Increasing risk of record-breaking summer temperatures in the future and the potential for mitigation

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BRACE contribution

- CESM1 “Large Ensemble”: 30 x 1920-2100 (RCP 8.5)
- CESM1 “Medium Ensemble”: 15 x 1920-2080 (RCP 4.5)
- Robust climate change mitigation?

Sanderson et al. (2015)
Record summer temperatures

What’s the probability of exceeding the historical record summer temperature?

Why does it matter?

Battisti & Naylor (2009, Science)

Does the probability scale with the emissions scenario?

What role does temperature variability play?
How often do we see a record? How „large“ is it?

Lehner, Deser, Sanderson (2016)
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Lehner, Deser, Sanderson (2016)
Records and the mean state

Lehner, Deser, Sanderson (2016)
Risk of record-breaking summers in the future

Probability to exceed historical record summer temperature

Lehner, Deser, Sanderson (2016)
Risk of record-breaking summers in the future

Lehner, Deser, Sanderson (2016)
Benefit from climate mitigation

(c) RCP 8.5 – RCP 4.5 2061-2080

Difference in probability

Lehner, Deser, Sanderson (2016)
Land fraction and population exposure

Lehner, Deser, Sanderson (2016)
Land fraction and population exposure

Lehner, Deser, Sanderson (2016)
Bias in summer temperature variability

(a) 1979-2014: model bias in $\sigma$

Simulated $\sigma$ / observed $\sigma$

Lehner, Deser, Sanderson (2016)
Influence of bias in summer temperature variability

Lehner, Deser, Sanderson (2016)
Change in summer temperature variability

(a) RCP 8.5 2061-2080 – 1920-2014

Lehner, Deser, Sanderson (2016)
Influence of change in temperature variability

(a) RCP 8.5 2061-2080 – 1920-2014

(c) RCP 8.5 2061-2080:
model $\sigma$ – model historical $\sigma$

Change in $\sigma$

$[\sigma]$

Difference in probability

$[\%]$
Conclusions

- Risk of record-breaking summer temperatures increases to 80% globally until 2061-2080 under RCP 8.5 (business-as-usual)
- Risk increase is halved under RCP 4.5 (moderate mitigation)
- Population is benefiting disproportionally from mitigation
- Change in temperature variability only marginally affects these results
- Results are robust globally, despite regional model biases in representation of temperature variability
Conclusions

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Lehner, F., C. Deser, B. M. Sanderson (in press):
Future risk of record-breaking summer temperatures and its mitigation
Climatic Change (BRACE Special Issue)
Benefit from climate mitigation

Lehner, Deser, Sanderson (2016)
Model bias in summer temperature

(a) 1979-2014: model bias in $\sigma$

Simulated $\sigma$ / observed $\sigma$

0.33 0.5 0.8 1 1.25 1.5 2 3
Influence of model bias

(a) 1979-2014: model bias in $\sigma$

(b) RCP 8.5 2061-2080: model historical $\sigma$ – observed $c$
Influence of changes in variability

(a) RCP 8.5 2061-2080: model $\sigma$ – model historical $\sigma$
Next steps: non-linearities and process understanding

c) RCP 8.5 - RCP 4.5: 2061-2080

sign. landarea = 19.87%

Change in $\sigma$
Next steps: non-linearities and process understanding

New Delhi, India

Cape Town, South Africa

Zurich, Switzerland

Moscow, Russia

- Black: obs (n=95)
- Gray: hist (n=1425)
- Blue: rcp45 (n=300)
- Red: rcp85 (n=300)
- Green: aerosol (n=280)
Next steps: non-linearities and process understanding

Summer warming normalized by global mean