

Reply to Reviewer#2

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➤ Main comments

- **#1:** *The analysis is based on four different dust events. However, using only the station names listed in Table 1 makes it difficult for readers to understand the spatial extent and characteristics of these events. It is recommended to provide additional information describing their spatial distribution and intensity. Furthermore, as the manuscript indicates that solar energy production is strongly influenced by dust aerosol optical depth, it would be helpful to include a brief description of the intensity of each dust event.*

Answer: Some additional information regarding the dust events' spatial distribution and intensity was included in the manuscript in Sect. 2.3, as follows (lines 195-199):

“The four selected dust events covered a wide range of transport regimes and intensities, from a widespread Saharan outbreak with maximum observed daily average AOD reaching 1.08 (Event A), to an efficient mid-tropospheric long-range transport event (Event B), with the maximum daily average AOD reaching 0.97, a spatially confined Middle Eastern outbreak (Event C) with a maximum AOD of 1.17 and a complex multi-source, basin-wide event with moderate dust loading, with daily average AOD not exceeding 1, affecting big part of the Mediterranean (Event D).”

- **#2:** *The introduction section lacks a clear and coherent logical structure. For example, after the discussion of atmospheric aerosols, with dust particles as the main focus (lines 57-60), the authors return to a general discussion of aerosols' direct and indirect radiative effects (lines 60-61).*

Answer: The introduction has been updated based on the reviewer's comment.

- **#3:** *The authors estimate PV output using ground-based measurements and METAL-WRF for AMX and Lampedusa. However, given the spatial and temporal variation of dust transport and aerosol properties, it would be helpful to explain whether the conclusions drawn from these two case studies can be generalized to the broader Mediterranean Basin. Furthermore, as these two stations are affected by Saharan and Middle Eastern dust events, respectively, it would be useful to discuss whether dust from these distinct source regions has distinct implications for PV energy production and model performance.*

Answer: Lines 590-595, the following explanation was included:

“The chemical composition and microphysical properties of dust, and consequently its optical properties, strongly depend on its source region. Therefore, dust originating from the same source region is expected to exert a similar influence on surface solar radiation (SSR) and, consequently, on PV power output. In this context, the selected cases can be regarded as representative of dust events affecting the Mediterranean Basin, rather than as isolated case studies. Such events regularly influence multiple regions across the Basin through recurring transport pathways, making them suitable case studies for assessing regional-scale impacts.”

➤ **Minor comments**

- **#1:** *Lines 64, 75: Please avoid having two sets of parentheses next to each other.*

Answer: The respective parentheses have been adjusted accordingly:

“(DRE; Li et al., 2004; Biagio et al., 2020)”, Line 81 in the updated manuscript.

“...with a range of +0.10 and +0.40 W/m² (Kok et al., 2023)”, Line 72 in the updated manuscript.

- **#2:** *Line 158: The reason for using Level 1.5 AERONET data should be provided.*

Answer: The reason for using Level 1.5 AERONET data was provided, as suggested, by the implementation of the following sentence, lines 158-160:

“The selection of L1.5 instead of L2 products was made to increase data availability, acknowledging the slightly larger uncertainties (0.01-0.02) associated with the absence of full calibration, especially at low AOD conditions.”

- **#3:** *Line 174: Need references for the criteria.*

Answer: A reference was included right after the criteria of the selection, line 174: “(e.g., Basart et al., 2009)”.

- **#4:** *Line 365: It is not clear how the “global direct radiation losses” are defined.*

Answer: The corresponding equation regarding the reported losses was included in section 3.1 – Results and discussion and linked to the figures including the respective results, as follows:

Lines 388-392:

“The resulting irradiance and PV energy losses are expressed relative to aerosol-free atmospheric conditions. More specifically, the afore-mentioned losses were calculated based on the following formula:

$$\text{Losses (\%)} = \frac{(R_{\text{clear-sky}} - R_{\text{all-sky}})}{R_{\text{all-sky}}} * 100 \quad (3)$$

Where R denotes the respective parameter in each case; DNI and GHI for radiation losses (presented in Fig.3) and solar energy for PV losses (presented in Fig. 4)”

- **#5:** *Line 434: Why are only two stations used?*

Answer:

The two stations have been selected:

(1) because they provide reliable measurements of the required SSR components - not available to most of the selected sites for the desired dates.

(2) because they were affected by events of different origin (Lampedusa/Saharan dust, AMX/Middle East dust) characterized by different optical properties. Thus, Lampedusa was selected as a representative case study of a strong Saharan dust event, while AMX was selected as a representative case study of a Middle East event.

A clarification was added in Section 3.3. where the two cases are introduced, as follows (lines 490-493):

“We focus on two stations affected by dust events of different origin, Sahara (Lampedusa, during event D) and the Middle East (Agia Marina Xyliatou- AMX, during event C), characterized by different optical properties.”

- **#6:** *Line 515: “These days have been excluded.” Please be specific.*

Answer: The days were clarified by rephrasing the sentence to:

“More specifically, days 1 and 3 have been excluded...”, lines 573-574.

- **#7:** *Please use either "Figure X" or "Fig. X" consistently throughout the manuscript when referring to figures.*

Answer: The format of the figure references has been revised to ensure consistent use of “Fig. X” format throughout the manuscript.

Please note that references cited herein are given in our original manuscript.