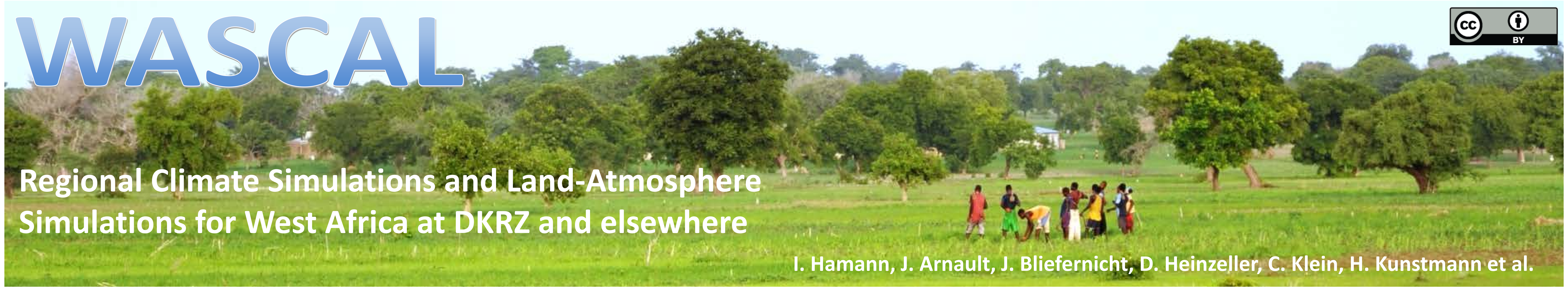
Installation of eddy covariance and climate stations in October 2012 and November 2013



WASCAL

Regional Climate Simulations and Land-Atmosphere Simulations for West Africa at DKRZ and elsewhere

I. Hamann, J. Arnault, J. Bliefernicht, D. Heinzeller, C. Klein, H. Kunstmann et al.

WASCAL

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, 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 a **Science Service Centre on Climate Change and Adapted Land Use (WASCAL) in West Africa.** This activity is accompanied by a program for an establishment of trans-boundary observation networks, an interdisciplinary core research program and graduate research programs on climate change and related issues.

The objective of this poster presentation is to highlight selected activities of the climate research group within WASCAL:

- Realizations of fine-resolved regional climate change simulation experiments for West Africa
- Development of regional climate models with an advanced land surface model for investigating regional land-atmosphere interactions
- Establishment of trans-national and local hydro-meteorological networks and a corresponding novel climate database
- Establishment of a scientific computing environment at the WASCAL Competence Center

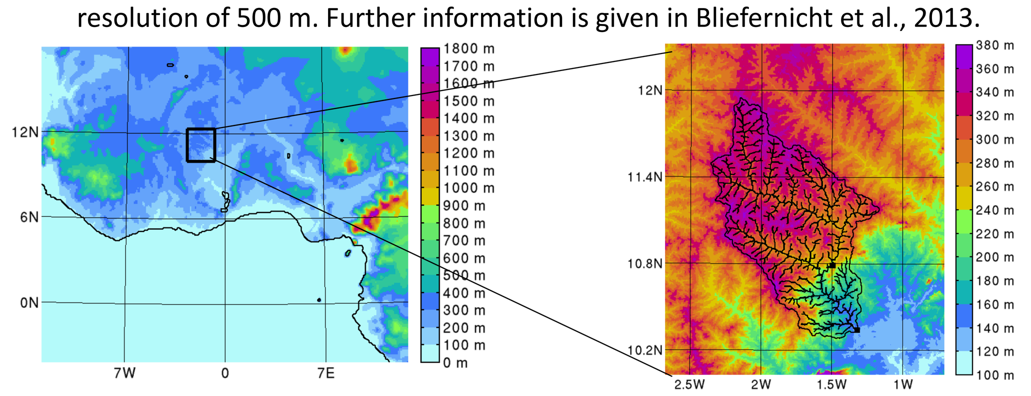
WASCAL West African partner countries

Senegal, The Gambia, Mali, Côte d'Ivoire, Burkina Faso, Ghana, Togo, Benin Niger, Nigeria

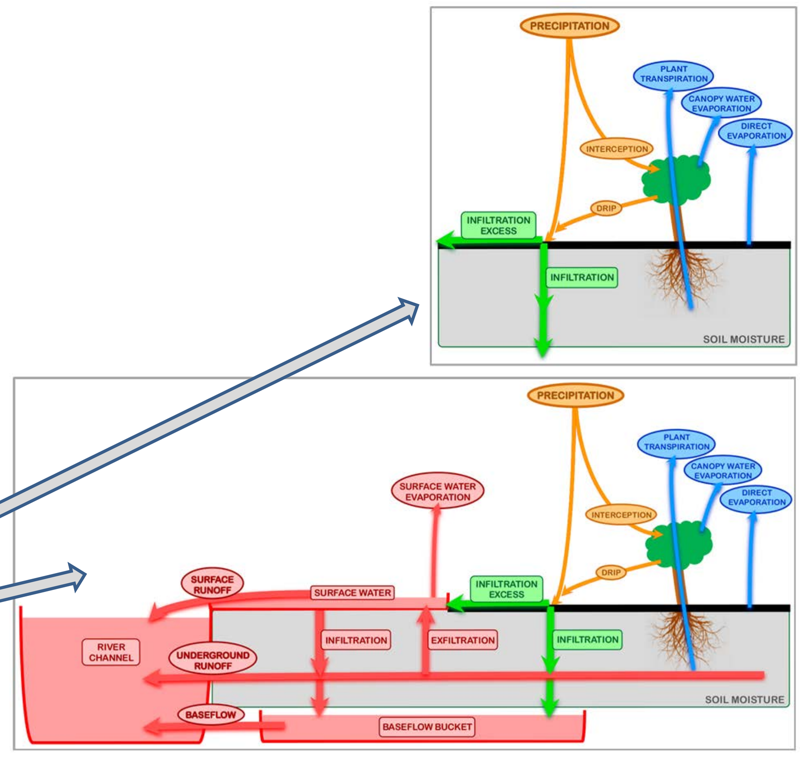
Regional Land-Atmosphere Simulations

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 processes 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.**

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 10 km to a resolution of 2 km for a domain covering the Sissili basin. The latter domain is coupled with the NDHMS using a grid at a resolution of 500 m. Further information is given in Bliefernicht et al., 2013.



Domain for WRF-Hydro simulations for the Sissili basin



Conceptual schematic graphs of the 1-D Noah land surface model used in WRF (above) and of the 1-D Noah LSM coupled with NDHMS used in WRF-Hydro (below) by Joel Arnault, KIT/IMK-IFU, Garmisch-Partenkirchen

Regional Climate Simulations and Projections

A key research activity is the realization of **regional climate simulations in a fine spatiotemporal resolution.** Currently available global circulation models and regional climate simulations are limited by their coarse grid spacing and temporal resolution. They often have problems in representing accurately the main West African Summer Monsoon features and do not allow for process studies on local scales (Hourdin et al., 2010; Sylla et al., 2010; Xue et al., 2010). However, the generation of regional climate simulations specifically targeted to West Africa and particularly for the **core research sites of WASCAL** at a fine spatial (12 km and below) and temporal (3hr) resolution for the present (e.g. 1960 – 2012) and near future time spans (e.g. until 2040) will produce climate information that is needed for subsequent local climate impact studies in agriculture, water resources and various socio-economic sectors.

The transient simulation experiments cover a large portion of the African continent and oceanic regions off West Africa and are carried out for periods from 1979 to 2100. To account for the uncertainty in regional climate projections, an ensemble approach is adopted. Three different regional climate models are used to perform the simulation experiments, i.e. **COSMO-CLM, RegCM4** and **WRF**, and each of these models is **driven by three different global circulation models for the two representative concentration pathways (RCP 4.5 and RCP 8.5)**. An input bias correction and a further statistical analysis of the output are applied to improve the model results. The **modeling is done in close cooperation with other BMBF funded projects such as CORDEX and DEPARTURE**.

Global circulation models:

MPI-ESM Echam6, Max-Planck Institute for Meteorology ESM, Germany (Stevens et al., 2013)

HadGEM3, UK Met Office Hadley Centre Global Environment Model (Hewitt et al., 2011)

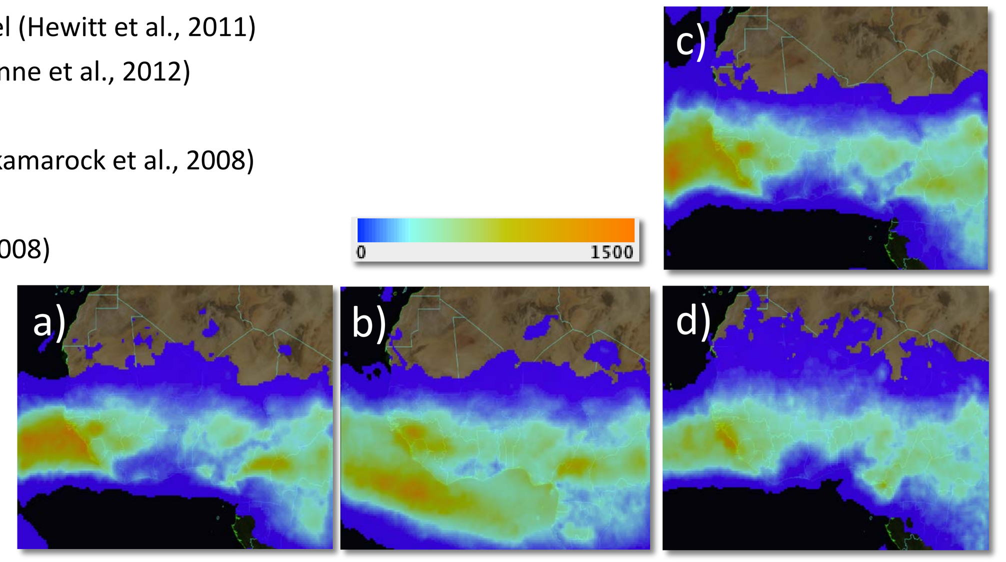
GFDL-ESM2, Geophysical Fluid Dynamics Laboratory ESM, USA (Dunne et al., 2012)

Regional climate models:

WRFV3.5.1, NCAR Weather Research & Forecasting Model, USA (Skamarock et al., 2008)

RegCM4.3, ICTP Regional Climate Model, Italy (Giorgi et al., 2012)

CCLM_4, Cosmo Model in Climate Mode, Germany (Rockel et al., 2008)



August precipitation average in mm for 2001-2006:
a) WRF/ERA-Interim
b) WRF/MPI-ESM
c) WRF/MPI-ESM bias corrected
d) TRMM (Huffman et al., 2007)

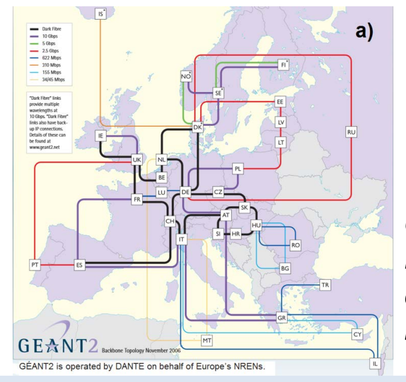
IT-Infrastructure, Scientific Computing, Model Data Management

Hardware and network prerequisites:

- HPC cluster of ≥ 10 compute nodes, located in an appropriately electrified and cooled building
- Network switches, storage and archival and visualization
- Internal storage media (in the TB range)

Internet connectivity of sufficient bandwidth Competences needed:

- High performance compute, storage, and visualization systems optimized for climate research
- Parallelization and optimization of climate models and workflows
- Efficient management of highest data volumes
- 3D visualization to communicate research results



Géant2 – TransEurasia Information Network :
a) Network connections in Europe
b) to other continents

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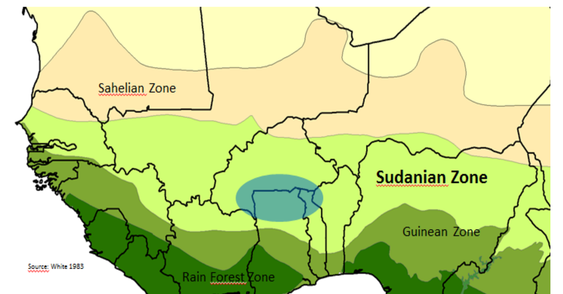
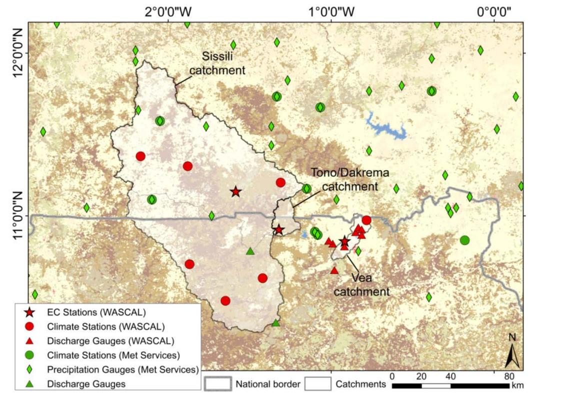
Hydro-Meteorological Observation Networks and Databases

A major task of **establishing a trans-national hydro-meteorological observation network** is to upgrade the current operational networks of the national weather and hydrological services by **36 automatic GCOS compatible climate stations, 80 discharge and 120 groundwater gauges.** The **measurements** taken by the various instruments **are transferred automatically** into the WASCAL database (i.e. the distributed Spatial Data Infrastructure **WADI) hosted at the Competence Center of WASCAL.**

In addition, **3 micro-meteorological stations, 17 basic weather stations, 20 discharge gauges** and further hydrological equipment were installed in 2012 and 2013 at the core research sites of WASCAL in close cooperation with the hydrologists. The **core research sites** are located in the **Sudanian Savanna belt in South Burkina Faso, North Ghana and North Benin.** An example of the hydro-meteorological observation network is illustrated below in the figure on the right for the river basins of the Vea and the Sissili.

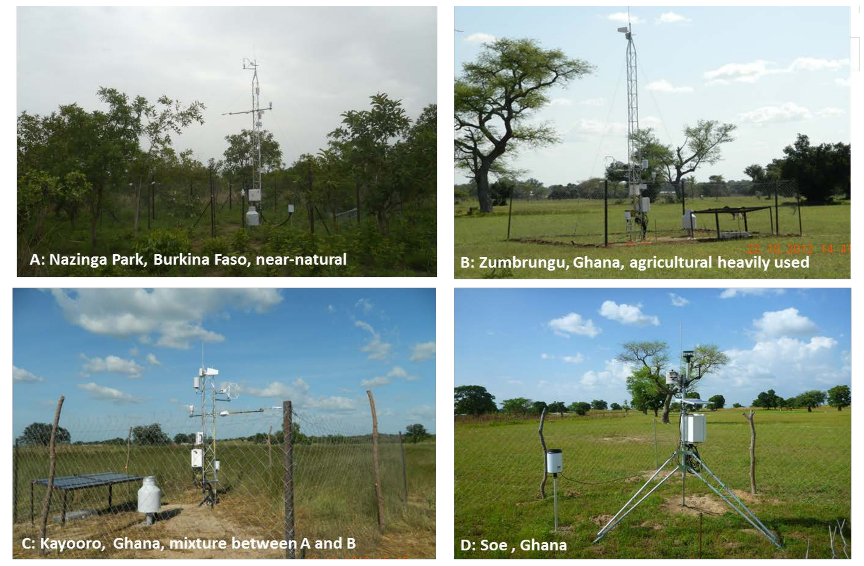


The core research zone of WASCAL and the hydro-meteorological observation network for the Sissili basin



A highlight of the novel networks are **three micro-meteorological stations using the eddy covariance (EC) technique** (see Bliefernicht et al., 2013). The EC stations are located along a transect of changing land cover characteristics to investigate **how land surface changes might alter land-atmosphere exchange processes.** Currently, there are only few sites in West Africa where continuous EC measurements are performed.

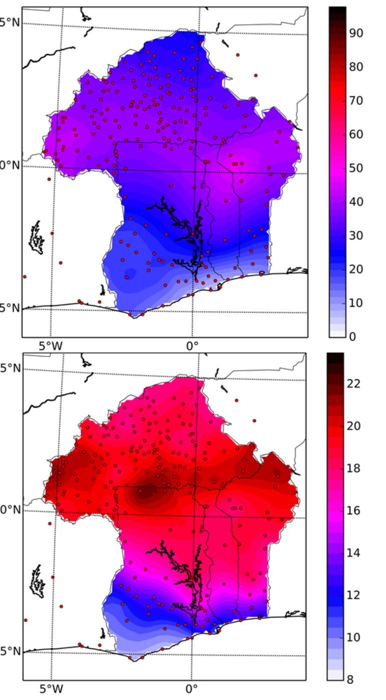
In addition, **new climate databases and products** are created based on long-term historical measurements in a fine spatiotemporal resolution. Two precipitation products are illustrated in the colored charts on the right below. The daily information has been collected from various global, regional and national archives. The climate observations are much needed for a validation of the model simulations and for subsequent impact studies in hydrology, agriculture and further disciplines.



Micro-meteorological stations (A, B, C) for investigating the impact of land surface changes on water, energy and CO_2-fluxes and an automatic weather station (D).

Average daily rainfall frequency (%) in August (1950 - 2010)

Average daily rainfall intensity (mm) in August (1950 – 2010)



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