Extreme Precipitation & Snowpack: Model and Observations

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Ruby Leung
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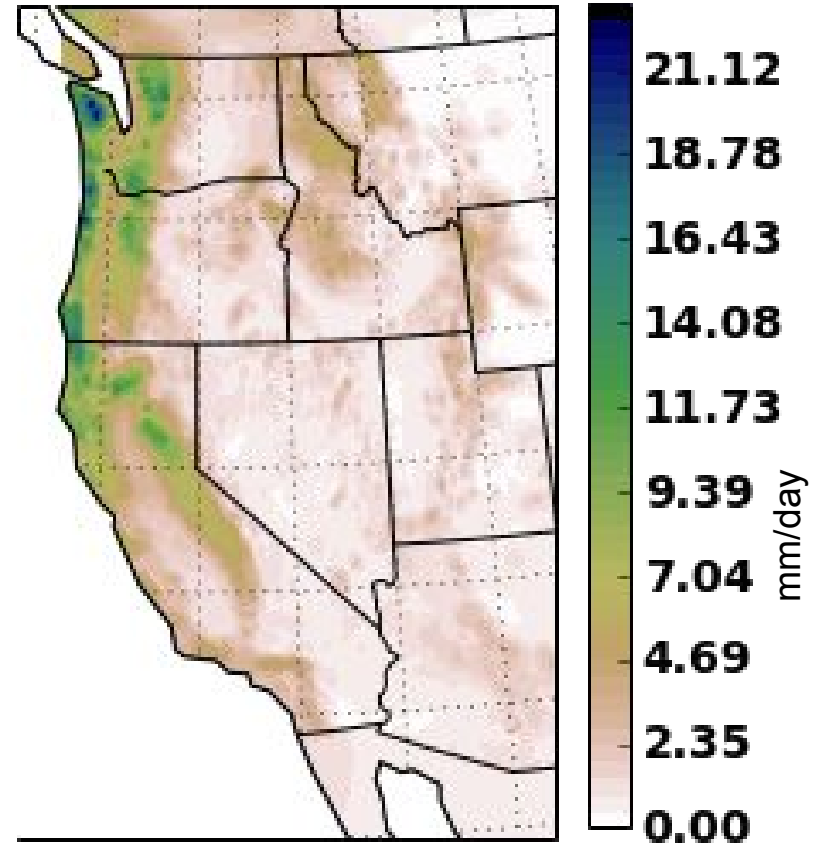
* PhD Candidate
University of Washington, Department of Atmospheric Sciences

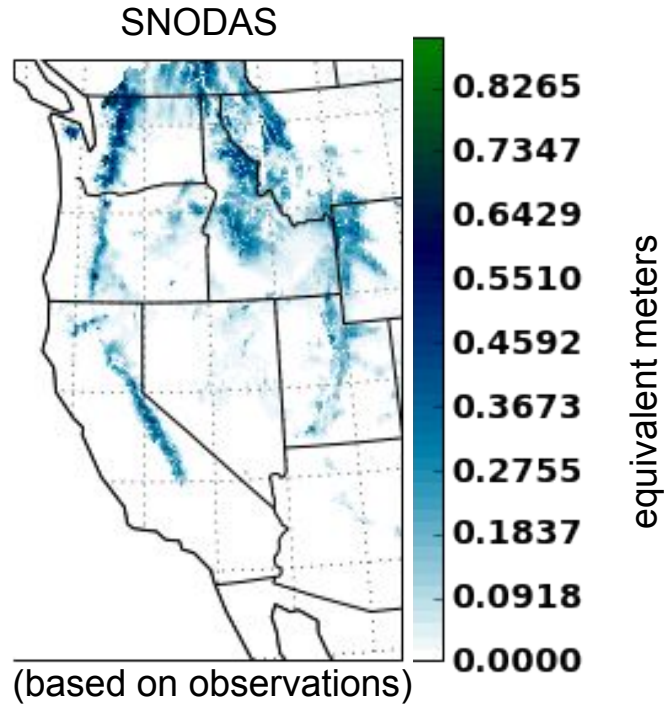# In western North America, topography is important

because of orographic precipitation and rain shadows

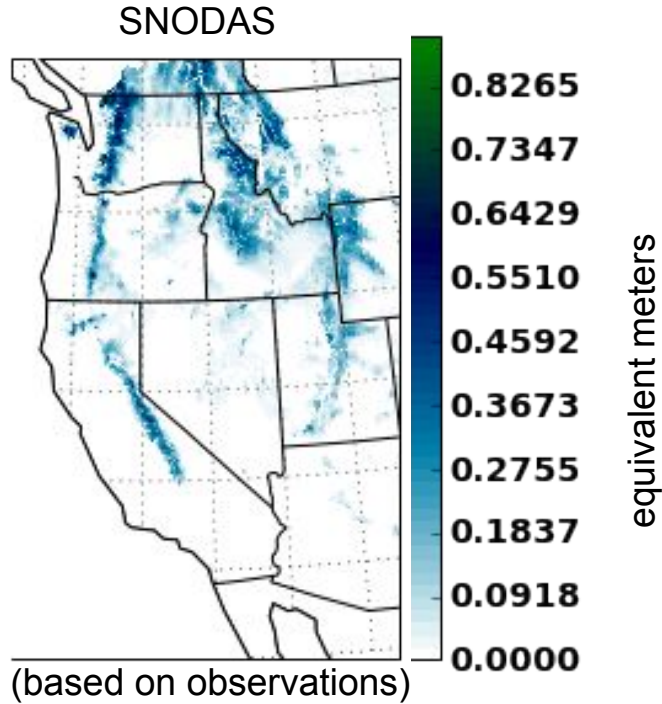

winter mean, NLDAS-2 forcing dataset

and where it is cold enough for snow.

* winter mean SWE

SNODAS

(based on observations)

Global models don't have the resolution.

* winter mean SWE

SNODAS

CAM5 AMIP (1°)

equivalent meters

0.8265
0.7347
0.6429
0.5510
0.4592
0.3673
0.2755
0.1837
0.0918
0.0000

(based on observations)

(typical global model)

We also need to know about the large-scale.

to understand where extreme precipitation comes from.
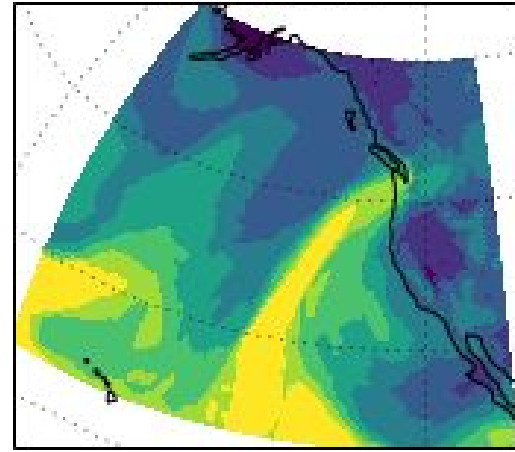
cm (total column precipitable water)

Internal Variability

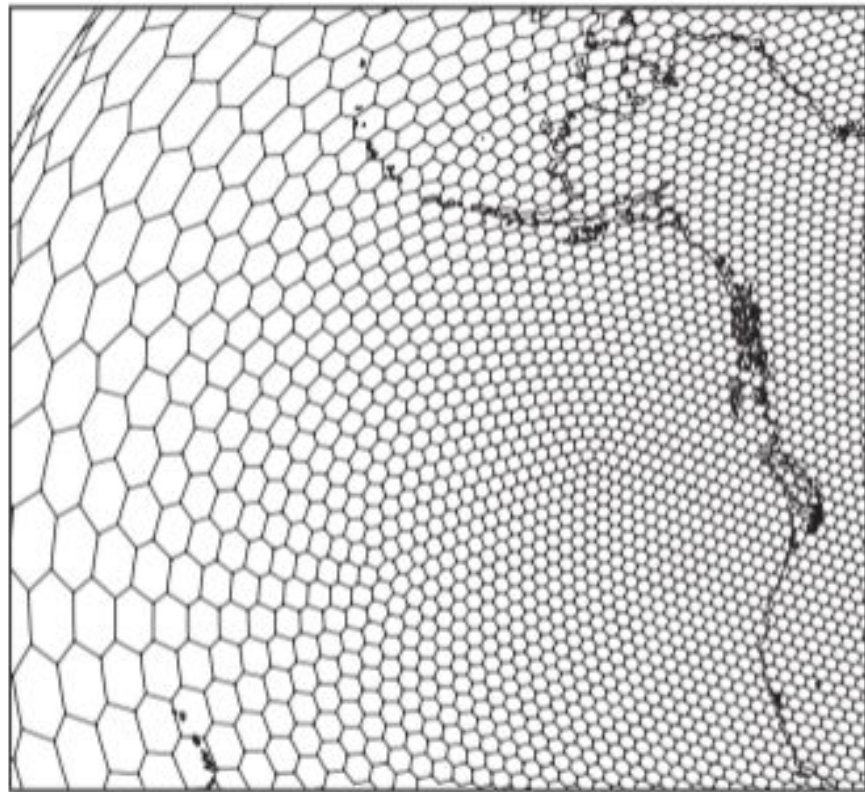Variations internal to the climate, not forced like warming that is forced by Greenhouse gases.

We can quantify internal variability with models

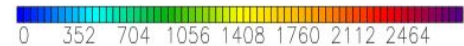...ensembles of simulations that are identical but for random tweaks of initial conditions.
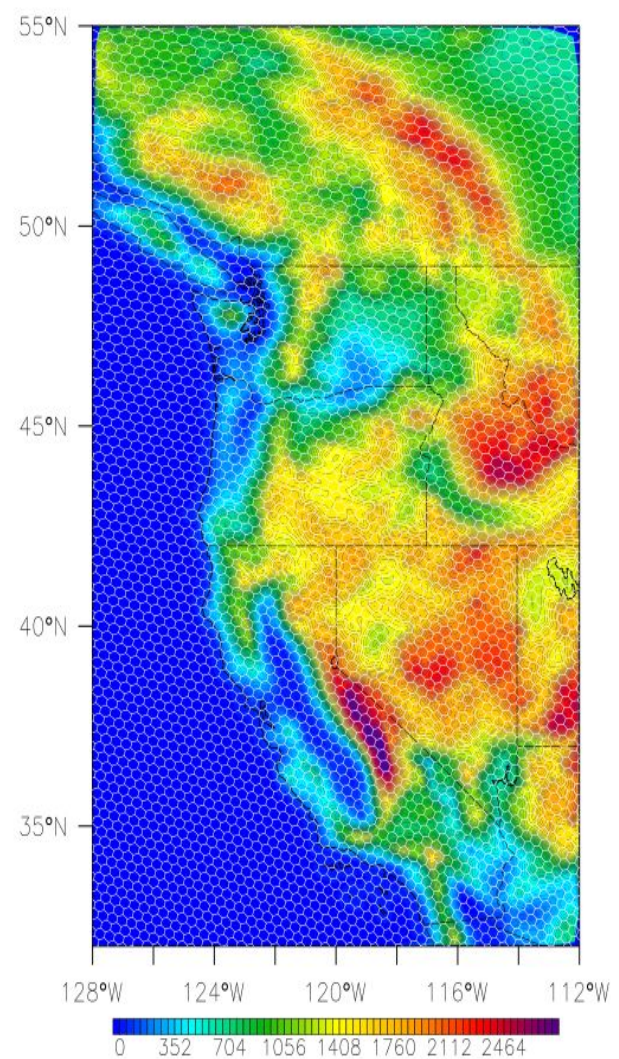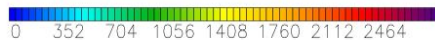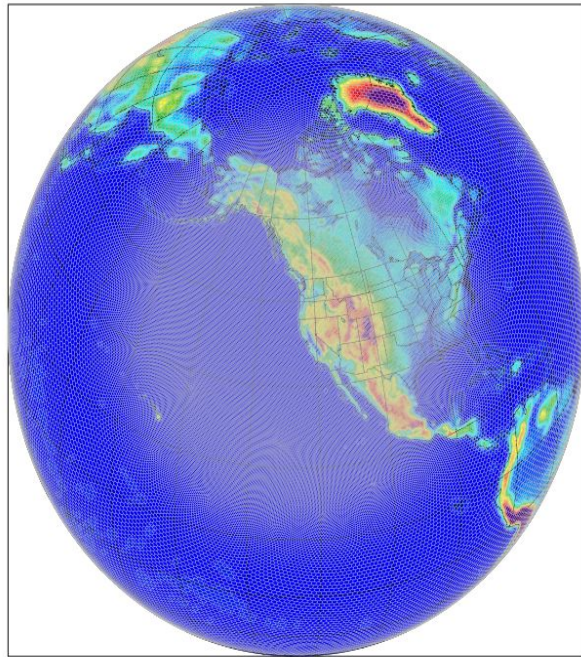
Any modeling setup needs to balance these considerations.

Model for Prediction Across Scales + CAM5*
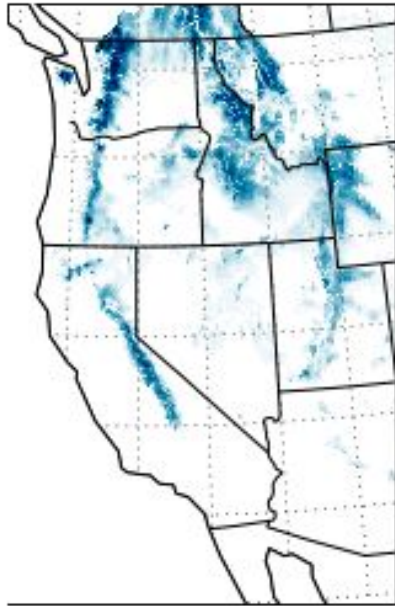
*Community Atmosphere Model, version 5 physics

Here's where we have higher resolution:
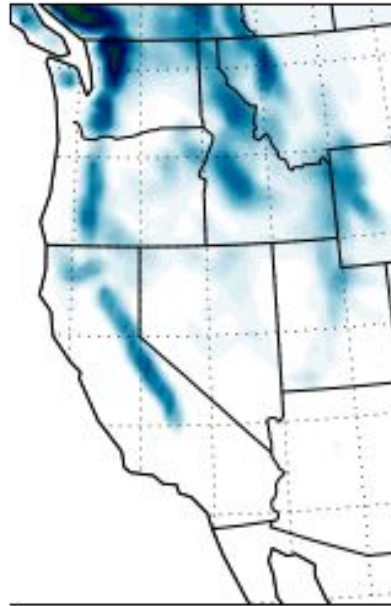
So we can resolve mountain snowpack*.
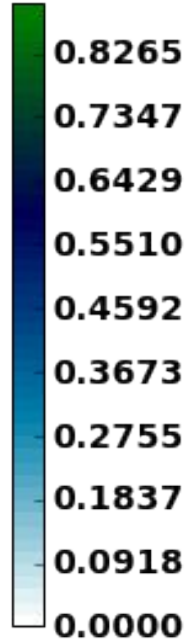
* winter mean SWE

SNODAS

MPAS-CAM5

CAM5 AMIP (1°)

(based on observations)

(our model)

(typical global model, same atmospheric physics)

equivalent meters

0.8265
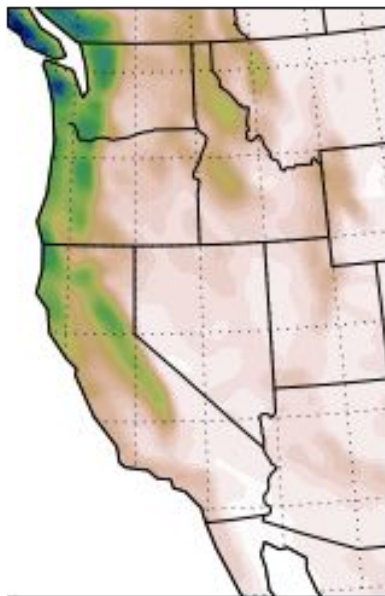0.7347
0.6429
0.5510
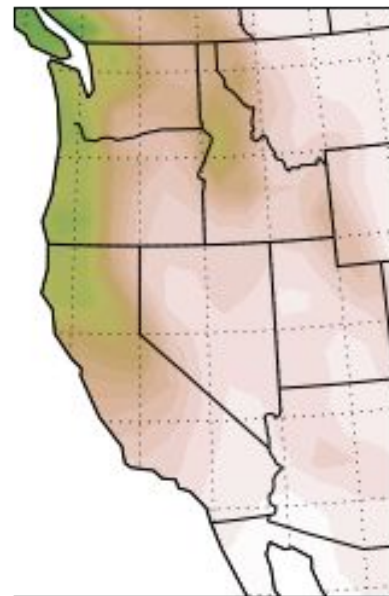0.4592
0.3673
0.2755
0.1837
0.0918
0.0000

precipitation

NLDAS-2
(based on observations)

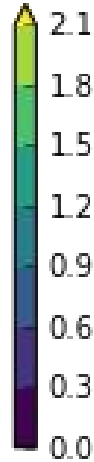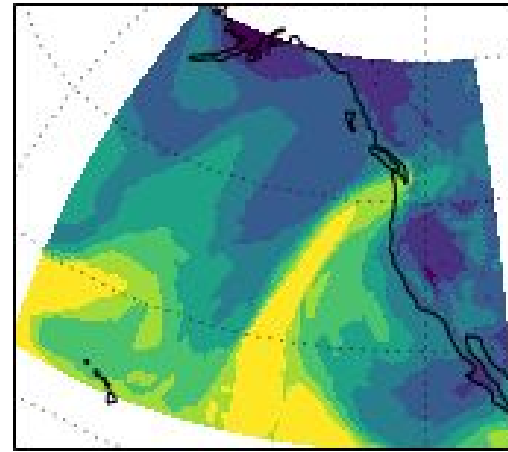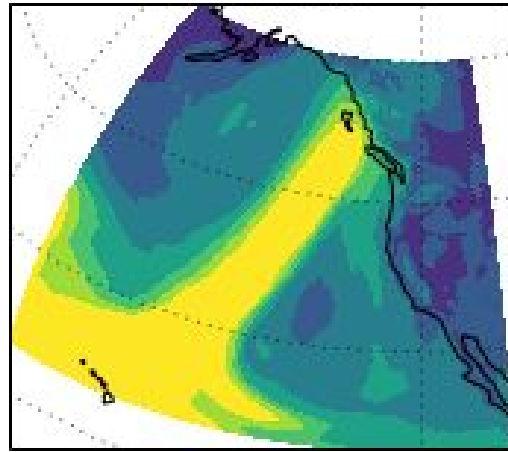MPAS-CAM5
(our model)

CAM5 AMIP (1°)
(typical global model,
same atmospheric physics)

mm/day

21.12
18.78
16.43
14.08
11.73
9.39
7.04
4.69
2.35
0.00
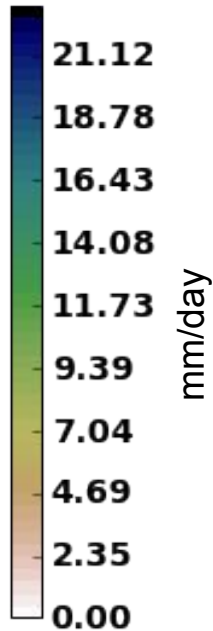
and atmospheric rivers ("Pineapple Express") … which *cause* the extreme precipitation.
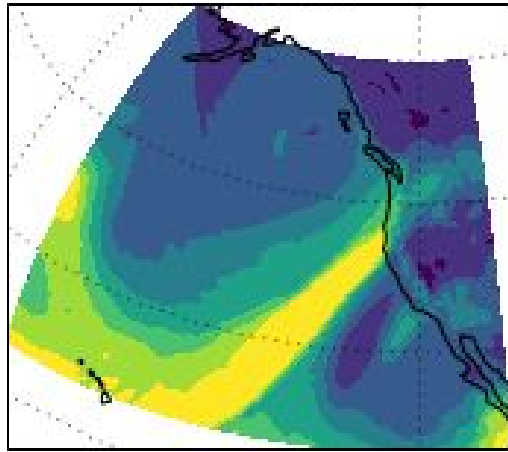
I have a fast way of detecting events.

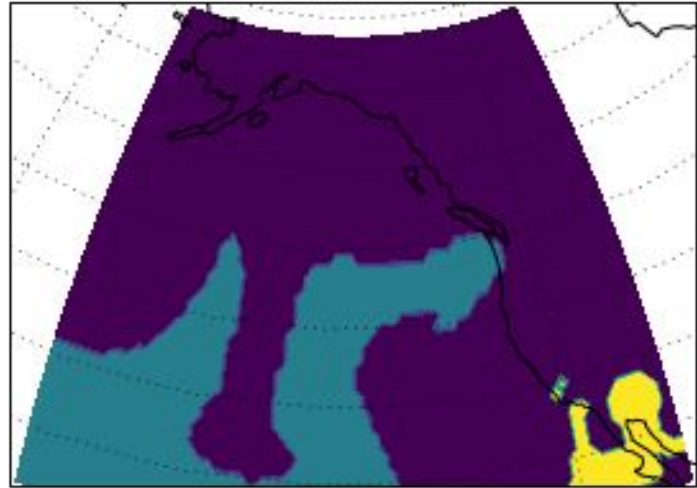# Some years have more, some have fewer.

time = 1984-11-24T09:00:00   time = 1984-11-26T09:00:00   time = 1984-12-26T09:00:00   time = 1984-12-31T09:00:00   time = 1985-01-06T09:00:00   time = 1985-01-09T09:00:00   time = 1985-01-15T09:00:00   time = 1985-01-21T09:00:00

time = 1985-01-24T09:00:00   time = 1985-01-29T09:00:00   time = 1985-02-05T09:00:00   time = 1985-02-12T09:00:00   time = 1985-02-16T09:00:00   time = 1985-02-22T09:00:00   time = 1985-03-26T09:00:00   time = 1985-04-21T09:00:00

time = 1985-04-30T09:00:00   time = 1985-05-12T09:00:00   time = 1985-11-08T09:00:00   time = 1985-11-16T09:00:00   time = 1985-11-29T09:00:00   time = 1985-12-24T09:00:00   time = 1986-01-03T09:00:00   time = 1986-01-05T09:00:00

time = 1986-01-09T09:00:00   time = 1986-02-01T09:00:00   time = 1986-02-09T09:00:00   time = 1986-02-20T09:00:00   time = 1986-02-23T09:00:00   time = 1986-03-04T09:00:00   time = 1986-03-09T09:00:00   time = 1986-04-23T09:00:00

time = 1986-05-14T09:00:00   time = 1986-11-19T09:00:00   time = 1986-12-12T09:00:00   time = 1986-12-31T09:00:00   time = 1987-01-02T09:00:00   time = 1982-01-01   time = 1987-01-16T09:00:00   time = 1987-02-08T09:00:00

time = 1987-03-24T09:00:00   time = 1987-03-28T09:00:00   time = 1987-12-06T09:00:00   time = 1987-12-10T09:00:00   time = 1987-12-13T09:00:00   time = 1987-12-17T09:00:00   time = 1988-01-03T09:00:00   time = 1988-01-16T09:00:00

We make an AR–index from the counts to study interannual variability.

Count atmospheric rivers impacting the Northwest...

- for winter or spring
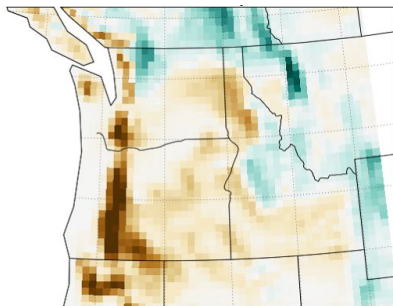
- in model or reanalysis

Northwest

California

So what do atmospheric rivers do to snowpack, on the whole?
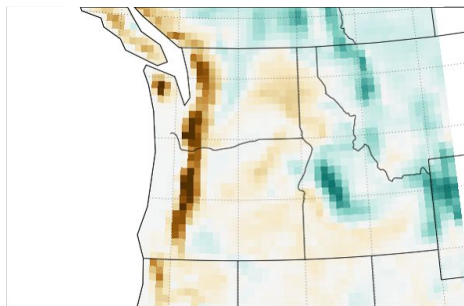
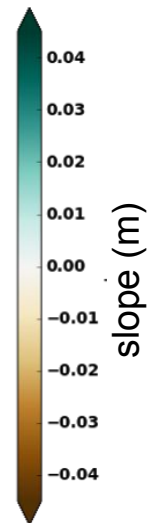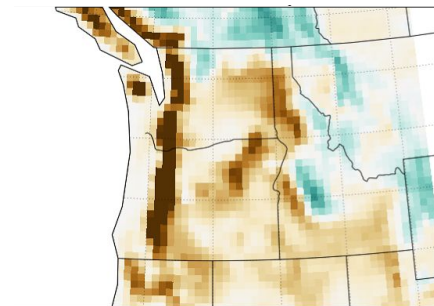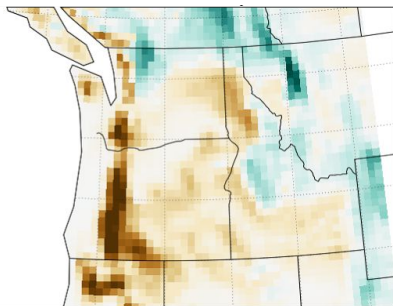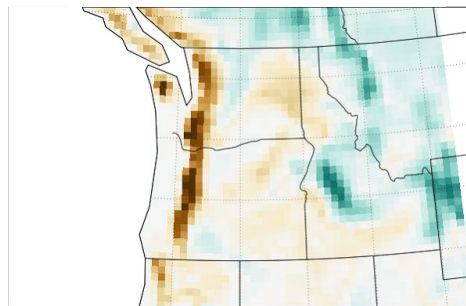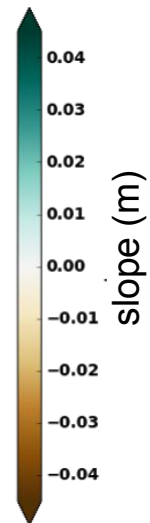# Three 30-year ensemble members from MPAS-CAM5... to study variability

snowpack (SWE) regressed on normalized winter AR index

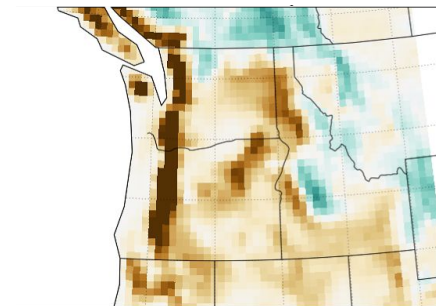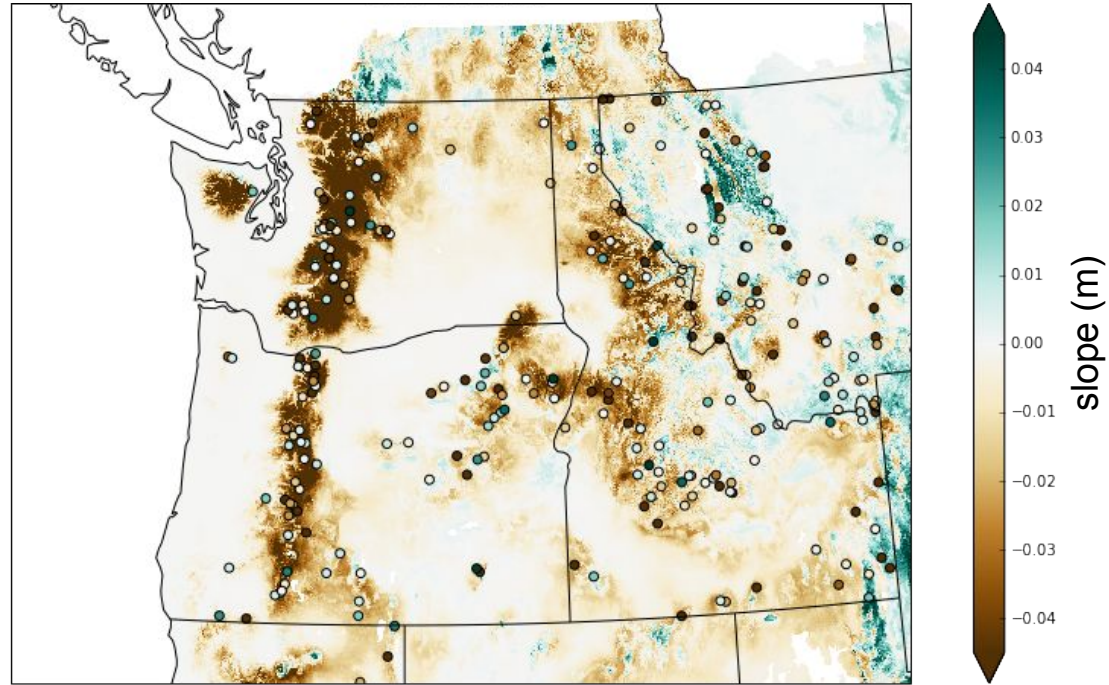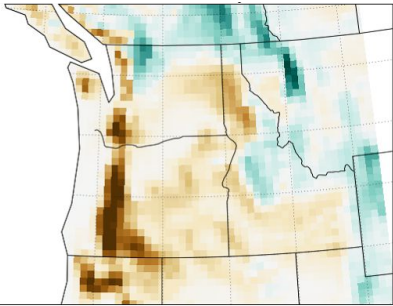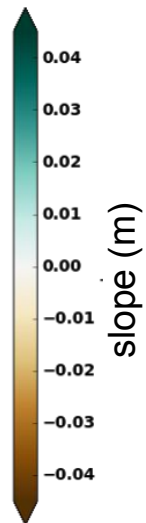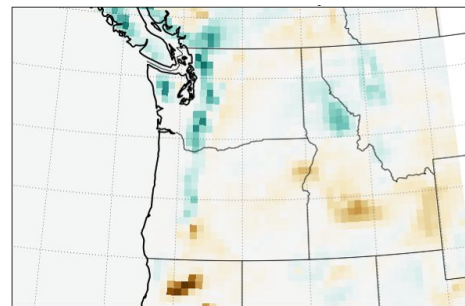# Years with more atmospheric rivers have less snowpack in the Cascades

#1   #2   #3

snowpack (SWE) regressed on normalized winter AR index

Compared with… SNODAS & SNOTEL (obs) regressed on reanalysis AR-index

#1

snowpack (SWE) regressed on normalized winter AR index
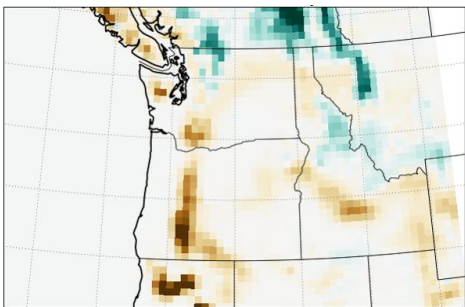
What about spring? from MPAS–CAM5
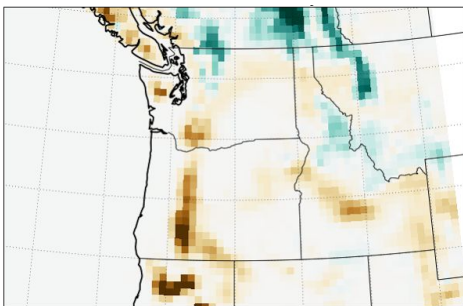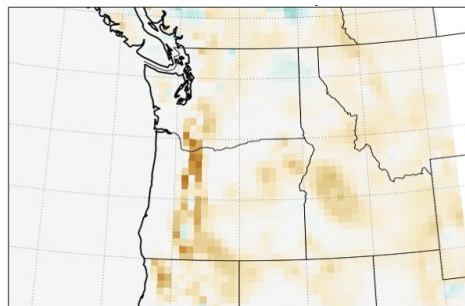
snowpack (SWE) regressed on normalized spring AR index

What about spring? ...SNODAS & SNOTEL (obs) regressed on reanalysis AR–index

#1
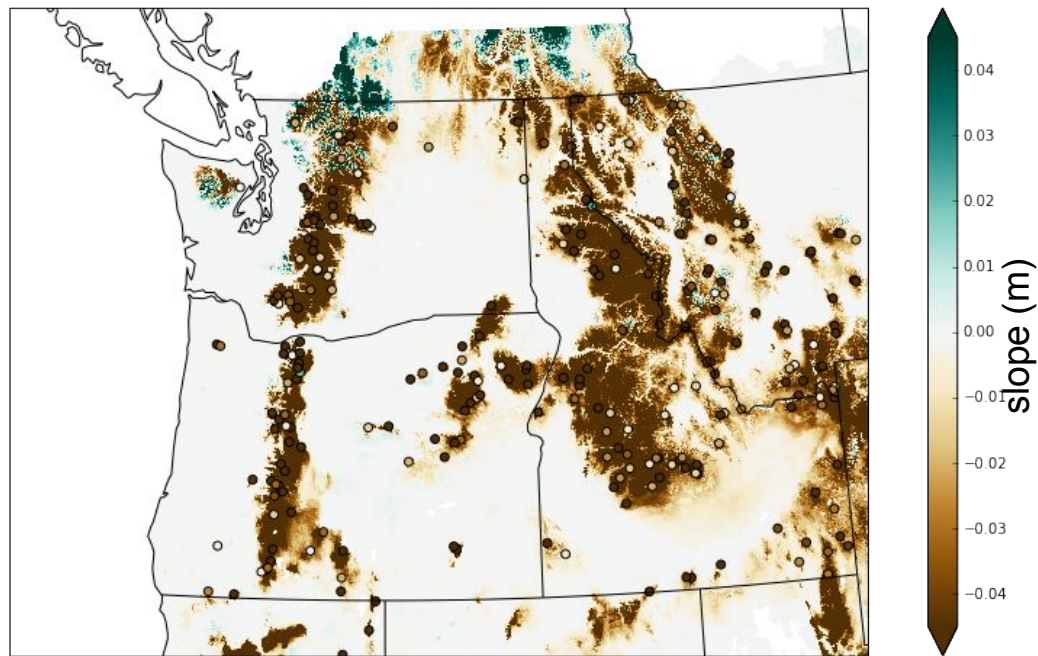
snowpack (SWE) regressed on normalized spring AR index

Summary & Questions

Multi-scale modeling is a good way to study relationships between large-scale circulation and regional hydrology.

More ARs in winter lead to less Cascades snowpack.
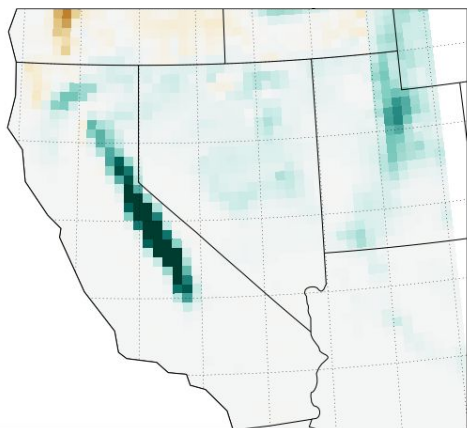
Is MPAS-CAM5 less good at spring?

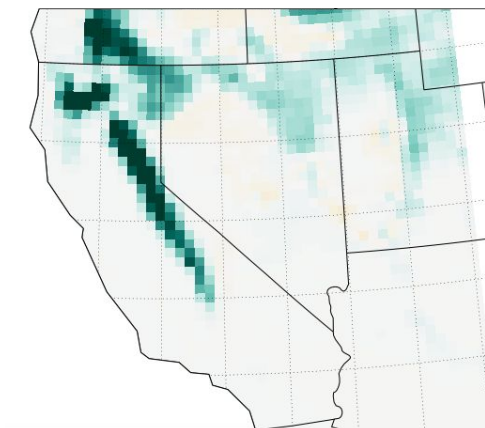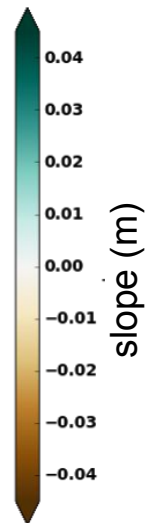Or is spring inherently more variable?
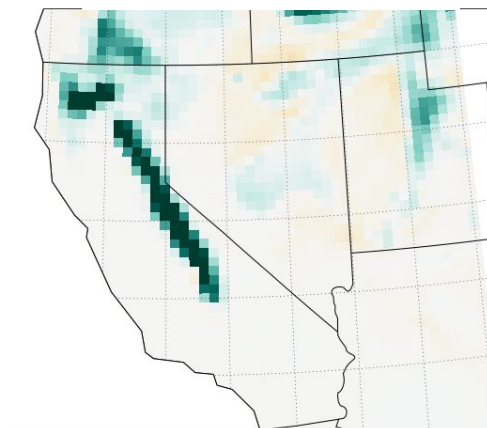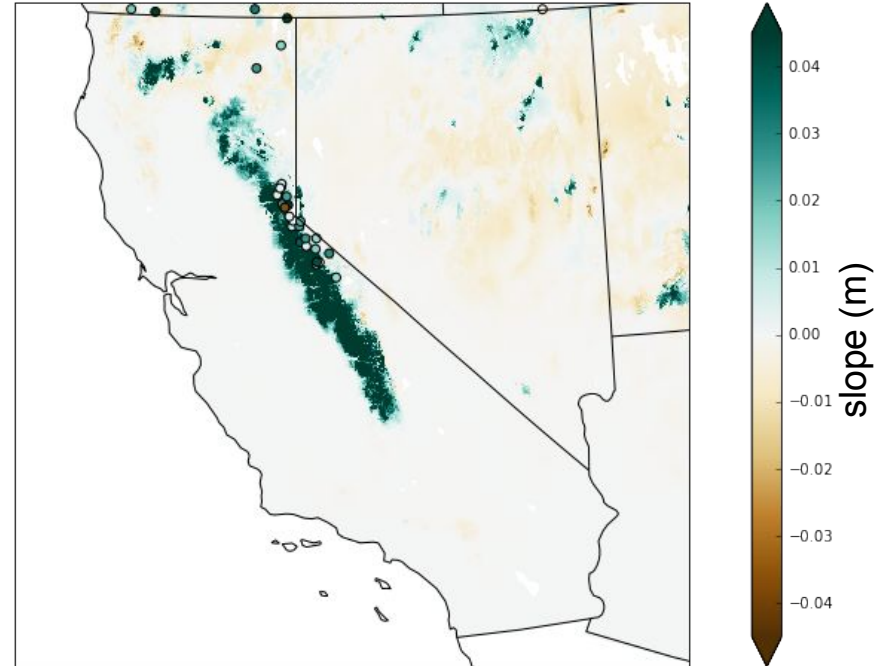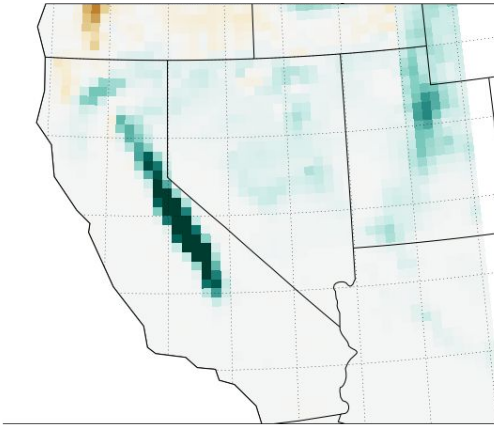
What about other regions?

What about California?

snowpack (SWE) regressed on normalized winter AR index

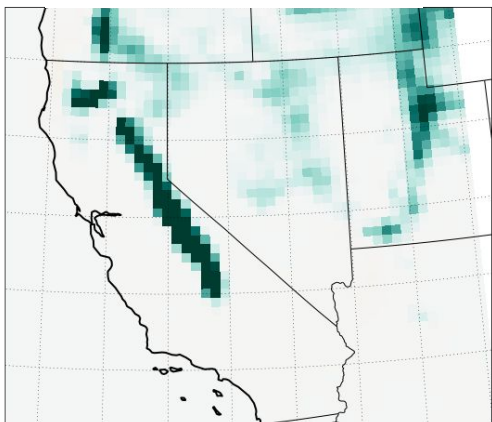# A consistent picture in winter.

#1
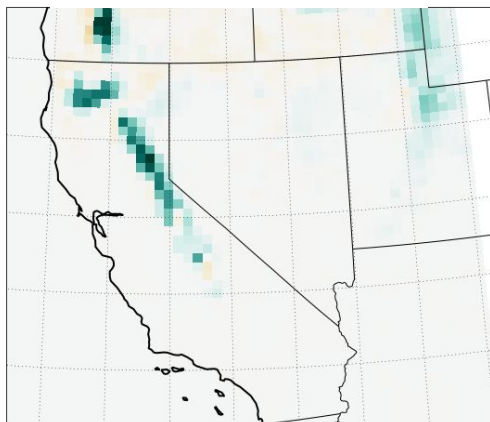
snowpack (SWE) regressed on normalized winter AR index

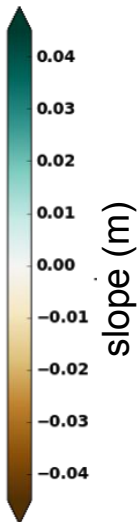# Like in the Northwest, spring is not robust.
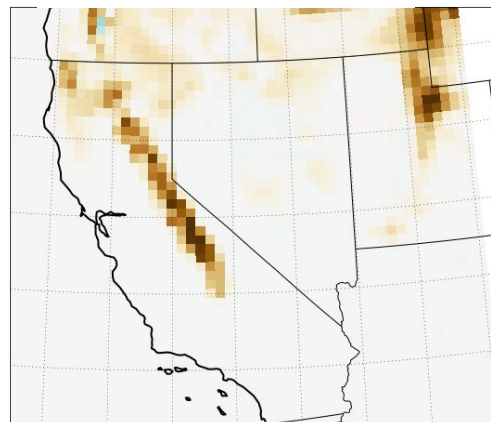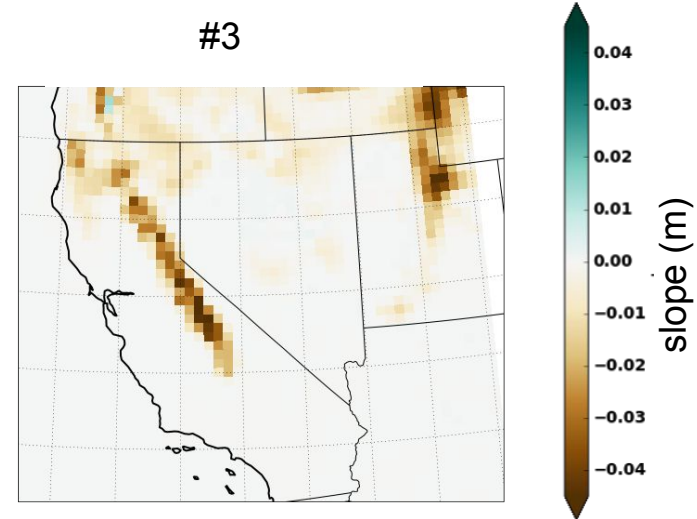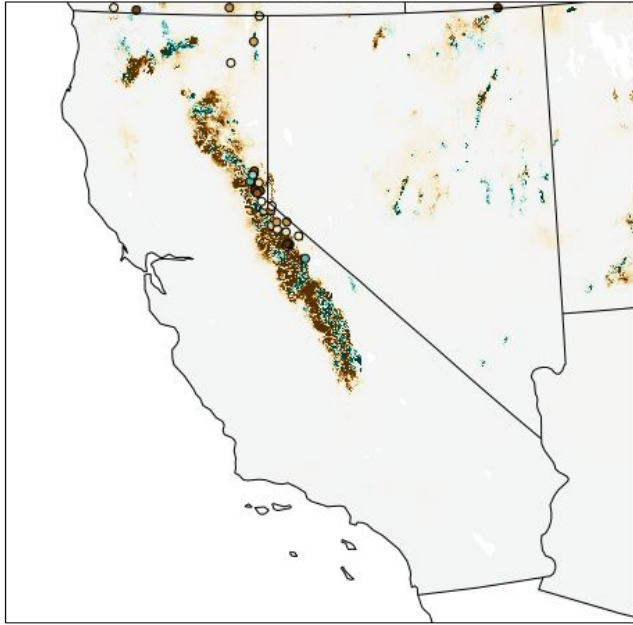

snowpack (SWE) regressed on normalized spring AR index

And a different ensemble member best matches observations.

#3

snowpack (SWE) regressed on normalized spring AR index

Questions?

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