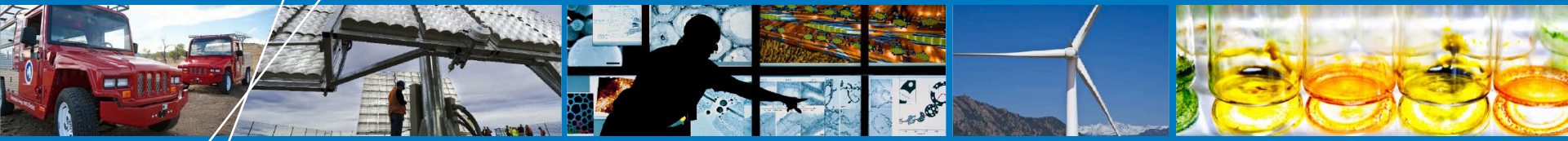
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Developing the Next Generation of Gridded TMYs



ASHRAE 2015 Annual Conference

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

NREL's Resource Assessment and Forecasting Background

- **Solar resource measurements**
  - Radiometer calibration and characterization
  - Data acquisition
  - Measurement uncertainty analysis
  - Station/network design, operations and maintenance
- **Solar resource modeling**
  - Physical and empirical solar resource models
  - Historical and forecast resources
- **Data assimilation, analysis, and dissemination**
  - Data quality assessments
  - Temporal and spatial resource characterizations
  - Outreach
- **Standards, expert committees, and collaborations**
  - ASTM G03—radiometry
  - IEA Task 46 Solar Resource Assessment and Forecasting
  - Subcontracts and cooperative research and development agreements with industry and academia

Overview

- **TMY data sets provide industry standard resource information for**
  - Solar heating and cooling systems
  - Photovoltaic and concentrating solar power system performance
  - Energy systems analysis

TMY Data Set Background

- **TMY data was first created by Sandia National Laboratories to assess building performance**
- **TMY data sets were developed from long-term data files in the National Solar Radiation Data Base (NSRDB)**

Source	Years	Description	Spatial Information	Temporal Information	Comment
NSRDB Version I	1961–1990	TMY 2: METSTAT (METeorological STATistical) Model—93% and Measured— 7%	Point data set	1-Hour	239 stations. TMY3 was generated using Version 1 and 2 of the NSRDB
NSRDB Version I and II	1961–2005	TMY 3: METSTAT SUNY Empirical model Measured (<1%)	Point data set	1-Hour	The update includes fields that allow users the flexibility to choose modeled or, if available, measured data for an application. Includes 1,020 stations.
NSRDB Version IV	**1998–2013**	**Gridded TMY**	**Gridded and point data set**	**Half hour**	**4 sq. km spatial resolution for all U.S. and part of South America**

National Solar Radiation Database

ftp://ftp.ncdc.noaa.gov/pub/data/nsrdb-solar/

Evolution of Solar Resource Data

1952–1975 SOLMET[1] [ERDA, NOAA, 1979]

1961–1990 NSRDB[2] [DOE, NOAA, 1994]

1991–2005 NSRDB-II[3] [DOE, NOAA, 2007]

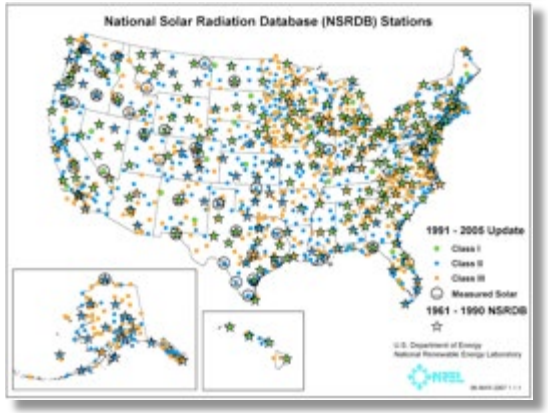
2005–2009 NSRDB-III [DOE,NOAA, 2012]

(1)
38 ***Measurement*** stations
1977–1980

(2)
239 ***Modeled*** locations
1990

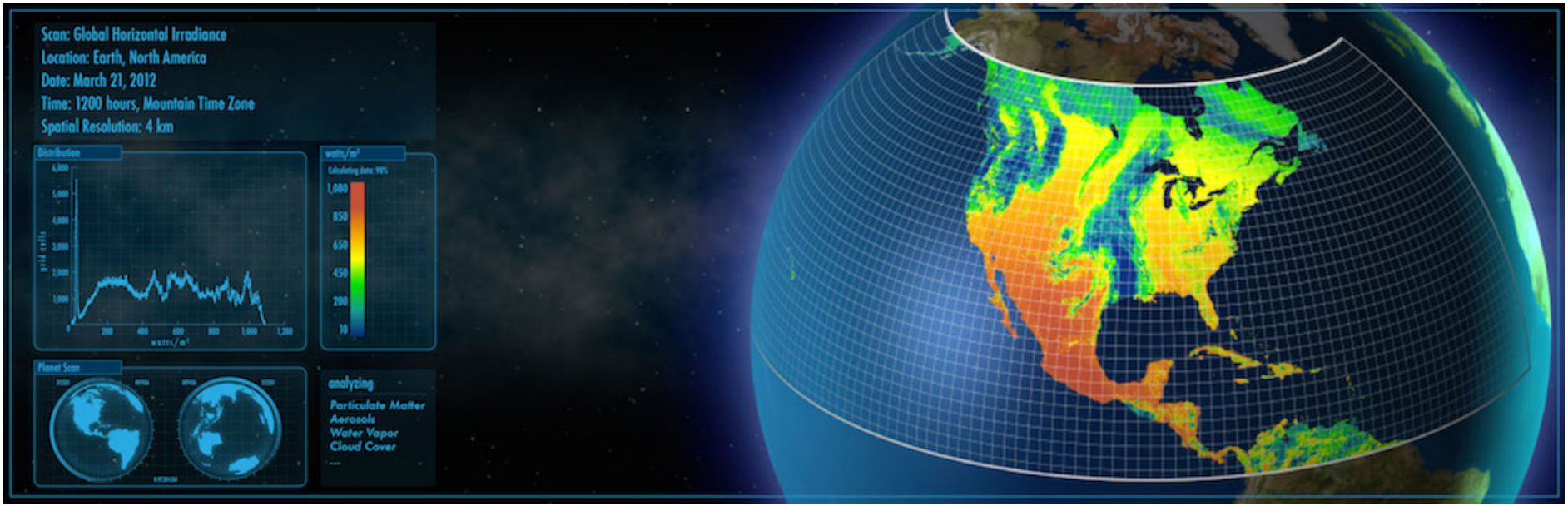
(3)
10 km x 10 km
1998–2005

(3)
1,454 ***Modeled*** locations
1991–2005

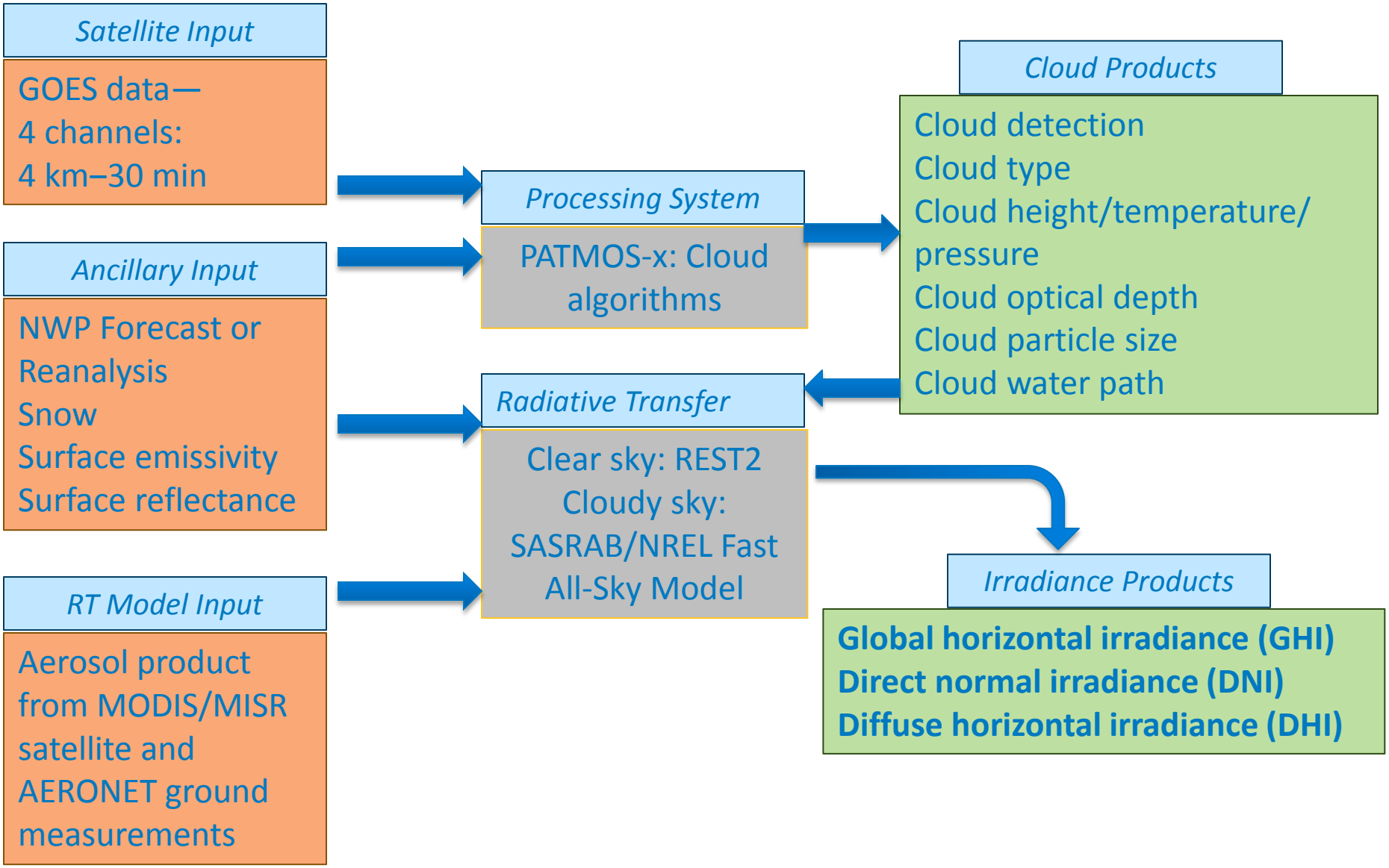


Gridded TMY

- **Source**
  - NSRDB Version IV: 4-km spatial and half-hourly temporal resolution of solar and meteorological data from 1998 to 2013



The Gridded NSRDB Product



Method to Develop Gridded TMY Data Set

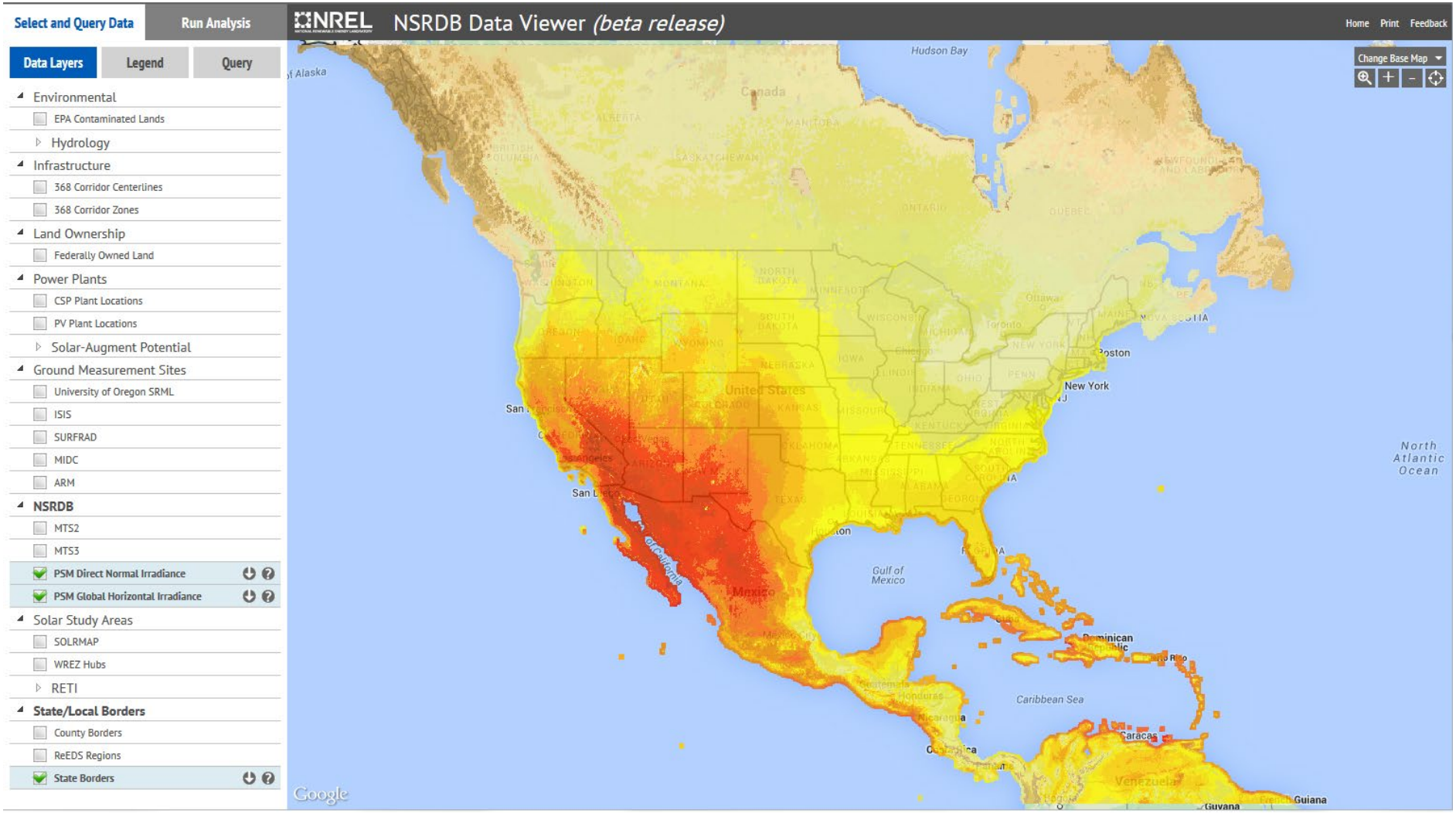
- Step 1
  - For each month of the calendar year, 5 candidate months with cumulative distribution functions (CDFs) for the daily indices that are closest to the long-term (30 years for the NSRDB) CDFs are selected.
- Step 2
  - The 5 candidate months are ranked with respect to closeness of the month to the long-term mean and median.
- Step 3
  - The persistence of mean dry bulb temperature and daily global horizontal radiation are evaluated by determining the frequency and run length above and below fixed long-term percentiles.
- Step 4
  - The 12 selected months are concatenated to make a complete year and smooth discontinuities at the month interfaces for 6 hours each side using curve-fitting techniques.

Weighting Parameters for the TMY, TDY, and TGY Data Sets (Modified from Wilcox and Marion 2008)

Index	TMY	TDY	TGY
Max Dry Bulb Temp	1/20	0	0
Min Dry Bulb Temp	1/20	0	0
Mean Dry Bulb Temp	2/20	0	0
Max Dew Point Temp	1/20	0	0
Min Dew Point Temp	1/20	0	0
Mean Dew Point Temp	2/20	0	0
Max Wind Velocity	1/20	0	0
Mean Wind Velocity	1/20	0	0
GHI	5/20	0	20/20
DNI	5/20	20/20	0

TMY: Typical meteorological year
TDY: Typical direct normal irradiance year
TGY: Typical global horizontal irradiance year

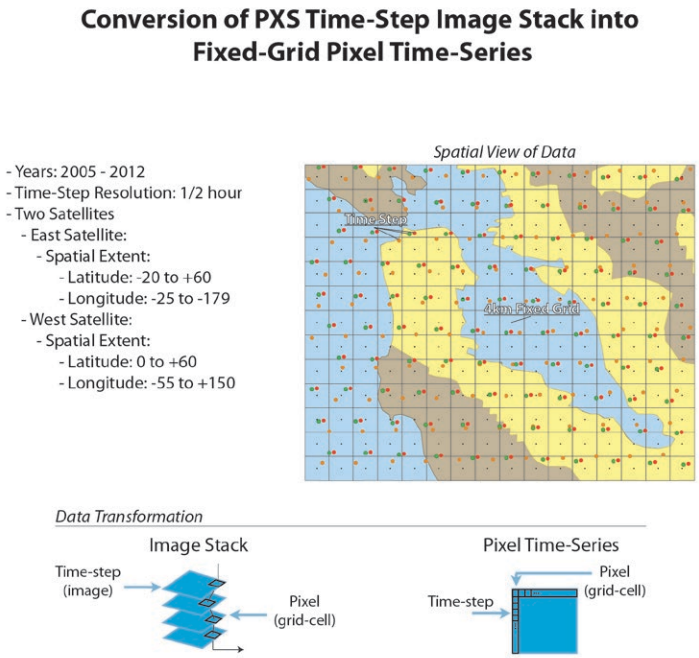
Accessing the NSRDB Data



GIS based data access with web-service for multi-pixel download

Timeline

- Beta product (2005–2012) is available now
- Final product (1998–2014) will be available by September 2015
- TMY product will be available by September 2015
- Intermediate monthly update available after September 2015 (possible daily product)

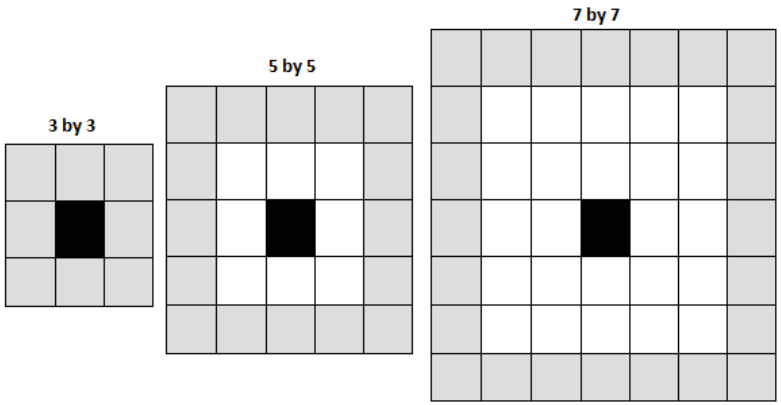


Gridded TMY Data Products

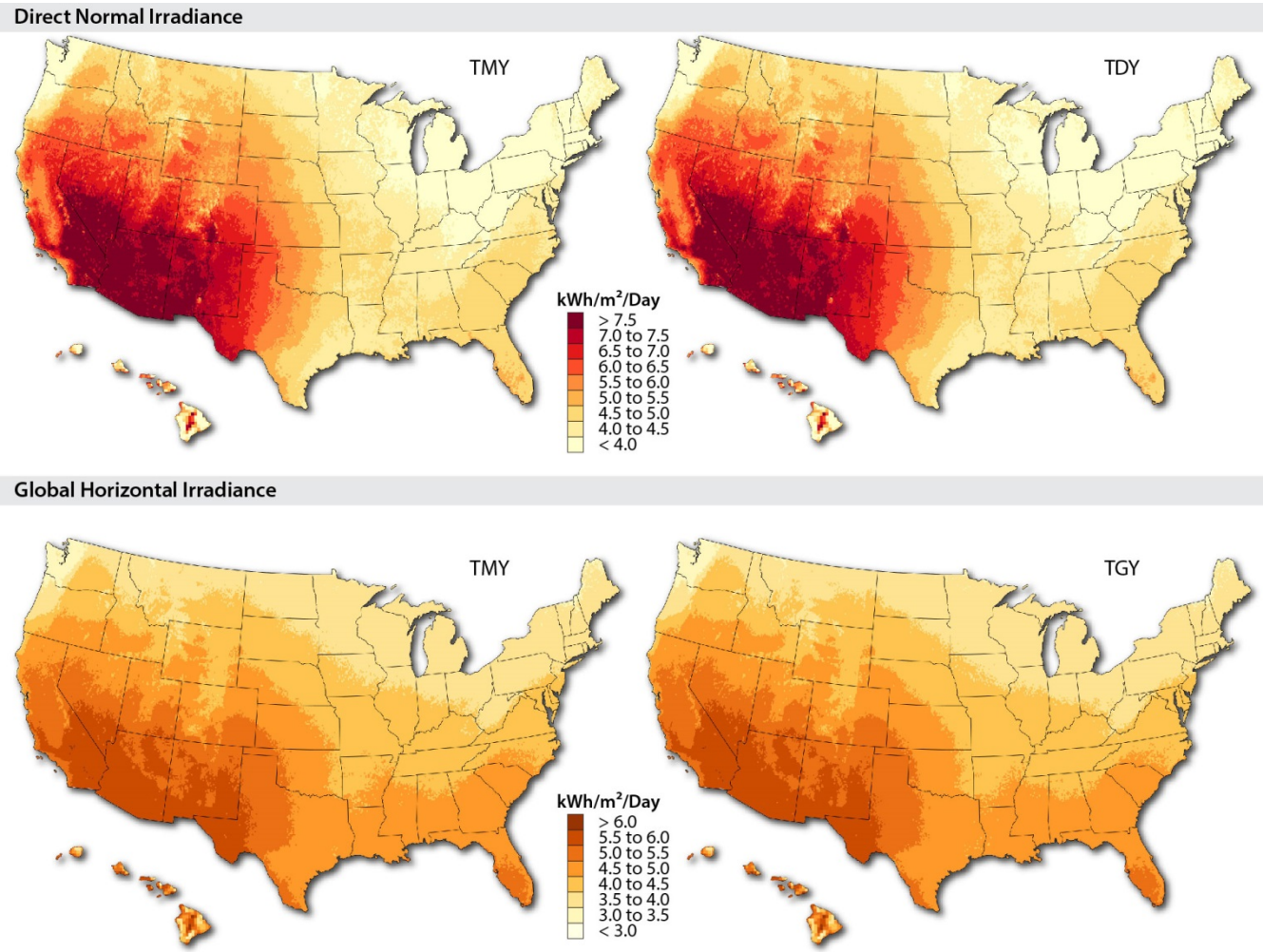
- **TMY, TDY, and TGY**
  - Understanding the difference between TMY compared to TDY, and TMY compared to TGY
  - Assessing the spatial variability among neighboring pixels of the gridded TMY, TDY, and TGY data
  - Understanding the temporal variability of these data sets

Method

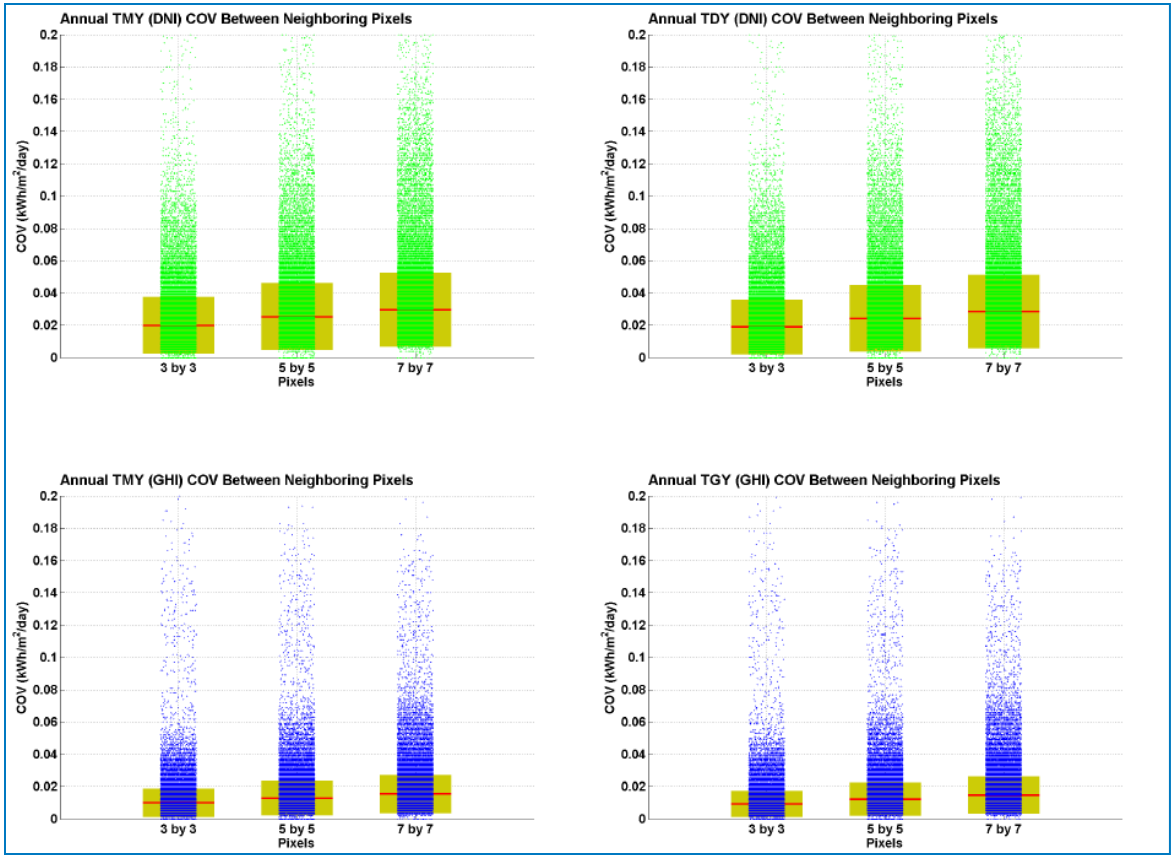
- **Spatial variability analysis using coefficient of variation (COV) for neighboring pixel**
- **Temporal variability using standard deviation calculation for the monthly gridded data set**
- **Understanding the differences among TMY, TDY, and TGY data sets**
  - TMY data set has includes non-zero weighting factors for both the solar and meteorological components
  - TDY and TGY have no meteorological elements as weighting factors
    - TDY data set is developed using 100% weighting for DNI
    - TGY data set uses 100% weighting for GHI



Results—Comparison among TMY, TDY, and TGY



Results—Spatial Variability

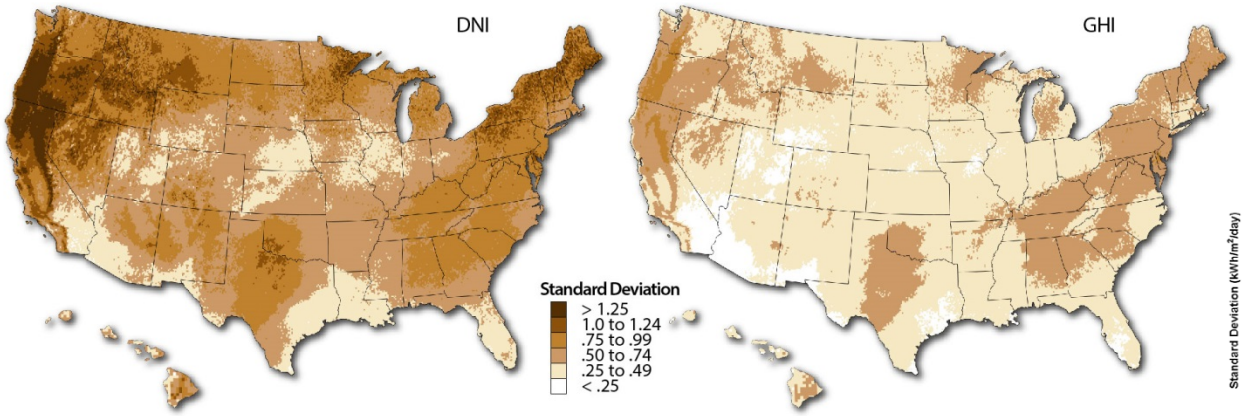


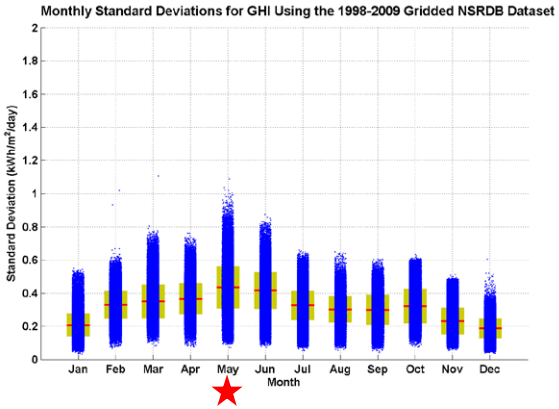
Average COV for a Typical Data Set Under Different Pixel Distance Comparisons

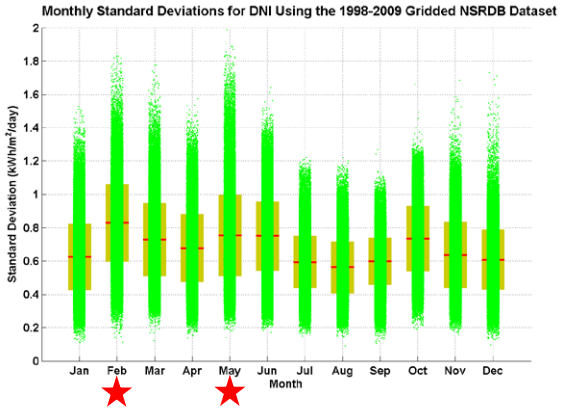
	COV			
	TMY (DNI)	TDY	TMY (GHI)	TGY
3x3	0.0198	0.01884	0.0098	0.0092
5x5	0.0252	0.0242	0.0128	0.0121
7x7	0.0296	0.0285	0.0152	0.0146

Results—Temporal Variability

Standard Deviation for the Month of May







Average Standard Deviation (Temporal Variability) Obtained from NSRDB 1998–2009 Data Set

Month	Average Std. Deviation (DNI)	Average Std. Deviation (GHI)
January	0.623	0.206
February	**0.828**	0.328
March	0.729	0.349
April	0.676	0.364
May	**0.752**	**0.434**
June	0.748	0.415
July	0.592	0.324
August	0.561	0.301
September	0.597	0.299
October	0.733	0.321
November	0.635	0.23
December	0.606	0.187

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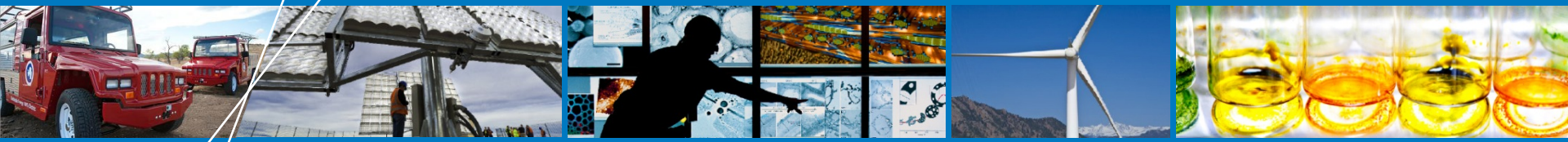

Thank you