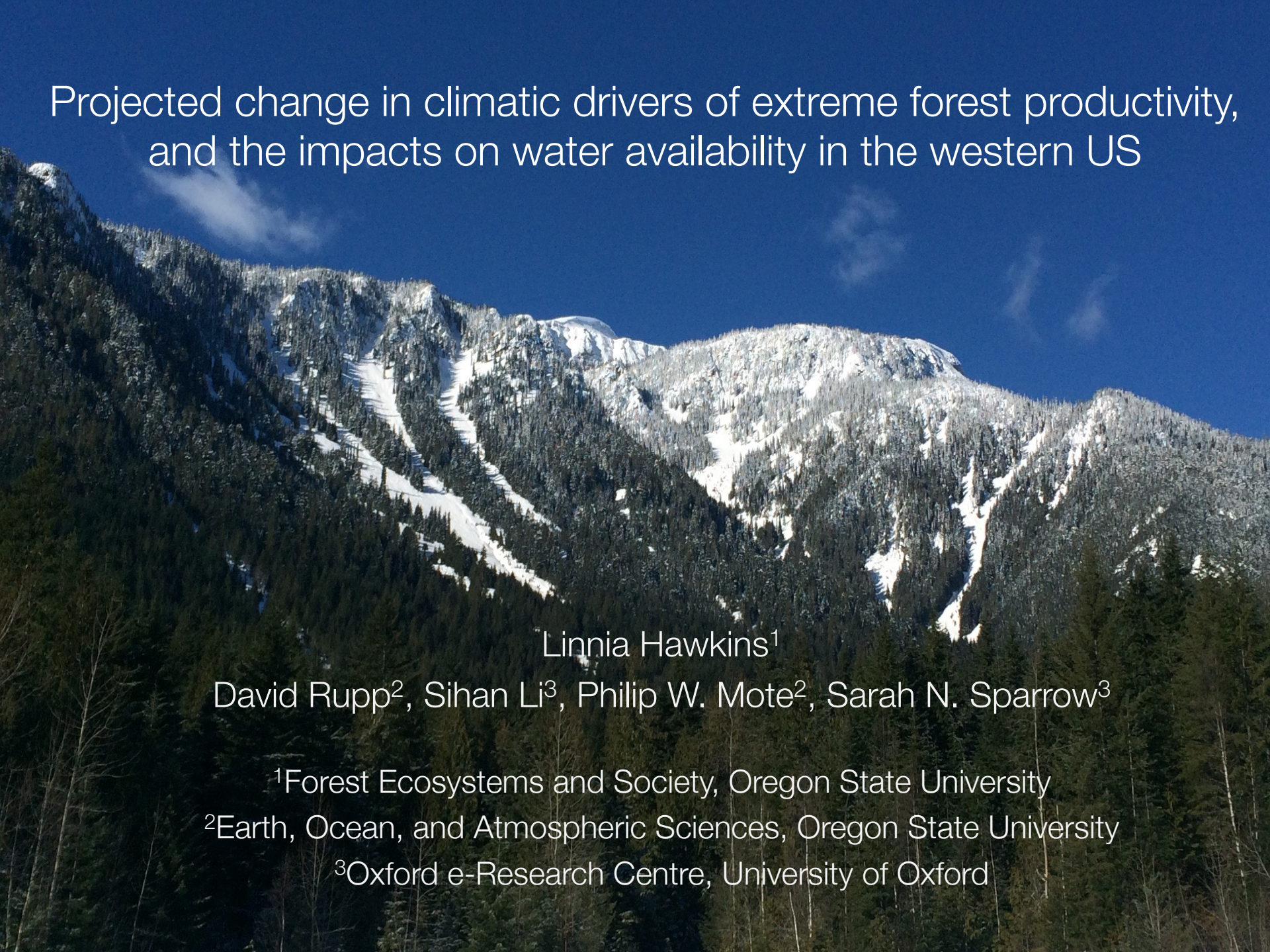
Projected change in climatic drivers of extreme forest productivity, and the impacts on water availability in the western US



Linnia Hawkins[1]

David Rupp[2], Sihan Li[3], Philip W. Mote[2], Sarah N. Sparrow[3]

[1]Forest Ecosystems and Society, Oregon State University

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Forest Vulnerability in a Changing Climate

esa ECOSPHERE

On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene

Craig D. Allen,[1,†] David D. Breshears,[2] and Nate G. McDowell[3]

REVIEW ARTICLE
PUBLISHED ONLINE: 9 SEPTEMBER 2012 | DOI: 10.1038/NCLIMATE1635
nature climate change

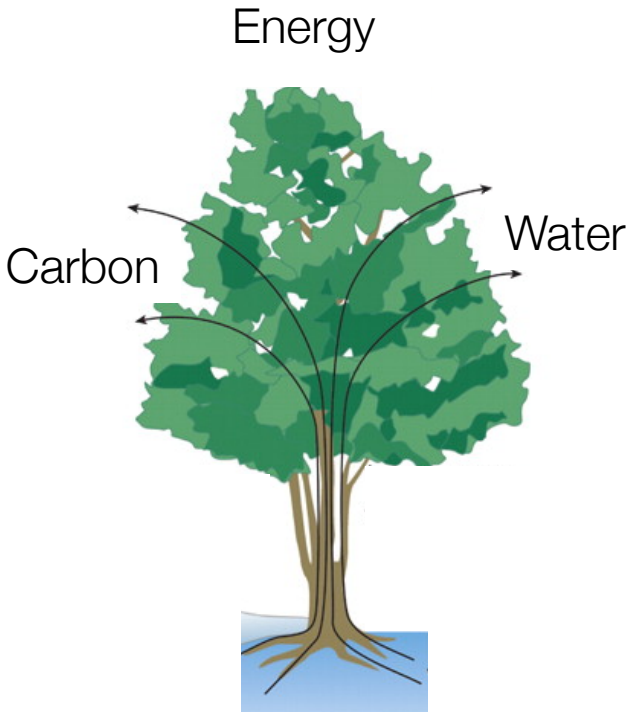
Consequences of widespread tree mortality triggered by drought and temperature stress

William R. L. Anderegg[1,2*], Jeffrey M. Kane[3] and Leander D. L. Anderegg[2]

New Phytologist

Research frontiers for improving our understanding of drought-induced tree and forest mortality

Henrik Hartmann, Catarina F. Moura, William R. L. Anderegg, Nadine K. Ruehr, Yann Salmon, Craig D. Allen, Stefan K. Arndt, David D. Breshears, Hendrik Davi, David Galbraith, Katinka X. Ruthrof, Jan Wunder, Henry D. Adams, Jasper Bloemen, Maxime Cailleret, Richard Cobb, Arthur Gessler, Thorsten E. E. Grams, Steven Jansen, Markus Kautz, Francisco Lloret, Michael O'Brien

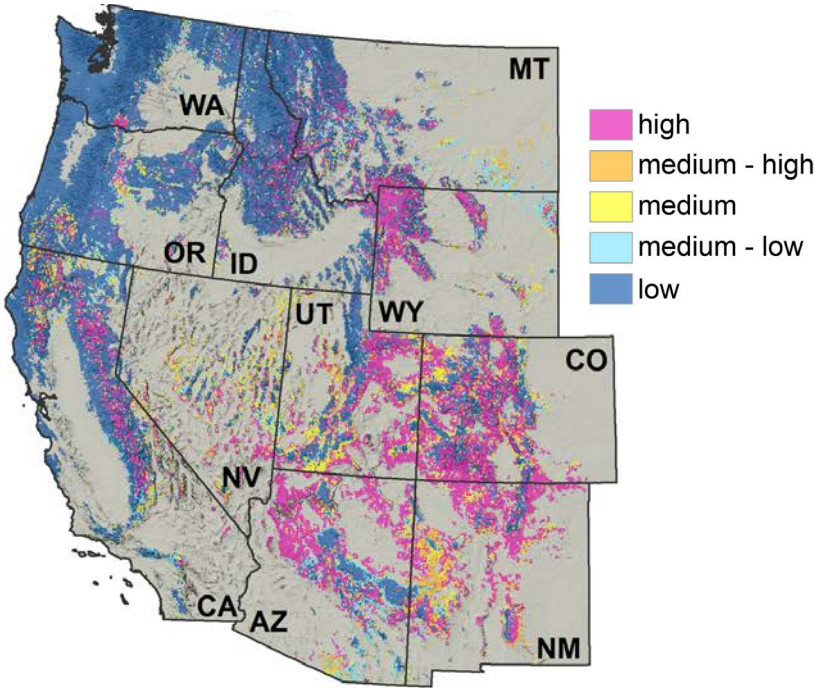


Forest Vulnerability in a Changing Climate

Drought & Temperature Stress

- decrease productivity
- increase vulnerability to mortality
- biotic and abiotic interactions

Drought or Fire
~2040



(Buotte *et al.,* 2019; *Global Change Biology)*

Forest productivity extremes in a large ensemble

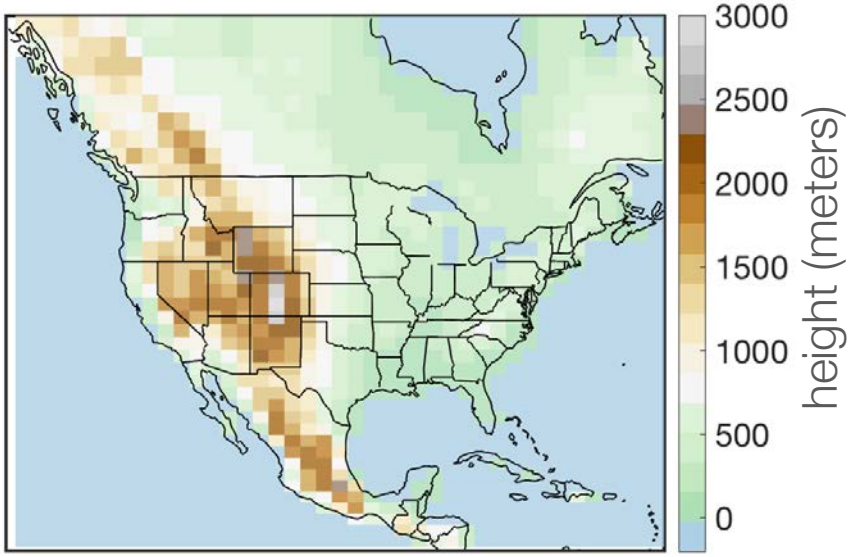
(1) How are low summer NPP extremes projected to change?

(2) What are the climatic drivers of low summer NPP extremes, and are they projected to change?

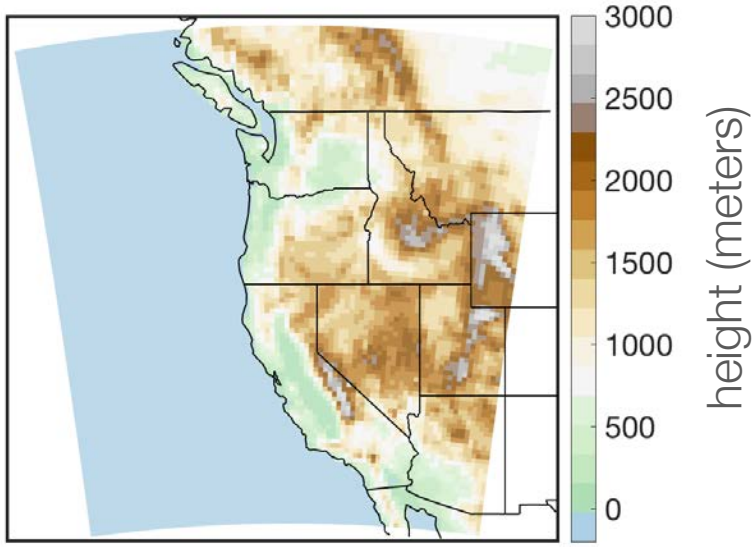
(3) What are the impacts of changes in NPP extremes on soil moisture?

Modeling Framework

Global Climate Model (1.875°x1.25°)
HadAM3p – MOSES2



Regional Climate Model (25km)
HadRM3p – MOSES2



1–way 20-min coupling

Prescribed SST's

Modeling Framework

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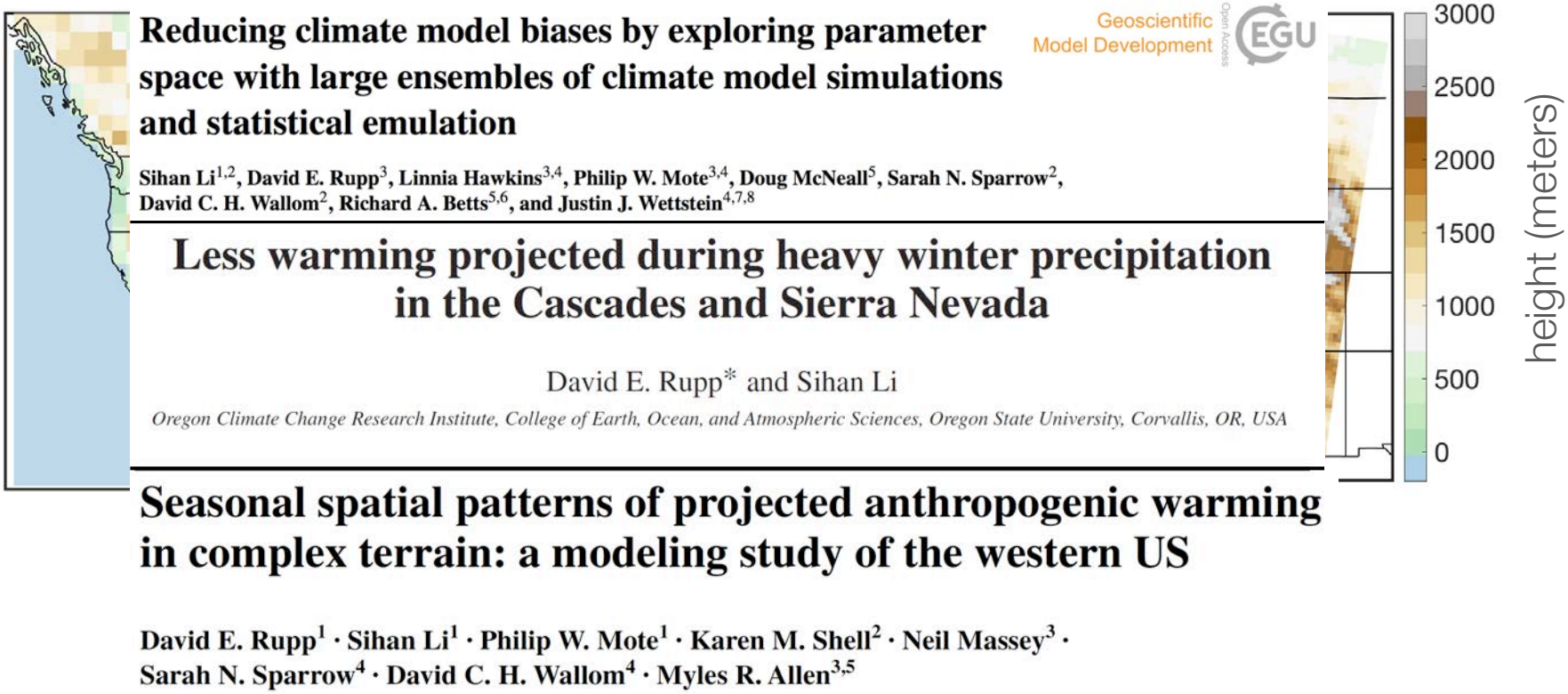
HadRM3p – MOSES2



Reducing climate model biases by exploring parameter space with large ensembles of climate model simulations and statistical emulation

Geoscientific Model Development

Sihan Li[1,2], David E. Rupp[3], Linnia Hawkins[3,4], Philip W. Mote[3,4], Doug McNeall[5], Sarah N. Sparrow[2], David C. H. Wallom[2], Richard A. Betts[5,6], and Justin J. Wettstein[4,7,8]

Less warming projected during heavy winter precipitation in the Cascades and Sierra Nevada

David E. Rupp* and Sihan Li

Oregon Climate Change Research Institute, College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA

Seasonal spatial patterns of projected anthropogenic warming in complex terrain: a modeling study of the western US

David E. Rupp[1] · Sihan Li[1] · Philip W. Mote[1] · Karen M. Shell[2] · Neil Massey[3] · Sarah N. Sparrow[4] · David C. H. Wallom[4] · Myles R. Allen[3,5]

Ensemble Design

Historical
(1987-2016)
3 model parameterizations
80 initial land-atmosphere conditions
7200 model years

Future *RCP 8.5*
(2047-2076)
3 model parameterizations
80 initial land-atmosphere conditions
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Ensemble Design

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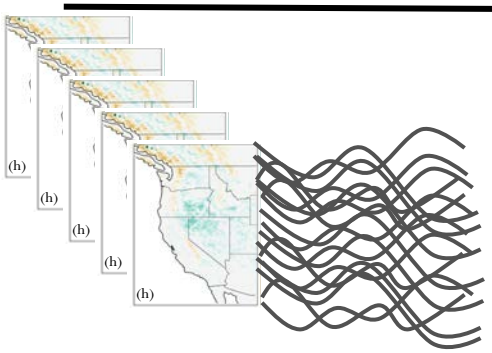
1987



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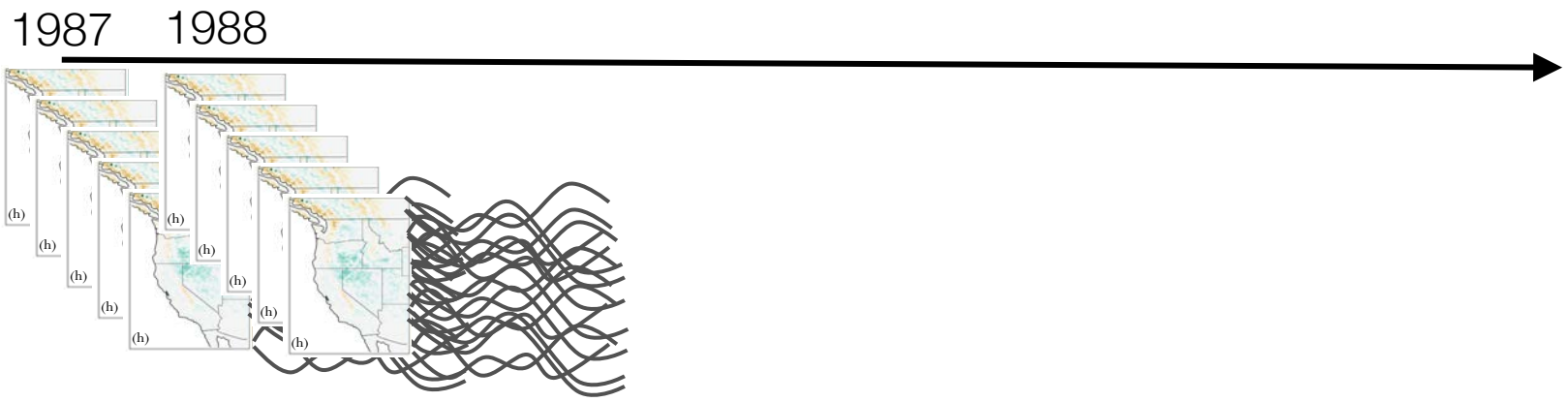

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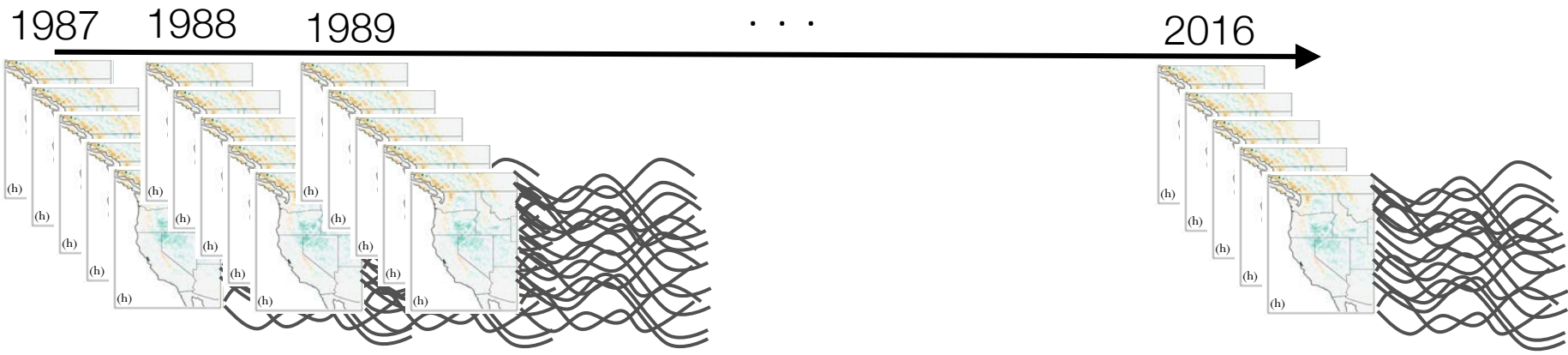
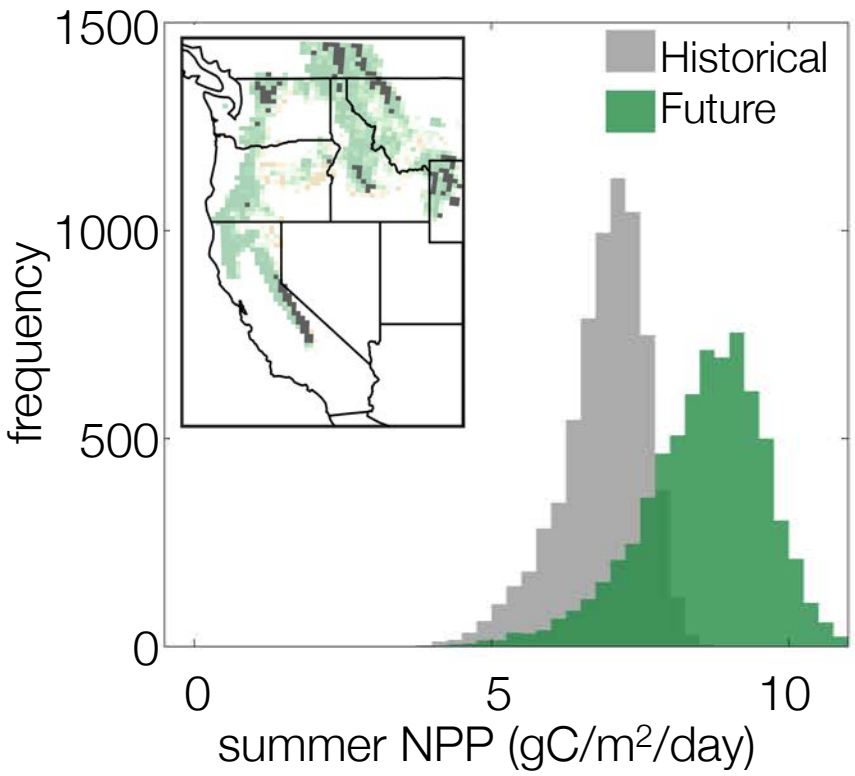


Projected Change in Forest Productivity

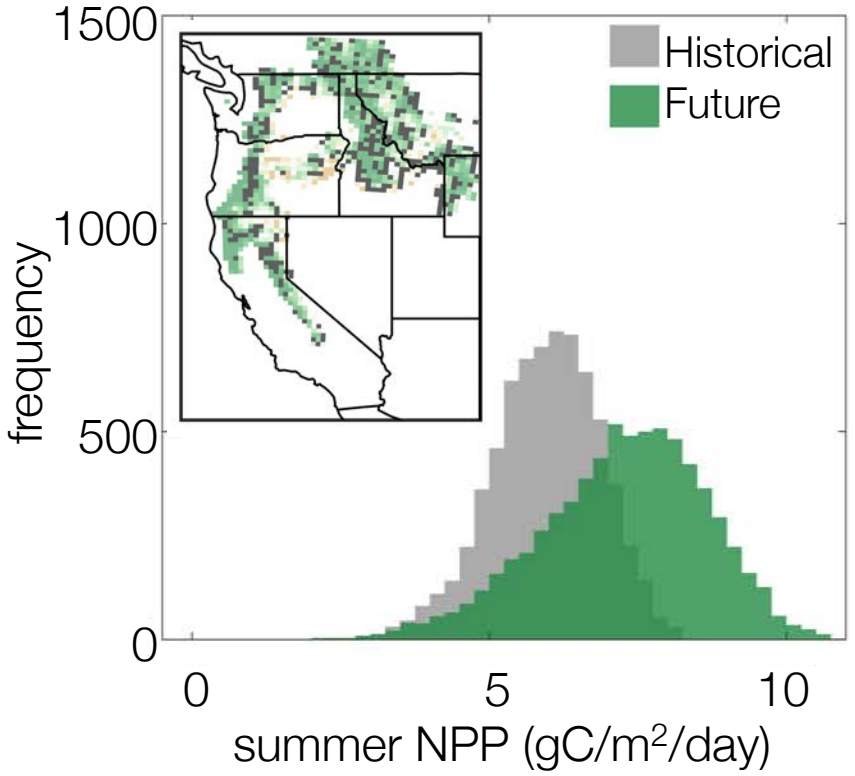
Retains Snowpack

April 1st SWE > 100mm

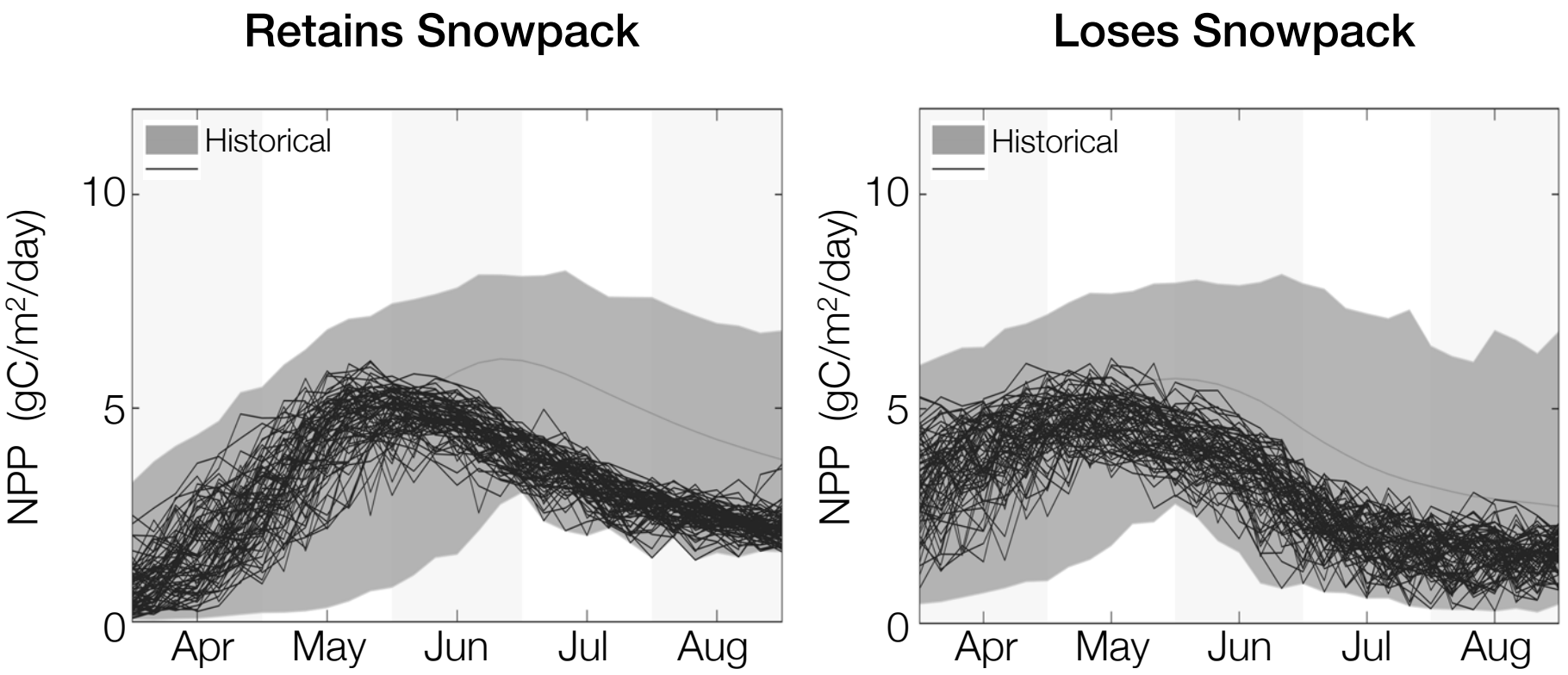


Loses Snowpack

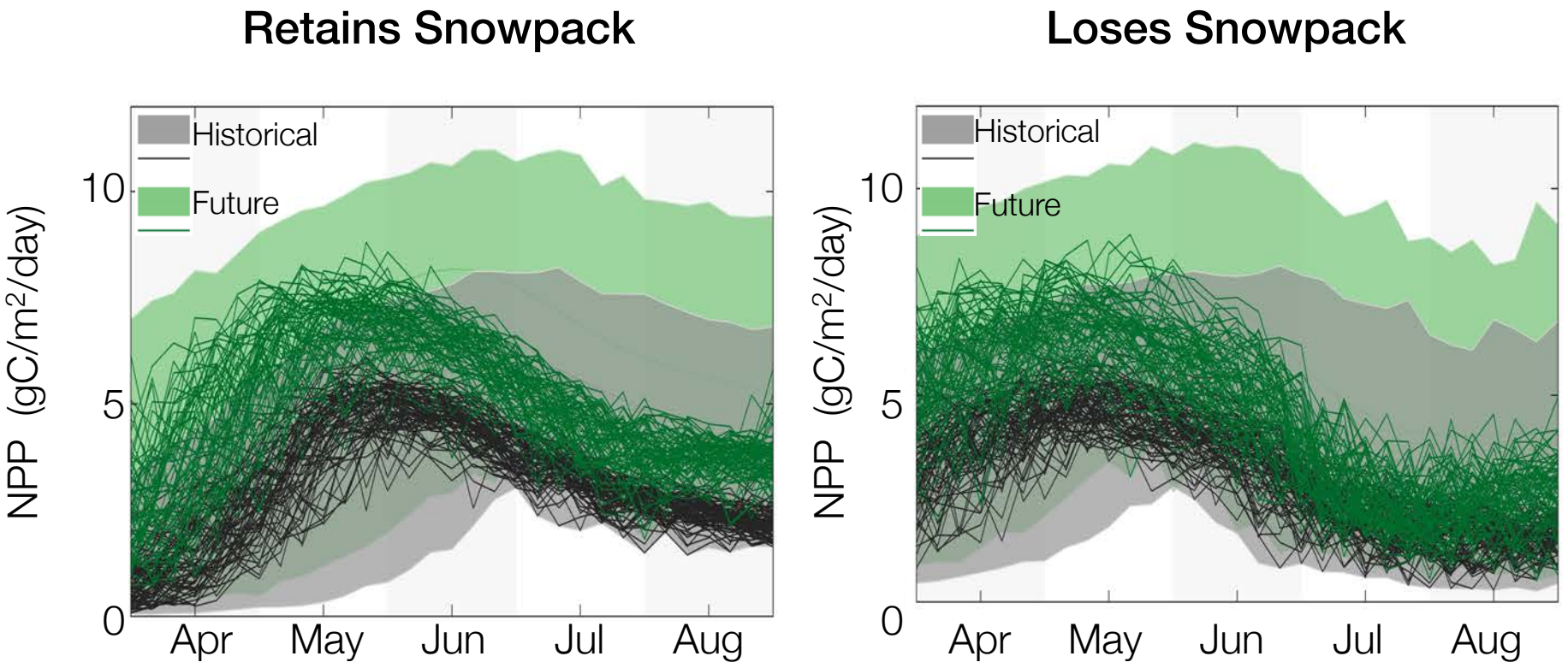
100mm < April 1st SWE < 10mm



Diagnosing climate drivers of low summer NPP



Diagnosing climate drivers of low summer NPP



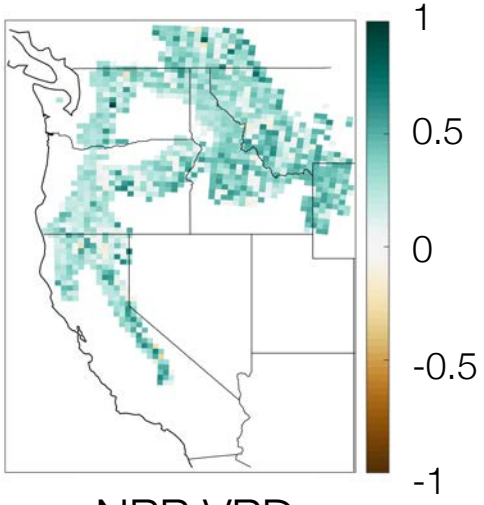
Diagnosing climate drivers of low summer NPP

Winter – precipitation

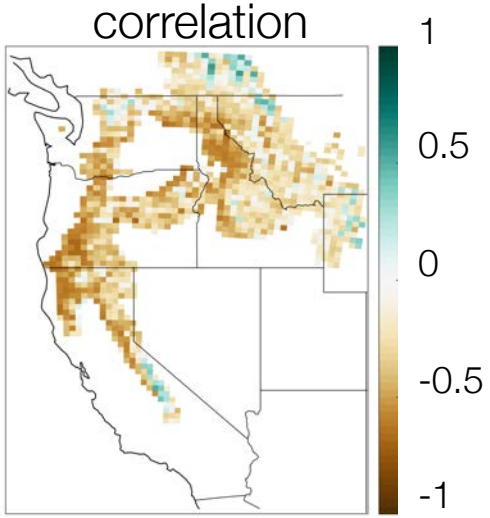
Spring – precipitation
– temperature
– NPP
– soil moisture

Summer – precipitation
– soil moisture
– VPD

NPP:SOILM correlation

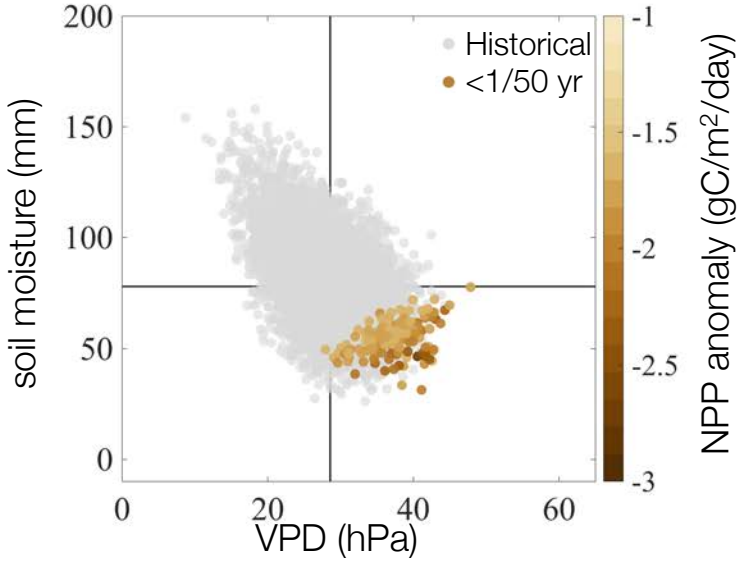


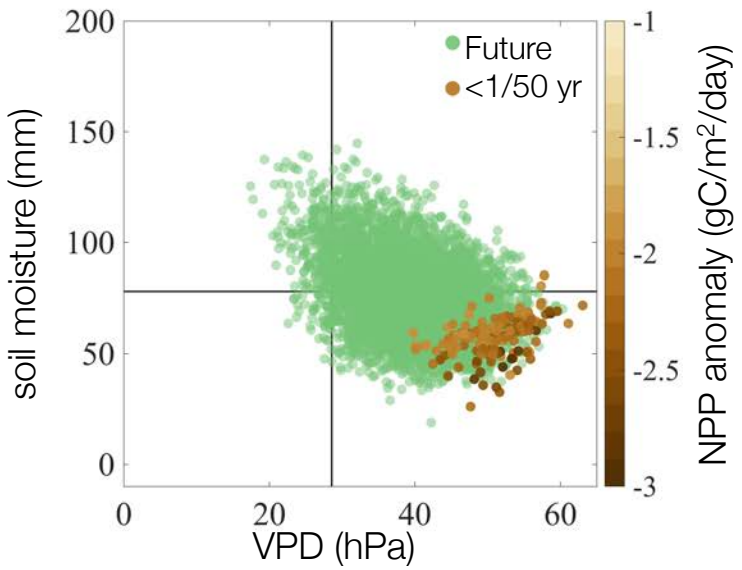
NPP:VPD correlation



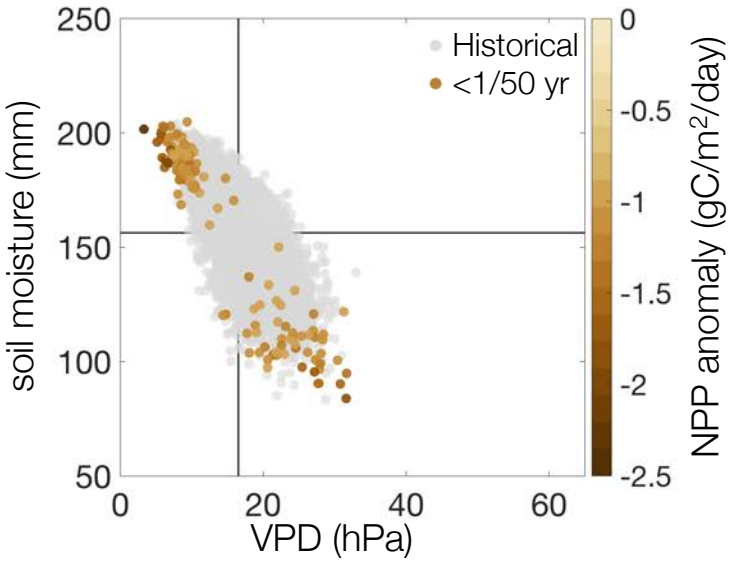
Change in climate drivers of extremes

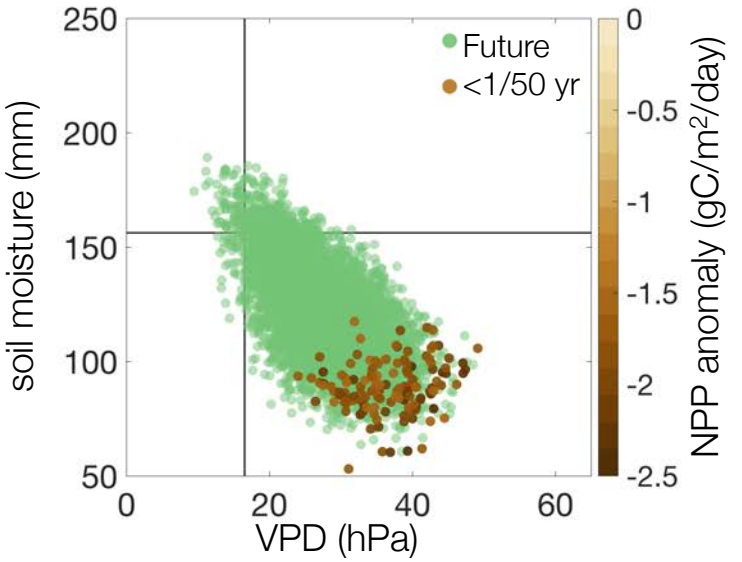
Loses snowpack





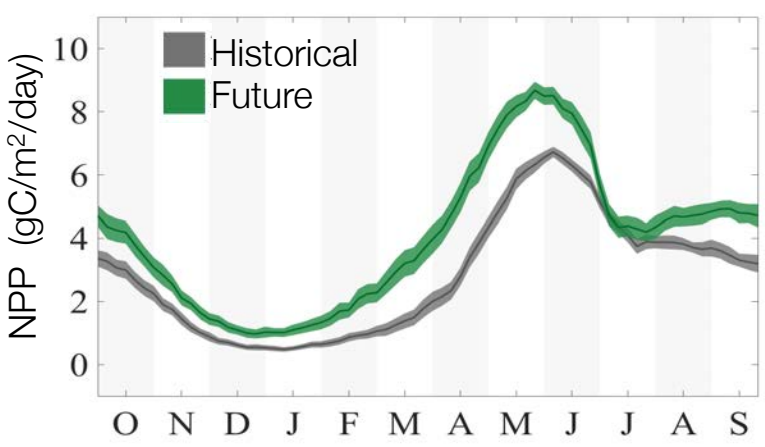
Retains snowpack

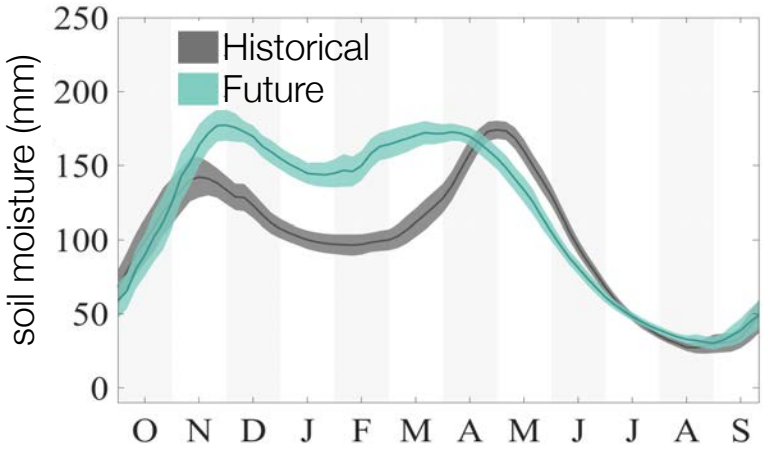




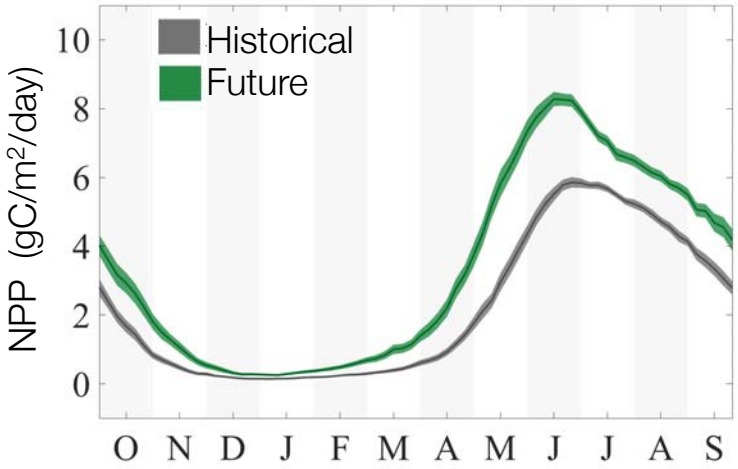
Impacts on water availability

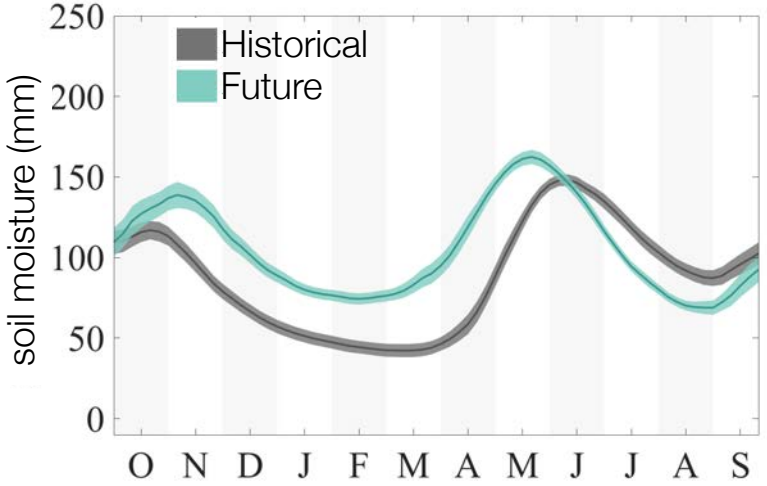
Loses snowpack





Retains snowpack





Take Away

(1) Projected change in mean summer NPP is larger than low NPP extremes
– interaction with snowpack decline

(2) Cool temperature constraints on growth are relaxed at high elevations.
Increased summer VPD and decreased soil moisture intensify low NPP extremes.

(3) Changes in vegetation functioning impacts projected changes in soil moisture.

Future directions

(1) Perturbed parameter experiments in regional dynamic downscaling?
AGU session: GEC – PPE's in Earth System Modeling

(2) Influence of vegetation/soil state on internal variability?


Thank you