Autonomous measurement system for PV and radiometer soiling losses

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Motivation and Objectives

- Soiling reduces PV installation efficiency [1]
  - Knowledge needed for optimal PV operation
- Radiation measurements can be too low due to soiling [2]
- Need for accurate low maintenance soiling measurements [3]

Fig. 1 Soiled PV panel

Fig. 2 Radguard prototype for reference cell

Principle of operation

- A lamp illuminates a sensor (pyranometer / reference cell) at night four times for 45 minutes each
- $I_{raw,1min}$ and $T_{raw,\ 1min}$ are obtained at the end of the illumination (Fig. 3). Irradiances O_1 and O_2 are measured before and after the illumination.
- $C(T_{raw,\ 1min})$ derived by evaluating the irradiance measurement of the setup in a climate chamber at various temperatures → correct signal so that $I_{cor,1min}$ refers to 25 °C:

$$I_{cor,1min} = (I_{raw,1min} - \frac{O_1+O_2}{2}) \cdot C(T_{raw,1min}) \quad \text{(eq. 1)}$$

- Comparing $I_{cor,\ 1min}$ of a night for which the soiling loss should be derived with $I_{cor,\ 1min,\ clean}$, measured at night after the last cleaning event, the soiling loss S can be calculated:

$$S = 1 - \frac{I_{cor,1min}}{I_{cor,1min,clean}} \quad \text{(eq. 2)}$$

Fig. 3 One of several irradiance and lamp temperature measurements at night

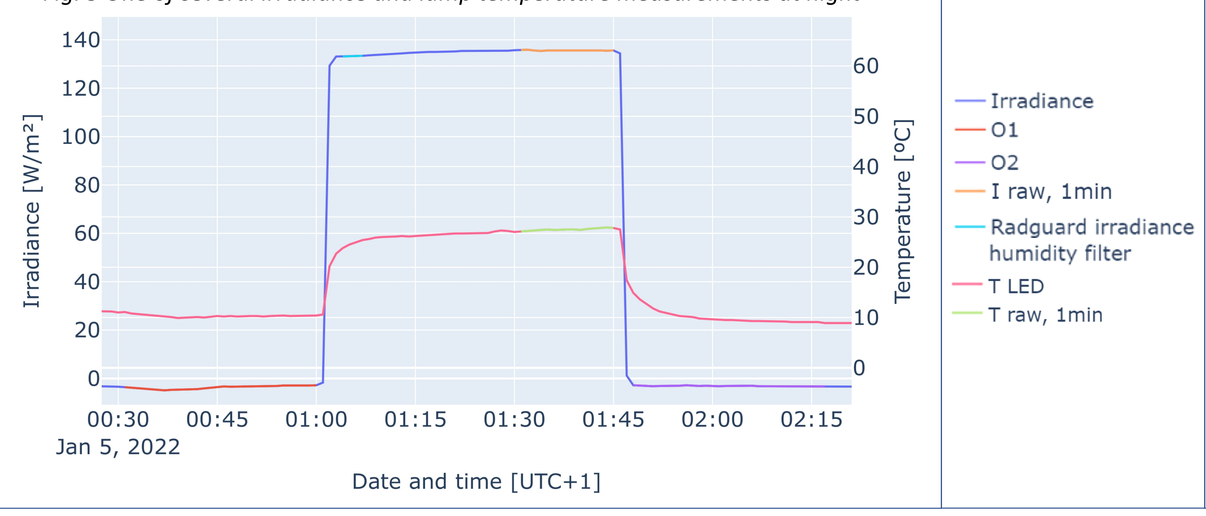
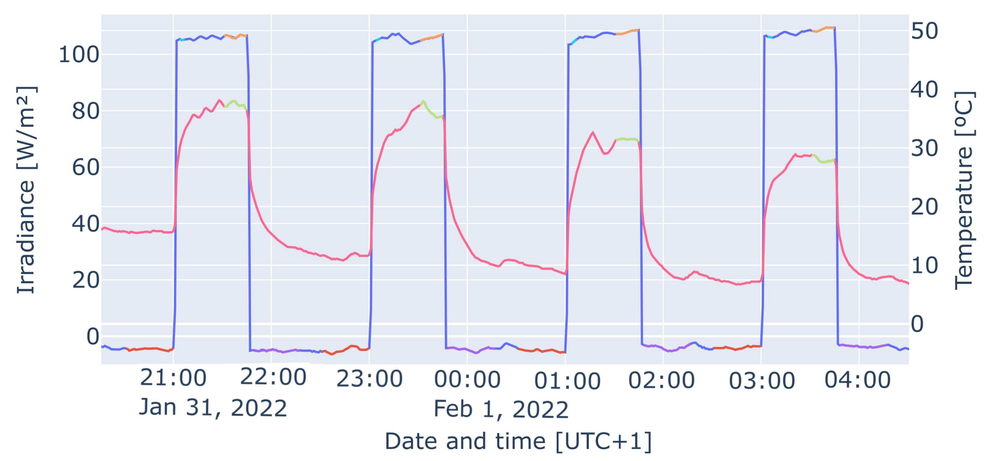


Fig. 4 Deviation of 4 signals used to sort out measurements affected by dew or raindrops



Results

Validation of system

- Comparison: Soiling loss from Radguard vs. soiling loss derived using pair of radiometers
- Test radiometer is equipped with Radguard lamp
- The test and reference radiometers are of the same model and calibrated relative to each other.
- Average of Radguard measurements of 2 subsequent nights are compared to reference soiling loss from the day between the nights (Exception rainy days).

Fig. 5 Radguard and reference soiling loss vs. time

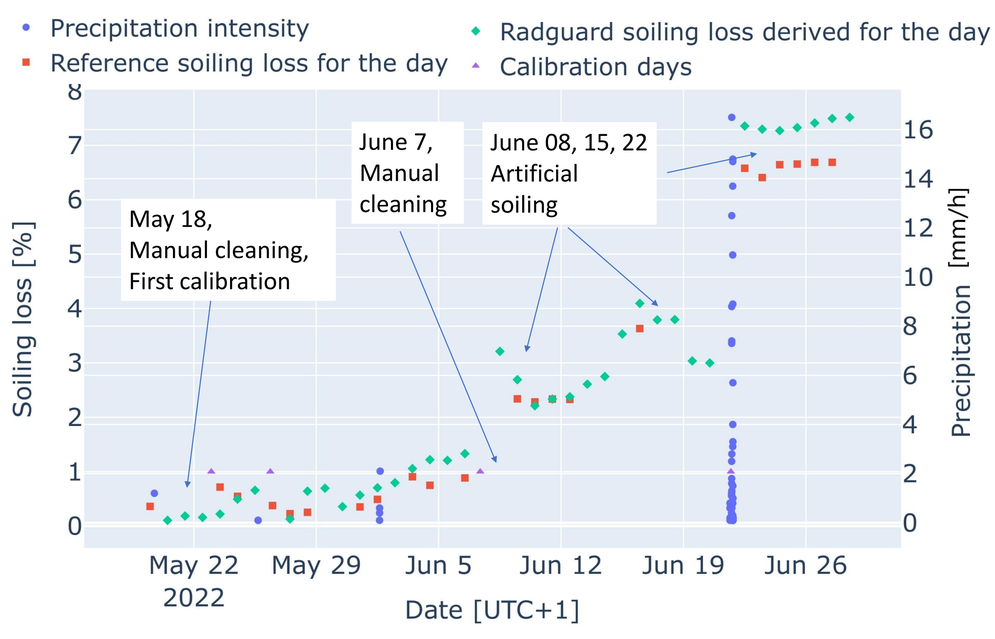
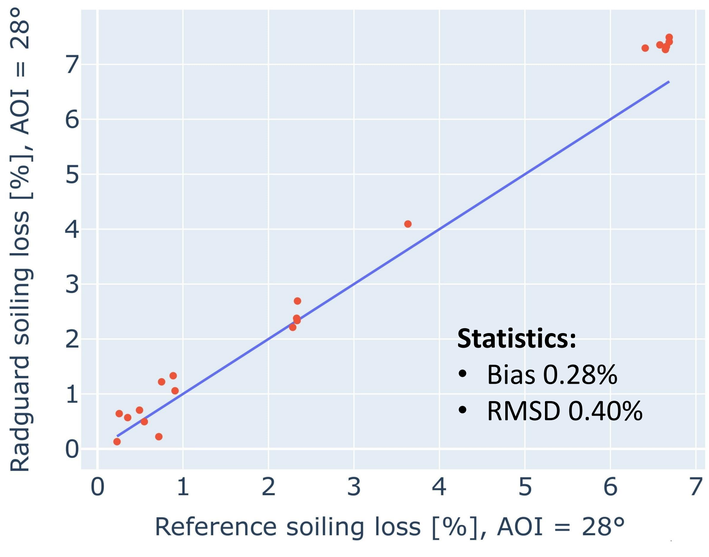


Fig. 6 Radguard and reference soiling measurements



Conclusions:

- Good agreement of Radguard and reference systems
- Higher data availability of Radguard system
  - Cloudy, unstable days → no reference soiling loss measurement
- Comparison of four soiling losses each night is important
- Important for reference cell: correction for angle of incidence (AOI)
  - AOI lamp of 60° → Soiling loss at AOI 60° is expected to be higher than that e.g. at solar noon [4,5].
  - Average AOI used to determine the reference data is ~28°→ correction derived for this specific AOI

Summary and Outlook

- New soiling measurement system for PV, reference cells and pyranometers designed and validated
- Outdoor test of several months shows accuracy similar to reference method
- More info: WCPEC-8 Conference proceedings and corresponding *Progress in Photovoltaics* paper

Ongoing and future work:

- New further Radguard installations and long-term outdoor tests (Southern Spain, Germany)

References:
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