Potential Predictability of Precipitation: Occurrence or Intensity?

Dan Gianotti, Bruce Anderson, and Guido Salvucci
Boston University
Department of Earth & Environment

BOSTON UNIVERSITY

U.S. DEPARTMENT OF ENERGY

NSF

Questions

- How *potentially* predictable is precipitation?

Questions

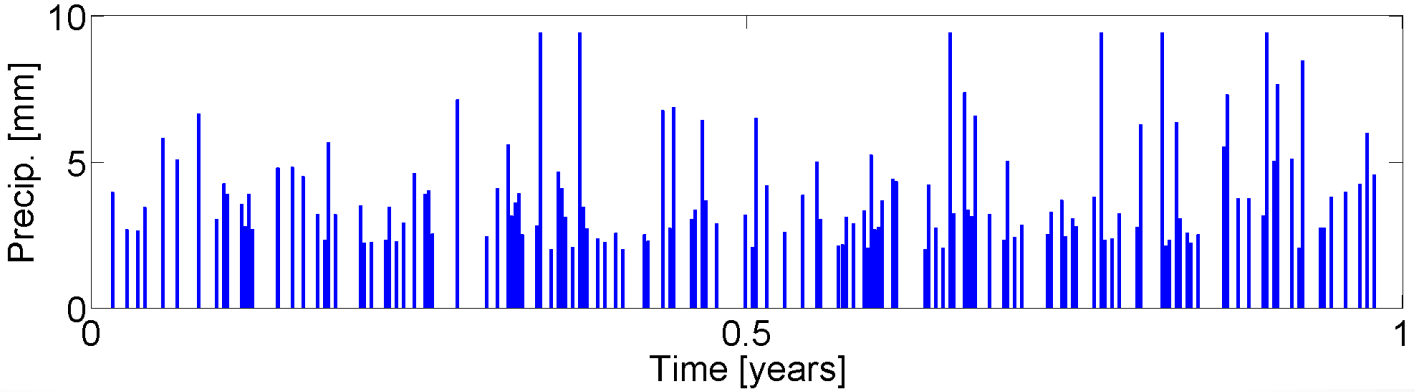
- How *potentially* predictable is precipitation?
- Can we tell if some of this predictability comes from precipitation occurrence processes or intensity processes?

Outline

- Signals and noise
- Potential Predictability
- Methods
- Occurrence and Intensity
- Results

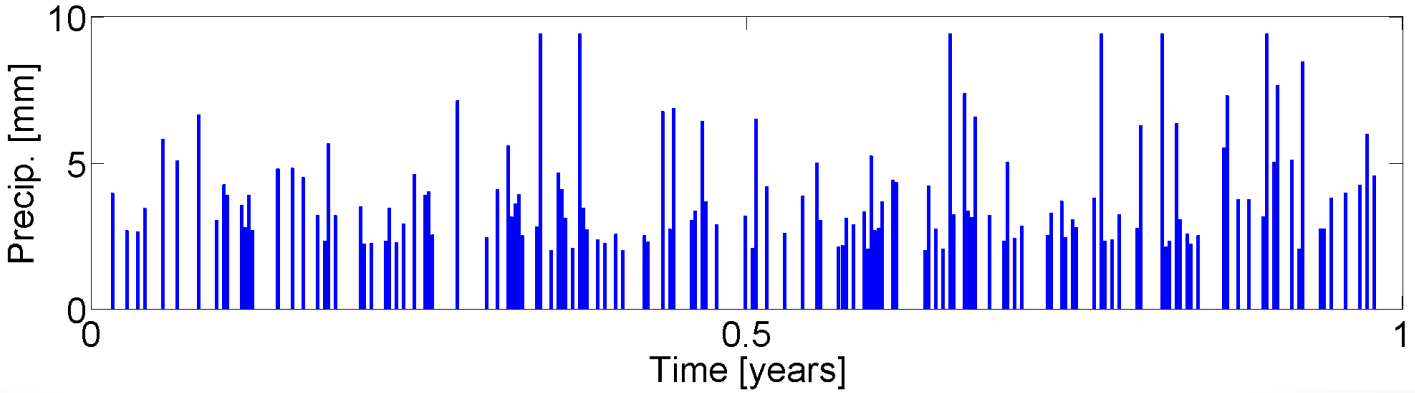
Climate Predictability: Signal or Noise?

IID (white noise)

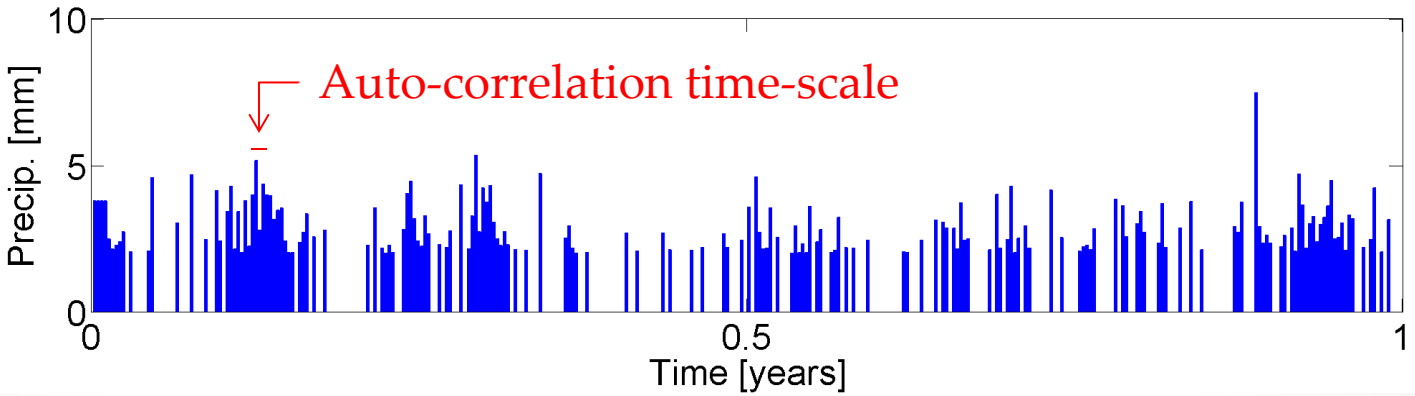


Climate Predictability: Signal or Noise?

IID (white noise)

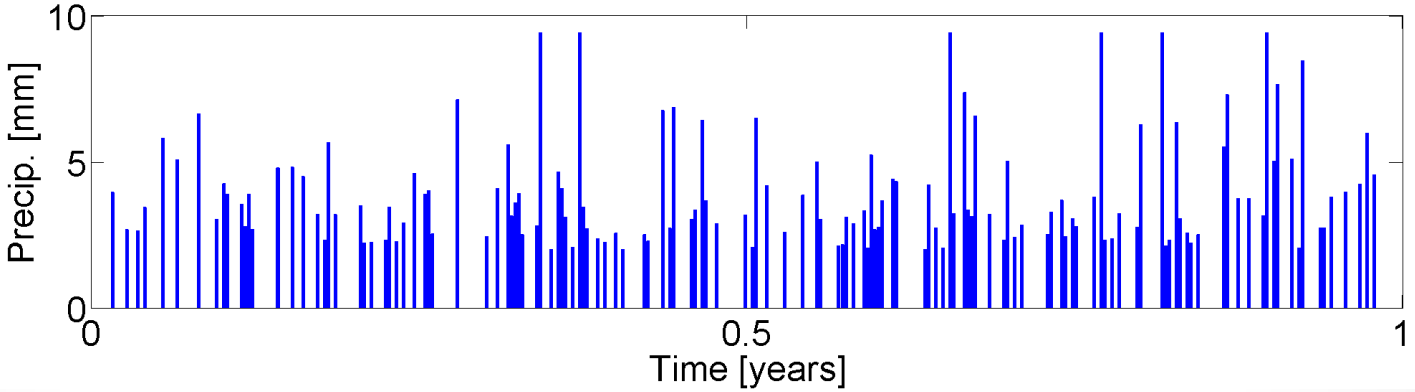


Auto-correlated

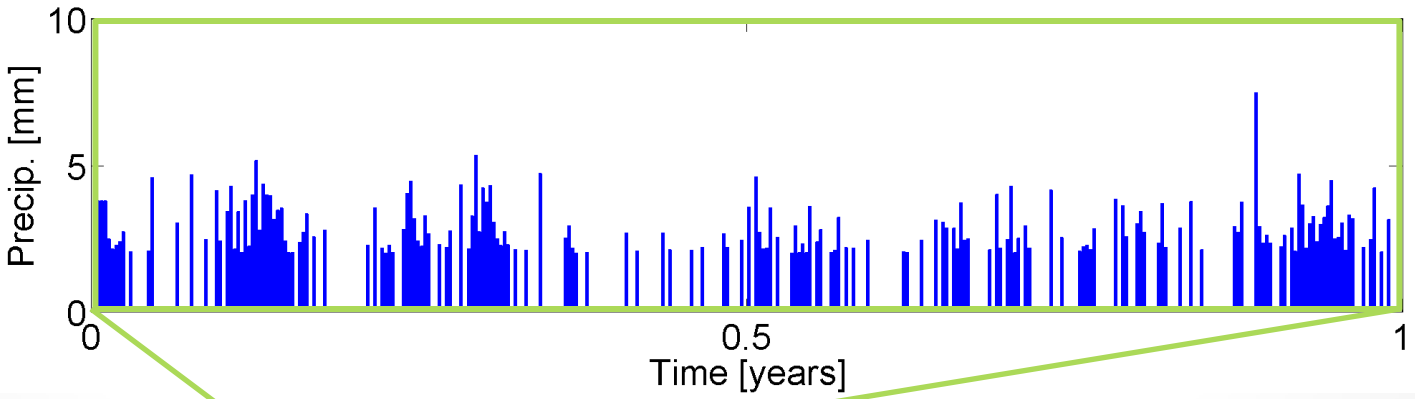


Climate Predictability: Signal or Noise?

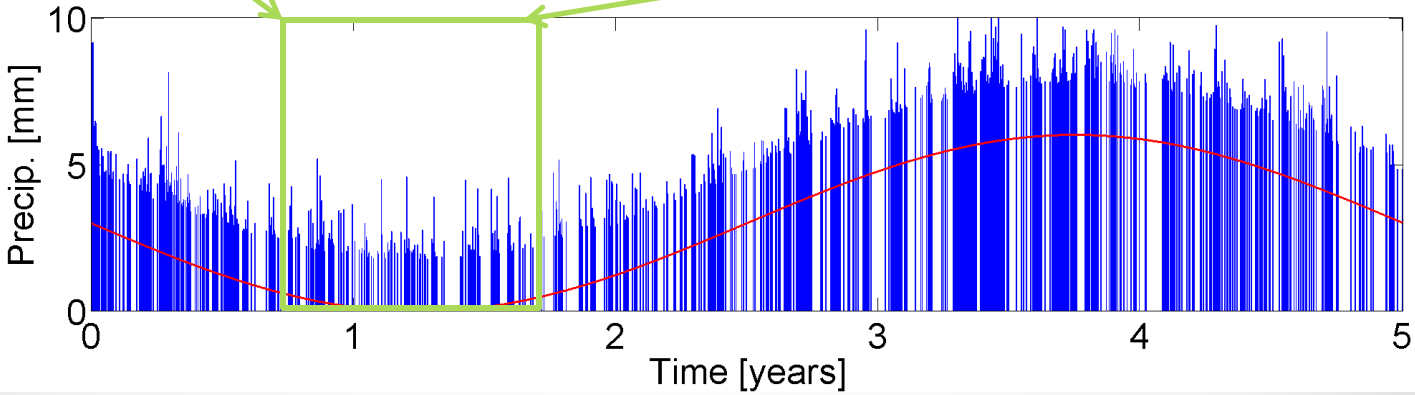
IID (white noise)



Auto-correlated



Climate signal



Potential Predictability (PP)

- What is potential predictability?

Potential Predictability (PP)

- What is potential predictability?

$$PP = \frac{\sigma^2_{signal}}{\sigma^2_{total}}$$

Potential Predictability (PP)

- What is potential predictability?

$$PP = \frac{\sigma^2_{signal}}{\sigma^2_{total}}$$

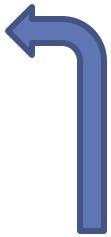
$$PP = \frac{\sigma^2_{total} - \sigma^2_{noise}}{\sigma^2_{total}}$$

Potential Predictability (PP)

- What is potential predictability?

$$PP = \frac{\sigma^2_{signal}}{\sigma^2_{total}}$$

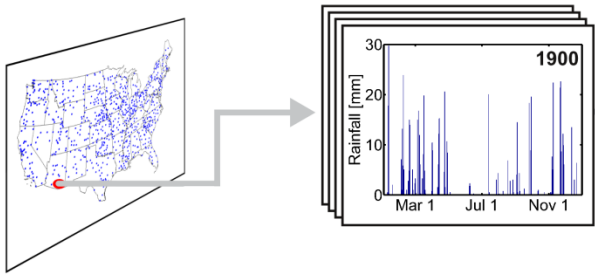
$$PP = \frac{\sigma^2_{total} - \sigma^2_{noise}}{\sigma^2_{total}}$$



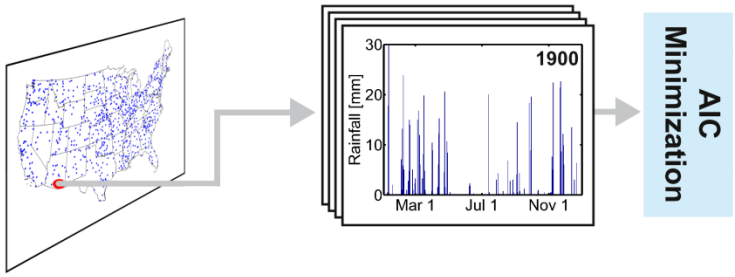
- We simulate the noise

Method Overview

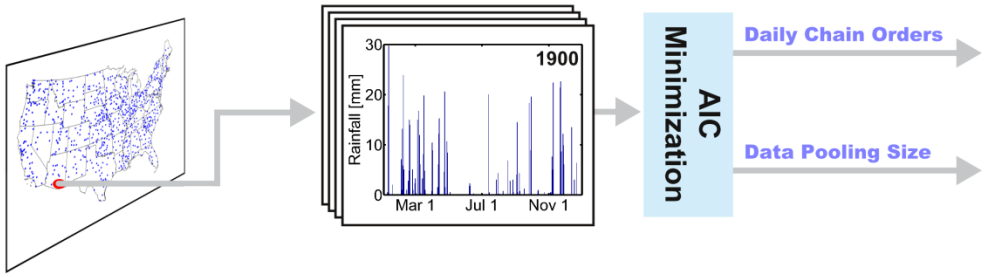
Method Overview



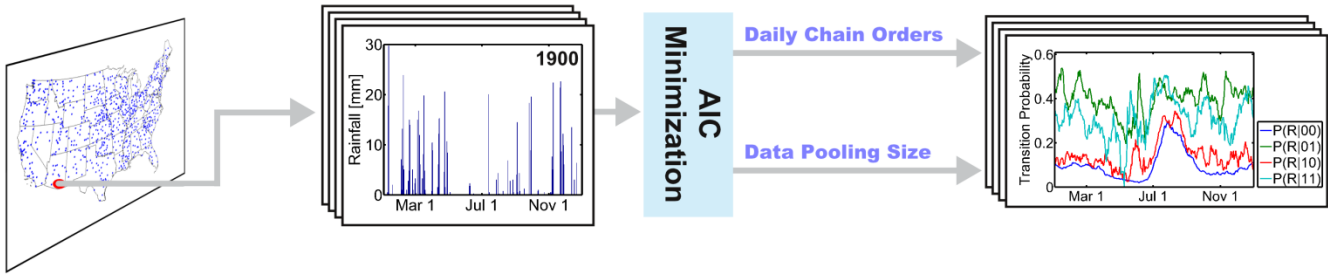
Method Overview



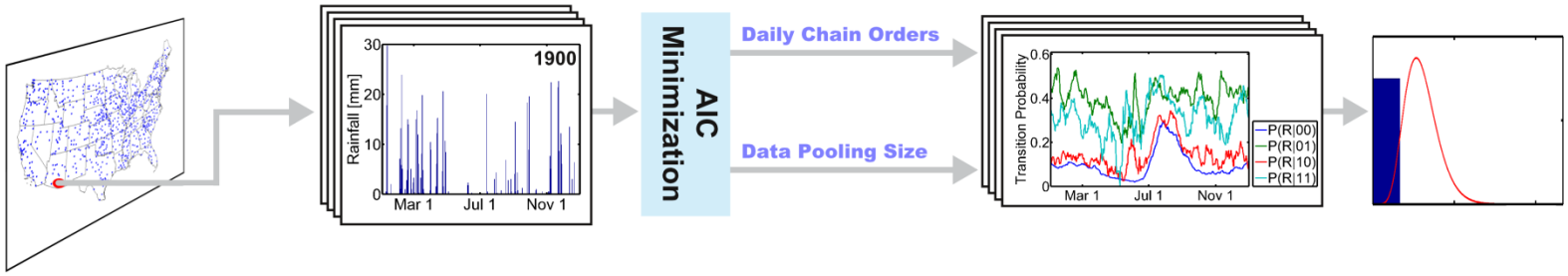
Method Overview



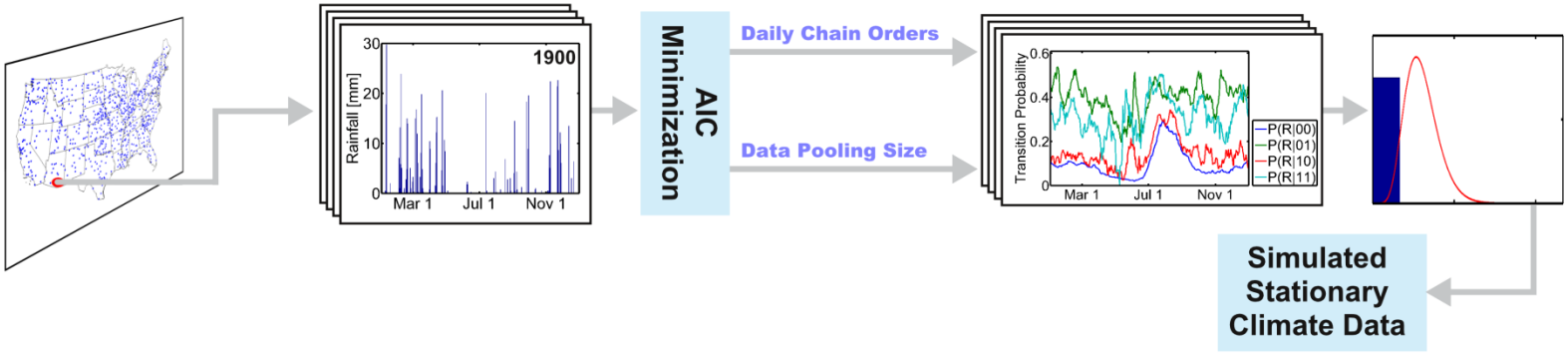
Method Overview



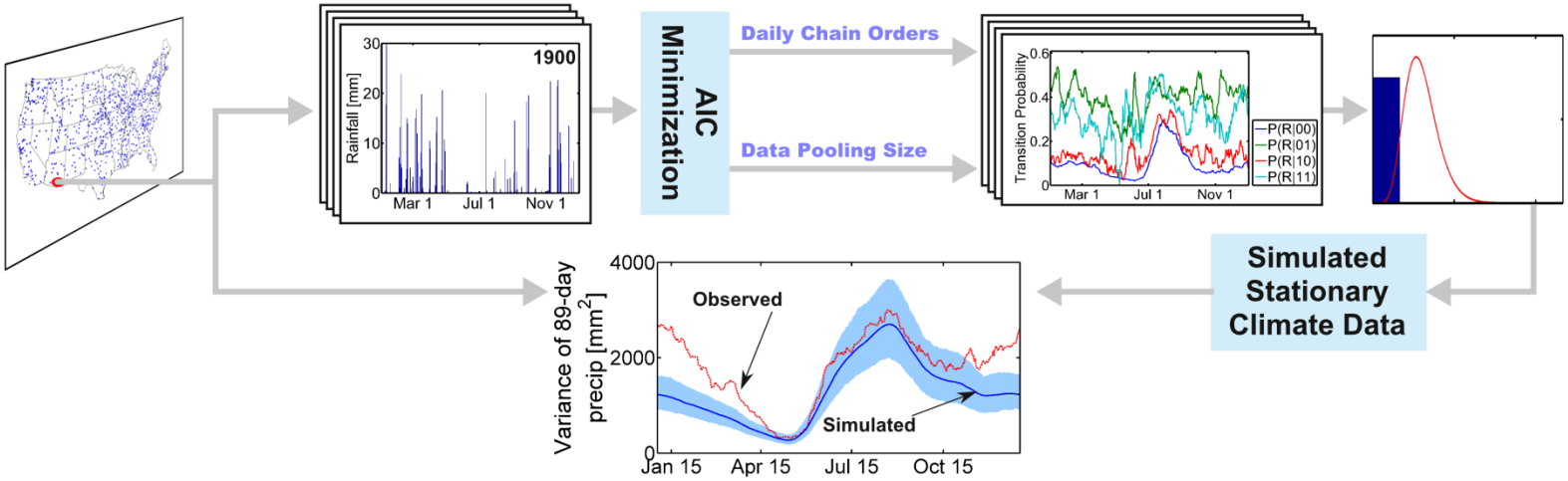
Method Overview



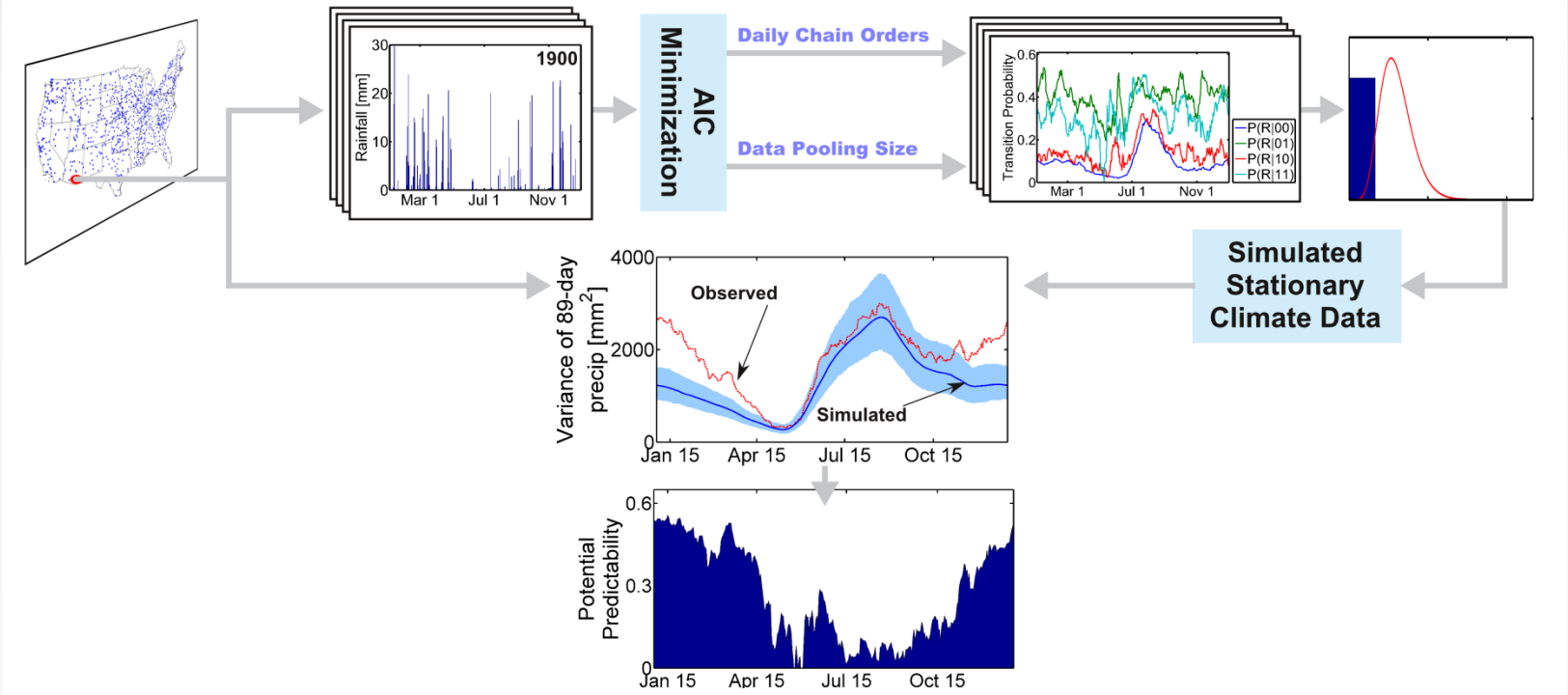
Method Overview



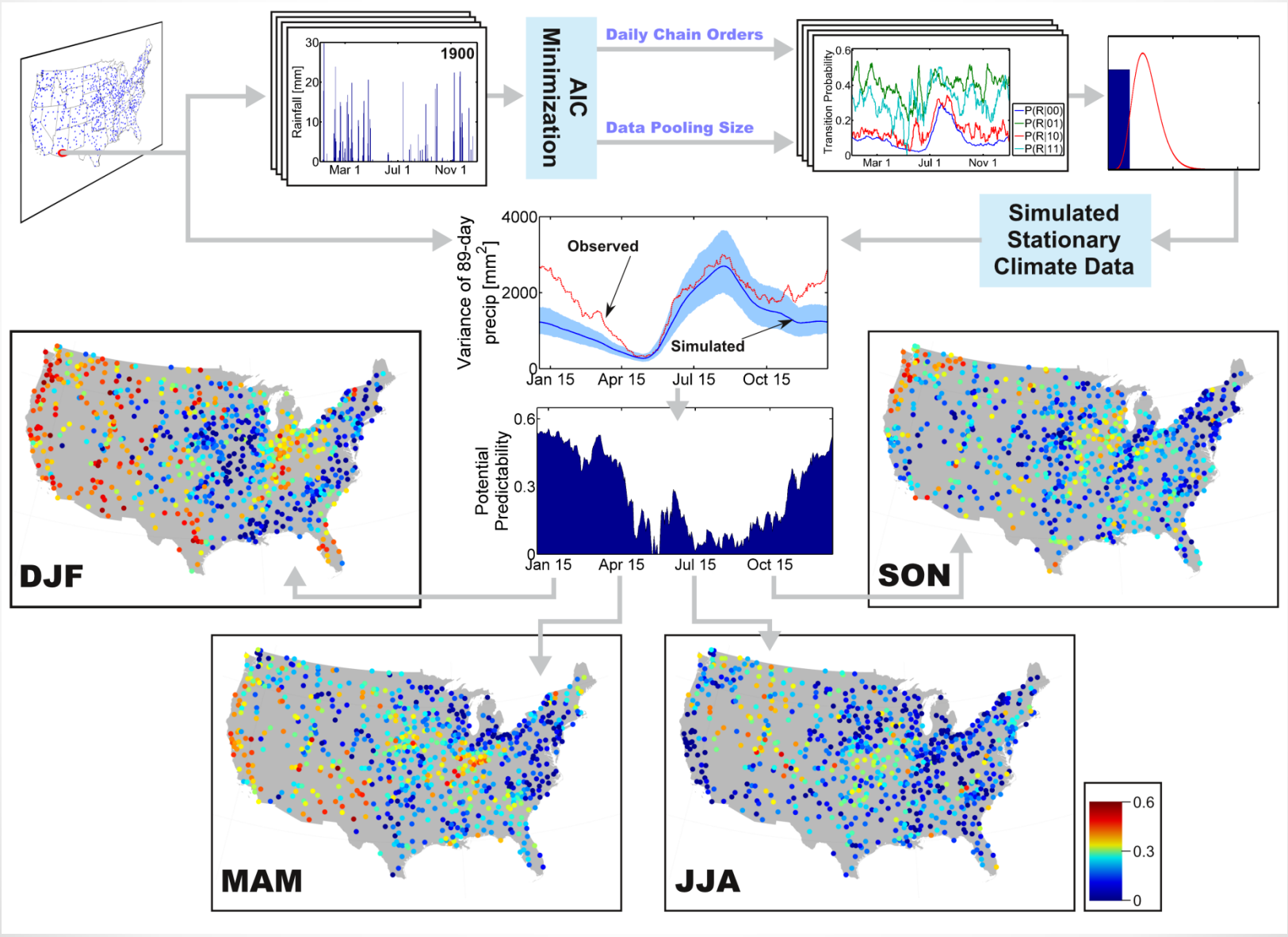
Method Overview



Method Overview



Method Overview



Totals, occurrence, and intensity

- Potential Predictability ✓

Totals, occurrence, and intensity

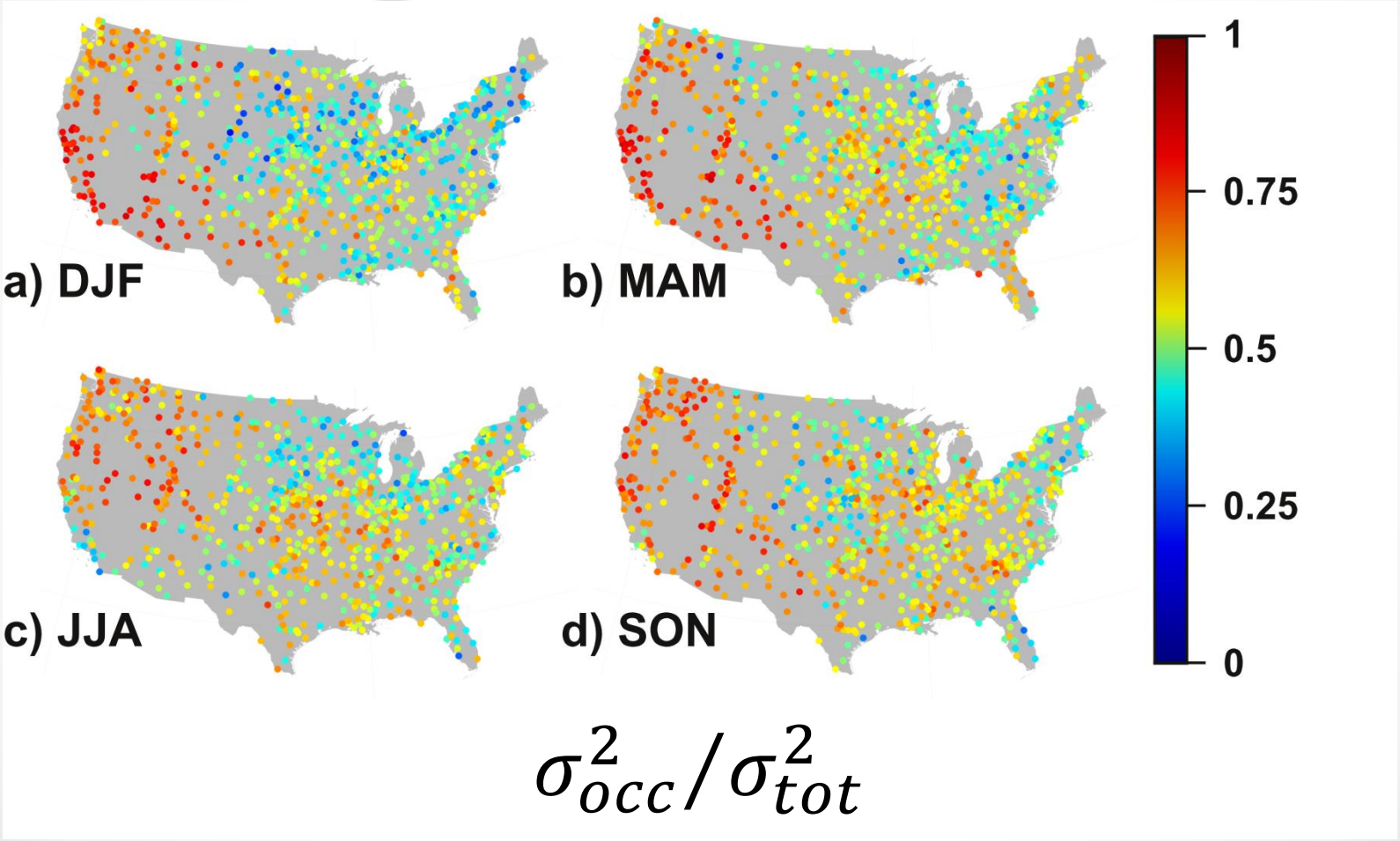
- Potential Predictability 
- Occurrence and intensity?

Totals, occurrence, and intensity

- Potential Predictability ✓
- Occurrence and intensity?
  - Law of total variance:

$$\underbrace{Var(T)}_{\sigma^2_{tot}} = \underbrace{E\{Var(T \mid N)\}}_{\sigma^2_{\text{int}}} + \underbrace{Var(E\{T \mid N\})}_{\sigma^2_{occ}}$$

What does the decomposition look like?



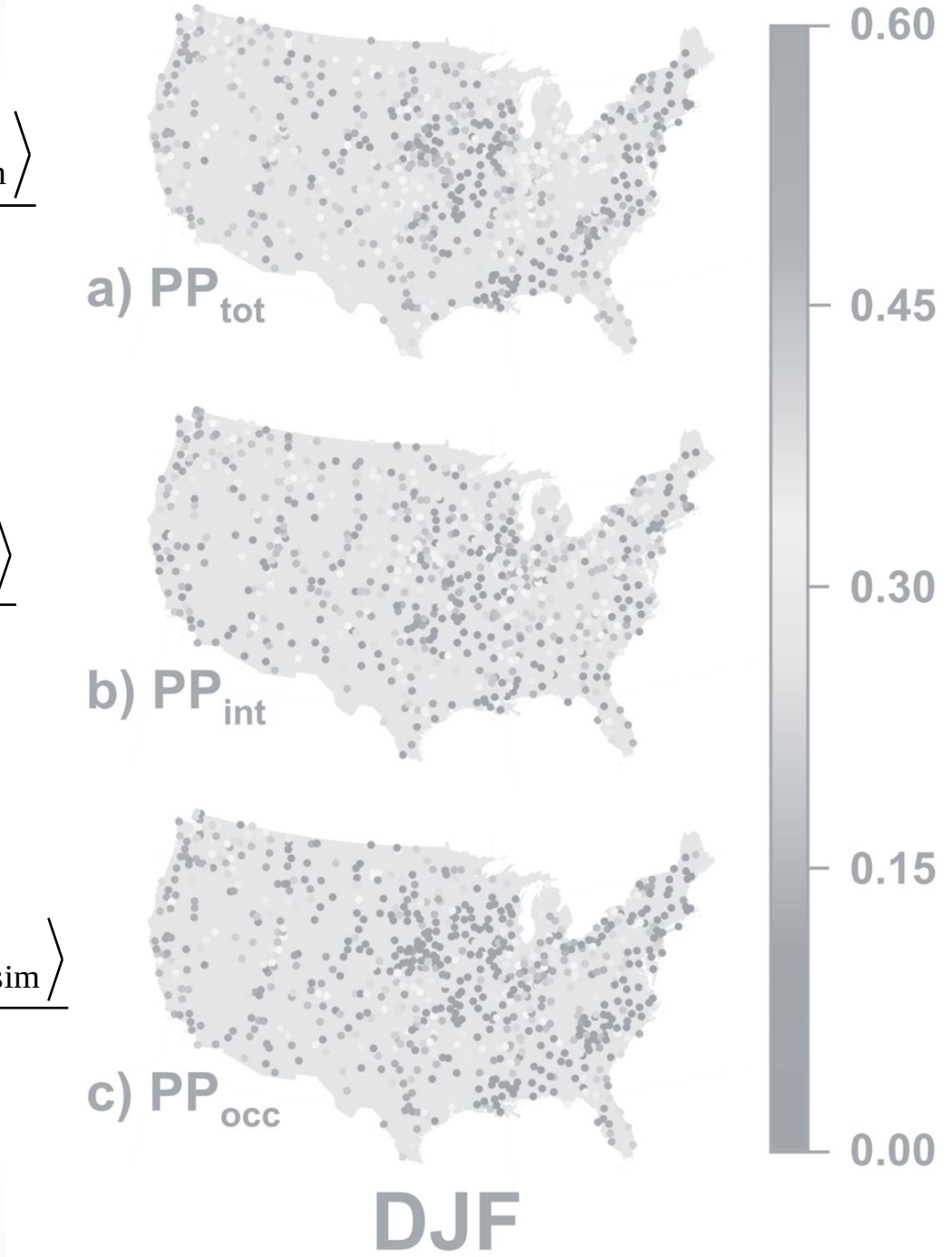
$$\sigma_{occ}^2 / \sigma_{tot}^2$$

DJF Potential Predictability

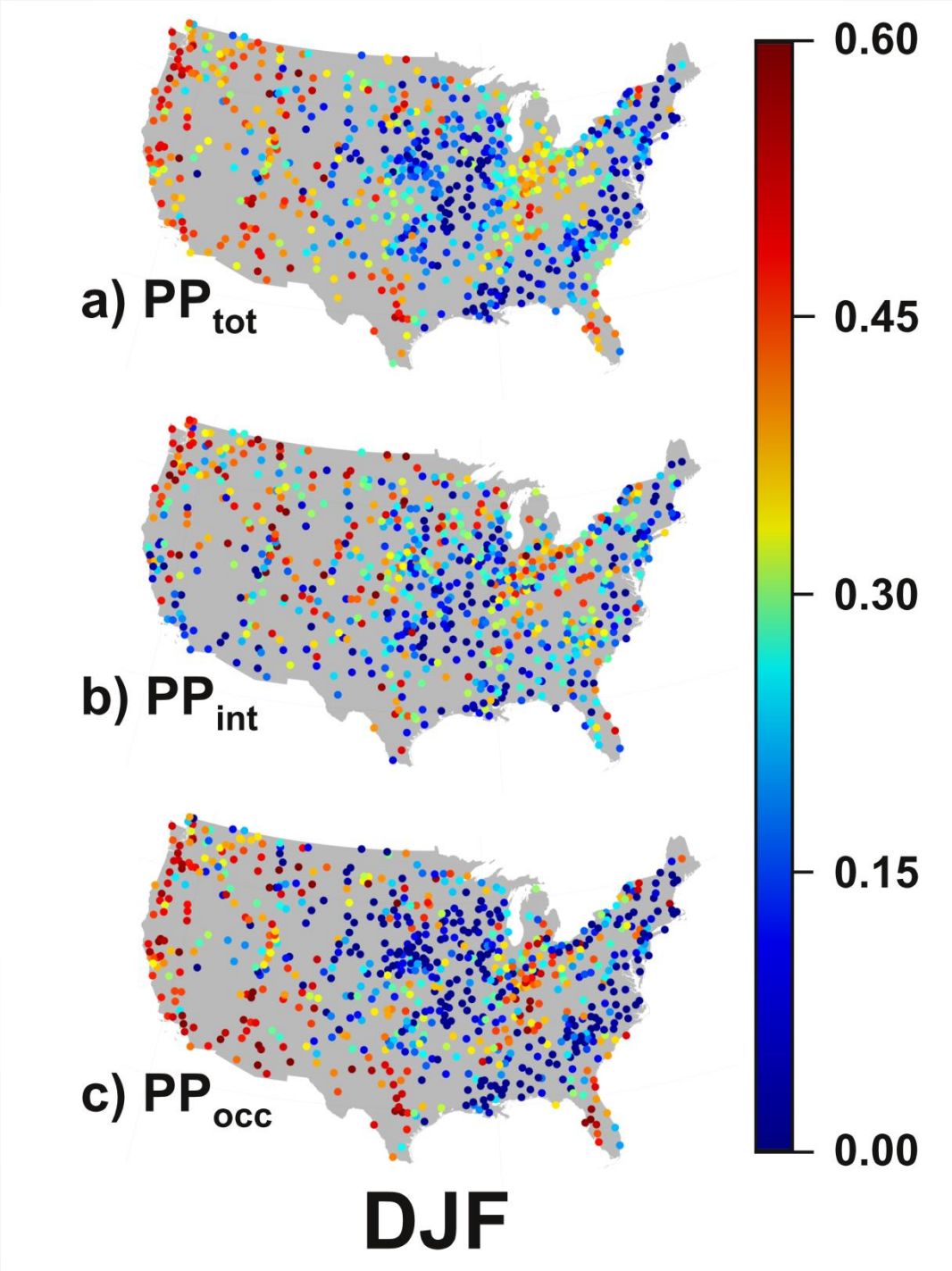
$$PP_{tot} = \frac{\sigma^2_{tot,obs} - \left\langle \sigma^2_{tot,sim} \right\rangle}{\sigma^2_{tot,obs}}$$

$$PP_{int} = \frac{\sigma^2_{int,obs} - \left\langle \sigma^2_{int,sim} \right\rangle}{\sigma^2_{int,obs}}$$

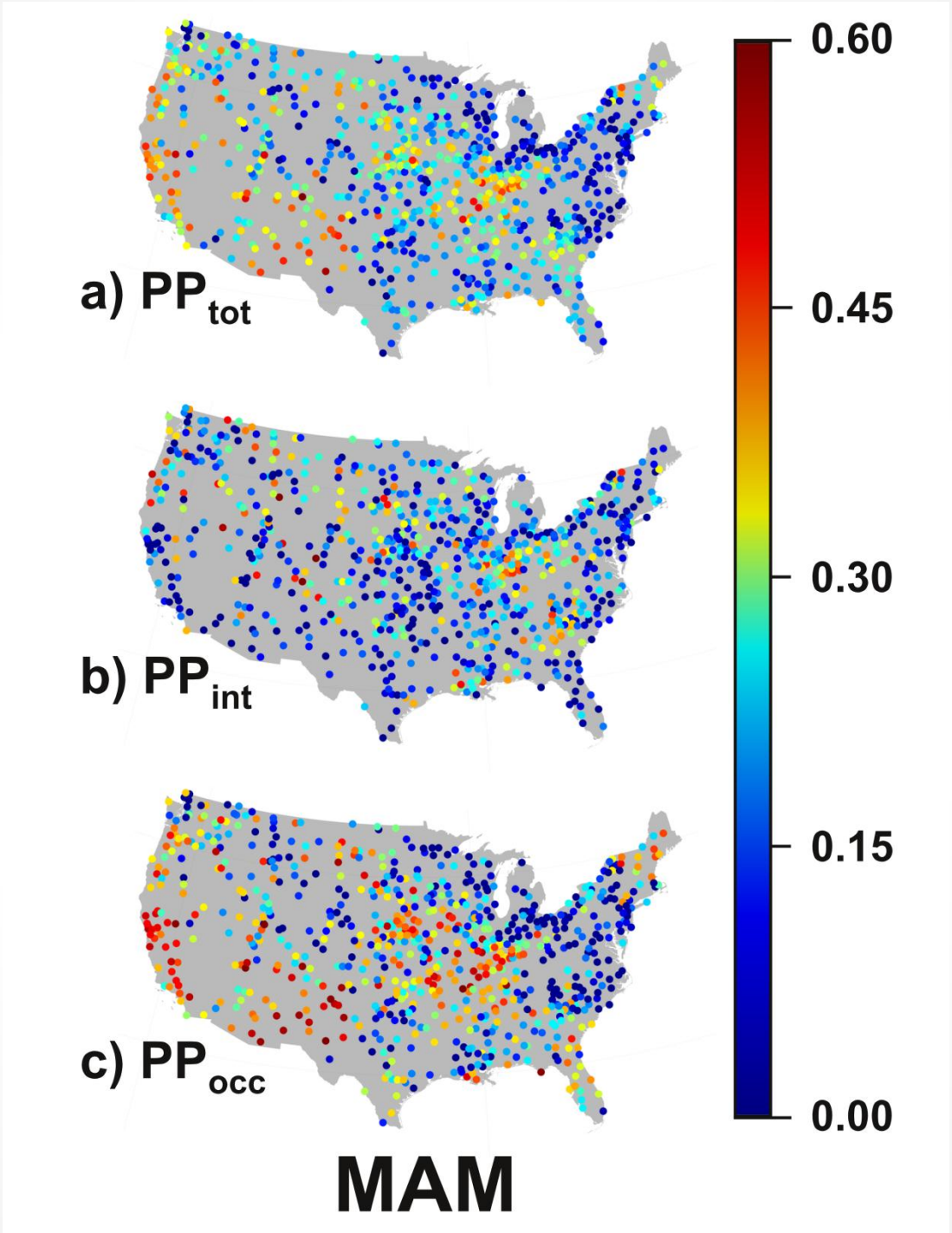
$$PP_{occ} = \frac{\sigma^2_{occ,obs} - \left\langle \sigma^2_{occ,sim} \right\rangle}{\sigma^2_{occ,obs}}$$



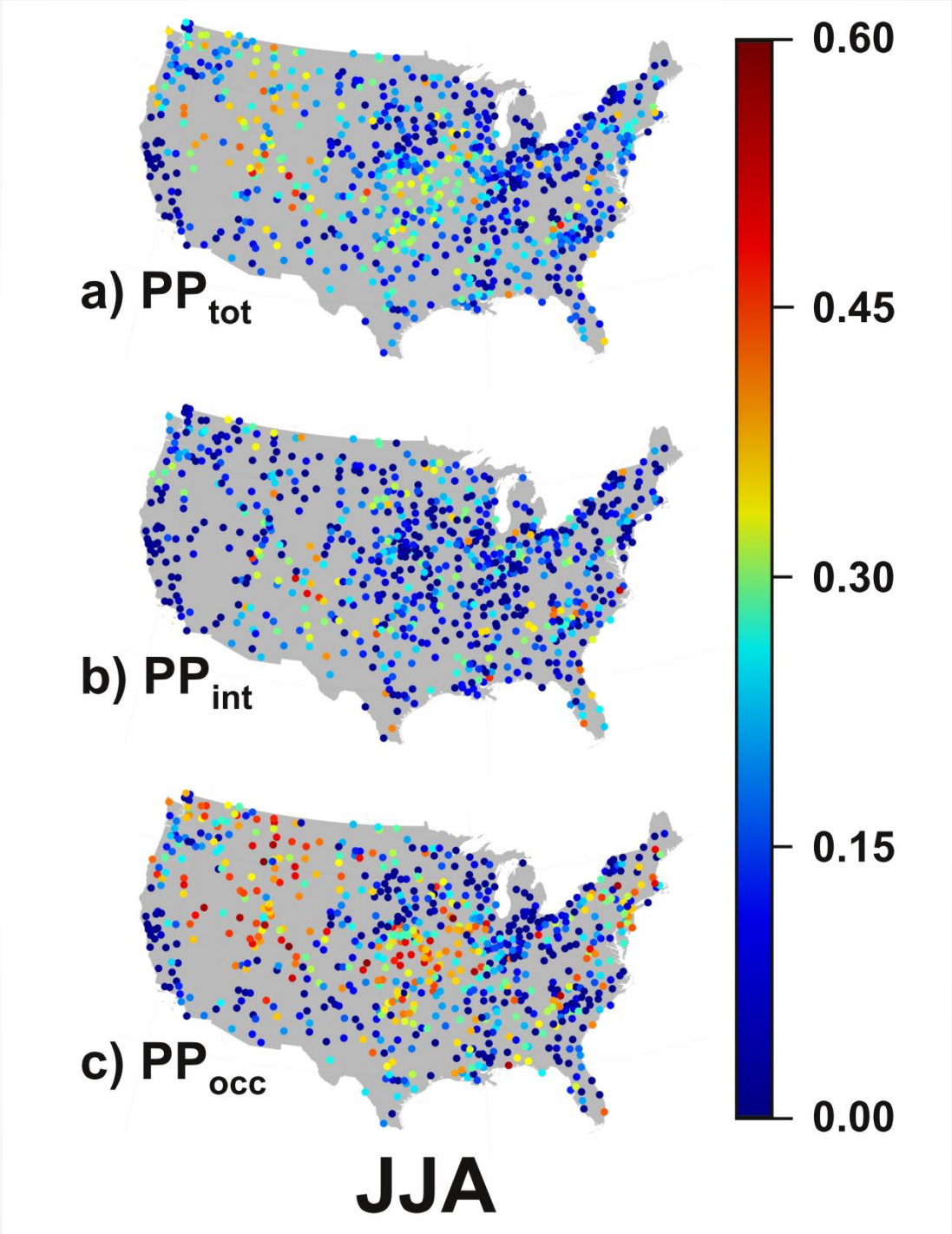
DJF Potential Predictability



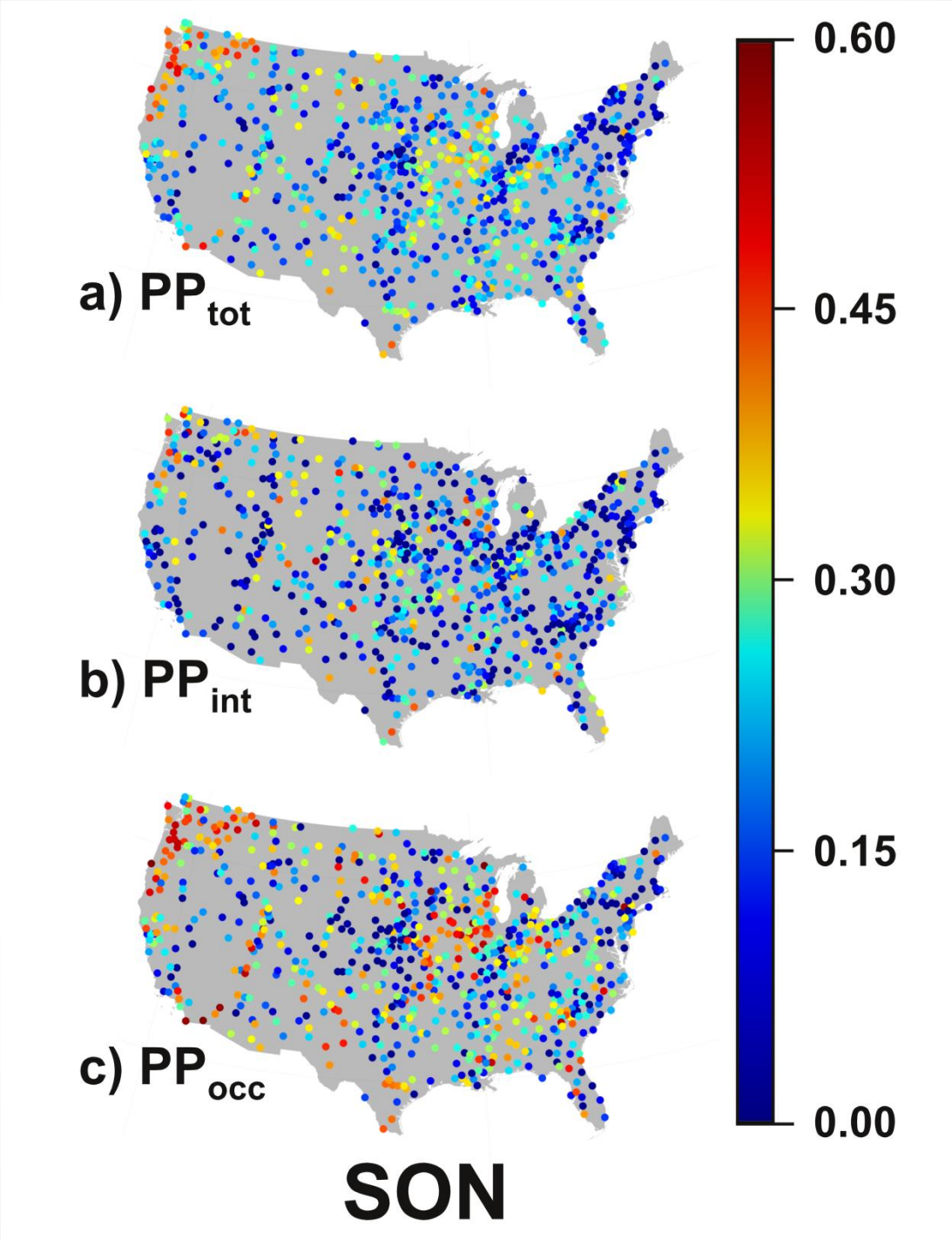
MAM Potential Predictability



JJA Potential Predictability

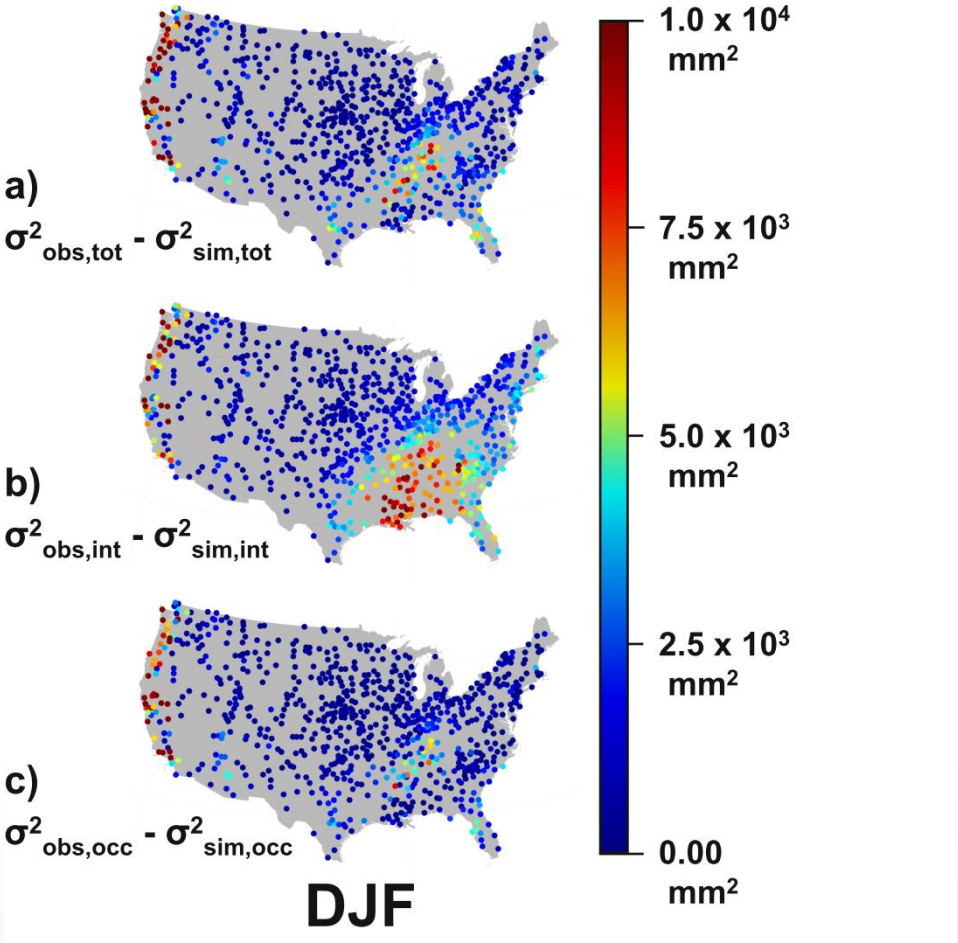


SON Potential Predictability

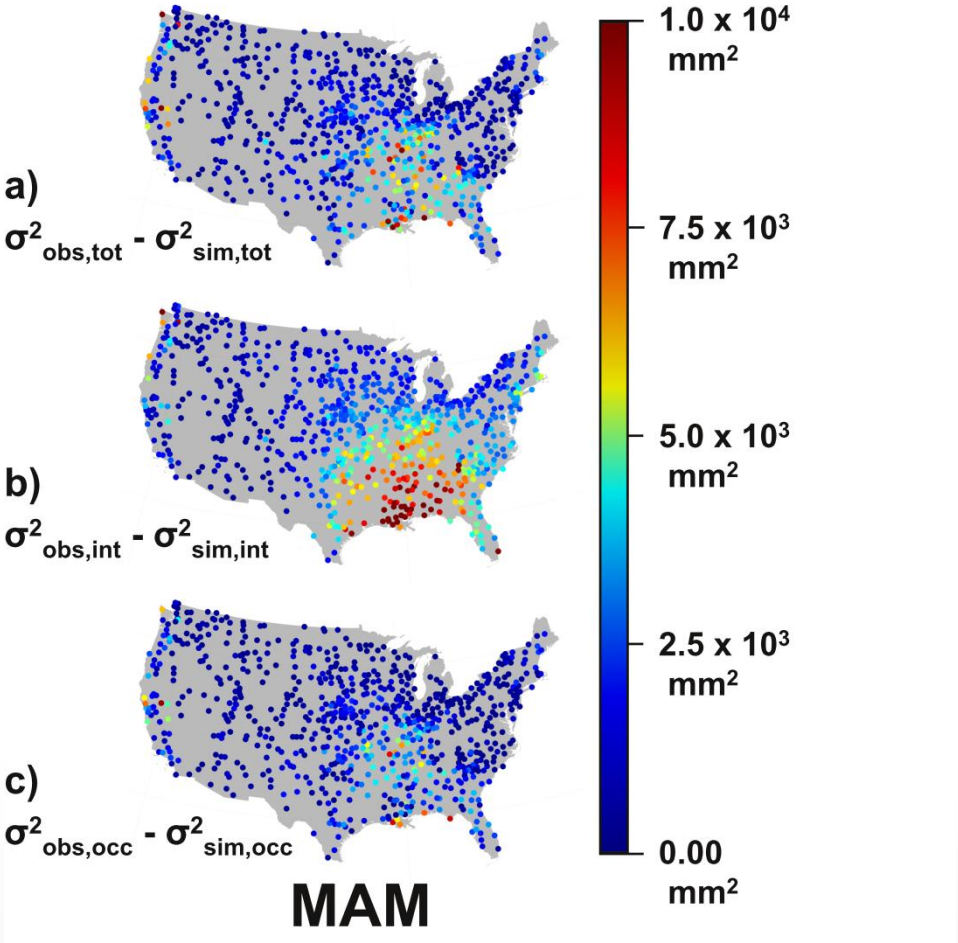


Questions?

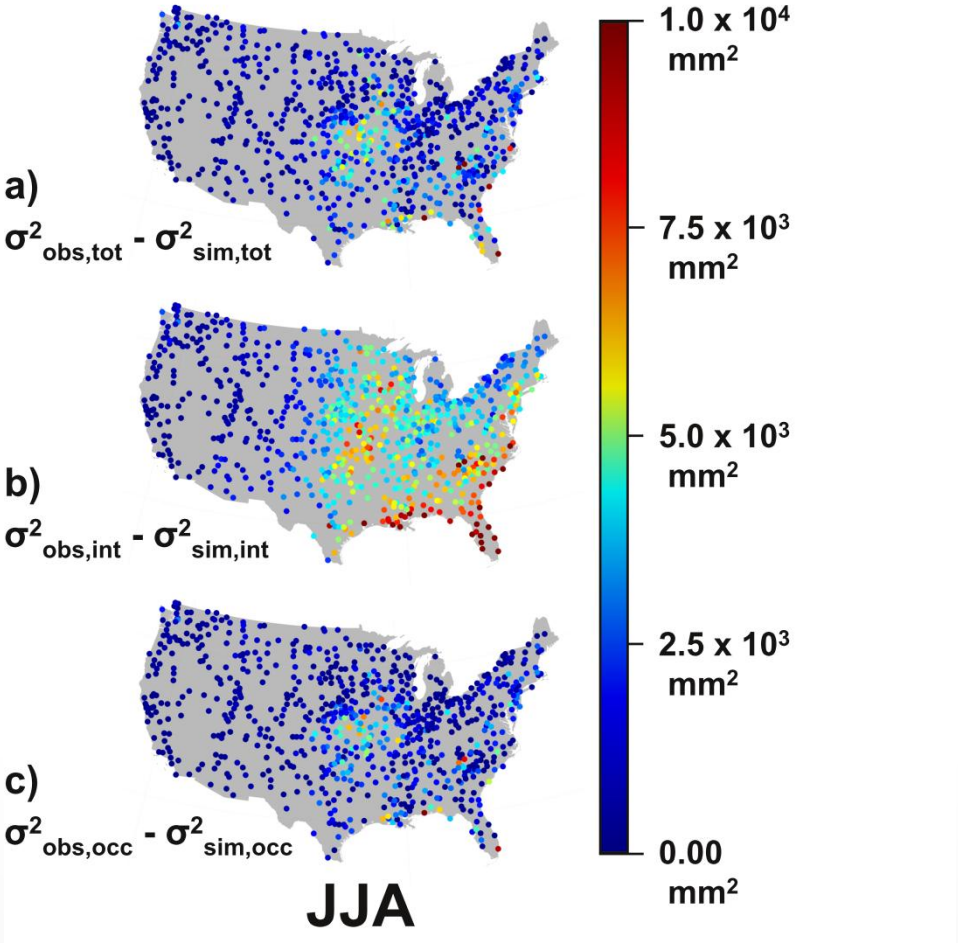
DJF Signal


a)
$\sigma^2_{obs,tot} - \sigma^2_{sim,tot}$
b)
$\sigma^2_{obs,int} - \sigma^2_{sim,int}$
c)
$\sigma^2_{obs,occ} - \sigma^2_{sim,occ}$
DJF
1.0 x 10^4 mm^2
7.5 x 10^3 mm^2
5.0 x 10^3 mm^2
2.5 x 10^3 mm^2
0.00 mm^2

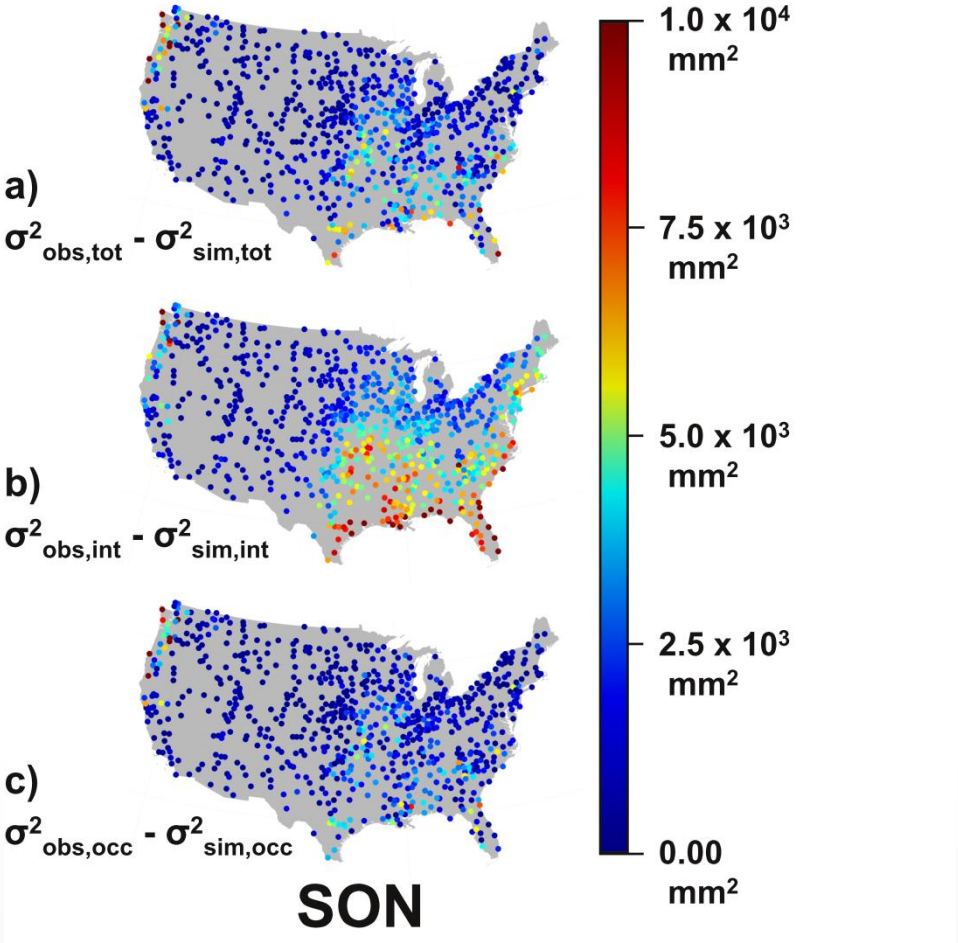
MAM Signal


a)
$\sigma^2_{obs,tot} - \sigma^2_{sim,tot}$
b)
$\sigma^2_{obs,int} - \sigma^2_{sim,int}$
c)
$\sigma^2_{obs,occ} - \sigma^2_{sim,occ}$
MAM
1.0 x 10^4 mm^2
7.5 x 10^3 mm^2
5.0 x 10^3 mm^2
2.5 x 10^3 mm^2
0.00 mm^2

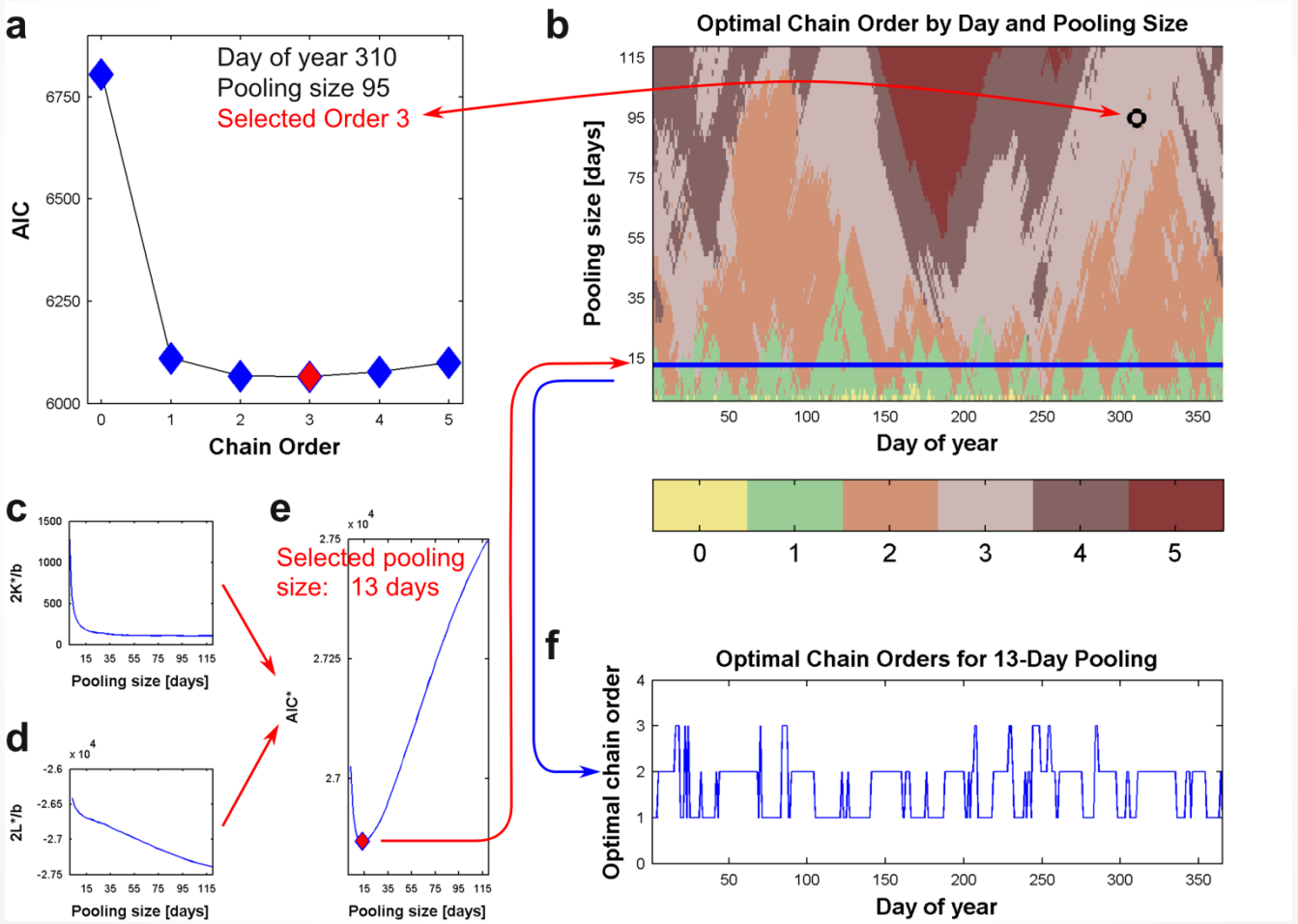
JJA Signal


a)
$\sigma^2_{obs,tot} - \sigma^2_{sim,tot}$
b)
$\sigma^2_{obs,int} - \sigma^2_{sim,int}$
c)
$\sigma^2_{obs,occ} - \sigma^2_{sim,occ}$
JJA
1.0×10^4 mm^2
7.5×10^3 mm^2
5.0×10^3 mm^2
2.5×10^3 mm^2
0.00 mm^2

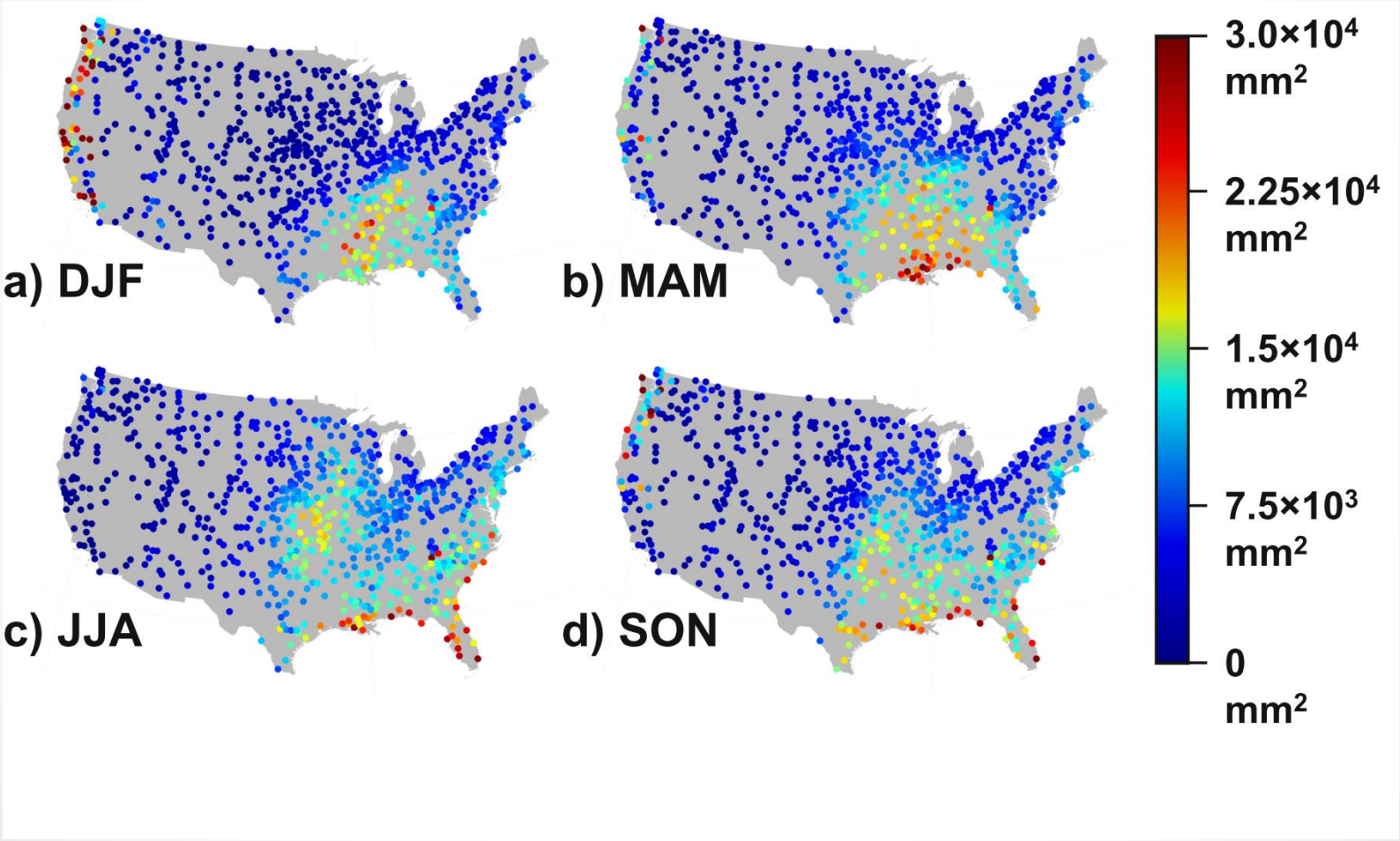
SON Signal


a)
$\sigma^2_{obs,tot} - \sigma^2_{sim,tot}$
b)
$\sigma^2_{obs,int} - \sigma^2_{sim,int}$
c)
$\sigma^2_{obs,occ} - \sigma^2_{sim,occ}$
SON
1.0 x 10^4 mm^2
7.5 x 10^3 mm^2
5.0 x 10^3 mm^2
2.5 x 10^3 mm^2
0.00 mm^2

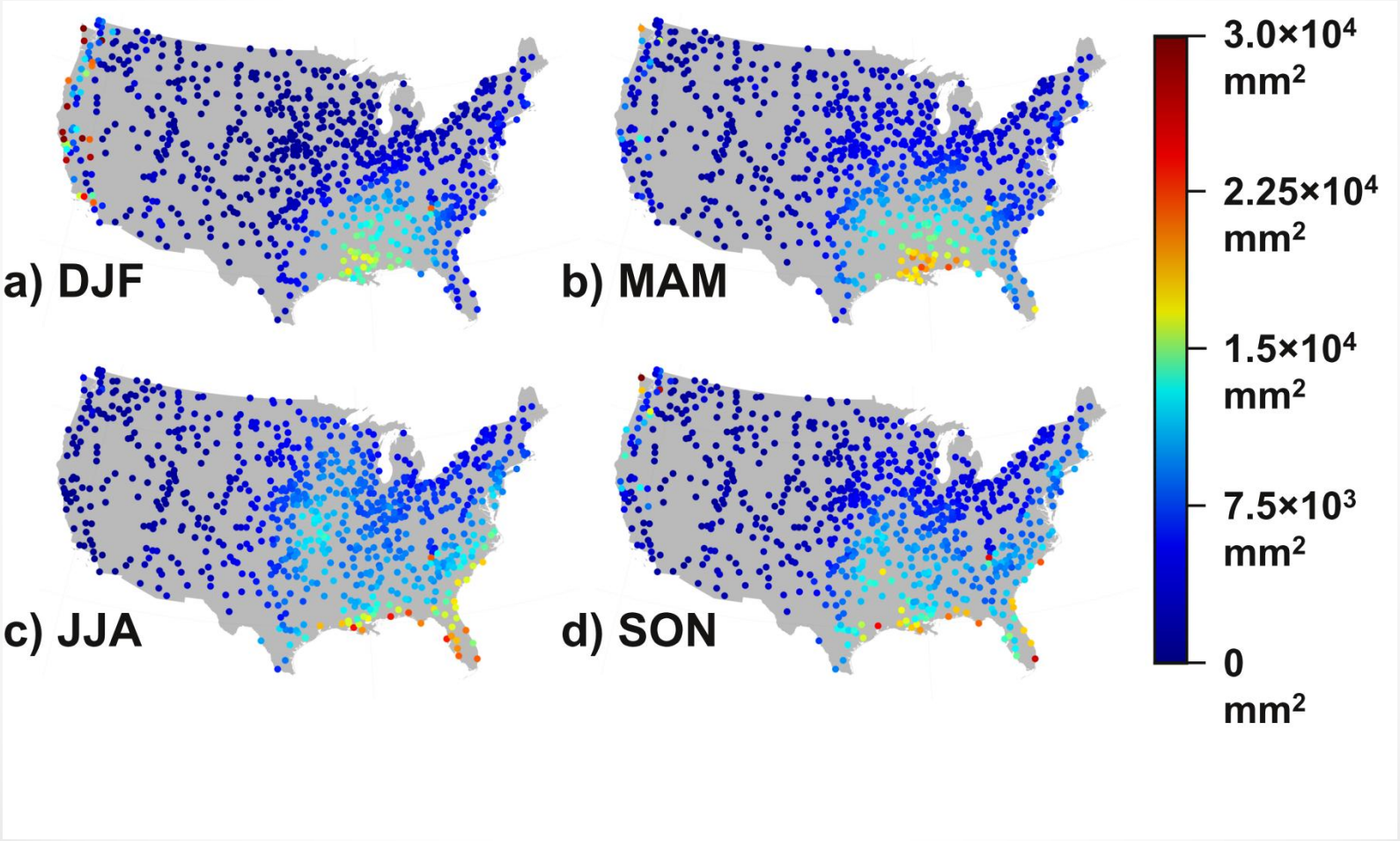
AIC Methods


a
Day of year 310
Pooling size 95
Selected Order 3
AIC
Chain Order
b
Optimal Chain Order by Day and Pooling Size
Pooling size [days]
Day of year
c
2K*/b
Pooling size [days]
d
2L*/b
Pooling size [days]
e
Selected pooling size: 13 days
AIC*
Pooling size [days]
f
Optimal Chain Orders for 13-Day Pooling
Optimal chain order
Day of year

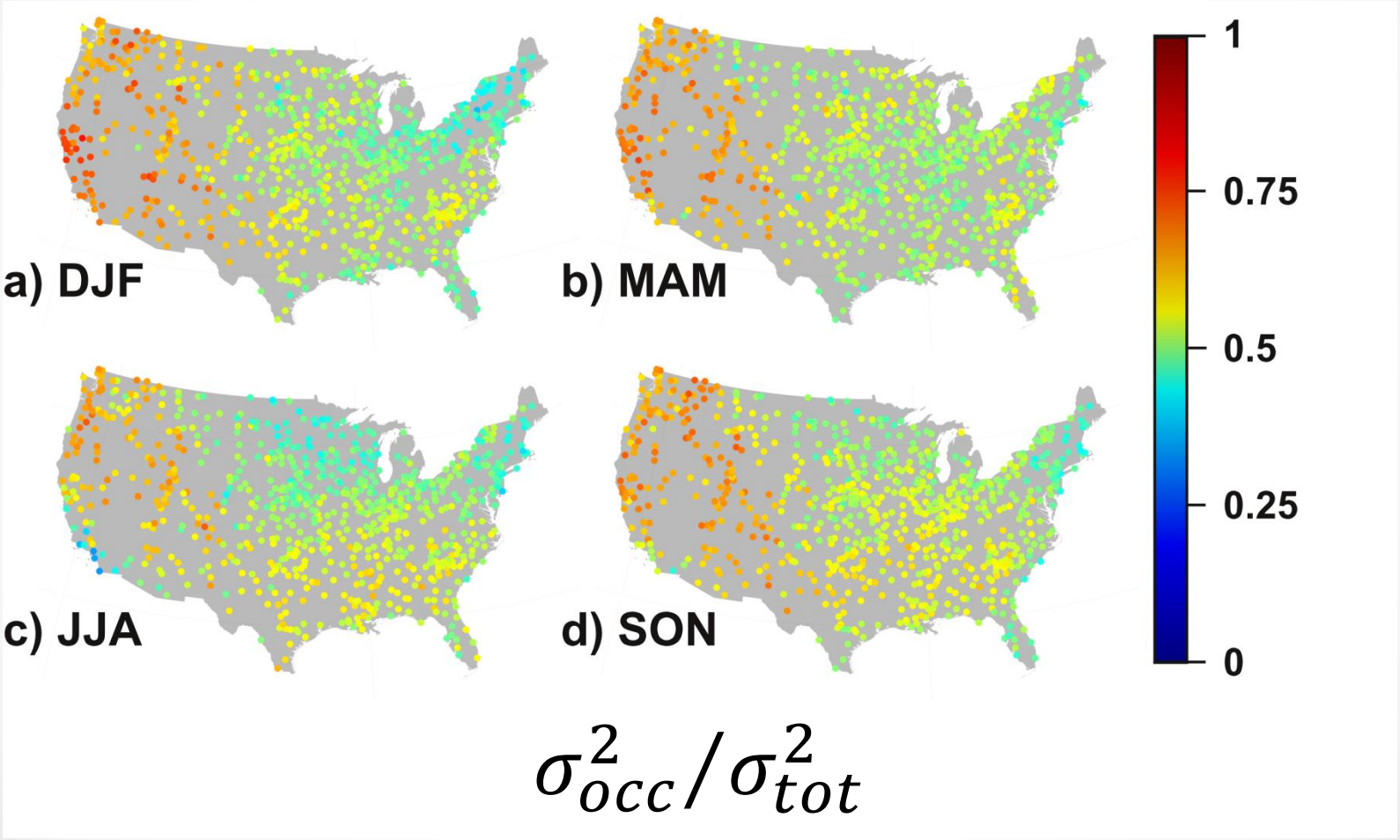
Observed Variance



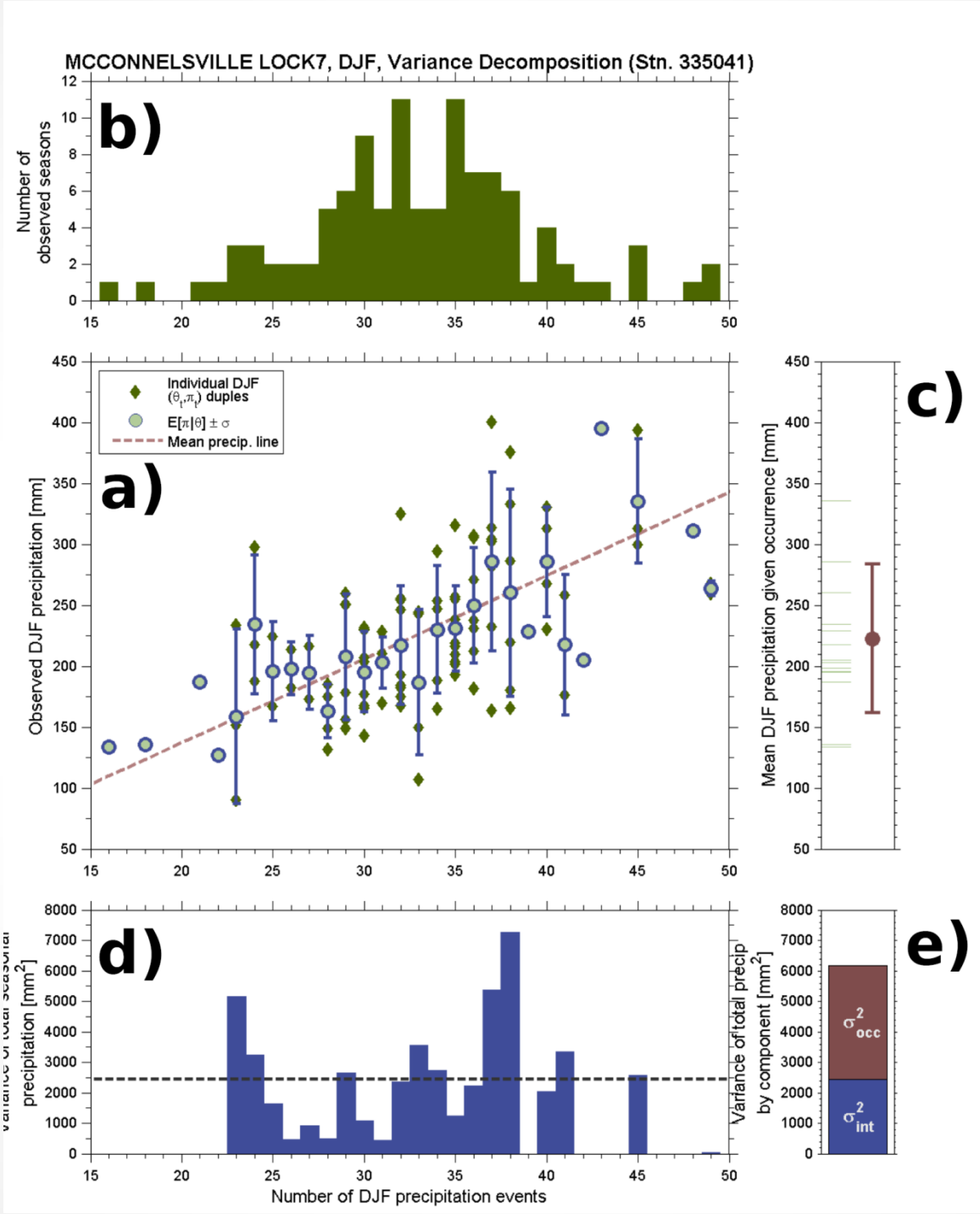
Simulated Variance



What does the decomposition look like? [Simulated]



$$\sigma_{occ}^2 / \sigma_{tot}^2$$


MCCONNELSVILLE LOCK7, DJF, Variance Decomposition (Stn. 335041)
b)
Number of observed seasons
a)
Individual DJF (θ_t,π_t) duples
E[$\pi|\theta$] ± σ
Mean precip. line
Observed DJF precipitation [mm]
c)
Mean DJF precipitation given occurrence [mm]
d)
precipitation [mm^2]
e)
Variance of total precip by component [mm^2]
σ^2_{occ}
σ^2_{int}
Number of DJF precipitation events