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Circumsolar Radiation – a Reason for Solar Resource Overestimation – Globally Characterized

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Circumsolar radiation is caused by forward scattering of the sun light on cloud or aerosol particles. Neglect of circumsolar radiation can lead to a systematic overestimation of the solar resource for Concentrating Solar Power (CSP) plants. In general (excluding the presence of inhomogeneous clouds) the radiance drops with angular distance from the sun. The steepness and shape of this angular gradient is determined by the properties of the scattering particles. Thus, perception of circumsolar radiation by any optics pointed at the sun is strongly dependent not only on its opening (half-)angle α but also on the sky conditions. Example for such an optics can be a pyrheliometer with $\alpha \approx 2.5^\circ$ but also a CSP plant with $\alpha \lesssim 1^\circ$. Furthermore, the discrepancy in perception caused by different opening angles is not constant but also varies with sky conditions. Since circumsolar radiation is commonly included in DNI measurements at higher amounts than perceived by CSP plants this can lead to systematic overestimation of the solar resource when DNI alone is available. On the other side, the angular distribution of the radiance – the so-called sunshape – is intricate to measure so that only very limited data sets are available. For site specific correction of DNI values, however, a data set with high temporal resolution covering all CSP relevant areas would be necessary. To bridge this gap, we have parametrized circumsolar radiation in terms of common atmospheric variables by means of extensive Monte Carlo radiative transfer calculations. This allows the accurate and fast computation of circumsolar radiation from satellite data and/or weather forecast models which provide the desired extent and resolution. In the presented case the considered atmospheric variables are ice cloud optical thickness and effective radius from Meteosat Second Generation as well as aerosol types and corresponding area mass loadings from a global weather model. However, the presented method can be applied to other data sources as well. The global characterization of circumsolar radiation will be useful for accurate site assessment.