Impact of Fine and Coarse Dust in the Middle East on Radiative Balance, Dust Deposition, and Solar Devices

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In desert regions, dust is a major environmental factor affecting climate and air quality. Dust also hampers solar energy devices by weakening downward solar flux and depositing on optically active surfaces. In this study, we use fine-resolution WRF-Chem simulations, AERONET data, and size-segregated measurements of dust deposition to quantify the contribution of fine ($r < 1.25$ um), coarse (1.25 um $< r <$ 10 um), and giant (10 um $< r <$ 100 um) dust particles in aerosols radiative forcing and mass deposition, and evaluate how they hamper harvesting of solar energy in desert regions like the Arabian Peninsula. We found that dust deposition rates calculated in WRF-Chem and reanalysis products are 2-3 times smaller than the observed because the model does not account for particle sizes $r > 10$ um. However, the deposition rate of particulate matter with a diameter smaller than 10 um (PM10) is in good agreement between the models and observations. In the Middle East, fine dust particles are predominantly responsible for the significant reduction (> 5 %) of the downward solar flux hampering solar energy production. Still, dust-deposited mass, primarily associated with coarse particles, causes about a 2% loss of PV panel efficiency daily due to soiling. As was suggested previously, WRF-Chem, like many other models, tends to overestimate the atmospheric concentration of fine dust particles and underestimate the concentration of coarse particles. As seen from the comparison of the size distribution of deposited dust in simulations and observations, the latter is caused not as much by too fast deposition of large particles but due to underestimating their emission in the models.

Keywords:
Dust deposition, radiative forcing, size distribution, giant particles, Arabian Peninsula