The WASCAL regional climate simulations for West Africa: How to add value to existing climate projections?

Dominikus Heinzeller[A] (heinzeller@kit.edu), Cornelia Klein[B], Diarra Dieng[A], Gerhard Smiatek[A], Jan Bliefernicht[B], Mouhamadou Bamba Sylla[C], Harald Kunstmann[A,B]

KIT Karlsruhe Institute of Technology · KIT-Campus Alpin IMK-IFU: Atmospheric Environmental Research · UNA
WASCAL West African Science Service Center on Climate Change and Adapted Land Use
Bundesministerium für Bildung und Forschung · DLR Projektträger

Climate projections for West Africa: highly needed but uncertain

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 to protect its constantly growing population. WASCAL (West African Science Service Center on Climate Change and Adapted Land Use, http://www.wascal.org) is a large-scale research-focused program designed to enhance the resilience of human and environmental systems to climate change and increased variability. An integral part of its climate services is the provisioning of a new set of high resolution, ensemble-based regional climate change scenarios for continental West Africa.

I. The WASCAL regional climate projections: experiment design

- Ensemble approach to determine uncertainty in regional climate simulations stemming from driving global circulation model and limited area model itself
- Multi-model mean and spread of ensemble describe the most likely projection and the uncertainty (e.g., CMIP5, CORDEX)
- Three global circulation models (GCM) and three regional climate models (RCM) for RCP4.5; historical runs and control runs using re-analysis data

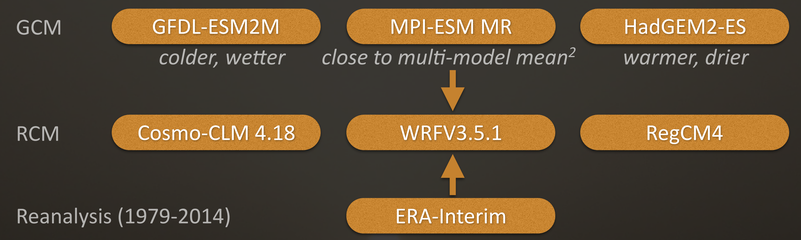


Fig 1. WASCAL experiments: historical (1979-2005) and RCP4.5 (2006-2100) runs

II. The WASCAL WRF simulations: model and domain setup

- West African Summer Monsoon as governing meteorological feature
- Large domain centered over West Africa to capture monsoon dynamics and to generate the mesoscale convective cells (Brown and Sylla ,2012)
- High spatial resolution of 12km with 5:1 nesting to provide added value
- Spectral nudging to keep the outer domain aligned with the driving model
- Large set of output variables on pressure levels provided every 3hr model time

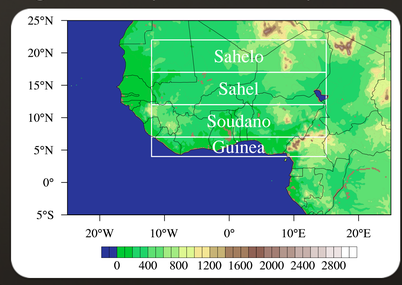
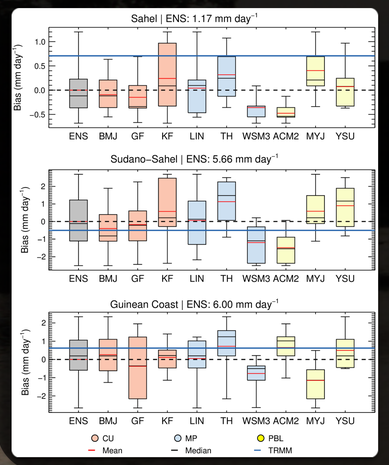


Fig. 2. Inner domain d02, 500x330x40 grid points, terrain height in m.

III. Towards a regional climate modeling system for West Africa

- Optimal model configuration for each RCM to reduce biases and reproduce the observed annual cycle of the West African monsoon precipitation
- Performance study of 29 WRF model configurations with respect to monsoon dynamics, precipitation patterns, temperature distribution and large-scale wind systems (Klein et al., 2015)
- CORDEX WA setup for Cosmo-CLM runs (Panitz et al., 2012)
- Sylla et al. (2010) setup for RegCM runs



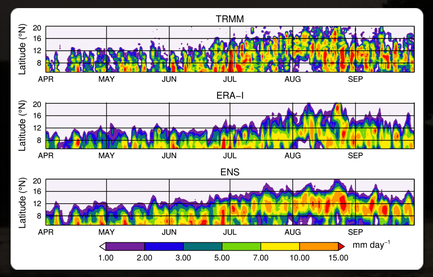
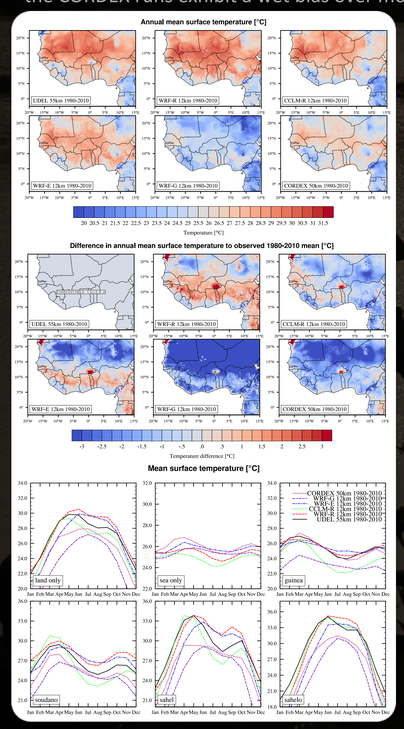
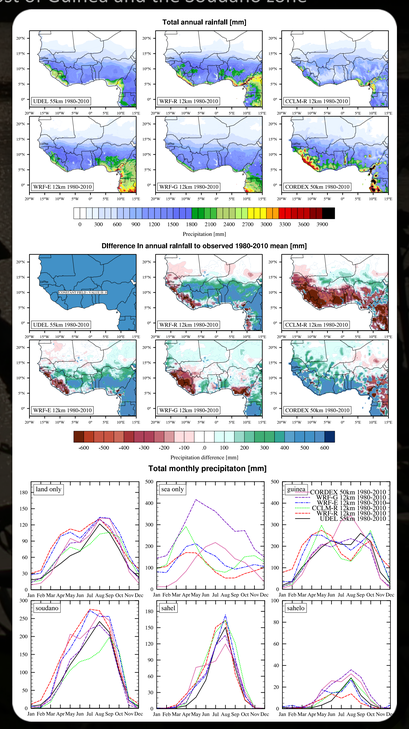


Fig 3. (left) Box plots of rainfall bias wrt. ensemble mean. CU schemes mostly affect sub-daily individual events, MP the amount of rainfall and PBL the position of the rain band. (top) Hovmöller diagrams of 1999 daily rain (Klein et al., 2015).

IV. Model validation: historical and control runs 1980-2010

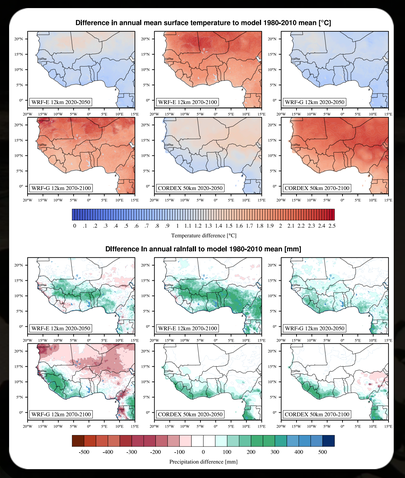
- WRF at 12km, driven by ERA-Interim (R), MPI-ESM MR (E) and GFDL-ESM2M (G)
- CCLM at 12km, UDEL observations, CORDEX-RCA4 ensemble (Colins et al., 2012)
- Observed mean surface temperatures are matched best by the WRF/CCLM-R control runs and WRF-E, the GFDL-driven model WRF-G shows a strong cold bias
- Monthly rainfall over WA is closest to UDEL for the WRF-G historical run, the WRF-R/E runs over-predict rainfall in Central Africa. The CCLM run shows a distinct dry bias, while the CORDEX runs exhibit a wet bias over most of Guinea and the Soudano zone

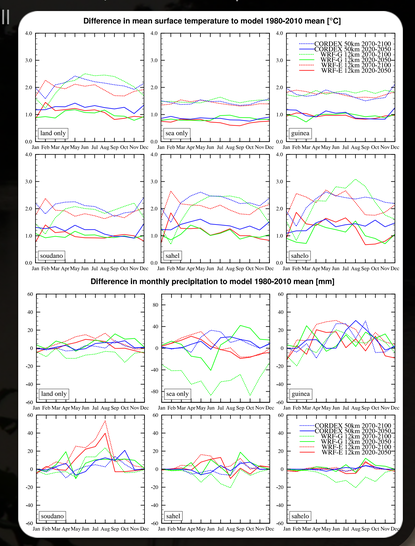




V. First projections: a warmer, but wetter or drier future?

- WRF-E, WRF-G and CORDEX show a warming signal of 2°C by the end of the 21st century
- WRF-E indicates an increase in rainfall for most of WA, while WRF-G predicts drier Sahel and Sahelo zone and an increase in rainfall along the coast - CORDEX lies in between





So, where is my added value?

Our historical runs indicate that the 12km models reproduce the annual cycle in temperature and rainfall better than existing CORDEX runs and provide more accurate results for the sub-saharan regions. The projected rise in temperature is consistent among all models. The spread in projected rainfall for different forcing data and/or regional models suggests to increase the ensemble size with further combinations of GCMs and RCMs and novel modelling approaches on global, variable-resolution meshes for a better estimation of the uncertainty. With a higher resolution in time and space, our data can also serve as input for further downscaling experiments at convection-resolving resolution (code available).

Affiliations

[A] Karlsruhe Institute of Technology (KIT), Institute of Meteorology and Climate Research, Garmisch-Partenkirchen, Germany
[B] Augsburg University, Chair for Regional Climate and Hydrology, Department of Geography, Augsburg, Germany
[C] WASCAL Competence Center, Ouagadougou, Burkina Faso

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