Weather and Climate Extremes: cape times shear

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Motivation

- Severe Weather generally on fine scales.

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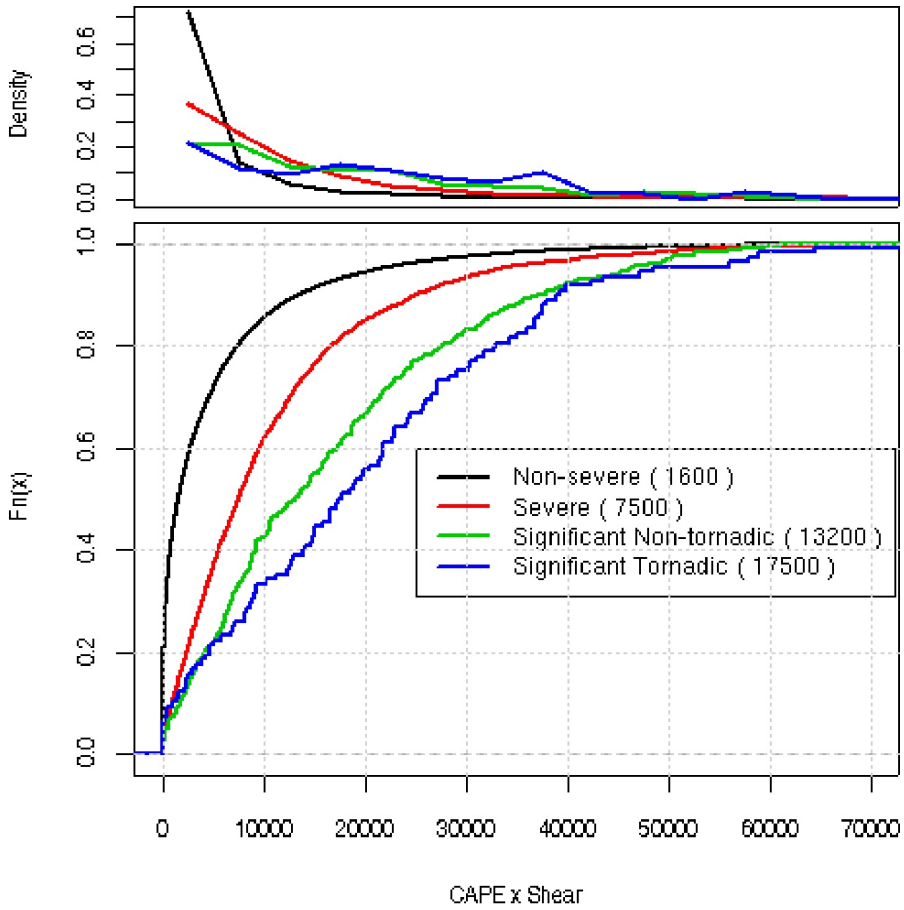
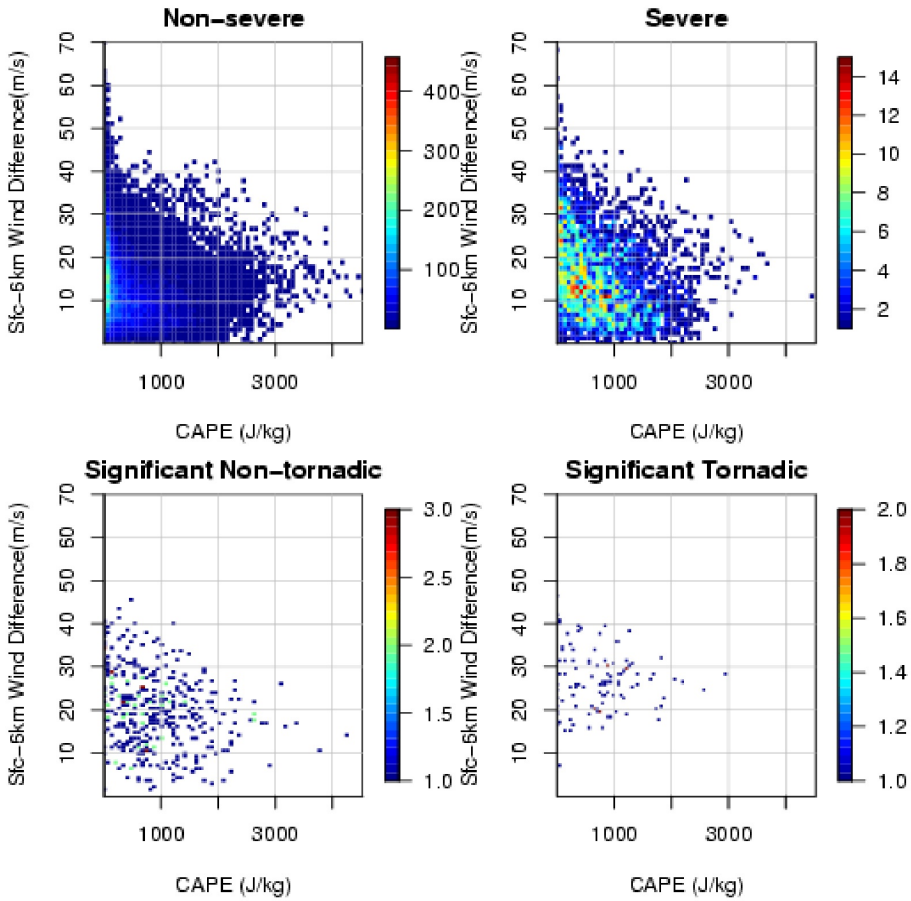
- Severe Weather generally on fine scales.
- Climate models on fairly coarse scales.
- Interest in gleaning information about severe weather under a changing climate.

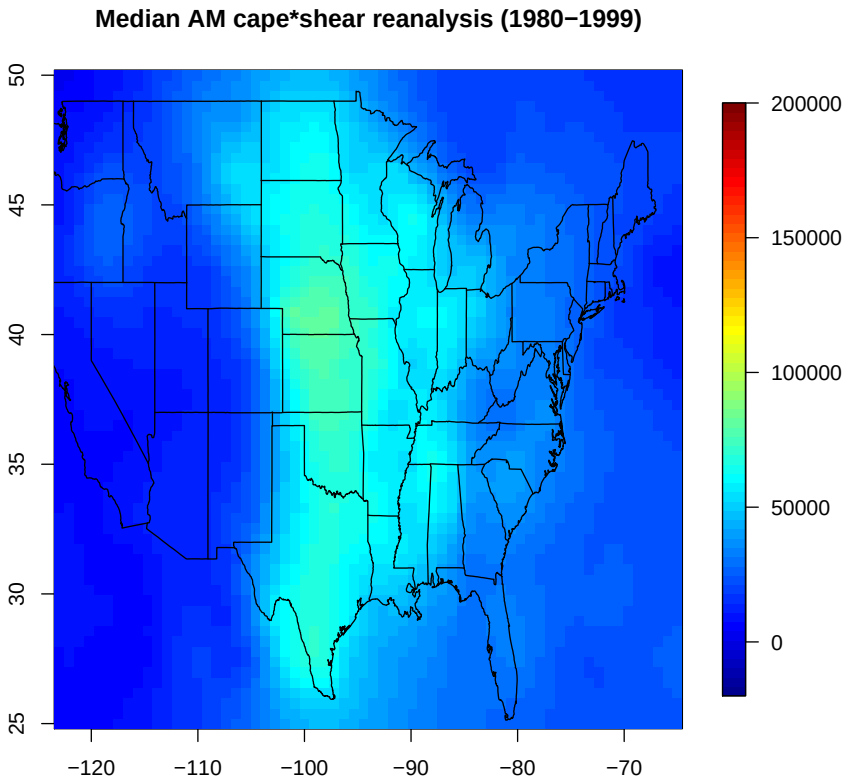
Motivation: CAPE (J/kg) and (0-6 km) Shear (m/s)





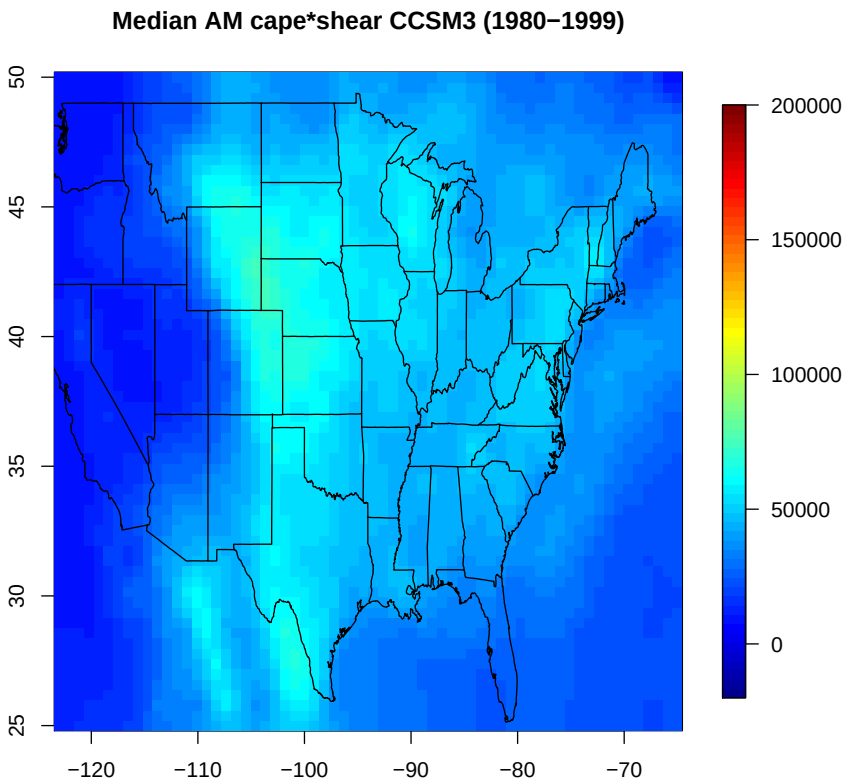
Measurements
Global Reanalysis

- 42 years available (1958-1999)
- 17,856 grid points (192×94)
- Resolution $\approx 1.875^o$ lon, 1.915^o lat



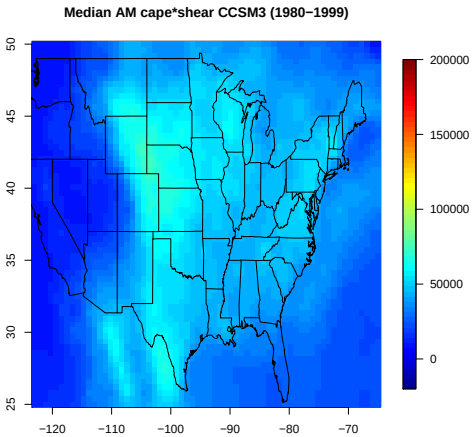
Measurements
CCSM3 Climate Model Output

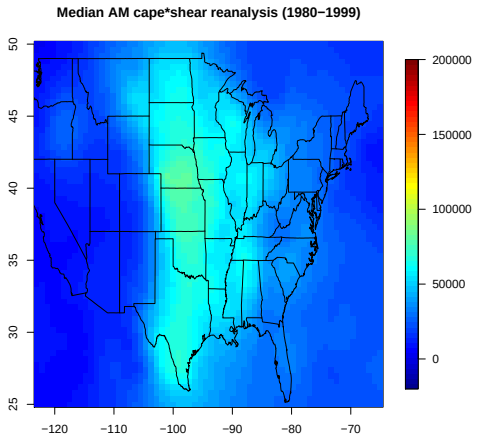
- 20 years (1980-1999)
- 756 grid points (42×18)
- Resolution $\approx 1.4^o$ lon, 1.4^o lat

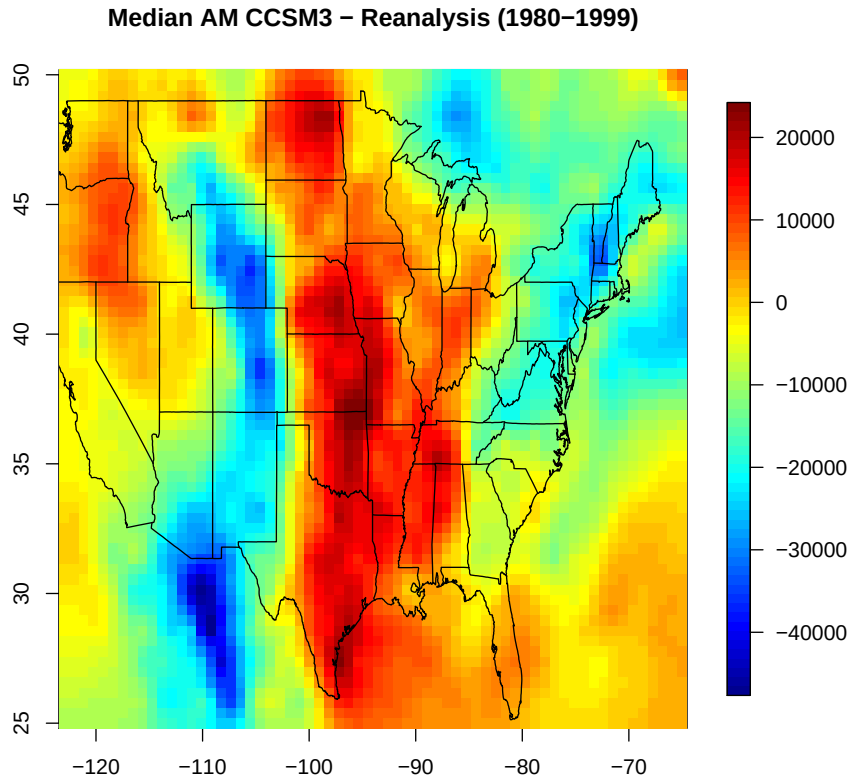


Measurments

- Large discrepancies in “observed" and CCSM3 modeled median AM cape*shear.
- Overall patterns similar.





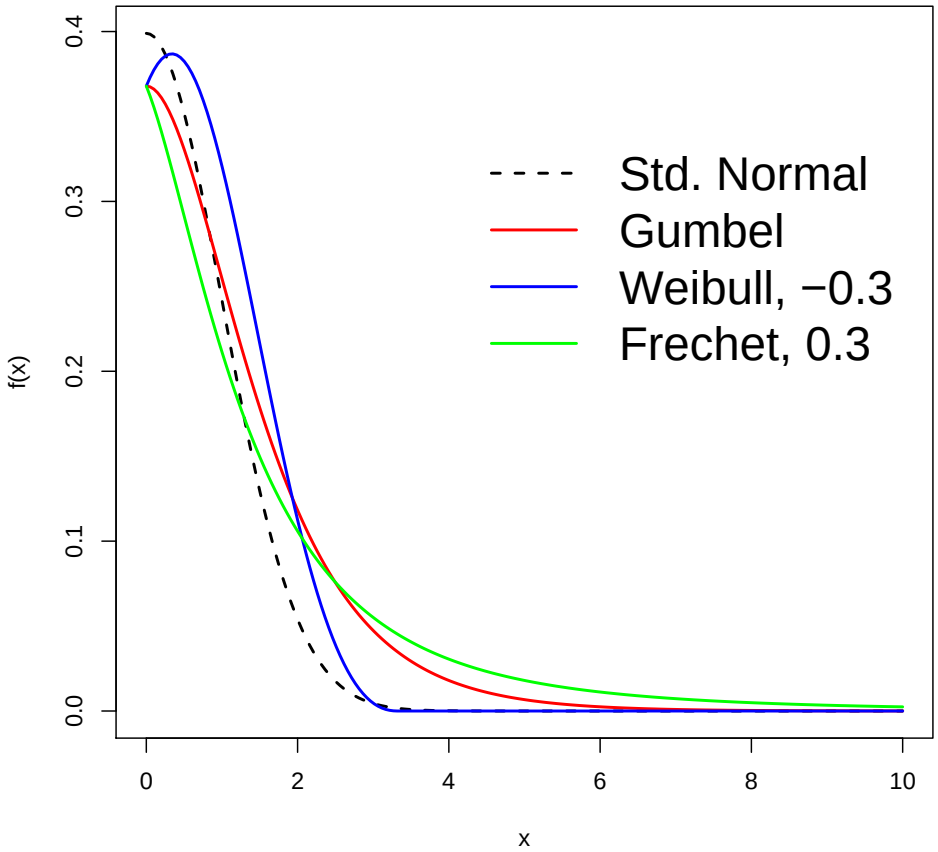


Goals

- Frequency of high values of cape*shear (Pocernich et al., in prep)
- Intensity of high values of cape*shear
  - Expected return values based on reanalysis fit to GEV.
  - Trends in observed data since 1958.
  - Comparison of Reanalysis and CCSM3 (1980-1999).
  - Comparison of above with CCSM3 future projections.
- Investigate severe weather under changing climate in other ways.
  - Regional models with future climate model initializations.
  - other?

Extreme Value Analysis
Generalized Extreme-Value (GEV) Distribution

$$f(x) = \exp\left\{-\left[1+\xi\left(\frac{x-\mu}{\sigma}\right)\right]^{-1/\xi}\right\}$$



Defined for
$\{x\colon\ 1+\xi(x-\mu)/\sigma > 0\}$,
$\mu, \xi \in (-\infty, \infty)$ and $\sigma > 0$.

Extreme Value Analysis
Parameter covariates

Can incorporate covariates into parameters of GEV to account for non-stationarity. For example,

$$\mu(\boldsymbol{x}) = \mu_0 + \sum_{i=1}^{m} g_i(\boldsymbol{x})\mu_i$$

$$\ln(\sigma(\boldsymbol{x})) = \sigma_0 + \sum_{j=1}^{\ell} h_j(\boldsymbol{x})\sigma_j$$

$$\xi(\boldsymbol{x}) = \xi_0 + \sum_{k=1}^{n} f_k(\boldsymbol{x})\xi_k$$

Extreme Value Analysis

Parameter covariates: Likelihood-ratio test

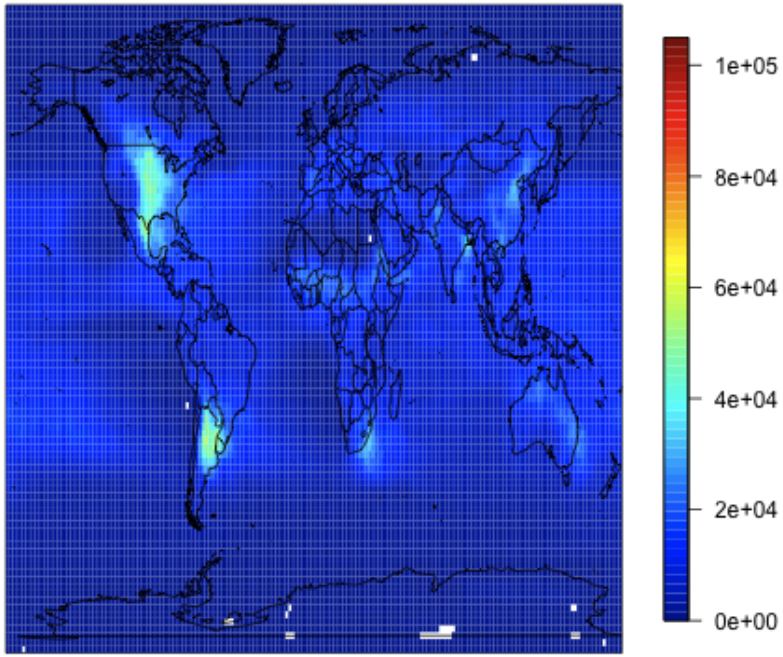
Adding covariate information always increases likelihood, so must test for significance. To compare a model $\mathcal{M}_1$ with n_1 parameters against a less complex (nested) model $\mathcal{M}_0$ with n_0 parameters, compare

$$D = 2\left\{\ell_1(\mathcal{M}_1) - \ell_0(\mathcal{M}_0)\right\}$$

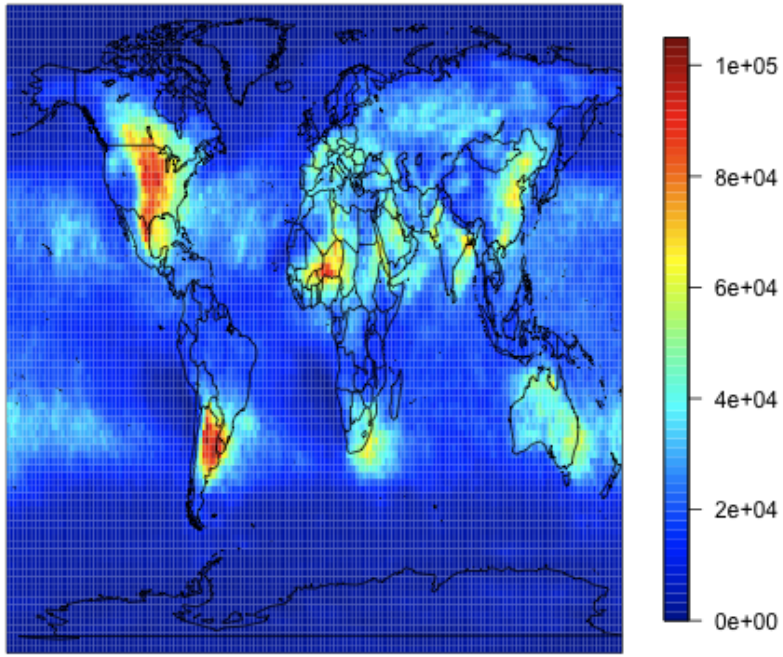
against the $(1-\alpha)$ quantile from the $\chi^2_{n_1-n_0}$ distribution. If D is greater, then reject the null hypothesis that $\mathcal{M}_0$ is the best choice model.

Initial Results: GEV fit without trend (20-year return level)

GEV-estimated



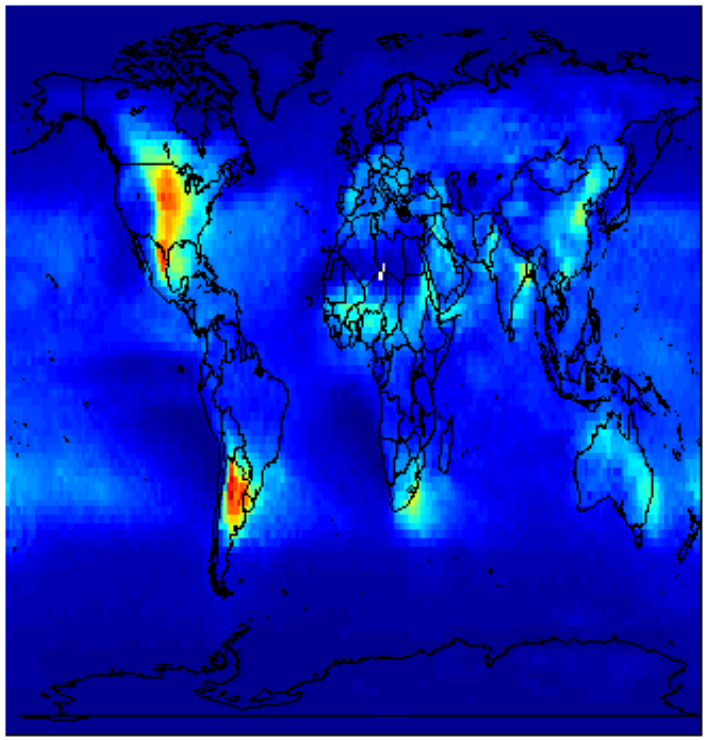
Empirical



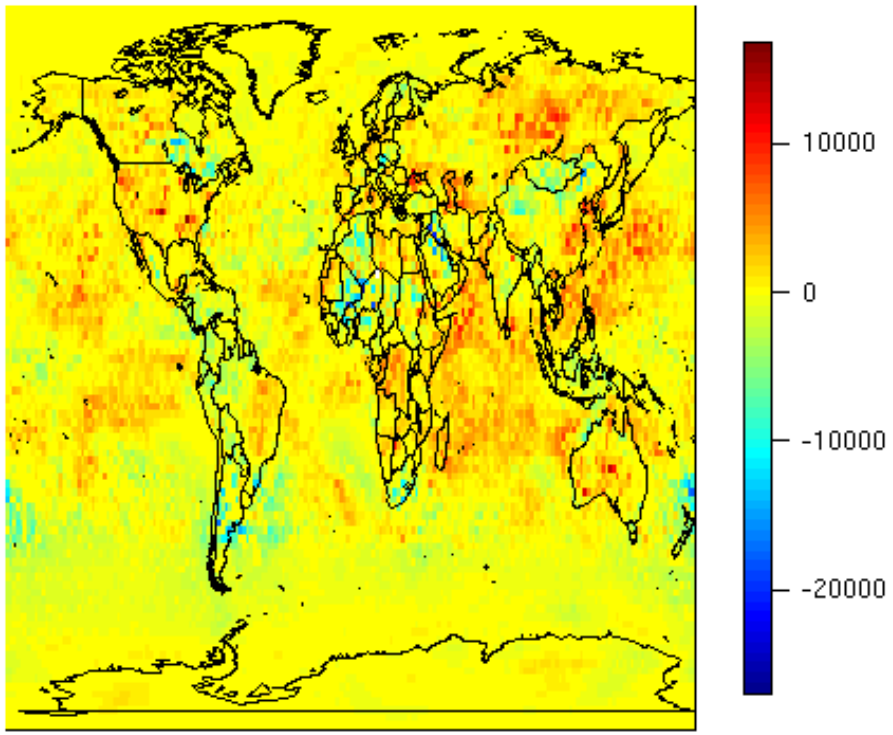
Initial Results: Trend (year) in GEV location parameter

$$\mu(\text{year}) = \mu_0 + \mu_1 \cdot \text{year}$$

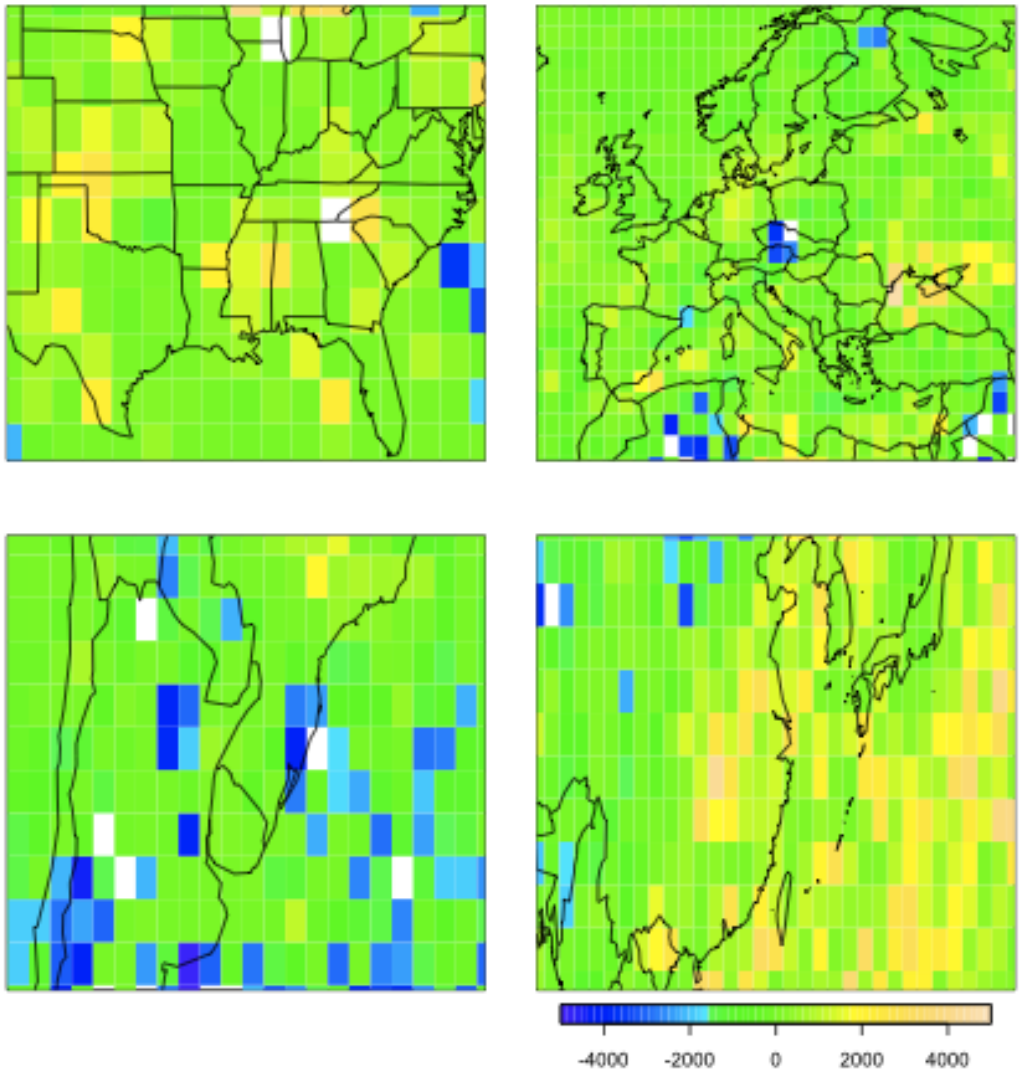
μ_0



μ_1

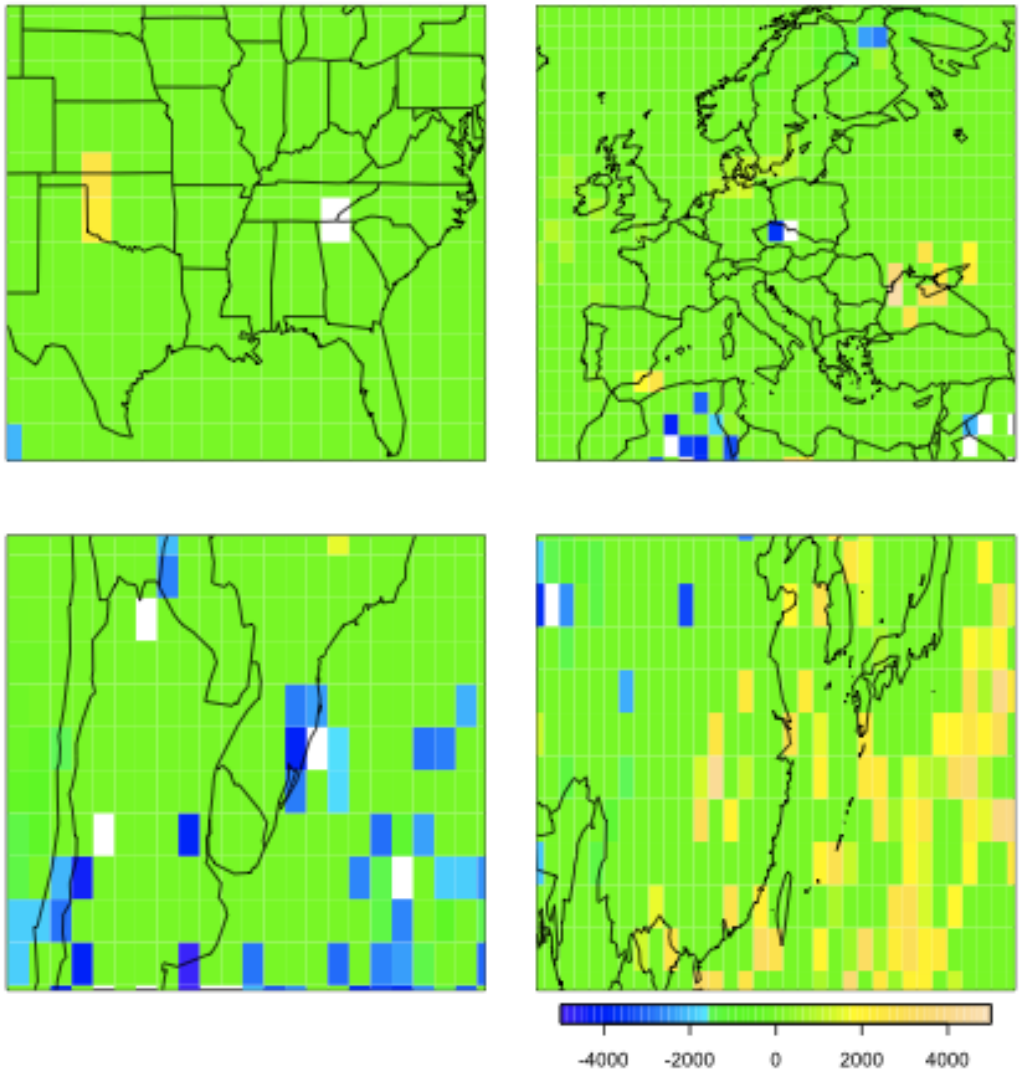


Initial Results: 20-year return level (1999-1980)



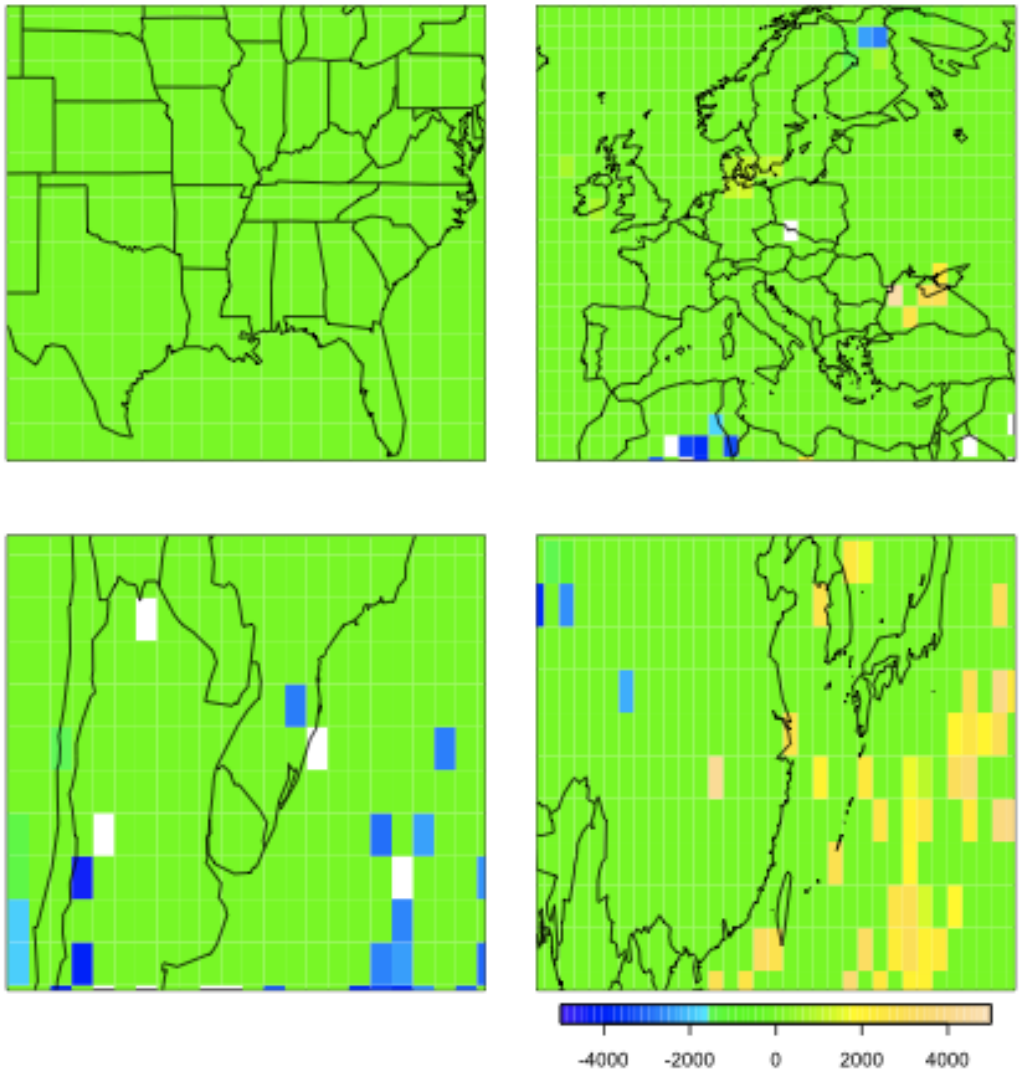
No account of significance

Initial Results: 20-year return level (1999-1980)



Pointwise significance

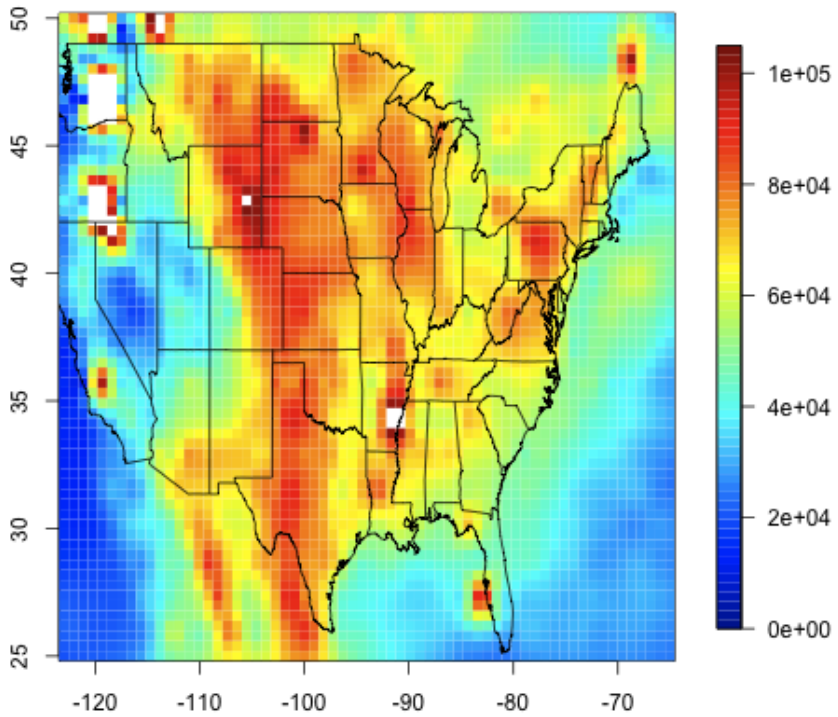
Initial Results: 20-year return level (1999-1980)



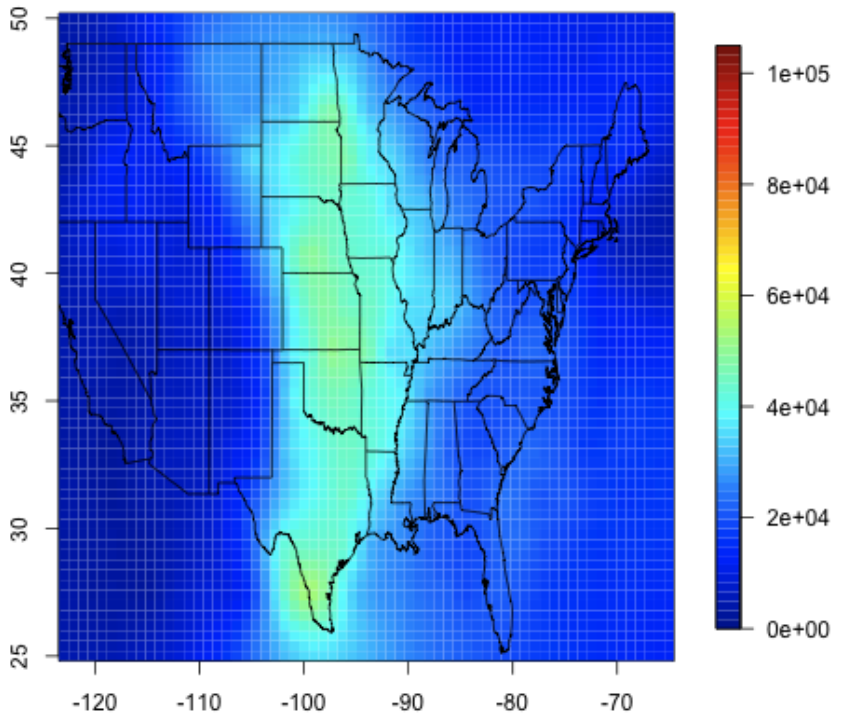
False Discovery Rate (Ventura *et al.*, 2004, *J. Climate* **17**:4343–4356).

Initial Results: CCSM3 (20-year GEV-estimated return levels)

CCSM3



Reanalysis



Initial Results: CCSM3 vs. Reanalysis (20-year return levels, GEV)

Some traditional verification statistics

MAE	37,600
ME	37,600
MSE	1.8×10^9
MSE - baseline	1.5×10^8
MSE - persistence	7.3×10^5
SS - baseline	-10.88

Issues, future and ongoing work

- cape*shear not ideally suited for EVA.
- CCSM3 cape not believable.
- Other large-scale indicators?
- Short record for verification.
- Investigate severe weather for changing climate more directly.
- Many new methods for spatial EVA.
- Employ new methods for spatial forecast verification.

That's all...

Questions?