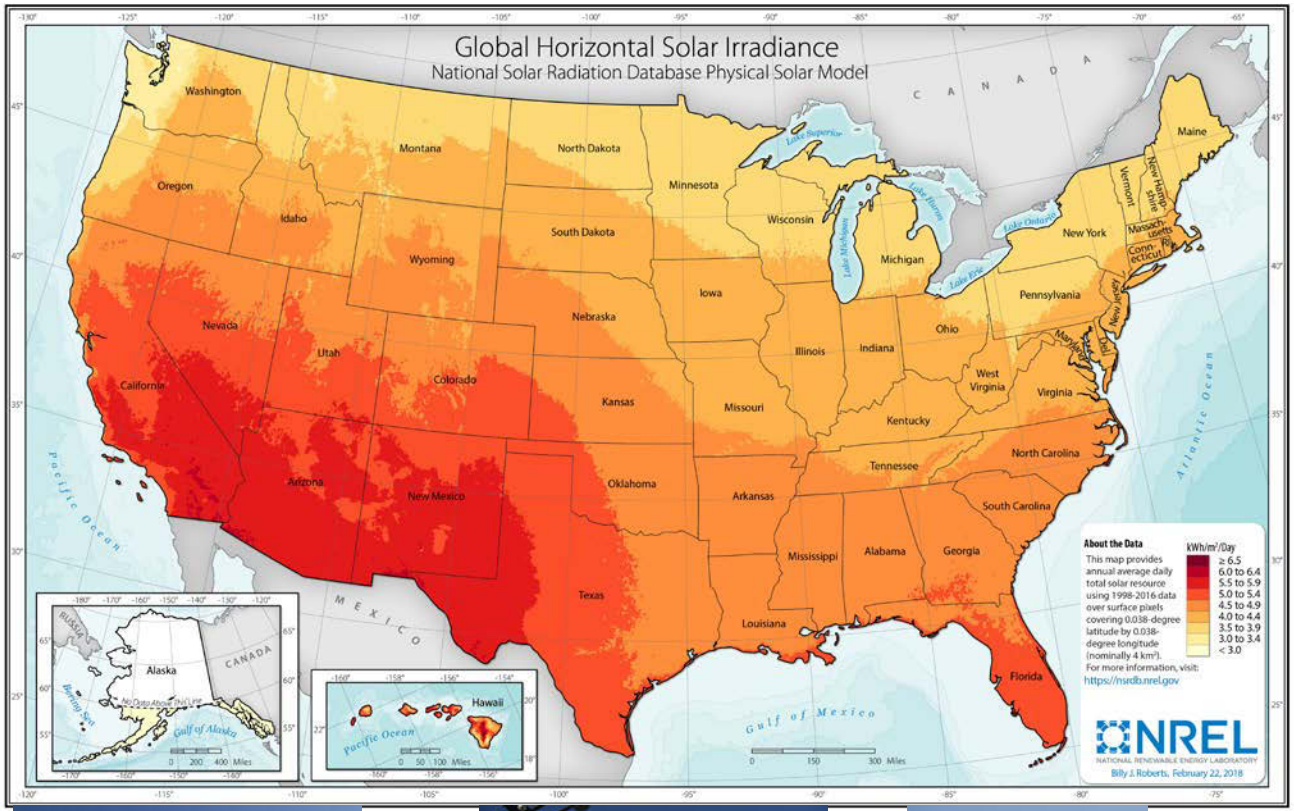
Data Quality Assessment Using SERI-QC

Manajit Sengupta



What Is Data Quality?

Data quality is a function of one's knowledge of the measurement environment and infrastructure.

1. Data quality is fixed (unchangeable) at the time a measurement is taken.
2. No amount of "quality control" after the fact can improve the fundamental data quality.
3. Data sets without good documentation are of *unknown quality*.

What Is Data Quality Assessment?

"A judgment of how well measurements represent the physical world."

Requires:

- A standard of measurement
- A criterion for judgment.

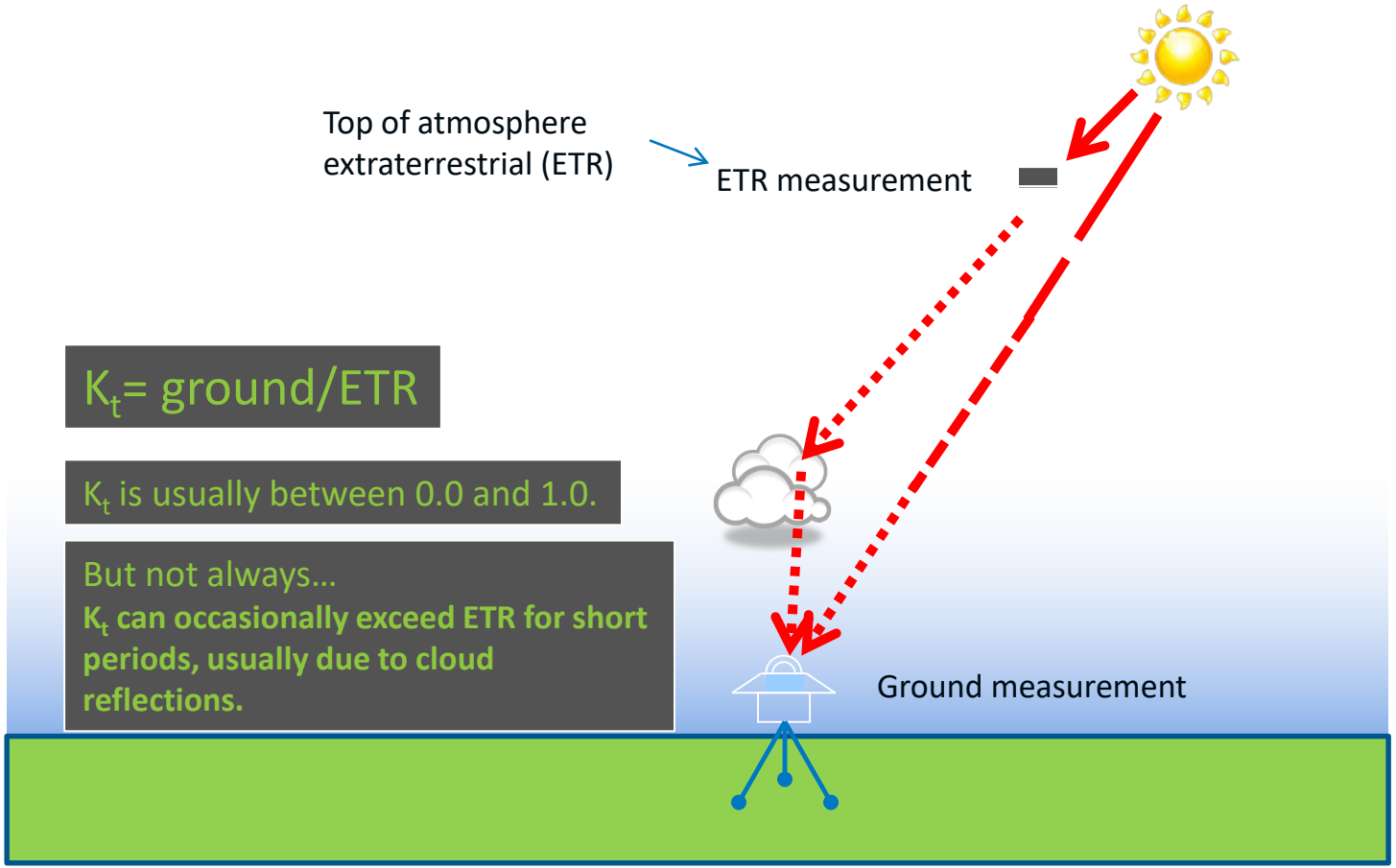
What Is Data Quality Assessment?

Quality assessment is not quality control.

- Quality assessment requires judgment and analysis. *This happens after the measurements*.

- Quality control is a supervisory process. *This happens before and during the measurements*.

Defining Clearness Index (K_t)



SERI-QC: Defining the K-Space

Operates in K-space: fraction of possible irradiance

Variable	Definition
K_t	Global / (ETRN * cos (Z))
K_n	Direct / ETRN
K_d	Diffuse / (ETRN * cos(Z))

ETRN = extraterrestrial radiation normal to the sun (DNI above the atmosphere)
K-space subscripts: t = total (global), n = normal (DNI), d = diffuse

$$K_t = K_n + K_d$$

https://www.nrel.gov/docs/legosti/old/5608.pdf

Data Quality Assessment Using NREL's SERI-QC

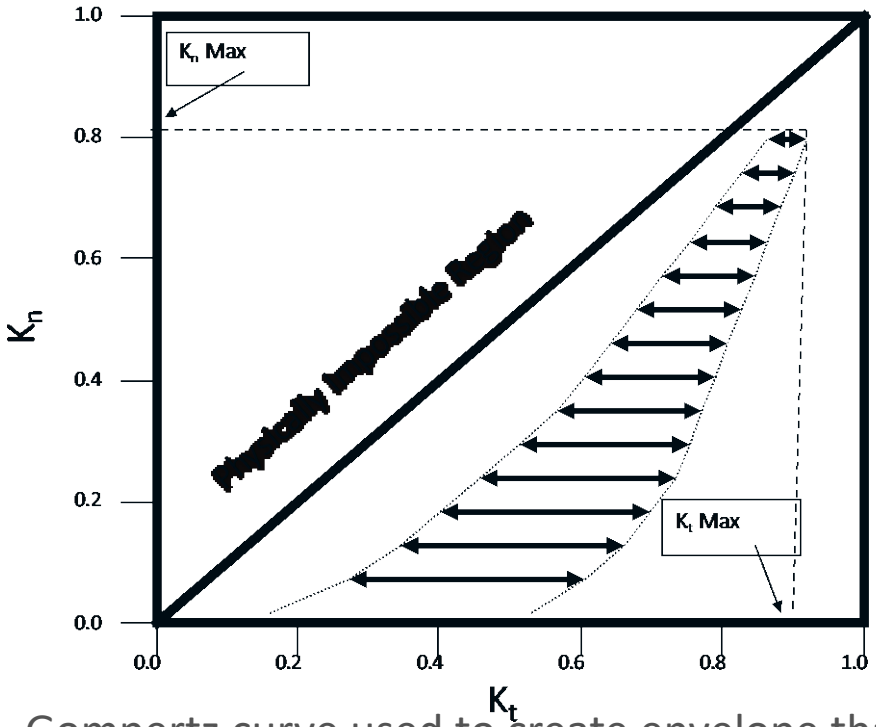
Depending on the available data, SERI-QC performs one-element, two-element, or three-element tests.

1. One-element test by defining a range of acceptable values between minimum and maximum values of K_t, K_d, or K_n, based on three air mass regimes and the month of the year.
2. Zenith angle (at the middle of the hour) < 80°and all three of the elements are present: Three-element test performed using a range of acceptable values fulfilling $K_t = K_d + K_n$ within arbitrary error limit of ± 0.03, which accounts for measurement uncertainties.
3. Data passes the three-element test (or at least two elements passed the one-element test): Two-element test performed by defining a range of acceptable values within boundaries.

SERI-QC publication: https://www.nrel.gov/docs/legosti/old/5608.pdf

QCFIT: Reducing the Area of Expected Values

Maximum K_t and K_n

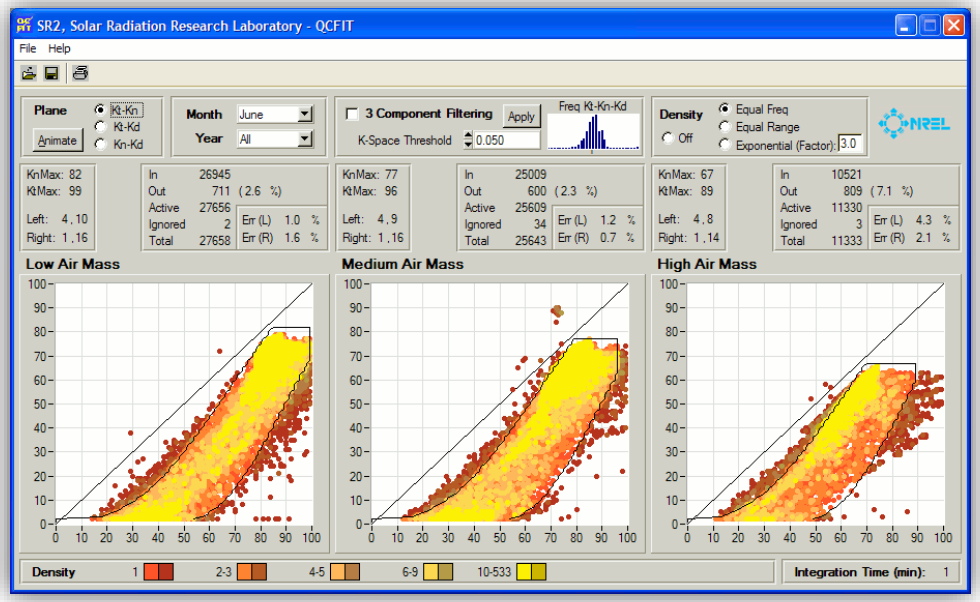


Gompertz curve used to create envelope that fits to multiyear ground measurements.

Air Mass / Zenith Angle Ranges

Range	Air Mass	Zenith Angle
Low	1.00–1.25	0.00–36.96
Medium	1.25–2.50	36.96–66.57
High	2.50–5.76	66.57–80.00

QCFIT: Reducing the Area of Expected Values



- The two-component analysis is useful for checking three-component data.
- An envelope is developed for application to the quality assessment process.

Data Quality Assessment Using NREL's SERI-QC

Flag	Description
00	Untested (raw data)
01	Passed one-component test; data fall within min-max limits of K_t, K_n, or K_d
02	Passed two-component test; data fall within 0.03 of the Gompertz boundaries
03	Passed three-component test; data come within 0.03 of satisfying $K_t = K_n + K_d$
04	Passed visual inspection; not used by SERI-QC
05	Failed visual inspection; not used by SERI-QC
06	Value estimated; passes all pertinent SERI-QC test
07	Failed one-component test; lower than allowed minimum
08	Failed one-component test; higher than allowed maximum
09	Passed three-component test but failed two-component test by >0.05
10-93	Failed two- or three-component tests in one of four ways. To determine the test failed and the manner of failure (high or low), examine the remainder of the calculation (flag + 2)/4. REM — Failure 0 — Parameter too low by three-component test ($K_t = K_n + K_d$) 1 — Parameter too high by three-component test ($K_t = K_n + K_d$) 2 — Parameter too low by two-component test (Gompertz boundaries) 3 — Parameter too high by two-component test (Gompertz boundaries) The magnitude of the test failure (distance in K-units) is determined from: d = (INT (flag +2)/4)/100.
94-97	Data fall into a physically impossible region where $K_n > K_t$ by K-space distances of 0.05–0.10 (94), 0.10–0.15 (95), 0.15–0.20 (96), or ±0.20 (97).
98	Not used
99	Missing data (associated data field is filled with -9900)

SERI-QC returns a two-digit quality flag:

- The magnitude of the error
- The direction of the error (high, low)
- The test that reported the error.

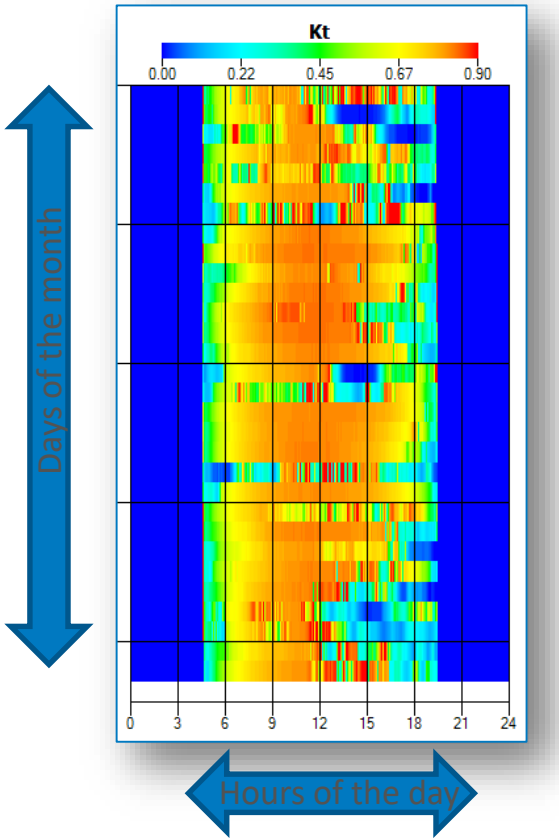
SERI-QC is currently a programming function, not an application. (It is currently being packaged as an application.)

Data Quality Assessment Using NREL's SERI-QC

Daily Quality Checks

SERI-QC cylinder plots:

- A full month of data and quality flags can be seen at a glance.
- Shows data for each of the three solar components.
- Errors become instantly evident.
- You can correlate flags with irradiance values
- You can view the three components in context with each other.



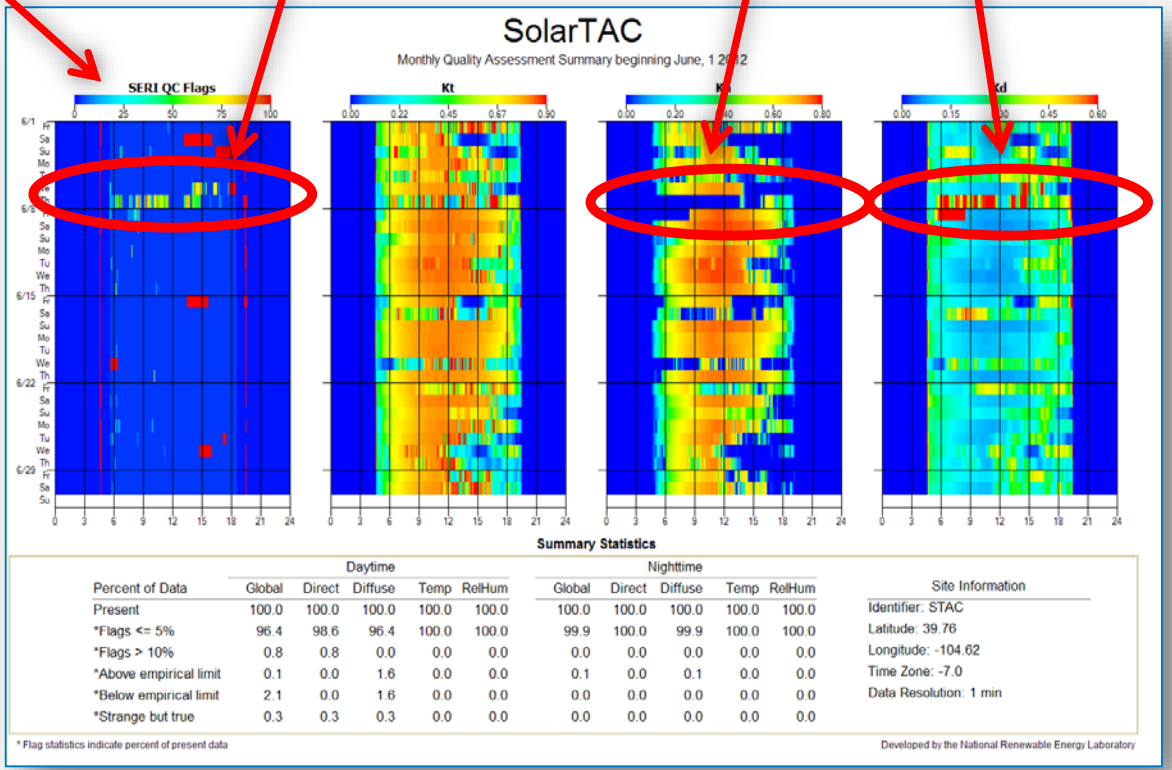
Data Quality Assessment Using NREL's SERI-QC

$\varepsilon = K_t - K_n - K_d$

High SERI-QC flags

Low K_n

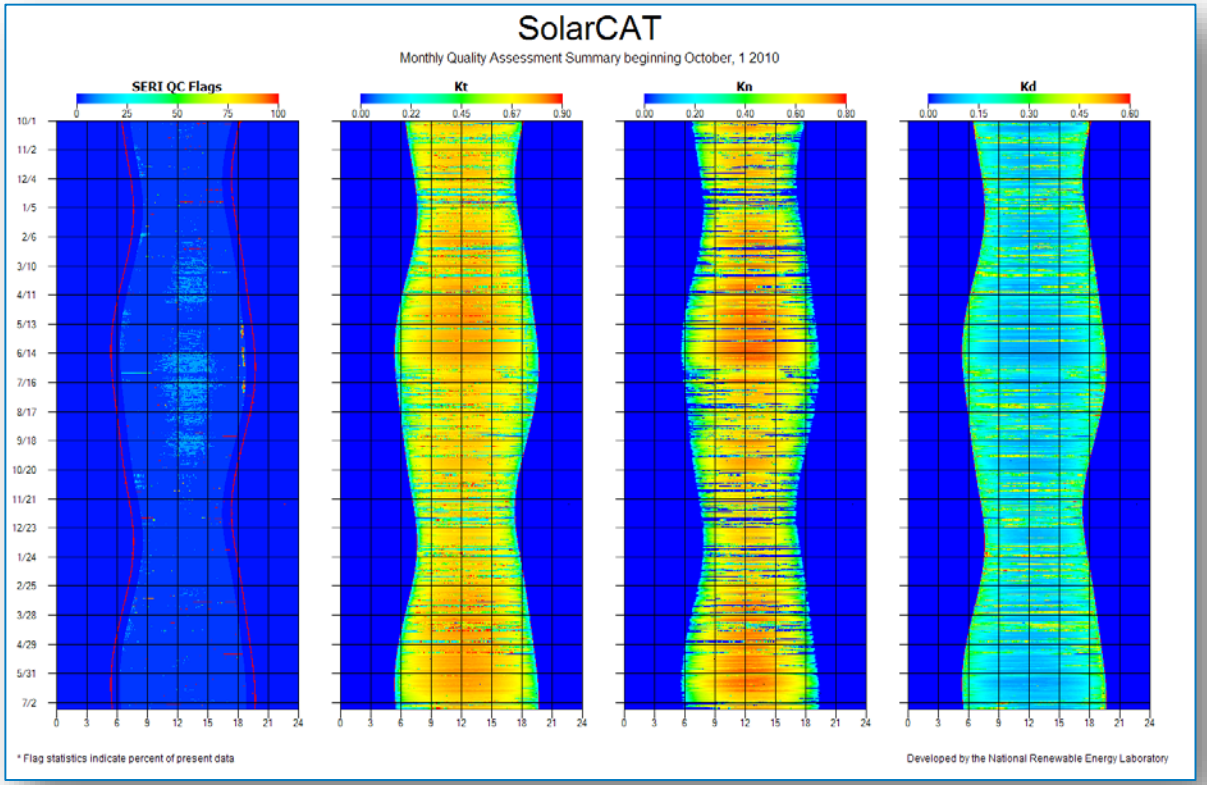
High K_d



Example: tracker failure June 6 and 7

Data Quality Assessment Using NREL's SERI-QC

A seasonal look at flags: data for 1.5 years



NREL's SERI-QC Limitations

- If the data set contains few data points, or points clustered in a small region, or many questionable points, the Gompertz curves needs to be edited.
- Great number of values for which the direct normal measurement is near zero and skews the automatic curve fitting algorithm.
- Data points with a Kn component <0.02 are excluded from consideration by QCFIT.

Future Plan for NREL's SERI-QC

- Make it available in other programming languages, such as Python.
- Remove limitations previously mentioned by making the QCFIT curve-fitting process more autonomous.
- Refine the partitioning atmospheric combinations to improve quality assessment.

Thank You

https://www.nrel.gov/midc

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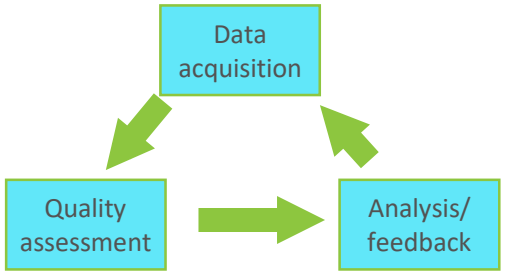
Additional Slides

Data Quality Assessment

Data quality analysis procedure:

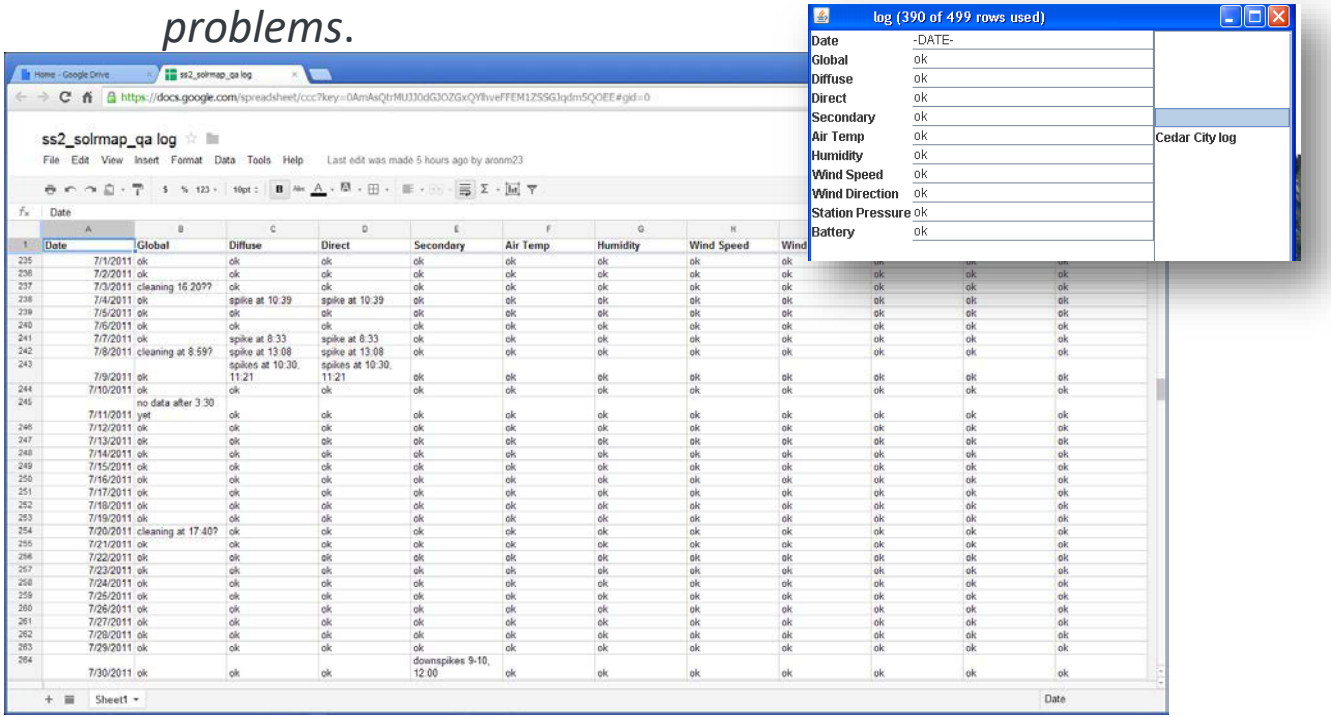
- **View all data as frequently as possible (daily is best).**
  - The longer the delay, the longer error conditions will persist.
  - The more frequent your data checks, the more in tune you are with your stations.
- View in context of other measurements.
  - Measurements by themselves can be deceiving.
- Automate the data plots as much as possible.
  - Spend your time *analyzing* data, not assembling data sets.
- Set up a feedback infrastructure.
  - Communicate findings back to the station.
  - Good results should be communicated also.



Data Quality Assessment

Documenting data quality:

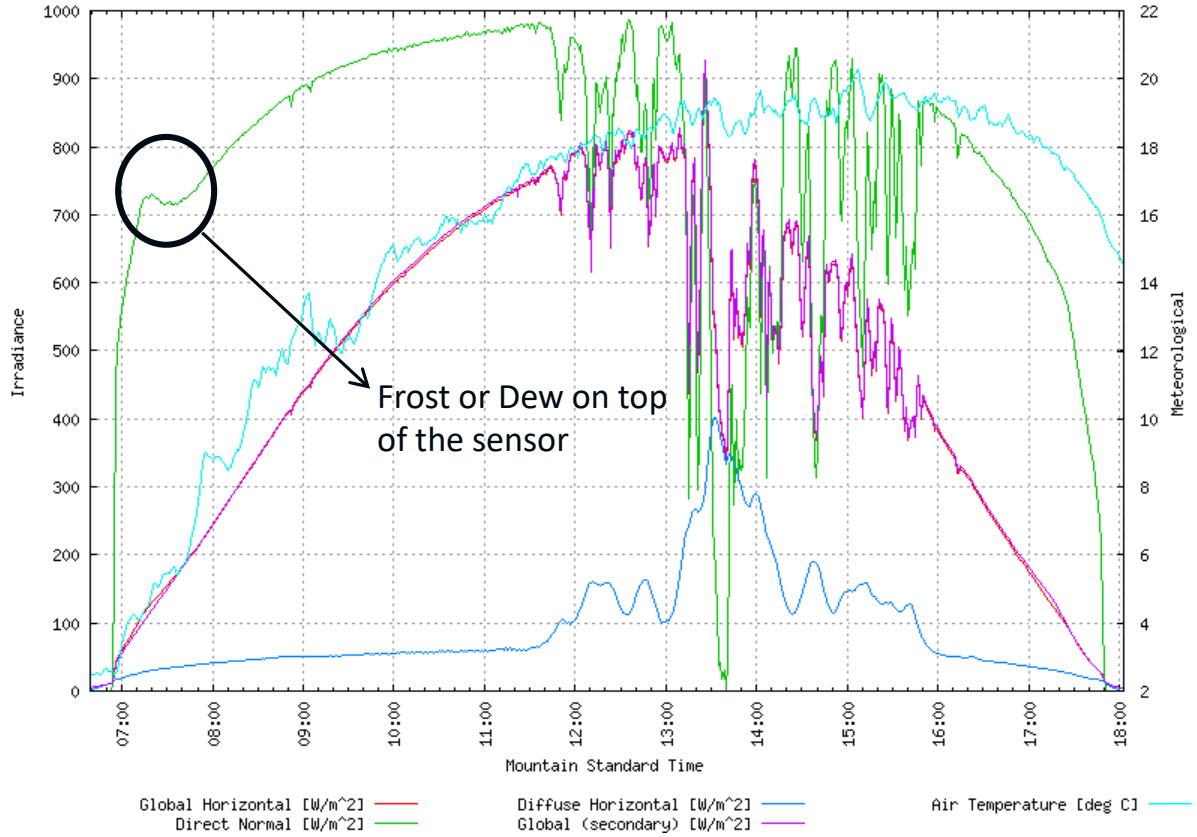
- Document all findings, *including findings of no problems*.



A Java script interfaces with Google Docs

Data Quality Issues

Anomalous data



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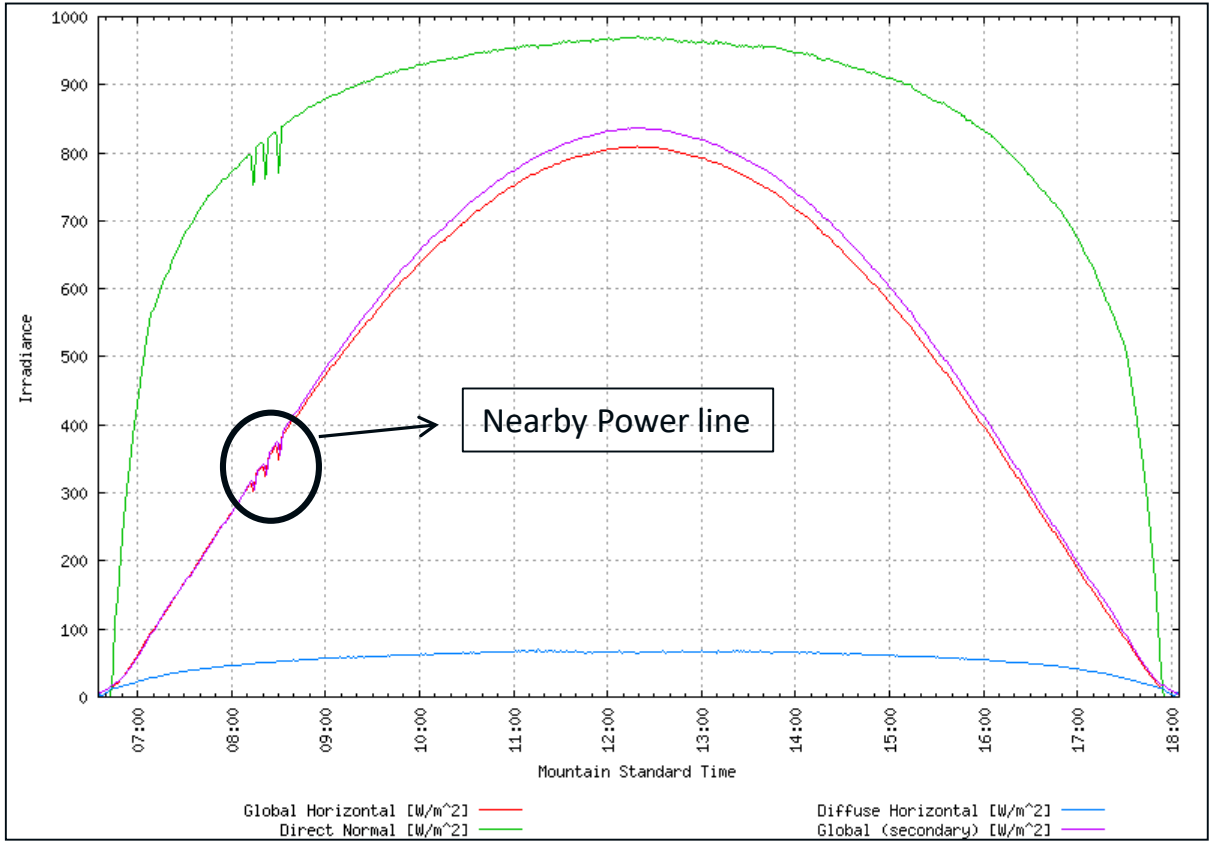

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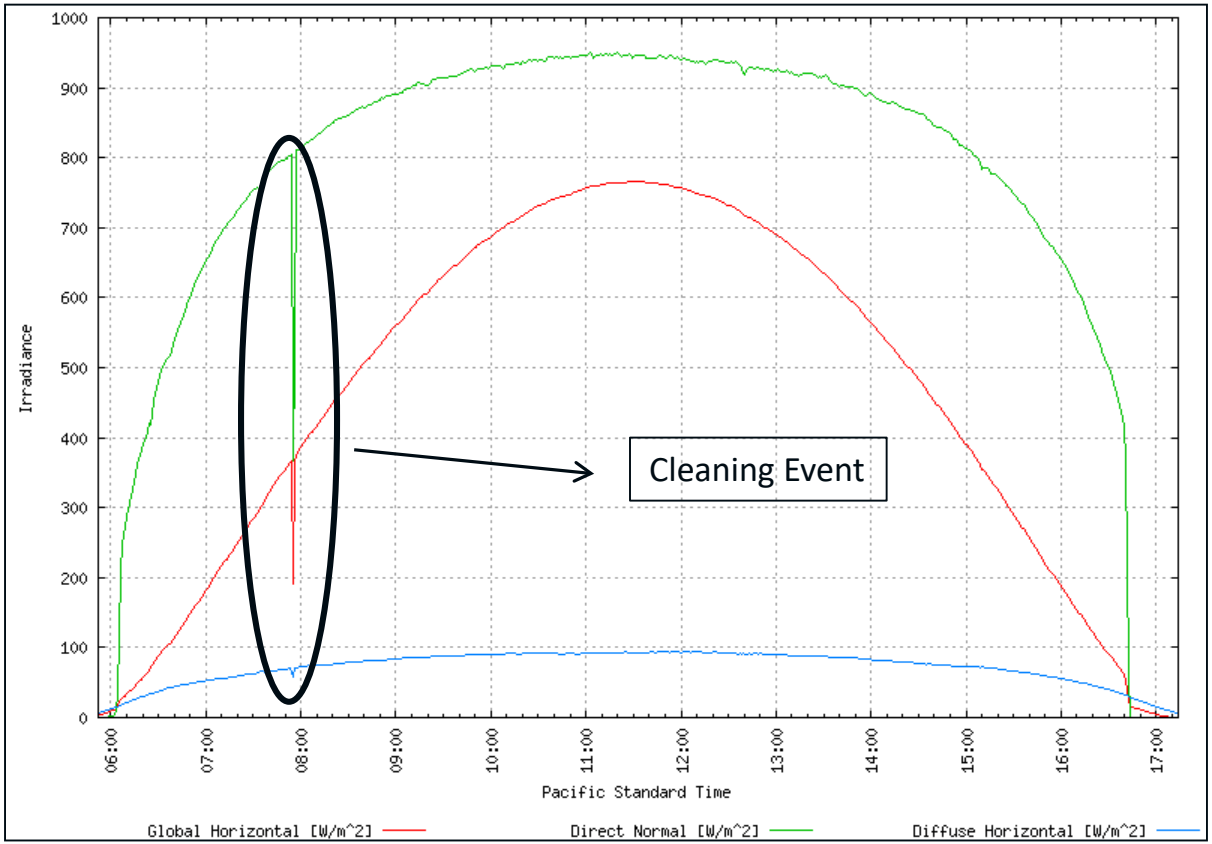

Data Quality Issues

Anomalous data