

# Intercomparison campaign of solar radiometers: preliminary results

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## INTRODUCTION

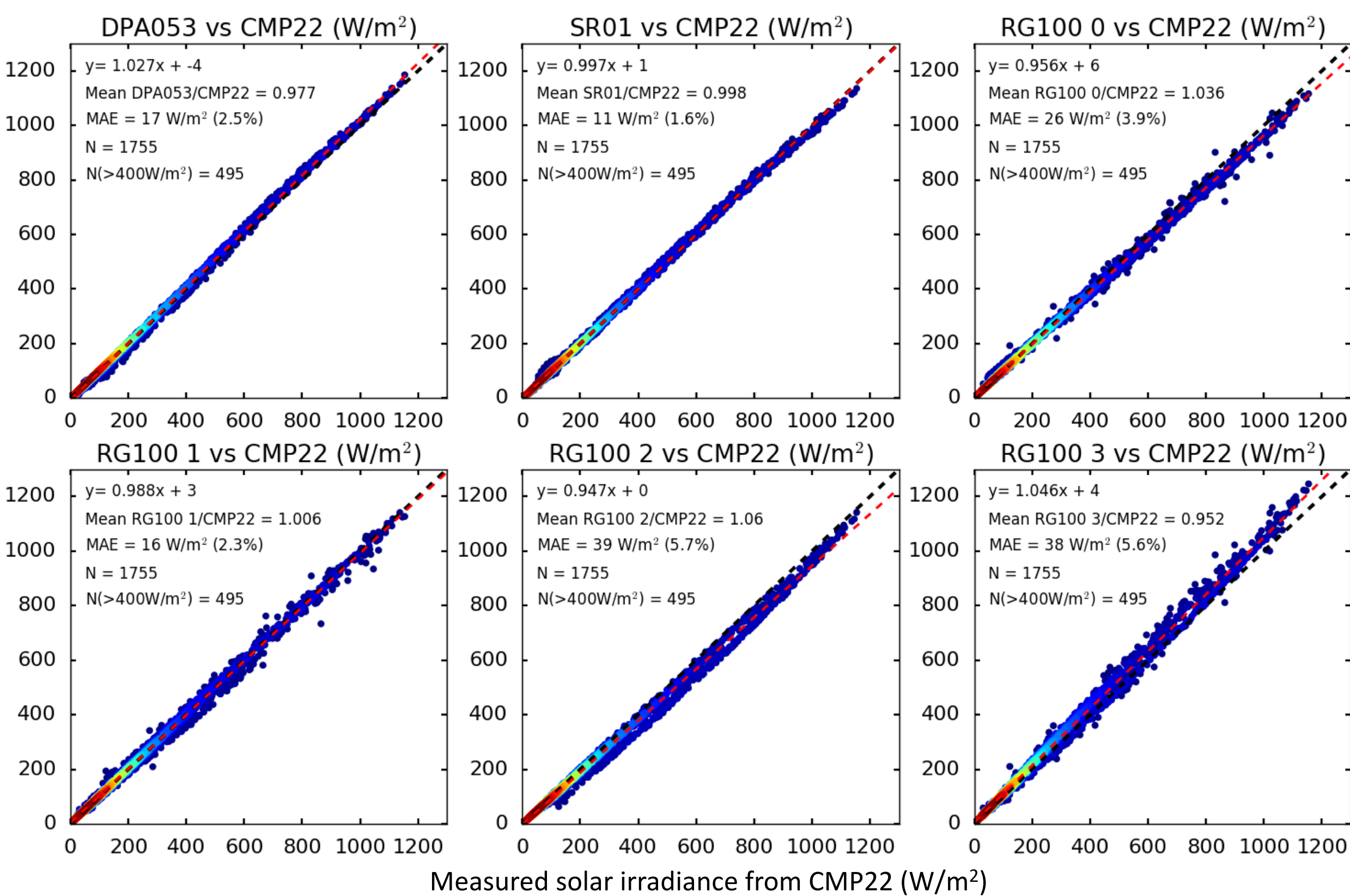
Solar radiation measurements (SRM) are needed in photovoltaics (PV) for:

- Resource assessment
- Efficiency evaluation
- Performance analysis
- Forecasting

Since 2014, a test bench was installed 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.

## METHOD AND RESULTS

For a fair comparison, data was averaged at 5 minutes steps and only periods with step-by-step variability of  $<100\text{W/m}^2$  where kept (black dots in the figure on the right). CMP22 was considered as reference and three comparison metrics were considered: 1) Linear fit, 2) the ratio of the average measurements and 3) the mean absolute error calculation. For these two latter, only measurements  $> 400\text{W/m}^2$  were considered.



As preliminary results, mean differences were found between 0.956 (RG100 0) to 1.046 (RG100 3). Relative (to the mean) MAE values ranged 1.6% (SR01) to 5.7% (RG100 2). RG100 2 and 3 sensors showed a directional problem (probably due to a deviation from the plane of the other sensors).

## REMERCIEMENTS

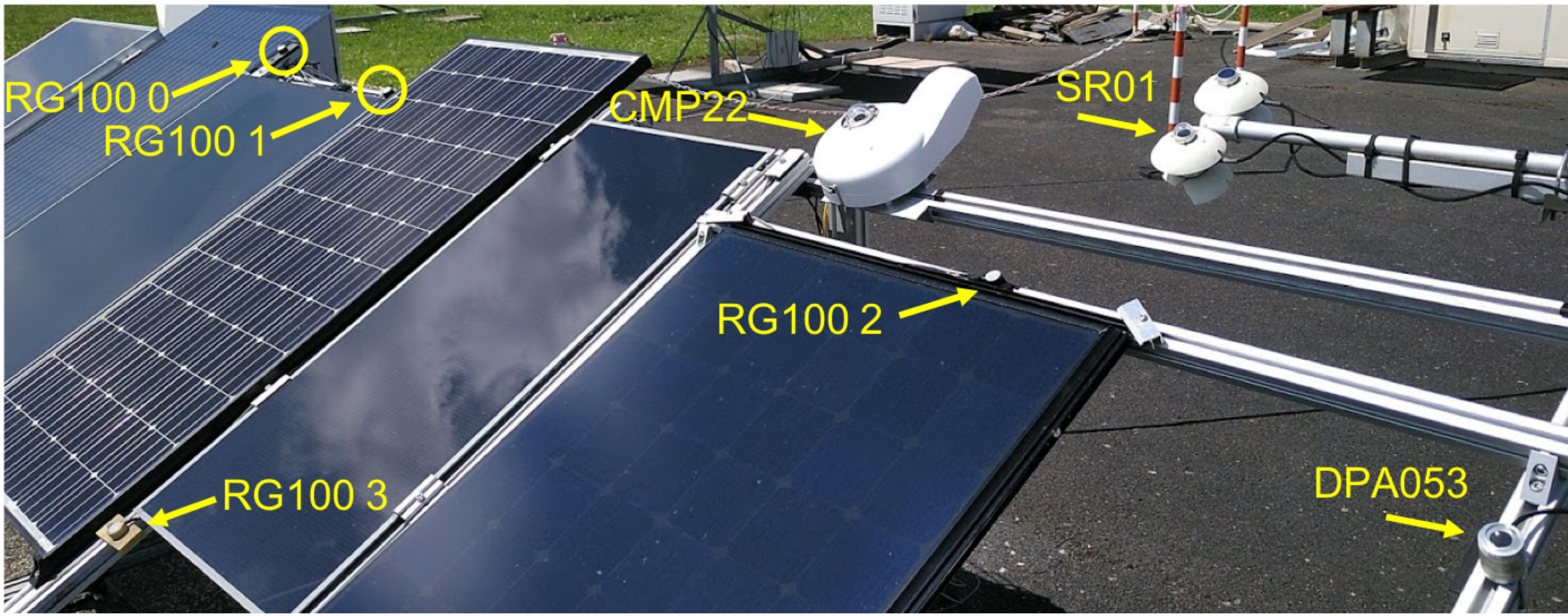
This work was undertaken under the frame of TREND-X research program from Ecole Polytechnique

## CAMPAIGN SET-UP

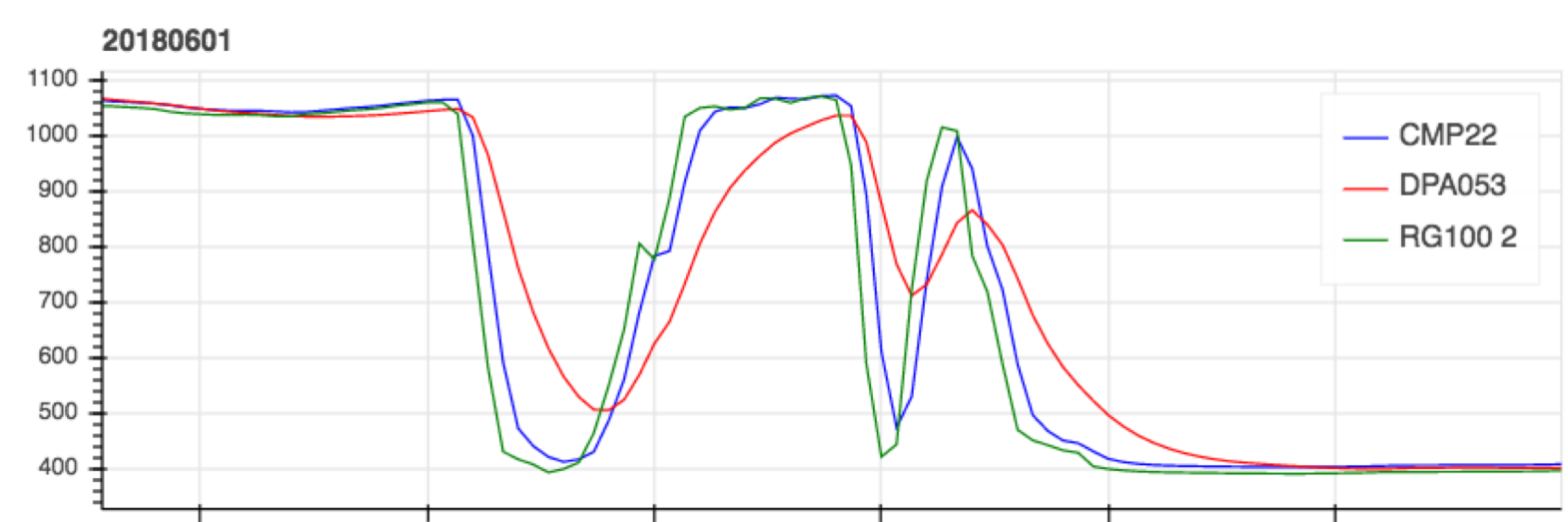
Seven radiometers were installed on the plane of the PV modules (27° tilt to the South). Four silicon quantum sensors (RG100, from Solems), two second class\* pyranometers (SR01 from Hukseflux and DPA053 from LSI) and one secondary standard\* pyranometer (CMP22 from Kipp & Zonen).

### \* ISO 9060 Pyranometer Classification

|                      | SECONDARY STANDARD    | FIRST CLASS           | SECOND CLASS          |
|----------------------|-----------------------|-----------------------|-----------------------|
| Response time        | < 15s                 | < 30s                 | < 60s                 |
| Zero Offset-A        | + 7 Wm <sup>-2</sup>  | + 7 Wm <sup>-2</sup>  | + 7 Wm <sup>-2</sup>  |
| Zero Offset-B        | ± 2 Wm <sup>-2</sup>  | ± 2 Wm <sup>-2</sup>  | ± 2 Wm <sup>-2</sup>  |
| Non-stability        | ± 0.8%                | ± 1.5%                | ± 3%                  |
| Non-linearity        | ± 0.5%                | ± 1%                  | ± 3%                  |
| Directional Response | ± 10 Wm <sup>-2</sup> | ± 20 Wm <sup>-2</sup> | ± 20 Wm <sup>-2</sup> |
| 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  $<1\text{s}$ ,  $5\text{s}$  and  $18\text{s}$ , respectively. The figure shows about 3 minutes of measurements with 2s sampling steps.



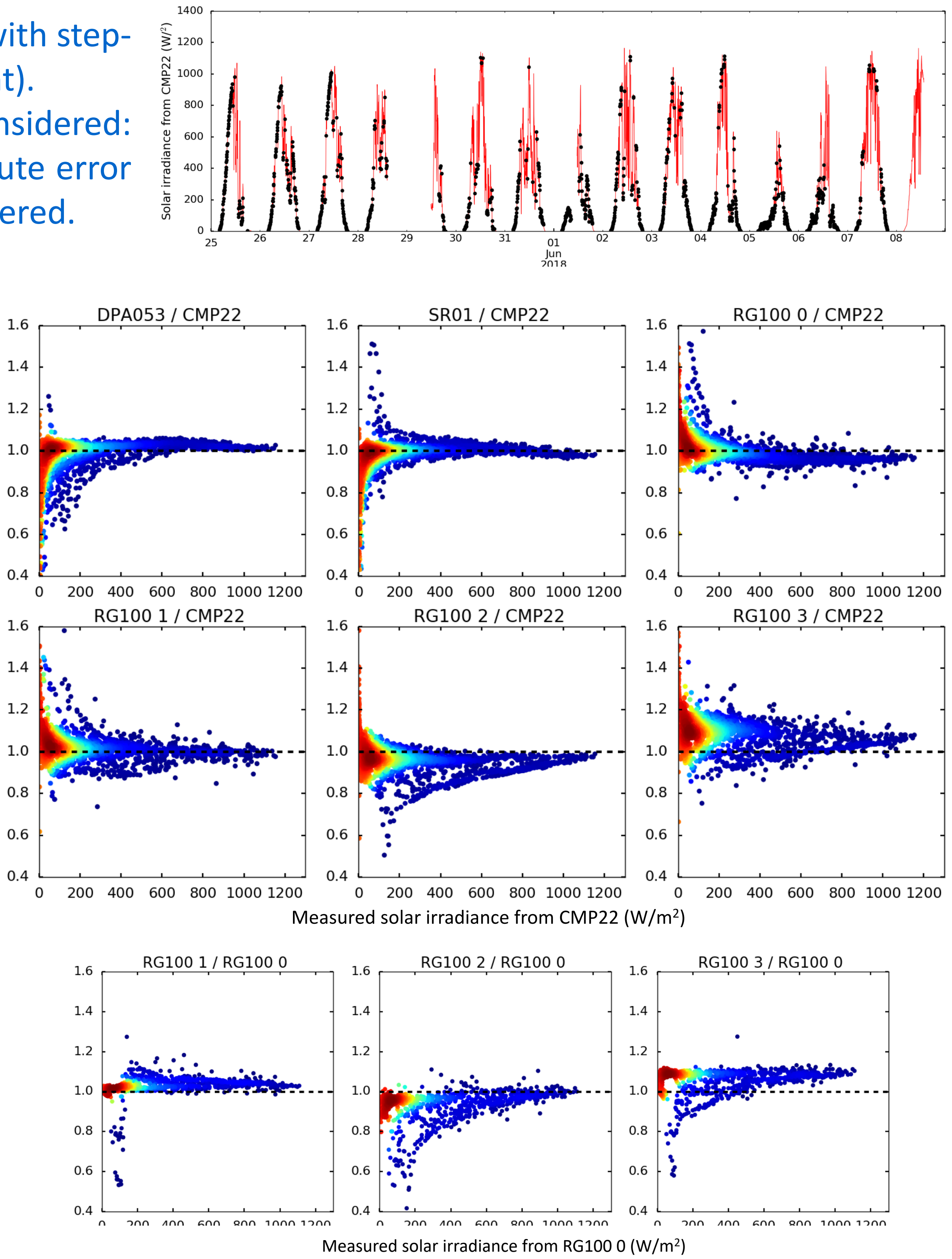
### Time sampling:

- Three measurement systems were performing the measurements at different samplings:
- RG100 0,1,3: 50 seconds
  - RG100 2, CMP22 and DPA053: 2 seconds
  - SR01: 10 seconds

The color scale in the figures account for the density of points, the red representing the highest.

The 6 figures on the left show the 1:1 comparison between the 6 radiometers against CMP22. The red line correspond to the  $y(x)$  linear fit

The 9 figures on the right show the ratio between the measurements of two instruments (shown in the title) vs solar irradiance



## REFERENCES

- RG100 sensor from Solems: <http://www.solems.com/mesure-du-rayonnement-solaire>
- CMP22 from Kipp & Zonen: [www.kippzonen.com/Product/15/CMP22-Pyranometer](http://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](https://www.hukseflux.com/sites/default/files/product_manual/NR01_RA01_manual_v1710.pdf)
- ISO 9060 Pyranometer classification: [http://www.eppleylab.com/wp-content/uploads/2016/09/pyranometer\\_specifications.pdf](http://www.eppleylab.com/wp-content/uploads/2016/09/pyranometer_specifications.pdf)
- CIMO guide from WMO (Measurement of radiation): <https://www.wmo.int/pages/prog/www/IMOP/CIMO-Guide.htm>