Quality Assessment Report

1 Technical features - station and instruments

Site name:	**Carpentras, France**
Latitude, longitude [°]:	44.083000, 5.059000
Altitude [m a. s. l.]:	100
Location on a map:	https://apps.solargis.com/prospect
Type:	Ground measurements
Source:	BSRN
URL:	https://www.pangaea.de/?q=project%3Alabel%3ABSRN+%2Bevent%3Alabel%3ACAR+-guide
Attribution:	Duprat, Thierry (2018): Basic measurements of radiation at station Carpentras (2018-02) [dataset]. Centre Radiometrique, PANGAEA, https://doi.org/10.1594/PANGAEA.888805, In: Brunier, Laurent; Duprat, Thierry; Morel, Jean-Philippe; Olivieri, Jean (2021): Basic measurements of radiation at station Carpentras (1996-09 - 2018-12) [dataset publication series]. Centre Radiometrique, PANGAEA, https://doi.org/10.1594/PANGAEA.932930
Time step:	5 minutes
Quality assessment status:	T R M I P

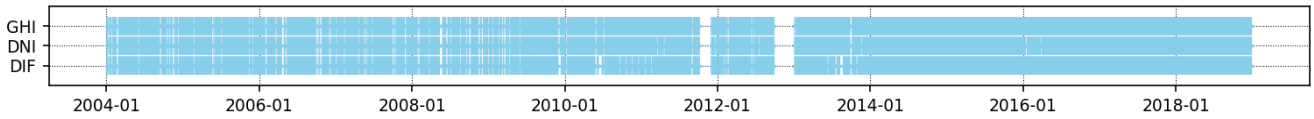

Fig. 1: Data availability for individual parameters

Tab. 1: Instruments installed at the station

Name	Type	Description	Class	Manufacturer	Model	Units	Uncertainty
GHI	GHI	Pyranometer	Class A	Kipp & Zonen	CMP21	W/m²	< ± 2.0 % (daily)
DNI	DNI	Pyrheliometer	Class A	Kipp & Zonen	CHP 1	W/m²	N/A
DIF	DIF	Pyranometer	Class A	Kipp & Zonen	CMP21	W/m²	< ± 2.0 % (daily)

Tab. 2: Test groups

Test group	GHI	DNI	DIF	GTI	RHI	ALB
Group_1	GHI	DNI	DIF	-	-	-

Multi-component tests are applied only for test groups with GHI, DNI, DIF or GTI columns.

2 Results of quality assessment

Prior to the comparison with satellite-based solar resource data, the ground-measured irradiance was quality-assessed by Solargis. Quality assessment (QA) is based on BSRN methods and methods implemented in-house by Solargis. The tests are applied in two runs: (i) first, the automatic tests are run to identify the obvious issues; next (ii) by the visual inspection we identify and flag inconsistencies, which are of more complex nature. Visual inspection is an iterative and time-consuming process.

The automatic QA tests may include:

- Correction of time shifts
- Identification of missing values
- Evaluation of measurements against sun position (Sun below and above horizon)
- Comparing the data with possible minimum and maximum physical limits
- Multi-component tests i.e. evaluation of consistency between solar radiation components (GHI, DNI and DIF) or relevant couples (GHI, RHI, DIF or GTI)
- Detection of outliers and patterns (TEMP)
- Tracker malfunction (DNI and DIF)

Automatic quality assessment can be applied on solar and meteorological data. The data readings not passing one or more QA tests were flagged.

Tab. 3: Availability of data readings for Carpentras station

	Data availability	
Sun below horizon	742 849	48.9%
Sun above horizon	775 300	51.1%
Total data readings	1 518 149	100.0%

Tab. 4: Summary of quality assessment results

Type of test	Occurrence of data readings (Sun above horizon)					
	GHI		DNI		DIF	
invalid values	6 035	0.8%	7 233	0.9%	12 605	1.6%
sun below horizon	553	0.1%	553	0.1%	553	0.1%
below minimum physical limit	1 819	0.2%	4	0.0%	1 770	0.2%
above maximum physical limit	0	0.0%	0	0.0%	10	0.0%
consecutive static value	4 338	0.6%	4 295	0.6%	4 341	0.6%
consistency issue	1 973	0.3%	1 973	0.3%	1 973	0.3%
not specified data issue	19 324	2.5%	25 683	3.3%	19 324	2.5%
Total excluded data readings	34 042	4.4%	39 741	5.1%	40 576	5.2%
Passed data readings	741 258	95.6%	735 559	94.9%	734 724	94.8%
Total data readings	775 300	100.0%	775 300	100.0%	775 300	100.0%

Fig. 2: Overview of quality assessment results for GHI

Fig. 3: Overview of quality assessment results for DNI

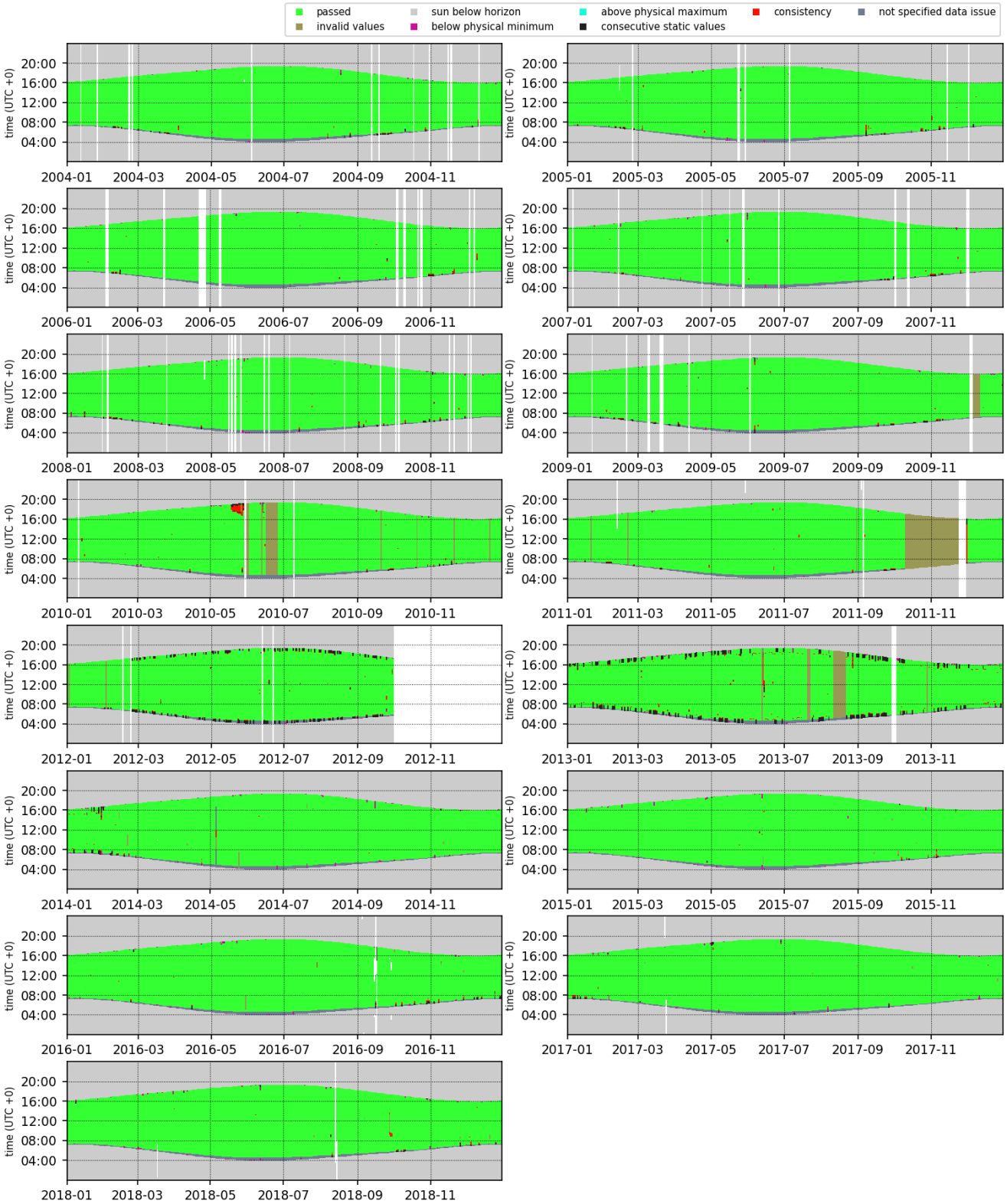

Fig. 4: Overview of quality assessment results for DIF

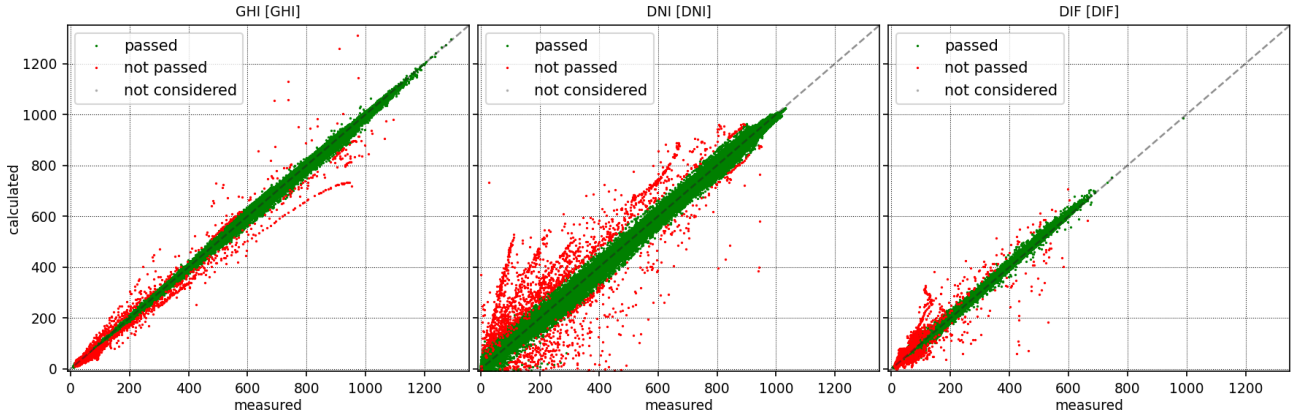

Fig. 5: Consistency plot of test group Group_1

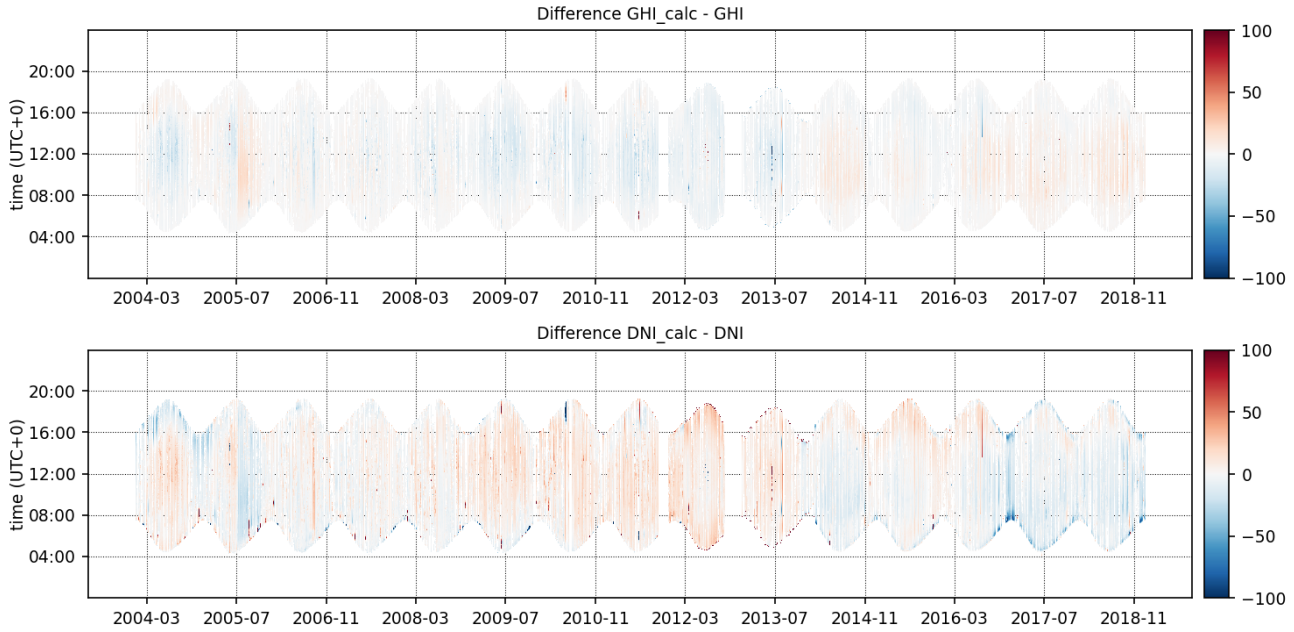

Fig. 6: Difference plot of test group Group_1

Tab. 5: Quality Control summary

Indicator	Quality	Note
Instrument accuracy		2x Class A instrument (CHP 1, CMP21)
Information on cleaning and maintenance		No information on instrument cleaning
Quality control complexity		Majority of quality control tests applied. Multi-component tests applied.
Availability of valid measurements		Approx. 174 months of DNI and GHI, 173 months of DIF after quality control

Not specified | Very good | Good | Medium | Problematic | Insufficient

Quality assessment summary

Data is measured with high accuracy pyranometers and pyrheliometer. Cleaning info is missing.

Issues identified in the data include minor shading in early morning and consecutive static values in years 2012 and 2013.

Only passed data records qualifies for model validation.

3 Comparison with model data

The validation statistics were calculated from valid records after quality control and sun elevation higher than 5°.
Dataset 1009022_Solargis_TS_BSRN_Carpentras_France_2004-2018 was used as model dataset for compare statistics.

Tab. 6: Global comparison of hourly values

	Bias		Root Mean Square Deviation, RMSD			Number of data pairs
	[W/m²]	[%]	Hourly [%]	Daily [%]	Monthly [%]	
GHI	2	0.6	11.6	5.6	1.3	58064
DNI	-8	-1.6	23.9	15.5	6.5	57810

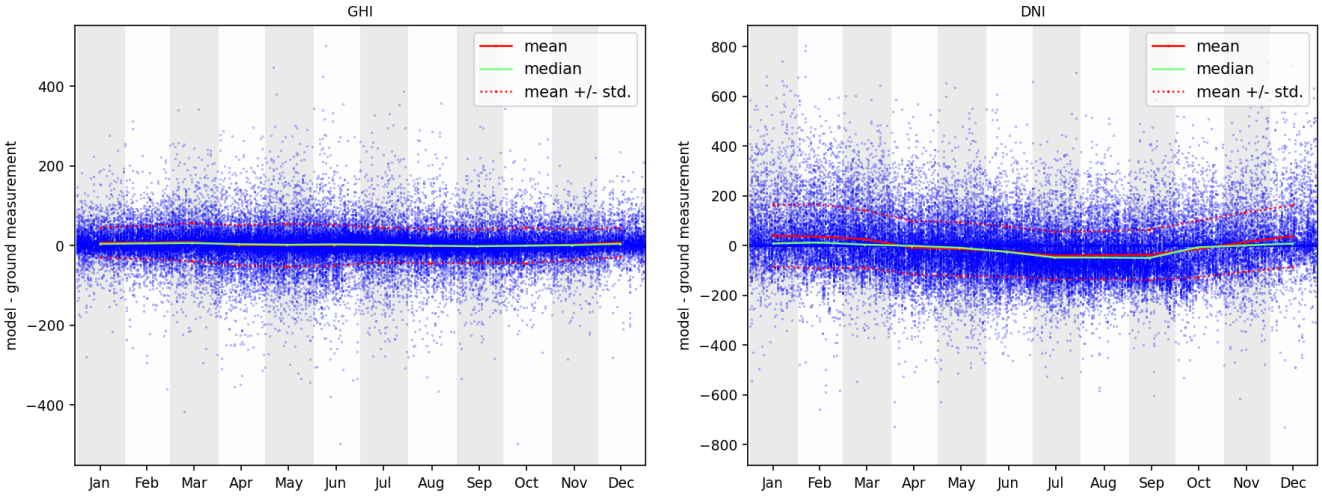

Fig. 7: Deviations of hourly DNI and GHI - Carpentras
X-axis: day of year DOY; Y-axis: difference between model and measurements

Tab. 7: Monthly comparison of hourly values – number of data pairs

Number of points	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GHI	3657	3941	4954	5550	5991	6179	6460	6007	4987	3922	3376	3040
DNI	3624	3927	4912	5518	5975	6169	6419	5990	4983	3913	3351	3029

Tab. 8: Monthly comparison of hourly values – bias

BIAS [%]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GHI	3.6	2.7	2.4	0.2	0.2	0.2	0.3	-0.3	-0.4	0.1	1.0	3.9
DNI	10.5	9.0	6.1	-1.7	-3.1	-4.4	-6.9	-6.9	-7.1	-3.4	3.5	9.7

Tab. 9: Monthly comparison of hourly values – RMSD

RMSD [%]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GHI	18.2	15.2	13.3	11.9	11.5	10.0	8.3	8.9	9.9	14.6	17.6	18.7
DNI	34.3	33.0	27.4	23.7	23.6	19.5	17.7	18.5	20.5	27.9	32.1	33.3

Acronyms

Parameter types

DIF	Diffuse horizontal irradiance
DNI	Direct normal irradiance
GHI	Global horizontal irradiance

Quality control statuses

T / T	Time reference check (missing / done)
R / R	Radiation automatic quality check (missing / done)
M / M	Meteo automatic quality check (missing / done)
I+ / I	Manual quality check (missing / done)
P / P	Post filtering check (missing / done)

Glossary

BIAS	Represents systematic deviation between modelled and measured values (positive bias indicates overestimation and negative bias shows underestimation of the model) and is calculated according to this formula: $Bias = measured - modeled$ Bias indicates systematic (annual or seasonal) issues of a solar or meteorological model. It can also indicate systematic problem in measurements. In solar radiation model, this can be determined by insufficient cloud identification, coarse resolution and regional imperfections of atmospheric data (aerosols, water vapour), terrain, sun position, satellite viewing angle, microclimate effects, high mountains, etc. Bias may also indicate a quality issue of the measured data, e.g. misalignment, miscalibration or soiling of a sensor. In solar radiation model, this can be determined by insufficient cloud identification, coarse resolution and regional imperfections of atmospheric data (aerosols, water vapour), terrain, sun position, satellite viewing angle, microclimate effects, high mountains, etc. Bias may also indicate a quality issue of the measured data, e.g. misalignment, miscalibration or soiling of a sensor.
Root Mean Square Deviation (RMSD)	Represents spread of deviations given by random discrepancies between measured and modelled data and is calculated according to this formula: $RMSD = \sqrt{\frac{\sum_{k=1}^{n}\left(X^{k}_{measured} - X^{k}_{modeled}\right)^{2}}{n}}$ Considering solar radiation or meteorological model, RMSD reflects inaccuracies of cloud identification (e.g. intermediate clouds), under/over estimation of atmospheric input, data, terrain, microclimate and other effects, which are not captured by the model. Par of this discrepancy is natural - as satellite monitors large area, while the sensor can see only micro area of approx. 1 squared centimeter. Higher RMSD may also indicate lower quality of the measured data, e.g. lower accuracy, miscalibration or misalignment of the instruments, by soiling of sensor due to insufficient cleaning or issues in a data logger. It can also indicate insufficient data quality control.

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