Intercomparison of 7 solar radiometers on a tilted plane for photovoltaic applications: preliminary results

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INTRODUCTION

Solar radiation measurements (SRM) are needed in photovoltaics (PV) for:

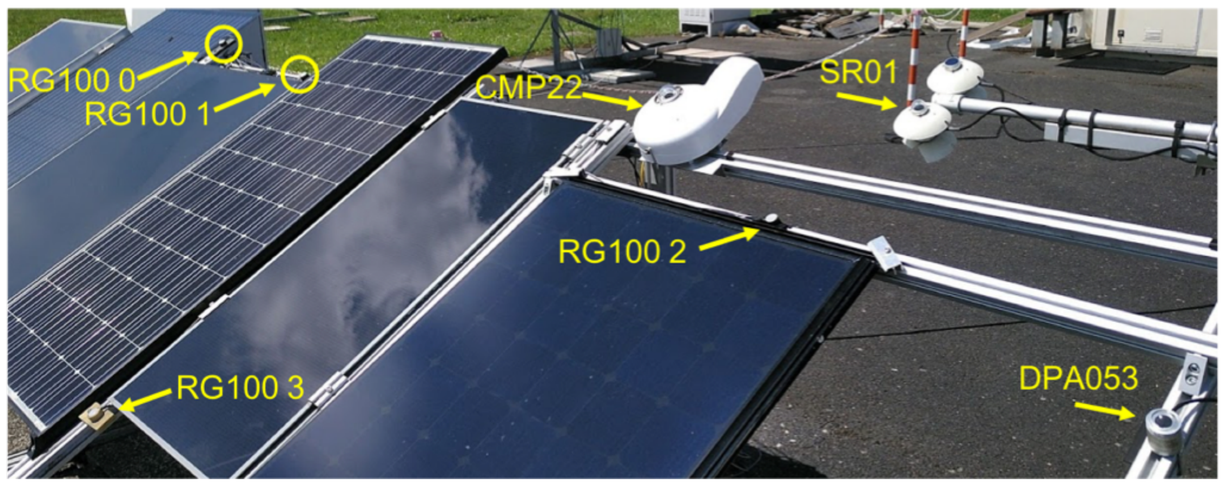
- Resource assessment
- Efficiency evaluation
- Performance analysis
- Forecasting

Since 2014, a test bench was installed in the SRTA Observatory (48.7ºN, 2.2ºE, Paris Region) to study PV modules under real-life conditions. The bench has permanent SRM with RG100 0 and SR01 sensors (see photo).

A two-week campaign was undertaken to assess for the quality and calibration of these radiometers when measuring on a titled plane.

CAMPAIGN SET-UP

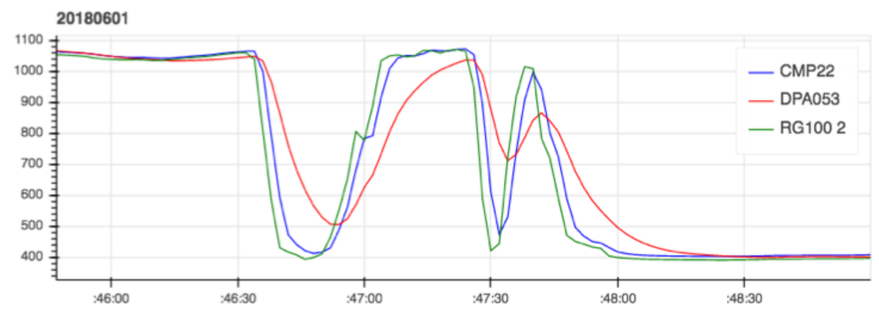
Seven radiometers where installed on the plane of the PV modules (27.5º tilt to the South). Four silicon quantum sensors (RG100, from Solems), two Second class* pyranometers (SR01 from Hukseflux and DPA053 from LSI) and one secondary standard* pyranometer (CMP22 from Kipp & Zonen).



* **ISO 9060 Pyranometer Classification**

	SECONDARY STANDARD	FIRST CLASS	SECOND CLASS
Response time	< 15s	< 30s	< 60s
Zero Offset-A	+ 7 Wm^{-2}	+ 7 Wm^{-2}	+ 7 Wm^{-2}
Zero Offset-B	± 2 Wm^{-2}	± 2 Wm^{-2}	± 2 Wm^{-2}
Non-stability	± 0.8%	± 1.5%	± 3%
Non-linearity	± 0.5%	± 1%	± 3%
Directional Response	± 10 Wm^{-2}	± 20 Wm^{-2}	± 20 Wm^{-2}
Spectral selectivity	± 3%	± 5%	± 10%
Temperature response	± 2%	± 4%	± 8%
Tilt response	± 0.5%	± 2%	± 5%

Time responses (95%) for RG100, CMP22 and DPA053 are <1s, 5s and 18s, respectively. The figure shows about 3 minutes of measurements with 2s sampling steps.



Time sampling:

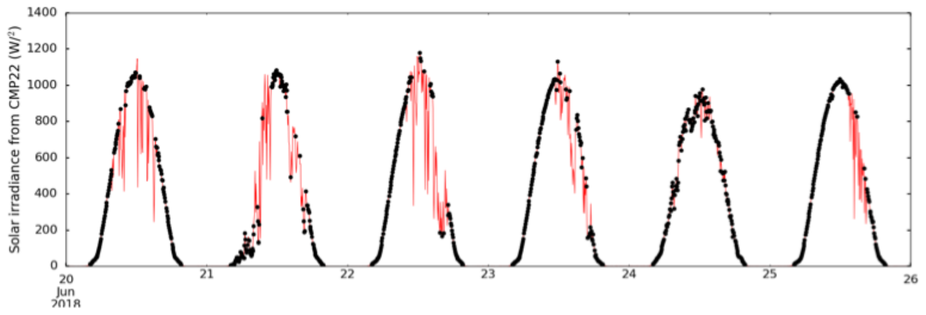
Three measurement systems where performing the measurements at different samplings:

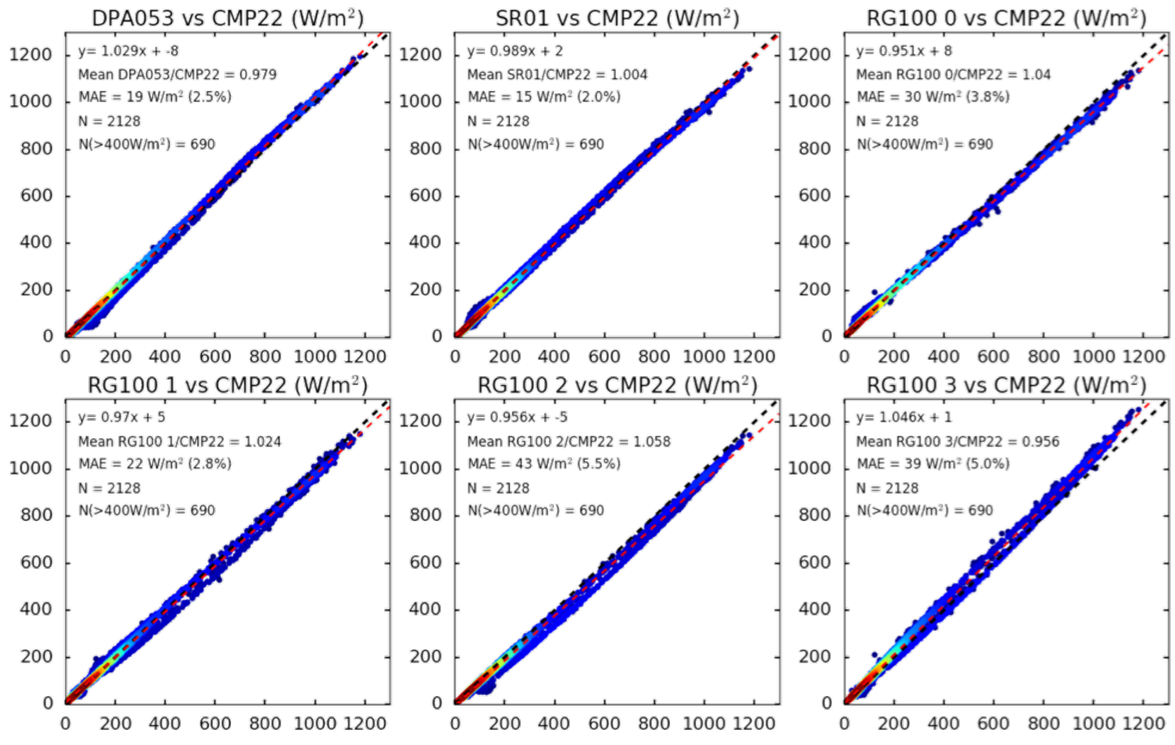
- RG100 0,1,3: 50 seconds
- RG100 2, CMP22 and DPA053: 2 seconds
- SR01: 10 seconds

METHOD AND RESULTS

For a fair comparison, data was averaged at 5 minutes steps and only low temporal variability where kept (black dots in the figure on the right).

CMP22 was considered as reference and three comparison metrics where considered: 1) Linear fit, 2) the ratio of the average measurements and 3) the mean absolute error calculation. For these two latter, only measurements > 400 W/m^2 where considered.

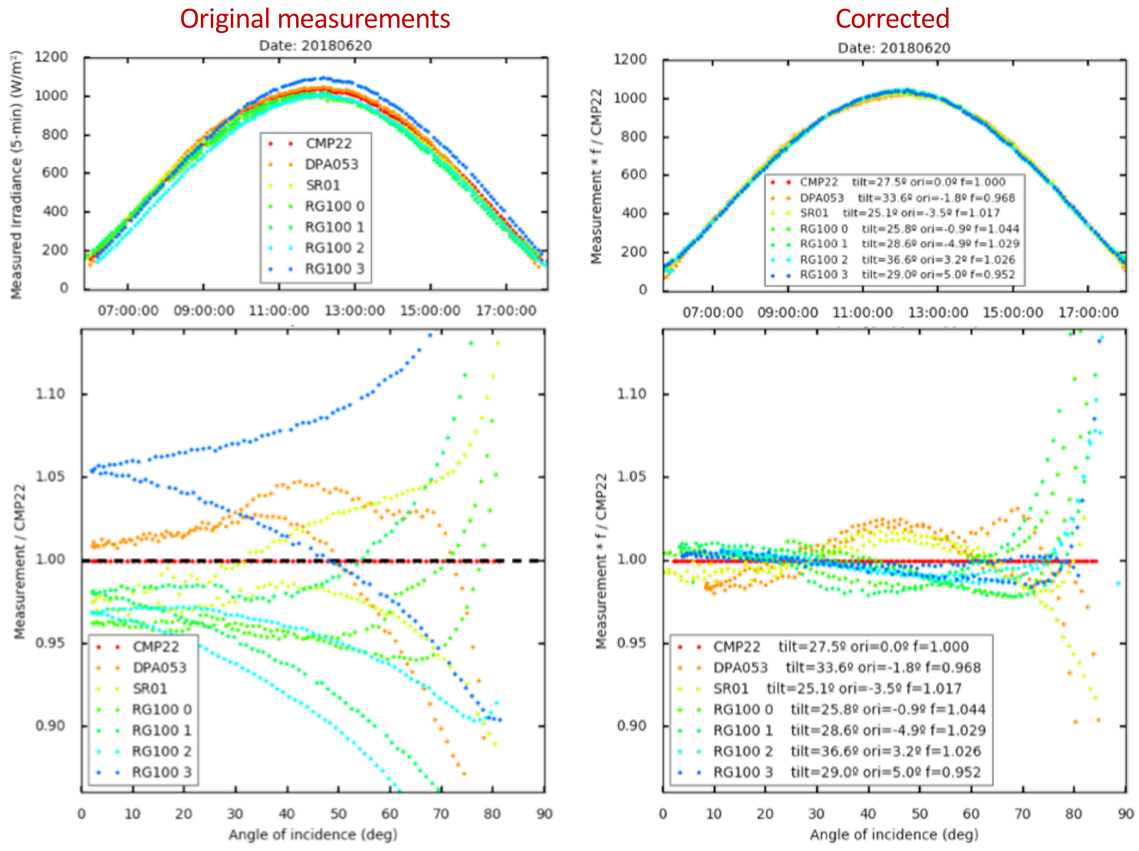




The ratios of the average measurements range 0.956 (RG100 0) to 1.058 (RG100 3). Relative (to the mean) MAE values ranged 2.0% (SR01) to 5.5% (RG100 2). Some radiometers are suspected to have tilt and orientation deviations from 27.5º and 0º, respectively

Correcting for tilt, orientation, calibration:

A two-step correction method was explored consisting in 1) plane reprojection (to correct for tilt and orientation) and 2) factor scaling (to correct for calibration). For step 1, the near-by PAL BSRN station global (GHI), diffuse (DHI) and direct normal (DNI) irradiance were used. For step 2, the CMP22 measurements were taken as reference.



ACKNOWLEDGEMENTS

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REFERENCES

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- CMP22 from Kipp & Zonen : www.kippzonen.com/Product/15/CMP22-Pyranometer
- DPA053 from LSI: http://www.lsi-lastem.it/en/products/meteorological-sensors/solar-radiation
- SR01 from Hukseflux: https://www.hukseflux.com/sites/default/files/product_manual/NR01_RA01_manual_v1710.pdf
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