Quality Assessment Report

SOLARGIS ANALYST

1   Technical features - station and instruments

|	
Site name:	**Sao Martinho da Serra, Brasil**
Latitude, longitude [°]:	-29.442783, -53.823051
Altitude [m a. s. l.]:	489
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%3ASMS+-guide
Attribution:	Pereira, Enio Bueno (2018): Basic measurements of radiation at station São Martinho da Serra (2017-01) [dataset]. Instituto Nacional de Pesquisas Espaciais, Brasilia, PANGAEA, https://doi.org/10.1594/PANGAEA.889427
Time step:	5 minutes
Quality assessment status:	T✓ R✓ M I✓ P
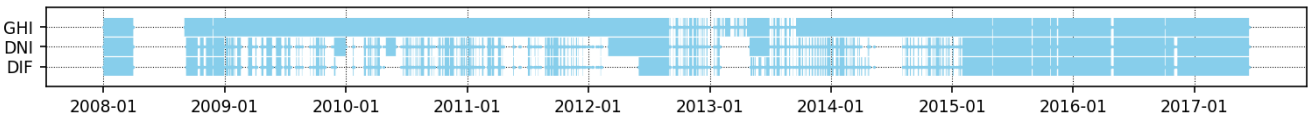
Fig. 1: Data availability for individual parameters

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	Normal Indicence pyrheliometer	Class B	Eppley Lab	NIP	W/m²	N/A
DIF	DIF	Pyranometer	Class A	Kipp & Zonen	CMP22	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 Sao Martinho da Serra station

	Data availability	
Sun below horizon	443 928	49.4%
Sun above horizon	455 135	50.6%
Total data readings	899 063	100.0%

Tab. 4: Summary of quality assessment results

Type of test	Occurrence of data readings (Sun above horizon)					
	GHI		DNI		DIF	
invalid values	1 431	0.3%	143 542	31.5%	171 435	37.7%
sun below horizon	315	0.1%	315	0.1%	315	0.1%
below minimum physical limit	2 269	0.5%	9 653	2.1%	673	0.1%
above maximum physical limit	0	0.0%	0	0.0%	36	0.0%
consistency issue	25 381	5.6%	25 381	5.6%	25 381	5.6%
visual check	12 319	2.7%	20 594	4.5%	13 287	2.9%
not specified data issue	35 576	7.8%	70 819	15.6%	49 269	10.8%
Total excluded data readings	77 291	17.0%	270 304	59.4%	260 396	57.2%
Passed data readings	377 844	83.0%	184 831	40.6%	194 739	42.8%
Total data readings	455 135	100.0%	455 135	100.0%	455 135	100.0%

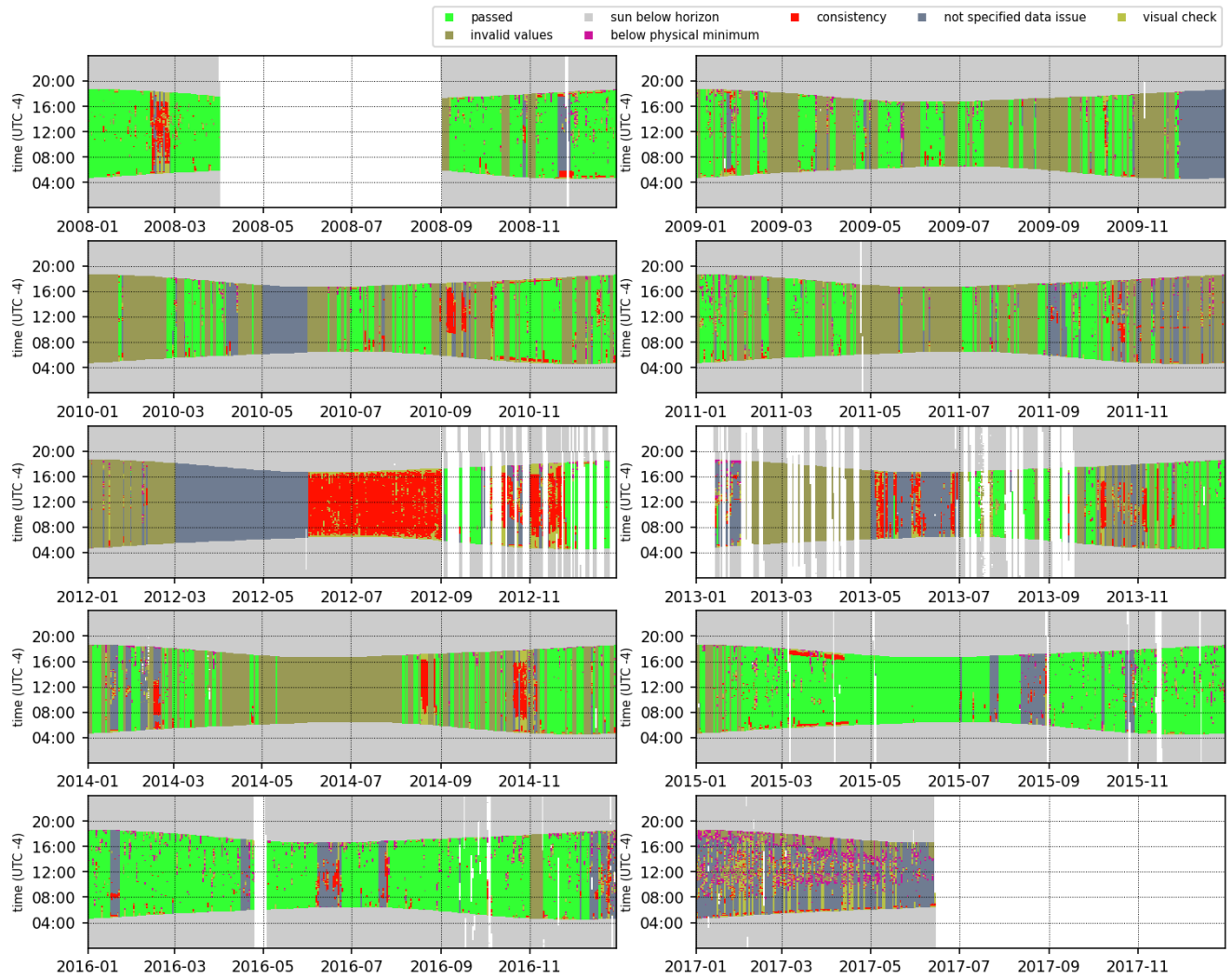Fig. 2: Overview of quality assessment results for GHI

Fig. 3: Overview of quality assessment results for DNI
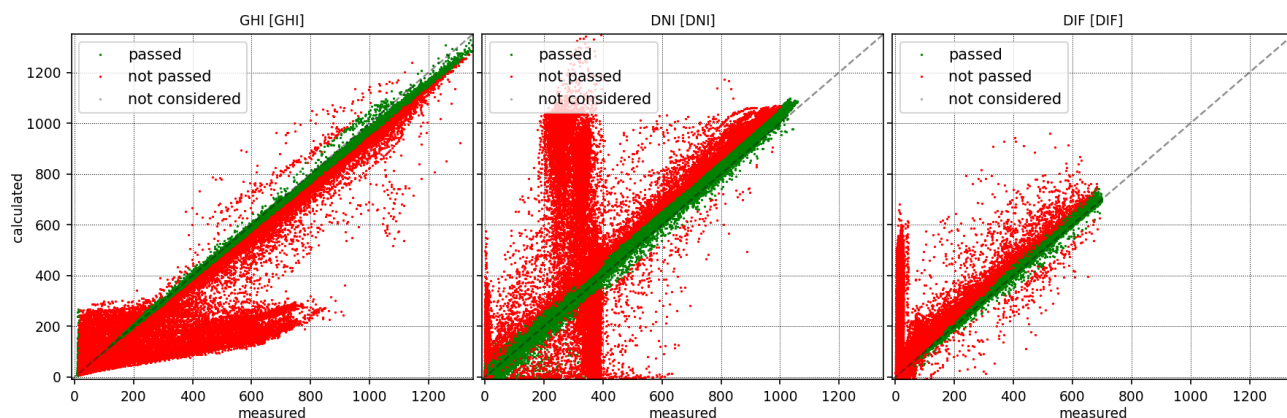
Fig. 4: Overview of quality assessment results for DIF

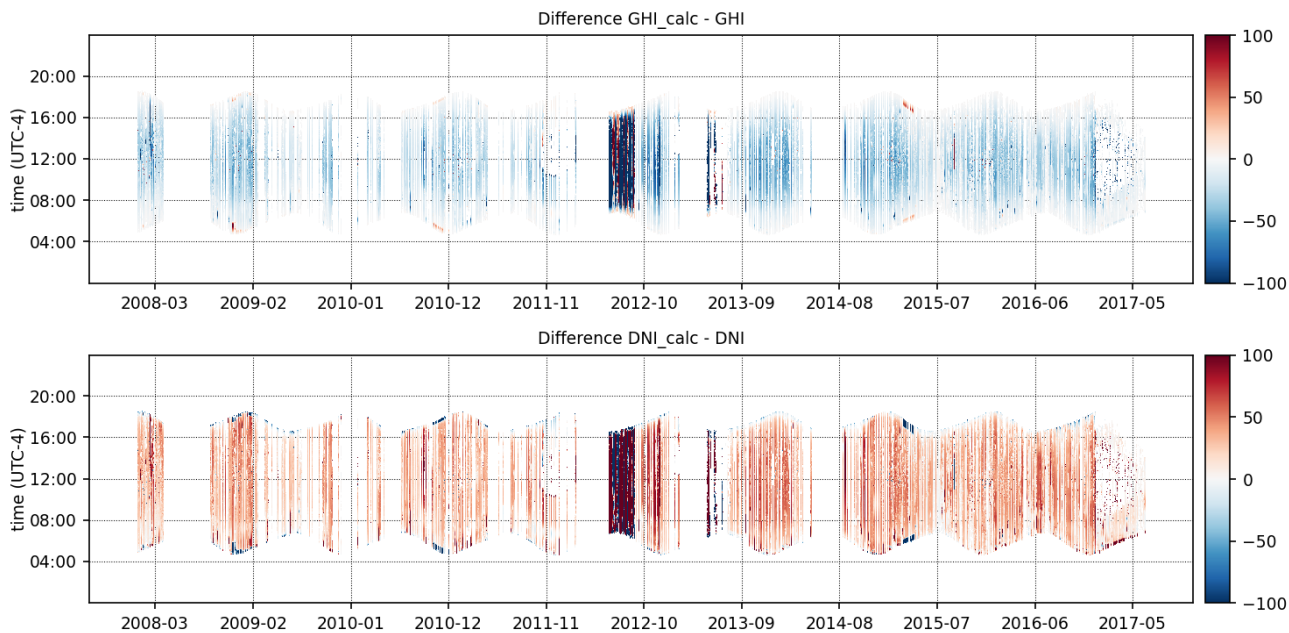
Fig. 5: Consistency plot of test group Group_1

Fig. 6: Difference plot of test group Group_1

Tab. 5: Quality Control summary

Indicator	Quality	Note
Instrument accuracy		2x Class A instrument (CMP21, CMP22)
		1x Class B instrument (NIP)
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. 89 months of GHI, 46 months of DIF and DNI after quality control

Not specified	Very good	Good	Medium	Problematic	Insufficient

Quality assessment summary

Data is measured with high accuracy pyranometers and medium accuracy pyrheliometer. Cleaning info is missing. Issues identified in the data include inconsistency between GHI, DNI and DIF, missing values, tracker malfunctions and degradation. 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 1009172_Solargis_TS_BSRN_SaoMartinhodaSerra_Brazil_2008_2017 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	3	0.7	15.9	7.0	1.5	29603
DNI	6	1.2	26.0	13.3	4.1	14725
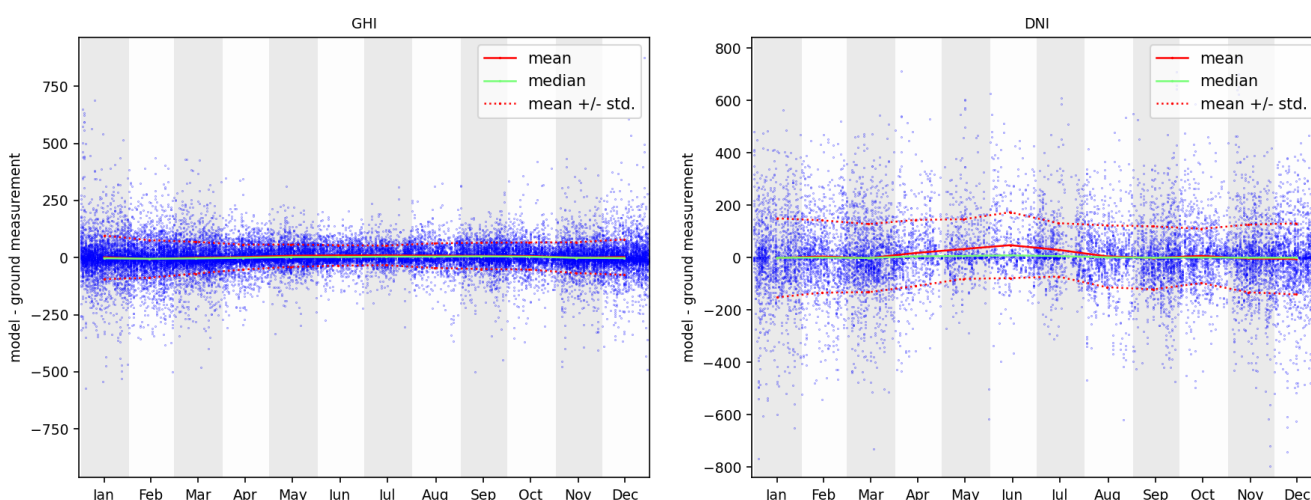
Fig. 7: Deviations of hourly GHI and DNI - Sao Martinho da Serra

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	3300	2902	3319	2500	2408	1748	1669	1714	2260	2031	2628	3124
DNI	1517	1196	1714	831	701	598	916	1018	1476	1423	1580	1755

Tab. 8: Monthly comparison of hourly values – bias

BIAS [%]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GHI	0.2	-1.2	-0.2	0.5	2.6	3.3	3.2	2.4	1.8	1.6	-0.1	0.4
DNI	-0.2	0.8	-0.4	4.0	9.4	11.4	7.2	0.9	-0.2	1.4	-0.6	-0.9

Tab. 9: Monthly comparison of hourly values – RMSD

RMSD [%]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GHI	19.0	16.8	14.9	14.3	15.7	16.1	15.2	15.6	14.5	13.8	13.4	14.9
DNI	29.1	27.4	24.6	29.0	34.0	32.5	25.9	23.1	24.5	24.2	23.2	24.1

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.

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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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