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Variation of solar radiation under cloud free conditions at BSRN sites using CMIP5 models

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Understanding the earth's energy balance is key to understanding global warming. The incoming solar radiation, and hence the energy received, is influenced by absorption and reflection processes during its travel through the atmosphere. Of particular interest is the effect of clouds on the reflection of solar radiation compared to a clear-sky situation, known as the cloud radiative effect (CRE). To assess the CRE, the clear-sky radiation is needed. However, surface observations at the Baseline Surface Radiation Network (BSRN) stations, satellite estimates from the Clouds and the Earth's Radiant Energy System (CERES) and simulations from Coupled Model Intercomparison Project phase 5 (CMIP5) models all differ in their long term global mean clear-sky radiation. Potential reasons include deficits in the modeling of clear-sky radiation or a different clear-sky definition in models and observations. In our study we therefore quantify the unforced variation of clear-sky solar radiation using data from the pre-industrial control run of the CMIP5 models on an annual, yearly and daily scale. Daily data are particularly well suited for the investigation of physical relationships between clear-sky radiation and possible influencing variables, such as water vapor, cloud cover and temperature in order to explain the variability. Furthermore, the effect of different time scales is quantified by comparing the results of daily, monthly and annual means. Using the pre-industrial control run of the CMIP5 models for all BSRN sites, an overall annual variability in clear-sky radiation of 6.1 W/m2 between the 5th and 95th percentile was found. Extreme values reach up to 20 W/m2 in annual variability. The differences between the stations are large as well, with highest variability in desert and monsoon areas. Our findings reveal a remarkable variability in solar radiation under cloud free conditions in the CMIP5 models, which should be considered in further studies.