Projections of PV energy production in the Eastern Mediterranean and Middle East during the 21st century: Assessing the role of atmospheric aerosols

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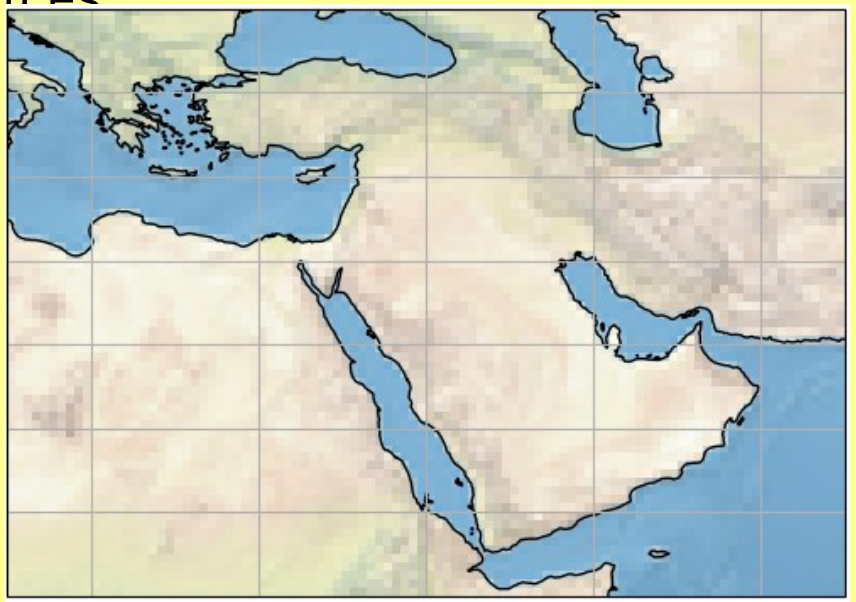
Background

The Eastern Mediterranean and Middle East (EMME) region

- Considered as a **climate hotspot**
- Characterized for its abundant **solar resources** – ideal for solar energy deployment
- Significant aerosol loads – major **desert-dust aerosol** sources



Solar Energy Modelling –

climate-related applications

- Essential for **strategic planning** PV installations
- Supports making **long-term energy policies**

Atmospheric Aerosols

- **Attenuate** Solar Irradiance
- Key parameter during **cloudless** periods when **solar resources peak** – differences increase in absolute terms

Data and Methodology – CMIP6 Climate Projections

We conduct comparisons of climate data between historical (1980-2000) and future projections (2080-2100)

Future projections based on the Shared Socioeconomic Pathway (SSP) – Representative Concentration Pathway (RCP) framework **(SSP-based scenarios)**	Retrieved **Climate Data**
• **SSP2-4.5:** *"Middle of the road"* – medium forcing • **SSP3-7.0:** *"Regional rivalry"* – high forcing • **SSP5-8.5:** *"Fossil-fueled development"* – high forcing	**GFDL – ESM4 Global Climate Model** - All-Sky and Clear-Sky downwelling solar irradiance (rsds & rsdscs) - **Aerosol Optical Depth** at 550nm (Total, Dust, Sulfate, Nitrate, Sea-Salt, Black Carbon, Organic) Temporal Resolution: Monthly

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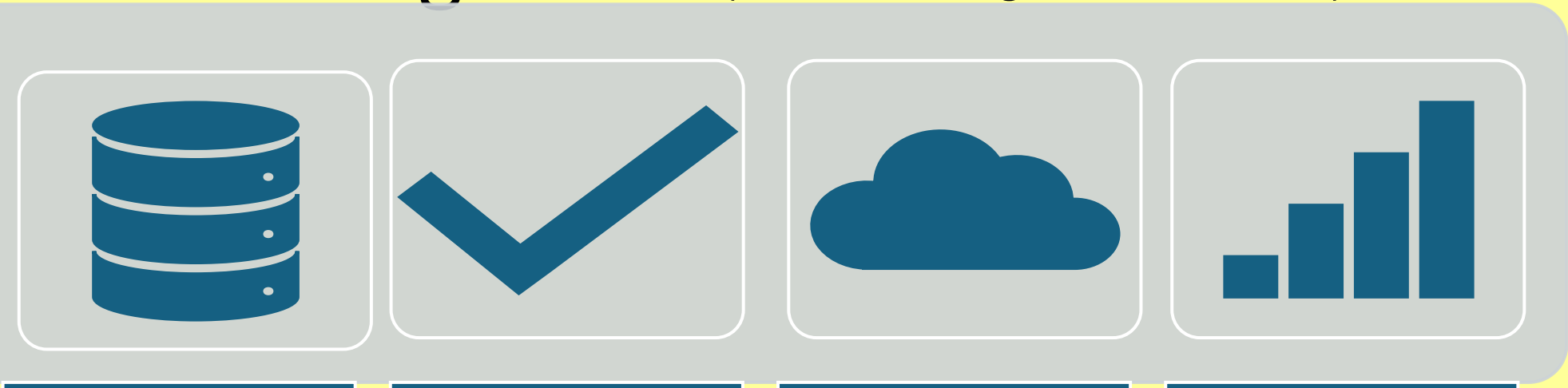
Data and Methodology – Solar PV power modelling

Solar energy production simulations with the Global Solar Energy Estimator (GSEE; Pfenninger & Staffel, 2016)



Input Data

Gridded: **f(** time, lat, lon**)**

Core: GHI

Optional: DHI, Ambient Temperature

System Configurations

- Mounting approach (Tilt & orientation / tracking)
- Capacity (kWp)
- Technology (c-Si, CdTe)

Climate Data Interface

Processing of datasets with lower than hourly resolutions (e.g., daily, monthly, seasonal, annual)

Output

PV energy production (kWh /kWp/ time)

Related Work: **Papadimitriou et al. 2026**

PV power modelling using solar radiation from ground-based measurements and CAMS: Assessing the diffuse component related uncertainties leveraging the Global Solar Energy Estimator (GSEE)

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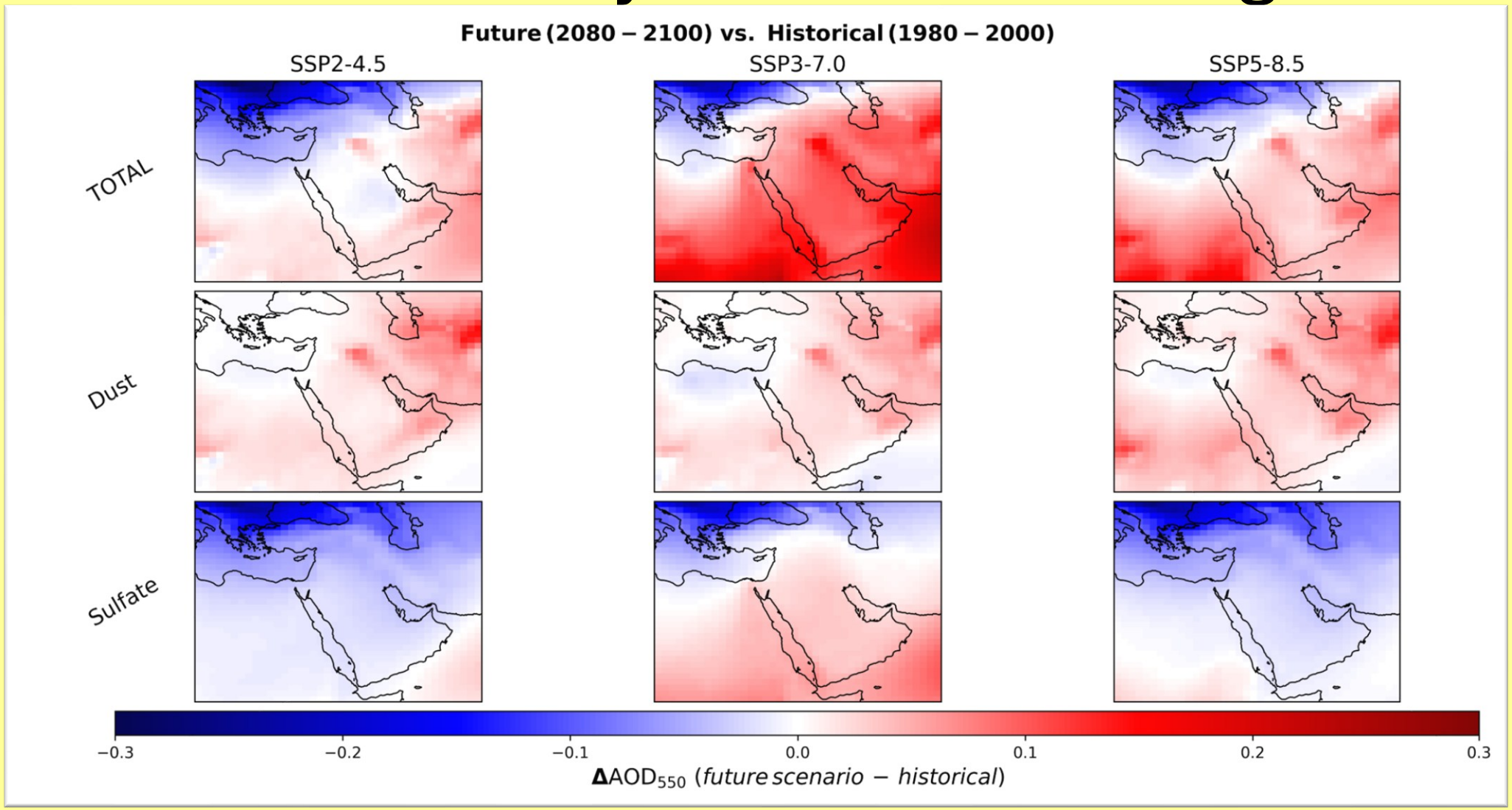
Results – Variability in aerosol loading



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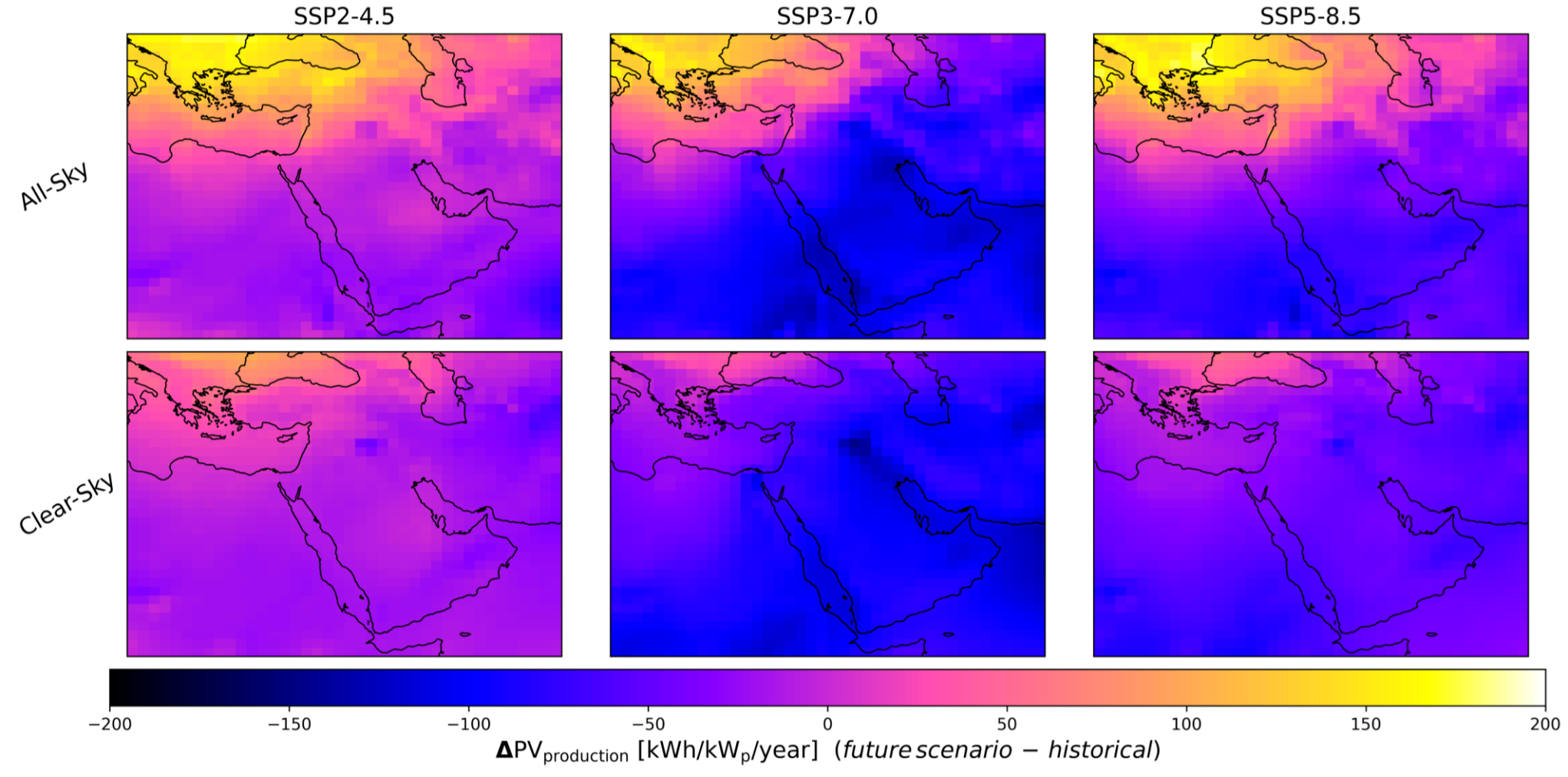
Results – Variability in PV power potential

Case 1: fixed panels (no tracking)



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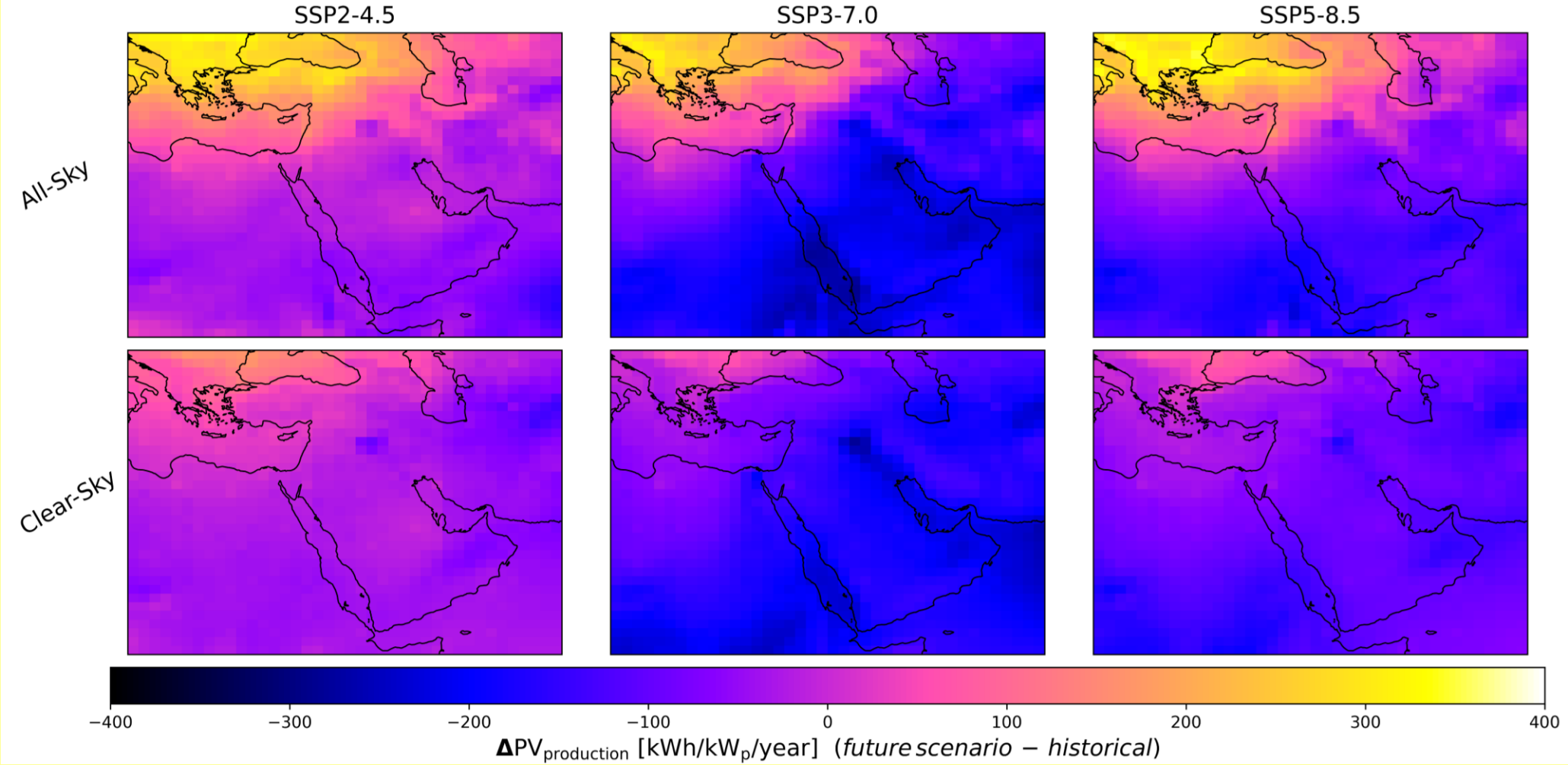
Results – Variability in PV power potential

Case 2: dual – axis tracking



Conclusions

- This study aimed to assess the **future variability of the PV power potential** in the Eastern Mediterranean and Middle East (EMME) region
- **Aerosol** loads tend to decrease in the Eastern Mediterranean and to increase in the Middle East
- **PV production** is expected to increase in the Eastern Mediterranean and decrease in the Middle East – **reflecting** the patterns of **differences** in aerosol loading
- The **decrease** of **Sulfate AOD** in the Eastern Mediterranean contributes to the increase of PV production potential in this region
- **Variability** in PV production is more **pronounced** within the modelling of **dual-axis tracking systems**
- Our findings highlight the need for further investigation into how variations in cloudiness and atmospheric aerosols shape the regional PV power potential

References

Pfenninger, S., & Staffell, I. (2016). Long-term patterns of European PV output using 30 years of validated hourly reanalysis and satellite data. Energy (Oxford, England), 114, 1251–1265. doi:10.1016/j.energy.2016.08.060

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