PROJECTED FUTURE CONDITIONS IN THE UMATILLA RIVER BASIN OF NORTHEAST OREGON

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INSTITUTE FOR A SUSTAINABLE ENVIRONMENT
UNIVERSITY OF OREGON

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INTRODUCTION

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

The Umatilla River Basin is located in the northeastern part of Oregon, in the Middle Columbia Basin, occupying approximately 2,500 square miles.[1] Two distinct ecoregions characterize the area, the Columbia Basin, a broad upland plain formed by basalt lava flows, and the Blue Mountain ecoregion, composed of rugged terrain created by the folding and faulting of volcanic, sedimentary and metamorphic rock.[2] The Columbia Basin extends from the base of the Blue Mountains northward to the Colombia River. The Blue Mountains form an arched band along the southern boundary of the Umatilla Basin. Elevations in the Umatilla Basin range from 270 feet near the Colombia River to over 5,500 feet in the Blue Mountains.[3]

The Umatilla River originates on the slopes of the Blue Mountains and flows about 90-miles from the confluence of the North and South Forks in a generally westward direction to the Columbia River.[4] The main stem Umatilla River has eight major tributaries: The North and South Forks of the Umatilla River and Meacham Creek in the upper Basin; Wildhorse, Tutuilla, McKay and Birch Creeks in the mid-Basin; and Butter Creek in the lower Basin.

The Umatilla Basin is one of the most developed of the major drainages in eastern Oregon and human activity has taken a toll on the ecological systems. The Umatilla Basin once supported runs of fall and spring chinook, coho salmon and steelhead, but fish production is now limited.[5]

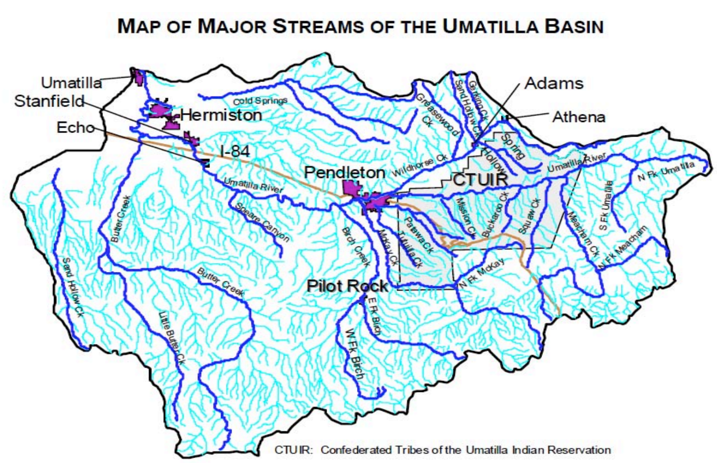

Figure 1. Map of Umatilla Basin.

[1] Umatilla Sub-Basin 2050 Water Management Plan, 2008.
[2] OWRD Umatilla Basin Ecological Priorities, 2004.
[3] Umatilla Sub-Basin 2050 Water Management Plan, 2008.

[4] Umatilla Sub-Basin 2050 Water Management Plan, 2008.
[5] Umatilla Sub-Basin 2050 Water Management Plan, 2008.

Natural conditions and extensive irrigation withdrawals have created extremely low streamflows during the summer months. Other limiting factors for fish production include dewatered stretches of river, high water temperatures and major diversion dams.[6]

Currently, over 50,000 people live within the Umatilla Basin.[7] Major population centers include Pilot Rock, Pendleton, Hermiston, and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR).

Private ownership is predominant in the Umatilla Basin, covering roughly 80 percent of the Basin land area (1,456,000 acres).[8] The US Forest Service manages about 13 percent of the land area while approximately 12 percent lies within the boundaries of the CTUIR.[9] About 13% of the land in the basin is forested, with around 6% in urban uses.[10] The rest –roughly 81% - is fairly evenly divided between agriculture and rangeland.[11][12]

Umatilla County is one of Oregon's leading agricultural producers. In 2002, Umatilla County ranked seventh in the state for total value of agricultural products sold, at approximately $205 million dollars[13]. The County ranked first in the state in the production of wheat and green peas (264,260 acres and 19,439 acres, respectively) and second in the state in the production of potatoes and vegetables harvested (11,842 acres and 24,768 acres respectively).[14] In 2004, the gross farm and ranch sales in Umatilla County were approximately $223 million dollars.[15] Major employers of the region include government agencies (state and federal), the CTUIR, and Wal-mart Corporation.[16]

Images courtesy USFS & Tom Foster

[6] Umatilla Sub-Basin 2050 Water Management Plan, 2008.
[7] U.S. Census, American Community Survey, 2008. http://www.co.umatilla.or.us/ubwc.htm
[8] DEQ, 2001.
[9] DEQ, 2001.
[10] OWRD Umatilla Basin Ecological Priorities, 2004.
[11] OWRD Umatilla Basin Ecological Priorities, 2004.
[12] http://www.co.umatilla.or.us/ubwc.htm
[13] OSU, 2006.
[14] OSU, 2006
[15] OSU, 2006.
[16] Pendelton Chamber of Commerce, 2009.

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, that approach is no longer reliable as climate change will produce changes in temperature, precipitation, streamflow, vegetation and fire patterns never before observed by humans. 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 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. These 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. The results cause differences in outputs creating some 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 causing this uncertainty is due to processes and feedbacks between different parts of the Earth's climate system that are not fully understood. We account for these variances by comparing groups of climate models, making it possible to project a credible range of possible future conditions.

Most climate models are created at global scales, but are difficult to downsize 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. In response, 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. While the models use the same inputs, they interpret reactions differently and therefore provide slightly different results. 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 Umatilla Basin project based on their ability to perform well in the Northwest:

- **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.[17] For this report, two scenarios (and in some cases three) were selected to model how different futures might play out:

- **A1b**: This scenario presumes increasing emissions due to continued growth in economies, population and technology, and reliance on mixed energy sources.
- **B1**: This is 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.
- **A2:** This line of scenarios represents a differentiated world. Trade flow is lowered, and there is slower capital stock turnover and technological change. The world is consolidated in a series of economic regions. Also referred to as "Business as Usual."

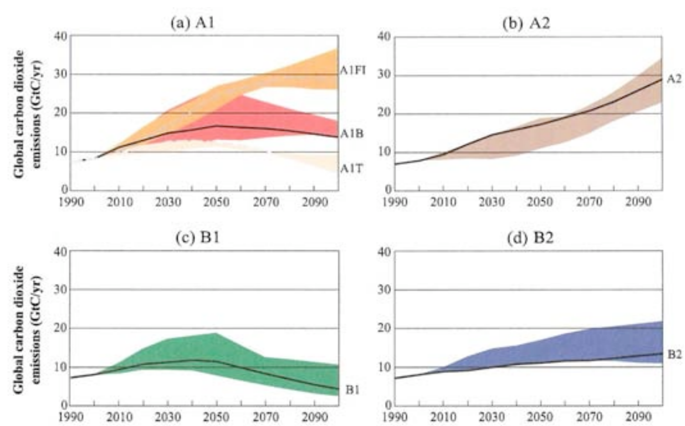

Figure 2. Emissions scenarios as described by the IPCC.

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 with envisioning what the conditions

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

and landscape may look like in the future as well as the potential magnitude and direction of change.

It is important to note that the scenarios described should be considered **possible outcomes** rather than definite predictions. 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.

GLOBAL CLIMATE CHANGE PROJECTIONS

The IPCC[18] and the U.S. Global Change Research Program[19] 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 equally as long or even centuries to restabilize the system. Reducing emissions is a vital mitigation measure to reduce further forcings on climate systems.

Additionally, 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 Umatilla will be better positioned to build resistance and resiliency within the systems they depend on for maintaining quality of life under a climate changed future.

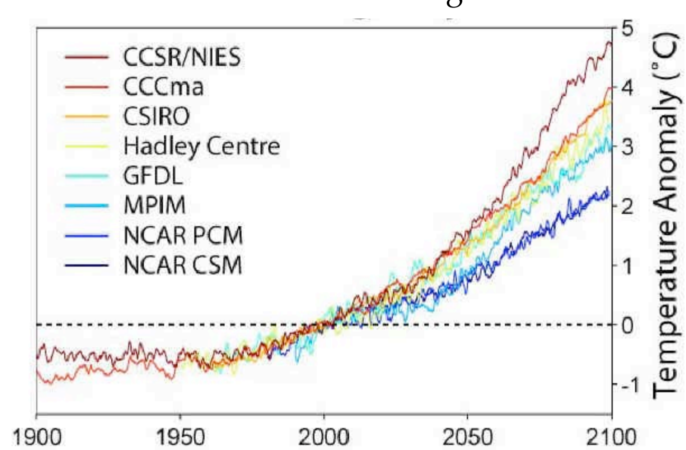

Figure 3. Projections for global temperature increase for a number of models used by the IPCC, compared with temperatures over the last one hundred years. Note that while projections for temperature increase vary by the end of the century, all models show a clear upward trend. Two of the models show different historical paths from 1900 to about 1950 and the others from 1960-2000 due to slight differentiations in the backcasting, as described in the text above. (From IPCC 2007)

[18] 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.
[19] USGCRP 2009. Global Climate Change Impacts in the United States. T. R. Karl, J. M. Melillo, and T. C. Peterson,(eds.). Cambridge University Press.

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; another approach is finding consistency in strategies that are effective no matter what change occurs. This will most likely involve building system resilience and resistance, as well as flexibility into the planning process.

SELECT RESOURCES FOR CURRENT ENVIRONMENTAL CONDITIONS WITHIN THE UMATILLA BASIN

Umatilla County. *Umatilla Sub-Basin 2050 Water Management Plan*. 2008.
http://www.co.umatilla.or.us/planning/pdf/2050 Plan Final.pdf

Oregon Department of Environmental Quality. *Umatilla River Basin Total Maximum Daily Load and Water Quality Management Plan*. 2001.
http://www.deq.state.or.us/wq/tmdls/umatilla.htm

Oregon Department of Environmental Quality. *Willow Creek Subbasin: Temperature, pH and Bacteria Total Maximum Daily Loads and Water Quality Management Plan*. 2007.
http://www.deq.state.or.us/wq/tmdls/umatilla.htm

Oregon Department of Environmental Quality. *Oregon Water Quality Index Report*. 1995.
http://www.deq.state.or.us/lab/wqm/wqindex/umatilla3.htm

Bonneville Power Administration. *Umatilla River Basin Anadromous Fish Habitat Enhancement Project*. 2003.
www.fishlib.org/library/Documents/BPA_Fish_and.../00006513-2.pdf

USGS. *Umatilla Ground-Water Study*. 2005.
http://or.water.usgs.gov/proj/umatilla_gw/index.html

CTUIR, Department of Natural Resources. *The Walla Walla Basin Natural Production Monitoring and Evaluation Project*. 2005.
http://data.umatilla.nsn.us/fisheries/index.aspx

Institute for Water and Watersheds, OSU. *Umatilla Sub-Basin Data Synthesis and Summary*. 2006.
http://www.co.umatilla.or.us/planning/pdf/Appendix M - Data Synthesis and Summary.pdf

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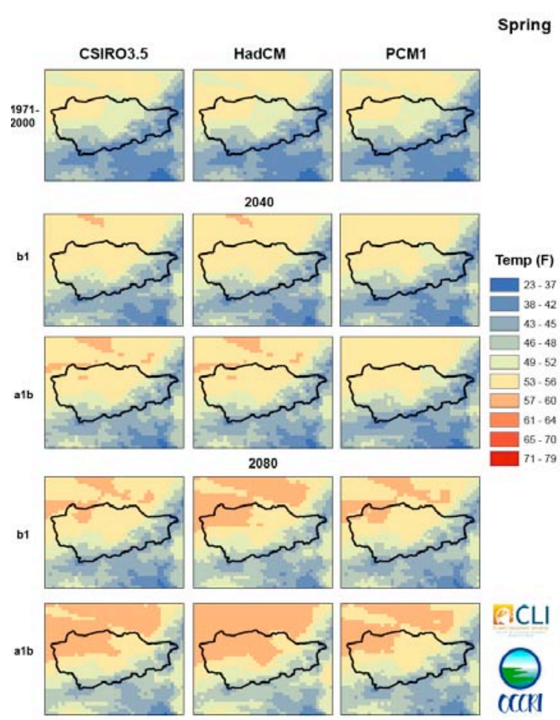
CLIMATE PROJECTIONS FOR THE UMATILLA BASIN OF NORTHEAST OREGON

Outputs of our climate models (PCM, CSIRO, and HadCM) and the vegetation model (MC1 coupled with CSIRO, HadCM and MIROC) 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 (2030-2059) 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 Basin. 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 in this document 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 in the appendix at the end of the document. The projections presented below 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 an historical baseline, 800m PRISM 1971-2000 climate grids were used to apply to the analysis and downscale the data.

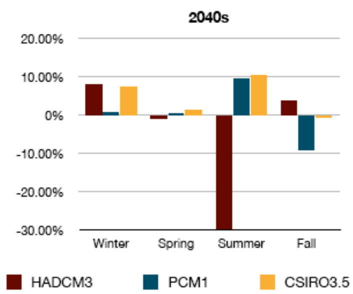


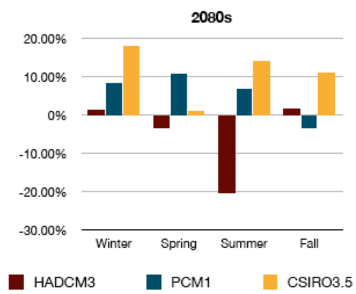
Temperature

All three models show an increase in seasonal and average annual temperatures by mid century, with more severe temperature increases by 2080. The HadCM models shows the greatest increase in warming, for instance, an increase of approximately 3-5° F for spring temperatures under both the B1 and A1b scenarios with more extensive warming under A1b. While summer temperatures show the greatest increase (e.g. 10-12° F for HadCM by end of century for A1b), winter shows the greatest percent of increase (from about an average of 28° F to 33° F by end of century under HadCM). Under both the A1b and B1 scenarios, PCM1 and CSIRO both show steady warming over the next seventy years, but not as intense as HadCM.

Precipitation

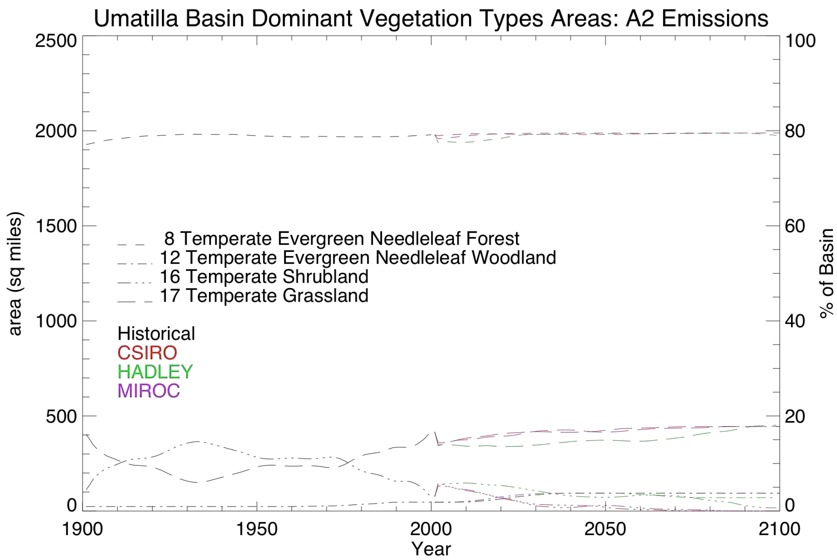
HadCM shows severe decrease in precipitation in the summer under both the B1 and A1b scenarios by mid and end of century, and all models show increasing precipitation in the winter for both mid and end of century under both scenarios. However, results for other models and seasons are mixed. In general, CSIRO demonstrates wetter winters, while HadCM shows drier summers, and PCM1 shows mixed results. PCM1 and CSIRO both show wetter summers.





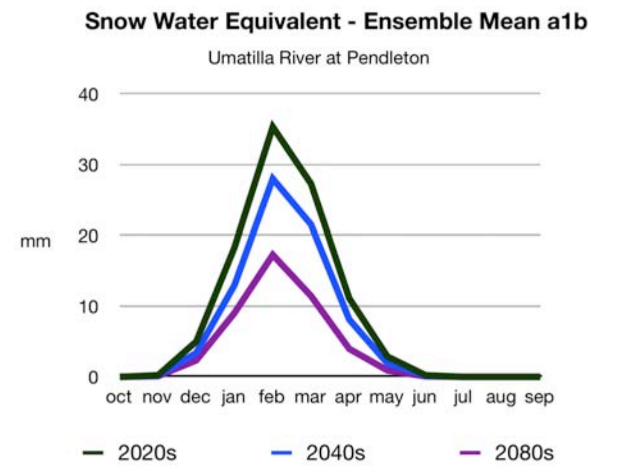
Vegetation

Most of the Umatilla Basin may be characterized as currently demonstrating the potential for hosting a Temperate Evergreen Needleleaf Forest type.[20] This type includes Douglas fir, true fir, and ponderosa pine species. However, agricultural practices have removed large areas of this forest type. Projections show very little change in vegetation type potential in the future, with possible decrease in Temperature shrubland in mid and end of century. (Data provided by Ray Drapek, Pacific Northwest Research Station.)

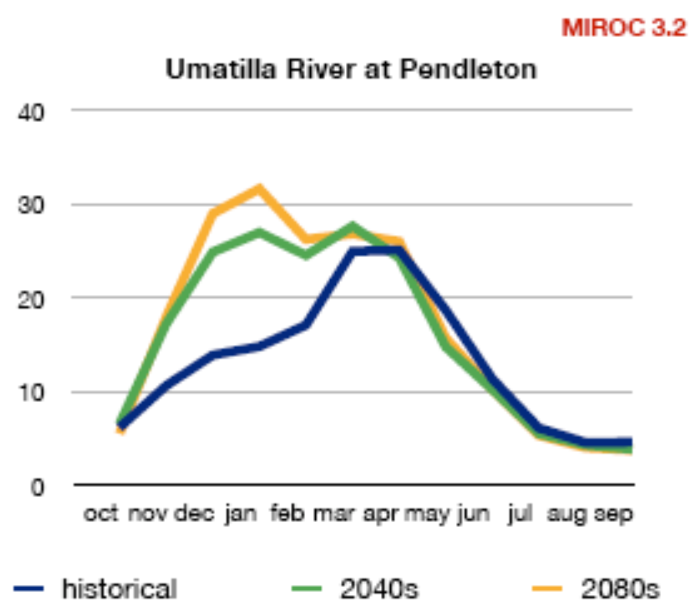


[20] This forest type is dominated by a mixture of evergreen/deciduous and broadleaf/needleleaf woody species. The difference between summer and winter temperatures is greater; it does freeze regularly. Douglas fir, true firs, and ponderosa pine savannahs are typical.

Snow Water Equivalent
Snow Water Equivalent (SWE)[21] decreases by almost a third by mid century under the business as usual model, and by over 50% by the 2080s. (Data courtesy Alan Hamlet, University of Washington.)



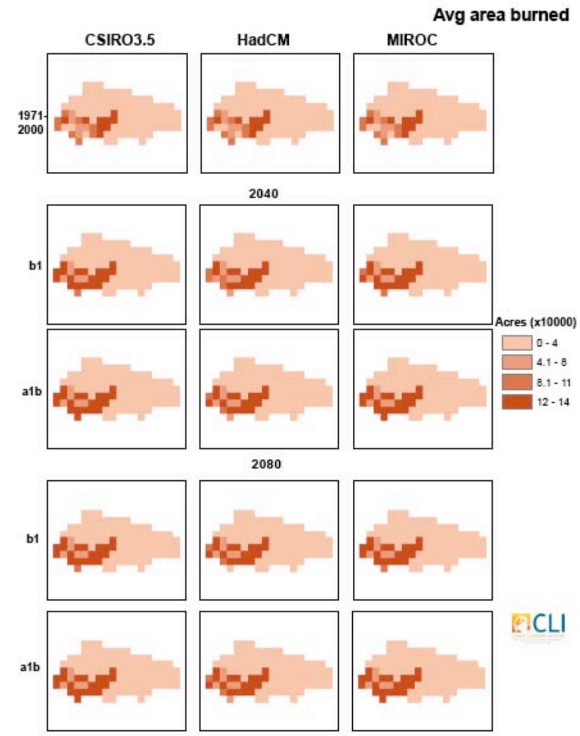
Streamflow
All three models show a doubling or tripling of flow rates in the late fall and early winter by mid and end of century, respectively, with higher flows through spring. Flows are slightly lower in the spring and summer. (Data courtesy Alan Hamlet, University of Washington.)

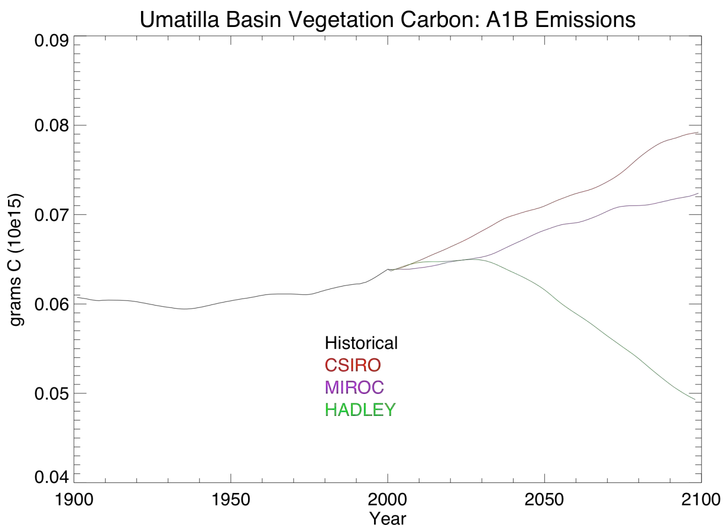


[21] Snow Water Equivalent (SWE) is a common snowpack measurement. It is the amount of water contained within the snowpack. It can be thought of as the depth of water that would theoretically result if you melted the entire snowpack instantaneously. From: http://www.or.nrcs.usda.gov/snow/about/swe.html

Vegetation Consumed & Acres Burned By Fire

Projections show a slight increase in vegetation consumed under all models, mostly increasing acreage in the southwest corner of the Basin. However, change in acres burned or vegetation consumed is not significant.





The vegetation carbon graphs show a marked decrease for HadCM and increase for the other models which reflects the effect of temperature and precipitation (higher and drier in the case of HadCM, wetter in the case of the other models) on available carbon sequestration and tree growth.

INTERPRETATIONS OF RESULTS

The questions listed below are intended for consideration by participants as the modeling results are reviewed.

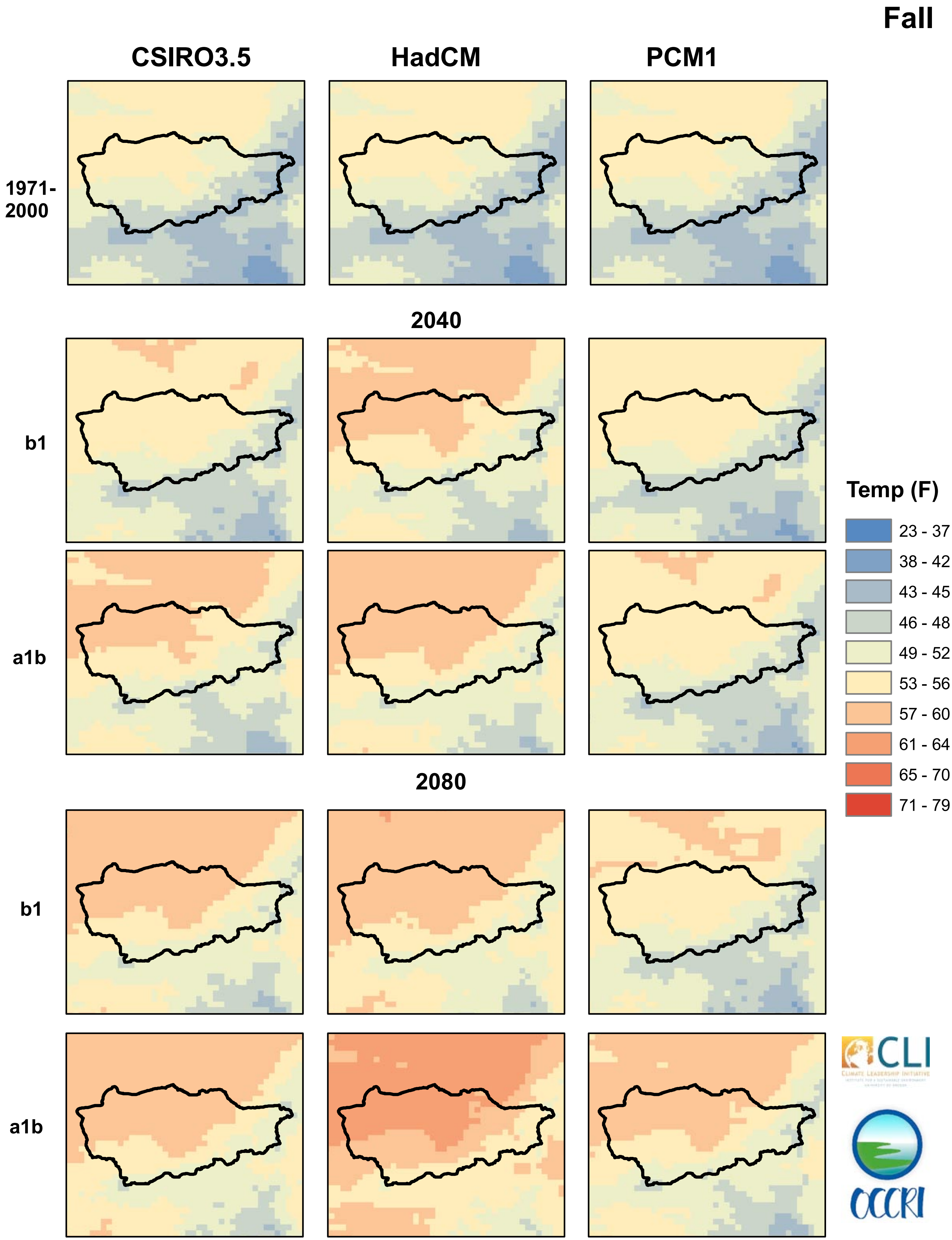
1. How will projected changes in temperature, precipitation, vegetation, streamflow, snowpack, and fire affect the condition of existing species and ecosystems?
2. What species and ecosystems of the Umatilla will be most vulnerable?
3. What species and ecosystems of the Umatilla will be most buffered?
4. What regions of the Umatilla will be most vulnerable to projected impacts?
5. What regions of the Umatilla will be most buffered from projected impacts?
6. How might the activities and behaviors of species and systems change as a result of the projections?
7. What new interactions may occur among species and among ecological communities? What are the possible consequences of those interactions?
8. What types of unexpected events or changes might occur? If they were to occur, what are the possible consequences?

RECOMMENDATIONS

1. What near, mid and long-term actions can be taken to build resistance and resiliency among species and ecosystems?
2. What species, areas, or ecosystem types should be prioritized for management?
3. What actions should be considered urgent? Who should be responsible for taking these actions?
4. How might actions for a single species, ecosystem or region affect other species, ecosystems or resources?
5. What other types of changes might occur that produce cascading effects in other systems or species? If they were to occur, what are the possible consequences?
6. What, if any, are other consequences or impacts that should be considered?

APPENDIX ONE: SPATIAL MAPS AND GRAPHS FOR CLIMATE PROJECTIONS FOR THE UMATILLA

1. Temperature Seasonal Spatial Maps
2. Temperature Bar Graphs
3. Precipitation Seasonal Spatial Maps
4. Precipitation Bar Graphs
5. Stream Flow Graphs (Umatilla River at Pendleton)
6. Snow Water Equivalent
7. Vegetation Type Graph (Spatial Map will be included in the future)
8. Vegetation Carbon
9. Vegetation Consumed by Fire
10. Vegetation Proportion Burned
11. Fire Spatial Map



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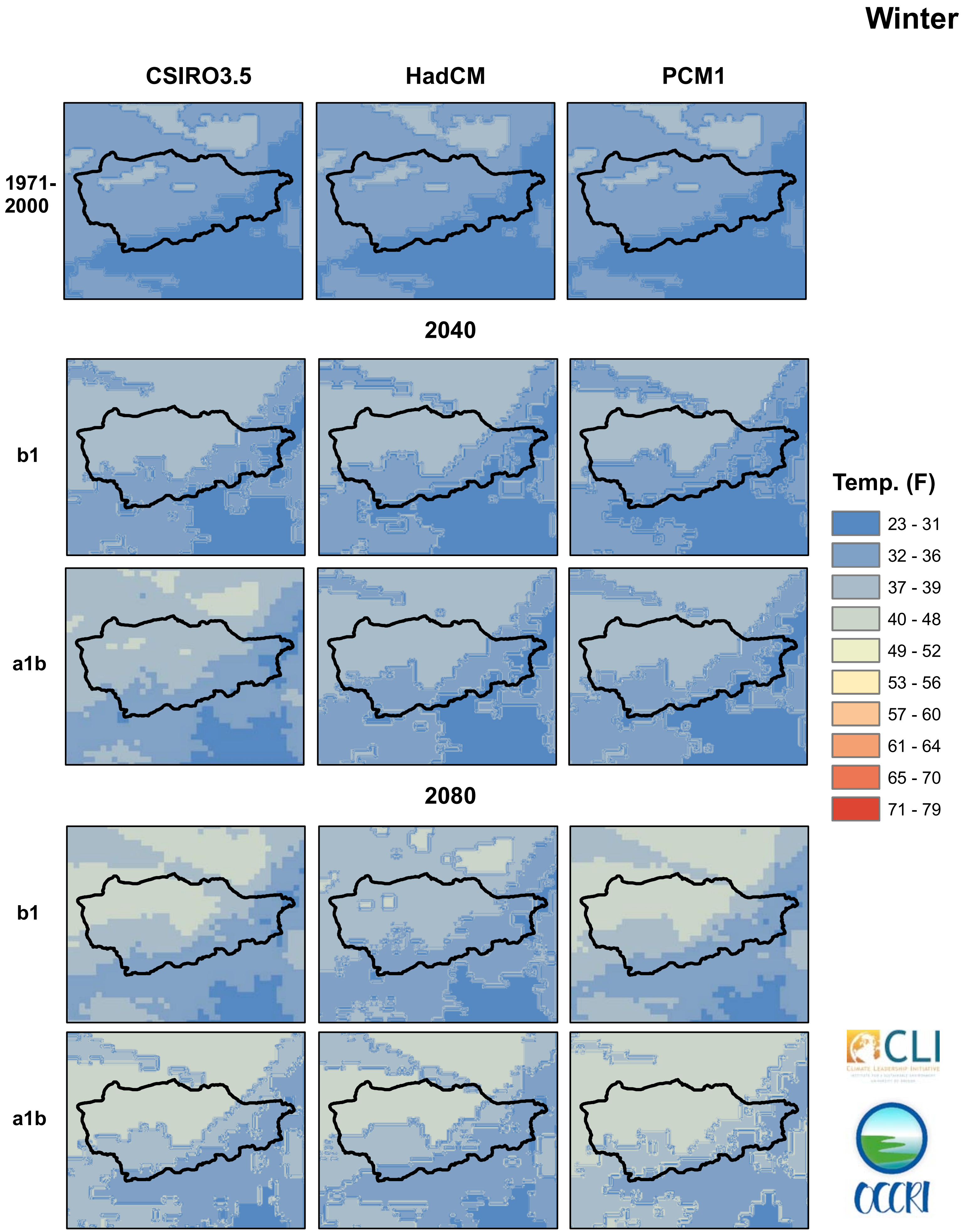
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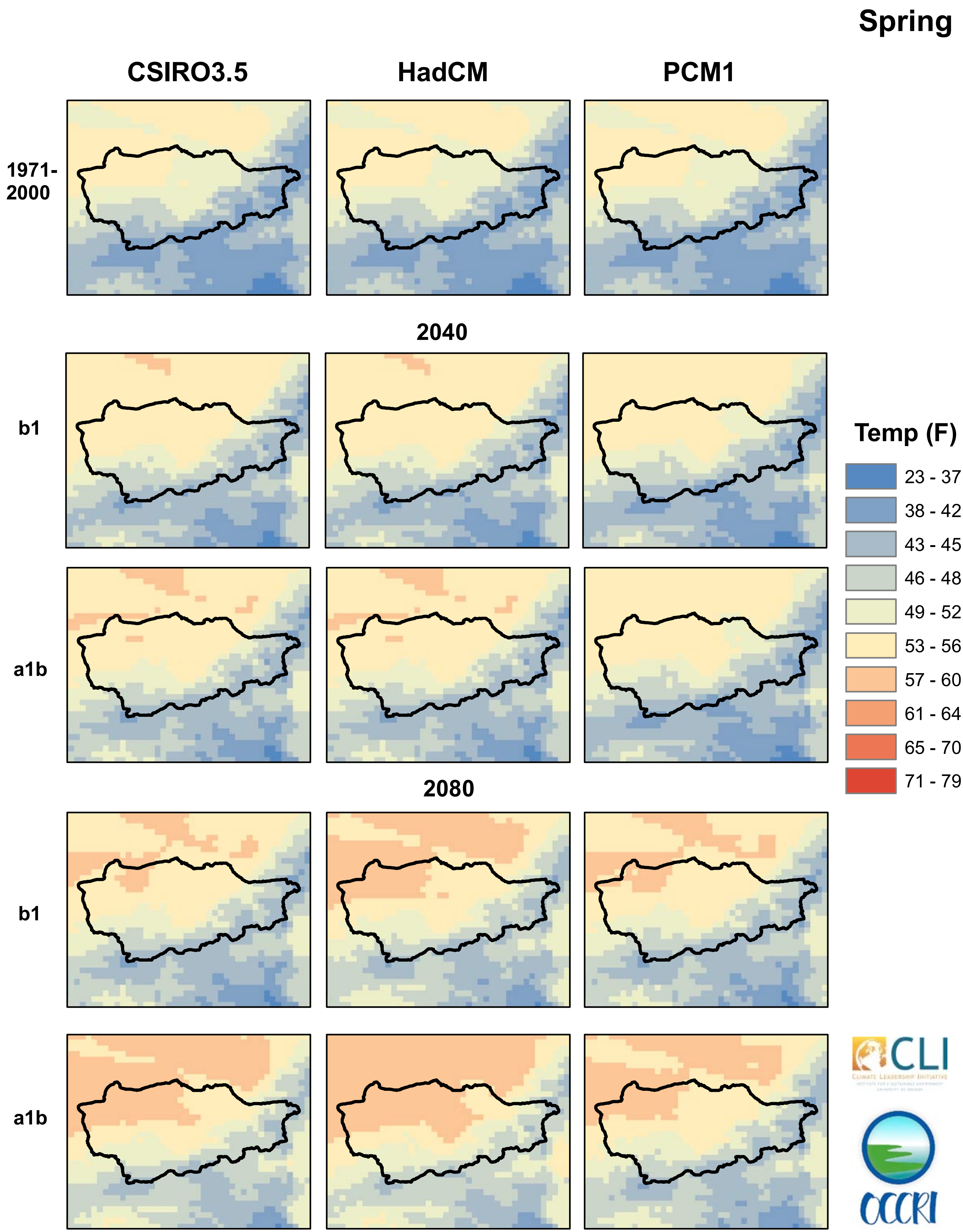
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Climate Leadership Initiative
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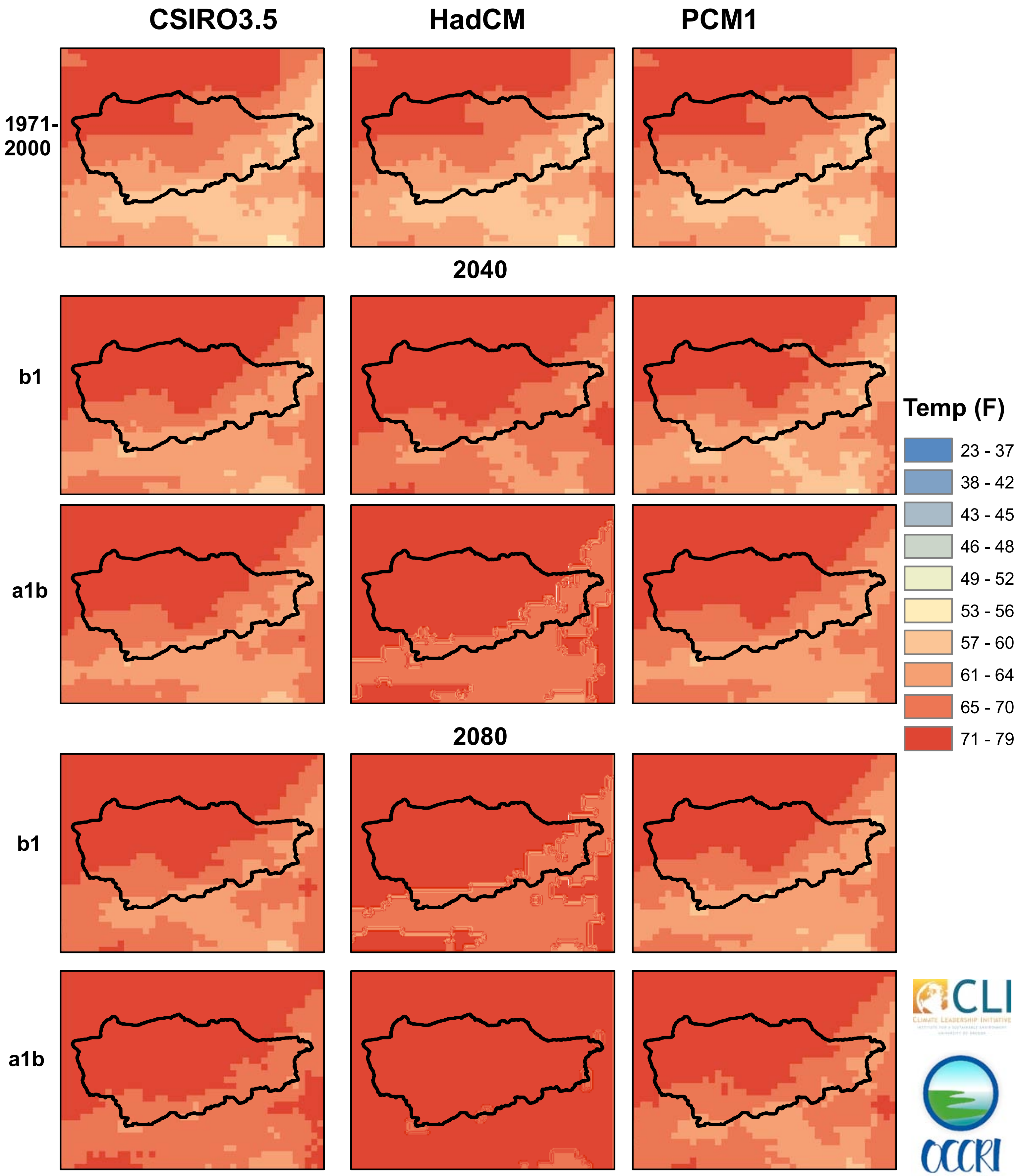
Summer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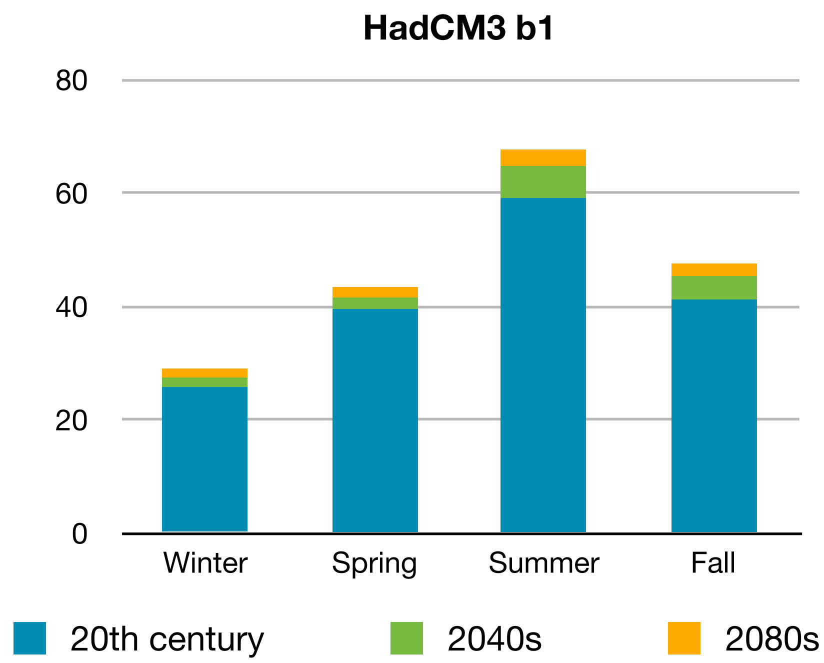
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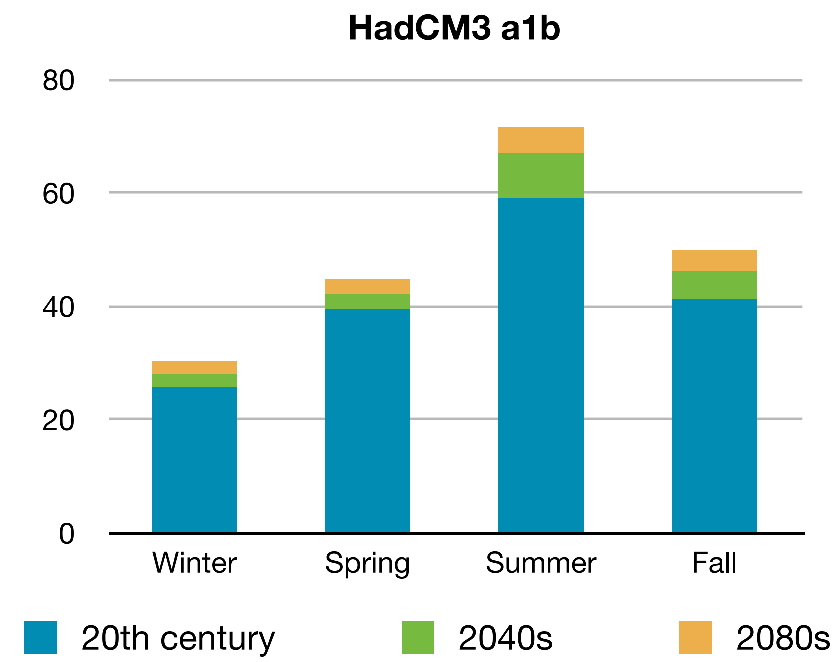
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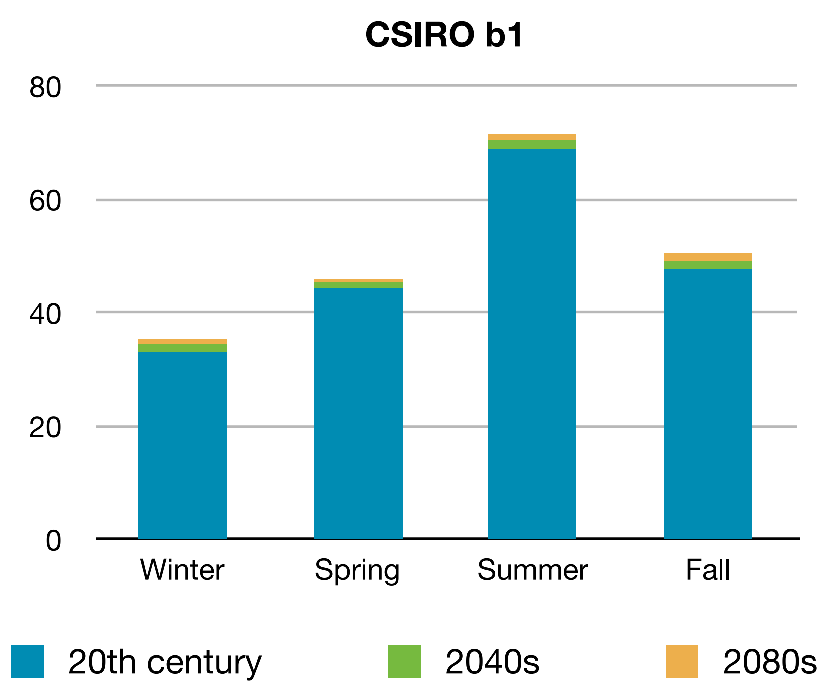
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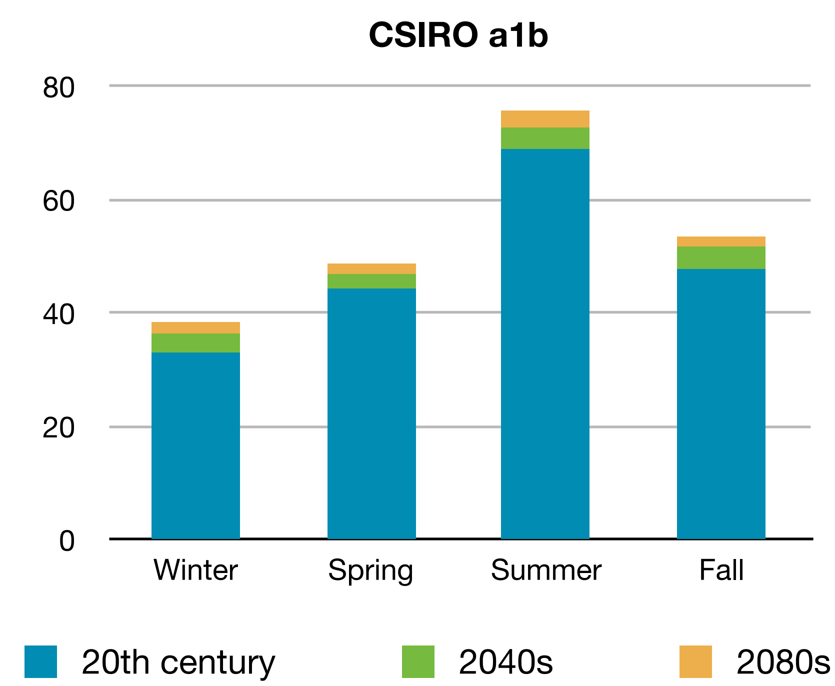
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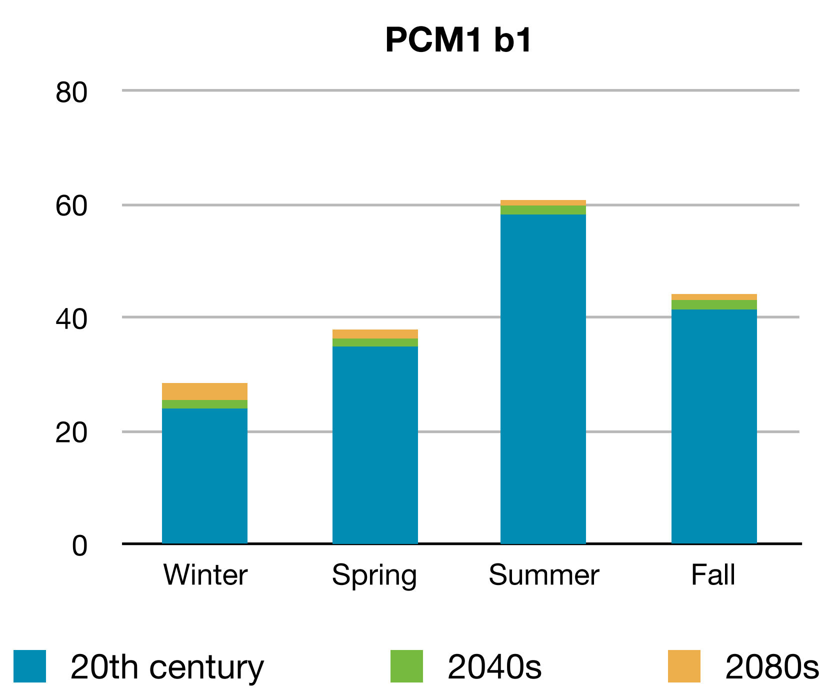
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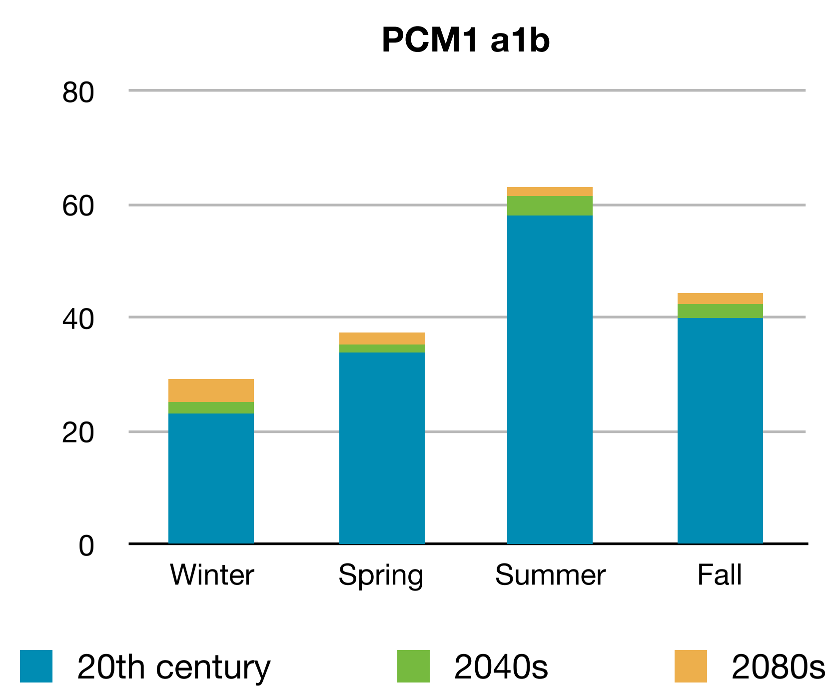
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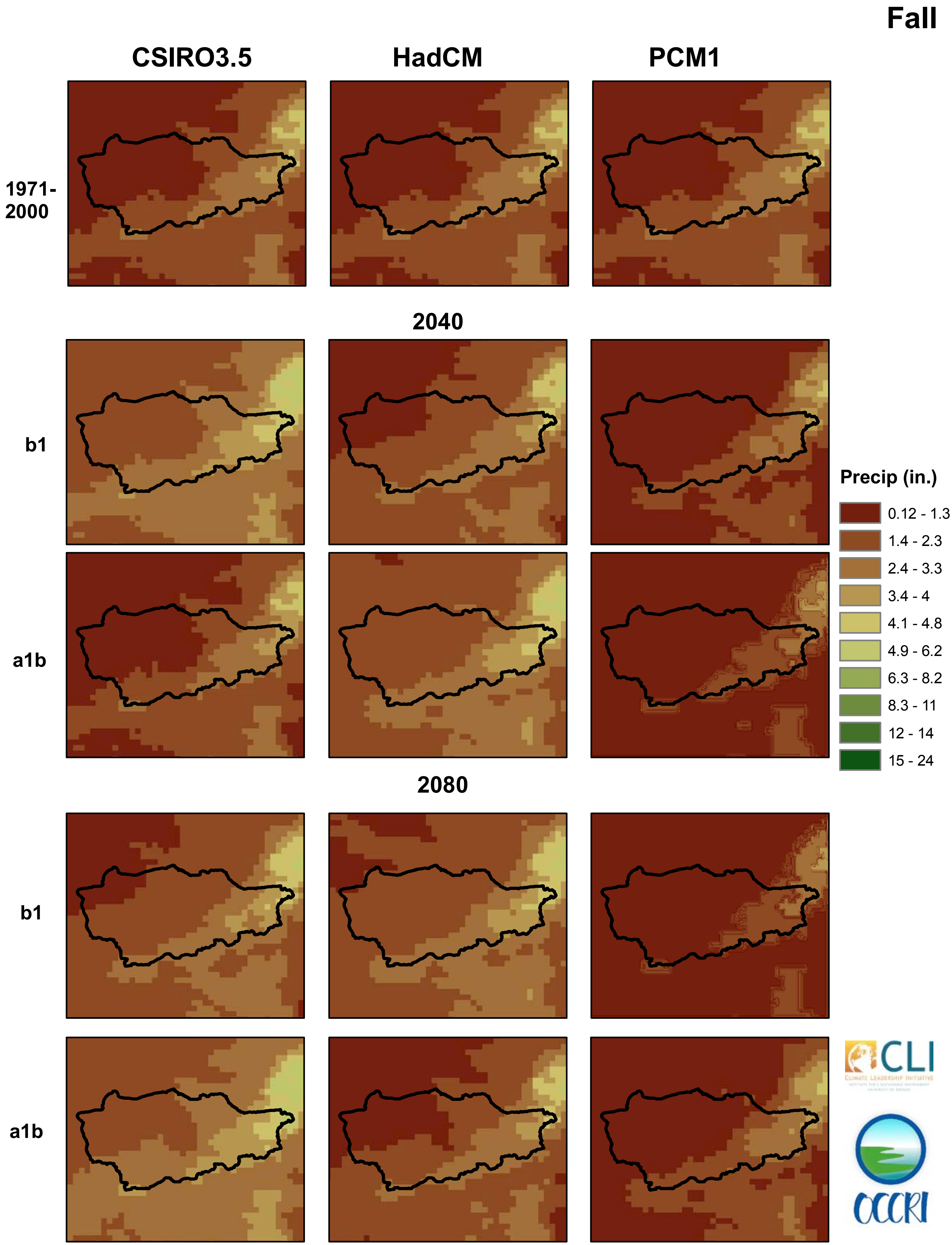
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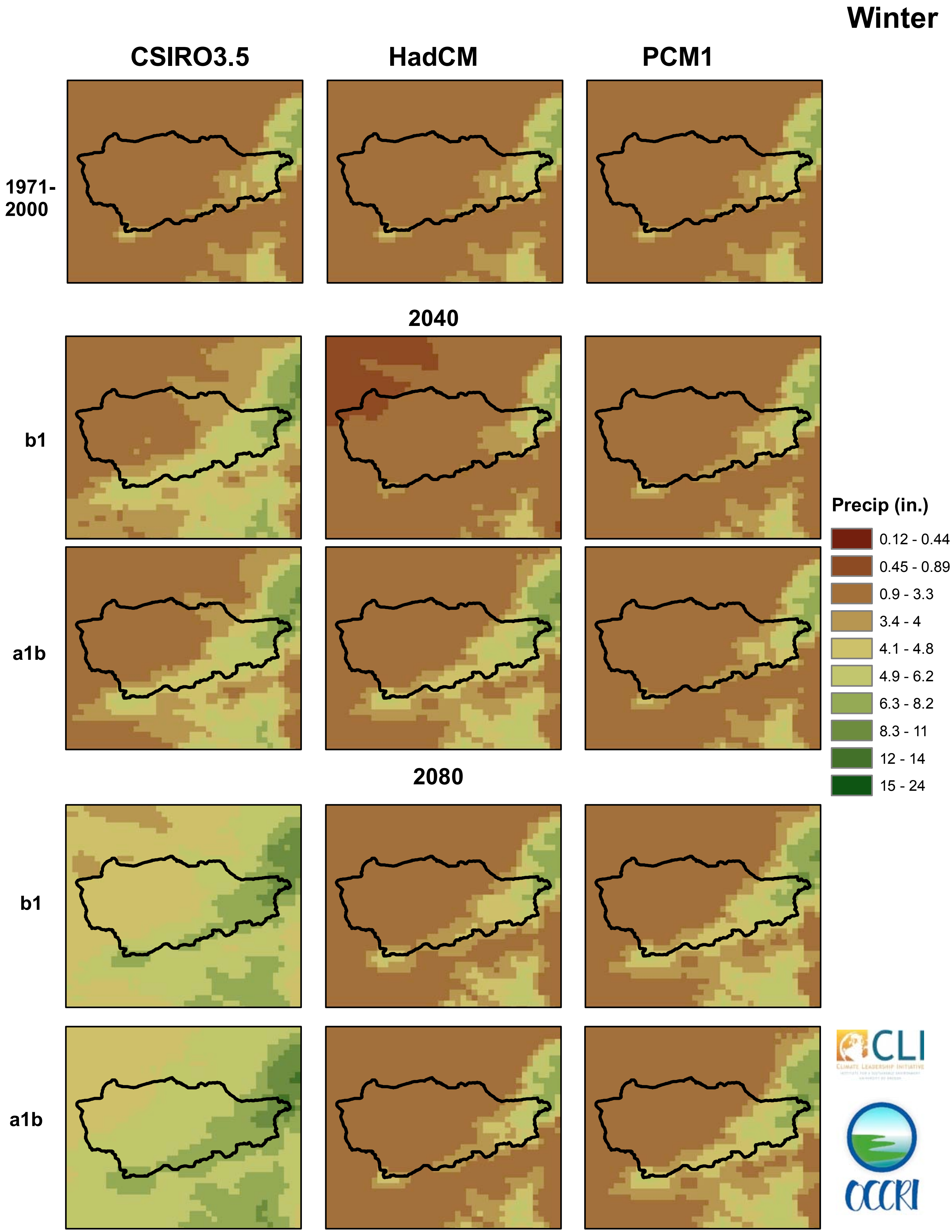
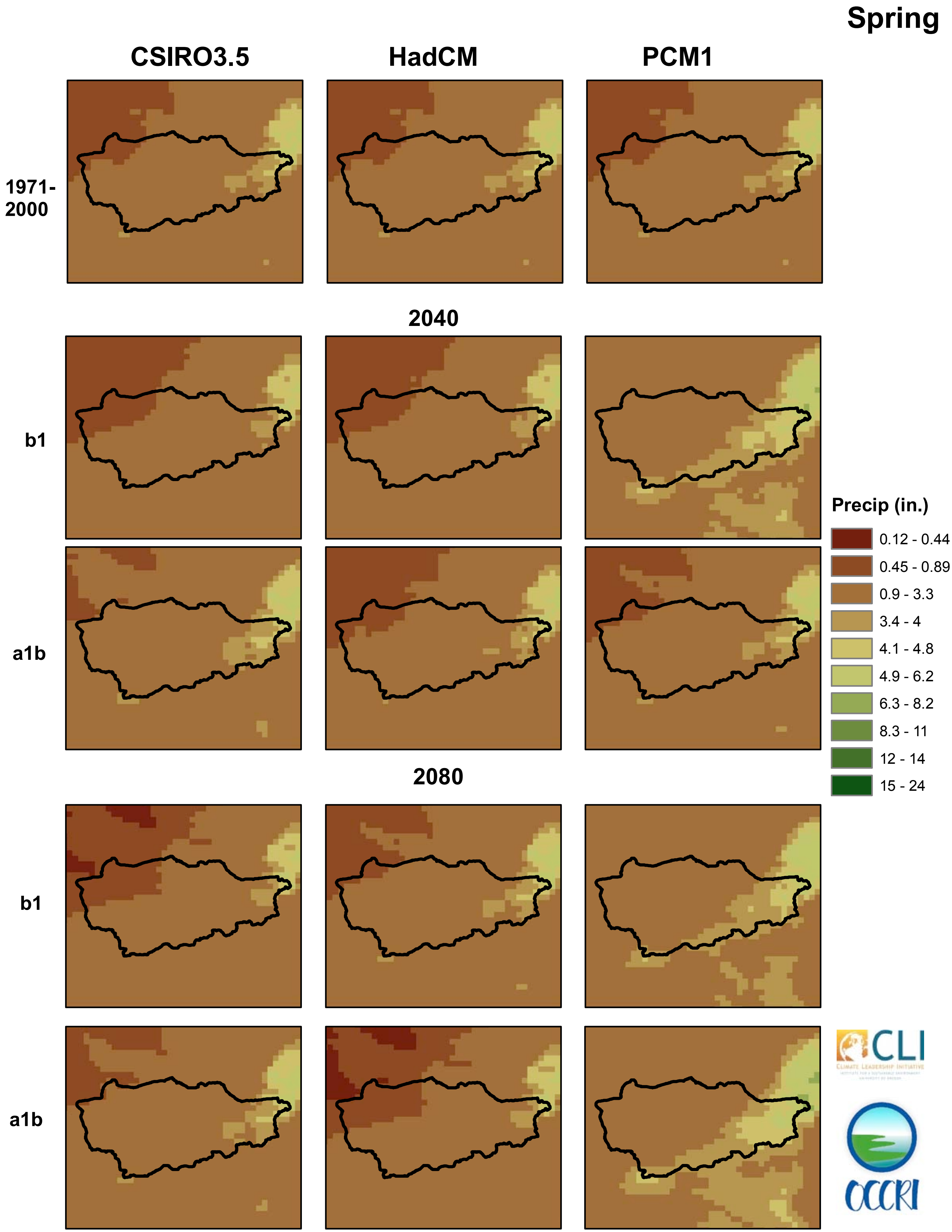
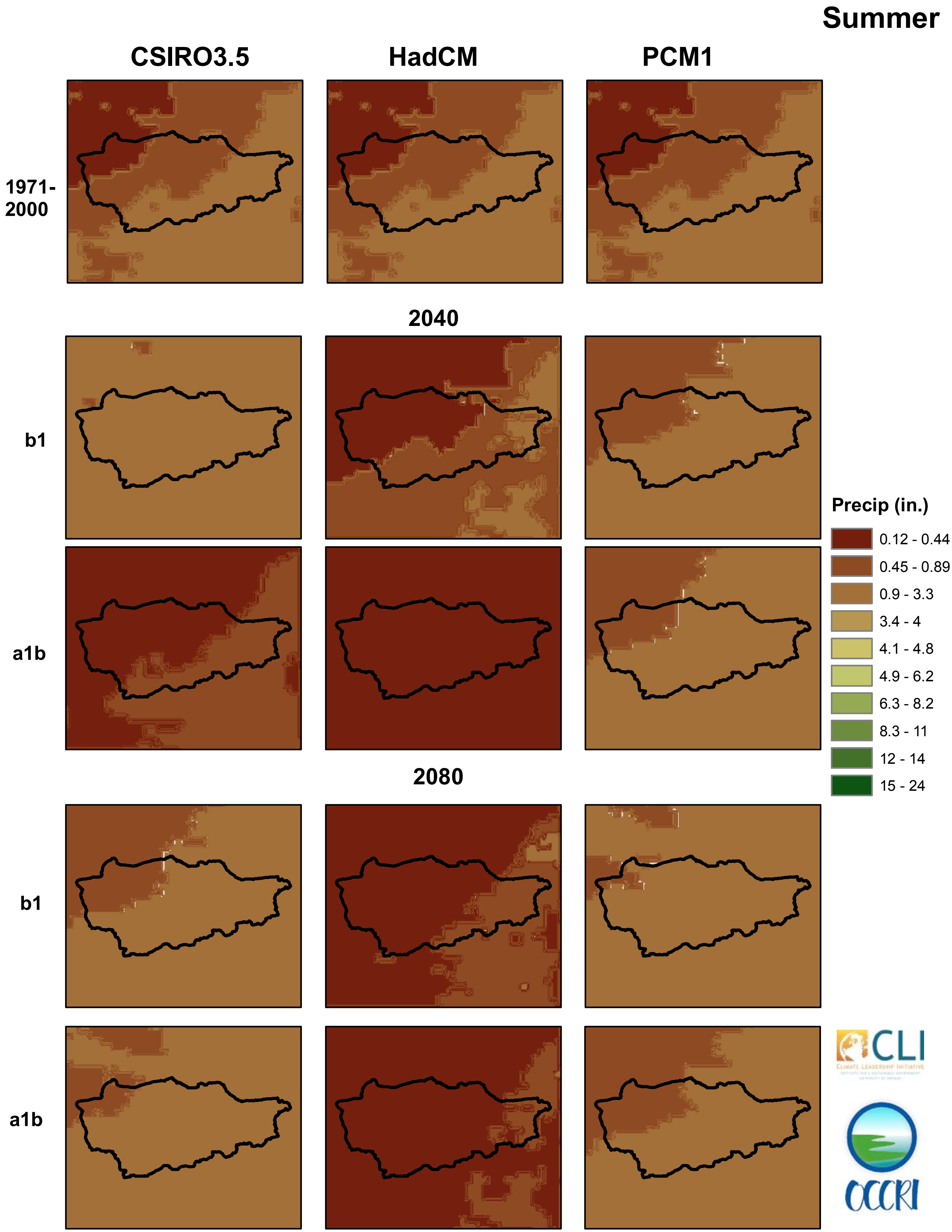
12 - 14
15 - 24

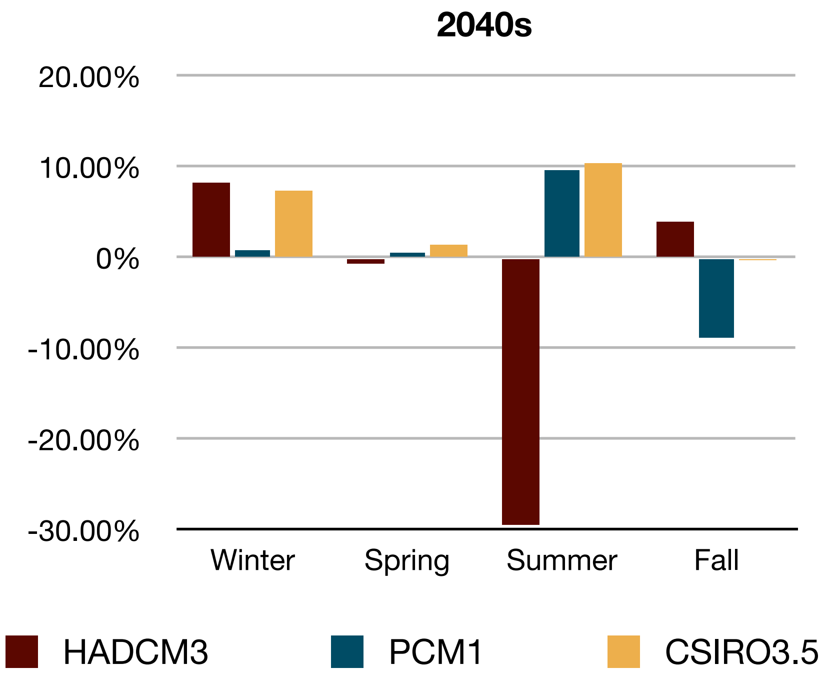


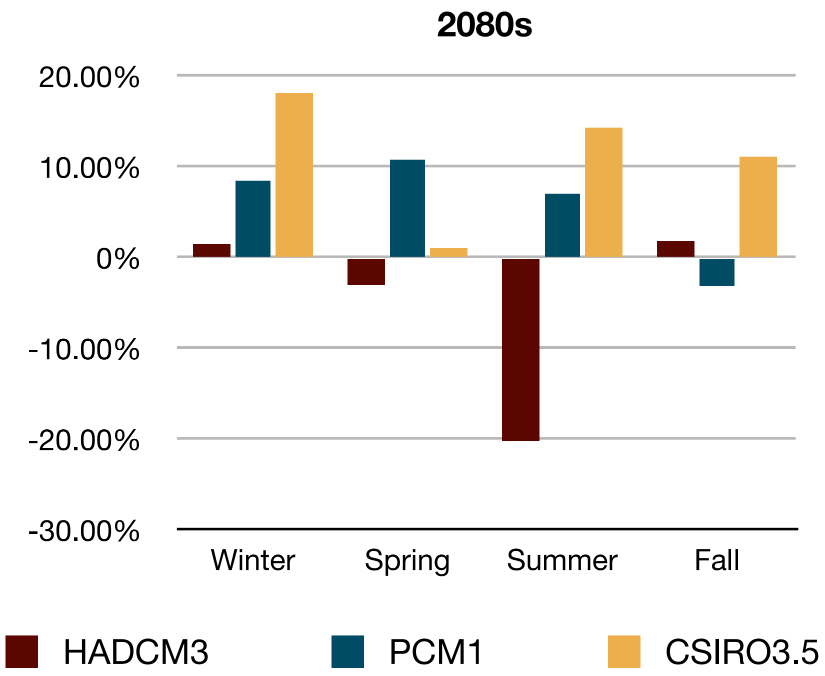
Winter
CSIRO3.5
HadCM
PCM1
1971-2000
2040
b1
a1b
2080
b1
a1b
Precip (in.)
0.12 - 0.44
0.45 - 0.89
0.9 - 3.3
3.4 - 4
4.1 - 4.8
4.9 - 6.2
6.3 - 8.2
8.3 - 11
12 - 14
15 - 24

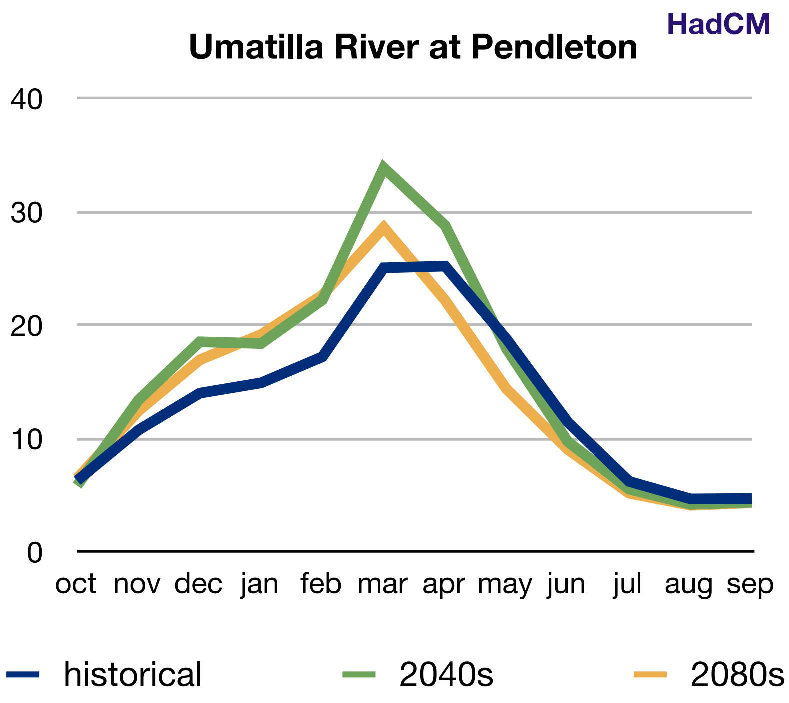

Spring
CSIRO3.5
HadCM
PCM1
1971-
2000
2040
b1
a1b
2080
b1
a1b
Precip (in.)
0.12 - 0.44
0.45 - 0.89
0.9 - 3.3
3.4 - 4
4.1 - 4.8
4.9 - 6.2
6.3 - 8.2
8.3 - 11
12 - 14
15 - 24

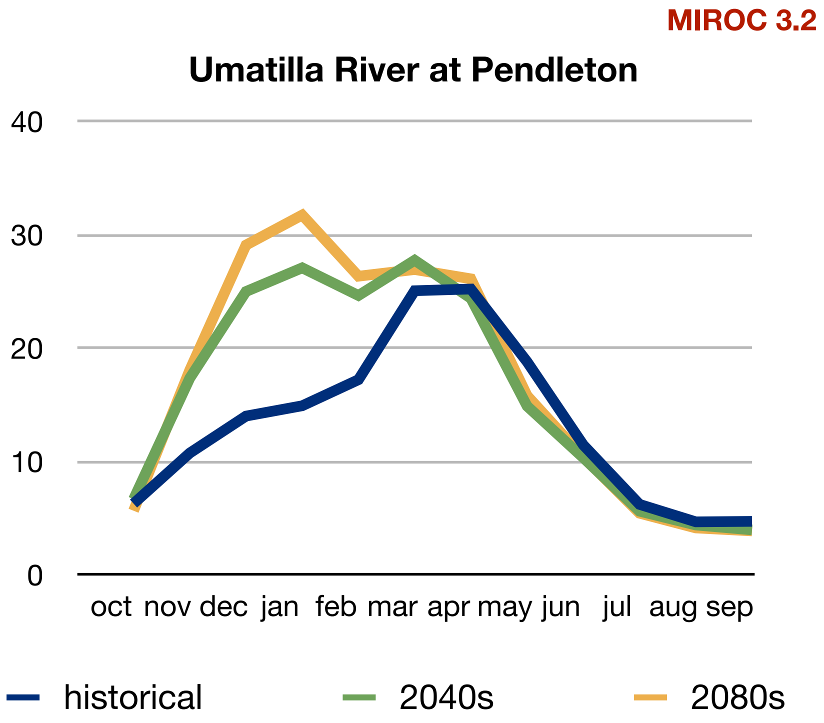


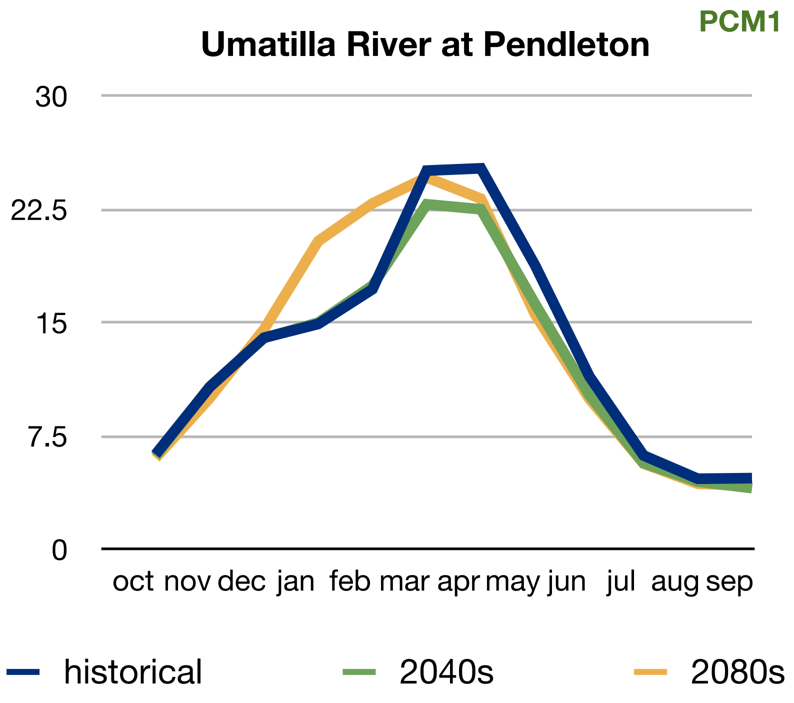
Summer
CSIRO3.5
HadCM
PCM1
1971-2000
2040
b1
a1b
2080
b1
a1b
Precip (in.)
0.12 - 0.44
0.45 - 0.89
0.9 - 3.3
3.4 - 4
4.1 - 4.8
4.9 - 6.2
6.3 - 8.2
8.3 - 11
12 - 14
15 - 24

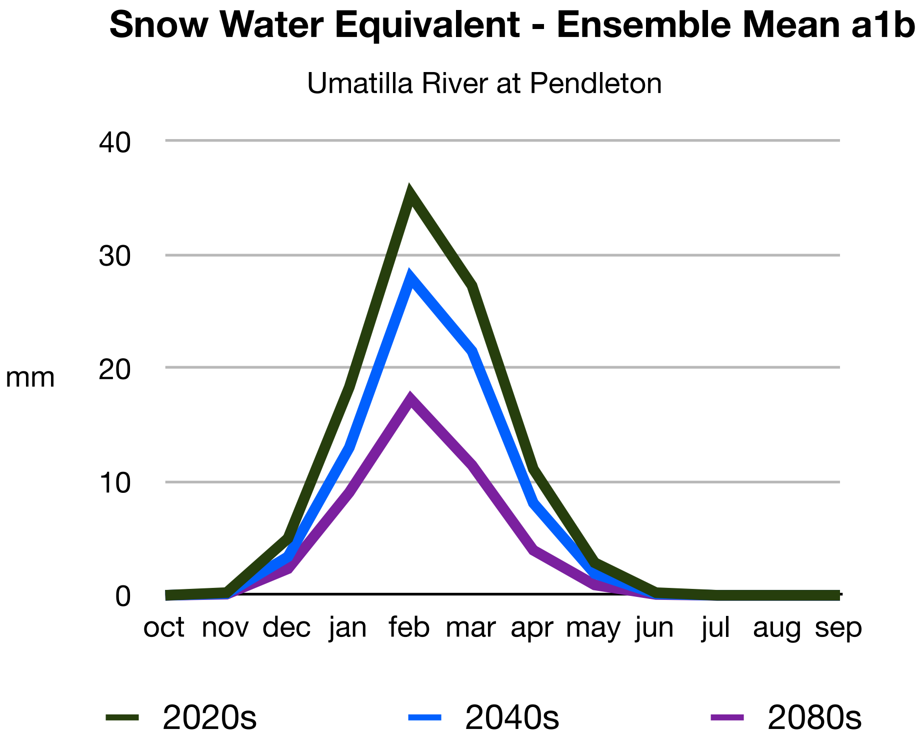

2040s
20.00%
10.00%
0%
-10.00%
-20.00%
-30.00%
Winter
Spring
Summer
Fall
HADCM3
PCM1
CSIRO3.5


2080s
20.00%
10.00%
0%
-10.00%
-20.00%
-30.00%
Winter
Spring
Summer
Fall
HADCM3
PCM1
CSIRO3.5

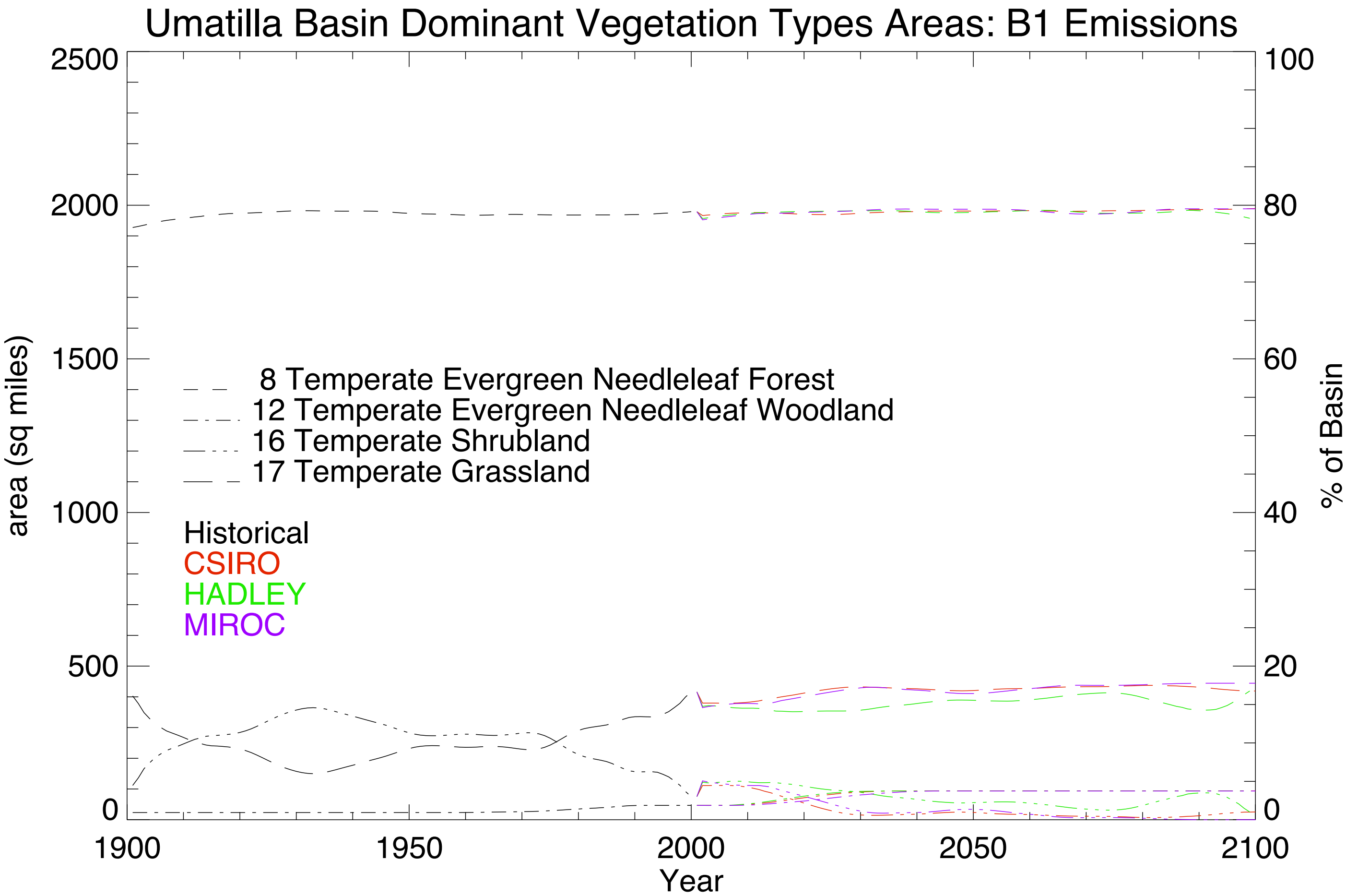

HadCM
Umatilla River at Pendleton
40
30
20
10
0
oct nov dec jan feb mar apr may jun jul aug sep
historical
2040s
2080s

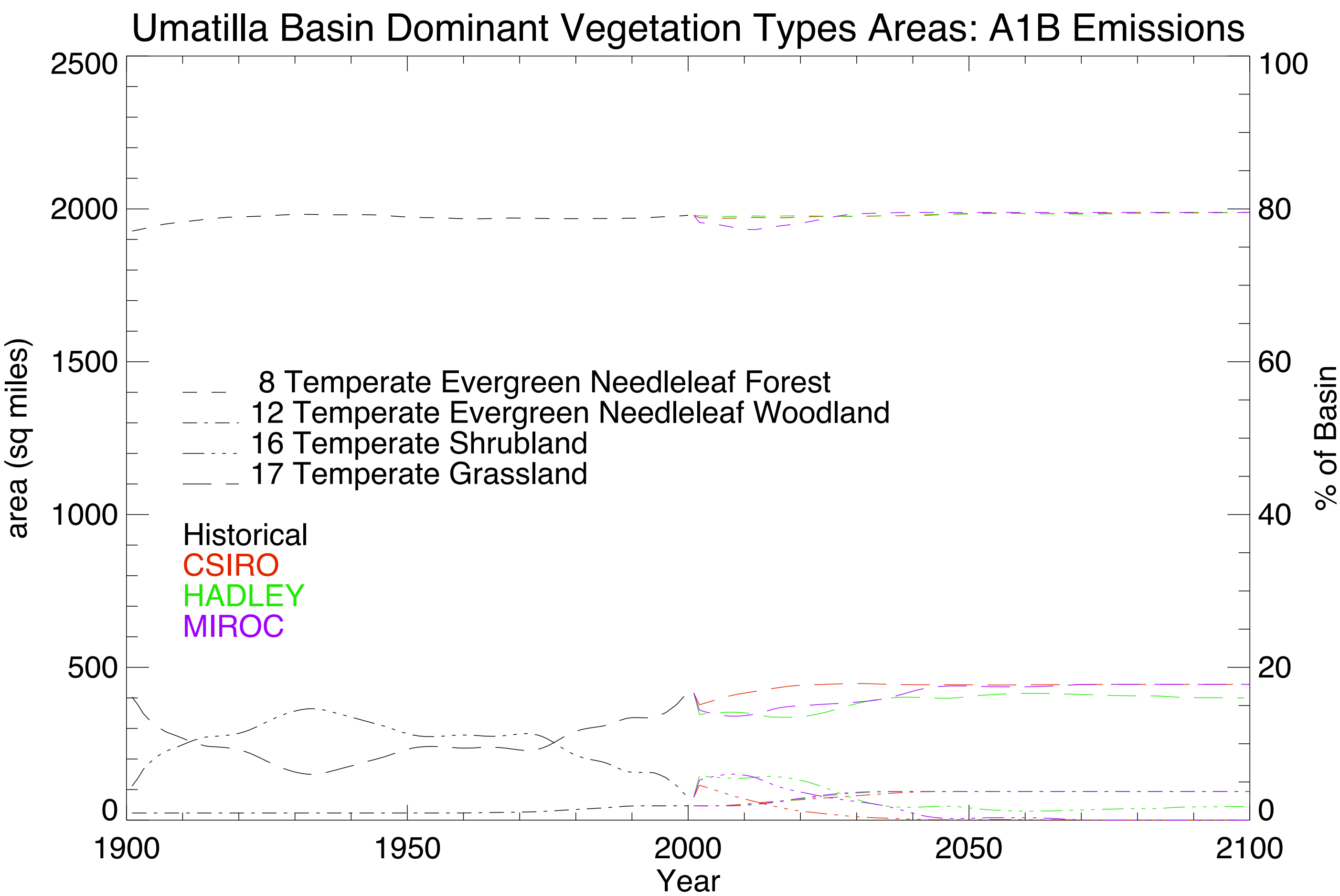

MIROC 3.2
Umatilla River at Pendleton
40
30
20
10
0
oct nov dec jan feb mar apr may jun jul aug sep
historical
2040s
2080s

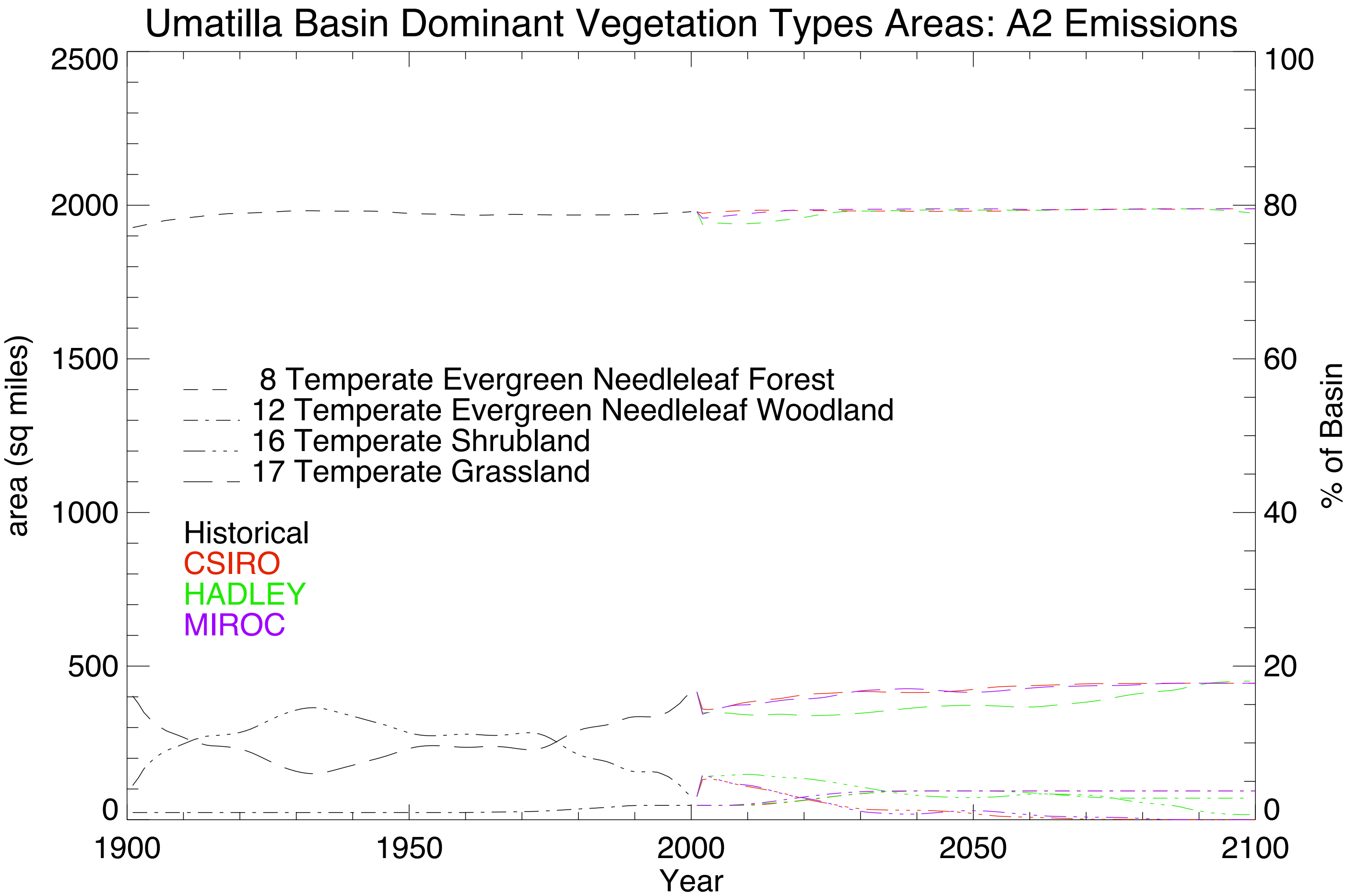

PCM1
Umatilla River at Pendleton
30
22.5
15
7.5
0
oct nov dec jan feb mar apr may jun jul aug sep
historical
2040s
2080s

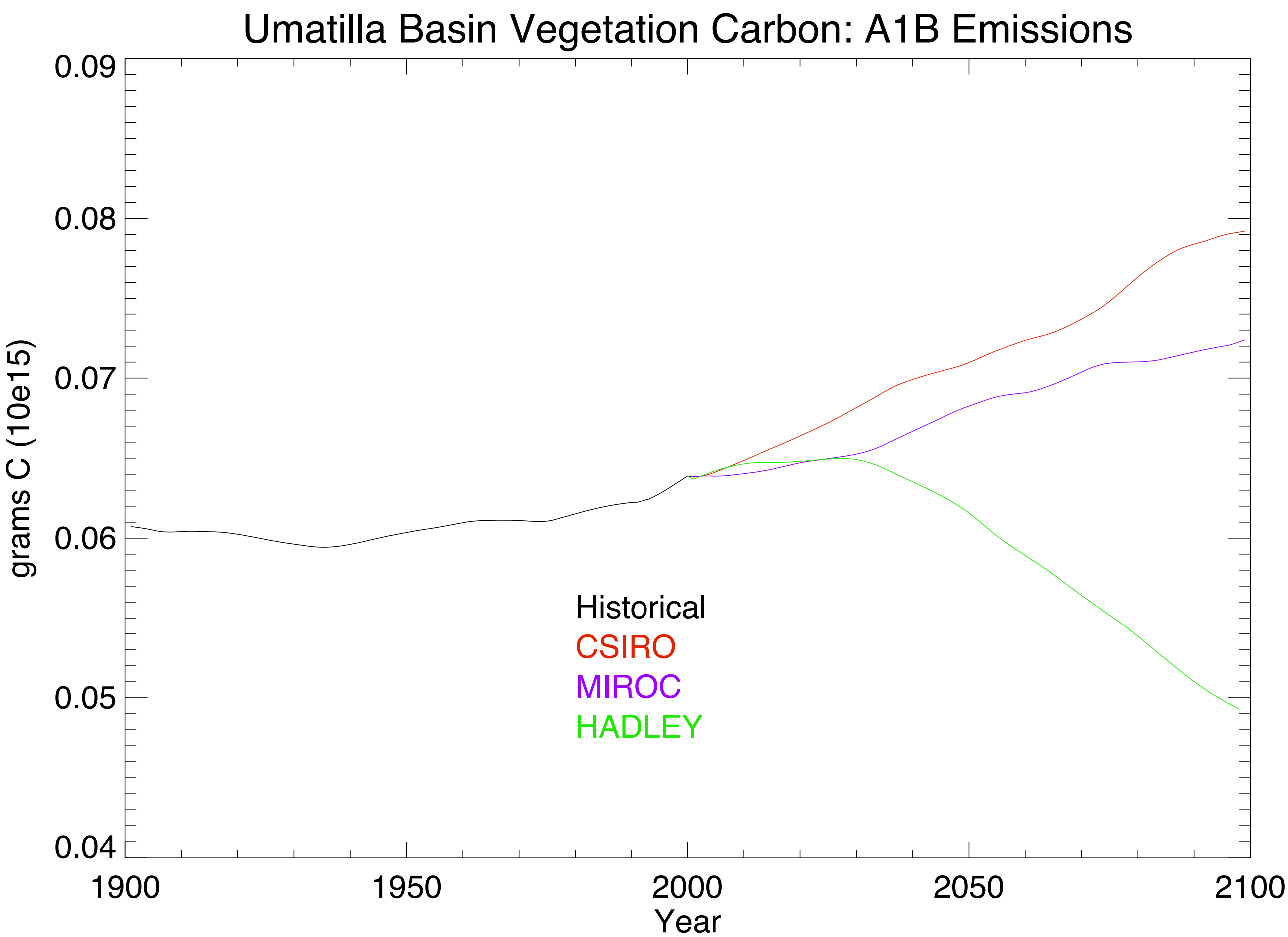


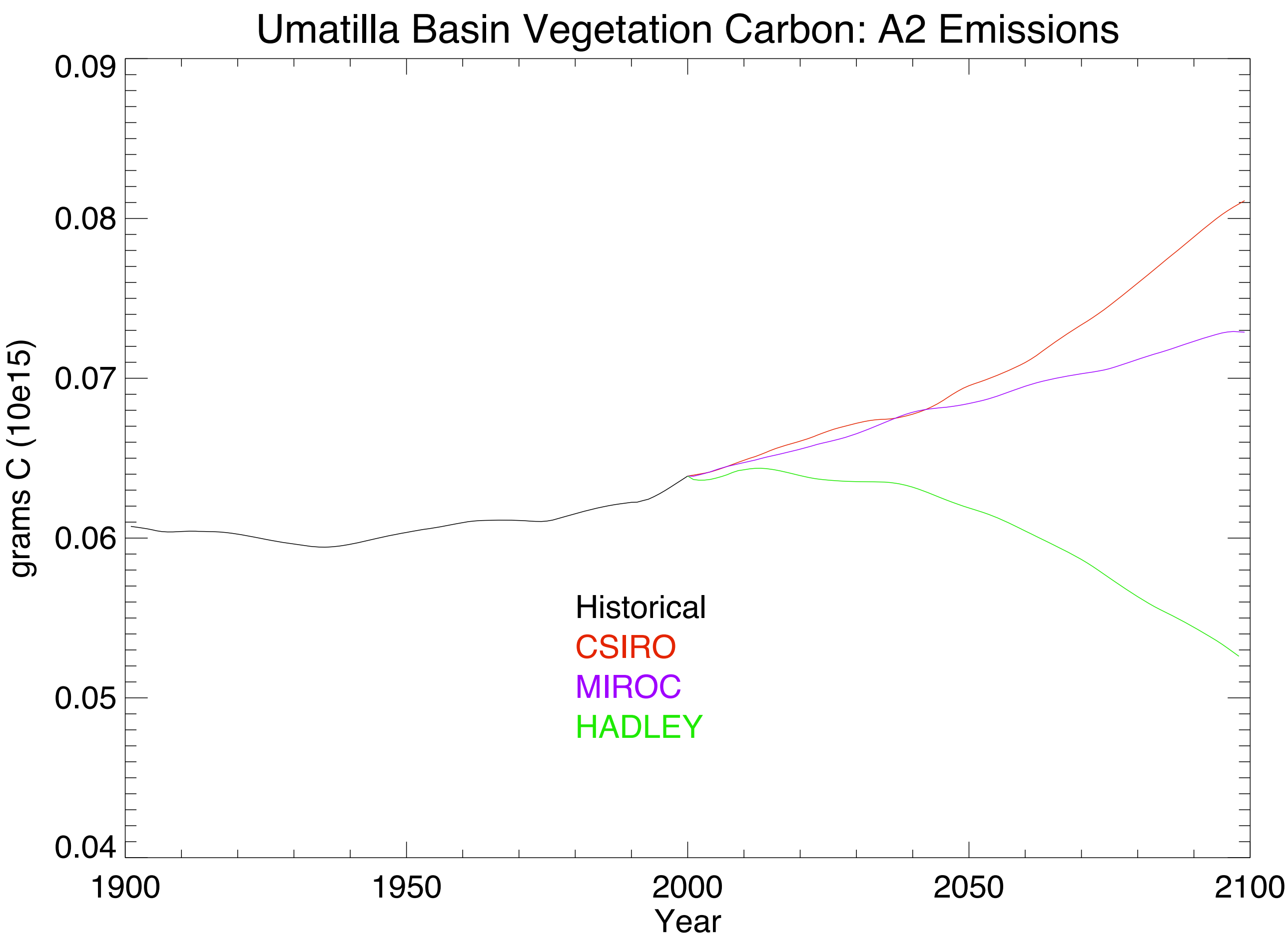
Snow Water Equivalent - Ensemble Mean a1b
Umatilla River at Pendleton
mm
40
30
20
10
0
oct
nov
dec
jan
feb
mar
apr
may
jun
jul
aug
sep
2020s
2040s
2080s

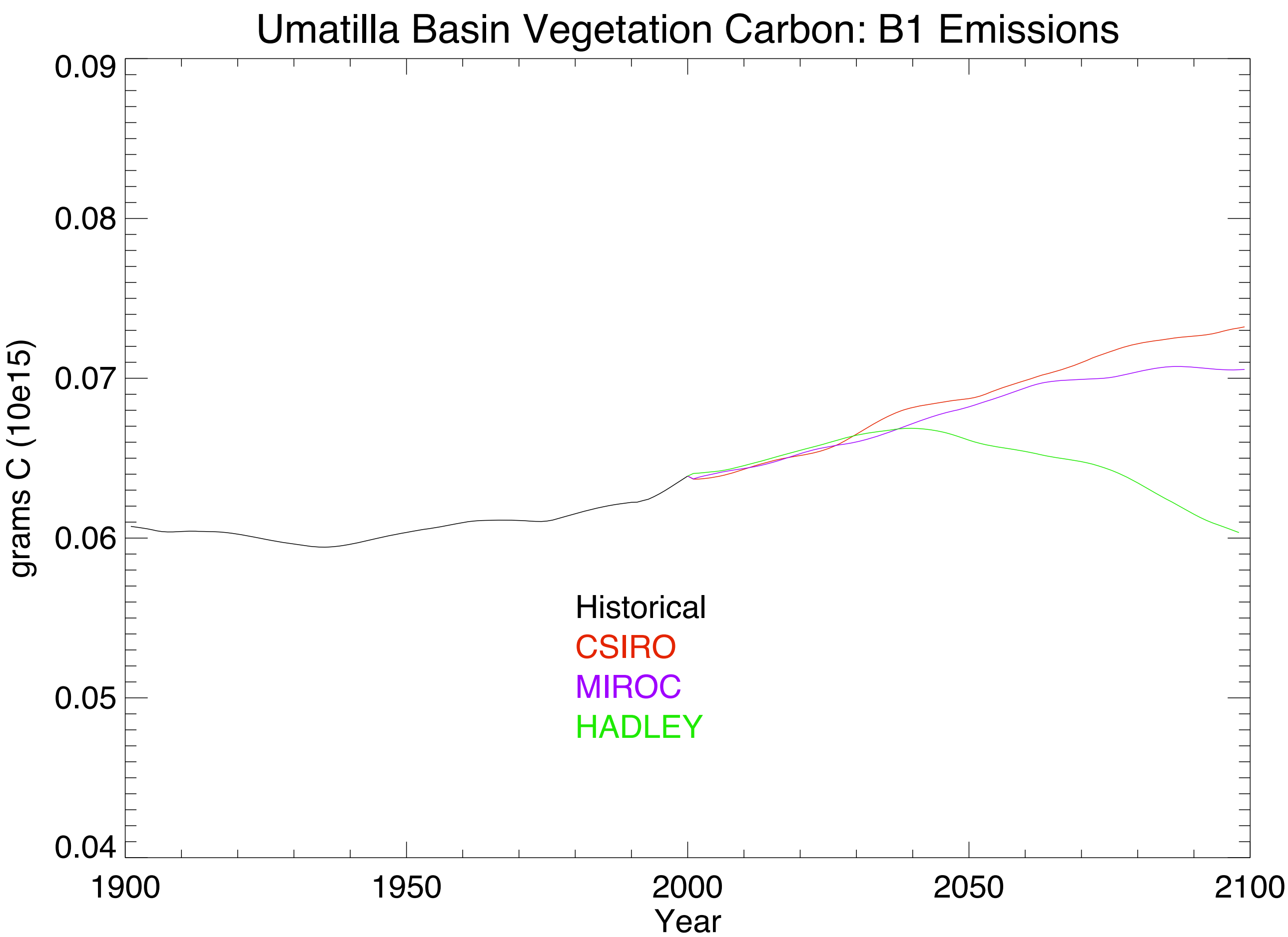

Umatilla Basin Dominant Vegetation Types Areas: B1 Emissions
area (sq miles)
% of Basin
Year
2500
2000
1500
1000
500
0
100
80
60
40
20
0
1900
1950
2000
2050
2100
8 Temperate Evergreen Needleleaf Forest
12 Temperate Evergreen Needleleaf Woodland
16 Temperate Shrubland
17 Temperate Grassland
Historical
CSIRO
HADLEY
MIROC


Umatilla Basin Dominant Vegetation Types Areas: A1B Emissions
area (sq miles)
% of Basin
Year
8 Temperate Evergreen Needleleaf Forest
12 Temperate Evergreen Needleleaf Woodland
16 Temperate Shrubland
17 Temperate Grassland
Historical
CSIRO
HADLEY
MIROC
2500
2000
1500
1000
500
0
100
80
60
40
20
0
1900
1950
2000
2050
2100

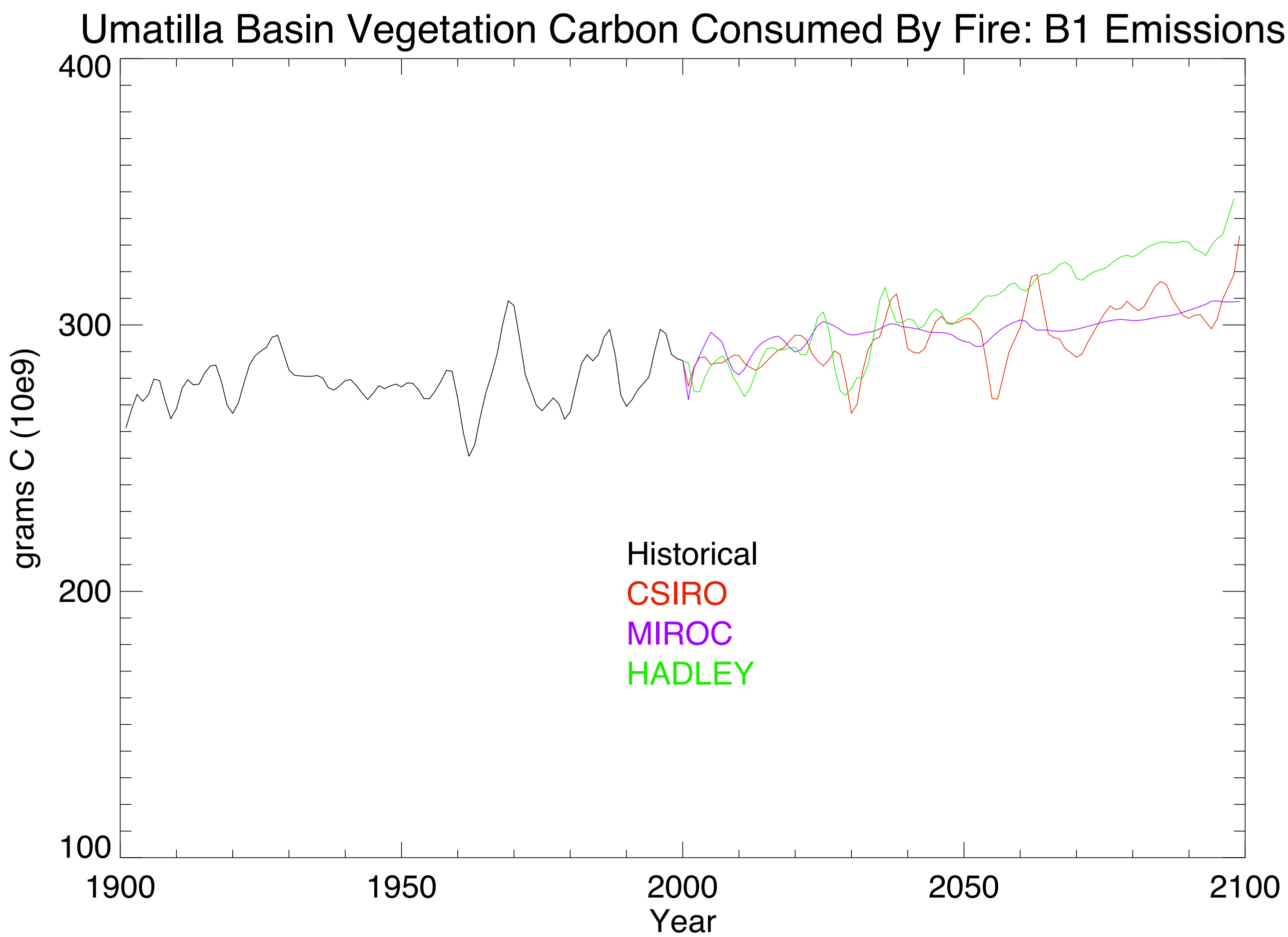

Umatilla Basin Dominant Vegetation Types Areas: A2 Emissions
area (sq miles)
% of Basin
Year
8 Temperate Evergreen Needleleaf Forest
12 Temperate Evergreen Needleleaf Woodland
16 Temperate Shrubland
17 Temperate Grassland
Historical
CSIRO
HADLEY
MIROC
0
500
1000
1500
2000
2500
0
20
40
60
80
100
1900
1950
2000
2050
2100


Umatilla Basin Vegetation Carbon: A1B Emissions
0.09
0.08
0.07
0.06
0.05
0.04
grams C (10e15)
1900
1950
2000
2050
2100
Year
Historical
CSIRO
MIROC
HADLEY

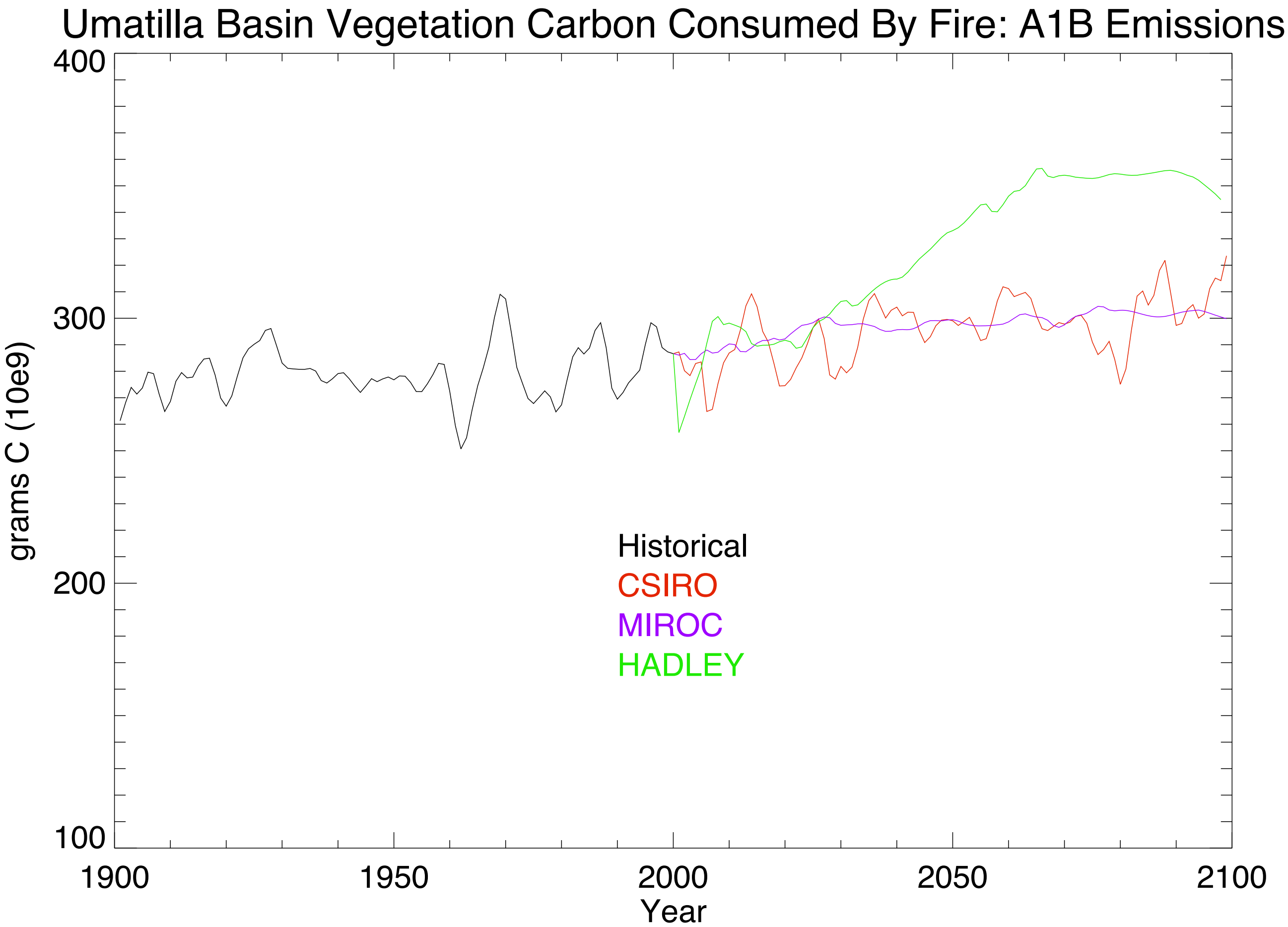

Umatilla Basin Vegetation Carbon: A2 Emissions
0.09
0.08
0.07
0.06
0.05
0.04
grams C (10e15)
1900
1950
2000
2050
2100
Year
Historical
CSIRO
MIROC
HADLEY



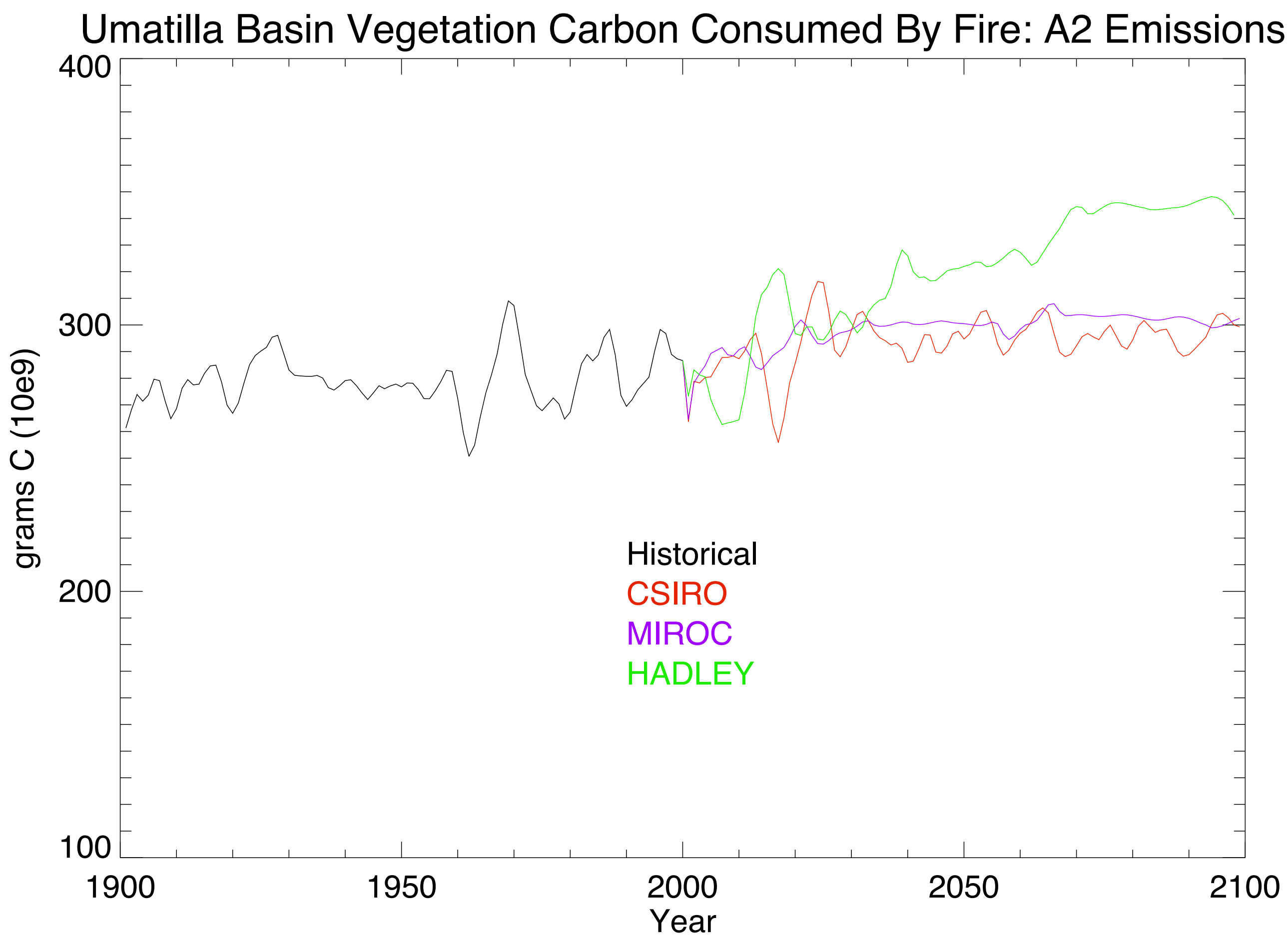
Umatilla Basin Vegetation Carbon: B1 Emissions
grams C (10e15)
0.09
0.08
0.07
0.06
0.05
0.04
1900
1950
2000
2050
2100
Year
Historical
CSIRO
MIROC
HADLEY

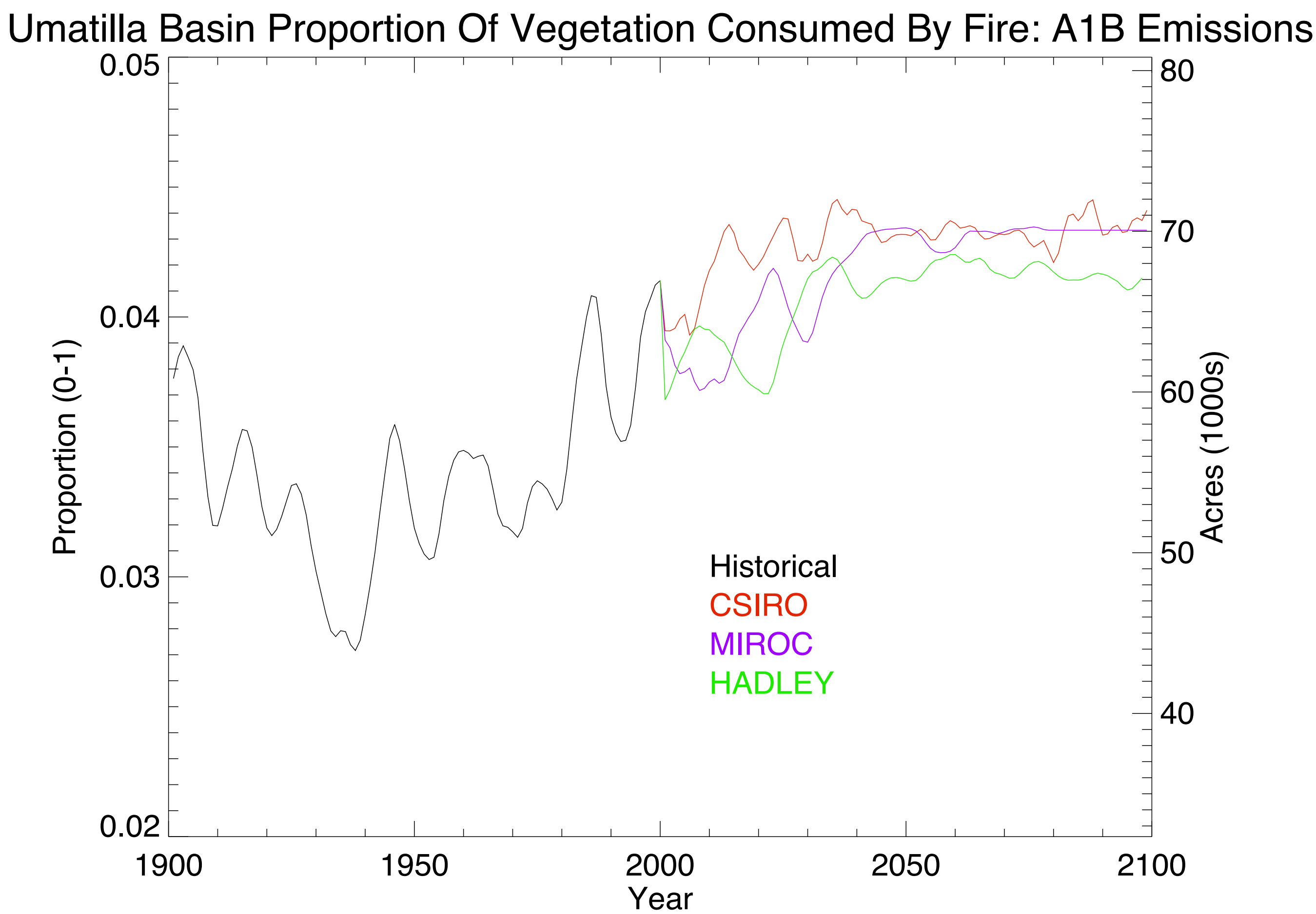


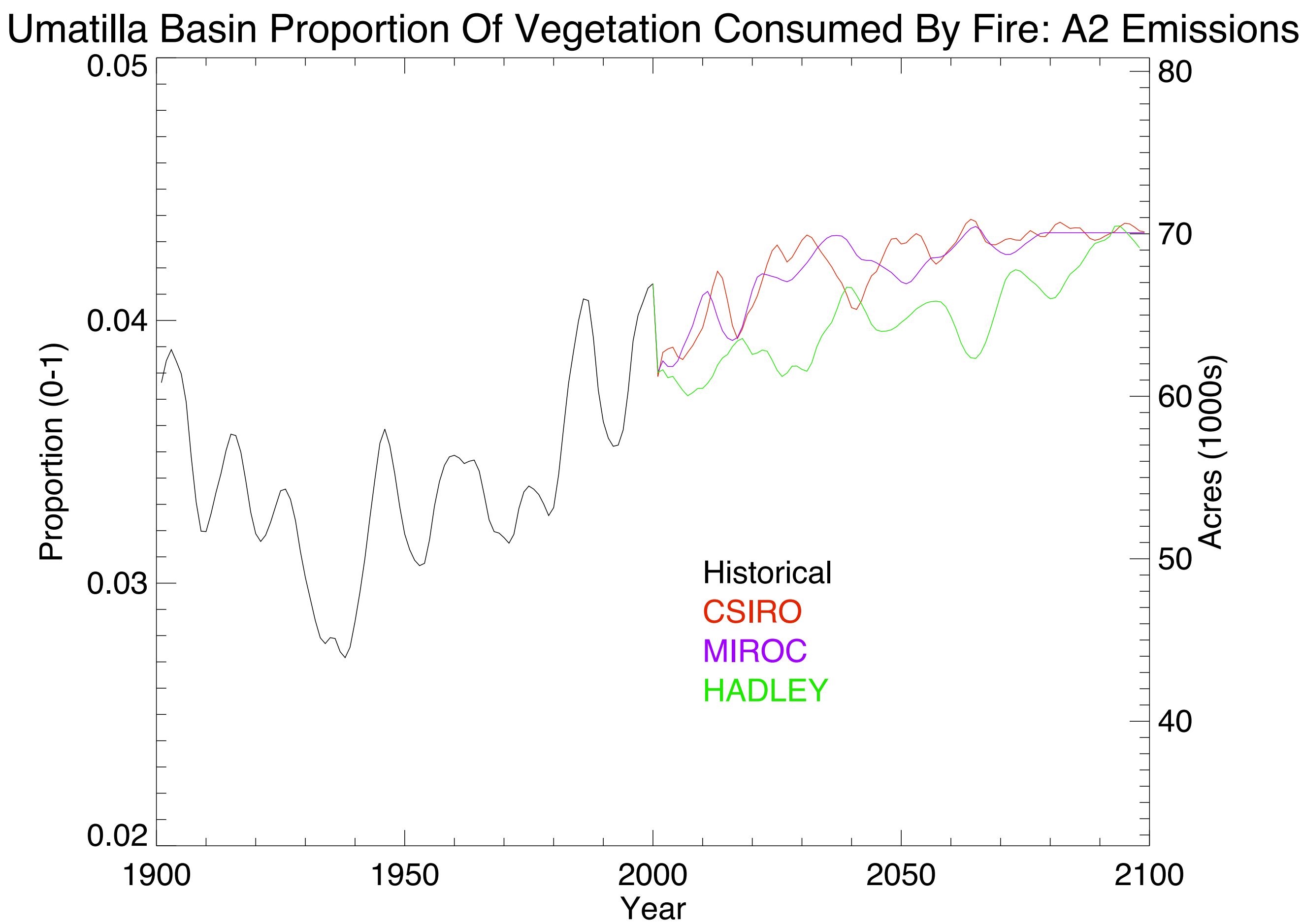
Umatilla Basin Vegetation Carbon Consumed By Fire: B1 Emissions
grams C (10e9)
400
300
200
100
1900
1950
2000
2050
2100
Year
Historical
CSIRO
MIROC
HADLEY



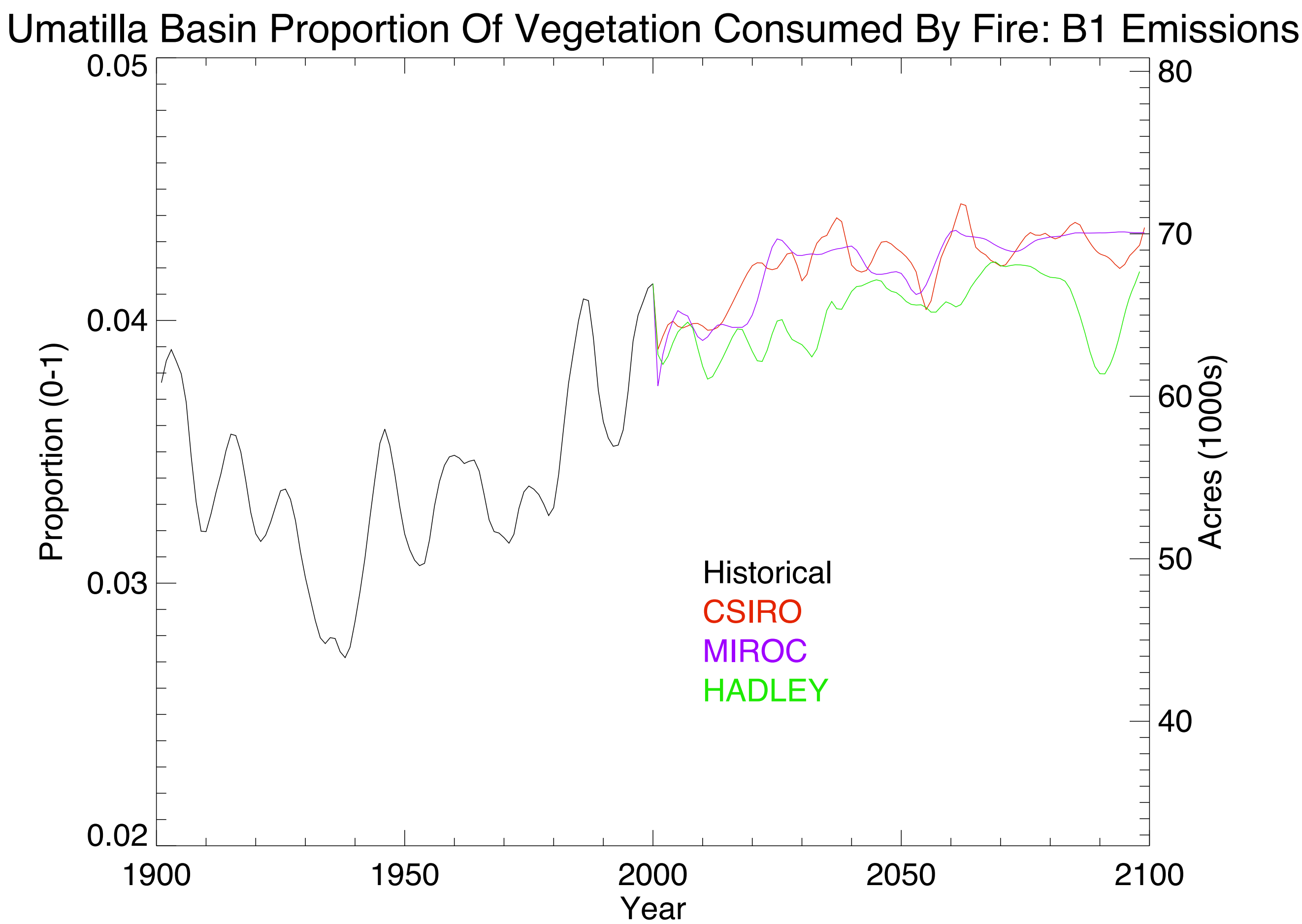
Umatilla Basin Vegetation Carbon Consumed By Fire: A1B Emissions
grams C (10e9)
400
300
200
100
1900
1950
2000
2050
2100
Year
Historical
CSIRO
MIROC
HADLEY

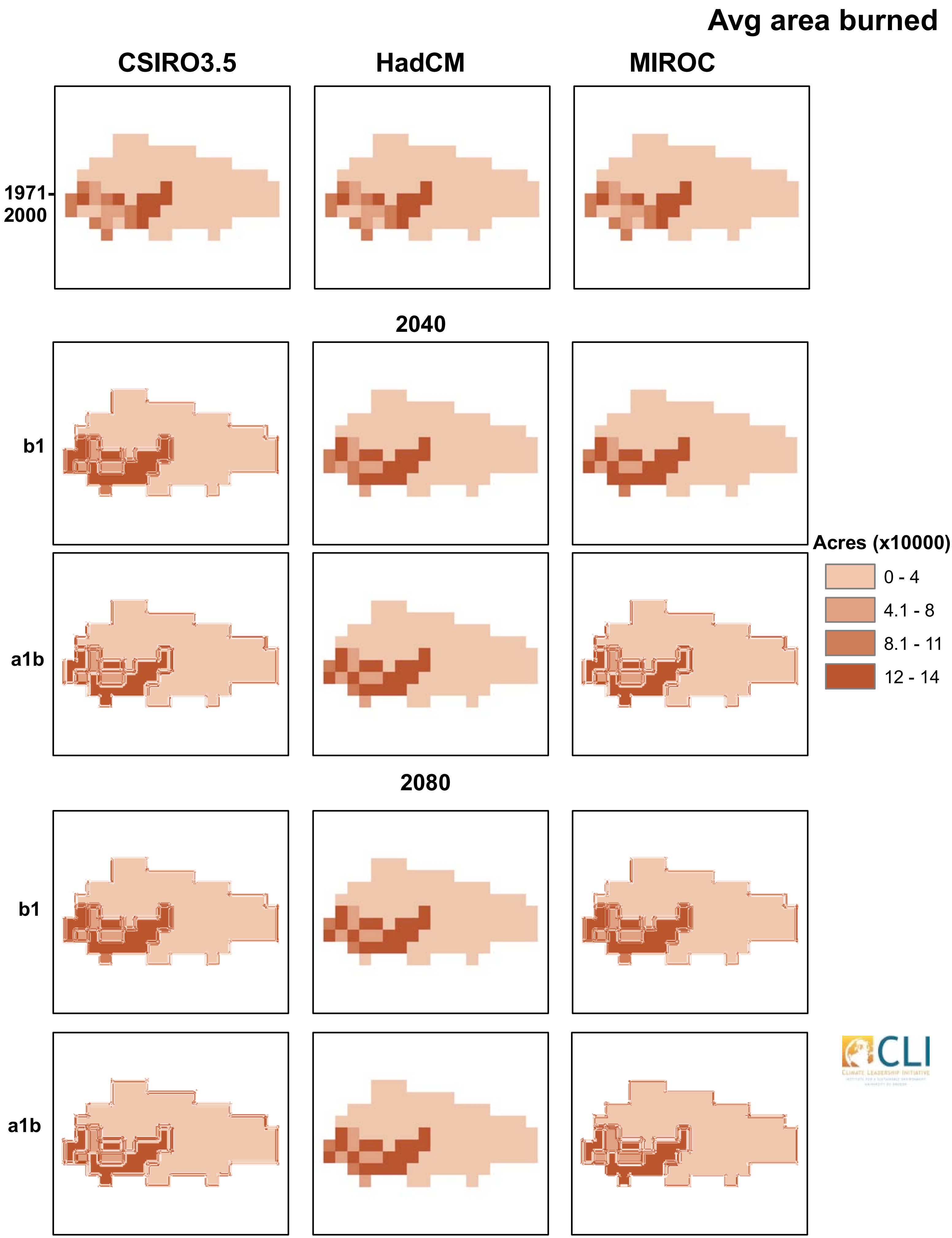

Umatilla Basin Vegetation Carbon Consumed By Fire: A2 Emissions
grams C (10e9)
400
300
200
100
1900
1950
2000
2050
2100
Year
Historical
CSIRO
MIROC
HADLEY


Umatilla Basin Proportion Of Vegetation Consumed By Fire: A1B Emissions
Proportion (0-1)
0.05
0.04
0.03
0.02
Acres (1000s)
80
70
60
50
40
1900
1950
2000
2050
2100
Year
Historical
CSIRO
MIROC
HADLEY



Umatilla Basin Proportion Of Vegetation Consumed By Fire: A2 Emissions
Proportion (0-1)
0.05
0.04
0.03
0.02
Acres (1000s)
80
70
60
50
40
1900
1950
2000
2050
2100
Year
Historical
CSIRO
MIROC
HADLEY


Umatilla Basin Proportion Of Vegetation Consumed By Fire: B1 Emissions
Proportion (0-1)
0.05
0.04
0.03
0.02
Acres (1000s)
80
70
60
50
40
1900
1950
2000
2050
2100
Year
Historical
CSIRO
MIROC
HADLEY



Avg area burned
CSIRO3.5
HadCM
MIROC
1971-
2000
2040
b1
a1b
2080
b1
a1b
Acres (x10000)
0 - 4
4.1 - 8
8.1 - 11
12 - 14