



10 WASCAL member states (red), 5 states (green) that also belong to the Economic Community of West African States (ECOWAS).

## Data Management for WASCAL at DKRZ

### WASCAL: West African Science Service Centre on Climate Change and Adapted Land Use

WASCAL is an organization that provides climate change-related services, research and capacity building. The Competence Center (CoC) in Ouagadougou, Burkina Faso, was newly established within the project to carry out research and provide science-based advice to policy-makers and stakeholders on climate change impacts, mitigation, and adaptation measures. The core research program complements the activities of the CoC and is implemented by a network of German and West African research institutes. In the graduate studies program doctoral and master degree programs in association with German counterpart institutions facilitate academic education amongst West African universities.

Under the framework program "Research for Sustainable Development", the German Federal Ministry of Education and Research (BMBF) 2010 and 2017 (funding code 01LG1202H). The project was coordinated by the Center for Development Research at the University of Bonn.

<https://www.wascal.org/>



### German Climate Computing Center (DKRZ)

The mission of DKRZ is to provide high performance computing (HPC) platforms, sophisticated and high capacity data management and services for premium climate science.

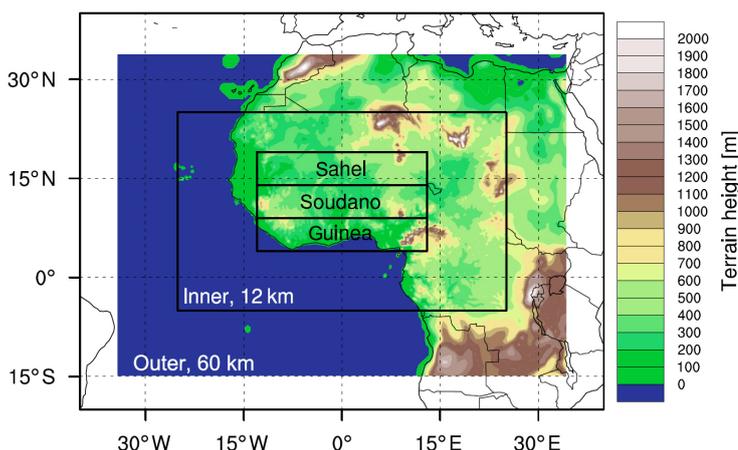
Besides providing HPC services, DKRZ supports projects in all aspects relevant to data management. This includes preparation, quality assessment, distribution, and long-term archiving of data.

[www.dkrz.de](http://www.dkrz.de)

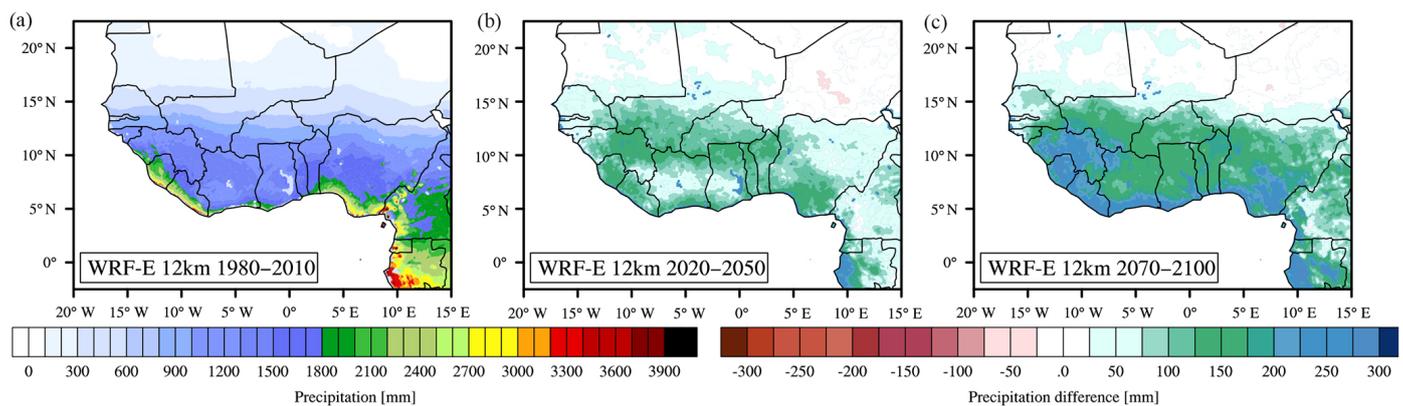
DKRZ has contributed to each of WASCAL's core areas: research, graduate studies program and build-up of scientific infrastructure at the Competence Center (CoC). Supercomputing resources were granted to WASCAL participants by DKRZ. Many of the participants were enrolled in the doctoral program 'West African Climate System' at the University of Akure, Nigeria. Supported by DKRZ with respect to data management practices such as long-term archiving, the students investigated hydro-meteorological research questions.

DKRZ advised the CoC on the procurement of a high-performance computing system – to enable simulations with Regional Climate Models (RCMs) – and of several powerful workstations required for model development, analysis and visualization of results. Accordingly, DKRZ formulated the technical specifications for the HPC and storage system for the CoC.

DKRZ was also involved in the training of CoC personnel for operating of the computing cluster as well as in tutoring on model data quality checks and curation of large output data volumes.



The figure shows the grid resolutions and domains of the two-way-nesting applied for the RCM simulations carried out within the project. The outer boundary conditions were taken from global climate simulations. The figure also shows the three distinct agro-climatic regions used in the analysis.



(a) Annual precipitation [mm] averaged over the historical reference period 1980-2010, (b) and climate change signal for the near future 2020-2050 and (c) the end of the 21st century 2070-2100 for the Weather Research and Forecasting (WRF) multi-model ensemble WRF-E (high spatial resolution 12 km).

## Long-term archiving in WDCC

To facilitate sustainable re-use of WASCAL data, the results are long-term archived at the World Data Center for Climate (WDCC) hosted at DKRZ.

In accordance with the WDCC storage policy and in cooperation with the WDCC, the WASCAL data producers have established the data management in the project. This included questions such as ownership, licensing and authorship as well as structuring the data with the aim of enabling subsequent re-use.

DKRZ Data Management provided interactive support:

- Provision of GCM data as boundary and initial conditions for RCM simulations (Data Management Stories, Issue 2)
- Review of data compliance with established standards like NetCDF/CF convention
- Check of metadata for consistency, completeness and clarity
- Ingestion and publication of data and metadata in the WDCC archiving system CERA
- Coordination of the publishing process of data by registration of a DataCite DOI (Digital Object Identifier)

## Future access to simulation results

WASCAL data will be available at WDCC and the WADI portal of the CoC: <https://cera-www.dkrz.de/WDCC/ui/ceraresearch/project?acronym=WASCAL>

## Logistical challenges

Since the transfer of 60 Terabytes of WRF output data from the KIT (Campus Alpin) in Garmisch-Partenkirchen to DKRZ in Hamburg via the Internet would have taken several weeks, the data were uploaded to a Network Attached Storage (NAS) device, transported by car to Hamburg and copied there within 47 hours after connecting the NAS to DKRZ's network.



A Network Attached Storage device was connected to DKRZ's HPC system.

## Training activity in Africa

DKRZ contributed to the Hydro-Climate and Remote Sensing Workshop for West African students and young scientists at the CoC in March 2017 by a hands-on workshop on how to prepare data to facilitate sustainable, interdisciplinary use.

## High Performance Computing concept for a Regional Climate Model System for West Africa

WASCAL's climate services provide a new set of high resolution, ensemble-based regional climate change scenarios for the region of West Africa. An ensemble approach was chosen to address model uncertainties and to provide statistical estimates of possible future climate change scenarios. The model system was designed by experienced atmospheric scientists of the Institute of Meteorology and Climate Research – Atmospheric Environmental Research of the Karlsruhe Institute of Technology (Germany), as well as African partners from the African Centre of Meteorological Applications for Development (Niger), the University „Félix Houphouët-Boigny“ (Côte D'Ivoire) and Cheikh Anta Diop University (Senegal). In the course of 8 years, atmospheric and hydrological modelers from these and other institutions performed model experiments on DKRZ's supercomputers.

The ensemble consists of three RCMs: WRFV3.5.1, COSMO-CLM 4.18, and REGCM4. Results from three CMIP5 models, i.e. MPI-ESM, GFDL-ESM2M and HadGEM2-ES, were dynamically downscaled by each of the regional models a) for the historical period from 1980 to 2010 and b) for the RCP4.5 scenario for two 30-year periods, i.e. from 2020 to 2050, and from 2070 to 2100. For the forcing of the control runs, the European Centre for Medium-Range Weather Forecasts ERA-Interim reanalysis from 1980 to 2014 were used. The RCM results were made available at both resolutions, 60 km and 12 km, for a large domain covering the greater region of West Africa from 25°W to 25°E and 5°S to 25°N. The figure on top shows the projected change in precipitation for the high-resolution runs.

In cooperation with the data manager and the HPC cluster manager at the CoC, DKRZ has drafted a future training session to enable the cluster manager to start the operational service once the components of the WASCAL computing and data platform will be installed.

## Reference

The WASCAL WRF modelers were the first whose results and model data set were published in the journal ESSD: Heinzeller, D., Dieng, D., Smiatek, G., Olusegun, C., Klein, C., Hamann, I., Salack, S., Bliedernicht, J., and Kunstmann, H.: The WASCAL high-resolution regional climate simulation ensemble for West Africa: concept, dissemination and assessment, *Earth System Science Data*, 10, 815-835, <https://doi.org/10.5194/essd-10-815-2018>, 2018.