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Kilometer-scale regional atmospheric modelling reveals underestimation of onshore wind energy potentials over southern Africa

Shuying Chen[1,2,3], Klaus Goergen[1,3], Harrie-Jan Hendricks Franssen[1,3], Christoph Winkler[2,4], Yoda Wahabou[1], Stefan Poll[1], Jochen Linssen[2], Harry Vereecken[1], Detlef Stolten[2], and Heidi Heinrichs[2]
[1]Institute of Bio- and Geosciences - Agrosphere (IBG-3), Forschungszentrum Jülich, Jülich, Germany
[2]Institute of Climate and Energy Systems Jülich Systems Analysis (ICE2), Forschungszentrum Jülich GmbH, Jülich, Germany
[3]Centre for High-Performance Scientific Computing in Terrestrial Systems, Geoverbund ABC/J, Jülich, Germany
[4]Chair for Fuel Cells, Faculty of Mechanical Engineering, RWTH Aachen University, Aachen, Germany

Wind energy is one pillar towards a decarbonized future energy system. A precondition for an efficient expansion and deployment of wind turbines is reliable and highly resolved information on wind energy potentials. Such detailed information is for example rare in many parts of Africa where it is crucially needed to explore large untapped renewable energy potentials. This study used a new high-resolution, kilometer-scale meteorological data set from dedicated ICON model atmospheric simulations in limited area mode over southern Africa (ICON-LAM). The wind speeds at hub height and wind energy potentials from ICON-LAM, the commonly used ERA5, and a statistical downscaling variant of ERA5 using the Global Wind Atlas (ERA5_GWA) were compared. The wind speed evaluation against weather mast measurements shows that ERA5 and ERA5_GWA underestimate hub-height wind speeds with a mean error (ME) of −1.8 m s^{-1} (−27%) and −0.3 m s^{-1} (−4.7%), respectively, while ICON-LAM has a ME of −0.1 m s^{-1} (−1.8%). Noteworthily, ICON-LAM especially outperforms ERA5 and ERA5_GWA by a large margin in simulating the most relevant range of wind speeds (from 11 m s^{-1} to 25 m s^{-1}) for wind turbines. This leads to a 48% higher average wind energy potential derived from ICON-LAM compared to ERA5. Estimates based on the ERA5_GWA show a similar average wind energy potential to ERA5, resulting from the spatial heterogeneity of wind energy potential. Such an underestimation of wind energy potential may hinder local development and deployment of wind energy by undervaluing the economic payback, which again underlines the importance of using highly resolved atmospheric model simulations.