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How do climate models represent wind resources in Southern Africa and predict their future changes?

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As intermittent meteorological resources become increasingly vital in our energy system, it is crucial to better understand how a changing climate may affect weather variability and, in turn, influence future wind energy production. This study evaluates the performance of climate models in reproducing wind resources over Southern Africa (SA), and in assessing potential impacts of climate change. An ensemble of climate simulations is evaluated over SA, which includes simulations from three Regional Climate Models (RCM; i.e., CCLM4, RegCM4, and REMO2009) that participated in the Coordinated Regional Downscaling Experiment program over Africa (CORDEX-Africa) at a horizontal resolution of approximately 25 km, and the coarser-resolution ones from their four driving General Circulation Models (GCMs; i.e., HadGEM2-ES, MPI-ESM-LR, MPI-ESM-MR, and NorESM1-M) from the Coupled Model Intercomparison Project Phase 5 (CMIP5). The simulated wind is first compared to the reference datasets, derived from ground-based measurements and reanalyses, during 2000-2023 at 3-hour intervals, covering both surface and hub-height (100 m) levels. The performances of both RCMs and GCMs are quantified and compared in terms of their representation of wind resource characteristics, including the mean wind speed and its spatio-temporal variability at hourly-to-annual timescales. Then wind energy potential and capacity factors are also derived for the wind resource assessment in SA, where direct observational data is limited. Finally, the potential impact of climate change on the 100-meter wind energy potential in SA is assessed based on this ensemble of climate projections, up to 2099, under the RCP2.6 and RCP8.5 scenarios. This study helps to understand the performance difference between regional and global models in simulating wind resources and provides insight into how changing climate conditions might affect wind energy production over the long term in SA.