A comparison of U.S. precipitation extremes under two climate change scenarios

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Motivation

September 2013 Boulder Flood (source: bouldercast.com)

Motivation

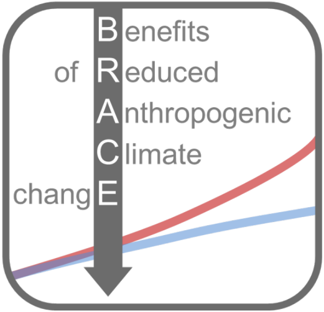

NATURE | NEWS
Global warming already driving increases in rainfall extremes
Precipitation extremes are affecting even arid parts of the world, study shows.
Climate Change Played Huge Role in Deadly Louisiana Flooding, Scientists Say
By John Upton | Published Sep 8 2016 11:57 AM EDT | Climate Central
Climate change raises flood risk, researchers say
By Richard Black
Environment correspondent, BBC News

Benefits of Reduced Anthropogenic Climate changE

We investigate two Representative Concentration Pathways (RCPs):

- RCP8.5: higher emissions
  (business-as-usual scenario)
- RCP4.5: lower emissions
  (moderate mitigation scenario)

BRACE[1] explores avoided impacts in RCP4.5 vs. RCP8.5



[1] https://chsp.ucar.edu/brace-benefits-reduced-anthropogenic-climate-change

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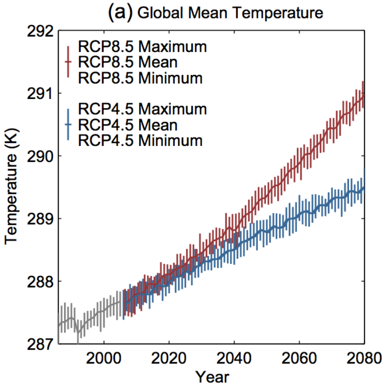

Sanderson et al. 2015

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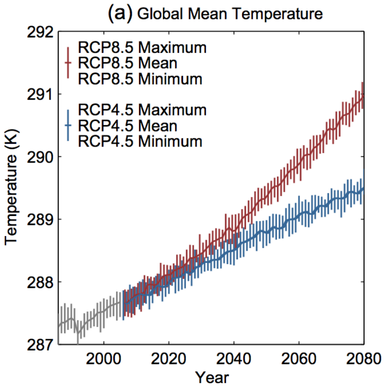
A unique "dataset"

We use output from two initial condition ensembles conducted with NCAR's Community Earth System Model (CESM):

- Large Ensemble[2] of 30 runs under RCP8.5 for 2006-2100 (CESM-LE; Kay et al. 2014)
- Medium Ensemble of 15 runs under RCP4.5 for 2006-2080 (CESM-ME; Sanderson et al. 2015)
- Both ensembles use historical forcings for 1920-2005



Sanderson et al. 2015

[2] http://www.cesm.ucar.edu/projects/community-projects/LENS/

Study objectives

- Fit nonstationary **generalized extreme value (GEV) models** to annual maximum daily precipitation simulated from CESM-LE (RCP8.5) and CESM-ME (RCP4.5) over the contiguous U.S.

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- Explore a **pattern scaling** approach for extremes

GEV model

Let M be the random variable representing the annual maximum daily precipitation amount . We assume

$$P(M \leq y) = \exp\left[-\left(1 + \xi \frac{y - \mu}{\sigma}\right)_{+}^{-1/\xi}\right]$$

The case of $\xi = 0$ is interpreted as the limit as $\xi \to 0$.

GEV model

Let $M(s\quad)$ be the random variable representing the annual maximum daily precipitation amount for grid cell s . We assume

$$P(M(s\quad) \leq y) = \exp\left[-\left(1+\xi(s)\frac{y-\mu(s\quad)}{\sigma(s\quad)}\right)_+^{-1/\xi(s)}\right]$$

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GEV model

Let $M(s,t)$ be the random variable representing the annual maximum daily precipitation amount for grid cell s and year t. We assume

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Let $x(t)$ be the global mean temperature in year t.
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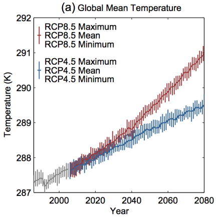

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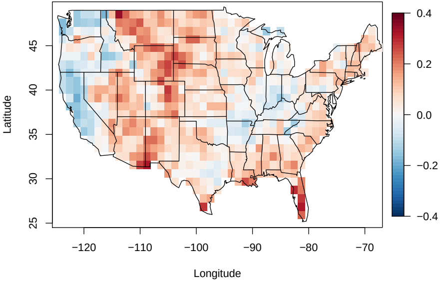
We fit separate models to CESM-LE (RCP8.5) and CESM-ME (RCP4.5).

Ensemble advantage

$\hat{\xi}(s)$



Single ensemble member

All ensemble members

Ensemble advantage

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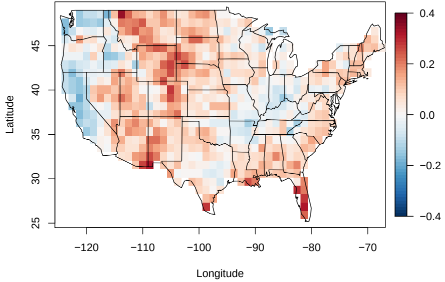
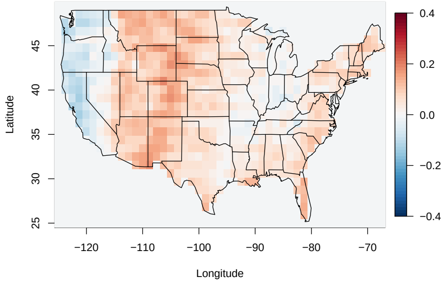
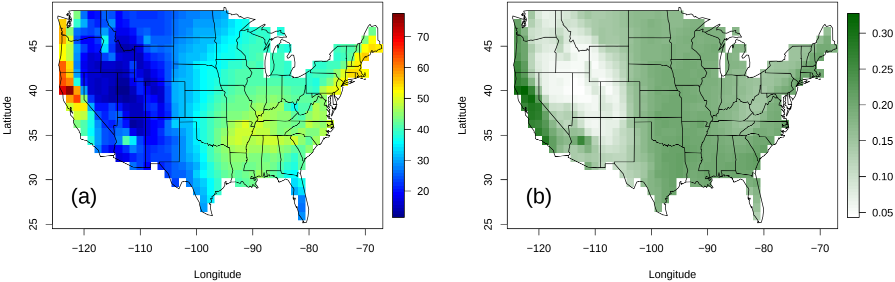


Single ensemble member

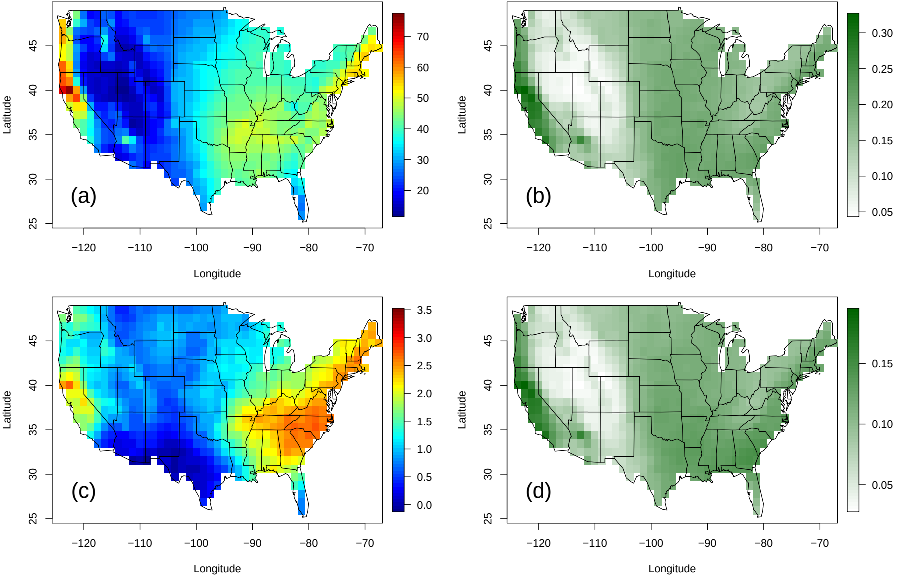


Single smoothed member (Tye & Cooley 2015)

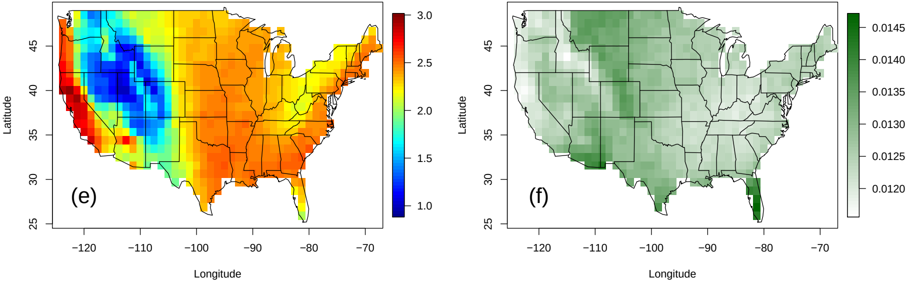
Parameter estimates and SEs: μ_0



Parameter estimates and SEs: μ_0, μ_1



Parameter estimates and SEs: ϕ_0



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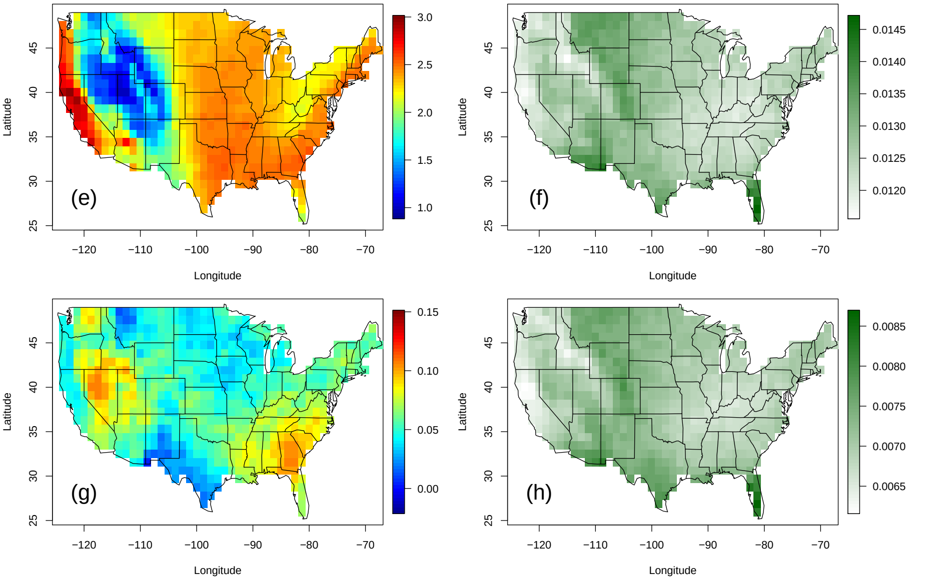
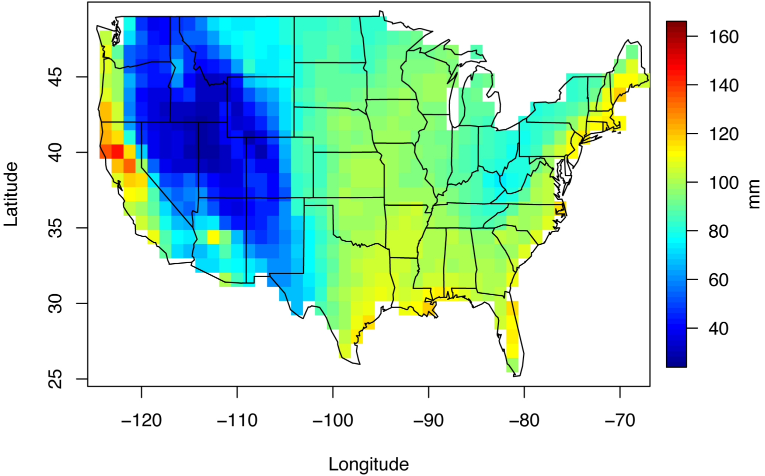


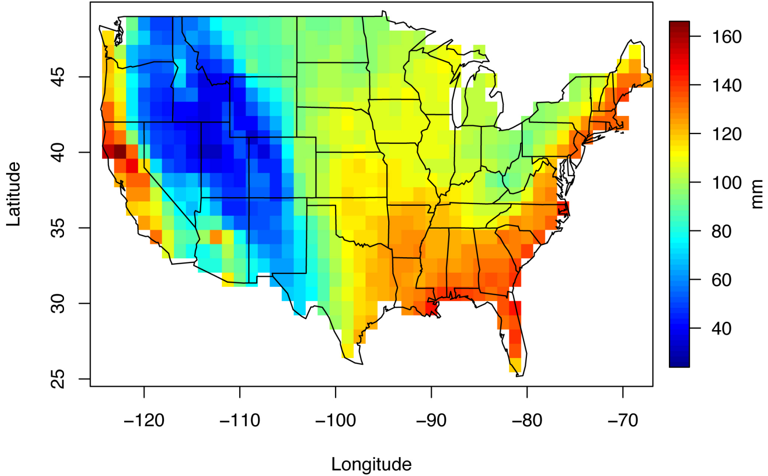
Results

1% AEP level in 2005



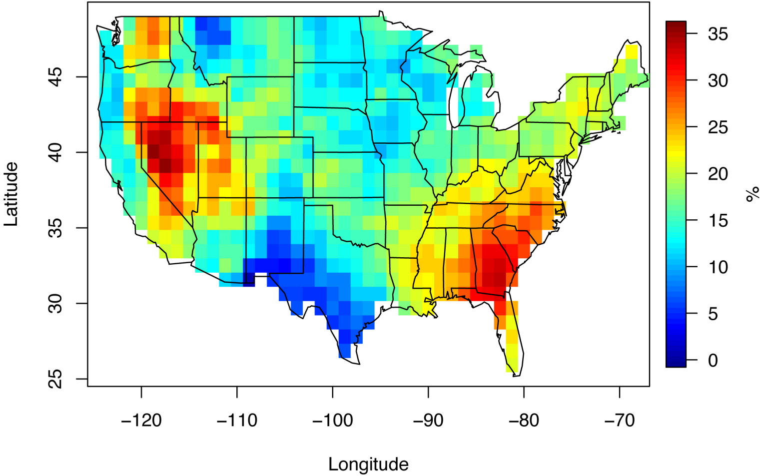
Results

1% AEP level in 2080 under RCP8.5



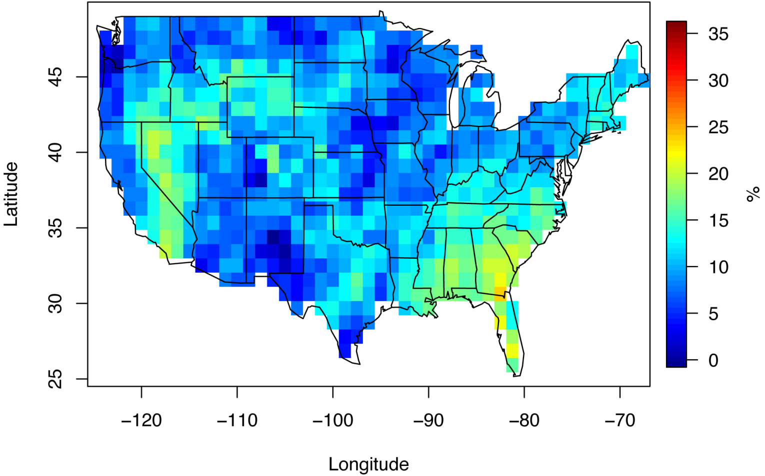
Results

Percentage change in 1% AEP level from 2005 to 2080 under RCP8.5



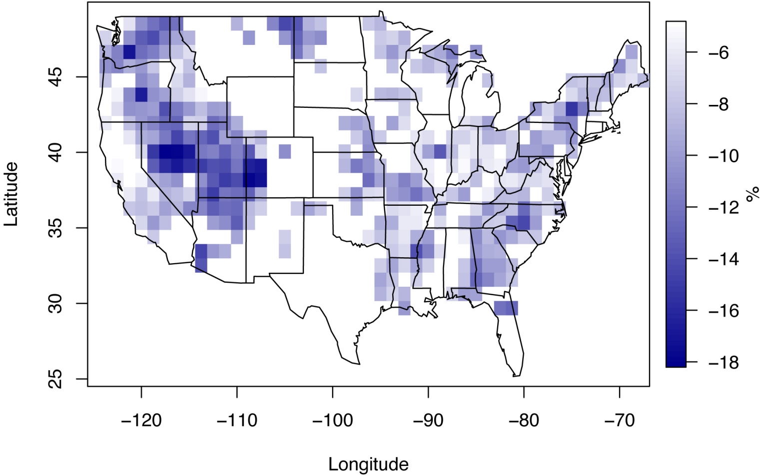
Results

Percentage change in 1% AEP level from 2005 to 2080 under RCP4.5



Results

Relative change in 2080 1% AEP level under RCP4.5 vs. RCP8.5



Pattern scaling for extremes

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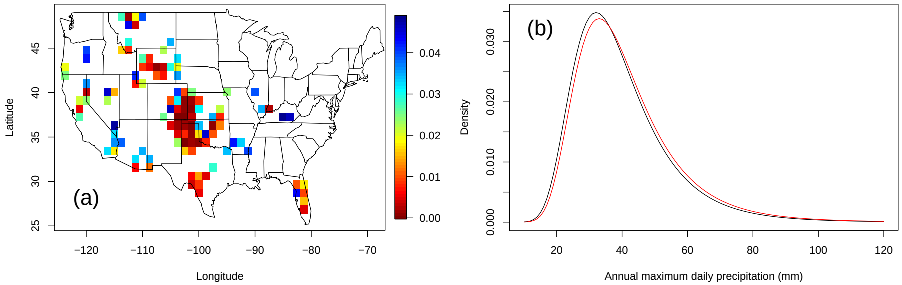
The CESM-ME RCP4.5 runs allow us to evaluate pattern scaling, where the GEV model is fit only to RCP8.5 output.

Evaluating pattern scaling



Acknowledgments

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- We would also like to acknowledge the modeling groups who created the CESM model and generated the initial condition ensembles used in this analysis.

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