A conditional extreme value model for severe storm environments

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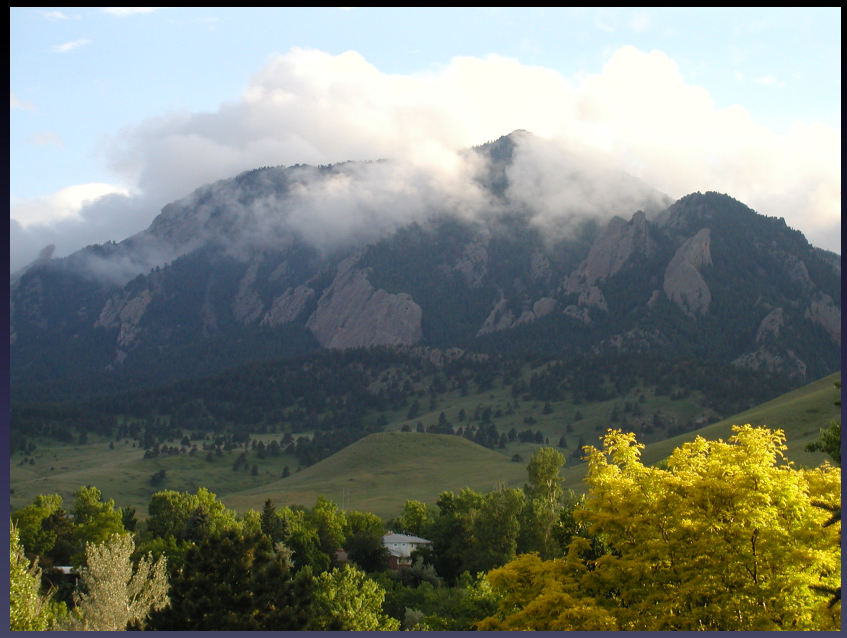


Photo by Everett Nychka

International Short Conference on Advances in Extreme Value Analysis and Application to Natural Hazards (EVAN2013)
18 – 20 September 2013, Siegen, Germany

Severe Weather

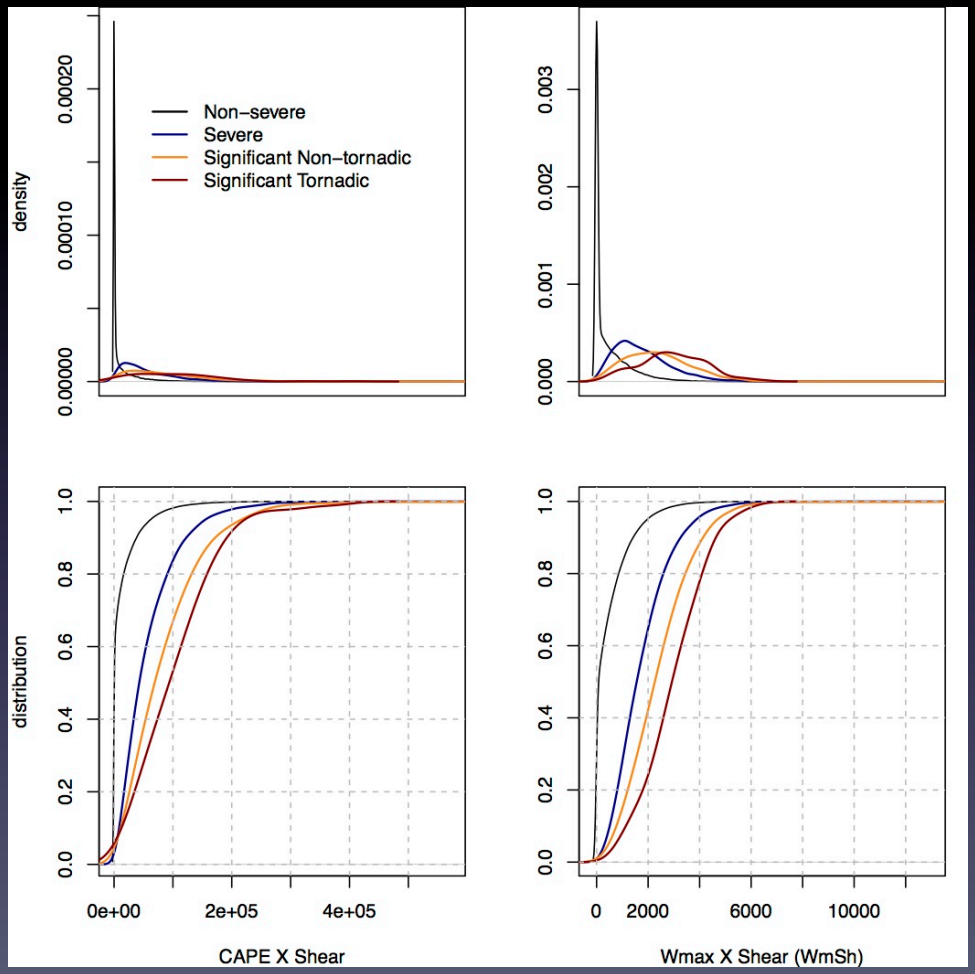
Photo Stolen from Doug Nychka

Severe Storm Environments

CAPE (J/kg)

✖

0 – 6 km Wind Shear (m/s)



Maximum updraft potential wind (Wmax, m/s)

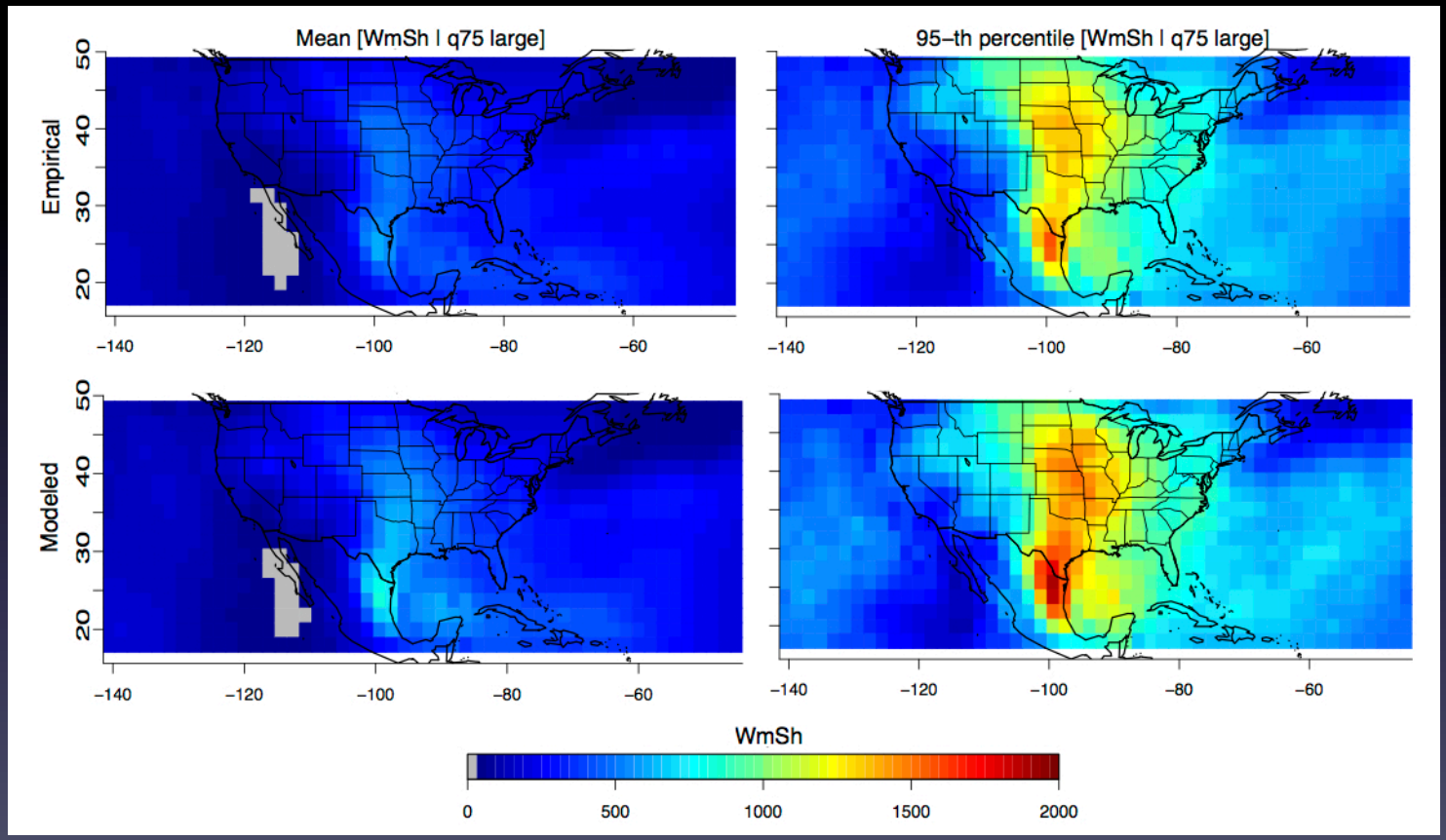
✖

0 – 6 km Wind Shear (m/s)

=

WmSh (m^2/s^2)

Severe Storm Environments



WmSh (m^2/s^2) NCAR/NCEP Global Reanalysis (1958 – 1999)
884 station subset

Conditional Extreme Value Model

X, Y Laplace-transformed random variables, assume:

$$\Pr\left\{Y > y, \frac{X - a(Y)}{b(Y)} \leq z \middle| Y > u\right\} \xrightarrow[u\to\infty]{} \exp(-y)G(z)$$

$$a(Y) = \alpha Y$$

$$b(Y) = Y^{\beta}$$

$$(\alpha, \beta) \in [-1,1] \times (-\infty, 1)$$

Heffernan and Tawn (2004, JRSS B, 66, 497 – 546)

Heffernan and Resnick (2007, Ann. Appl. Prob., 17, 537 – 571)

Keef et al. (2012, Environmetrics, doi: 10.1002/env.2190)

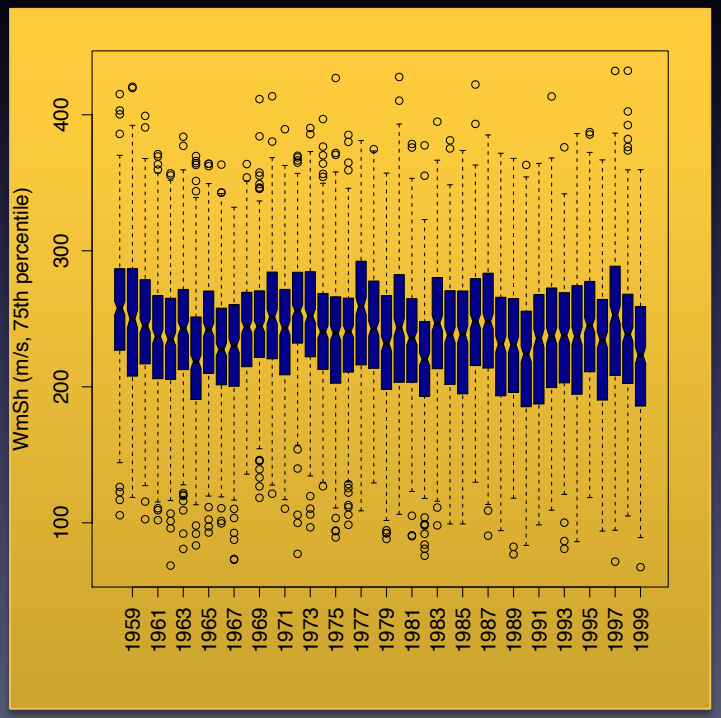
Conditional Extreme Value Model

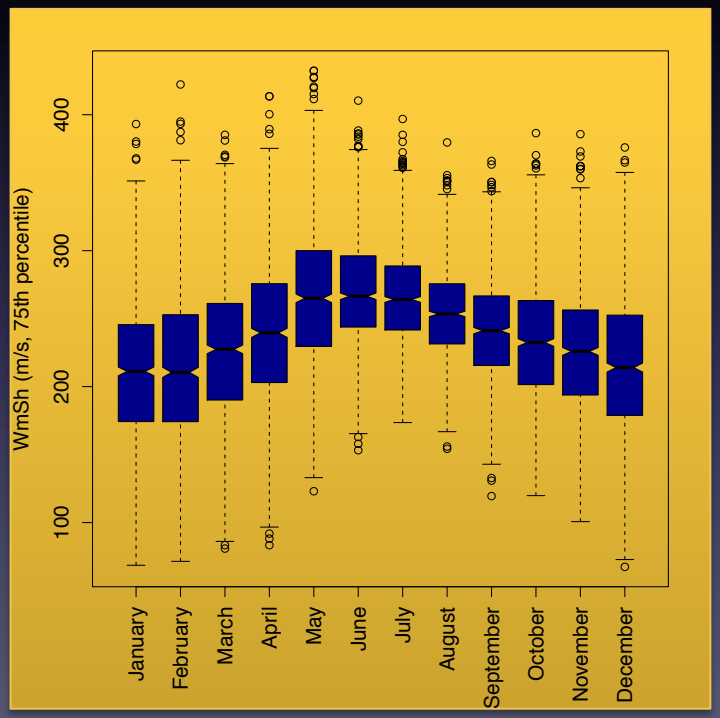
$$\Pr\left\{Y > y, \frac{X - a(Y)}{b(Y)} \le z \middle| Y > u\right\} \xrightarrow[u\to\infty]{} \exp(-y)G(z)$$

$$X_{|Y>u} = \alpha Y + Y^{\beta} Z_{|Y>u}$$

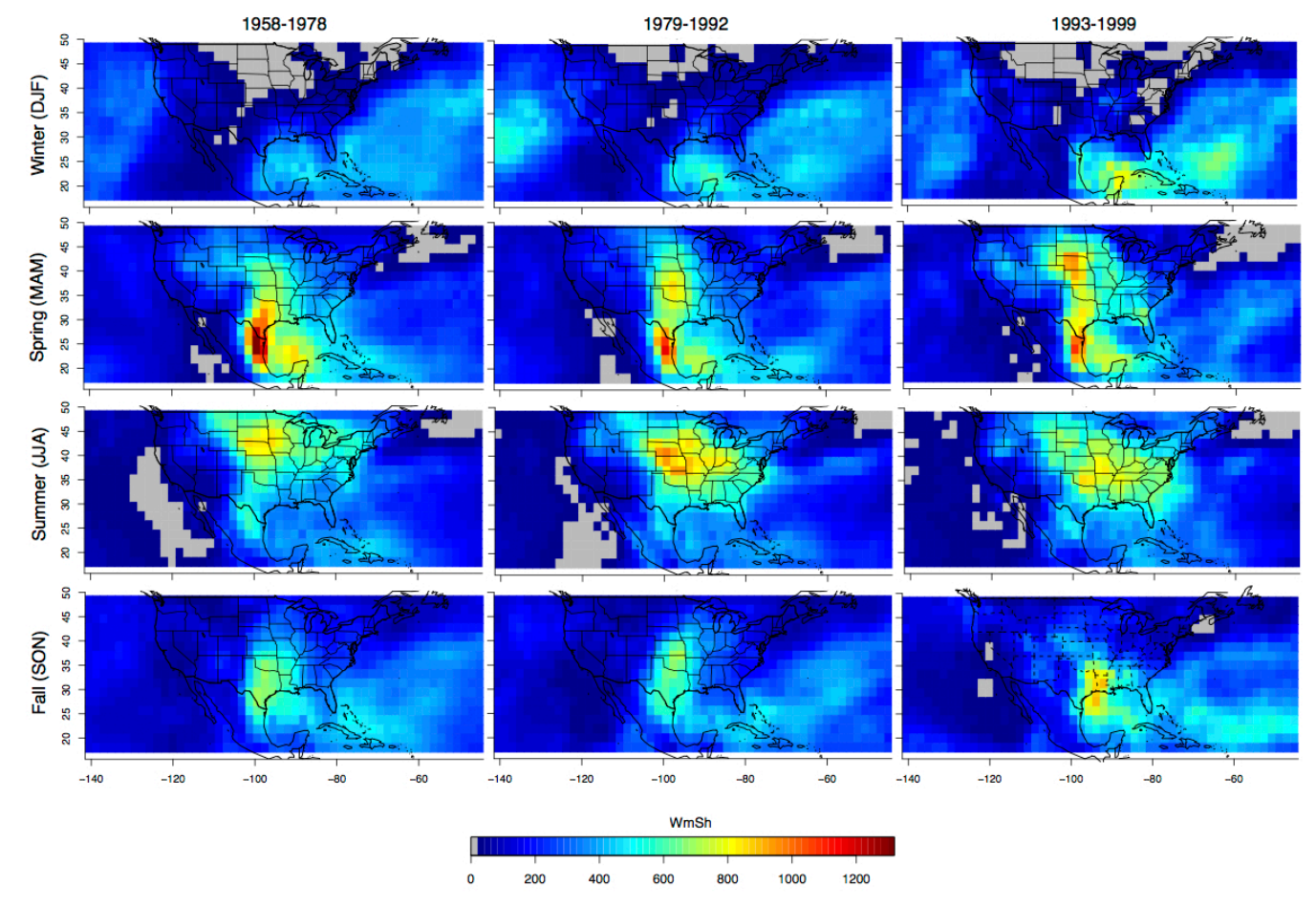
Conditional Extreme Value Model for Severe Storm Environments

Condition WmSh at each grid point on having "*extreme energy*" in the field





Conditional Extreme Value Model for Severe Storm Environments



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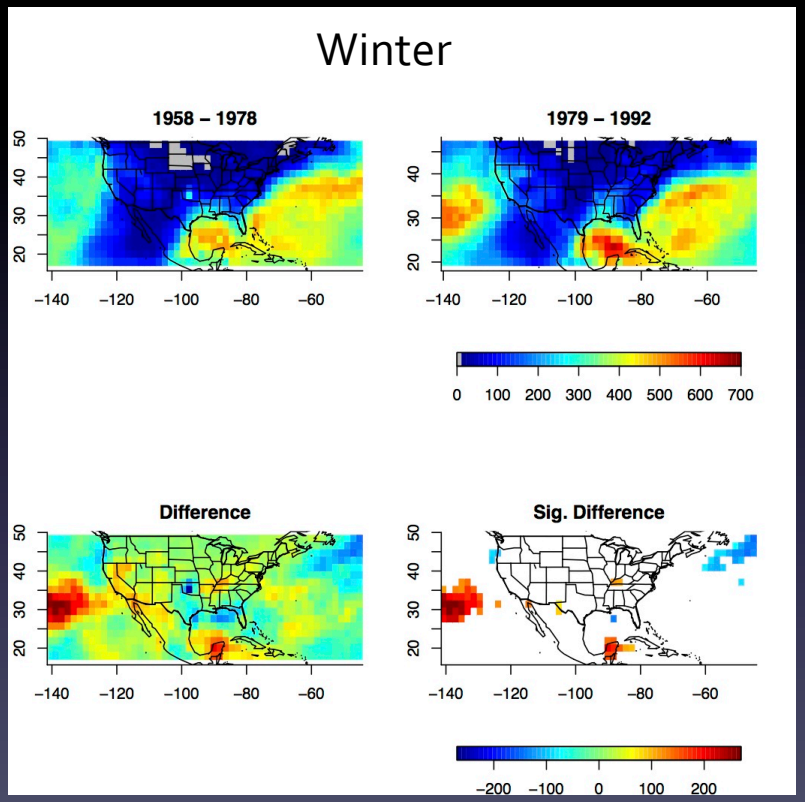

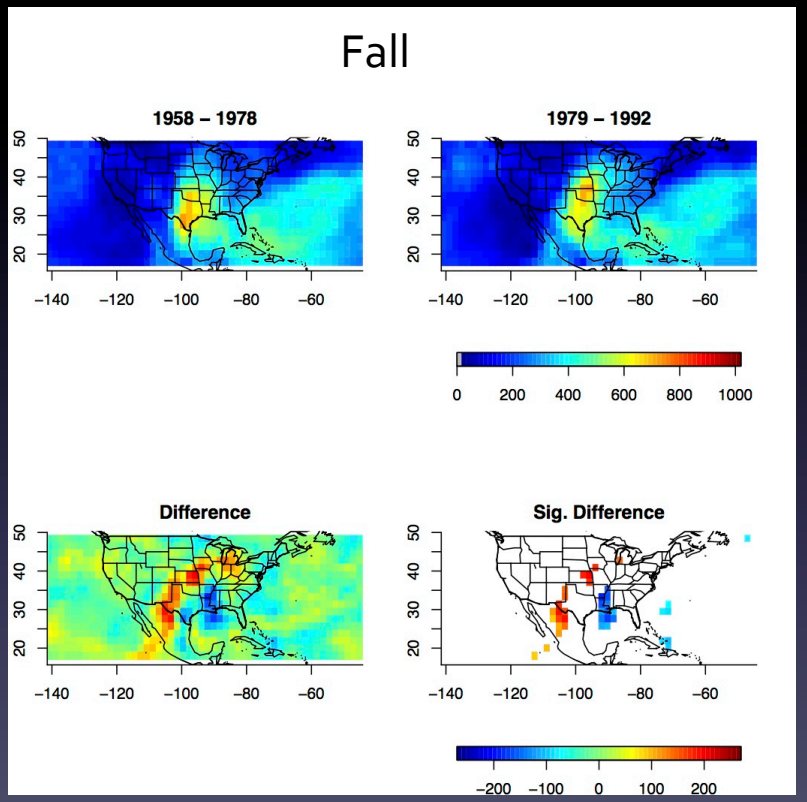

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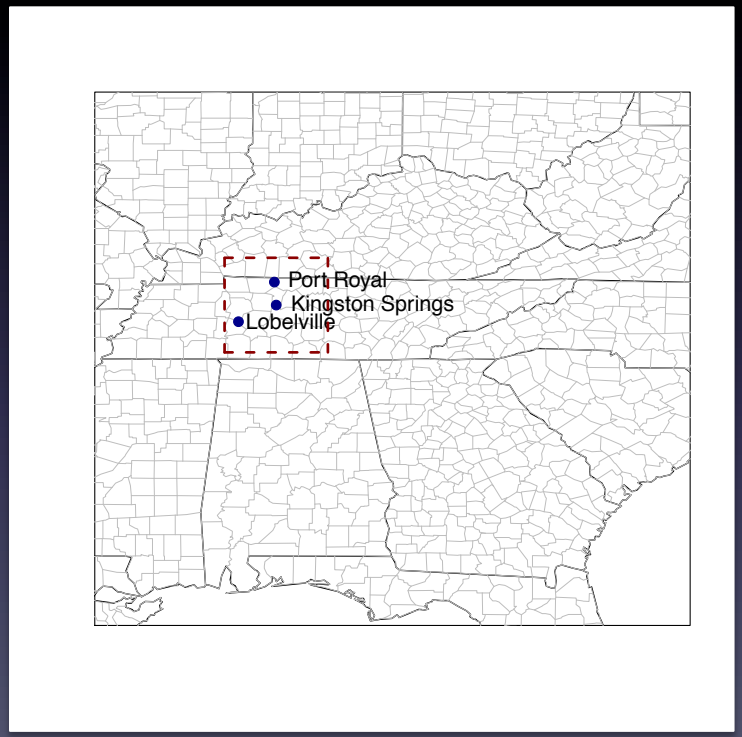
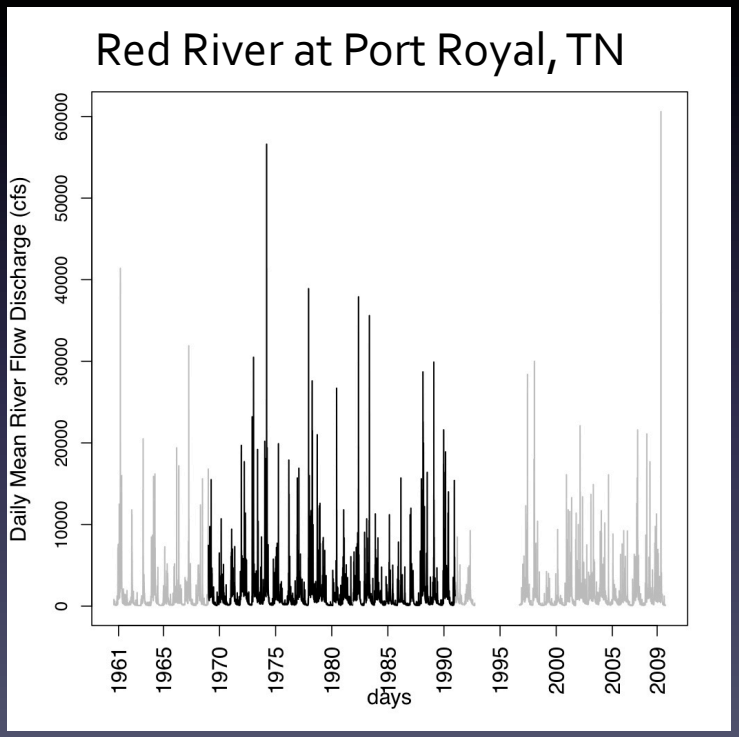
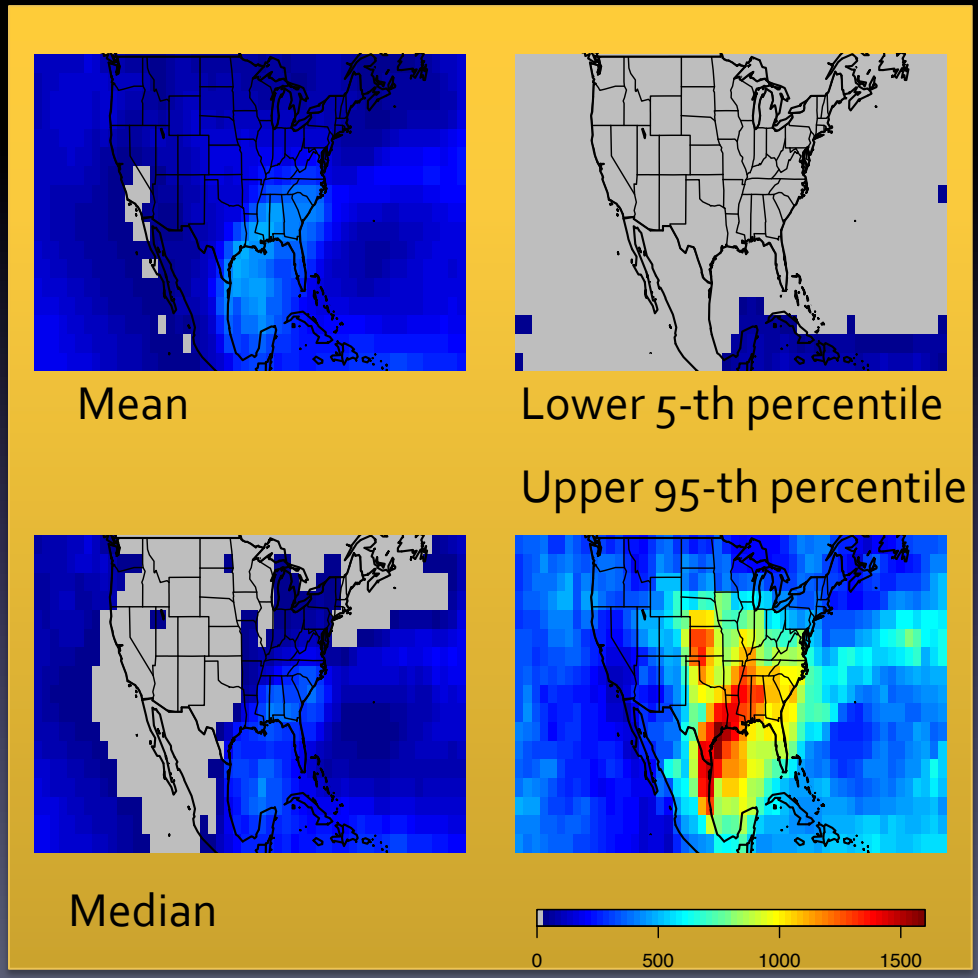




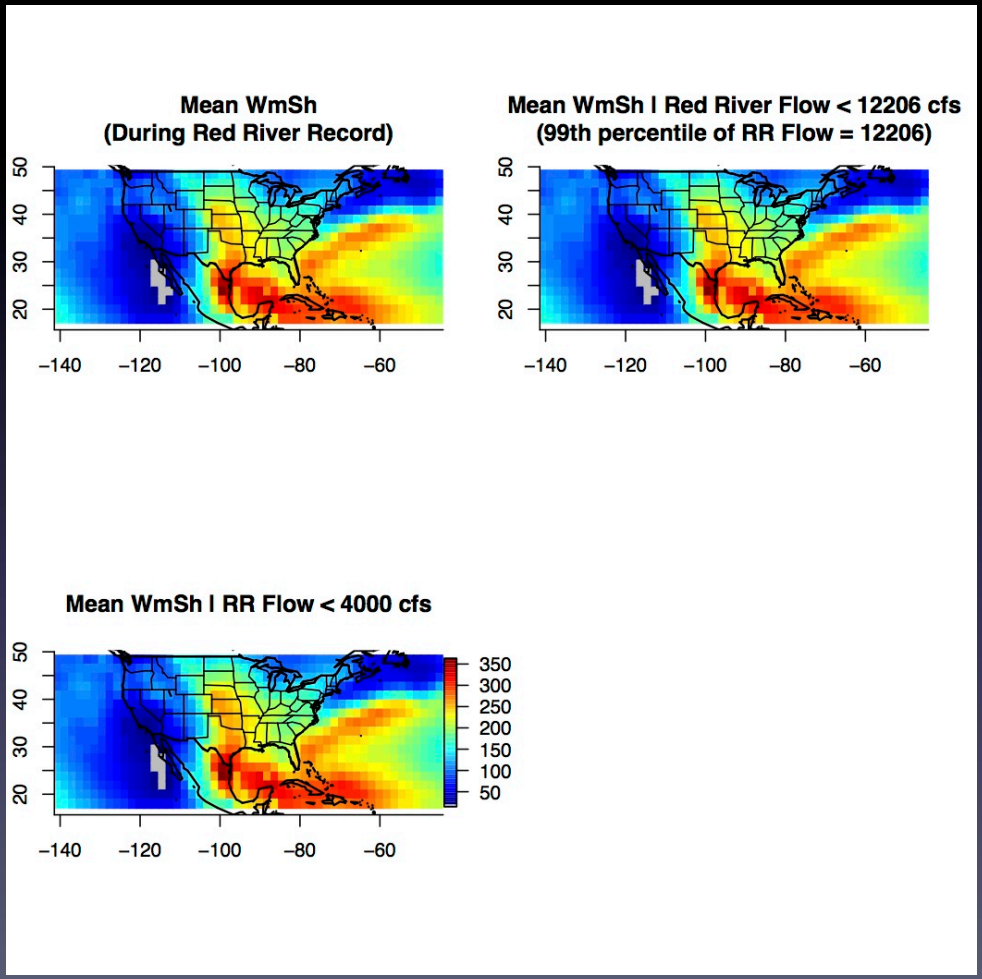
Conditional Extreme Value Model for Severe Storm Environments

WmSh (m^2/s^2) conditioned on high river flow (cfs)



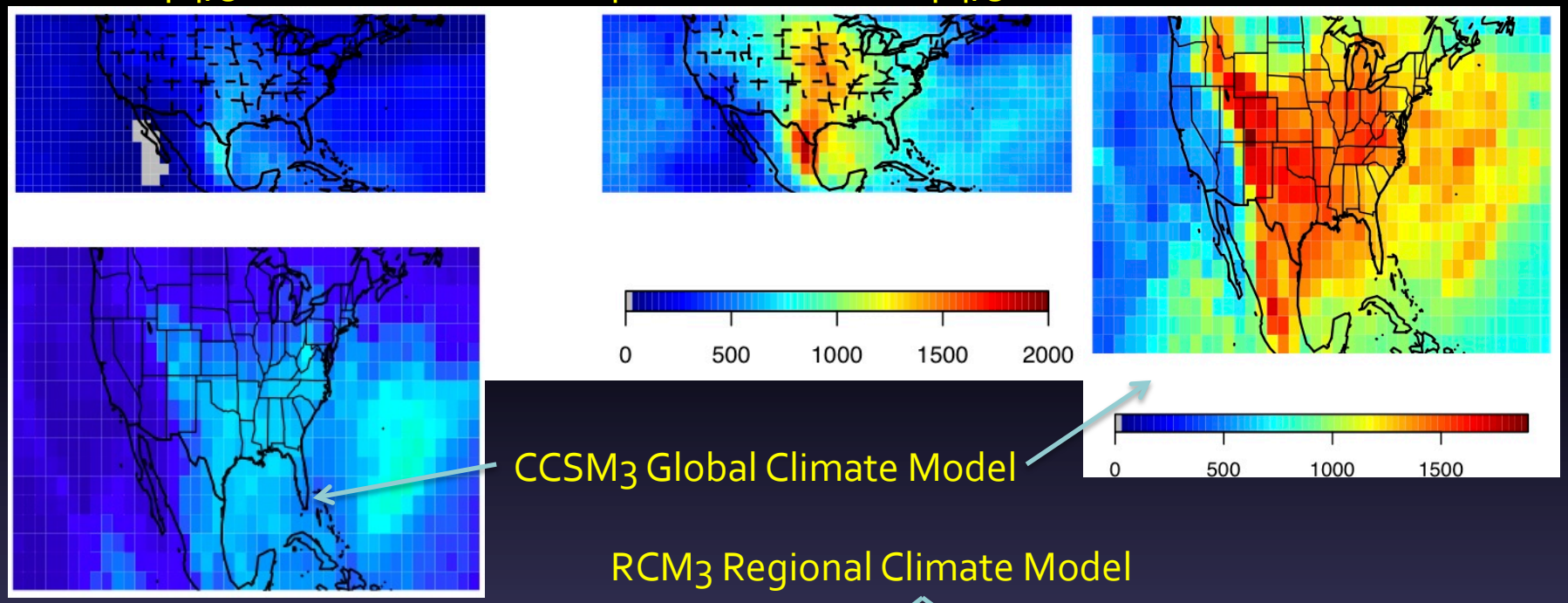
Conditional Extreme Value Model for Severe Storm Environments

WmSh (m^2/s^2) conditioned on lower river flow (cfs)



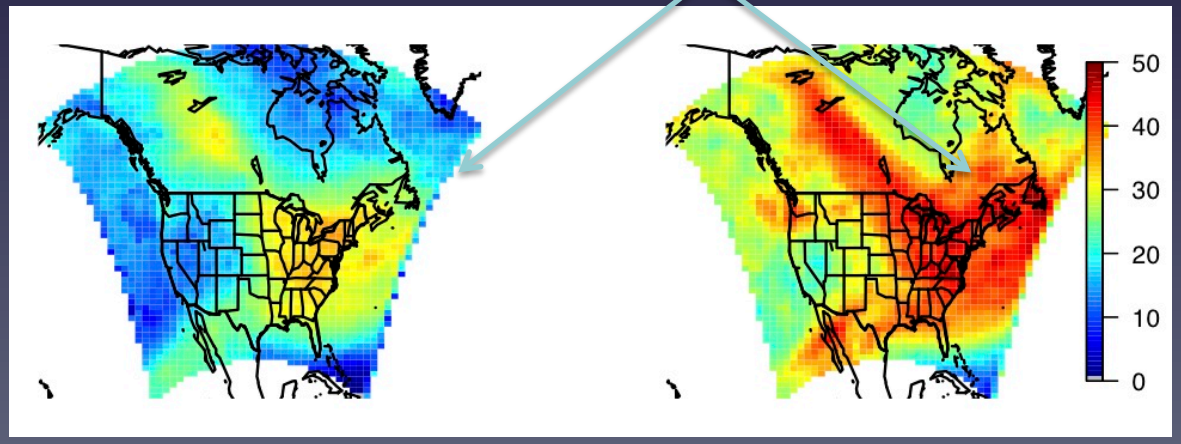
Observed Reanalysis Mean [WmSh | q75 > u]

Observed Reanalysis 95-th percentile [WmSh | q75 > u]



CCSM3 Global Climate Model

RCM3 Regional Climate Model



Summary and Future Work

- Use of large-scale indicators for severe storm environments is one way to project extremes in future climates without requiring high-resolution output
- Conditional EVA model introduced by Heffernan and Tawn provides a good way to model the extreme environments spatially (to examine the spatial structures that result)
- Could be useful for evaluating climate model output in terms of capturing extreme storm environments
- Can Estimation and Inference be improved?
  - empirical Bayes is showing promise here
- extRemes version 2.0 to be released soon.

Heffernan and Tawn conditional EVA model was fit using the R (http://www.r-project.org) package, texmex.

Image plots were made using the poly.image function from the R package, fields.