EGU22-5888
https://doi.org/10.5194/egusphere-egu22-5888
EGU General Assembly 2022

Inter-comparison of PV power simulations from seven gridded irradiance data sets

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Accurate irradiance data is necessary for model estimates of expected photovoltaic (PV) power production. Such data is freely available from reanalysis and satellite products with a high temporal and spatial resolution, including locations without ground-based measurements. Gridded irradiance data is therefore used for the characterization of solar resources at specific locations and larger areas, e.g. by power system modellers. Past assessments of irradiance data for PV modelling often relied on the evaluation of global horizontal irradiance (Q_{GHI}). However, the direct and diffuse irradiance components as well as differences in seasonal characteristics can strongly affect the PV capacity factors (C) potentially leading to larger biases in C than for Q_{GHI}. We therefore systematically assess differences in Q_{GHI}, direct and diffuse horizontal irradiance (Q_{dir} and Q_{dif}) and quantify the subsequent bias propagation from individual radiation components to C in a contemporary PV power model. Our PV model simulations use seven different gridded irradiance data sets, namely ERA5, COSMO-REA6, COSMO-REA6pp, COSMO-REA2, CAMS radiation service, SARAH-2 and CERES Syn1Deg. All data sets provide Q_{dir} and Q_{dif} as separate time series spanning seven to 43 years and with a temporal resolution of 15 minutes to one hour. The results are compared against seven years of simulations based on reference measurements from 30 weather stations of the German Weather Service. We compute metrics characterizing biases in seasonal and annual spatial means, day-to-day variability and extremes in C, considering single stations and a simulated PV fleet. Our results highlight biases of -1.4 % (COSMO-REA6) to +8.2 % (ERA5) in annual and spatial means of C at single stations across Germany, while the bias in Q_{GHI} is -3 % for COSMO-REA6 to +3.6 % for ERA5. We also show the bias on days of very low PV production, relevant for extreme event analysis: The days within the lowest ten percent of daily PV production in a PV fleet show a bias of +70.2 % in ERA5, while it is only +4 % in the post-processed COSMO-REA6 data (COSMO-REA6pp). SARAH-2 and COSMO-REA6pp outperform the other products for many metrics, but also cause some biases in C. For instance, SARAH-2 yields good results in summer, but overestimates C in winter by 16 % averaged across all stations. COSMO-REA6pp represents day-to-day variability in C of a simulated PV fleet very well and has a relatively small bias of +0.5 % in the annual spatial means, but this is partly due to compensating biases from individual stations. Our results suggest that gridded irradiance data should be used with caution for site assessments and should ideally be complemented by local measurements. For power system modellers, our results may provide guidance for the

quantification of uncertainties caused by gridded irradiance data.

Reference:

Kenny, D., and Fiedler, S., in press, Which gridded irradiance data is best for modelling photovoltaic power production in Germany?, Solar Energy.