The NSRDB Team

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• 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

**Data Sources**
- **GOES**
- **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.

**Model Inputs**
- Cloud Properties
- Atmospheric Profile
- Aerosol Properties
- Surface Albedo
- Snow Albedo

**Radiative Transfer 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.
- **GHI**
- **DNI**
- **DHI**

**Solar Irradiance Time-Series Variables**
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)
<table>
<thead>
<tr>
<th>Version</th>
<th>Effective Date</th>
<th>Data Years*</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1.0</td>
<td>9/23/2019</td>
<td>2018+</td>
<td>Complete refactoring of NSRDB processing code for NSRDB 2018</td>
</tr>
<tr>
<td>3.1.2</td>
<td>6/8/2020</td>
<td>2020</td>
<td>Added feature to adjust cloud coordinates based on solar position and shading geometry.</td>
</tr>
<tr>
<td>3.2.0</td>
<td>3/17/2021</td>
<td>2020</td>
<td>Enabled cloud solar shading coordinate adjustment by default, enabled MLClouds machine learning gap fill method for missing cloud properties (cloud fill flag #7)</td>
</tr>
<tr>
<td>3.2.1</td>
<td>1/12/2021</td>
<td>2021</td>
<td>Implemented an algorithm to re-map the parallax and shading and corrected cloud coordinates to the nominal GOES coordinate system.</td>
</tr>
<tr>
<td>3.2.2</td>
<td>2/25/2022</td>
<td>1998-2021</td>
<td>Implemented a model for snowy albedo as a function of temperature from MERRA2 based on the paper &quot;A comparison of simulated and observed fluctuations in summertime Arctic surface albedo&quot; by Becky Ross and John E. Walsh</td>
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</tbody>
</table>
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)).
Future Implementation
<table>
<thead>
<tr>
<th>Version</th>
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<tbody>
<tr>
<td>4.0</td>
<td>May 2023</td>
<td>2022</td>
<td>Implement FARMS-DNI model to calculate solar radiation under cloudy conditions.</td>
</tr>
<tr>
<td>Spectral</td>
<td>June 2023</td>
<td>1998-2022</td>
<td>Implement clear-sky spectra Implement spectral-mismatch correction factor for multiple PV technologies</td>
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</tbody>
</table>
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.


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°
✓ (3) GHI > 5 W/m², (4) DNI > 50 W/m²

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.
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%)

![Graph showing MBE (W/m²) for different locations under overcast conditions.](image-url)
Comparing DNI from FARMS DNI vs DISC

All-sky conditions

MBE (W/m²)
Data Quality and Validation
NSRDB Validation for PSM v 3.2

Cloud Cover
- All Sky
- Cloudy
- Clear
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**

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

Primary reference

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


https://doi.org/10.1016/j.rser.2018.03.003.
Thank You!  
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