EGU21-14726
https://doi.org/10.5194/egusphere-egu21-14726
EGU General Assembly 2021

Deriving cloud information from all-sky images for intra-hour PV nowcasting

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Energy output from photovoltaics (PV) strongly depends on the respective weather situation. To ensure continuous energy availability in power grids with large PV contribution, flexibly manageable power plants have to compensate for variations in PV power production. Within the project NETFLEX, an intra-hour irradiance now-casting algorithm is developed as a basis for a PV power forecast used for management of a combined PV / biogas power plant.

The now-casting algorithm is designed around a cloud representation in a simplistic 2D advection model, which is updated with currently measured data and which projects cloud situations up to 15 minutes into the future. Main input to the model are images captured by two CMS Schreder all-sky imagers (ASI) installed at the PV plant in locations separated by about 530m. Captured images are processed to extract cloud masks, cloud base heights and cloud movement. To obtain cloud masks, ratios of red and blue channels as well as saturation and brightness are compared to reference data from a clearsky library. This library is composed from synthetic clearsky data computed by the radiative transfer model *libRadtran* (Mayer and Kylling, 2005), which are processed to resemble imager geometry and optics. The creation of synthetic references allows for any desired sun position and aerosol condition. Simultaneously captured images of both cameras are evaluated and corresponding pixels are matched. Exact calibration of the imager geometry then allows for cloud base height derivation using the method of miss-pointing vectors (Kölling et al., 2019). Consecutive images are evaluated for each ASI to estimate horizontal cloud motion by matching corresponding pixels. All cloud information computed from ASI images is assimilated into the 2D model as a base for cloud field predictions with information about cloud position, base height and velocity. The model-centered approach allows for flexible integration of additional data sources, e.g. satellite imagery and numerical weather prediction data.

Validation of image evaluation methods and now-casting model is done using synthetic all-sky images of LES cloud fields. Additionally, cloud base height from a ceilometer as well as global and direct integrated solar irradiance were measured on site of the PV power plant. This also allows for validation on real world cases.

Literature:

Kölling, T., Zinner, T., and Mayer, B.: *Aircraft-based stereographic reconstruction of 3-D cloud geometry*, Atmos. Meas. Tech., 12, 1155–1166, 2019.

Mayer, B. and Kylling, A.: *Technical note: The libRadtran software package for radiative transfer calculations - description and examples of use*, Atmos. Chem. Phys., 5, 1855–1877, 2005.