



Hrvatsko  
meteorološko  
društvo

# Seasonal shifts in the Mediterranean type climates\*

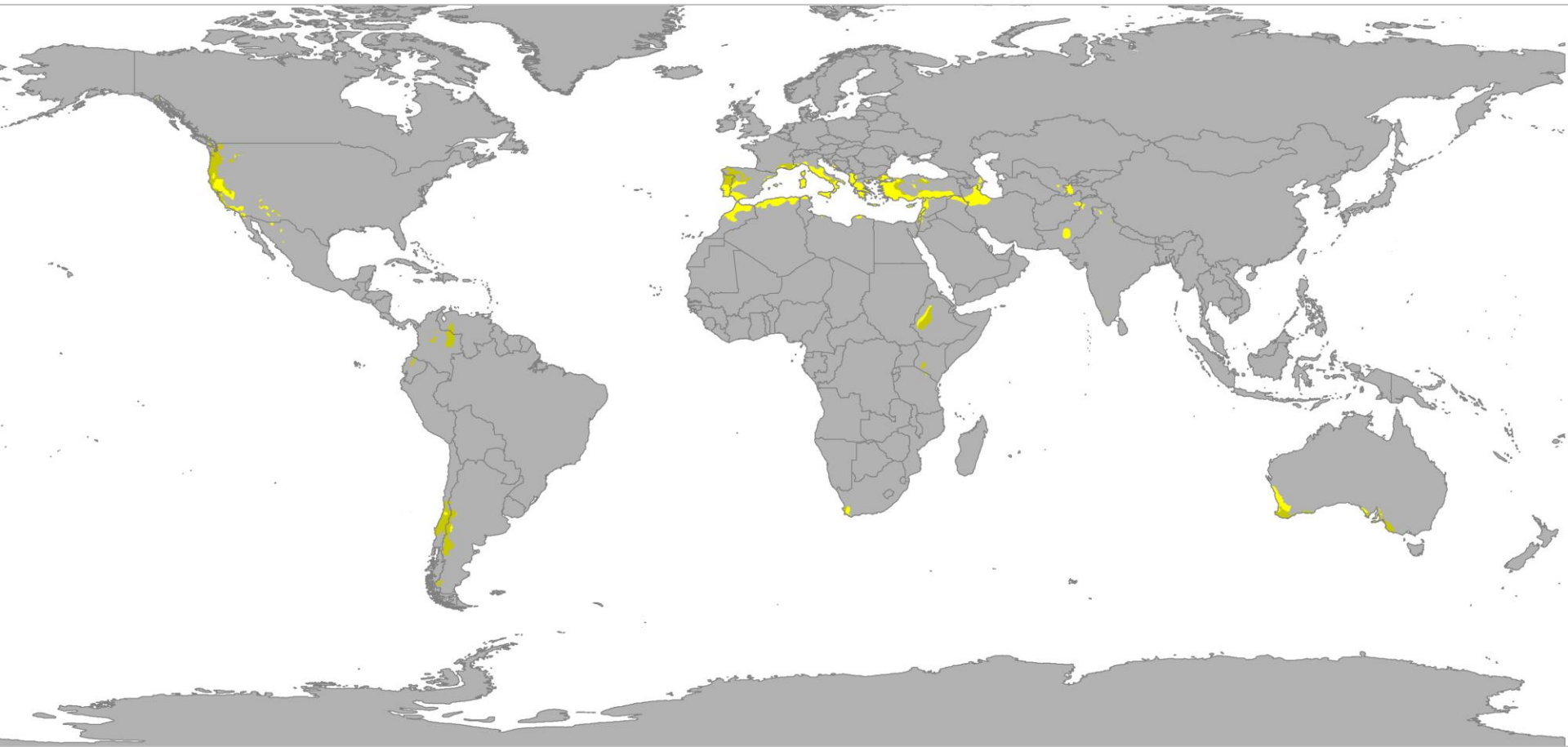
Jelena Luković

*University of Belgrade, Serbia*

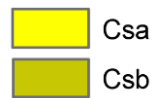
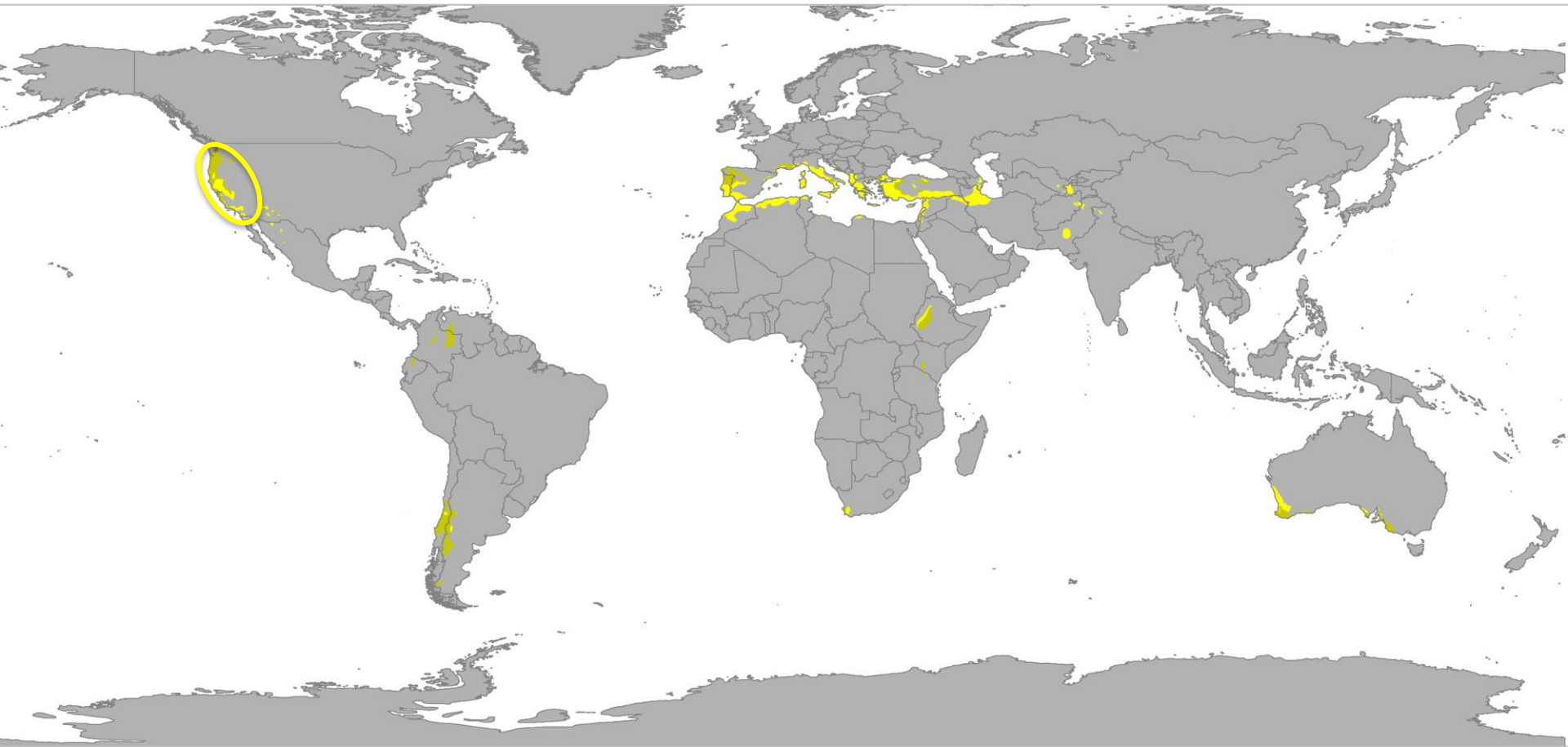
*with John Chiang, University of California Berkeley*

*\*Acknowledgments to: Fulbright Scholar Program*

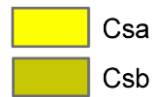
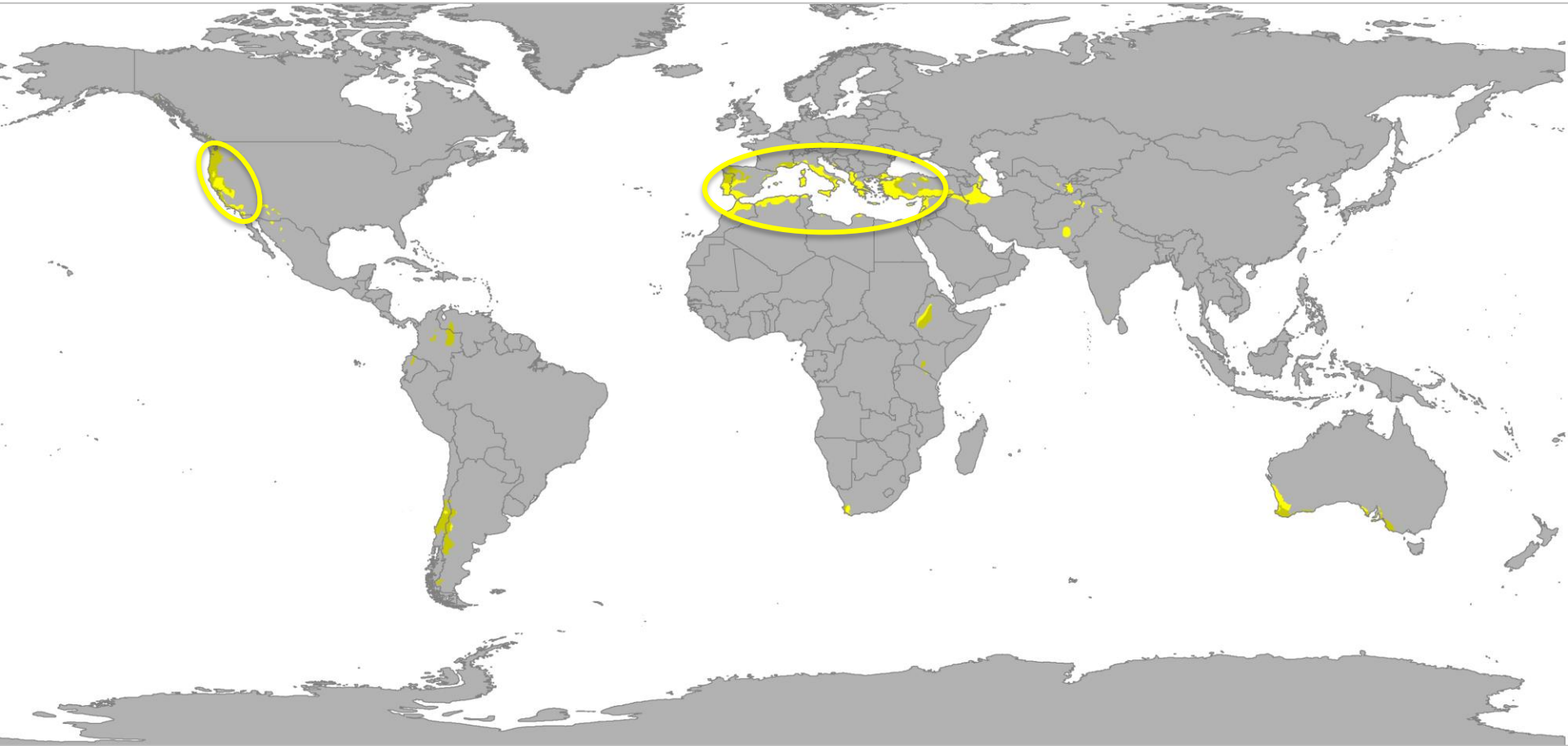
# Mediterranean type climates



# Mediterranean type climates



# Mediterranean type climates



Signatures of the recent climate trends



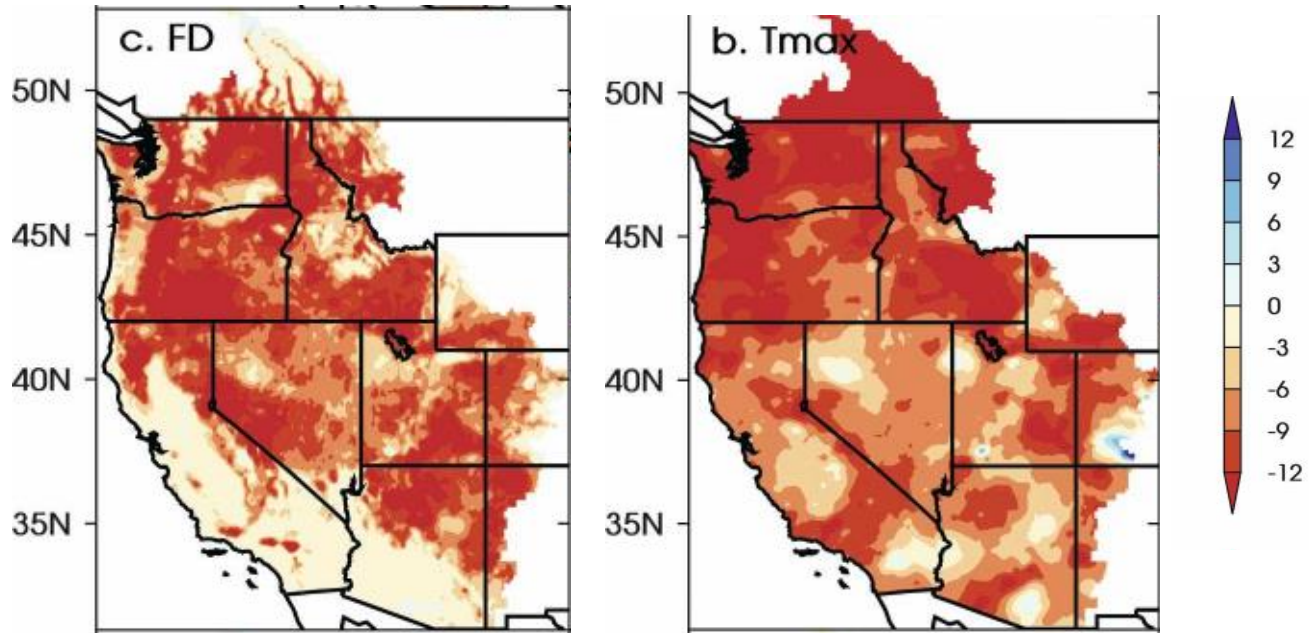
Shifts in seasonal cycles



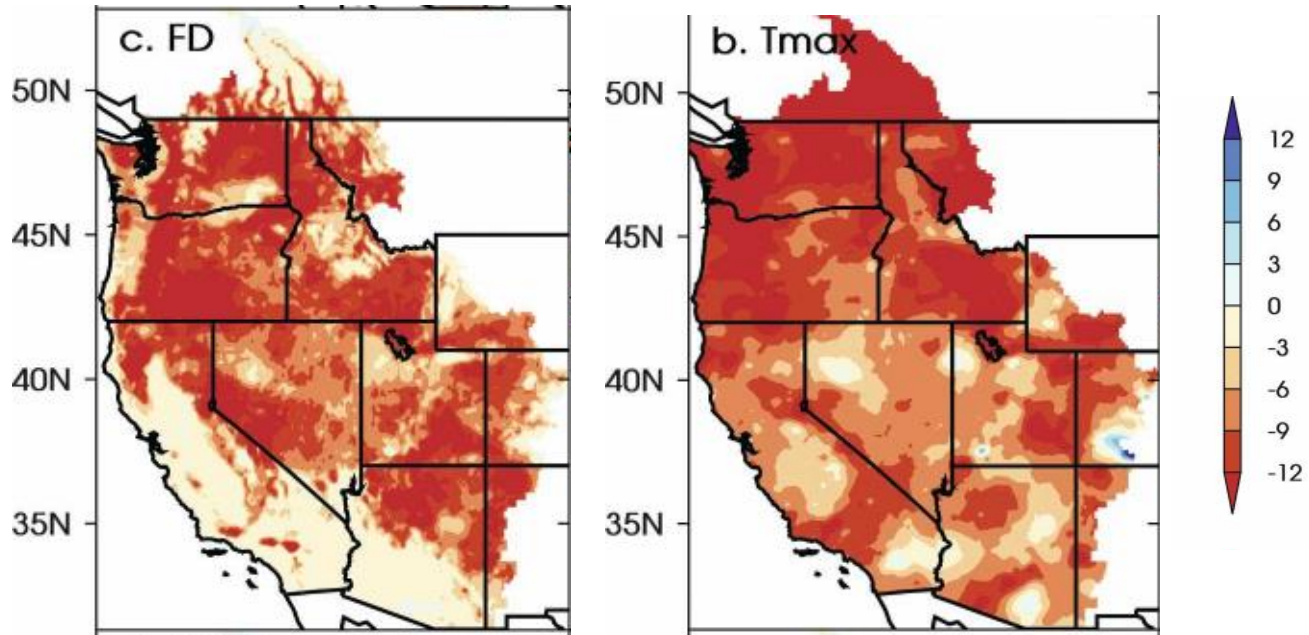
Temperature  
driven

Precipitation  
driven

# Trends in winter (Jan-Mar) temperature

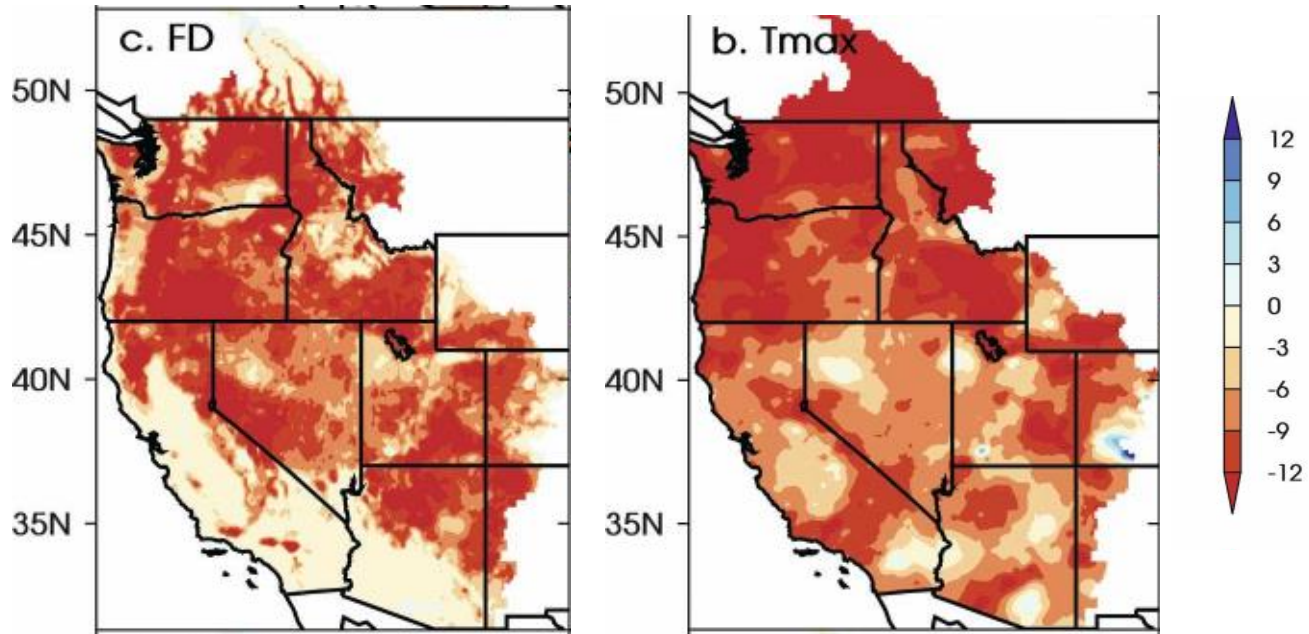


# Trends in winter (Jan-Mar) temperature



Decrease in snow cover

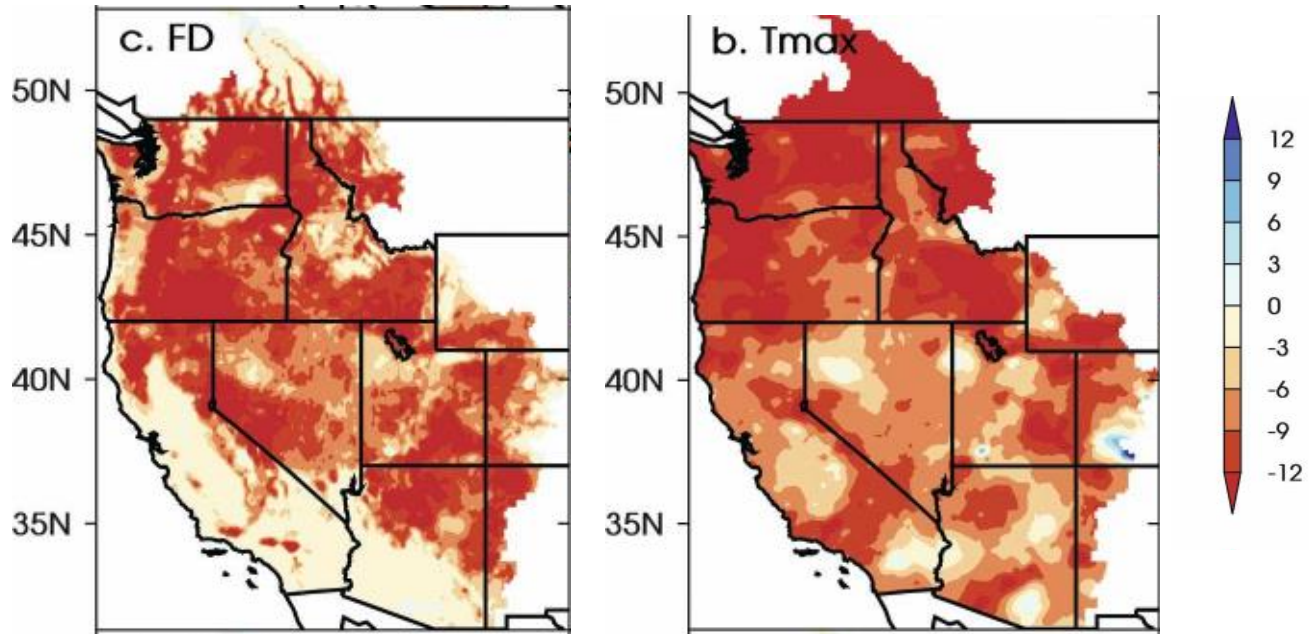
# Trends in winter (Jan-Mar) temperature



Decrease in snow cover  
Shifts in peak discharge timing

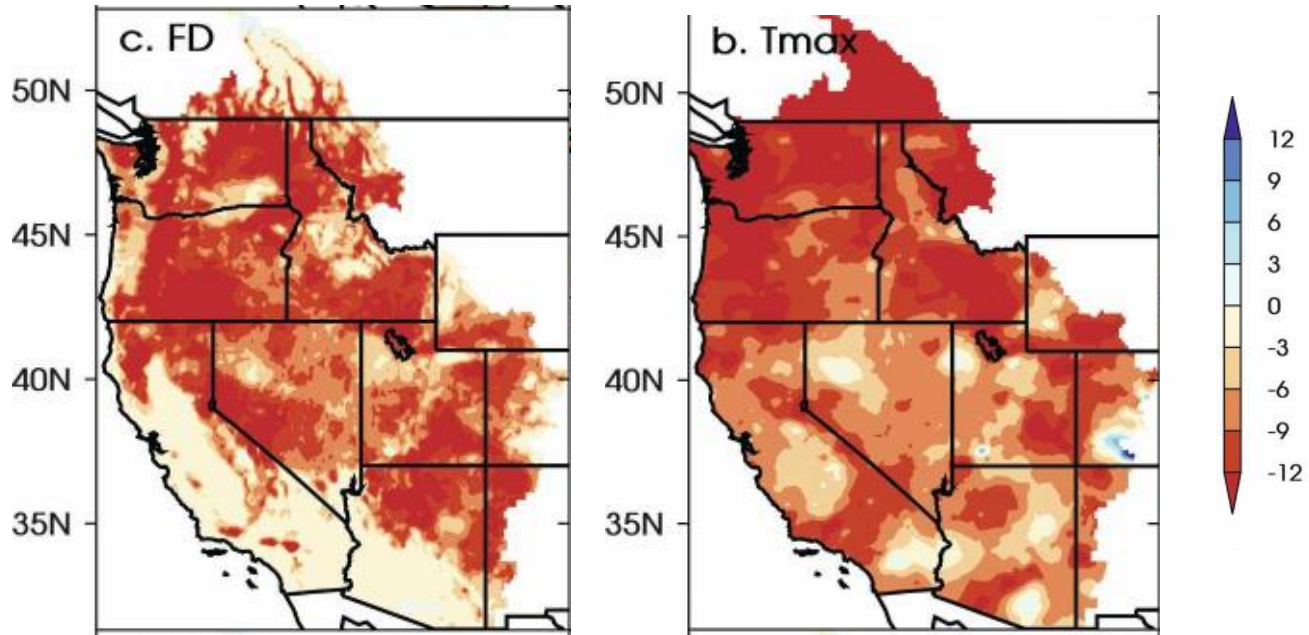


# Trends in winter (Jan-Mar) temperature



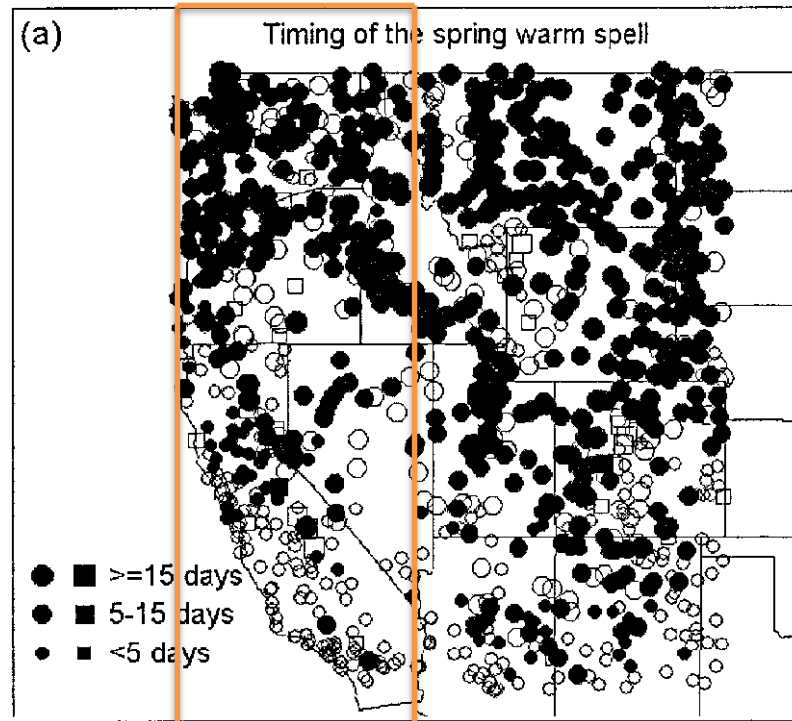
Decrease in snow cover  
Shifts in peak discharge timing  
Early blossom of the plants

# Trends in winter (Jan-Mar) temperature



Decrease in snow cover  
Shifts in peak discharge timing  
Early blossom of the plants  
Extended growing season

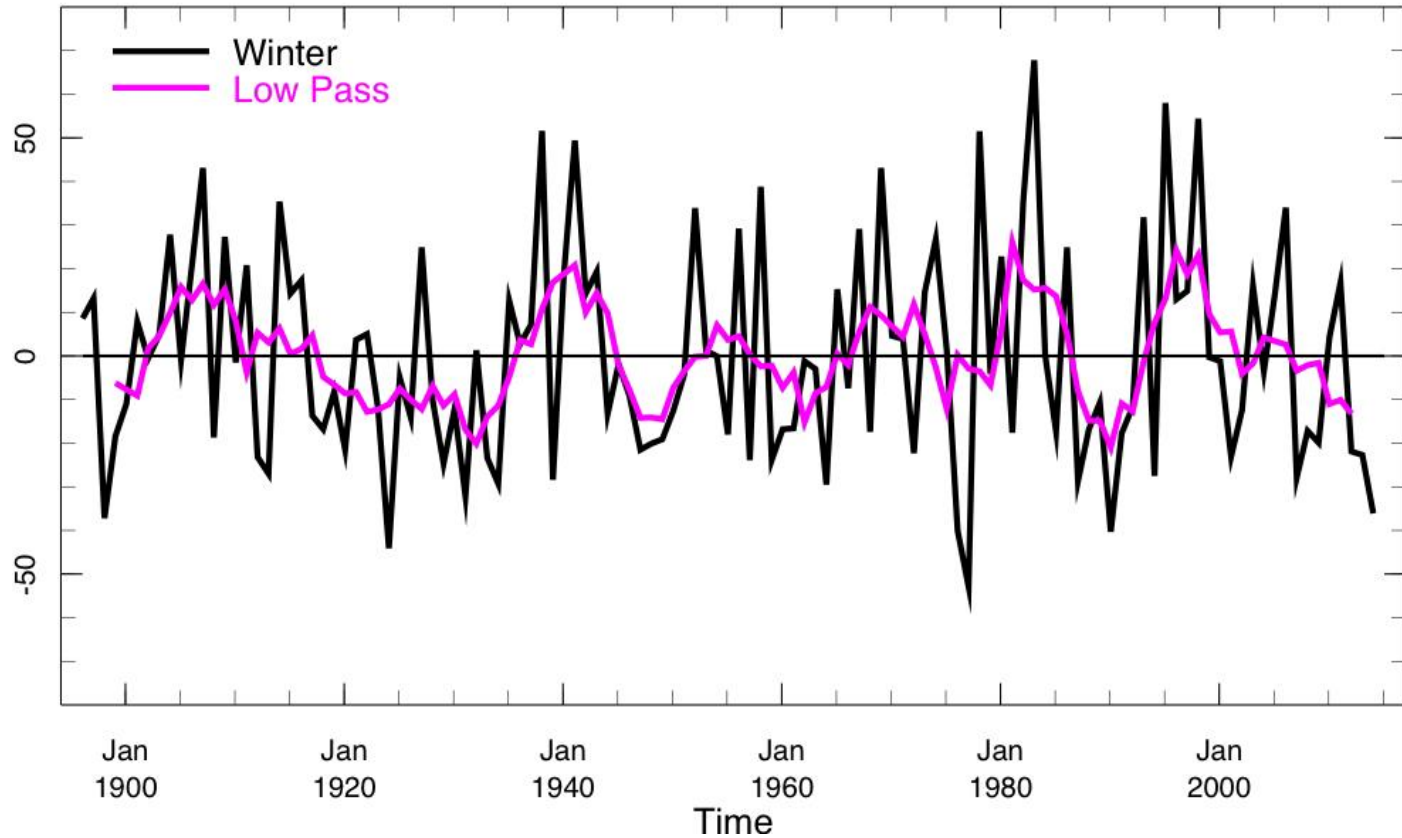
# Trends in winter (Nov-Mar) precipitation



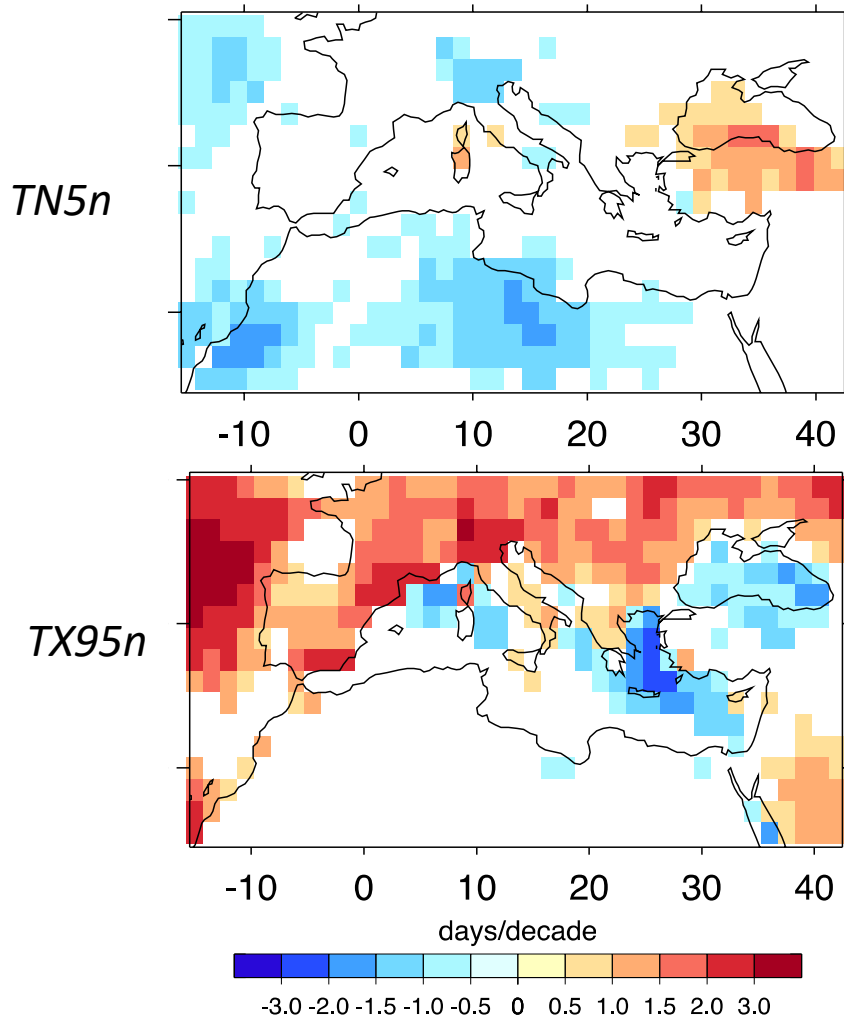
Trends in the winter rainfall (1950-1999)

decreasing values  
Increasing values

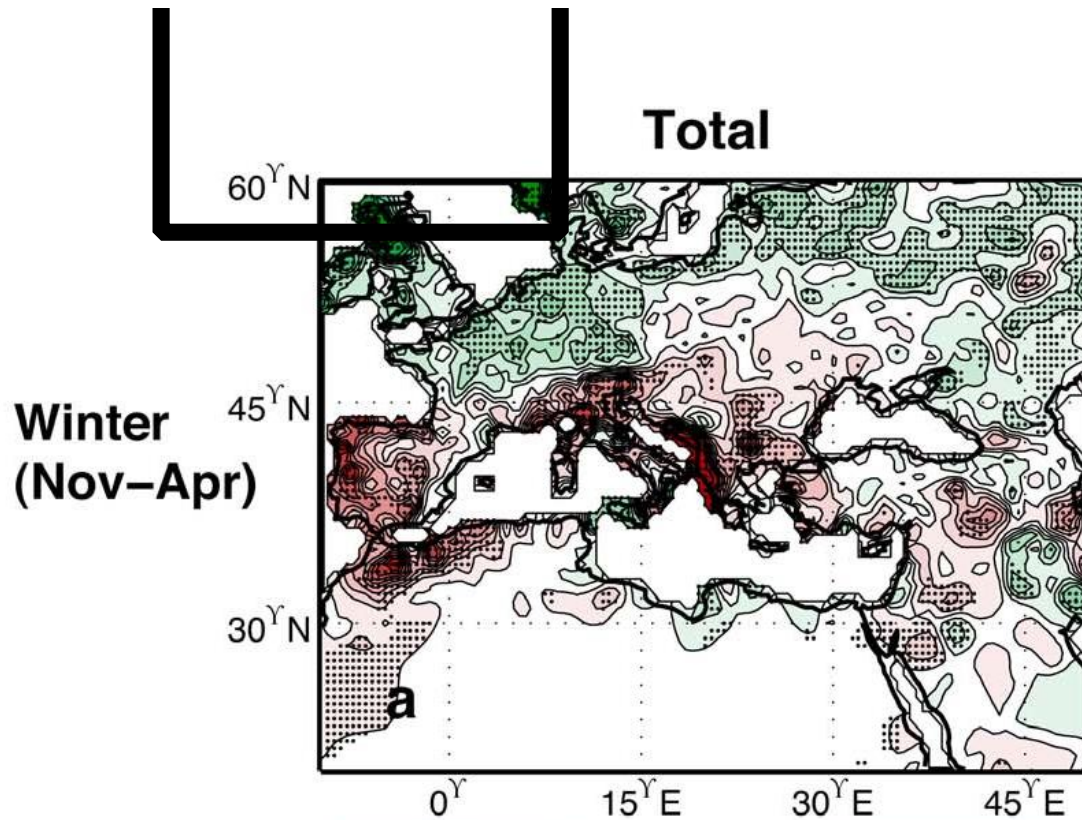
# Trends in winter (Nov-Mar) precipitation



# Trends in winter (DJF) temperature



# Trends in winter (Nov-April) precipitation



Signatures of the recent climate trends



Shifts in seasonal cycles



Temperature  
driven



Precipitation  
driven

Decrease in snow cover  
Shifts in peak discharge timing  
Early blossom of the plants  
Extended growing season

Signatures of the recent climate trends



Shifts in seasonal cycles



Temperature  
driven

Decrease in snow cover  
Shifts in peak discharge timing  
Early blossom of the plants  
Extended growing season



Precipitation  
driven

?



# The main question

Are there shifts in seasonality  
in the Mediterranean Hydroclimate?

# The main question

Are there shifts in seasonality  
in the Mediterranean Hydroclimate?

or

# The main question

Are there shifts in seasonality  
in the Mediterranean Hydroclimate?

or

What are the trends and spatial signatures in seasonal and monthly rainfall?

# The main question

Are there shifts in seasonality  
in the Mediterranean Hydroclimate?

or

What are the trends and spatial signatures in seasonal and monthly rainfall?  
What is a relationship to large scale circulation patterns?

# The main question

Are there shifts in seasonality  
in the Mediterranean Hydroclimate?

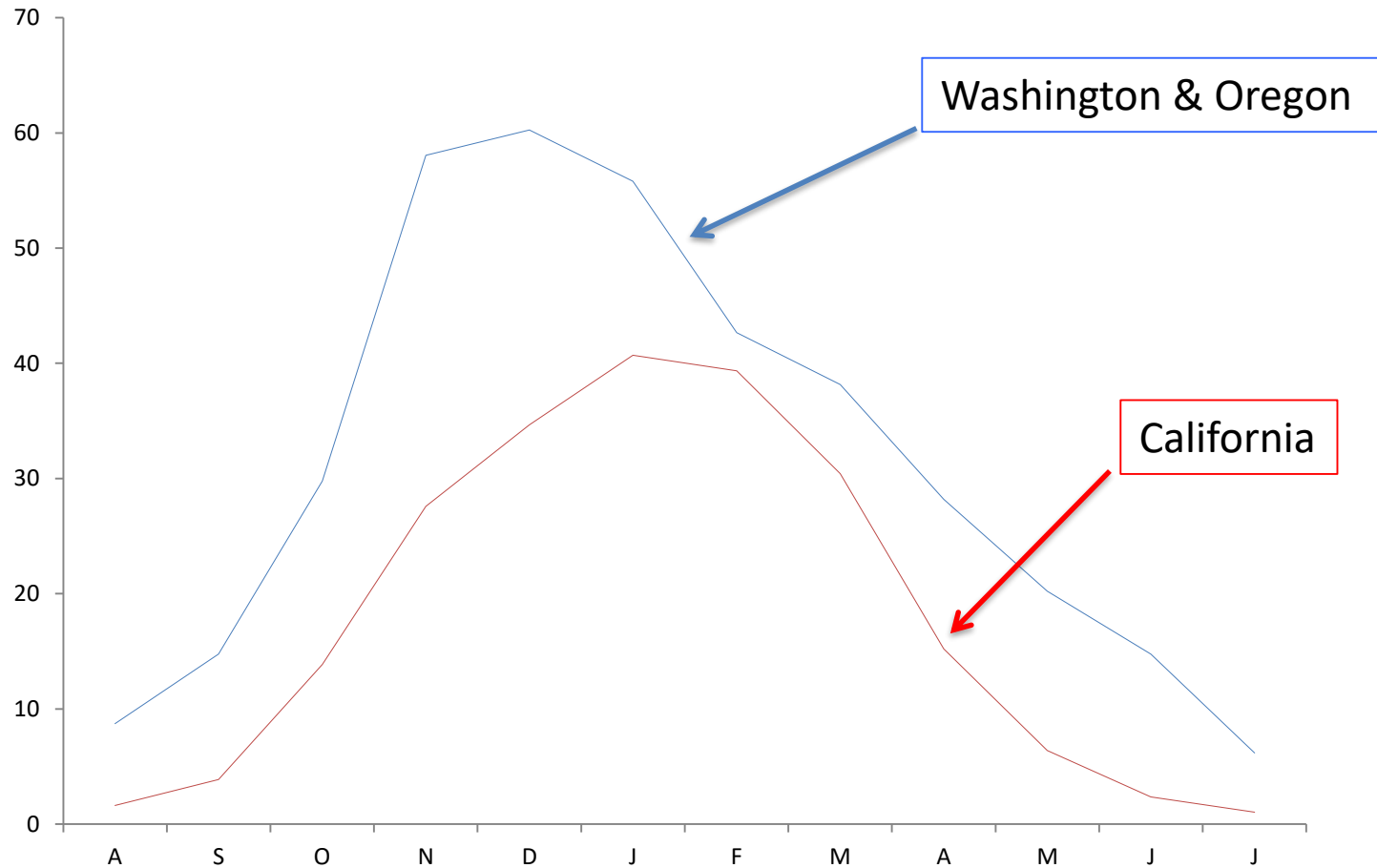
or

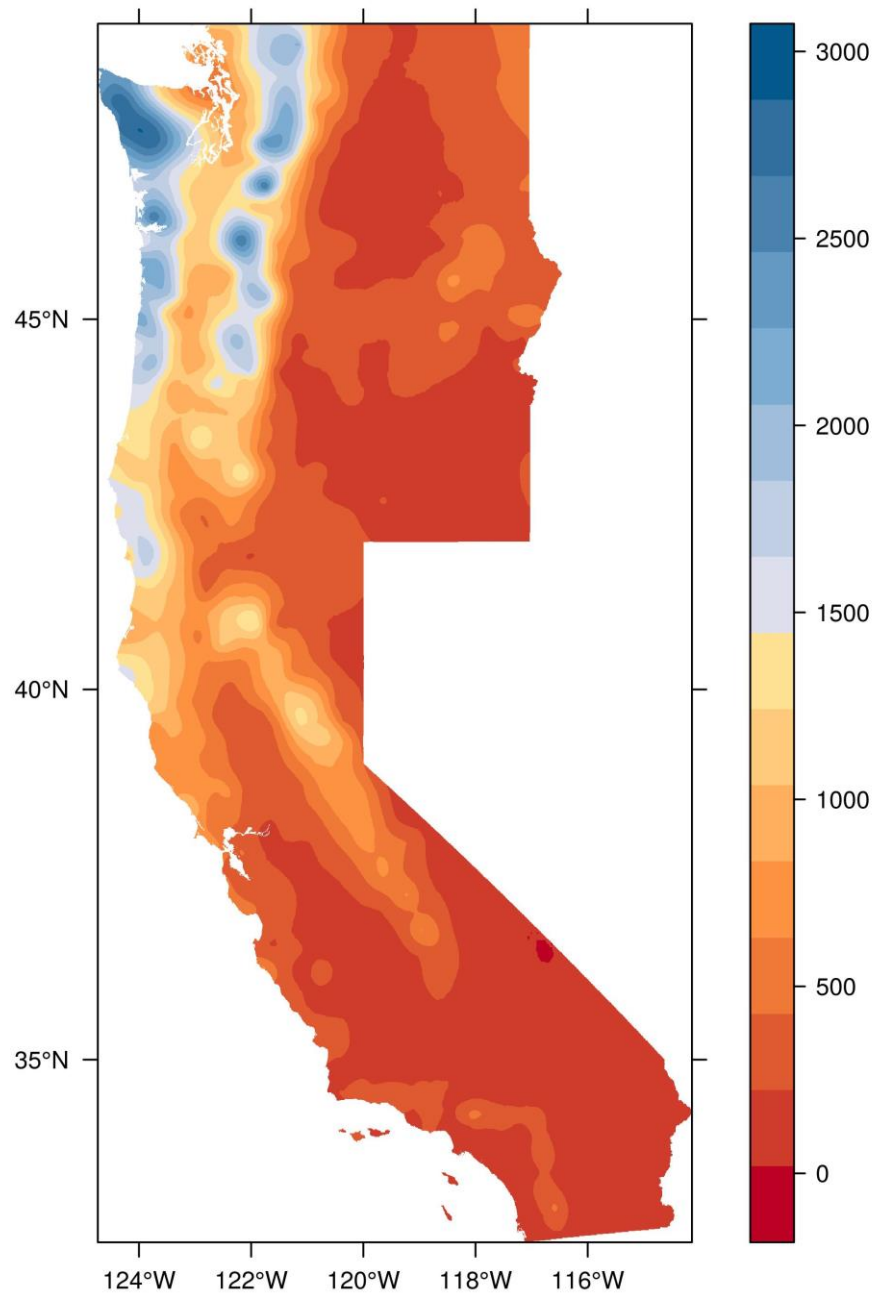
What are the trends and spatial signatures in seasonal and monthly rainfall?  
What is a relationship to large scale circulation patterns?

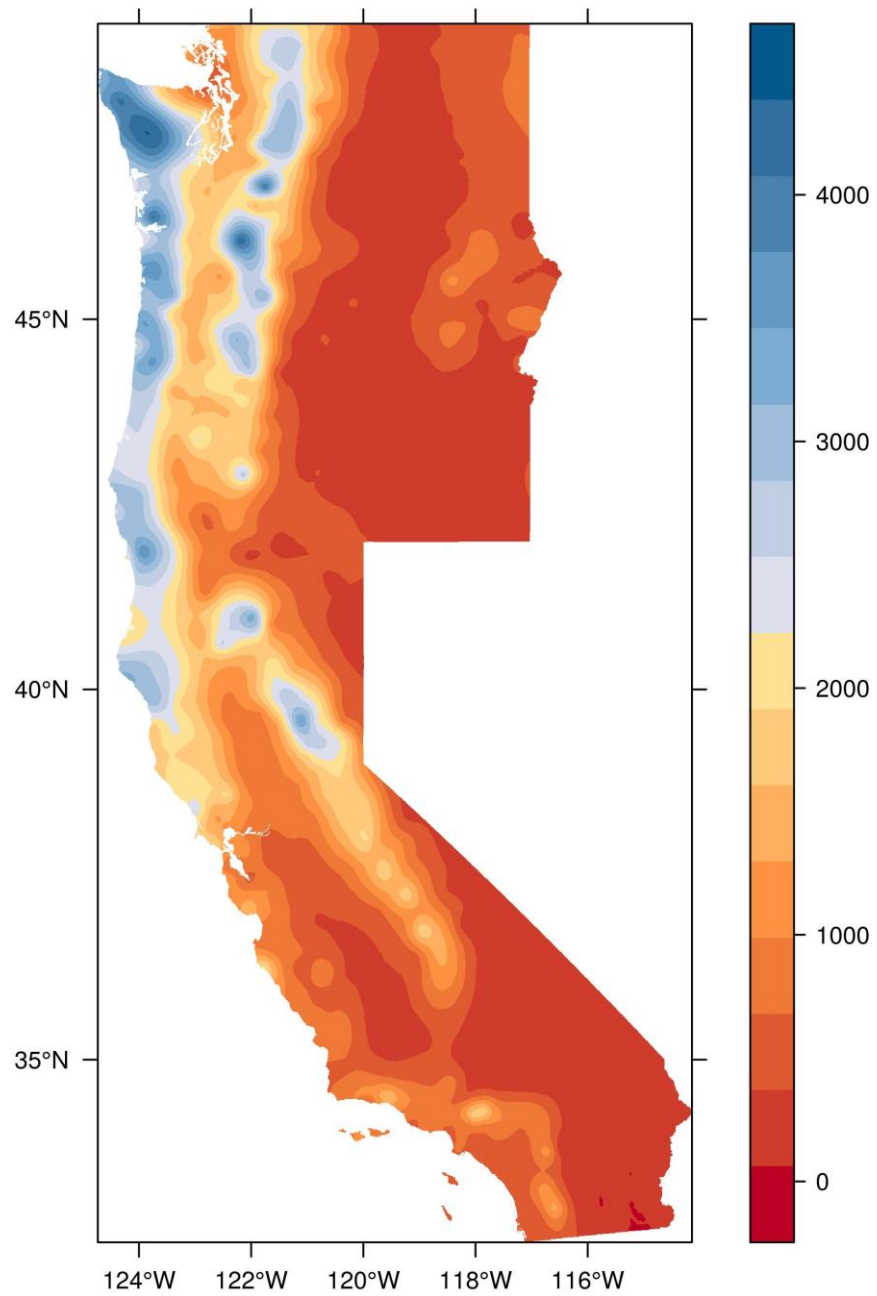
we use

1. Observations from National Weather Service Cooperative Network (COOP) for 1961-2010.
2. NCEP/NCAR Reanalysis 1 for 1961-2010.
3. ERA-Interim for 1979-2017.

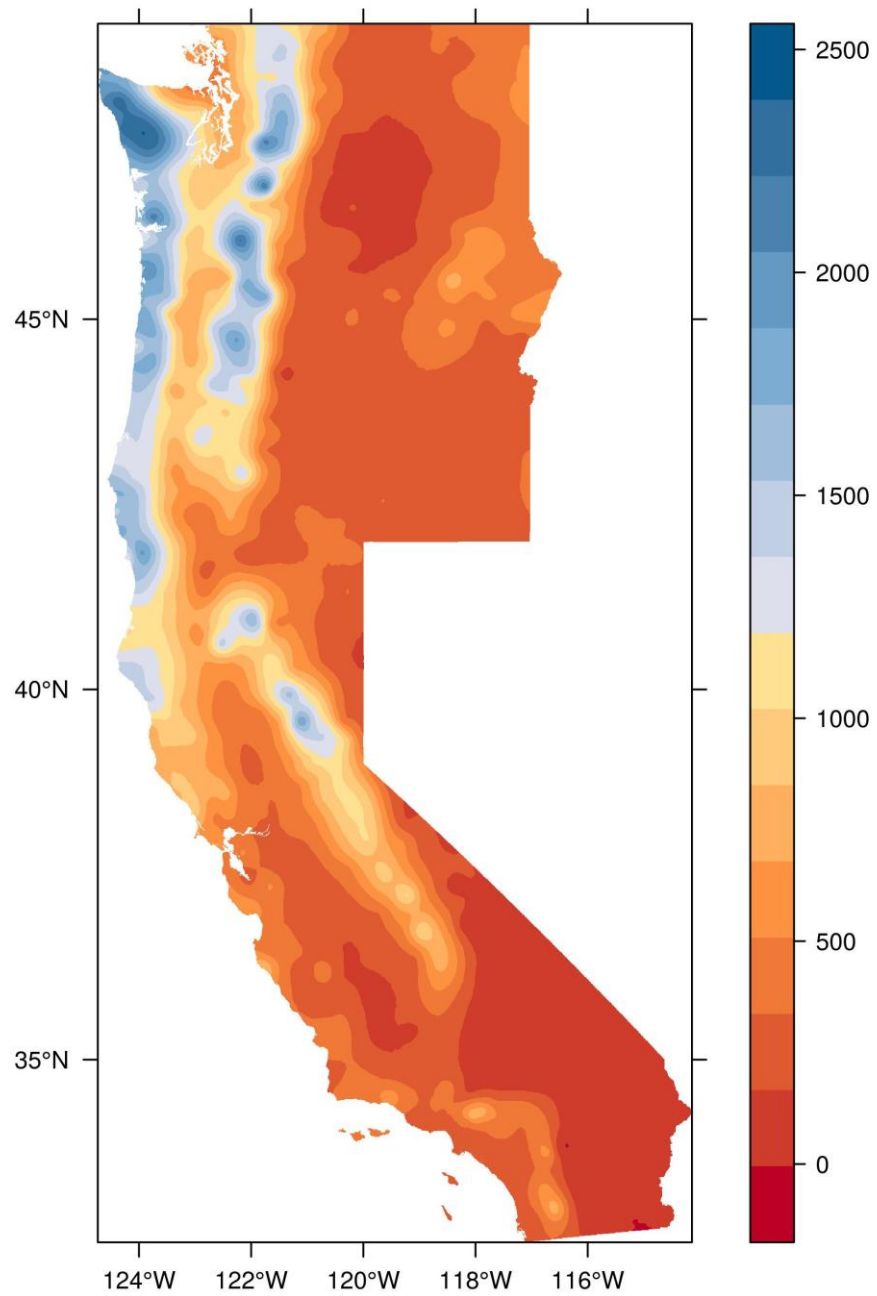
# Western US Climatology

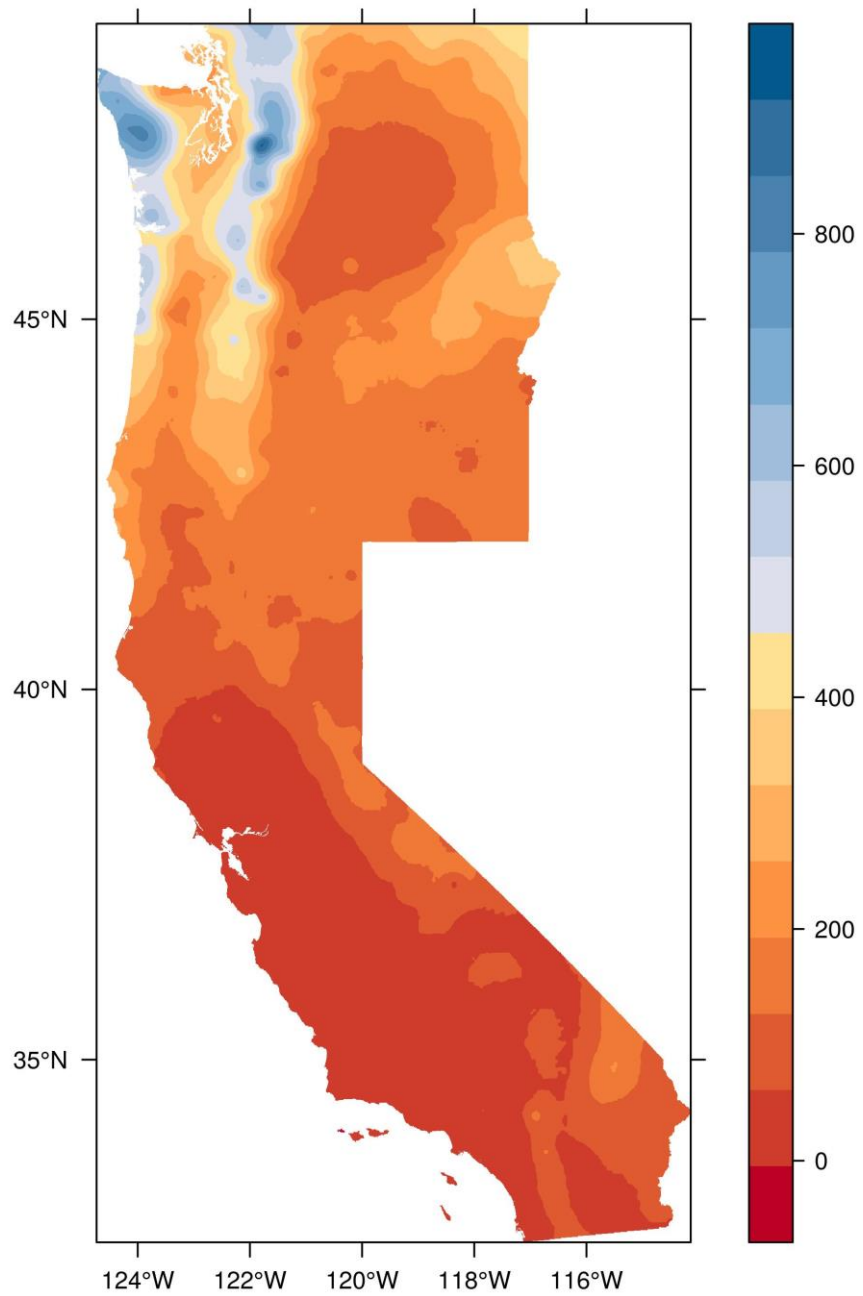






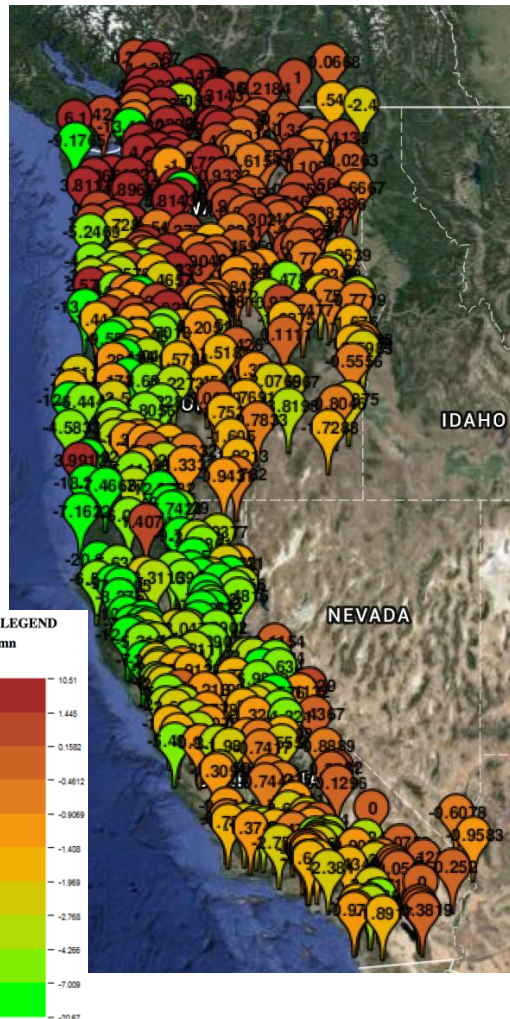




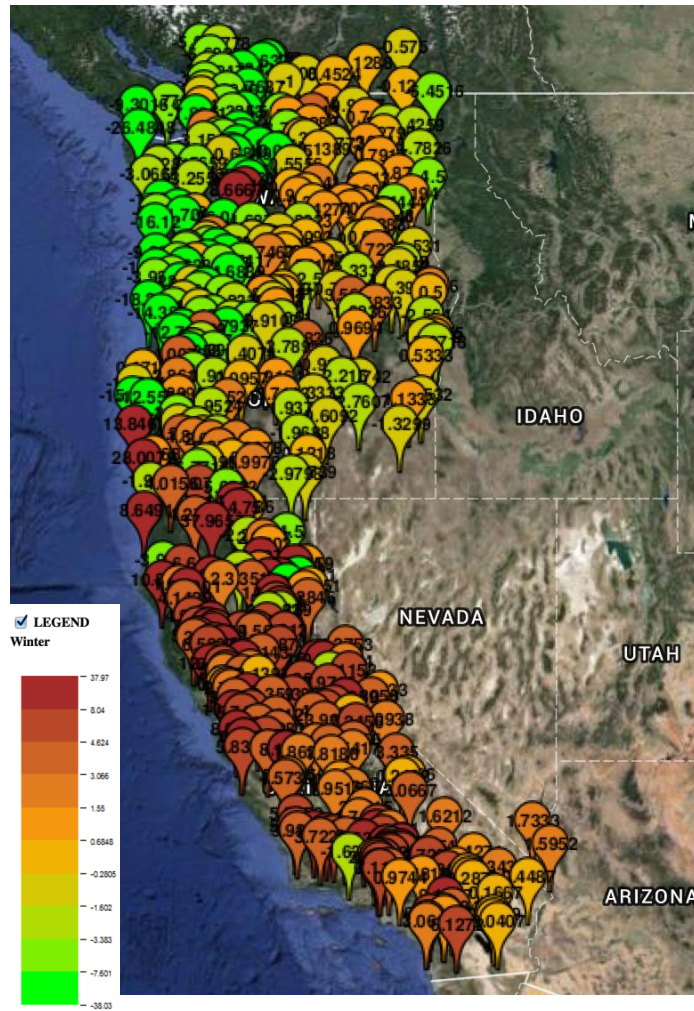


# Seasonal rainfall trends

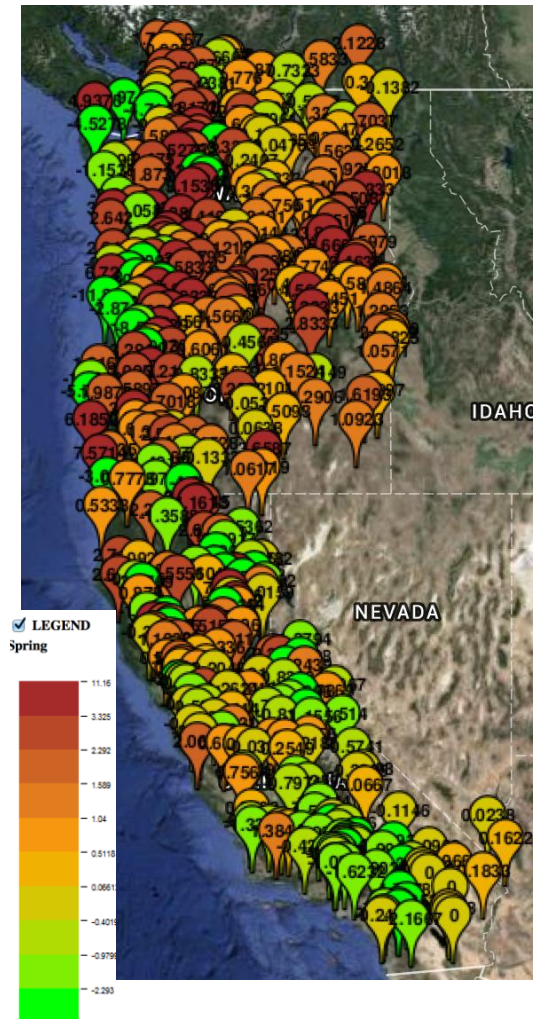
Autumn (SON)



Winter (DJF)

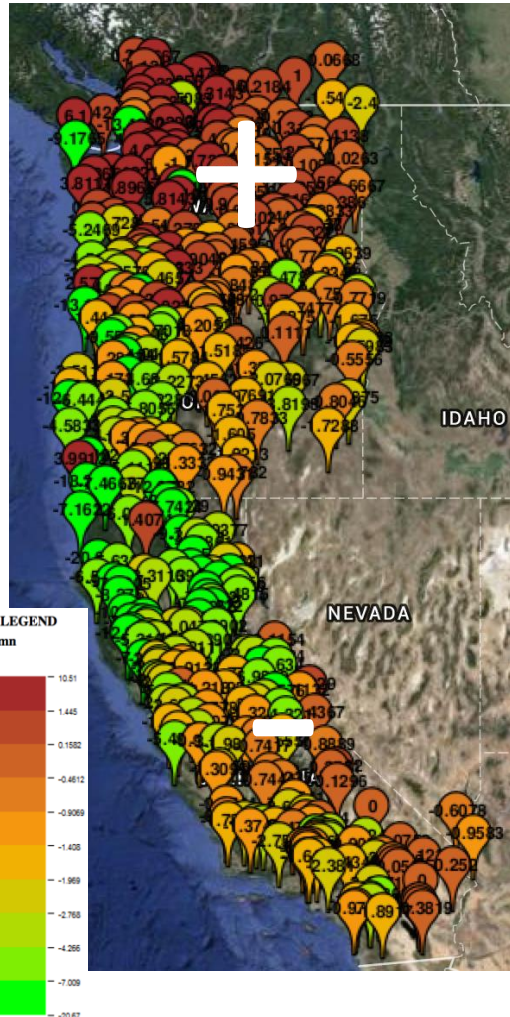


Spring (MAM)

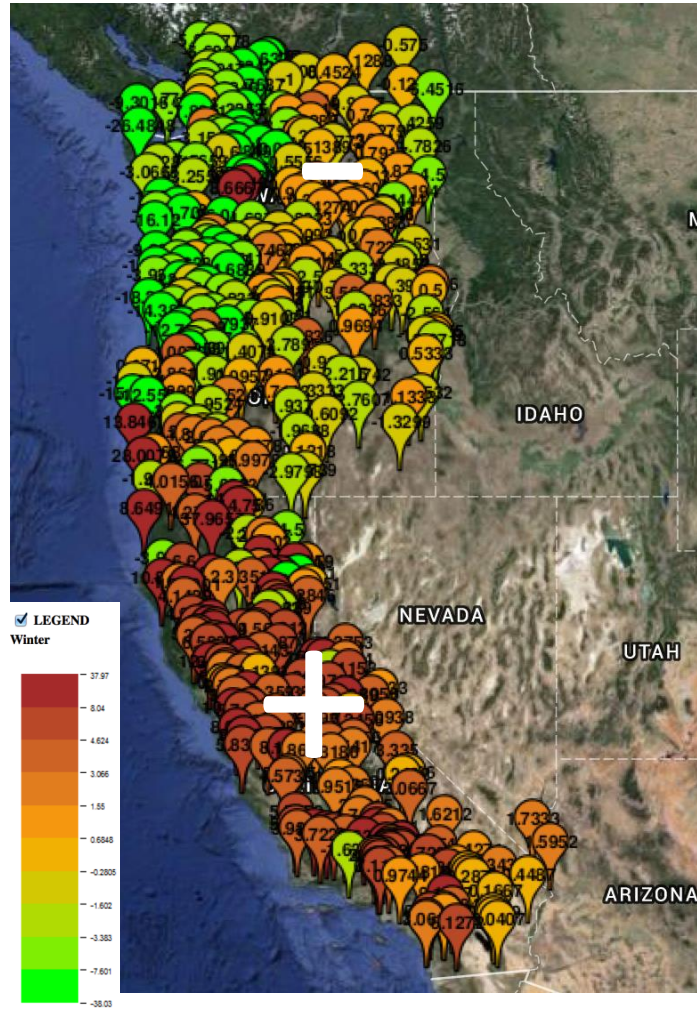


# Seasonal rainfall trends

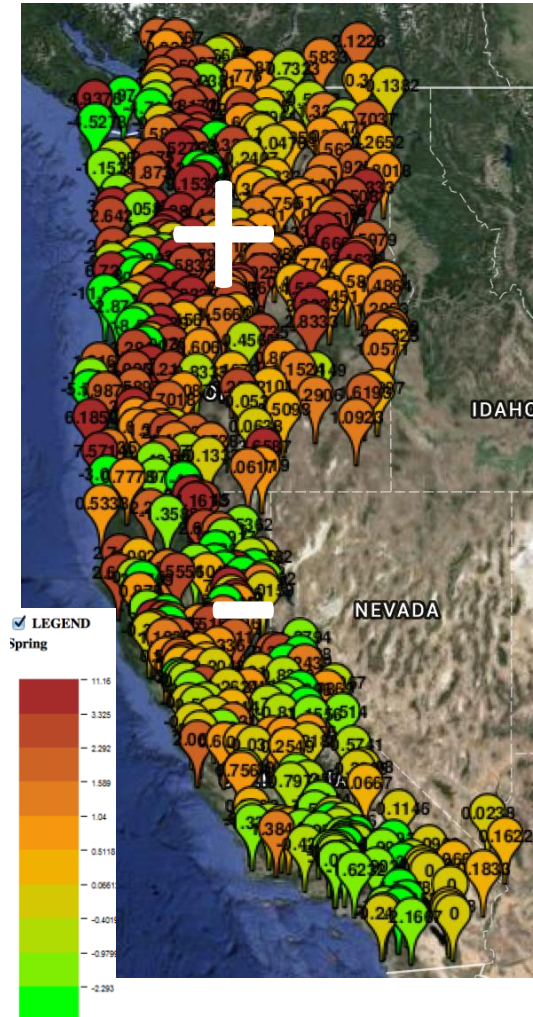
Autumn (SON)



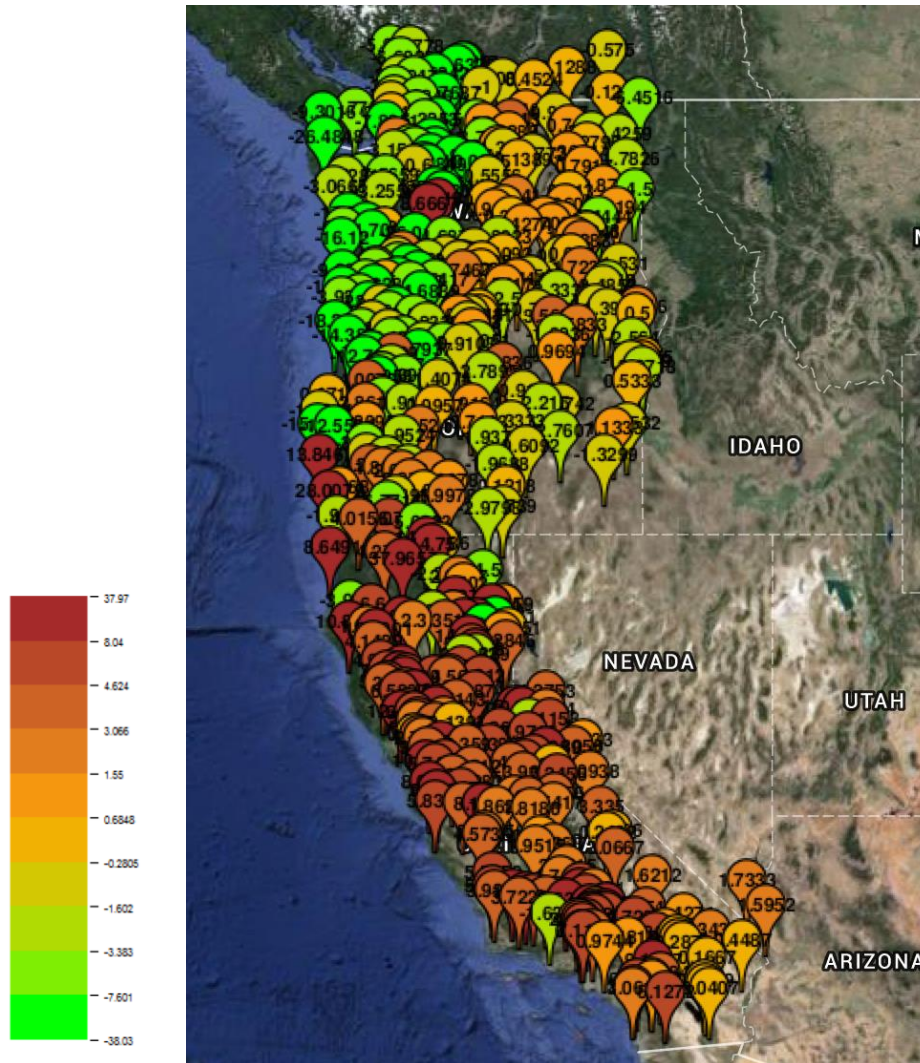
Winter (DJF)



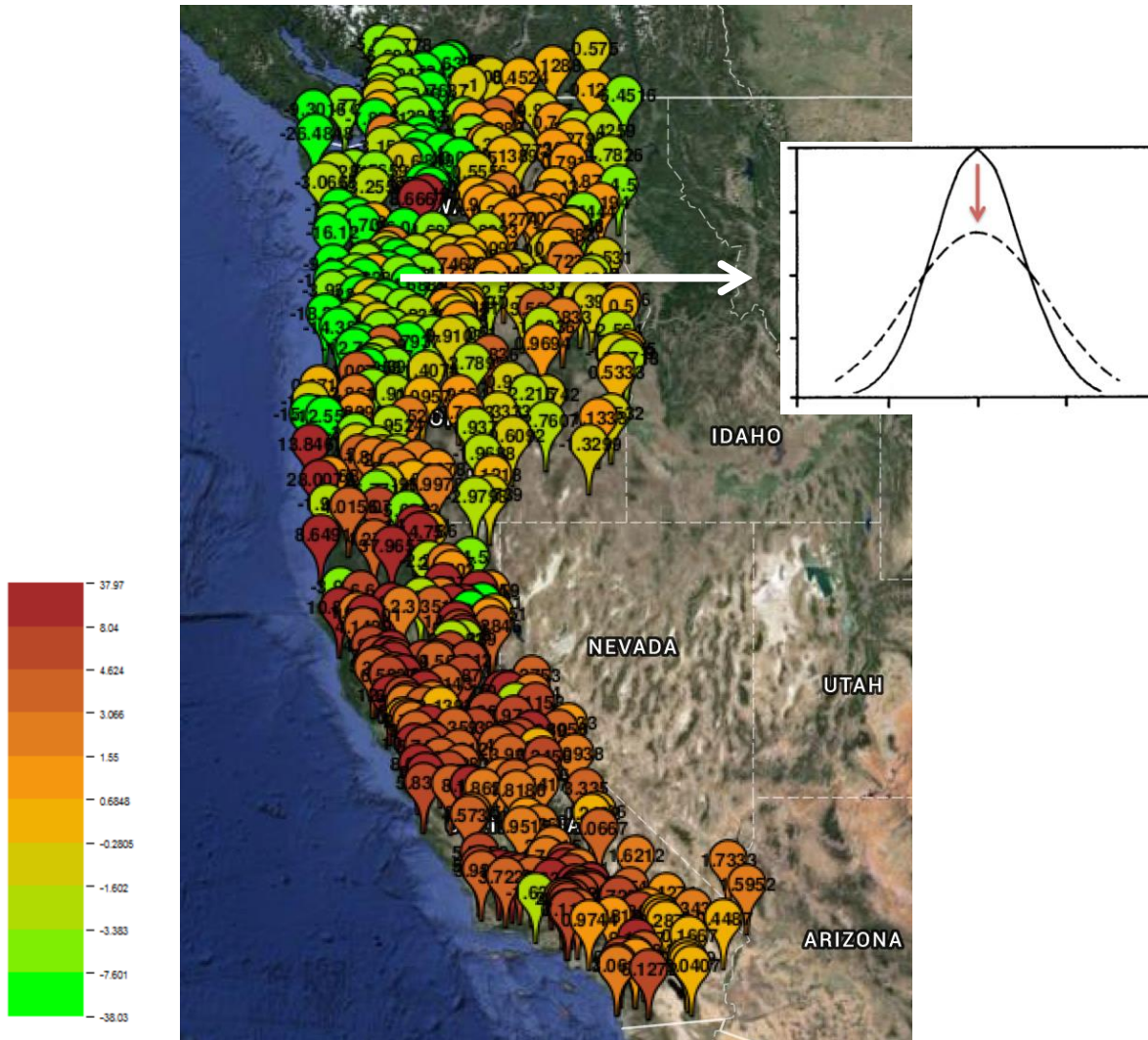
Spring (MAM)



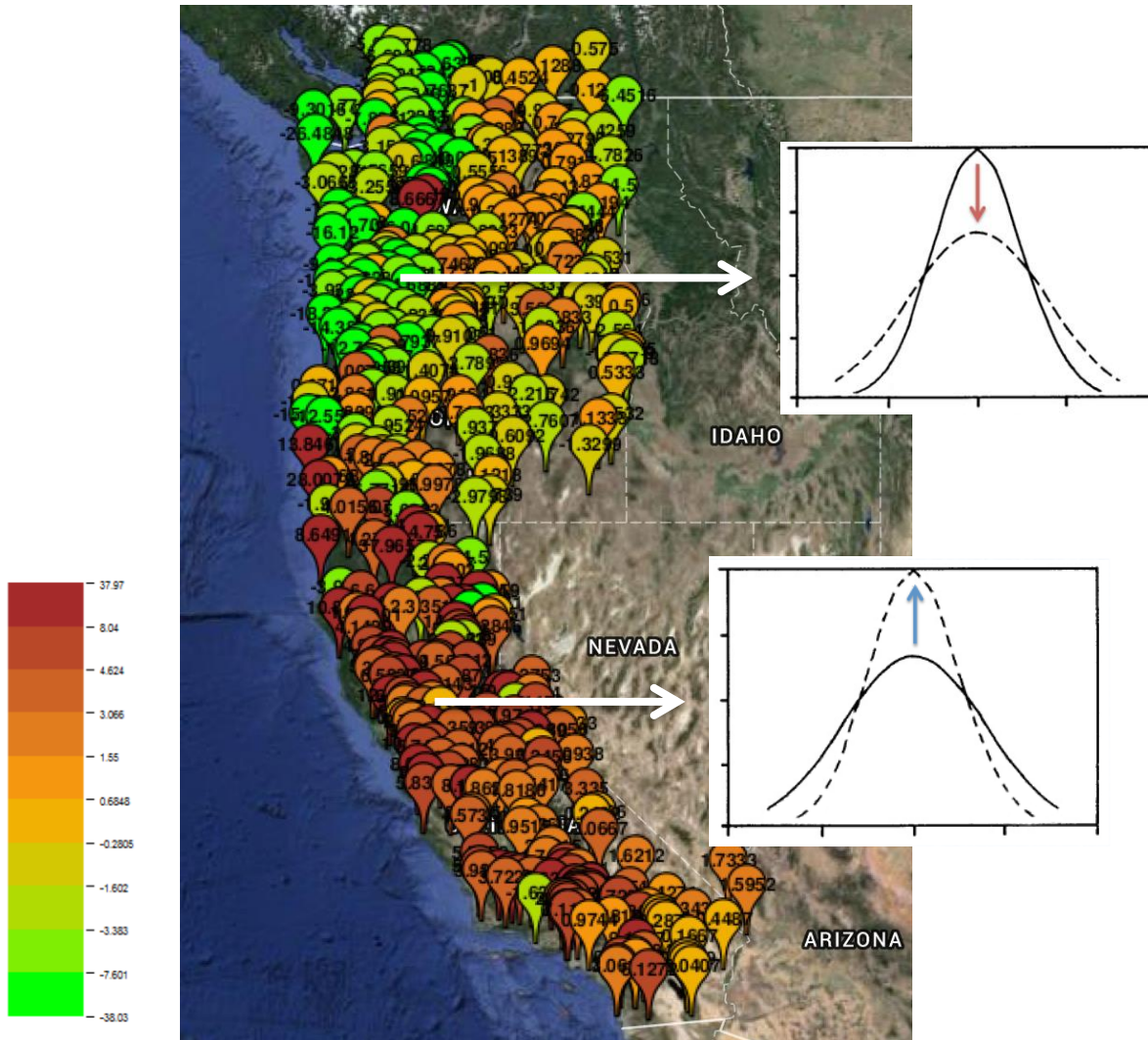
# Trends in winter (DJF) rainfall



# Trends in winter (DJF) rainfall

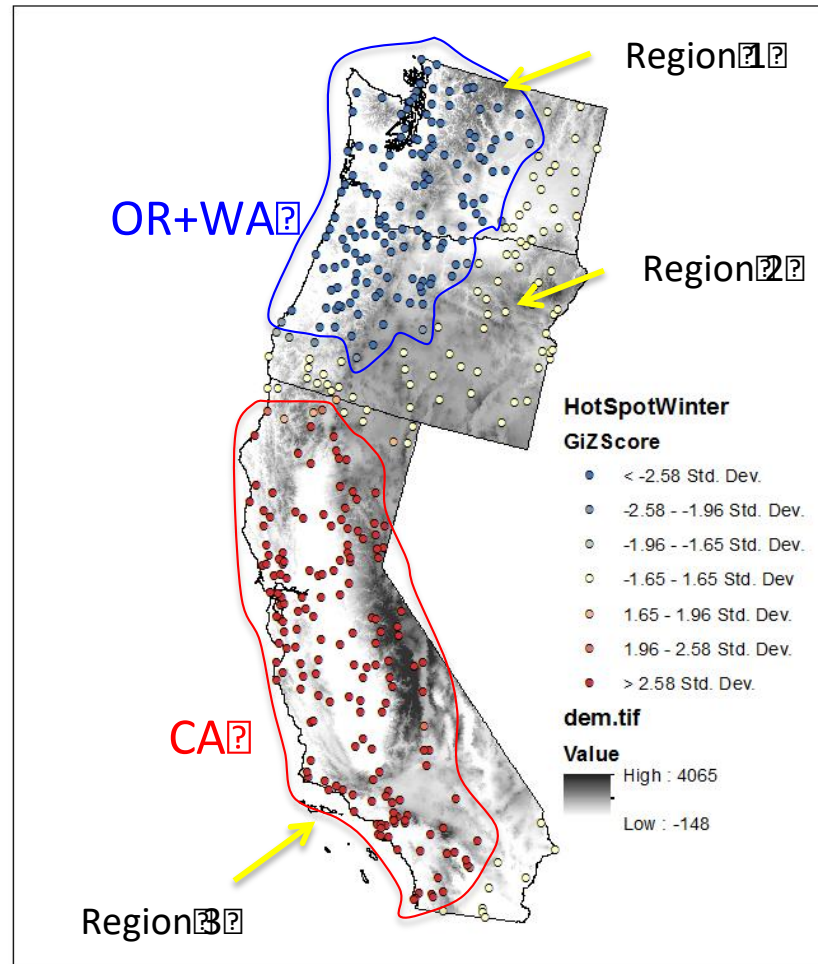


# Trends in winter (DJF) rainfall



# Winter trend spatial statistics

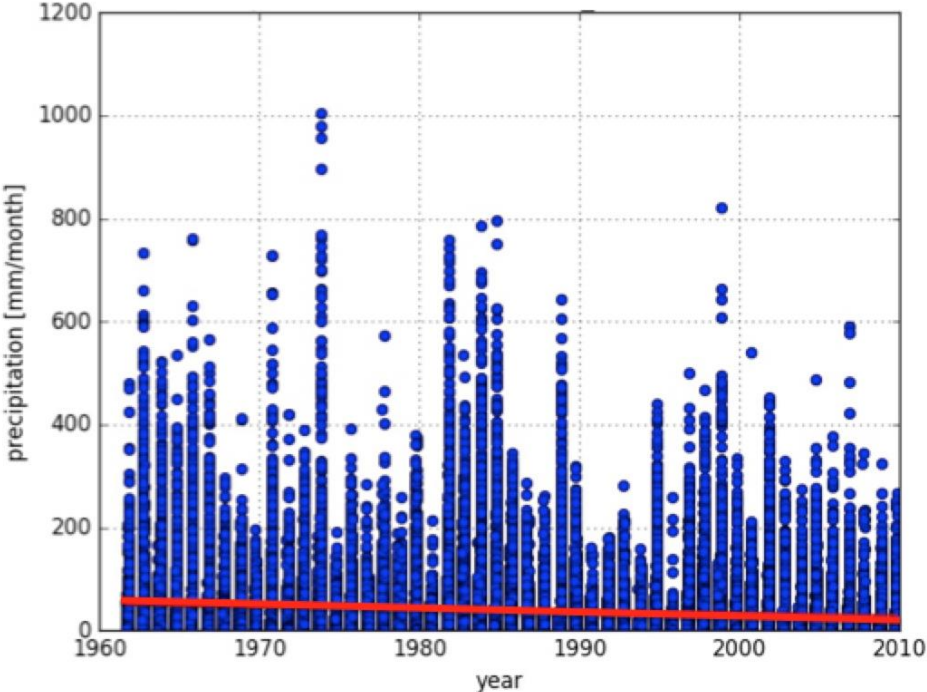
## *Hot Spot Analysis*



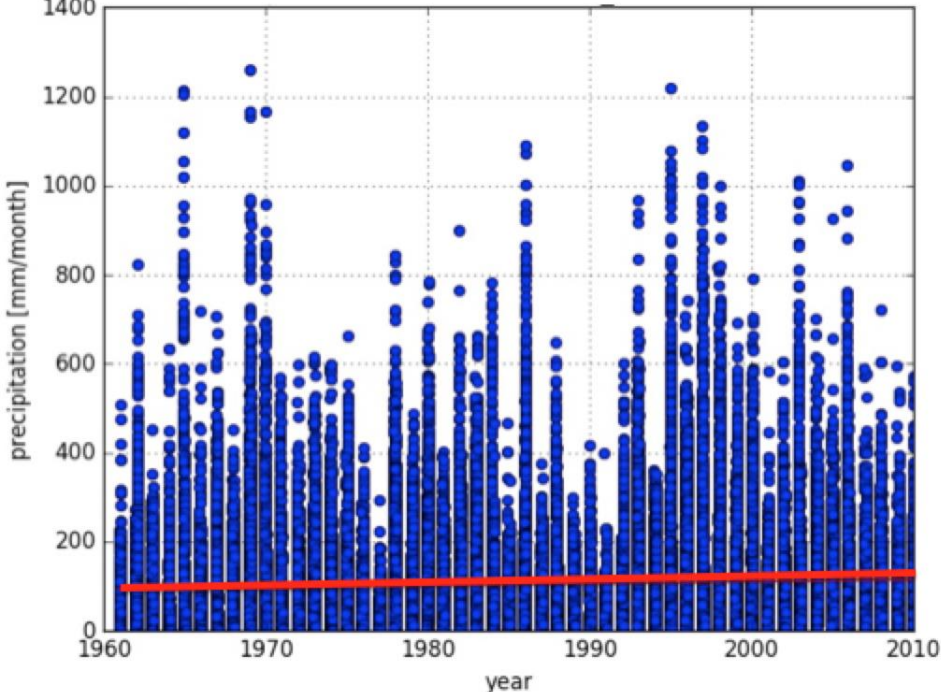


# Seasonal rainfall trends for California

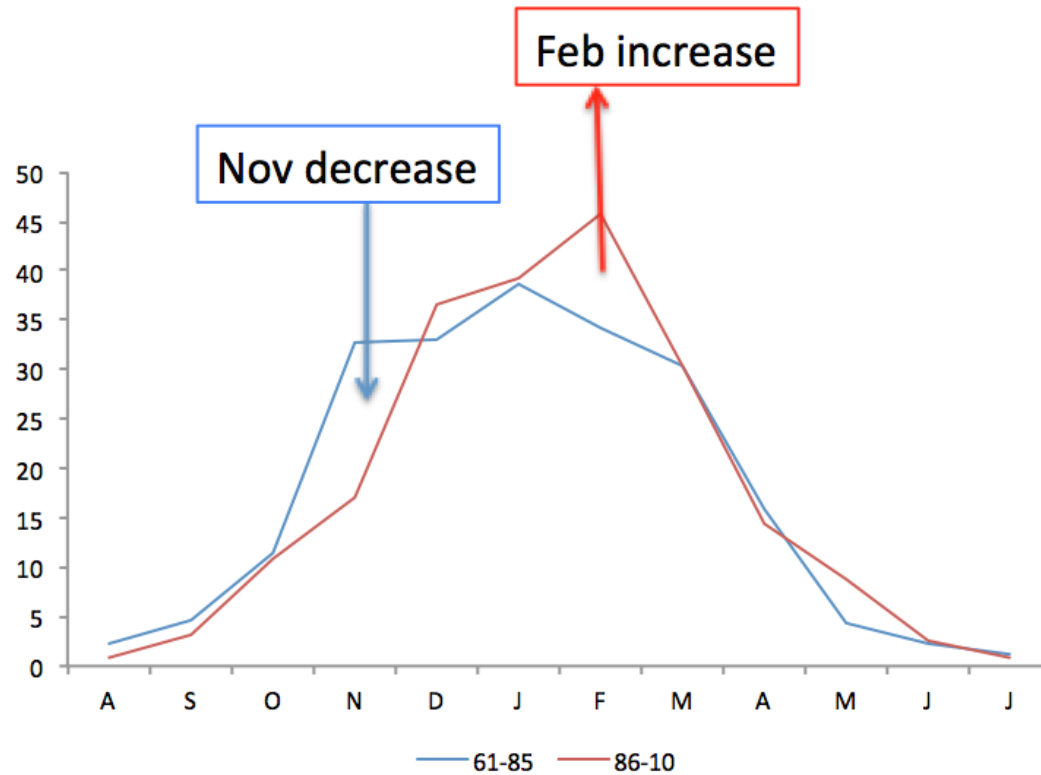
Autumn (SON)



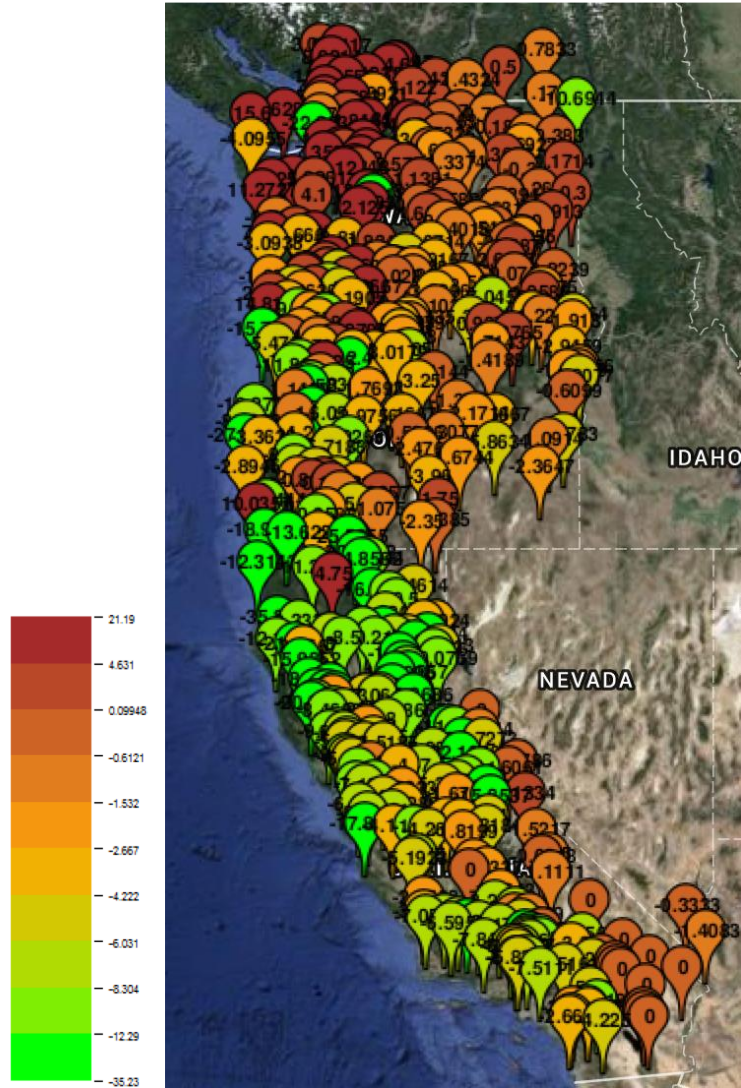
Winter (DJF)



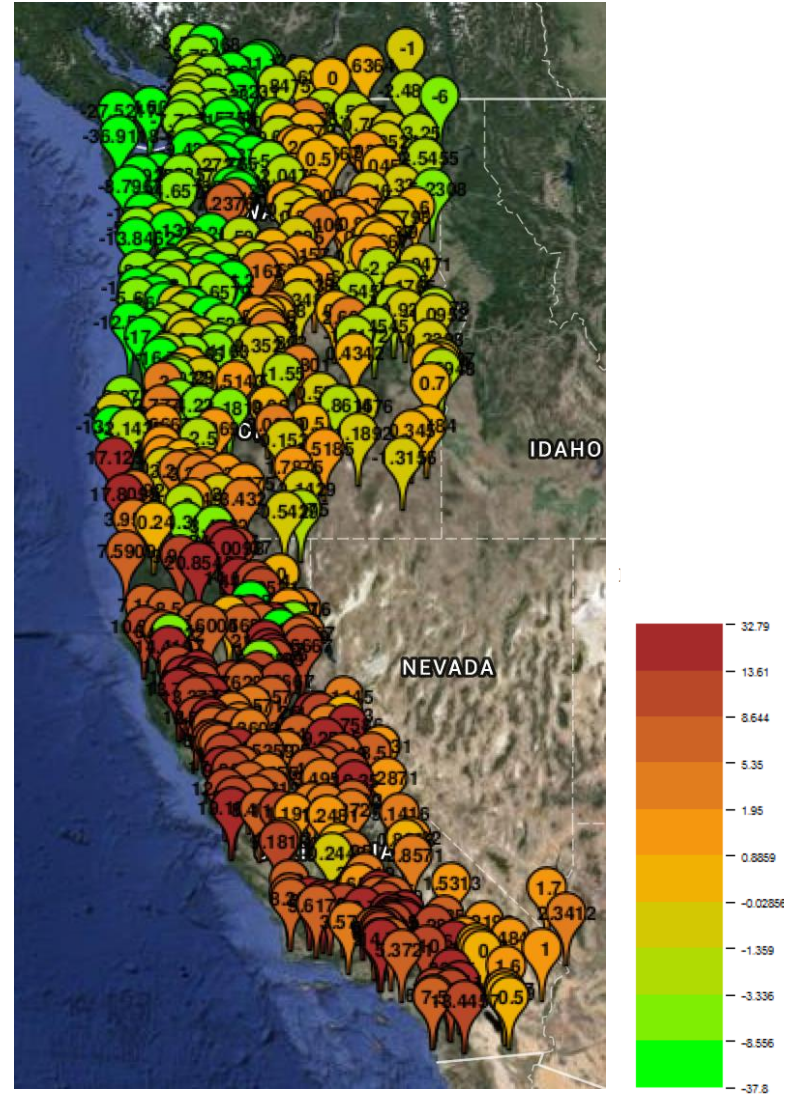
# California climatology 1961/1985 - 1986/2010



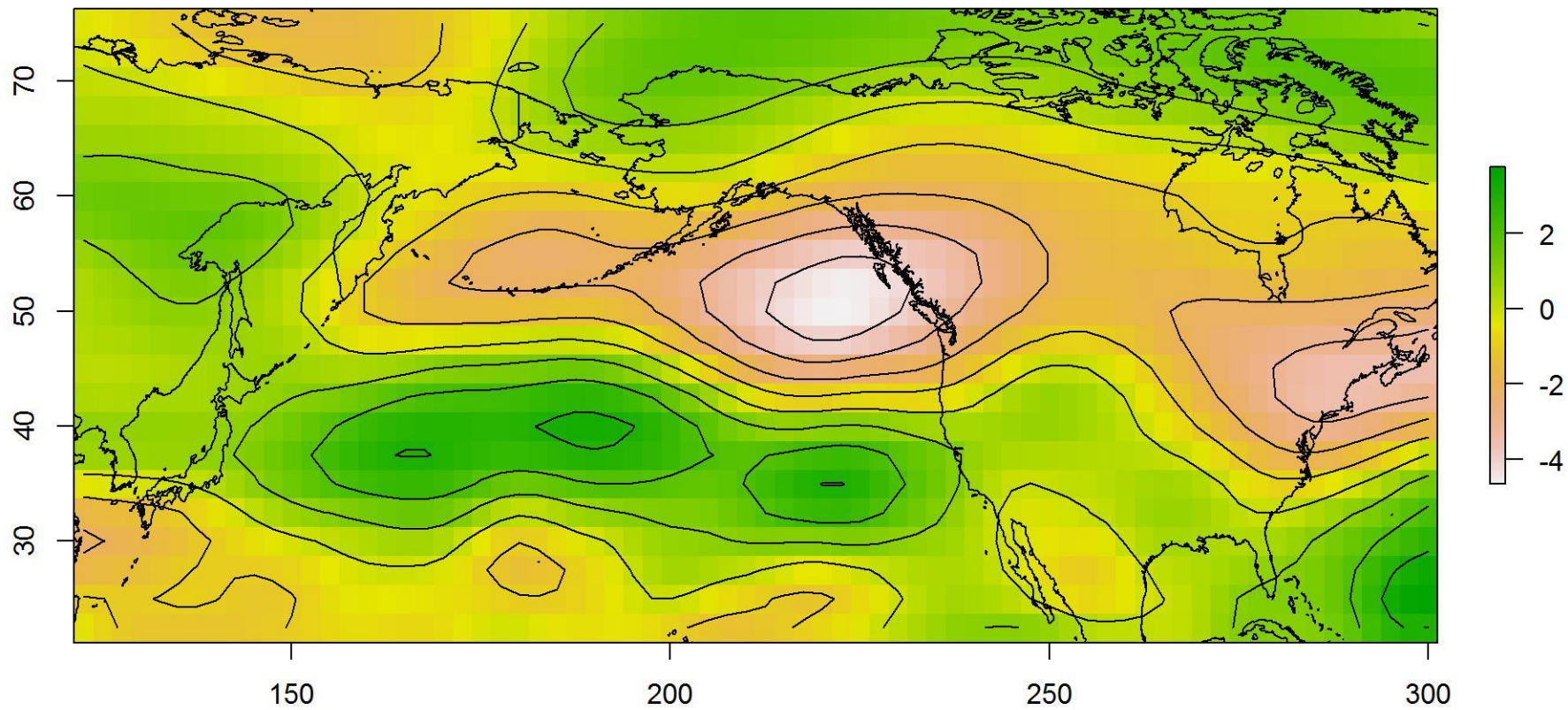
# Nov trends



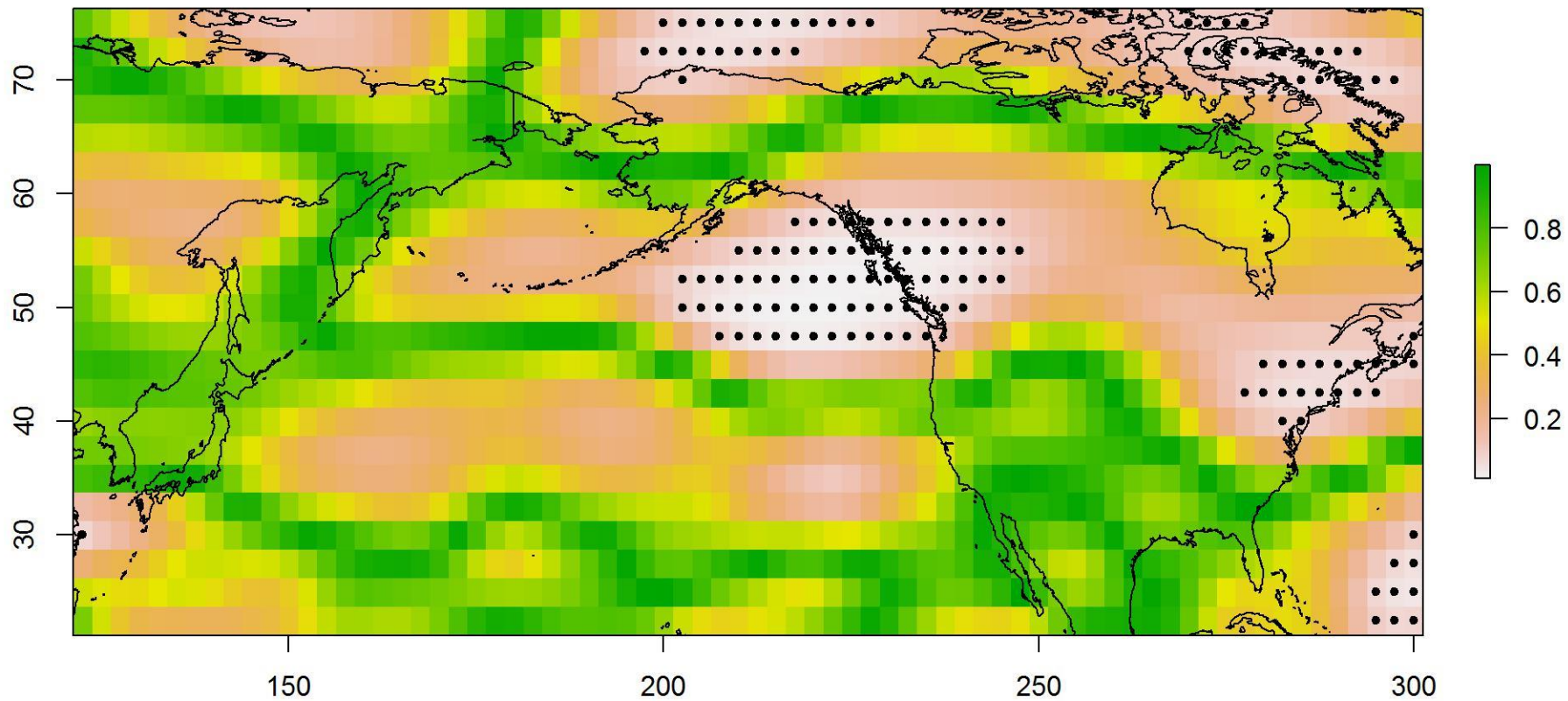
# Feb trends



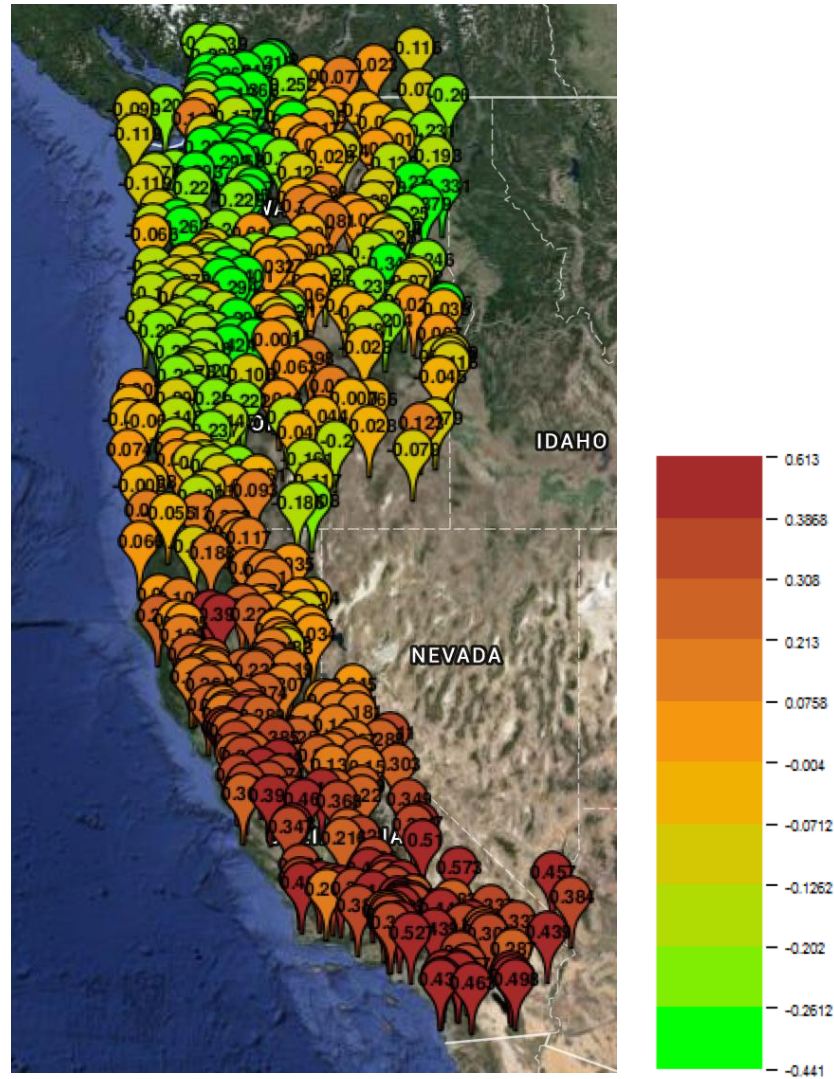
### Difference of Mean U wind 200 mb for November



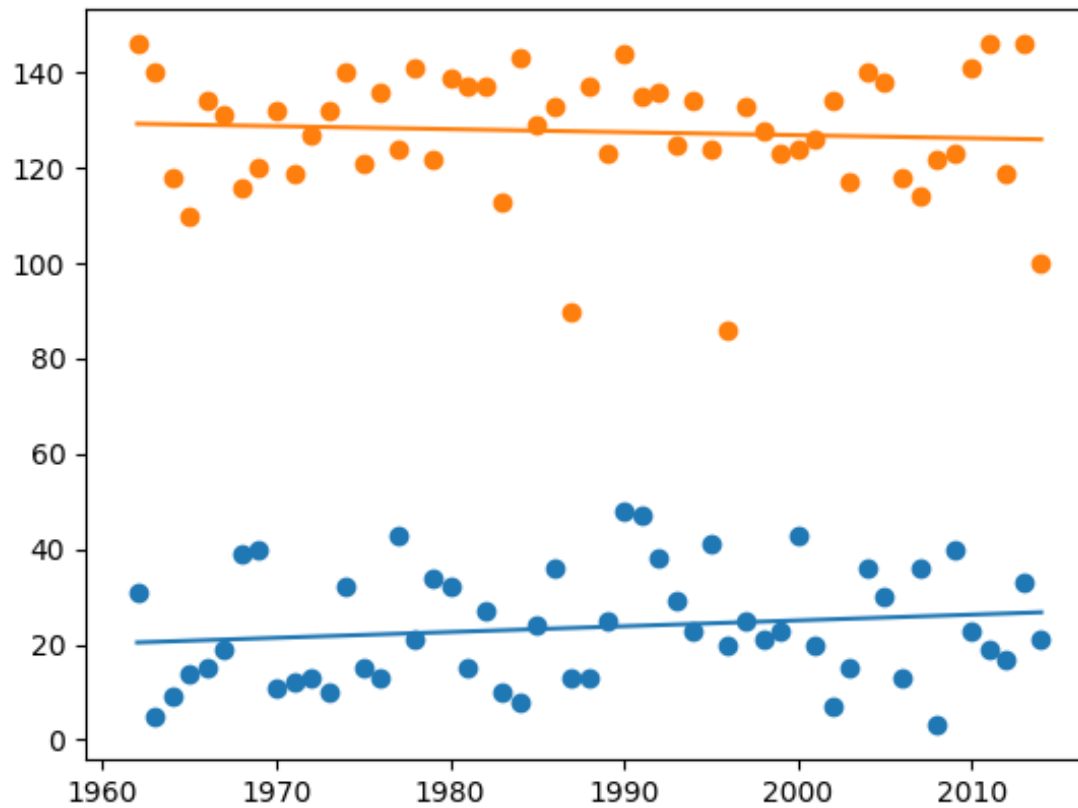
p-value of T-test - Mean U wind 200 mb for November (0.1)



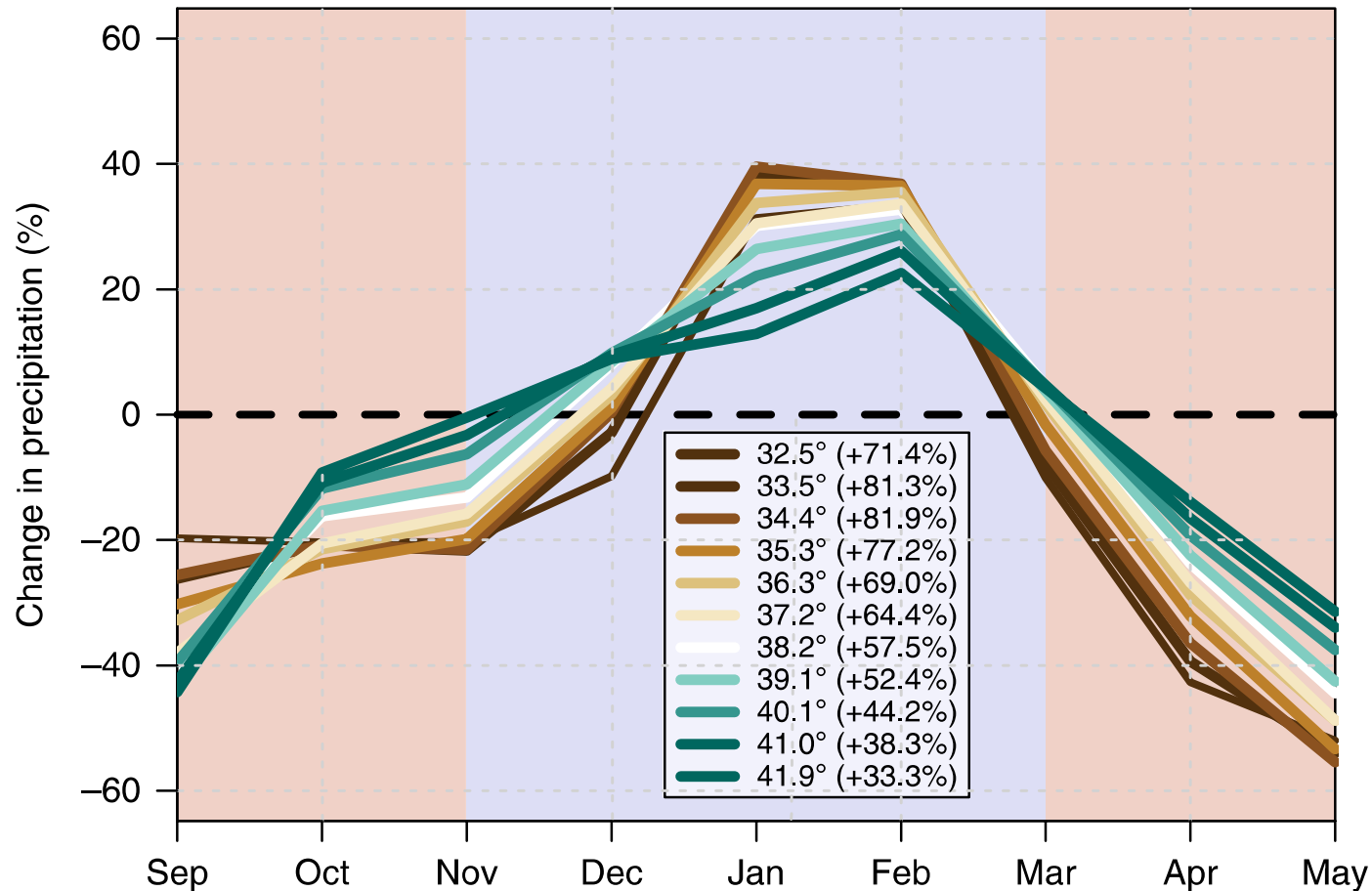
# Nino 3.4 & Feb rainfall correlations



# Trend in timing 10% and 90% of the annual rainfall

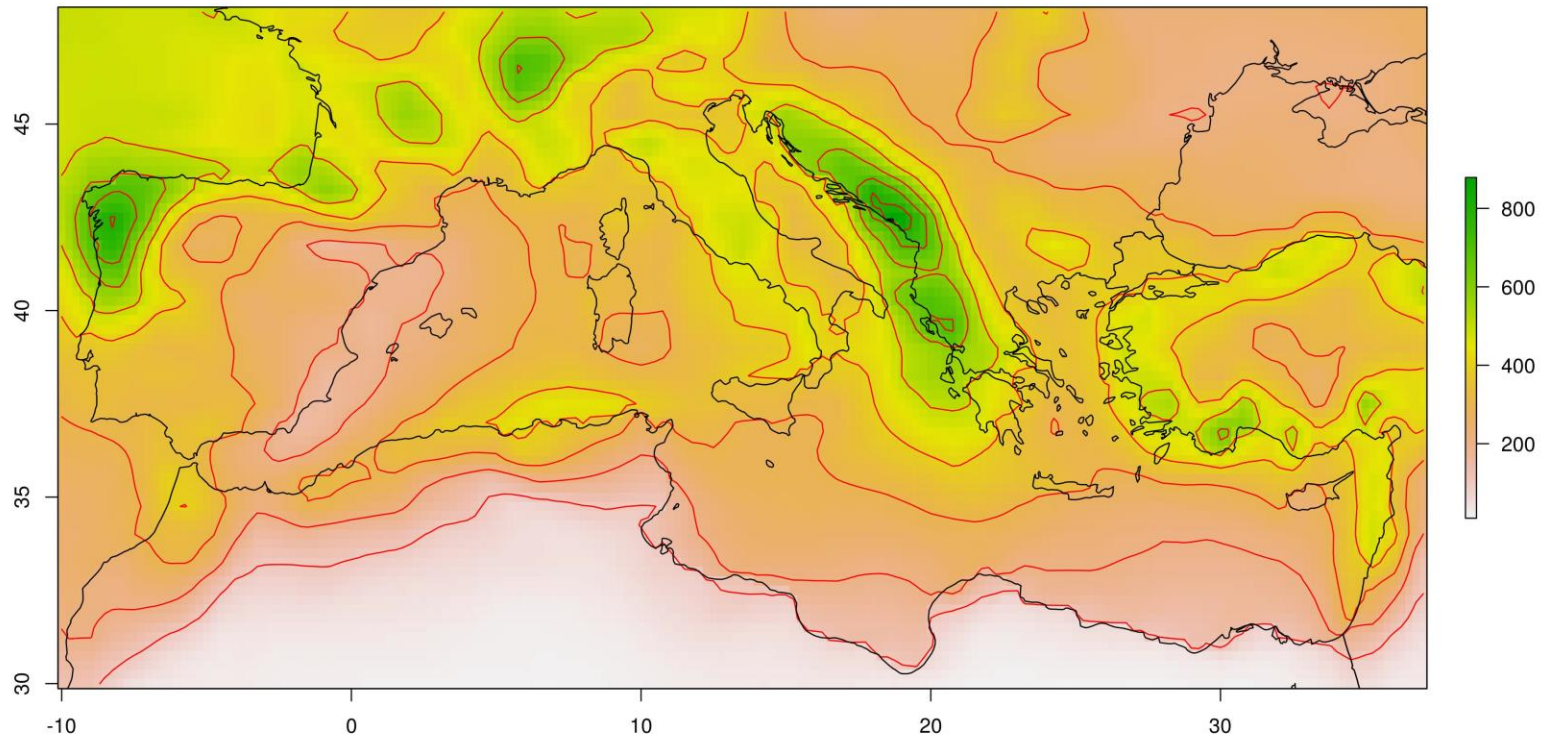


# Shifts in precipitation seasonality (2070-2100)

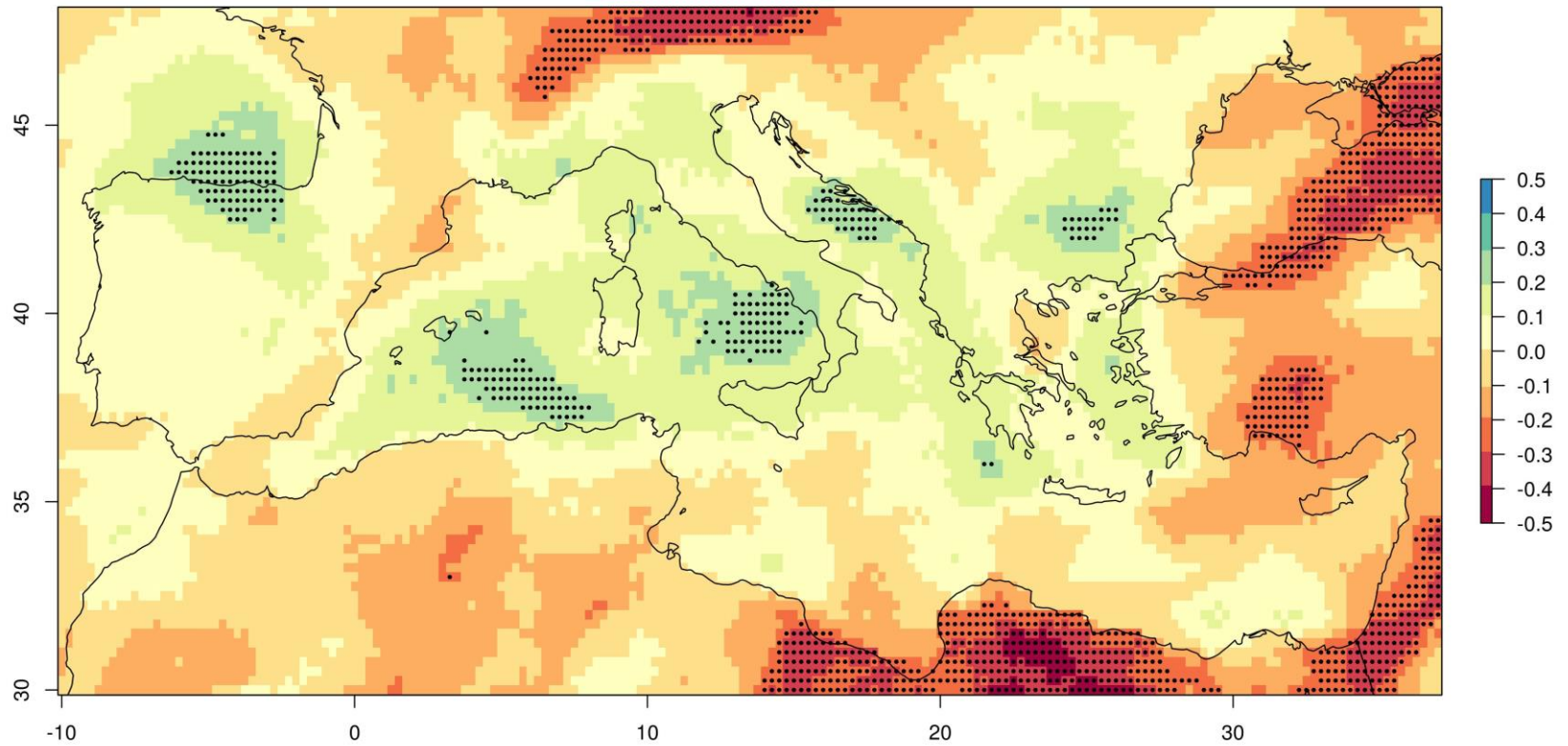




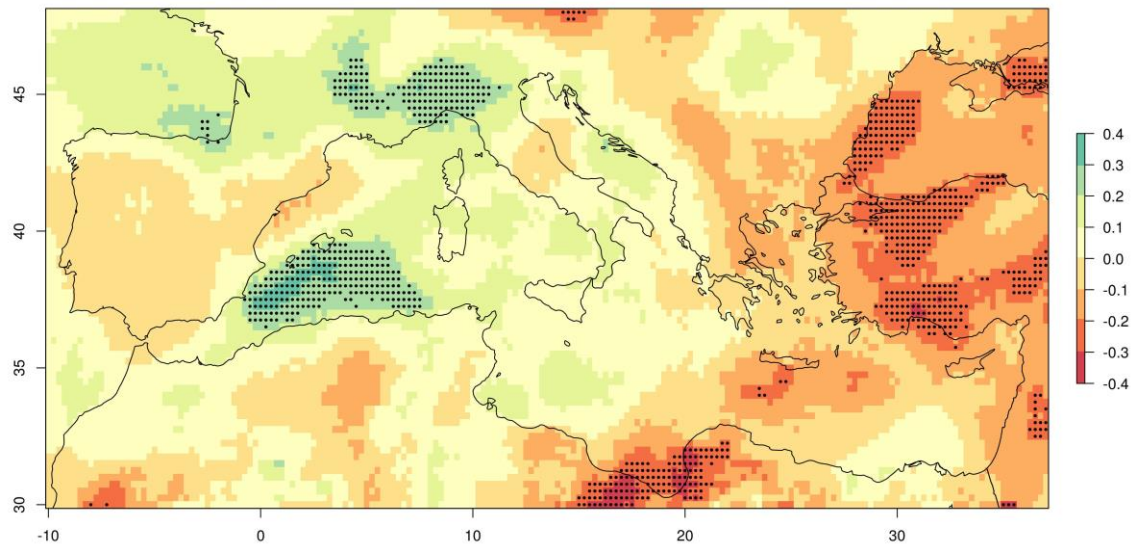
# Mediterranean (Nov-Apr) climatology



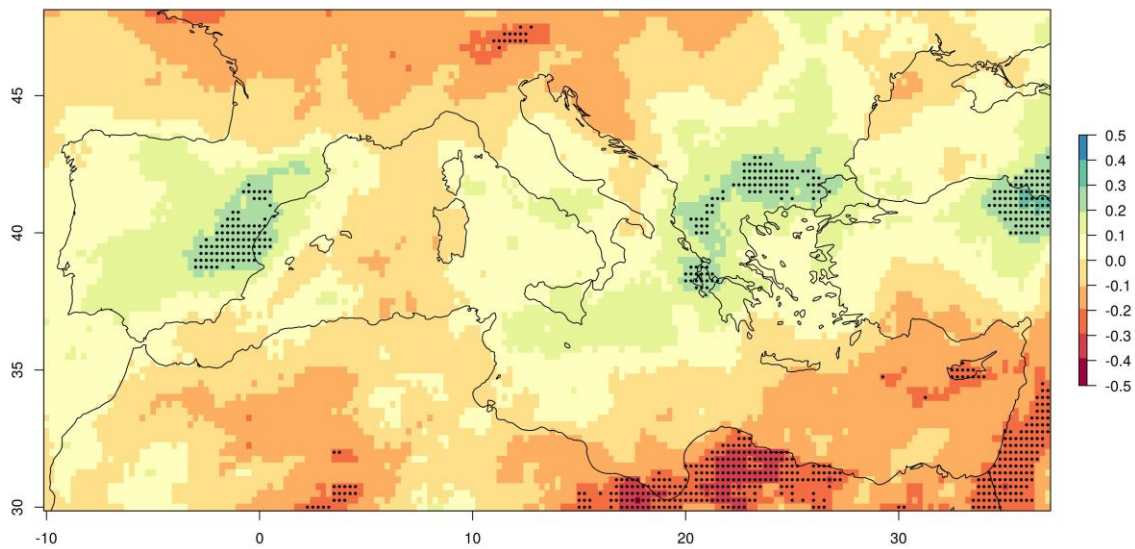
# Seasonal (Nov-Apr) rainfall trends



Nov trends



March trends



# Summary

Are there shifts in seasonality in the Mediterranean Hydroclimate?

or

- What are the trends and spatial signatures in seasonal and monthly rainfall?
- What is a relationship to large scale circulation patterns?

# Summary

Are there shifts in seasonality in the Mediterranean Hydroclimate?

**YES**

or

- What are the trends and spatial signatures in seasonal and monthly rainfall?
- What is a relationship to large scale circulation patterns?

# Summary

Are there shifts in seasonality in the Mediterranean Hydroclimate?

**YES**

or

- What are the trends and spatial signatures in seasonal and monthly rainfall?

**Nov- Feb+**

- What is a relationship to large scale circulation patterns?

# Summary

Are there shifts in seasonality in the Mediterranean Hydroclimate?

**YES**

or

- What are the trends and spatial signatures in seasonal and monthly rainfall?

**Nov- Feb+**

- What is a relationship to large scale circulation patterns?

**U200mb, El Niño**



Hrvatsko  
meteorološko  
društvo

Thank you very much!