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NATIONAL RENEWABLE ENERGY LABORATORY

Innovation for Our Energy Future

Measurements to Support Economic and Technical Decisions for Power Conversion Projects

American Solar Energy Society—Phoenix, AZ

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Why Do We Measure?

Measurements help us understand the magnitude of the solar resource

- How much energy is available for conversion
- What are expected returns given the resource and efficiency of the conversion system
- Where best to consider building a project

Measurements help us understand the variability of the solar resource

- What are the minimums and maximums
- Where/when/why do excursions occur and how do they affect operations or economics

Model vs. Measured

Modeled data generally are of higher uncertainty than measured data

- There are exceptions
- If a model developed from measured data, the perfect model can be no better than the measured data
- Models are often easy to run over a long period of record

Measured data are generally more expensive than modeled data

- Assumes that model input data are of lower cost than solar measurements (e.g. meteorological data paid for by other interests)
- Measured data generally have a narrower geographical scope
- Measured data sets are usually of a shorter period of record

How Good Should the Data Be?

What are the uncertainty specifications?

"The best available… Whatever I can get."
- "Whatever I can get without a lot of expense."
- "Whatever I can get without a lot of expense and work."

"I have a data set-Tell me my uncertainty."
- "Can you help me make the data set better?"

"What is the best tradeoff between cost and accuracy?"
- "There certainly *must* be an industry standard for really good measurements at a reasonable cost."

Specifications must be decided before any design or data.
- What are the sensitivities of your analysis (or *analysts*)
- What is your budget?

Only you can decide these specifications

The Financier's Point of View

People lending lots of money want to be assured that the analysis is correct and they understand all risks. They need reassurance, not unknowns. For the underlying data –

They do want:

- to feel good about the data
- confidence in how the data were obtained
- someone with expertise to vouch for the data.

They don't want

- questionable or poorly defined methods or practices
- a lot of hand-waving to explain the data

Building Confidence

Station design

- Does the location represent the climate (or microclimate) of the target area?
- Can the instrument choice be expected to yield the accuracy or uncertainty required for the analysis?
- Does the layout provide unobstructed solar access (no trees, buildings, towers, etc.)?
- Is the design adequate to withstand long-term exposure to the elements?
- Is adequate access provided for easy and effective maintenance and repairs?
- Is power reliable—possible need for backup or battery power?

Building Confidence

Station Operations

- Are maintenance personnel adequately trained and supplemental documentation available?
- Are maintenance equipment and supplies readily available (ladders, cleaning liquids, tools, etc.)?
- Is the station maintenance log easily accessible and updated regularly?
- Is frequent communication established between management/analyists and maintenance personnel?

Building Confidence

Routine maintenance procedures should be well-defined with an inspection protocol, checklist, and log sheets.

All observations should be documented in the maintenance log.

- Deficiencies noted with correction action.
- *All normal operations should be noted*.
- Robustness of the station infrastructure should be described
- Ancillary observations should be routine (e.g. clouds, wind, storms, flora, animal/human activity) . *These convey a sense of engagement and completeness in station operations that builds confidence in the data set.*

The maintenance protocol and documentation should designed to convey that deficiencies are quickly found and corrected *and that the station is operating properly at all other times*.

Building Confidence

Calibrations

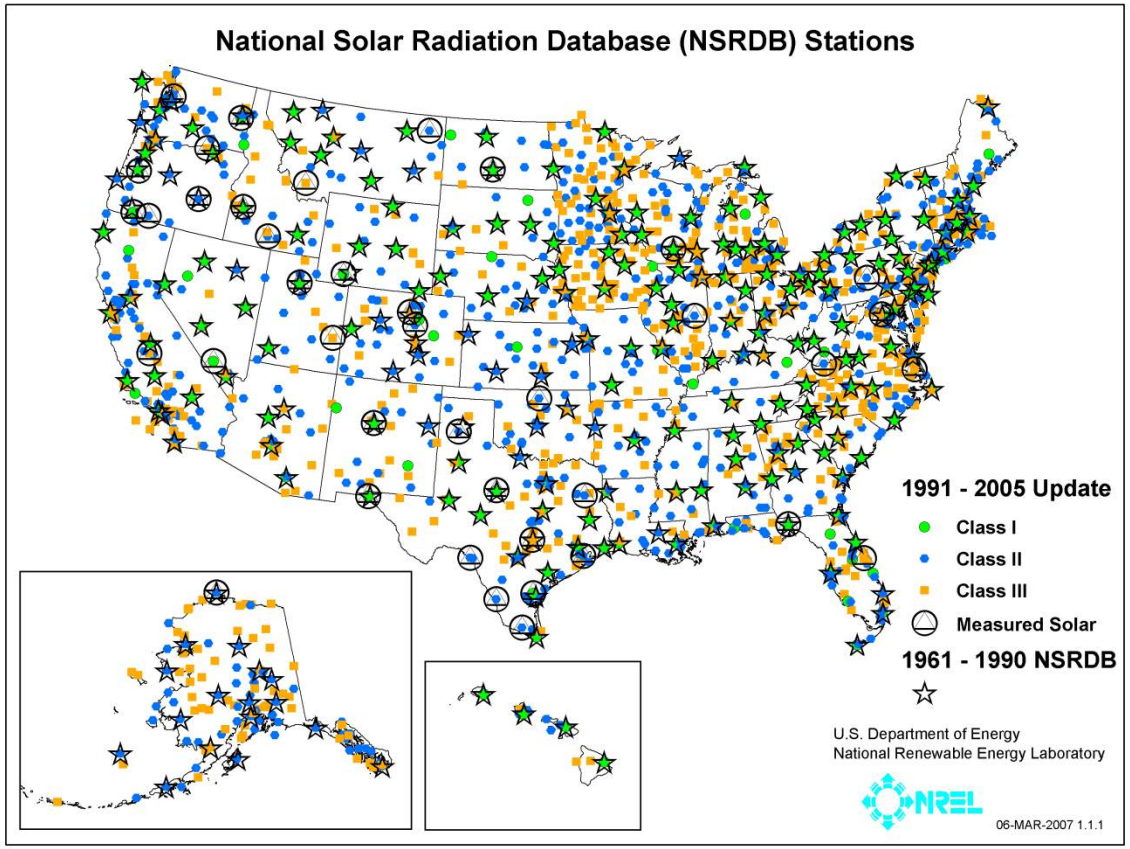
- All instruments must be calibrated on the recommended calibration cycle (typically annually).
  - Lack of regular calibrations is an easy target for questioning the validity of a data set.
  - Shelf spares are recommended as part of a calibration protocol to avoid loss of data during instrument removal. (Shelf spares must be calibrated also!)

Building Confidence

Data Quality Assurance

- Data inspection complements the on-site instrument inspections and cleaning
- Measurements should be inspected frequently (daily) to minimize loss of data.
- Data loss can have a cascading effect that goes far beyond the scope of the period of failure.
- Logger time (ideally automated to conform to reliable time reference).

Other Large Scale Sources of Data



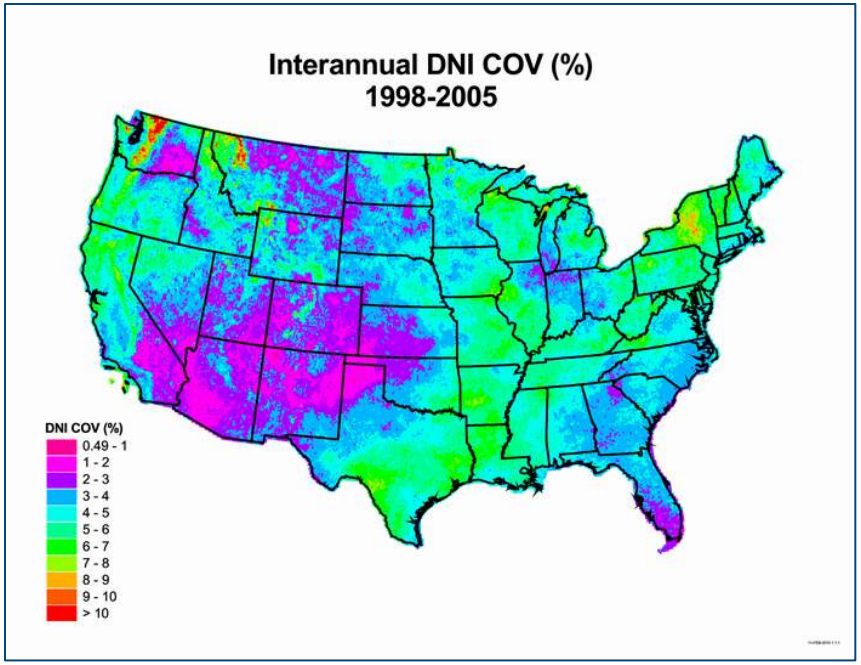
- National Solar Radiation Database
- Typical Meteorological Year (TMY)
- Clean Power Research (Solar Anywhere)
- 3-Tier
- Solar Data Warehouse

Using Short-term Measurements

A year of data cannot be assumed to represent a solar climate—often too much interannual variability

Can short-term measurements be related to long-term models—yes, biases in the model can sometimes be identified and used to adjust a multi-year modeled data set.

Do some areas have an inherently more stable interannual climate, increasing the validity of a short-term data set.



Summary

Be proactive in your design and record keeping to avoid difficult or indefensible questions about your data

- Document your station design and measurement campaign rationale
  - What are you trying to measure and to what degree of accuracy
  - How have you designed for the desired accuracy (instruments, maintenance)
  - How representative is the station location to that of the target analysis
- Provide a well structured and strict maintenance protocol
- Retain and organize all maintenance and repair records
  - Show convincing evidence that the station was well maintained and was *routinely operating properly*
- Show evidence of regular and frequent data inspection and follow up correction action when necessary
- Maintain instrument calibrations