



#### 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



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www.imk-ifu.kit.edu

## WRF sensitivity study for West Africa (C. Klein)





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

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



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

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WRF sensitivity study for Woot Africa (C. Klein)





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## **Seasonal precipitation sensitivity**





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## **Seasonal precipitation sensitivity**



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







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**Climate Change and Adapted Land Use** 



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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#### Two concurring bias correction algorithms







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#### **Bias correction of sea surface temperature**



#### Model input mean sea surface temperature [K]



#### **Bias correction of sea surface temperature**



# Both methods improve on average over the GCM



#### Model output mean 2m temperature [K]



# Both methods improve on average over the GCM



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#### Model output mean 2m temperature [K]

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## PAC produces too little (monsoon) precipitation





#### Model output mean rainfall [mm]

100 500 900 1300 1700 2100 2500 2900 3300 3700 4100 4500 4900 5300 5700 6000



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#### Model output mean rainfall [mm]

100 500 900 1300 1700 2100 2500 2900 3300 3700 4100 4500 4900 5300 5700 6000





## A strong change in GCM monsoon dynamics



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## One step closer to a WA climate modeling system

#### WRF sensitivity study

PBL scheme determines position of monsoon rainsMP scheme determines total amount of precipitationCU 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







Leibniz Supercomputing Centre of the Bavarian Academy of Sciences and Humanities





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http://www.fifa.com http://www.colourswallpapers.com http://worldcupzones.com



# 2019 FIFA World Cup Brazil





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



## **Supplementary material**





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#### **Bias correction of sea surface temperature**



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



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#### Pseudo-global warming beats the raw GCM ...



#### Model output mean 2m temperature for August [K]

16



KIT-Campus Alpin IMK-IFU: Atmospheric Environmental Research

#### Pseudo-global warming beats the raw GCM ...



#### Model output mean 2m temperature for August [K]

16

## PAC has problems with monsoon precipitation





#### Model output mean rainfall for August [mm]

100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500



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## **Global climate trends on regional scales**





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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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Credits: C. Klein

## West African Monsoon - the big sea breeze







## West African Monsoon - the big sea breeze



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## West African Monsoon (WAM) - a cooking recipe







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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#### **Core Research Program**

Climate and land-use change, social/scientific impact studies

West-African Consortium German Consortium Wascal Headquarters

Accra, Ghana Administration, coordination

Ougadougou, Burkina Faso Competence Center

#### **Graduate Research Program**

National universities and German partners

Graduate Research Programs Master Research Programs



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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







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**Climate Change and Adapted Land Use** 

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

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