

Evaluation of precipitation statistics in the CLM and sensitivity to physical parameterizations

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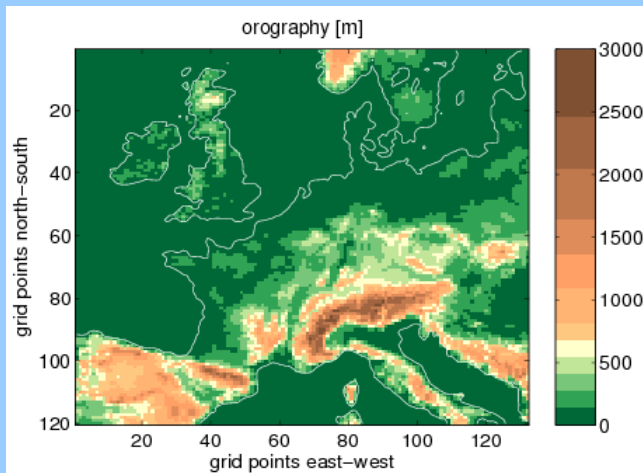
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Climate scenarios into the future

global Scenarios
(CO₂-doubling...)

- model validation
- knowledge of today's climate

Regional Climate Model CLM



future regional climate

- more intense precipitation events?
- more floods or droughts?

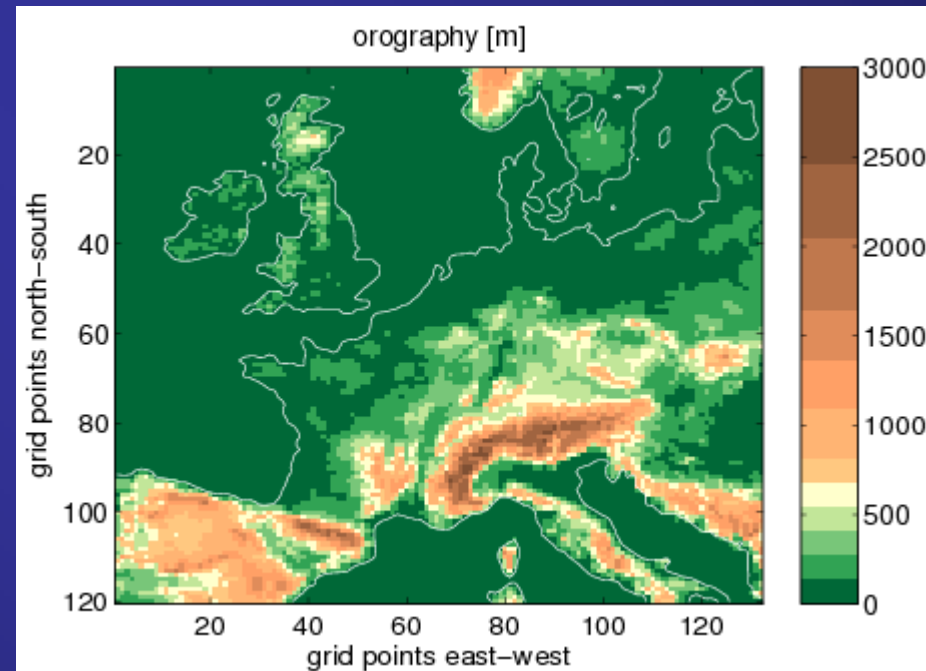


Strategy

- **Statistical properties** of summer precipitation in regional climate simulations; forced by „observations“
- Using **non-parametric** techniques
- Evaluate CLM:
 1. **performance of the model**
→ comparison to station data (daily, DWD)
 2. **model uncertainty**
→ comparison of model ensemble (physical parameterizations)

CLM: model configuration

- horizontal: 132*120 grid points
- vertical: 20 atmospheric and 9 soil levels
- 1/6° grid spacing (~18km)
- initial and boundary forcing by ERA40 reanalysis data (every 6h)
- timestep 75 s
- different parameterizations

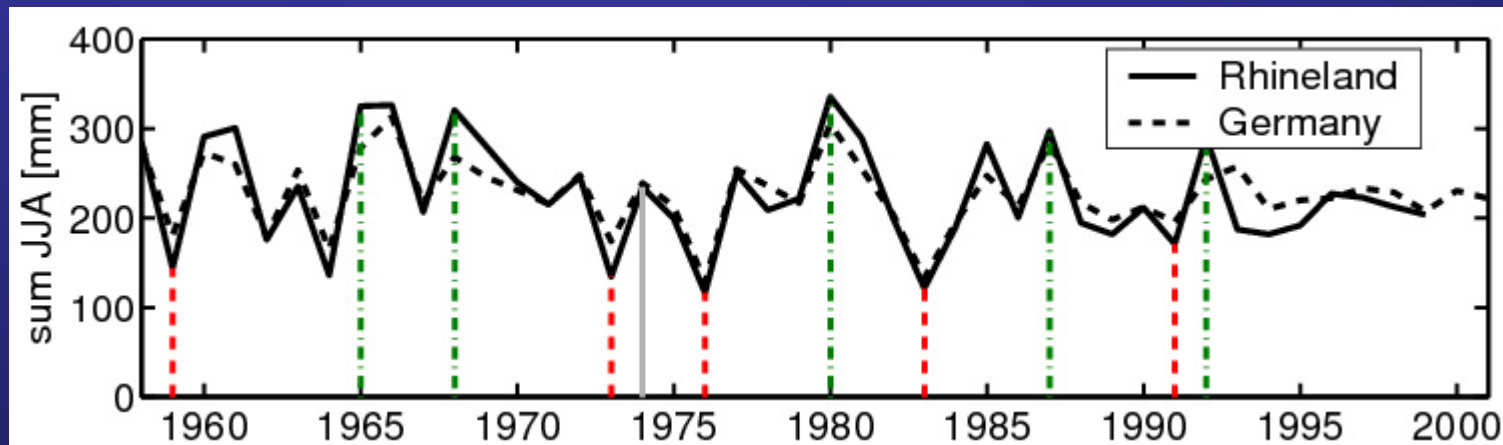


Simulations (1)

11 summer seasons:

simulation period: 1. May – 2. Sep.

analysis: June, July, August (JJA)



wet: 1959
1973
1976
1983
1991

dry: 1965
1968
1980
1987
1992

average

1974

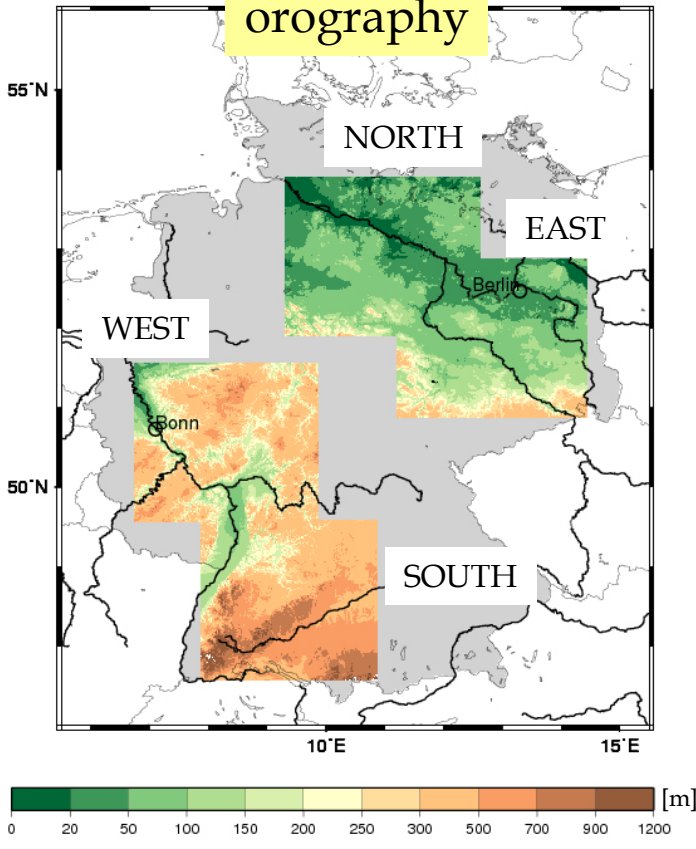
Simulations (2)

12 configurations for the parameterizations

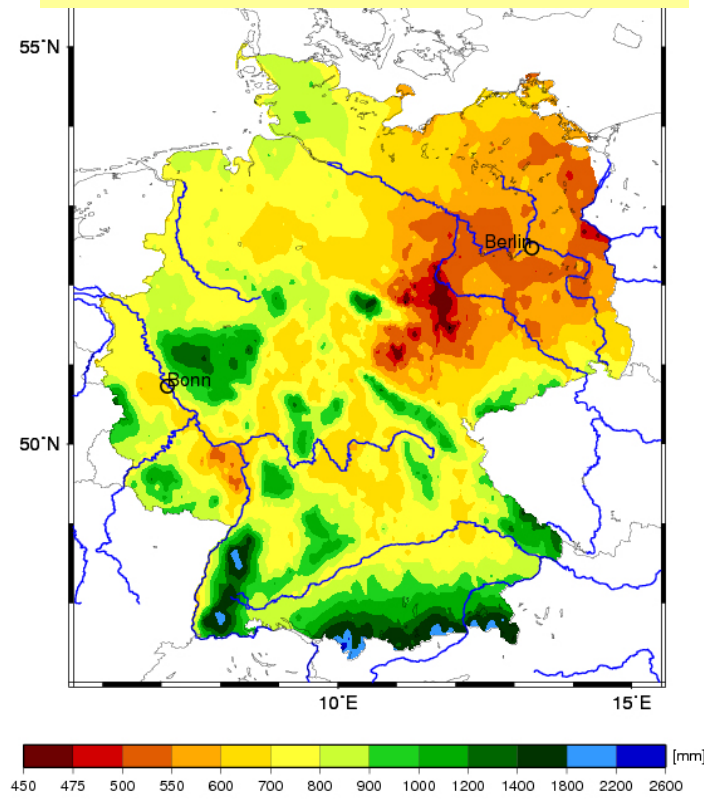
consortial runs	CONTROL (<i>CON</i>)	TURB_DIAGN-TKE (<i>TDT</i>)	} turbulence
convection	CONV_TCAPE (<i>CTC</i>)	TURB_SUBCLOUD (<i>TSC</i>)	
	CONV_KF (<i>CKF</i>)	RAD_FREQ (<i>RFR</i>)	} radiation
	CONV_FREQ (<i>CFR</i>)	SOIL_BUCKET (<i>SBU</i>)	} soil (evaporation)
grid-scale precipitation	PREC_ICE (<i>PIC</i>)	SOIL_STOMATA (<i>SST</i>)	
	PREC_ICE-AUTOCONV (<i>PIA</i>)	SOIL_AREAINDEX (<i>SAI</i>)	

Regional analysis

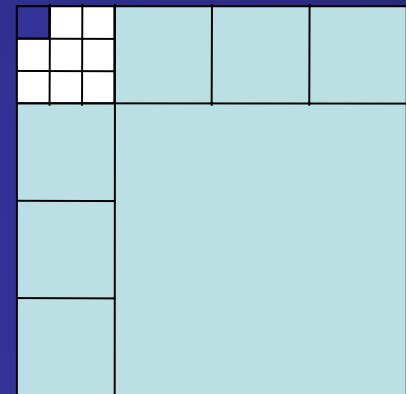
orography



Average yearly precipitation



- comparison:
- each grid box
 - 3*3 box average
 - domain average



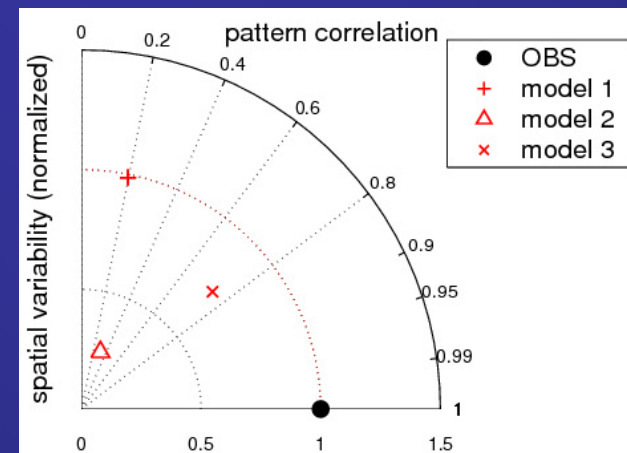
on average 3-5 stations per grid box
(depending on summer and region)

Results on...

- Summer total precipitation Germany
- Frequency distribution → Kolmogorov- Smirnov test
- 6 statistics

FREQ [%]	wet-day frequency (% of days with RR \geq 1mm)
INT [mm/d]	mean wet-day intensity
Q90 [mm/d]	90th percentile value
RX5day [mm]	max. precip. on 5 consecutive days
CCD [1]	max. number of consecutive dry days
R90pTOT [%]	Precipitation total from days with RR \geq Q90

- Comparison of simulations by medians and spatial structure (e.g. boxplots and Taylor plots)



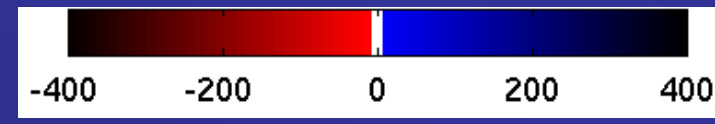
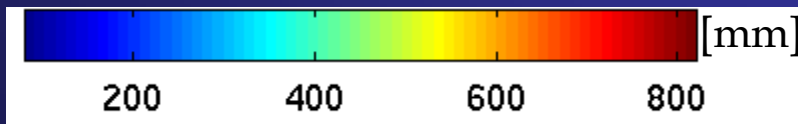
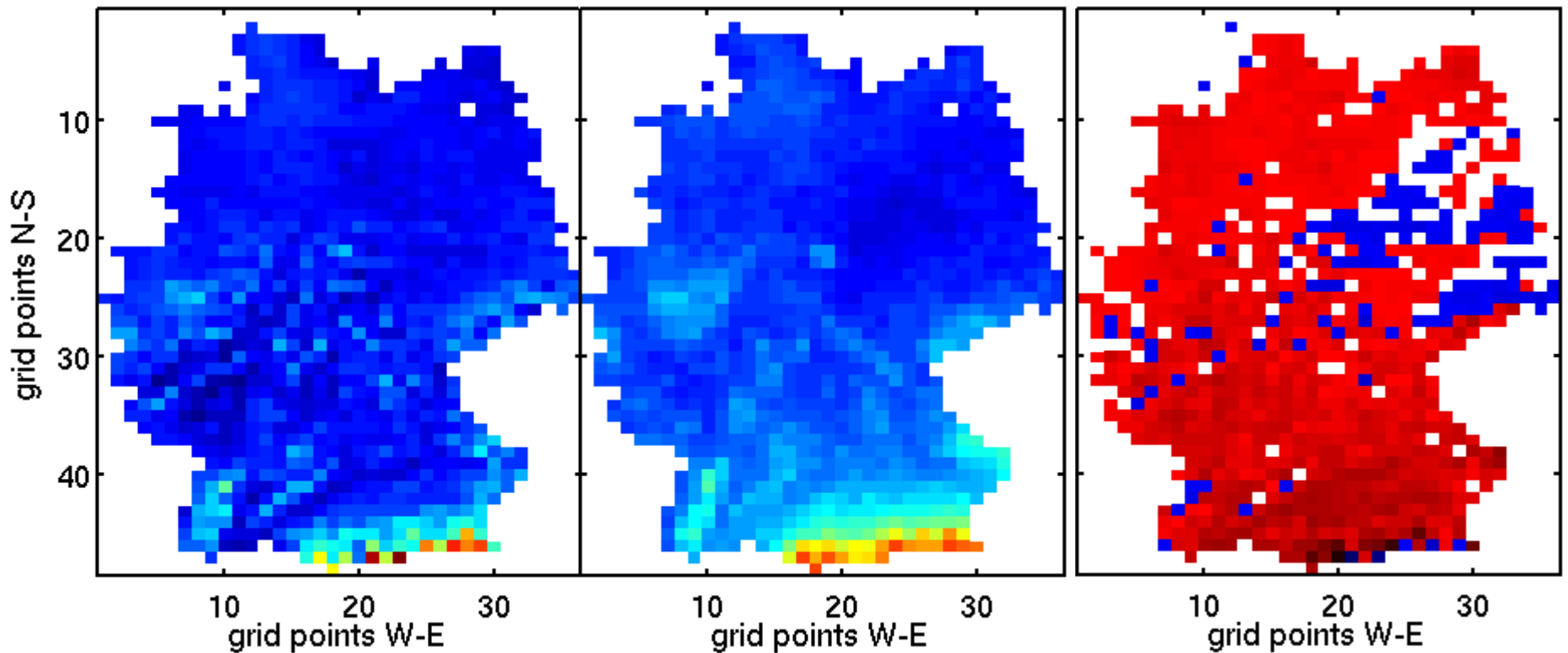
JJA total - Germany

(average over 11 summers)

model

data

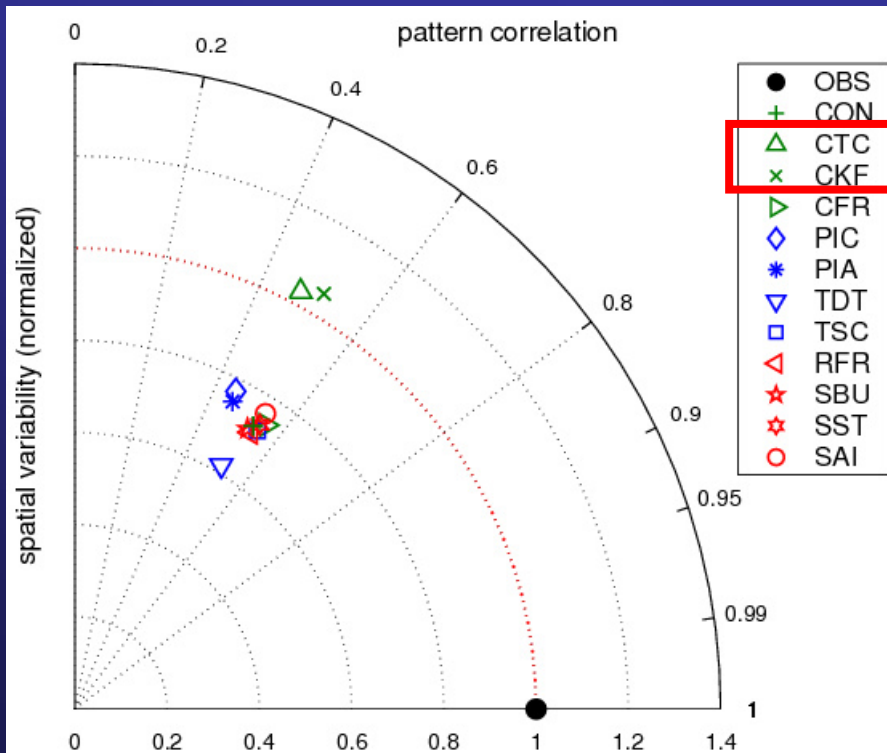
model - data



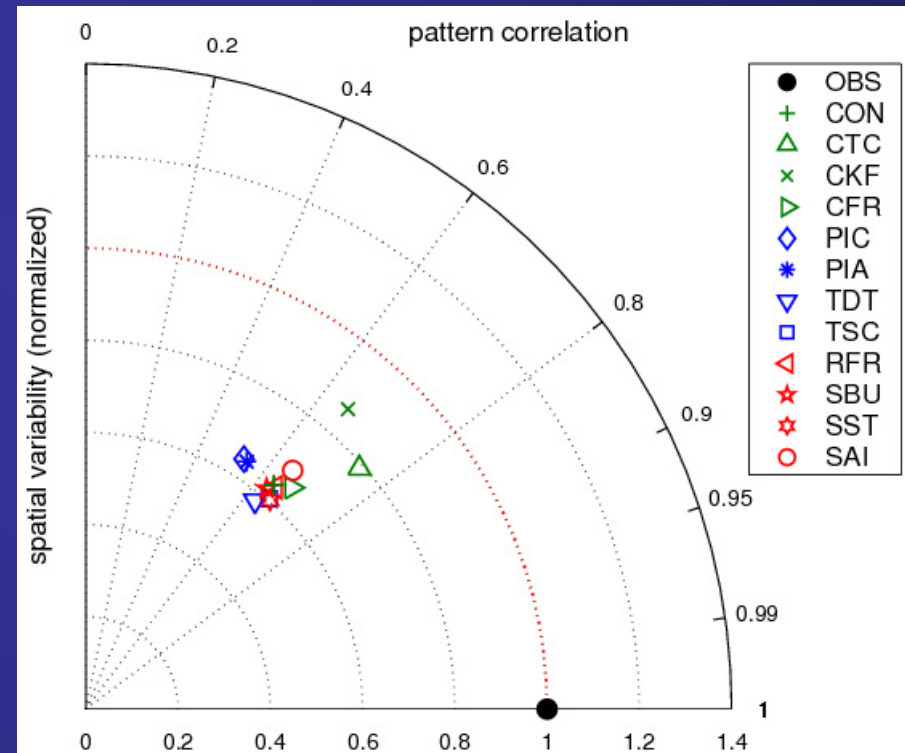
BIAS: -41 mm RMSE: 64 mm

...spatial pattern sum_JJA_D

grid boxes



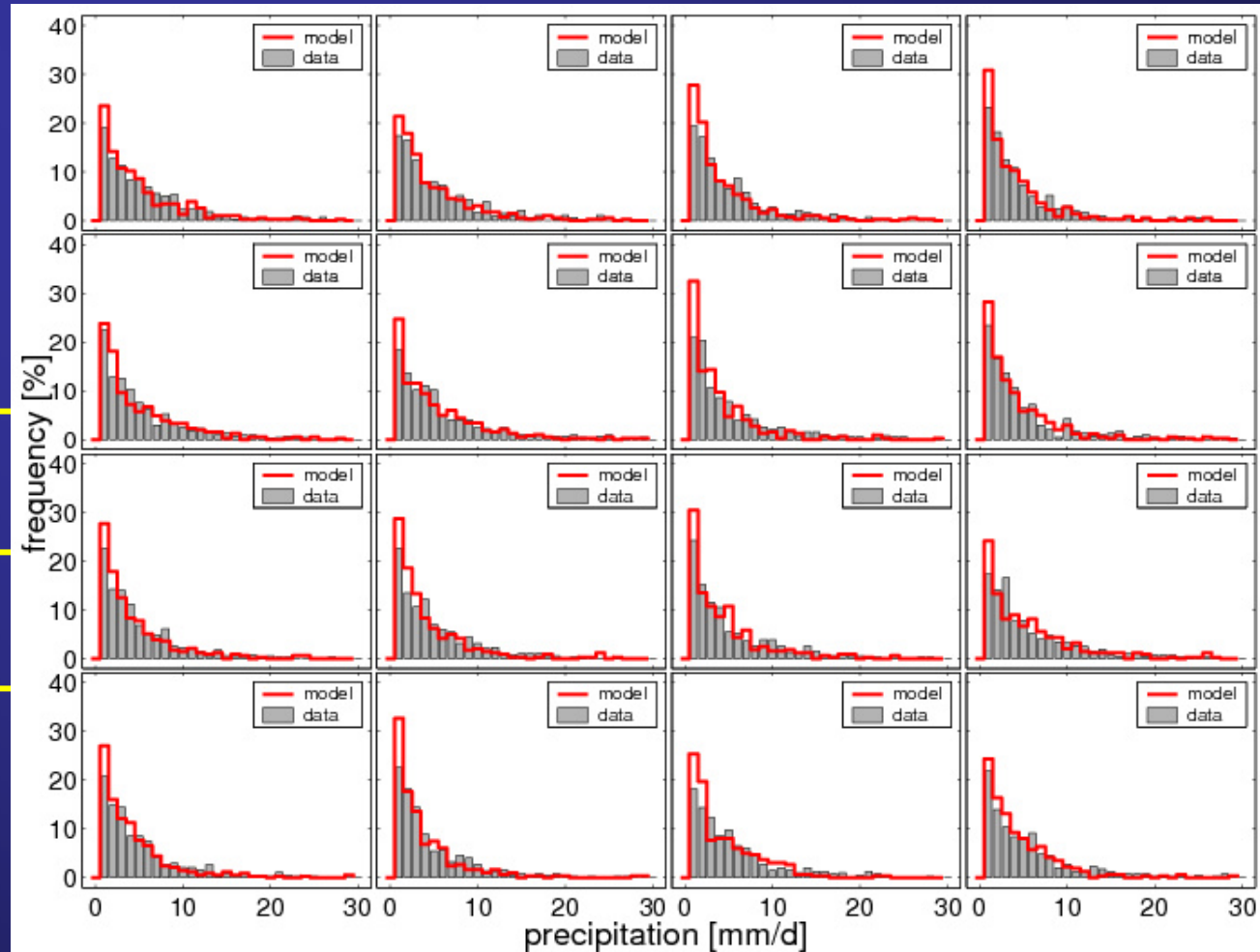
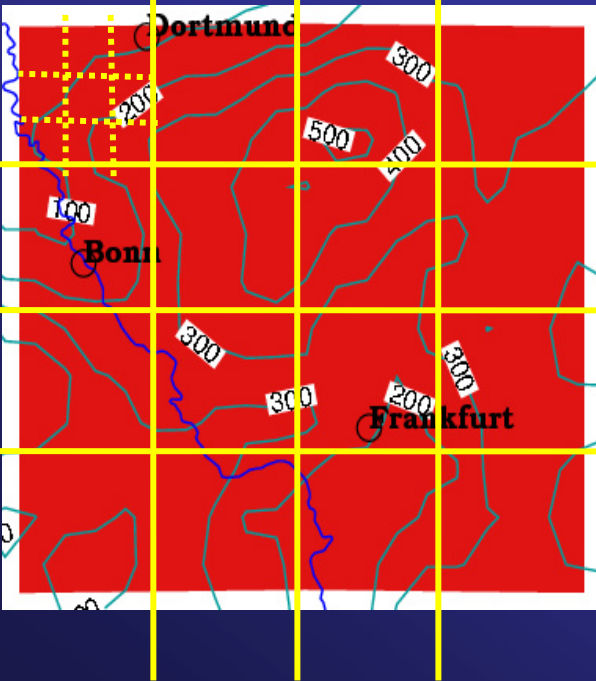
3*3 box averages



CTC: Tiedtke convection with CAPE closure
CKF: Kain-Fritsch convection

Regional scale: Frequency distribution of wet days (>1mm)

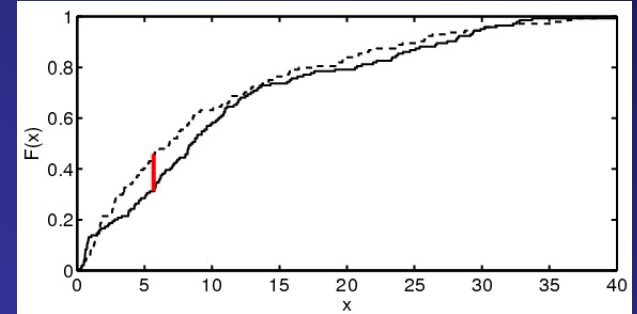
All years together
WEST
3*3-box-averages



Similarity of distributions

Kolmogorov-Smirnov test:

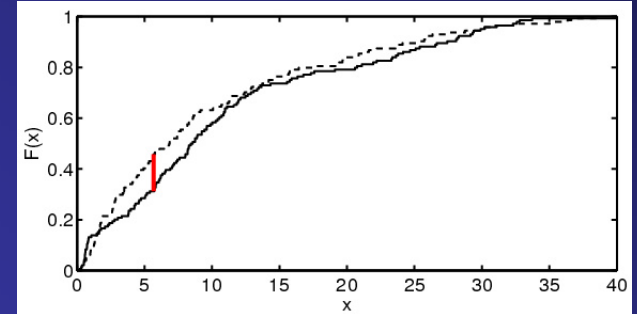
D_{KS} : maximum distance of distribution functions



Similarity of distributions

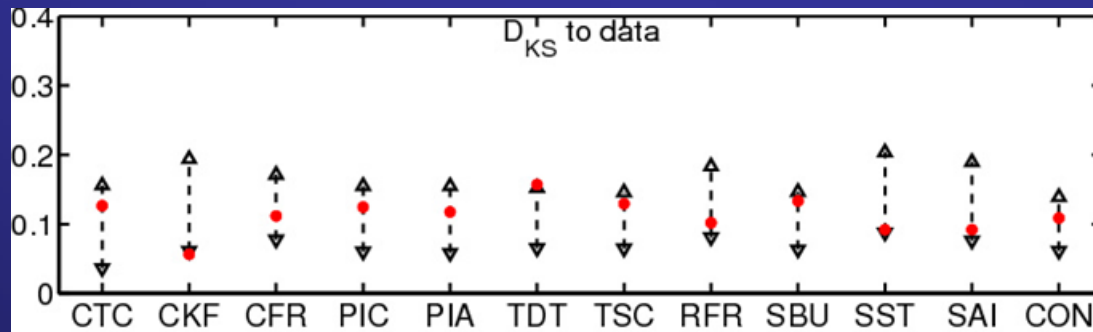
Kolmogorov-Smirnov test:

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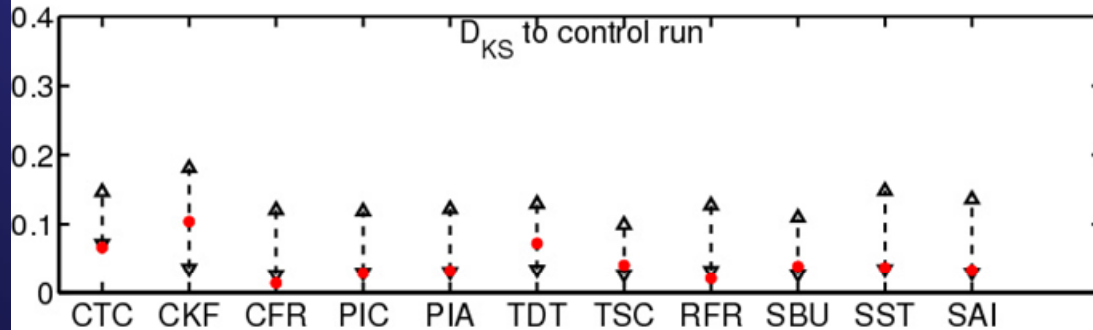


region WEST

→ data



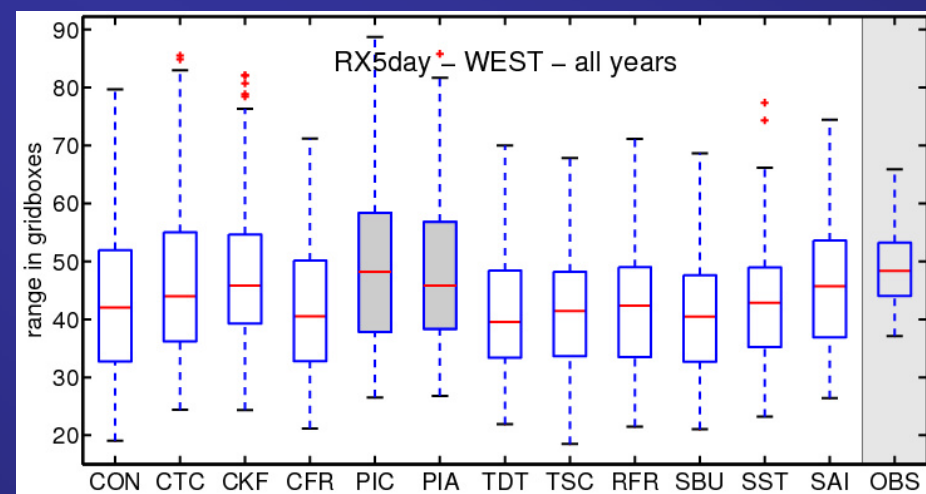
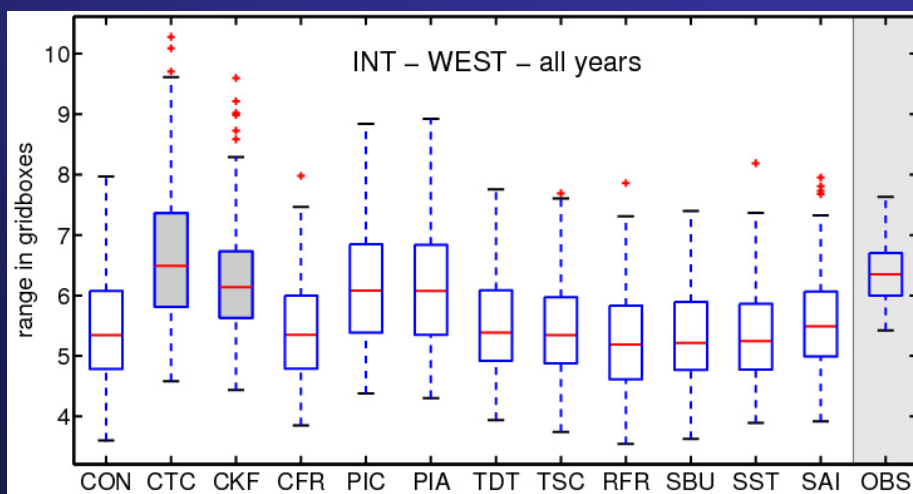
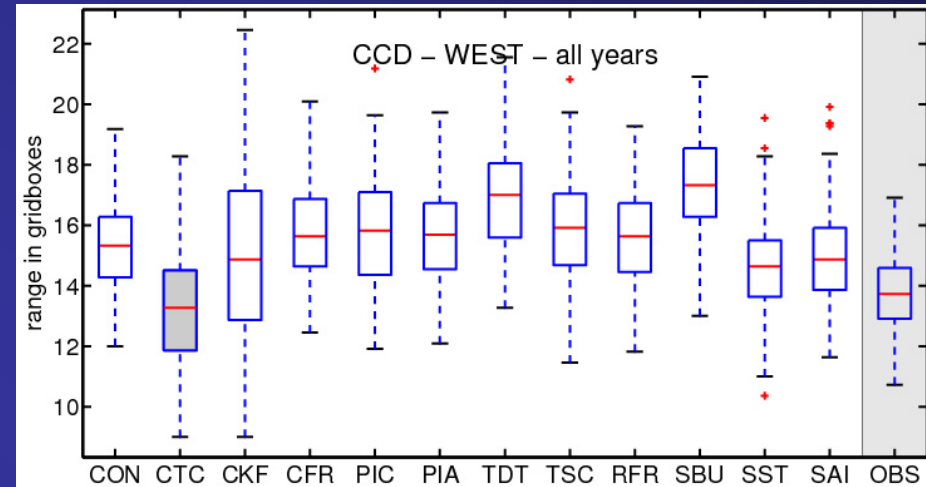
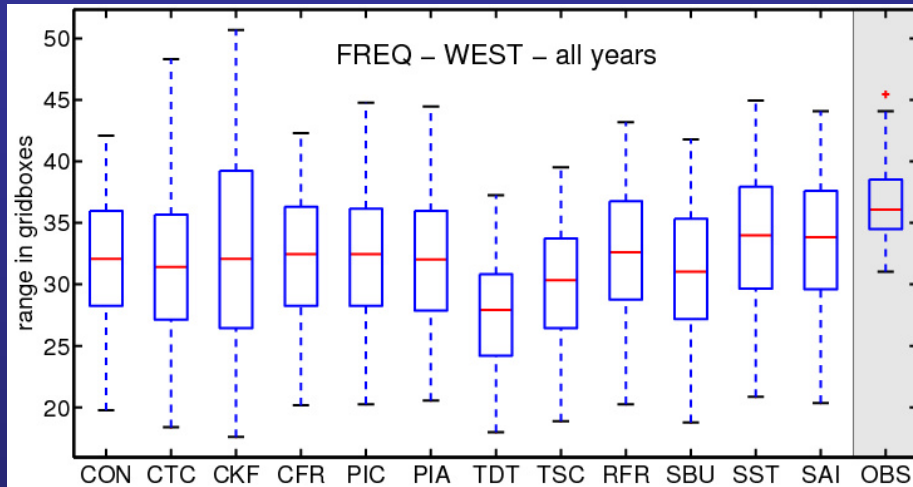
→ CON



↕ Range from grid boxes
● Domain average

x-axis: ensemble simulations

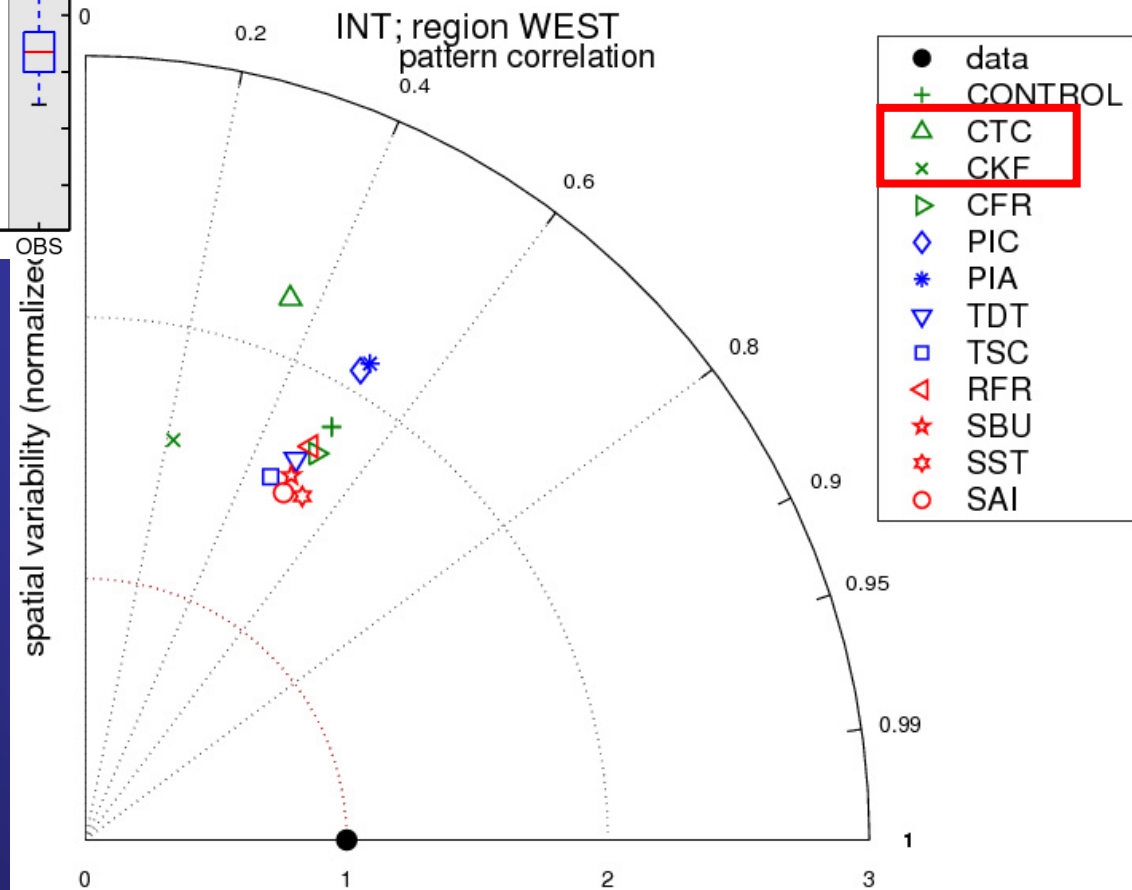
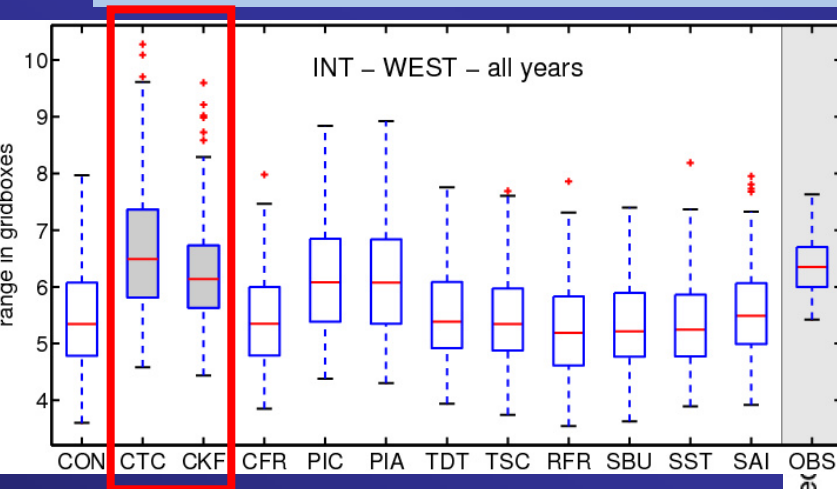
Variability in statistics



x-axis: ensemble simulations + OBS

shading: medians similar according to Wilcoxon test

...spatial structure



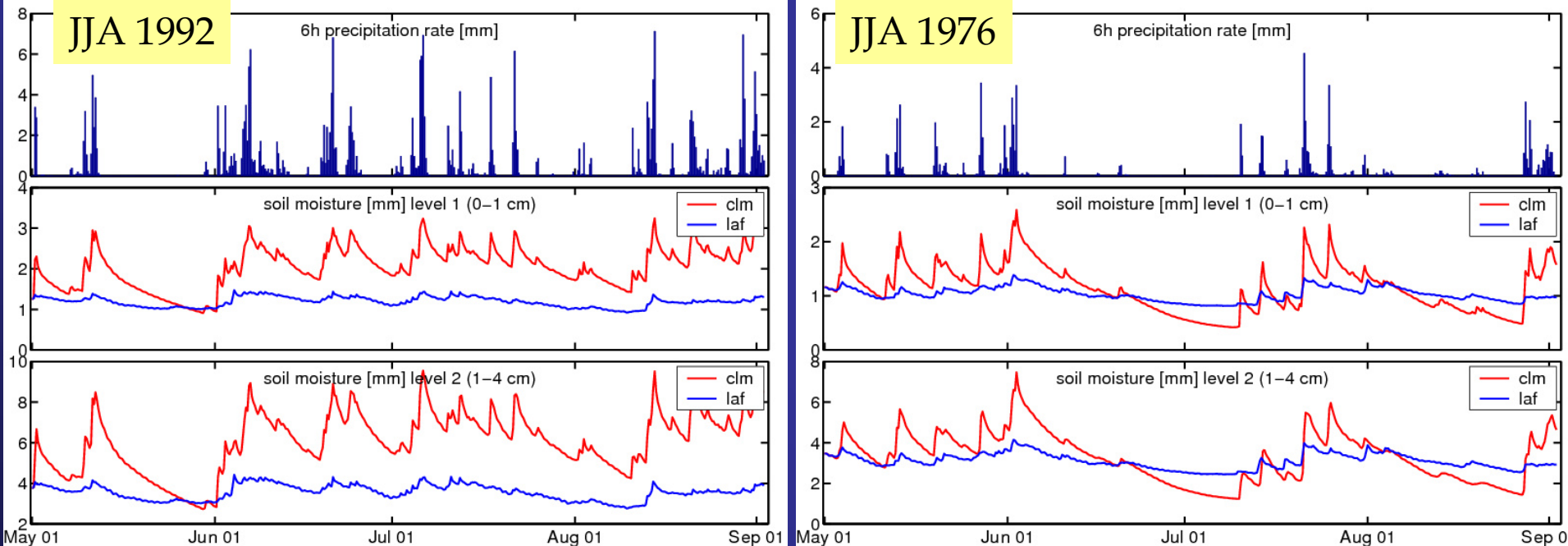
Other convection schemes:

- Mean values closer to observations,
- but higher spatial variability and lower correlation

Comparison CLM-ERA40: reaction of soil moisture

Time series, region WEST, domain average

— CLM
— ERA40 input



x-axis: time (whole simulation period, $\Delta t=6h$)

➤ CLM soil moisture reacts well to precipitation; much more variability than ERA40

Summary

- **CLM performance**: quite some differences on grid box level; e.g. already differences in summer total over Germany (also for other statistics in the regions, not shown); frequency distribution for all years ok
- Problems with **spatial structure** (mostly the spatial variability is overestimated)
- **Interannual variability** (not shown): very high
- **Uncertainty** in physical parameterizations:
 - visible especially for convection scheme (+ grid-scale precip, turbulence 1):
mean values better but spatial structure less good
 - small for radiation, soil, turbulence 2

...therefore...

Be careful when interpreting scenario simulations!!

- only possible for **larger regions** (~country) and averages over **several years** (>11)
- still **large errorbars** on statistics other than mean, so be very careful for rainfall extremes
- Large **uncertainty** especially for **convection parameterization**
(e.g. RMSD of daily values in some regions larger than climatological average or spatial standard deviation [cf. Temperature at lowest atm. level: only 1-2%])
→ consider **ensembles** (in one or several models)
(at least for convection, maybe also grid-scale precipitation)