Karlsruhe Institute of Technology

FONA Decadal Climate Prediction BMBF

MiKlip

Assessing the decadal predictability of West African monsoon precipitation in a multi-model RCM downscaling experiment

M. Warscher[1], H. Kunstmann[1], A. Paxian[2], H. Paeth[2], D. Sein[3], D. Jacob[4], M. Breil[5], H.J. Panitz[5], T. Engel[6], A. Fink[5], J. Tödter[7], B. Ahrens[7]

Karlsruhe Institute of Technology (KIT), Campus Alpin – Institute of Meteorology and Climate Research (IMK-IFU)

[1]**Karlsruhe Institute of Technology KIT, Institute of Meteorology and Climate Research IMK-IFU**, Garmisch-Partenkirchen, Germany.

[2]**University of Würzburg, Institute of Geography**, Würzburg, Germany.

[3]**Alfred Wegener Institute, Climate Sciences- Climate Dynamics**, Bremerhaven, Germany.

[4]**Max Planck Institute for Meteorology, Climate Service Center**, Hamburg, Germany.

[5]**Karlsruhe Institute of Technology KIT, Institute of Meteorology and Climate Research IMK-TRO**, Karlsruhe, Germany.

[6]**University of Cologne, Institute for Geophysics and Meteorology**, Cologne, Germany.

[7]**University of Frankfurt, Institute for Atmospheric and Environmental Sciences**, Frankfurt, Germany.

Outline

- **Introduction**
  - Motivation
  - Projects MiKlip and DEPARTURE
- **Methods**
  - Global prediction system
  - Regional Ensemble Generation
  - RCM Experiments
- **Results**
  - Bias (ITCZ, SST, WAM rainfall)
  - Skills Decadal Predictability
- **Conclusion**

Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Motivation

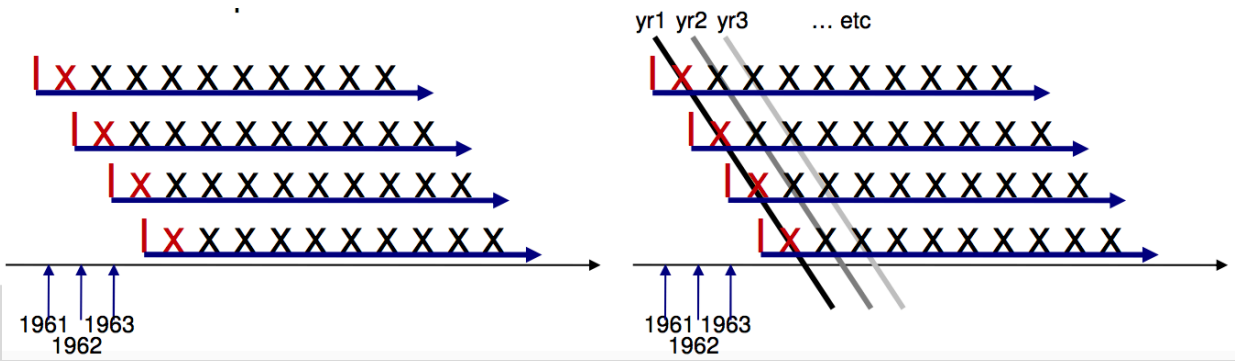
- West Africa: decadal timescale and monsoon precipitation are highly relevant for the region
- Monsoon precipitation is a promising candidate for decadal predictability
- Project **MiKlip** (BMBF, Federal Ministry of Education and Research, Germany), http://www.fona-miklip.de/, dedicated to decadal predictions
- Regionalization: Focus on Europe and **Africa** (**DEPARTURE** - Decadal Prediction of African Rainfall and Atlantic Hurricane Activity)

Global Decadal Prediction

- **Global Decadal Prediction System MiKlip**
- MPI-ESM-LR (CMIP5-version)

- Assimilation of 3D ocean temperature and salinity anomalies from ECMWF NEMOVAR plus wind, temperature and pressure from ERA40 / ERA-Interim into the coupled model **-> “best” initial conditions**

- Yearly initialised **retrospective decadal predictions 1961-2012**
  - start yearly, let model run free for 10 years (decadal simulation)
  - x10 ensemble members for each run (disturbed initial conditions)

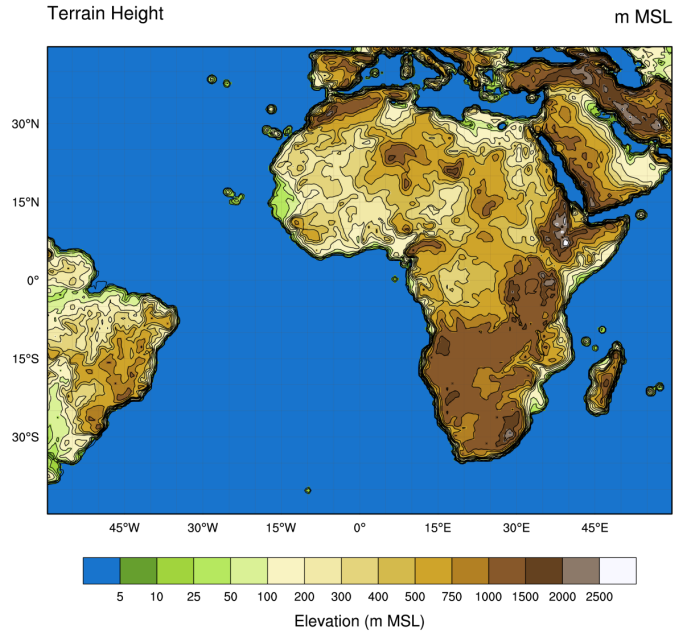


RCM Ensemble

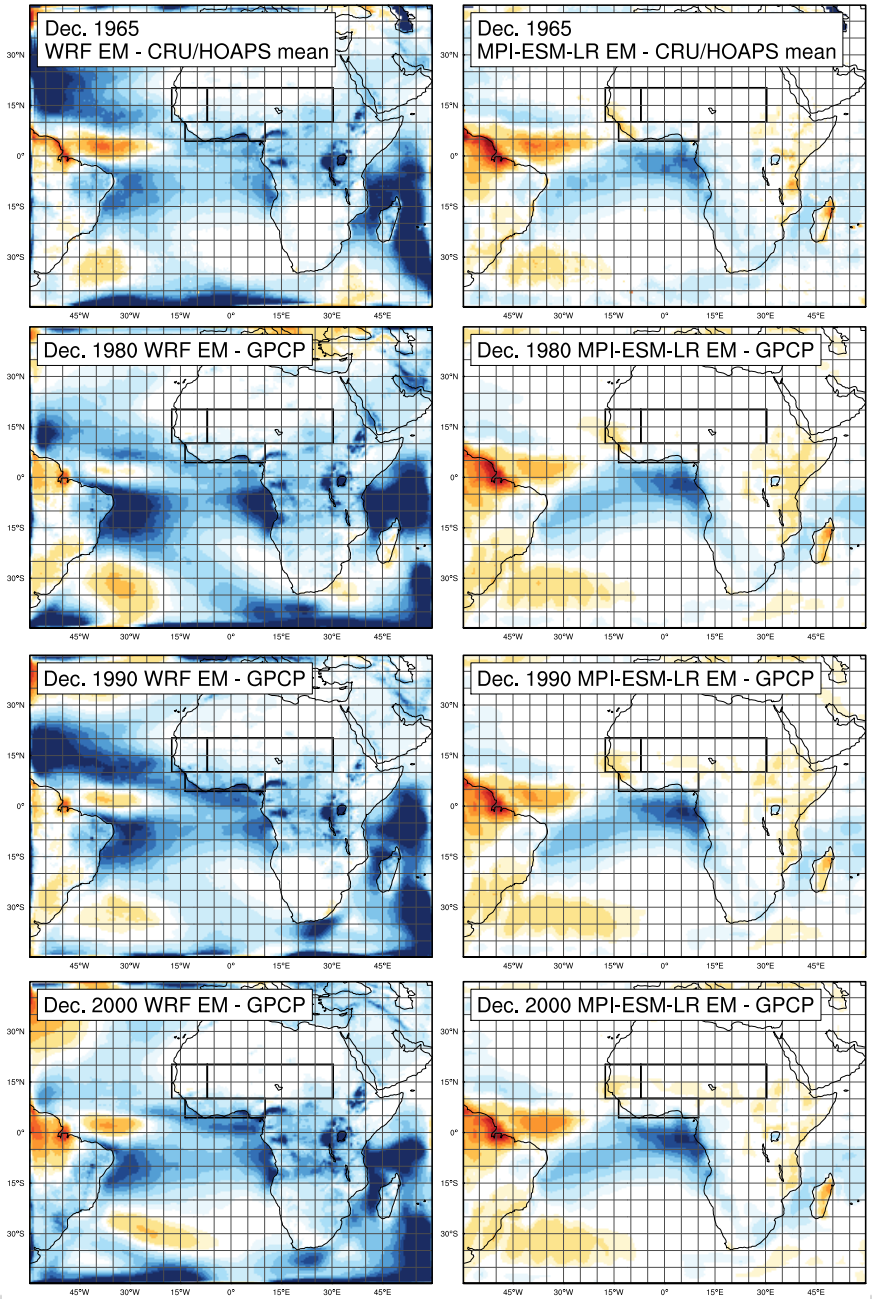
- **3 RCMs in different versions**
- CCLM REMO WRF (0.44°)

- **4 decades, 3 ensemble members**
  - 1966-1975 1981-1990 1991-2000 2001-2010
  - 3 members (best / worst / middle realisation based on evaluation of SSTs)

- **Many experiments**
  - Boundary conditions (aerosols, landuse)
  - Alternative SVAT (Veg3D)
  - Coupling to regional ocean model
  - SST bias correction
  - Model configuration
  - Soil initialisation
  - Spin-up procedures



Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology



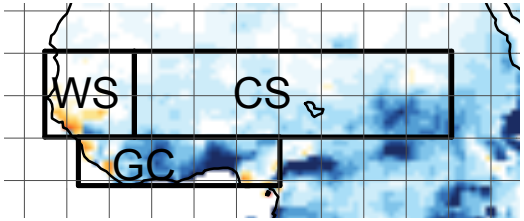
FONA Decadal Climate Prediction BMBF

MiKlip

KIT Karlsruhe Institute of Technology

West Sahel WS

Central Sahel CS

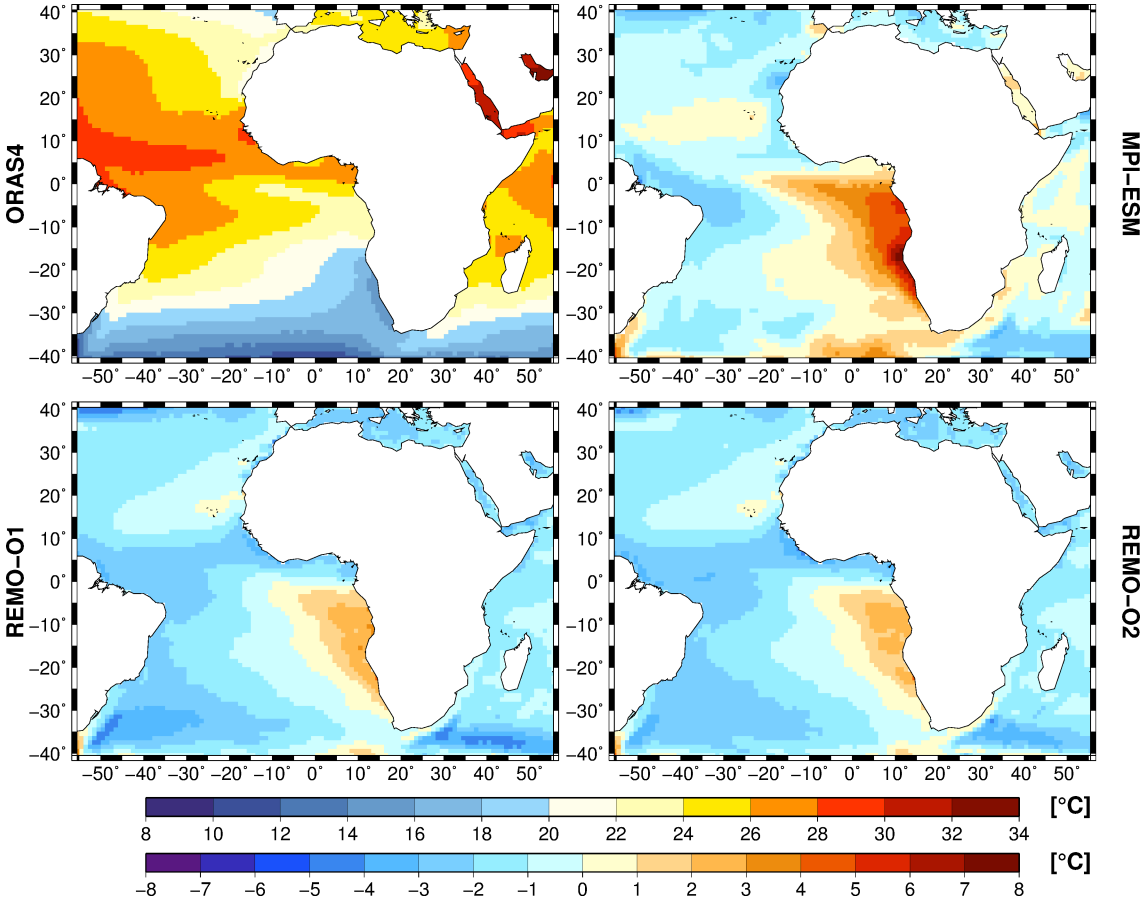


Guinea Coast GC

Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

SST Bias

Observed and modeled SST during JJAS season (decade 2001-2010)



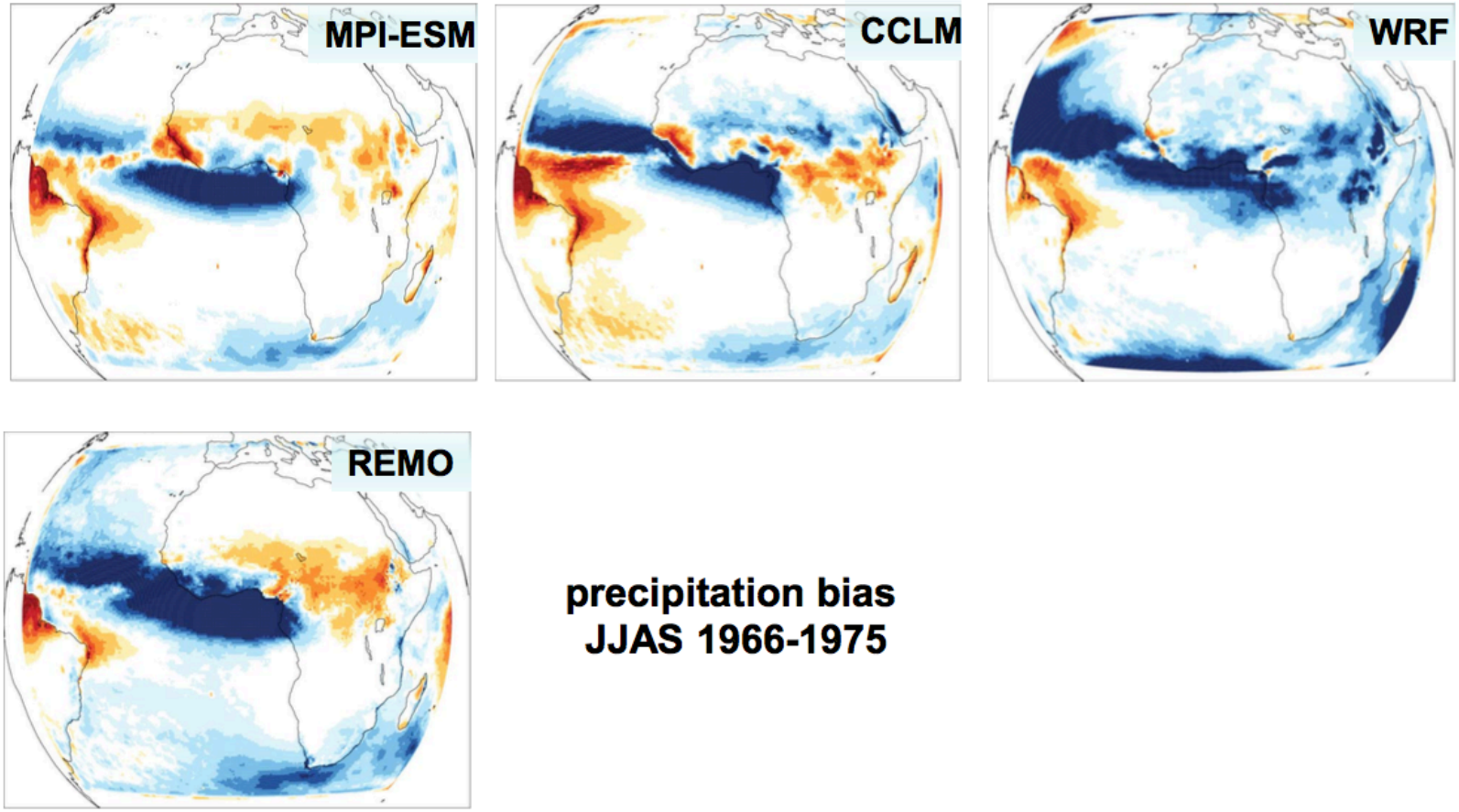
“Biased” SST from GCM

RCM coupled to ocean model (D. Sein)

→ SST modeled in high RCM resolution

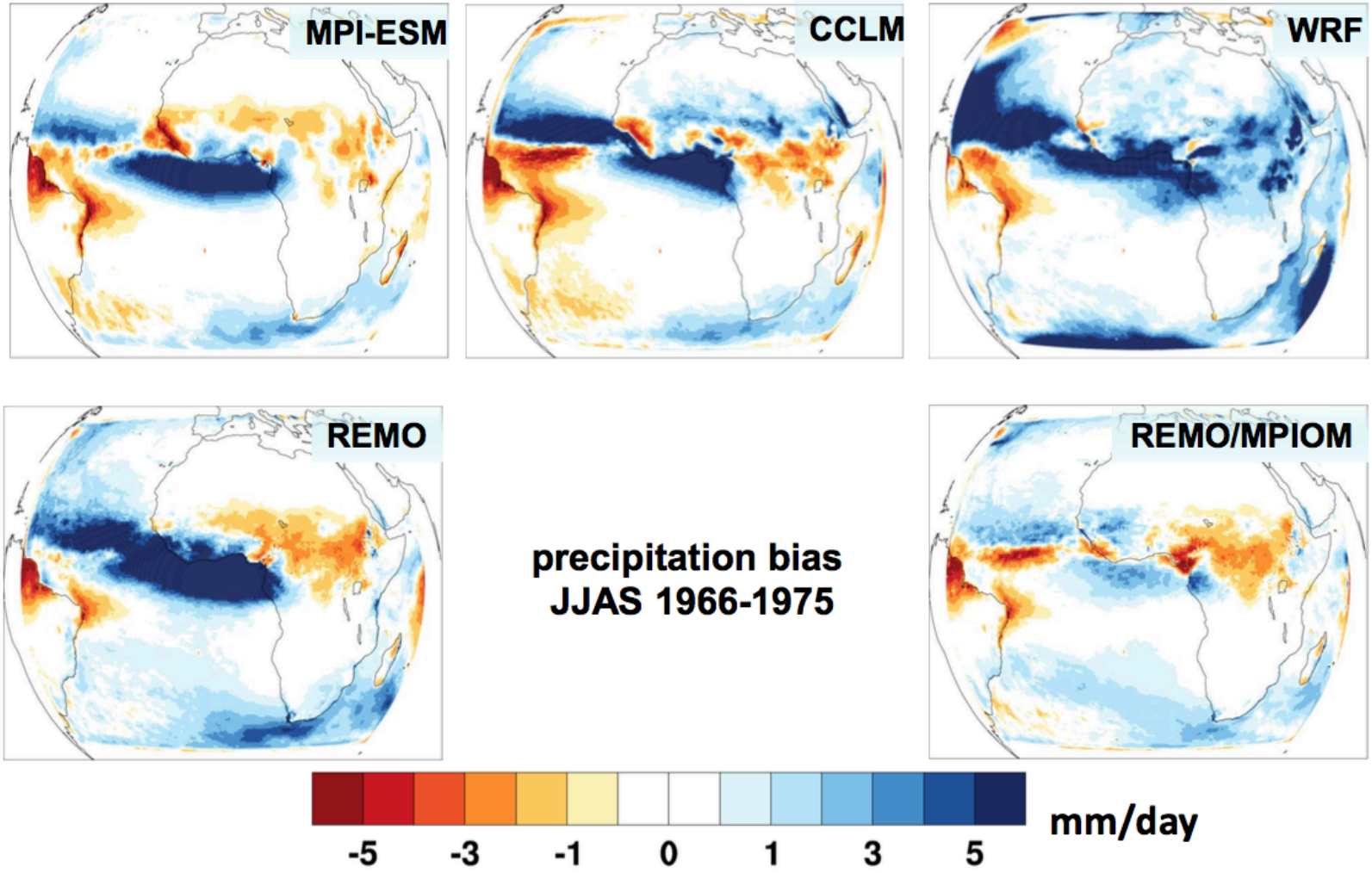
Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

WAM Rainfall Bias



Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

WAM Rainfall Bias

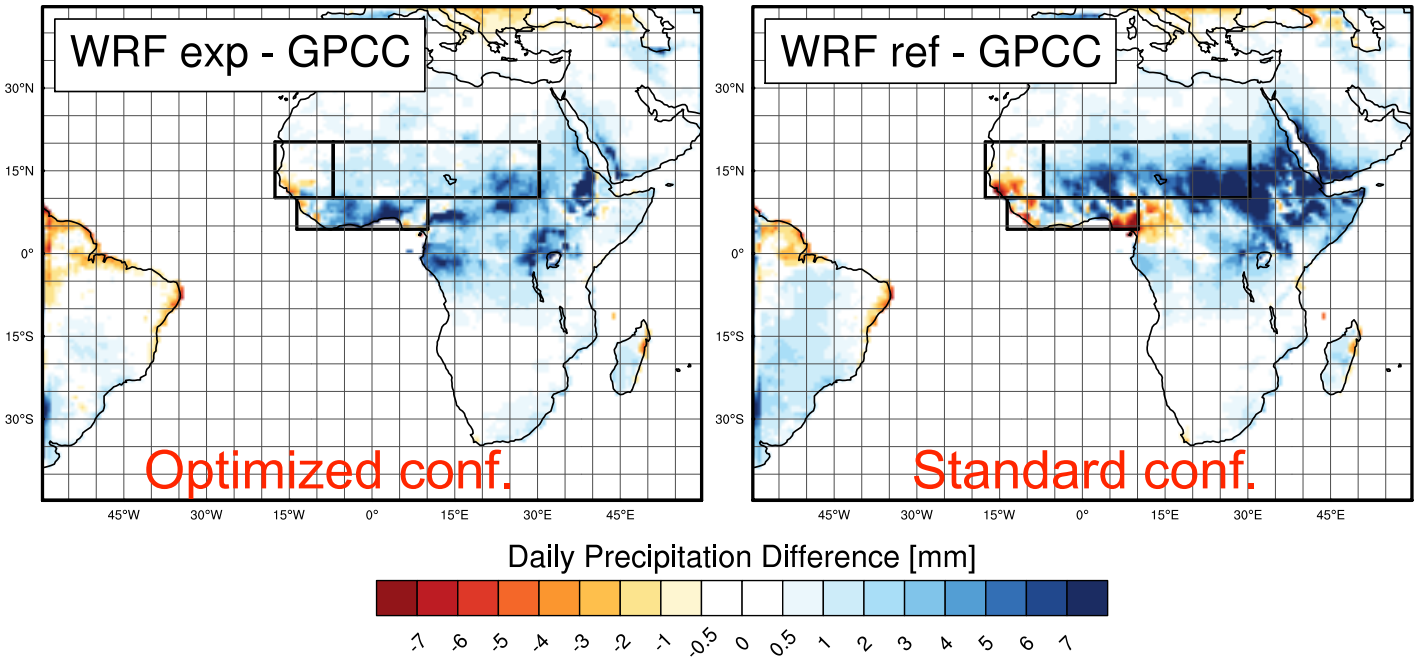


Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

WAM Rainfall Bias

WRF model physics

JJAS Precipitation 1966-1975 - R5



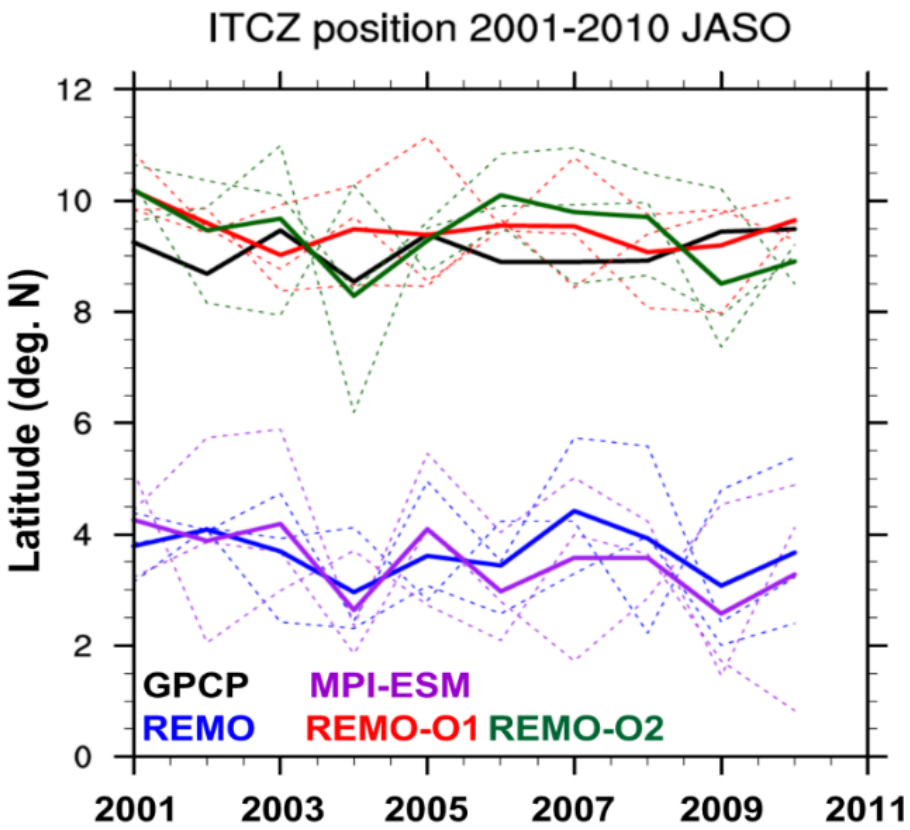
Best choice of
- cumulus parameterization
- planetary boundary layer scheme
- microphysics scheme

WRF ref (old): CU - KF / PBL - YSU / MP - WSM5

WRF exp (new): CU - BMJ / PBL - ACM2 / MP - TH

Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Bias ITCZ Position



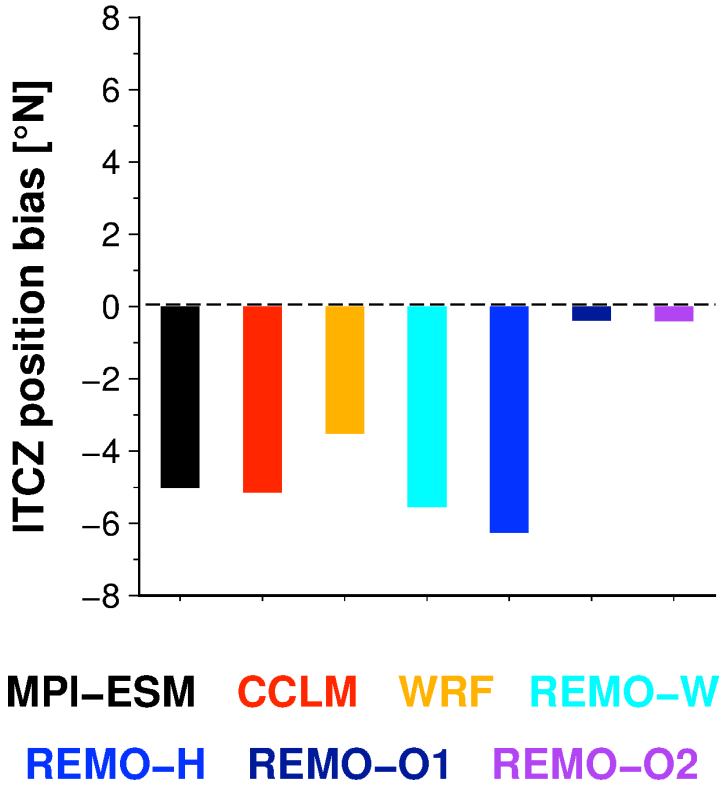
Observations & coupled REMO

MPI-ESM & uncoupled REMO

Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Bias ITCZ Position

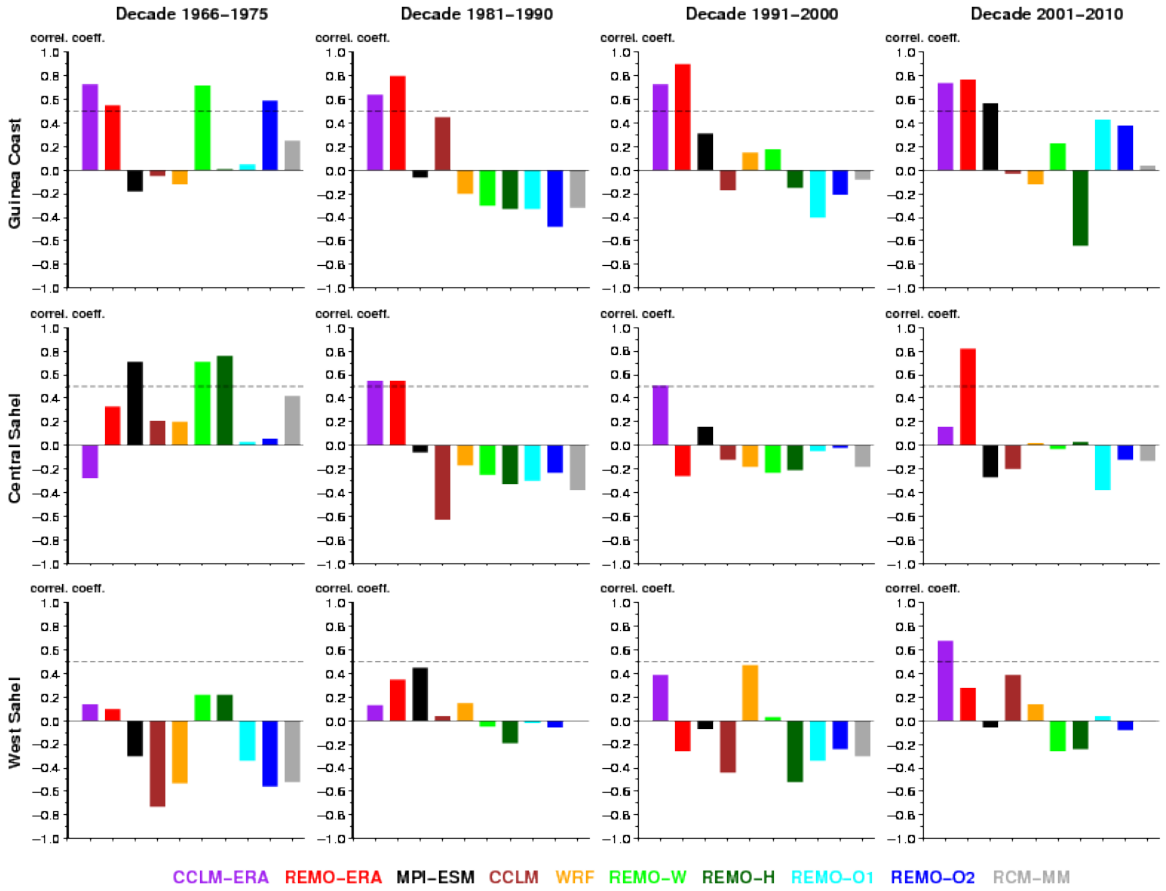
ITCZ position from GCM and RCM ensemble means compared to GPCP, Decade 2001 – 2010 JJAS

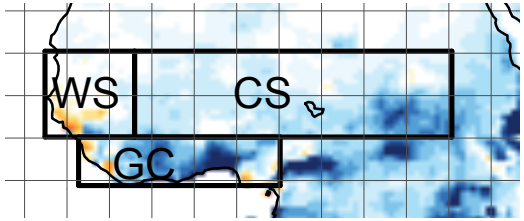


Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Decadal Predictability

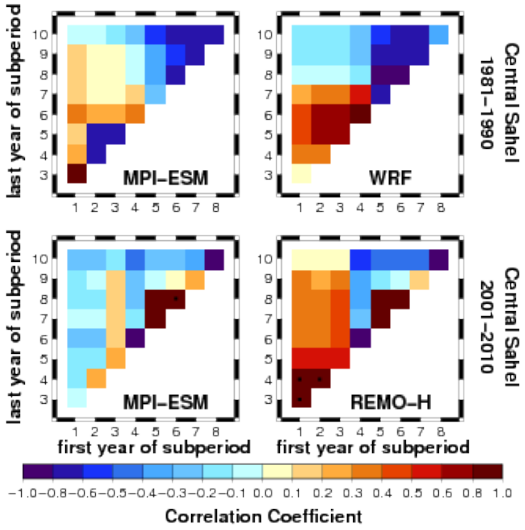
Correlation coefficients JJAS precipitation compared to DEL (Willmott-Matsuura)

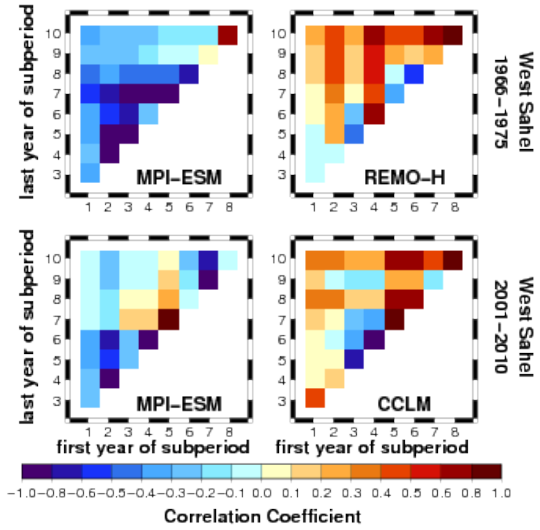


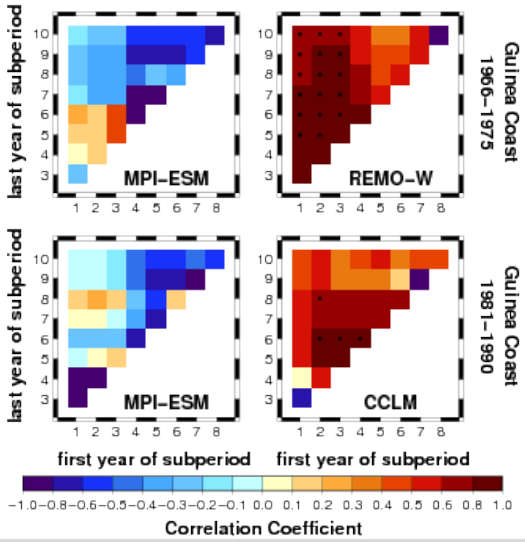


Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

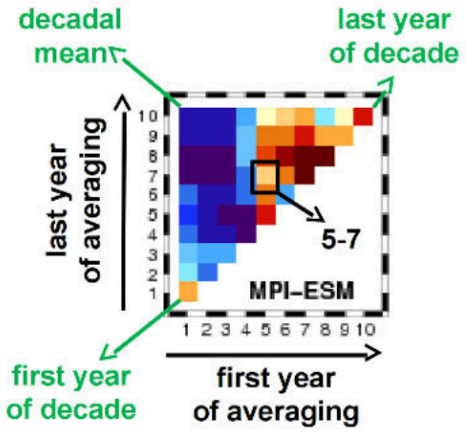
Decadal Predictability







Added value of RCMs



Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

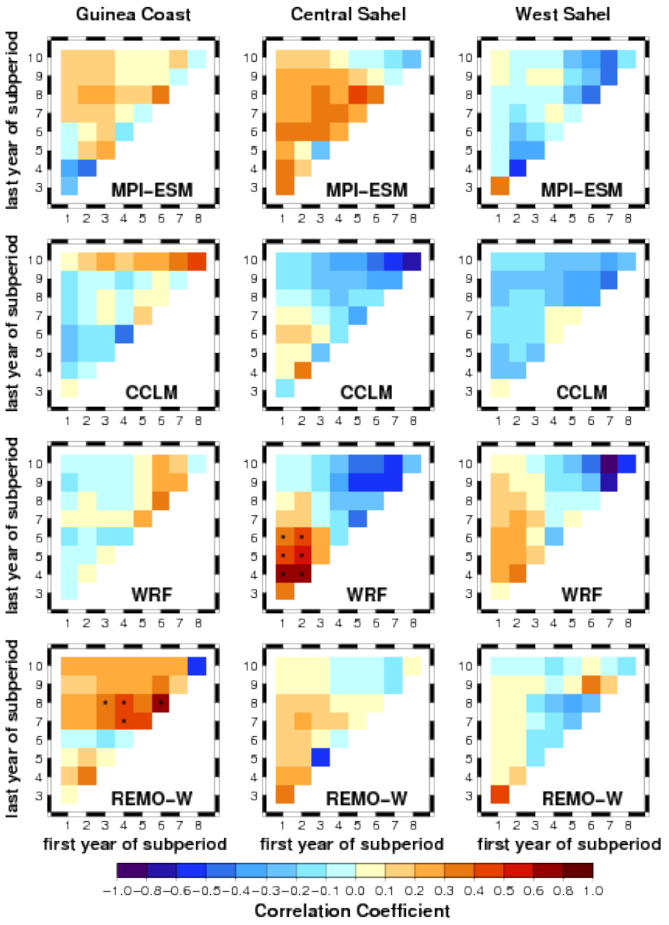
Decadal Predictability

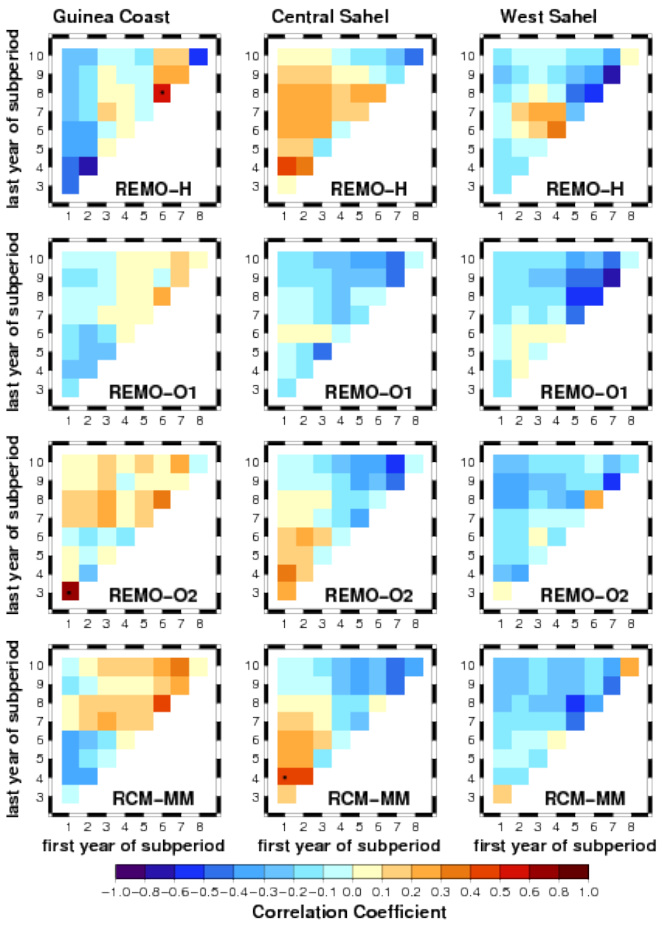
FONA Decadal Climate Prediction BMBF

MiKlip

KIT Karlsruhe Institute of Technology

Prediction skill: all models, regions and decades

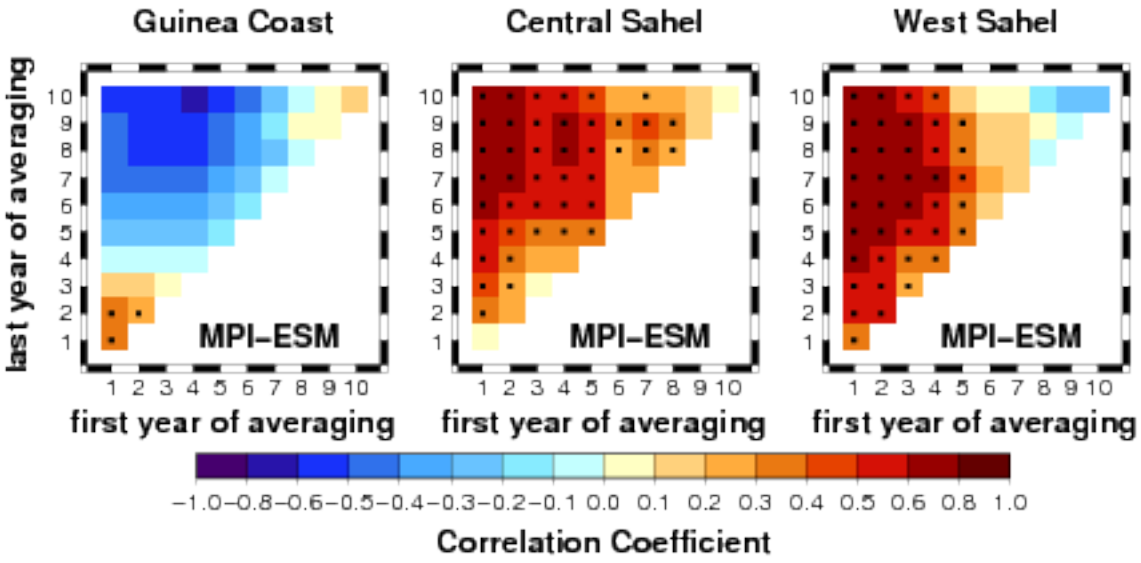




Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Decadal Predictability

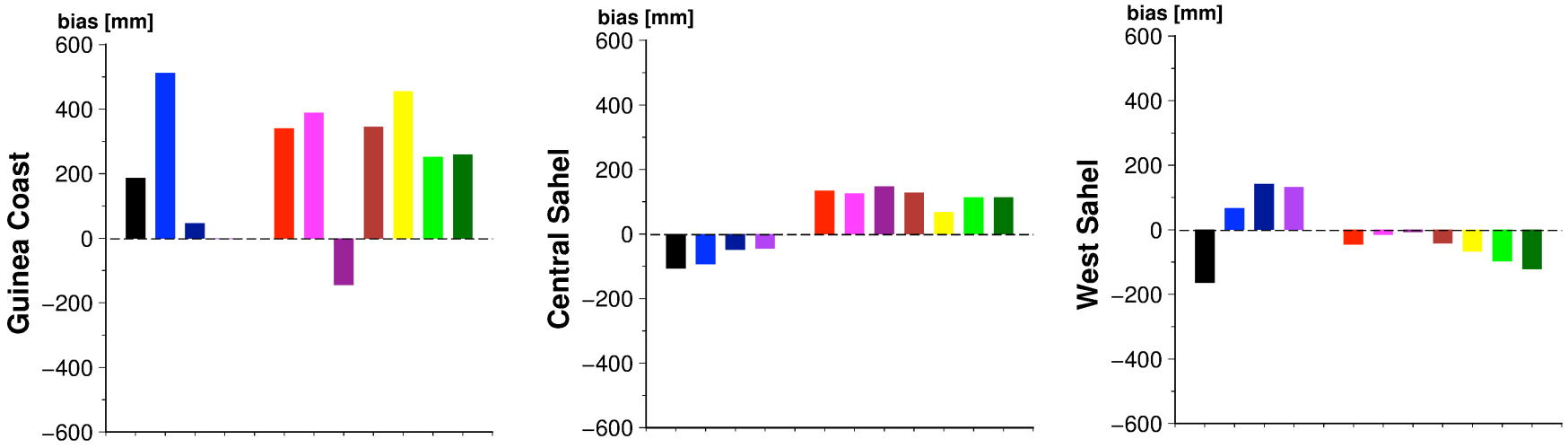
Performance of the global system, correlations from decade to decade based on 41 decades (1961 – 2001, starting each year) and 10 ensemble members for each decade (**410 decadal hindcasts**)



Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Boundary Conditions

RCM sensitivity to different boundary conditions / experiments
JJAS precipitation bias 2001-2010 compared to DEL



AOD: slightly positive effects
SST: positive effects almost everywhere
SOIL INIT.: almost no effects

CCLM-VEG: positive in CS, negative in GC
CCLM LUC and LUV: positive in GC, negative in WS

Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Conclusion

- RCMs have been further developed and adjusted for decadal predictions for Africa
- Bias reduction (SST, ITCZ position and WAM rainfall)
- Sensitivities to boundary conditions and model complexity relevant for decadal predictability
- Predictability: Skill and added value of RCMs
- MiKlip Database: an unprecedented database has been established for decadal climate simulations (global and regional)

Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Outlook and Publications

- Outlook
  - Application of boundary conditions (AOD, LCC) to ensemble runs
  - Further systematical assessment of RCM skill and bias
  - Transfer to a best RCM approach for decadal climate prediction

- Publications
  - Paeth et al..: *Decadal predictability of the West African monsoon and the added value of dynamical downscaling*, Climate Dynamics (submitted), 2015.
  - Paxian et al.: *Bias reduction in decadal predictions of West African monsoon rainfall,* in prep.
  - www.fona-miklip.de/en

Decadal Predictability

WRF JJAS precipitation: correlation coefficients for different observation datasets

Region 1, **West Sahel**						
		GPCC	**GPCP**	**CRU**	**DEL**	**TRMM**
Dec. 2000	**MPI a**	0.062	0.033	0.332	0.027	0.145
	MPI b	-0.224	0.033	0.056	-0.135	-0.307
	MPI EM	-0.060	-0.149	0.231	-0.043	-0.044
	WRF a	0.034	0.050	0.434	-0.108	0.126
	WRF b	0.357	0.193	0.338	0.318	0.156
	WRF EM	0.179	0.122	0.440	0.048	0.168

GCM

RCM

Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Decadal Predictability

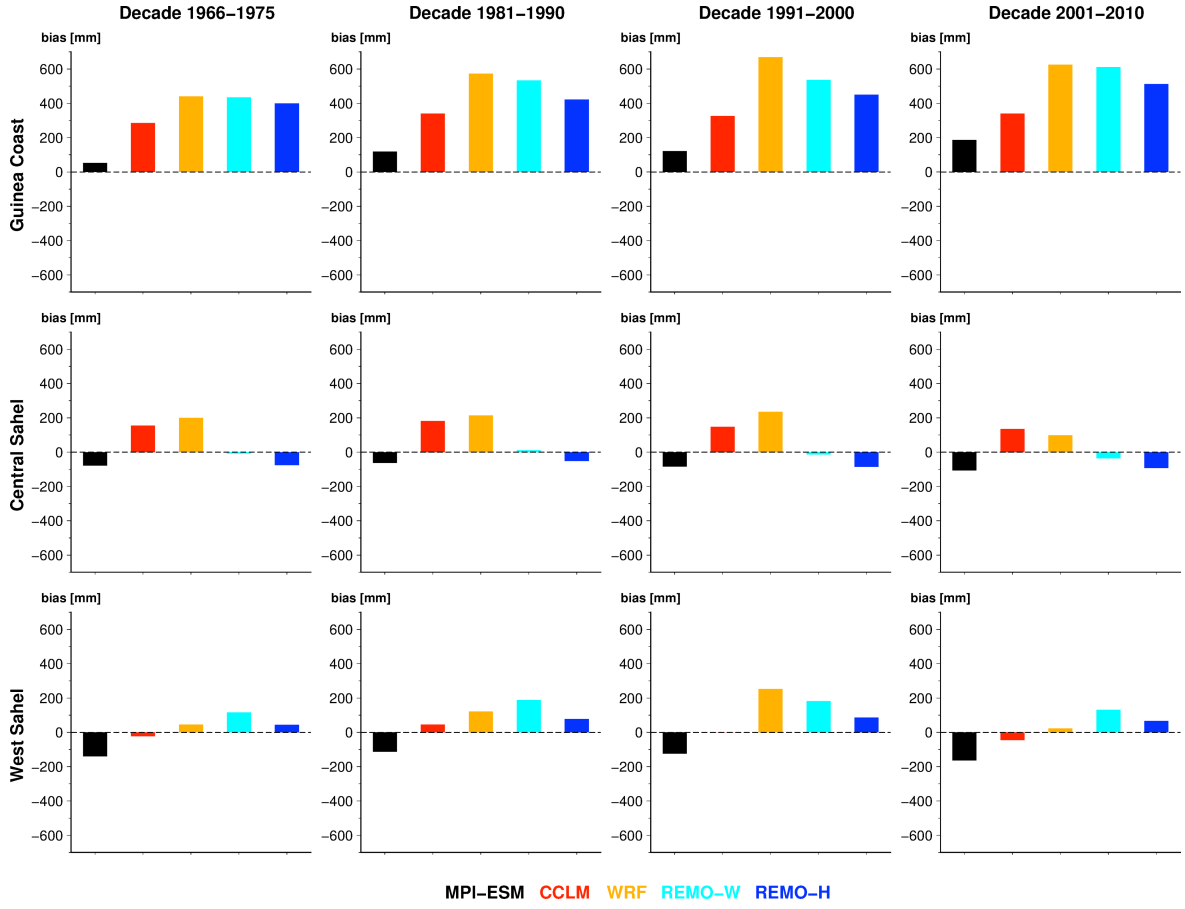
WRF JJAS precipitation: correlation coefficients for different observation datasets

Region 1, **West Sahel**							
		GPCC	**GPCP**	**CRU**	**DEL**	**TRMM**	
Dec. 2000	**MPI a**	0.062	0.033	0.332	0.027	0.145	GCM
	MPI b	-0.224	0.033	0.056	-0.135	-0.307	
	MPI EM	-0.060	-0.149	0.231	-0.043	-0.044	
	WRF a	0.034	0.050	0.434	-0.108	0.126	RCM
	WRF b	0.357	0.193	0.338	0.318	0.156	
	WRF EM	0.179	0.122	0.440	0.048	0.168	
Region 3, **Guinea Coast**							
		GPCC	**GPCP**	**CRU**	**DEL**	**TRMM**	
Dec. 1980	**MPI a**	0.497	0.421	0.363	0.454	-	GCM
	MPI b	0.026	0.421	-0.137	-0.028	-	
	MPI EM	0.316	0.204	0.153	0.263	-	
	WRF a	-0.417	-0.397	-0.382	-0.464	-	RCM
	WRF b	0.159	0.164	0.166	0.193	-	
	WRF EM	-0.237	-0.209	-0.190	-0.242	-	

Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

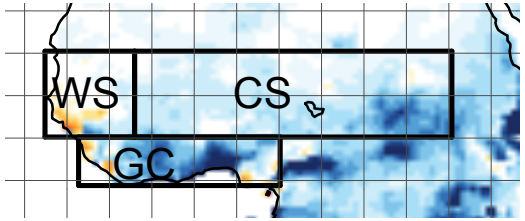
WAM Rainfall Bias

JJAS precipitation from ensemble means compared to observations (DEL, Willmott-Matsuura)



West Sahel WS

Central Sahel CS

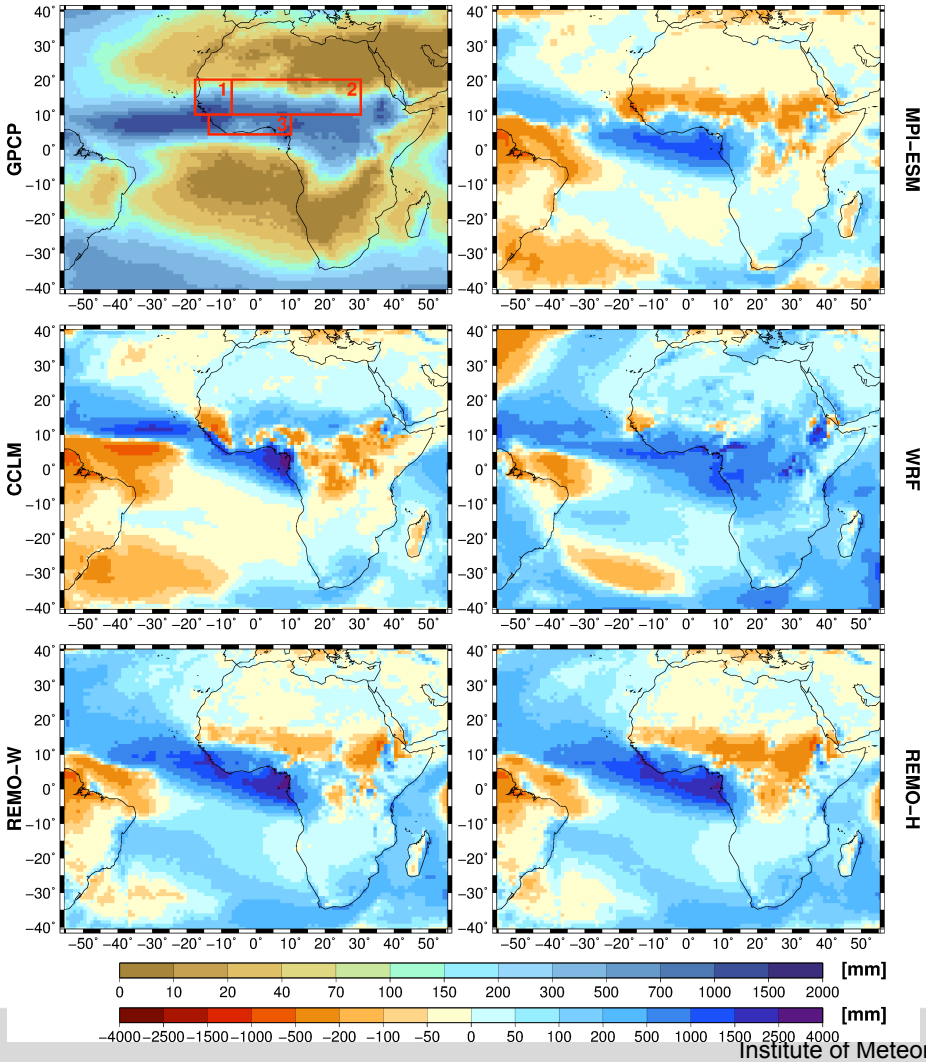


Guinea Coast GC

Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

WAM Rainfall Bias

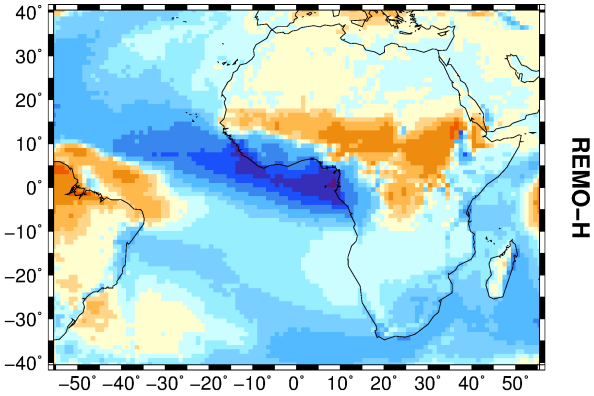
Precipitation compared to GPCP JJAS 2001-2010



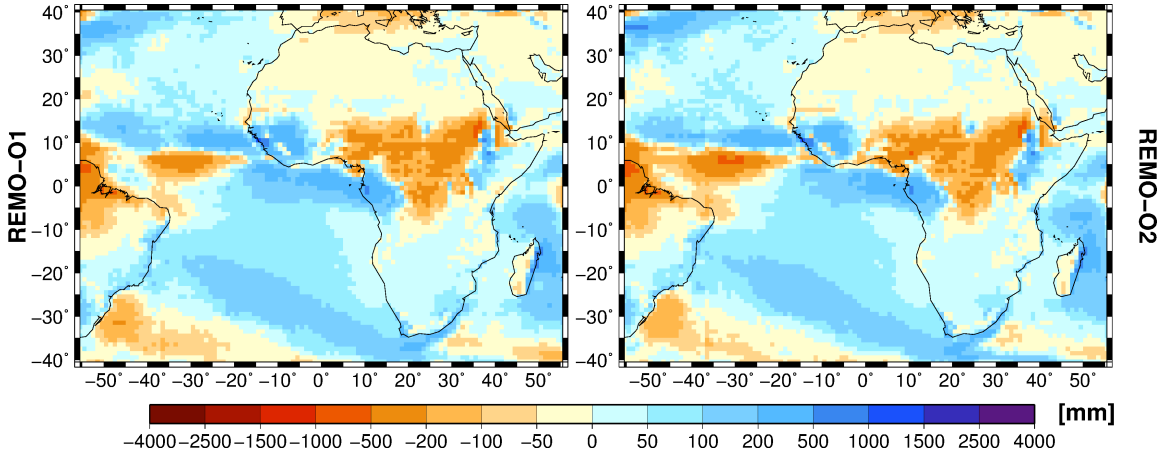
Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

SST and WAM Rainfall Bias

RCM precipitation compared to GPCP JJAS 2001-2010



“Biased” SST from GCM as boundary condition

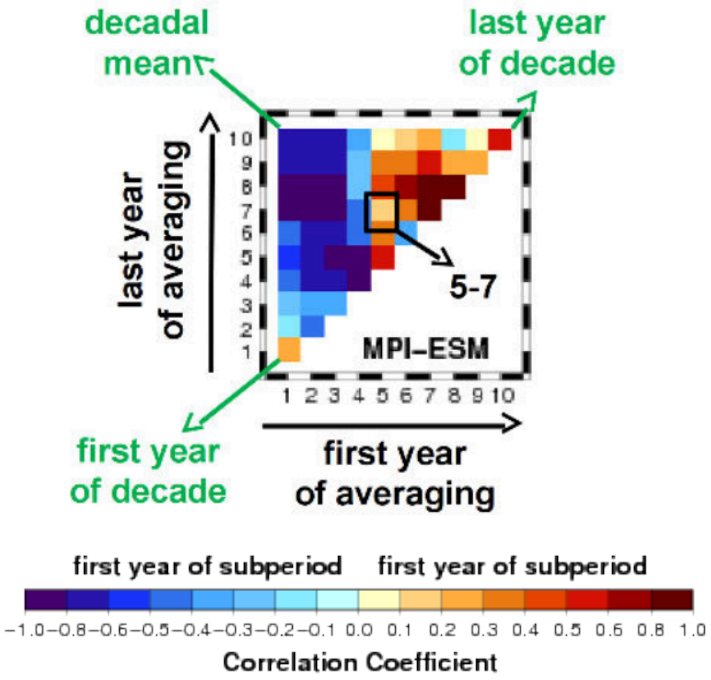


RCM coupled to GCM ocean model

→ SST modeled in high RCM resolution

Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Decadal Predictability



Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

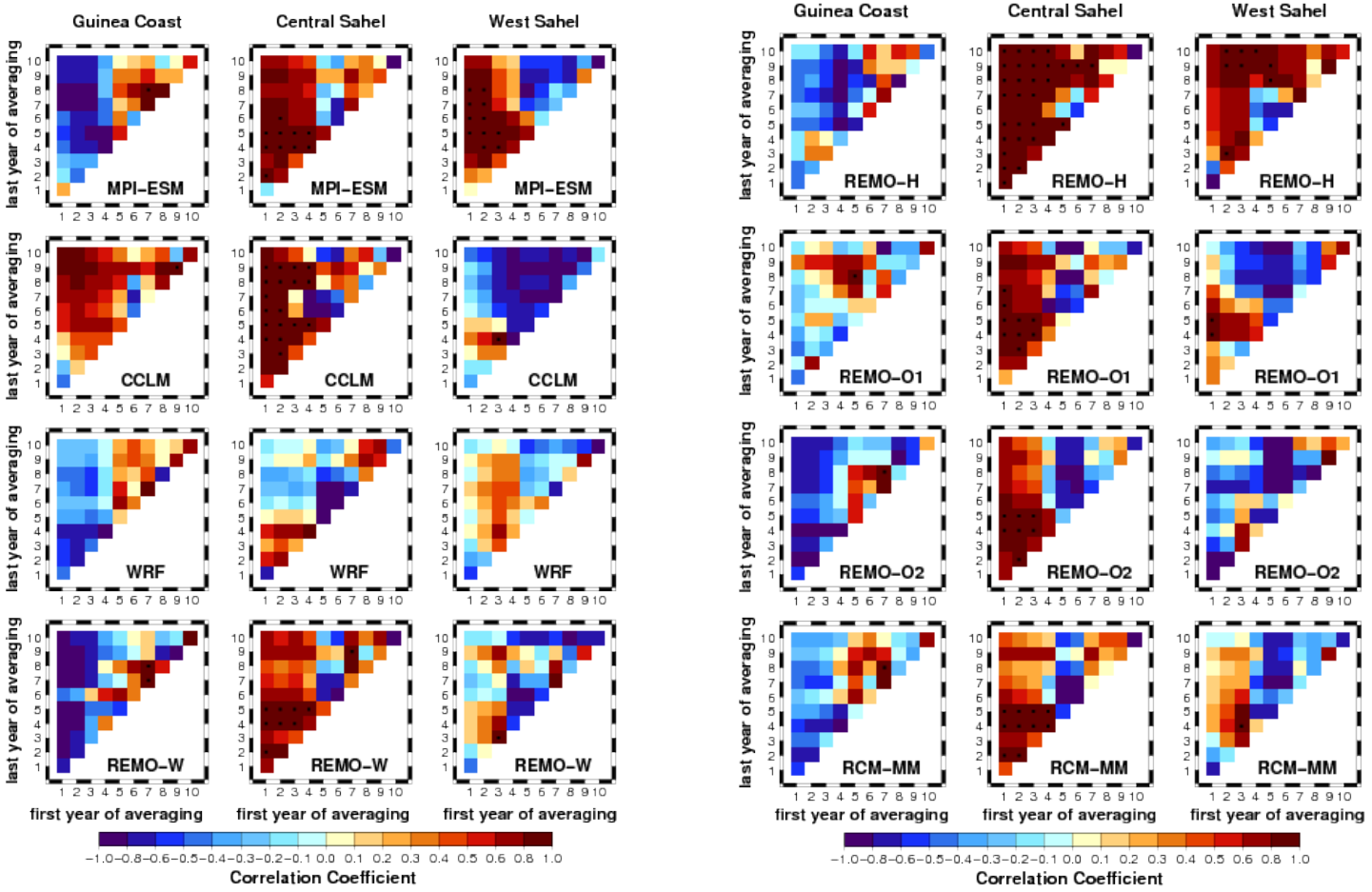
Decadal Predictability

FONA Decadal Climate Prediction BMBF

MiKlip

KIT Karlsruhe Institute of Technology

Correlation coefficients from decade to decade

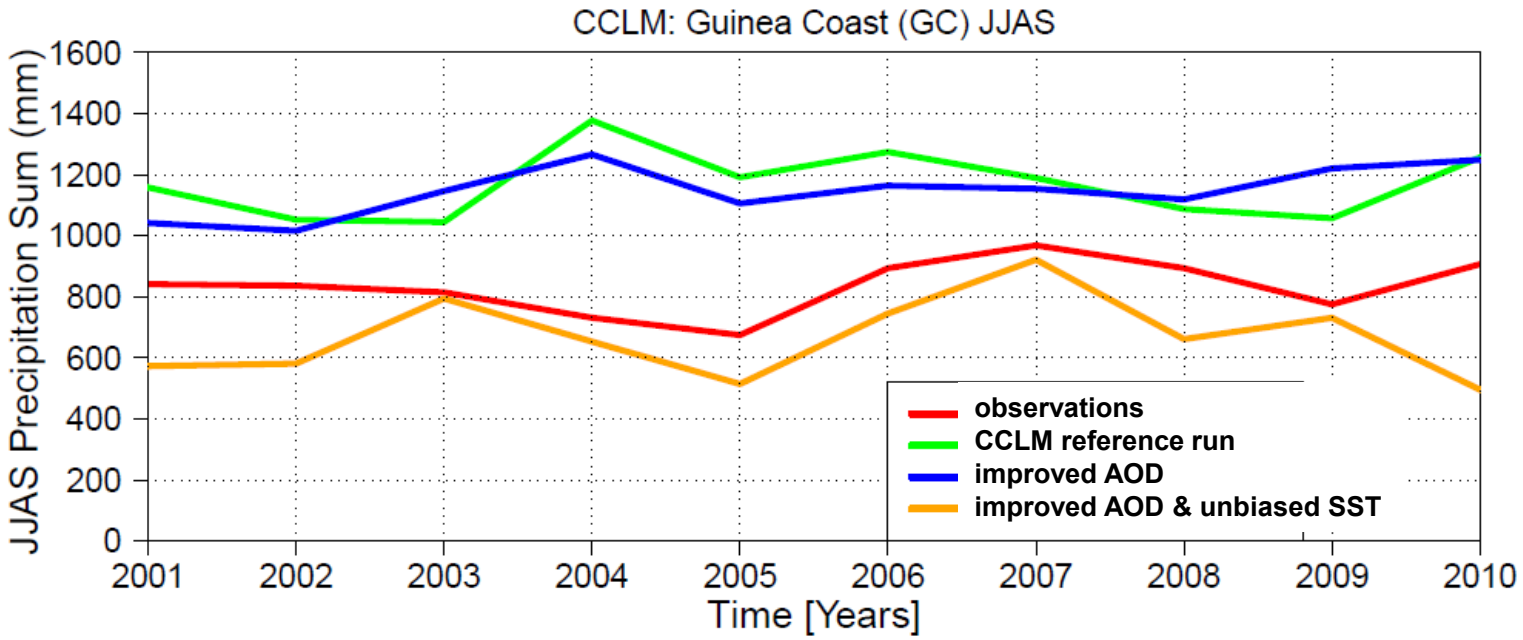


Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Boundary Conditions

Aerosols

WAM precipitation: effect of improved AOD



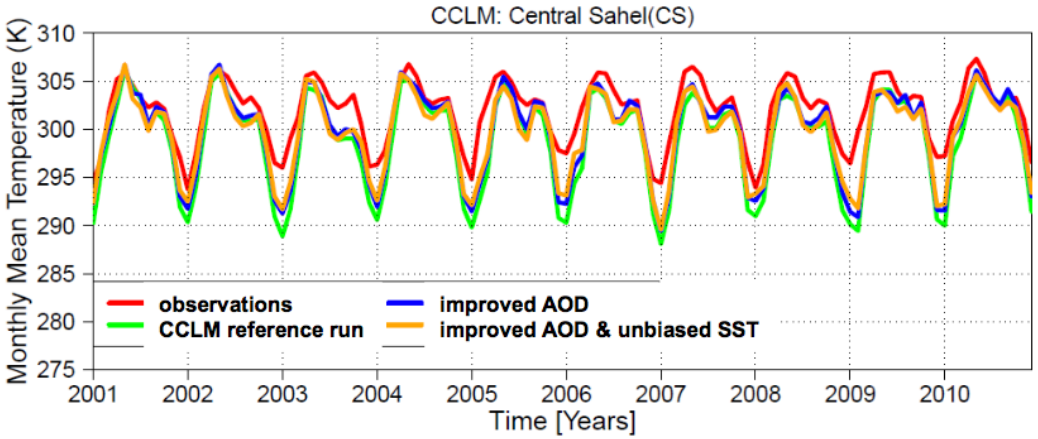
aerosol optical depth from Kinne (annual cycle) instead of Tanré (stationary pattern)

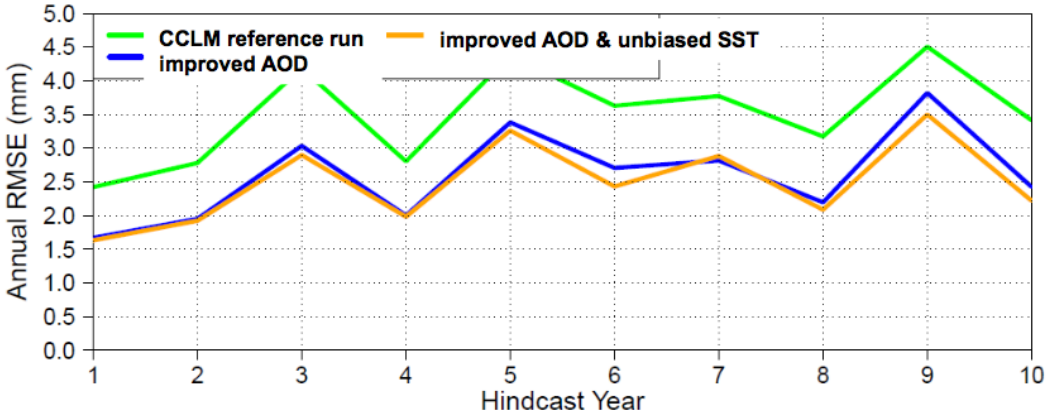
Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology

Boundary Conditions

Aerosols

WAM precipitation: effect of improved AOD





Institute of Meteorology and Climate Research
Karlsruhe Institute of Technology