Dust Effect on Solar Energy Production in the European and North African Regions

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Motivation & Methodology

This study deals with the effect of two intense dust episodes into the surface solar radiation (SSR) and energy production in the European and North African (ENA) regions. Their evolution, dispersion, interaction and coexistence with cloud formations and the subsequent financial losses were also quantified following the methodology of Kosmopoulos et al (2019). Both episodes started from the Northern Africa, with the first one taking place during 16 – 19 April 2021 affecting the eastern Mediterranean countries and reaching the Black sea, while the second episode (15 – 18 March 2022) affected the western Europe with the dust transport reaching the northern parts of Europe (Figure A). To this direction Earth Observation (EO) data and techniques were used, namely, aerosol forecasts from the Copernicus Atmosphere Monitoring Service (CAMS), cloud monitoring from the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and radiative transfer modelling exploiting rapid computing architectures (Kosmopoulos et al, 2018). The intensity of the events was extremely high, with aerosol optical depths (AOD) reaching 1.2 – 2.7 more than 2000 km from the dust sources. The energy production from photovoltaics (PV) and concentrated solar power (CSP) systems reduced by almost 32-41% and 55-78% respectively (Figure B shows an example from the city of Athens in Greece), leading to an estimated overall economic loss of € 1.12 million and € 2.81 million during the first and the second dust episodes, respectively, affecting almost the 13 % (7 GW) of installed solar capacity across the ENA countries (Figure C).

Energy Management & Financial Analysis

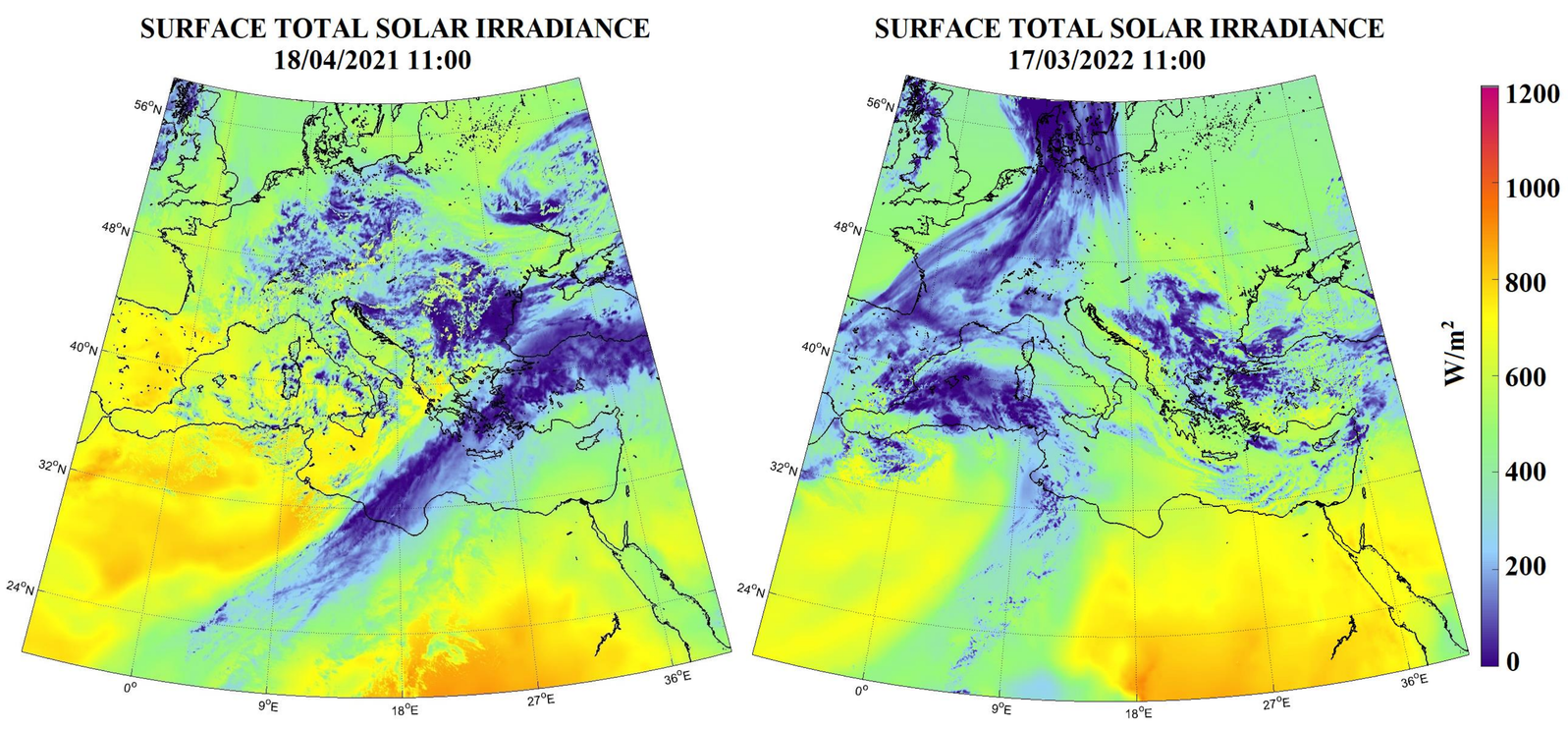


Figure A: Operational solar irradiation mapping in Europe and North Africa during the extreme dust events that affected the Eastern Mediterranean counties (left plot) and the Western Europe countries (right plot).

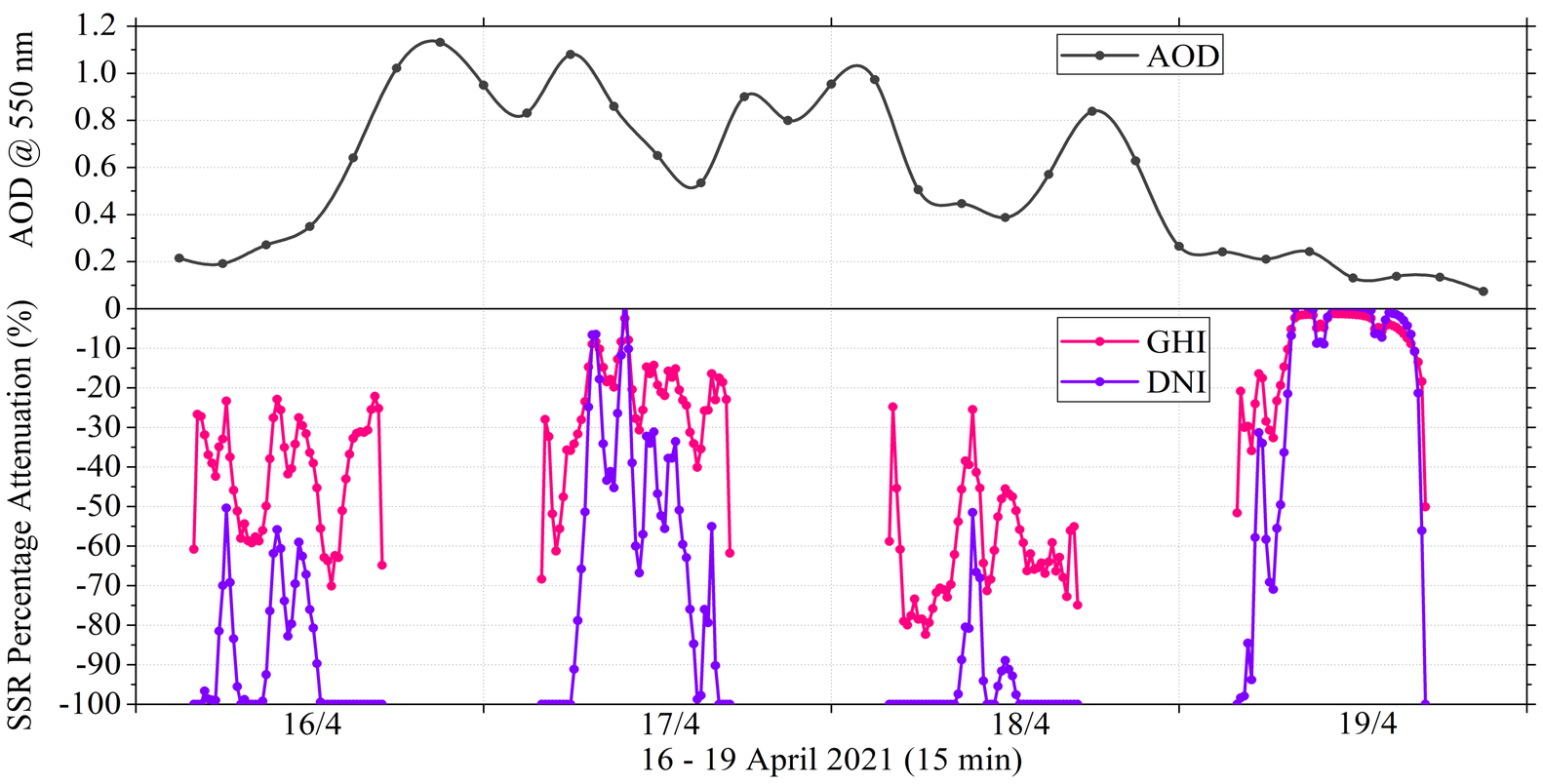


Figure B: The AOD levels during the period 16 - 19 April 2021 and the subsequent percentage attenuation of the global and direct radiation (GHI and DNI for PV and CSP operation, respectively) for the city of Athens in Greece.

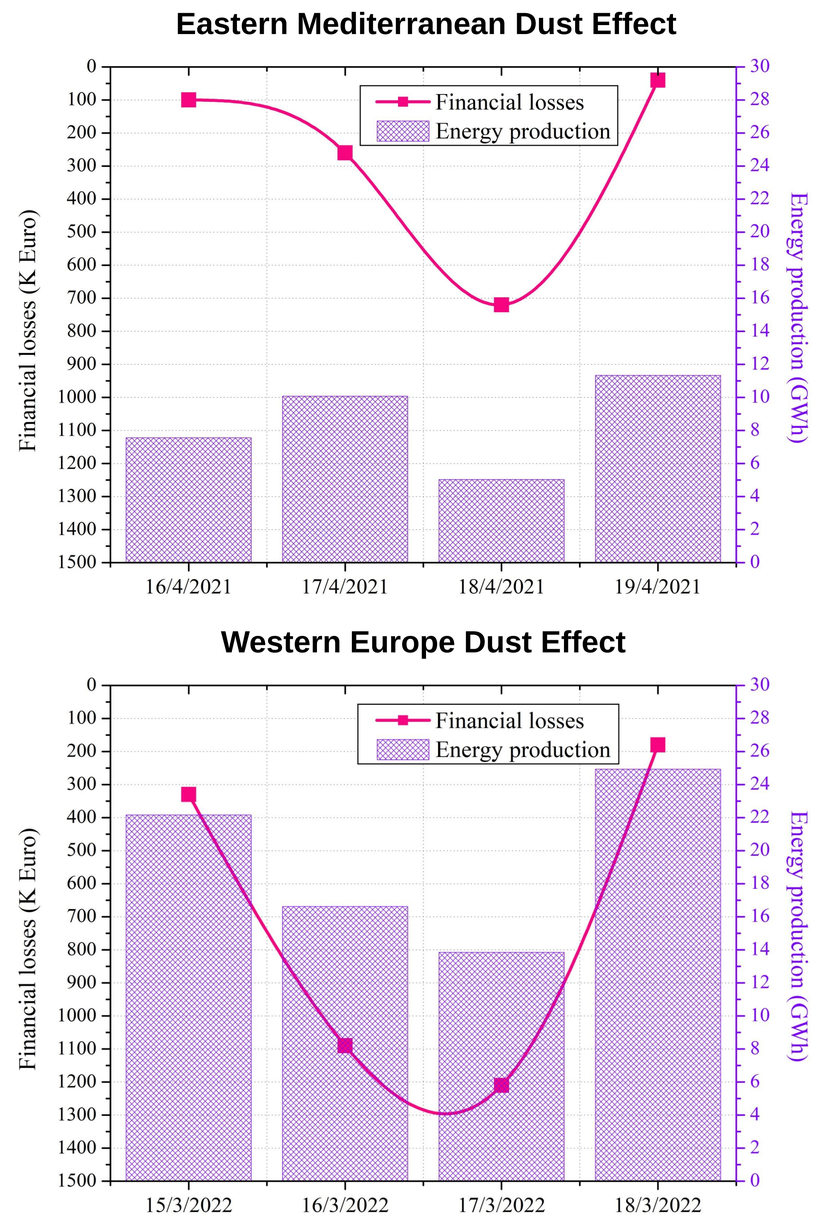
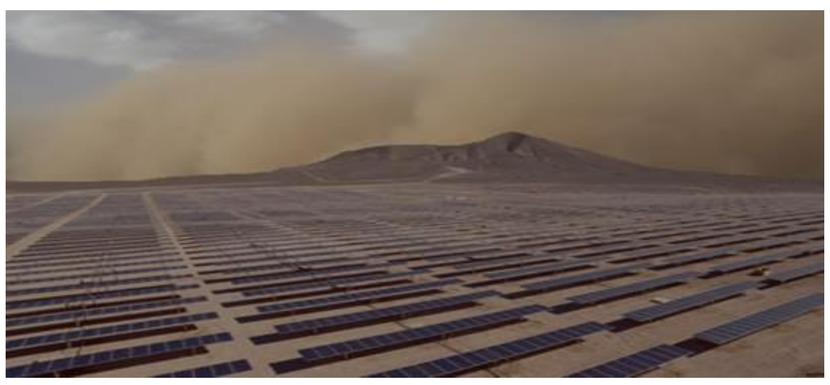


Figure C: Solar plants energy production in the Eastern Mediterranean (2.2 GW) & the Western Europe (4.8 GW) countries and the financial losses during the dust events.



Conclusions & References

Such analysis of real-world scenarios contributes to the renewable energy sector awareness of the impact range of high aerosol loads into solar plants production and energy security at continental scale and promotes the use of early warning applications (http://solea.gr/solar-irradiance-monitoring/) for monitoring and forecasting of potential power generation failures due to dust (Masoom et al, 2021). As a result, the current EO capabilities are able to actively support the solar energy producers for optimal energy management and maintenance planning as well as the electricity handling entities into the day-to-day electricity transmission and distribution.

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