



"I mean, what if we just come out and say that we have no idea what the weather will be?"

WA Weather and Climate: Trends and Projections



Office of the Washington State Climatologist

Nick Bond & Karin Bumbaco

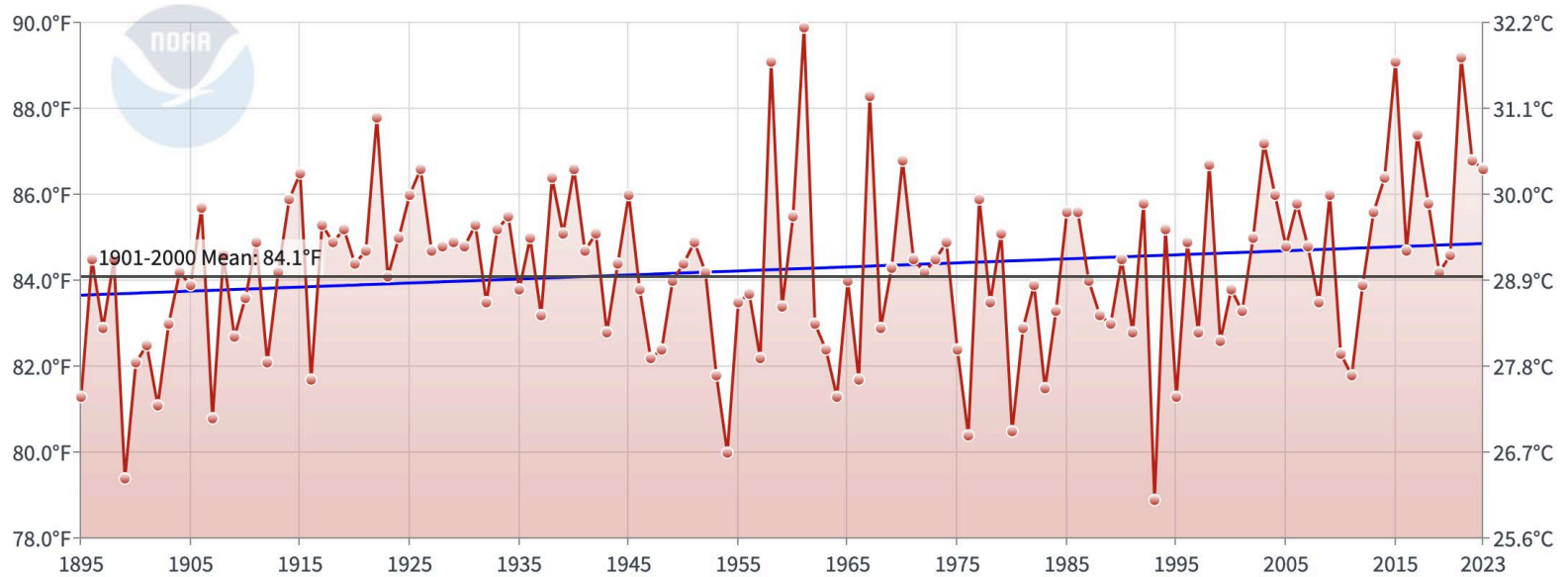
**Historical Context for Recent Weather
Model Projections for Future Decades
The Winter Ahead**

Washington, Climate Division 8 Maximum Temperature

June-August

Summer – Central Basin

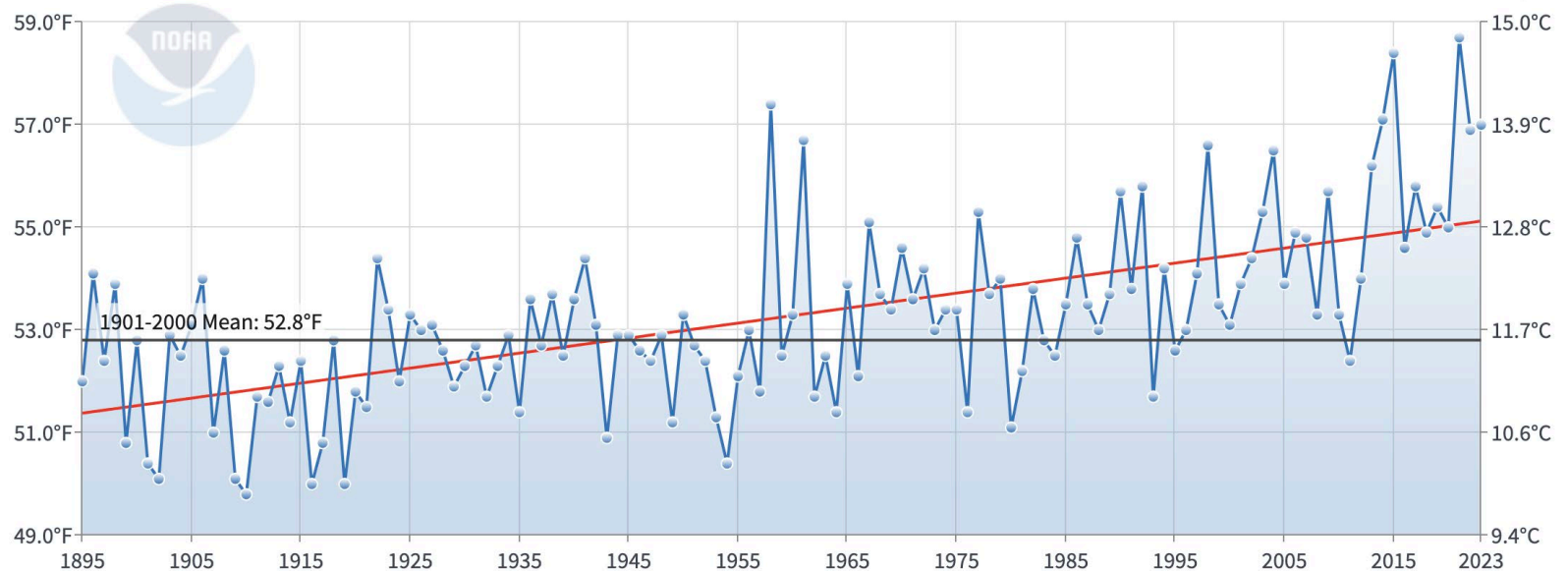
1895-2023 Trend
(+0.9°F/Century)



Washington, Climate Division 8 Minimum Temperature

June-August

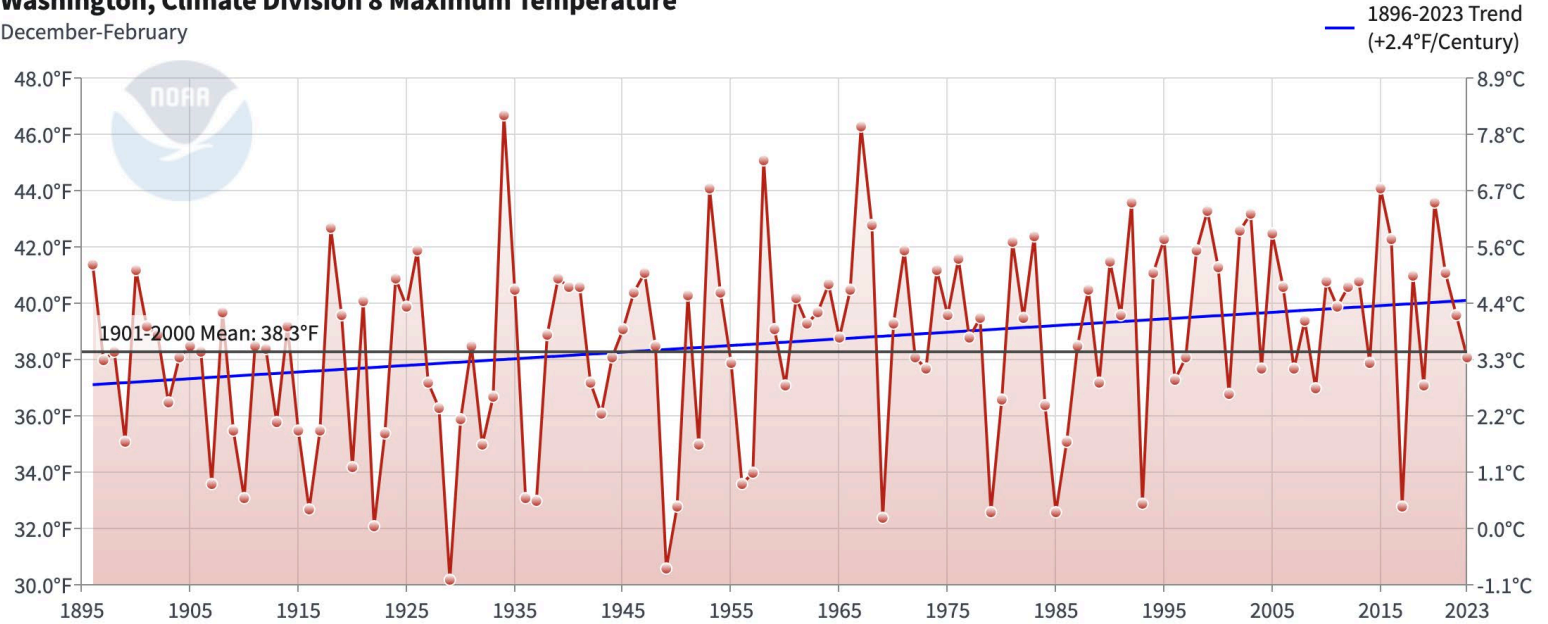
1895-2023 Trend
(+2.9°F/Century)



Winter – Central Basin

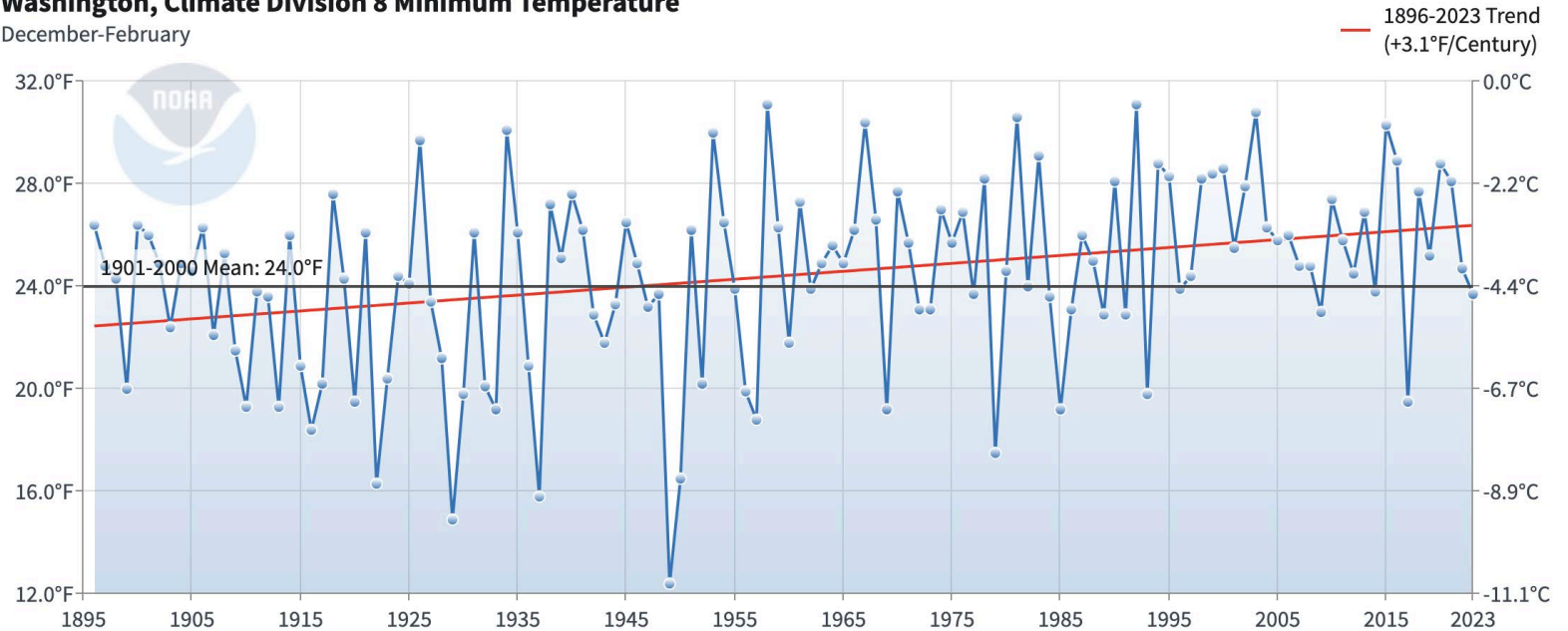
Washington, Climate Division 8 Maximum Temperature

December-February



Washington, Climate Division 8 Minimum Temperature

December-February

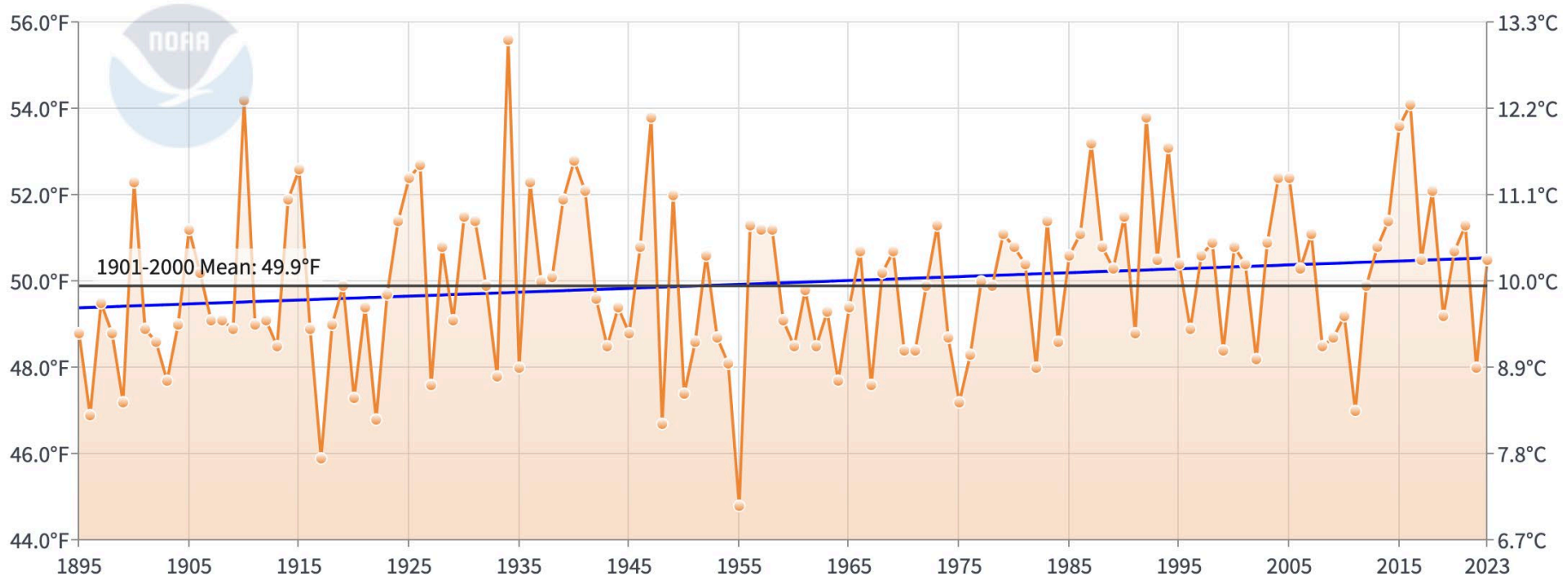


Spring Temperatures : Lesser Change

Washington, Climate Division 8 Average Temperature

March-May

1895-2023 Trend
(+0.9°F/Century)



Odessa WA: Last and First Frost Days

Oct 1

Aug 1

Jun 1

Apr 1

1910

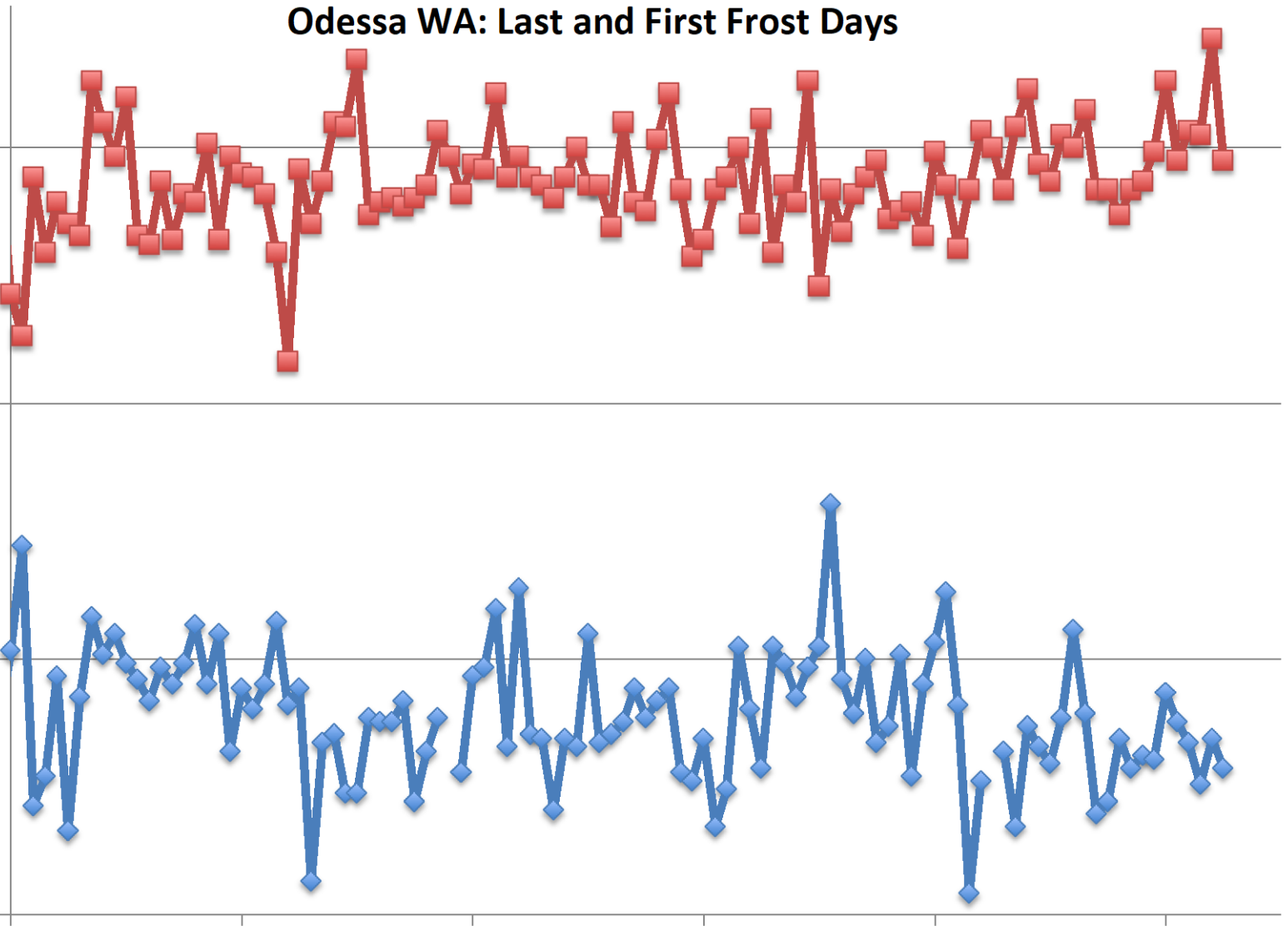
1930

1950

1970

1990

2010

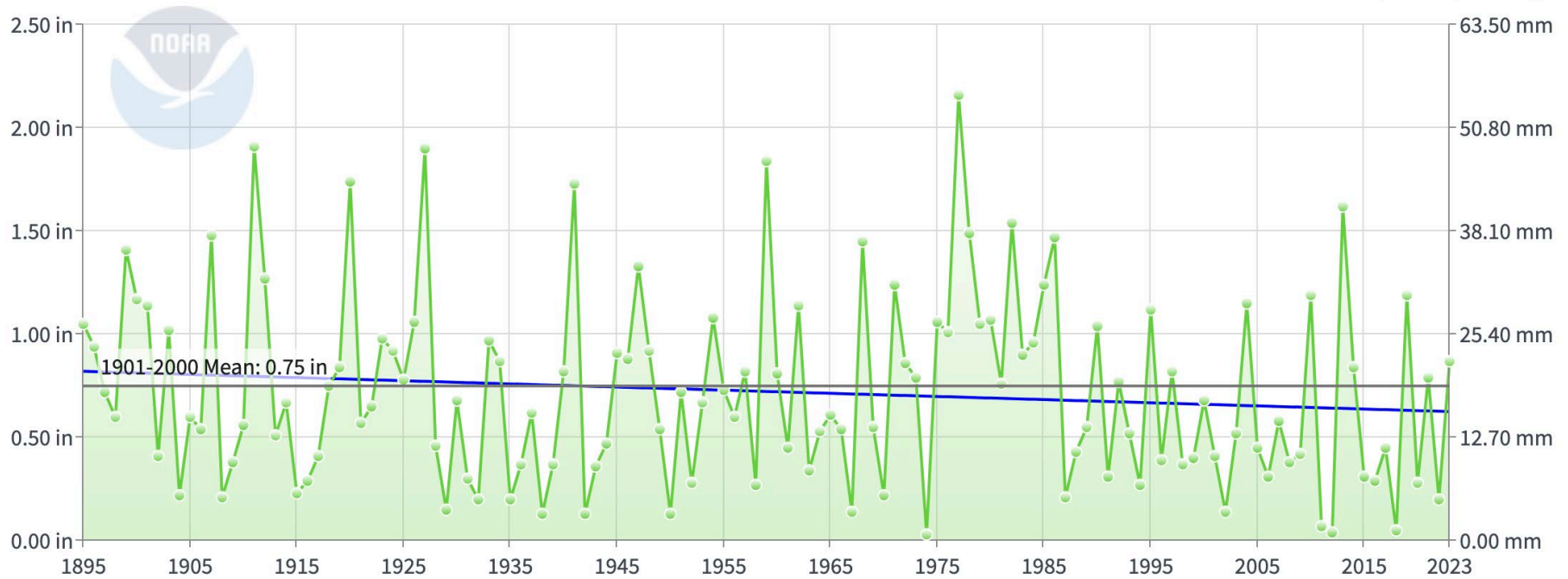


Late Summer Precipitation – Previous 3 Decades have been Mostly Dry

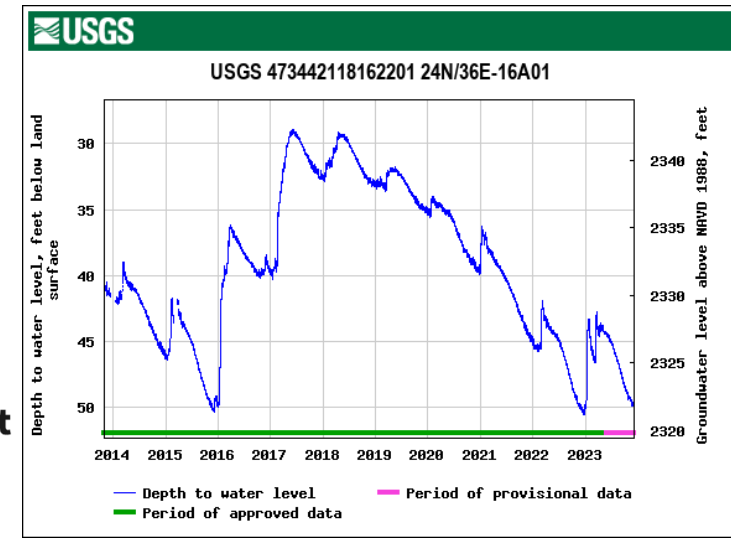
Washington, Climate Division 8 Precipitation

August-September

1895-2023 Trend
(-0.15 in/Century)



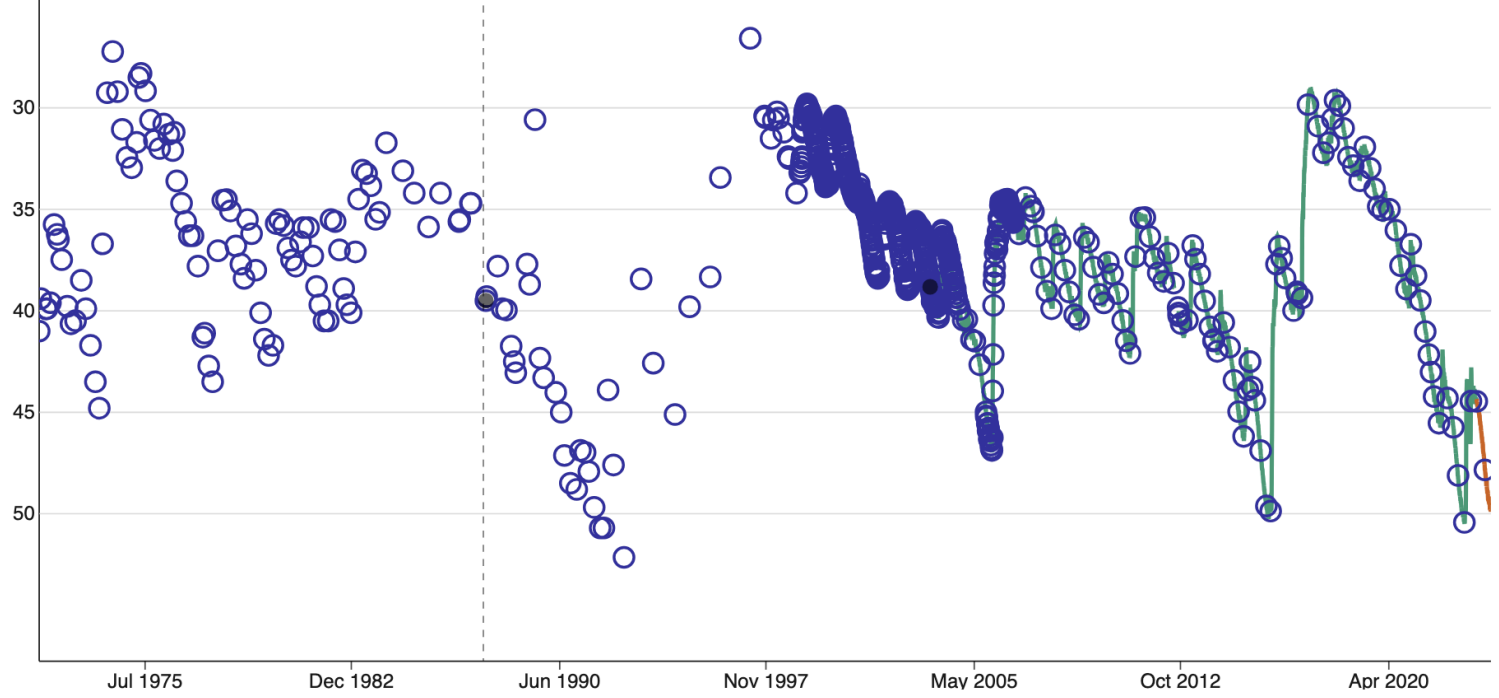
Davenport Index Well Water Levels



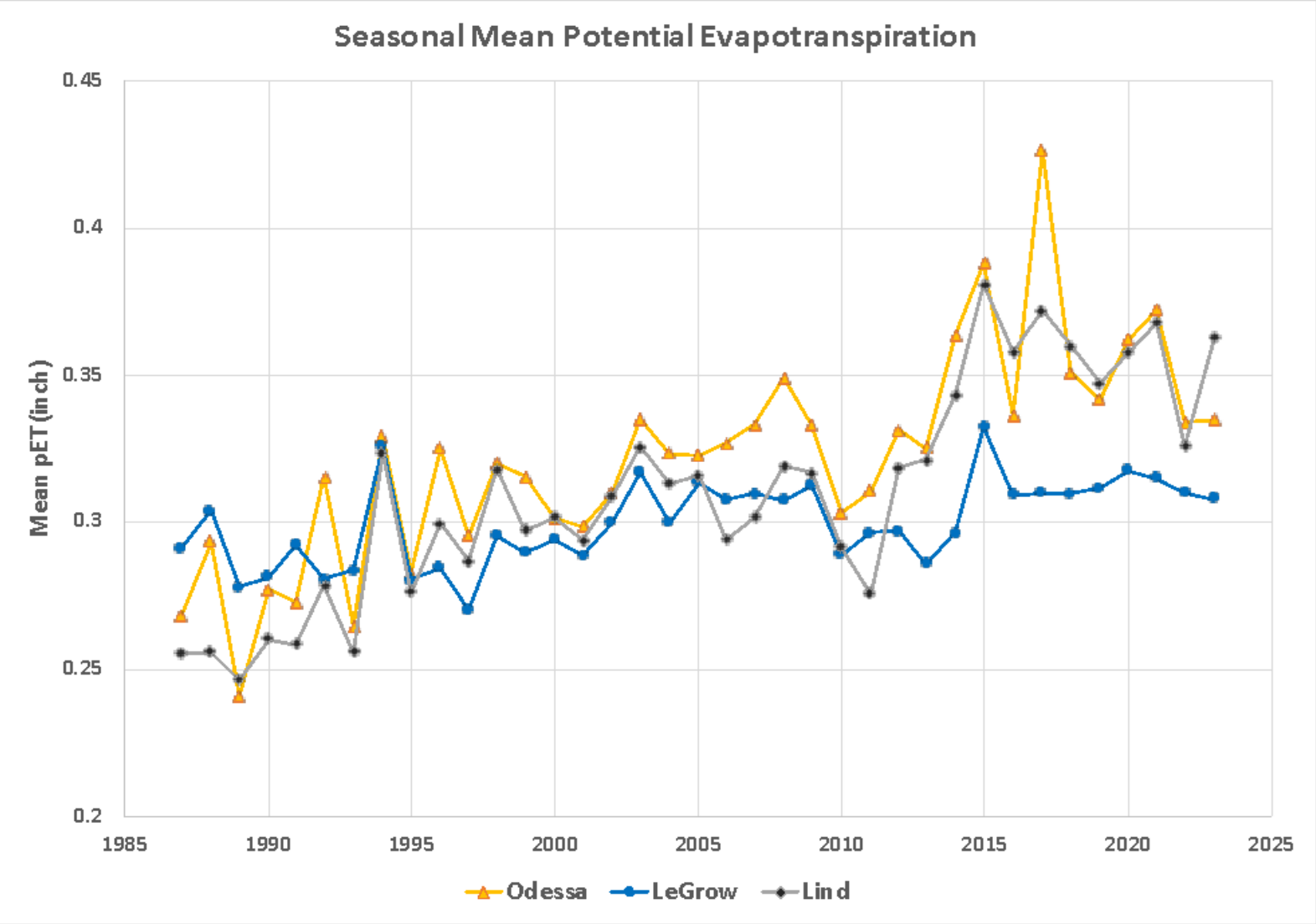
Depth to water level, ft below land surface, ft

Mean 38.82 ft - 2003-09-30

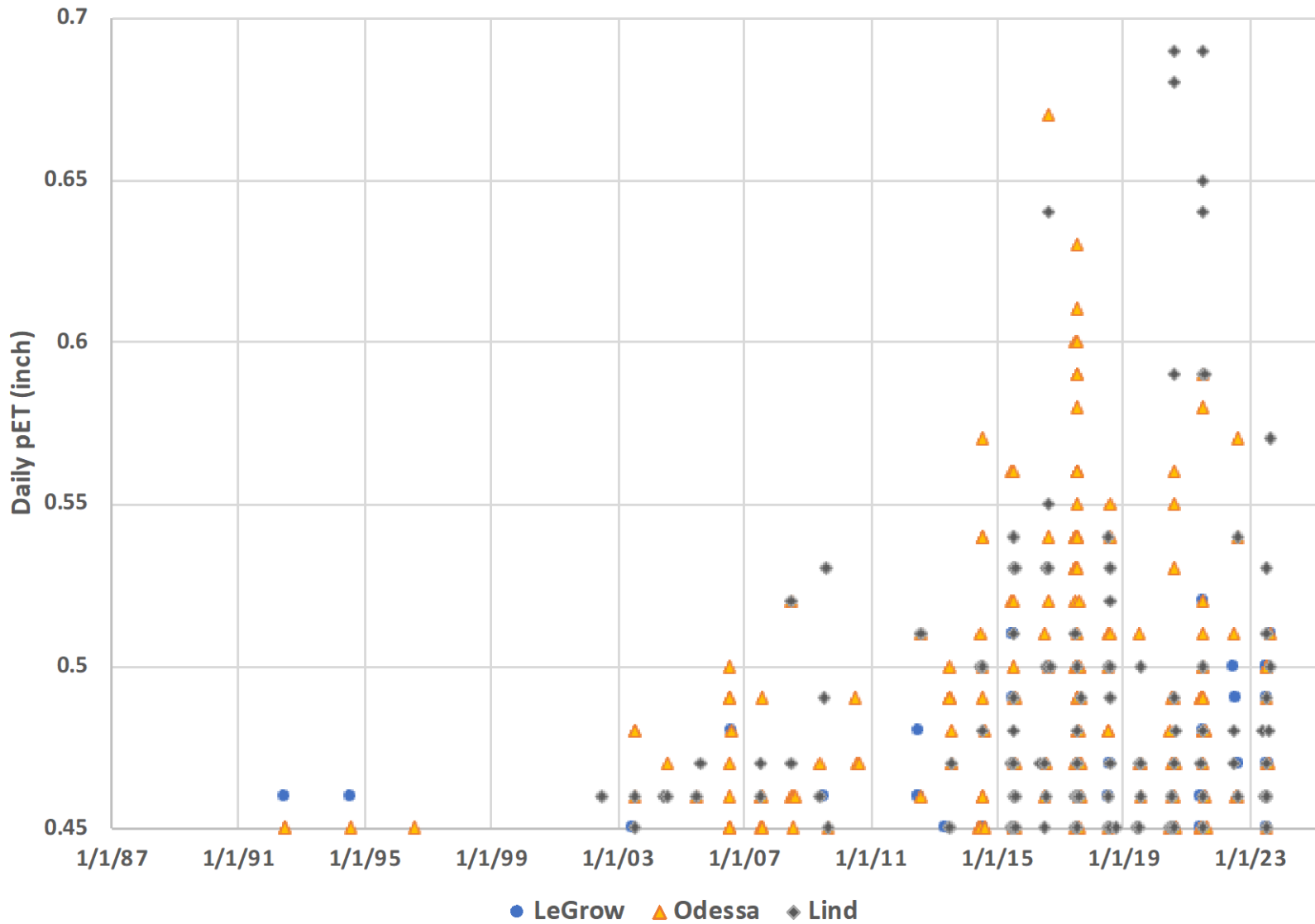
Visit 39.50 - 1987-10-05



Summer potential evapotranspiration is increasing in the Columbia Basin, and continued rises are projected.



High Potential Evapotranspiration Days in Eastern WA



2023 USDA Plant Hardiness Zone Map Washington

Average Annual Extreme Minimum Temperature 1991-2020

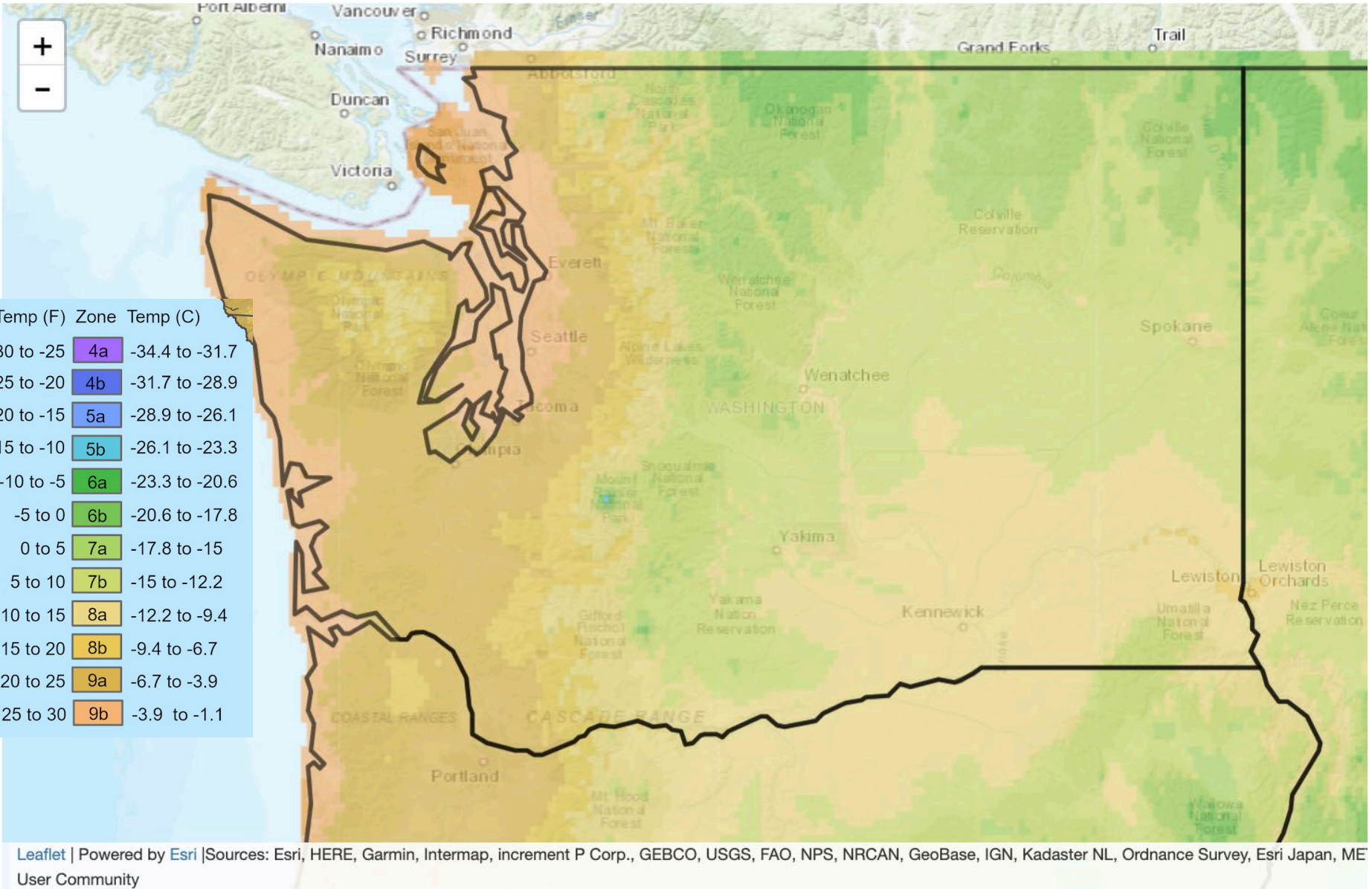
Temp (F)	Zone	Temp (C)
-30 to -25	4a	-34.4 to -31.7
-25 to -20	4b	-31.7 to -28.9
-20 to -15	5a	-28.9 to -26.1
-15 to -10	5b	-26.1 to -23.3
-10 to -5	6a	-23.3 to -20.6
-5 to 0	6b	-20.6 to -17.8
0 to 5	7a	-17.8 to -15
5 to 10	7b	-15 to -12.2
10 to 15	8a	-12.2 to -9.4
15 to 20	8b	-9.4 to -6.7
20 to 25	9a	-6.7 to -3.9
25 to 30	9b	-3.9 to -1.1



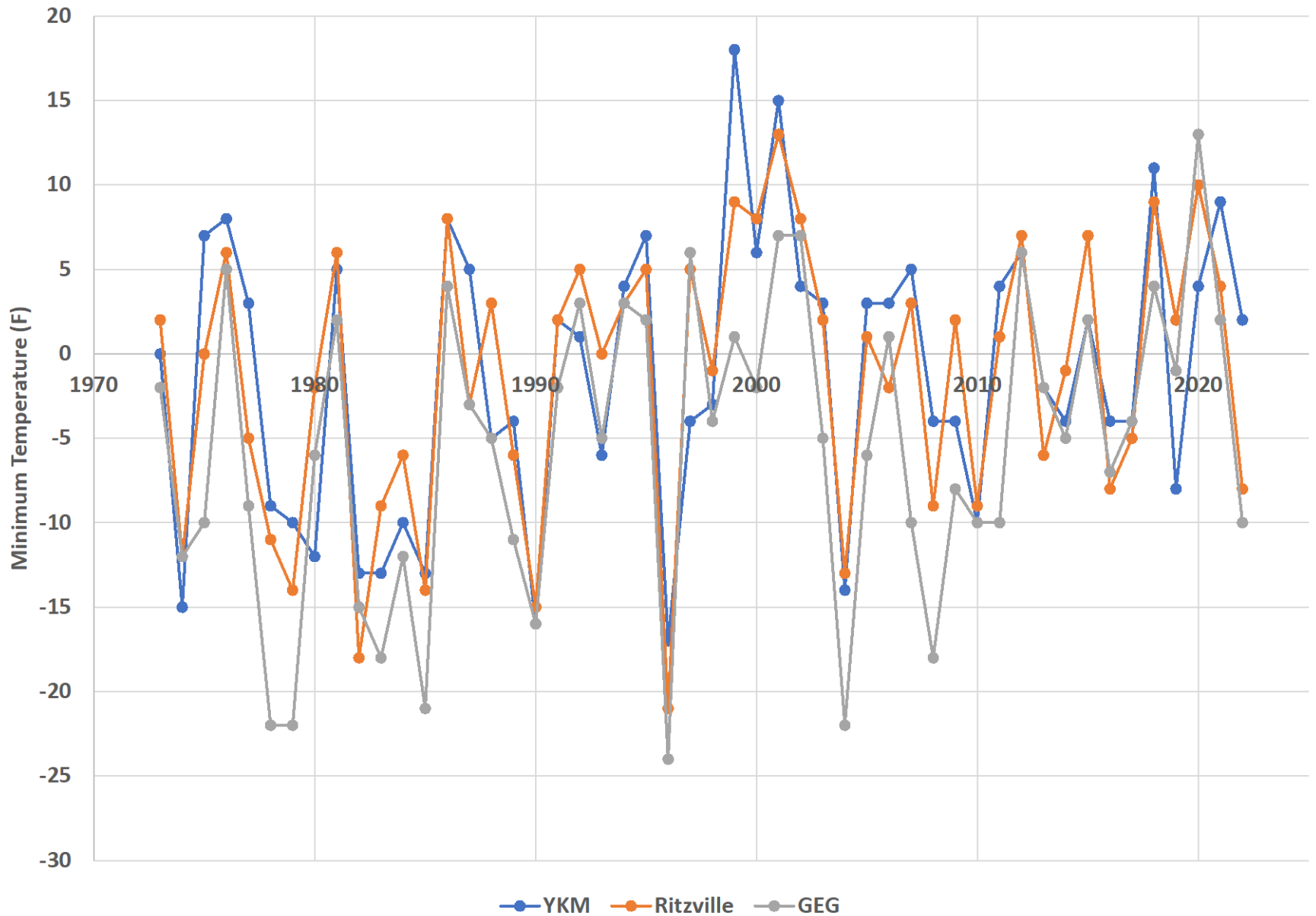
Mapping by the
PRISM Climate Group
College of Engineering
Oregon State University

Cold Hardiness Zones

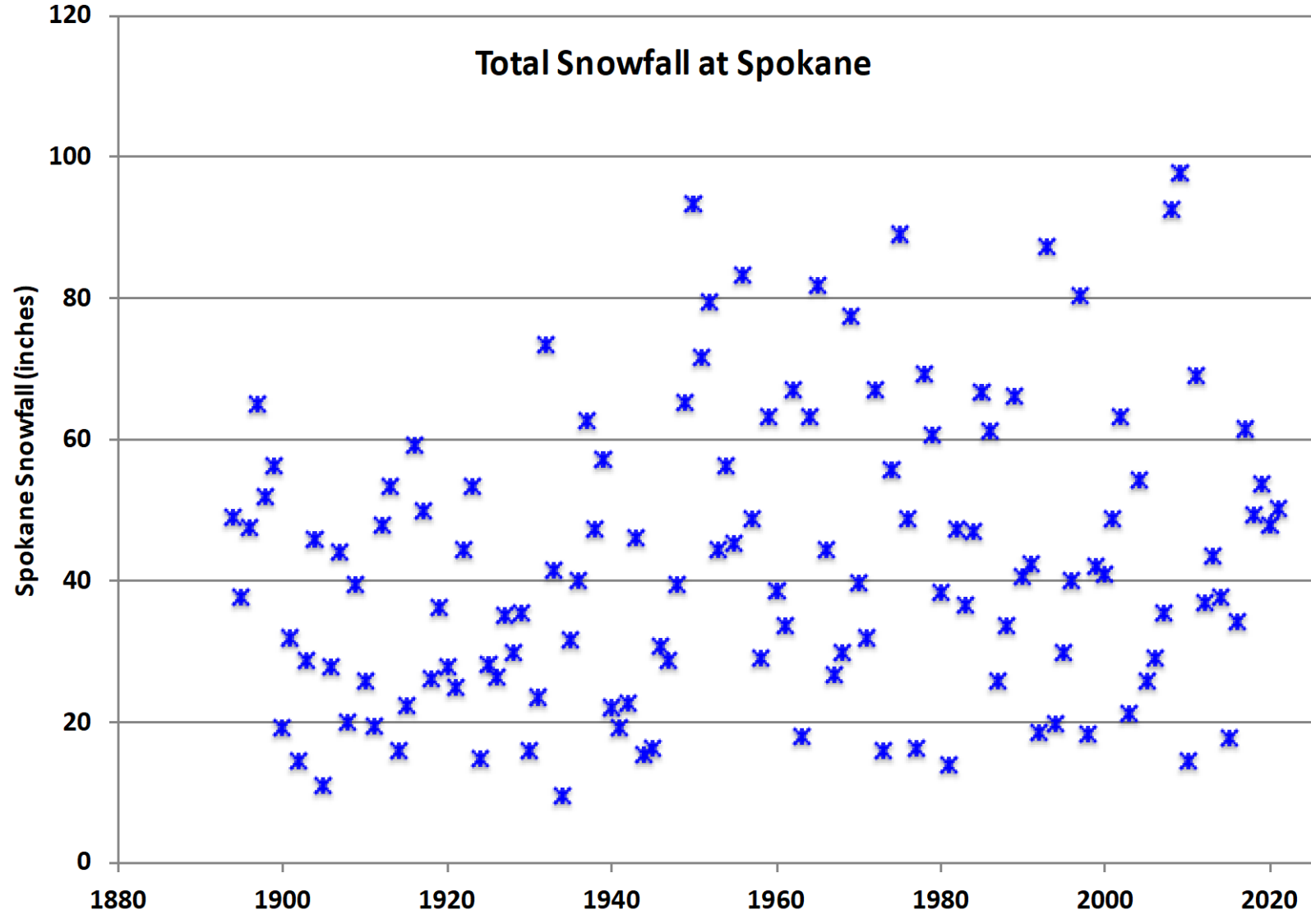
2040-2069, Higher Emissions (RCP 8.5)



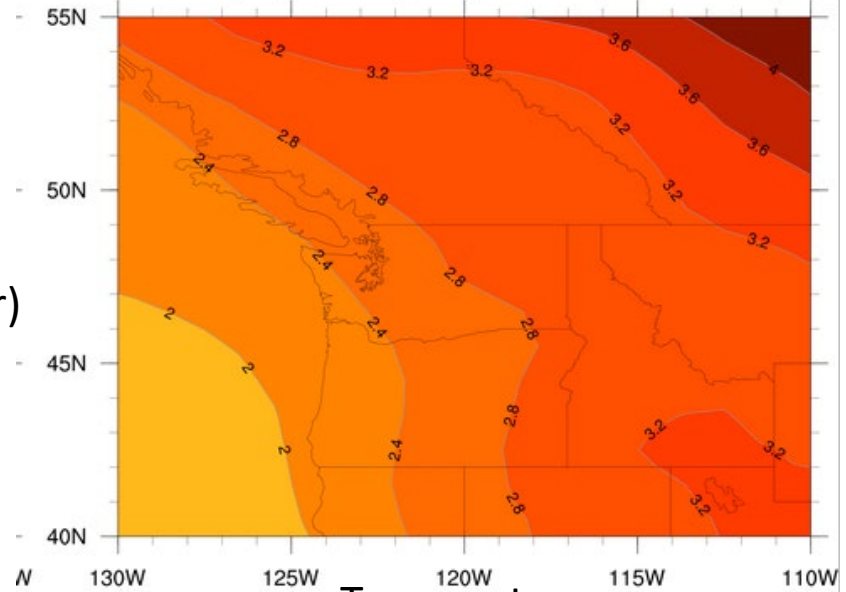
Annual Minimum Temperatures in Eastern WA



Total Snowfall at Spokane

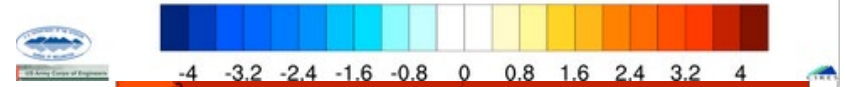


ENSMN rcp85 (2040-2069) - hist (1979-2008) deg C

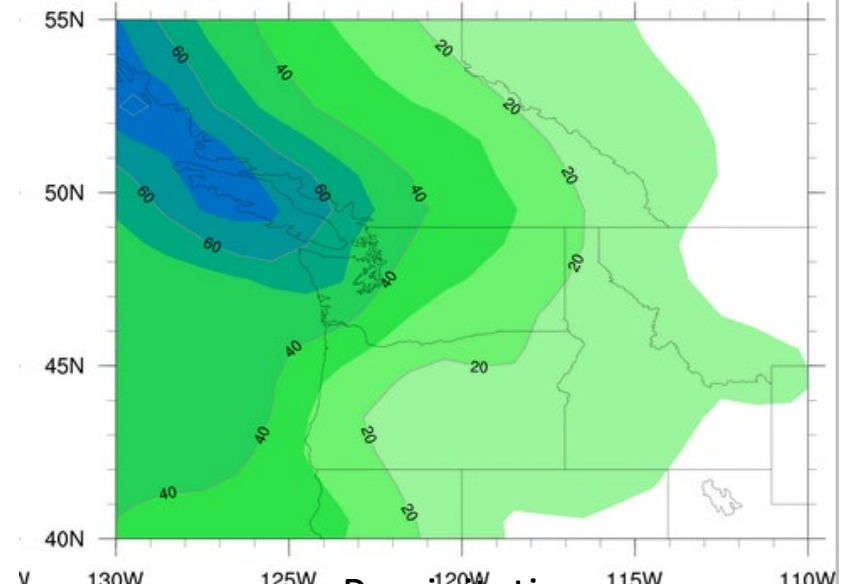


Winter
(Nov-Mar)

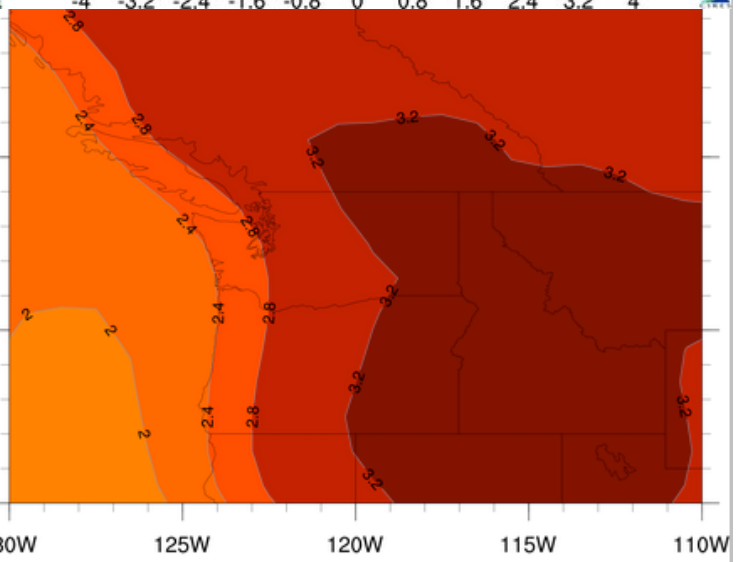
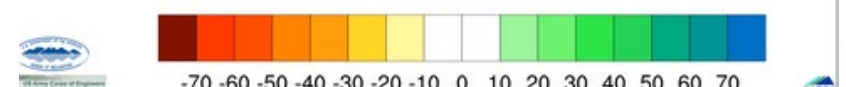
Temperature



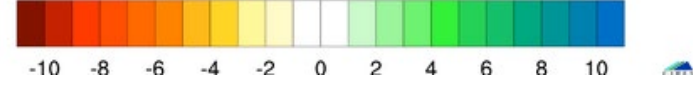
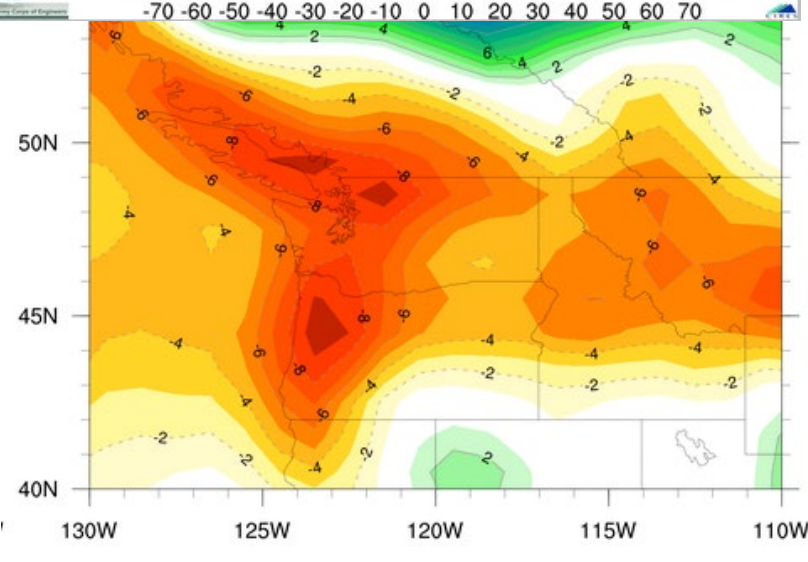
ENSMN rcp85 (2040-2069) - hist (1979-2008) mm



Precipitation

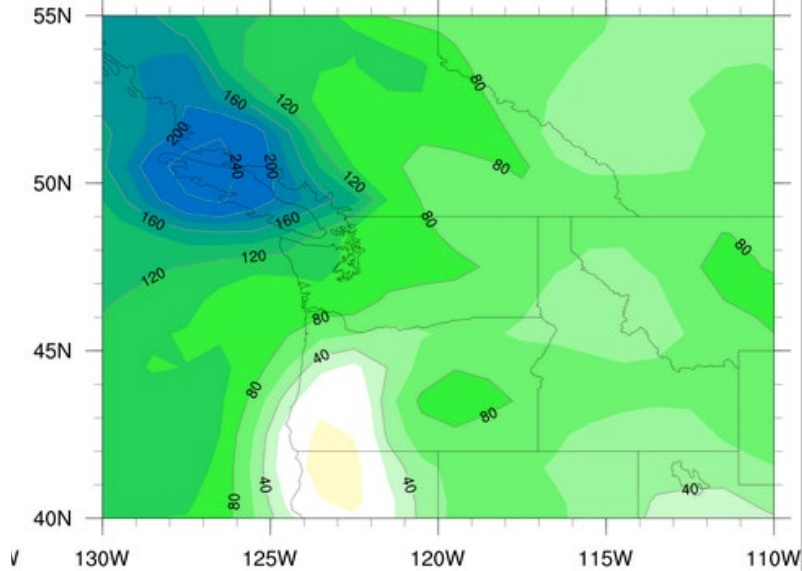


Summer
(Jun-Aug)



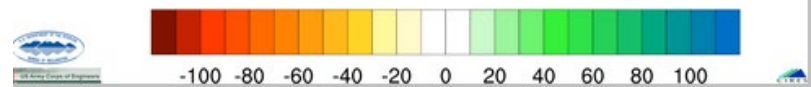
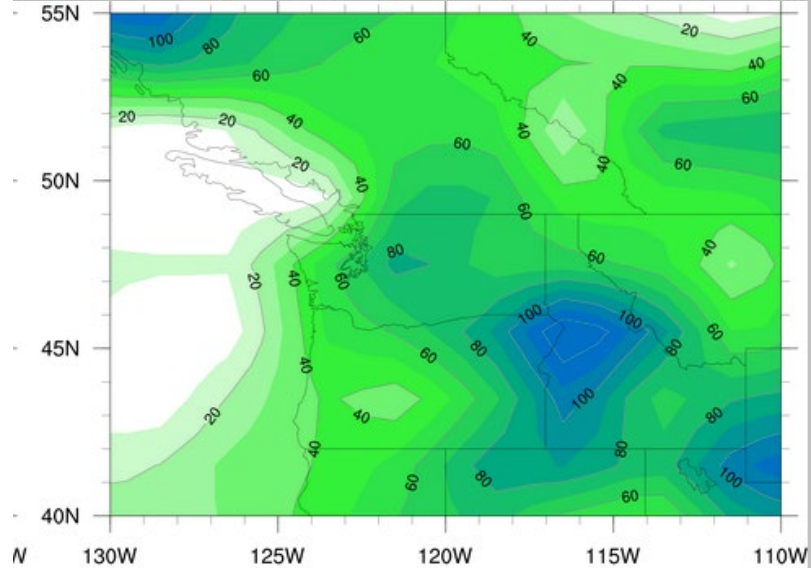
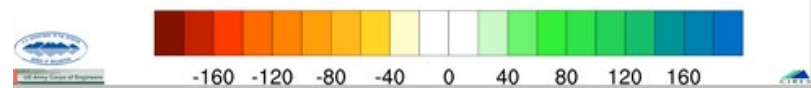
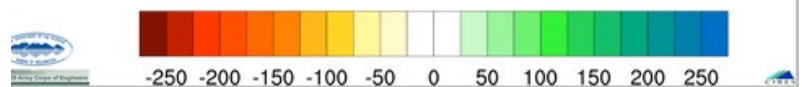
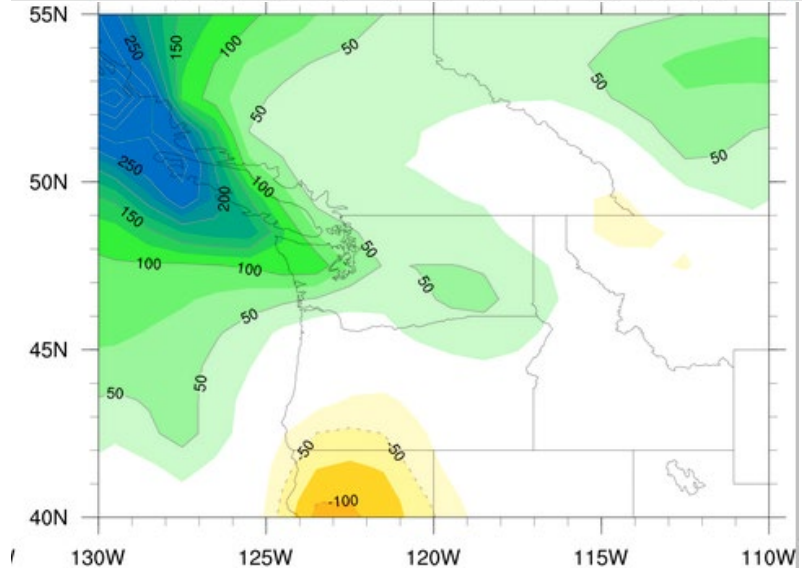
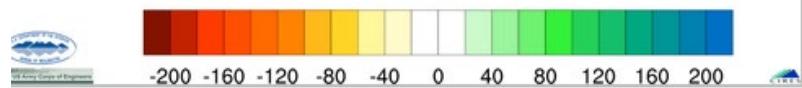
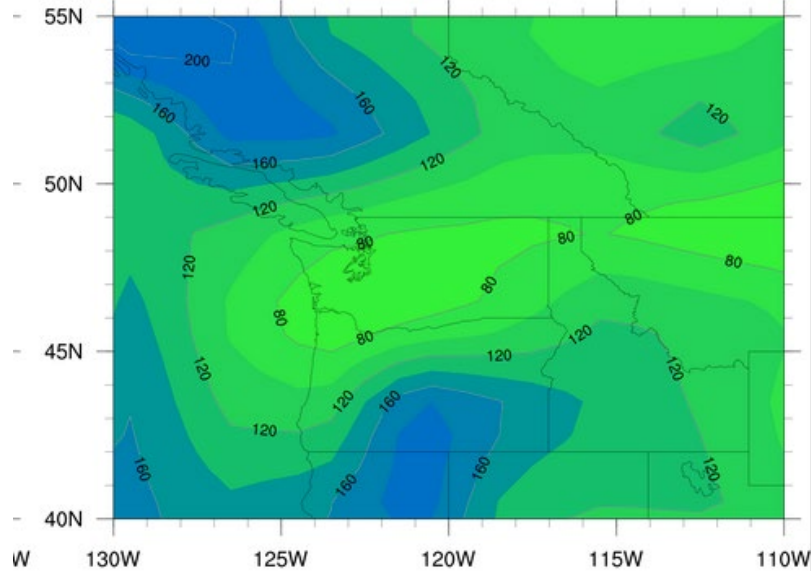
CESM1-CAM5 rcp85 (2040-2069) - hist (1979-2008)

mm

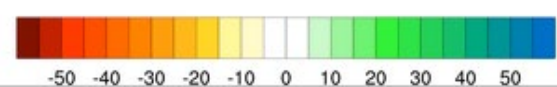
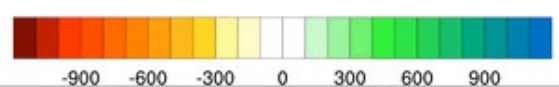
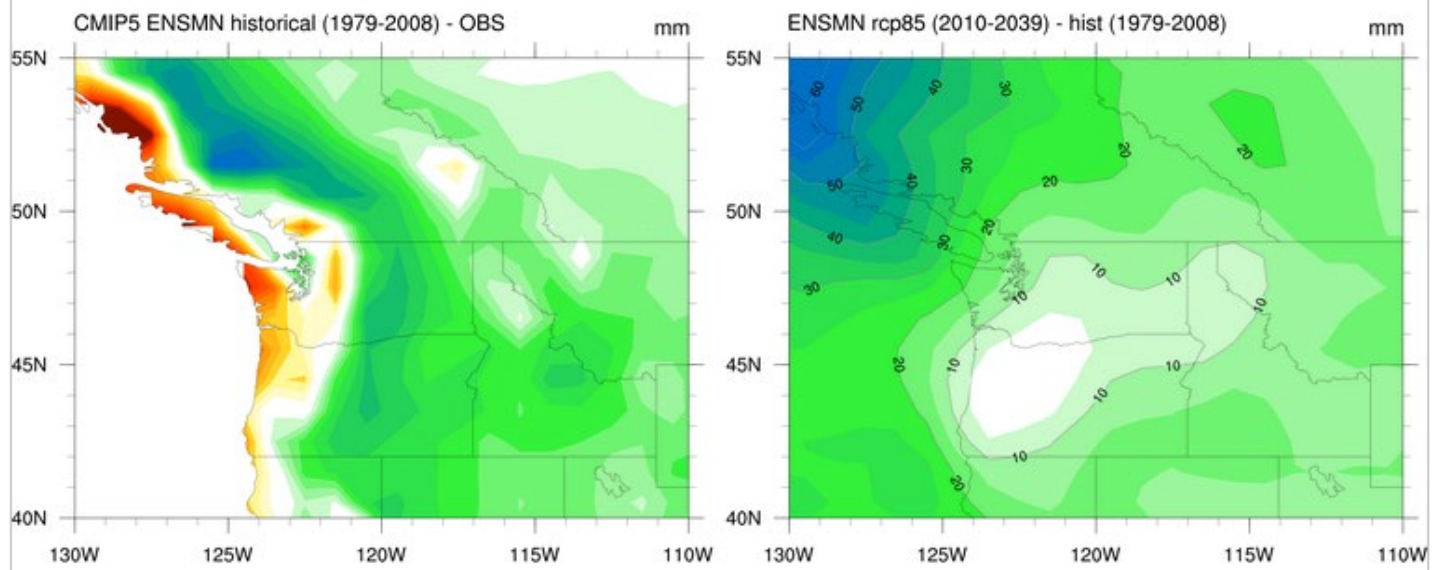
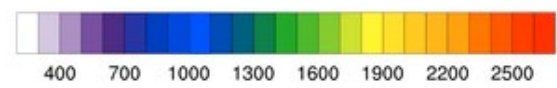
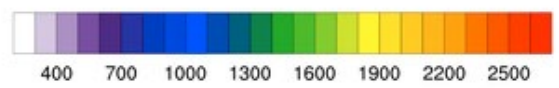
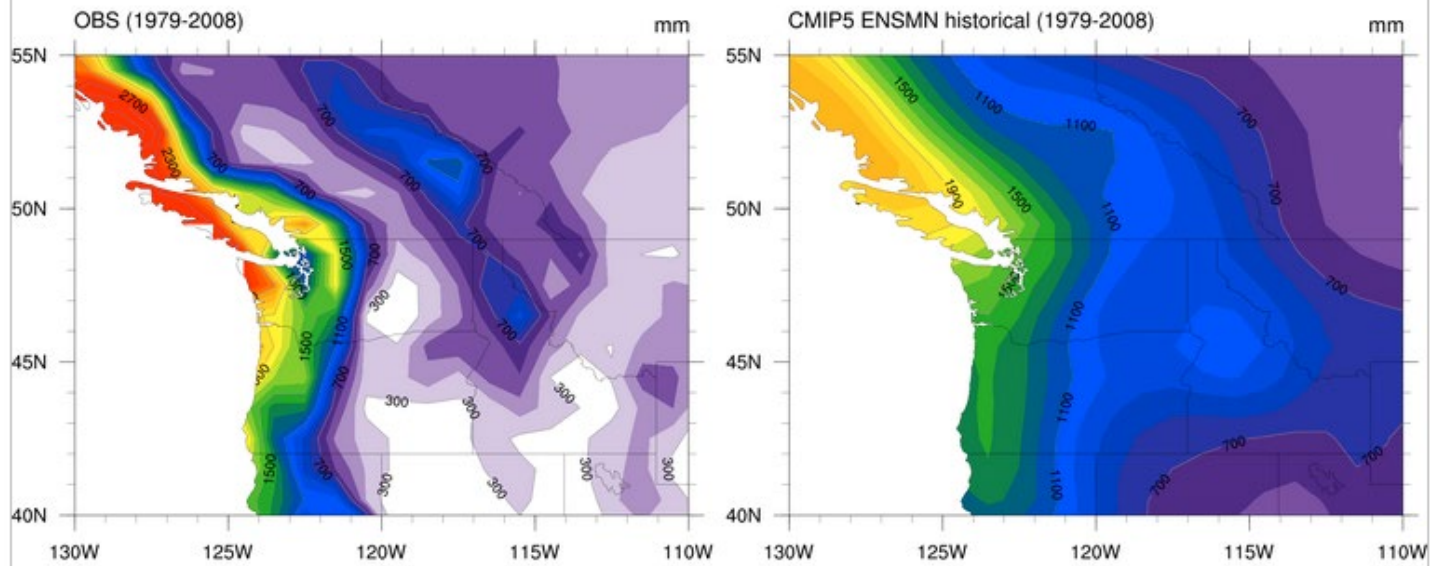


CAN-ESM2 rcp85 (2040-2069) - hist (1979-2008)

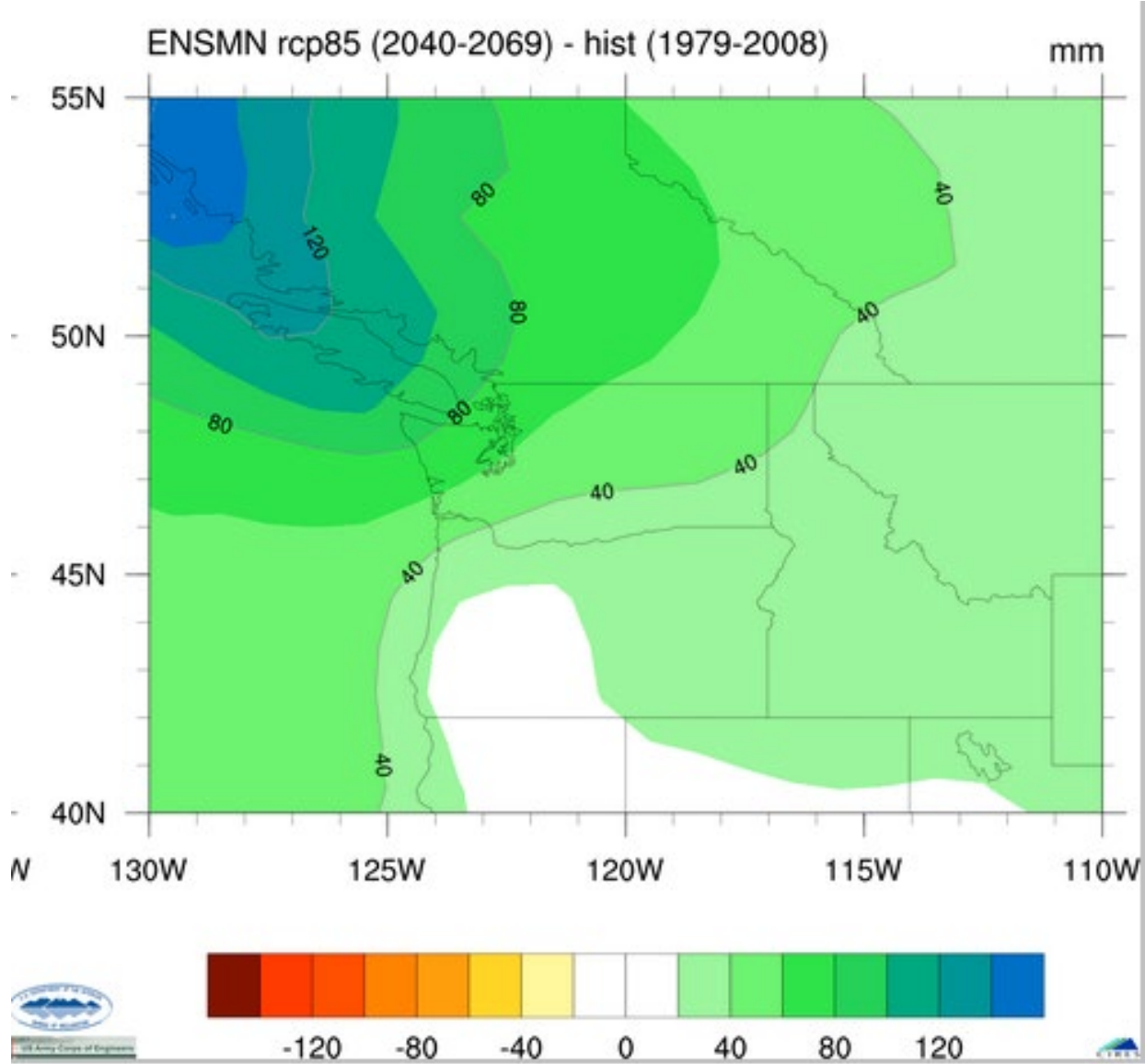
mm



Total Precipitation Climatology ANN

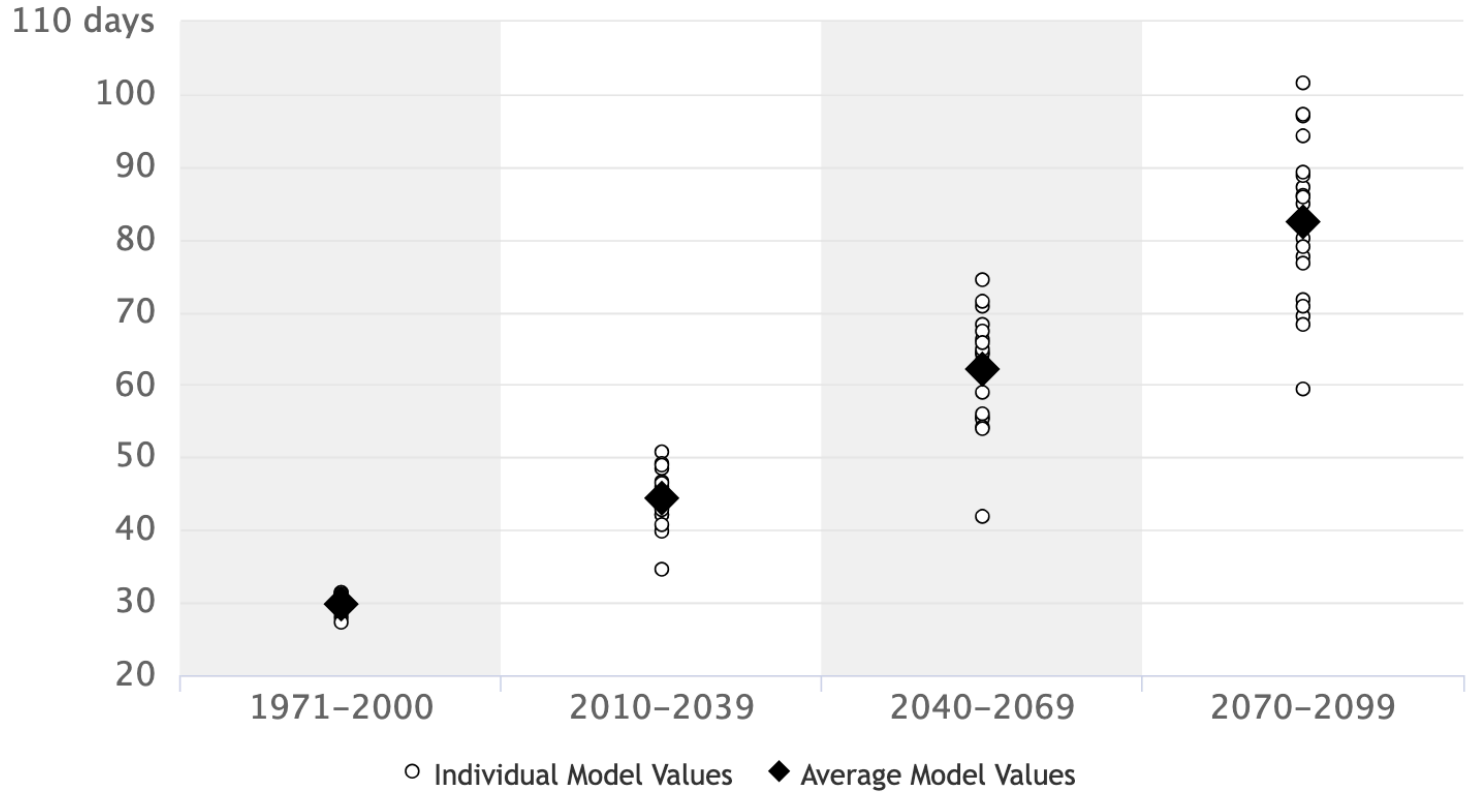


Projected Change in Annual Mean Precipitation



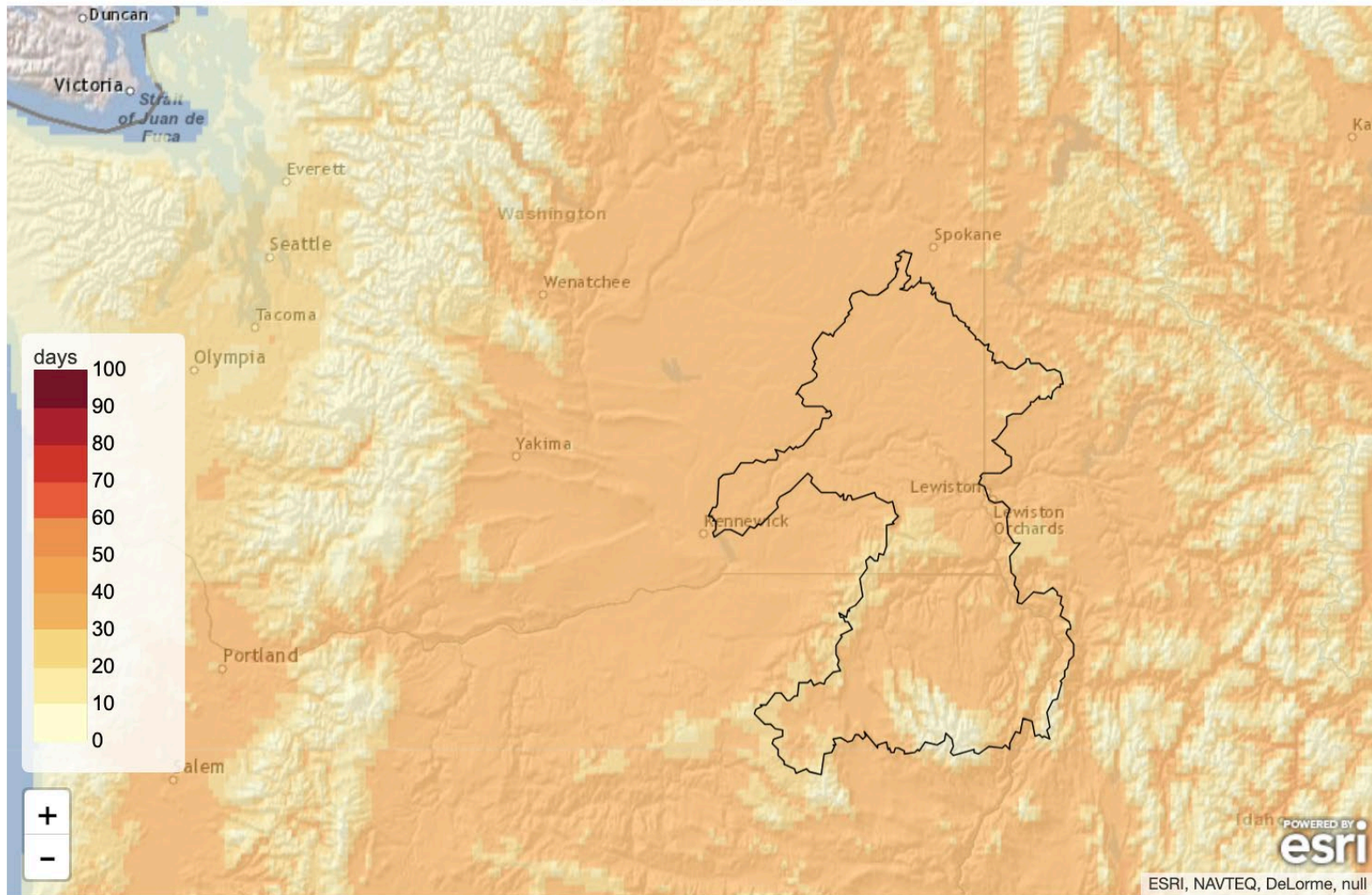
Annual Days With Maximum Temperature Above 86° F (30° C), Higher Emissions (RCP 8.5) ☰

Lower Snake Basin



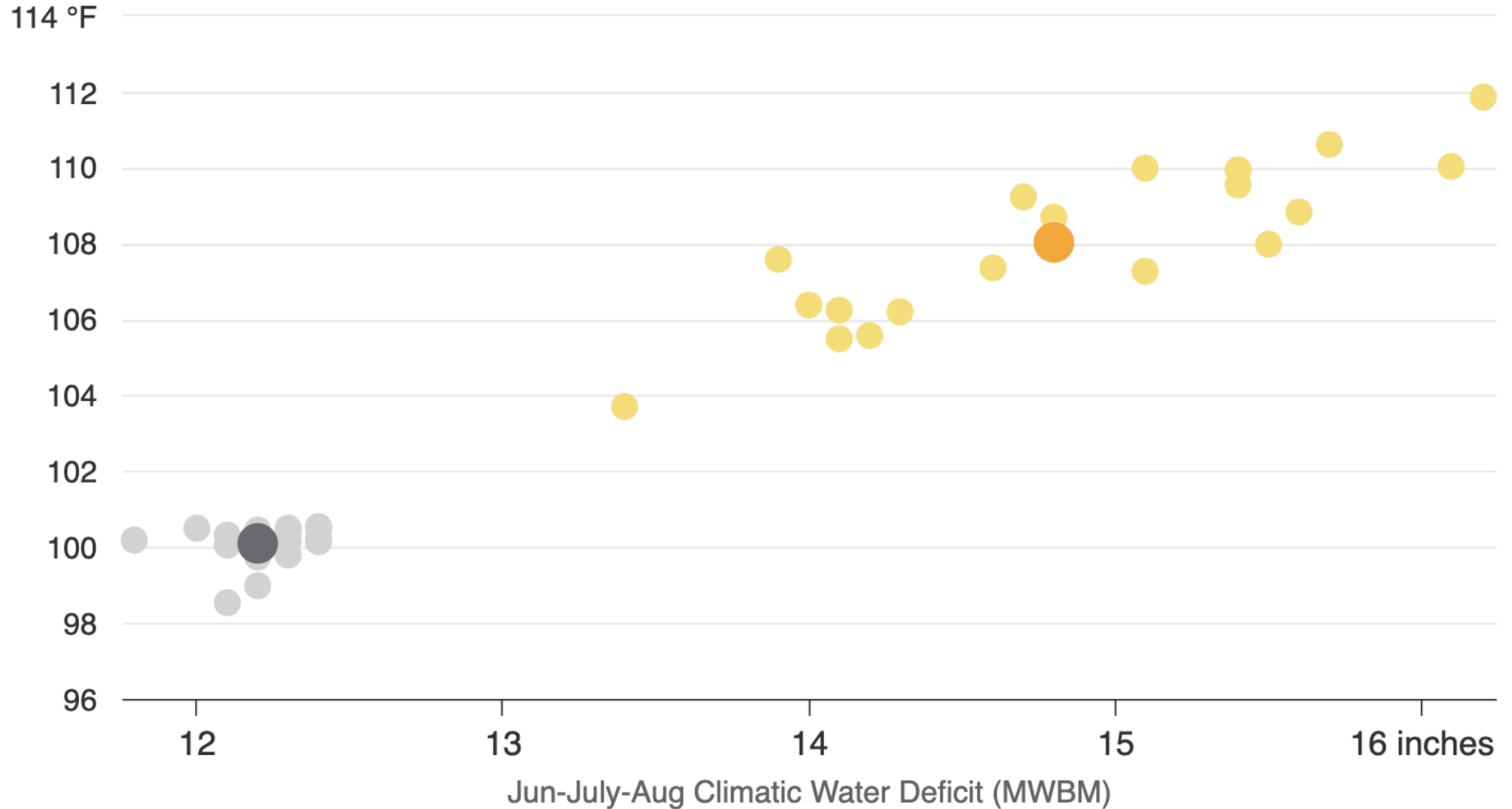
Tribal Climate Tool, Climate Toolbox, Data: MACAv2-METDATA, RCP 8.5, 20-Model Mean

Projected Change in Annual Days With Maximum Temperature Above 86° F (30° C)
2040-2069 (Higher Emissions (RCP 8.5)) vs. 1971-2000 (Historical)
Lower Snake Basin



Projections for 2040-2069 Higher Emissions (RCP8.5) Future Scenario Grant County, Washington

Hottest Day Temperature



Climate Toolbox, Data Source: MACAv2-METDATA (UC Merced)

Graph

Projections for 2040-2069 Higher Emissions (RCP8.5) Future Scenario Franklin County, Washington

Jun-July-Aug Min. Temperature

68 °F

66

64

62

60

58

56

54

20

25

30

35

40

45

50

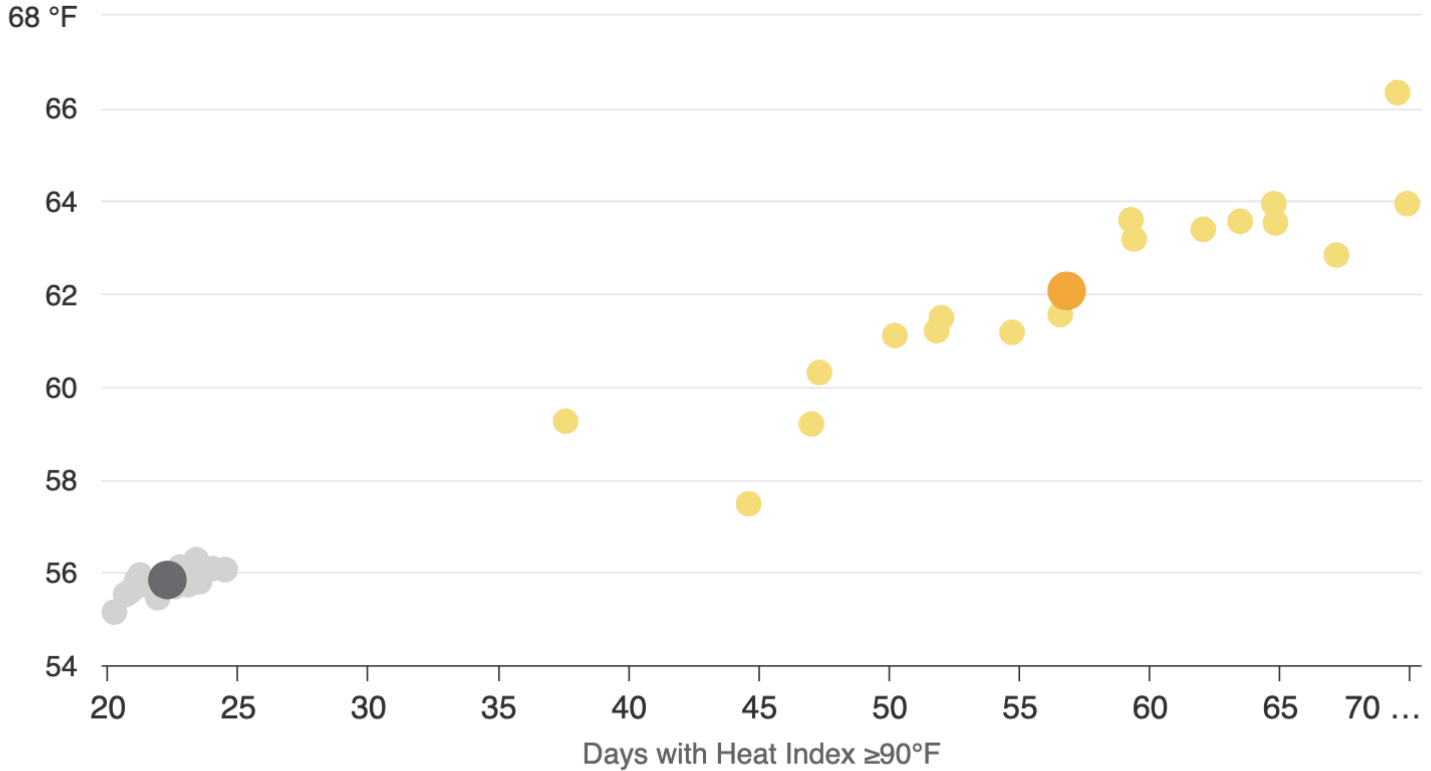
55

60

65

70 ...

Days with Heat Index $\geq 90^\circ\text{F}$



Current Climate Analogs (Moderate Heat Stress)

Whitman Mission National Historic Site
(Visitor Center)



Best
(0-1 st.dev)



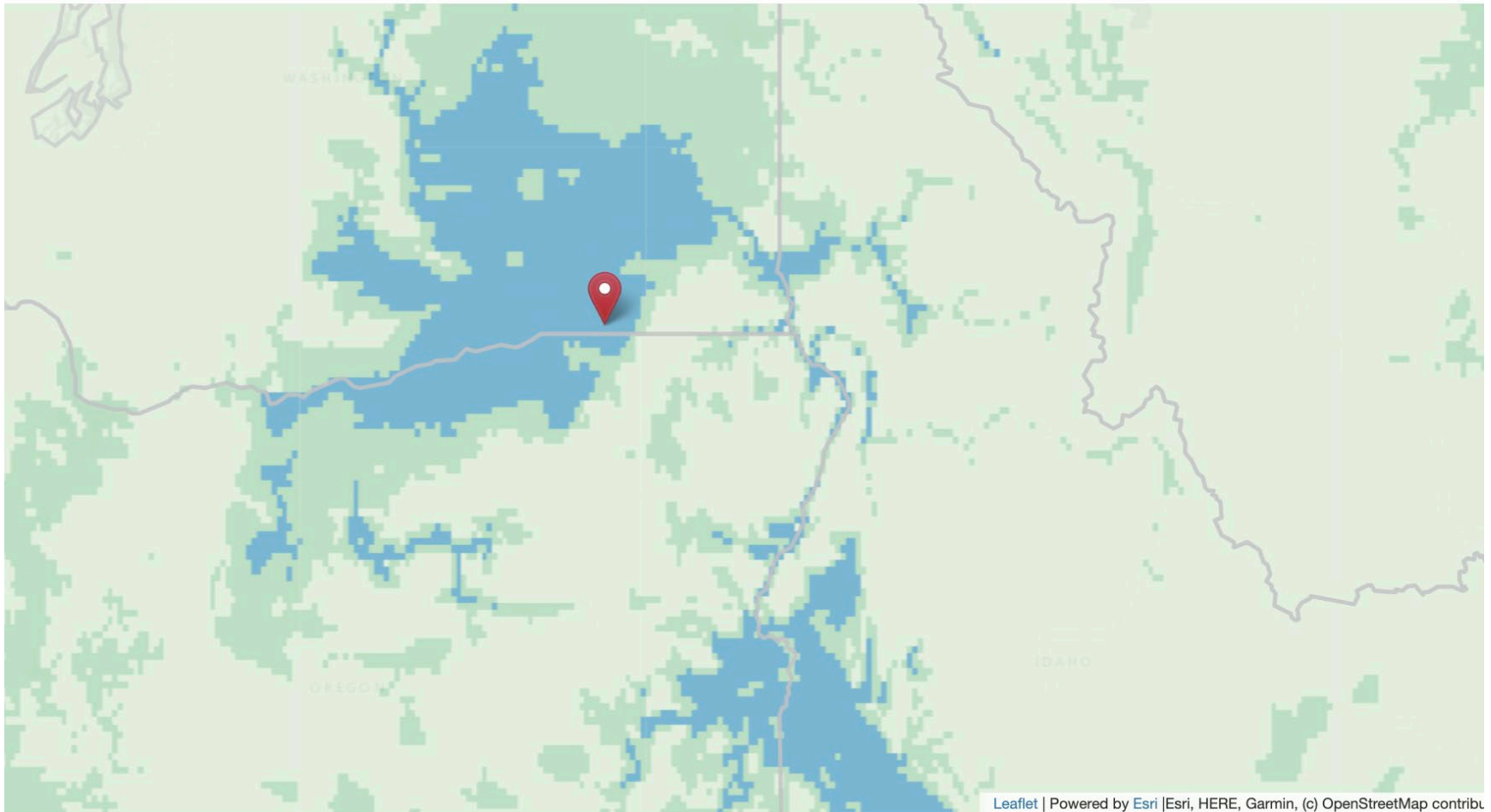
Moderate
(1-2 st.dev)



Poor
(2-3 st.dev)



Not Similar
(>3 st.dev)

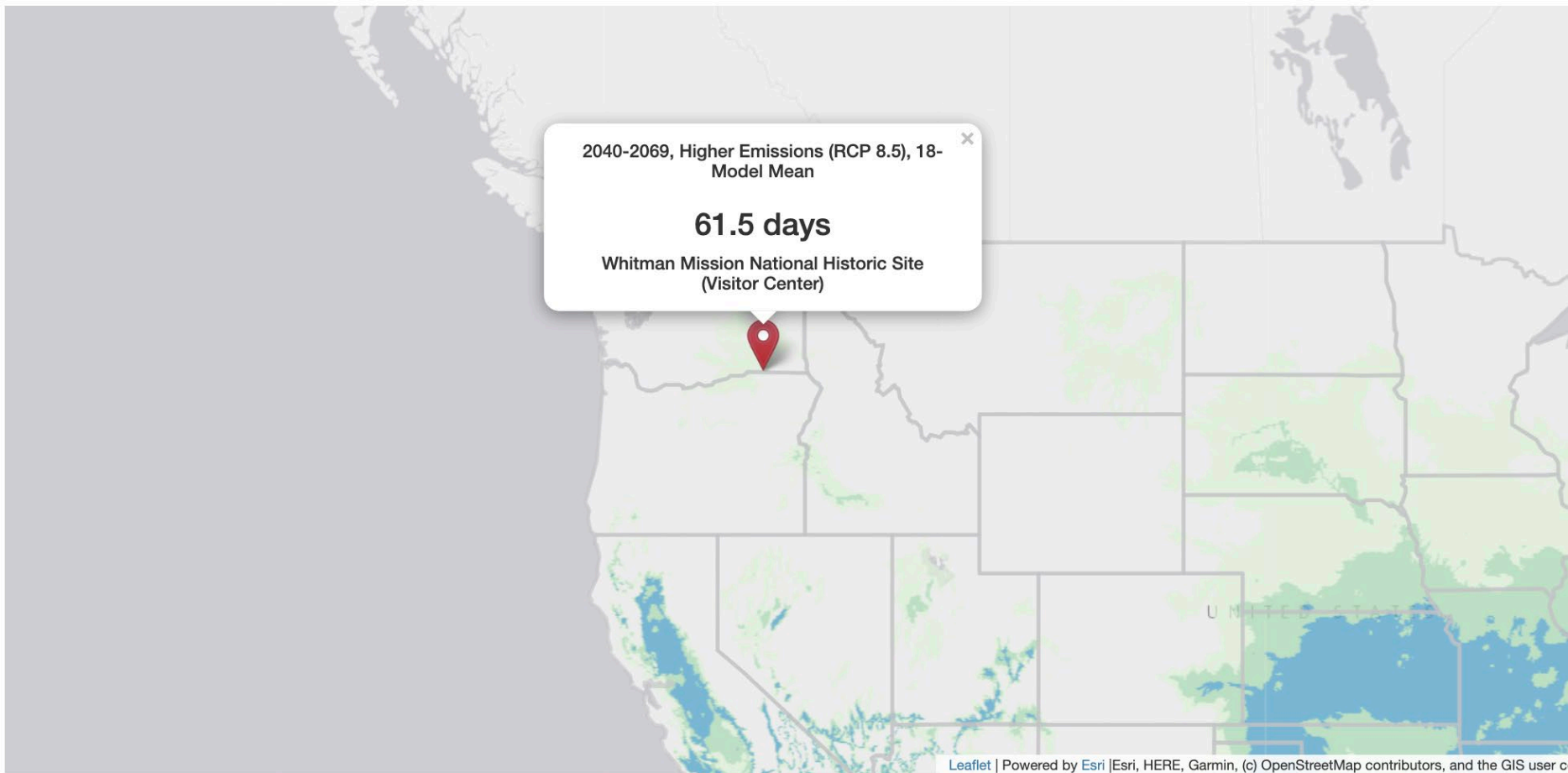
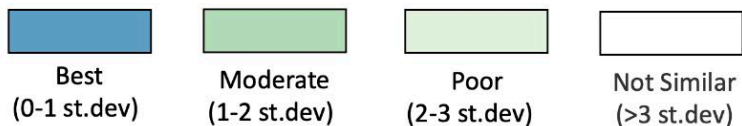


Moderate Heat Stress (Days of Heat Index \geq 90F in Apr-Oct)

1971-2000, Historical Emissions, 18-Model Mean

Future Climate Analogs

Whitman Mission National Historic Site (Visitor Center)

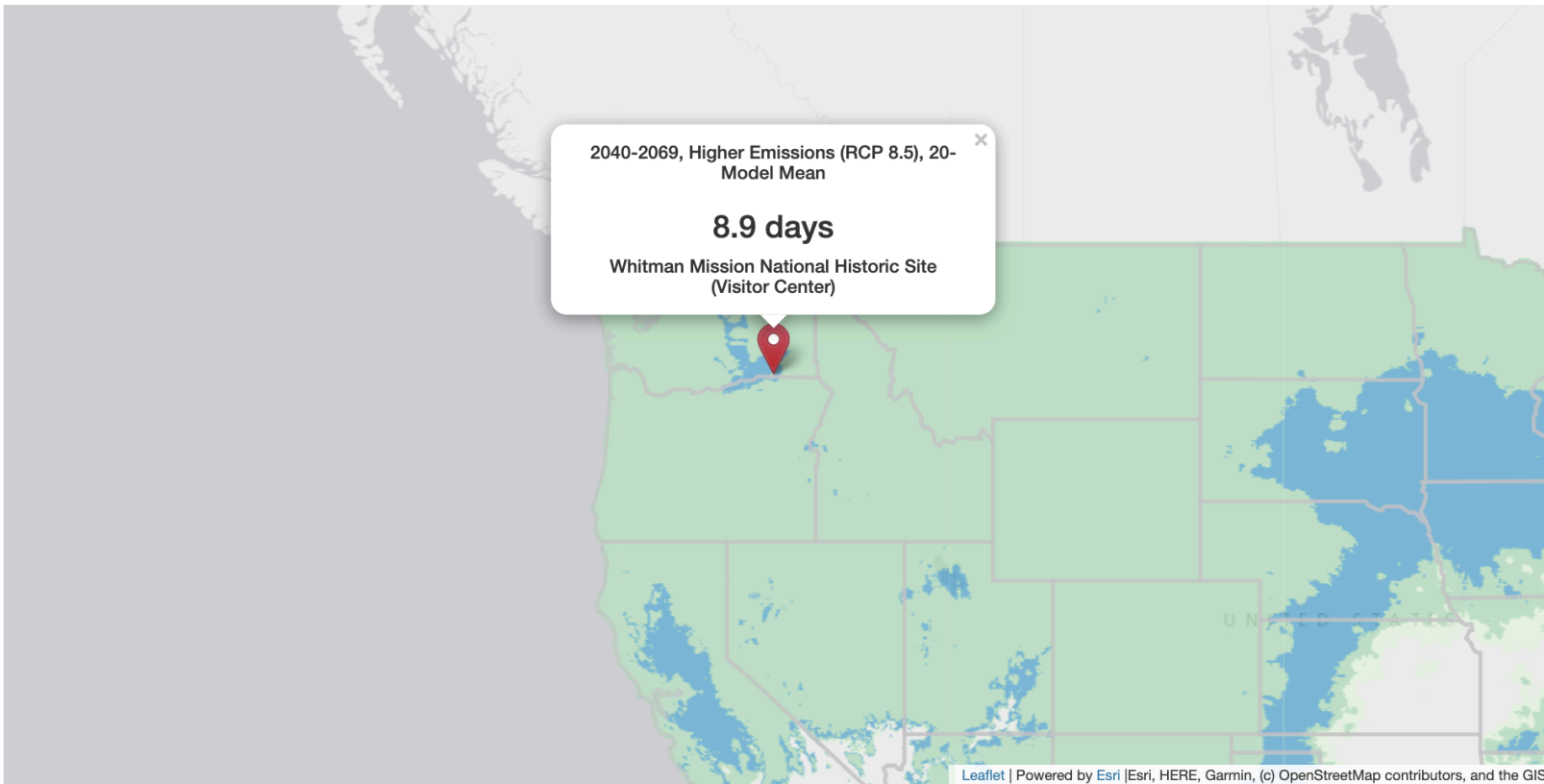


Moderate Heat Stress (Days of Heat Index \geq 90F in Apr-Oct)

2040-2069, Higher Emissions (RCP 8.5), 18-Model Mean

Future Climate Analogs

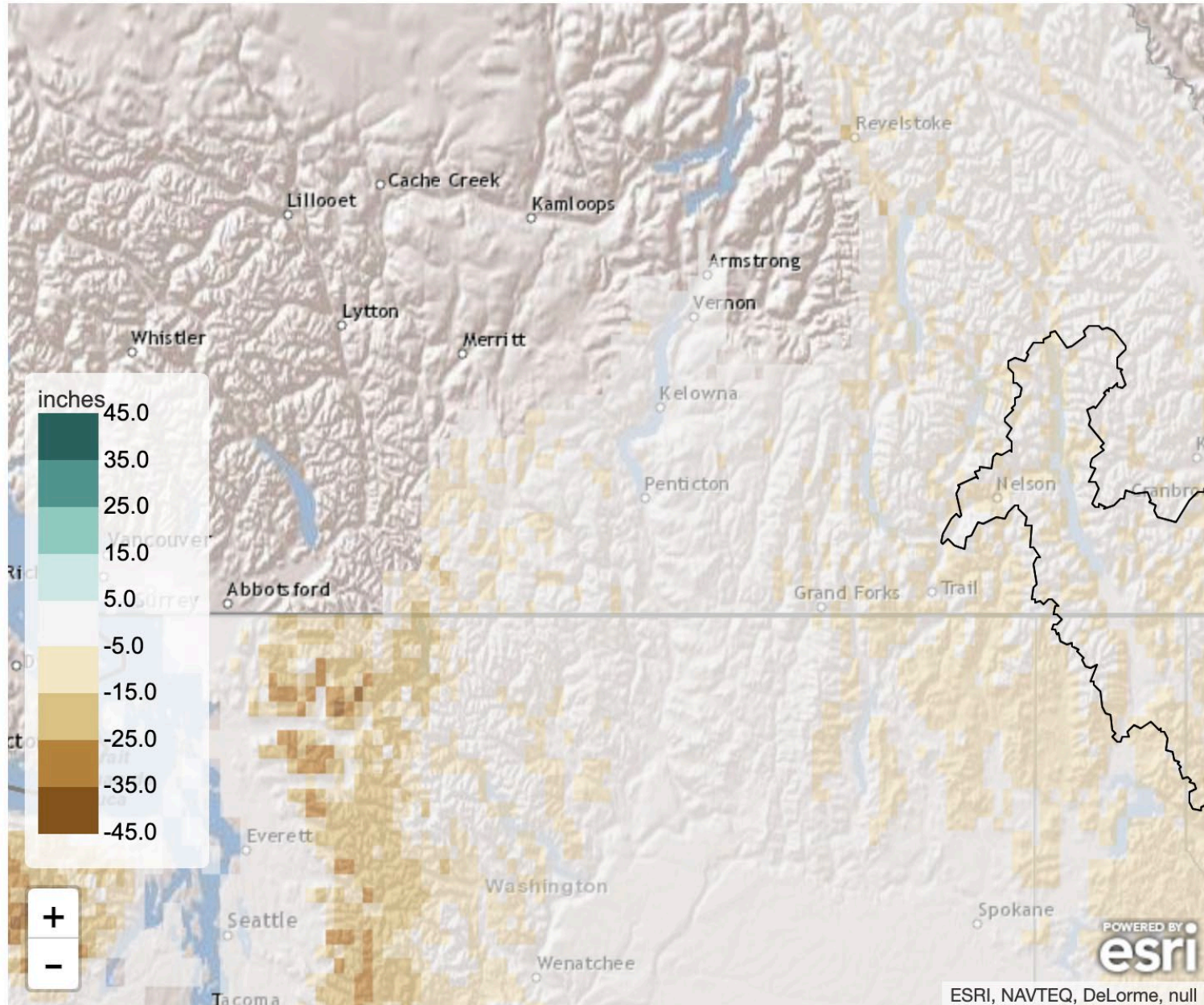
Whitman Mission National Historic Site
(Visitor Center)



Hot Nights (Days of Min Temperature \geq 70F)

2040-2069, Higher Emissions (RCP 8.5), 20-Model Mean

Projected Change in Apr. 1st Average Snow Water Equivalent 2040-2069 (Higher Emissions (RCP 8.5)) vs. 1971-2000 (Historical) Kootenai Basin



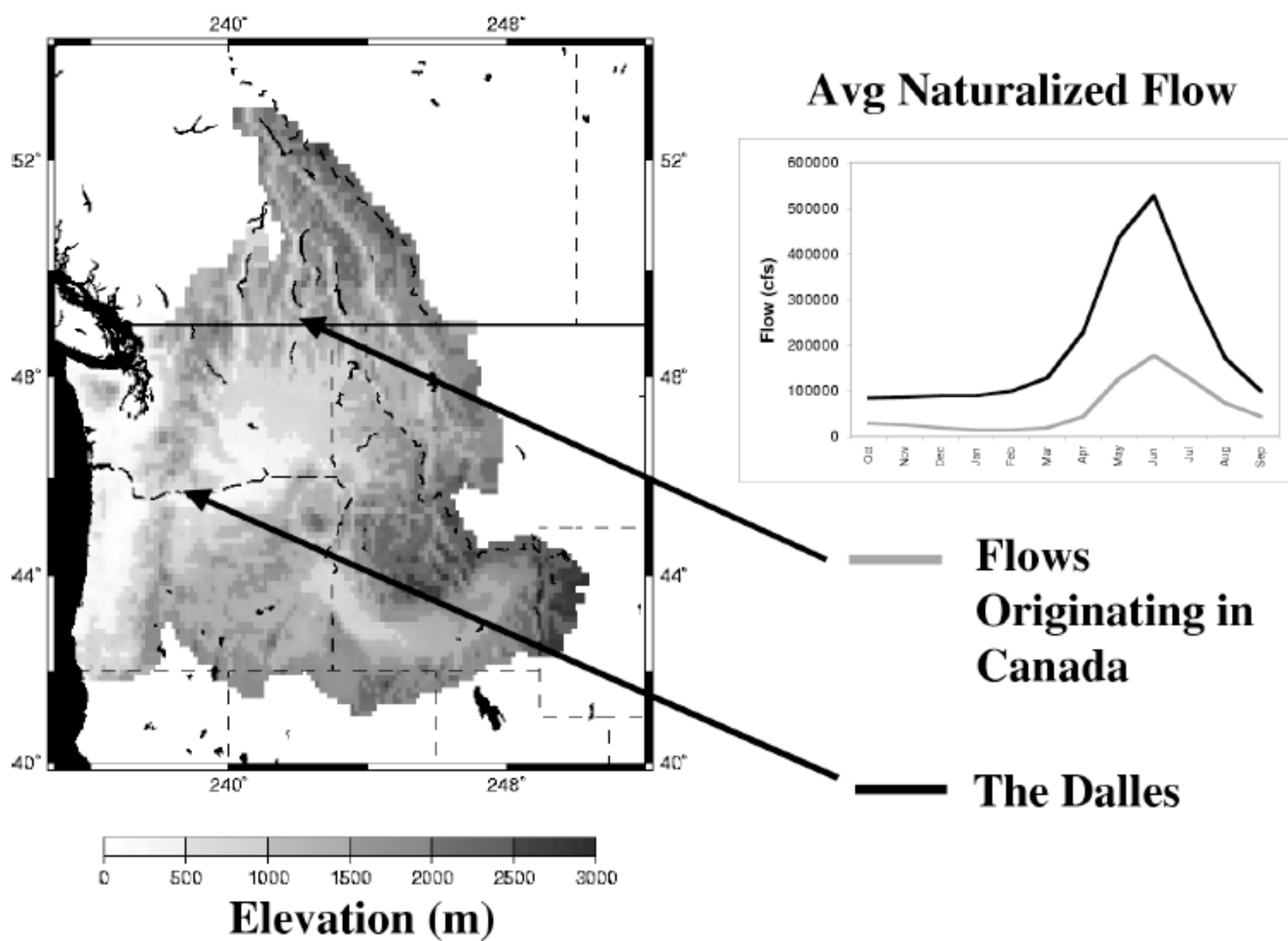


Figure 1. Topography of the Columbia River Basin, and composite mean monthly hydrographs for natural flows at The Dalles, Oregon, and flows originating in Canada.

INDESCRIBABLE...

INDESTRUCTIBLE!

NOTHING CAN STOP IT!

THE BLOB

STORY BY
**STEVEN
McQUEEN**

SCREENPLAY BY
**ANITA
CORSEAUT · ROWE**

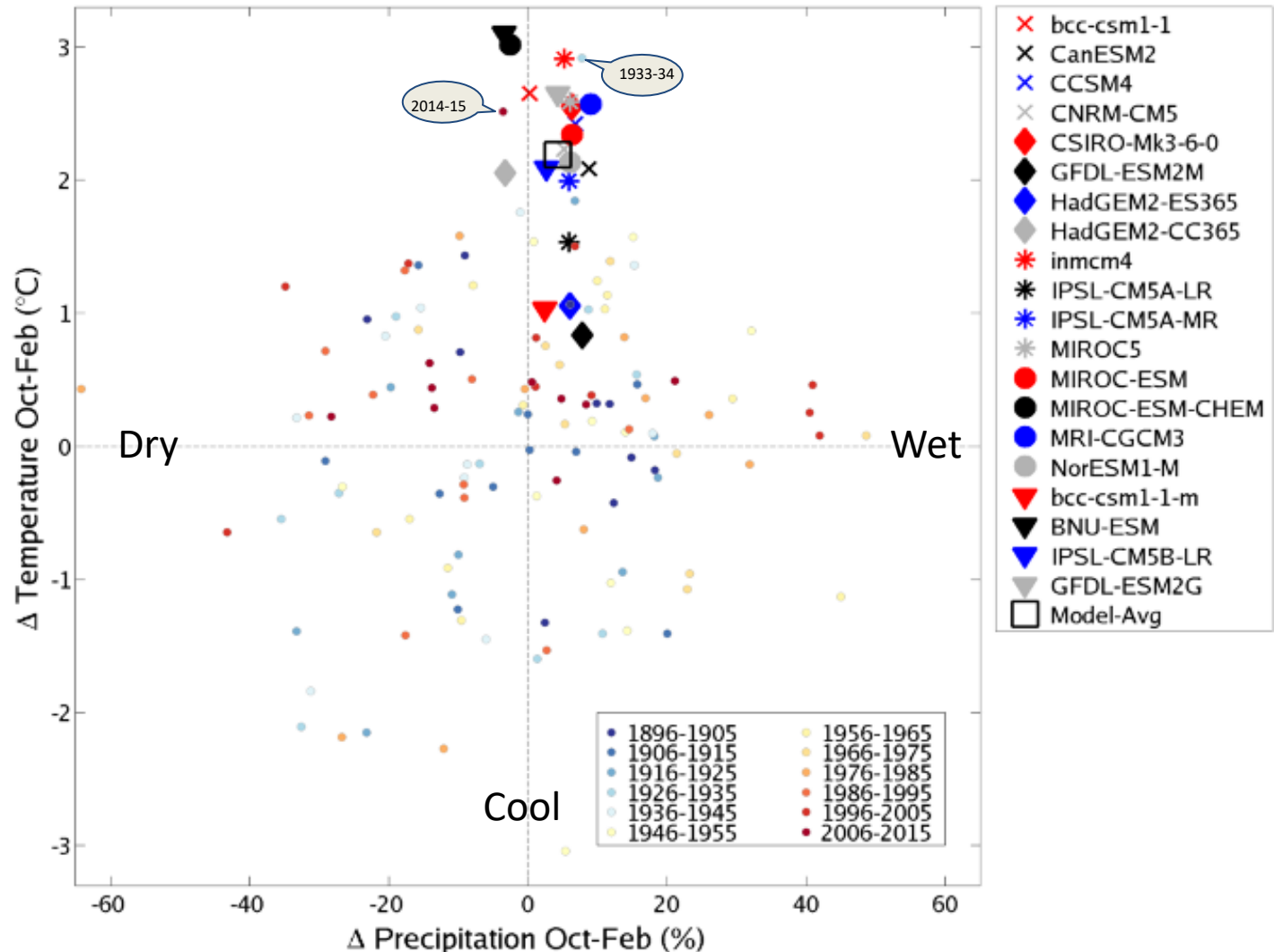
PRODUCED BY **JACK H. HARRIS · IRVIN S. YEAWORTH, JR.** DIRECTED BY **THEODORE SIMONSON** AND **KATE PHILLIPS**

SCREENPLAY BY
FROM AN IDEA BY IRVING H. MOLLGATE
A TONYLYN PRODUCTION · **LOAN BY DE LOVE**



The 2015 drought is the type of drought we expect to become more common in a warmer climate.

US Pacific Northwest, 42-48°N, 112-124°W ; 2040-2069, RCP4.5
Oct-Feb Temperature vs. Oct-Feb Precipitation

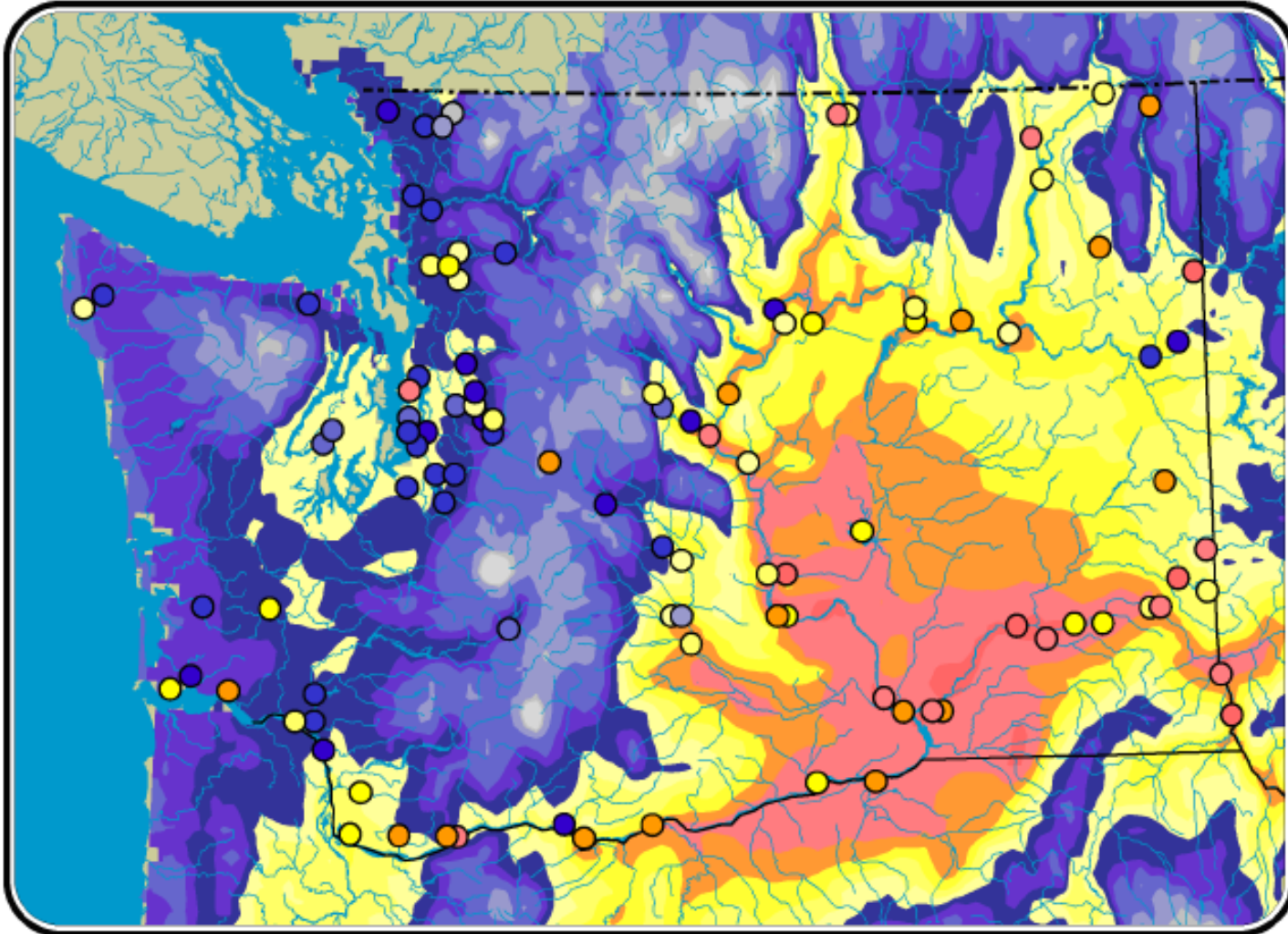




**Mouth of
White Salmon River
July 2015**

*Northwest Power
and Conservation
Council*

August Mean Surface Air Temperature and Maximum Stream Temperature, 1970-1999

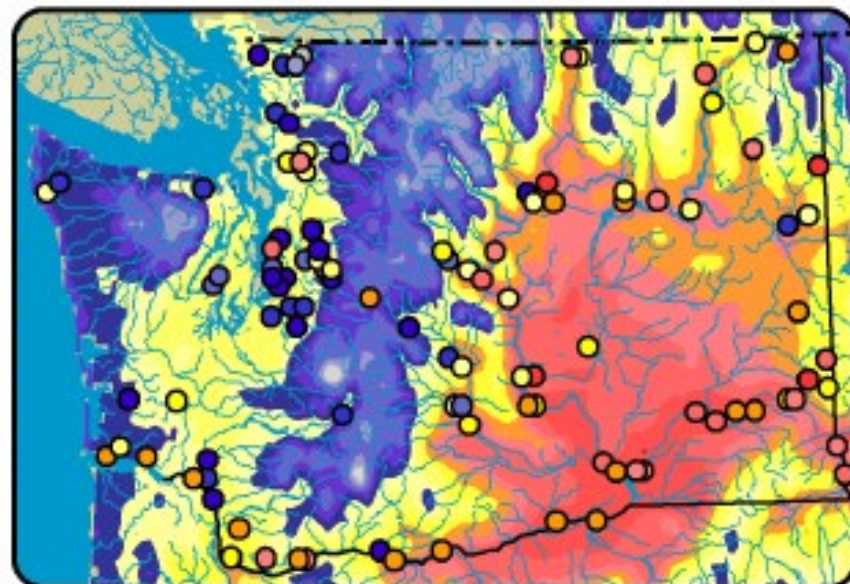
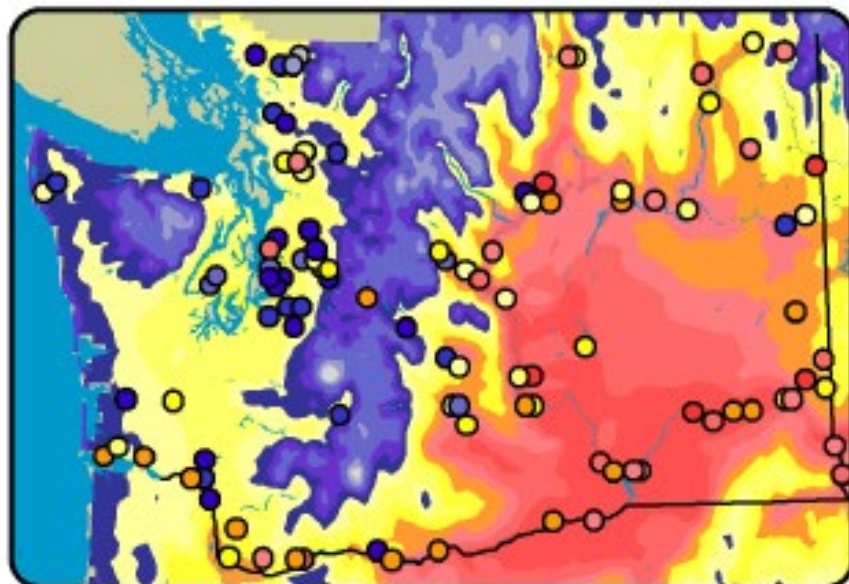


August Mean Surface Air Temperature and Maximum Stream Temperature

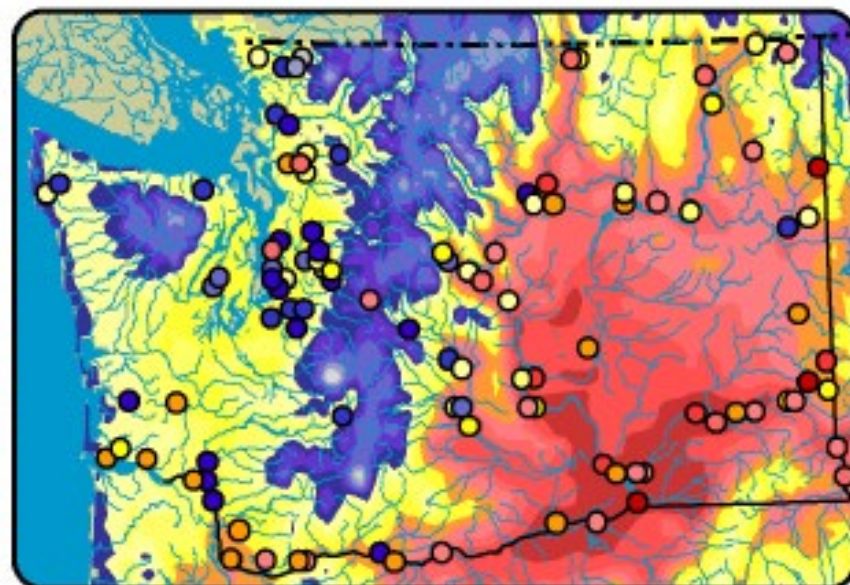
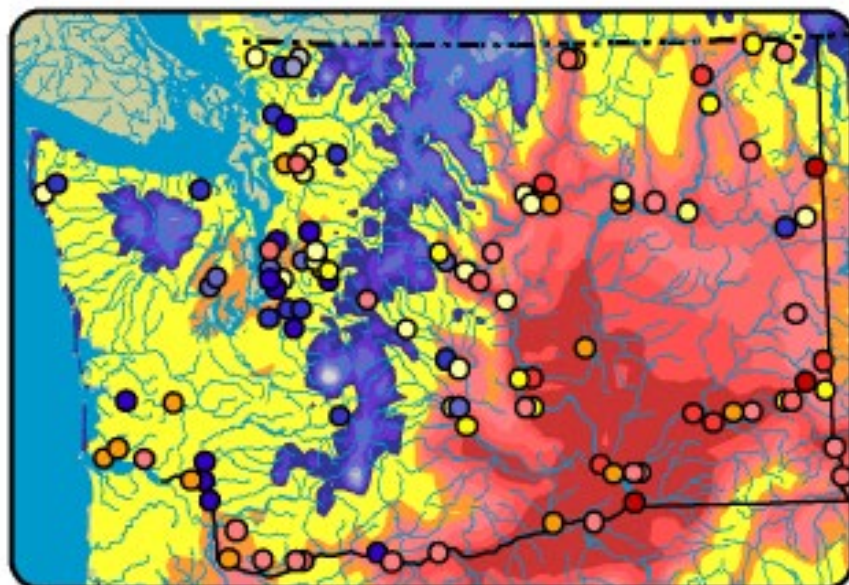
A1B

B1

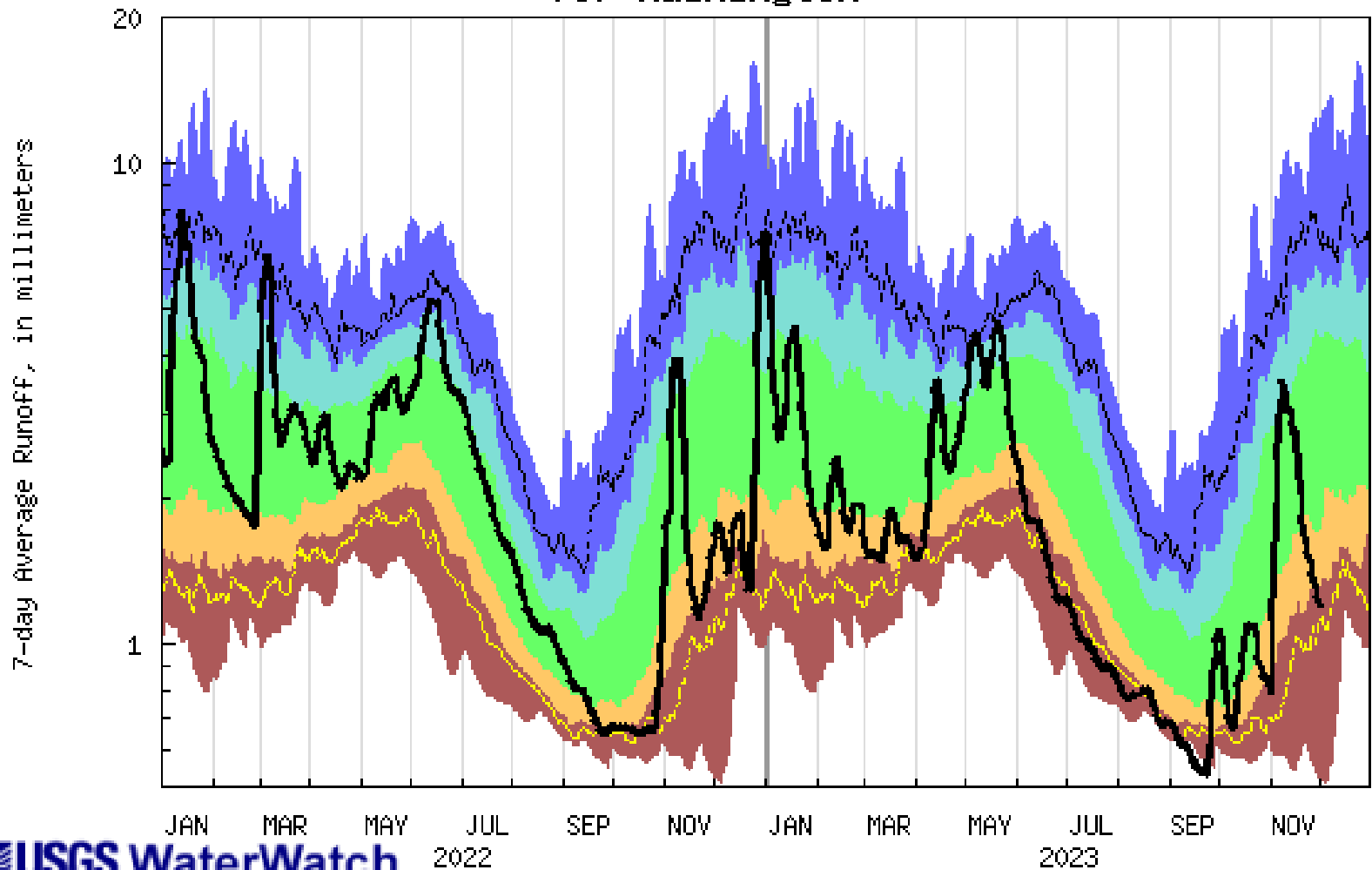
2020s



2040s




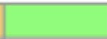





Duration hydrograph of 7-day average runoff for Washington



USGS WaterWatch

Last updated: 2023-12-02

Explanation - Percentile classes						
						
lowest-10th percentile	5	10-24	25-75	76-90	95	90th percentile-highest
Much below Normal	Below normal	Normal	Above normal	Much above normal		Runoff

TAKE AWAY POINTS

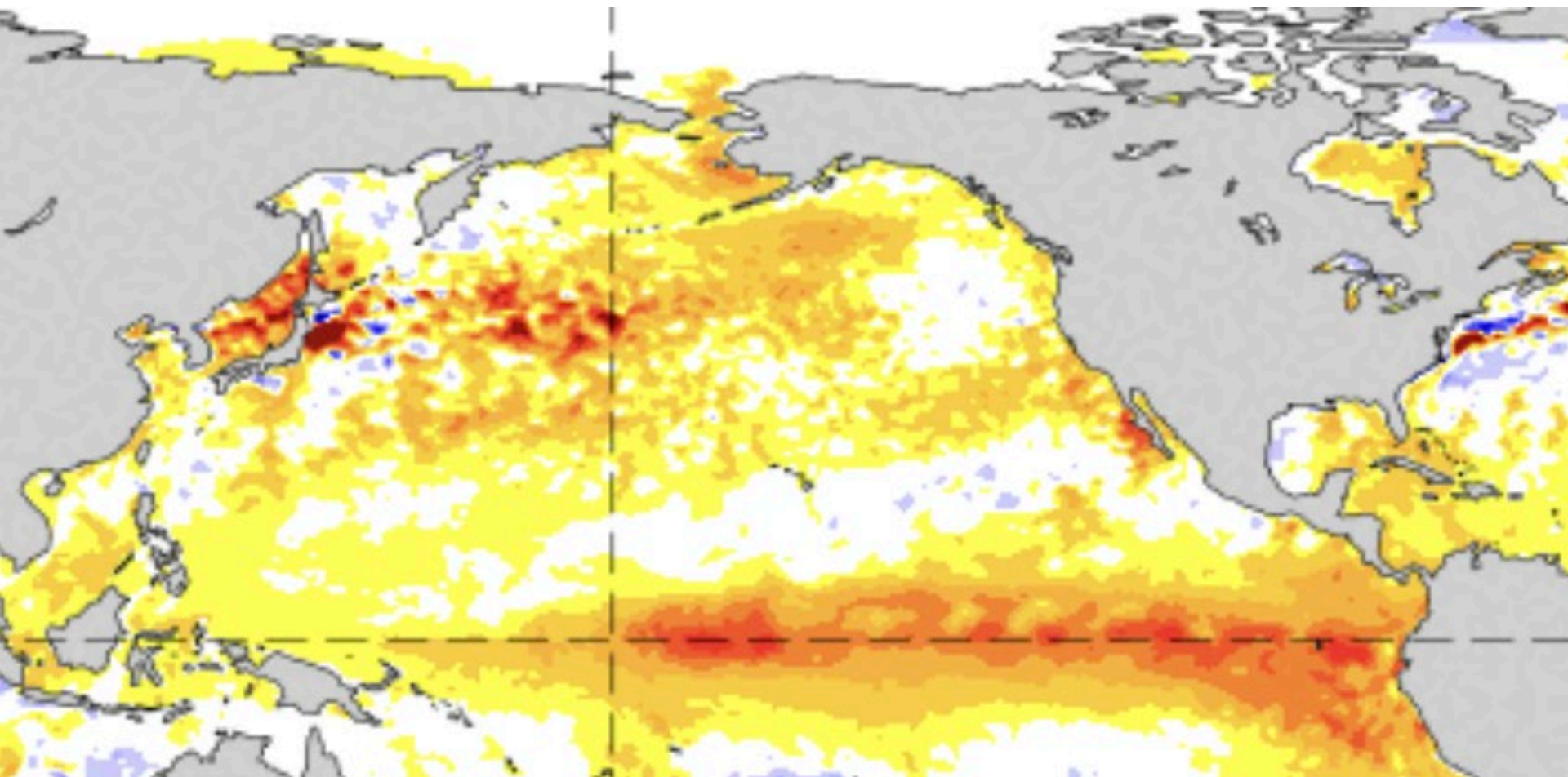
Observations indicate slowly rising temperatures with considerable variability on time scales of years to decades

Trends in observed precipitation in the region are minimal, except in summer (maybe!)

Climate model projections indicate that trends in mean temperature will surpass the present variability near the middle of the 21st century

The consensus of the climate models is for wetter winters and slightly drier summers

SST Anomalies: 26 Nov – 2 Dec 2023



EL NIÑO

LALO
ALCARAZ
©2016
DISTRIBUTED BY
UNIVERSAL PICTURES
SYNCHRONIC



Weather

El Niño

El Beño

El Producto

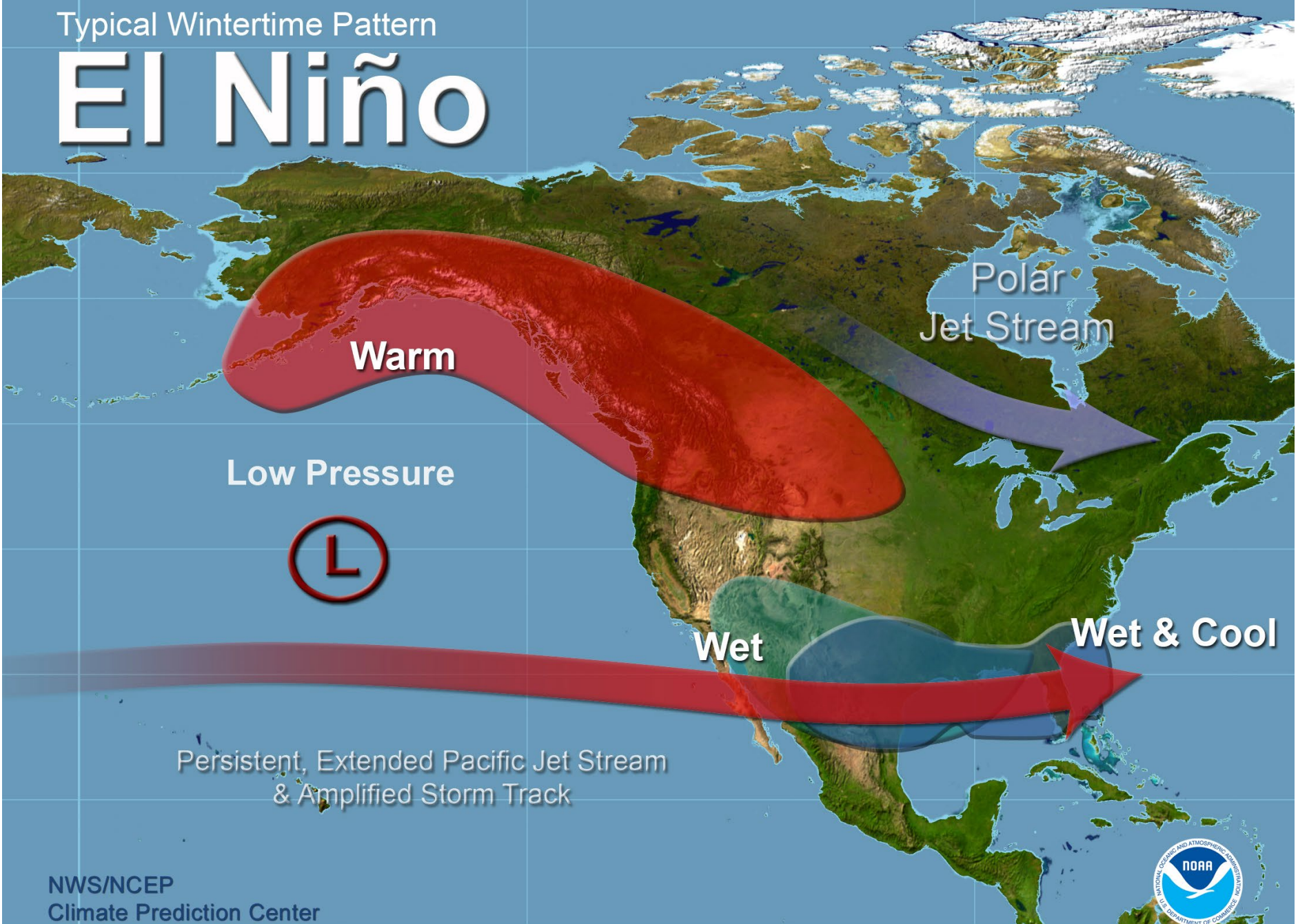
El Xpresso
Machino

El Streamo del Jetto

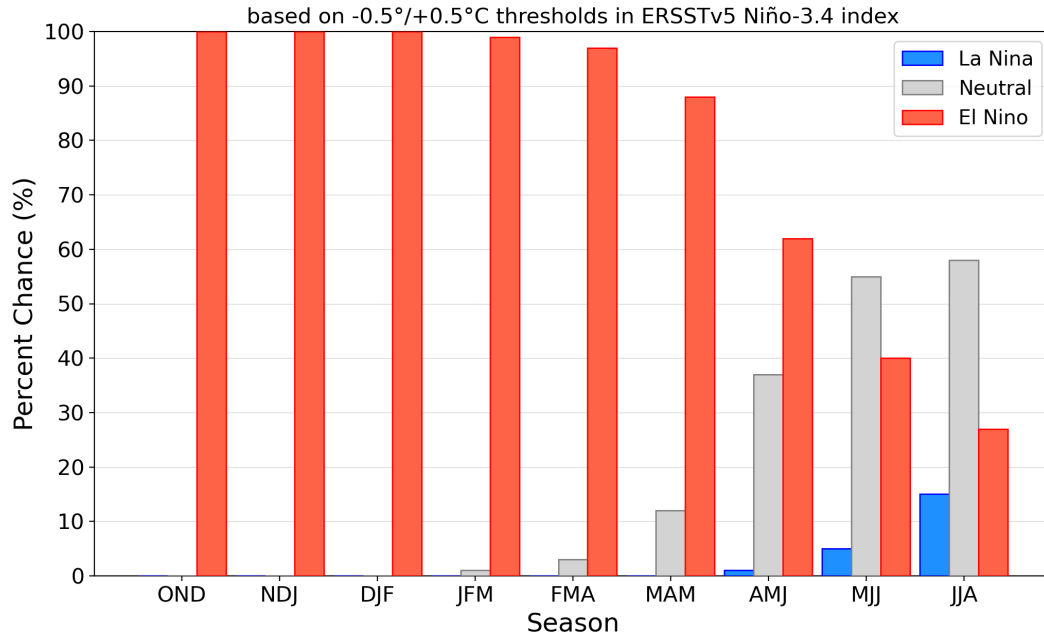


Typical Wintertime Pattern

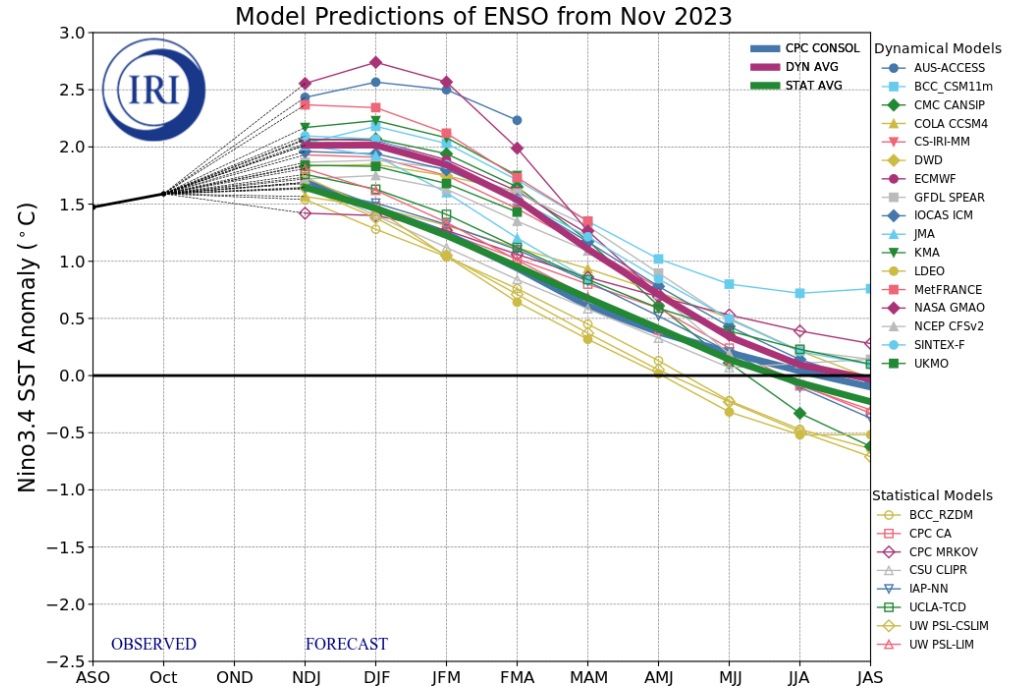
El Niño



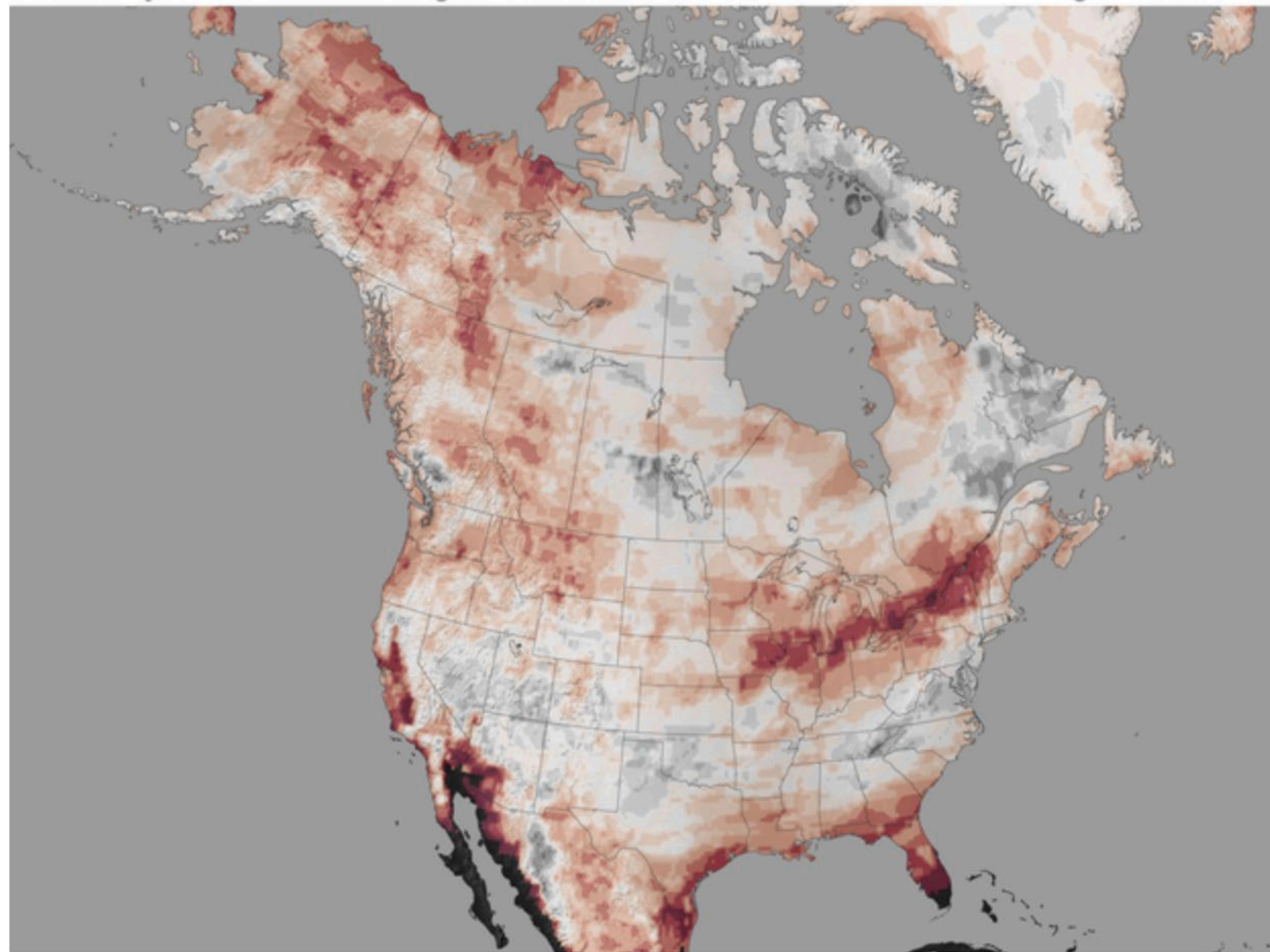
Official NOAA CPC ENSO Probabilities (issued Nov. 2023)



El Nino continuing this winter is a lead-pipe cinch, but how strong?



How many moderate-to-strong El Niño winters (Jan-Mar) had below-average snowfall?



1959-2023

number of years (out of 13)



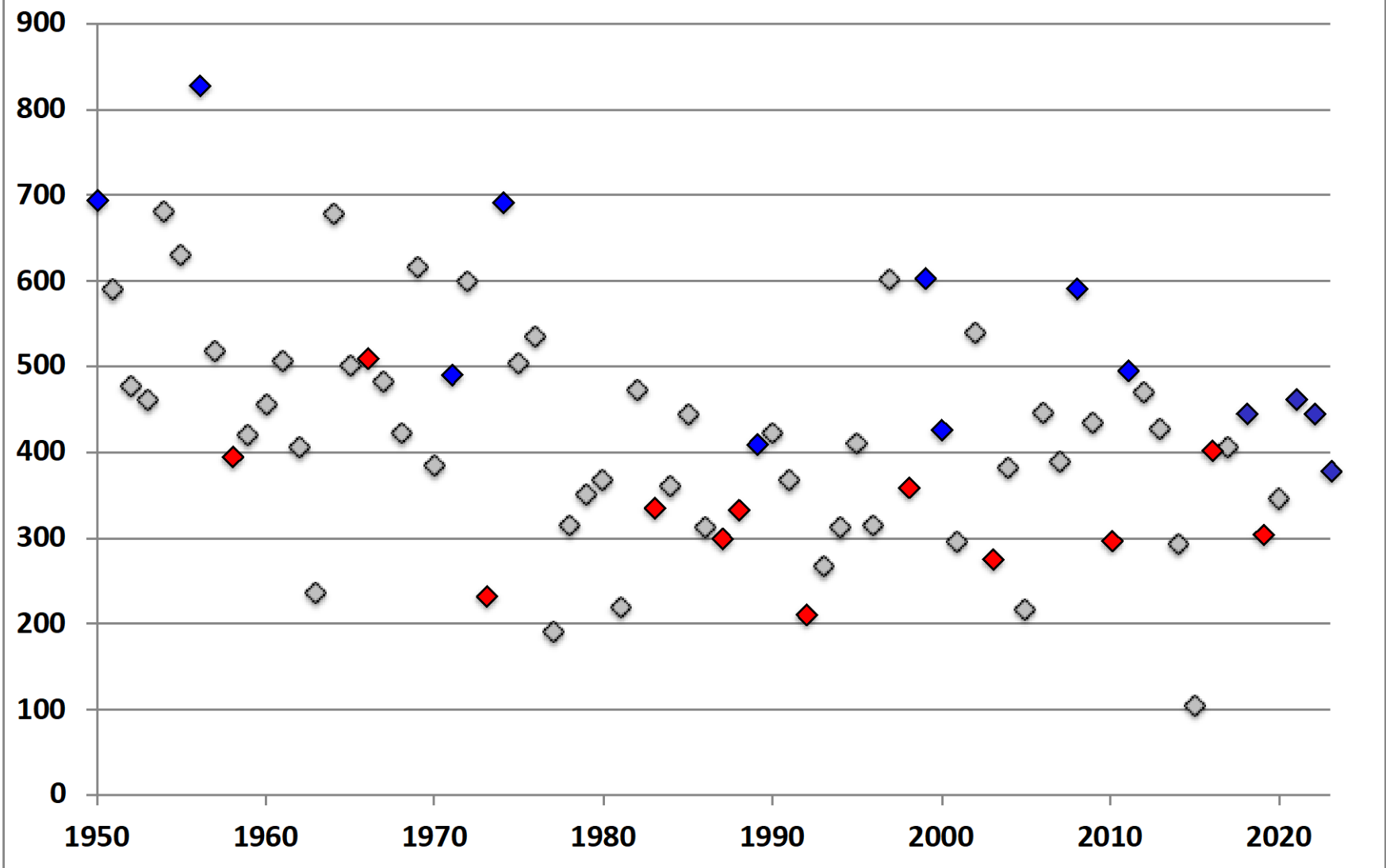
NOAA Climate.gov
Data: ERA5





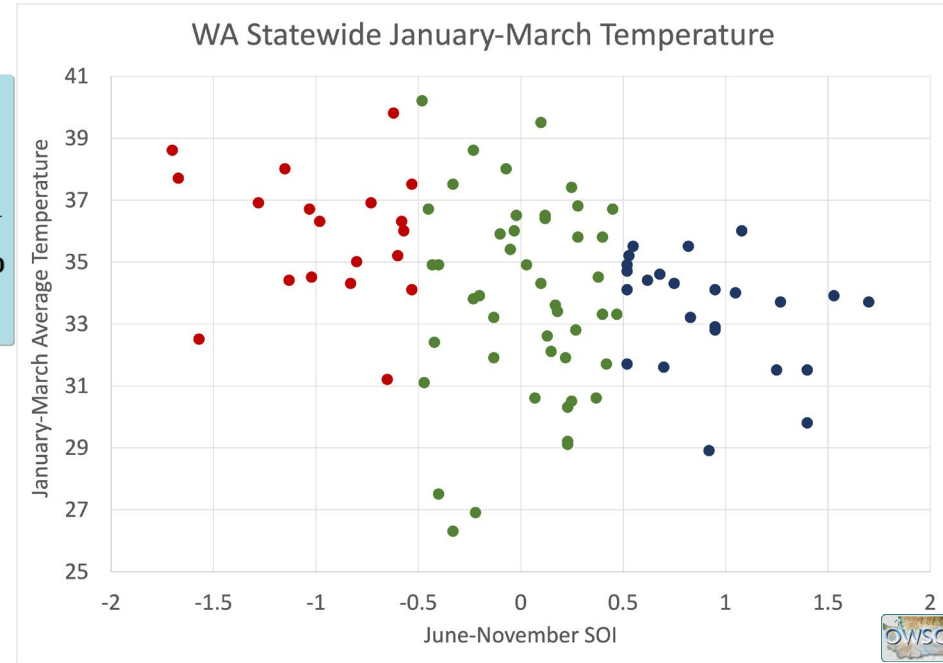
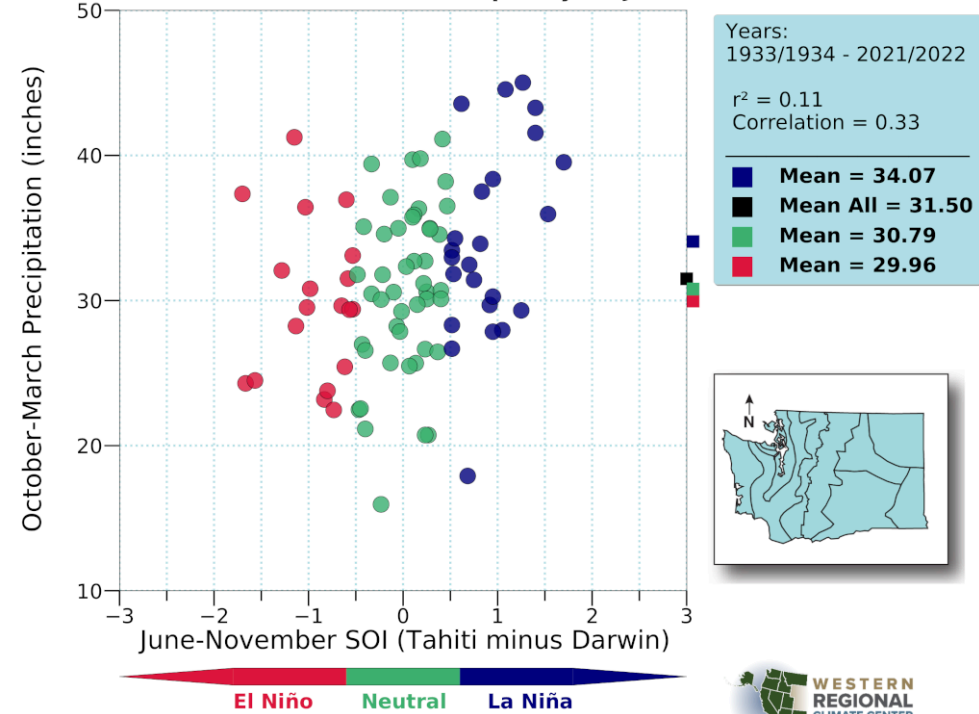
Sad children trying to scrape together enough snow to make a snowball in the D.C. area last winter. Even worse, they didn't get a snow day. Photo credit: Michelle L'Heureux.

Total Winter Snowfall (inches) at Snoqualmie Pass (3022 feet)



JAN-MAR TEMP & OCT-MAR PRECIP

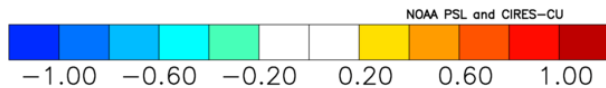
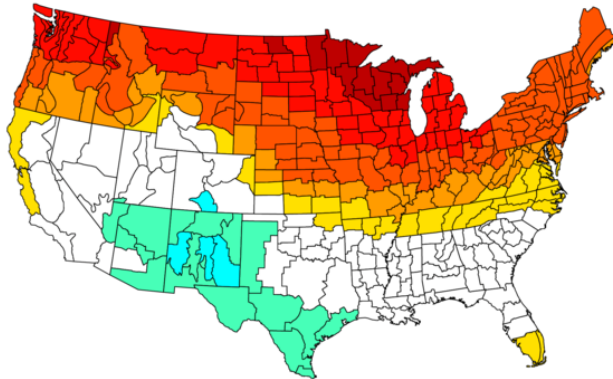
WA Statewide October-March Precipitation
(versus Southern Oscillation Index for prior year June-November)



Winter (Nov-Mar) Anomalies with Strong El Niño Events

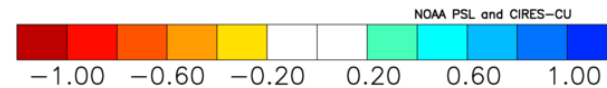
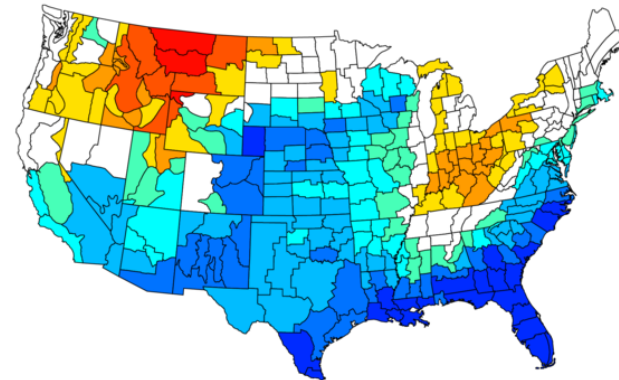
Temperature

NOAA/NCEI Climate Division Composite Standardized Temperature Anomalies Versus 1951–2010 Longterm Average
Nov to Mar 1965–66, 1972–73, 1982–83, 1986–87, 1987–88, 1991–92, 1997–98, 2002–03, 2009–10, 2015–16,



Precipitation

NOAA/NCEI Climate Division Composite Standardized Precipitation Anomalies Versus 1951–2010 Longterm Average
Nov to Mar 1965–66, 1972–73, 1982–83, 1986–87, 1987–88, 1991–92, 1997–98, 2002–03, 2009–10, 2015–16,

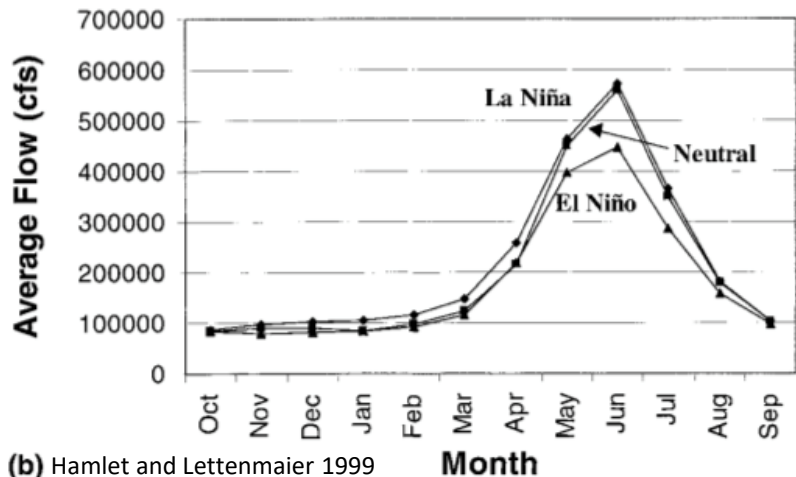


10 past El Niño events:

1965/66, 1972/73, 1982/83, 1986/87, 1987/88, 1991/92, 1997/98, 2002/03, 2009/10, 2015/16

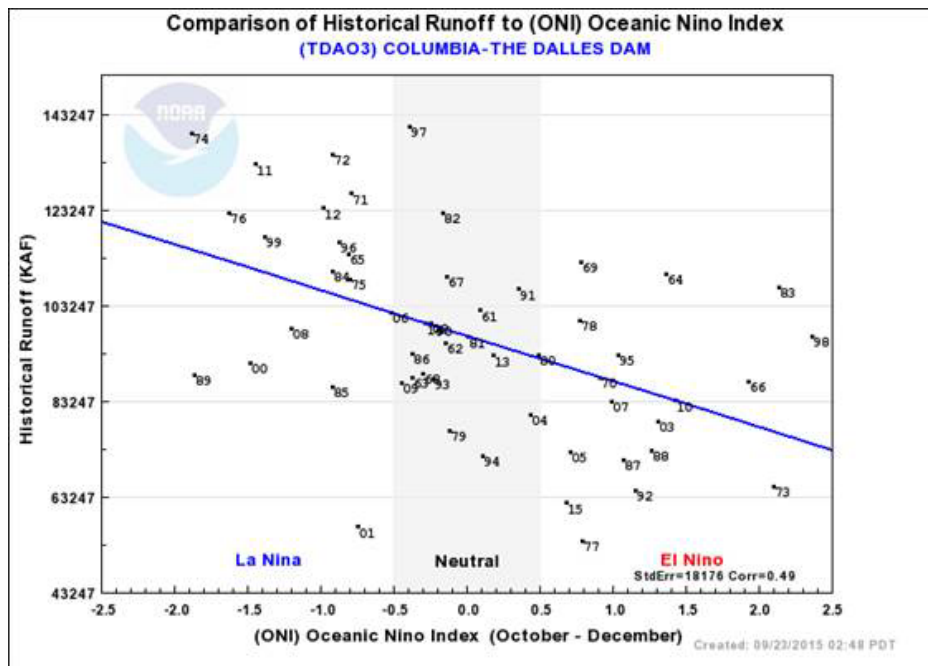
Past El Niño Events and Streamflow

Columbia River at The Dalles

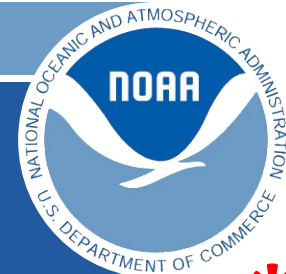


(b) Hamlet and Lettenmaier 1999

El Niño Year	May-Jun % of normal	Apr-Sep % of normal
1957/58	112	96
1965/66	79	81
1972/73	39	52
1982/83	81	90
1986/87	51	56
1987/88	48	53
1991/92	53	57
1997/98	85	83
2002/03	64	69
2009/10	72	70
2015/16	59	71
		USGS



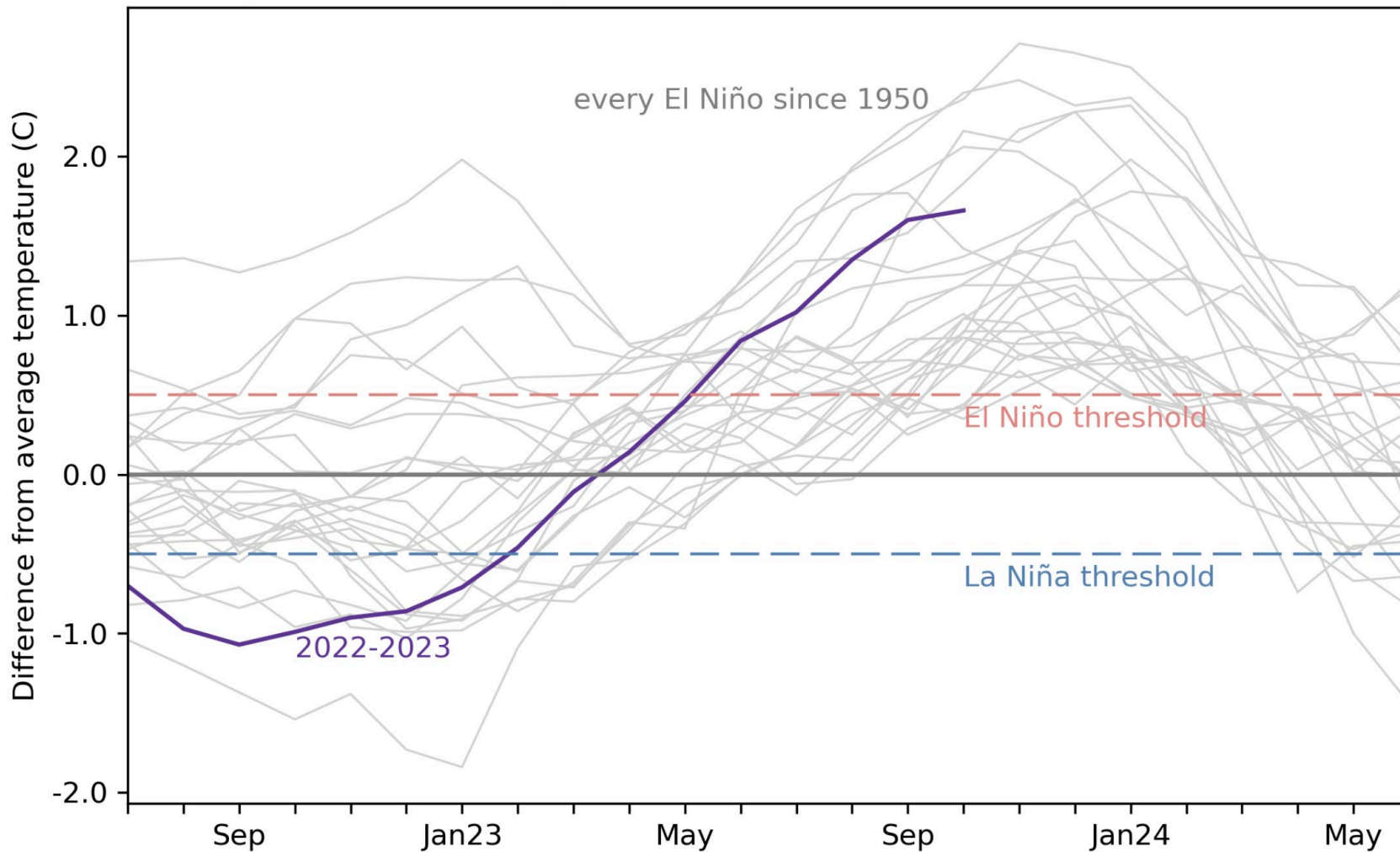
Apr-Sept Runoff



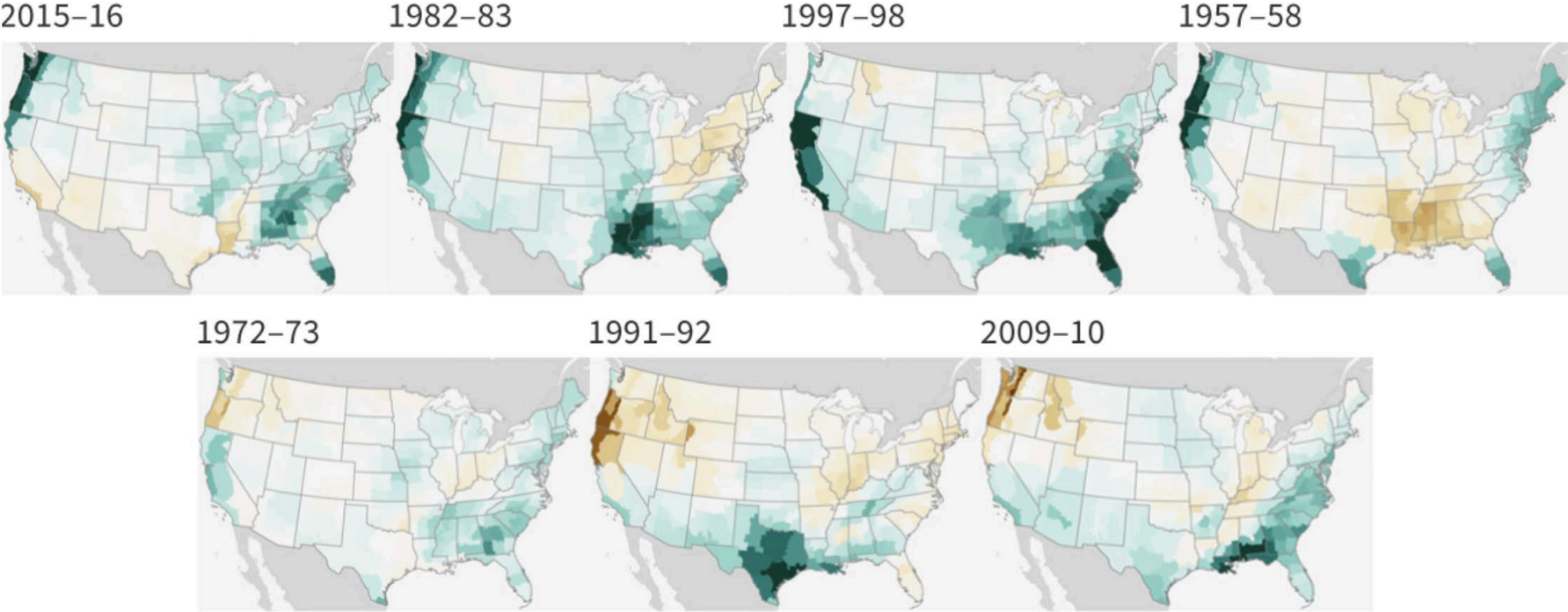
Past El Niño Events



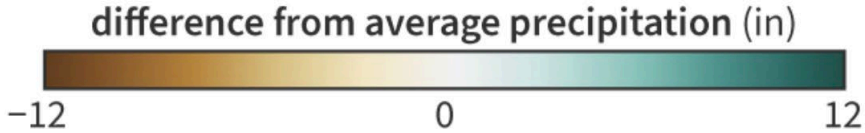
Monthly sea surface temperature Niño3.4 Index values



U.S. winter precipitation during the 7 strongest El Niños since 1950



December-February
compared to 1981-2010



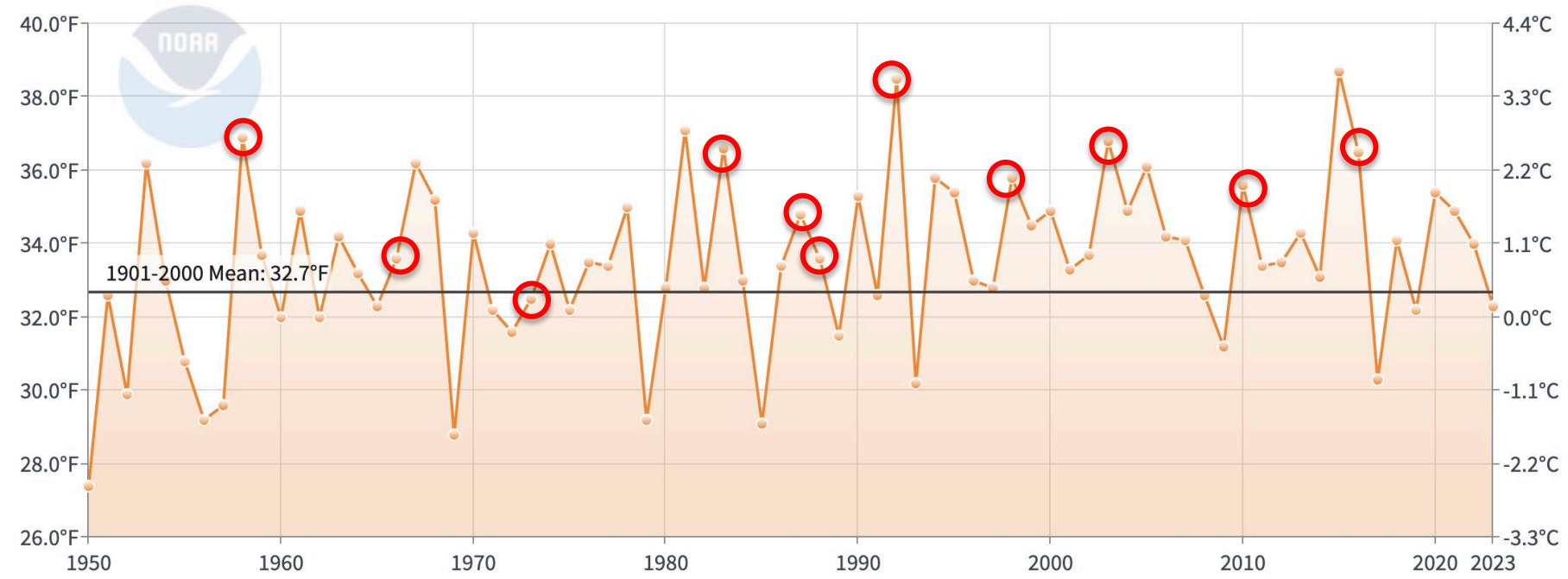
NOAA Climate.gov
Data: ESRL/NCEI

WA State Winter (Dec-Mar) Temperatures

○ Strong El Ninos

Washington Average Temperature

December-March

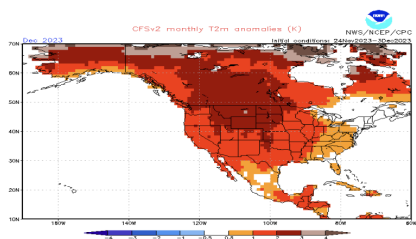


Monthly Forecasts from NOAA/CPC's Climate Forecast System Model

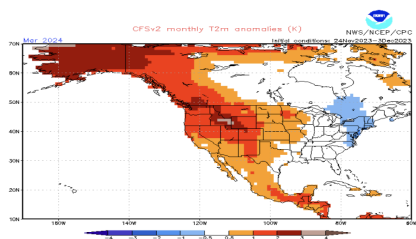
CFSv2 forecast monthly T2m anomalies

ICs: 20231124 - 20231203

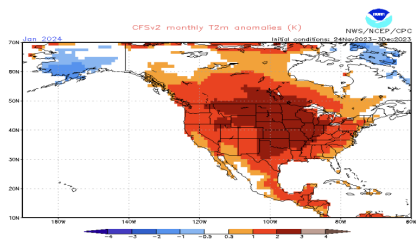
Dec 2023



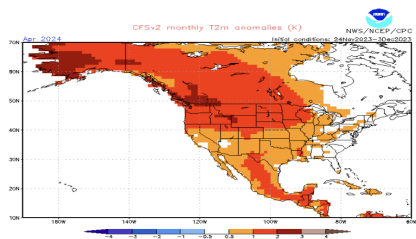
Mar 2024



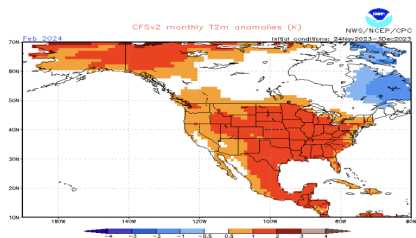
Jan 2024



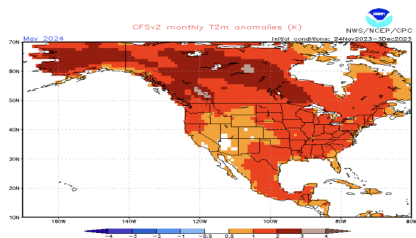
Apr 2024



Feb 2024



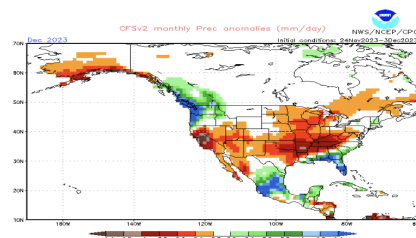
May 2024



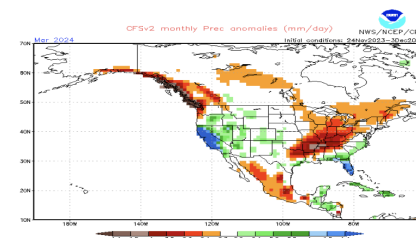
CFSv2 forecast monthly Prec anomalies

ICs: 20231124 - 20231203

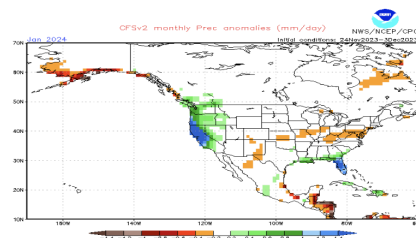
Dec 2023



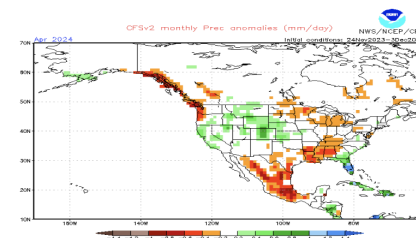
Mar 2024



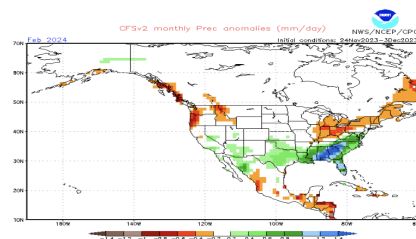
Jan 2024



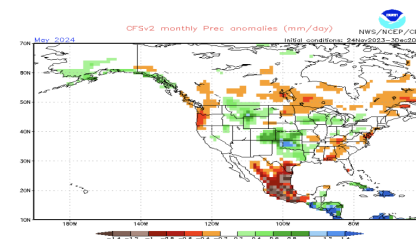
Apr 2024



Feb 2024



May 2024



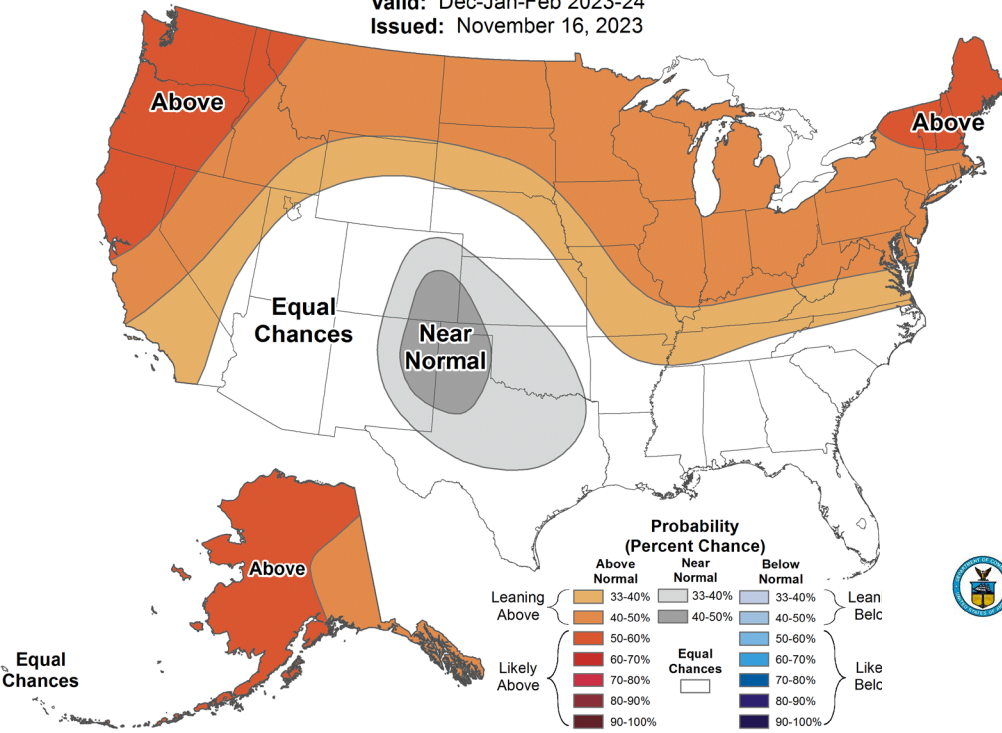


Seasonal Temperature Outlook

Valid: Dec-Jan-Feb 2023-24
Issued: November 16, 2023

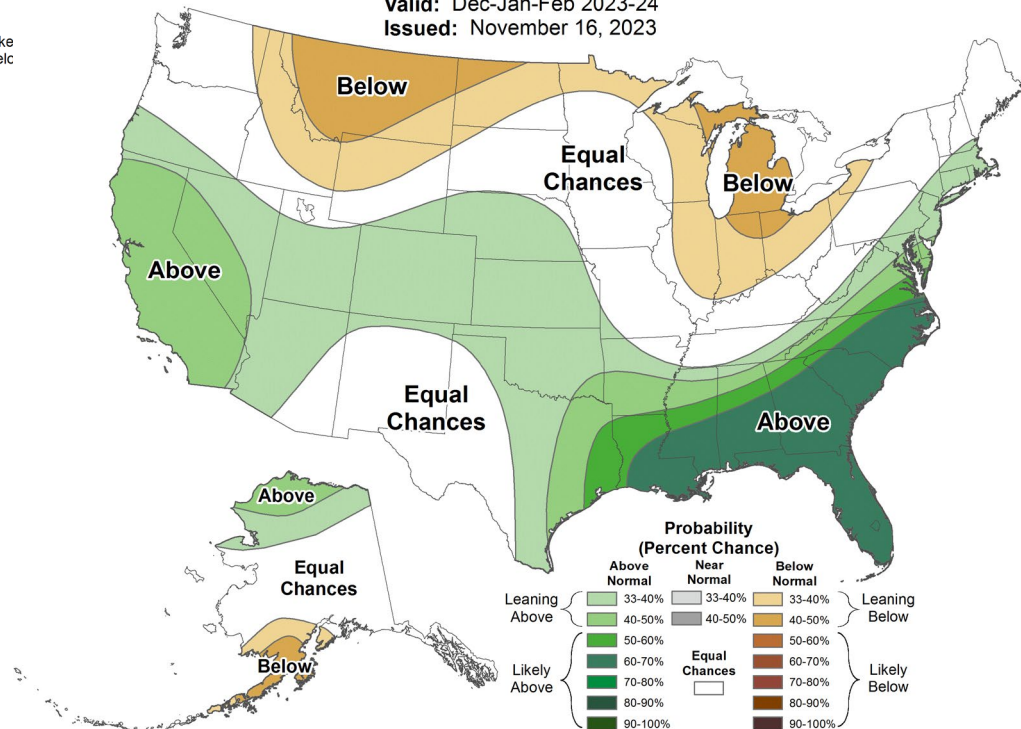


Seasonal Forecasts from NOAA's Climate Prediction Center (CPC) for Dec 2023 – Feb 2024



Seasonal Precipitation Outlook

Valid: Dec-Jan-Feb 2023-24
Issued: November 16, 2023

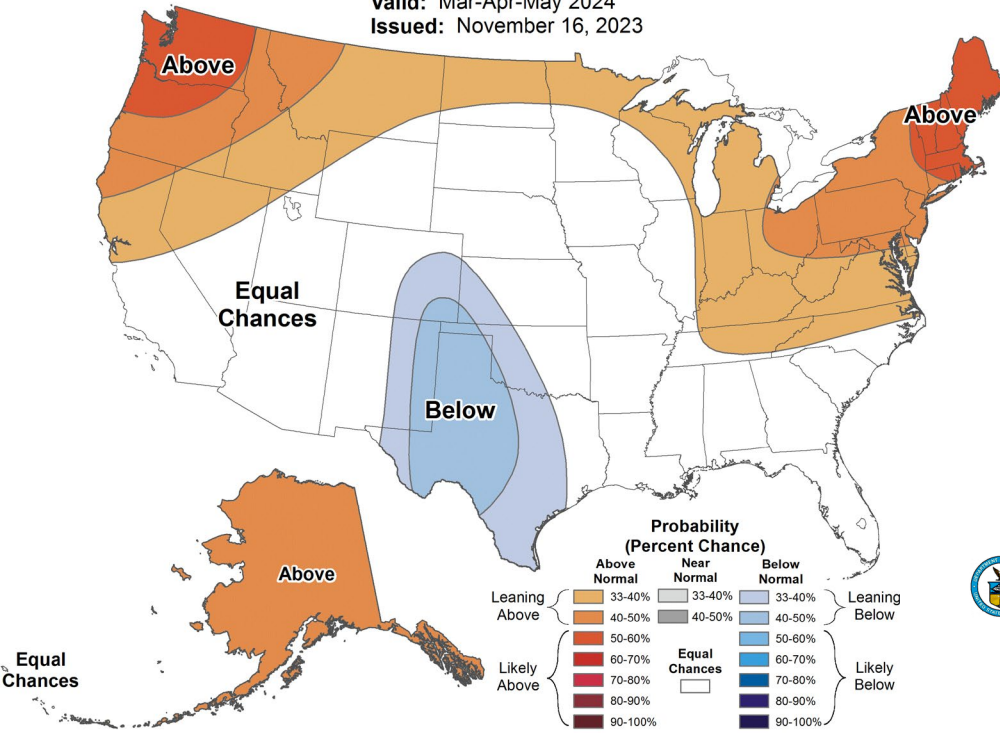




Seasonal Temperature Outlook



Valid: Mar-Apr-May 2024
Issued: November 16, 2023



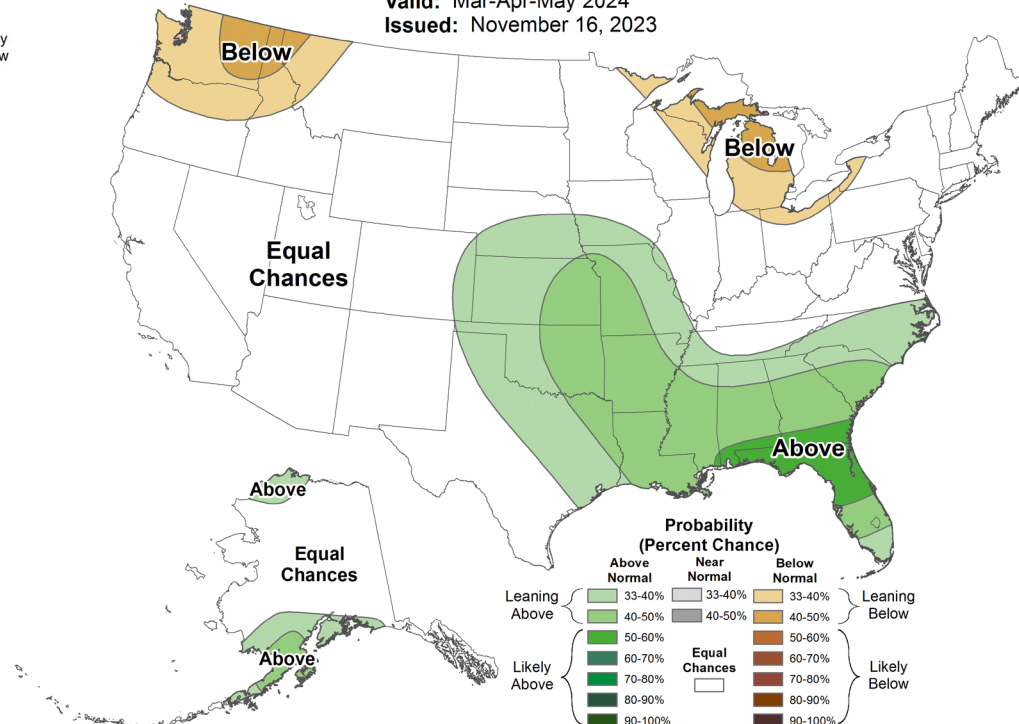
Seasonal Forecasts from NOAA's Climate Prediction Center (CPC) for Mar-May 2024



Seasonal Precipitation Outlook



Valid: Mar-Apr-May 2024
Issued: November 16, 2023



Summary

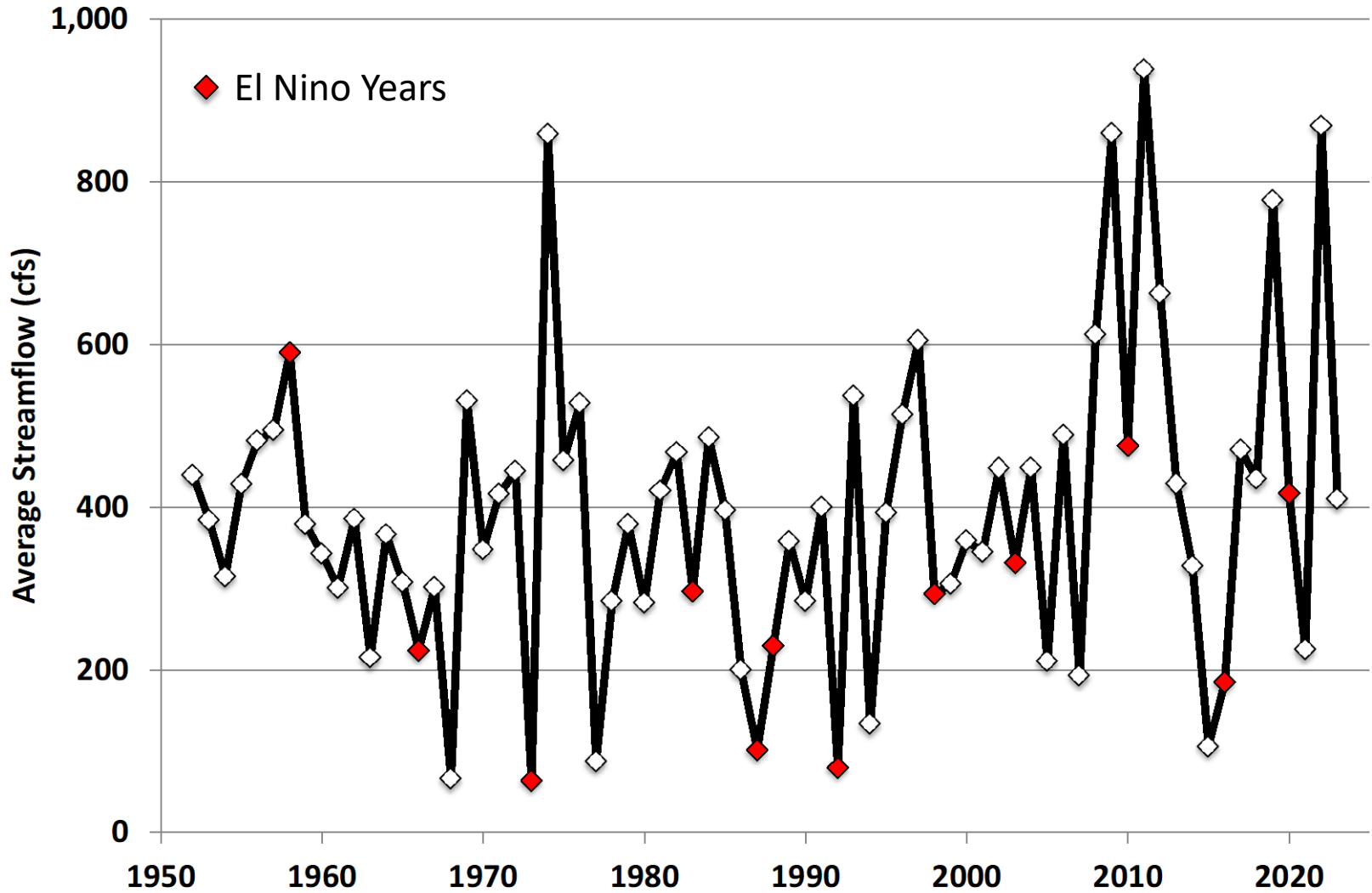
- The wet season is getting off to a typical start
- El Nino will be with this through winter and then wimp out in spring/summer 2024
- There is a chance that it will be a strong to very strong El Nino, and if so, we are more likely to get near normal precipitation totals
- The odds of warmer than normal winter temperatures are considerably higher than usual

How are the upcoming fall and winter seasons liable to play out?

- Floods – Lower probability of **severe** flooding in WA (the atmospheric rivers at the beginning of December have caused major flooding, which is not uncommon)
- Windstorms – Slightly lower odds than usual (there always is the **possibility of an intense storm**)
- Cold-air Outbreaks – Less likely than in the historical record; extremely low temperatures would be quite the surprise
- End of Season Snowpack – Probably skimpier than a typical year during the last decade or two

Questions?

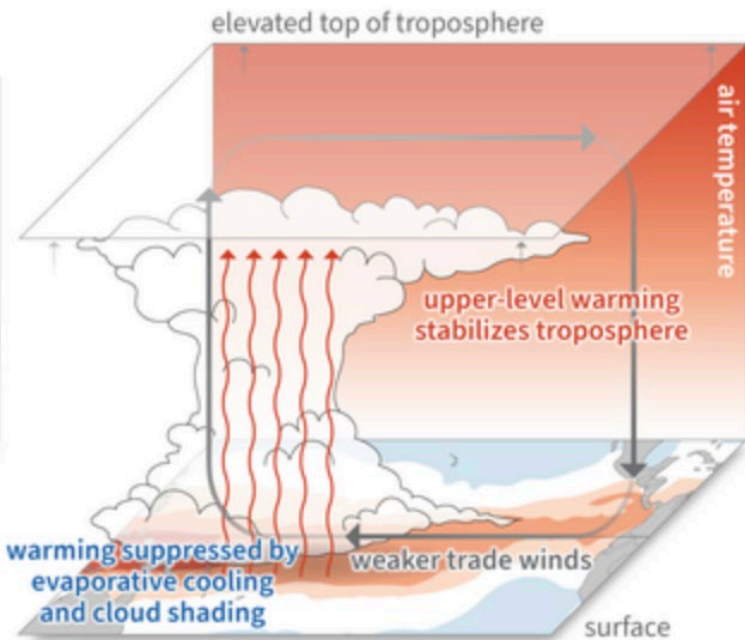
Walla Walla River Apr-Sep Streamflow



IN A CHANGING CLIMATE, ENSO IS EXPECTED TO...

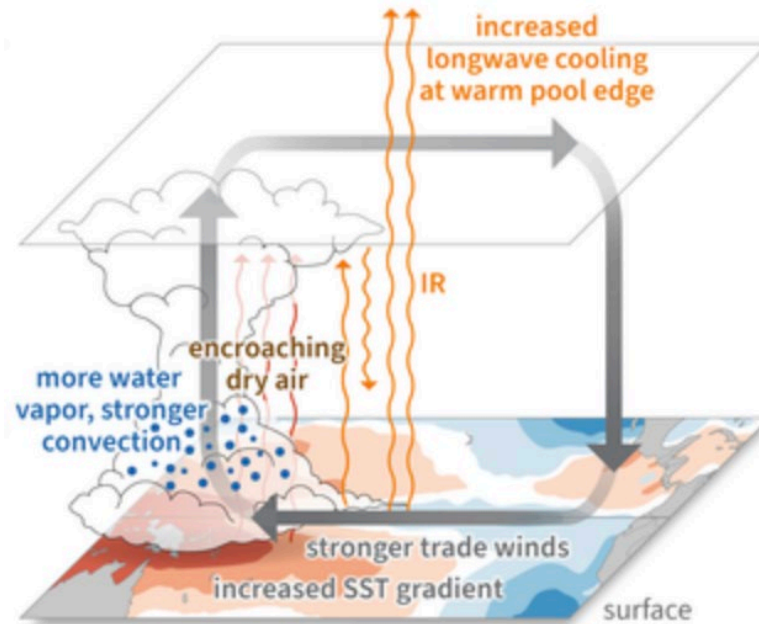
The last 4 decades have featured a preponderance of La Niña conditions but we cannot be sure this is anything but a fluke.

Processes that could lead to
El Niño-like future



NOAA Climate.gov

Processes that could lead to
La Niña-like future



NOAA Climate.gov

Lee et al. (2022)

East Slopes Cascades Climate Division

Washington, Climate Division 6, Average Temperature, December-March

