Complementing and analyzing the CORDEX-EUR11 Ensemble

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How will the climate in Germany change until the end of the century?

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“It is difficult to make predictions, especially about the future.”

Niels Bohr or Yogi Berra or Storm P or Markus M. Ronner or Danish proverb

How will the climate in Germany change until the end of the century?

ReKliEs-De
Regionale Klimaprojektionen Ensemble für Deutschland

DKRZ
DEUTSCHES KLIMARECHENZENTRUM

b-tu Brandenburgische Technische Universität Cottbus

Deutscher Wetterdienst
Wetter und Klima aus einer Hand
DWD

HLNUG
Hessisches Landesamt für Naturschutz, Umwelt und Geologie
Für eine lebenswerte Zukunft

UNIVERSITÄT HOHENHEIM 1818

PIK

GERICS
Climate Service Center Germany

Objectives of ReKliEs-De:

- Evaluate climate change signals for Germany for the 21st century from EURO-CORDEX simulations
- Systematically complement existing simulations with new experiments based on dynamical and statistical downscaling methods
- Estimate ranges for development of major climate parameters in the future
- Assessment of avoidable climate change
- Investigate the robustness of climate change parameters derived from the model ensemble

The overall goal is to provide robust climate change information on high spatial resolution for Germany.

Simulations planned in ReKliEs-De:

	CCLM	REMO	WRF	STARS	WETTREG
MPI-ESM-LR RCP 2.6	BTU	EURO-CORDEX	UHOH	PIK	PIK
MPI-ESM-LR RCP 8.5	EURO-CORDEX	EURO-CORDEX	EURO-CORDEX	PIK	PIK
HadGEM2ES RCP 8.5	EURO-CORDEX	HZG	UHOH	PIK	PIK
EC-EARTH RCP 8.5	EURO-CORDEX	HZG	UHOH	PIK	PIK
CNRM-CM5 RCP 8.5	BTU	HZG	X	PIK	PIK
CanESM2 RCP8.5	DWD	HZG	X	PIK	PIK
MIROC5 RCP 8.5	DWD	HZG	UHOH	PIK	PIK
MIROC5 RCP 2.6	DWD	X	X	X	X

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HadGEM2ES RCP 8.5	EURO-CORDEX	HZG	UHOH	PIK	PIK
EC-EARTH RCP 8.5	EURO-CORDEX	HZG	UHOH	PIK	PIK
CNRM-CM5 RCP 8.5	BTU	HZG	X	PIK	PIK
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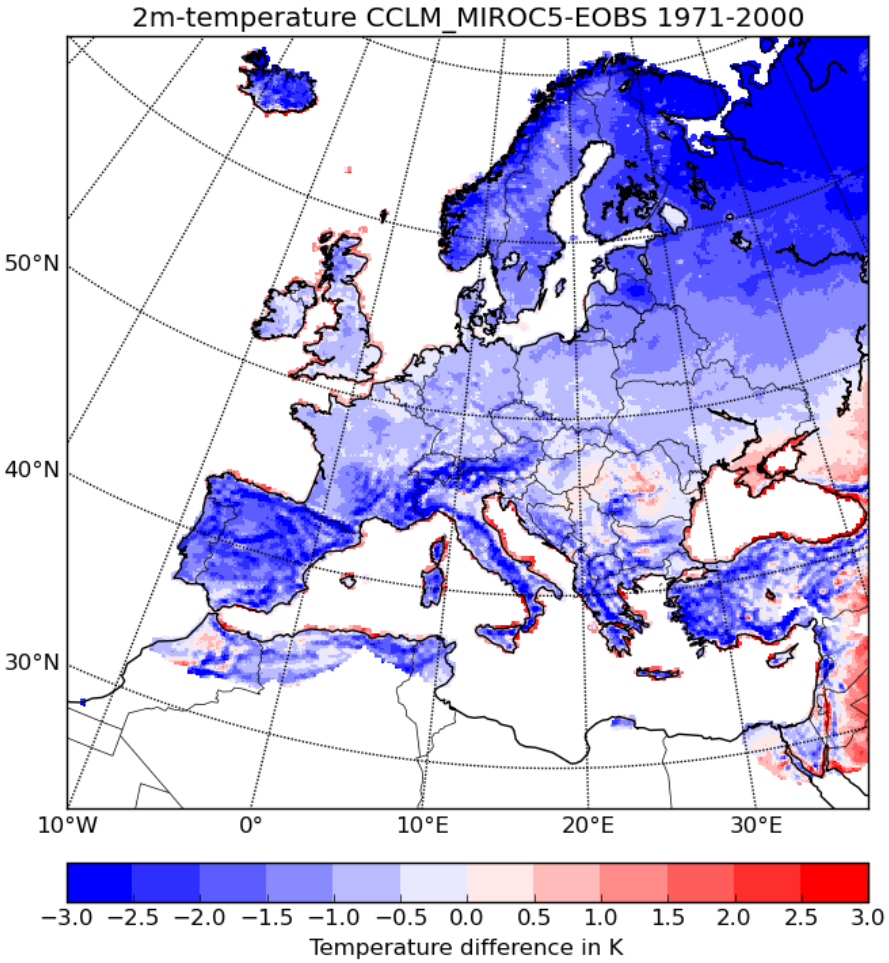
MIROC5 RCP 8.5	DWD	HZG	UHOH	PIK	PIK
MIROC5 RCP 2.6	DWD	X	X	X	X

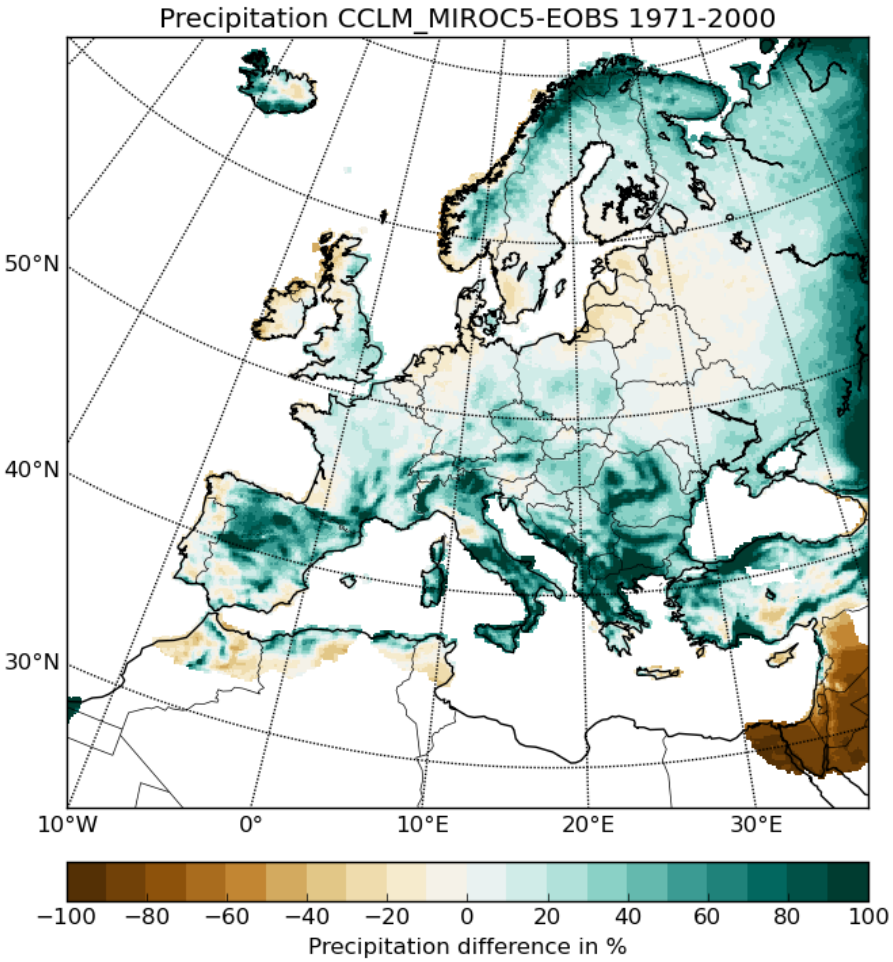
Outline:

1. Validation of the CCLM simulation with MIROC5 boundary conditions
2. First results from the EURO-CORDEX/ReKliEs-De ensemble
3. Outlook

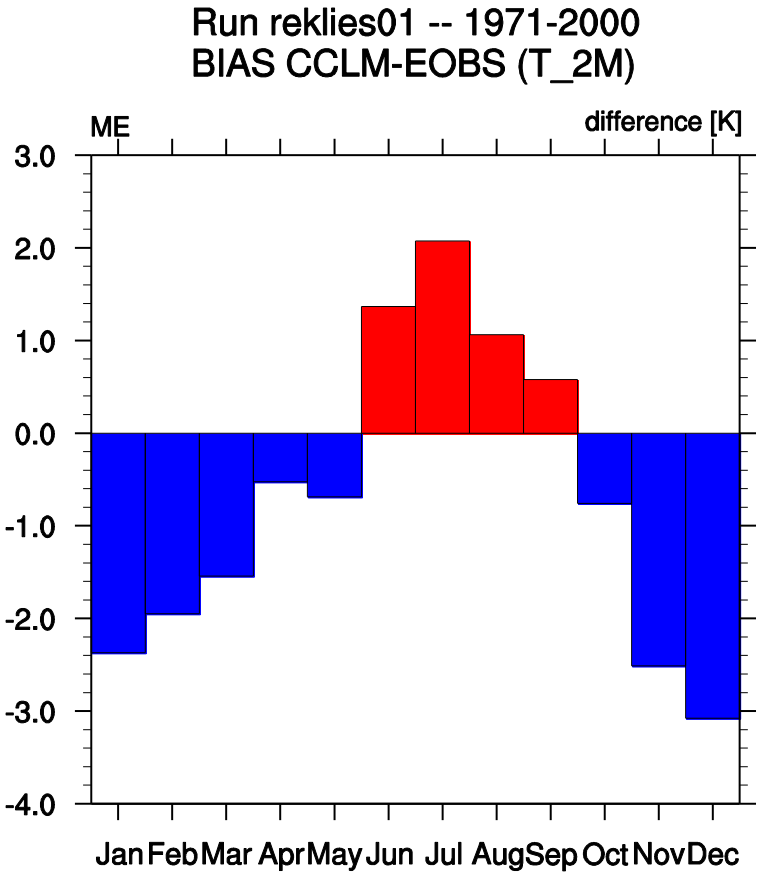
Bias 2m-temperature (TAS) compared to E-OBS for 1971-2000



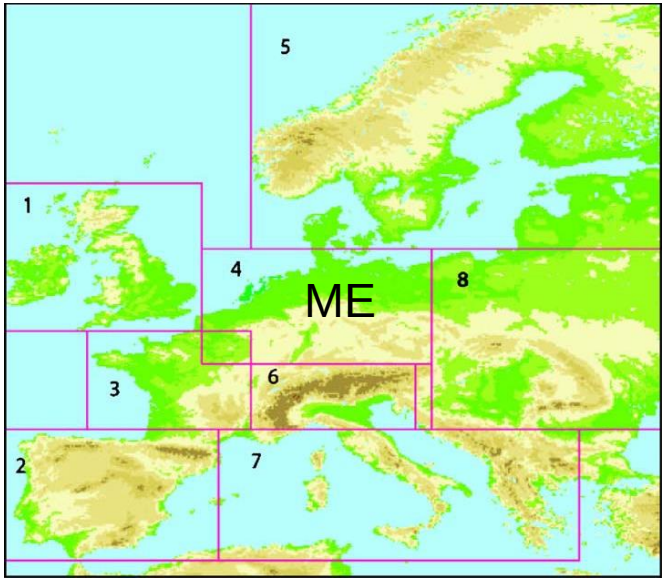
Bias precipitation (PR) compared to E-OBS for 1971-2000



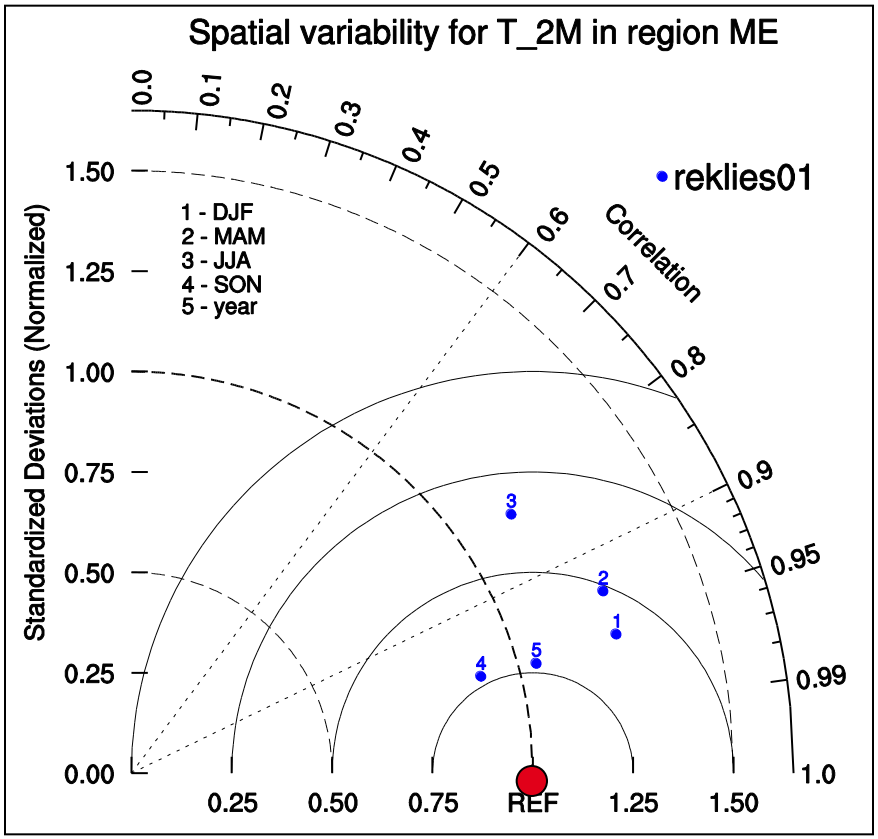
Bias TAS monthly for PRUDENCE region 4 (ME)



PRUDENCE regions



Spatial variability TAS for PRUDENCE region 4 (ME)

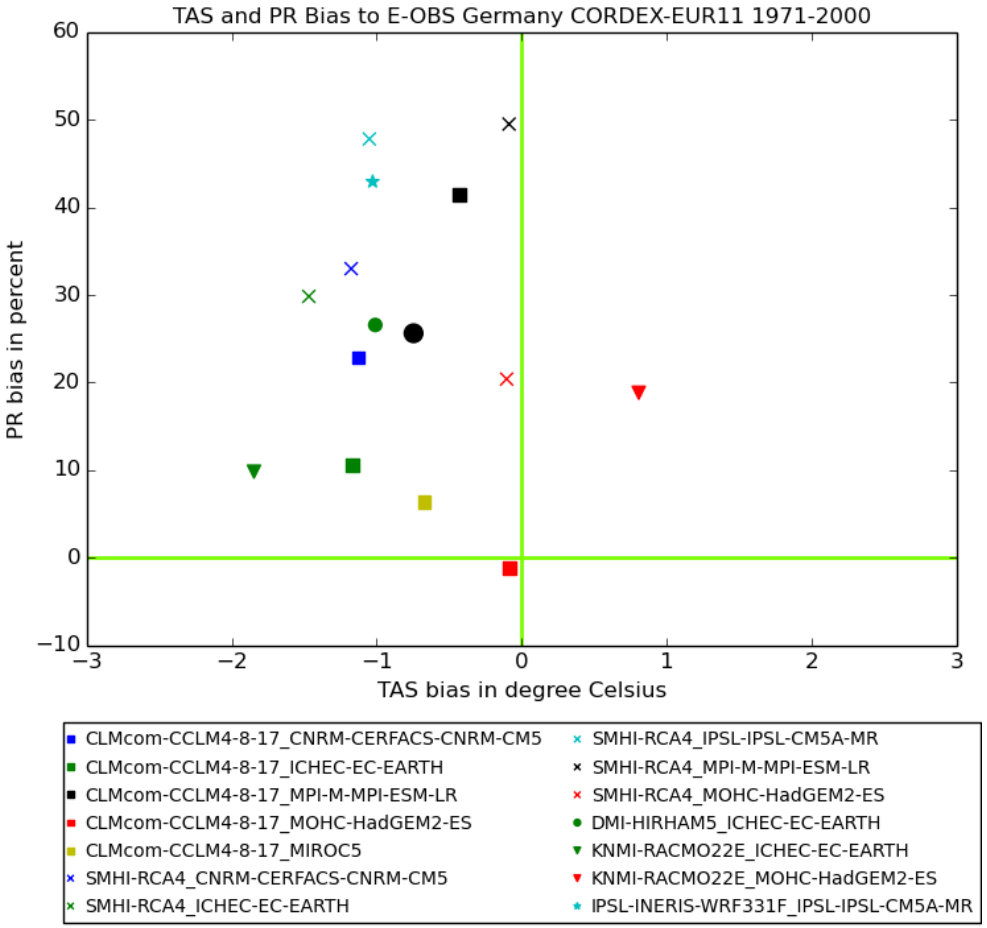


Comparison model - observations

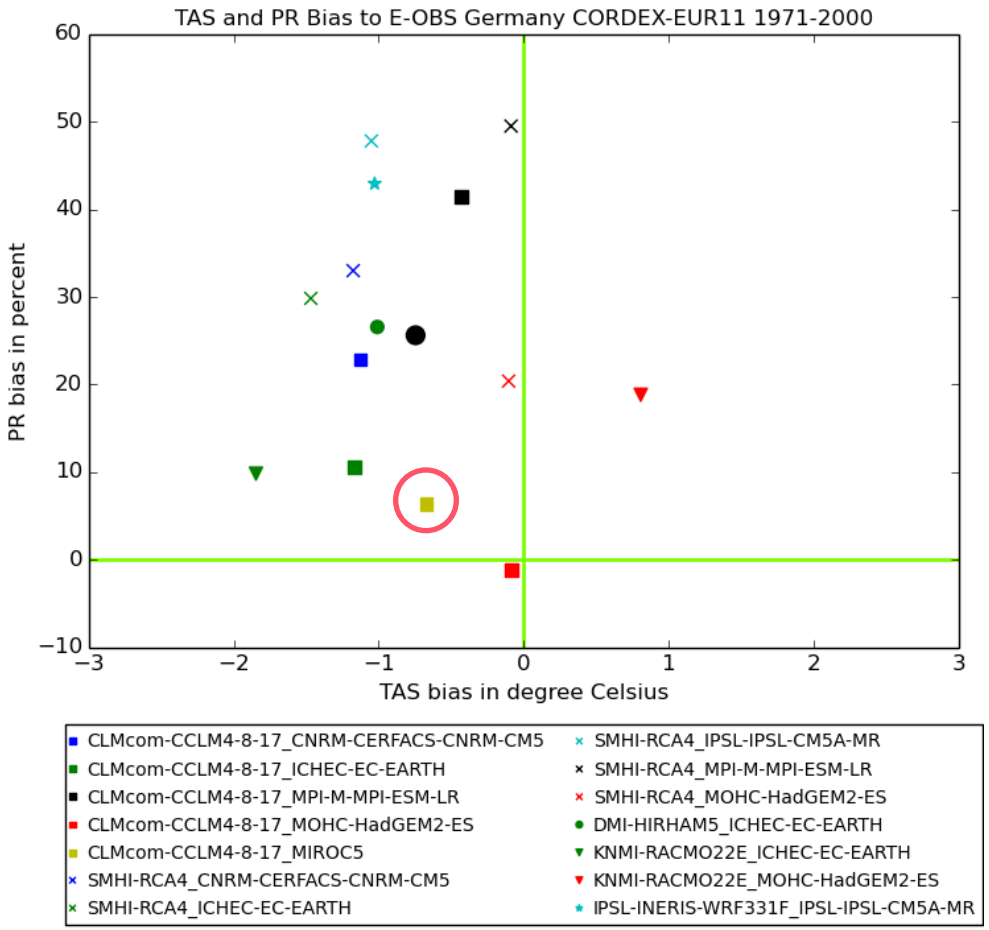
- Spatial correlation
- Standard deviation (normalized)
- RMS error (normalized)

- **Better when closer to** ●

Bias TAS und PR for Germany 1971-2000 for CORDEX-EUR11 Ensemble (historical)



Bias TAS und PR for Germany 1971-2000 for CORDEX-EUR11 Ensemble (historical)



Conclusion CCLM-MIROC5:

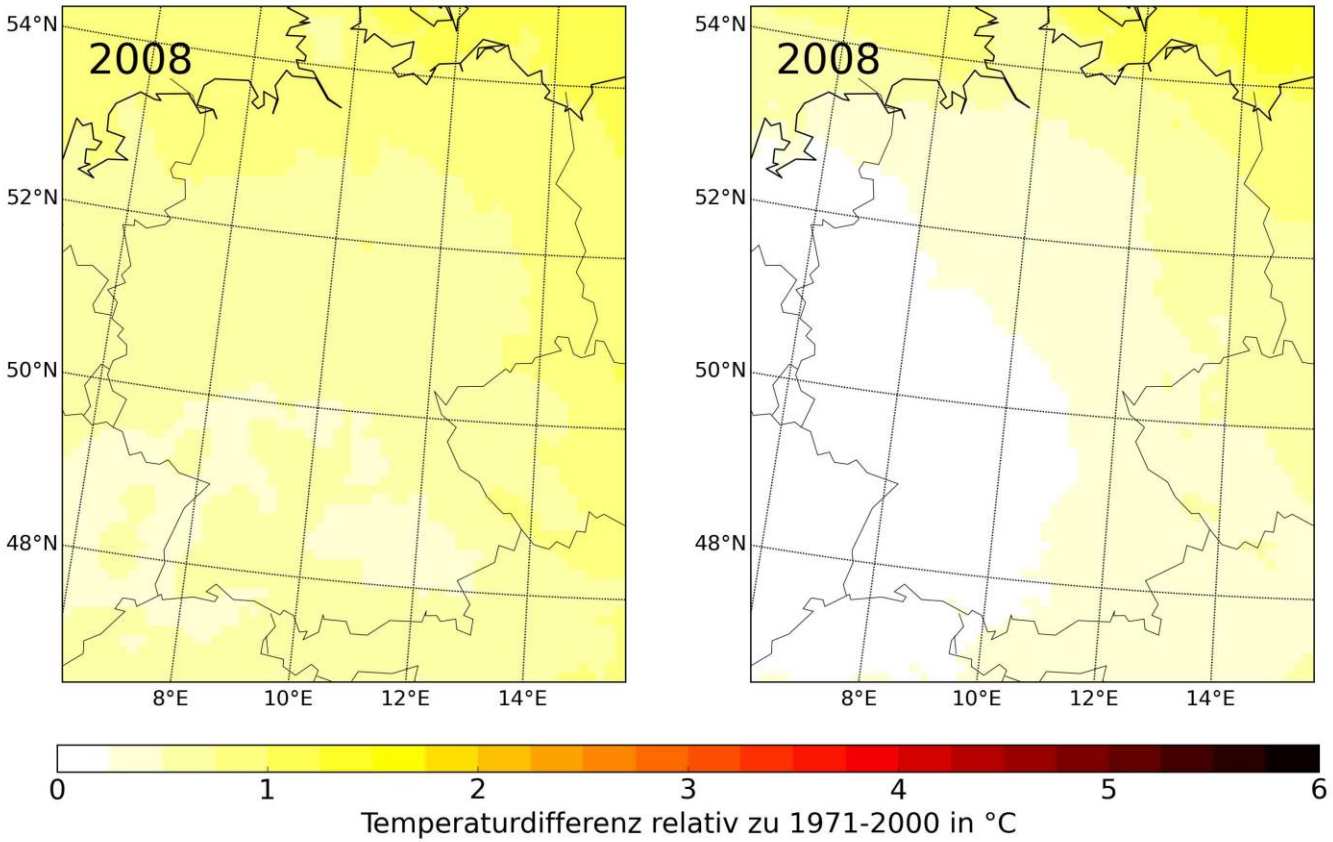
- On average temperature bias
- Very small precipitation bias
- TAS is overestimated in summer but underestimated in all other months
- Good reproduction of the spatial pattern

- **Simulation COSMO-CLM with MIROC5 can be used**

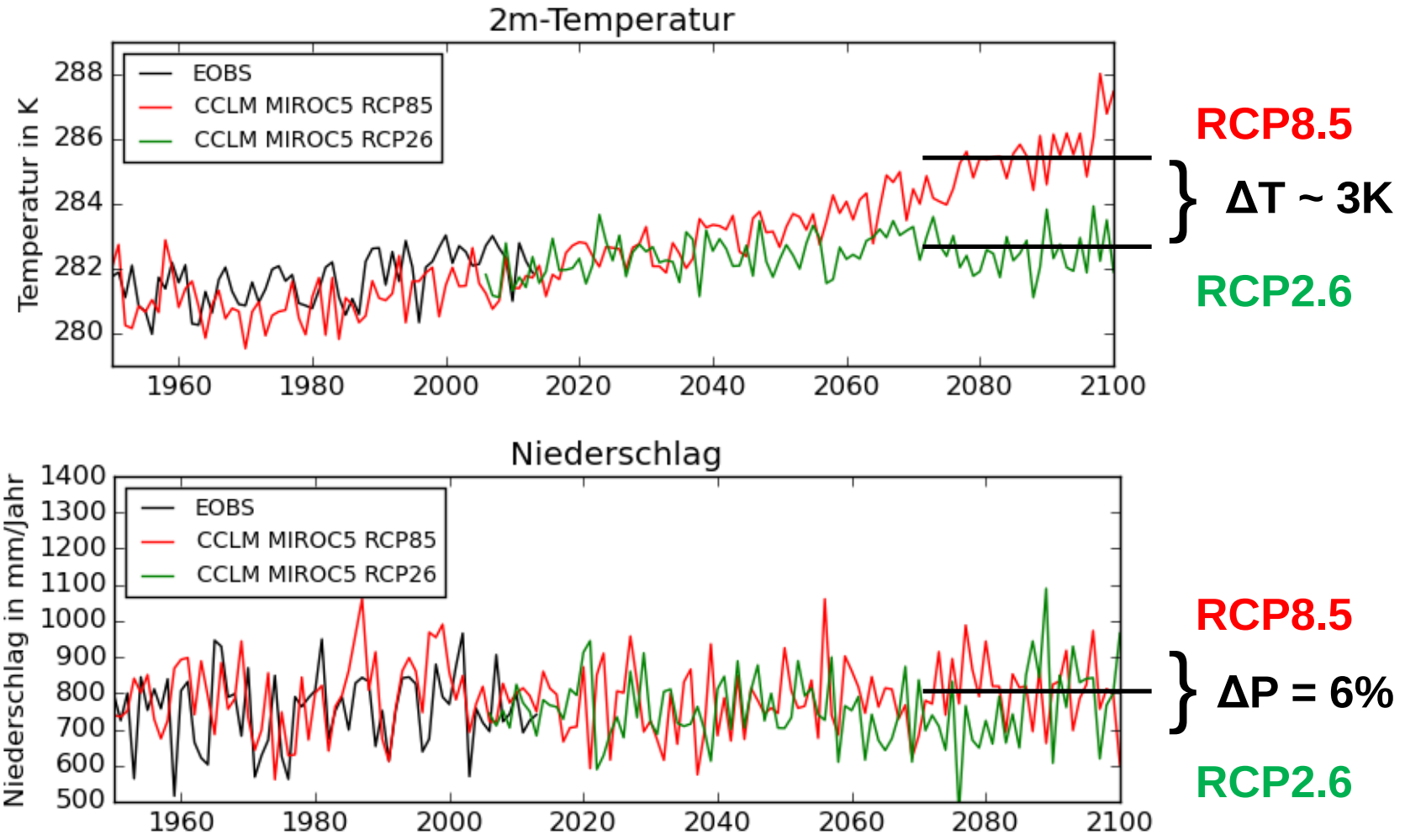
Comparison development TAS

RCP2.6

RCP8.5



Time series TAS and PR for Germany



Outline:

1. Validation of the CCLM simulation with MIROC5 boundary conditions
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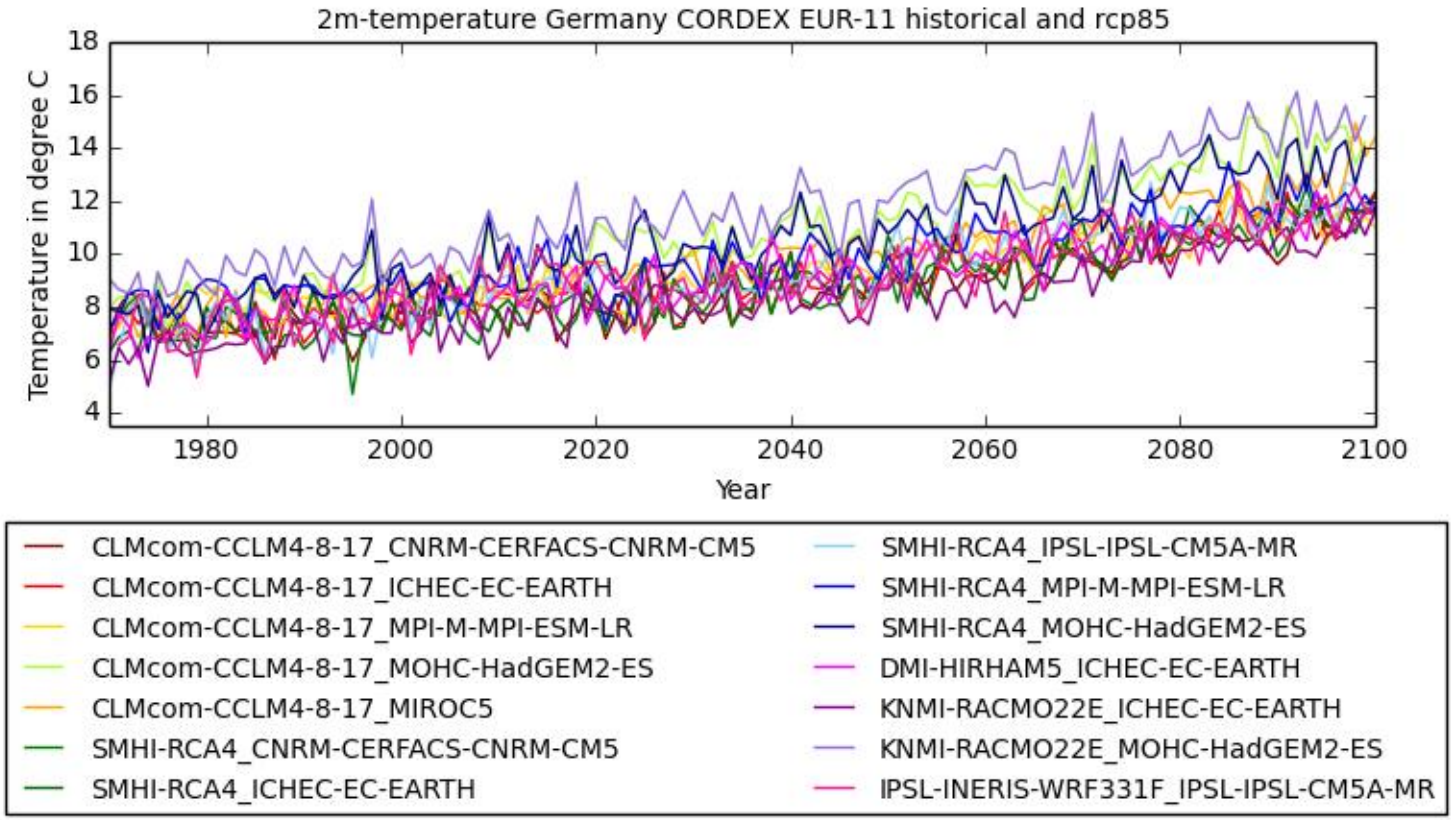
Available CORDEX-EUR11 simulations

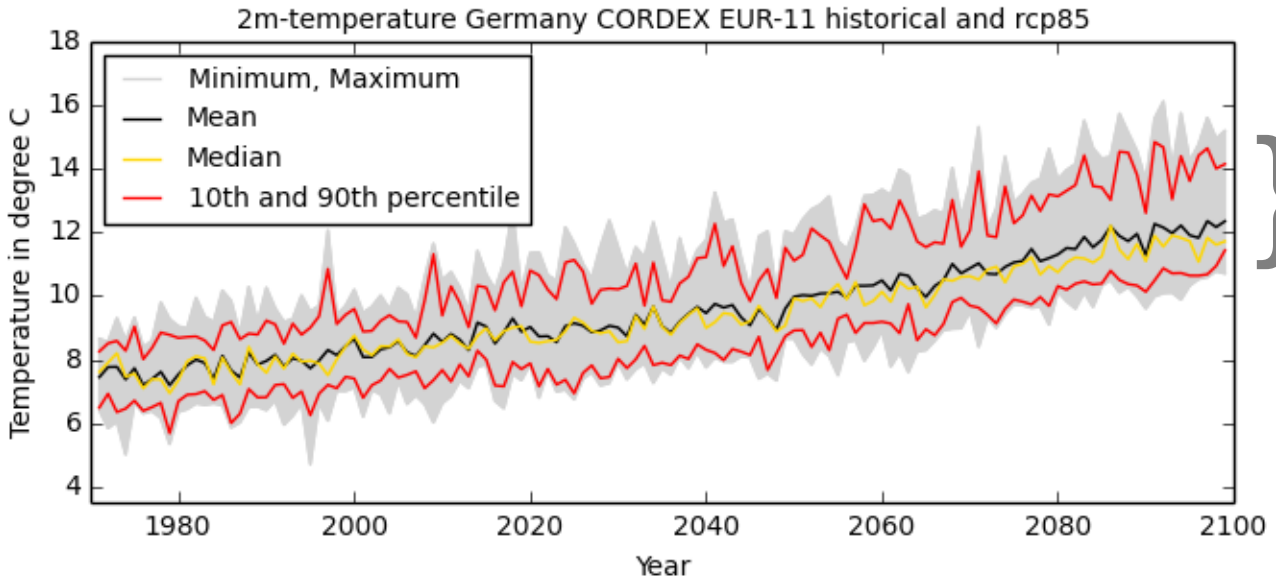
	CCLM	RCA4	HIRHAM5	RACMO22E	WRF331F
CNRM-CM5	■	■			
EC-EARTH	■	■	■	■	
MPI-ESM-LR	■	■			
HadGEM2-ES	■	■		■	
MIROC5	■				
IPSL-CM5A-MR		■			■
Total (14)	5	5	1	2	1

Time series TAS for all CORDEX-EUR11 simulations for Germany



14 simulations

Time series of important parameters from all CORDEX-EUR11 simulations for Germany



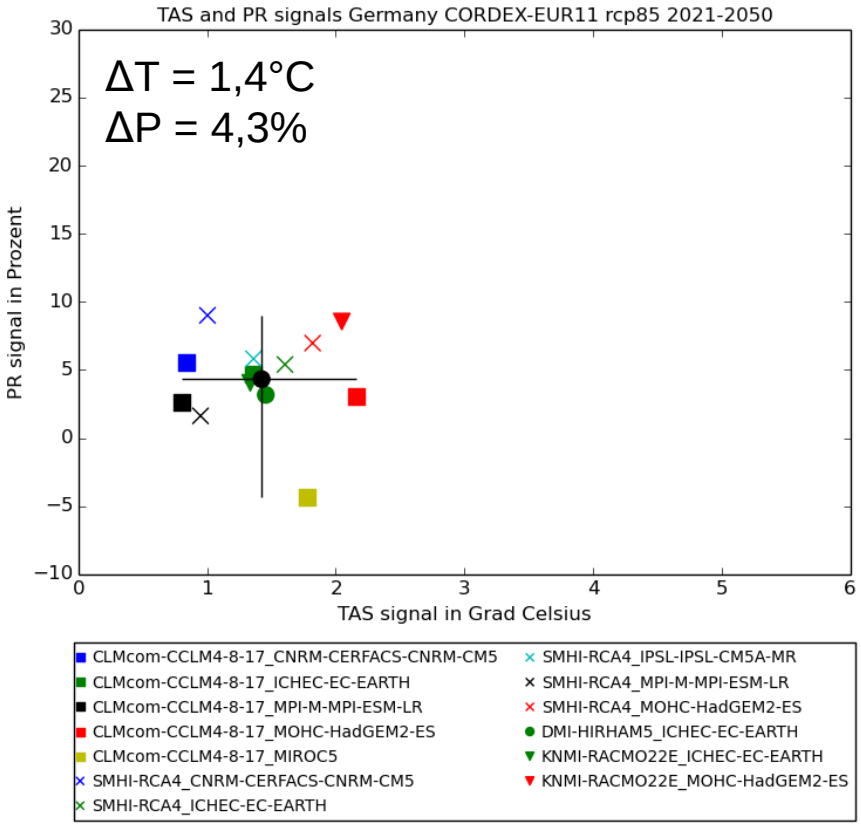
ΔT ~ 4K

ΔT ~ 2,5K

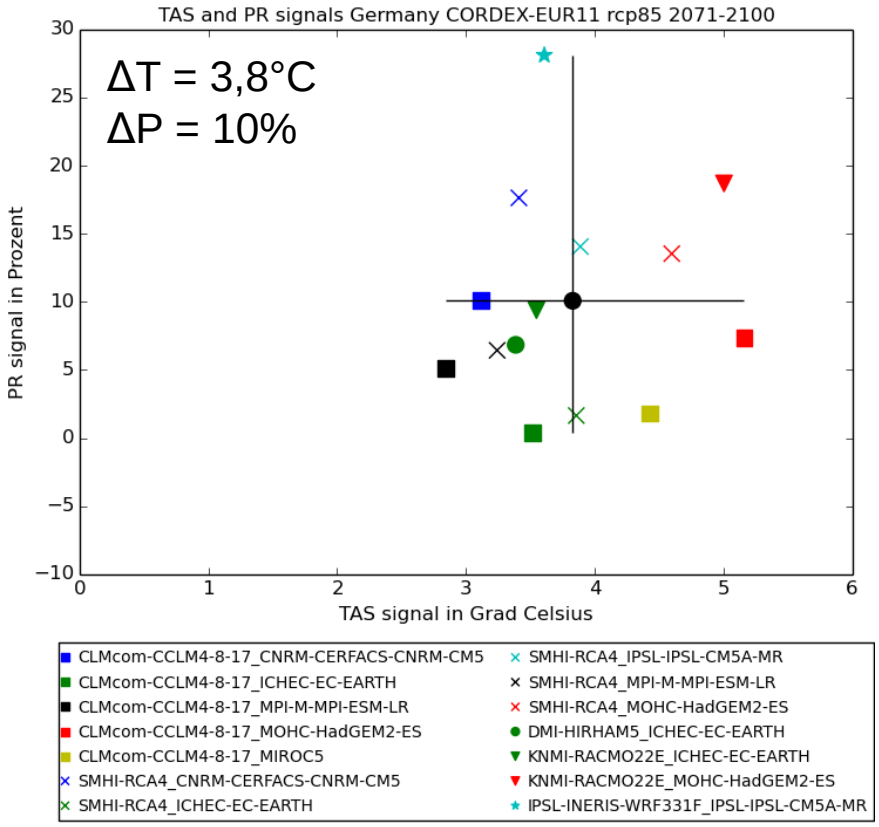
➔ **Information from 14 simulations in condensed form**

Signals TAS and PR for Germany in rcp85

2021-2050

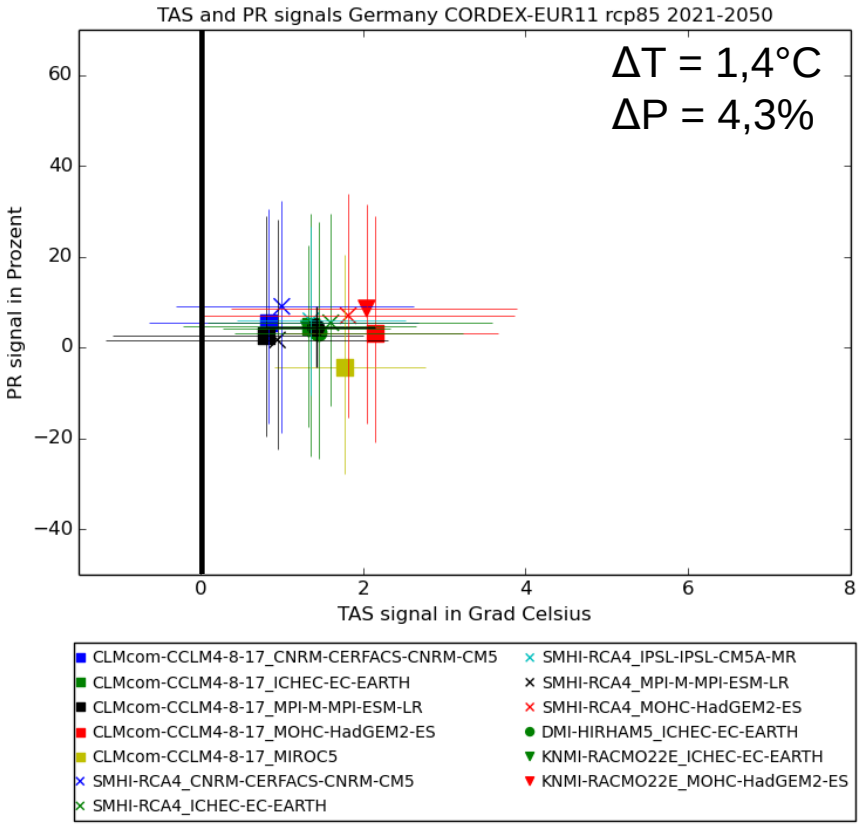


2071-2100

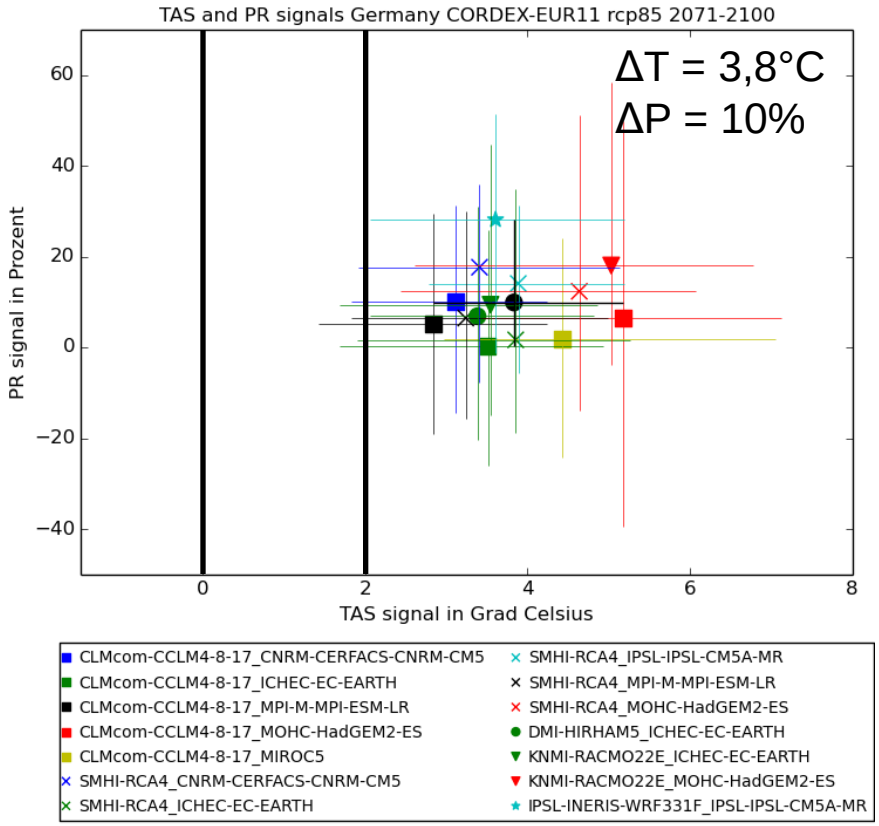


Signals and variability of the individual years for TAS and PR for Germany in rcp85

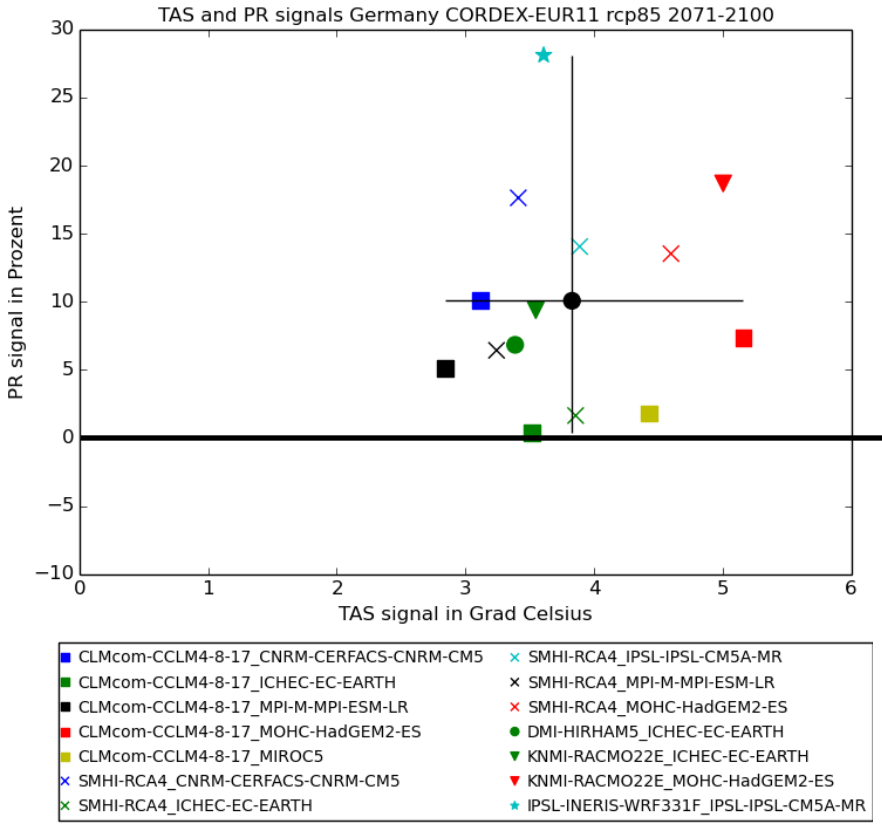
2021-2050

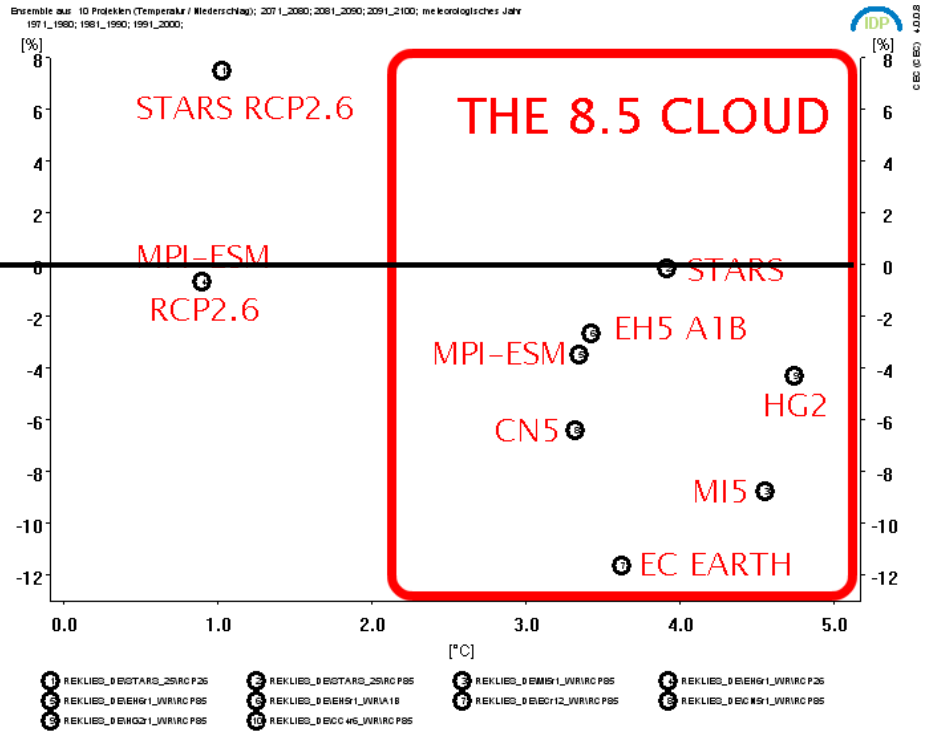


2071-2100



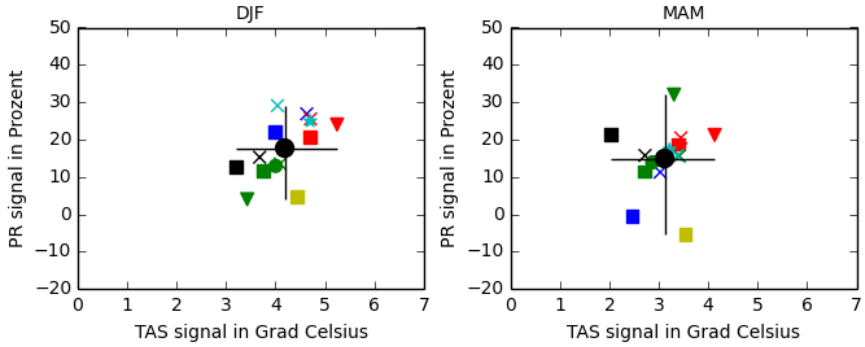
Comparison of the mean annual change signals in dynamical and statistical models





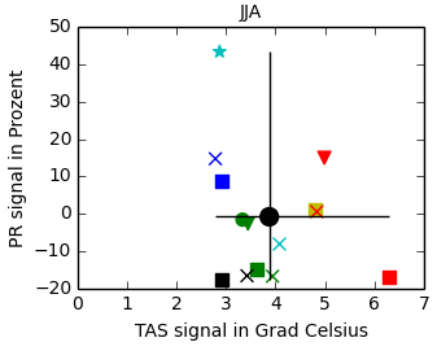
Seasonal signals TAS and PR for Germany in rcp85 2071-2100

ΔT = 4,2°C
ΔP = 18%

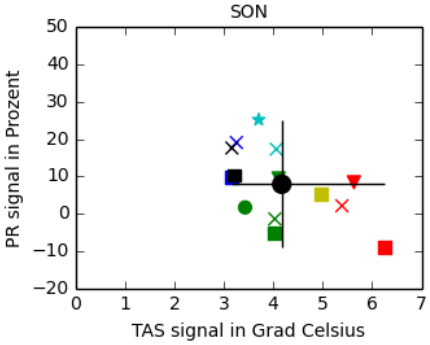


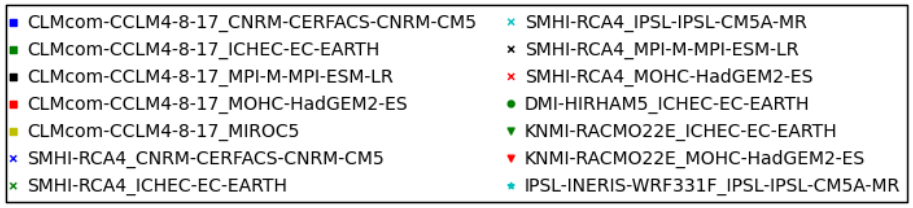
ΔT = 3,1°C
ΔP = 15%

ΔT = 3,9°C
ΔP = -0,79%



ΔT = 4,2°C
ΔP = 7,9%





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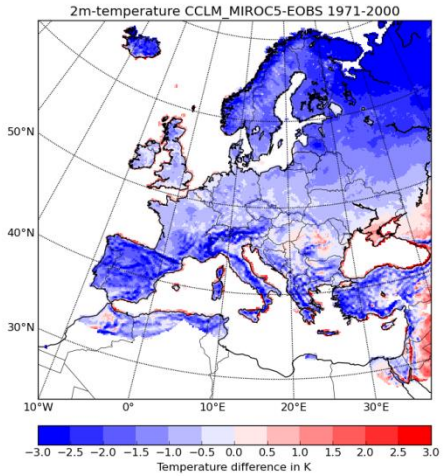
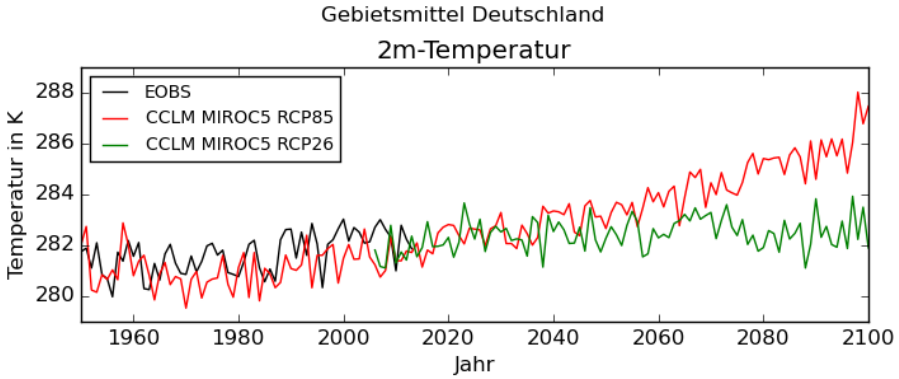
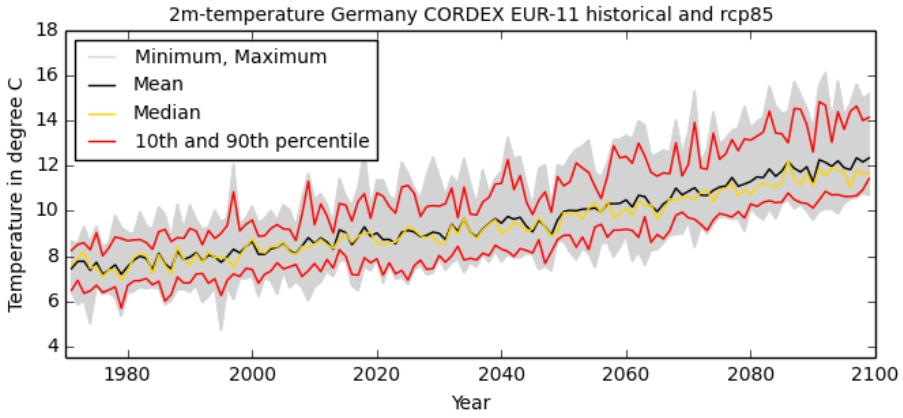
Outlook:

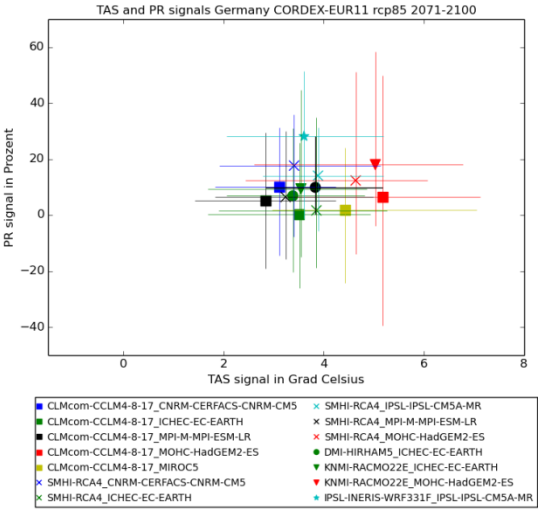
- Standardization (CMOR) of the model output
- Computation of further climate change indices based on the CORDEX/ReKliEs ensemble
- Analysis of the climate change signals in dependence of the size and the composition of the ensemble
- Analysis of frequency distribution of extreme values


2m-temperature CCLM_MIROC5-EOBS 1971-2000
50°N
40°N
30°N
10°W
0°
10°E
20°E
30°E
−3.0 −2.5 −2.0 −1.5 −1.0 −0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0
Temperature difference in K


Gebietsmittel Deutschland
2m-Temperatur
EOBS
CCLM MIROC5 RCP85
CCLM MIROC5 RCP26
Temperatur in K
288
286
284
282
280
1960
1980
2000
2020
2040
2060
2080
2100
Jahr

Questions?


2m-temperature Germany CORDEX EUR-11 historical and rcp85
Minimum, Maximum
Mean
Median
10th and 90th percentile
Temperature in degree C
18
16
14
12
10
8
6
4
1980
2000
2020
2040
2060
2080
2100
Year


TAS and PR signals Germany CORDEX-EUR11 rcp85 2071-2100
PR signal in Prozent
60
40
20
0
−20
−40
0
2
4
6
8
TAS signal in Grad Celsius
CLMcom-CCLM4-8-17_CNRM-CERFACS-CNRM-CM5
CLMcom-CCLM4-8-17_ICHEC-EC-EARTH
CLMcom-CCLM4-8-17_MPI-M-MPI-ESM-LR
CLMcom-CCLM4-8-17_MOHC-HadGEM2-ES
CLMcom-CCLM4-8-17_MIROC5
SMHI-RCA4_CNRM-CERFACS-CNRM-CM5
SMHI-RCA4_ICHEC-EC-EARTH
SMHI-RCA4_IPSL-IPSL-CM5A-MR
SMHI-RCA4_MPI-M-MPI-ESM-LR
SMHI-RCA4_MOHC-HadGEM2-ES
DMI-HIRHAM5_ICHEC-EC-EARTH
KNMI-RACMO22E_ICHEC-EC-EARTH
KNMI-RACMO22E_MOHC-HadGEM2-ES
IPSL-INERIS-WRF331F_IPSL-IPSL-CM5A-MR