Effects of Projected Climate Change on the Hydrology of the Pacific Northwest and Cascade Mountain Range

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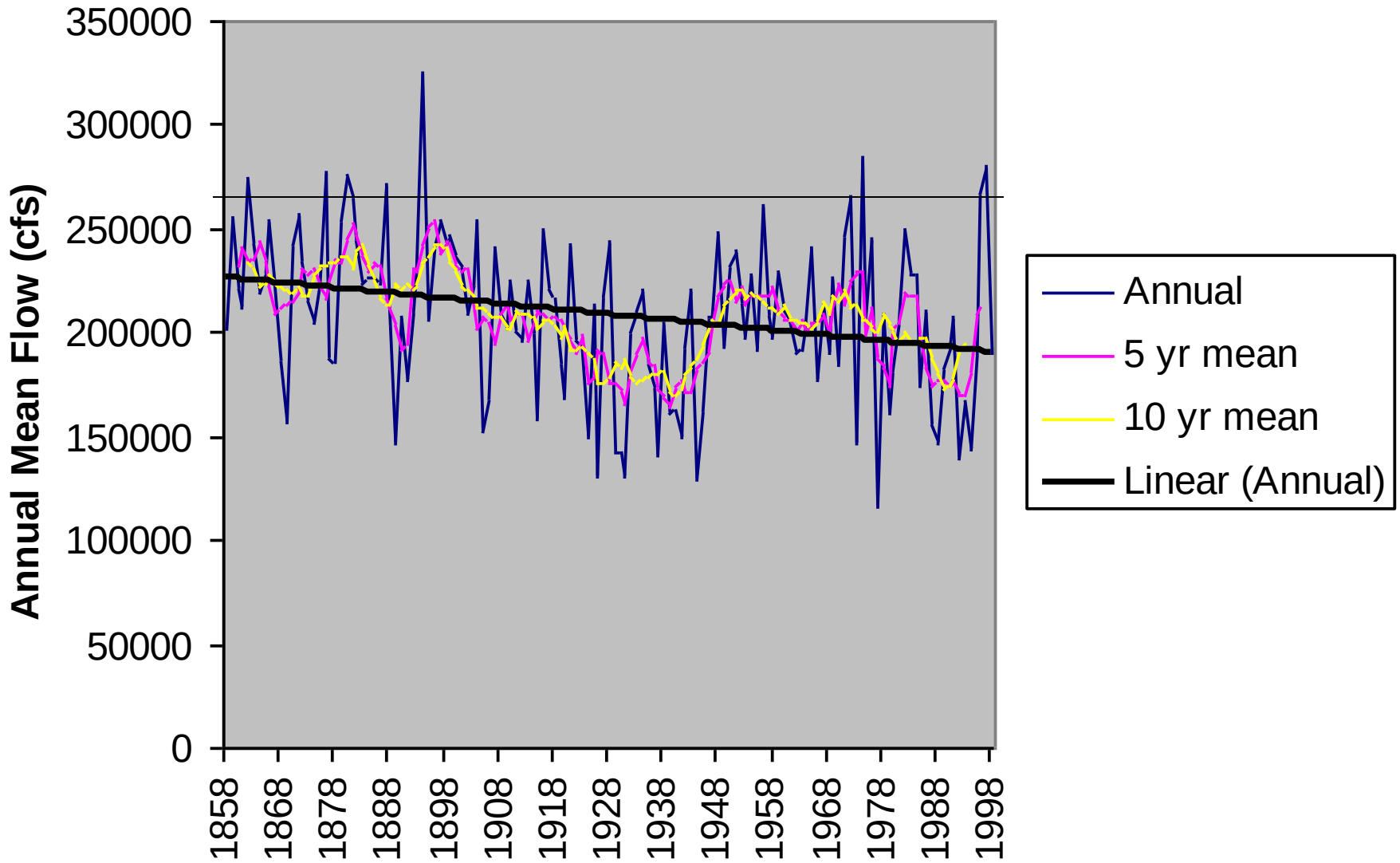
Eric Salathé
Amy Snover
Ingrid Tohver
Andy Wood

A Few Points Regarding Natural Climate Variability

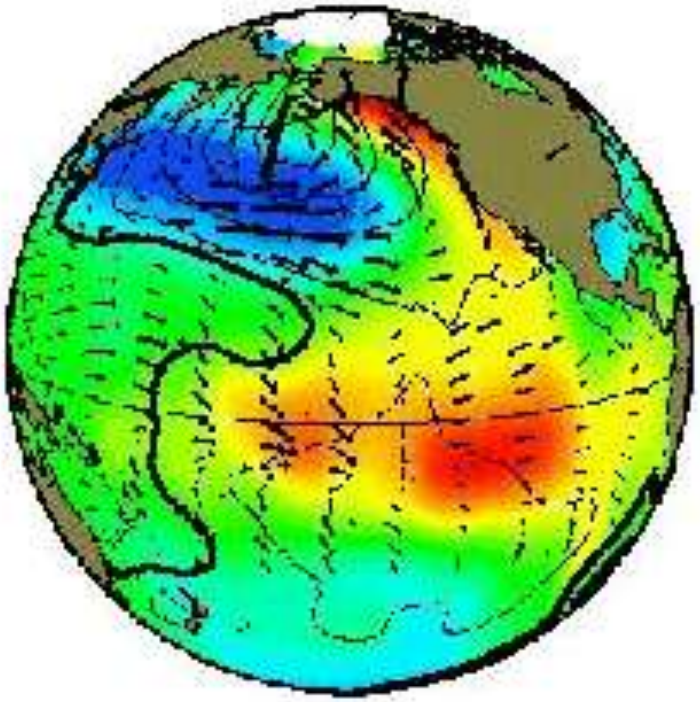
Climate Varies on Centennial, Decadal, and Interannual Time Scales

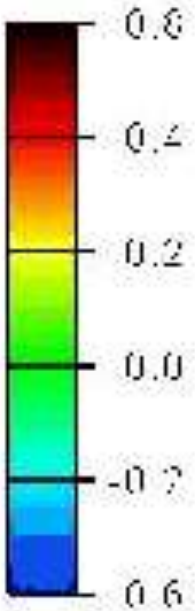


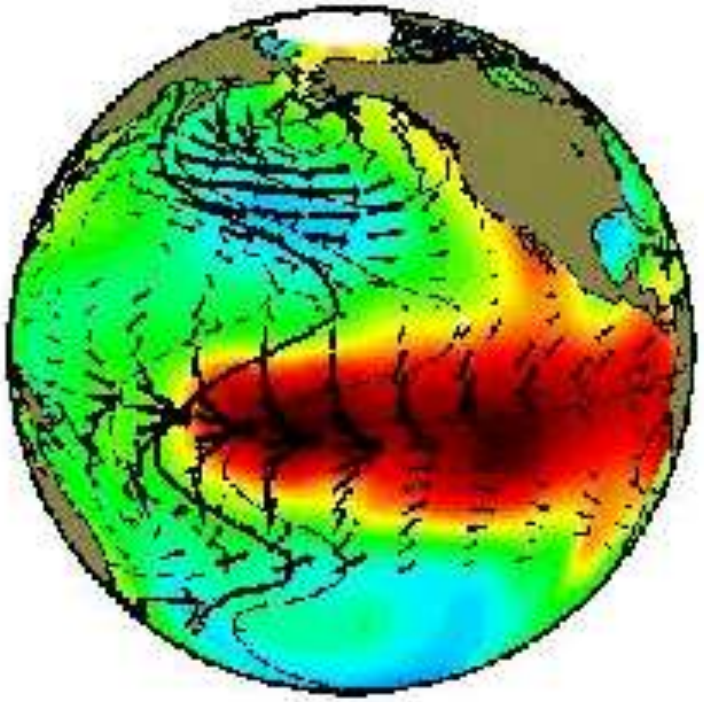
Naturalized Flow in the Columbia River at The Dalles, OR

Pacific Decadal Oscillation

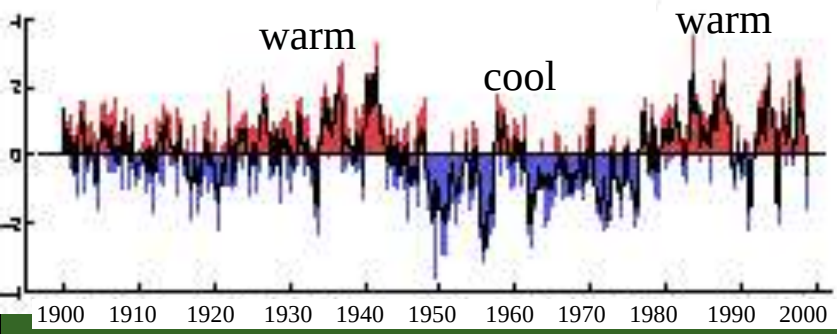
El Niño Southern Oscillation



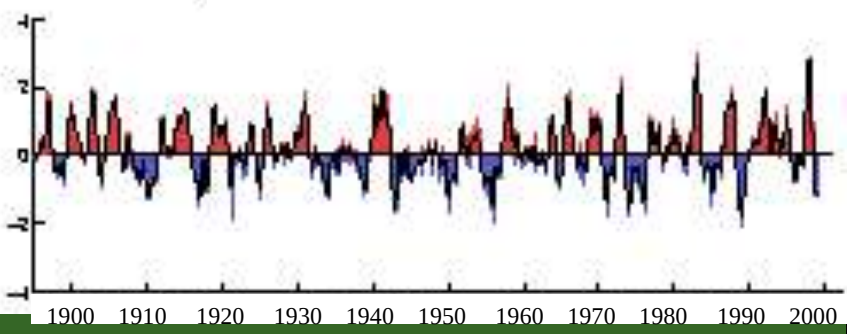




A history of the PDO

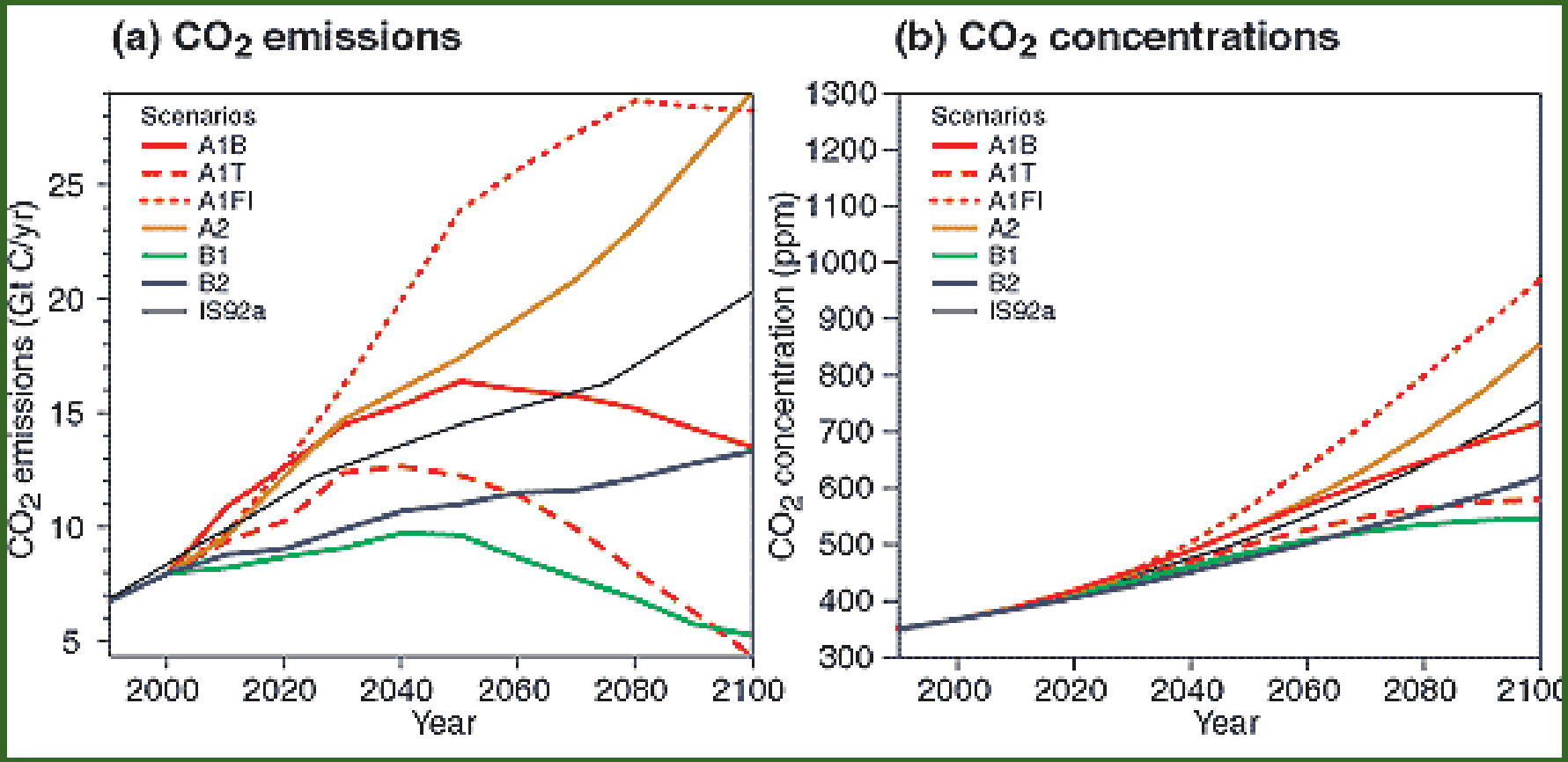


A history of ENSO

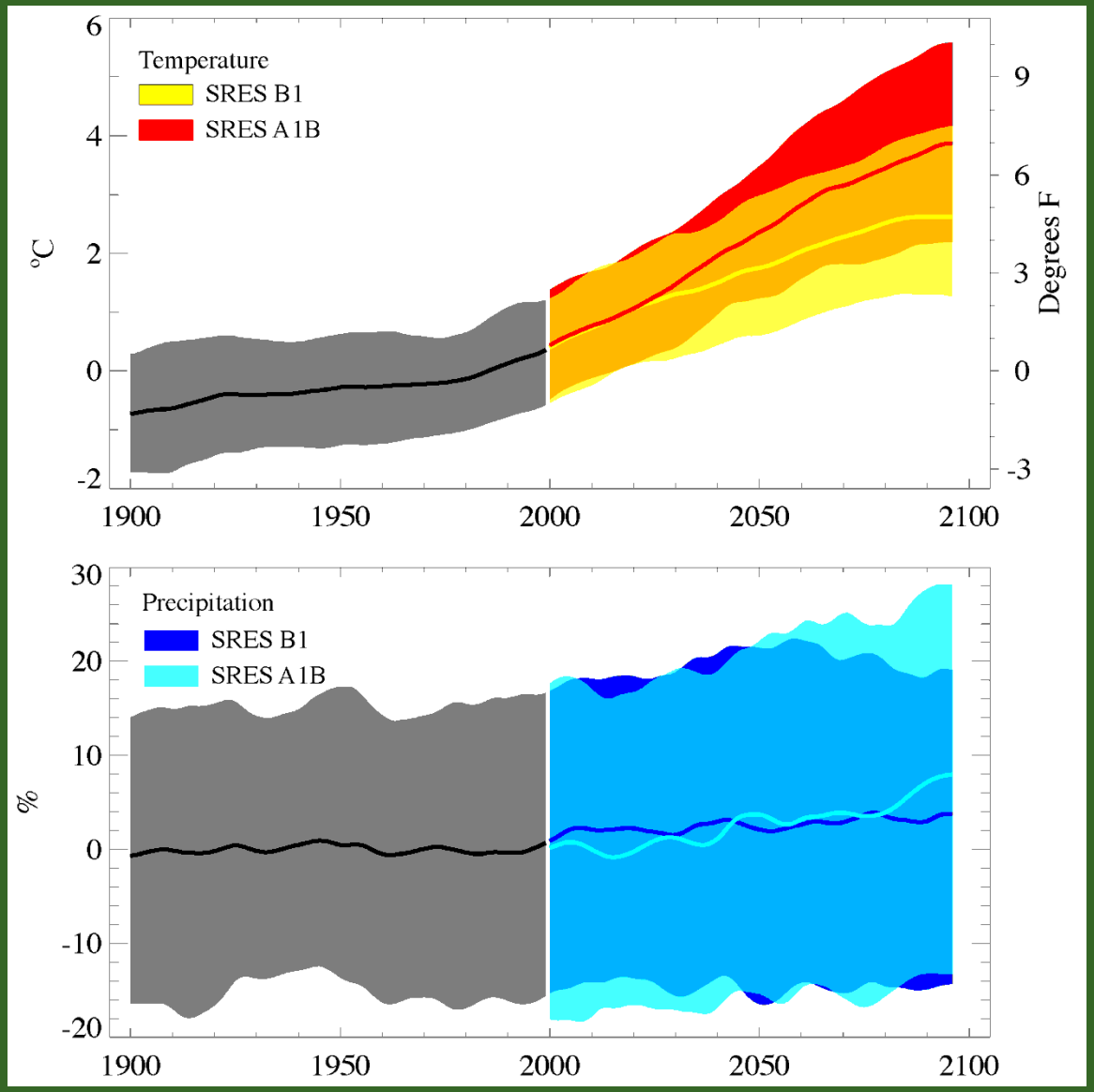


Global Climate Change Scenarios for the PNW

IPCC Emissions Scenarios



21st Century Climate Impacts for the Pacific Northwest Region



Mote, P.W. and E. P. Salathe Jr., 2010: Future climate in the Pacific Northwest, Climatic Change, DOI: 10.1007/s10584-010-9848-z

Seasonal Precipitation Changes for the Pacific Northwest

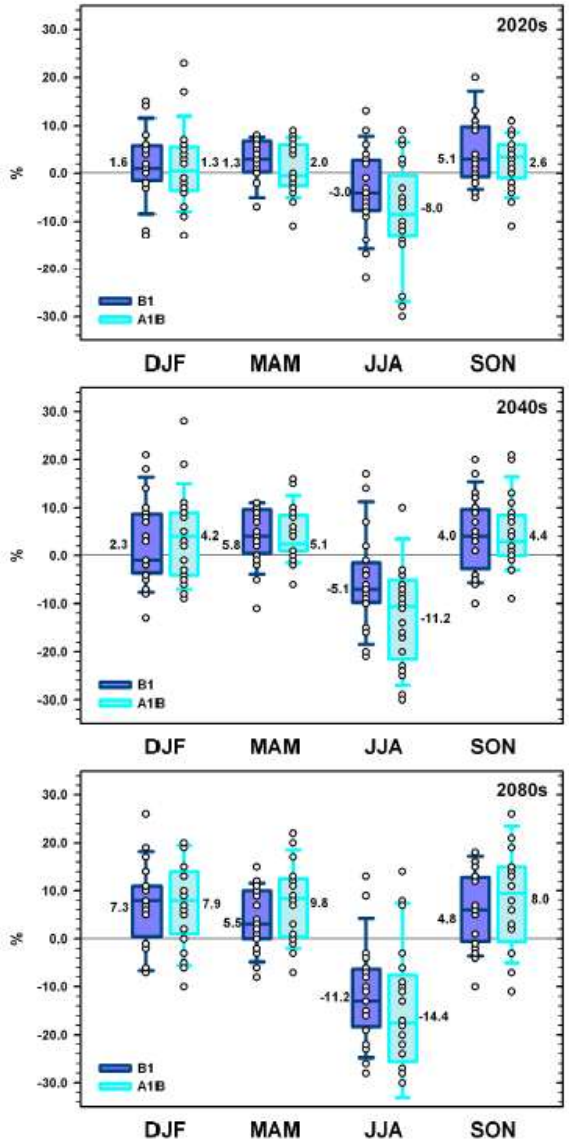
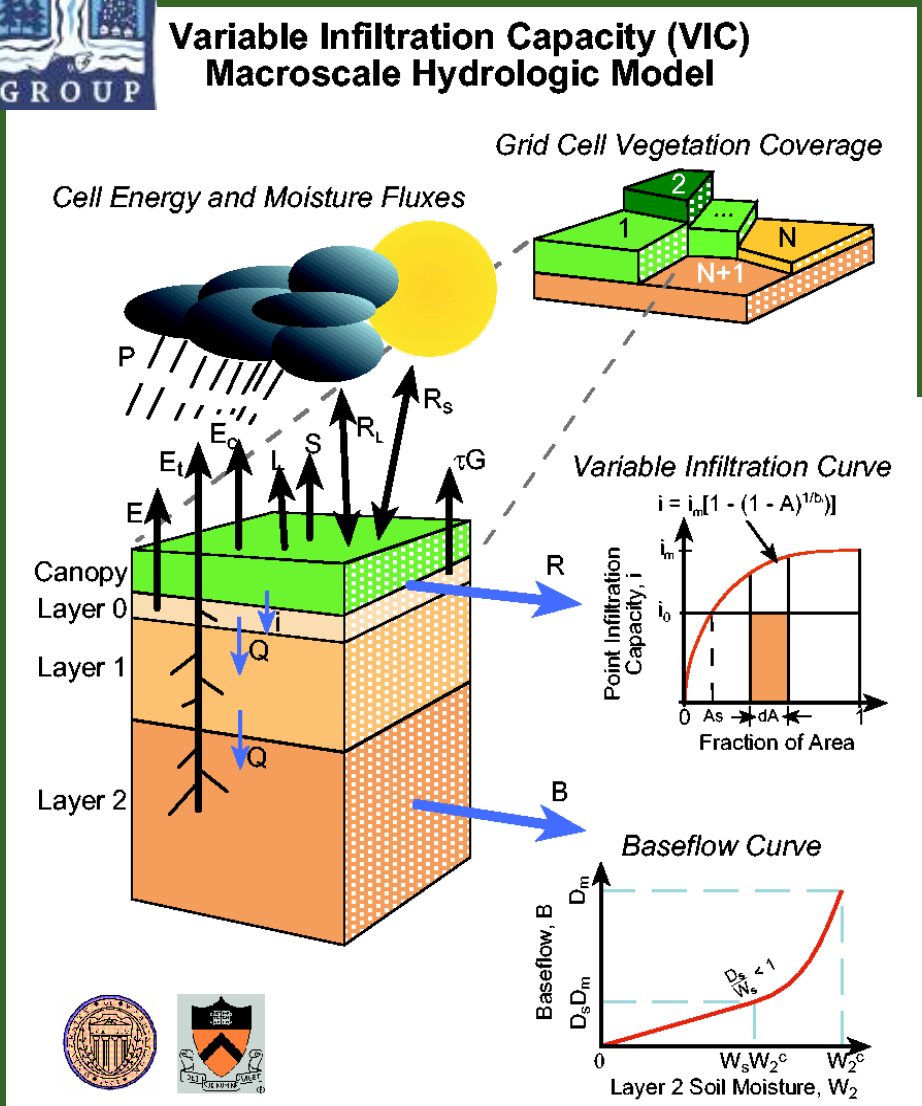


Figure 10. As in Figure 9, but for precipitation. The height of the bars indicates actual water precipitation but the percentages are calculated with respect to a reference value for that season, so that -11% in JJA is much less than -11% in DJF. The reference values for the extremes are that model's 20th century mean for that season (or annual mean), and for the REA average the reference is the all-model 20th century value. Unlike for temperature, for any season some models project increases and some project decreases, though the vast majority project decreases for summer and increases for winter by the 2080s

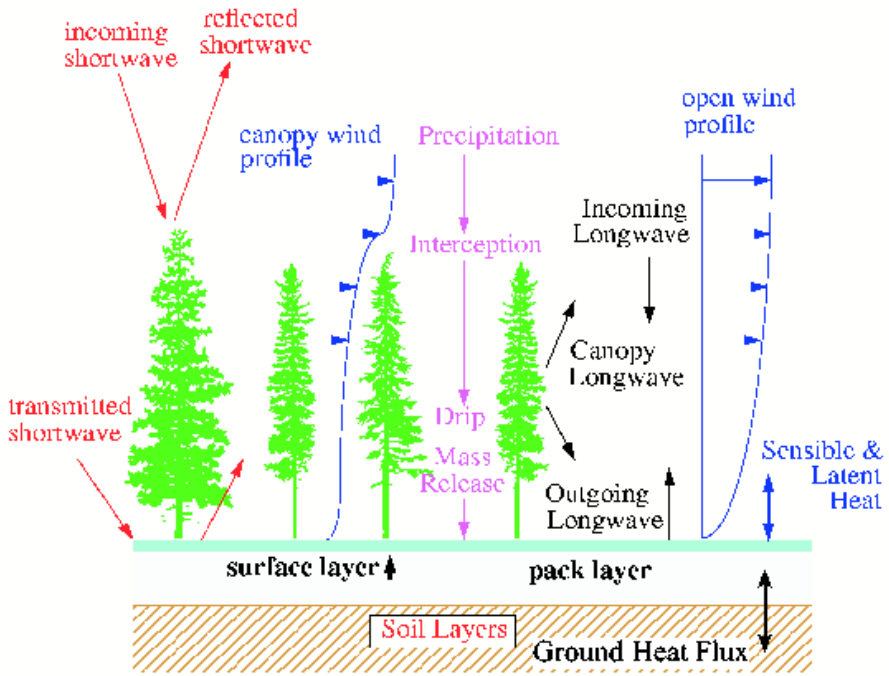
http://cses.washington.edu/db/pdf/wacciach1scenarios642.pdf

Hydrologic Projections

Schematic of VIC Hydrologic Model



- Sophisticated, fully distributed, physically based hydrologic model
- Widely used globally in climate change applications
- 1/16 Degree Resolution
  (~5km x 6km or ~ 3mi x 4mi)



General Model Schematic

Snow Model

Hydrologic Climate Change Scenarios for the Pacific Northwest Columbia River Basin and Coastal Drainages

- Project Home
- Introduction for New Users
- Join Project's Listserve
- Project Report
- Citations and Contacts
- Project Updates
- Climate Scenarios
  - Site-specific Data
  - Primary Data
  - Reservoir Model Input Data

Climate change is projected to have substantial impacts on Pacific Northwest water resources and ecosystems. Recognizing this, resource managers have expressed growing interest in incorporating climate change information into long-range planning. The availability of hydrologic scenarios to support climate change adaptation and long-range planning, however, has been limited until very recently to a relatively small number of selected case studies. More comprehensive resources needed to support regional planning have been lacking. Furthermore, ecosystem studies at the landscape scale need consistent climate change information and databases over large geographic areas. Products using a common set of methods that would support such studies have not been readily available.

To address these needs, the Climate Impacts Group worked with several prominent water management agencies in the Pacific Northwest to develop hydrologic climate change scenarios for approximately 300 streamflow locations in the Columbia River basin and selected coastal drainages west of the Cascades. Study partners are listed below. The scenarios, provided to the public for free via this website, allow planners to consider how hydrologic changes may affect water resources management objectives and ecosystems.

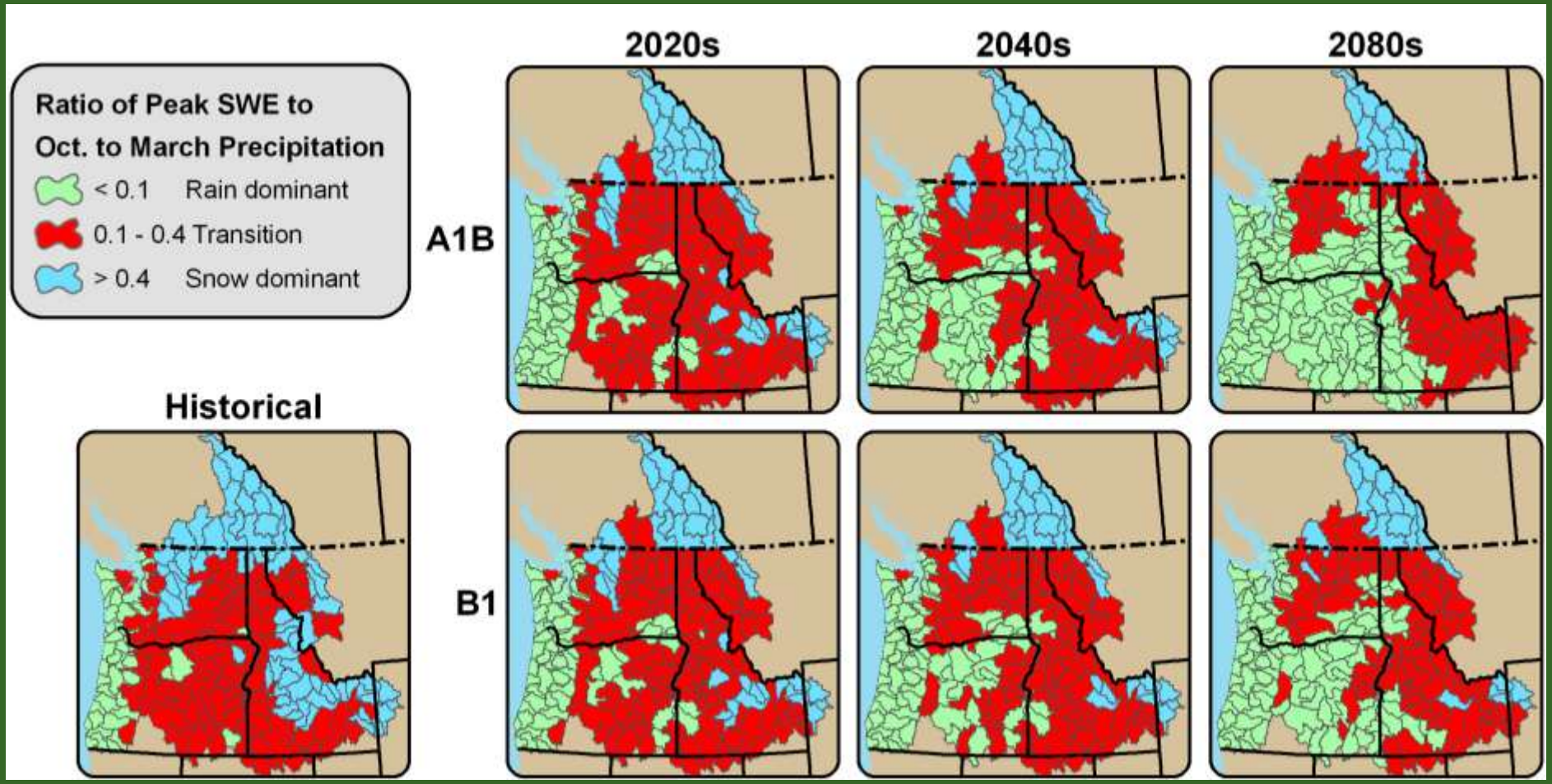
Access to the data and summary products is available from the menu to the left. The hydrologic data produced by the study are based on climate change scenarios produced for the IPCC Fourth Assessment effort. Information on the methods and modeling tools used in the study is provided in the summary report. For new users of the site, a guide to the website and the data resources contained within it is also provided.

The Climate Impacts Group was funded by the following research partners to develop the Columbia River Basin and coastal drainages climate change scenarios:

- WA State Department of Ecology
- Bonneville Power Administration
- Northwest Power and Conservation Council
- Oregon Department of Water Resources
- British Columbia Ministry of Environment

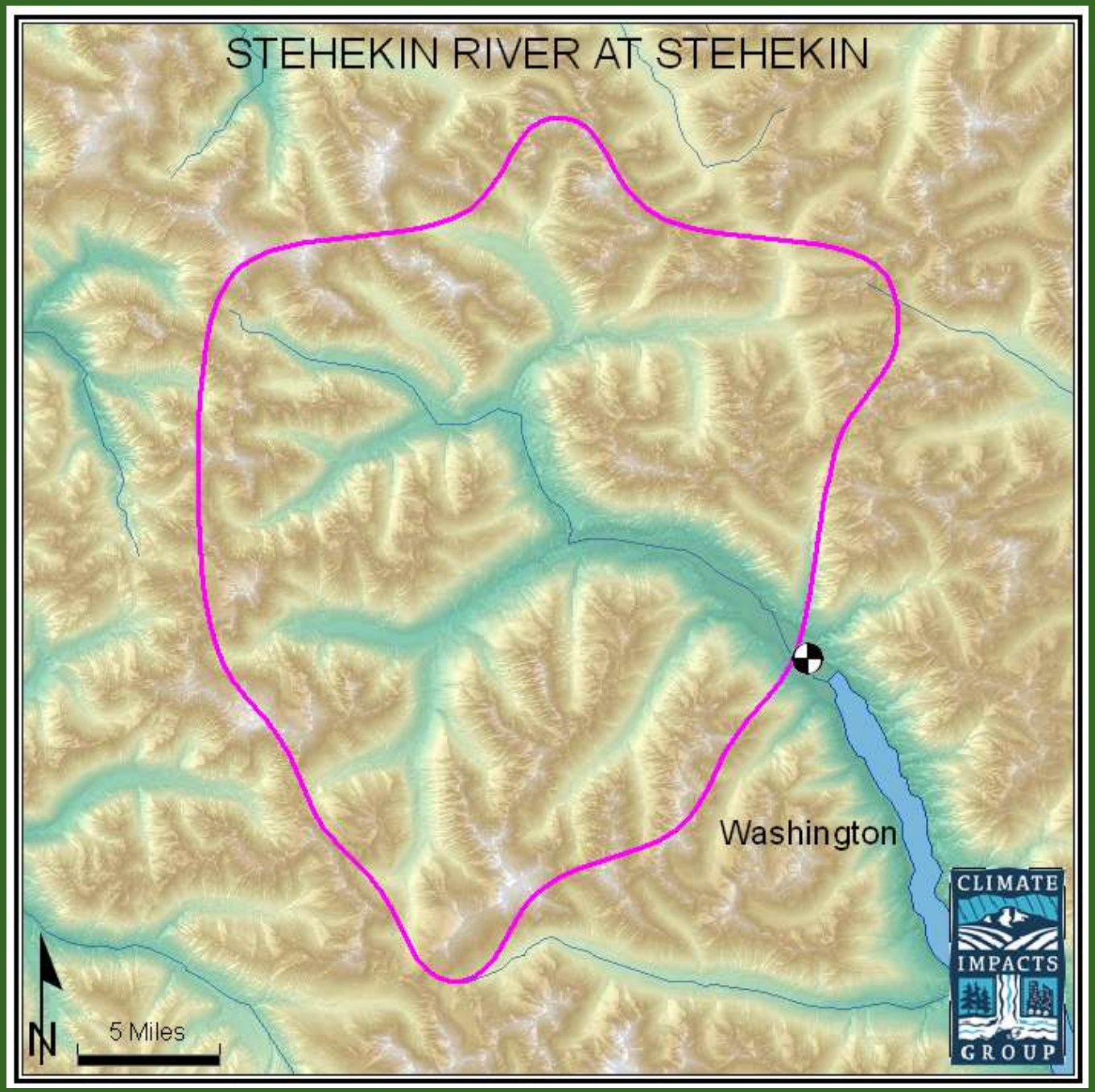
http://www.hydro.washington.edu/2860/

Watershed Classifications:
Transformation From Snow to Rain



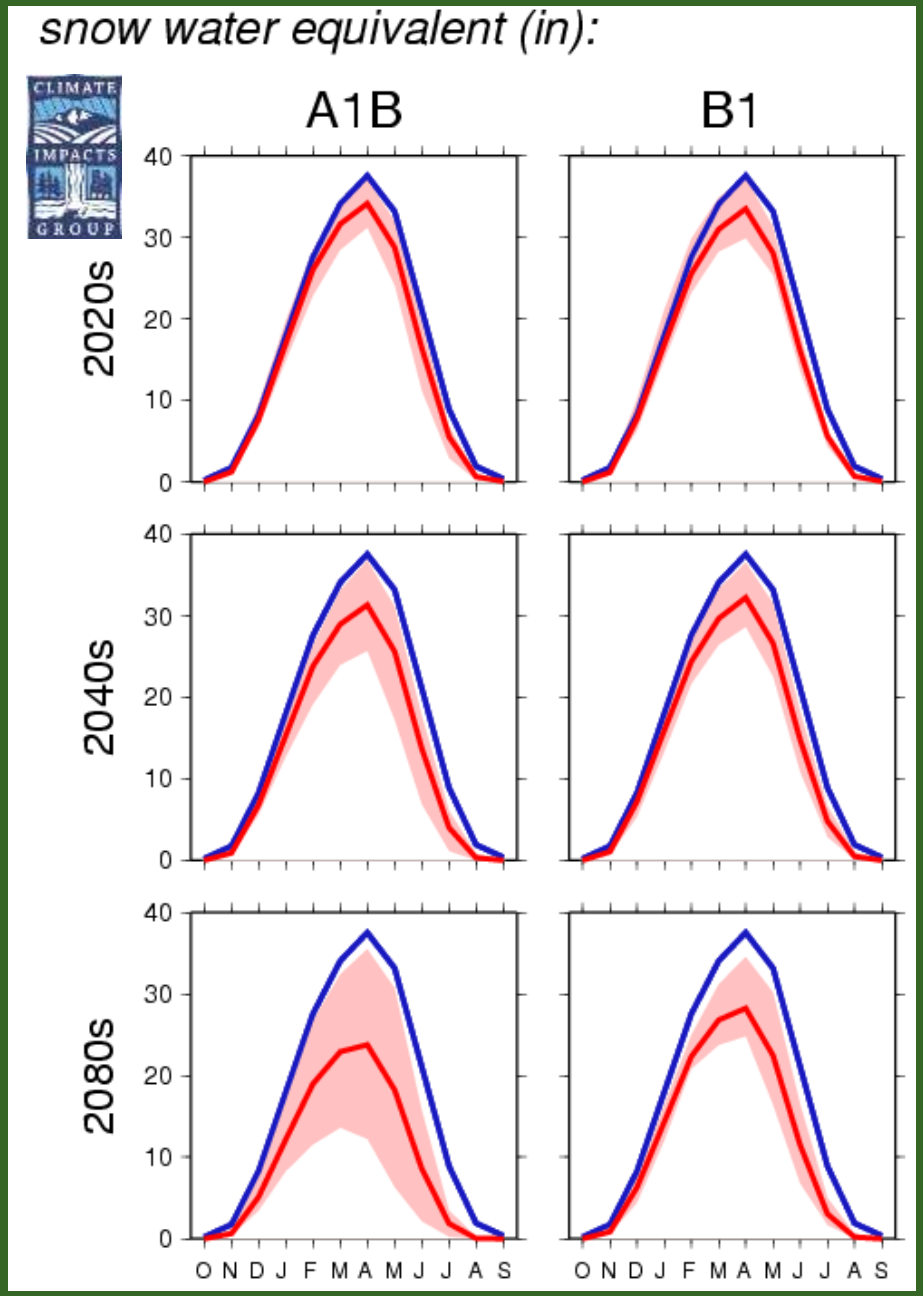
Map: Rob Norheim, CIG

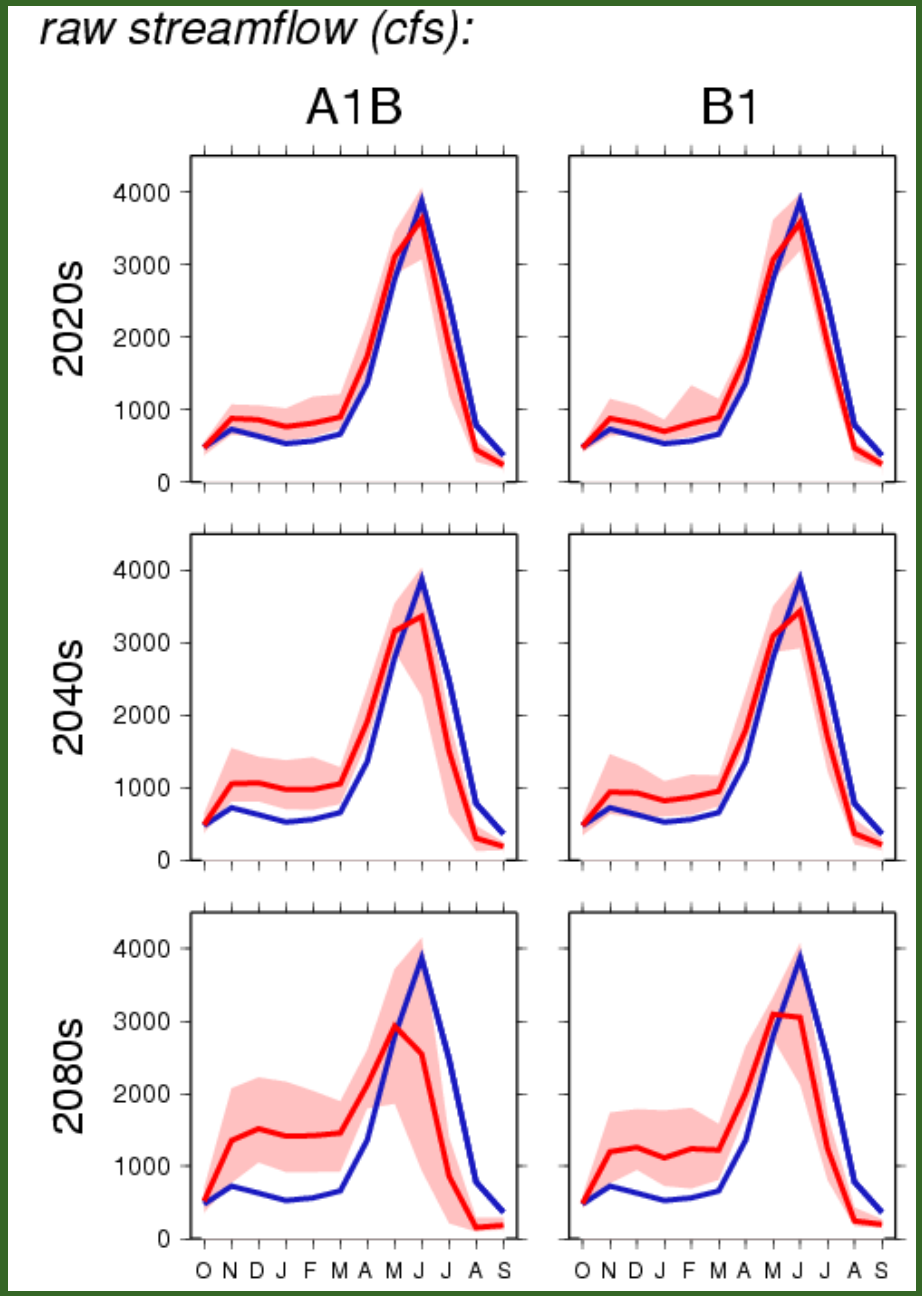
Impacts to the Stehekin River Basin


STEHEKIN RIVER AT STEHEKIN
Washington
N
5 Miles
CLIMATE
IMPACTS
GROUP

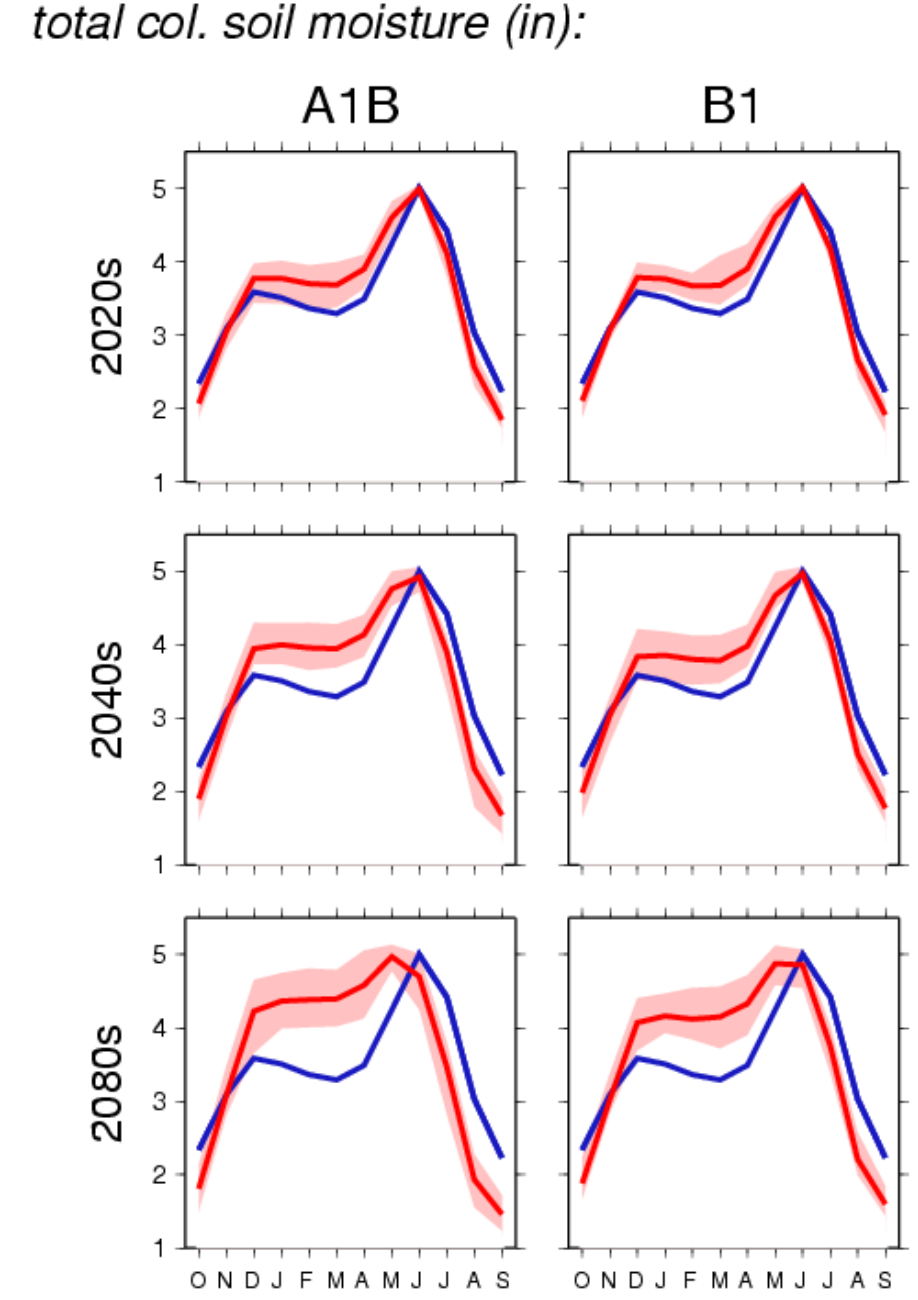
Snow

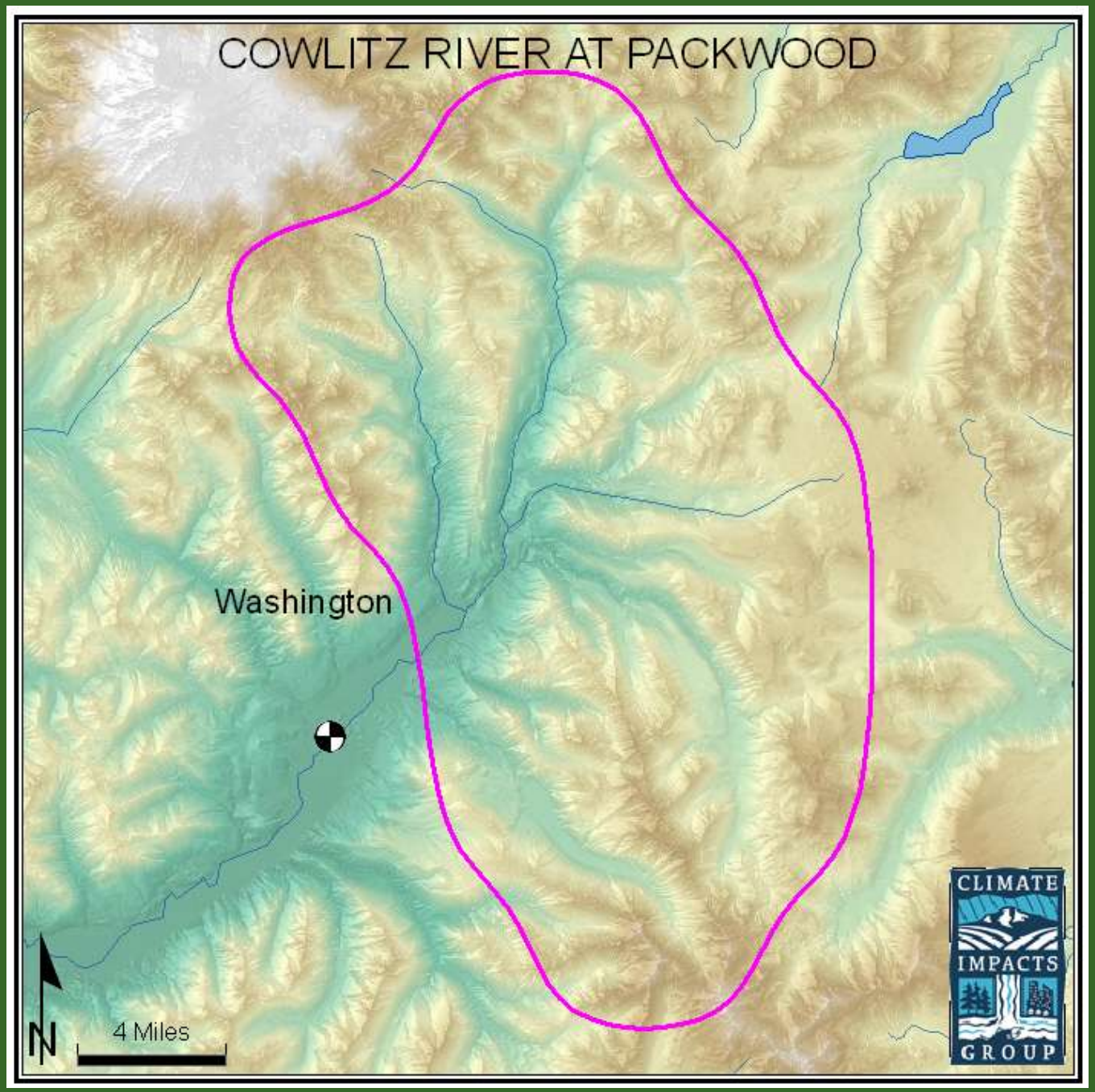
Flow


snow water equivalent (in):
A1B
B1
2020s
2040s
2080s
0
10
20
30
40
O N D J F M A M J J A S

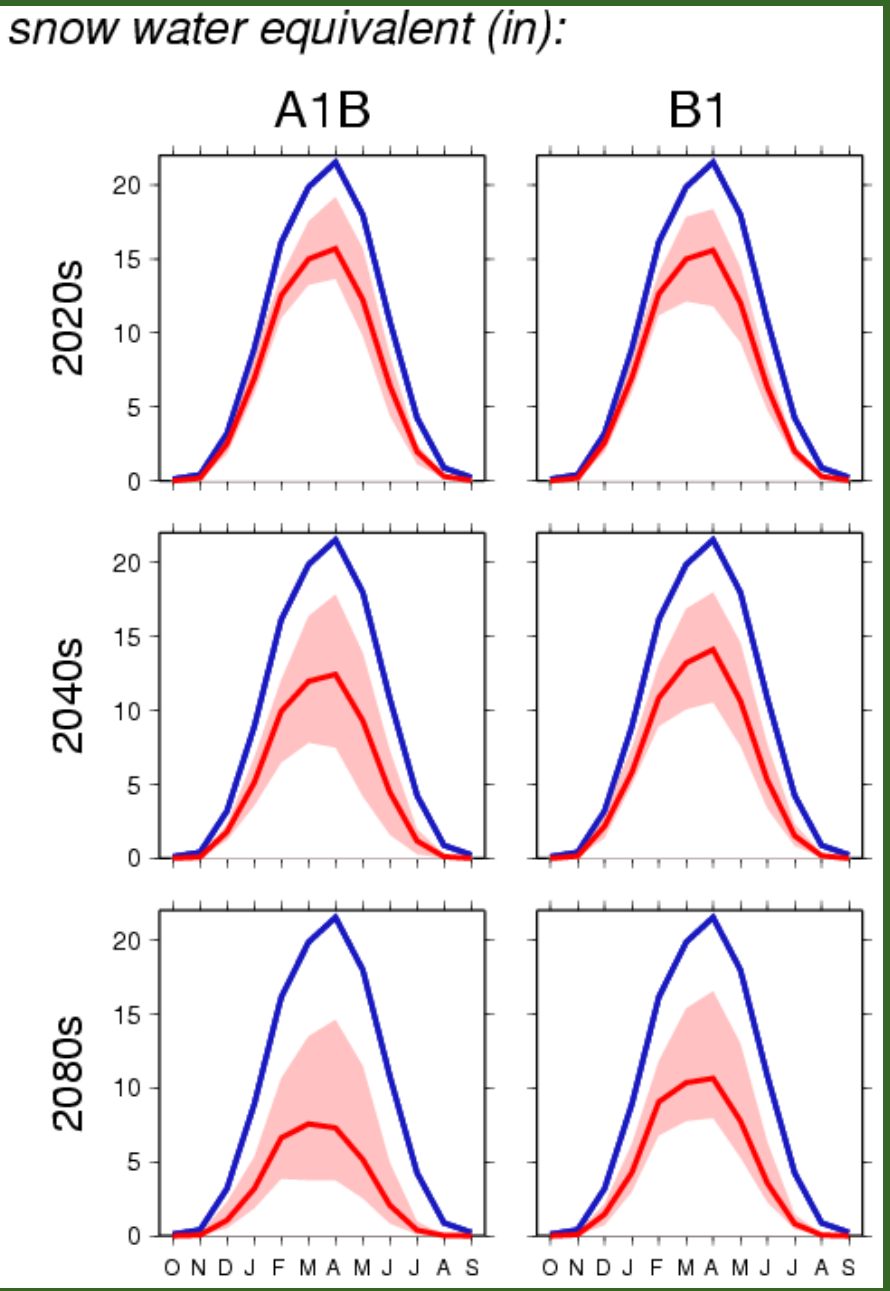

raw streamflow (cfs):
A1B
B1
2020s
2040s
2080s
0
1000
2000
3000
4000
O N D J F M A M J J A S

Soil Moisture

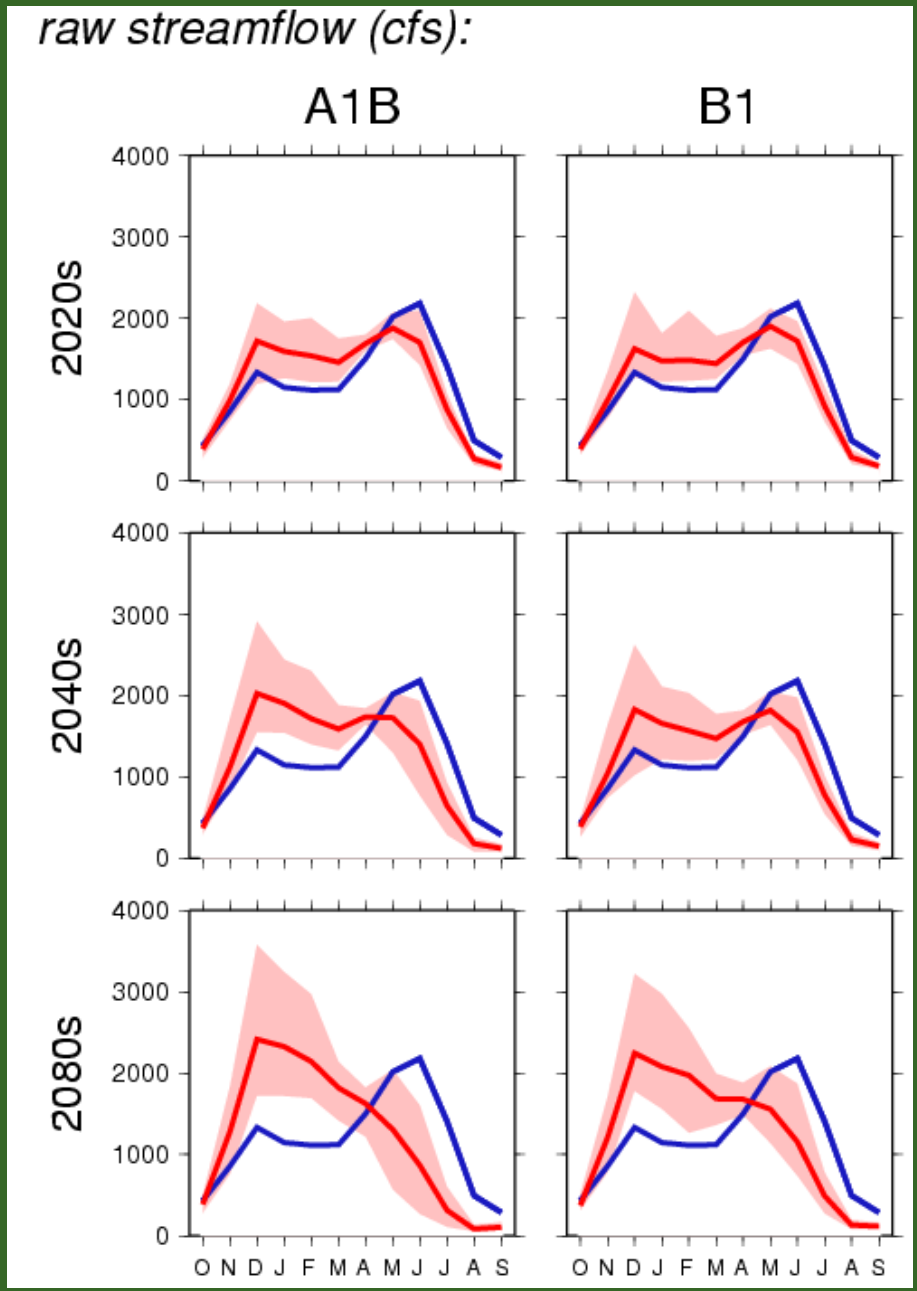



COWLITZ RIVER AT PACKWOOD
Washington
N
4 Miles
CLIMATE
IMPACTS
GROUP

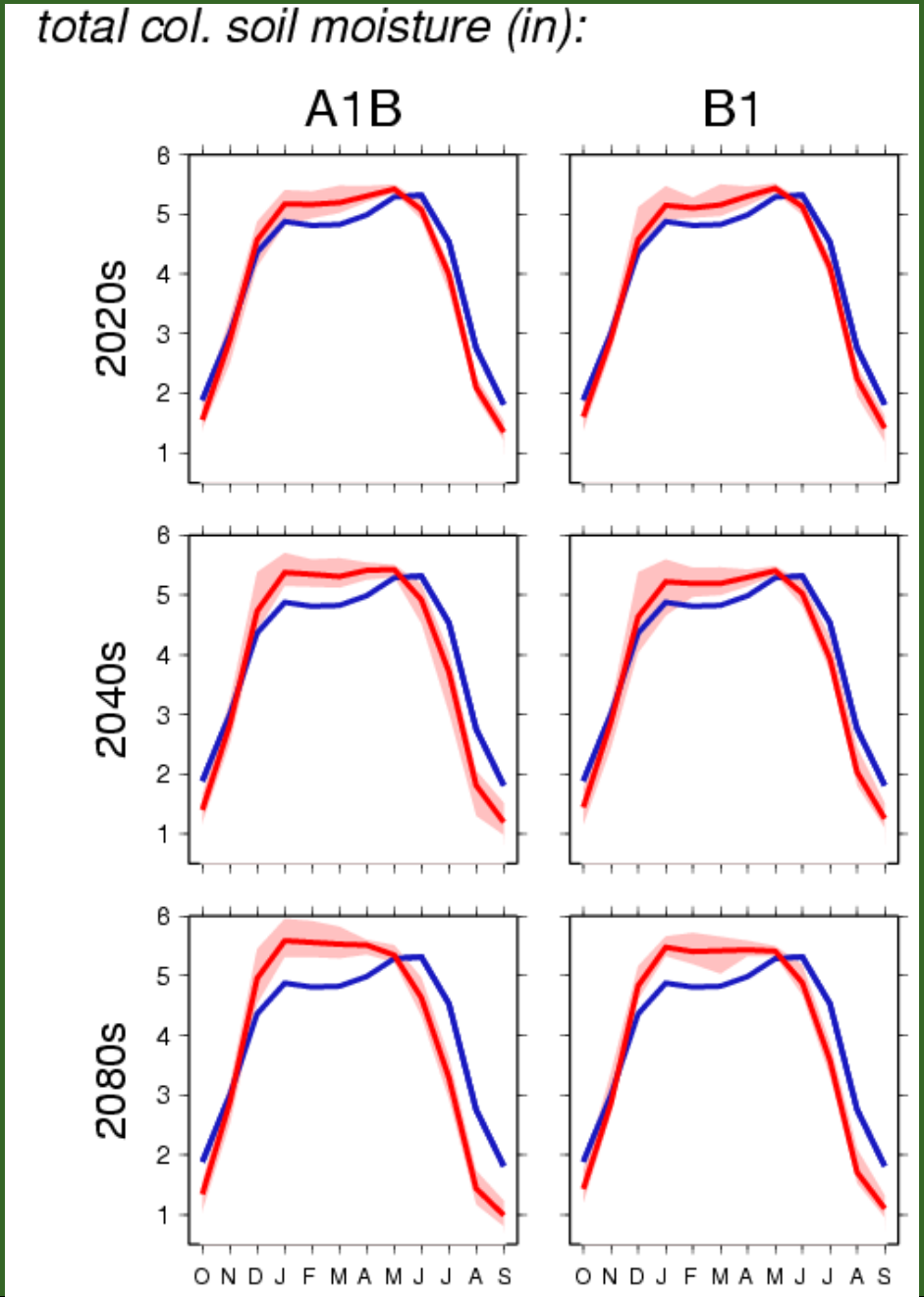
Snow


snow water equivalent (in):
A1B
B1
2020s
2040s
2080s
0
5
10
15
20
O N D J F M A M J J A S

Flow


raw streamflow (cfs):
A1B
B1
2020s
2040s
2080s
0
1000
2000
3000
4000
O N D J F M A M J J A S

Soil Moisture

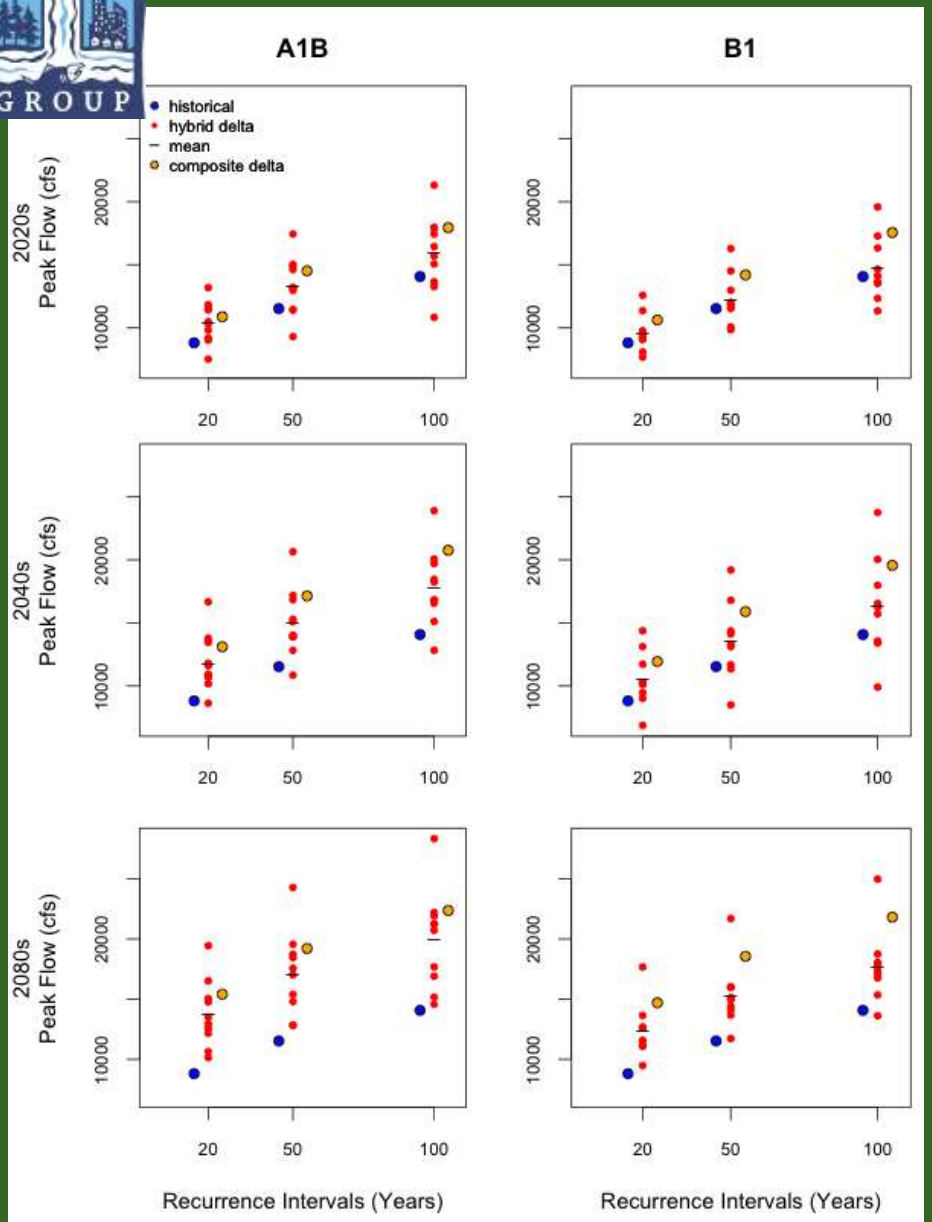


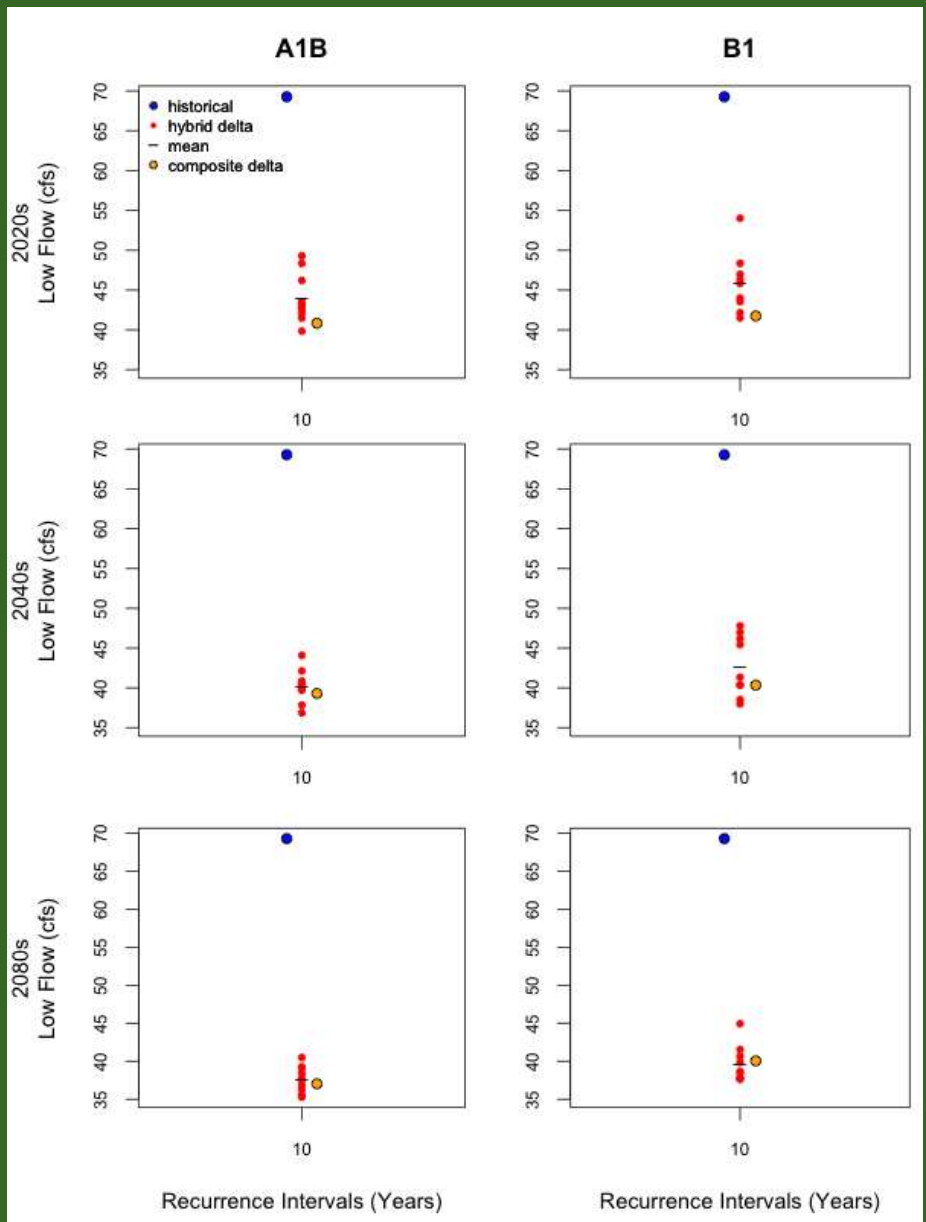
Changes in Hydrologic Extremes

http://www.nps.gov/mora/parknews/upload/floodPP.pdf

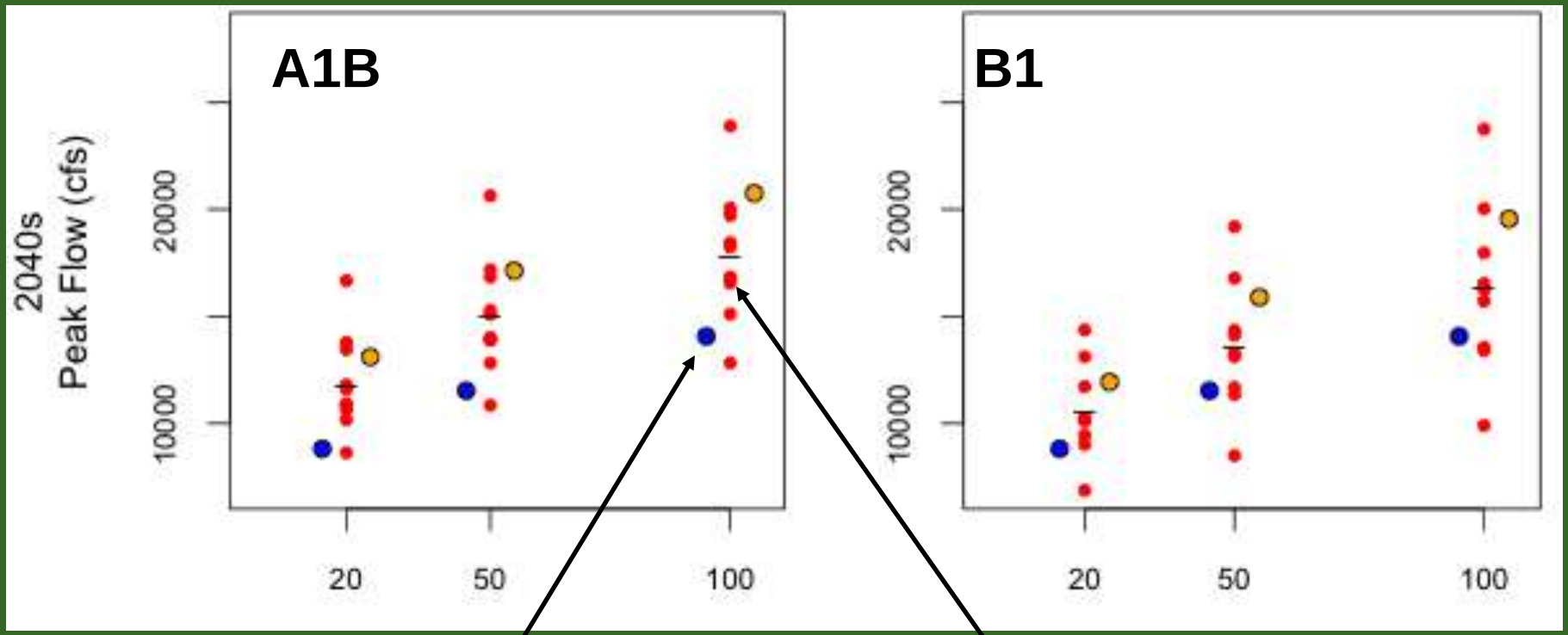
Q100

7Q10

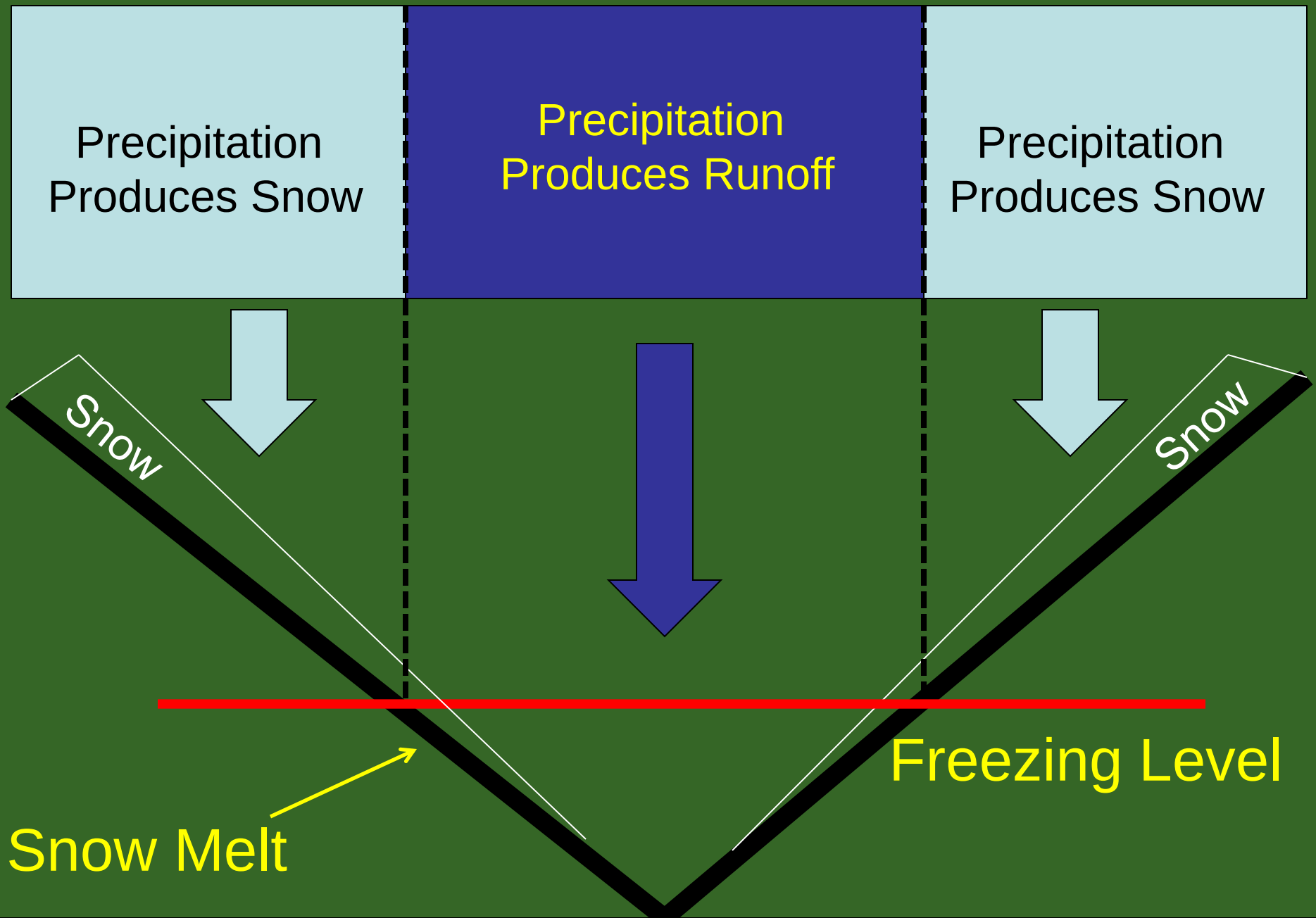

A1B
B1
historical
hybrid delta
mean
composite delta
2020s Peak Flow (cfs)
2040s Peak Flow (cfs)
2080s Peak Flow (cfs)
10000
20000
20
50
100
Recurrence Intervals (Years)


A1B
B1
historical
hybrid delta
mean
composite delta
2020s Low Flow (cfs)
2040s Low Flow (cfs)
2080s Low Flow (cfs)
35
40
45
50
55
60
65
70
10
Recurrence Intervals (Years)

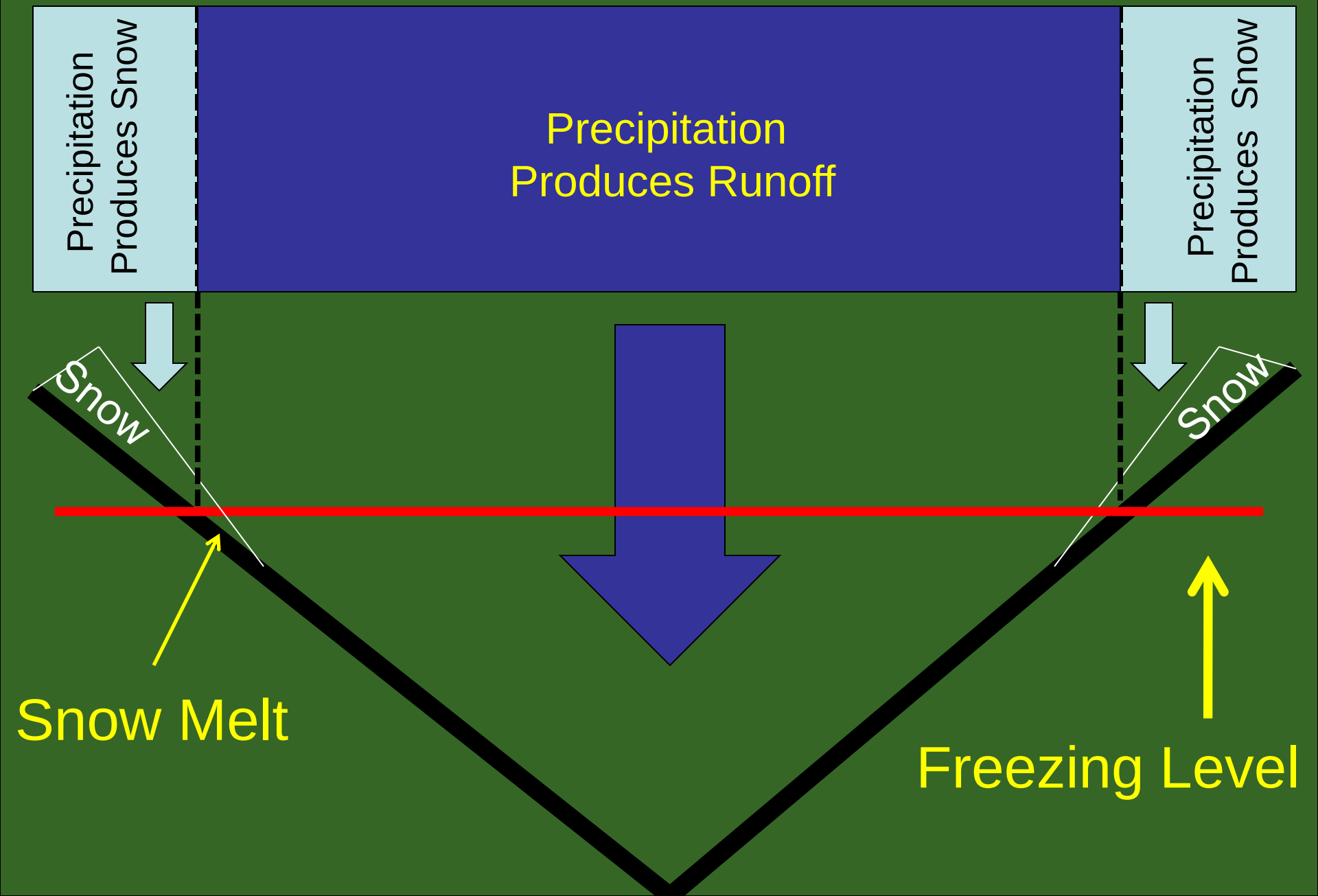
2040s Changes in Flood Risk (Cowlitz at Packwood)



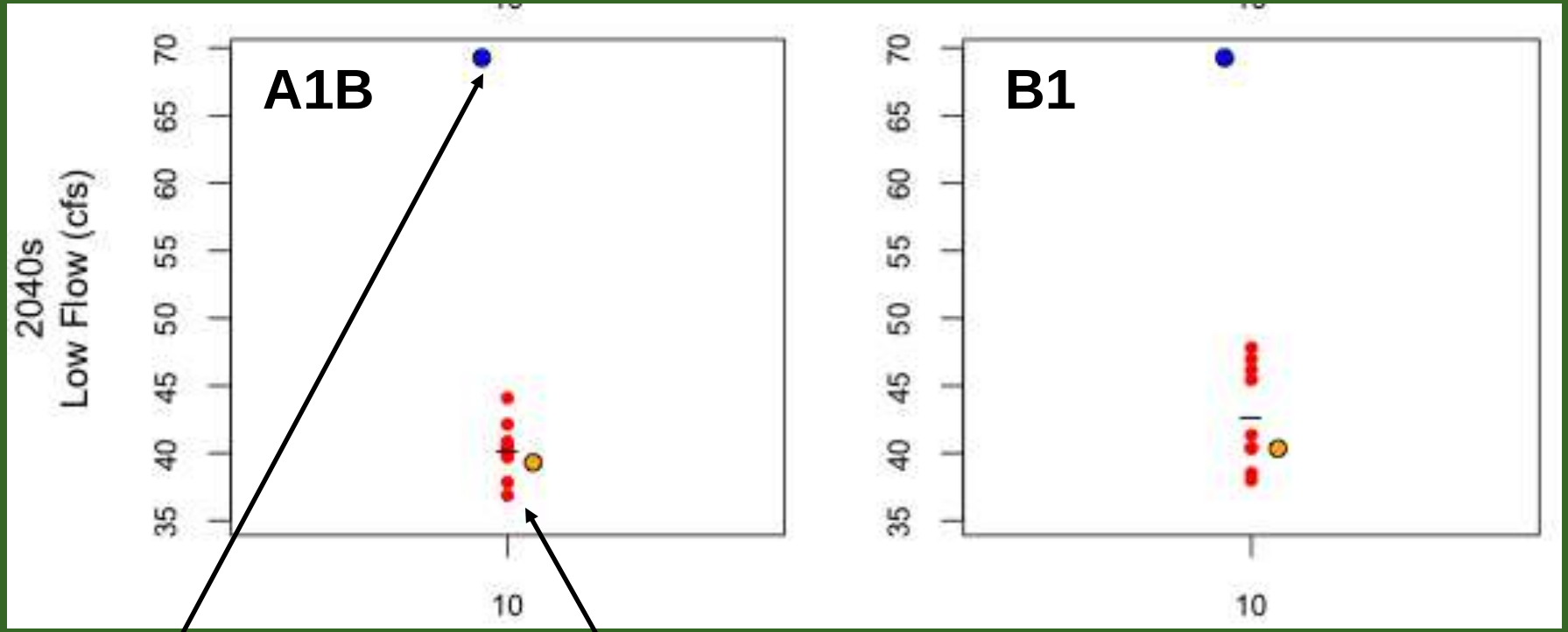
Schematic of a Cool Climate Flood



Schematic of a Warm Climate Flood



2040s Changes in Extreme Low Flows (Cowlitz at Packwood)

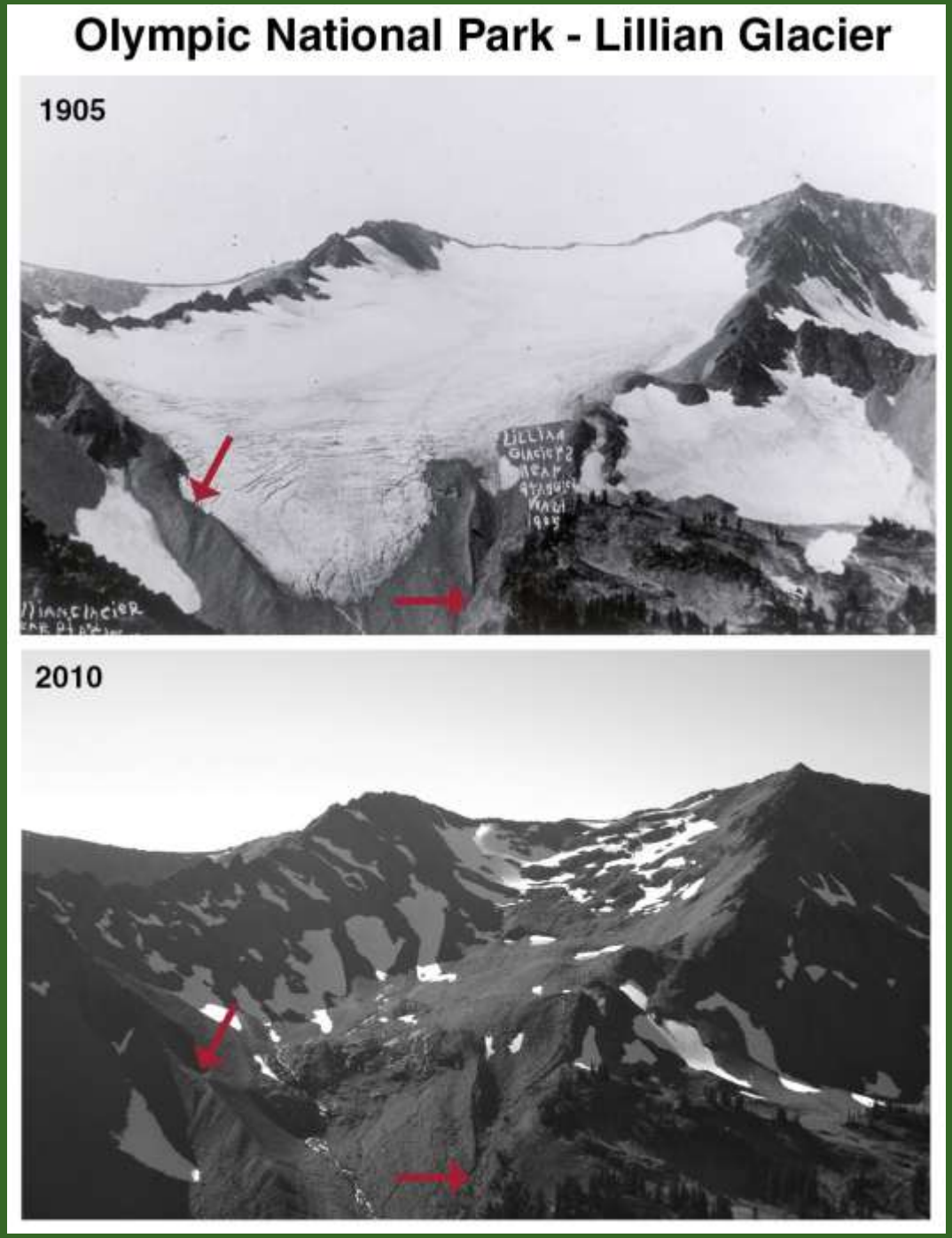


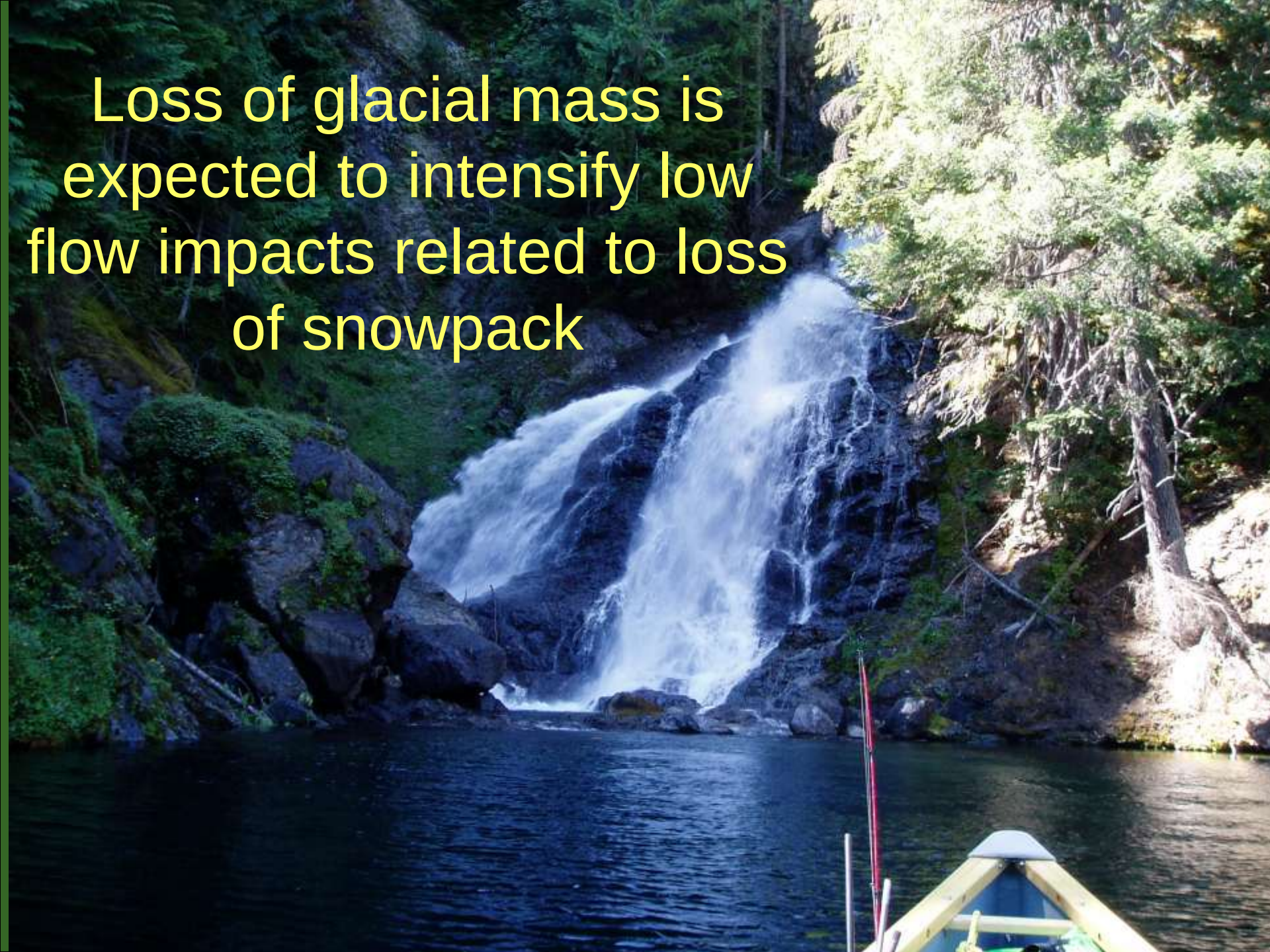
Historical

10 Member Ensemble
Using the Hybrid Delta
Downscaling Approach

PNW Glaciers are rapidly receding.

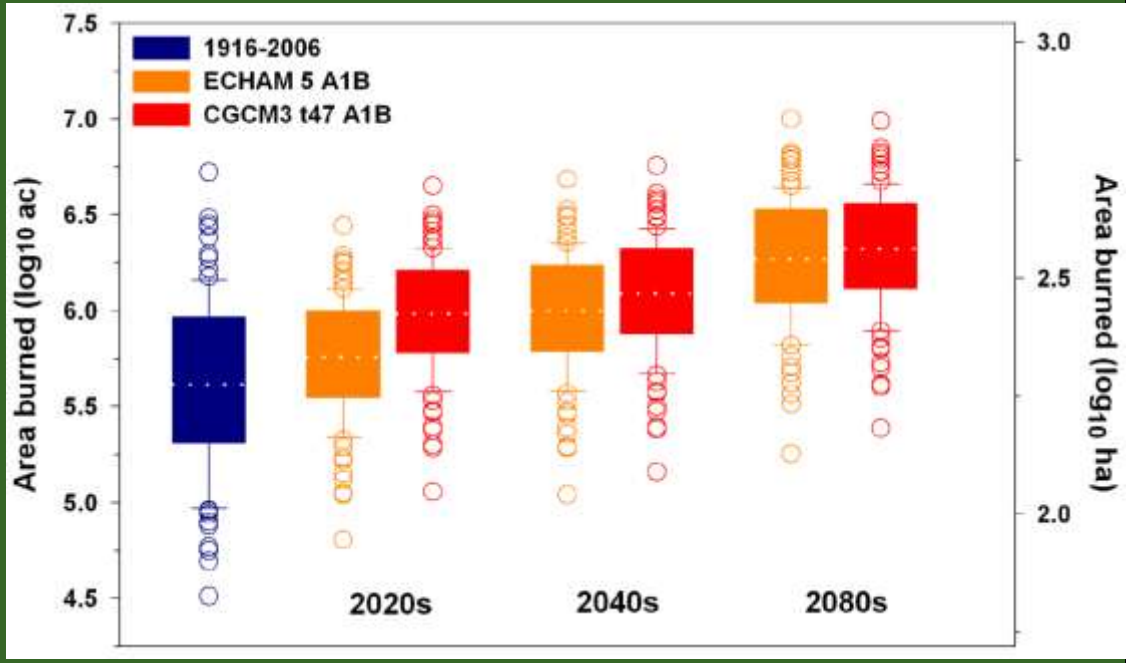
Some, like Lillian Glacier in the ONP, are already gone.




Loss of glacial mass is expected to intensify low flow impacts related to loss of snowpack

Access Related Impacts

Forest Disturbance



Projected Area Burned in WA

Littell, J.S., E.E. Oneil, D. McKenzie, J.A. Hicke, J.A. Lutz, R.A. Norheim, and M.M. Elsner. 2010. Forest ecosystems, disturbance, and climatic change in Washington State, USA. Climatic Change 102(1-2): 129-158, doi: 10.1007/s10584-010-9858-x

Damage to Roads from River Flooding

Cascade River Road, 2006

Nisqually River at Sunshine Point (Nov, 2006)

http://www.nps.gov/mora/parknews/upload/flooddamagev3.pdf

Sediment Impacts

RAINIER'S ROCKS ARE FILLING RIVERBEDS

Dr. Tim Abbe | 01.04.10 | Restoration | 2 Comments

Paul Kennard, NPS [by Steve Ringman, Seattle Times]

The fallout from Mount Rainier's shrinking glaciers is beginning to roll downhill, and nowhere is the impact more striking than on the volcano's west side.

By Sandi Doughton
Seattle Times science reporter

Related:
flows (PDF)
Archive | State's shrinking glaciers: Going ... going ... gone? (2006)

The fallout from Mount Rainier's shrinking glaciers is beginning to roll downhill, and nowhere is the impact more striking than on the volcano's west side.

"This is it in spades," said Park Service geologist Paul Kennard, scrambling up a 10-foot-tall mass of dirt and boulders bulldozed back just enough to clear the road.

As receding glaciers expose crumbly slopes, vast amounts of gravel and sediment are being sluiced into the rivers that flow from the Northwest's tallest peak. Much of the material sweeps down in rain-driven slurries called debris flows, like those that repeatedly have slammed Mount Rainier National Park's Westside Road.

http://www.abbegeomorphology.com/?p=69

Changing Landslide Risks

Winter Road Closures and Snow Removal

Plowing the Road at Hurricane Ridge

Winter Recreation

Summer Recreation

Lake Recreation