


Uncertainty in Solar Energy Estimates

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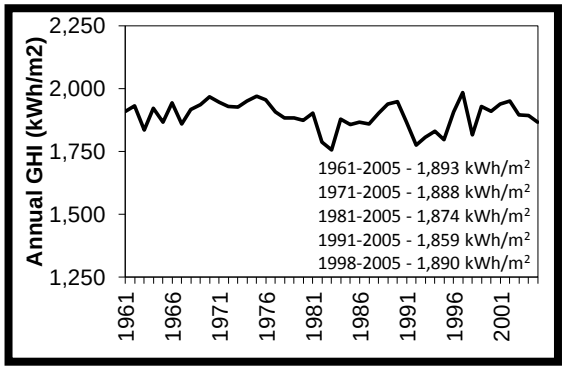
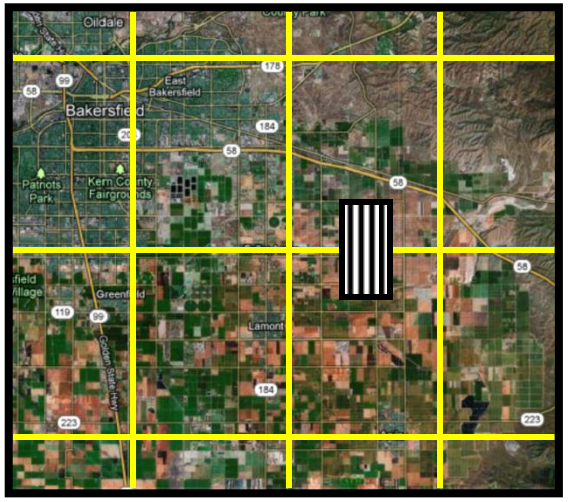
Sources of Error in Estimating any Solar Resource

- Period of record
  - Will an estimate based on X years of data represent the coming 25 years, even if the model/measurements are exactly correct? (Neglecting climate change.)
- Spatial uncertainty
  - For satellite, spatial averaging over pixel vs. exact project location, and/or in many cases a project site spanning multiple pixels
  - For ground measurements, distance between reference data source and project site
- Model and/or measurement uncertainty
  - Discussed in previous presentations today, for purposes of this discussion let's assume these uncertainties are known or at least knowable
- For purposes of this discussion, not treating inter-annual variability as an "uncertainty"





Courtesy NREL Solar Prospector

Case Study – Southern Central Valley, California

	Location	Data Source	Complete Years of Data	Approx. Dist. from Project (km)	Ele. (m)	Annual GHI (kWh/m²)	% Delta vs. Ref.
A	Project Site (South Pixel)	CPR GHI Average Months	15	N/A	170	1,946	N/A
B	Project Site (North Pixel)	CPR GHI Average Months	15	N/A	170	1,954	+0.4
C	Project Site (South Pixel)	Prospector GHI	13	N/A	170	1,973	+1.4
D	Project Site (South Pixel)	Prospector TMY	13	N/A	170	1,951	+0.3
E	Project Site (North Pixel)	Prospector GHI	13	N/A	170	1,975	+1.5
F	Project Site (North Pixel)	Prospector TMY	13	N/A	170	1,975	+1.5
G	Bakersfield	TMY3 Class I	24	25	150	1,895	-2.6
H	Arvin-Edison	CIMIS	17	10	150	1,853	-4.8
I	Shafter	CIMIS	26	50	110	1,915	-1.6
J	Famoso	CIMIS	15	50	130	1,843	-5.3

CIMIS = California Irrigation Management Information System, CPR = Clean Power Research, GHI = global horizontal irradiance
km = kilometers, m = meters, kWh/m2 = kilowatt-hours per square meter, TMY = typical meteorological year

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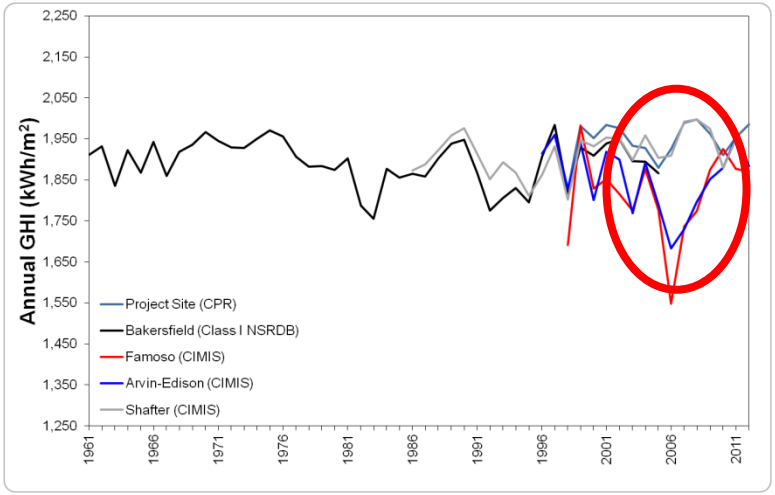
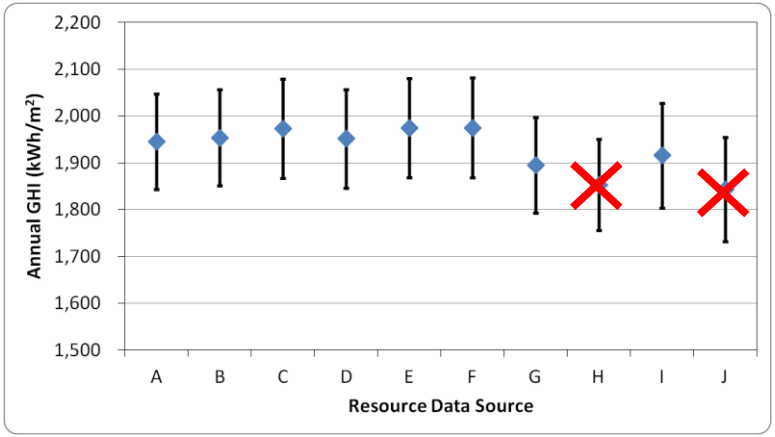
Is There Really a ~7% Range Between Data Sources…

- …before we even consider uncertainty?
  - Two CIMIS locations have significant anomalies (>20% below CPR in some years)
    - Not fully explained by missing data
- We are left with:
  - Six inherently related satellite values
  - One Class I TMY3
  - One long-term ground measured data source with unknown measurement uncertainty
    - Shafter CIMIS agrees quite well over 25+ years with NSRDB and CPR satellite data
- ~4% range min to max for these remaining data sources – is "the truth" in there?

NSRDB = National Solar Radiation Database





Error bars for illustration only

Questions to Ponder and Discuss

- For the project developers in the room:
  - Why didn't you just save everyone all this trouble and install a high-quality MET station with redundant sensors at least one year in advance of anticipated financial close and keep those sensors carefully aligned, calibrated, and cleaned, with rigorous documentation of maintenance practices?
  - Even if this is the case, rigorously quantifying sensor uncertainty is not trivial
- If you choose the "most representative" TMY for your project site based on proximity, period of record, and data quality…
  - How different are the other data sources? Should they be different due to location, climate, and/or period of record? Do those differences make you more or less confident in the chosen source?
  - If multiple, independent sources give roughly the same answer, is it actually probable that the "truth" is at the far end of any of those error bars?
- If you take all viable data sources and average or weight (one way or another)…
  - Why does giving weight to less reliable, further away, and/or shorter-term data give a better answer?
  - Not saying it doesn't or can't, but these questions must be considered

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Thank You

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