Cedar River Council
North Bend, WA
June 27, 2016

Partial draft of SPU's Climate Change Analysis

Seattle Public Utilities

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Outline

- background and context
- Seattle's PUMA project
- projected climate impacts on:
  - snowpack
  - hydrology
  - yield
- effects of two potential adaptation approaches
- next steps

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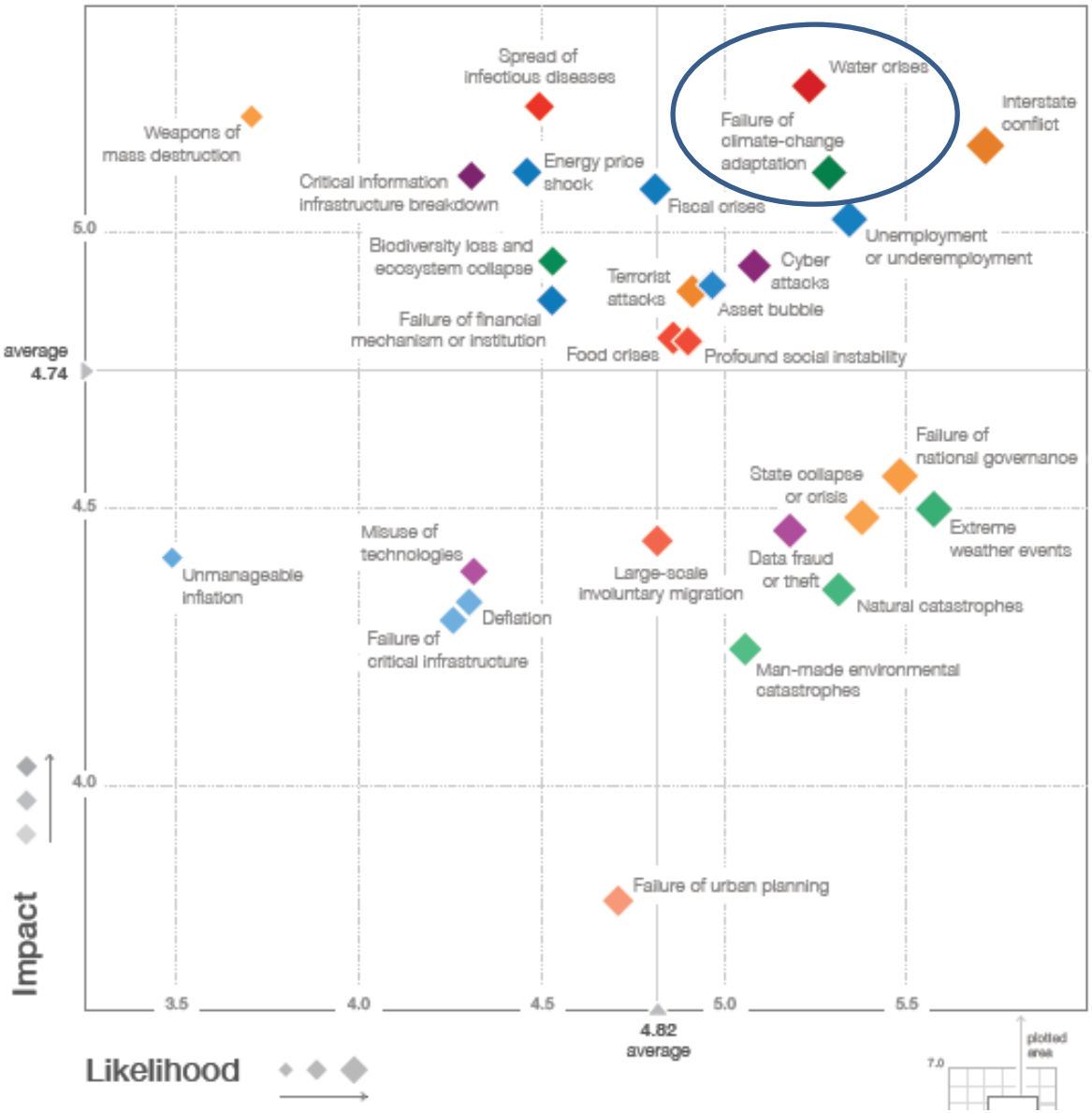
Figure 1: The Global Risks Landscape 2015



http://www.weforum.org/reports/global-risks-report-2015

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U.S. National Climate Assessment

Adaptation and Institutional Responses

Key Message 10: Water Resources Management

In most U.S. regions, water resources managers and planners will encounter new risks, vulnerabilities, and opportunities that may not be properly managed within existing practices.

Climate Change Impacts in the United States

CHAPTER 3
WATER RESOURCES

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On the Web: http://nca2014.globalchange.gov/report/sectors/water

INFORMATION DRAWN FROM THIS CHAPTER IS INCLUDED IN THE HIGHLIGHTS REPORT AND IS IDENTIFIED BY THIS ICON

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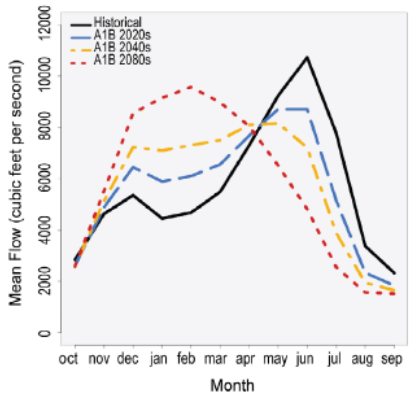
National Climate Assessment

Key Message 1: Water-related Challenges

Changes in the timing of streamflow related to changing snowmelt have been observed and will continue, reducing the supply of water for many competing demands and causing far-reaching ecological and socioeconomic consequences.

Future Shift in Timing of Stream Flows



Reduced Summer Flows

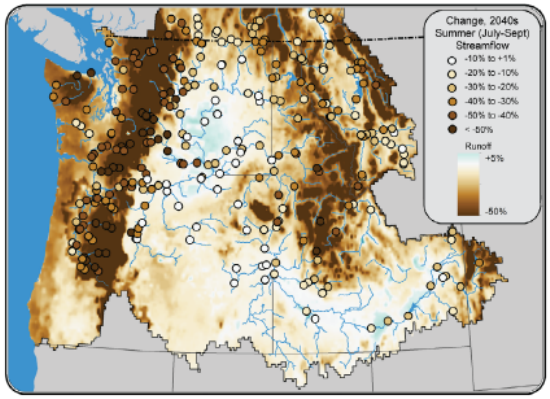


Figure 21.2. (Left) Projected increased winter flows and decreased summer flows in many Northwest rivers will cause widespread impacts. Mixed rain-snow watersheds, such as the Yakima River basin, an important agricultural area in eastern Washington, will see increased winter flows, earlier spring peak flows, and decreased summer flows in a warming climate. Changes in average monthly streamflow by the 2020s, 2040s, and 2080s (as compared to the period 1916 to 2006) indicate that the Yakima River basin could change from a snow-dominant to a rain-dominant basin by the 2080s under the A1B emissions scenario (with eventual reductions from current rising emissions trends). (Figure source: adapted from Elsner et al. 2010)[24].

(Right) Natural surface water availability during the already dry late summer period is projected to decrease across most of the Northwest. The map shows projected changes in local runoff (shading) and streamflow (colored circles) for the 2040s (compared to the period 1915 to 2006) under the same scenario as the left figure (A1B).[29] Streamflow reductions such as these would stress freshwater fish species (for instance, endangered salmon and bull trout) and necessitate increasing tradeoffs among conflicting uses of summer water. Watersheds with significant groundwater contributions to summer streamflow may be less responsive to climate change than indicated here.[26]

On the Web: http://nca2014.globalchange.gov/report/regions/northwest

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WUCA
Water Utility Climate Alliance

<u>Mission</u>: The Water Utility Climate Alliances provides leadership in assessing and adapting to the potential effects of climate change through collaborative action. We seek to enhance the ***usefulness of climate science*** *for the adaptation community and improve water management* ***decision-making in the face of climate uncertainty.***

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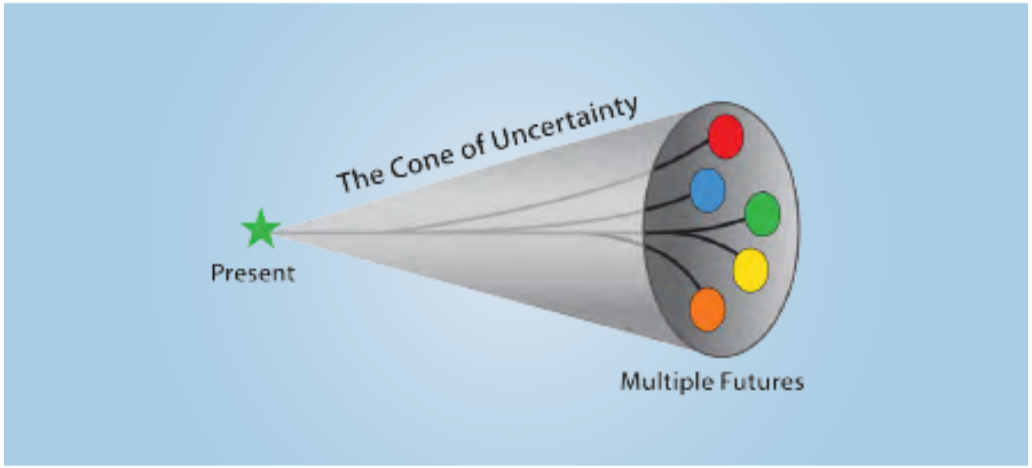
EMBRACING UNCERTAINTY

A Case Study Examination of How Climate Change is Shifting Water Utility Planning



Prepared for:

Water Utility Climate Alliance (WUCA)
American Water Works Association (AWWA)
Water Research Foundation (WRF)
Association of Metropolitan Water Agencies (AMWA)

Project Manager: Laurna Kaatz, Denver Water

WUCA
American Water Works Association
Water Research Foundation
ASSOCIATION OF METROPOLITAN WATER AGENCIES

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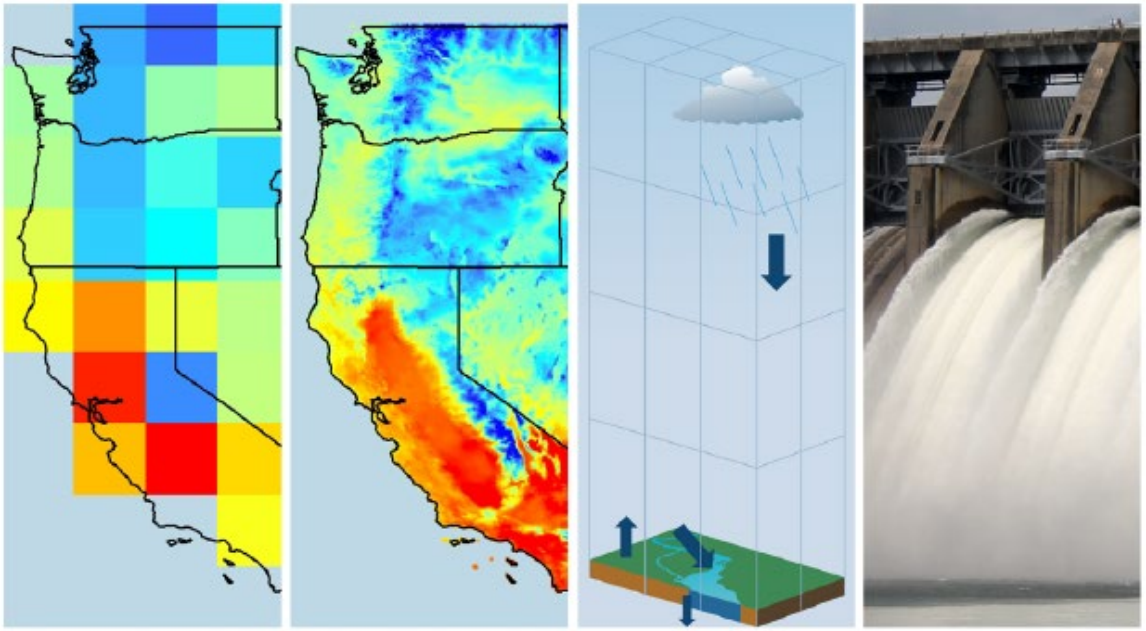
ACTIONABLE SCIENCE IN PRACTICE

Co-producing Climate Change Information for Water Utility Vulnerability Assessments



WUCA
Water Utility Climate Alliance

Final Report of the Piloting Utility Modeling Applications (PUMA) Project

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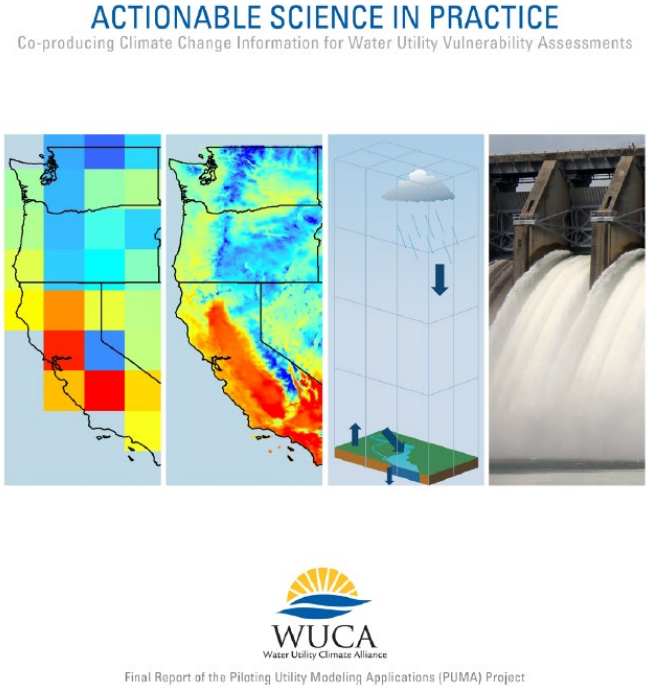
What is PUMA?

- **P**iloting **U**tility **M**odeling **A**pplications
  - "An effort to (co)-produce actionable science through close collaboration between climate experts and utility personnel to meet the needs of four water utilities."
  - "…four WUCA utilities agreed to forge partnerships with scientific institutions to explore how to integrate climate considerations into their specific management context."
- NYC, Portland, Tampa Bay, Seattle
- WUCA funded the white paper that documents the PUMA activities of the four



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What is PUMA (cont'd)?

- SPU partnered with CIRC – Climate Impacts Research Consortium
- Multi-year study
- Opportunity to use new science to update impacts assessment
  - obtained met data for 40 climate scenarios at 16 locations in the region
  - expand focus to examine: AR's, ENSO, timing of fall rains, fire, changes in thresholds
- Foster collaboration with researchers and utilities

CIRC
Climate Impacts Research Consortium
A NOAA RISA TEAM

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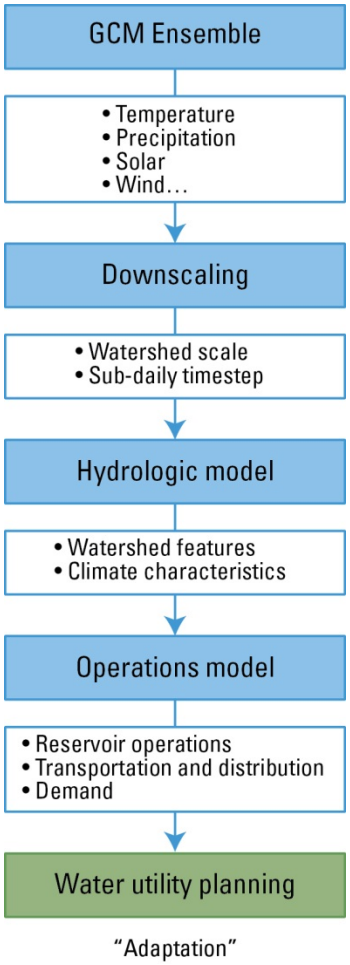
Assessing climate impacts: the chain of models approach



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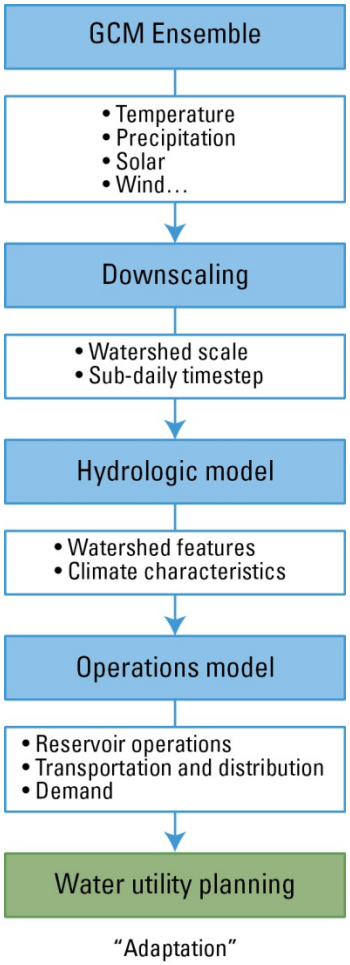
SPU's evolving institutional capacity: co-production and the chain of models

Researchers role in chain of models

PUMA:
researchers "manage" 2links in chain of models

2007 Study:
researchers "manage" 3 links in chain of models

2002 Study:
researchers "manage" 4 links in chain of models

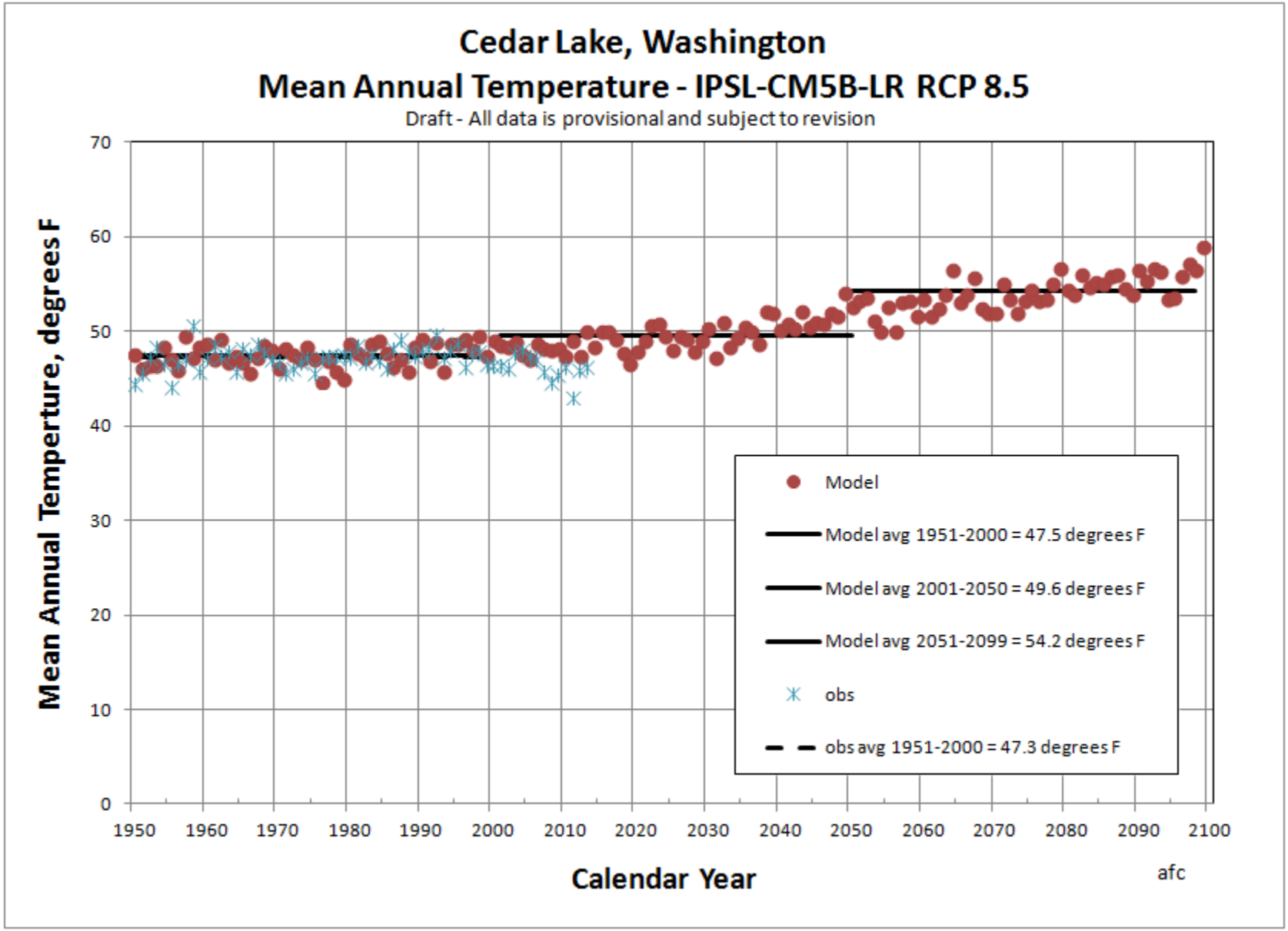


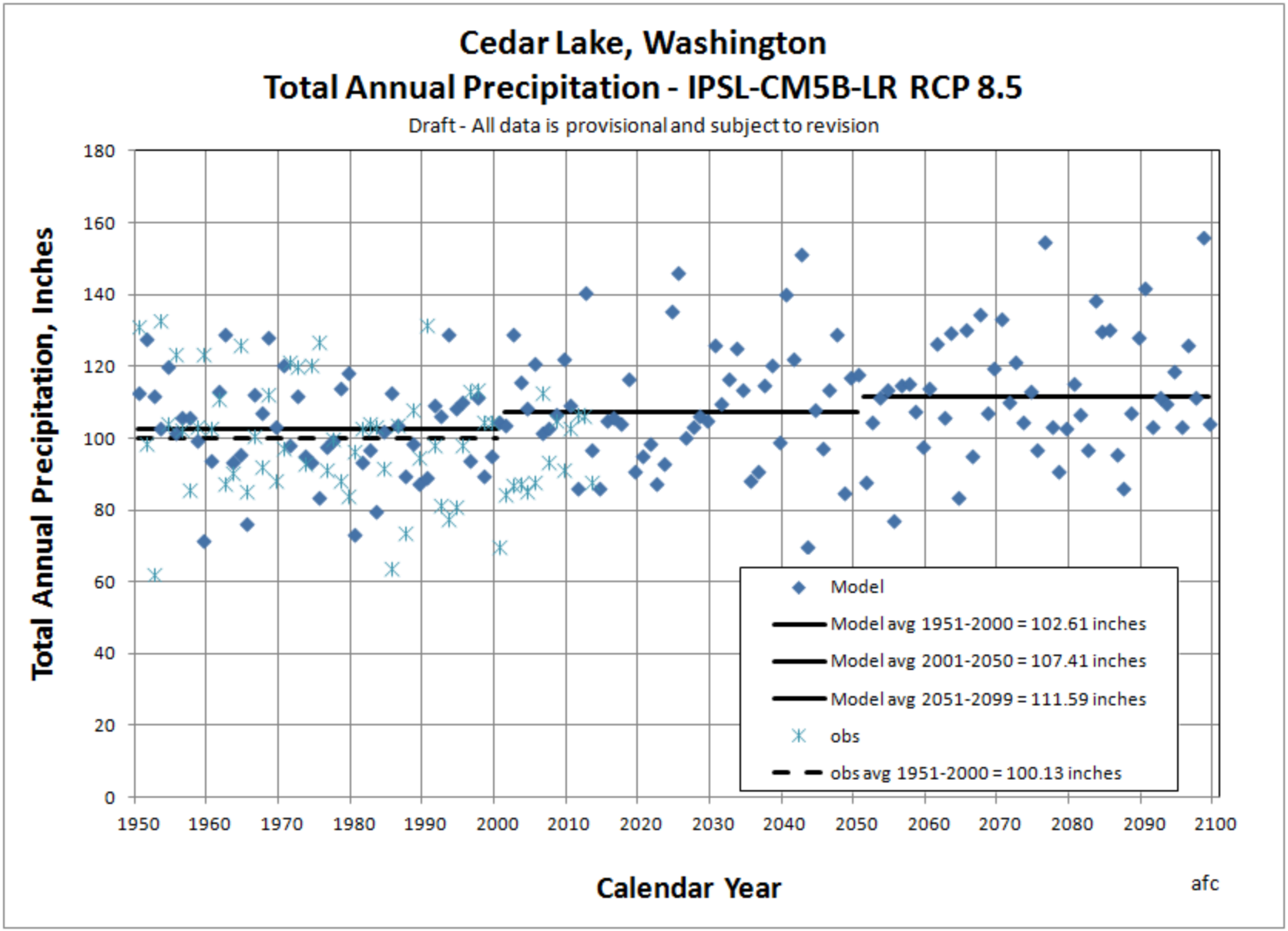
SPU's role in chain of models

PUMA:
SPU "manages" 3 links in chain of models – hydrologic model, operations/system model and utility planning

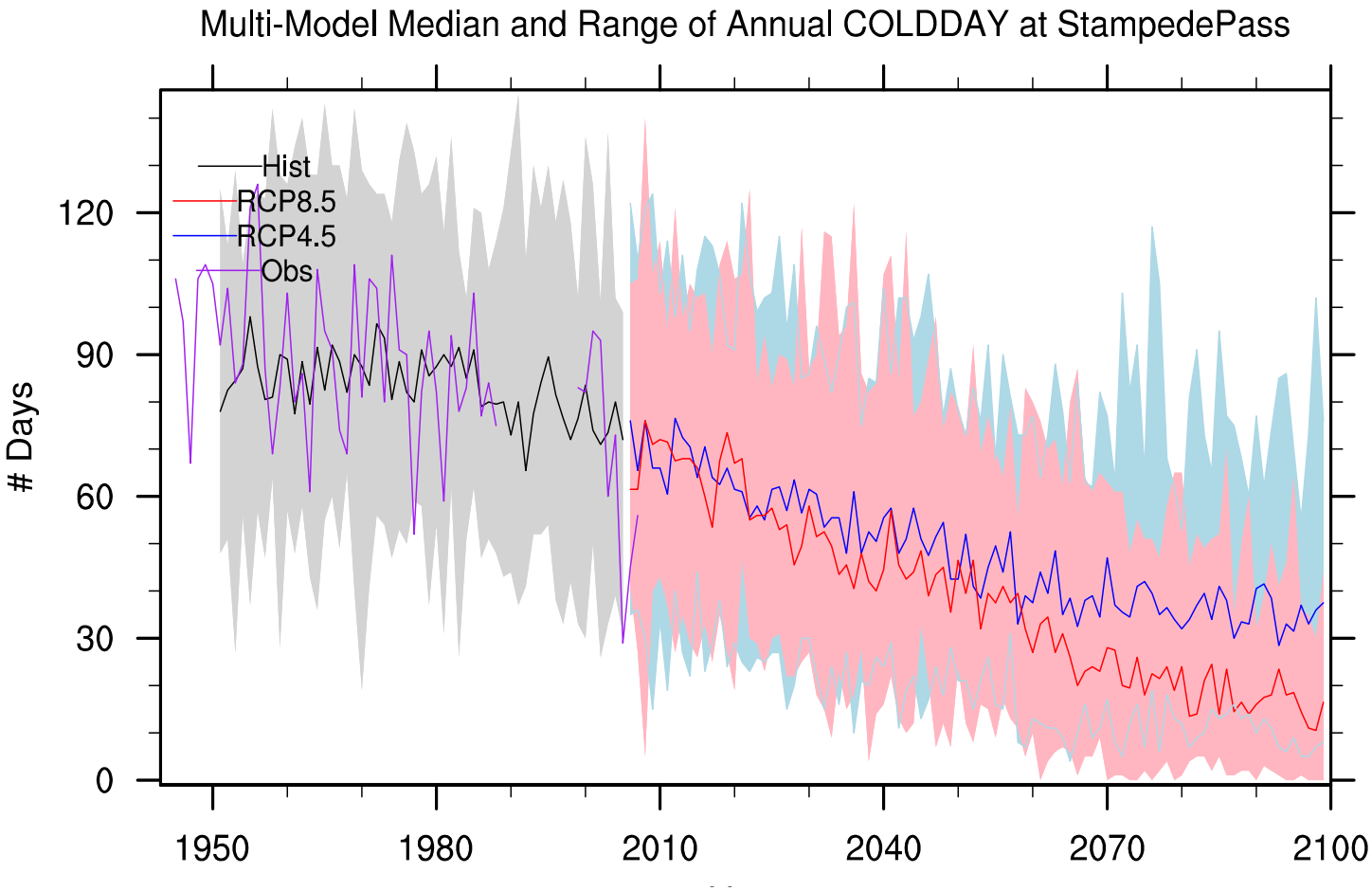
2007 Study:
SPU "manages" 2 links in chain of models – operations/system model and utility planning

2002 Study:
SPU "manages" one link in chain of models - utility planning


Cedar Lake, Washington
Mean Annual Temperature - IPSL-CM5B-LR RCP 8.5
Draft - All data is provisional and subject to revision
Mean Annual Temperture, degrees F
70
60
50
40
30
20
10
0
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Calendar Year
afc
Model
Model avg 1951-2000 = 47.5 degrees F
Model avg 2001-2050 = 49.6 degrees F
Model avg 2051-2099 = 54.2 degrees F
obs
obs avg 1951-2000 = 47.3 degrees F


Cedar Lake, Washington
Total Annual Precipitation - IPSL-CM5B-LR RCP 8.5
Draft - All data is provisional and subject to revision
Total Annual Precipitation, Inches
180
160
140
120
100
80
60
40
20
0
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Calendar Year
Model
Model avg 1951-2000 = 102.61 inches
Model avg 2001-2050 = 107.41 inches
Model avg 2051-2099 = 111.59 inches
obs
obs avg 1951-2000 = 100.13 inches
afc

PUMA projections: change in # of cold days

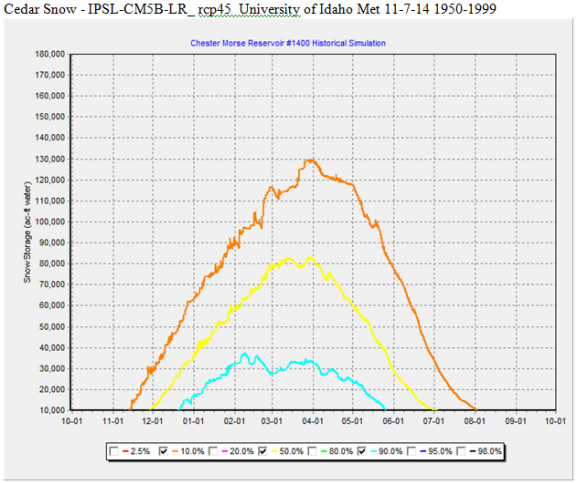


PUMA climate-altered snowpack

IPSL RCP 4.5

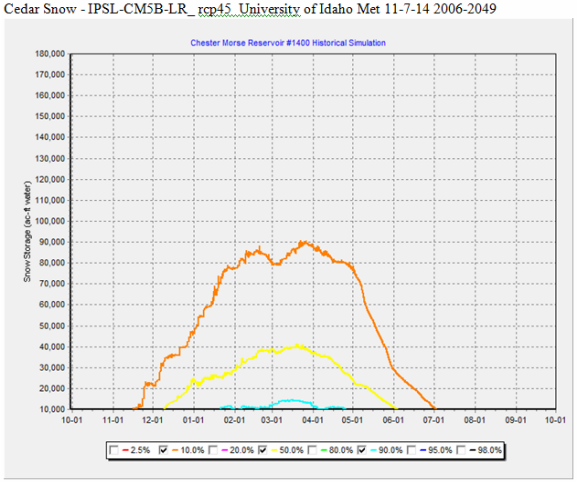
1950-1999

Cedar Snow - IPSL-CM5B-LR_ rcp45_University of Idaho Met 11-7-14 1950-1999



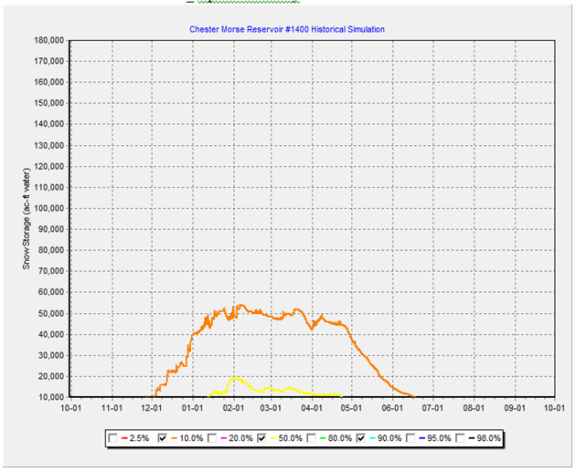
2006-2049

Cedar Snow - IPSL-CM5B-LR_ rcp45_University of Idaho Met 11-7-14 2006-2049



2050-2099

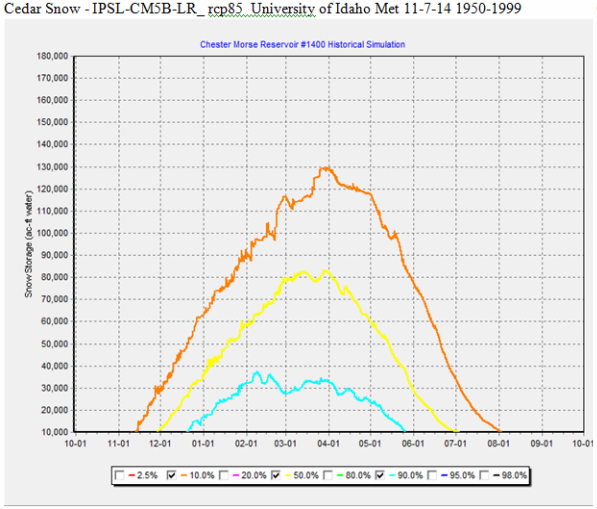
Cedar Snow - IPSL-CM5B-LR_ rcp45_University of Idaho Met 11-7-14 2050-2099



IPSL RCP 8.5

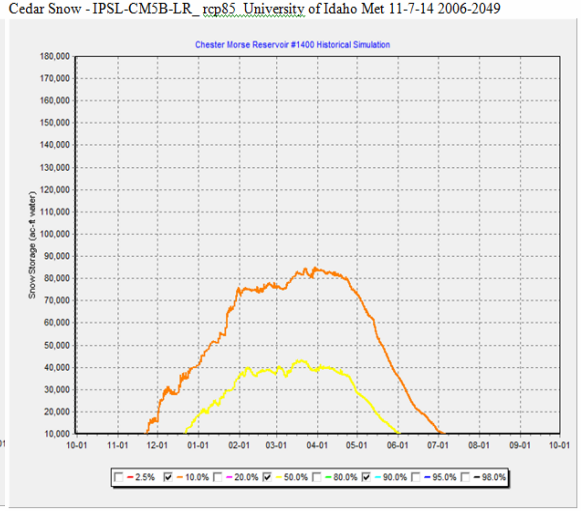
1950-1999

Cedar Snow - IPSL-CM5B-LR_ rcp85_University of Idaho Met 11-7-14 1950-1999



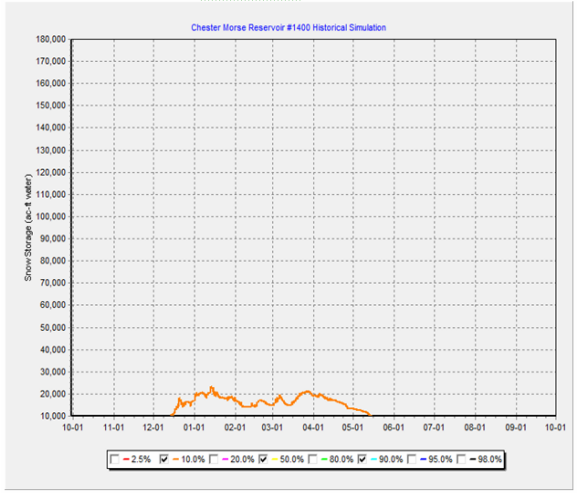
2006-2049

Cedar Snow - IPSL-CM5B-LR_ rcp85_University of Idaho Met 11-7-14 2006-2049

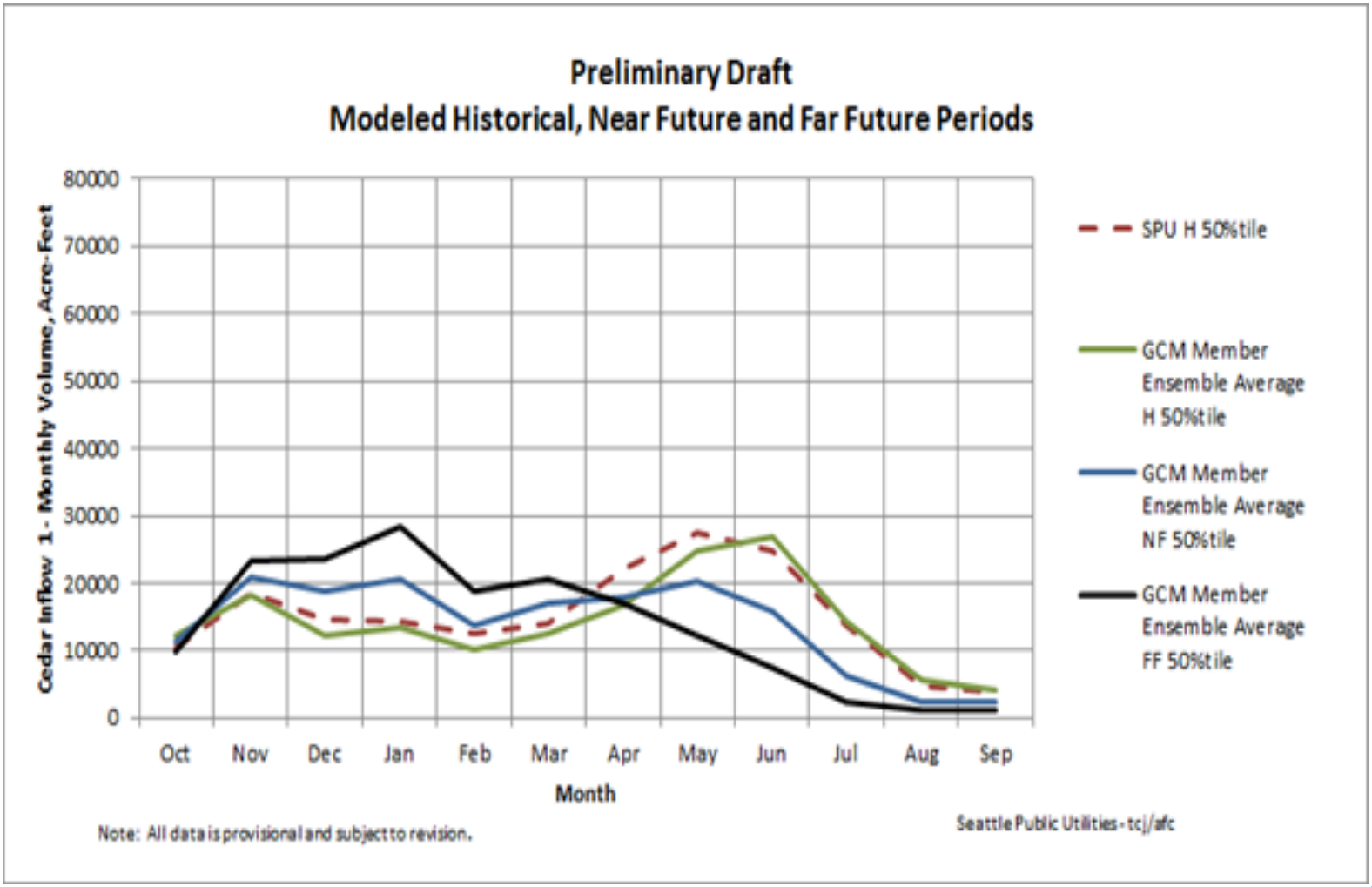


2050-2099

Cedar Snow - IPSL-CM5B-LR_ rcp85_University of Idaho Met 11-7-14 2050-2099



PUMA climate-altered hydrology



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Proposed climate scenarios for Water Supply Forum

The 8 PUMA Scenarios selected by our model selection team:

- CCSM4 RCP 8.5
- CCSM4 RCP 4.5
- CSIRO-Mk3-6-0 RCP 8.5
- CSIRO-Mk3-6-0 RCP 4.5
- HadGEM2-CC365 RCP 8.5
- IPSL-CM5B-LR RCP 8.5
- MIROC-ESM-CHEM RCP 8.5
- MIROC-ESM CHEM RCP 4.5

Note: 40 PUMA Scenarios are available.

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Method for Calculating Relative Reduction or Gain in Baseline Yield

- For each of the 8 PUMA climate-altered hydrology datasets, calculate the **baseline yield** for the **historical baseline** (H), **near future** (NF), and **far future** (FF) **periods** which are defined as:
  - **H** = 1951 to 2000 (50-years)
  - **NF** = 2001 to 2050 (50-years)
  - **FF** = 2051 to 2099 (49-years)
- Then, calculate the **reduction** or **gain** in yield for the near future and far future periods **relative to the historical baseline period.**

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A Quick Review of Some Official Firm Yield Modeling Assumptions

- **98 percent** reliability standard
- **Monthly demand** distribution based on actual demands experienced during 2005 through 2009 (**no curtailments**)
- **Current in-stream flow** requirements (includes ability to switch to critical flows).
- **Current reservoir storage** operating levels
- **Fixed reservoir rule curves** (no early refill on Cedar Supply)
- **No pumps** turned on to access emergency storage in CML below 1532 feet.
- SF Tolt Reservoir storage drawdown limited to 1710 feet.

Reference: SPU, Firm Yield of Seattle's Existing Water Supply Sources, November 2011

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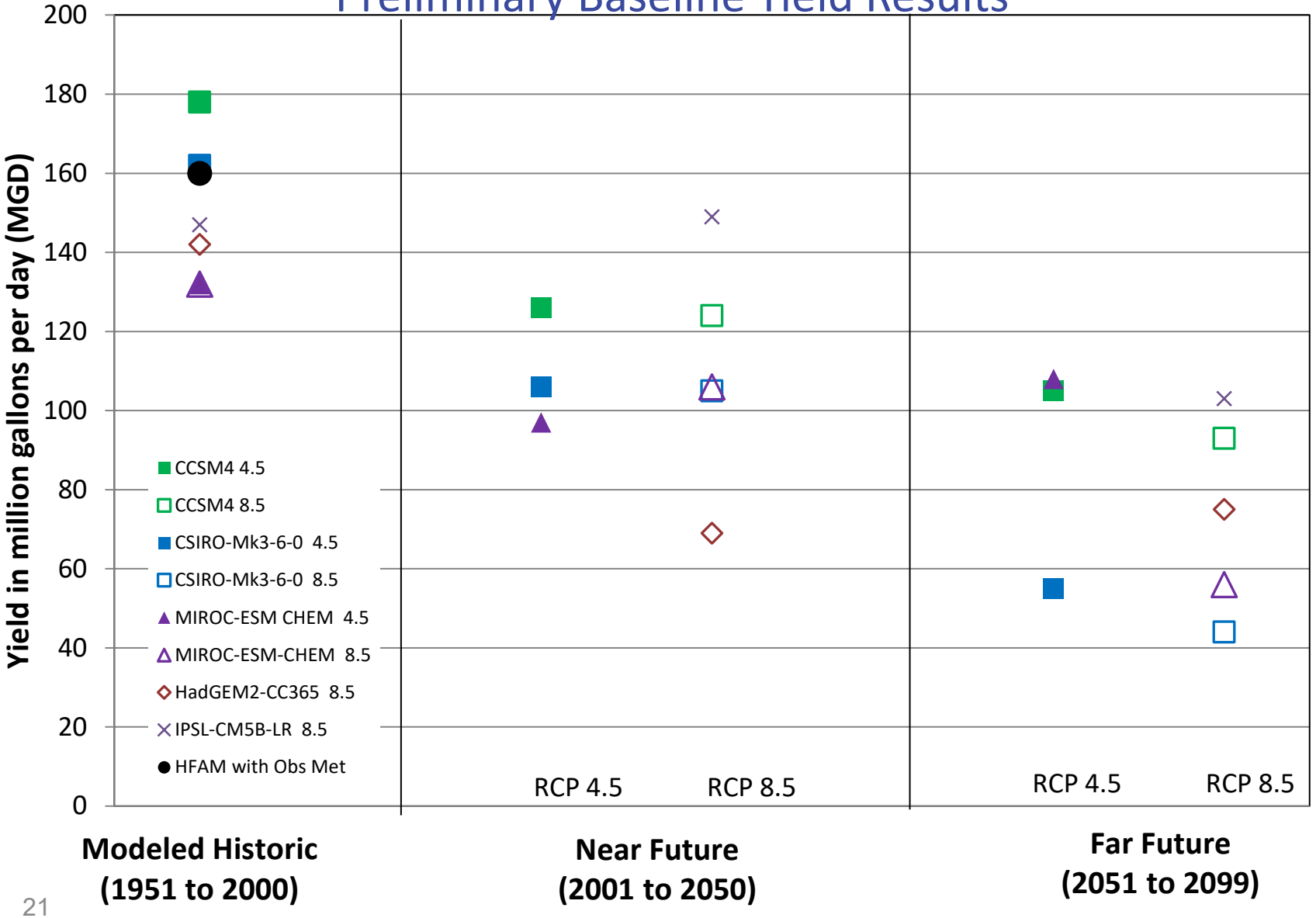
Preliminary Draft

Preliminary Baseline Yield Results



Preliminary Draft
Table of Preliminary Reduction or Gain in Future Baseline Yield Results Relative to Historical Baseline Period

RCP 8.5	**H**	**NF**	**FF**
• CCSM4	baseline	-30.3%	-47.8%
• CSIRO-Mk3-6-0	baseline	-35.2%	-72.8%
• HadGEM2-CC365	baseline	-51.4%	-47.2%
• IPSL-CM5B-LR	baseline	+1.4%	-29.9%
• MIROC-ESM-CHEM	baseline	-19.7%	-57.6%
5 Member Ensemble Mean	baseline	**-27.0%**	**-51.1%**
RCP 4.5	**H**	**NF**	**FF**
• CCSM4	baseline	-29.2%	-41.0%
• CSIRO-Mk3-6-0	baseline	-34.6%	-66.0%
• MIROC-ESM CHEM	baseline	-26.5%	-18.2%
3 Member Ensemble Mean	baseline	**-30.1%**	**-41.7%**

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Potential Adaptation Approaches

Operational

- Earlier refill in Chester Morse Lake – allow reservoir refill to 1563 feet beginning first week in March
- Deeper drawdown for South Fork Tolt Reservoir – allow reservoir to drawdown to 1690 feet anytime

Preliminary Draft
Effect of adaptation options: gain/reduction in yield relative to baseline historic

RCP 8.5		**H**	**NF**	**FF**
• CSIRO-Mk3-6-0	Baseline	0%	-35%	-73%
• *CSIRO-Mk3-6-0*	*Adaptation*	*+12%*	*-26%*	*-60%*
• IPSL-CM5B-LR	Baseline	0%	+1%	-30%
• *IPSL-CM5B-LR*	*Adaptation*	*0%*	*+9%*	*-17%*

So in the near future, these two adaption options would add back, relative to the unmitigated effects, between 8-9% and in the far future, 13%.

adaptation options are:

- earlier refill in Chester Morse Lake
- deeper drawdown in South Fork Tolt Reservoir

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Next Steps

- SPU to evaluate remaining 32 scenarios
- SPU to conduct “forensics” on yield defining events
- SPU to identify and evaluate adaptation options
- Integration into SPU’s 2019 Water System Plan
- Continued engagement with research and utility communities

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END

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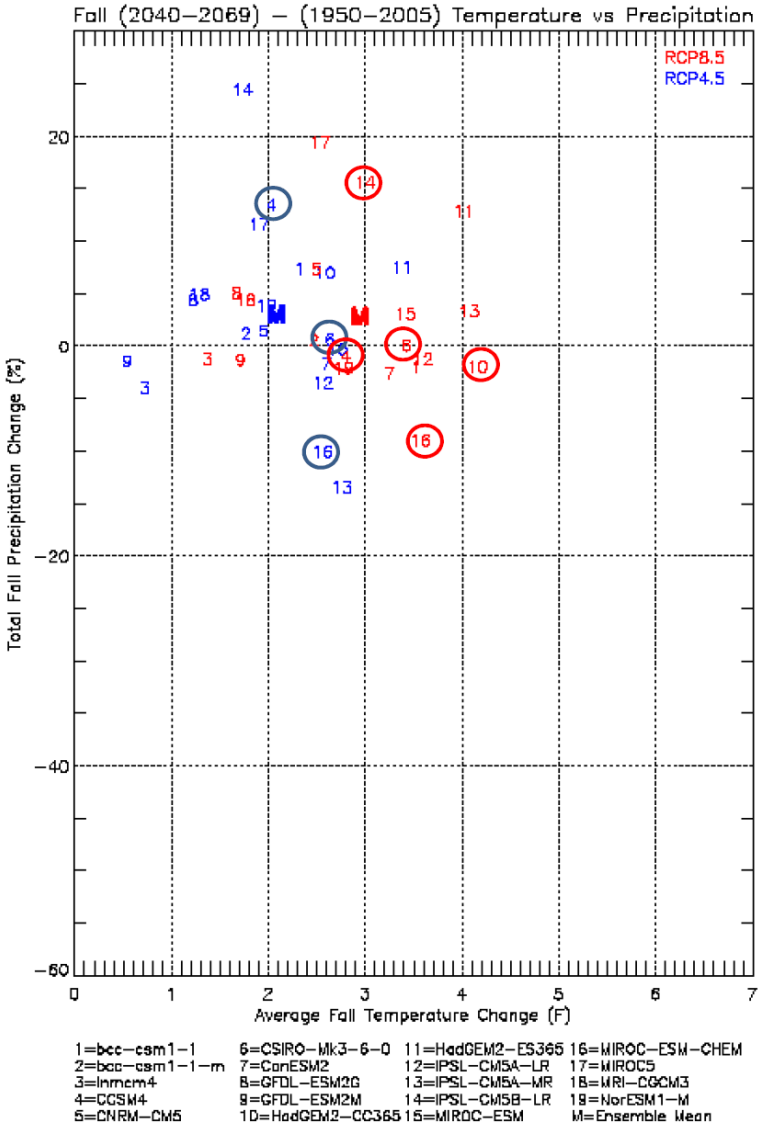
Fall delta T vs delta P



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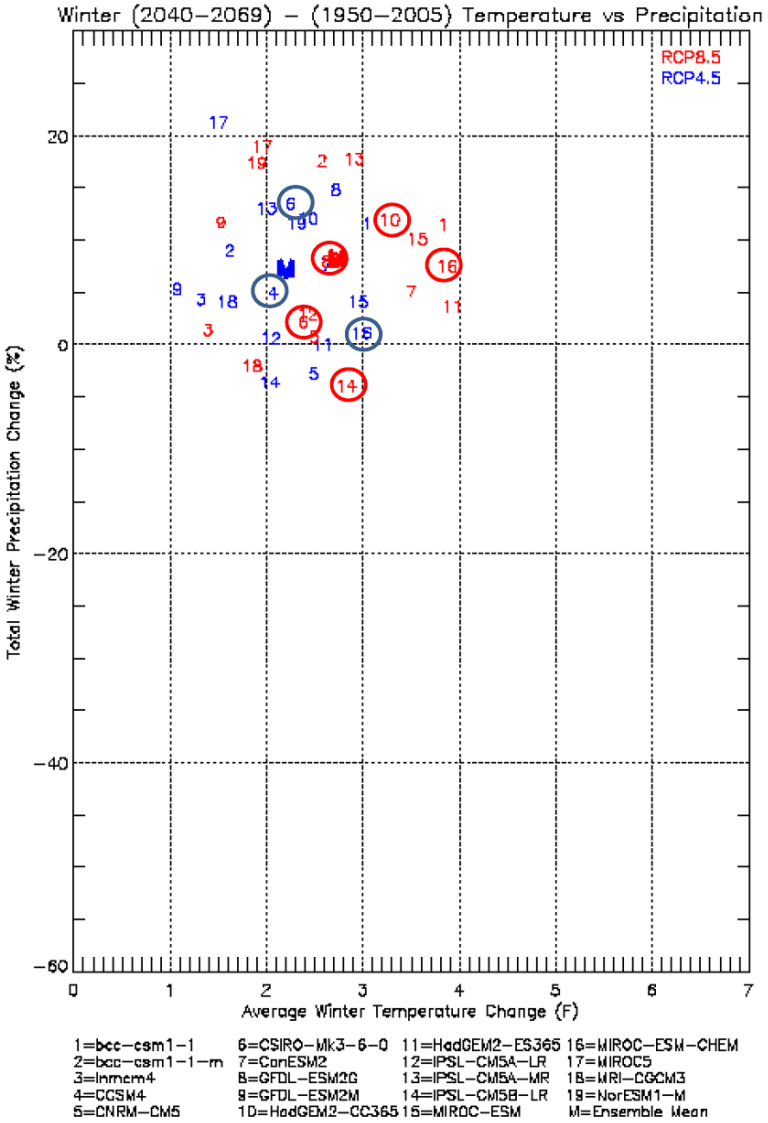
Winter delta T vs delta P



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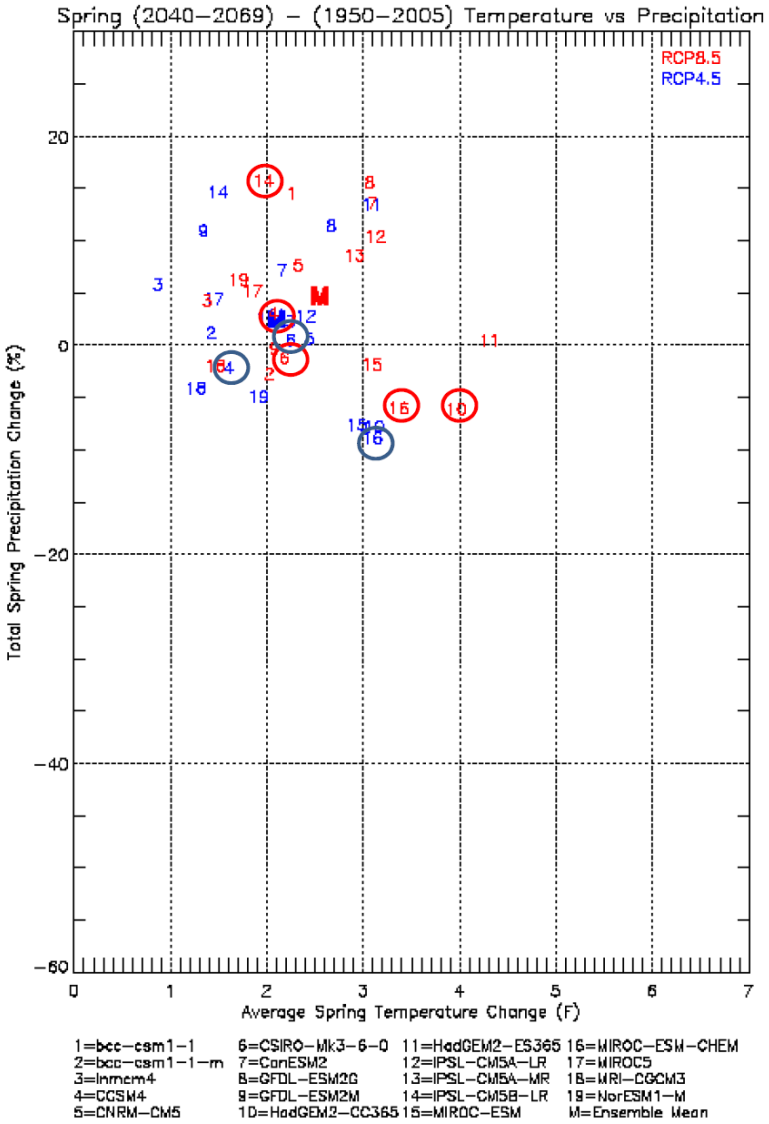
Spring delta T vs delta P



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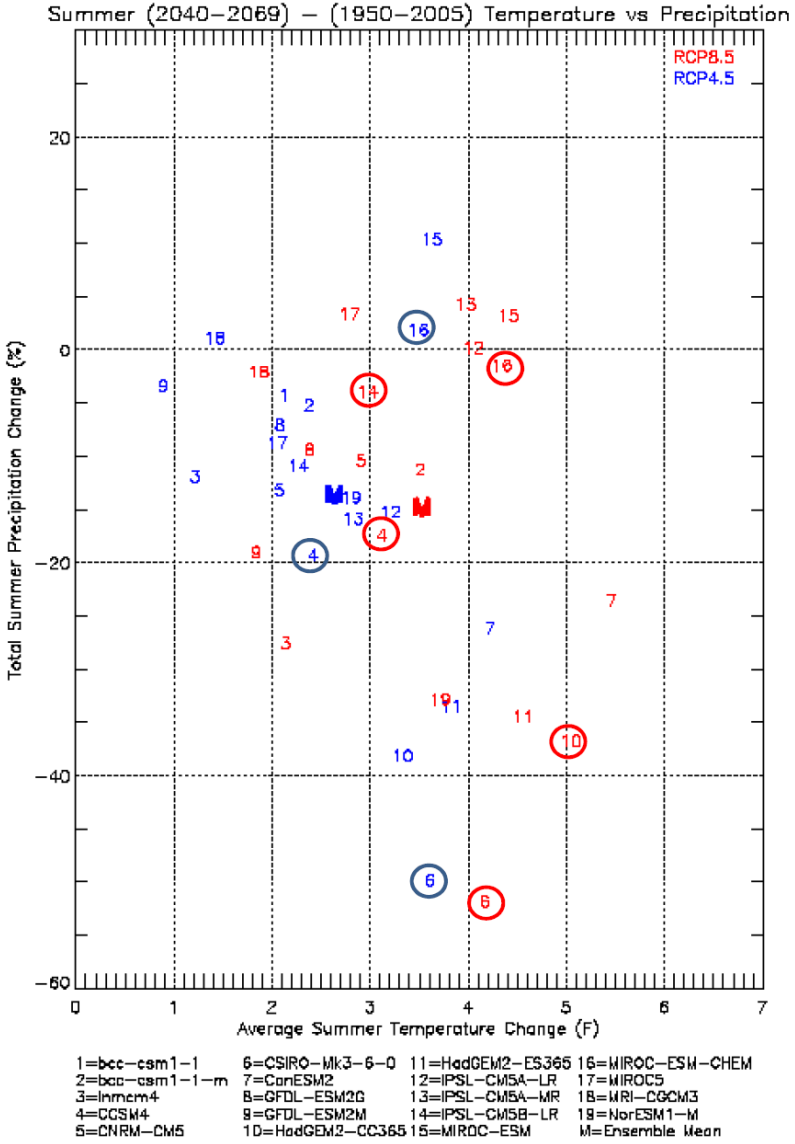
Summer delta T vs delta P



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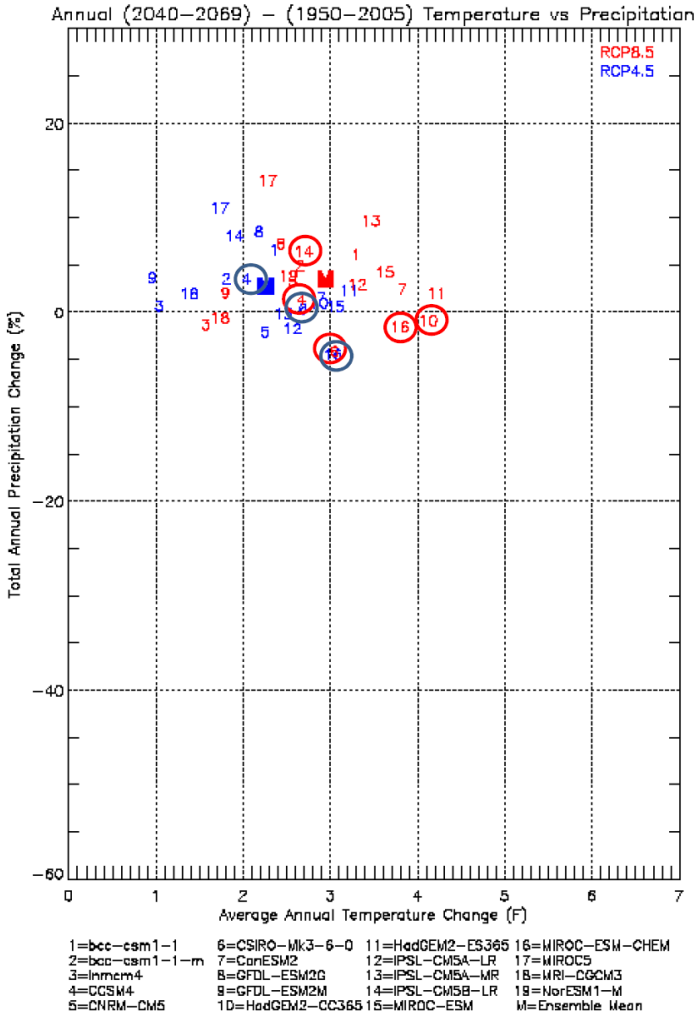
PUMA projections: annual delta T vs delta P



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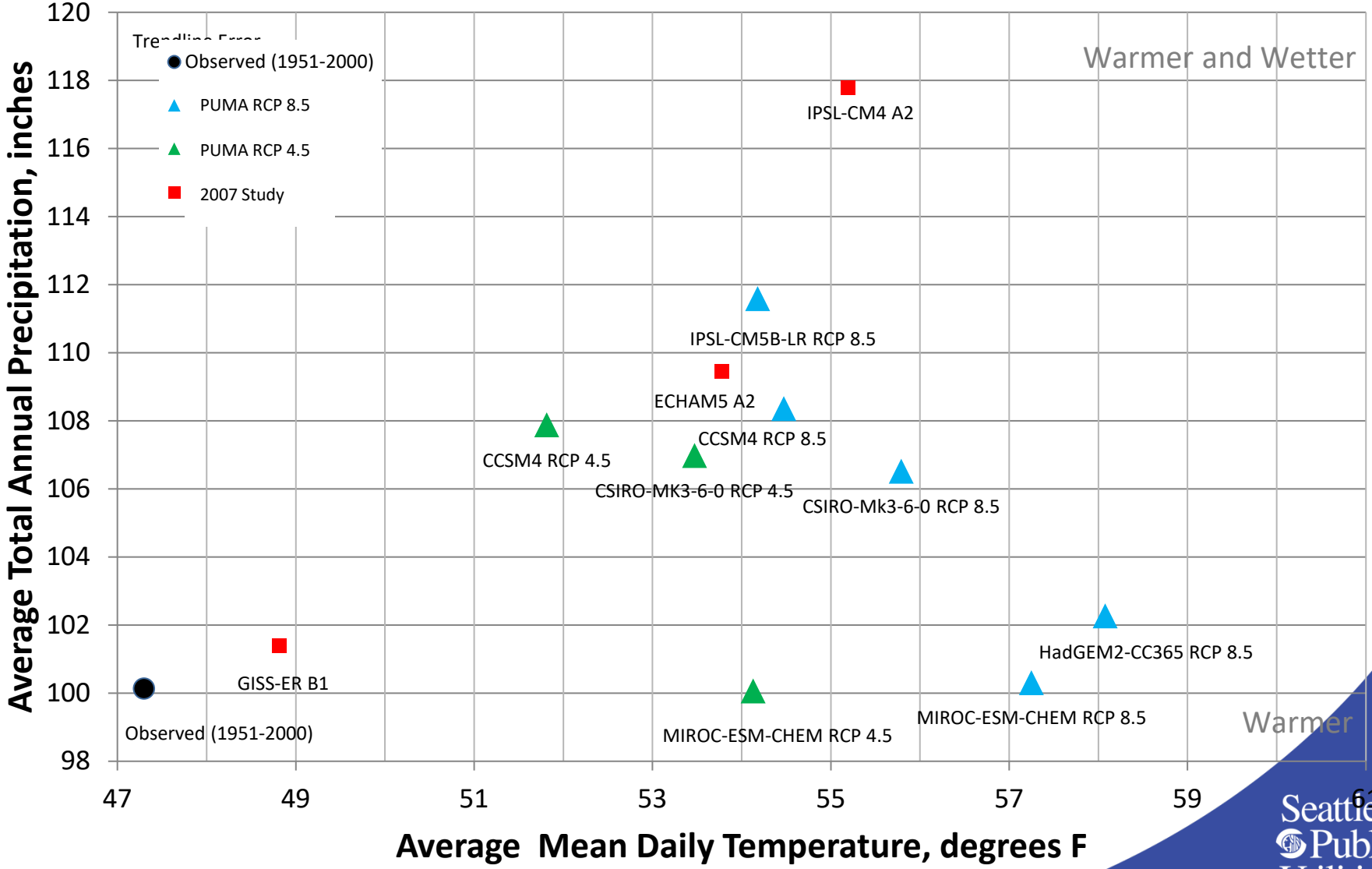
Cedar Lake, Washington

Mean Annual Temperature versus Total Annual Precipitation

Average for Observed Historic, FF (2051-2099) and 2075 (2060-2090)



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