



## Use of MERRA-2 in the National Solar Radiation Database and Beyond

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# Outline

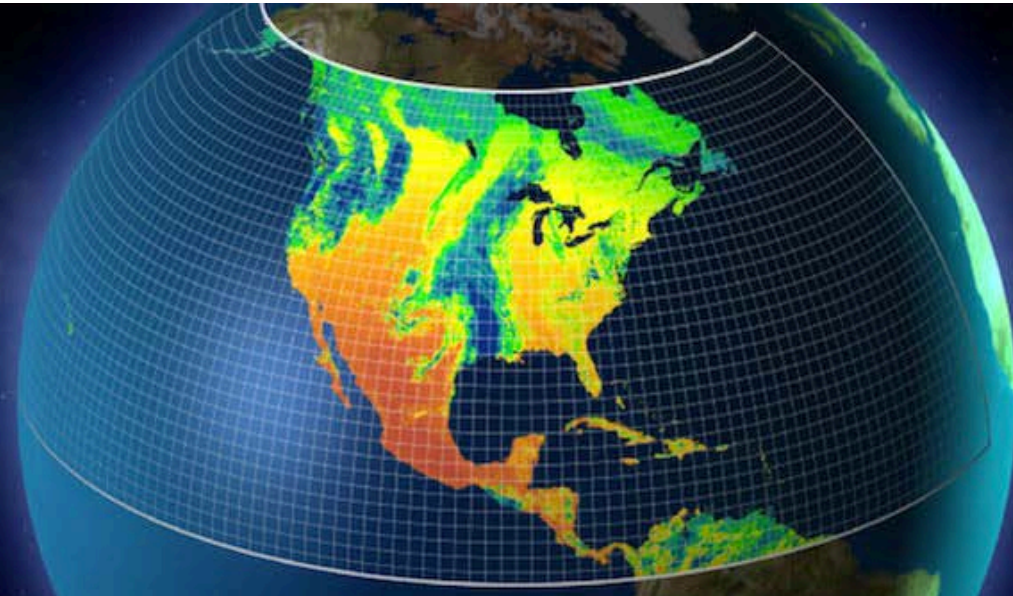
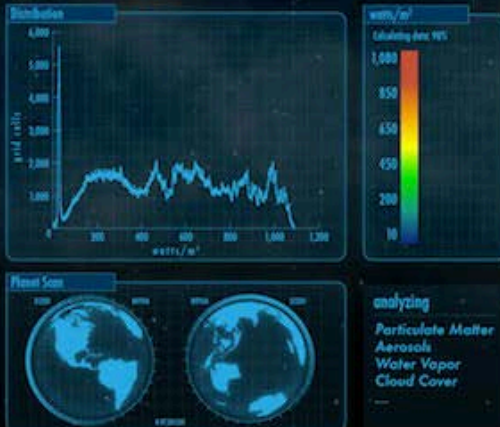
- National Solar Radiation Database (NSRDB)
- Physical Solar Model (PSM) in the NSRDB
- Data sets required for the NSRDB
- Why MERRA-2 is used in the NSRDB?
- Use of NSRDB in general
- Use of NSRDB at NREL
- Wish list for future use.

# National Solar Radiation Database

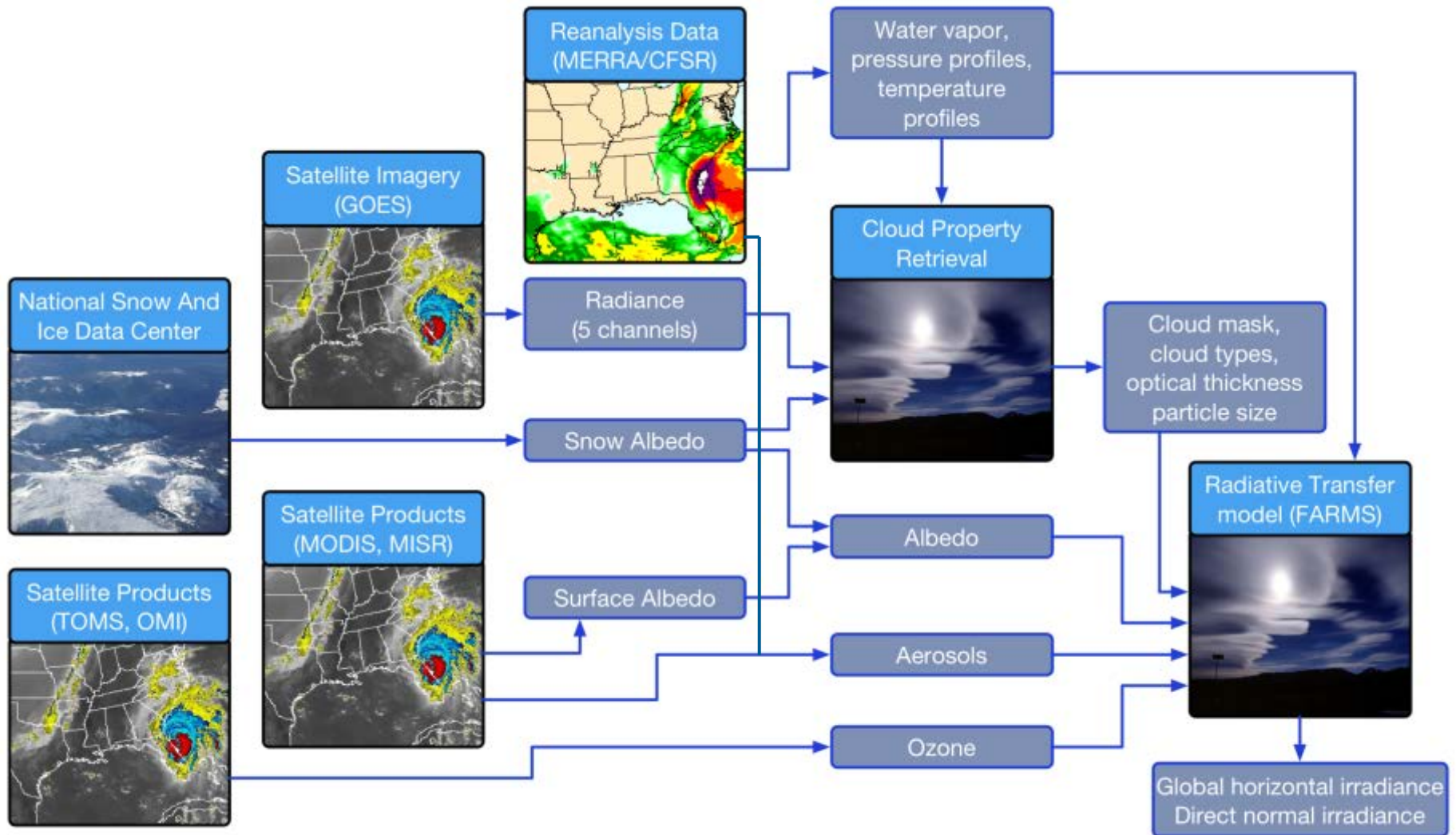
- The NSRDB seeks to advance our knowledge of solar radiation and its application for renewable energy and beyond.
- The NSRDB provides a serially complete database of solar irradiance and meteorological information across the United States and in a growing number of international locations.
- The NSRDB provides 18 years (+ Typical Meteorological Year) of half-hourly data at a 4x4-km spatial resolution.
- The NSRDB uses the physics-based model, the **PSM**.

Scan: Global Horizontal Irradiance  
Location: Earth, North America  
Date: March 21, 2012  
Time: 1200 hours, Mountain Time Zone  
Spatial Resolution: 4 km

<https://nsrdb.nrel.gov>



# Physical Solar Model Framework



# Data Sets in the NSRDB

## 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/National Snow and Ice Data Center
  - Surface albedo.

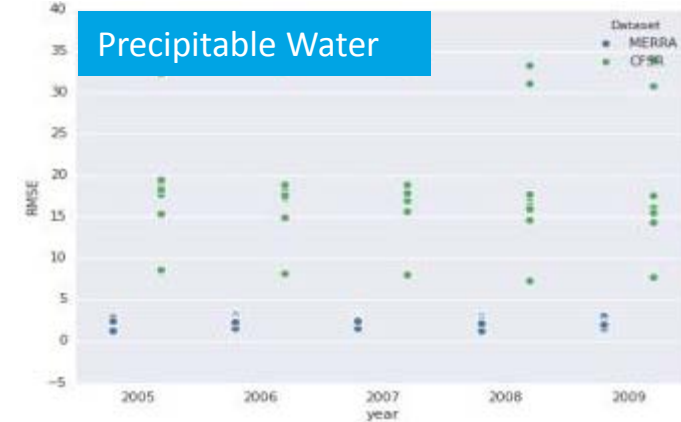
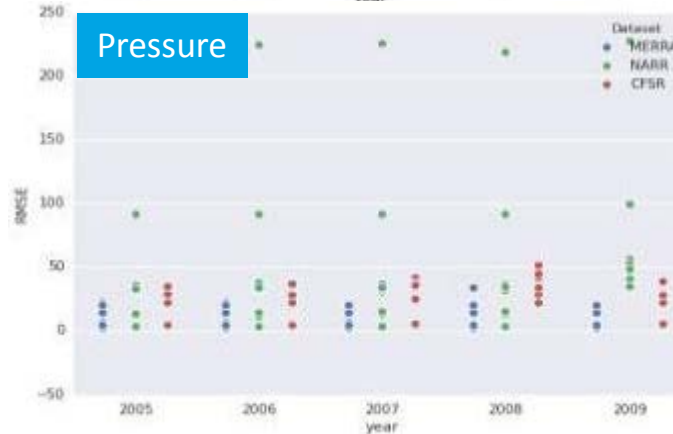
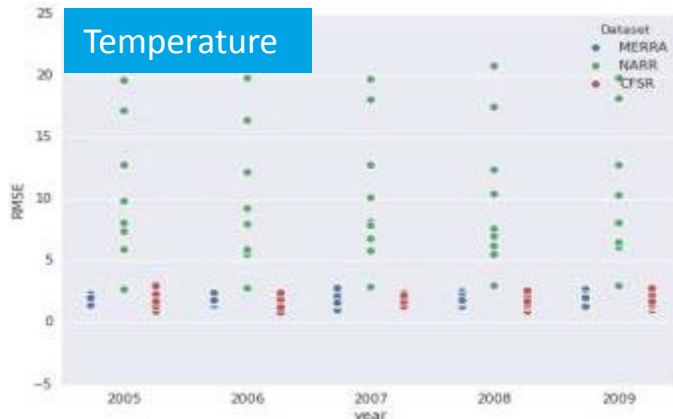
## Delivered to the Public:

- 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.\*

\* Source: MERRA-2

# Evaluation of Meteorological Data for Use in the NSRDB

MERRA data were found to have lower root-mean-square error (RMSE) compared to CFSR\* and NARR\*.



● CFSR      ● NARR      ● MERRA

Comparison with 216 stations for 2006–2012 period.

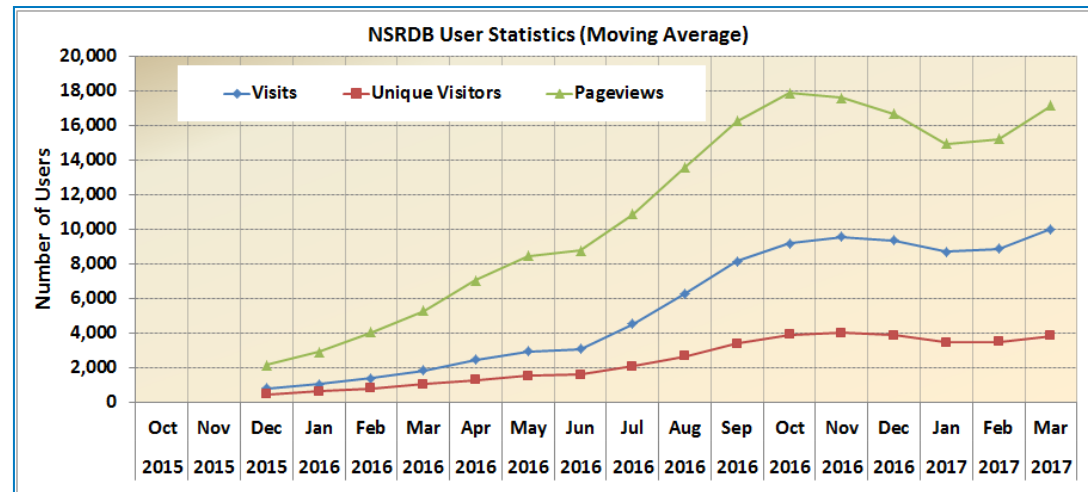
\*Climate Forecast System Reanalysis (CFSR)  
\*North American Regional Reanalysis (NARR)

# How Is the NSRDB Used?

The NSRDB and thus MERRA-2 are used by a variety of public and private organizations.

## Uses include

- Solar energy prospecting
- Solar generator design
- Cancer research
- Education and general research
- Power system modeling and planning
- Microgrid and rural electrification
- Solar variability
- Climate change research
- Forecasting
- And more...



*The NSRDB has become a heavily used data set in less than two years of deployment. Innovative small companies are significant users, leading to a reduction in barriers to solar development. More than \$20 million in internal NREL research on **grid integration, energy modeling, resource planning, and production cost modeling** are facilitated by the NSRDB.*

# How Is the NSRDB Used at NREL?

**Large analysis and vision studies use a variety of models that use the NSRDB:**

- Grid-planning modeling (ReEDS, RPM)
- Grid operations modeling (PLEXOS)
- Distributed Generation Market Demand modeling (dGen)
- Techno-economic assessment (reV)
- Performance and financial modeling (SAM).

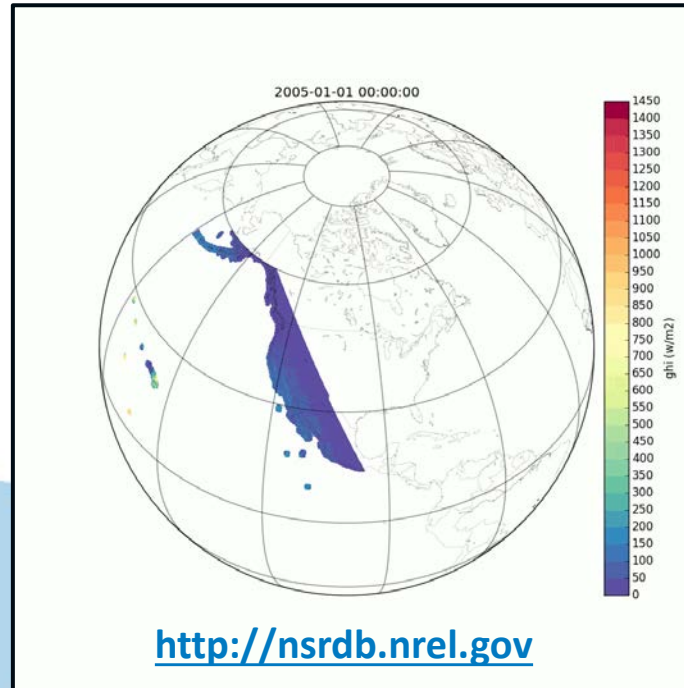




# Our Wish List for MERRA-2 and Beyond

- Standardized or consensus methodology for spatial downscaling of the  $\sim 0.5$ -degree MERRA-2 data
- Increase in spatial resolution
- Addition of data sets:
  - Dew point
  - Relative humidity
  - Surface elevation information.

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[www.nrel.gov](http://www.nrel.gov)

