NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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1977 – 2017





UPDATE OF THE NATIONAL SOLAR RADIATION DATABASE (1998-2016) : VERSION 3

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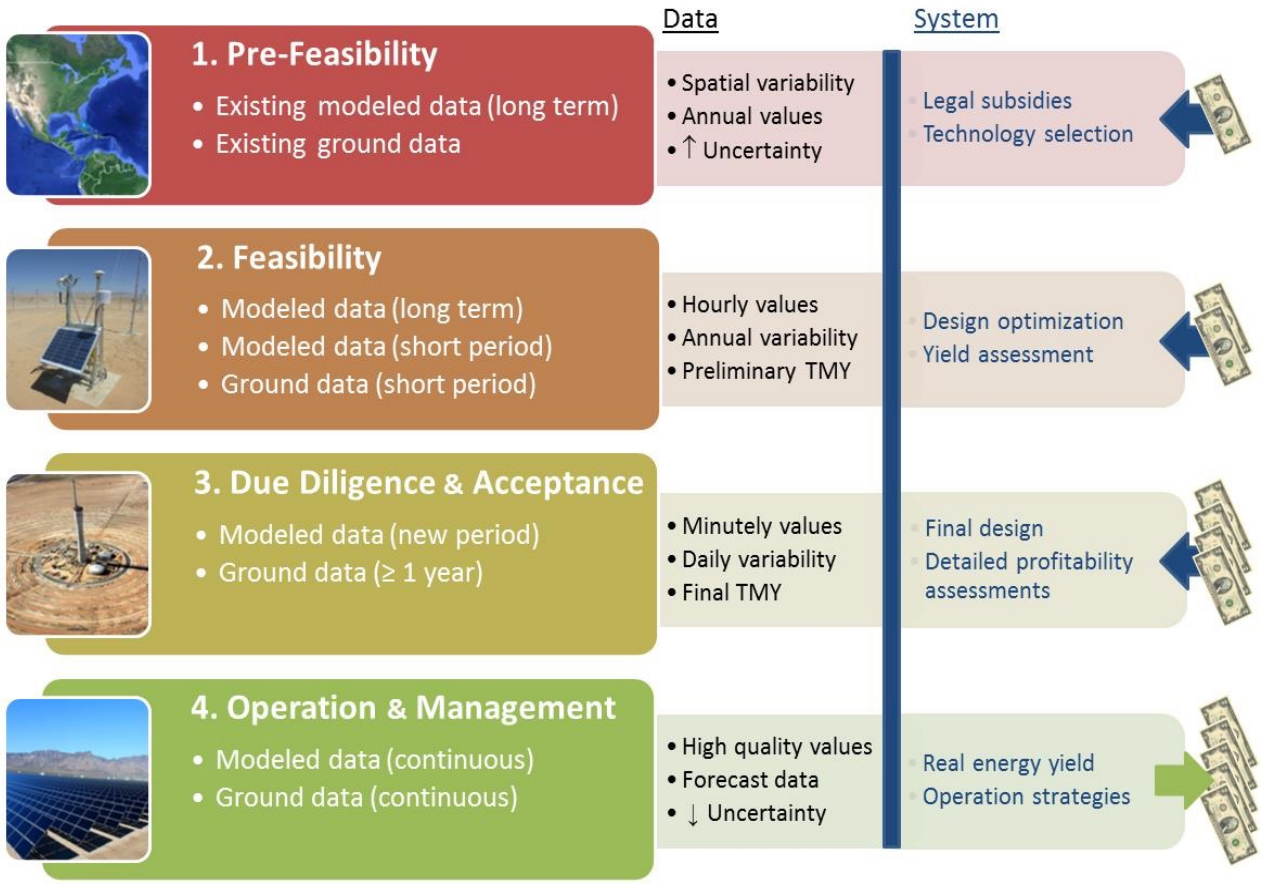
PV Performance Modeling and Monitoring Workshop

May 01–03, 2018

Application of Solar Resource Information

Support the U.S. Department of Energy (DOE) SunShot goal of reducing solar deployment and financing costs through improving accuracy in solar resource modeling.

Funded by the SI subprogram of DOE EERE Solar Energy Technology Program

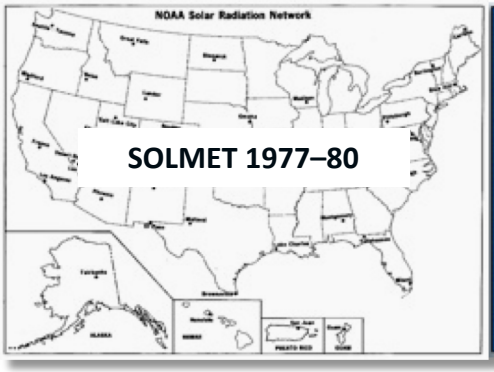


Source: https://www.nrel.gov/docs/fy18osti/68886.pdf

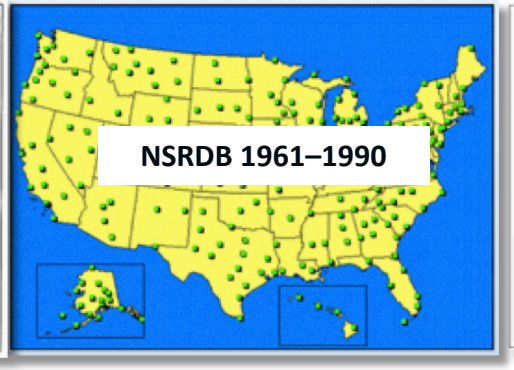
Outline

- Evolution of NSRDB
- The Physical Solar Model (PSM)
- What's new in PSM Version 3
- Validation of the NSRDB
- GOES East and West Comparisons
- Typical Meteorological Year (TMY)
- Accessing NSRDB and available parameters
- Future Work

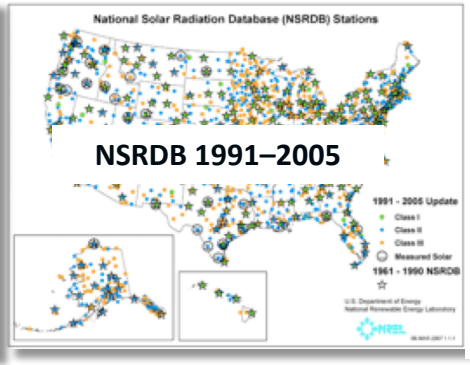
Evolution of the National Solar Radiation Database



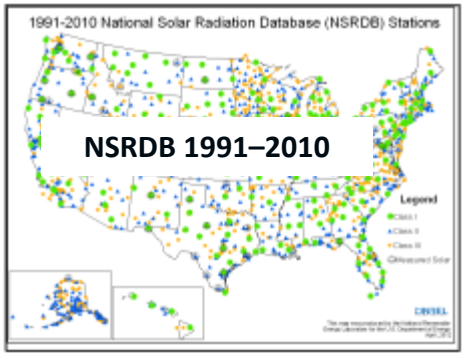
248 weather stations with 26 ***Solar measurement*** stations [ERDA, NOAA, 1979]



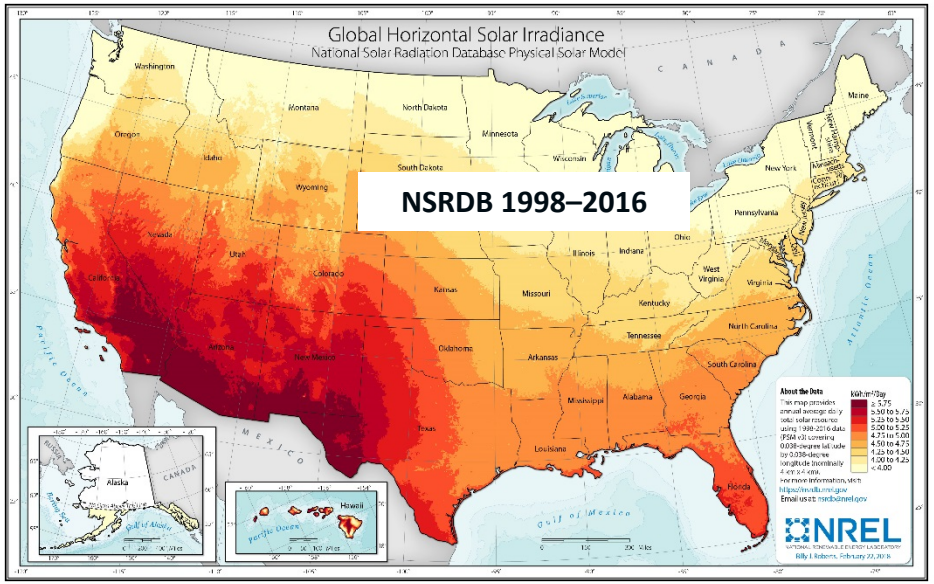
239 ***modeled*** stations with 56 partial measurement stations [DOE, NOAA, 1994]

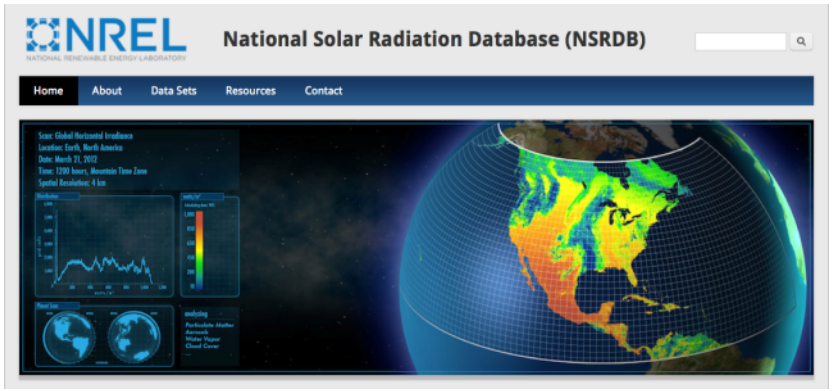


1,454 ***modeled*** locations [DOE, SUNY-A, NOAA, 2007]



1,454 ***modeled*** locations [DOE, CPR, 2012]

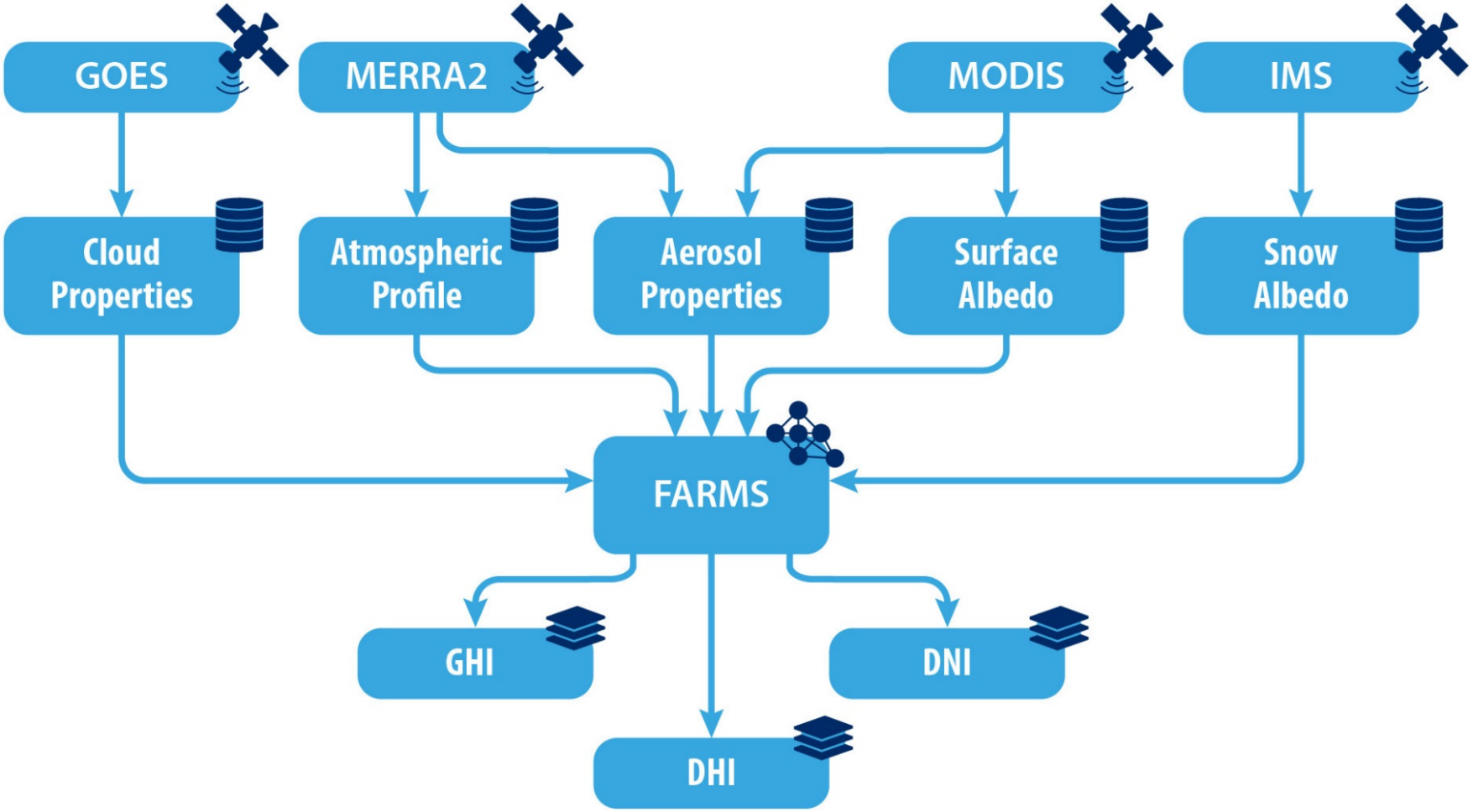




http://nsrdb.nrel.gov

Satellite-based, gridded, 4 km x 4 km, half-hourly [DOE, NOAA, UW, SCS 2016]

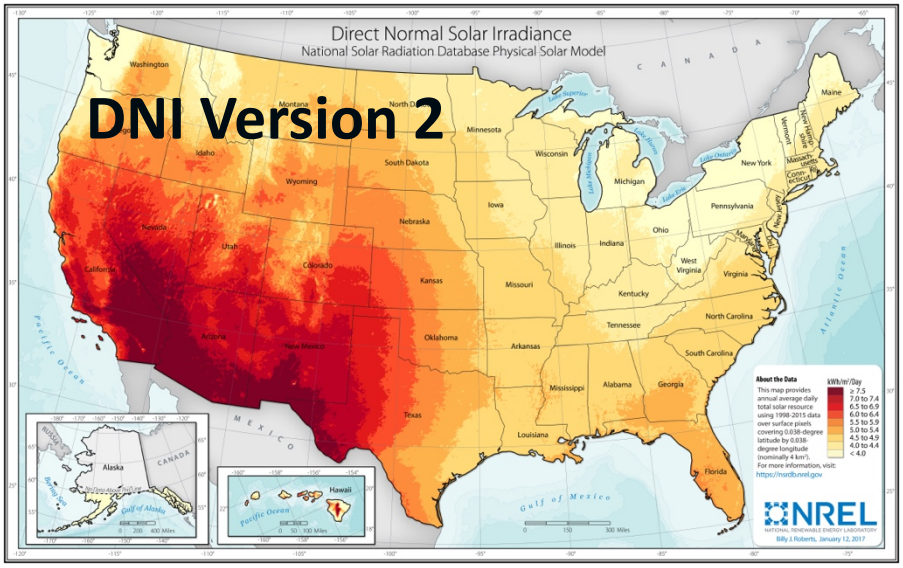
Physical Solar Model (PSM) Framework

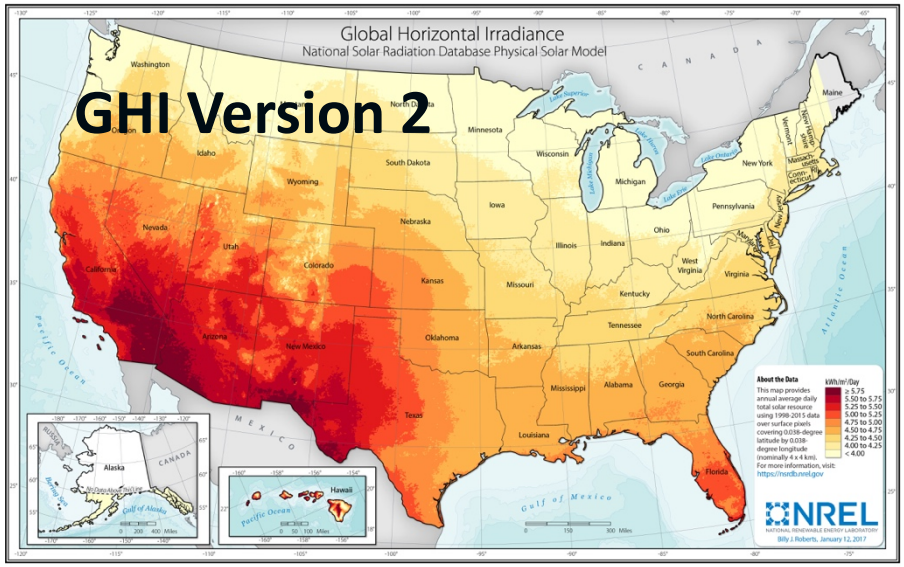


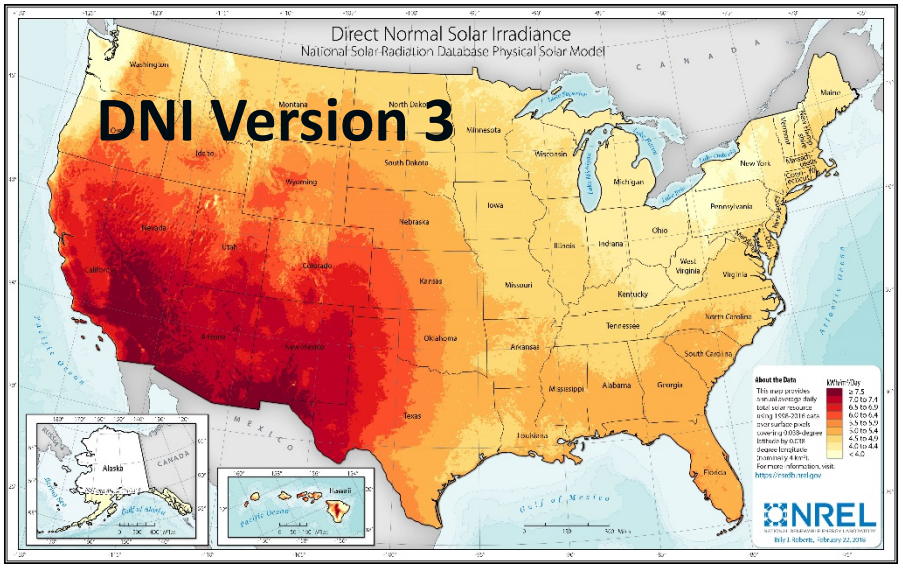
NSRDB (PSM-V3): What's New

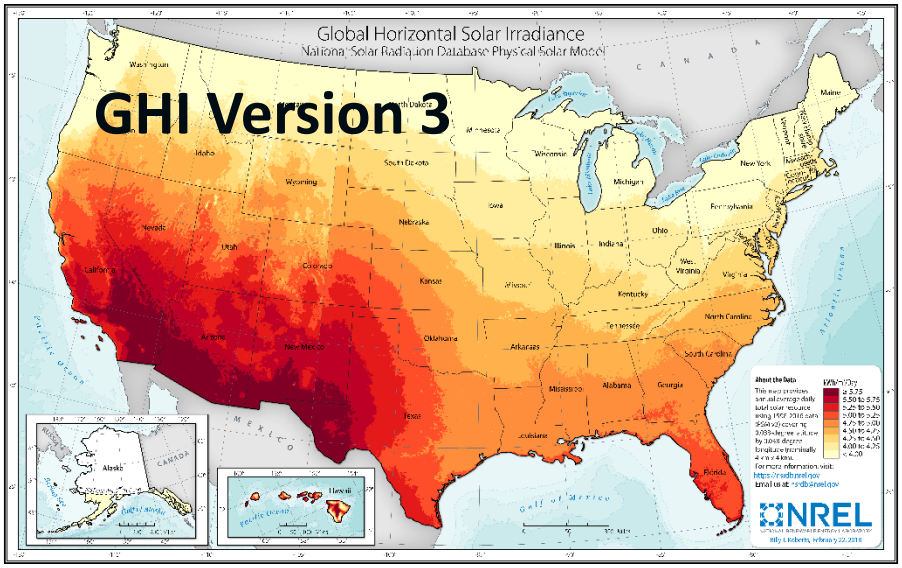
- Hourly aerosol optical depth (1998-2016) from Modern-Era Retrospective analysis for Research and Applications Version 2 (MERRA2).
- Snow-free Surface Albedo from MODIS (2001-2015) (MCD43GF CMG Gap-Filled Snow-Free Products from University of Massachusetts, Boston).
- Snow cover from Integrated Multi-Sensor Snow and Ice Mapping System (IMS) daily snow cover product (National Snow and Ice Data Center).
- GOES-East time-shift applied to cloud properties instead of solar radiation.
- Ancillary data (pressure, humidity, wind speed etc.) from MERRA2.

NSRDB Version 2 and 3 Comparison



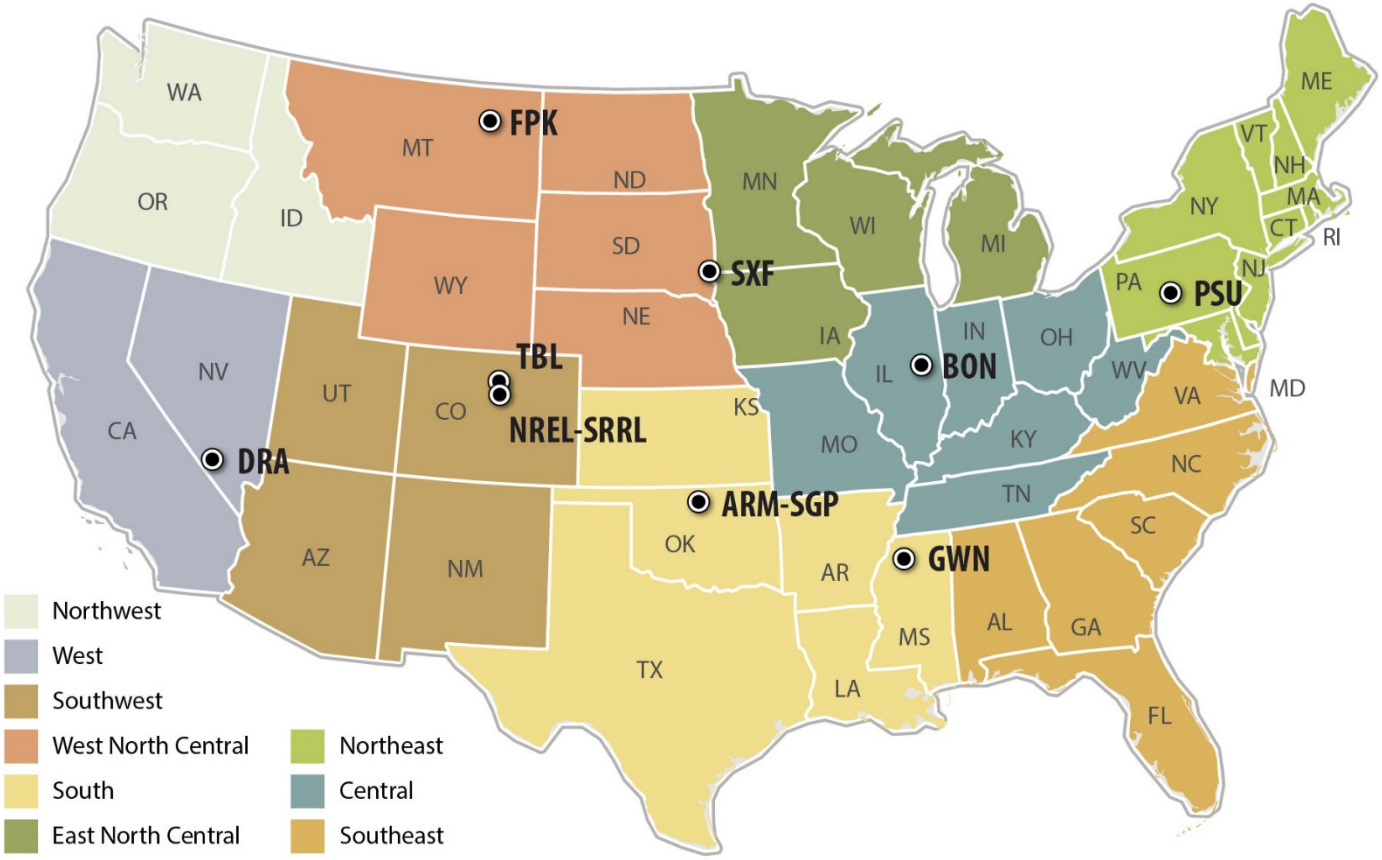






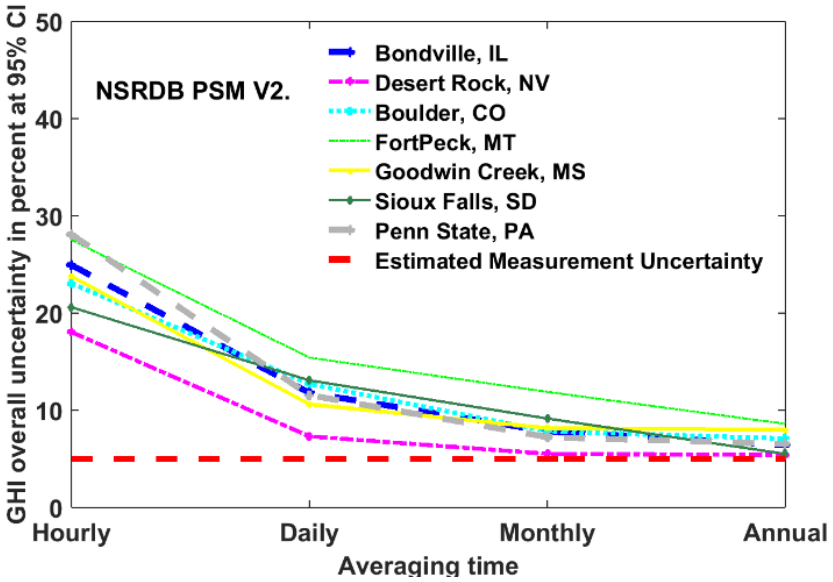
Validation of NSRDB Using Surface-Based Measurements

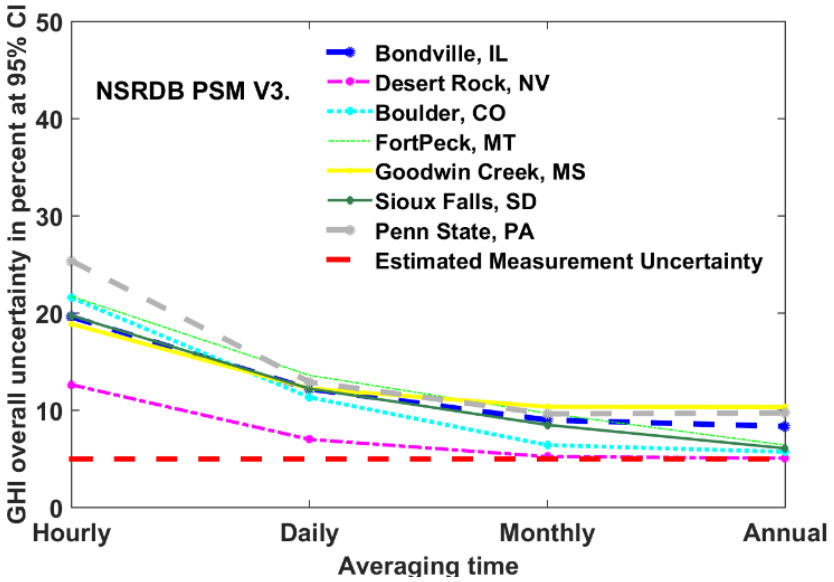
Surface Radiation (SURFRAD) Network, NREL's Solar Radiation Research Laboratory (SRRL), and the Atmospheric Radiation Measurement (ARM) Southern Great Plains locations



Validation of NSRDB Using Surface-Based Measurements

GHI: Overall estimated uncertainty—NSRDB (1998–2015)

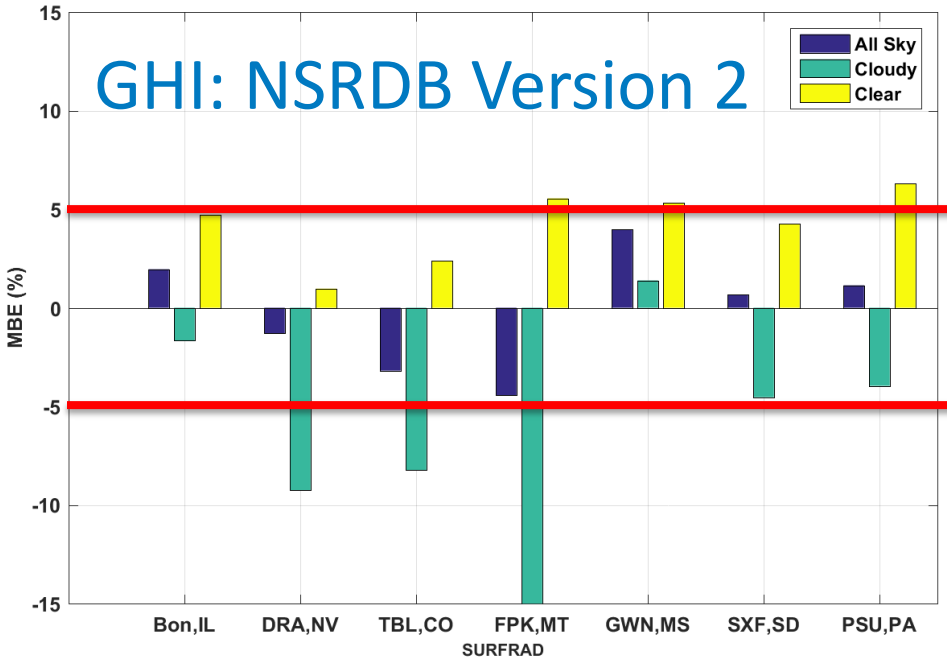


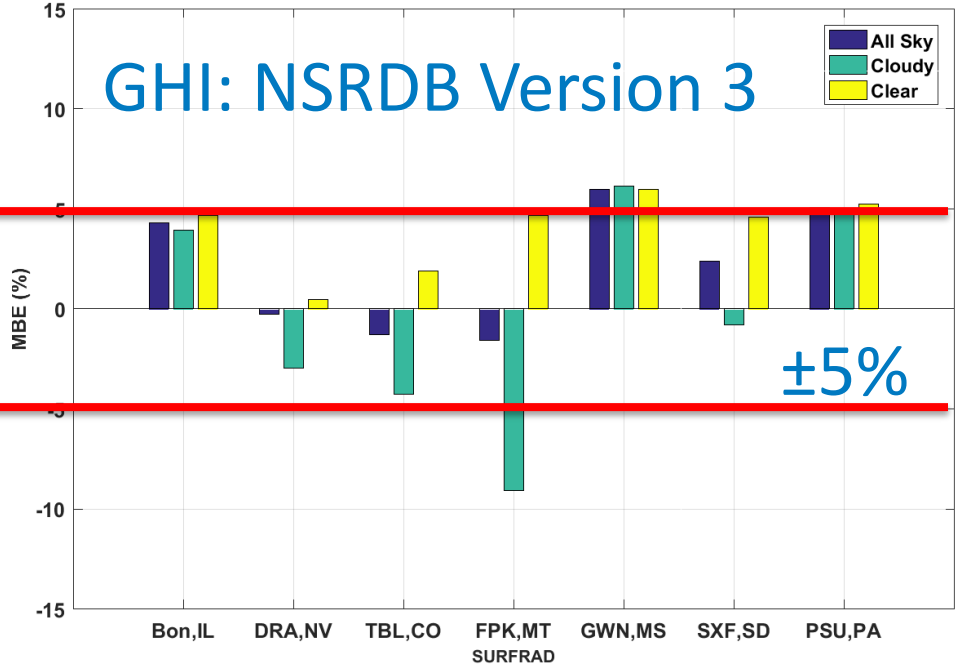


Uncertainty estimation includes:

- MBE
- RMSE
- Surface measurement uncertainty.

Validation of NSRDB Using Surface-Based Measurements

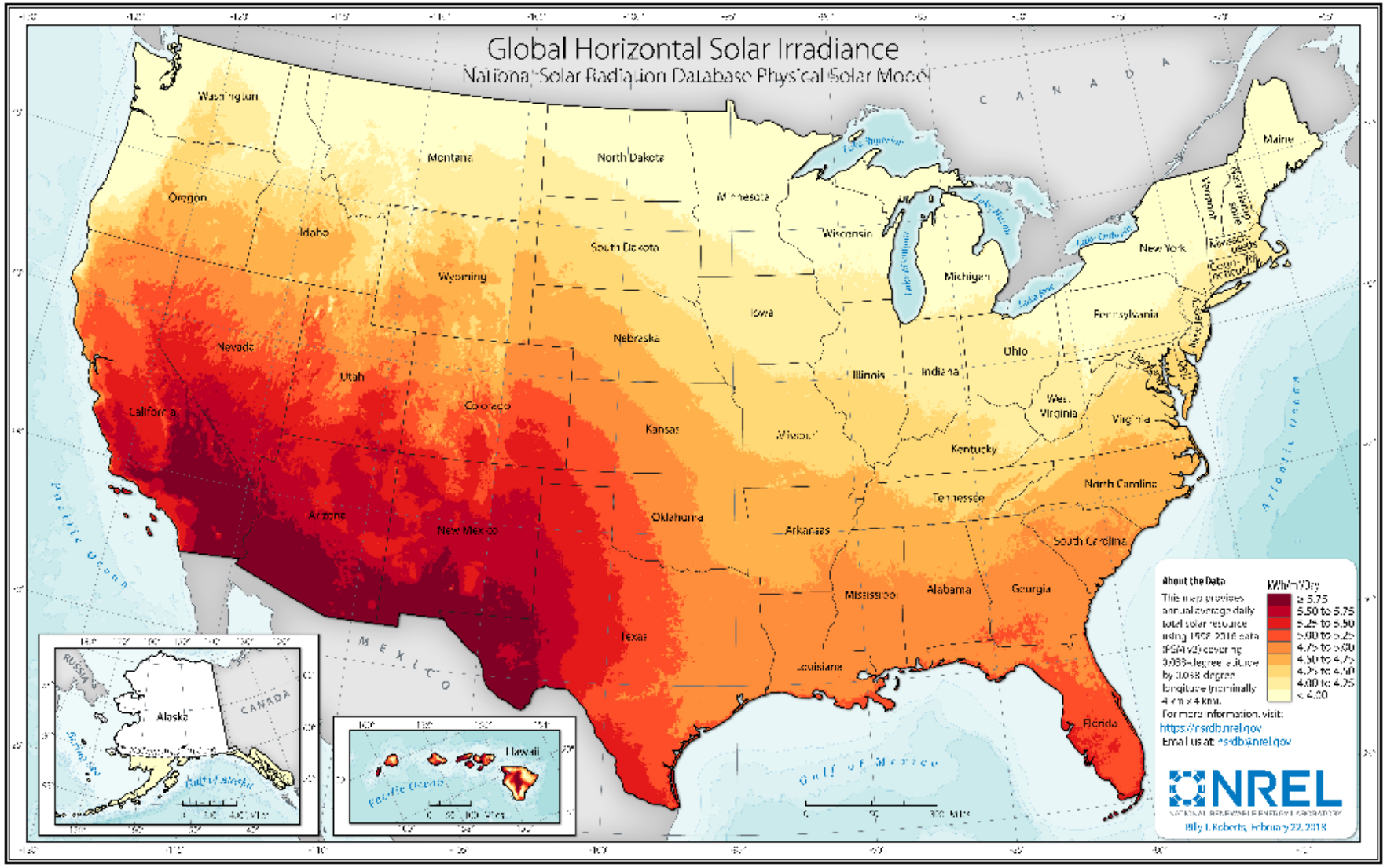




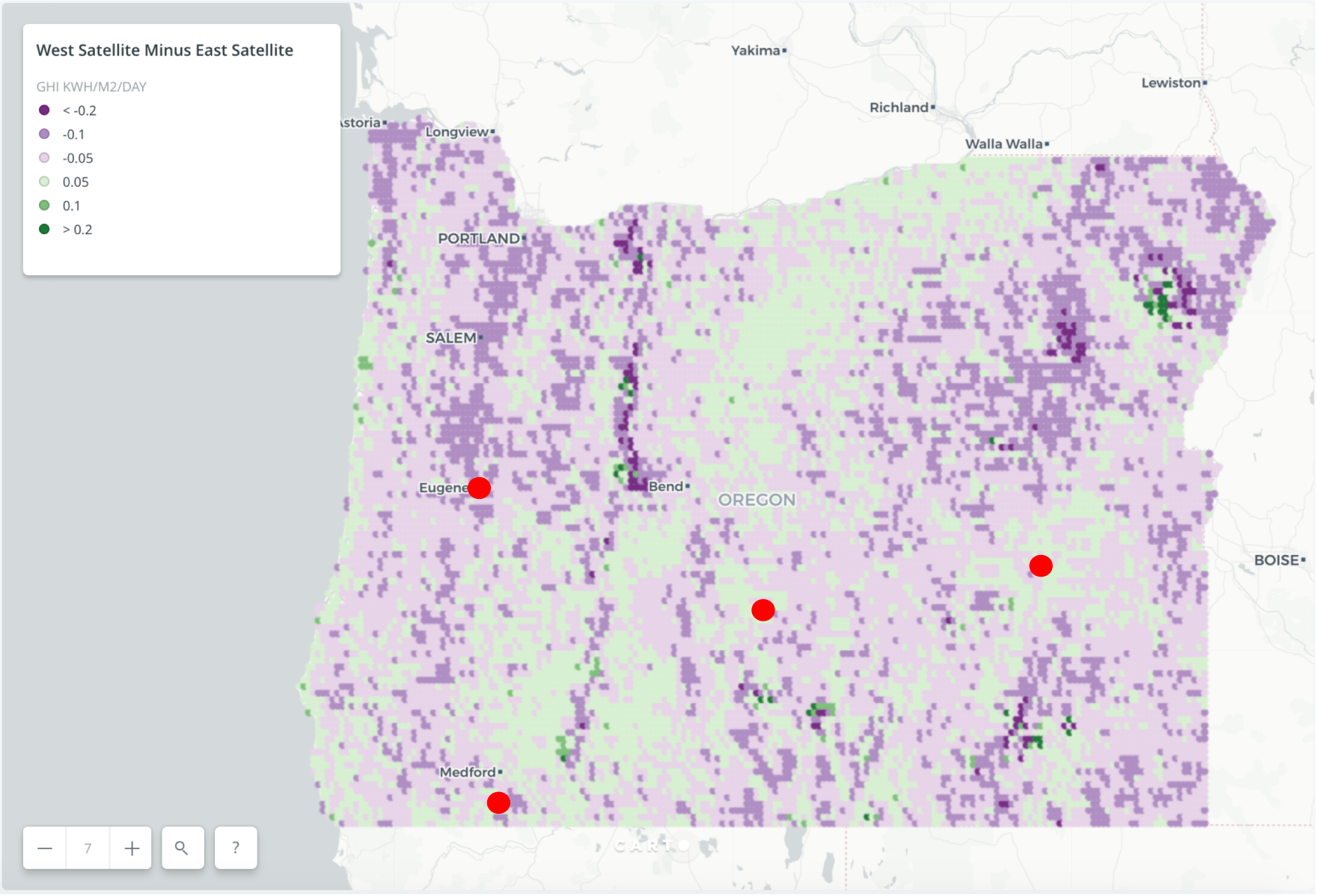
Difference between the two versions:

- MERRA-2 AOD vs climatological AOD
- Precipitable water vapor from MERRA2
- Surface Albedo from MODIS and Snow Cover from IMS
- Some of downscaling calculations for ancillary variables
- Time shifting method on GOES East.

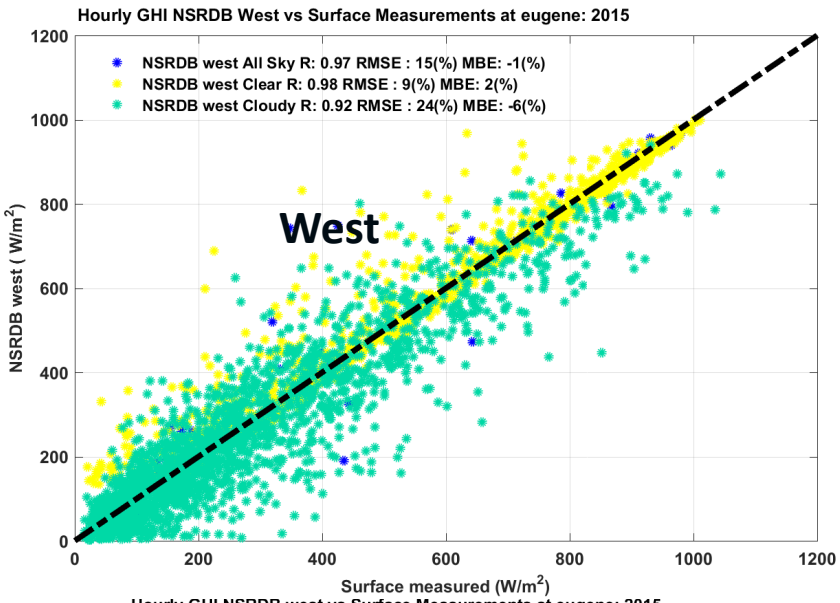
GOES East and West Comparison

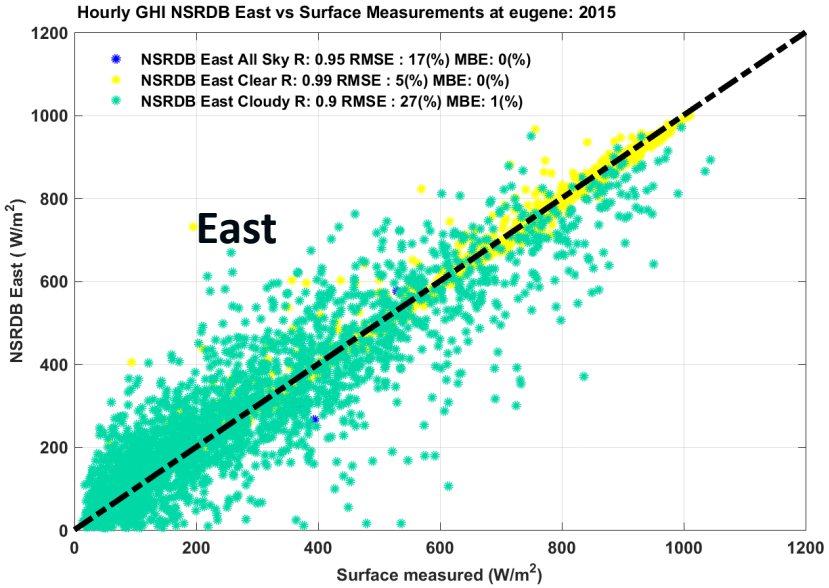


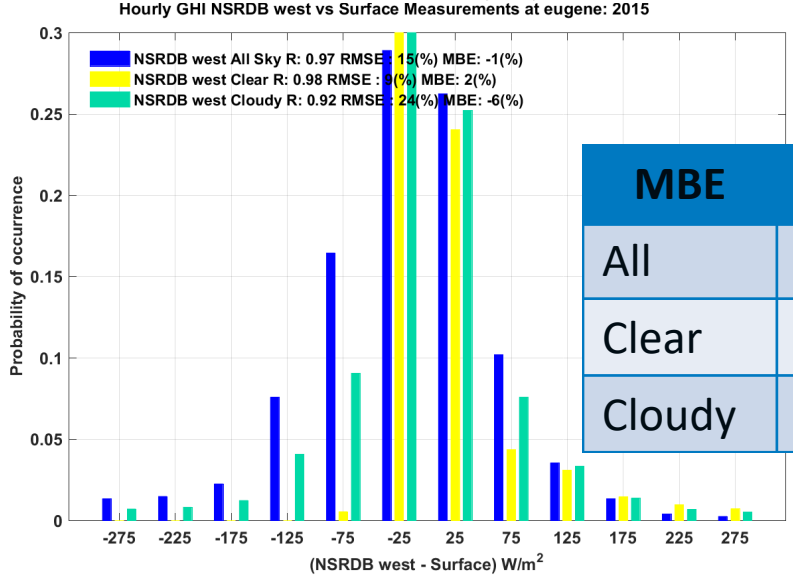
GOES East and West Comparison



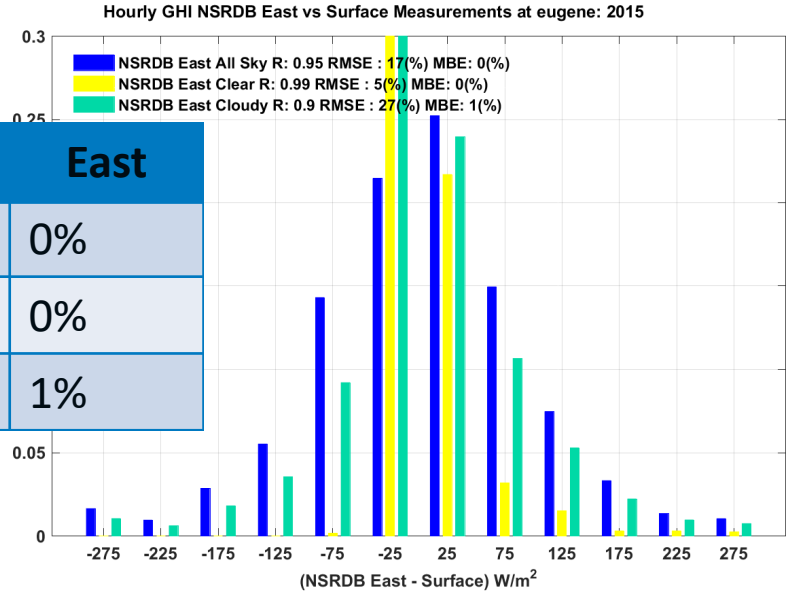
GOES East and West Comparison with Surface Measurements





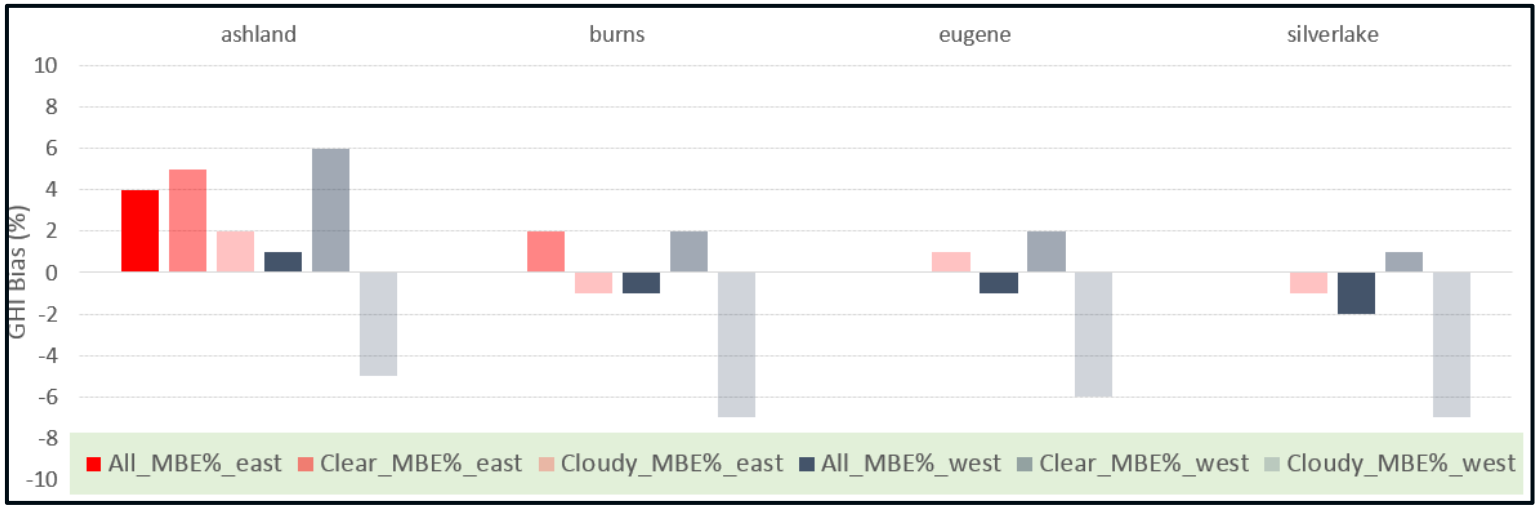


MBE	West	East
All	-1%	0%
Clear	2%	0%
Cloudy	-6%	1%



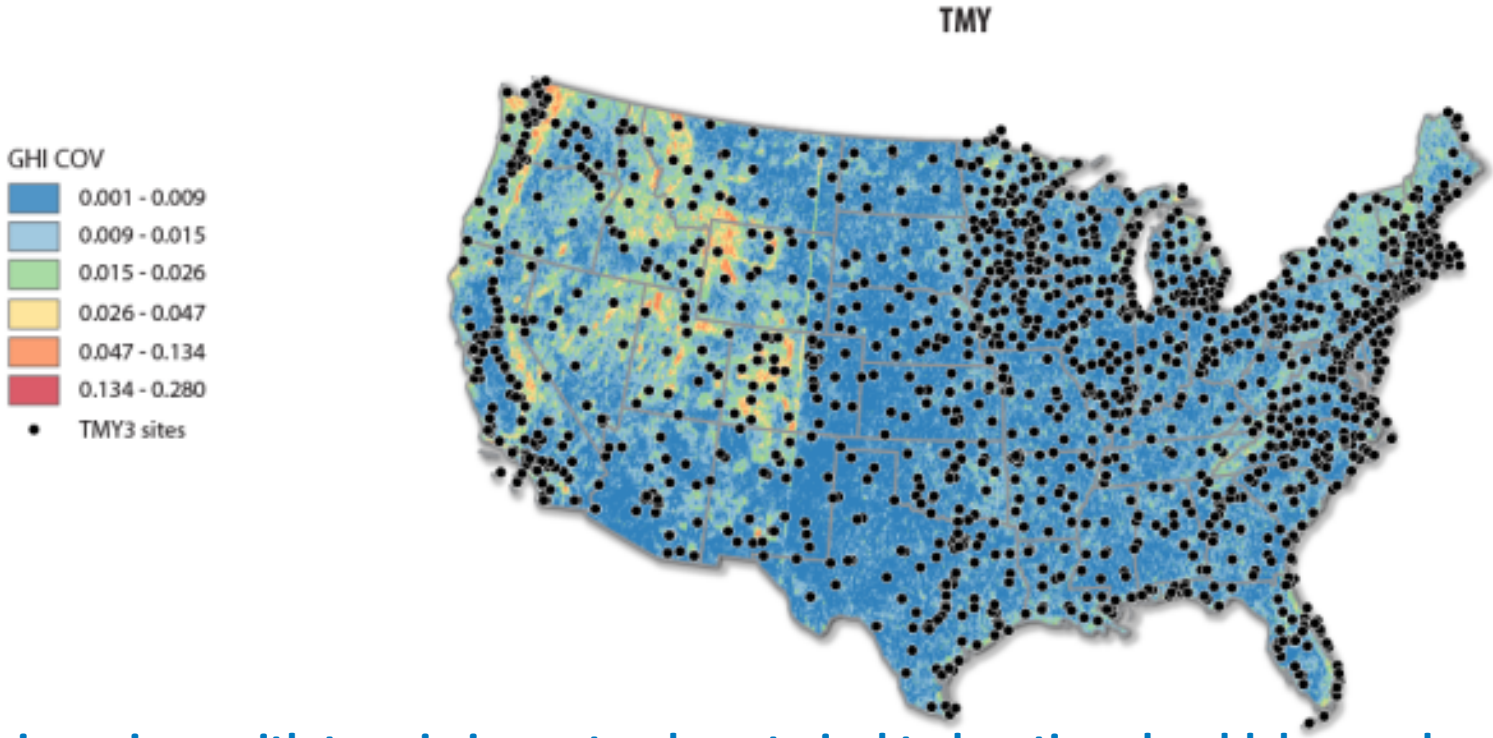
GOES East and West Comparison with Surface Measurements

			MBE%					
			East			West		
Station	Latitude	Longitude	All	Clear	Cloudy	All	Clear	Cloudy
Ashland	42.19	-122.7	4	5	2	1	6	-5
Burns	43.52	-119.02	0	2	-1	-1	2	-7
Eugene	44.05	-123.07	0	0	1	-1	2	-6
Silverlake	43.12	-121.06	0	0	-1	-2	1	-7



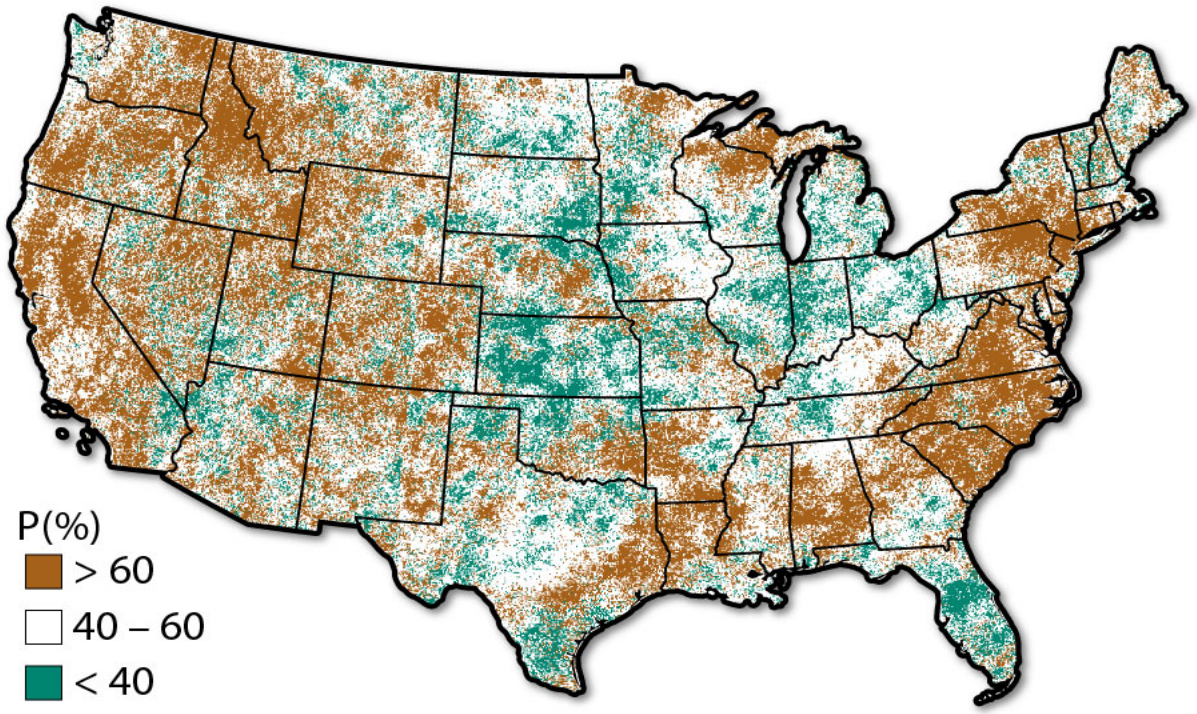
TMY: Spatial Variability using Coefficient of Variation

COV (σ/μ) using 5x5 pixels. Each NSRDB pixel is 4km x 4km.



COV is higher in regions with terrain impacts: closest pixel to location should be used. Measurements should be taken as close as possible to actual location.

Probability of Exceedance using TMY



Calculation of PV generation using TMY after converting to single-axis tracking solar resource using Perez transposition model.

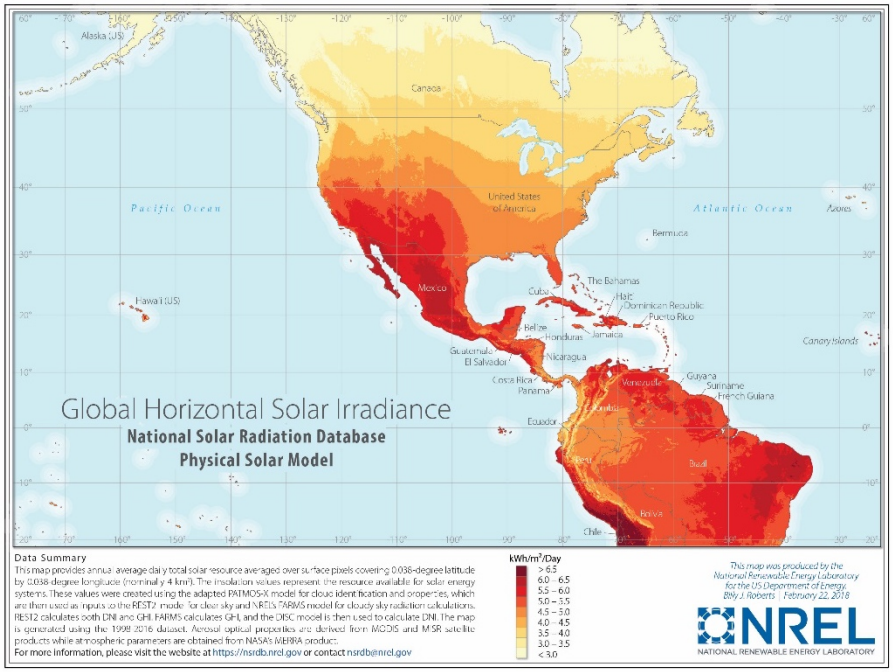
TMY represents median for horizontal but does not represent the median for other orientation.

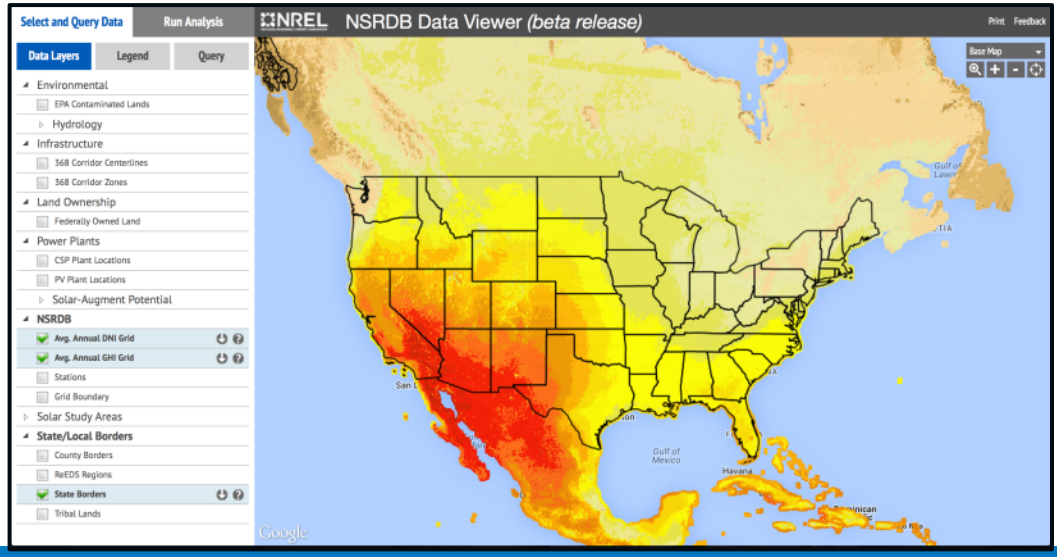
Do we need tilt-specific TMY?

Accessing the NSRDB Data: What's Available

USA and North and South America:

- Current product (4-km, half-hourly) available from 1998–2016 (Model V3)
- Typical meteorological year (TMY) product is also available.
- Multiple summary products are available with current data sets.





https://nsrdb.nrel.gov

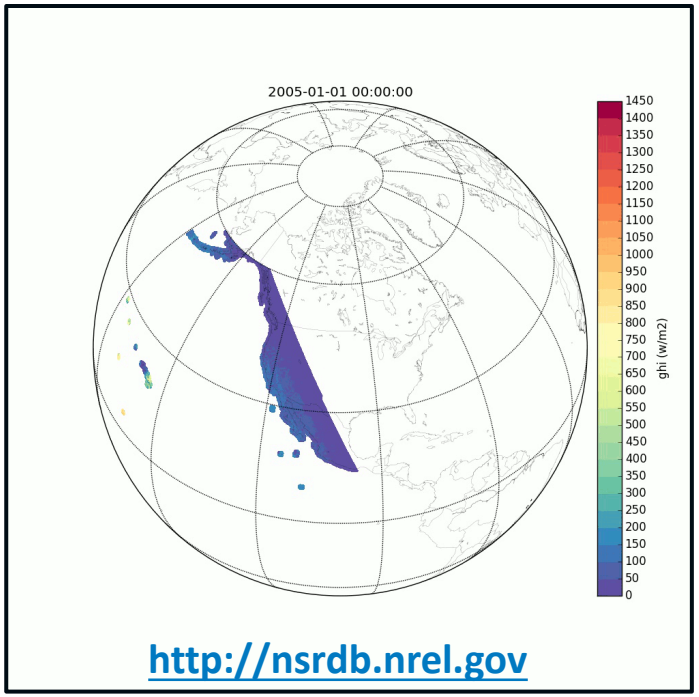
Accessing the NSRDB Data: What's Available

15 Variables are Delivered Publicly:

Dataset in the NSRDB	
Data used in PSM	**Publicly available datasets**
• MERRA-2 ○ Atmospheric pressure ○ Surface albedo ○ Aerosols ○ Aerosol optical thickness ○ Single scattering albedo ○ Aerosol Angstrom parameter. ○ Total ozone ○ Precipitable water. • GOES (PATMOS-X retrievals) ○ Cloud effective radius ○ Cloud optical depth ○ Cloud type. • Moderate Resolution Imaging Spectroradiometer/National Snow and Ice Data Center ○ Surface albedo.	• Global horizontal irradiance (GHI) • Direct normal irradiance (DNI) • Diffuse horizontal irradiance (DHI) • Clear-sky GHI, DNI, and DHI • Cloud type • Dew point** • Air temperature* • Atmospheric pressure • Relative humidity** • Solar zenith angle • Precipitable water* • Wind direction** • Wind speed.**
* From MERRA-2 ** Recalculated from MERRA-2	

Future Work

- Improved identification and use of high albedo surfaces (sand and snow).
- Spectral data sets in the plane of array.
- Improved cloud retrievals from GOES-16.
- Aerosol retrieval from GOES-16.
- 5-min. data from GOES-16.



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