How does our GHI data compare with other sources?

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Background

It is generally acknowledged that ground-based measurements of solar radiation can be significantly more accurate than satellite-based models, but only if the radiation sensors are well-maintained and the location is reasonably close to the user's area of interest [1], [2], [3], [4]. Our Ground-Site Irradiance Database (GSID) consists of daily and hourly observations of Global Horizontal Irradiance (GHI) for the period 2005-2018 from over 7000 professionally operated sites covering the US. GSID data is carefully quality controlled using artificial intelligence techniques and interpolated onto a 10 km grid.

Validation Methodology

A widely accepted source of solar radiation data in the United States is the National Solar Radiation Database 1998-2017 (NSRDB) produced by the National Renewable Energy Lab (NREL). To validate the GSID we attempted to duplicate the methodology used in validating the NSRDB, using the same high-quality data from the NOAA's Surface Budget network (SURFRAD) network as the basis of comparison [5].

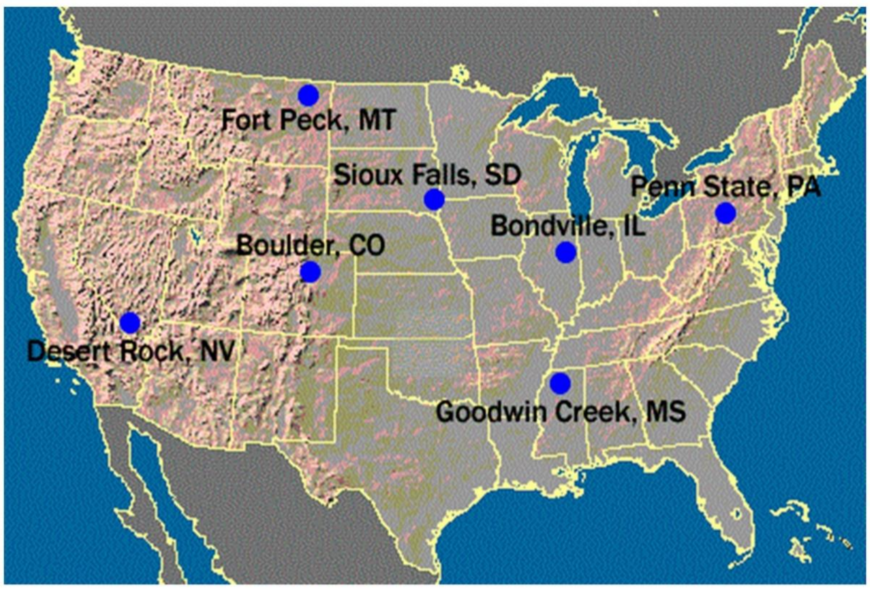

Figure 1 - SURFRAD sites used for our comparison

Both Mean Absolute Error (MAE) and confidence intervals (based on Root Mean Square Error) are commonly used to quantify the errors one might expect in sensor observations [6]. Figure 2 showing mean absolute percent error (MA%E) indicates in a randomly selected <u>hourly</u> observation, one should expect about a 21% error when using the NSRDB and about 12% error in our GSID database. Similarly, one should expect an error of 12% when using a <u>daily</u> observation from the NSRDB and an 8% error from the GSID data. Both the NSRDB and GSID demonstrated similar accuracy for the monthly and annual observations.

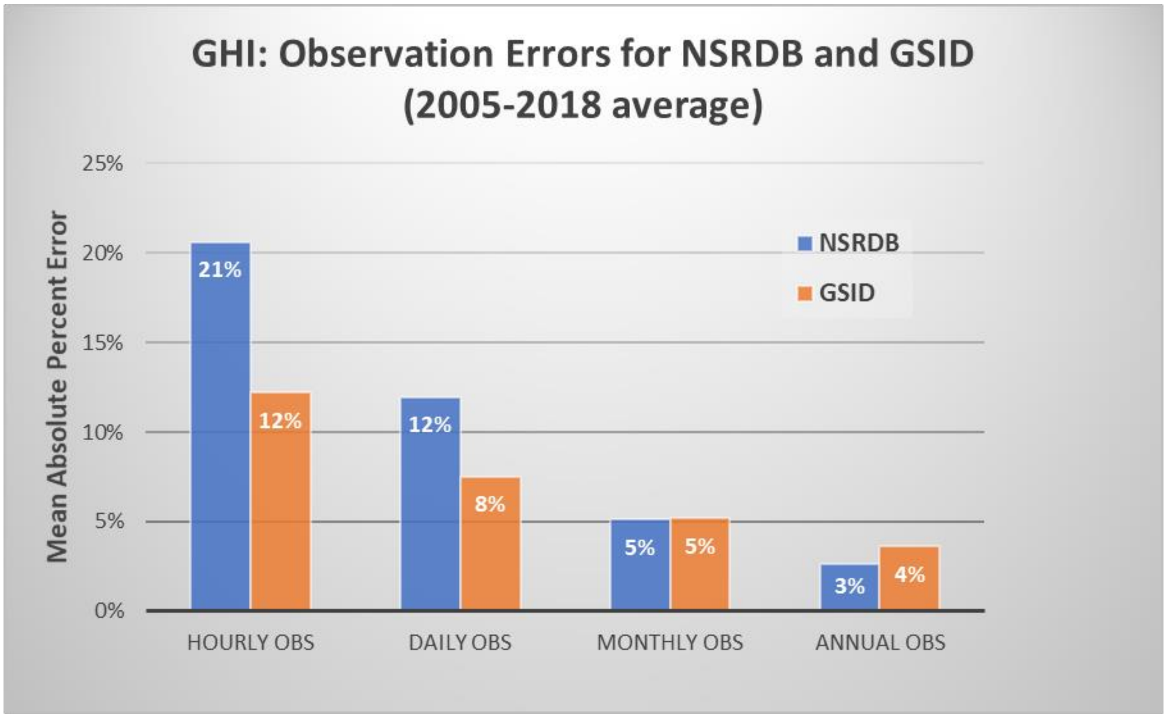

Figure 2 – Mean observation errors (%) for the MSRDB and the GSID database

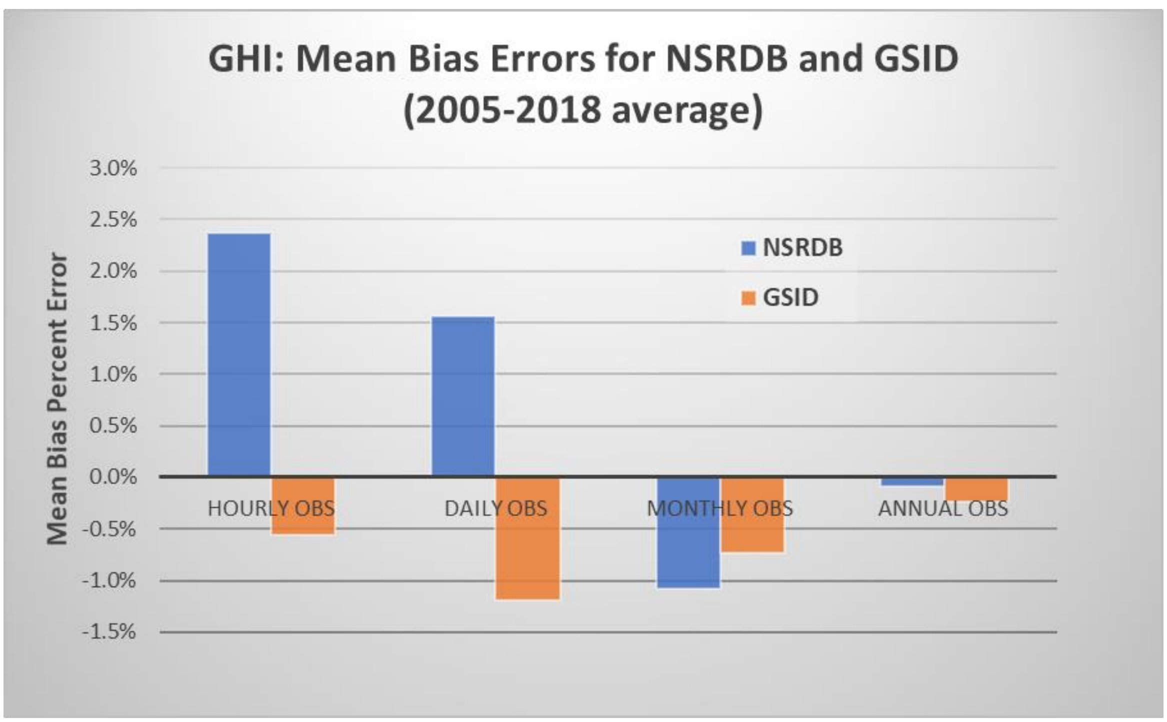

Figure 3 – Mean Bias errors (%) for the MSRDB and the GSID database

A plot of measurement uncertainty at 95% confidence (Figure 4) shows similar results based on the root mean square percent errors (RSM%E) and Mean Bias Percent Error (MB%E). Our GSID has roughly half the expected percent error for hourly and daily observations, and is comparable in accuracy for monthly and annual values. We found that the annual and monthly uncertainties in our analysis are very close to those reported by NREL in their validation of the NSRDB [4]. However, the hourly and daily uncertainties for the NSRDB relative to SURFRAD are significantly higher in our study than those reported by NREL in their analysis. To reduce skewing of the full-day results from high percent errors under low-light conditions (typically dusk and dawn when there is little solar production of interest), we included only hourly observations where GHI was greater than 50 W/m2. The difference in the reported hourly uncertainty could be explained if NREL used a higher threshold in their validation, however this would not affect the daily uncertainty shown.

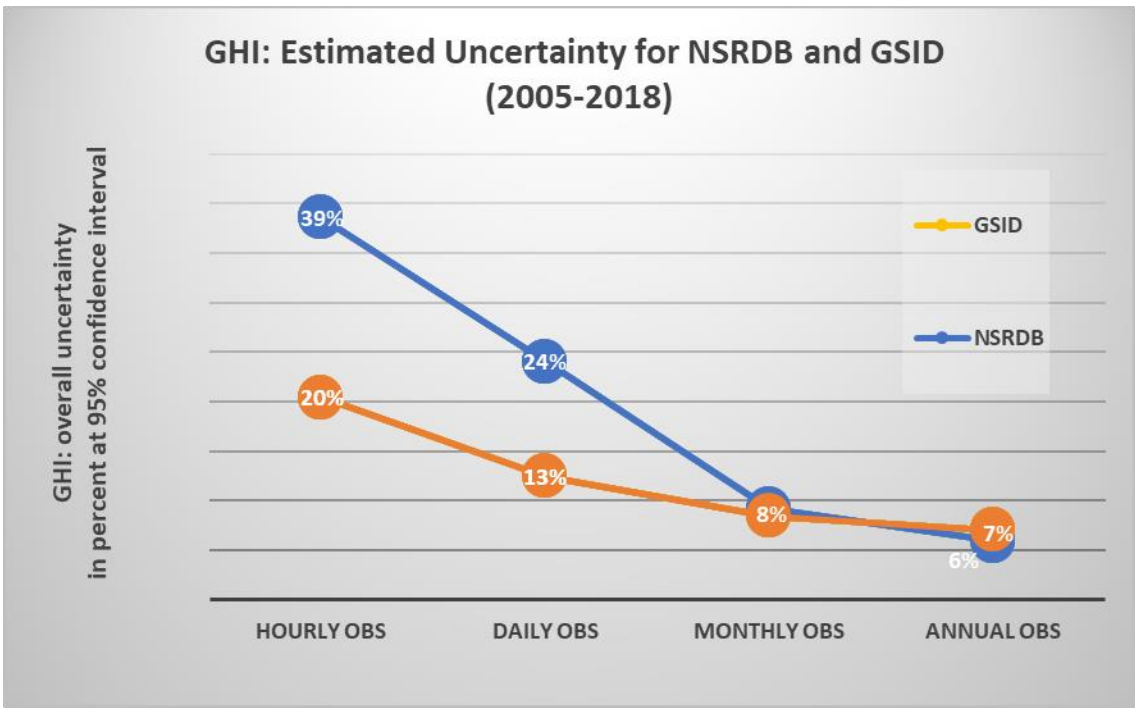

Figure 4 – Overall uncertainty (%) at the 95% confidence interval for the NSRDB and the GSID

Conclusion

Our Ground-Site Irradiance Database was compared with scientific-quality SURFRAD data for daily, hourly, and monthly intervals for 2005-2018. The same comparison was made using NREL's National Solar Radiation Database, which is derived from satellite data. The satellite data had slightly less Mean Absolute Percent Error on the annual intervals. For monthly intervals, the satellite and measured data were close to the same. At daily intervals, our measured data showed half the error of the satellite data. The average Mean Absolute Percent Error for hourly observations was 12% for measured data and 21% for the satellite data.

Sources

[1] Frank Vignola, Cathy Grover, Nick Lemon, Andrew McMahan, 2012. “Building a Bankable Solar Radiation Dataset”. http://solardat.uoregon.edu/download/Papers/BuildingaBankableSolarRadiationDataset_abstractSE.pdf

[2] Aron Habte, Manajit Sengupta, Afshin Andreas, Mike Dooraghi, Ibrahim Reda, and Mark Kutchenreiter 2018. “Evaluating the Sources of Uncertainties in the Measurements from Multiple Pyranometers and Pyrheliometers”. NREL/PO-5D00-68065 https://www.nrel.gov/docs/fy17osti/68065.pdf

[3] “Interpreting Solar Irradiance Data From Pyranometers” https://16iwyl195vvfgoqu3136p2ly-wpengine.netdna-ssl.com/wp-content/uploads/2017/10/kippzonen_Pyranometer-Data-Interpretation_pvm-webinar-23-01-2017.pdf

[4] Tom Stoffel, Dave Renne, Darryl Myers, Steve Wilcox, Manajit Sengupta, Ray George and Craig Turchi 2010. “Concentrating Solar Power, Best Practices Handbook for the Collection and use of Solar Resource Data”. NREL/TP-550-47465.

[5] Aron Habte, Manajit Sengupta, and Anthony Lopez 2017. “Evaluation of the National Solar Radiation Database (NSRDB Version 2): 1998–2015.” Technical Report NREL/TP-5D00-67722, https://www.nrel.gov/research/publications.html

[6] Gary Brassington 2017. “Mean absolute error and root mean square error: which is the better metric for assessing model performance?” 19th EGU General Assembly, EGU2017, proceedings from the conference held 23-28 April, 2017 in Vienna, Austria., p.3574