Climate and the future of water resources in the Northwest

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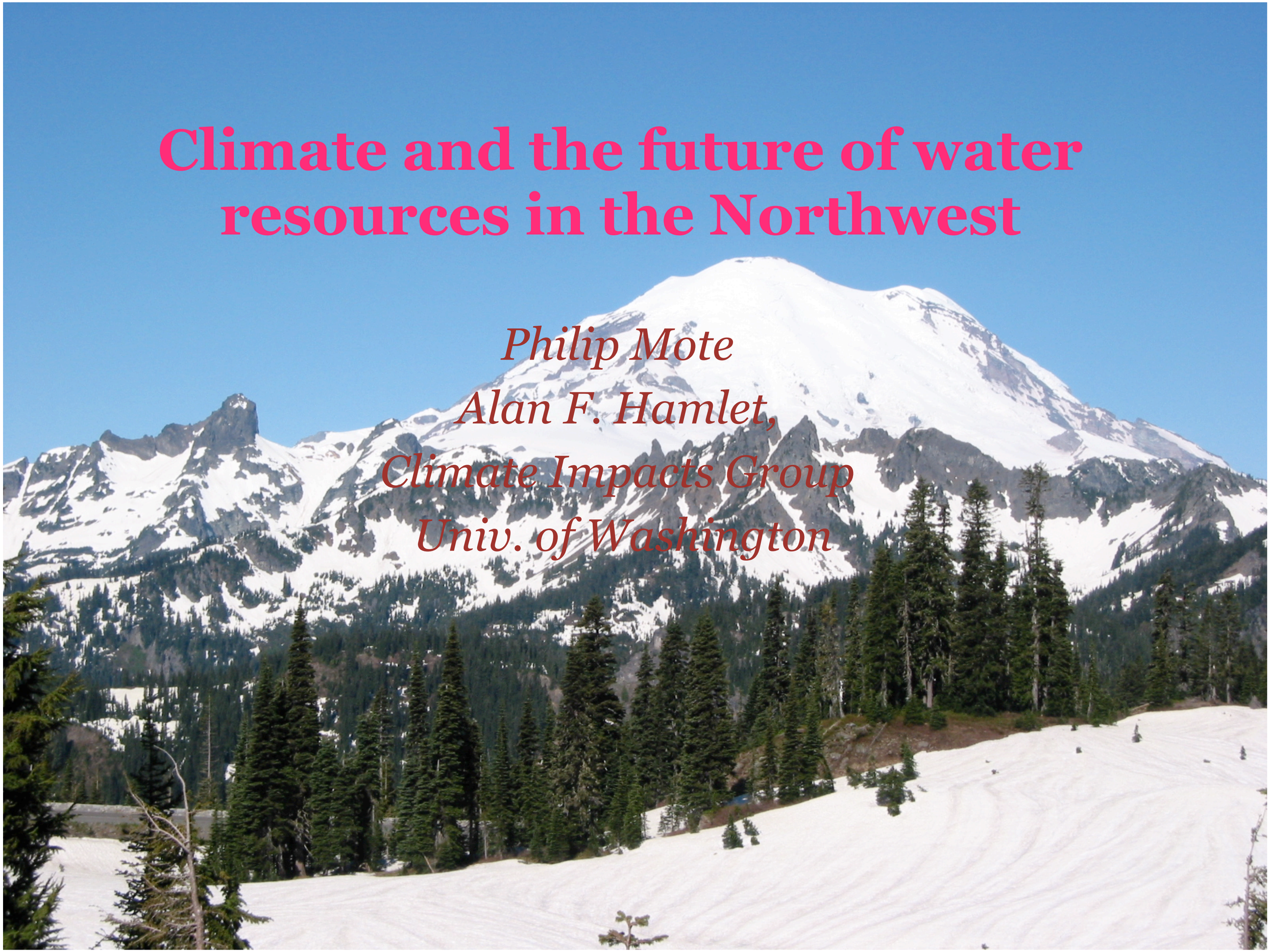
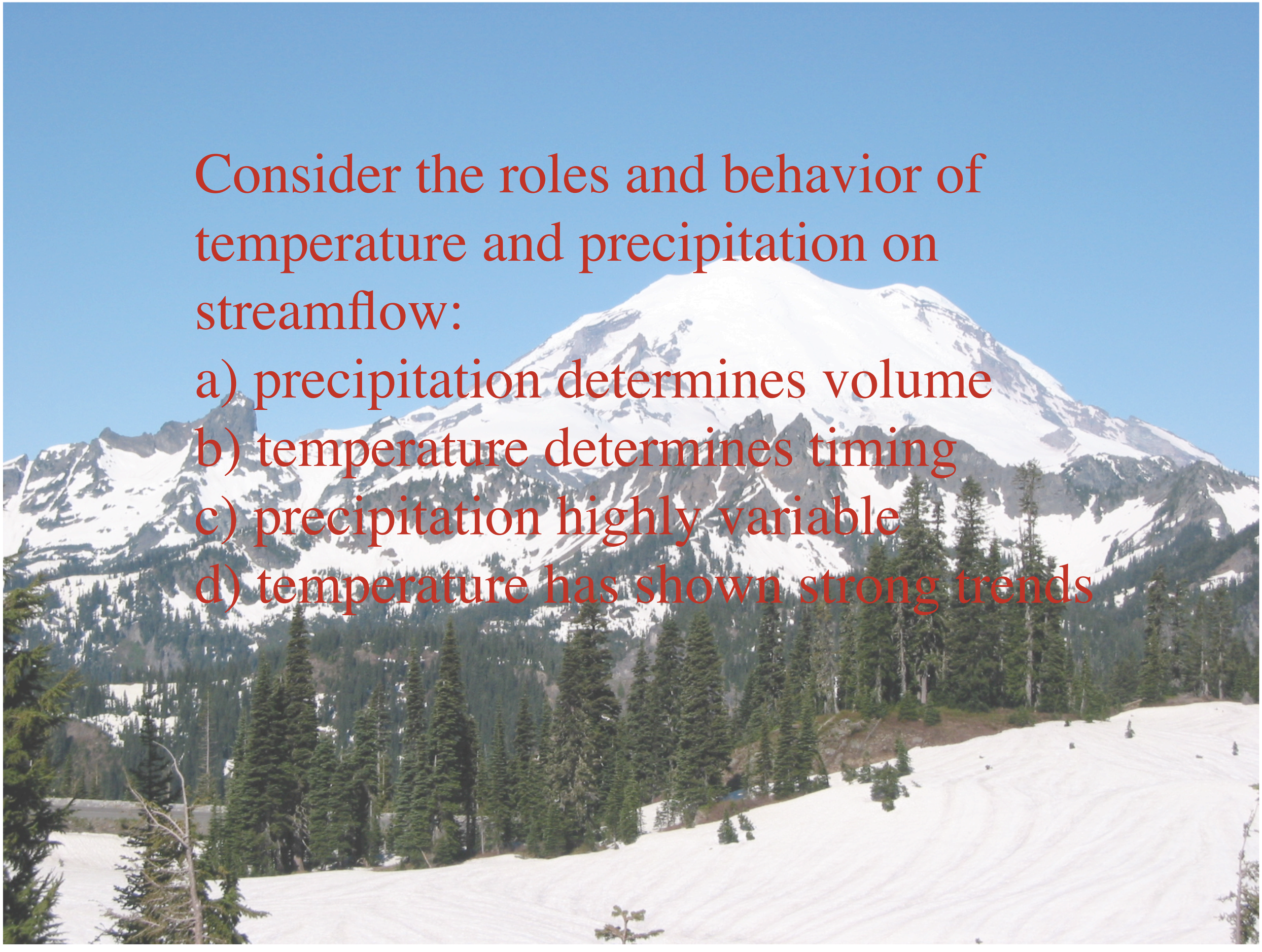




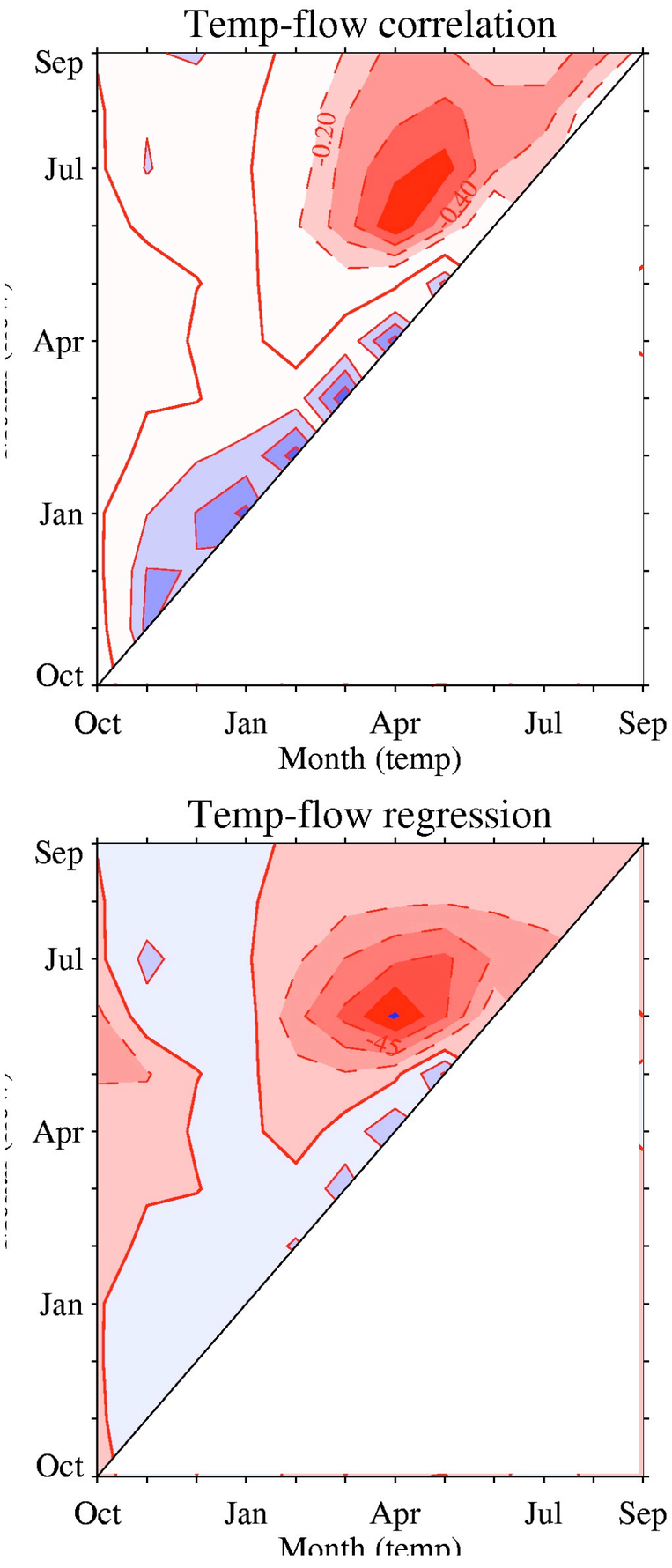
Consider the roles and behavior of temperature and precipitation on streamflow:

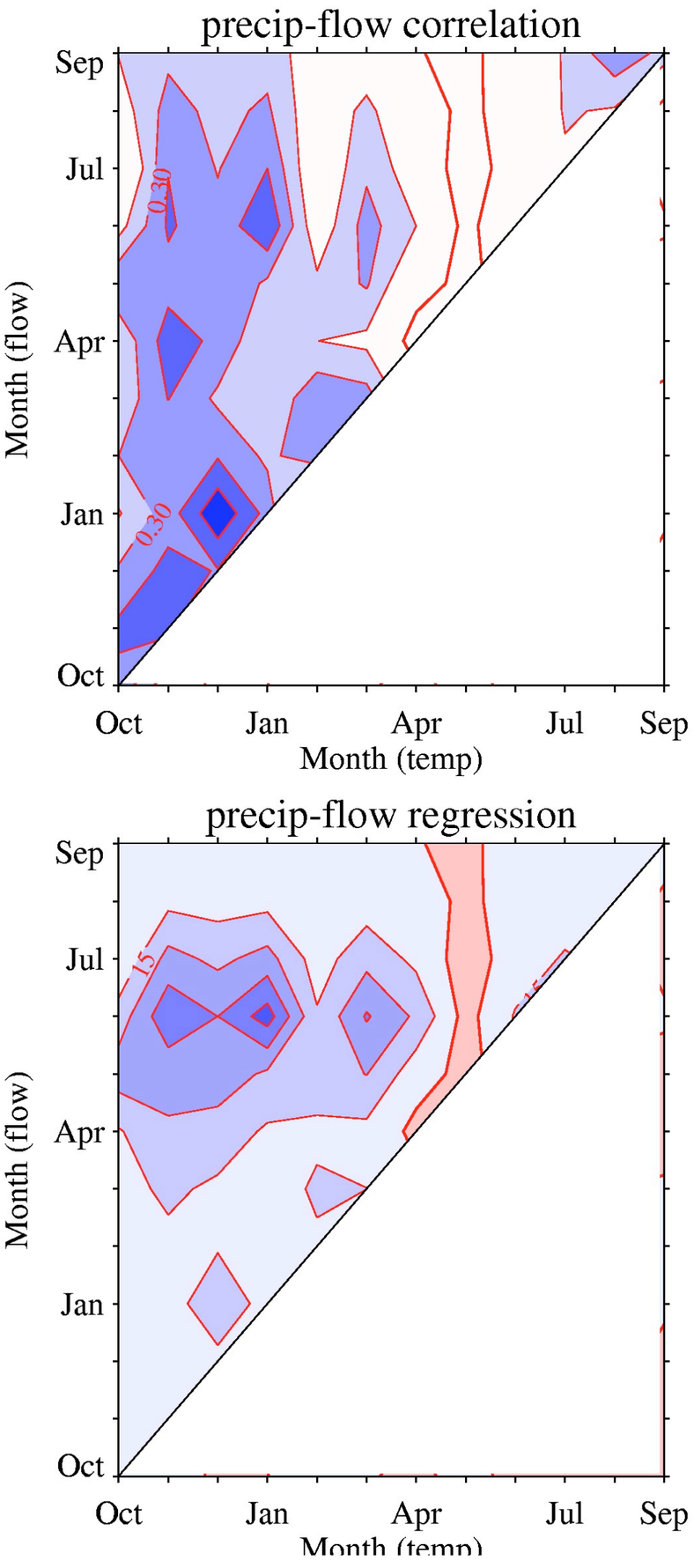
a) precipitation determines volume

b) temperature determines timing

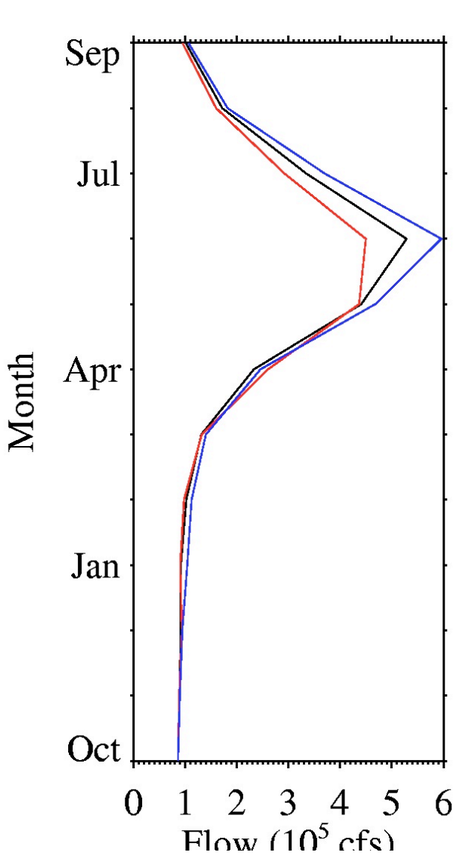
c) precipitation highly variable

d) temperature has shown strong trends

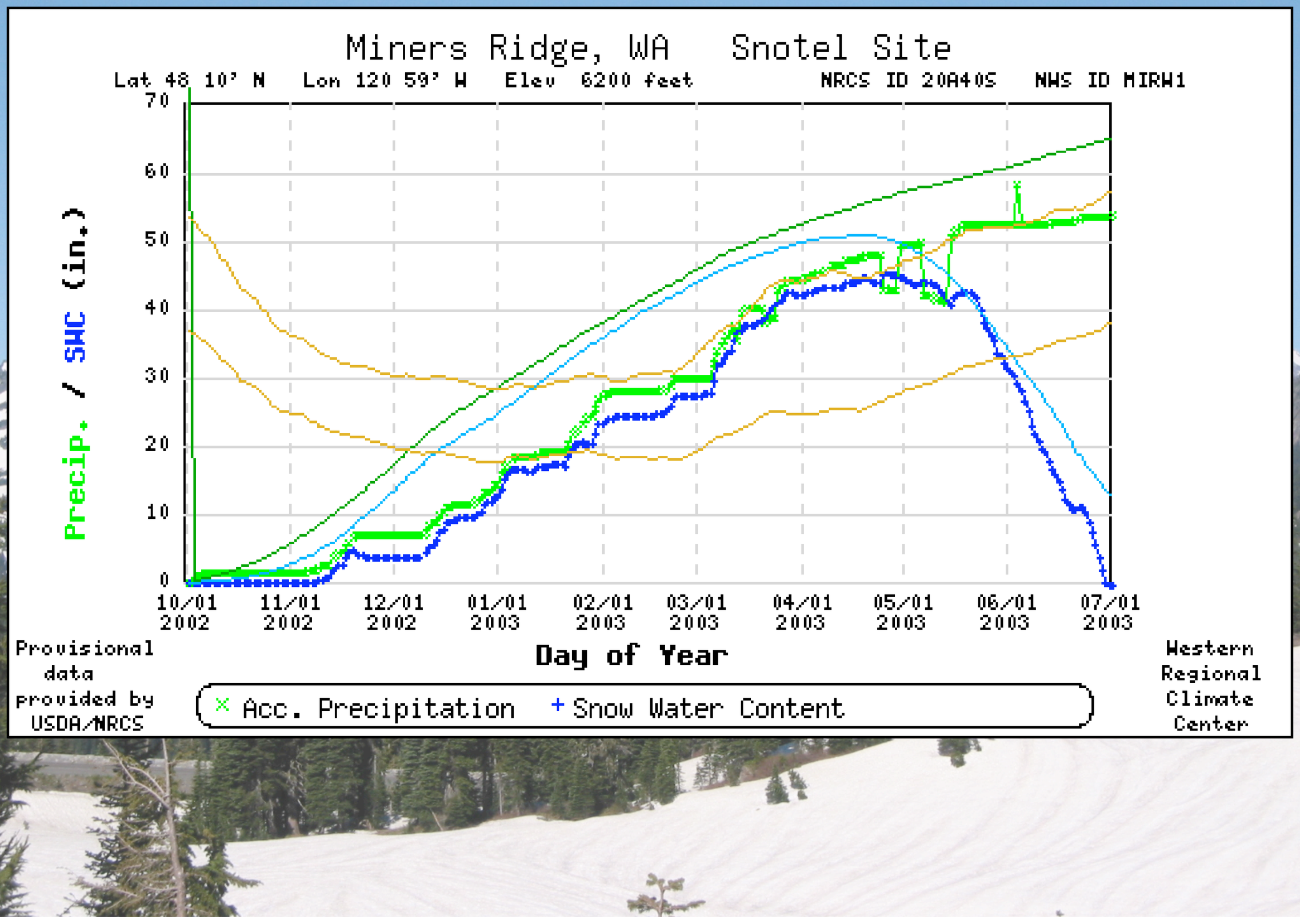


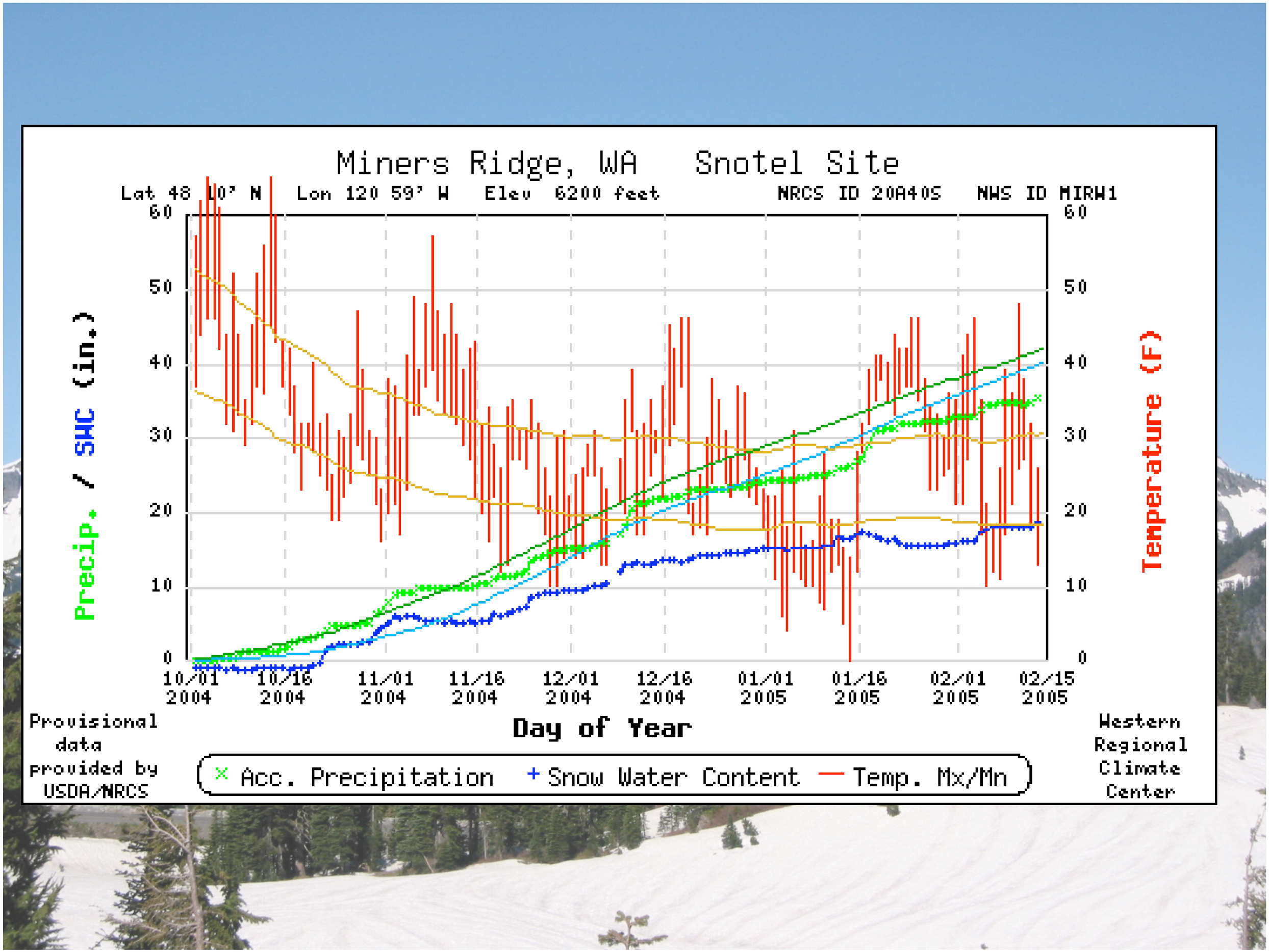


Relationship between climate and Columbia River flow at The Dalles



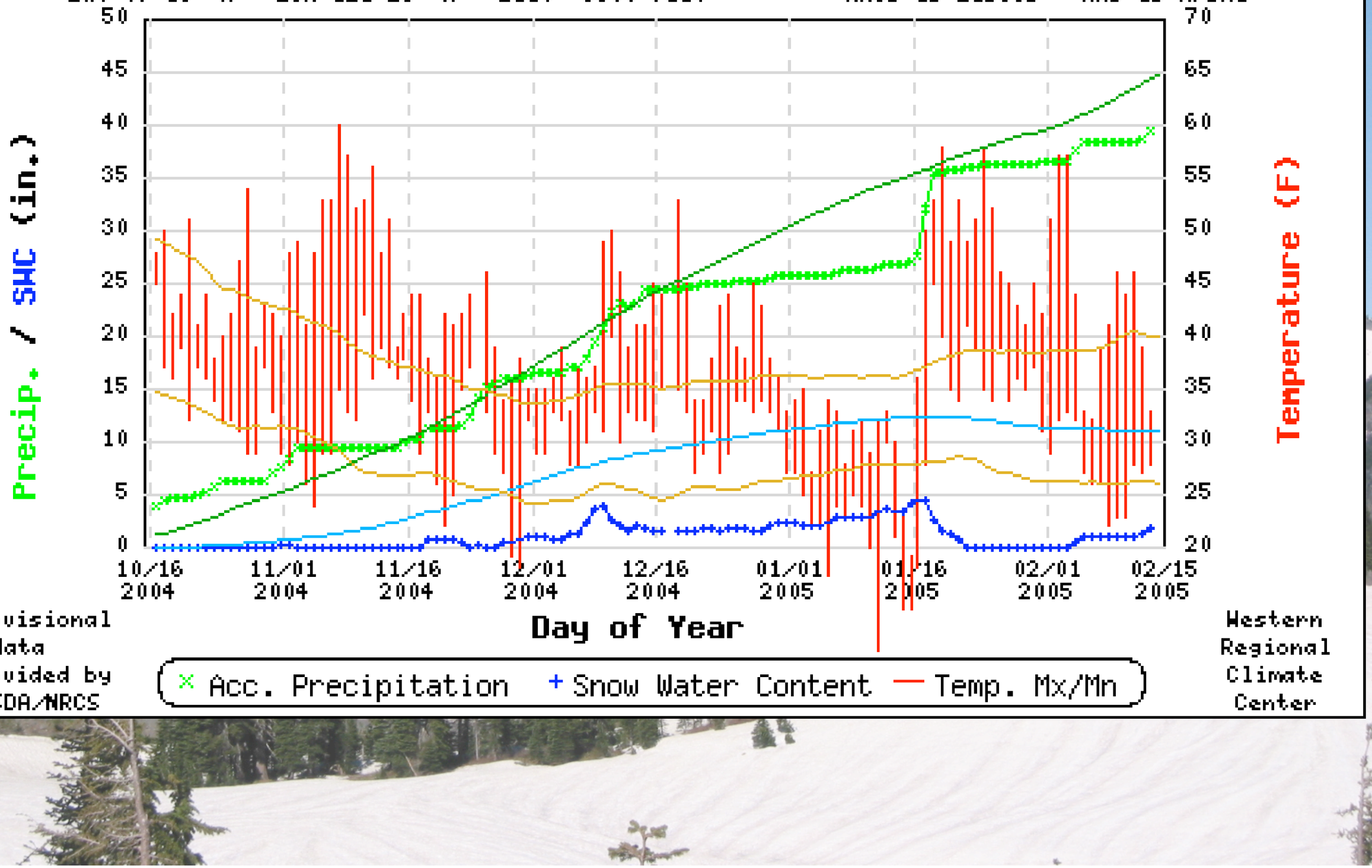
Meadows Pass
SNOTEL site


Miners Ridge, WA Snotel Site
Lat 48 10' N Lon 120 59' W Elev 6200 feet
NRCS ID 20A40S NWS ID MIRW1
Precip. / SWC (in.)
70
60
50
40
30
20
10
0
10/01 2002
11/01 2002
12/01 2002
01/01 2003
02/01 2003
03/01 2003
04/01 2003
05/01 2003
06/01 2003
07/01 2003
Day of Year
Provisional data provided by USDA/NRCS
× Acc. Precipitation + Snow Water Content
Western Regional Climate Center


Miners Ridge, WA Snotel Site
Lat 48 10' N Lon 120 59' W Elev 6200 feet NRCS ID 20A40S NWS ID MIRW1
Precip. / SWC (in.)
Temperature (F)
60
50
40
30
20
10
0
10/01 2004
10/16 2004
11/01 2004
11/16 2004
12/01 2004
12/16 2004
01/01 2005
01/16 2005
02/01 2005
02/15 2005
Day of Year
Provisional data provided by USDA/NRCS
Acc. Precipitation
Snow Water Content
Temp. Mx/Mn
Western Regional Climate Center

Meadows Pass, WA Snotel Site

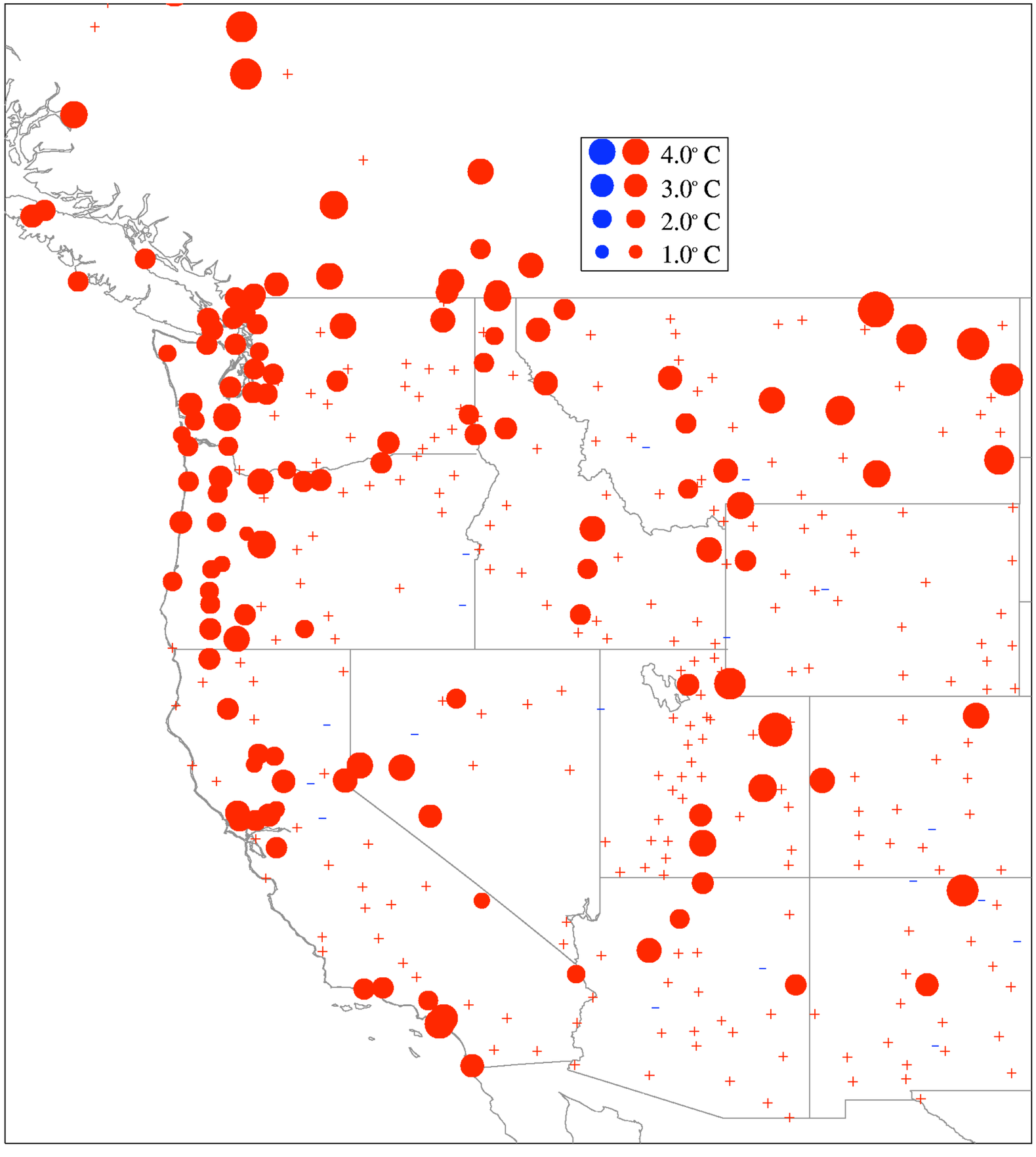
Lat 47 16' N Lon 121 28' W Elev 3500 feet NRCS ID 21B59S NWS ID MPSW1



Provisional data provided by USDA/NRCS

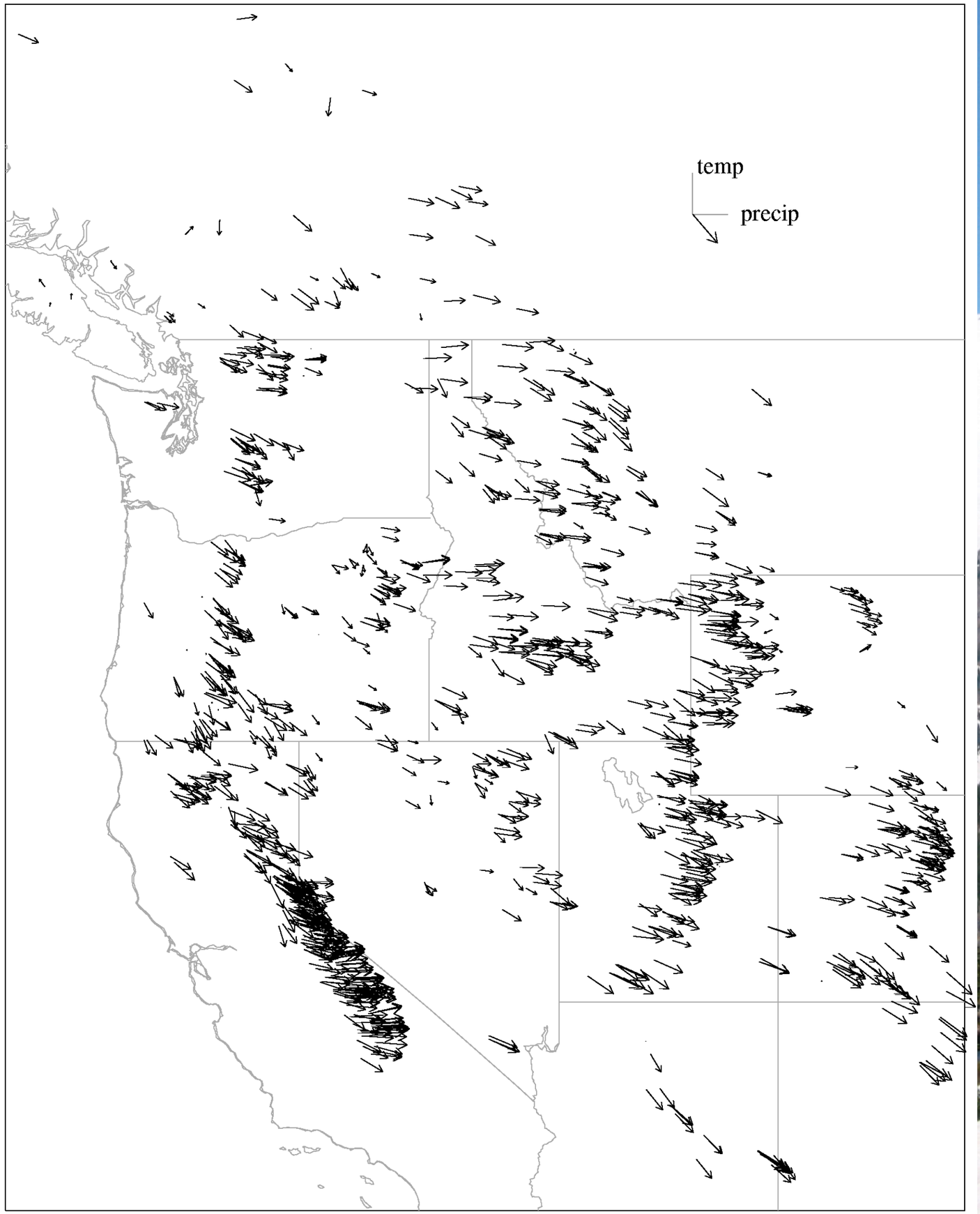
Western Regional Climate Center

Trends in Nov-Mar temperature, 1950 to 2000



At almost every USHCN station, winters warmed

+ signs: warming but not statistically significant



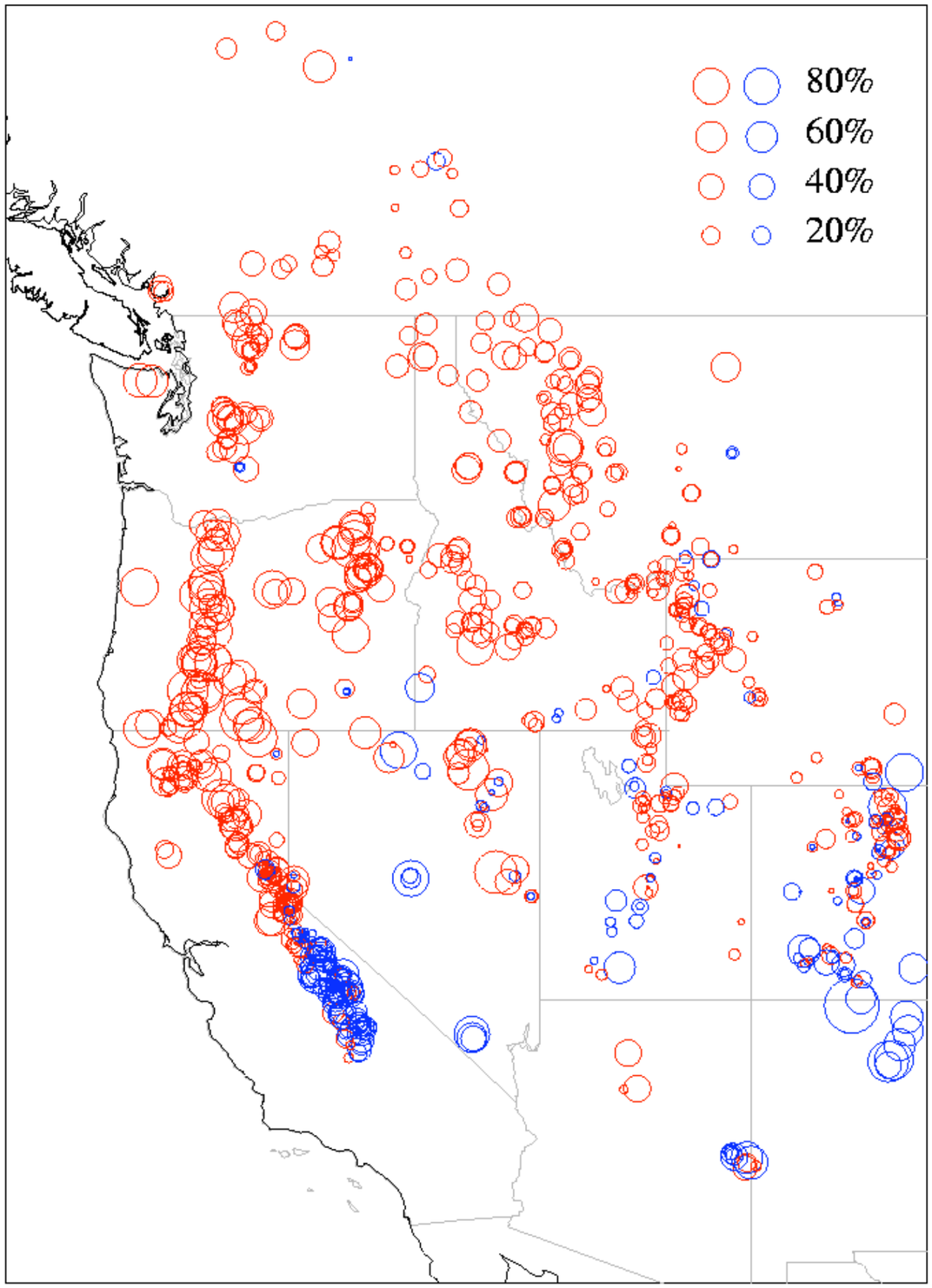
Correlations between Nov-Mar climate and Apr 1 SWE

X-direction: precip
Y-direction: temp

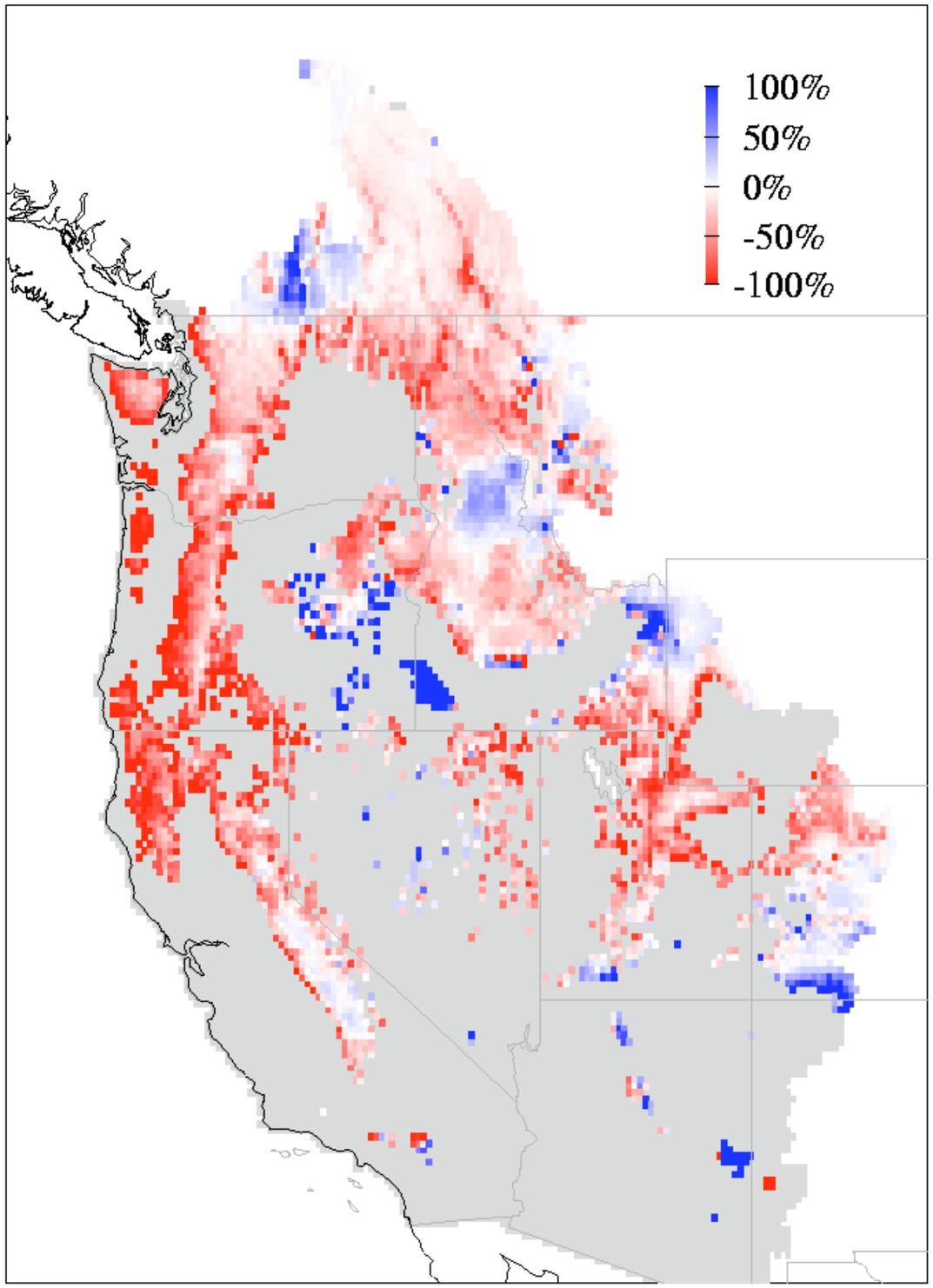
Coldest locations insensitive to temperature
Cascades very sensitive

Relative trends 1950-1997

a. Observations

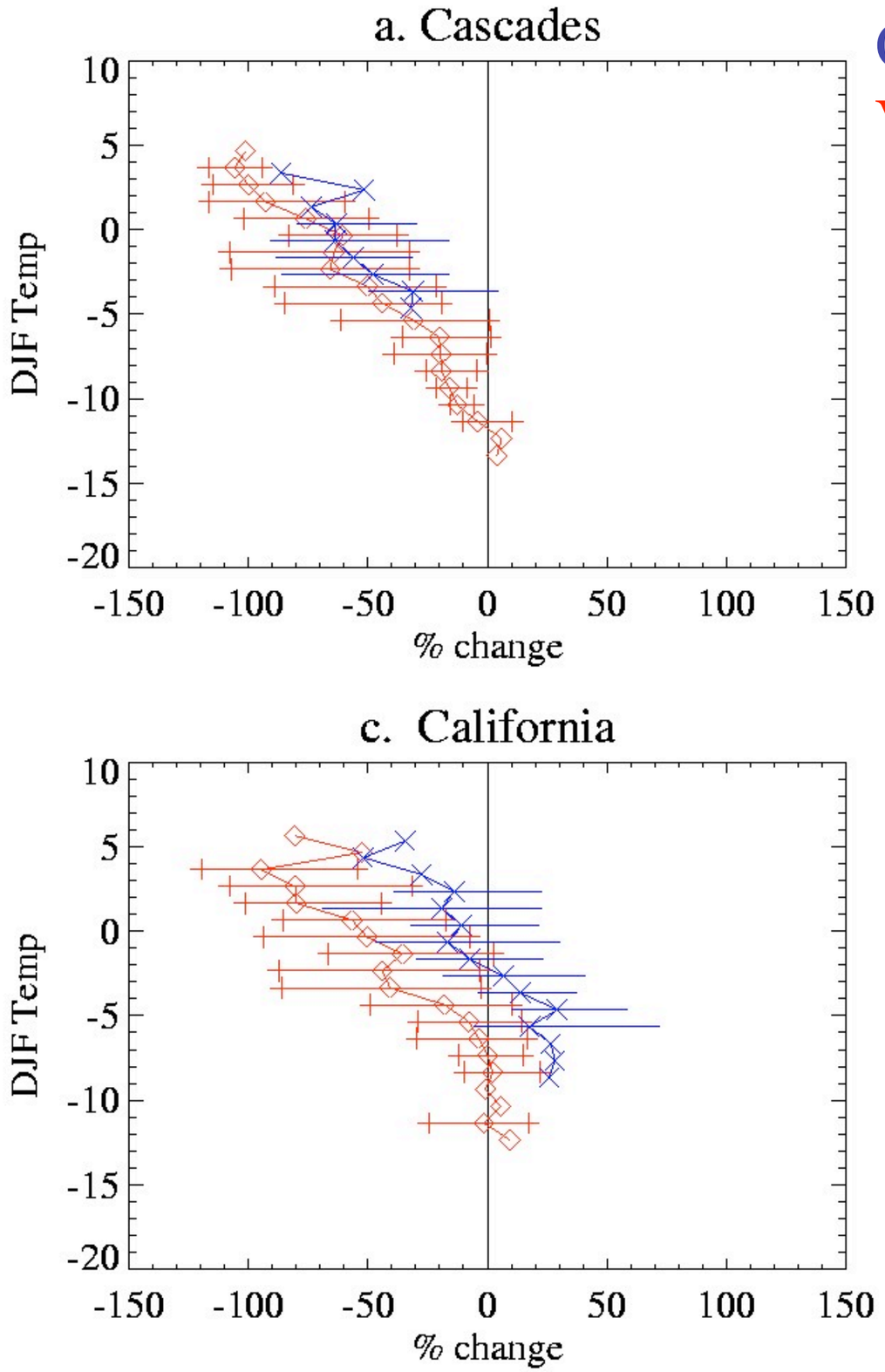


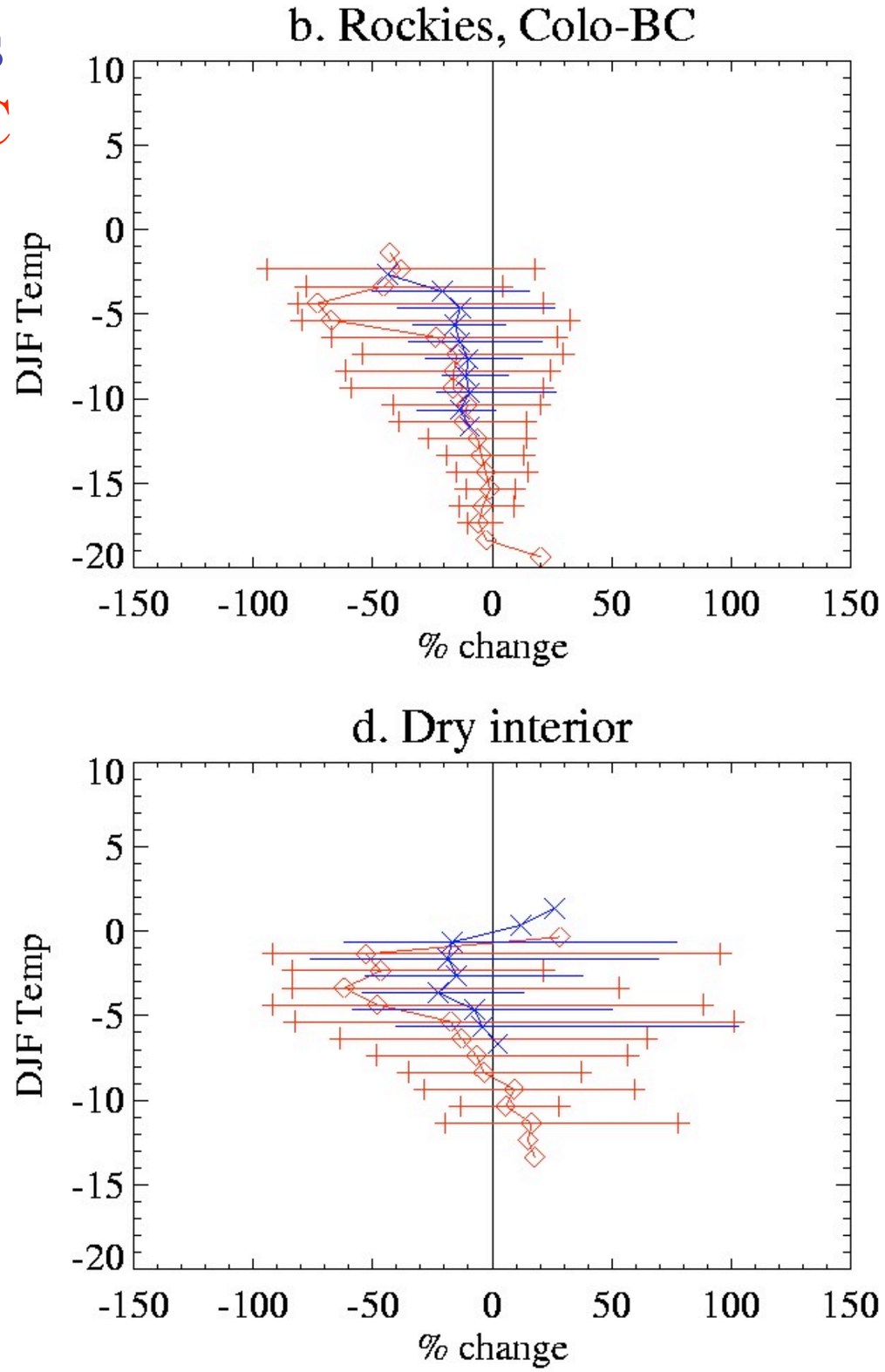
b. VIC



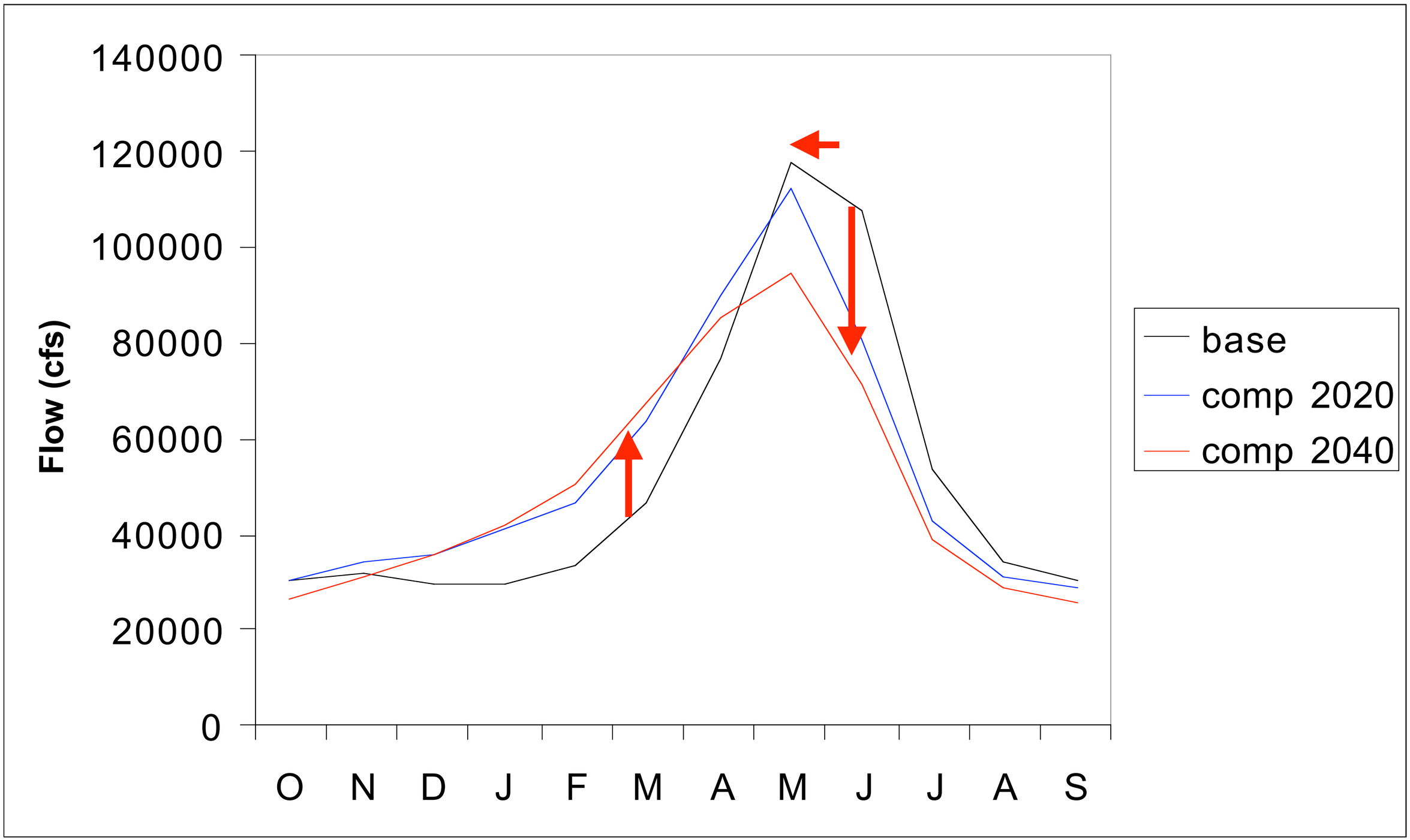
1950-1997 relative trends vs DJF temperature

Obs
VIC

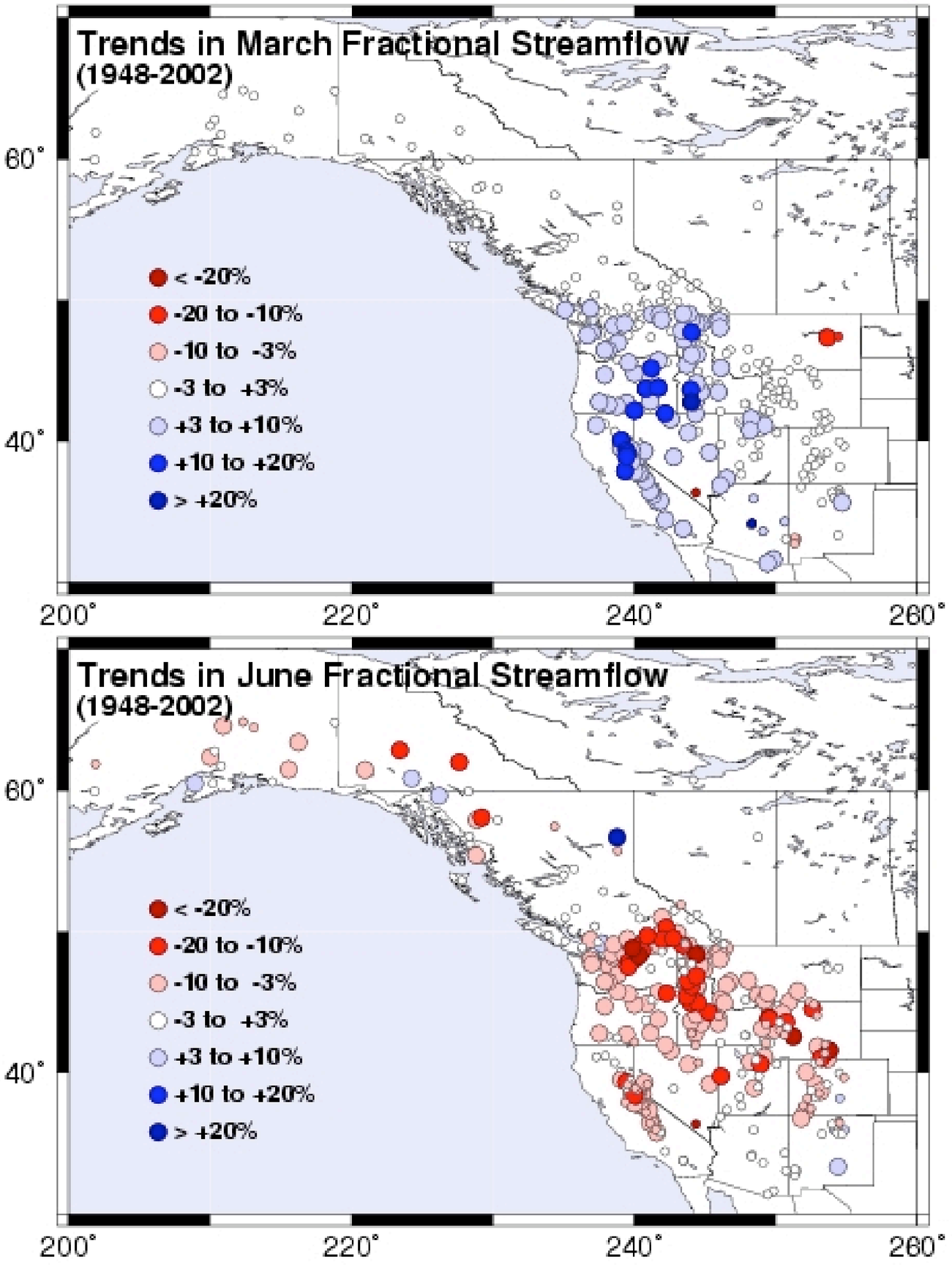




Snake River at Ice Harbor



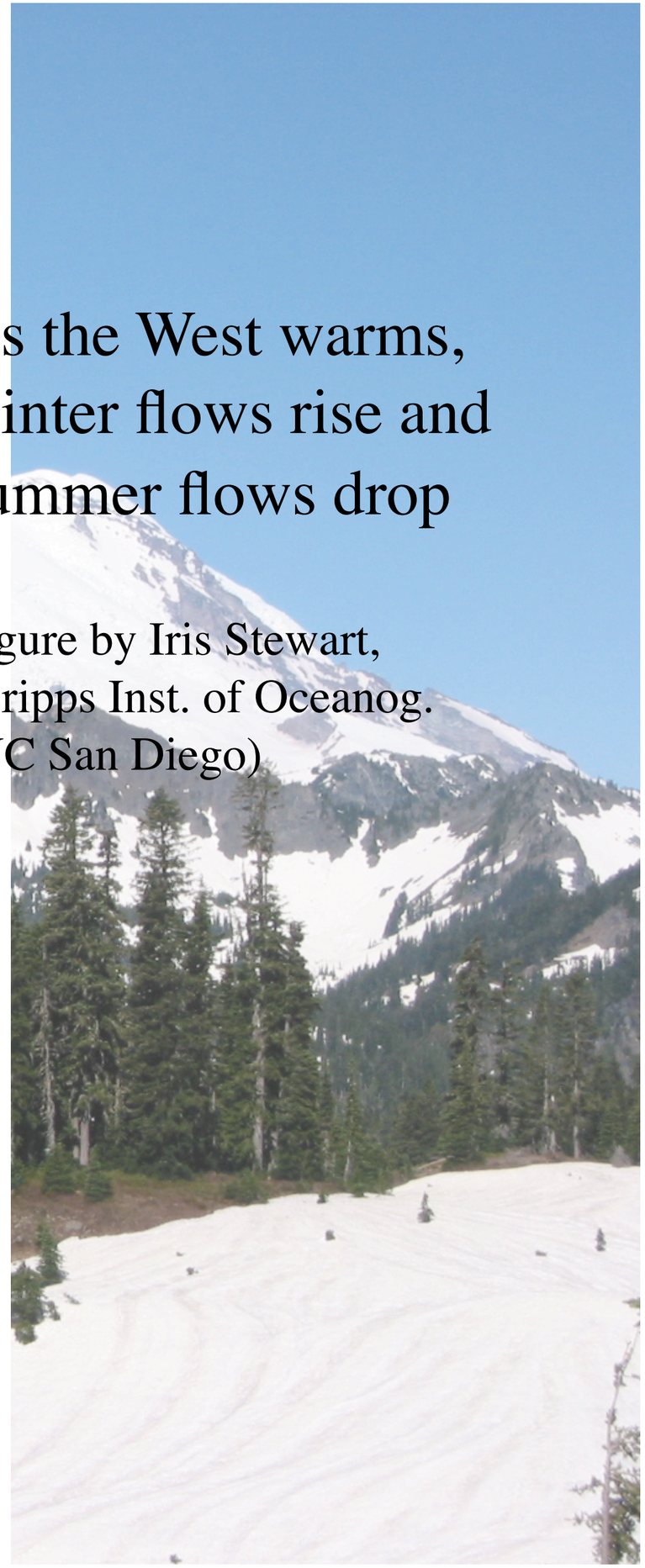
Three effects of warming



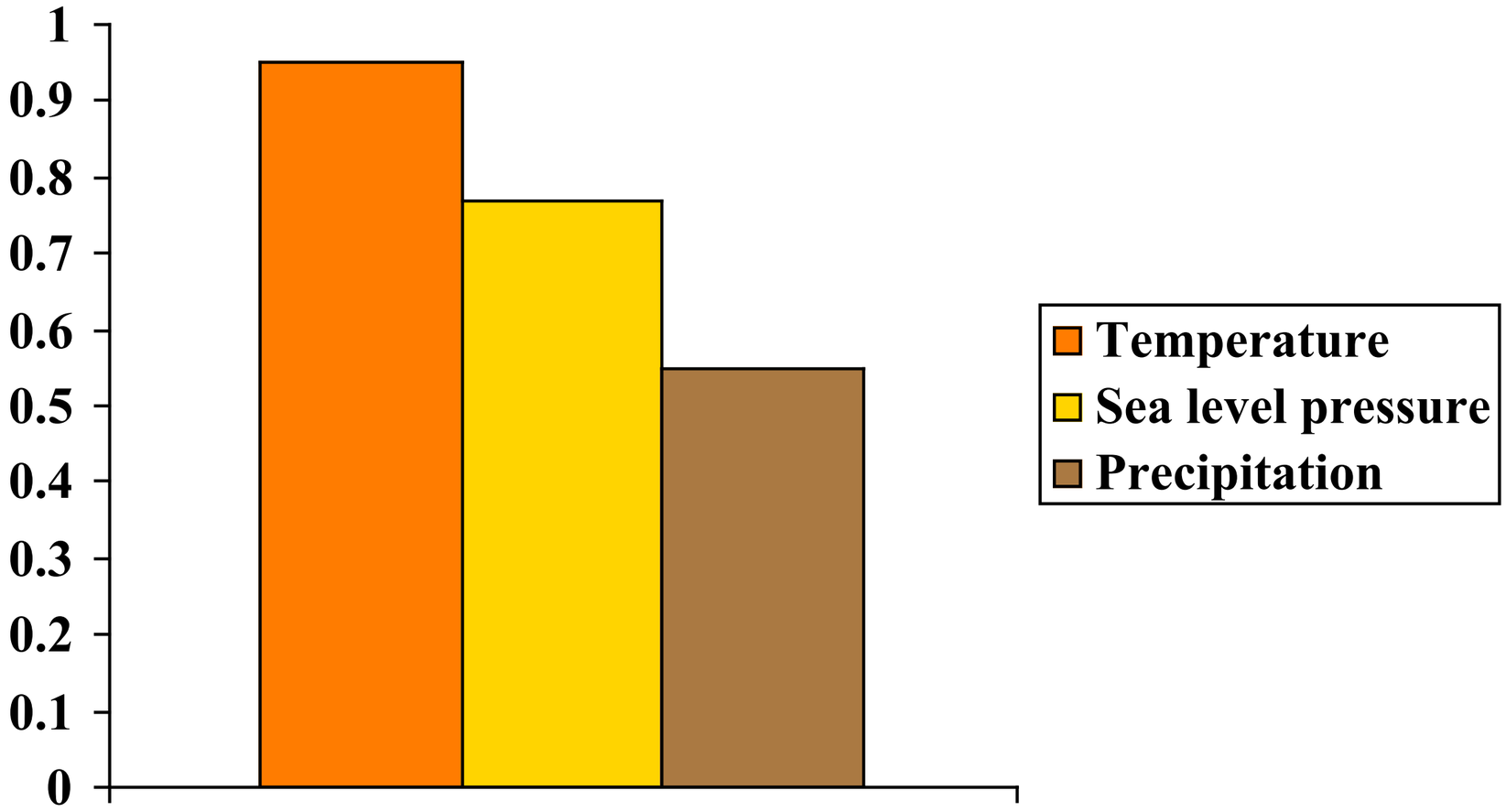
from:
Stewart, I.T., D.R. Cayan, and M.D. Dettinger (2004)
Changes toward earlier streamflow timing across western North America

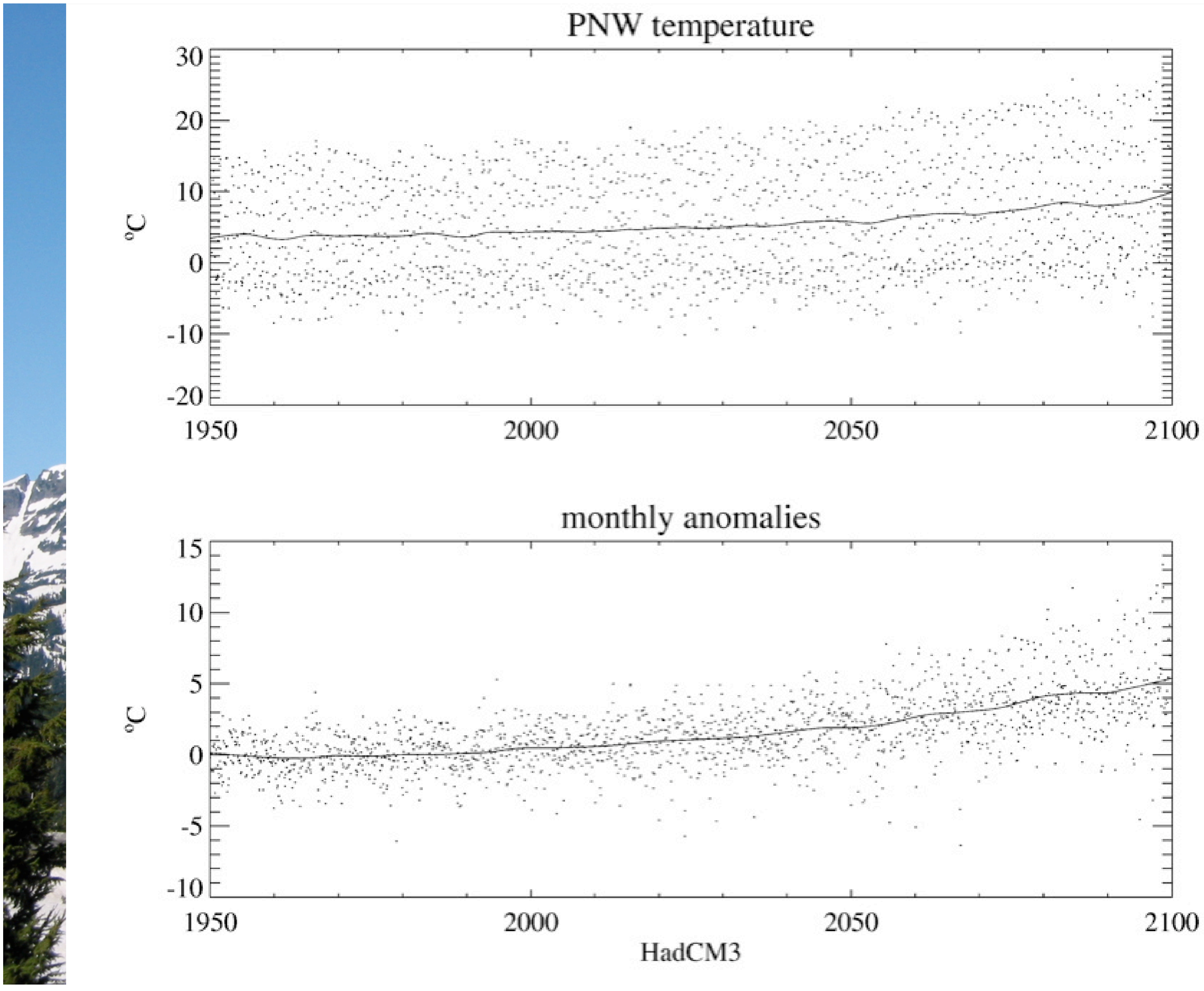
As the West warms, winter flows rise and summer flows drop

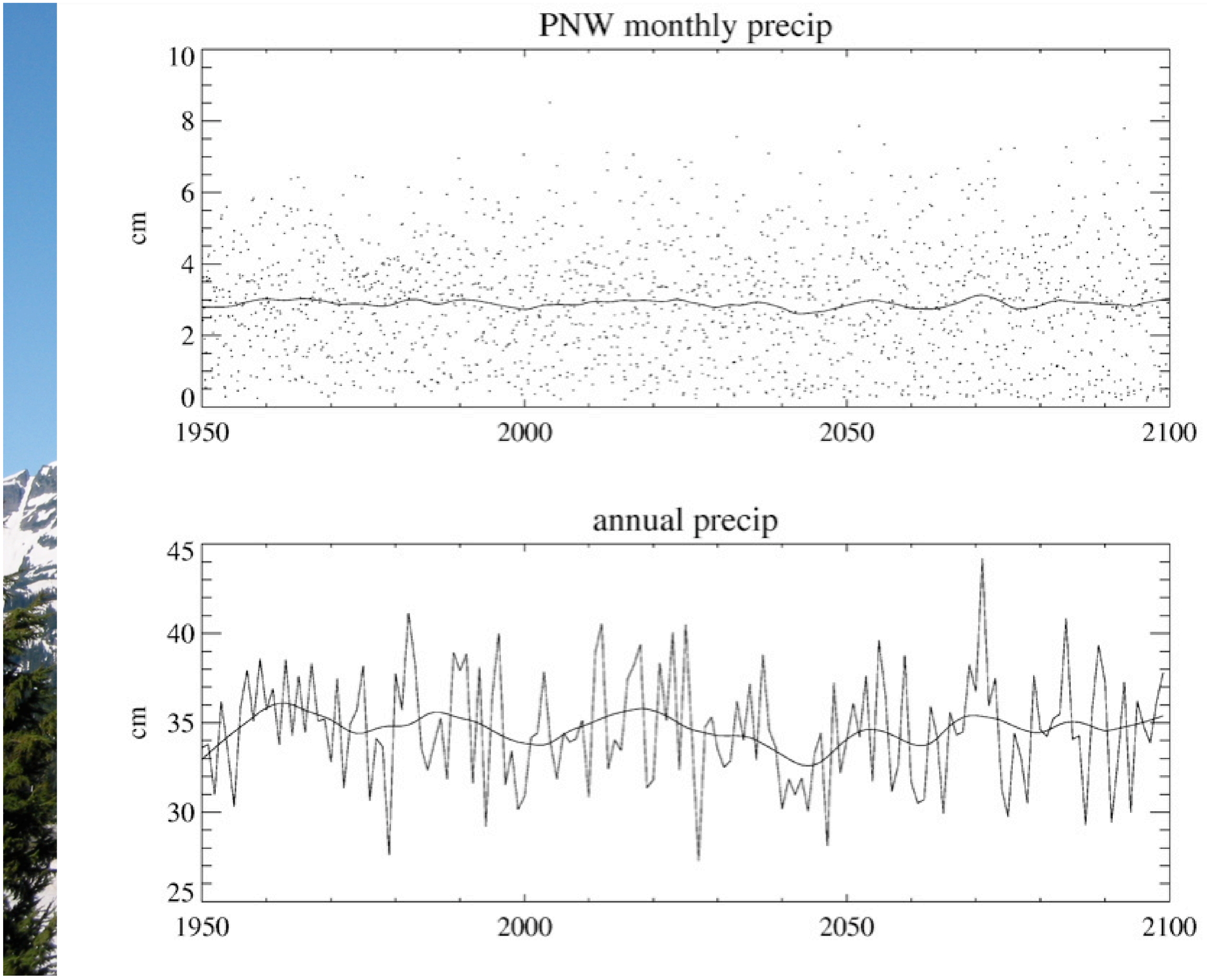
Figure by Iris Stewart, Scripps Inst. of Oceanog. (UC San Diego)

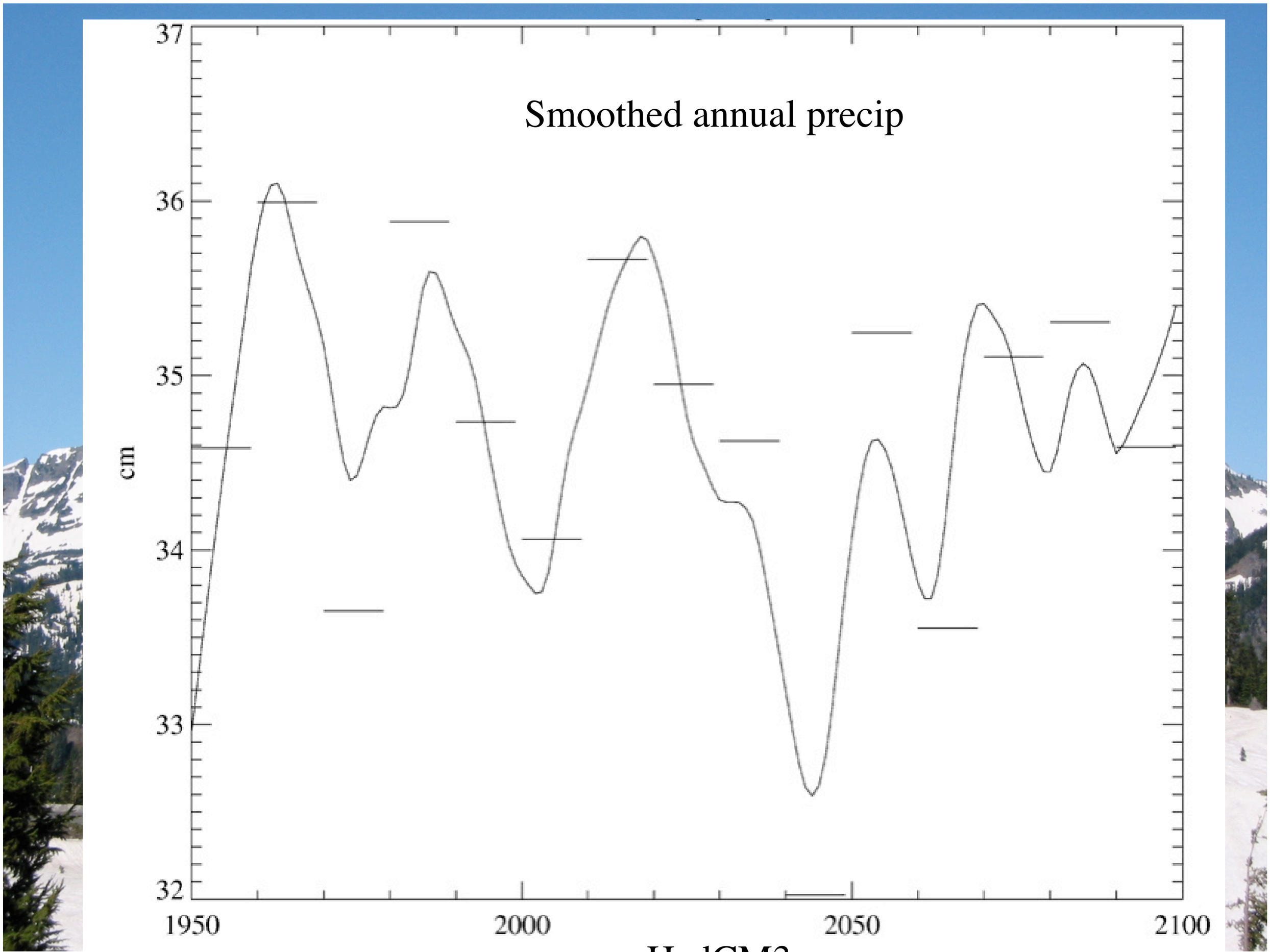


Correlations of modeled and observed climate variables




PNW temperature
30
20
10
0
-10
-20
°C
1950
2000
2050
2100
monthly anomalies
15
10
5
0
-5
-10
°C
1950
2000
2050
2100
HadCM3

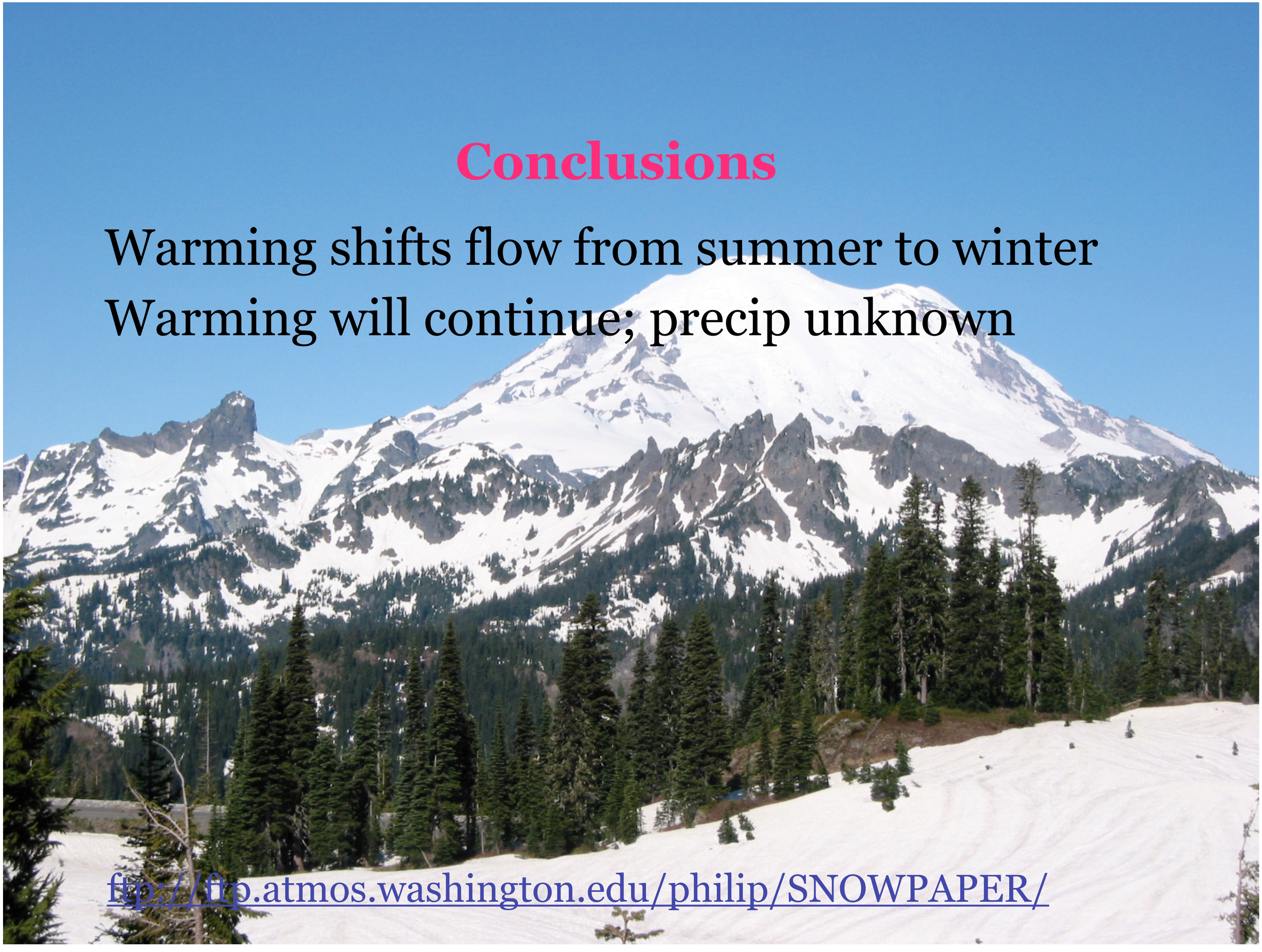

PNW monthly precip
cm
10
8
6
4
2
0
1950
2000
2050
2100
annual precip
cm
45
40
35
30
25
1950
2000
2050
2100


Smoothed annual precip
37
36
35
34
33
32
cm
1950
2000
2050
2100
HadCM3

Conclusions

Warming shifts flow from summer to winter

Warming will continue; precip unknown



ftp://ftp.atmos.washington.edu/philip/SNOWPAPER/

Trends in timing of peak snowpack

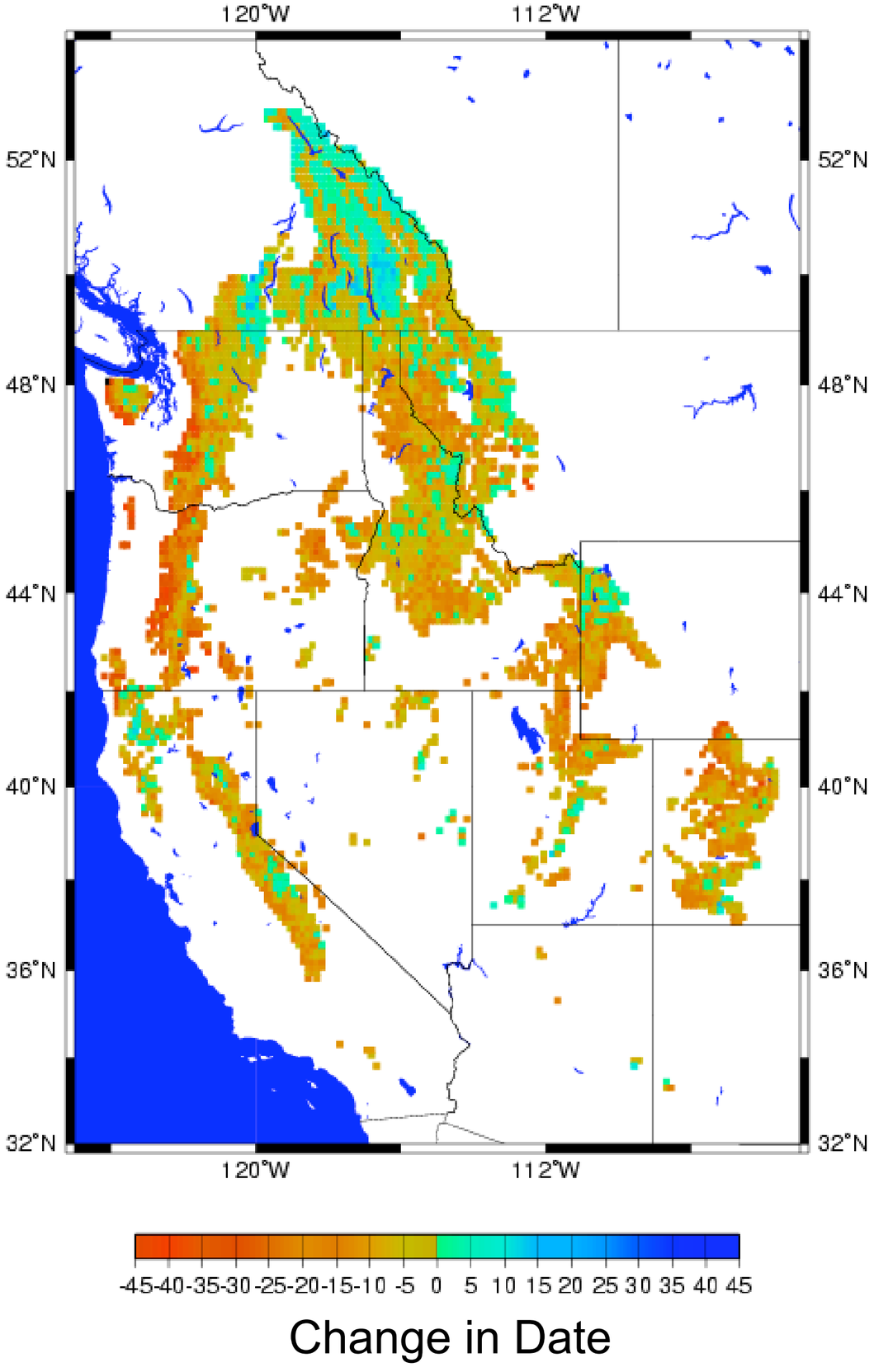
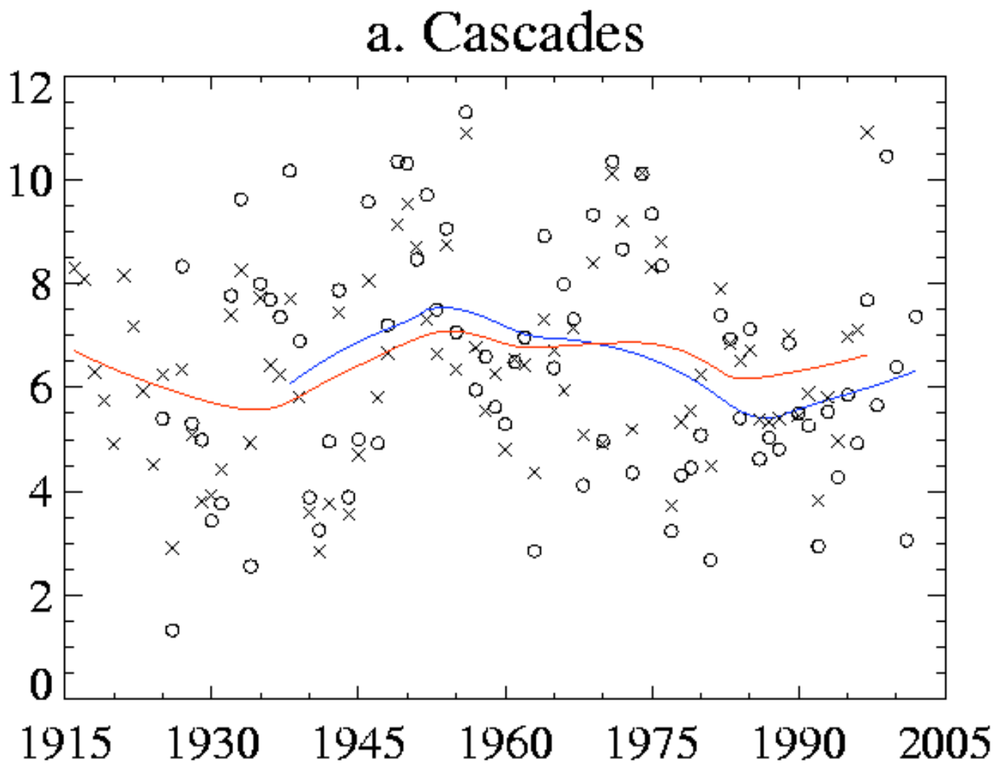


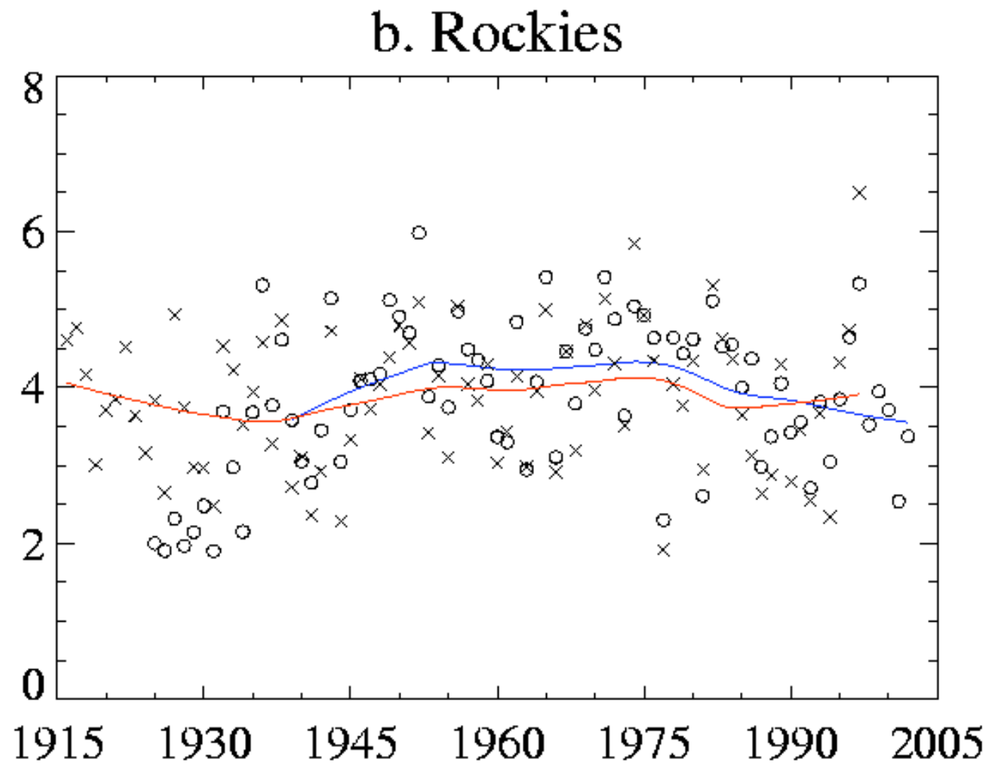
Figure by Alan Hamlet, UW

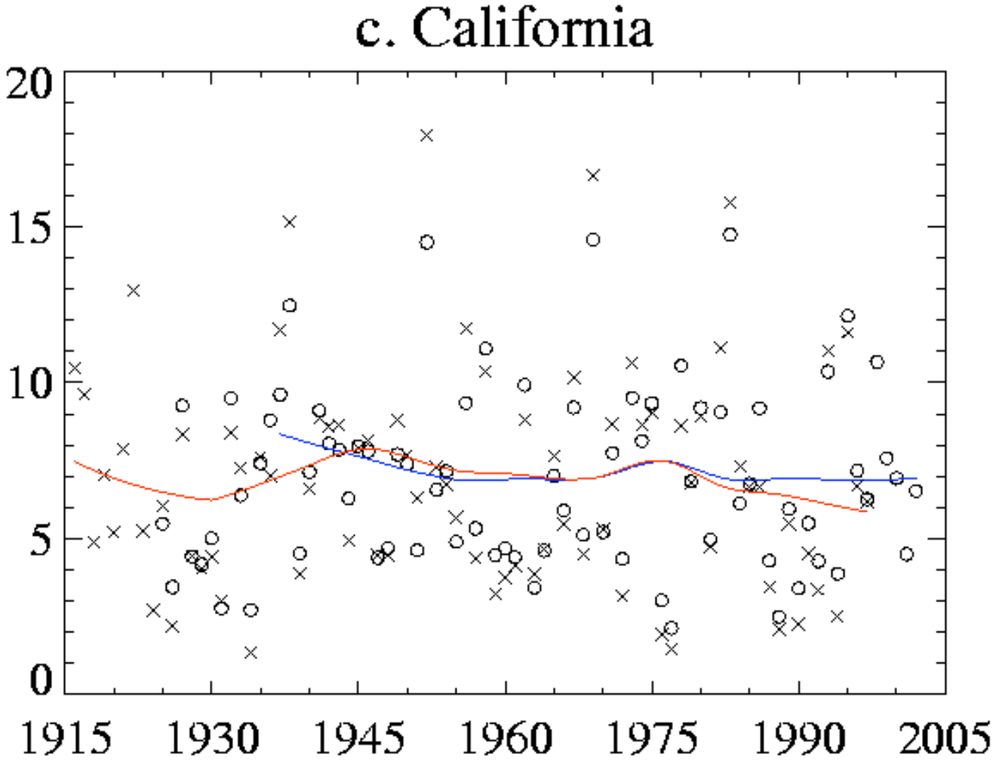
Regional average April 1 SWE

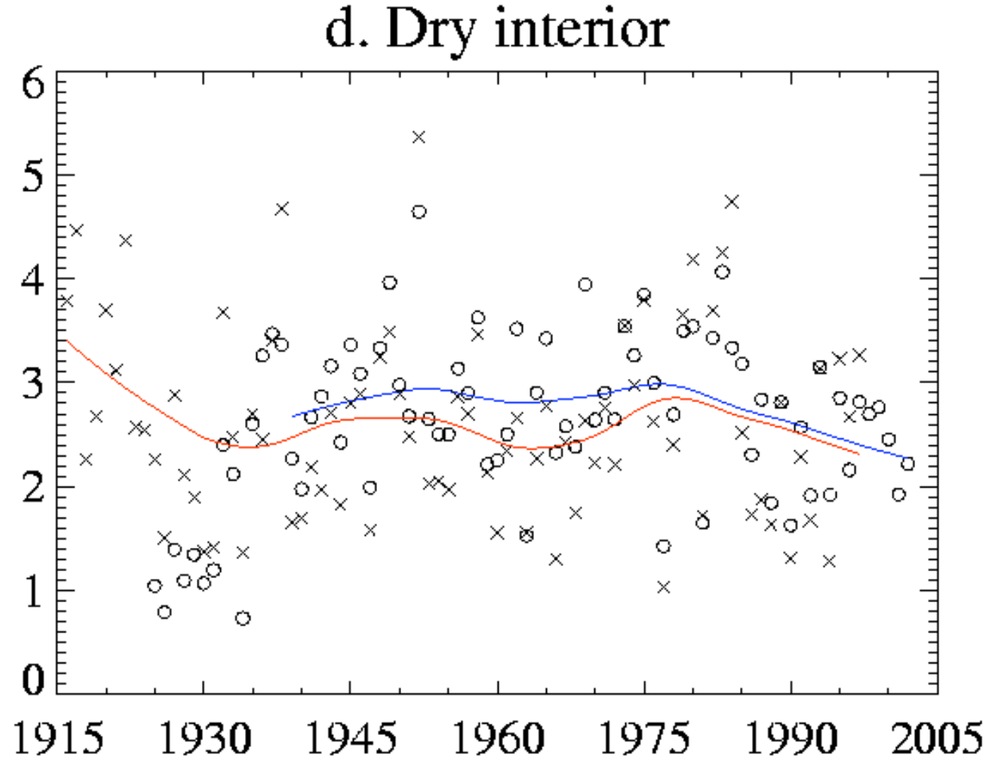


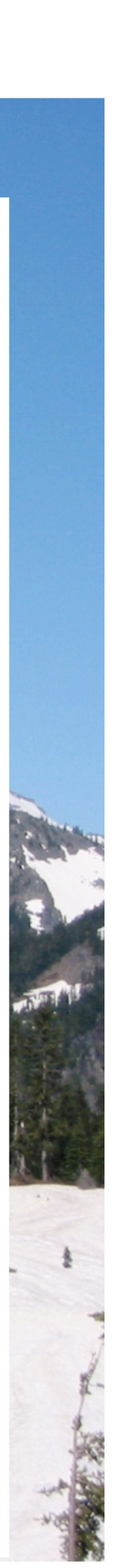
Obs o

VIC x





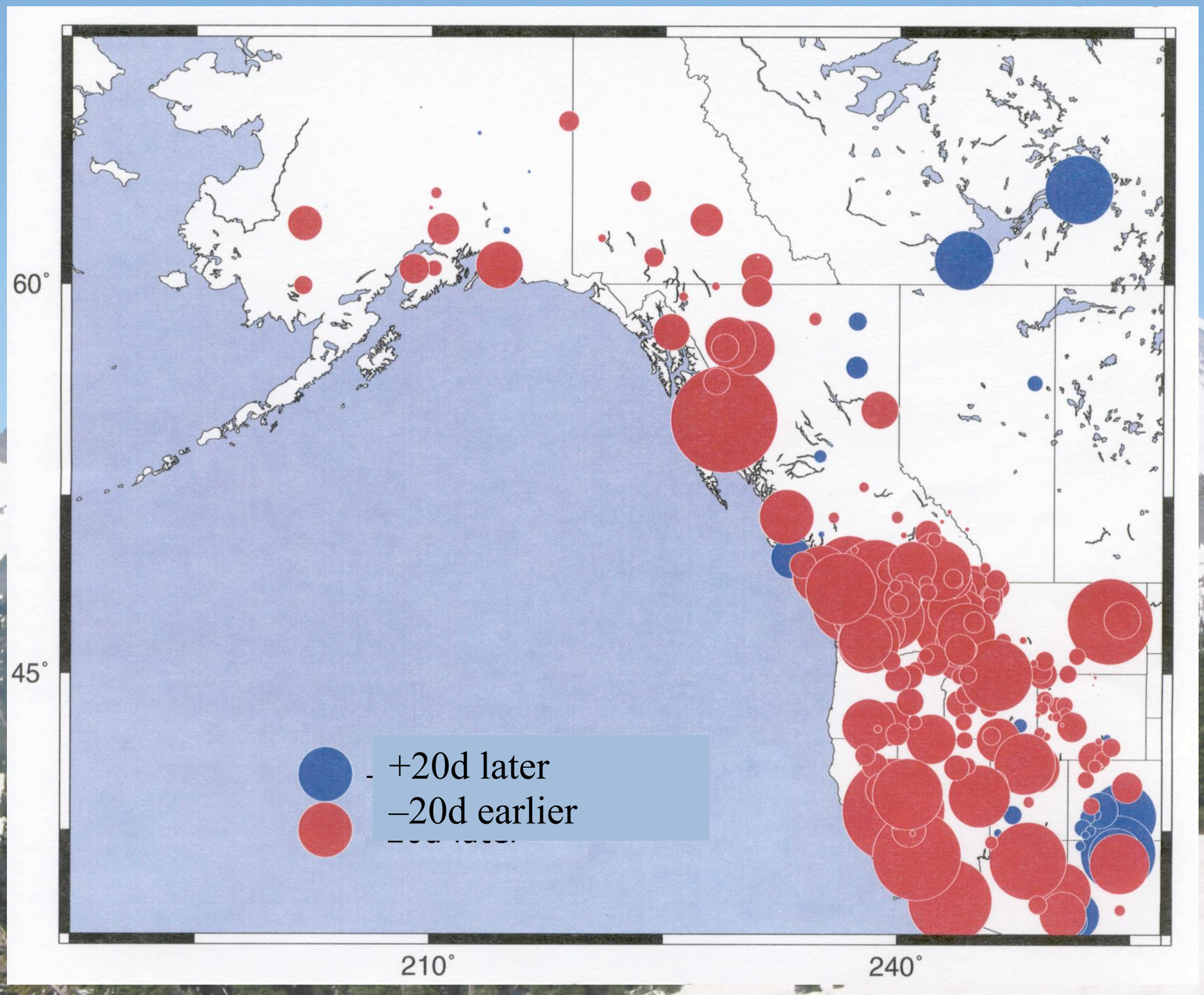




Changes in SWE vs changes in precip

	1930s to 1990s			1945-55 to 1990s		
	Obs SWE	VIC SWE	Precip	Obs SWE	VIC SWE	Precip
Cascades	-14%	+1%	+4%	-29%	-16%	-5%
Rockies	+11%	+2%	+9%	-16%	-9%	+1%
California	+3%	-14%	+10%	-2%	-25%	-1%
Interior	+9%	-6%	+10%	-22%	-18%	+2%

Trends in timing of spring snowmelt (1948-2000)



Courtesy of Mike Dettinger, Iris Stewart, Dan Cayan