Future climate and water in the Pacific Northwest

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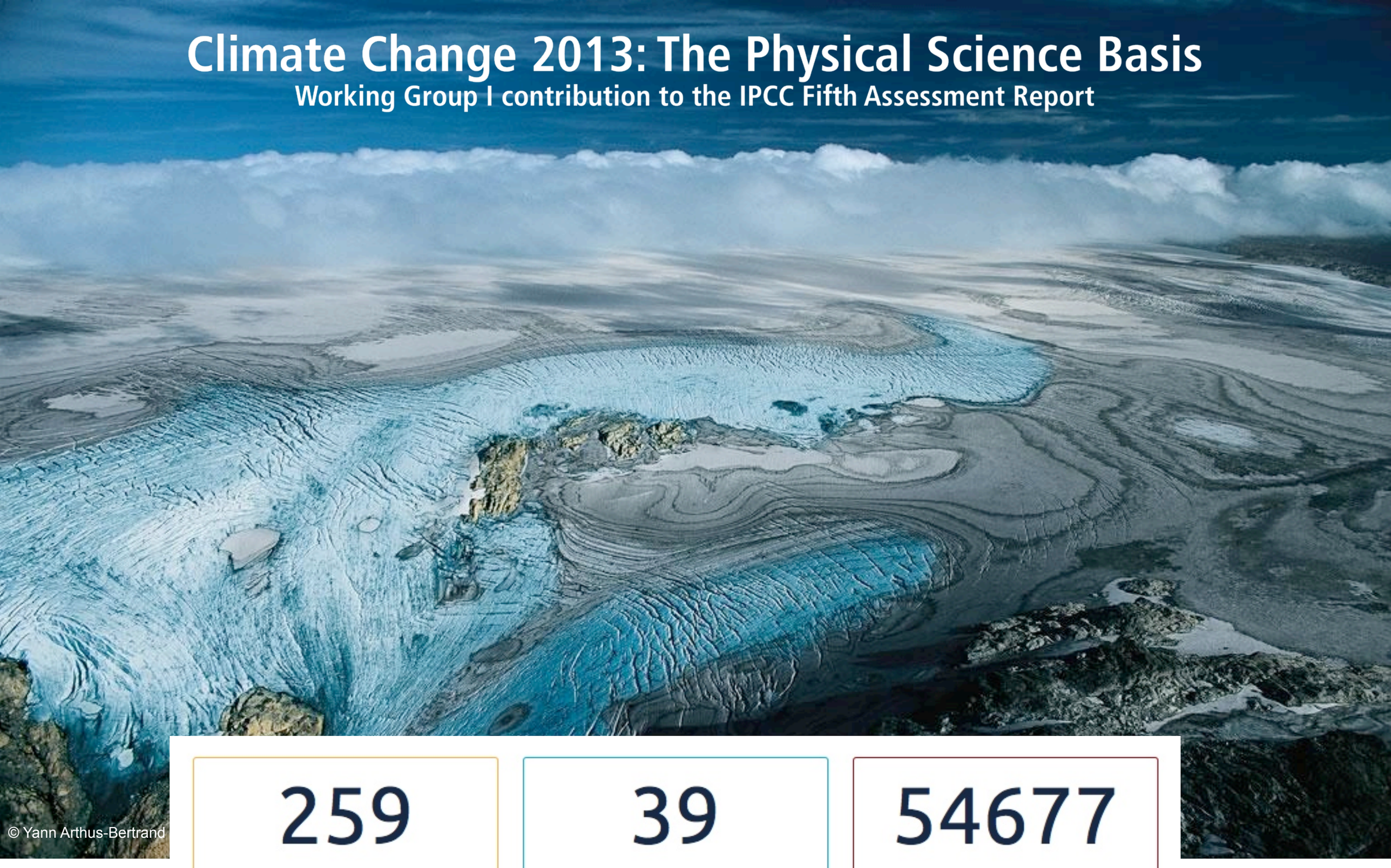
Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report



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259	39	54677
AUTHORS	COUNTRIES	COMMENTS

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Headline statements

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented ... The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen...

Human influence on the climate system is clear.

It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century.

Global surface temperature change for the end of the 21st century is *likely* to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios except RCP2.6.

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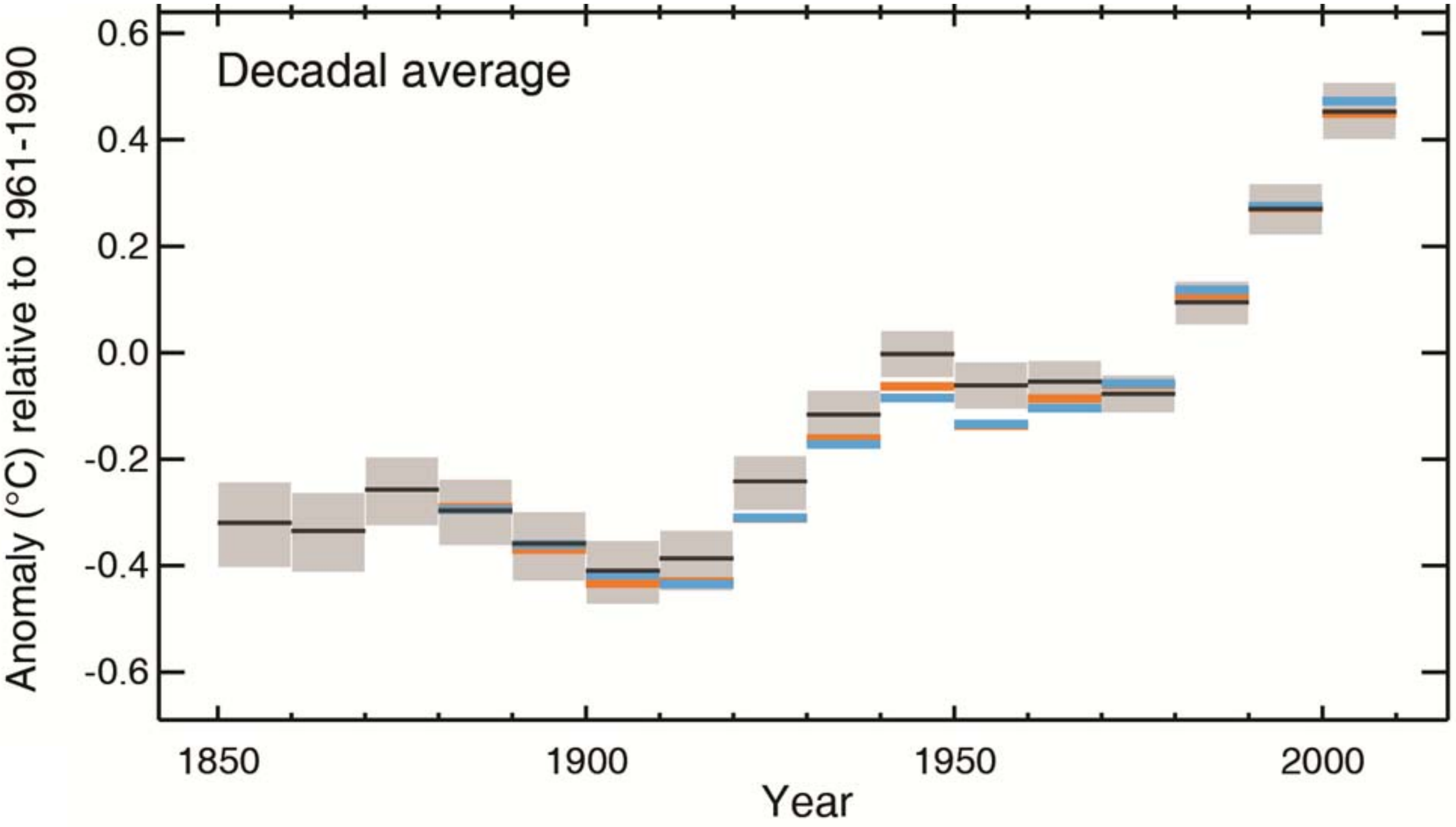
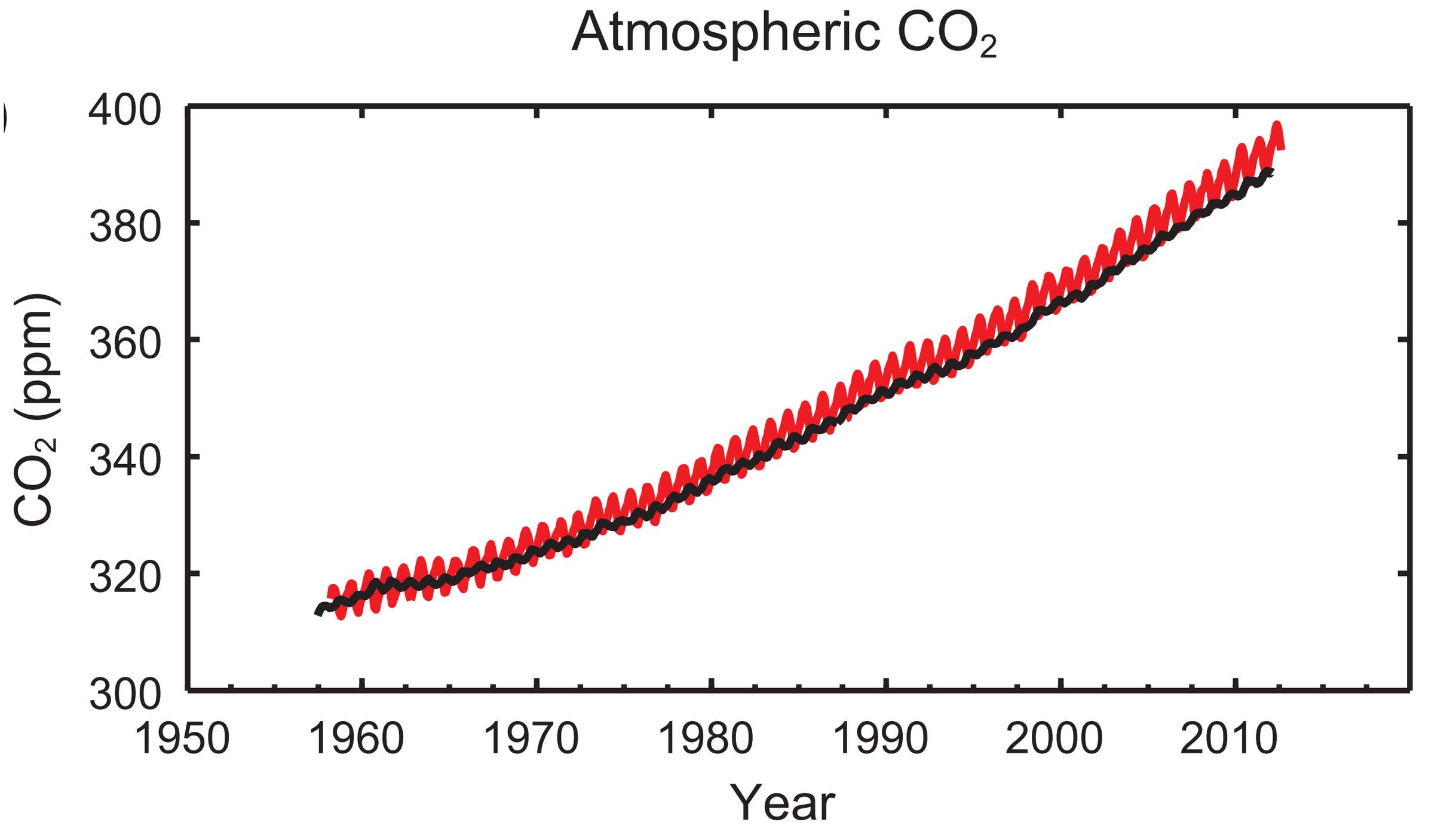
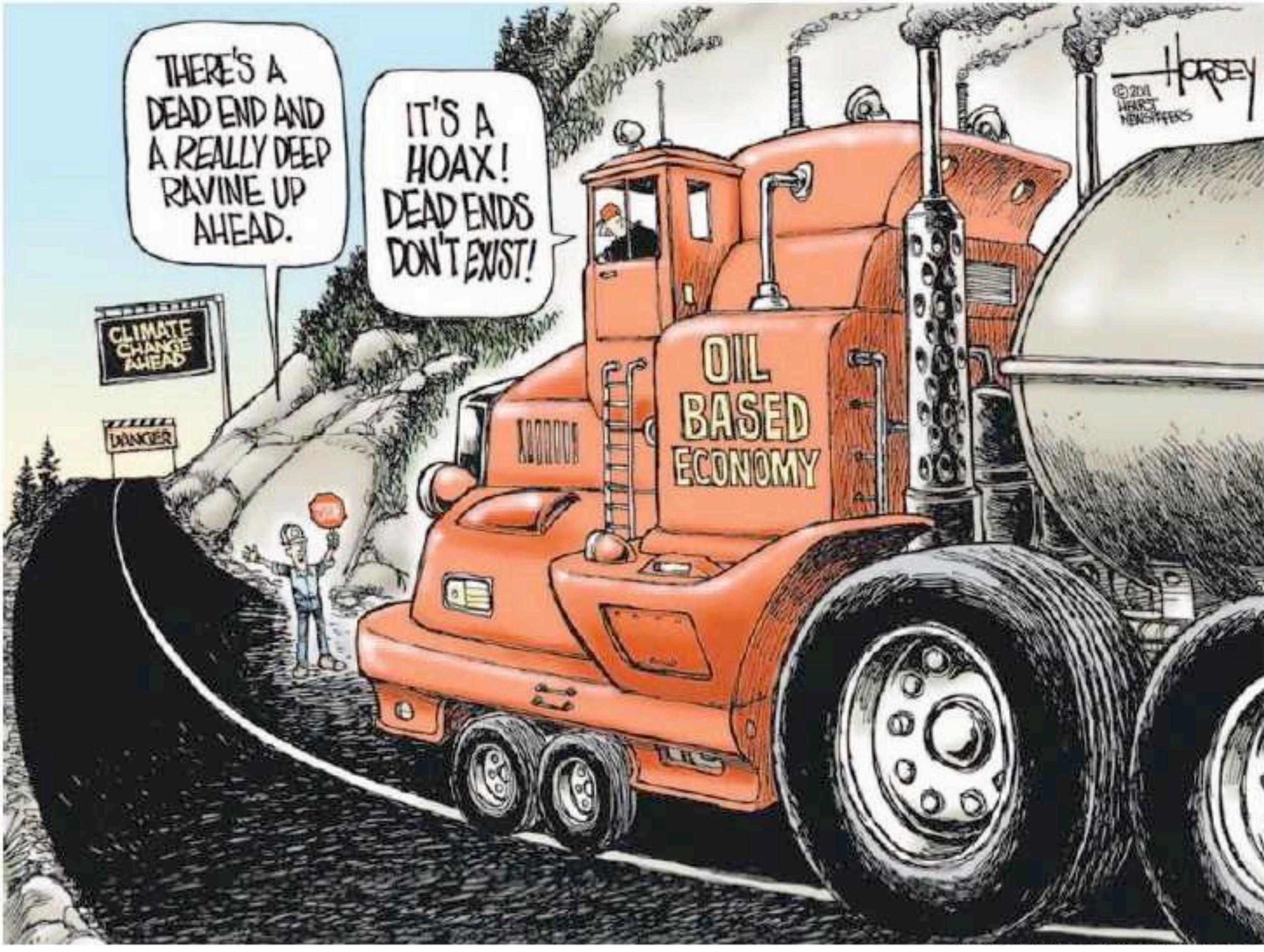

Decadal average
Anomaly (°C) relative to 1961-1990
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
1850
1900
1950
2000
Year



atmospheric concentrations of carbon dioxide (CO2) from Mauna Loa (19°32'N, 155°34'W – red) and South Pole (89°59'S, 24°48'W – black) since 1958;


THERE'S A DEAD END AND A REALLY DEEP RAVINE UP AHEAD.
IT'S A HOAX! DEAD ENDS DON'T EXIST!
CLIMATE CHANGE AHEAD
DANGER
OIL BASED ECONOMY
HORSEY

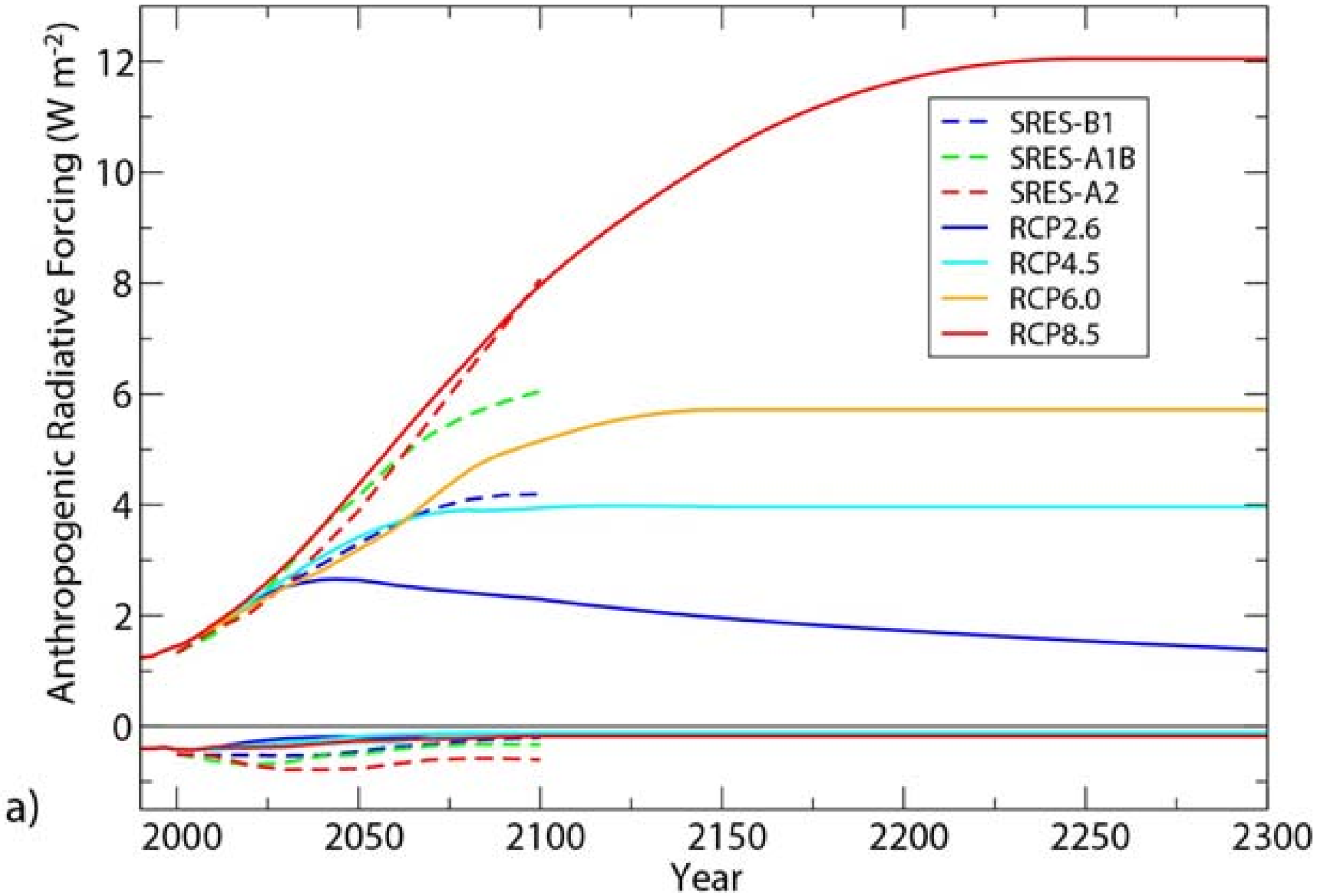
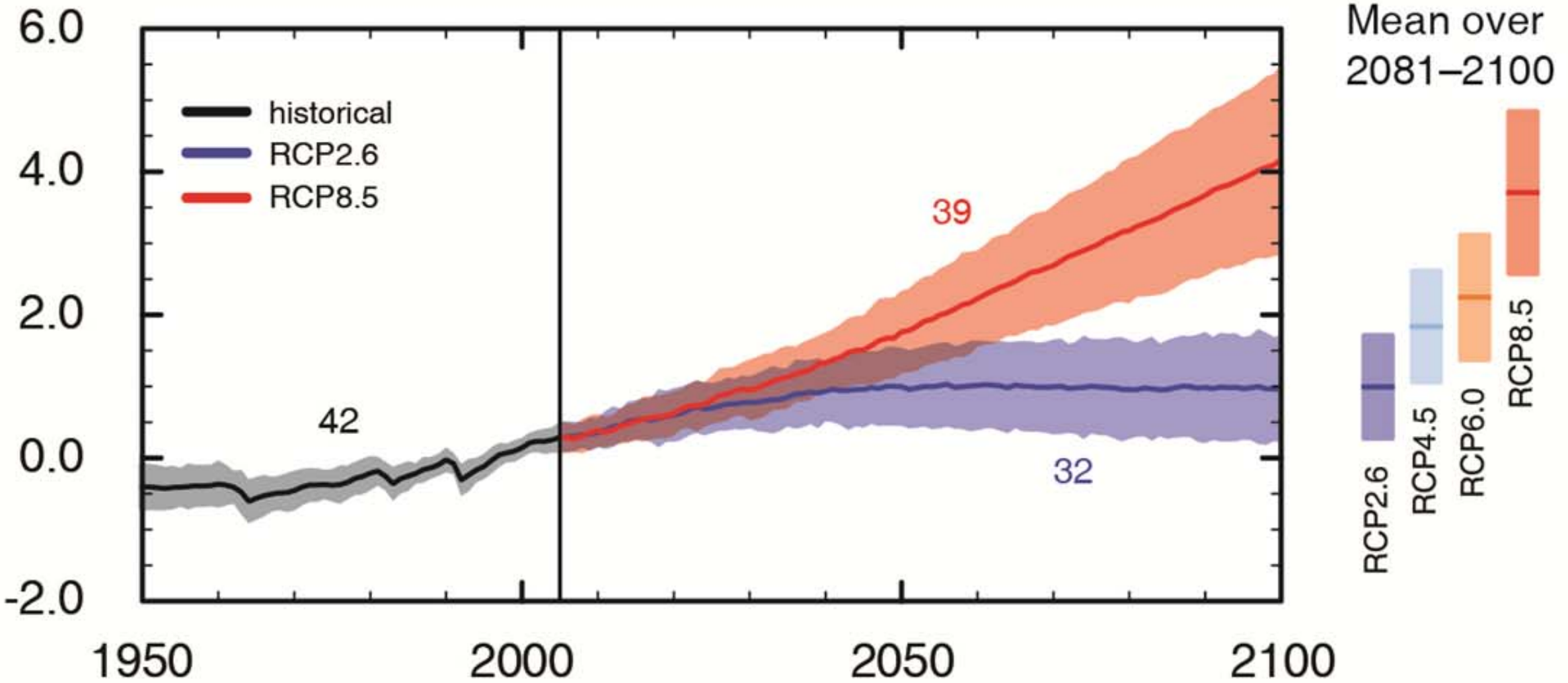


Figure 12.3: (a) Time evolution of the total anthropogenic (positive) and anthropogenic aerosol (negative) radiative forcing relative to preindustrial (~1765) between 2000 and 2300 for RCP scenarios and their extensions (continuous lines), and SRES scenarios (dashed lines) as computed by the integrated assessment models (IAMs) used to develop those scenarios. The four RCP scenarios used in CMIP5 are: RCP2.6 (dark blue), RCP4.5 (light blue), RCP6.0 (orange) and RCP8.5 (red). The three SRES scenarios used in CMIP3 are: B1 (blue, dashed), A1B (green, dashed) and A2 (red, dashed). Positive values correspond to the total anthropogenic radiative forcing. Negative values correspond to the forcing from all anthropogenic aerosol-radiation interactions (i.e., direct effects only). The total radiative forcing of the SRES and RCP families of scenarios differs in 2000 because the number of forcings represented and our knowledge about them have changed since the TAR. The total radiative forcing of the RCP family is computed taking into account the efficacy of the various forcings (Meinshausen et al., 2011a).

(a)


Global average surface temperature change
6.0
4.0
2.0
0.0
-2.0
(°C)
historical
RCP2.6
RCP8.5
42
39
32
1950
2000
2050
2100
Mean over
2081–2100
RCP2.6
RCP4.5
RCP6.0
RCP8.5

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Previous NW reports

- 1999, as part of 1st National Assessment
- *2009* Washington Climate Change Impacts Assessment
- *2010* Oregon Climate Assessment Report

OCCRI - HB3543

(3) The Oregon Climate Change Research Institute shall assess, at least once each biennium, the state of climate change science, including biological, physical and social science, as it relates to Oregon and the likely effects of climate change on the state. The institute shall submit the assessment to the Legislative Assembly in the manner provided in ORS 192.245 and to the Governor.

Climate Change in the Northwest

Implications for Our Landscapes, Waters, and Communities

Edited by:

Meghan M. Dalton

Philip W. Mote

Amy K. Snover

30 authors, 2+ countries, 601 review comments

ISLANDPRESS

the plus indicates tribes.

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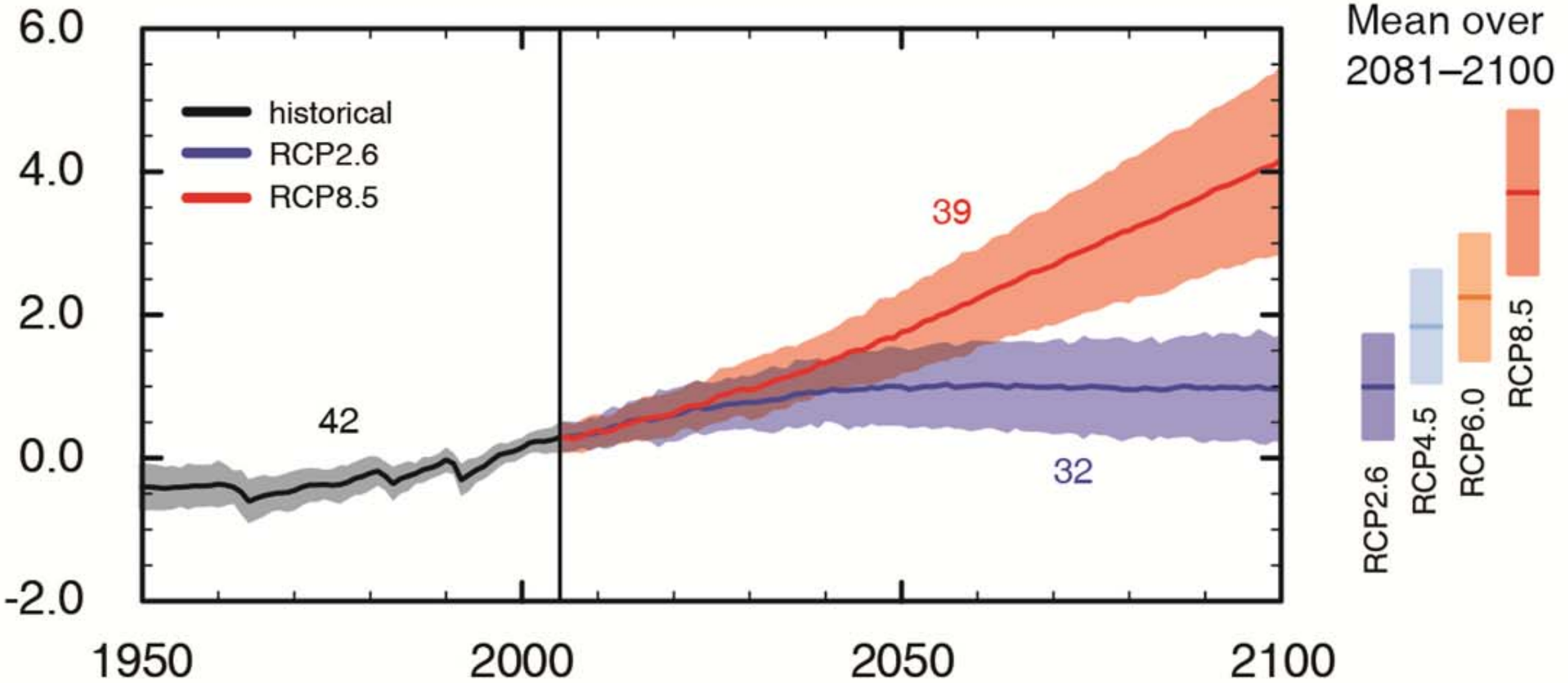
One-sentence summary

"Key regionally consequential risks in the Northwest include impacts of warming on watersheds where snowmelt is important, coastal consequences of sea level rise combined with other stressors, and the cumulative effects of fire, insects, and disease on forest ecosystems."

(a)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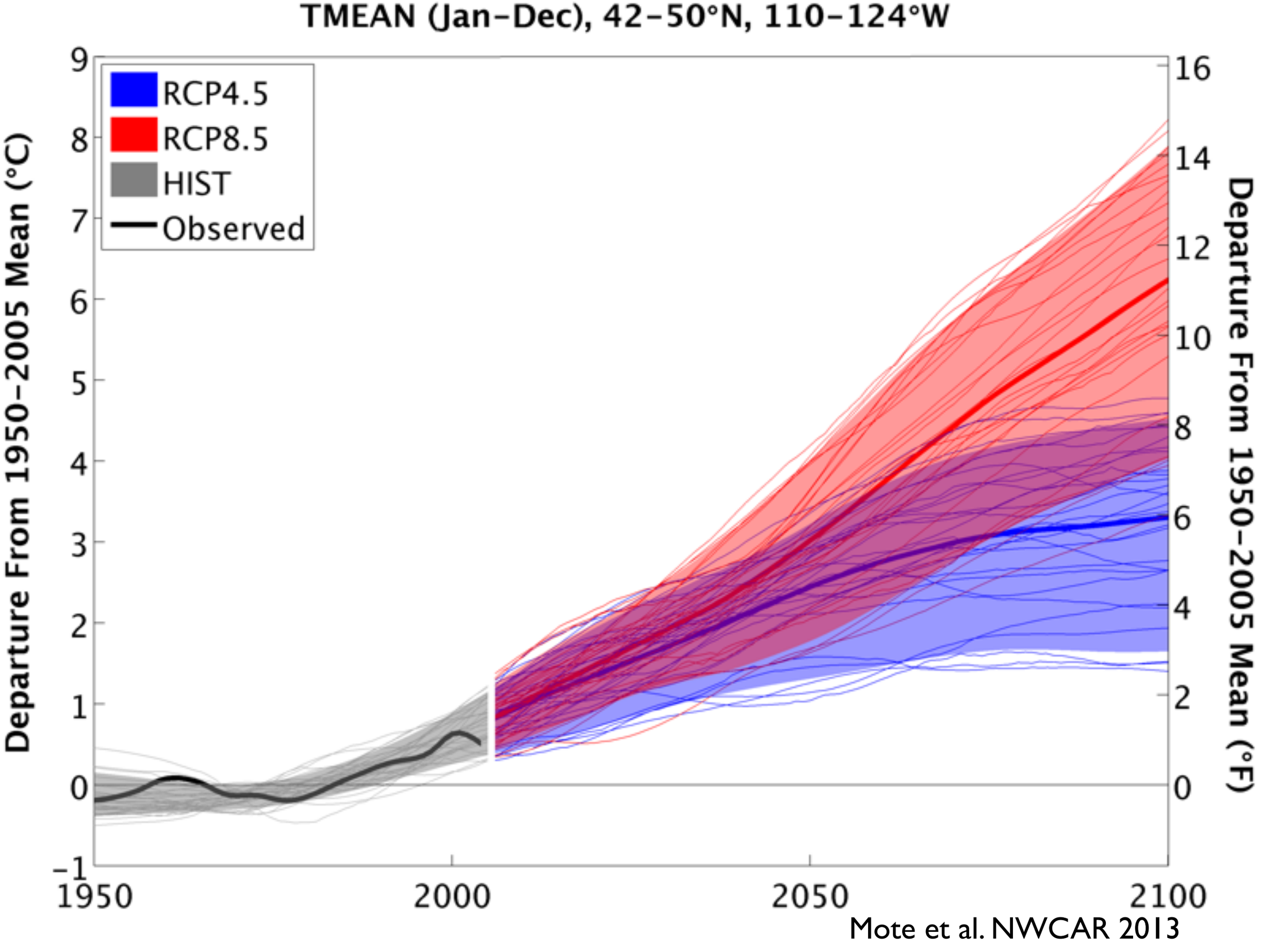

TMEAN (Jan–Dec), 42–50°N, 110–124°W
RCP4.5
RCP8.5
HIST
Observed
Departure From 1950–2005 Mean (°C)
Departure From 1950–2005 Mean (°F)
9
8
7
6
5
4
3
2
1
0
−1
16
14
12
10
8
6
4
2
0
1950
2000
2050
2100
Mote et al. NWCAR 2013

PNW warming 2041-70 minus 1950-99

Temp	Annual		DJF		MAM		JJA		SON	
°C	4.5	8.5	4.5	8.5	4.5	8.5	4.5	8.5	4.5	8.5
max	3.7	4.7	4.0	5.1	4.1	4.6	4.1	5.2	3.2	4.6
75th	2.9	3.9	2.8	3.8	2.9	3.9	3.3	4.4	2.8	3.7
mean	2.4	3.2	2.5	3.2	2.4	3.0	2.6	3.6	2.2	3.1
25th	2.1	2.8	2.0	2.3	1.8	2.2	2.1	3.2	1.8	2.7
min	1.1	1.7	0.9	1.3	0.5	1.0	1.3	1.9	0.8	1.6

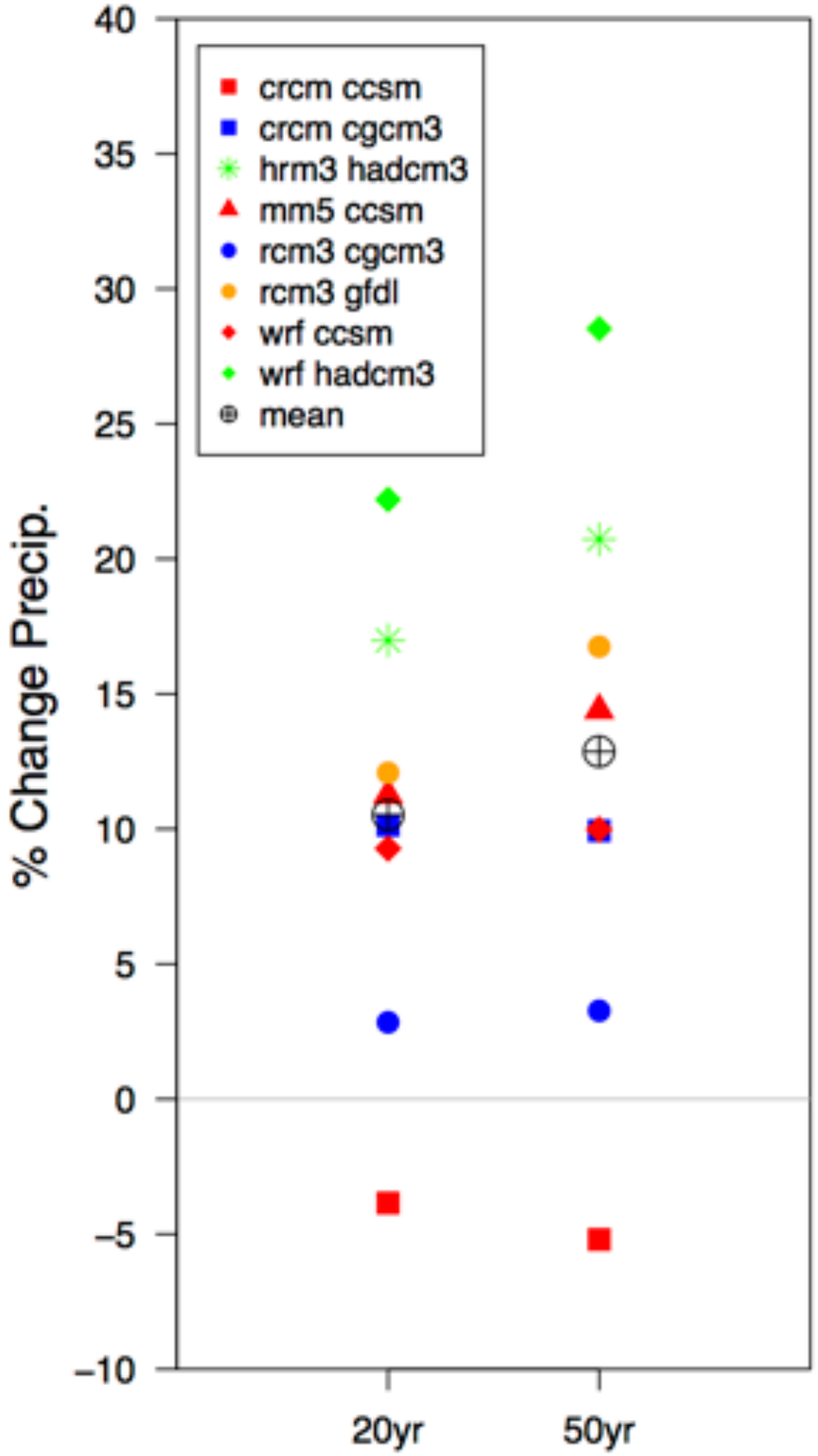
Mote et al. NWCAR 2013

PNW precipitation 2041-70 minus 1950-99

Precip	Annual		DJF		MAM		JJA		SON	
%	4.5	8.5	4.5	8.5	4.5	8.5	4.5	8.5	4.5	8.5
max	10.1	13.5	16.3	19.8	18.8	26.6	18	12.4	13.1	12.3
75th	4.7	6.5	10.3	11.3	8.8	9.3	2	0.7	6.7	6.5
mean	2.8	3.2	5.4	7.2	4.3	6.5	-5.6	-7.5	3.2	1.5
25th	0.9	0	-1.2	3.5	-0.4	2.8	-12.3	-15.9	0.2	-4.3
min	-4.3	-4.7	-5.6	-10.6	-6.8	-10.6	-33.6	-27.8	-8.5	-11

Mote et al. NWCAR 2013

Changes in extreme precipitation (NARCCAP)



Mote et al. NWCAR 2013
after Dominguez et al 2012

Future climate

- Warming already underway; will be warmer in all seasons, how much is uncertain
- Beyond ~2040, amount of warming depends on GHG emissions *now*
- Precipitation changes likely to be indistinguishable from natural variability, except possibly drying summers and more extremes
- Summer likely to warm more than other seasons
- Quality weighting raises warming estimates


WELCOME TO THE
GLOBAL WARMING DENIERS
WINTER GAMES
DIST. BY UNIVERSAL UCLICK
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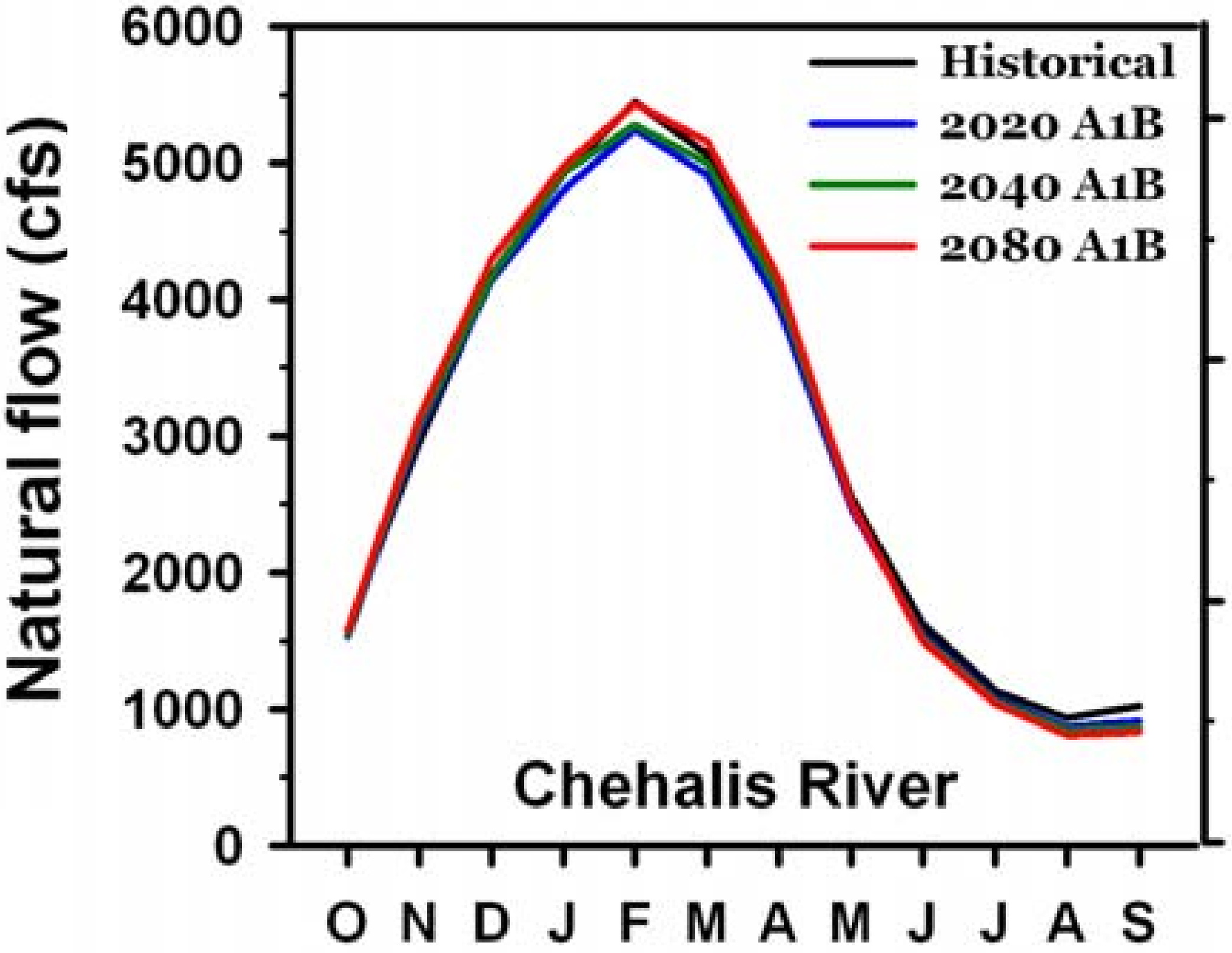
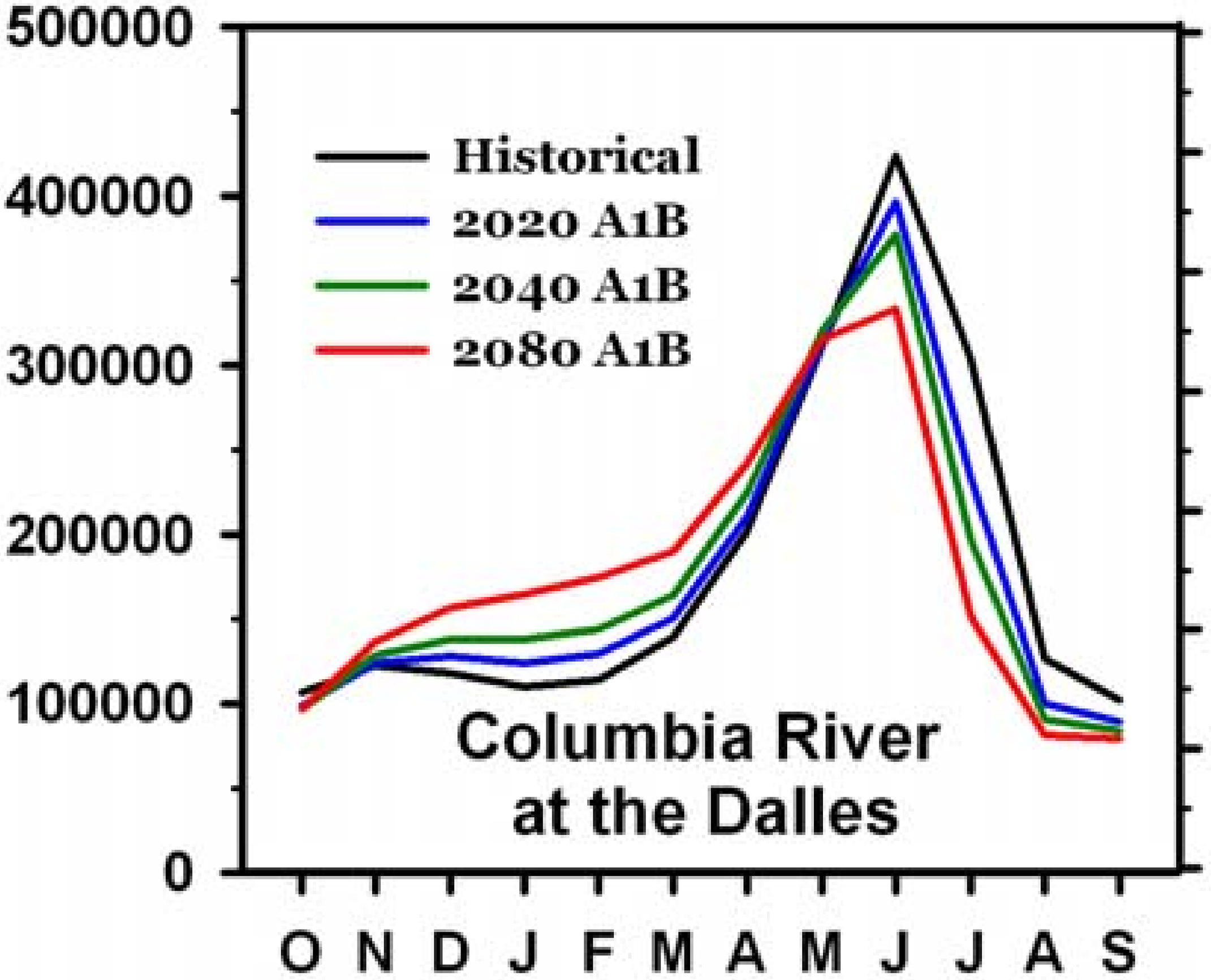


Dello, OCCRI; Hamlet, UW



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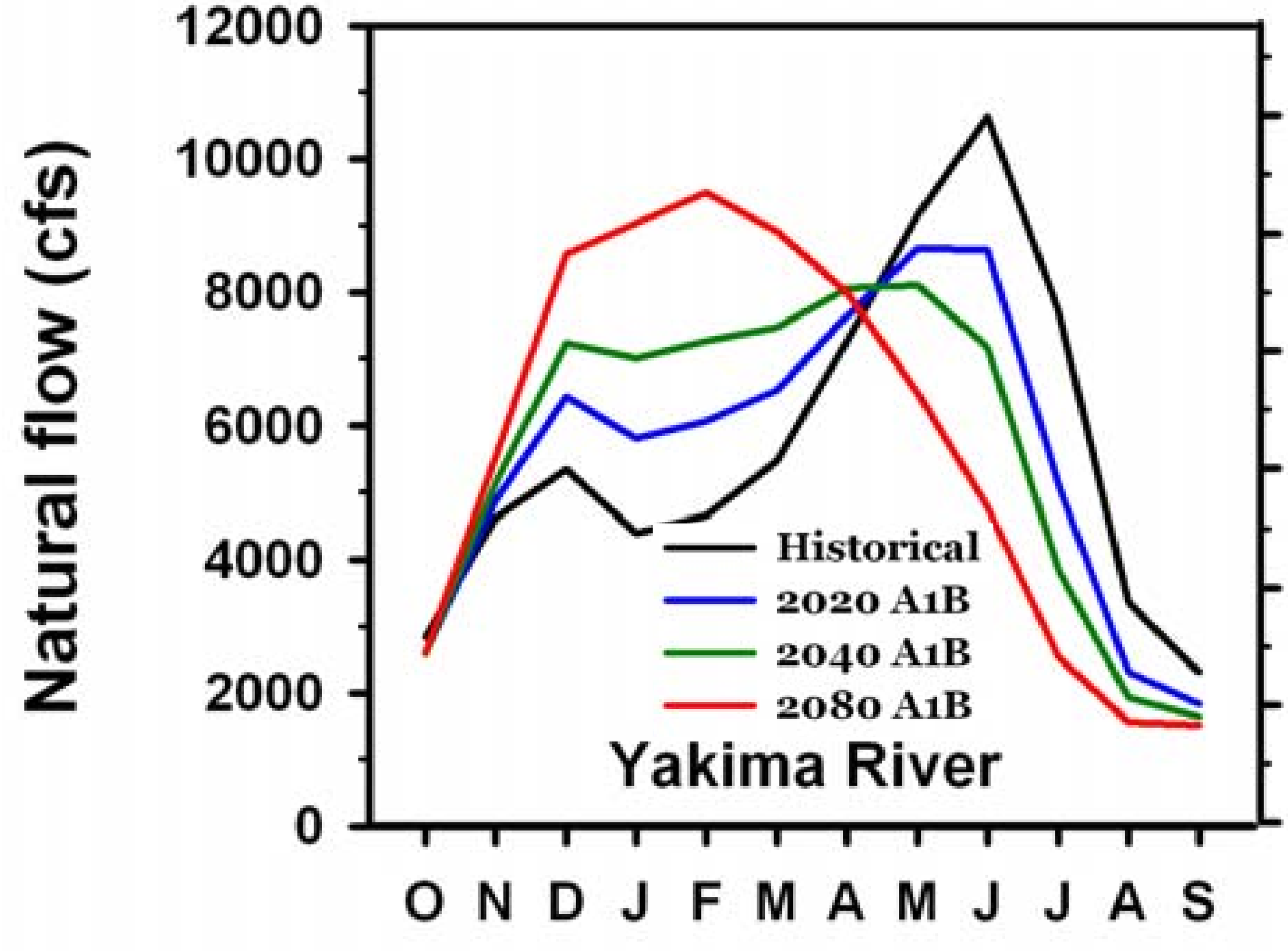
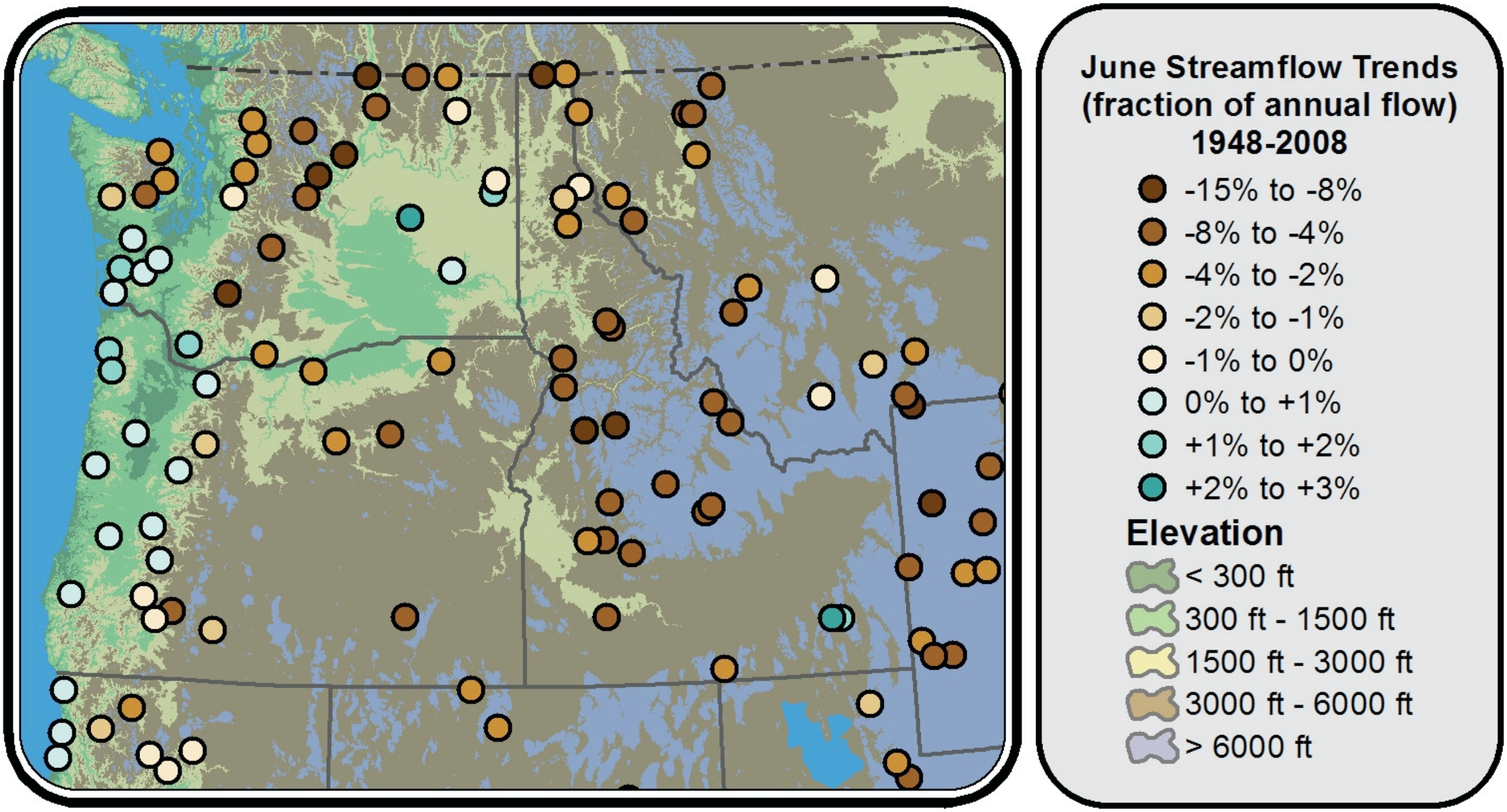


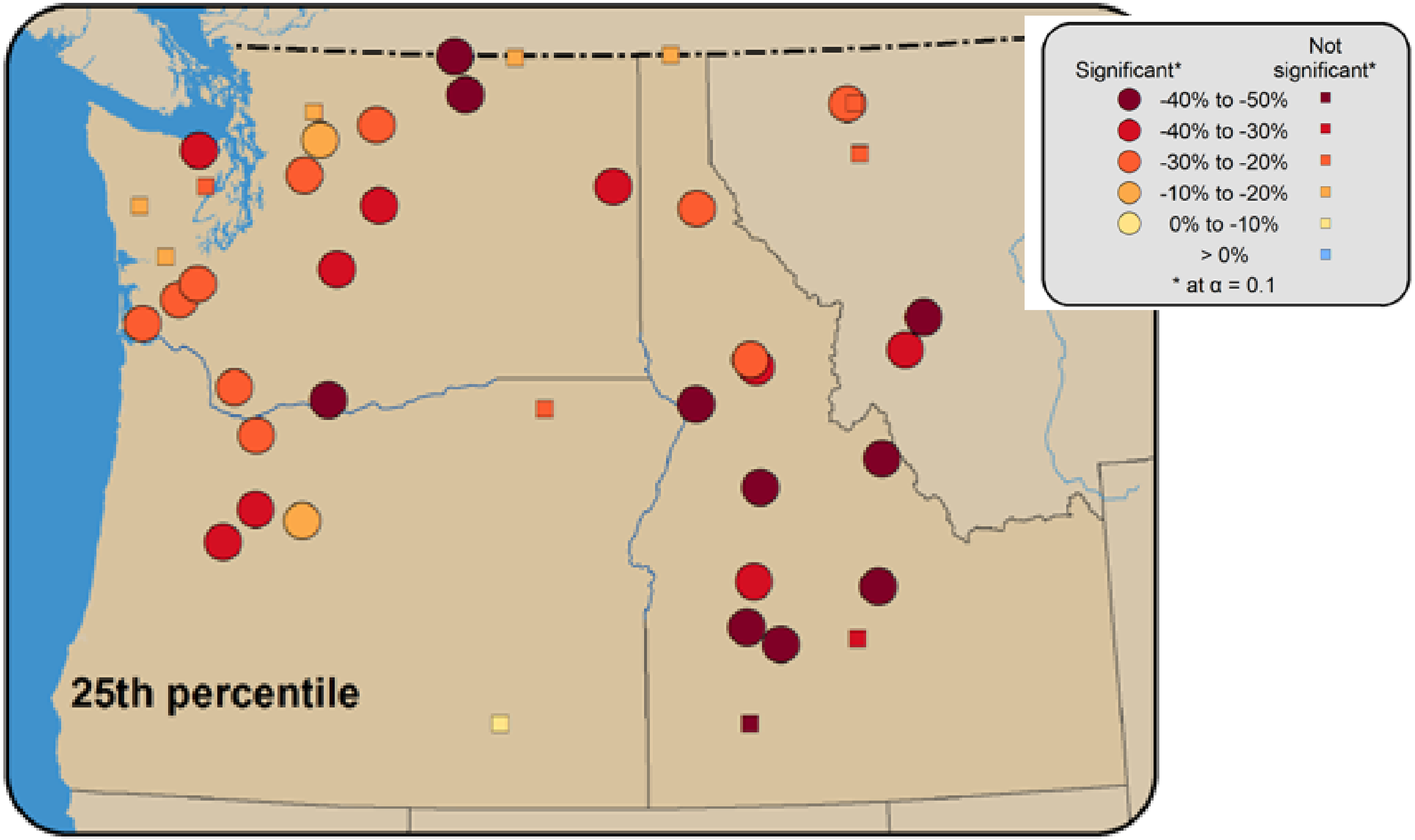
Dello, OCCRI; Hamlet, UW

Total storage on 5 reservoirs is 1.07 MaF, or 18,000 cfs-months. Almost makes up the difference between historical and 2080s.

Decreasing summer flow in snowmelt watersheds

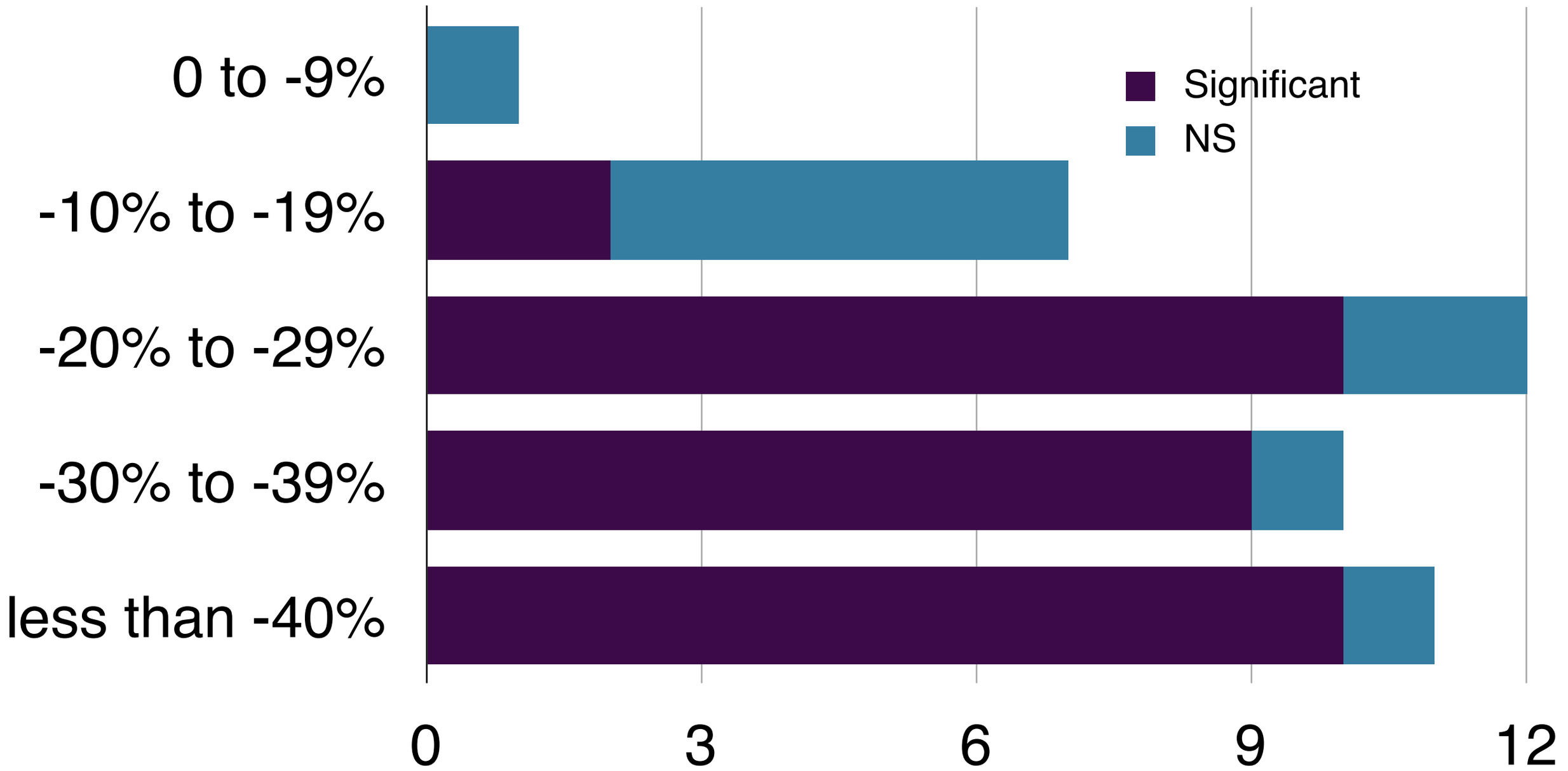


Low flow changes



1948-2006; adapted from Luce and Holden, 2009

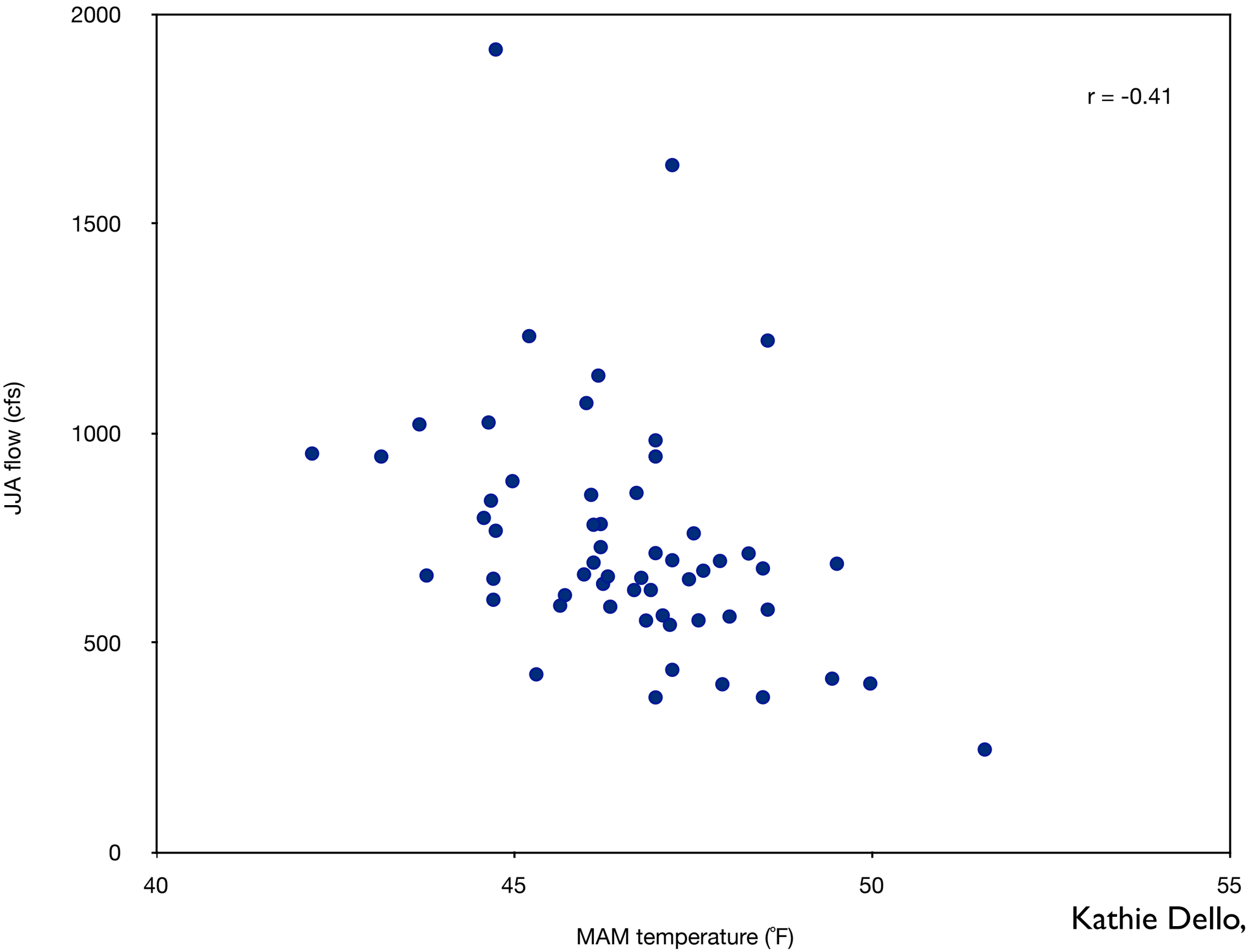
Low flow changes



Number of NW stream gauges with statistically significant (maroon) and not significant (blue) linear trends in 25th percentile annual flow, over the 1948-2006 period. None have increased.

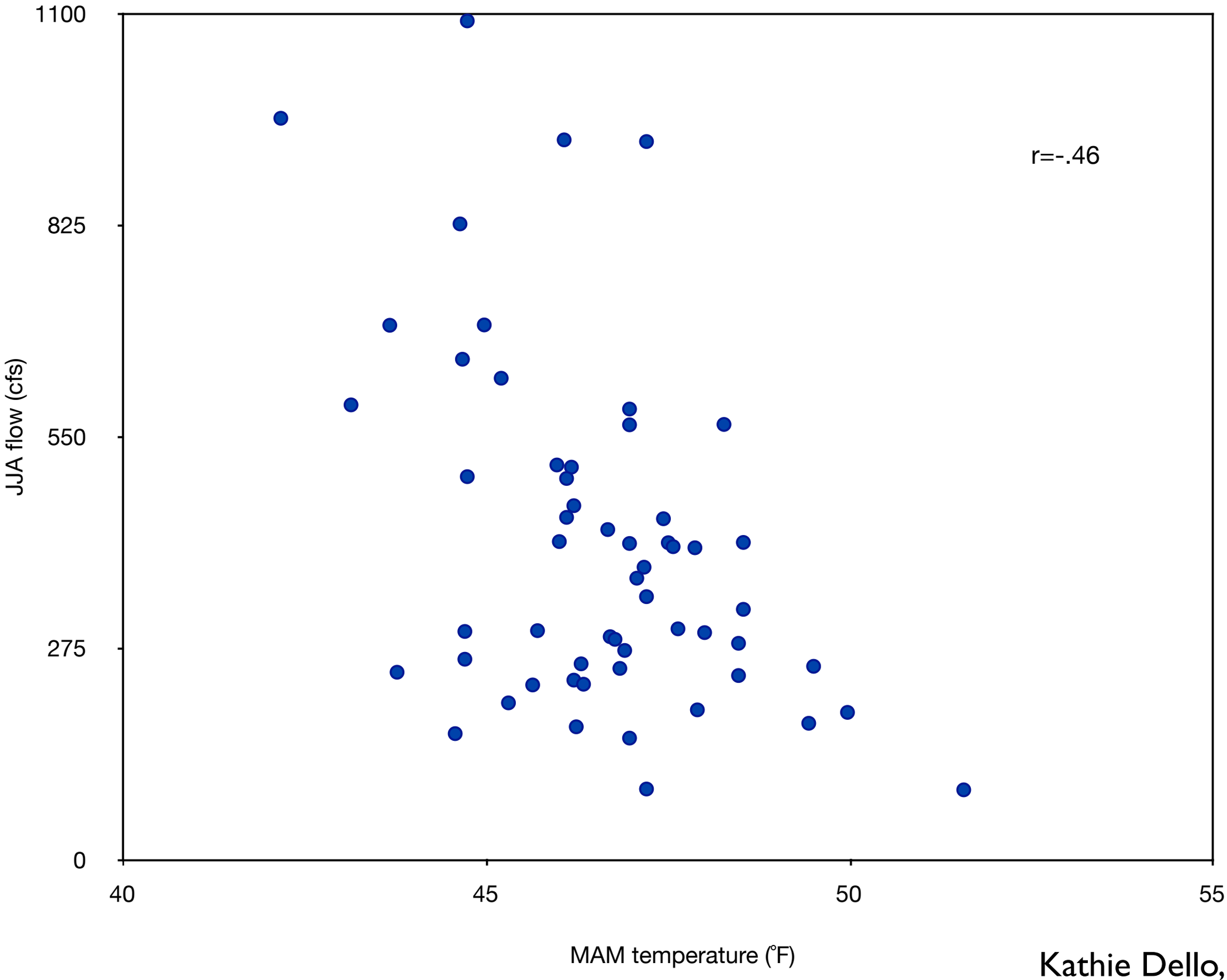
this just replots the data on the previous slide

Hood River at Tucker Bridge



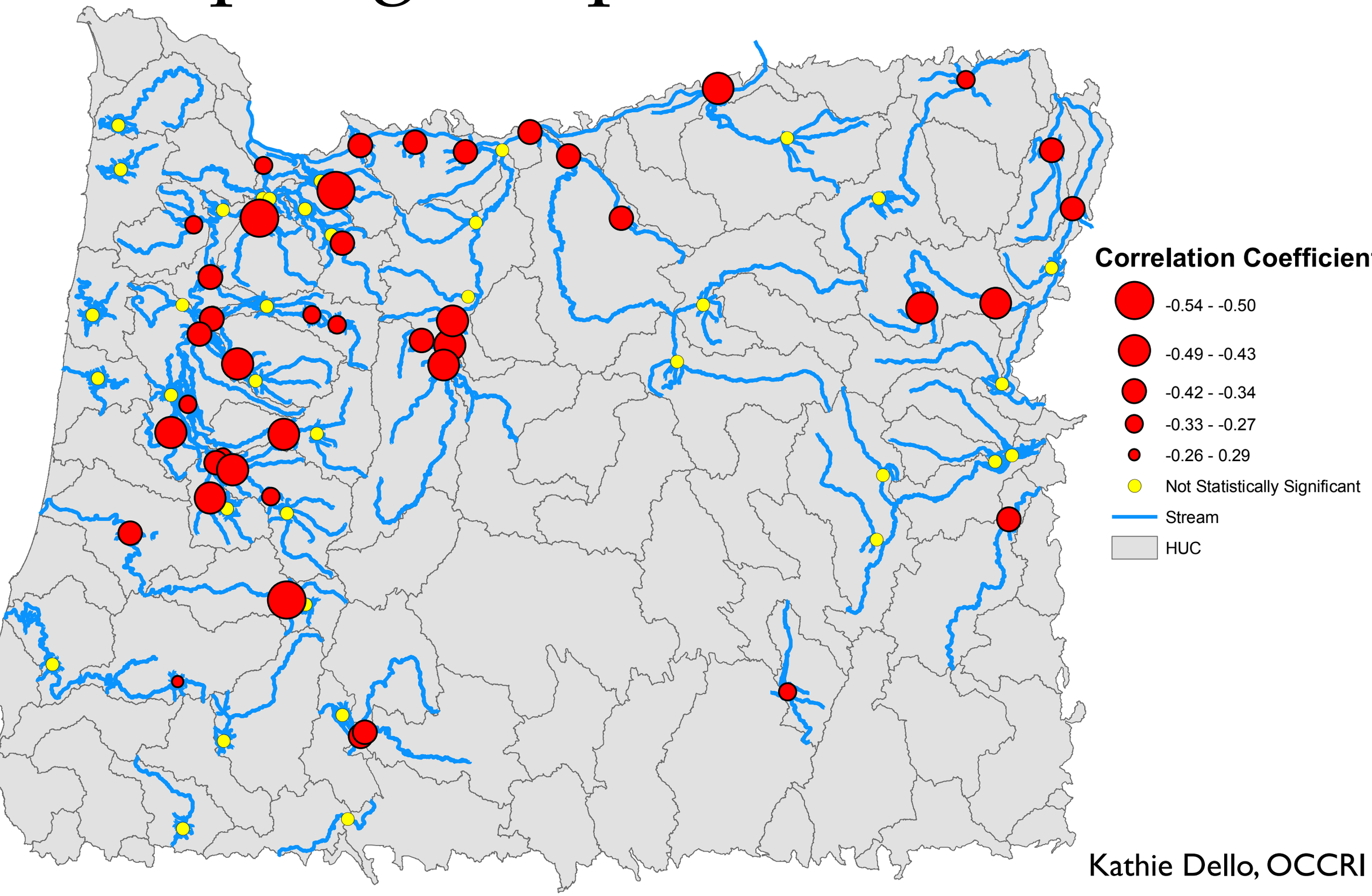
Kathie Dello, OCCRI

McKenzie River near Vida

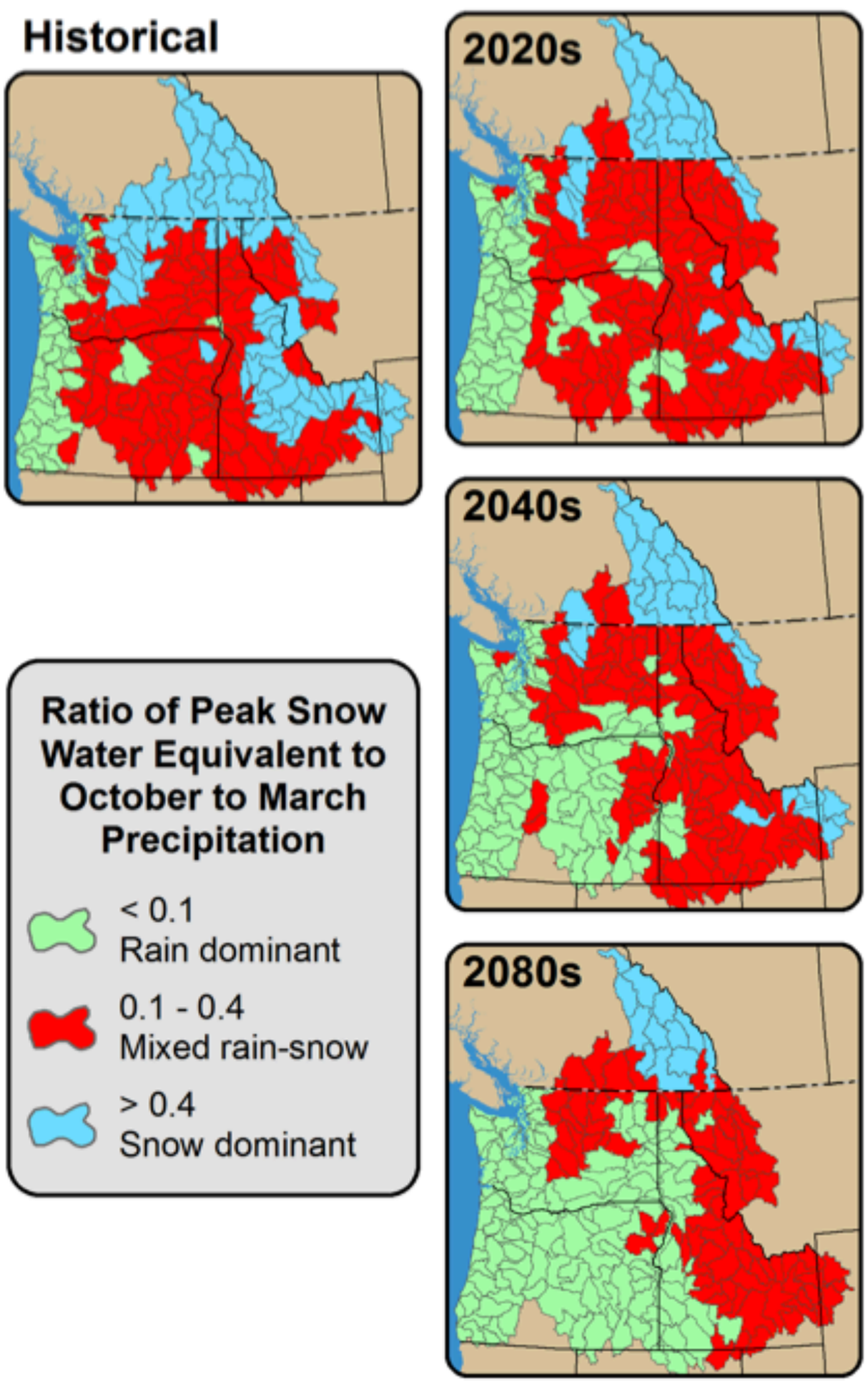


Kathie Dello, OCCRI

Spring temp - summer flow



Kathie Dello, OCCRI



Transition to more rain dominated watersheds

AIB emissions

Hamlet et al. 2010, NWCAR

Suitable habitat for fresh water salmonids in the PNW is projected to decline significantly (up to 92% for for bull trout).

Salmonid habitat may not all be impacted equally (e.g. high vs. low elevation).

Wikimedia commons

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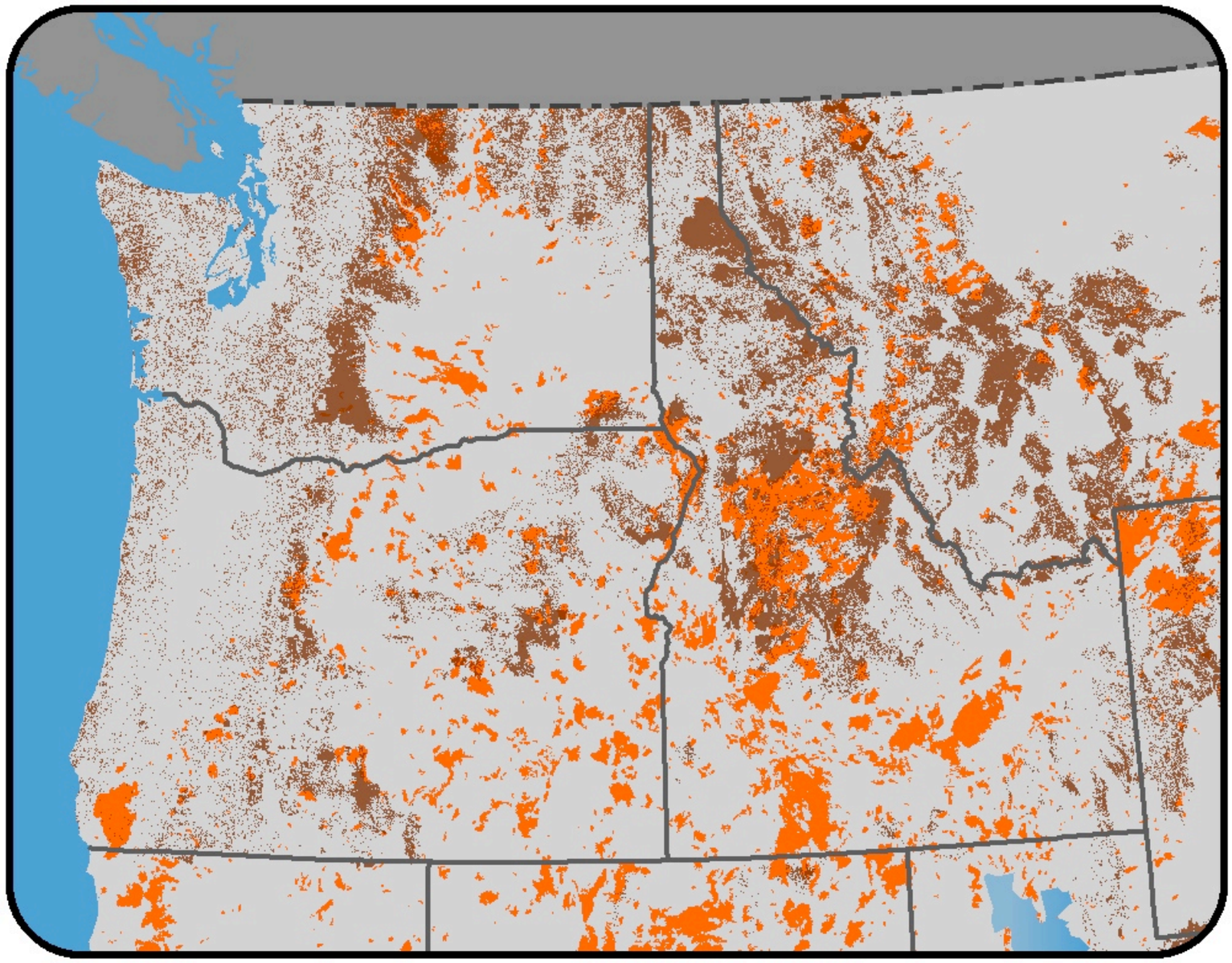
OCAR 2010

Risks to forests



Recent Disturbance

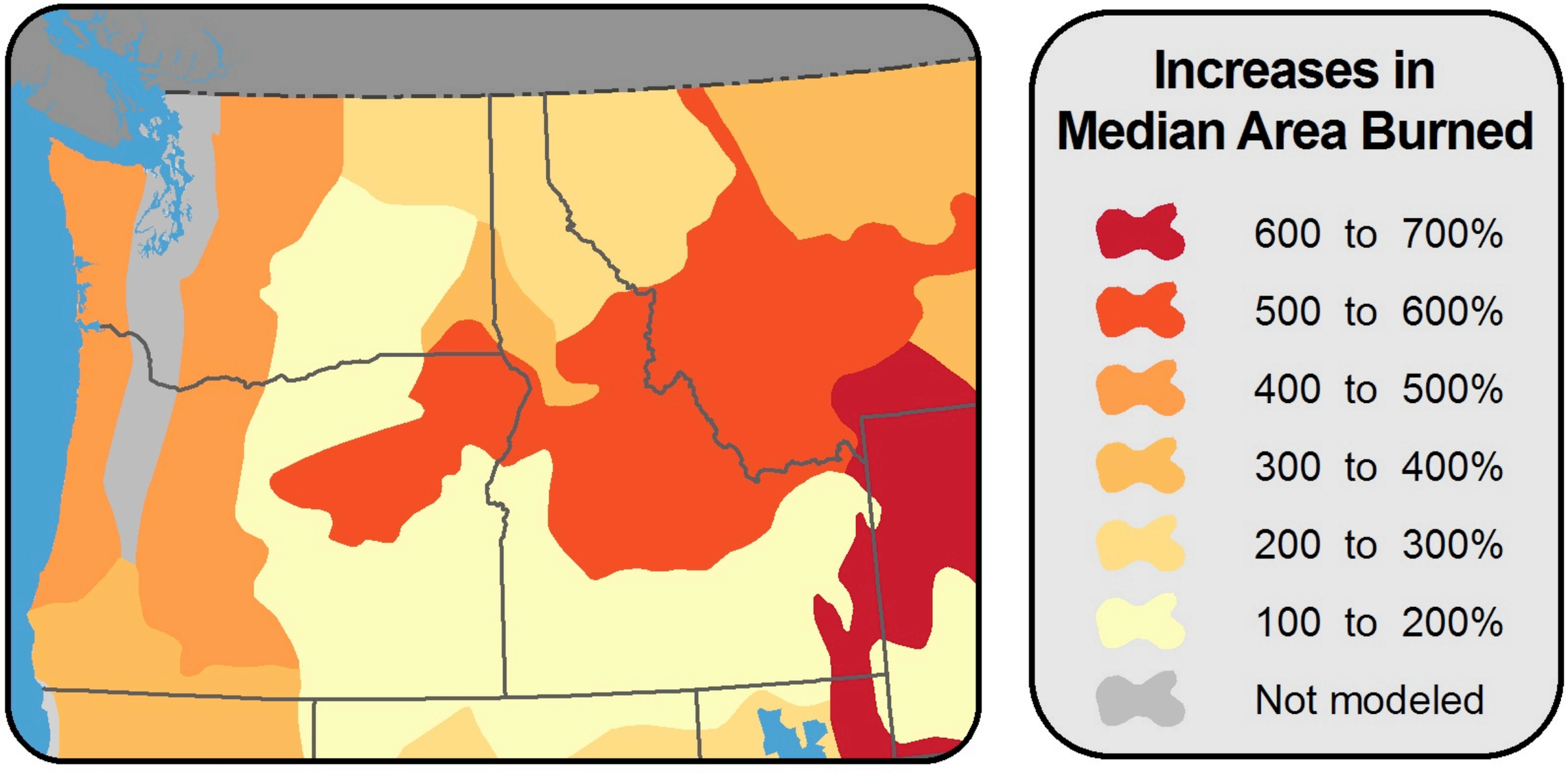
Fire area

Insect and disease area

NWCAR 2013

areas recently burned (1984-2008) (Eidenshink et al. 2007; USGS 2012) or affected by insects or disease (1997-2008)

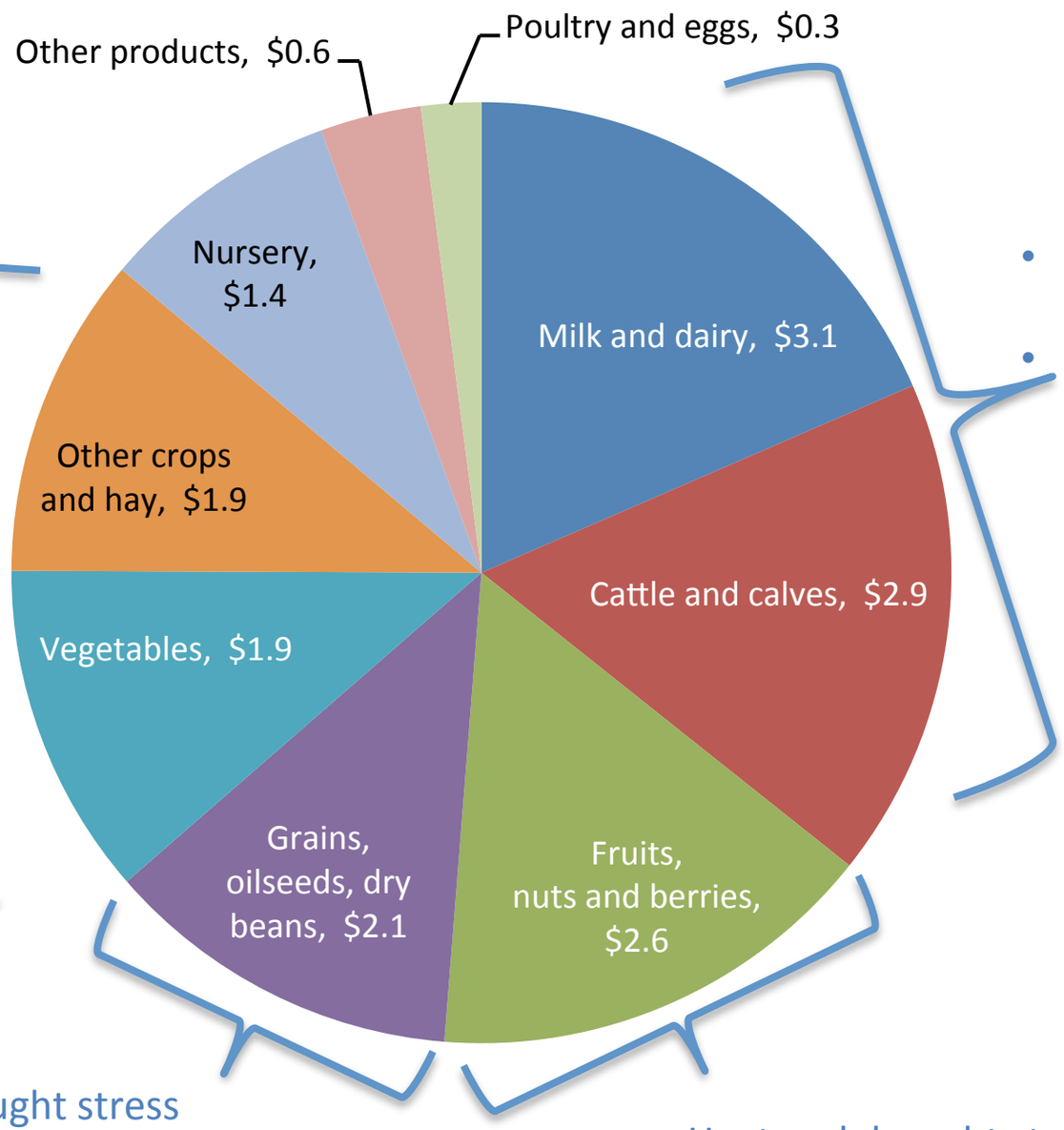
For 2.2°F global warming



NWCAR 2013

Sensitivity of area burned to a 2.2°F global warming, including both the expected temperature and precipitation changes (NRC 2011). The divisions are areas that share broad climatic and vegetation characteristics (Bailey 1995).

Impacts on agriculture



- CO_2 fertilization benefits
- Reduced availability of water for irrigation

- Direct heat stress effects on the animals
- Changes in forage quality

- Heat and drought stress
- Changes in precipitation regimes that affect farming operations
- CO_2 fertilization benefits
- Reduced availability of water for irrigation

- Heat and drought stress, changes in precipitation regimes
- Effects on chilling regimes, pests and diseases
- CO_2 fertilization benefits
- Reduced availability of water for irrigation

Northwest agricultural commodities with market values shown in $ (billion). Potential effects of climate change on these sectors, if any have been projected, are shown. Total value of commodities is $16.8 billion.

Conclusions

- We are moving rapidly to an unfamiliar environment: snow-dominant and mixed rain-snow watersheds moving toward rain-dominant
- Additional water stresses: ag demand, forest damage, water temperature
- Coming soon: new quantitative projections of PNW streamflow