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Estimation and forecast of PV generation on a regional scale using satellite data and high resolution WRF output combined with machine learning techniques

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Large shares of PV power might pose a challenge for the stability of the electrical grid, on a regional and national level, introducing into the electric load a stochastic variability dependent on meteorological conditions. Thus with growing PV penetration, estimation and forecast of regional PV generation becomes increasingly important to real time distributed PV power supervision, net load prediction, transmission scheduling and energy trading.
On a regional scale, upscaling methods are essential for the estimation and forecast of distributed power generation.
In this work an upscaling method based on a clustering technique to aggregate PV plants, several Artificial Neural Network (ANN) ensemble models to convert physical or data-driven irradiance forecasts or NWP output into power production and a model to estimate the forecast uncertainty, was developed. The method makes use of high resolution satellite and WRF data for power estimation and mid-term forecasts. Results from a test case on over 2000 photovoltaic plants heterogeneously distributed over complex orography in an alpine region are discussed.
Initial grouping of PV plants is performed by a spatial clustering through the K-mean algorithm to generate a statistical sample representative of the regional solar irradiance. The advantage is twofold: to economize computation avoiding single PV plant generation estimation and forecast and to perform spatial smoothing to reduce errors.
Then, for real time PV power estimation with an hour granularity, high resolution satellite derived GHI (0.05 degrees horizontal spacing) on cluster centroids is used as input for a power production ANN model. This procedure leads to a RMSE of 3% and a MAE of 2% of the nominal power with respect to the measured regional PV production.
For day ahead power forecasts, high resolution WRF-ARW 3.7 output ($\sim$3km horizontal resolution) on cluster centroids is used as input for a power production ANN model ensemble. The result is a probabilistic forecast through which forecast uncertainty can be estimated.
PV production forecast validation is underway.