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# Extreme surface solar radiation events and implications for PV energy generation

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In the context of climate science and climate change, extreme events take a prominent place because of their potentially devastating impacts on various aspects of society, from economic losses to premature deaths. Much effort has gone, in particular, into the study of heat waves and droughts. Extreme events in surface solar downwelling radiation (SSR) have, by contrast, gained little interest so far. This neglect is at odds with the prominent role that photo-voltaic (PV) energy production, which feeds on SSR, is to play in the future.

Based on daily-mean data from nine global climate models participating in the pre-industrial control experiment (piControl) of the Coupled Model Intercomparison Project-Phase 6 (CMIP6), we provide a descriptive analysis of extreme events in surface solar radiation (SSR) arising from internal variability of the climate system, with a geographical focus on central Europe, where we also anchor our analysis in 38 years of observed daily mean SSR data. Two kinds of extreme events are investigated: sustained radiation events (SREs, periods of L consecutive days with extremely high or low SSR on each single day) and cumulative radiation events (CREs, yearly minimum mean SSR over a period of L days). To explore the role of extreme SSR events in PV energy generation, we use the Global Solar Energy Estimator (GSEE, https://github.com/renewables-ninja/gsee).

Selected findings from our analysis include the following. In central Europe, the frequency of SREs shows an exponential dependence on L, their duration in days. High SREs are more frequent than low SREs over global land. CREs in central Europe are well described by Generalized Extreme Value statistics with a negative shape parameter, similar to wind and temperature extremes. PV production associated with low SREs in central Europe is roughly linear in SSR with little sensitivity to panel orientation, while for high SREs PV production depends non-linearly on SSR and sensitivity to panel orientation is pronounced. PV production of high SRE events in winter greatly exceeds PV production of low SRE events in summer. Our results are a first step in examining the characteristics and relevance of SSR extreme events, highlighting the need for further studies.