EMS Annual Meeting Abstracts
Vol. 20, EMS2023-148, 2023, updated on 20 May 2024
https://doi.org/10.5194/ems2023-148
EMS Annual Meeting 2023

Renewable Energy Potential Estimates Based on High-Resolution Regional Atmospheric Modeling over Southern Africa

Shuying Chen[1,2,3], Stefan Poll[2,4], Harrie-Jan Hendricks-Franssen[1,2], Heidi Heinrichs[3], and Klaus Goergen[1,2]
[1]Forschungszentrum Jülich GmbH, Institute of Bio- and Geosciences - Agrosphere (IBG-3), 52425 Jülich, Germany
[2]Centre for High-Performance Scientific Computing in Terrestrial Systems, Geoverbund ABC/J, Germany
[3]Forschungszentrum Jülich GmbH, Institute of Energy and Climate Research - Techno-economic Systems Analysis (IEK-3), 52425 Jülich, Germany
[4]Forschungszentrum Jülich GmbH, Jülich Supercomputing Centre - Simulation and Data Laboratory Terrestrial Systems, 52425 Jülich, Germany

Three-quarters of the global population that lacks reliable electricity supply lives in Africa, despite the fact of large untapped wind and solar energy potentials on the African continent. Using renewable energy to bridge the power supply gap in Africa also means a possibility to address climate change mitigation at the same time. Reliable, highly resolved spatio-temporal information on renewable energy potentials (REP) is albeit imperative for developing strategies for solar and wind energy expansion. Applying atmospheric datasets over Africa to REP estimations face challenges like data gaps in space and time, relatively coarse spatial resolution, and data quality. With the aim to produce a reliable atmospheric dataset for REP simulations at high spatial and temporal resolution, we conducted dedicated convection-permitting atmospheric simulations for a study domain in southern Africa, which features favorable meteorological conditions for solar and wind energy generation. Based on an evaluation study, further investigations on the added value of km-scale resolution for REP estimations will be shown.

In a dynamical downscaling setup, the ICOsahedral Nonhydrostatic (ICON) Numerical Weather Prediction (ICON-NWP) model v2.6.4 is run in limited area mode (ICON-LAM) with a weather forecasting configuration, driven by the operational 13km ICON global analysis from the German Weather Service (DWD). Our simulations cover the three years 2017 to 2019 at 3.3km resolution over a southern African model domain. To ensure a good agreement of the ICON-LAM simulations with observed weather over the large model domain, the atmosphere is reinitialized every five days with one preceding spin-up day, and the land surface as well as subsurface are run transiently.

Variables of 10m wind speed (sfcwind), surface solar irradiance (rsds), 2m air temperature (tas), and precipitation (pr) are extensively validated using satellite data, composite data products, and in-situ data from meteorological stations. Results show that ICON-LAM is capable of reproducing observations on temporally aggregated and hourly time scales. Typical seasonal meteorological

features are well reproduced during austral summer and winter. The average mean error (ME) for simulated hourly sfcwind is 1.12 (± 0.83) m s-1, and for 69% of the considered sites the correlation coefficients between observed and simulated hourly sfcwind are above 0.6. Simulated daytime rsds has an average ME of 50.8 (± 42.21) W m-2 and the mean daytime rsds correlation between observations and simulations is 0.87 (± 0.05); this indicates a well-represented daytime rsds variation in ICON-LAM simulations. A small bias is in the tas simulation with an average ME of 0.23 (± 0.99) °C. We also found the simulated monthly pr biases increasing from the West to the East of the model domain, following precipitation gradients associated with the general atmospheric circulation.