Regional climate simulations for West Africa: comparison of input bias correction methods

Dominikus Heinzeller[1] (heinzeller@kit.edu), Harald Kunstmann[1,2]
[1] Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research
[2] Augsburg University, Department of Geography

Abstract. Regional climate simulations are valuable tools to study climate change on local scales, yet do they often carry large biases. These stem from the bias of the regional model itself and from the bias of the driving global model. In this project, we developed a program to correct the global model data prior to ingesting it into the regional climate model.

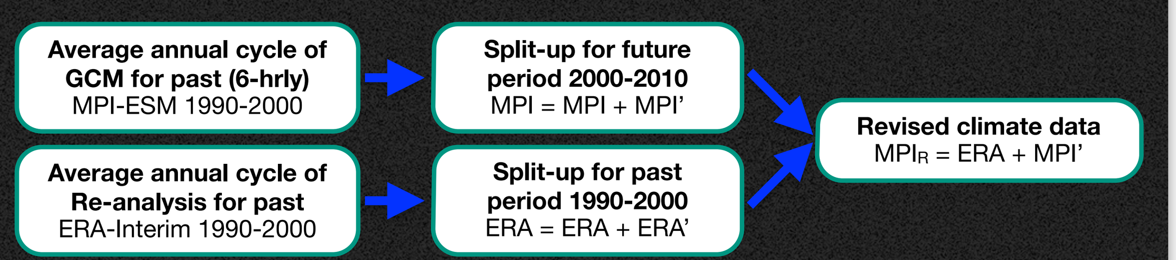
Climate projections for West Africa: highly needed, highly uncertain

West Africa is mostly covered by semi-arid regions with a strong variability in rainfall. The West African monsoon precipitation response to future anthropogenic climate change is highly uncertain, not least due to a large spread among the climate projections. Regional climate models (RCMs) are applied at higher resolution than global climate models (GCMs) and have a better representation of local processes and land surface variations. Yet, RCMs often have large biases, which stem from the regional model itself and from the GCM which serves as forcing data. One way to improve the regional models is to correct the bias of the GCM before ingesting it into the regional model. Different methods can be used for this purpose, among which we have chosen two currently favored approaches.

Implementation and comparison of two bias-correction methods

Both methods rely on re-analysis data as truth field for a past reference period and differences of a GCM between a future application period and the reference period. The PGW (1) method allows to see how current weather would look like in the future without large changes to the atmospheric circulations. The PAC (2) method allows changes in circulation and local weather.

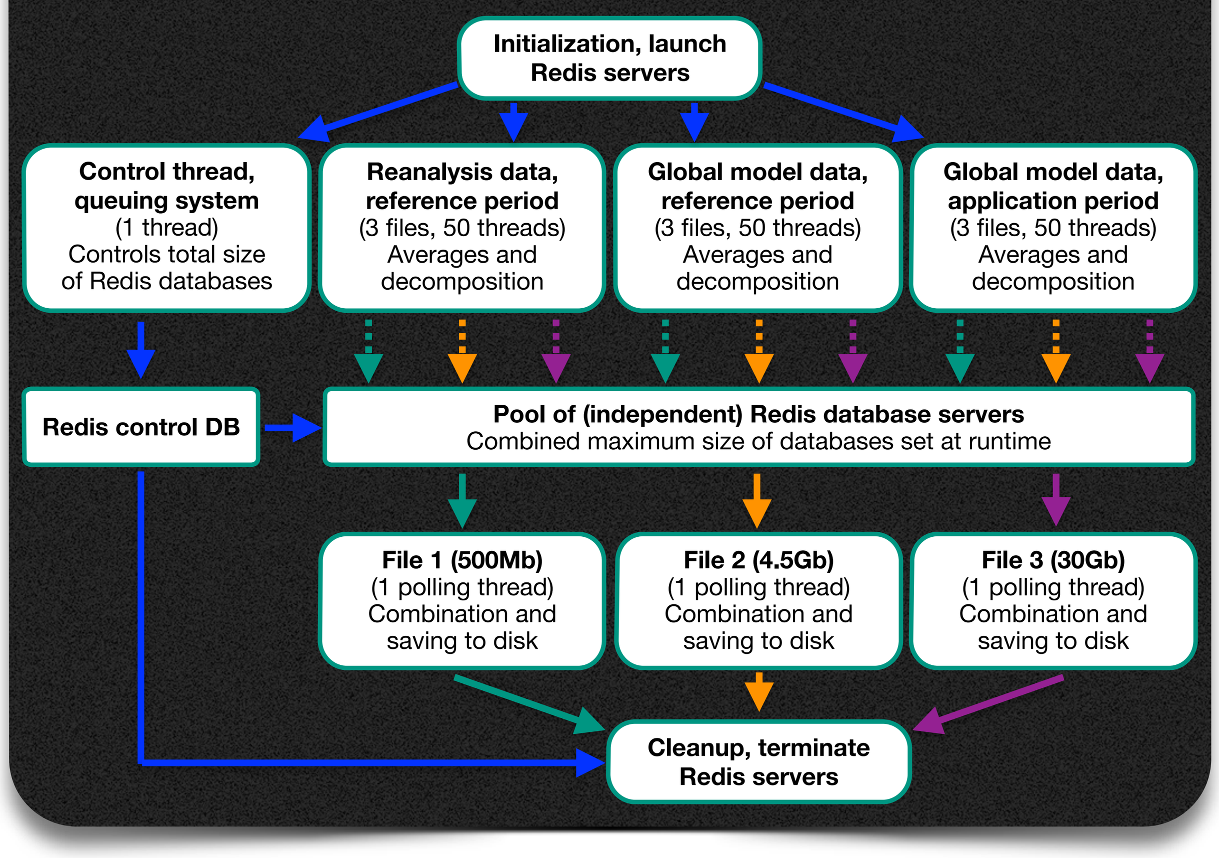
(1) Pseudo-global warming Rasmussen et al. (2011)



(2) Perturbed average climate Done et al. (2012)

Parallelization and queuing realized with Python and Redis

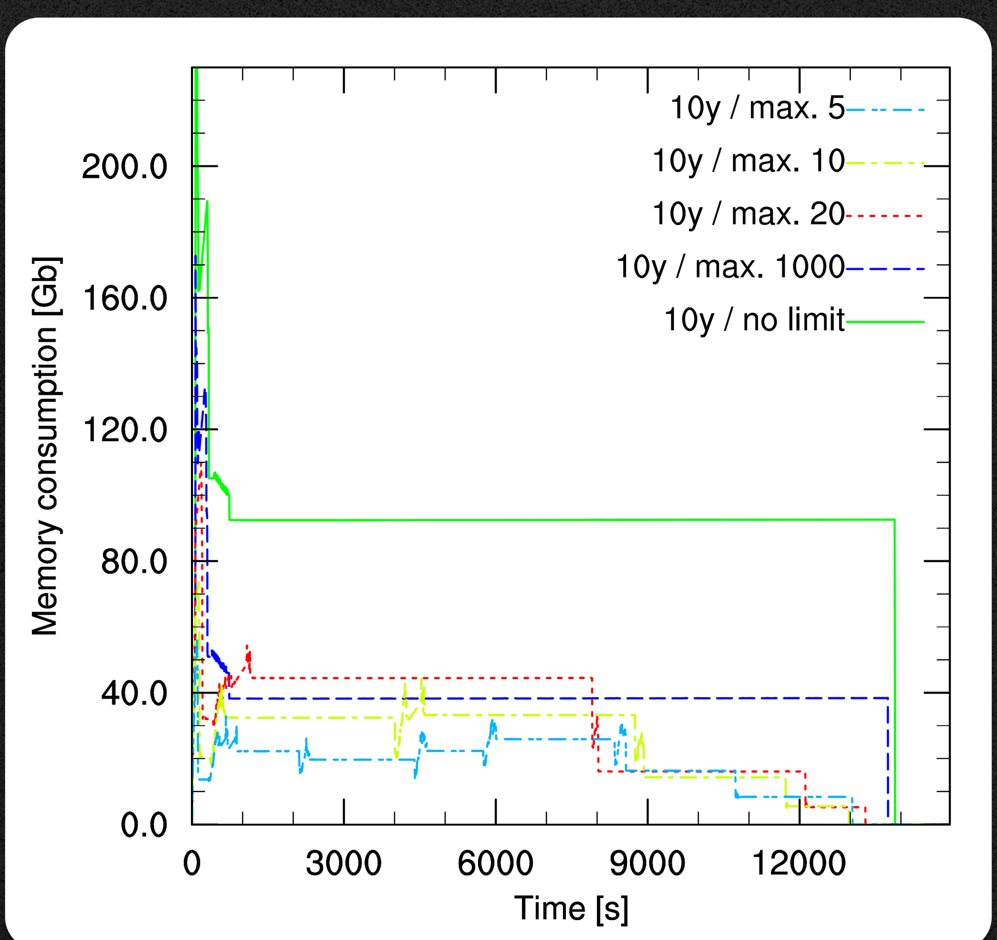
The program is parallelized as a private-memory code in Python. Exchange of data and queueing are implemented with the NoSQL DB Redis. A unit testing suite facilitates further development. The last bottleneck is writing the output to disk.



Random access memory usage regulated through size of queue

A runtime parameter regulates the maximum size of the queue. Read threads are blocked if this limit is reached. The 3 polling write threads access the queue without limitation and remove the data, combine it and write it to disk.

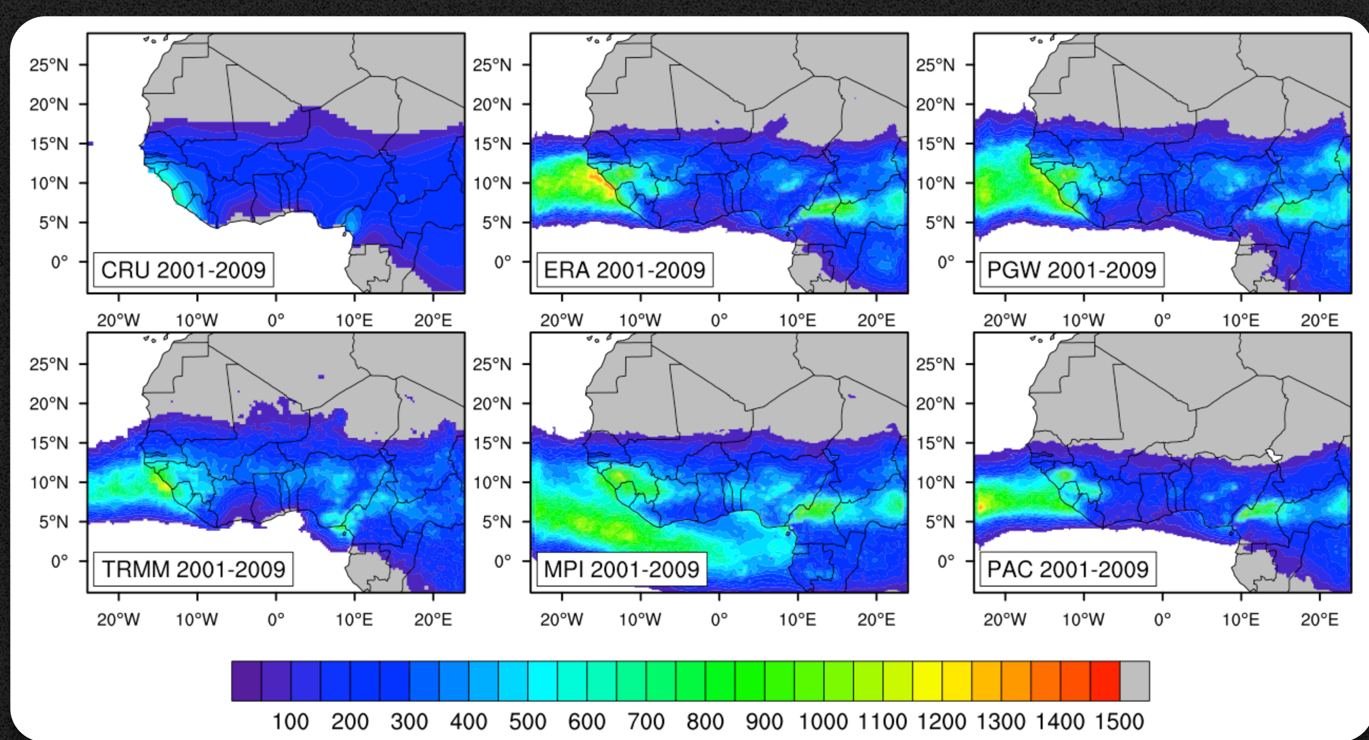
Max. queue size	Peak mem.	Runtime
no limit	230Gb	231m 21s
1000	180Gb	229m 02s
20	110Gb	221m 38s
10	75Gb	216m 12s
5	56Gb	217m 25s



Scientific validation of bias correction methods with 10-year long simulations

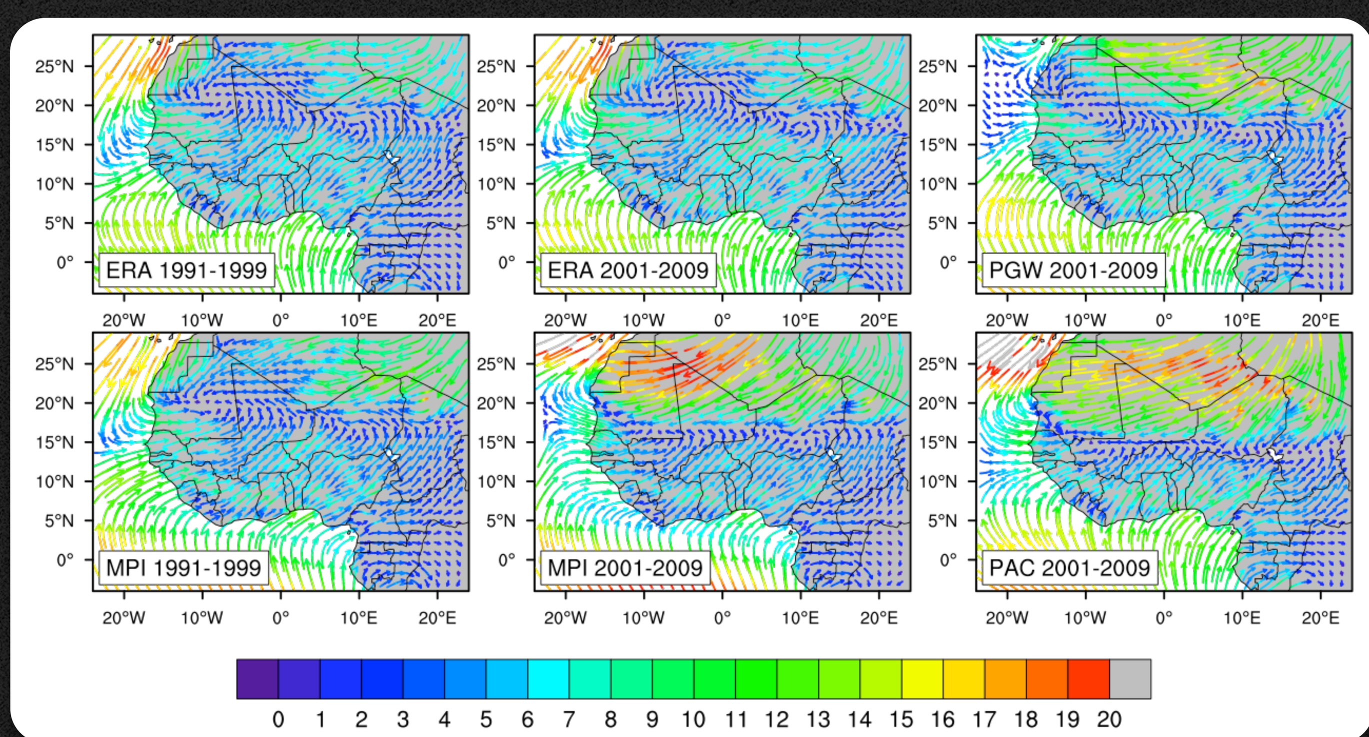
Regional climate simulations were conducted for a period of ten years for six lateral boundary conditions: ERA-Interim re-analysis 1990-1999 and 2000-2009, uncorrected MPI-ESM Echam6 GCM 1990-1999 and 2000-2009, PGW 2000-2009, PAC 2000-2009. Model results are compared to observational data sets for temperature and precipitation. A detailed analysis will be published in a forthcoming paper.

The climate and in particular the annual rainfall cycle in West Africa are dominated by the monsoon. This seasonal movement of the rain band from South to North peaks in August over the Sahel zone (12-18°N). On the right, we compare average rainfall (top) and average wind fields (bottom) for August for 9 simulation years. Model runs ERA, PGW match the observations (CRU, TRMM) well. MPI has too much rain over the Gulf of Guinea (sea surface temp. too high) and too little rain in the Sahel. PAC underestimates rainfall in the Sahel by far.



Average monsoon rainfall [mm] in August for 2001-2009

Analysis of the wind fields shows a large change in circulation in the MPI GCM data between these decades. PGW follows ERA to some extend, PAC is closer to MPI. The bias correction of sea surface temperature in PGW and PAC leads to weaker and drier monsoon winds (from SW), which for PAC allows the dry Harmattan winds (from NE) to penetrate further South. This suggests PGW to be superior. But, while the change in circulation in MPI is not reality for 2000-2009, it may be in the future. If so, PGW would remove valuable information!



Average wind speed [m/s] and direction in August for 2001-2009

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