Evaluation of uncertainty sources and propagation from irradiance sensors to PV yield

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AIM

1) Reducing uncertainty of (global) irradiance measurements through pyranometers.
2) Assessing impact of reduced expanded uncertainty on the evaluation of PV performance in a solar farm

WHY

Energy production uncertainty affects financial costs and bankability

Better understanding and evaluation of systematic and random effects needed.

Incoherencies on uncertainty: *from 4.7% to 25.3% for solar data but from 3% to 12% on measurements & modelling*

HOW

1) **Data quality** management
2) ***almost clear-sky days*** sampling for uncertainty assessment.
3) Use of calibration data for point-based **directional response and temperature dependency** of uncertainty.

SUBJECTS

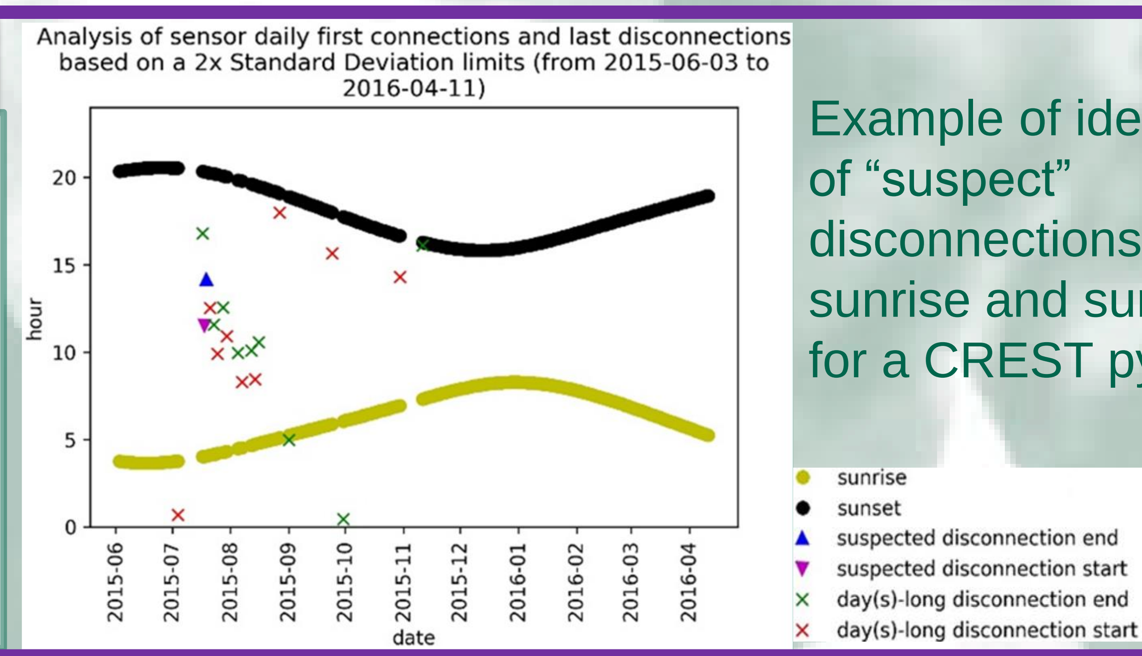
CREST: calibrated ventilated Kipp & Zonen CMP21 pyranometers with Pt-100 temperature sensor

COM: fielded pyranometer, CMP21 assumed (datasheet specifications)

HOW (1): data quality

Including (and not limited to):

- Physically possible and extreme rare limits (BSRN checks).
- Exclusion of days with disconnections checked against sunrise and sunset paths



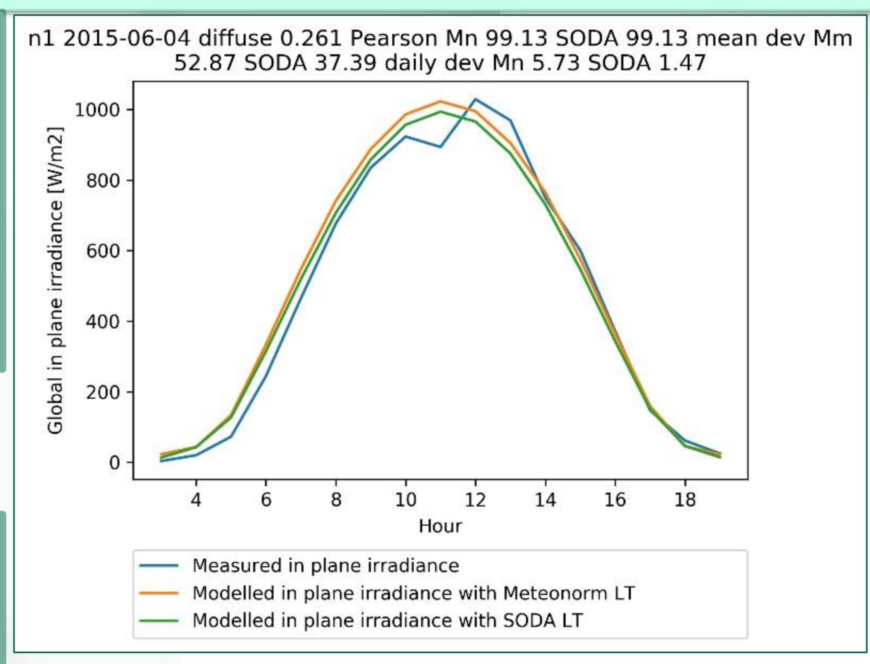
Example of identification of "suspect" disconnections against sunrise and sunset paths for a CREST pyranometer.

HOW (2): almost-clear sky days

Relevance of clear sky conditions for energy production and thermal offset in irradiance measurements (ISO 9060) but rare in UK.

Almost clear sky days, closest to:

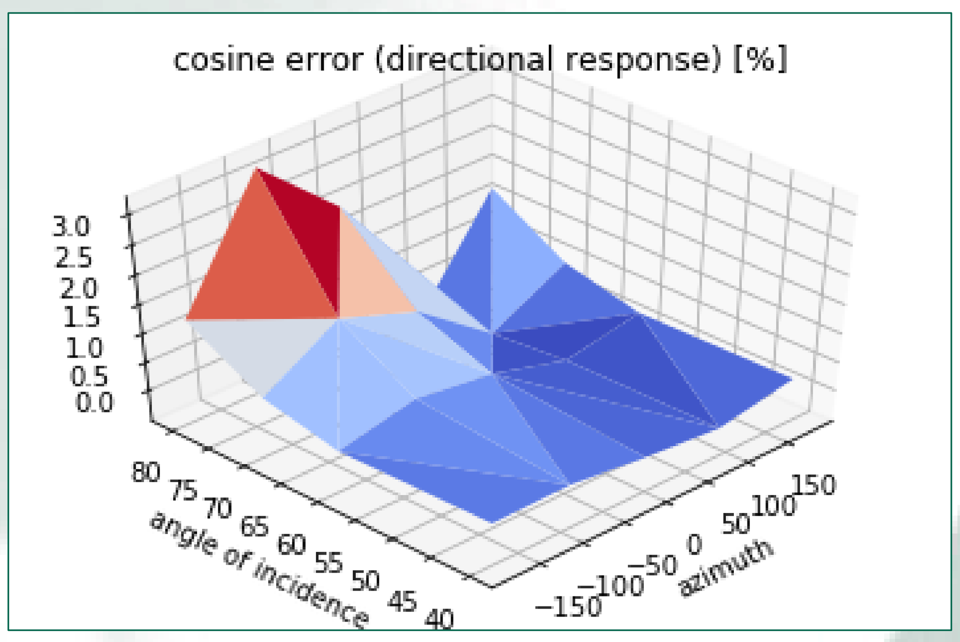
- Diffuse fraction of 0.2
- Pearson coefficient r (against Perez's clear sky model) of 0.95
- Irradiance deviation of 5%

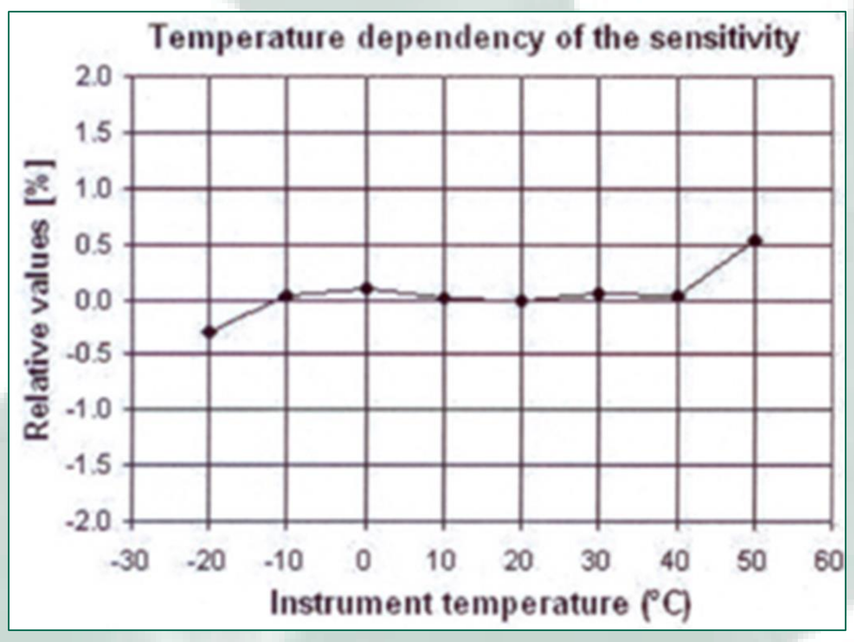


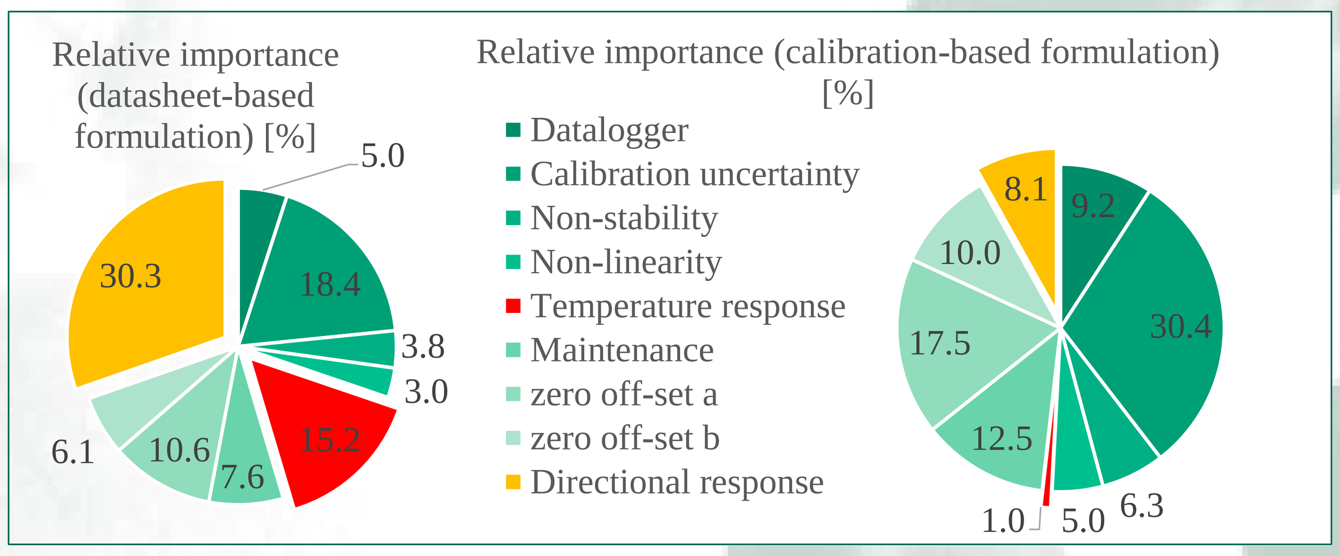
Identification of an almost-clear sky day. Monitored data against calculation through Perez's model based on Linke Turbidity from Meteonorm and EU project SODA.

HOW (3): directional response and temperature dependency

Interpolated values (based on calibration certification) filled into the formulation of uncertainty from JCGM 100:2008.







Calibration-based formulation reduces relative importance of directional and temperature uncertainties

Relative importance:

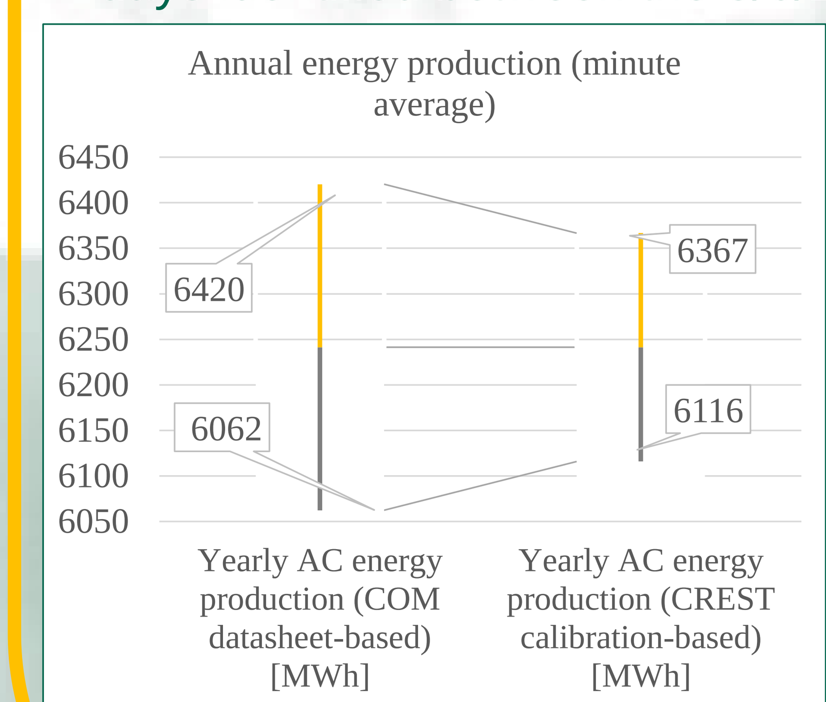
$$\frac{\frac{u(i)\cdot c_i}{u}}{\sum_i\left(\frac{u(i)\cdot c_i}{u}\right)}$$

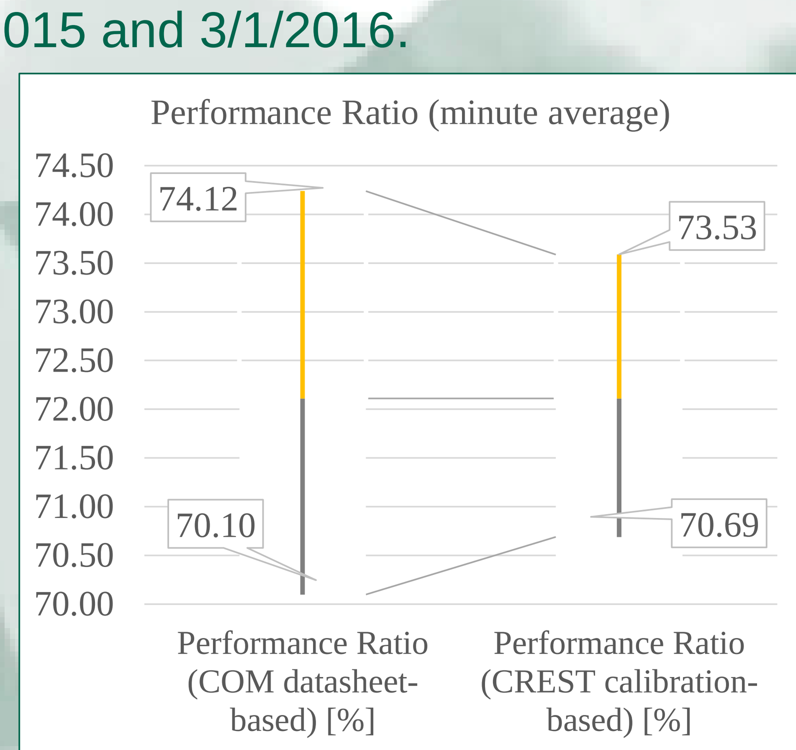
u: corrected standard uncertainty
c: sensitivity coefficient

RESULTS

	Input data	Time resolution [s]	Percentage deviation [%]	Average expanded uncertainty [W/m^2]
COM	datasheet-based	60	± 2.87	13.83
		3600	± 3.07	13.83
CREST	calibration-based	60	± 2.01	7.93
		3600	± 2.18	7.94
CREST	datasheet-based	60	± 3.51	13.84
		3600	± 3.79	13.84

Calculation of uncertainty for the 20 selected almost-clear sky days identified between the 3/6/2015 and 3/1/2016.





Effects of uncertainty on estimation of yearly performance (10/8/15-10/8/16) of a PV solar farm (7389 kWp) based on found deviations.

MAIN CONCLUSIONS

By applying a few calibration-based information, irradiance uncertainty is reduced by about 40%.

FUTURE STEPS

Future independent calibrations will better estimate uncertainty dependency on environmental parameters in irradiance measurements.

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