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Climatology and Spatial Patterns of Cloud Shadows and Irradiance Peaks

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Surface irradiance variability is present on many spatio-temporal scales, but most strongly on the scale of minutes to seconds due to low broken clouds. Fast and large fluctuations, or spatial heterogeneity, of irradiance affects solar energy production. In idealised settings, let alone in operational forecasts, the modelling of realistic fields of surface irradiance in the presence of clouds is challenging. It relies on realistic cloud fields, is computationally demanding due to the nature of 3-d radiative transfer models, and ultimately requires observations for validation. Dense spatial observation of irradiance on the scale of cloud shadows or solar energy parks are rare, however. Even 1-d time series are often not available at high enough resolution.

In ongoing work, we provide those missing observations. I will present our gathering and analyses of new and detailed observations of surface irradiance to address knowledge gaps in our physical understanding and provide validation datasets for models. In 2021, we deployed a dense network of custom, low-cost radiometers at two field campaigns, FESSTVaL (Germany) and LIAISE (Spain), to observe spatial patterns of irradiance driven by clouds. The instruments are able to closely match expensive conventional instruments, and combined with skyview imagery, the spatial observations are directly linked to observed clouds. To complement these short term spatial data, long-term statistics of irradiance variability are derived from a 10-year 1 Hz resolution data from the Baseline Surface Radiation Network station in Cabauw, the Netherlands. Distributions and typical spatio-temporal scales of cloud shadows and irradiance peaks can be related to cloud type and meteorological conditions. The gathering and study of these datasets will lead to a better understanding of the physics, help validate models, and ultimately improve our ability to accurately forecast irradiance variability at the small scales.