Data Verification Examples Using Global Horizontal Irradiance (GHI) Sensors

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Background

There is general agreement that ground-based measurements of solar radiation are more accurate than satellite models when the sensors are well-sited and operating correctly [1], [2], [3], [4]. Solar radiation sensors can be fickle [5], [6], so how does one know they are operating correctly? This problem is common in AI (artificial intelligence) applications where data from multiple sensors must be fused together and validated, so we utilize many of the same data processing and analysis techniques.

Methodology

Much can be learned by comparing solar observations from one site to neighboring sites. For example, the image below shows the daily average GHI on one day around Sacramento, CA. One of the readings is significantly below the others. This might be a one-day anomaly due to a microclimate. However, if this trend continues the data should not be used and the site flagged until the situation is corrected.

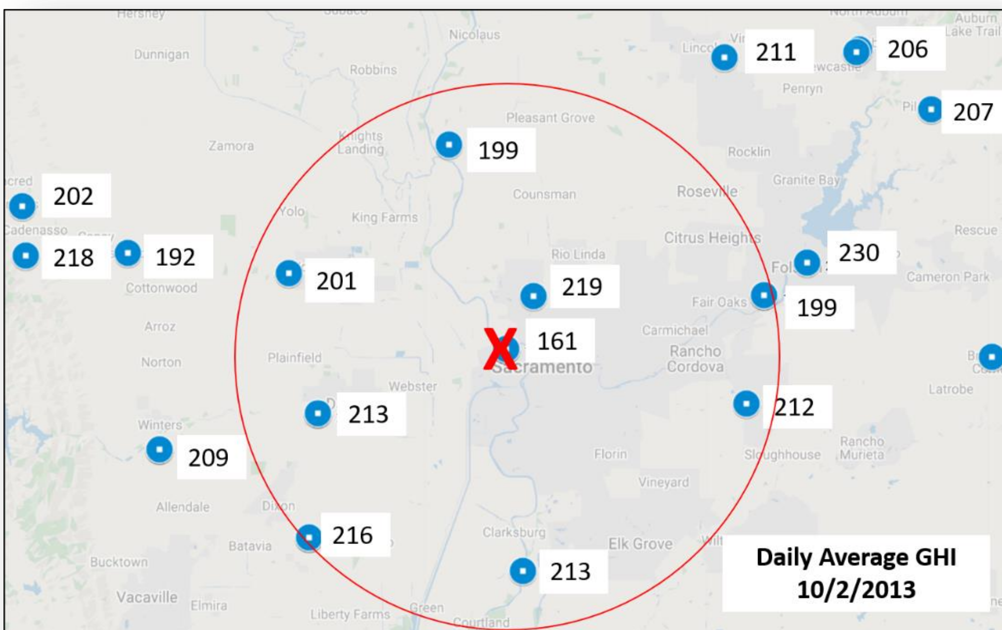

Figure 1 - GHI sensors near Sacramento

Figure 2, taken from several sites in Mississippi, shows what can be learned by comparing the time histories for neighboring sites. Sensor MS161-1 is tracking well with its neighbors up until early September when it starts to fail – giving occasional readings until finally going dead. It appears the sensor was replaced in mid-October, but the calibration is suspect as indicated by consistently higher readings compared to the neighboring sites.

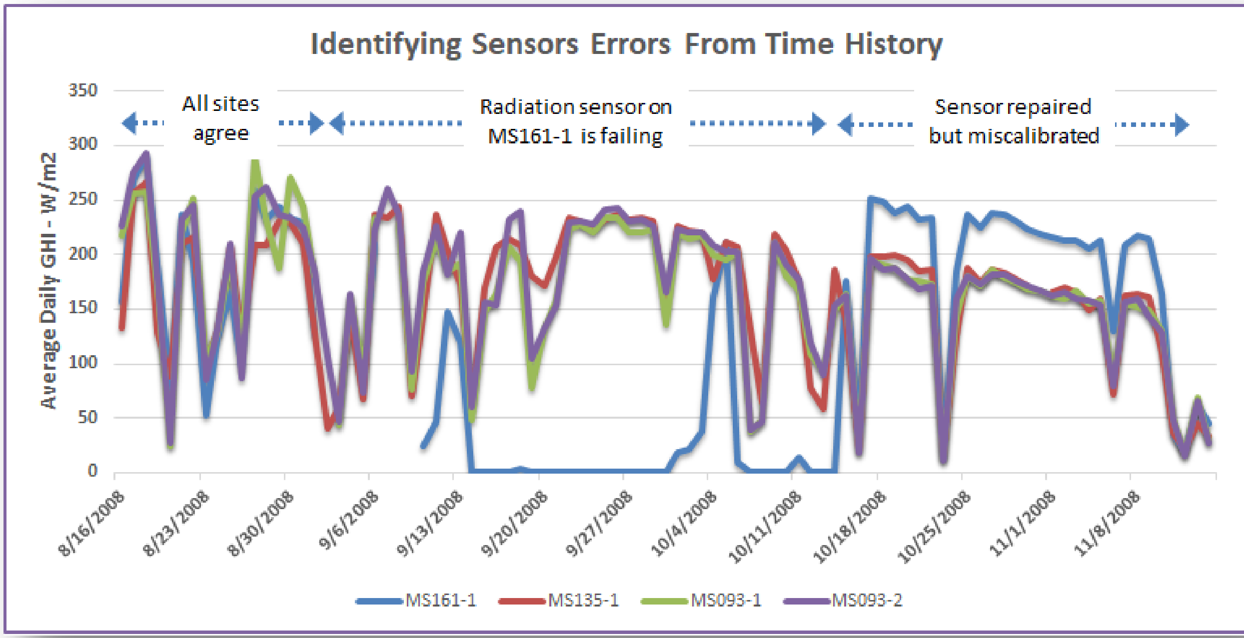

Figure 2 - Mississippi site comparison with neighbors

In a similar way, it is possible use hourly time histories on clear sky days to see if a given sensor is becoming overly soiled or if shading from nearby obstacles is occurring.

All of these techniques require having a significant amount of data from multiple, overlapping solar radiation networks. It is not possible to catch and remove all of the errors coming from 7000+ sites, but applying AI techniques like those shown significantly improve the overall accuracy of our USMSR database.

Conclusion

Comparing GHI observations and time histories from as many nearby sites as possible allows us to determine how well an individual station is performing.

Sources

[1] Frank Vignola, Cathy Grover, Nick Lemon, Andrew McMahan, 2012. “Building a Bankable Solar Radiation Dataset”.
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[2] Aron Habte, Manajit Sengupta, Afshin Andreas, Mike Dooraghi, Ibrahim Reda, and Mark Kutchenreiter 2018. "Evaluating the Sources of Uncertainties in the Measurements from Multiple Pyranometers and Pyrheliometers". NREL/PO-5D00-68065 https://www.nrel.gov/docs/fy17osti/68065.pdf

[3] "Interpreting Solar Irradiance Data From Pyranometers" https://16iwyl195vvfgoqu3136p2ly-wpengine.netdna-ssl.com/wp-content/uploads/2017/10/kippzonen_Pyranometer-Data-Interpretation_pvm-webinar-23-01-2017.pdf

[4] Tom Stoffel, Dave Renne, Darryl Myers, Steve Wilcox, Manajit Sengupta, Ray George and Craig Turchi 2010. "Concentrating Solar Power, Best Practices Handbook for the Collection and use of Solar Resource Data". NREL/TP-550-47465.

[5] Martin Waters, Tejas Tirumalai, Michael Gostein, Bill Stueve 2017. "Soiling Rates of PV Modules vs. Thermopile Pyranometers" https://www.researchgate.net/publication/326211675_Soiling_Rates_of_PV_Modules_vs_Thermopile_Pyranometers

[6] Frank Vignola, Josh Peterson, Rich Kessler, Fotis Mavromatakis, Mike Dooraghi, and Manajit Sengupta 2016. "Use of Pyranometers to Estimate PV Module Degradation Rates in the Field." Presented at the 43rd IEEE Photovoltaic Specialists Conference Portland, Oregon