Montana Climate Office

USFS Drought Workshop
March 14th, 2017

Montana Climate (past and future) trends and meteorological influences to drought

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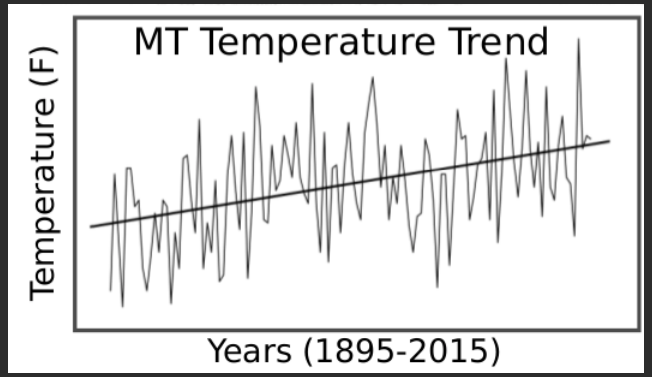
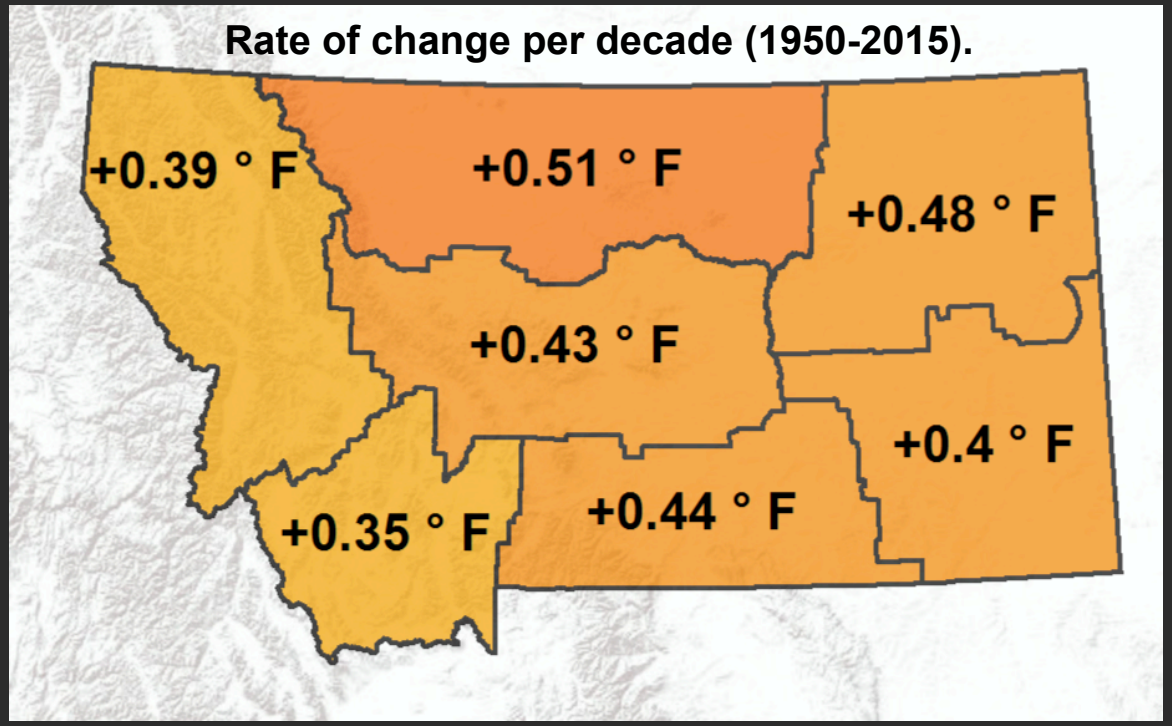
Outline

1. Briefly talk about historical trends in temp and precip
2. Introduce the Montana Climate Assessment
3. Show future projections of temp and precip
4. Discuss connections between meteorological and hydrological drought

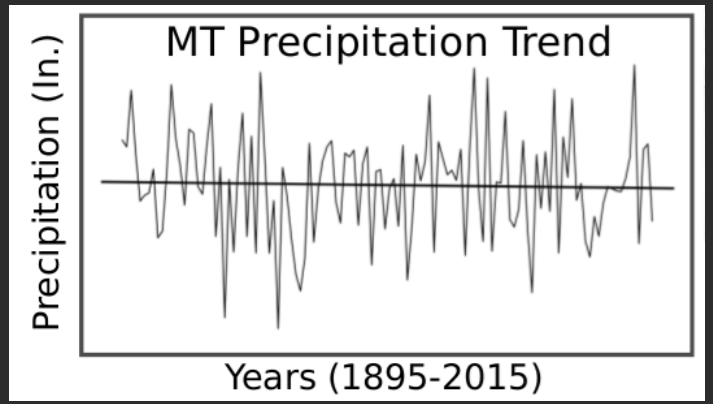
Montana Temperature Trends



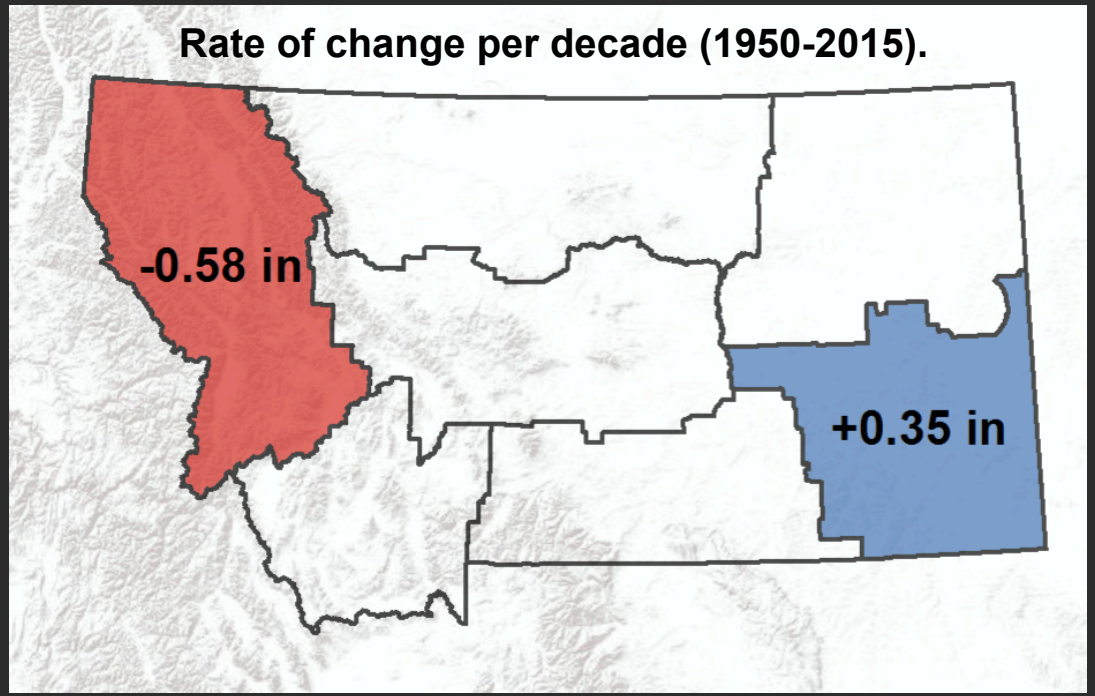
Montana temperature has increased around **2°F** from 1985-2015.



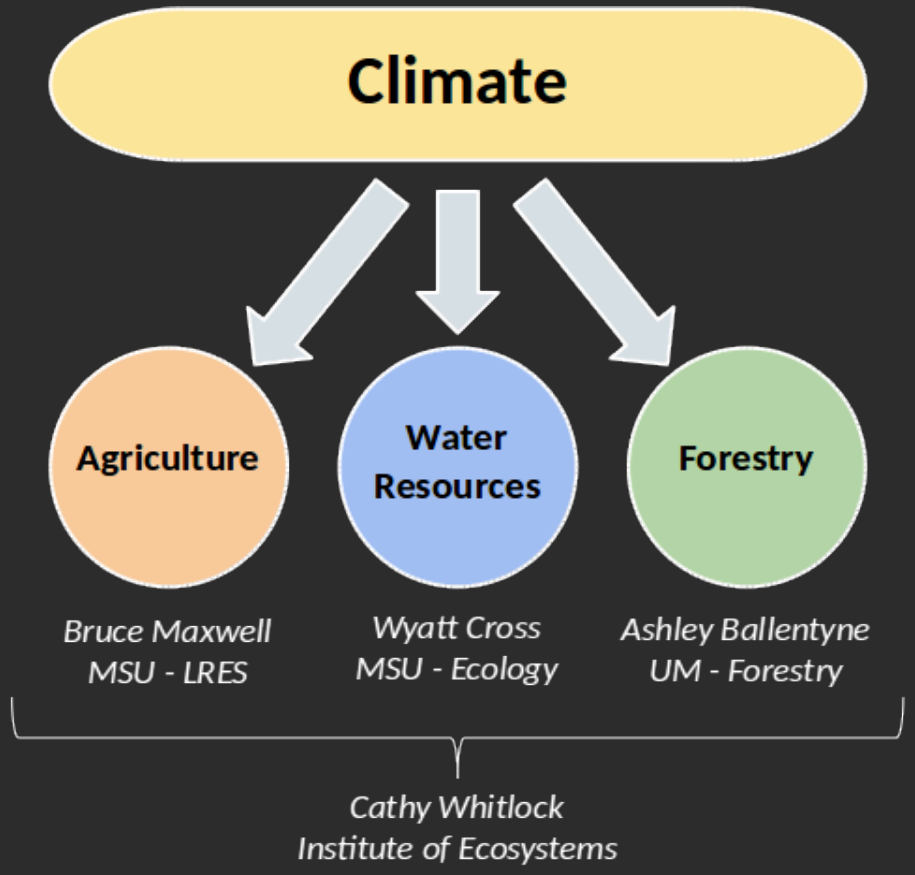
Montana Precipitation Trends



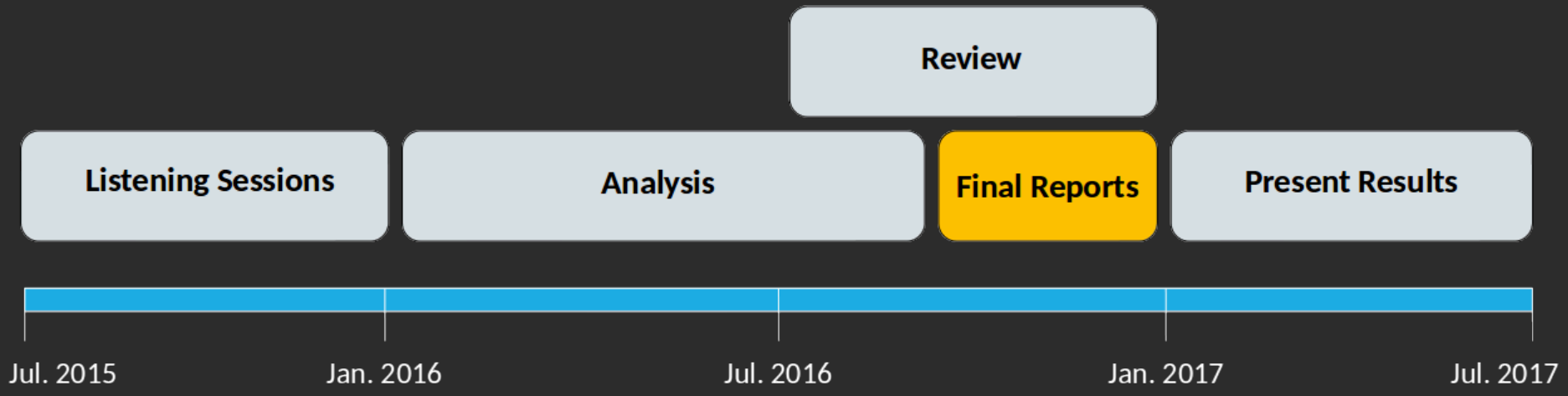
Precipitation has shown **no** statistically significant trend from 1985-2015.



Montana Climate Assessment



Timeline


Review
Listening Sessions
Analysis
Final Reports
Present Results
Jul. 2015
Jan. 2016
Jul. 2016
Jan. 2017
Jul. 2017

Montana Climate Projections

20 different models make up the <u>ensemble</u>

- This gives us a range of projections

Downscaled 4km resolution using statistical downscaling but aggregated to the Climate Division

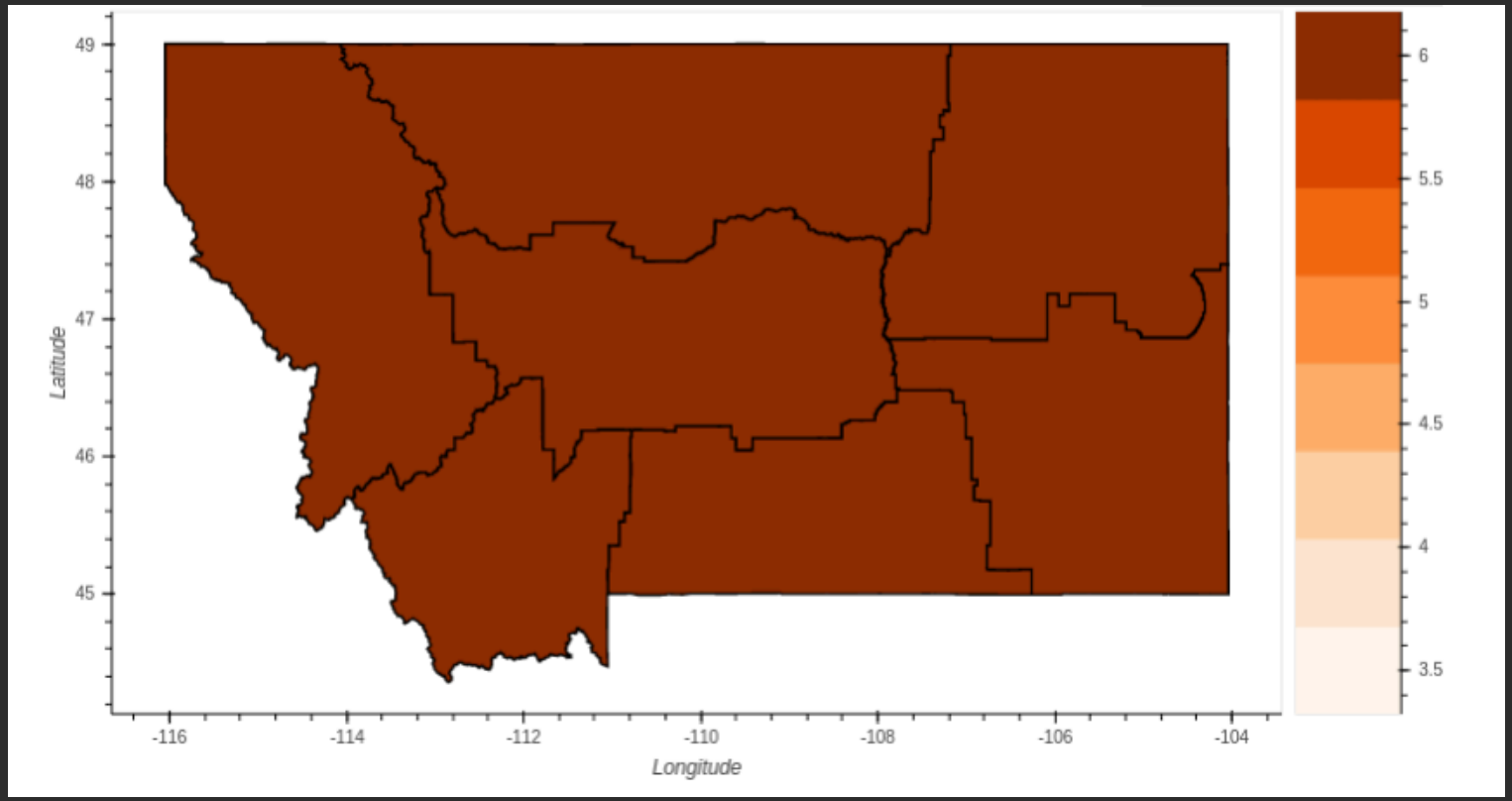
Two RCP scenarios (4.5 and 8.5)

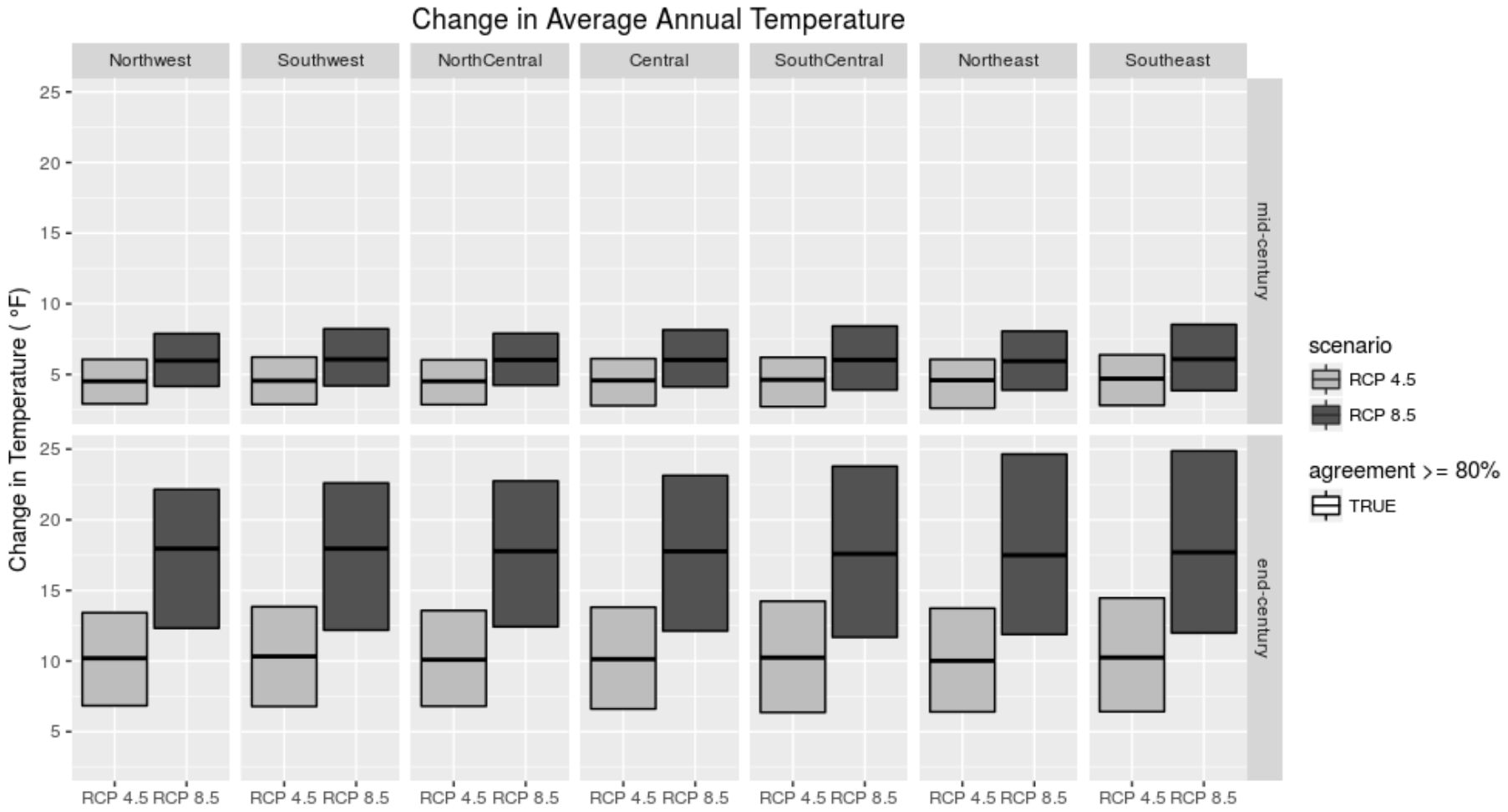
Comparison of mid- and end-of-century time periods

- Historical (1971—2000)
- Mid-century (2040—2069)
- End-of-century (2070—2099)

Change Avg. Annual Temperature (ºF)

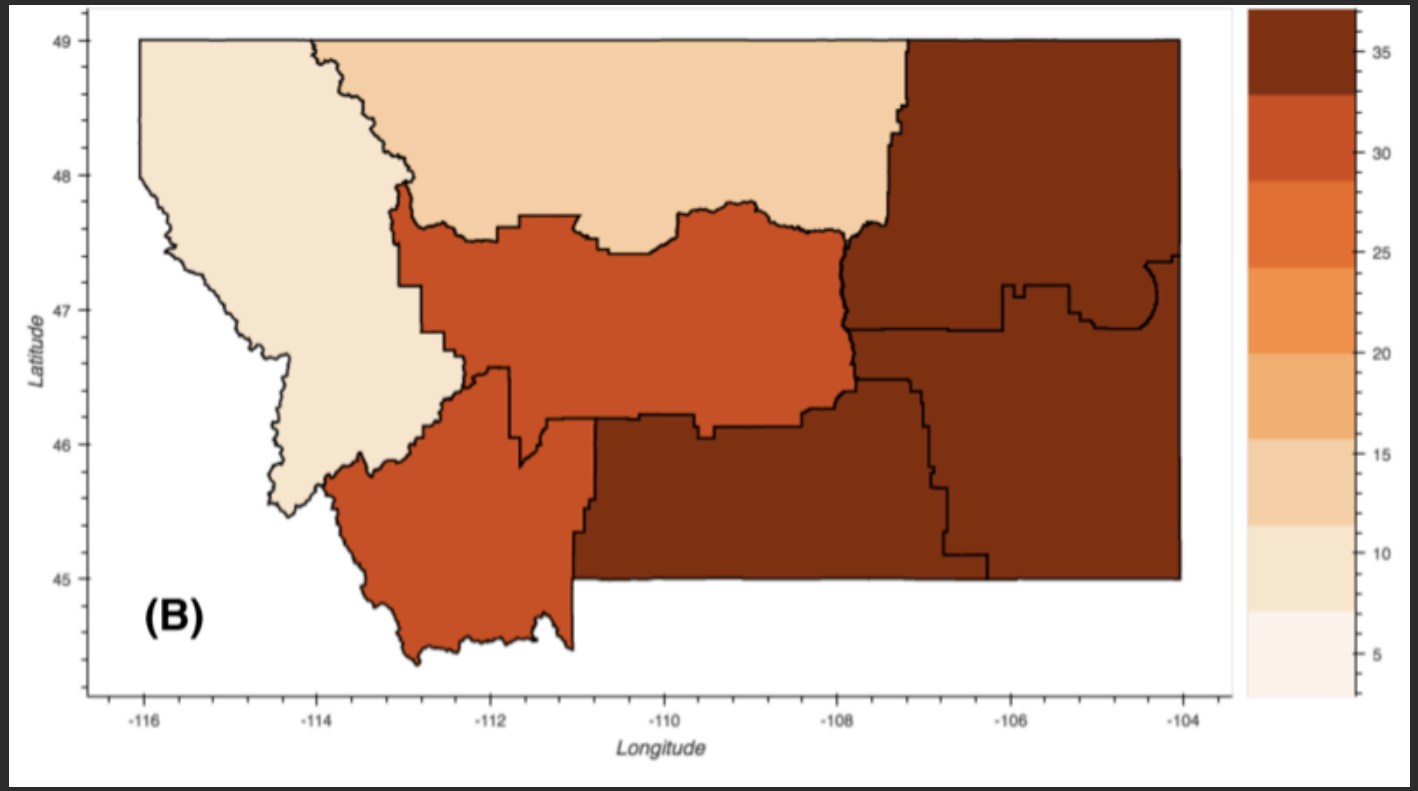
Mid-Century RCP 8.5

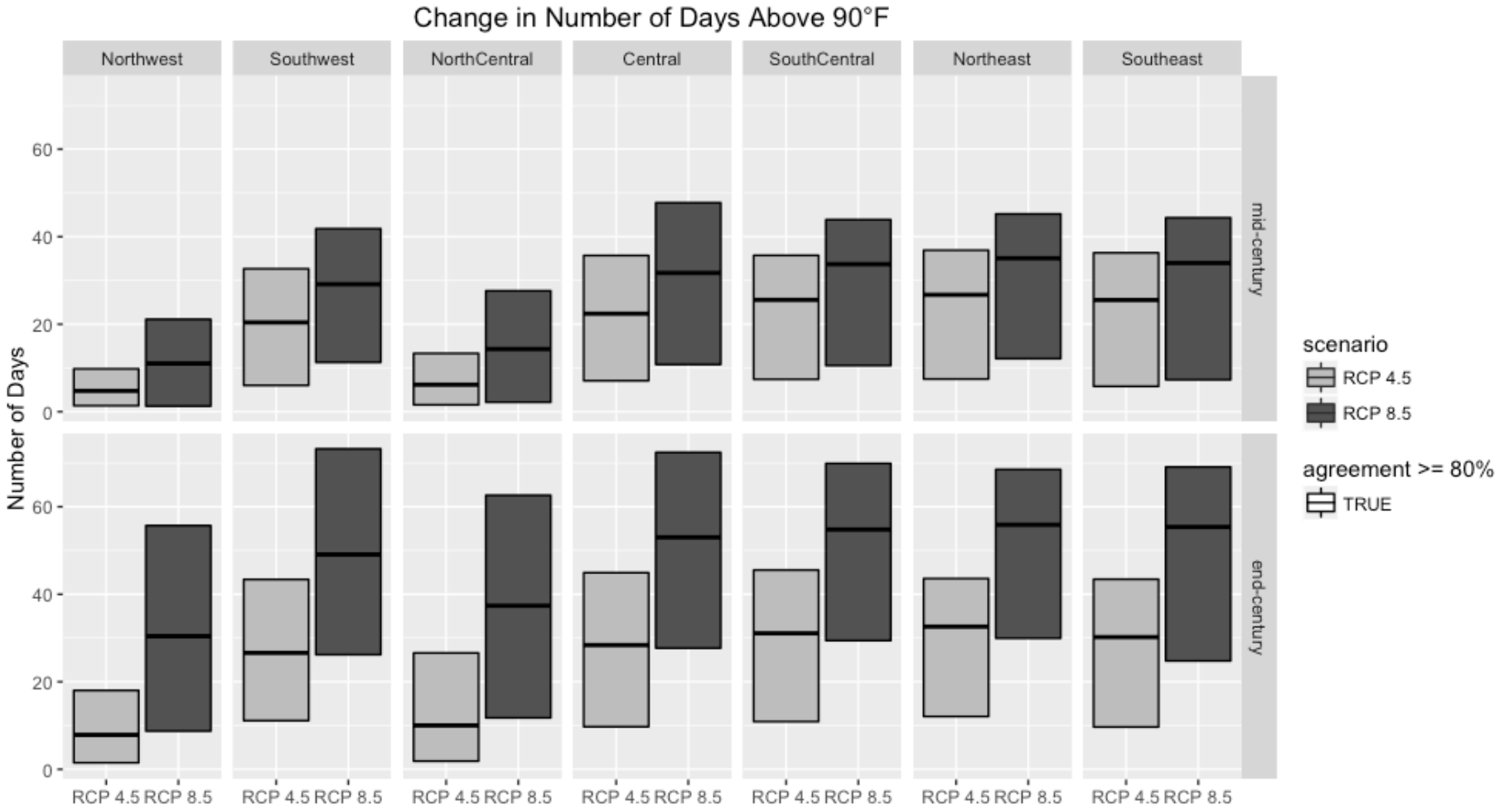



Change in Average Annual Temperature
Northwest
Southwest
NorthCentral
Central
SouthCentral
Northeast
Southeast
mid-century
end-century
Change in Temperature (°F)
25
20
15
10
5
RCP 4.5
RCP 8.5
scenario
RCP 4.5
RCP 8.5
agreement >= 80%
TRUE

Change in # of Days Above 90 ºF

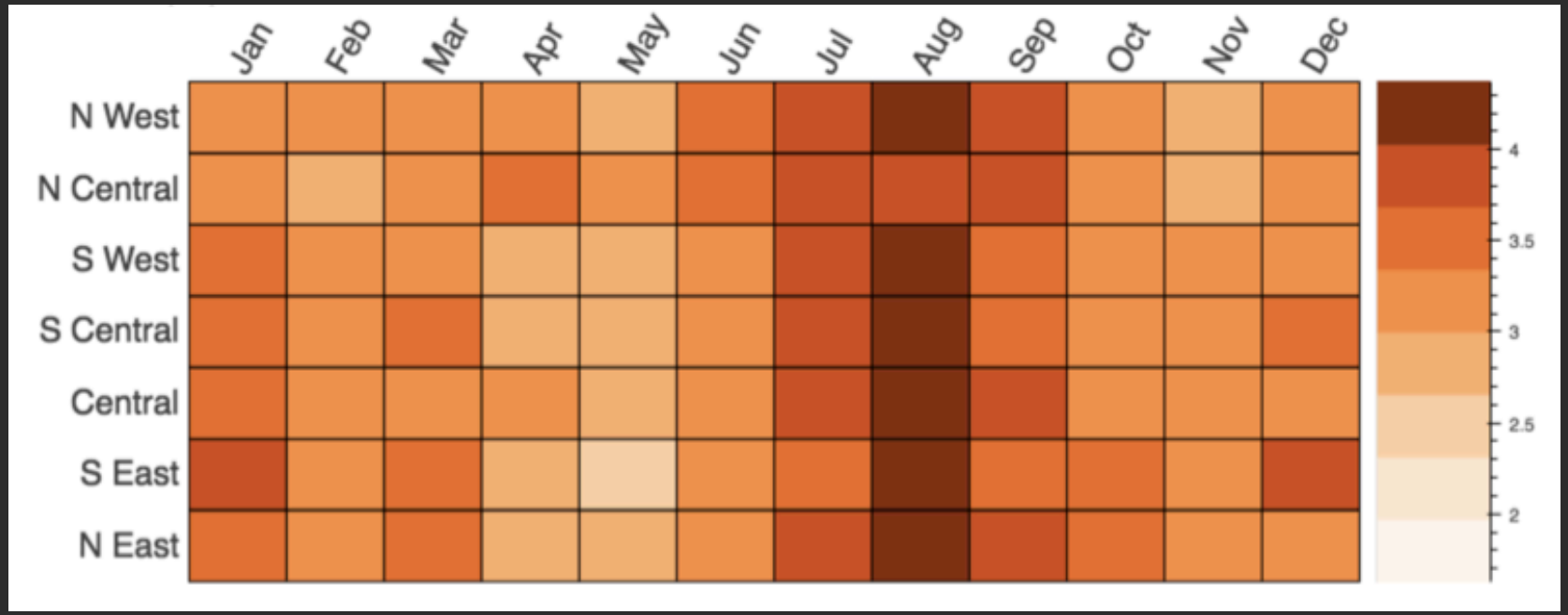
Mid-Century RCP 8.5




Change in Number of Days Above 90°F
Northwest
Southwest
NorthCentral
Central
SouthCentral
Northeast
Southeast
mid-century
end-century
Number of Days
0
20
40
60
RCP 4.5
RCP 8.5
scenario
RCP 4.5
RCP 8.5
agreement >= 80%
TRUE

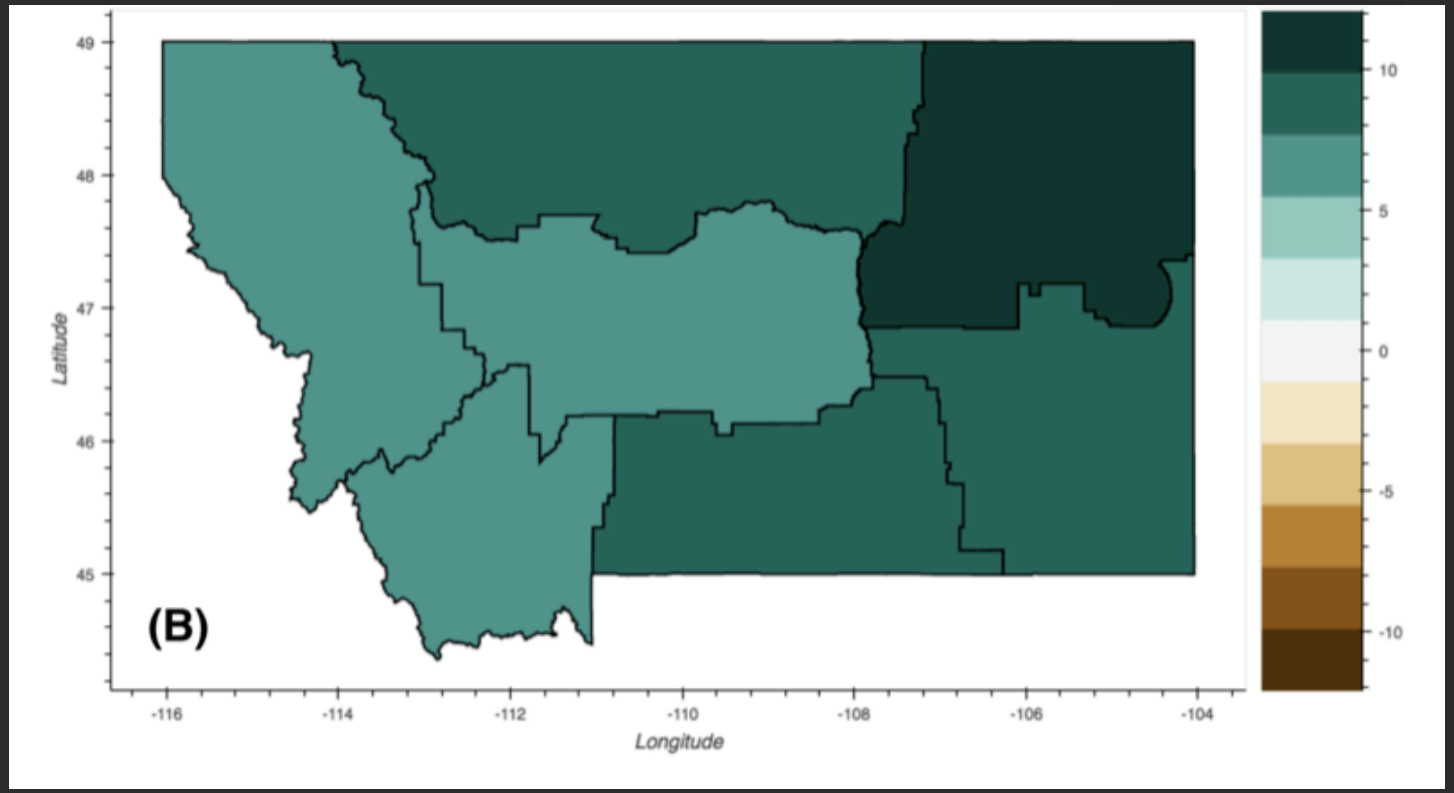
Change in Monthly Avg. Temp. (ºF)

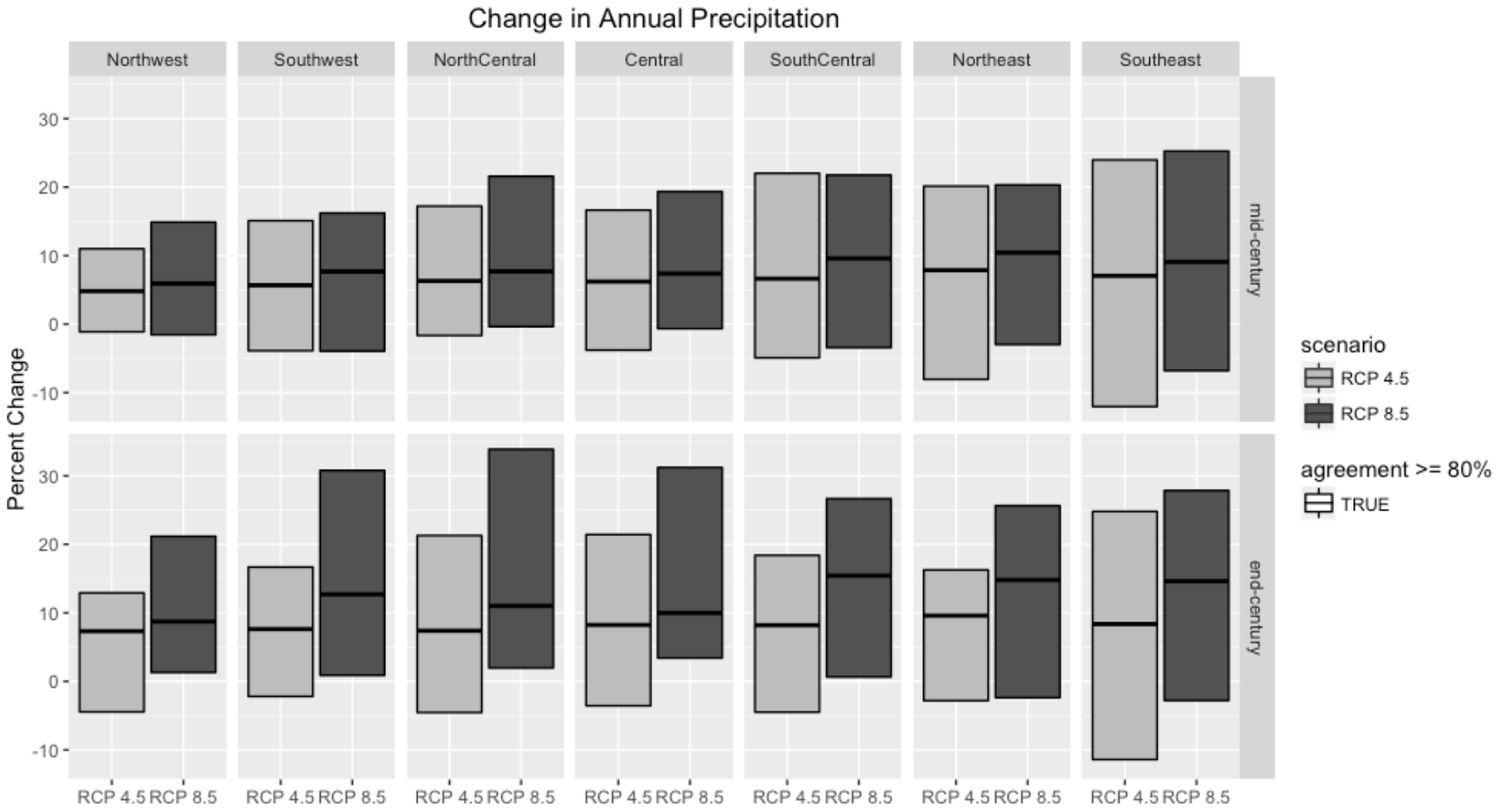
Mid-Century RCP 8.5



Change Avg. Annual Precipitation (%)

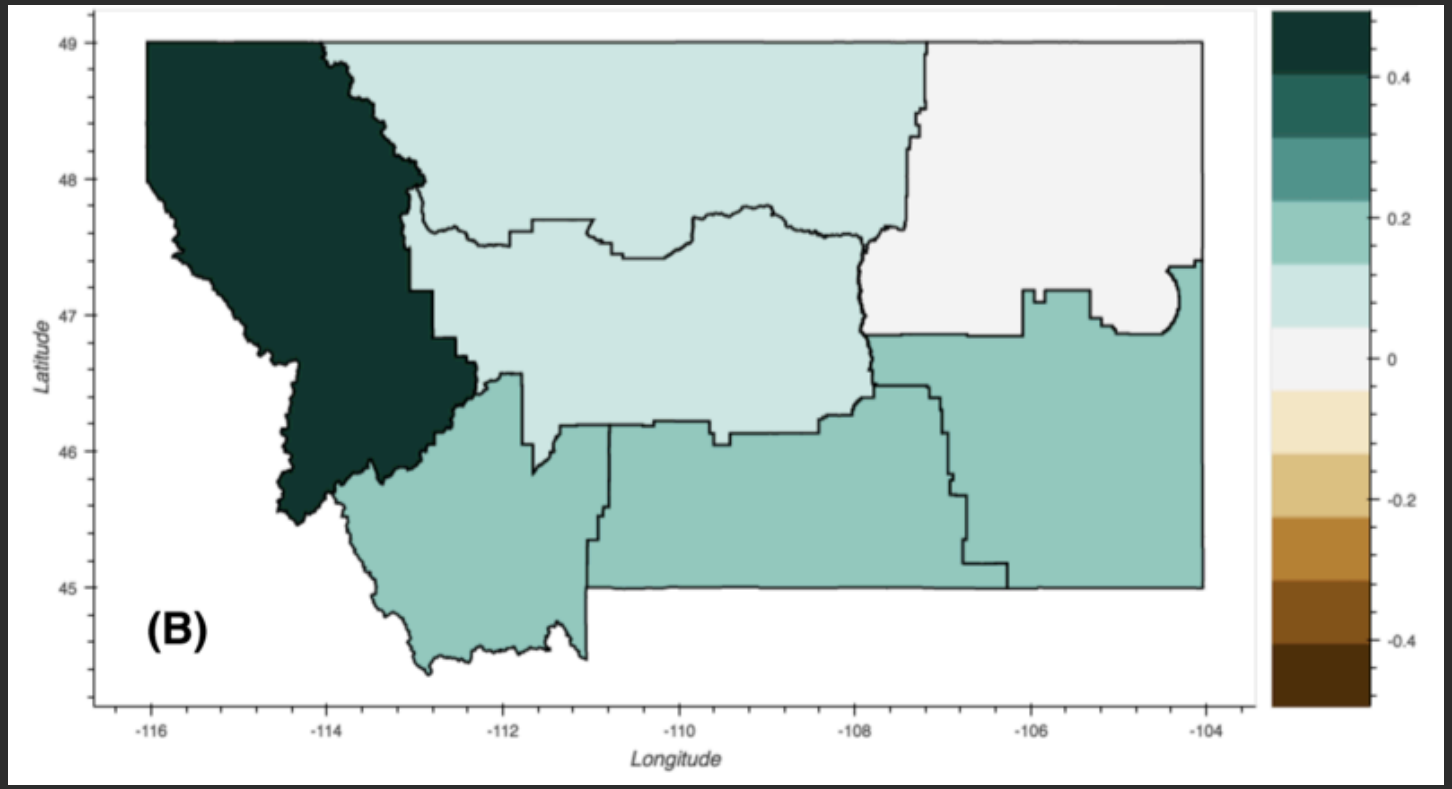
Mid-Century RCP 8.5

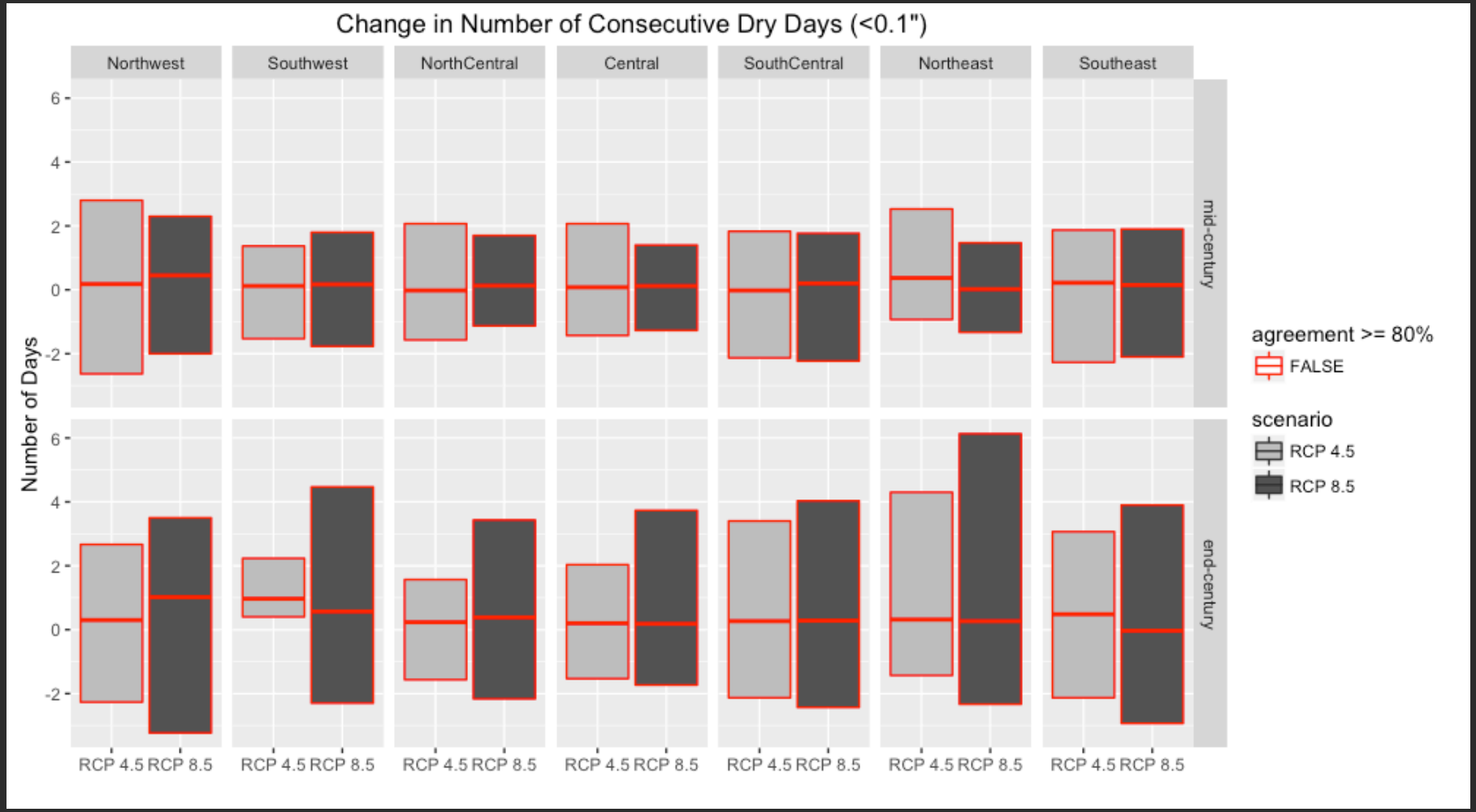



Change in Annual Precipitation
Northwest
Southwest
NorthCentral
Central
SouthCentral
Northeast
Southeast
mid-century
end-century
Percent Change
30
20
10
0
-10
RCP 4.5
RCP 8.5
scenario
RCP 4.5
RCP 8.5
agreement >= 80%
TRUE

Change in # of Consecutive Dry Days

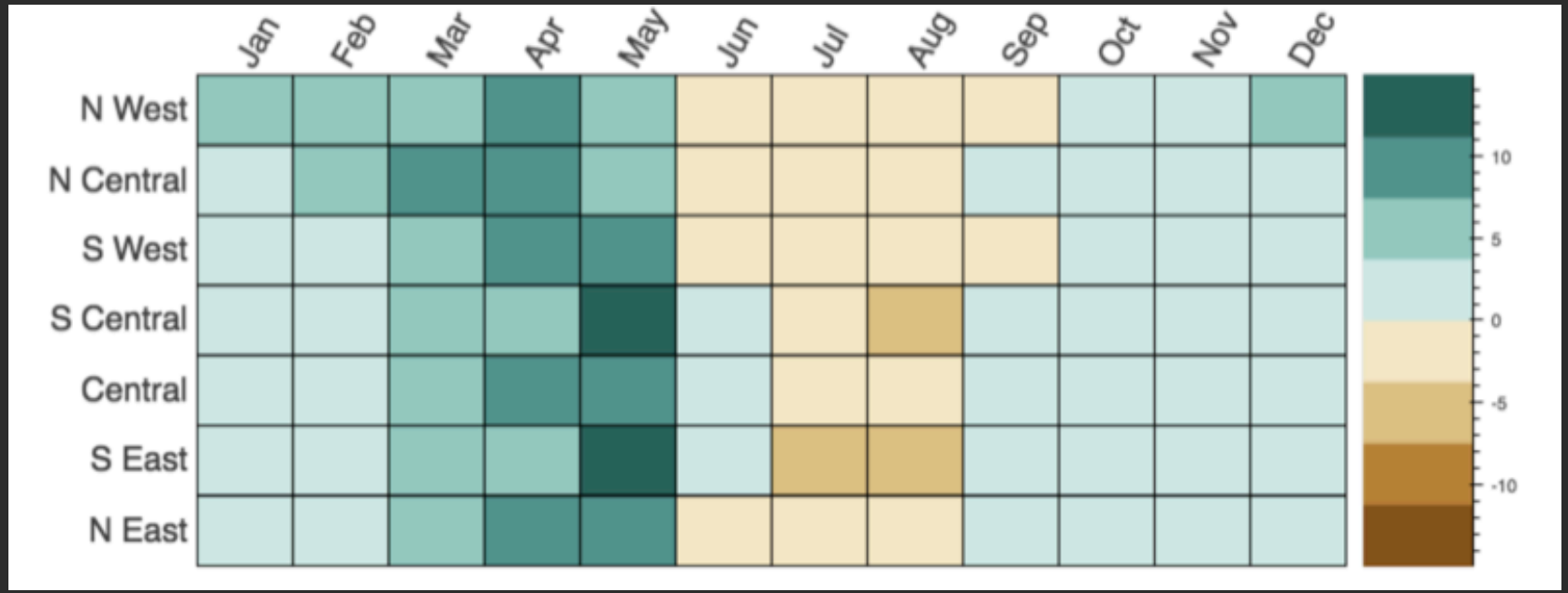
Mid-Century RCP 8.5

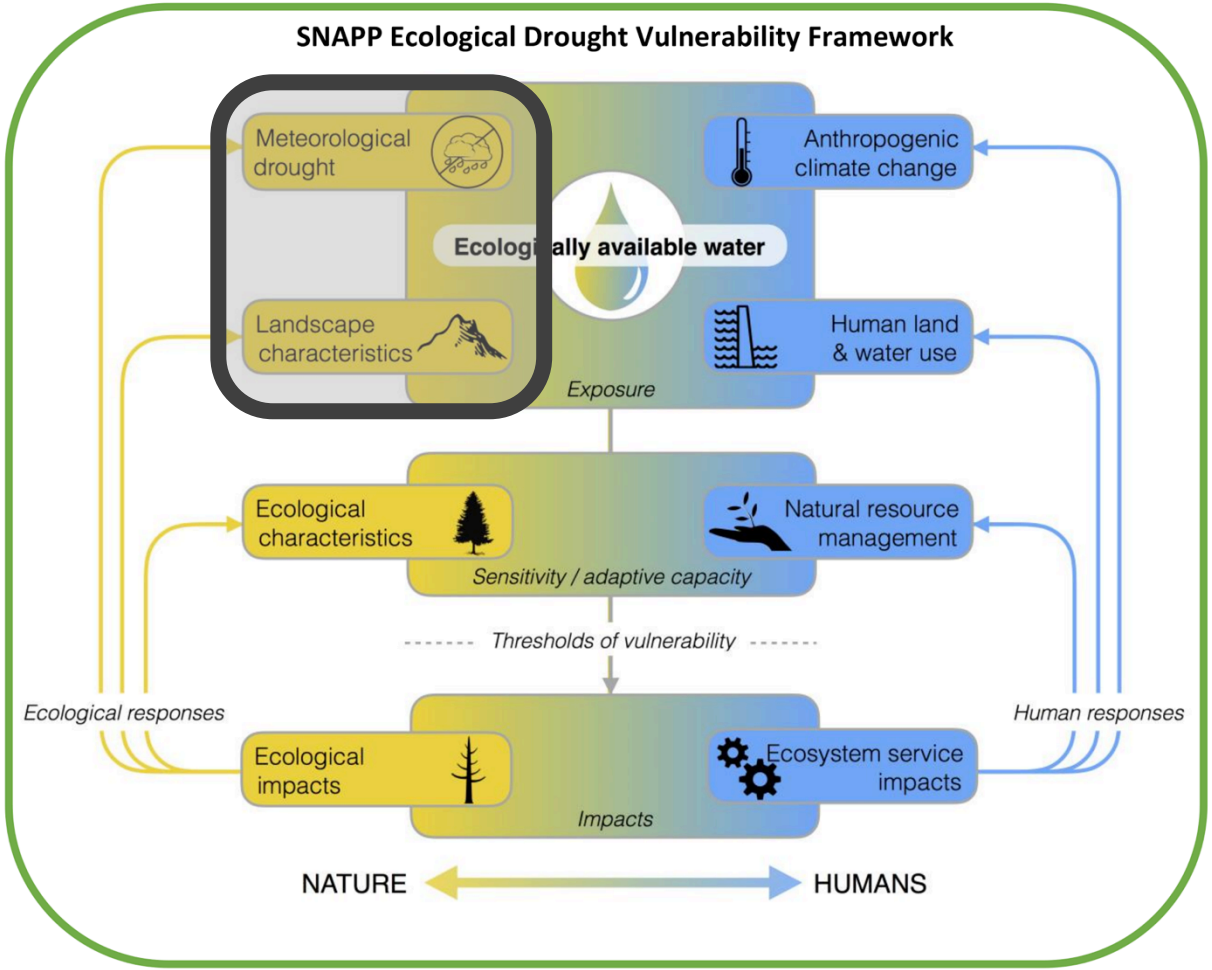



Change in Number of Consecutive Dry Days (<0.1")
Northwest
Southwest
NorthCentral
Central
SouthCentral
Northeast
Southeast
mid-century
end-century
Number of Days
6
4
2
0
-2
RCP 4.5
RCP 8.5
agreement >= 80%
FALSE
scenario
RCP 4.5
RCP 8.5

Change in Monthly Average Temps (ºF)

Mid-Century RCP 8.5




SNAPP Ecological Drought Vulnerability Framework
Meteorological drought
Landscape characteristics
Ecologically available water
Anthropogenic climate change
Human land & water use
Exposure
Ecological characteristics
Natural resource management
Sensitivity / adaptive capacity
Thresholds of vulnerability
Ecological responses
Human responses
Ecological impacts
Ecosystem service impacts
Impacts
NATURE
HUMANS

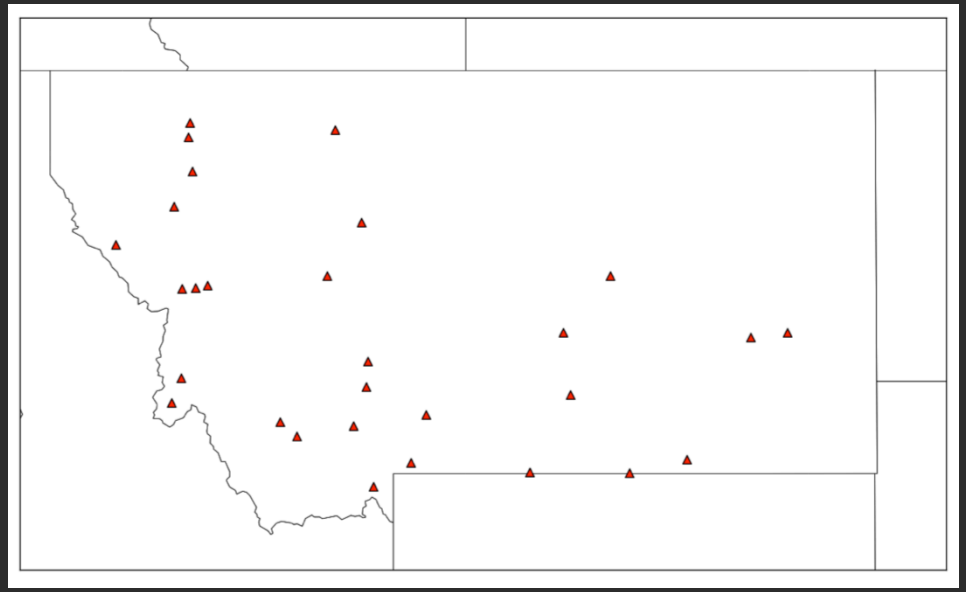
How well (historically) does temperature and precipitation predict Montana streamflow?

Streamflow data:

- Continuous 60-year record (1950--2009)
- Currently active
- Watersheds < 50,000 sq. miles
- 29 USGS stream gages

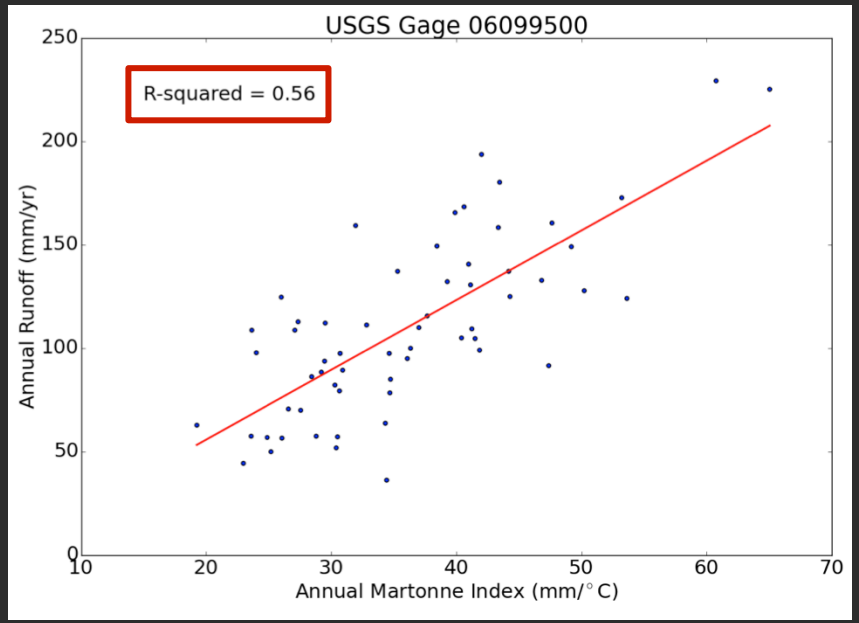
Climate data:

- 4km PRISM precipitation
- 4km PRISM temperature

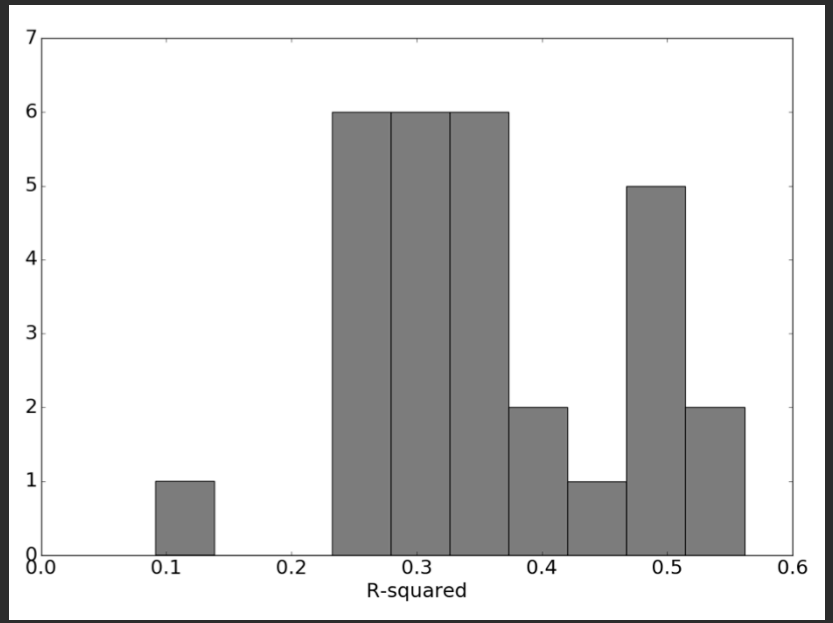


Streamflow vs. Martonne Index

Maximum Correlation



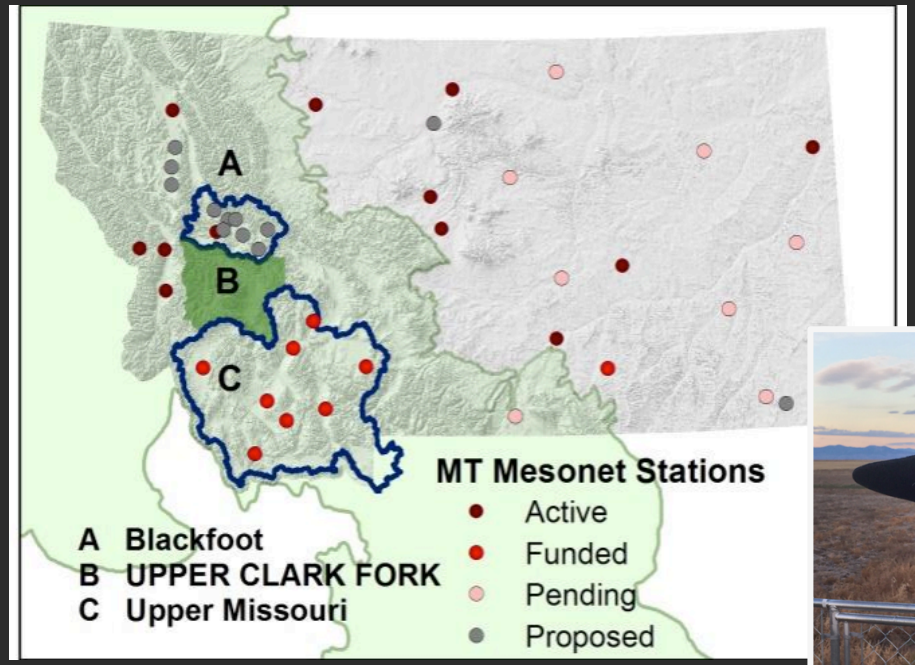
Histogram of R-squareds



Summary

Temperature has increased historically and is projected to increase by another 4-6 ^{o}F by mid-century.
Precipitation has stayed about the same historically but is projected to increase by around 6-10 % by mid-century.
Drought metrics (i.e. consecutive dry days) are not projected to change much but are highly uncertain.
However, meteorological drivers only explain around ~60% of the variation in streamflow in Montana.
Therefore, we need to be considering how to adapt our management of the other ~40%.

Montana Soil Moisture Monitoring



Kevin Hyde
Mesonet Coordinator

Questions???

Montana Climate Office

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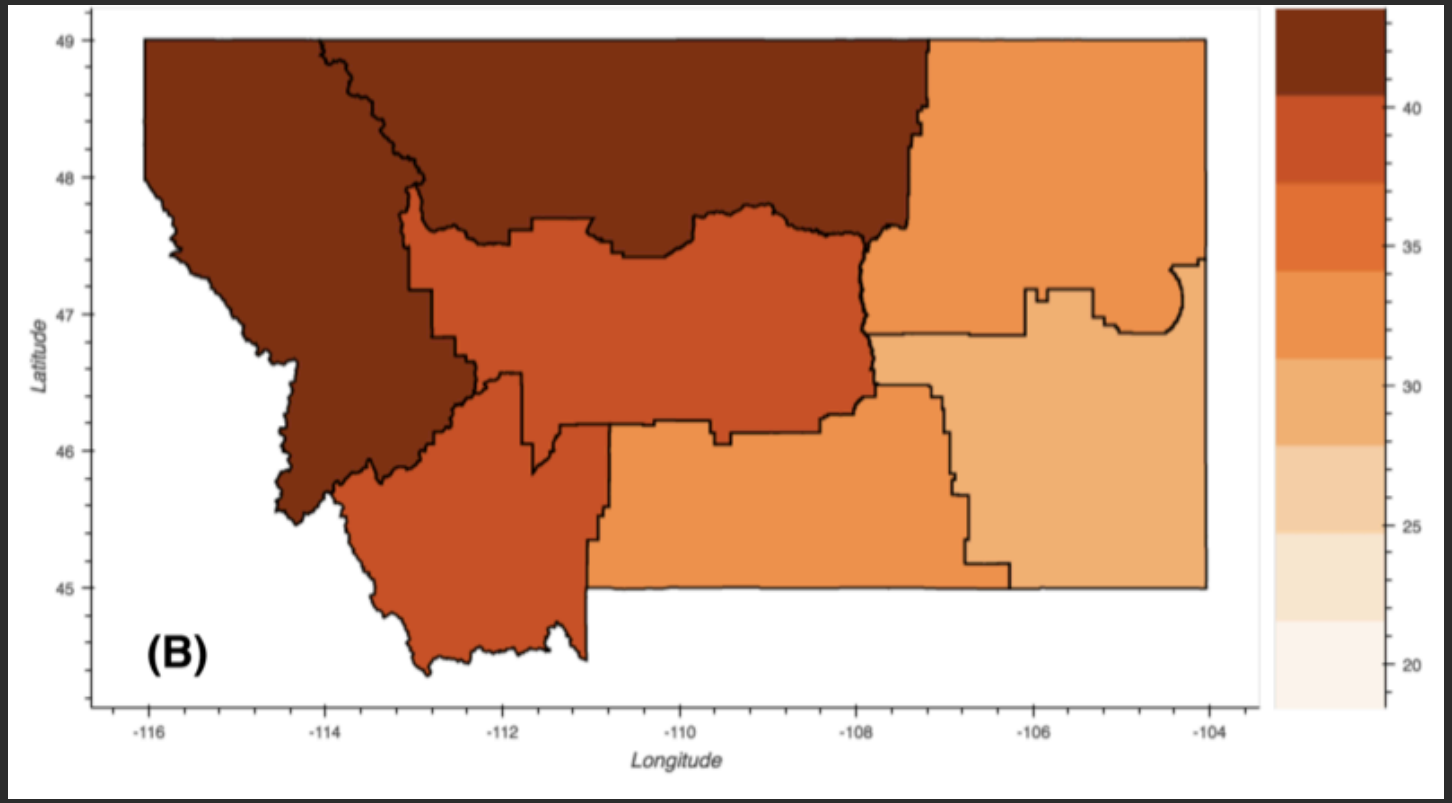
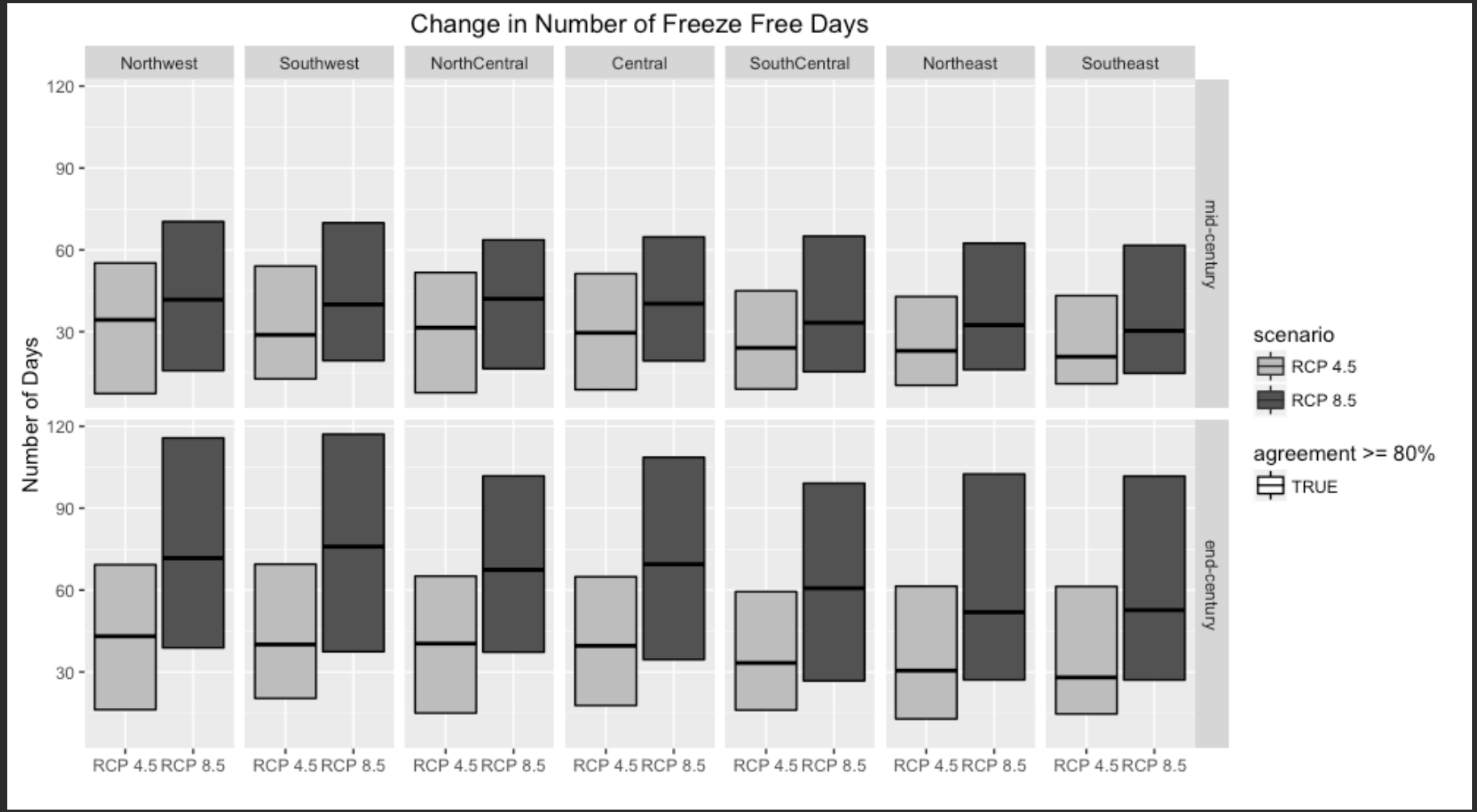
Change in # of Freeze Free Days

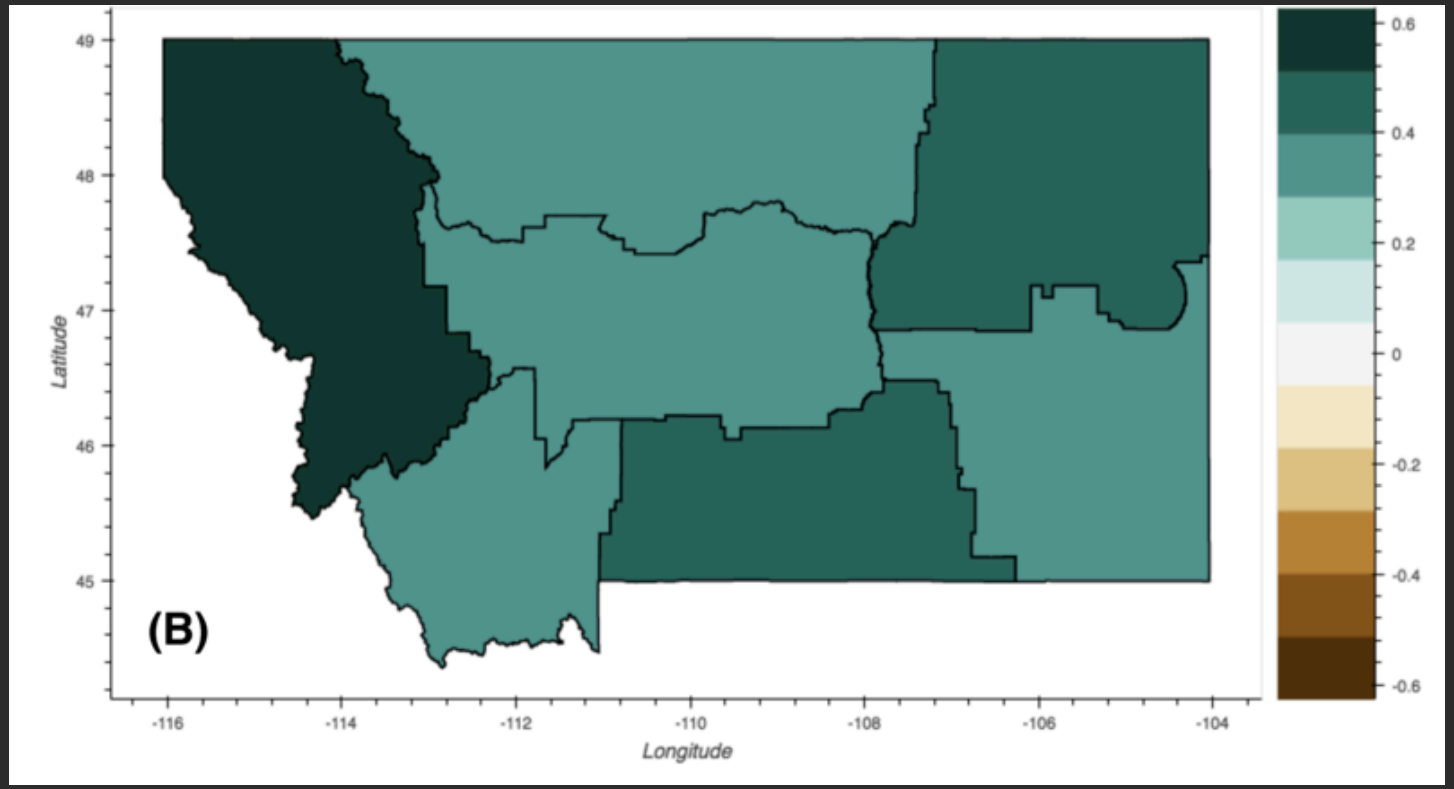
Mid-Century RCP 8.5

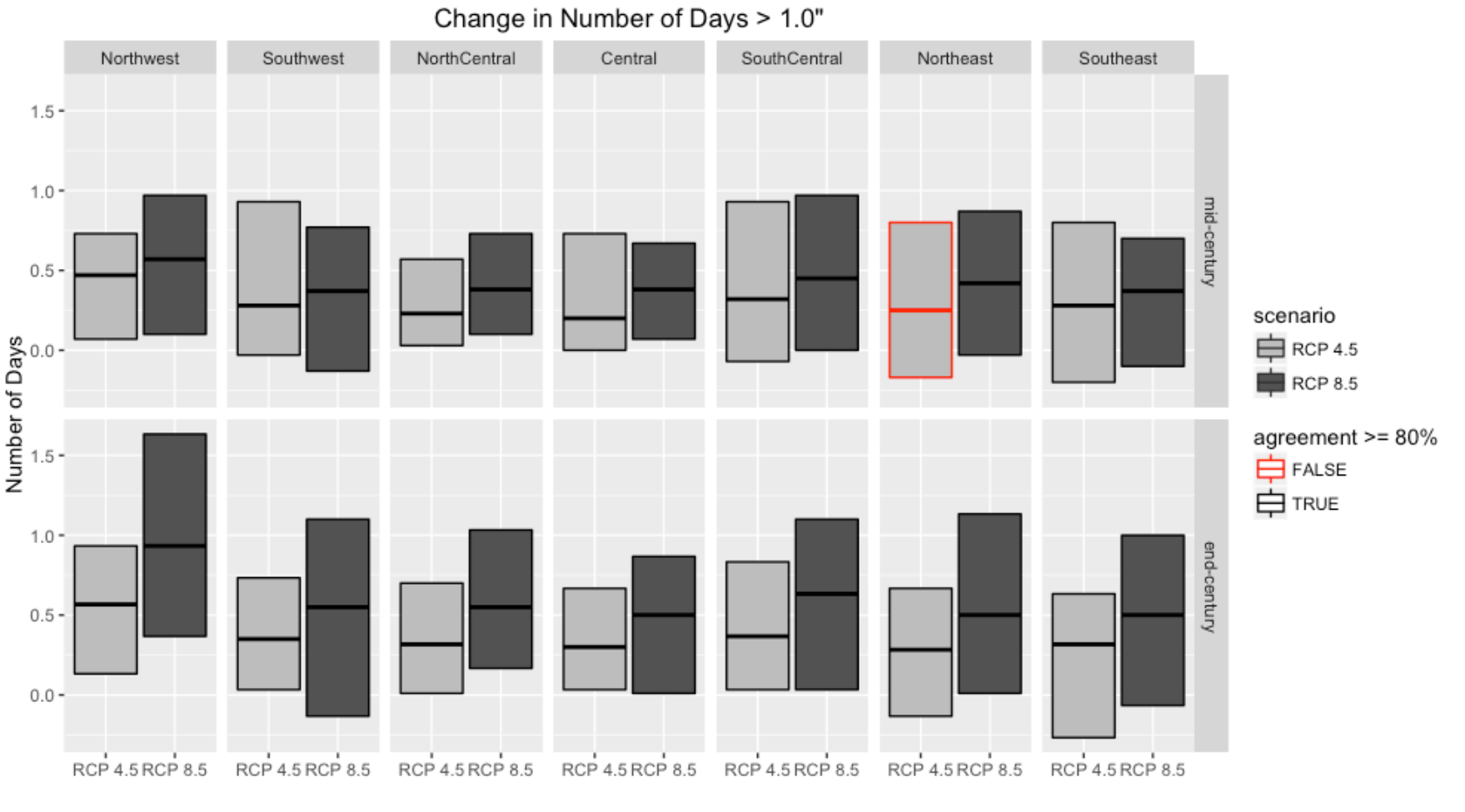



Change in Number of Freeze Free Days
Northwest
Southwest
NorthCentral
Central
SouthCentral
Northeast
Southeast
mid-century
end-century
Number of Days
120
90
60
30
RCP 4.5
RCP 8.5
scenario
RCP 4.5
RCP 8.5
agreement >= 80%
TRUE

Change in # of Days Above 1.0”

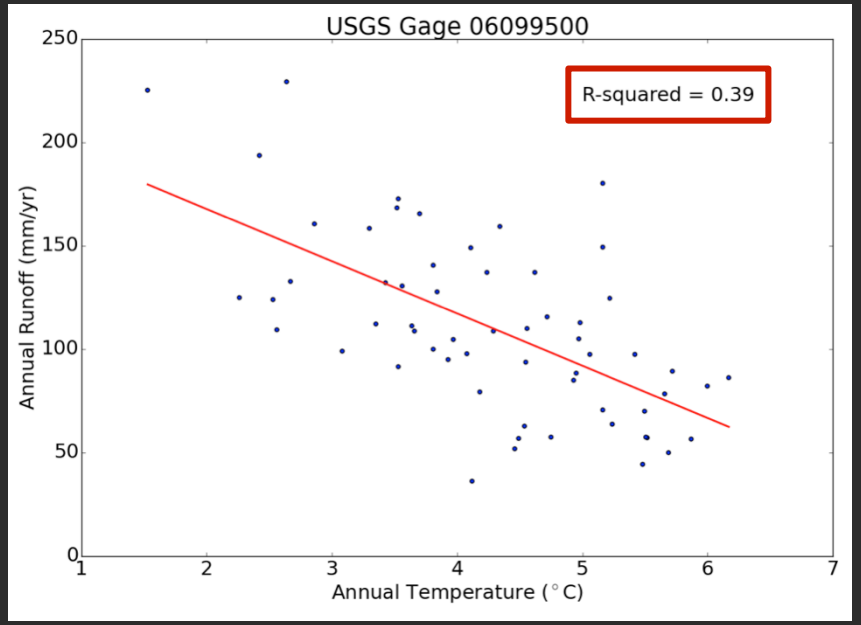
Mid-Century RCP 8.5



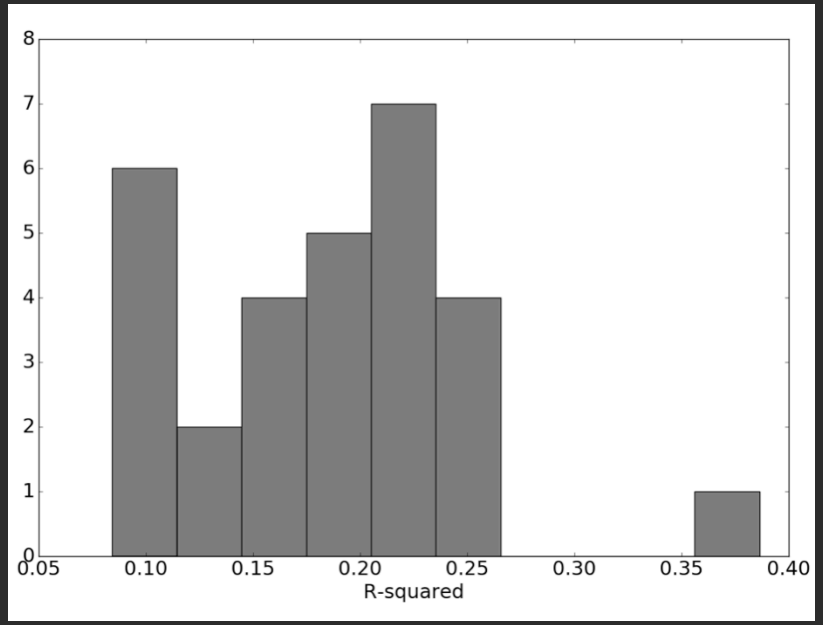

Change in Number of Days > 1.0"
Northwest
Southwest
NorthCentral
Central
SouthCentral
Northeast
Southeast
mid-century
end-century
Number of Days
1.5
1.0
0.5
0.0
RCP 4.5
RCP 8.5
scenario
RCP 4.5
RCP 8.5
agreement >= 80%
FALSE
TRUE

Streamflow vs. Temperature

Maximum Correlation

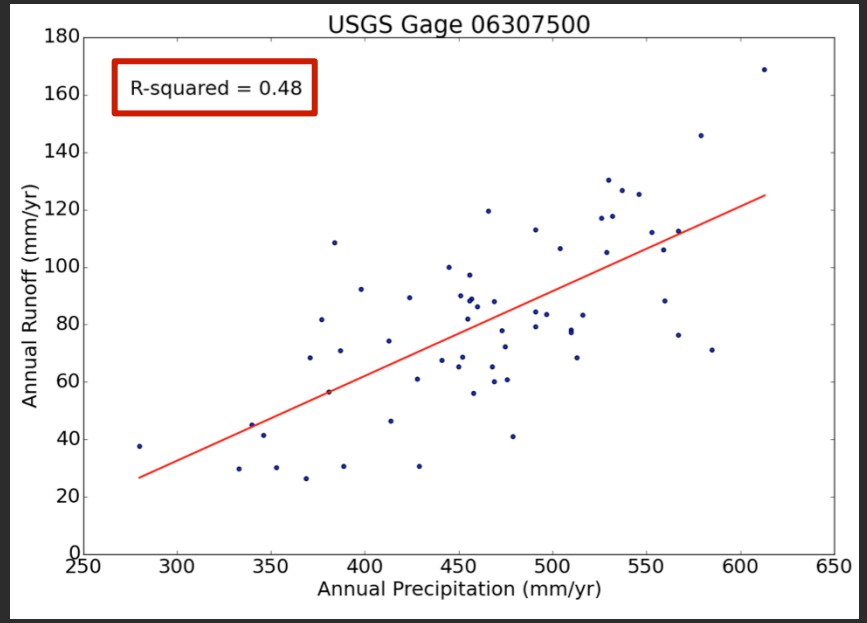


Histogram of R-squareds

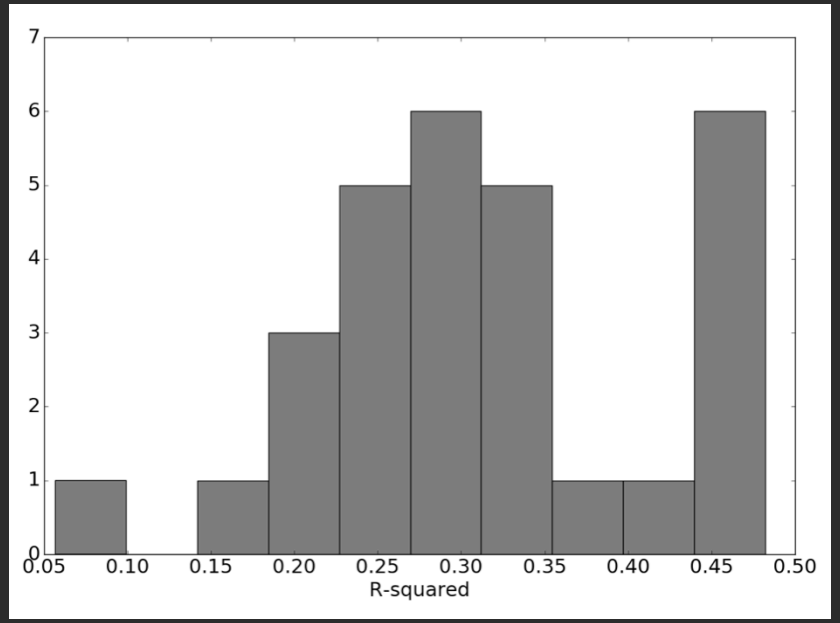


Streamflow vs. Precipitation

Maximum Correlation



Histogram of R-squareds



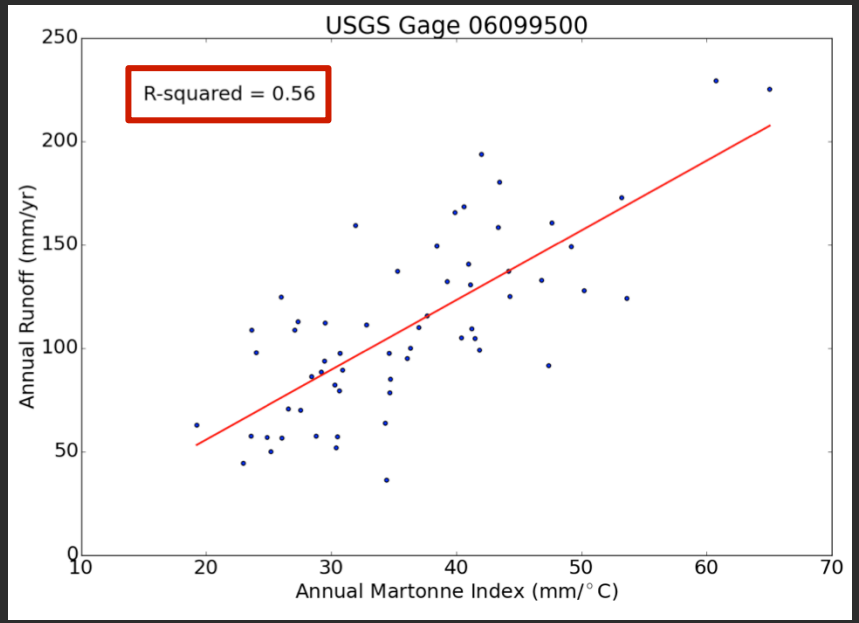
What about combining P and T?

Martonne Index (De Martonne, 1926):

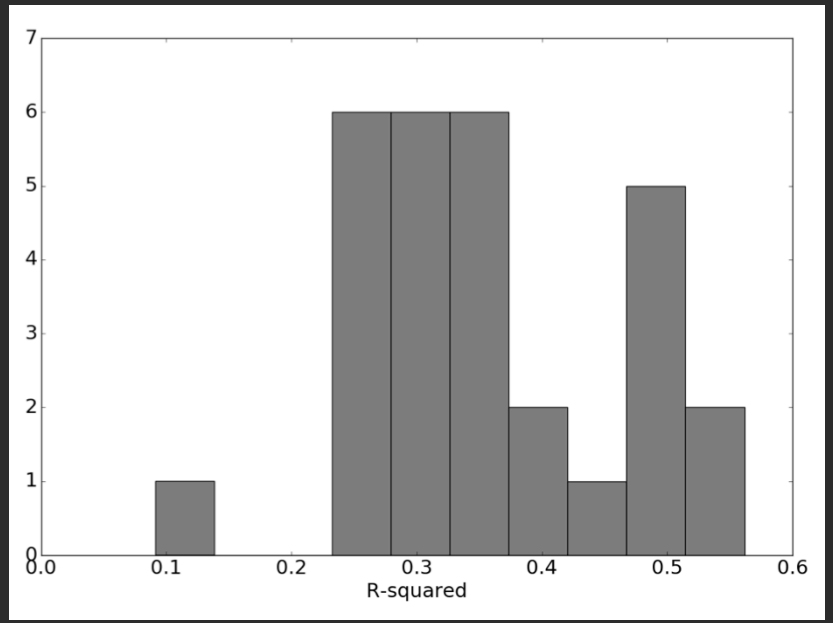
$$MI = \frac{P}{T + 10}$$

Streamflow vs. Martonne Index

Maximum Correlation



Histogram of R-squareds



What's left to explain Q?

$$Q = P - ET - \cancelto{0}{\Delta S}$$

Evapotranspiration (ET)

- Irrigation
- Crop type
- Forest management
- Wildfire
- Beetle kill
- Vegetation adaptation

Broader perspectives on change...