



# DustIQ

DustIQ Soiling Measurement System



# Introduction

In recent years, **photovoltaic (PV)** technology has emerged as one of the leading renewable energy technologies currently available. The PV plant performance is, aside from hardware, determined by three main parameters: **irradiance, temperature and soiling**. Irradiance and temperature are well understood and high quality measurements are available. However, for soiling there is less understanding and only basic measurements.

The effect of soiling on the PV plant performance is shown by the accumulation of soiling per day for different locations [1] in figure 1. The accumulation of soiling is location dependent and an indication of the global distribution [2] is shown in figure 2. Furthermore, the soiling accumulation is also dependent on the time of year [3].



## Soiling accumulation loss per day

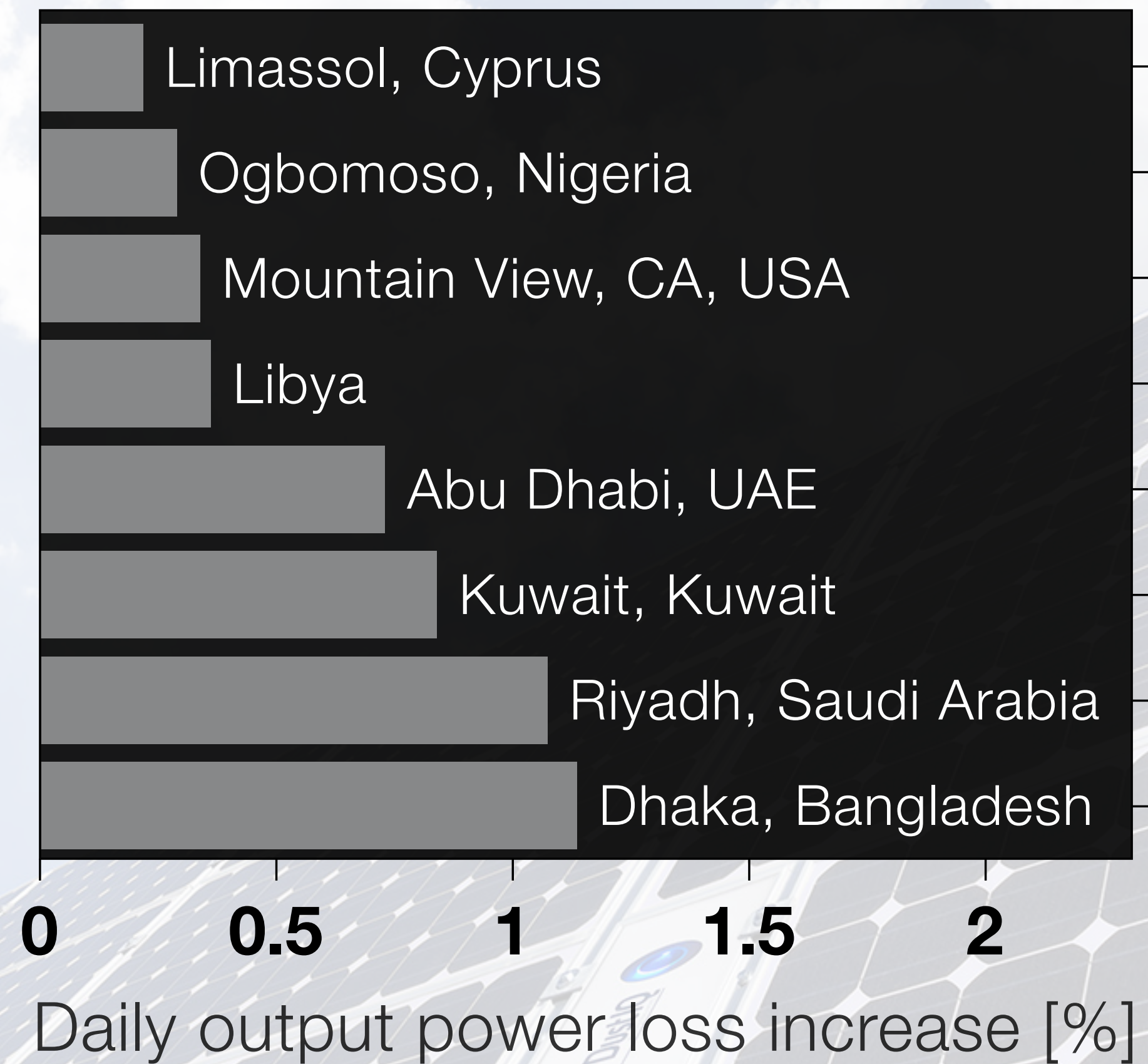


Figure 1: Soiling loss accumulation per day for different locations; recreated from [1].



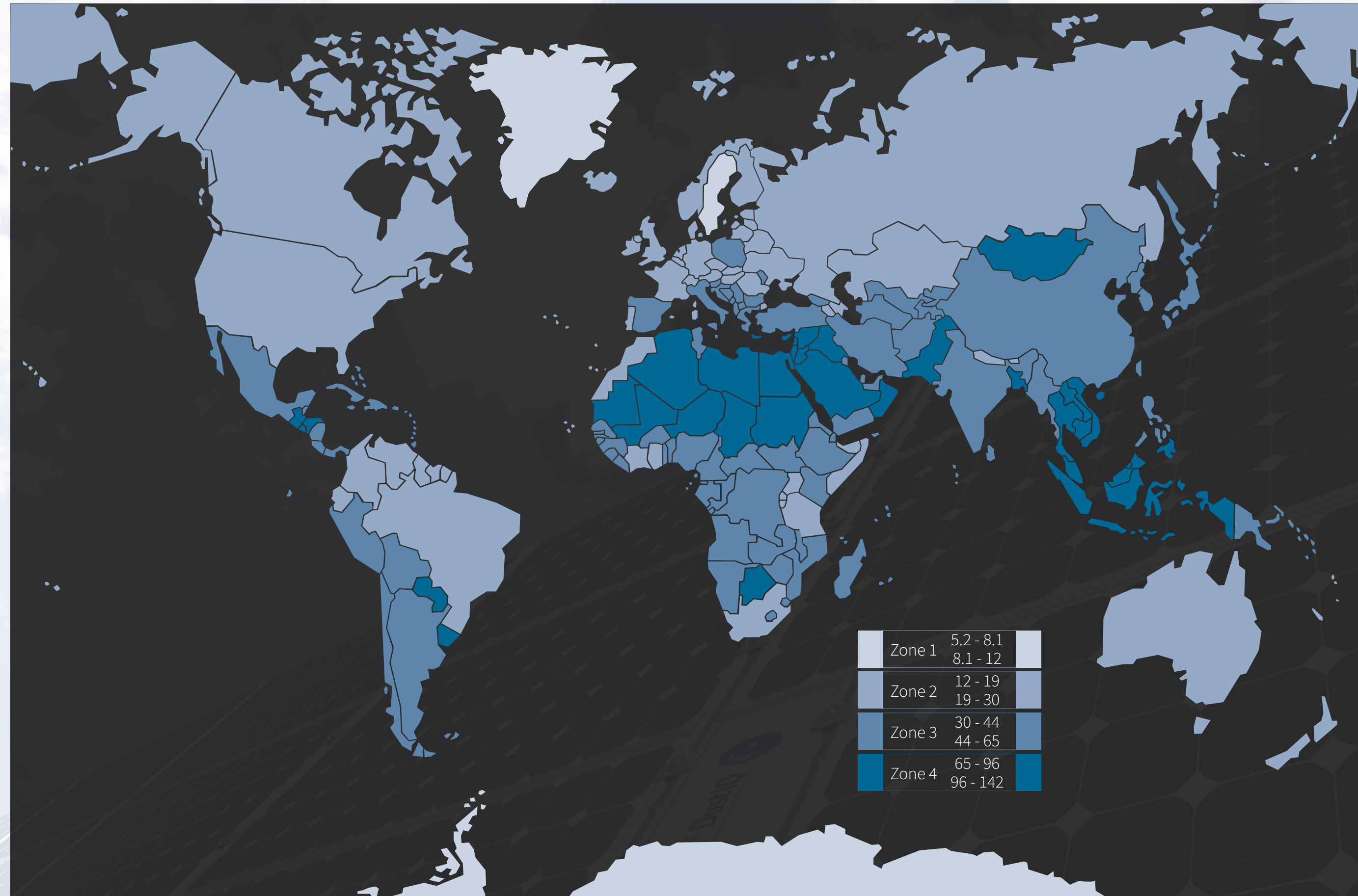
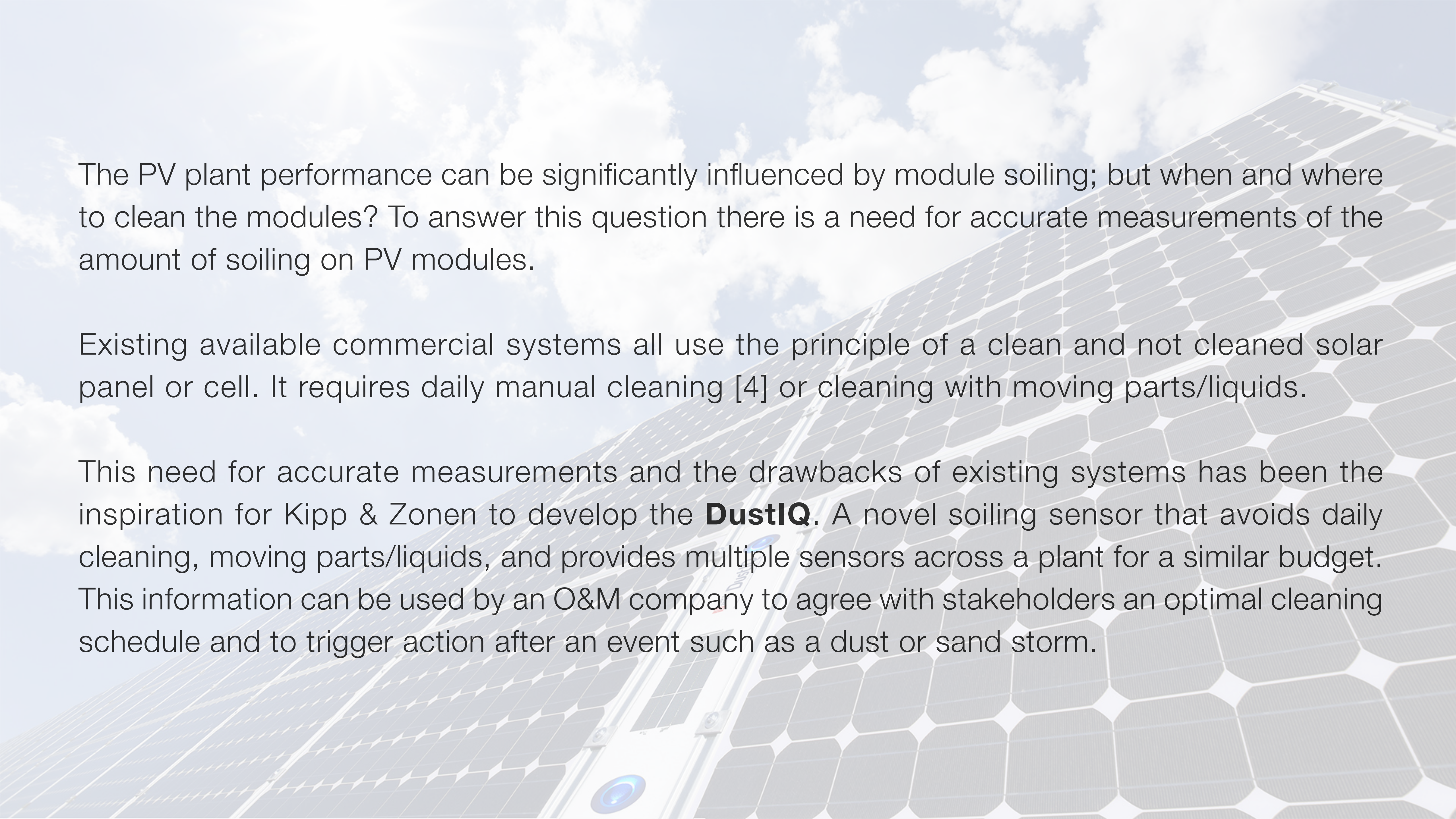


Figure 2: Global dust intensity, the darker colours represent a higher  $\mu\text{g}/\text{m}^3$  PM10 (recreated from [2])





The PV plant performance can be significantly influenced by module soiling; but when and where to clean the modules? To answer this question there is a need for accurate measurements of the amount of soiling on PV modules.

Existing available commercial systems all use the principle of a clean and not cleaned solar panel or cell. It requires daily manual cleaning [4] or cleaning with moving parts/liquids.

This need for accurate measurements and the drawbacks of existing systems has been the inspiration for Kipp & Zonen to develop the **DustIQ**. A novel soiling sensor that avoids daily cleaning, moving parts/liquids, and provides multiple sensors across a plant for a similar budget. This information can be used by an O&M company to agree with stakeholders an optimal cleaning schedule and to trigger action after an event such as a dust or sand storm.



# DustIQ Soiling Measurement System

The DustIQ system consists of glass plate, the same as in a PV panel, mounted next to or in between the PV modules to ensure that the instrument follows the same soiling and cleaning patterns as the PV panels. Below this glass plate, there are two sensor heads using the **Optical Soiling Measurement (OSM)** technology to measure the scattered light from soiling on top of the glass panel (figure 3).

With an on-board calculation, the transmission loss due to soiling is determined from the two OSM sensors. The transmission loss is equivalent to the **Soiling Ratio (SR)** around solar noon. This SR is defined as the ratio in short circuit current,  $I_{sc}$ , or maximum power,  $P_{max}$ , between a soiled and a cleaned PV panel in the IEC 61724-1 [5]. For a completely clean panel the SR is 100 % and for a soiled panel it is closer to 0 %. Even if the soiling is constant, the SR is not constant over the day but is largest around solar noon, and gets smaller closer to sunset and sunrise [3,6,7].



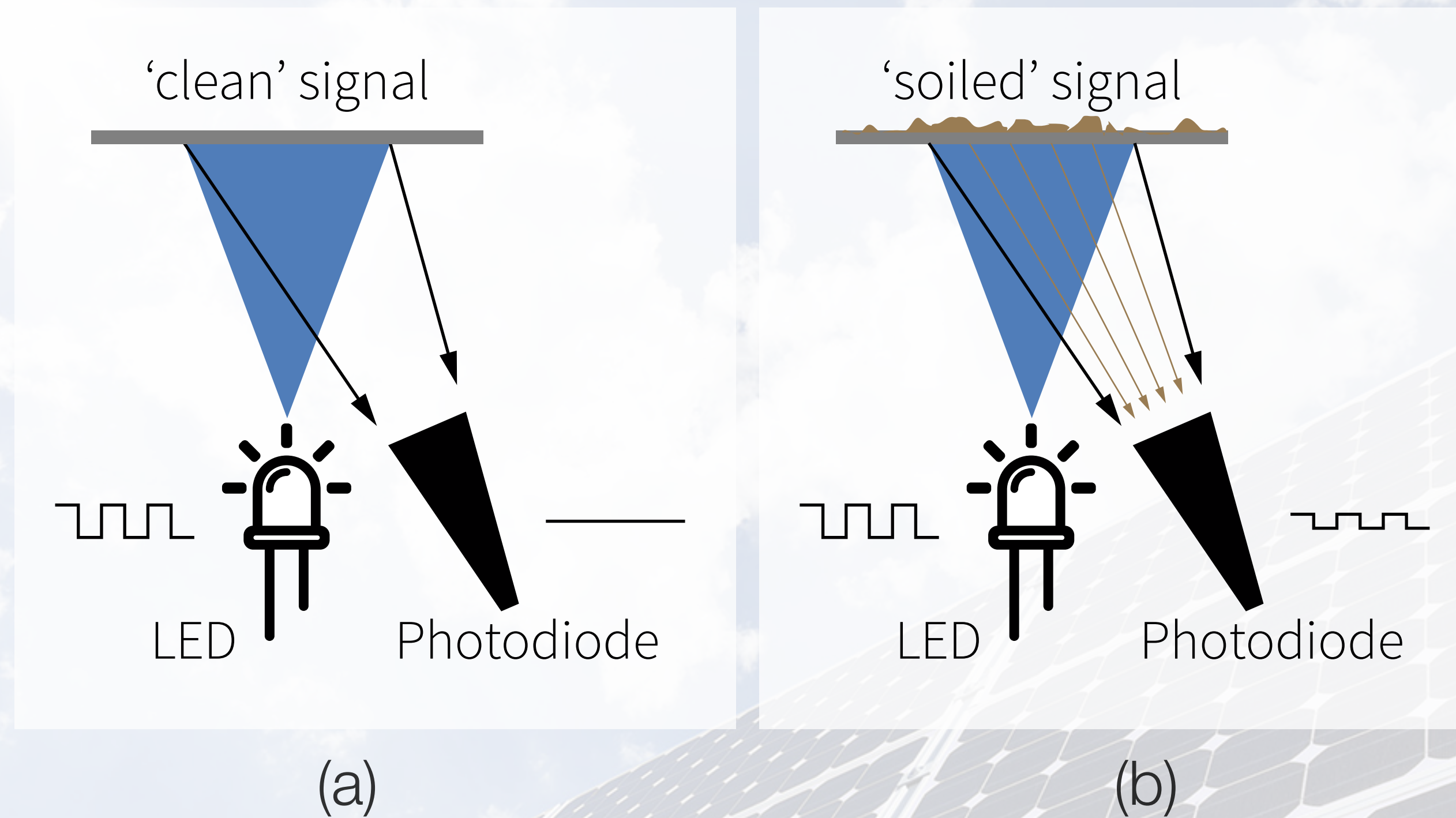


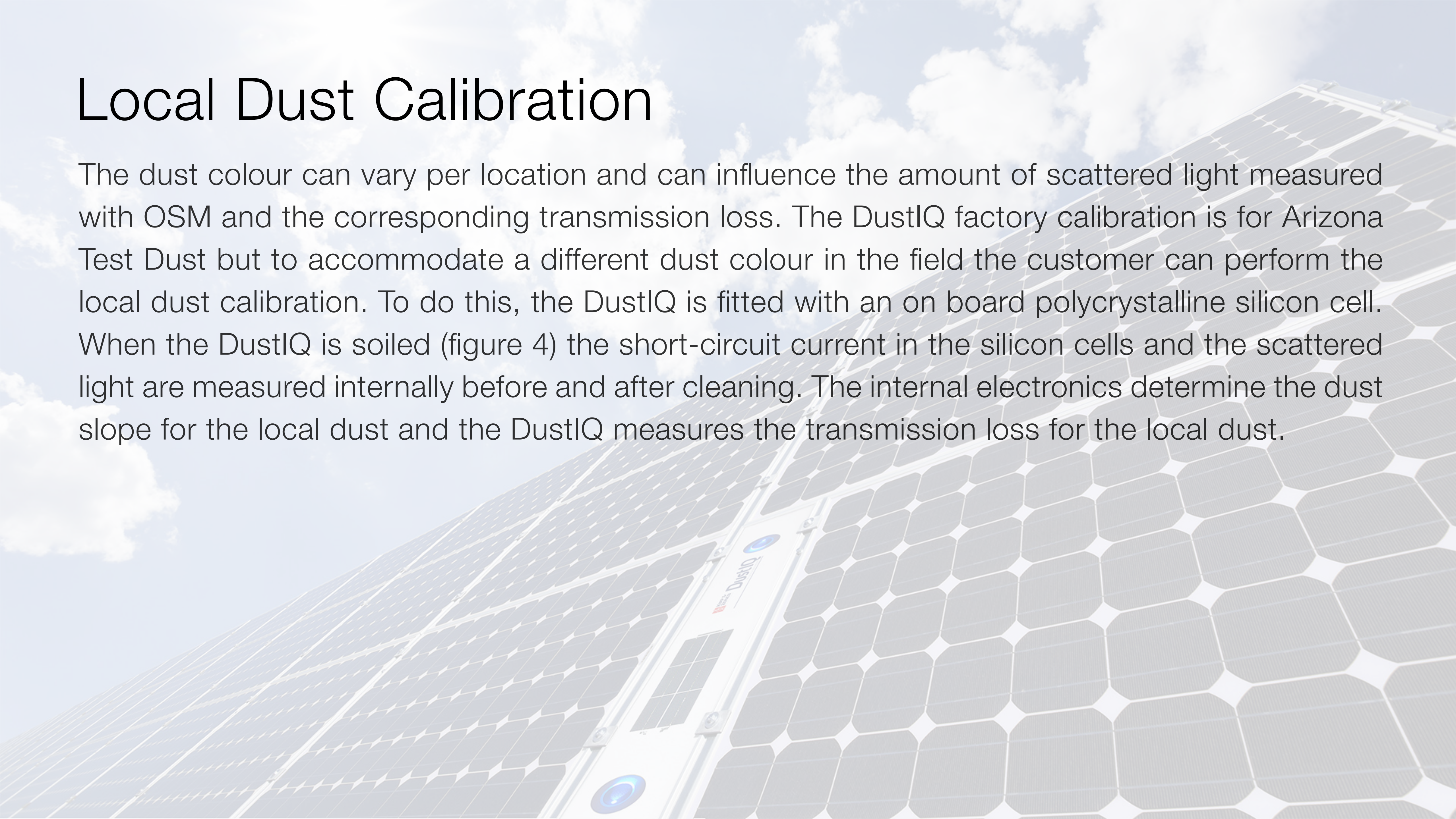
Figure 3: diagram of DustIQ function with pulsed LED and photodiode with (a) clean glass and (b) soiled glass resulting in detection of scattered light.

A unique feature is that the soiling measurement does not use the irradiance of the sun, therefore it is independent of the sun position and sky conditions. The system communicates using the Modbus<sup>®</sup> RTU protocol like all Kipp & Zonen Smart instruments with suitable inverters and data acquisition systems.



# Local Dust Calibration

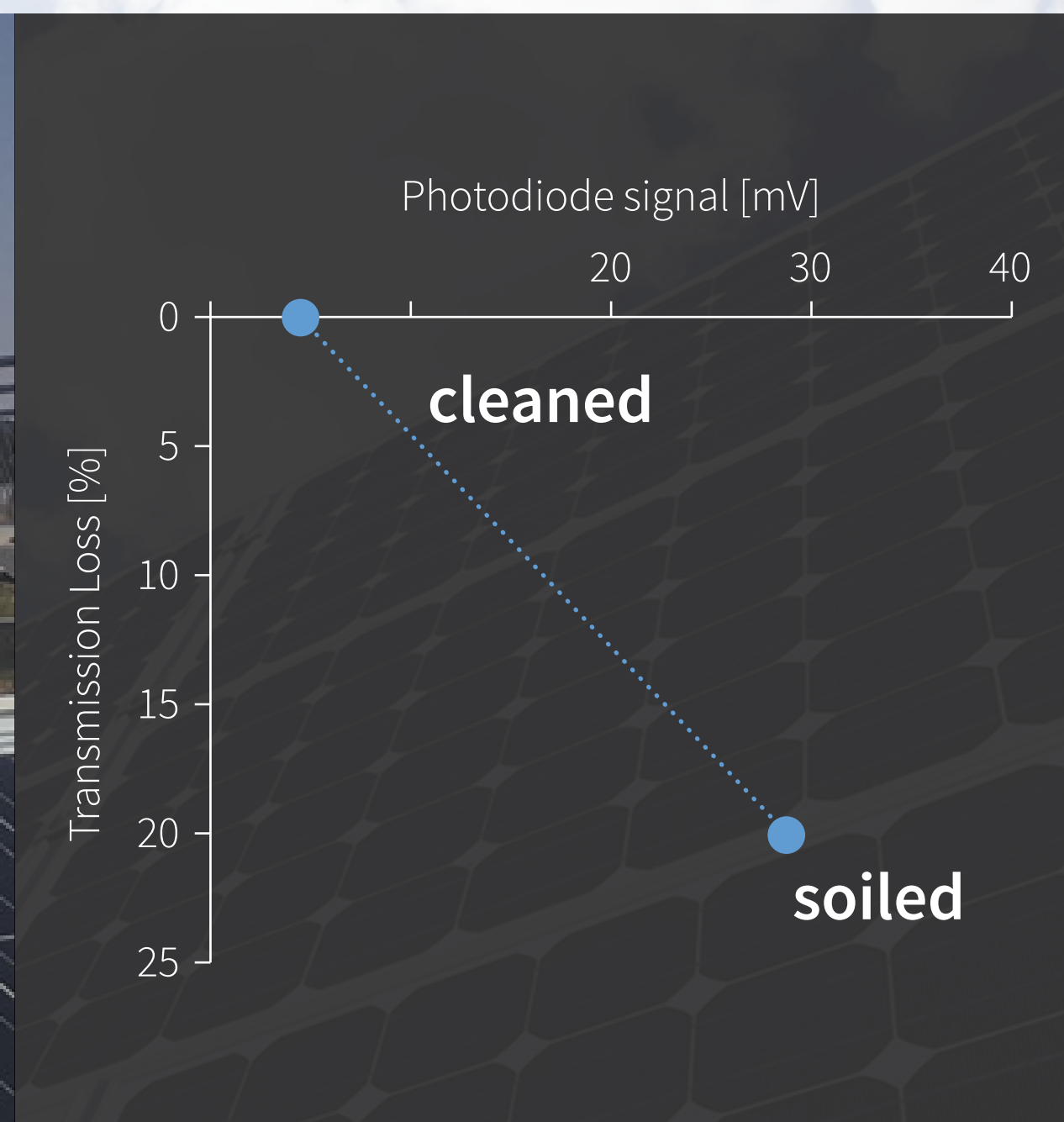
The dust colour can vary per location and can influence the amount of scattered light measured with OSM and the corresponding transmission loss. The DustIQ factory calibration is for Arizona Test Dust but to accommodate a different dust colour in the field the customer can perform the local dust calibration. To do this, the DustIQ is fitted with an on board polycrystalline silicon cell. When the DustIQ is soiled (figure 4) the short-circuit current in the silicon cells and the scattered light are measured internally before and after cleaning. The internal electronics determine the dust slope for the local dust and the DustIQ measures the transmission loss for the local dust.







(a)



(b)

Figure 4: (a) A naturally soiled DustIQ in Morocco with the small silicon-cell module in between the two round OSM sensors (left and right). (b) Possible local dust calibration result showing the soiled and cleaned state and the local dust slope.



# Preliminary Results Field Campaign Morocco

The DustIQ was installed at the Green Energy Park (figure 5) next to PV modules.



Figure 5 An overview of Green Energy Park, IRESEN, where the DustIQ is installed.



The first results from March till July (figure 6) show a small buildup of soiling in early spring followed by higher soiling losses in summer up to 14%. The blue curve represents the raw SR value that is influenced by soiling and by short term influences such as by nighttime dew or rain. An algorithm generated trendline (red), also implemented internally in the DustIQ, shows the trend of the soiling data, minimizing the daily dew/rain signal. The DustIQ sensor shows an increase of soiling over time, with the site in Morocco soiling at a rate of up to 0.4% SR per day.

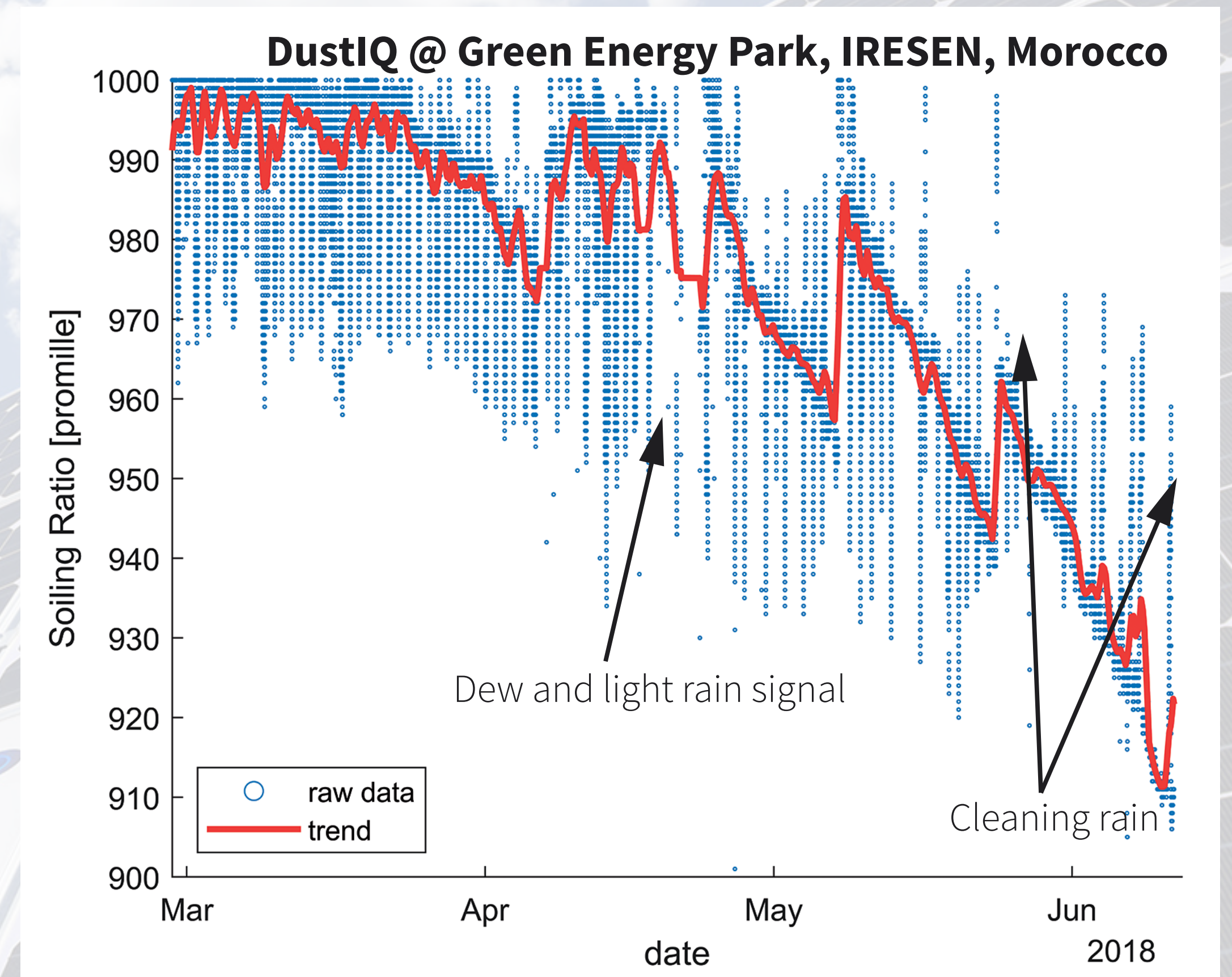


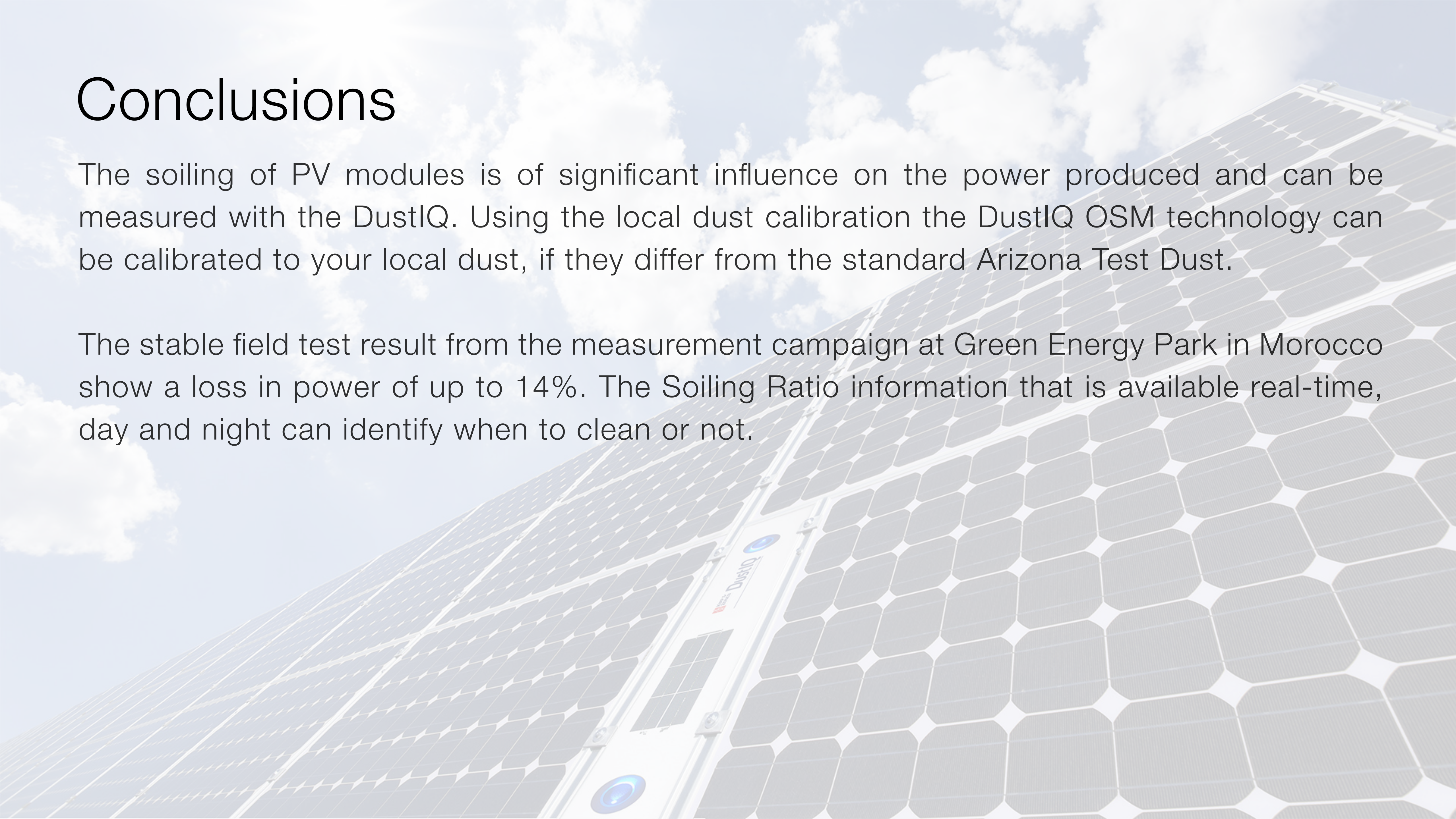
Figure 6 First results of Soiling Ratio measurement with the DustIQ at PSA.



# Conclusions

The soiling of PV modules is of significant influence on the power produced and can be measured with the DustIQ. Using the local dust calibration the DustIQ OSM technology can be calibrated to your local dust, if they differ from the standard Arizona Test Dust.

The stable field test result from the measurement campaign at Green Energy Park in Morocco show a loss in power of up to 14%. The Soiling Ratio information that is available real-time, day and night can identify when to clean or not.





# Acknowledgements

We acknowledge the good collaboration with dr. Ahmed Alami Merrouni at Green Energy Park IRESEN in Ben Guerir Morocco and with dr. Fabian Wolferstetter and dr. Stefan Wilbert at DLR and CIEMAT at CIEMATs Plataforma Solar de Almeria.

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