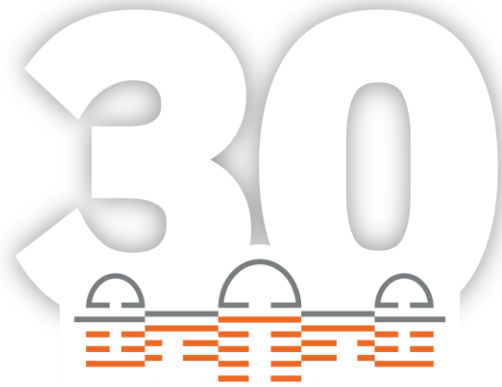




# CROSSDRO



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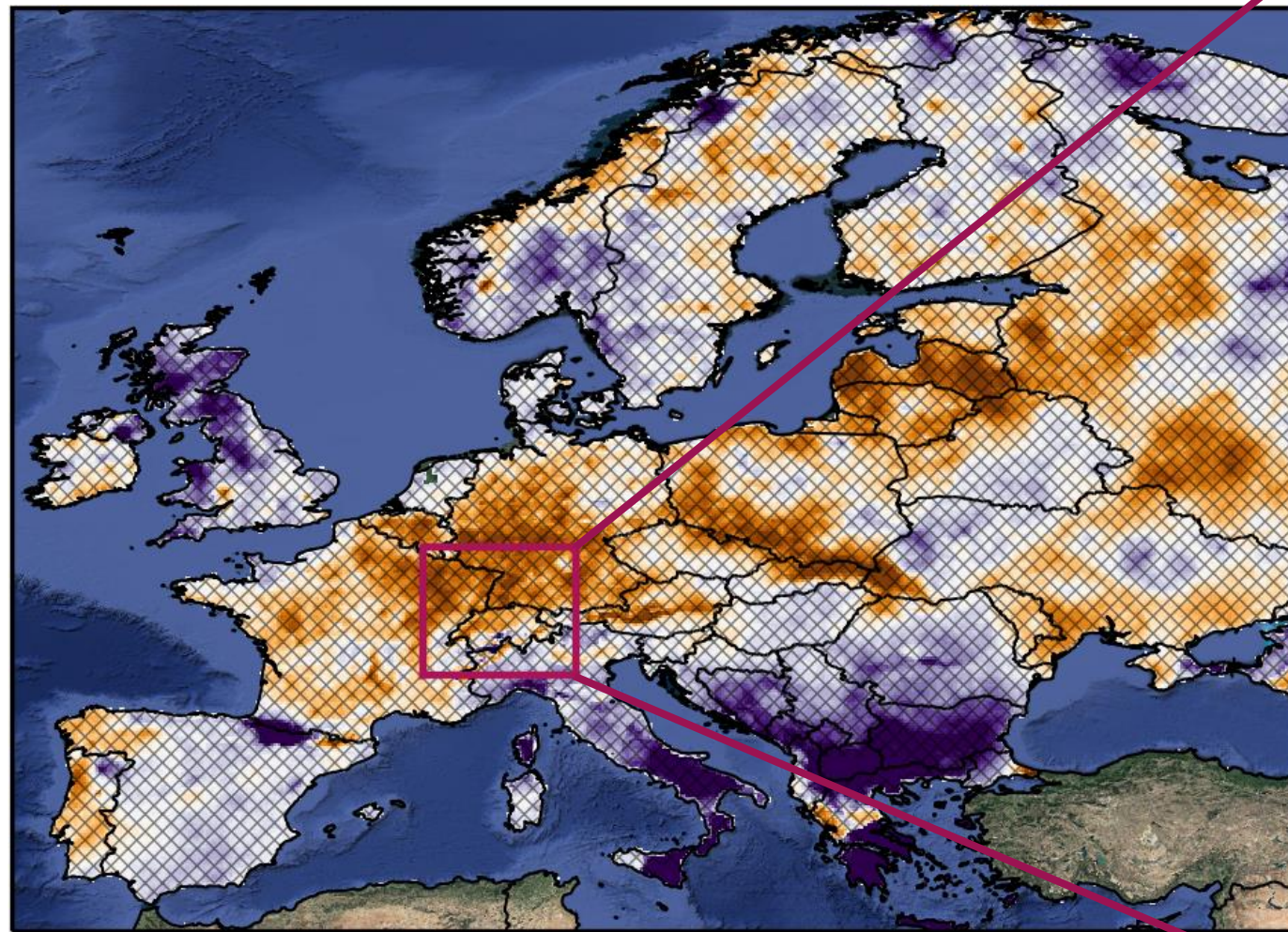
# Projected changes in meteorological drought risk under future climate change scenarios

Christoph Menz

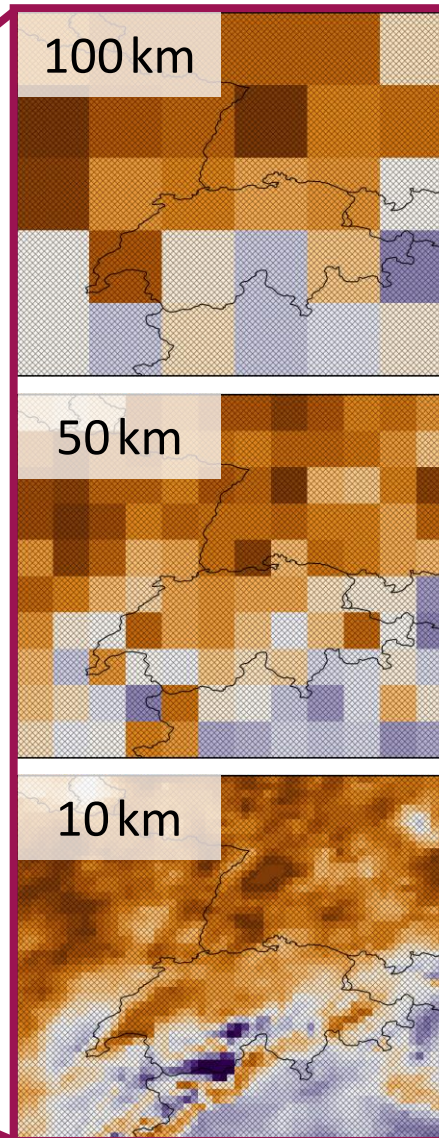
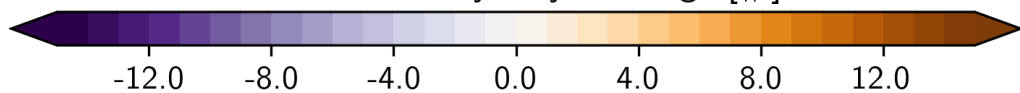
Research Department II: Climate Resilience

Potsdam Institute for Climate Impact Research

# Motivation



Number of Dry Days Change [#]



**Observed  
Climate Change**

**2001-2020  
vs.  
1981-2000**

- E-OBS v24.0e
- Annual accumulation
- 90% Significance level



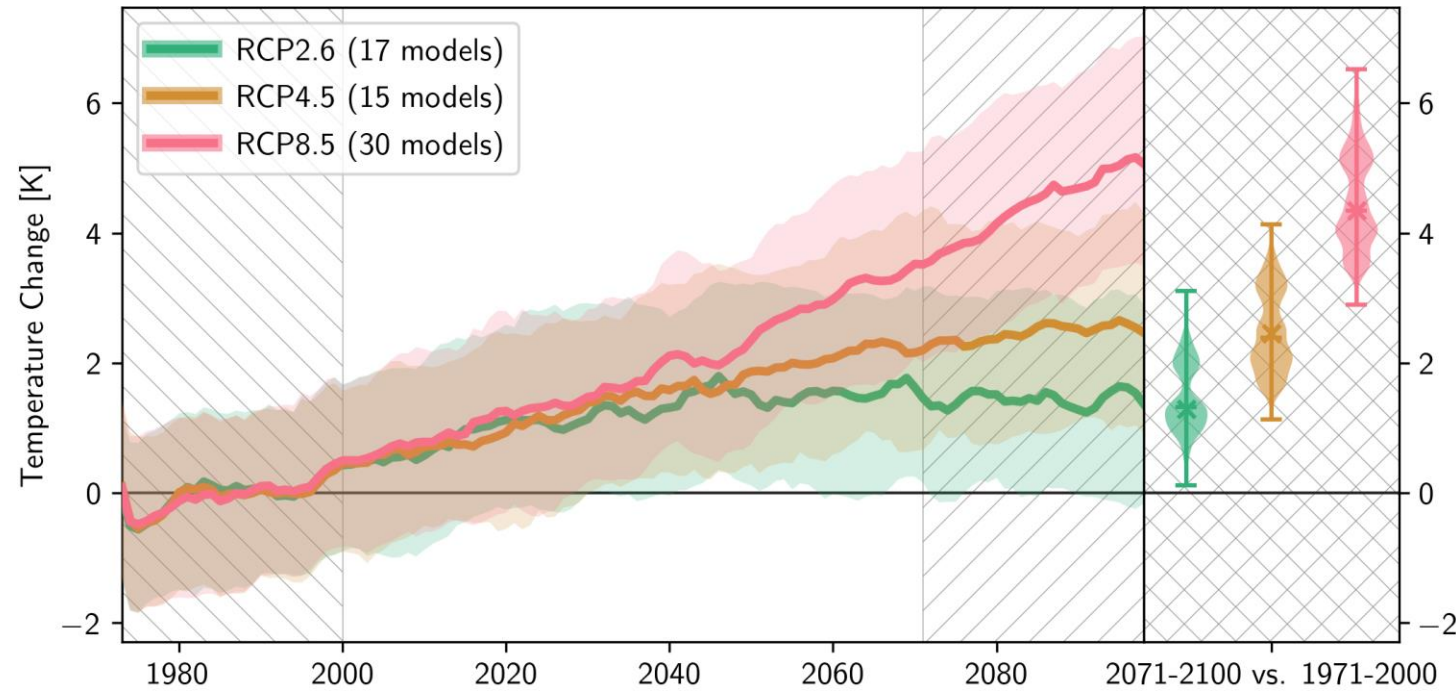
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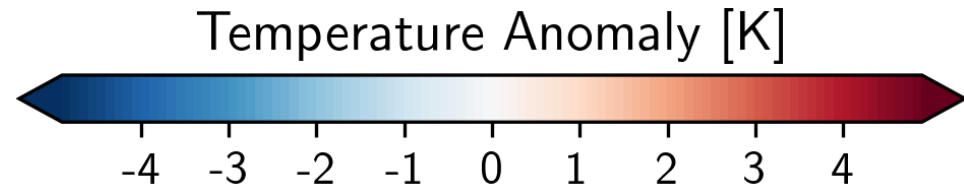
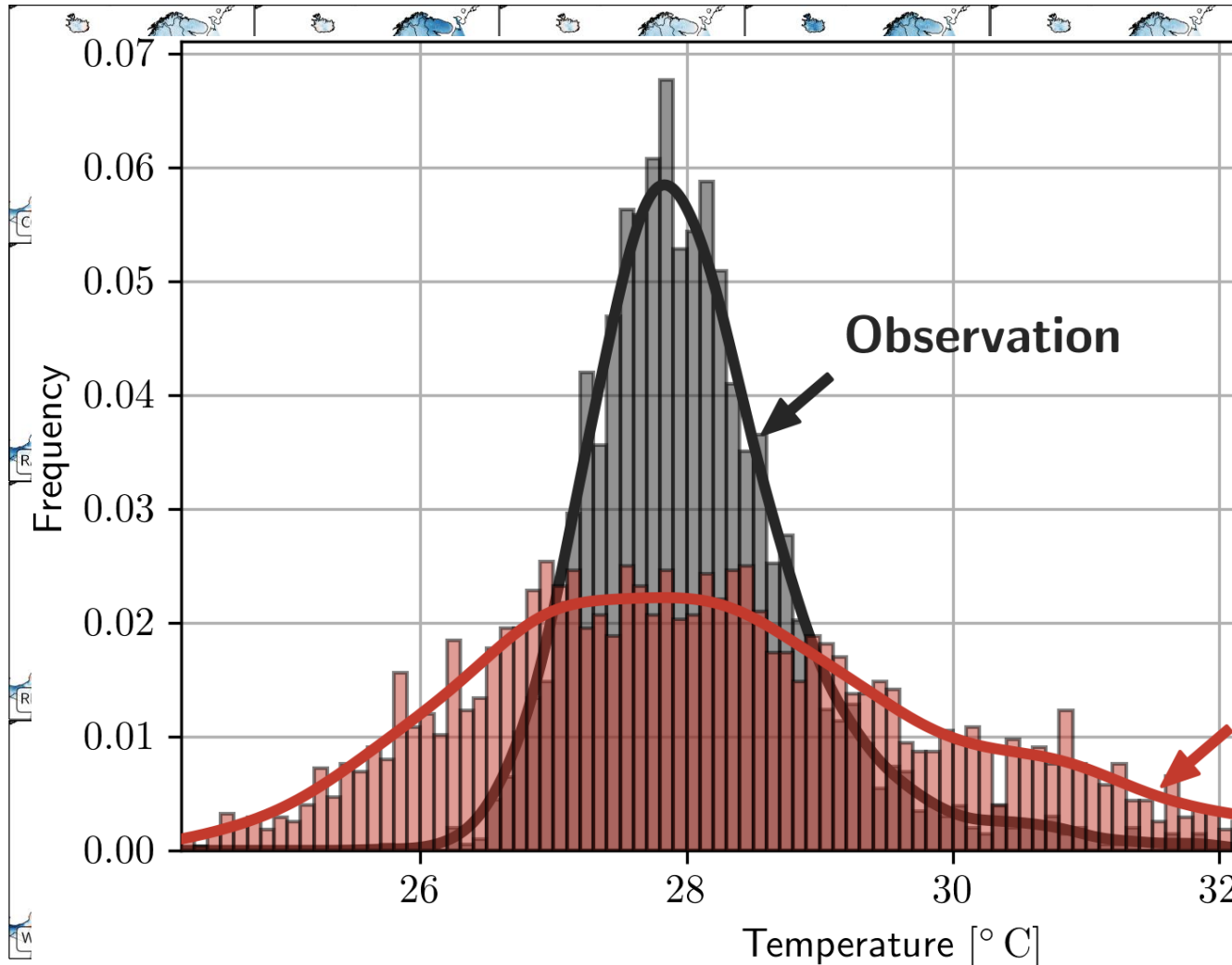
# Regional Climate Projections

- Ensemble of 62 high resolution regional climate model simulations
- CORDEX-EUR11 framework: Europe @12.5km
- Daily temperature and precipitation

GCM/RCM	ALADIN53	ALARO-0	CCLM	HIRHAM5	RACMO22E	RCA4	REMO2009	REMO2015	WRF331F	WRF361H	WRF381P
CanESM2			X					X			
CNRM-CM5	X	X	X	X	X	X		X			
EC-EARTH			X	X	X	X		X		X	
CM5A-LR								X			
CM5A-MR						X			X		X
MIROC5			X					X			
HadGEM2-ES			X	X	X	X		X		X	X
MPI-ESM-LR			X			X	X			X	
NorESM1-M				X		X		X			
GFDL-ESM2G								X			



# Bias Adjustment



- 1971-2000
- Reference: E-OBS v19.0e

Geosci. Model Dev., 12, 3055–3070, 2019  
<https://doi.org/10.5194/gmd-12-3055-2019>  
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## Trend-preserving bias adjustment and statistical downscaling with ISIMIP3BASD (v1.0)

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**Abstract.** In this paper, we present new methods for bias adjustment of climate simulation data. Bias adjustment as it is commonly understood involves two main steps: (i) statistical downscaling to the spatial resolution of the observation data, and (ii) bias adjustment to the spatial resolution of the observation data. Commonly, the bulk of resources for the development of solutions to these problems is allocated to problem (i), and problem (ii) is solved by a mere spatial interpolation of the simulation data to the spatial resolution of the observation data prior to bias adjustment. For example, this approach was adopted in the ISIMIP East Track (Hempel et al., 2013), the NEX-GDDP (Thrasher et al., 2012), and for the generation of the NEX-GDDP Global Daily Downscaled Projections data set (NEX-GDDP; Thrasher et al., 2012). The same univariate bias adjustment method is independently applied in every cell of the observation data grid. The bias adjustment then retains the spatial coherence of the interpolated simulation data and inflates temporal variability at their original spatial resolution (Maraun, 2013). These issues can be overcome by spatially multivariate bias adjustment or, as suggested by Maraun (2013), using a statistical downscaling method which is able to add the spatiotemporal variability that is missing at the simulation data resolution. He argues that such a method should be stochastic.

### 1 Introduction

Bias adjustment in climate research is the adjustment of statistics of climate simulation data for the purpose of making them more similar to climate observation data. In many application cases, these climate simulation and observation data have different spatial resolution. In most of these cases, the climate observation data are more highly resolved. In any of these cases, bias adjustment requires bridging the resolu-

- Distribution focused bias adjustment
- Adjust especially tails of distribution
- Preserve trend of each model in every percentile
- Not Explicitly Considered
- Consecutive/long lasting events (e.g., drought spells)

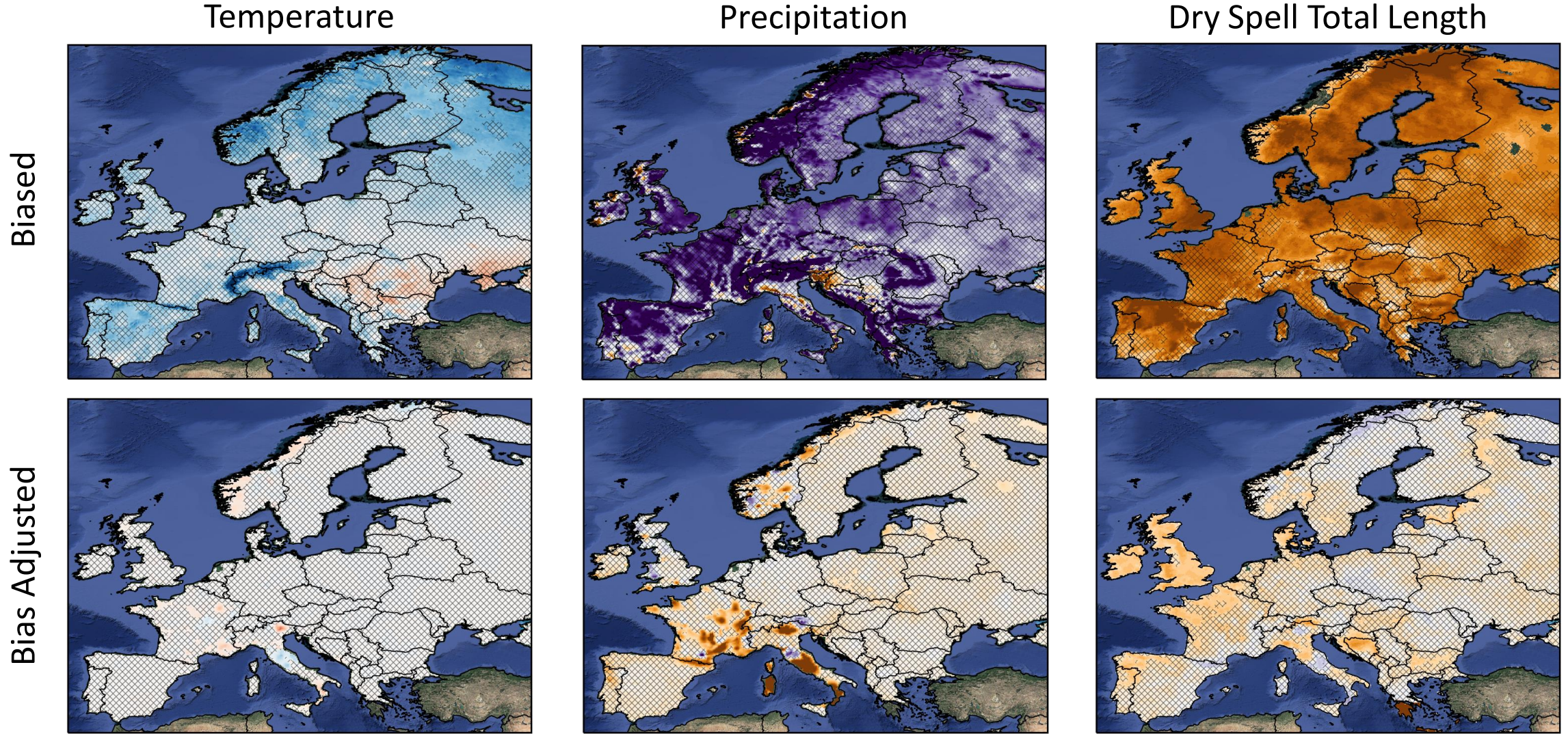


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# Bias Adjustment - Evaluation

1971-2000 vs. E-OBS v24.0e



Temperature

Precipitation

Dry Spell Total Length

Biased

Bias Adjusted

Temperature Bias [K]

Precipitation Bias [mm/d]

Dry Spell Length Bias [d]

-3 -2 -1 0 1 2 3

-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 -0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7

-75.0 -50.0 -25.0 0.0 25.0 50.0 75.0

min. 7 days below 0.1mm

# Regional Climate Projections – General Overview

Global Models

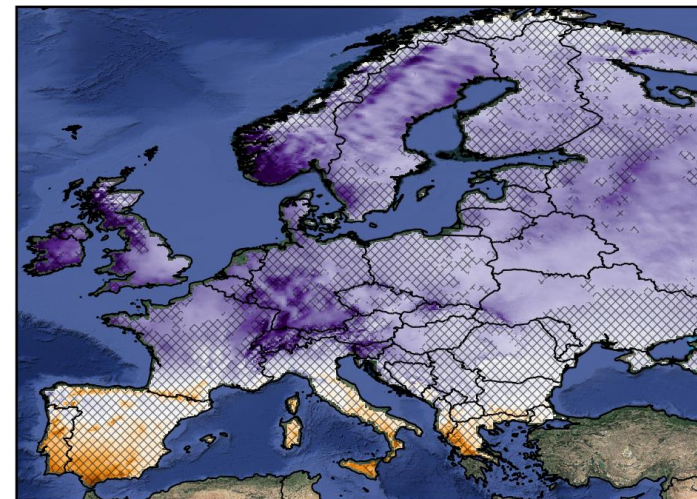
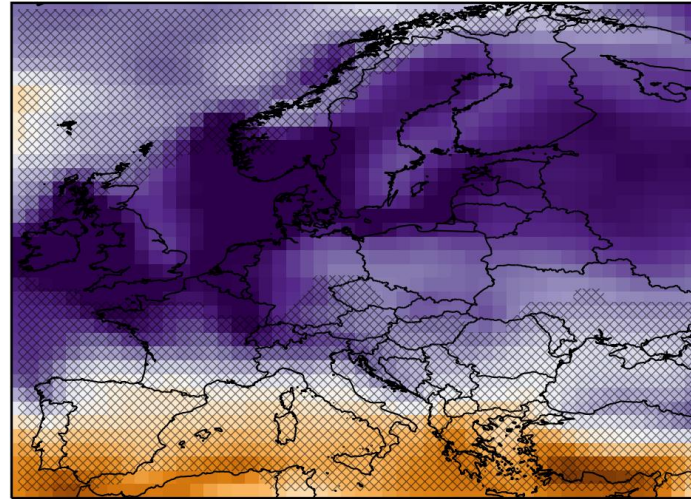
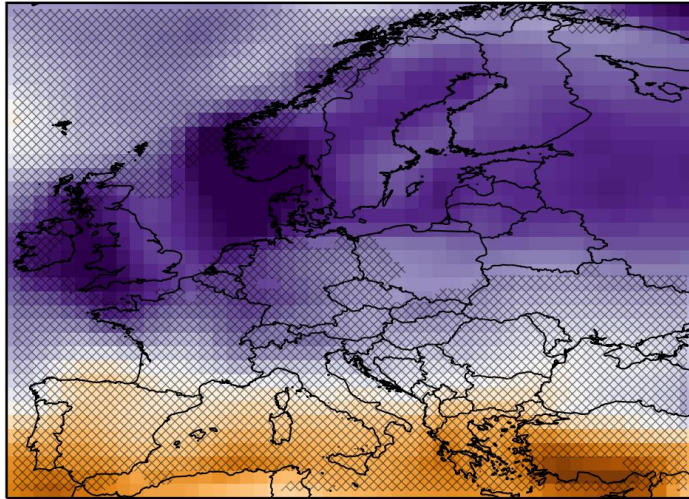
Regional Models

CMIP 5 (IPCC-AR5)

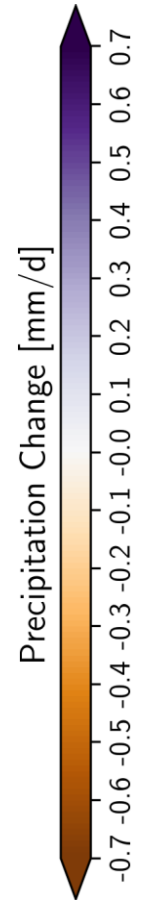
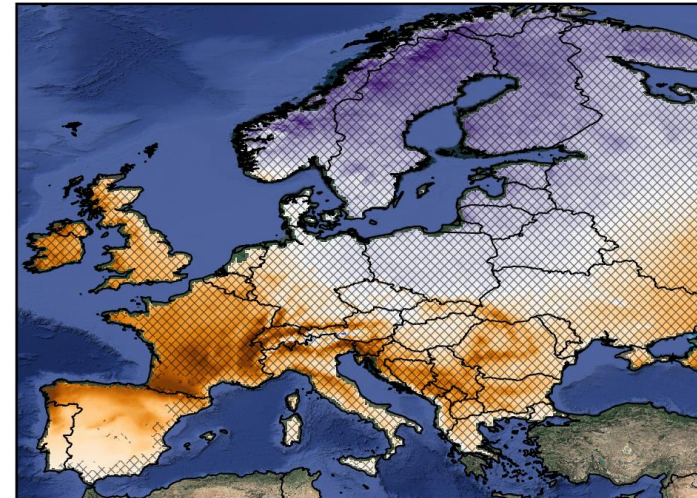
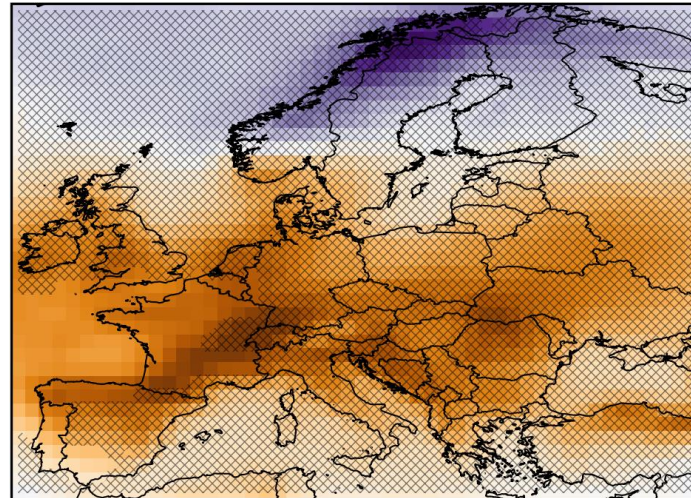
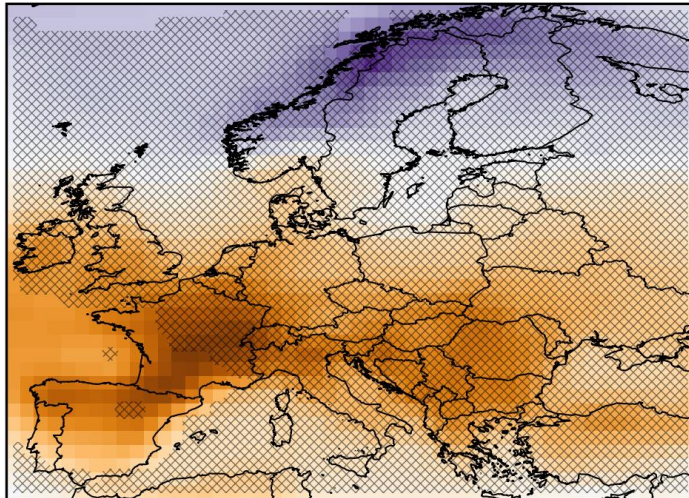
CMIP 6 (IPCC-AR6)

CORDEX-EUR11

DJF



JJA



2071-2100 vs. 1971-2000

RCP8.5/SSP5-8.5

90% Significance Level

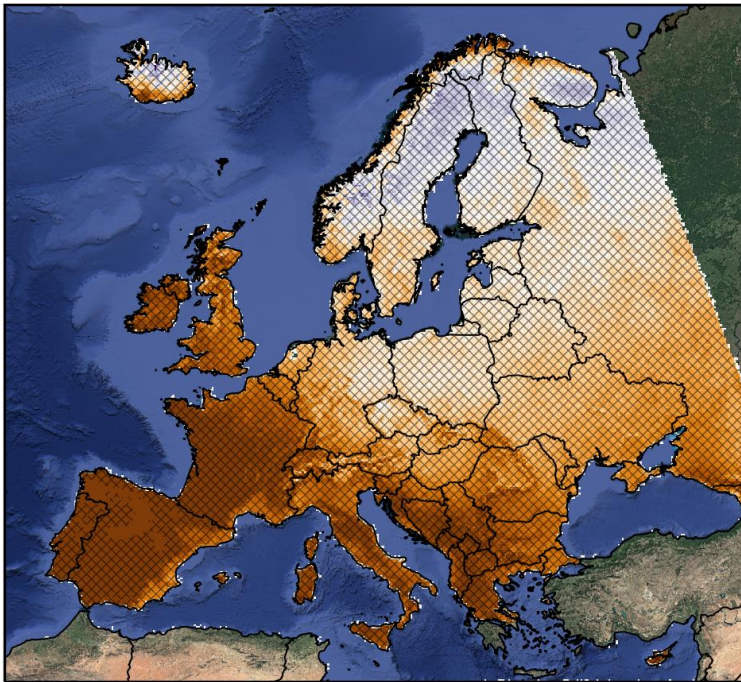


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# Regional Climate Projections – Drought Spell Change

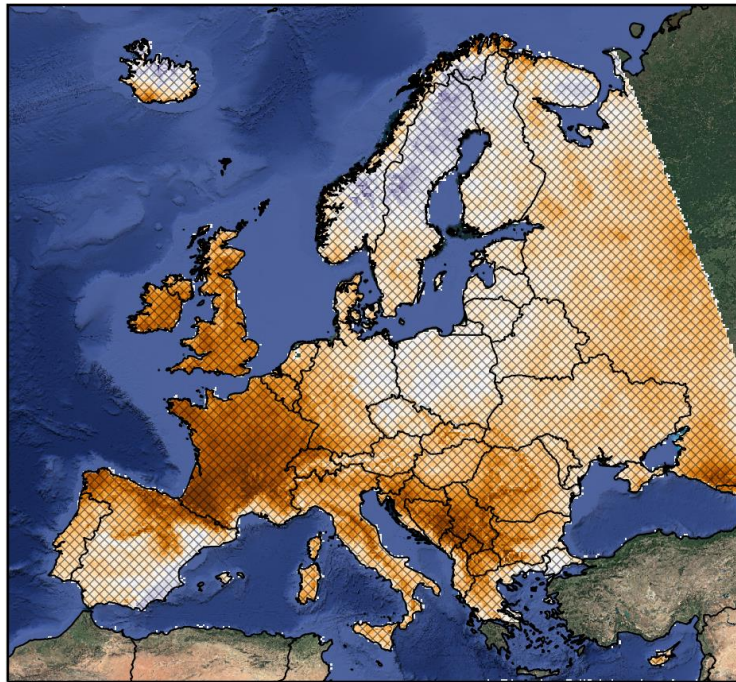
## # Dry Days



Number of Dry Days Change [#]

-12.0 -8.0 -4.0 0.0 4.0 8.0 12.0

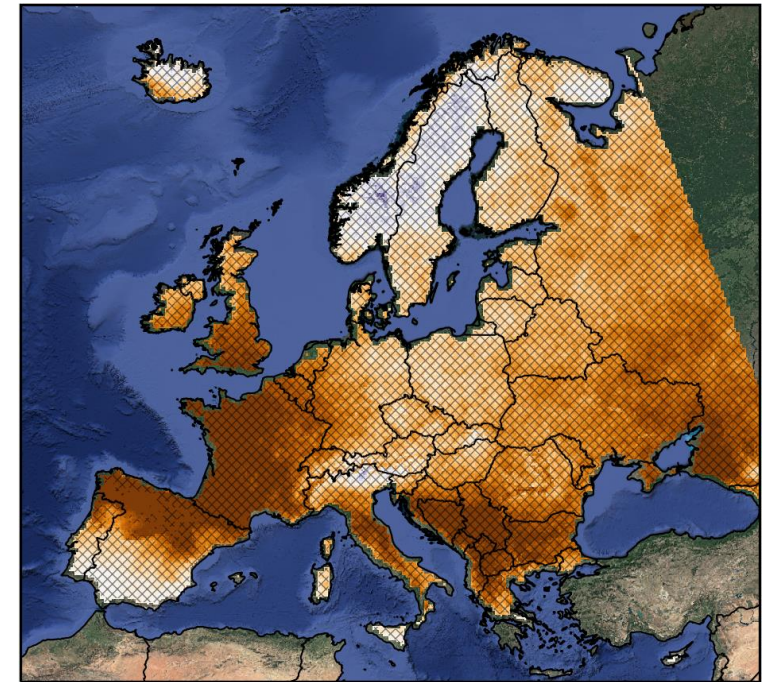
## Dry Spell Frequency



Dry Spell Frequency Change [1/t]

-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0

## Length of Most Severe Drought



Maximum Number of Consecutive Dry Days Change [#]

-2.5 -2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0 2.5

2071-2100 vs. 1971-2000

CORDEX-EUR11 RCP8.5

Annual Changes

90% Significance Level

min. 7 days below 0.1mm



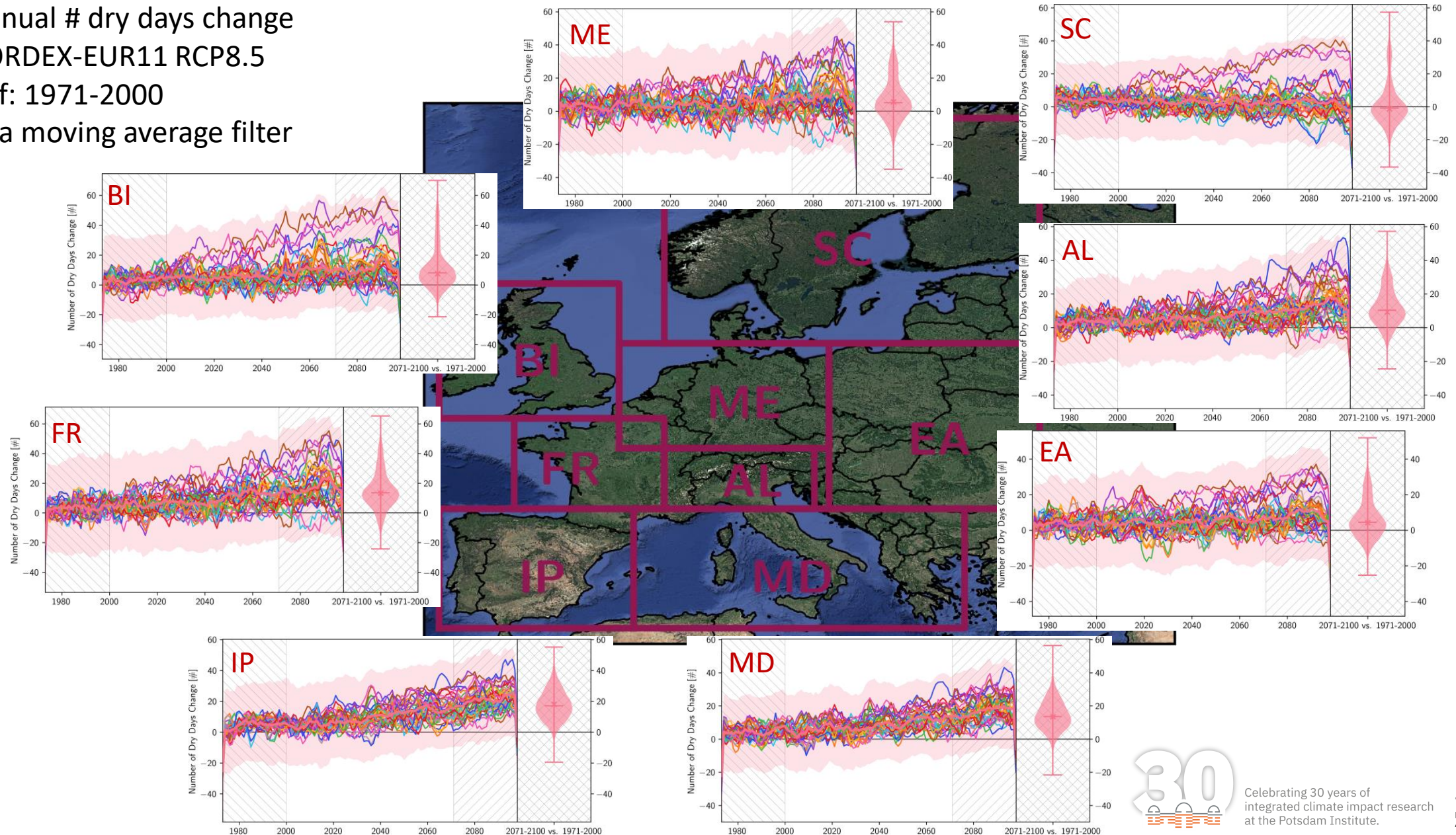
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# Regional Climate Projections – # Dry Days Change Time Series

- Annual # dry days change
- CORDEX-EUR11 RCP8.5
- Ref: 1971-2000
- 10a moving average filter

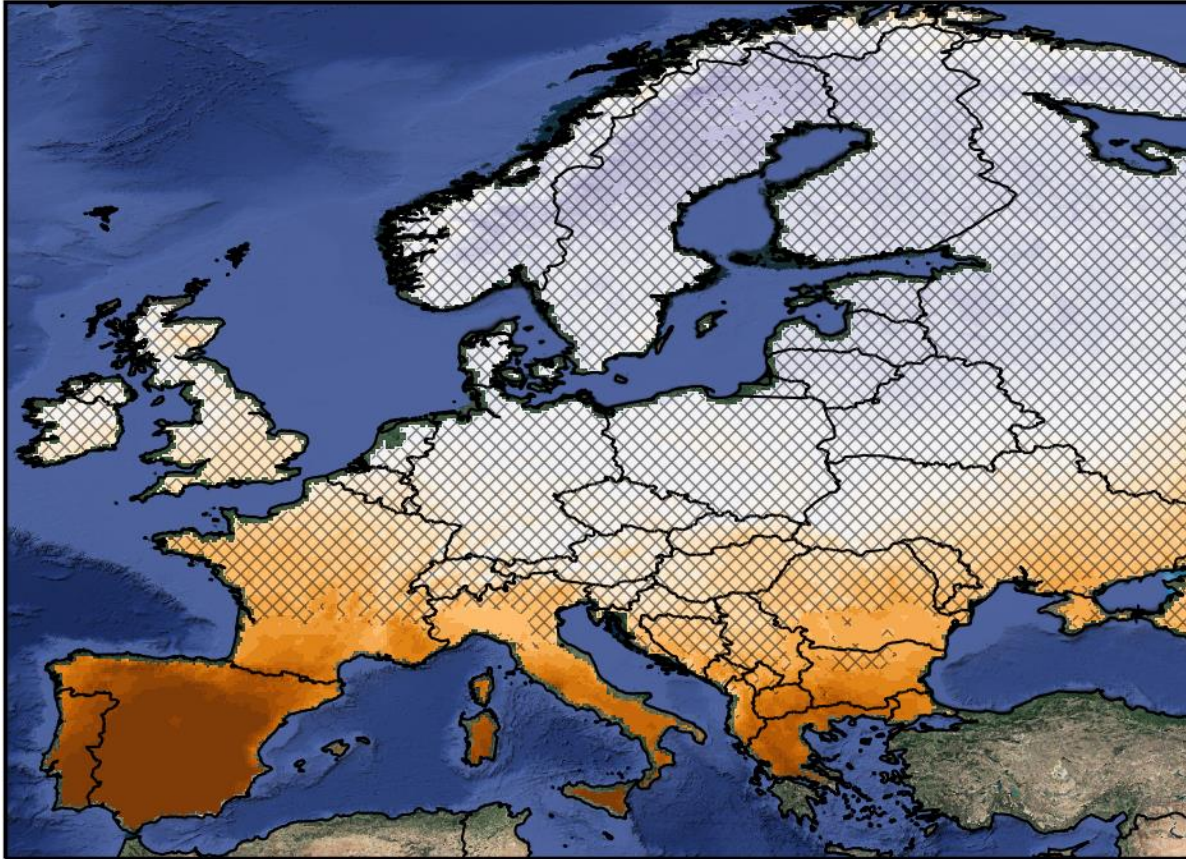


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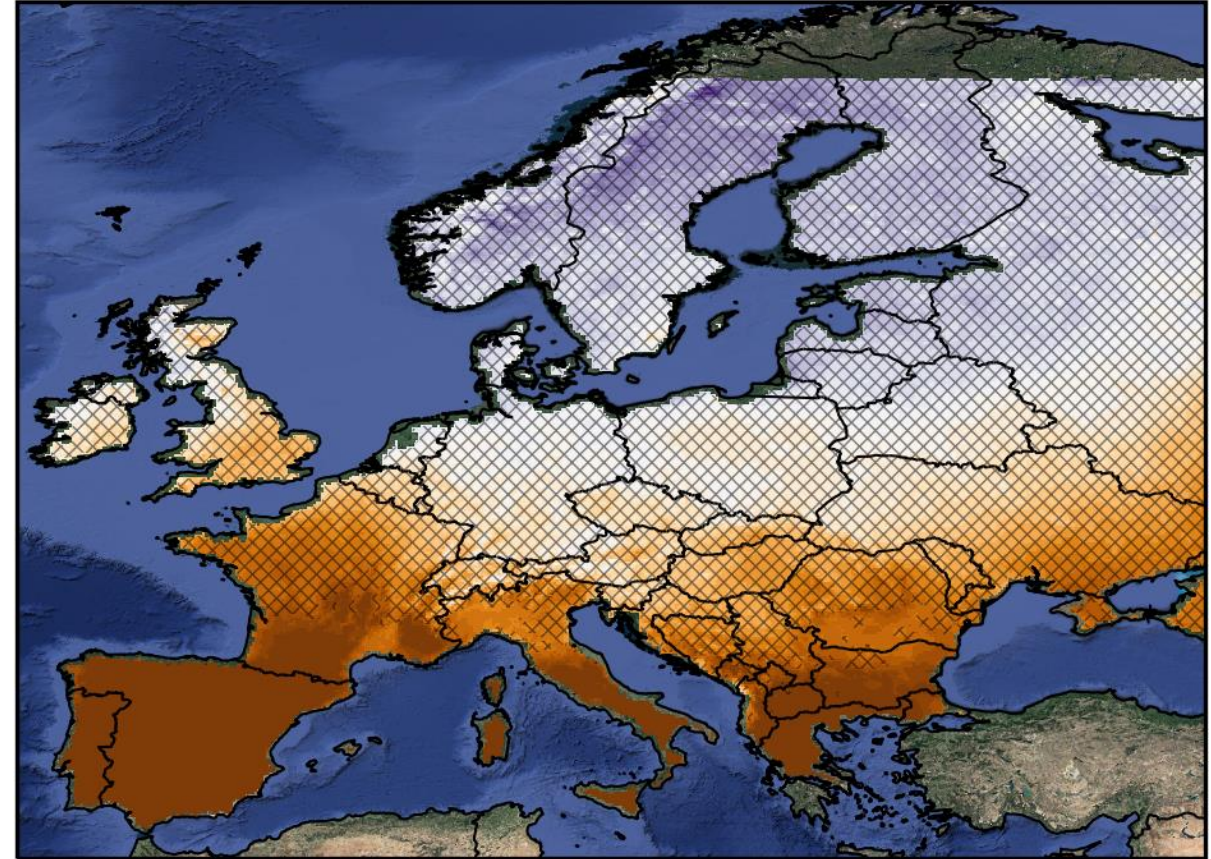


# Regional Climate Projections – SPEI Change

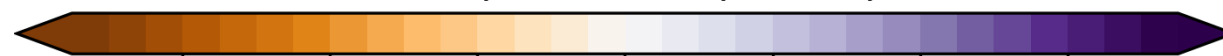
SPEI – 3 Month



SPEI – 12 Month



Standardized Precipitation Evapotranspiration Index



-1.2 -0.8 -0.4 -0.0 0.4 0.8 1.2

Potential Evapotranspiration based on Hargreaves

2071-2100 vs. 1971-2000  
CORDEX-EUR11 RCP8.5  
Annual Changes  
90% Significance Level



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# Summary

- Ensemble of 62 high resolution regional climate model simulations are available for the project
- Bias adjustment reduces bias significantly, also for prolonged drought event
- North-South gradient in climate change signal, but different border between different ensembles
- Increase number of drought events and length of drought spells
- Precipitation related changes are uncertain with any ensemble (CMIP5, CMIP6 and CORDEX-EUR11)
  - High natural variability
  - High inter-model variability
- Strongest changes anticipated for France, Italy and Balkans
- Long-scale SPEI (>12 month) show stronger increase



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