PROJECTED FUTURE CONDITIONS IN THE LOWER WILLAMETTE RIVER SUBBASIN OF NORTHWEST OREGON:

CLACKAMAS, MULTNOMAH & WASHINGTON COUNTIES

Roger Hamilton, Bob Doppelt, Steve Adams & Stacy Vynne
(University of Oregon, Climate Leadership Initiative)

Maps and Graphs by Kathie Dello and Darrin Sharp
(Oregon Climate Change Research Institute)

With Support from the Lower Willamette Advisory Team

December 2009

OREGON CLIMATE CHANGE RESEARCH INSTITUTE

CLIMATE LEADERSHIP INITIATIVE
INSTITUTE FOR A SUSTAINABLE ENVIRONMENT
UNIVERSITY OF OREGON

TABLE OF CONTENTS

INTRODUCTION 3

MODELS & LIMITATIONS 4

GLOBAL CLIMATE CHANGE PROJECTIONS 6

SELECT RESOURCES FOR CURRENT ENVIRONMENTAL CONDITIONS WITHIN THE LOWER WILLAMETTE SUBBASIN 7

CLIMATE PROJECTIONS FOR THE LOWER WILLAMETTE: CLACKAMAS, MULTNOMAH AND WASHINGTON COUNTIES OF NORTHWEST OREGON 8

- TEMPERATURE 8
- PRECIPITATION 10
- VEGETATION 11
- SNOW WATER EQUIVALENT 13
- STREAMFLOW 13
- ACRES BURNED 14

APPENDIX A: SPATIAL MAPS AND GRAPHS OF MODELING RESULTS 17

INTRODUCTION

The Lower Willamette River Subbasin of western Oregon is rich in history, culture, and biological diversity. For the purposes of this assessment we have defined the Subbasin as the counties of Clackamas, Multnomah, and Washington, including the mouth of the Willamette River (flowing into the Columbia River) and the Tualatin and Clackamas river subbasins.

The Lower Willamette Subbasin is the most downstream (yet northern) portion of the Willamette River Basin. It is the most extensively urbanized Subbasin in this assessment with 51% in urban land use. Most of the greater Portland metropolitan region is in this Subbasin, with 25 cities, the urban portions of three counties and about 40 percent of the state's population. Portland, home to 570,000 people, is the largest city in the state with 2.2 million people in the greater metropolitan area.

The entire Willamette Basin stretches from Cottage Grove in the south to Portland in the north. The Basin is nestled in between the Cascade Range to the East and the Coastal Range to the West. Major tributaries include the Calapooya, Clackamas, Coast Fork, Long Tom, Luckiamute, McKenzie, Mary's, Middle Fork, Molalla, Santiam, Tualatin and Yamhill Rivers. With its fertile soils, the River Basin has attracted settlers since the early 1800s. The entire Willamette Basin includes a land area of 11,500 square miles, a population of 2.5 million and about 75% of Oregon's economy. While the Lower Basin is less than a third of the landmass in the entire River Basin, it contains the majority of the Basin and state's population and economy.

Figure 1. Willamette River Basin (in yellow) with focus for this report in red (Washington, Multnomah & Clackamas counties)

This report in intended to provide an ecological overview of the Subbasin and localized projections of the consequences of climate change in the Lower Willamette Subbasin. It is provided to support climate preparedness and adaptation planning and policy development in the Lower Willamette. The climate change models presented in this report were mapped by scientists at the Oregon Climate Change Research Institute. The Climate Leadership Initiative at the University of Oregon helped develop this summary of the assessment.

MODELS & LIMITATIONS

Preparing and planning for climate change is, above all, an exercise in risk management. Traditionally, future planning has been based on historical conditions and experiences. However, this approach is no longer reliable as climate change will produce never before seen changes in temperature, precipitation, streamflow, vegetation and fire patterns. To understand the possible impacts on natural, built, economic, human and cultural systems, climate models are used to project future conditions.

Understanding what actions should be taken to prepare natural, built, human, cultural and economic systems for climate change is challenging as the Earth's climate and ocean systems are too complex to be simulated in a laboratory experiment or reactor. Therefore, climate scientists use global climate models to estimate how climate change might affect conditions in mid- and end-of-century. Climate models incorporate the physical laws and chemical interactions of the Earth. Future conditions are calculated based on different "scenarios" (or estimations) of future greenhouse gas emissions, policies and regulations that would limit emissions, technological improvements, and behavioral changes. (For the scenarios selected in this project, please see below.) In order to test the climate models, they are backcasted against observed data to see how well they "predict" the past. While each of the inputs to the models are the same, they vary in their level of detail and manner of interpretation. This results in some differences in outputs and uncertainty as to which future scenario is most likely to occur (and therefore the importance of running multiple models). The difference in detail and interpretation that leads to this uncertainty is due to processes and feedbacks between different parts of the Earth's climate system that are not fully understood. However, by comparing a group of climate models, it is possible to project a credible range of possible future conditions.

Most climate models are created at global scales, but are difficult to downscale to local or regional scales because the more localized they become the greater the chance of errors and uncertainty. However, managers and policymakers need regional and local data that reflect how climate change will impact their region in order to plan and develop policies. The Oregon Climate Change Research Institute (OCCRI) has adjusted global model results to local and regional scales to support this effort.

The Intergovernmental Panel on Climate Change (IPCC) uses approximately 27 models to make global climate projections. The models are developed by different institutions in different countries around the world and are subject to different interpretations.

OCCRI has selected the following models for use in the Lower Willamette Basin project:

- **PCM1**: The Parallel Climate

Model, developed through a collaboration of United States federal agencies.
- **CSIRO-MK3**: Developed by the Atmospheric Research Office in Australia.
- **HadCM3**: Developed by the Met Office, the national weather office for the United Kingdom.
- **MIROC**: A Japanese model used for the MC1 vegetation models (shown in results for fire and vegetation projections).

These models were selected because they use temperature and precipitation forcing agents including changes in greenhouse gas emissions, aerosols, water vapor and cloud cover, solar radiation, and changes in land use to represent possible future conditions.

To further refine these projected futures, the IPCC has developed a range of scenarios under which climate models are run. These scenarios, as described in the IPCC's Special Report on Emissions Scenarios (SRES), describe different futures for greenhouse gas emissions, land use, and agricultural practices based on global policy decision-making.[1] For this report, two scenarios were selected to model how different futures might play out:

- **A1b**: The business as usual scenario (for which current global emissions are actually exceeding) that presumes continued growth in economies, population and technology, and reliance on mixed energy sources.
- **B1**: The 'greener' emissions scenario, which suggests emissions increasing slightly in the coming decades but then falling to lower than current levels by 2100 due to deployment of low carbon energy and transportation systems.

Model outputs were converted to local scales using local data on recent temperature and precipitation patterns. The MC1 vegetation model provides information on possible future vegetation types and wildfire patterns.

The utility of the model results presented in this report is to assist public and private entities envision what the conditions and landscape may look like in the future and the potential magnitude and direction of change.

It is important to note that the scenarios described in this report utilize the best available information. However, they are not predictions. Instead, they should be considered **possible outcomes**. Actual conditions may vary quite substantially from those depicted in these scenarios. Readers are therefore urged to **focus on the range of projections and the trends they suggest**, as opposed to relying on the outputs of a single model or on a particular number

[1] For more information on SRES, visit: http://www.ipcc-data.org/ddc_envdata.html

GLOBAL CLIMATE CHANGE PROJECTIONS

The IPCC[2] and the U.S. Global Change Research Program[3] agree that the evidence is "unequivocal" that the Earth's atmosphere and oceans are warming, and that this warming is due primarily to human activities including the emission of CO_2, methane, and other greenhouse gases, along with land conversion and deforestation. Average global air temperature has already increased by 0.7° C (1.4° F) over the last hundred years and is expected to increase up to 6.4° C (11.5° F) within the next century (Figure 1).

Even with immediate reductions in greenhouse gas emissions, impacts from the current build up of greenhouse gas emissions in the atmosphere will continue to be felt for decades. It may take decades or centuries to restabilize the system. Reducing emissions is a vital mitigation measure to prevent further impacts on climate systems. However, countries and communities must also begin to plan and prepare for the likely impacts that will be experienced as a result of the emissions already present in the atmosphere. By taking proactive steps to plan for changes, residents of the Lower Willamette will be better positioned to build resistance and resiliency of the systems they depend on for maintaining quality of life under a climate changed future.

When using projections to prepare for climate change, we must consider how to deal with the uncertainty of models and make decisions that are robust against a range of future scenarios. One approach is finding consistency in models; if consistencies do not exist, then we must consider strategies that are effective no matter what change occurs. This is likely to involve building system resiliency and resistancy, as well as flexibility into the planning process.

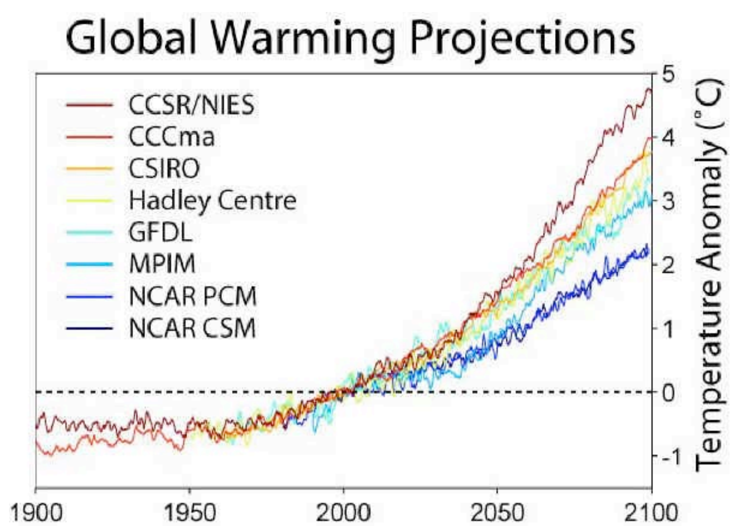


Figure 2. Projections for global temperature increase for a number of models used by the IPCC, compared with temperatures over the last one hundred years. Note that while projections for temperature increase vary by the end of the century, all models show a clear upward trend. (From IPCC 2007)

---

[2] IPCC 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

[3] USGCRP 2009. Global Climate Change Impacts in the United States. T. R. Karl, J. M. Melillo, and T. C. Peterson,(eds.). Cambridge University Press.

SELECT RESOURCES FOR CURRENT ENVIRONMENTAL CONDITIONS WITHIN THE LOWER WILLAMETTE SUBBASIN

City of Portland Endangered Species Program
http://www.portlandonline.com/bes/fish/index.cfm

City of Portland Invasive Plants Strategy Report. 2008
http://www.portlandonline.com/bes/index.cfm?c=47815&a=217069

City of Portland - Willamette Watershed Characterization Report
http://www.portlandonline.com/BES/index.cfm?c=31806

Oregon Department of Environmental Quality. 2008 Air Annual Report.
http://www.deq.state.or.us/aq/forms/2008AQreport.pdf

Department of Environmental Quality Willamette Basin Report. 2009.
http://www.deq.state.or.us/about/eqc/agendas/attachments/2009oct/F-WillametteBasinAssessmentRpt.pdf

Oregon State University - Institute for Natural Resources - Oregon Explorer
http://inr.oregonstate.edu/oregon_explorer.html

Oregon State University - Oregon Natural Heritage Information Center
http://oregonstate.edu/ornhic/index.html

Oregon State University - Willamette Basin Explorer
http://www.willametteexplorer.info/

Outputs of our climate models (PCM, CSIRO, and HadCM) and the vegetation model (MC1) include projections for changes in temperature, precipitation, percent of landscape burned, suitable vegetation types and distribution, snowpack, and streamflow. A historical baseline of 1971-2000 was used in order to make comparisons of projections for the 2040s (1930-1959) and 2080s (2070-2099) (scientists use thirty year time slices, or averages, to account for interannual and interdecadel variability). Stream data is for 2020s and 2040s, due to data availability. The results present a range of different possible future conditions in the Lower Willamette. Unforeseen circumstances such as uncertainties about chemical reactions or international policy to drastically reduce greenhouse gas emissions, may result in a future different than has been projected.

Climate change projections are provided here as bar graphs, charts and spatial maps to demonstrate the results of the modeling using a variety of visualizations that may be useful for different decision-making groups. Samples for each factor are posted below: the full suite of maps, charts and graphs can be found at the end of the document.

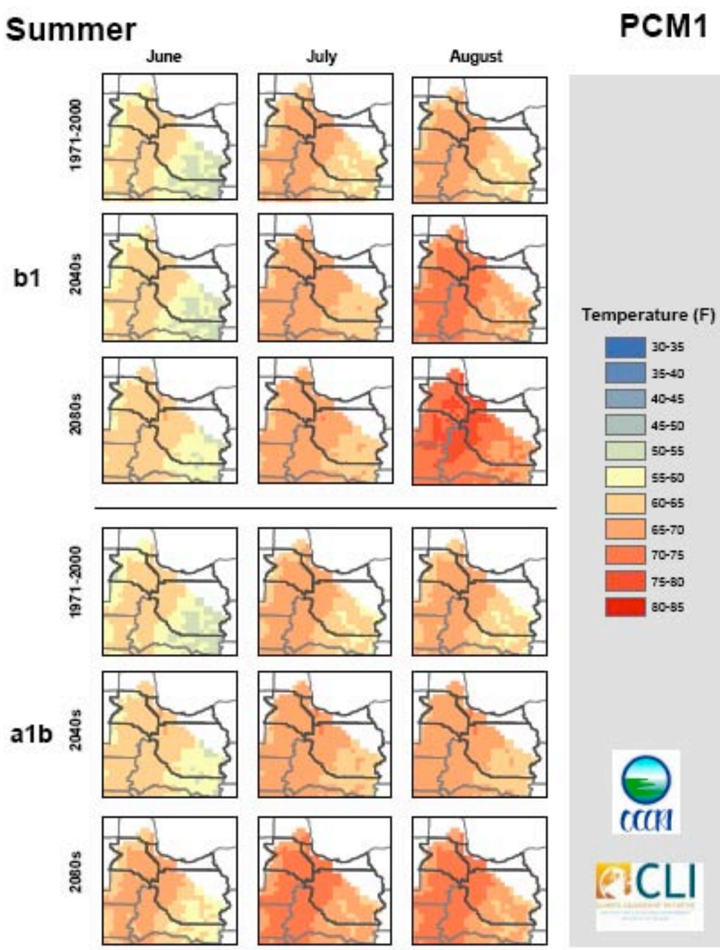


Figure 3. Sample of spatial maps for summer temperature projections. PCM1 Model projections for both scenarios with historic baseline (1971-2000), mid- and end-century projections. Darker red indicates warmer temperatures.

The modeling results come from the global modeling results available from the IPCC Fourth Assessment Report. Implications for the Pacific Northwest are based on the twenty global climate models analyzed by Mote and Salathé (2009). For historical baseline, 800m PRISM 1971-2000 climate grids were used to apply to the analysis and 'downscale' the data.

Temperature

The overall trend for temperature shows warming for the entire Lower Willamette by the end of the century. The most intense warming of 10-15º F is in summer. Warming is also most intense along the Interstate 5 corridor (running through the most populated area of the Basin). There is also warming during the winter months, but less extreme than in the summer (about 3-5º F). In the B1 scenario, there is still warming, but warming is less severe in the summer months compared with the higher emissions scenario, and minimal in winter.

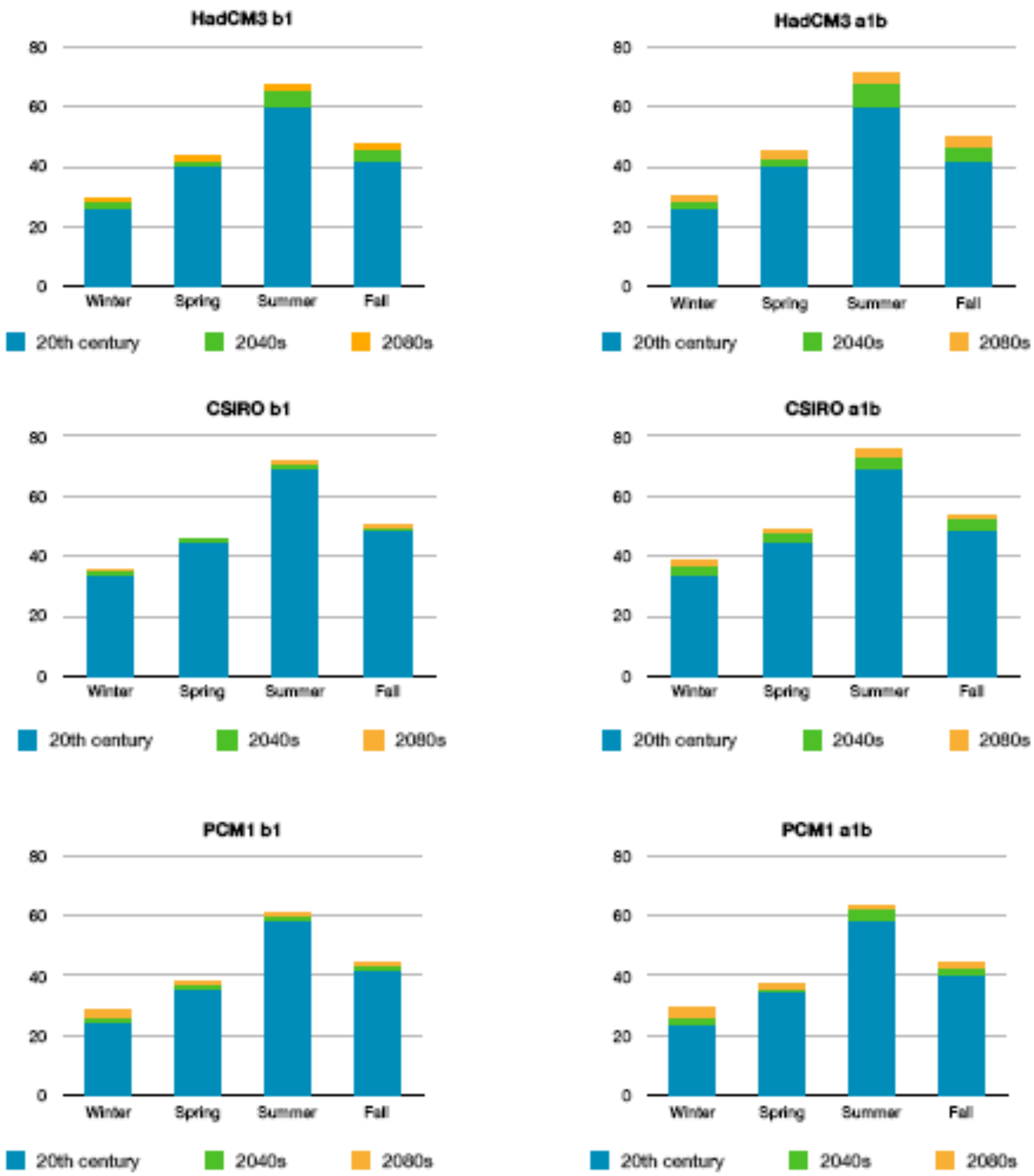


Figure 4. Projections for seasonal change in temperature for all models and both scenarios.

Precipitation

Precipitation is one of the variables most difficult for climate models to project, particularly for the Pacific Northwest. For the mid-century A1b scenario, an increase in precipitation is seen in the winter for all models (minimal for PCM1), with least change in the spring, and mixed results in the summer. HadCM shows severe drought in the summer, while CSIRO and PCM1 show a slight increase in precipitation. For the fall months, the models project mixed results in precipitation. In the 2080s, the CSIRO and PCM1 models show an increase in precipitation for most of the year. HadCM projects slight reduction in the spring and drought in the summer, but not as severe a drought as shown in the 2040s.

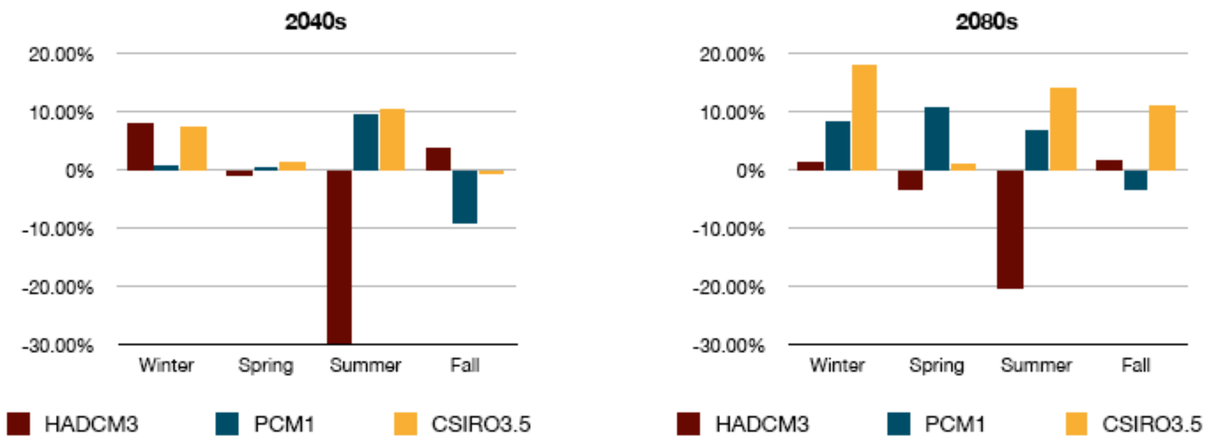


Figure 5. Projections for percent change in precipitation compared to historical (1971-2000) for all models under the A1b scenario.

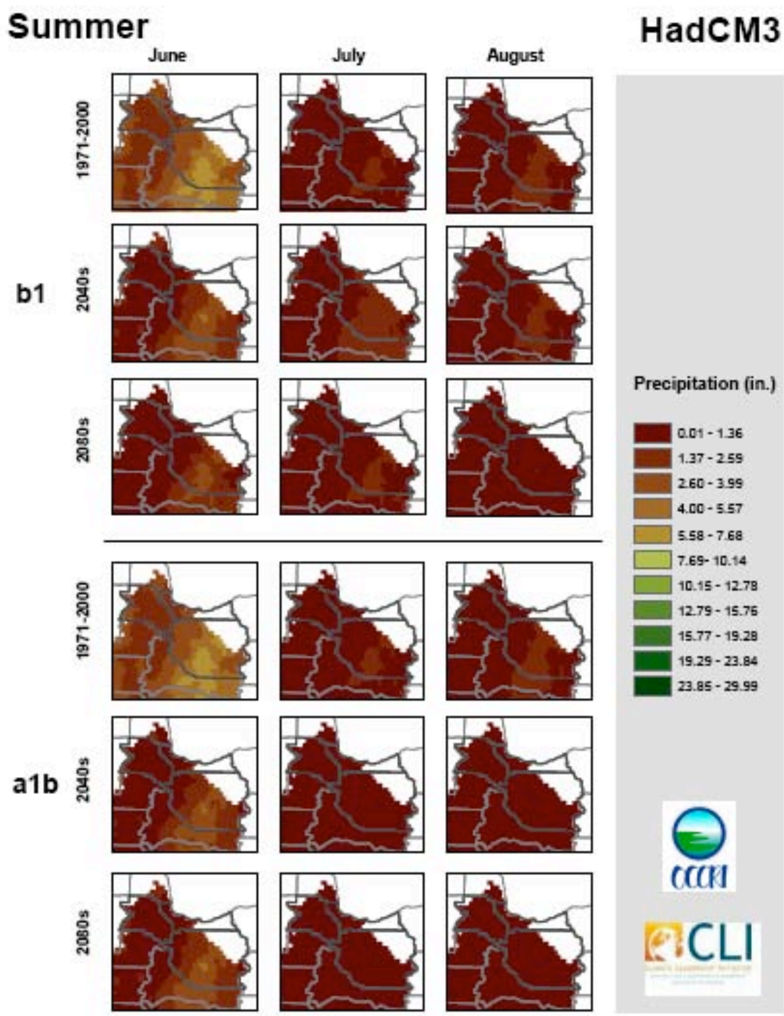
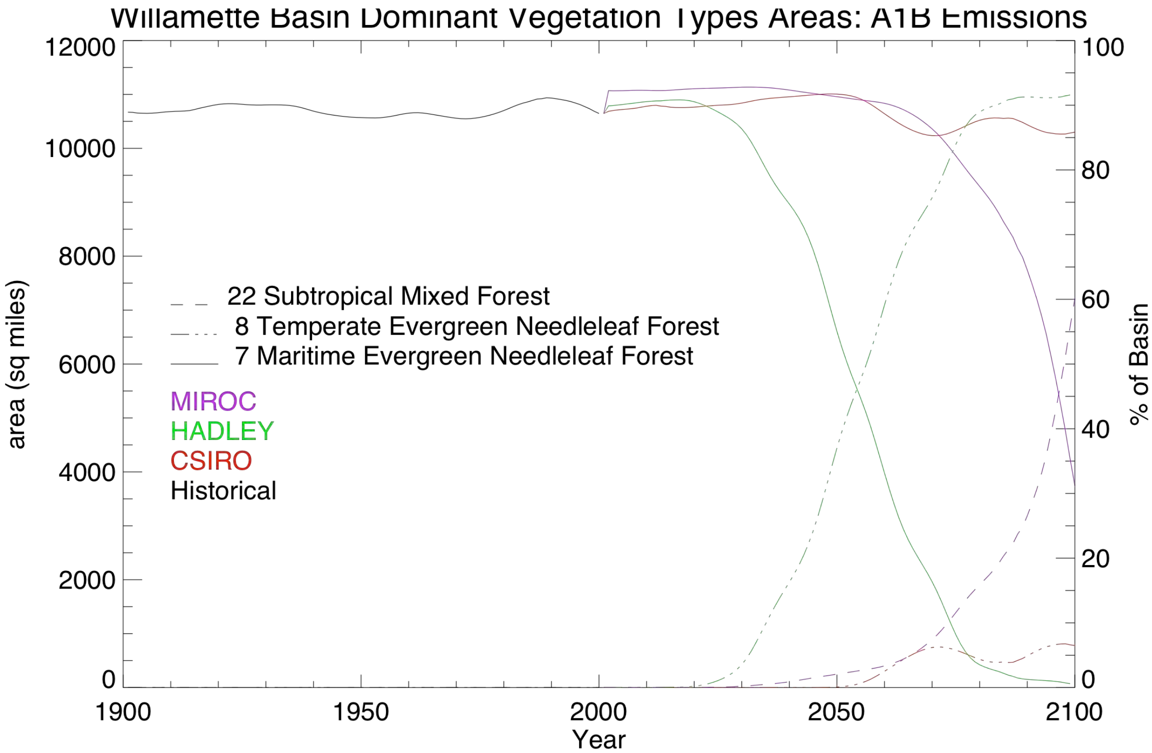
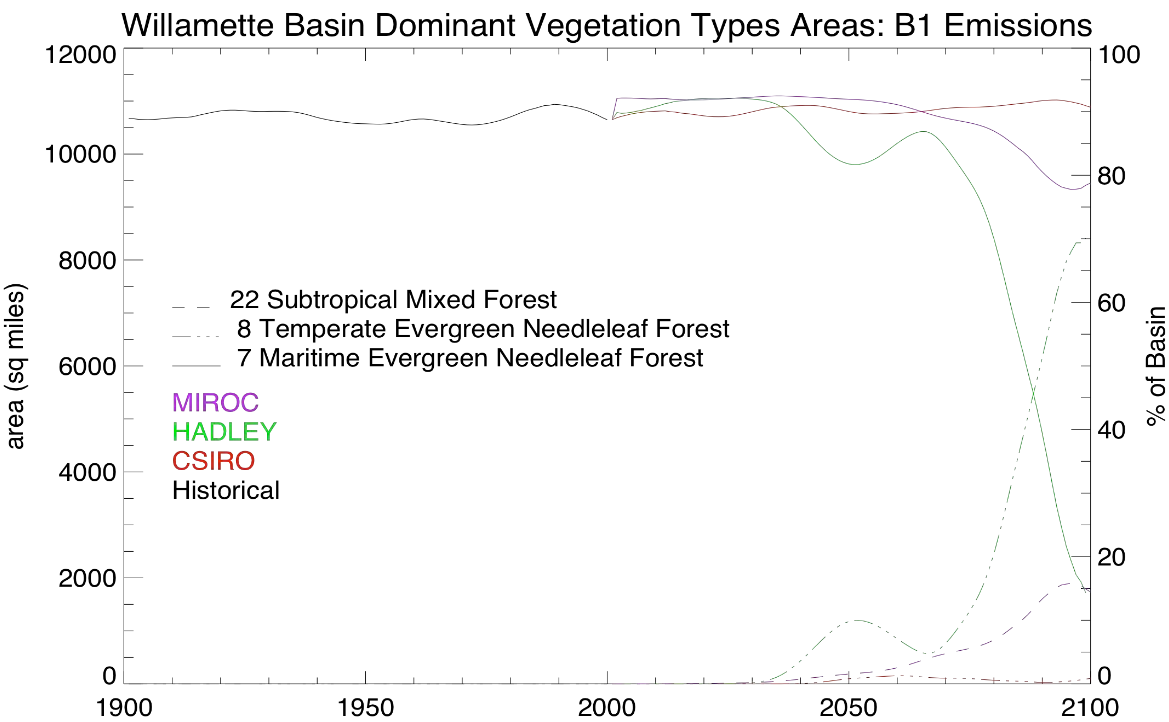


Figure 6. Sample spatial maps for summer projections for the HadCM model for both scenarios. Darker red indicates less precipitation.

Vegetation

For Maritime Evergreen Needleleaf species, the HadCM and MIROC models project a significant decline, with near disappearance by the end of the century. CSIRO also shows a decline, but not as severe as the other models. HadCM shows a rapid increase in Temperate Evergreen Needleleaf species, replacing Maritime species. MIROC and CSIRO also project an increase in Temperate Evergreen species, but not as rapidly as HadCM. Subtropical Mixed Forest species also increases slightly in abundance, with rapid increase after mid-century under the MIROC model, but less change for HadCM and CSIRO. (Data provided by Ray Drapek, Pacific Northwest Research Station.)





Figures 7-8. Changes in dominant vegetation for both scenarios using the MC1 model.

Snow Water Equivalent

Under the A1b scenario, the model projects a severe decrease in snow water equivalent with near disappearance (greater than 80% loss) by the end of the century. (Data provided by Heejun Chang, Portland State University.)

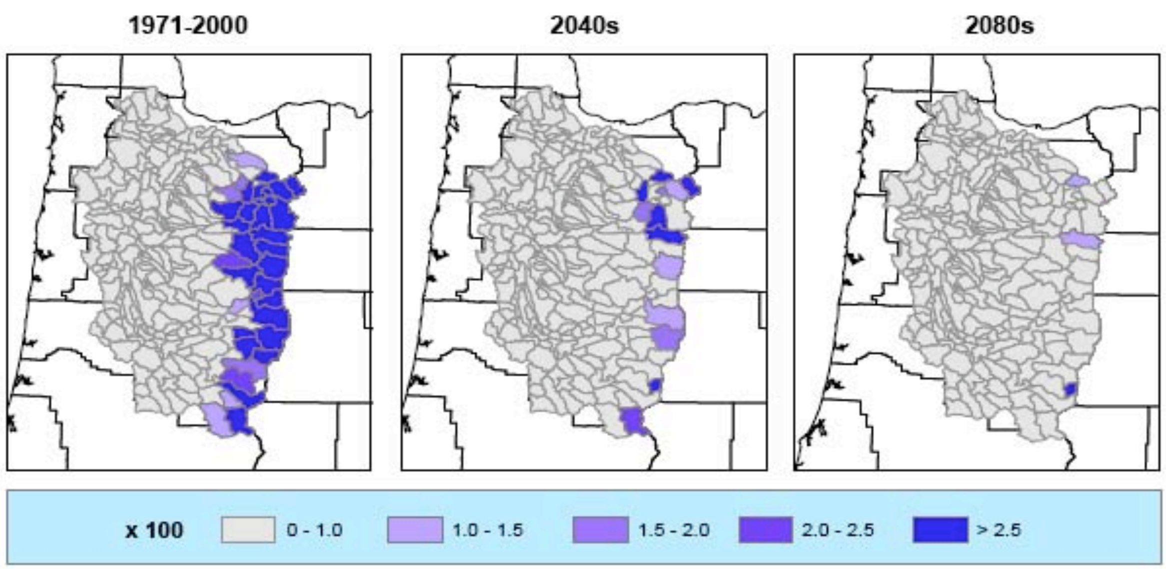


Figure 9. Ensemble mean changes in April 1 snow water equivalent for A1b scenario.

Streamflow

Projections show that streams are likely to become flashier in the winter and early spring– that is, higher high flows and more frequent and severe flooding, and lower low flows with more streams going dry – due to temperature, more precipitation falling as rain, groundwater and storm severity changes. All three models show a slight increase in winter flow, with moderate decrease in historical summer flows.

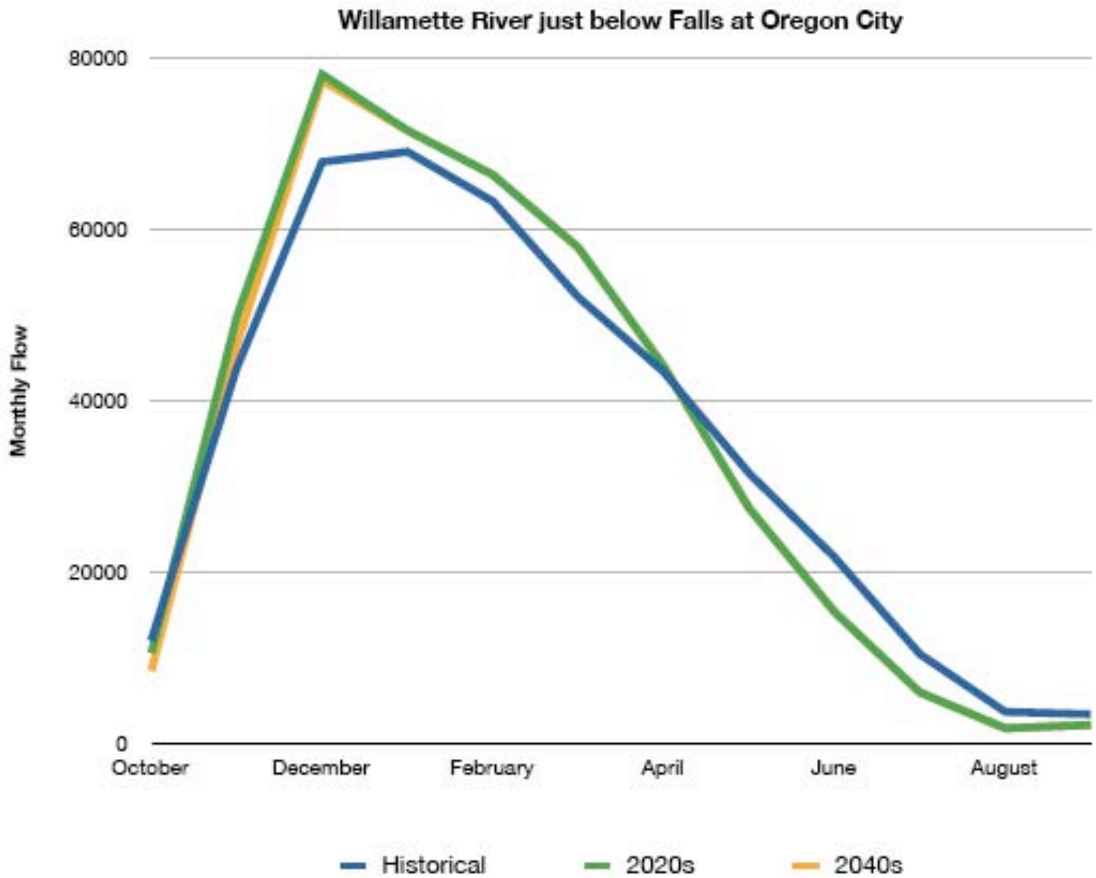


Figure 10. Sample stream flow change for 2020s and 2040s under the HadCM model.

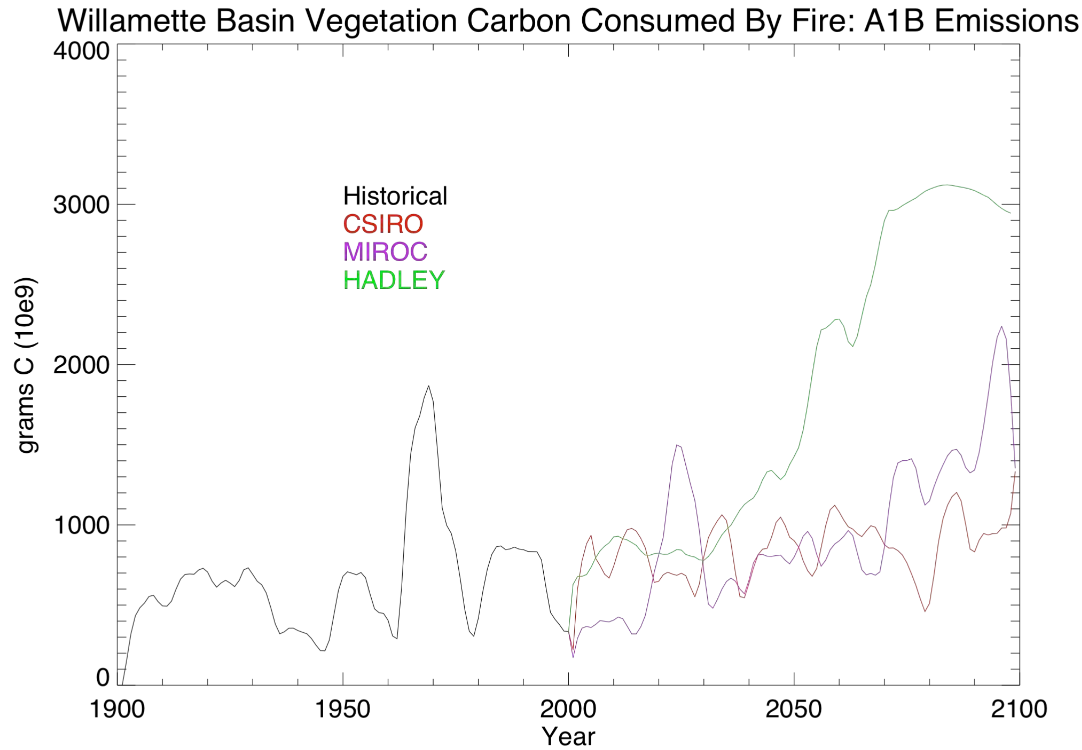
Acres Burned

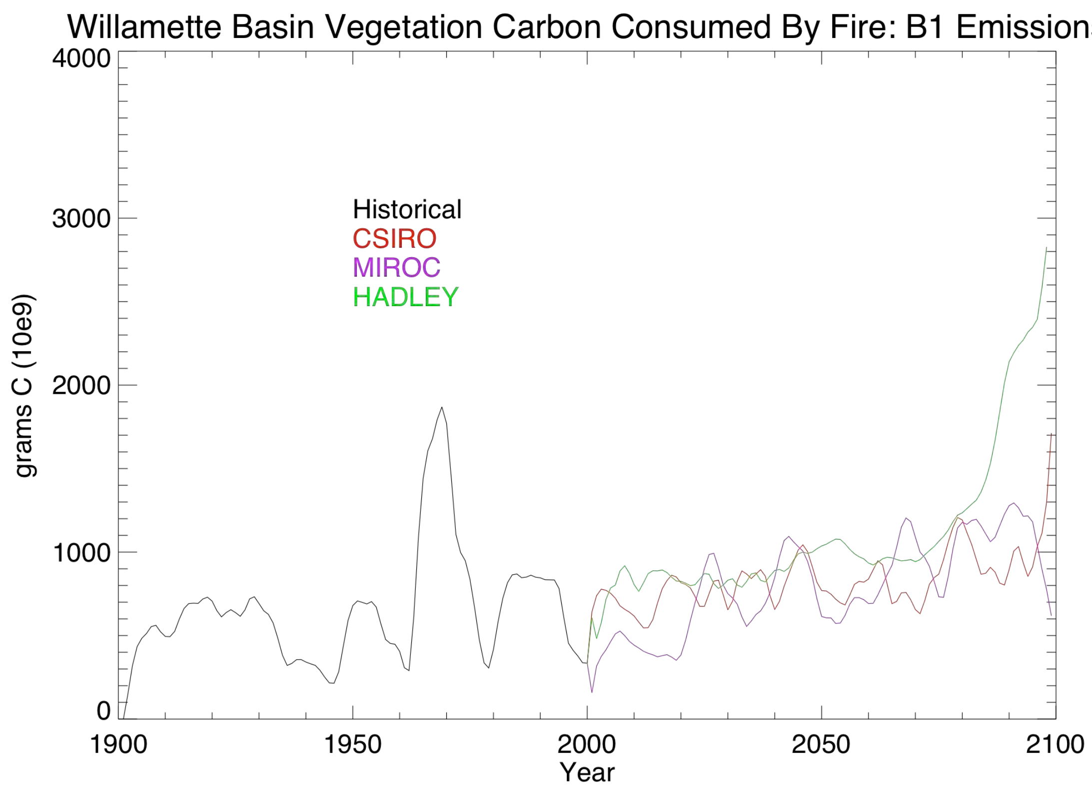
The data below shows percent of area in each grid cell (8km) projected to be burned for the entire Willamette Basin (note, counties for the Lower Subbasin could not be overlaid). Under both scenarios, HadCM projects a greater proportion burned with almost 2% of each grid cell burned by 2080. MIROC and HadCM show an increase in intensity of areas burned, especially under the A1b scenario and for the Lower Willamette Subbasin. CSIRO, which tends to be a wetter and cooler model, shows less change in proportion burned. (Data provided by Ray Drapek, Pacific Northwest Research Station.)

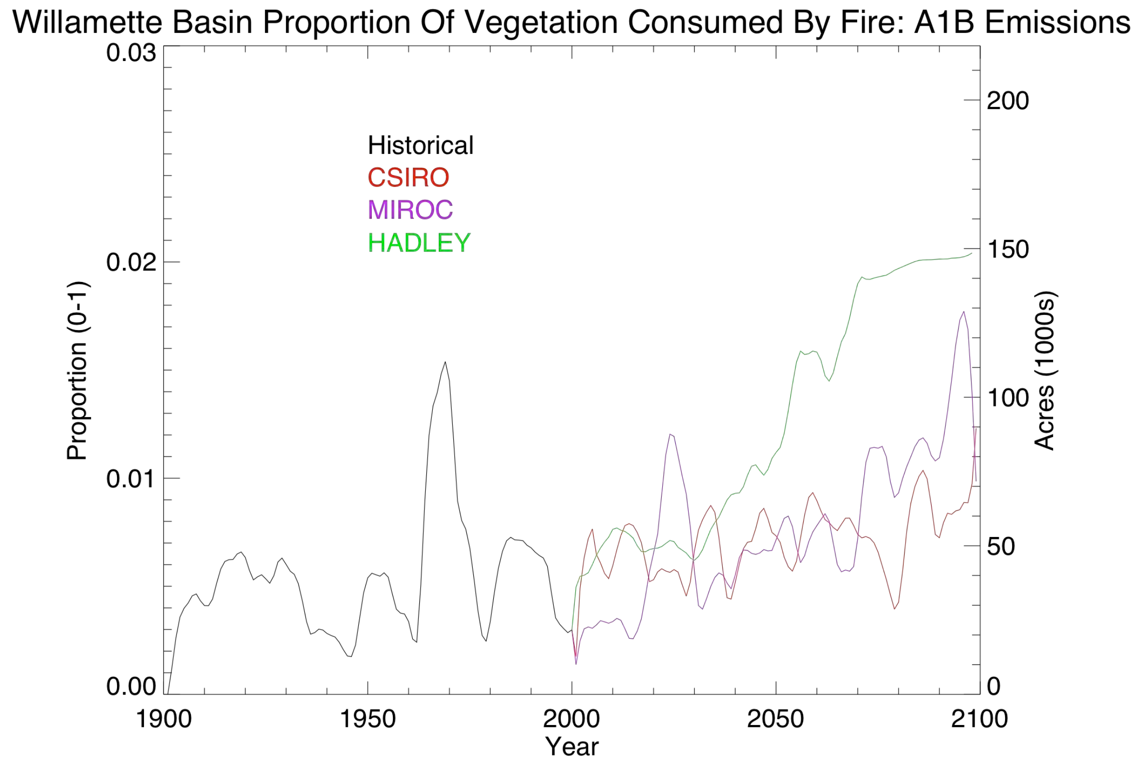
Figure 11. Percent area burned for all models under both scenarios.

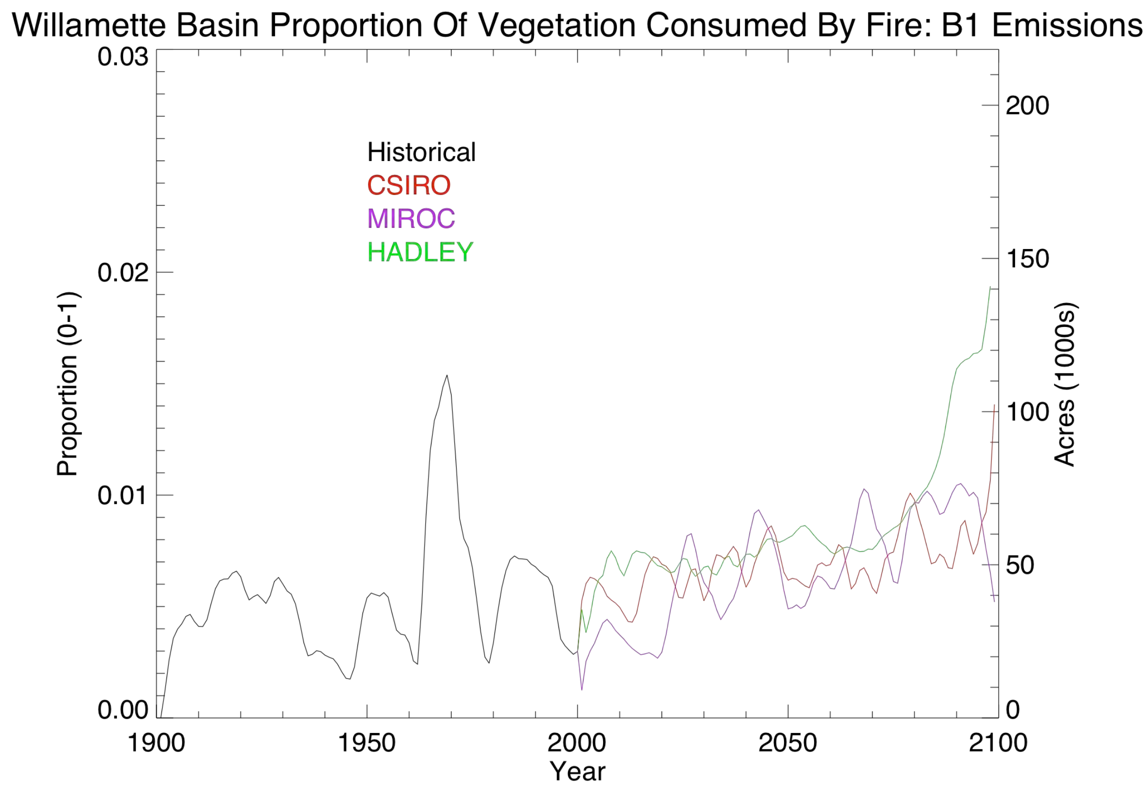
Appendix A: Spatial Maps and Graphs of Modeling Results

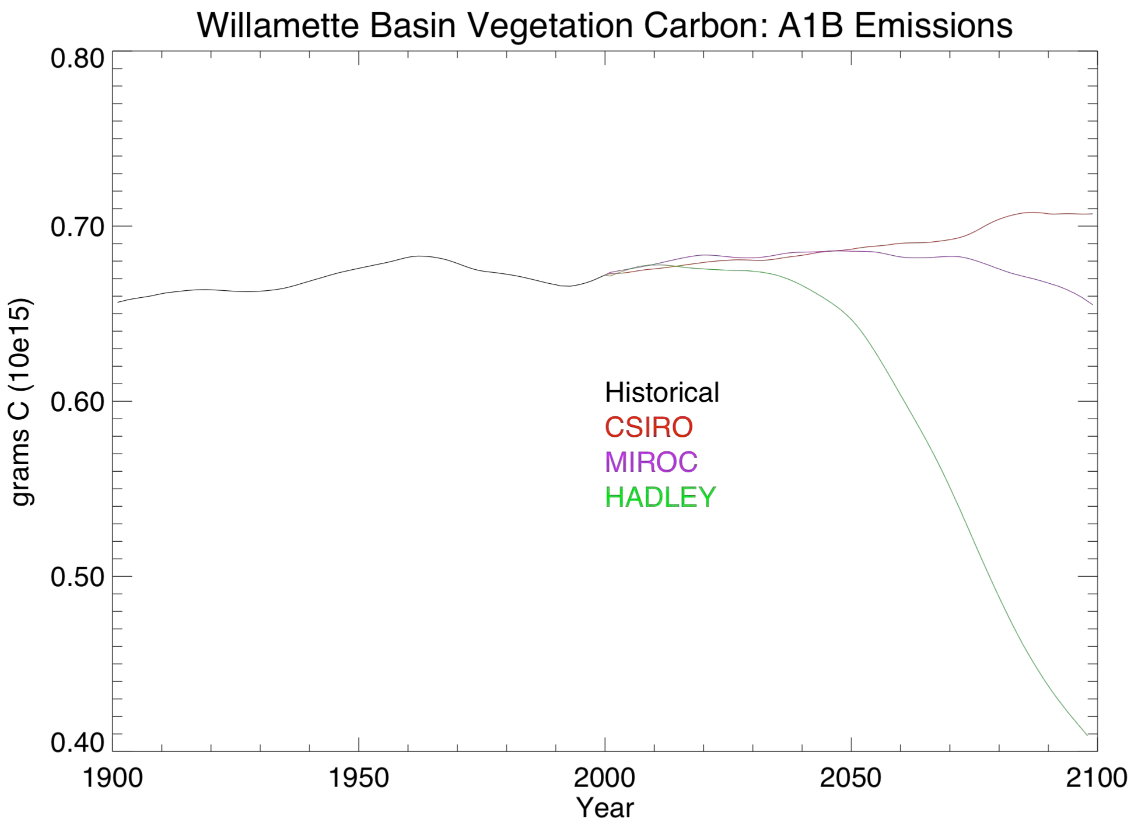
A1-2 Biomass consumed by fire for HadCM, MIROC and CSIRO
A3-4 Proportion biomass burned for HadCM, MIROC and CSIRO
A5-6 Vegetation carbon for HadCM, MIROC and CSIRO
A7-8 Change in vegetation type for HadCM, MIROC and CSIRO
A9-20. Seasonal temperature spatial maps for HadCM, CSIRO, PCM1
A21-32 Seasonal precipitation spatial maps for HadCM, CSIRO, PCM1
A33-52 Streamflow graphs for HadCM, MIROC and CSIRO

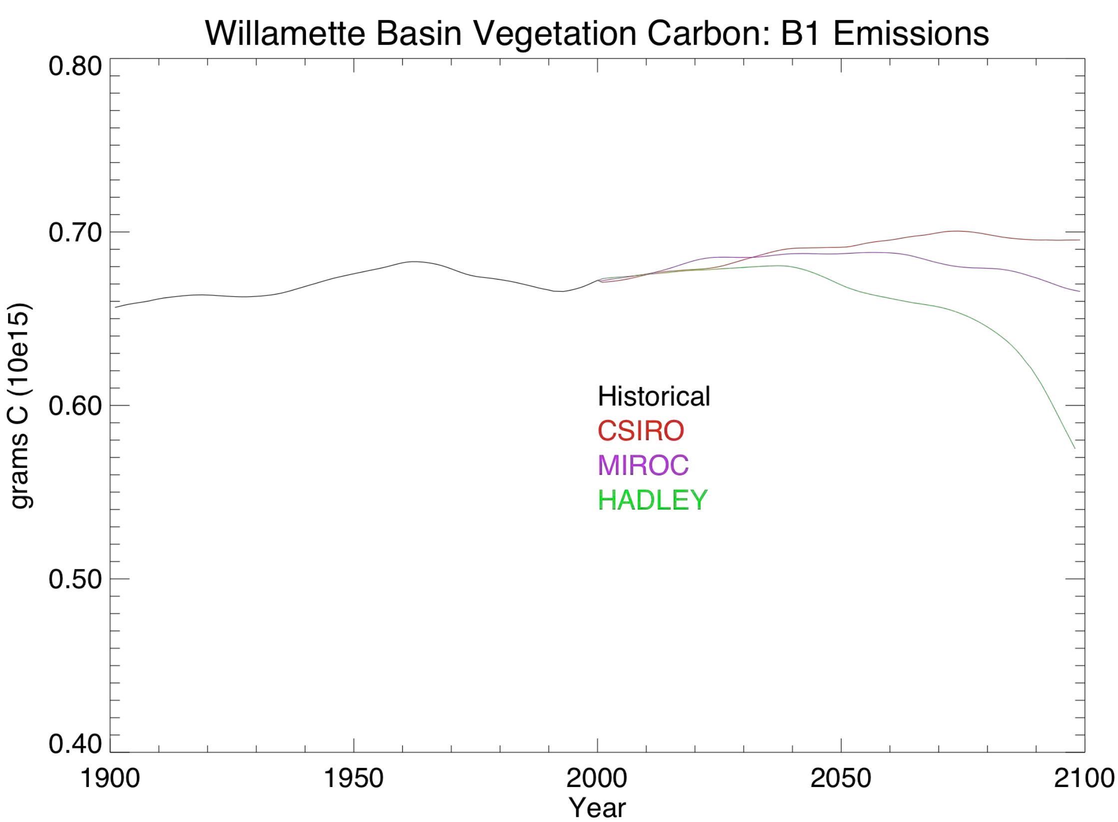

Willamette Basin Vegetation Carbon Consumed By Fire: A1B Emissions
Historical
CSIRO
MIROC
HADLEY
grams C (10e9)
4000
3000
2000
1000
0
1900
1950
2000
2050
2100
Year

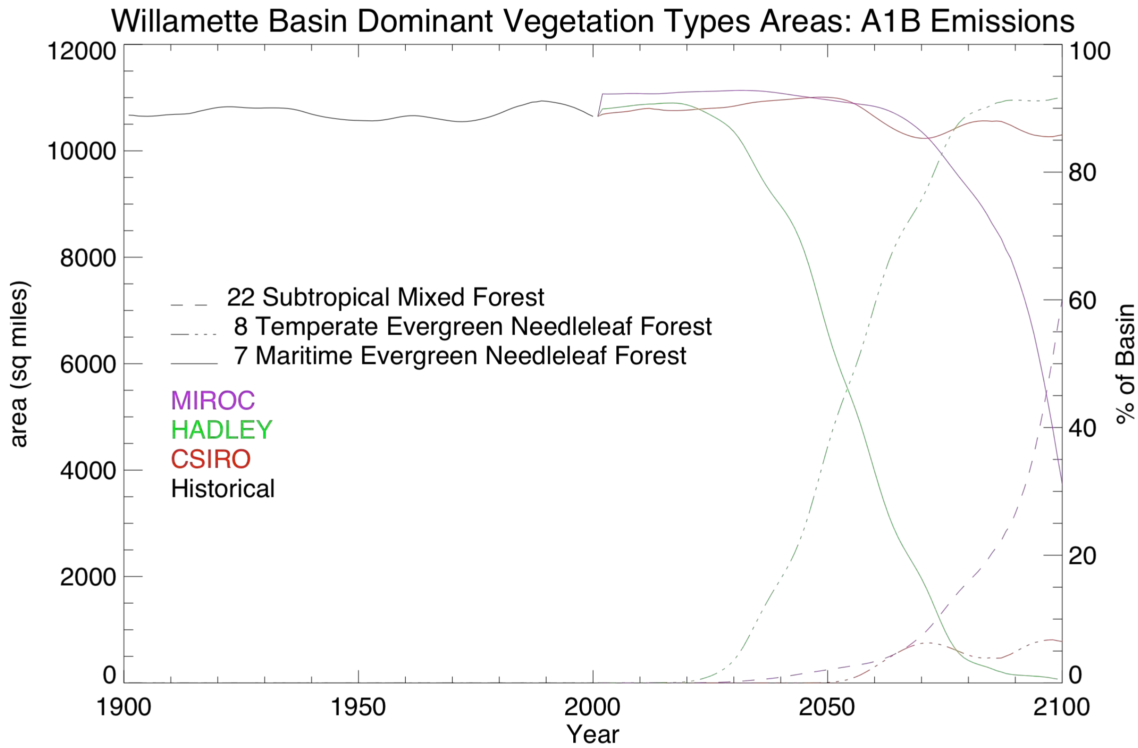

Willamette Basin Vegetation Carbon Consumed By Fire: B1 Emissions
Historical
CSIRO
MIROC
HADLEY
grams C (10e9)
4000
3000
2000
1000
0
1900
1950
2000
2050
2100
Year

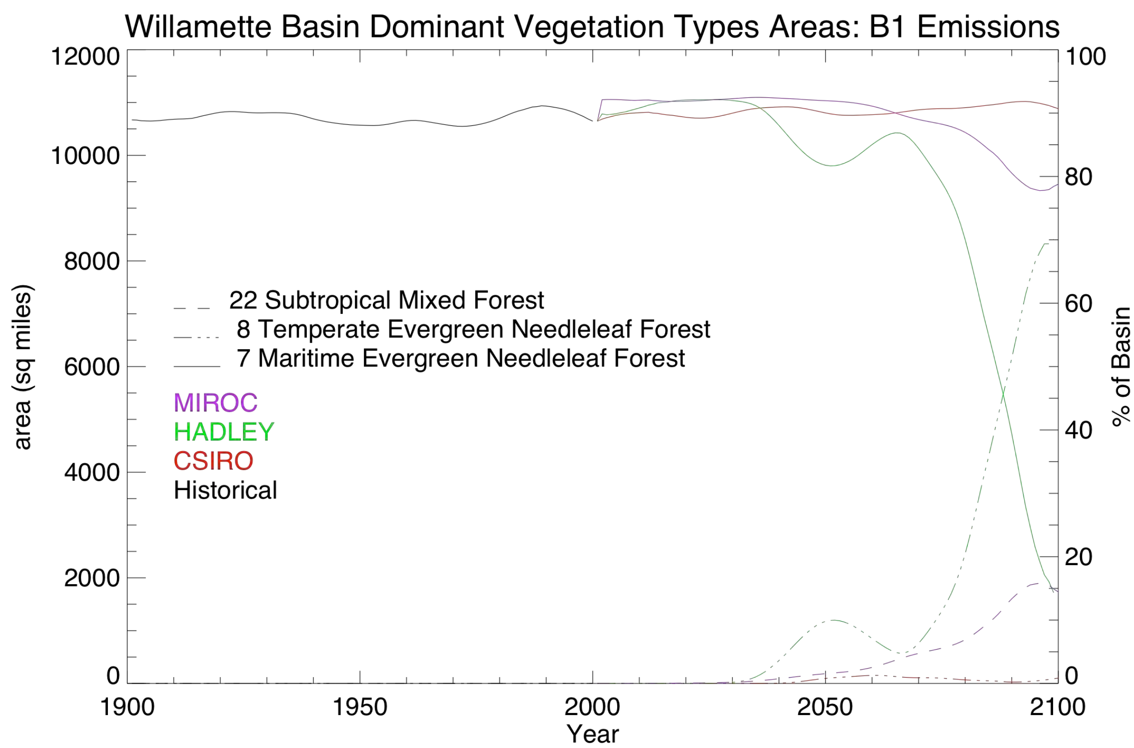

Willamette Basin Proportion Of Vegetation Consumed By Fire: A1B Emissions
0.03
0.02
0.01
0.00
200
150
100
50
0
Historical
CSIRO
MIROC
HADLEY
Proportion (0-1)
Acres (1000s)
1900
1950
2000
2050
2100
Year


Willamette Basin Proportion Of Vegetation Consumed By Fire: B1 Emissions
0.03
0.02
0.01
0.00
200
150
100
50
0
Historical
CSIRO
MIROC
HADLEY
Proportion (0-1)
Acres (1000s)
1900
1950
2000
2050
2100
Year

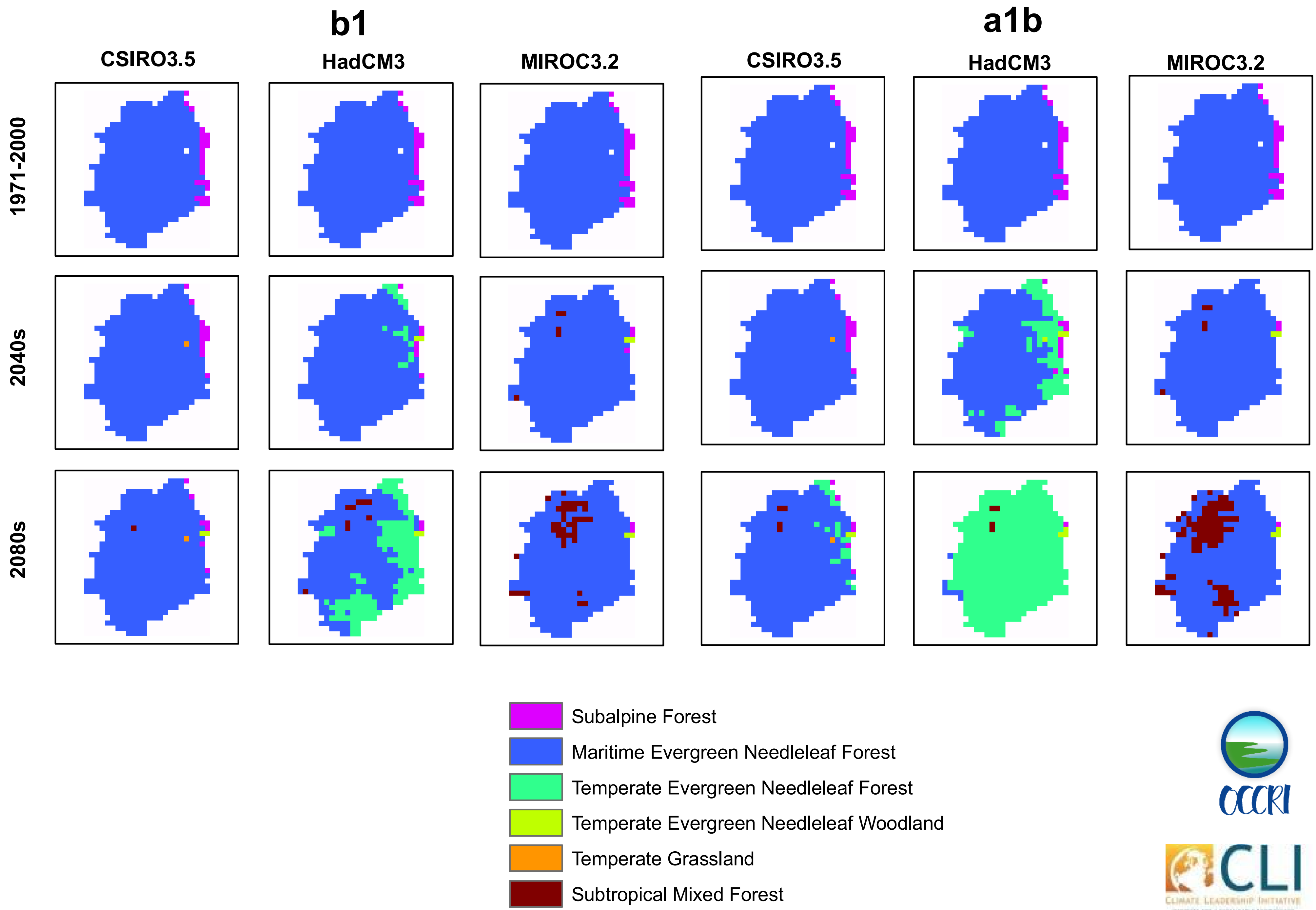

Willamette Basin Vegetation Carbon: A1B Emissions
0.80
0.70
0.60
0.50
0.40
grams C (10e15)
1900
1950
2000
2050
2100
Year
Historical
CSIRO
MIROC
HADLEY

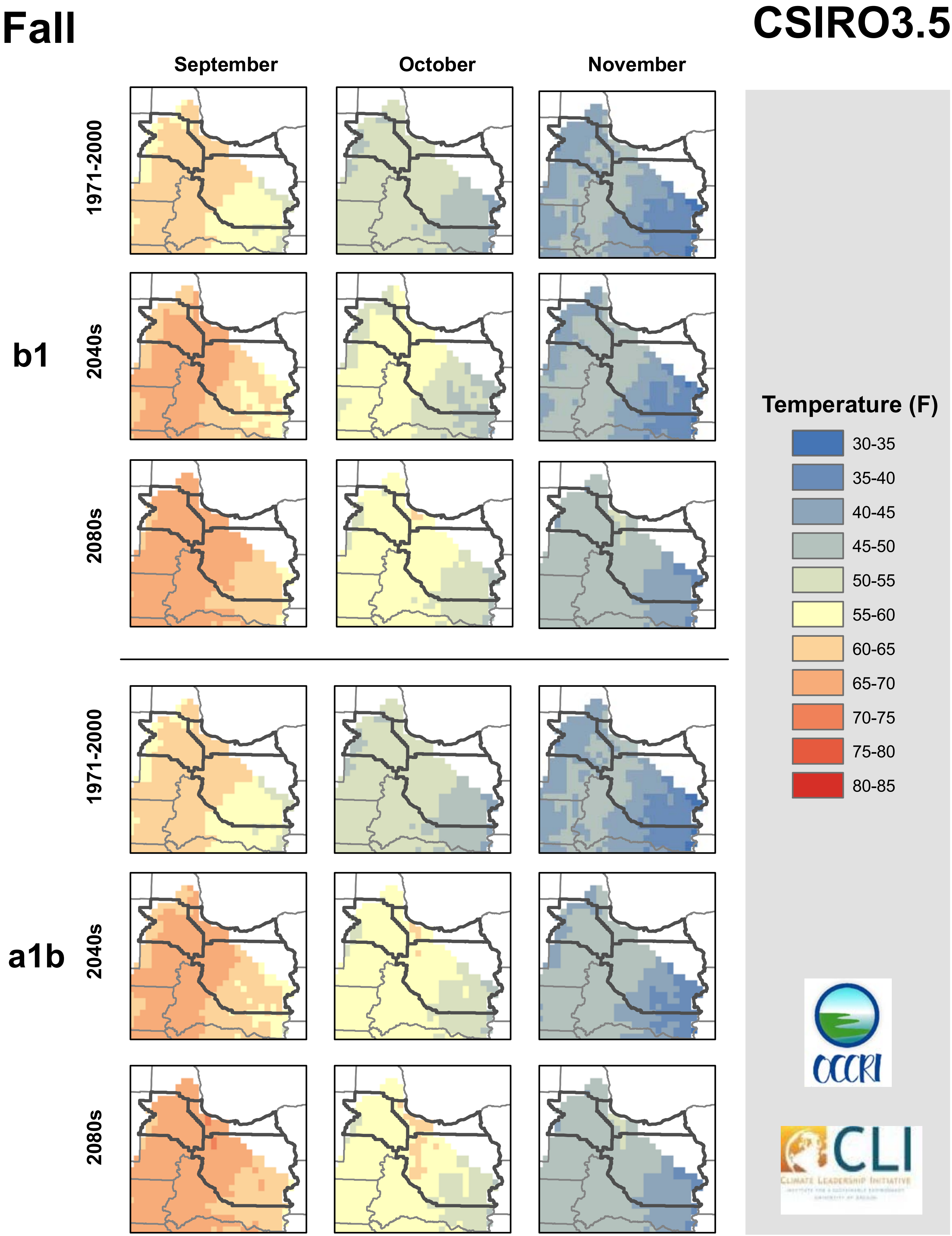

Willamette Basin Vegetation Carbon: B1 Emissions
0.80
0.70
0.60
0.50
0.40
grams C (10e15)
1900
1950
2000
2050
2100
Year
Historical
CSIRO
MIROC
HADLEY


Willamette Basin Dominant Vegetation Types Areas: A1B Emissions
area (sq miles)
% of Basin
Year
22 Subtropical Mixed Forest
8 Temperate Evergreen Needleleaf Forest
7 Maritime Evergreen Needleleaf Forest
MIROC
HADLEY
CSIRO
Historical
12000
10000
8000
6000
4000
2000
0
100
80
60
40
20
1900
1950
2000
2050
2100


Willamette Basin Dominant Vegetation Types Areas: B1 Emissions
area (sq miles)
% of Basin
Year
22 Subtropical Mixed Forest
8 Temperate Evergreen Needleleaf Forest
7 Maritime Evergreen Needleleaf Forest
MIROC
HADLEY
CSIRO
Historical
12000
10000
8000
6000
4000
2000
0
100
80
60
40
20
1900
1950
2000
2050
2100

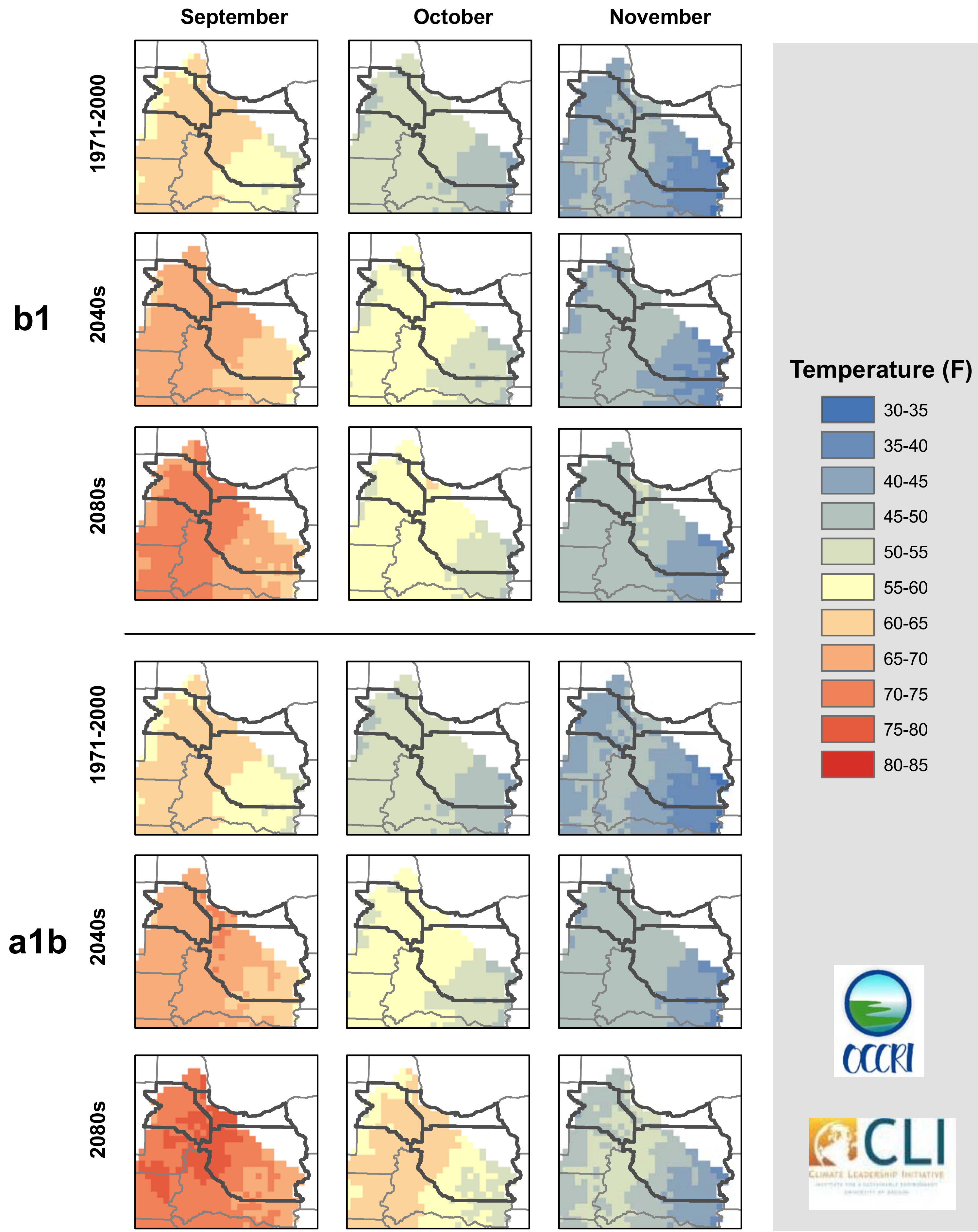
Predominant Vegetation Type




Fall
CSIRO3.5
September
October
November
b1
1971-2000
2040s
2080s
a1b
1971-2000
2040s
2080s
Temperature (F)
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
80-85

Fall

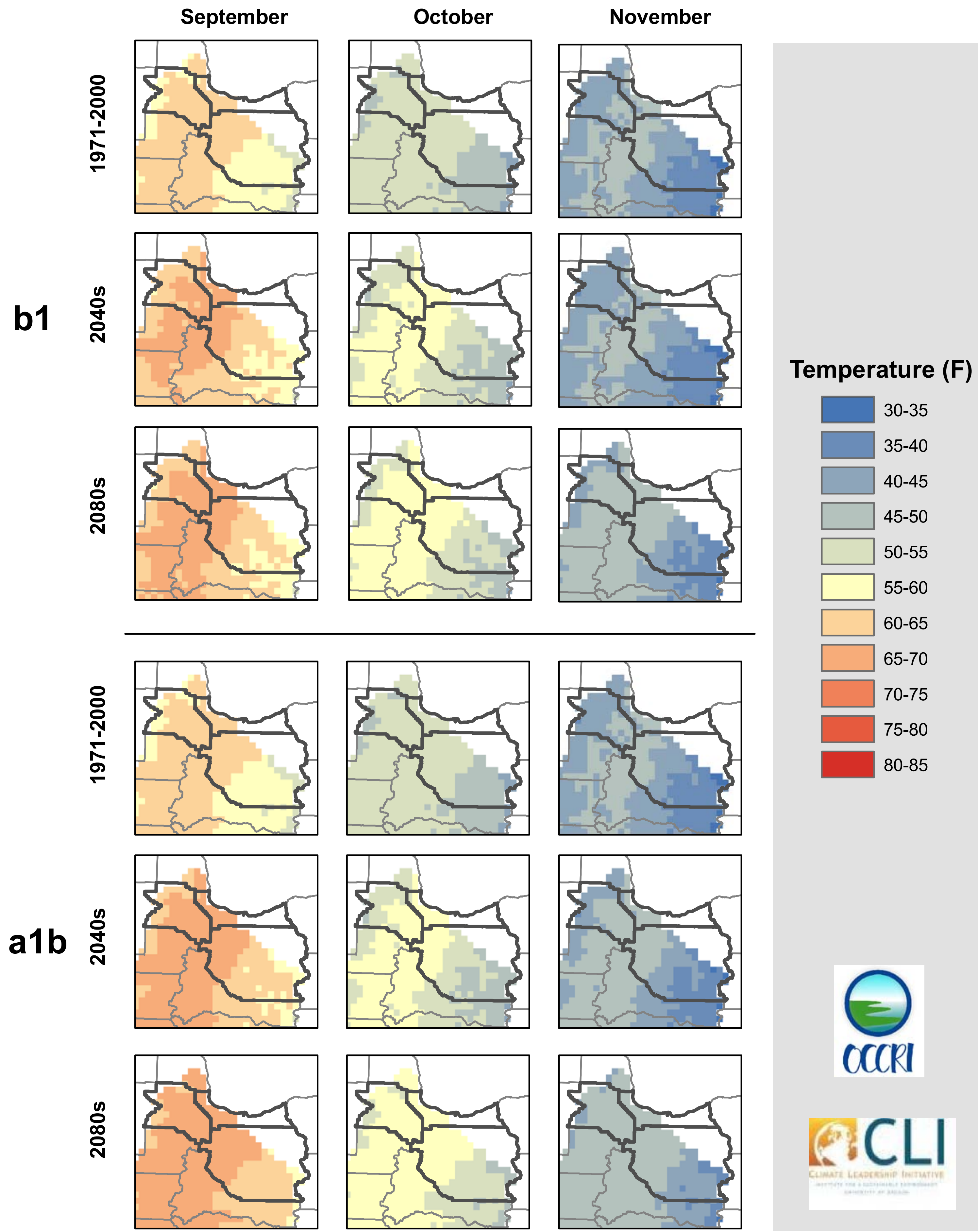
HadCM3



September
October
November
b1
1971-2000
2040s
2080s
a1b
1971-2000
2040s
2080s
Temperature (F)
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
80-85
OCCRI
CLI
CLIMATE LEADERSHIP INITIATIVE

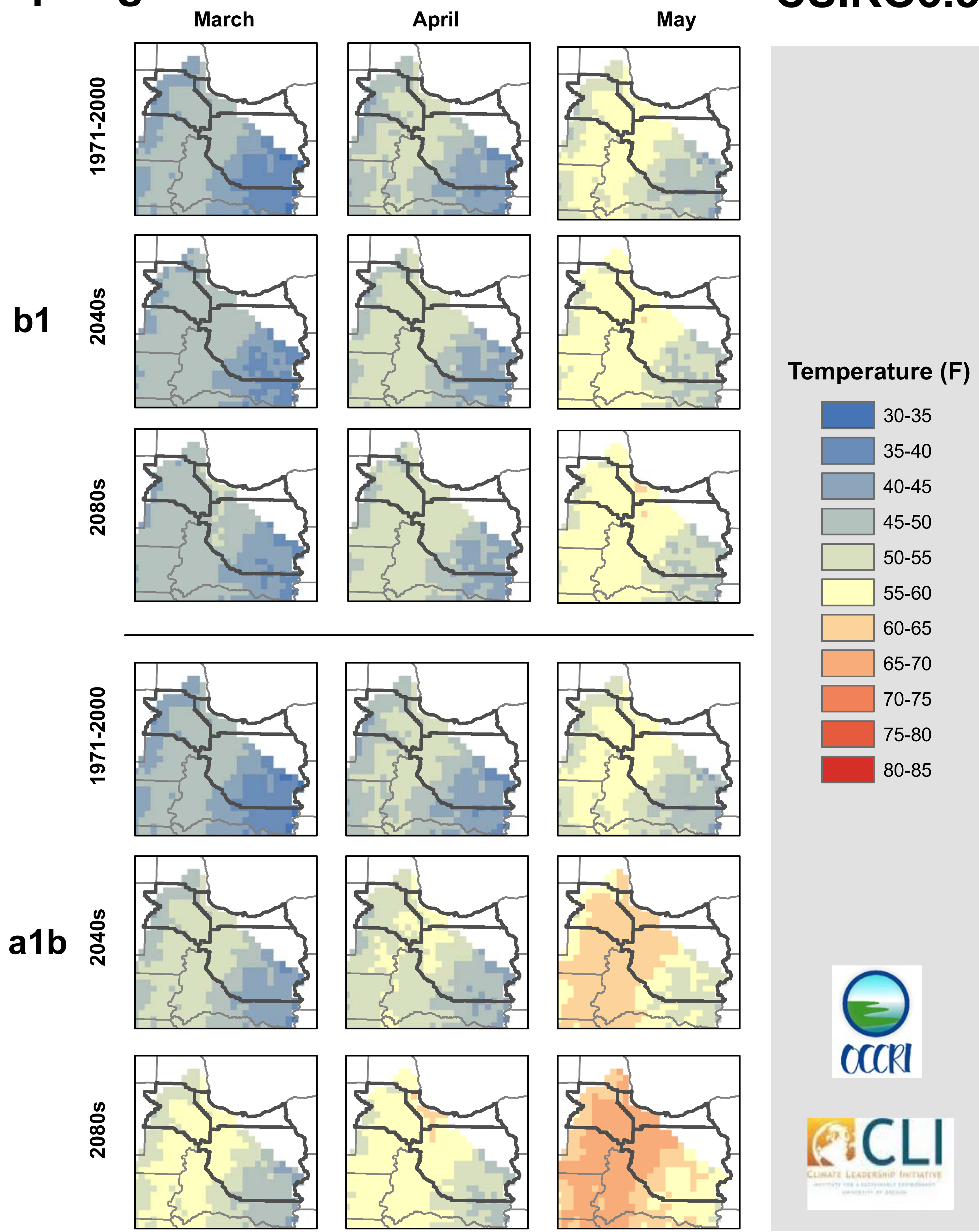
Fall

PCM1


September
October
November
1971-2000
b1
2040s
2080s
1971-2000
a1b
2040s
2080s
Temperature (F)
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
80-85

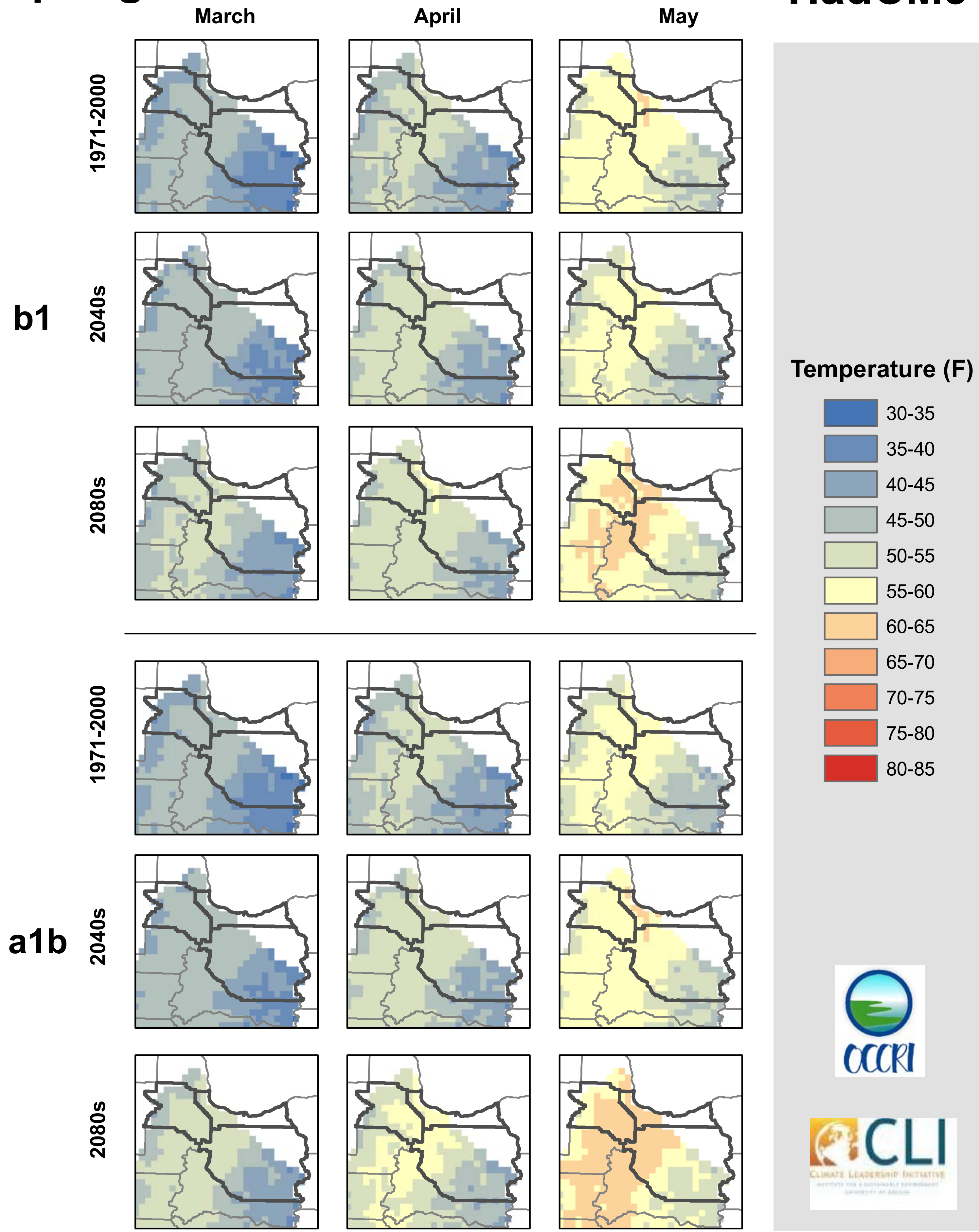
Spring

CSIRO3.5



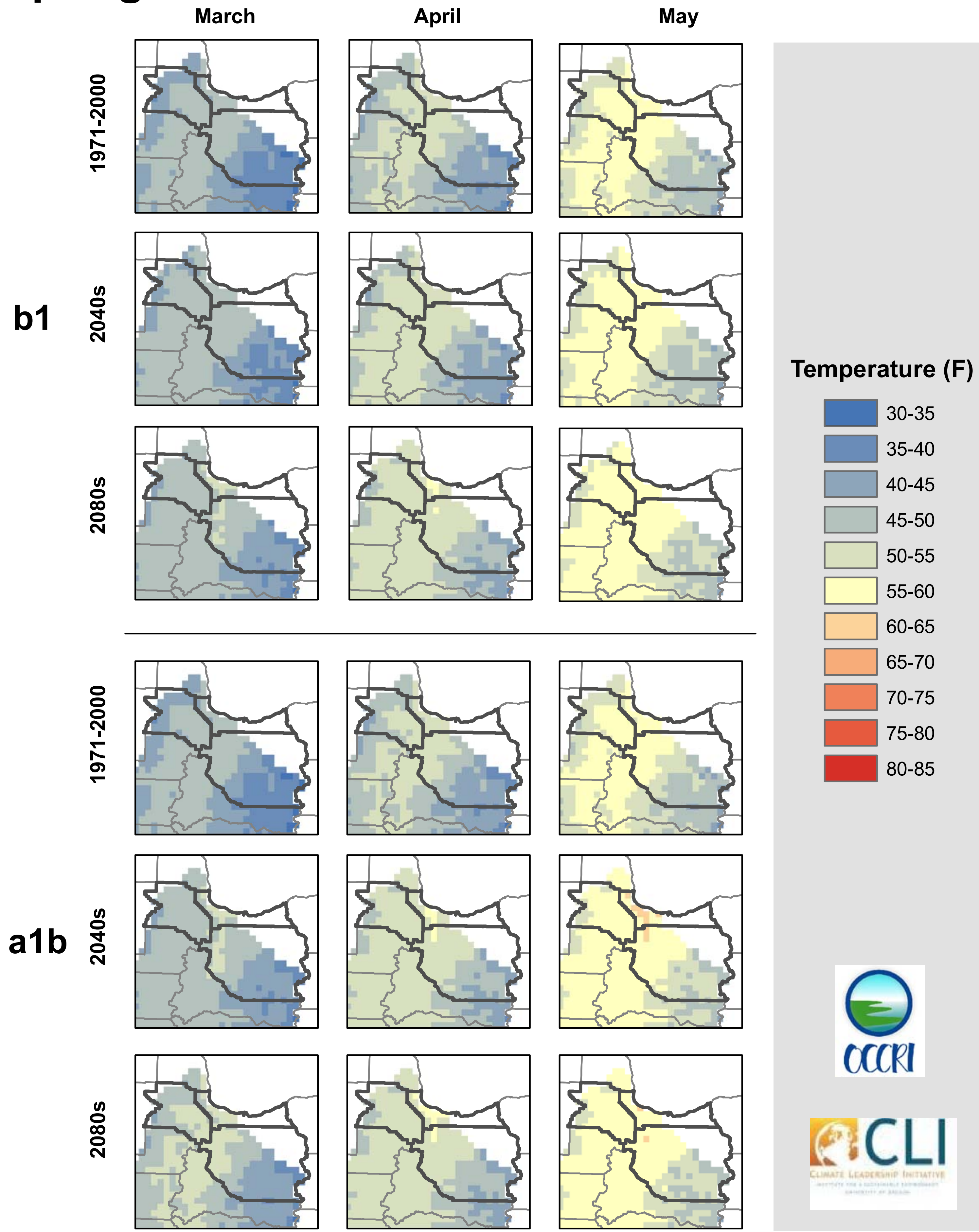
Spring

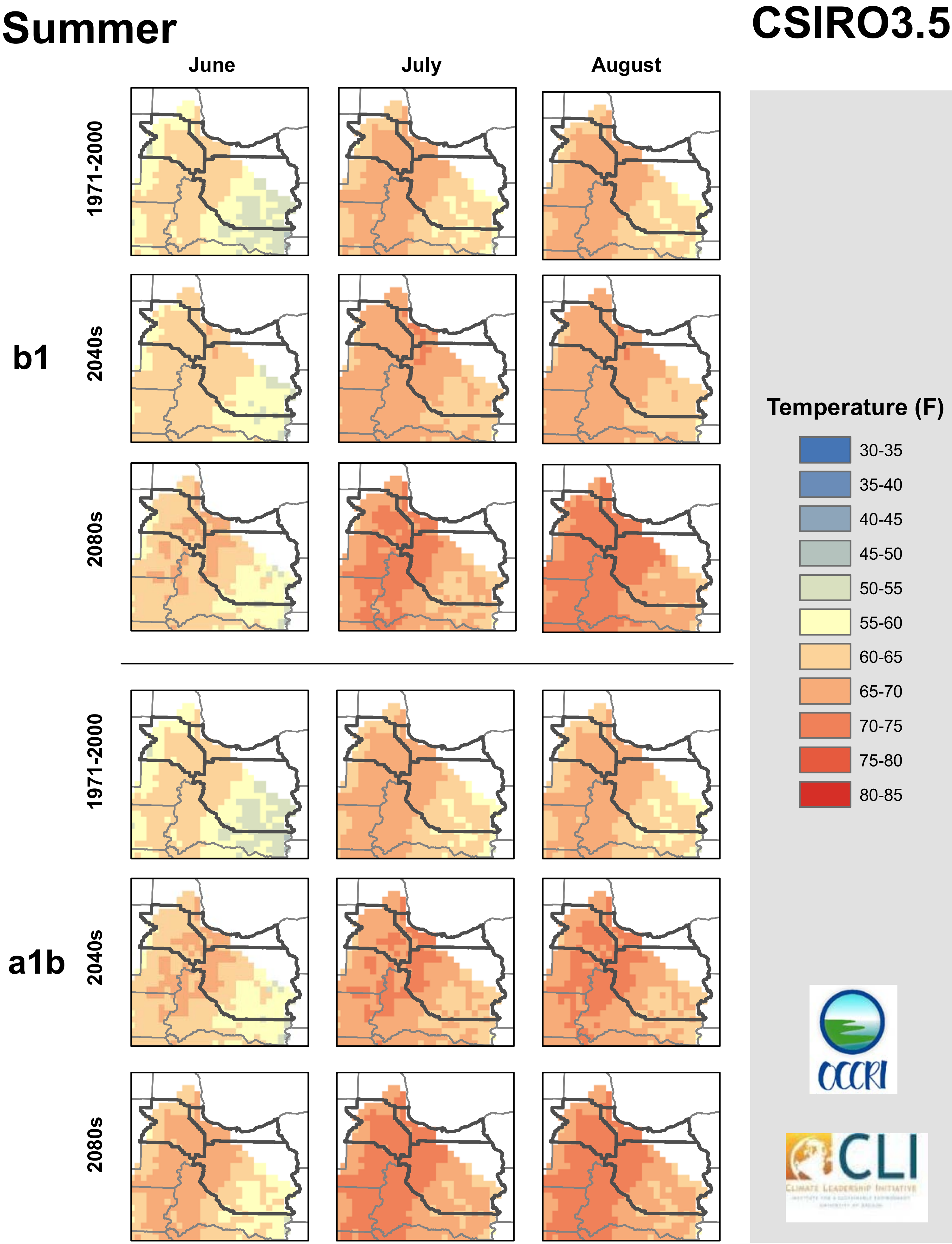
HadCM3

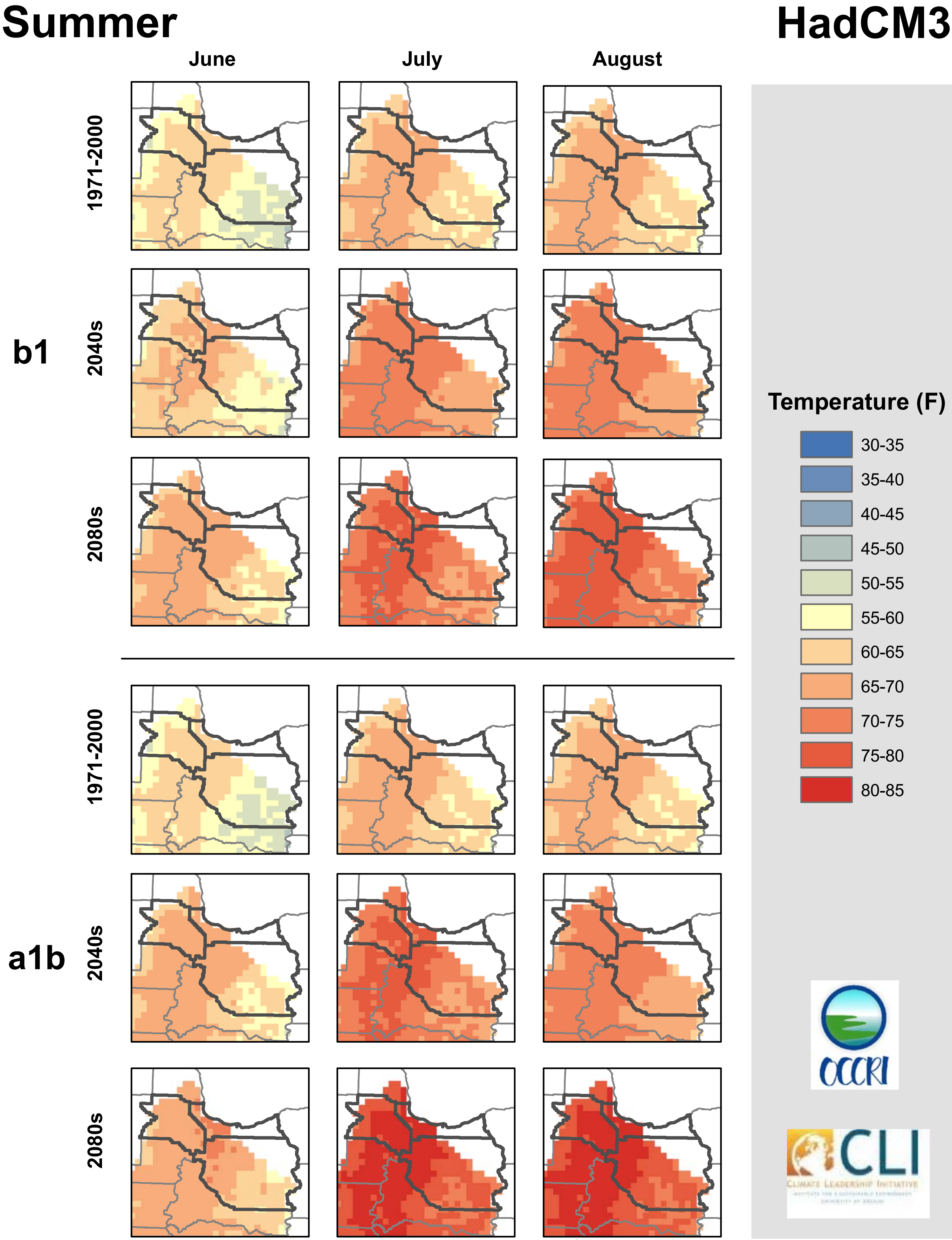


Spring

PCM1

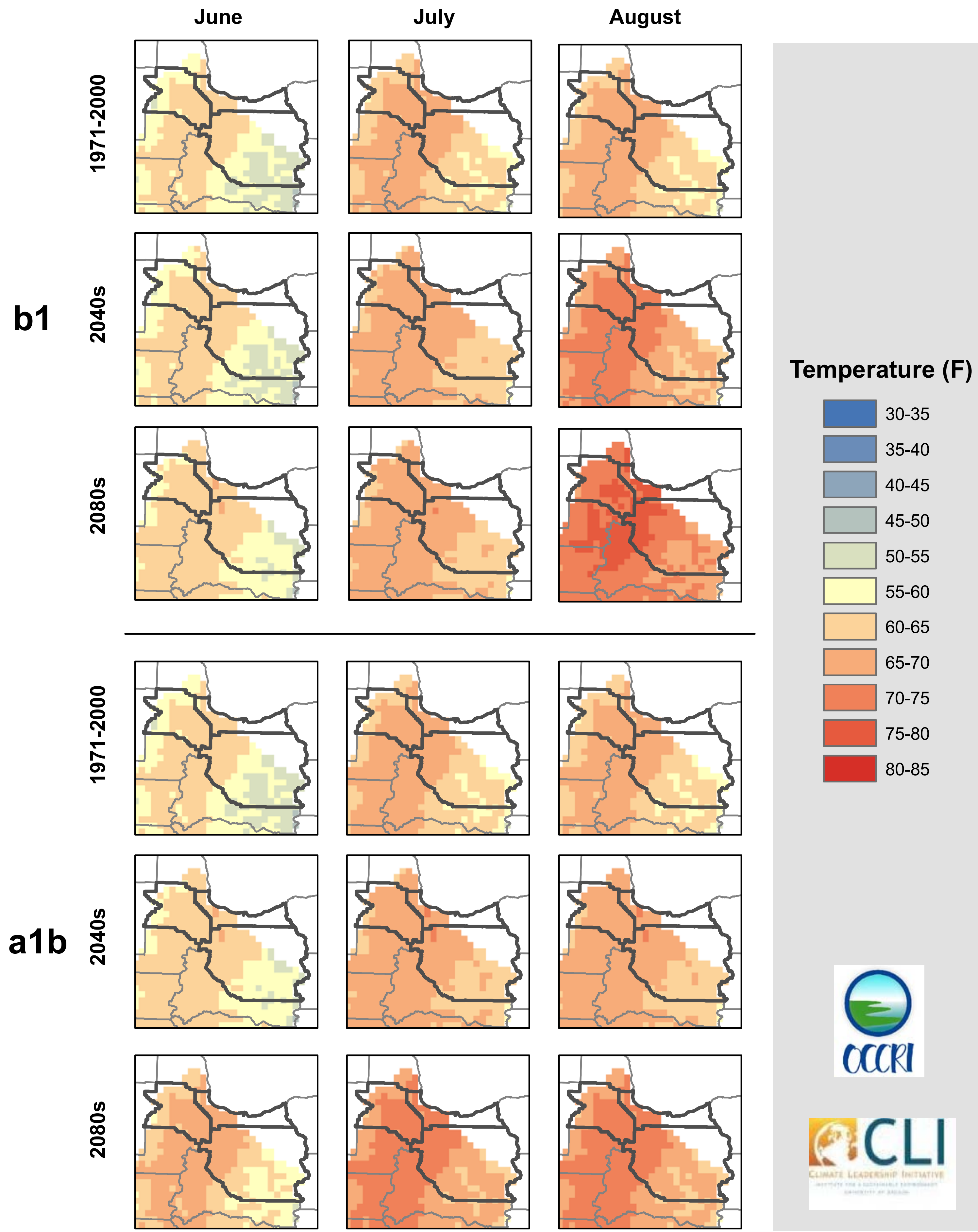

March
April
May
1971-2000
b1
2040s
2080s
1971-2000
a1b
2040s
2080s
Temperature (F)
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
80-85


Summer
CSIRO3.5
June
July
August
1971-2000
b1
2040s
2080s
1971-2000
a1b
2040s
2080s
Temperature (F)
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
80-85

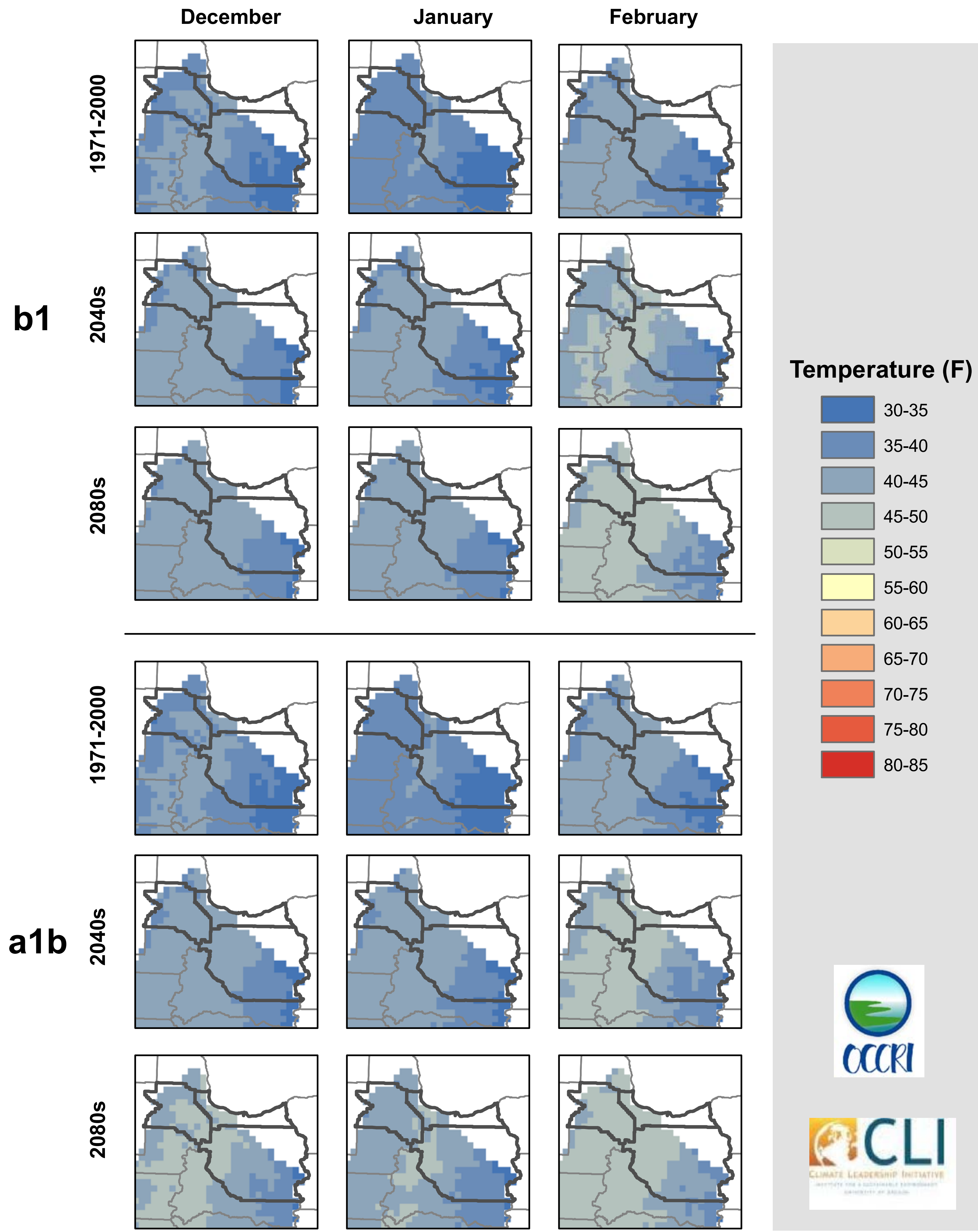

Summer
HadCM3
June
July
August
b1
1971-2000
2040s
2080s
a1b
1971-2000
2040s
2080s
Temperature (F)
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
80-85
OCCRI
CLI
Climate Leadership Initiative

Summer

PCM1

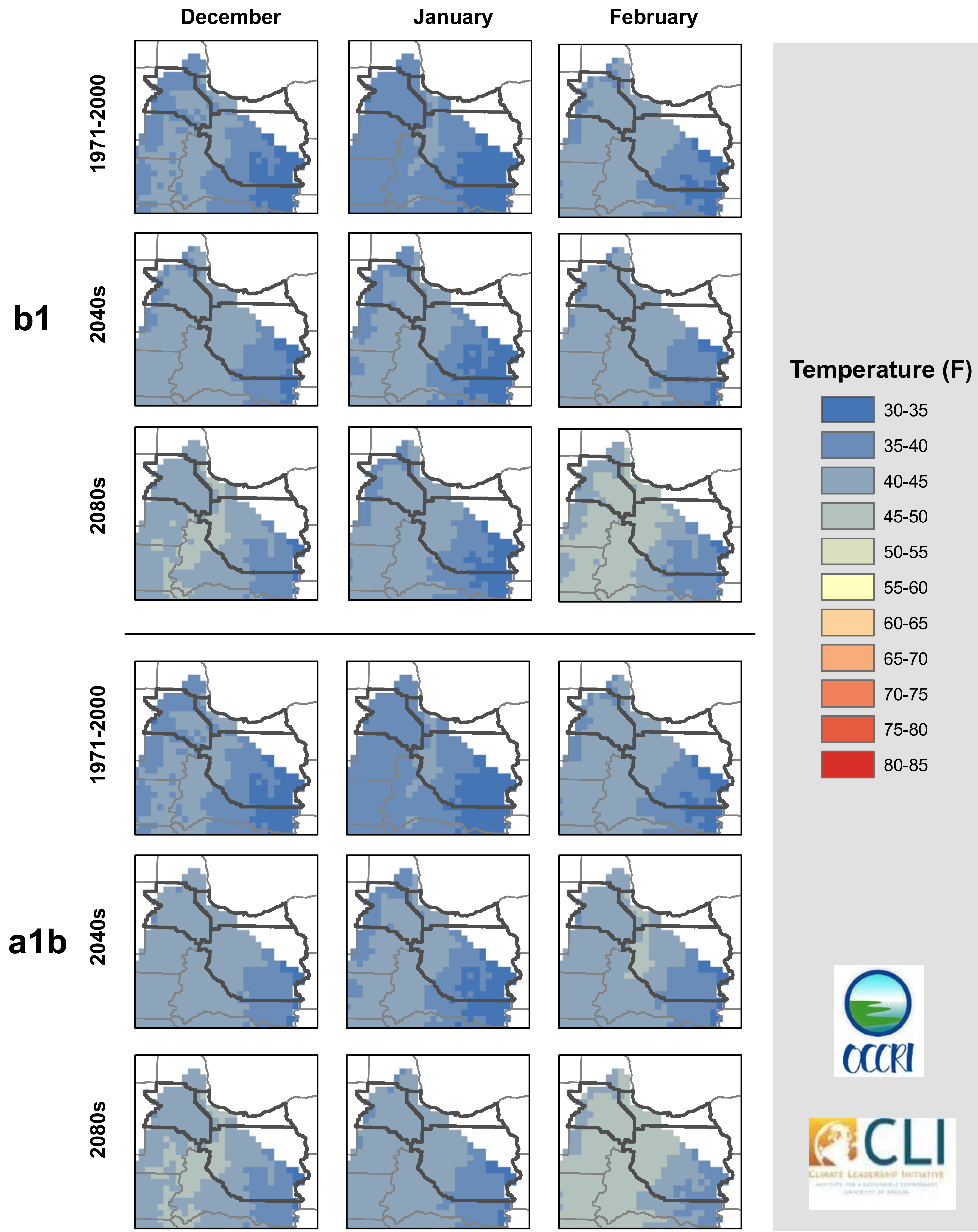

June
July
August
1971-2000
2040s
2080s
b1
1971-2000
2040s
2080s
a1b
Temperature (F)
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
80-85
OCCRI
CLI
Climate Leadership Initiative

Winter CSIRO3.5



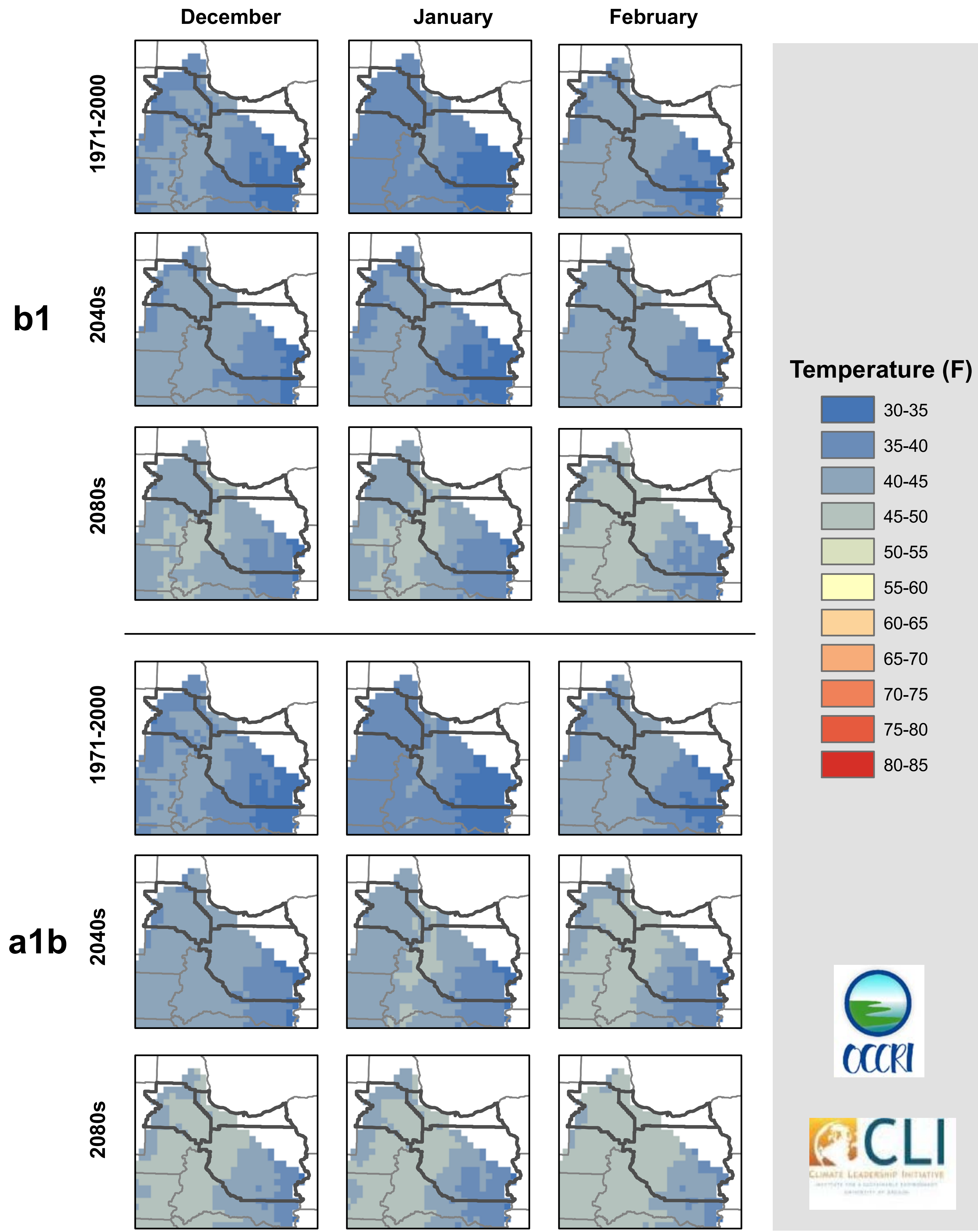
Winter

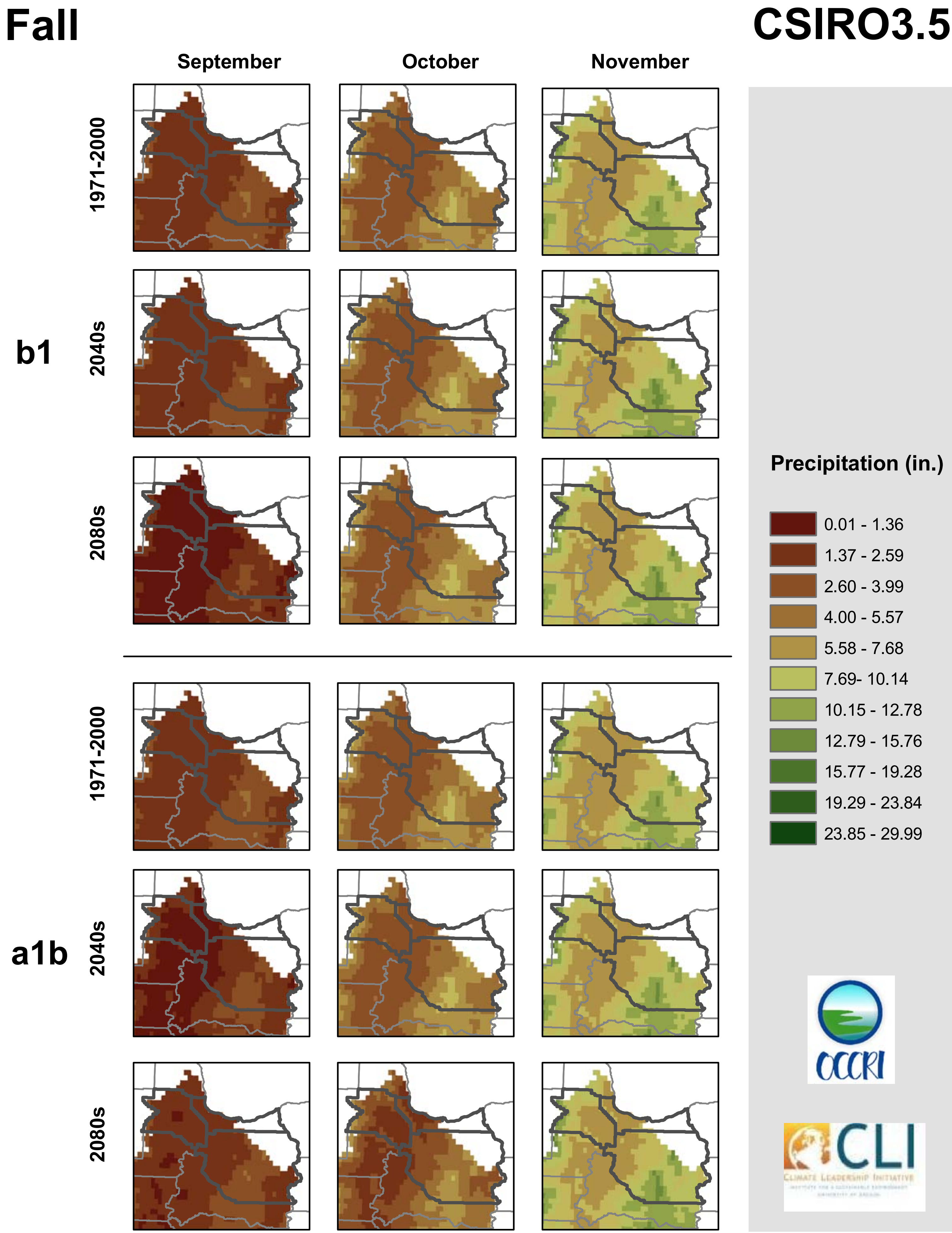
HadCM3



Winter

CSIRO3.5





Fall
CSIRO3.5
September
October
November
b1
1971-2000
2040s
2080s
a1b
1971-2000
2040s
2080s
Precipitation (in.)
0.01 - 1.36
1.37 - 2.59
2.60 - 3.99
4.00 - 5.57
5.58 - 7.68
7.69- 10.14
10.15 - 12.78
12.79 - 15.76
15.77 - 19.28
19.29 - 23.84
23.85 - 29.99
OCCRI
CLI
Climate Leadership Initiative

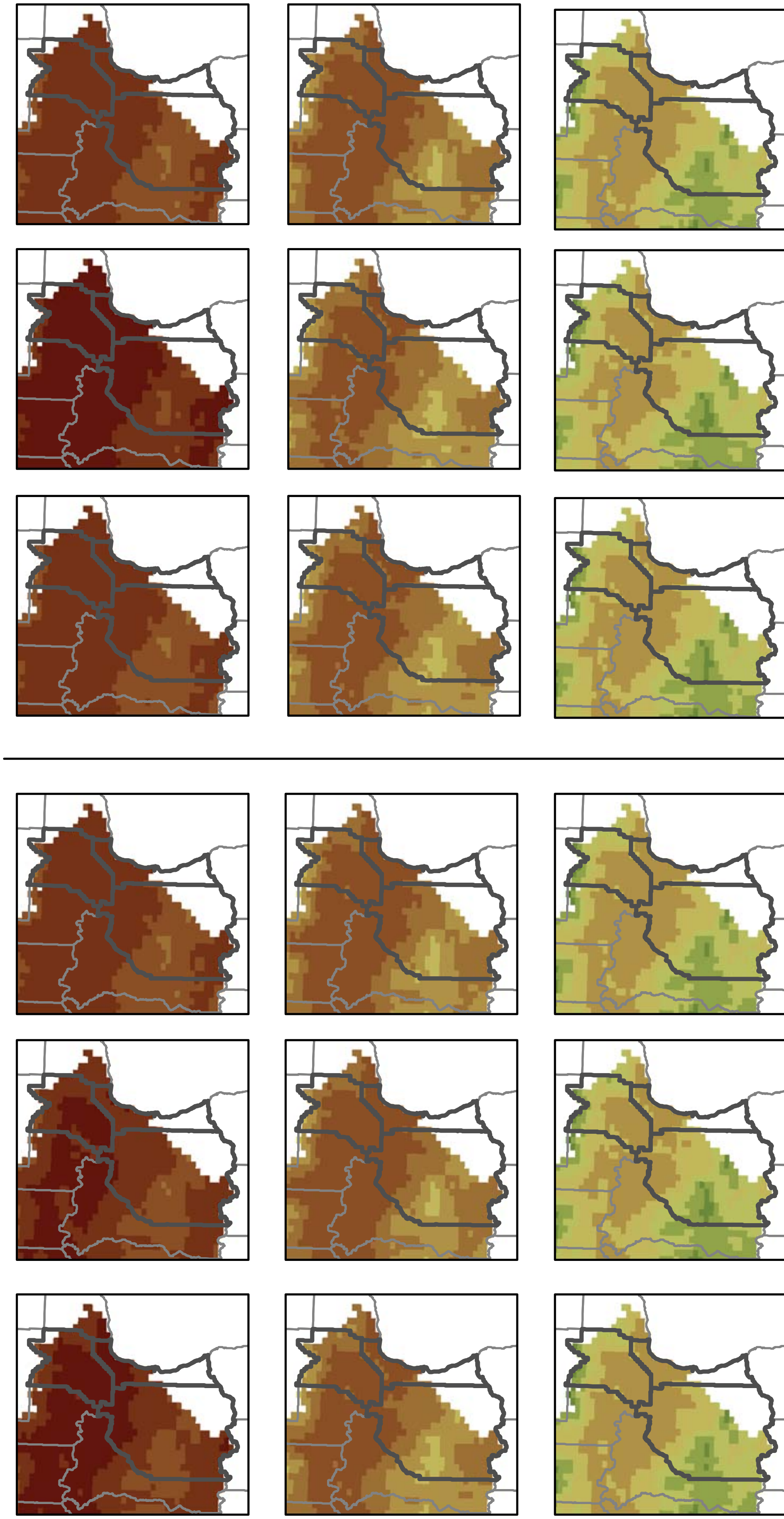
Fall

HadCM3

September | October | November

b1: 1971-2000, 2040s, 2080s

a1b: 1971-2000, 2040s, 2080s



Precipitation (in.)

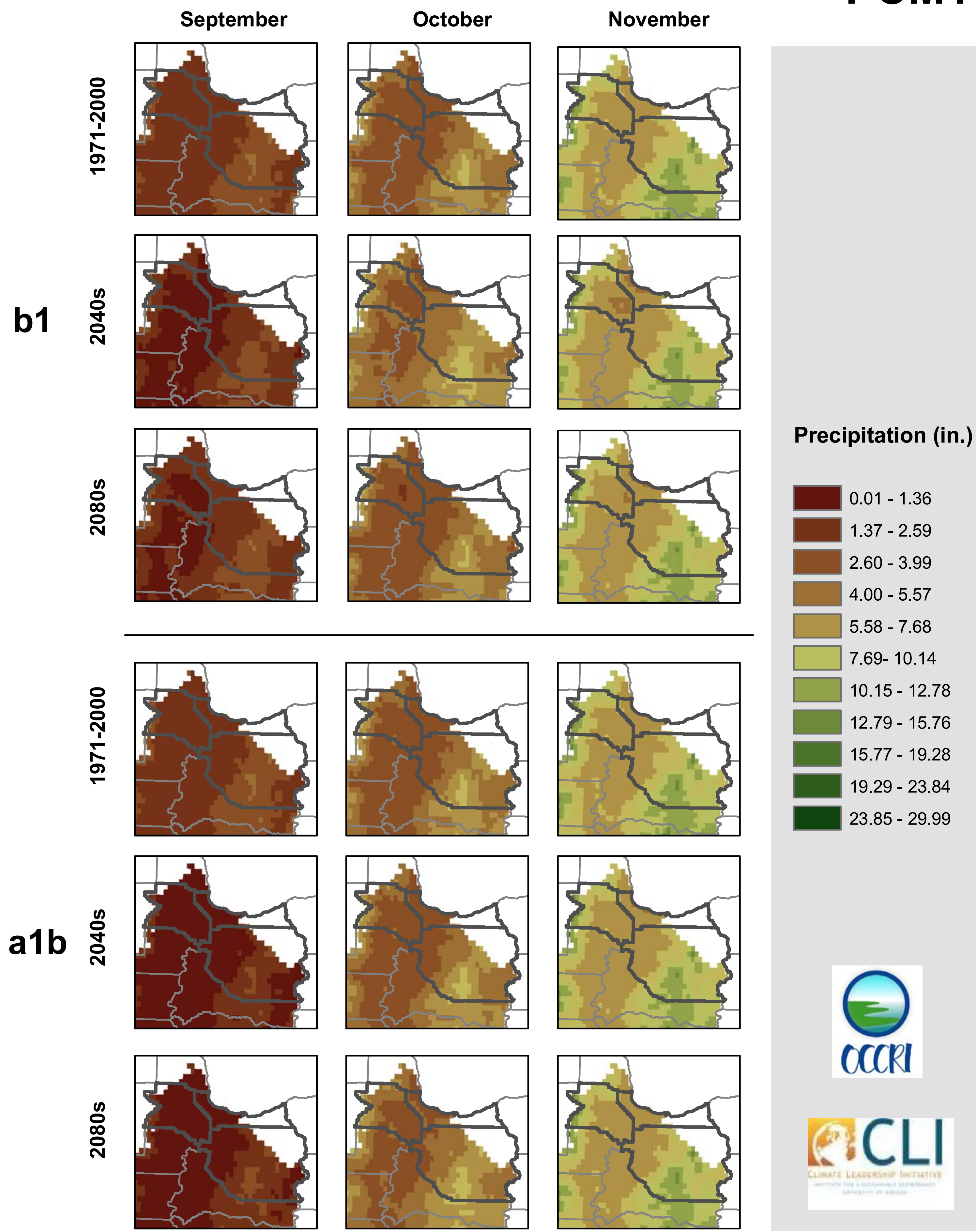
- 0.01 - 1.36
- 1.37 - 2.59
- 2.60 - 3.99
- 4.00 - 5.57
- 5.58 - 7.68
- 7.69- 10.14
- 10.15 - 12.78
- 12.79 - 15.76
- 15.77 - 19.28
- 19.29 - 23.84
- 23.85 - 29.99

OCCRI

CLI
CLIMATE LEADERSHIP INITIATIVE

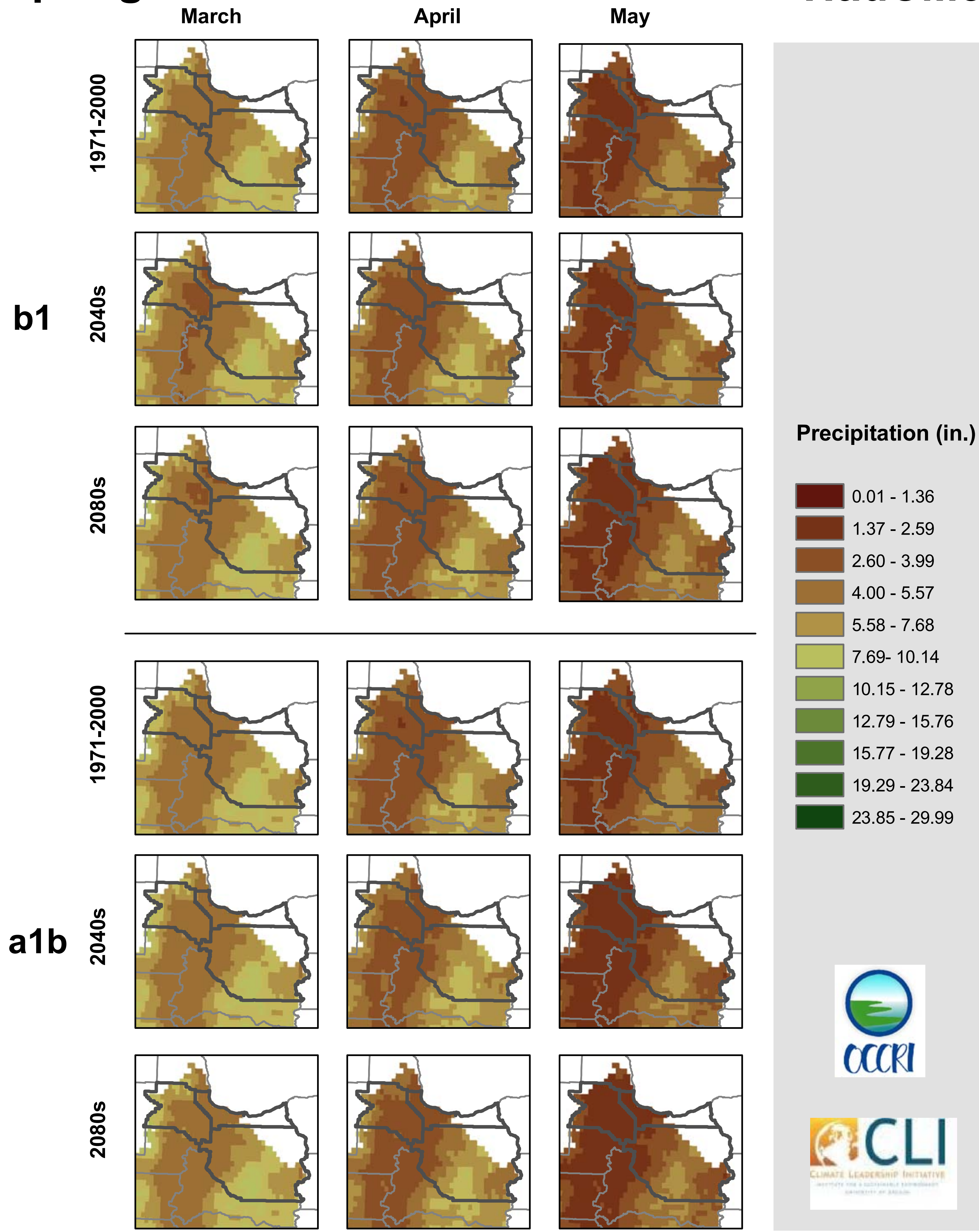
Fall

PCM1

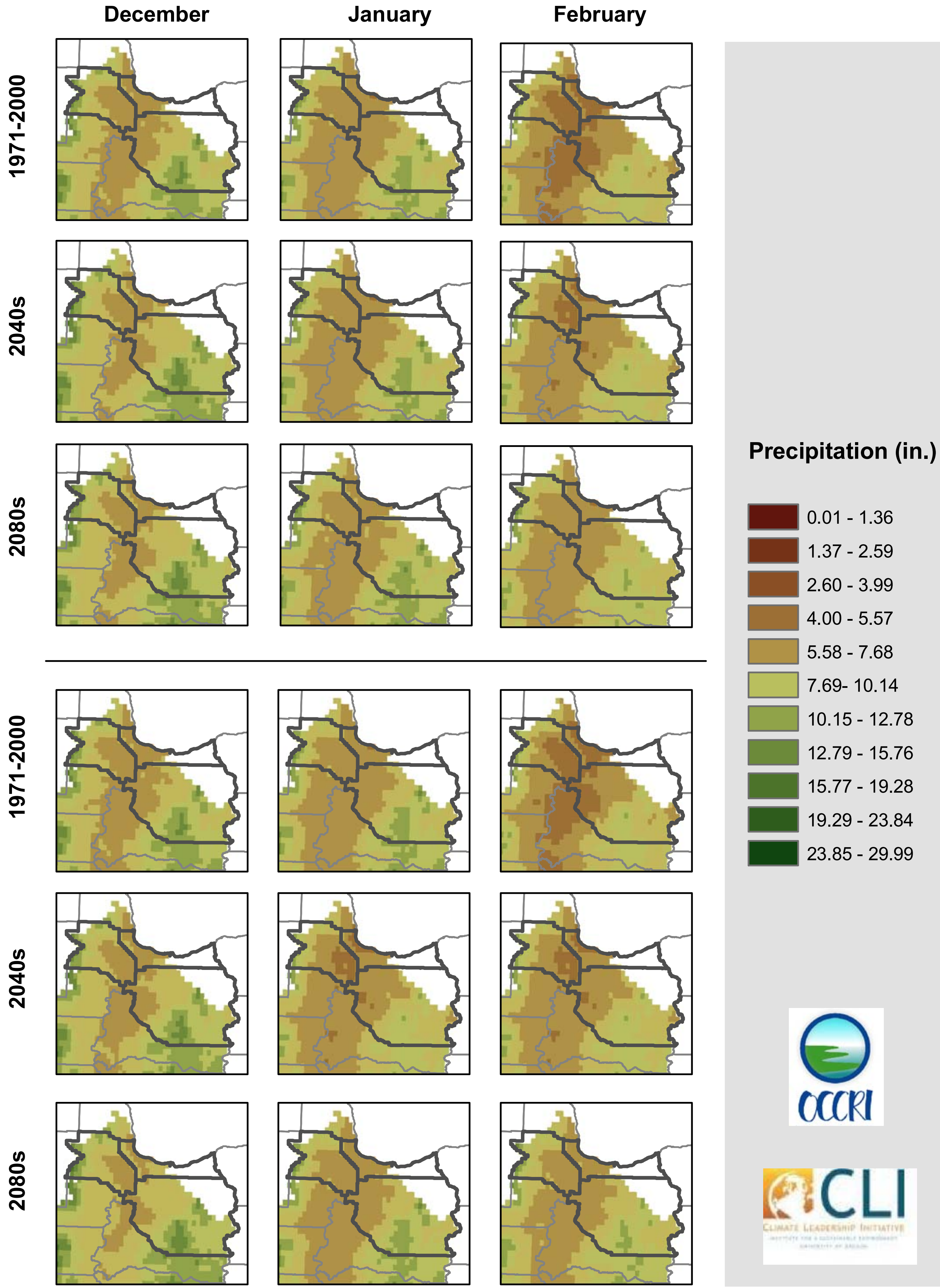

September
October
November
b1
1971-2000
2040s
2080s
a1b
1971-2000
2040s
2080s
Precipitation (in.)
0.01 - 1.36
1.37 - 2.59
2.60 - 3.99
4.00 - 5.57
5.58 - 7.68
7.69- 10.14
10.15 - 12.78
12.79 - 15.76
15.77 - 19.28
19.29 - 23.84
23.85 - 29.99

Spring

HadCM3

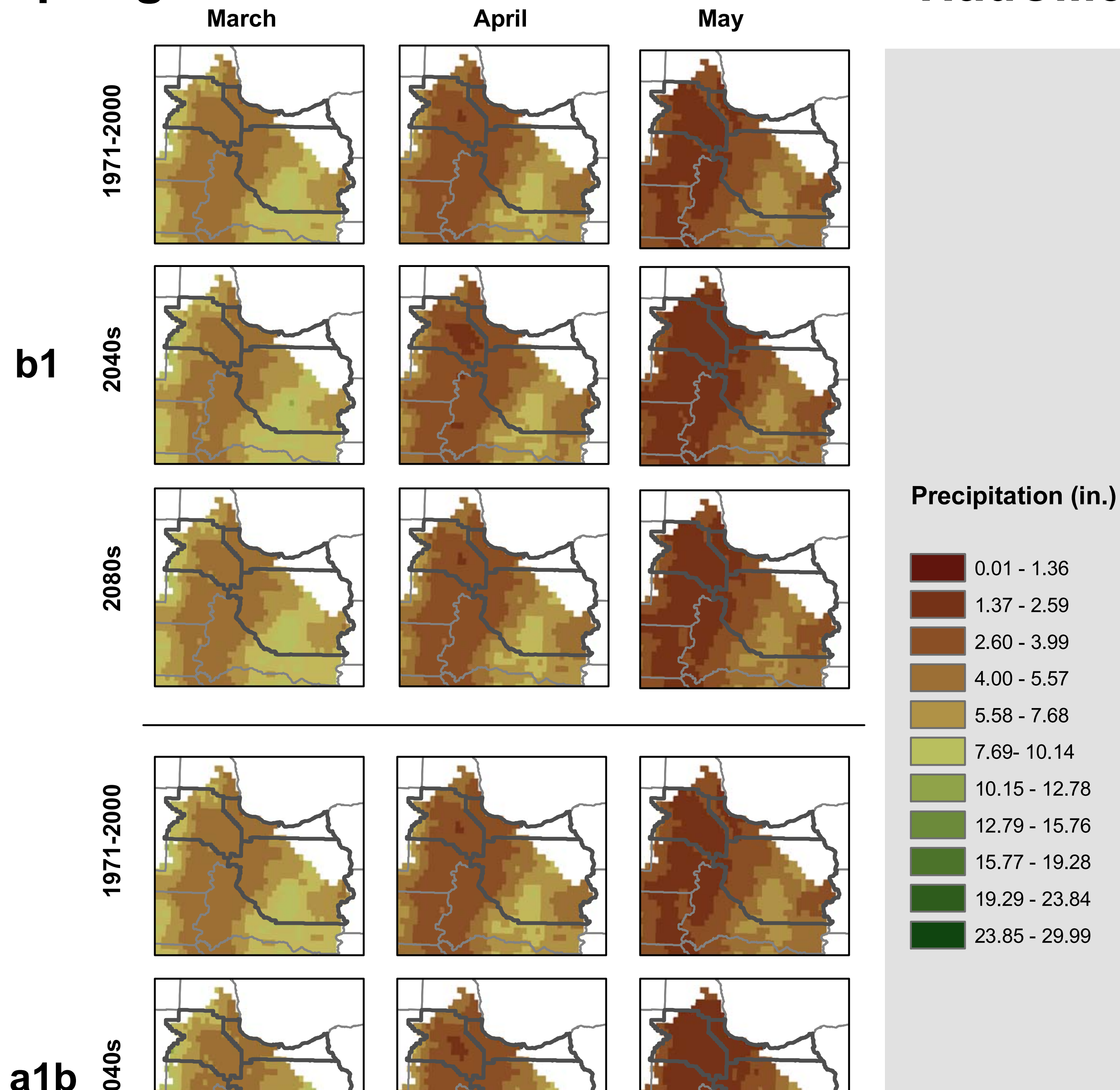


Winter CSIRO3.5



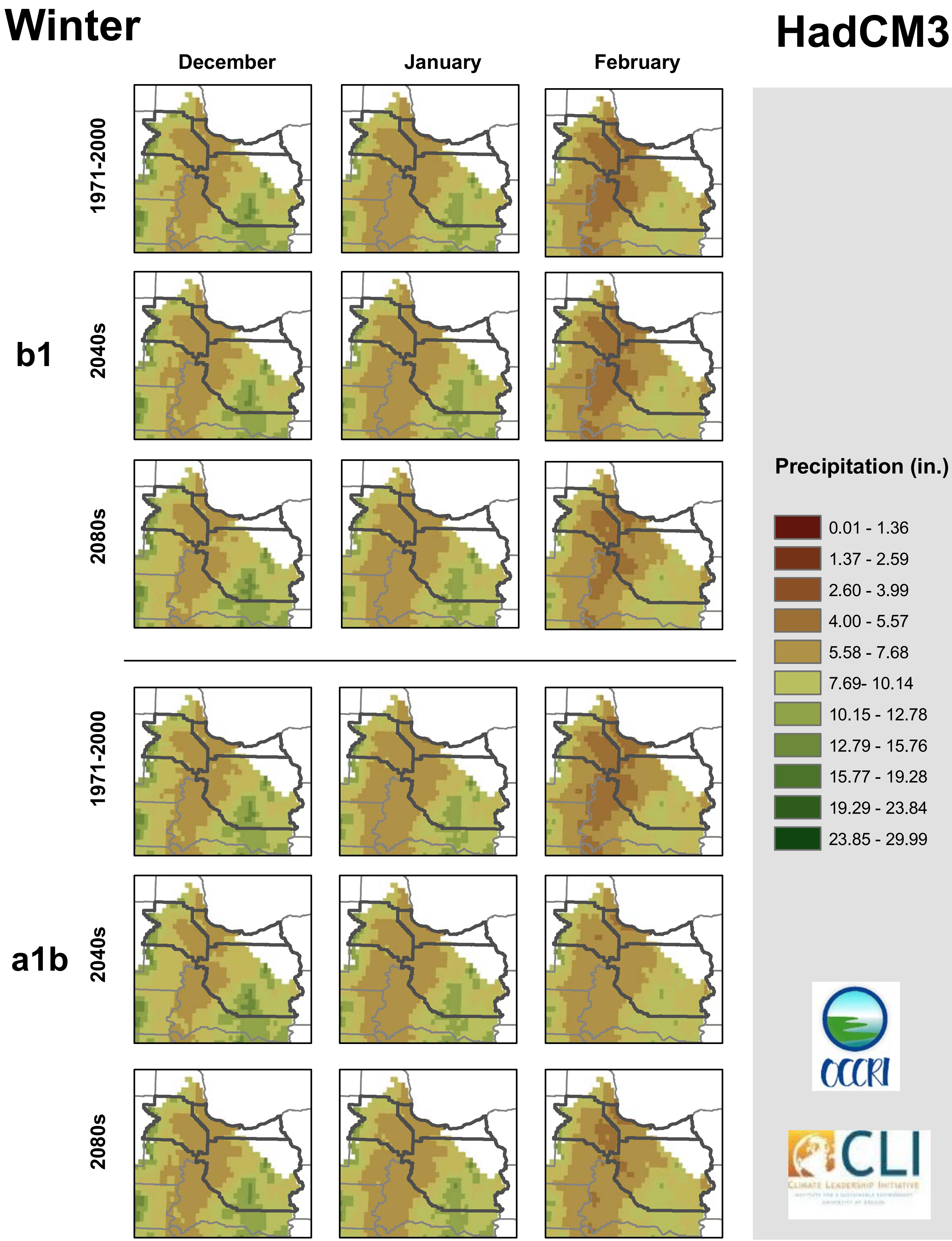
Spring

HadCM3



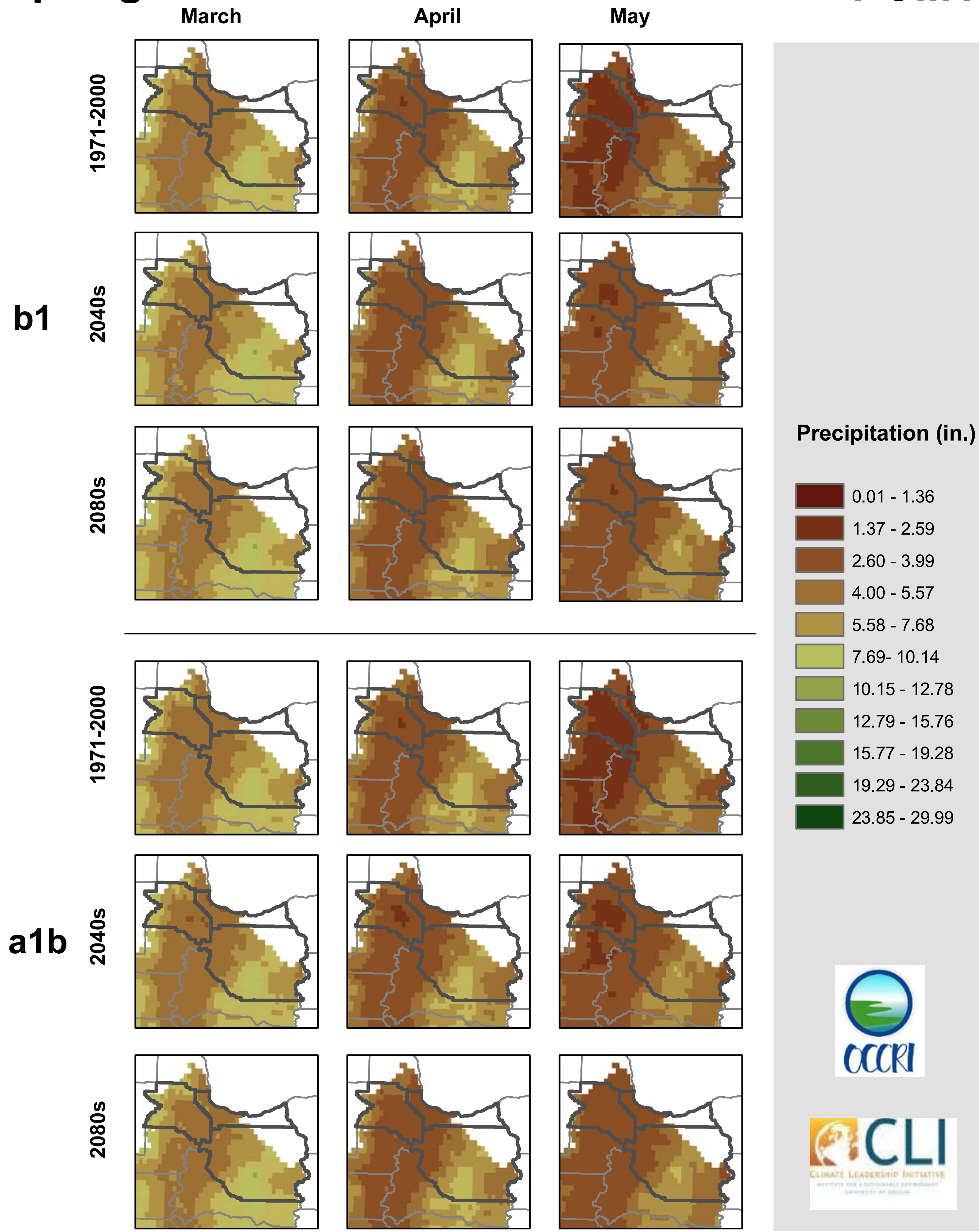
OCCRI

CLI
Climate Leadership Initiative


Winter
HadCM3
December
January
February
b1
1971-2000
2040s
2080s
a1b
1971-2000
2040s
2080s
Precipitation (in.)
0.01 - 1.36
1.37 - 2.59
2.60 - 3.99
4.00 - 5.57
5.58 - 7.68
7.69- 10.14
10.15 - 12.78
12.79 - 15.76
15.77 - 19.28
19.29 - 23.84
23.85 - 29.99
OCCRI
CLI
CLIMATE LEADERSHIP INITIATIVE

Spring

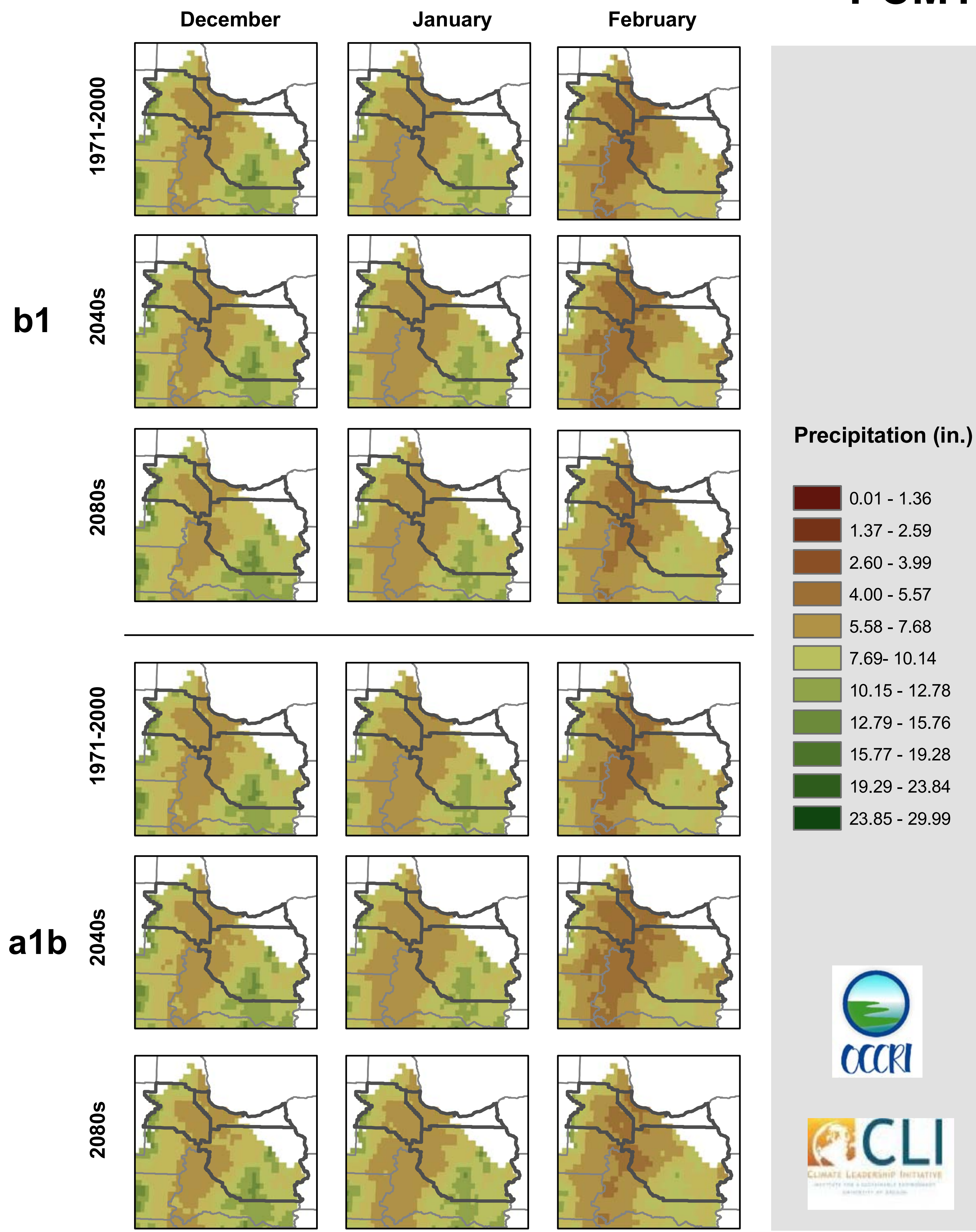
PCM1

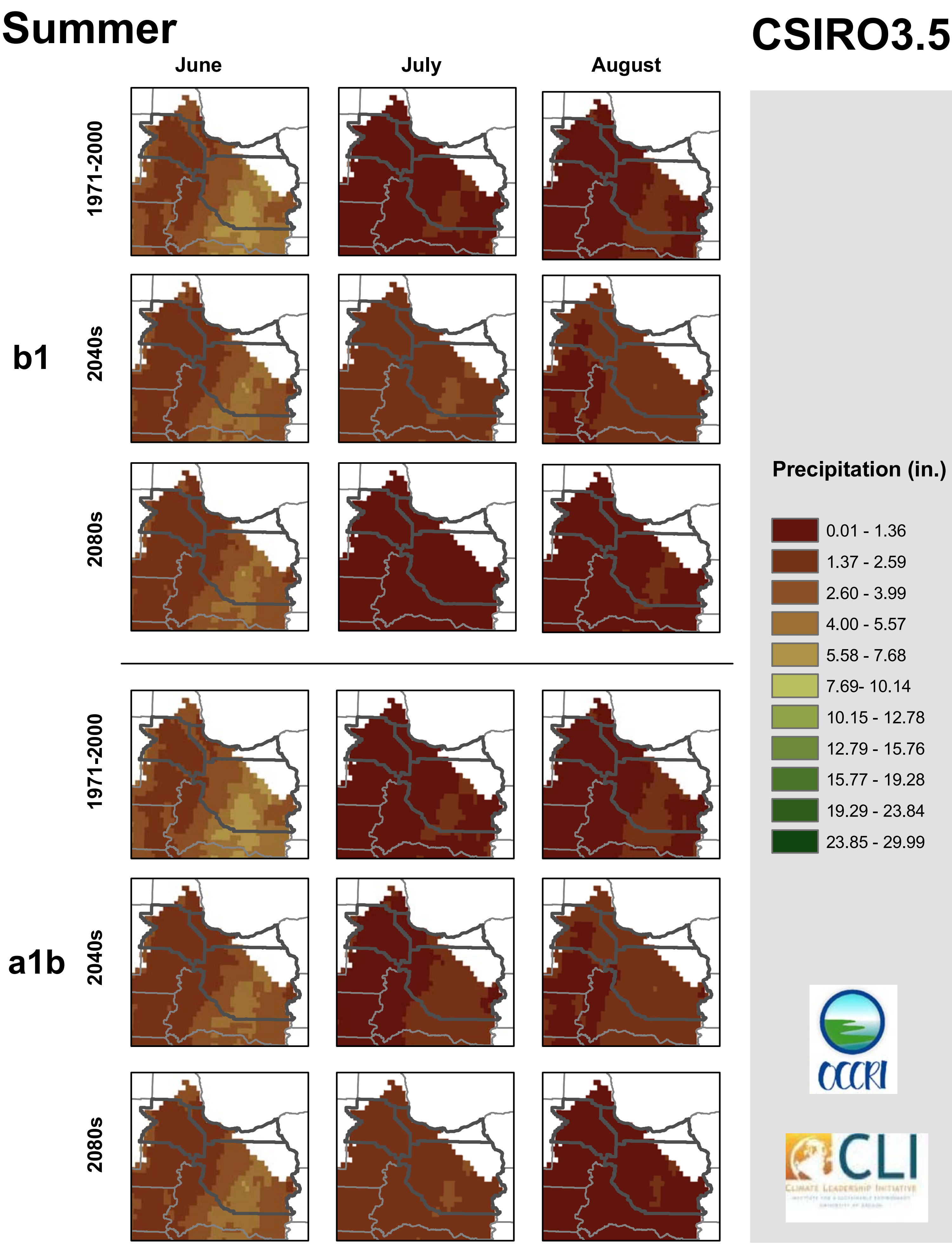


March
April
May
b1
1971-2000
2040s
2080s
a1b
1971-2000
2040s
2080s
Precipitation (in.)
0.01 - 1.36
1.37 - 2.59
2.60 - 3.99
4.00 - 5.57
5.58 - 7.68
7.69- 10.14
10.15 - 12.78
12.79 - 15.76
15.77 - 19.28
19.29 - 23.84
23.85 - 29.99

Winter

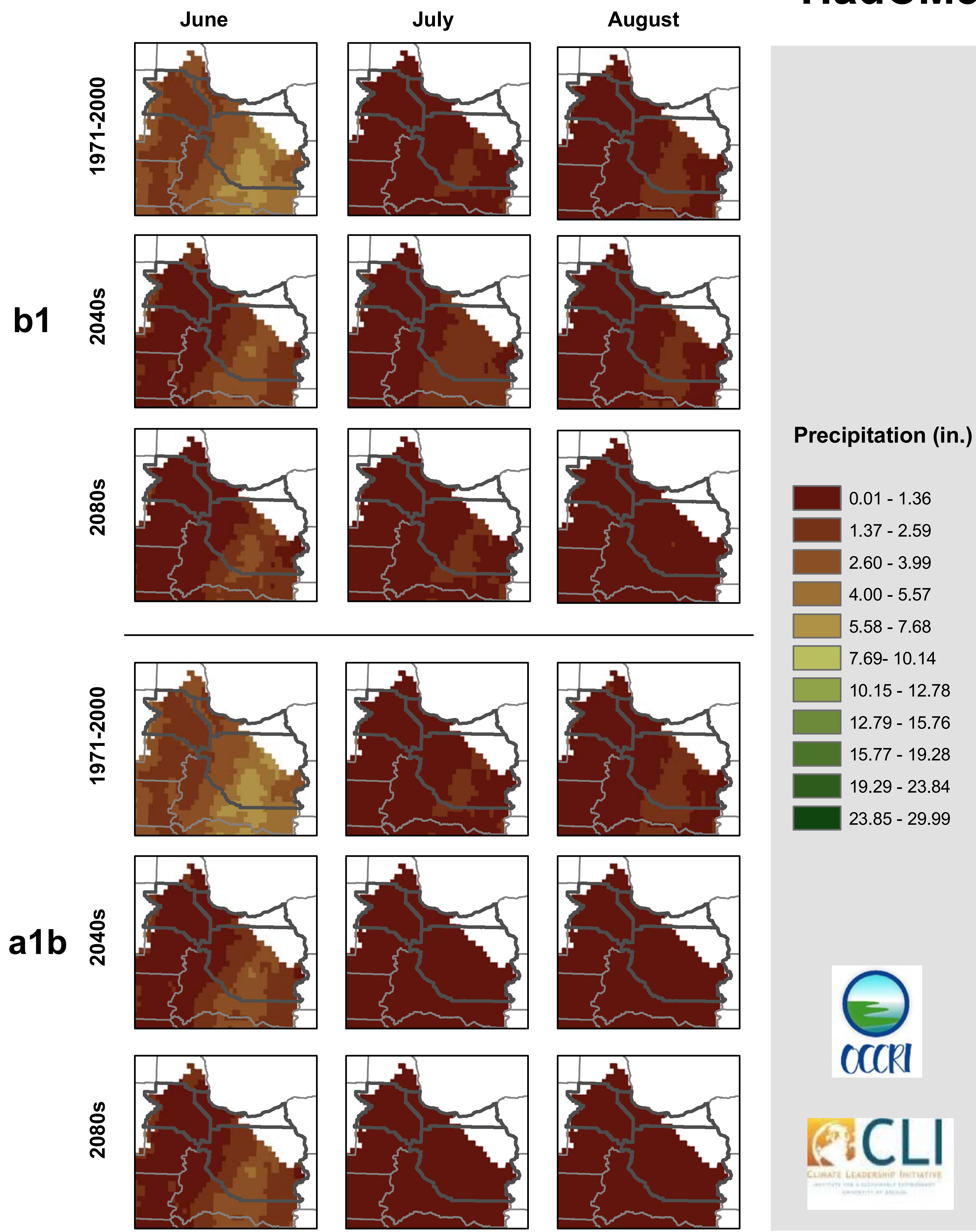
PCM1


December
January
February
b1
1971-2000
2040s
2080s
a1b
1971-2000
2040s
2080s
Precipitation (in.)
0.01 - 1.36
1.37 - 2.59
2.60 - 3.99
4.00 - 5.57
5.58 - 7.68
7.69- 10.14
10.15 - 12.78
12.79 - 15.76
15.77 - 19.28
19.29 - 23.84
23.85 - 29.99


Summer
CSIRO3.5
June
July
August
b1
1971-2000
2040s
2080s
a1b
1971-2000
2040s
2080s
Precipitation (in.)
0.01 - 1.36
1.37 - 2.59
2.60 - 3.99
4.00 - 5.57
5.58 - 7.68
7.69- 10.14
10.15 - 12.78
12.79 - 15.76
15.77 - 19.28
19.29 - 23.84
23.85 - 29.99
OCCRI
CLI
CLIMATE LEADERSHIP INITIATIVE

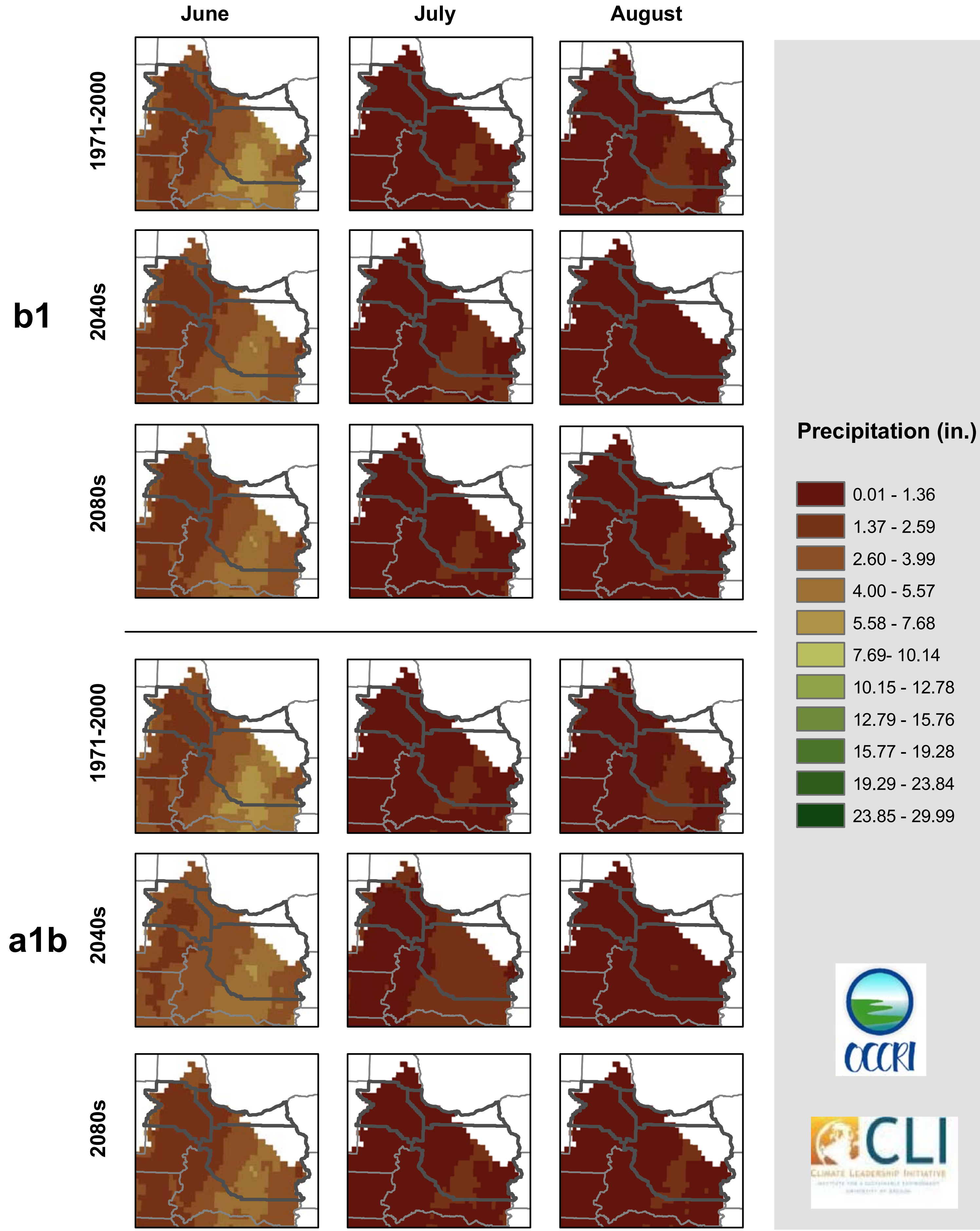
Summer

HadCM3



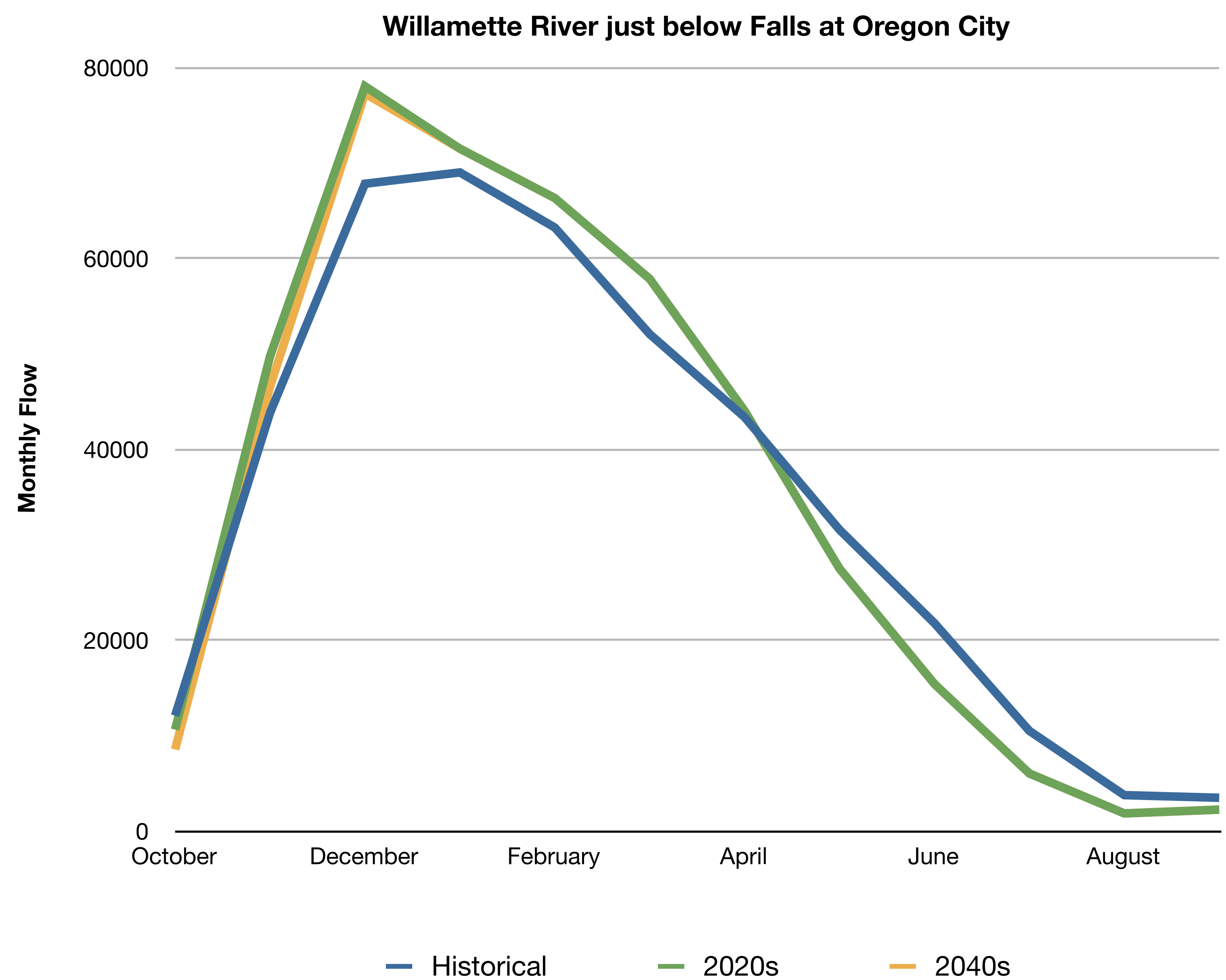
Summer

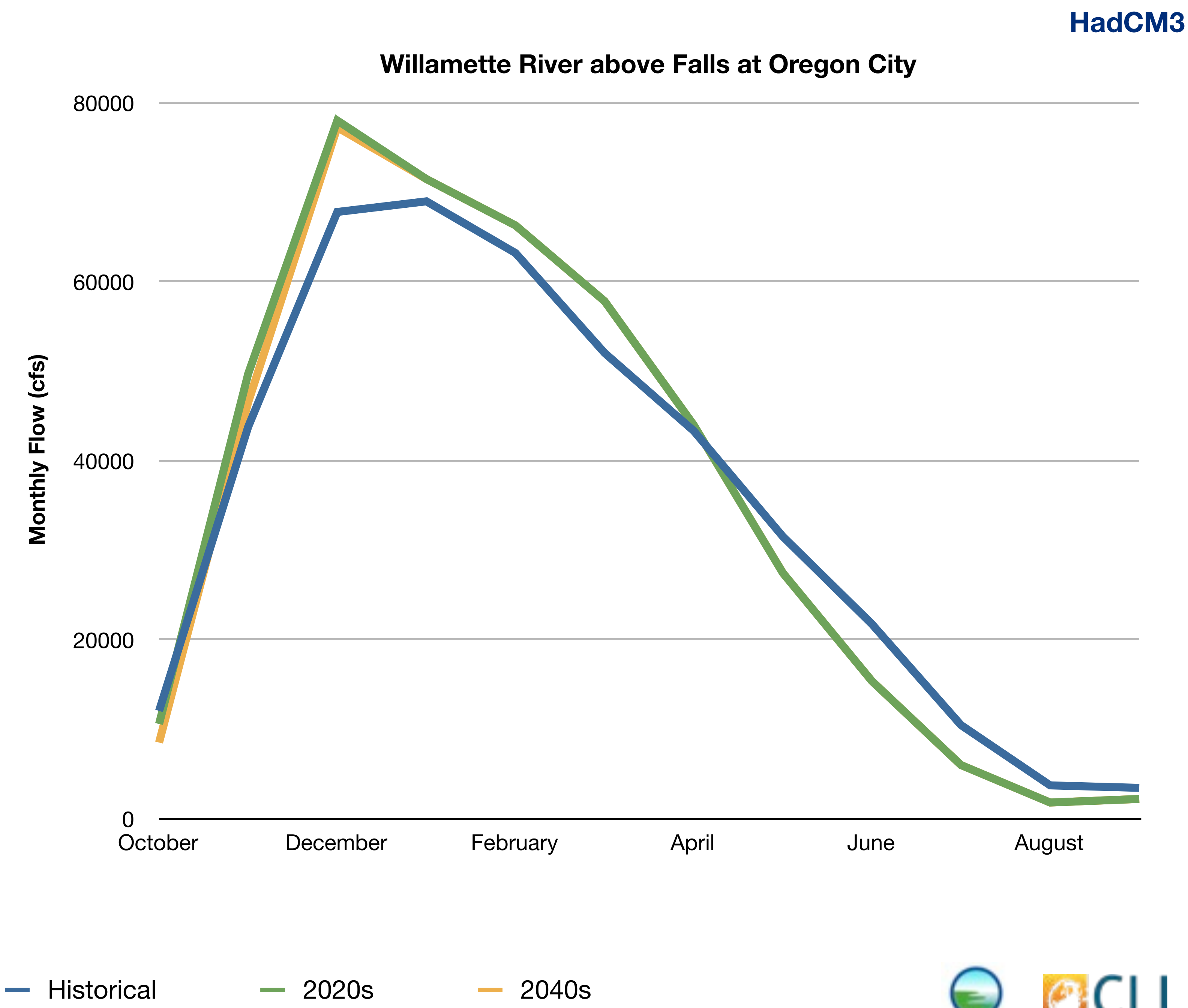
PCM1

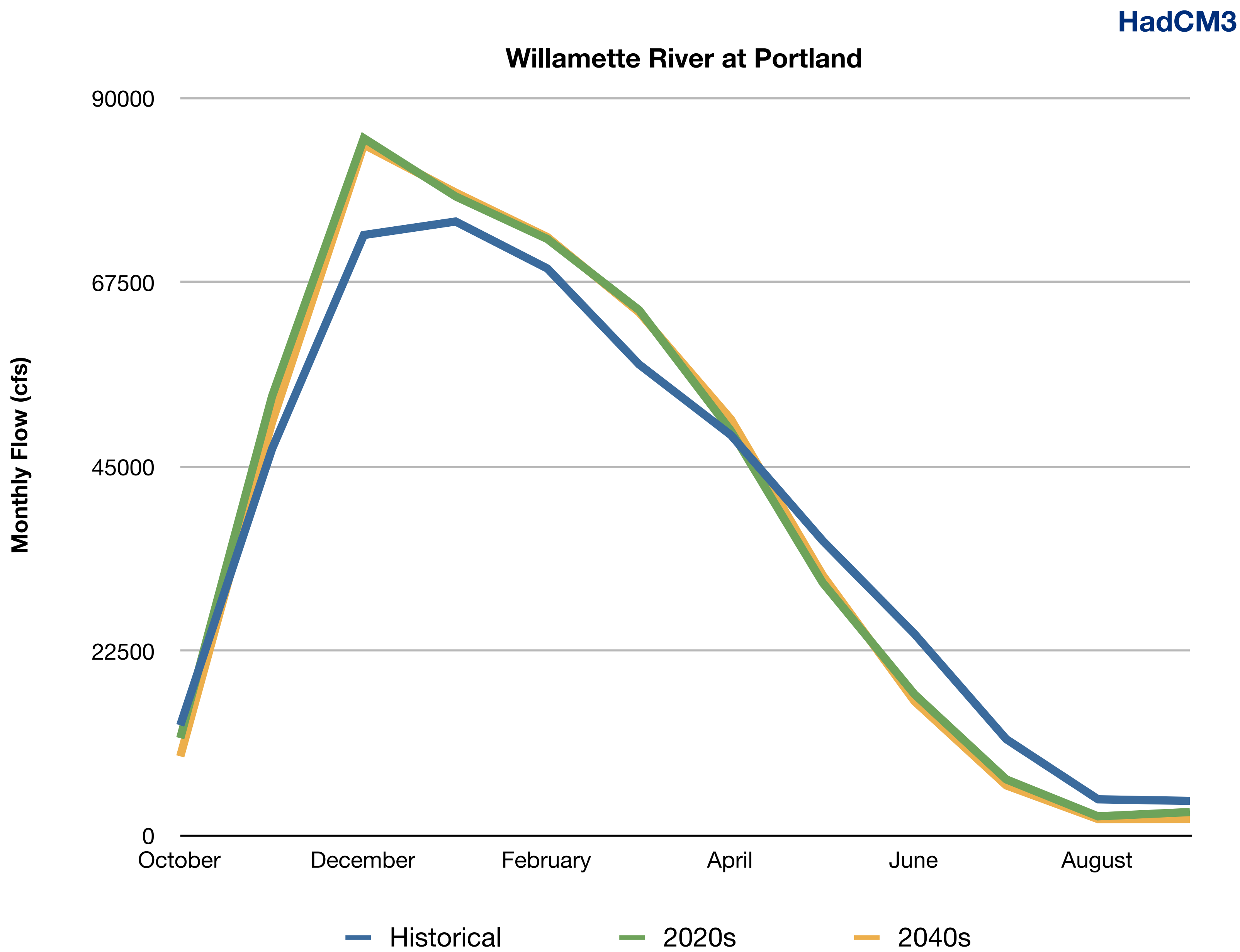


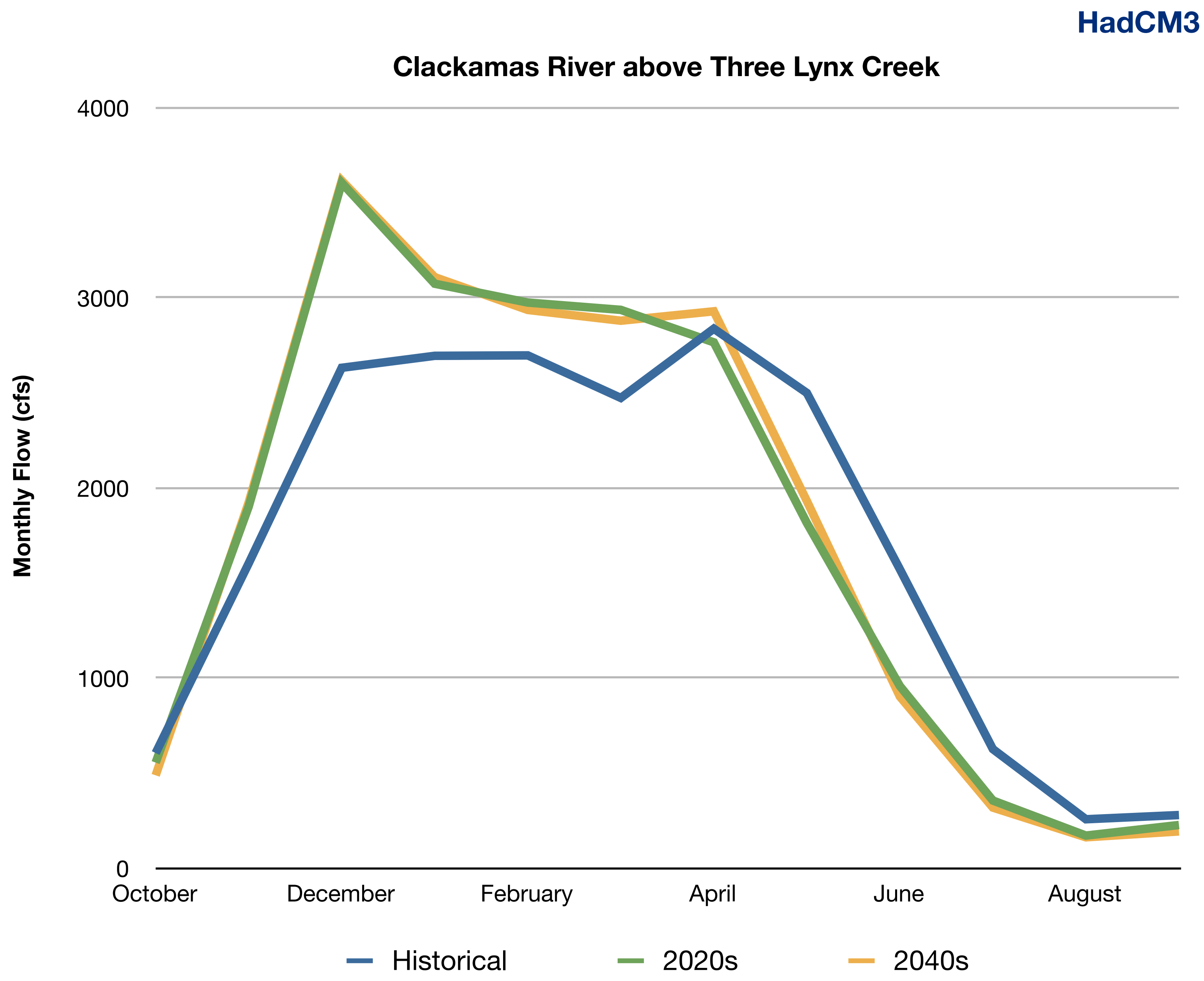
June
July
August
b1
1971-2000
2040s
2080s
a1b
1971-2000
2040s
2080s
Precipitation (in.)
0.01 - 1.36
1.37 - 2.59
2.60 - 3.99
4.00 - 5.57
5.58 - 7.68
7.69- 10.14
10.15 - 12.78
12.79 - 15.76
15.77 - 19.28
19.29 - 23.84
23.85 - 29.99
OCCRI
CLI
Climate Leadership Initiative

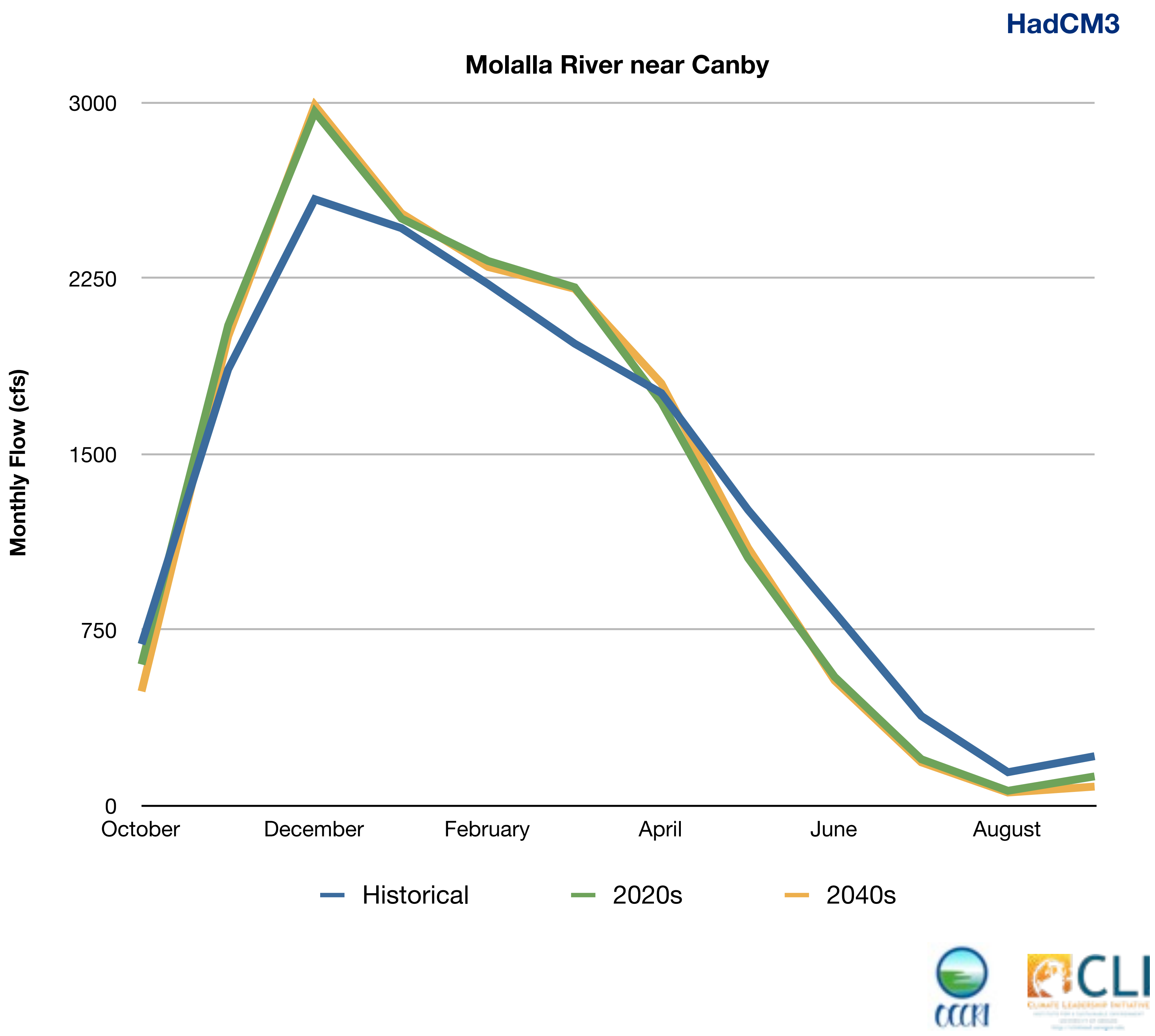
October	12089.0518	10625.6875	8551.72754
November	43828.4453	49754.2188	46570.9297
December	67830.4922	78045.9531	77284.2578
January	69016.1719	71506.375	71506.375
February	63242.8203	66327.3125	66327.3125
March	52075.6211	57860.7617	57860.7617
April	43373.5156	44029.4766	44029.4766
May	31571.2148	27501.6797	27501.6797
June	21786.75	15417.5176	15417.5176
July	10500.6689	6036.96143	6036.96143
August	3766.96899	1851.12805	1851.12805
September	3490.72217	2249.32617	2249.32617

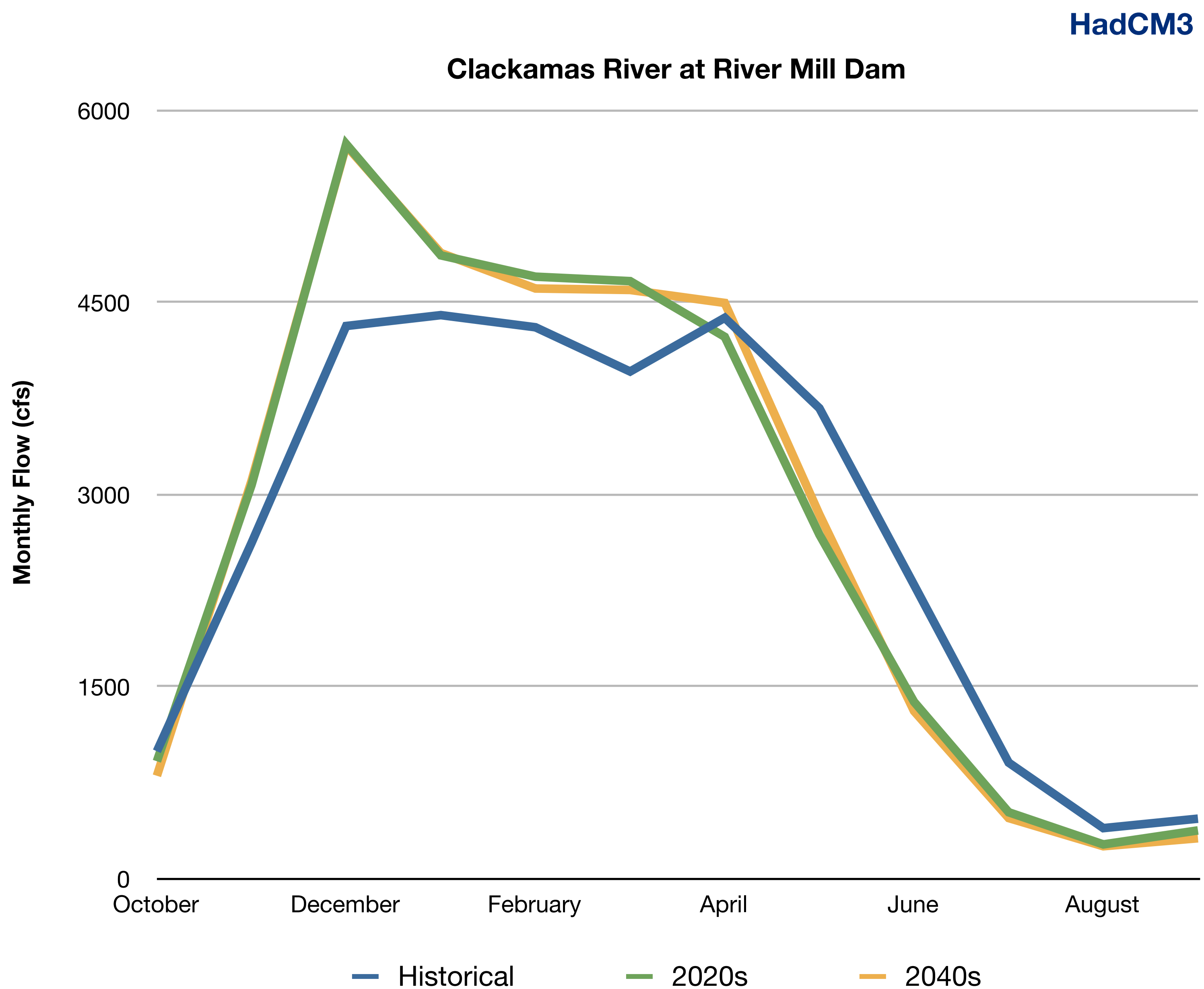



HadCM3
Willamette River above Falls at Oregon City
Monthly Flow (cfs)
80000
60000
40000
20000
0
October
December
February
April
June
August
Historical
2020s
2040s

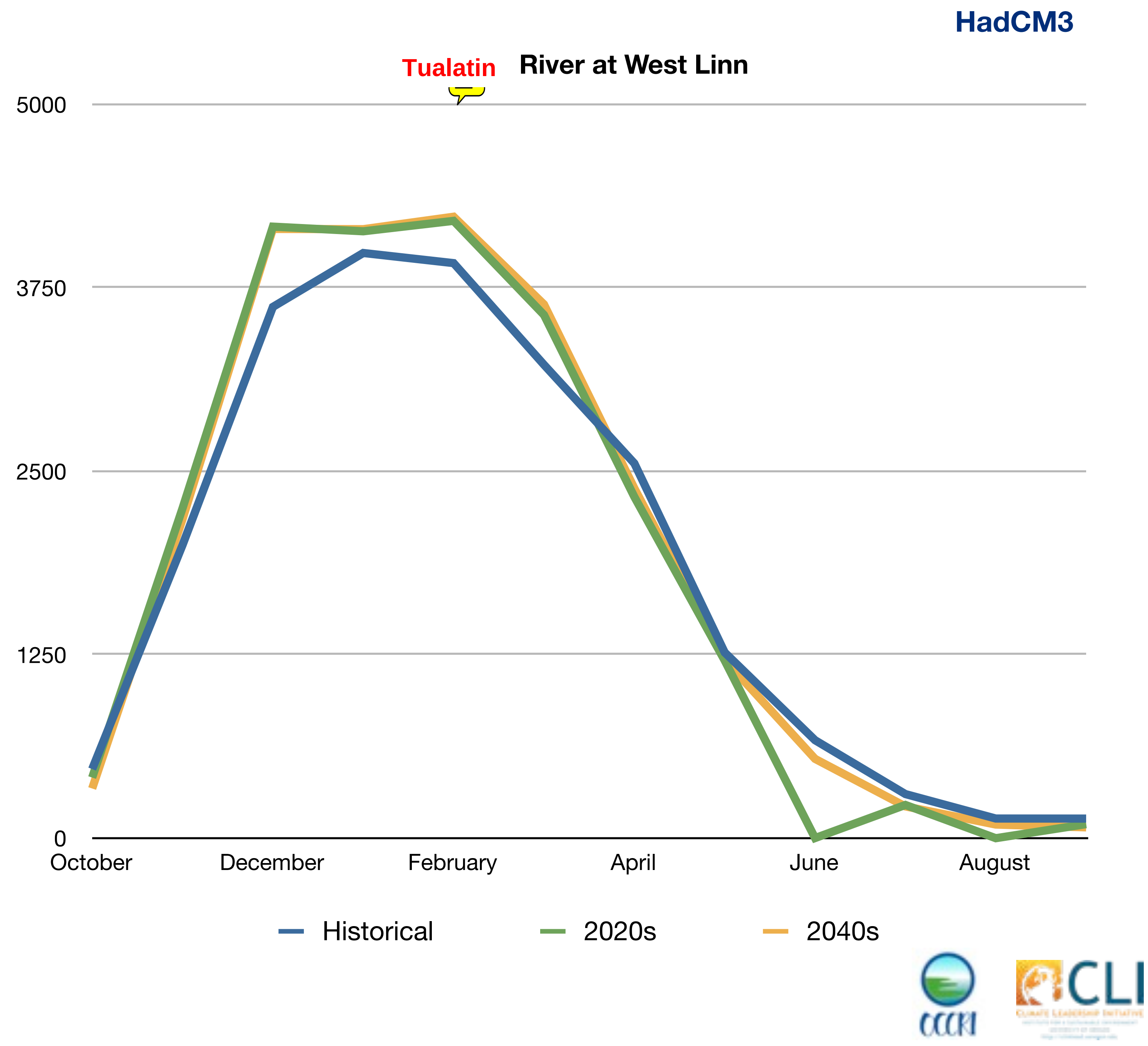

HadCM3
Willamette River at Portland
90000
67500
45000
22500
0
Monthly Flow (cfs)
October
December
February
April
June
August
Historical
2020s
2040s


HadCM3
Clackamas River above Three Lynx Creek
Monthly Flow (cfs)
4000
3000
2000
1000
0
October
December
February
April
June
August
Historical
2020s
2040s

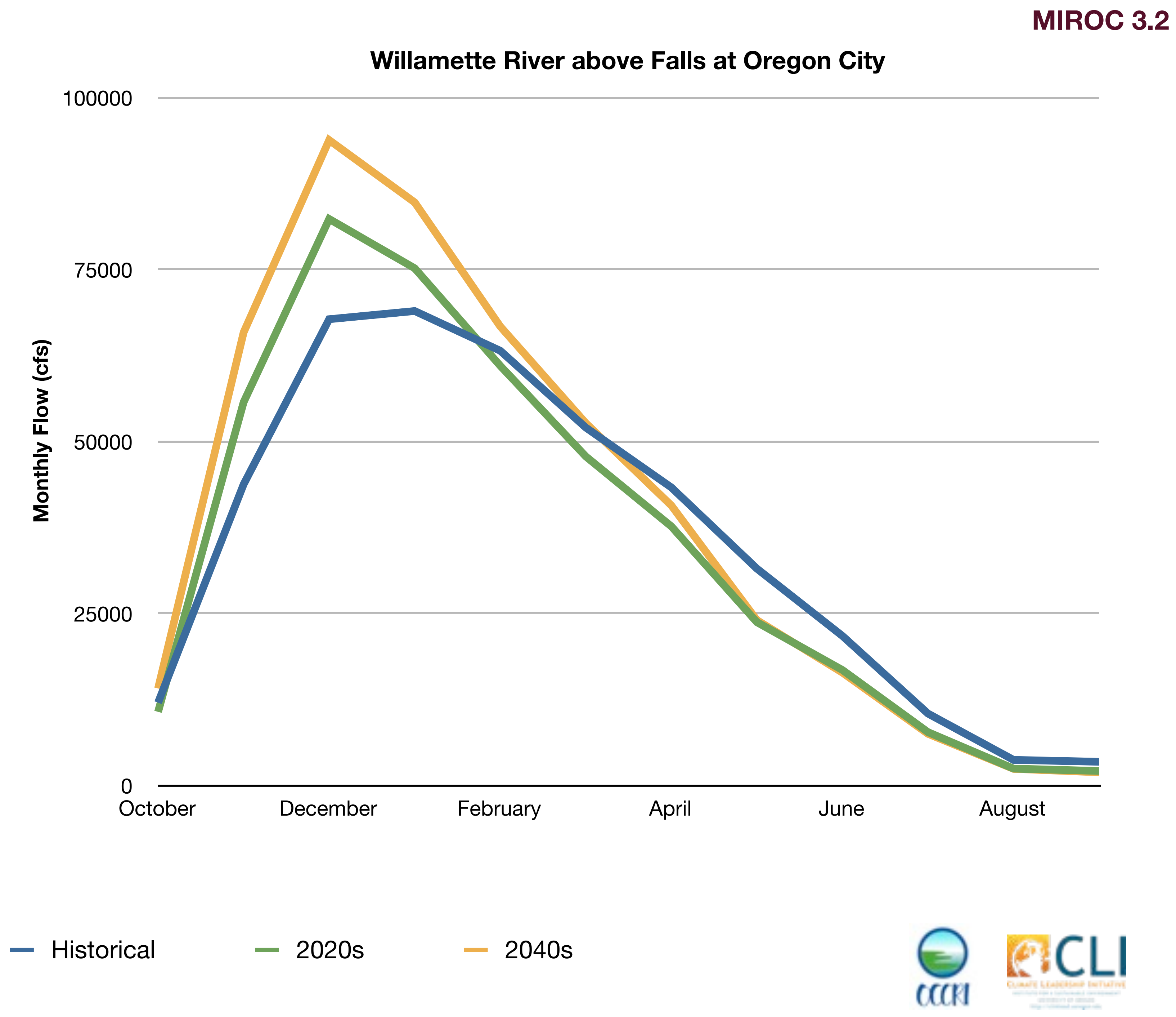

HadCM3
Molalla River near Canby
Monthly Flow (cfs)
3000
2250
1500
750
0
October
December
February
April
June
August
Historical
2020s
2040s
CCCRI
CLI
CLIMATE LEADERSHIP INITIATIVE



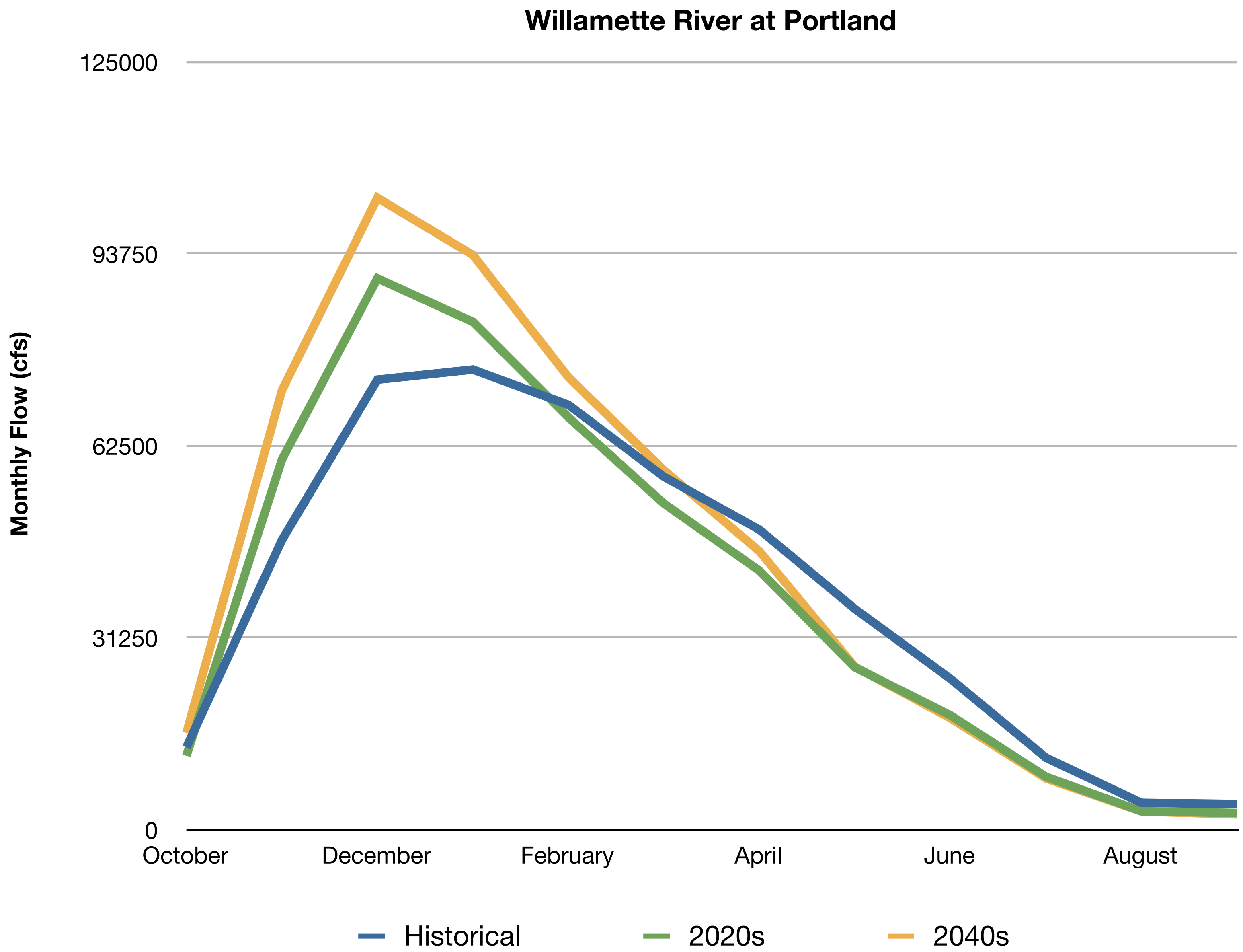
HadCM3
Clackamas River at River Mill Dam
Monthly Flow (cfs)
6000
4500
3000
1500
0
October
December
February
April
June
August
Historical
2020s
2040s



HadCM3
Tualatin River at West Linn
5000
3750
2500
1250
0
October
December
February
April
June
August
Historical
2020s
2040s
CCCRI
CLI

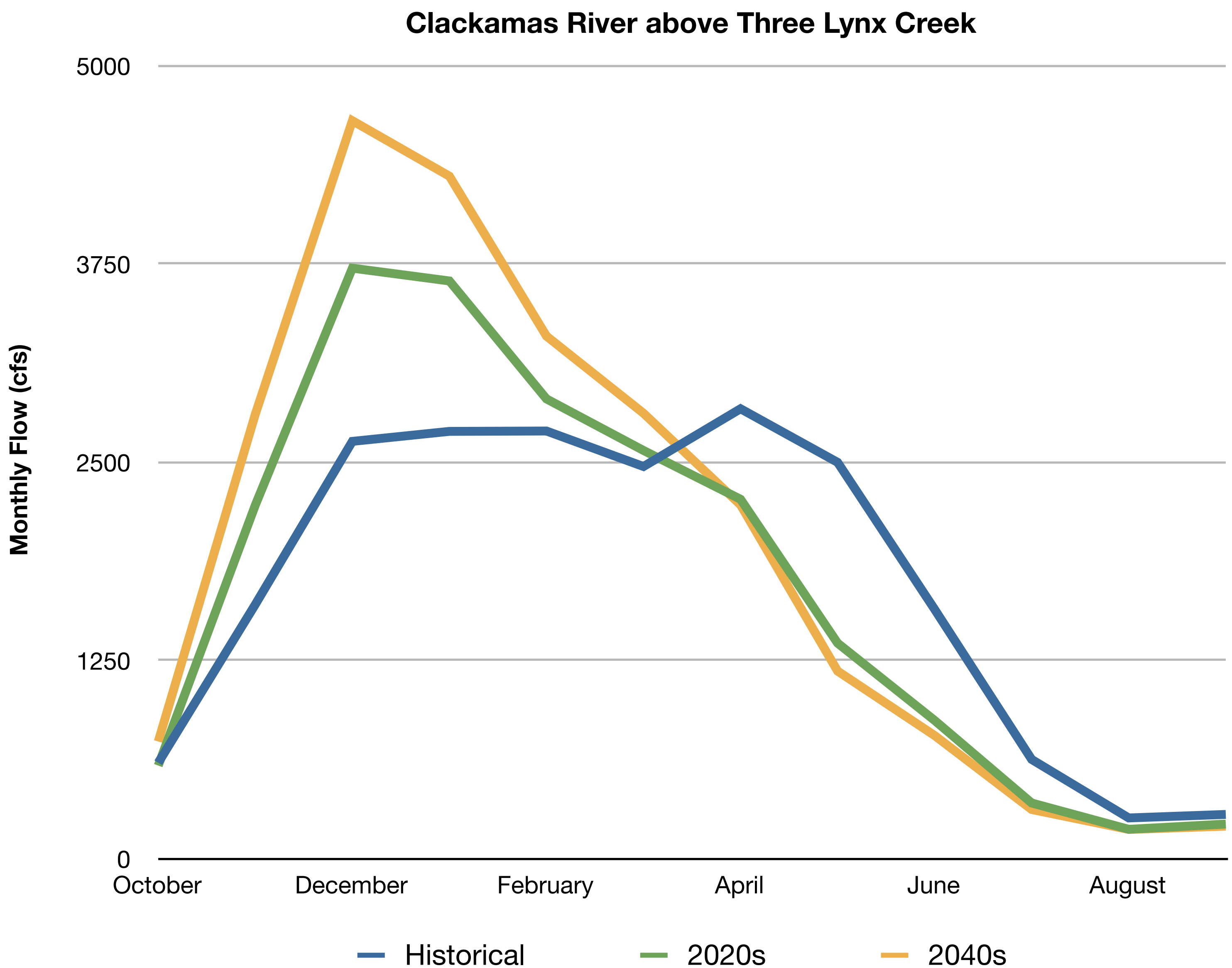

MIROC 3.2
Willamette River above Falls at Oregon City
Monthly Flow (cfs)
100000
75000
50000
25000
0
October
December
February
April
June
August
Historical
2020s
2040s
CCCRI
CLI
CLIMATE LEADERSHIP INITIATIVE

MIROC 3.2



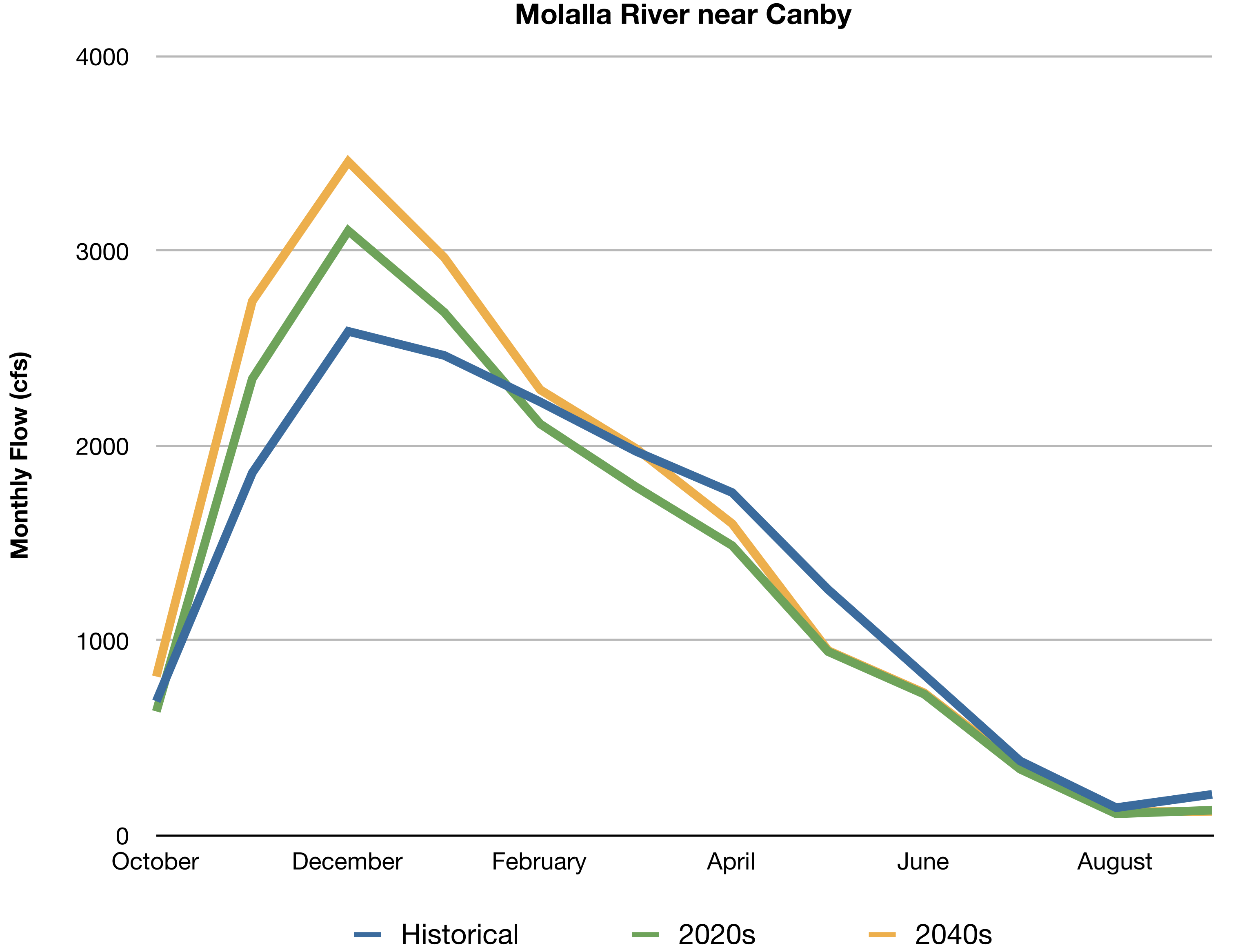
Willamette River at Portland
Monthly Flow (cfs)
125000
93750
62500
31250
0
October
December
February
April
June
August
Historical
2020s
2040s

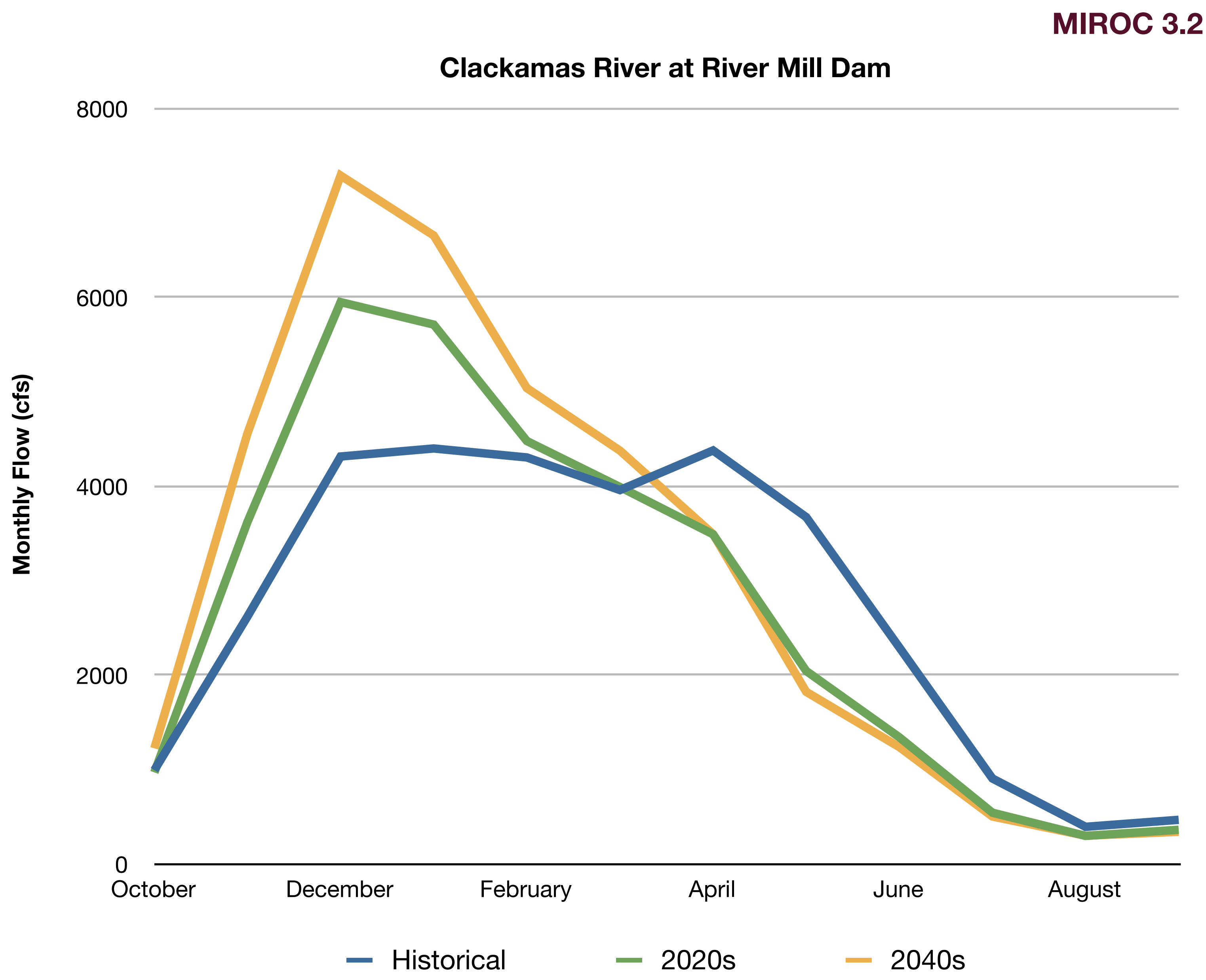
MIROC 3.2

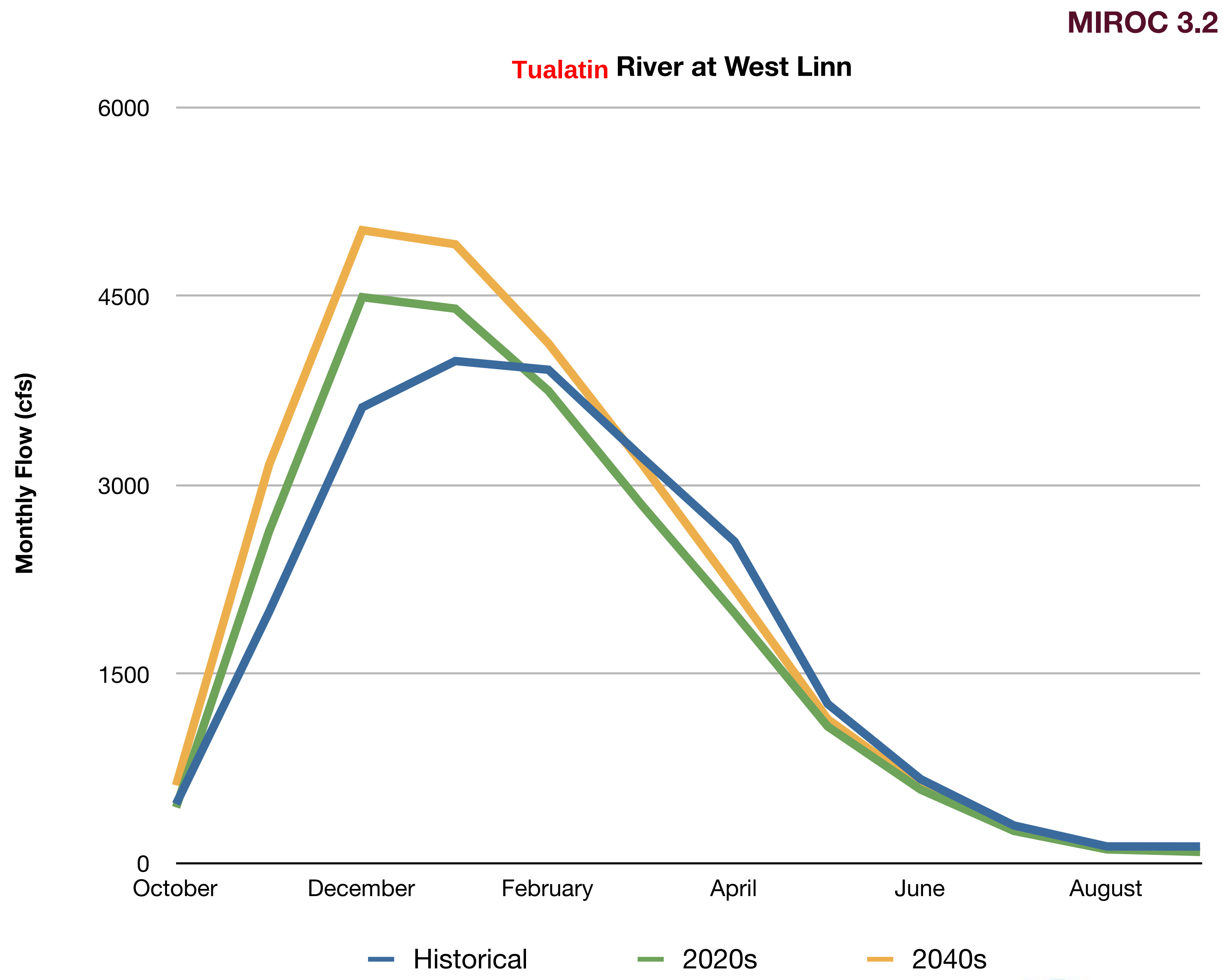


Clackamas River above Three Lynx Creek
Monthly Flow (cfs)
5000
3750
2500
1250
0
October
December
February
April
June
August
Historical
2020s
2040s

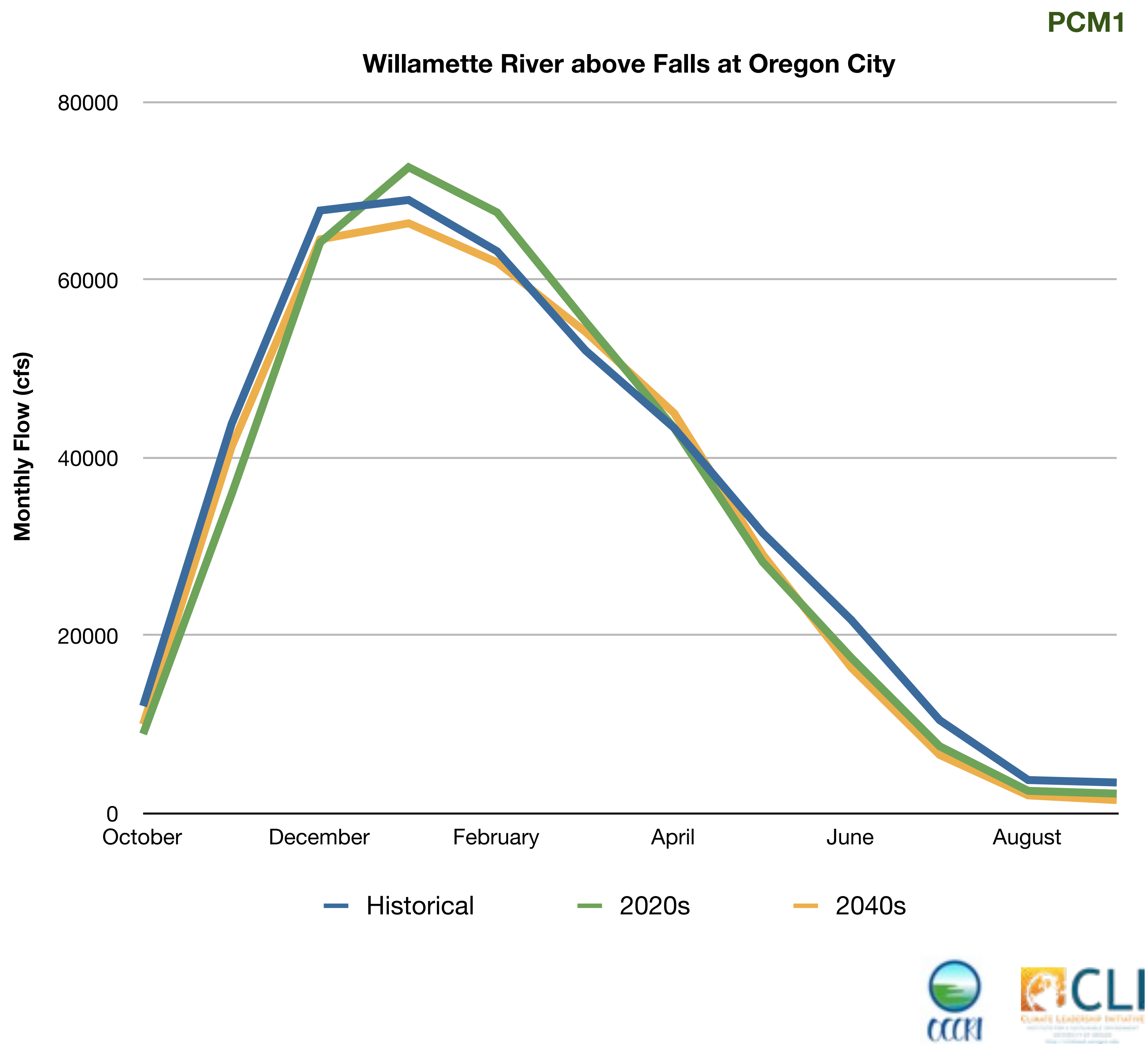
MIROC 3.2

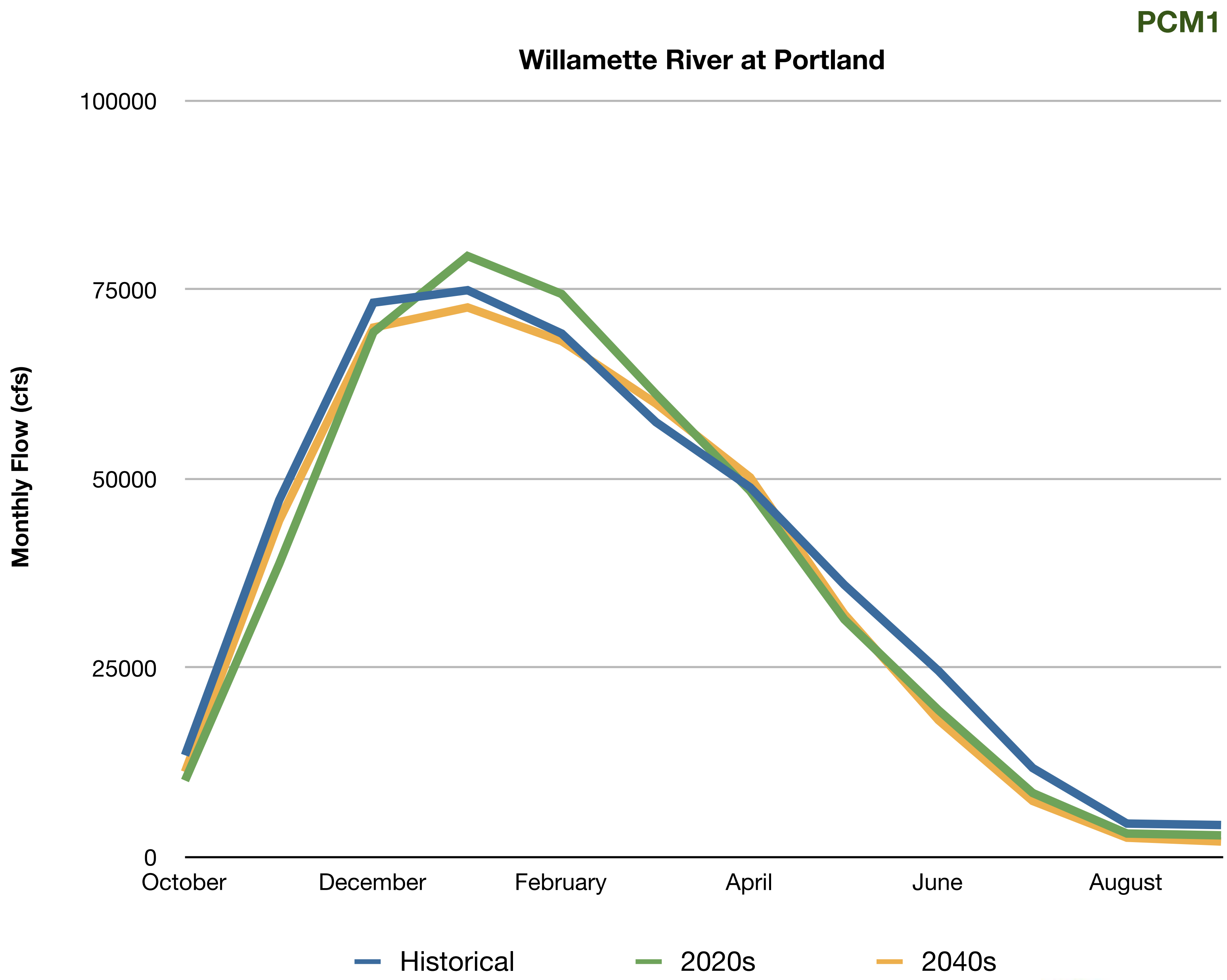

Molalla River near Canby
Monthly Flow (cfs)
4000
3000
2000
1000
0
October
December
February
April
June
August
Historical
2020s
2040s

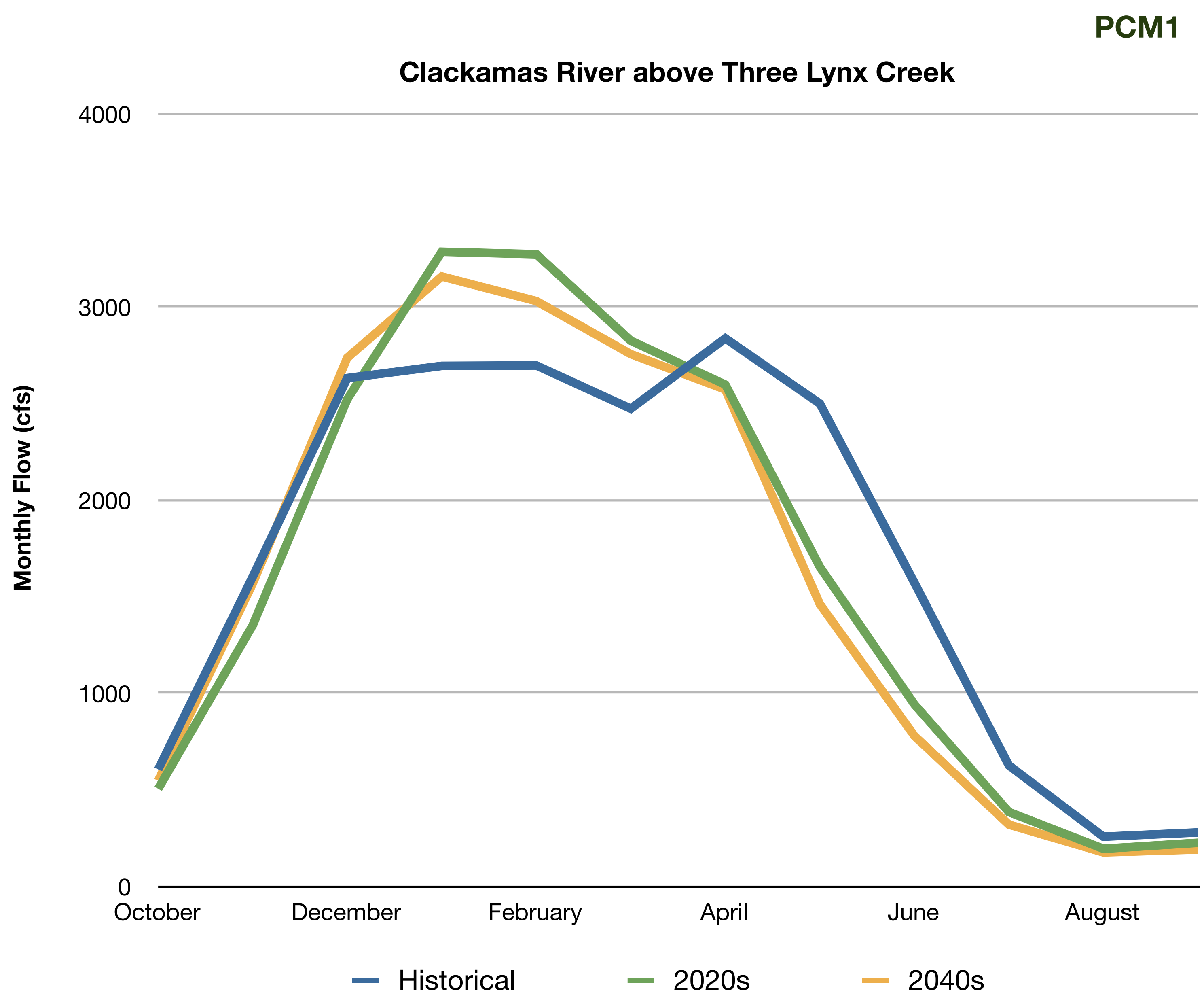

MIROC 3.2
Clackamas River at River Mill Dam
Monthly Flow (cfs)
8000
6000
4000
2000
0
October
December
February
April
June
August
Historical
2020s
2040s

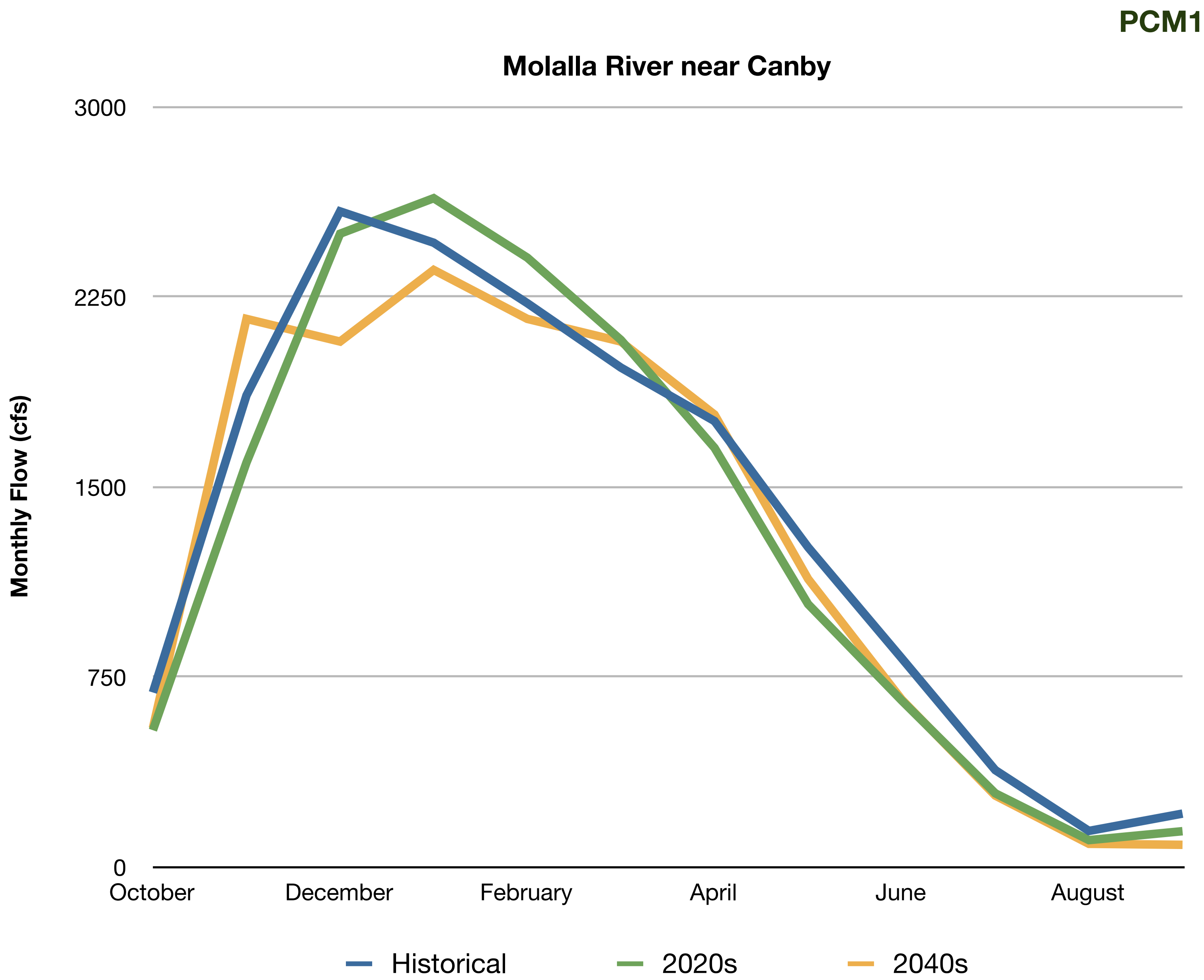


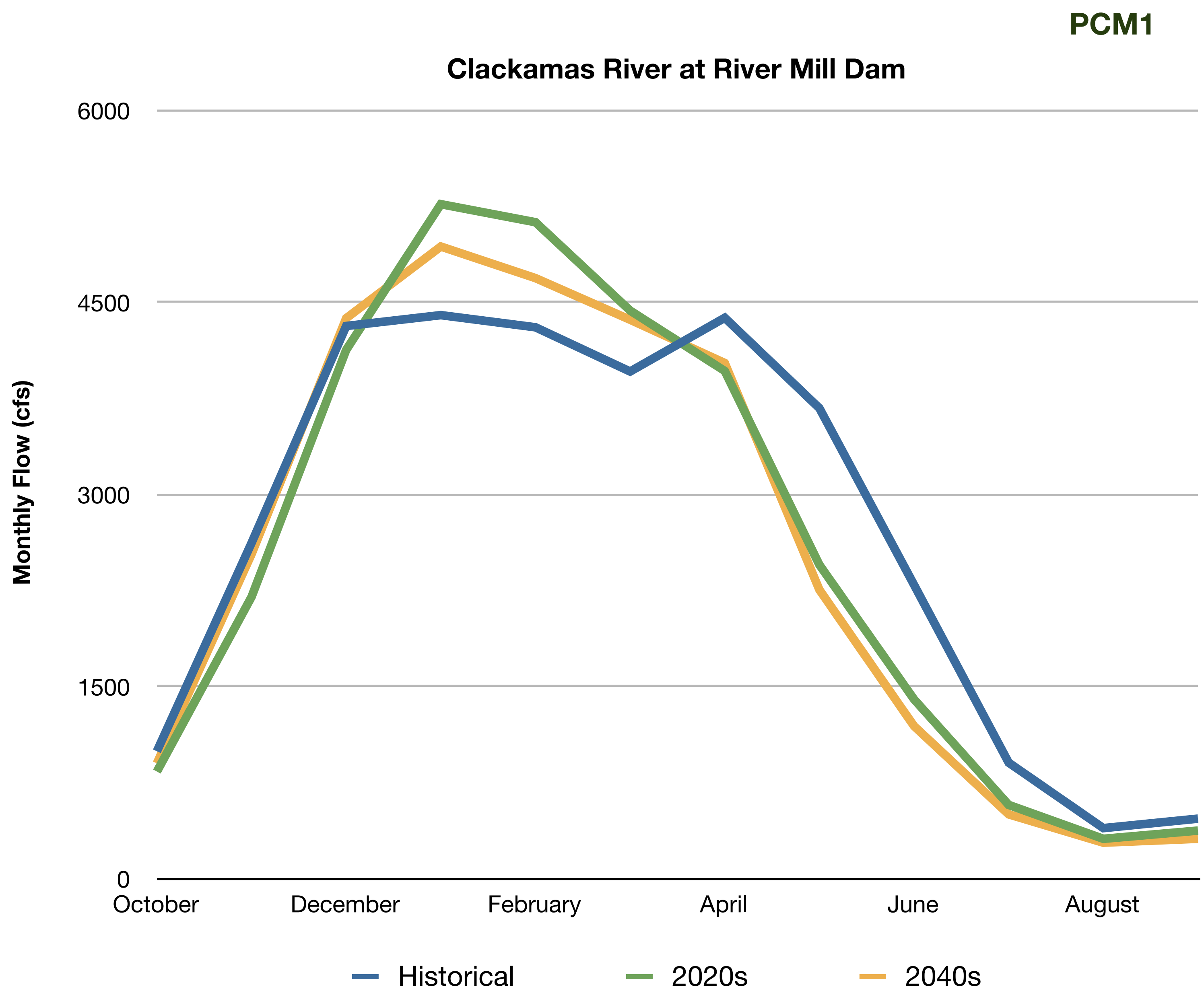
MIROC 3.2
Tualatin River at West Linn
6000
4500
3000
1500
0
Monthly Flow (cfs)
October
December
February
April
June
August
Historical
2020s
2040s


PCM1
Willamette River above Falls at Oregon City
Monthly Flow (cfs)
80000
60000
40000
20000
0
October
December
February
April
June
August
Historical
2020s
2040s
CCCRI
CLI

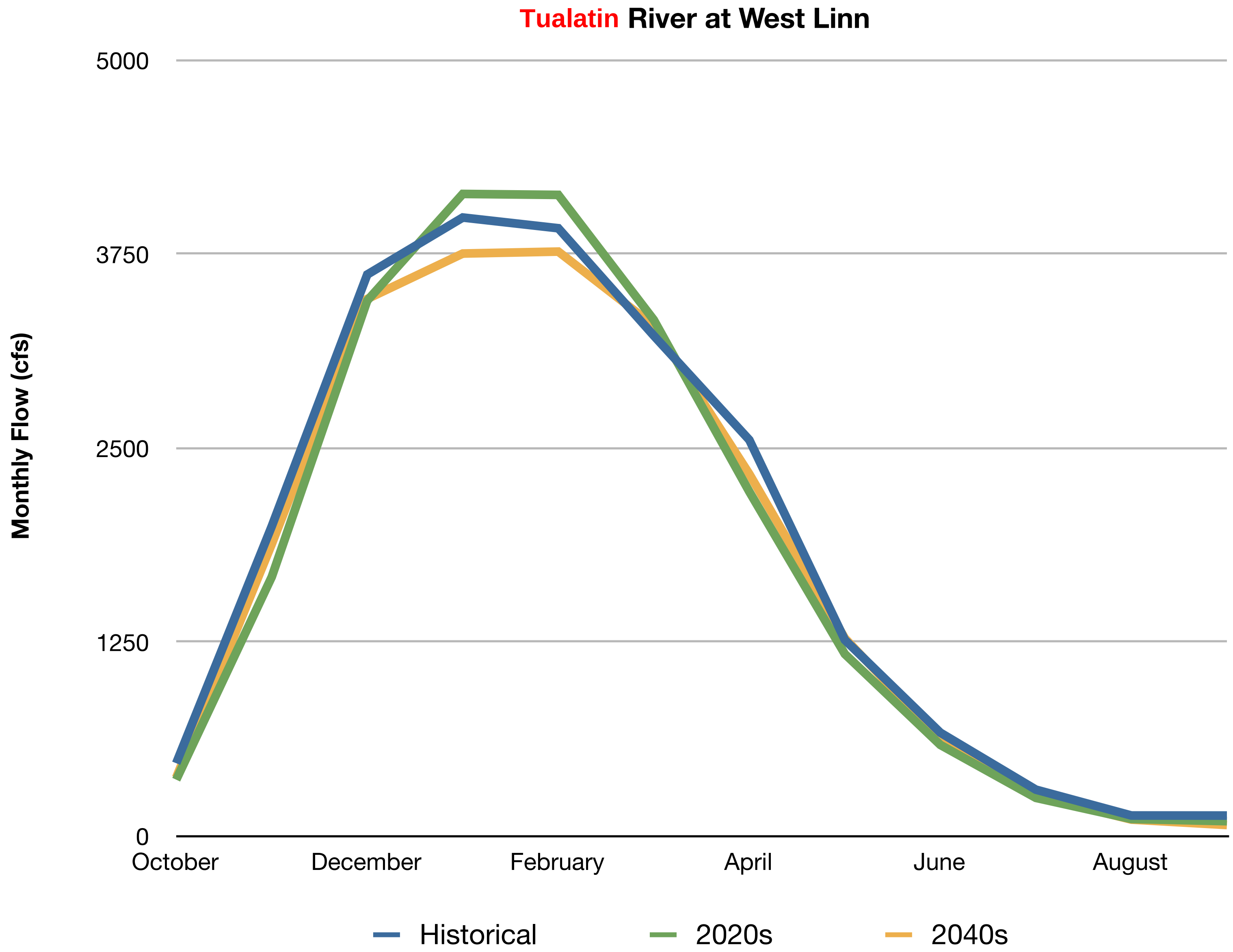

PCM1
Willamette River at Portland
Monthly Flow (cfs)
100000
75000
50000
25000
0
October
December
February
April
June
August
Historical
2020s
2040s


PCM1
Clackamas River above Three Lynx Creek
4000
3000
2000
1000
0
Monthly Flow (cfs)
October
December
February
April
June
August
Historical
2020s
2040s


PCM1
Molalla River near Canby
Monthly Flow (cfs)
3000
2250
1500
750
0
October
December
February
April
June
August
Historical
2020s
2040s


PCM1
Clackamas River at River Mill Dam
Monthly Flow (cfs)
6000
4500
3000
1500
0
October
December
February
April
June
August
Historical
2020s
2040s

PCM1



Tualatin River at West Linn
5000
3750
2500
1250
0
Monthly Flow (cfs)
October
December
February
April
June
August
Historical
2020s
2040s