



Dust and sand storms: risks and recommendations for monitoring and mitigation

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Agenda



Introduction

- Definition and Frequency

Associated Risks

- Concurrent and Subsequent effects
- Case studies

Recommendations

- Monitoring
- Mitigation

Introduction: Definition



During dust storms, large amounts of particles are suspended in the atmosphere. These reduce the intensity of irradiance reaching the Earth's surface.



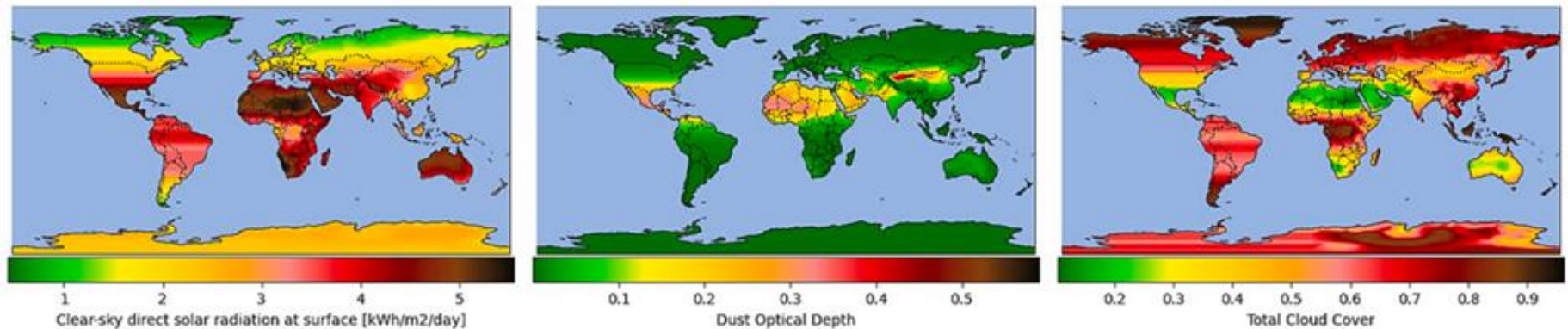
Skies over Malaga city centre during the historic calima of March 2022. Photo: Nany Lavado / Video: Pedro J. Quero

Introduction: Frequency



Locations with higher solar potential are more exposed to dust storms due to:

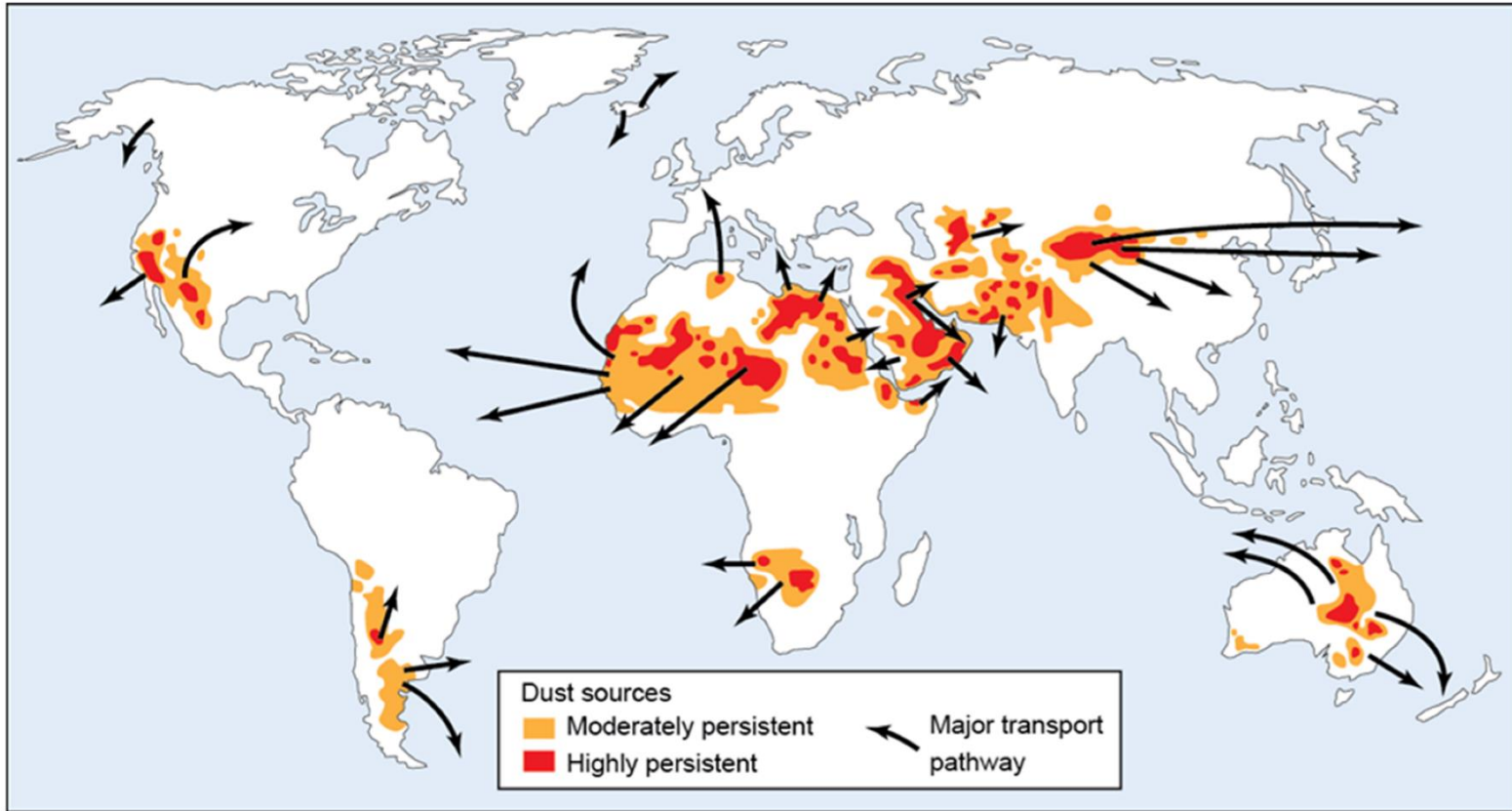
- 1) their more **arid/desert environments** or their proximity to them,
- 2) to the typically **lower probability of cloud cover**



Introduction: Global Map



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Introduction: Frequency



Even if predominant in **arid and semi-arid** regions, dust intrusions have been reported over different countries in the past years.

Sahara dust cloud sweeps UK as experts issue warning

Satellite images show dust cloud moving 1,200 miles across Mediterranean to UK

Maryam Zakir-Hussain • Thursday 07 September 2023 16:17



INDEPENDENT

Saharan dust cloud makes English skies glow orange

Rayleigh scattering phenomenon in the south comes as hottest day of year so far forecast for Saturday



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Photos: Dust from the Sahara has turned the snow orange in Russia and Eastern Europe

The Washington Post
Democracy Dies in Darkness

Observation and modeling of the historic “Godzilla” African dust intrusion into the Caribbean Basin and the southern US in June 2020

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Atmospheric
Chemistry
and Physics



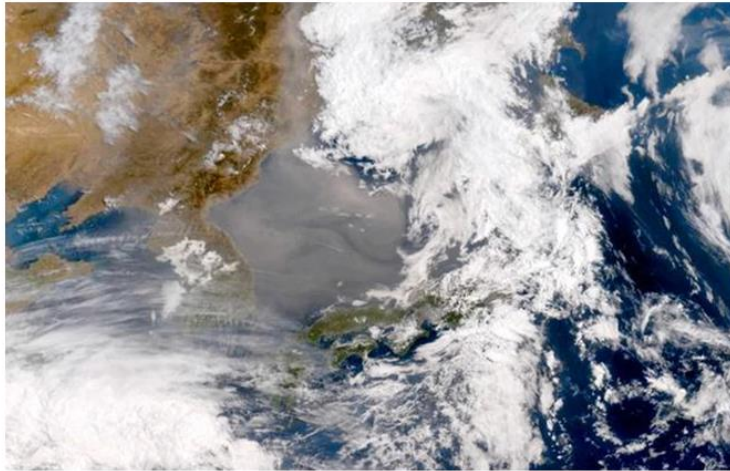
Introduction: Frequency



The Sahara is the largest source of atmospheric desert dust, followed by the deserts in China, Central Asia, Saudi Arabia, and Australia.

Seasonal yellow sand from China clouds skies over western Japan

By RYO OYAMA/ Staff Writer
April 17, 2024 at 16:50 JST



A satellite image of the area around the Japanese islands as of 9 a.m. on April 17 shows yellow sand (the light brown color around the Sea of Japan) coming from the Eurasian continent. (From the Japan Meteorological Agency website)

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News

Top Japan Features Weather Earthquake Video



Yellow sand reaches parts of Japan

Wednesday April 12, 2023



Yellow sand from China's desert regions has reached parts of Japan. Weather officials expect that in the coming days sandstorms will hit wider areas of the country, possibly affecting traffic and flights.

Associated Risks



Concurrent
effect

Reduction in the intensity
of surface irradiance



Subsequent
effect

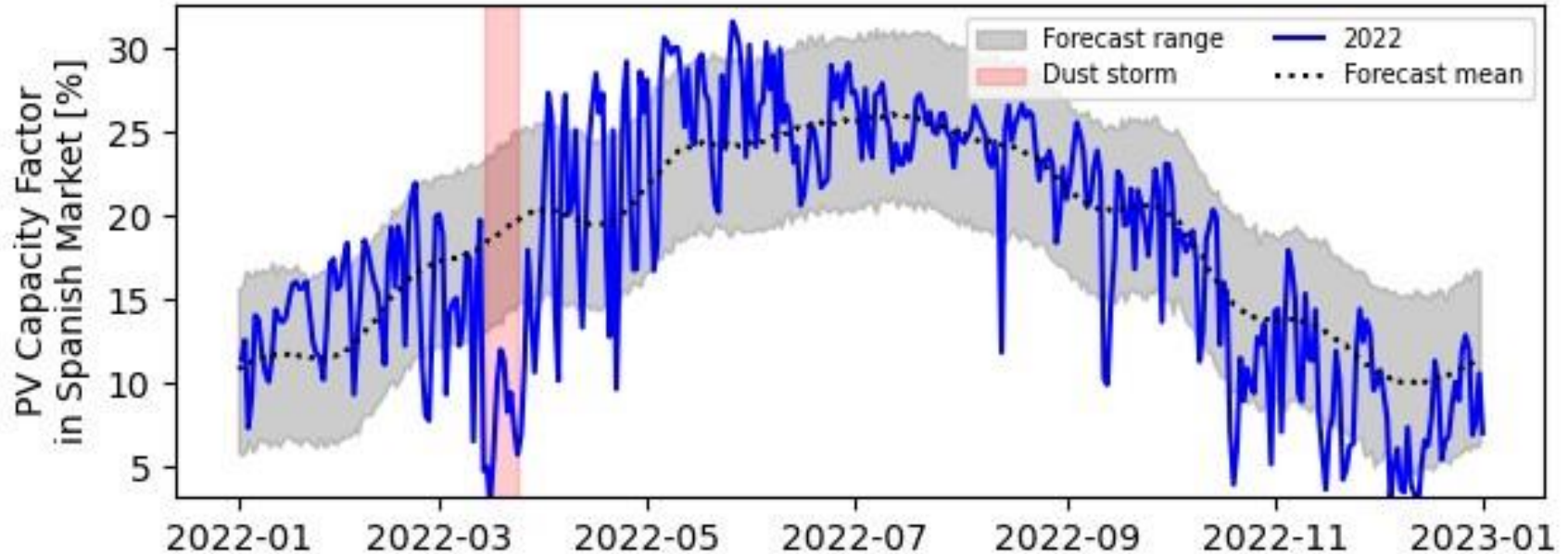
Increased accumulation
of particles (i.e., soiling)



Case Study: Spain



The effect is not just local → It can affect the **national electricity grid**.
In March 2022, a dust storm halved the capacity factor of the national Spanish PV fleet.



$$\text{Capacity Factor}(d) = \frac{\text{National Daily PV Generation}(d)}{\text{National Daily PV Capacity}(d) \cdot 24h}$$

Case Study: Portugal

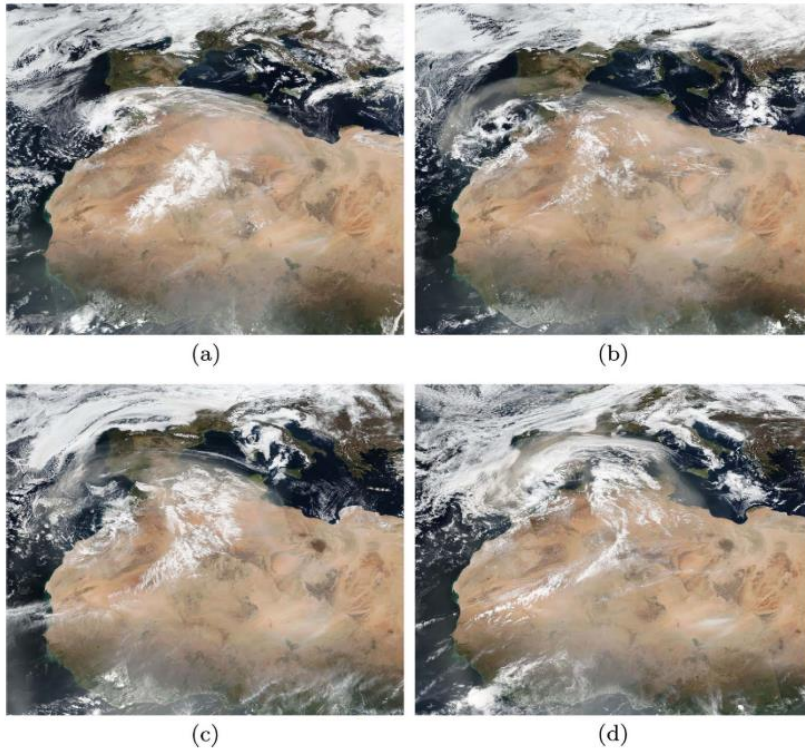
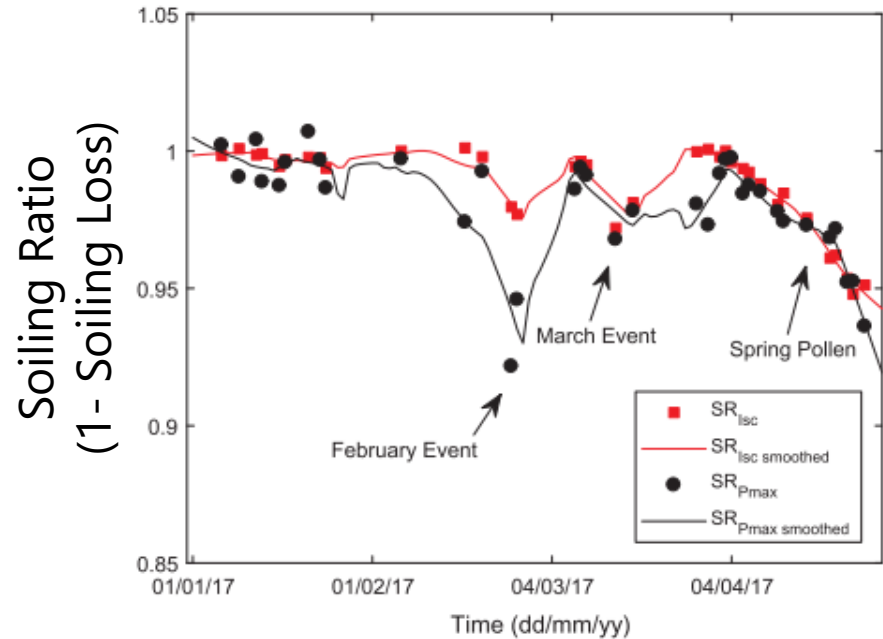


Fig. 2. NASA VSIIR dust event true image colors: (a) 20th February; (b) 21st February; (c) 22nd February; (d) 23rd February.

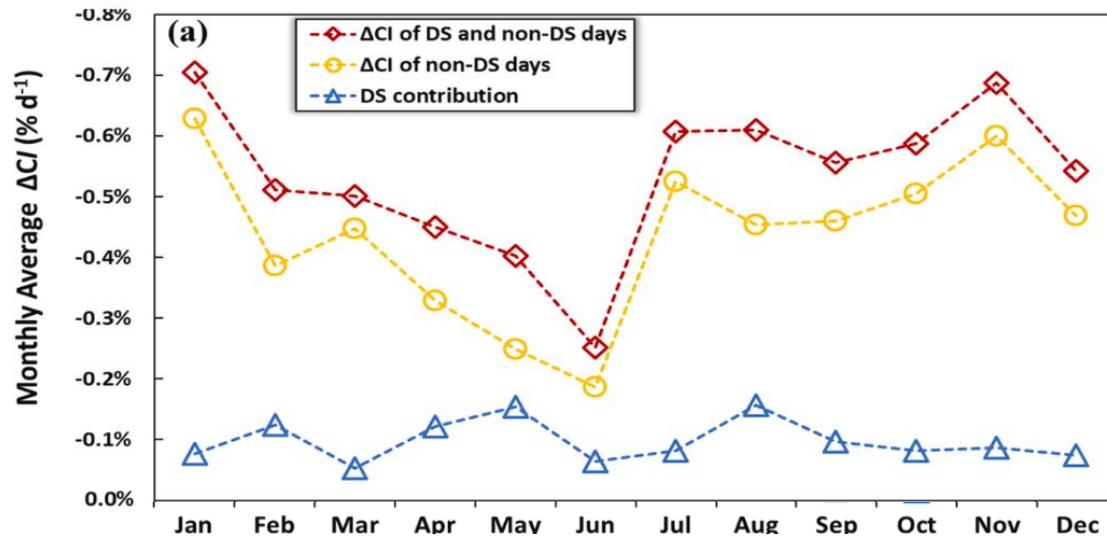
In spring 2017, several dust storms occurred over the Iberian peninsula.



Case Study: Qatar



In Qatar, dust storms are more common, cause **8% attenuation of solar radiation** and **increase soiling deposition rates by 23%**.



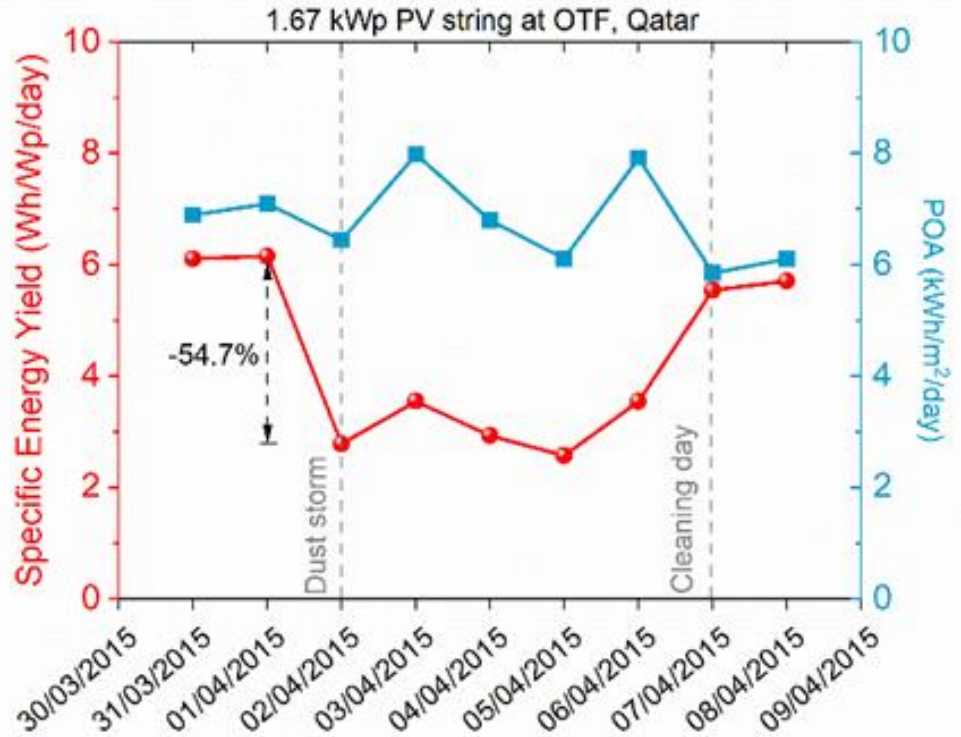
ΔCI : daily soiling accumulation rate

Case Study: Qatar

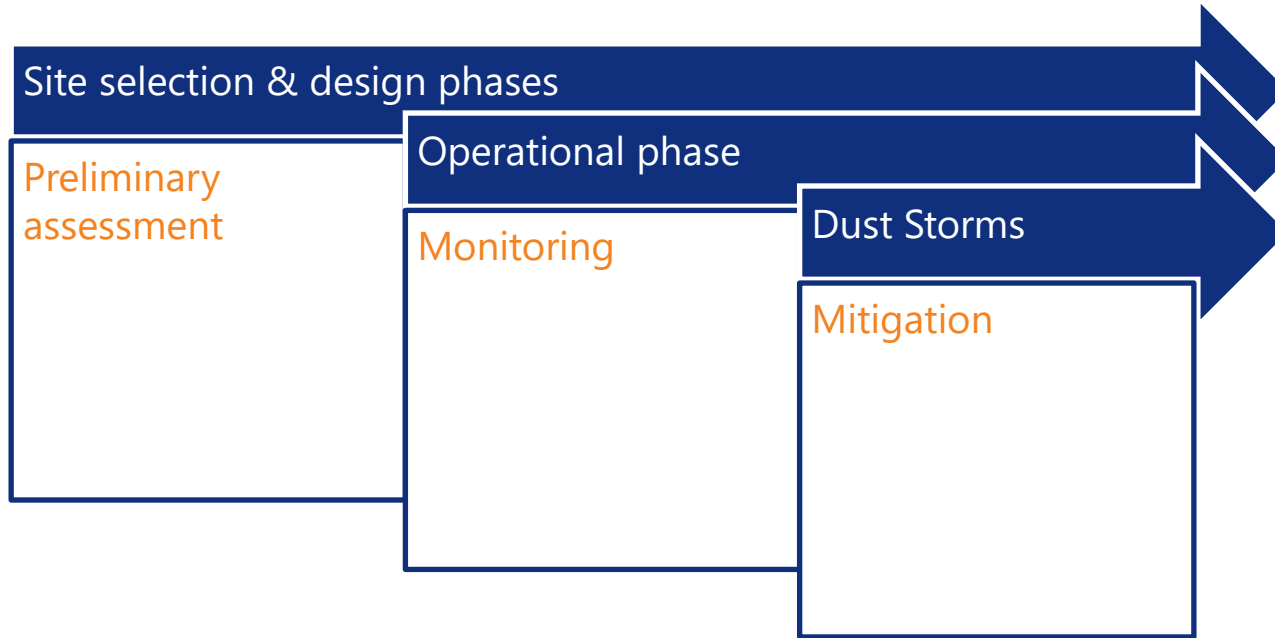


After an extreme DSS event, in April 2015, the energy yield of a system in Doha, Qatar, dropped by more than 50%.

Even if that event is considered the most severe episode in decades, DSSs of lower but still substantial severity are not uncommon.



Key Recommendations



Key Recommendations: Preliminary Assessment



Evaluate the **frequency and intensity** of dust storms: understanding the patterns will help in predicting and preparing for potential production losses.

Define the **optimal strategy** to mitigate the impact of dust storms.



Optimize the design of the PV system to reduce the losses and facilitate O&M.

Include dust storm and associate soiling losses in **economic assessment** of PV.

Key Recommendations: Preliminary Assessment



The occurrence of extreme dust storm events can be tracked from the analysis of the aerosol optical depth (AOD).

Dust storms are defined

“intense” if: $AOD(d) > \overline{AOD} + 2\sigma_{AOD}$

“extreme” if: $AOD(d) > \overline{AOD} + 4\sigma_{AOD}$

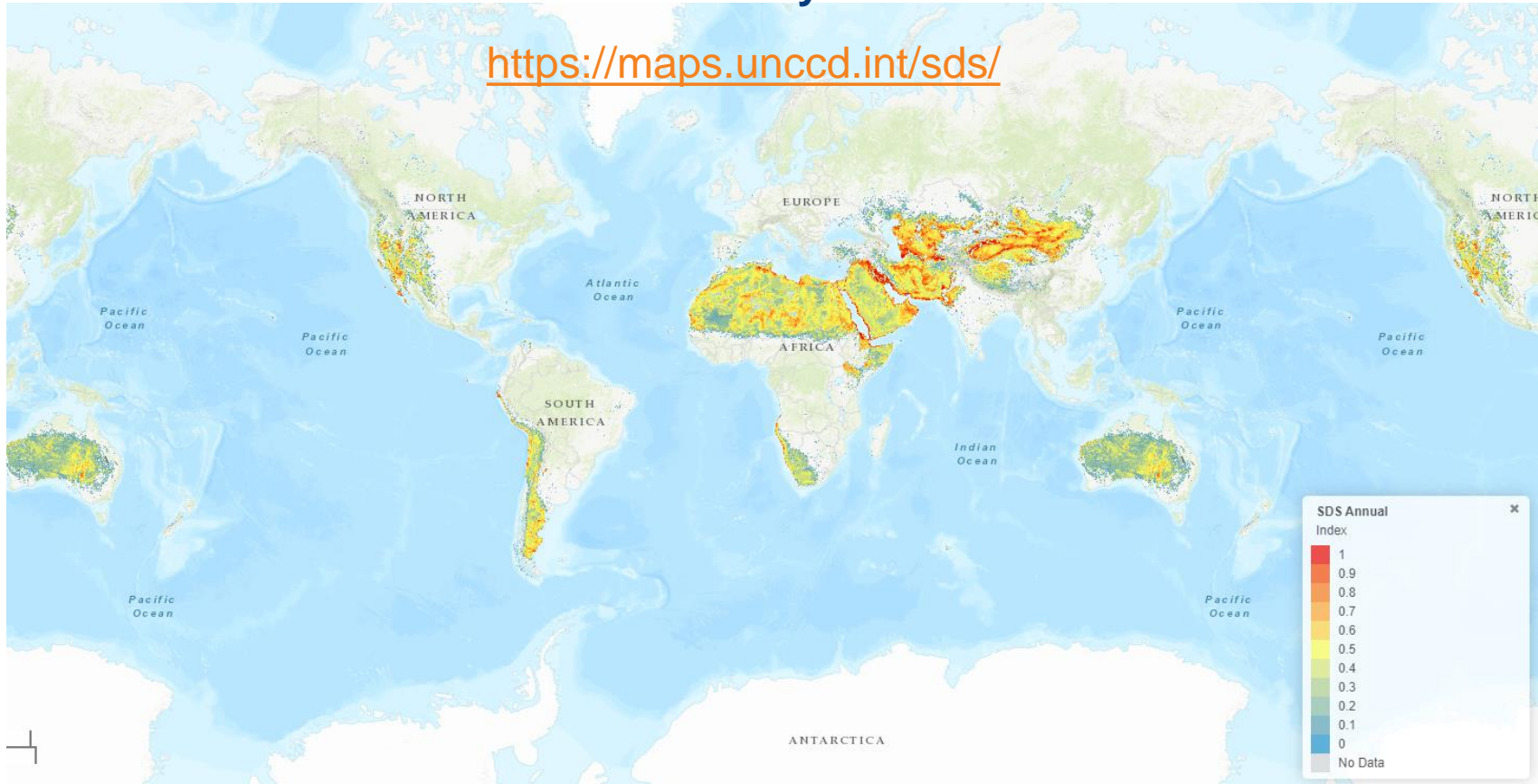
Alternative indicators are the DOD (dust optical depth) and the PM (particulate matter).

Key Recommendations: Preliminary Assessment



Sand and Dust Storms are tracked by UN to address desertification

<https://maps.unccd.int/sds/>

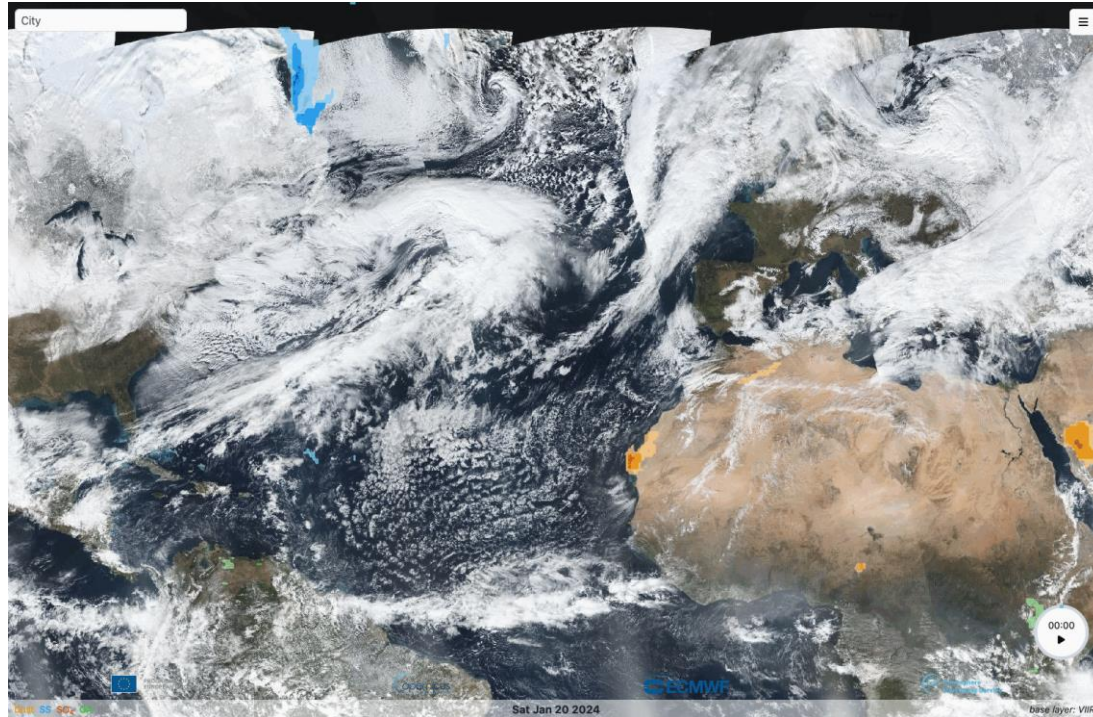


Key Recommendations: Monitoring



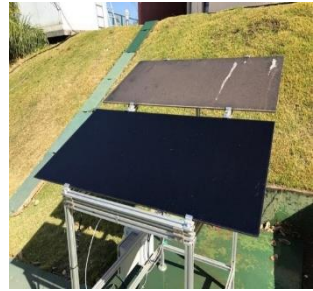
Copernicus has launched a **Aerosol Alerts service**.

<https://aerosol-alerts.atmosphere.copernicus.eu/>



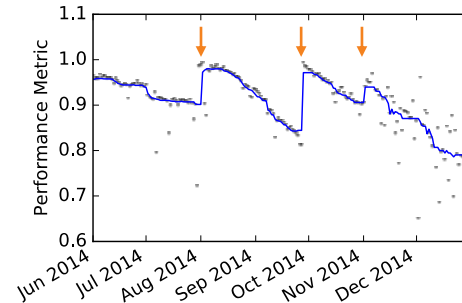
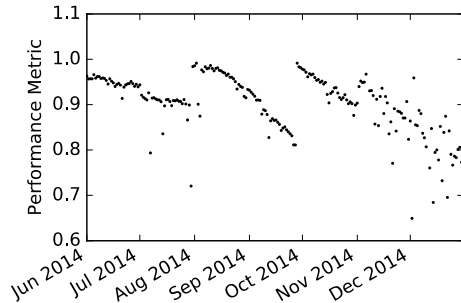
Key Recommendations: Monitoring

Soiling losses can be monitored using specific sensors



...or through the analysis of the PV data

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Soiling Losses – Impact on the Performance of Photovoltaic Power Plants 2022



Key Recommendations: Mitigation




Absorption, reflection and scattering of the sunlight caused by the suspended dust particles	Increased accumulation of dust particles (soiling)
	<p>Soiling mitigation strategies</p> <ul style="list-style-type: none">• Extraordinary and regular cleanings*• Upside down positioned modules during storms



Dust storms are an increasingly concern worldwide. → Not only an issue for desertic/arid areas.

Dust storms have different frequency and severity... so also the impact and the mitigation strategies change from country to country.



Food and Agriculture Organization of the United Nations

Sand and dust storms (SDS): A transboundary issue of growing concern

SDS are complex environmental phenomena, the result of a series of interlinked natural and anthropogenic drivers operating at different scales. They have gained growing attention in the past decade due to their impacts on the environment and a range of socioeconomic sectors. SDS result in land degradation and production losses on croplands and rangelands. Transport is disrupted by reduced visibility and sand deposits that block roads. There are numerous impacts on health – for people, plants and animals – and dust deposited on solar panels results in less electricity being produced. Economic losses from a single SDS event can cost hundreds of millions of US dollars.

Thank You for Your Attention!

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