Project: **1340**

Project title: **Long-term simulations with improved and extended REMO versions**

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Report period: **2023-11-01 to 2024-10-31**

Thanks to the DKRZ resources for 2024 we have been able to run the regional climate model REMO for AFR-44 and a new defined domain WAF-11 (see figures below) effectively, which has led to significant insights regarding the climate in West Africa. These findings not only enhance our understanding of the regional climate dynamics but also contribute to the ongoing improvements of REMO where we did some sensitivity studies with different soil data sets, parametrisations, soil hydrological scheme, and first test with a new vegetation module.

Figure 1 presents results from the benchmark runs of REMO covering the 30-year time period of 1981-2010 using already the new soil hydrological scheme (5layer). The figure shows the trend of precipitation [mm/decade] for era5land (used as validation data) and the AFR-44 compared to WAF-11 model run. Dots highlight significant trends with alpha = 5%. We can conclude that the higher spatial resolution model run has a better overall agreement with era5land than the AFR-44. Nevertheless, the benchmark run of WAF-11 still differs in sign compared to the validation data in some parts of the domain which is a signal that there is room for improvement.

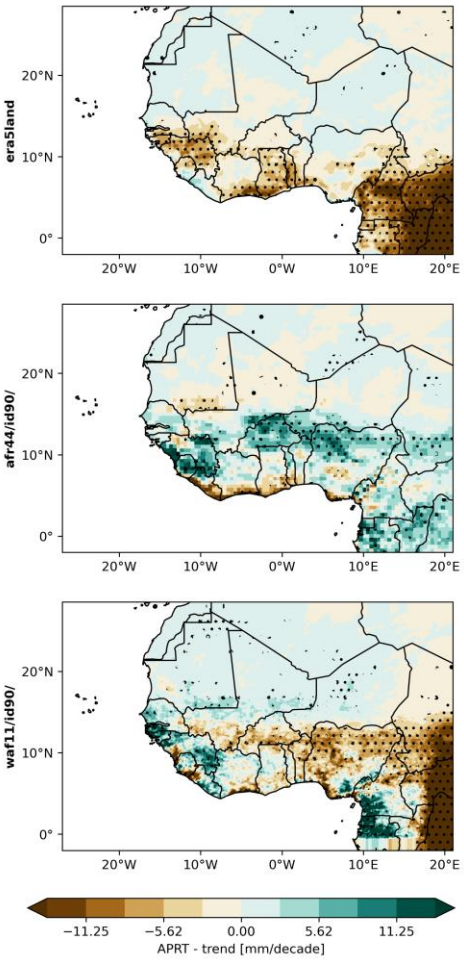
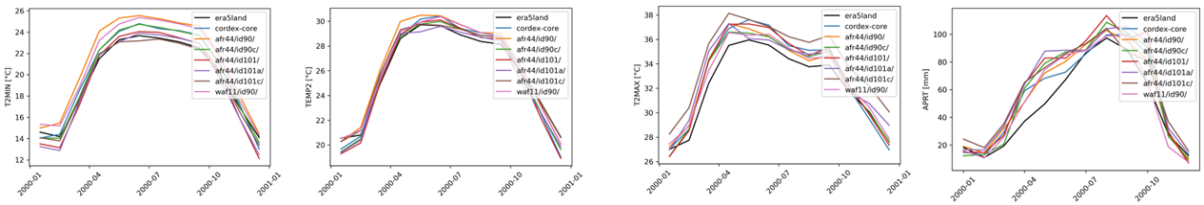


Figure 1: Trend of benchmark runs for precipitation (1981-2010), dots mark significant (alpha = 5%) values.

Figure 2 shows six of the done model sensitivity runs compared to era5land and the corresponding CORDEX-CORE AFR-22 (without 5layer) simulation from REMO as spatial mean of the WAF-11 domain per month for minimum (T2MIN), mean (TEMP2), maximum (T2MAX) temperature, and precipitation (APRT). In terms of temperature (especially T2MIN) the more advanced model simulations (afr44/101[a/c]) perform better than the benchmark runs compared to era5land. For TEMP2 all simulations are good and for T2MAX we still see a positive model bias (with the afr44/id101c getting worse than previous model versions). For precipitation, all REMO versions still have a bigger bias for the months April-June compared to the other months, hence using the 5layer scheme does not affect the spatial mean performance for precipitation even if other variables (not shown) do vary significantly.



Afr44/id90: GTOPO/FAO/5lay/noimove/
Afr44/id90c: GTOPO/Soilgrid/5lay/noimove/ltemp=false, layer_total=false, soil=true (=texture)
Afr44/id101: GTOPO/FAO/no5lay/noimove/
Afr44/id101a: GTOPO/Soilgrid/5lay/noimove/ltemp=false, layer_total=false, soil=true (=texture)
Afr44/id101c: GTOPO/Soilgrid/5lay/noimove/ltemp=true, layer_total=true, soil=false (=sand/clay/org)
Waf11/id90: GTOPO/FAO/5lay/noimove/

Figure 2: Different sensitivity studies for the year 2000

Figure 3 shows a result of the iMOVE studies done in LANDSURF. This is the spatial summary for AFR-44 of the input file of plant functional types (PFT) that needs to be prepared for a REMO-iMOVE run. Here, a 30-year running mean of ERA5Land is used to calculate the Holdridge classification and combine them with a global land cover map to get the listed PFTs. Previous test with REMO-iMOVE (only done for Europe and in a small area of Central Asia) did only use CRU (0.5° instead of 0.1° of ERA5Land) and did not use the running mean, which is quite important, especially for Africa, as we see that e.g. the tropical broadleaf evergreen trees PFT increases in area over time.

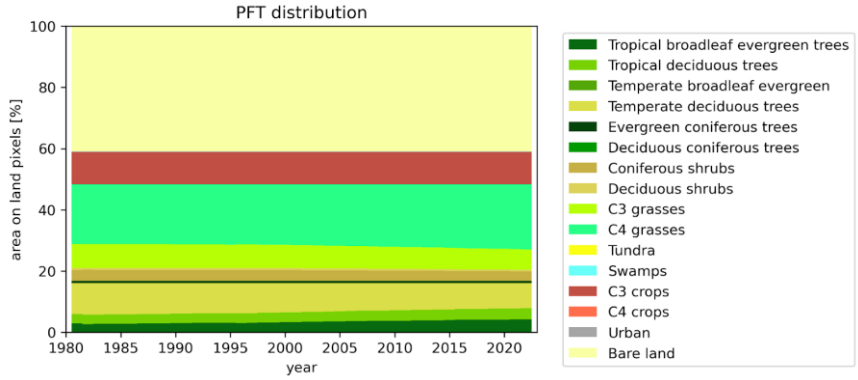


Figure 3: Distribution of the 16 PFT classes for AFR-44 (with ERA5Land, 30a running mean) for 1981-2022

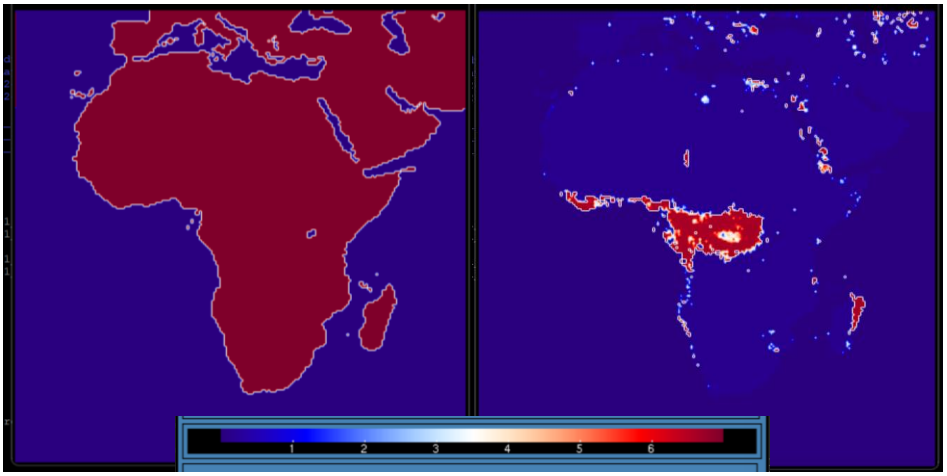


Figure 4: LAI of PFT1 (Tropical broadleaf evergreen trees), left: at the beginning of the sensitivity run 1st January, right: at 31st of January

Figure 4 shows the LAI (leaf area index) for PFT1 of a sensitivity run of REMO-iMOVE where we set 100% tropical trees in entire Africa at the beginning of the model run to see what effect this has on the climate. However, after only 1 month running time, the model let the rainforest die because the 'climatological' conditions do not fit to the vegetation class. The right subfigure shows the remaining fractions on 31st January. It demonstrates that there are only areas around the equator and in Madagascar left with a high LAI value > 6m^2/m^2 indicating that there are still some tropical evergreen trees left. Similar studies were performed for different PFTs to be able to compare these effects and learn more about the sensitivity of REMO-iMOVE to input masks and how these are processed within the model.

Some of the results of the research done in LANDSURF were collected in a scientific paper that is currently under review with 'Environmental Research: Climate'.