The National Solar Radiation Database (NSRDB): Recent Updates, New Developments and Status in 2022

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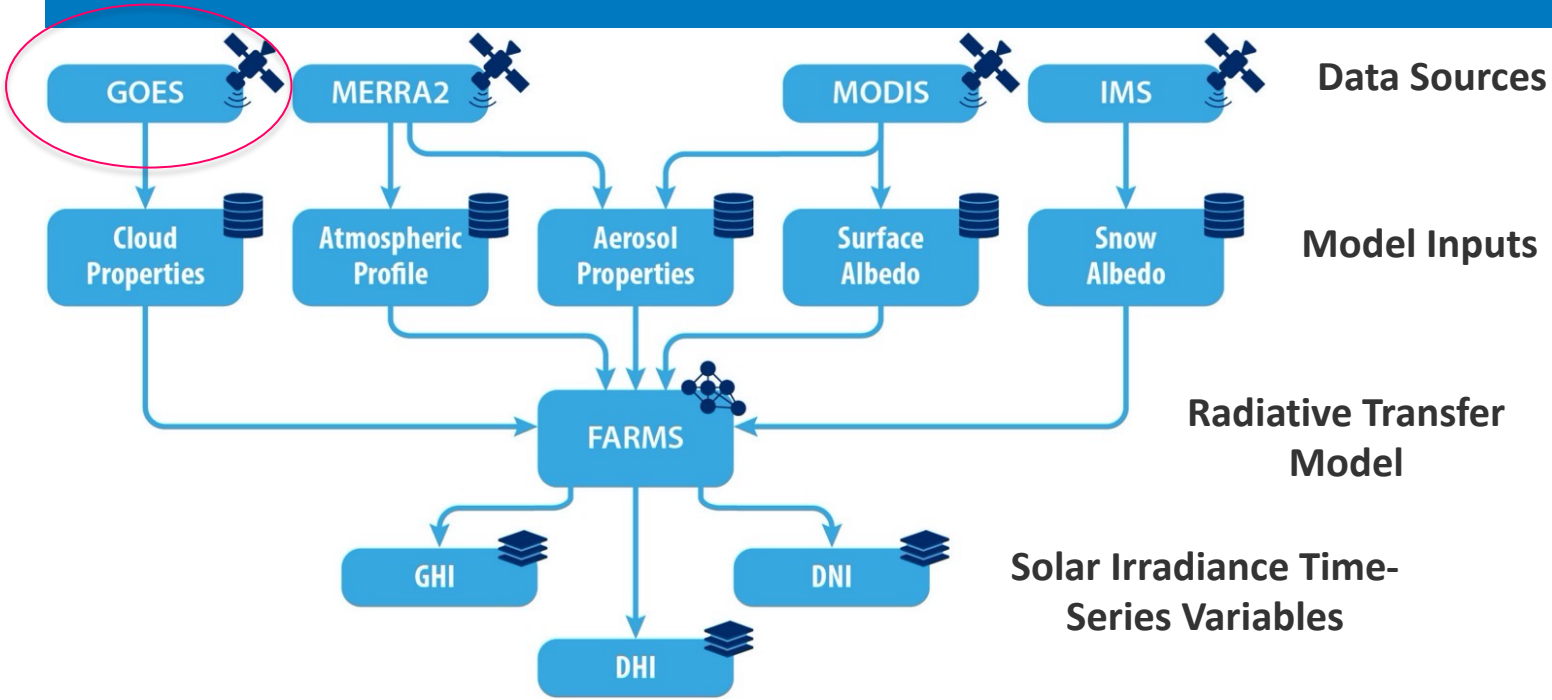
Outline

- 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

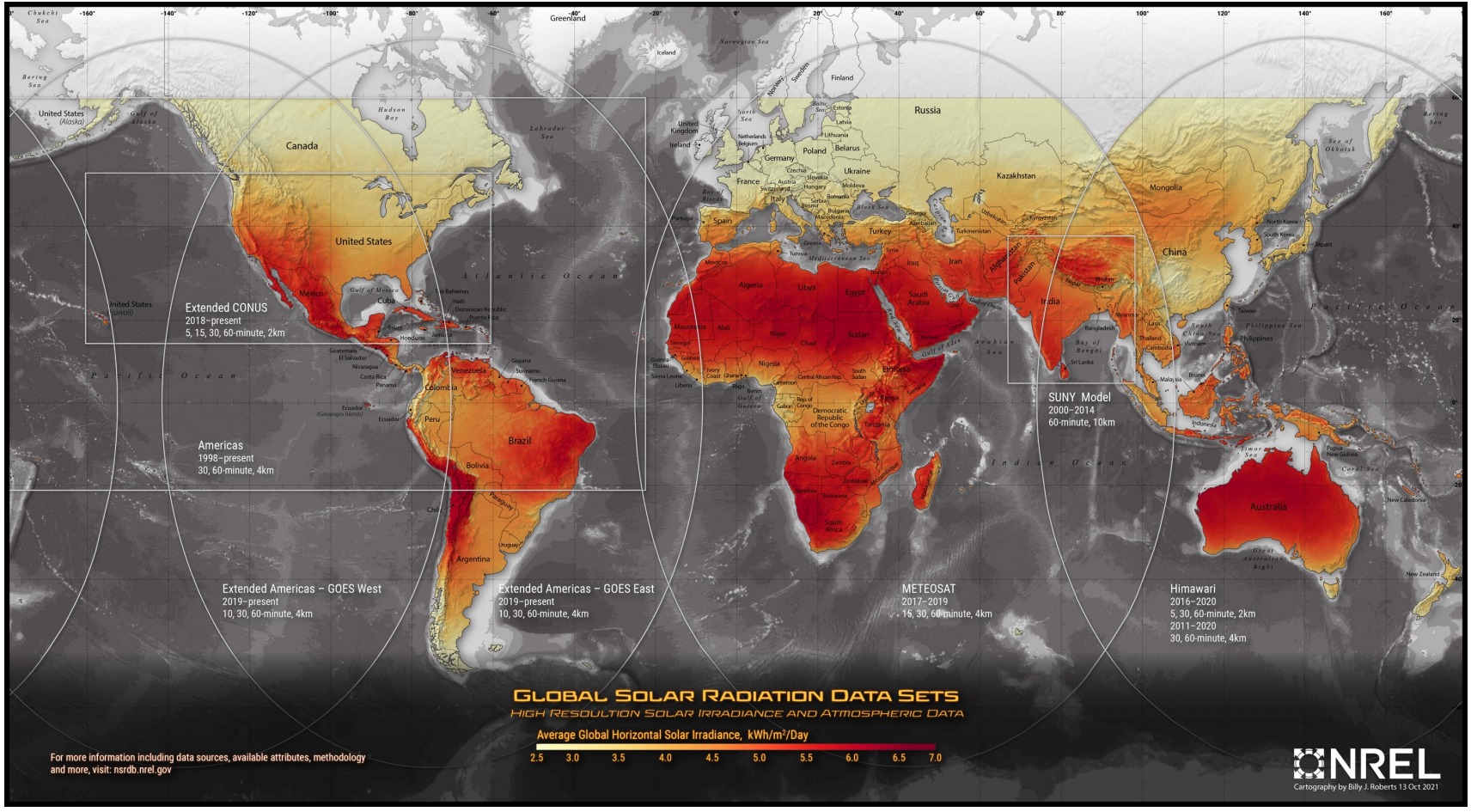
PSM Workflow



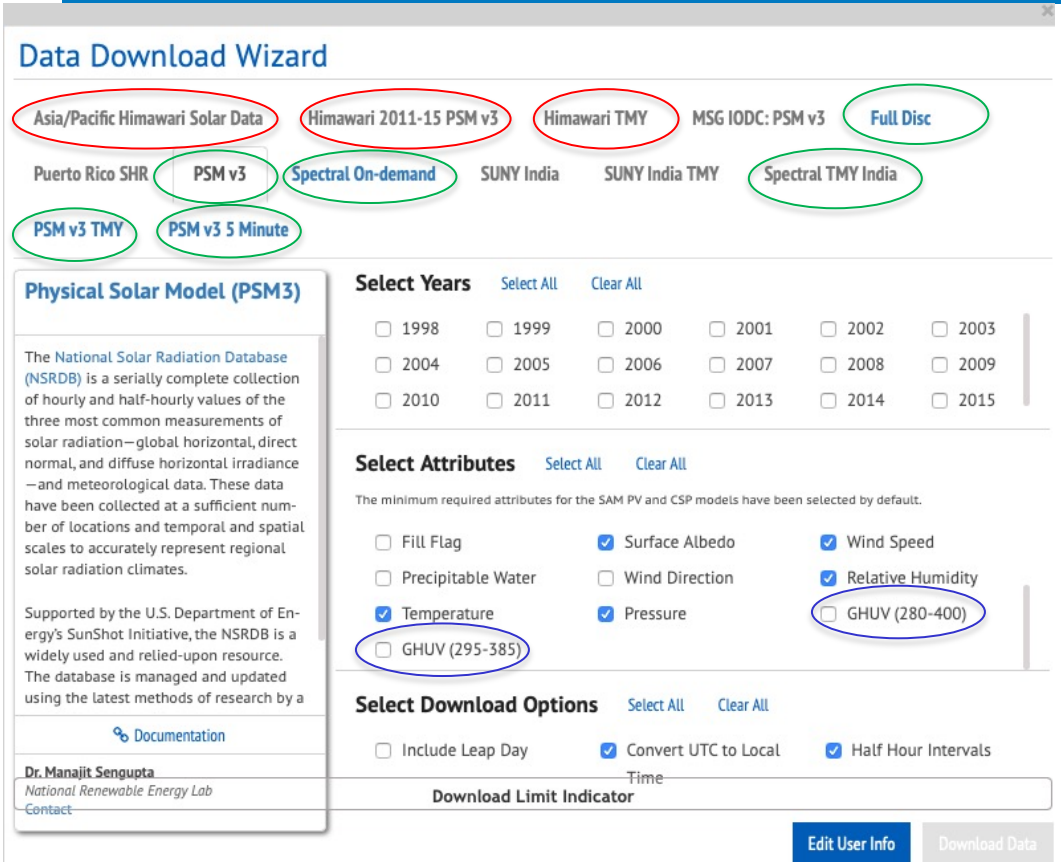
FARMS – Fast All-sky Radiation Model for Solar (FARMS) applications developed by NREL. This is a suite of radiative transfer models that represent how solar radiation interacts with the atmosphere and the Earth's land cover as it reaches the surface.
MERRA2 – Modern-Era Retrospective analysis for Research 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.

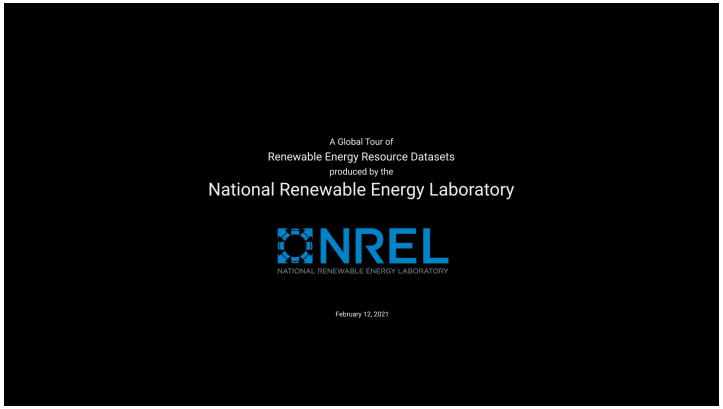
What’s New in the NSRDB

Geostationary Satellites in the NSRDB



What Data Are Newly Available?





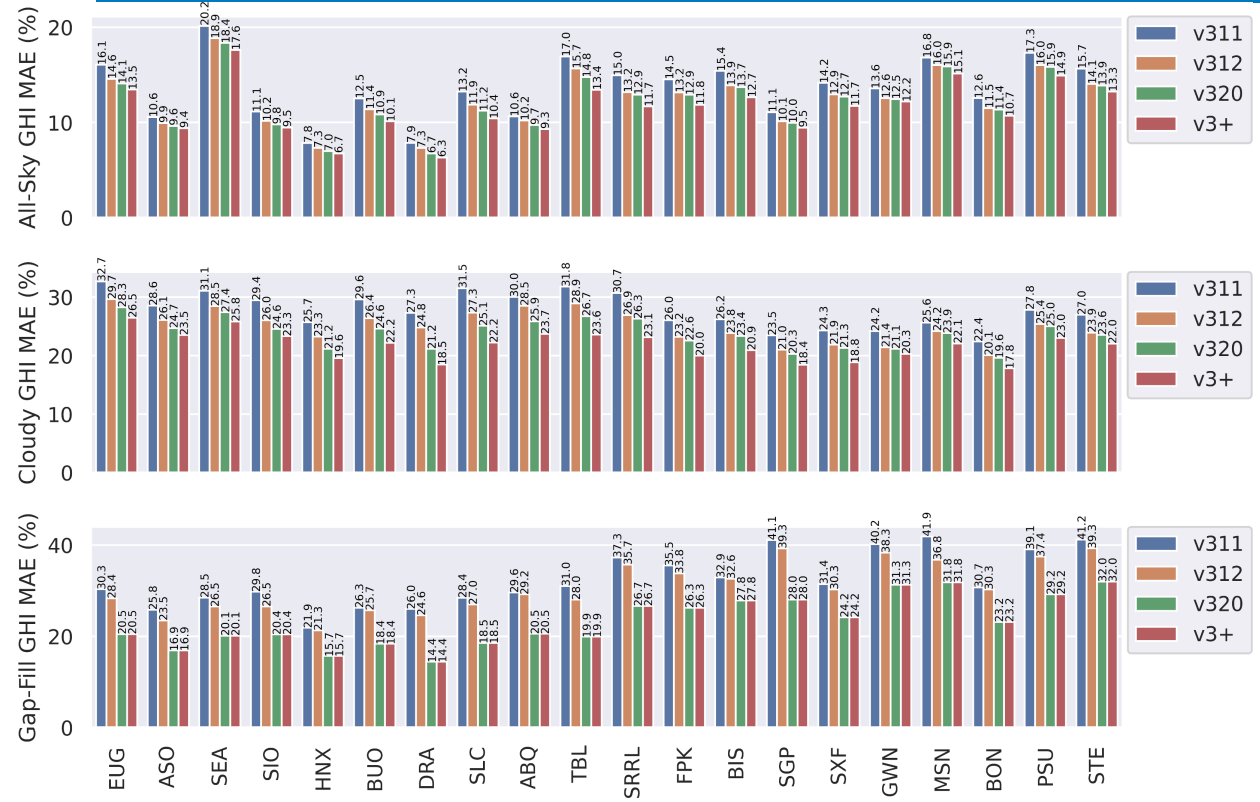
Updated product to contain 2021 data.

Products released in 2021.

Version Logs

Version	Effective Date	Data Years*	Notes
3.0.1	2018	2017+	Moved from timeshift of radiation to timeshift of cloud properties.
3.0.2	2/25/2019	1998-2017	Air temperature data recomputed from MERRA2 with elevation correction
3.0.3	2/25/2019	1998-2017	Wind data recomputed to fix corrupted data in western extent
3.0.4	3/29/2019	1998-2017	Aerosol optical depth patched with physical range from 0 to 3.2
3.0.5	4/8/2019	1998-2017	Cloud pressure attributes and scale/offset fixed for 2016 and 2017
3.0.6	4/23/2019	1998-2017	Missing data for all cloud properties gap filled using heuristics method
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)

Gap-Filling Cloud Properties Using Machine Learning



- Each subsequent version improves the accuracy of the NSRDB irradiance data.
- Improvement in cloudy gap-filled sky conditions using the MLClouds model (V3.2.0).

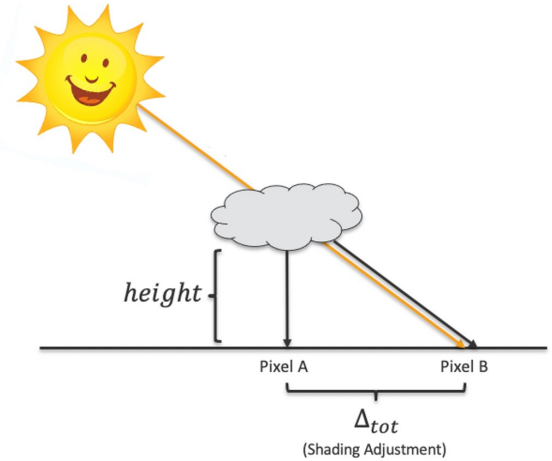
https://doi.org/10.1016/j.solener.2022.01.004

Near Future Implementation

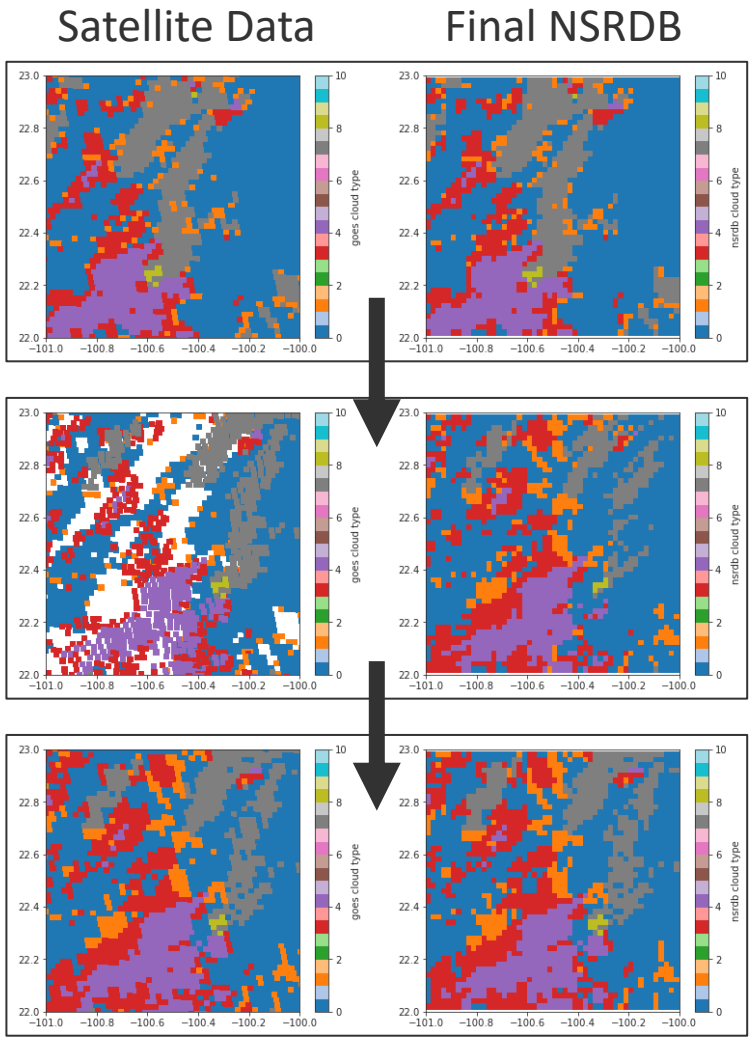
Updates in Fiscal Year 2022

Version	Effective Date	Data Years*	Notes
3.2.1	1/12/2021	2021	Implemented an algorithm to re-map the parallax and shading corrected cloud coordinates to the nominal GOES coordinate system. This fixes the issue of PC cloud coordinates conflicting with clear-sky coordinates. This also fixes a strange pattern that was found in the long-term means generated from PC data.
3.2.2	2/25/2022	1998-2022	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

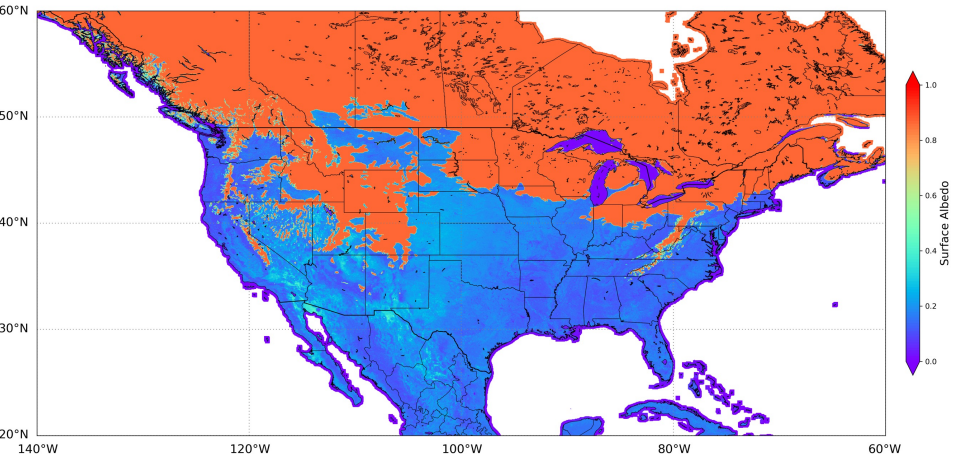
Parallax-Correction and Shading Remapping



- Better algorithm for projecting clouds onto the NSRDB grid based on the cloud geometry-based parallax and shading corrections.



Albedo Adjustment



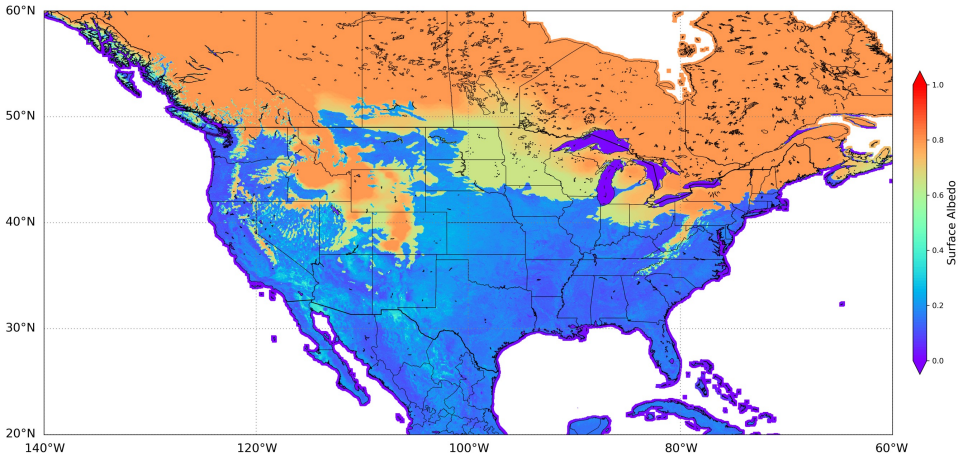
Previous surface albedo on March 1, 2020.

The snow/ice albedo is updated according to Ross and Walsh (1987).

$$\alpha = \begin{cases} 0.8 \; when \; T < 268K \\ 0.65 + 0.03(273 - T) \; when \; 268K < T < 273K \\ 0.65 \; when \; T = 273K \end{cases}$$

Ross and Walsh (1987) suggested a parameterization that decreases the albedo linearly with temperature when it approaches the freezing point.

Updated surface albedo on March 1, 2020.

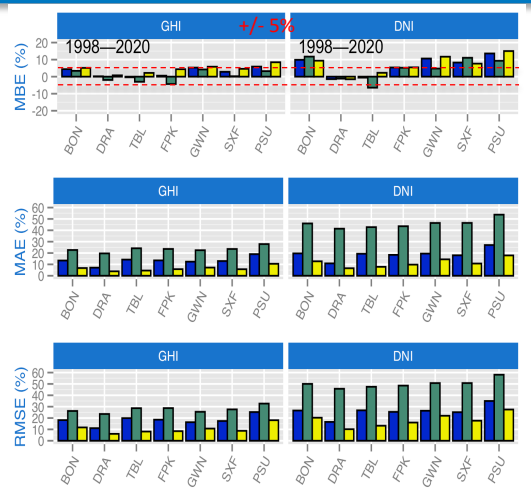


Ross, Becky and John E. Walsh. “A comparison of simulated and observed fluctuations in summertime Arctic surface albedo.” *Journal of Geophysical Research* 92 (1987): 13115-13125.

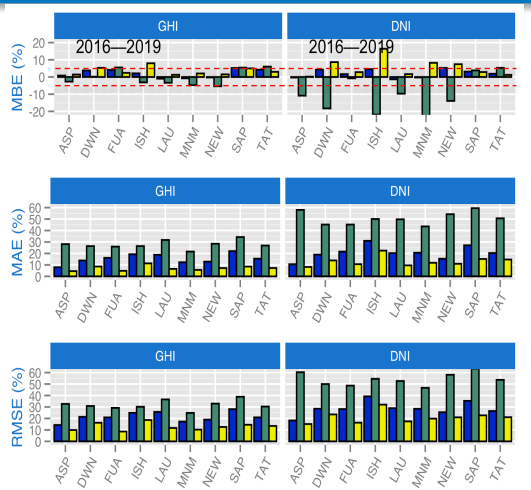
Data Quality and Validation

NSRDB Validation

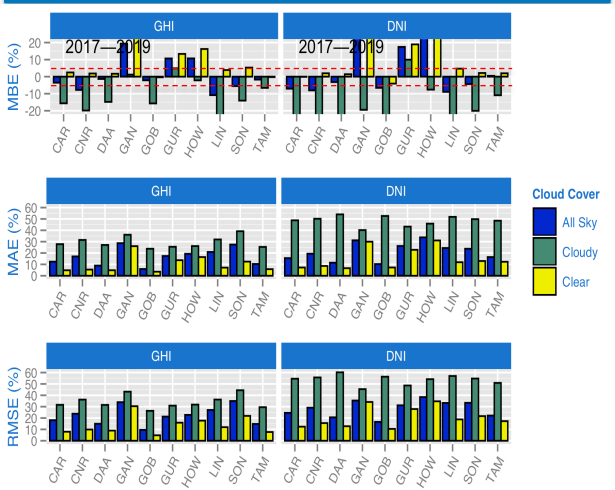
GOES Satellite



Himawari-8 Satellite



Meteosat IODC Satellite



- The National Oceanic and Atmospheric Administration Surface Radiation Budget (SURFRAD) and Baseline Surface Radiation Network (BSRN) stations were used for the evaluation.
- The NSRDB data based on a Geostationary Operational Environment Satellite (GOES) was evaluated using the hourly data from 4-km by 4-km pixels that encompass the ground measurement location.
- In most cases, the NSRDB accuracy for annual total global horizontal irradiance is mean bias error within ±5% and root mean square error <20

Data Dissemination

Data Dissemination

The data sets can be accessed:

- 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).

Announcement: Fully reprocessed data for the GOES extent using PSM V3.2.2 and covering 1998-2021 will be released by the end of September 2022. This will replace all data that is currently available.

Future Development

- Implement the **FARMS – DNI model.**
- Implement machine learning/artificial intelligence-based derivation of cloud identification.
- Investigate the availability of aerosol data sets from GOES-16 and GOES-17 satellites.
- 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.

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!

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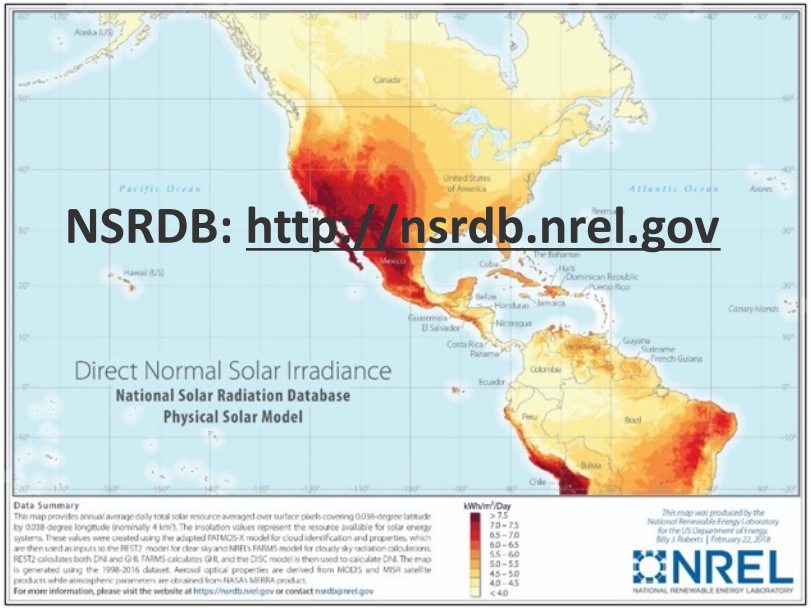

Sengupta, Manajit, Yu Xie, Anthony Lopez, Aron Habte, Galen Maclaurin, and James Shelby. 2018. "The National Solar Radiation Data Base (NSRDB)." ***Renewable and Sustainable Energy Rev.*** **89: 51–60. https://doi.org/10.1016/j.rser.2018.03.003.**

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