Analyzing the Extreme Behavior of . . .

Large-Scale Meteorlogical Variables Found To Have Influence on Severe Storms and Tornadic Events Using Global Reanalysis Data

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Outline

- Motivation and Goals
- Reanalysis Data
- Preliminary Analysis
- Preliminary Results
- Future and Ongoing Work

Motivation and Goals

Primary Goal: Project Frequency and Intensity of Severe Weather



Motivation and Goals

Challenges

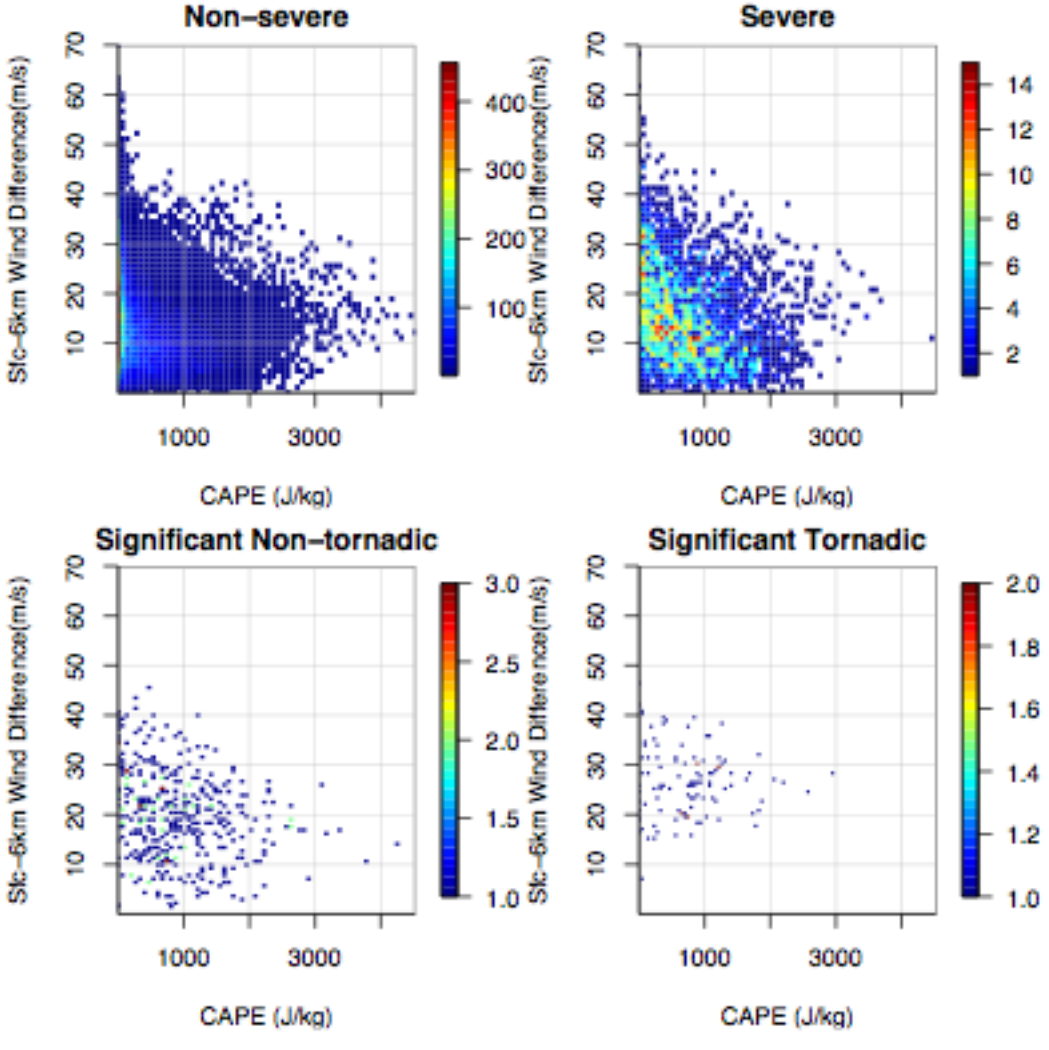
- Severe convective storms not resolved by Global Models or Datasets
- Historical records limited
- Weak relationship to larger-scale phenomena

Motivation and Goals

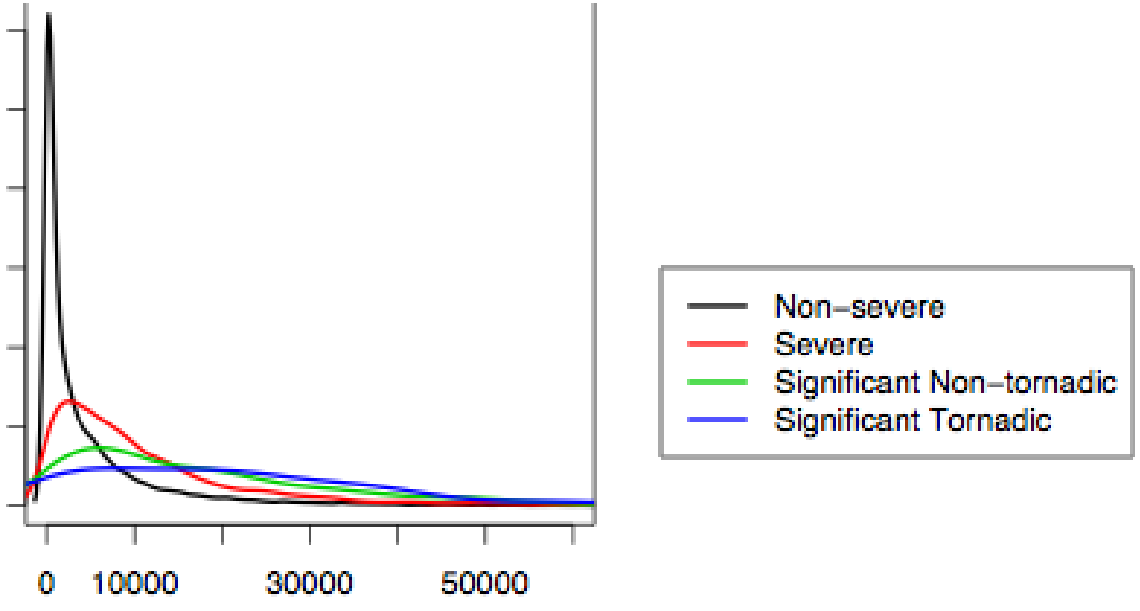
Intermediate Goals: Large-scale indicators for severe weather

- Characteristics
- Verification
- Past and Future trends

Large-scale indicators: CAPE (J/kg) and 6-km shear (m/s)



Motivation and Goals: Large-scale indicators

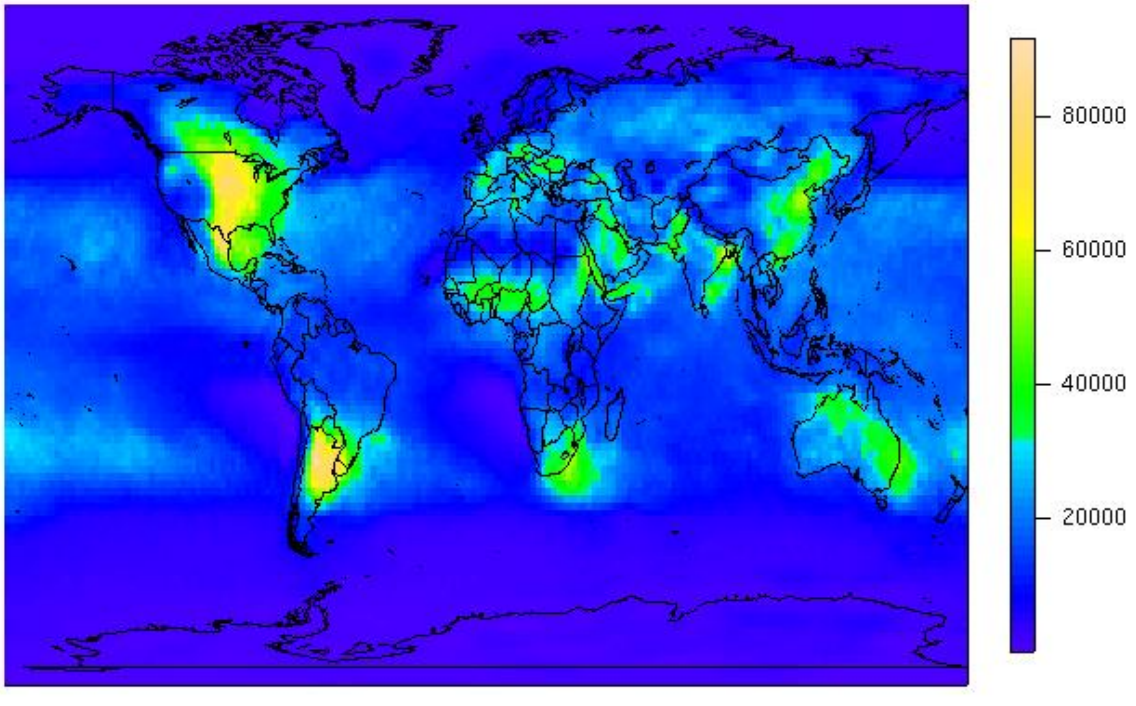


CAPE (J/kg) $\times$ shear (m/s)

Reanalysis Data

- Resolution $\approx 1.875^o$ longitude by 1.915^o latitude
- 17 856 grid point locations (192×94 grid)
- Temporal spacing every 6 hours
- 1958 through 1999 (42 years)
- Convective available potential energy (CAPE, J/kg)
- Magnitude of vector difference between surface and 6-km wind (shear, m/s)
- Both CAPE and shear ≥ 0 (Lots of zeros!)

Reanalysis Data



Upper quartile of annual maximum CAPE $\times$ shear

Preliminary Analysis

- Initially looked at trends in *mean* CAPE, shear and CAPE $\times$ shear
- Trends in counts of CAPE $\times$ shear $> 10\ 000$
- Trends in counts of CAPE $\times$ shear $> 20\ 000$
- Annual maximum CAPE $\times$ shear fit to GEV (ignoring spatial dependence!)

Preliminary Analysis

Initially modeling counts with a generalized linear model (GLM) with negative binomial family.

CAPE $\times$ shear seldom exceeds 10 000 over most of the globe. Therefore, only areas where an exceedance occurred at least once per year are examined.

Although no spatial analysis performed (*yet*), multiple comparisons and spatial dependence are accounted for by way of protecting against the false discovery rate (FDR) using the methods of Ventura *et al.* (2004).

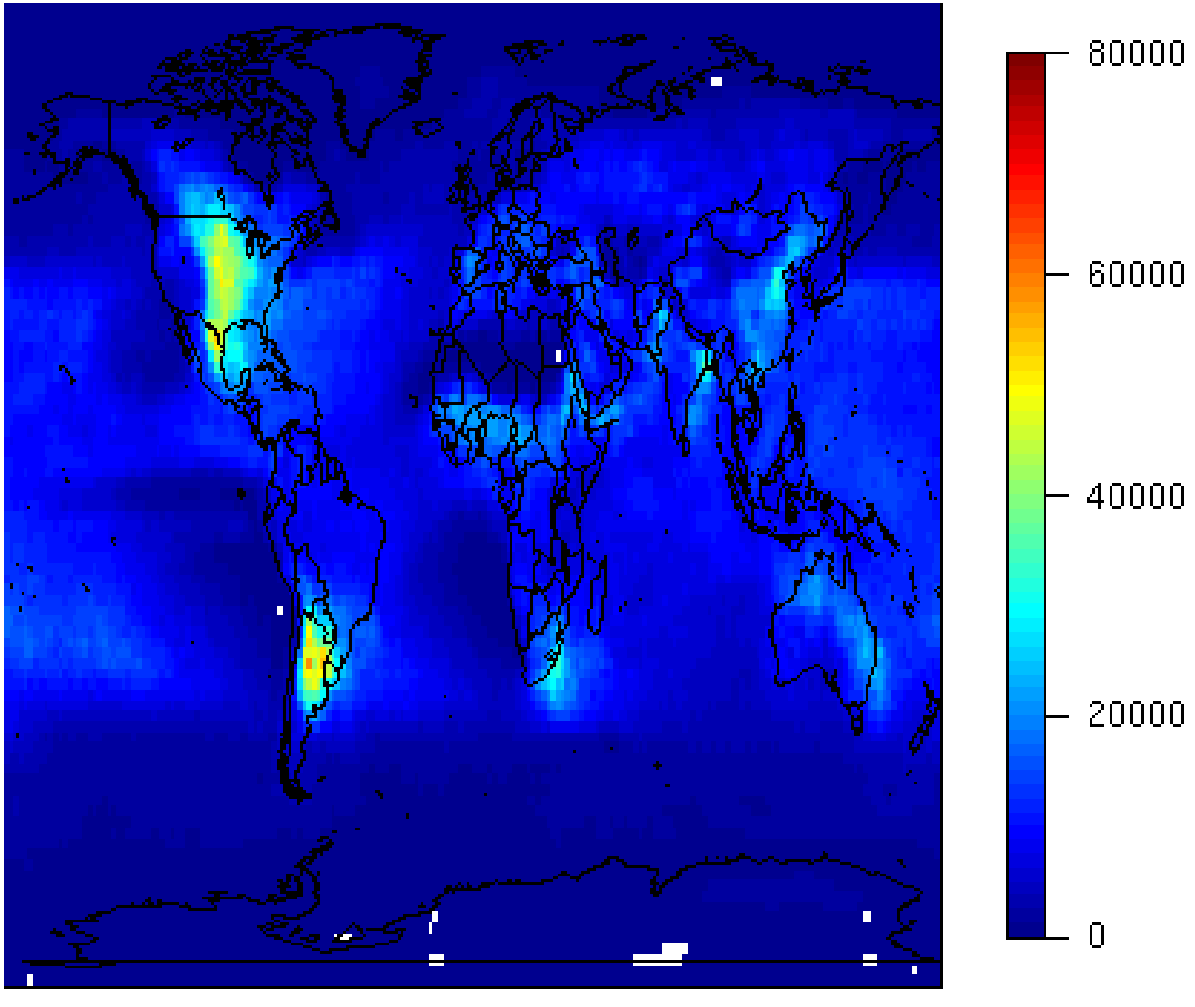
Preliminary Analysis

Extreme-value theory

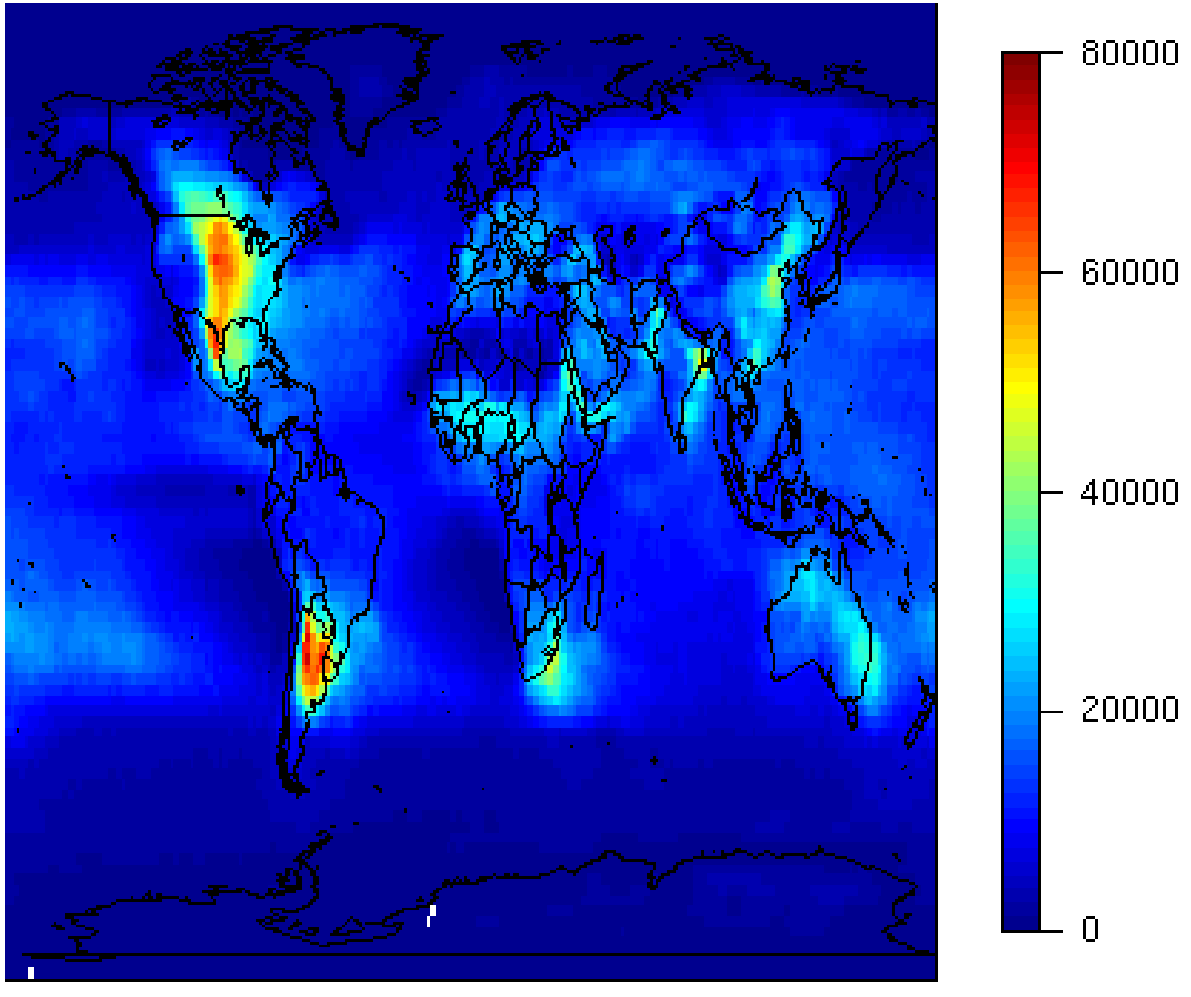
- Bivariate extremes difficult because CAPE and shear tend not to be large together
- Nonstationary spatial structure

Initial analysis: just fit GEV to individual grid points without worrying about spatial structure.

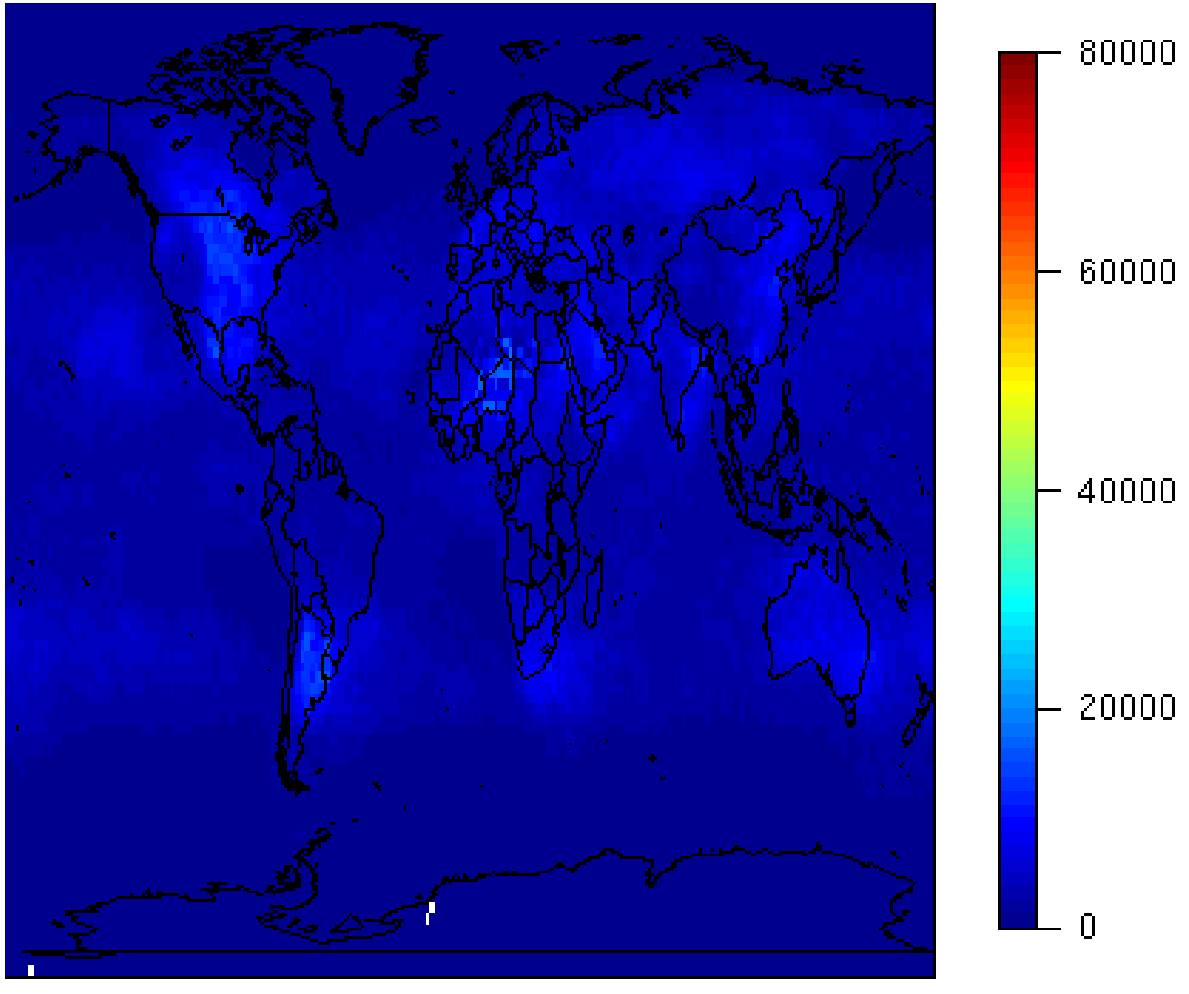
Preliminary Results: Estimated 20-year Return Level



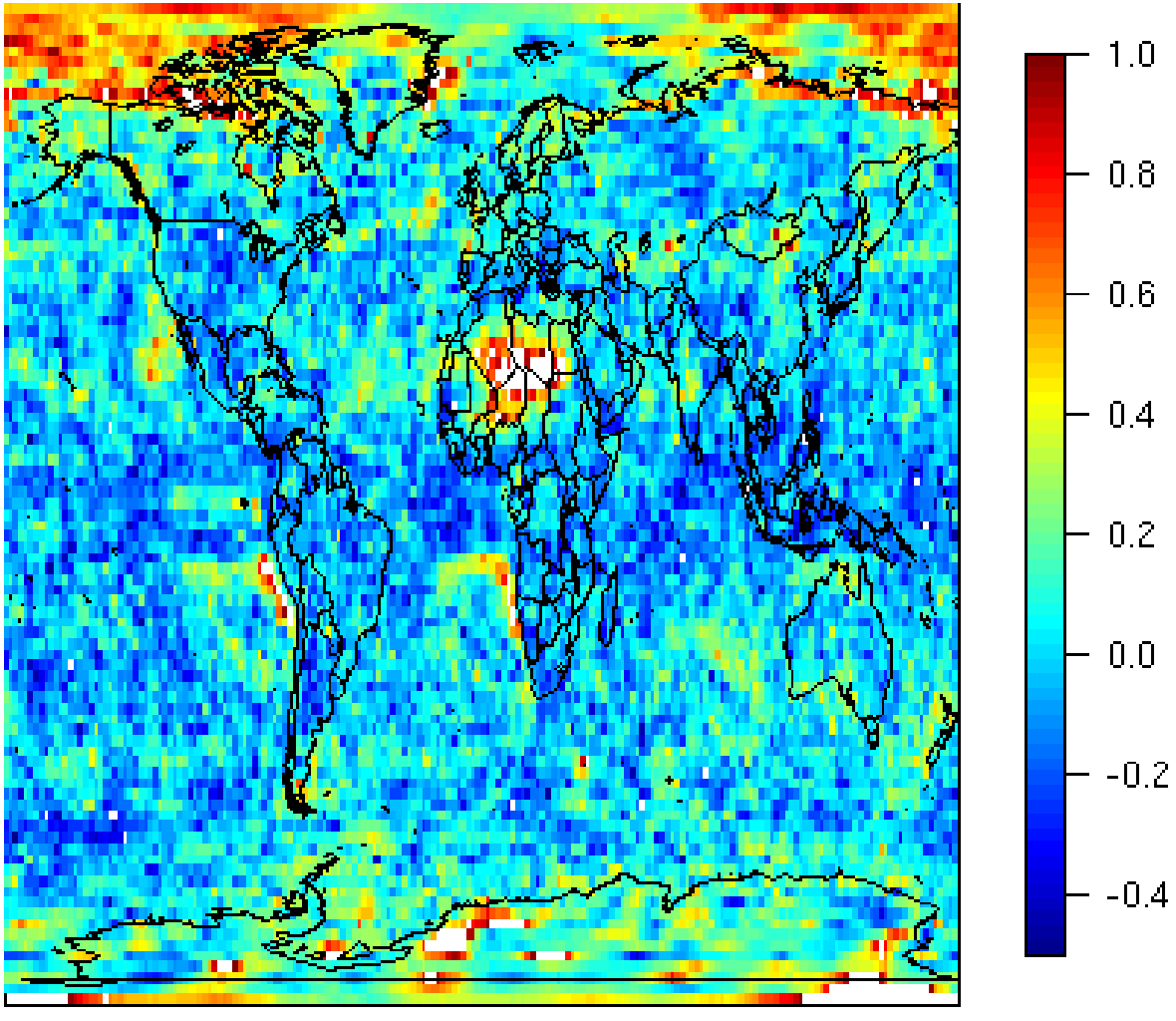
Preliminary Analysis: Location Parameter



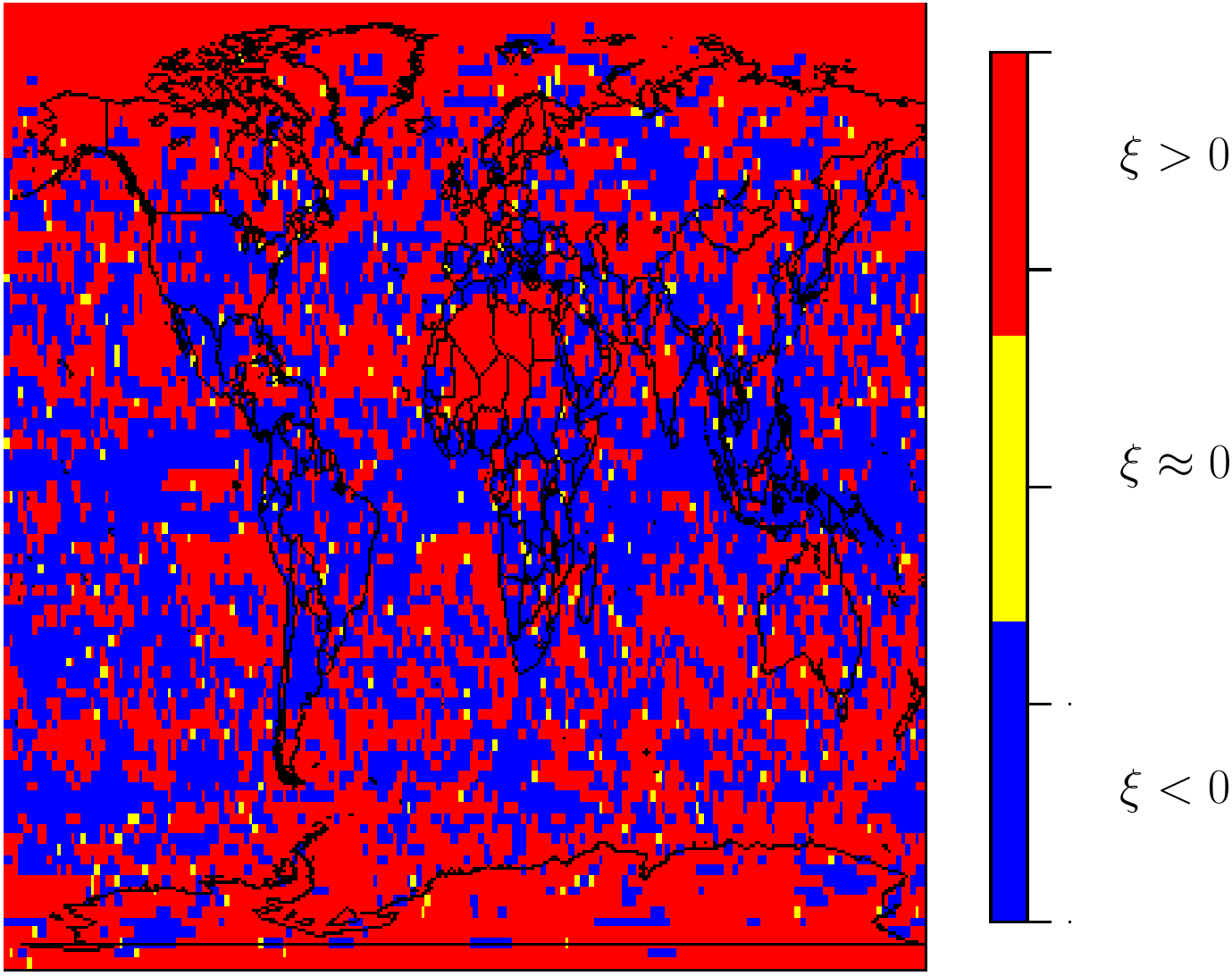
Preliminary Analysis: Scale Parameter



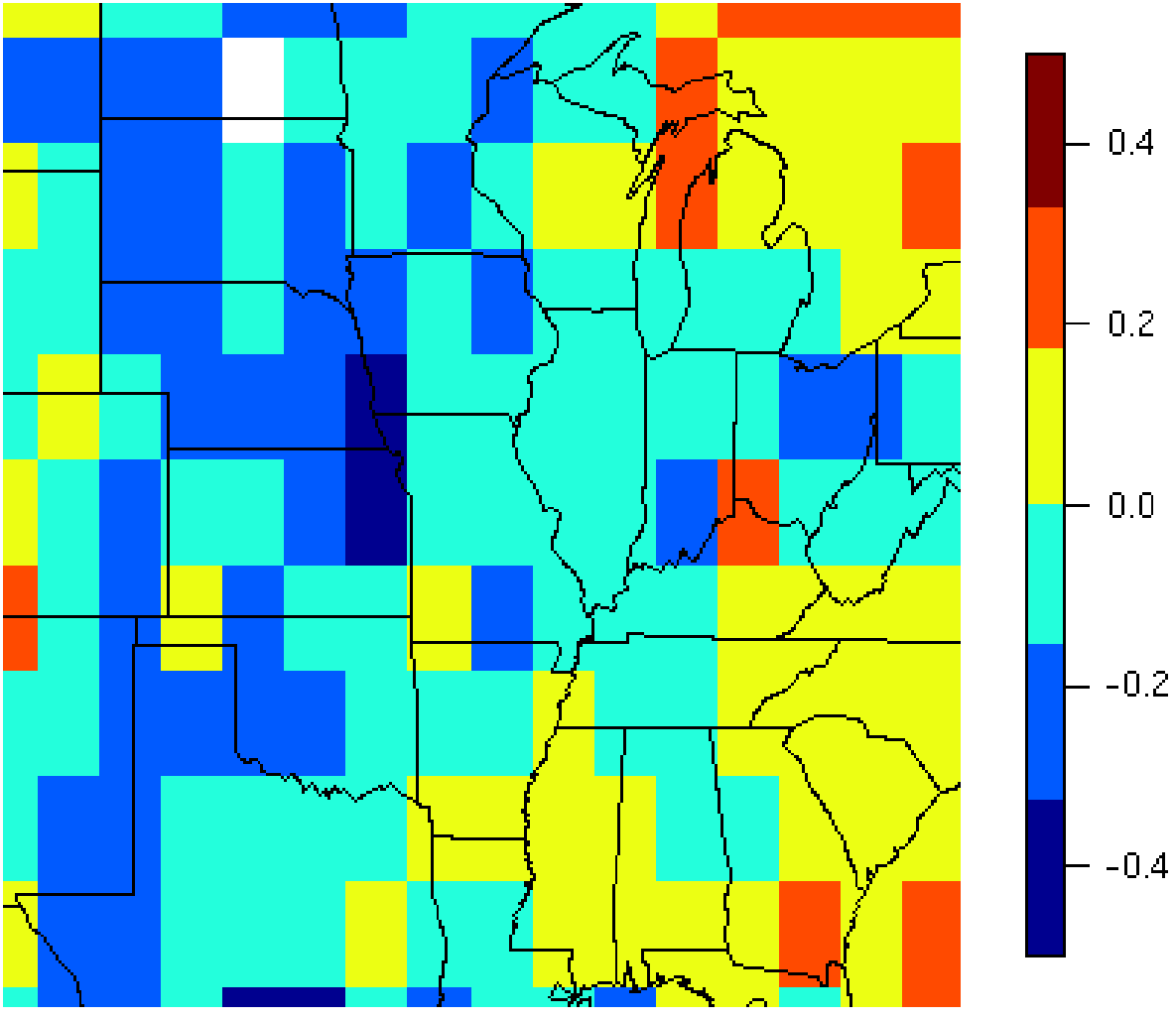
Preliminary Analysis: Shape Parameter



Preliminary Analysis: Shape Parameter Sign

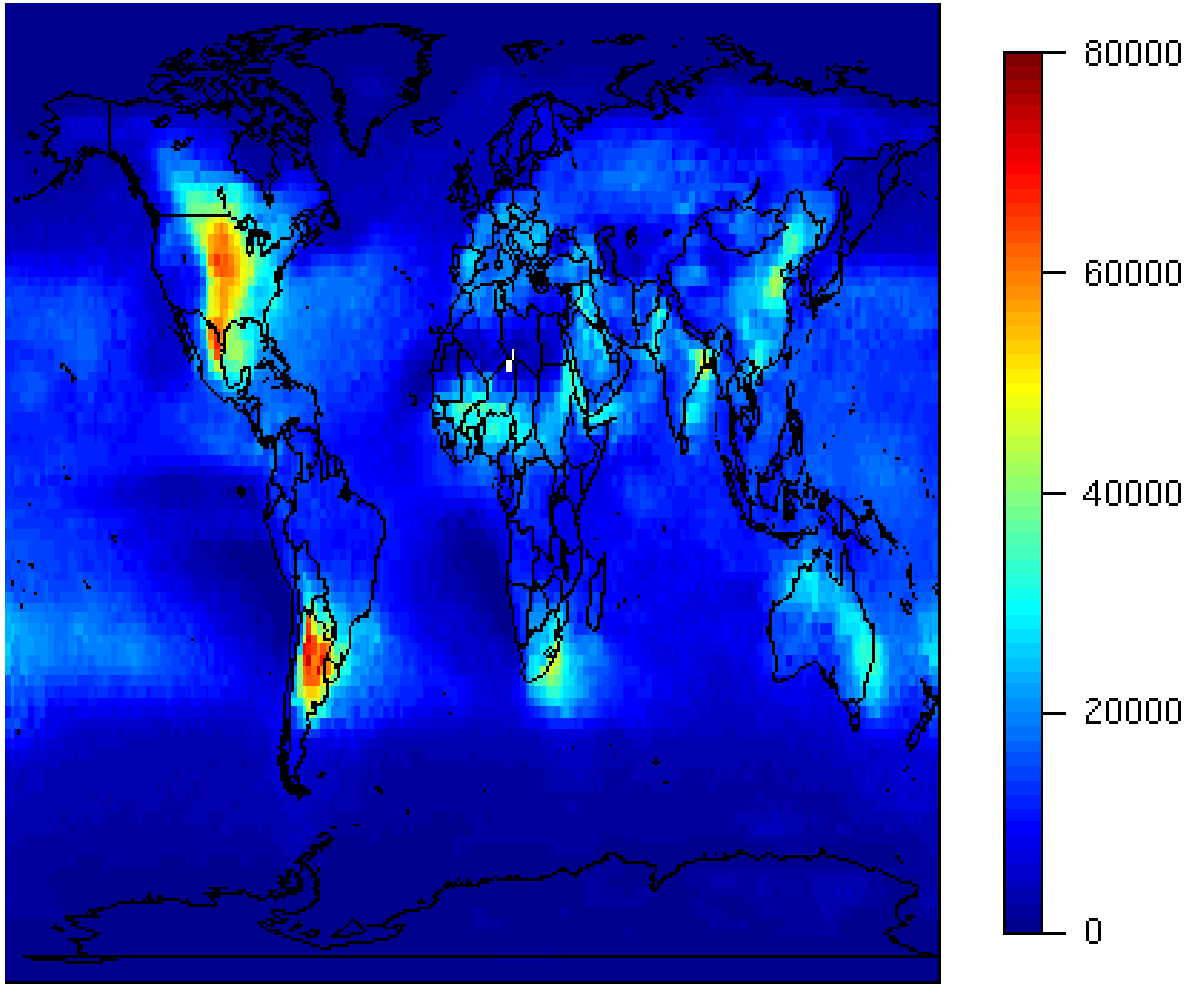


Preliminary Analysis: Shape Parameter (smaller region)



Preliminary Analysis

Trend in location parameter: $\mu(\text{year}) = \boldsymbol{\mu_0} + \mu_1 \cdot \text{year}$



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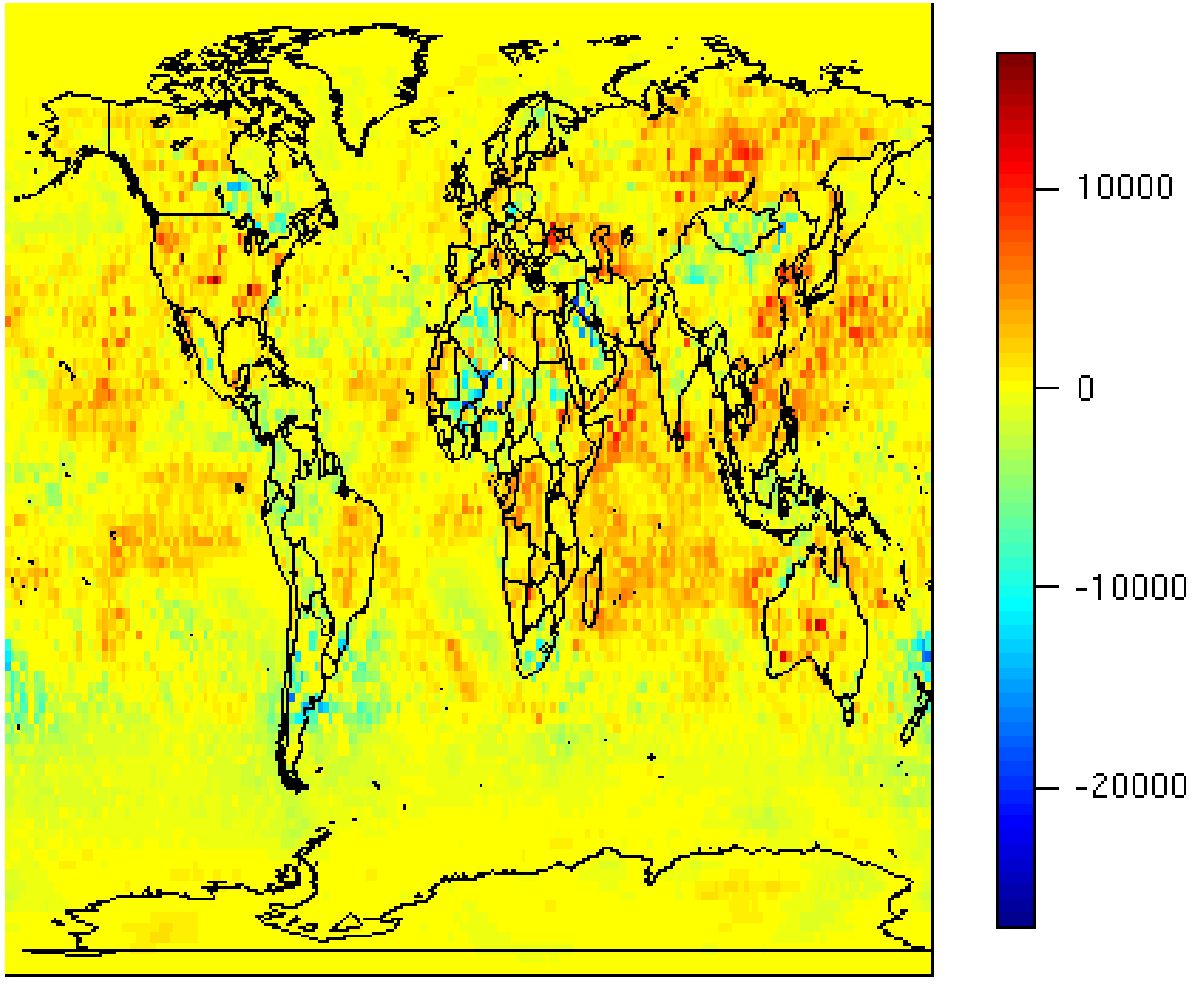
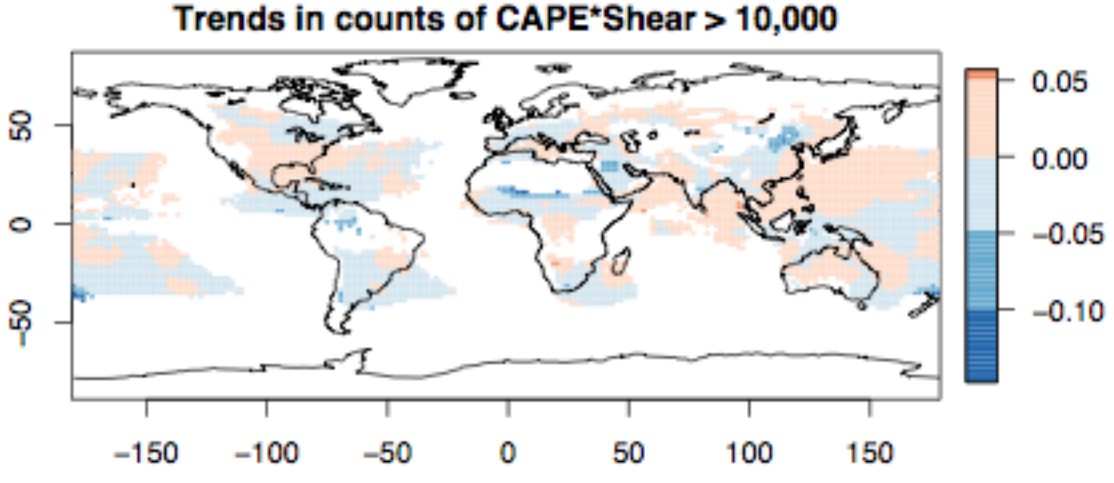
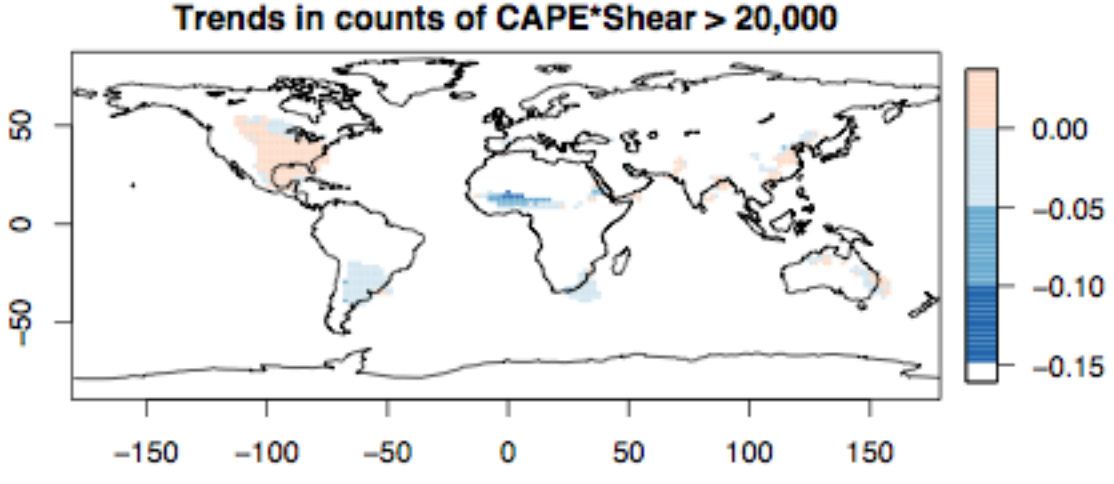


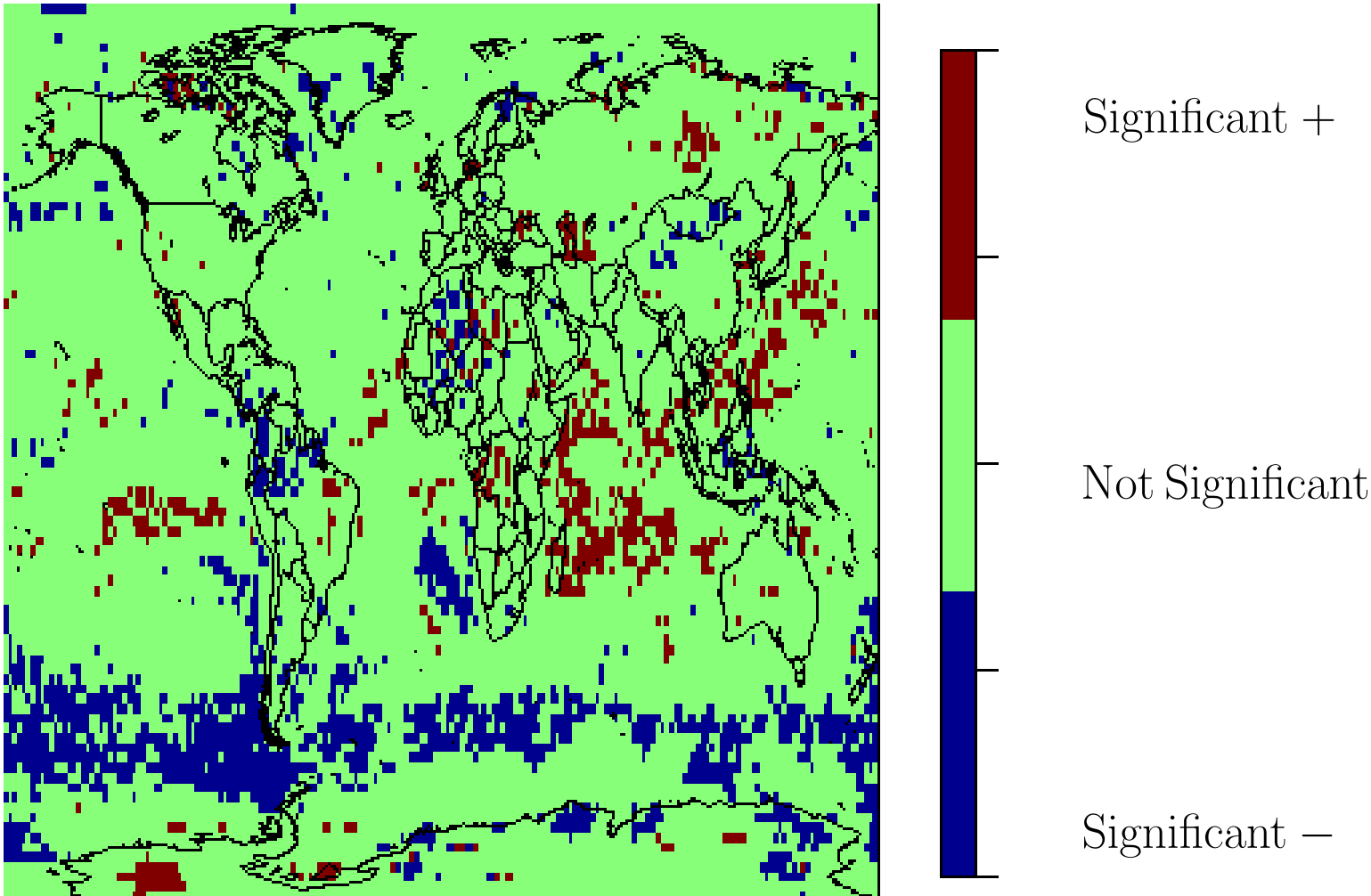
Preliminary Results





Preliminary Results

Significance?



Future and Ongoing Work

- Incorporate spatial dependence into the parameter estimates
- Incorporate spatial structure into the random processes
- Model counts of high CAPE $\times$ shear spatially
- Work out hypothesis testing for trends in location parameter
- Apply techniques to Global climate model data

References

Ventura, V., C.J. Paciorek, and J.S. Risbey. 2004. Controlling the proportion of falsely-rejected hypotheses when conducting multiple tests with climatological data. *J. Climate* **17**:4343-4356.