2016 ASHRAE Annual Conference

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Seminar 63 –Moving Beyond Typical Year Weather Data

Understanding the Temporal and Spatial Variability of New Generation Gridded TMYs

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St. Louis, Missouri

NREL/PR-6A20-68197

Learning Objectives

Objective 1: Learn about what's new and different in the Climatic Design Conditions Table in the 2013 ASHRAE Handbook of Fundamentals

Objective 2: Learn about the new 2013 edition of ASHRAE Standard 169 Climatic Data for Building Design Standards

Objective 3: Learn about new climatic data products from the U.S. National Climatic Data Center, including advanced GIS and Web services that allow for direct access to data, including surface-based observations for thousands of stations, climate reanalysis data, and products derived from satellite data

Objective 4: Understand new developments in NREL's solar databases based on both observed data and satellite-derived gridded data, status of TMY3 weather files, and NREL's plans for the next-generation TMY weather files

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Acknowledgments

- This work was supported by the U.S. Department of Energy under Contract No. DE-AC36-08-GO28308 with the National Renewable Energy Laboratory.
- We would like to thank the contributors of this work; Manajit Sengupta, Aron Habte, Yu Xie and Andrew Weekley.

Outline/Agenda

- Background - National Solar Radiation Database (NSRDB)
- Current Methodology
- Meteorological Data
- Validation
- Typical Meteorological Year (TMY) Data
- Spatiotemporal Variability of TMY
- NSRDB Website and Data Access

National Solar Radiation Data Base

http://nsrdb.nrel.gov

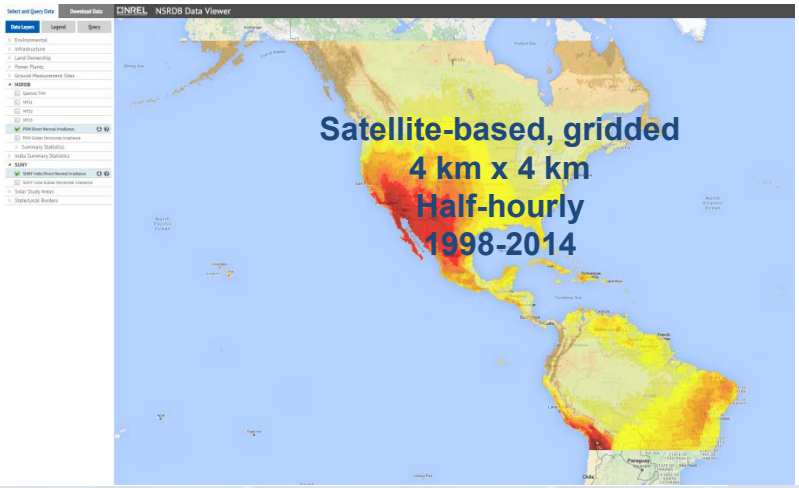
Evolution of Solar Resource Data

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

1961-1990 NSRDB[2] [DOE, NOAA, 1994]

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

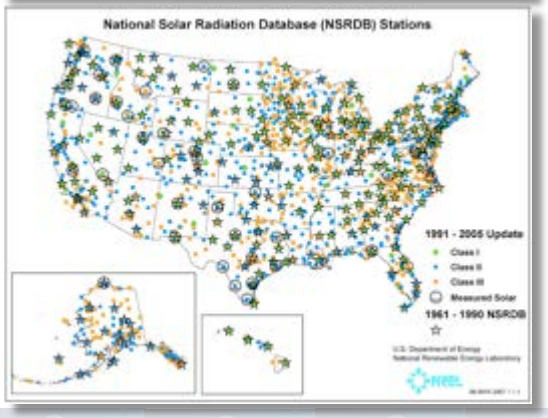
1998-2014 NSRDB [DOE, NOAA, UW 2015]



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

(2)
239
Modeled
Stations with
56 partial
measureme
nt stations
1990

(3)
1,454 ***Modeled***
Locations
1991-2005

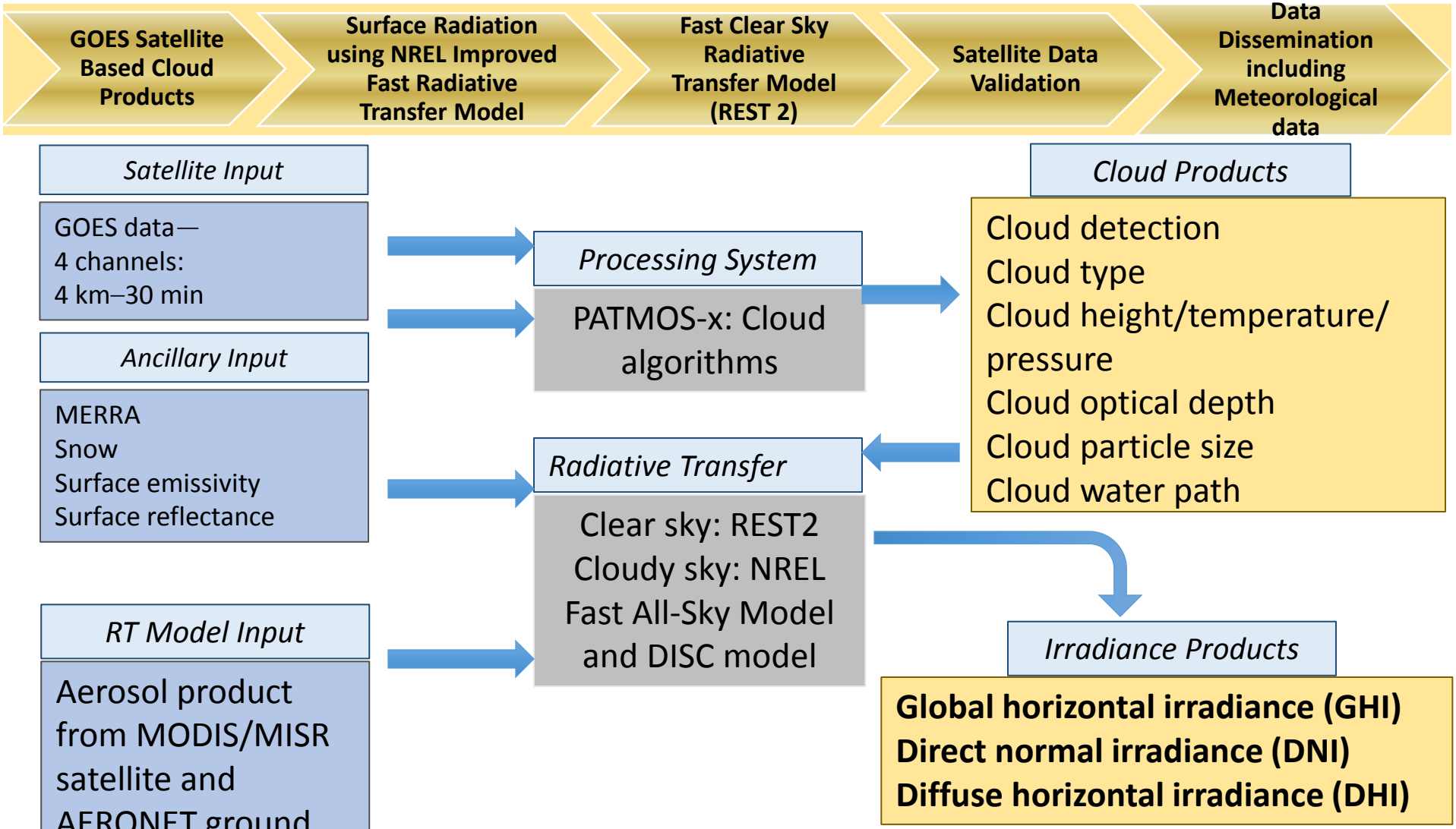


How do satellites model surface radiation?

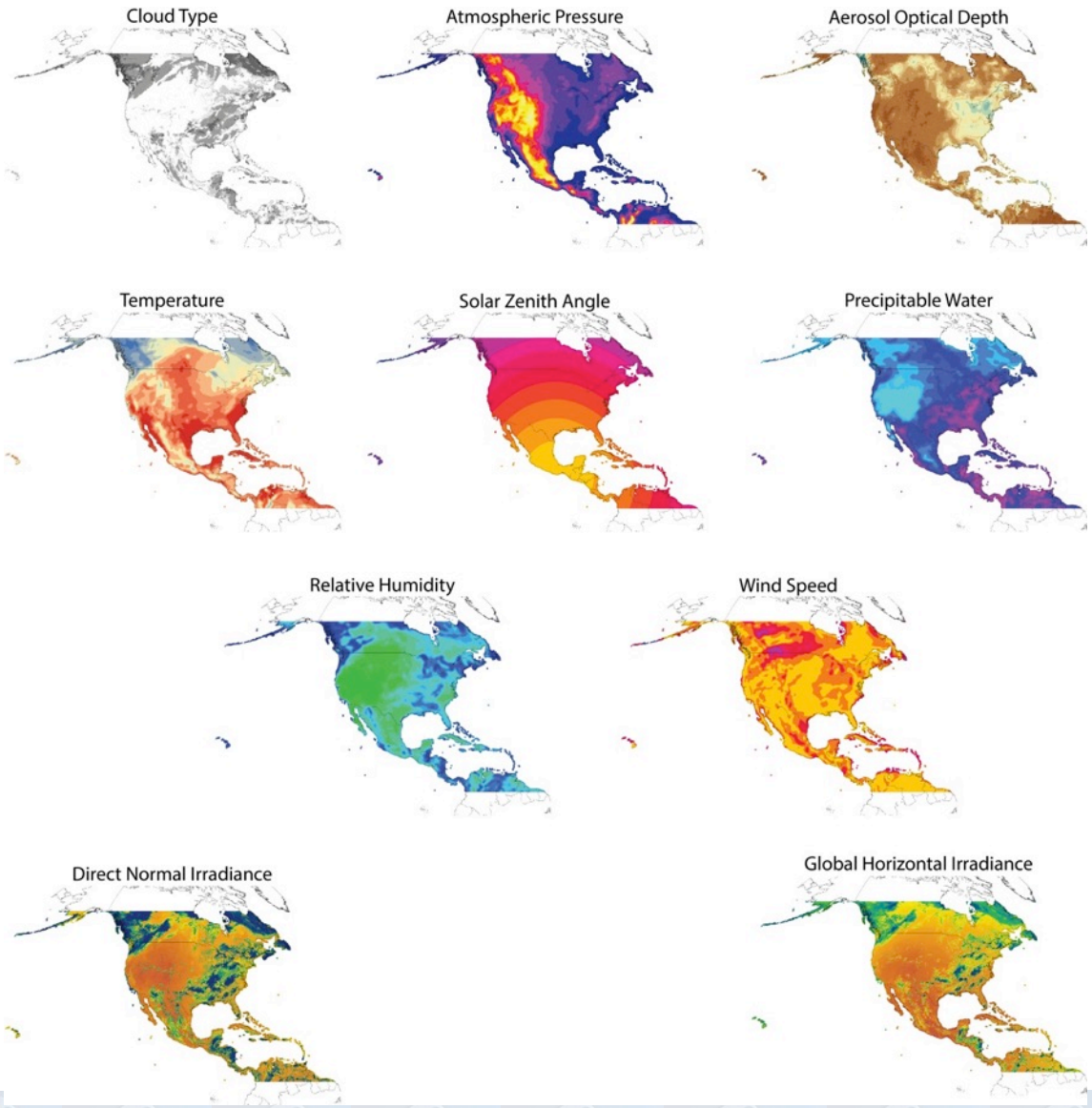
- **Empirical Approach (Industry standard traditional approach):**
  - Build model relating satellite measurements and ground observations.(cloud index and clearness index)
  - Use those models to obtain solar radiation at the surface from satellite measurements.

- **Physical Approach: (the new approach)**
  - Retrieve cloud and aerosol information from satellites
  - Use the information in a radiative transfer model

Physical Solar Model (PSM) Framework



Met Data for the NSRDB



Gridded NSRDB – Comprises various variables which include meteorological parameters that are obtained from the Modern Era-Retrospective Analysis (MERRA) dataset.

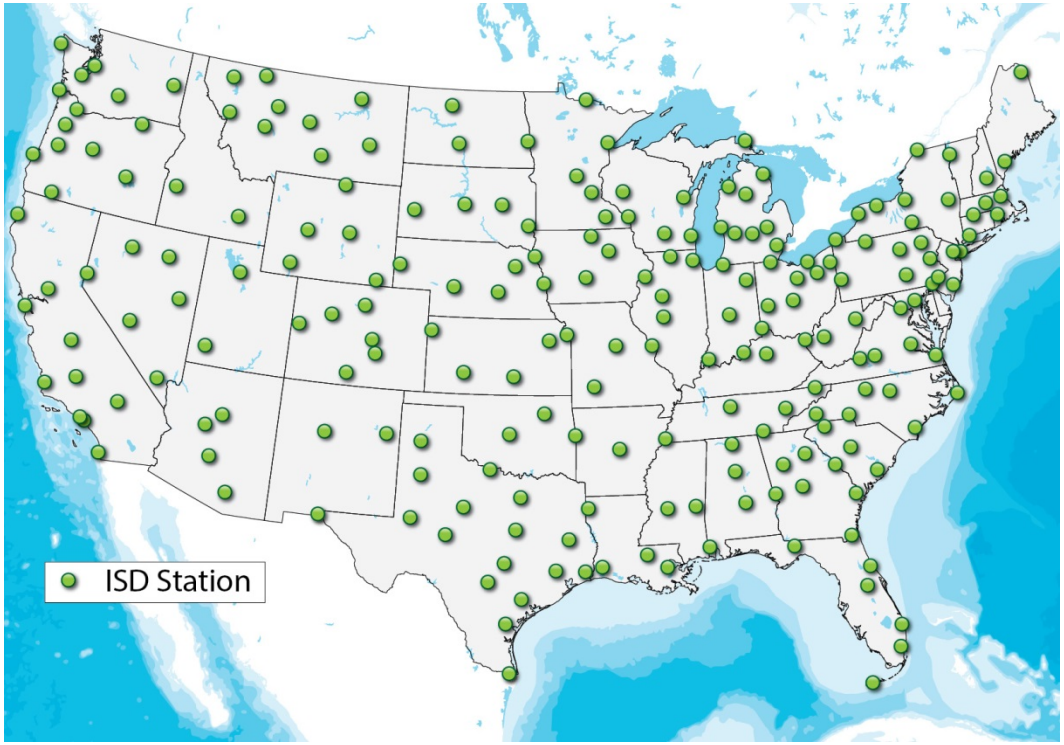
Note: Some of these parameters are part of the NSRDB release data and some are used for processing the gridded data.

Meteorological Data Comparison

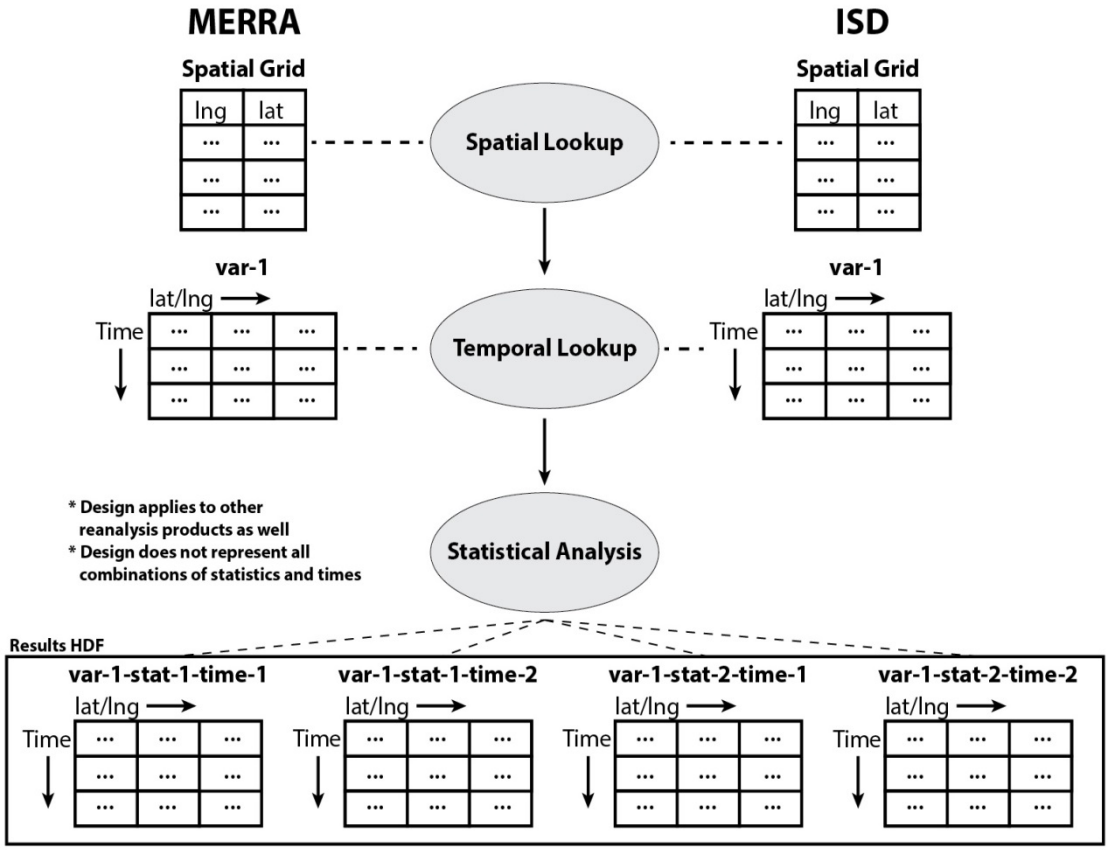
The three data sets evaluated are:

- Modern-Era Retrospective Analysis for Research and Applications (MERAA),
- North American Regional Reanalysis (NARR), and
- Climate Forecast System Reanalysis (CFSR).

These datasets were evaluated against 216 ISD stations located in the contiguous United States.

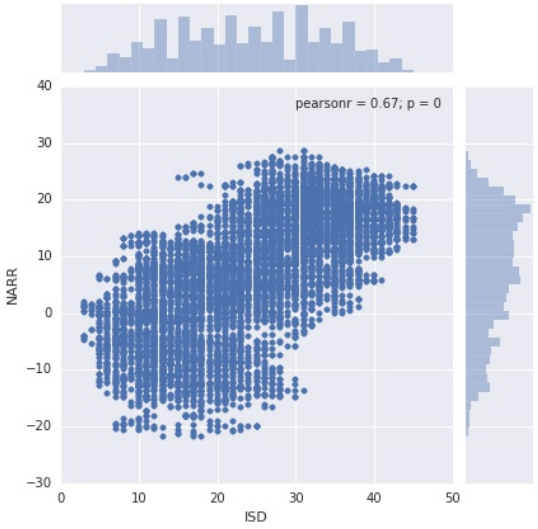


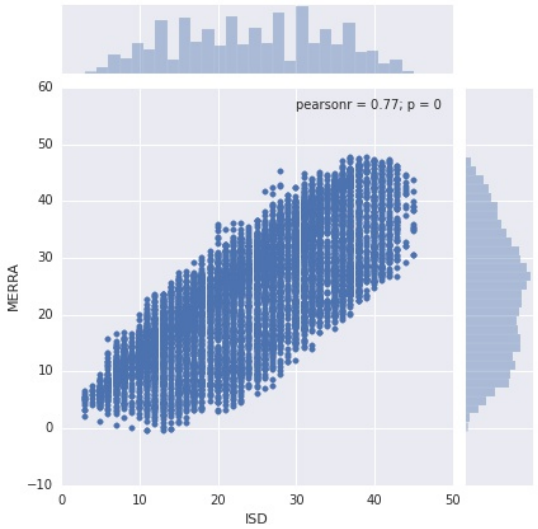
Analysis Sequence

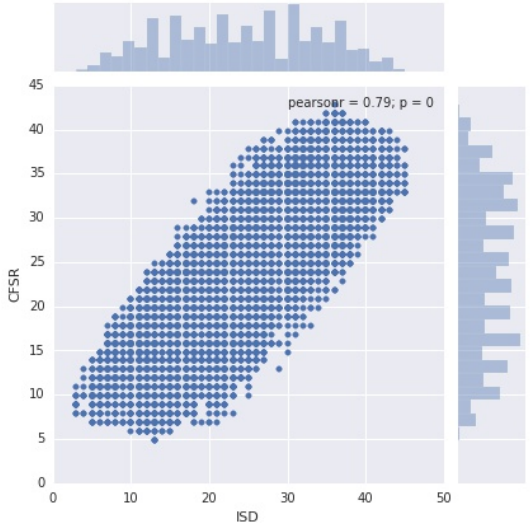


Meteorological Data Comparison

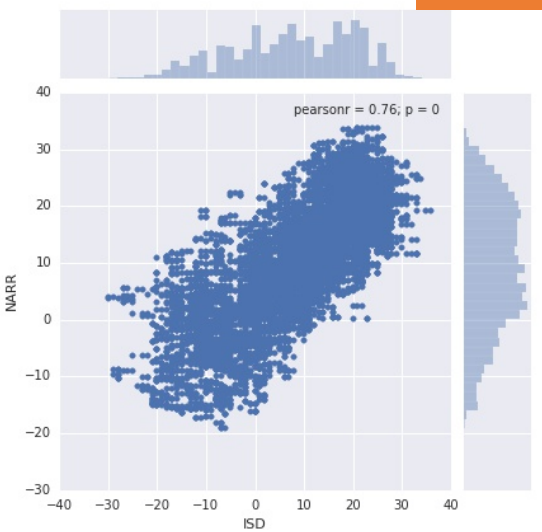
Temperature Comparison for Phoenix, AZ

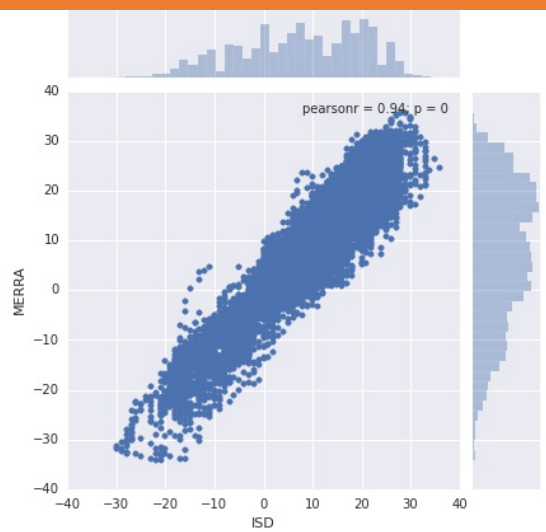


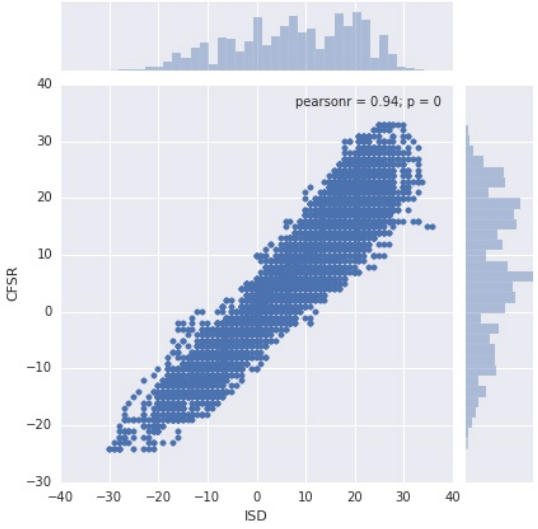




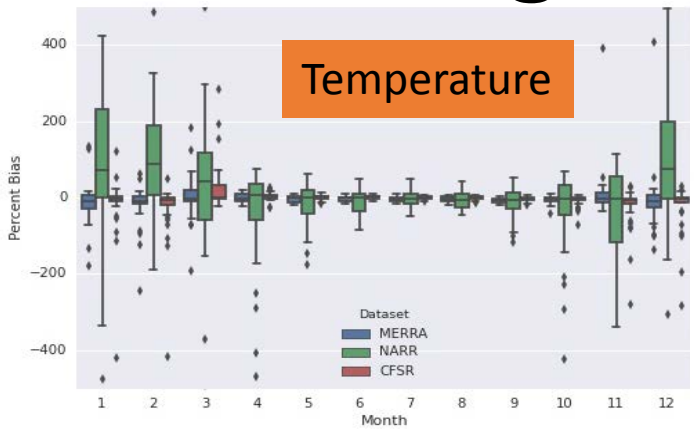
Temperature Comparison for Minneapolis, MN

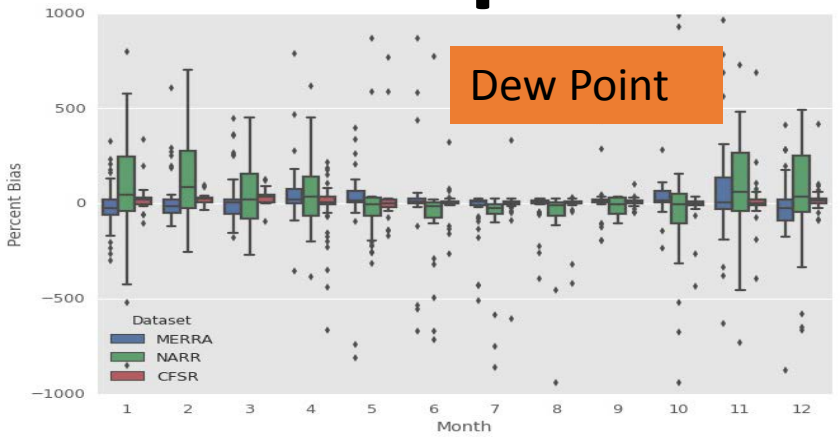


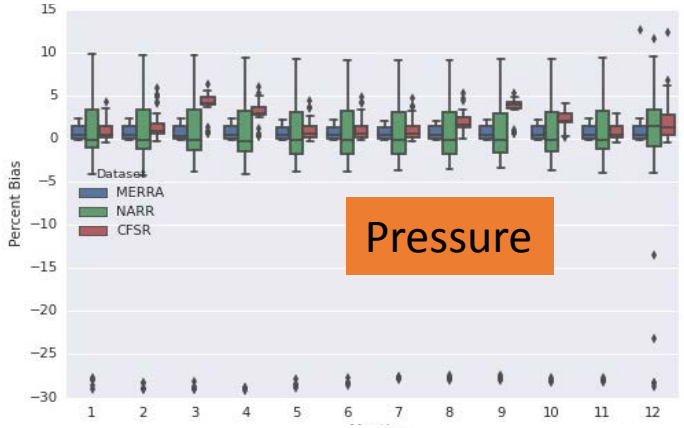


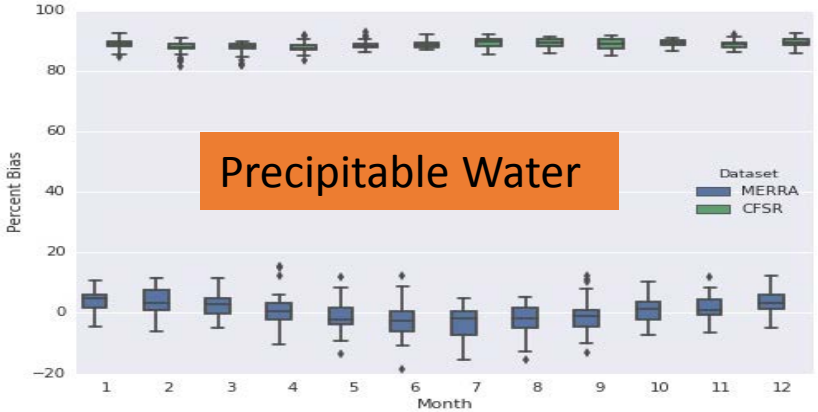


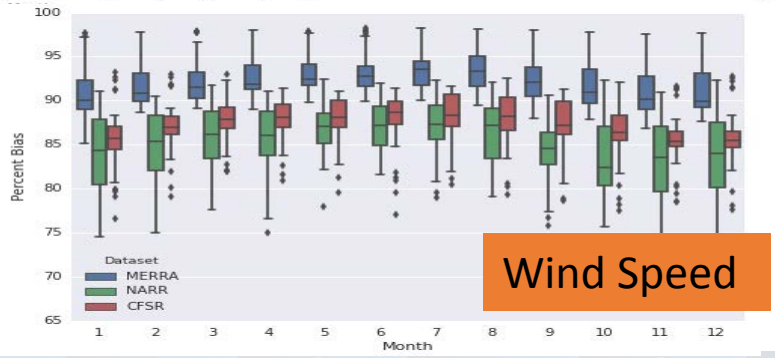
Meteorological Data Comparison



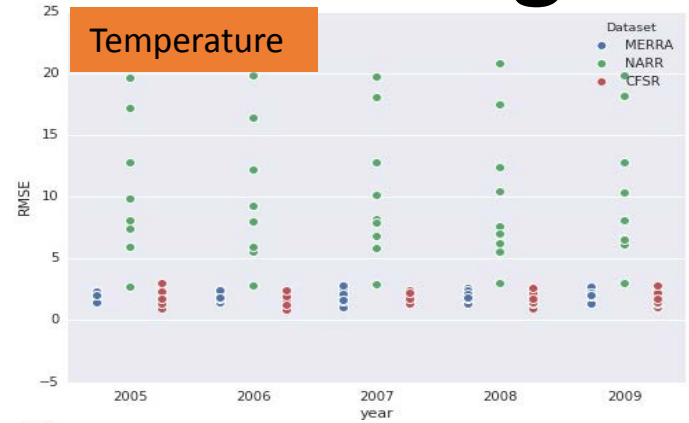


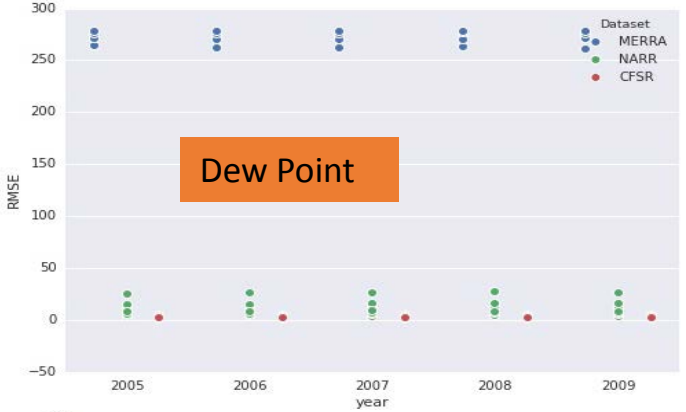


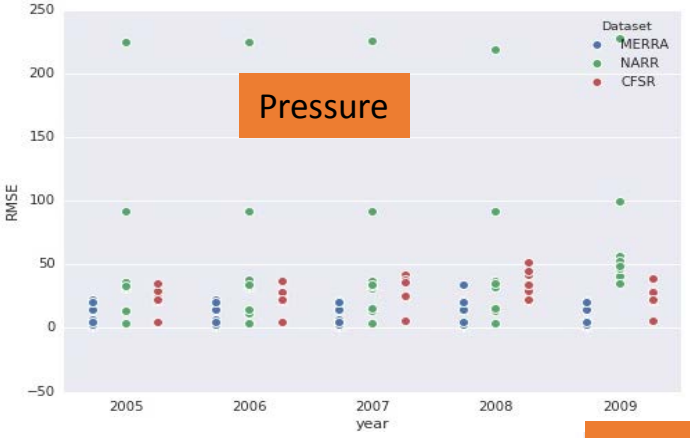


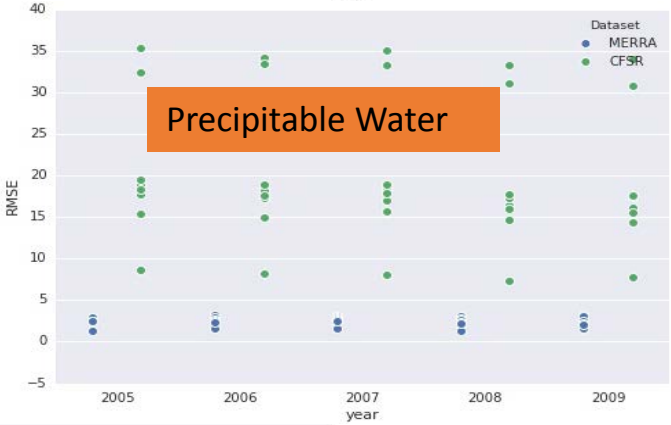


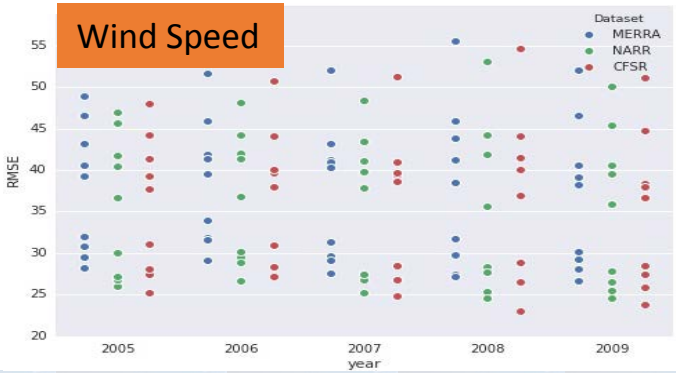
Meteorological Data Comparison





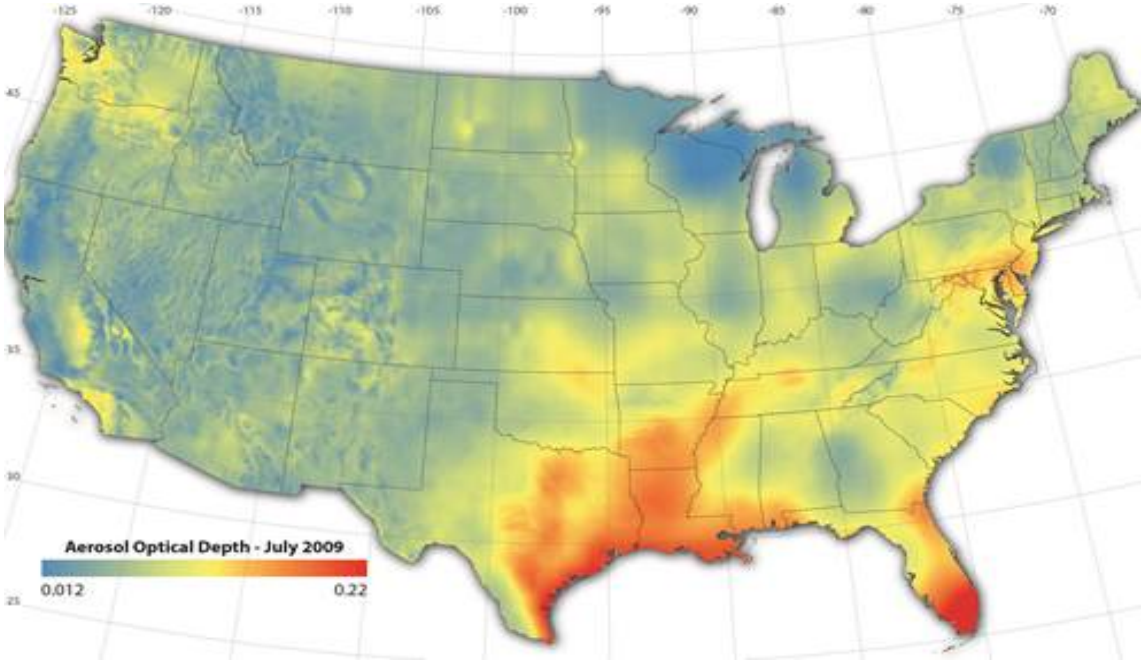






Current AOD Retrieval Process

AOD

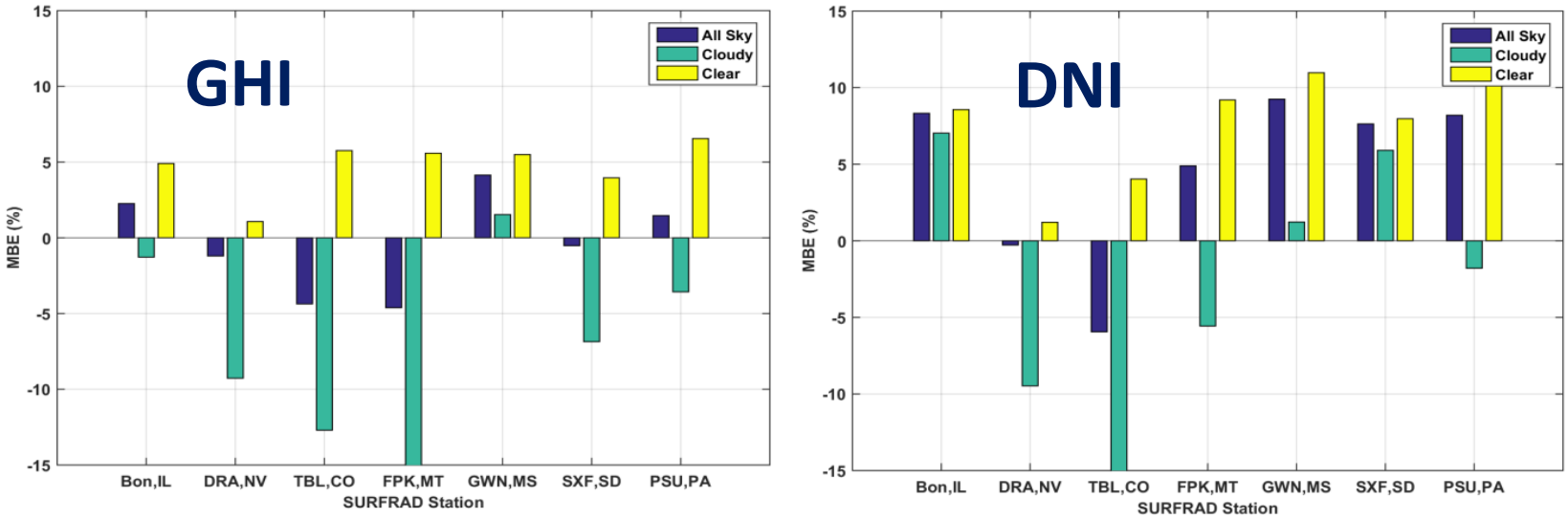


	AOD	MAE(W/m^2)	MAE(%)	RMSE(W/m^2)
Desert Rock, NV	Monthly	17	1.84	20
	Daily	12	1.34	16
Goodwin Creek, MS	Monthly	47	5.96	53
	Daily	30	3.76	36
Bondville, IL	Monthly	62	7.76	67
	Daily	37	4.65	48
Table Mtn., Co	Monthly	35	3.84	41
	Daily	24	2.57	30

Validation of the NSRDB

Validation of NSRDB

- **Validation of gridded NSRDB dataset**
  - Evaluation of the new NSRDB dataset was carried out using high quality SURFRAD ground stations.
  - Accuracy of NSRDB datasets is significantly high.



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

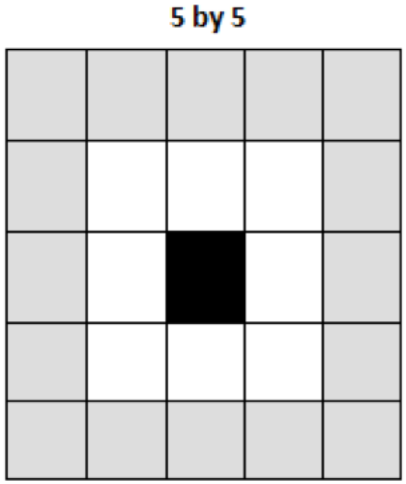
Gridded TMY

Product Variables

Element	Unit or Description
Year	1998-2014
Month	1-12
Day	1-28,1-30 or 1-31
Hour	1-23
Minute	0
Dew Point	Degree C
DHI	Watt per square meter
DNI	Watt per square meter
GHI	Watt per square meter
Temperature	Degree C
Pressure	Millibar
Wind Direction	Degrees
Wind Speed	meter per second

TMY Spatial Variability

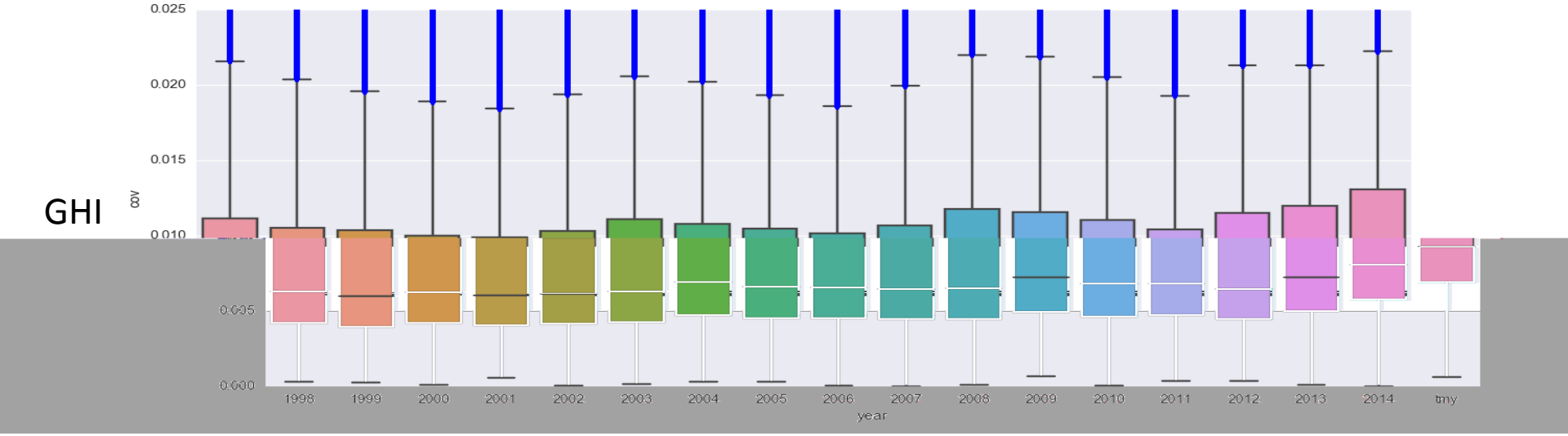
$$COV(TxY_a, TxY_b) = \frac{\left(\sqrt{\frac{\sum_{i=1}^{i=n}(\overline{TxY_{b_i}} - \overline{TxY_a})^2}{n}}\right)}{\overline{TxY_a}}$$



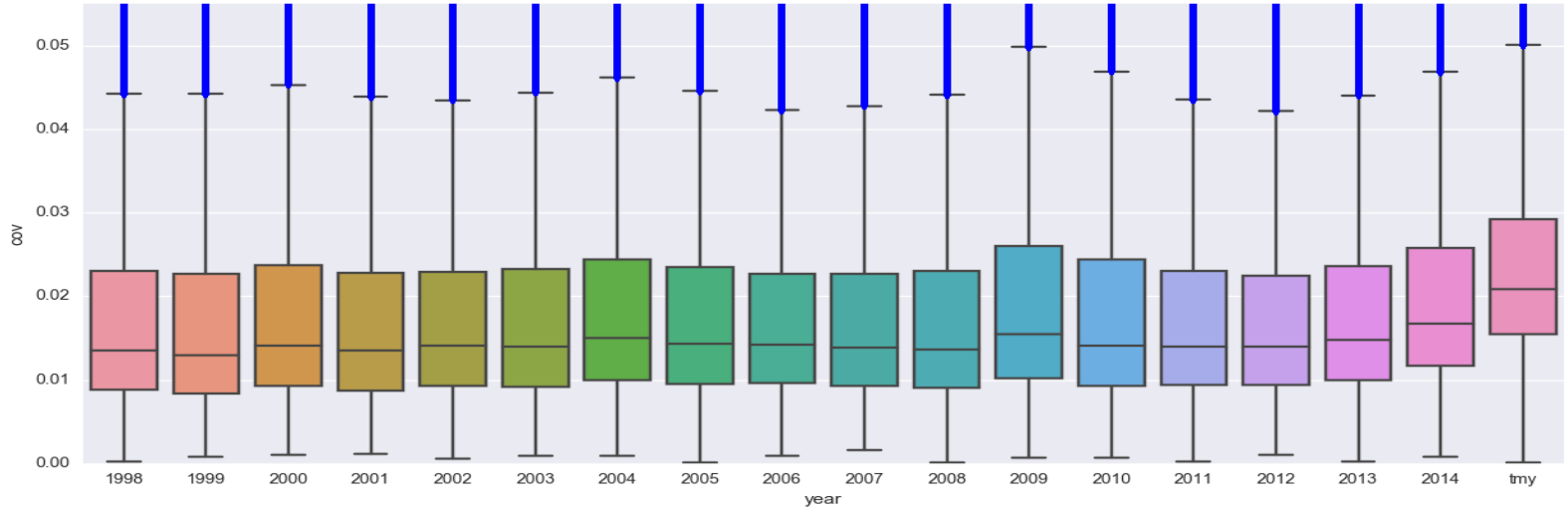
TxYa: average irradiance of the center pixel
TxYb: average irradiance of the comparison pixel(s)
n: number of surrounding pixels compared

TMY Spatial Variability

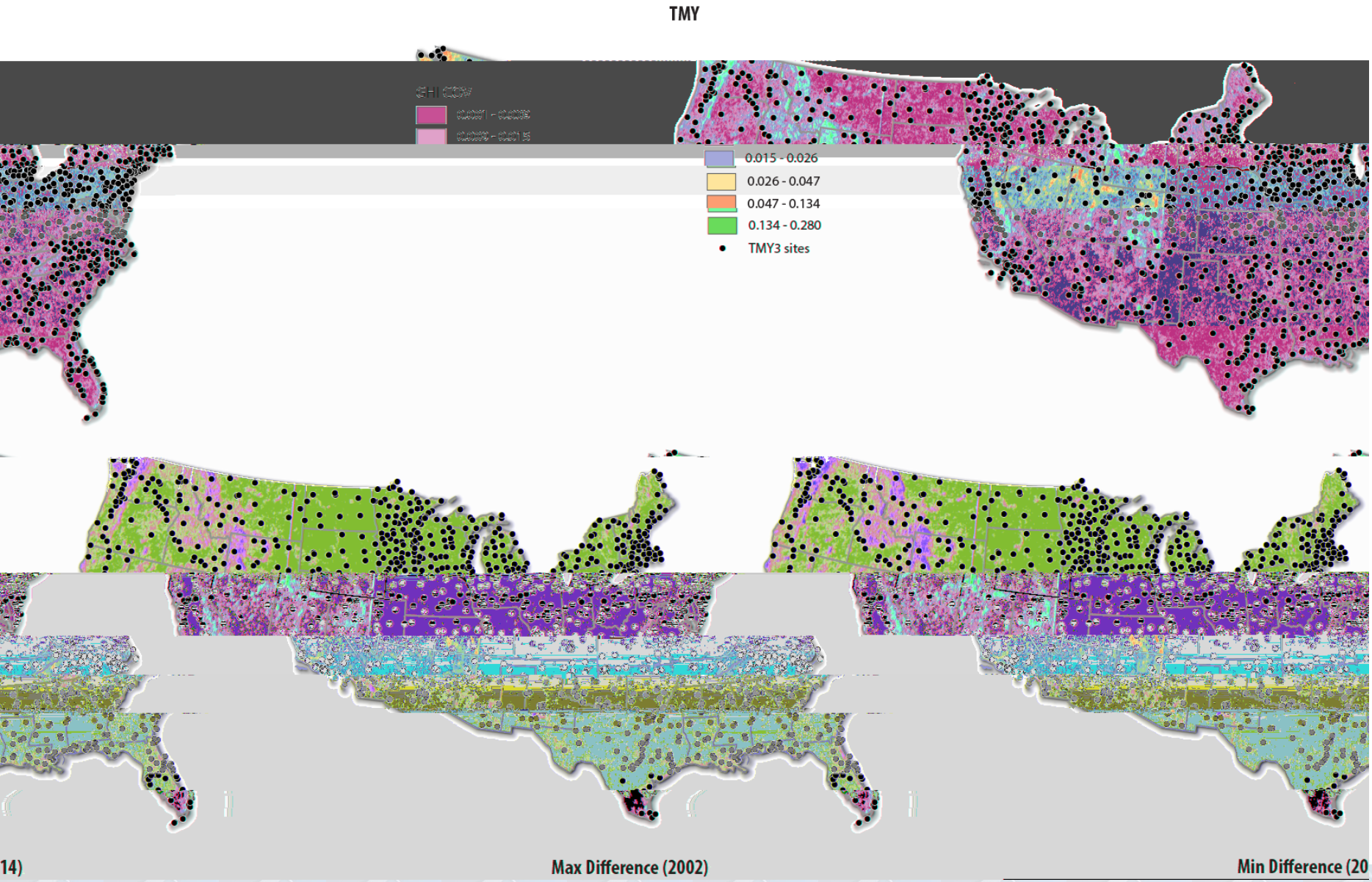
GHI



DNI



TMY Spatial Variability

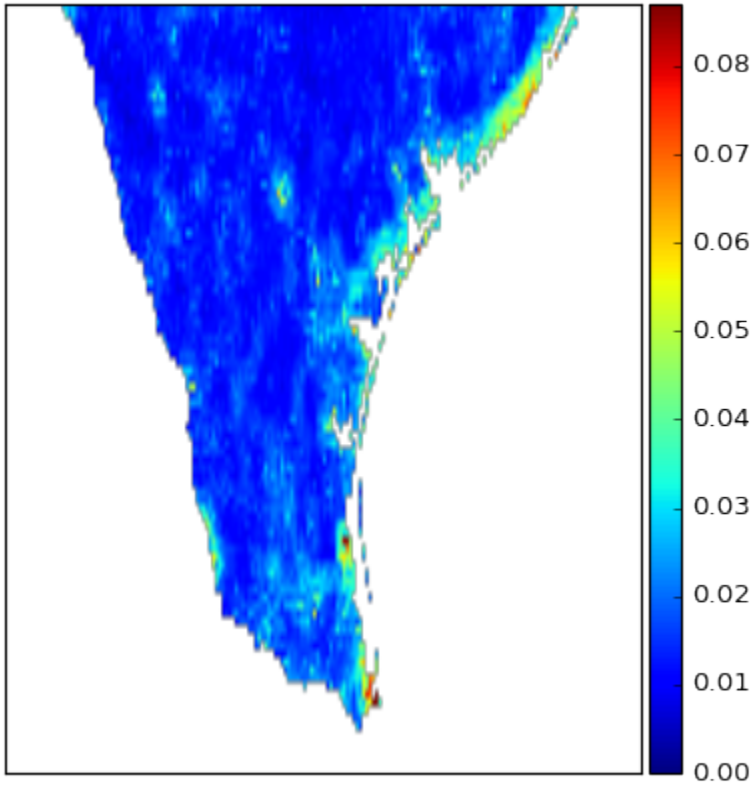


TMY Spatial Variability

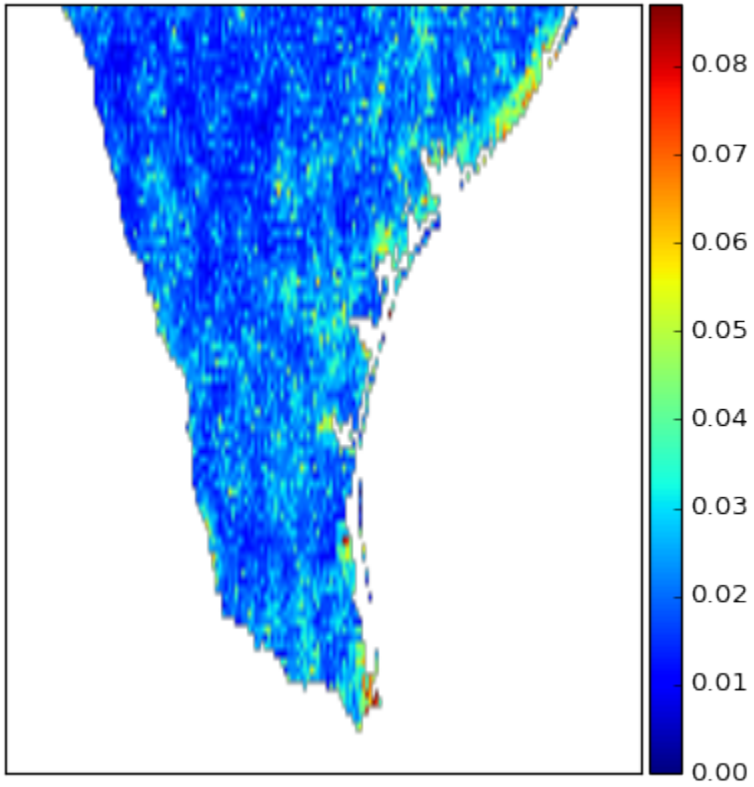
1998-2014 COV

TMY COV

TMY Spatial Variability



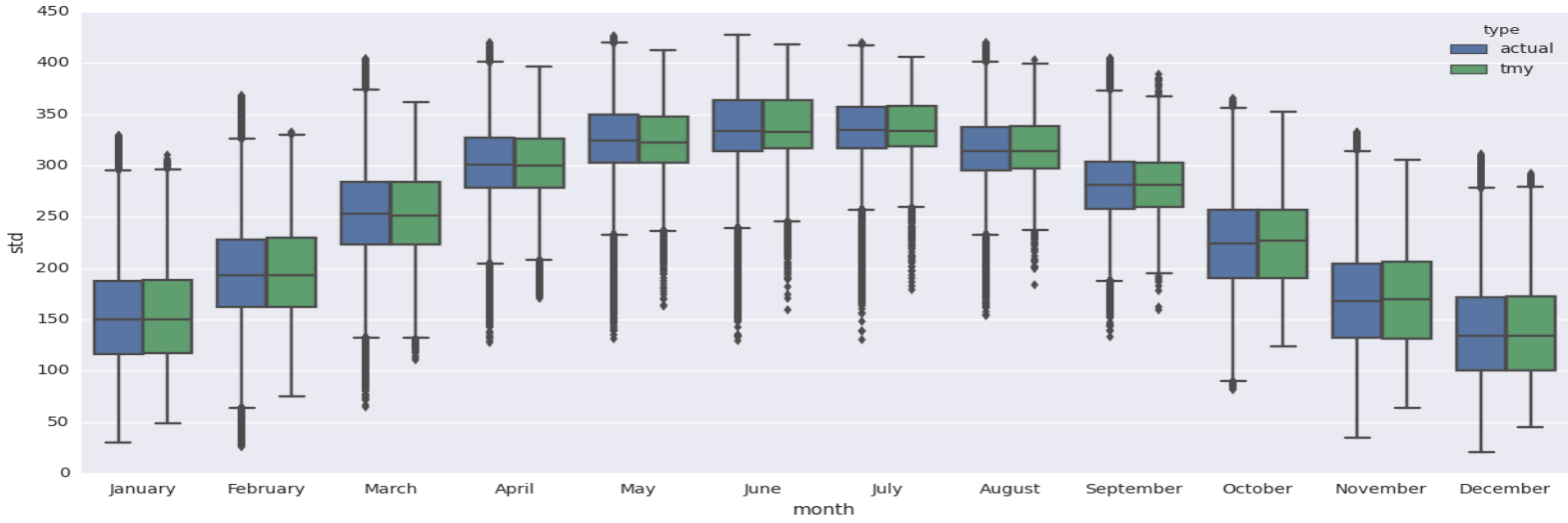
1998-2014 COV



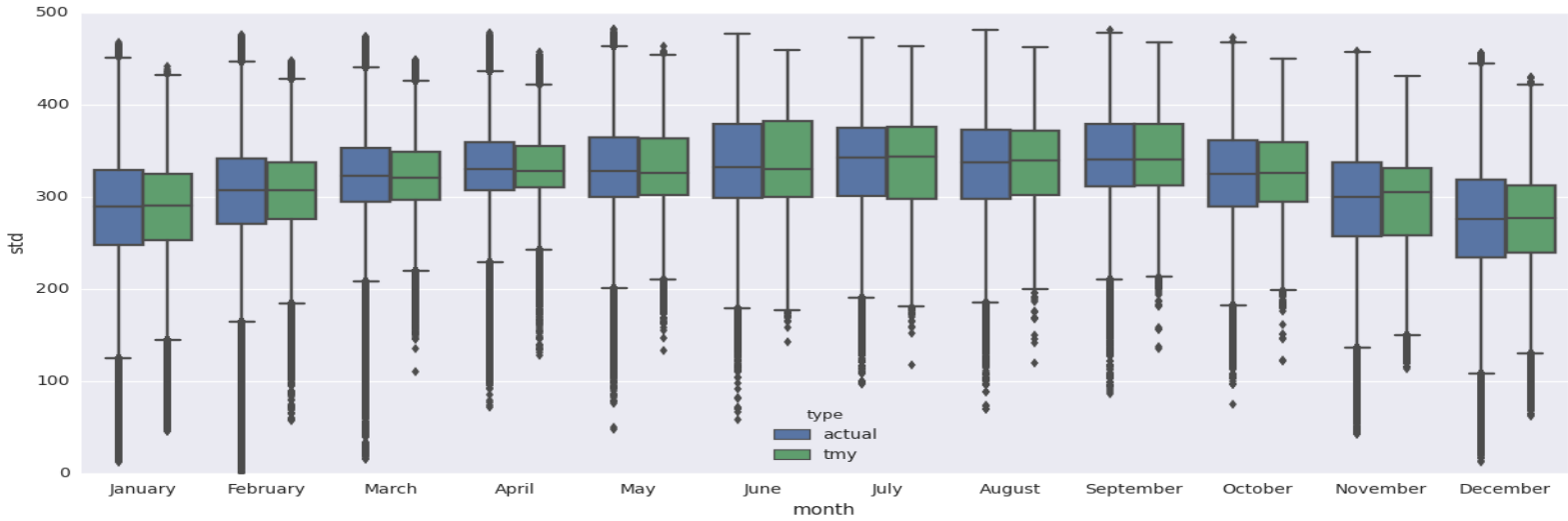
TMY COV

TMY Temporal Variability

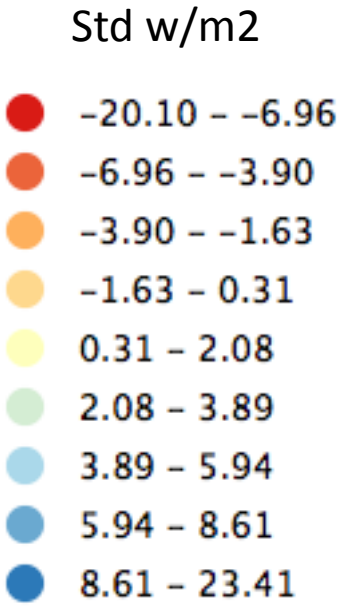
GHI



DNI



TMY Temporal Variability



DNI

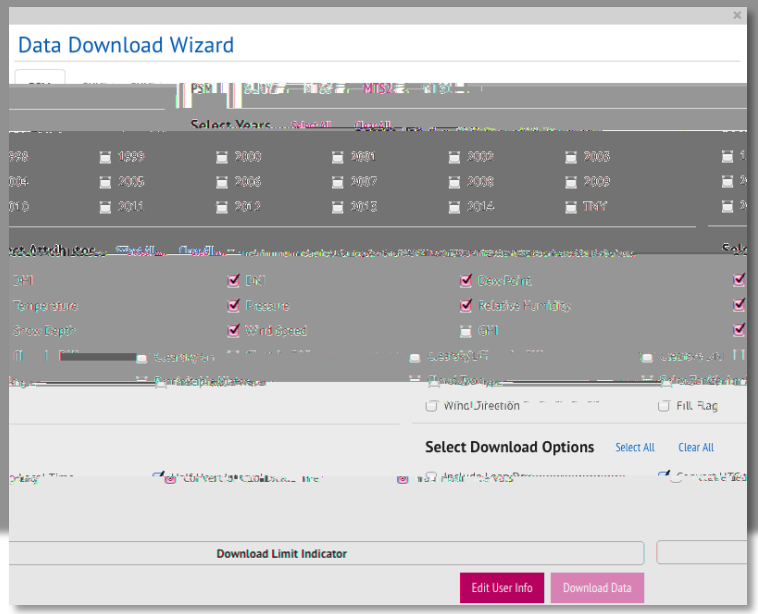
GHI

Difference between monthly standard deviation means for actuals with monthly standard deviation for TMY

NSRDB Website

http://nsrdb.nrel.gov

NSRDB Viewer



Data API

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

National Solar Radiation Database (NSRDB)

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Home » Data Sets » API Instructions

API Instructions

NSRDB and SAM Python APIs: Automated download of resource data and SAM simulation

- NSRDB Website: https://nsrdb.nrel.gov
- Get NSRDB API Key: https://developer.nrel.gov/signup/
- SAM Website: https://sam.nrel.gov
- Download the SAM Software Development Kit (SDK): https://sam.nrel.gov/sdk

This example shows how to use the NSRDB API for automated data download in Section 1 and then provides an example of using these data with the SAM Software Development Kit (SDK) in Section 2. A plotting example is offered in Section 3.

In [1]:
```
import pandas as pd
import numpy as np
import sys, os
```

Conclusions

- Reanalysis meteorological data sets demonstrated different levels of accuracy compared to the ISD data sets. MERRA data set demonstrated relatively better agreement than NARR and CFSR data sets (especially in precipitable water).
- The TMY data set demonstrated relatively good comparison with the time series NSRDB data set. However the results are aggregated results which could cancel some of the difference over longer period of time/aggregation.
- TMY does impact spatial variability structure of the data
- Depending on the funding, we have a plan to update the TMY process to make it more representative of the long term data set
- TMY data set will be updated on yearly basis, current TMY is generated using the 1998-2014 NSRDB data set.

Bibliography

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Questions?

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