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West African dust load modeling and its impact on solar radiation forecast during the dry season

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The expected growth of solar photovoltaic (PV) production in West Africa over the coming decades poses challenges to the electrical network requiring accurate solar forecasts for both energy producers and power grid managers. Furthermore, solar radiation is affected by dust aerosols which play a significant role in West African meteorology, due to the proximity of this region to the Sahara desert, which is the world's largest source of mineral dust aerosols emissions.

In this general context, our research aims at identifying the impact of mineral dust on solar energy production. Thus, this study focuses on evaluating the influence of dust aerosols on solar radiation forecasts for the Zagtouli solar plant in Burkina Faso.

Employing a coupled approach between a meteorological model (WRF) and a chemical transport model (CHIMERE), two dust events that are representative of the dry season are simulated in line with West African climatology. While one event is linked to dust emissions from the Bodélé plateau (Chad), the other is related to dust sources located within the South Atlas area.

The model undergoes rigorous assessment in regards to dust life cycle parameters (Aerosol Optical Depth (AOD), PM10, size distribution) and variables essential for solar energy production (Global Horizontal Irradiance (GHI), temperature) using in-situ measurements from long-term observatories (AERONET, INDAAF, AMMA-CATCH) and from the solar farm (GHI), satellite observations (AQUA/TERRA-MODIS, CALIPSO-CALIOP), and reanalysis data (CAMS). This evaluation shows a robust performance of the model.

In addition, sensitivity studies are implemented to evaluate the respective impacts of direct and indirect effects of dust aerosols on the amount of solar radiation available at the surface.

Overall, this study provides strong support for a modeling approach that couples meteorological processes with the dust life cycle to refine solar forecasts in the West African region.