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Dust-aerosol optical depth in CMIP6 models and implication for PV-power generation

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Renewable energy produced by photovoltaic (PV) power plants strongly depends on the meteorological conditions. Desert-dust aerosols impair the radiative transfer in the atmosphere, but their effect on PV power is poorly understood from a climatological perspective. Past climate model simulations are known to have a large spread in dust-aerosol loading. With the new CMIP6 model simulations now being available, we revisit the climate-model spread in representing desert-dust aerosols for 1985 to 2014, assess the dust-aerosol changes until 2100, and estimate the associated differences in the PV power potential. To this end, we evaluate the dust aerosol optical depth (DOD) in the CMIP6 historical simulations using modern reanalysis and satellite data. Our results highlight the persistent model spread for DOD in CMIP6, but a multi-model mean DOD close to the reanalysis and satellite data. We identify only slight changes in both the global and regional mean DOD in a green scenario (ssp126) at the end of the 21st century. For a future with continued strong warming (ssp245, ssp585), the simulations suggest an increase (decrease) in regional DOD associated with North-African, Transatlantic transport, and Australia (Taklamakan Desert) dust emissions. The differences in simulated DOD imply changes in the PV power potential for regions affected by dust aerosols. We compute the change in the PV power potential from surface irradiance, temperature, and wind speed in the CMIP6 scenarios against present-day. Our results point to a PV power potential for North Africa that is similarly affected by a future increase in temperature and decrease in irradiance associated with more dust aerosols. In mid-latitude regions of the northern hemisphere, a future change in PV power potential is controlled by changes of clouds and temperature. Our PV power estimates underline the impacts of the model uncertainty in DOD, the degree of future warming, and the unclear response of clouds and circulation to the warming.