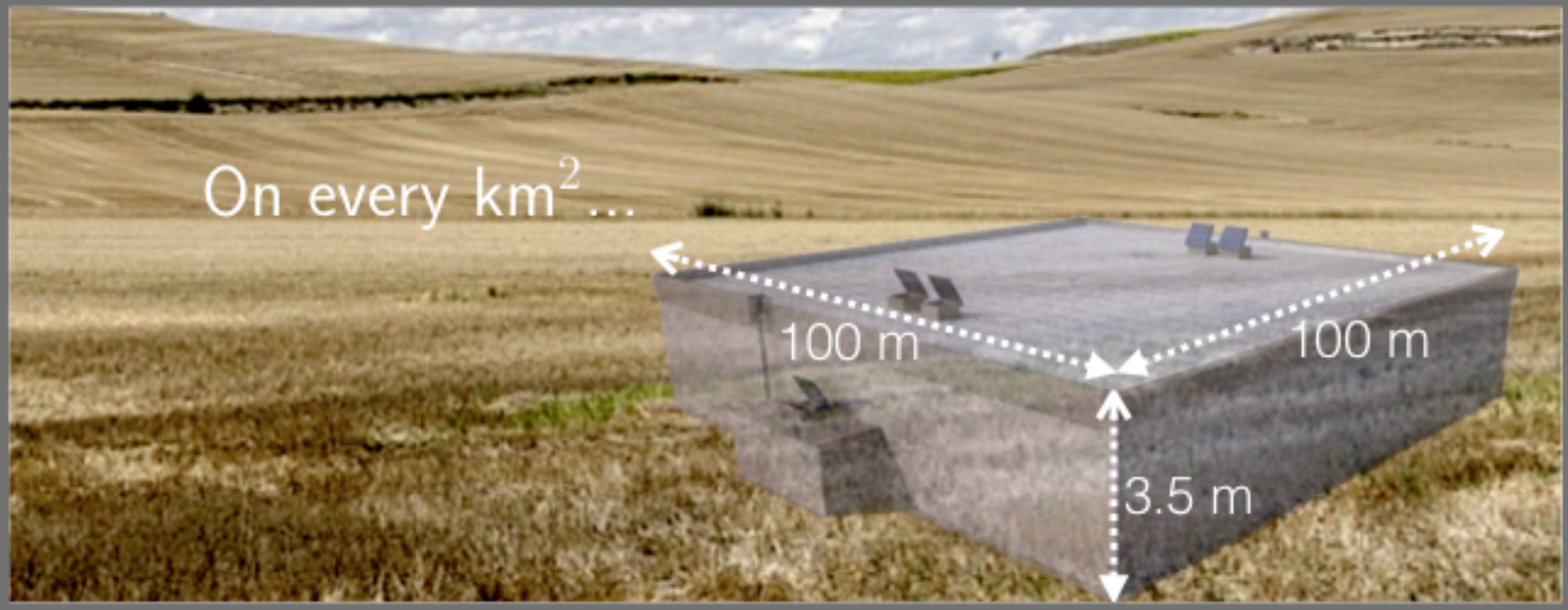
# Climate change exacerbates soil moisture droughts in Europe

Stephan Thober, Luis Samaniego, Rohini Kumar, Niko Wanders, Oldrich Rakovec, Ming Pan, Matthias Zink, Justin Sheffield, Eric Wood, Andreas Marx




8th GEWEX conference,
Canmore, May 9th 2018

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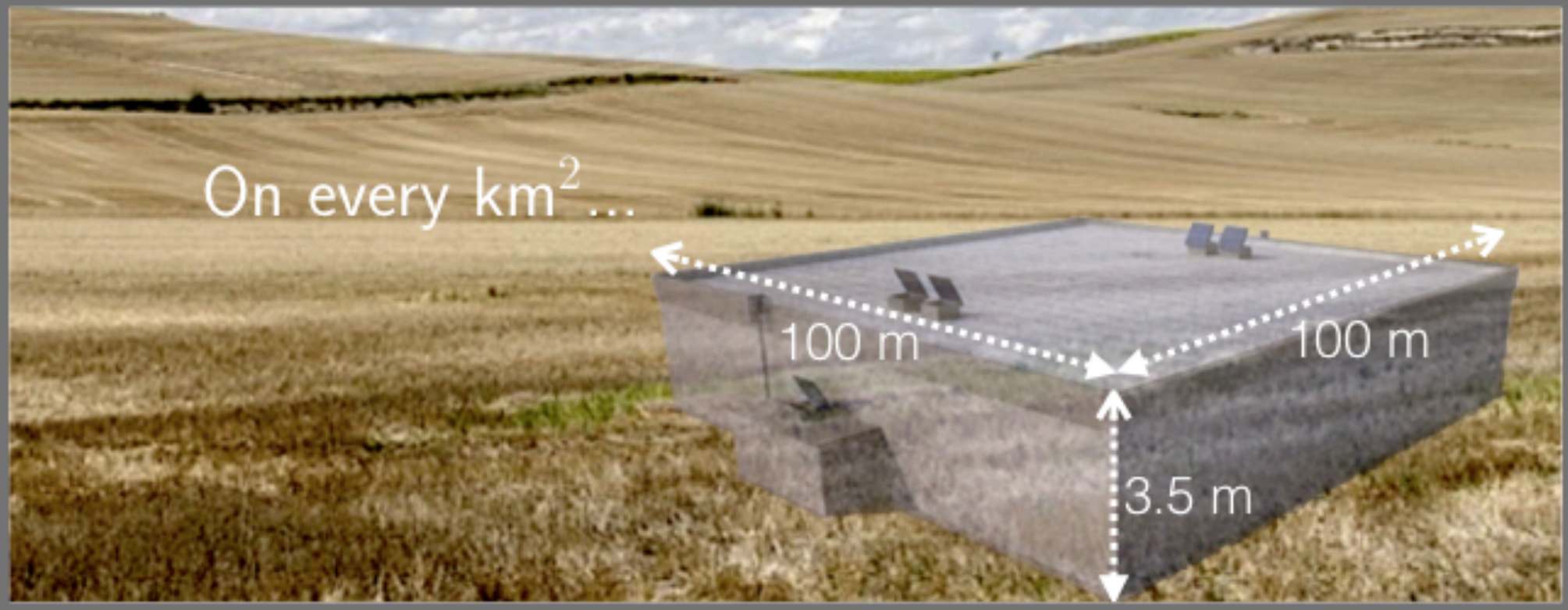


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# HOKLIM (www.ufz.de/hoklim)

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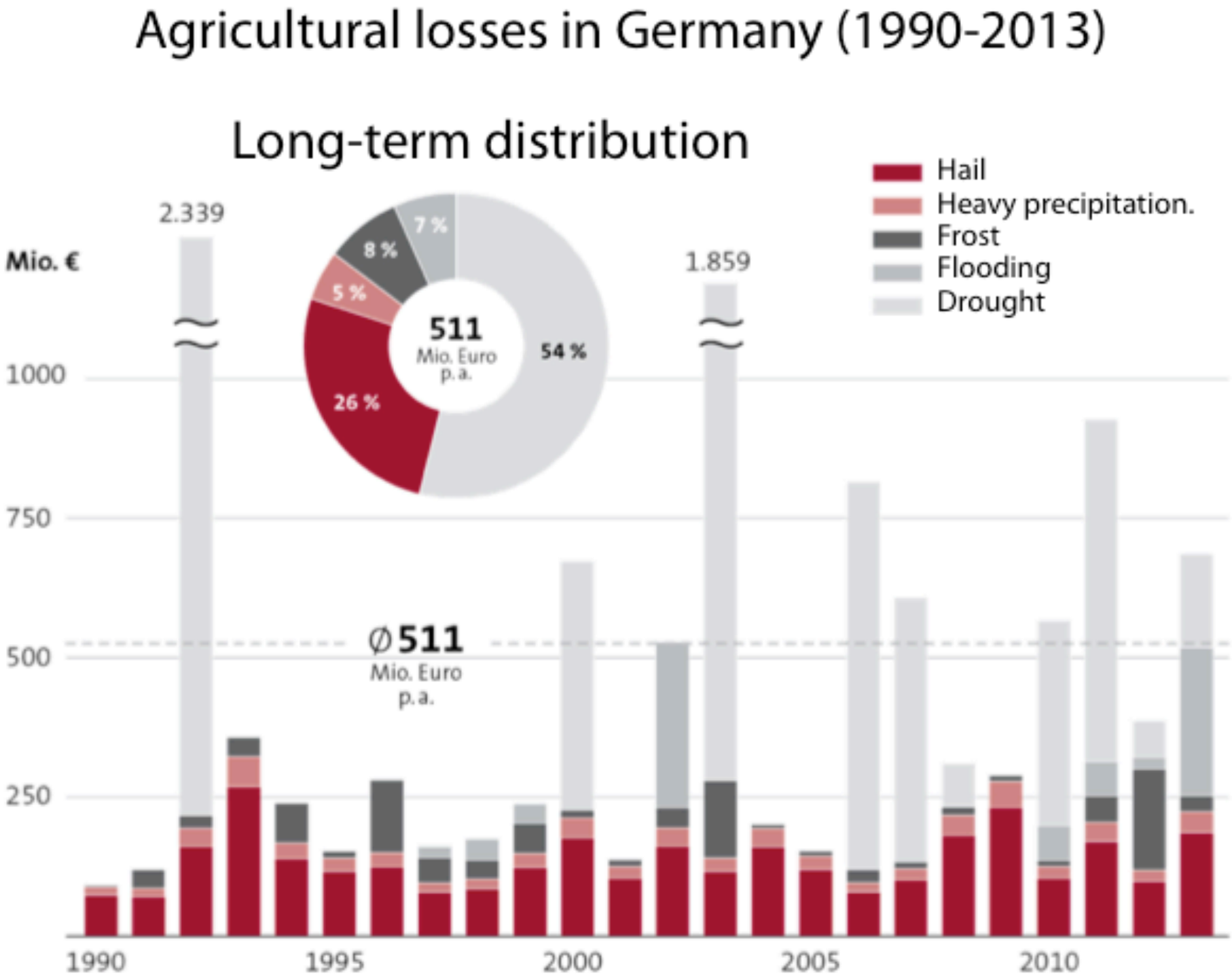
## Climate change impacts in Europe



# Motivation




Quelle: www.gdv.de | Gesamtverband der Deutschen Versicherungswirtschaft (GDV)

# Motivation

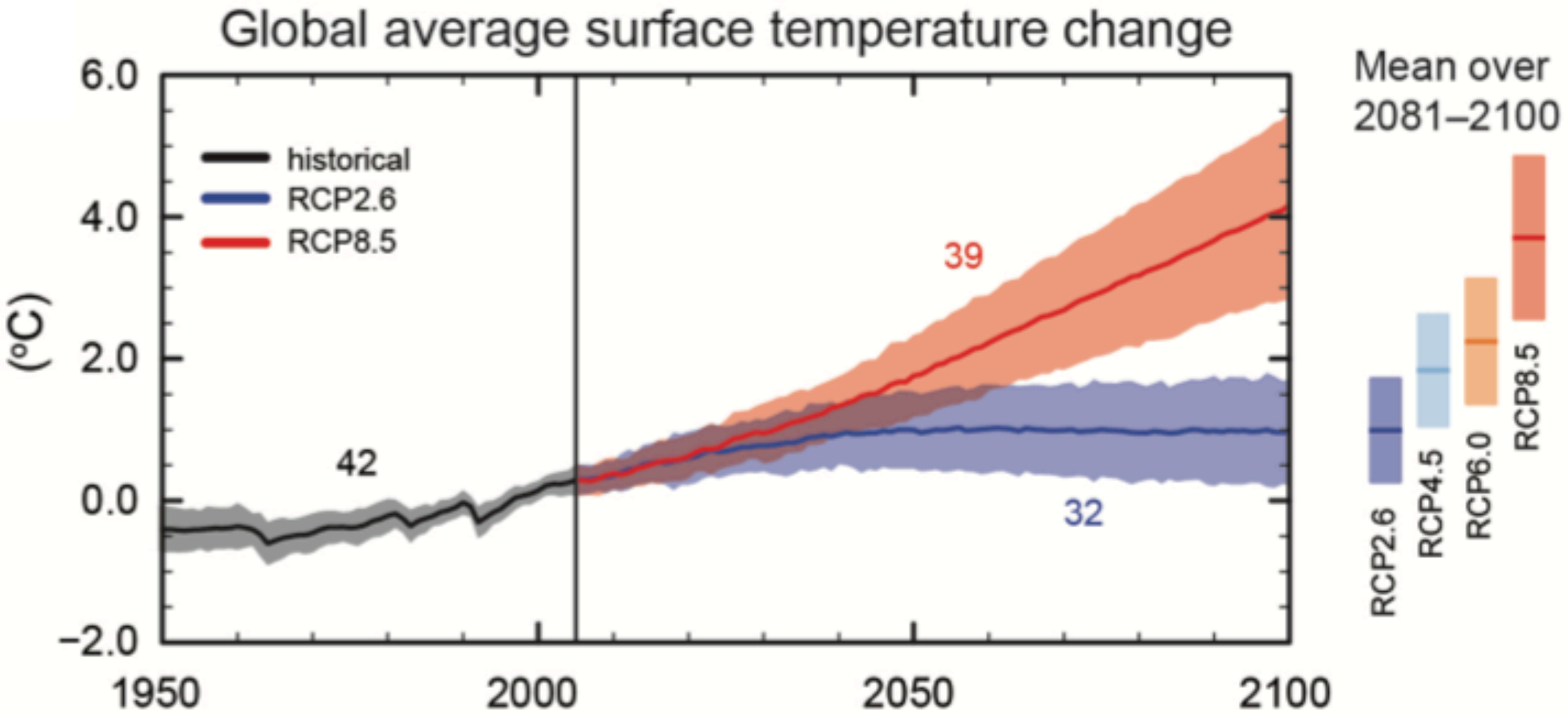



Abb. 7a, AR5 "The Physical Science Basis", IPCC (2013)

Parise climate change agreement 2015:
"Constrain global warming to well below 2° C, even pursuit efforts to limit global warming below 1.5° C"

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WHO UNEP

# Research questions

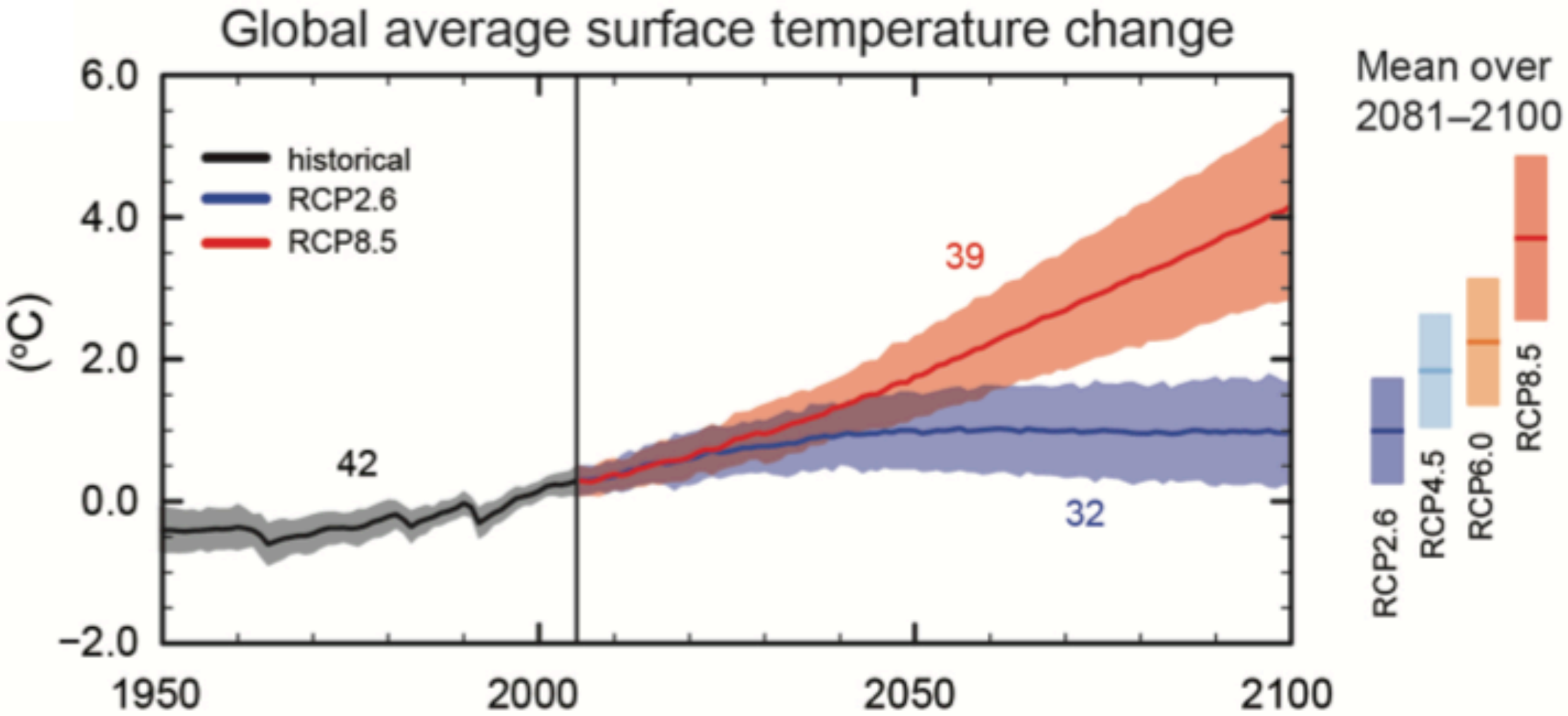
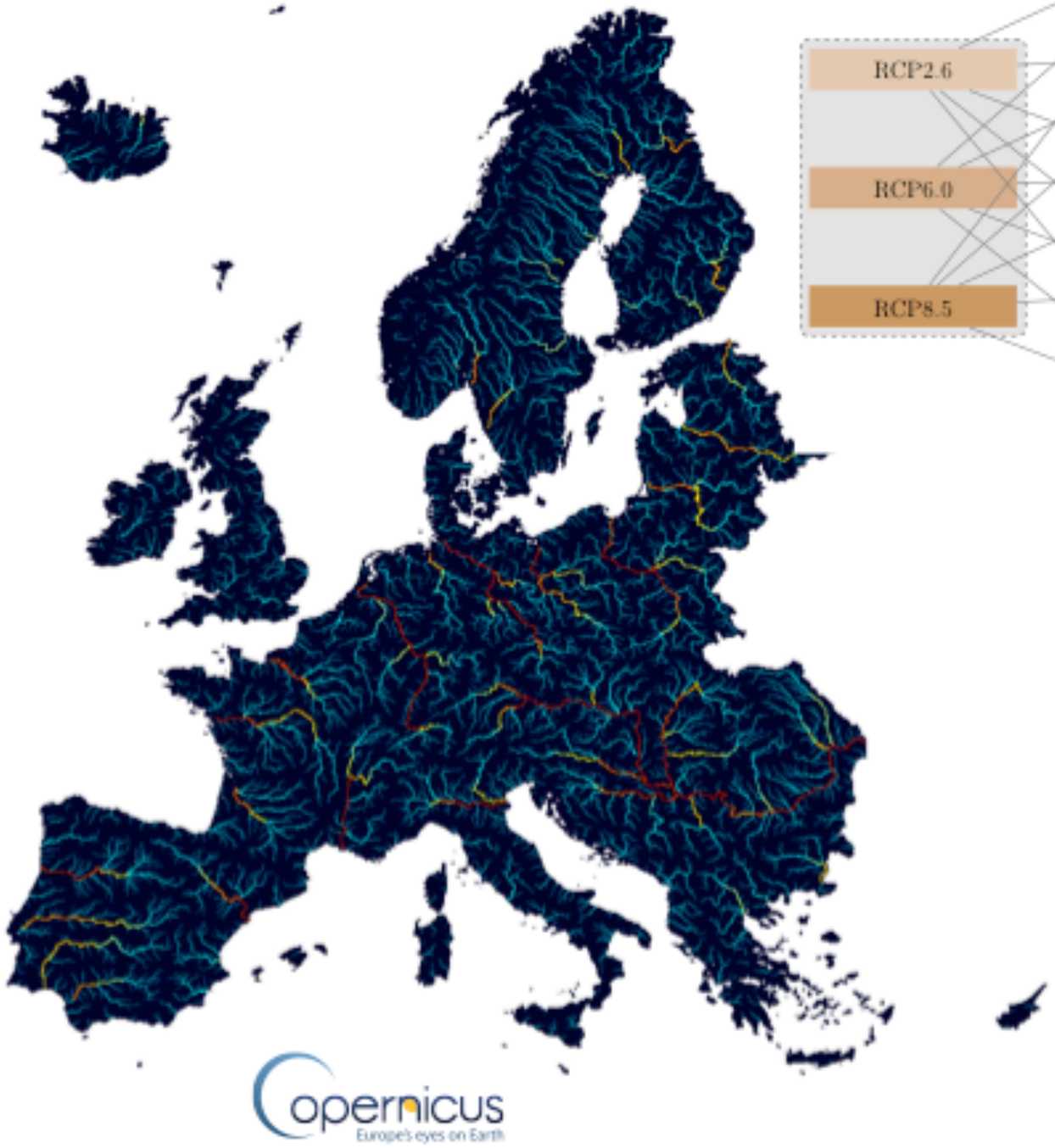
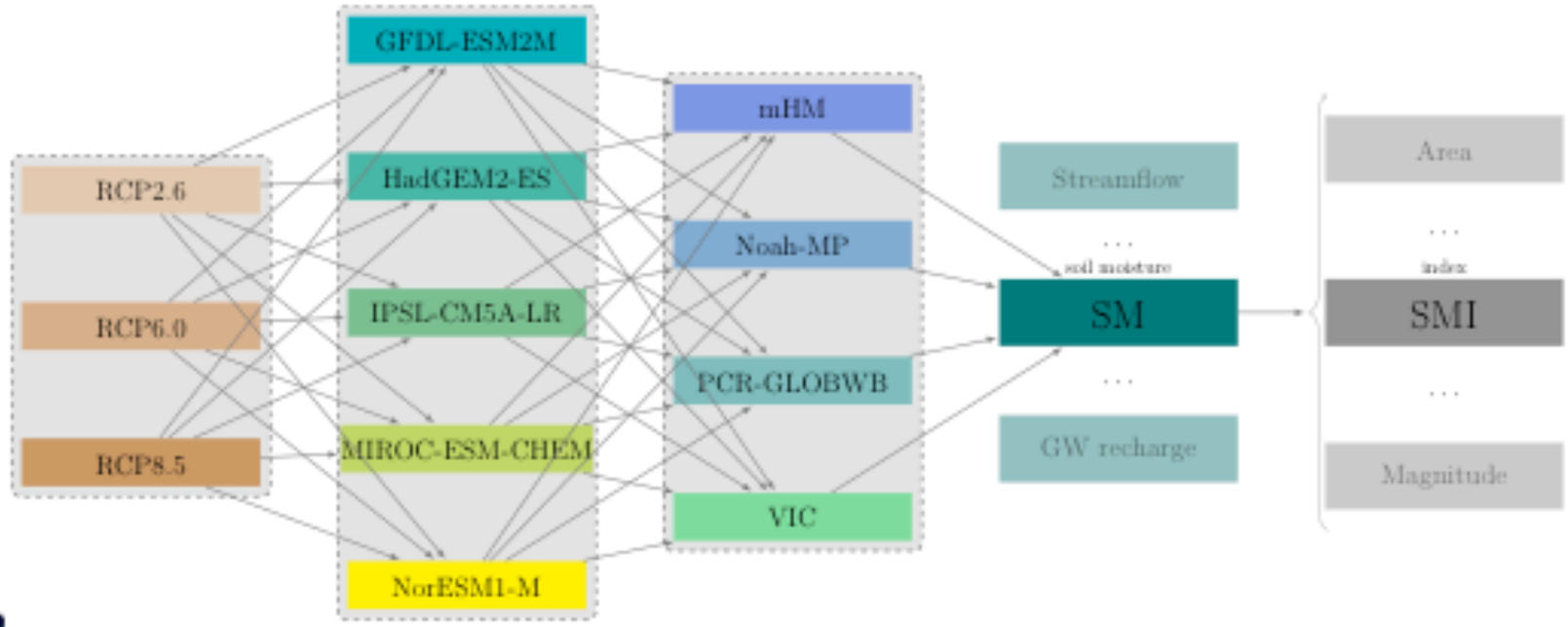



Abb. 7a, AR5 "The Physical Science Basis", IPCC (2013)

1. What is the impact of the amount of global warming on future extreme soil moisture droughts in Europe?
2. Are there regional differences within Europe?
3. What level of adaptation is required?

# Modeling chain



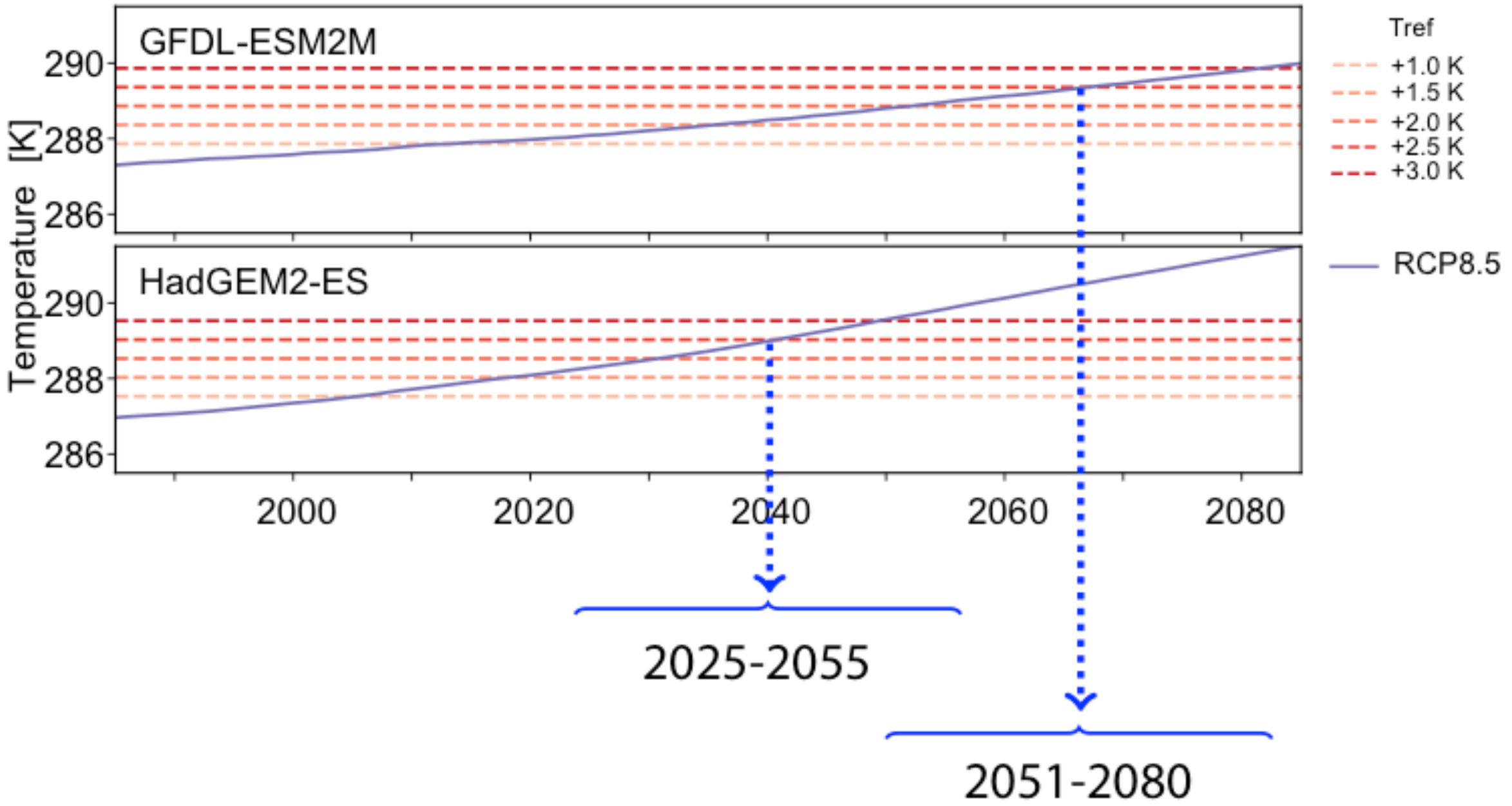



Consistent model setup:

- Soil map: SoilGrids (ISRIC), Hengl et al. (2017, PLoS ONE)
- Soil depth: 2 m
- Land cover: CORINE (COPERNICUS)
- EU-DEM (EEA)
- Historic Forcing: E-OBS (ECAD)

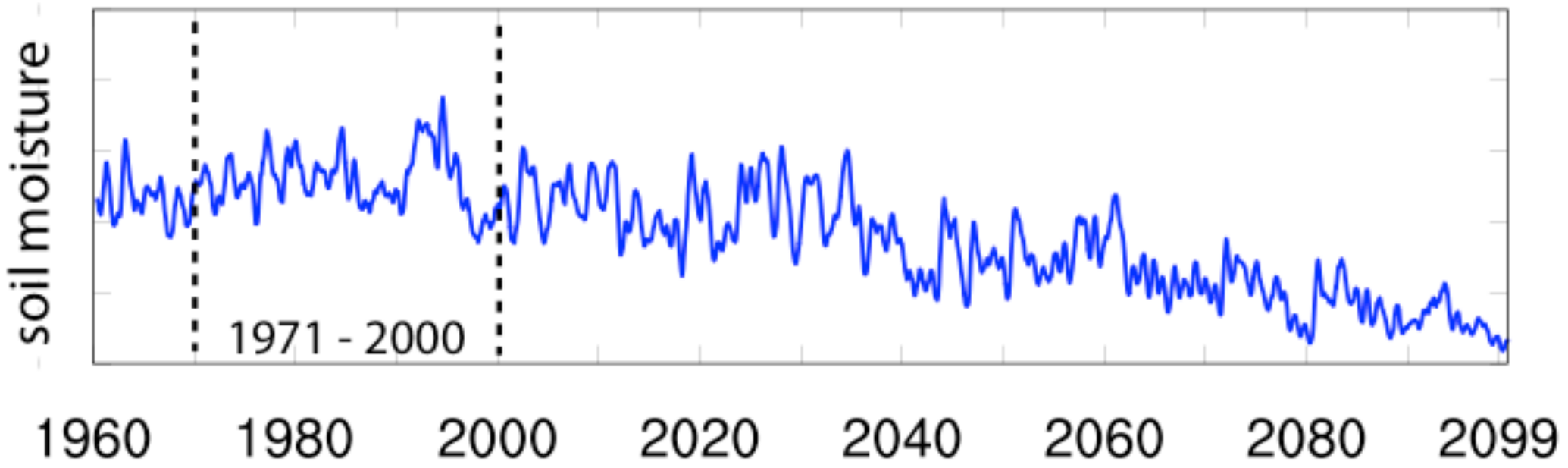
edge.climate.copernicus.eu

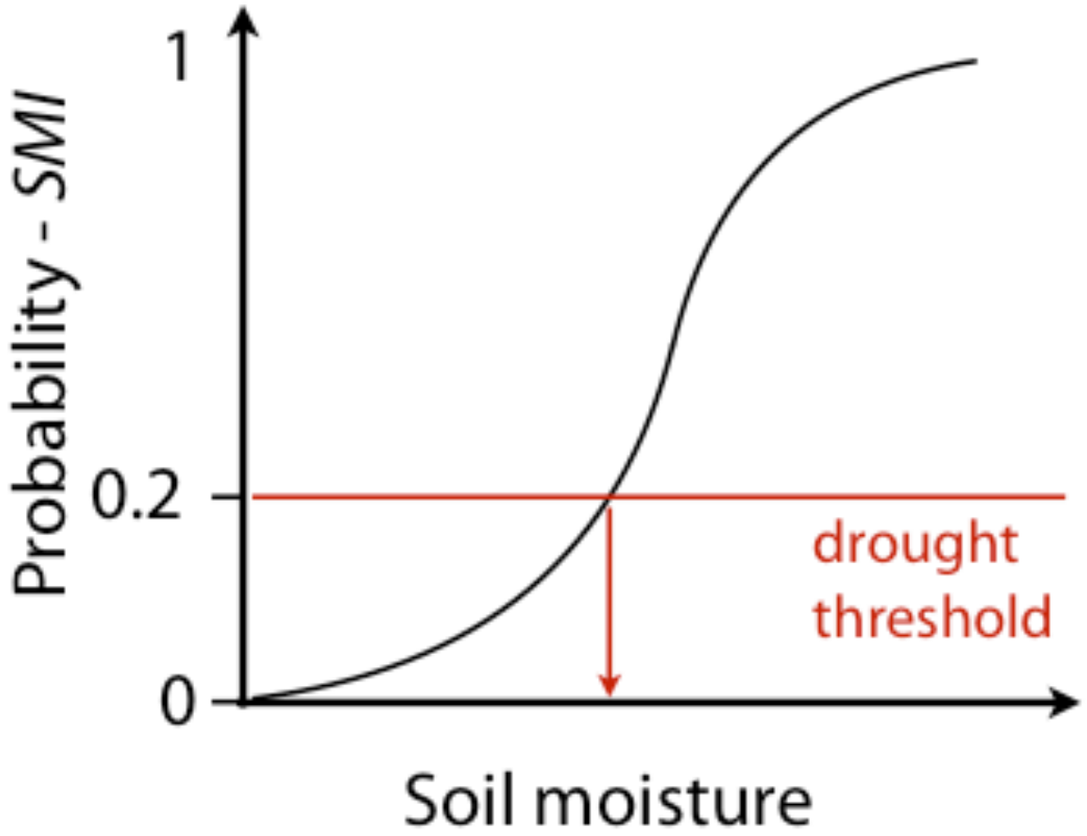
# Determining global warming levels




Time-sampling approach (James et al., 2017, Wiley Interdisciplinary Reviews-Climate Change)

# Definition of agricultural droughts




Soil moisture index:

$$SMI_t = F(x_t)$$

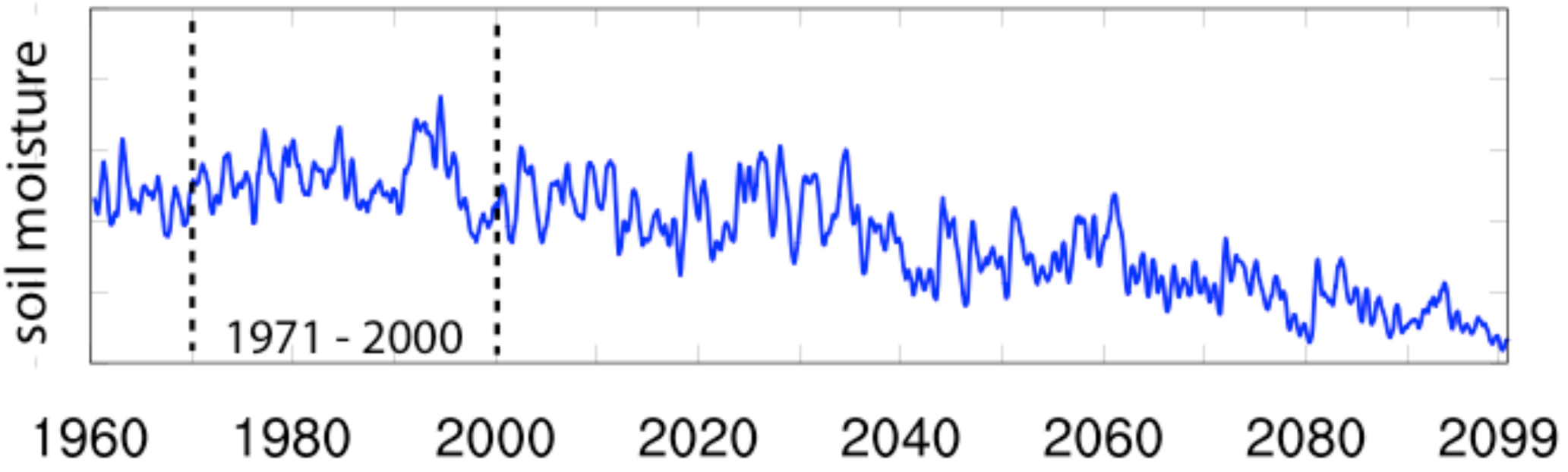
Drought:

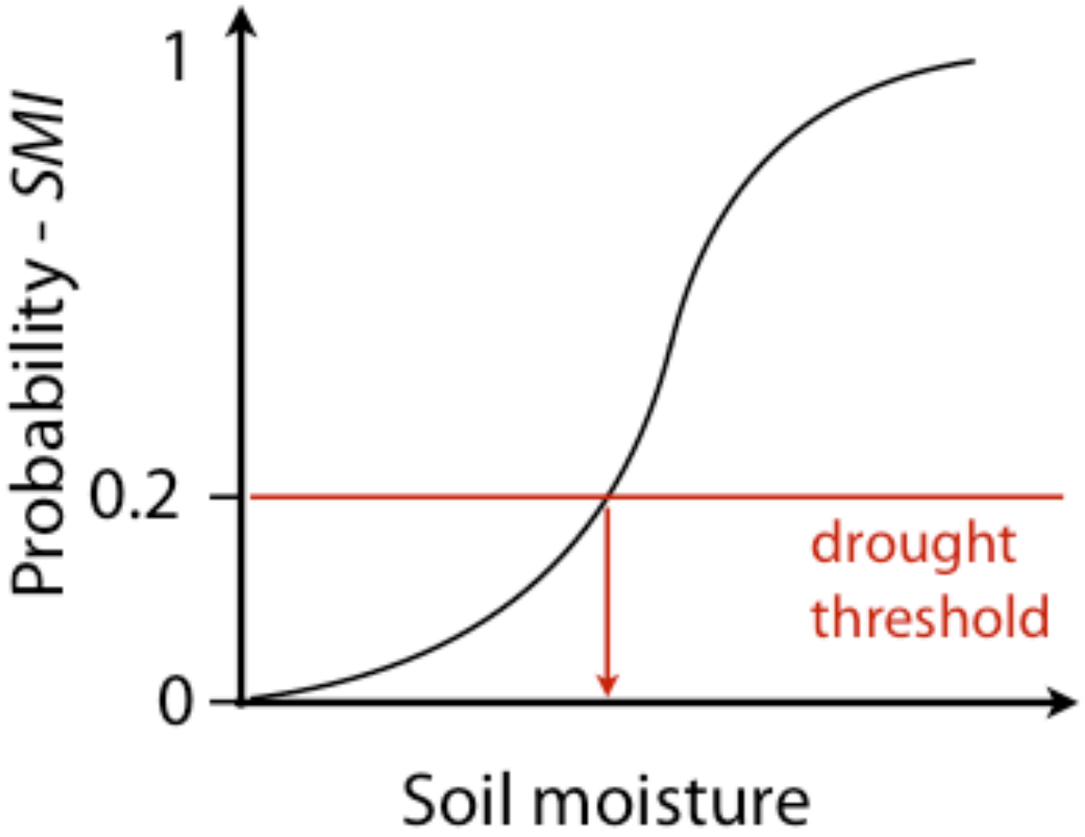
$$SMI_t < 0.2$$

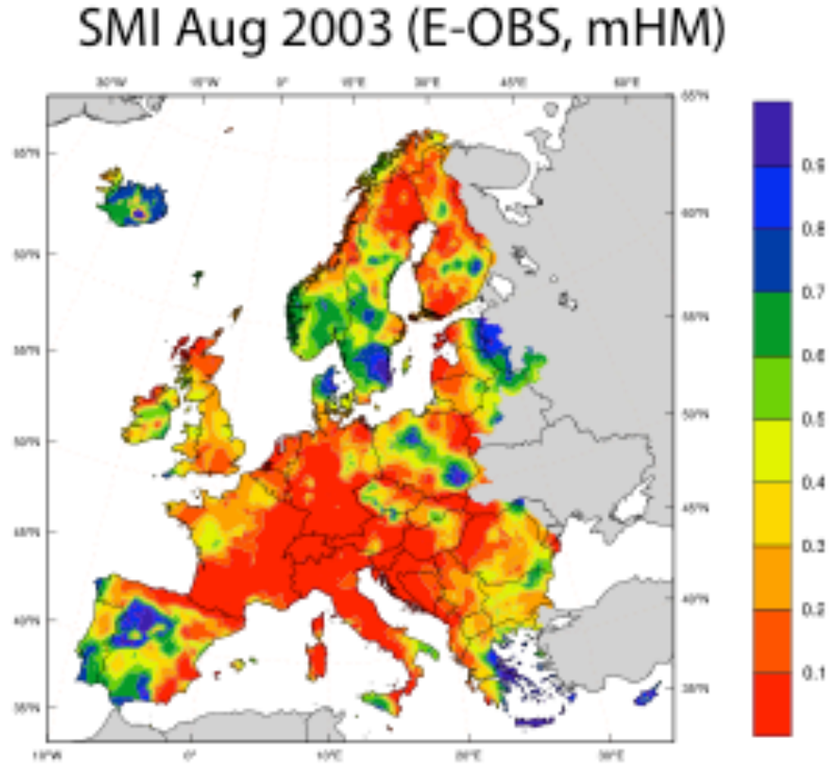
Samaniego et al. (2013, JHM)

Characteristics: Duration and area of strongest drought

# Definition of agricultural droughts

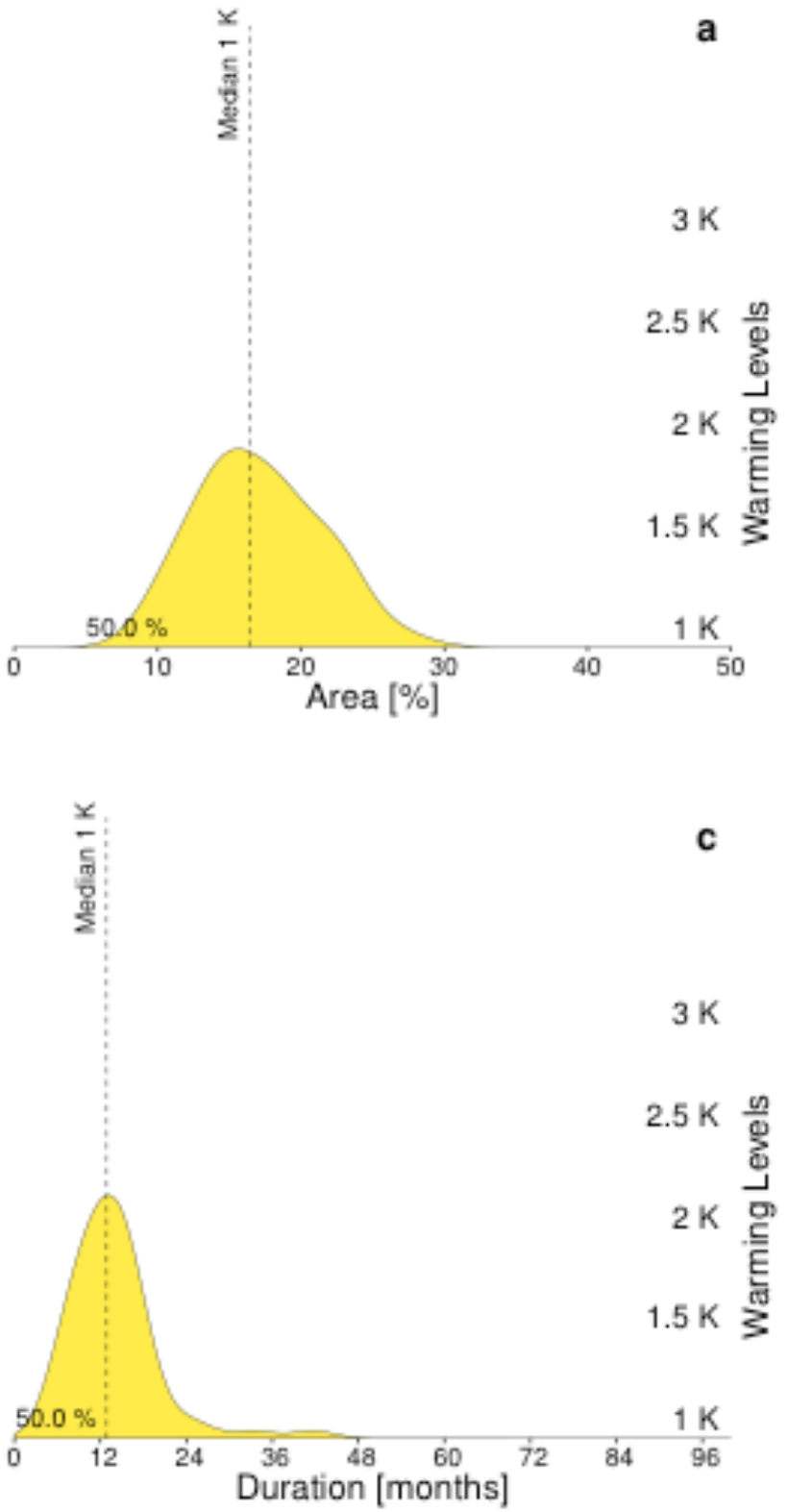


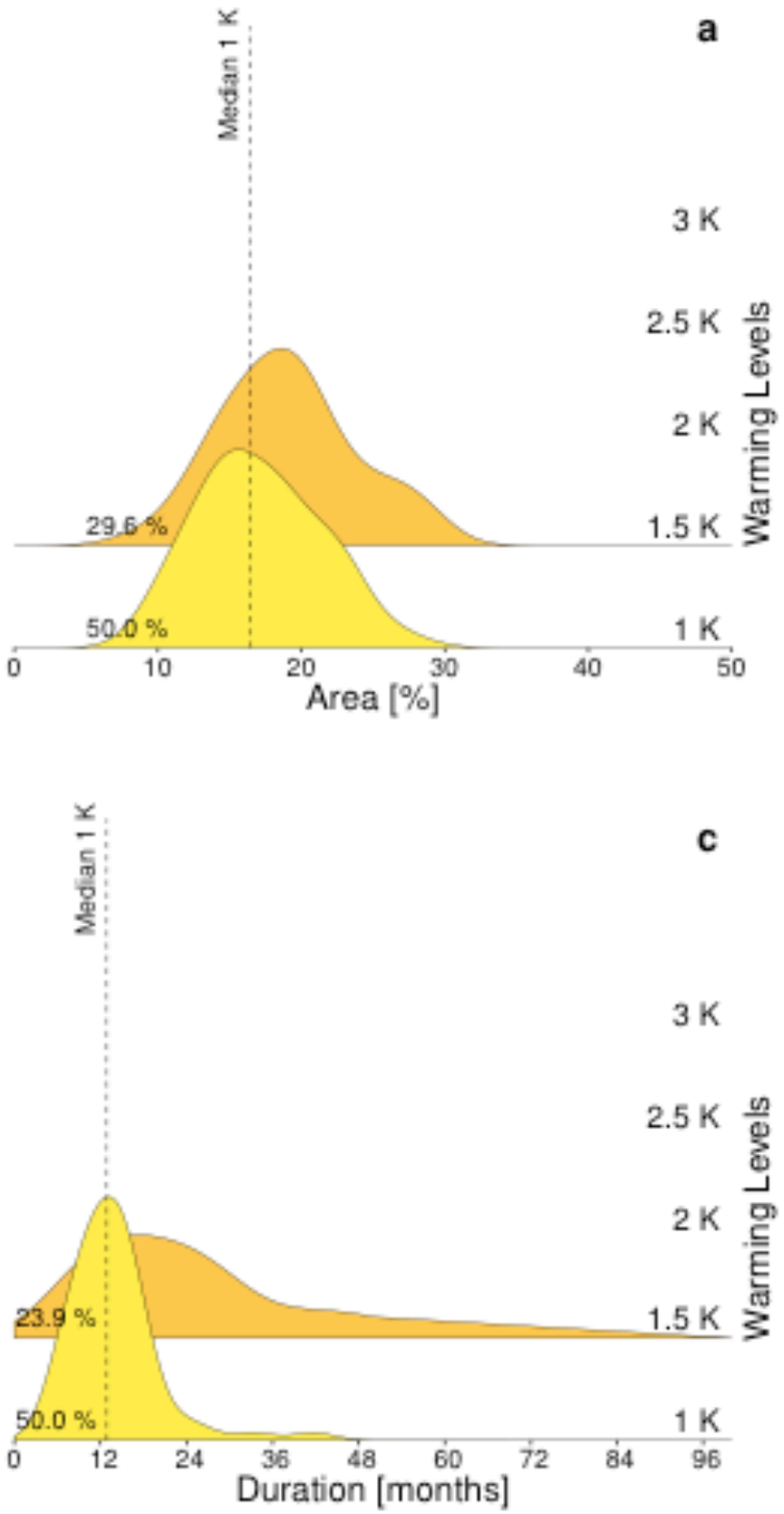




Characteristics: Duration and area of strongest drought

# Impact of global warming



# Impact of global warming



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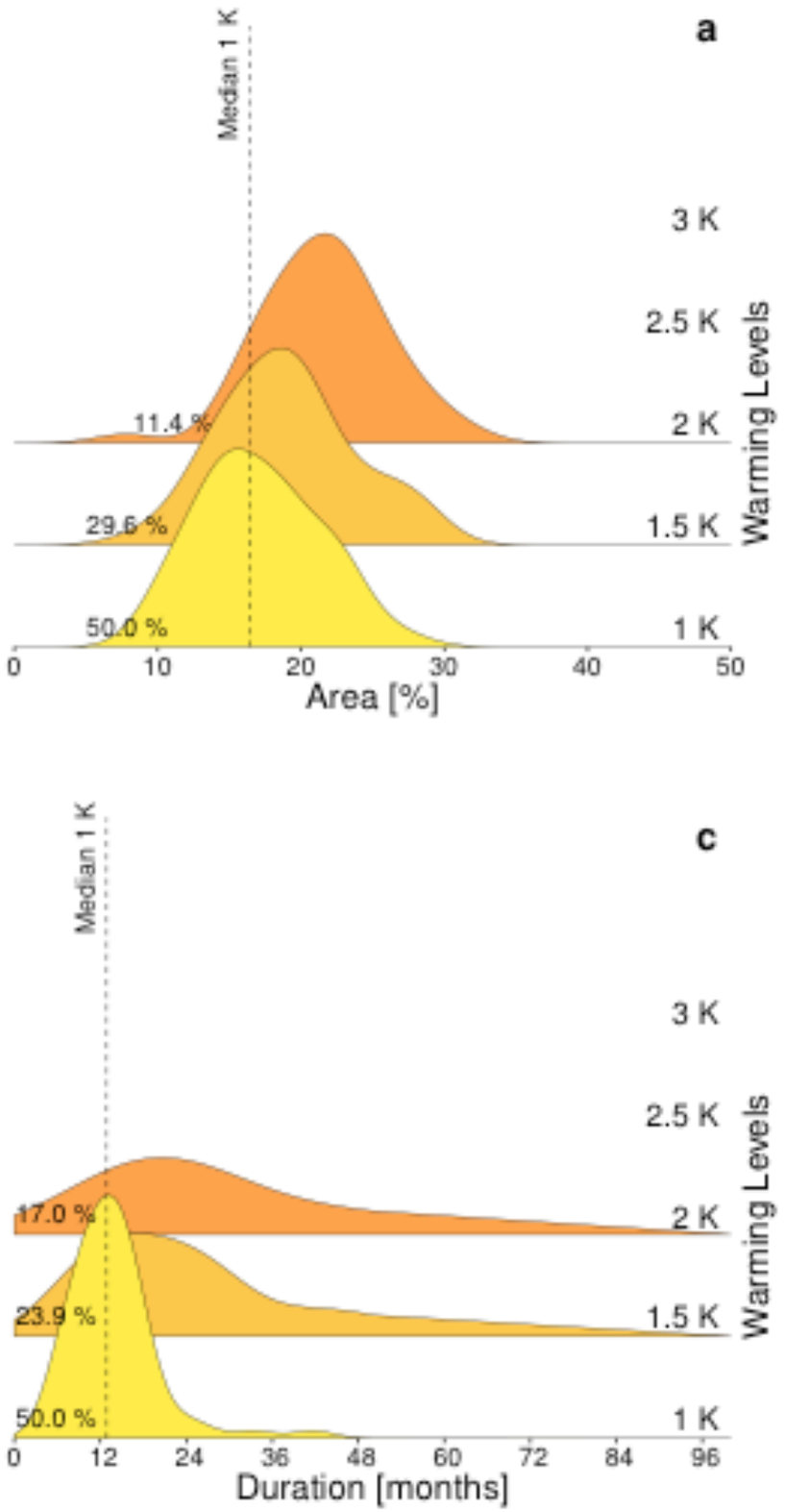

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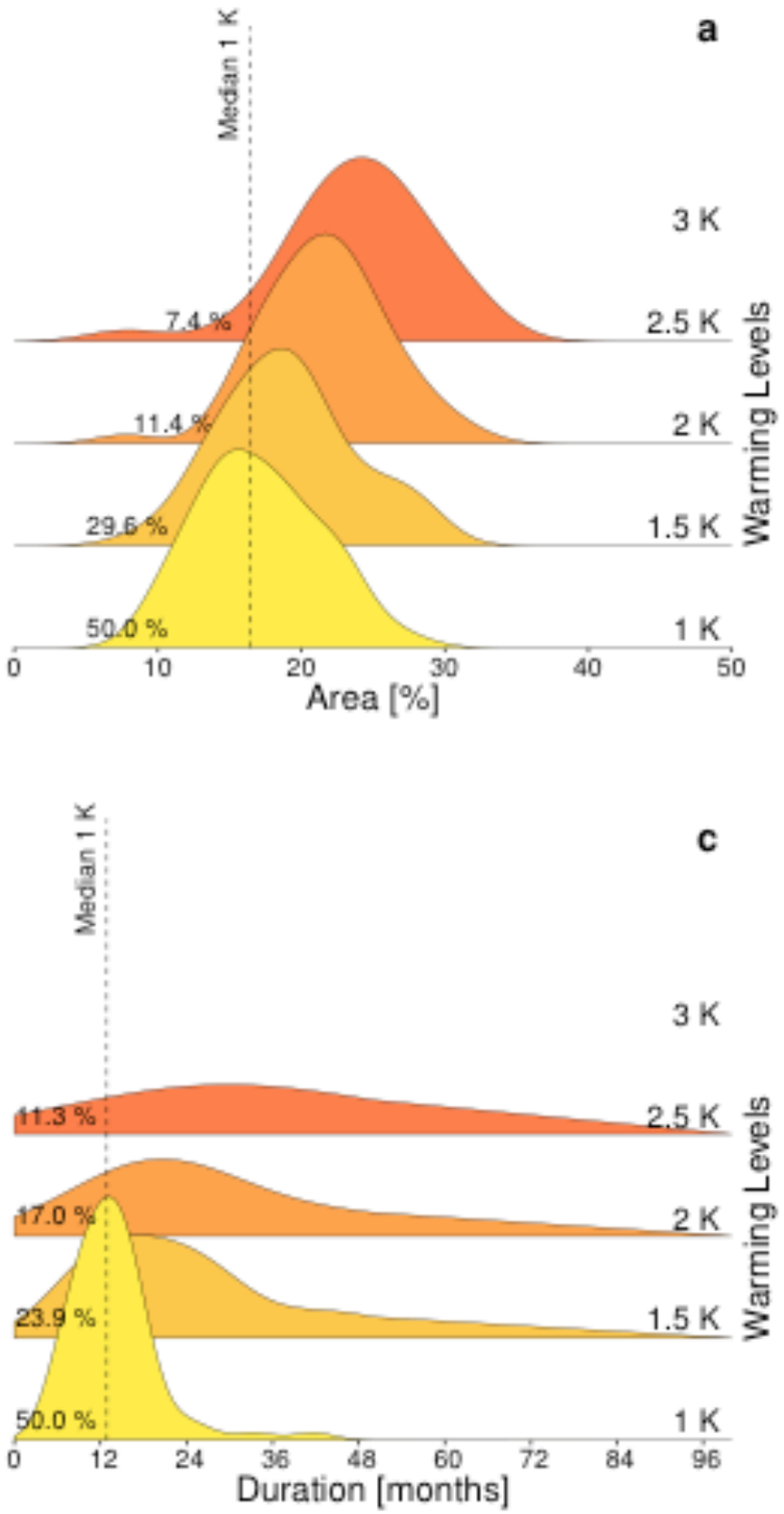

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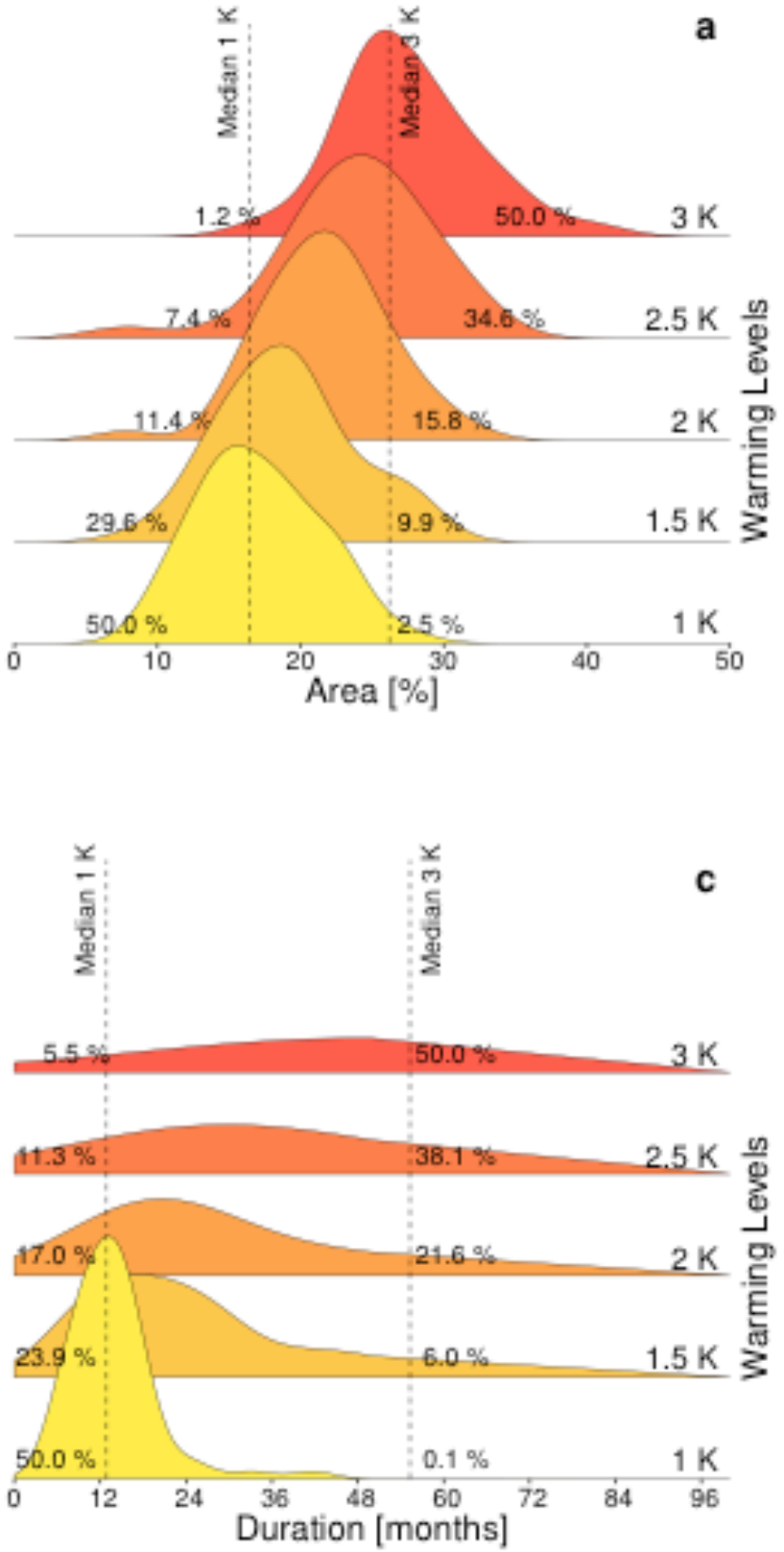
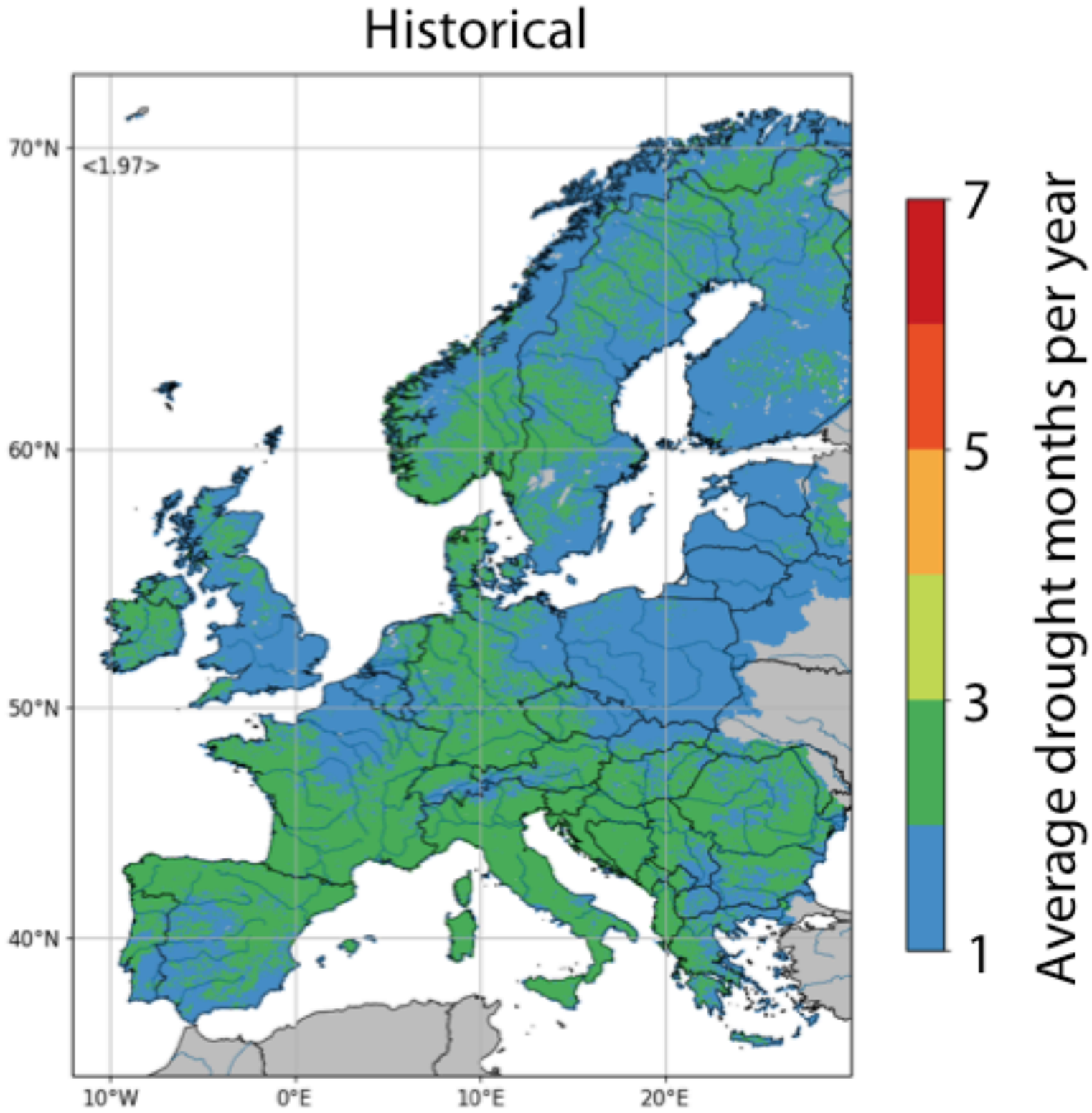



Comparing1.5 K and 3 K:

- Drought area will increase by 40% (±24%)
- Duration of droughts will triple

# Regional differences within Europe



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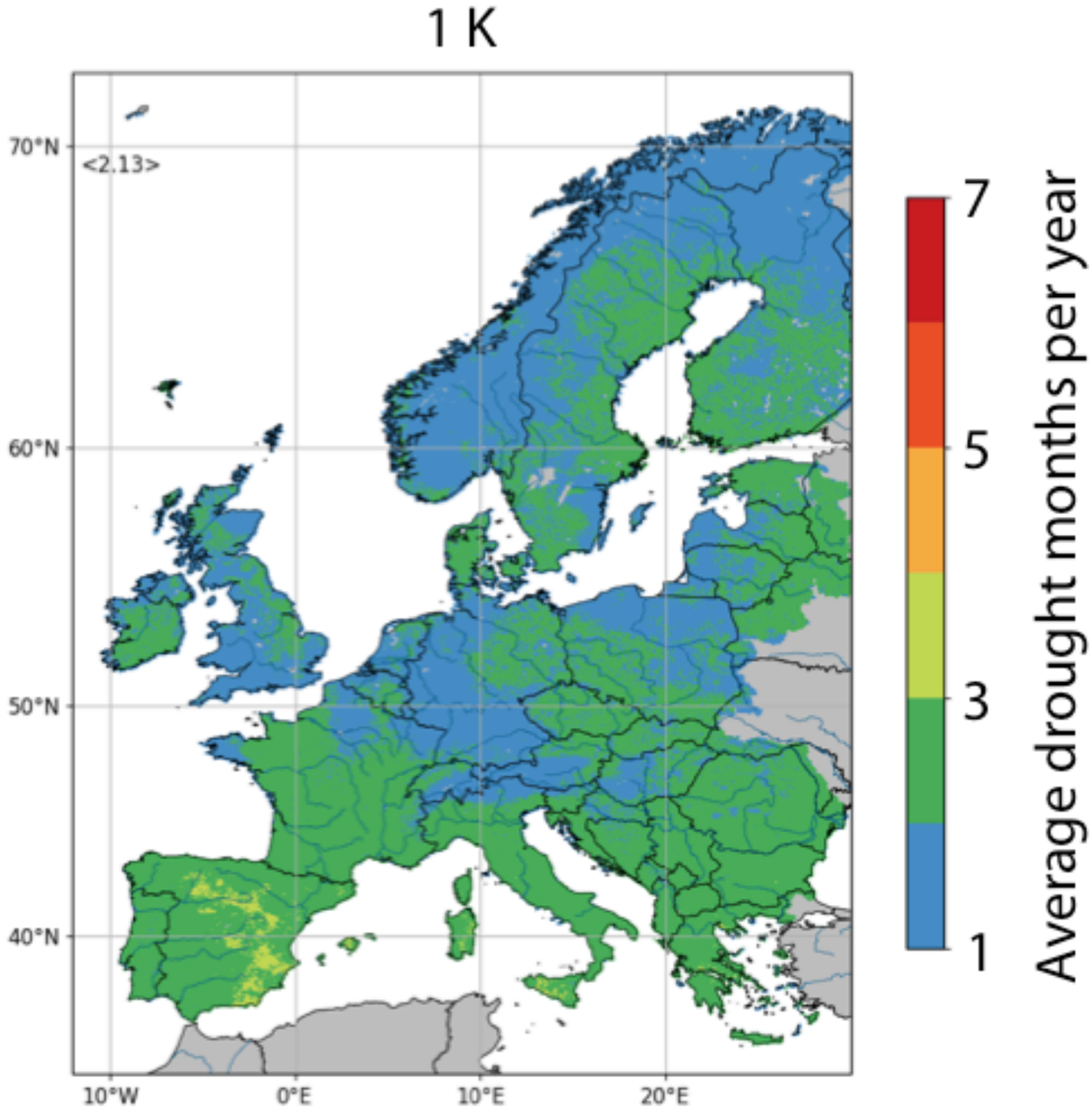

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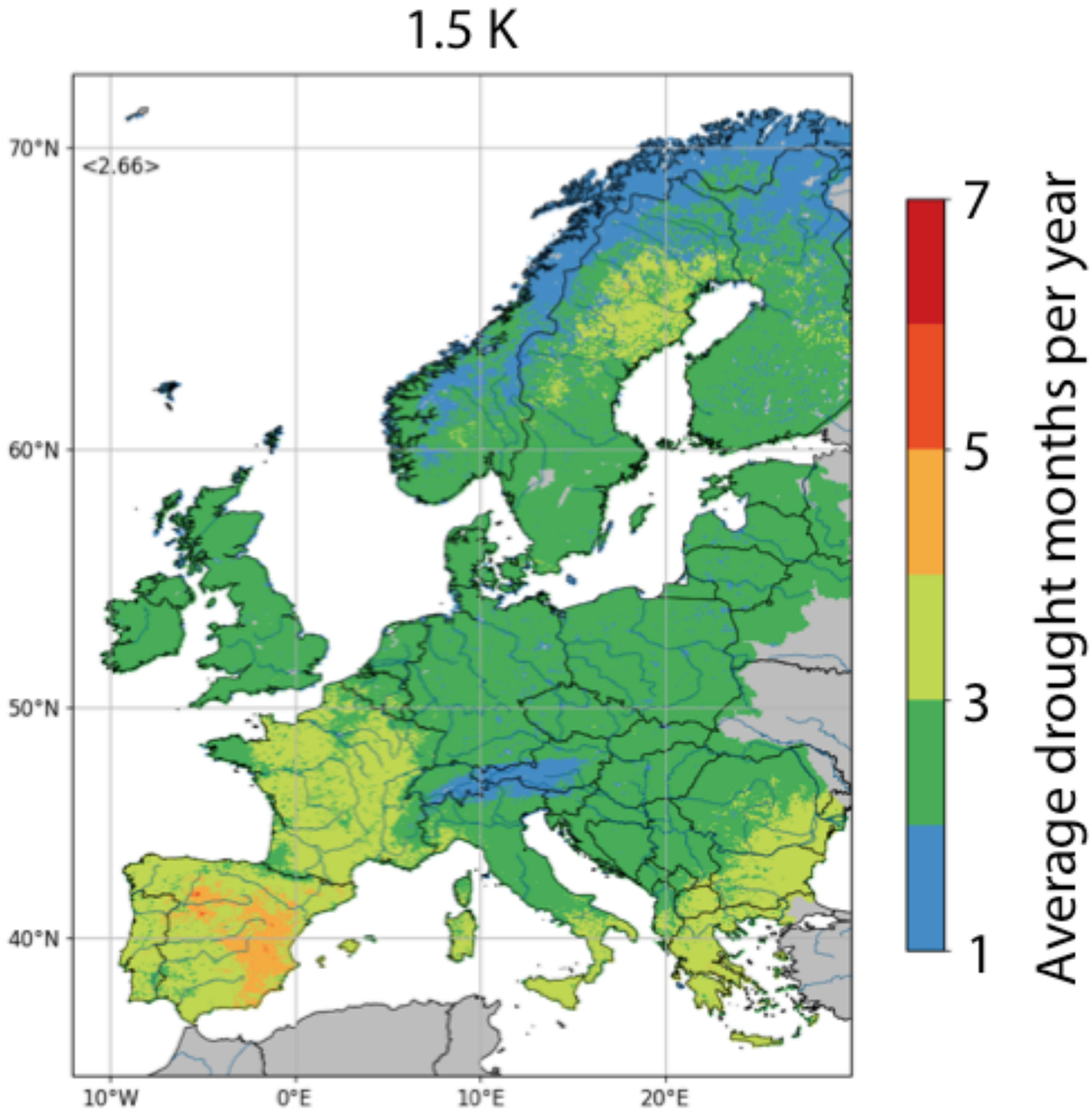

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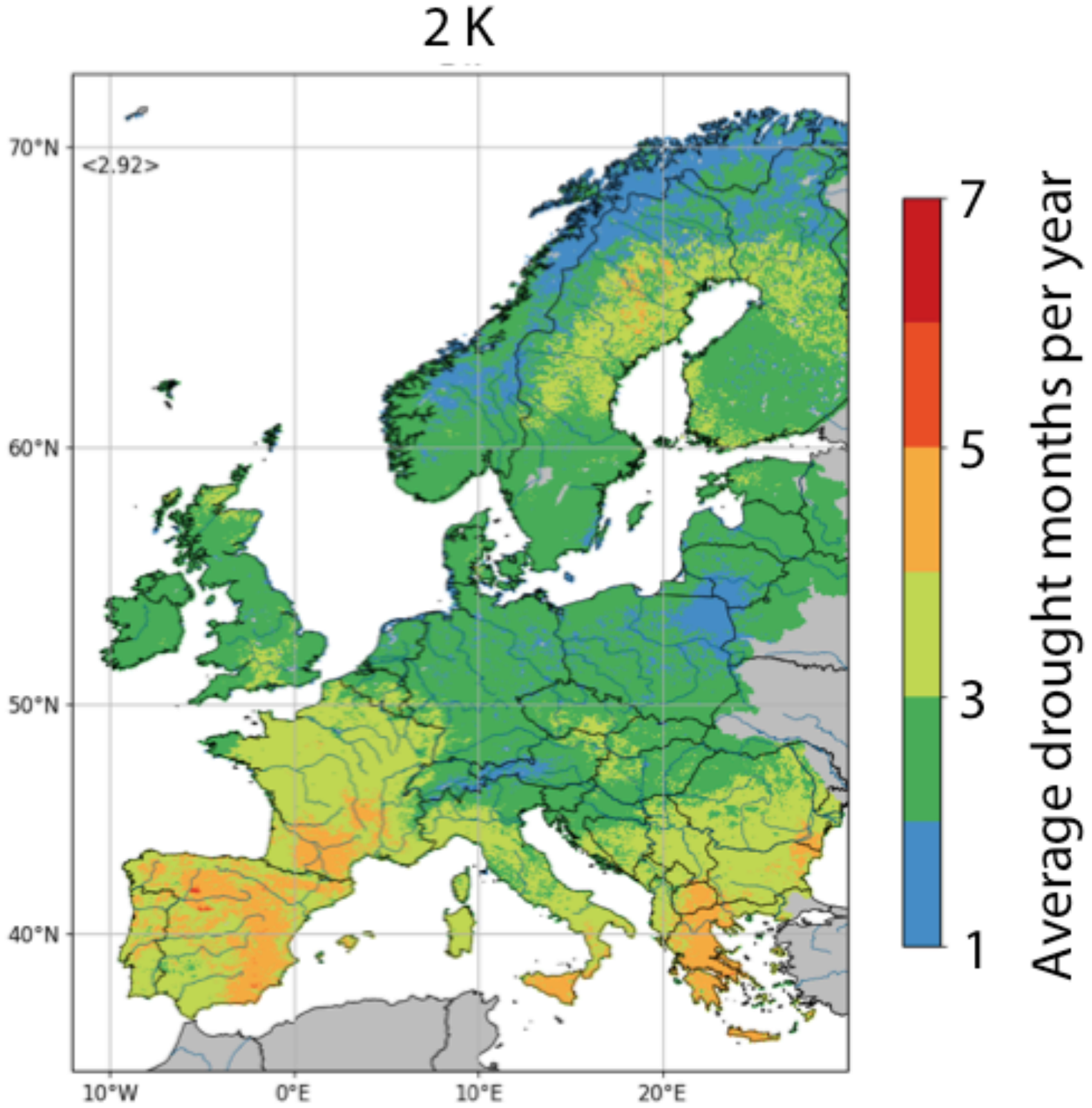

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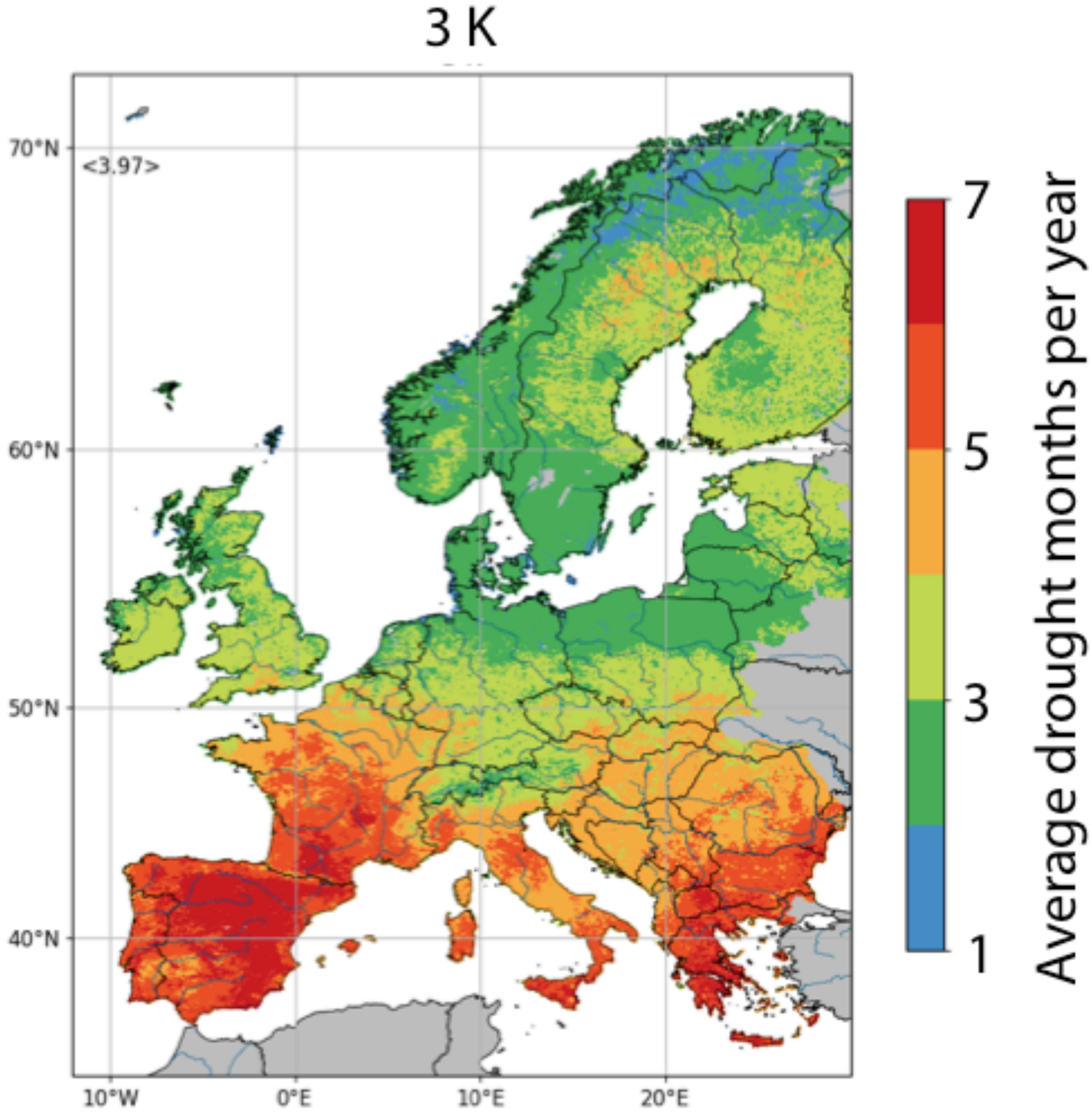
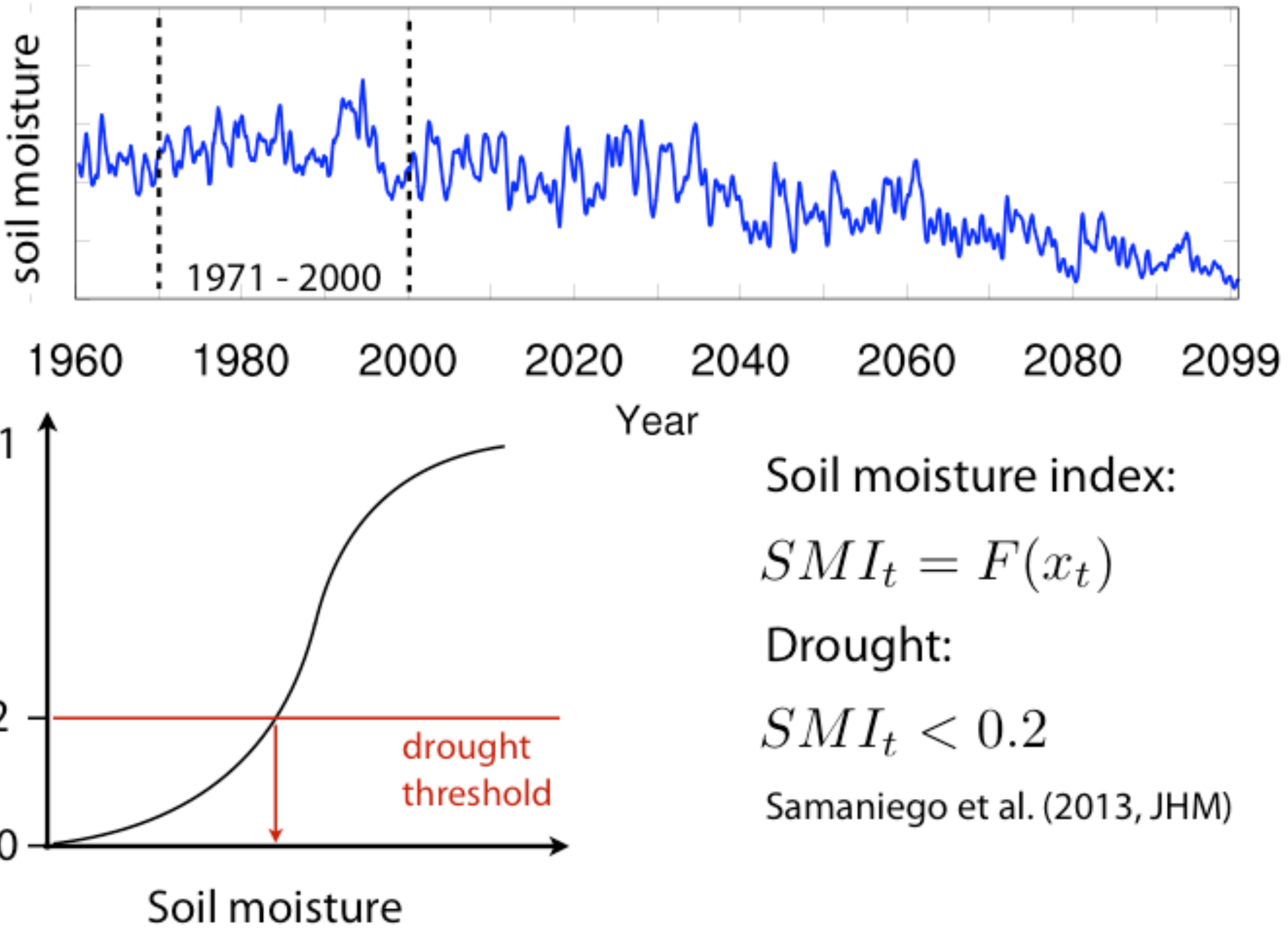


# Definition of agricultural droughts




Soil moisture index:

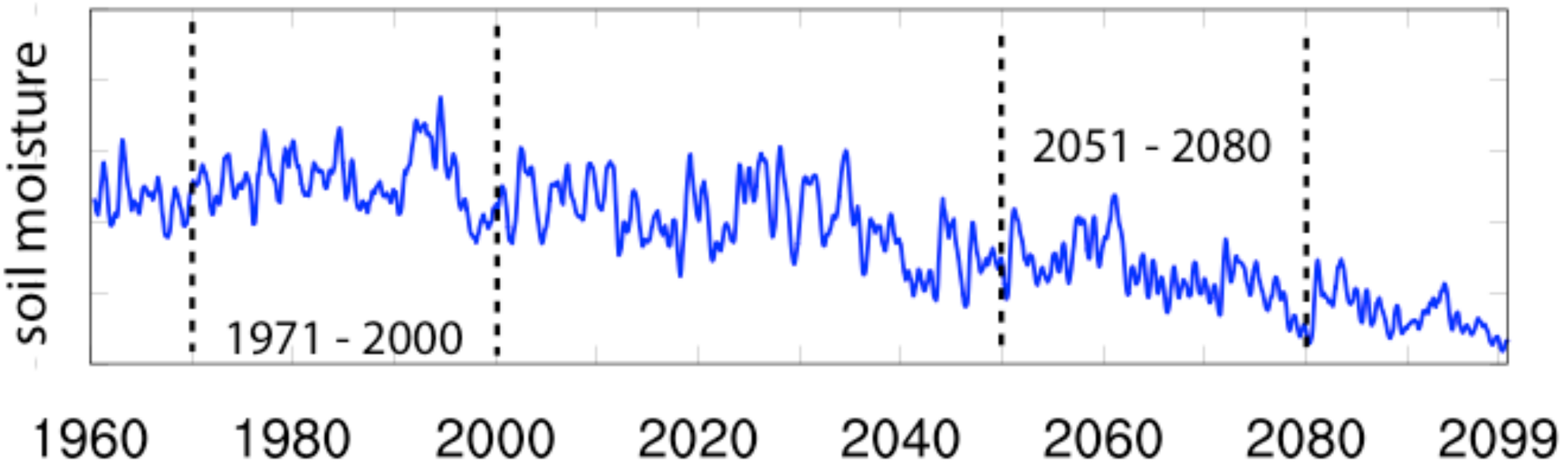
$$SMI_t = F(x_t)$$

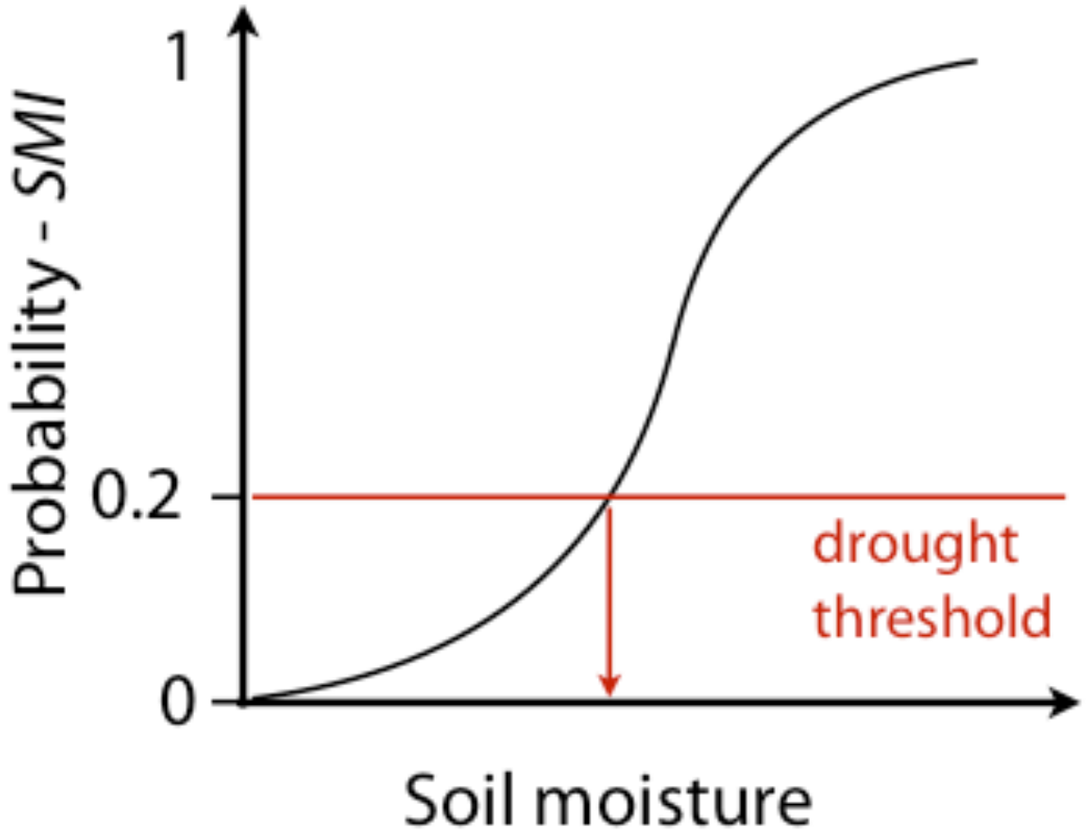
Drought:

$$SMI_t < 0.2$$

Samaniego et al. (2013, JHM)

# Definition of agricultural droughts




Soil moisture index:

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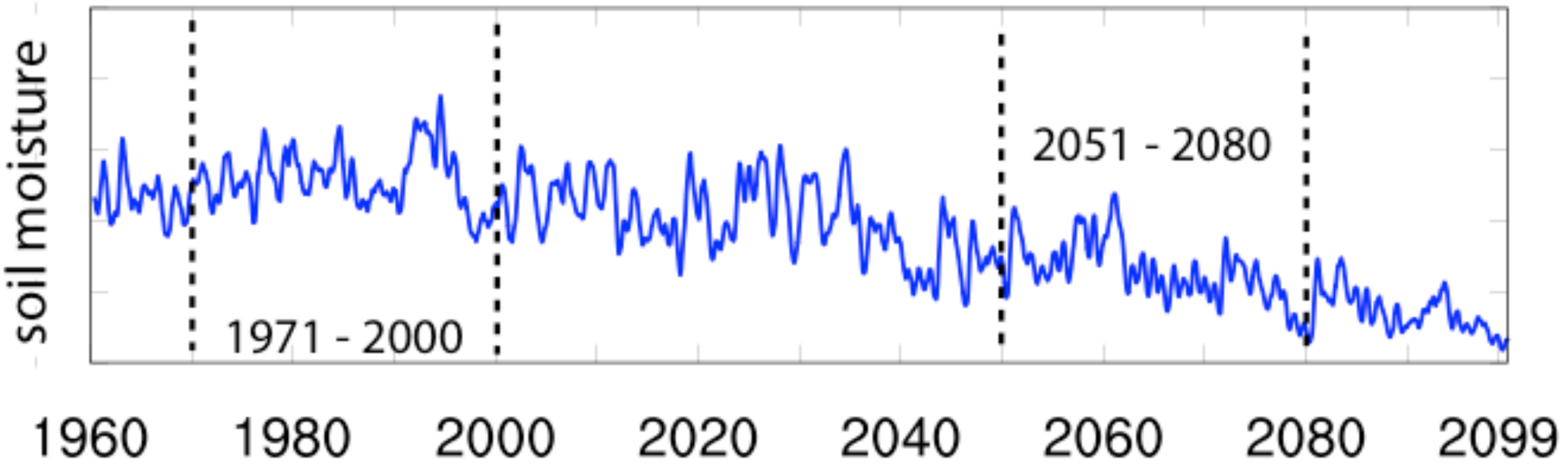
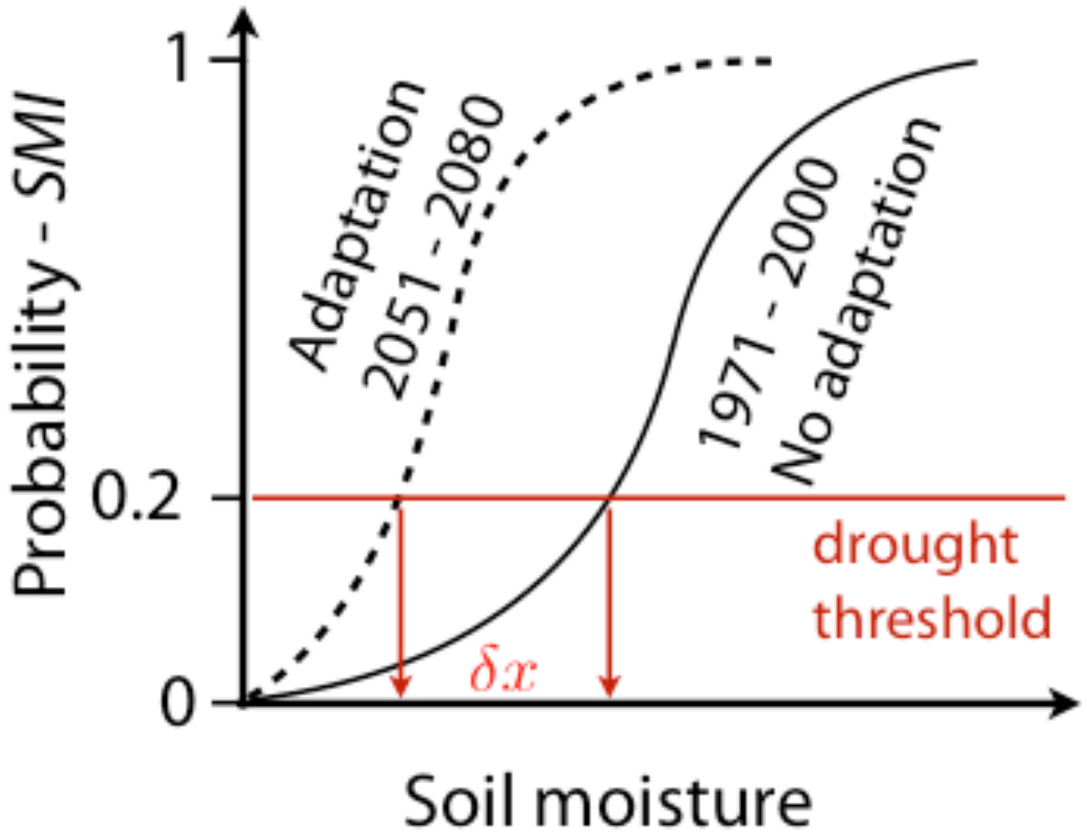
# Definition of agricultural droughts (with adaptation)

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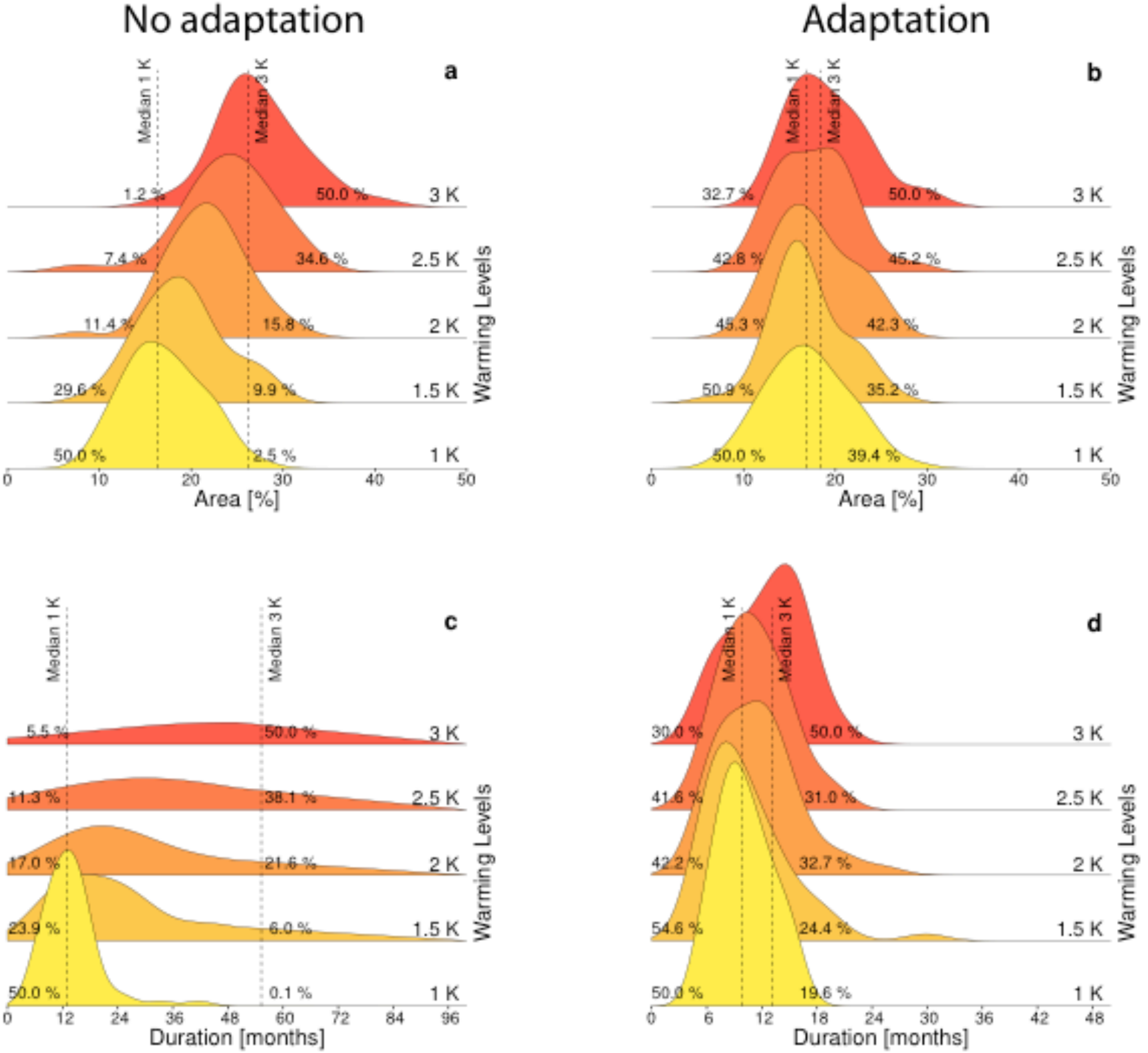
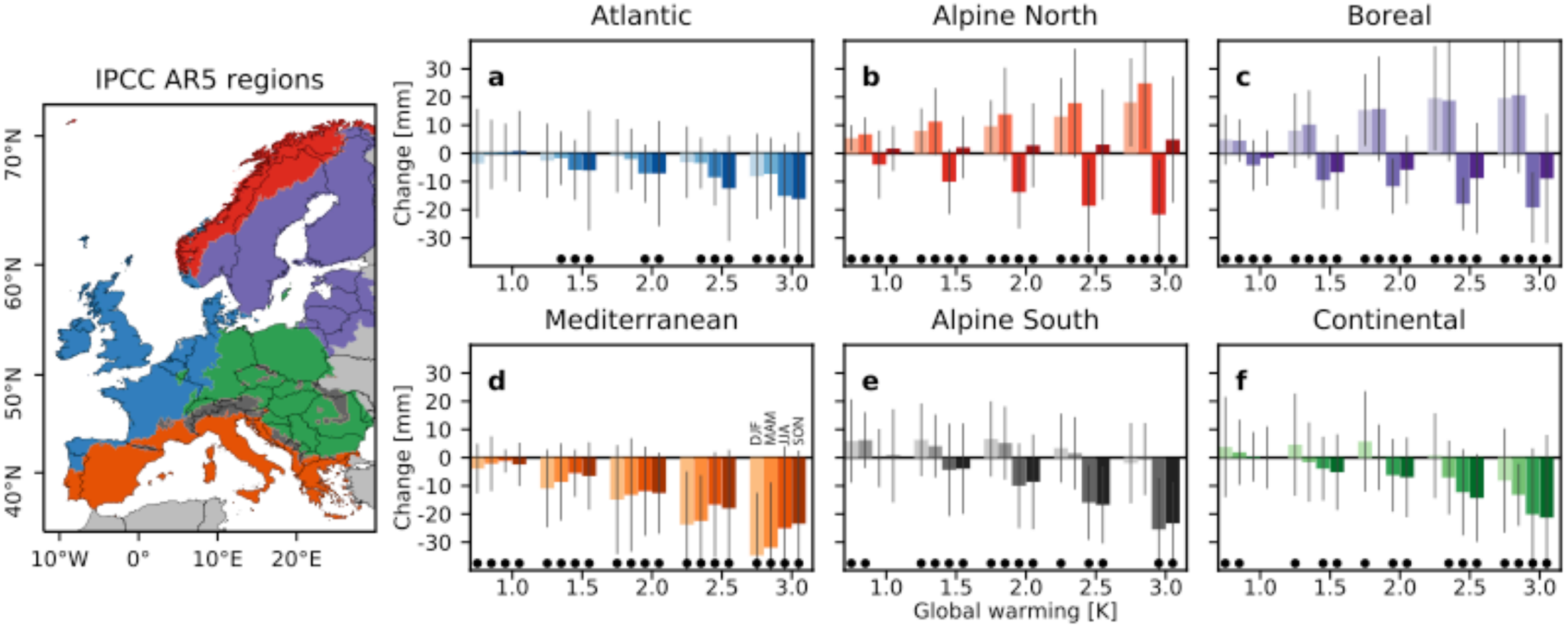
Samaniego et al. (2013, JHM)

Change in aridity [mm]: $\delta x$

# Effect of adaptation to climate change



# Change in aridity



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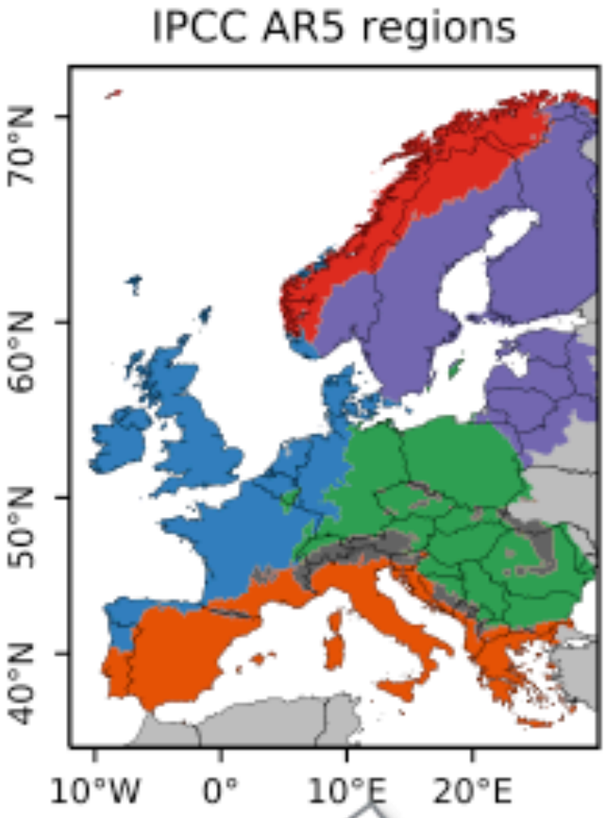
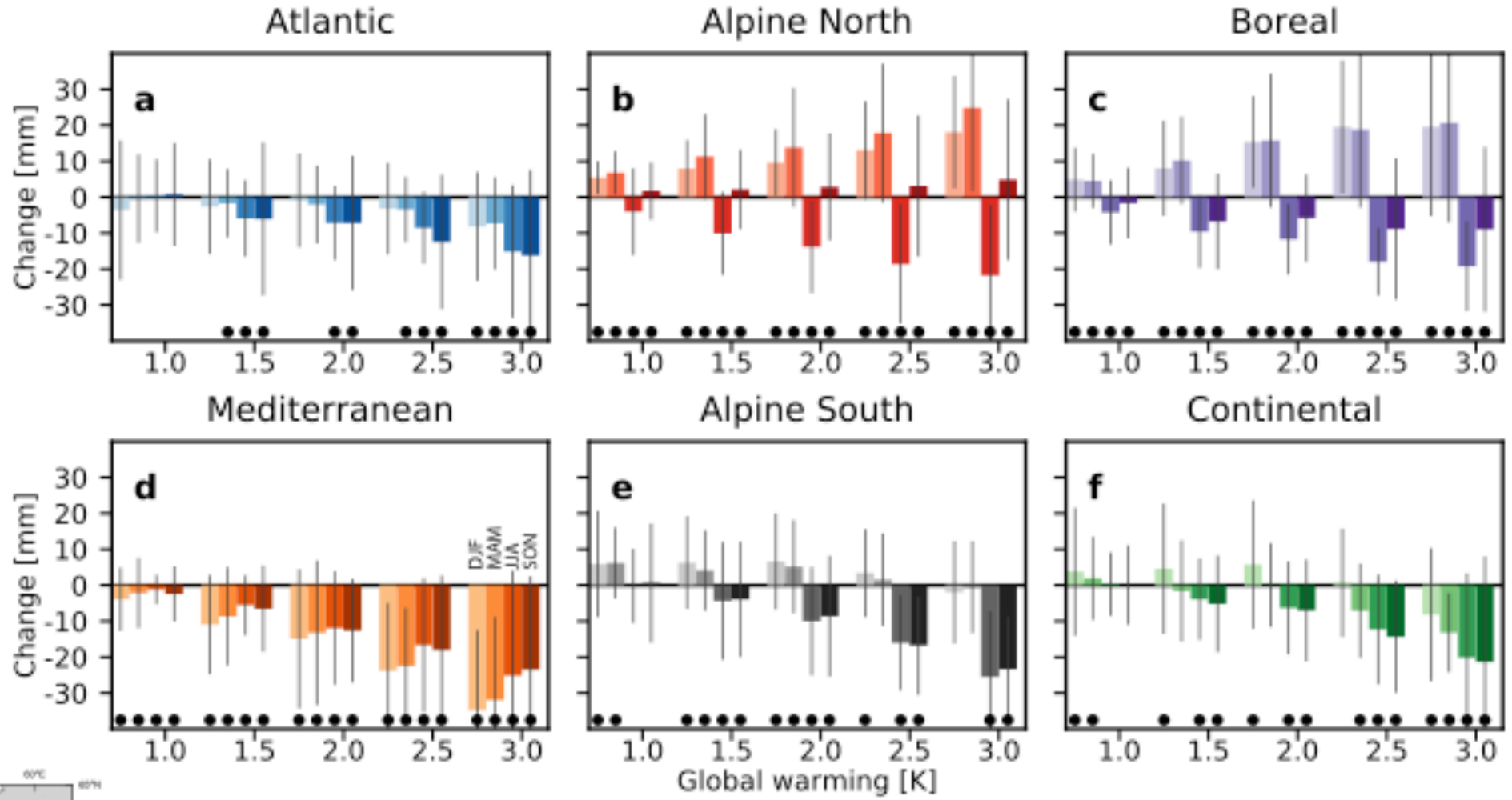
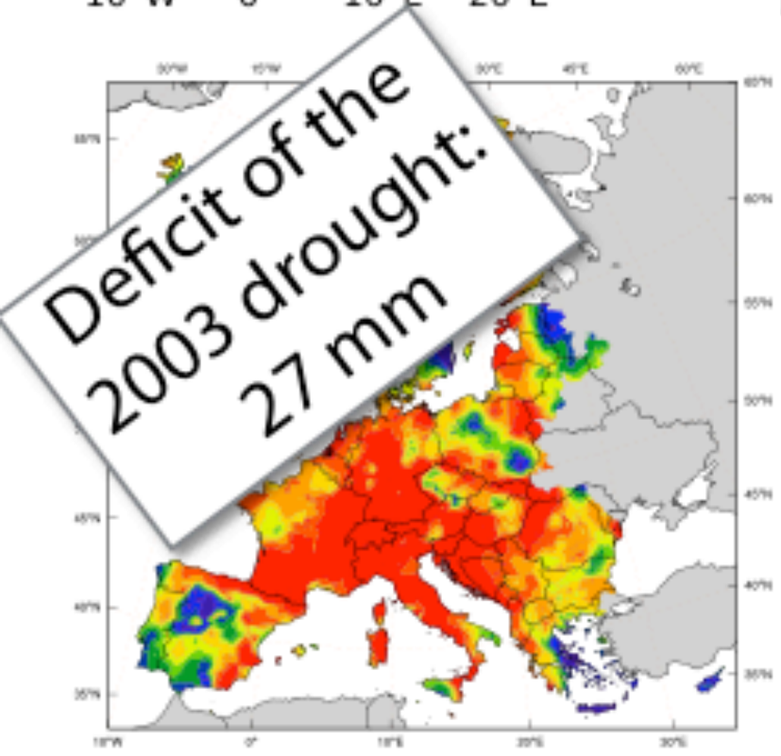
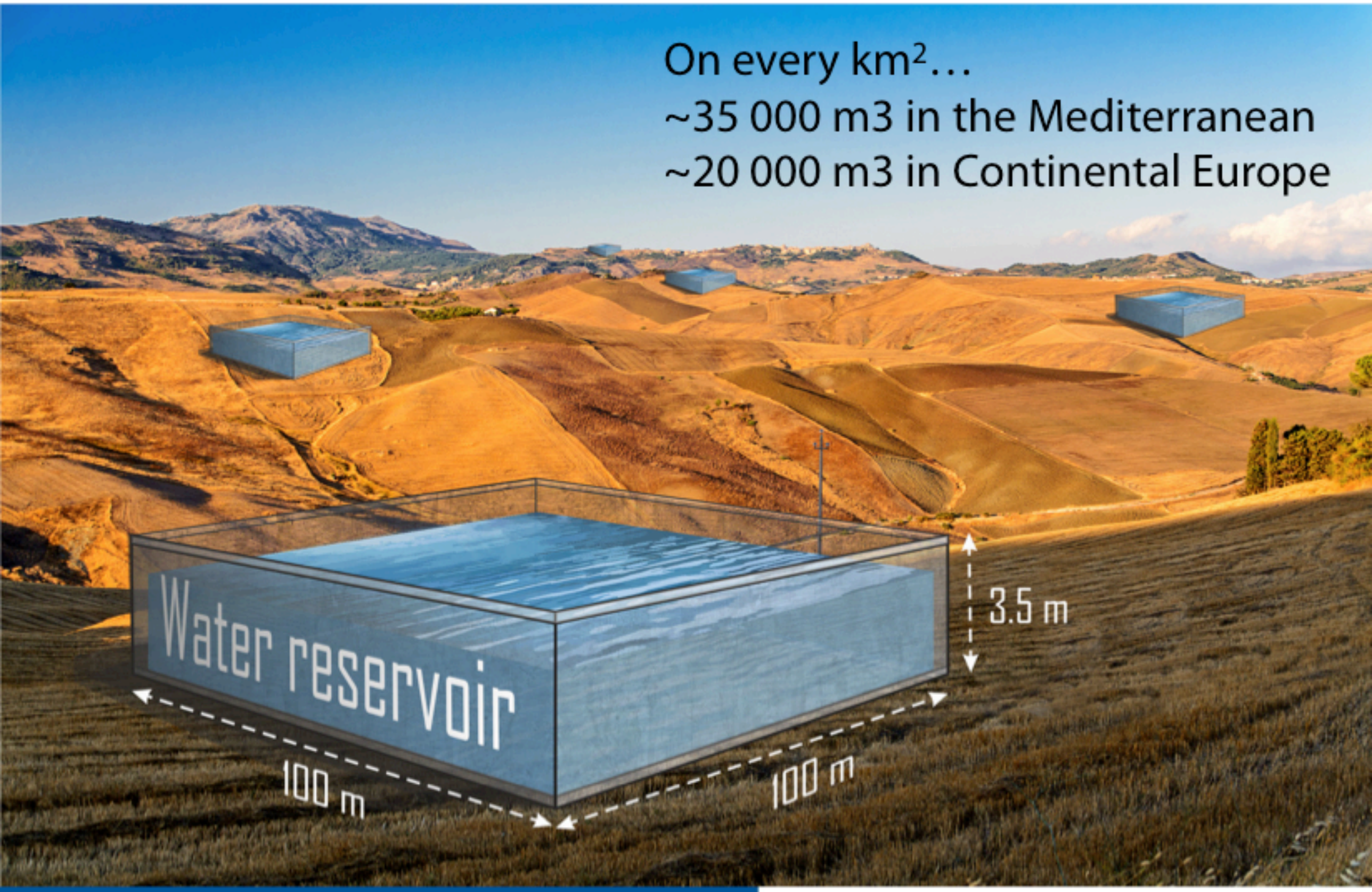



- "Wetter" droughts in Northern Europe during winter and spring
- During summer und autumn, droughts will become "drier" over entire Europe
- 2003 drought will not be classified as drought in the future

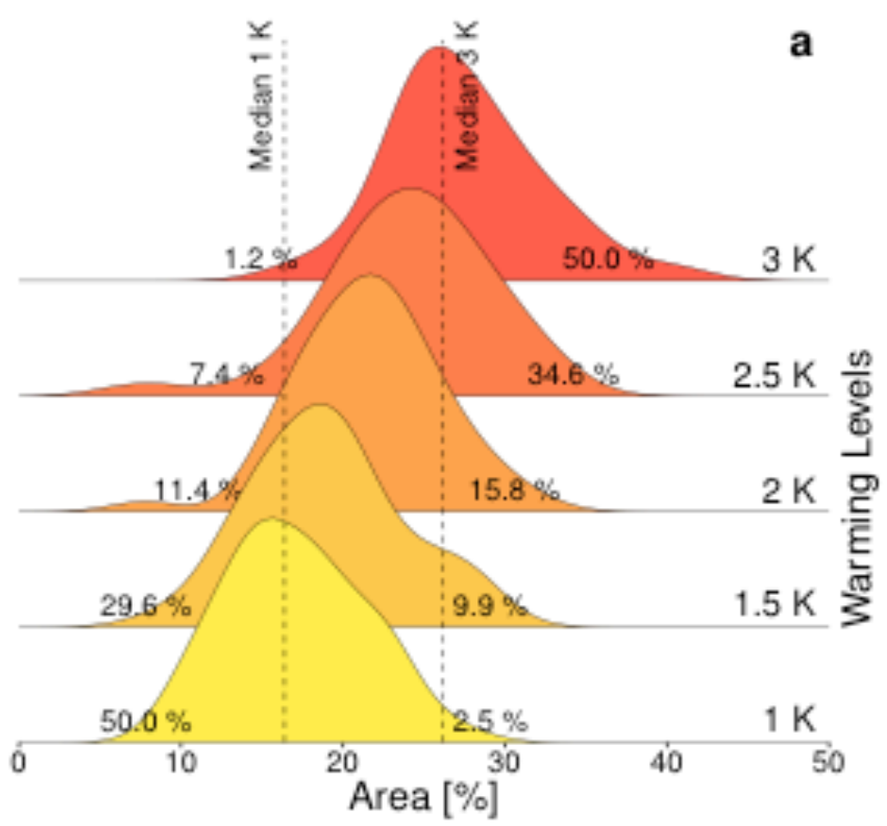
# What adaptation has to cope with…

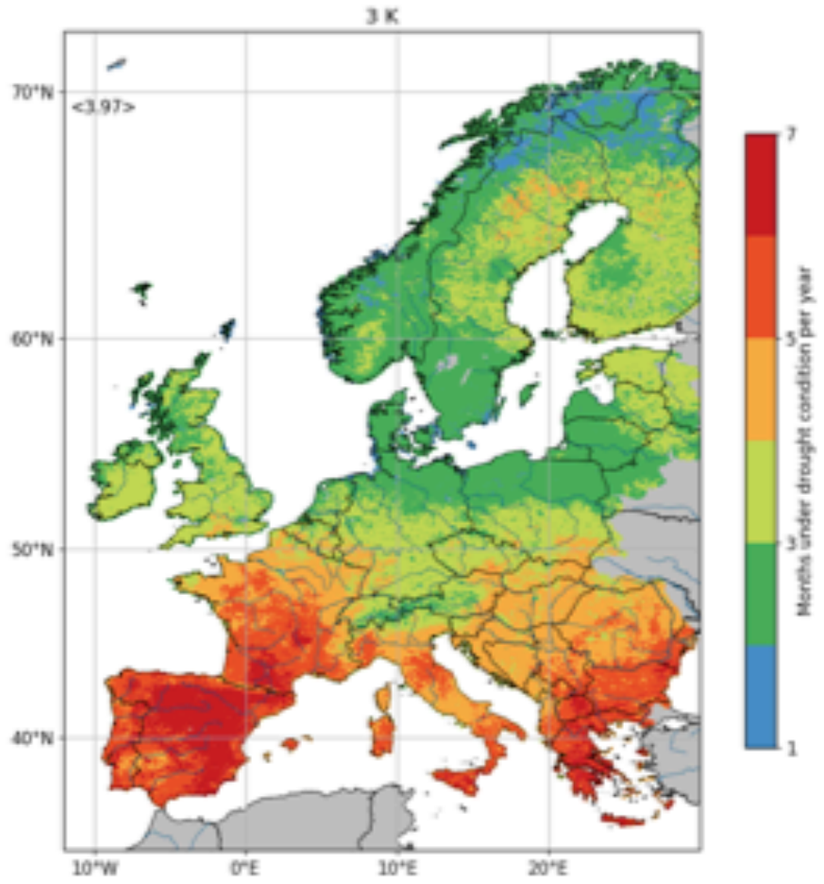


# Conclusions

- Climate change exercabates soil moisture droughts in Europe, in particular in the Mediterranean
- 2003 extreme event will not be classified as a drought if global warming reaches 3 K
- Drought area increases by 40% (±24%) if global warming increases from 1.5 K to 3 K

Samaniego and Thober et al.,
(Nature Climate Change, 2018)



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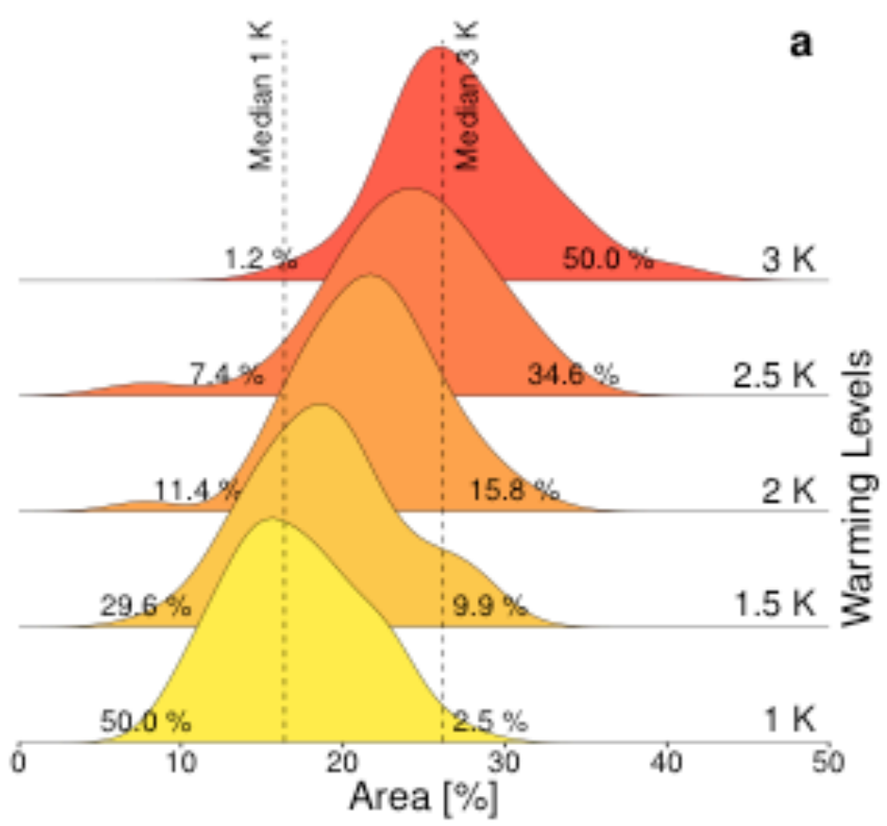
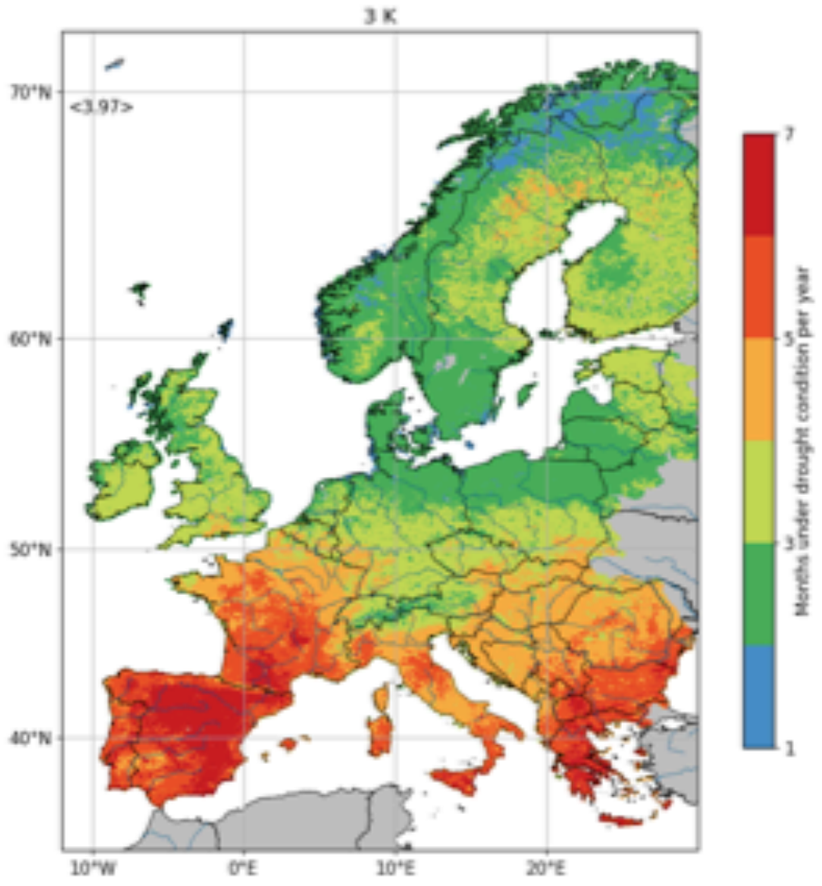
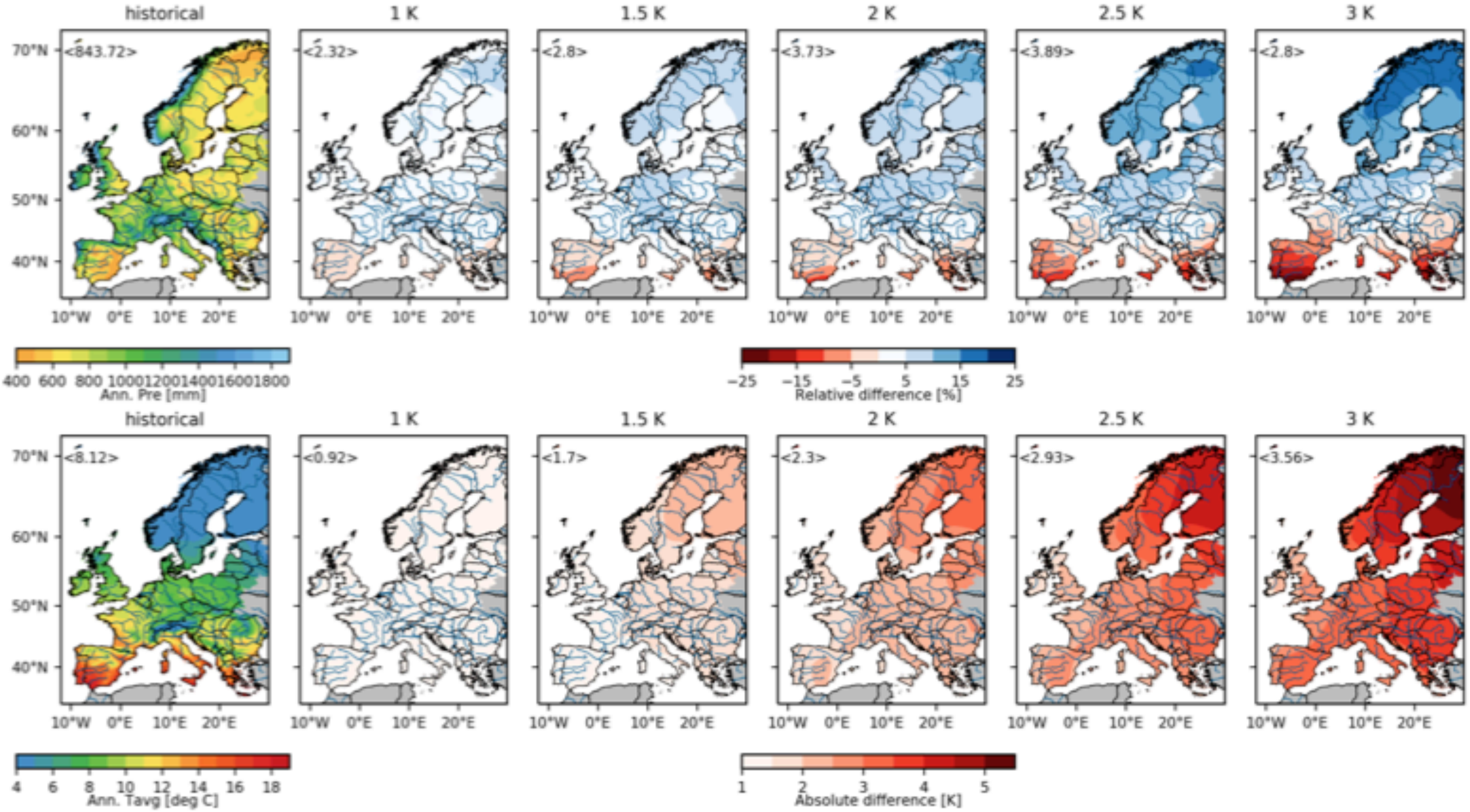



Thank You!

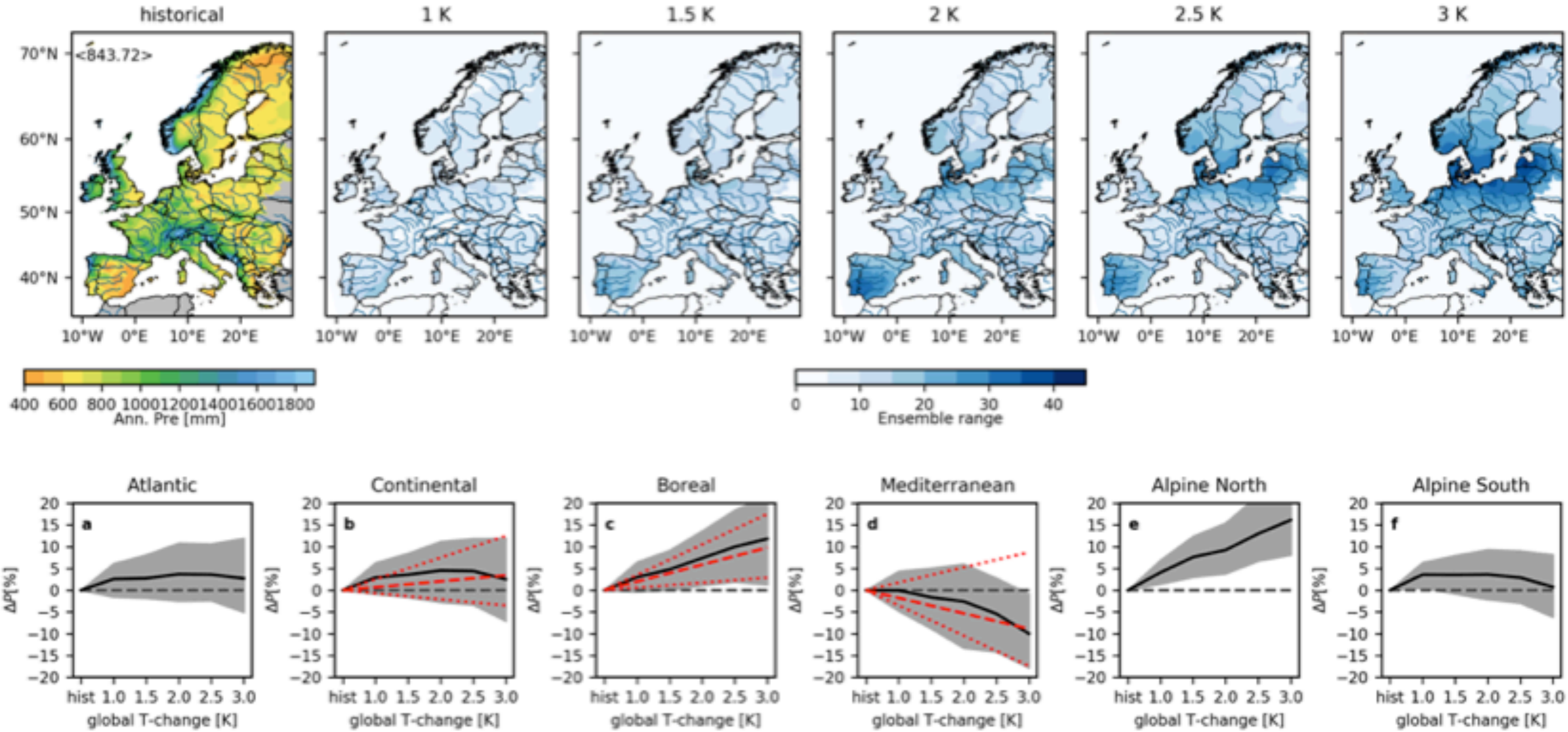


# Appendix

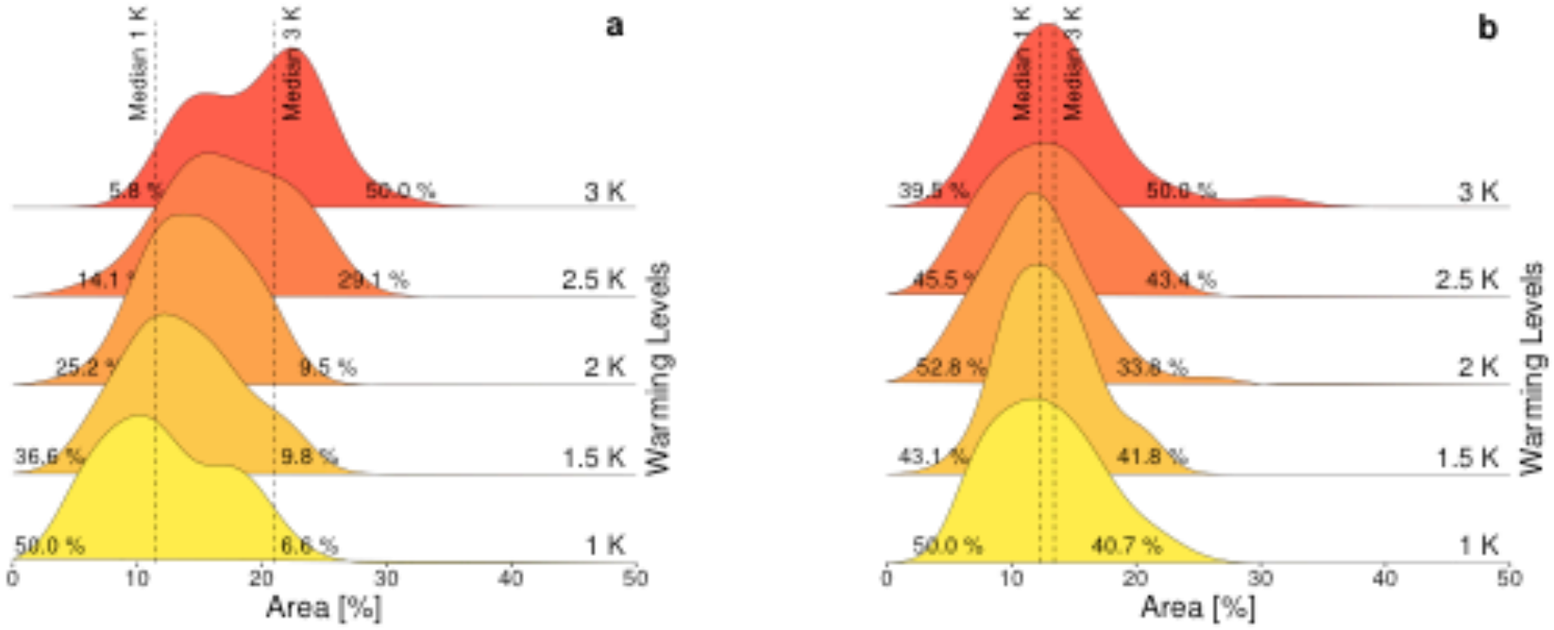
# Projected precipitation and temperature changes

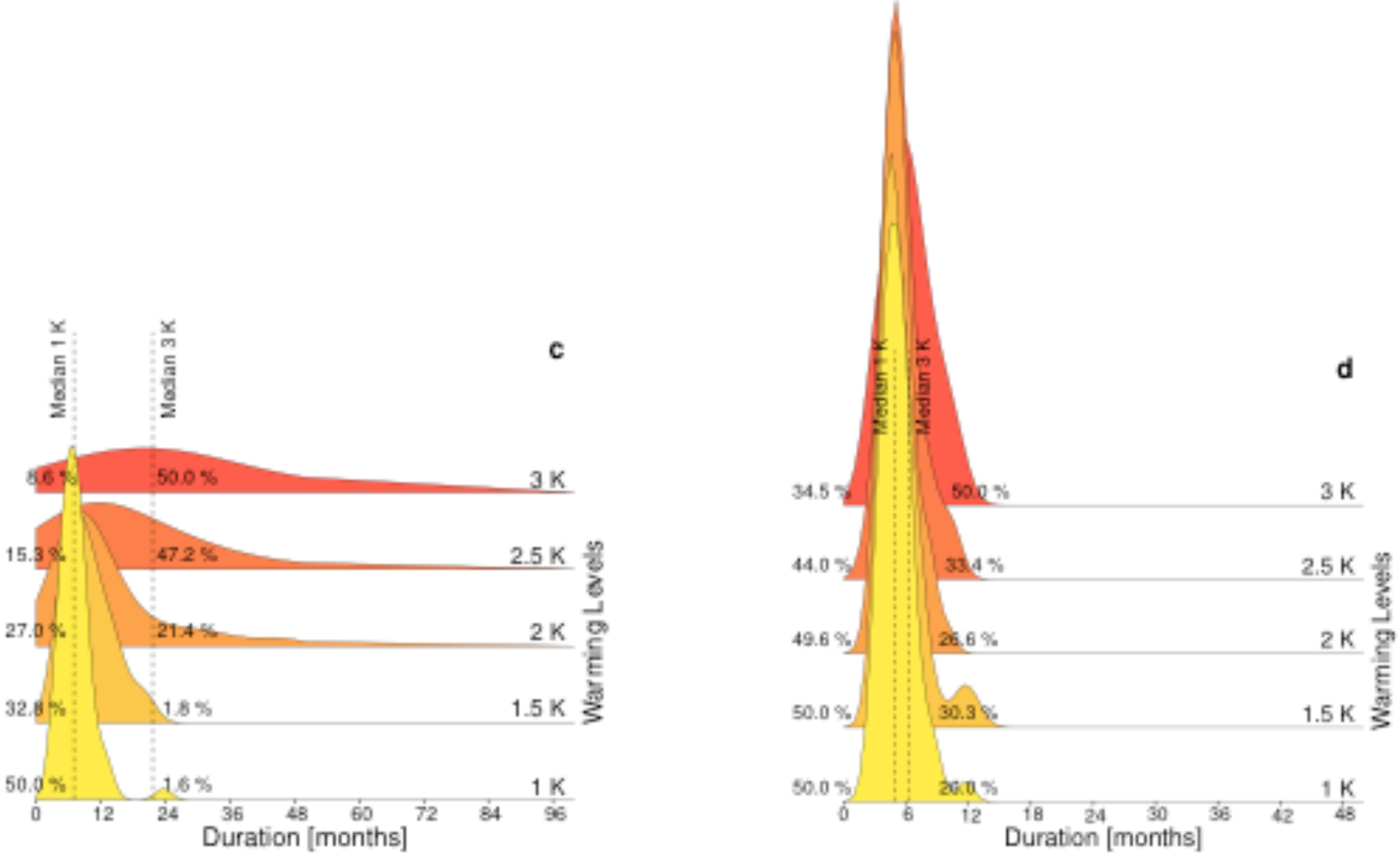


# Uncertainty in projected precipitation

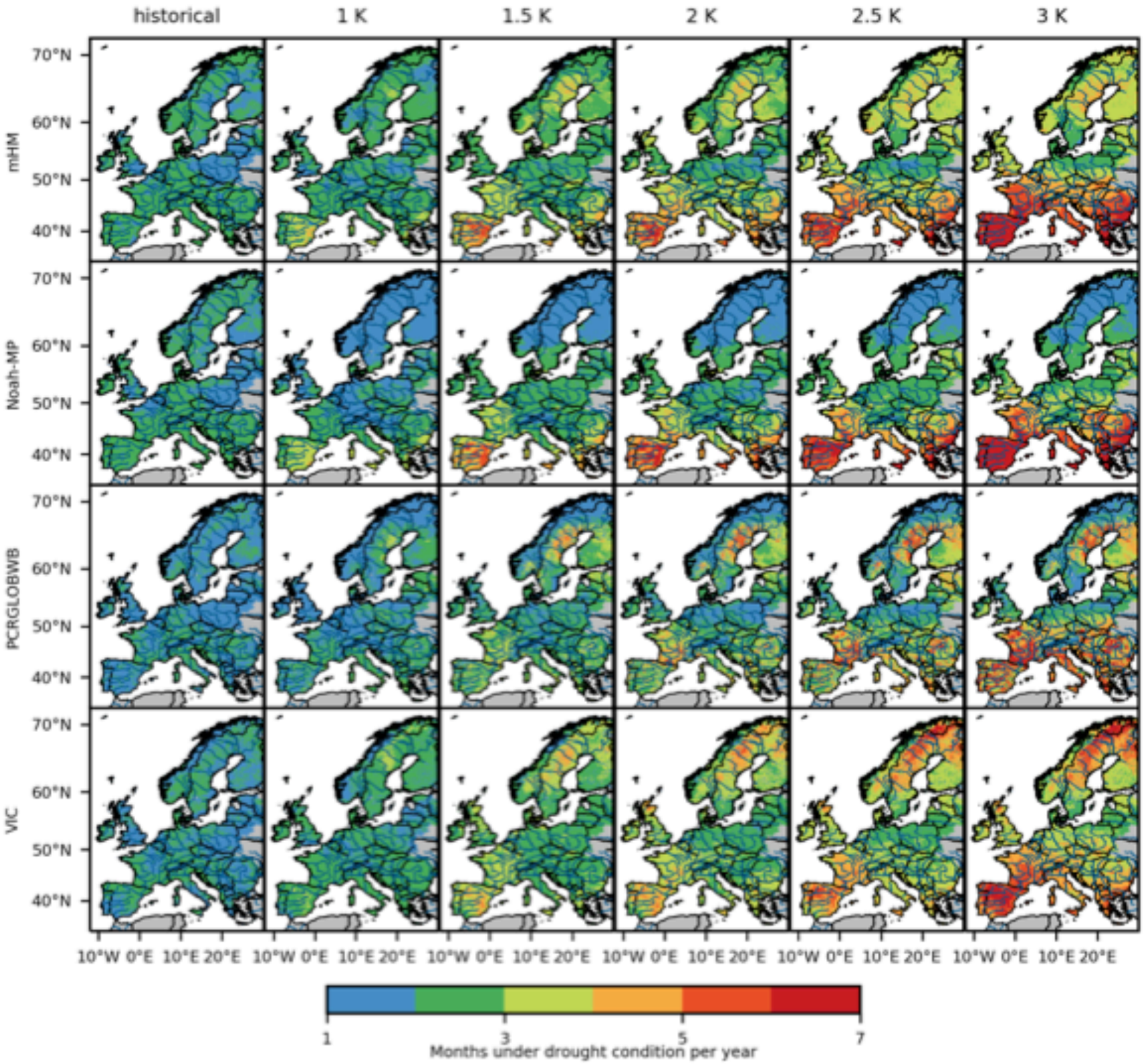


# SMI drought threshold of 0.1

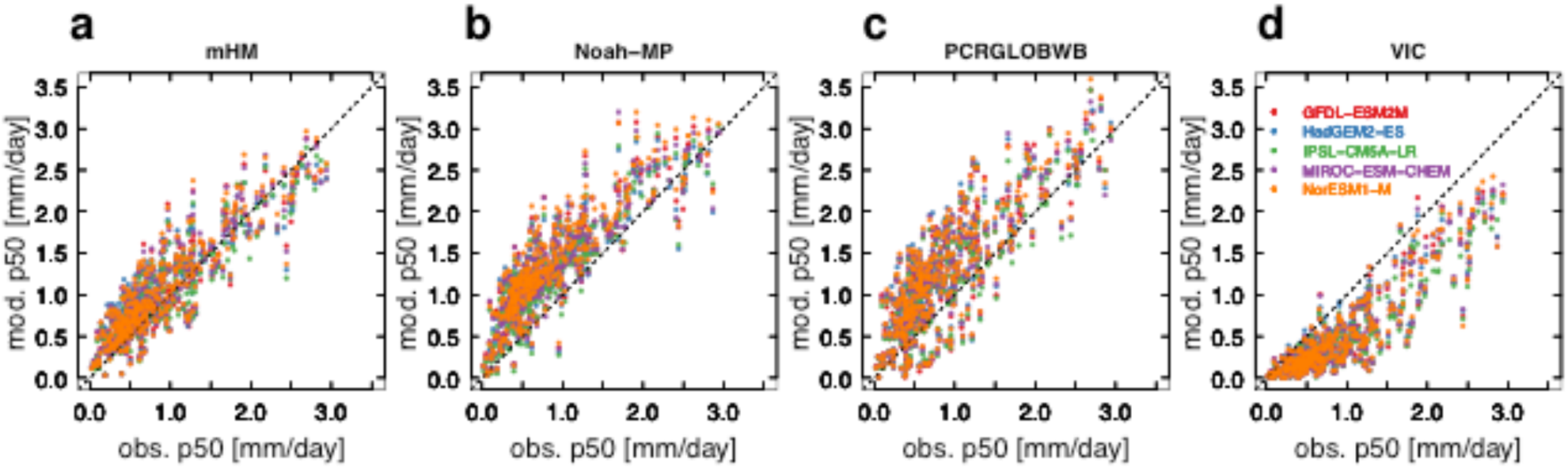


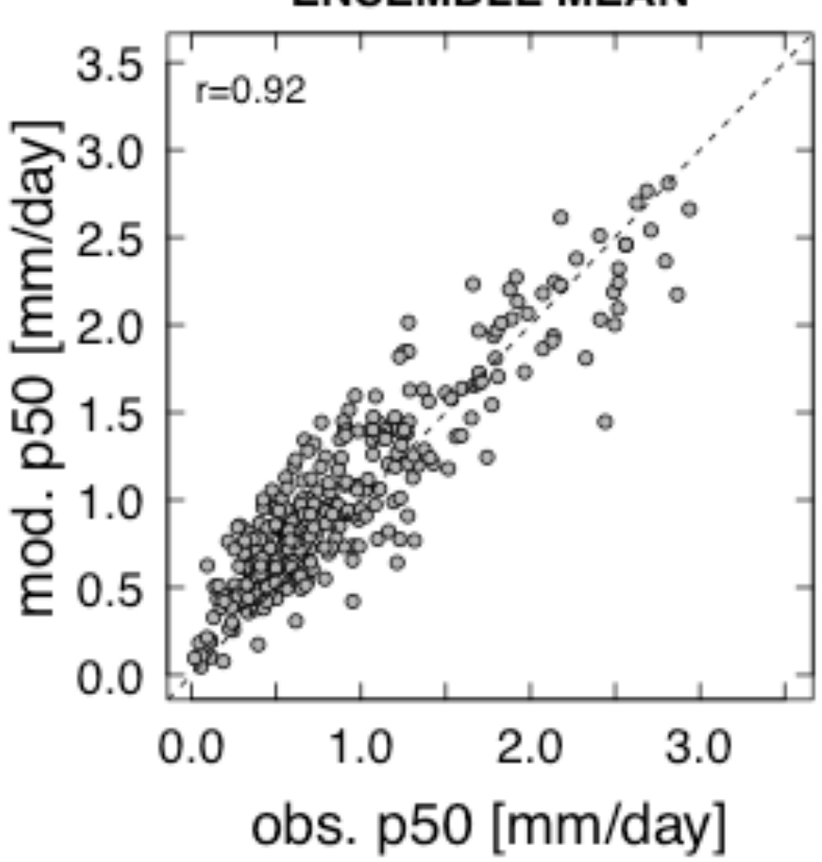



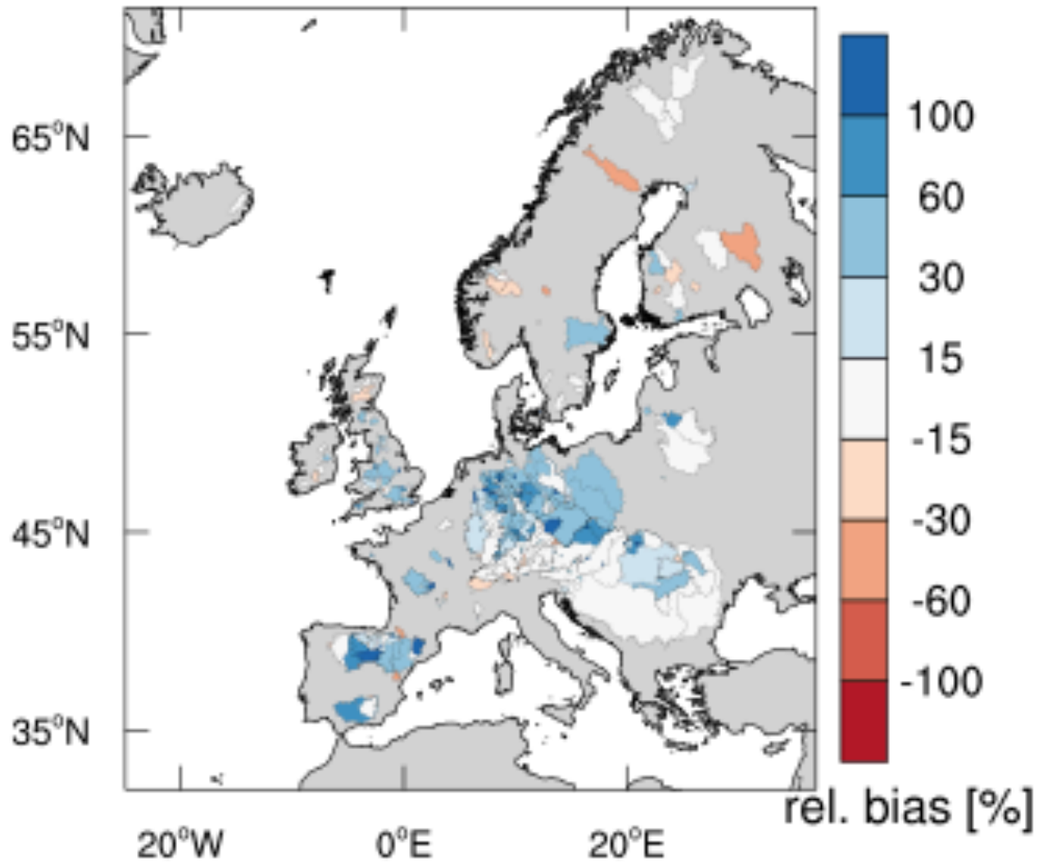
# Drought frequency of individual Has



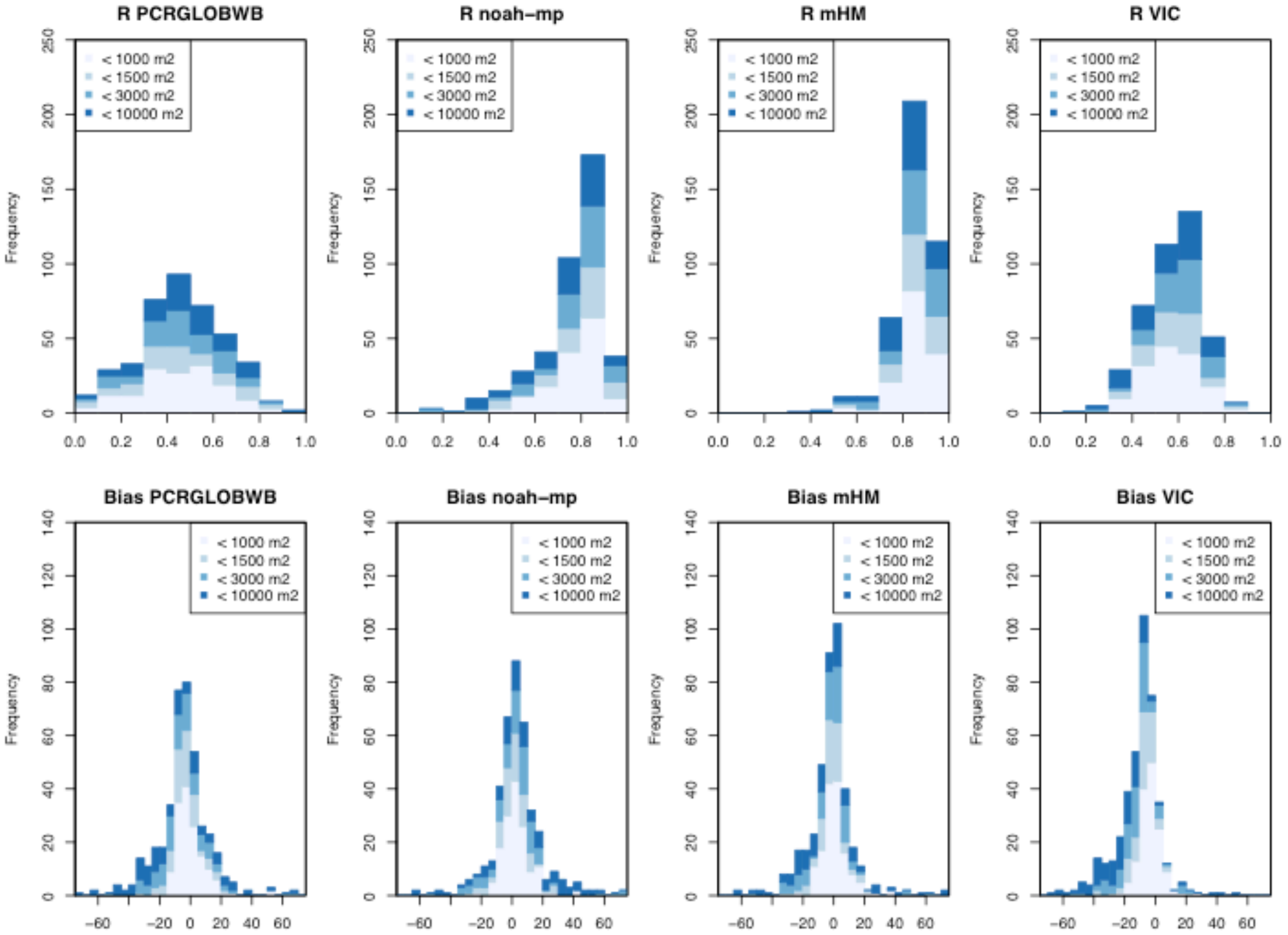
# Model verification using GCMs



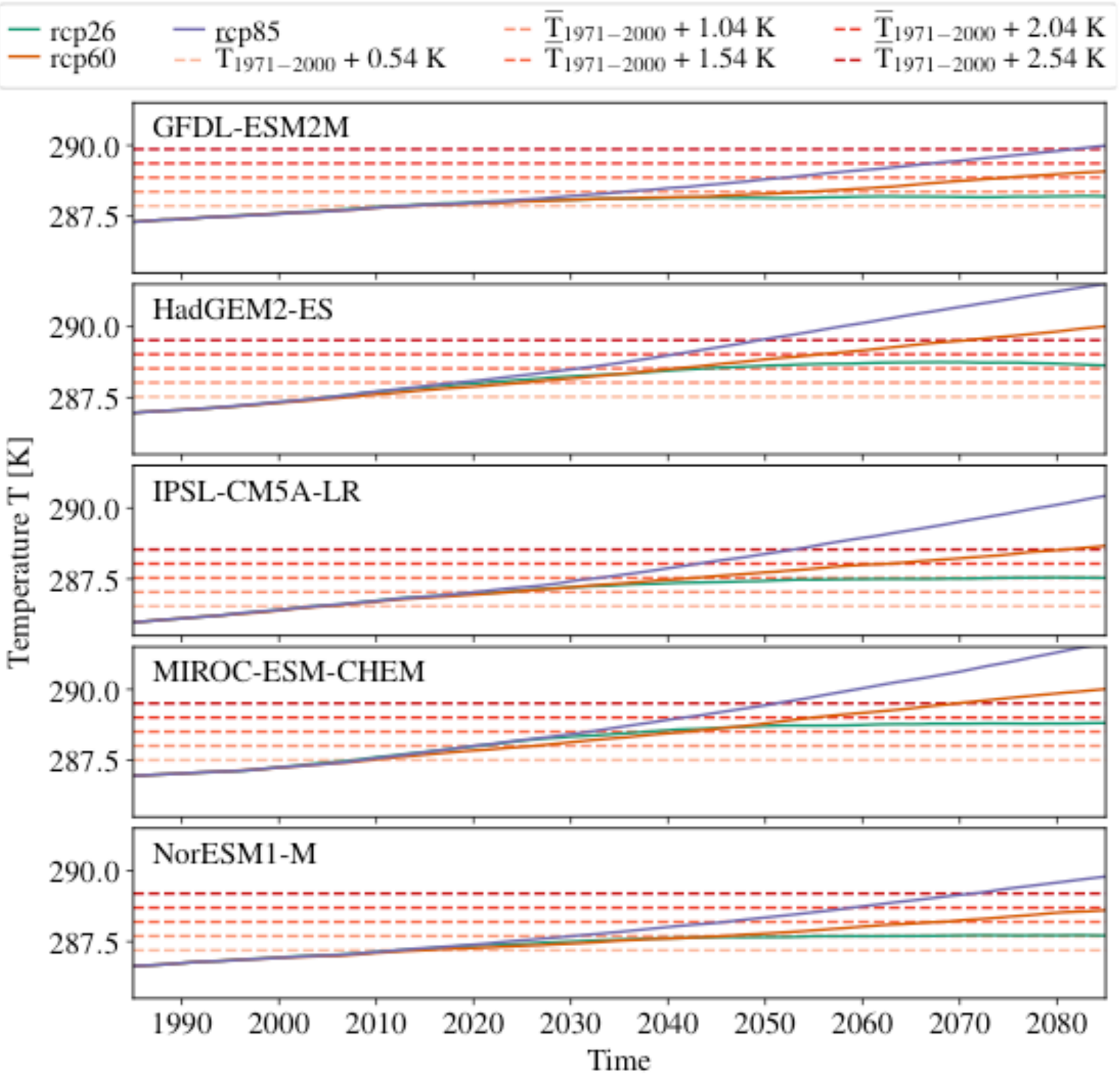



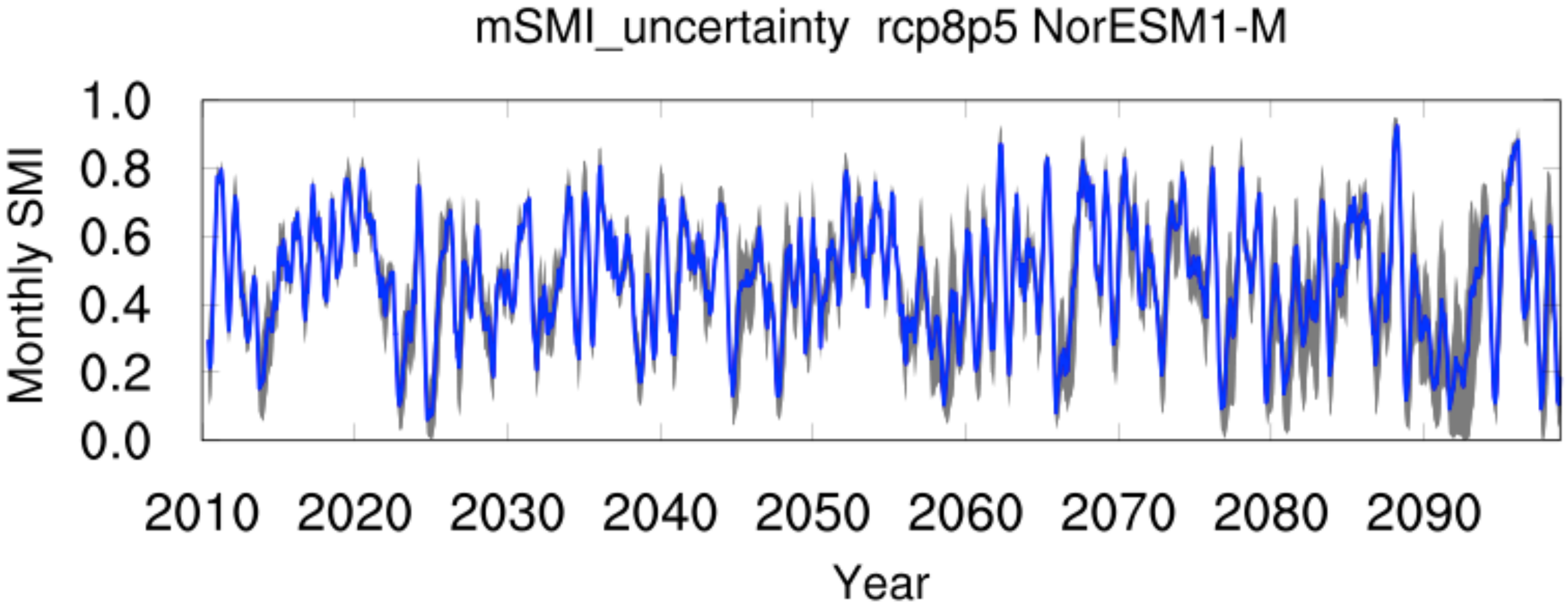
# Model verification using E-OBS



# Global warming levels



# SMI for one grid cell



# Comparison with PDSI in Saxony