SolarAnywhere®
by Clean Power Research®

SolarAnywhere® Validation Data Version 4.1

Updated May 2026
Clean Power Research®

DISCLAIMER:

This report has been modified from its original version. Please contact Clean Power Research for full analysis.

Foreword

This document provides reference information and validation statistics for SolarAnywhere® irradiance datasets, published May 2026 alongside the release of SolarAnywhere Data Version 4.1 (“V4.1”). We believe the metrics in this paper to be a transparent assessment of our irradiance values against a set of global reference sites.

At Clean Power Research®, we know that bankable, accurate data is critically important to developing renewable energy and achieving a future of a clean powered planet. The SolarAnywhere team takes great care in each Data Version update to improve our data sources, irradiance model and calibrations to deliver reliable solar resource data to clients all over the world.

We stand by our validation and want to thank our partners—both academic and industry—for their many years of technical collaboration.

Evan Kyte
Lead Product Manager

Alex Kubiniec
Data Quality Engineer

Contact Us

Clean Power Research, LLC
support@solaranywhere.com

Updated May 2026

SolarAnywhere is a product of Clean Power Research, whose mission is to power the worldwide energy transformation with trusted, adaptable and efficient software.

1. Executive Summary

SolarAnywhere is a software product maintained by Clean Power Research that provides on-demand access to bankable solar irradiance data.

SolarAnywhere irradiance data are generated using visible and infrared-channel data captured by geosynchronous orbiting satellites. This remote-sensing method supports a long record of solar data independent of ground measurements used for bankable resource assessment, operational monitoring and solar forecasting. These datasets are suitable for solar PV system design as well as solar project financing.

SolarAnywhere Data Version 4.1 (V4.1) validation covers a maximum date period from 1998 to 2025, depending on region. The statistics presented below reflect data accuracy for the specified period but should not be considered as a definitive indicator of overall accuracy.

SolarAnywhere Global Horizontal Irradiance (GHI) has a global 95% confidence interval of -4.43% to 4.59% (a range of +/- 4.51%) when compared to 1,241 reference years of ground data. Long term Mean Bias Error (rMBE) ranges from -0.33% to +0.70% depending on geographic region. See Figure 1.1.1 below.

1.1.1 Figure: SolarAnywhere GHI Annual Accuracy Metrics

Region	rMBE	95% Conf. Interval	Std. Dev.	Sites	Reference Years
North America	0.27%	[-2.92%, 3.47%]	1.63%	19	296
South America	0.01%	[-4.06%, 4.08%]	2.08%	17	80
Europe	-0.33%	[-5.14%, 4.48%]	2.45%	27	498
Oceania & East Asia	0.37%	[-4.59%, 5.33%]	2.53%	30	230
Africa & West Asia	0.70%	[-4.10%, 5.50%]	2.45%	40	137
All	**0.08%**	**[-4.43%, 4.59%]**	**2.30%**	**133**	**1,241**

2. Clean Power Research

Clean Power Research® has delivered award-winning cloud software solutions to utilities and industry for more than 26 years. The PowerClerk®[1], WattPlan®[2] and SolarAnywhere®[3] product families allow customers to prepare and thrive amid the energy transformation. Clean Power Research has offices in Napa, California and Bellevue, Washington.

SolarAnywhere

SolarAnywhere irradiance data are generated using visible- and infrared-channel data captured by geosynchronous orbiting satellites. The satellite images are processed using the most advanced algorithms developed by Dr. Richard Perez[4] at the University at Albany (SUNY). These algorithms extract cloud indices from the satellite's visible and infrared data. A self-calibrating feedback process adjusts for seasonal and local variations in ground albedo. The cloud indices are used to modulate physically based radiative-transfer models describing localized clear-sky climatology.

The Perez model is applied in a pseudo-empirical fashion that is periodically calibrated with a select few ground stations. However, it operates largely independently of ongoing ground data input. This approach is unique to the industry and enables ground-to-satellite correlation studies to be truly based on two independently derived measurement sources.

Clean Power Research has exclusive relationships with Dr. Perez and SUNY-Albany to implement the latest satellite-to-solar irradiance methodology advances. More information on the extensive validation of the Perez model can be found in the References section of this document.

The National Solar Radiation Database (NSRDB) 2005 (SUNY version 1) and 2010 (SolarAnywhere Version 2.3) releases utilized Perez model-based satellite irradiance data in agreement with the U.S. Department of Energy through the National Laboratory of the Rockies (NLR, formerly NREL). While the output format of SolarAnywhere satellite irradiance data is similar to NSRDB data, SolarAnywhere now provides more recent and more accurate datasets intended for commercial use.

The newest version of the SolarAnywhere model has been implemented operationally as Data Version 4.1 (V4.1).

[1] www.powerclerk.com
[2] www.cleanpower.com/products/wattplan/
[3] www.solaranywhere.com
[4] www.solaranywhere.com/validation/leadership-bankability/dr-richard-perez/

3. Validation Methodology

3.1 Evaluation Metrics

The SolarAnywhere model has three critical properties for the purposes of data validation and overall confidence in the model's performance.

- First, the model focuses on minimizing error across many sites and climates rather than any specific single location. To do the latter could lead to over-fitting and a false sense of accuracy.
- Second, the model operates independently of ongoing ground data input. This means that any assessment of accuracy reflects satellite modeling rather than uncertainty in validation data, which is considered the ground truth for simplicity.
- Third, SolarAnywhere utilizes a single historical model regardless of the time and location (with adaptations for each satellite platform). Because of these properties, the irradiance model generalizes well, and the accuracy statistics are representative of the model's performance globally.

SolarAnywhere irradiance data are generated in both GHI and DNI components. The following geometric balancing equation is used to calculate diffuse horizontal irradiance (DHI):

$$DHI = GHI - DNI \times \cos(\alpha_{zenith}) \quad (2)$$

The GHI, DNI and DHI data are compared at hourly, monthly and annual intervals using traditional error metrics such as relative Mean Bias Error (rMBE), Mean Absolute Error (MAE) and Root Mean Square Error (RMSE).

The error metrics are defined by the following formulas:

$$rMBE = \frac{\sum_{i=1}^{N}(x_i{}^{SA} - x_i{}^{obs})}{N} \frac{100\%}{\overline{x_i{}^{obs}}} \quad (3)$$

$$rMAE = \frac{\sum_{i=1}^{N}|(x_i{}^{SA} - x_i{}^{obs})|}{N} \frac{100\%}{\overline{x_i{}^{obs}}} \quad (4)$$

$$rRMSE = \sqrt{\frac{\sum_{i=1}^{N}(x_i{}^{SA} - x_i{}^{obs})^2}{N}} \frac{100\%}{\overline{x_i{}^{obs}}} \quad (5)$$

An x represents the variable being considered (GHI, DNI or DHI); N is the number of data points used; and the superscripts SA and obs stand for SolarAnywhere and ground-observed data. The error metrics are normalized by the mean of the ground-observed data and denoted by $rMBE$, $rMAE$ and $rRMSE$.

Hoff et al. have previously discussed the applicability of various error metrics for solar irradiance in the paper "Reporting of Irradiance Model Relative Errors."[5] Standard deviations and confidence intervals are also presented.

The statistics presented here are indicative of product performance but should not be considered a definitive measure of overall accuracy. Despite best efforts to quality control the reference data, no dataset is perfect.

4. Validation Results by Geography

Validation results are organized by time period (long-term, annual, monthly and hourly) and geography (North America, South America, Europe, etc.)

4.1 Long Term Averages

The GHI and DNI average mean bias error (rMBE) for each validation site is plotted and color coded on the maps below. Each point represents the full period for which validation data are considered.

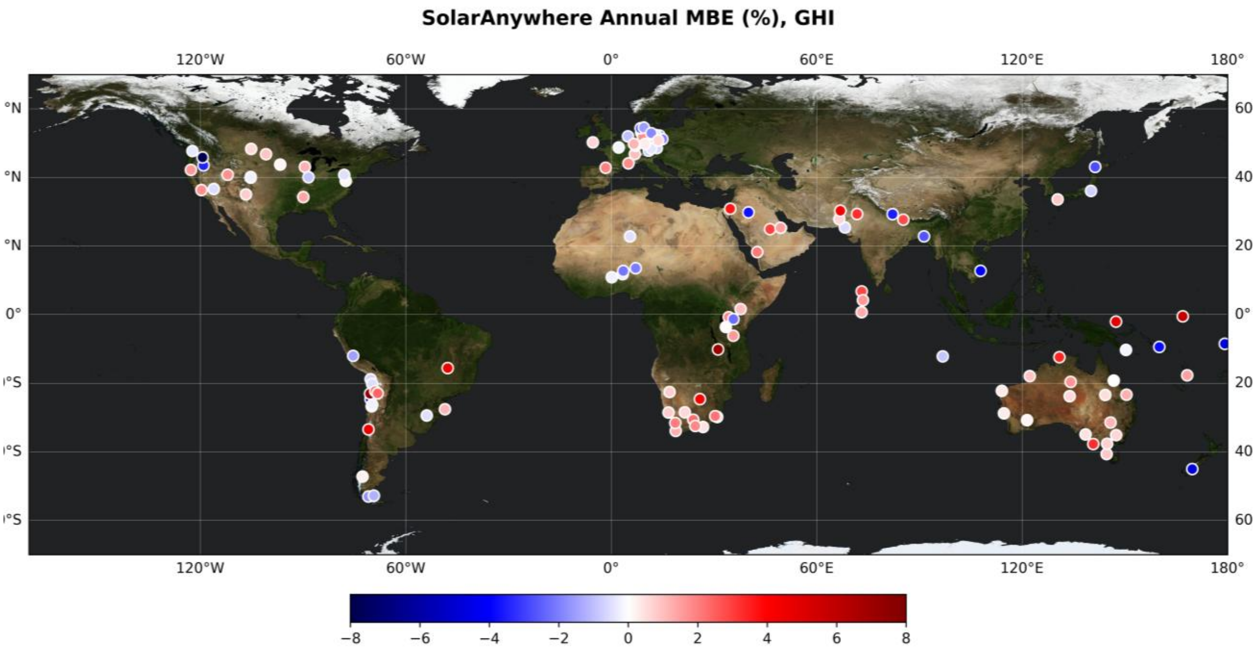
A bias close to zero means that the model is well calibrated, while a bias farther from zero means the model is over- or under-estimating solar resource on a long-term average. The map below displays how SolarAnywhere irradiance models perform over each continent and satellite region.

The global rMBE of GHI predicted by the V4.1 irradiance model is 0.08%, with a standard deviation of 2.30% across rMBE results, and a corresponding 95% confidence interval ranging from -4.43% to 4.59%. Because model uncertainty varies per region, it is recommended to apply uncertainty metrics reported per region for the purposes of yield assessment. Metrics per geographic region are tabulated later in the section.

In North America, the mean rMBE is 0.27%, with a standard deviation of 1.63% across rMBE results, and a corresponding 95% confidence interval of -2.92% to 3.47%.

[5] www.cleanpower.com/resource/reporting-of-irradiance-model-relative-errors/

4.1.1 Figure: Map of Long-Term rMBE Error, GHI

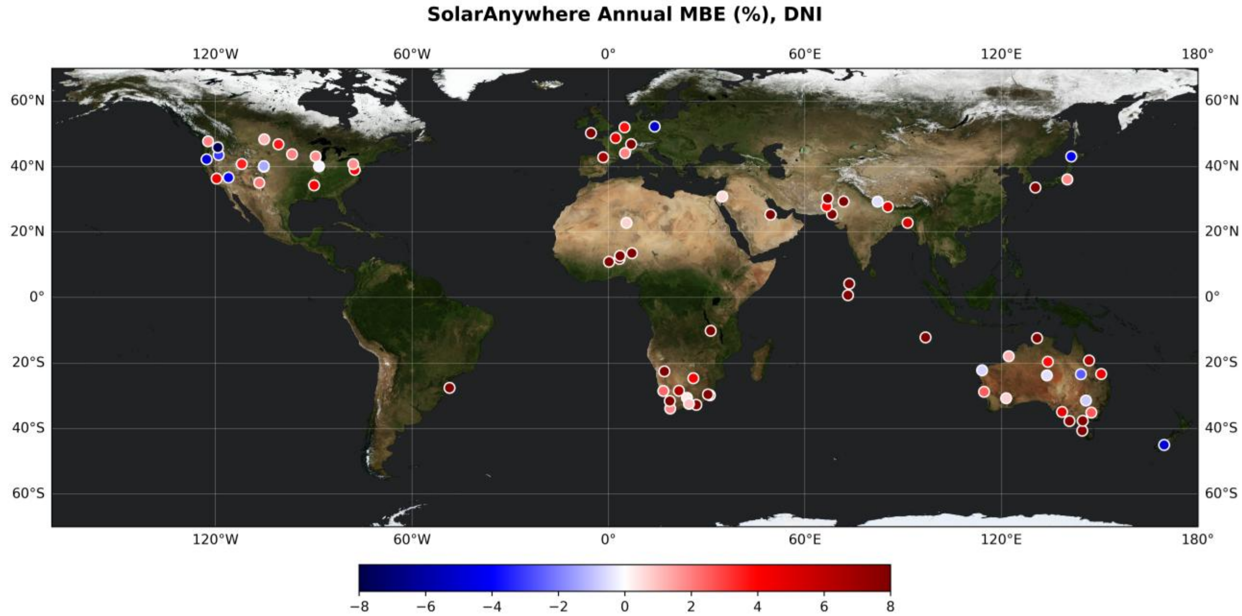


An analogous map below displays SolarAnywhere irradiance rMBE for DNI. Globally, the mean rMBE for DNI is 1.29%, with a standard deviation of 3.81% across rMBE results, and a corresponding 95% confidence interval ranging from -6.18% to 8.76%.[6]

[6] M Sandia National Laboratories: PV Performance Modeling Collaborative (PVPMC). *Direct Normal Irradiance.* https://pvpmc.sandia.gov/modeling-guide/1-weather-design-inputs/irradiance-insolation/direct-normal-irradiance/https://pvpmc.sandia.gov/modeling-guide/1-weather-design-inputs/irradiance-insolation/direct-normal-irradiance/

Measuring DNI is more difficult than GHI because specialized instrumentation is required to capture irradiance directly normal to the sun. In some cases, it is necessary to indirectly calculate DNI from co-planar measurements by applying corrections for the field of view when data is unreliable. For these reasons, error metrics surrounding DNI is generally higher than that of GHI, which is relatively easier to measure accurately.

4.1.2 Figure: Map of Long-Term rMBE Error, DNI



4.2 Annual Results

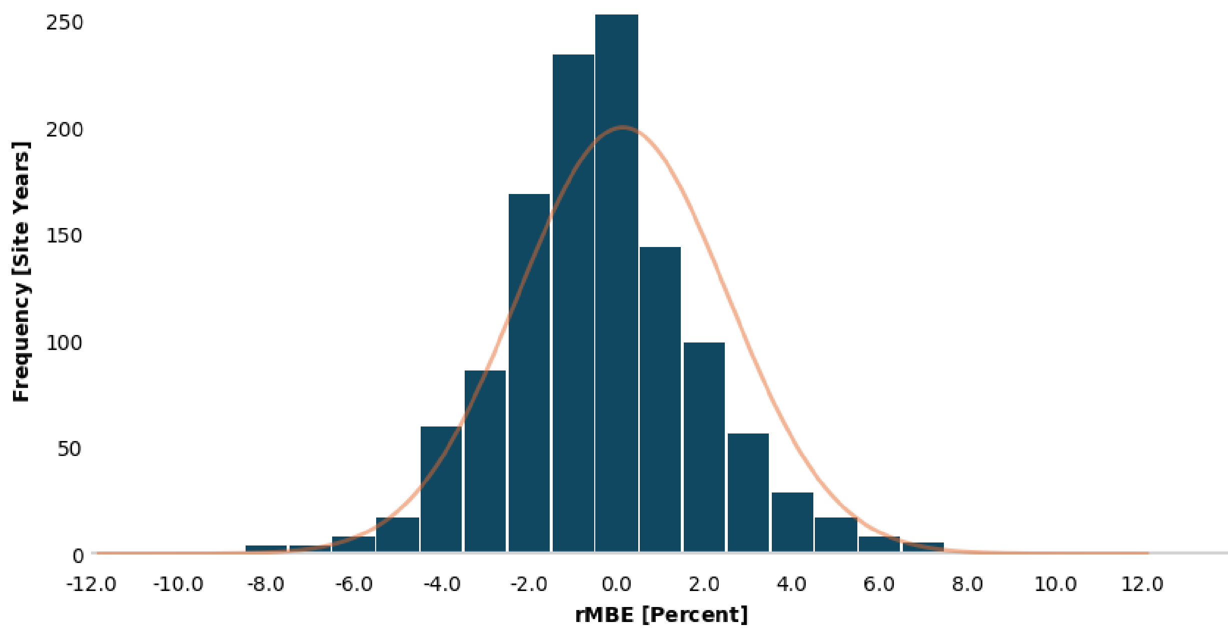
An assessment of annual errors is crucial for understanding the consistency and uncertainty of the satellite model, as long-term averages may hide offsetting errors. Annual metrics are also common in the solar industry, with some of the use cases identified below:

- **Resource assessment** – to compare recent and long-term satellite-derived data to a year-long ground measurement campaign
- **Development and financing** – to assess interannual variability and the ability of a solar project to meet debt coverage requirements in a low insolation year
- **Operations and asset management** – to compare expected and actual production

The histogram below displays each reference year of mean bias error (rMBE) from global reference data. Many sites exhibit an rMBE that falls within one standard deviation of 2.30%. Assuming a normal distribution, the 95% confidence interval of GHI annual mean bias error is -4.43% to 4.59%.

These data reflect a well-calibrated model as the error distribution is mostly normal with few outliers.

4.2.1 Figure: Aggregate Annual Error rMBE, GHI



Annual GHI error is displayed per geographic region in the following table. The distribution of annual error (rMBE) for GHI has a global mean bias error of 0.08% with a standard deviation of 2.30%. Assuming a normal distribution, the 95% confidence interval is -4.43% to 4.59% for N=1241 site-years.

4.2.2 Table: Annual Accuracy Metrics, GHI

Region	rMBE	95% Conf. Interval	Std. Dev.	Sites	Reference Years
North America	0.27%	[-2.92%, 3.47%]	1.63%	19	296
South America	0.01%	[-4.06%, 4.08%]	2.08%	17	80
Europe	-0.33%	[-5.14%, 4.48%]	2.45%	27	498
Oceania & East Asia	0.37%	[-4.59%, 5.33%]	2.53%	30	230
Africa & West Asia	0.70%	[-4.10%, 5.50%]	2.45%	40	137
All	**0.08%**	**[-4.43%, 4.59%]**	**2.30%**	**133**	**1,241**

5. Validation Results by Climate

Satellite-based irradiance uncertainty is most often reported by geographic region. Due to variations in data quality management practices among the government agencies operating geostationary weather satellites, it is helpful to calculate error separately for each of the regions covered by different satellite operators. Additionally, because solar development companies typically operate within the coverage area of a single satellite, regionalized error metrics provide targeted insights localized to the region where projects are assessed and built.

An alternative and more nuanced perspective on uncertainty could reflect variations with climate type. Satellite model performance might vary based on physical weather and atmospheric phenomena; mechanisms like cloud motion, aerosols and particulate matter directly influence the final irradiance estimations. SolarAnywhere satellite-based irradiance models are consistently applied across all satellites within the global coverage. Since atmospheric phenomena differ across climate zones, validating model uncertainty across diverse climates is crucial.

5.1 Climate Classification

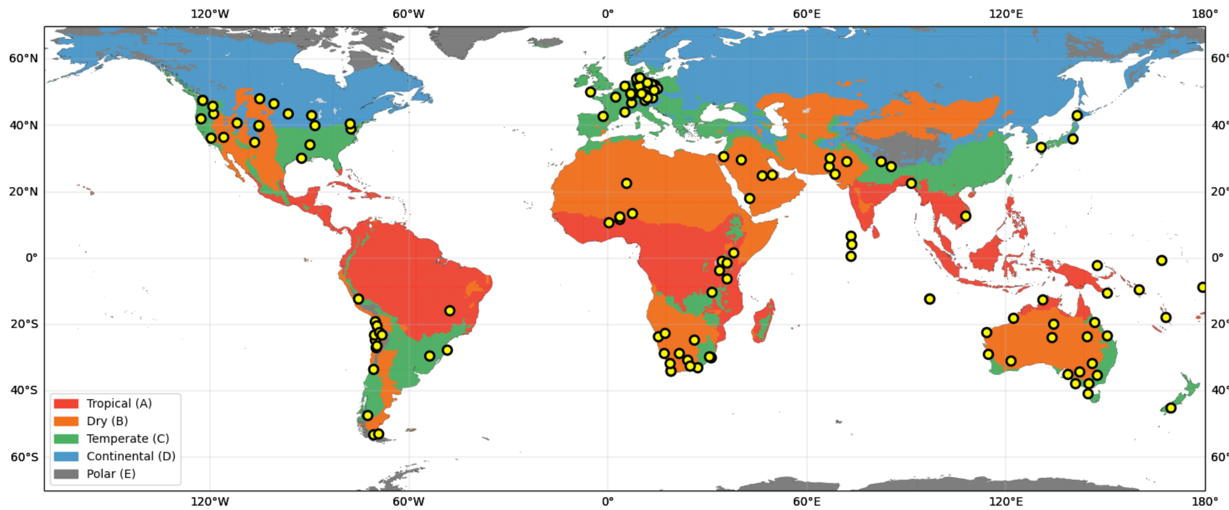
The Köppen-Geiger climate classification is a globally accepted convention that categorizes regions across the globe based on factors such as temperature and precipitation. The five main climatic zones and sub-types are listed in the following table.

5.1.1 The Table: Köppen-Geiger Climatic Zones

Type	Description	Criterion
A	Equatorial climates	$T_{min} \geq +18$ °C
B	Arid climates	$P_{annual} < 10\ P_{th}$
C	Warm temperate climates	-3 °C $< T_{min} < +18$ °C
D	Continental climates (snow)	$T_{min} \leq -3$ °C
E	Polar climates	$T_{max} < +10$ °C

In the following figure and table, the global validation sites are categorized by first-letter classification of the climate zone: Tropical (A), Dry (B), Temperate (C), Continental (D) and Polar (E).

5.1.2 Figure: Reference Sites by Climate Type



The table below lists ground stations used for validation of global horizontal irradiance (GHI), grouped by primary Köppen–Geiger climate classification. Annual rMBE values for GHI are shown across climate zones, with all classifications falling within a -4.38% to 4.49% 95% confidence interval. These results are consistent with the global annual rMBE for GHI when sites are evaluated without climate-based categorization, indicating stable model performance across a wide range of climatic regimes.

5.1.3 Table: Annual Error by Climate Type, GHI

Climate	rMBE	95% Conf. Interval	Std. Dev.	Sites[7]	Reference Years
Tropical (A)	2.00%	[-3.46%, 7.47%]	2.79%	12	36
Dry (B)	0.43%	[-3.40%, 4.26%]	1.95%	51	315
Temperate (C)	-0.19%	[-4.71%, 4.32%]	2.30%	59	795
Continental (D)	0.12%	[-3.92%, 4.16%]	2.06%	4	61
Polar (E)	N/A	N/A	N/A	0	0
All	**0.05%**	**[-4.38%, 4.49%]**	**2.26%**	**126**	**1,207**

[7] Data from seven of the ground sites included in Table 1.1.1 have been intentionally excluded from Table 5.1.3, causing a mismatch in reference years. The omitted sites are located on remote islands, and the data for table 5.1.3 is limited to mainland ground sites.

6. Conclusion

SolarAnywhere provides globally bankable solar resource data. The information presented validates the uncertainty of SolarAnywhere Data and its use in solar resource assessment for photovoltaic (PV) project financing. The global rMBE of GHI predicted by the V4.1 irradiance model is 0.08%, with a standard deviation of 2.30% and a 95% confidence interval ranging from -4.43% to 4.59%.

The model has consistency across geographies, climate types and over 27 years of record. Monthly and hourly statistics demonstrate the ability of the model to represent shorter time periods and the full range of possible weather for operational use cases. SolarAnywhere data may be used as a long-term solar reference independent of the need for regional or site-specific analysis.

SolarAnywhere satellite-based irradiance data track closely to ground measurements and are adequate for both solar site assessment and operations.

SolarAnywhere is a part of Clean Power Research, whose mission is to power the worldwide energy transformation with trusted, adaptable and efficient software.