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# Extremely hot or not?

Divergent projections for precipitation in  
Central Europe explain uncertainties in  
extreme temperatures

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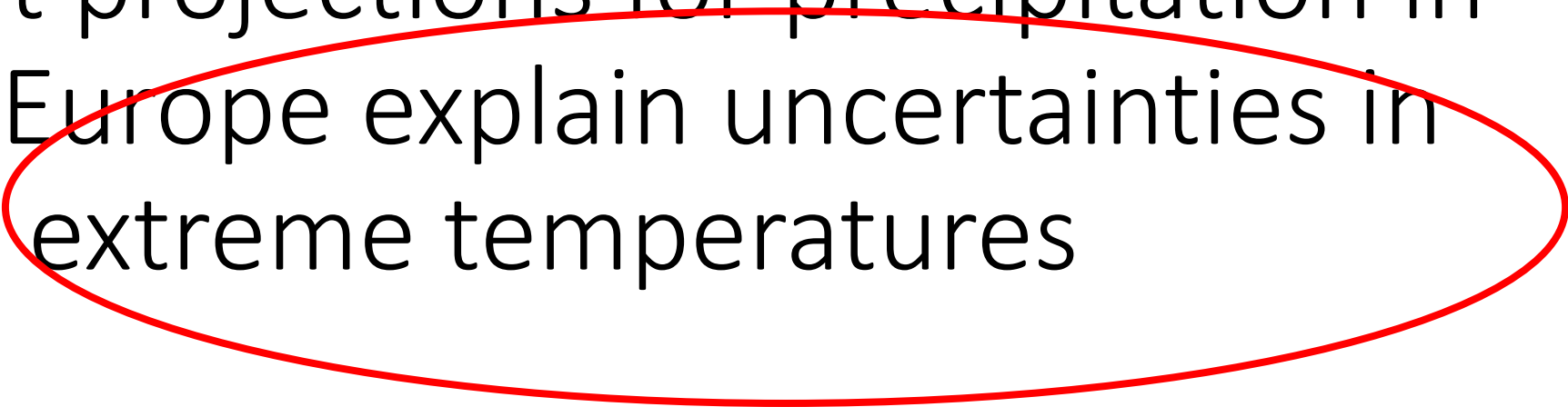
[martha.vogel@env.ethz.ch](mailto:martha.vogel@env.ethz.ch)

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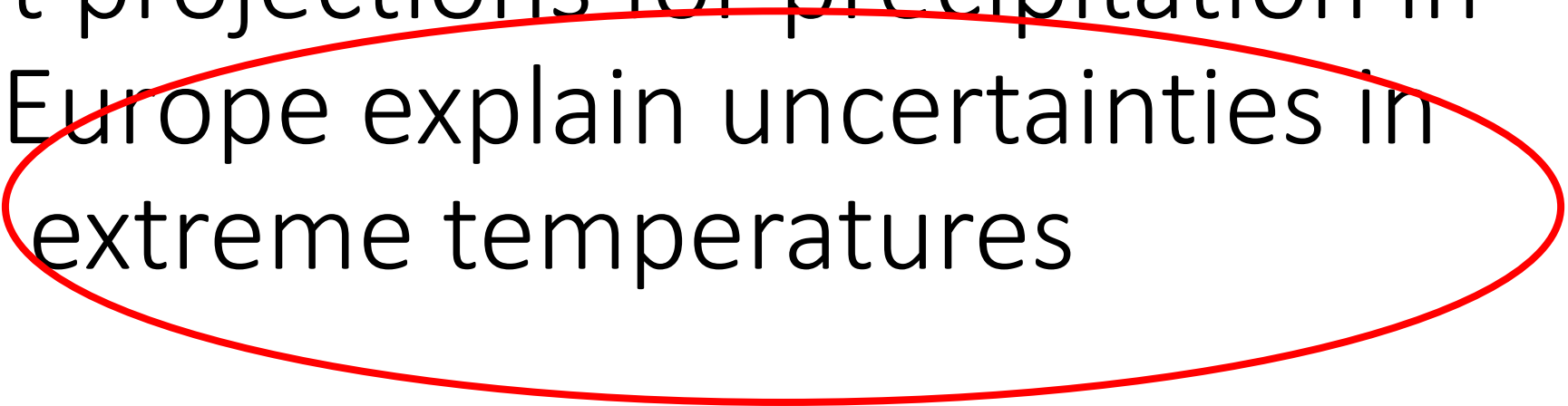
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Divergent projections for precipitation in  
Central Europe explain uncertainties in  
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(e.g. Borodina et al. 2017, Donat et al. 2017, Sippel et al. 2017)

1. Which underlying processes in models cause the large spread and increase in extreme temperature projections in Central Europe?

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2. Can we then constrain extreme temperature projections in Central Europe?

# Data and Methods

CMIP5 ensemble (Taylor et al. 2012)

- 23 models, 1-10 ensemble members
- Emission scenario RCP8.5
- Resolution: 2.5°x2.5°



CMIP5 ensemble (Taylor et al. 2012)

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- Resolution:  $2.5^{\circ} \times 2.5^{\circ}$

Time period: 1950-2100

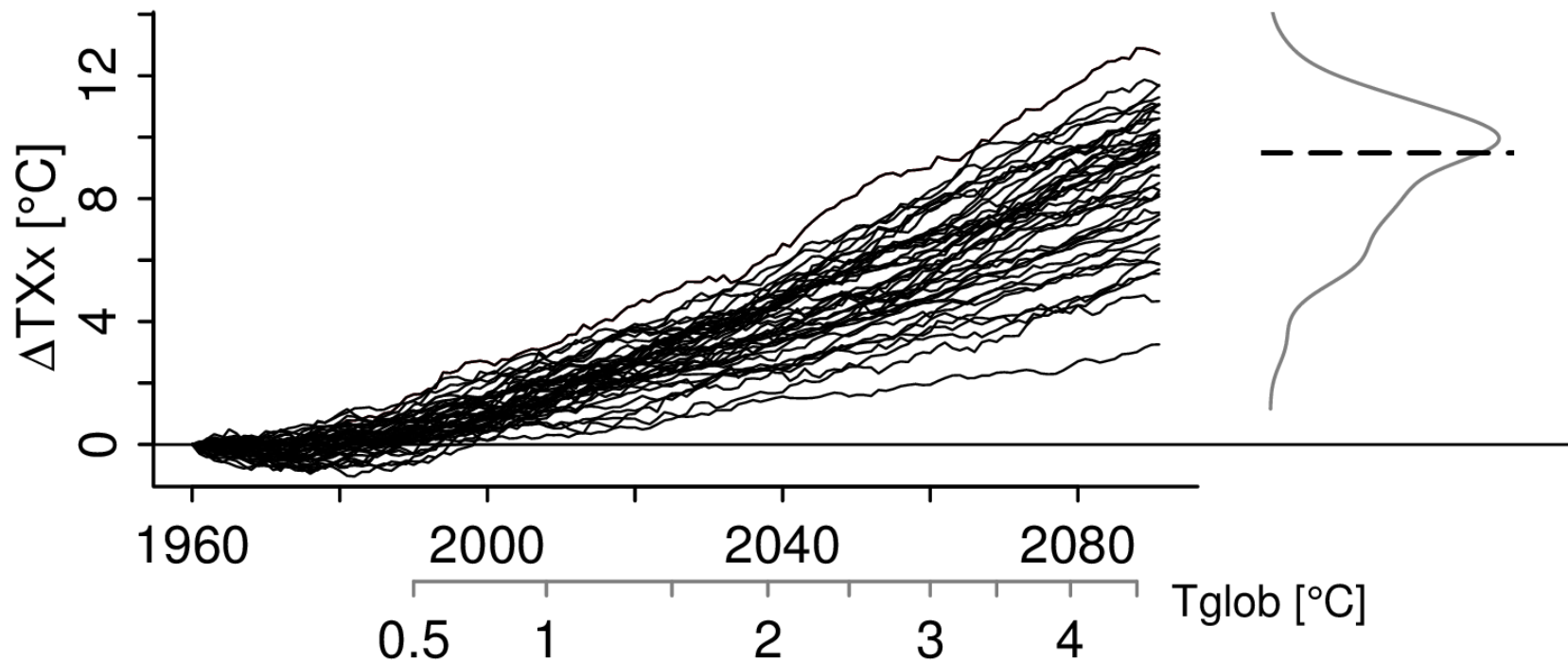
Hottest day of a year (TXx)

Summer months (JJA) for other variables

Central European Domain (SREX, 2012)



# Results



Central Europe

20-year running means

Base period: 1950-1969

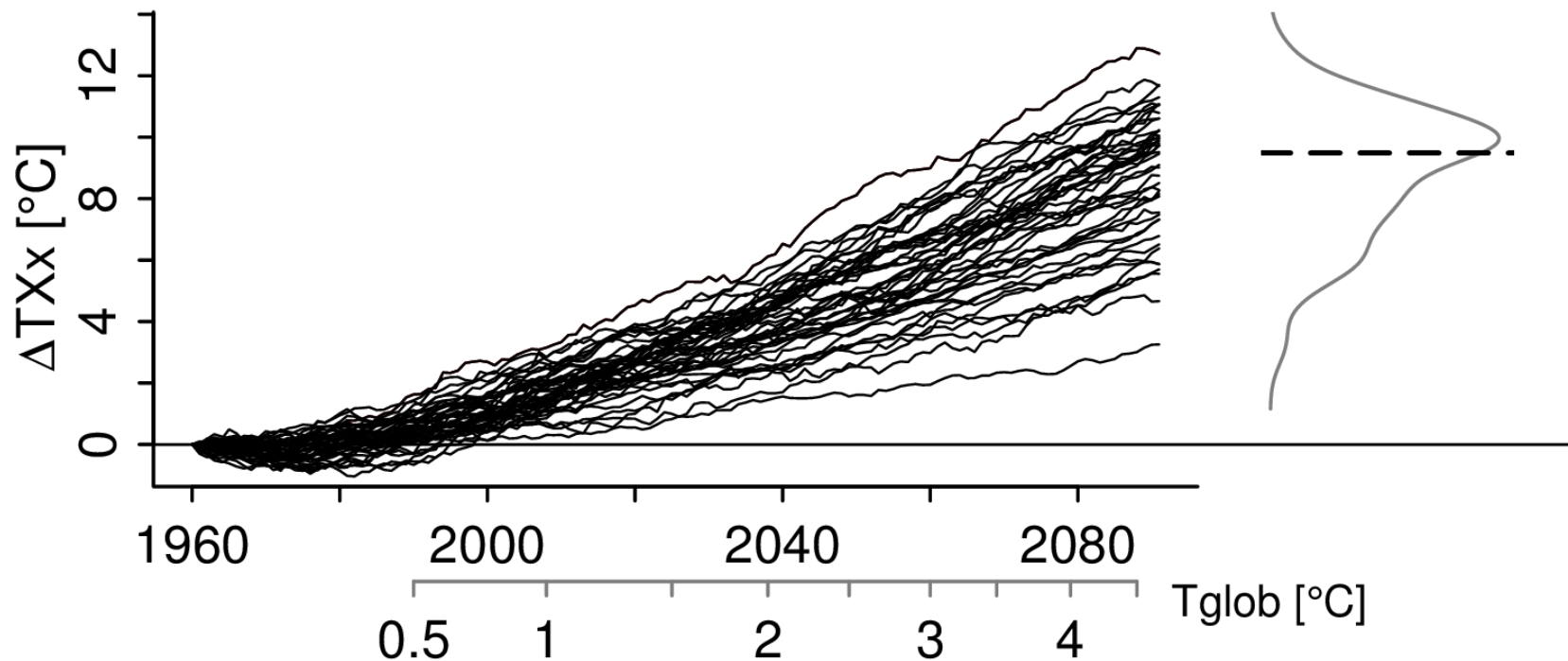
Distribution: 2081-2100

Motivation

Methods

Results

Summary



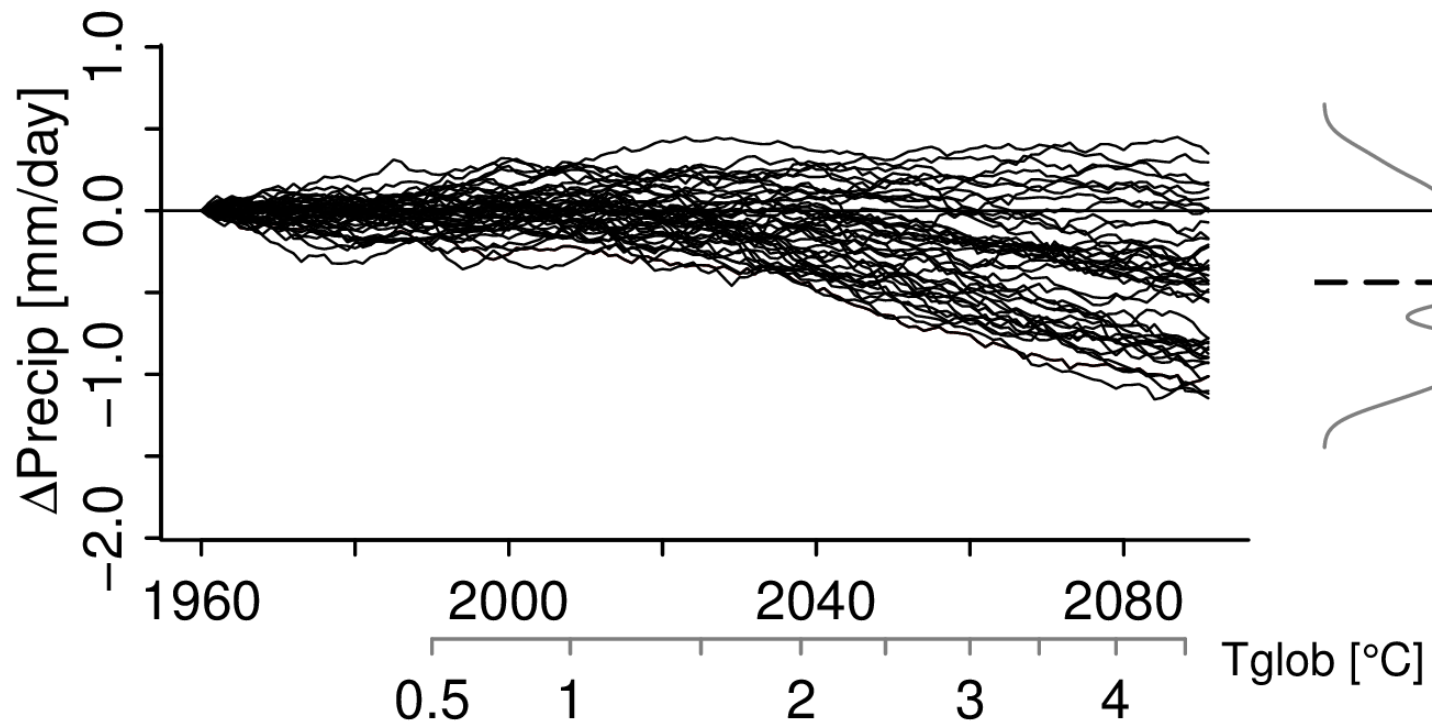
Central Europe

20-year running means

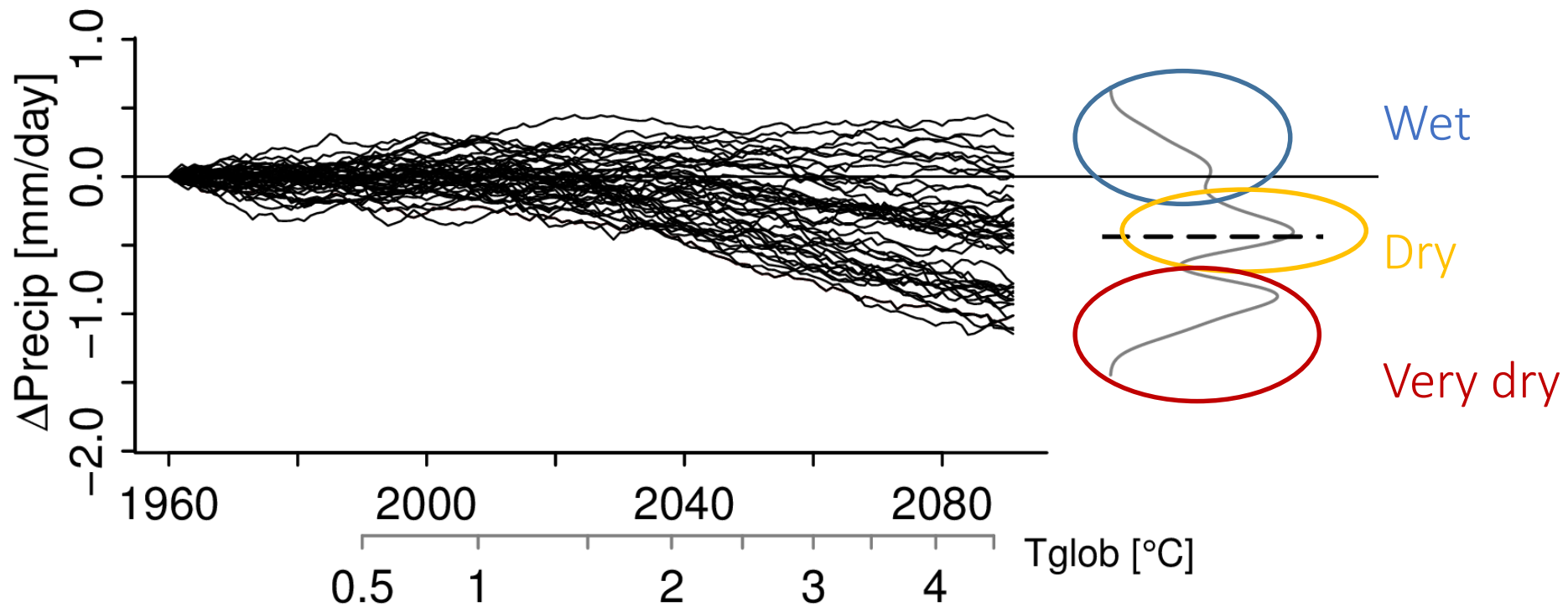
Base period: 1950-1969

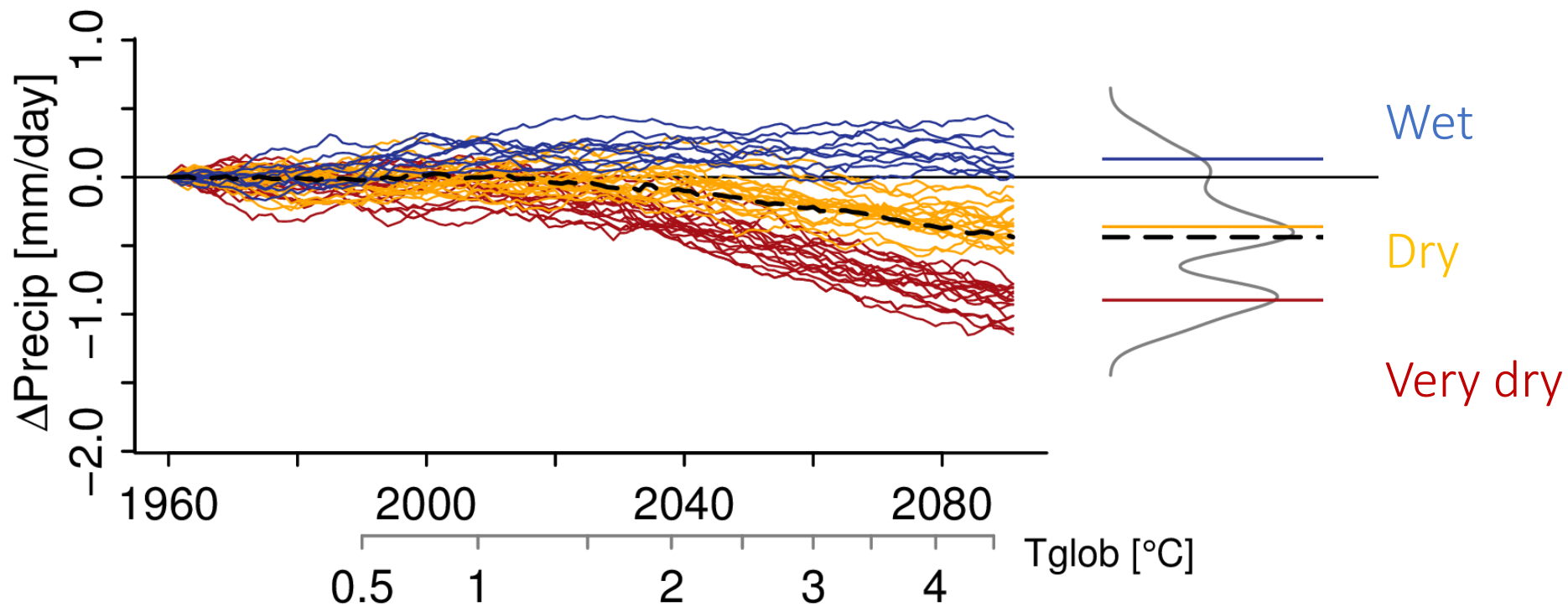
Distribution: 2081-2100

Strong and continuous  
increase

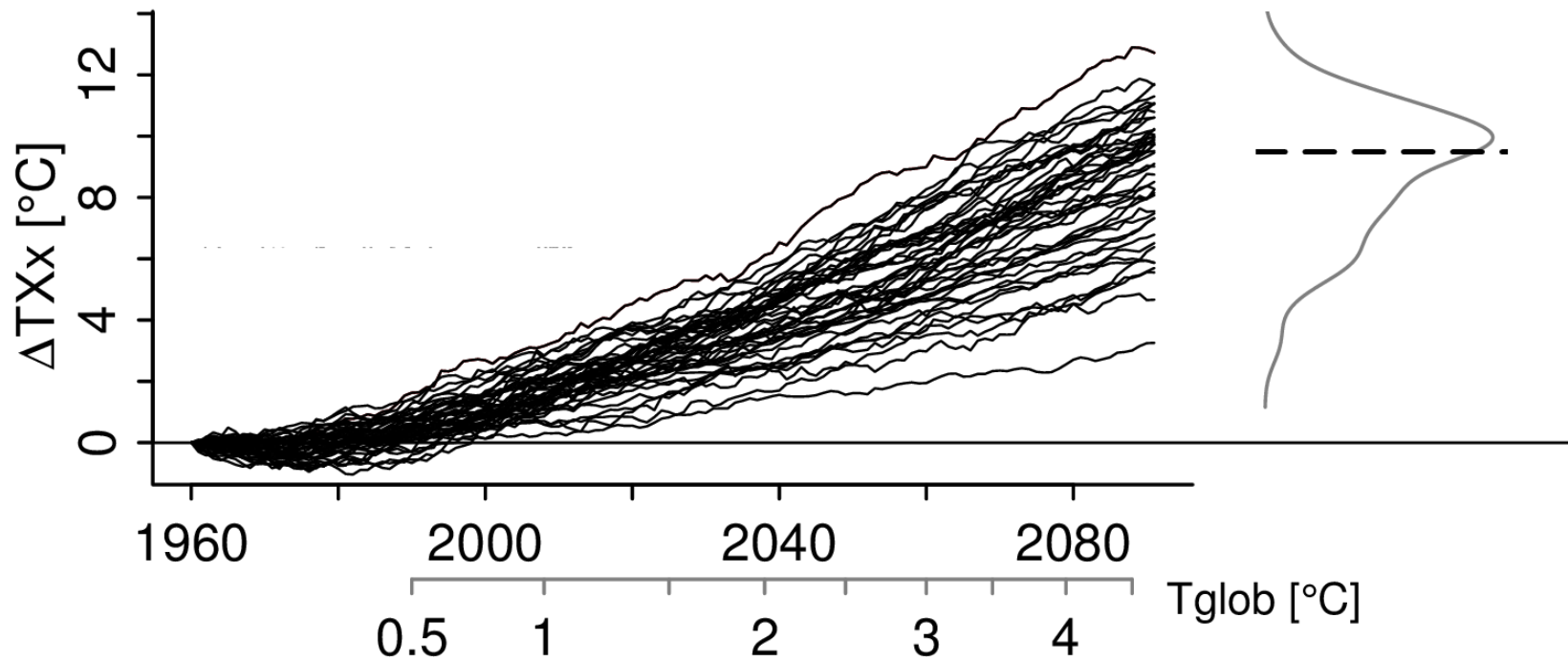


Divergent behavior of summer precipitation (precip):  
Trimodal distribution (2081-2100)



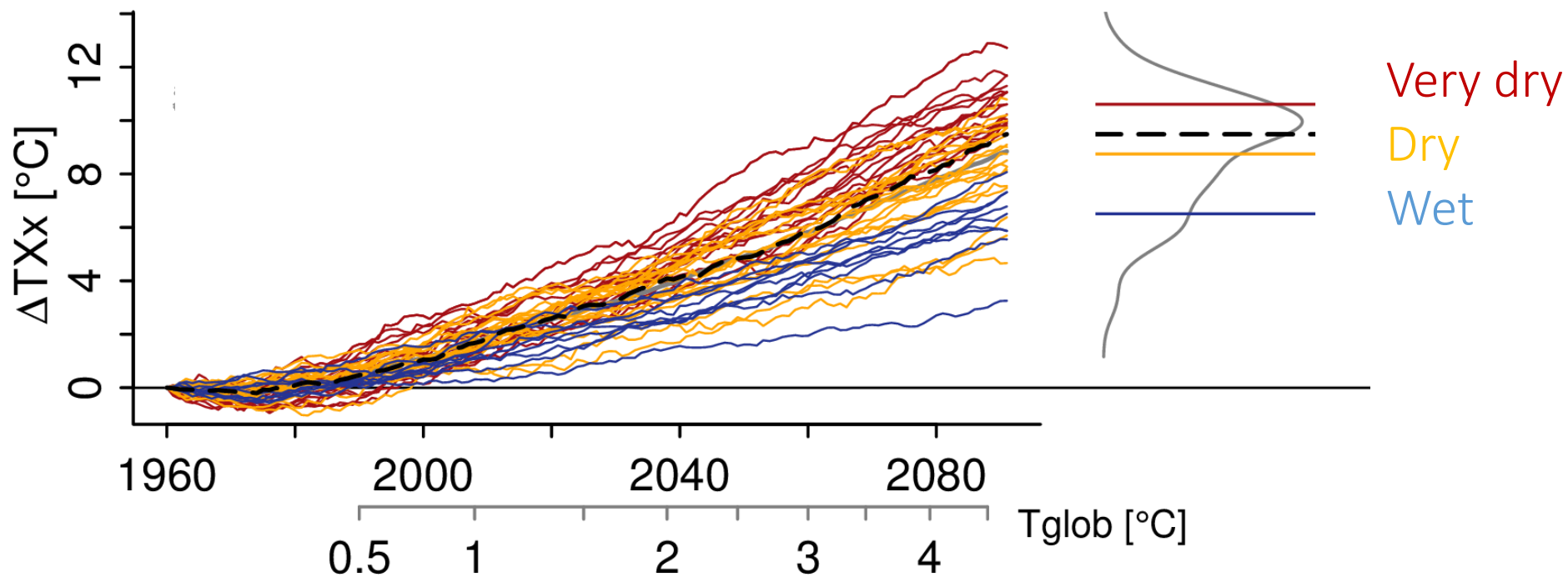


Subgroups for TXx





Subgroups for TXx

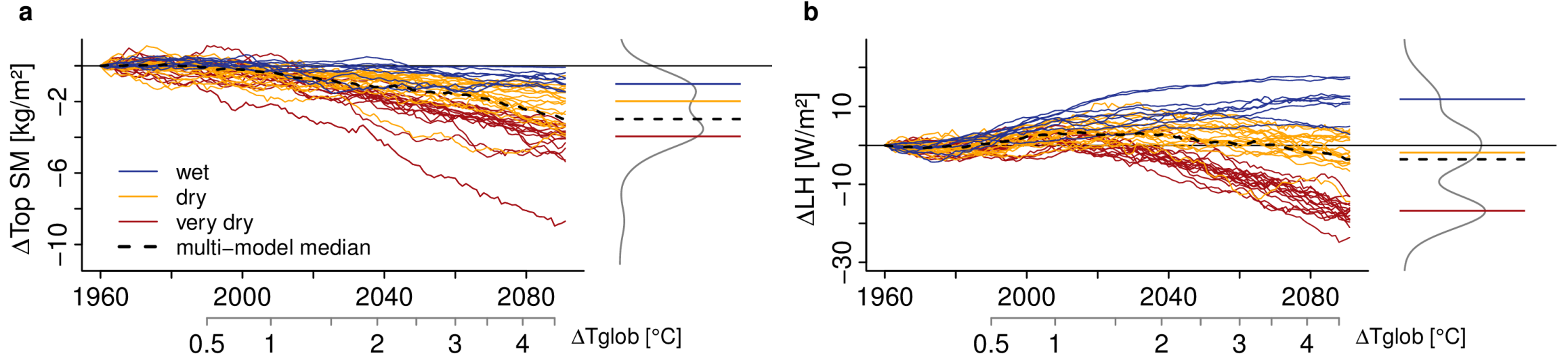


Motivation

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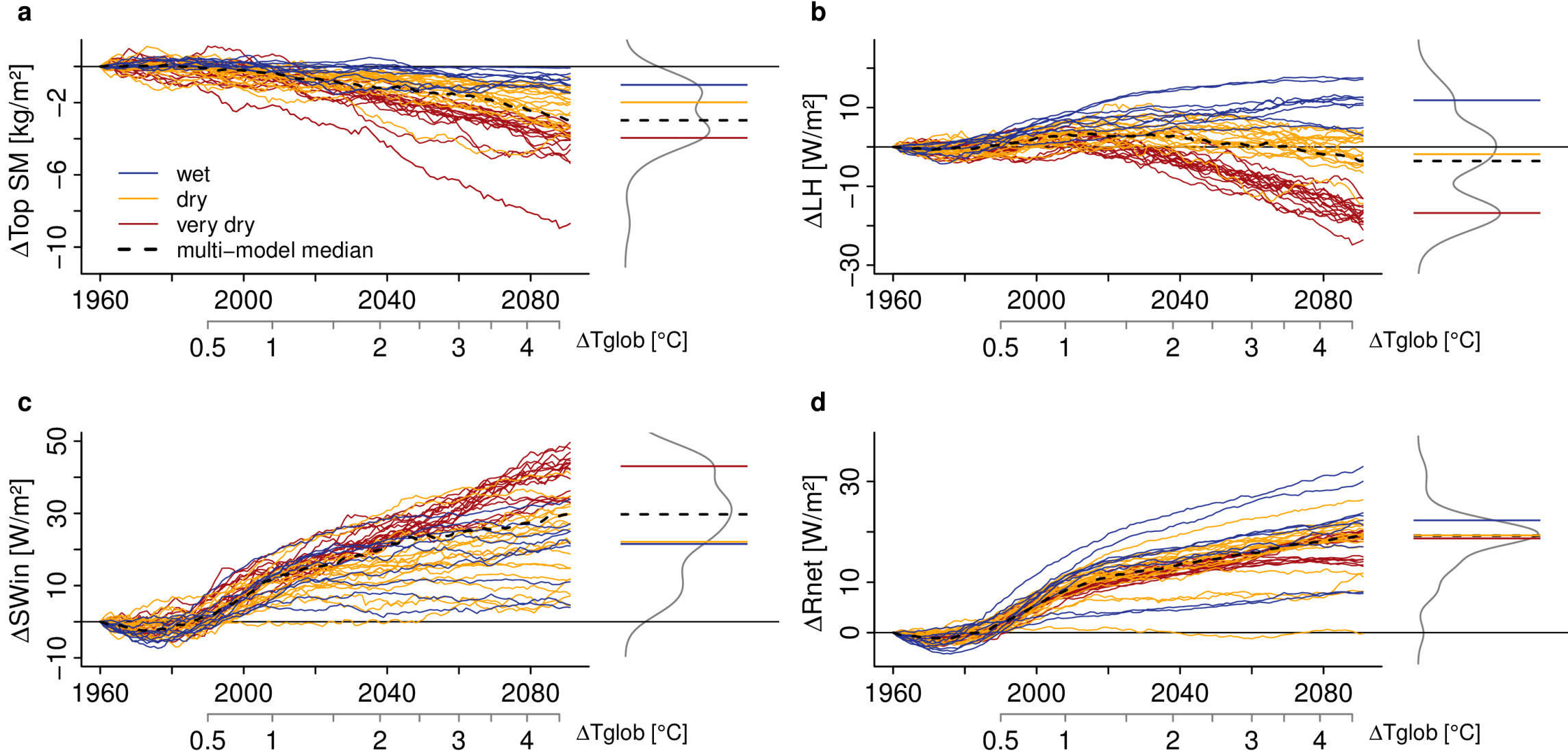
Clustering of three model subgroups

Motivation

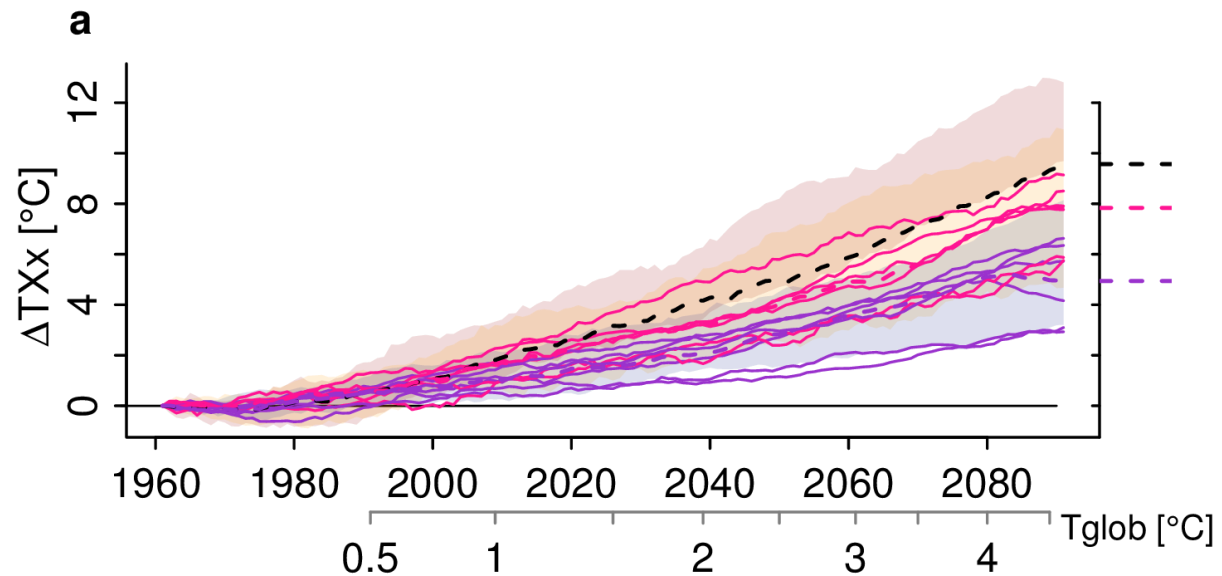
Methods

Results

Summary



Distinct characteristics of three model subgroups

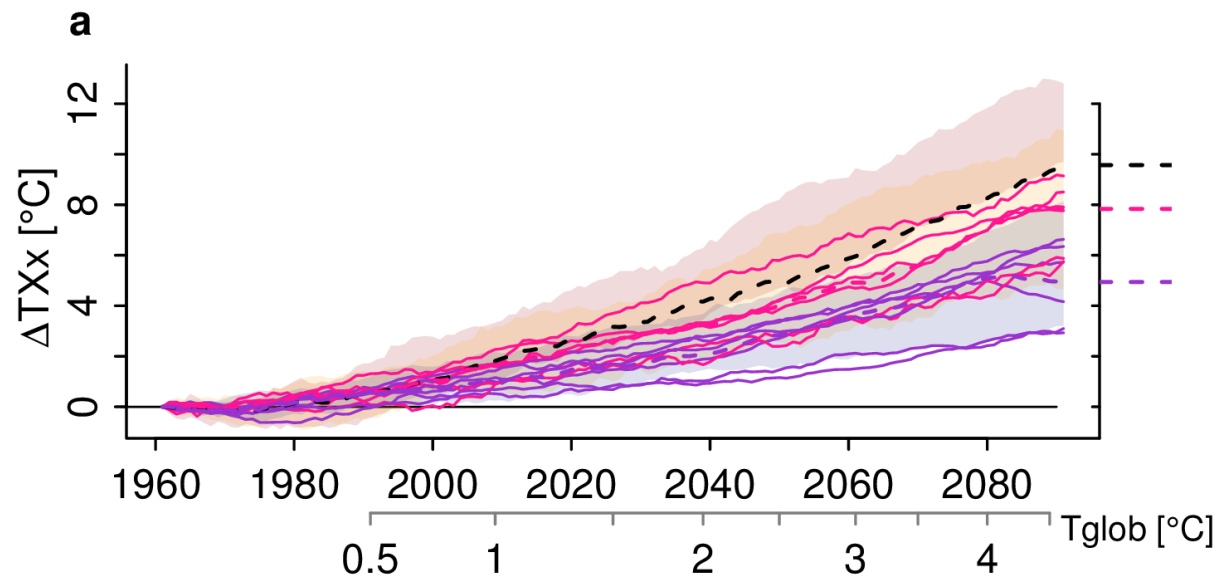


GLACE SM20c :

soil moisture-climate feedbacks are inhibited

GLACE CTL: control simulations

GLACE-CMIP5 (Seneviratne et al. 2013)



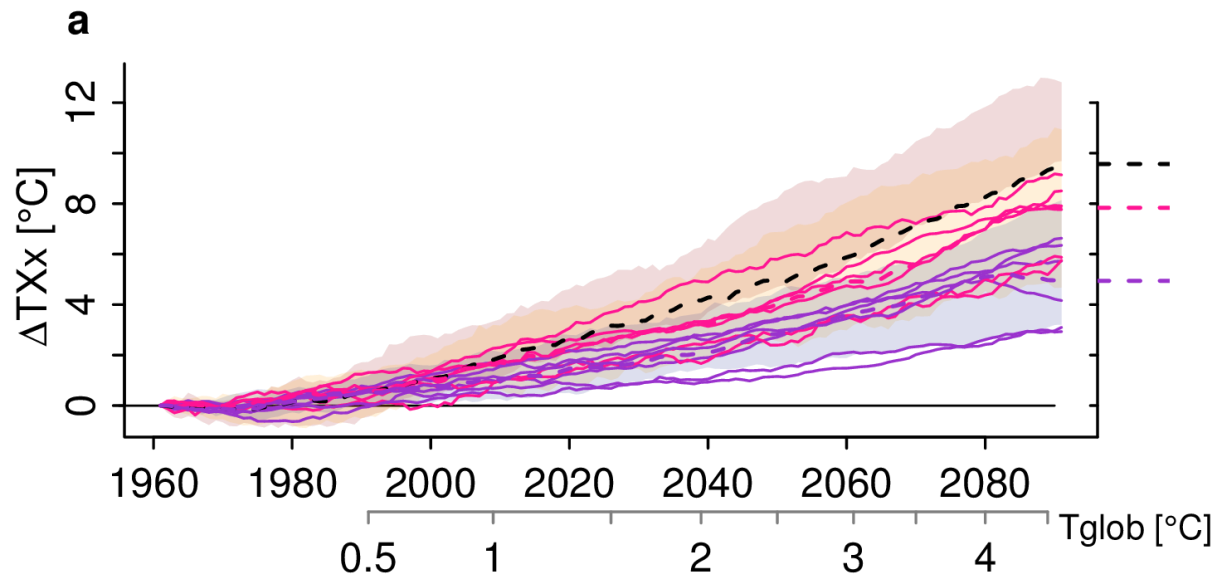
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TXx increase less strong in GLACE SM20c

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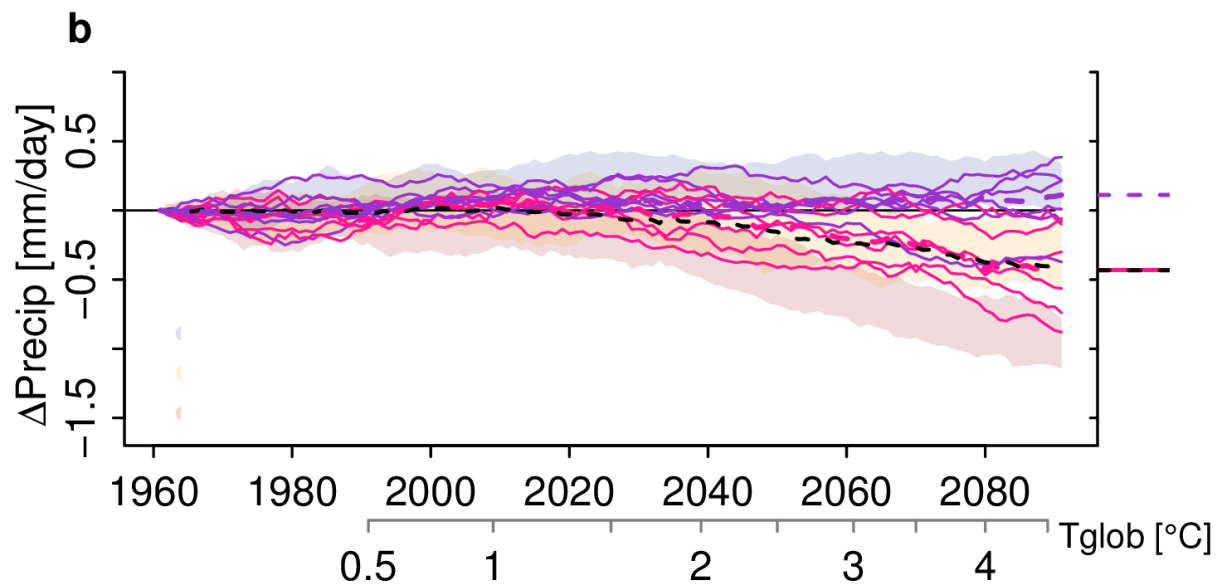


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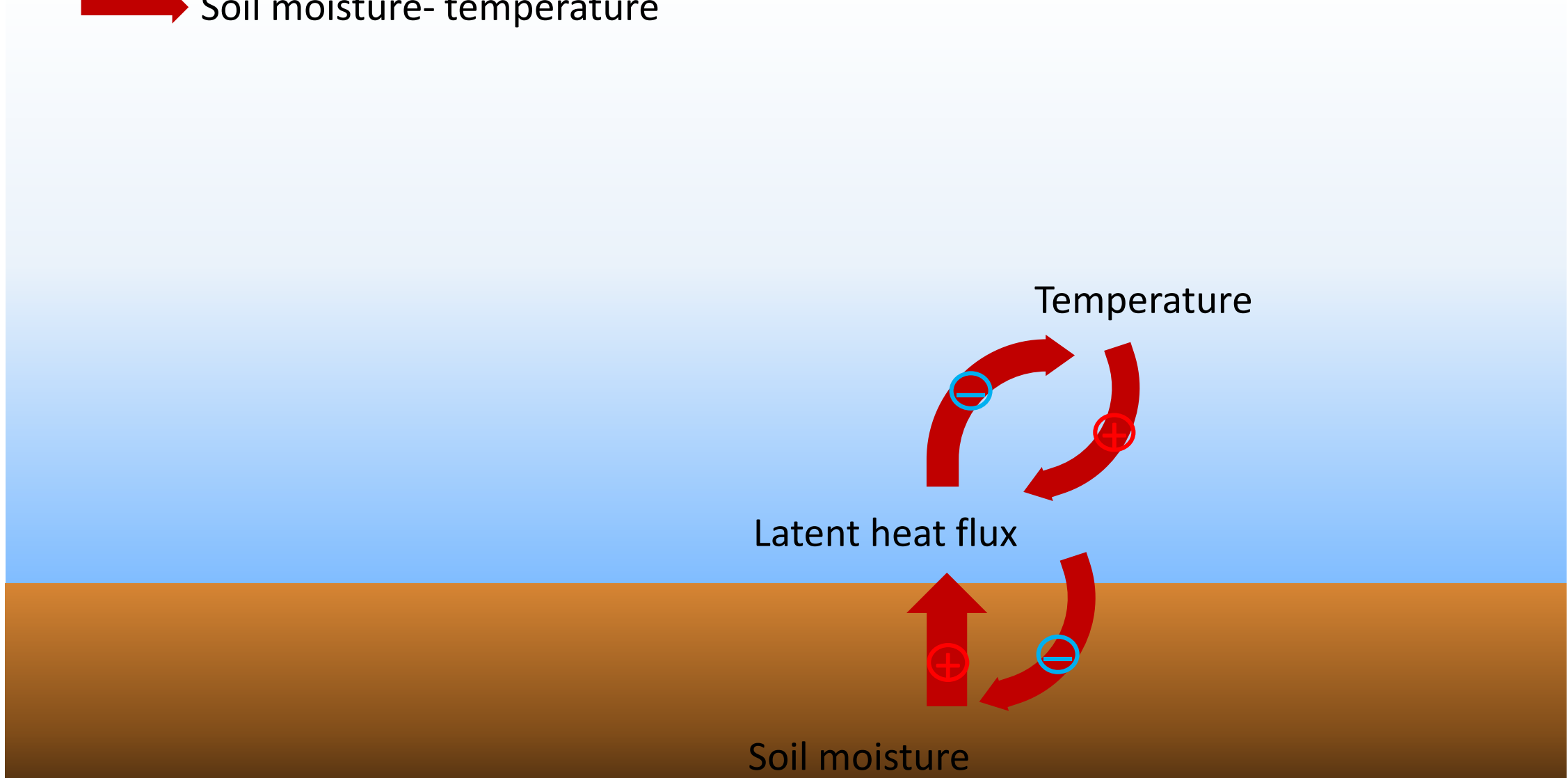


Precip distribution shifted towards wet conditions for GLACE SM20c

GLACE-CMIP5 (Seneviratne et al. 2013)

Positive feedbacks:

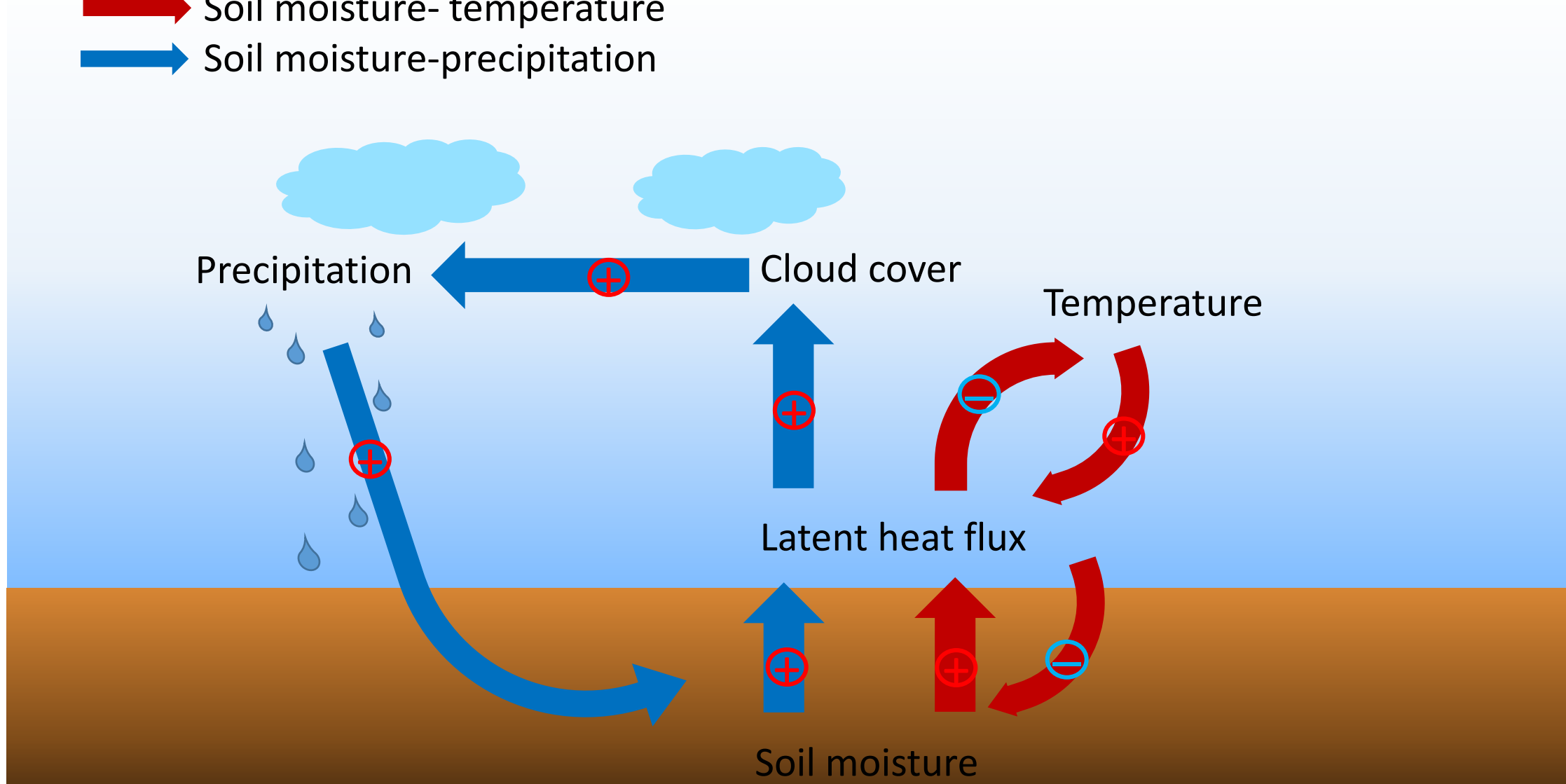
**→** Soil moisture- temperature



Positive feedbacks:

➔ Soil moisture- temperature

➔ Soil moisture-precipitation





Motivation

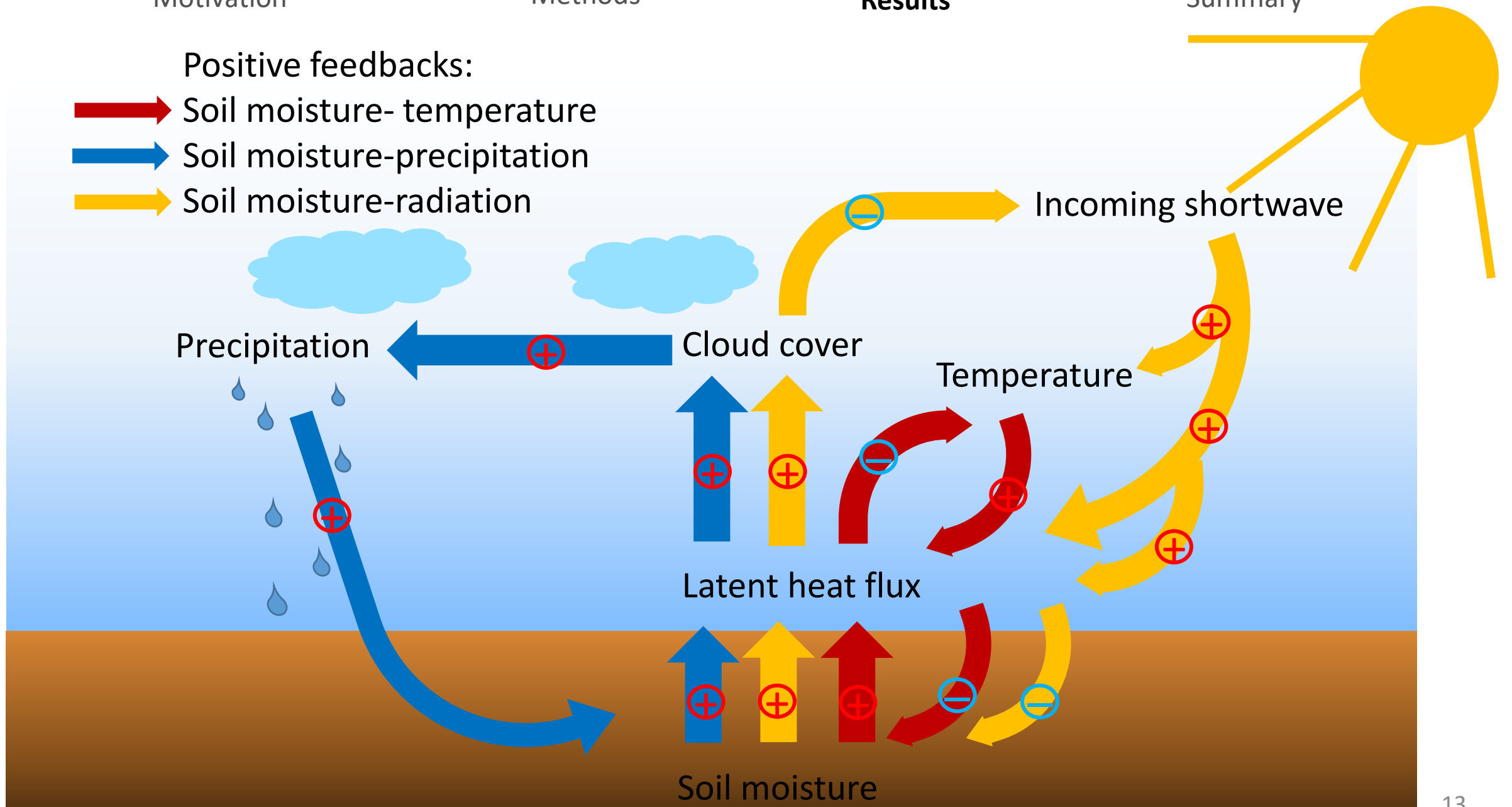
Methods


Results

Summary

Positive feedbacks:

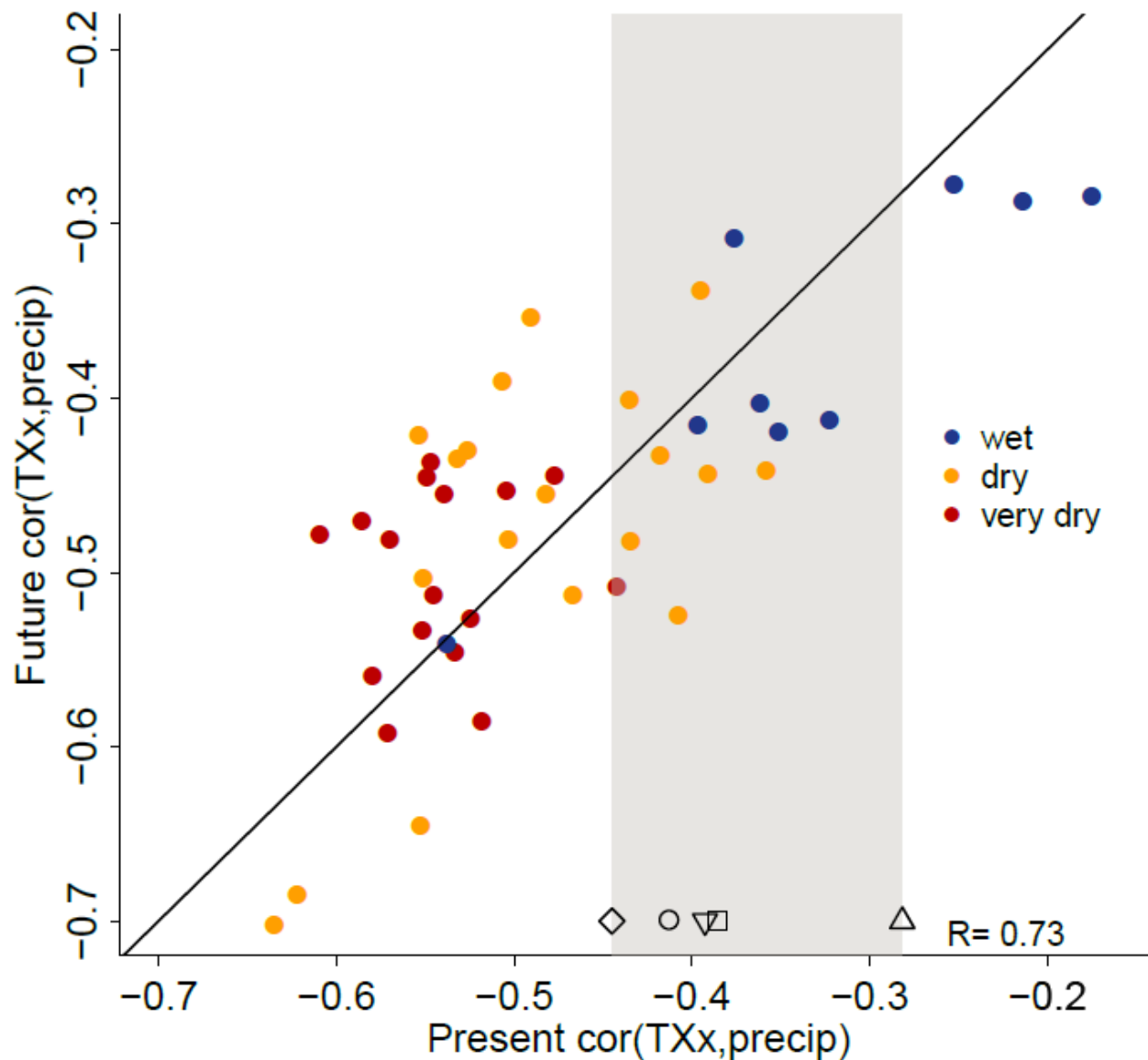
- Soil moisture- temperature
- Soil moisture-precipitation
- Soil moisture-radiation



1. Which underlying processes in models cause the large spread and increase in extreme temperature projections in Central Europe?
  2. Can we then constrain extreme temperature projections in Central Europe?
- 

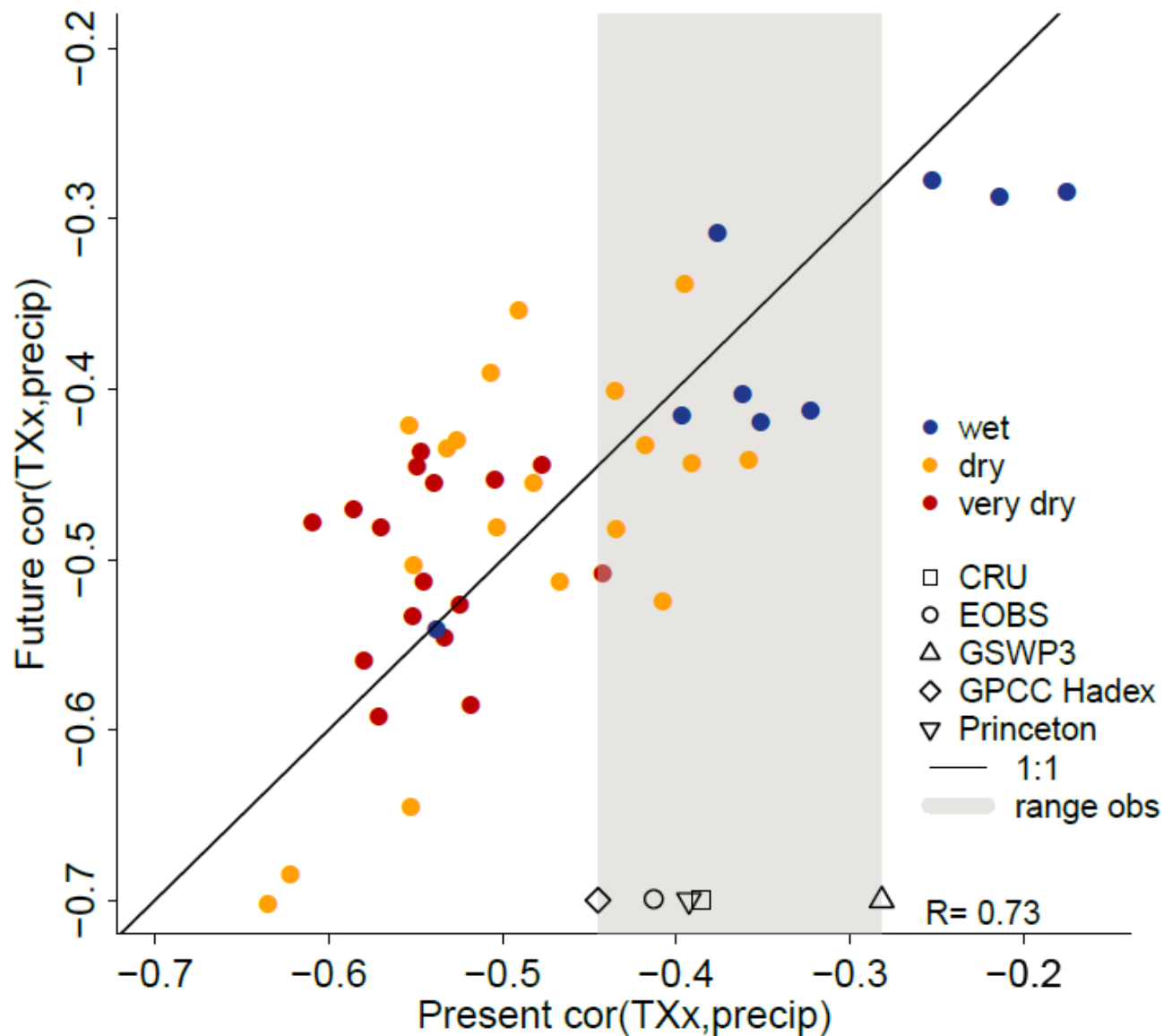
1. Which underlying processes in models cause the large spread and increase in extreme temperature projections in Central Europe?
2. **Can we then constrain extreme temperature projections in Central Europe?**





cor(TXx,precip):  
 correlation of precip and TXx  
 as process-based metric

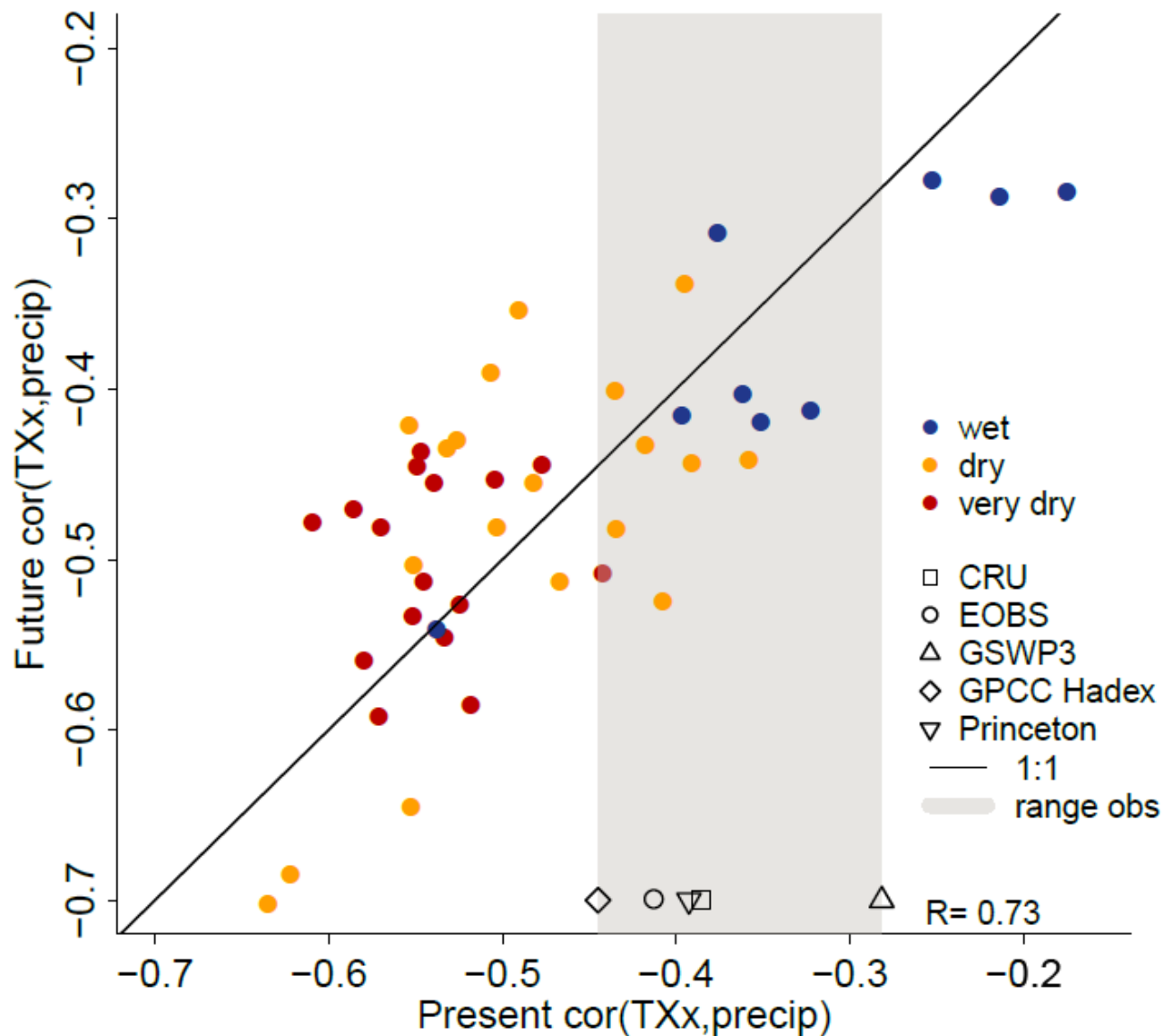
present (1961-1990)  
 future (2071-2100)



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5 observational datasets



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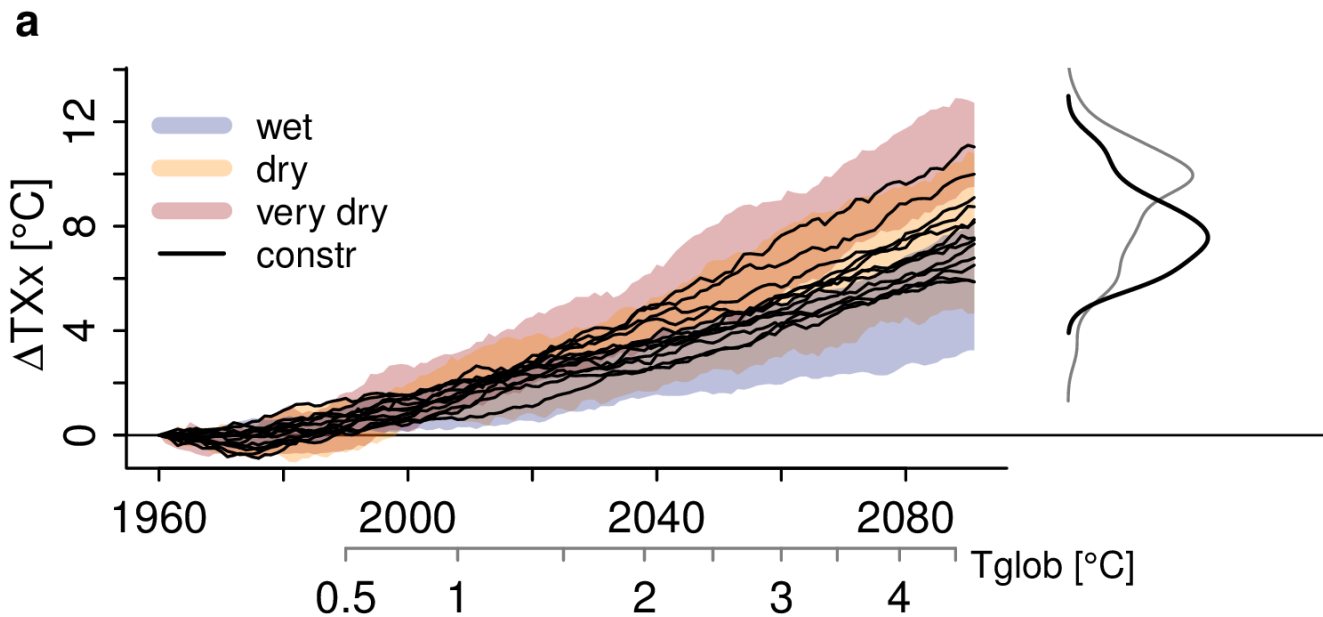
Selection of mainly **wet** and  
**dry** models

Motivation

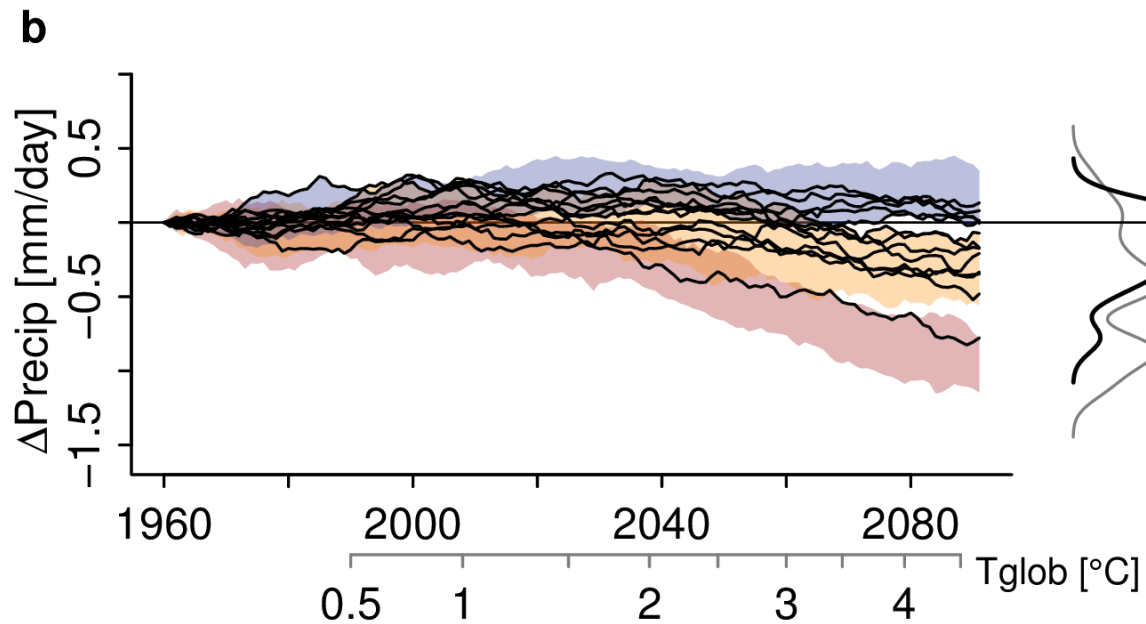
Methods

Results

Summary



Multi-model median for constrained ensemble is decreased by 20% (2°C) for TXx



For precip only slightly projected decrease

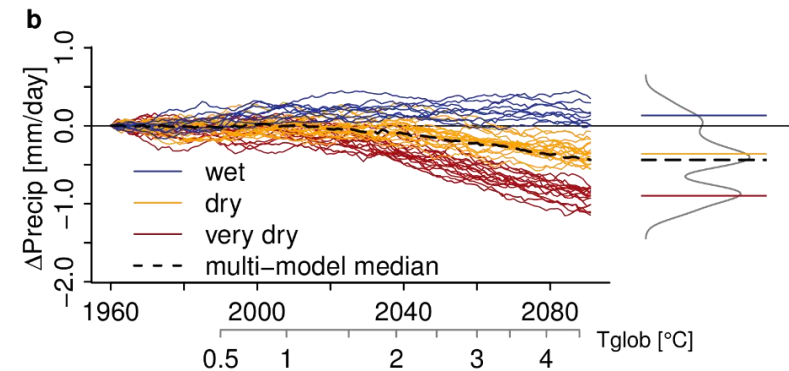
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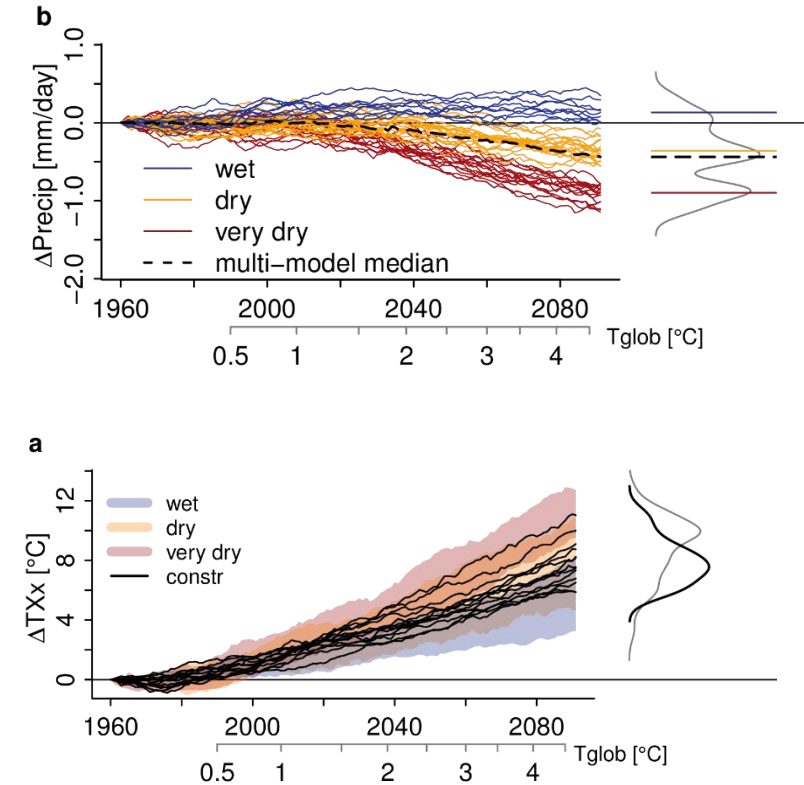


# Summary

- Divergent behavior of summer precipitation linked to uncertainties in TXx
- Identification of three model subgroups and relevant soil moisture-atmosphere feedbacks



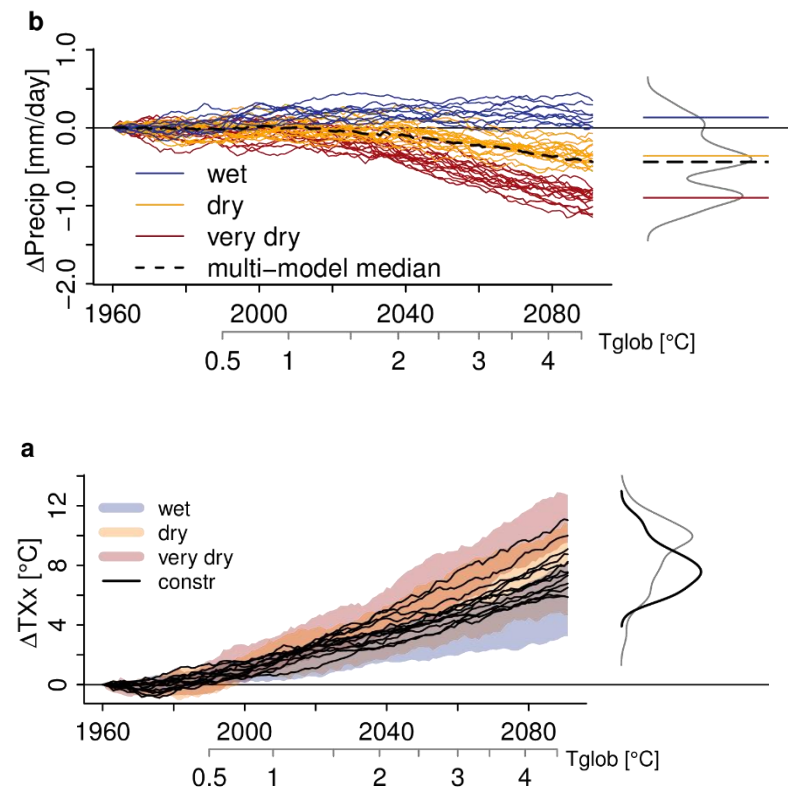
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- Long-term changes in TXx less high (20%) and less dry than projected by full ensemble



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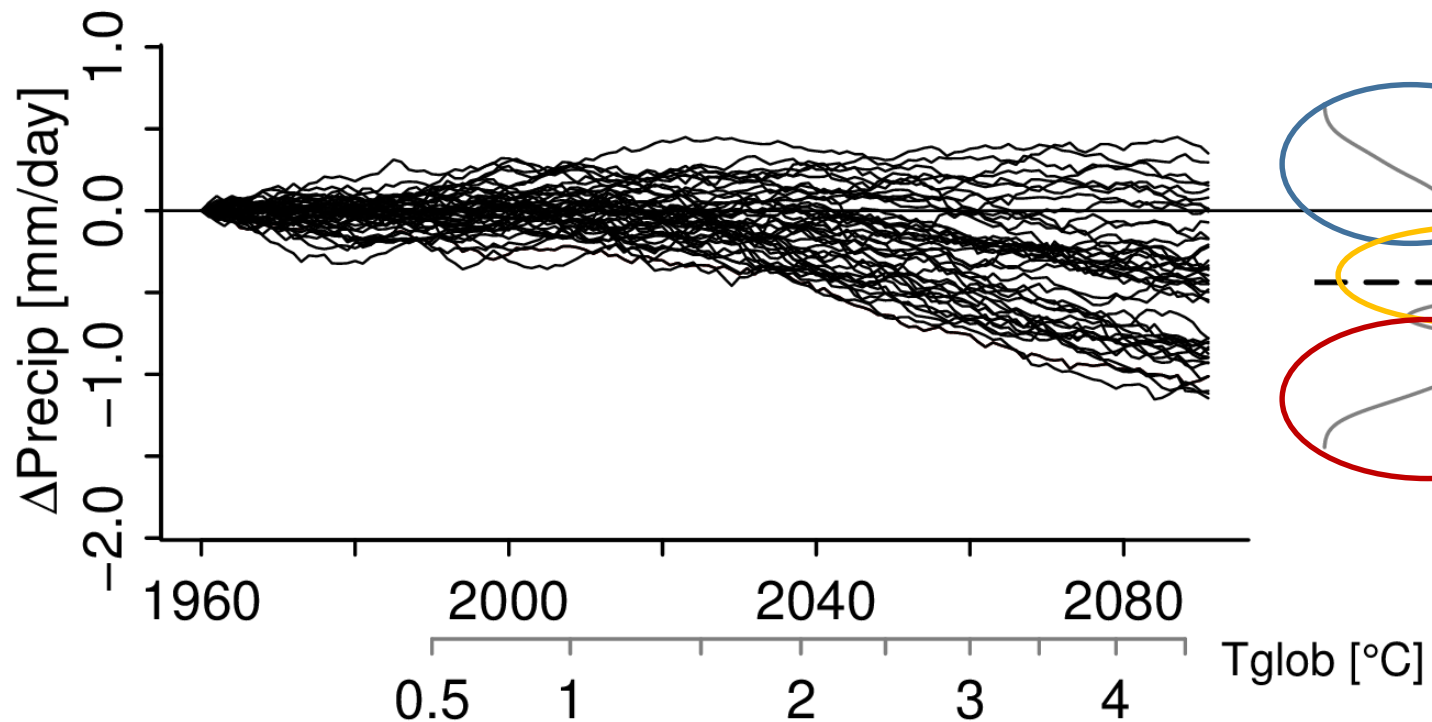
Thank you!

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*Varying soil moisture-atmosphere feedbacks explain divergent temperatures extremes and precipitation projections in Central Europe, Earth System Dynamics Discussions, <https://doi.org/10.5194/esd-2018-24>*

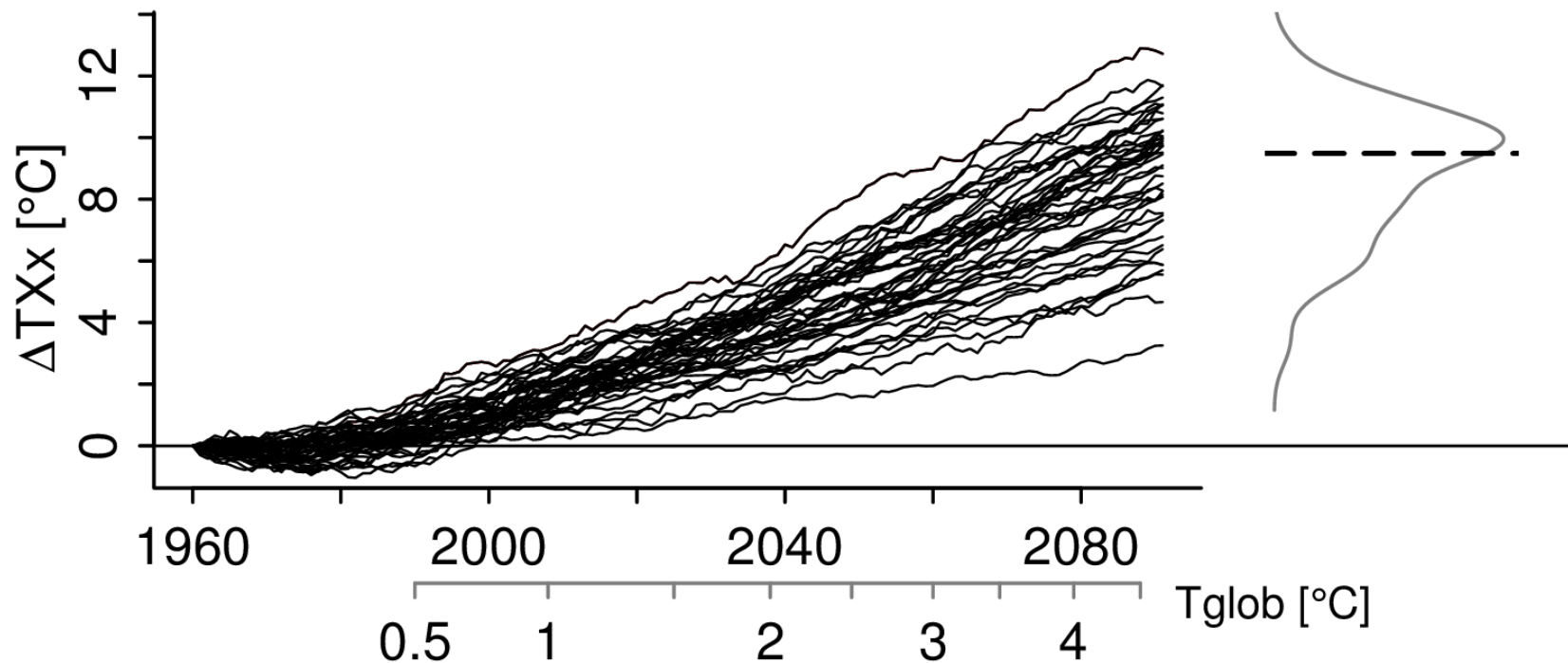
Backup



**Wet:** positive precip anomaly  
at the end of 21<sup>st</sup> century

**Dry:** slightly decreasing  
precip

**Very dry:** strong decrease of  
precip



Central Europe  
20-year running means  
Base period: 1950-1969  
Distribution: 2081-2100

Strong and continuous  
increase

Underlying processes?

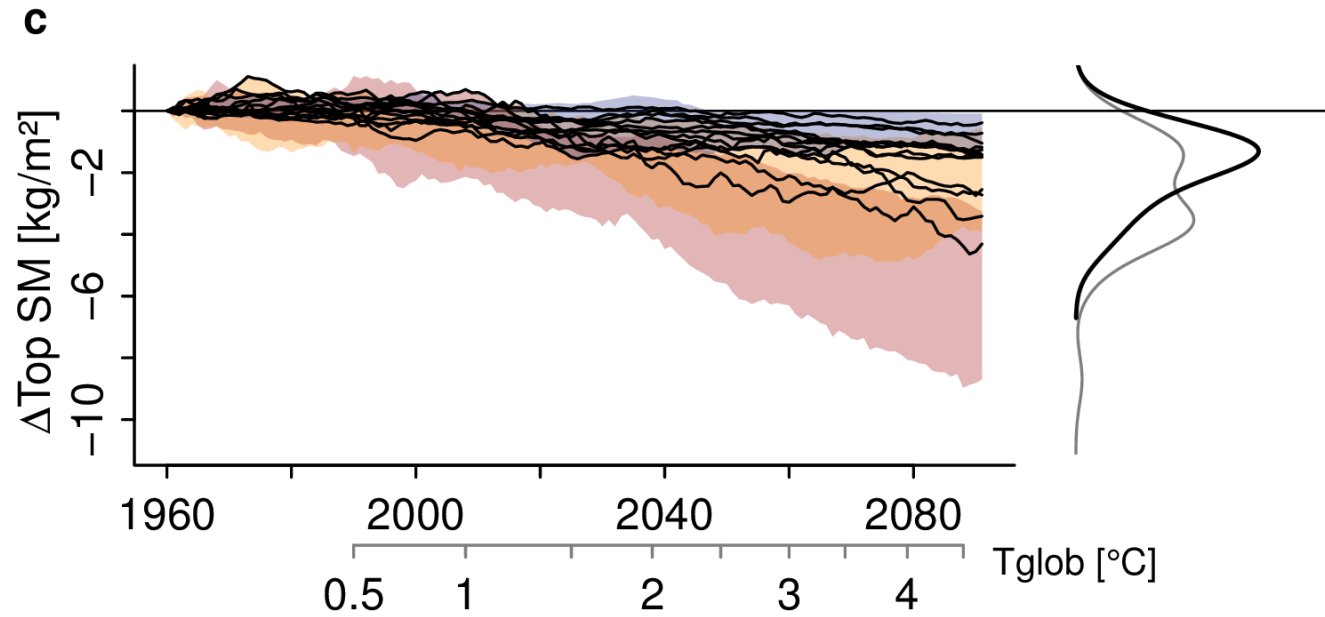
Investigating timeseries of summer surface energy fluxes, radiation, soil moisture and precipitation

Motivation

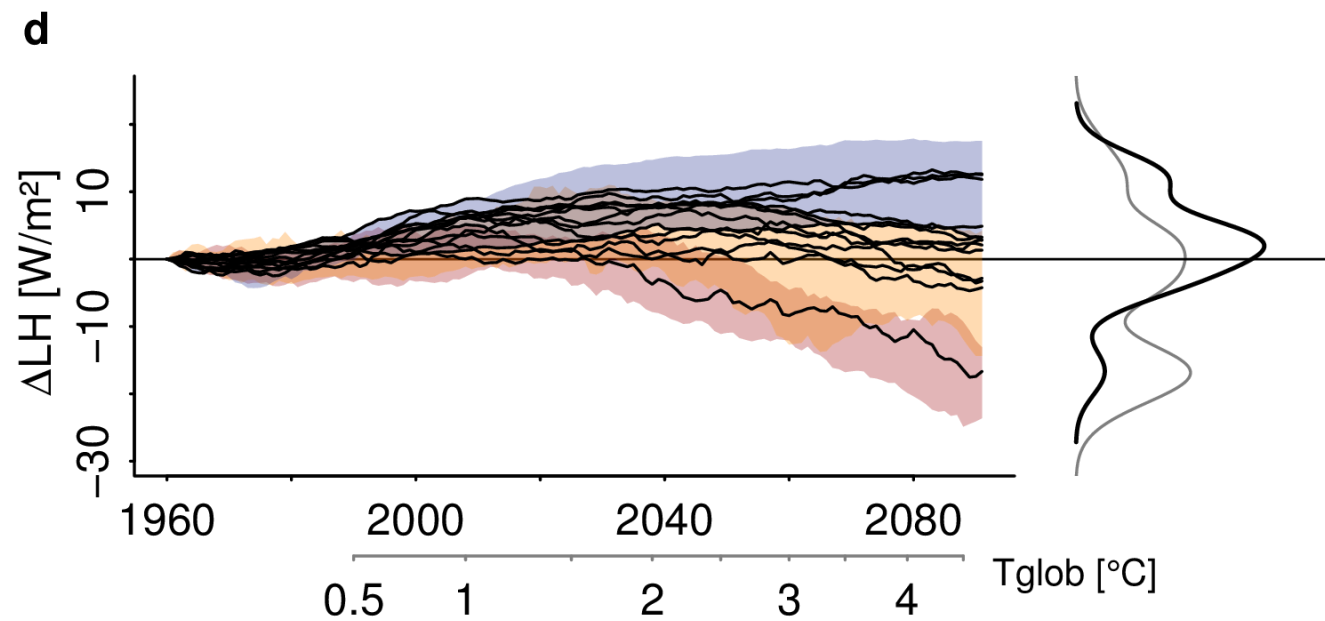
Methods

Results

Summary

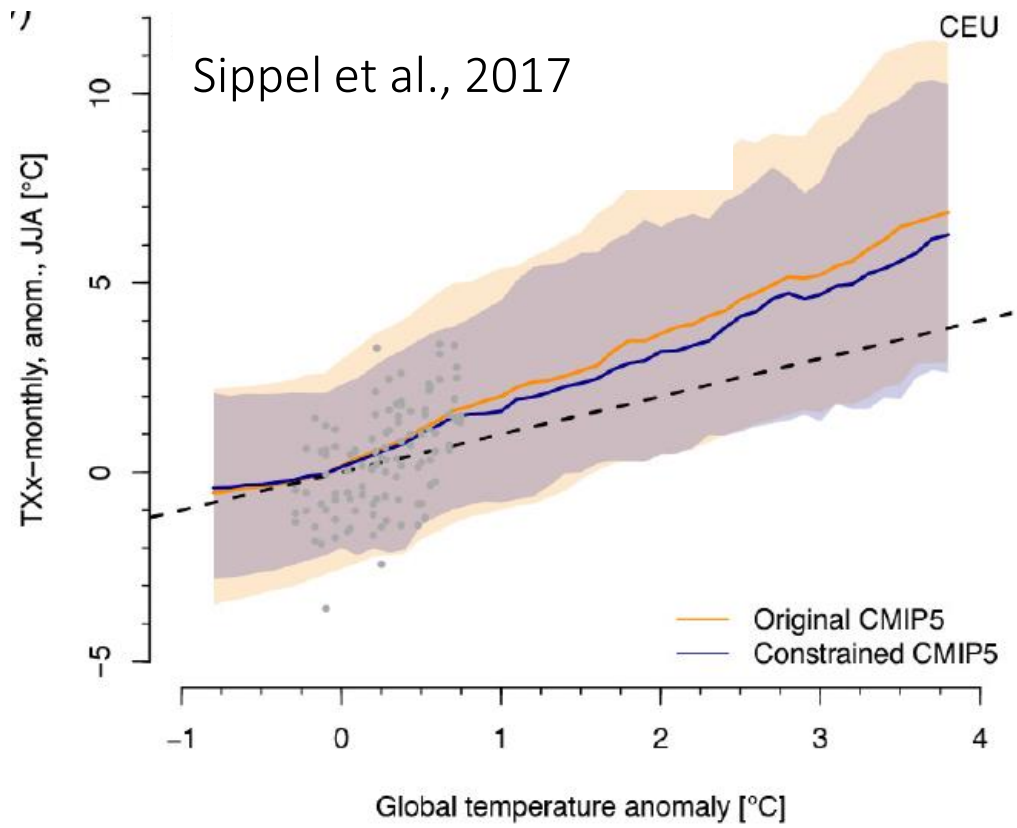


Particularly very dry models are excluded



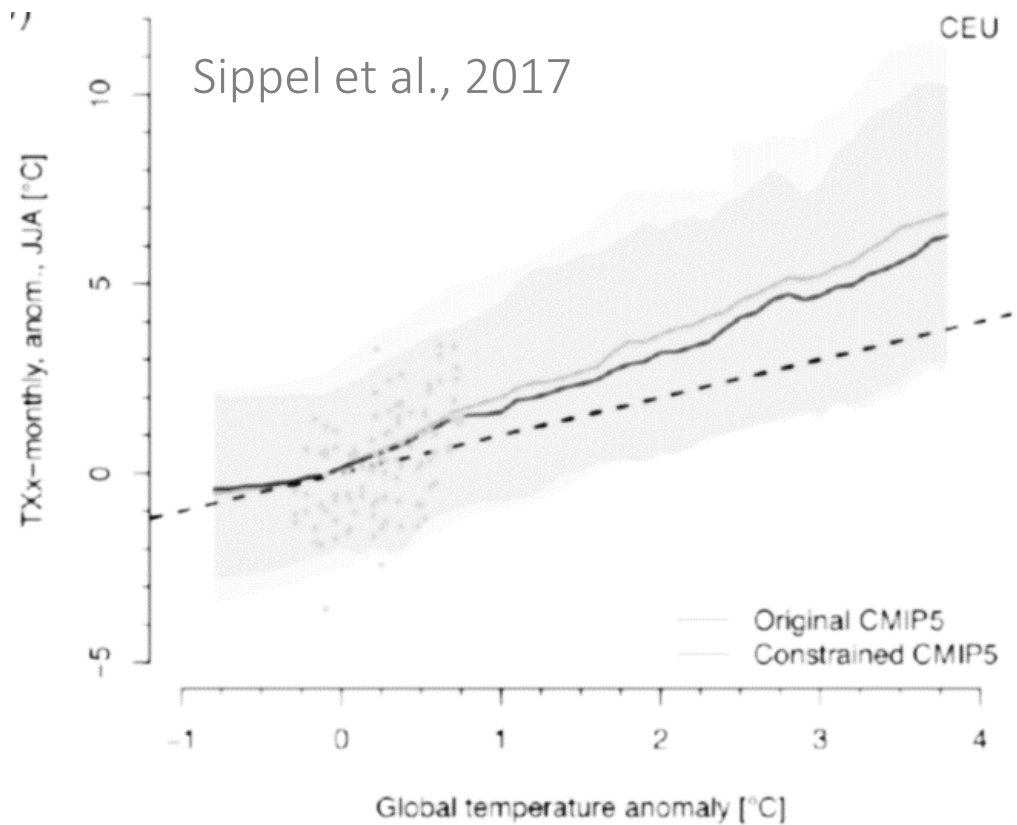
Latent heat flux overall positive





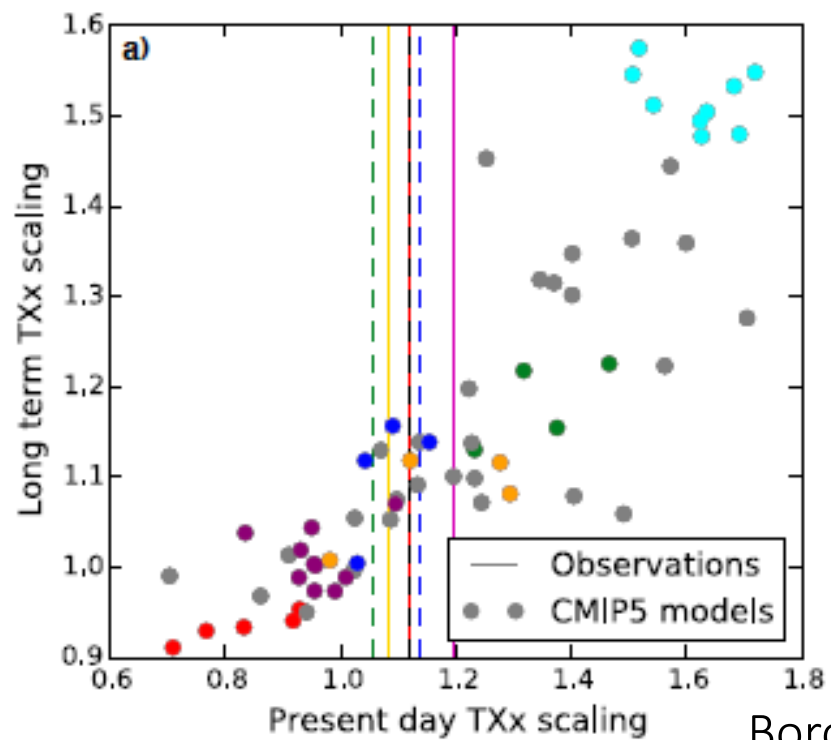
## Motivation

## Methods



## Results

## Summary



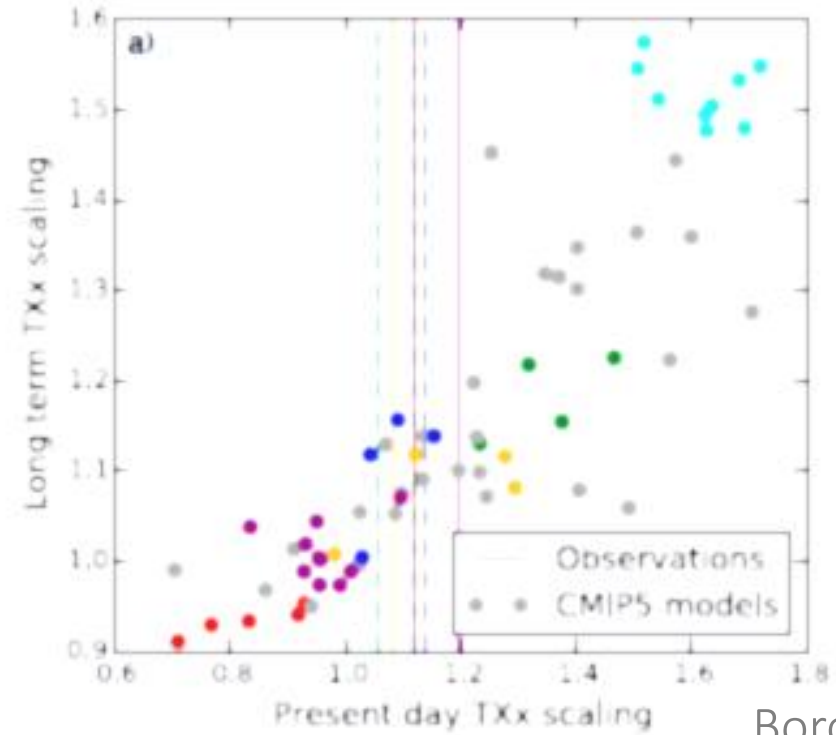
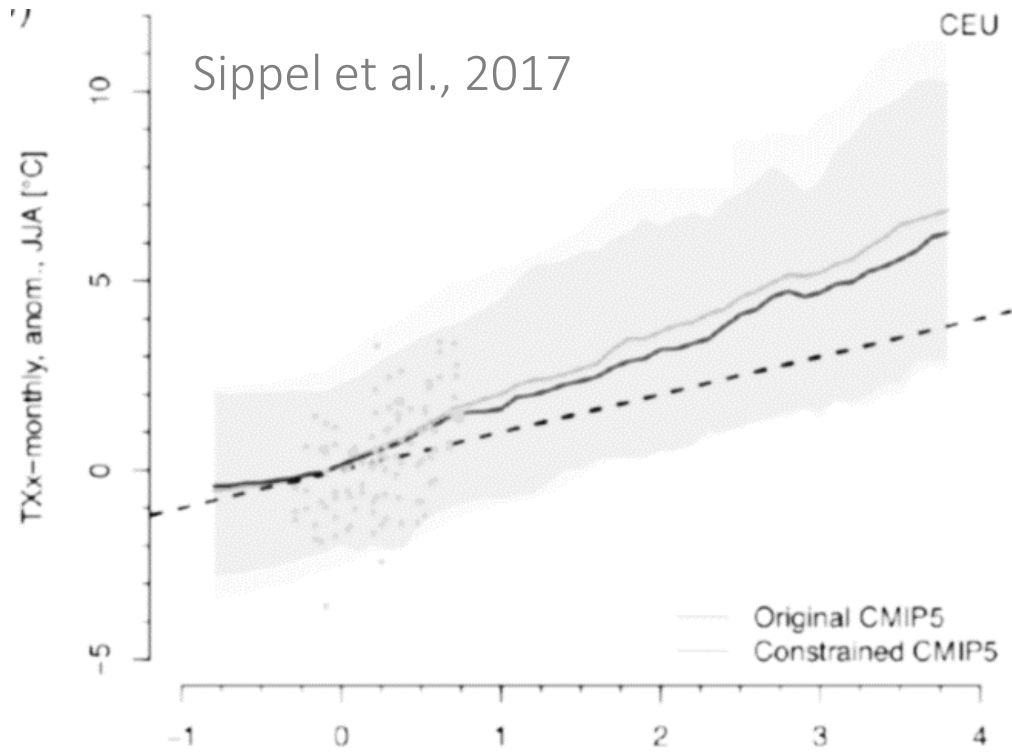
Borodina et al., 2017

# Motivation

# Methods

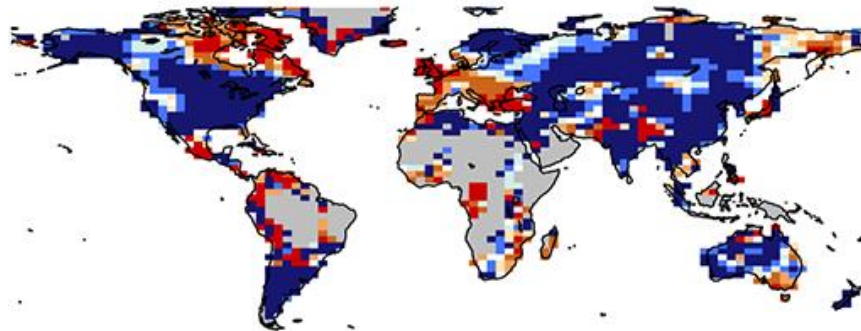
# Results

# Summary

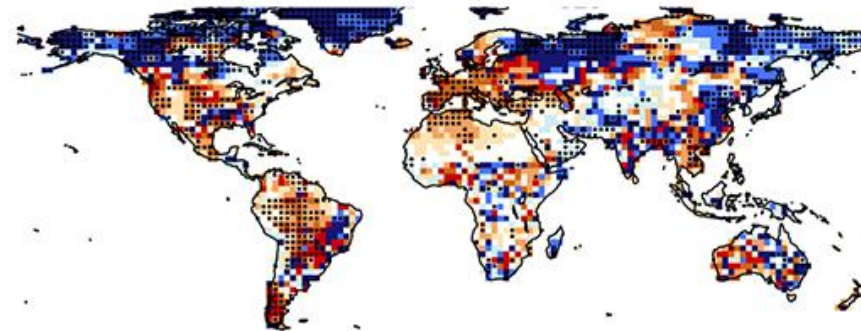


Borodina et al., 2017

Observations



CMIP5 ensemble mean



[°C/°C]



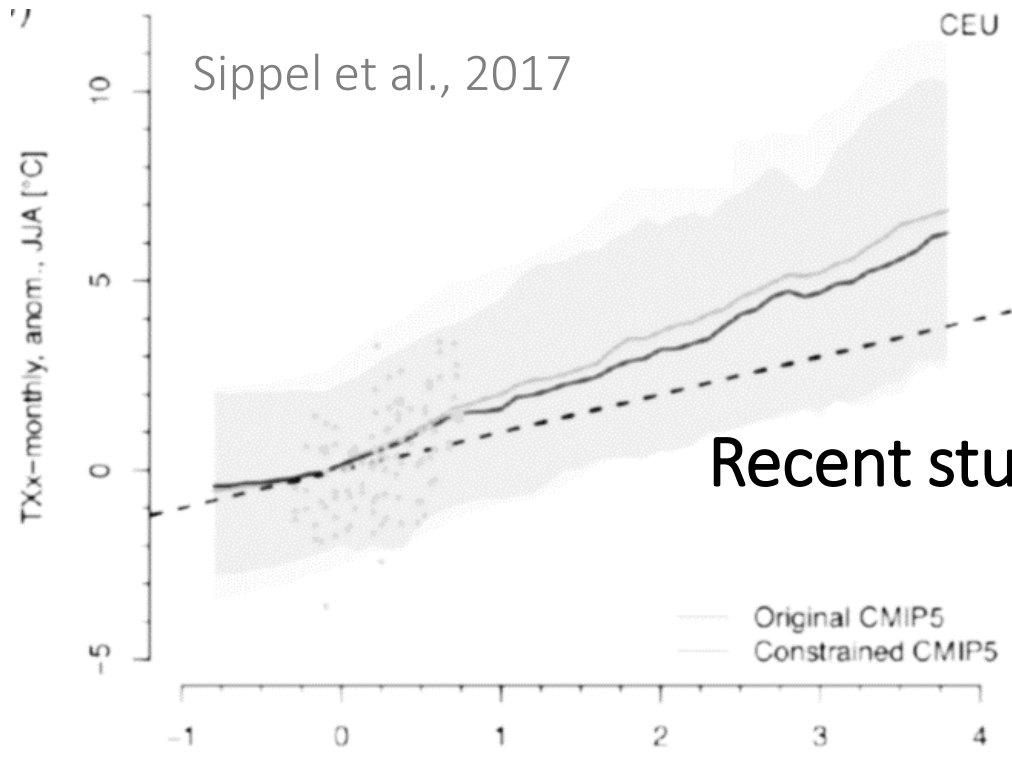
Donat et al., 2017

Motivation

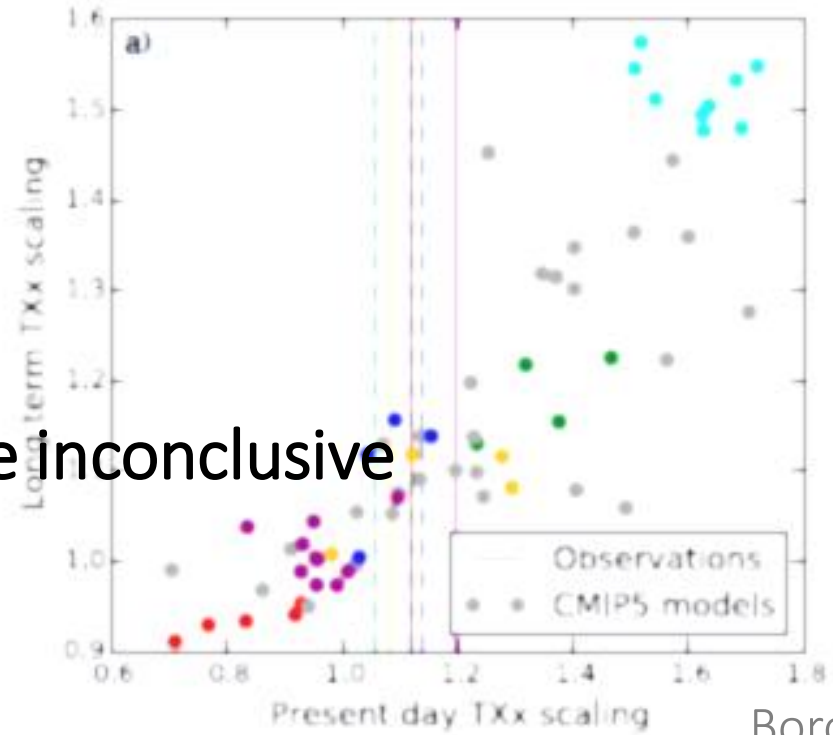
Methods

Results

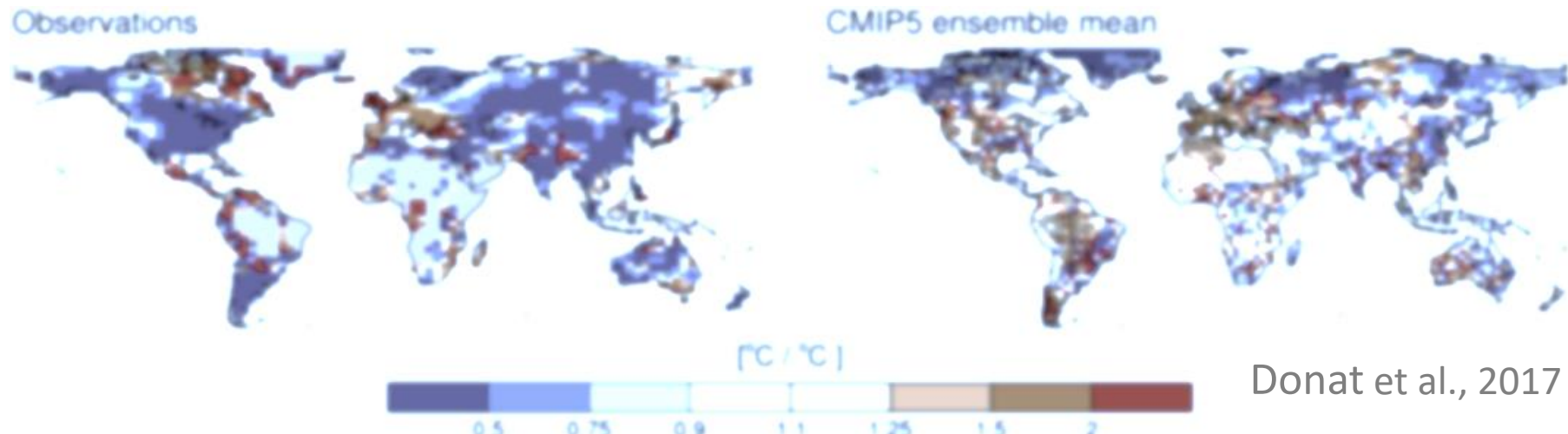
Summary



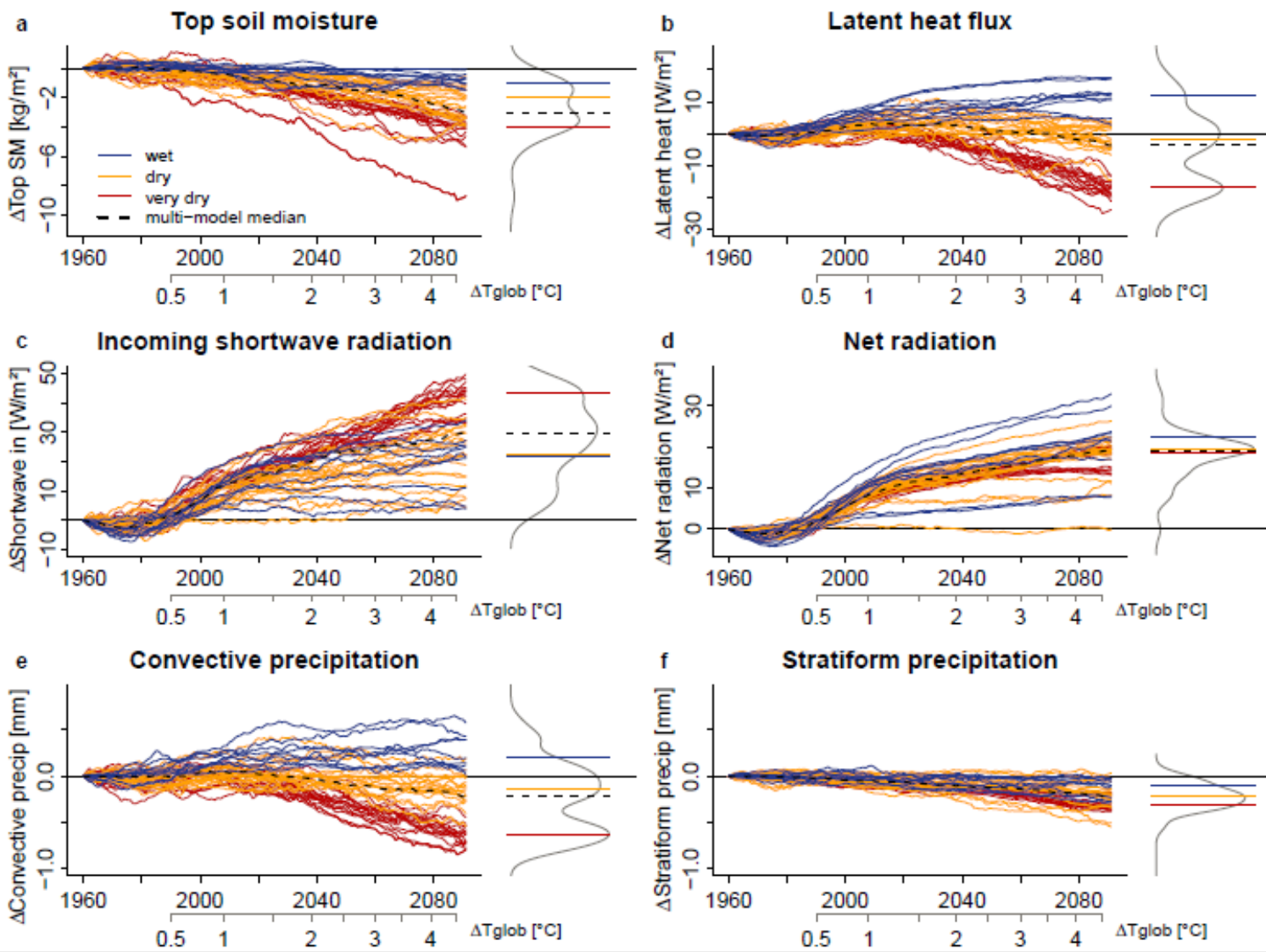
Recent studies are inconclusive

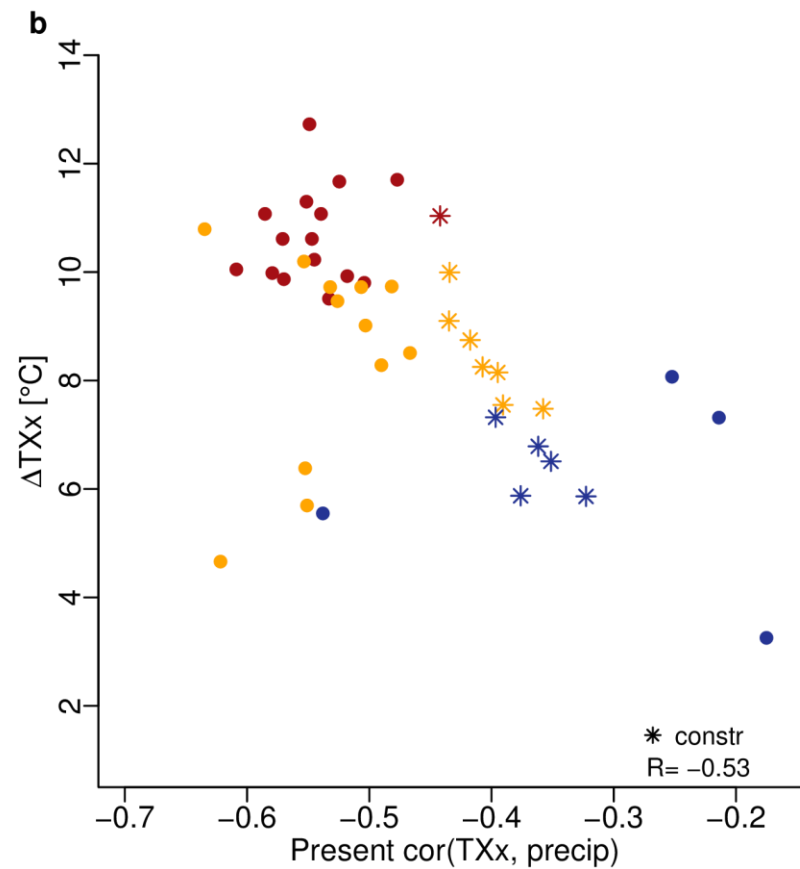
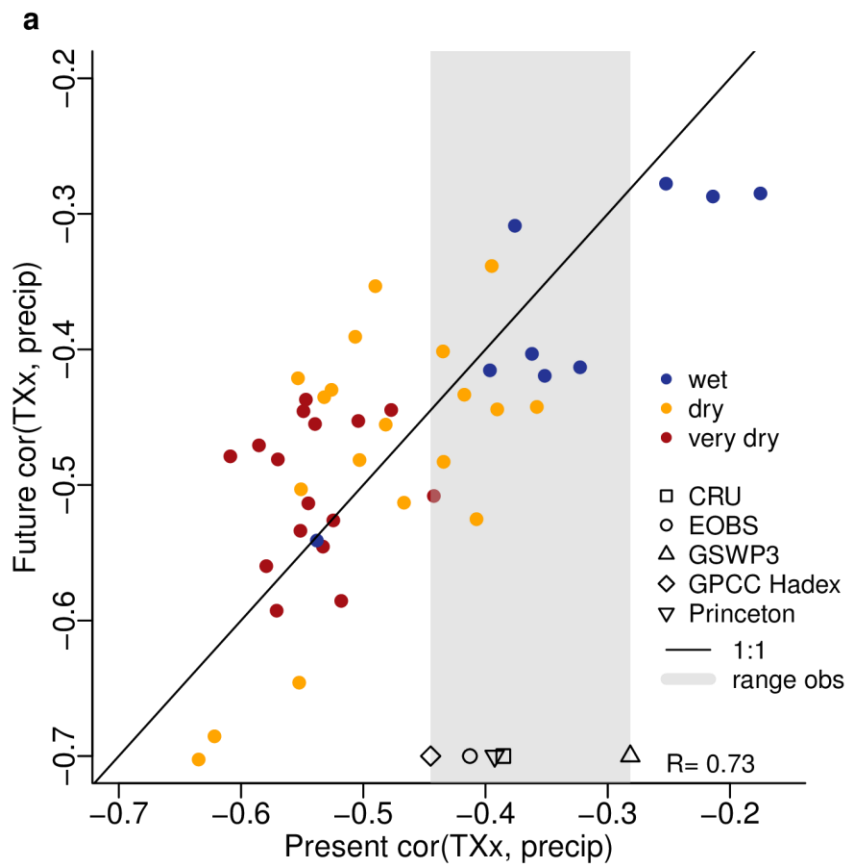


Borodina et al., 2017



Donat et al., 2017

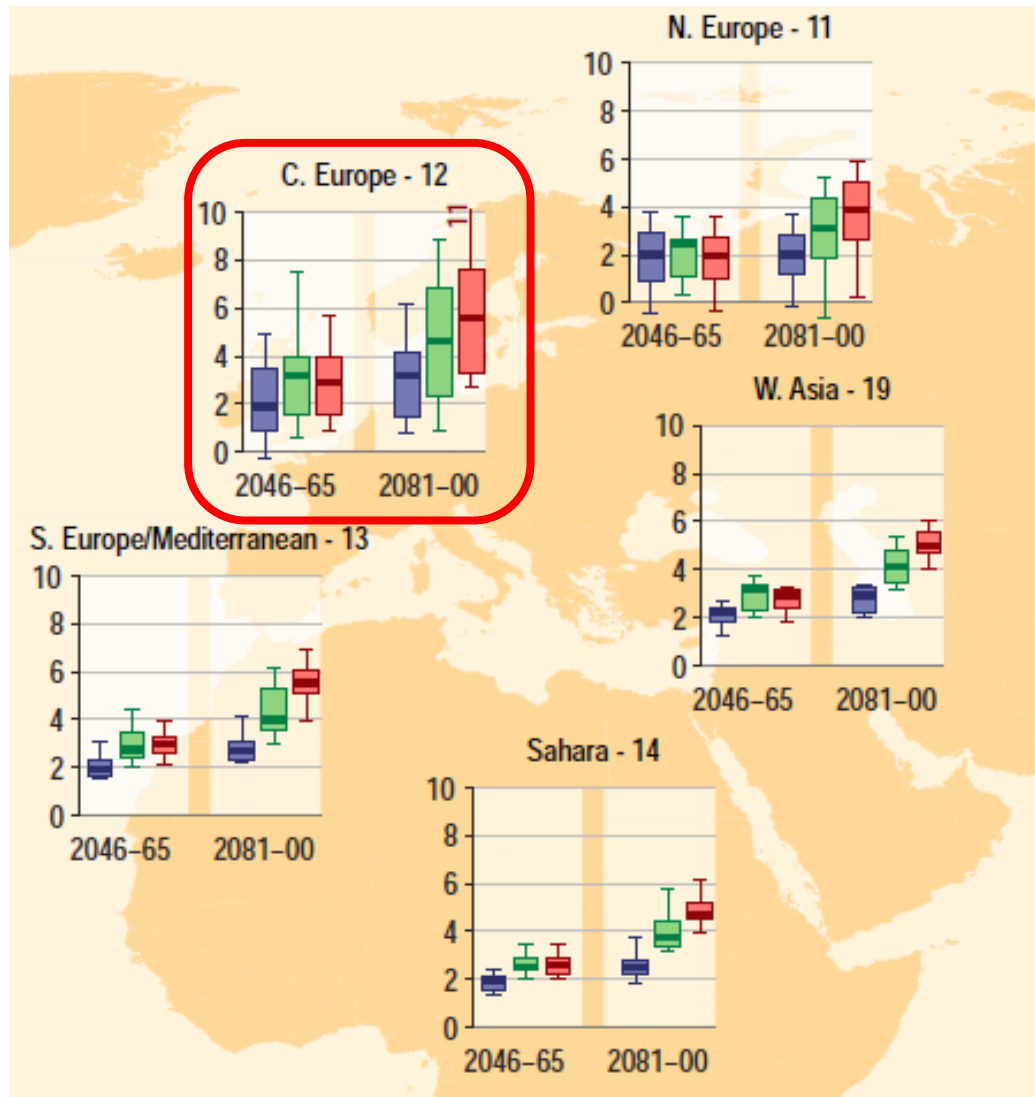






Model group	Net radiation	Precipitation	Latent heat	Top soil moisture	TXx
<i>Wet</i>	↑↑	↑	↑	↘	↑
<i>Dry</i>	↑	↓	↓	↓	↑↑
<i>Very dry</i>	↑	↓↓	↓↓	↓↓	↑↑↑



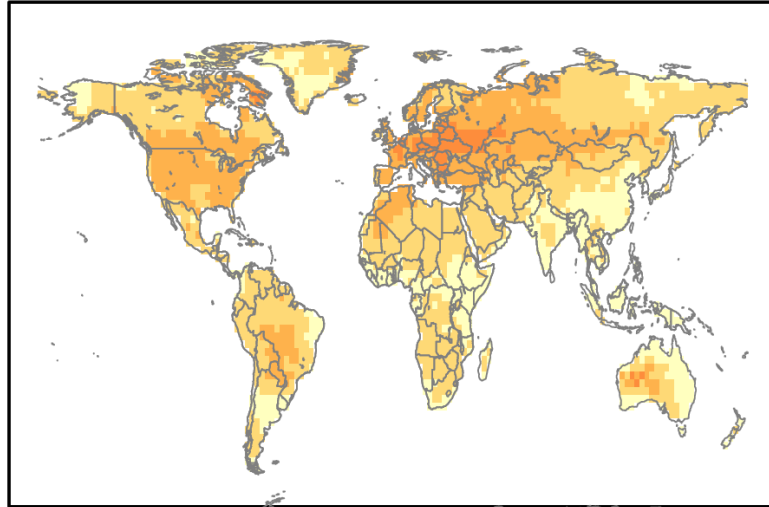


...extreme temperature projections

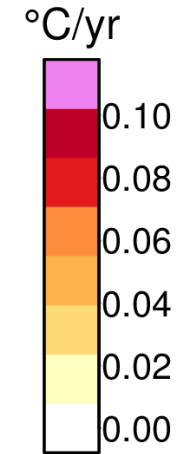
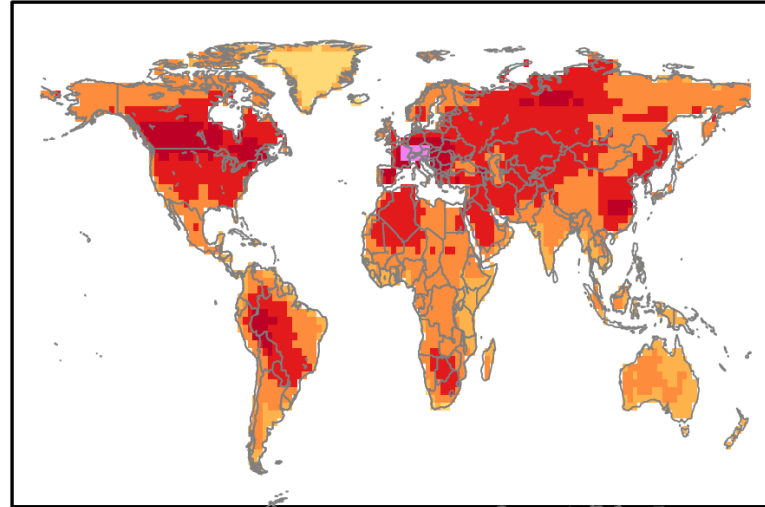
Large uncertainties for projected changes of extreme temperatures in particular in Central Europe

SREX, 2012

MMM TXx trend [1971–2010]

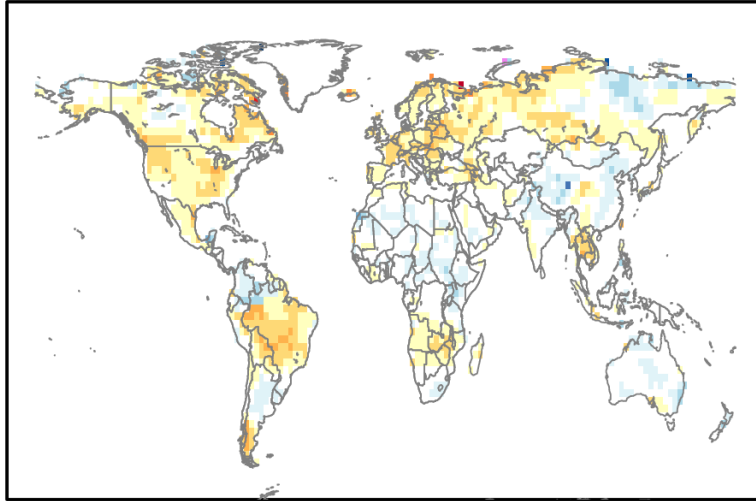


MMM TXx trend [2011–2100]

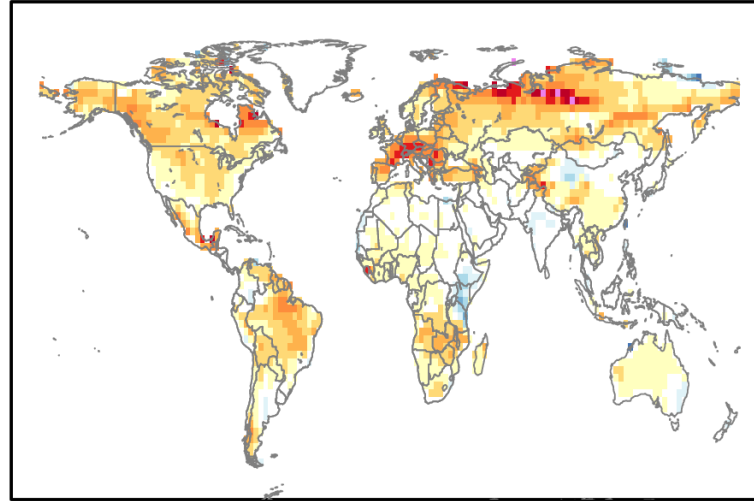


Strong future trend in TXx in particular in CEU

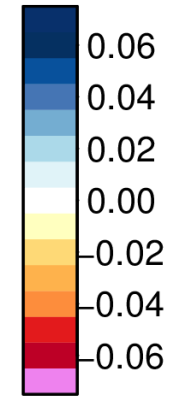
MMM top SM trend [1971–2010]



MMM top SM trend [2011–2100]

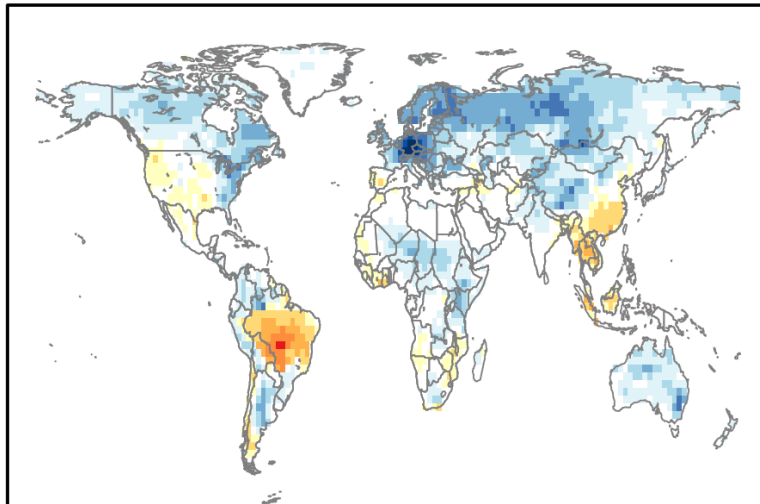


[kg/m<sup>2</sup>]/yr

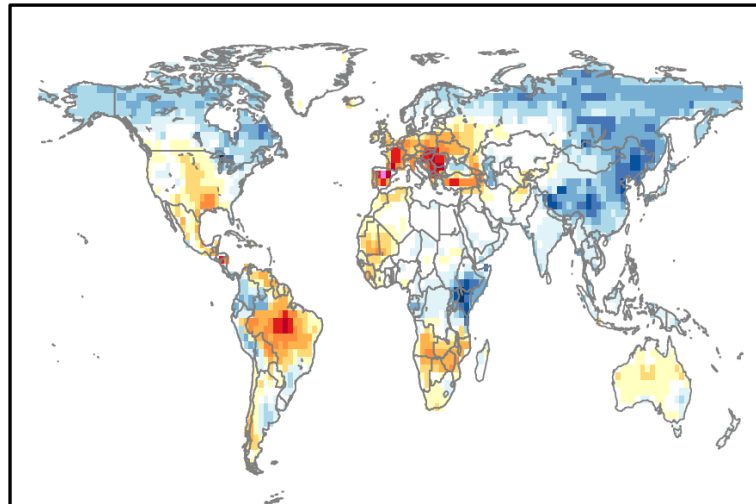


Strong present and future trends in top soil moisture and latent heat in CEU, but sign is changing

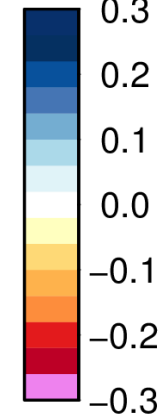
MMM latent heat trend [1971–2010]



MMM latent heat trend [2011–2100]



[W/m<sup>2</sup>]/yr



Motivation:  
Uncertainties in extreme temperatures