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Influence of aerosols on photovoltaic power in Ghana: Case study from Koforidua

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West Africa has great potential for the use of solar energy systems, as it has both a high solar radiation rate and a lack of energy production. West Africa is a very aerosol-rich region, whose effects on photovoltaic (PV) use are due to both atmospheric conditions and existing solar technology. This study reports the variability of aerosol optical properties in the city of Koforidua, Ghana over the period 2016 to 2020, and their impact on the radiation intensity and efficiency of a PV cell. The study used AERONET ground (Giles et al., 2019) and satellite data produced by CAMS (Gschwind, et al., 2019), which both provide aerosol optical depth (AOD) and metrological parameters used for radiative transfer calculations with libRadtran (Emde, et al., 2016). A spectrally resolved PV model (Herman-Czezuch et al., 2022) is then used to calculate the PV yield of two PV technologies: polycrystalline and amorphous silicon. It is observed that for both data sets, the aerosol is mainly composed of dust and organic matter, with a very increased AOD load during the harmattan period (December-February), also due to the fires observed during this period.

We compared CAMS satellite data with AERONET ground data. A good annual correlation (correlation coefficient, R^2 ~0.8) was observed between the CAMS and AERONET AOD data. However, CAMS satellites tend to underestimate the high AOD measured on the ground by AERONET photometers; but they also overestimate the low AOD compared to AERONET. Both datasets also show differences in the average assumed optical properties of the aerosol encountered. A detailed analysis of the year 2020 shows a daily reduction in PV yield for the polycrystalline cell of up to 90% with the AERONET data and of up to 32% with the CAMS data. For the amorphous cell, the daily reduction in PV yield is up to 71% with the AERONET data and 34% with the CAMS data. These strong differences are due to the seasonal dispersion of the measured AODs but also to the variability of water vapor and ozone concentrations provided by CAMS and AERONET over Koforidua.

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