Karlsruhe Institute of Technology

Towards a climate modeling system for West Africa

Sensitivity studies and input bias correction for WRF

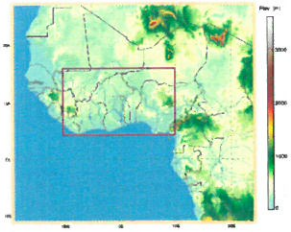
INSTITUTE OF METEOROLOGY AND CLIMATE RESEARCH, ATMOSPHERIC ENVIRONMENTAL RESEARCH (IMK-IFU)
Regional Climate Systems/Regional Climate and Hydrology
KIT-Campus Alpin

15th Annual WRF Users' Workshop, Boulder, 26th June 2014

Dominikus Heinzeller, Cornelia Klein and Harald Kunstmann

KIT – University of the State of Baden-Württemberg and
National Research Center of the Helmholtz Association

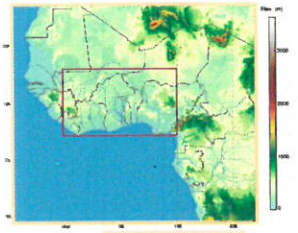
WRF sensitivity study for West Africa (C. Klein)



Forcing Data	ERA-Interim
Resolution	24km
Time period	Mar-Oct 1999 /2002
Vert. Layers	36 / 10 hPa
Spin-Up	1 month
External SST	NCDC, daily
Other Options	SST/LAI/ALB update Adjusted lake T MODIS Landcover
Non-varying physics	Noah LSM Dudhia SW RRTM LW

Evaluation of 55 WRF configurations using ERA-Interim re-analysis and MPI-ESM (Echam6) as forcing data

WRF sensitivity study for West Africa (C. Klein)



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27 WRF configurations
+ Noble et al. 2013 (ACM2/GD/WSM5)
+ Default NCAR 2013 (YSU/KF/WSM6)

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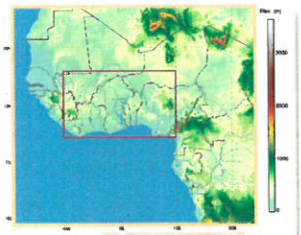

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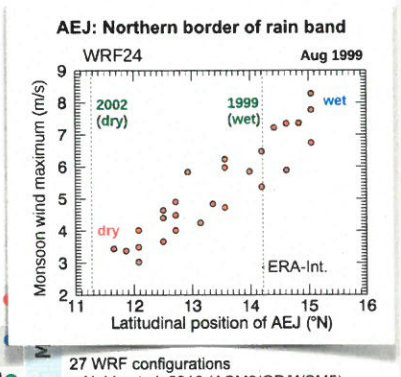

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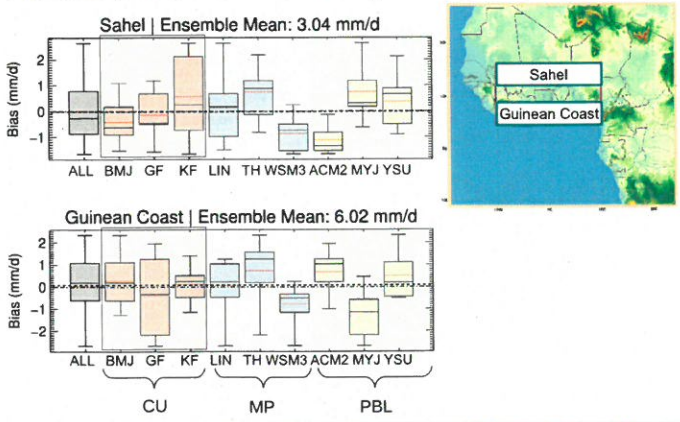
Seasonal precipitation sensitivity



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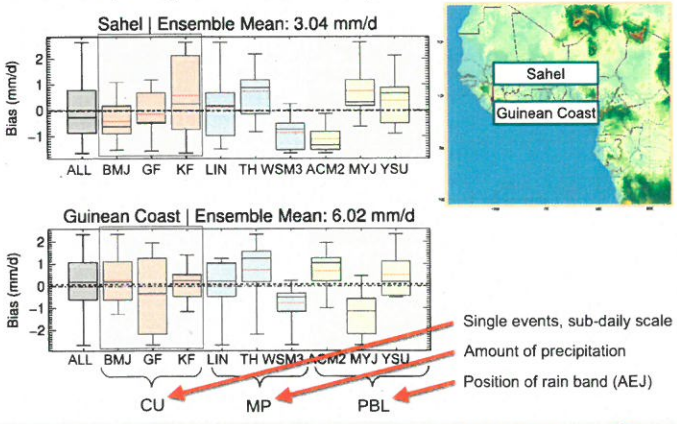
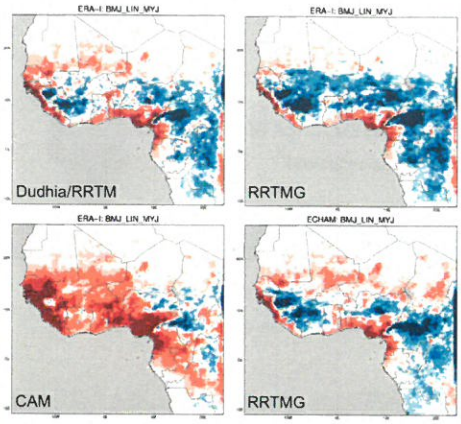
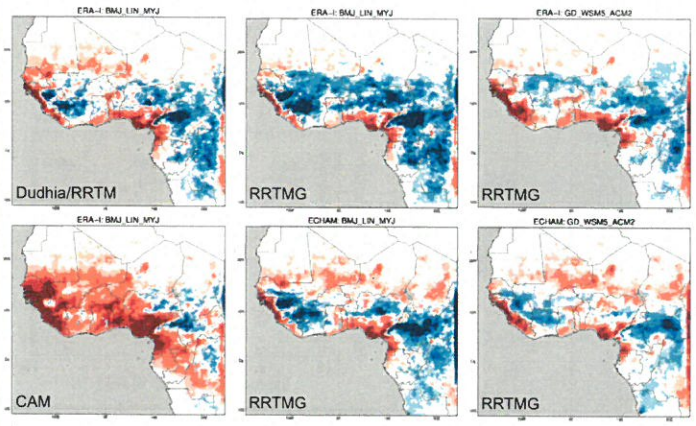


From control runs to regional climate projections

Candidate configurations from ERA-Interim runs → Replace LW/SW radiation with CAM and RRTMG → Force with ERA-Interim and MPI-ESM (Echam6)



Average precipitation bias [mm/day] for July-September 1999 wrt. TRMM



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Bias correction of forcing GCM data

> On two occasions I have been asked, "Pray, Mr. Babbage, if you put into the machine wrong figures, will the right answers come out?" ... I am not able rightly to apprehend the kind of confusion of ideas that could provoke such a question.
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> Charles Babbage, *Passages from the Life of a Philosopher*

GCM (MPI-ESM) → RCM (WRF) → Model output

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Bias correction of GCM data at the domain boundary

GCM vs re-analysis

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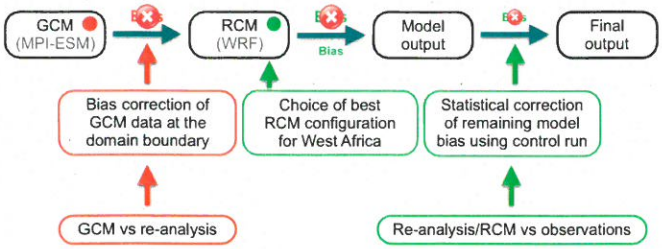
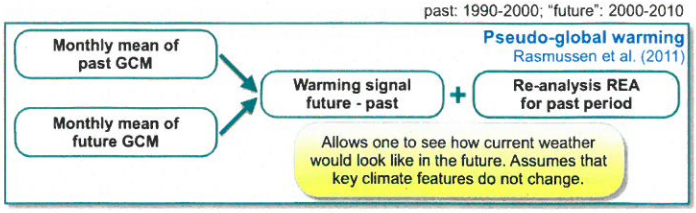


Two concurring bias correction algorithms

past: 1990-2000; "future": 2000-2010



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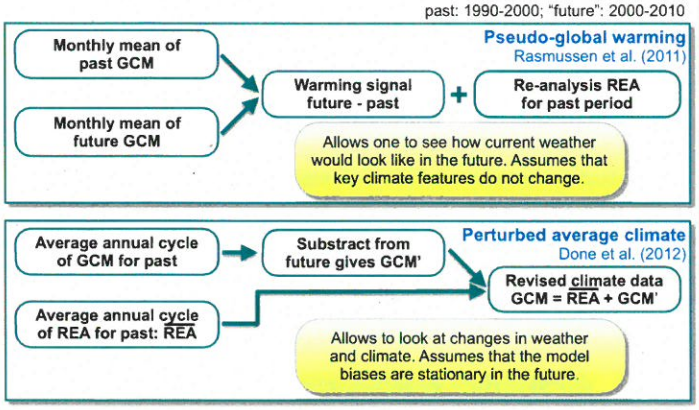
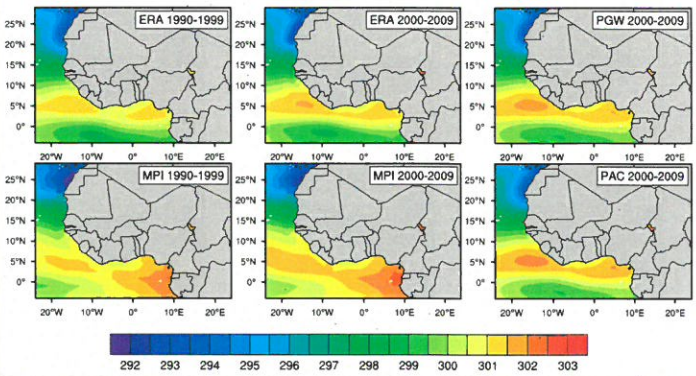


Bias correction of sea surface temperature

Model *input* mean sea surface temperature [K]



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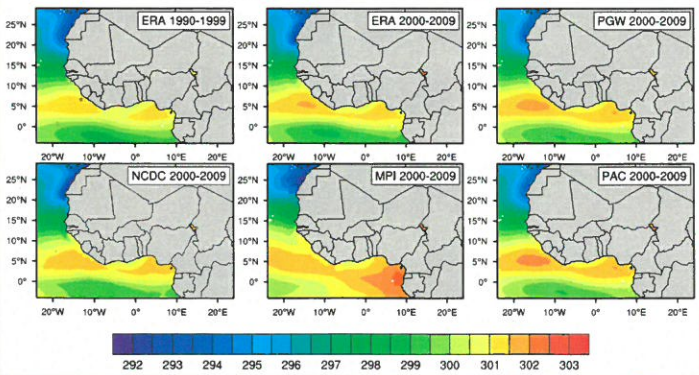
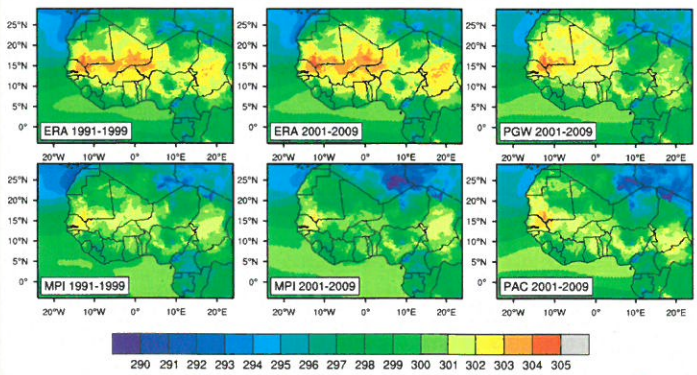


Both methods improve on average over the GCM

Model *output* mean 2m temperature [K]



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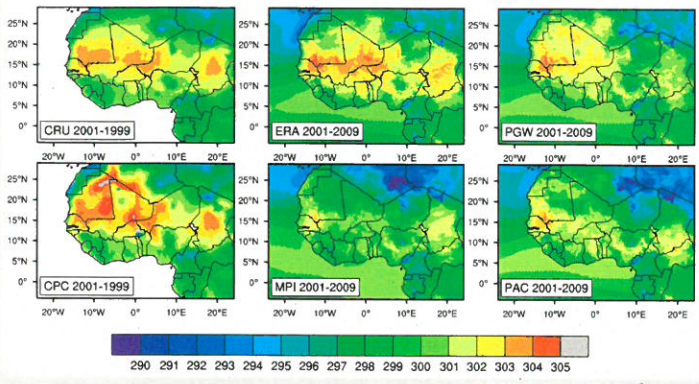
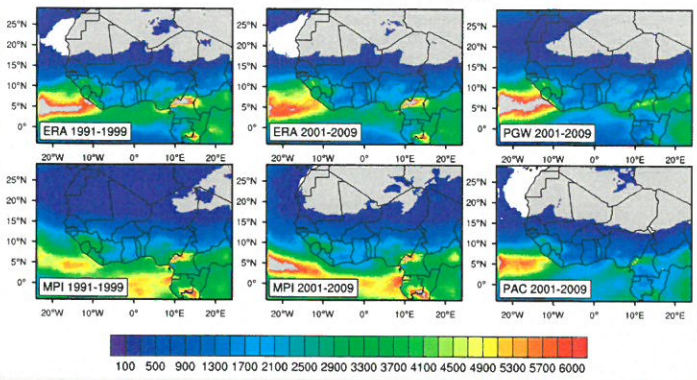


PAC produces too little (monsoon) precipitation

Model *output* mean rainfall [mm]



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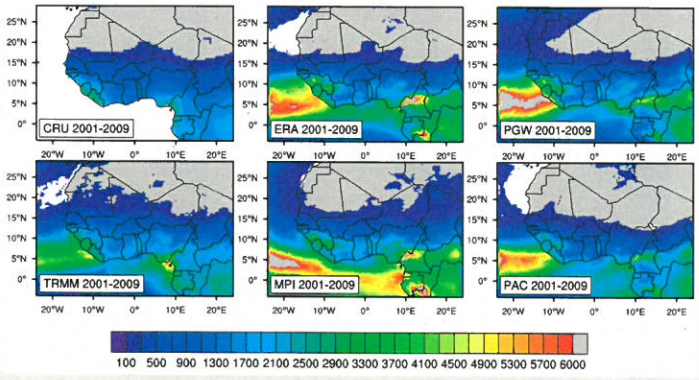
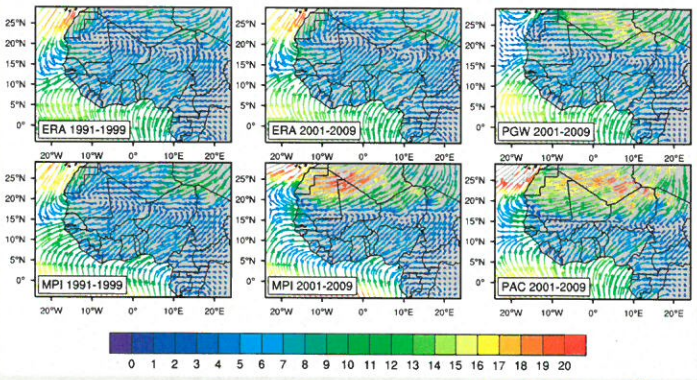


A strong change in GCM monsoon dynamics

Model *output* mean 10m wind for August [knots]



One step closer to a WA climate modeling system

WRF sensitivity study

PBL scheme determines position of monsoon rains
MP scheme determines total amount of precipitation
CU scheme less important on seasonal time scales

CAM drier, RRTMG wetter than DUDHIA/RRTM

"Best" configuration for regional climate simulations: Noble et al. (2013), GD_WSM5_ACM2_RRTMG

Bias correction of forcing GCM data

Large bias and change in forcing GCM circulation, MPI-ESM drier/wetter than ERA-Int. over land/sea

Pseudo-Global Warming closer to ERA-Interim and observations, **Perturbed Average Climate** improves on average over GCM, but problems with rainfall

Supported by

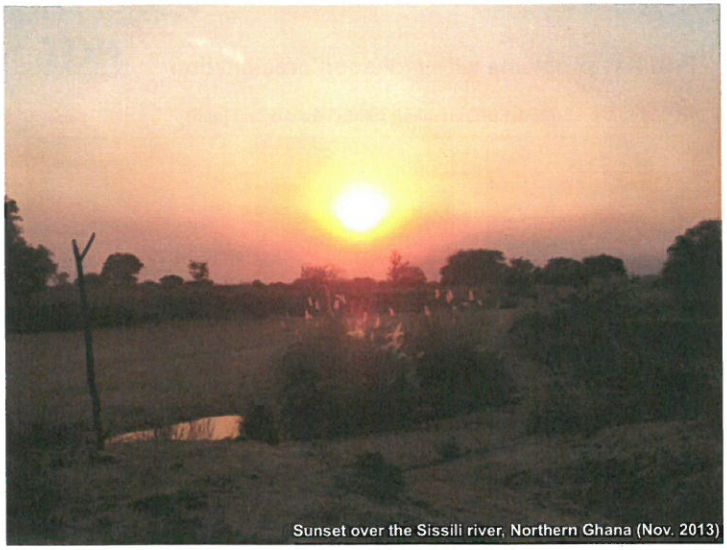
Bundesministerium für Bildung und Forschung

DKRZ Deutsches Klimarechenzentrum

Leibniz Supercomputing Centre of the Bavarian Academy of Sciences and Humanities

Future SOC Lab

JÜLICH Forschungszentrum

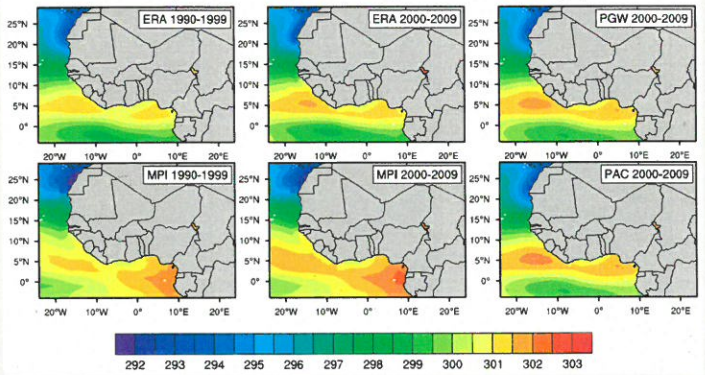


Sunset over the Sissili river, Northern Ghana (Nov. 2013)

Supplementary material

Bias correction of sea surface temperature

Model *input* mean sea surface temperature 2000-2009 [K]



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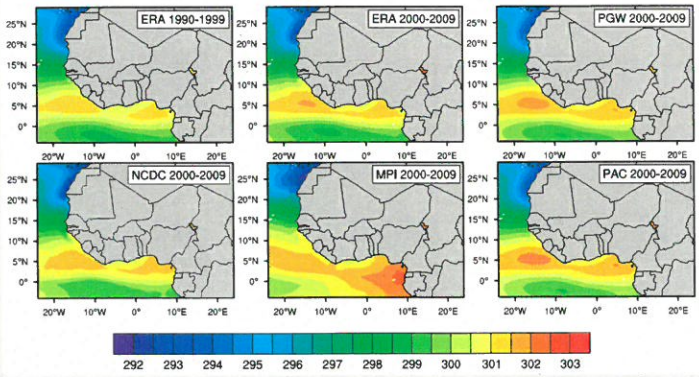

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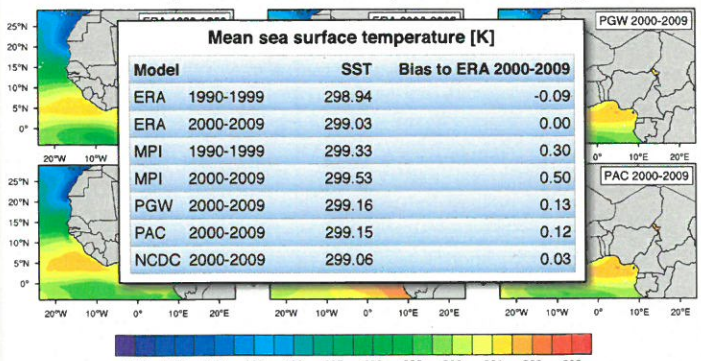

Mean sea surface temperature [K]

Model		SST	Bias to ERA 2000-2009
ERA	1990-1999	298.94	-0.09
ERA	2000-2009	299.03	0.00
MPI	1990-1999	299.33	0.30
MPI	2000-2009	299.53	0.50
PGW	2000-2009	299.16	0.13
PAC	2000-2009	299.15	0.12
NCDC	2000-2009	299.06	0.03

Pseudo-global warming beats the raw GCM ...

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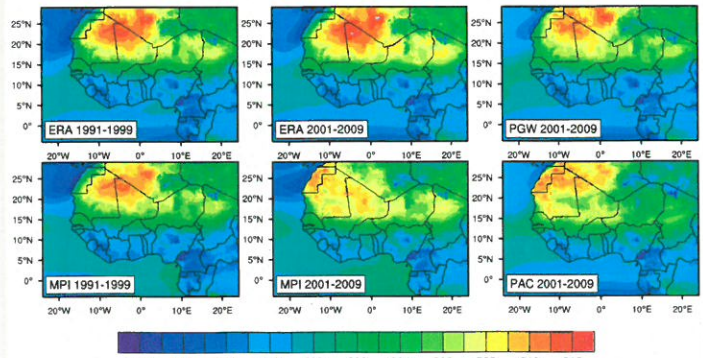

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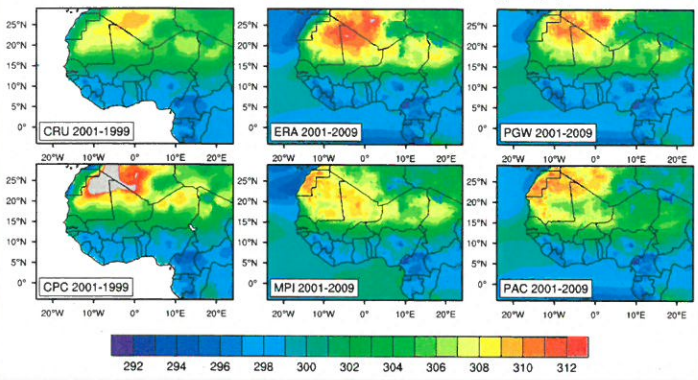

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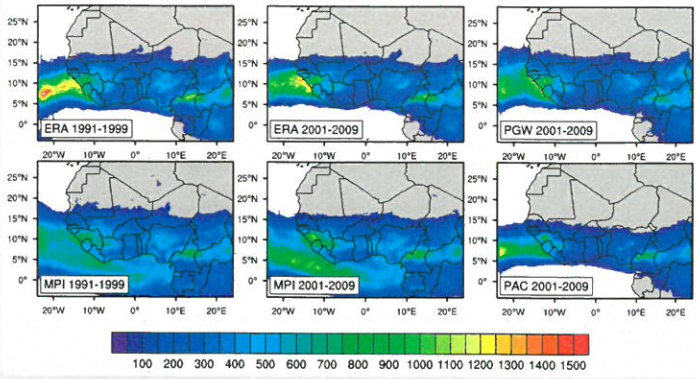

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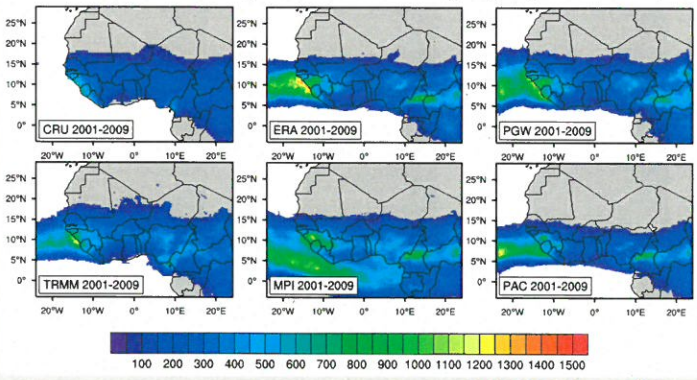

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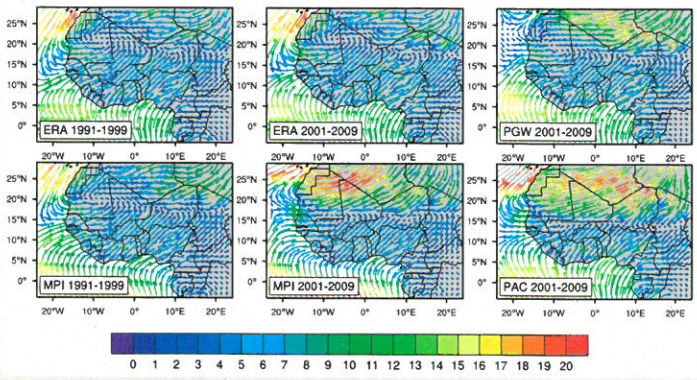
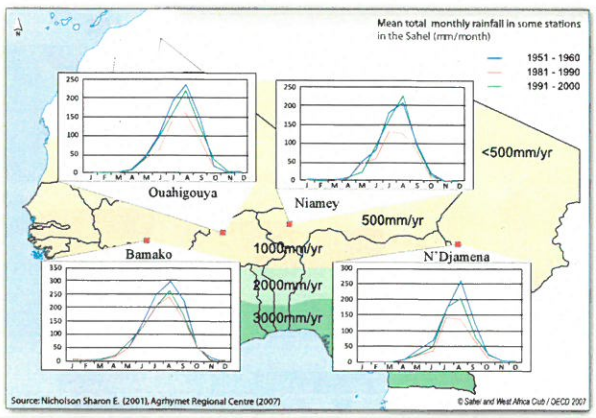


Global climate trends on regional scales



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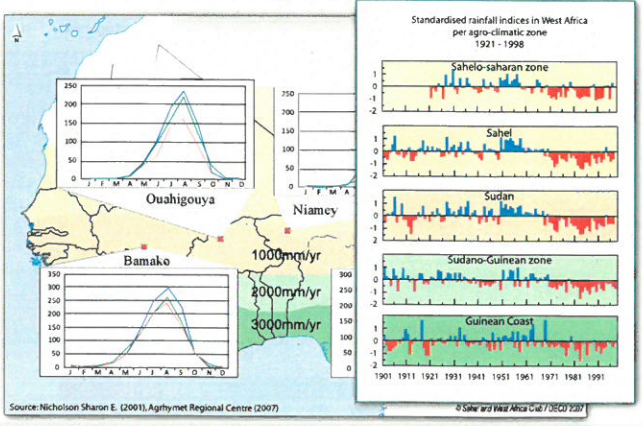
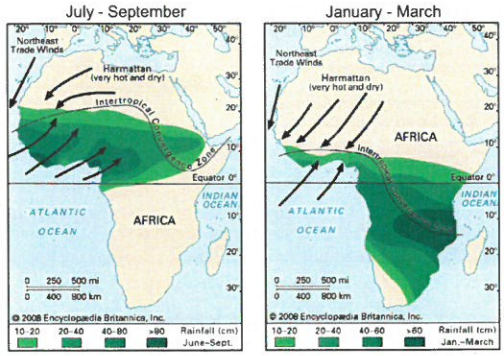


West African Monsoon - the big sea breeze



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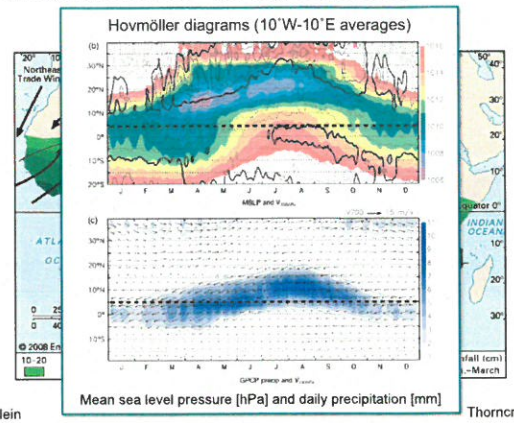

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Thorncroft et al. (2011)

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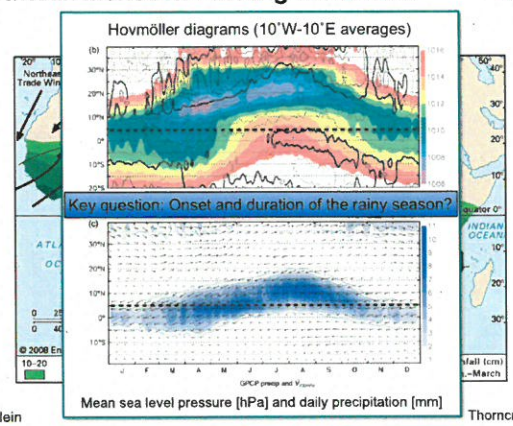

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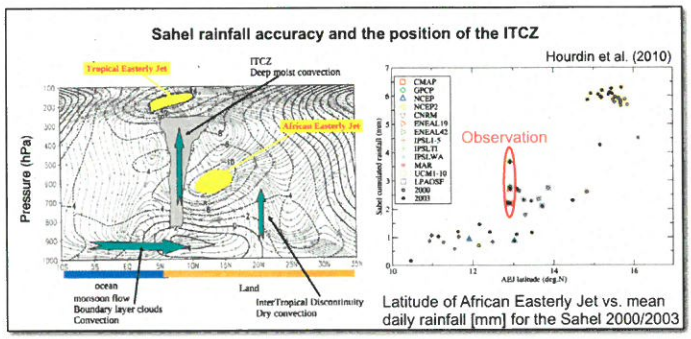
West African Monsoon (WAM) - a cooking recipe



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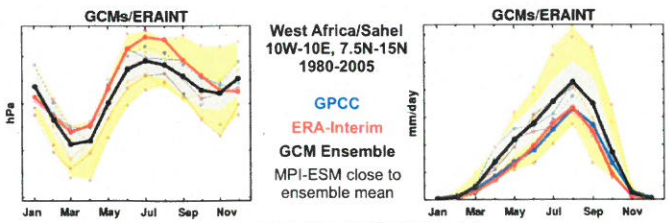

Jones et al. (2012): Africa-CORDEX Simulations
http://web2.sca.uqam.ca/~wgne/CMOS/PRESENTATIONS/5536_3b6_jones_colin.pdf

WASCAL - a large-scale international program

With climate change being one of the most severe challenges to rural Africa in the 21st century, West Africa is facing an urgent need to develop effective adaptation and mitigation measures.

WASCAL is a large-scale research-focused program designed to help tackle this challenge …

WASCAL partner countries

Bénin
Burkina Faso
Côte d'Ivoire
Gambia
Ghana
Mali
Niger
Nigeria
Sénégal
Togo

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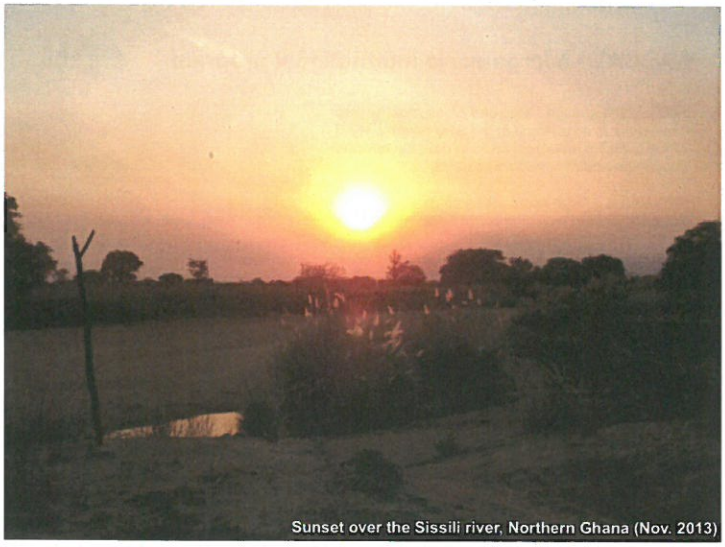
High-resolution regional climate projections

Regional climate system for West Africa
Validation through joint observation networks
Climate change and land-use changes
Impact studies, forcing data for further studies

23

24

Setup of climate station Gwasi in Northern Ghana (Nov. 2013)



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