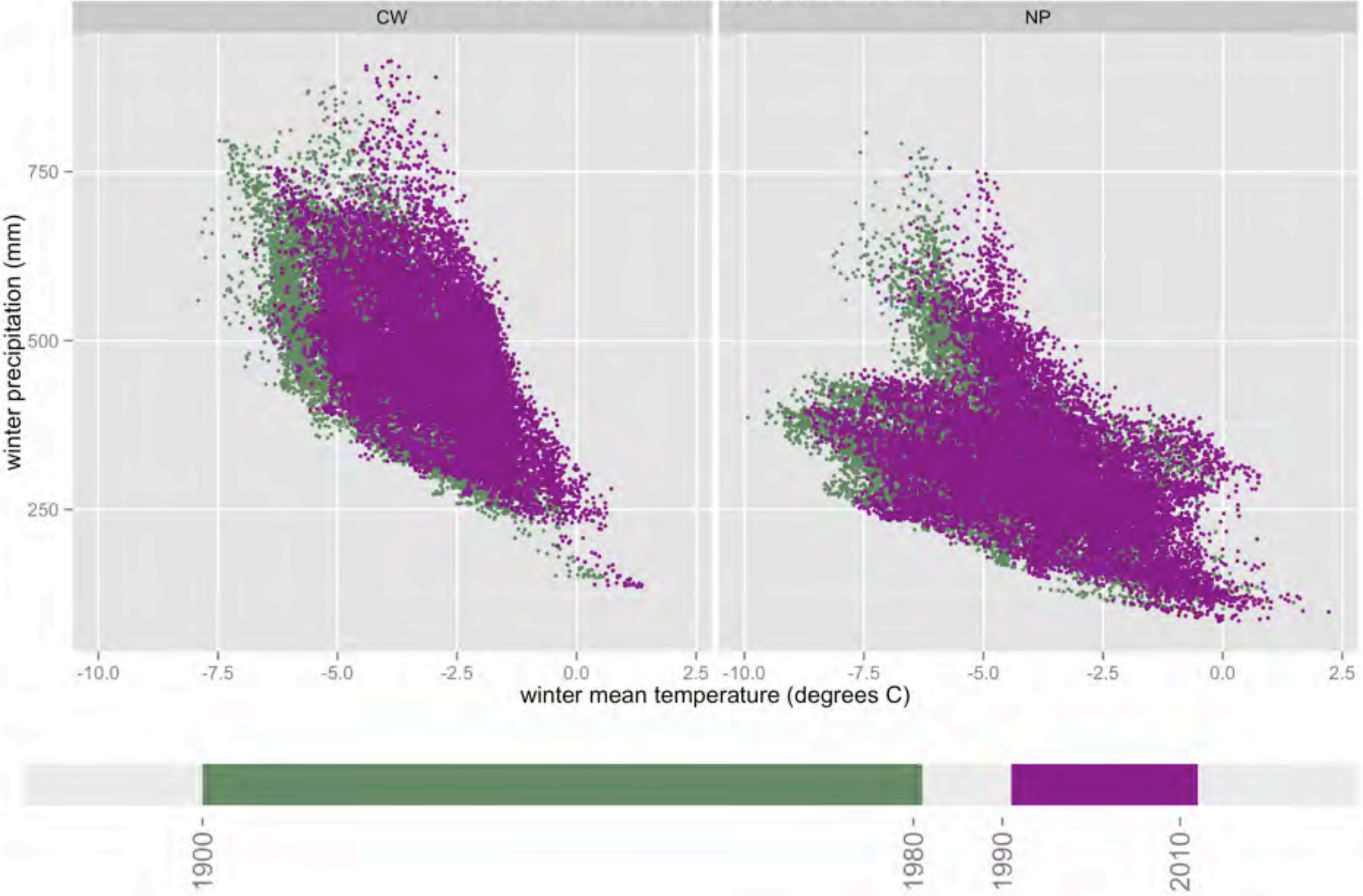

Nez-Perce & Clearwater
Outer HUC Boundary
100
Miles

## NPCW winter climate space over time

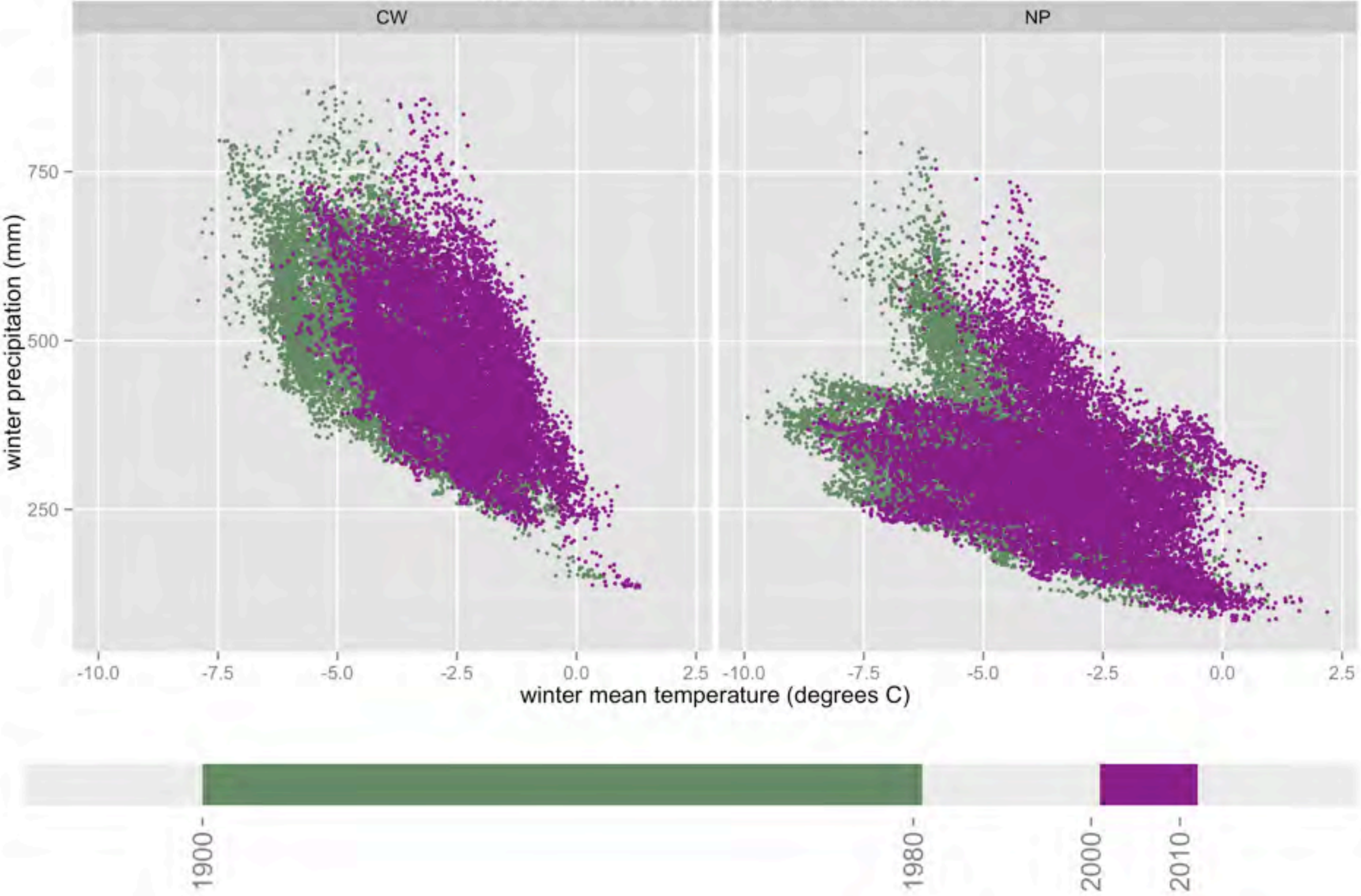


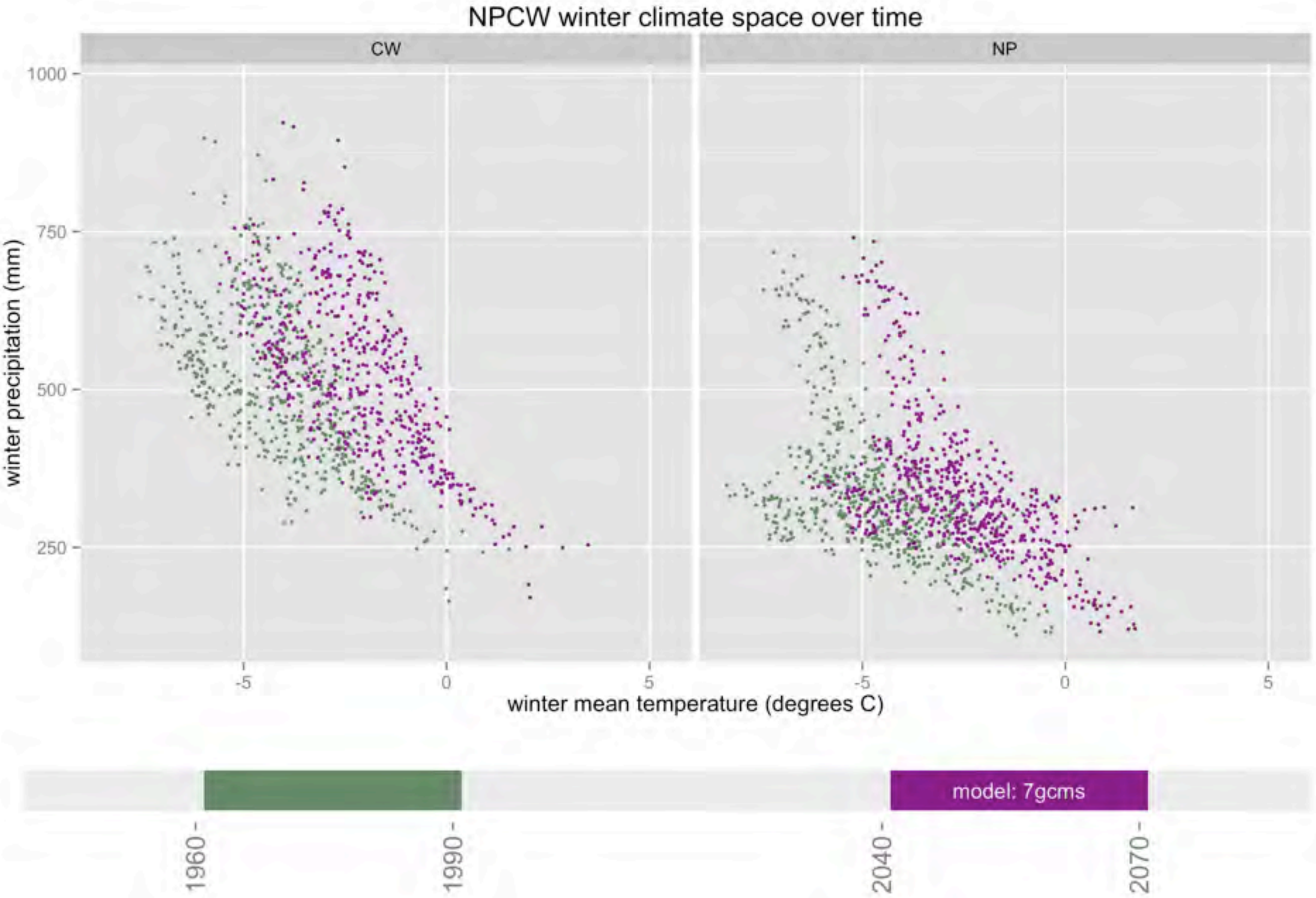

NPCW winter climate space over time
CW
NP
winter precipitation (mm)
750
500
250
-10.0
-7.5
-5.0
-2.5
0.0
2.5
winter mean temperature (degrees C)
1900
1980
2010

# NPCW winter climate space over time



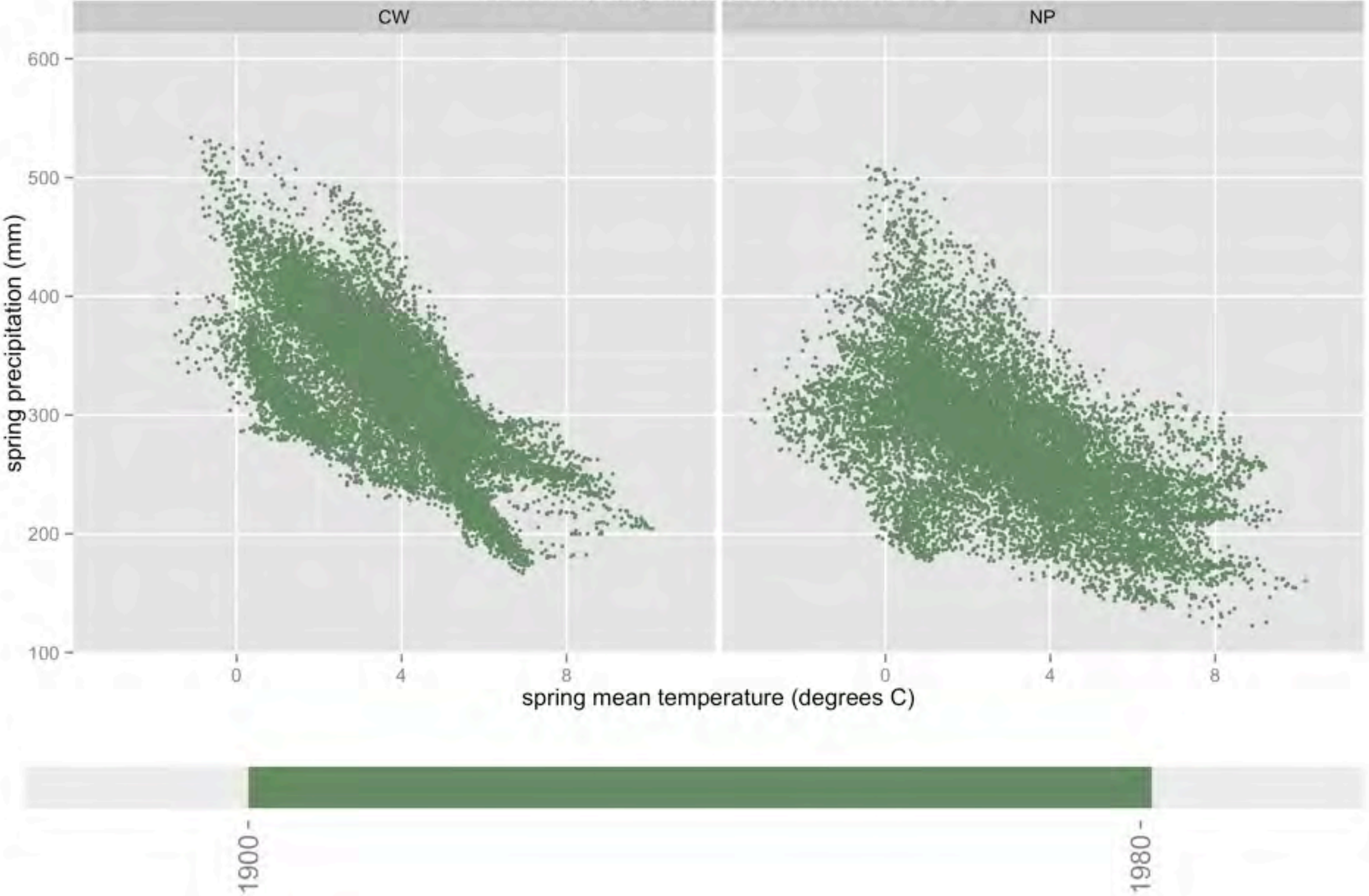
# NPCW winter climate space over time

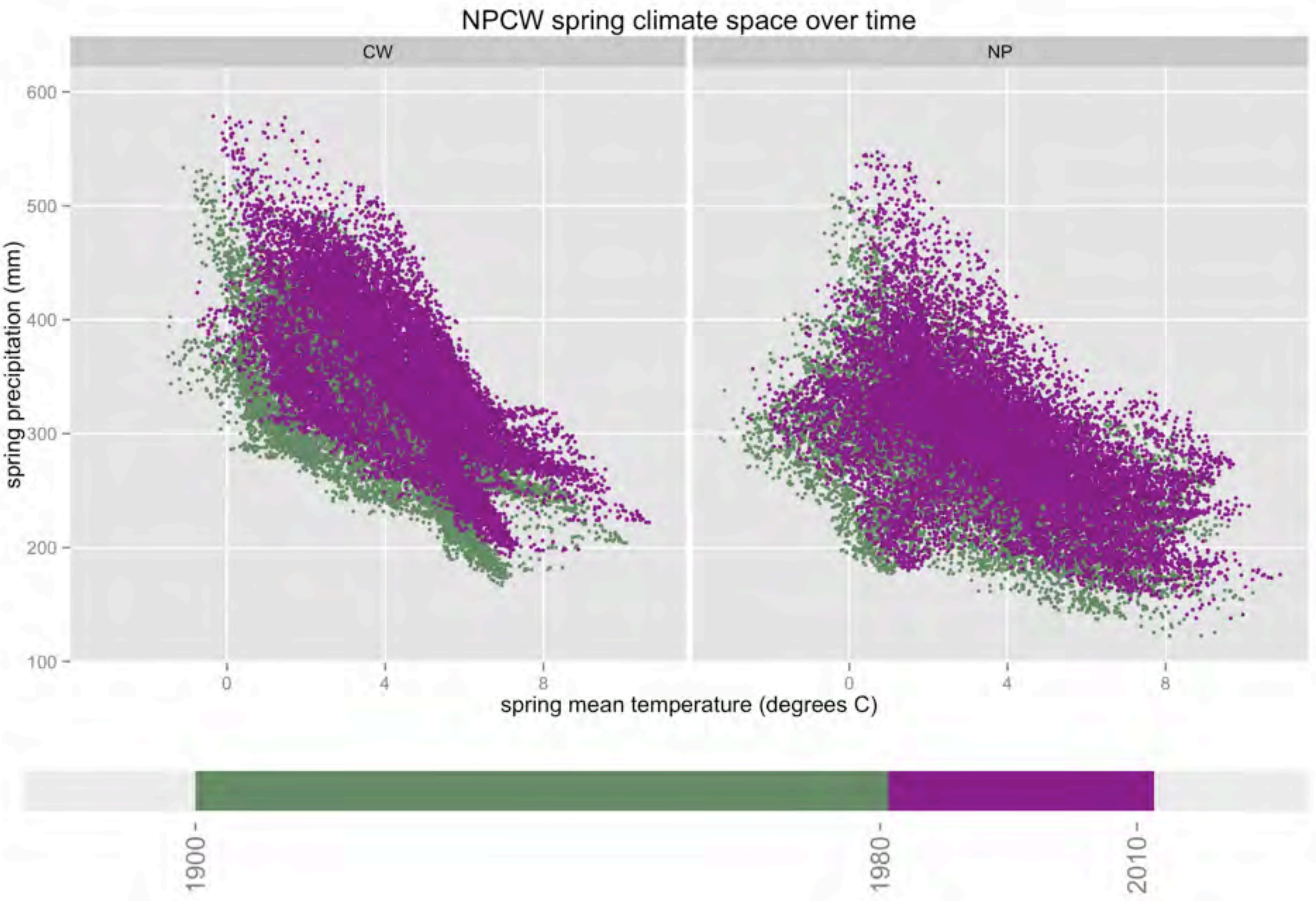




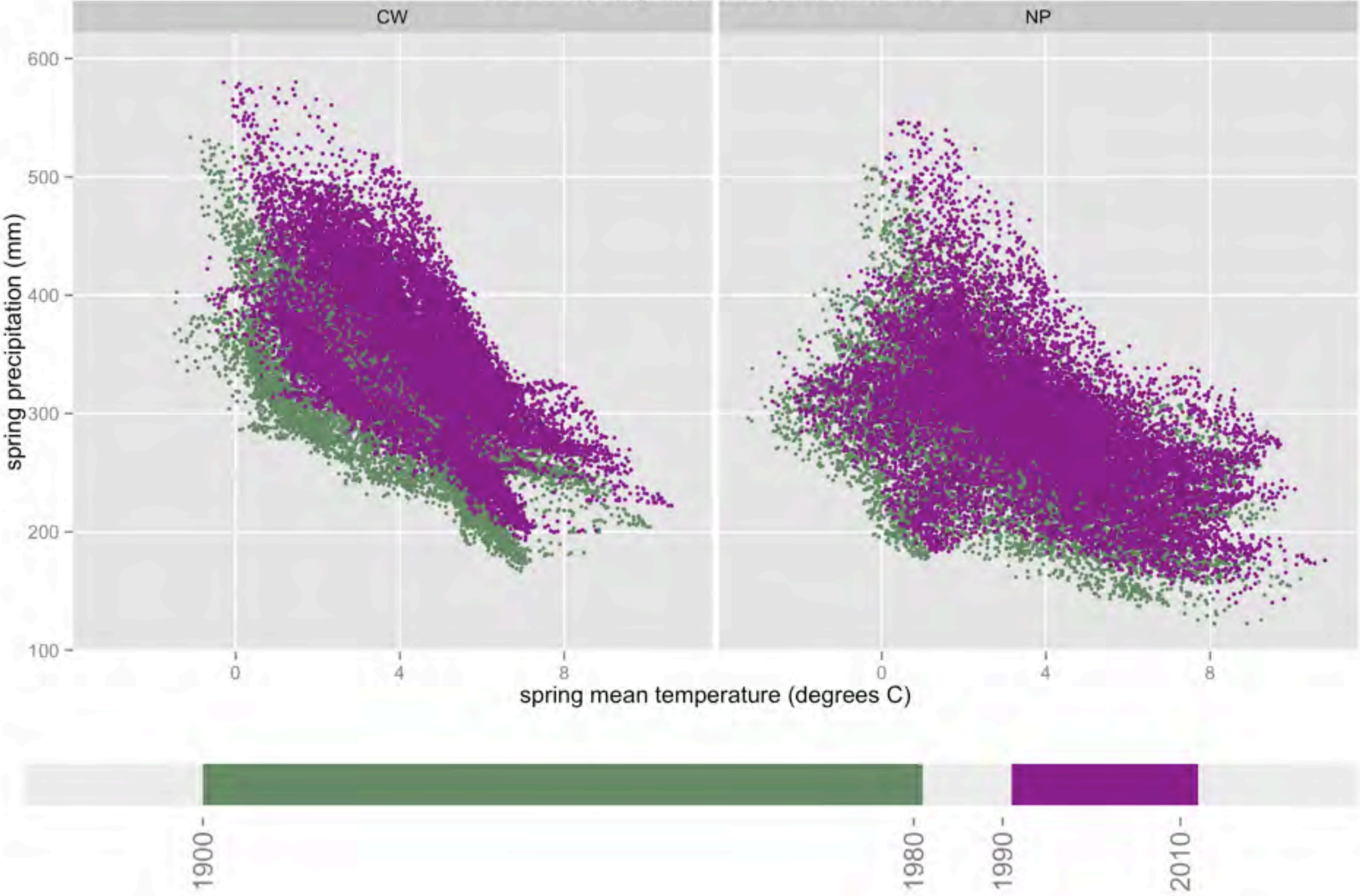
NPCW winter climate space over time

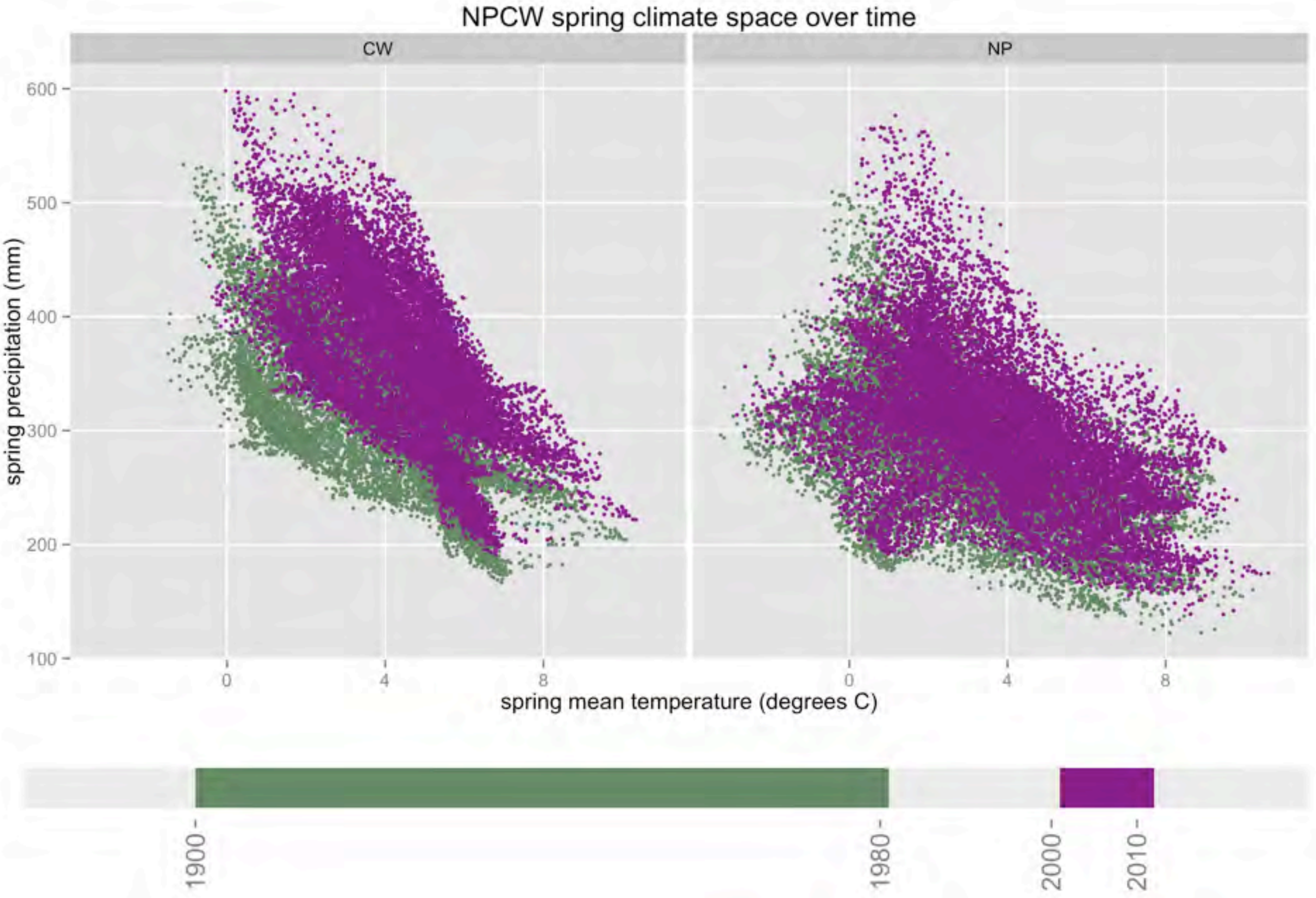
# NPCW spring climate space over time



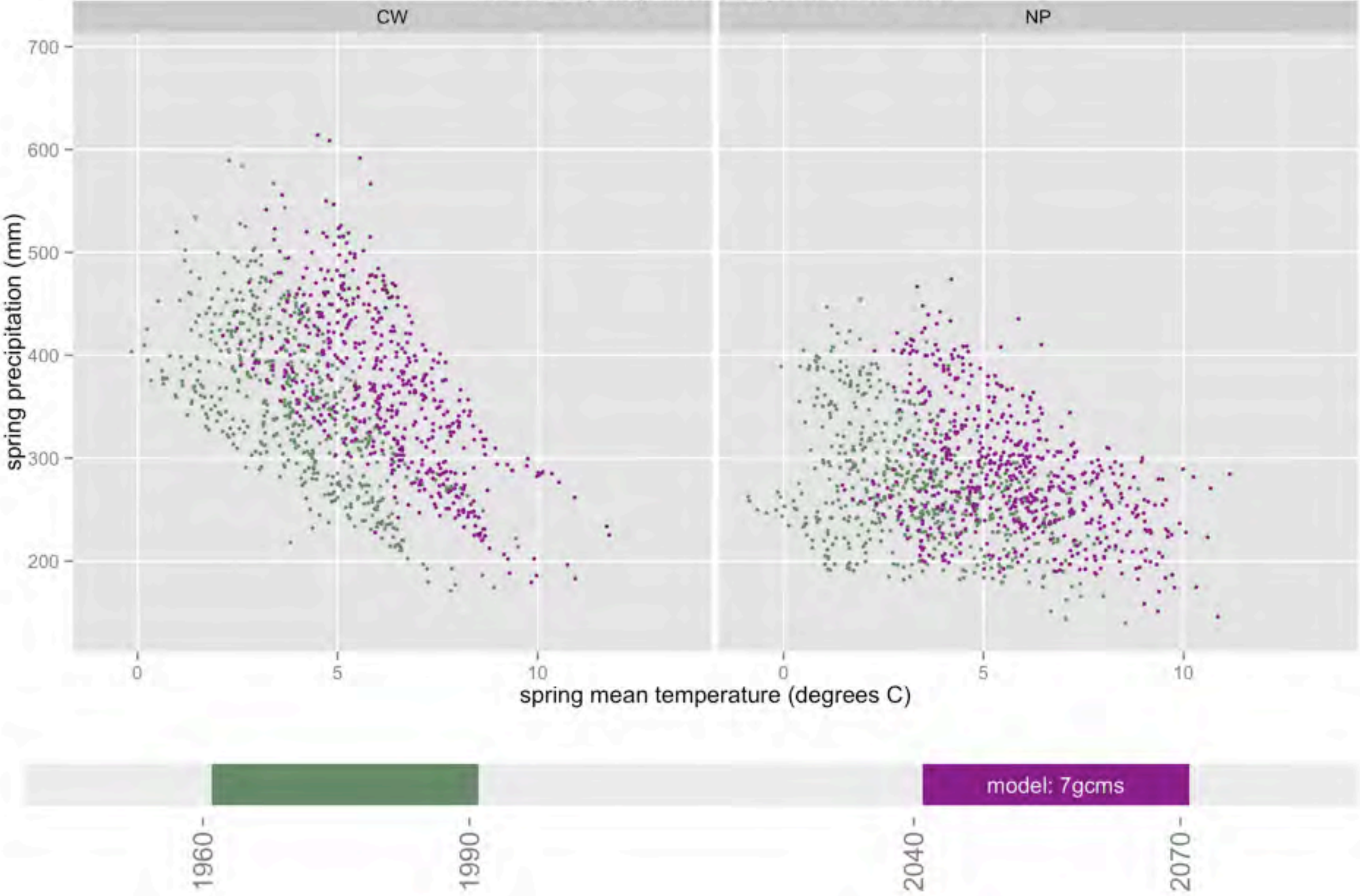

NPCW spring climate space over time
CW
NP
spring precipitation (mm)
600
500
400
300
200
100
spring mean temperature (degrees C)
0
4
8
0
4
8
1900
1980
2010

# NPCW spring climate space over time

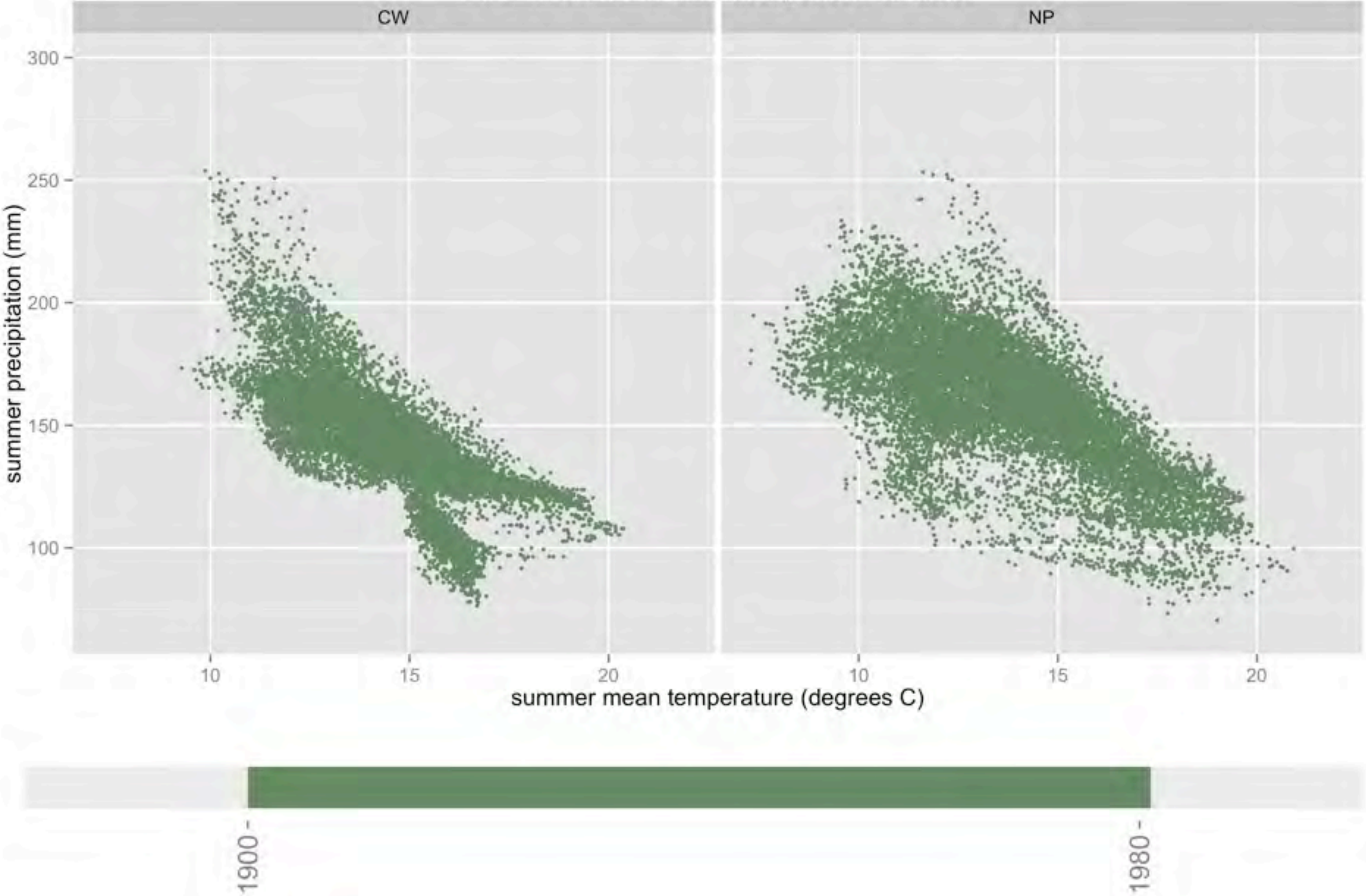


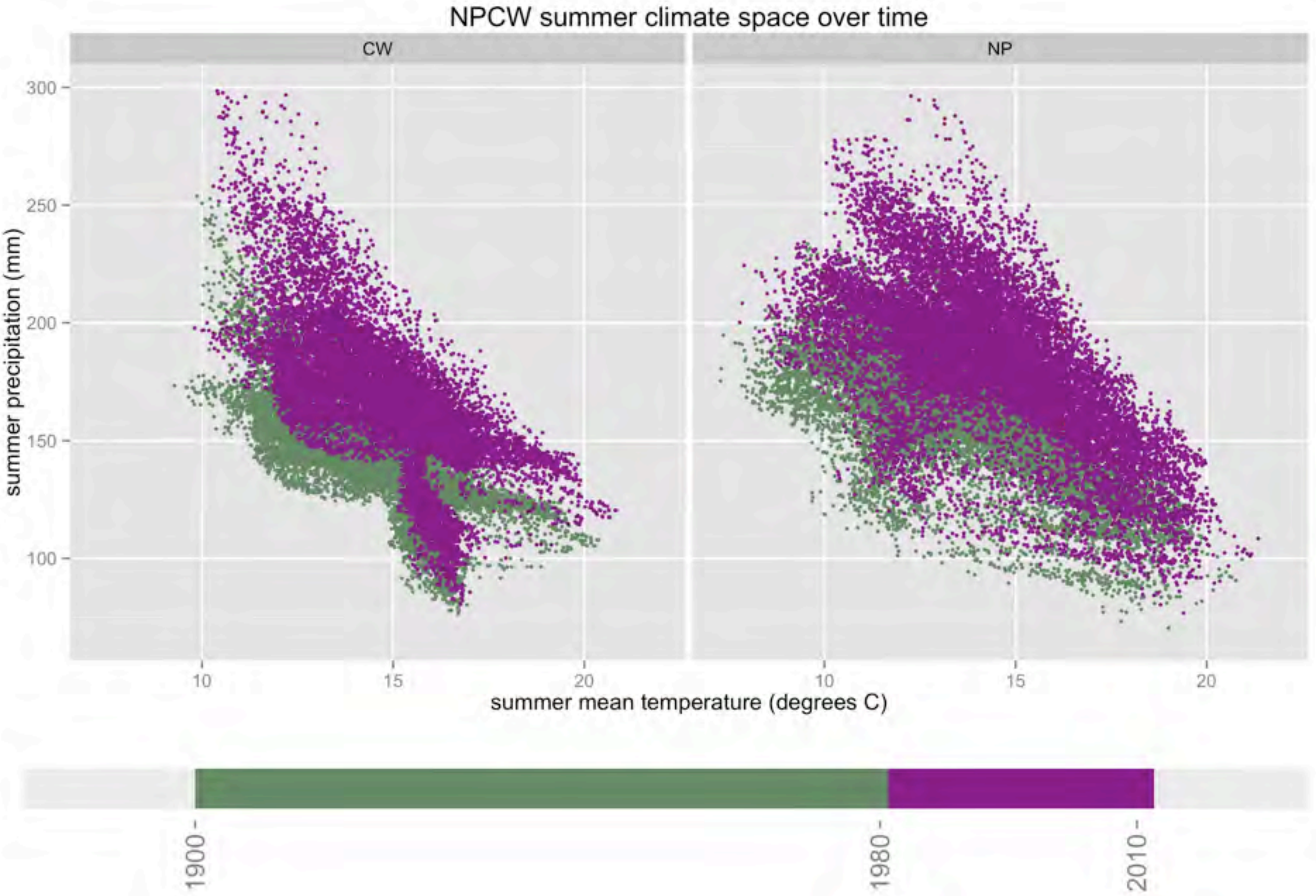

NPCW spring climate space over time
CW
NP
spring precipitation (mm)
600
500
400
300
200
100
0
4
8
spring mean temperature (degrees C)
1900
1980
2000
2010

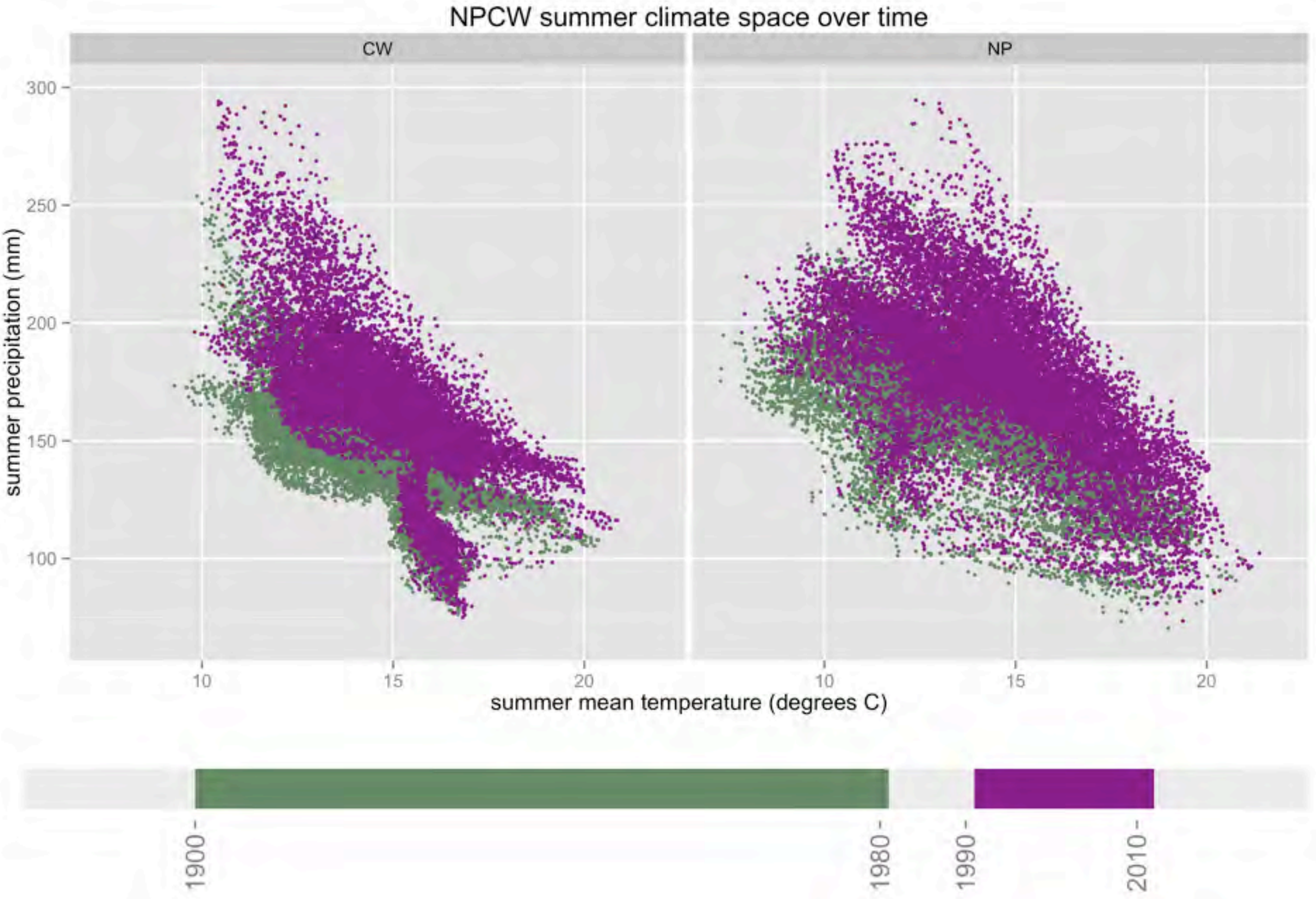
# NPCW spring climate space over time



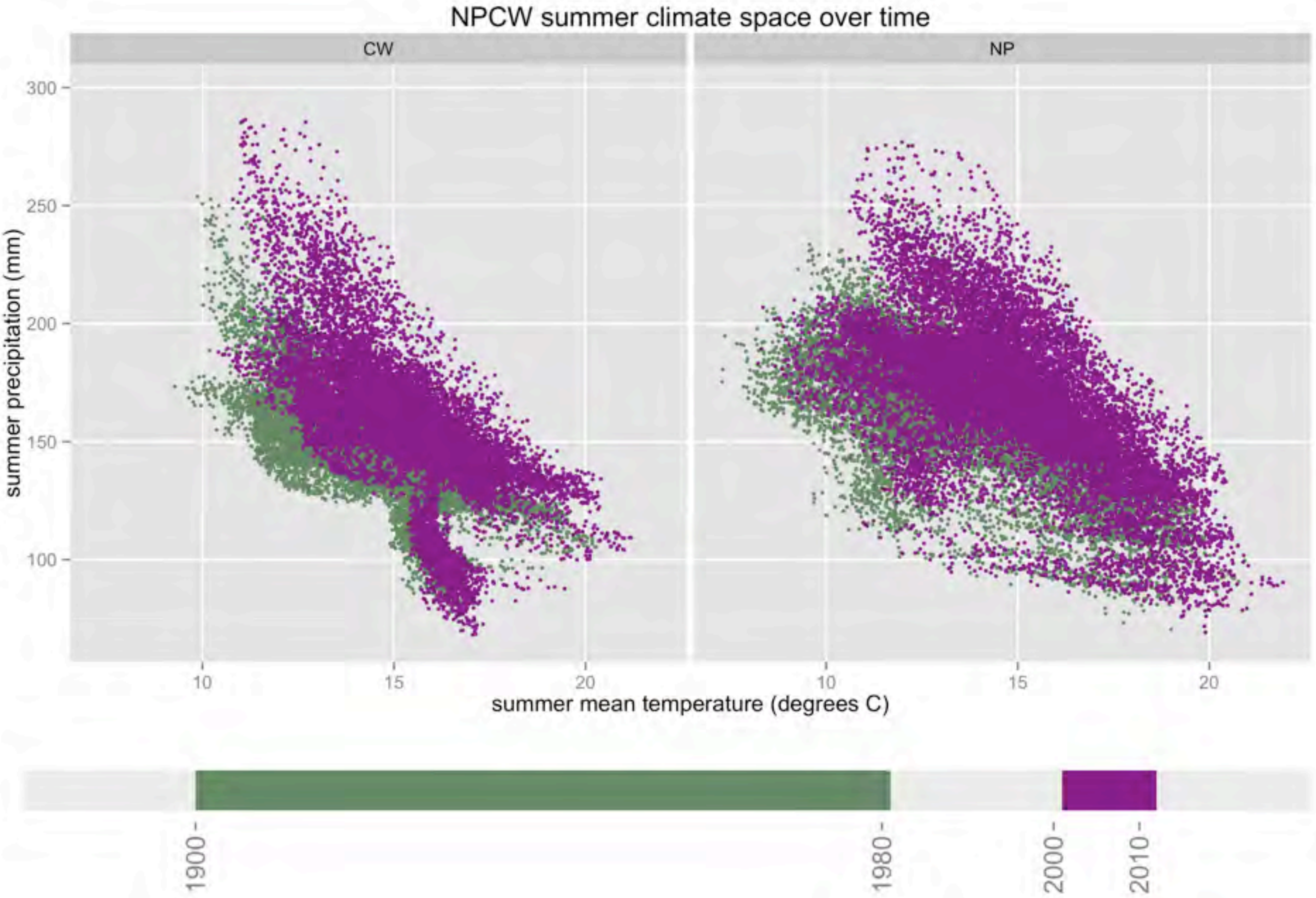
# NPCW summer climate space over time



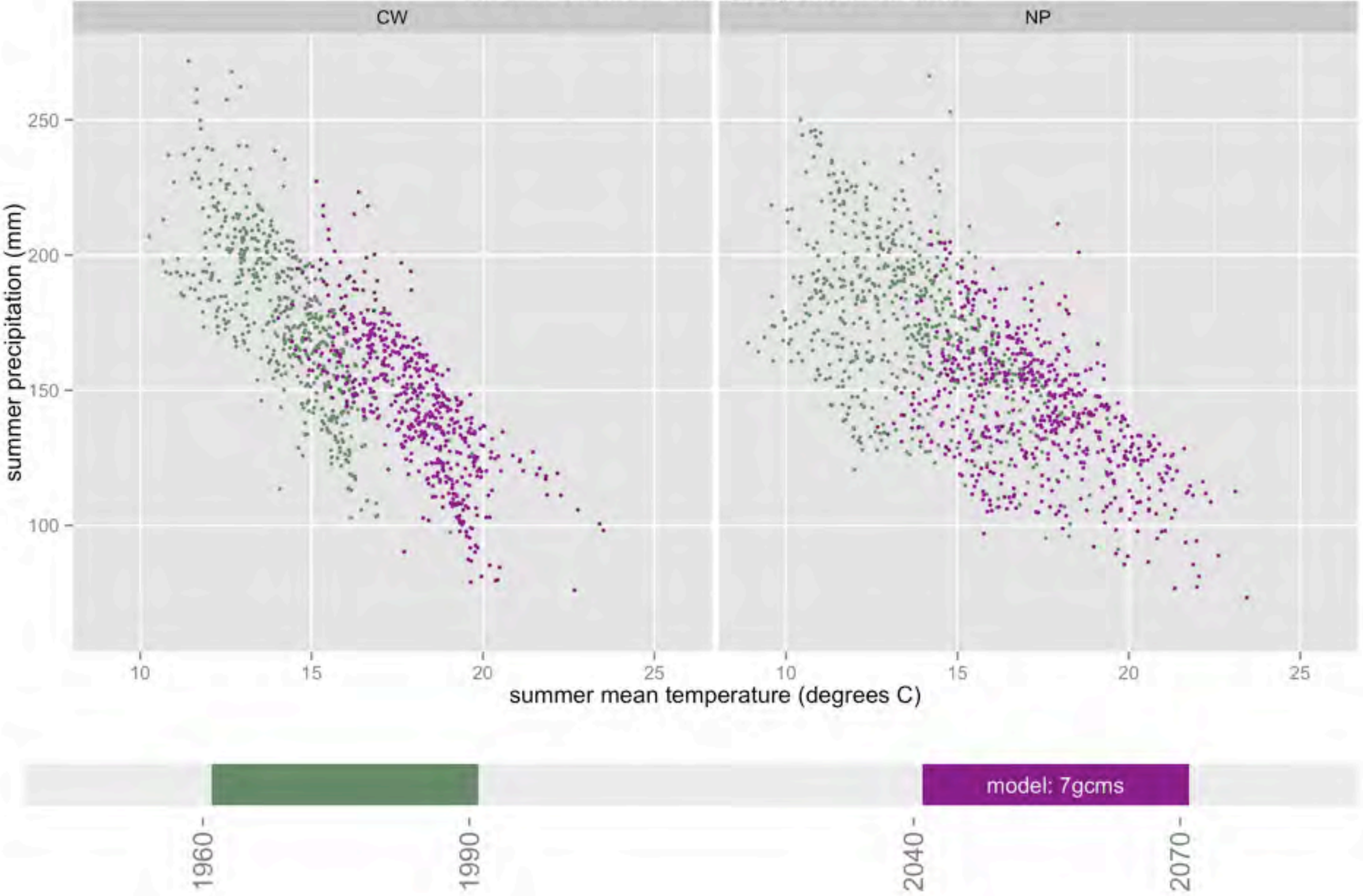

NPCW summer climate space over time
CW
NP
summer precipitation (mm)
300
250
200
150
100
10
15
20
10
15
20
summer mean temperature (degrees C)
1900
1980
2010



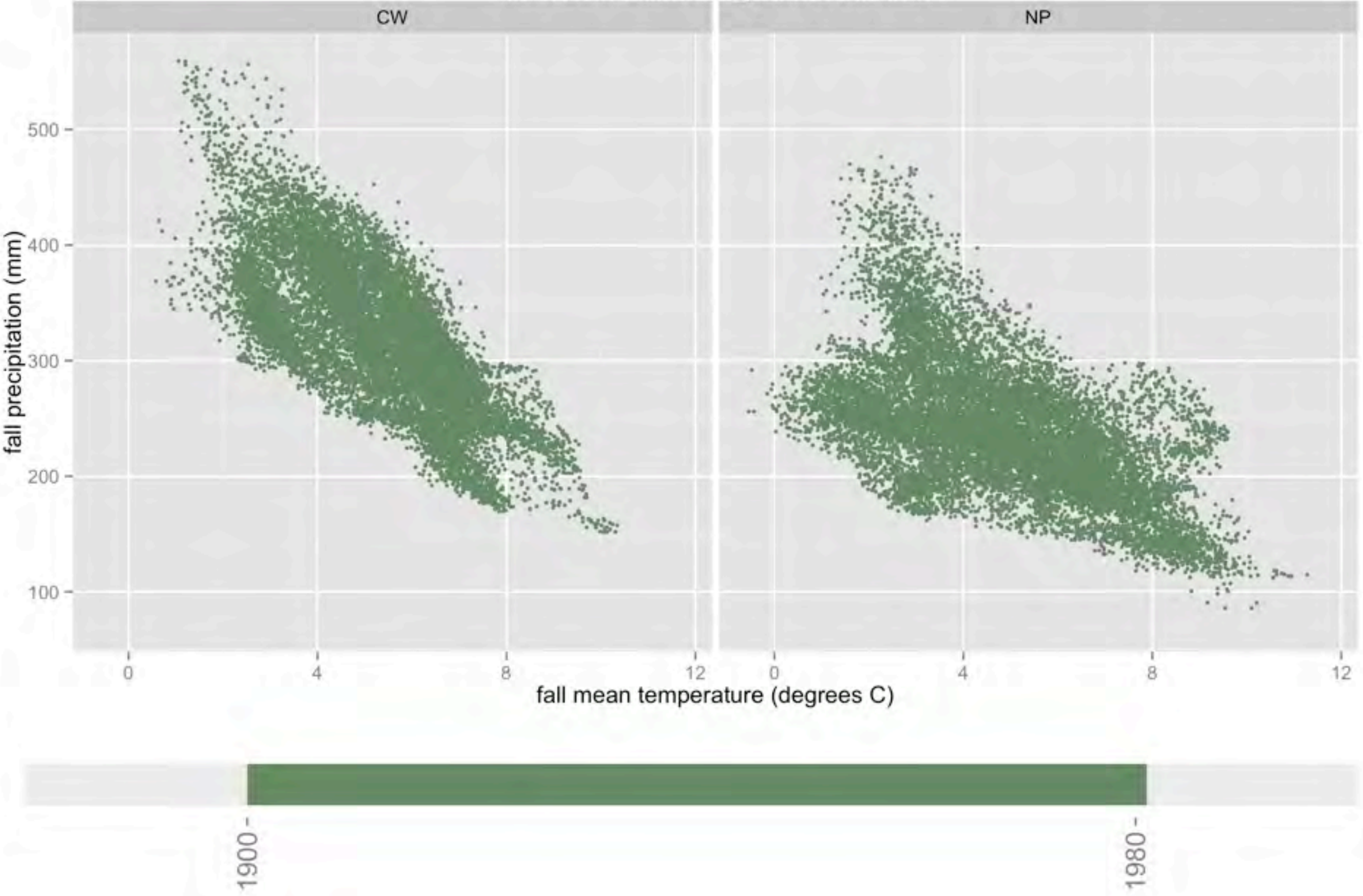
NPCW summer climate space over time

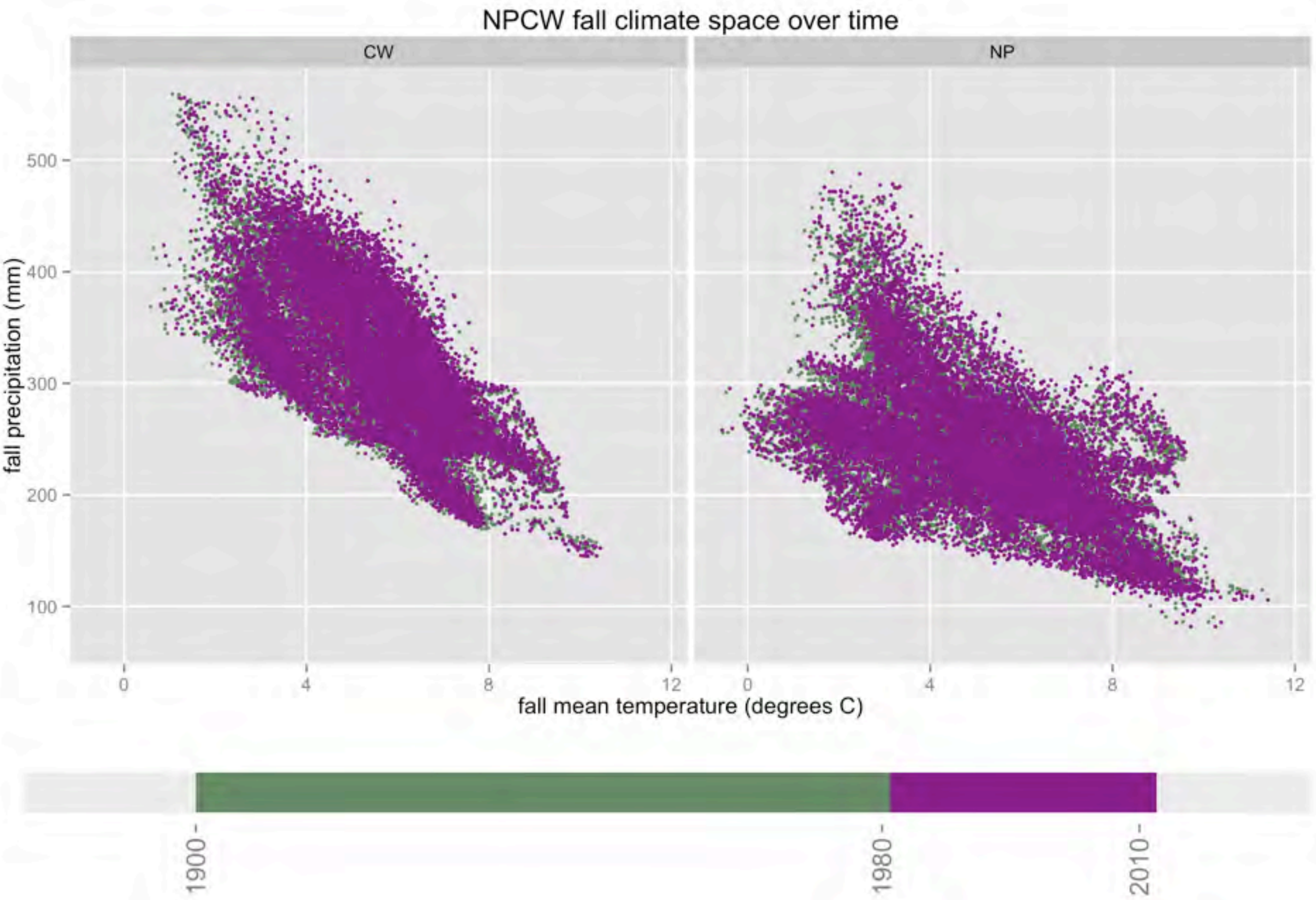

NPCW summer climate space over time
CW
NP
summer precipitation (mm)
300
250
200
150
100
10
15
20
summer mean temperature (degrees C)
1900
1980
2000
2010

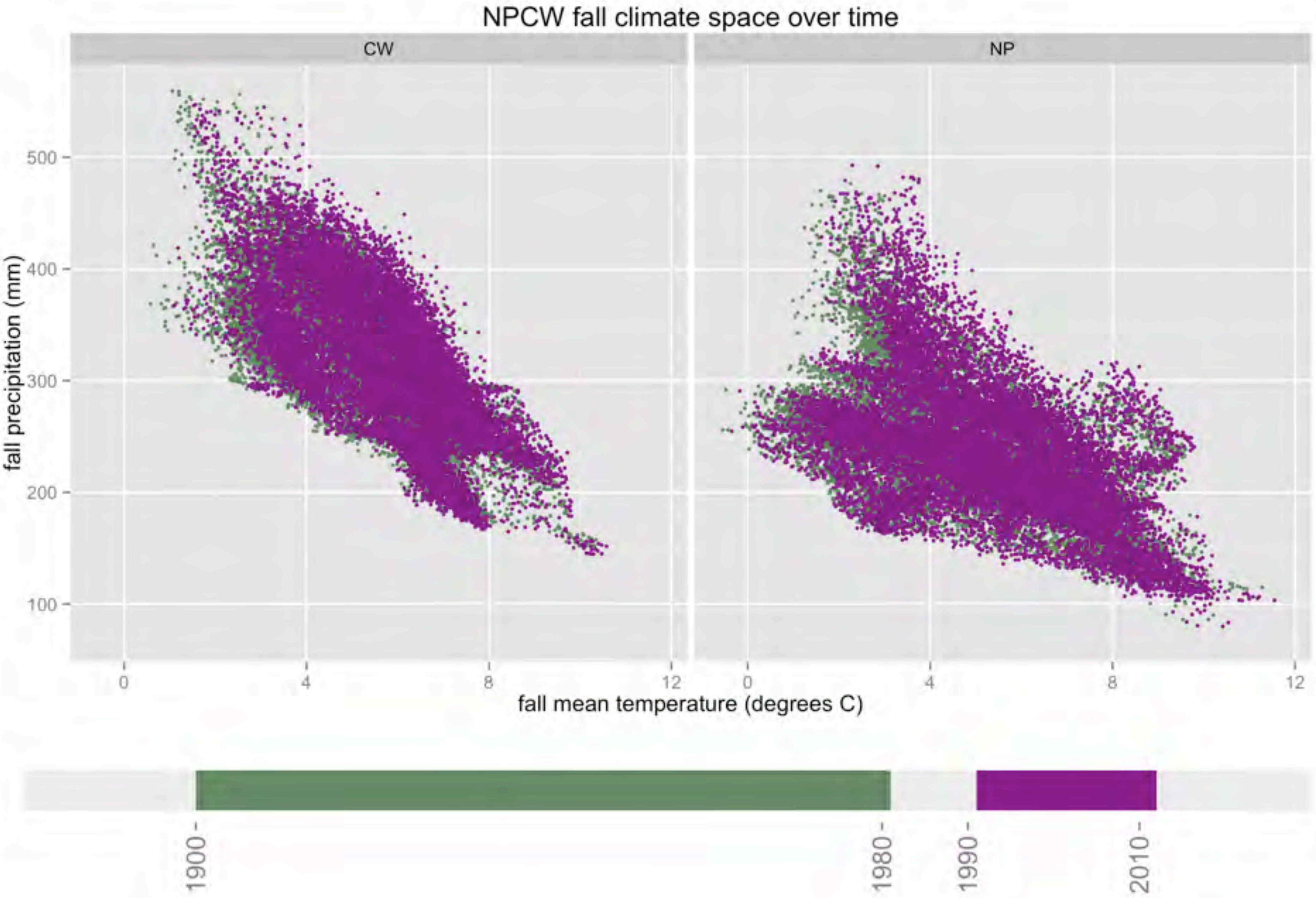
# NPCW summer climate space over time



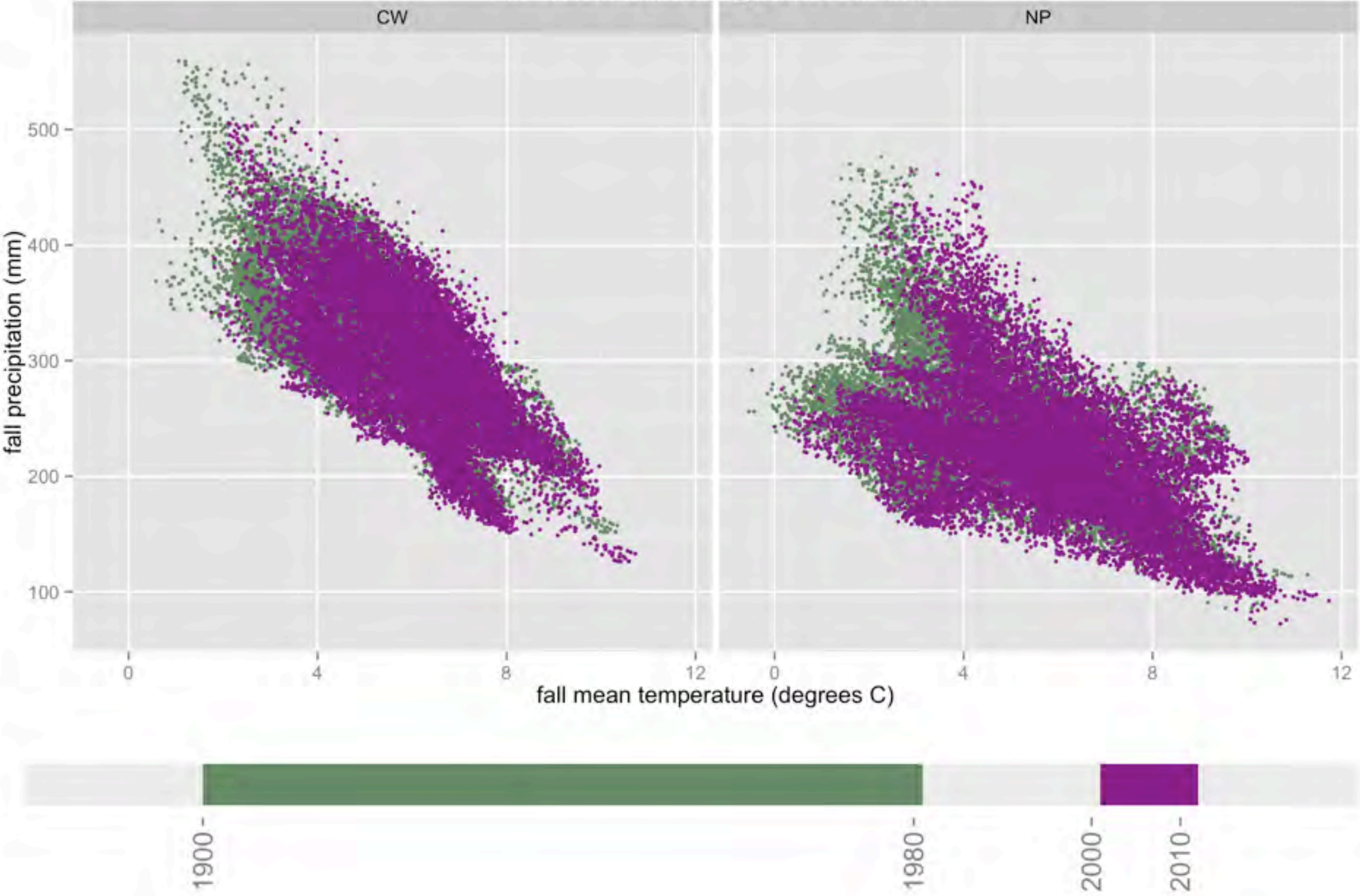
# NPCW fall climate space over time

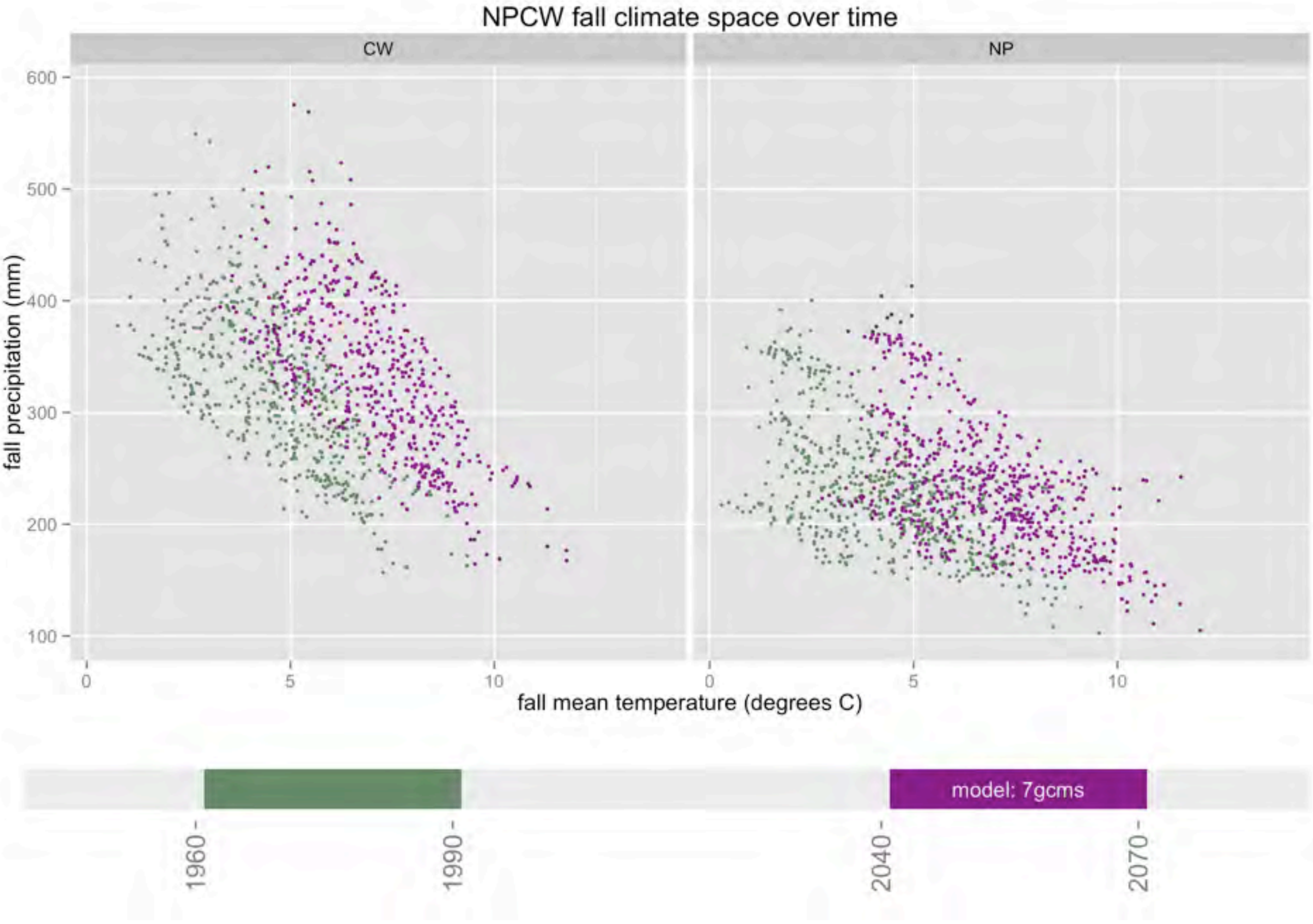



NPCW fall climate space over time
CW
NP
fall precipitation (mm)
500
400
300
200
100
fall mean temperature (degrees C)
0
4
8
12
0
4
8
12
1900
1980
2010

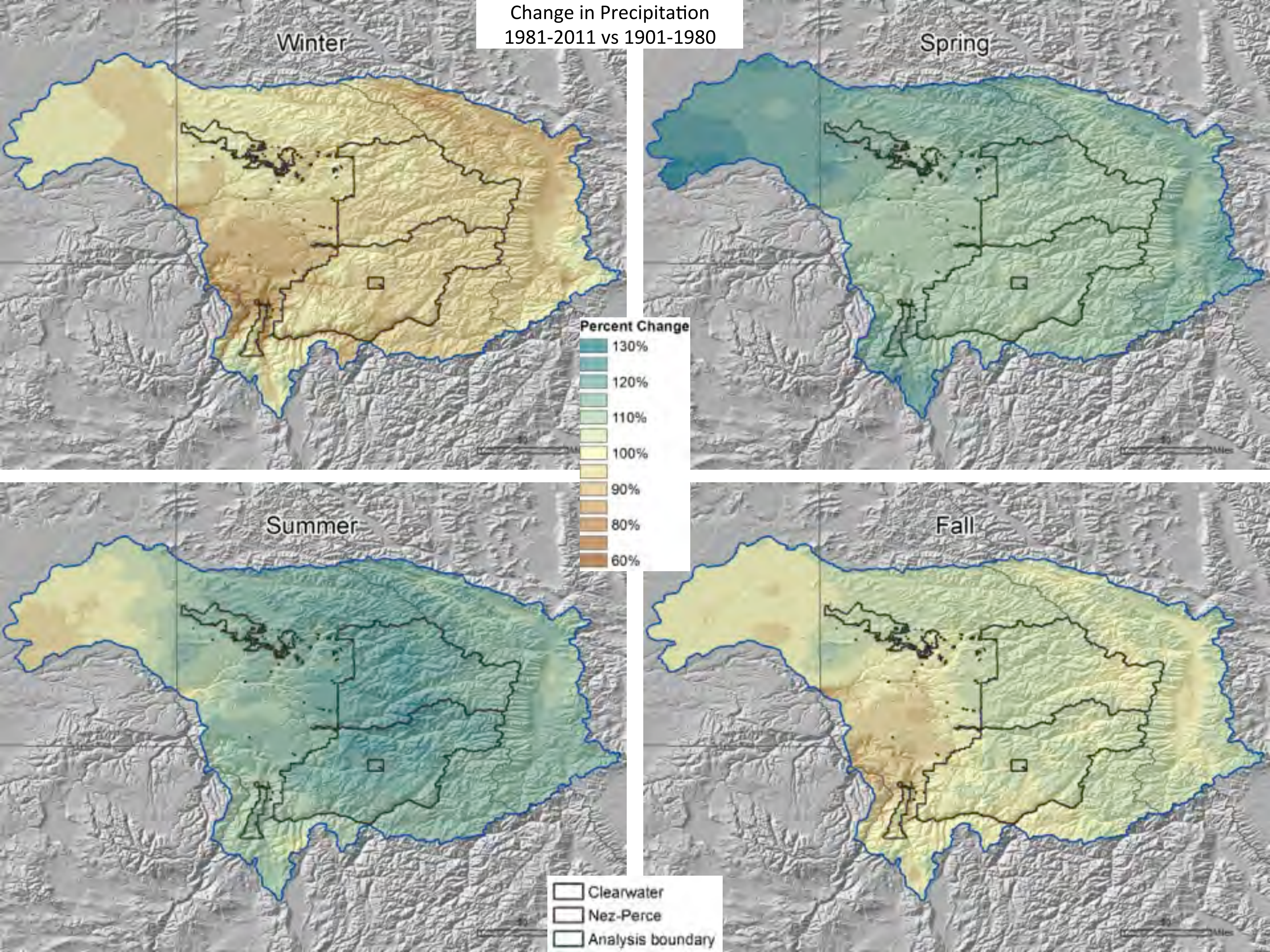

NPCW fall climate space over time
CW
NP
fall precipitation (mm)
500
400
300
200
100
0
4
8
12
0
4
8
12
fall mean temperature (degrees C)
1900
1980
1990
2010

# NPCW fall climate space over time

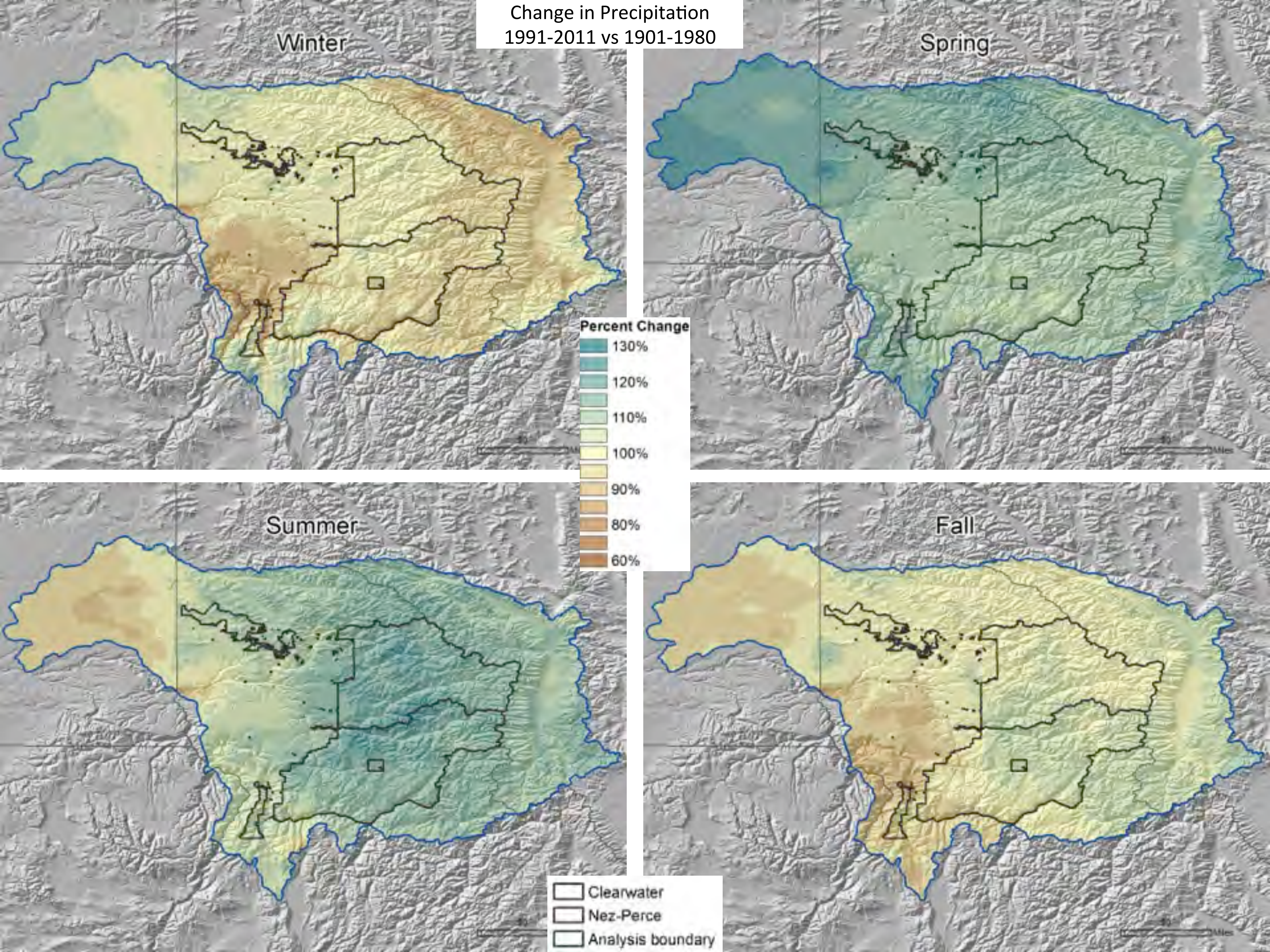



NPCW fall climate space over time
CW
NP
fall precipitation (mm)
600
500
400
300
200
100
0
5
10
0
5
10
fall mean temperature (degrees C)
model: 7gcms
1960
1990
2040
2070

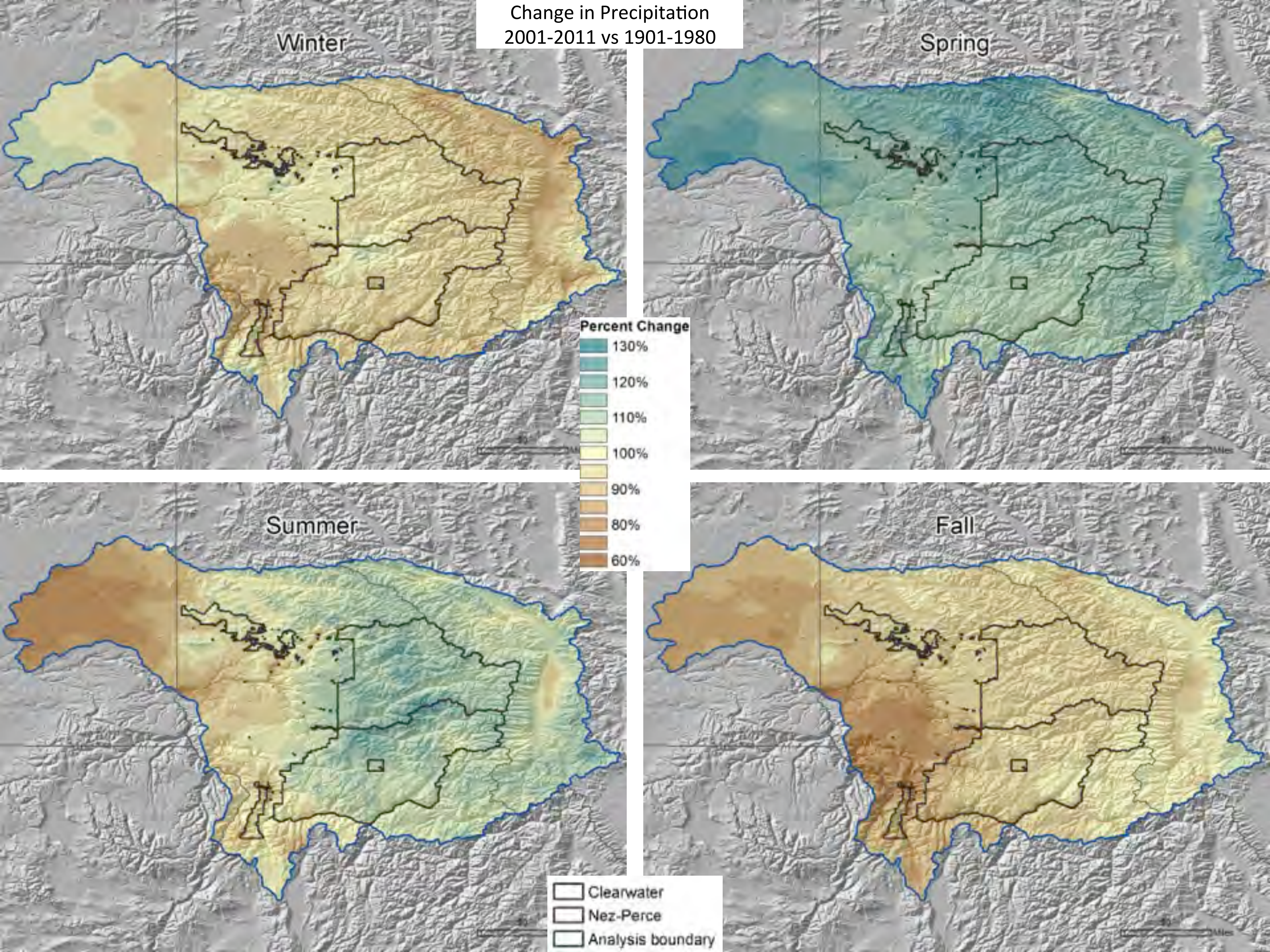
# Change in Precipitation
# 1981-2011 vs 1901-1980


Winter
Spring
Summer
Fall
Percent Change
130%
120%
110%
100%
90%
80%
60%
Clearwater
Nez-Perce
Analysis boundary

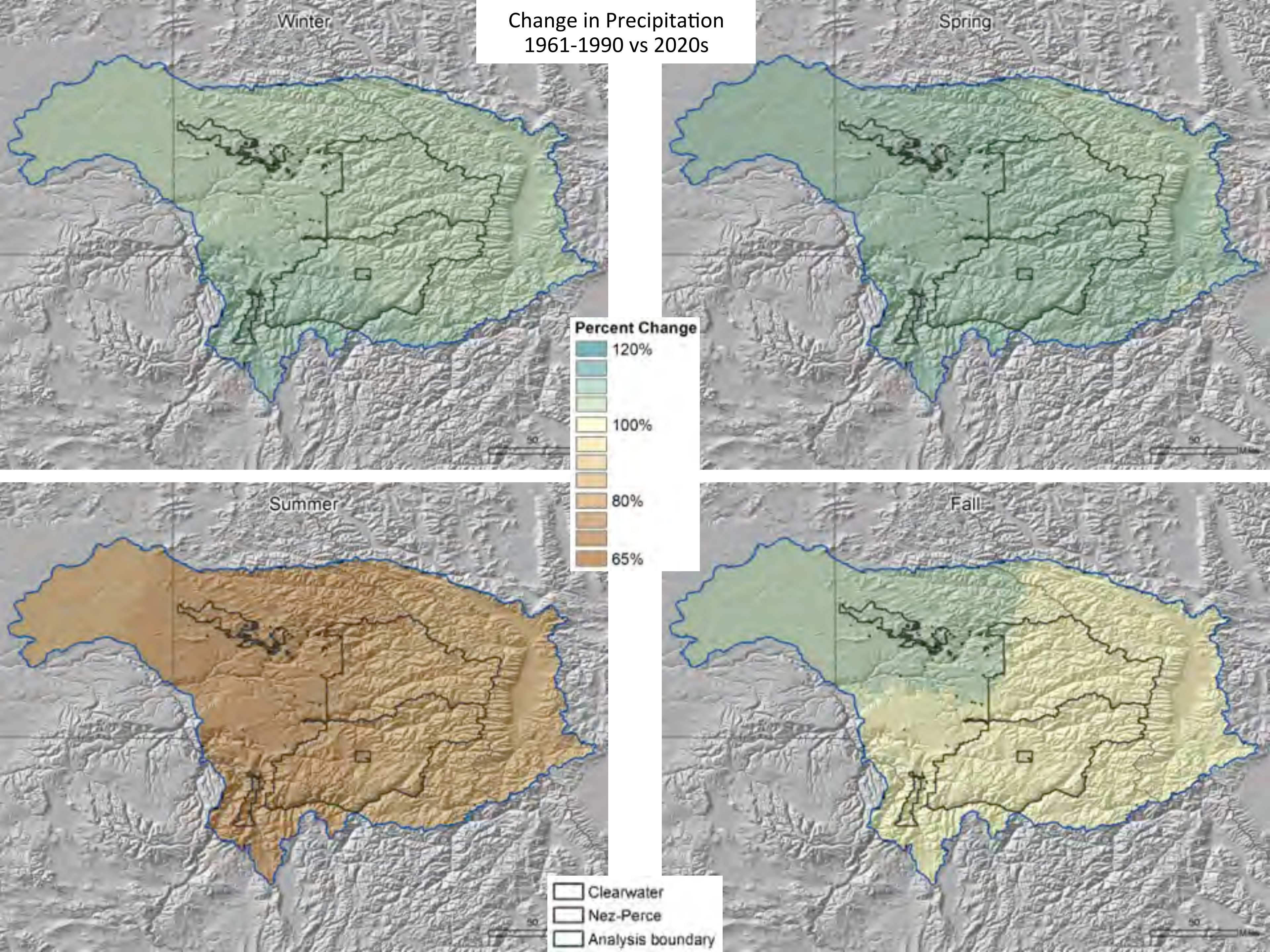
# Change in Precipitation
# 1991-2011 vs 1901-1980


Winter
Spring
Summer
Fall
Percent Change
130%
120%
110%
100%
90%
80%
60%
Clearwater
Nez-Perce
Analysis boundary

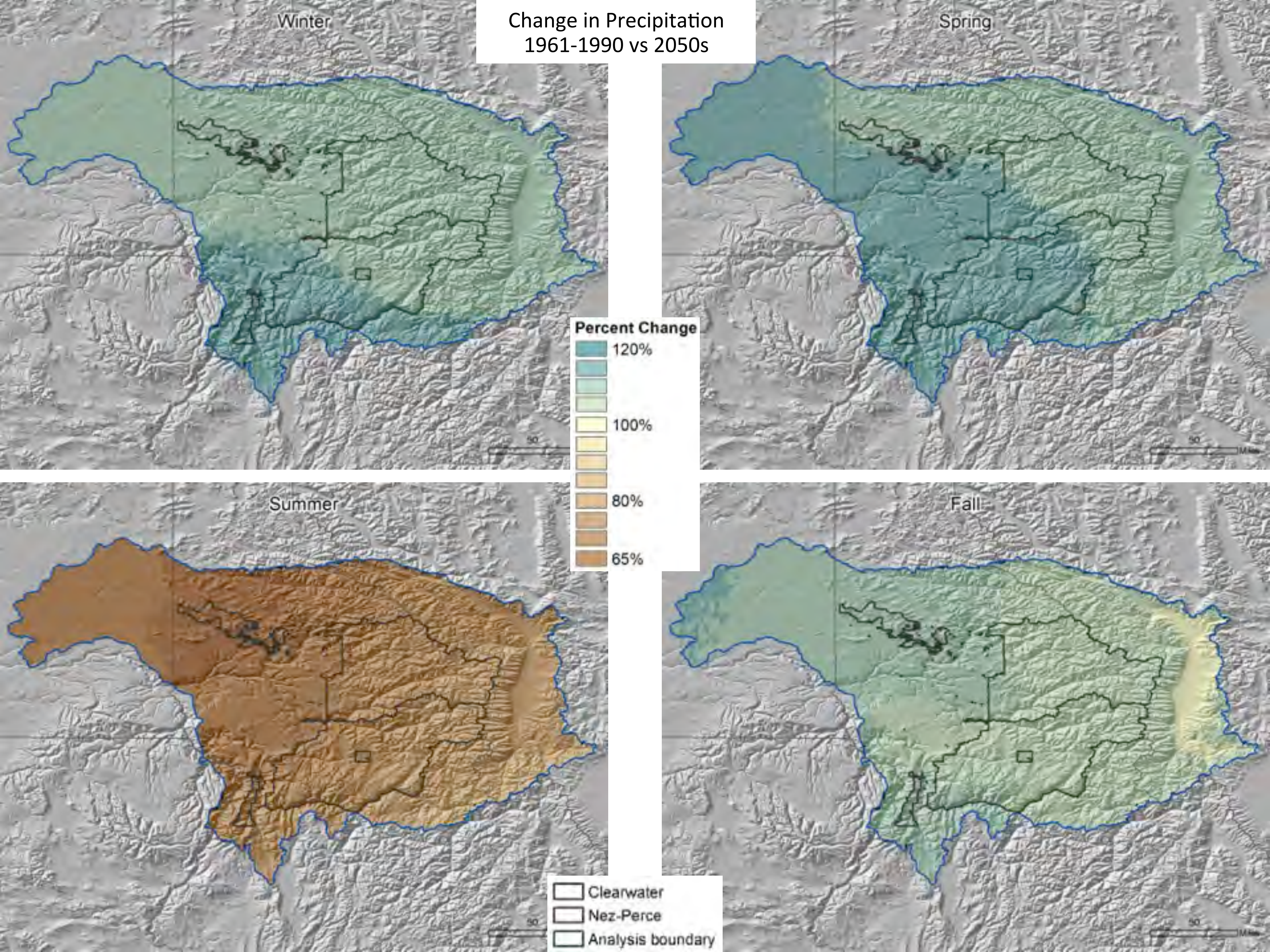
# Change in Precipitation
2001-2011 vs 1901-1980


Winter
Spring
Summer
Fall
Percent Change
130%
120%
110%
100%
90%
80%
60%
Clearwater
Nez-Perce
Analysis boundary

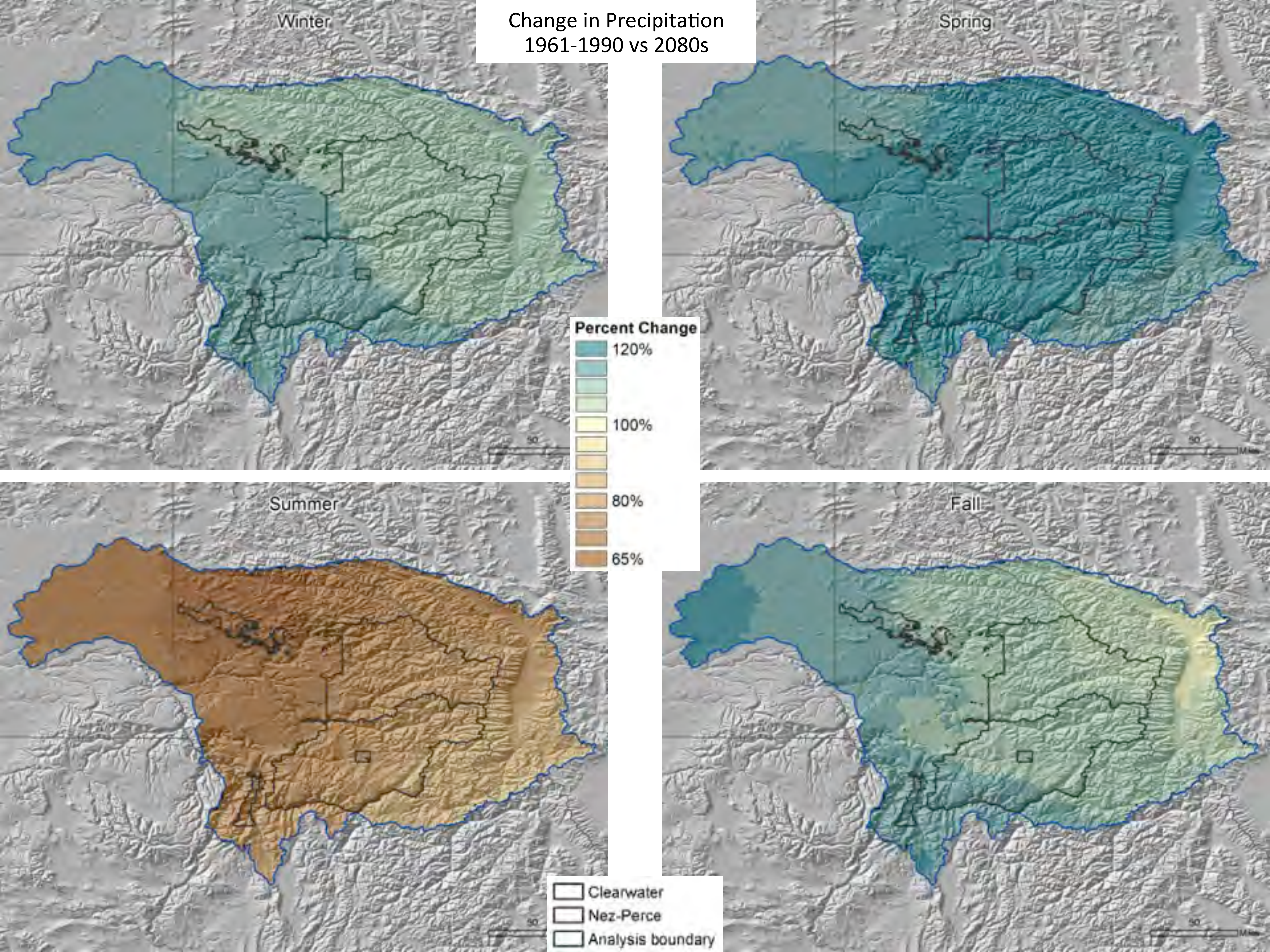
# Change in Precipitation
1961-1990 vs 2020s


Winter
Spring
Summer
Fall
Percent Change
120%
100%
80%
65%
Clearwater
Nez-Perce
Analysis boundary
50
Miles

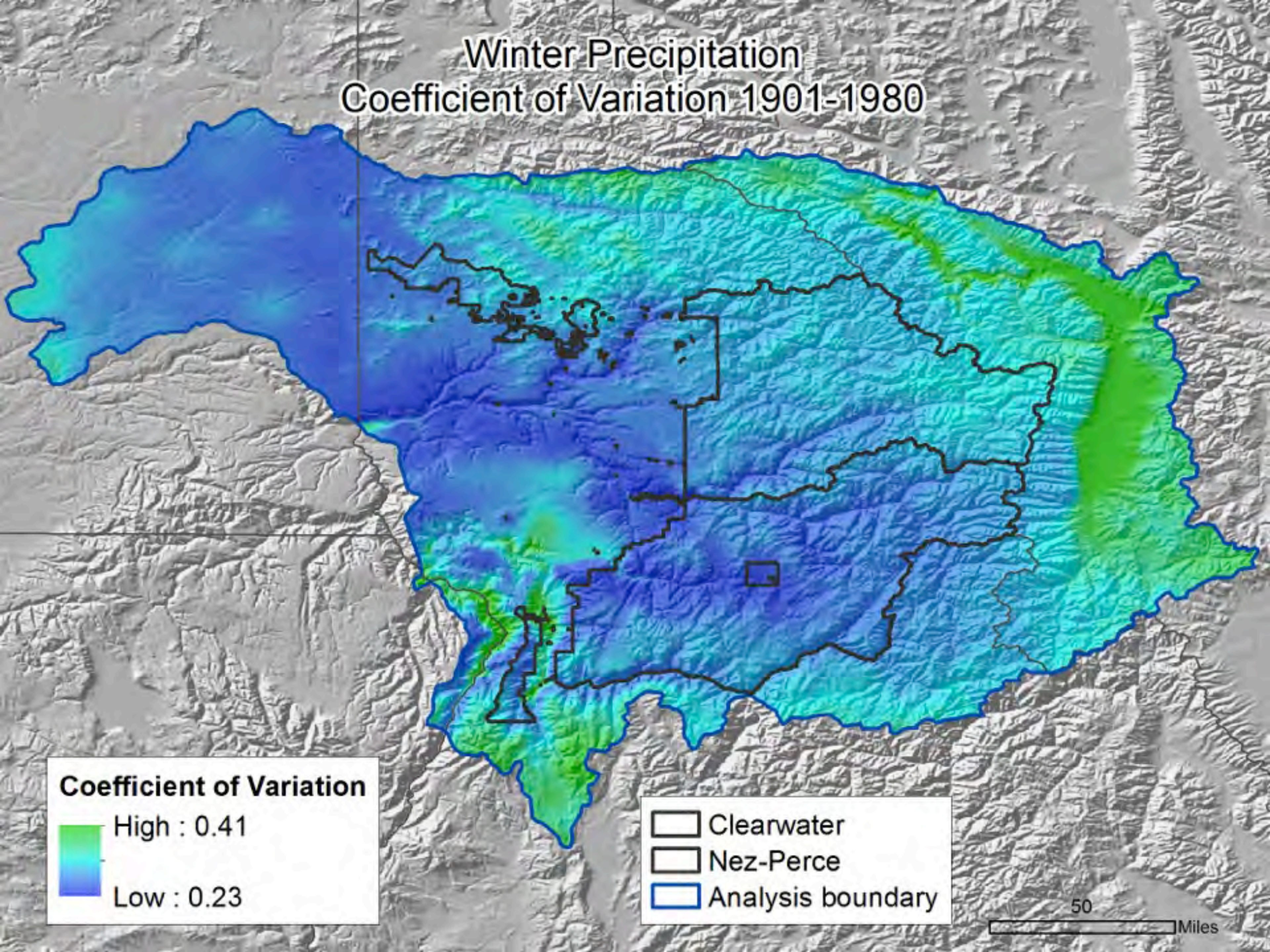
# Change in Precipitation
# 1961-1990 vs 2050s


Winter
Spring
Summer
Fall
Percent Change
120%
100%
80%
65%
Clearwater
Nez-Perce
Analysis boundary
50
Miles

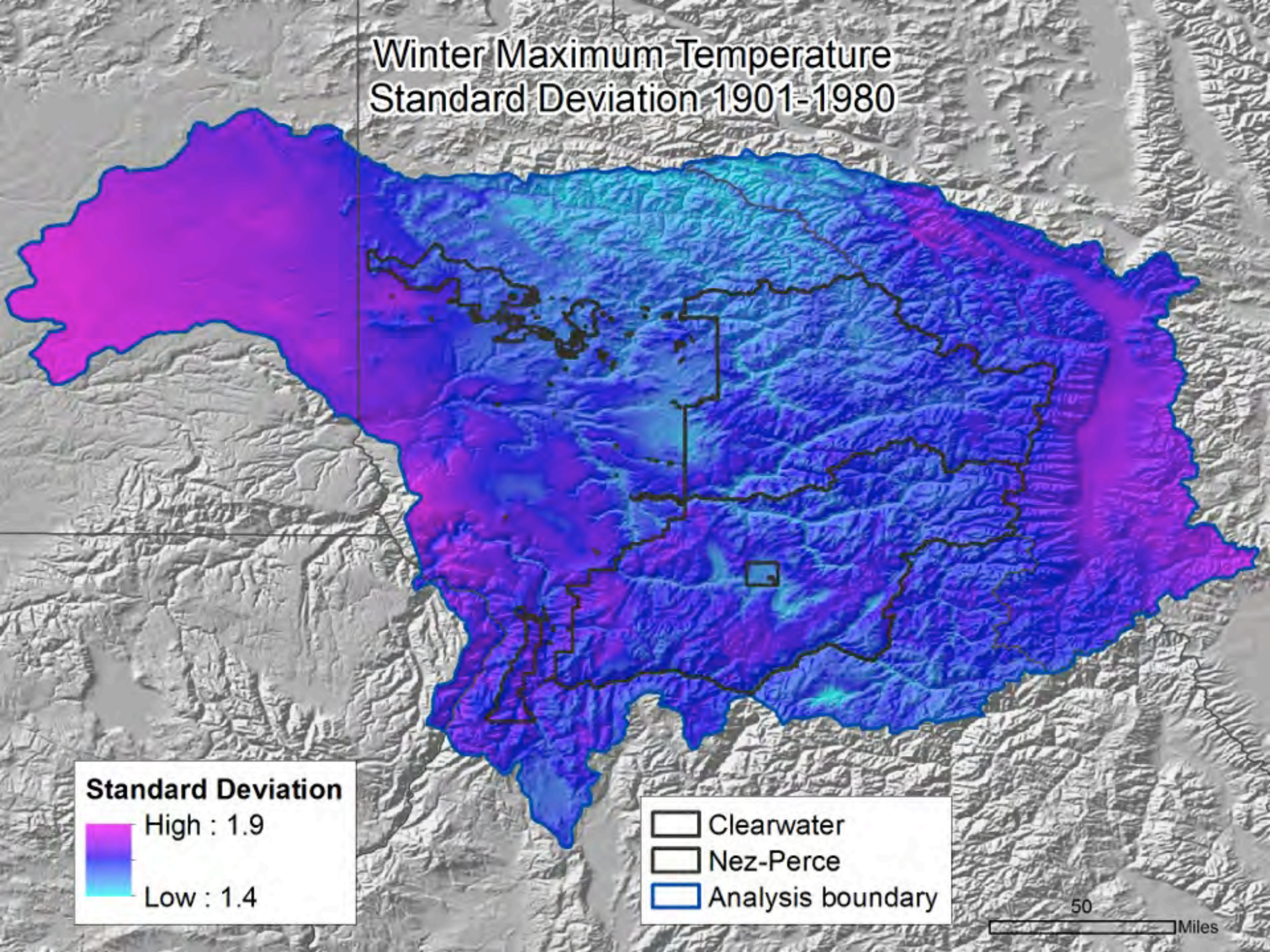
# Change in Precipitation
1961-1990 vs 2080s


Winter
Spring
Summer
Fall
Percent Change
120%
100%
80%
65%
Clearwater
Nez-Perce
Analysis boundary
50
Miles

# Winter Precipitation
Coefficient of Variation 1901-1980

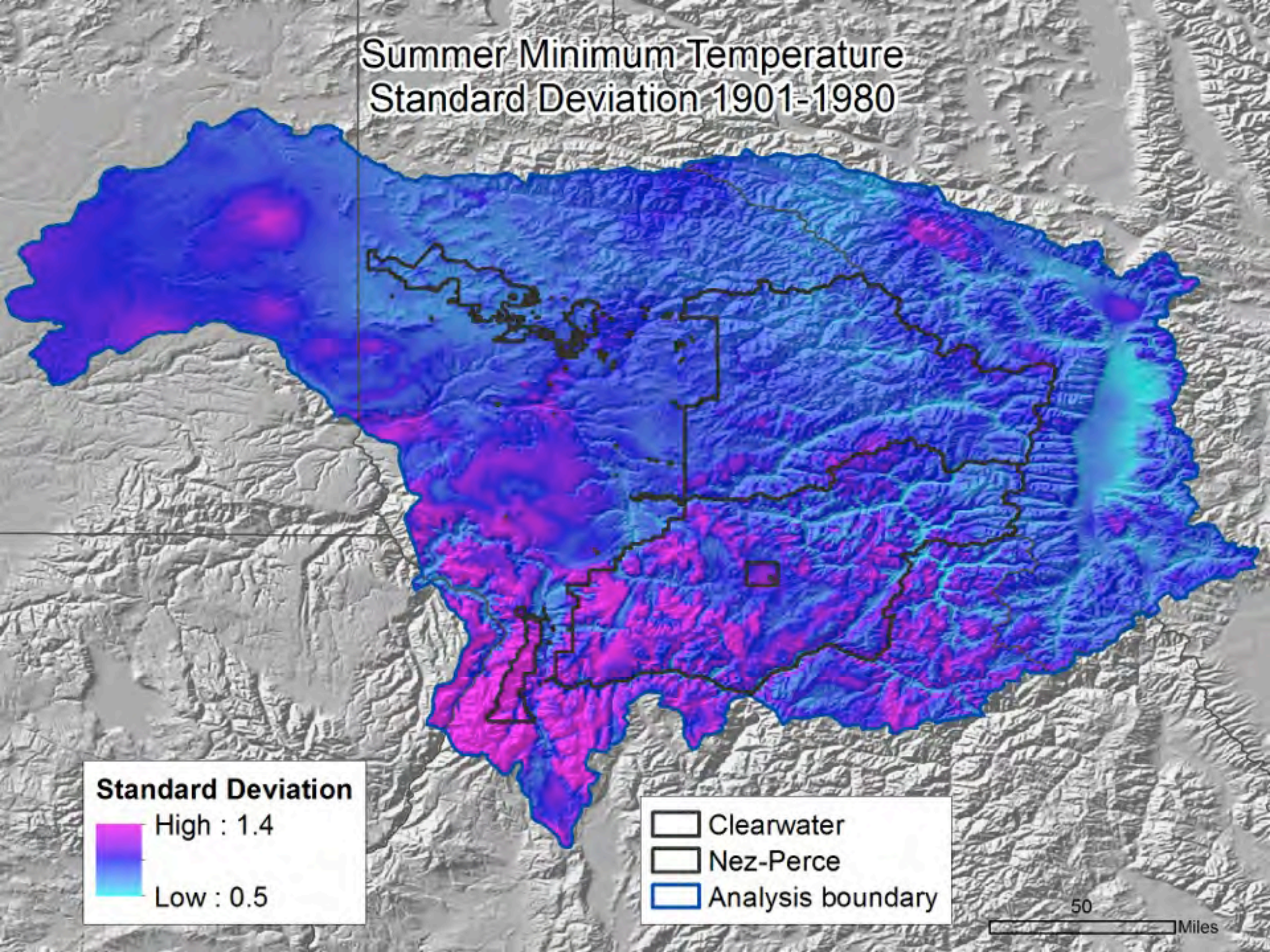


Coefficient of Variation
High : 0.41
Low : 0.23
Clearwater
Nez-Perce
Analysis boundary
50
Miles



Winter Maximum Temperature Standard Deviation 1901-1980

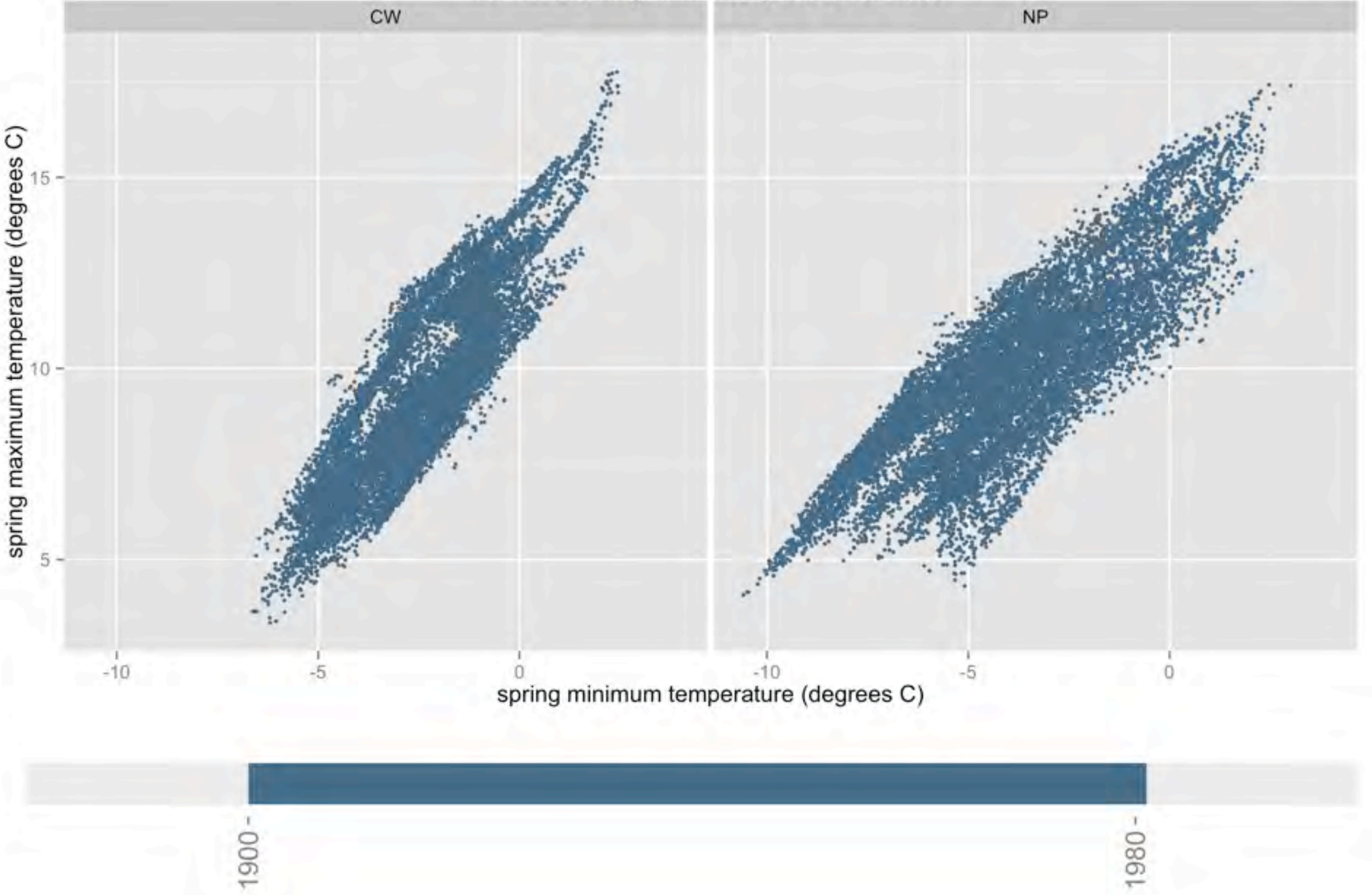
Standard Deviation
High : 1.9
Low : 1.4
Clearwater
Nez-Perce
Analysis boundary
50
Miles



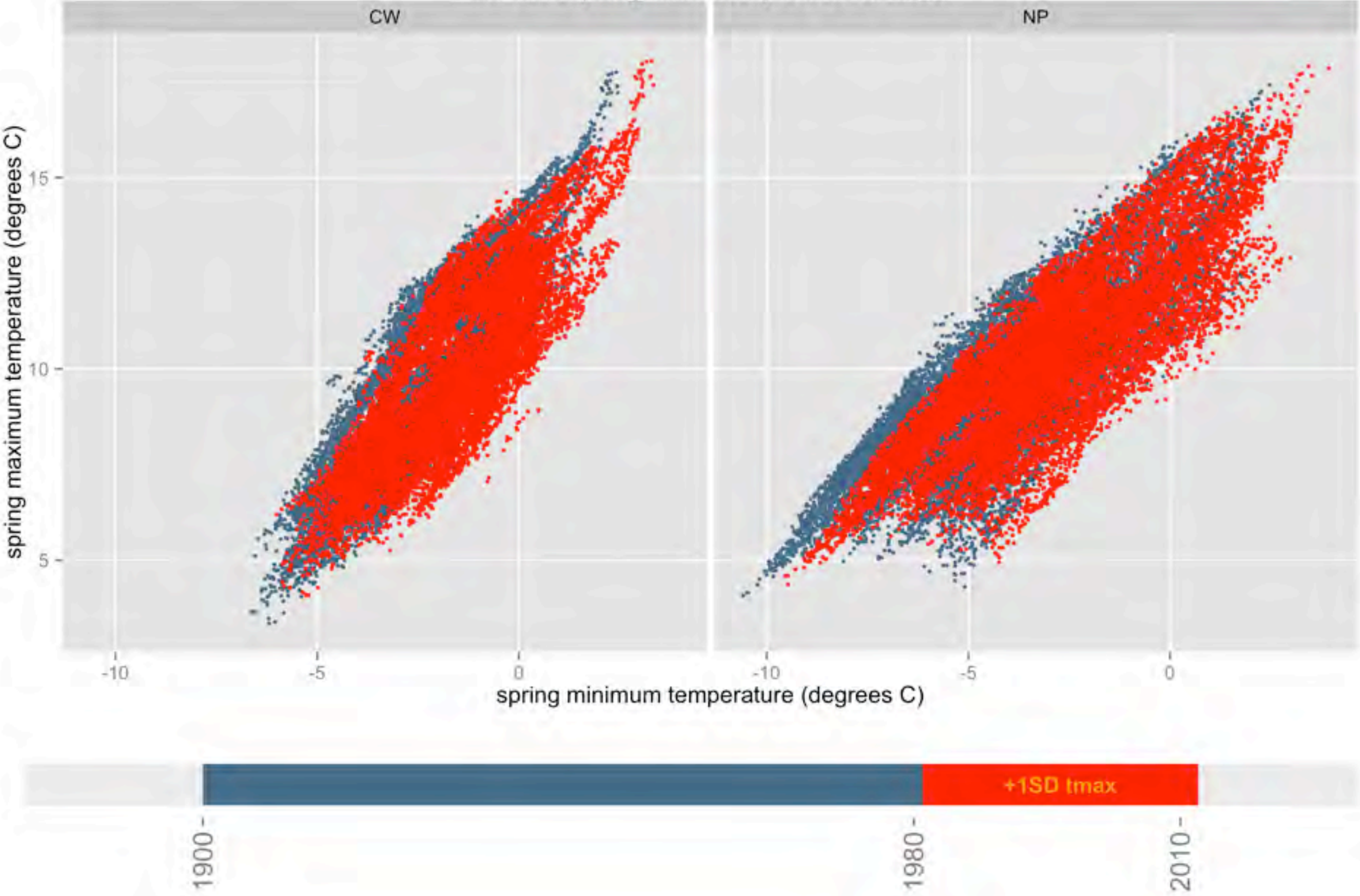
Summer Minimum Temperature Standard Deviation 1901-1980

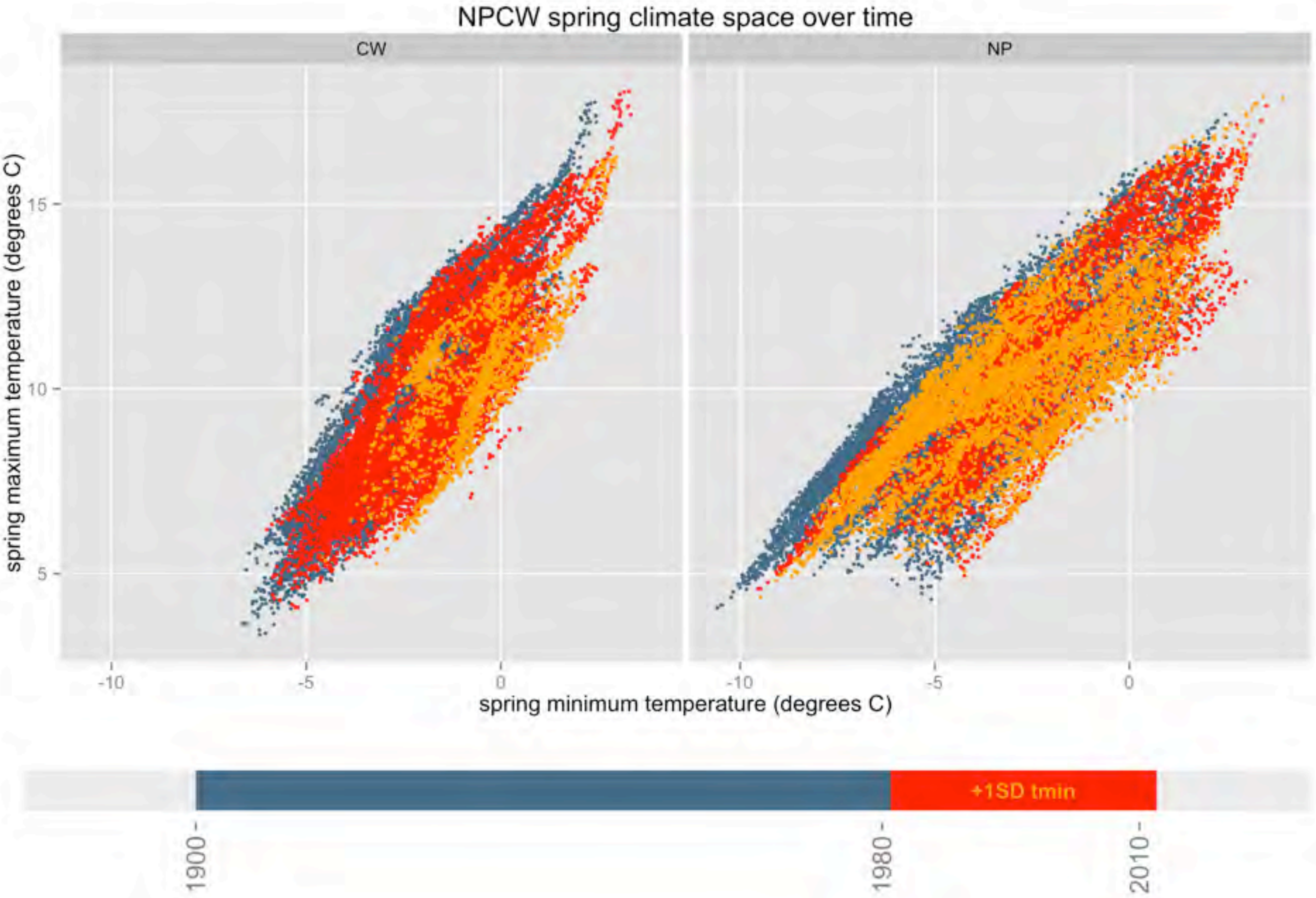
Standard Deviation
High : 1.4
Low : 0.5
Clearwater
Nez-Perce
Analysis boundary
50
Miles

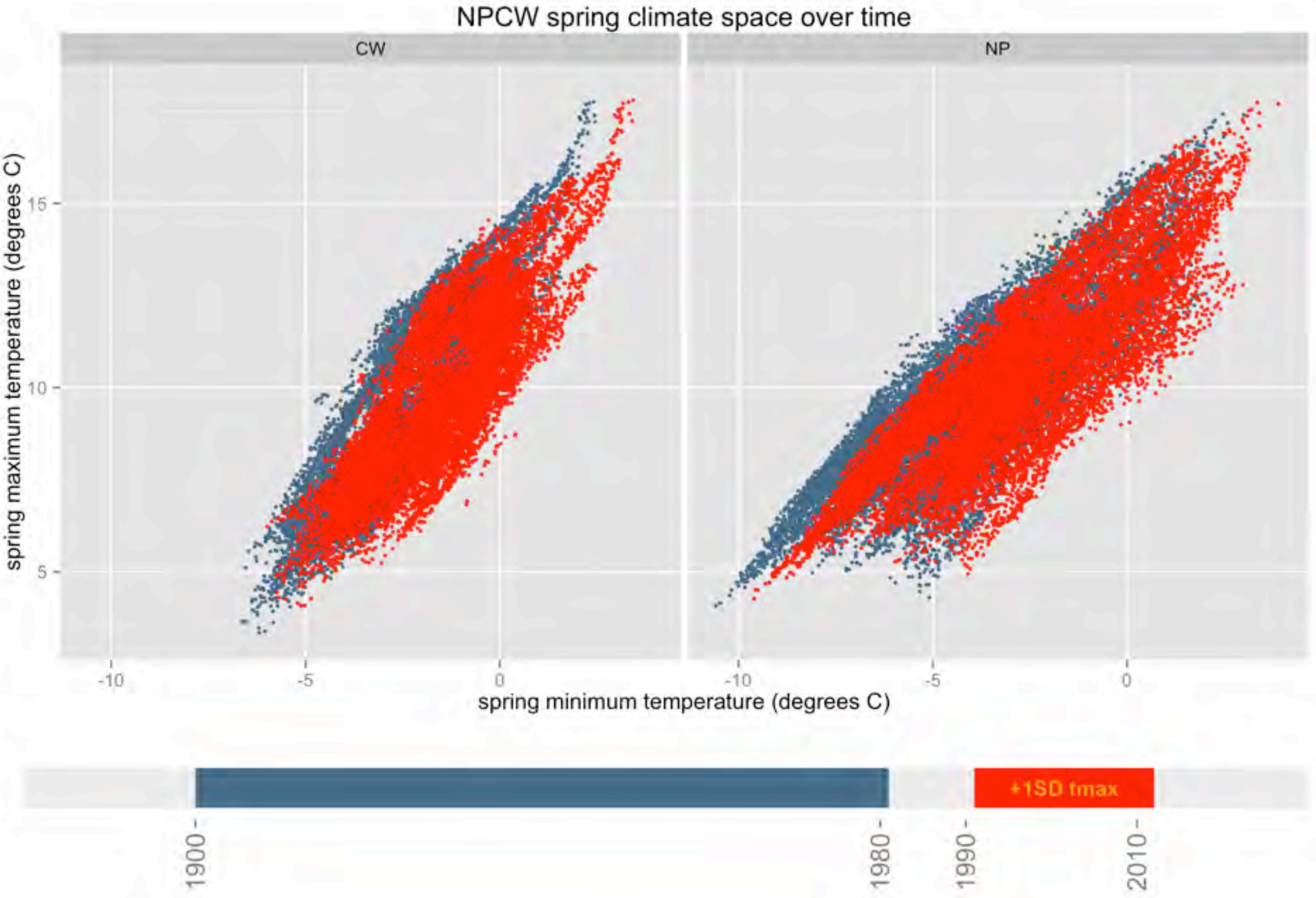
# NPCW spring climate space over time



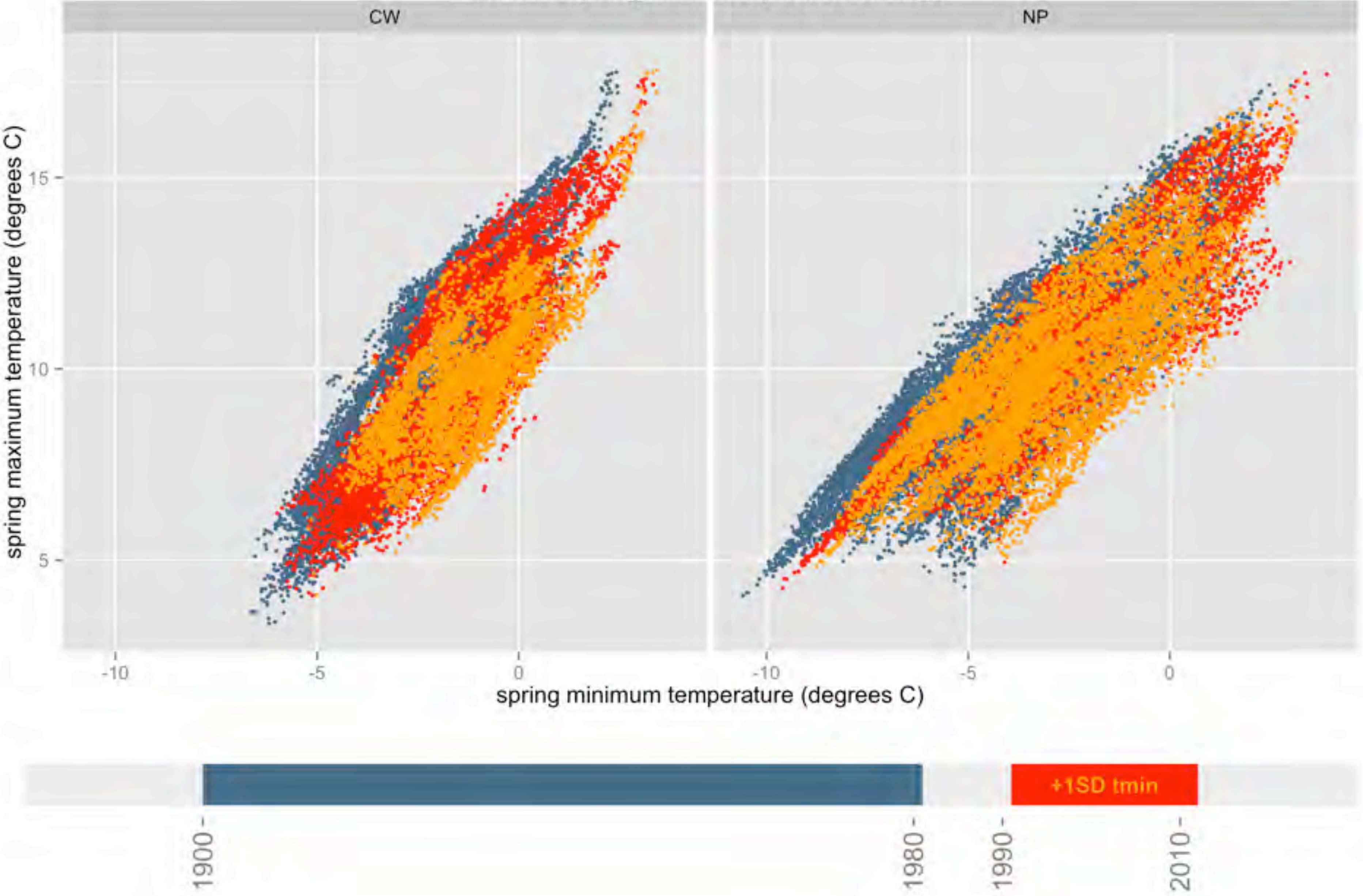
# NPCW spring climate space over time



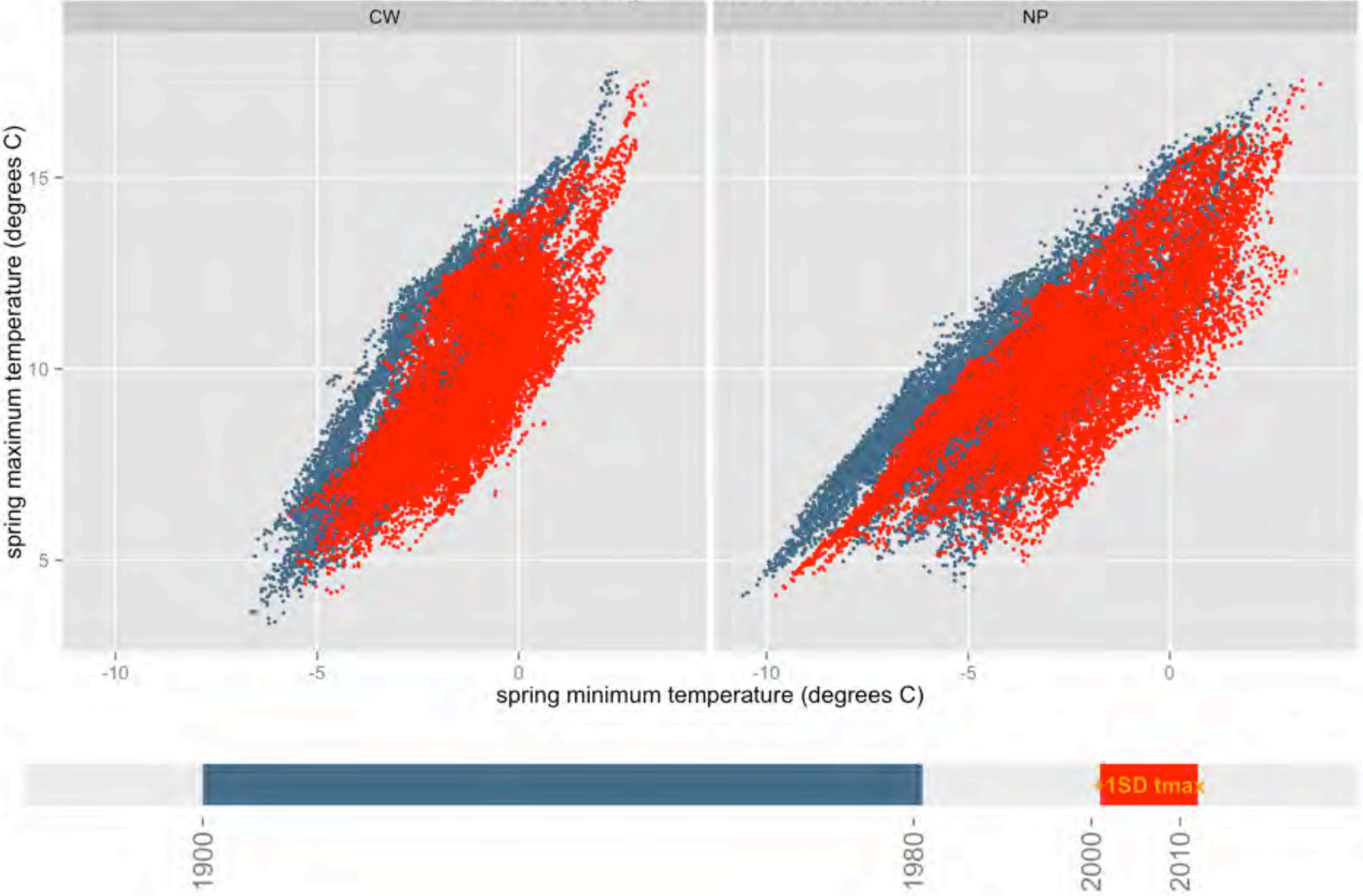

NPCW spring climate space over time
CW
NP
spring maximum temperature (degrees C)
15
10
5
-10
-5
0
-10
-5
0
spring minimum temperature (degrees C)
+1SD tmin
1900
1980
2010


NPCW spring climate space over time
CW
NP
spring maximum temperature (degrees C)
15
10
5
-10
-5
0
-10
-5
0
spring minimum temperature (degrees C)
+1SD tmax
1900
1980
1990
2010

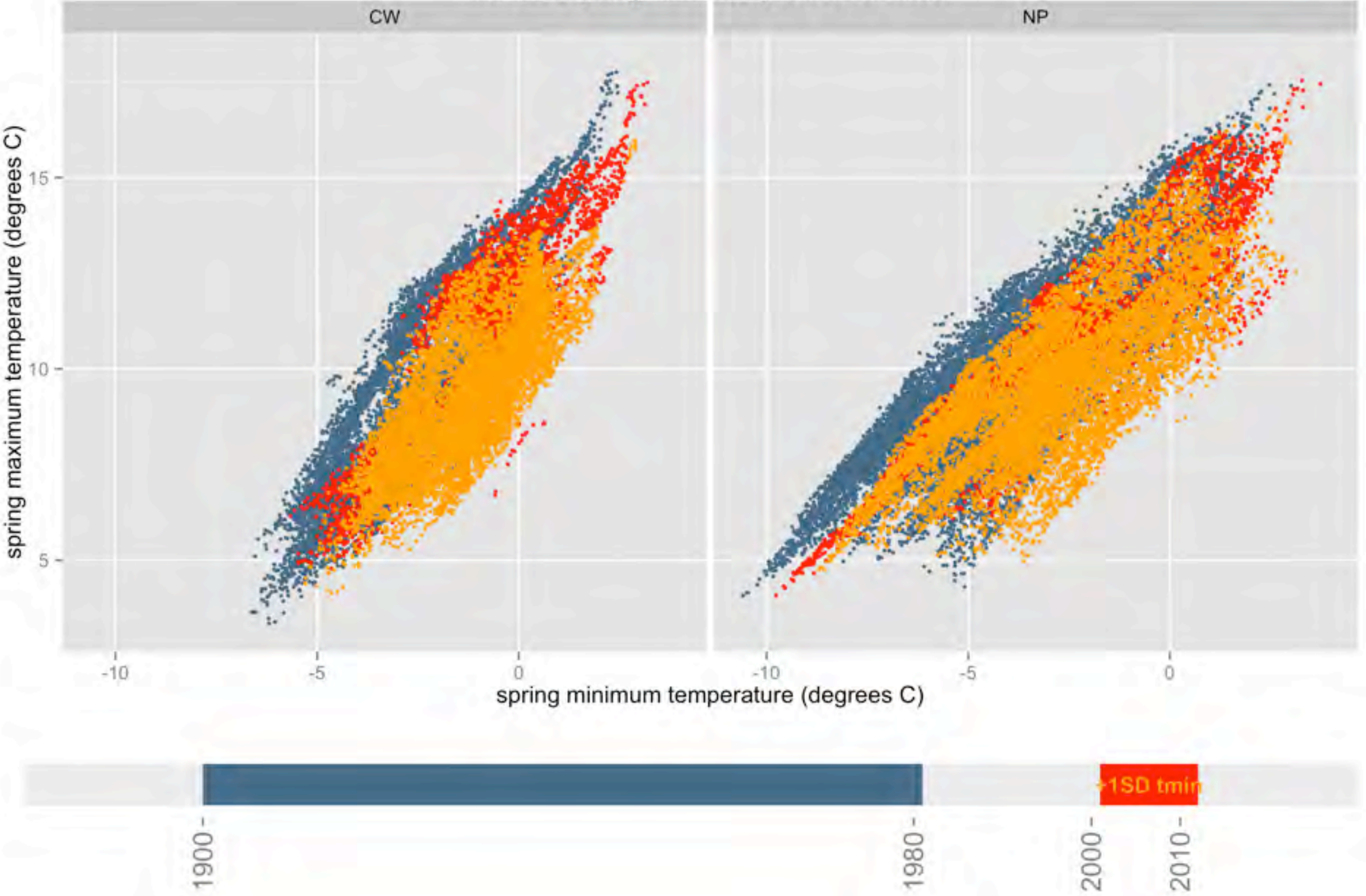
# NPCW spring climate space over time



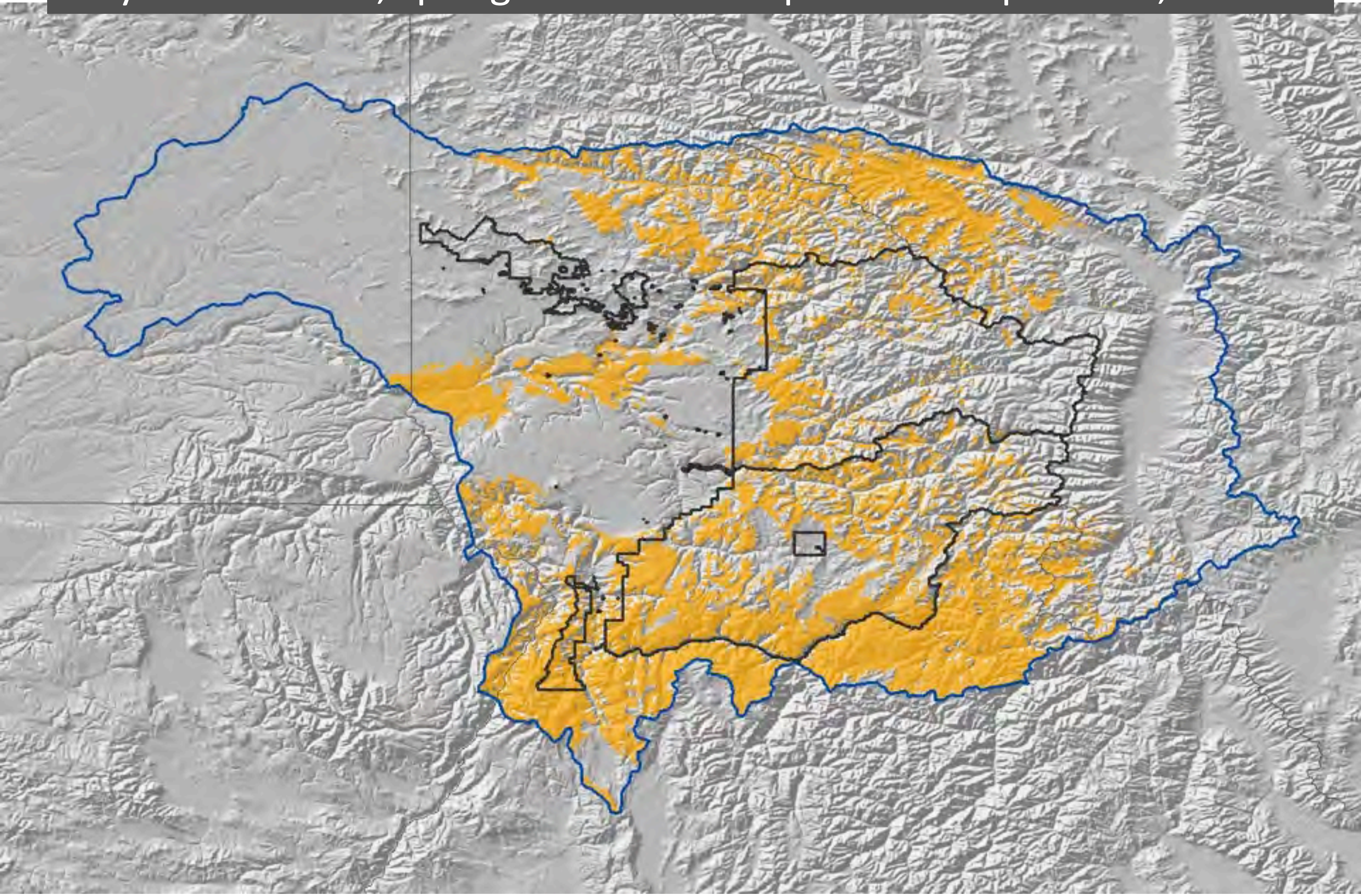
# NPCW spring climate space over time



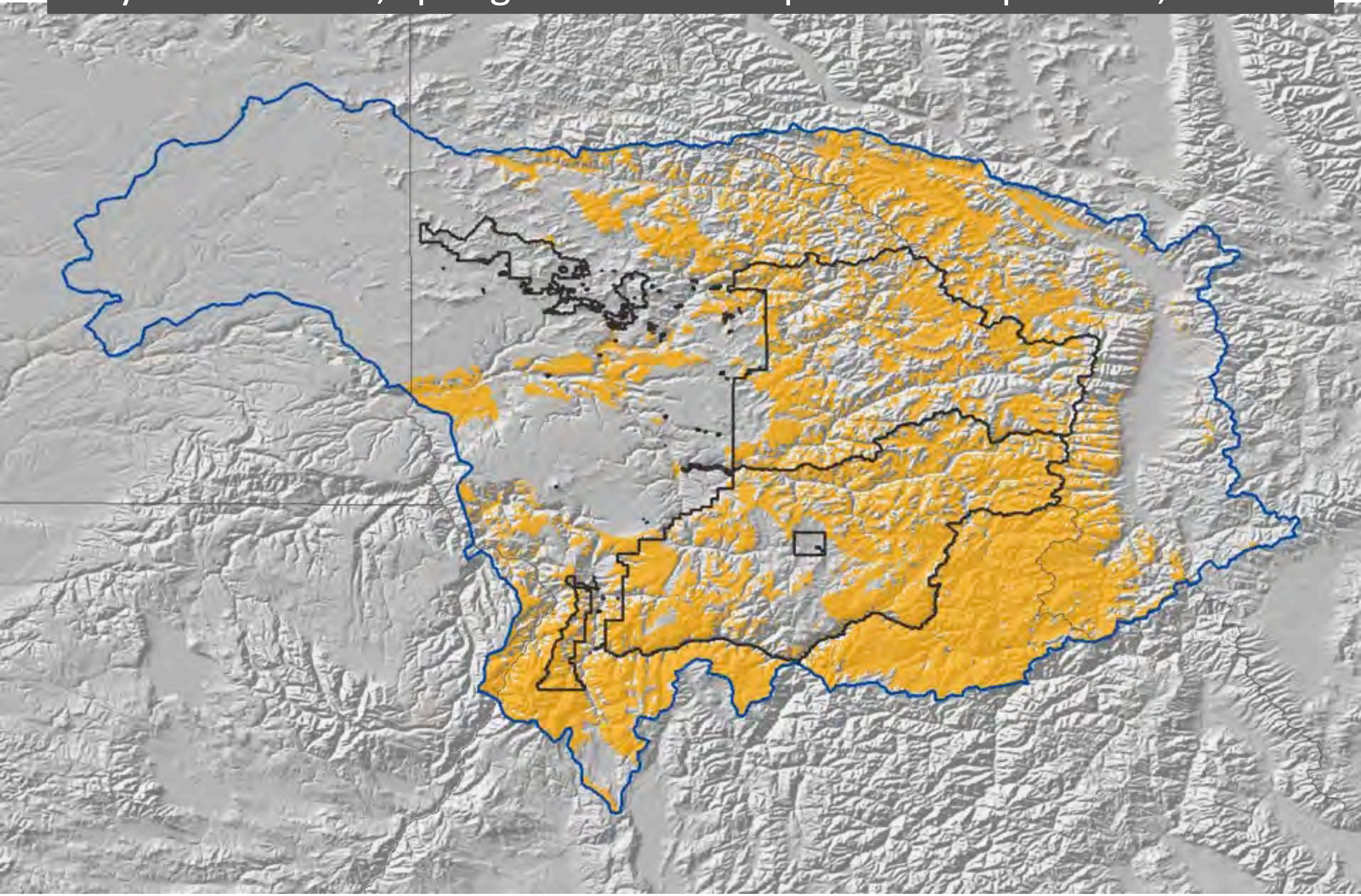
## NPCW spring climate space over time



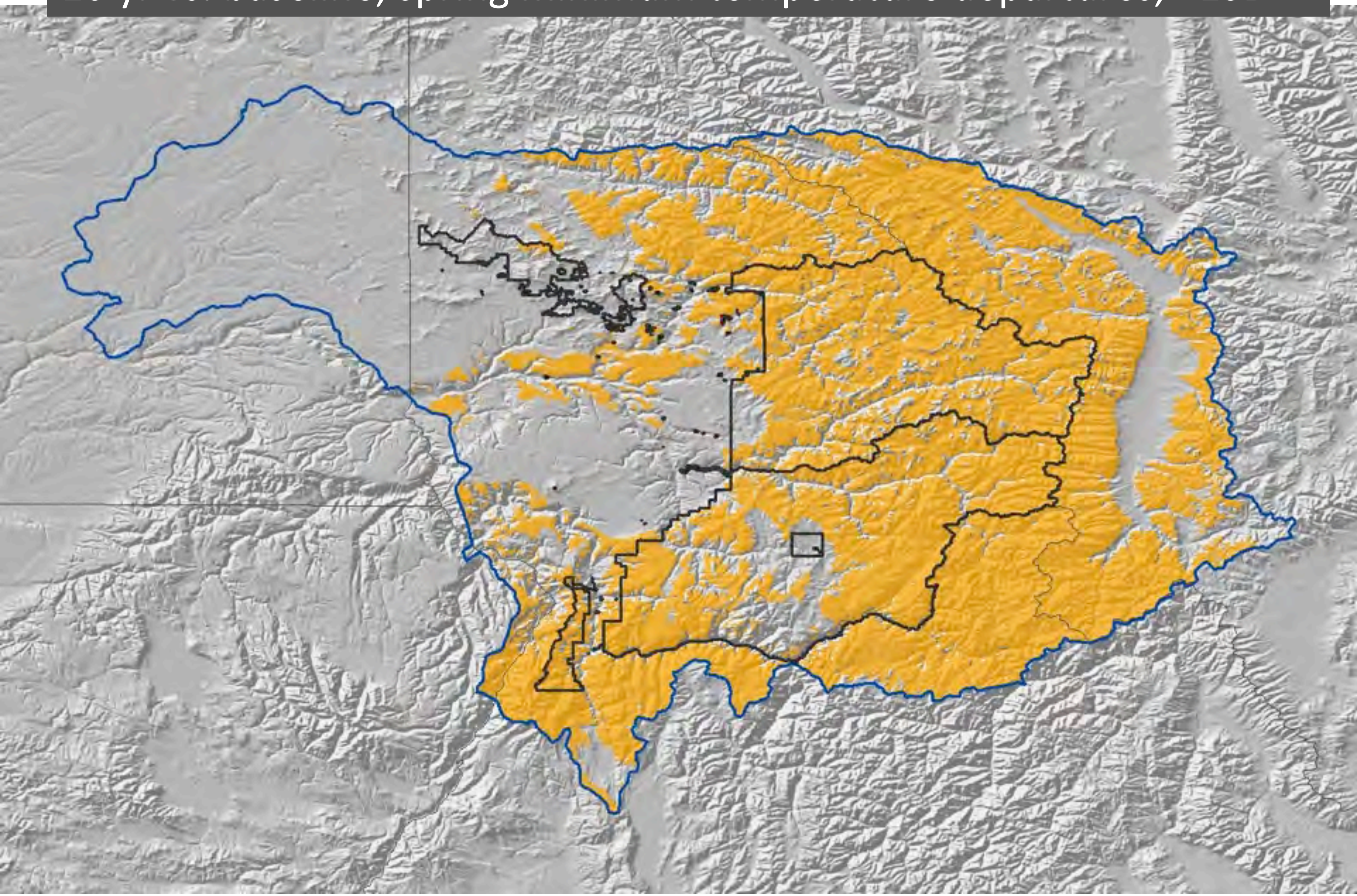
# 30 yr vs. baseline, spring minimum temperature departures, +1SD

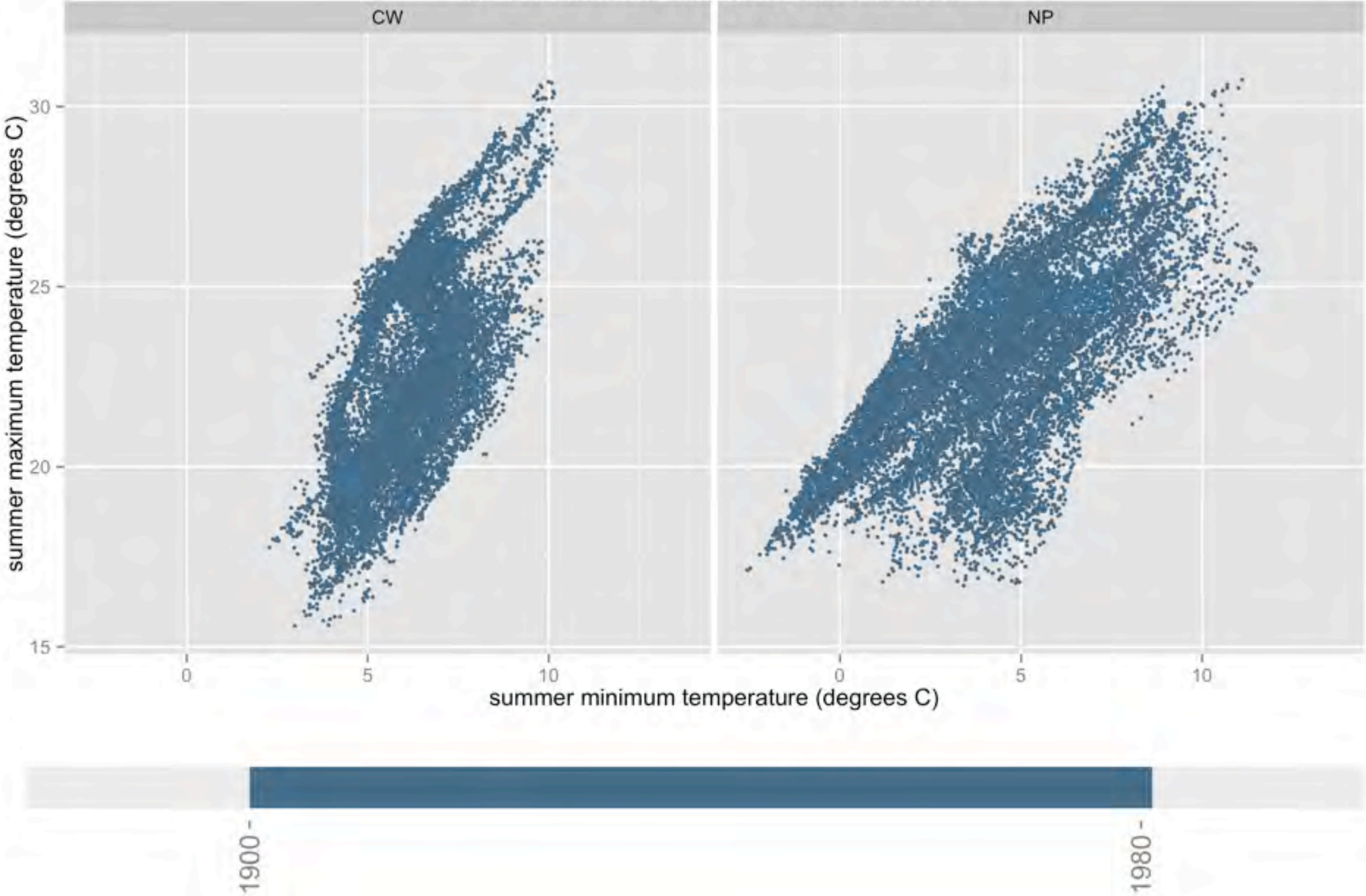


# 20 yr vs. baseline, spring minimum temperature departures, +1SD

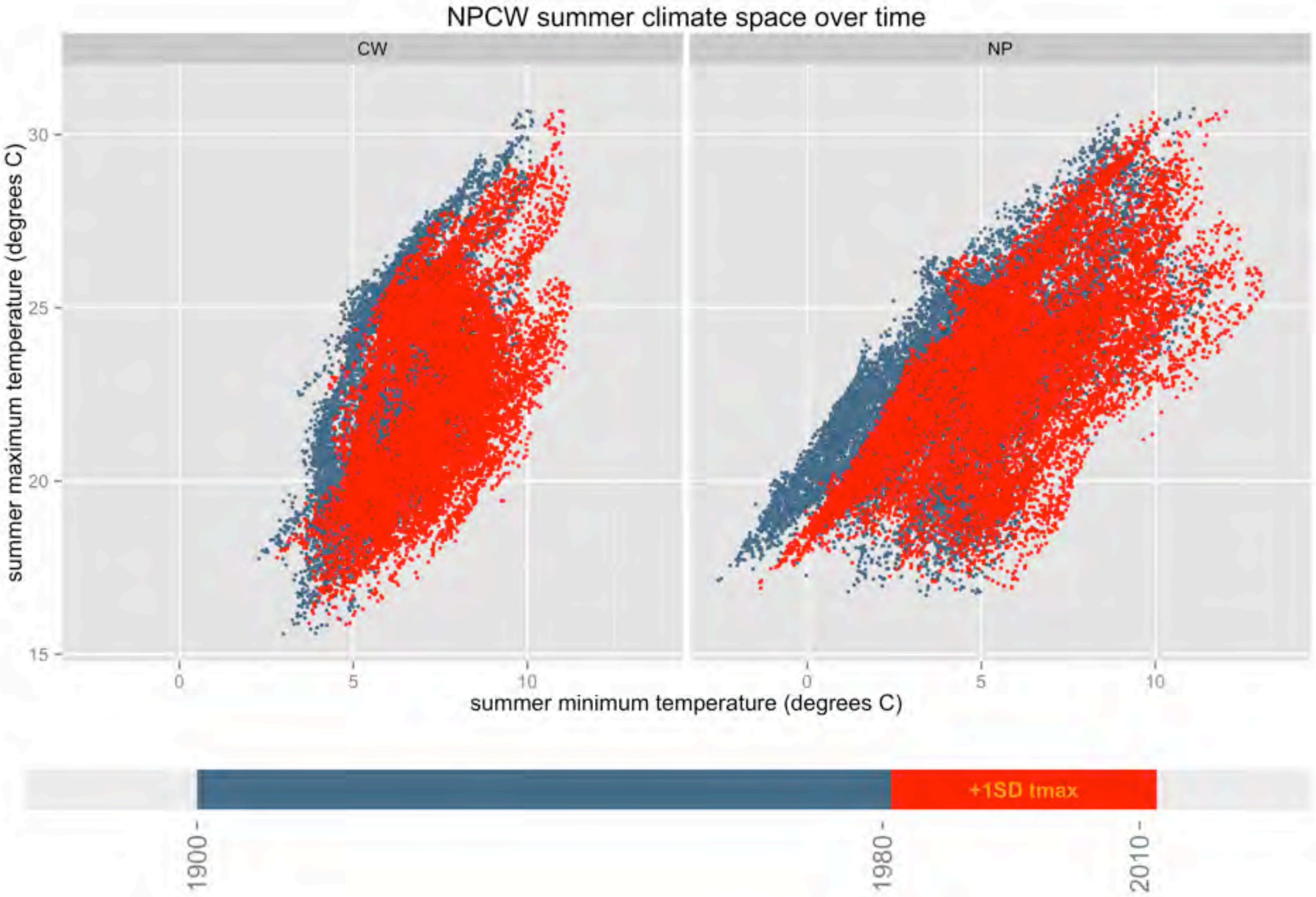


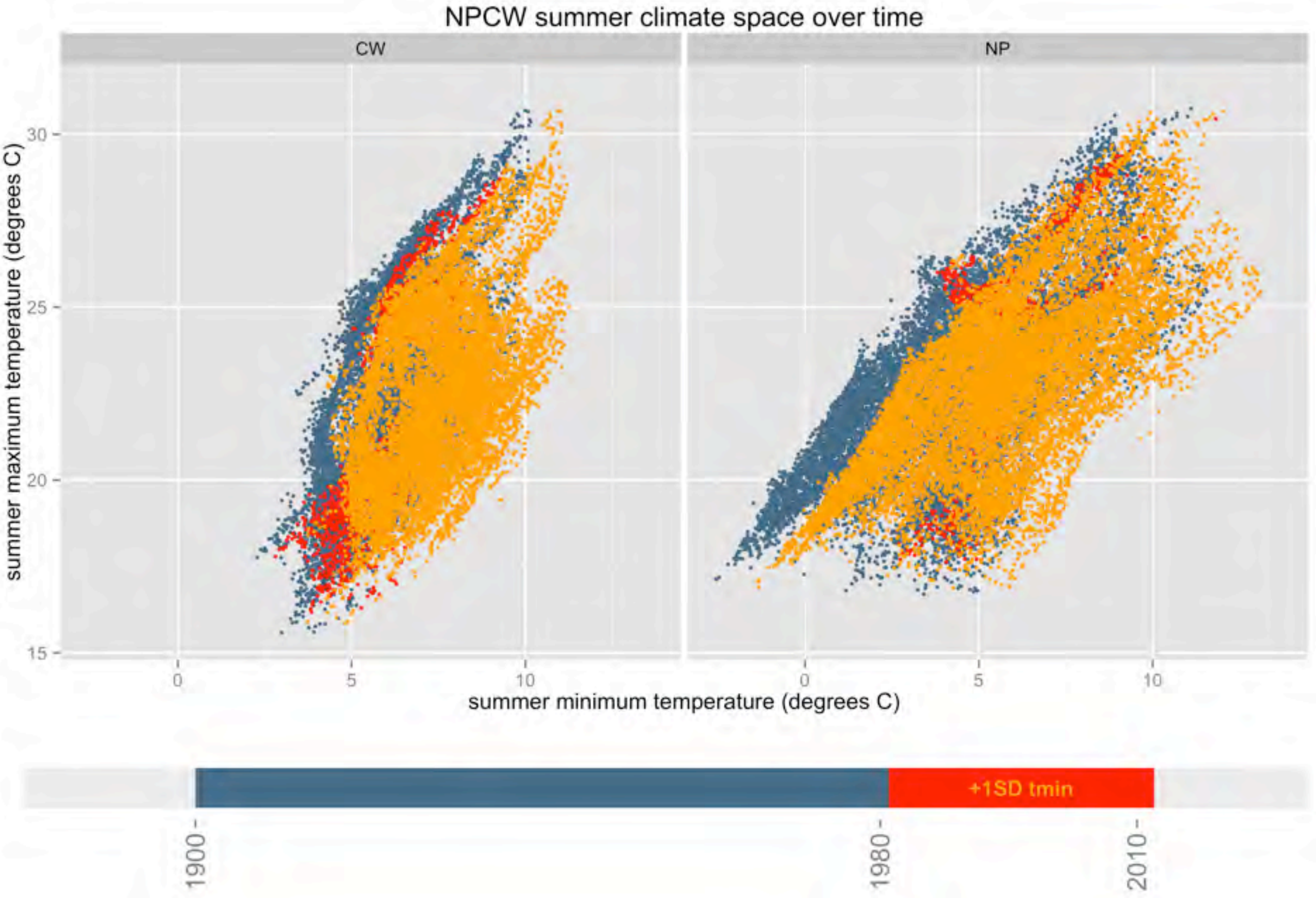
# 10 yr vs. baseline, spring minimum temperature departures, +1SD



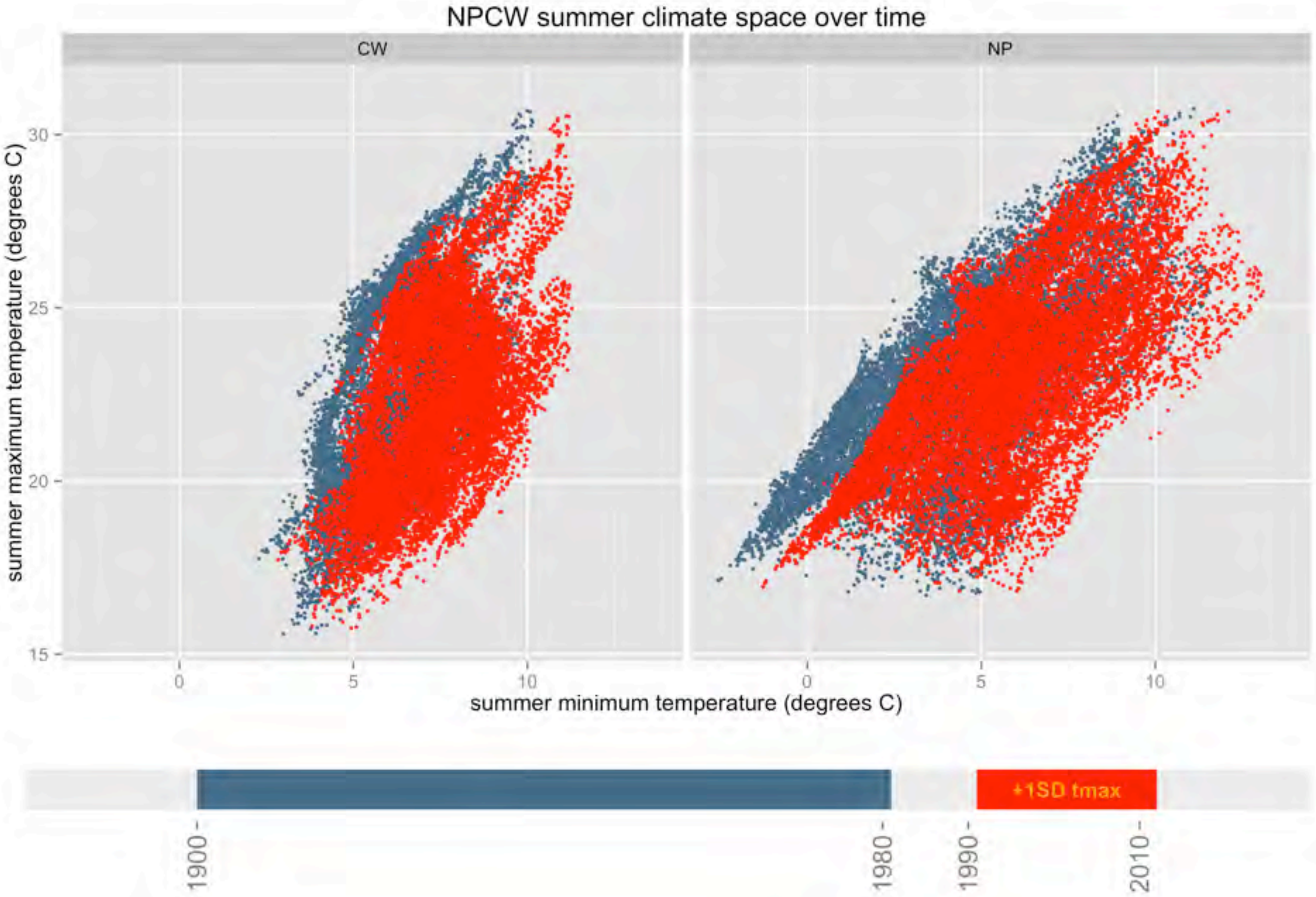


NPCW summer climate space over time

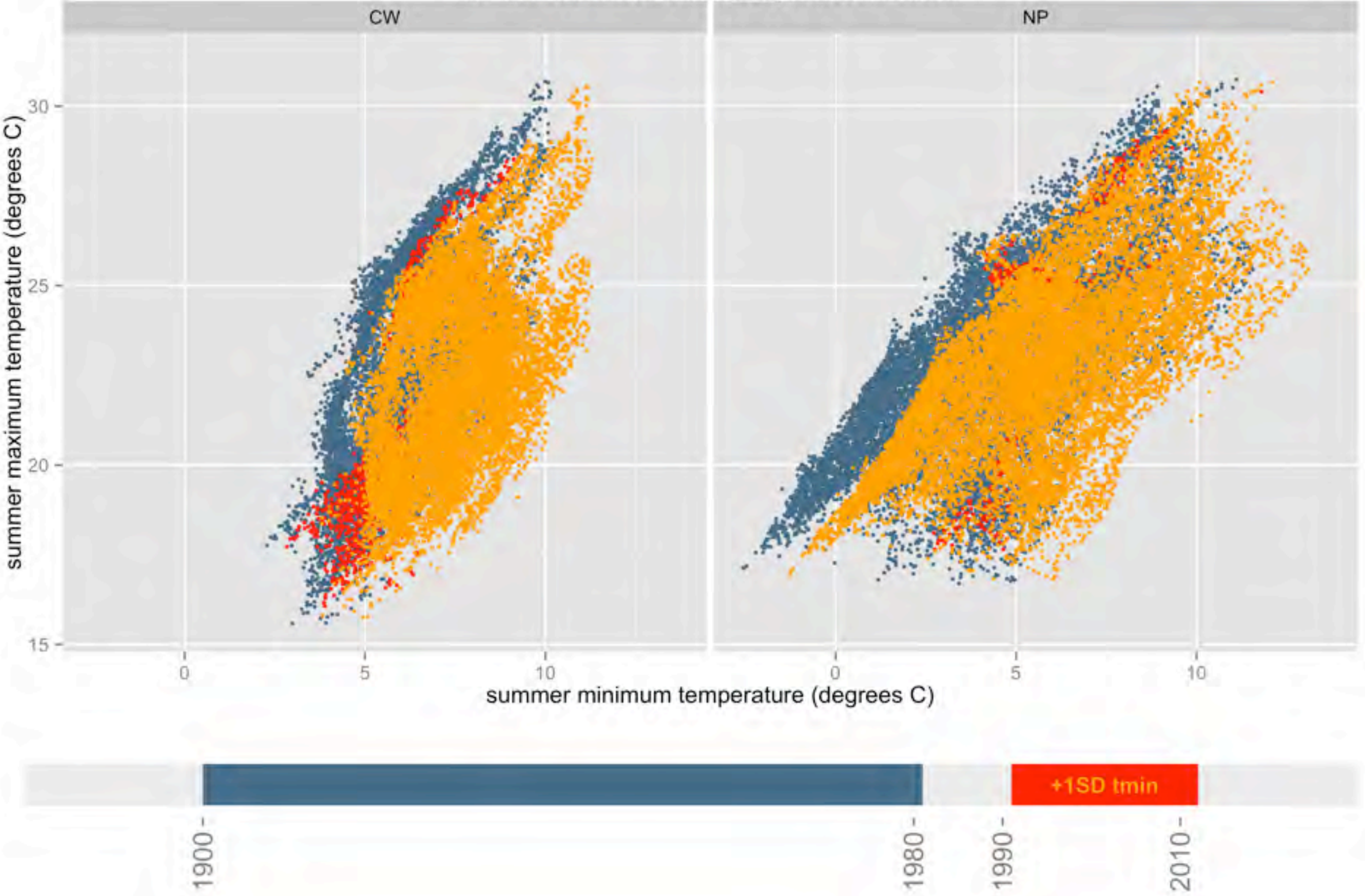

NPCW summer climate space over time
CW
NP
summer maximum temperature (degrees C)
30
25
20
15
0
5
10
0
5
10
summer minimum temperature (degrees C)
+1SD tmax
1900
1980
2010



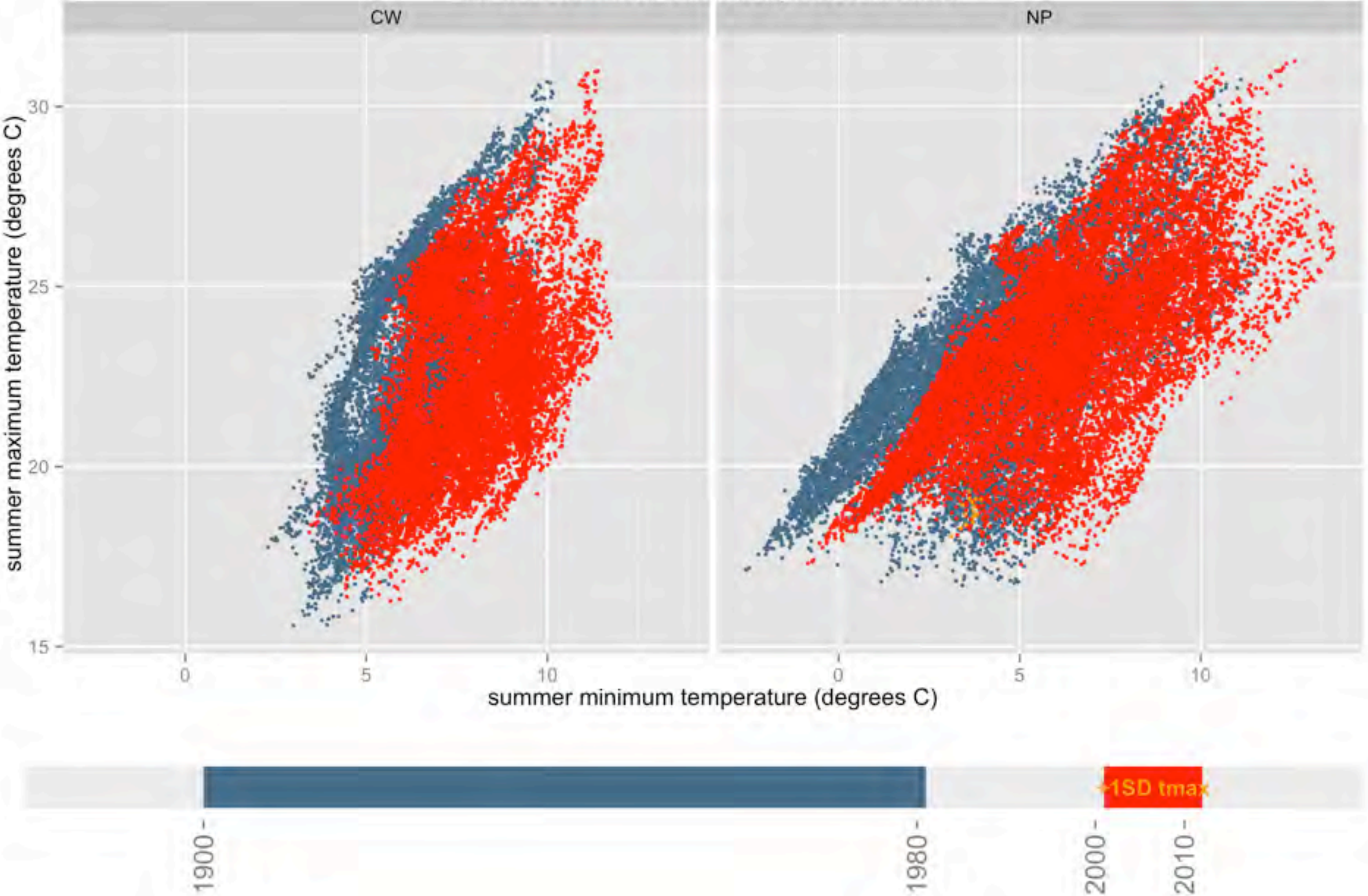
NPCW summer climate space over time


NPCW summer climate space over time
CW
NP
summer maximum temperature (degrees C)
30
25
20
15
0
5
10
0
5
10
summer minimum temperature (degrees C)
+1SD tmax
1900
1980
1990
2010

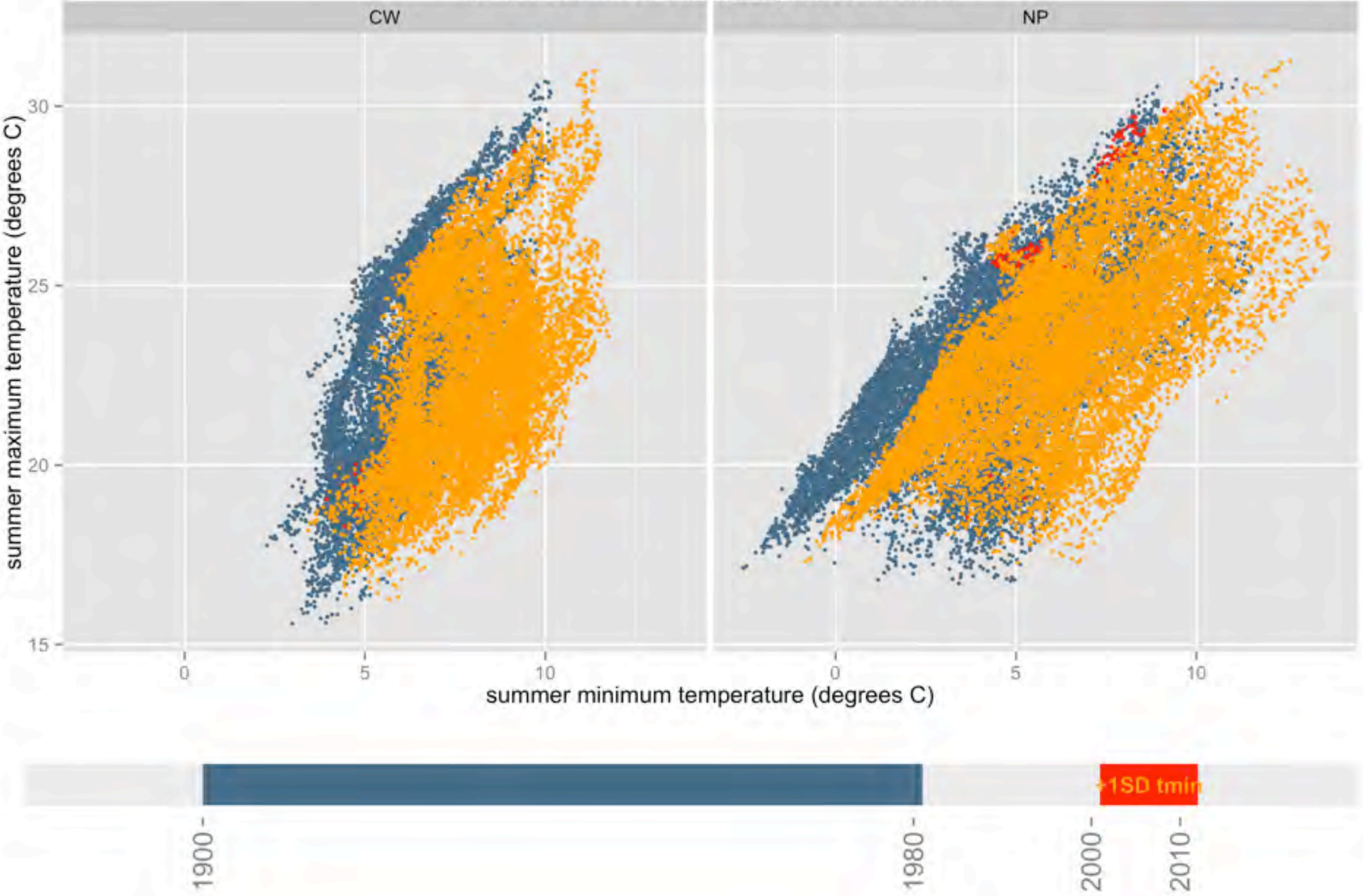
# NPCW summer climate space over time



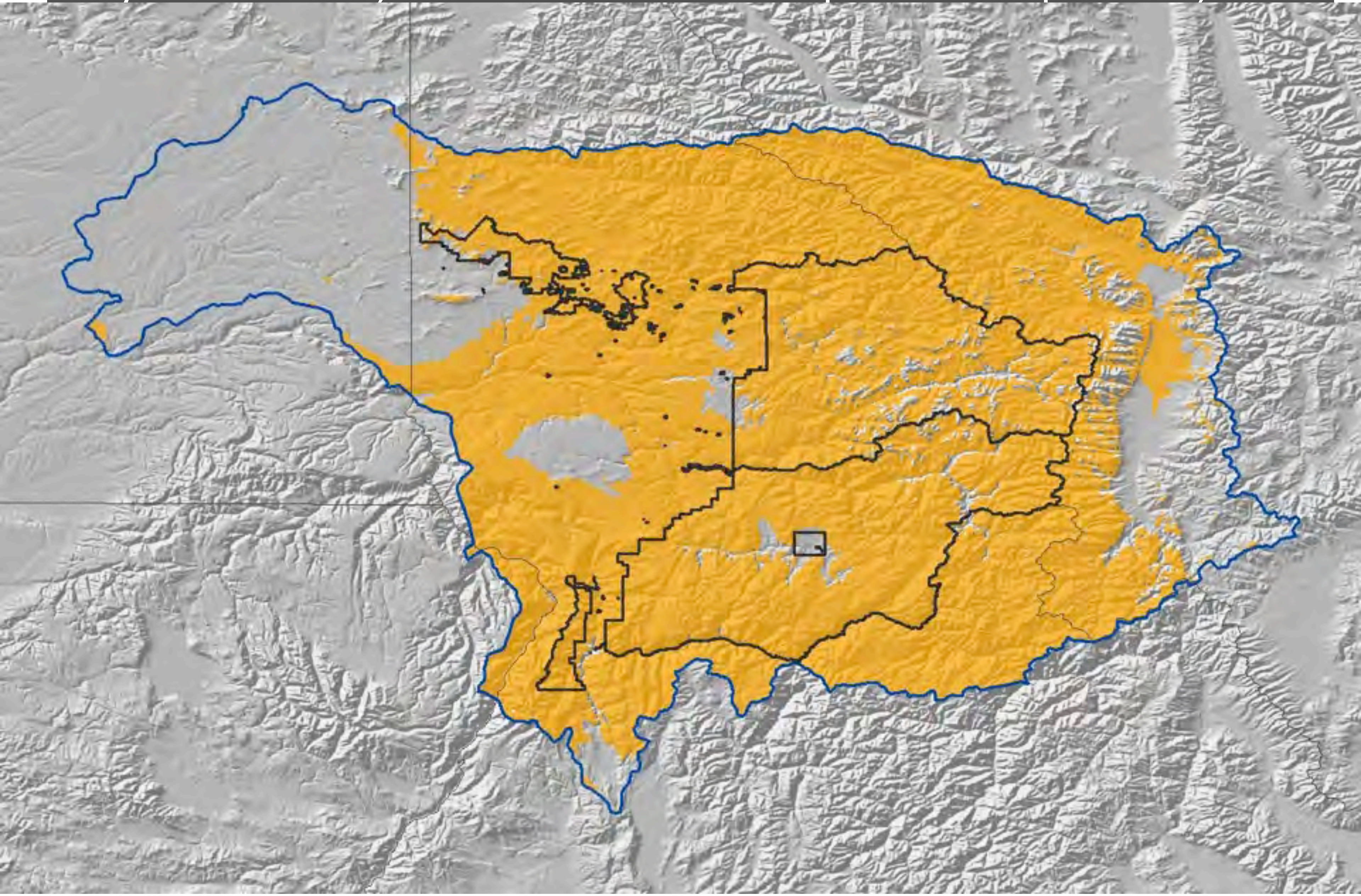
NPCW summer climate space over time



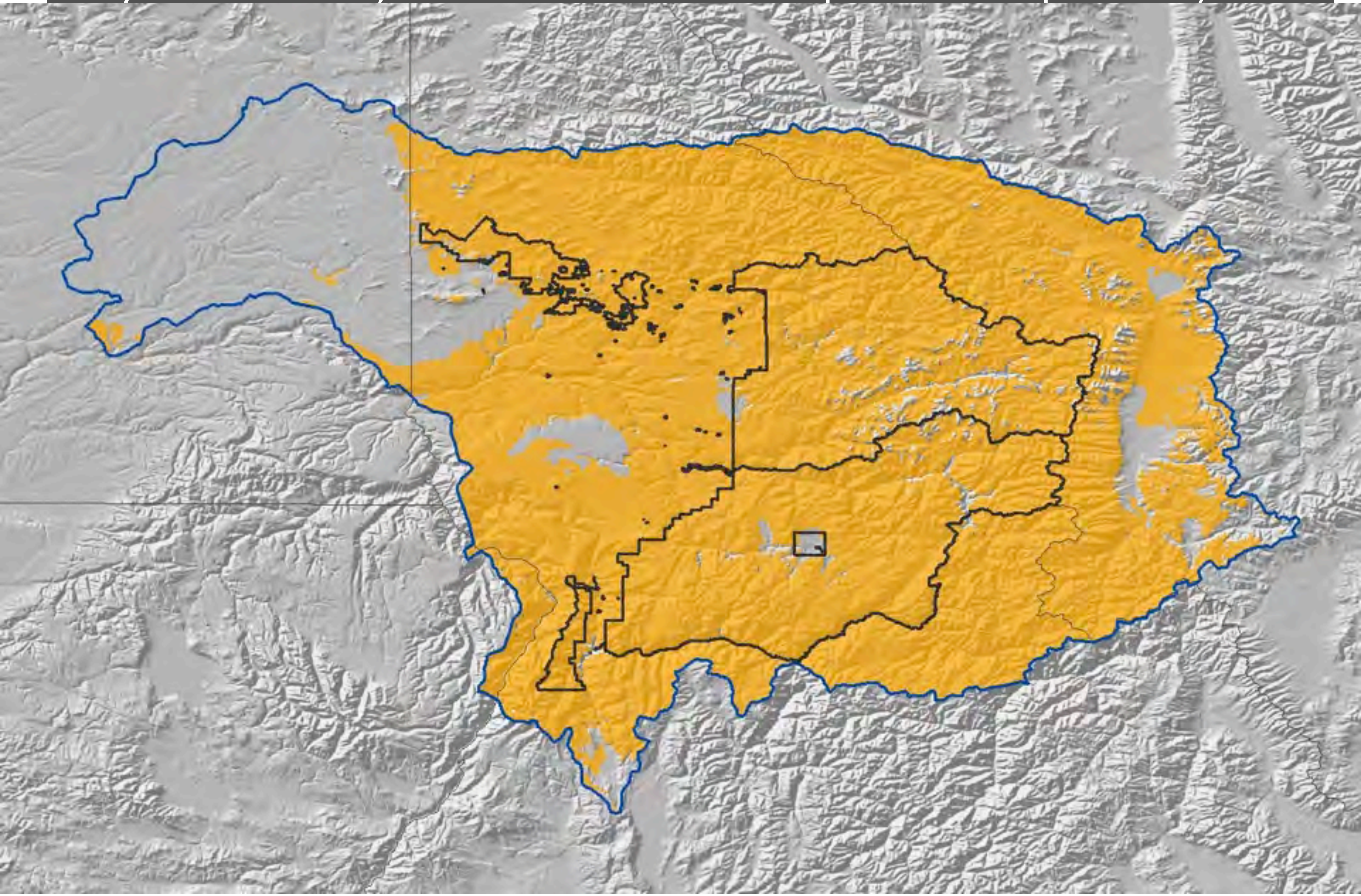
## NPCW summer climate space over time



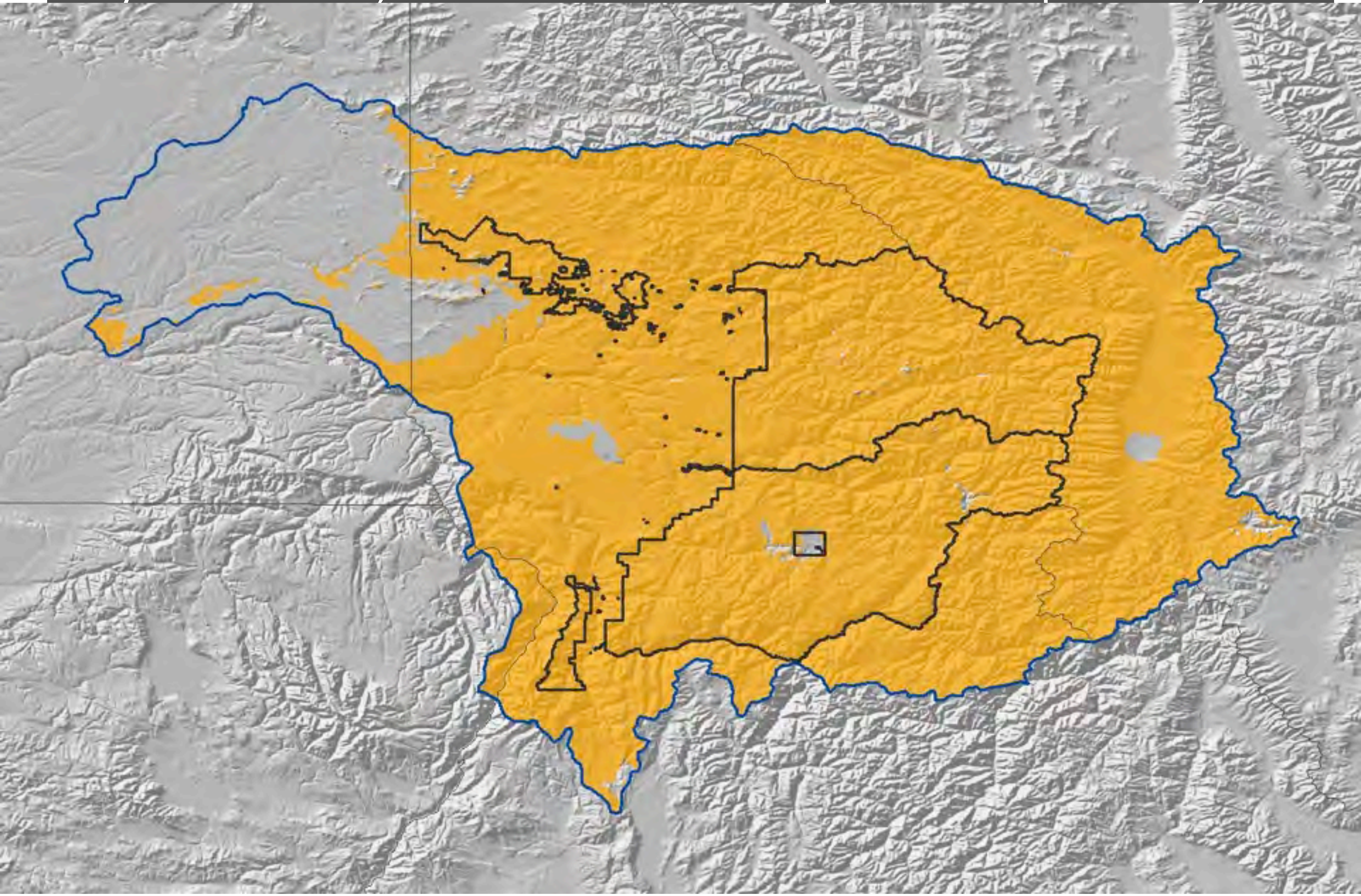
# 30 yr vs. baseline, summer minimum temperature departures, +1SD



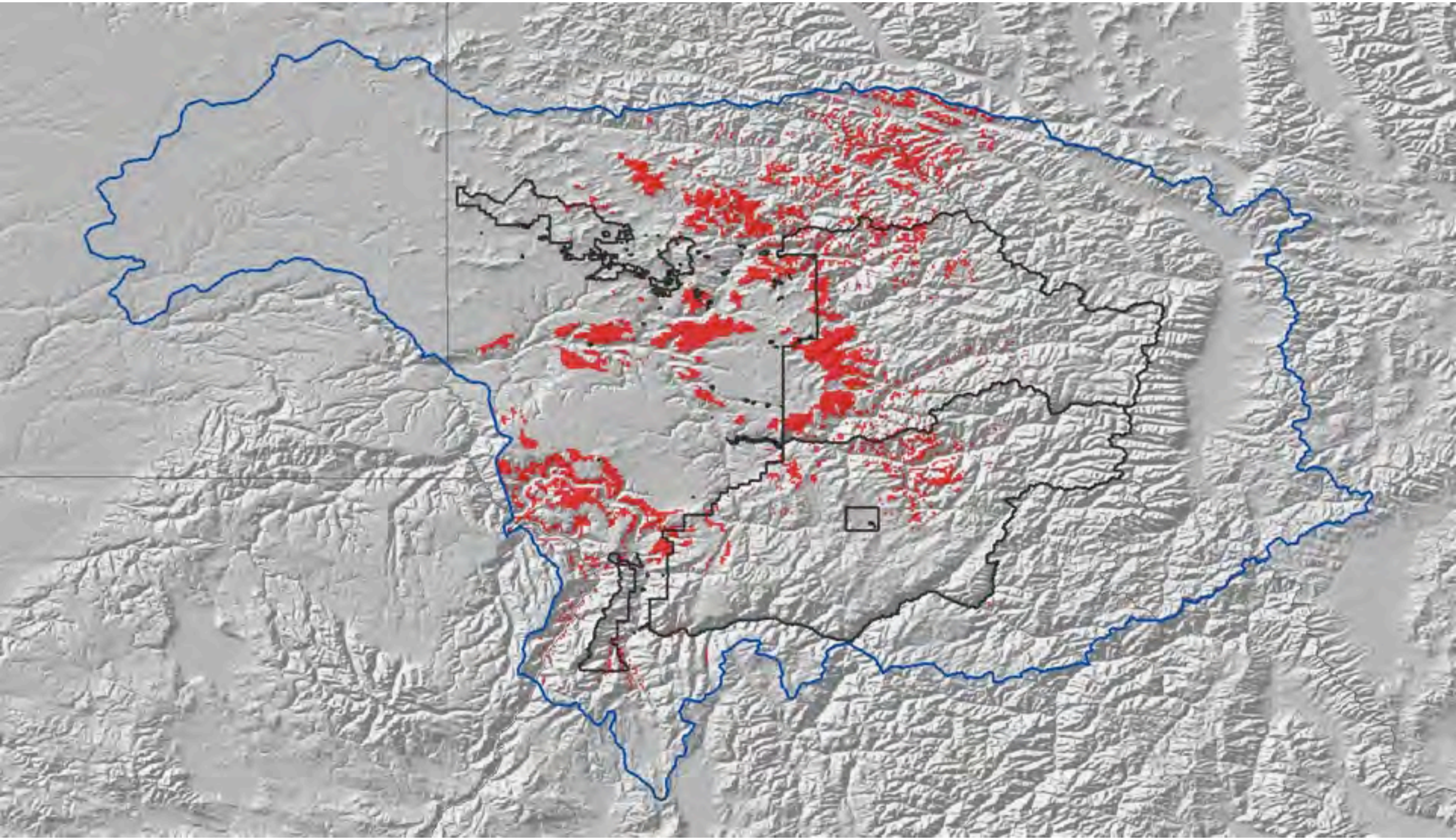
# 20 yr vs. baseline, summer minimum temperature departures, +1SD



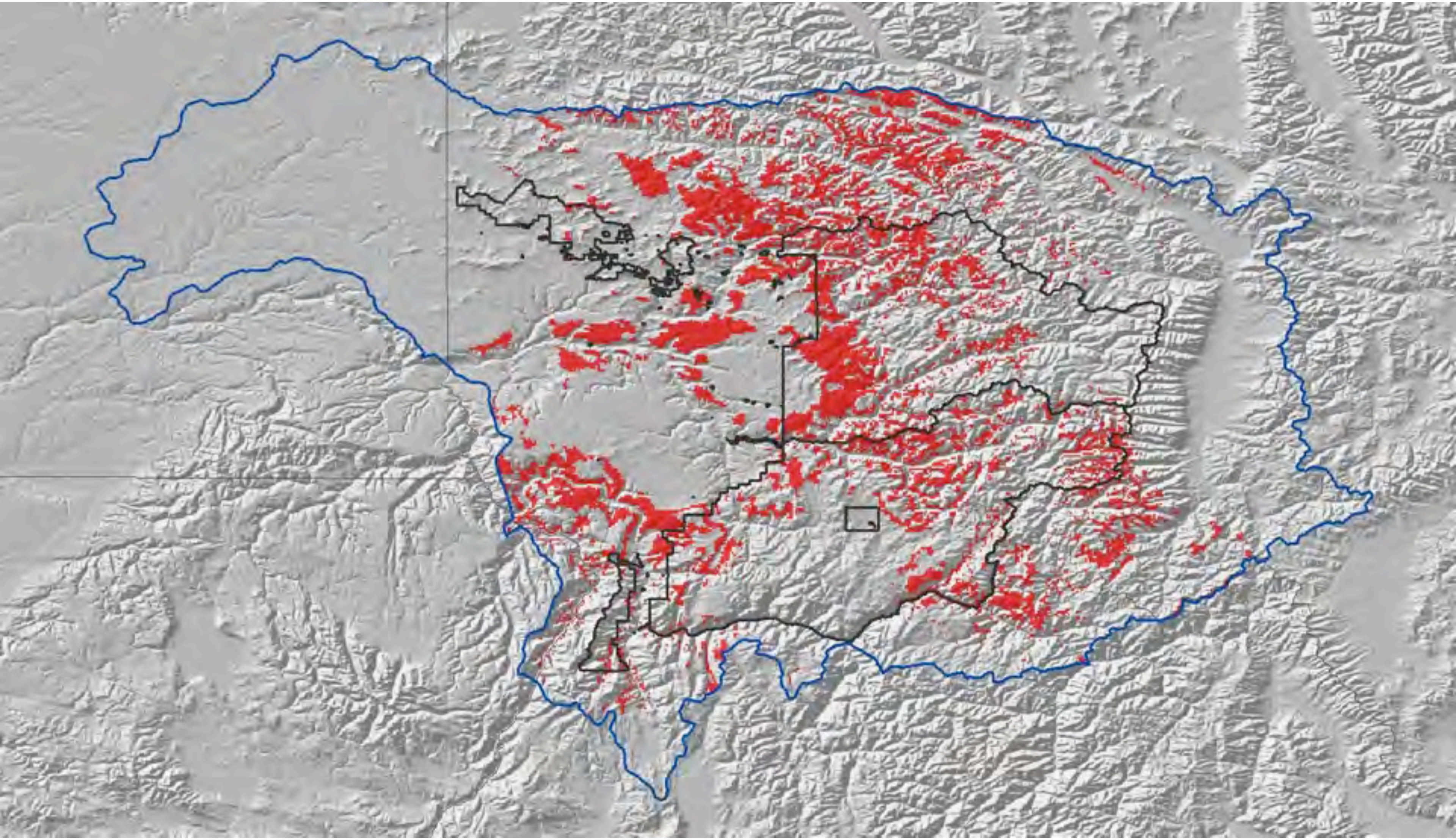
# 10 yr vs. baseline, summer minimum temperature departures, +1SD



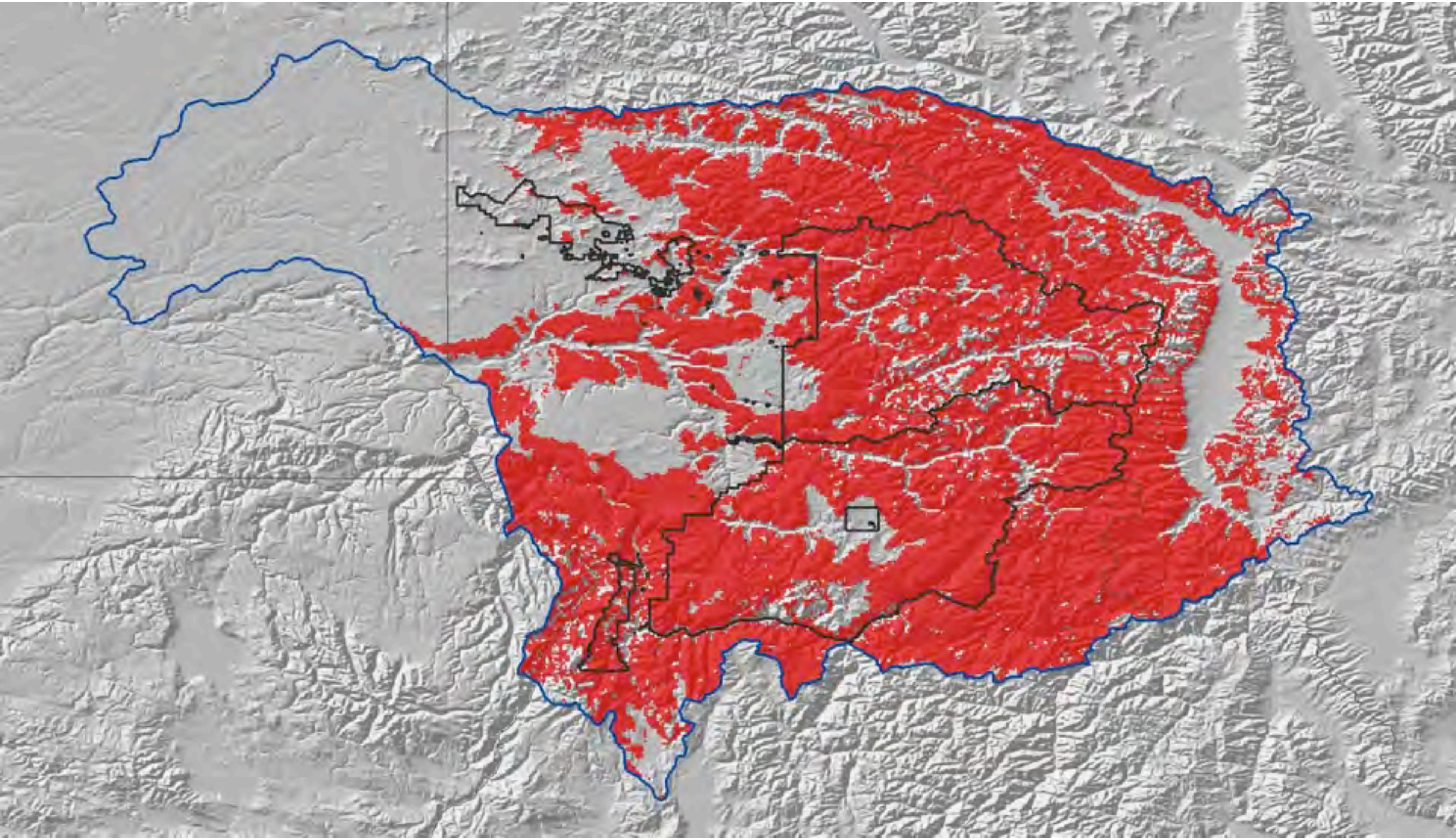
# 30 yr vs. baseline, summer minimum temperature departures, +2SD



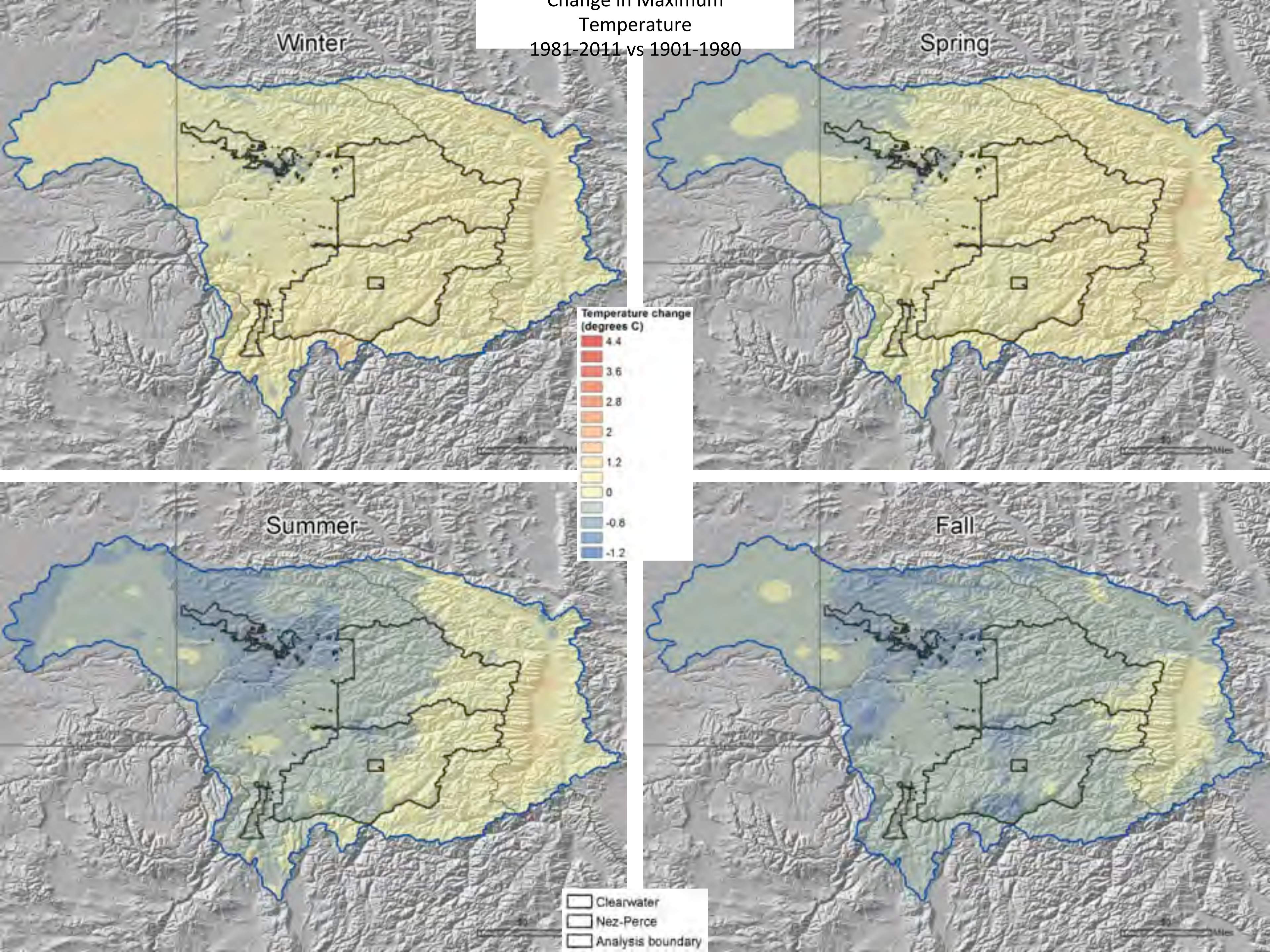
# 20 yr vs. baseline, summer minimum temperature departures, +2SD



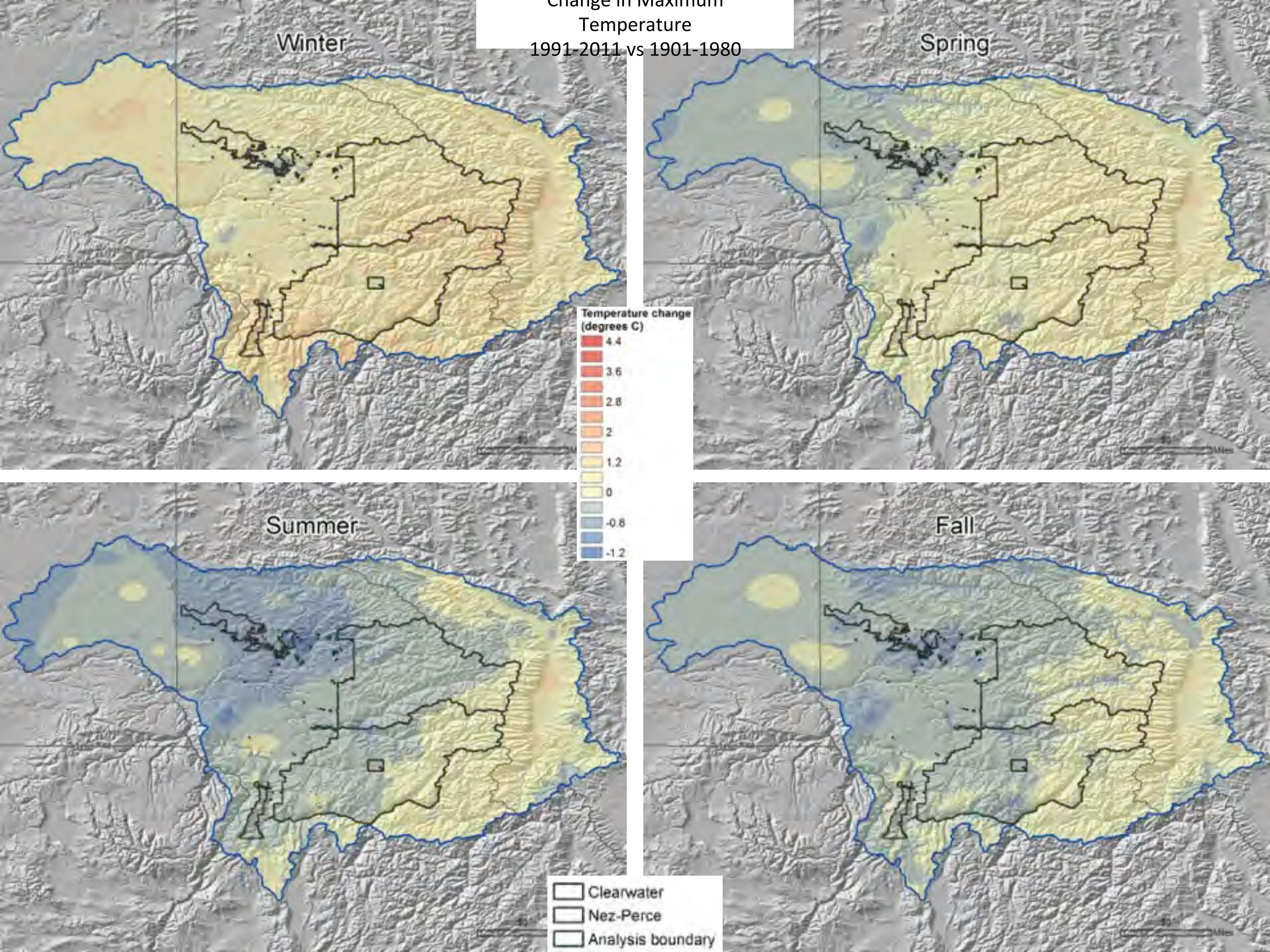
# 10 yr vs. baseline, summer minimum temperature departures, +2SD



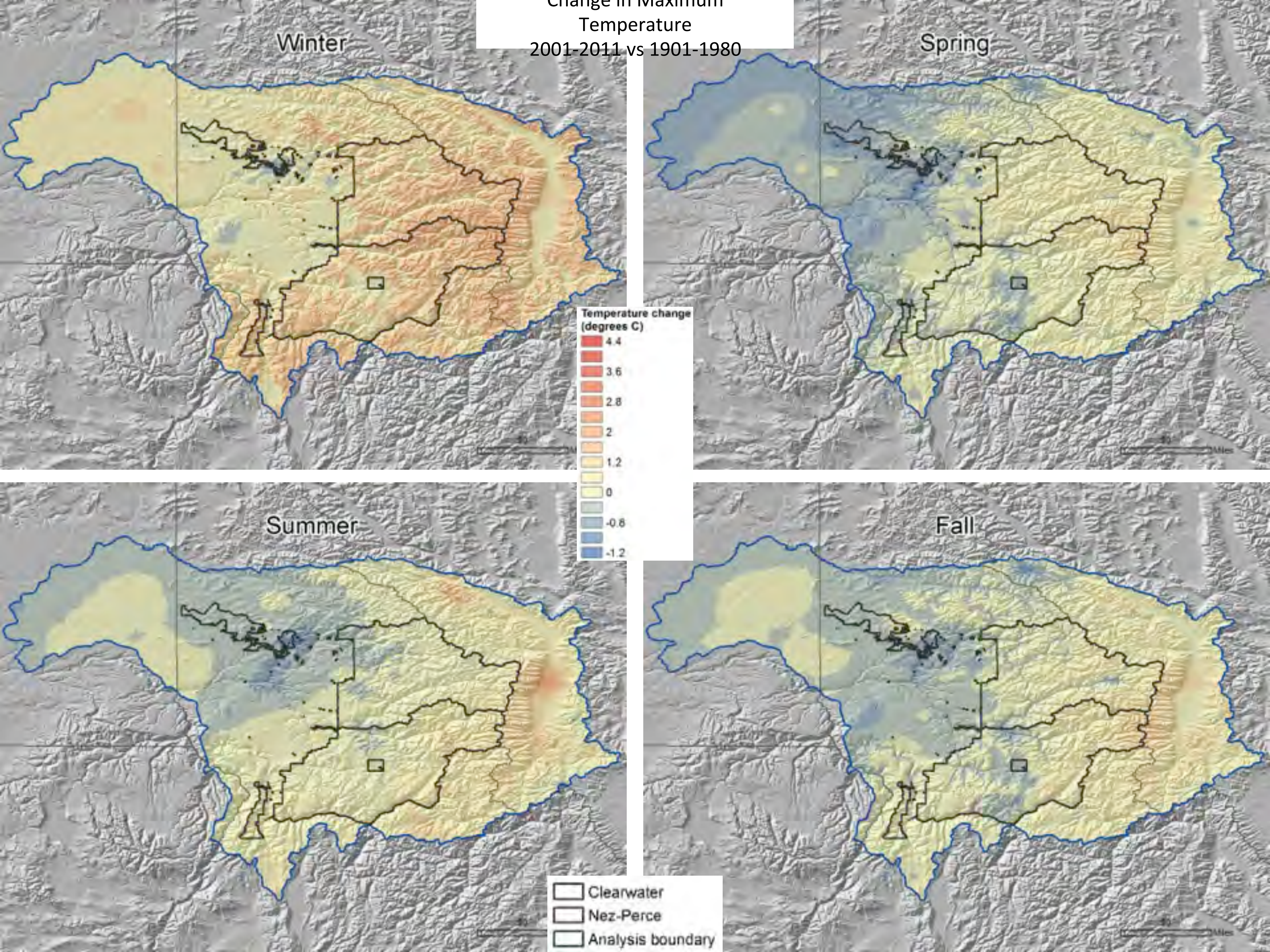
# Change in Maximum Temperature 1981-2011 vs 1901-1980


Winter
Spring
Summer
Fall
Temperature change (degrees C)
4.4
3.6
2.8
2
1.2
0
-0.8
-1.2
Clearwater
Nez-Perce
Analysis boundary
50
Miles

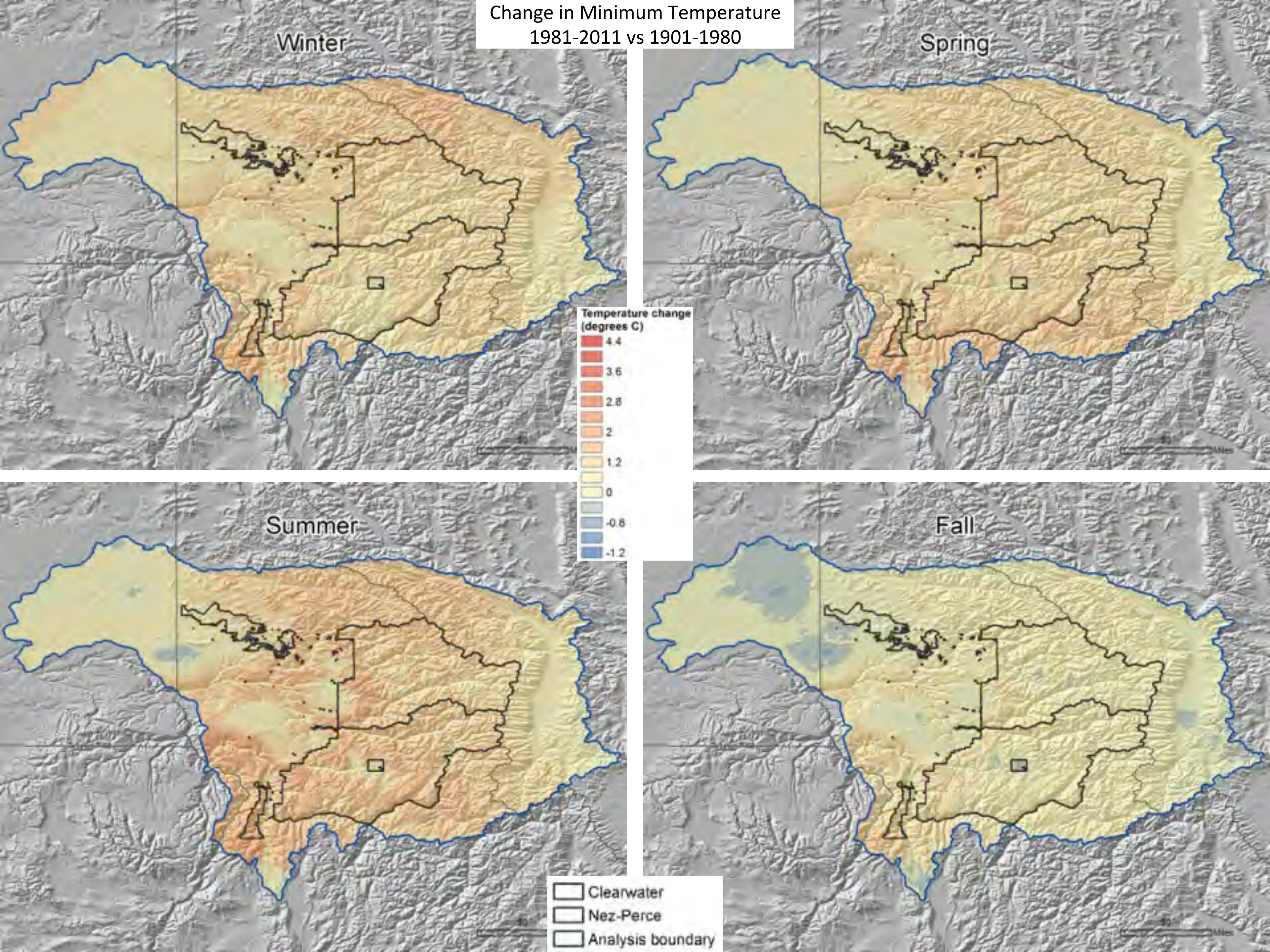
# Change in Maximum Temperature
1991-2011 vs 1901-1980


Winter
Spring
Summer
Fall
Temperature change (degrees C)
4.4
3.6
2.8
2
1.2
0
-0.8
-1.2
Clearwater
Nez-Perce
Analysis boundary
50
Miles

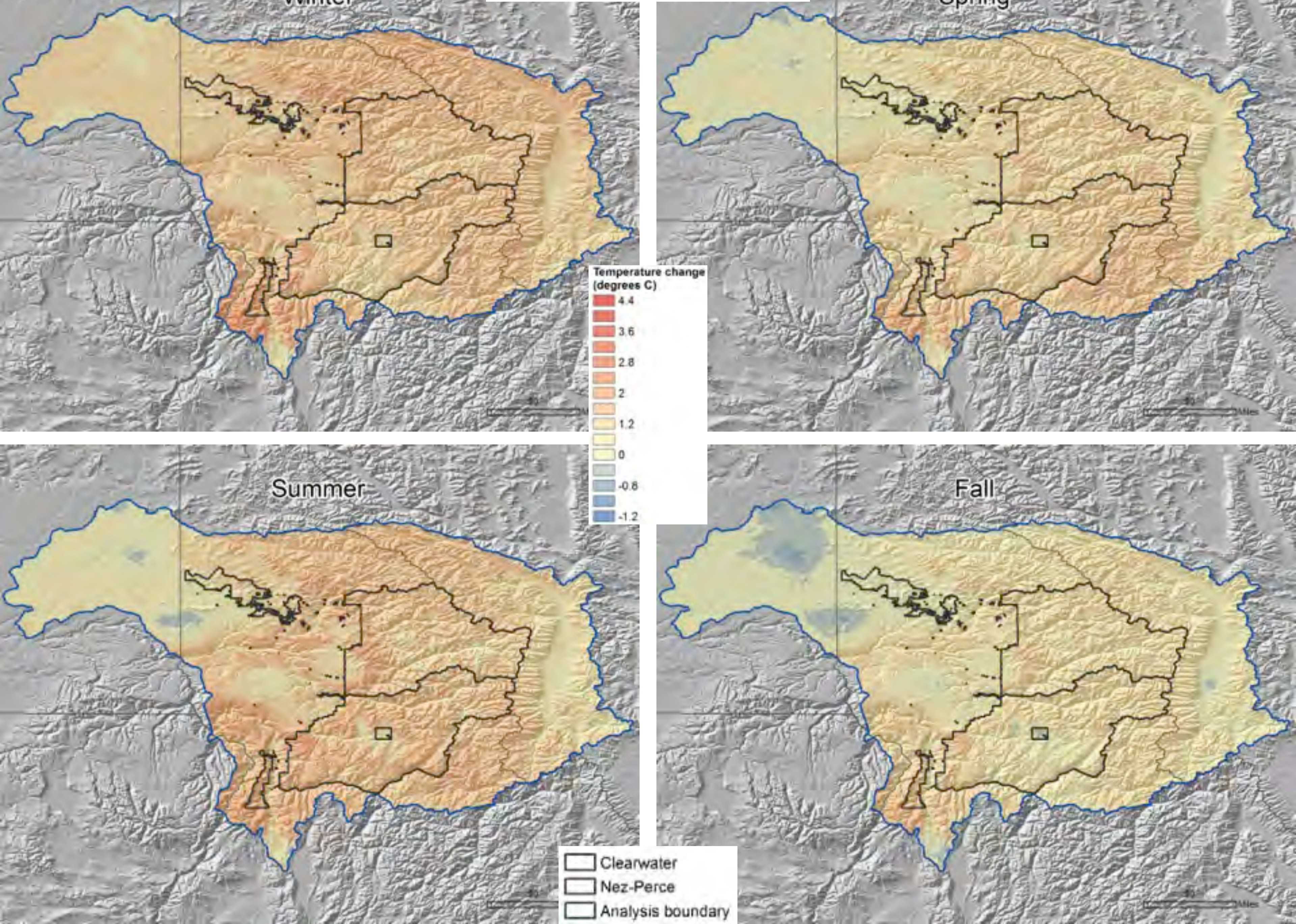
# Change in Maximum Temperature 2001-2011 vs 1901-1980


Winter
Spring
Summer
Fall
Temperature change (degrees C)
4.4
3.6
2.8
2
1.2
0
-0.8
-1.2
Clearwater
Nez-Perce
Analysis boundary
50
Miles

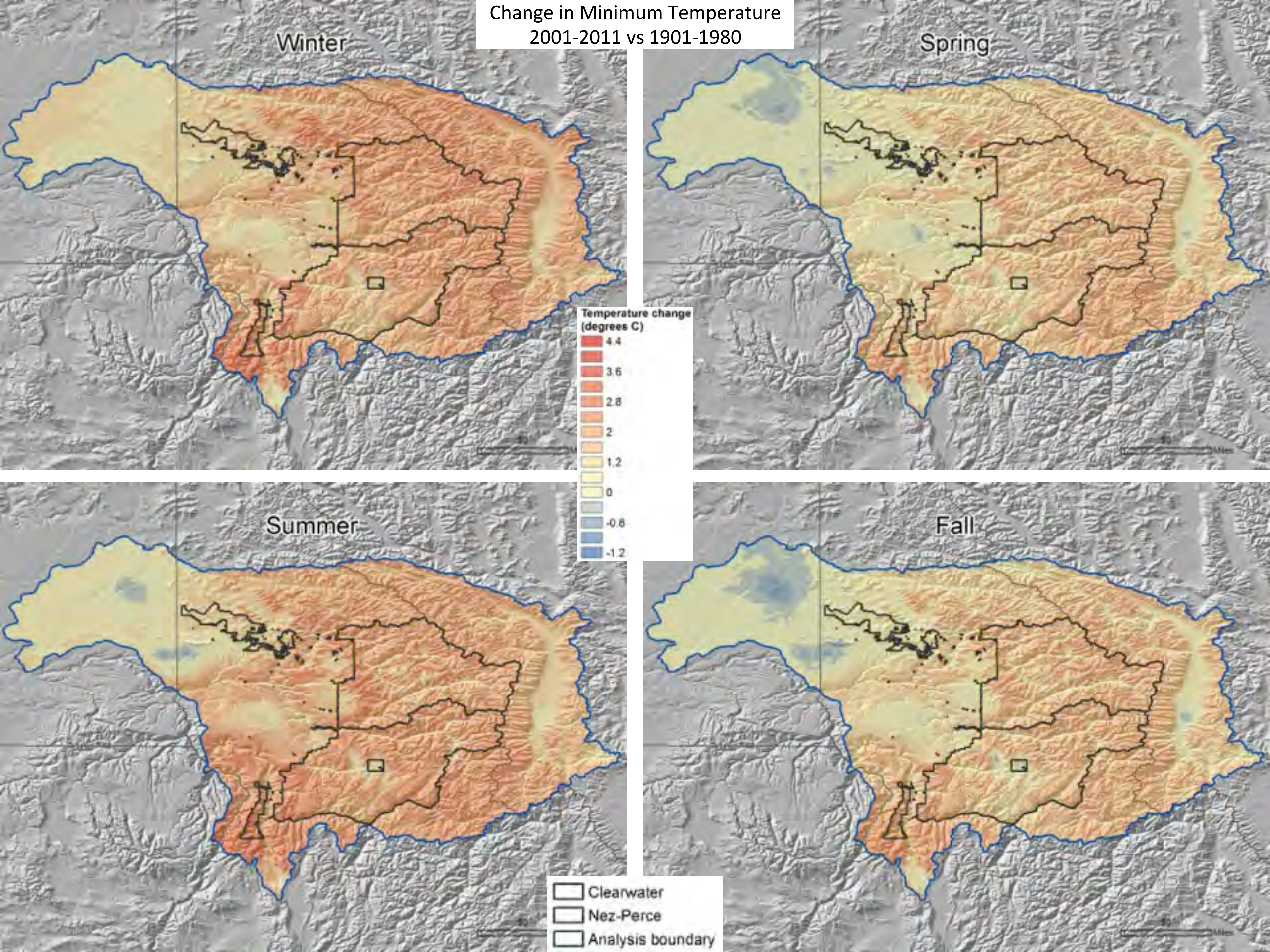
# Change in Minimum Temperature
1981-2011 vs 1901-1980

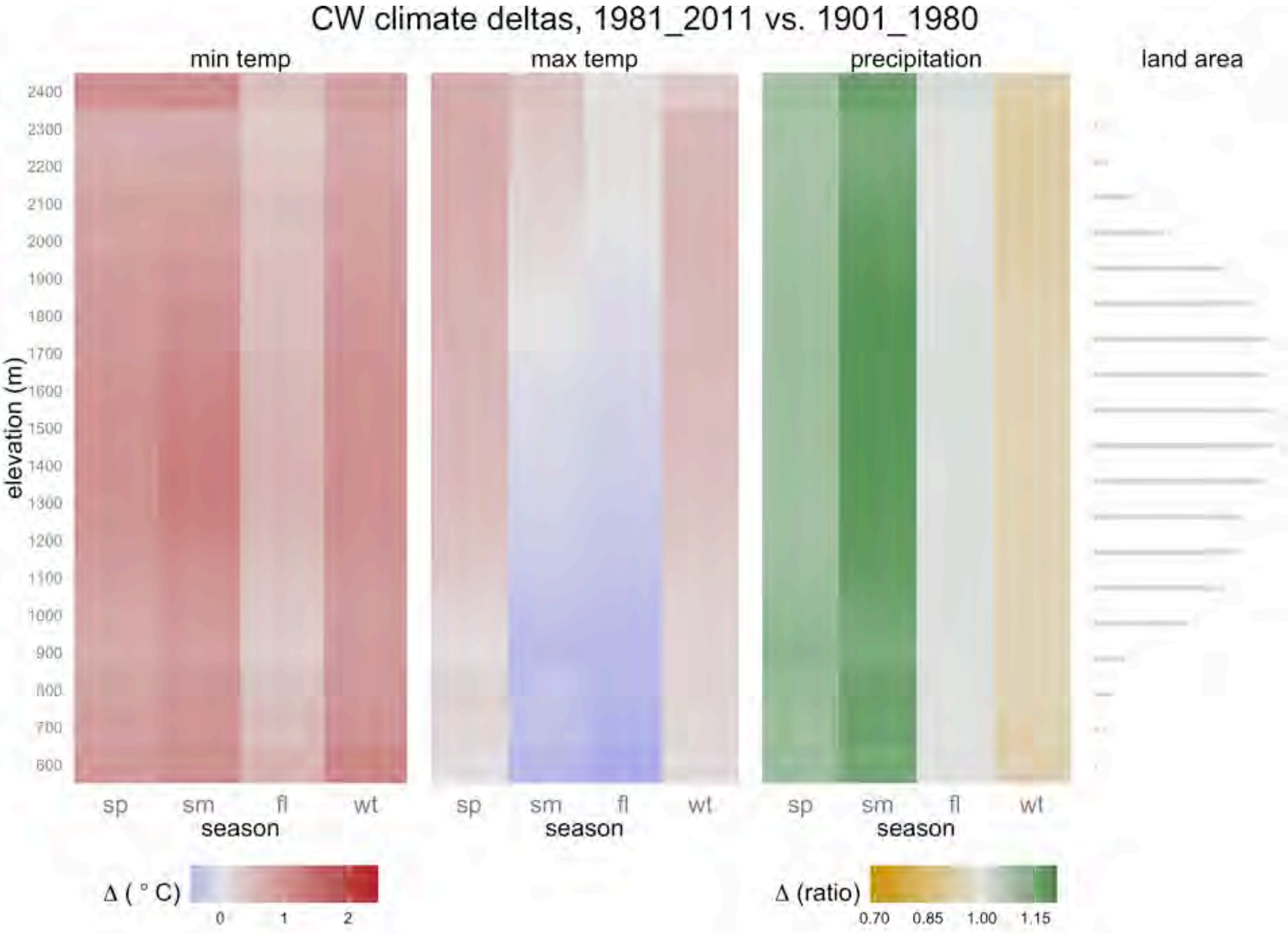

Winter
Spring
Summer
Fall
Temperature change (degrees C)
4.4
3.6
2.8
2
1.2
0
-0.8
-1.2
Clearwater
Nez-Perce
Analysis boundary
50
Miles

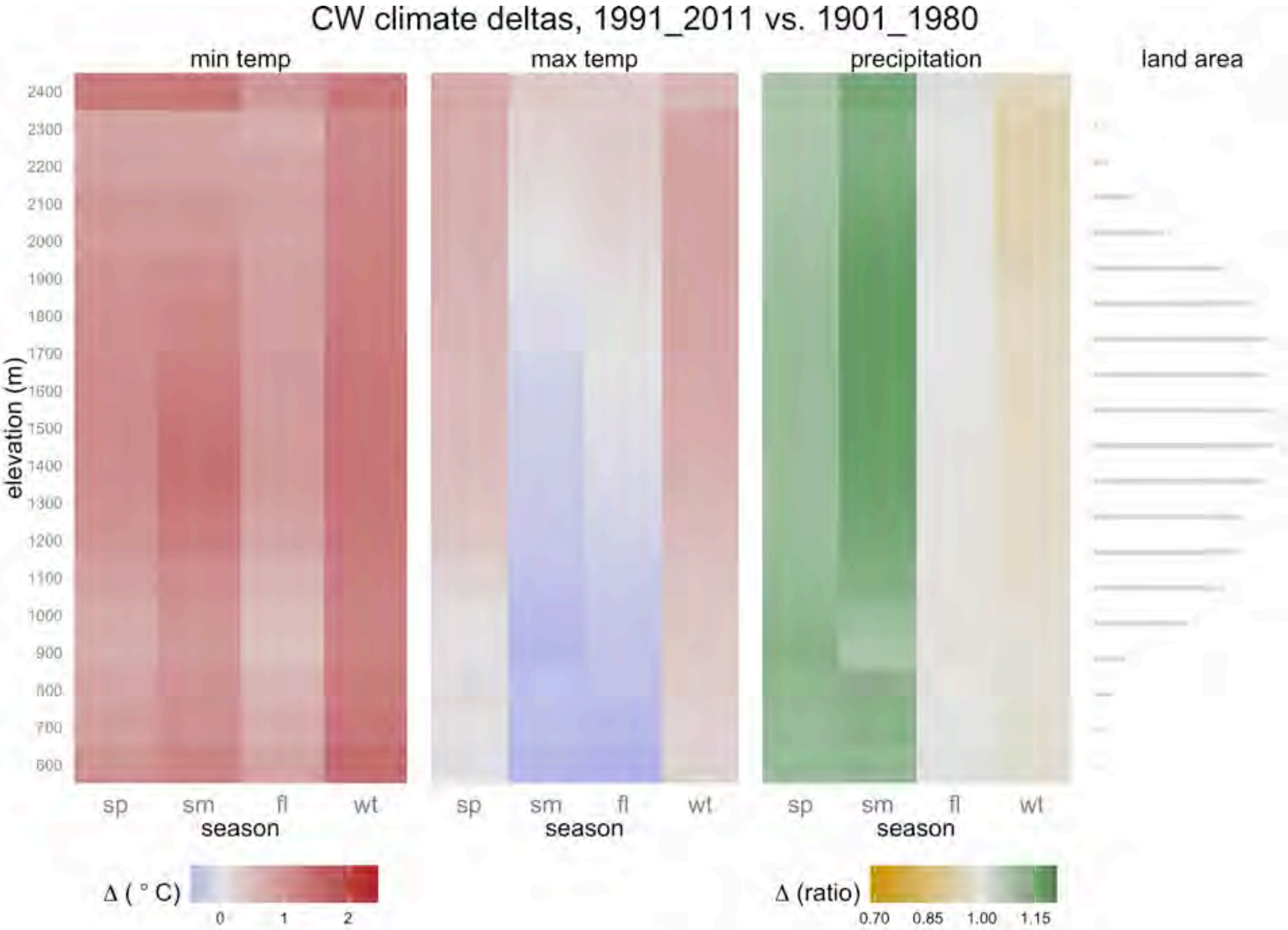
# Change in Minimum Temperature
1991-2011 vs 1901-1980

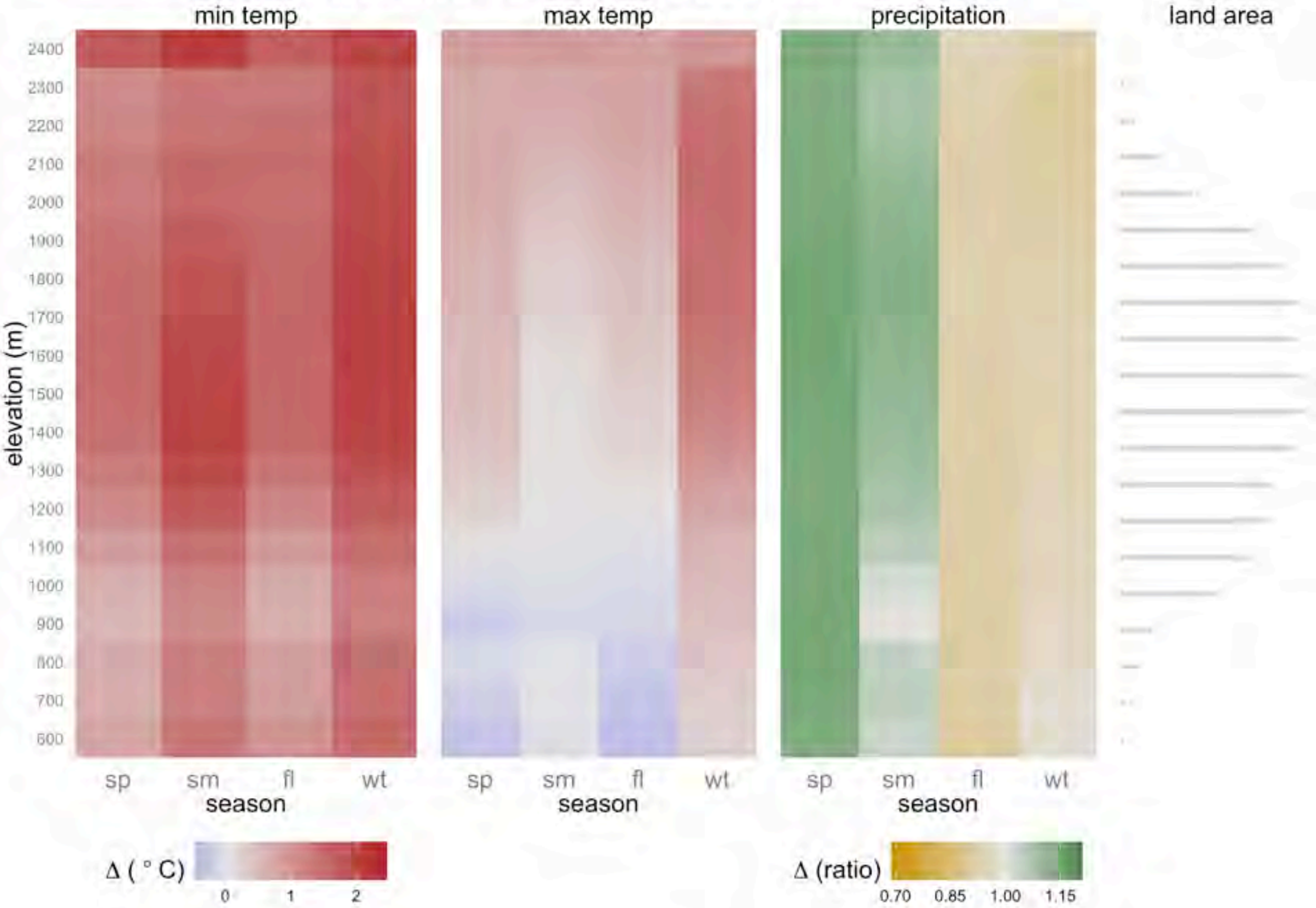

Winter
Spring
Summer
Fall
Temperature change (degrees C)
4.4
3.6
2.8
2
1.2
0
-0.8
-1.2
Clearwater
Nez-Perce
Analysis boundary
50
Miles

# Change in Minimum Temperature 2001-2011 vs 1901-1980

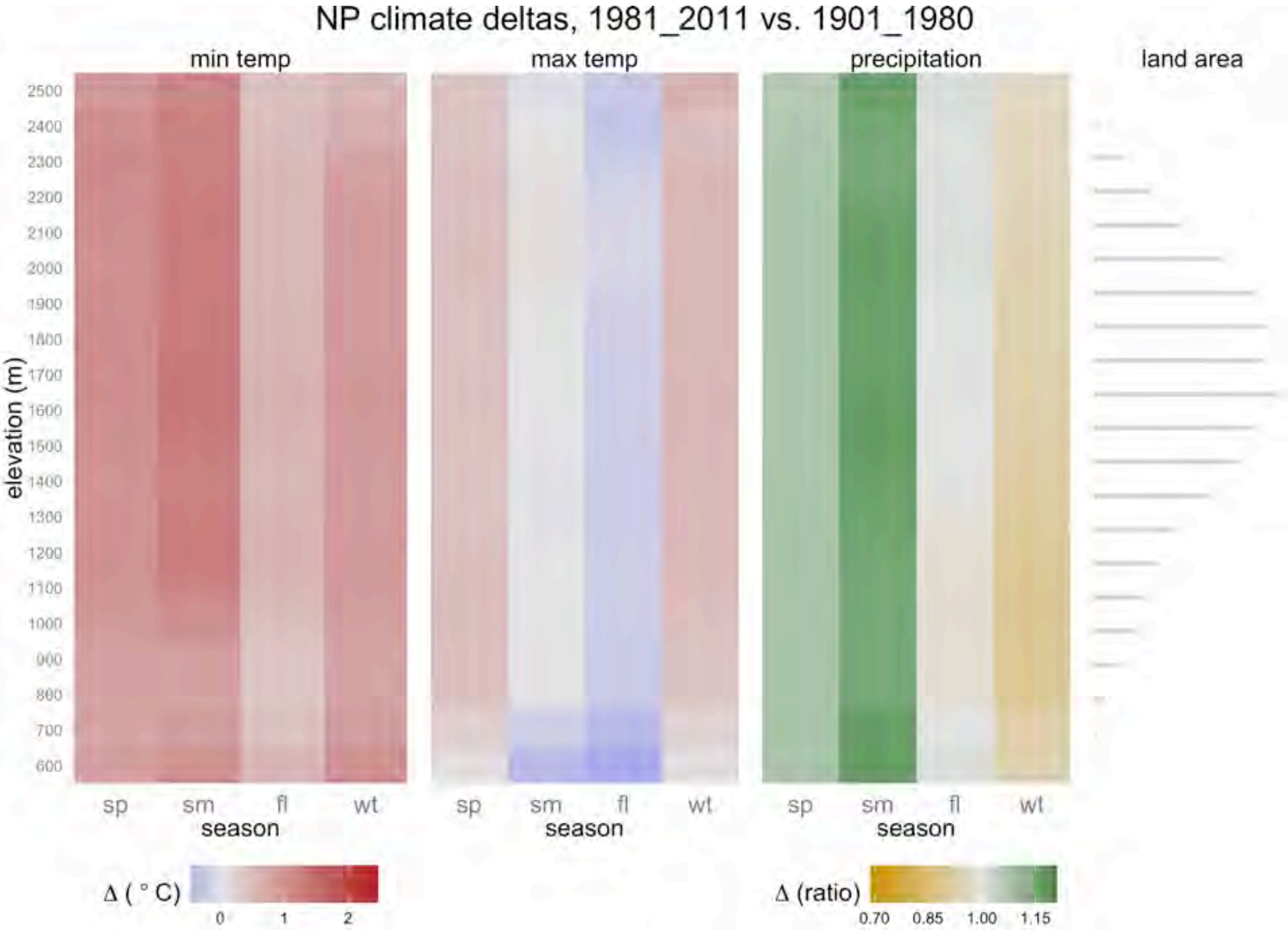

Winter
Spring
Summer
Fall
Temperature change (degrees C)
4.4
3.6
2.8
2
1.2
0
-0.8
-1.2
50
Miles
Clearwater
Nez-Perce
Analysis boundary

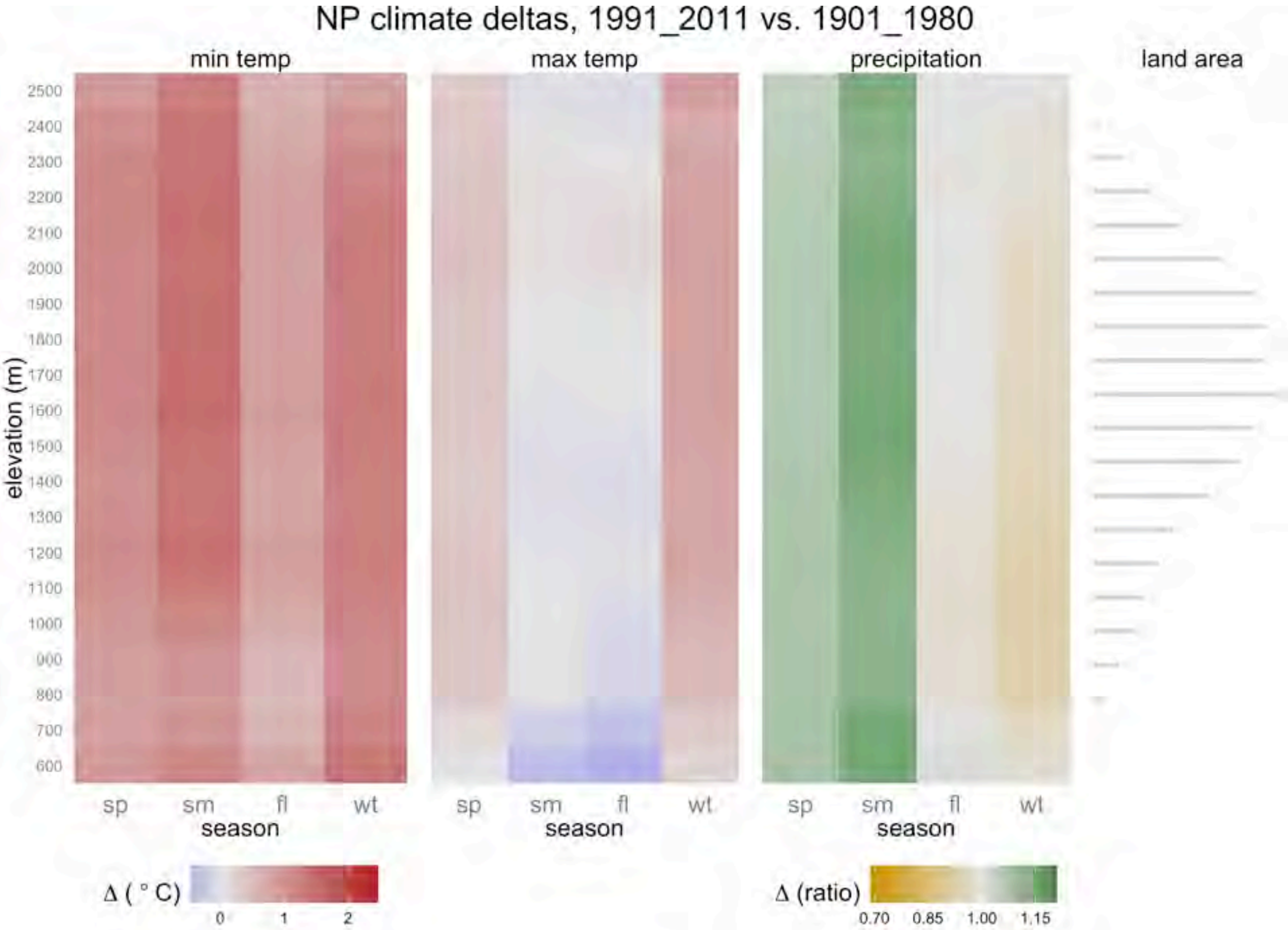

CW climate deltas, 1981_2011 vs. 1901_1980
min temp
max temp
precipitation
land area
elevation (m)
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
sp
sm
fl
wt
season
sp
sm
fl
wt
season
sp
sm
fl
wt
season
Δ ( ° C)
0
1
2
Δ (ratio)
0.70
0.85
1.00
1.15

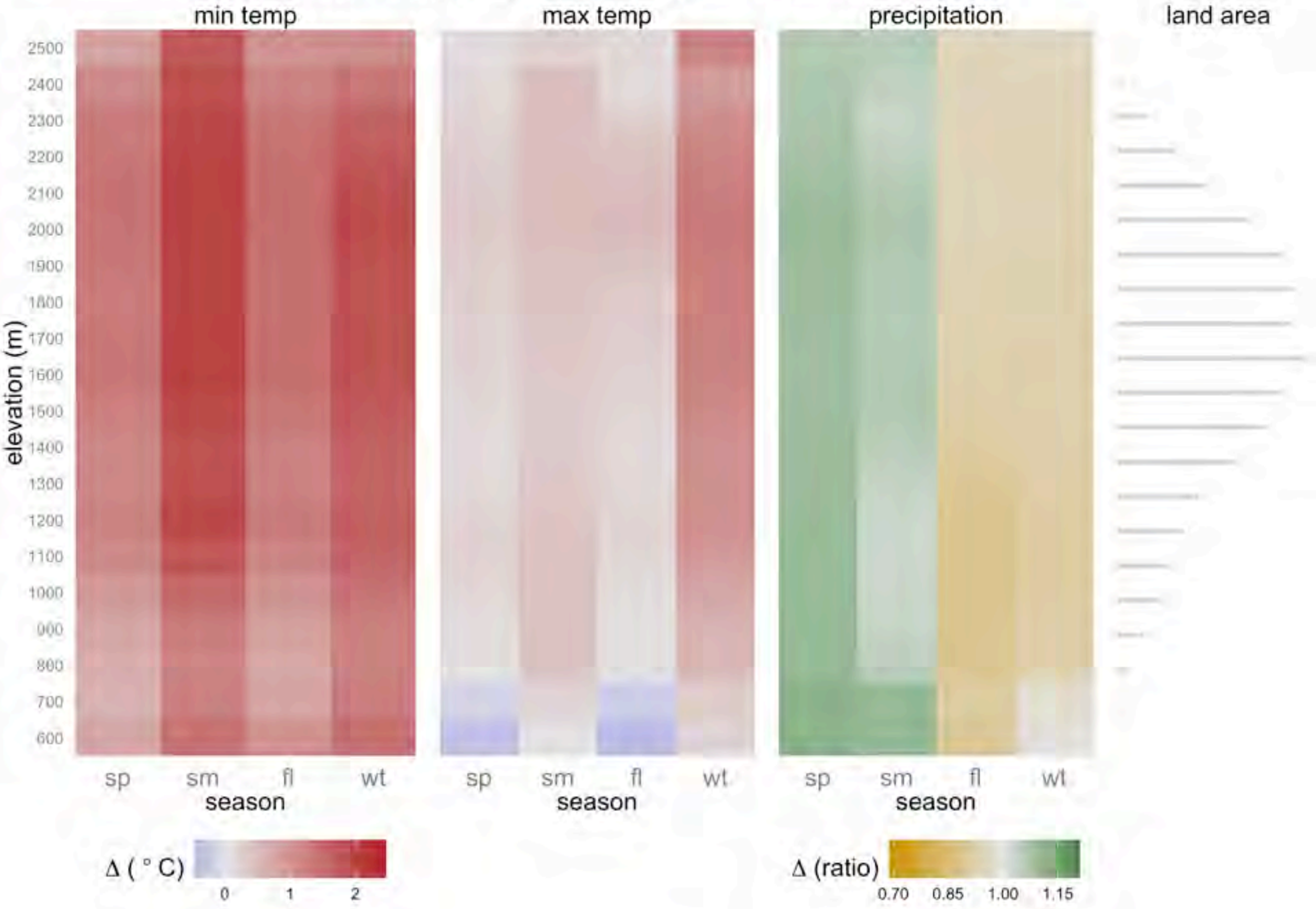

CW climate deltas, 1991_2011 vs. 1901_1980
min temp
max temp
precipitation
land area
elevation (m)
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
sp
sm
fl
wt
season
sp
sm
fl
wt
season
sp
sm
fl
wt
season
Δ ( ° C)
0
1
2
Δ (ratio)
0.70
0.85
1.00
1.15



CW climate deltas, 2001_2011 vs. 1901_1980

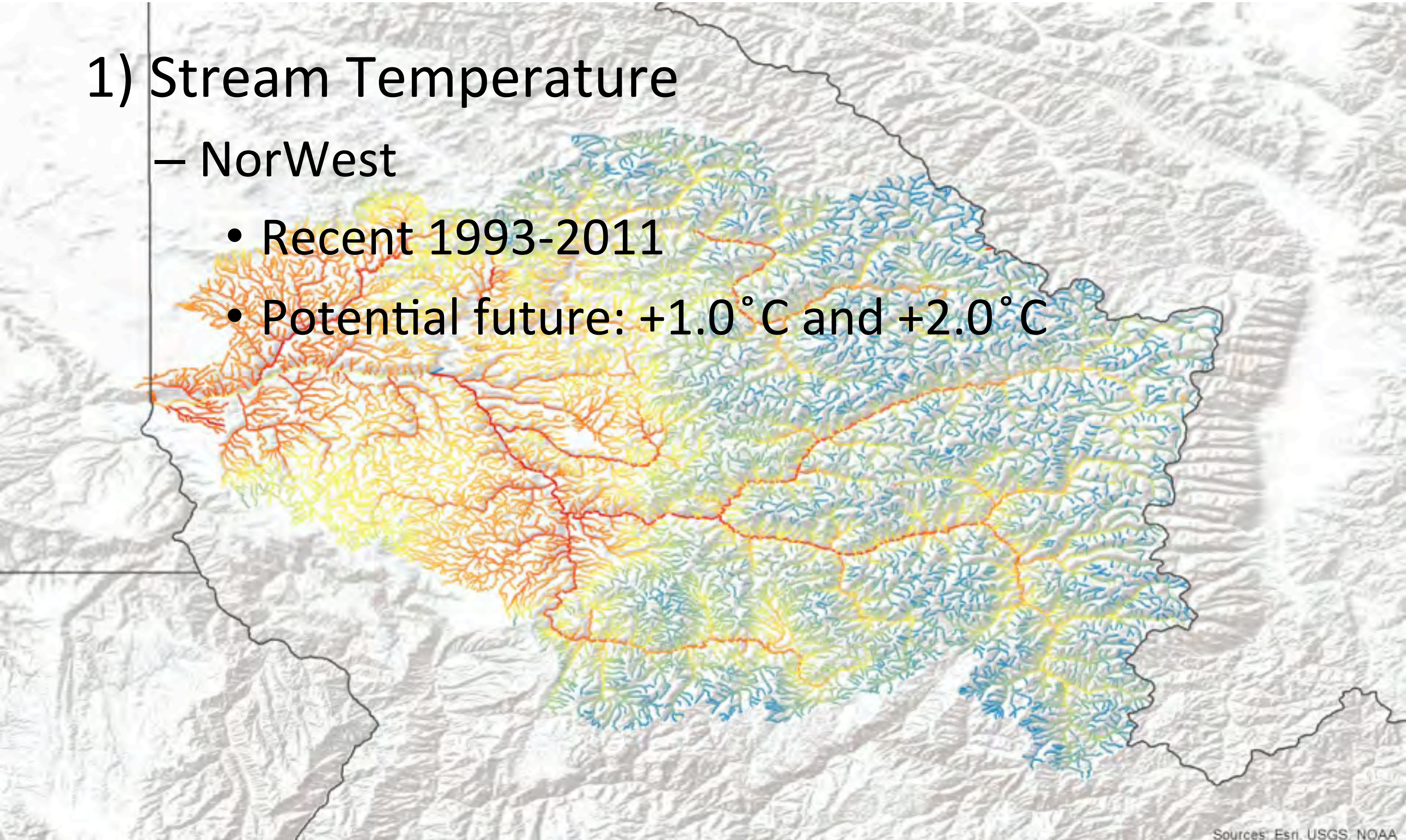

NP climate deltas, 1981_2011 vs. 1901_1980
min temp
max temp
precipitation
land area
elevation (m)
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
sp
sm
fl
wt
season
sp
sm
fl
wt
season
sp
sm
fl
wt
season
Δ ( ° C)
0
1
2
Δ (ratio)
0.70
0.85
1.00
1.15


NP climate deltas, 1991_2011 vs. 1901_1980
min temp
max temp
precipitation
land area
elevation (m)
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
sp
sm
fl
wt
season
sp
sm
fl
wt
season
sp
sm
fl
wt
season
Δ ( ° C)
0
1
2
Δ (ratio)
0.70
0.85
1.00
1.15



NP climate deltas, 2001_2011 vs. 1901_1980

# Proposed Spatial Analysis
# Water Resources



1) Stream Temperature
  - NorWest
    - Recent 1993-2011
    - Potential future: +1.0˚C and +2.0˚C

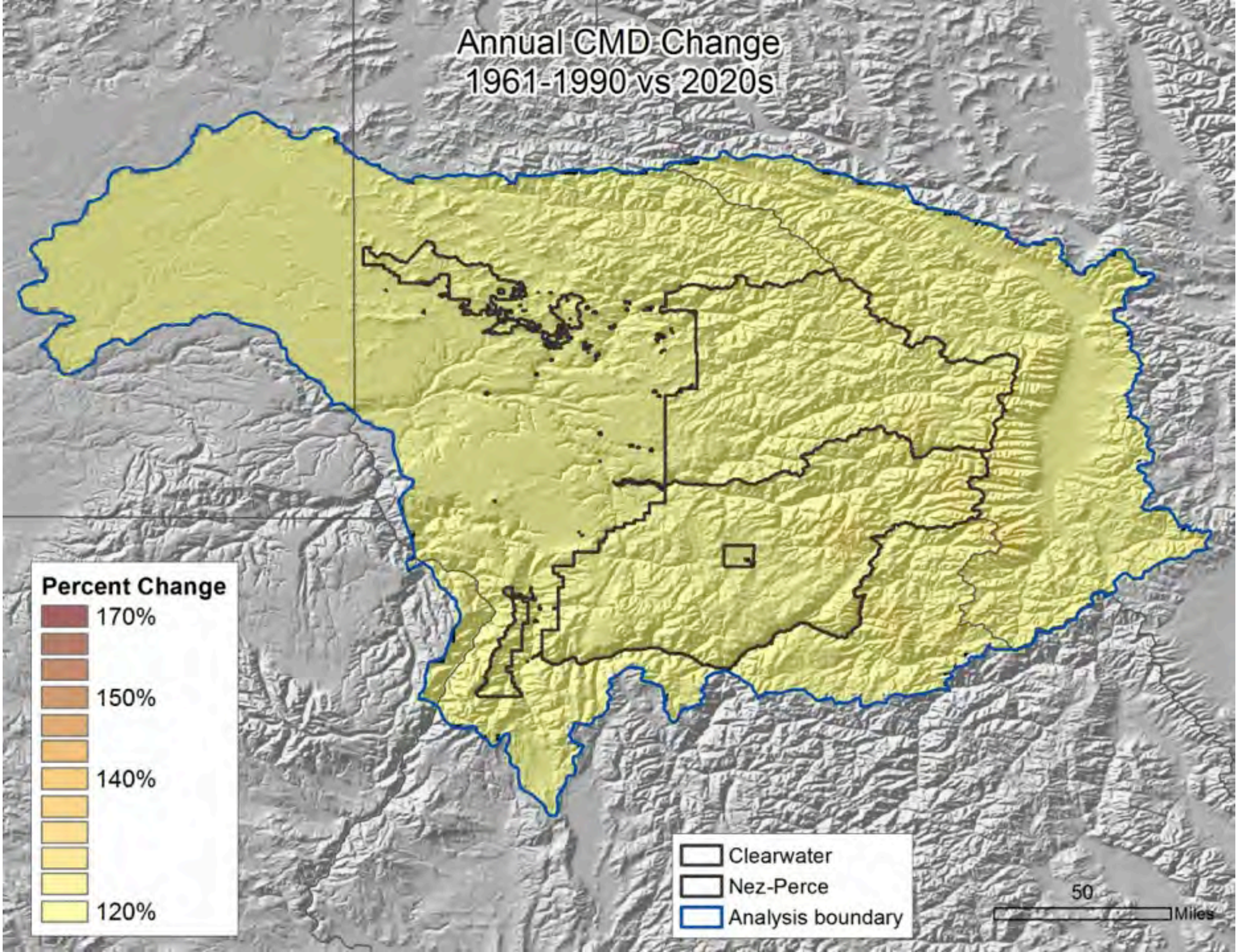
Sources: Esri, USGS, NOAA

# Proposed Spatial Analysis
# Water Resources

2) Stream Flow

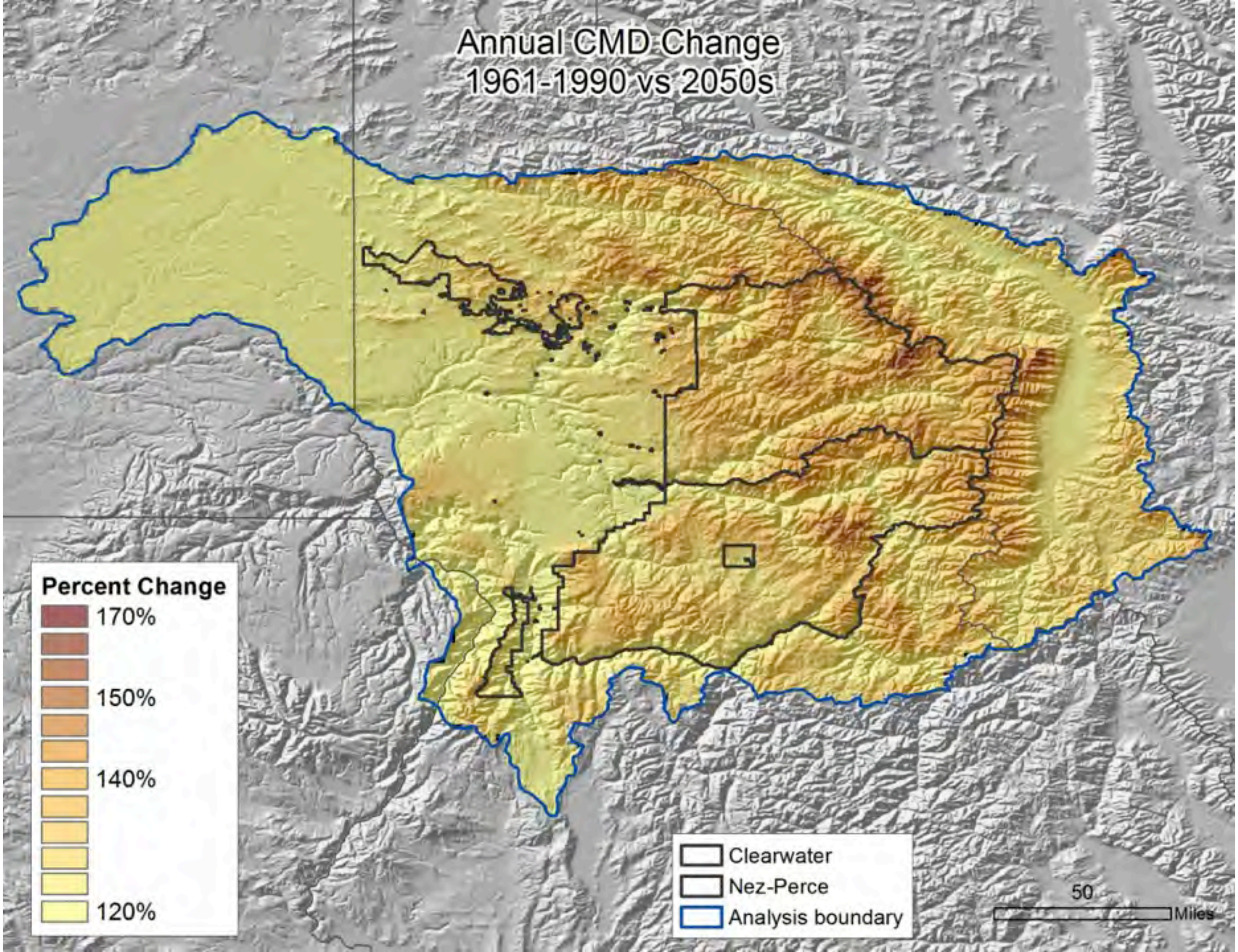
- VIC (Variable Infiltration Capacity)
  - Historic vs 2040s (ensemble of 10 GCMs)

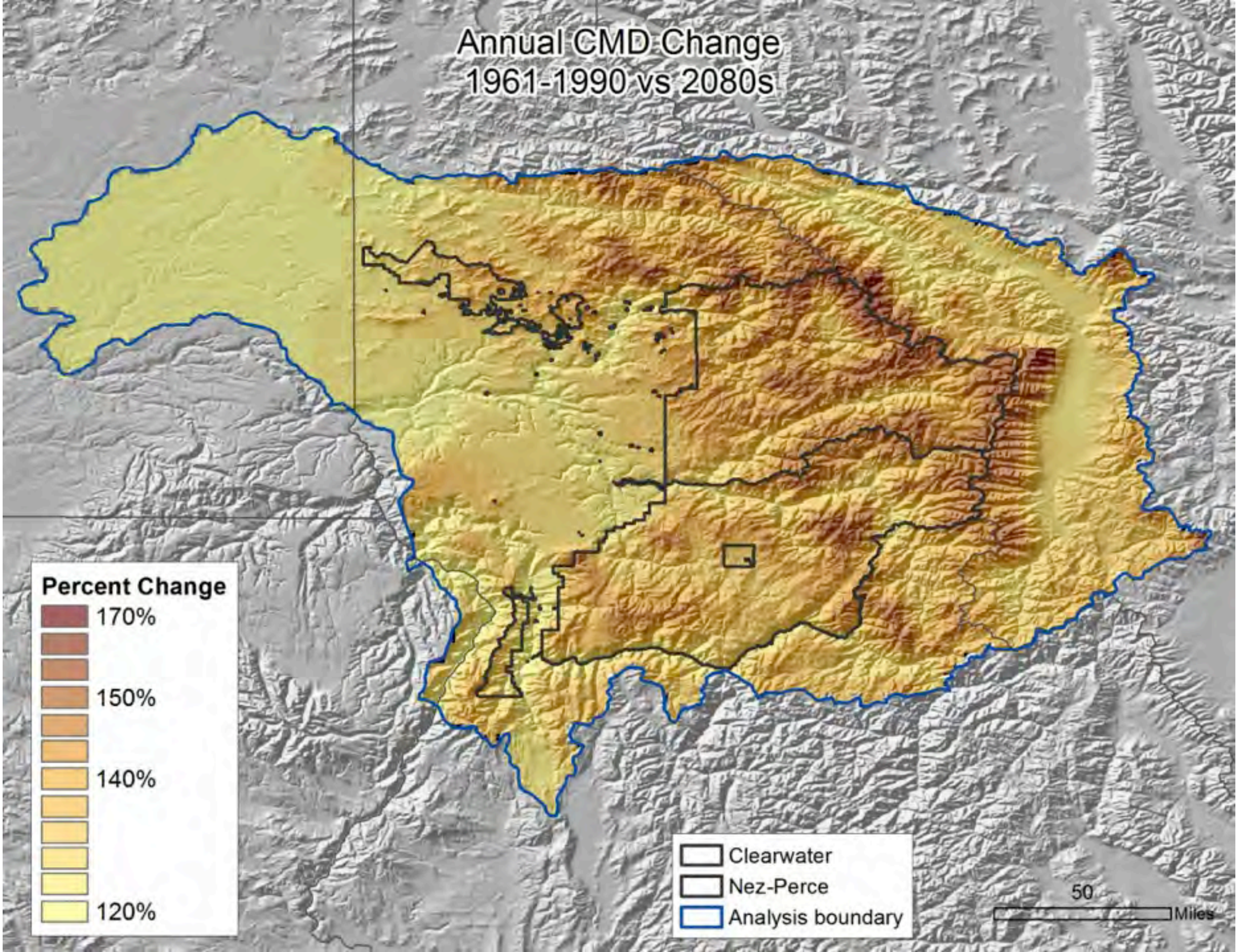
- Variables:
  - Mean Annual Flow
  - Channel flow
  - Center of Timing
  - Flow7q10: 7-day low flow with a 10-year return interval



Annual CMD Change
1961-1990 vs 2020s

Percent Change
170%
150%
140%
120%
Clearwater
Nez-Perce
Analysis boundary
50
Miles

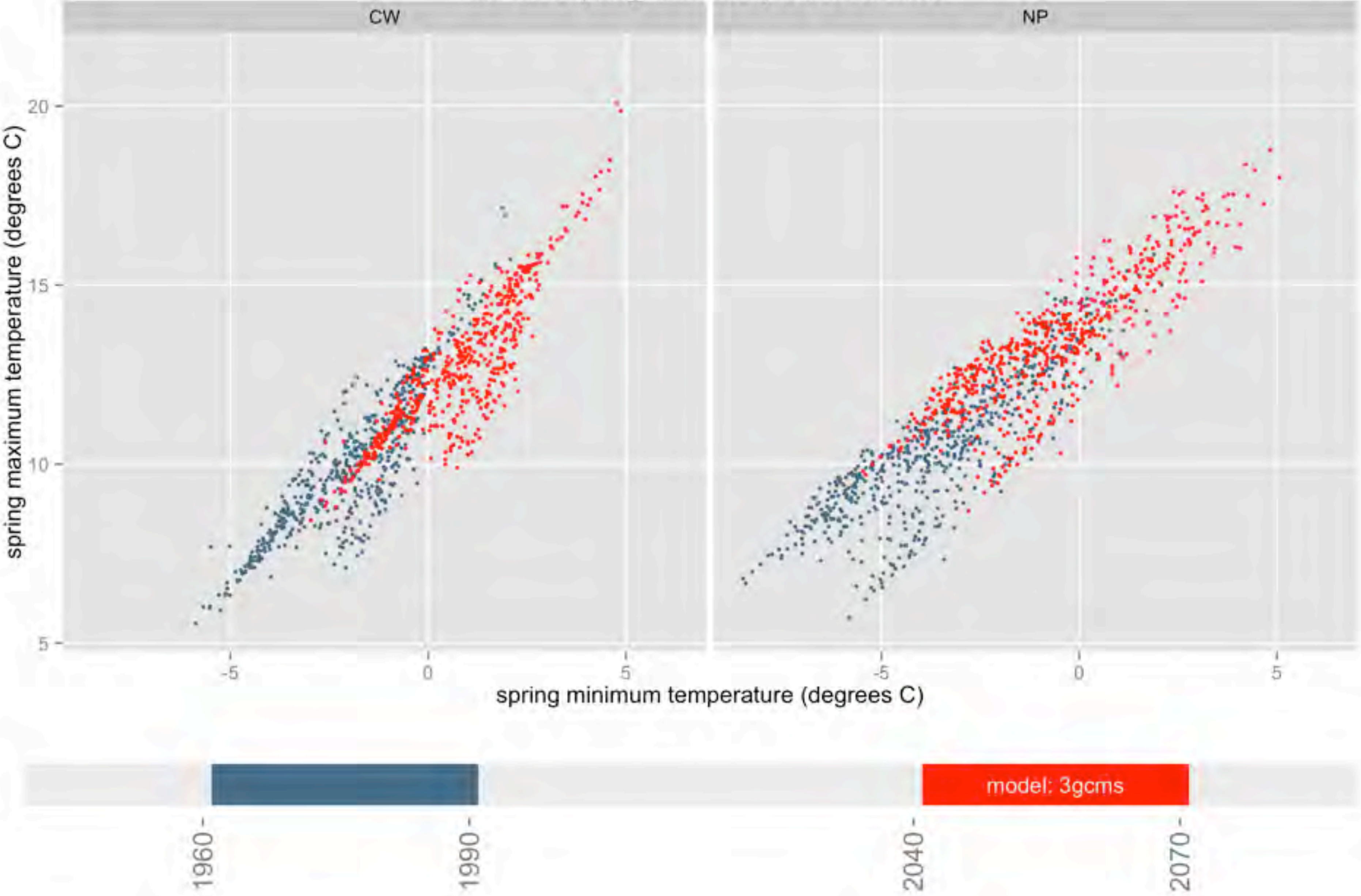

Annual CMD Change
1961-1990 vs 2050s
Percent Change
170%
150%
140%
120%
Clearwater
Nez-Perce
Analysis boundary
50
Miles



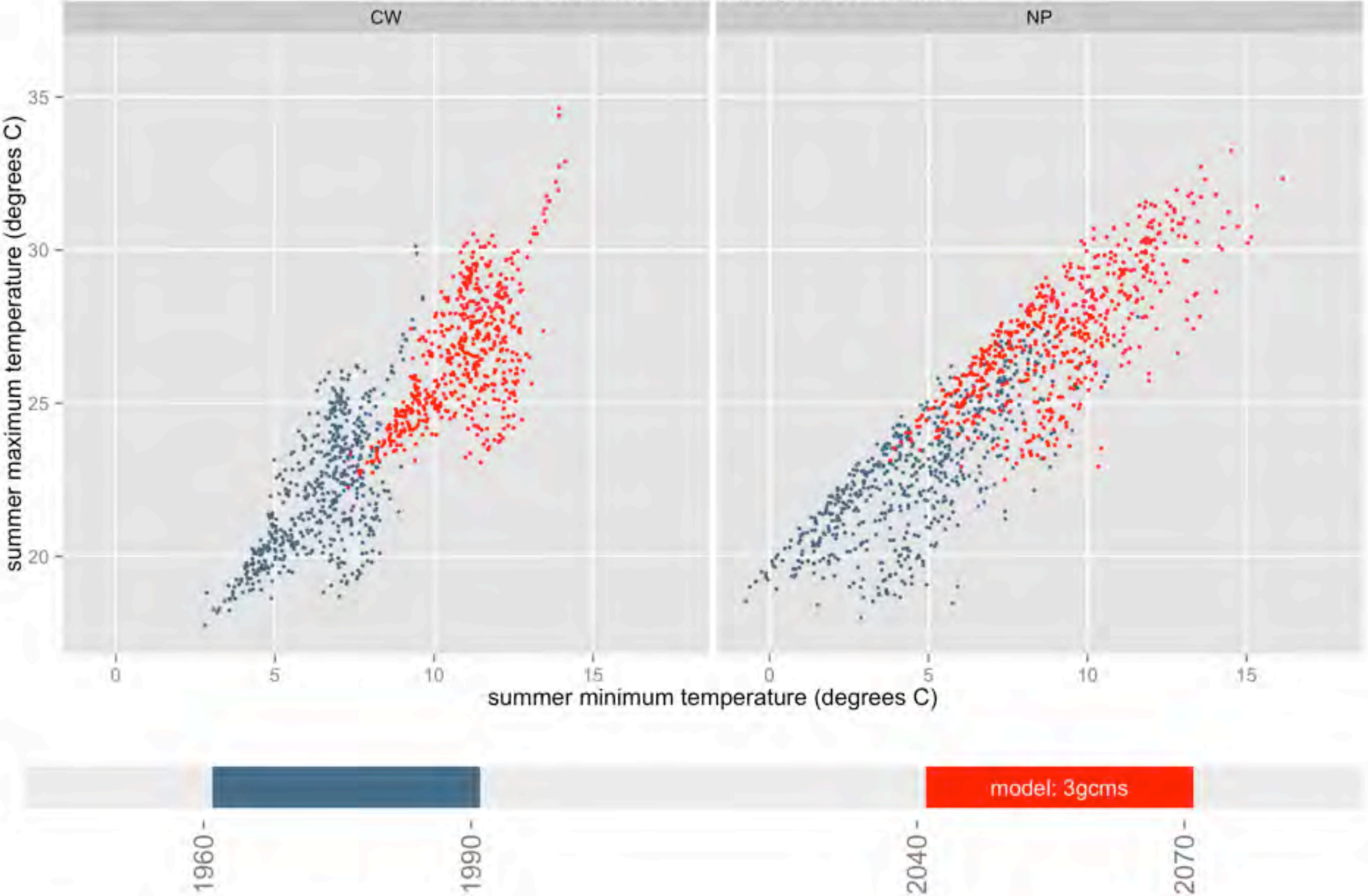
Annual CMD Change
1961-1990 vs 2080s

Percent Change
170%
150%
140%
120%
Clearwater
Nez-Perce
Analysis boundary
50
Miles

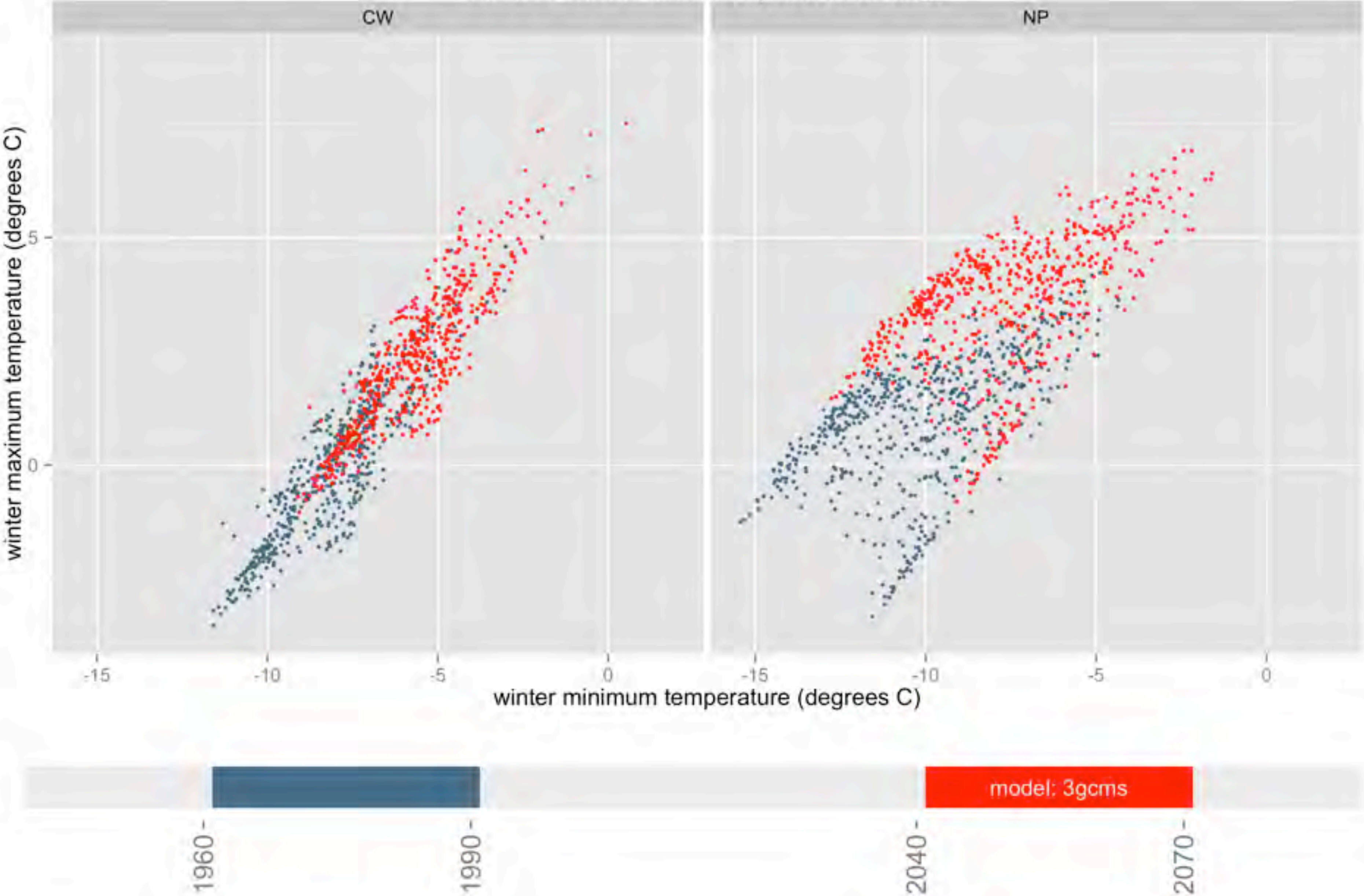
# NPCW spring climate space over time



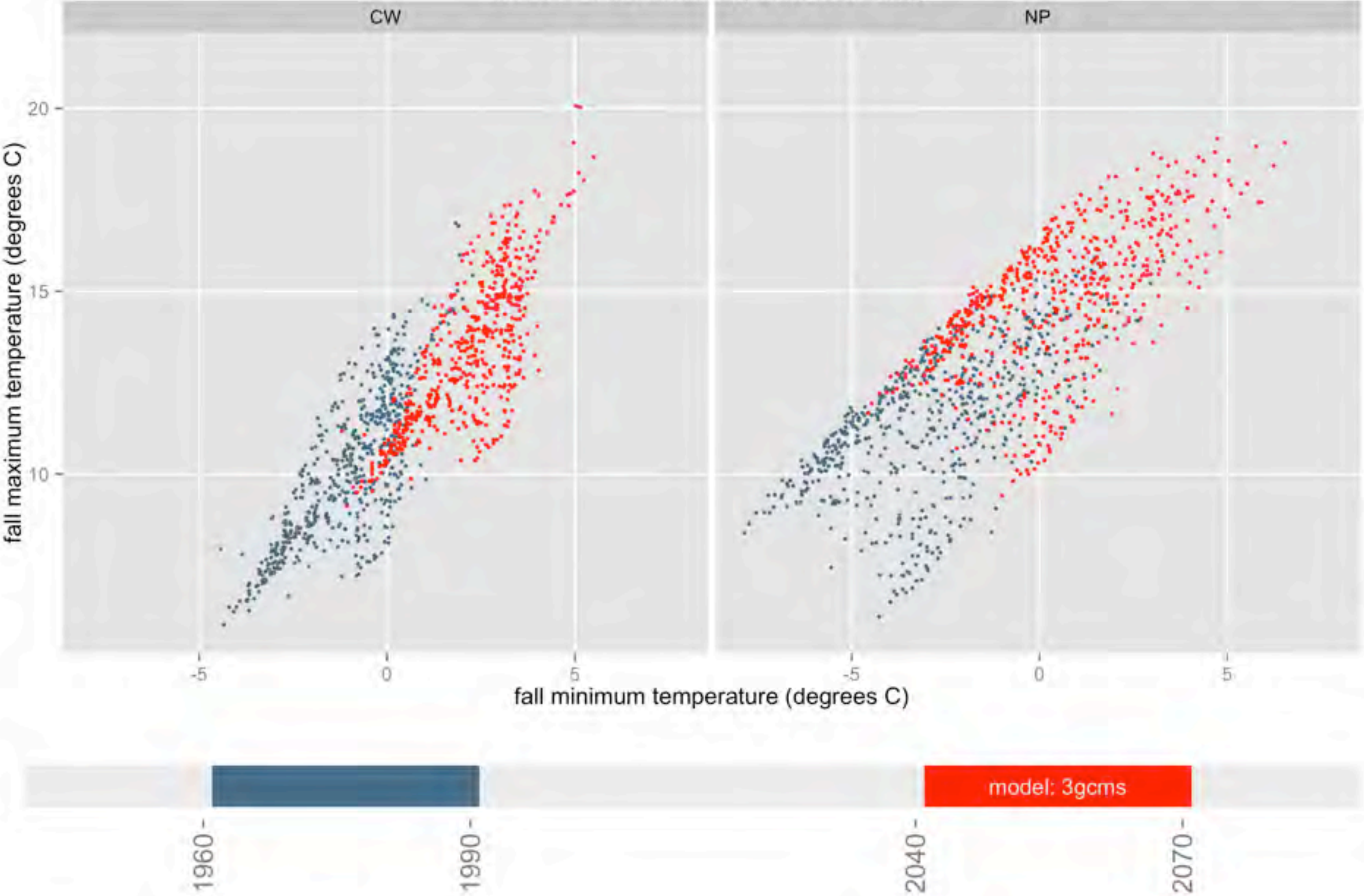
## NPCW summer climate space over time

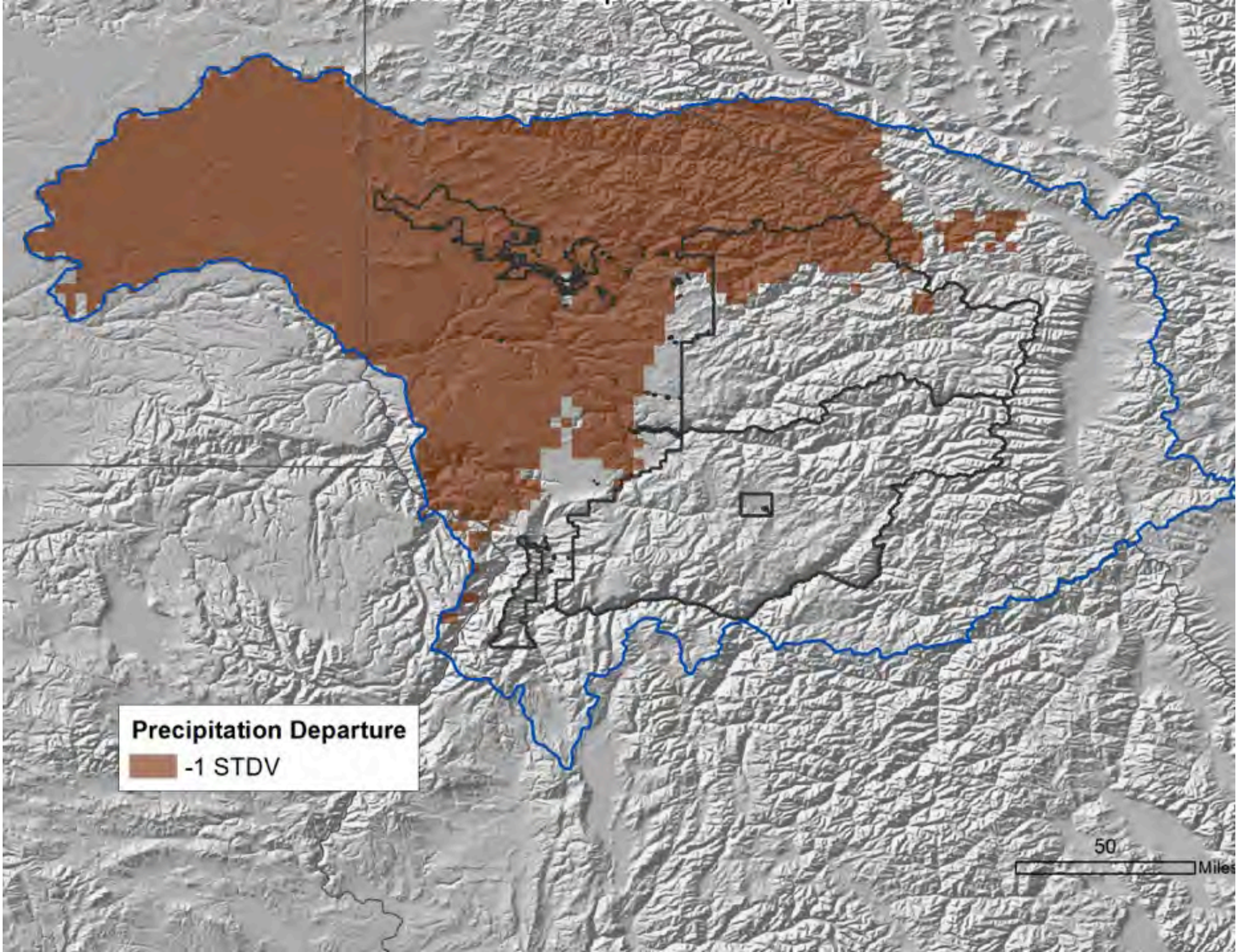


# NPCW winter climate space over time



NPCW fall climate space over time




Precipitation Departure
-1 STDV
50
Miles