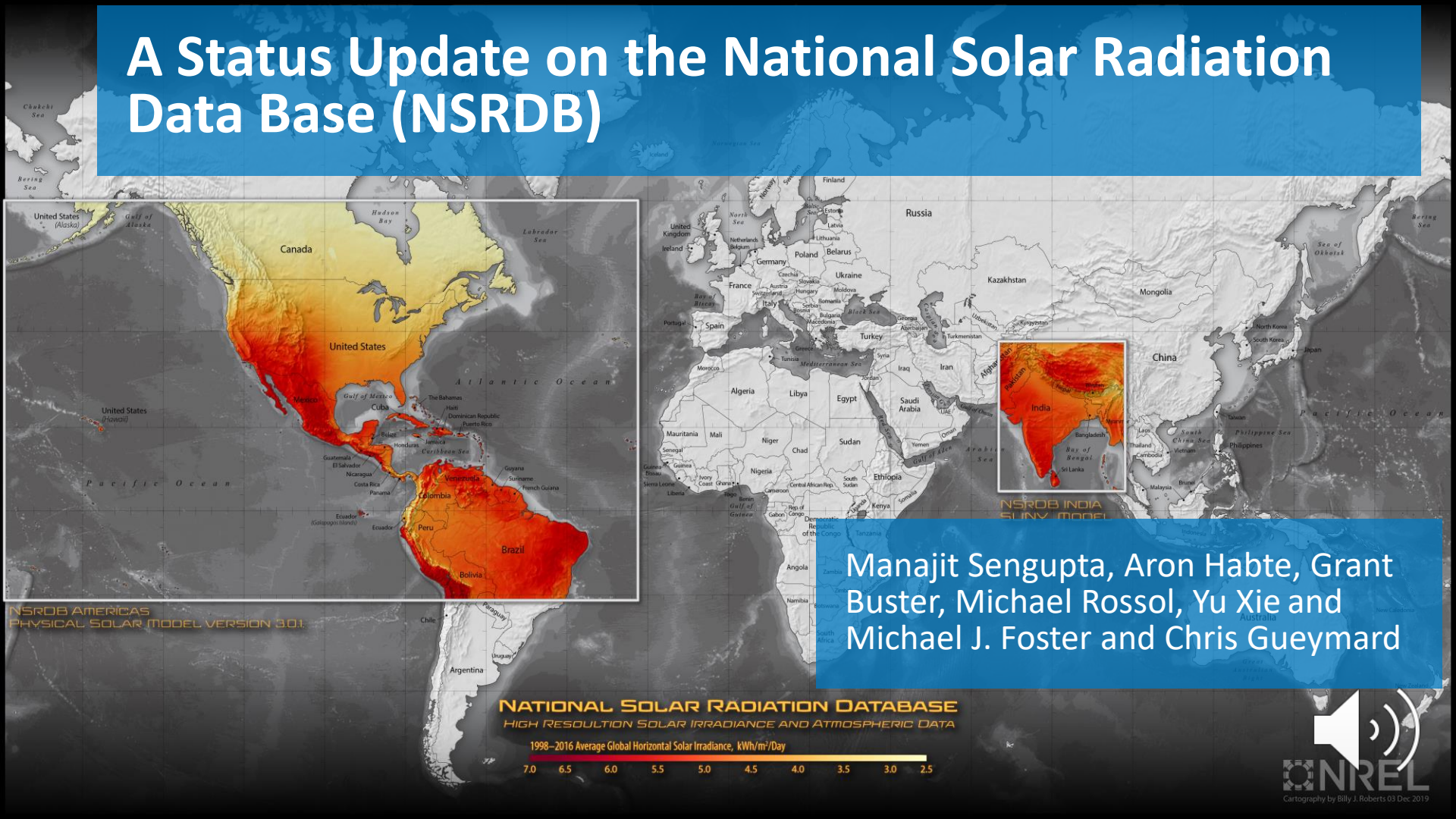
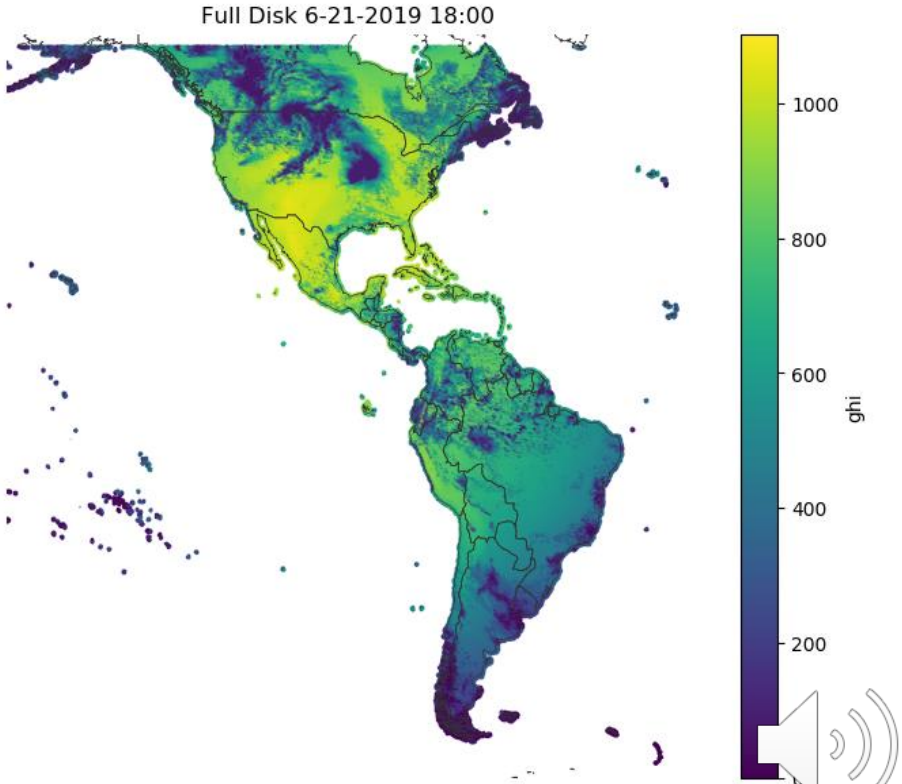
A Status Update on the National Solar Radiation Data Base (NSRDB)



Manajit Sengupta, Aron Habte, Grant Buster, Michael Rossol, Yu Xie and Michael J. Foster and Chris Gueymard

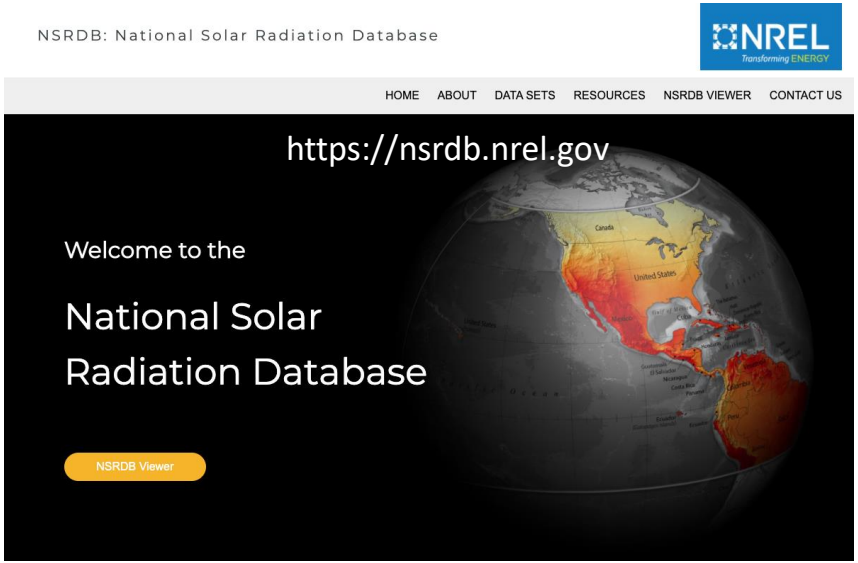
Overview

- National Solar Radiation Database (NSRDB) PSM V3 (1998-2018)
- NSRDB downstream products
- Studying long-term variability using 20 years NSRDB data

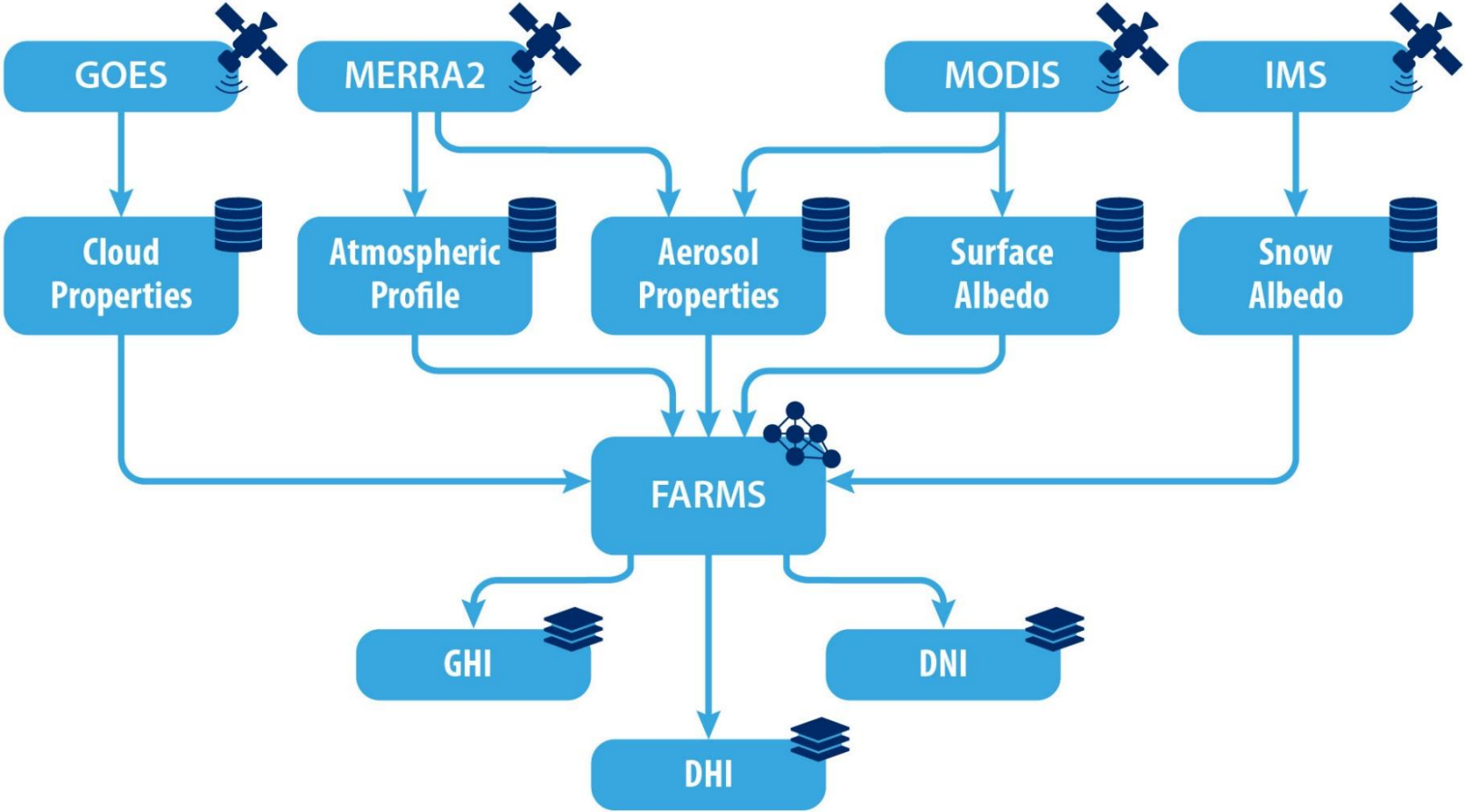


What Does the National Solar Radiation Database Provide?

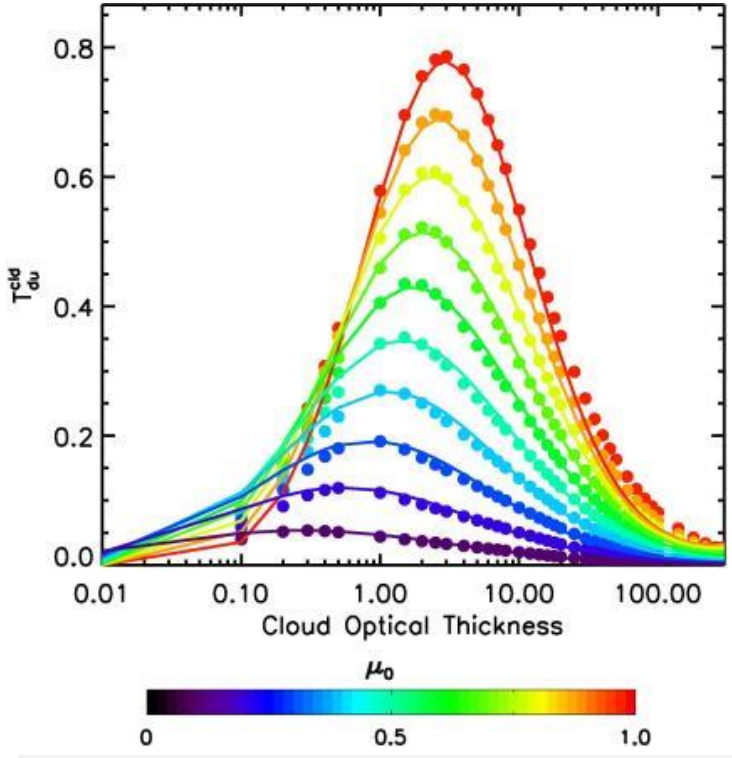
- The NSRDB seeks to advance our knowledge of solar radiation and its applications for renewable energy.
- The NSRDB provides a serially complete database of solar irradiance and meteorological information across the United States and other locations.
- The NSRDB provides **21 years** (+ typical meteorological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

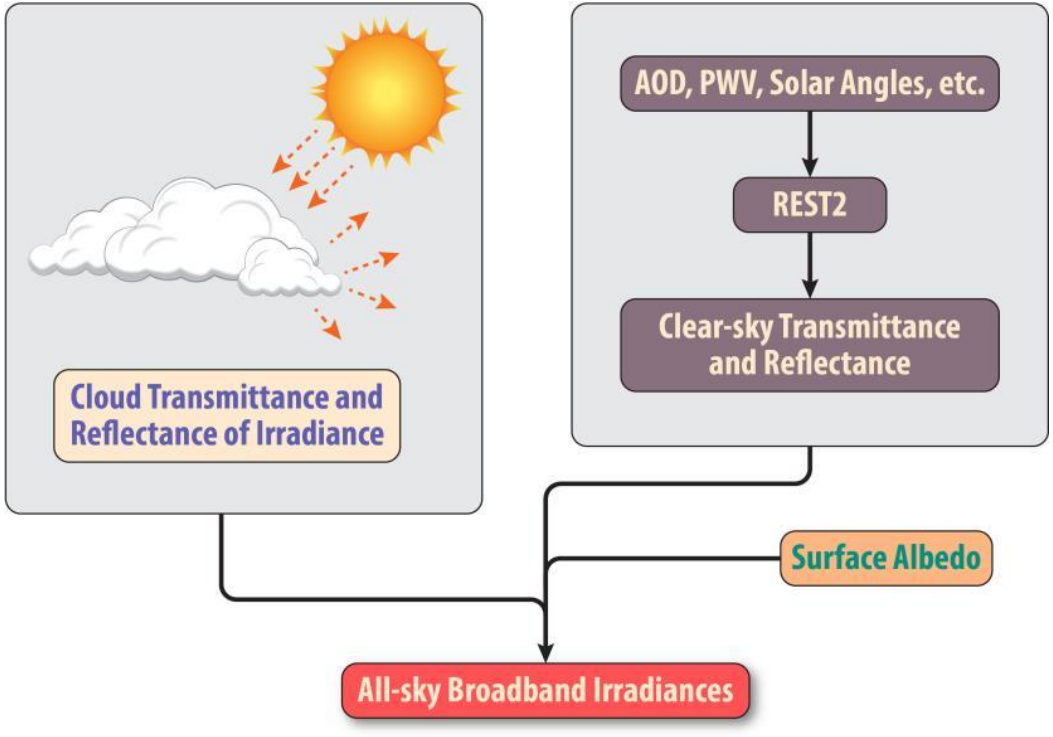


National Solar Radiation Database: PSM Workflow



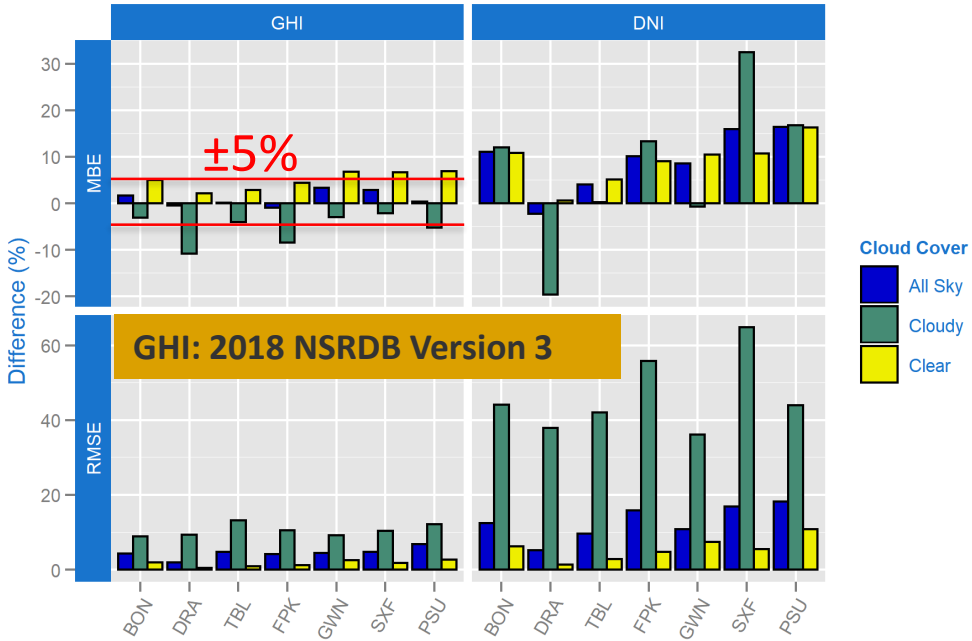
Fast All-Sky Radiation Model for Solar Applications (FARMS)

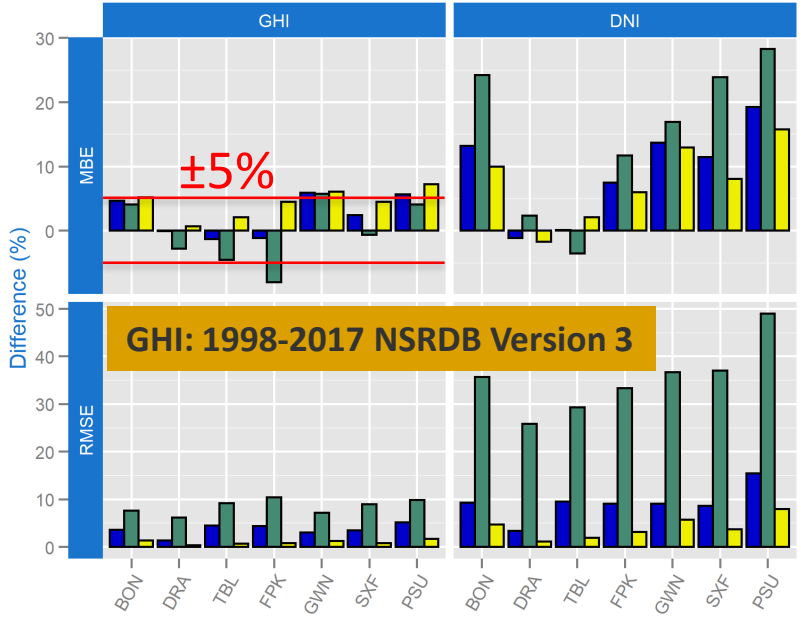




Cloud transmittances can be parameterized as exponential functions of cloud optical thickness and solar zenith angles.

Validation of 2018 High-Resolution Data

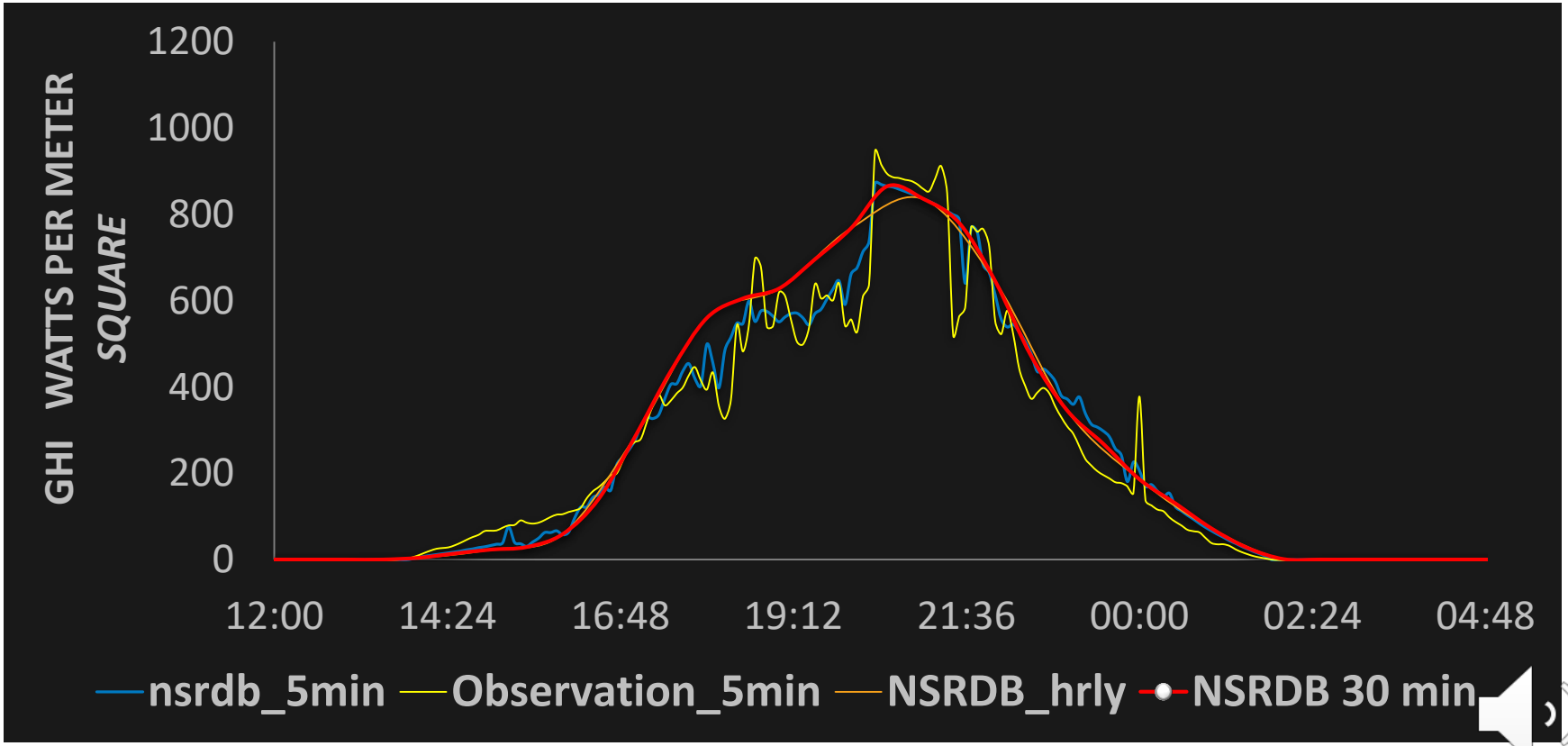




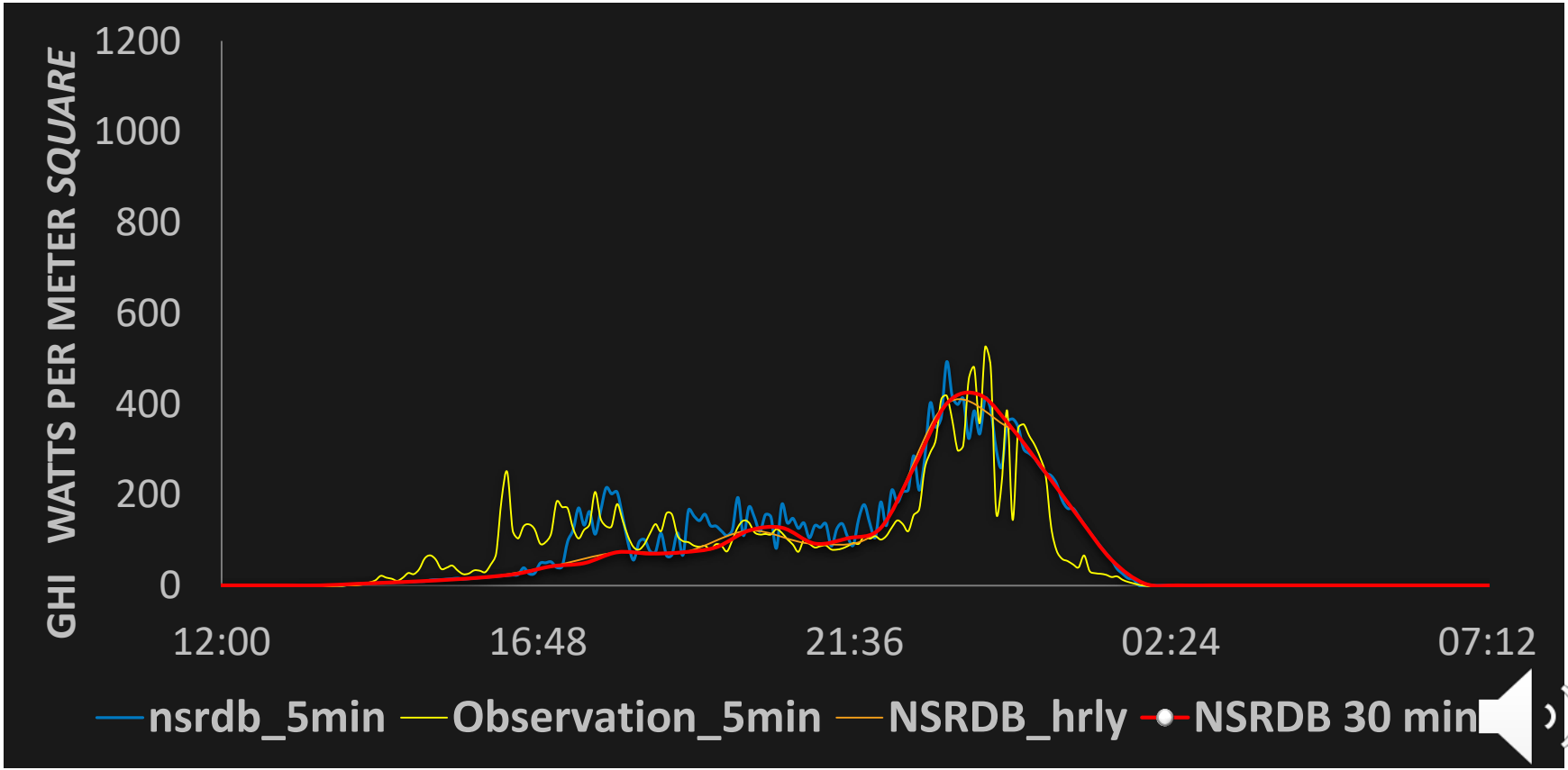
Annual difference between the two versions:

- 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

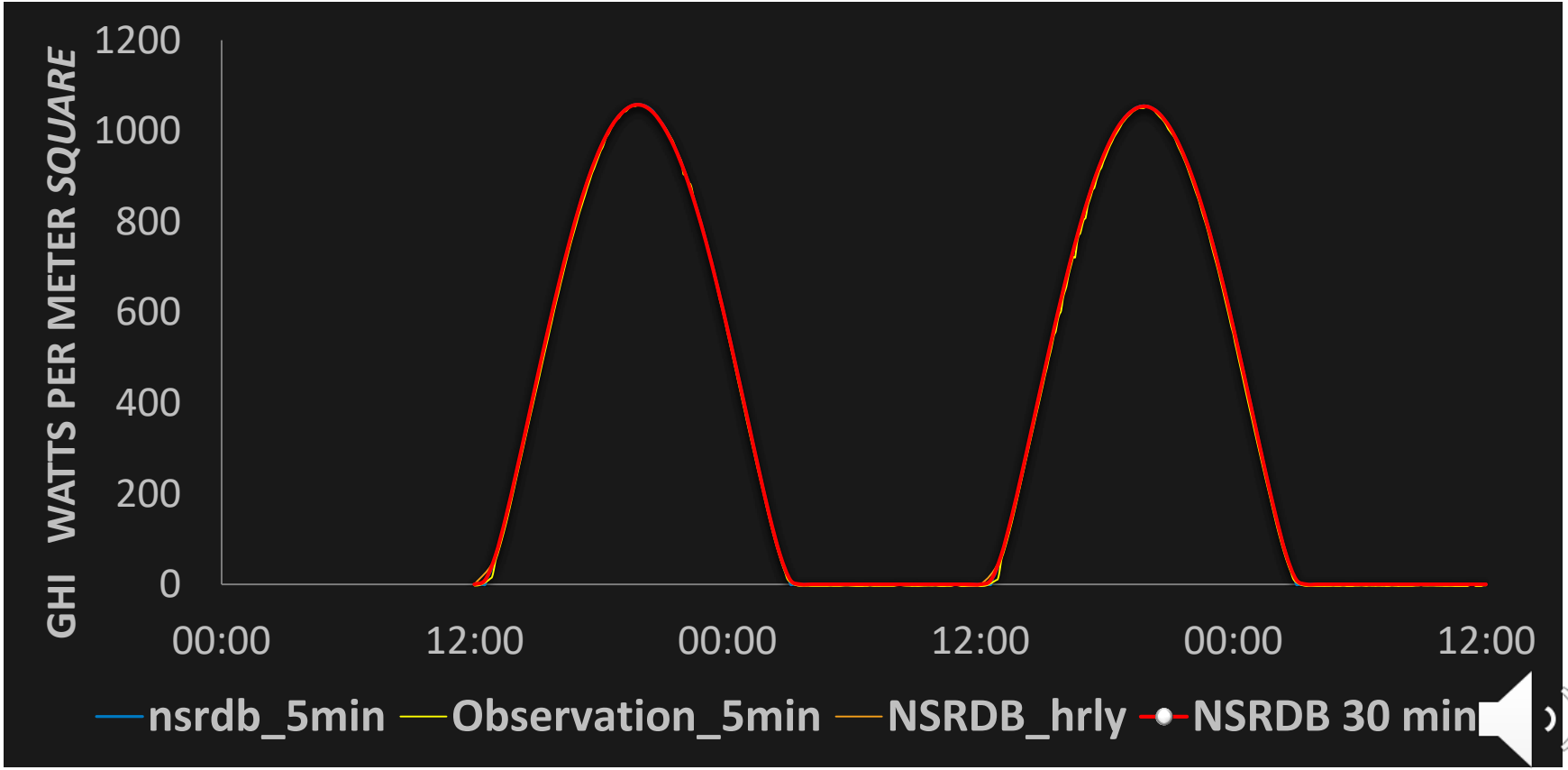
Desert Rock: March 20, 2018



Desert Rock: March 22, 2018



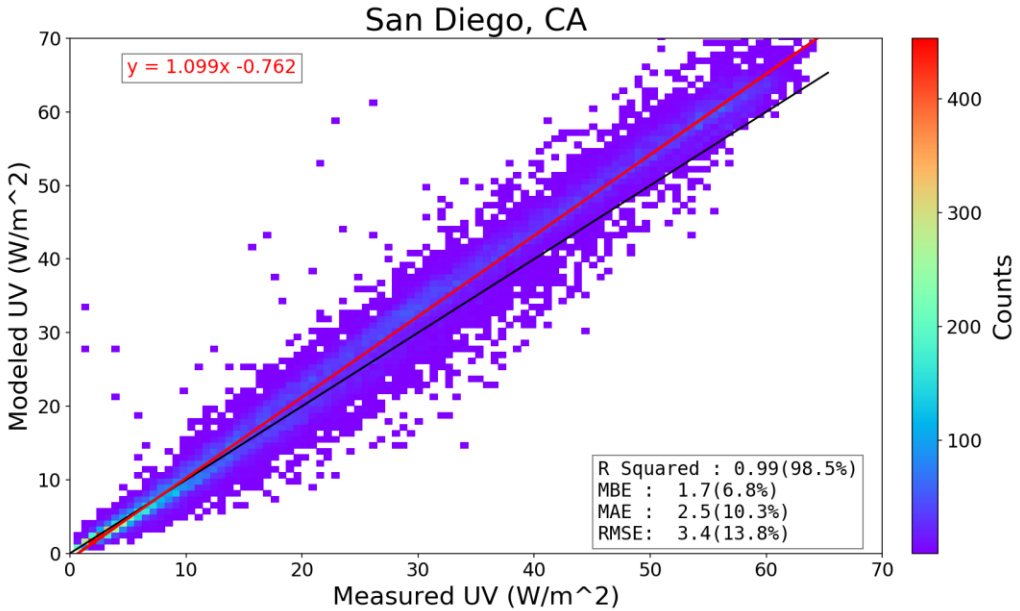
Desert Rock: June 19–20, 2018



Downstream Products:

Spectral and UV dataset

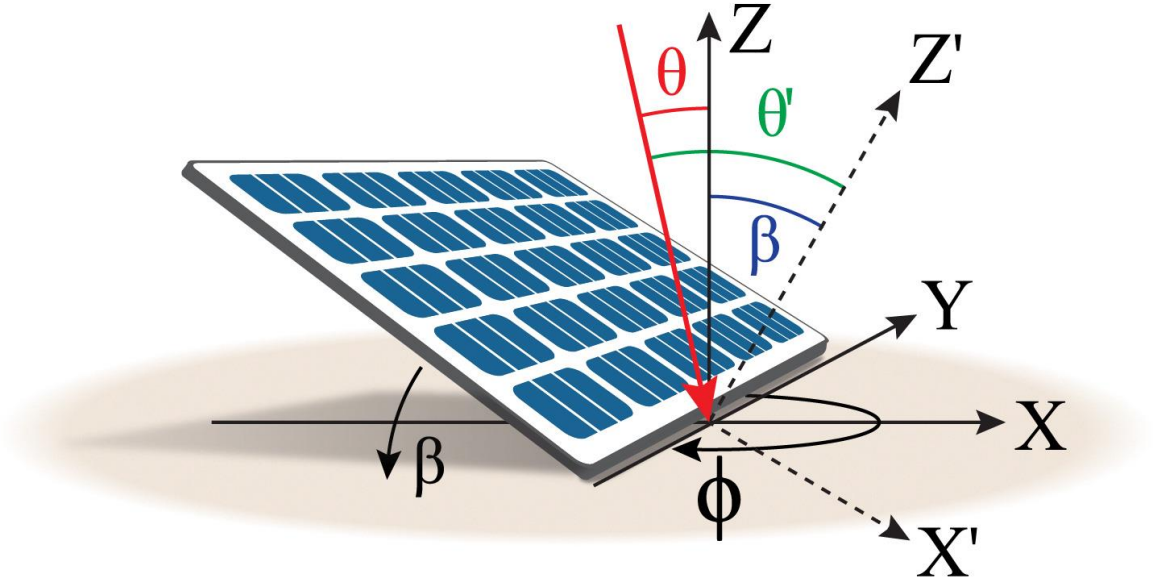
UV model Validation



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

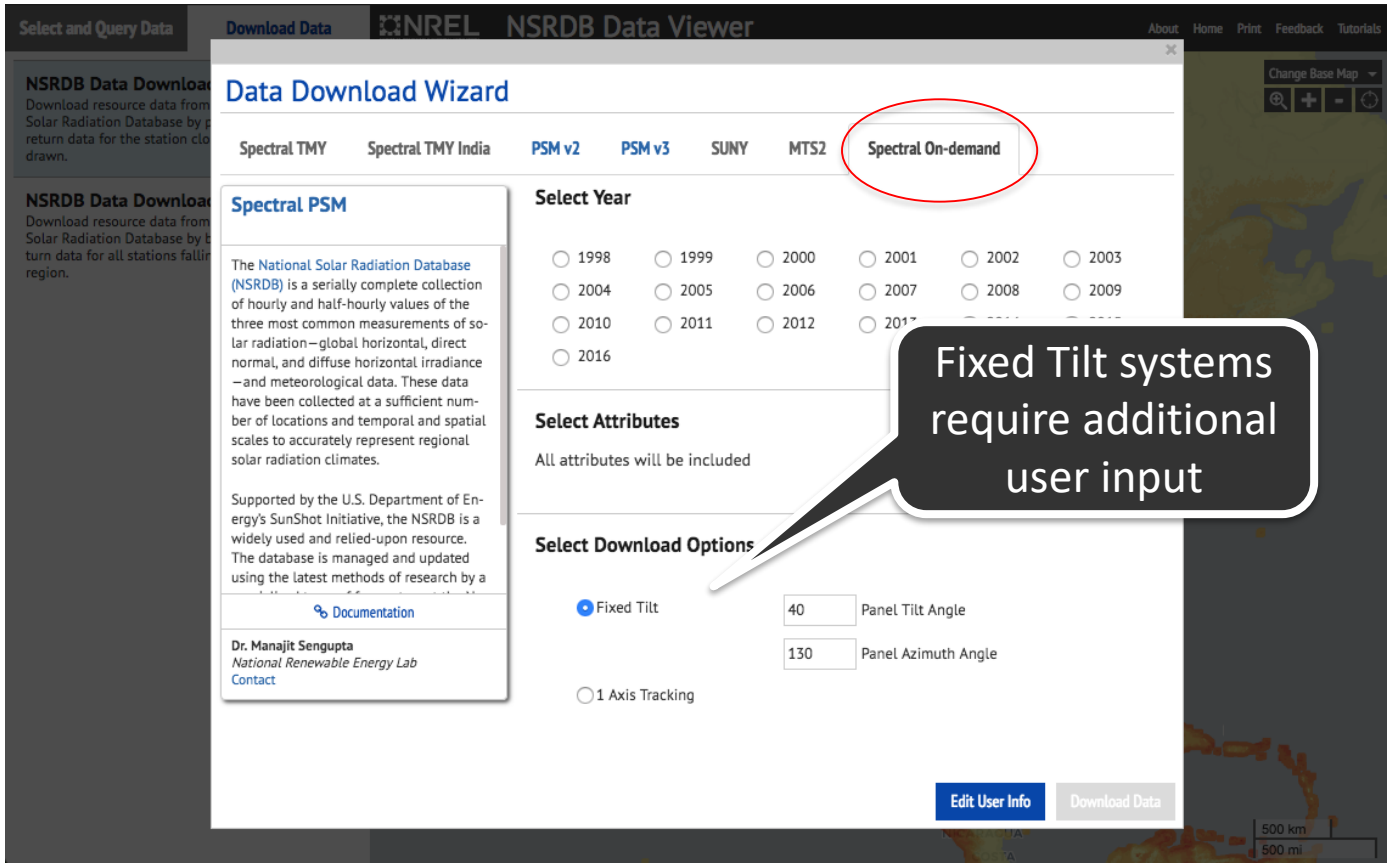
- NREL developed a UV model to estimate the total UV irradiance from measured or modeled total solar irradiance under all-sky conditions.
- The validation shows good agreement with measurement and provides confidence about the accuracy of the model.
- The model bias on average is only ±2W/m^2 when validated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

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



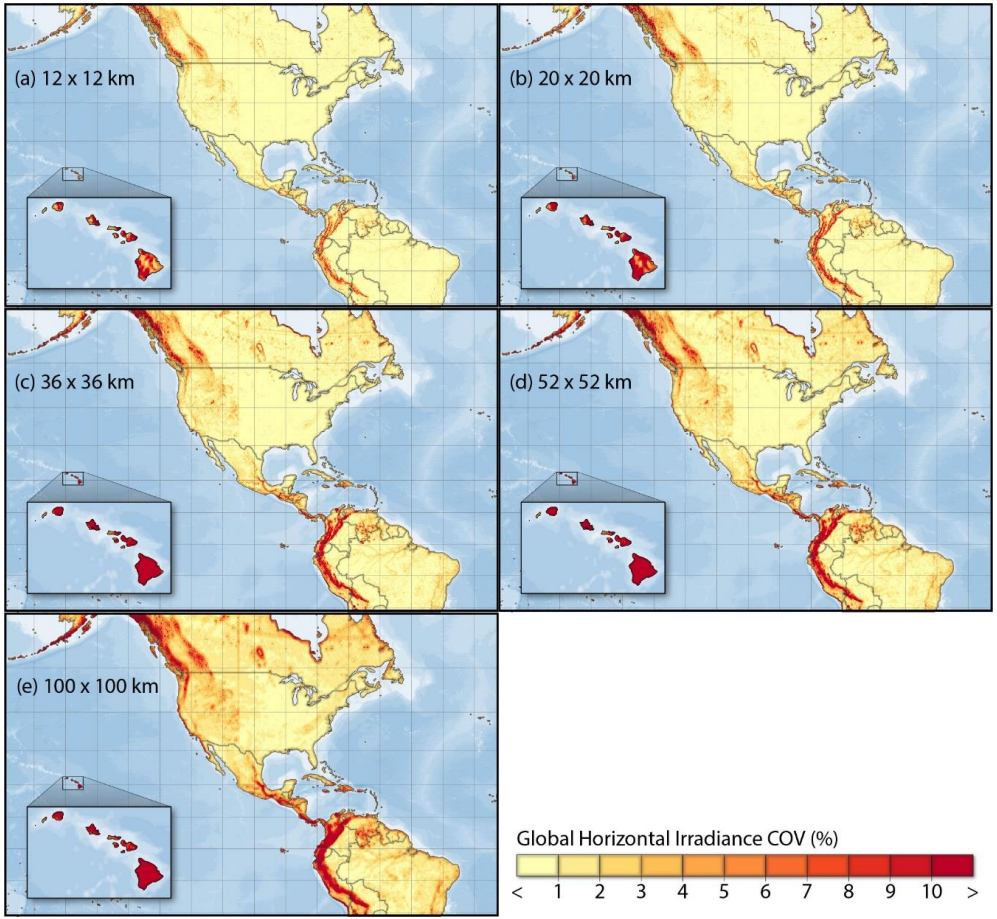
- FARMS-NIT uses a pre-computed database of cloud transmittance properties to provide spectral radiation (2002 wavelength bands) in the plane of array (POA).
- With our current server that can use multiple-processors we can compute and deliver spectral data for 1 year in ~2 minutes.

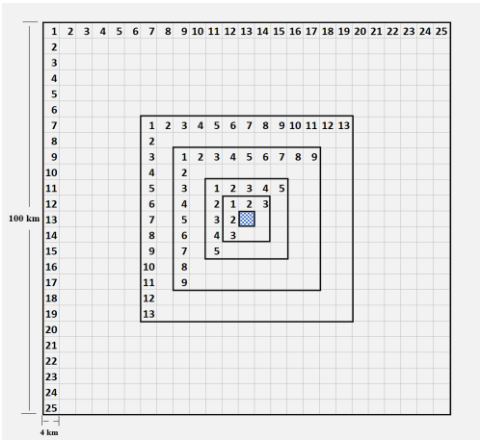
NSRDB Spectral Data Download



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

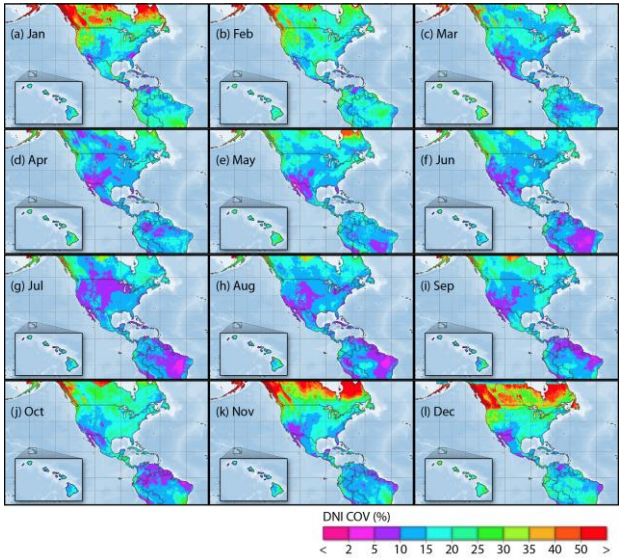
Annual Long-term Spatial Variability - GHI

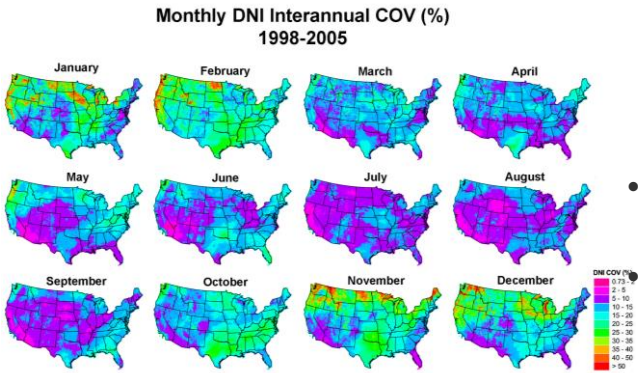




- Variability increases as the distance from the center pixel increases.
- DNI's spatial coefficient of variation (COV) is about twice that of the GHI COV.
- Hawaii, the western and southwestern United States, parts of Canada, and western South America have high-variability.

DNI Long-term Temporal Variability

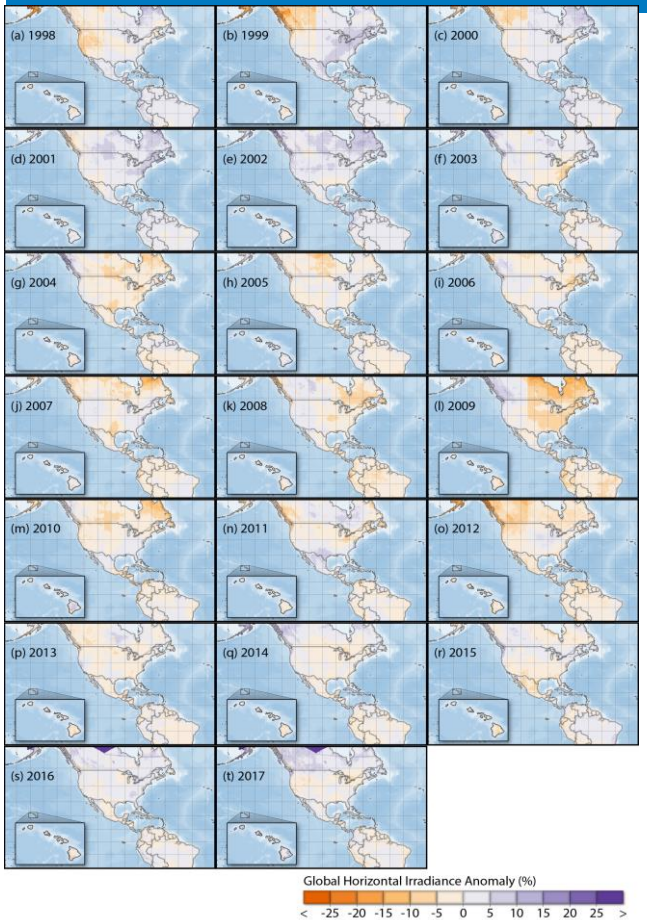




Monthly interannual variability in DNI (left) from the present study (1998-2017) compared to the earlier study (1998-2005) (Gueymard and Wilcox, 2011).

- The NSRDB version used in the previous study was based on the semi-empirical 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

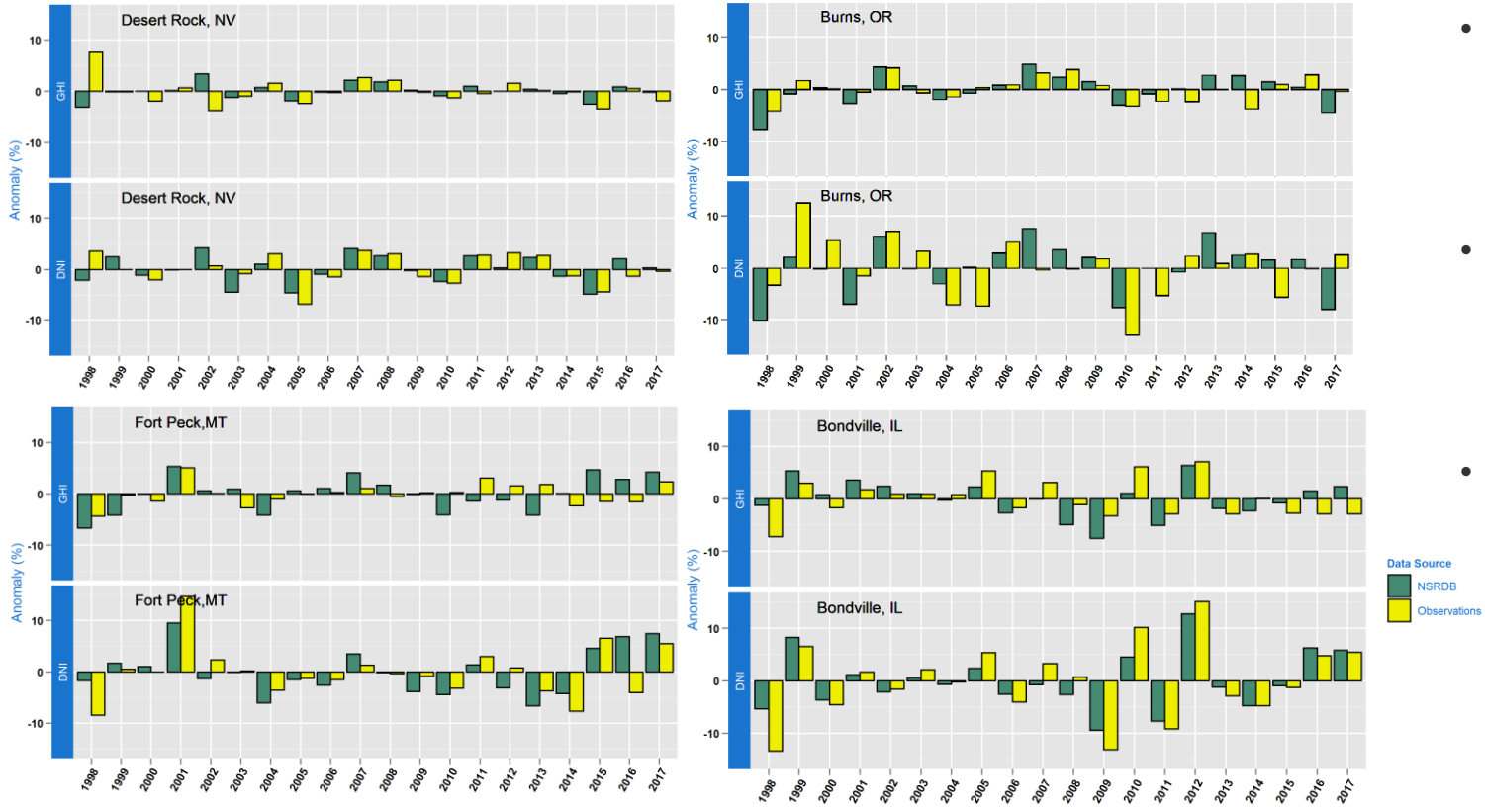


The anomalies are found to be particularly significant for a few specific years

- During 2002 most of CONUS and Canada had an increase of up to ≈10% in both GHI and DNI.
- Conversely, the central and southern plains of CONUS 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



Percent 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.
- Even though exceptions do 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 Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) are of high quality.
- The 5-minute data are available from AWS, whereas 21 years of 4-km, 30-minute data are available from the NSRDB website and through API downloads.
- Spectral data are also available for download from the NSRDB website.
- UV data will be available for download next month.
- 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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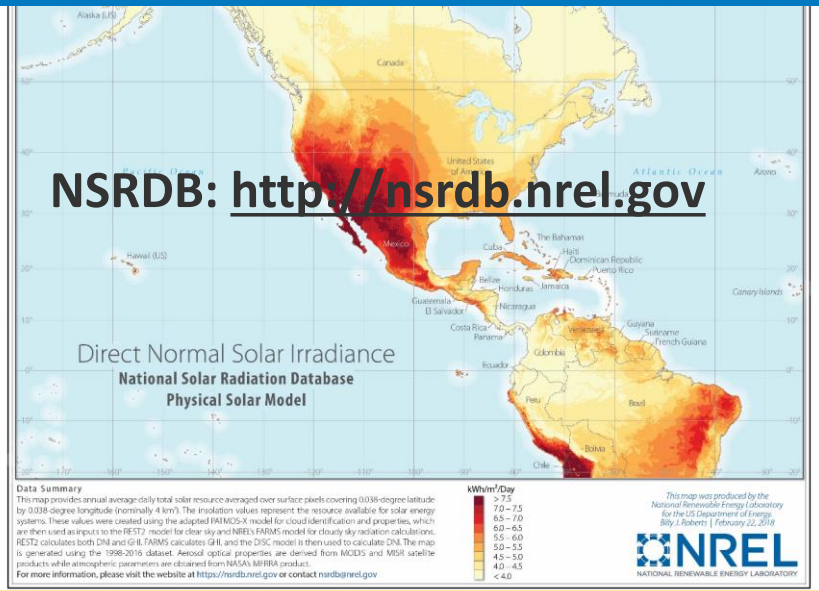

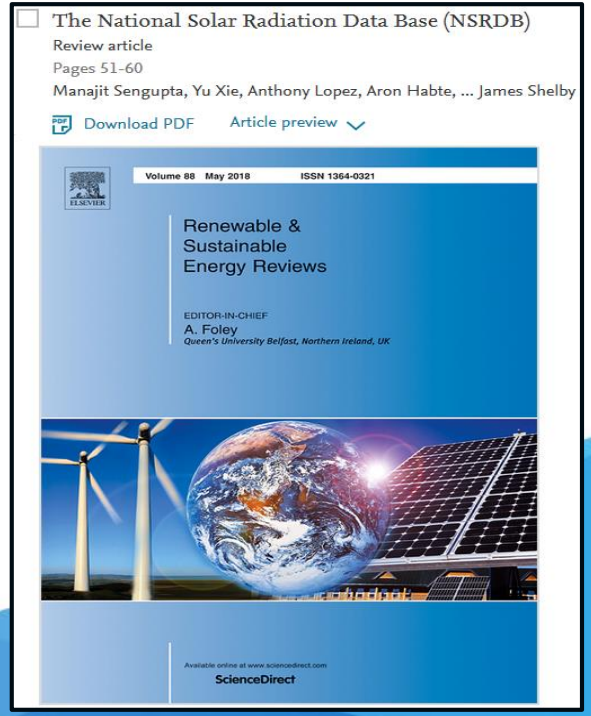

Sengupta, M., Y. Xie, A. Lopez, A. Habte, G. Maclaurin, and J. Shelby. 2018. "The National Solar Radiation Data Base (NSRDB)." ***Renew. Sustain. Energy Rev.*****, 89: 51–60. https://doi.org/10.1016/j.rser.2018.03.003.**

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