

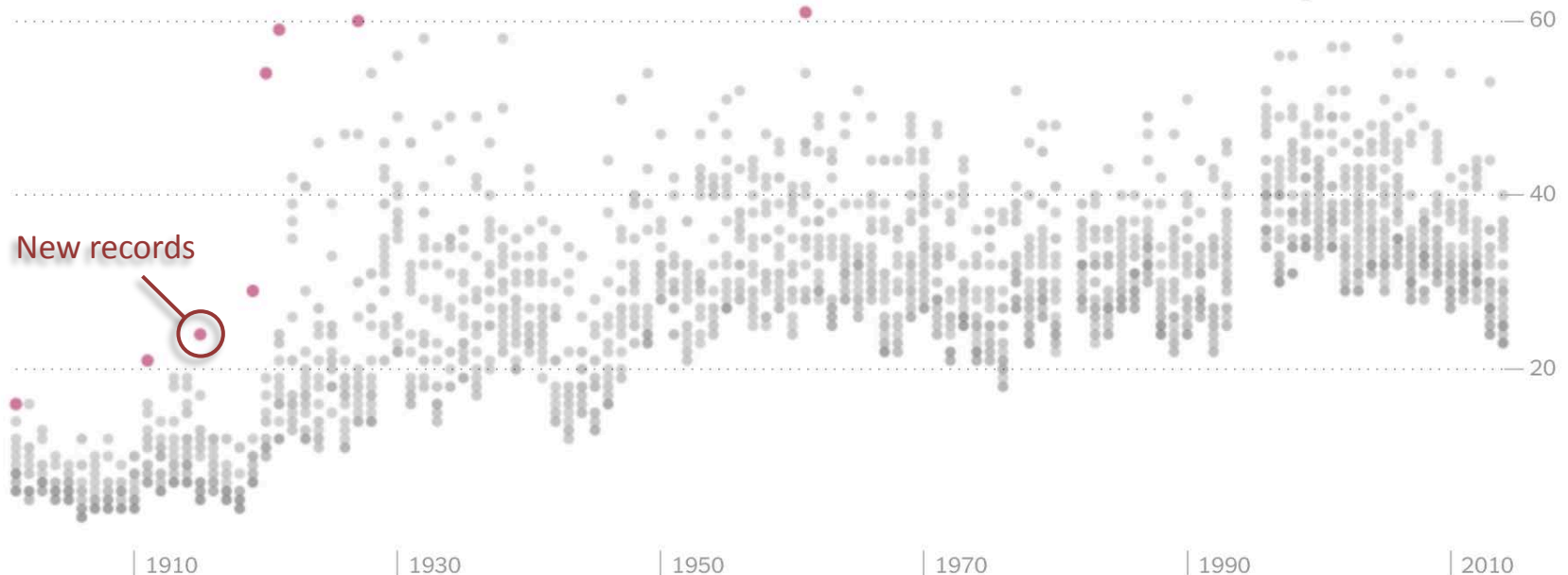
# Increasing risk of record-breaking summer temperatures in the future and the potential for mitigation

Flavio Lehner, Clara Deser, Benjamin Sanderson

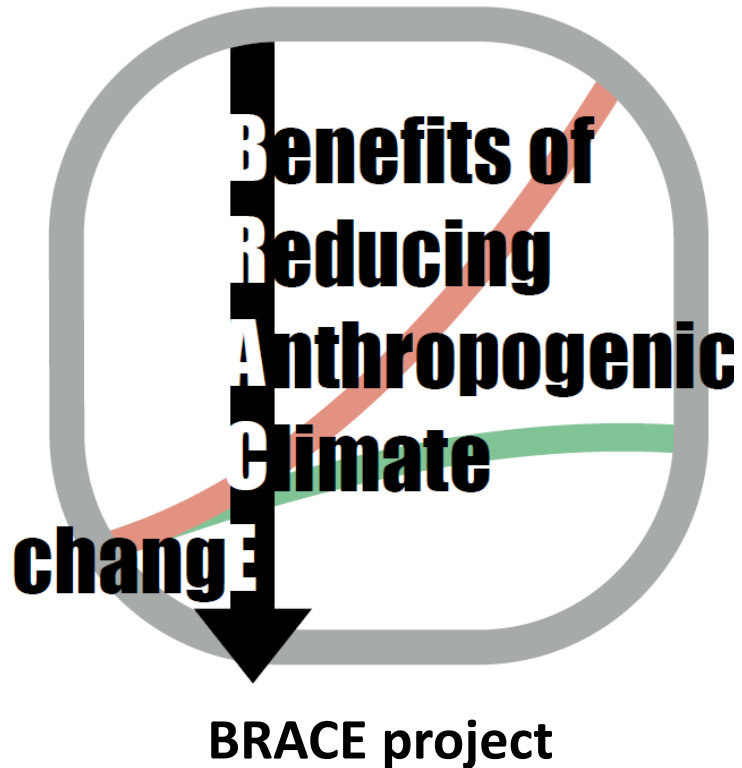
*Climate and Global Dynamics Lab, NCAR*

Barry Bonds, 2001 **73**

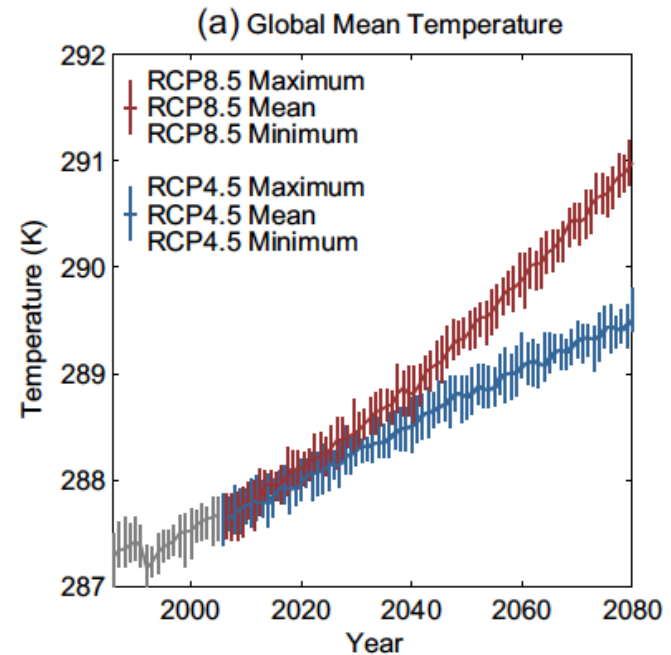
Home runs per season



# 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?



# Record summer temperatures

**What's the probability of exceeding the historical record summer temperature?**

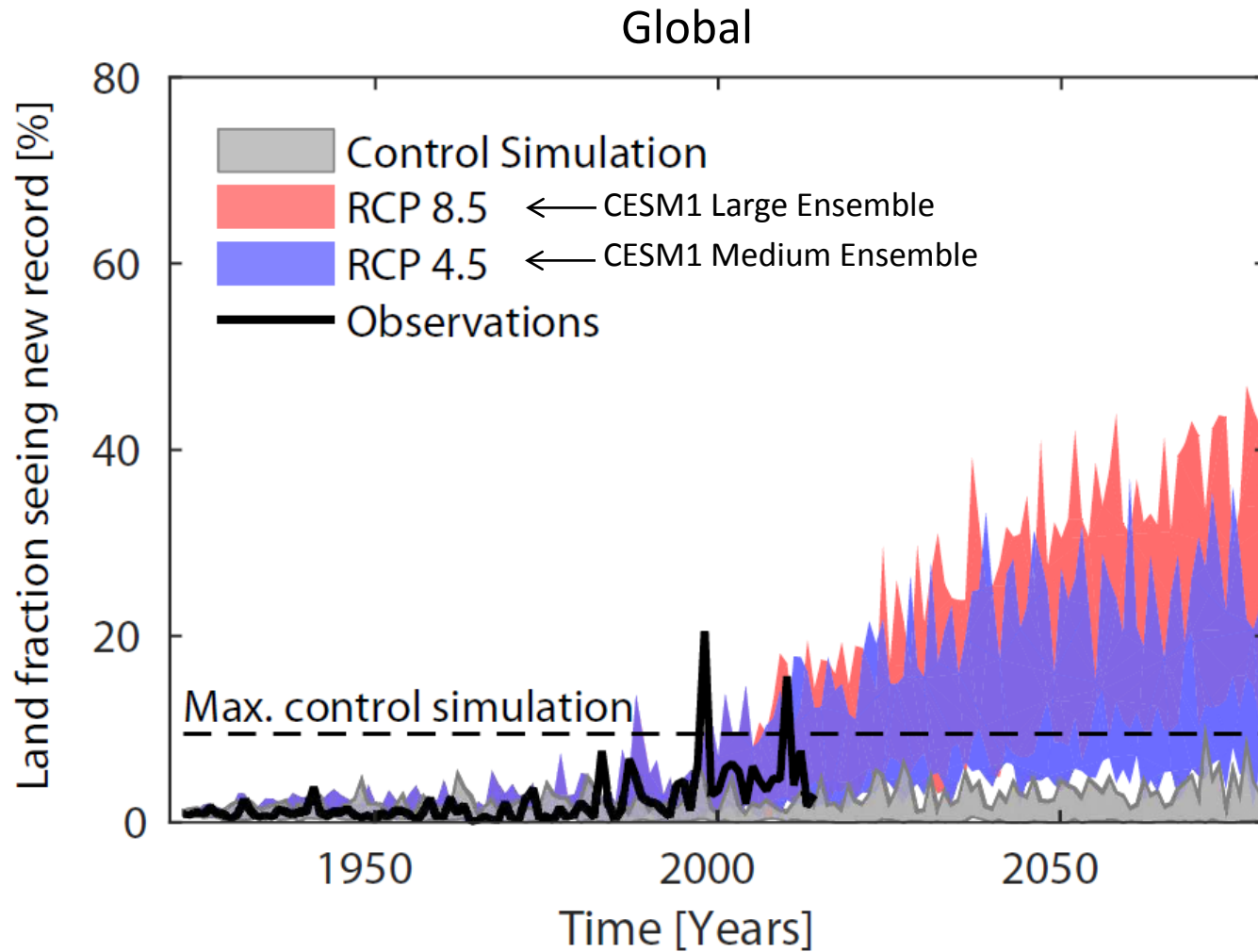
**Why does it matter?**

[Battisti & Naylor \(2009, Science\)](#)

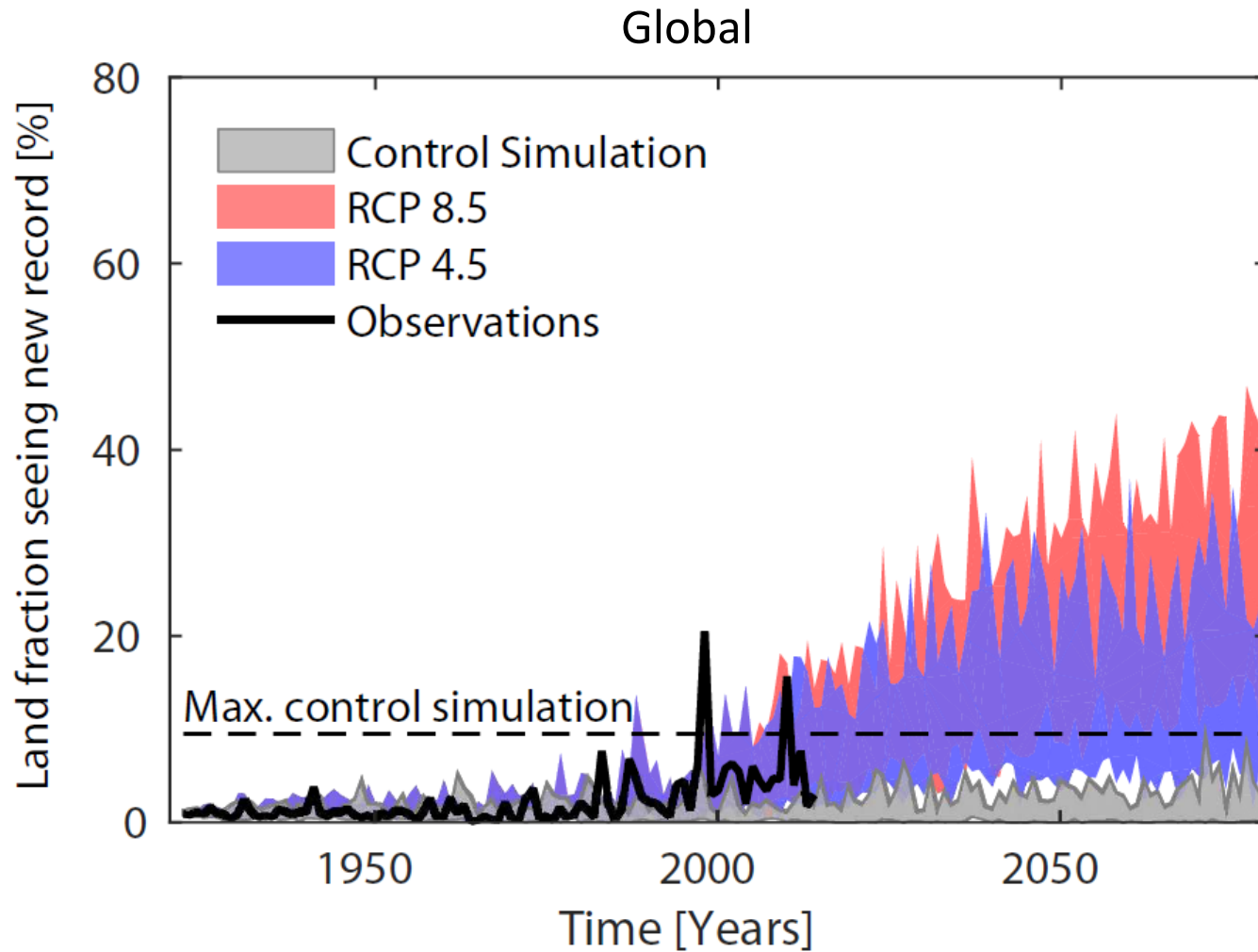
Does the probability scale with the emissions scenario?

What role does temperature variability play?

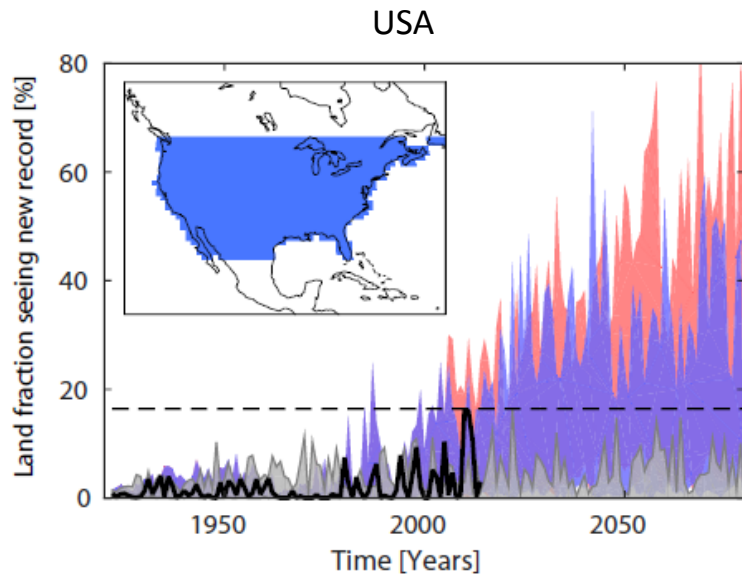
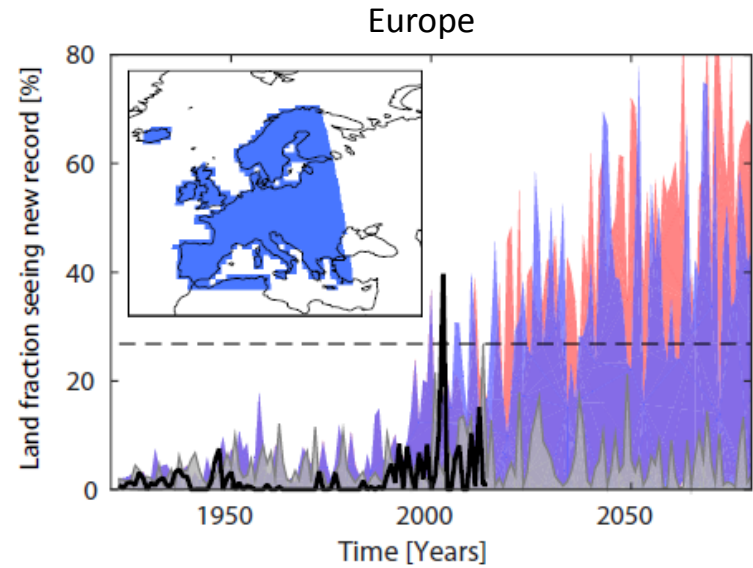
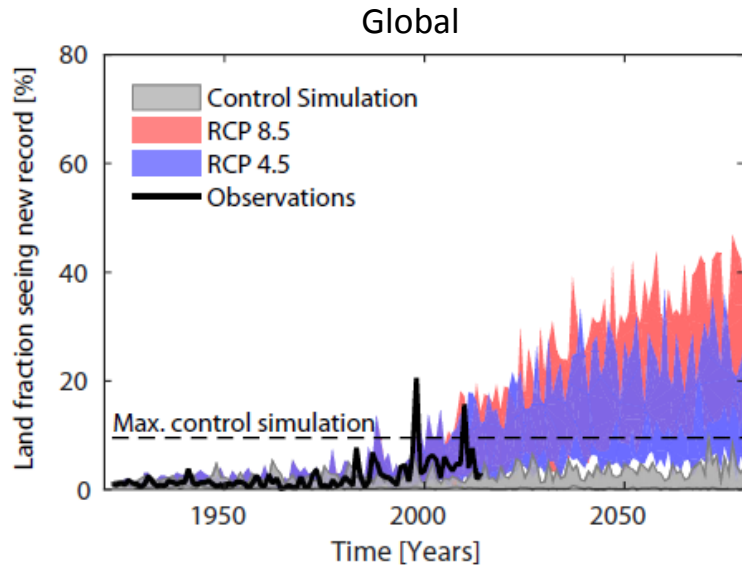
# How often do we see a record? How „large“ is it?



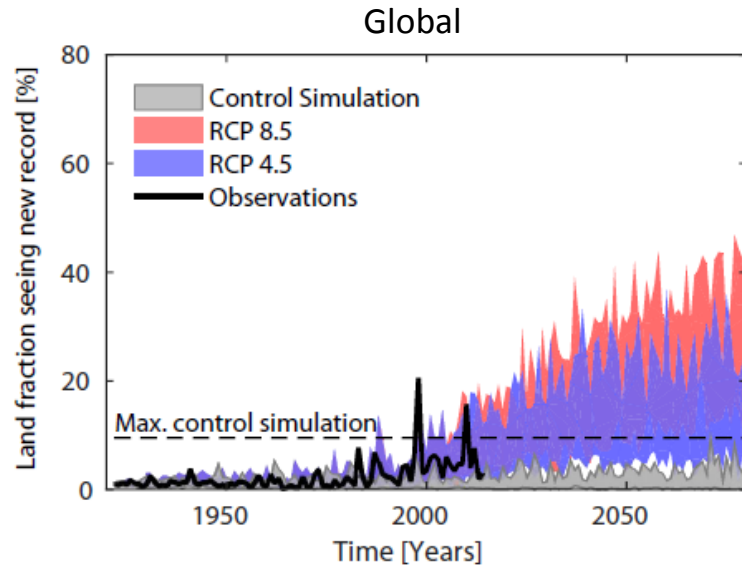
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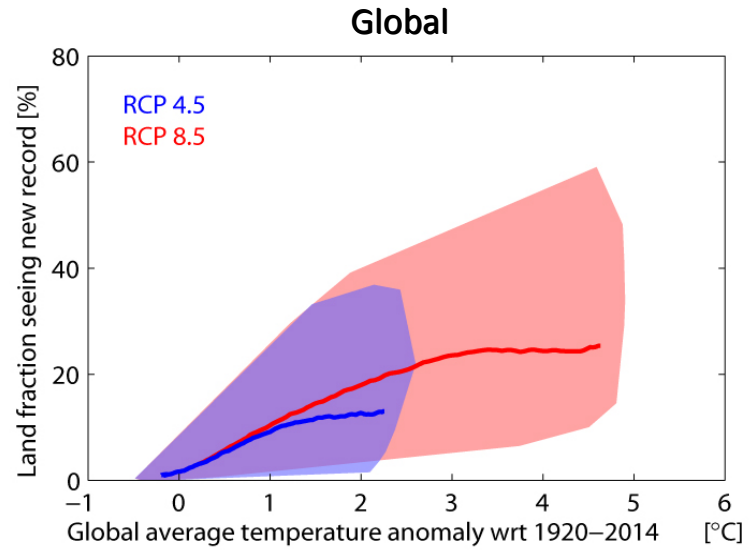
# How often do we see a record? How “large” is it?



# How often do we see a record? How “large” is it?



# Records and the mean state



Risk?

Risk?



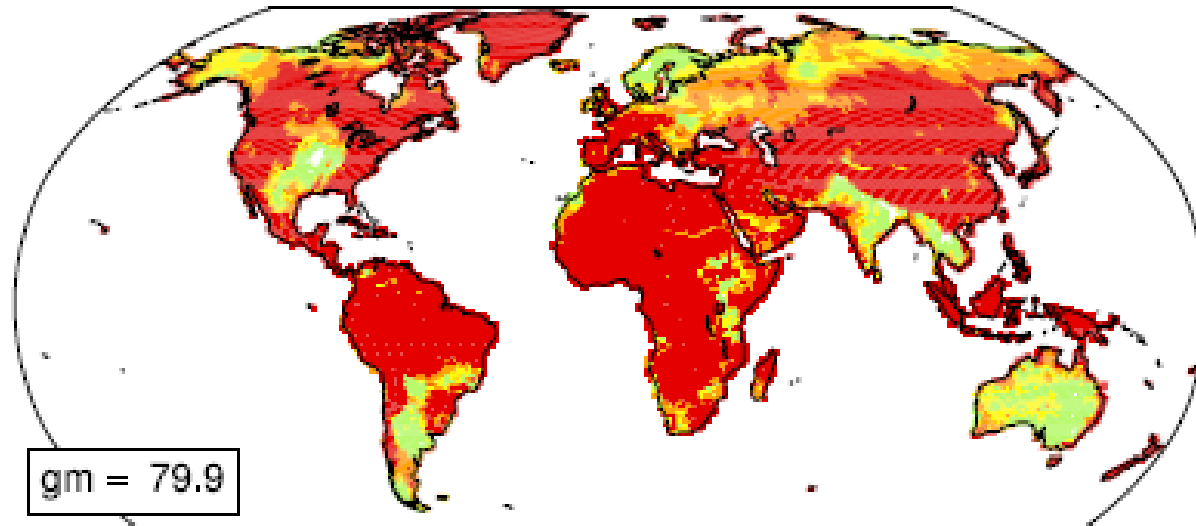
# Risk of record-breaking summers in the future



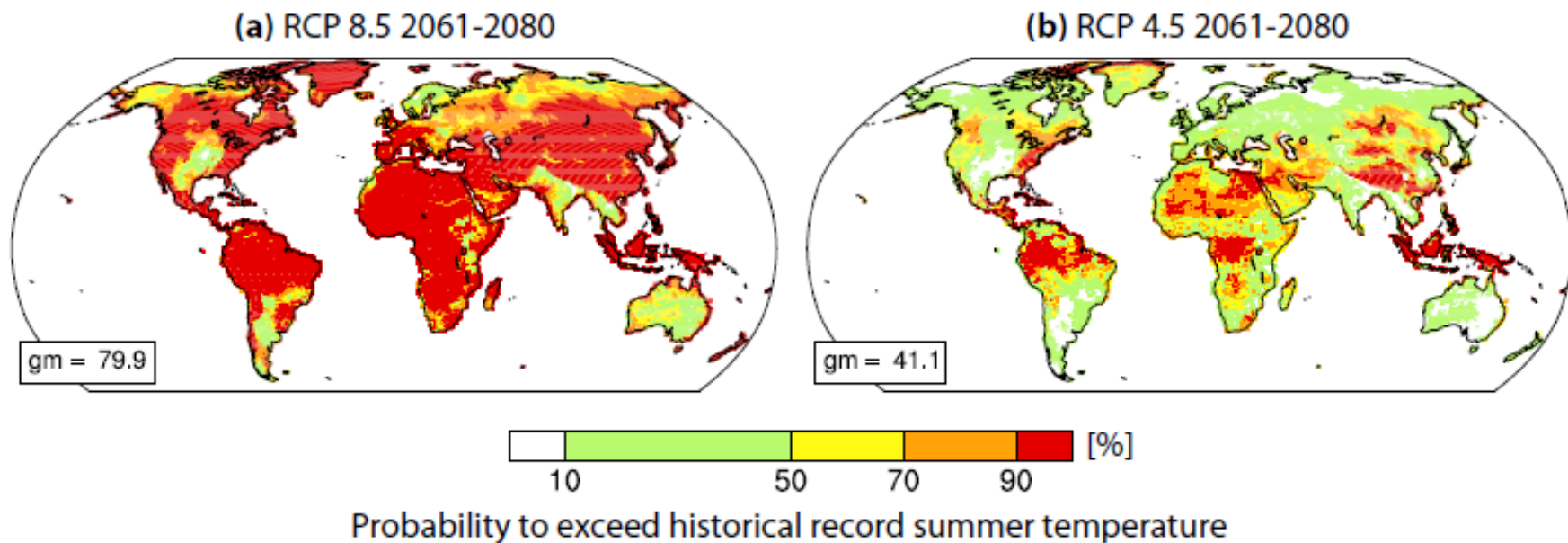
Probability to exceed historical record summer temperature

# Risk of record-breaking summers in the future

(a) RCP 8.5 2061-2080

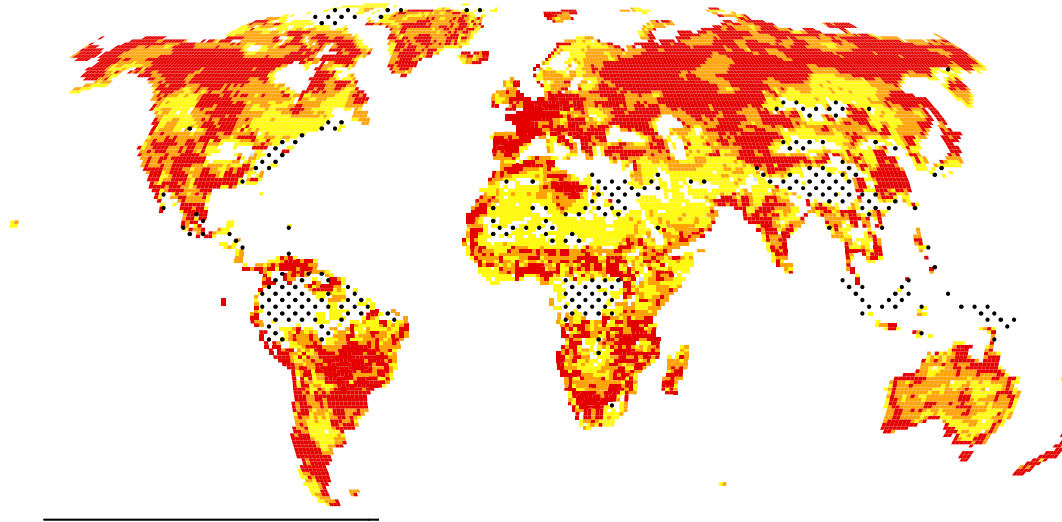


# Risk of record-breaking summers in the future



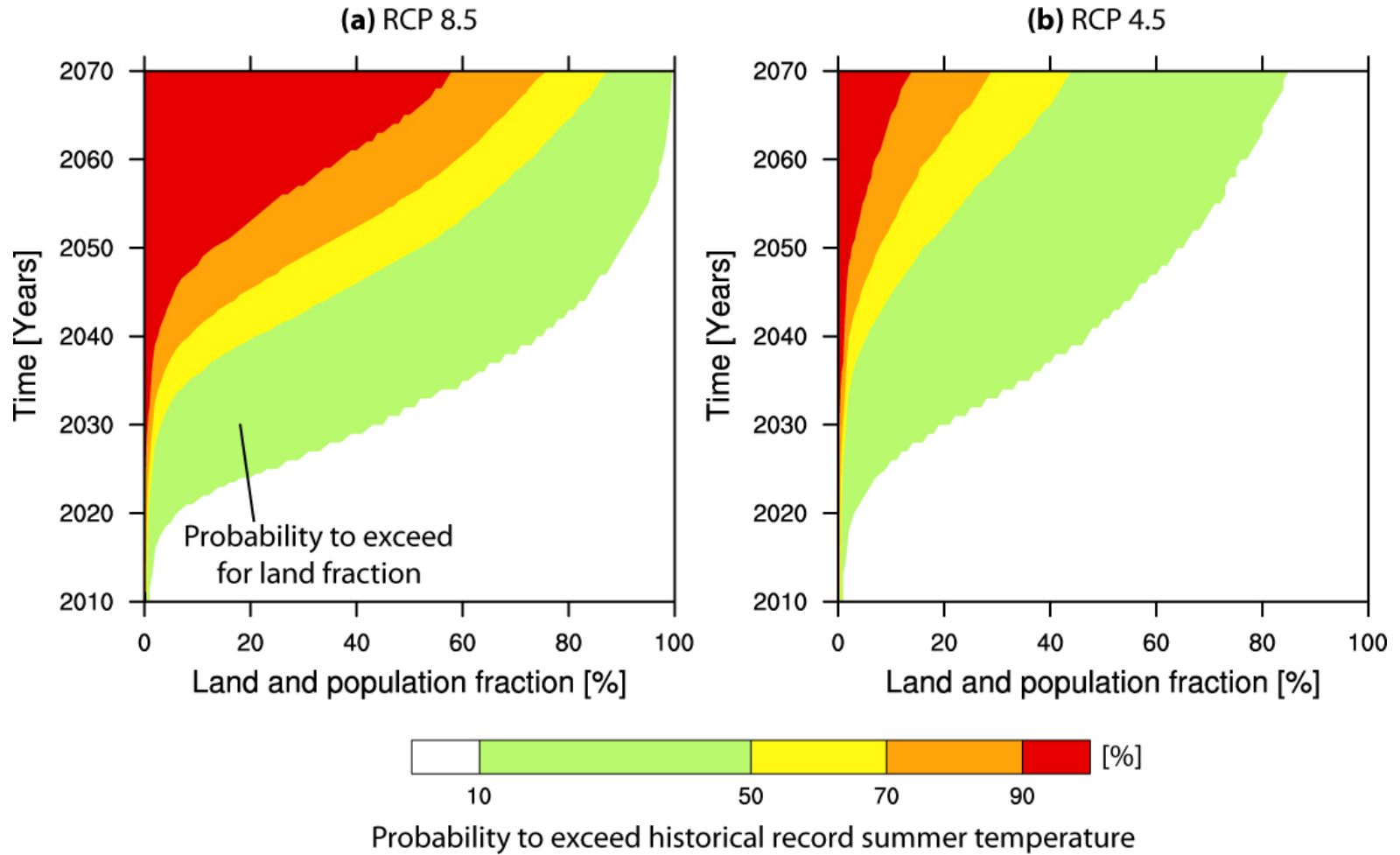
# Benefit from climate mitigation

(c) RCP 8.5 – RCP 4.5 2061-2080

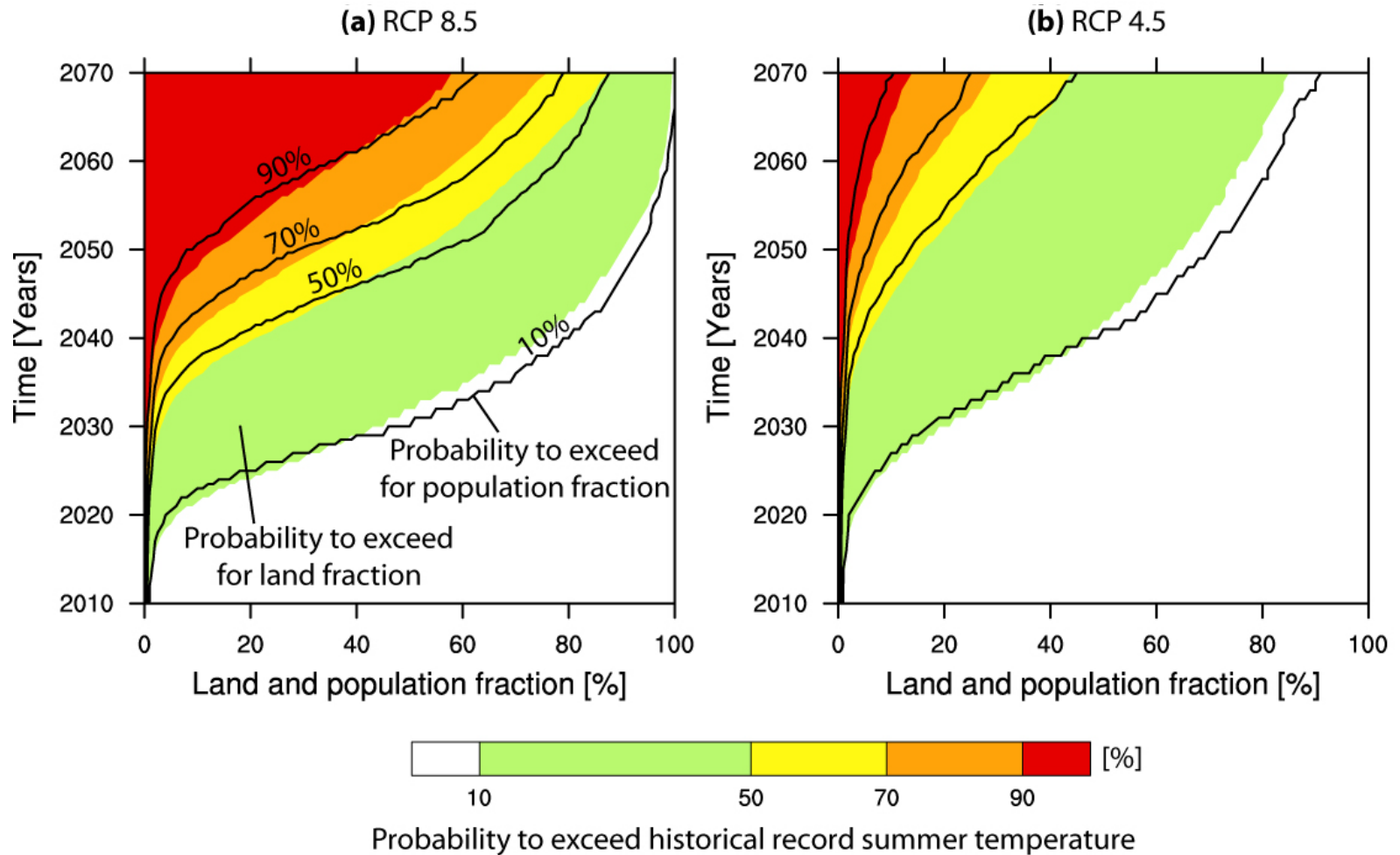


Difference in probability

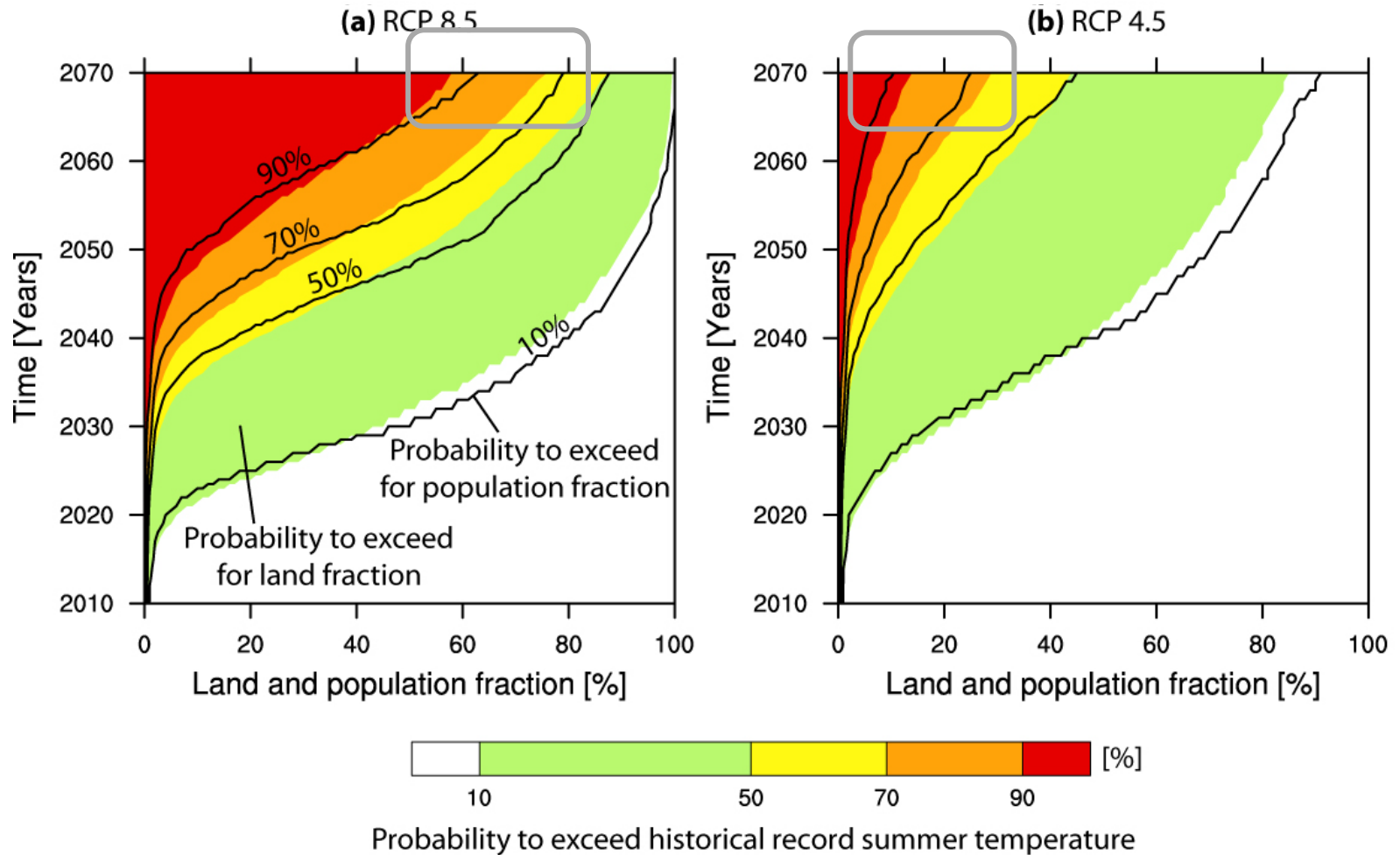
# Land fraction and population exposure



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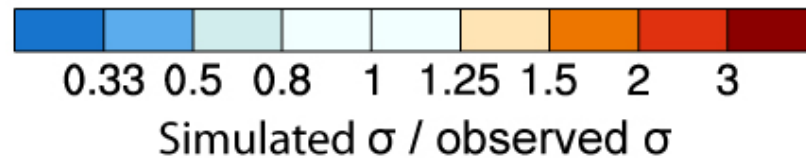
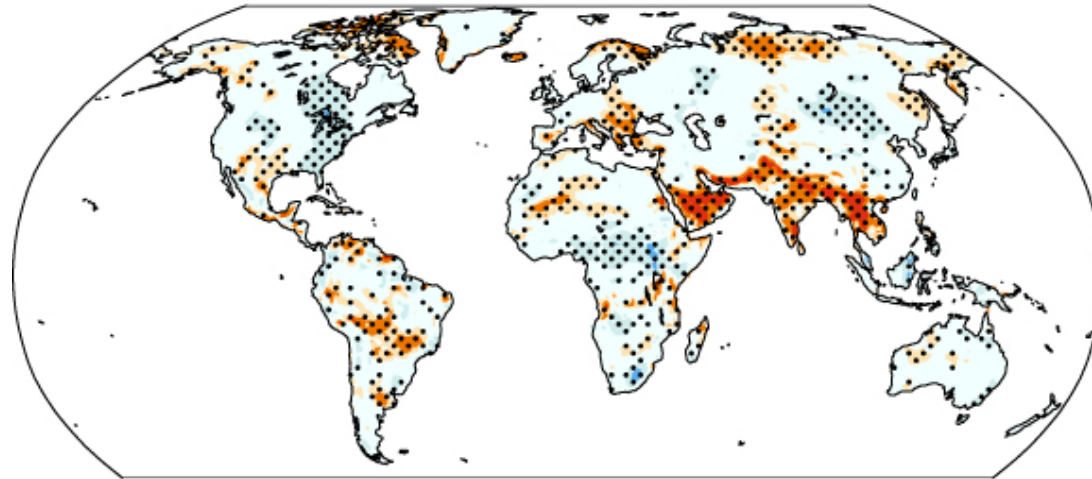


# Land fraction and population exposure



# Bias in summer temperature variability

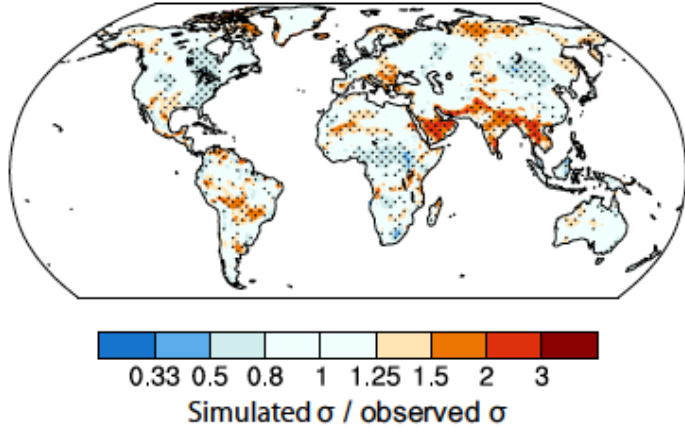
(a) 1979-2014: model bias in  $\sigma$



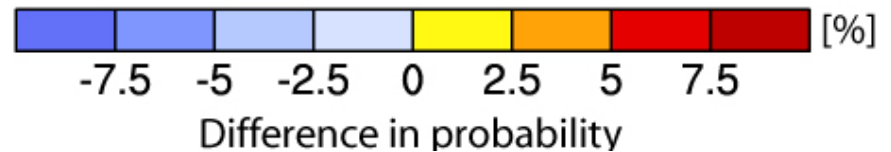
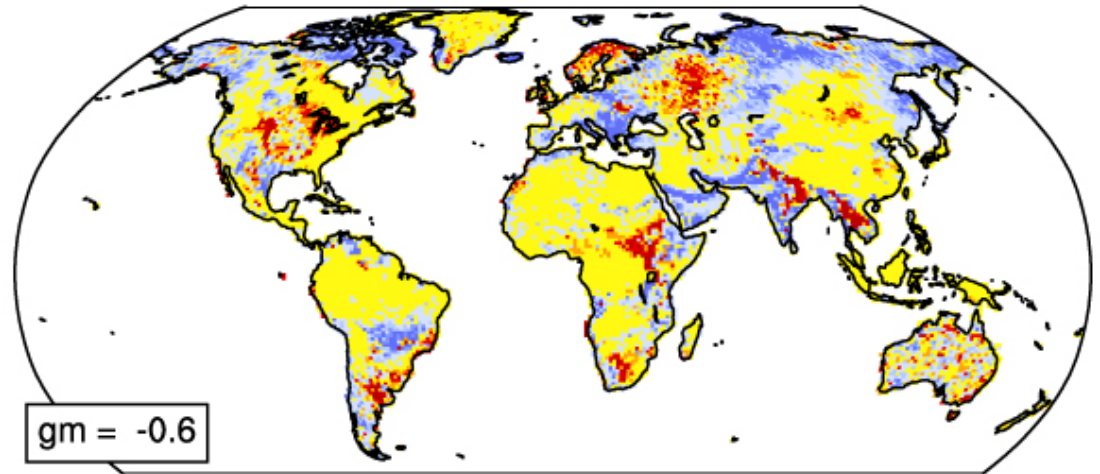


# Influence of bias in summer temperature variability

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



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



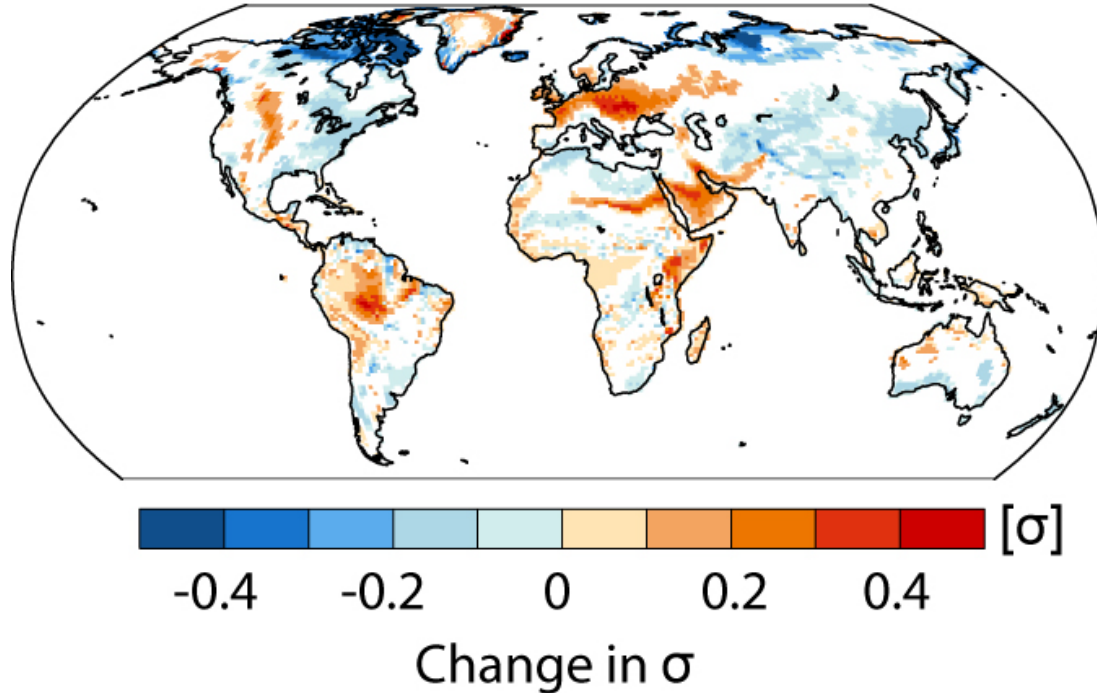
Risk underestimated



Risk overestimated

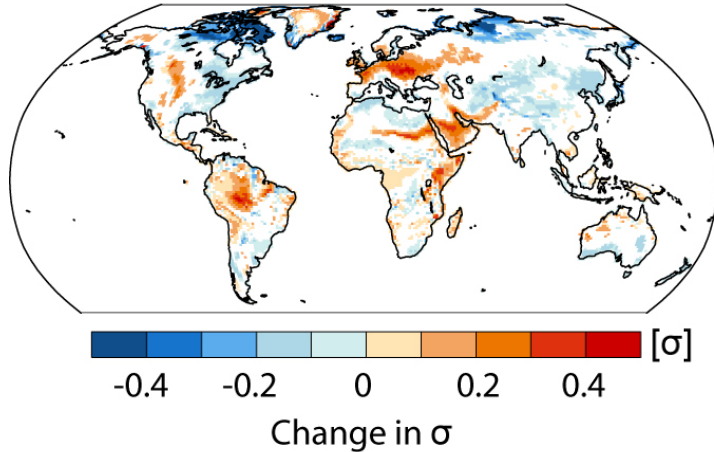
# Change in summer temperature variability

(a) RCP 8.5 2061-2080 – 1920-2014

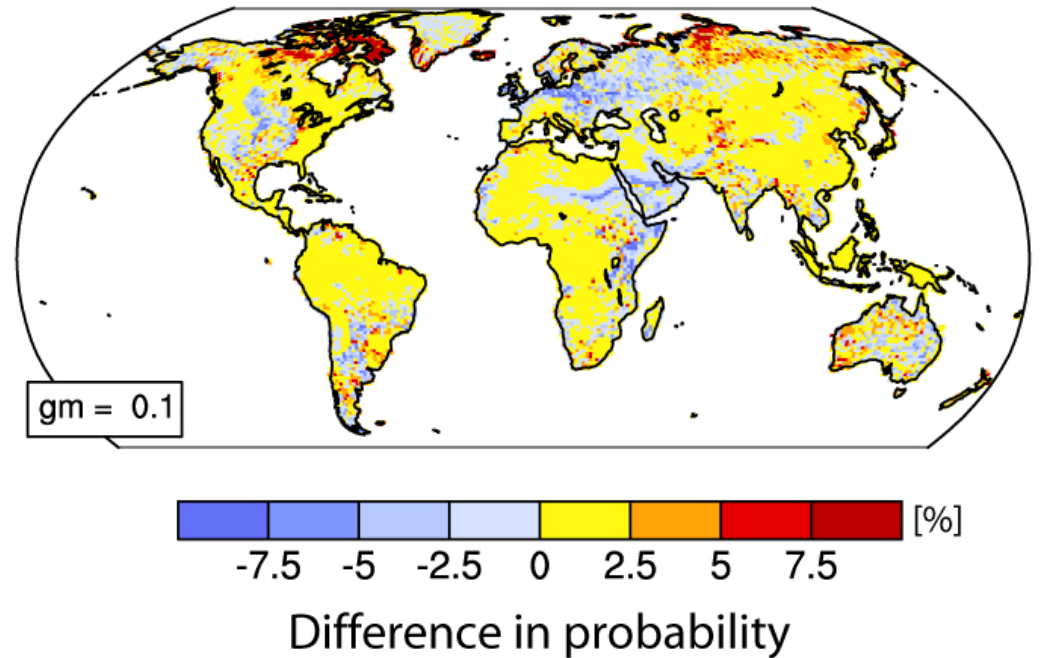


# Influence of change in temperature variability

(a) RCP 8.5 2061-2080 – 1920-2014



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



# 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 disproportionately from mitigation
- Change in temperature variability only marginally affects these results
- Results are robust globally, despite regional model biases in representation of temperature variability

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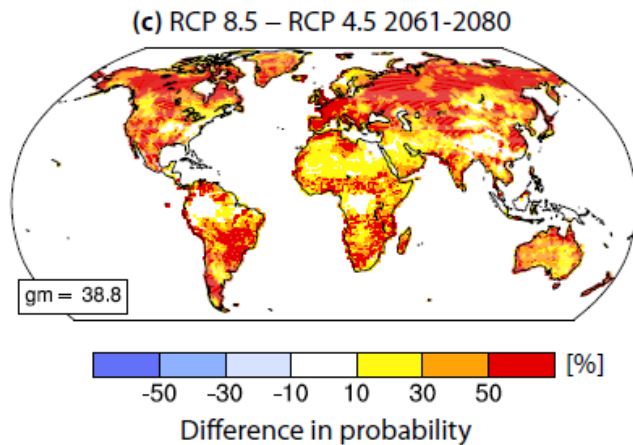
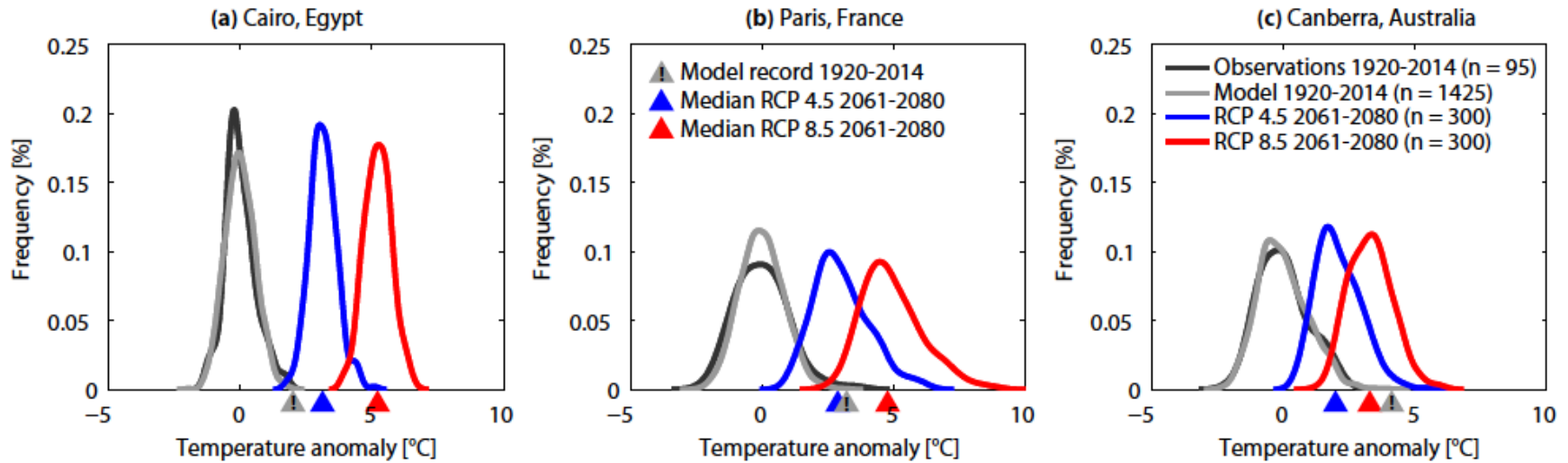
→ Lehner, F., C. Deser, B. M. Sanderson (in press):  
Future risk of record-breaking summer temperatures and its mitigation  
*Climatic Change (BRACE Special Issue)*

Thank you



Death Valley 2015

# Benefit from climate mitigation

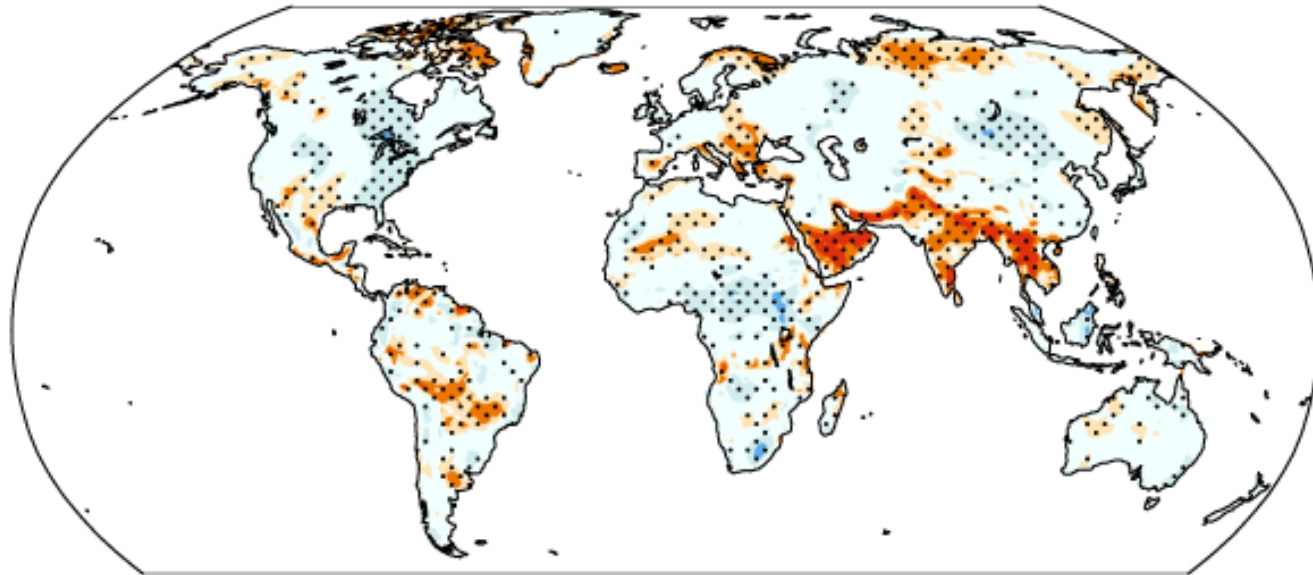






# Model bias in summer temperature

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

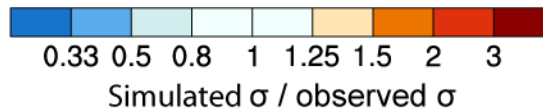
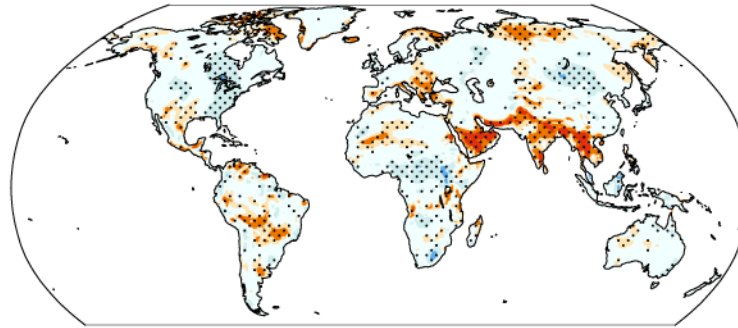


0.33 0.5 0.8 1 1.25 1.5 2 3

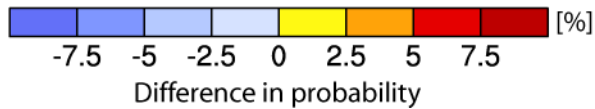
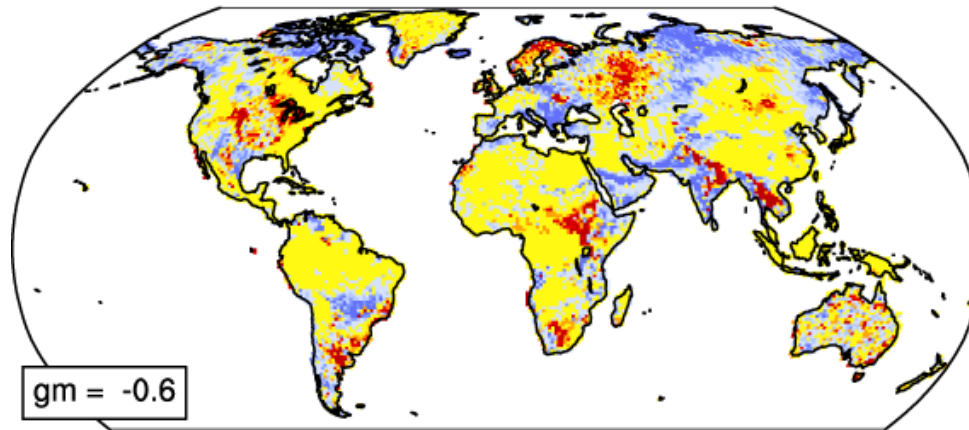
Simulated  $\sigma$  / observed  $\sigma$

# Influence of model bias

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



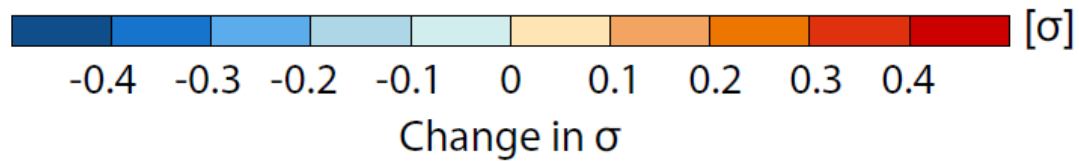
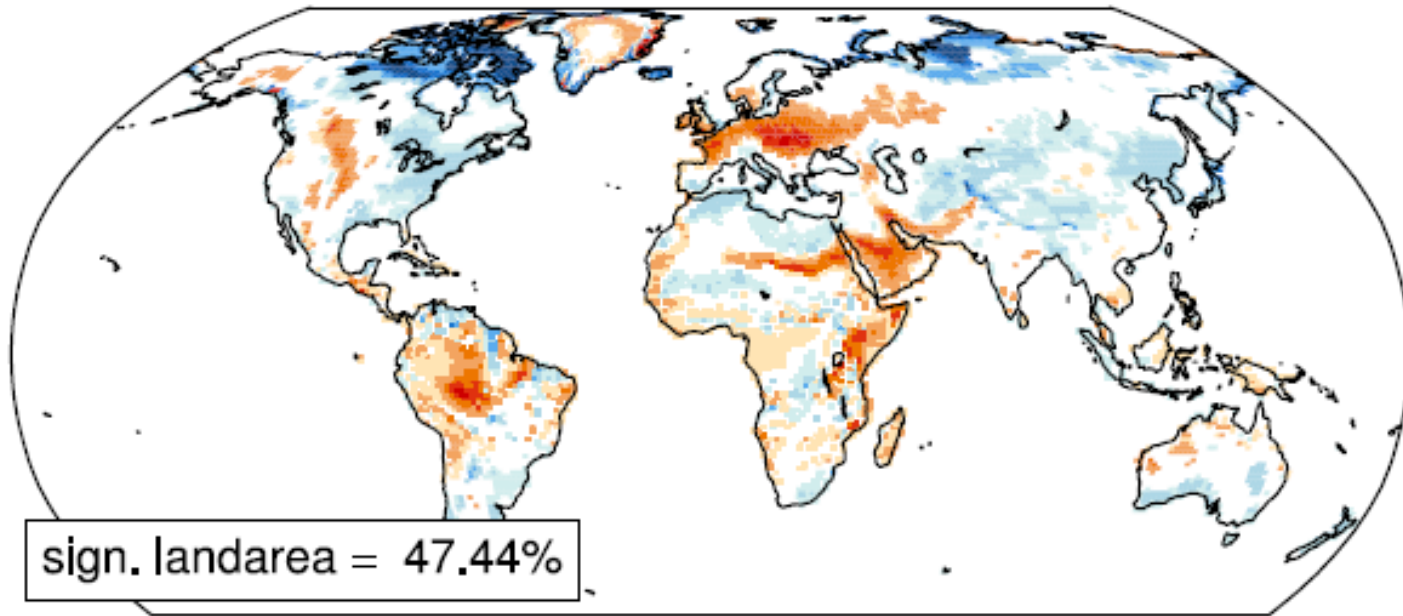
(b) RCP 8.5 2061-2080: model historical  $\sigma$  – observed  $\sigma$





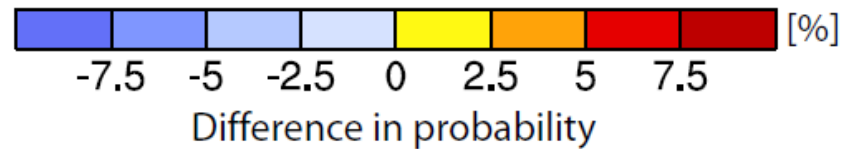
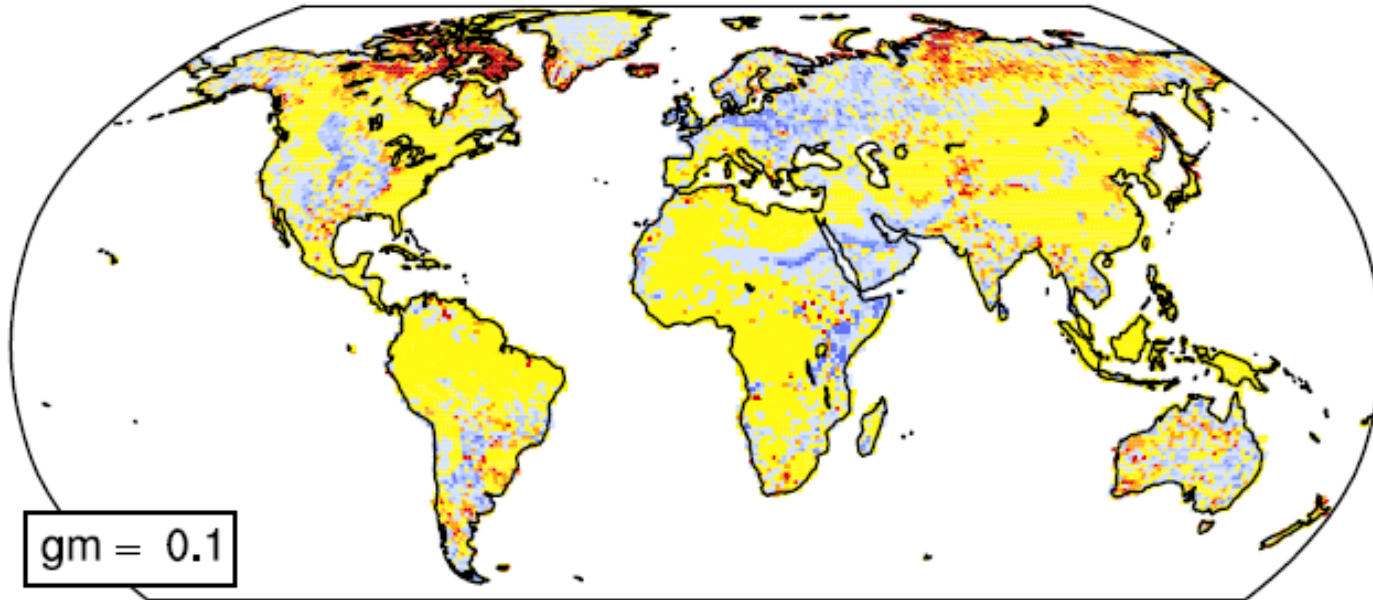
# Changes in variability

**(a)** RCP 8.5 2061-2080 – 1920-2014

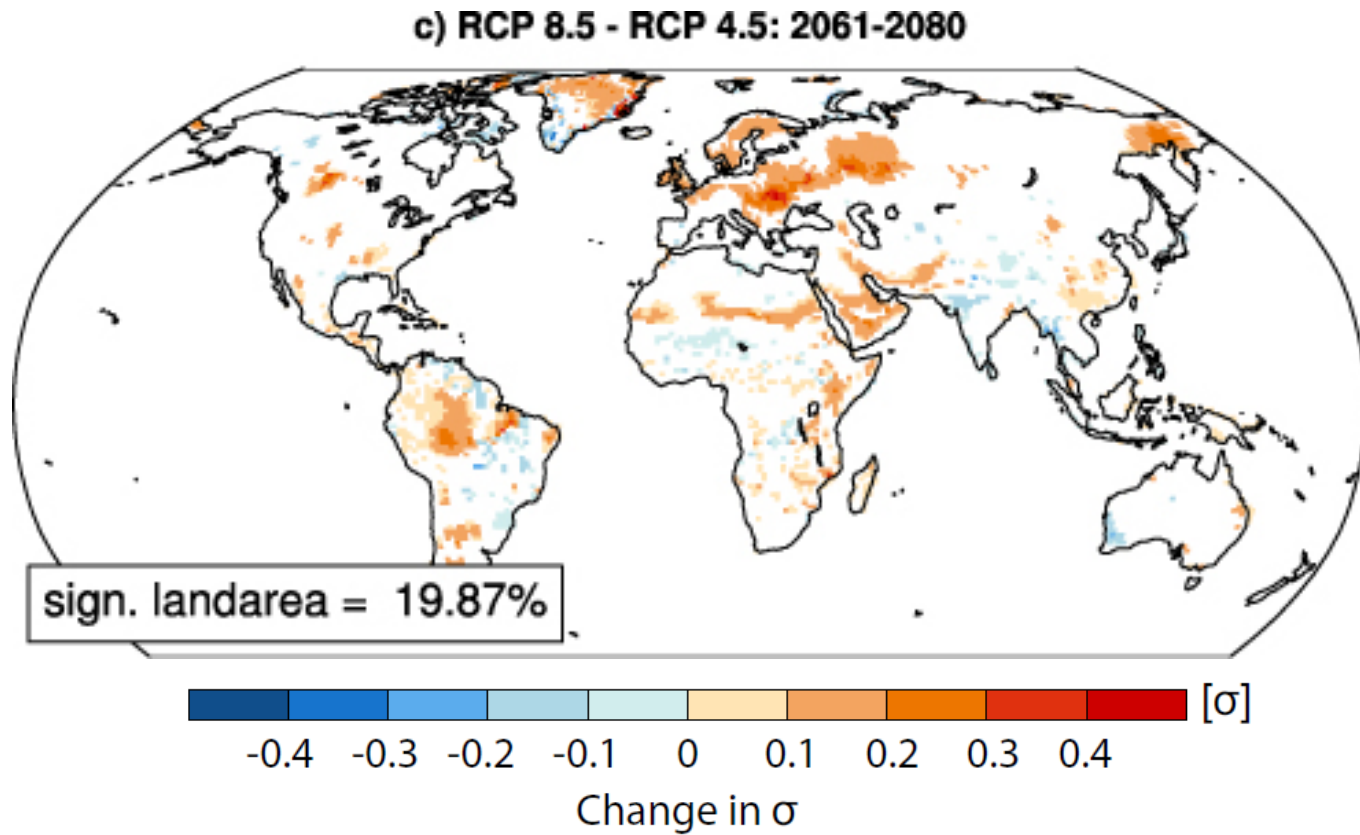


# Influence of changes in variability

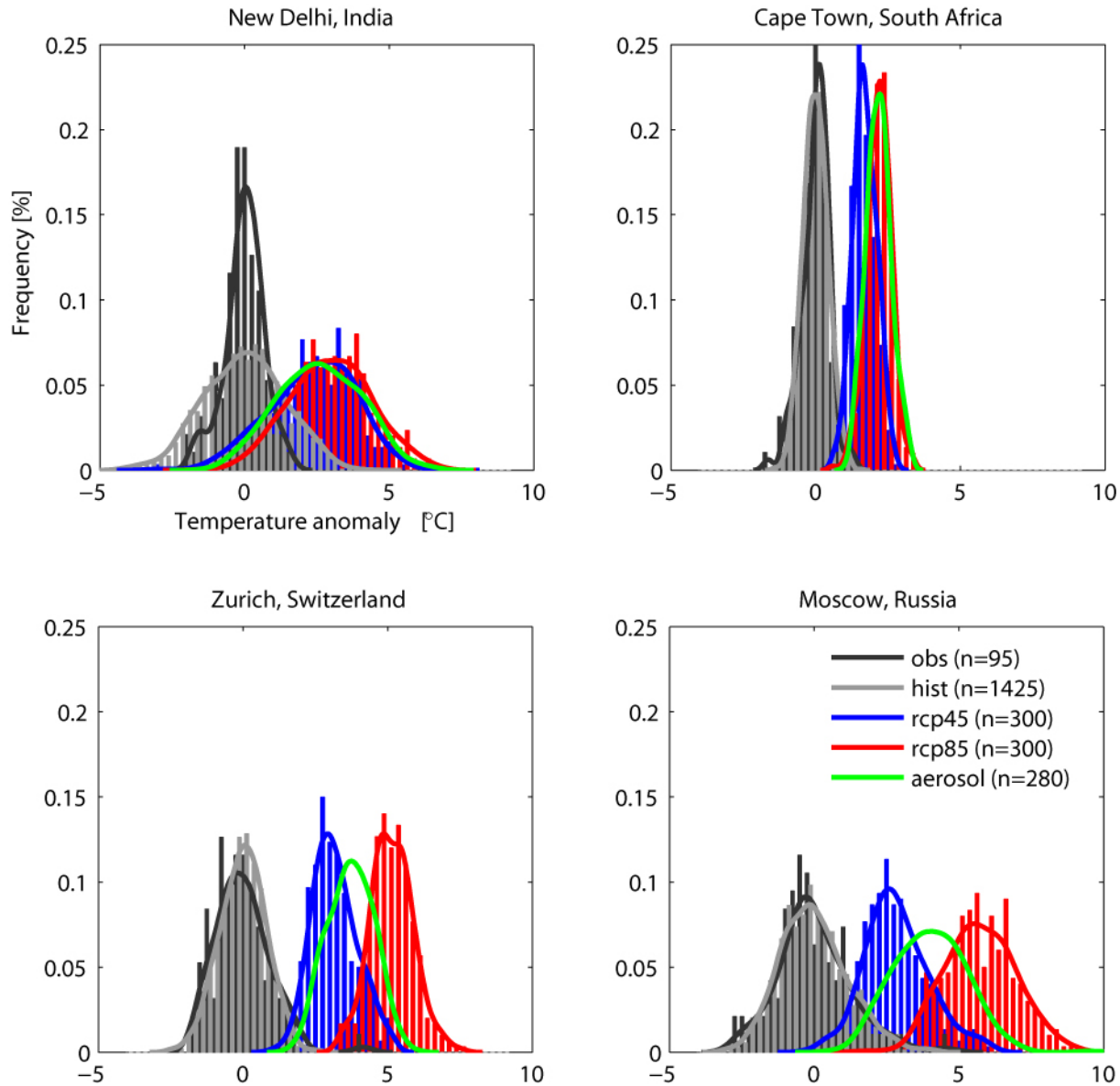
(a) RCP 8.5 2061-2080: model  $\sigma$  – model historical  $\sigma$



## Next steps: non-linearities and process understanding



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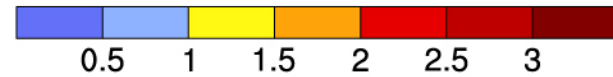
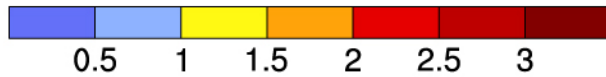
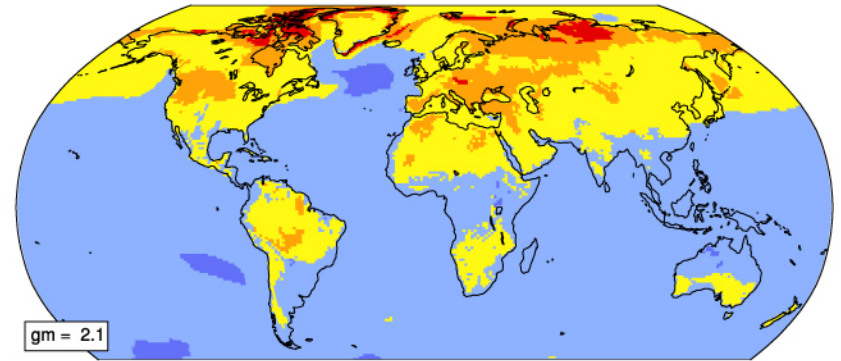
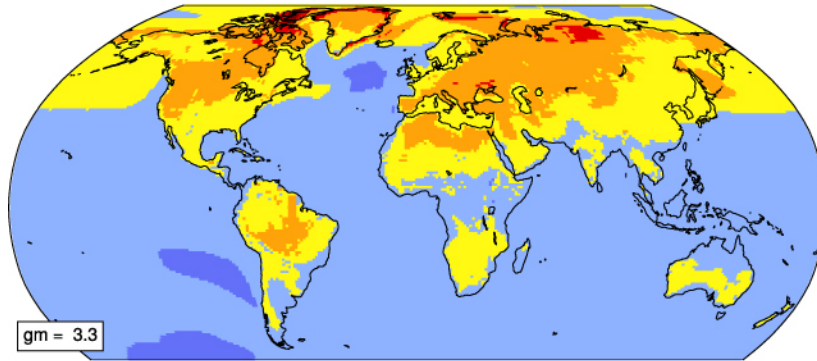


# Next steps: non-linearities and process understanding

## Summer warming normalized by global mean

RCP 8.5 2061-2080

RCP 4.5 2061-2080



RCP 8.5 - RCP 4.5 2061-2080

