

APPLICATION OF SOILING MONITORING IN SOLAR POWER PLANTS

Marc Korevaar

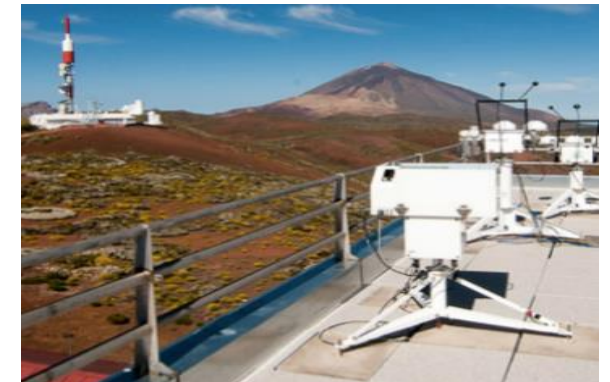
inDust user workshop May 16th, 2019, Intersolar Europe

Since 1830

Solar Energy & Meteorology



Atmospheric Science



OVERVIEW

- Soiling in PV
- DustIQ soiling measurement instrument
- Field tests
- Applications in PV plants
- Conclusions

PV PERFORMANCE VARIATIONS

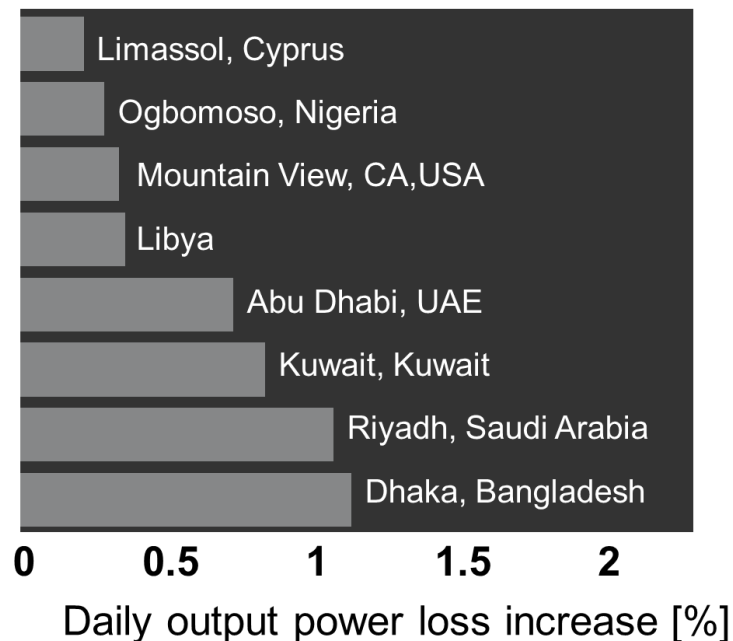
- Three main parameters (aside from hardware) influence PV performance:
 - Irradiance
 - Temperature
 - Soiling

- Good understanding & measurement of Irradiance & Temperature
- Developing understanding and measurement of Soiling

- Soiling is the parameter you can influence

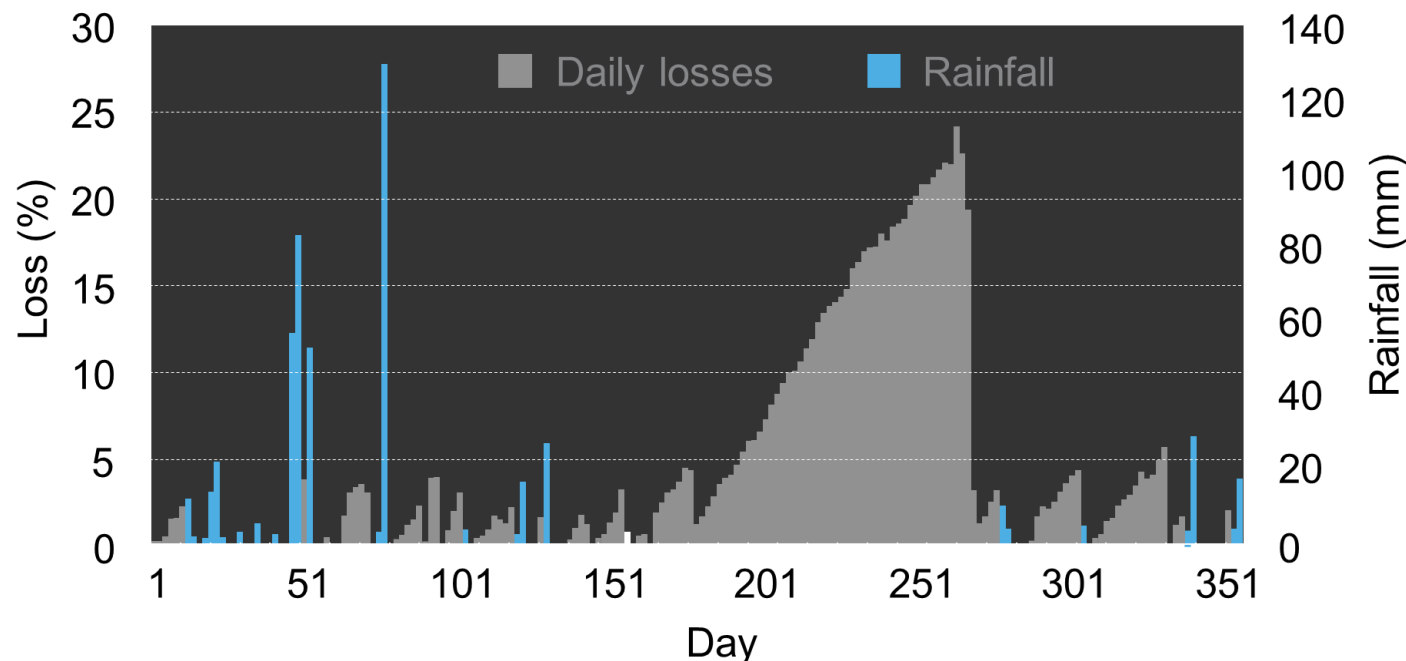
SIGNIFICANCE OF SOILING LOSSES

Soiling accumulation loss per day



Sayyah et al. Solar energy (2014)

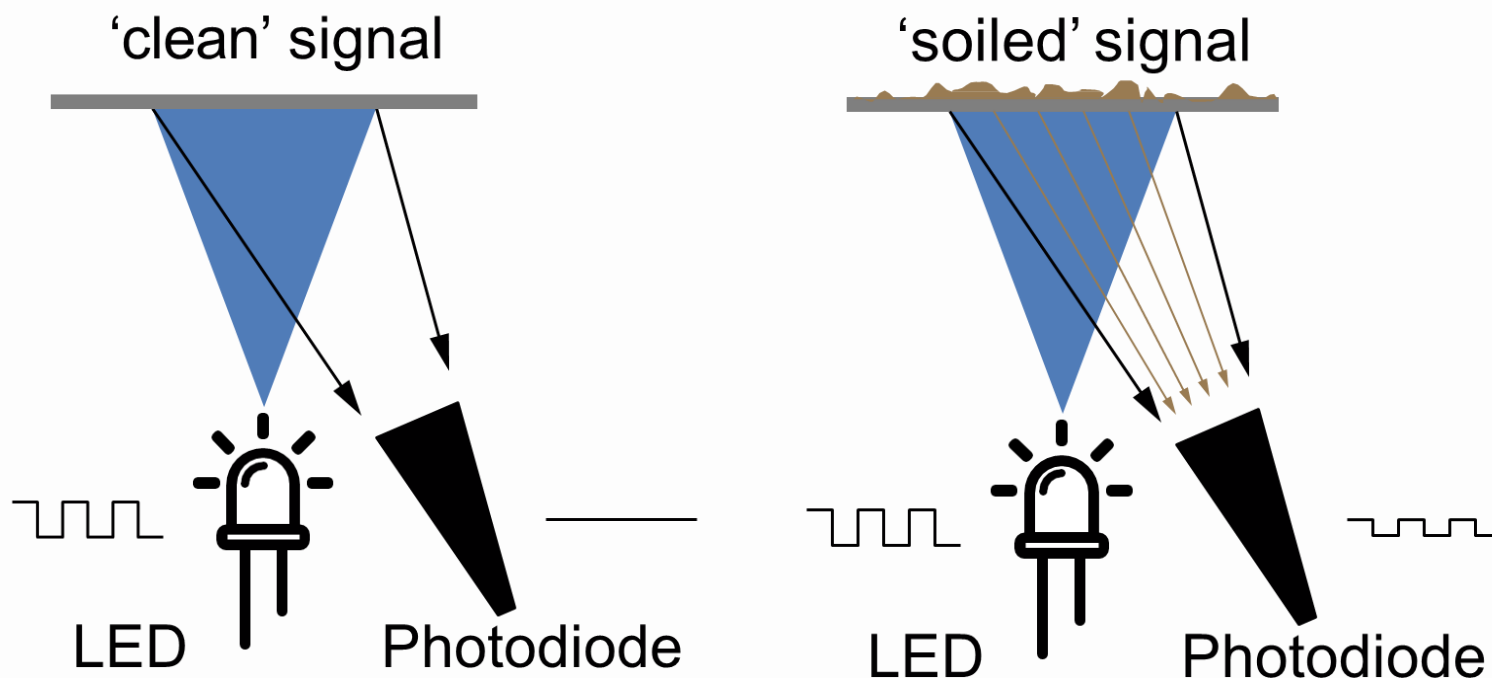
Soiling accumulation over days



Zorrilla-Casanova et al. (2011)

- Soiling loss location dependent, 0 to 2 % per day
- Rain events reduce soiling losses
- Business case for cleaning cost vs loss is location dependent

DUSTIQ MEASUREMENT PRINCIPLE



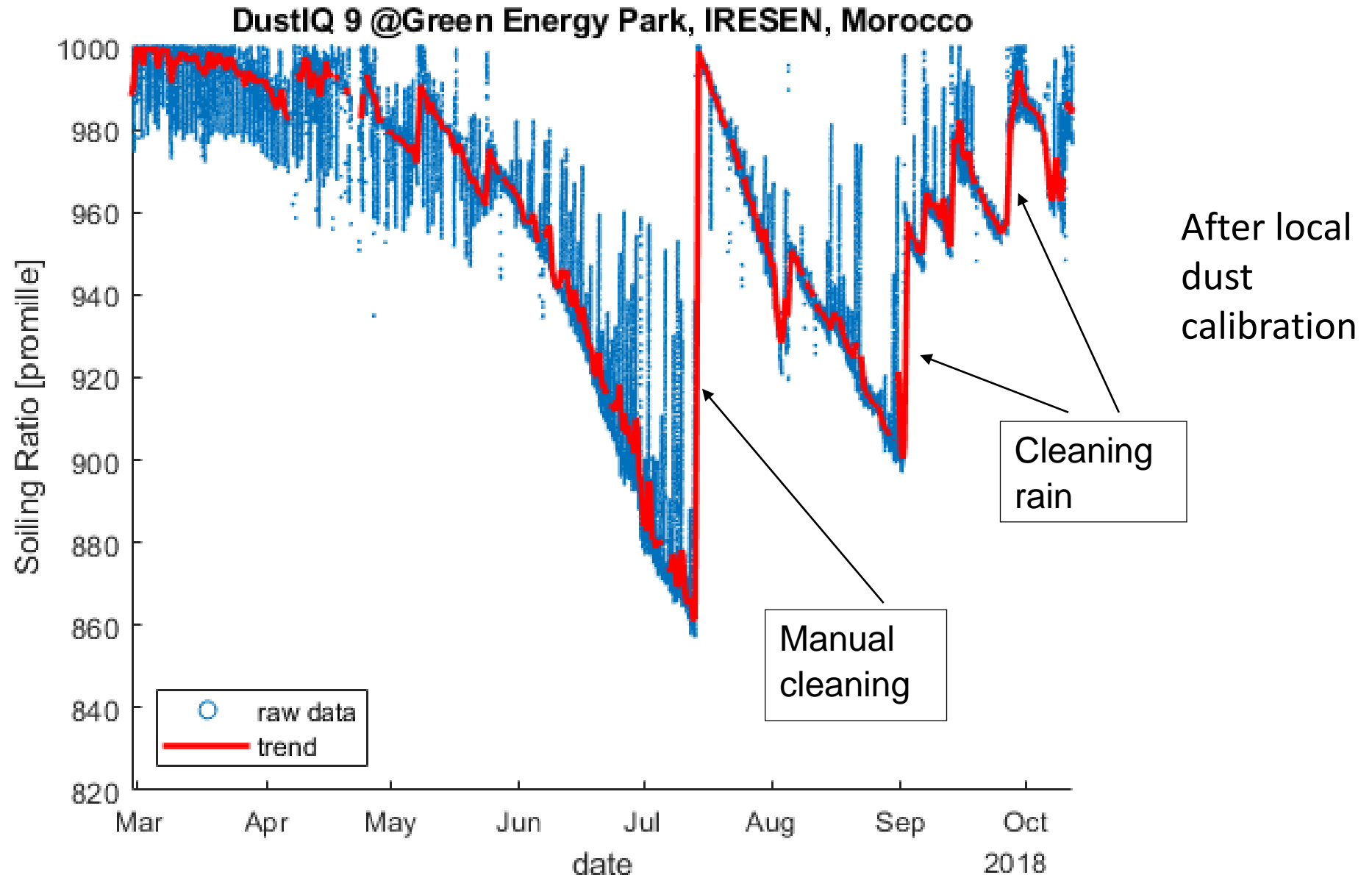
- Inspiration: can we measure soiling but prevent
 - Daily cleaning/maintenance?
 - Moving parts/fluids?
- Optical Soiling Measurement (OSM) Technology
- Measured from the inside: Scattered signal -> Transmission Loss

FIELD TEST GREEN ENERGY PARK (IRESEN, MOROCCO)



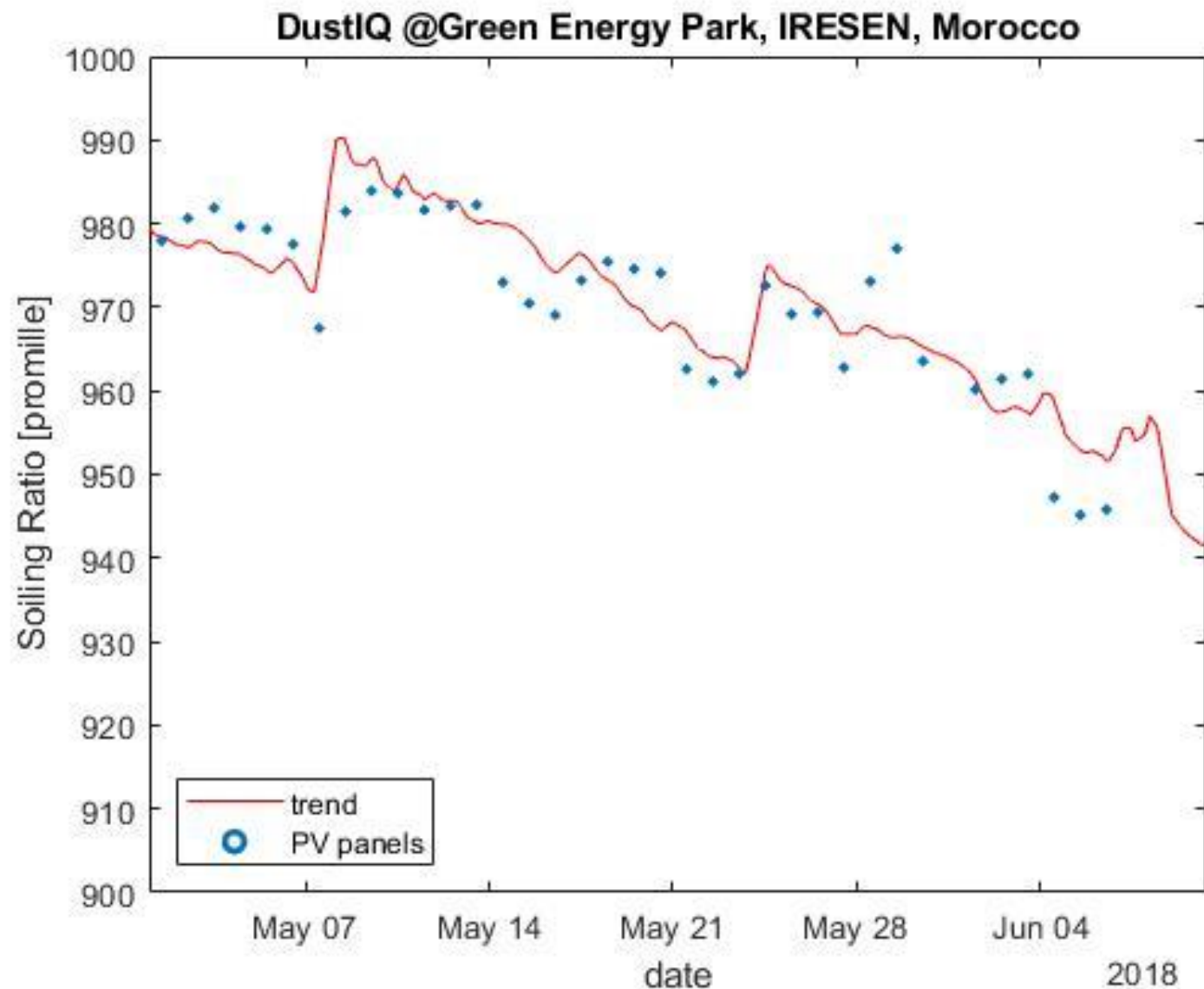
- DustIQ after soiling of 14% (SR 86%) (notice cleaned and non cleaned panel)

FIELD DATA MOROCCO



○ DustIQ 9 shows buildup of soiling to SR of 86% and manual cleaning in July

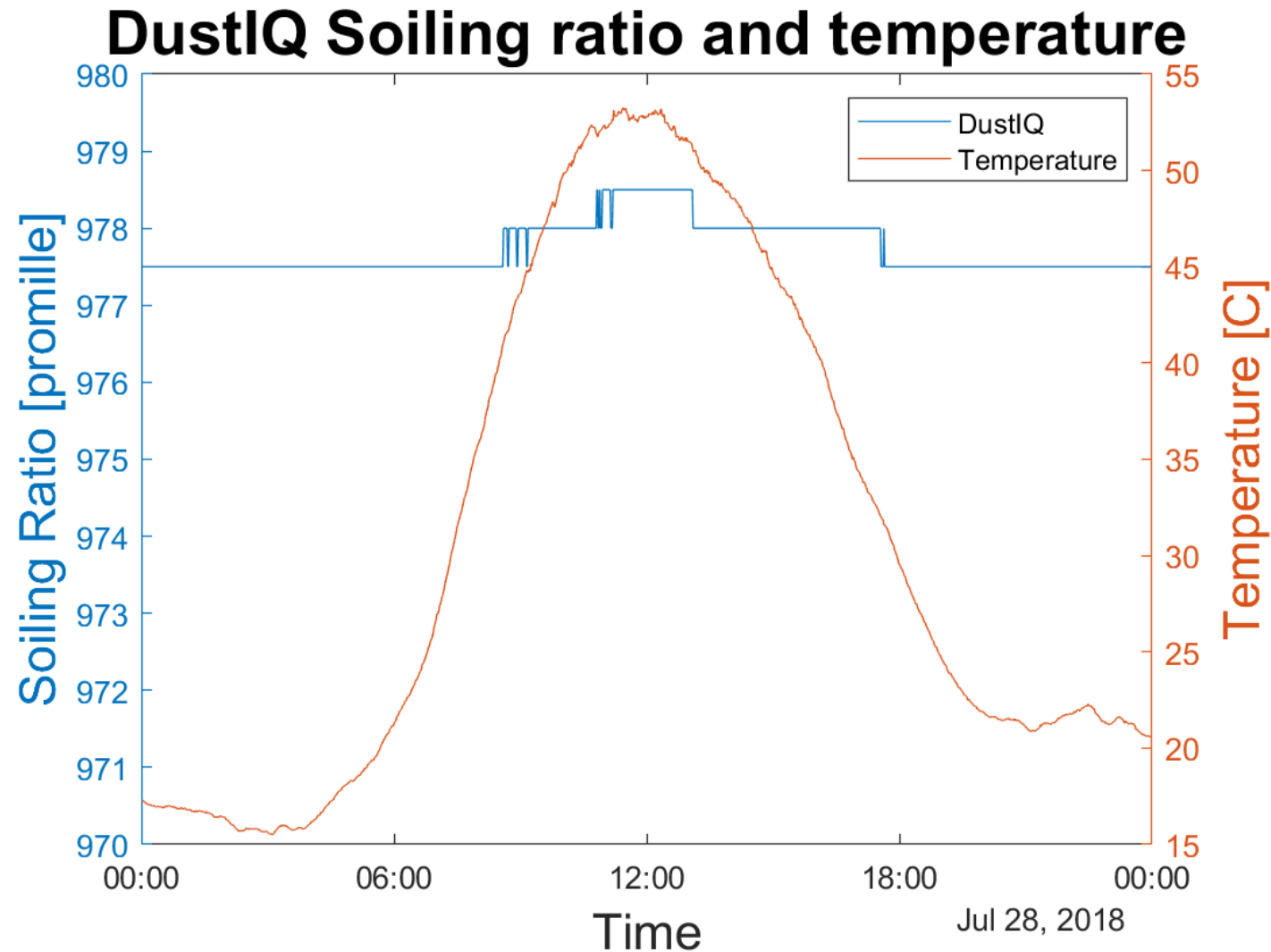
PRELIMINARY COMPARISON PV MODULES



After local
dust
calibration

○ After local dust calibration preliminary comparison DustIQ and PV panels is good

DUSTIQ FIELD DATA ALMERIA (SPAIN)



- Stable with large temperature change: $\pm 35^{\circ}$ shows change in SR of $\pm 0.1\%$

USER APPLICATION



○ Zonnepark Apeldoorn,
the Netherlands



○ Bifacial PV park Rilland,
the Netherlands

USER APPLICATION



○ Italia Apulia PV plant 12 MW_p



○ China TIG rooftop & in PV park



USER APPLICATION



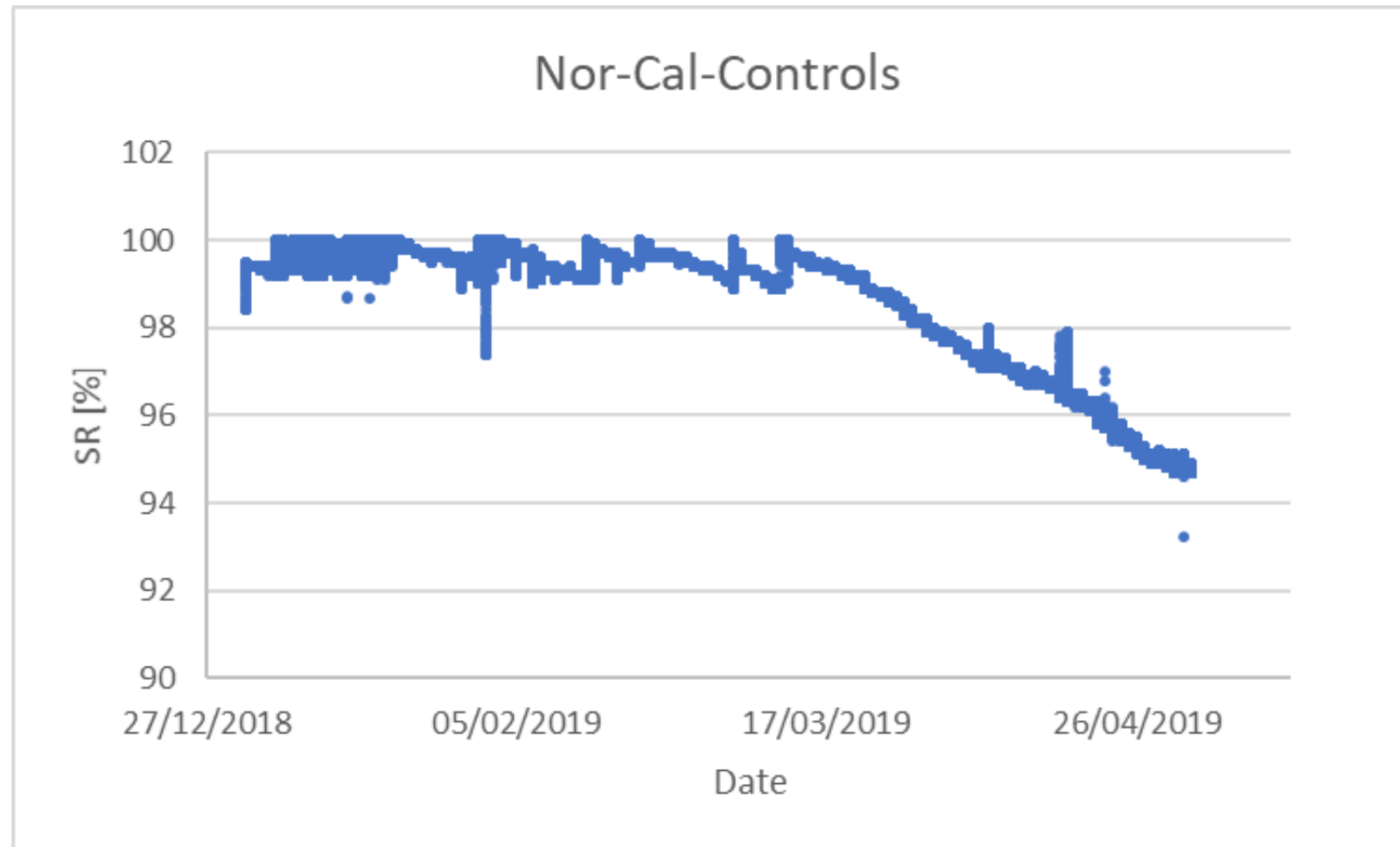
- 94 MW_p, Australia
- DustIQ connection with Modbus® into the site SCADA system

USER APPLICATION NOR-CAL CONTROLS



- Nor-Cal Controls ES, inc.
- 30 MW PV CIS thin film in Calipatria California

USER APPLICATION NOR-CAL CONTROLS



- Soiling on DustIQ starts to build up in spring, up to 5% soiling loss

USER APPLICATION



- North Chile, $\pm 5\%$ soiling per month
- Installation was easy, fitting in between panels
- Customer sees DustIQ as a low cost technology that can be distributed spatially in plant

USER APPLICATION SUNGROW (CHINA)

- Comparison of DustIQ with soiling Instrument A, correlation coefficient:

DustIQ – Instrument A	Correlation Coefficient
DustIQ Top sensor	0.933
DustIQ Bottom sensor	0.923
DustIQ average	0.94

After the exception data is excluded (**104** Days remaining)

- Good correlation between instrument A and DustIQ



USER APPLICATION SUNGROW

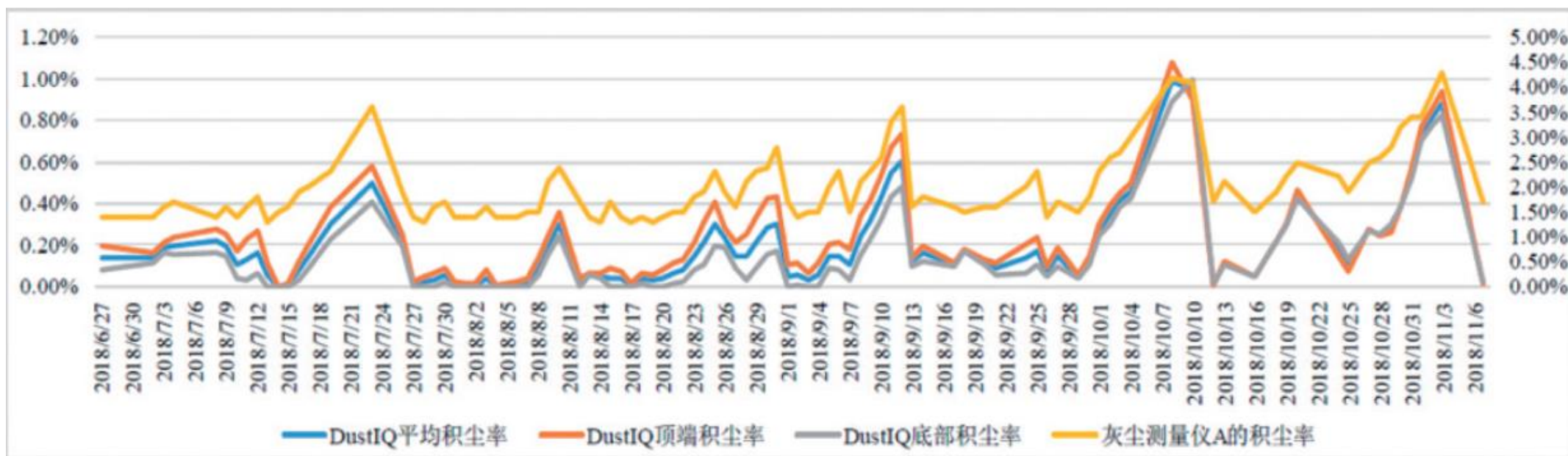
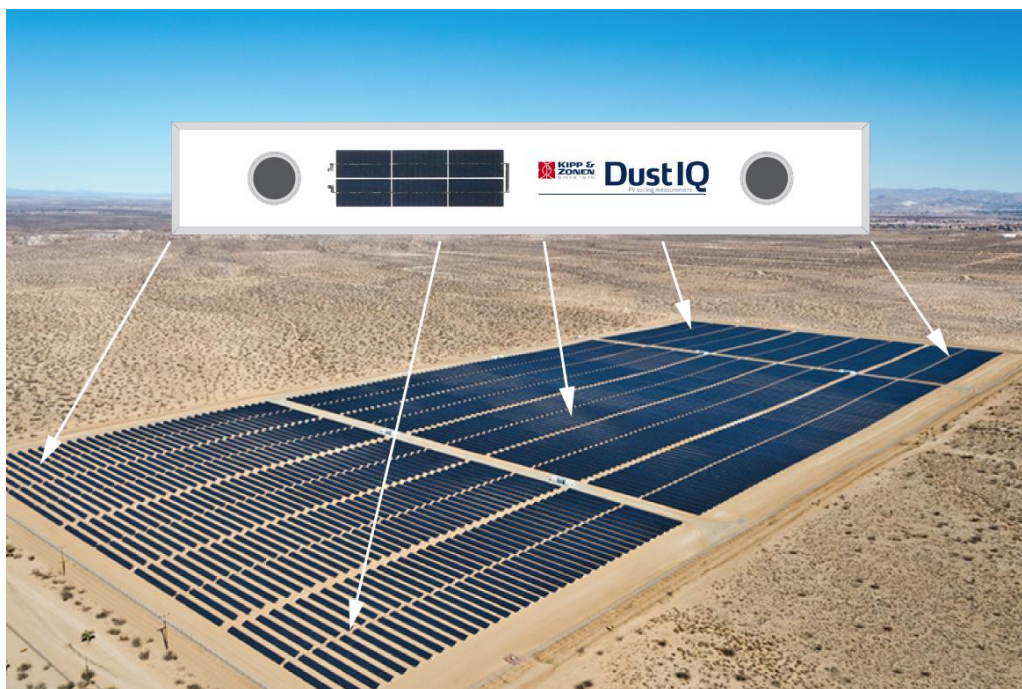


Figure 4. DustIQ and instrument A comparison of dust results (after removing abnormal data)

- Yellow: Instrument A transmission loss (right-hand scale)
- Brown: DustIQ top sensor transmission loss
- Blue: DustIQ average transmission loss
- Grey: DustIQ bottom sensor transmission loss

- No local dust calibration can be reason for difference in magnitude
- Reliability of the DustIQ is improved by removing light rainy weather, fog and dew data.
- Independent measurement report available from Kipp & Zonen

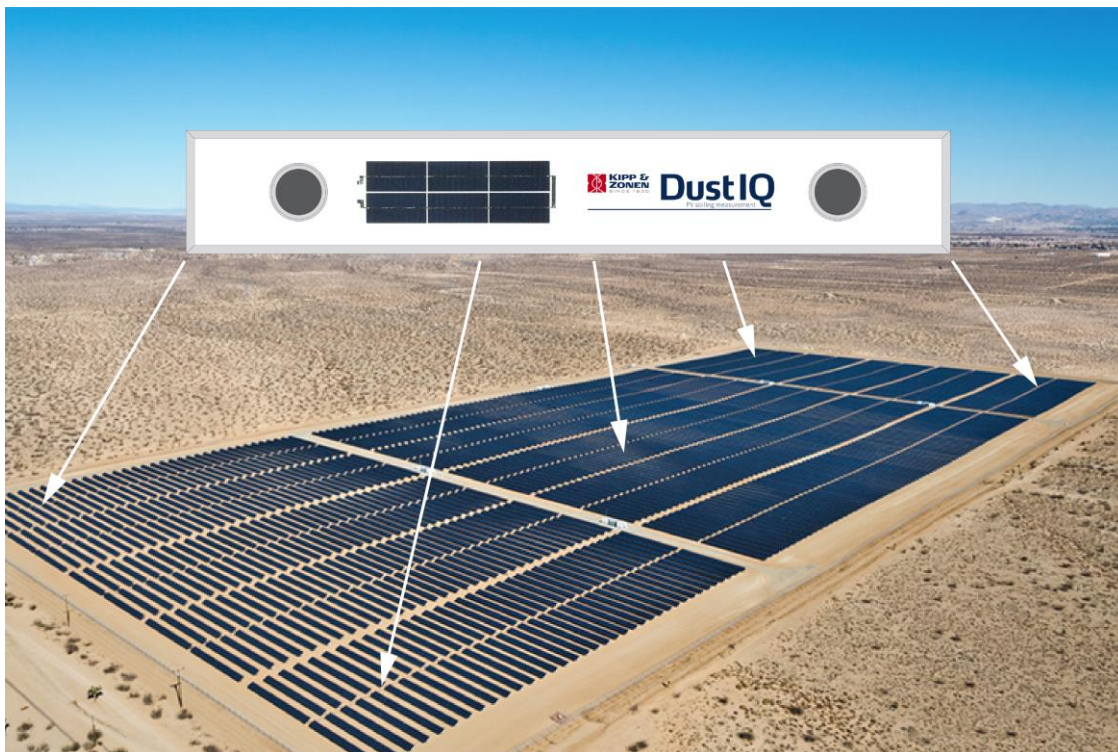
HOW MANY SOILING SENSORS IN PLANT?



System size (AC)	Number of soiling sensors Class A monitoring (IEC 61724)
< 5 MW	1
≥ 5 MW to < 40 MW	2
≥ 40 MW to < 100 MW	3
≥ 100 MW to < 200 MW	4
≥ 200 MW to < 300 MW	5
≥ 300 MW to < 500 MW	6
≥ 500 MW to < 750 MW	7
≥ 750 MW	8

- IEC 61724: Soiling measurement required for Class A monitoring system if expected soiling losses > 2%

WHERE TO PLACE THE SOILING SENSORS



- Amount of soiling depends on location in plant
- For a good measurement of soiling across plant, install multiple soiling sensors.
- Place soiling sensors where it is representative of majority of panels, so try to avoid bottom row, which typically shows more soiling

CLEANING STRATEGIES

- PV park integrator:
 - Alarm can be set on measured soiling level

- Cleaning robot manufacturer:
 - M&O contracts often allow max. $\pm 3\%$ soiling
 - If you can prove to capture the remaining 3% -> bonus
 - Accurate measurement of soiling is essential to prove this.

- We hope to tell more in the future.

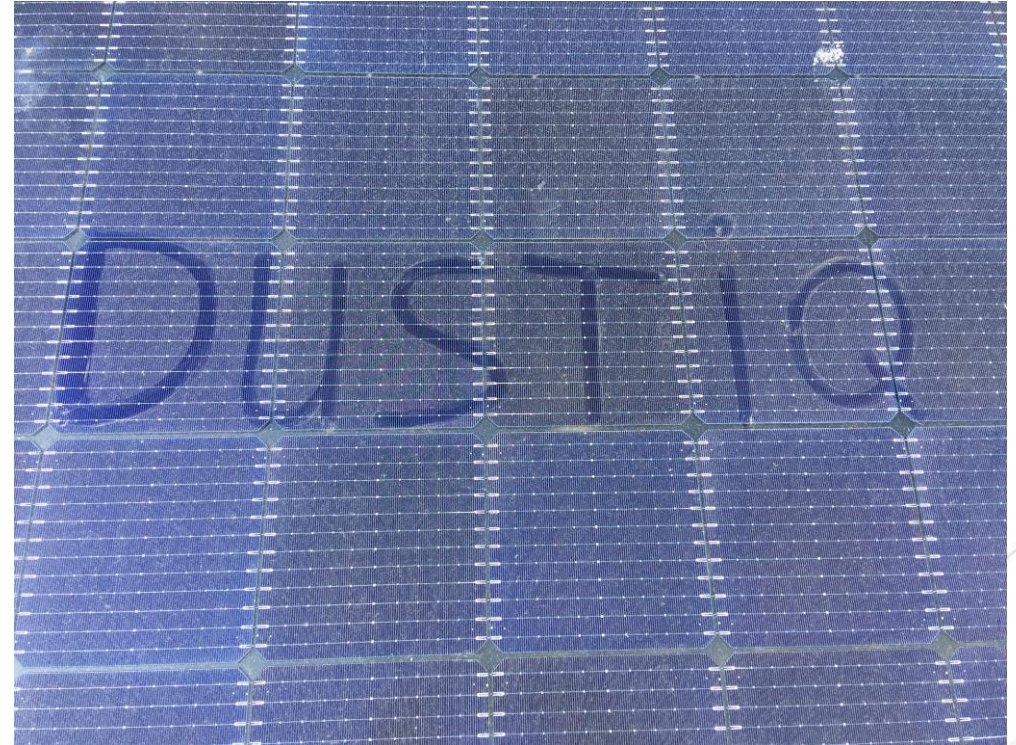
CONCLUSIONS

- Soiling can be measured with the DustIQ, and shows up to 16% soiling in Morocco field data
- After local dust calibration a preliminary comparison of DustIQ with PV panels is good
- Customer feedback: easy installation, and DustIQ works well. Kipp & Zonen advises local dust calibration for correct magnitude of soiling ratio.
- The SR from the DustIQ, available every minute, gives valuable info for maximizing the PV plant performance

ACKNOWLEDGEMENTS

- Thanks to the whole Kipp & Zonen Team
- Dr. Ahmed Alami Merrouni & Abdellatif Ghennioui, IRESEN Morocco
- Dr. Fabian Wolfertstetter & dr. Stefan Wilbert & team, DLR PSA Almeria Spain
- All the customers and relations that have provided input in text, photo and data

THANK YOU FOR YOUR ATTENTION



For more information and availability please visit
www.kippzonen.com/dustiq