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numerical simulations of Surface Solar Radiation over southern Africa for the past and future

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This study evaluates the possible impacts of climate change on Surface Solar Radiation (SSR), as a renewable energy resource, in Southern Africa (SA). Performance of climate models in reproducing the mean states and long-term trend of SSR are assessed by validating five Regional Climate Models (RCM) that participated in the Coordinated Regional Downscaling Experiment program over Africa (CORDEX-Africa) along with their ten driving General Circulation Models (GCMs) from the Coupled Model Intercomparison Project Phase 5 (CMIP5) over SA. Then the possible impacts of climate change on SSR are evaluated. The uncertainties in the GCM-RCM model chains have also been quantitatively estimated.

Results show that in the past (1) GCMs overestimate SSR over SA in terms of their multi-model mean by about 1 W/m^2 (compensation of opposite biases over sub-regions) and 7.5 W/m^2 in austral summer and winter respectively compared to SARAH-2 (Surface Solar Radiation Data Set—Heliosat Edition 2); However, RCMs underestimate SSR in both seasons with Mean Bias Errors of about −30 W/m^{2}in austral summer and about −14 W/m^2 in winter. And the discrepancies in the simulated SSR are larger in the RCMs than in the GCMs. (2) In terms of trend during the "brightening" period 1990–2005, both GCMs and RCMs (driven by ERA-Interim and GCMs) simulate an SSR trend of less than 1 W/m^2 per decade. However, variations of SSR trend exist among different references data. (3) For individual RCM models, their SSR bias fields seem rather insensitive with respect to the different lateral forcings provided by ERA-INTERIM and various GCMs, in line with previous findings over Europe.

In future, (1) multi-model mean projections of SSR trends are consistent between the GCMs and their nested RCMs. Two areas with statistically significant SSR changes are found: over the center of SA, GCMs and RCMs project a statistically significant increase in SSR by 2099 of about +1.5 W/m^2 per decade in RCP8.5 during the DJF season. Over Eastern Equatorial Africa a statistically significant decrease in SSR of about −2 W/m^2 per decade in RCP8.5 is found in the ensemble means in DJF. (3) SSR projections are fairly similar between RCP8.5 and RCP4.5 before 2050 and then the differences between those two scenarios increase up to about 1 W/m^2 per decade with larger changes in RCP8.5 than in RCP4.5 scenario. (4) These SSR evolutions are generally consistent with projected changes in Cloud Cover Fraction over SA and may also related to the changes in atmosphere water vapor content. (5) SSR change signals emerge earlier out of internal variability

estimated from ERA-Interim in DJF in RCMs than in GCMs, which suggests a higher sensitivity of RCMs to the forcing RCP scenarios than their driving GCMs in simulating SSR changes. (6) The uncertainty in SSR change projections is likely dominated by the internal climate variability before 2050, and after that model and scenario uncertainties become as important as internal variability until the end of the 21st century.