A National Database for Solar Resource Assessment from Ground-Based Observations

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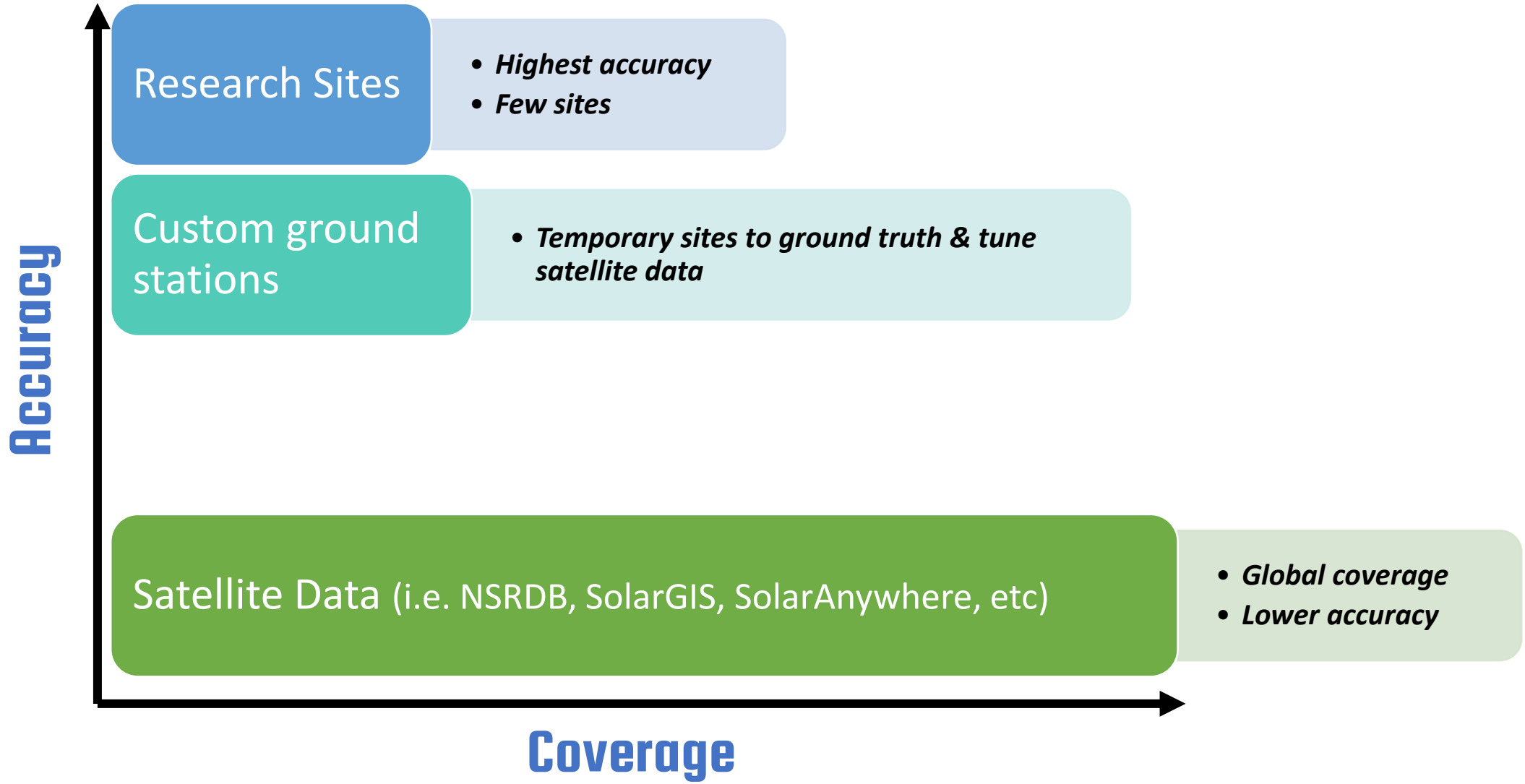
Previous Solar Resource

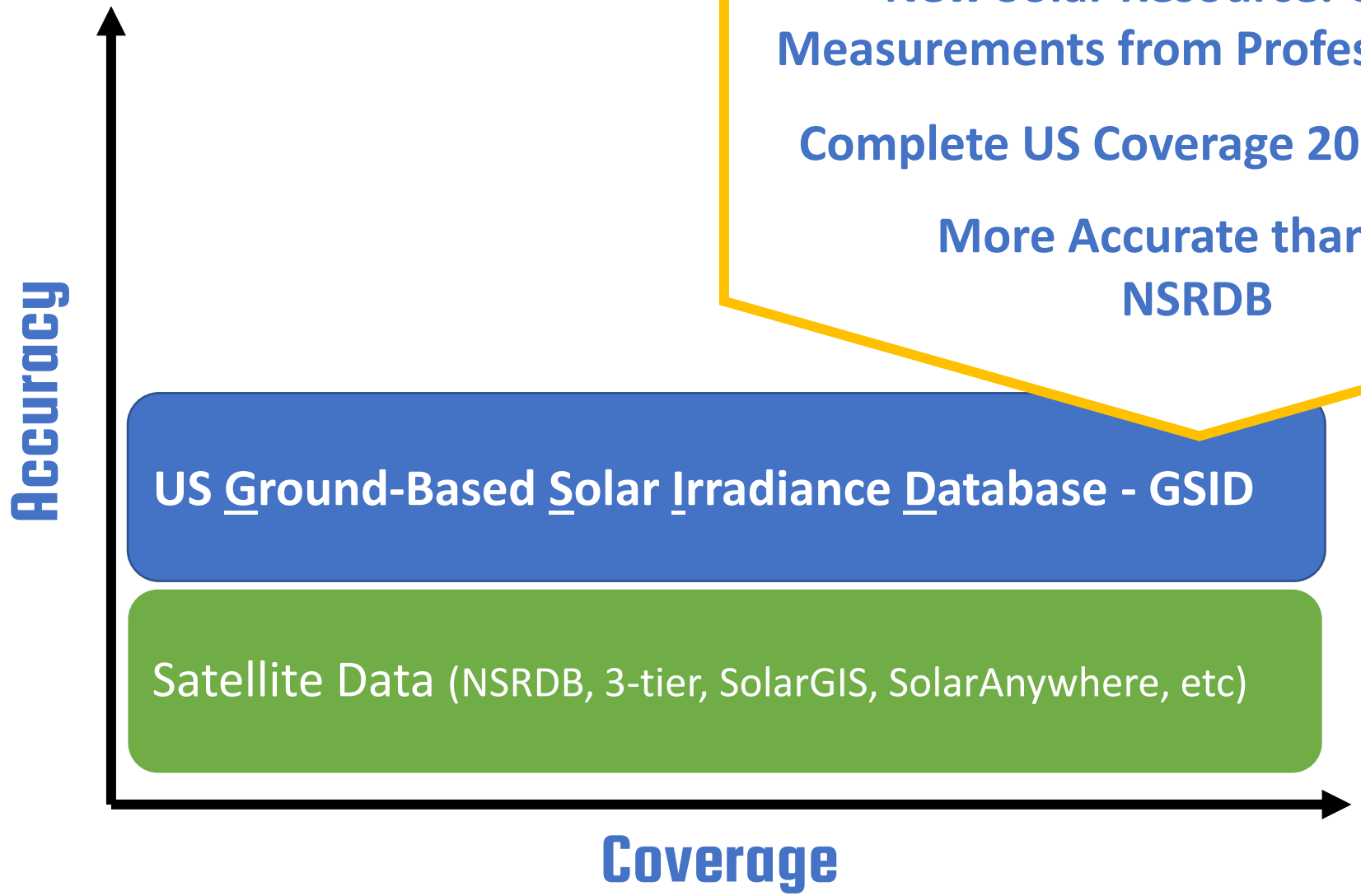


New Solar Resource

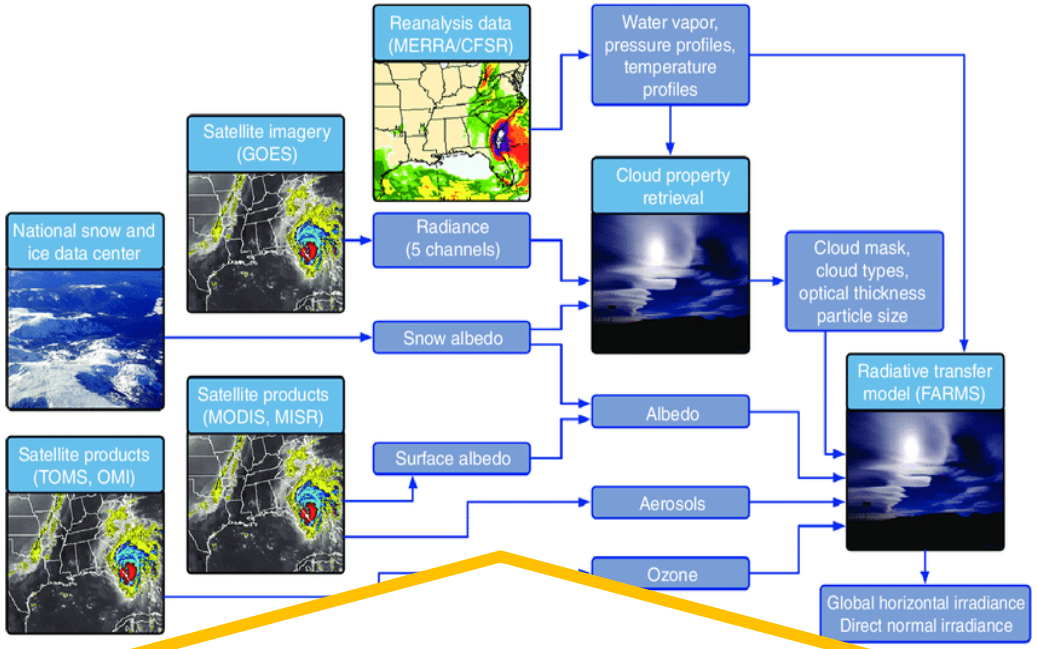
New Solar Resource: Ground Measurements from Professional Sites

Complete US Coverage 2005-Present

More Accurate than the NSRDB



Satellite vs Ground Observations



Satellite-Based Solar Resource

A series of complex models converts cloud images into irradiance estimates[1].

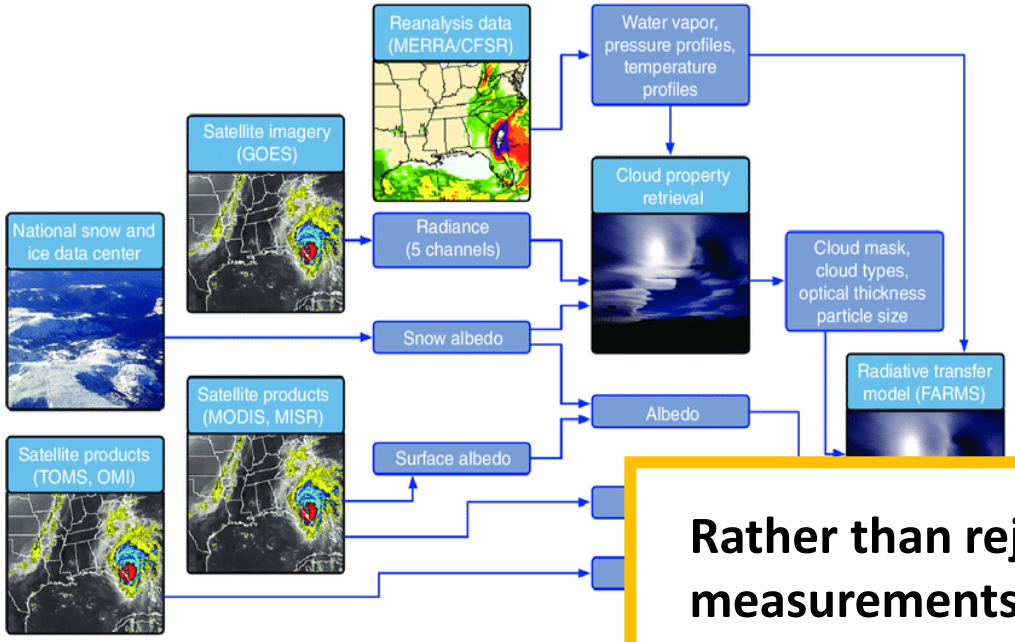
The Ground-Based Solar Irradiance Database (GSID)

Actual surface measurements from professional sites.

warning: actual measurements - may contain errors

Measurement

Satellite vs Ground Observations



The US Ground-Based Solar Irradiance Database (GSID)

Actual surface measurements from professional sites.

warning: actual measurements - may contain errors

AI Quality Control

GSID

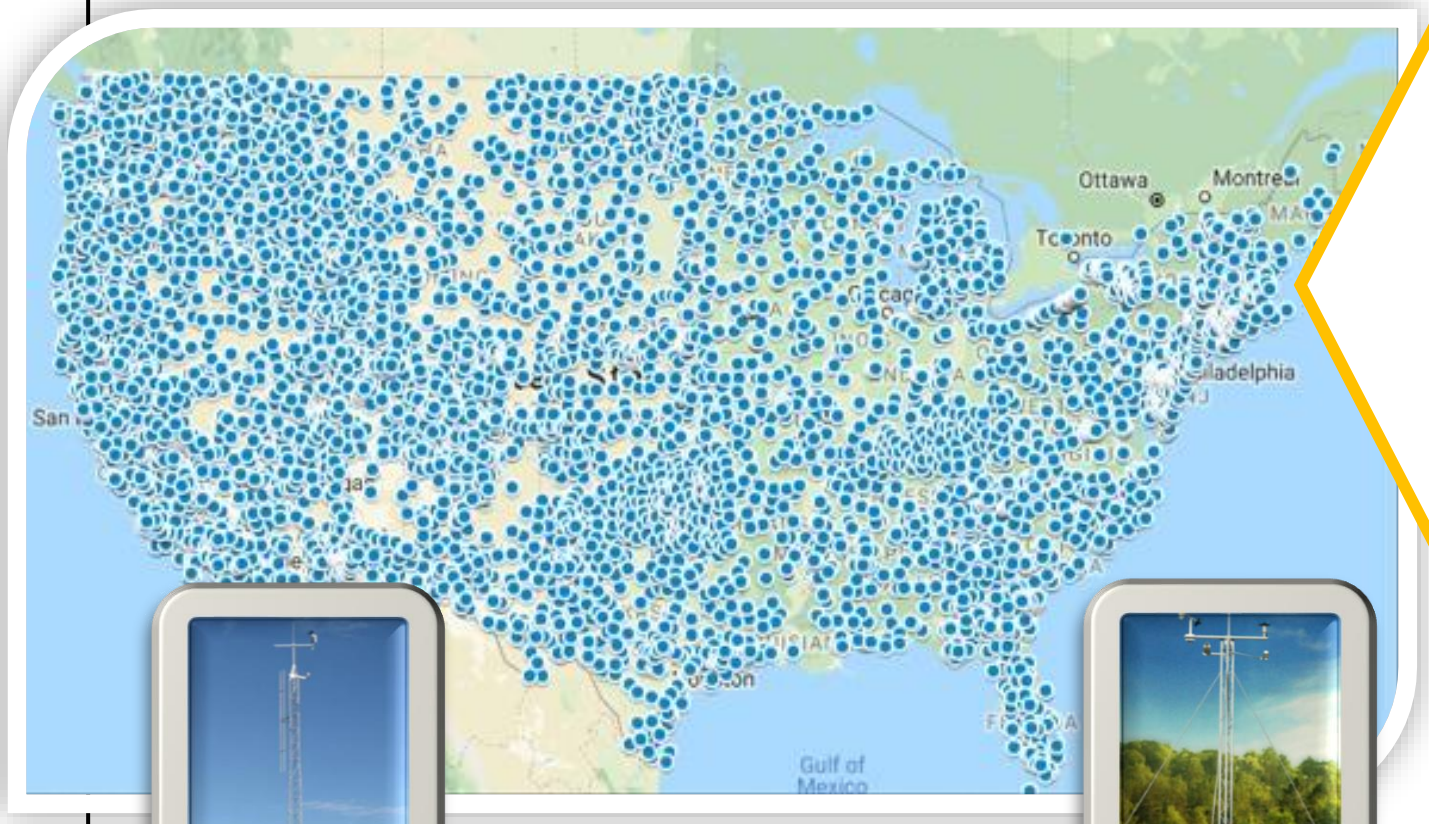
Rather than rejecting these measurements because some may contain errors,

Artificial Intelligence

is used to filter out the errors.

US GSID

Complete Coverage



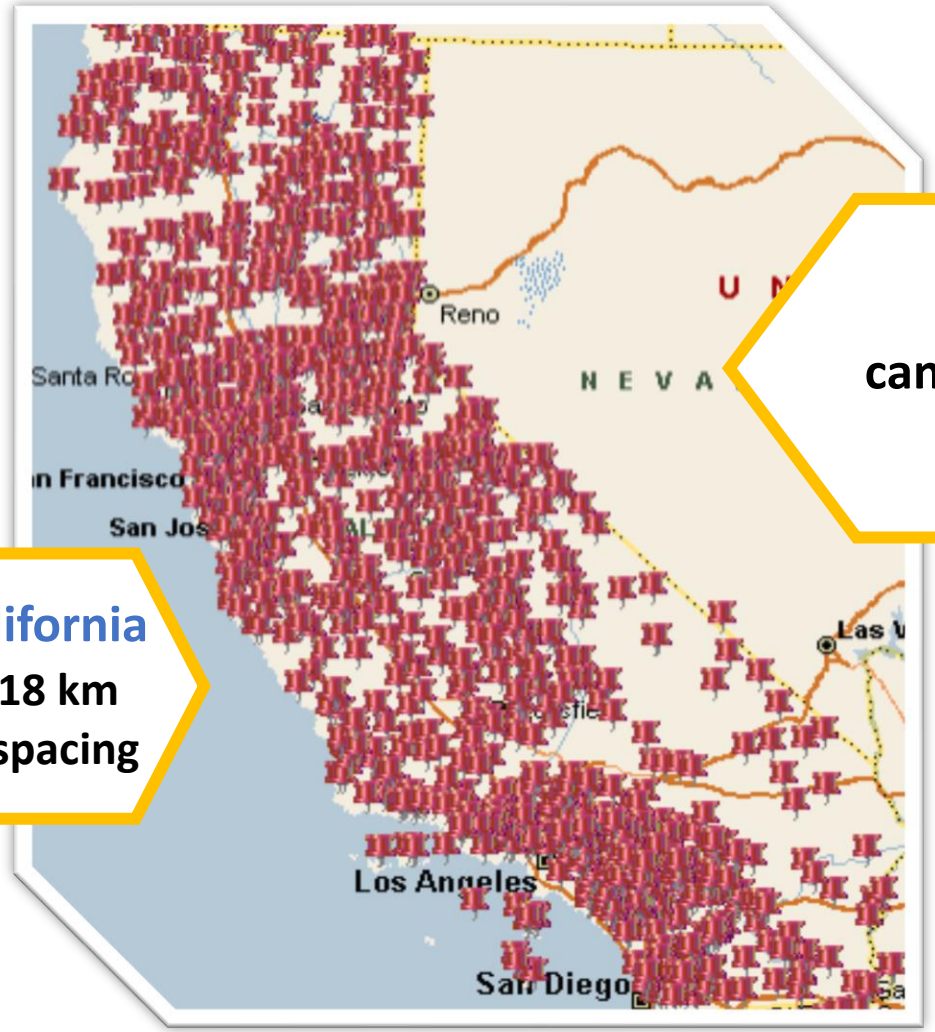
Ground-Based Observations
from ~ 100 overlapping networks, over 7000 US sites.

Professionally Operated Sites
maintained by Federal Agencies, States and Universities

37 km Average Spacing

US GSID

Better Spatial Resolution in Key Areas

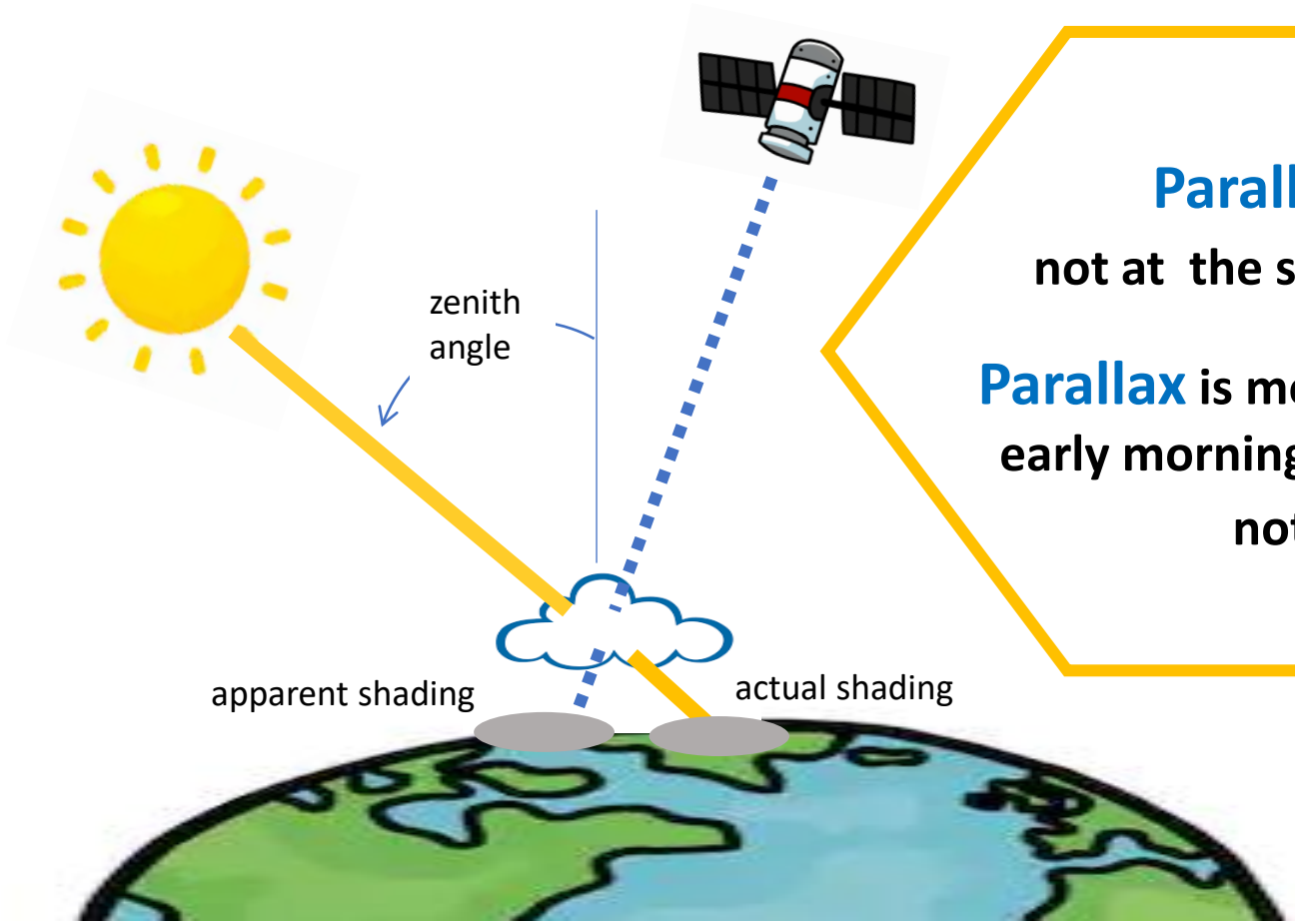


1350 California Sites ~18 km average spacing

Satellite Models
can have significant errors in coastal areas and other microclimates[2]

US GSID

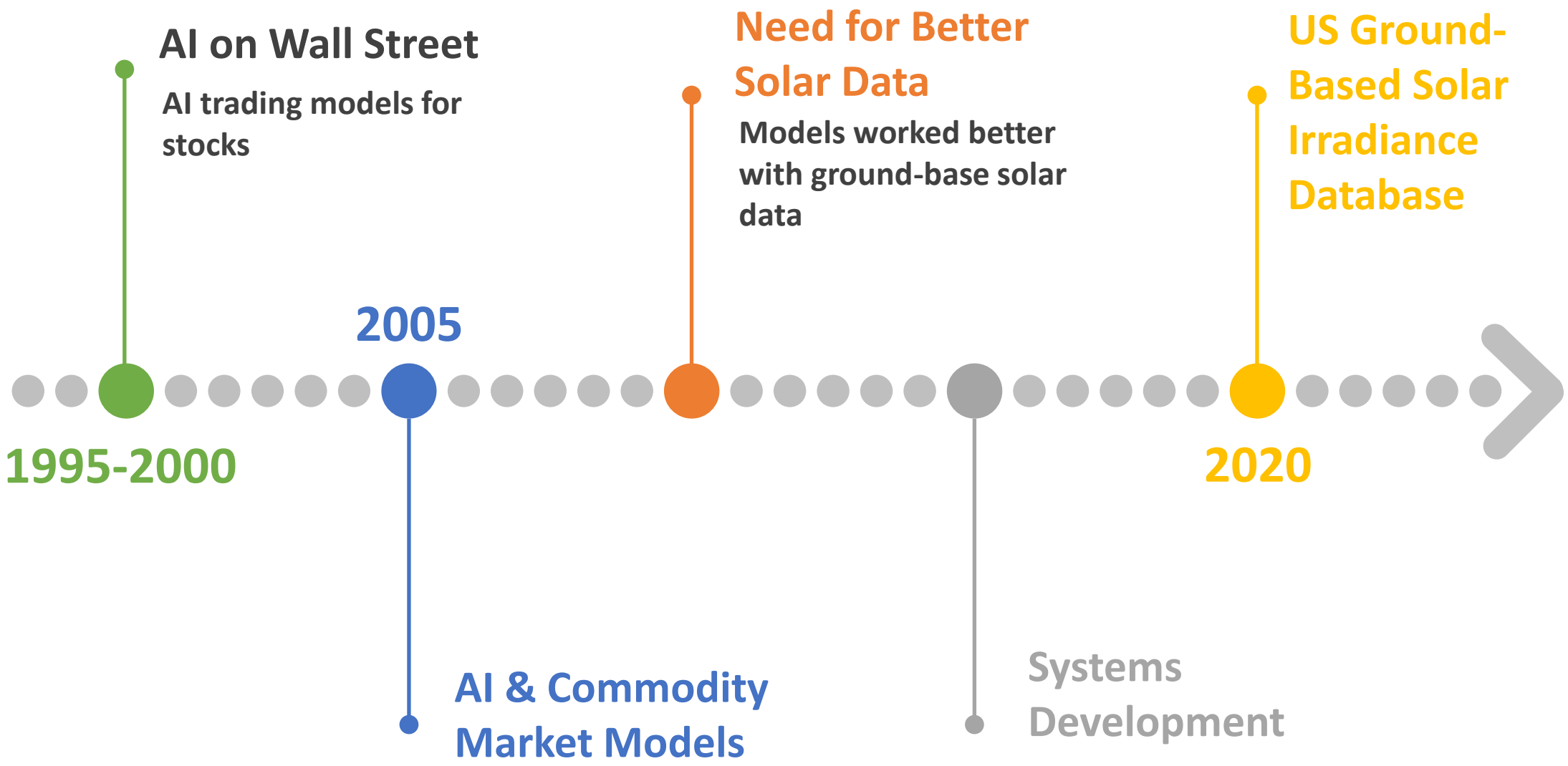
No Parallax Errors



Satellite Models can experience **Parallax,** where the **Apparent Shadow** is not at the same position as the **Actual Shadow.**

Parallax is most severe at high zenith angles - these early morning and late afternoon observations were not included in the original **NSRDB** error calculations[4].

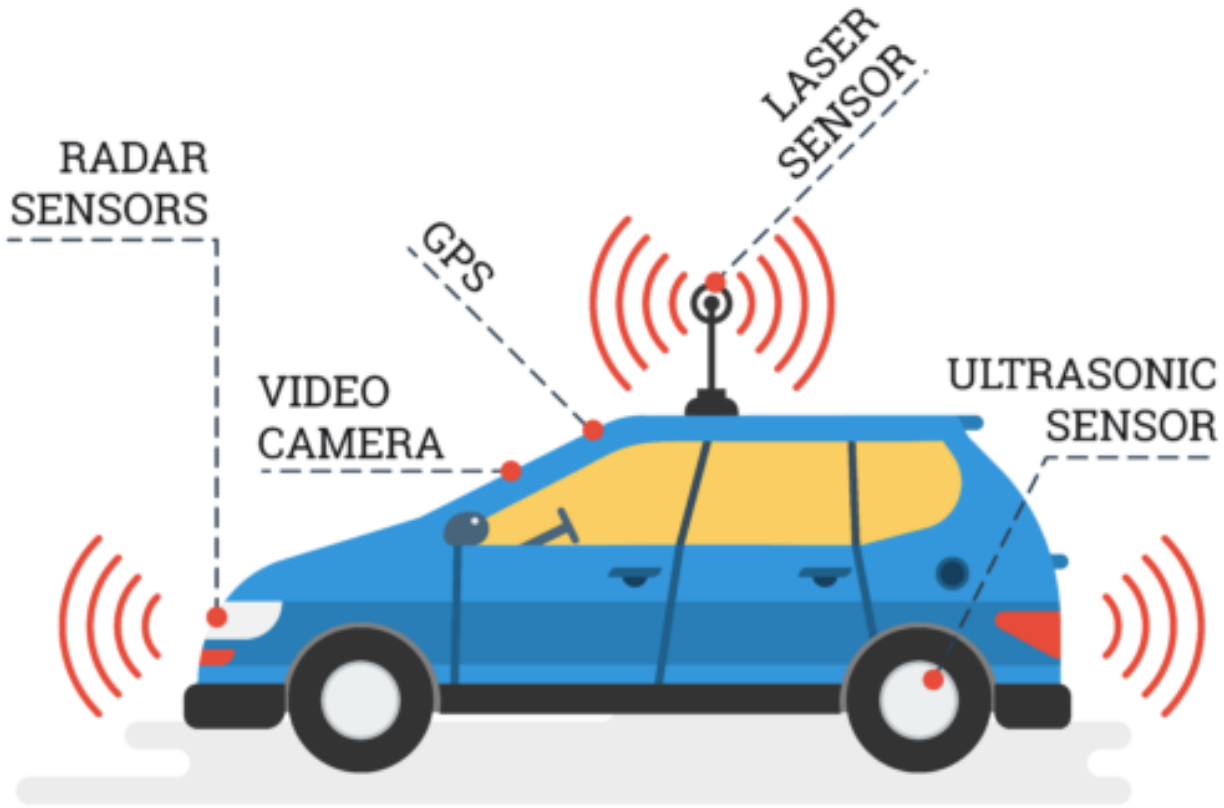
The Back Story



AI Quality Control

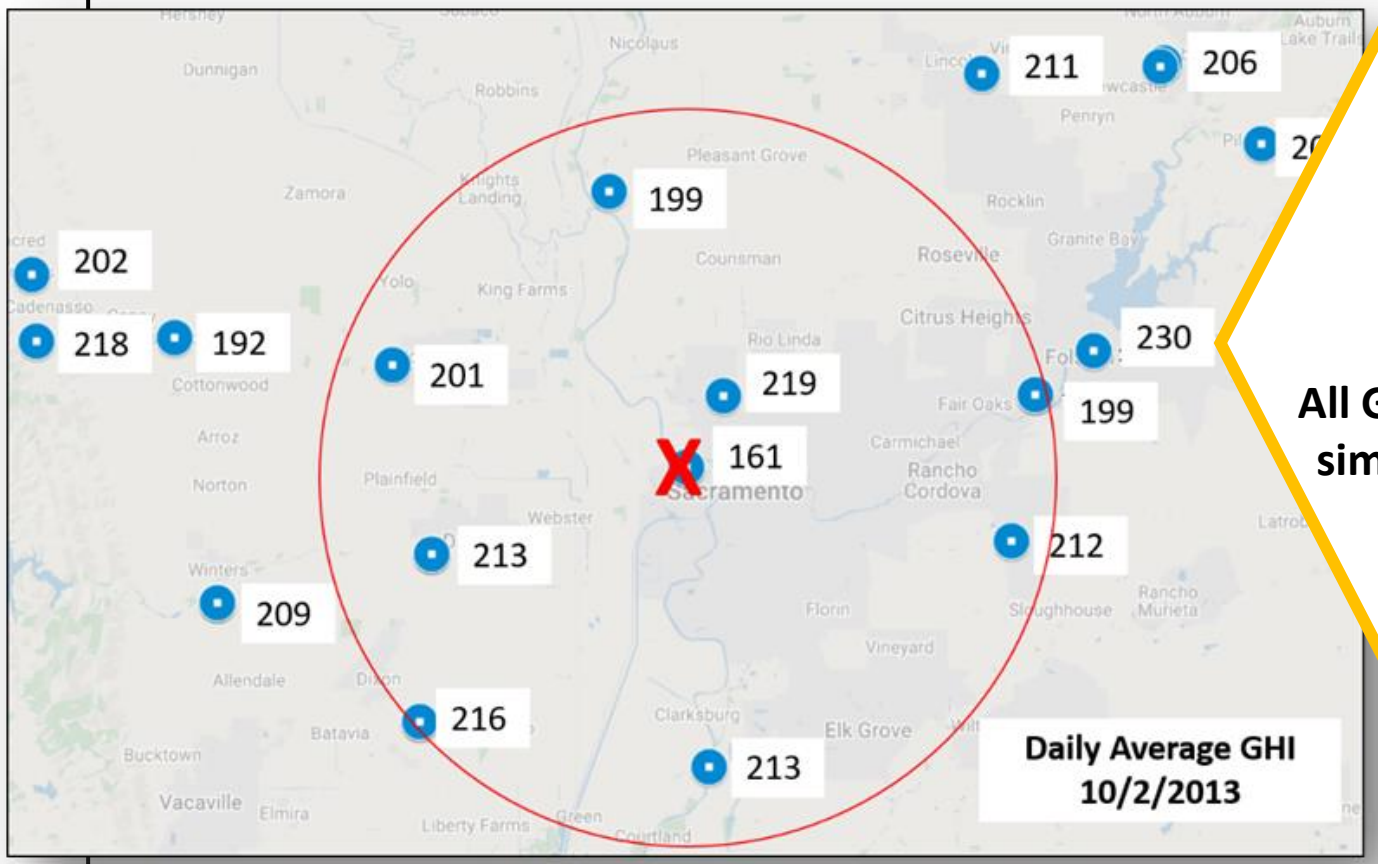
Sensor Fusion - Data from multiple sensors seeing the same event are combined in such a way that the result has less uncertainty.

Self-Driving Cars,
for example, filter and fuse data from different sensors to plan vehicle path and speed.



US GSID

AI filtering and Quality Control



Sensor Fusion

can sometimes be accomplished with simple filters and models.

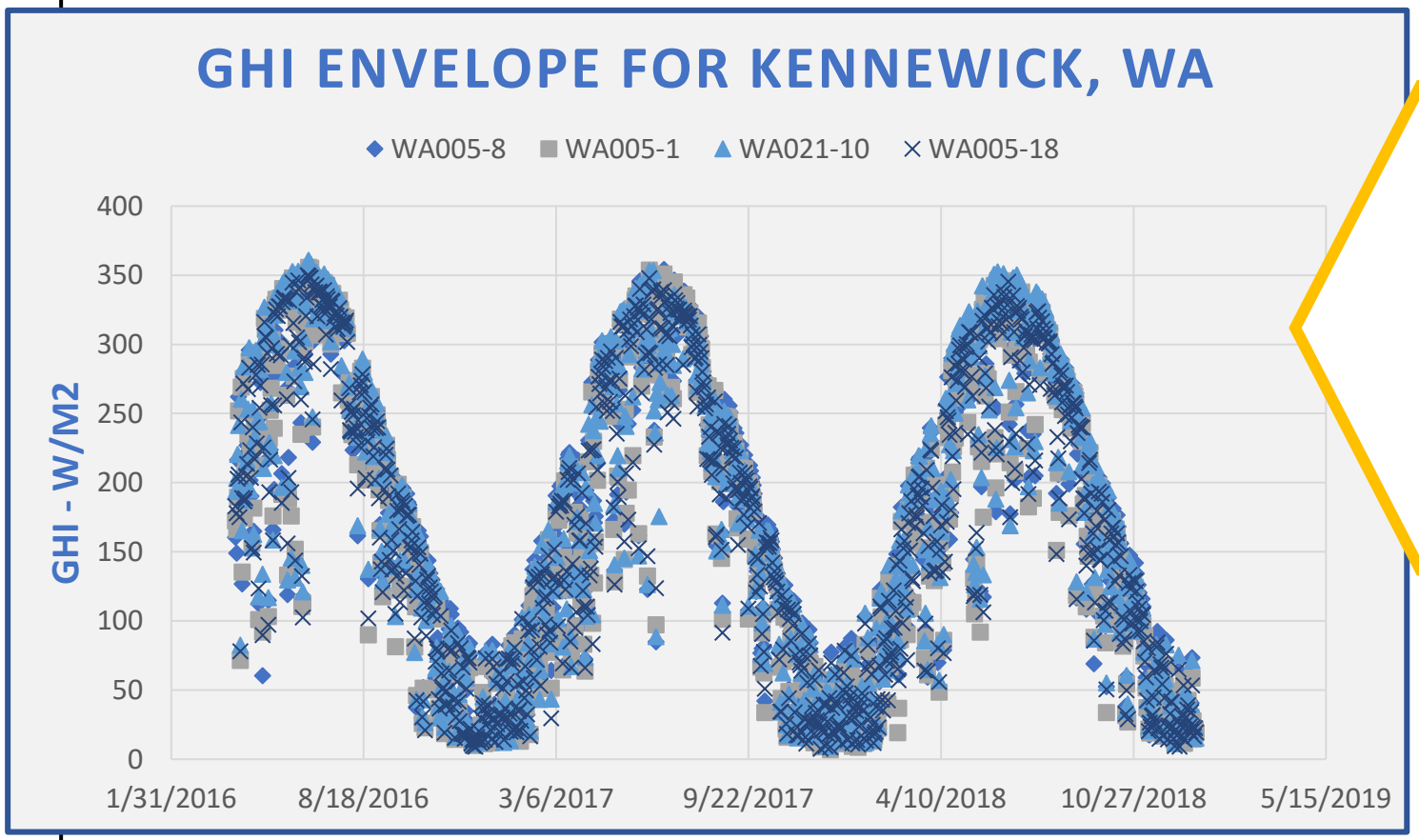
In this case, we identified a

Clear Sky Day near Sacramento.

All GHI observations in the area should be similar. One site was malfunctioning and removed from the data stream until repaired.

US GSID

AI filtering and Quality Control



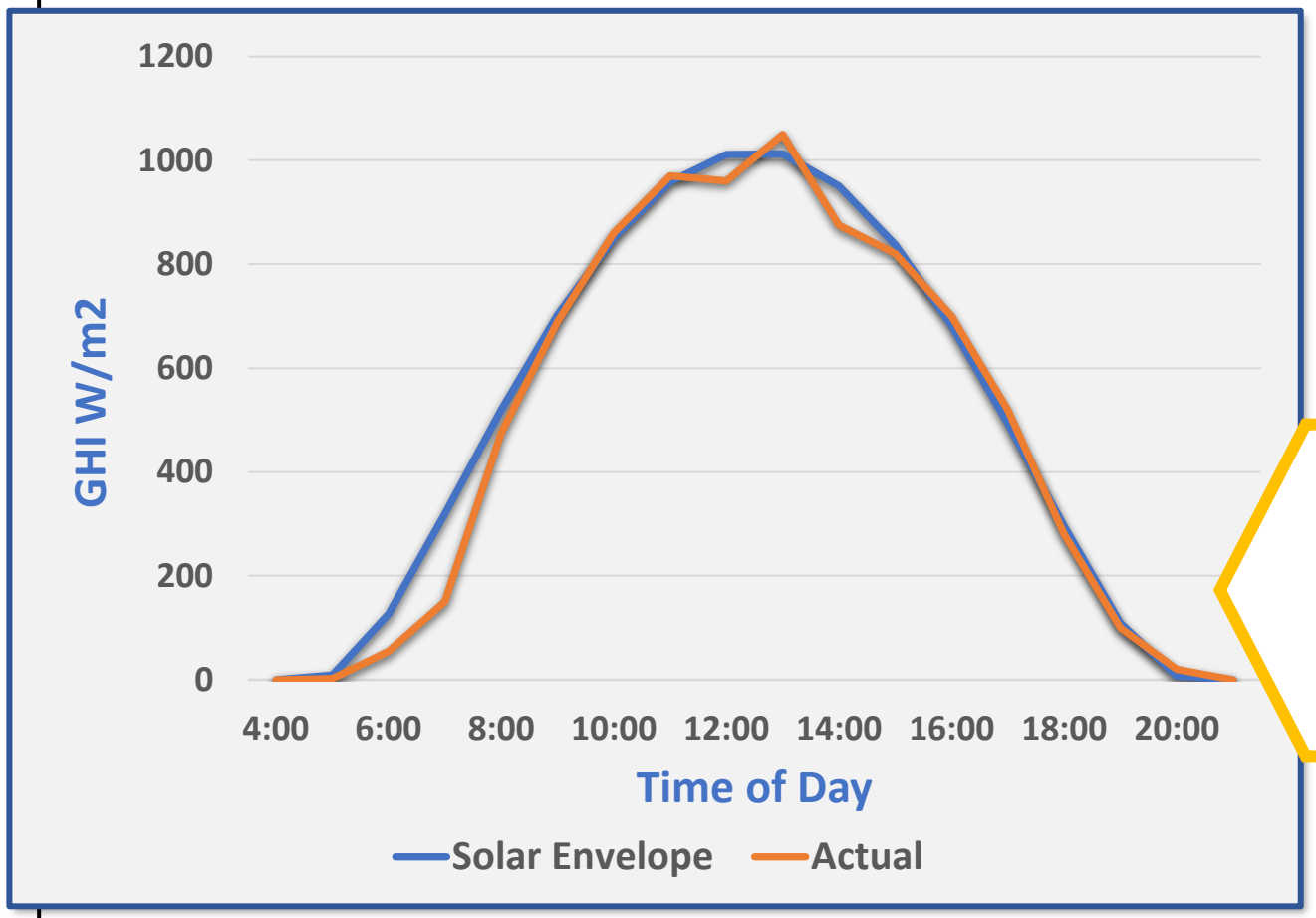
Clear Sky Events

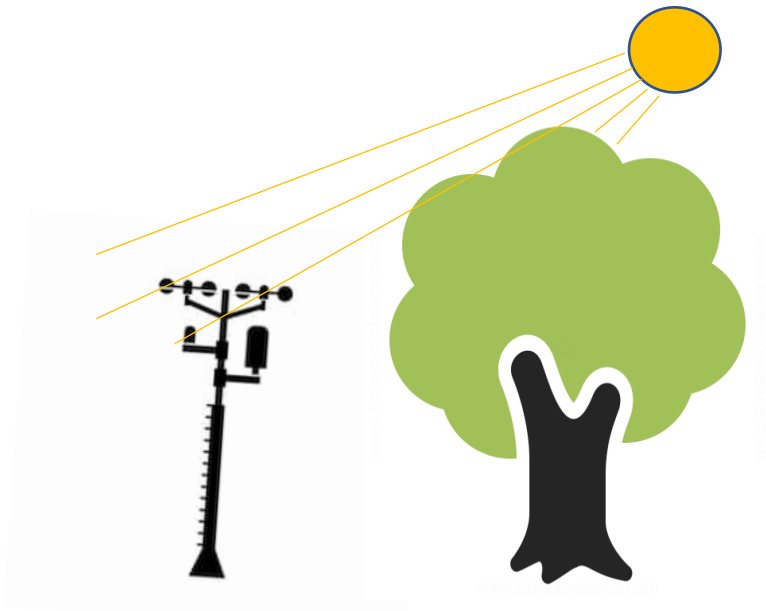
Plotting the historical data shows the upper limits for solar radiation for any location and day of year.

Observations outside this envelope are probably errors.

US USID

AI filtering and Quality Control

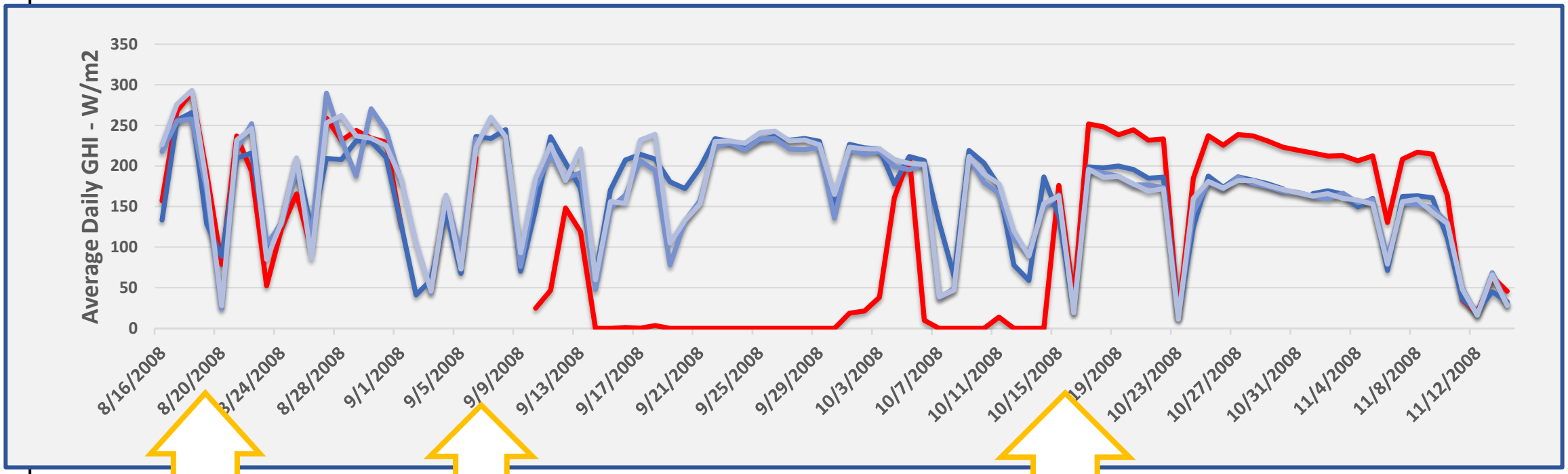




Consistent deviations from the Hourly Clear Sky Envelope can help identify poor sensor alignment or sensor shading.

US USID

AI filtering and Quality Control



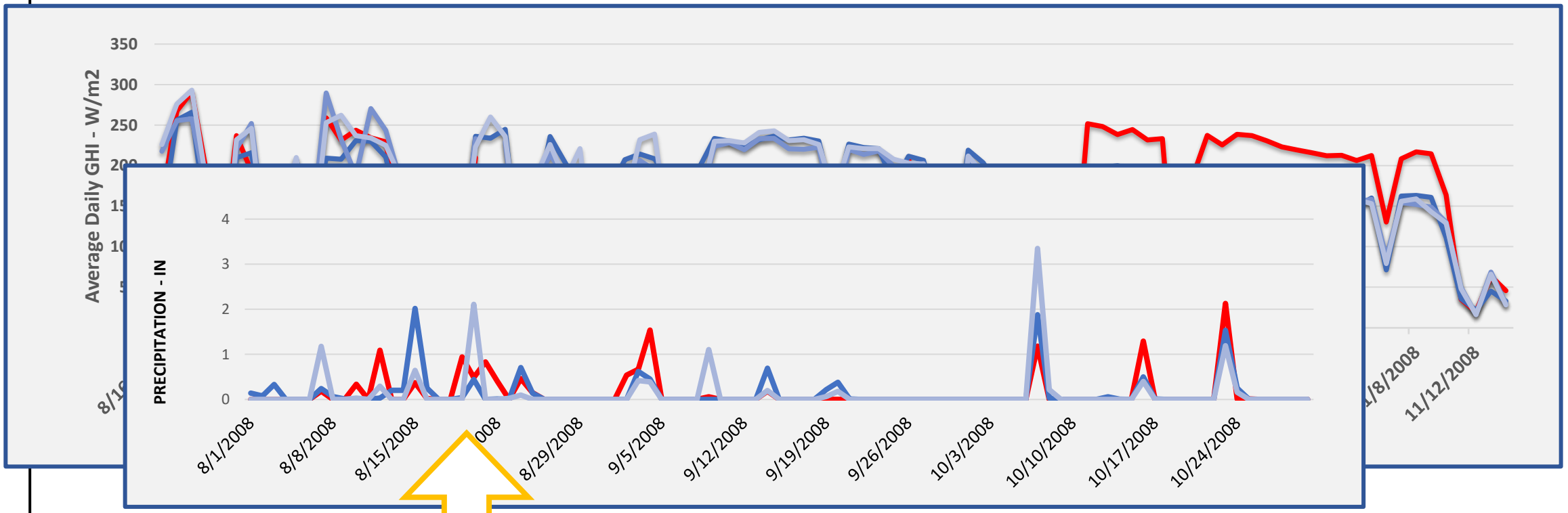
4 neighboring sites in Mississippi track together…

until one site (red) fails

The sensor was repaired/replaced, but now it does not track with the others – could be miscalibration, or the other sensors might all be soiled

US USID

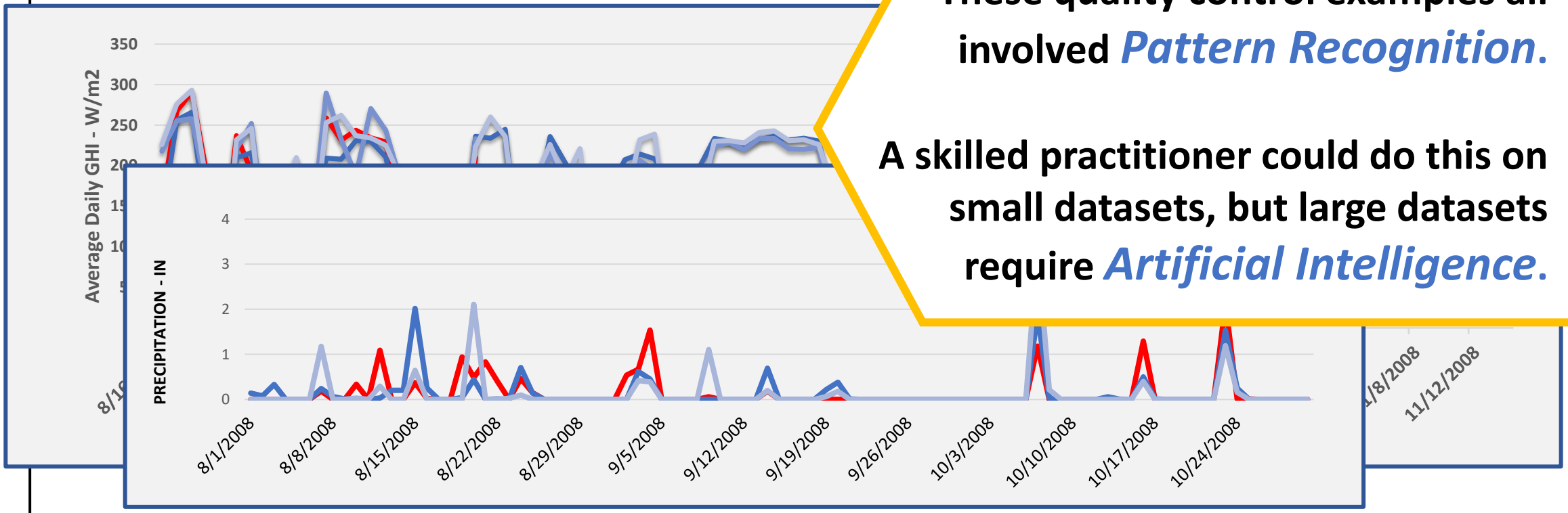
AI filtering and Quality Control



Precipitation History shows significant rain events during this period making sensor soiling unlikely. Site in red was excluded until it was fixed.

US USID

AI filtering and Quality Control



These quality control examples all involved *Pattern Recognition*.

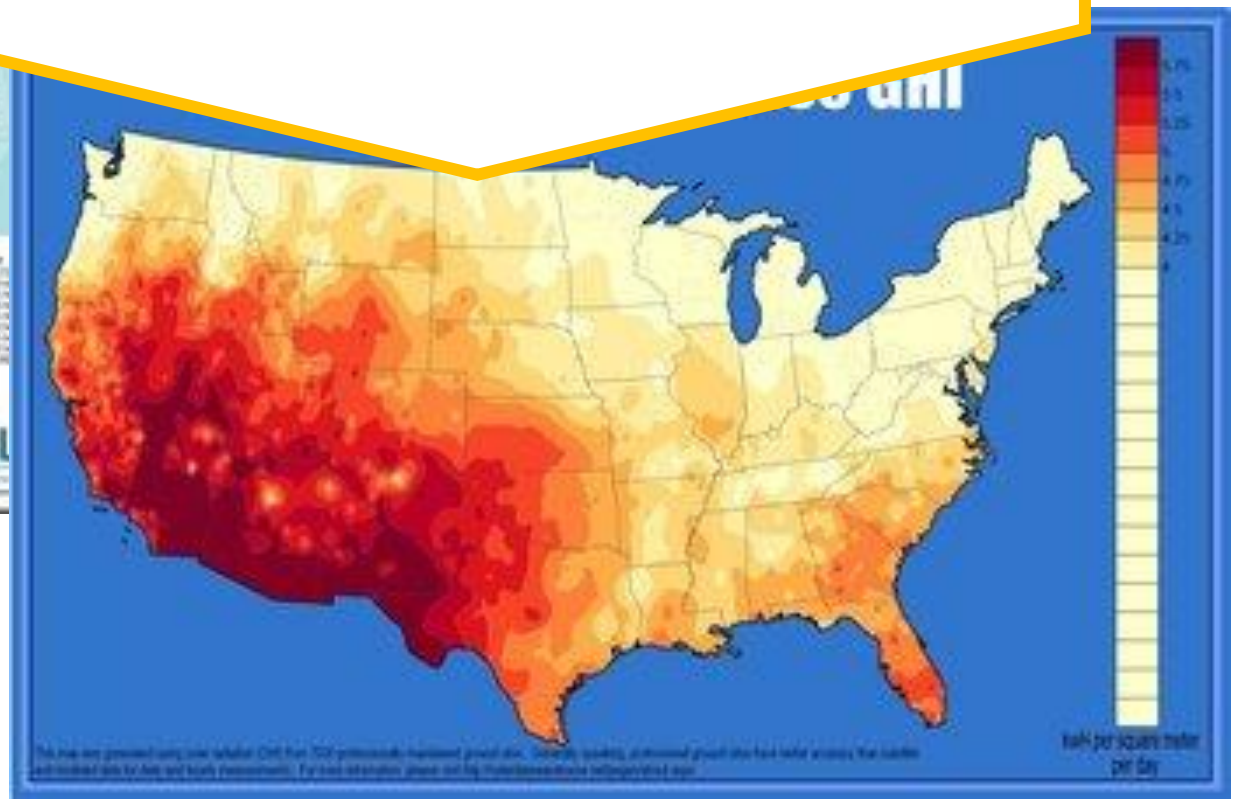
A skilled practitioner could do this on small datasets, but large datasets require *Artificial Intelligence*.

Validation of NREL's NSRDB

NREL's National Solar Radiation Database was Validated by comparing satellite estimates to research-quality data from the NOAA's SURFRAD network.[3,4]

US GSID Validation

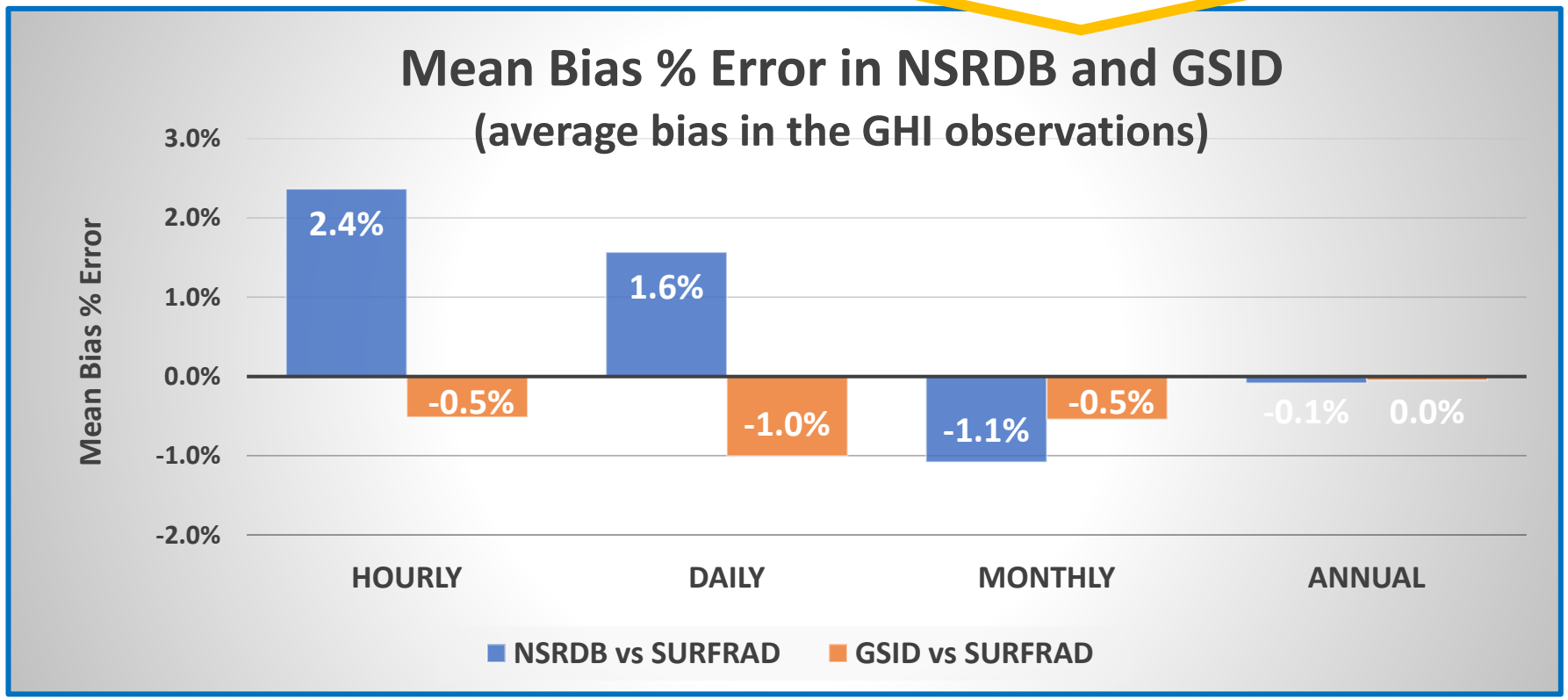
The US Ground-Based Solar Irradiance Database followed this same validation methodology



One small difference:* ***Both validations excluded low-irradiance observations. We defined these as GHI < 50W/m2 at SURFRAD sites. The original NSRDB procedure defined them as zenith angles >75 degrees (sun low in sky).*

US GSID Validation

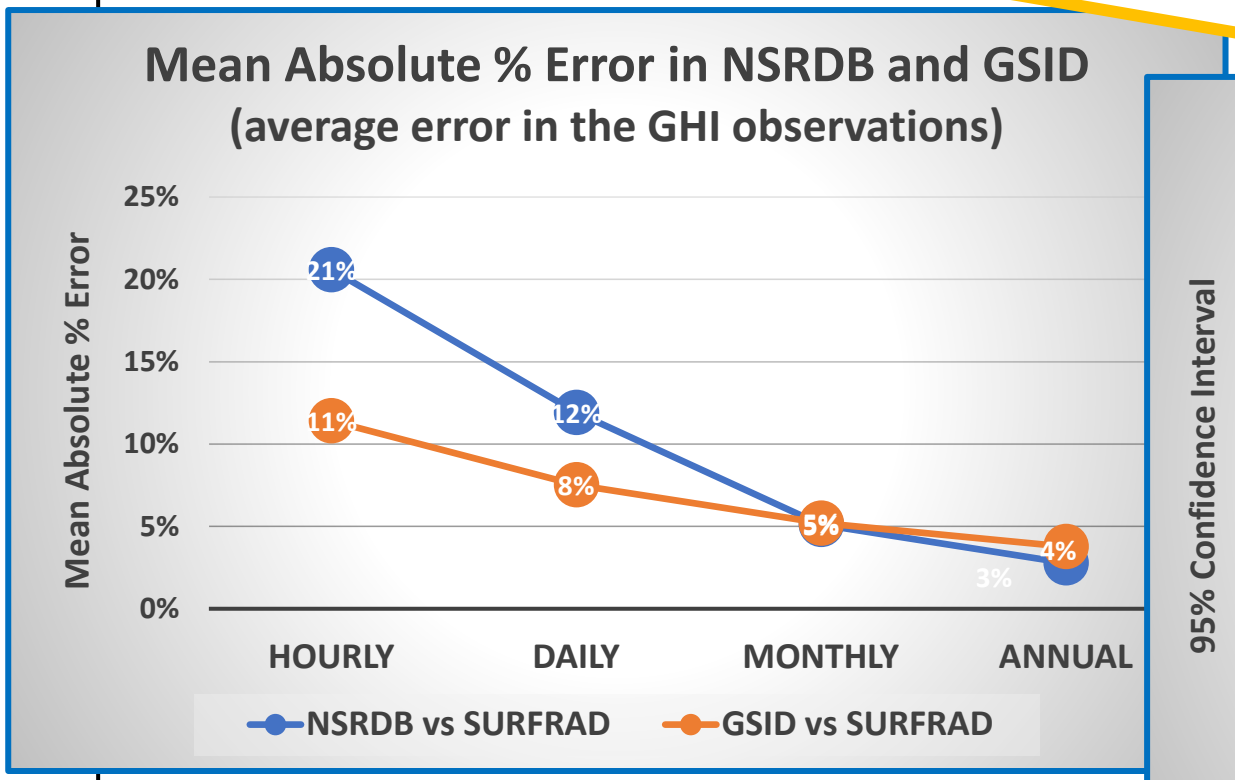
The GSID had Lower Bias Error than the NSRDB for hourly, daily, monthly and annual observations

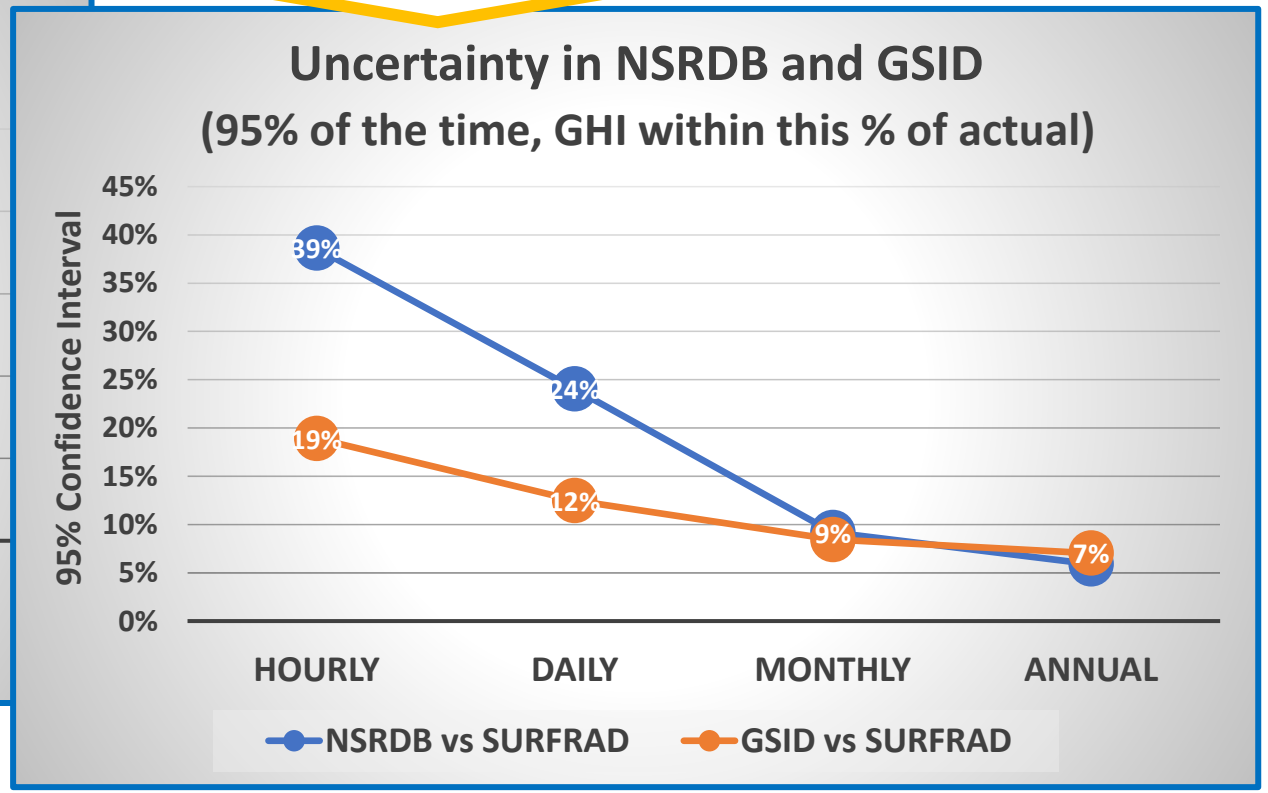


US GSID Validation

US GSID is More Accurate than the NSRDB

- ✓Significantly lower Mean Absolute Error - hourly & daily
- ✓Significantly lower Uncertainty - hourly & daily
- ✓Similar monthly & annual values

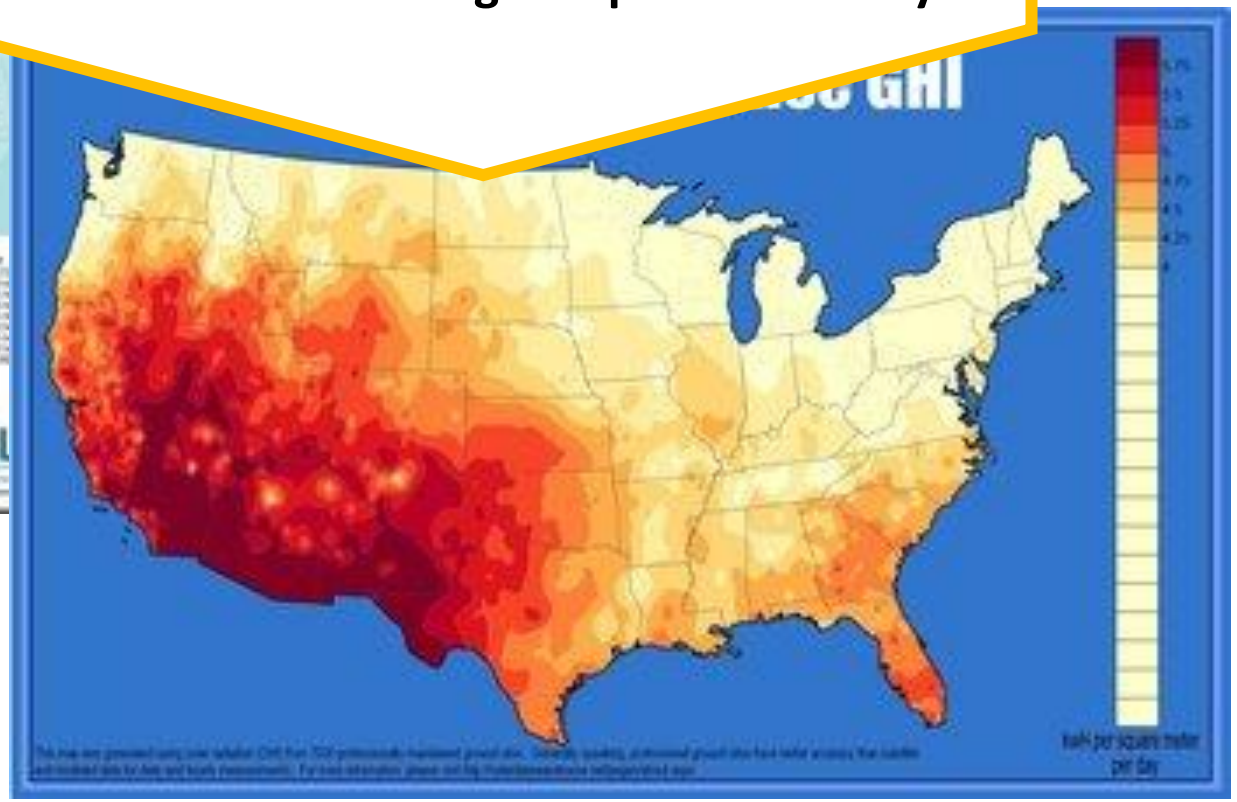




Solar Resource Comparison

US Ground-Based Solar Irradiance Database:

- ✓ Demonstrated higher temporal accuracy
- ✓ Demonstrated higher spatial accuracy

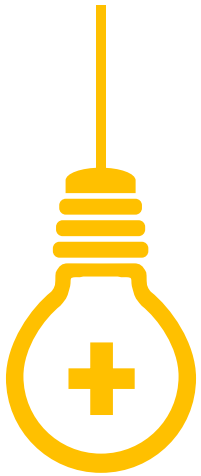


Summary

New Solar Resource Available From Ground Observations

Quality Control Using AI Technology

Validated - Accuracy Better Than NSRDB Satellite Observations



Stand Alone Resource or Combine with Other Solar Data

Thanks

Does anyone have questions?

Gridded daily GHI data for 2005-2018 can be downloaded for free on our website.

For additional data or information visit us at
www.SolarDataWarehouse.net
or call James Hall at 970.286.8238

References & Credits

[1] Andrew Clifton, Bri-Mathias Hodge, Caroline Draxl, Jake Badger & Aron Habte (2017). “Wind and solar resource data sets”

[2] Anders Nottrott & Jan Kleissi (2012). “Validation of the National Solar Radiation Database in California”

[3] Sengupta, M.; Weekley, A.; Habte, A.; Lopez, A.; Molling, C.; Heidinger, A. (2015). "Validation of the National Solar Radiation Database (NSRDB) (2005–2012)

[4] Aron Habte, Manajit Sengupta, Anthony Lopez (2017). Evaluation of the National Solar Radiation Database (NSRDB Version 2): 1998–2015

Graphic images courtesy of Slidesgo.com, New York Mesonet, West Texas Mesonet, US Climate Reference Network