WASCAL

West African Science Service Center on Climate Change and Adapted Land Use

DKRZ Project 726 - Regional Climate Simulations and Land-Atmosphere Simulations for West Africa

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Installation of eddy covariance and climate stations in October 2012

WASCAL

Changing climate and hydro-meteorological boundary conditions are among the most severe challenges to Africa in the 21st century. In particular West Africa faces an urgent need to develop effective adaptation and mitigation strategies to cope with negative impacts on humans and environment due to climate change, increased hydro-meteorological variability and land use changes.

To help meet these challenges, the German Federal Ministry of Education and Research (BMBF) started an initiative with institutions in Germany and West African countries to establish together a **West African Science Service Center on Climate Change and Adapted Land Use (WASCAL).** This activity is accompanied by an establishment of trans-boundary observation networks, an interdisciplinary **core research program** and **graduate research programs** on climate change and related issues for strengthening the analytical capabilities of the **Science Service Center**.

This poster illustrates key activities of the climate group of WASCAL with a special focus on current and planned simulation experiments using regional climate models (RCM) within the project 726 at the German Climate Computing Center (DKRZ).

WASCAL West African partner countries

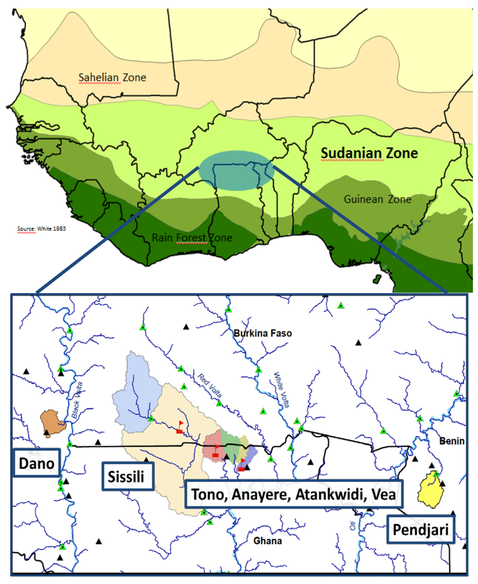
Regional Climate Simulations and Projections

A key research activity of the **WASCAL Competence Center** is the provision of regional climate simulations in a fine spatio-temporal resolution for the core research sites of WASCAL for the present (e.g. 1960 – 2012) and the near future (e.g. until 2040). The climate information is needed for subsequent local climate impact studies in agriculture, water resources and further socio-economic sectors.

The simulation experiments are performed using regional climate models such as COSMO-CLM (Rockel et al., 2008), RegCM4 (Giorgi et al., 2012) and WRF (Skamarock et al., 2008) and statistical techniques for a further refinement of the projections. The modeling is done in cooperation with further BMBF funded projects such as CORDEX and DEPARTURE. The **start of the simulation experiments in the competence center is expected for summer 2013**.

The core research sites of WASCAL are located in the Sudanian Savannah belt in Northern Ghana, Southern Burkina Faso and Northern Benin. The climate in this region is semi-arid with six rainy months.

Core Research Sites



The Sudanian Savannah is also called as the potential breadbasket for West African countries.

Due to the strong population growth in West Africa, many areas of the Sudanian Savannah have been already converted to farmland since the majority of the people are living directly or indirectly from the income produced in agriculture.

Graduate Research Program on the West African Climate System and High Performance Computing at the Competence Center

The simulation experiments of the Competence Centre and the Core Research Program are accompanied by the **WASCAL Graduate Research Program on the West African Climate System (GRP-WACS)**.

The GRP-WACS provides **ten scholarships per year for West African PhD students** with a duration of three years including a 6-month research stay in Germany.

RCM course in May 2012, Nigeria

WASCAL PhD students are presently using RCMs to investigate

- the onset and cessation of rainfall as well as its amounts and variability over the Sahelian region of West Africa
- the influence of climate change on water resources e.g. in the Volta Basin (Ghana, Burkina Faso)
- the influence of aerosols on precipitation and further atmospheric processes
- the influence of land surface processes and SST on rainfall variability over West Africa

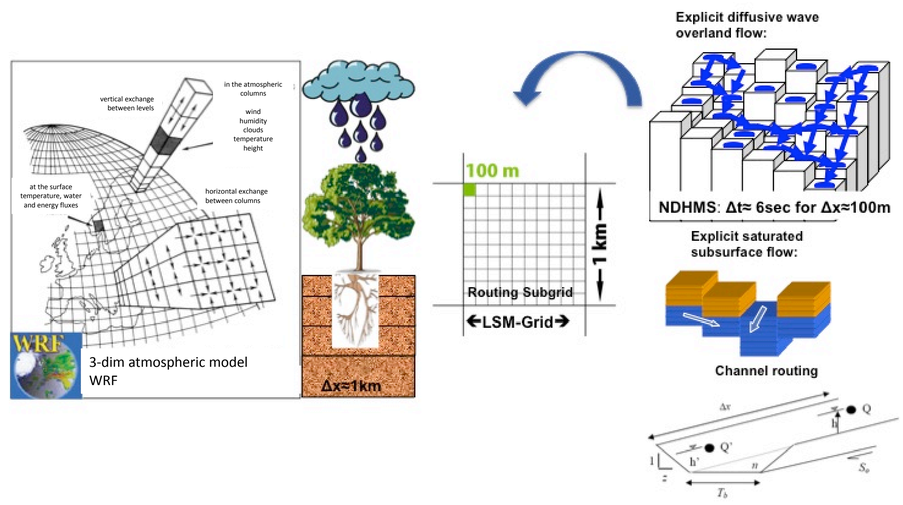
These and future WASCAL PhD thesis will constitute one important user group of the Linux cluster that will be installed at the Competence Center in Ouagadougou, Burkina Faso.

Regional Land-Atmosphere Simulations

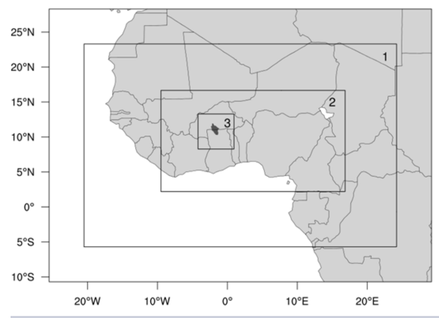
A **key research activity** of the **WASCAL Core Research Program** is the analysis of interactions between the land surface and the atmosphere to investigate how land surface changes affect hydro-meteorological surface fluxes such as evapotranspiration.

Since current land surface models of global and regional climate models neglect dominant lateral hydrological process such as surface runoff, **a novel land surface model is used, the NCAR Distributed Hydrological Modeling System (NDHMS; Gochis et al., 2010).** This model can be coupled to WRF (WRF-Hydro) **to perform two-way coupled atmospheric-hydrological simulations for the watershed of interest.**

Compartment Crossing Water Balance Simulations with WRF-Hydro



Domain for WRF-Hydro simulations for the Sissili basin.



The WRF-Hydro simulations are performed using large-scale atmospheric information from the ERA-Interim reanalysis archive (Dee et al., 2011) which has been generated by an atmospheric general circulation model (AGCM).

The AGCM information is stepwise transferred from a horizontal resolution of approximately 80 km to a final resolution of 2.5 km using three domains.

Preliminary Investigations and First Outcomes

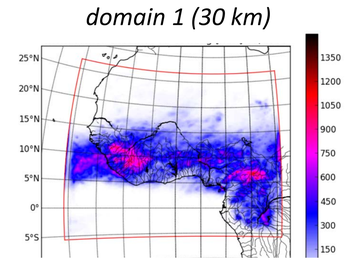
The NDHMS and WRF have been successfully compiled at the HPC environment of DKRZ. In addition, several test runs were carried out with WRF for different geographical regions using forecast information from the Global Forecast System (GFS) and reanalysis information of ERA-Interim as test datasets.

In a further preliminary analysis, several WRF simulations have been performed using different parameterization schemes to identify a specific model configuration for a simulation of daily precipitation characteristics.

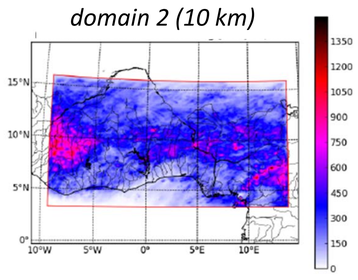
The WRF simulations have been performed for a rainy season (April to September) of a very humid year (1999) and for a markedly drier year (1992).

WRF simulation run 6, July 1999 monthly precipitation amount [mm]

domain 1 (30 km)



domain 2 (10 km)



Tab. 1: The systematic differences (bias) between the mean observed and mean simulated daily precipitation of more than 70 locations in Ghana and Burkina Faso. In each WRF run a different set of parameterisation approaches is selected; rainy season 1999.

WRF run	LS	MP	CU	PBL	SLR	SL	bias [mm/d]
standard	Noah	WSM3	KF	YSU	RD	MM5	2.9
2	Noah	WSM5	GD3D	YSU	RRTMG	MM5	5.3
3	Noah	THM	GD3D	YSU	RRTMG	MM5	4.9
4	Noah	WSM5	BMJ	YSU	RRTMG	MM5	1.3
5	Noah	WSM5	SAS	YSU	RRTMG	MM5	1.7
6	Noah	WSM5	BMJ	MYJ	RRTMG	ETA	0.9
7	Noah	WSM5	GD3D	MYJ	RRTMG	ETA	3.2

LS, land surface; MP, microphysics; CU, cumulus; PBL, planetary boundary layer; SLR, shortwave and longwave radiation; SL, Surface Layer; Noah, Noah LSM; THM, Thompson; KF, Kain-Fritsch; GR3D, Grell-Devenyi; BMJ, Betts-Miller-Janjic ; SAS, New Simplified Arakawa Schubert Scheme; YSU, Yonsei State University; MYJ, Mellor-Yamada-Janjic; RRTMG = Rapid Radiative Transfer Model; RD, Rapid Radiative Transfer Model and Dudhia; MM5, MM5, Monin-Obukov; ETA, Monin-Obukov (Janjic) scheme, after WRF Version 3.4

Outlook for 2013: Initialisation of RCM experiments

- Event-based simulations with COSMO-CLM, WRF, RegCM4 e.g. for the West Africa flood 2009
- Multiple simulations with CCLM, RegCM4 and WRF for selected rainy seasons using ERA-Interim reanalysis information for a model comparison.
- Multiple simulations with WRF, NDHMS and WRF-Hydro for selected rainy seasons.

In future, the model simulation will be validated with additional information provided by the WASCAL climate observation network

Dee et al. (2011): The ERA-Interim reanalysis: configuration and performance of the data assimilation system. QJR Meteorol. Soc.
Gochis D. J., Wei Y. & David N. Y. (2010): The NCAR Distributed Hydrological Modeling System (NDHMS): User's guide and technical description.
Skamarock, W. C., Klemp J. B., Dudhia J., Gill D. O., Barker D. M., Duda M., Huang X.-Y., Wang, W. & Powers, J. G. (2008): A Description of the Advanced Research WRF Version 3, NCAR Technical Note.
Giorgi, F., et al. : RegCM4: model description and preliminary tests over multiple CORDEX domains. *Climate Research*, 2012, 2. Jg., S. 7.
Rockel, Burkhard; Will, Andreas; Hense, Andreas. The regional climate model COSMO-CLM (CCLM). Meteorologische Zeitschrift, 2008, 17. Jg., Nr. 4, S. 347-348.

Bundesministerium für Bildung und Forschung

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