Forecasting sub-resolution temporal variability of irradiance

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Variability of solar irradiance is an important factor concerning large-scale integration of solar photovoltaics (PV) systems onto the electricity grid. Calculations of irradiance are computationally expensive, leaving operational meso-scale forecasting models struggling to achieve accurate results. Moreover, such models deliver outputs at a temporal resolution in the order of hours, whereas from a grid-integration point of view, minute-to-minute variability is a major concern. In previous work, we found that absolute power peaks in the order of seconds are up to 18% higher compared to 15-minute resolution for irradiance and even upwards of 22% higher for household PV systems. Moreover, these maximum peaks in output power are solely observed under mixed-cloud conditions, for which also the greatest variability is found. In this work we present a machine-learning model which can forecast sub-resolution variability of irradiance, based on standard meso-scale outputs of the HARMONIE model of the The Royal Netherlands Meteorological Institute (KNMI). For training and validation, irradiance measurements obtained at a 1-second interval are used of the Baseline Surface Radiation Network (BSRN) site of Cabauw. A tree-based model was employed, for which the optimum members were constructed using extreme gradient boosting. In this work, we explore the dominant features of the model and link the machine-learned-relations to meteorological processes and dynamics. This research was executed in collaboration with the Distribution Grid Operator Alliander.