The importance of radiation in regional climate models for Africa

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SUMMARY

The representation of the surface radiation budget is important in climate modeling, as well as in hydrological and vegetation modeling. Our studies show that:

1) the radiation budget for Africa is simulated with large uncertainties in regional climate model simulations
2) these uncertainties influence the simulation of the West African Monsoon (WAM) and
3) simple considerations of topographic effects can improve regional models

UNCERTAINTIES[1]

- There are large errors in radiation flux components simulated by regional climate models for Africa (Fig. 1)
- Quantifications of the impact of errors in cloud fraction (ΔCFR), surface albedo (ΔALB), and surface temperature (ΔTS) on net radiation fluxes showed:
  - ΔCFR and ΔALB explain more than 50 % of the uncertainty in the short-wave radiation components; ΔCFR is predominant over the ocean but over land ΔCFR and ΔALB have similar impacts (Fig. 2)
  - In long-wave spectrum strong influence of ΔCFR (> 60 %) and negligible impact of ΔTS in oceanic regions; comparable impact of ΔCFR and ΔTS over land (≈ 30 %)
  - ΔALB most important factor for uncertainties in the Sahara and Sahel region

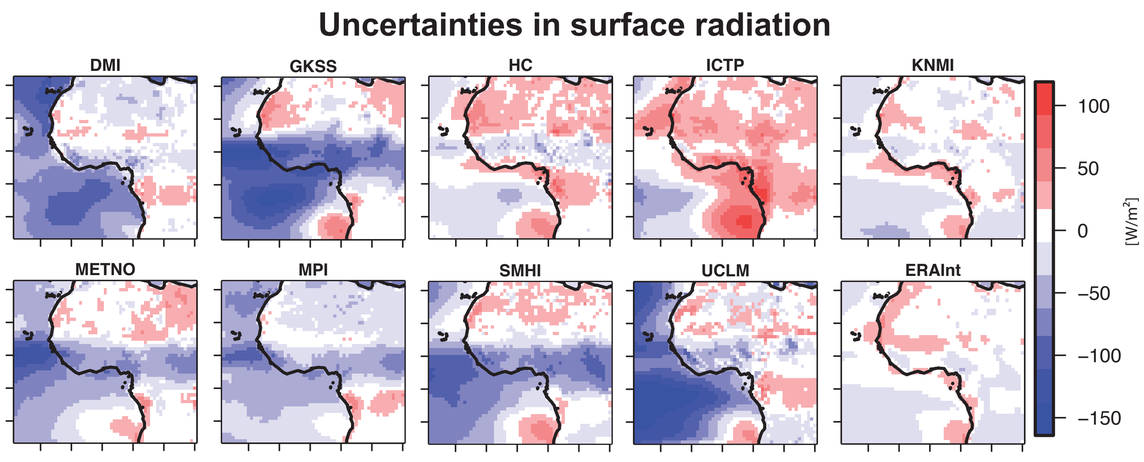

Figure 1 Differences in surface net short-wave radiation (W/m²) of RCM simulations and ERA-Interim to SRB satellite-based data for the mean summer (June to August, 1990–2006).

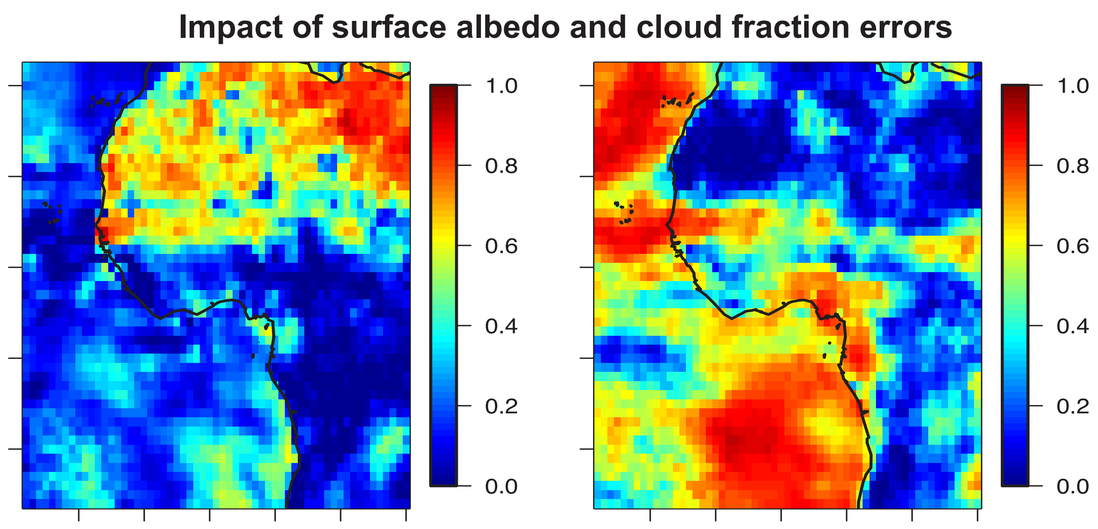

Figure 2 Explained variances of radiation errors attributable to uncertainties in surface albedo ΔALB (left) and cloud fraction ΔCFR (right). Shown are exemplary results for the RegCM of the ICTP.

WEST AFRICAN MONSOON[2]

- Our evaluation showed that the regional climate model COSMO-CLM is able to reproduce main features of the WAM and that the model adds value on global model simulations (Fig. 3)
- But, there are errors in simulated precipitation (Fig. 3) or convection
- Sea surface temperature and strength of Saharan heat low have crucial influence on WAM
- Saharan heat low is overestimated due to errors in surface radiation

REFERENCES

[1]Kothe, S. & B. Ahrens, 2010: On the Radiation Budget in Regional Climate Simulations for West Africa. J. Geophys. Res., in press
[2]Kothe, S. & B. Ahrens, 2011: Analysis of the West African Monsoon system in the regional climate model COSMO-CLM. submitted to Climate Dynamics
[3]Kothe, S. & B. Ahrens, 2011: The influence of topography on the simulated radiation in a regional climate model. undern preparation

"There are errors, which have an impact on results, but we can fix some of them."

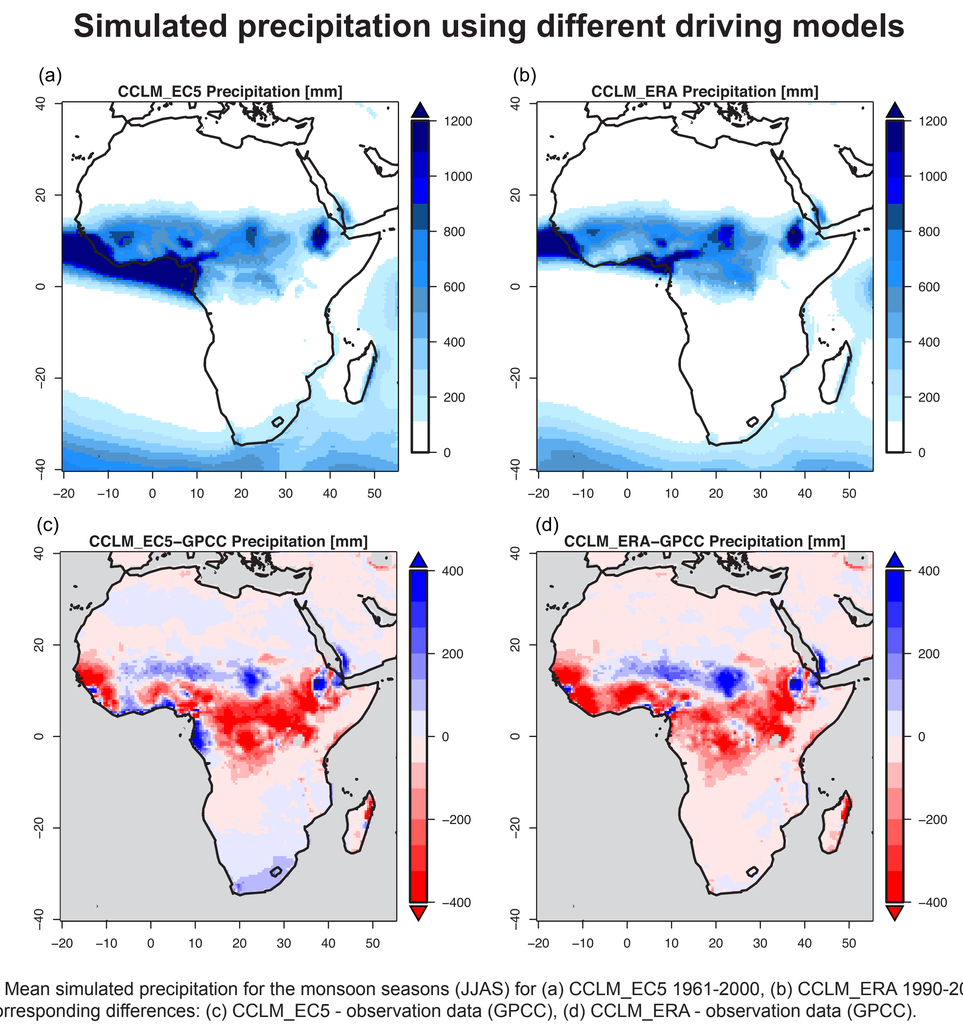

Figure 3 Mean simulated precipitation for the monsoon seasons (JJAS) for (a) CCLM_EC5 1961-2000, (b) CCLM_ERA 1990-2008, and the corresponding differences: (c) CCLM_EC5 - observation data (GPCC), (d) CCLM_ERA - observation data (GPCC).

INFLUENCE OF TOPOGRAPHY[3]

- Simple consideration of topographic effects on surface albedo and direct solar radiation to enhance the currently simplified parameterization (Fig. 4)
- Adding of a strong and weak zenith angle dependence of surface albedo for direct parallel radiation and topographic correction of direct solar radiation at the surface have regional impact of more than 1 K (not shown)

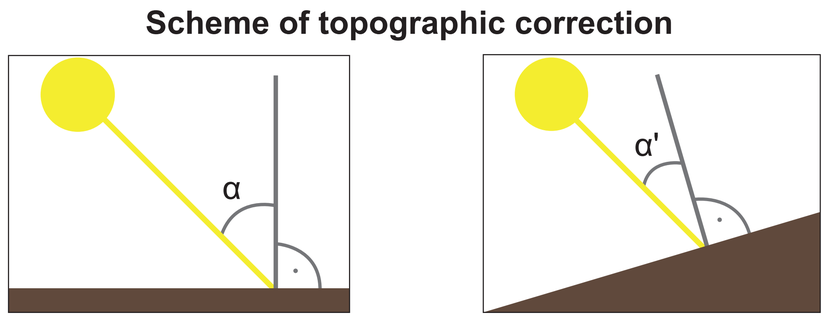

Figure 4 Incidence of solar parallel radiation: Simplified only for horizontal planes (left) and enhanced including sloping topography (right).

OUTLOOK

- Evaluation of new surface albedo parameterization and of final model setup within the COSMO-CLM (www.clm-community.eu) and the CORDEX (wcrp.ipsl.jussieu.fr/RCD_CORDEX.html) communities
- Realization of regional climate projections for the next IPCC assessment report and the BiK-F Climate Atlas (cf. Fig. 5)

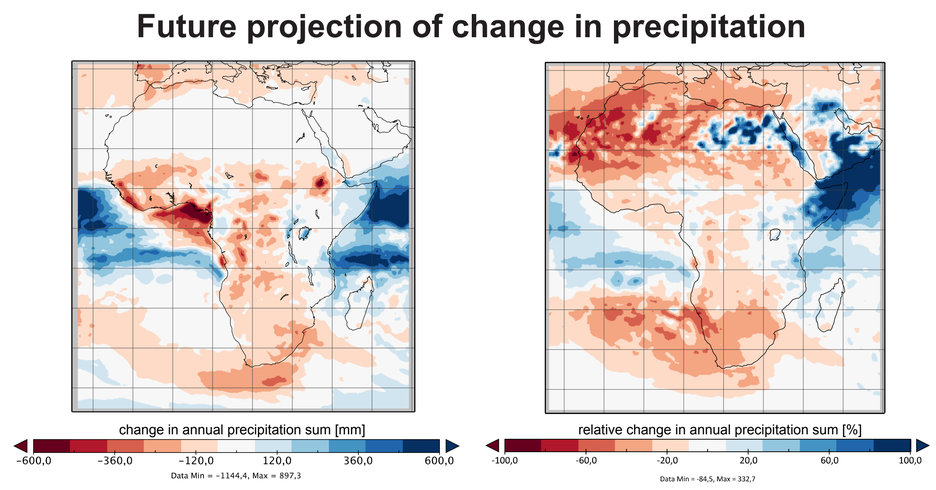

Figure 5 Absolute (left) and relative (right) change in mean simulated precipitation for the time period 2071-2100 with respect to control period 1961-1990.