EGU24-1776, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-1776
EGU General Assembly 2024

Assessment of the Impact of Coarse and Fine Dust on Solar Devices in the Middle East

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Dust in the Middle East (ME) significantly impacts regional climates and negatively affects the operation of solar farms in the ME region. Suspended dust particles attenuate downward short wave (SW) radiation, while dust deposited on the solar devices decreases effectiveness. This study theoretically assesses dust's attenuation and soiling effects on solar panels within the ME, employing a Weather Research Forecasting Model coupled with the aerosol-chemistry module, WRF-Chem, constrained by observed dust depositions. By analyzing the size distribution of dust deposition samples, we found that a major part of the deposited mass resulted from the deposition of dust particles with radii > 10 um. However, the models usually consider only particles with radii < 10 um.

We corrected this deficiency and conducted a year-long simulation using WRF-Chem. We found that the dust (primarily fine particles with radii < 3 □m) reduces the downward SW radiation near the surface by 5-10%. Meanwhile, dust deposition (mostly coarse dust particles with radii > 6 □m) imposes soiling losses of 12 to 36 % in different parts of the ME, assuming a weekly cleaning cycle.

Our findings unveil a complex interplay between dust size and its multifaceted impact on solar energy production. This novel insight could lead to optimized maintenance strategies and novel mitigation approaches tailored to the unique dust burden of the Middle East. Ultimately, this study aims to advance solar energy resource assessment and pave the way for enhanced photovoltaic efficiency in dust-prone regions.