Comparison of Soiling Rate Data from two Sites and its Application to Yield Analysis

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Soiling rate measurements

The measurement instrument TraCS (Tracked Cleanliness Sensor) shown in Fig. 1 has been used to measure the soiling rate over more than five years at Plataforma Solar de Almeria (PSA) in Spain and Missour (MIS) in Morocco. It compares the directly measured DNI with the DNI reflected from a rotating sample mirror to derive its cleanliness and the soiling rate (SR). The rotation of the mirror increases the measurement area and hence the accuracy.

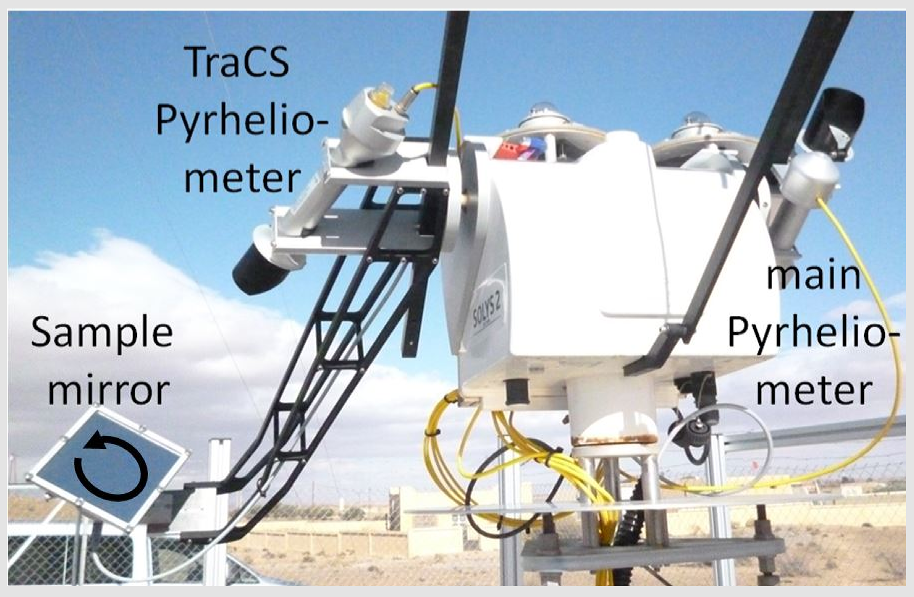

Fig. 1: The TraCS instrument as installed in Missour, Morocco (MIS).

Soiling rate site comparison

The soiling rate data from both sites is shown in Fig. 2 in daily time resolution. The location of the sites is shown in Fig. 3.

The main observations in Fig. 2 are:

- Elevated soiling at PSA at first half of the year, lower soiling intensity at MIS from September to January
- Four exceptionally high soiling events coincide at both sites supposedly due to dust transport over the 480km distance between the sites

Fig. 4 and Tab. 1 summarize the statistical properties of the datasets. The main difference in soiling between both sites is the stronger average soiling in MIS that also shows a higher variability.

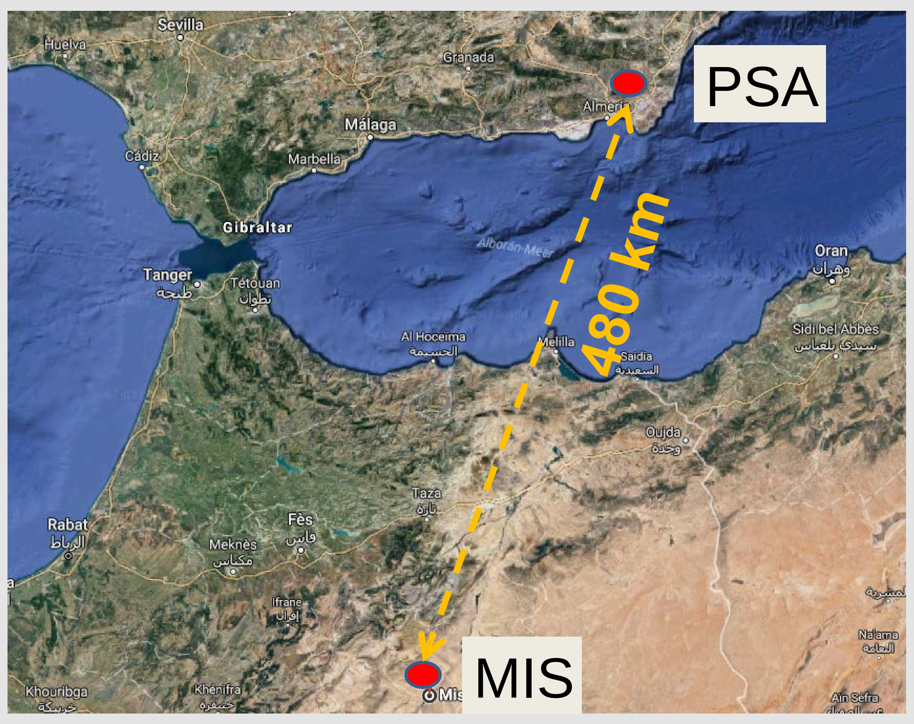

Fig. 3: Position of the two investigated sites including distance between the sites (Map: Google).

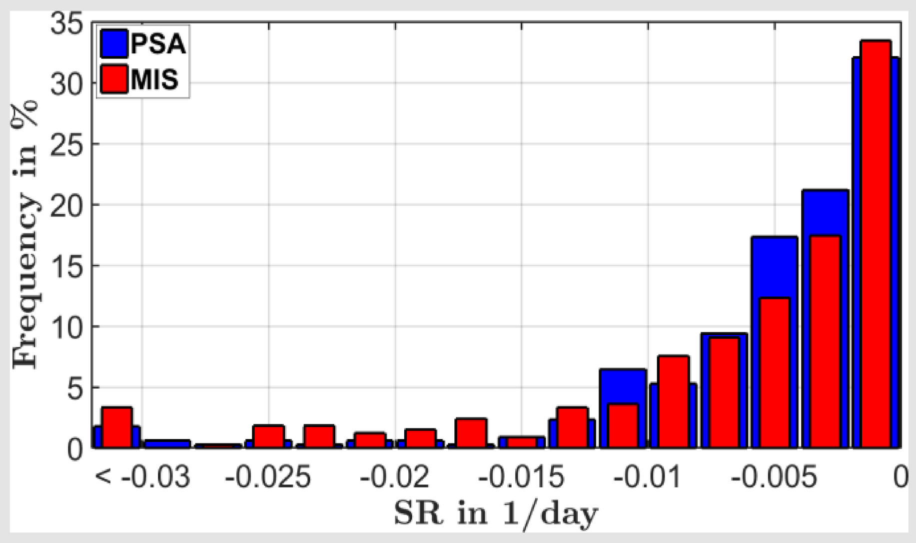

Fig. 4: Histogram of the measured soiling rate for MIS and PSA in bins of -0.002/day. The last bin counts all occurrences of SR < -0.03/day.

Tab. 1: Statistical properties of the SR datasets from both sites. Units in 1/day if not specified.

	PSA	MIS
Mean (SR)	-0.0051	-0.0071
Median (SR)	-0.0032	-0.0034
Minimum (SR)	-0.042	-0.093
St. deviation (SR)	0.006	0.011
Probability for SR > -0.005	66 %	57 %

Application to yield analysis

The different soiling characteristics for both sites have implications for cleaning scheduling in operational power plants and site selection. For example, at sites with a higher variability, investing in a greater cleaning fleet could pay off by increased flexibility. To quantify these effects the yield analysis software greenius (*freegreenius.dlr.de*) has been coupled with a novel cleaning simulation tool that traces each cleaning vehicle's movement in the solar field. The comparison parameter is the relative profit increase (RPI) compared to constant cleaning with one cleaning vehicle.

The simulation has been performed for two 50MW power plant configurations, with and without a 7h storage, indicated as Solar Only (SO) and Storage (Sto), respectively.

The result is shown in Fig. 5 for constant cleaning frequency. The higher soiling level in MIS favors a higher number of cleaning vehicles ($N_{vehicles}$) compared to the PSA case.

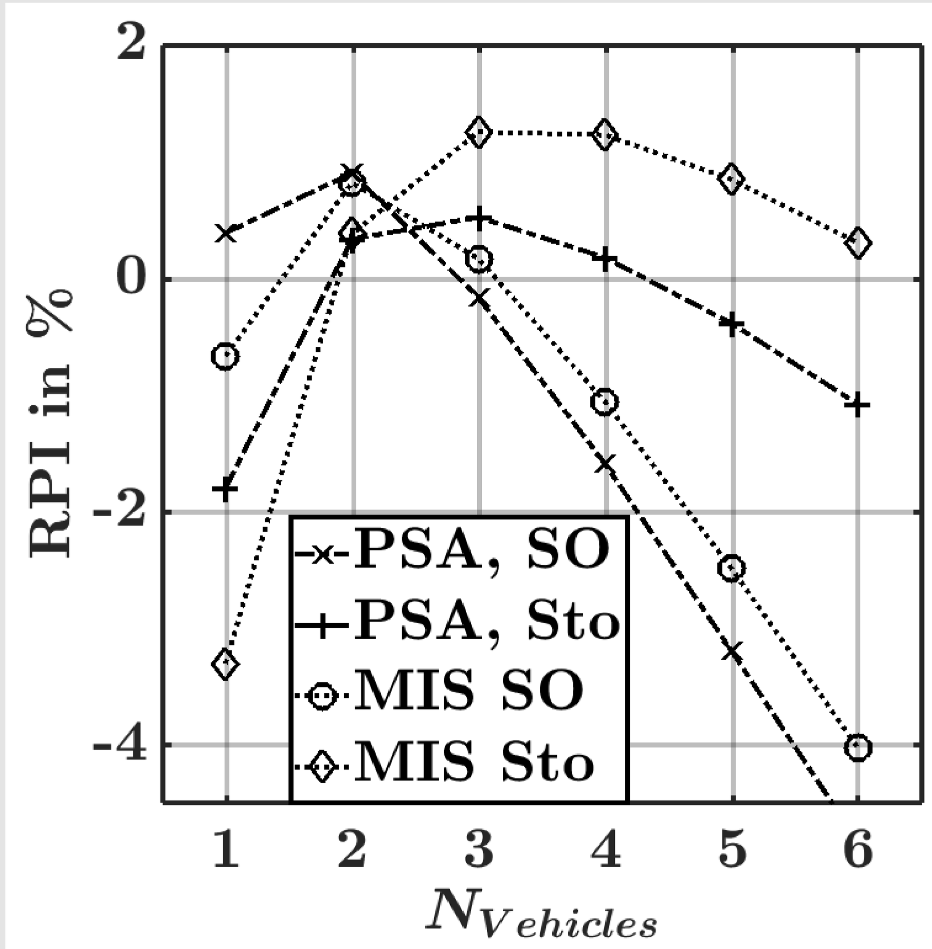

Fig. 5: Relative profit increase plotted against the number of cleaning vehicles for power plants with (Sto) and without (SO) thermal storage.

SR-adapted cleaning strategies trigger cleaning activities only if the mean solar field cleanliness (ξ_{Field}) drops below a given threshold. They can increase the profit further, as shown in Fig. 6 for the case of the Sto power plant and the PSA site.

The software tool can thus significantly increase accuracy for yield analysis and site selection. Given the availability of a soiling rate forecast, it could optimize cleaning schedules in a running power plant.

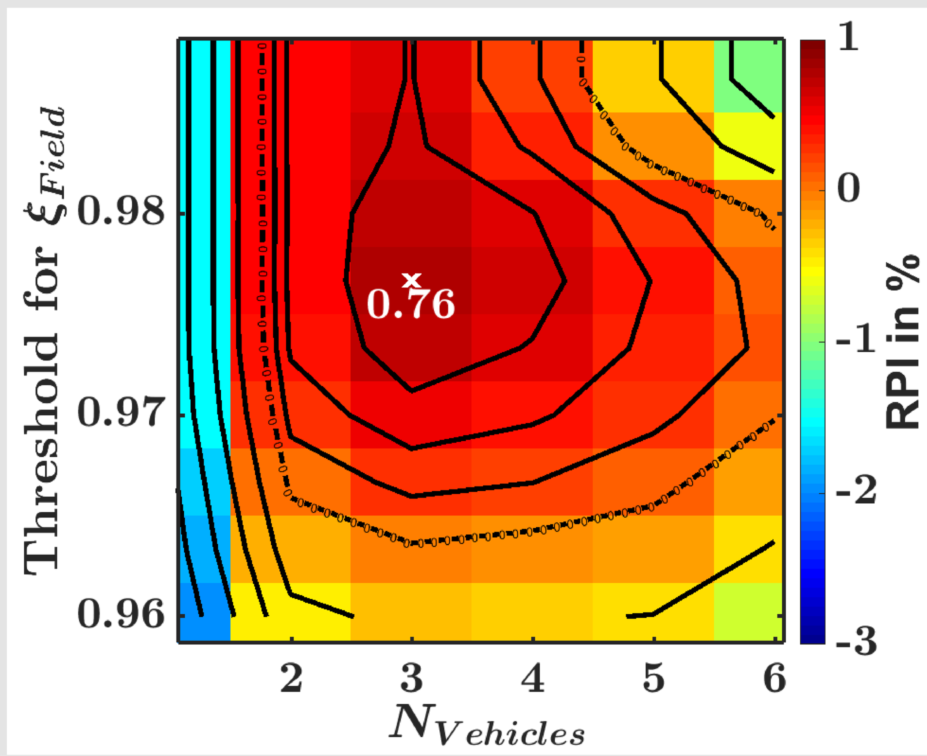

Fig. 4: RPI in color for cleanliness threshold and number of cleaning vehicles for PSA and a CSP plant with 7h of storage.

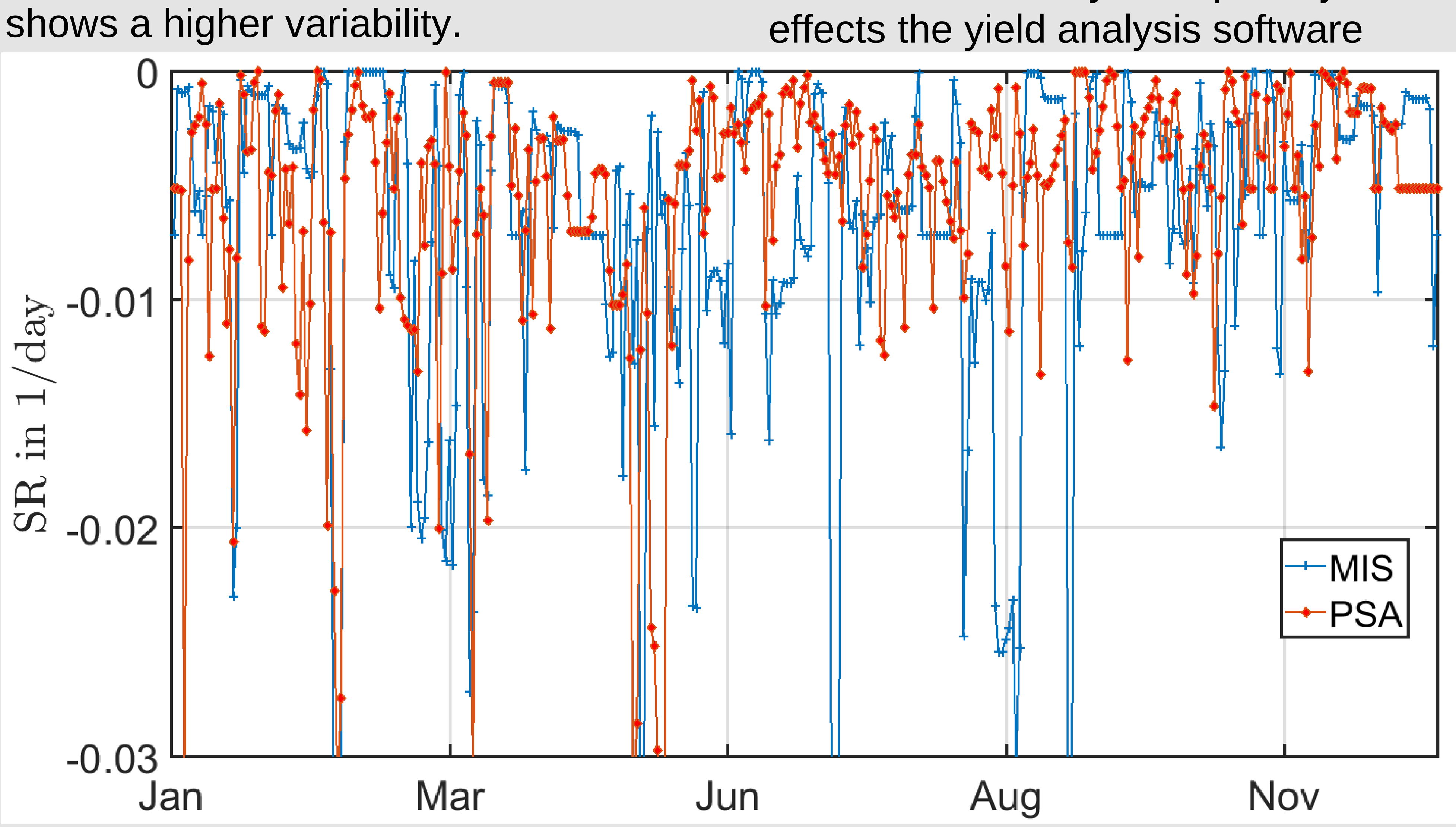

Fig. 2: Soiling rate data from MIS and PSA for the year 2014 in daily time resolution.

References:

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Wolfertstetter, Pottler, Geuder, Affolter, Merrouni, Mezrhab, and Pitz-Paal, (2014). Monitoring of Mirror and Sensor Soiling with TraCS for Improved Quality of Ground based Irradiance Measurements. Energy Procedia, 49:2422–2432

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