Evaluation of the CCLM and WRF Climate Change Simulations for West Africa

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Motivation

WASCAL (West African Science Service Center on Climate Change and Adapted Land use) is a project between West Africa and German partners to enhance the resilience of human and environmental systems against climate change.

Tasks contributed by KIT and University of Augsburg are:

- High-resolution climate information for the WASCAL region (see Figure 1).
- Assessment of the ability of CCLM and WRF to represent the variability and major changes in daily rainfall events by comparing the relevant statistics (mean, daily frequency and intensity).
- Analysis of short- and long-term simulations based on ERA-Interim and MPI-LSM-LR boundary forcing.
- Provisioning of climate change data covering West Africa to the WASCAL graduate schools.

Methodology

Applied regional climate models:

The present analyses use two RCMs driven by ERA-Interim lateral boundary data (control run):

- CCLM version 4.8_clm19 (3h boundary update, albedo=2)
- CCLM version 4.25_clm3 (6h boundary update)
- WRF version 3.5.1. (3h boundary update)

Experimental design:

- Domain D1: 0.44° (50 km) on rotated grid (CCLM) and Mercator grid (WRF).
- Domain D2 (nested): 0.11° (12 km) on rotated / Mercator grid.
- 40 vertical levels up to 10hPa.
- WSM5-ACM2-GF configuration for WRF.
- CORDEX-AFRICA configuration for CCLM.

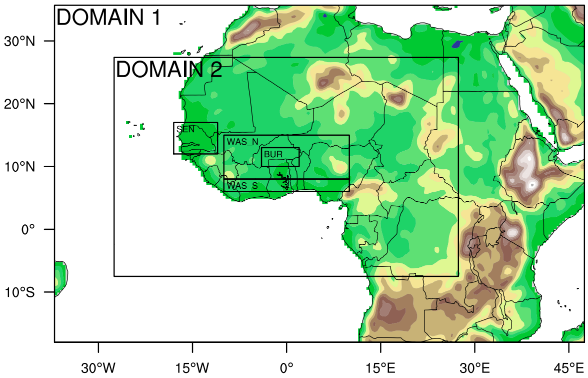

Figure 1 Model domains and investigation areas: Senegal (SEN), Burkina Faso (BUR), WASCAL south (WAS_S) and WASCAL north (WAS_N).

Validations dataset

Daily rainfall data is provided by the national weather services of three WASCAL member countries Burkina Faso, Ghana, and Benin. Further data sources such as GHCN historical data from the Glowa/Volta project are added and the data is interpolated using ordinary Kriging techniques.

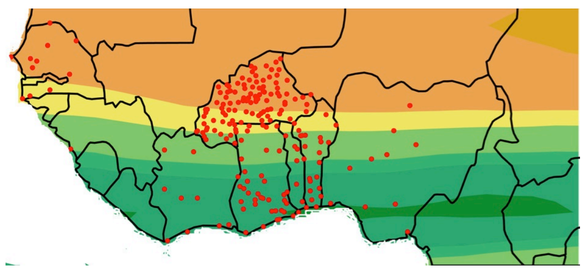

Figure 2: Daily rain gauge network (red dots) over WASCAL research sites. overlaid on the precipitation gradient (annual mean) of ERA-Interim.

Model runs

The simulations are performed for the period 1979-2013 and cover West Africa between (5ºS-25ºN) and (25ºW-25ºE). The domain size was chosen to capture the large-scale atmospheric patterns in the region within the limited area model.

Results

Spatial precipitation patterns

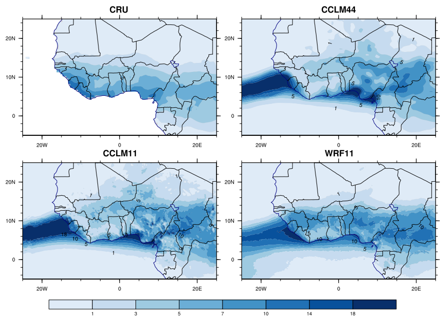

Figure 3 Spatial distribution of observed and simulated precipitation in the monsoon season (JJA) in mm/day for the period 1979-1993.

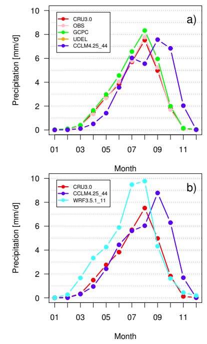

Figure 4 Observed and simulated monthly mean precipitation in the BUR area for 1989-2008 (a) and 1979-1993 (b) .

Seasonal precipitation patterns

Rainfall features in the regions WAS_N, WAS_S , SEN and BUR with different characteristics of the annual cycle of rainfall are used in model evaluation (Figure 4 - Figure 6).

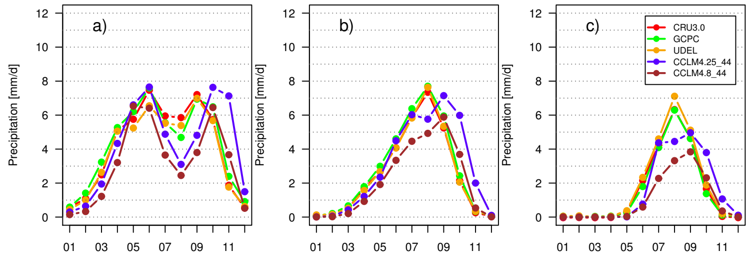

Figure 5 Observed and simulated monthly mean precipitation in the period 1989-2008 and for the areas WA_S (a), WA_N (b) and SEN (c). Simulations with 0.44° resolution.

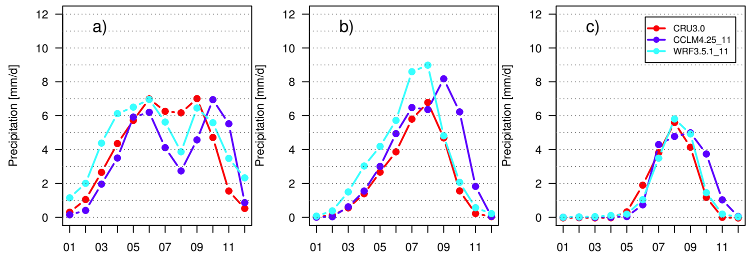

Figure 6 Observed and simulated monthly mean precipitation in the period 1979-1993 and the areas WA_S (a), WA_N (b) and SEN (c). Simulations with 0.11° resolution.

Selected climate indices for the period 1979-1993

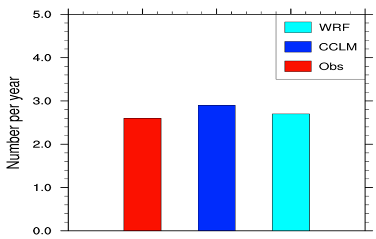

Figure 7 Observed and simulated number of consecutive wet days (dd > 5).

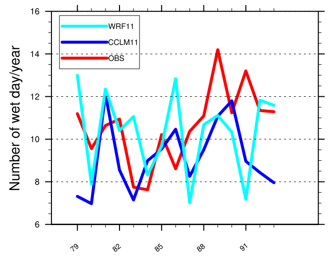

Figure 7 Observed and simulated number of wet days (rr > 1 mm) in the BUR area.

Conclusions

- Reasonable reproduction of precipitation patterns in the WASCAL area.
- Shift in the end of the wet season present in the CCLM simulations.
- Early onset of the wet season present in the WRF simulations.

Next steps

- MPI-ESM-LR historical and climate runs (RCP4.5) from 1979 to 2100.
- Further analysis of daily temperatures using observation data from WASCAL member countries.
- Extended analysis of the atmospheric monsoon circulation.