Overview of New Capabilities in the NSRDB

Presenter: Manajit Sengupta, NREL

Aron Habte, Yu Xie, Grant Buster, Jaemo Yang, Haiku Sky, Brandon Benton, Galen Maclaurin (NREL)

Michael Foster (Univ. of Wisc.), Andrew Heidinger (NOAA)

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The NSRDB Team

Dr. Tassos Golnas

Technology Manager,
Solar Energy Technologies Office,
U.S. Department of Energy

Dr. Manajit Sengupta

Dr. Yu Xie

Aron Habte

Grant Buster

Dr. Brandon Benton

Paul Edwards

Haiku Sky

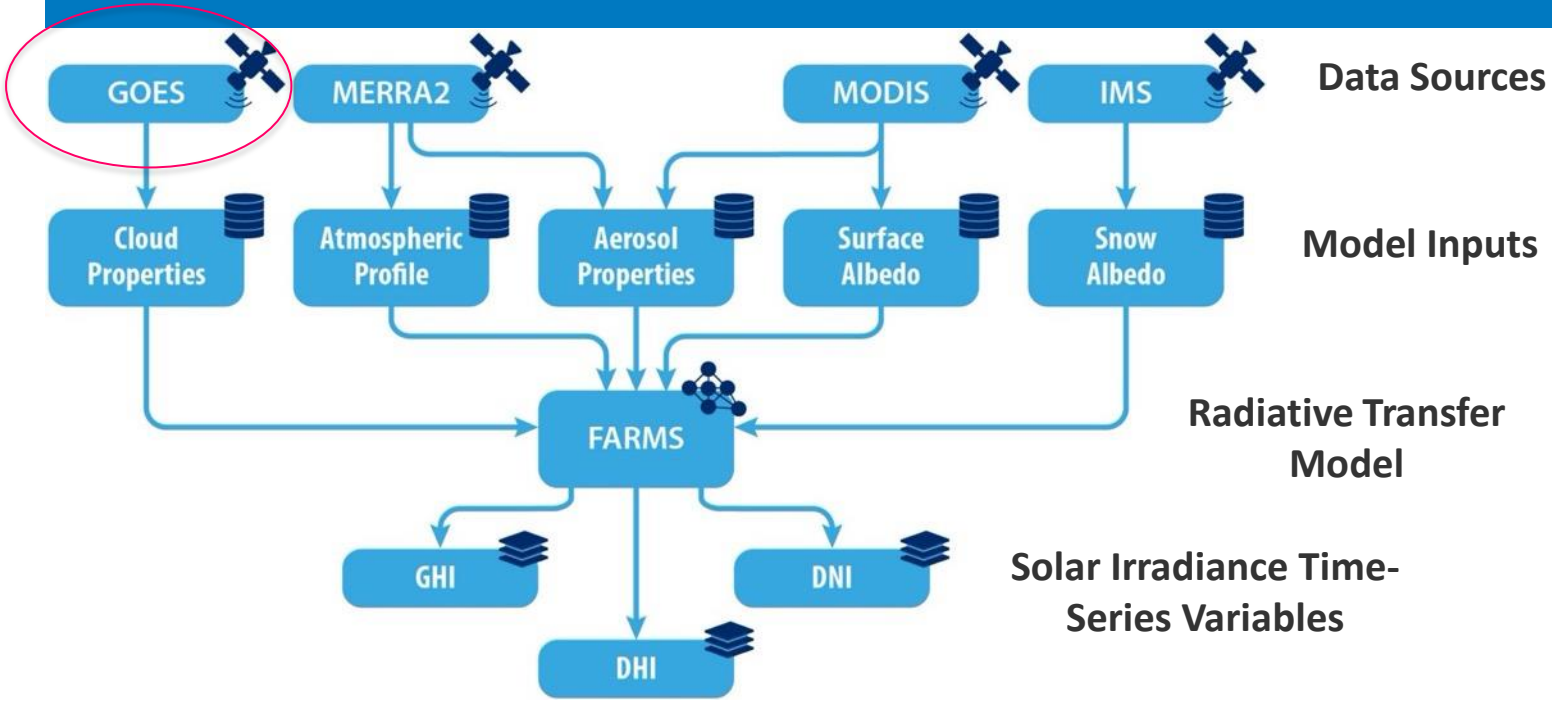
Nicholas Gilroy

Outline

- The Physical Solar Model (PSM)
- What's new in the National Solar Radiation Database (NSRDB)
- Validation of the NSRDB
- Data dissemination
- Future work

The PSM

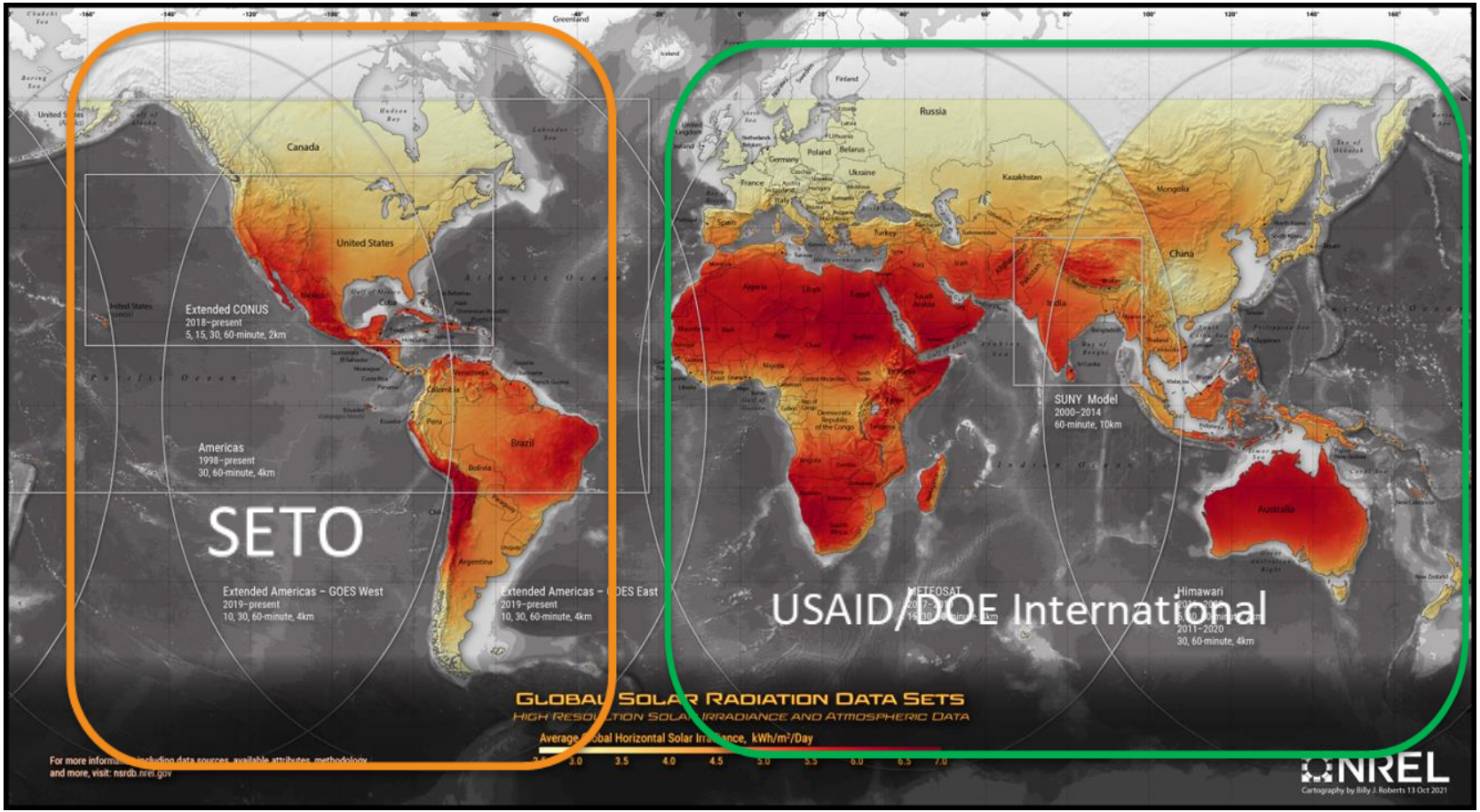
The Physical Solar Model



FARMS – Fast All-sky Radiation Model for Solar (FARMS) applications developed by NREL. This is a suite of radiative transfer models that represent how solar radiation interacts with the atmosphere and the Earth's land cover as it reaches the surface.
MERRA2 – Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) provides ancillary meteorological variables including aerosol optical depth (AOD) and the atmospheric profile.
MODIS – Moderate Resolution Imaging Spectroradiometer (MODIS) provides satellite- derived aerosol optical depth (AOD) and albedo.
IMS – Interactive Multisensor Snow and Ice Mapping System (IMS) provides daily snow coverage to represent snow albedo.

What’s New in the NSRDB

Geostationary Satellites in the NSRDB



NSRDB Datasets

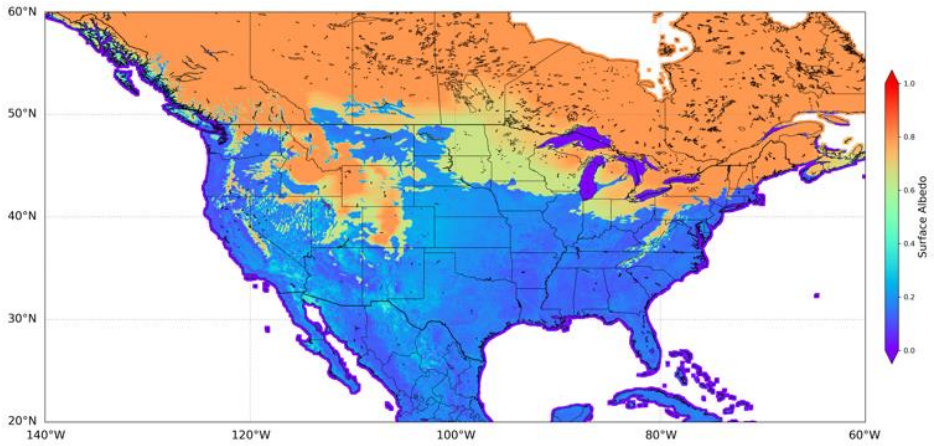
- Time series data – depends on satellite (e.g. GOES coverage 1998-2021)
- Typical Meteorological Year (updated every year)
- Cloud type, optical depth and effective radius
- Aerosol optical depth
- Surface Albedo including snow
- Temperature, humidity and wind speed
- Ultraviolet radiation (UV-A and UV-B)
- Spectral data (2001 wavelengths)

PSM Version Logs

Version	Effective Date	Data Years*	Notes
3.1.0	9/23/2019	2018+	Complete refactor of NSRDB processing code for NSRDB 2018
3.1.1	12/5/2019	2018+, TMY/TDY/TGY-2018	Complete refactor of TMY processing code.
3.1.2	6/8/2020	2020	Added feature to adjust cloud coordinates based on solar position and shading geometry.
3.2.0	3/17/2021	2020	Enabled cloud solar shading coordinate adjustment by default, enabled MLClouds machine learning gap fill method for missing cloud properties (cloud fill flag #7)
3.2.1	**1/12/2021**	**2021**	**Implemented an algorithm to re-map the parallax and shading and corrected cloud coordinates to the nominal GOES coordinate system.**
3.2.2	**2/25/2022**	**1998-2021**	**Implemented a model for snowy albedo as a function of temperature from MERRA2 based on the paper "A comparison of simulated and observed fluctuations in summertime Arctic surface albedo" by Becky Ross and John E. Walsh**

PSM Updates Included in Current NSRDB (1998-2021)

- Parallax correction for cloud location, cloud shading and remapping
- Gap-filling of missing cloud properties
- New algorithm for snow-albedo based on surface temperature



Updated surface albedo on March 1, 2020 (based on Ross and Walsh (1987)).

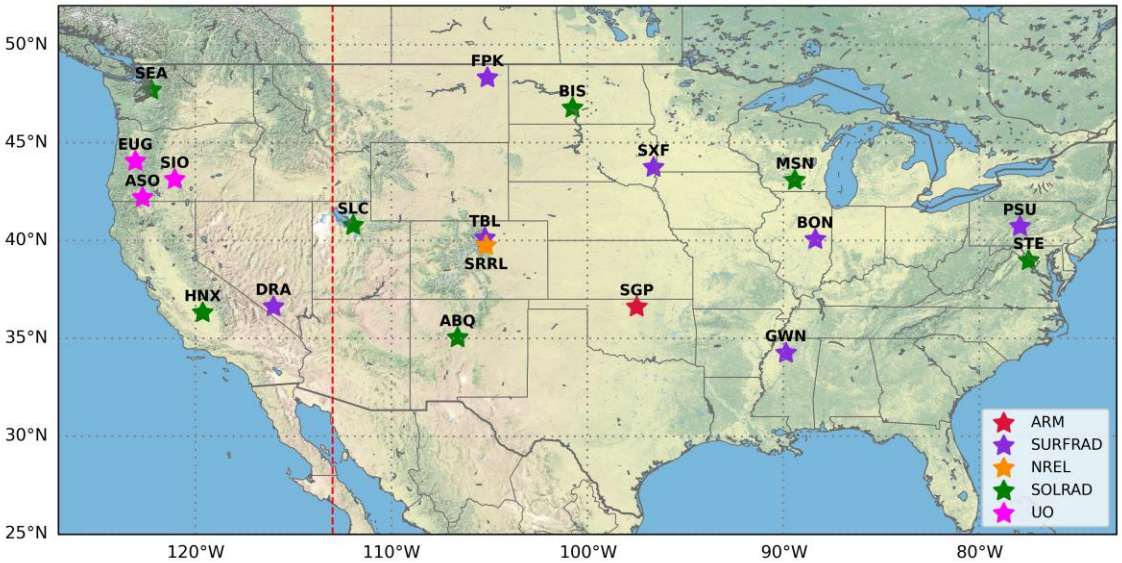
Ross, Becky and John E. Walsh. “A comparison of simulated and observed fluctuations in summertime Arctic surface albedo.” *Journal of Geophysical Research* 92 (1987): 13115-13125.

Future Implementation

Updates in Fiscal Year 2023

Version	Effective Date	Data Years*	Notes
4.0	May 2023	2022	Implement FARMS-DNI model to calculate solar radiation under cloudy conditions.
Spectral 3.2/4.0	June 2023	1998-2022	Implement clear-sky spectra Implement spectral-mismatch correction factor for multiple PV technologies

Validation of the FARM-DNI model



- DNI for 2 km grids every 5 min from 2019-2021 is computed using the NSRDB PSM with Lambert law, DISC, and FARMS-DNI.
- The satellite-based simulation is validated using surface observations.
- 6 and 13 stations (divided by the red line) are used to validate the data from GOES-West and GOES-East, respectively.

Yu Xie, Jaemo Yang, Manajit Sengupta, Yangang Liu, Xin Zhou, (2022), Improving the prediction of DNI with physics-based representation of all-sky circumsolar radiation, Solar Energy, Volume 231, 758-766, https://doi.org/10.1016/j.solener.2021.12.016.

Xie, Y., Sengupta, M., Liu, Y., Long, H., Min, Q., Liu, W., Habte, A., (2020), A Physics-Based DNI Model Assessing All-Sky Circumsolar Radiation, iScience, 23(3), 100893, https://doi.org/10.1016/j.isci.2020.100893.

Evaluation of Cloudy-sky Identification

Simple criteria to identify cloudy sky from ground measurements and satellites:

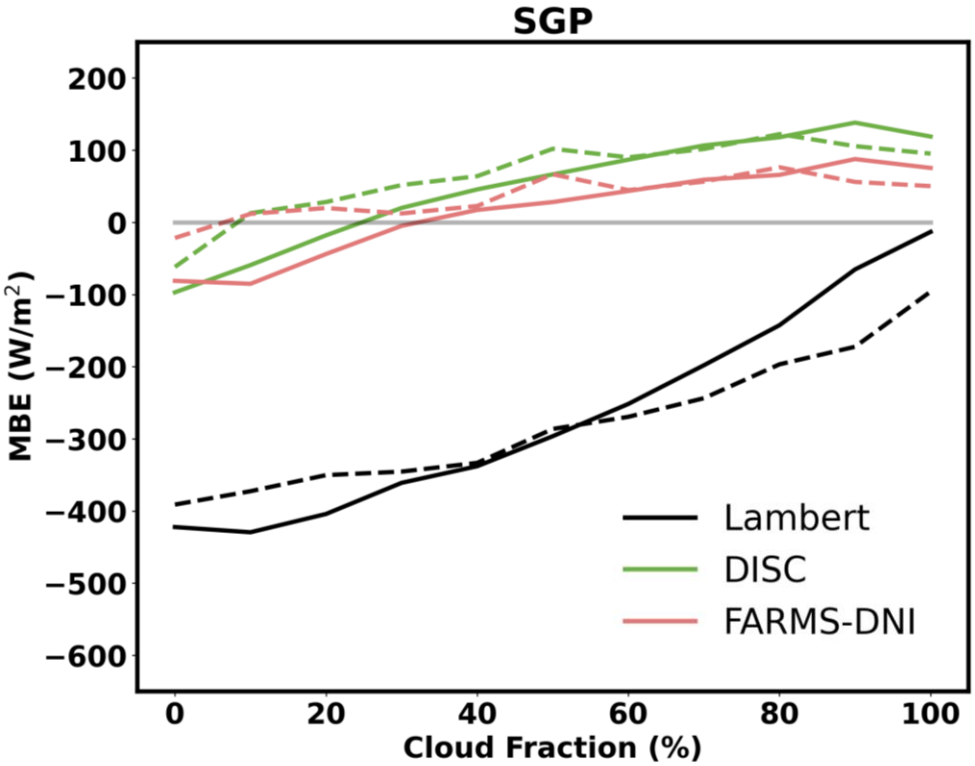
- ✓ (1) GHI < GHI (clear)
- ✓ (2) DNI < DNI (clear)
- ✓ (3) categorized as cloudy by satellite
- ✓ (2) solar zenith smaller than 80^o
- ✓ (3) GHI >5 W/m^2, (4) DNI > 50 W/m^2

ARM SGP cloud fraction from sky-imager used for validation:

- (1) 6351 scenes identified as cloudy from both ground and satellite data.
- (2) 5133 scenes (81%) identified as cloudy (with cloud fraction>80%).
- This number increases to 92% for cloud fraction>60%.

In general ground and satellite measurements can confidently identify cloudy scenes.

Error in DNI as a Function of Cloud Fraction

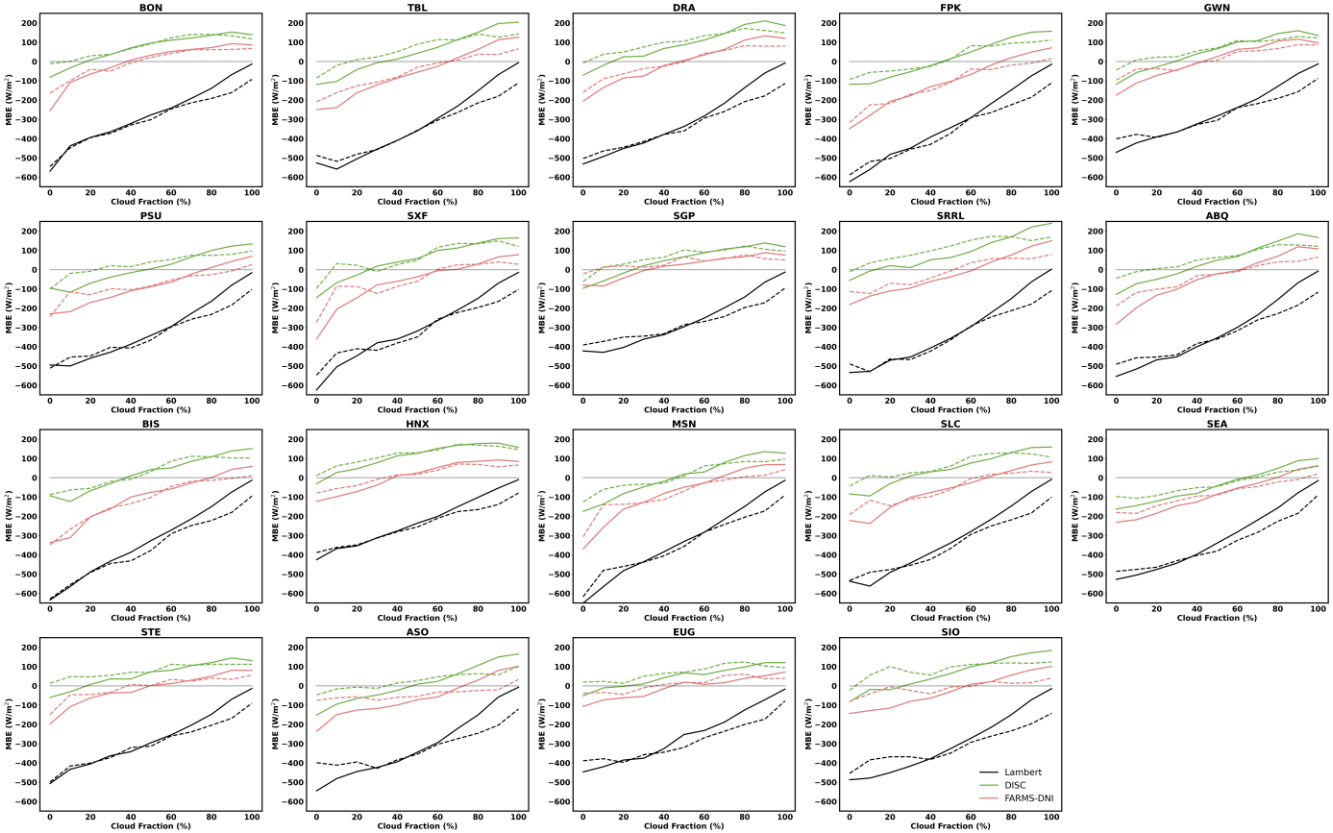


Cloud fraction is estimated for case when:

1. surface observed GHI and DNI are smaller than clear-sky (solid)
2. ratio between DNI and clear-sky DNI (cloudy when <0.6 (dashed)).

For high confidence cloudy conditions, FARMS-DNI performance better than DISC.

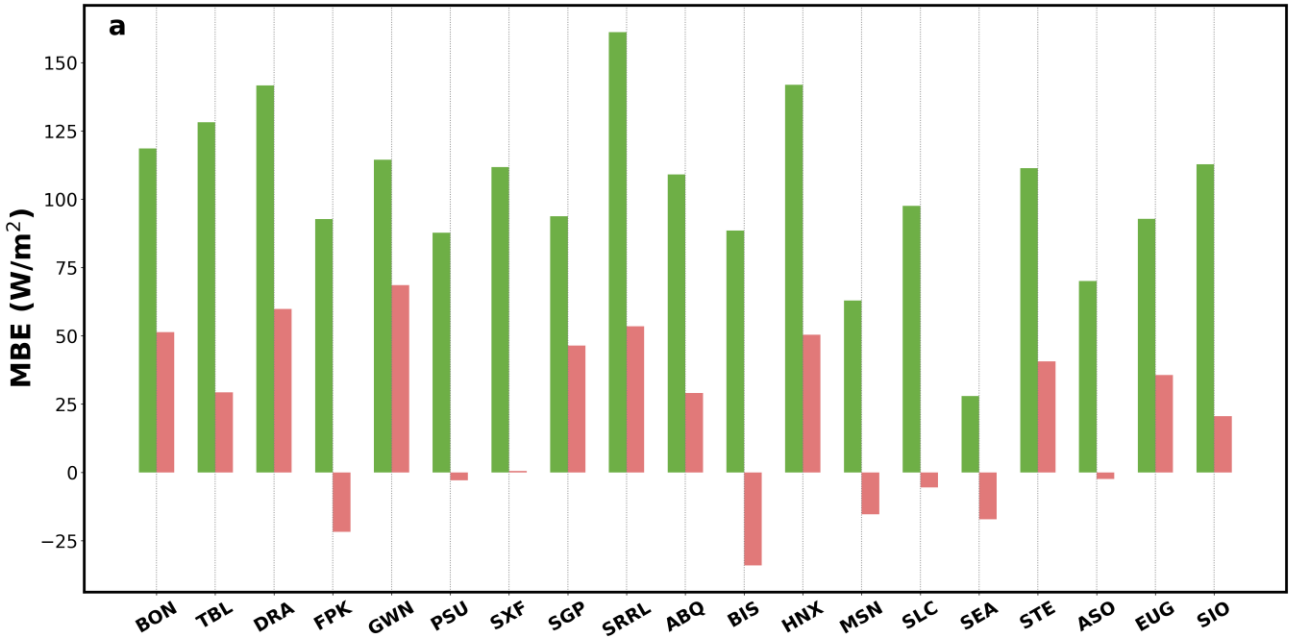
Comparing DNI from FARMS DNI vs DISC



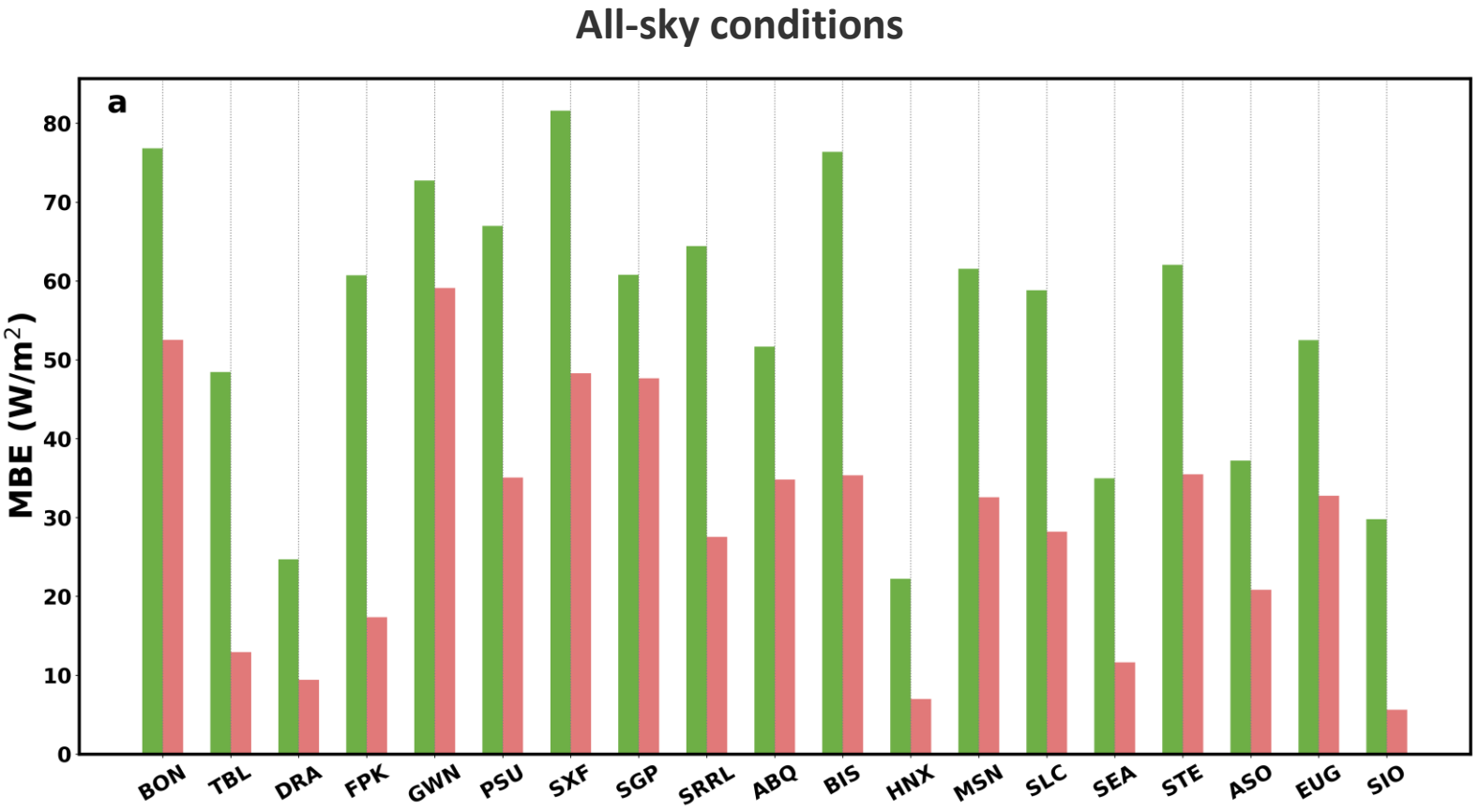
For all sites we find that for confidently cloudy conditions, FARMS-DNI significantly improved performance than DISC.

Comparing DNI from FARMS DNI vs DISC

Overcast cloud scenes (cloud fraction higher than 80%)

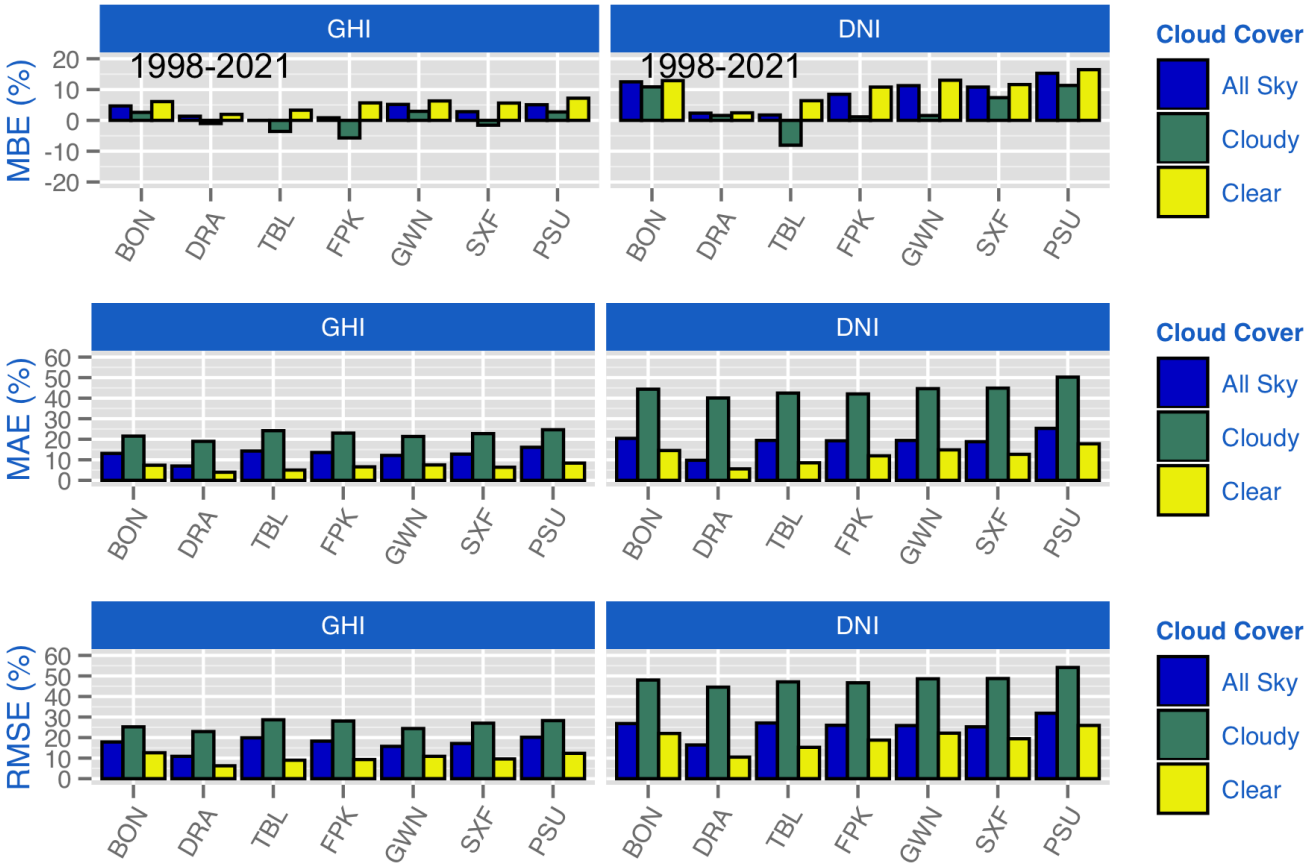


Comparing DNI from FARMS DNI vs DISC



Data Quality and Validation

NSRDB Validation for PSM v 3.2



Data Dissemination

Data Dissemination

NSRDB Access:

- By point location or a small area can be downloaded through the NSRDB Data Viewer (https://maps.nrel.gov/nsrdb-viewer/)
- By application programming interface to access larger quantities of data through automated approaches (https://nsrdb.nrel.gov/data-sets/api-instructions.html)
- Through the Highly Scalable Data Service hosted on Amazon Web Services (https://nsrdb.nrel.gov/data-sets/nsrdb-data-hsds-demo.html).

Fully reprocessed data for the GOES extent using PSM V3.2.2 and covering 1998-2021 has been released.
2022 data calculated using PSM V4.0 will be released in September 2023.

Future Development

- Investigate the availability of aerosol data sets from GOES-16 and GOES-17 satellites.
- Improvement in the accuracy of spectral datasets from the NSRDB
- Custom Typical Meteorological Year in the plane-of-array.
- High-resolution cloud properties (500 m) to get cloud fraction and improved cloud optical depth.
- A 50-year projected solar radiation data set going out to 2070 from regional climate models.
- Inclusion of Meteosat to cover Europe and Africa (2007-2022)

The NSRDB paper:

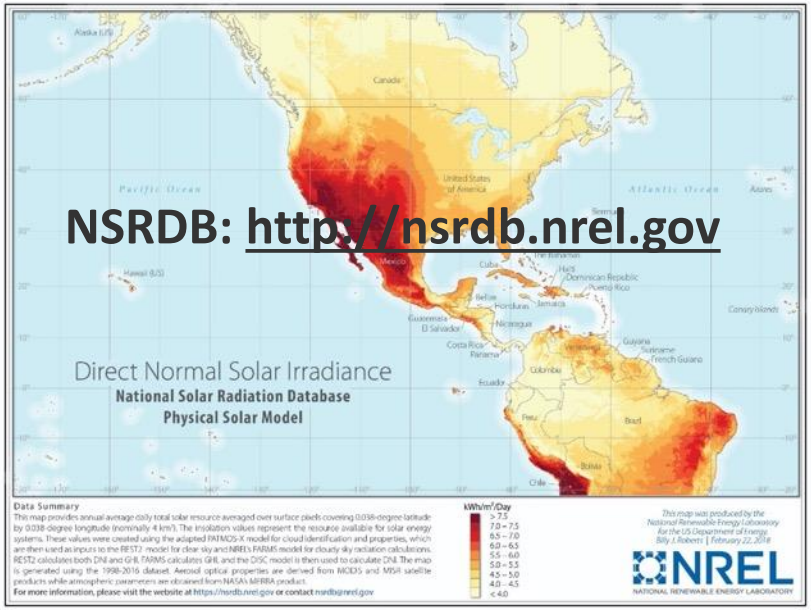
Primary reference

Publication freely available on website (https://nsrdb.nrel.gov).

Sengupta, Manajit, Yu Xie, Anthony Lopez, Aron Habte, Galen Maclaurin, and James Shelby. 2018. “The National Solar Radiation Database (NSRDB).” *Renewable and Sustainable Energy Reviews* 89: 51–60. SSN 1364-0321. https://doi.org/10.1016/j.rser.2018.03.003.

Thank You!

Contact: Manajit.Sengupta@nrel.gov



Sengupta, Manajit, Yu Xie, Anthony Lopez, Aron Habte, Galen Maclaurin, and James Shelby. 2018. "The National Solar Radiation Data Base (NSRDB)." ***Renewable and Sustainable Energy Rev.*** **89: 51–60. https://doi.org/10.1016/j.rser.2018.03.003.**

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