Project: **1439**

Project title: **WaRisCo - Water Risks and Resilience in Urban-Rural Areas in Southern Africa**

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Report period: **2025-07-01 to 2026-04-30**

Project report

The work on the ongoing project WaRisCo (see initial proposal) was delayed due to the late appointment of an employee for carrying out the model simulations. However, in this reporting period the convection permitting regional climate model REMO-NH has been tested for the WaRisCo domain WRC-3 to find out the best setup for the simulations. Furthermore, the evaluation runs EVAL_WAR-22 and EVAL_WAR-03 have been completed and first results are analysed.

To prepare convection permitting climate projections using the REMO-NH model, test simulations were conducted for the WRC-3 model domain (see Fig. 1), which covers the eastern part of South Africa. These simulations were performed using double nesting (intermediate domain: AFR-22) and ERA-5 forcing for the year 1990 and compared with CHIRPS precipitation data. The standard configuration (DIFF2) for REMO-NH results in a very strong positive bias of up to 10 mm/day during the SON and JJA seasons (see Fig. 2a). To improve the results, the parameterization of horizontal turbulent exchange was tested, as this has a strong influence on the development of convective clouds—and thus on convective precipitation—via entrainment. In the standard configuration, this is implemented using simple second-order diffusion. REMO-NH also offers the option of fourth-order diffusion. However, a simulation using this diffusion (DIFF4) even increases the bias (Fig. 2b), and thus this option proves unsuitable. Finally, a 3-dimensional turbulence scheme was developed for REMO-NH that describes horizontal turbulent exchange through local shear production. The simulation using this scheme (TURB3D) shows a much smaller precipitation bias (Fig. 2c). Therefore, this configuration was selected for the evaluation run EVAL_WAR-03. In addition to the advantage of more realistic precipitation modeling, the 3D turbulence scheme has the disadvantage of longer computation time, which increases by approximately 50% due to the necessary shorter time step.

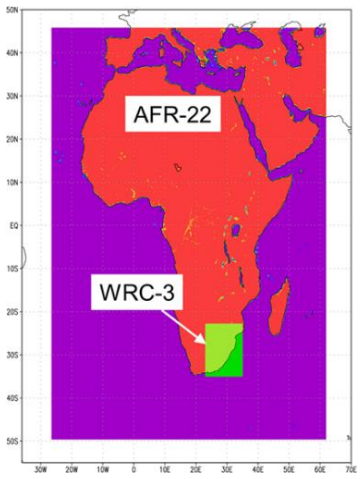

Fig. 1: Model domains AFR-22 and WRC-3 which are used for double nesting of REMO/REMO-NH.

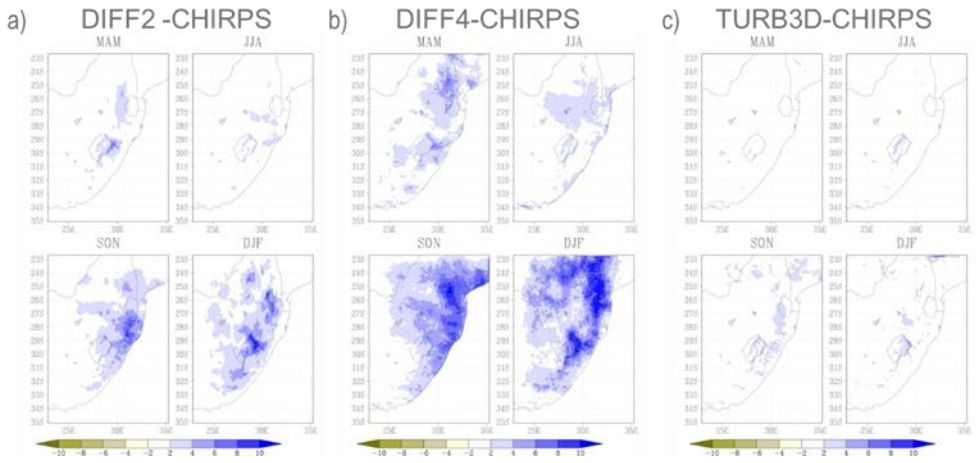

Fig. 2: Bias of the average daily precipitation (mm/day) of the different seasons for the test simulations with REMO-NH with respect to CHIRPS. a) Simulation DIFF2, b) Simulation DIFF4 and c) Simulation TURB3D.

To prepare the ERA5 evaluation run, the REMO model with a resolution of approximately 24 km was directly driven by ERA-5 and time-integrated over the period 1979–2024 for the AFR-22 domain (Fig. 1). According to the concept of double nesting, the results of the AFR-22 run serve forcing for the REMO-NH with 3km resolution for the domain WRC-3 (Fig. 1). This run was divided into two time slices 1990-2013 and 2013-2024 to save time. In addition, the entire integration period was shortened from 1979-2024 to 1990-2024 due to the longer computing time required and the limitation of the quota by the DKRZ. These simulations were completed in March 2026. Fig. 3 on the left shows the deviation of the climate mean from precipitation over the period 1991-2010 by CHIRPS for the different seasons. The DJF season is too dry with deviations of up to 4mm/d. This bias was not yet evident in the test simulation over the year 1990 (see Fig. 2). The comparison of the climate mean of the 2m temperature with ERA5-Land values (Fig. 3 right) shows a positive bias. This is strongest in the JJA season. In addition, it occurs more frequently in valleys. There may also be an error in the reanalysis here, as the orography is insufficiently resolved. Since the focus of the project is on the hydrological cycle, the temperature bias is of secondary importance.

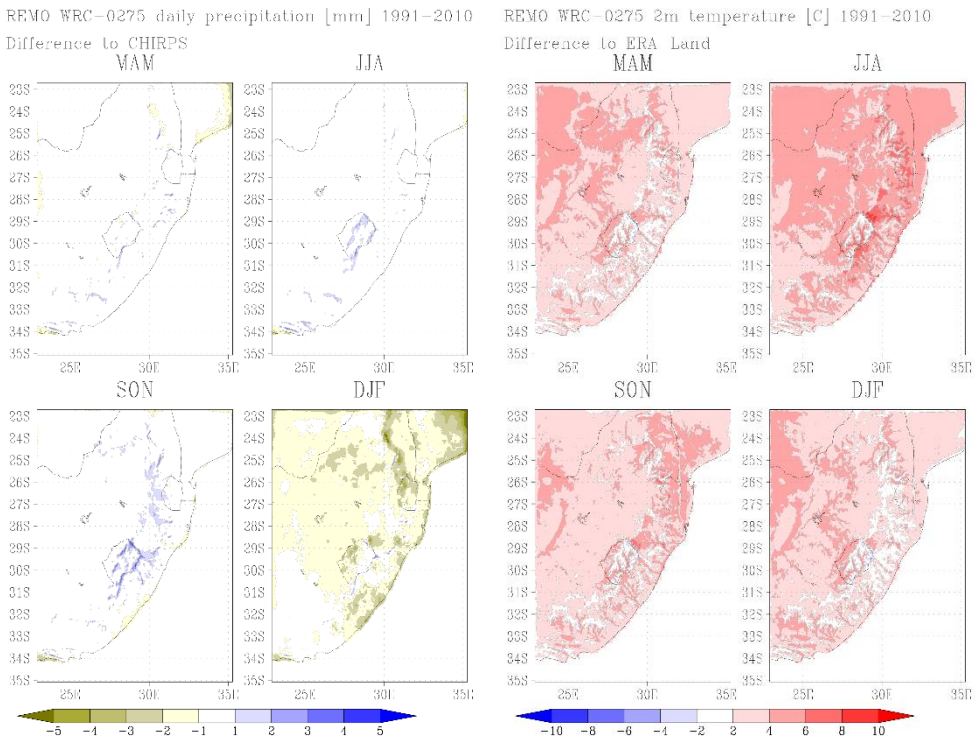

Fig. 4 Left: Deviation of the 1991–2010 climate mean of precipitation [mm/day] from CHIRPS for the convection-allowing simulation with REMO-NH over the WRC-3 domain. Right: Deviation of the climate mean of the 2 m temperature [K] over the period 1991–2010 from ERA-Land for the convection-permitting simulation with REMO-NH over the WRC-3 domain.

In addition to the implementation of the ERA-5 evaluation run, a scenario run was prepared. This is based on the SSP3-70 scenario and is driven by the ESM EC-Earth3. The driving data from 1970 to 2100 were downloaded from the ESGF portal and pre-processed for the AFR-22 domain. The proposed simulations HIST_WAR-22 and FUT_WAR-22 (see previous proposal) are driven with this ESM and the run will be finalized in May 2026.