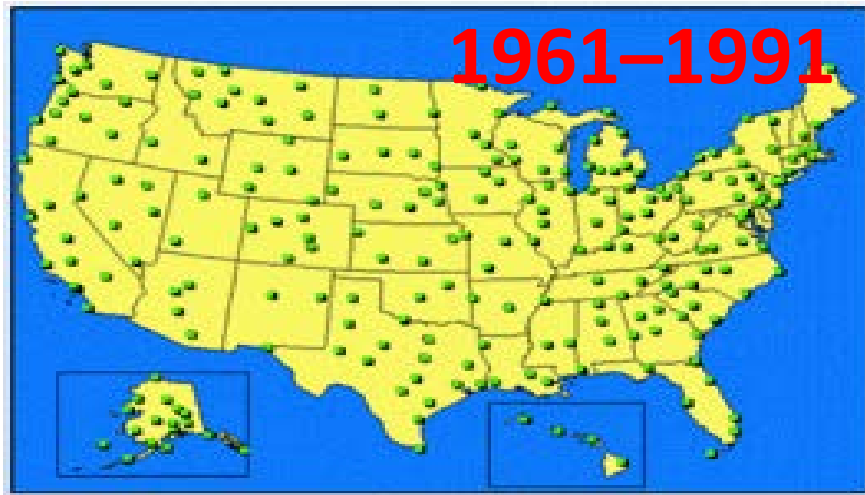




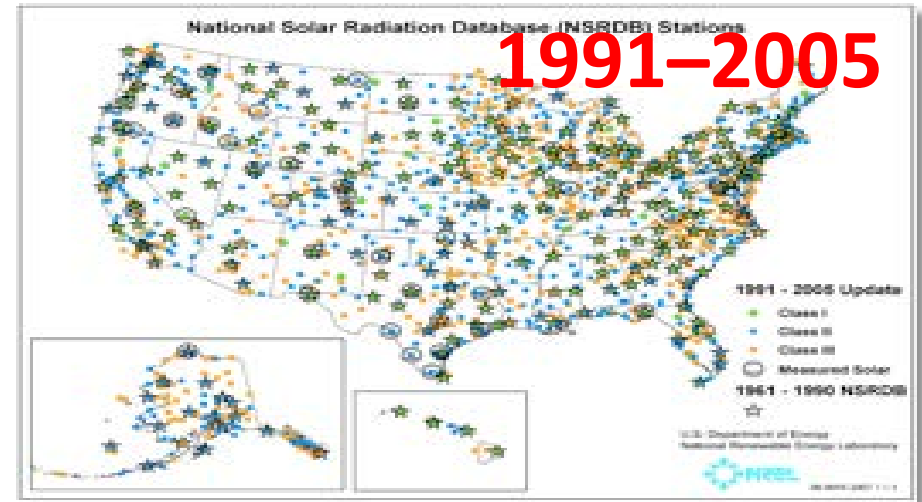
## The National Solar Radiation Data Base (NSRDB)

**Manajit Sengupta, Aron Habte, Anthony Lopez, and Yu Xie**  
**AGU Fall Meeting, December 12, 2017**

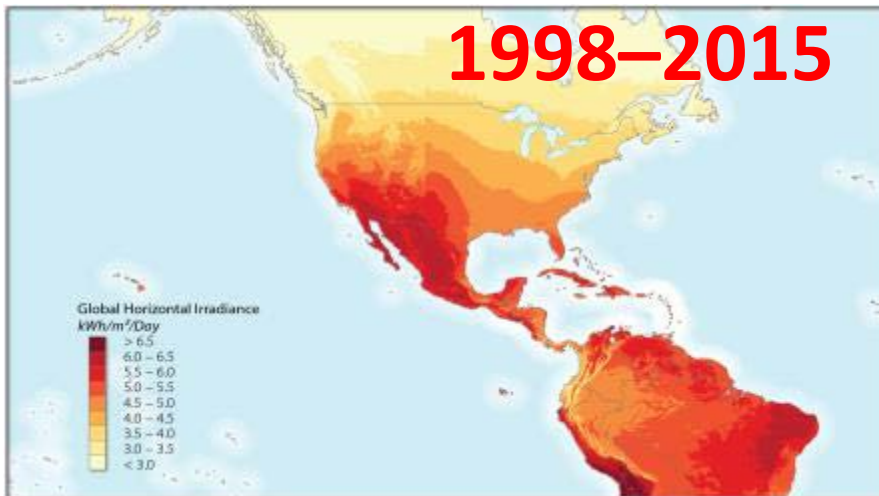
# History of the NSRDB



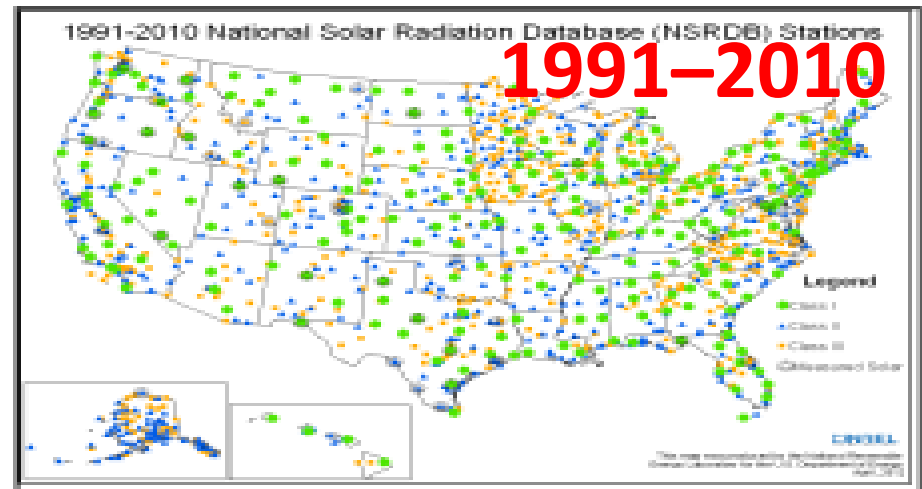
239 locations (DOE, NOAA, **1994**)



1,454 locations (DOE, SUNY, NOAA, **2007**)



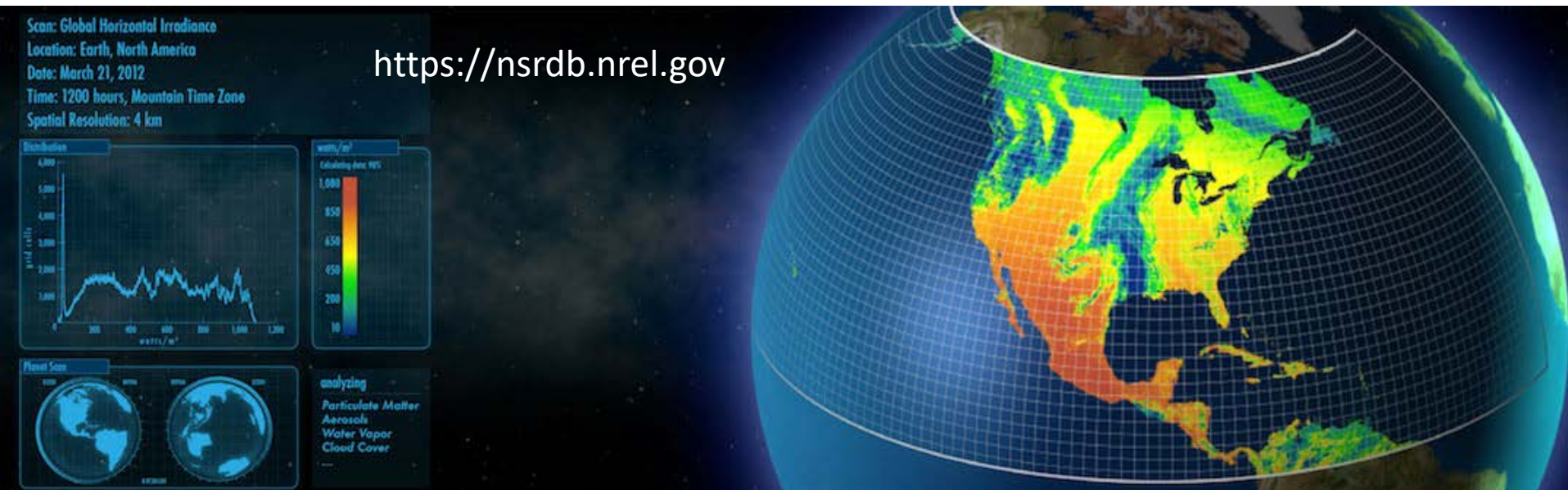
4 km x 4 km, half-hourly (DOE, NOAA, UW, SCS, **2016**)



1,454 locations (DOE, CPR, **2012**)

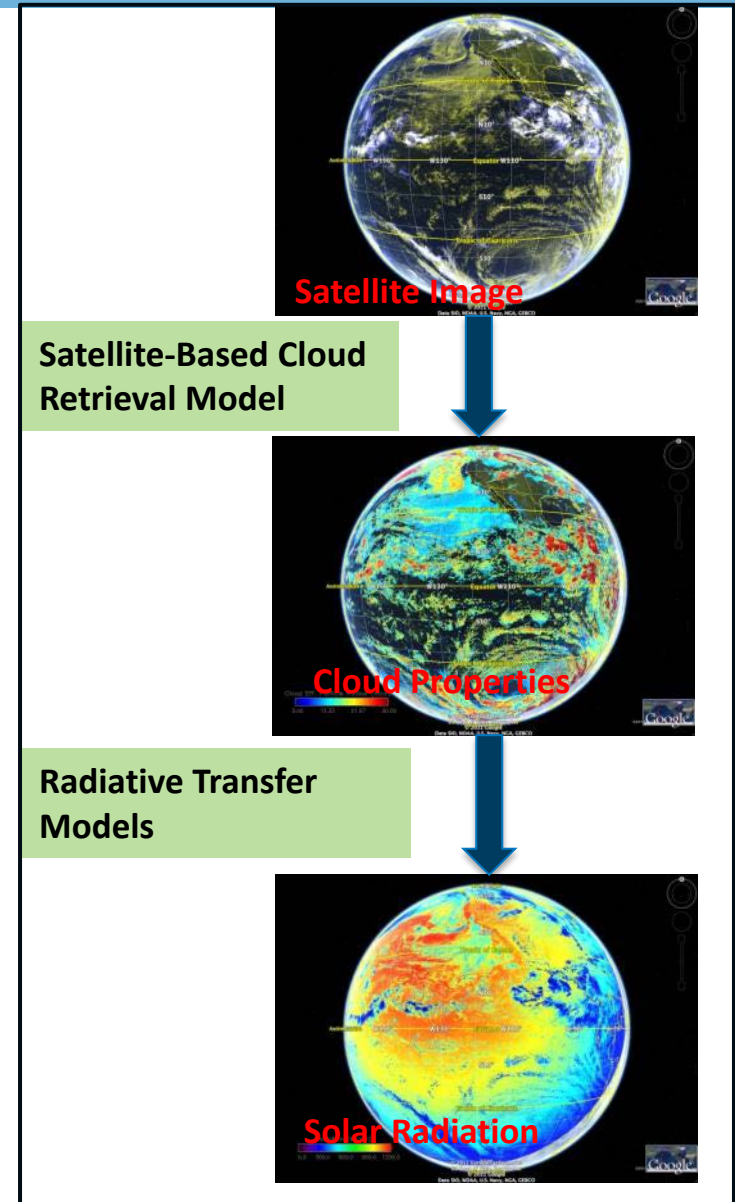
# The Latest Version of the NSRDB

- The NSRDB was developed using GOES satellite data across the United States and Central America and in a growing number of international locations (India, Bangladesh, Bhutan...).
- The NSRDB provides 18 years (+ Typical Meteorological Year) of half-hourly data at a 4x4 km spatial resolution.
- The NSRDB uses a 2-step physics-based solar model, the PSM.

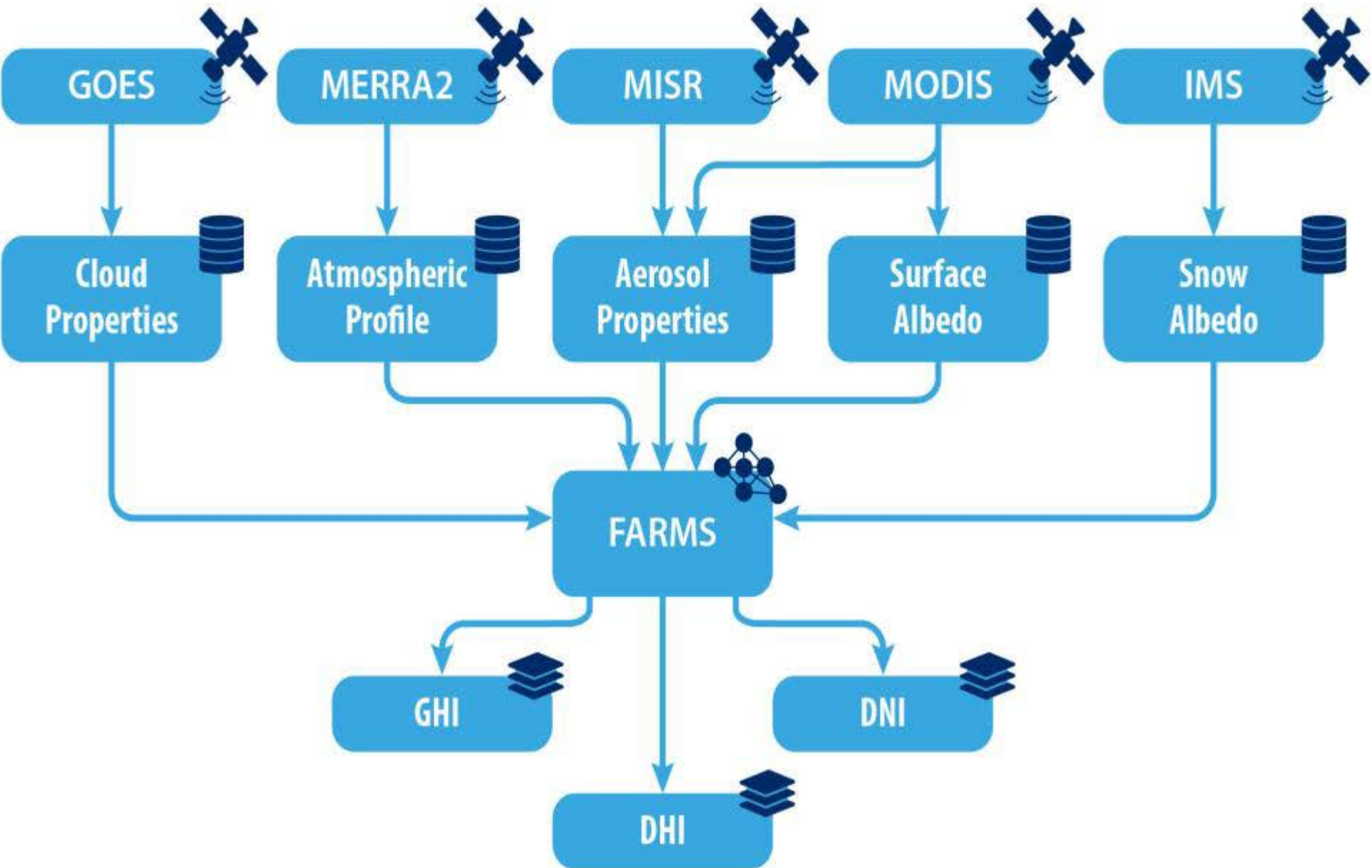


# How Do Satellites Model Surface Radiation?

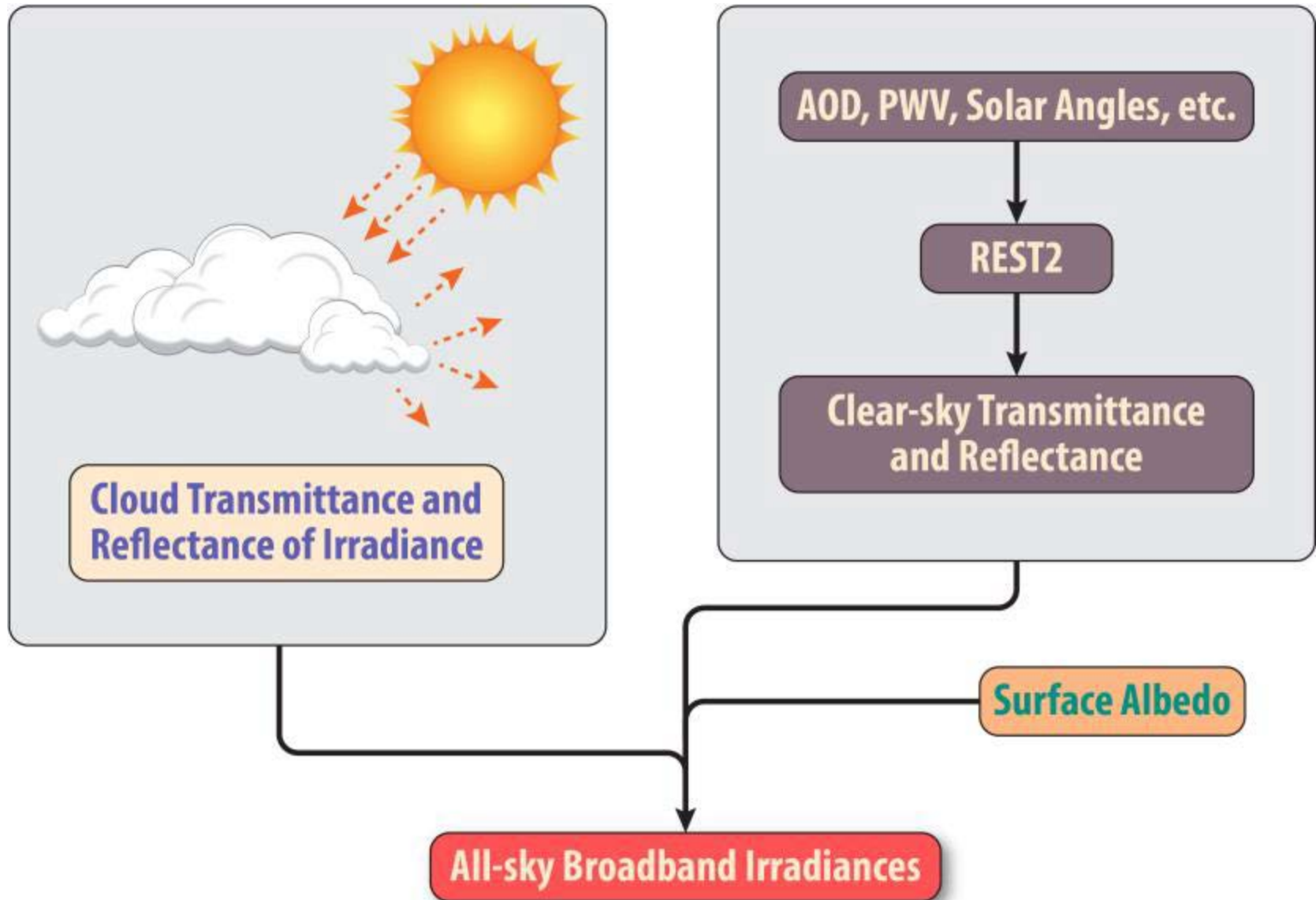
- **Empirical approach**  
Regression functions relating GHI measurements at selected locations to the data from satellite's visible channels.
- **Semi-Empirical approach**  
A clearness index is determined and used to scale the clear-sky irradiance to estimate GHI.
- **Physics approach**
  - Retrieve cloud and aerosol information from satellite data.
  - Use the information in a radiative transfer model.



# Physical Solar Model (PSM) Framework



# Fast All-sky Radiation Model for Solar applications (FARMS)



Xie et al., *Solar Energy* (2016)

# Data Processing for consistent spatial and temporal mapping

Reprocesses input data into the NSRDB grids (4 km)

**Regridding**

**Temporal Interpolating**

Assigns data to the NSRDB time intervals (30 mins)

Supplements the NSRDB for data gaps in the long-term cloud properties

**Gap Filling**

**Time Shifting**

Projects cloud properties to the NSRDB time stamps.

# Data Processing

- **NREL's Peregrine is the largest HPC system in the world for renewable energy and energy efficiency technologies.**
- **58,752 Intel Xeon processors which provide a total of about 2.26 PetaFLOPS**

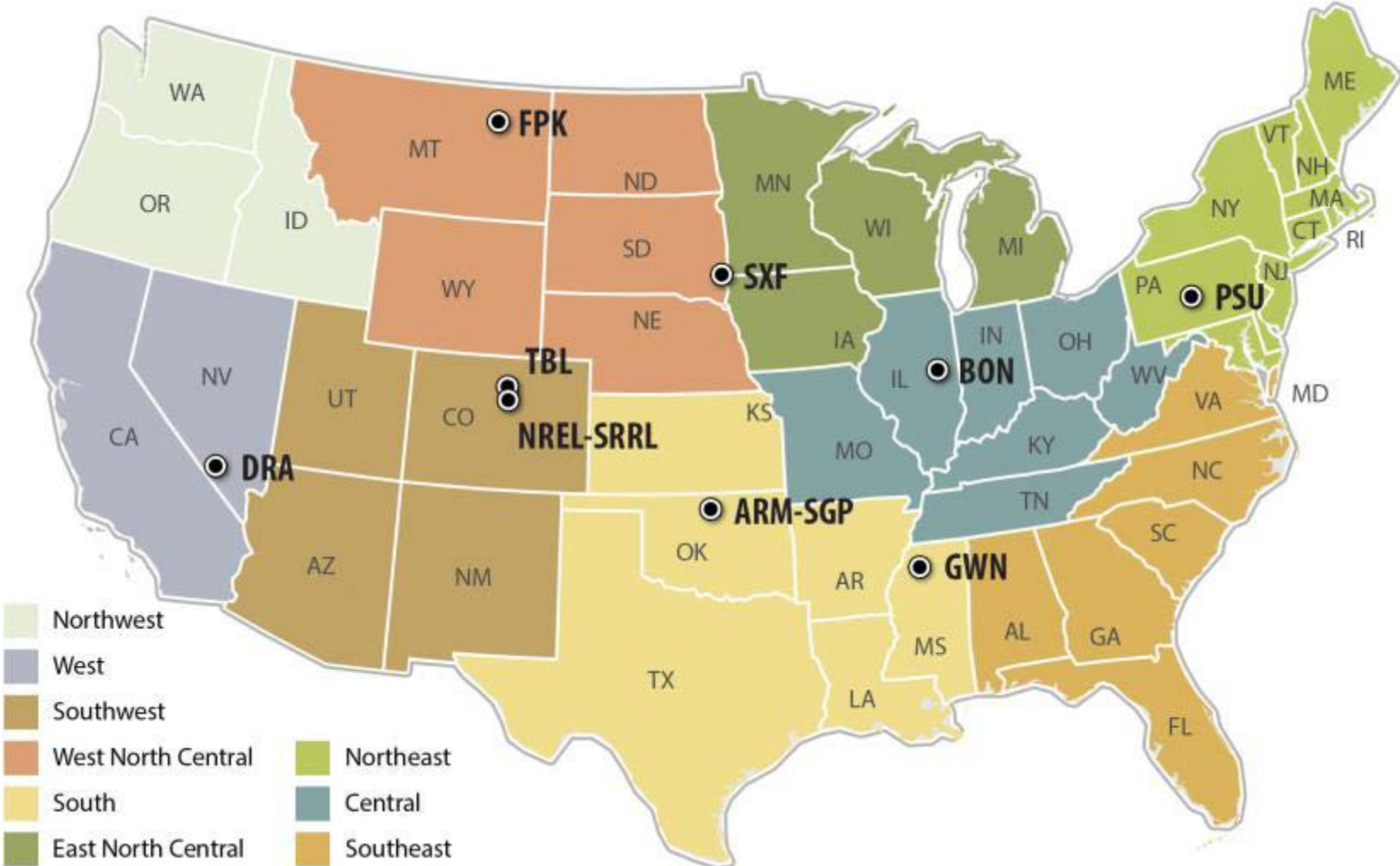


Photo by Dennis Schroeder, NREL 45369.

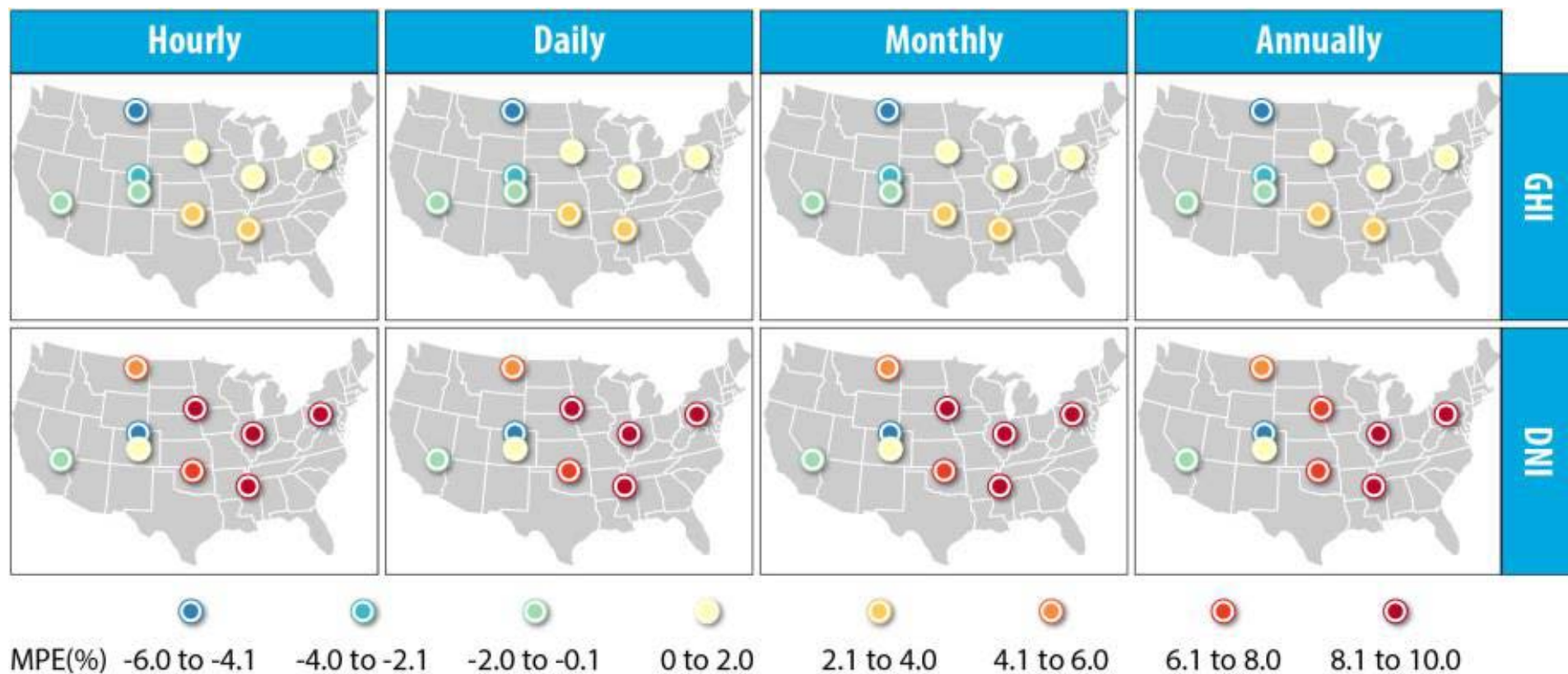


# Validation of Satellite Product Using Surface-Based Measurements

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

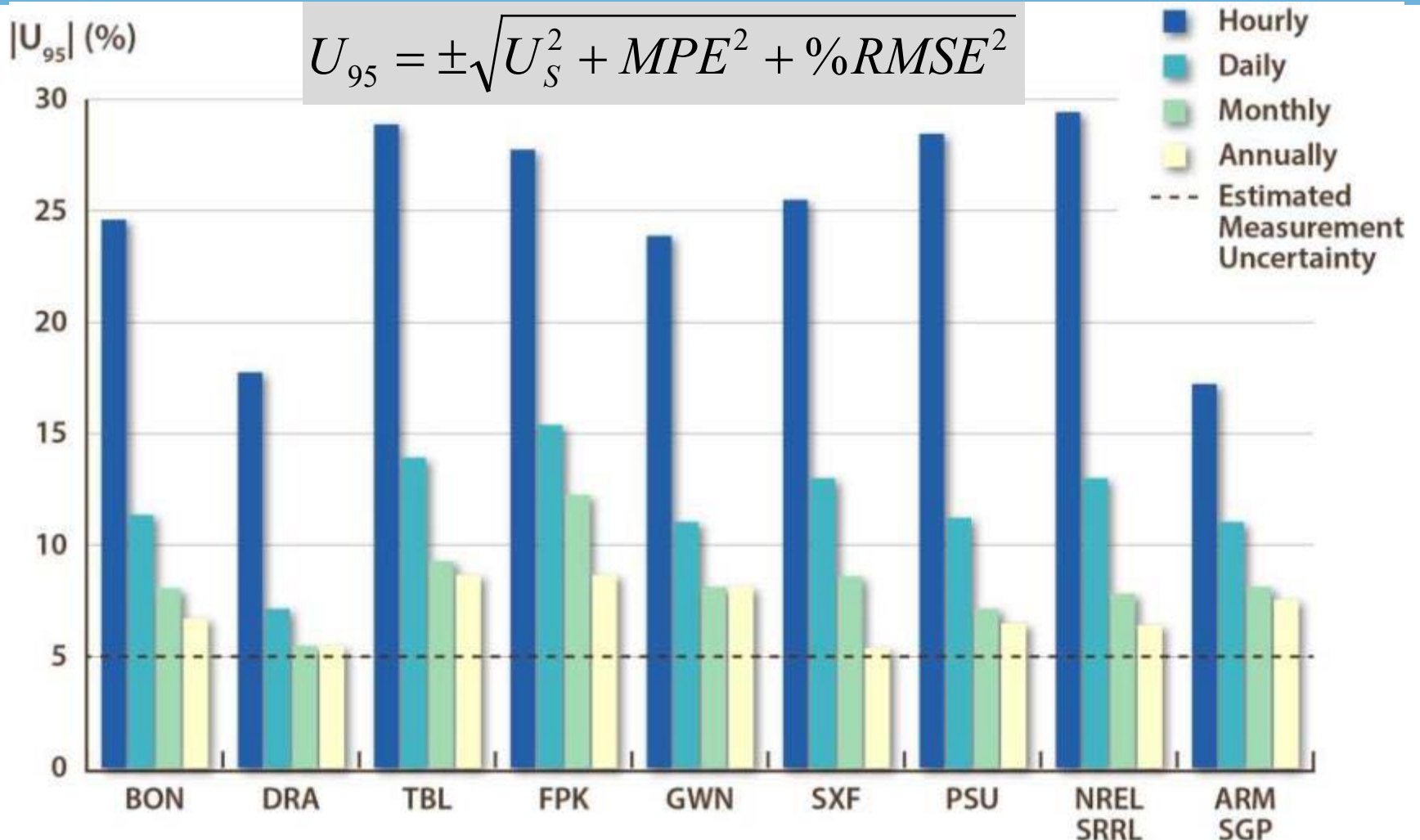


# Validation with Surface-Based Measurements



- The MPEs of hourly, daily, monthly, and annually averaged NSRDB do not significantly vary.
- The MPE of GHI is within 5%. The MPE of DNI is within 10%.
- Advanced technology in satellite remote sensing of clouds is needed to improve the accuracy in the DNI simulation.

# Guide to the Expression of Uncertainty in Measurement (GUM)



The analysis based on GUM implements the effects of statistical distributions, accounts for uncertainty in observations, and represents model bias with a confidence interval.

# NSRDB Viewer

Select and Query Data | Download Data | NREL NSRDB Data Viewer

**Data Layers** | Legend | Query

- Environmental
- Infrastructure
- Land Ownership
- Power Plants
- Ground Measurement Sites
- NSRDB**
  - Spectral TMY
  - MTS1
  - MTS2
  - MTS3
  - PSM Direct Normal Irradiance
  - PSM Global Horizontal Irradiance
  - Summary Statistics
  - India Summary Statistics
- SUNY
- Solar Study Areas
- State/Local Borders

**Download Site Data**

**Query**

**Style**

**Download Data Set**

**View Map Layers**

- MTS3
- PSM Direct Normal Irradiance
- PSM Global Horizontal Irradiance
- Summary Statistics
- India Summary Statistics

<https://nsrdb.nrel.gov> or the Application Programming Interface

# Accessing the NSRDB Data: What's Available

## Used in the PSM:

- 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/Interactive Multisensor Snow and Ice Mapping System.

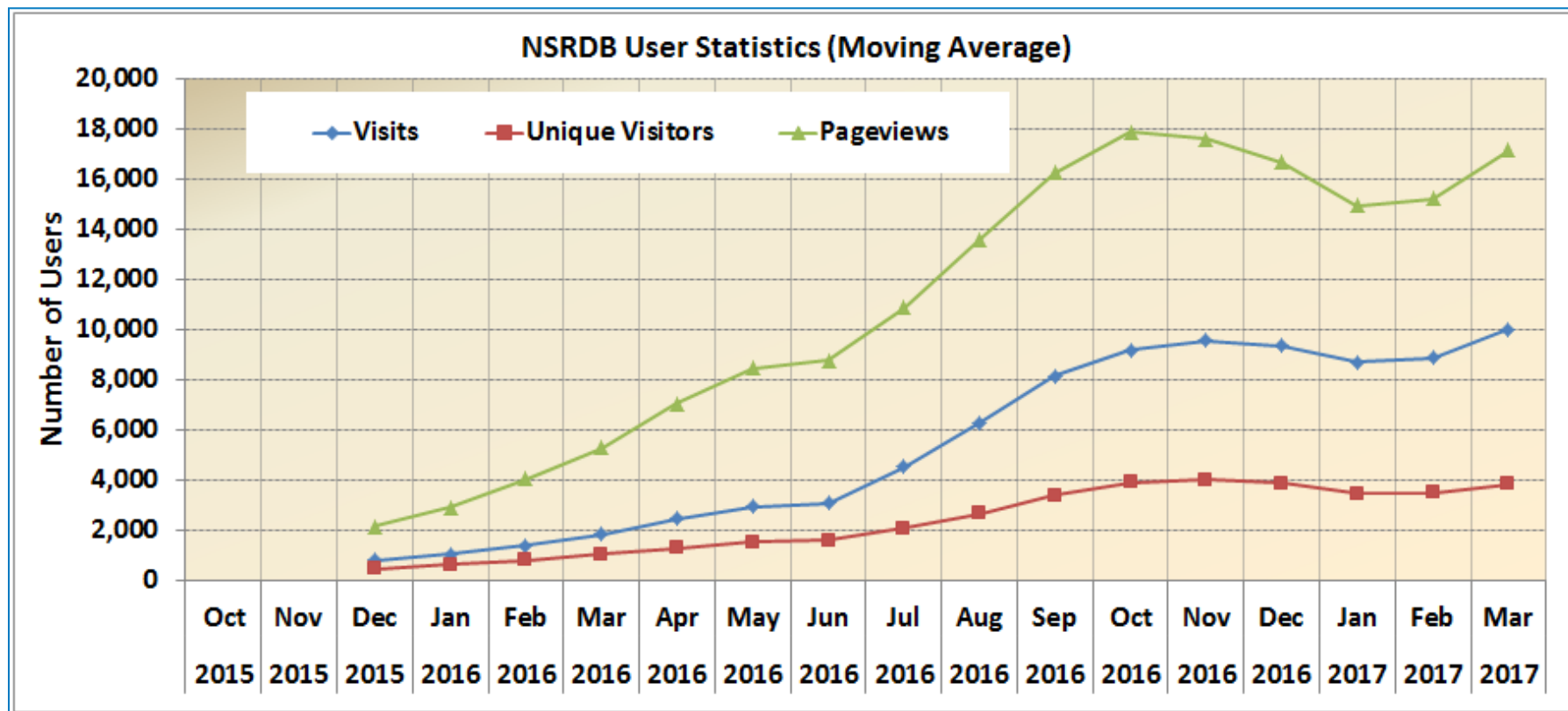
## Delivered to the Public:

- 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.\*

**We also deliver meteorological data from MERRA2 that are regridded and interpolated to the NSRDB resolutions.**

\* Source: MERRA-2

# How Is the NSRDB Used?



- The latest NSRDB has become a heavily and increasingly used dataset in the 2 years since its deployment.
- Monthly data visit has doubled to more than 10,000 in 12 months.
- Users include universities, governments, research institutes, utilities, and energy and high-technology companies.

# How Is the NSRDB Used?

Energy related applications include building design, grid planning and operation models, and models to estimate power output or assess cost and feasibility.

Non-energy related applications include helping understand the geographic disparities in cancer prognosis.



# Future work

- **Spectral irradiances in the POA**
- **A new DNI model to bridge the gap between model simulation and surface observation.**
- **New satellite retrievals in 2016 and improved AOD data from MERRA2. Improved cloud products from GOES-16.**
- **Identifying low clouds and fog; discrimination of clouds from snow; specular reflection on bright surfaces; and reducing uncertainties of parallax.**

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# Q&A or Thank you

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