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Shadow camera system for the validation of nowcasted plant-size irradiance maps

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All Sky Imager (ASI) derived nowcasts of spatially resolved irradiance maps help to enable efficient solar plant operations. Within the DNICast project, a nowcasting system was developed and validated. For this validation, novel approaches are developed, which gained general insights regarding spatial and temporal variations and their effects on nowcasting errors.

Key element for these validations is an image-based reference system consisting of six cameras. These cameras take photos of the ground from the top of an 87 m high solar tower located at the Plataforma Solar de Almería (PSA) in southern Spain. Six concurrent images are combined to one so-called orthoimage. Using the orthoimage of the investigated timestamp and two reference orthoimages, taken when no cloud shadow fell on the PSA and when the PSA was completely shaded, as well as Direct Normal Irradiance (DNI) measurements, a spatially resolved DNI map is calculated. These DNI maps have a spatial resolution of 25 m2 and are generated every 15 s. They are used as a reference for ASI derived nowcasted DNI maps. This way, spatial aggregation effects on the deviations of nowcasting systems are studied in detail.

Spatial aggregation occurs both in large photovoltaic plants and solar thermal plants. Additionally, temporal aggregation is relevant for photovoltaic plants with battery storage and for solar thermal plants, in which the heat transfer fluid has thermal inertia. Thus, for many industrial applications, the nowcast is needed in temporally and spatially aggregated values, but beyond the resolutions of satellite-based forecasts.

Therefore, understanding the effects of spatial and temporal aggregation on the nowcasting errors is of special interest. It has been found that such aggregations significantly reduce forecasting deviations. For instance, using a nowcasting system with four ASIs and a day with many transient clouds, root mean square errors (DNI) of only 6.5 % for 10 min lead time, a field size of 4 km2 and a temporal average of 15 min were found. This value increases to 13.0 % for a single pixel of the DNI map (25 m2, 15 min temporal average, 10 min lead time) and to 14.9 % for a single pixel and 1 min temporal average (10 min lead time).

In summary, the shadow camera system installed at PSA is a unique tool which allows validations and analyses of ASI derived nowcasts with industrial relevance. Thus optimized nowcasting systems will support the integration of solar power generation into electricity grids.