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## Main research problem

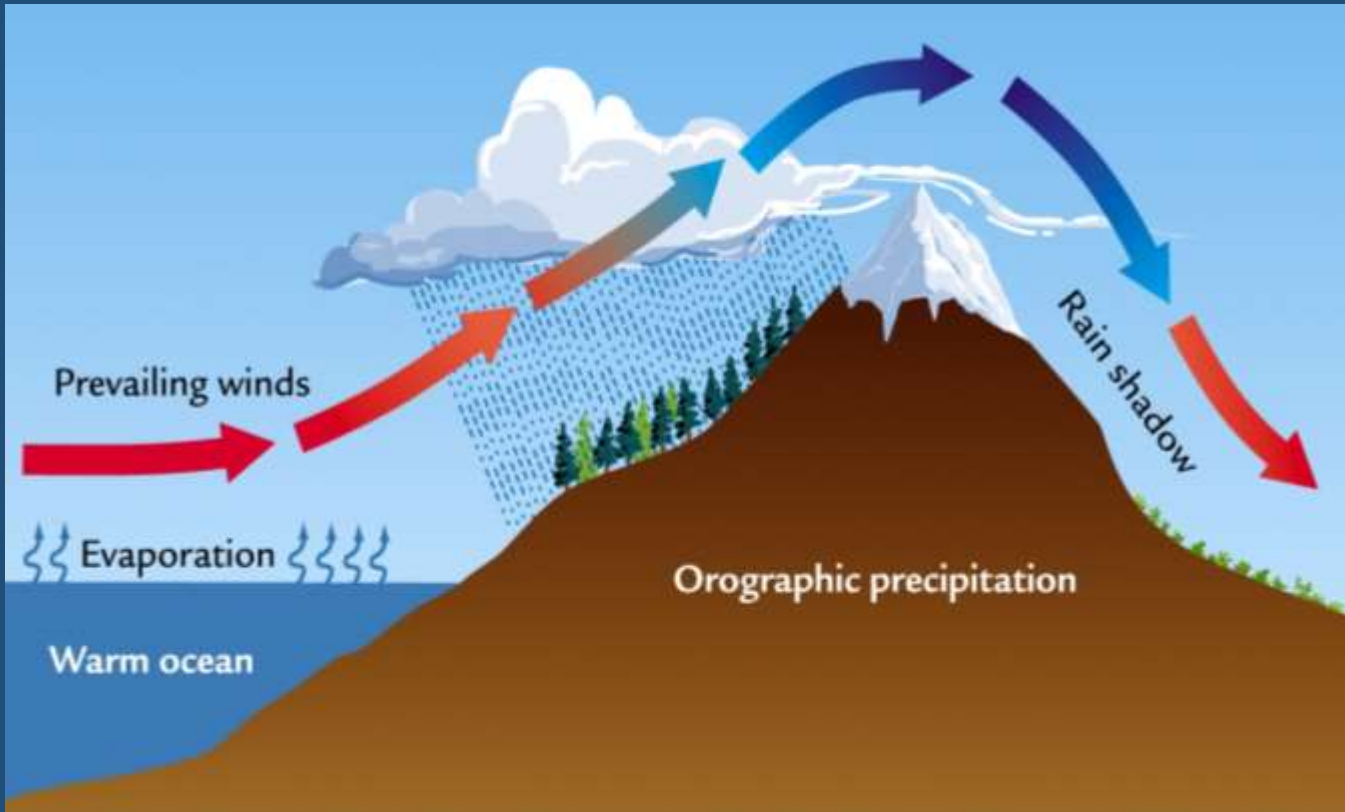


Image from [earthscience-in-the-nationalparks.wikispaces.com](http://earthscience-in-the-nationalparks.wikispaces.com), 07/08/13

Modelling climate in fine detail  
in the Pacific Northwest

climate varies greatly over short  
distances  
due to mountains, ocean, etc.

Need to add these processes into climate predictions from global simulations  
for a regional climate model with high spatial resolution



## Wider relevance

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Farmers, businesses, residents, investors and government agencies all need to know about future climate in the region:

predicted changes (amounts, frequency)

and associated uncertainty

for a multitude of variables relating to  
temperatures, precipitation, water storage

and extreme weather events (droughts, floods)



## Research Questions

- Q1 What climate changes does the model simulate for 1959 – 2009 ?
  
- Q2 How will climate change in the Pacific Northwest and the REACCH study area, in the next 40 years?





## Methods

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General climate models:

- initial conditions

- forcing scenarios:

  - greenhouse gas timelines (future only)

  - solar energy

- physics described by full equations

- and by physical parameters (unresolved, small scale processes)

High resolution? Problem of computer power

Nested regional model - regCPDN

Ensemble runs (varying initial conditions)

Crowdsourced data



## Methods – Q1 Climate changes for 1959 – 2009

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Model is run for past (1959 to 2009)

A set of variables is saved for each month of each year

    maximum and minimum temperatures of the day (averaged over the month)

Months are split into seasons:

    Winter: December, January, February

    Spring: March, April, May

    Summer: June, July, August

    Fall: September, October, November

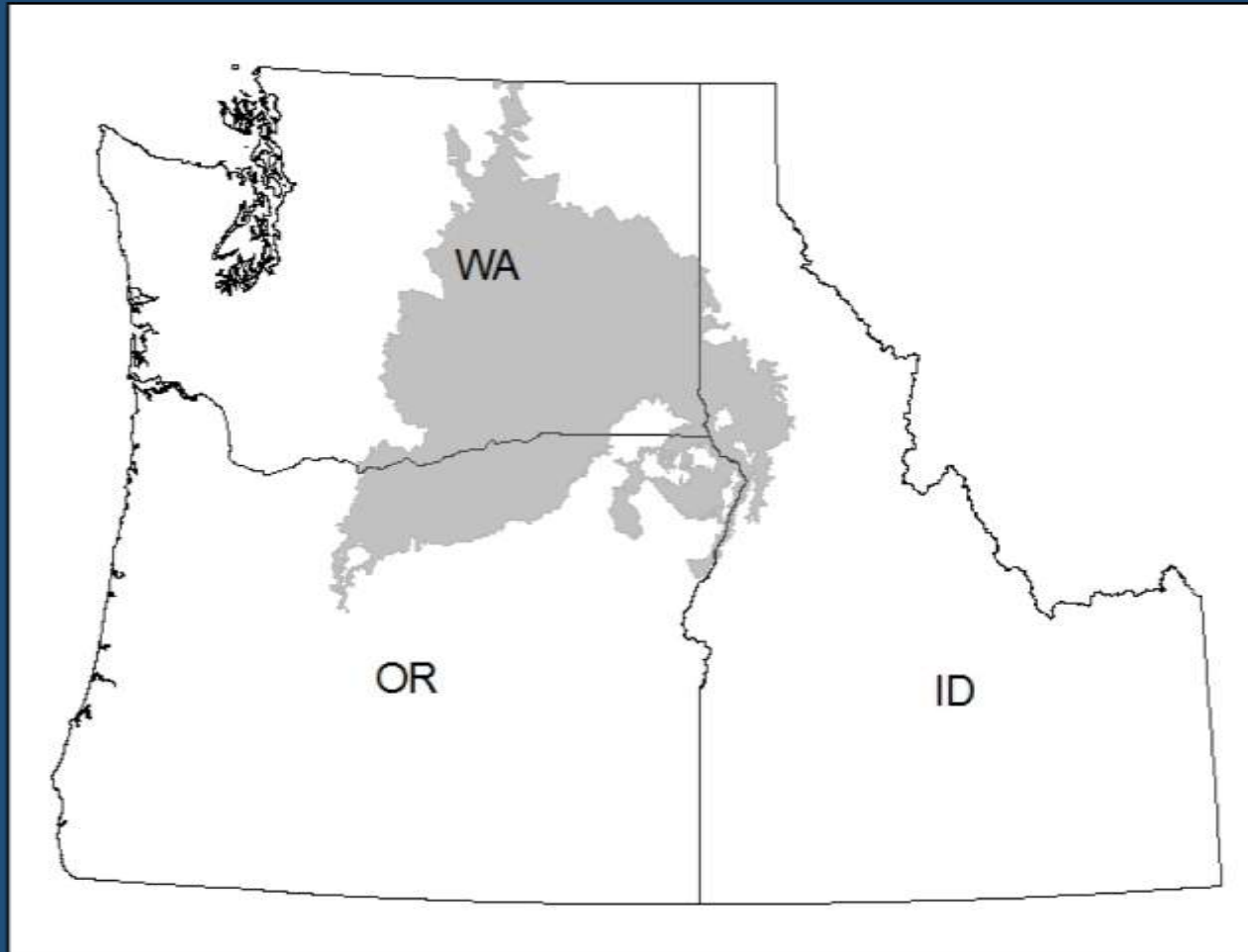
For each variable and each season, and for each grid point, the variable is averaged over the relevant months

A linear trend over time is calculated, for each grid point, minimising the Chi-squared error

This is plotted in a contour map, using IDL (Interactive Data Language)



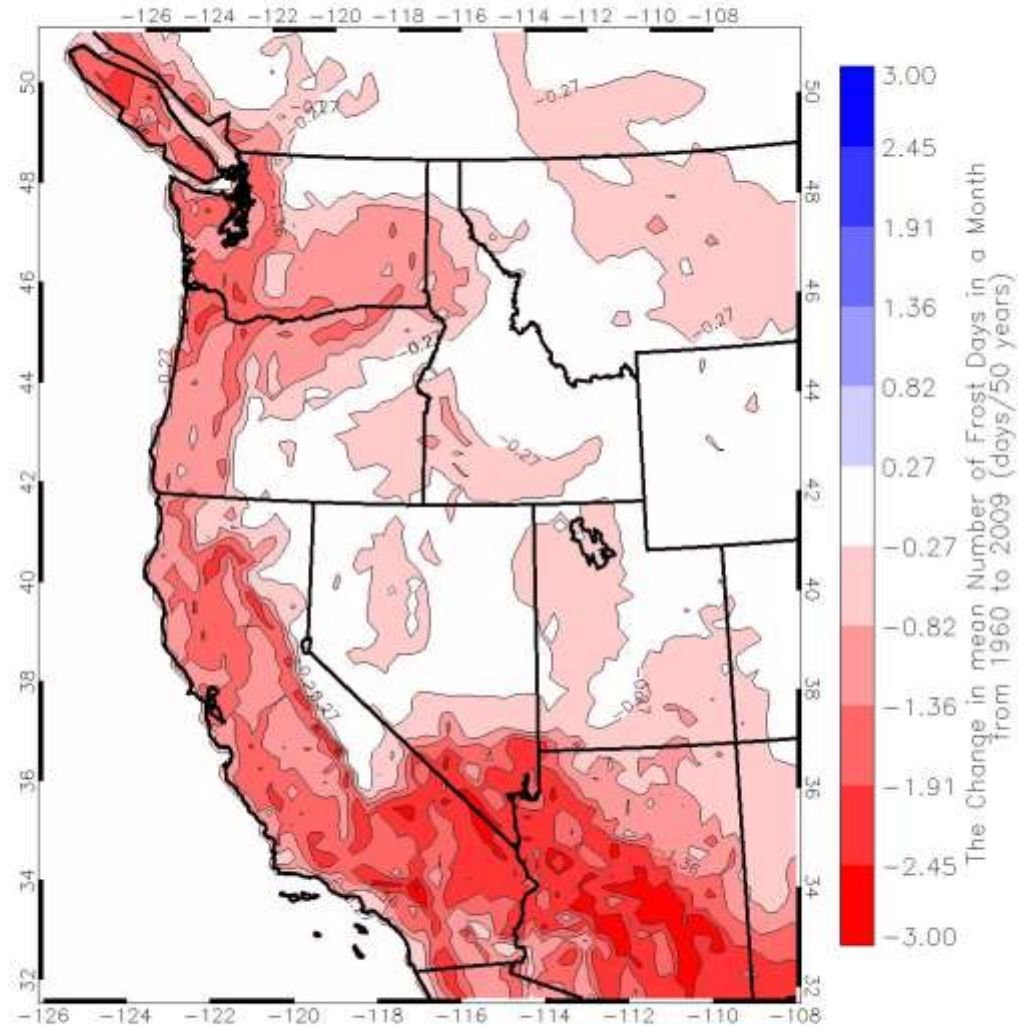
## Results and Analysis – Q1 Climate changes for 1959 – 2009



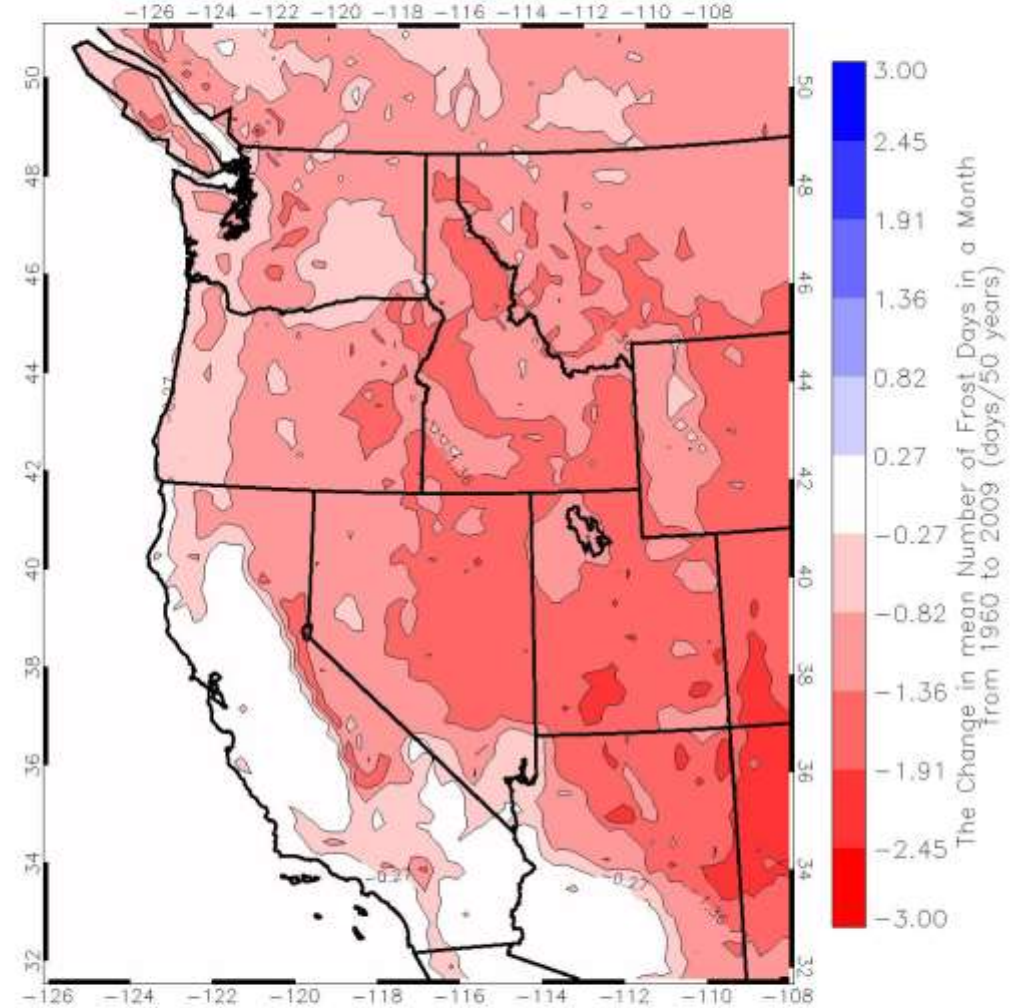


# Results and Analysis – Q1 Climate changes for 1959 – 2009

### Winter Number of Frost Days in a Month



### Spring Number of Frost Days in a Month

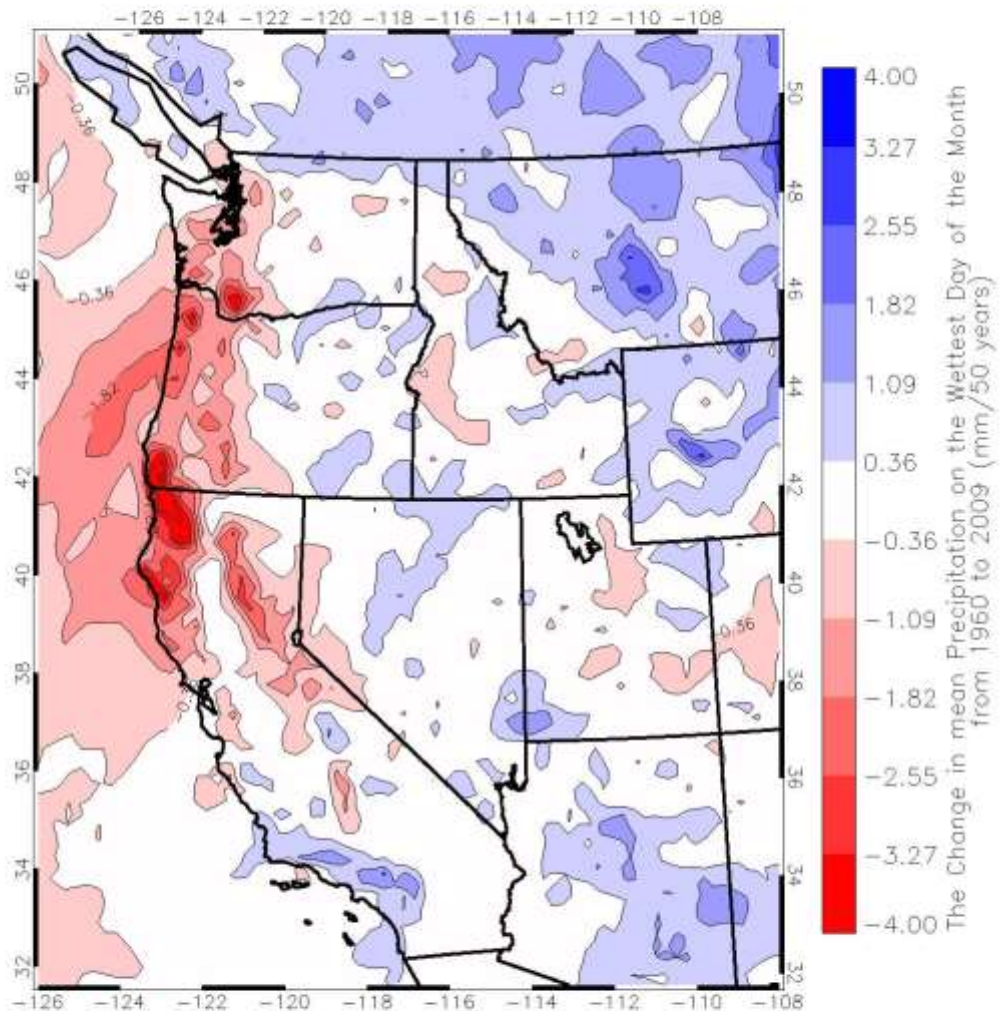




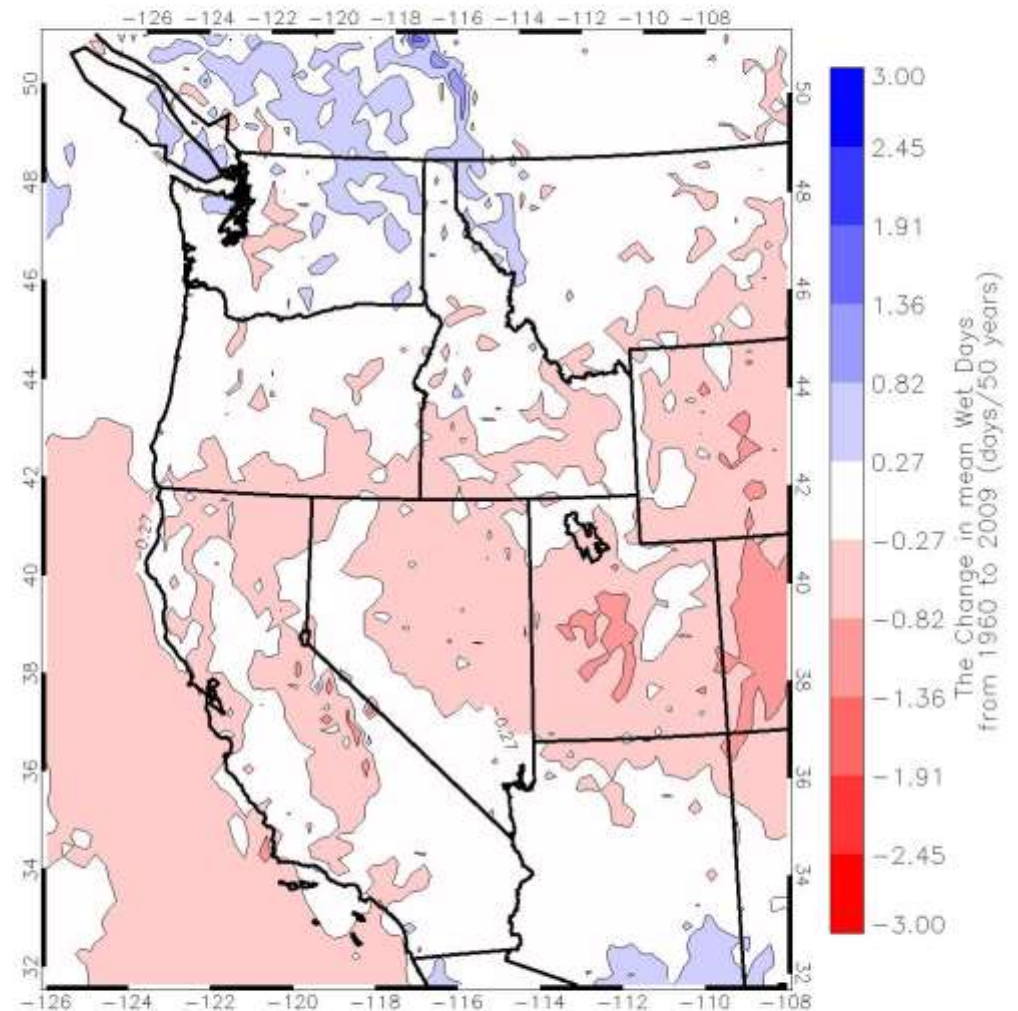


# Results and Analysis – Q1 Climate changes for 1959 – 2009

Spring Precipitation on the Wettest Day of the Month



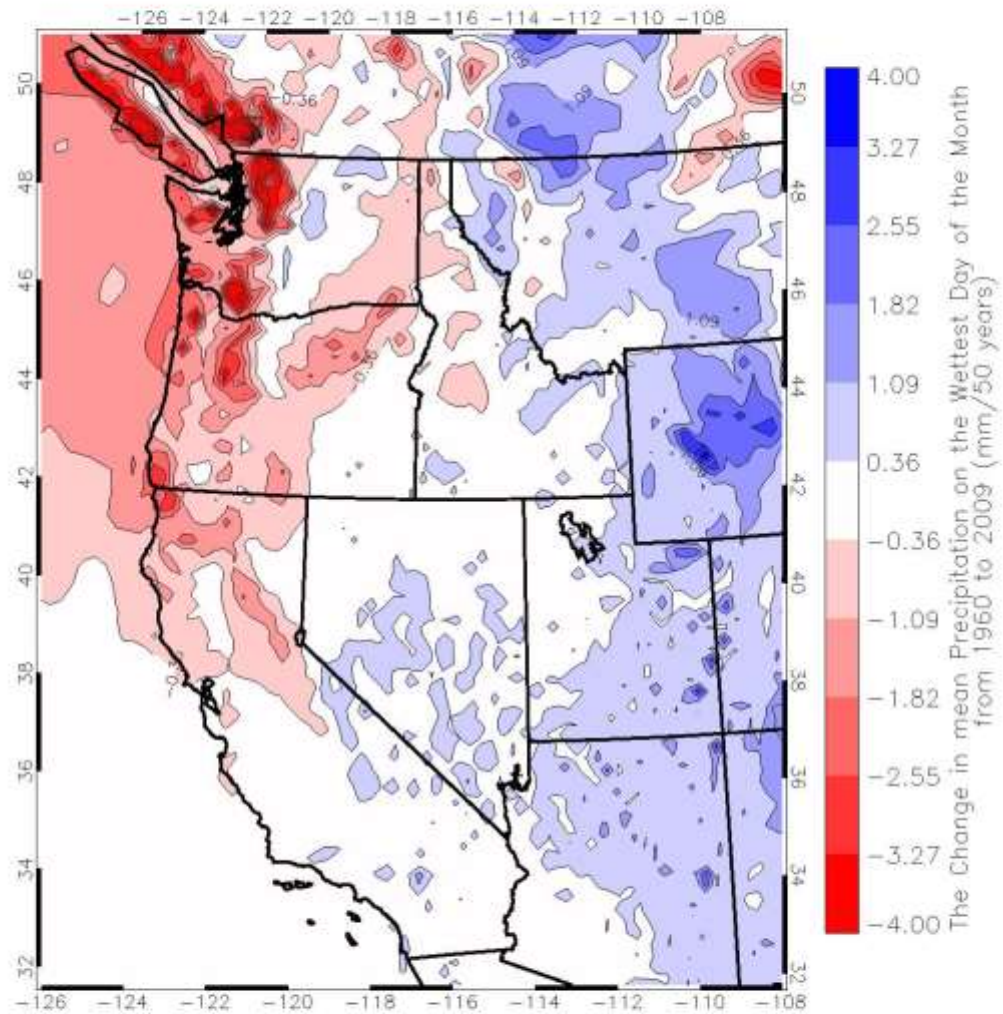
Spring Wet Days



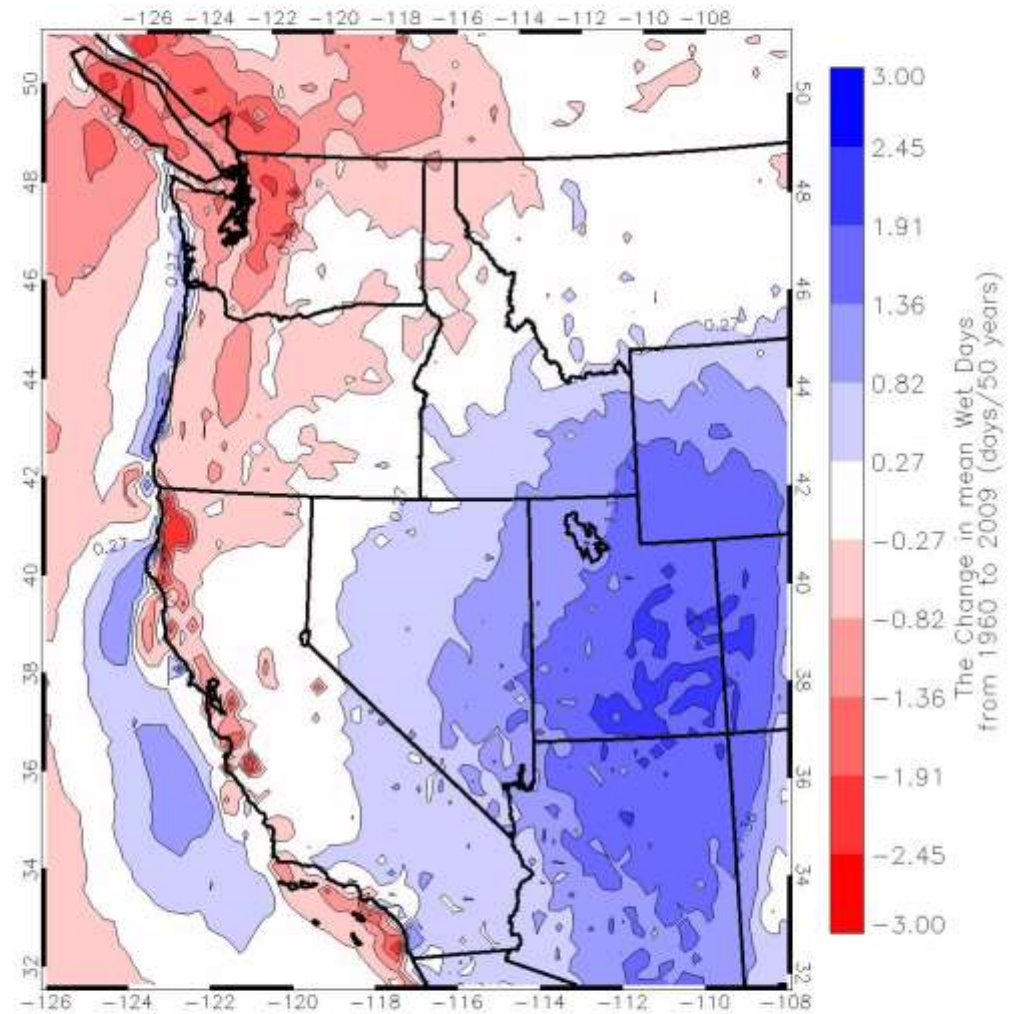


# Results and Analysis – Q1 Climate changes for 1959 – 2009

Summer Precipitation on the Wettest Day of the Month



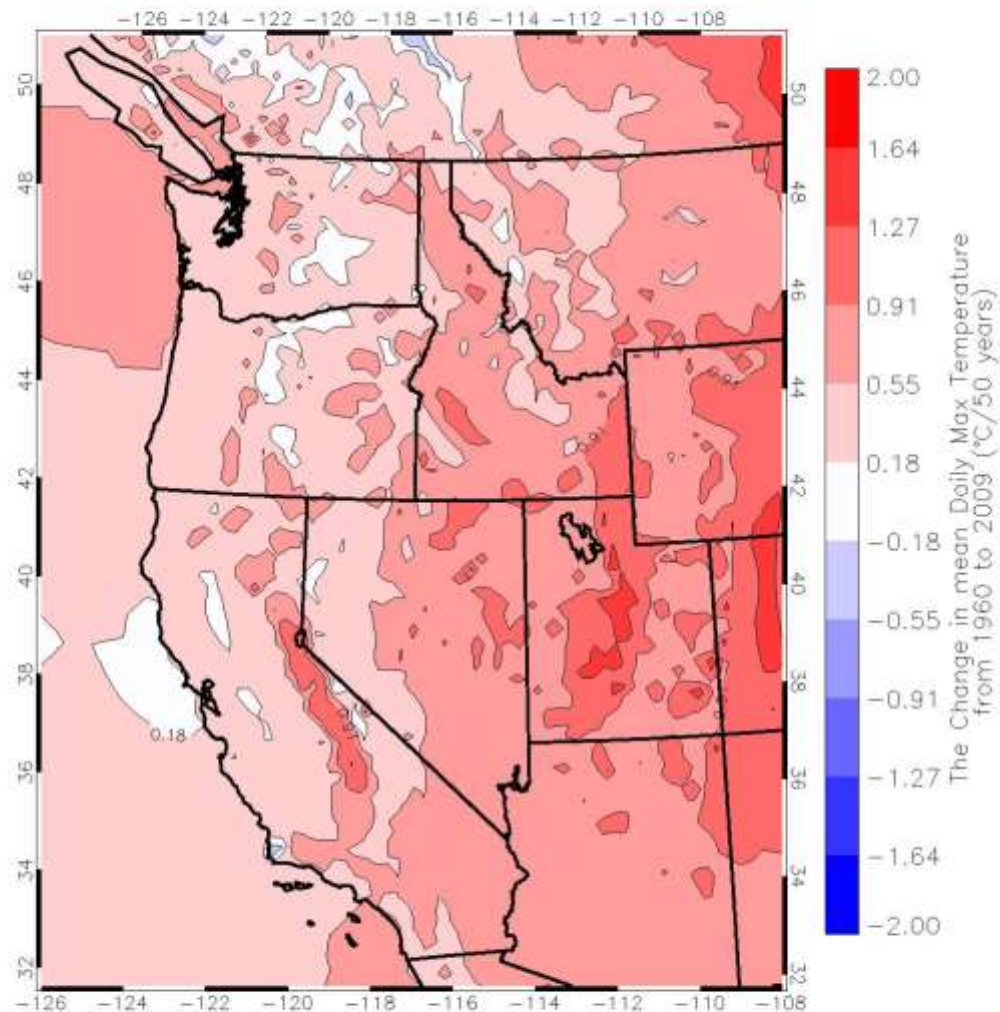
Summer Wet Days



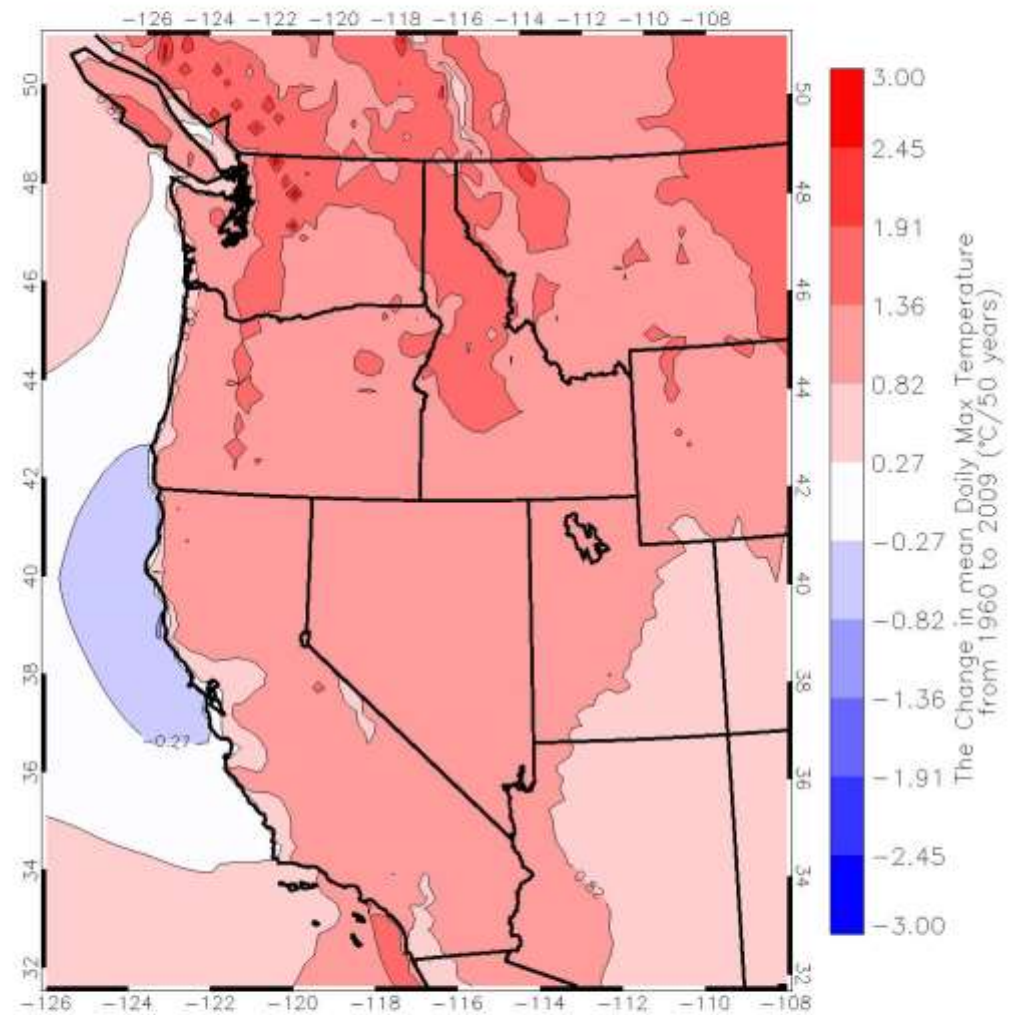


# Results and Analysis – Q1 Climate changes for 1959 – 2009

### Spring Daily Max Temperature



### Summer Daily Max Temperature





## Methods – Q2

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For one variable and one season, values at all grid points for all relevant months of all years are collected

These are plotted in a histogram

This is calculated separately for past and future, on the same graph, so that the distributions can be compared

Also for different regions (whole regCPDN region, REACCH study area)

Computed and plotted using MATLAB



## Results and Analysis – Q2

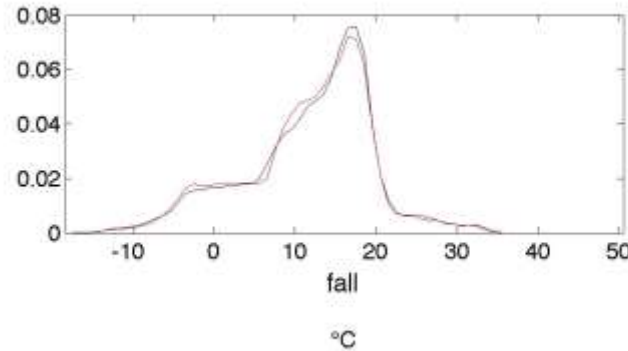
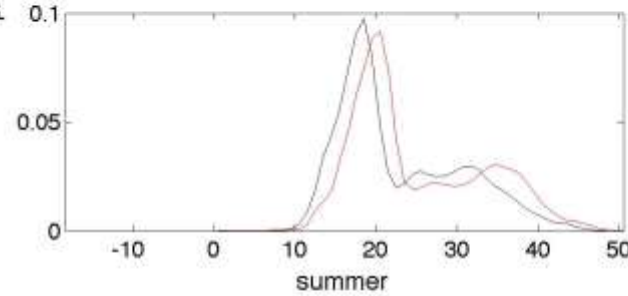
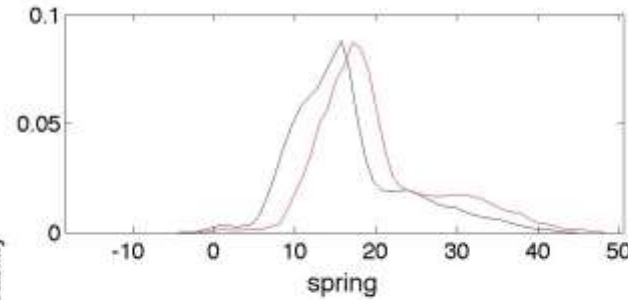
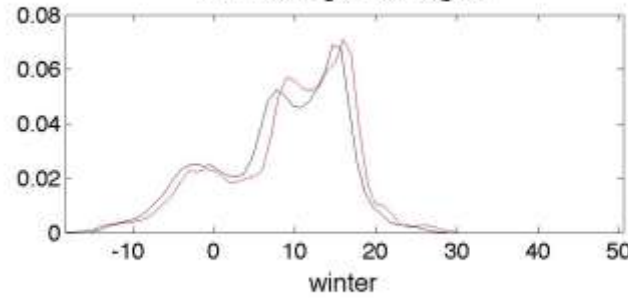
How will climate change in the Pacific Northwest, in the next 40 years?

Some warming

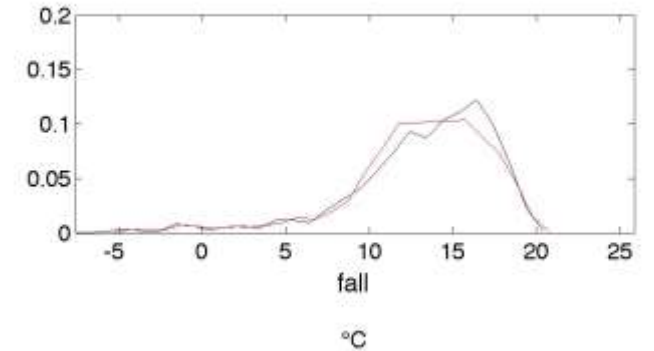
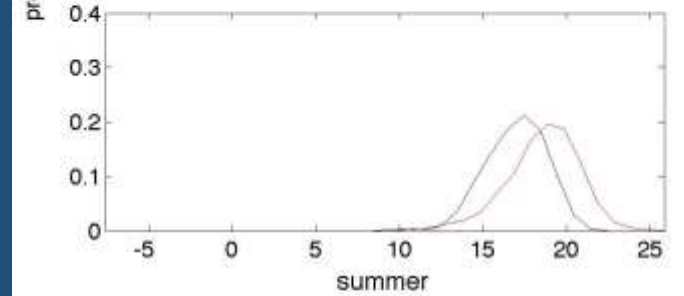
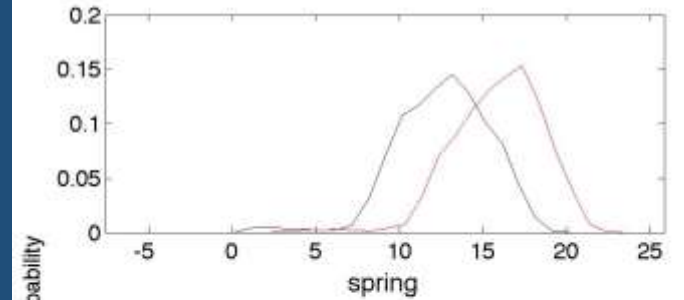
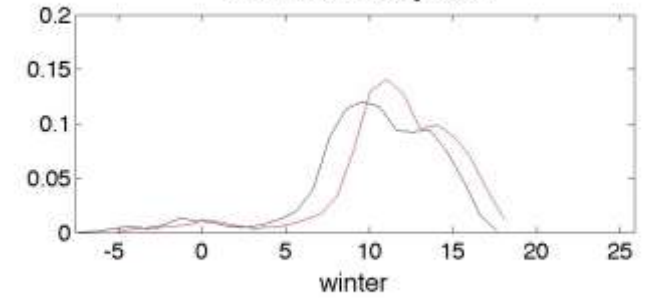
Why no warming in fall?

a bug in the model?  
or extraction of data?  
or code for figures?

Histograms of past (black) and future (red) for average of maximum daily temperature in whole regCPDN region



Histograms of past (black) and future (red) for average of maximum daily temperature in REACCH study area





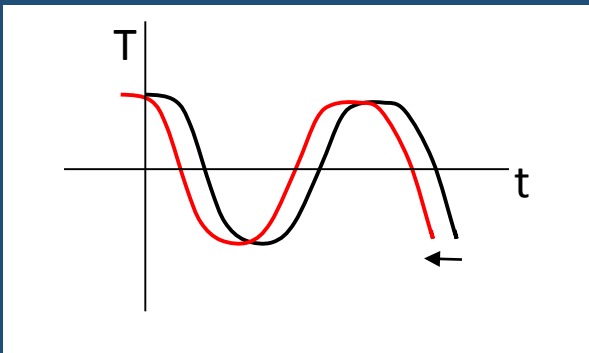
## Results and Analysis – Q2

How will climate change in the Pacific Northwest, in the next 40 years?

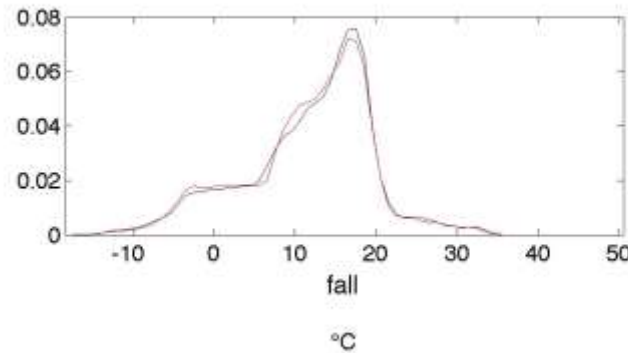
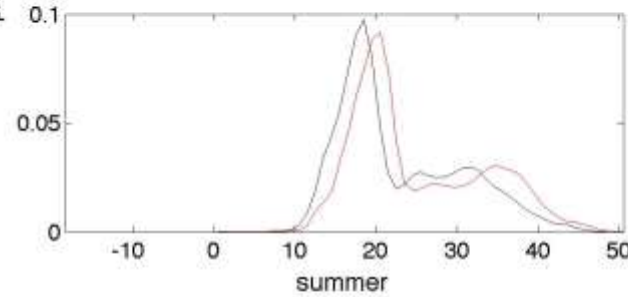
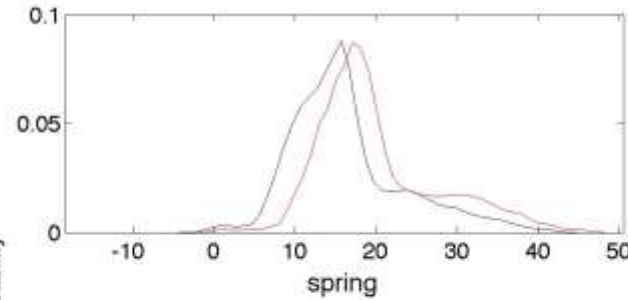
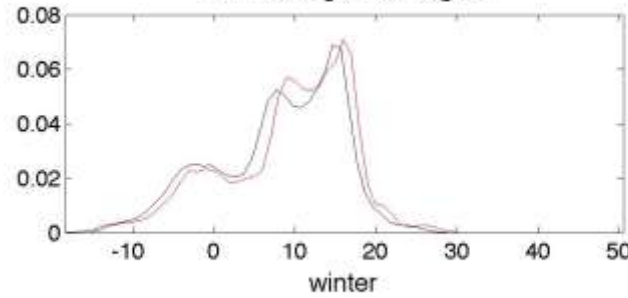
Some warming

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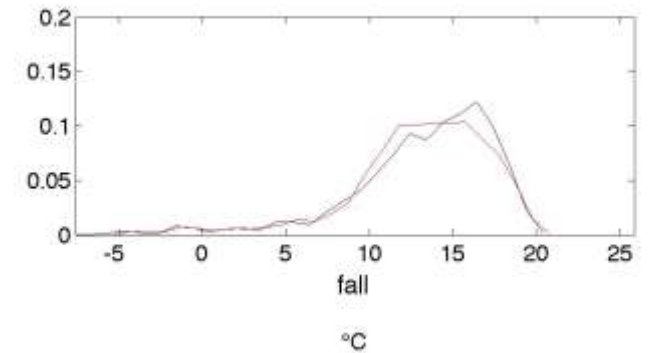
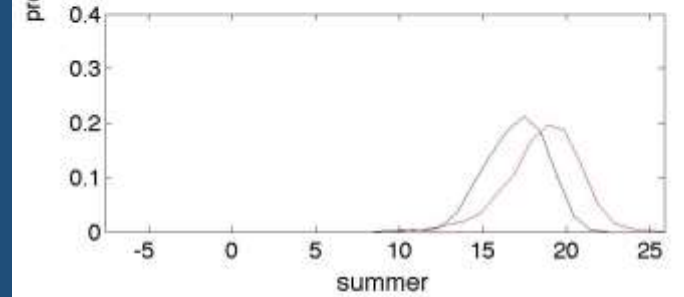
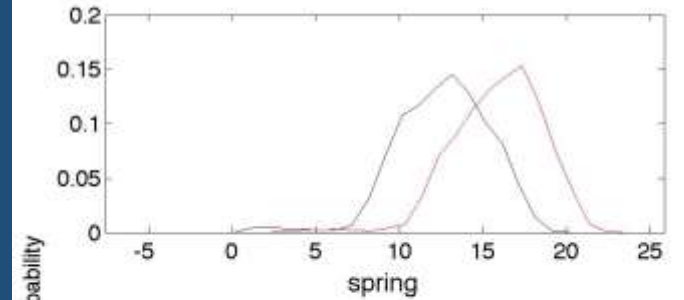
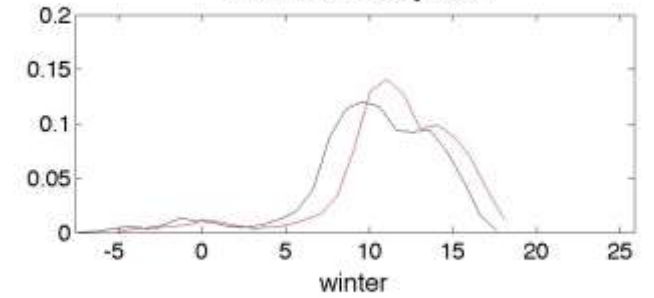
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Histograms of past (black) and future (red) for average of maximum daily temperature in whole regCPDN region



Histograms of past (black) and future (red) for average of maximum daily temperature in REACCH study area





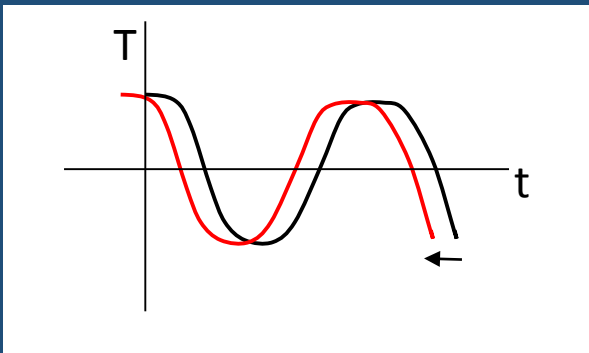
## Results and Analysis – Q2

How will climate change in the Pacific Northwest, in the next 40 years?

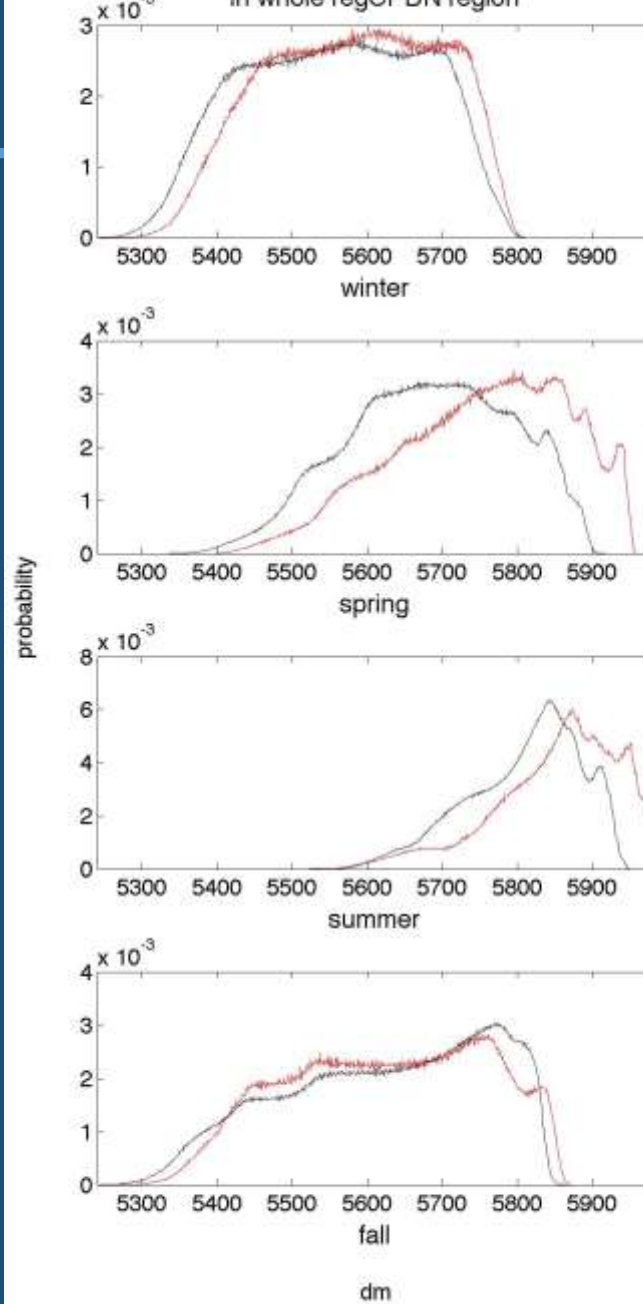
Some warming

Why no warming in fall?

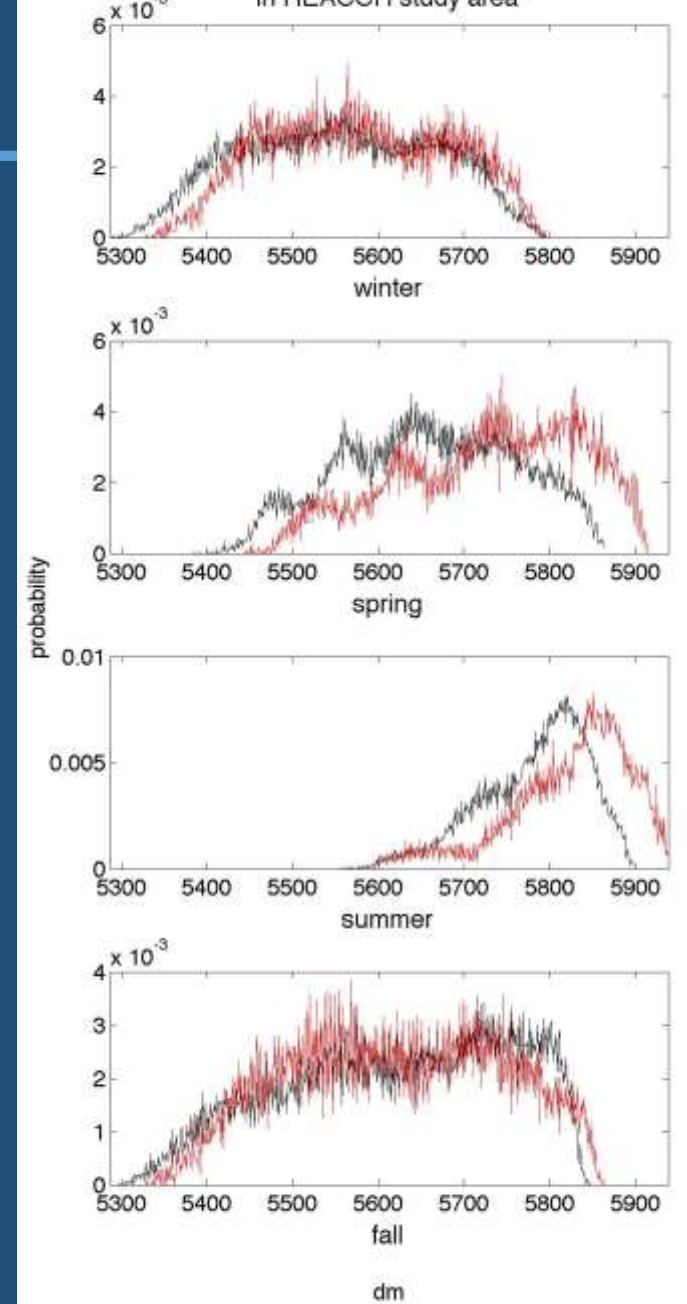
a bug in the model?  
or extraction of data?  
or code for figures?



Histograms of past (black) and future (red) for monthly mean of geopotential height at 500mb in whole regCPDN region



Histograms of past (black) and future (red) for monthly mean of geopotential height at 500mb in REACCH study area



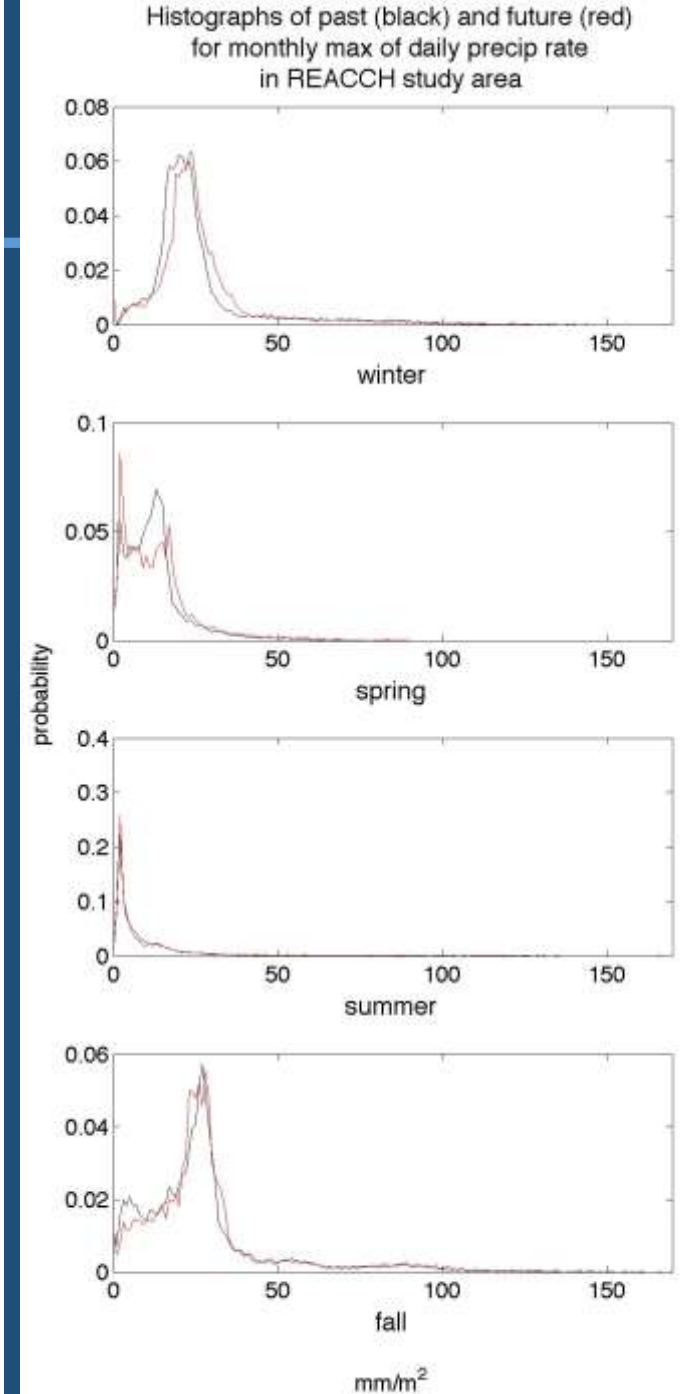
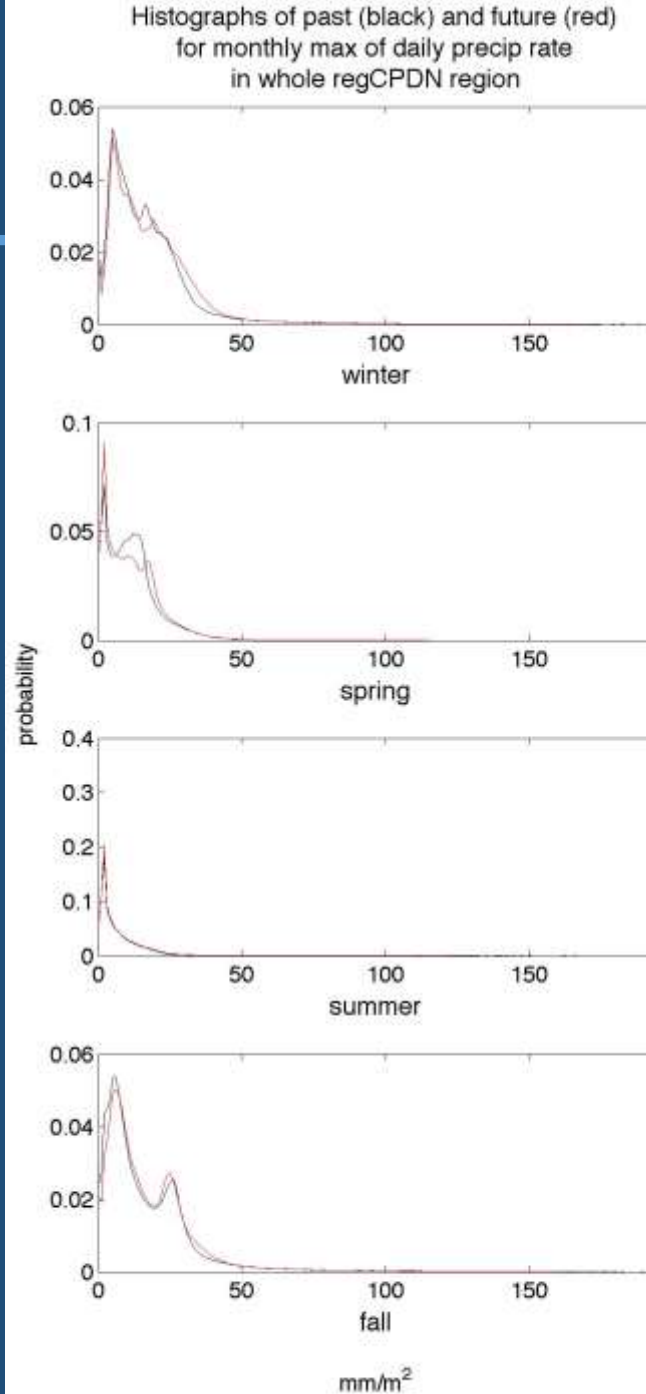


## Results and Analysis – Q2

How will climate change in the Pacific Northwest, in the next 40 years?

The REACCH study area is one of the areas with higher max precip rates

Spring shows significant decrease in max precip rates



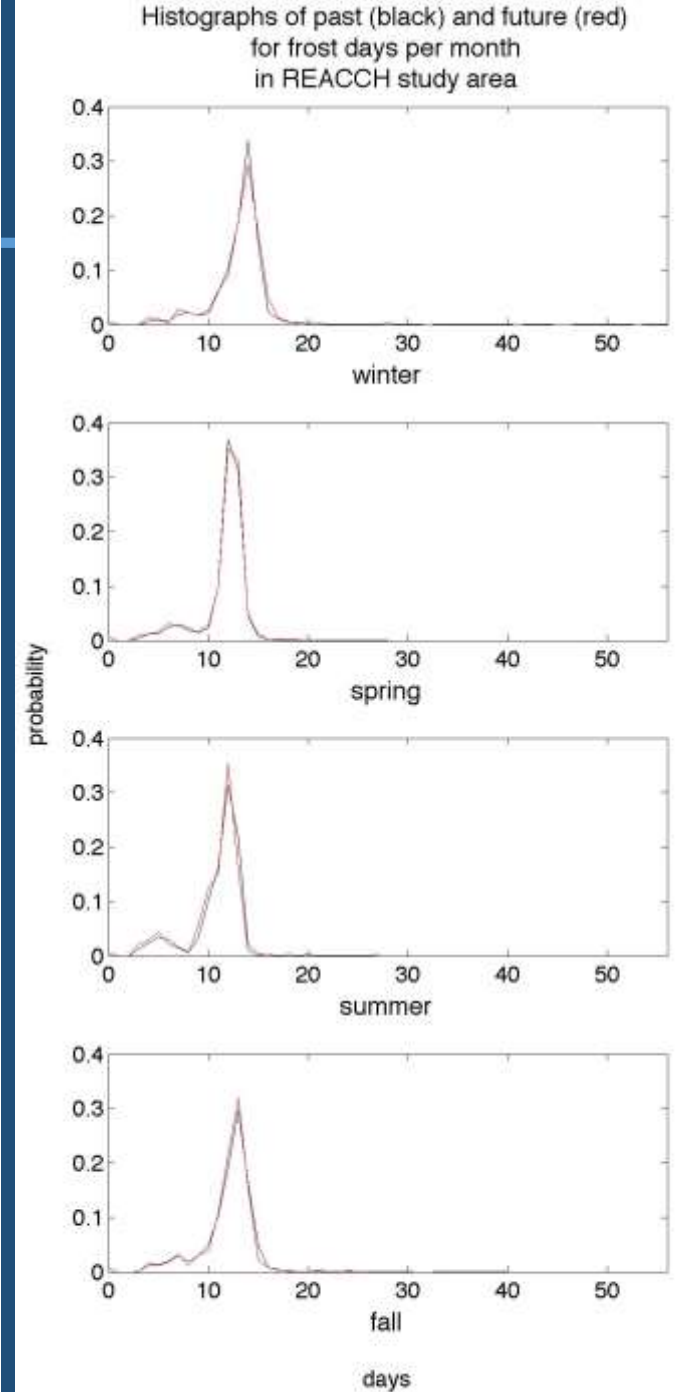
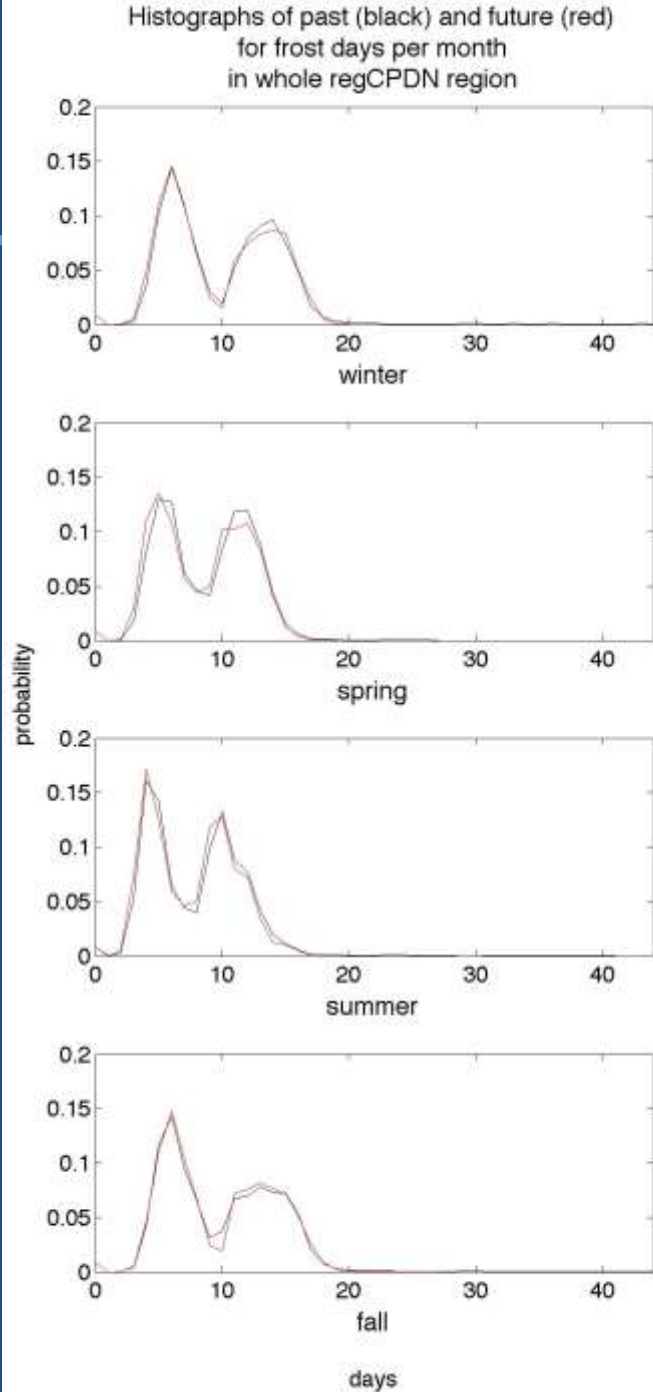




## Results and Analysis – Q2

How will climate change in the Pacific Northwest, in the next 40 years?

Not much difference between past and future –  
a bug in the model?  
or extraction of data?  
or code for figures?





## Conclusions

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Q1 - What climate changes does the model simulate for 1959 – 2009 ?

Spatially variable warming

Reduced precipitation

Reduced water storage in snowpack, affecting summer river flux?

Q2 - How will climate change in the Pacific Northwest and the REACCH study area, in the next 40 years?

Warmer, drier futures for the REACCH study area



## Future work and limitations

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### Next week:

- finish histogram code

- more regions – Bureau of Land Management (BLM)

  - West OR and WA

  - Cascades

  - East OR and WA

- maps of change in future

### Limitations:

The future models all have an assumed timeline of CO<sub>2</sub> increase.

The models are run on parameters chosen

- parameter perturbation – superensemble

Future model runs are few in early years (model bugs – more data on the way)



Thanks to ...



Photos from ceas.oregonstate.edu, 07/08/13

Philip Mote,

David Rupp,

Sihan Li,

Oregon Climate Change Research Institute (OCCRI)

ClimatePrediction.net (CPDN),

Oregon State University (OSU)

Regional Approaches to Climate Change in Pacific Northwest Agriculture (REACCH)

