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High resolution irradiance measurement network for validation and optimization of sky imager based forecasts

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Shortest term solar irradiance forecasts based on sky imagers are a promising method for predicting the variable output of PV power plants with a high temporal resolution. Such high resolution forecasts are valuable e.g. for standalone PV-Diesel systems with typical ramp-up times of a few minutes for improving their stability and reducing the fuel consumption. Spatial sky imager forecasts are, furthermore, interesting for local grid operators for assessing the energy production of aggregated PV power from rooftops in a city or for PV plant operators for large PV fields.

For the validation and optimization of sky imager based forecasts a radiation measurement network was set up in Freiburg. Freiburg is located in southern Germany in the Rhine Valley in direct neighbourhood to the Black Forest, a meteorologically interesting location due to a lot of convective clouds over the mountains. The camera used for this evaluation is a commercial surveillance camera from VIVOTEK with a HDR option. Cloud height measurements are available from a ceilometer operated by the German Weather Service in 1 km distance from the sky imager. The measurement network consists of eight stations, distributed in a radius of 10 km around the sky imager. The specially developed measurement stations collect data in a high temporal resolution of one second and transfer the measurements in real time via the mobile phone network. The stations integrate horizontal and tilted irradiance sensors: Horizontal irradiance is measured using a photodiode. Four of the stations additionally include a ventilated secondary standard pyranometer for high quality measurements. Furthermore, a tilted reference cell is included as a basis for simulating the output from PV power plants.

The forecast algorithm includes detection of clouds, calculation of cloud motion and shadow projections using cloud height in order to get spatial cloud information. Irradiance is calculated based on this cloud information and measurement data using statistical methods. The forecasting algorithm is developed with focus on optimal performance for different cloud types and weather situations. An algorithm for cloud detection, based on the red-to-blue-ratio, was optimised with a training data set of over 1000 manually classified pixel. In a validation dataset created from pictures with different cloud types and sun elevations in total 90.3 % of the pixel were classified correctly. A majority of the wrong classified pixel could be assigned to situations with cirrus. An improved algorithm considering cloud heights is planned. A flow method for calculating cloud motion vectors is currently optimised based on a test dataset consisting of picture sequences with different cloud velocities and cloud types. For the presentation we will add first results of irradiance forecast performance using the data of the measurement network for spatial validation.