Release of the New National Solar Radiation Database (NSRDB)

NSRDB Webinar

Dr. Manajit Sengupta, Anthony Lopez, Aron Habte, Dr. Yu Xie, Andrew Weekley, Christine Molling, Christian Gueymard, Paul Edwards, and Dan Getman

December 08, 2015
Webinar Outline

- Motivation and History
- Development of the New Gridded NSRDB
  - Physical Solar Model (PSM) Framework
- New NSRDB Website and How to Access Data
- Data Availability
- Future Plans
Support DOE SunShot goal of reducing the costs of solar deployment and financing through providing high-quality publicly available solar resource information.
National Solar Radiation Database: History

http://nsrdb.nrel.gov

Evolution of Public Solar Data

1952-1975 SOLMET\(^1\) [ERDA, NOAA, 1979]

1961-1990 NSRDB\(^2\) [DOE, NOAA, 1994]

1991-2005 NSRDB-II\(^3\) [DOE, NOAA, 2007]

1998-2014 NSRDB [DOE, NOAA, UW, SCS 2015]

(1) 248 stations with 26 Measurement Stations 1977-80

(2) 239 Modeled Stations with 56 partial measurement stations 1990

(3) 1,454 Modeled Locations 1991-2005
How Do Satellites Model Surface Radiation?

• **Empirical Approach (Traditional Approach):**
  – Build model relating satellite measurements and ground observations (cloud index and clearness index)
  – Use those models to obtain solar radiation at the surface from satellite measurements

• **Physical Approach: (New Approach)**
  – Retrieve cloud and aerosol information from satellites
  – Use the information in a radiative transfer model
Physical Approach to Satellite Modeling

Satellite Image

Satellite-Based Cloud Retrieval Model

Cloud Properties

Radiative Transfer Models

Solar Radiation
Physical Solar Model (PSM) Framework

**Satellite Input**
- GOES data—4 channels: 4 km–30 min

**Ancillary Input**
- NWP Forecast or Reanalysis
- Snow
- Surface emissivity
- Surface reflectance

**RT Model Input**
- Aerosol product from MODIS/MISR satellite and AERONET ground measurements

**Retrieval System**
- PATMOS-x: Cloud algorithms

**Radiative Transfer**
- Clear sky: REST2
- Cloudy sky: NREL FARMS model and DISC model

**Cloud Products**
- Cloud mask
- Cloud type
- Cloud height/temperature/pressure
- Cloud optical depth
- Cloud particle size
- Cloud water path

**Irradiance Products**
- Global horizontal irradiance (GHI)
- Direct normal irradiance (DNI)
- Diffuse horizontal irradiance (DHI)
**PSM: Ancillary/Met Data**

**GOES Satellite-Based Cloud Products**

**Aerosols and Water Vapor From Ancillary Sources**

**Solar Resource using Fast Radiative Transfer Models**

**Satellite Data Validation**

**Data Dissemination**

**Satellite Input**
- GOES data—4 channels: 4 km–30 min

**Ancillary Input**
- NWP Forecast or Reanalysis
- Snow
- Surface emissivity
- Surface reflectance

**RT Model Input**
- Aerosol product from MODIS/MISR satellite and AERONET ground measurements

**Retrieval System**
- PATMOS-x: Cloud algorithms

**Radiative Transfer**
- Clear sky: REST2
- Cloudy sky: NREL FARMS model and DISC model

**Cloud Products**
- Cloud mask
- Cloud type
- Cloud height/temperature/pressure
- Cloud optical depth
- Cloud particle size
- Cloud water path

**Irradiance Products**
- Global horizontal irradiance (GHI)
- Direct normal irradiance (DNI)
- Diffuse horizontal irradiance (DHI)
Met Data for PSM

• Accurate meteorological dataset for use in the NSRDB

• Various reanalysis datasets compared with ground measurements (all Integrated Surface Database (ISD) stations) to identify best data

• NASA Modern Era-Retrospective Analysis (MERRA) dataset, NOAA’s North American Regional Reanalysis (NARR) dataset, and NOAA’s Climate Forecast System Reanalysis (CFSR) compared

• MERRA found to be the most accurate

Comparison between ISD and MERRA, CFSR, and NARR dataset for 9 stations
(A) Dew Point, (B) Precipitable Water, (C) Atmospheric Pressure, and (D) Wind Speed comparison
PSM: Cloud Products

Satellite Input
- GOES data—4 channels: 4 km–30 min

Ancillary Input
- NWP Forecast or Reanalysis
- Snow
- Surface emissivity
- Surface reflectance

RT Model Input
- Aerosol product from MODIS/MISR satellite and AERONET ground measurements

Retrieval System
- PATMOS-x: Cloud algorithms

Radiative Transfer
- Clear sky: REST2
- Cloudy sky: NREL FARMS model and DISC model

Cloud Products
- Cloud mask
- Cloud type
- Cloud height/temperature/pressure
- Cloud optical depth
- Cloud particle size
- Cloud water path

Irradiance Products
- Global horizontal irradiance (GHI)
- Direct normal irradiance (DNI)
- Diffuse horizontal irradiance (DHI)
Cloud Products for PSM

- In collaboration with the University of Wisconsin, NREL developed an improved version of the PATMOS-x processing system, which was used to process GOES-WEST and -EAST data for years 1998-2014
- Cloud properties:
  - Cloud mask
  - Cloud type
  - Cloud height/temperature/pressure
  - Cloud optical depth
  - Cloud particle size
  - Cloud water path
Aerosols for PSM

- Developed accurate gridded aerosol product using multiple data sources

- Developed monthly 0.5° aerosol optical depth (AOD) for 1998-2014 using satellite and ground-based measurements
- Monthly results interpolated to form daily 4-km AOD data
- Daily data calibrated using ground measurements to develop accurate AOD product

<table>
<thead>
<tr>
<th>Location</th>
<th>Monthly AOD</th>
<th>MAE(W/m²)</th>
<th>MAE(%)</th>
<th>RMSE(W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desert Rock, NV</td>
<td>17</td>
<td>1.84</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Goodwin Creek, MS</td>
<td>47</td>
<td>5.96</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>Bondville, IL</td>
<td>62</td>
<td>7.76</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Table Mtn., Co</td>
<td>35</td>
<td>3.84</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>2.57</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

![Image of aerosol optical depth map and scatter plots]
PSM: Radiative Transfer Models

**GOES Satellite-Based Cloud Products**

**Aerosols and Water Vapor From Ancillary Sources**

**Solar Resource using Fast Radiative Transfer Models**

**Satellite Data Validation**

**Data Dissemination**

---

### Satellite Input

- GOES data—4 channels: 4 km–30 min

### Ancillary Input

- NWP Forecast or Reanalysis
- Snow
- Surface emissivity
- Surface reflectance

### RT Model Input

- Aerosol product from MODIS/MISR satellite and AERONET ground measurements

---

**Retrieval System**

- PATMOS-x: Cloud algorithms

---

**Radiative Transfer**

- Clear sky: REST2
- Cloudy sky: NREL FARMS model and DISC model

---

**Cloud Products**

- Cloud mask
- Cloud type
- Cloud height/temperature/pressure
- Cloud optical depth
- Cloud particle size
- Cloud water path

---

**Irradiance Products**

- Global horizontal irradiance (GHI)
- Direct normal irradiance (DNI)
- Diffuse horizontal irradiance (DHI)
REST2 Clear Sky Model Output with Better AOD Input

- SASRAB model initially tested but provided biased results
- 3 next-generation models (Bird, MMAC, and REST2 models) tested with high-quality aerosol data
- All models provided significantly accurate results
- REST2 provides the most accurate results and was implemented in the PSM framework
All-Sky Radiative Transfer Model for PSM

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

- Developed new radiative transfer model for use in satellite and forecasting applications
- 2-stream approximation (industry standard) and FARMS have similar performance
- FARMS is 1,000 times more efficient in the computation of solar radiation

<table>
<thead>
<tr>
<th></th>
<th>SASRAB</th>
<th>FARMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBE%</td>
<td>5.9</td>
<td>0.4</td>
</tr>
<tr>
<td>MAE%</td>
<td>29.9</td>
<td>27.6</td>
</tr>
<tr>
<td>MBE (W/m^2)</td>
<td>16.5</td>
<td>1</td>
</tr>
</tbody>
</table>

Transmittance

Radiative Transfer
Validation of the PSM

- Evaluation of the new NSRDB dataset was carried out using high-quality SURFRAD ground stations.

MBE in percent for all years (1998-2014) for the seven SURFRAD sites.

GHI

DNI
The area covers 25° W to 175° W and 20° S to 60° N
- Includes **half-hourly** satellite modeled solar data for years 1998-2014 on 4-km grid
- Time-series solar data for a location can be combined with hourly met data for PV and CSP simulation
# NSRDB Product Variables

<table>
<thead>
<tr>
<th>Element</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
</table>
| Clearsky DHI  | Watt per square meter       | - Modeled solar radiation on a horizontal surface received from the sky excluding the solar disk.  
|               |                             | - This is assuming clear sky condition                                        |
| Clearsky DNI  | Watt per square meter       | - Modeled solar radiation obtained from the direction of the sun.             
|               |                             | - This is assuming clear sky condition                                        |
| Clearsky GHI  | Watt per square meter       | - Modeled solar radiation on a horizontal surface received from the sky.     
|               |                             | - This is assuming clear sky condition                                        |
| Cloud Type    | Unitless                    | Obtained from PATMOS-X                                                      |
| Dew Point     | Degree C                    | Calculated from specific humidity                                            |
| DHI           | Watt per square meter       | Modeled solar radiation on a horizontal surface received from the sky excluding the solar disk. |
| DNI           | Watt per square meter       | Modeled solar radiation obtained from the direction of the sun.              |
| GHI           | Watt per square meter       | Modeled solar radiation on a horizontal surface received from the sky.       |
| Fill Flag     | Unitless                    | 'N/A': 0, 'Missing Image': 1, 'Low Irradiance': 2, 'Exceeds Clearsky': 3, 'Missing Cloud Properties': 4, 'Rayleigh Violation': 5 |
| Snow Depth    | meters                      | Source: MERRA                                                               |
| Solar Zenith Angle | Degrees                 | Angle between the sun and the zenith                                          |
| Temperature   | Degree C                    | Source: MERRA                                                               |
| Pressure      | Millibar                    | Source: MERRA                                                               |
| Relative Humidity | Percent                    | Calculated from specific humidity                                            |
| Precipitable Water | Millimeter                | Source: MERRA                                                               |
| Wind Direction | Degrees                    | Source: MERRA                                                               |
| Wind Speed    | meter per second            | Source: MERRA                                                               |
Gridded TMY - Developed using the gridded NSRDB (1998-2014)

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 candidate months with cumulative distribution functions (CDFs) for the daily indices that are closest to the long-term (30 years for the NSRDB) CDFs are selected.</td>
<td>The 5 candidate months are ranked with respect to closeness of the month to the long-term mean and median.</td>
<td>The persistence of mean daily dry-bulb temperature and daily global horizontal radiation are evaluated by determining the frequency and run length above and below fixed long-term percentiles.</td>
<td>The 12 selected months are concatenated to make a complete year.</td>
</tr>
</tbody>
</table>

**TMY**

**Gridded TMY**

Example figures representing DNI and GHI datasets for TMY developed using meteorological and irradiance weighting factors.

TMY data sets provide industry standard resource information for:

- Building design and performance
- Solar heating and cooling systems
- Photovoltaic and concentrating solar power system performance
- Energy systems analysis
## TMY Product Variables

<table>
<thead>
<tr>
<th>Element</th>
<th>Unit or Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>1998-2014</td>
</tr>
<tr>
<td>Month</td>
<td>1-12</td>
</tr>
<tr>
<td>Day</td>
<td>1-28,1-30 or 1-31</td>
</tr>
<tr>
<td>Hour</td>
<td>1-23</td>
</tr>
<tr>
<td>Minute</td>
<td>0</td>
</tr>
<tr>
<td>Dew Point</td>
<td>Degree C</td>
</tr>
<tr>
<td>DHI</td>
<td>Watt per square meter</td>
</tr>
<tr>
<td>DNI</td>
<td>Watt per square meter</td>
</tr>
<tr>
<td>GHI</td>
<td>Watt per square meter</td>
</tr>
<tr>
<td>Temperature</td>
<td>Degree C</td>
</tr>
<tr>
<td>Pressure</td>
<td>Millibar</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>Degrees</td>
</tr>
<tr>
<td>Wind Speed</td>
<td>meter per second</td>
</tr>
</tbody>
</table>
NSRDB Website & Data Access
New NSRDB Website

http://nsrdb.nrel.gov
New NSRDB Website

Learn about the current and historic datasets, TMY, history, and more

http://nsrdb.nrel.gov
New NSRDB Website

Access the data

National Solar Radiation Database (NSRDB)

http://nsrdb.nrel.gov
New NSRDB Website

Users manuals, helpful links, *publications*, and a user forum

http://nsrdb.nrel.gov
New NSRDB Website

Still have questions? Contact us.

http://nsrdb.nrel.gov
New NSRDB Viewer

Data Layers
- Environmental
- Infrastructure
- Land Ownership
- Power Plants
- Ground Measurement Sites
- NSRDB
- Solar Study Areas
- State/Local Borders
Use the layer tree to find and display data layers.
Use the layer tree to find and display data layers
Use the layer tree to find and display data layers.
Use the layer tree to find and display data layers.
Browse Data Layers

Use the layer tree to find and display data layers.
Browse Data Layers

Use the layer tree to find and display data layers
Use the Legend tab to view legend and style layers.
Use the Legend tab to view legend and style layers.
Change the order of each layer
Change the order of each layer.
Change the layer transparency
Browse Data Layers

Change the layer transparency
Browse Data Layers

Change the layer transparency
Query Data Layers

Query displayed layers

PSM Direct Normal Irradiance (kWh/sq.m/day)

- < 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- 5.0 - 5.5
- 5.5 - 6.0
- 6.0 - 6.5
- 6.5 - 7.0
- 7.0 - 7.5
- 7.5 - 8.0
- 8.0 - 8.5
- > 8.5

Transparency: 28%
Query Data Layers

Query by point...
Query Data Layers

**Point Query**
Select a single point on the map and get data for that location.

**Region Query**
Select an area on the map and get data for that area.

**Custom Shape Query**
Draw a custom shape on the map and view data for that area.

**Attribute Query**
Use this advanced feature to filter your query based on specific attributes.

...rectangle...
Query Data Layers

Point Query
Select a single point on the map and get data for that location.

Region Query
Select an area on the map and get data for that area.

Custom Shape Query
Draw a custom shape on the map and view data for that area.

Attribute Query
Use this advanced feature to filter your query based on specific attributes.

...custom drawn shape...
Query Data Layers

Point Query
Select a single point on the map and get data for that location.

Region Query
Select an area on the map and get data for that area.

Custom Shape Query
Draw a custom shape on the map and view data for that area.

Attribute Query
Use this advanced feature to filter your query based on specific attributes.

...or attribute.
Layer Metadata

View metadata for each layer
Layer Metadata

View metadata for each layer

This data provides monthly average and annual average daily total solar resource averaged over surface cells of 0.038 degrees in both latitude and longitude, or nominally 4 km in size. The solar radiation values represent the resource available to solar energy systems. The data was created using cloud properties which are generated using the AVHRR Pathfinder Atmospheres-Extended (PATMOS-x) algorithms. Fast all-
Layer Downloads

Download layers
Layer Downloads

Download layers
NSRDB Data Downloads
NSRDB Data Download

Download from NSRDB database
NSRDB Data Download

Download Solar Resource Data
By Point
Select a location on the map by clicking once. You will then be presented with a variety of download choices.

Download Solar Resource Data
By Region
Use the drawing tool to draw a rectangle around the desired region. You will then be presented with a variety of download choices.

Download from NSRDB database
NSRDB Data Download

Download Solar Resource Data
By Point
Select a location on the map by clicking once. You will then be presented with a variety of download choices.

Download Solar Resource Data
By Region
Use the drawing tool to draw a rectangle around the desired region. You will then be presented with a variety of download choices.

Download by point location
Enter information (required for downloads)
NSRDB Data Download

Select a point location
NSRDB Data Download

Choose years to download
Choose years to download
Select attributes to download

### Select Years
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014

### Select Attributes
- DHI
- DNI
- GHI
- Clear Sky DHI
- Clear Sky DNI
- Clear Sky GHI
- Cloud Type
- Dew Point
- Relative Humidity
- Pressure
- Snow Depth
- Solar Zenith Angle
- Total Precipitable Water
- Wind Speed
- Wind Direction
- Fill Flag

### Select Downloads
- Include Local Time
- Convert UTC to Local Time
- Half Hour Intervals
Select all attributes and/or years.
Select all attributes and/or years
Clear all attributes and/or years
Clear all attributes and/or years
Include leap day
Convert data from UTC to Local Time
Uncheck to download hourly data
NSRDB Data Download

Select from PSM...
NSRDB Data Download

### NSRDB Data Viewer

#### Download Solar Resource Data By Point
Select a location on the map by clicking once. You will then be presented with a variety of download choices.

#### Download Solar Resource Data By Region
Use the drawing tool to draw a rectangle around the desired region. You will then be presented with a variety of download choices.

---

**Select and Query Data**

**Download Data**

---

**NSRDB Data Viewer**

<table>
<thead>
<tr>
<th>PSM</th>
<th>MTS3</th>
<th>MTS2</th>
<th>MTS1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select Years</td>
<td>Select All</td>
<td>Clear All</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>2002</td>
<td>2003</td>
<td>2004</td>
</tr>
</tbody>
</table>

**Select Attributes**

- DNI
- GHI
- Temperature
- Pressure
- ETR
- ETRN
- Broadband AOD
- Wind Speed

**Download Options**

- Include Uncertainty
- Include Leap Day

---

**Download Limit Indicator**
NSRDB Data Download
NSRDB Data Download

...or MTS1 datasets
NSRDB Data Download

TMY datasets available for PSM, MTS1, & MTS2
Click Download Data button when ready
NSRDB Data Download

Instructions for obtaining download will be emailed
NSRDB Data Download

Download data by region
NSRDB Data Download

Draw rectangle to obtain data for that region
NSRDB Data Download

Draw rectangle to obtain data for that region
NSRDB Data Download

Observe download limit indicator to ensure valid download (this is per session)
NSRDB Data Download

Your data is ready! Please click the link below to download your file. This link will remain valid for 24 hours.

https://maps.nrel.gov/api/developer_proxy?site_url=solar/nsrdb_file_download&filename=bfe1c9c1a9586a827001dbba3439bcad.zip

Thank you for using The NSRDB Data Viewer at https://maps.nrel.gov/nsrdb-viewer
NSRDB Data Download

For relatively small downloads, a direct link to the zip file will be included in the email.

Your data is ready! Please click the link below to download the file. This link will remain valid for 24 hours.

https://maps.nrel.gov/api/developer_proxy?site_url=solar/nsrdb_file_download&filename=bfe1c9c1a9586a827001dbba3439bcad.zip

Thank you for using The NSRDB Data Viewer at https://maps.nrel.gov/nsrdb-viewer
Larger downloads use the Globus service. Follow the instructions in the link to set up an account.

Your data is ready! The file is named 2015-11-30_15:42:21/9aa67fe001a132e6aee08396673d20e1.zip. This file will be available for 24 hours.

For full instructions on completing your download via Globus Connect, please view the page at: https://nsrdb.nrel.gov/nsrdb-viewer

Thank you for using The NSRDB Data Viewer at https://maps.nrel.gov/nsrdb-viewer
NSRDB Data Download

Globus Data Download Instructions

STEP 1
- Sign up for a Globus account at https://www.globus.org/SignUp. The email verification link will likely open a new browser window from your inbox and log you into Globus.

STEP 2
- If the verification does not log you in, sign in at https://www.globus.org/.

STEP 3
- Go to "Transfer Files."

STEP 4
- Set up a Globus Connect Personal Endpoint.

NOTE:
NSRDB Data Download

Globus Data Download Instructions

STEP 1
- Sign up for a Globus account at https://www.globus.org/SignUp. The email verification link will likely open a new browser window from your inbox and log you into Globus.

STEP 2
- If the verification does not log you in, sign in at https://www.globus.org/.

STEP 3
- Go to "Transfer Files."

Once your account has been created, sign in to your account

- Set up a Globus Connect Personal Endpoint.

NOTE:
Once your account has been created, sign in to your account.
NSRDB Data Download

Navigate to the “Transfer Files” tab
Click the link and follow instructions to install Globus Connect Personal.
Enter a name for your personal endpoint
NSRDB Data Download

Enter a name for your personal endpoint

Step 1 Get Your Globus Connect Personal Setup

Please enter a unique name for your Globus Connect Personal endpoint to help you identify it.

Endpoint Name: jduckwor#nsrdb_demo

Generate Setup Key

Step 2 Download & Install Globus Connect Personal

Click one of the buttons below to download and install Globus Connect Personal for your operating system.

- for Mac OS X
- for Linux
- for Windows

Once downloaded, run the installer. When prompted, paste in the Setup Key to complete the installation.
Then generate and copy the setup key.
NSRDB Data Download

Download the application for your operating system and follow the installation instructions, entering the setup key when prompted.
NSRDB Data Download

With Globus Connect
Personal set up, search for the nrelgds#nrel_nsrdb endpoint
Find the directory specified in the email, which will contain your downloads.
NSRDB Data Download

Find the directory specified in the email, which will contain your downloads.
NSRDB Data Download

Search for your personal endpoint...
NSRDB Data Download

... and select the directory to which you would like to direct the downloads
NSRDB Data Download

... and select the directory to which you would like to direct the downloads
Click the right arrow to transfer files to your chosen directory
NSRDB Data Download

Monitor download progress at the bottom of the page
**Data Format**

**Standard Time-Series Data File Format**
also known as **SAM CSV**

## Header

<table>
<thead>
<tr>
<th>Field</th>
<th>Units</th>
<th>Recognized Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>degrees</td>
<td>latitude, lat</td>
</tr>
<tr>
<td>Longitude</td>
<td>degrees</td>
<td>longitude, lon, long, lng</td>
</tr>
<tr>
<td>Time zone</td>
<td>hours offset from GMT</td>
<td>tz, timezone, time zone</td>
</tr>
<tr>
<td>Site elevation</td>
<td>meters above sea level</td>
<td>el, elev, elevation, site elevation</td>
</tr>
<tr>
<td>Year</td>
<td>n/a</td>
<td>year</td>
</tr>
<tr>
<td>Location ID</td>
<td>n/a</td>
<td>id, location, location id, station, station id, wban, wban #</td>
</tr>
<tr>
<td>City</td>
<td>n/a</td>
<td>city</td>
</tr>
<tr>
<td>State</td>
<td>n/a</td>
<td>state, province, region</td>
</tr>
<tr>
<td>Country</td>
<td>n/a</td>
<td>country</td>
</tr>
<tr>
<td>Source</td>
<td>n/a</td>
<td>source, src</td>
</tr>
<tr>
<td>Description</td>
<td>n/a</td>
<td>description, desc</td>
</tr>
<tr>
<td>URL</td>
<td>n/a</td>
<td>url</td>
</tr>
<tr>
<td>Units flag</td>
<td>yes or no</td>
<td>hasunits, units</td>
</tr>
<tr>
<td>Interpolate flag</td>
<td>yes or no</td>
<td>interpmet</td>
</tr>
</tbody>
</table>
### Data Format

#### Data Columns

<table>
<thead>
<tr>
<th>Field</th>
<th>Units</th>
<th>Recognized names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>1950-2050</td>
<td>year, yr</td>
</tr>
<tr>
<td>Month</td>
<td>1-12</td>
<td>month, mo</td>
</tr>
<tr>
<td>Day</td>
<td>1-31</td>
<td>day</td>
</tr>
<tr>
<td>Hour</td>
<td>0-23</td>
<td>hour, hr</td>
</tr>
<tr>
<td>Minute</td>
<td>0-59</td>
<td>min, minute</td>
</tr>
<tr>
<td>Global horizontal irradiance</td>
<td>W/m²</td>
<td>gh, ghi, global, global horizontal, global horizontal irradiance</td>
</tr>
<tr>
<td>Beam normal irradiance</td>
<td>W/m²</td>
<td>dn, dni, beam, direct normal, direct normal irradiance</td>
</tr>
<tr>
<td>Diffuse horizontal irradiance</td>
<td>W/m²</td>
<td>df, dhi, diffuse, diffuse horizontal, diffuse horizontal irradiance</td>
</tr>
<tr>
<td>Ambient dry bulb temperature</td>
<td>°C</td>
<td>tdry, dry bulb, dry bulb temp, temperature, ambient, ambient temp</td>
</tr>
<tr>
<td>Wet bulb temperature</td>
<td>°C</td>
<td>twet, wet bulb, wet bulb temperature</td>
</tr>
<tr>
<td>Dew point temperature</td>
<td>°C</td>
<td>tdew, dew point, dew point temperature</td>
</tr>
<tr>
<td>Wind speed</td>
<td>m/s</td>
<td>wspd, wind speed</td>
</tr>
<tr>
<td>Wind direction</td>
<td>deg</td>
<td>wdir, wind direction</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>%</td>
<td>rh, rhum, relative humidity, humidity</td>
</tr>
<tr>
<td>Atmospheric pressure</td>
<td>millibar</td>
<td>pres, pressure</td>
</tr>
<tr>
<td>Snow cover</td>
<td>cm</td>
<td>snow, snow cover, snow depth</td>
</tr>
<tr>
<td>Ground reflectance (albedo)</td>
<td>0..1</td>
<td>albedo, alb</td>
</tr>
<tr>
<td>Aerosol optical depth</td>
<td>0..1</td>
<td>aod, aerosol, aerosol optical depth</td>
</tr>
<tr>
<td>Variable</td>
<td>Description</td>
<td>Inputs</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>--------</td>
</tr>
<tr>
<td>names</td>
<td>Year of interest</td>
<td>1998-2014; tmy</td>
</tr>
<tr>
<td>interval</td>
<td>30 minute or hourly data</td>
<td>30; 60</td>
</tr>
<tr>
<td>full_name</td>
<td>Name user</td>
<td>Text</td>
</tr>
<tr>
<td>affiliation</td>
<td>Affiliation of user</td>
<td>Text</td>
</tr>
<tr>
<td>reason</td>
<td>Short description of purpose for downloading data</td>
<td>Text</td>
</tr>
<tr>
<td>Attributes</td>
<td>Attributes to return</td>
<td>dhi,dni,ghi,clearsky_dhi,clearsky_dni,clearsky_ghi,cloud_type,dew_point,surface_air_temperature_nwp,surface_pressure_background,surface_relative_humidity_nwp,solar_zenith_angle,total_precipitable_water_nwp,snow_depth,wind_direction_10m_nwp,wind_speed_10m_nwp,fill_flag</td>
</tr>
</tbody>
</table>
NSRDB API

http://developer.nrel.gov/api/solar/nsrdb_0512_download.csv?wkt=POINT(-104.5%2039.5)&names=1998&leap_day=false&interval=30&utc=false&full_name=YOUR_NAME&email=YOUR_EMAIL&affiliation=NREL&mailing_list=false&reason=SAM&api_key=YOUR_API&attributes=dhi,dni,windspeed,surfaceair_temperature

Sample API Call

Sample Python using Pandas

```
In [2]:
# year and location of interest
year, lon, lat = 2006, -104.5, 39.5
# Grabbing all but first 2 lines
df = pd.read_csv('http://developer.nrel.gov/api/solar/nsrdb_0512_download.csv?wkt=POINT({lon}%20{lat})&names={year}&leap_day=false&interval=30&utc=false&full_name=YOUR_NAME&email=YOUR_EMAIL&affiliation=NREL&mailing_list=false&reason=SAM&api_key=YOUR_API&attributes=dhi,dni,windspeed,surfaceair_temperature')
# Set the time index in the pandas dataframe
df = df.set_index(pd.date_range('1/1/yr'.format(yr=year), freq='30Min', periods=17520))
# off and running!
df.head()
```

```
<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Day</th>
<th>Hour</th>
<th>Minute</th>
<th>DHI</th>
<th>DNI</th>
<th>Temperature</th>
<th>Wind Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-01-01 00:00:00</td>
<td>2006</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.487848</td>
<td>5.069017</td>
</tr>
<tr>
<td>2006-01-01 00:30:00</td>
<td>2006</td>
<td>1</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>3.631738</td>
<td>4.952465</td>
</tr>
<tr>
<td>2006-01-01 01:00:00</td>
<td>2006</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.775598</td>
<td>4.835914</td>
</tr>
<tr>
<td>2006-01-01 01:30:00</td>
<td>2006</td>
<td>1</td>
<td>1</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>3.790118</td>
<td>4.583948</td>
</tr>
<tr>
<td>2006-01-01 02:00:00</td>
<td>2006</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.806238</td>
<td>4.331983</td>
</tr>
</tbody>
</table>
```
Data Availability

- **USA: 1998-2014**
- **Other countries: 1998-2014, with 2005-2012 available publicly**
  - List of Countries: Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, British Virgin Islands, Canada, Cape Verde, Cayman Island, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Kiribati, Mexico, Montserrat, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Saint Barthélemy, Saint Lucia, Sint Maarten, St Vincent and the Grenadines, St-Martin, St. Kitts and Nevis, St. Pierre and Miquelon, Suriname, Trinidad and Tobago, Turks and Caicos Islands, U.S. Minor Outlying Islands, U.S. Virgin Islands, and Venezuela
  - To obtain the full 1998-2014 dataset, please contact nsrdb@nrel.gov
Future Plan

- Summary statistics layers
- Biannual updates
- Spectral data
- Plane-of-array irradiance
- Algorithm improvements
- Fix some outstanding issues
  - Relative humidity
Questions?

Main Website: nsrdb.nrel.gov

Publications: nsrdb.nrel.gov/publications

Access Data: nsrdb.nrel.gov/nsrdb-viewer