

# Establishing Potential Predictability of U.S. Precipitation Using Rain Gauge Data

Dan Gianotti

Advisors:

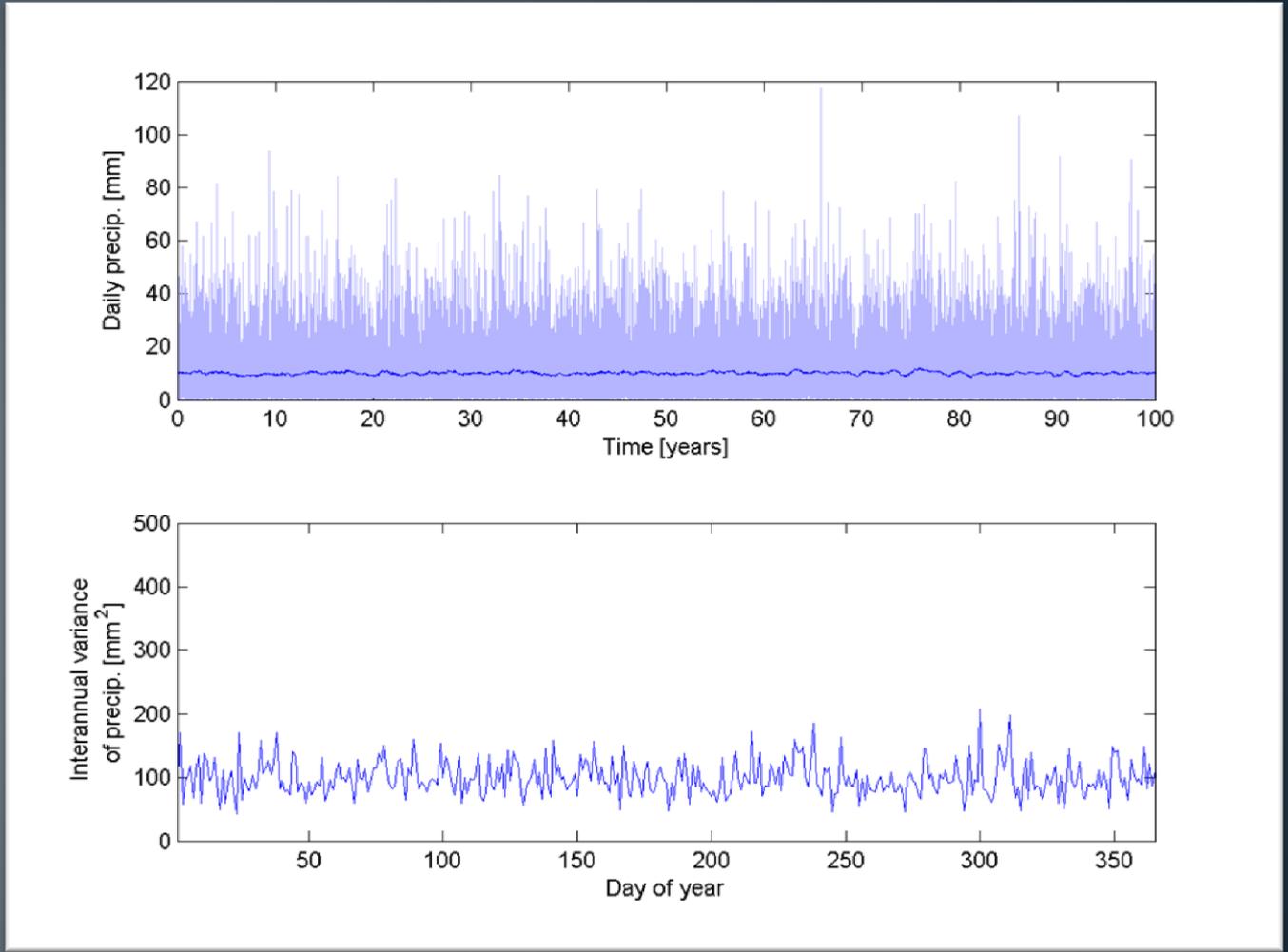
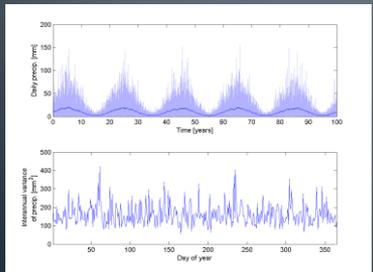
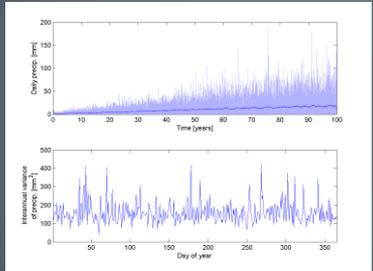
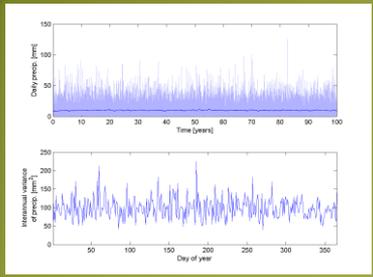
Bruce Anderson & Guido Salvucci

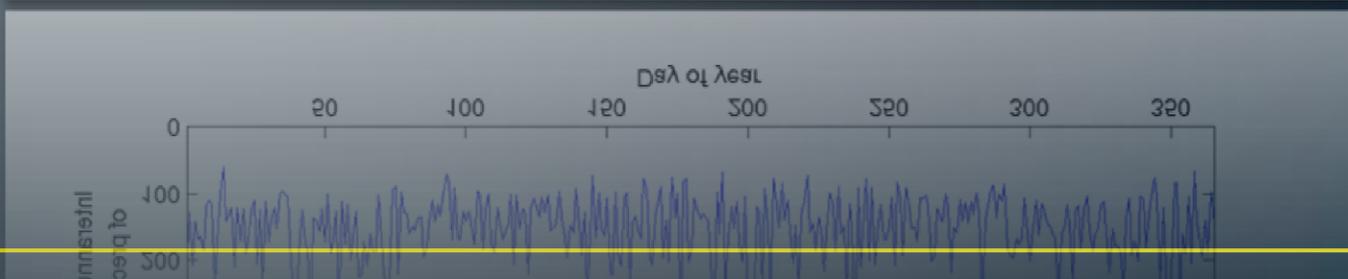
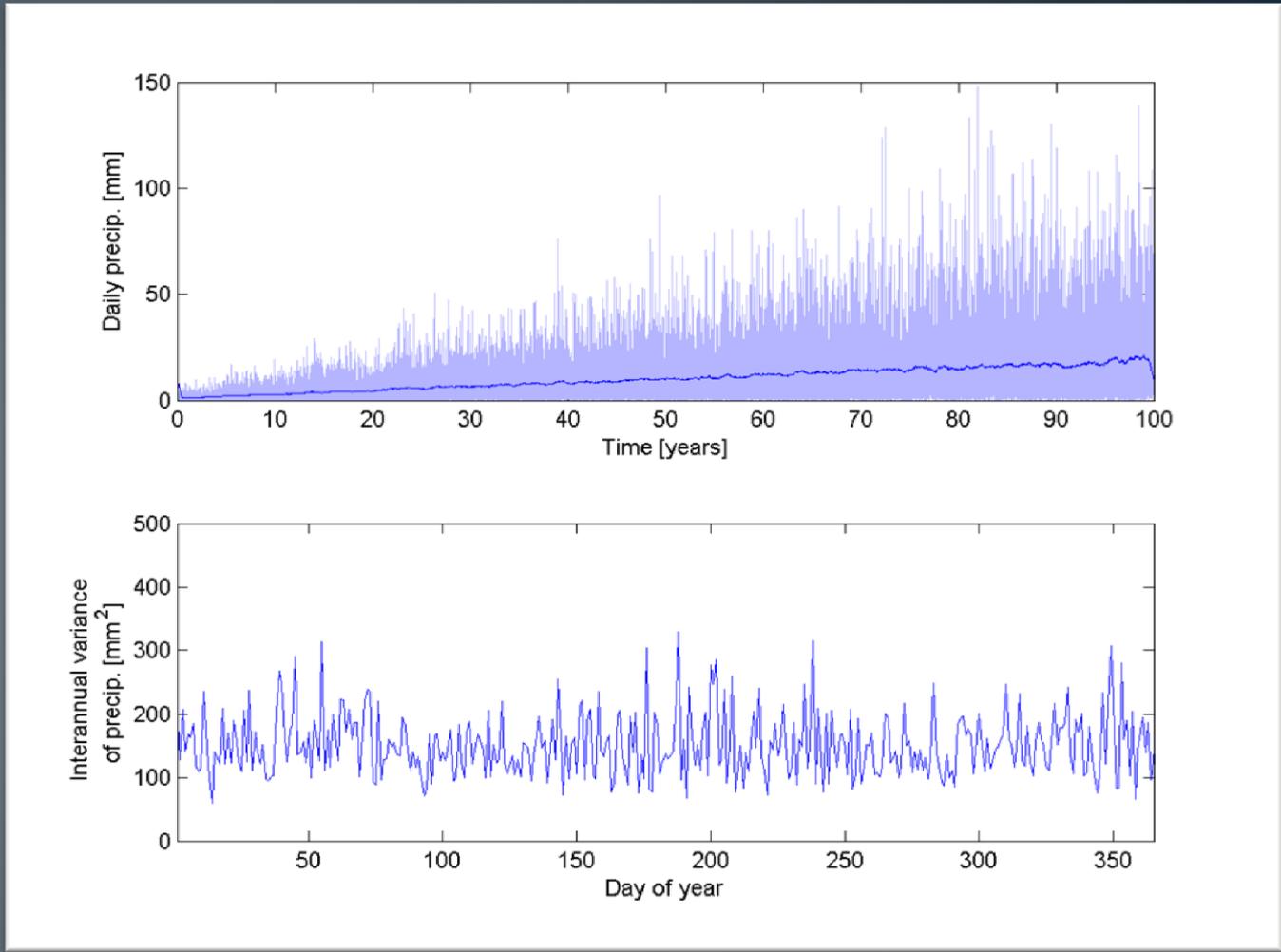
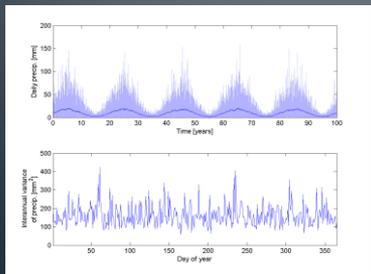
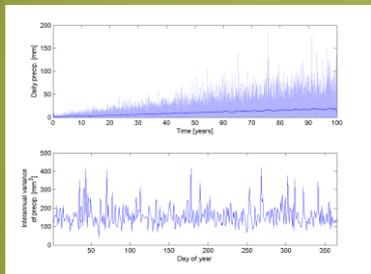
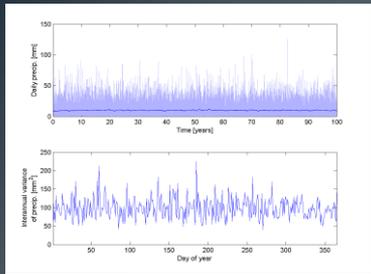


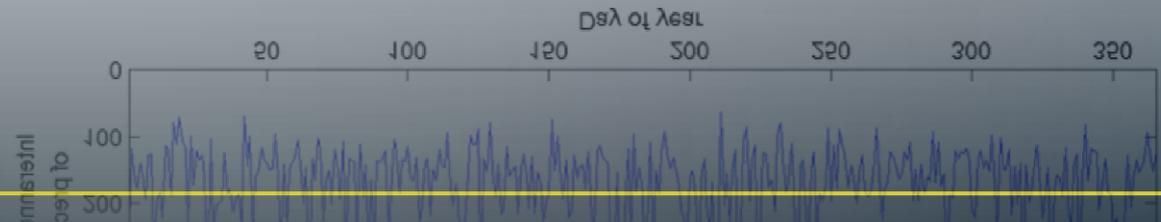
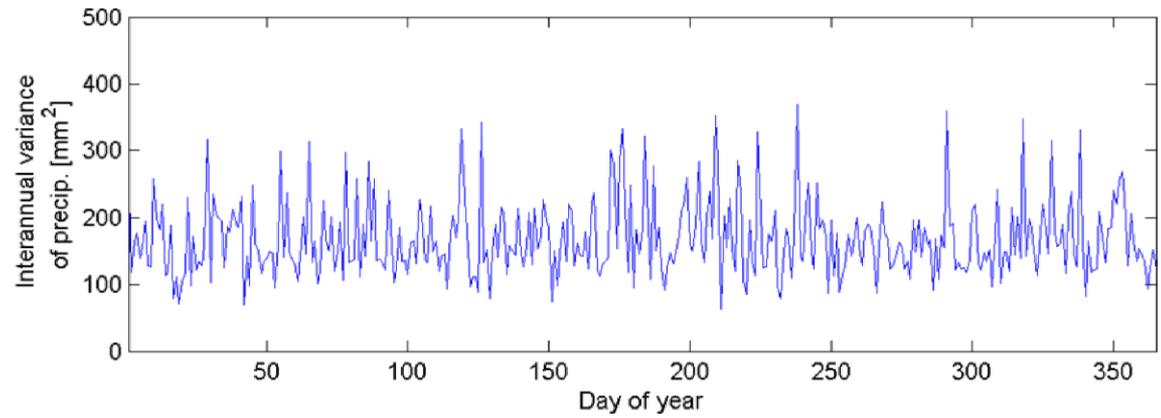
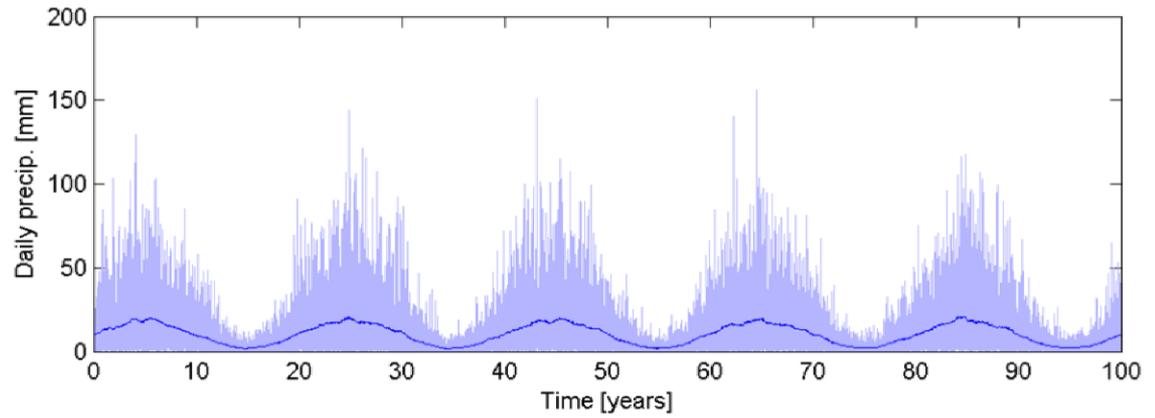
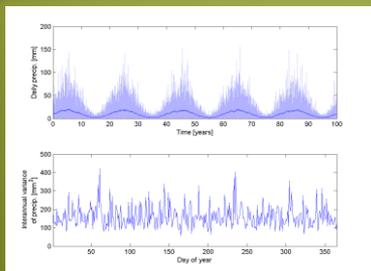
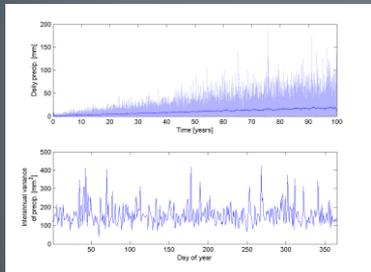
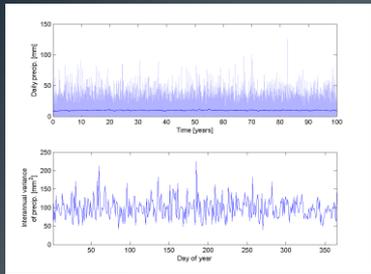
Department of  
Earth & Environment

# Climate and Weather

- **Questions:**
  - When and where can we predict climate better?
  - When and where is it fundamentally stochastic?
- We can only predict something when there is variability







# Potential Predictability

- Variance fraction:

$$P_p = \frac{\sigma_o^2 - \sigma_s^2}{\sigma_o^2}$$

- Look at interannual variability
- Metric?

# Potential Predictability

- Variance fraction:

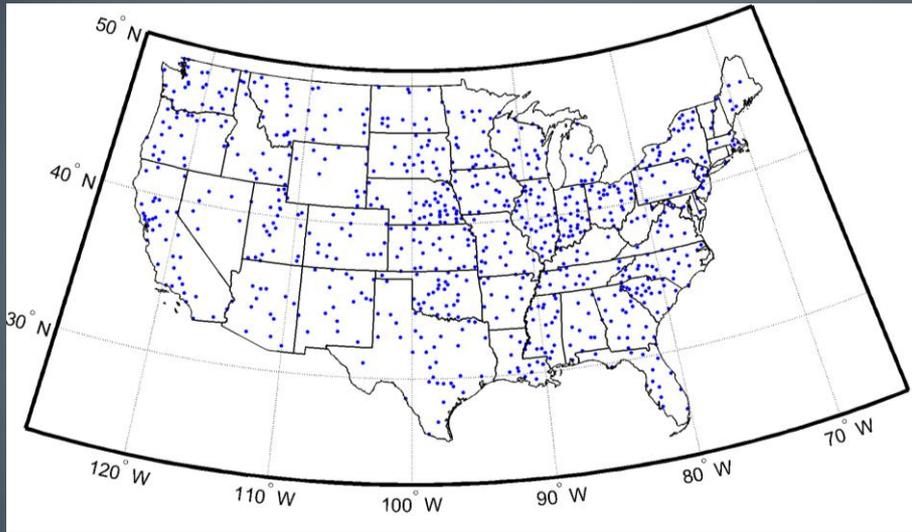
$$P_p = \frac{\sigma_o^2 - \sigma_s^2}{\sigma_o^2}$$

- Look at interannual variability
- Metric?

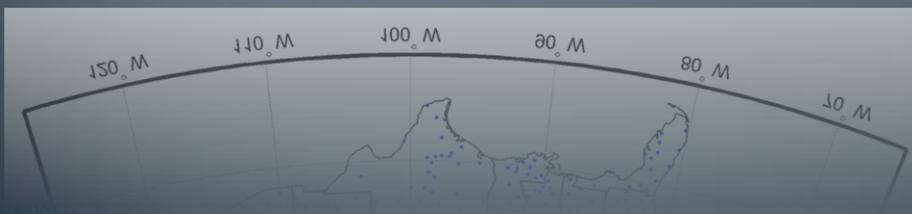
**Seasonal occurrence counts:**

$$P_{p,89} = \frac{\sigma_{o,89}^2 - \sigma_{s,89}^2}{\sigma_{o,89}^2}$$

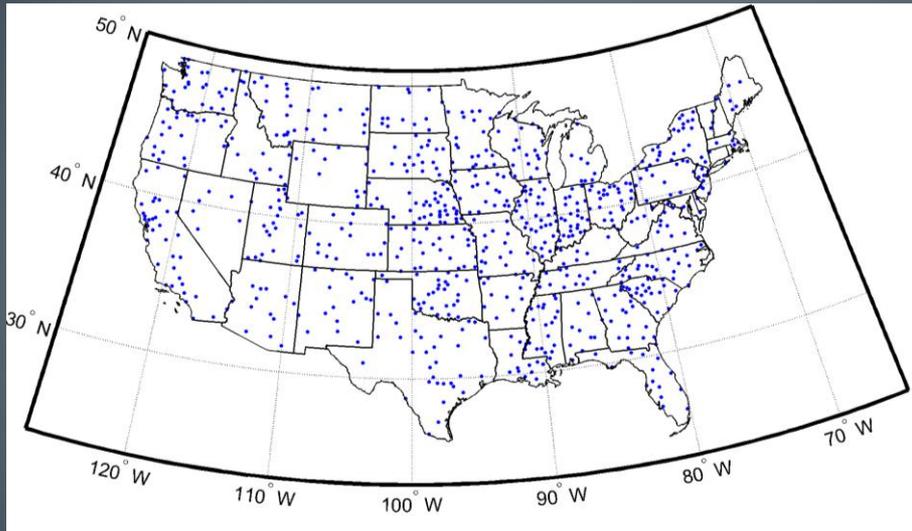
# We Need Data!



- US Historical Climate Network
  - > 80 years of data
  - > 95% complete data



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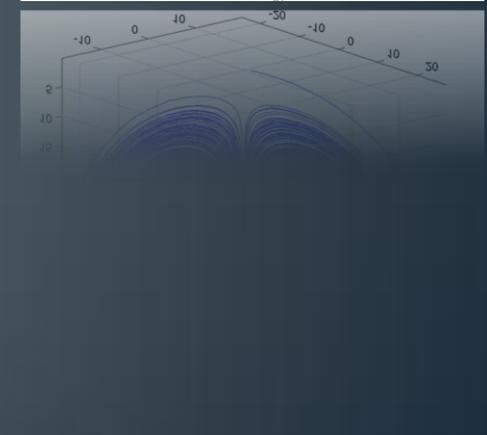
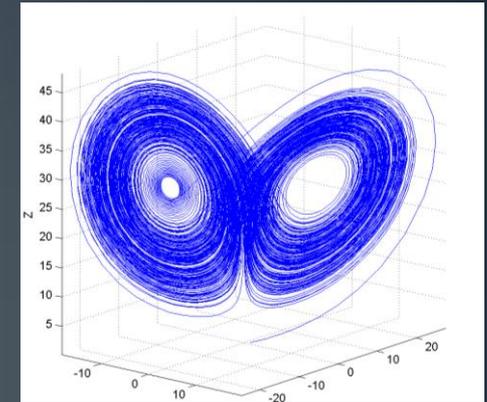
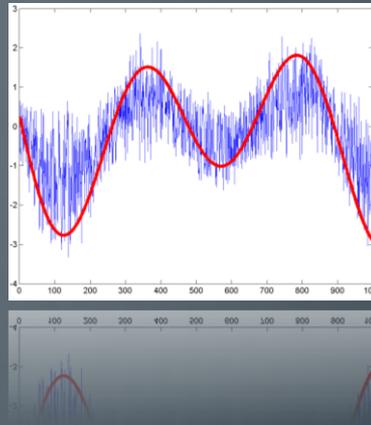


- US Historical Climate Network
  - > 80 years of data
  - > 95% complete data

$$\frac{\sigma_o^2 - \sigma_s^2}{\sigma_o^2}$$

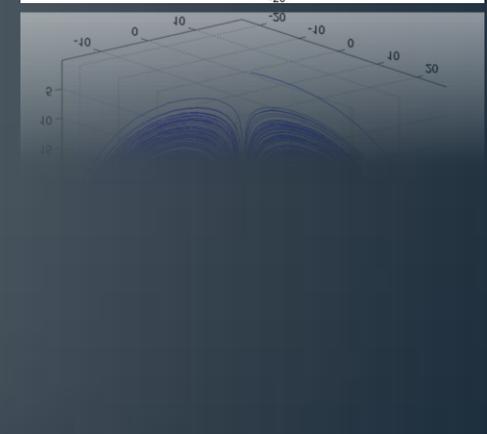
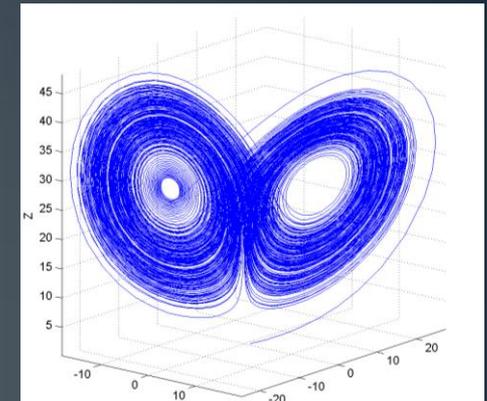
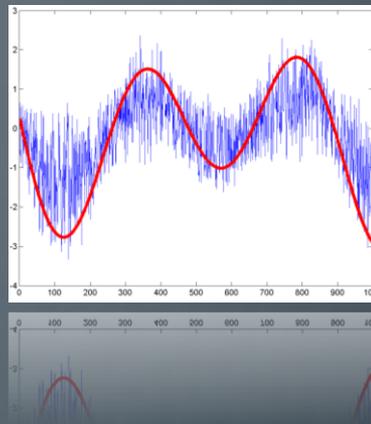
# How to Find $\sigma_s^2$ ?

- Approach 1:
  - Dynamical systems and divergence of states
- Approach 2:
  - Signal/noise



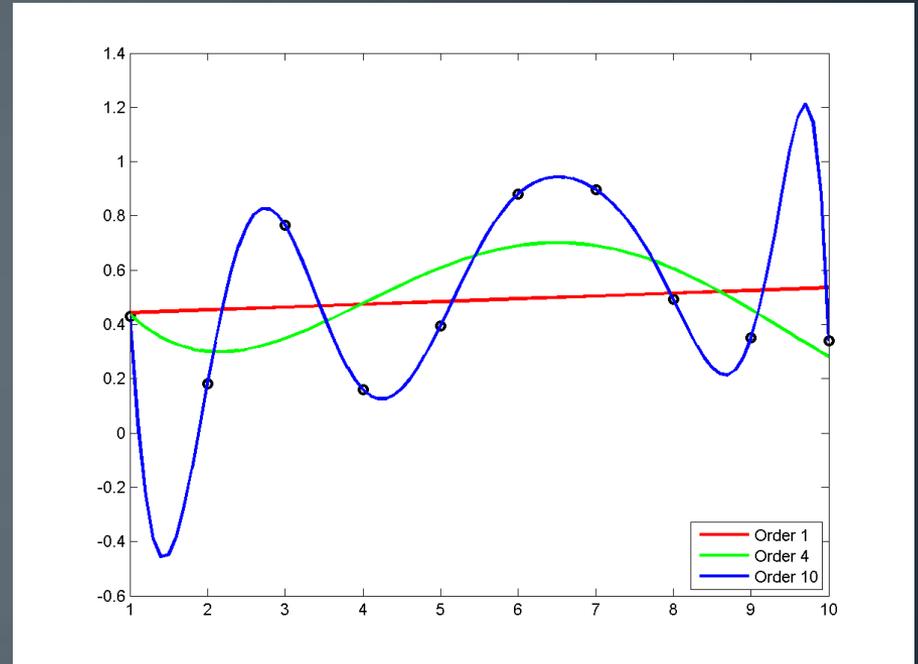
# How to Find $\sigma_s^2$ ?

- Approach 1:
  - Dynamical systems and divergence of states
- Approach 2:
  - Signal/noise
- Our approach:
  - **Simulate it**



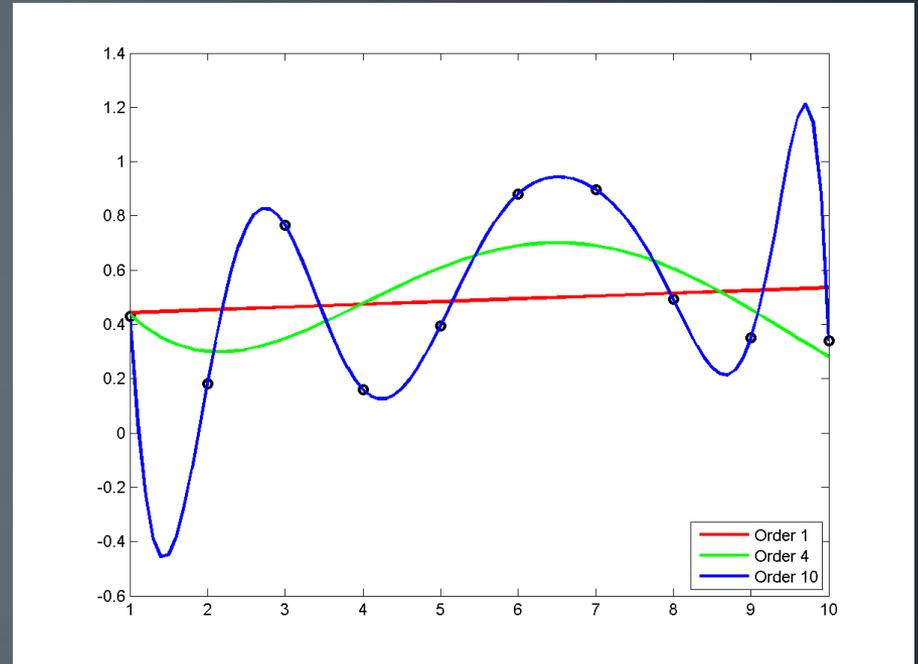
# Models and Complexity

- Simple models
  - Low variability, poor fit
- Complex models
  - High variability, good fit



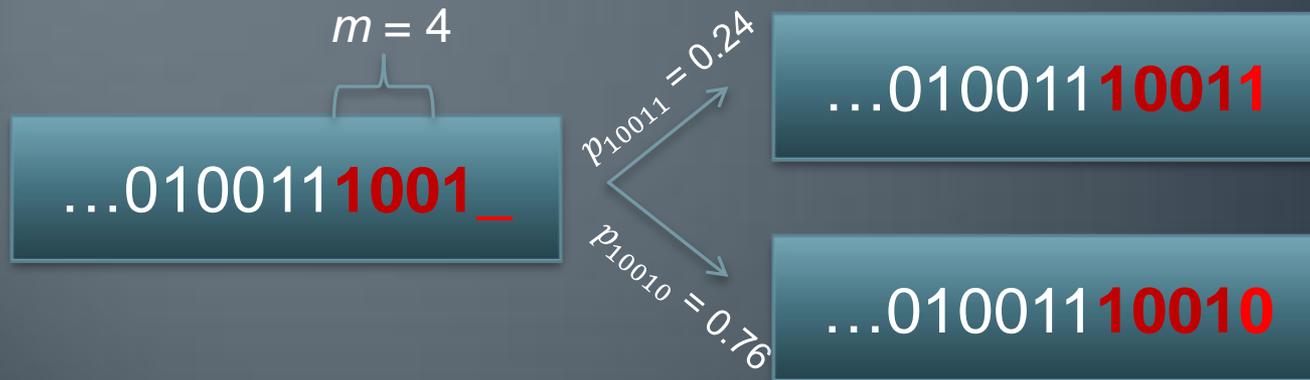
# Models and Complexity

- Simple models
  - Low variability, poor fit
- Complex models
  - High variability, good fit
- How much is just right?
  - **Akaike Information Criterion (AIC)**



# Our Models

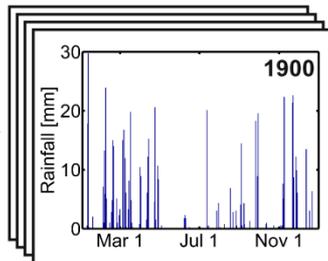
- Variable order Markov chains
- Probability of rain depends on  $m$  days' worth of history



# Simulate!

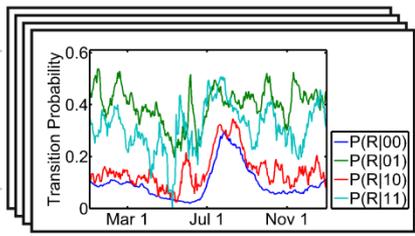
- Run them all for ~100 years
- Do that 1000 times
  - Distribution of (stationary) histories

$$\frac{\sigma_o^2 - \sigma_s^2}{\sigma_o^2}$$

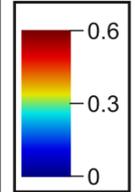
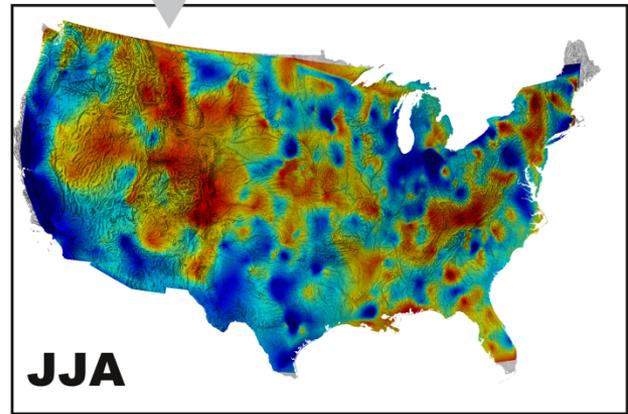
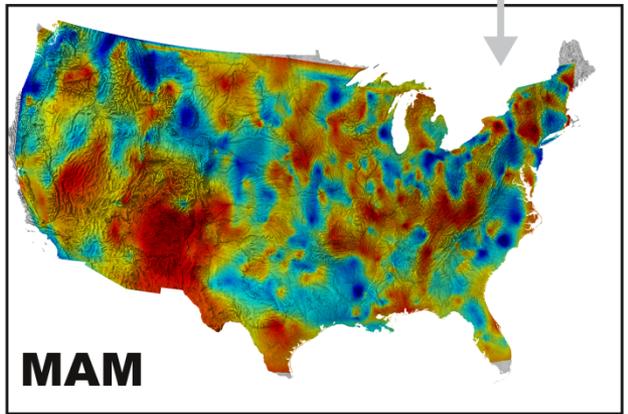
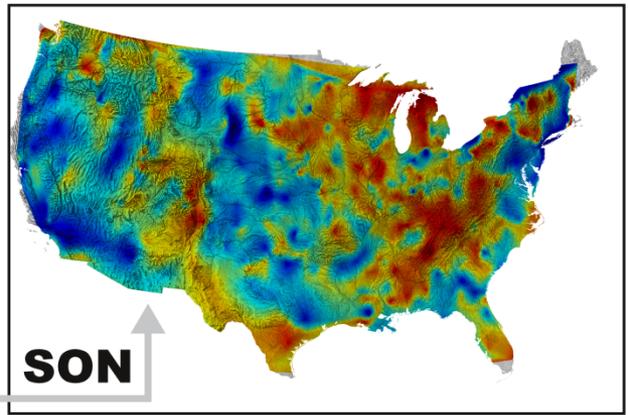
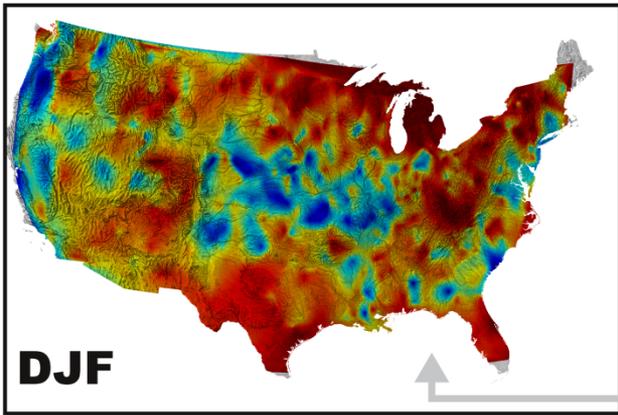
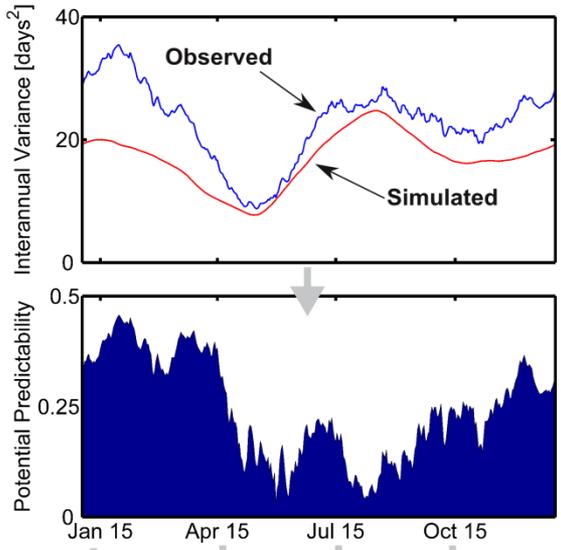


**Minimization**  
AIC

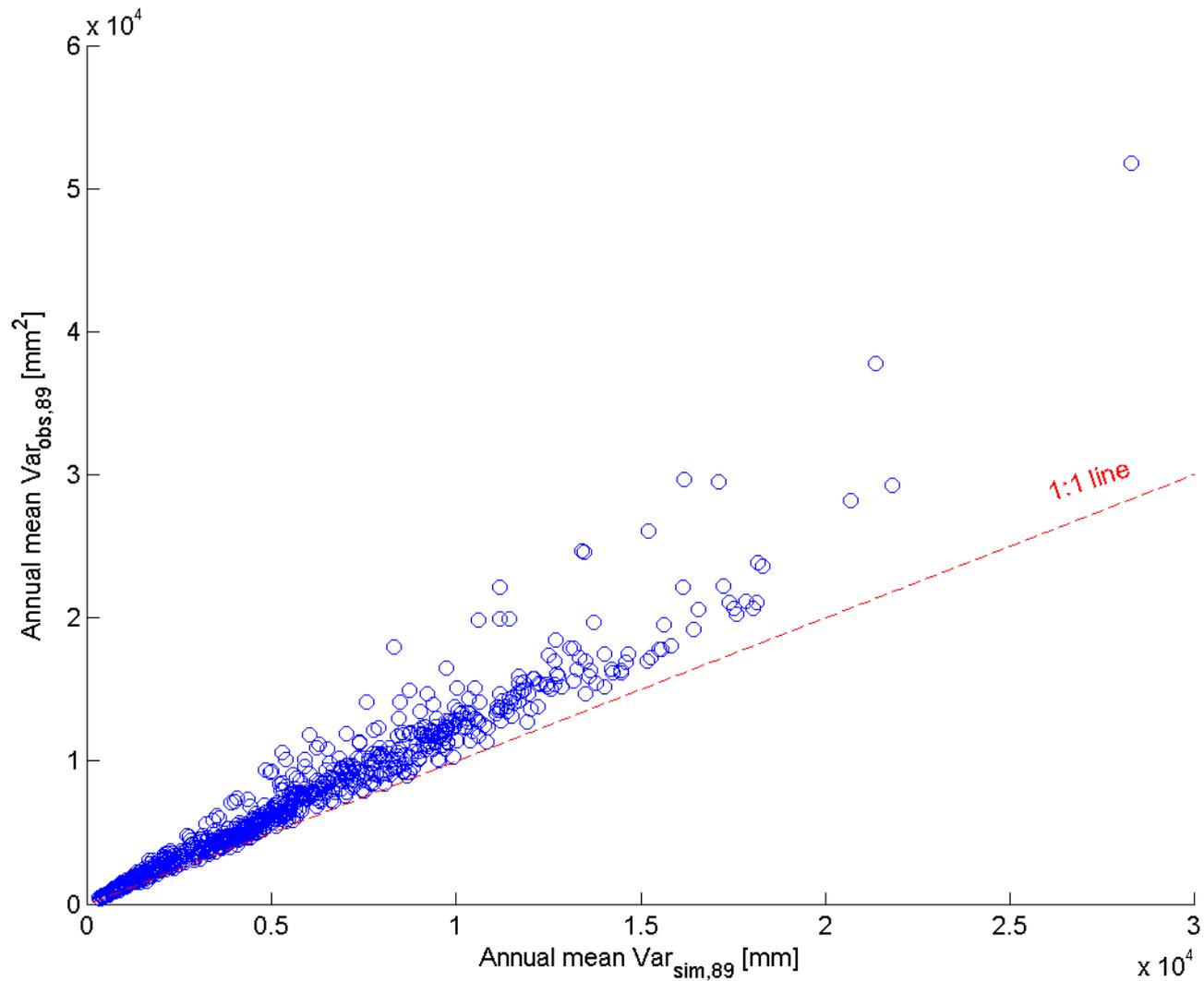
Daily Chain Orders  
Data Pooling Size



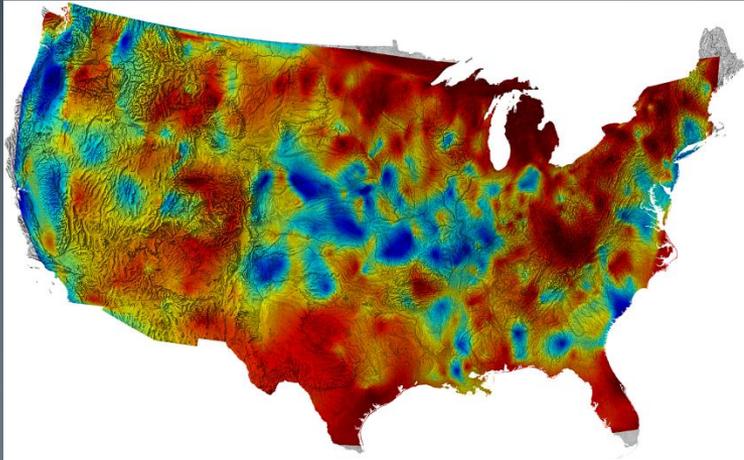
**Simulated Stationary Climate Data**



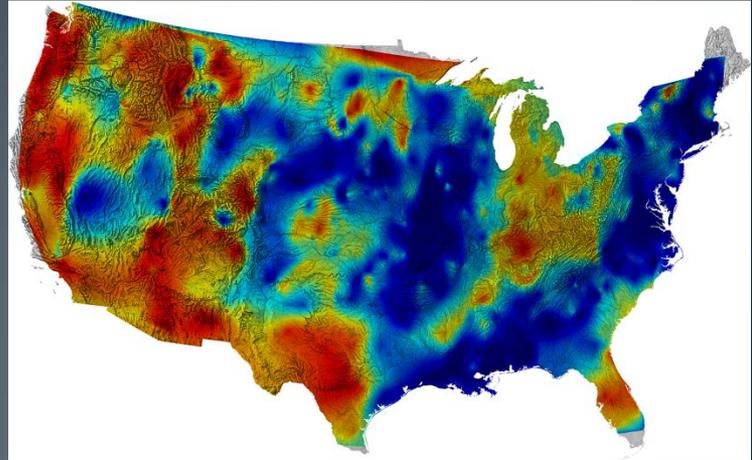
# Cumulative Seasonal Precipitation Overdispersion



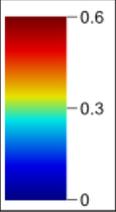
D  
J  
F



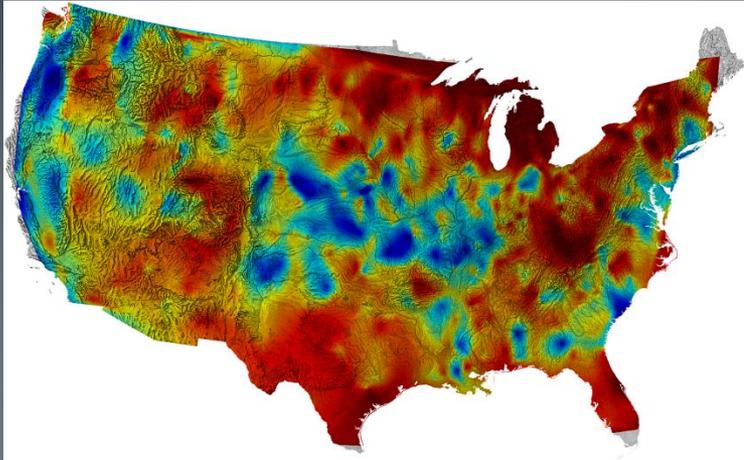
Occurrence



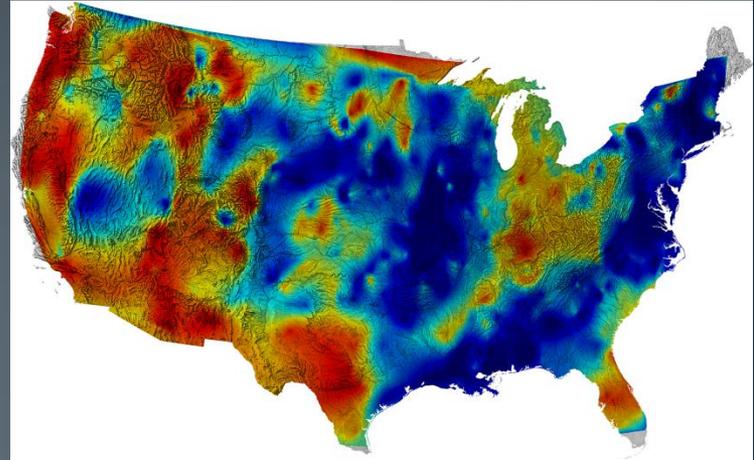
Total



D  
J  
F

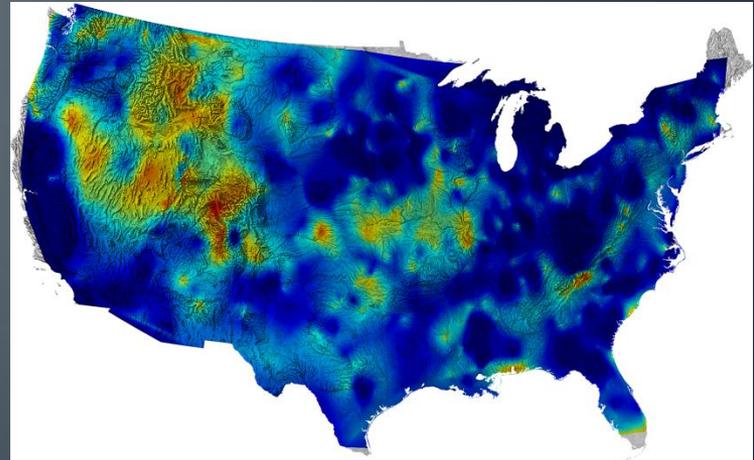
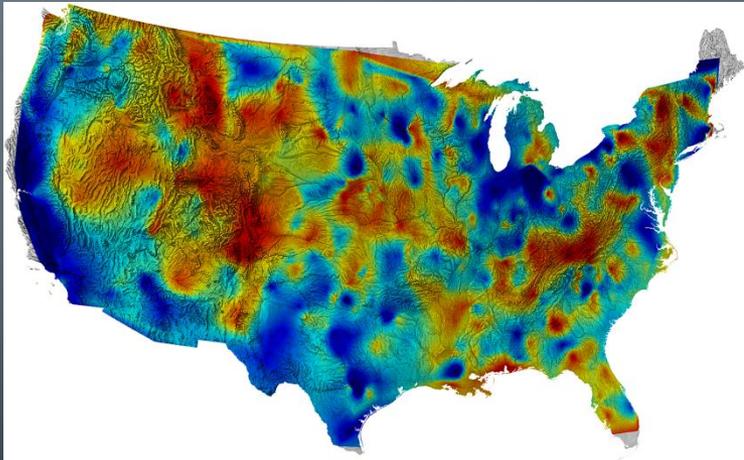


Occurrence

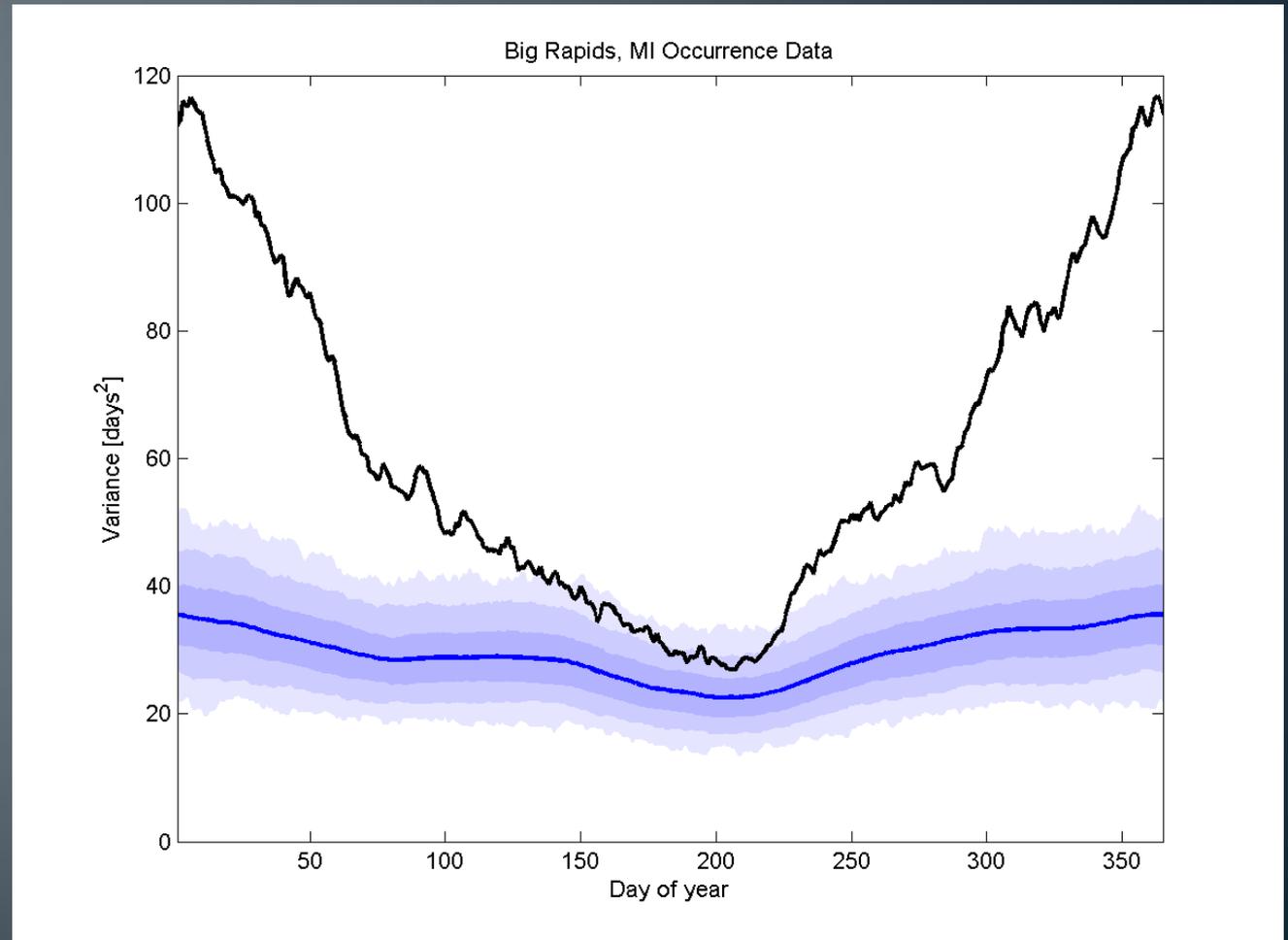


Total

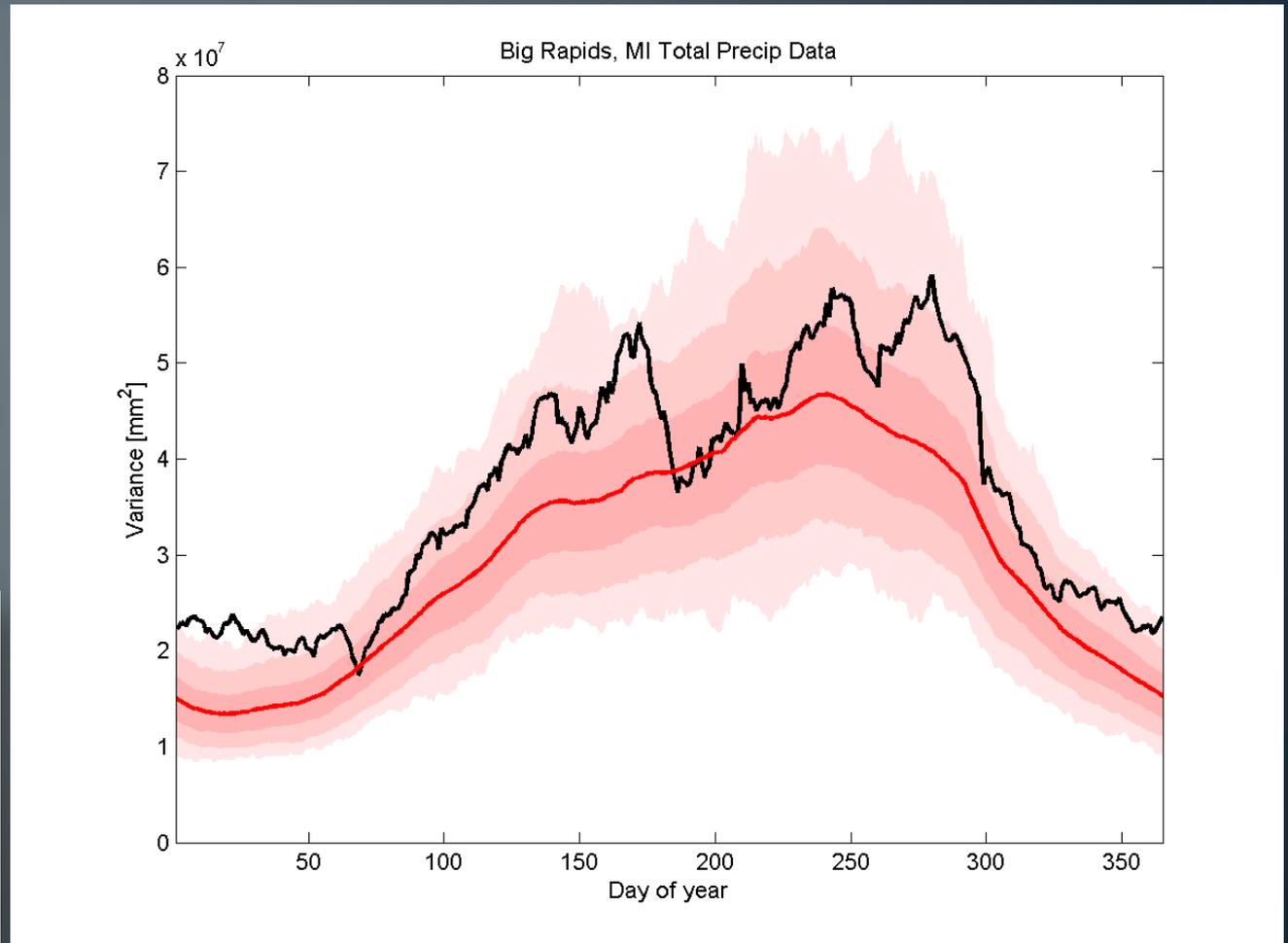
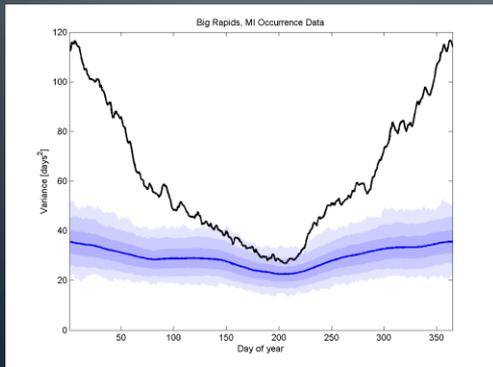
J  
J  
A



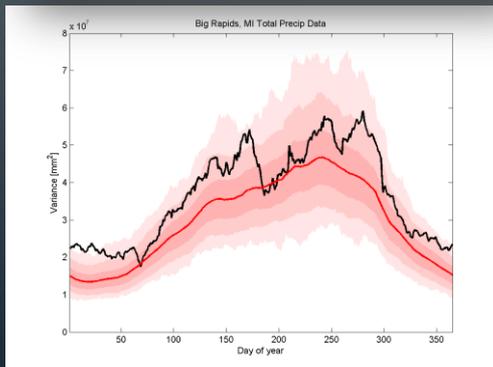
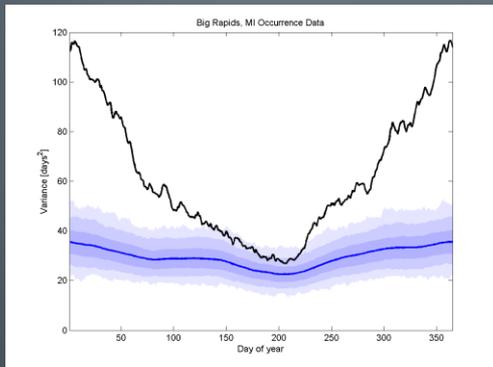
# Big Rapids, MI



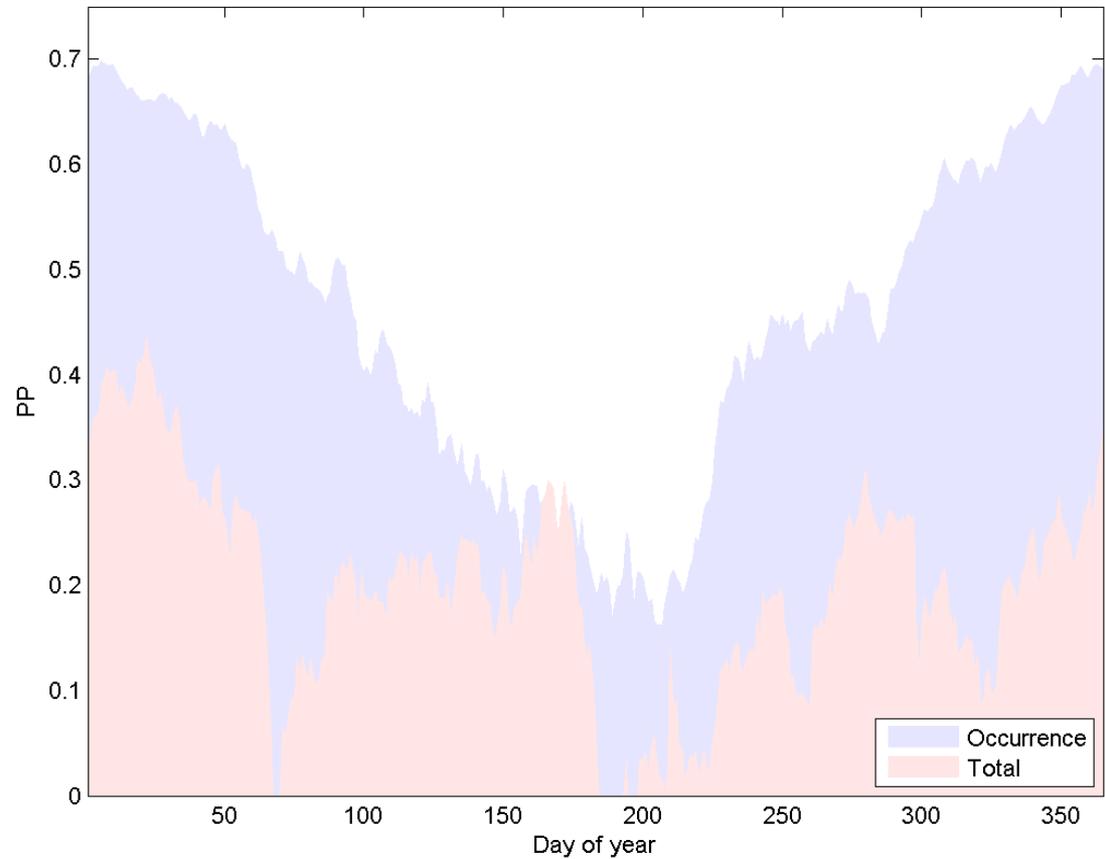
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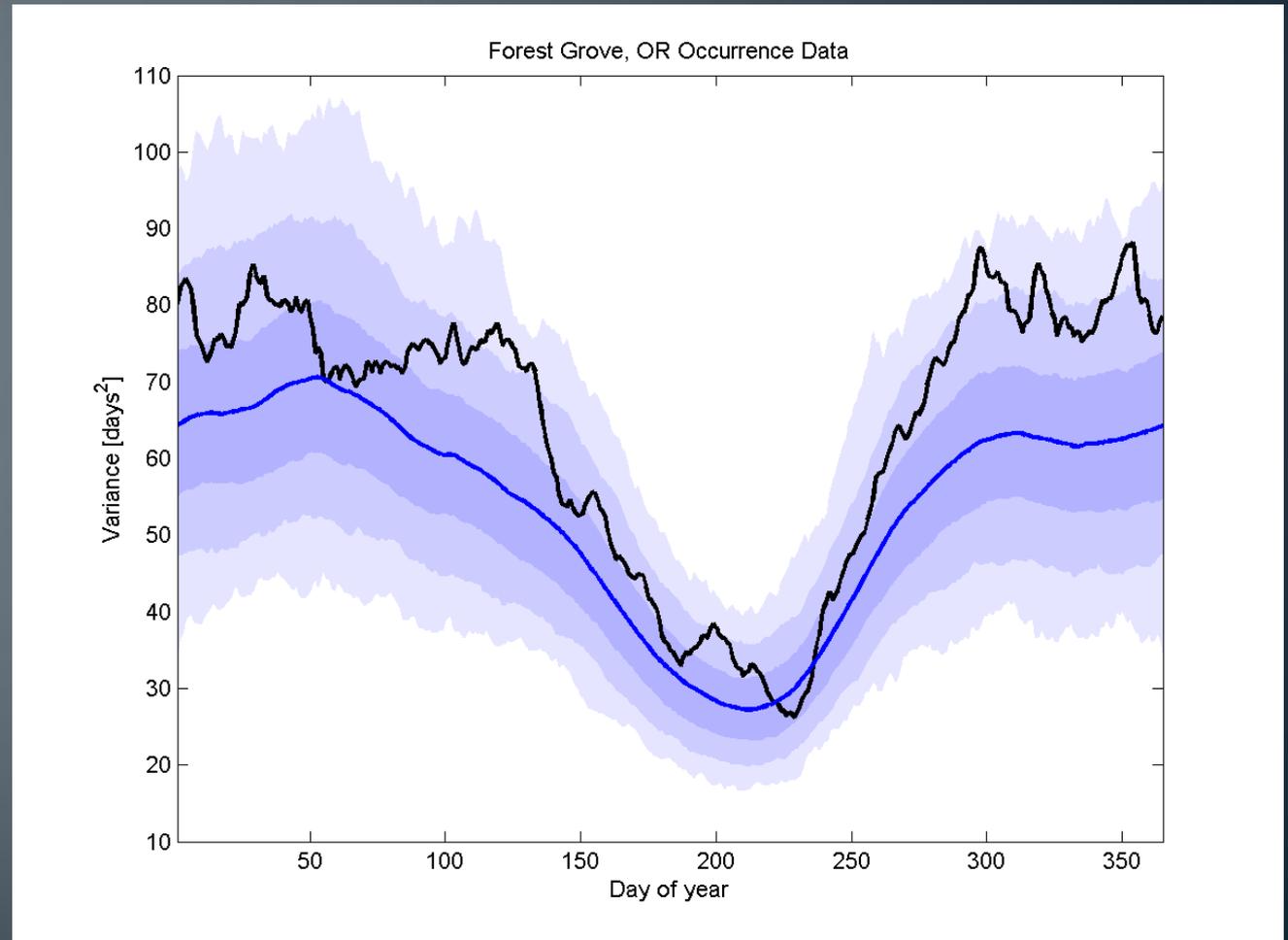
# Big Rapids, MI



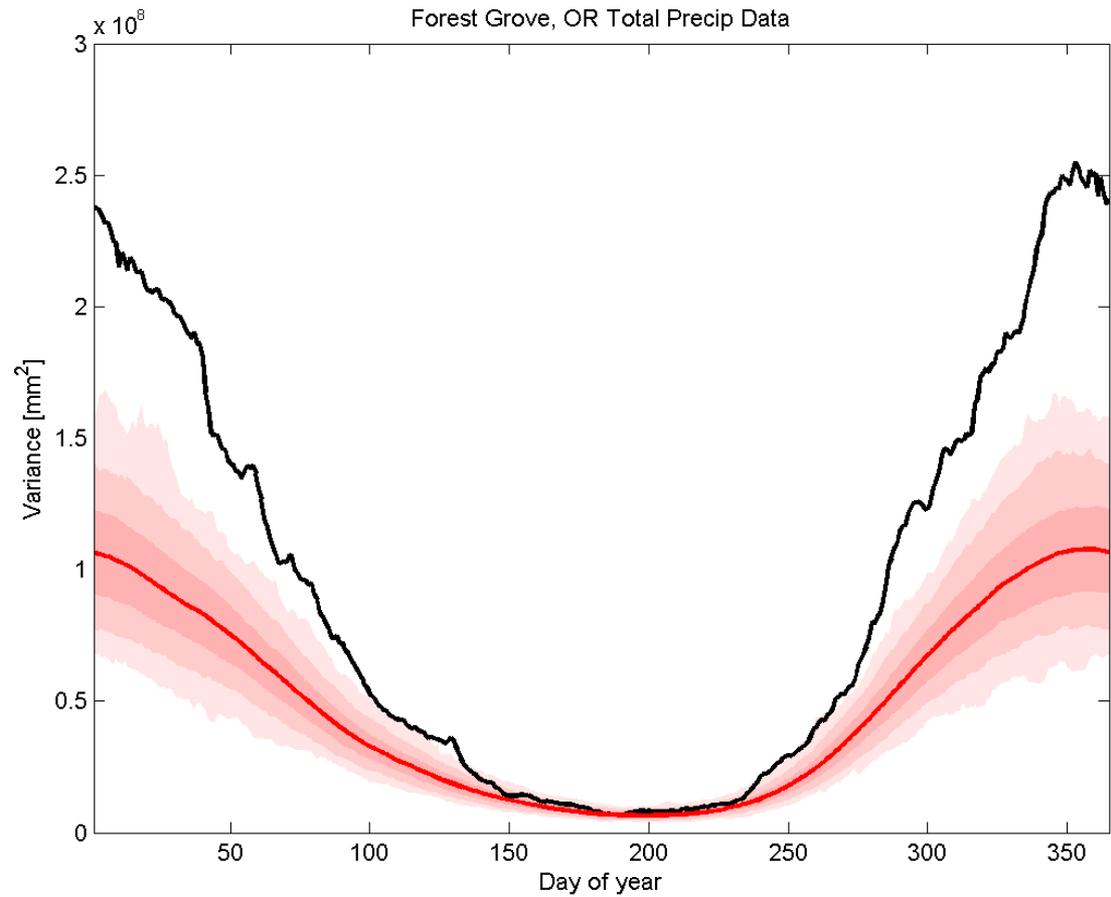
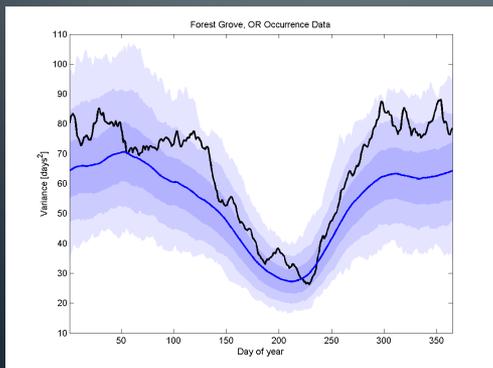
Potential Predictability: Big Rapids, MI



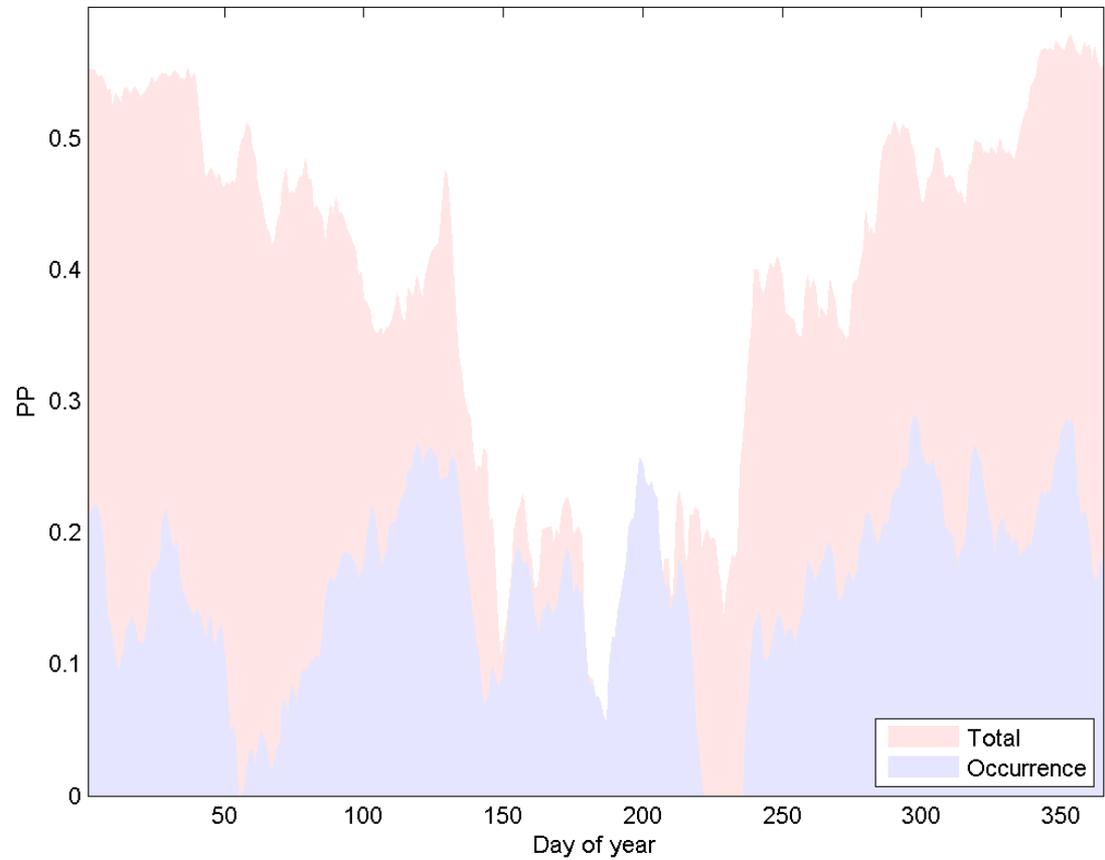
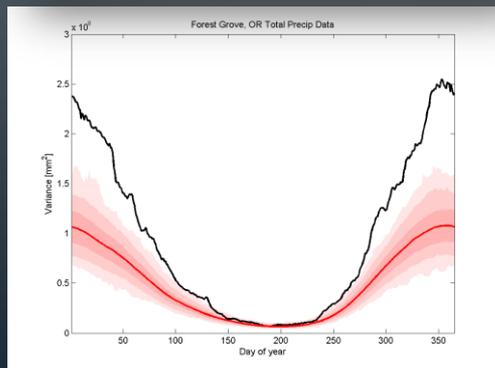
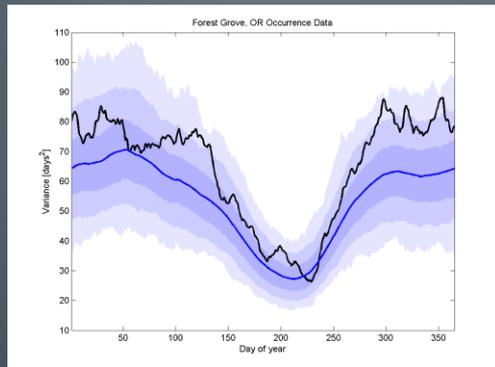
# Forest Grove, OR



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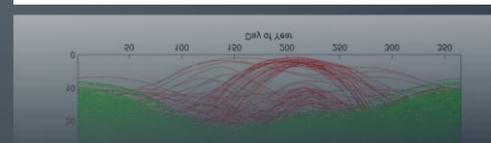
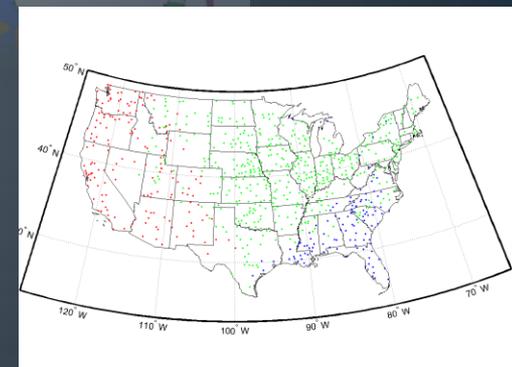
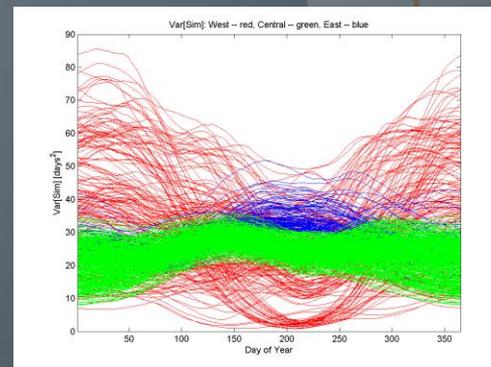
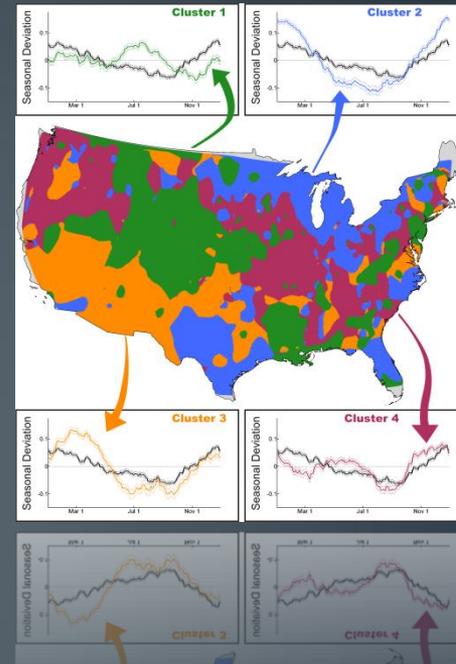


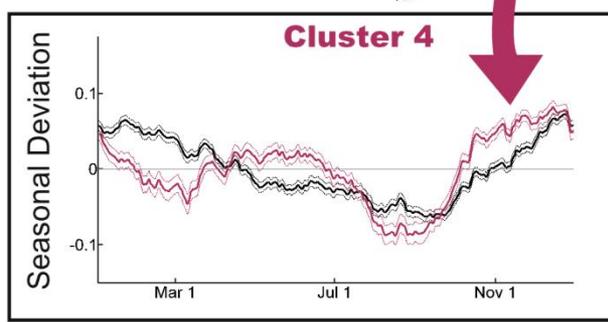
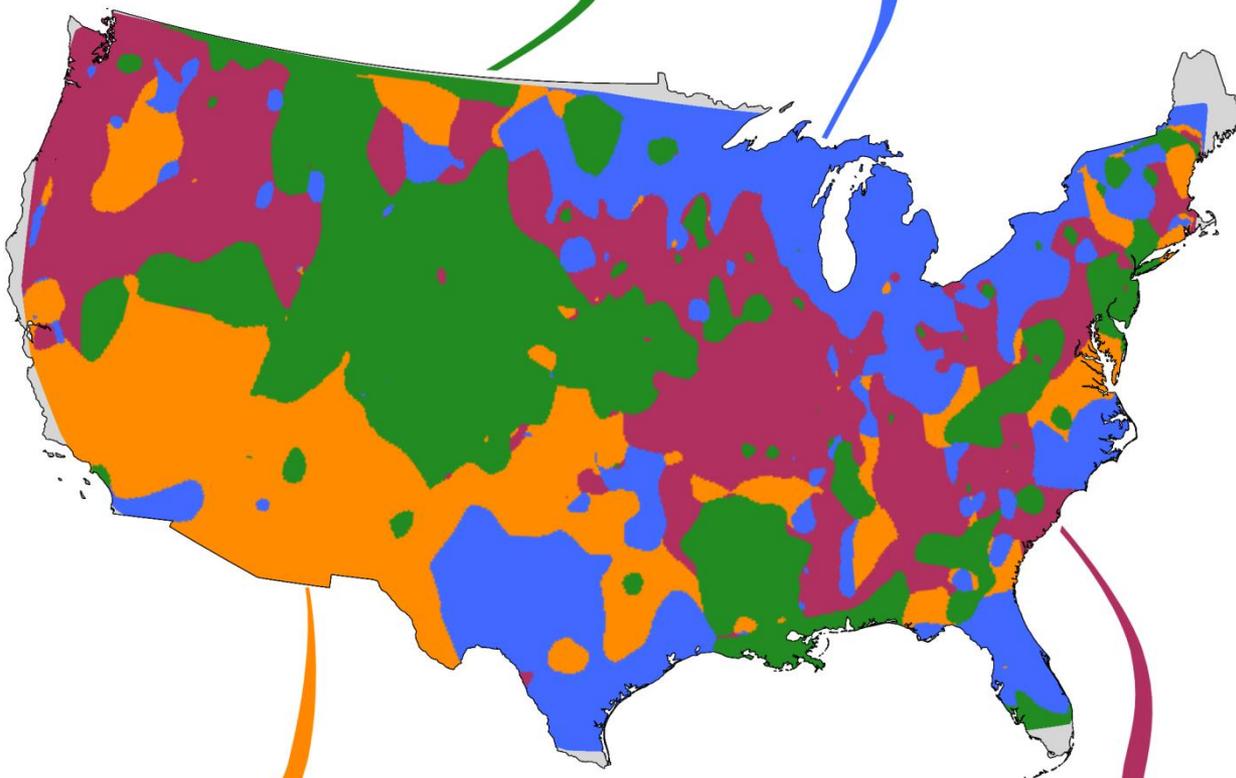
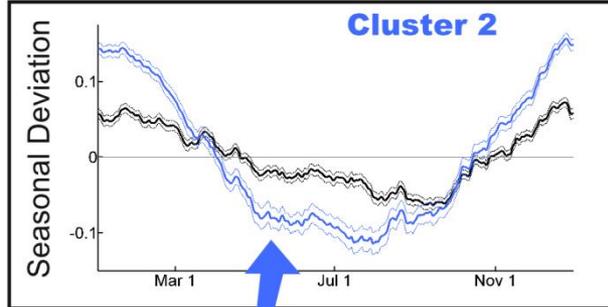
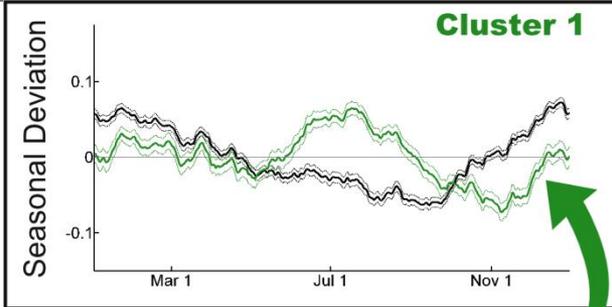
# Forest Grove, OR

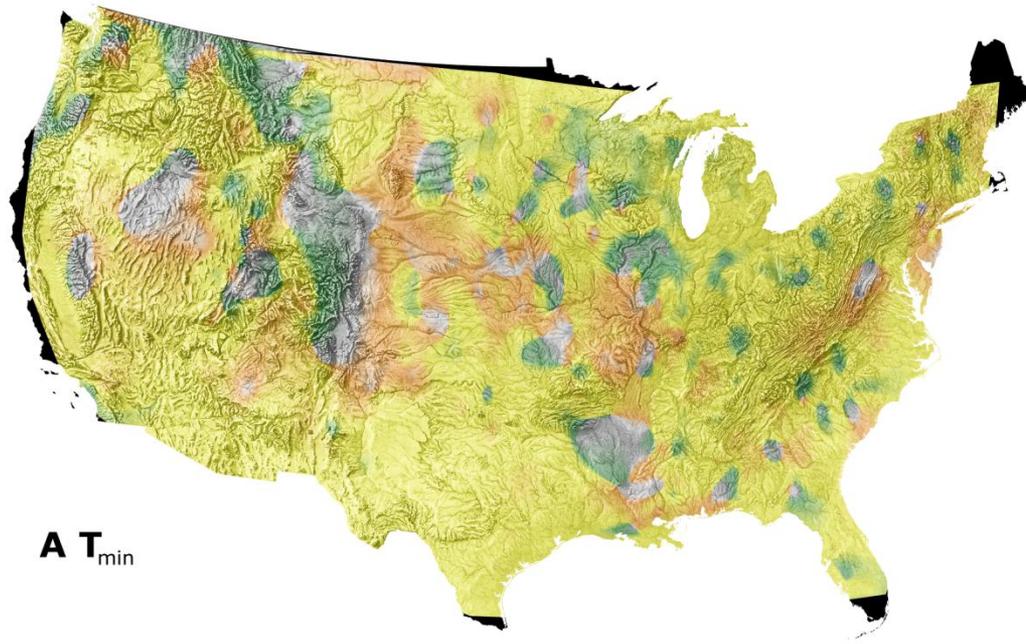


# Conclusions

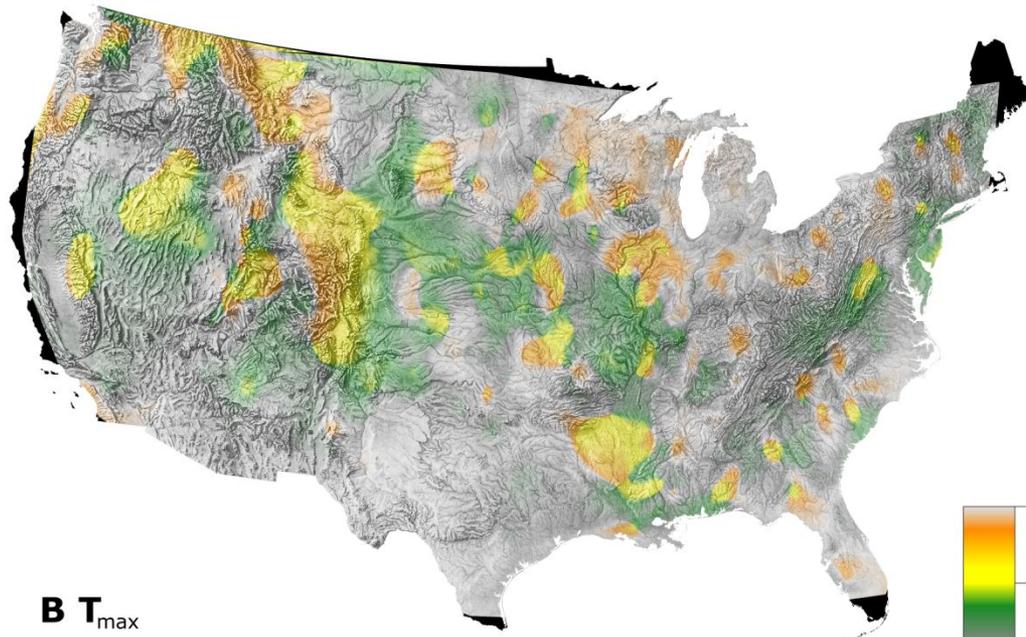
- Questions:
  - When and where can we predict climate better?
  - When and where is it fundamentally stochastic?
- Attribution
- Spatial patterns and clustering



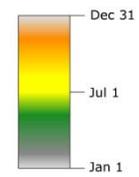




**A**  $T_{\min}$



**B**  $T_{\max}$



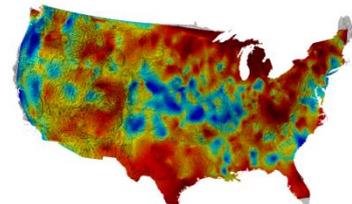
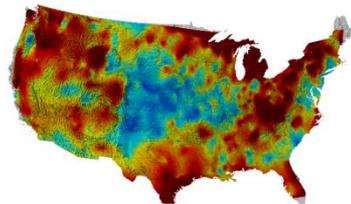
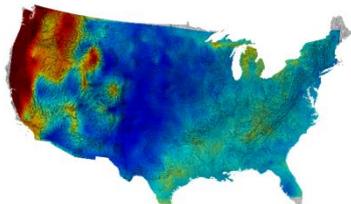
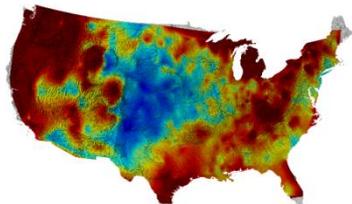
**Var(Obs)**

**Var(Sim)**

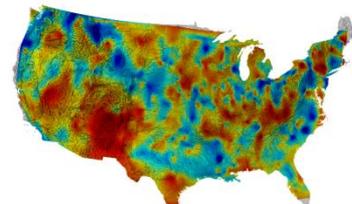
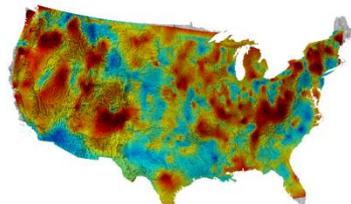
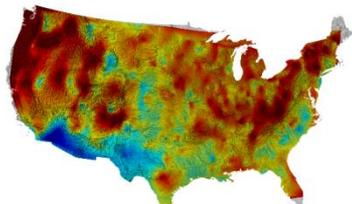
**Var(Obs)-Var(Sim)**

**[Var(Obs)-Var(Sim)] /  
Var(Obs)**

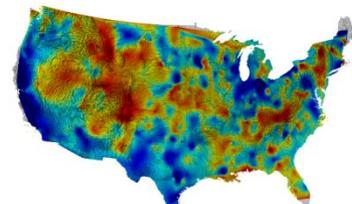
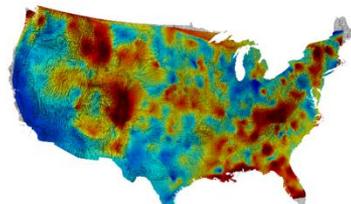
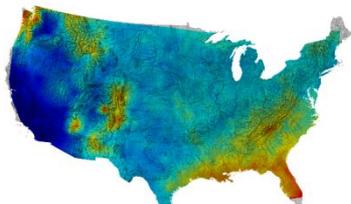
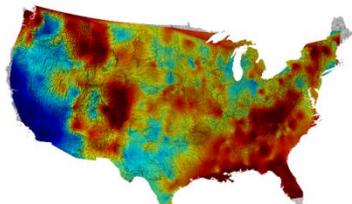
**DJF**



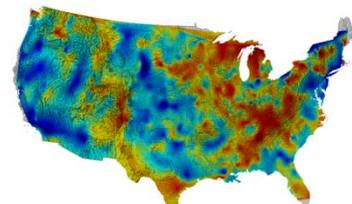
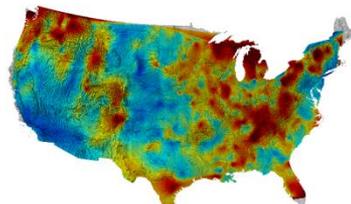
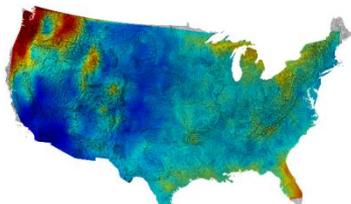
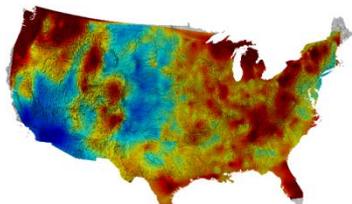
**MAM**



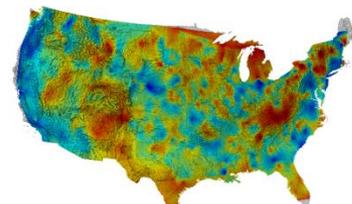
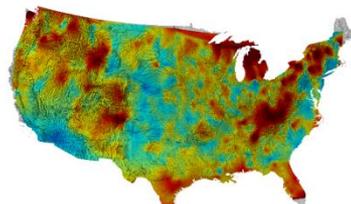
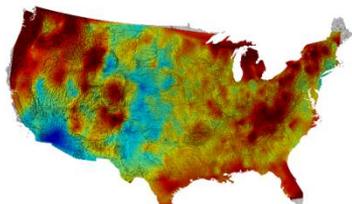
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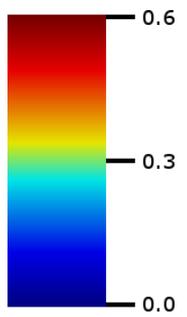
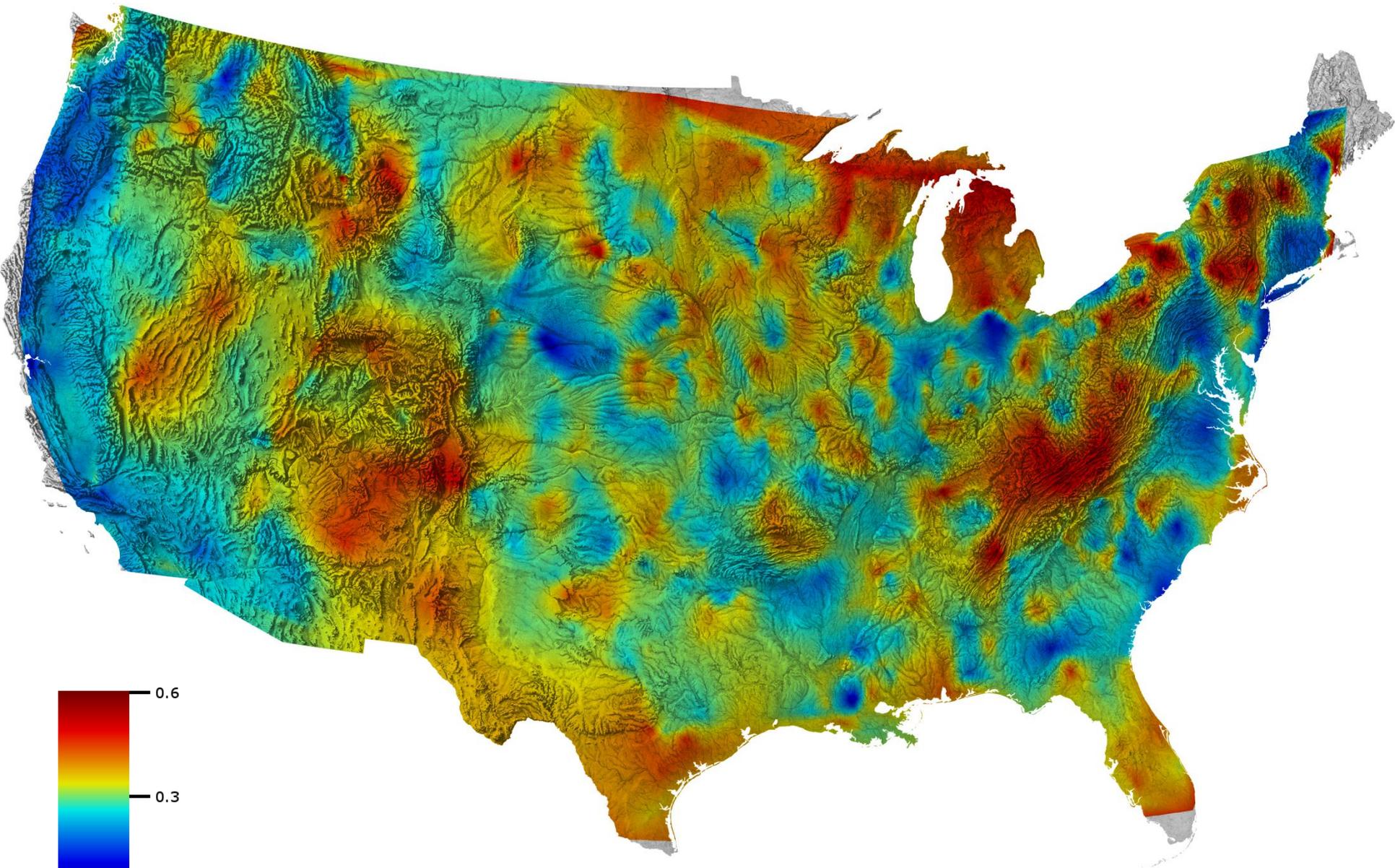


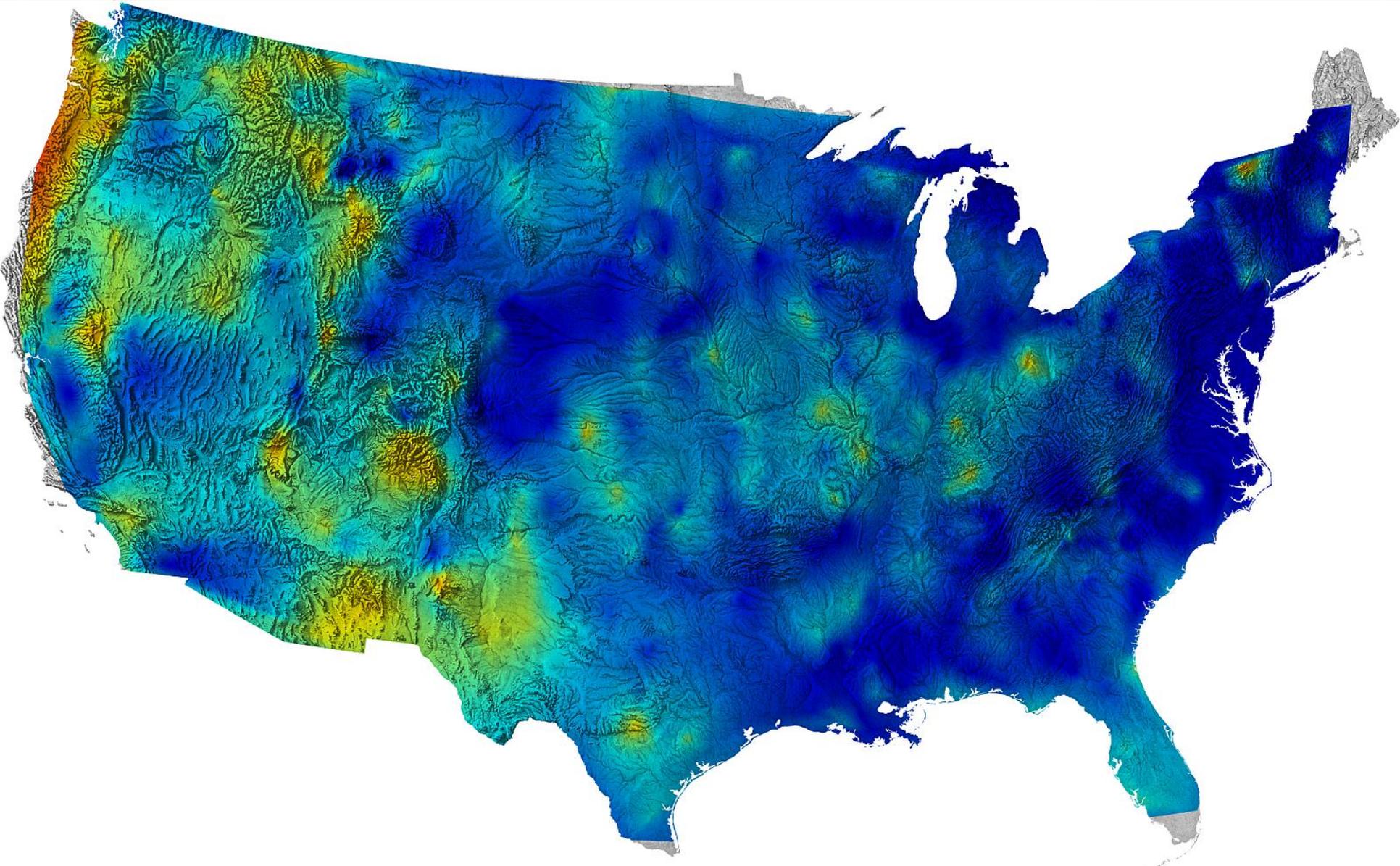
**SON**



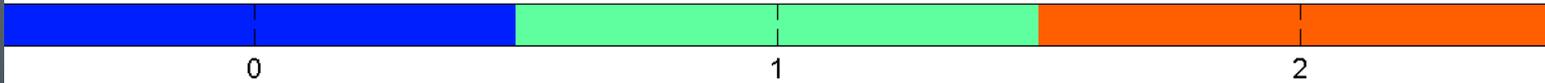
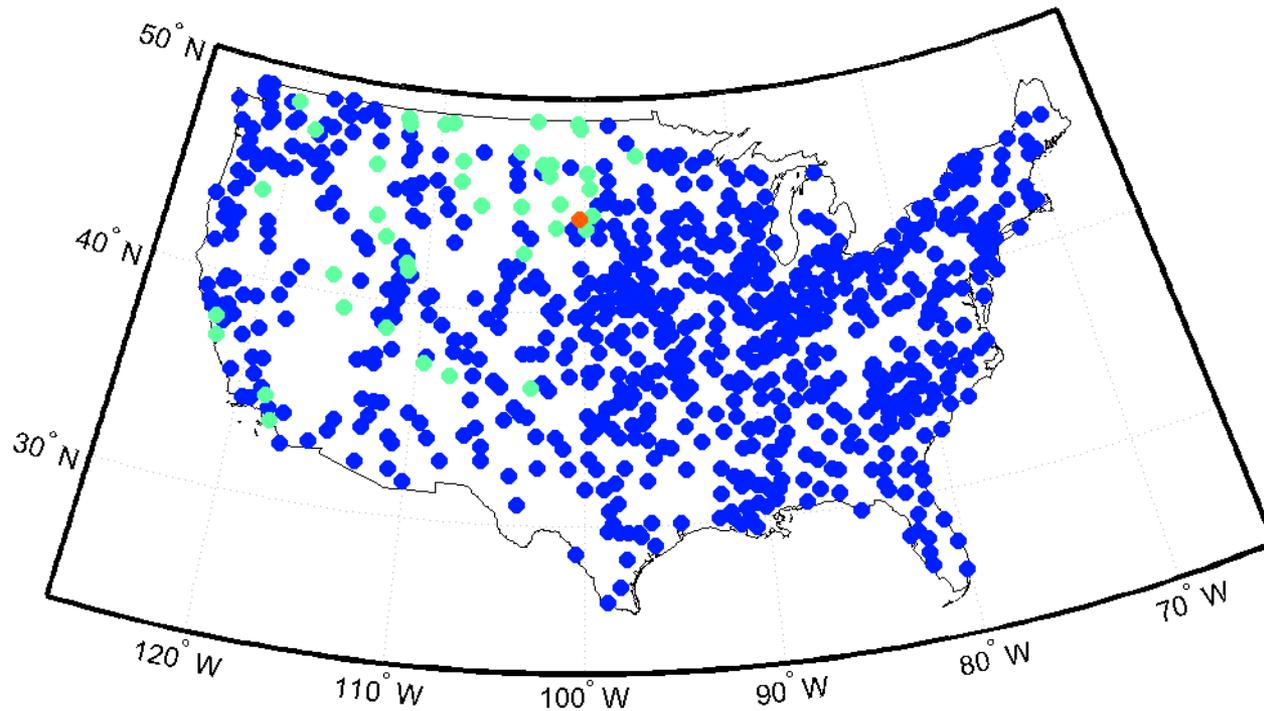
**Annual**



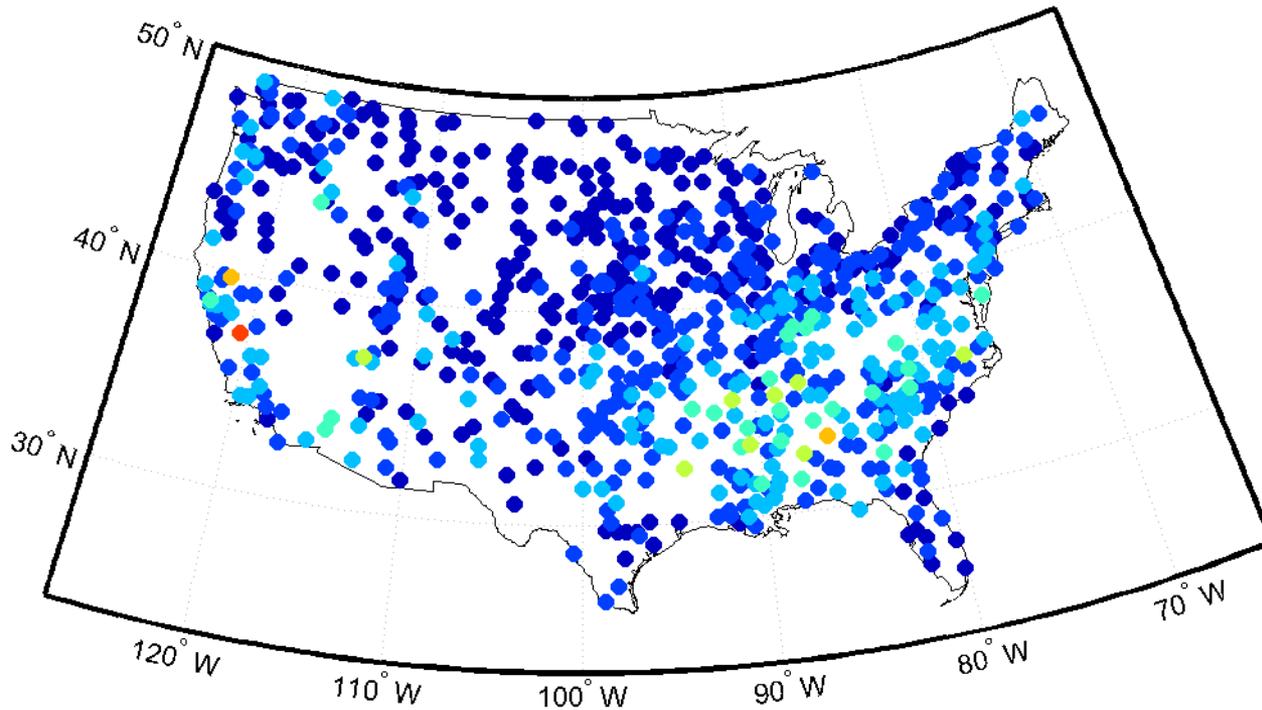




Intensity Model Maximum Chain Order



Intensity Model Pooling Size [days]



1-15

16-30

31-45

46-60

61-75

76-90

91-106

106-120