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Predicting variability of horizontal surface solar irradiance using machine learning

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Renewable energies play an increasingly important role for energy production in Europe. Unlike coal or gas power plants, solar energy production is highly variable in space and time. This is due to the strong variability of clouds and their influence on the surface solar irradiance. Especially in regions with large contribution from photovoltaic power production, the intermittent energy feed-in to the power grid can be a risk for grid stability. Therefore good forecasts of temporal and spatial variability of surface irradiance are necessary to be able to properly regulate the power supply.
Numerical Weather Prediction (NWP) models like the operational COSMO-DE have a grid spacing of 2.8 km or more, which means that the spatial variability of clouds and surface irradiance is only poorly captured on smaller scales. We tackle this problem by analyzing simulations of cloud resolving models coupled to a three-dimensional radiative transfer model as well as measurements of horizontal solar irradiance from a pyranometer network operated during a field campaign in Kempten (Germany) in autumn 2018. The campaign took place within the project MetPVNet funded by the Federal Ministry for Economic Affairs and Energy. The distances between individual measurement sites range from several hundred meters (subgrid scale) up to kilometers (grid scale). The frequency distribution of measured and simulated solar irradiance values as well as their spatial correlation is analyzed and measures to describe their distribution are defined. Finally a machine learning technique is used to predict the previously defined variability measures based on forecast parameters of the COSMO NWP model.