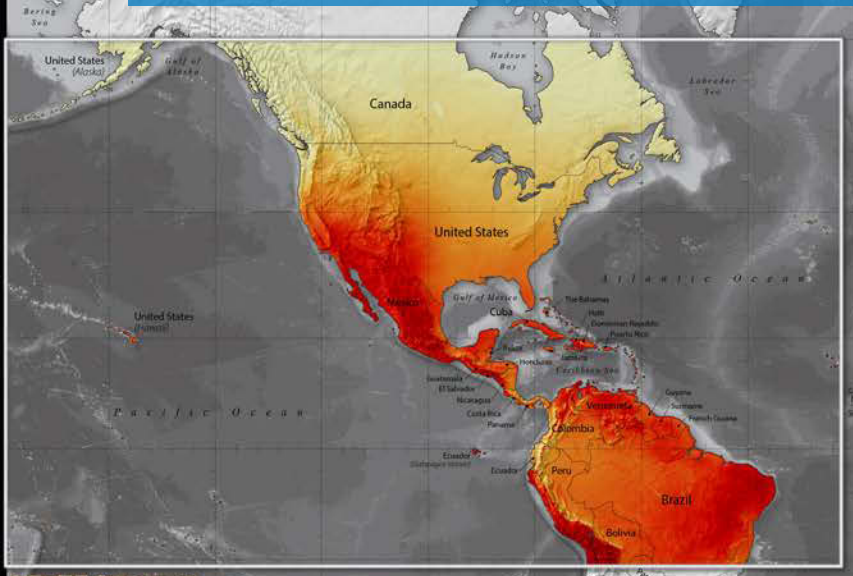
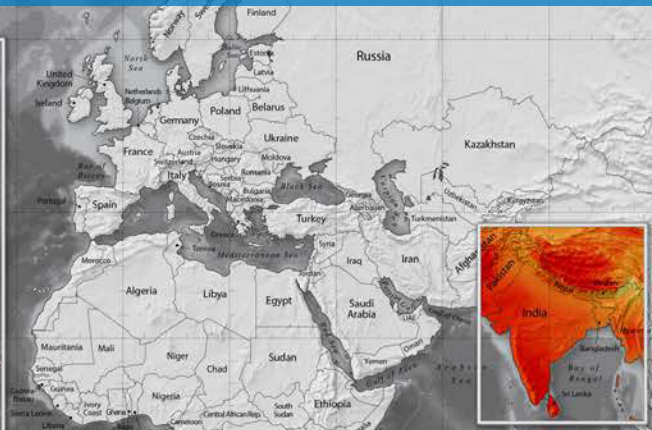
A Status Update on the National Solar Radiation Database (NSRDB)





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NATIONAL SOLAR RADIATION DATABASE
HIGH RESOLUTION SOLAR IRRADIANCE AND ATMOSPHERIC DATA

1998–2016 Average Global Horizontal Solar Irradiance, kWh/m²/Day

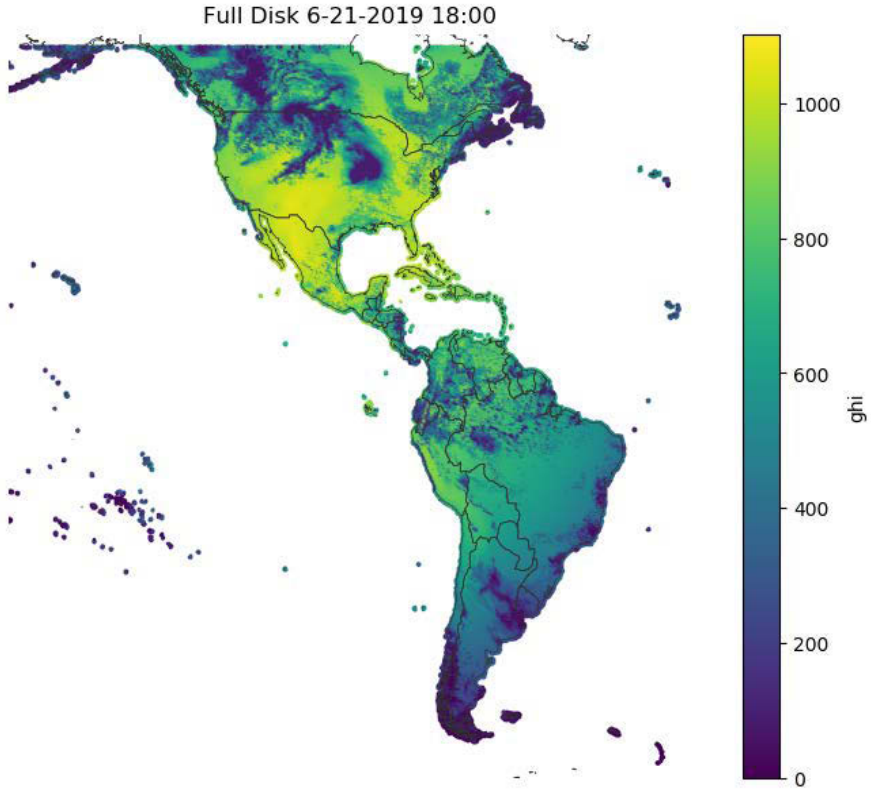
7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5

June 24, 2020 – PVPMC Webinar on Solar Resource Assessment for PV Performance Modeling

NREL

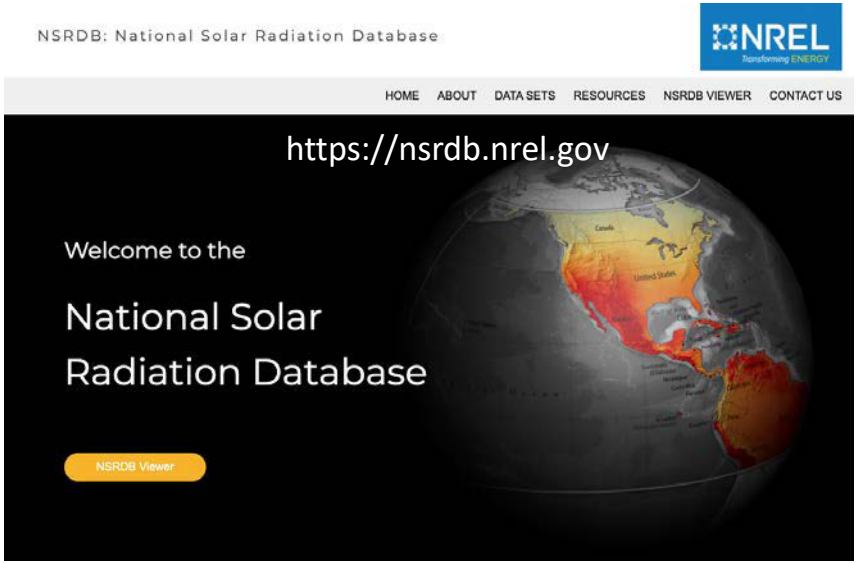
Overview

- National Solar Radiation Database (NSRDB) Physical Solar Model (PSM) Version 3 (1998–2018)
- NSRDB downstream products
- Studying long-term variability using 20 years of NSRDB data.

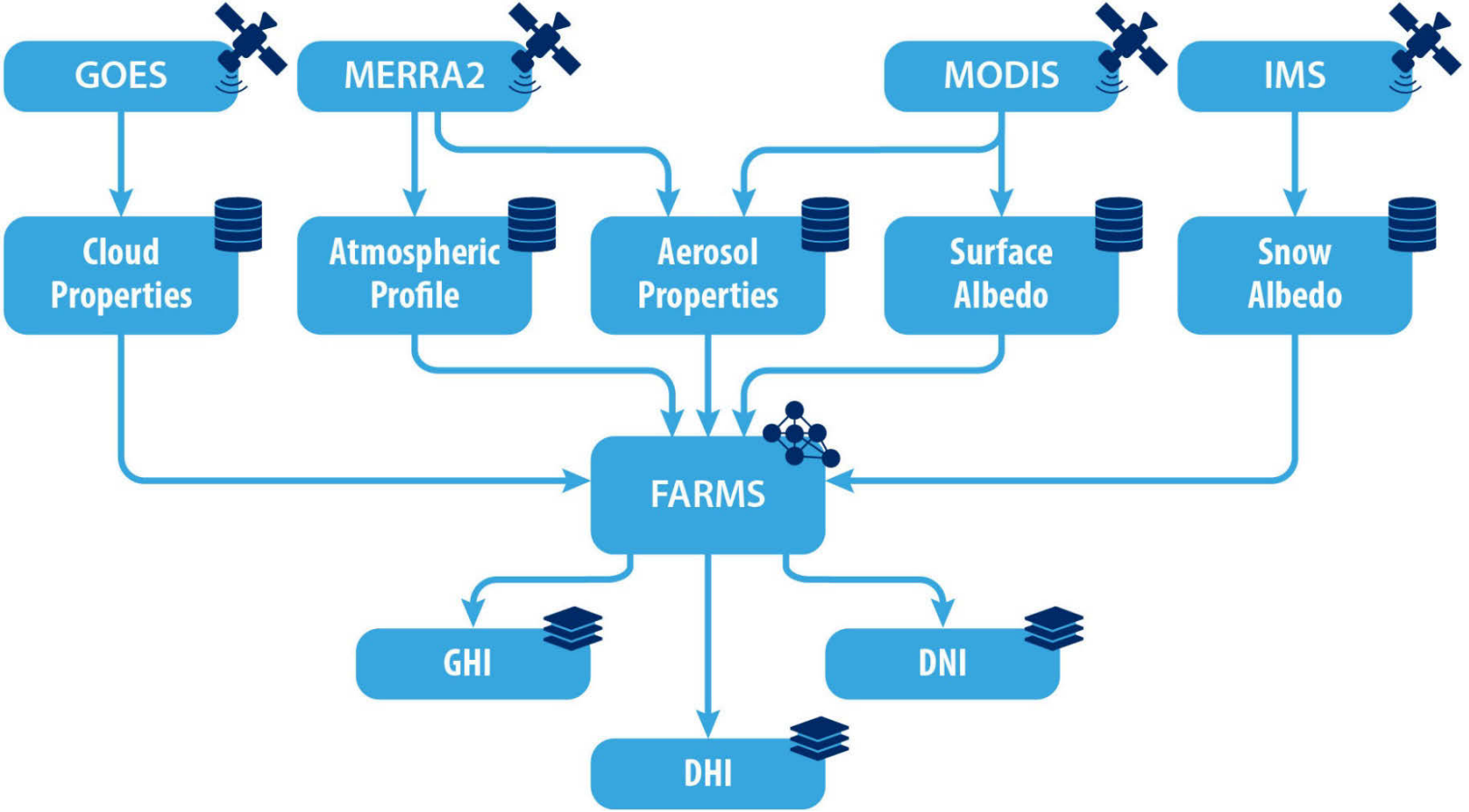


What Does the National Solar Radiation Database Provide?

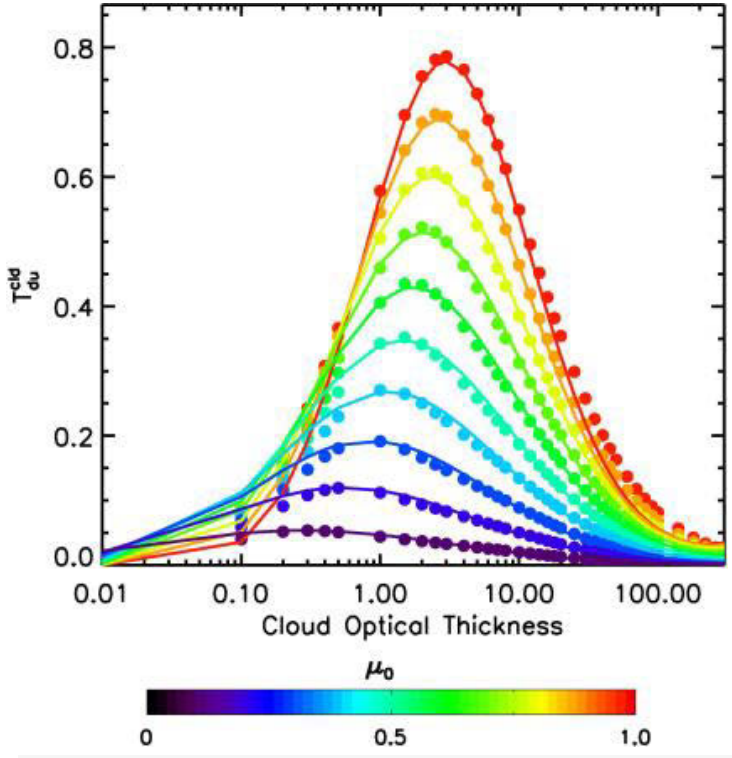
- The NSRDB seeks to advance our knowledge of solar radiation and its applications for renewable energy.
- The NSRDB provides a serially complete database of solar irradiance and meteorological information across the United States and other locations.
- The NSRDB provides **21 years** (+ typical meteorological year) of half-hourly data at a 4-km by 4-km spatial resolution.
- The NSRDB provides 5-min 2-km data from 2018.
- The NSRDB uses a physics-based model, the **PSM.**

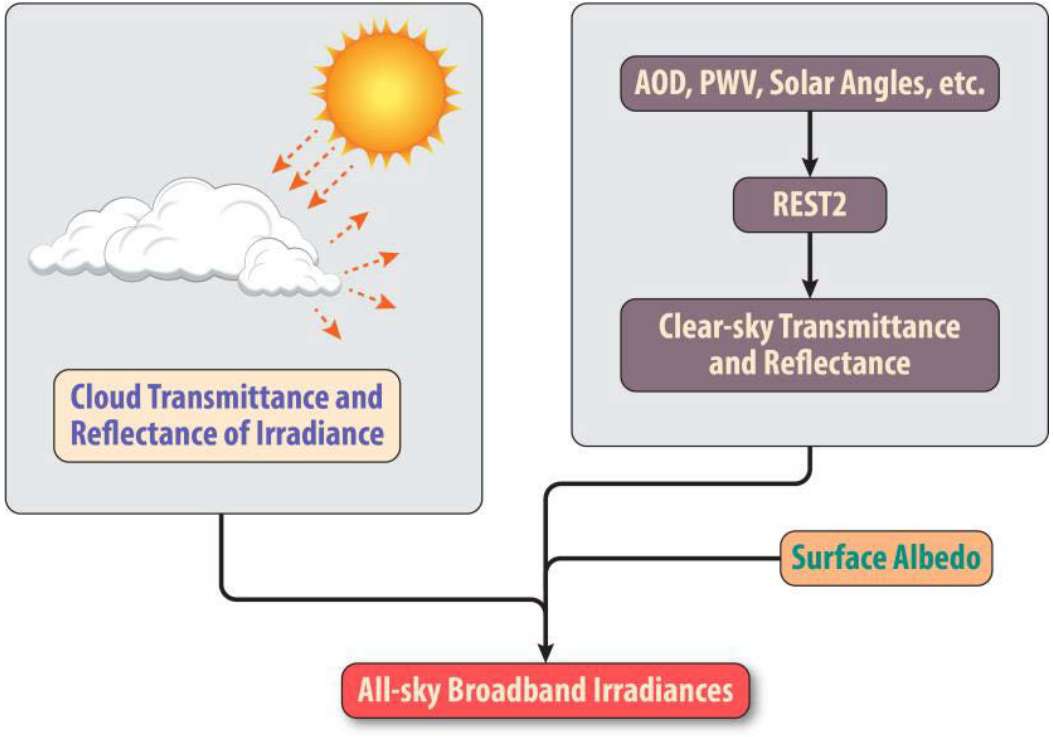


National Solar Radiation Database: Physical Solar Model PSM Workflow



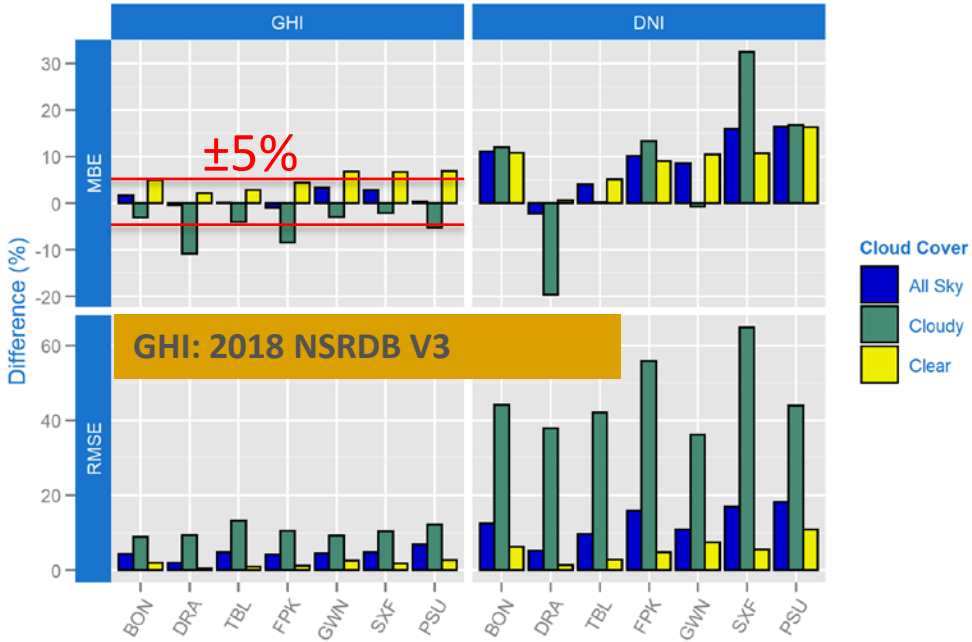
Fast All-Sky Radiation Model for Solar Applications (FARMS)

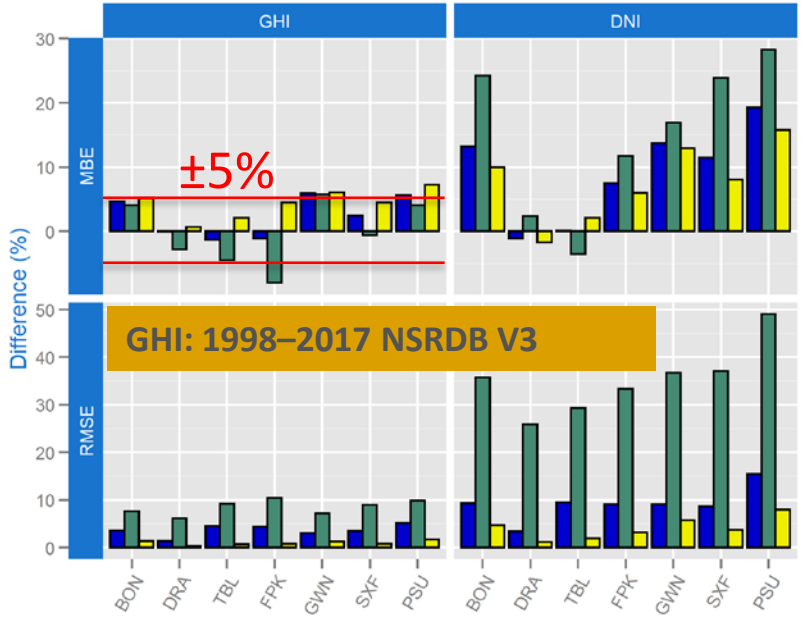




Cloud transmittances can be parameterized as exponential functions of cloud optical thickness and solar zenith angles.

Validation of 2018 High-Resolution Data

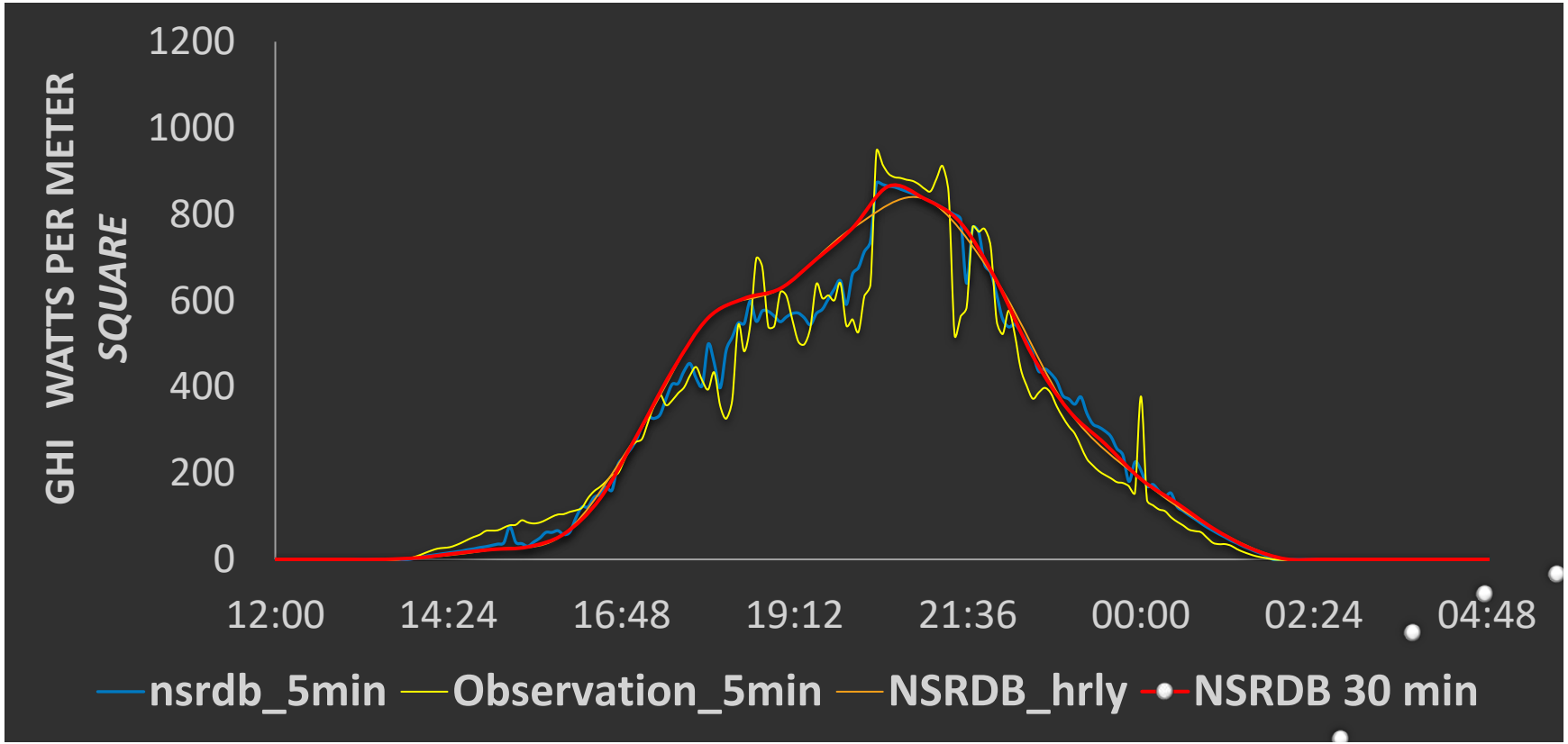




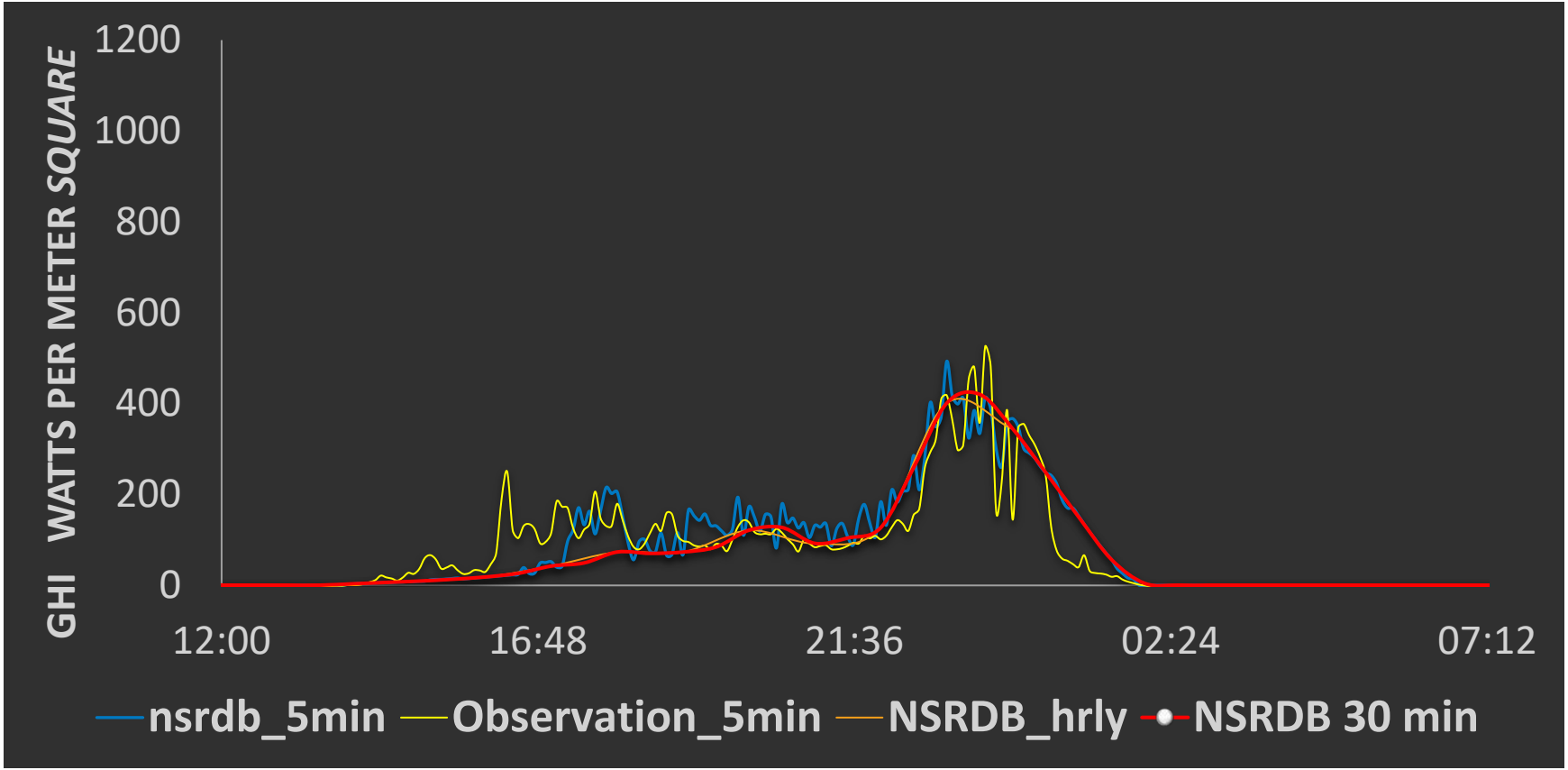
Annual difference between the two versions:

- 2018 NSRDB data are every 5 min and 2 km by 2 km and new satellite: Geostationary Operational Environmental Satellite 16 (GOES-16)
- 1998–2017 NSRDB data are every 30 min and 4 km by 4 km.

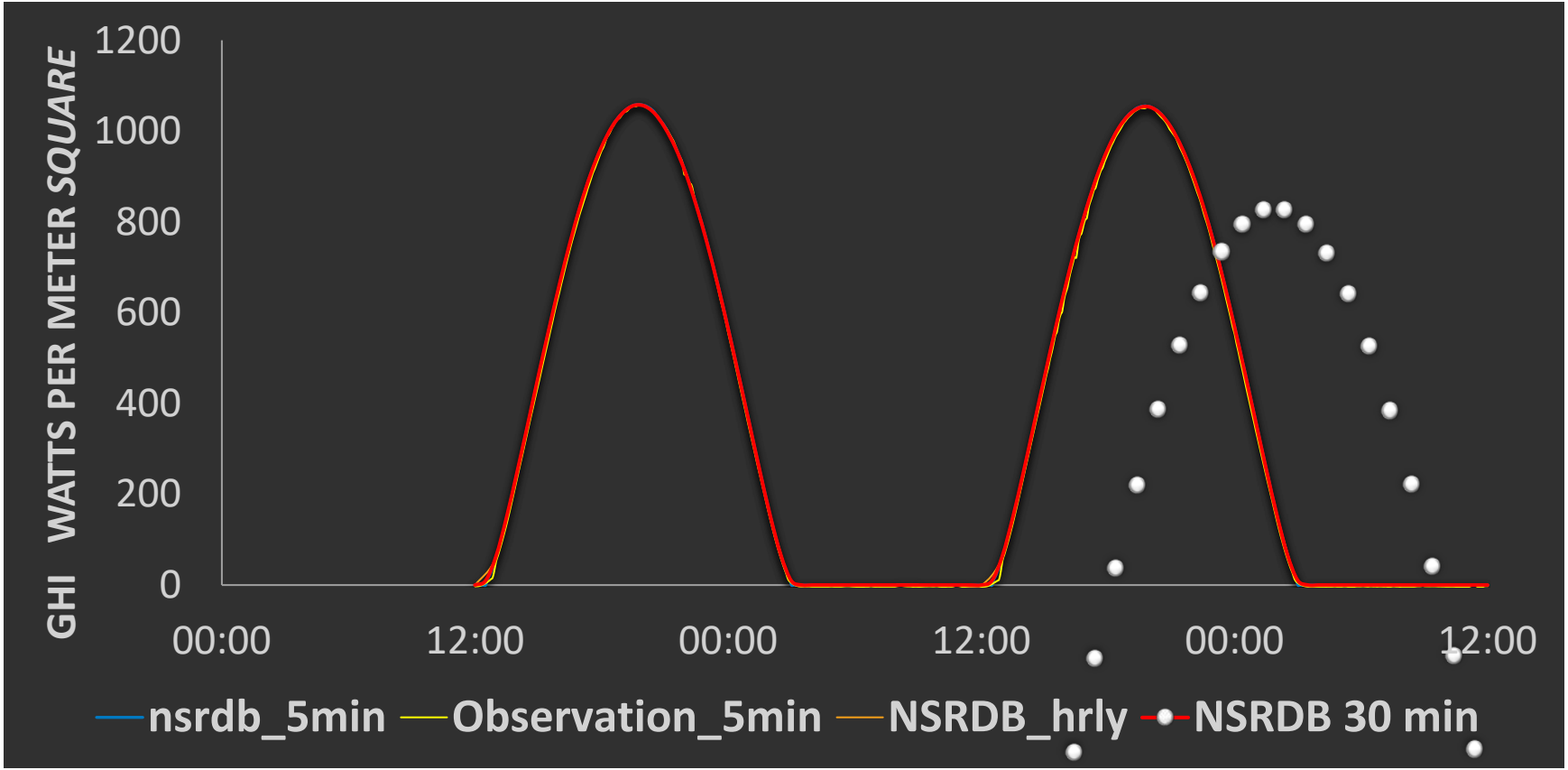
Desert Rock: March 20, 2018



Desert Rock: March 22, 2018



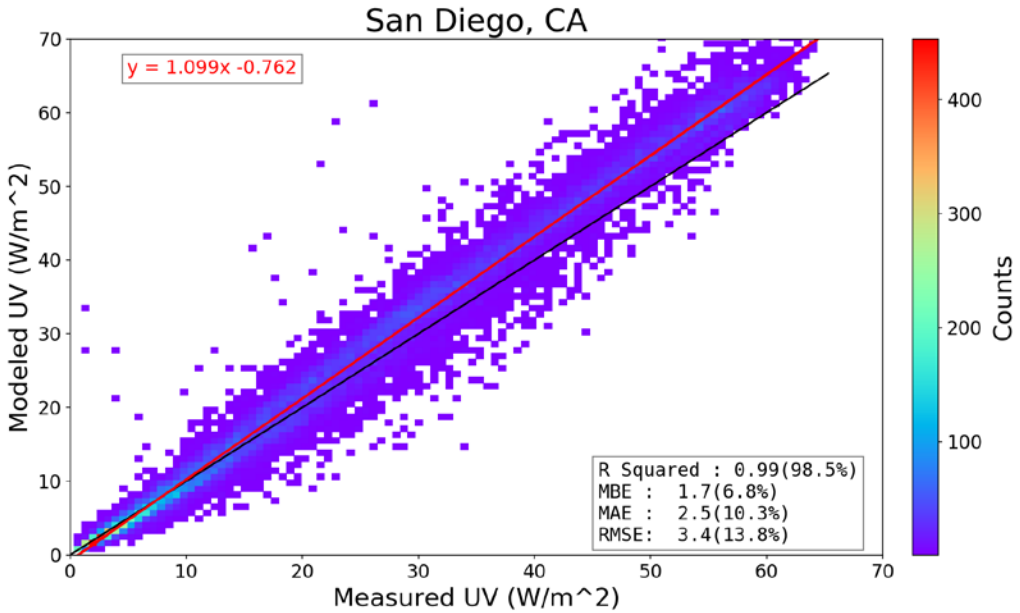
Desert Rock: June 19–20, 2018



Downstream Products

Spectral and ultraviolet data set

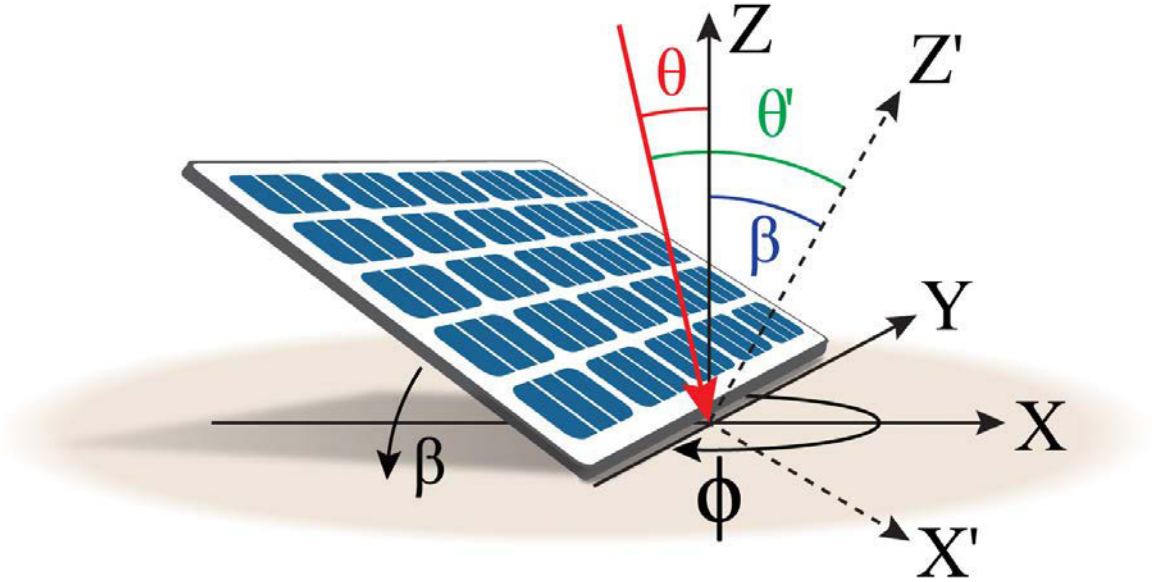
Ultraviolet Model Validation



https://ieeexplore.ieee.org/abstract/document/8529229

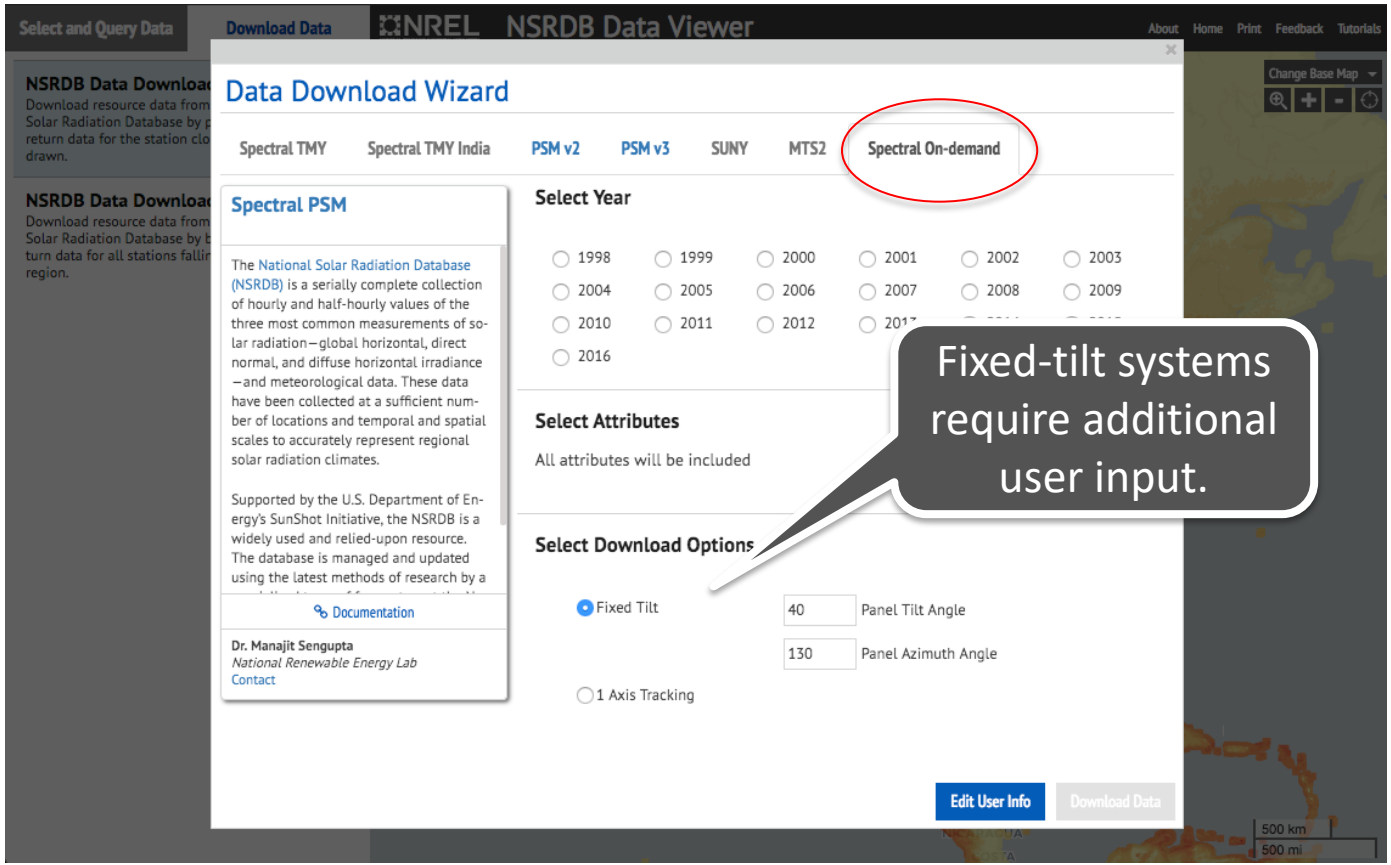
- NREL developed an ultraviolet (UV) model to estimate the total UV irradiance from measured or modeled total solar irradiance under all-sky conditions.
- The validation shows good agreement with measurement and provides confidence about the accuracy of the model.
- The model bias on average is only ±2W/m^2 when validated for multiple locations.
- By the end of June 2020, the data will be disseminated through the NSRDB viewer at https://nsrdb.nrel.gov.

FARMS for Narrowband Irradiances on Tilted Surfaces (FARMS-NIT)



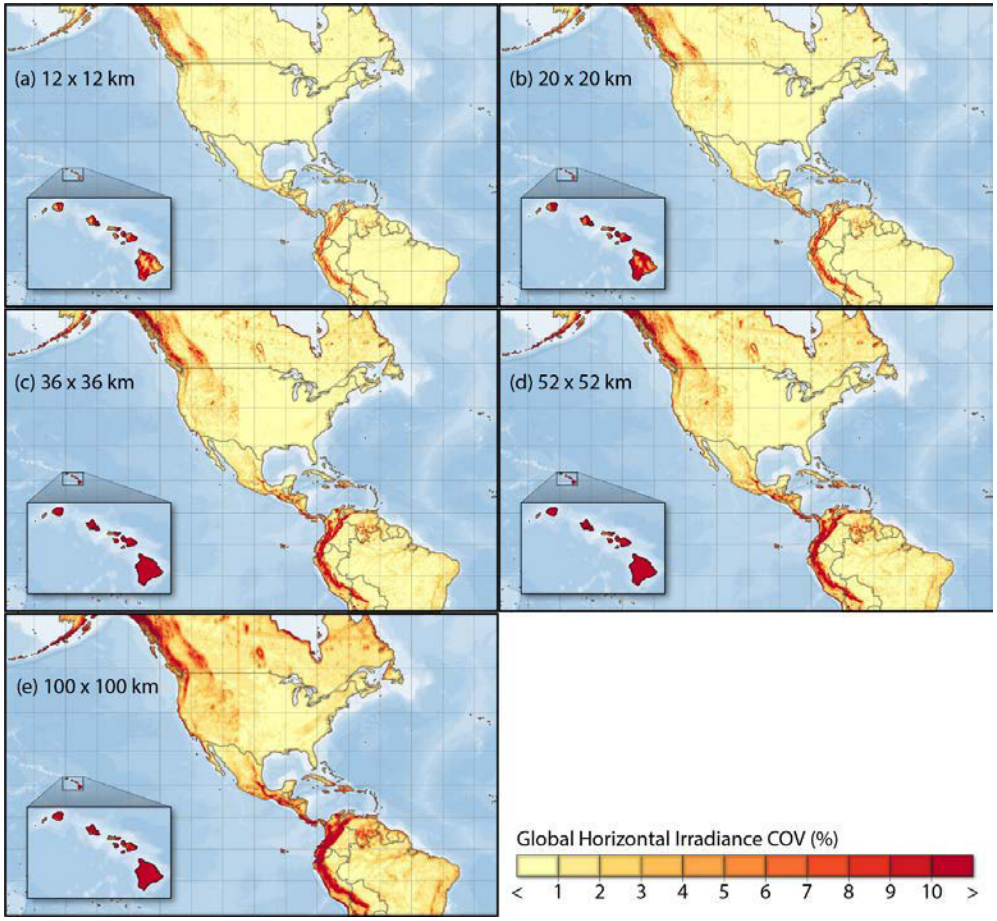
- **FARMS-NIT uses a precomputed database of cloud transmittance properties to provide spectral radiation (2002 wavelength bands) in the plane of array.**
- **With our current server, which can use multiple processors, we can compute and deliver spectral data for 1 year in ~2 minutes.**

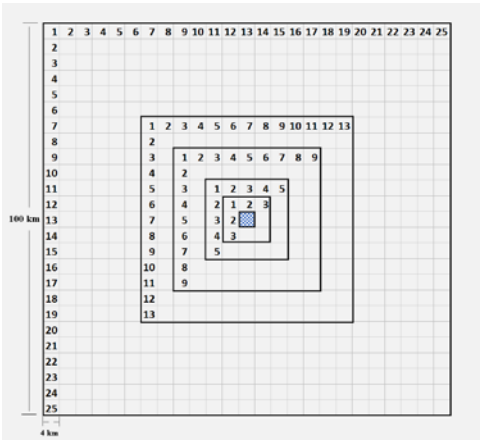
NSRDB Spectral Data Download



Overview of Long-Term Spatial and Temporal Solar Resource Variability Using the NSRDB (1998–2017)

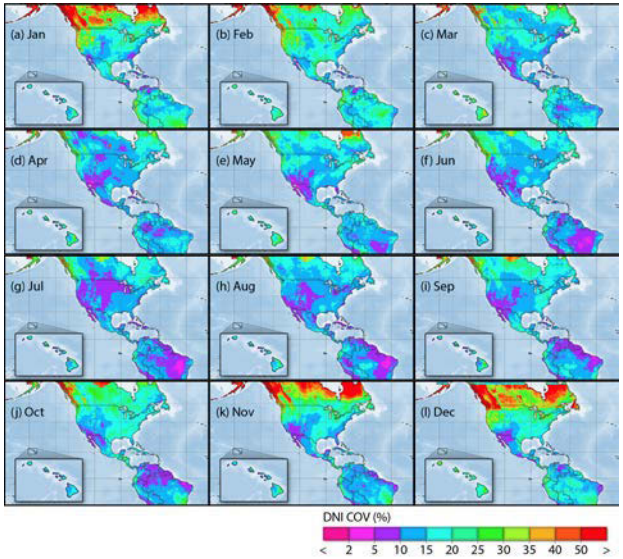
Annual Long-Term Spatial Variability: Global Horizontal Irradiance

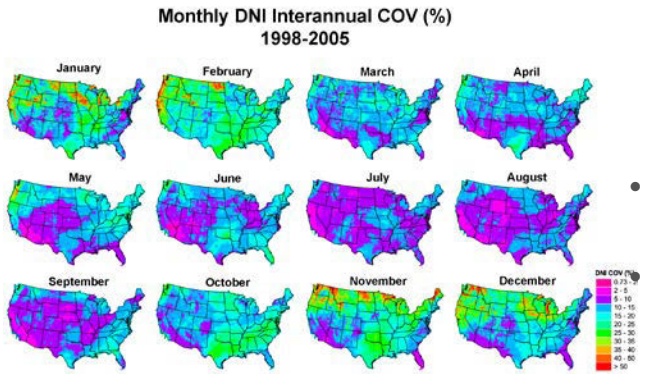




- Variability increases as the distance from the center pixel increases.
- The spatial coefficient of variation of direct normal irradiance (DNI) is about twice that of the global horizontal irradiance (GHI).
- Hawaii, the western and southwestern United States, parts of Canada, and western South America have high variability.

Direct Normal Irradiance
Long-Term Temporal Variability



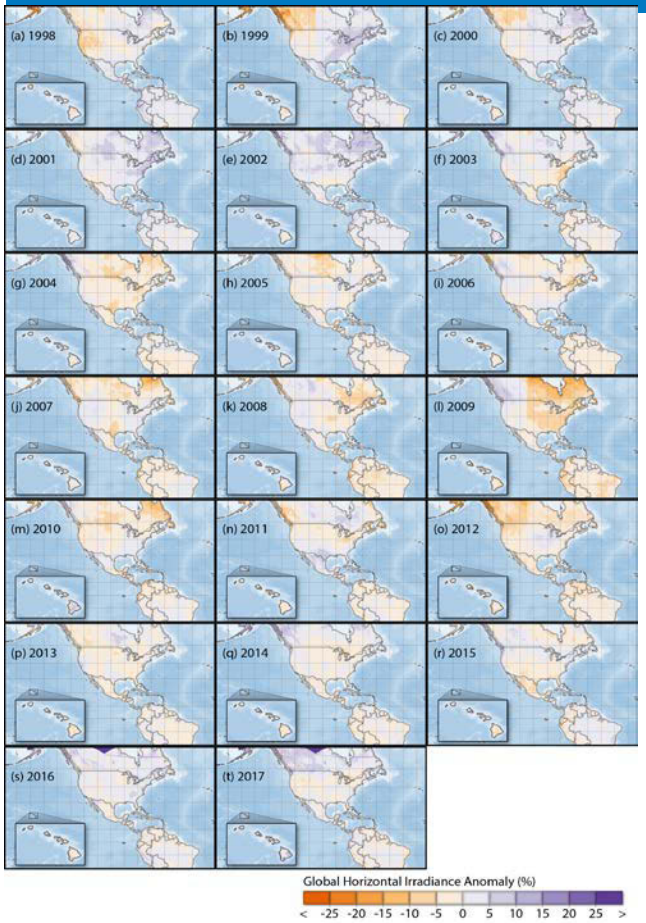


https://www.nrel.gov/grid/solar-resource/assets/data/ases_47760_final.pdf

Monthly interannual variability in DNI (left) from the present study (1998–2017) compared to the earlier study (1998–2005) (Gueymard and Wilcox 2011)

- The NSRDB version used in the previous study was based on the semiempirical State University of New York satellite model covering only 1998–2005.
- Similar maps with the same color coding are used.
  The relative distribution for each month is similar between the two studies.
- The current study demonstrates higher variability because of:
  - Model differences
  - Differing spatial resolutions of the data sets (10x10 km vs. 4x4 km)
  - Longer period of the current study.

Solar Resource Anomaly

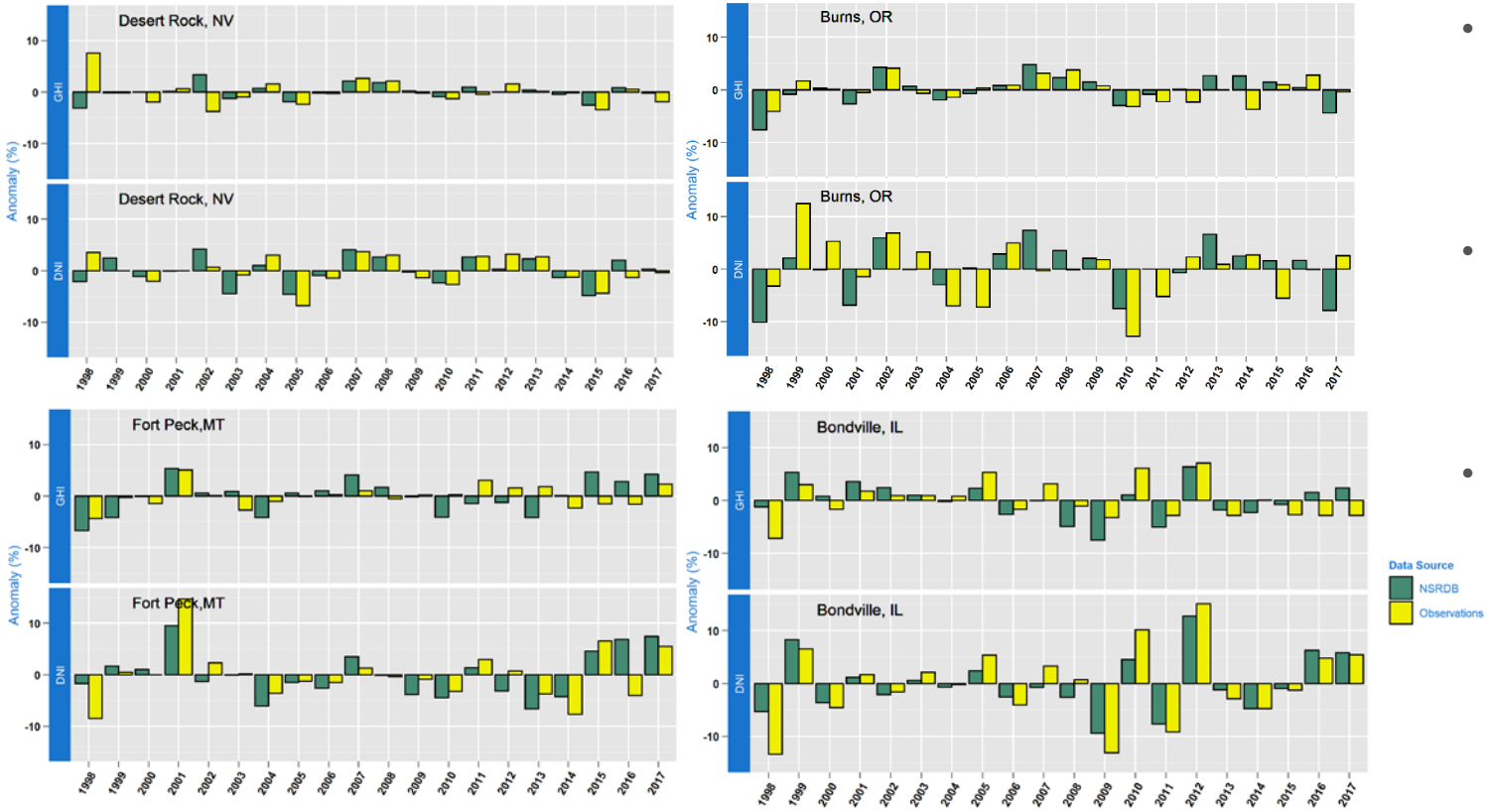


The anomalies are found to be particularly significant for a few specific years:

- During 2002, most of the contiguous United States and Canada had an increase of up to ≈10% in both GHI and DNI.
- Conversely, the central and southern plains of the contiguous United States had up to 5%–10% reduction in irradiance in 2015.

This anomaly analysis seems to be impacted by known satellite issues. In particular, calibration adjustments need to be made periodically to account for sensor degradation and to smooth out sudden ramps around periods of transition between one satellite and the next.

Solar Resource Anomaly



Percentage annual anomaly of ground measurements (yellow bar) and NSRDB (green bar) for GHI (top row) and DNI (bottom row) at four locations during the period 1998–2017 (x-axis).

- The NSRDB and surface measurements capture similar positive or negative deviations and magnitudes.
- This gives confidence that the NSRDB data are potentially able to predict long-term variability accurately.
- Exceptions occur during some years when the anomaly magnitudes differ for reasons still unclear.

Conclusion and Future Work

- High-resolution cloud properties at 2-km resolution are available from 2018 for GOES-16.
- The solar radiation calculated using GOES-16 cloud properties is of high accuracy when compared with ground measurements.
- The variability and ramps in solar radiation are better observed using the GOES-16 data.
- The solar radiation estimates are highly accurate in clear-sky situations, indicating that the aerosol optical depths from the Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) are of high quality.
- The 5-min data are available from AWS, whereas 21 years of 4-km, 30-min data are available from the NSRDB website and through application programming interface downloads.
- Spectral data are also available for download from the NSRDB website.
- UV data will be available for download next month.
- Year 2019 data is in the pipeline and will be updated using GOES-16 and GOES-17.
- Future efforts will focus on representing partly cloudy situations using 500-m satellite data to estimate cloud fraction.

Thank You!

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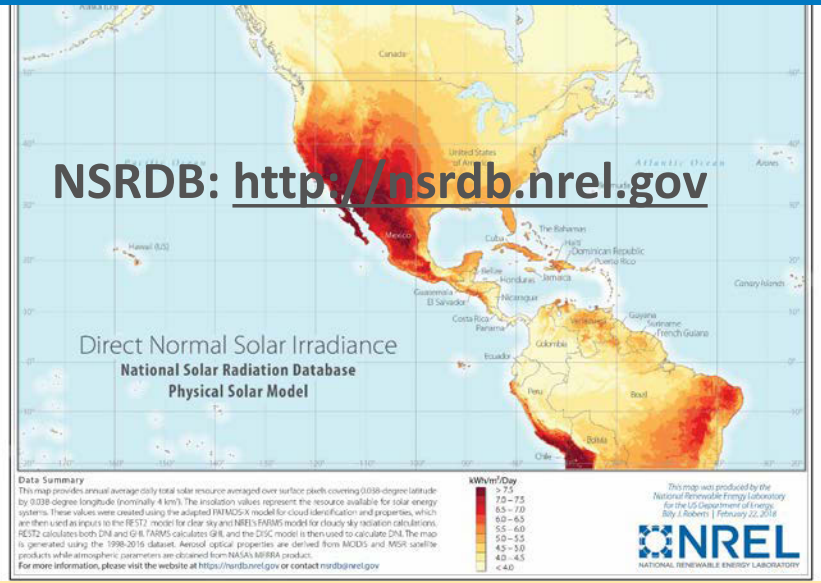

NREL/PR-5D00-77121

Sengupta, M., Y. Xie, A. Lopez, A. Habte, G. Maclaurin, and J. Shelby. 2018. "The National Solar Radiation Data Base (NSRDB)." ***Renew. Sustain. Energy Rev.*****, 89: 51–60. https://doi.org/10.1016/j.rser.2018.03.003.**

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