

PV Expected Energy Modeling

Will Hobbs¹, Ishtiza Azad²

¹Southern Company R&D, ²Southern Power Company

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PVPMC

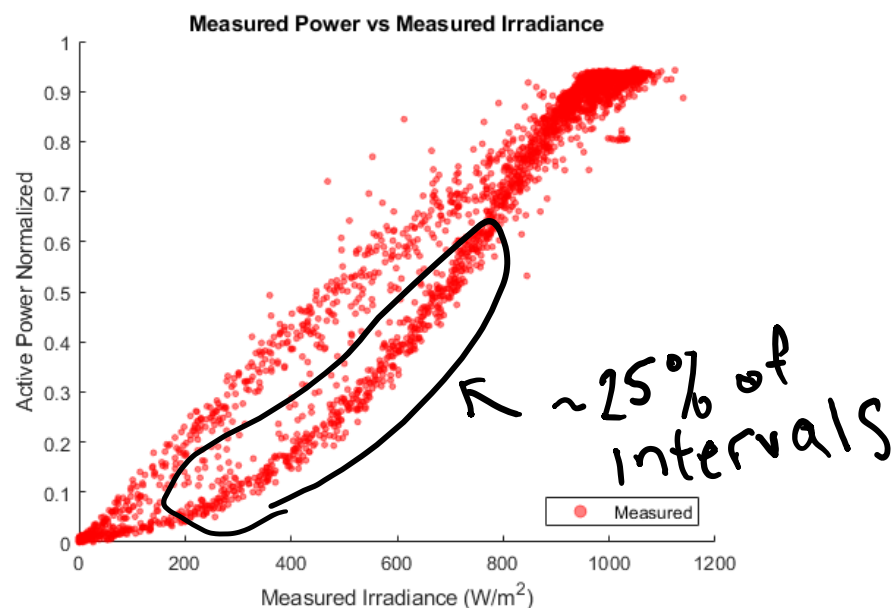


PV Expected Energy Modeling

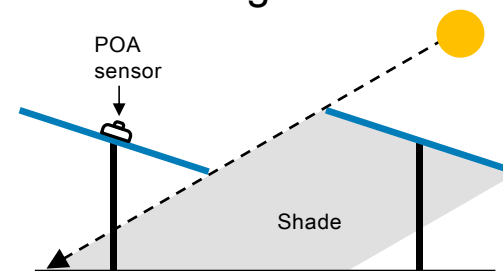
- Southern Company's utilities own or operate over 2,500 MW of PV
- We model expected energy to benchmark plants using on-site weather data and past performance
- Look for underperformance and sources
- **This talk is about trying to improve those models**

Previous Work: Simple Self-Shade Correction

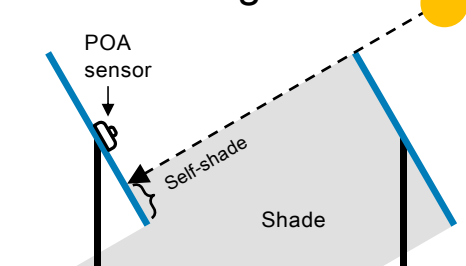
- Thin-film trackers have true-tracking and self-shade, so power is not always linear with measured POA.



Backtracking



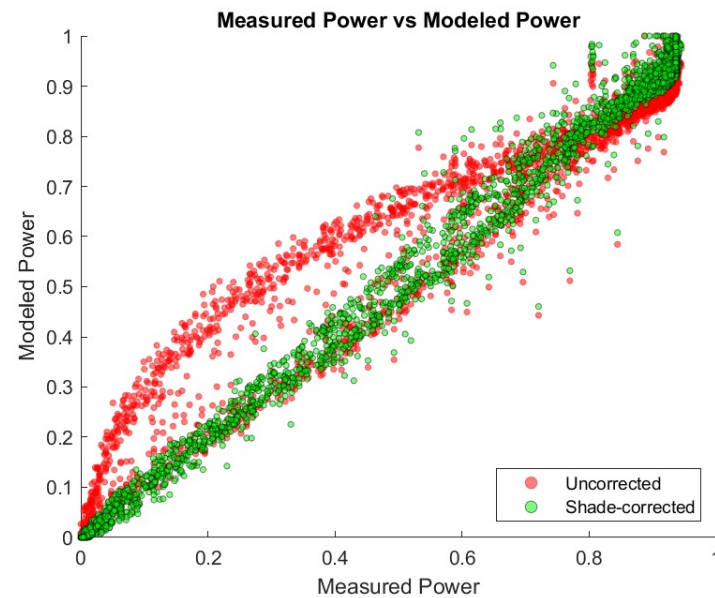
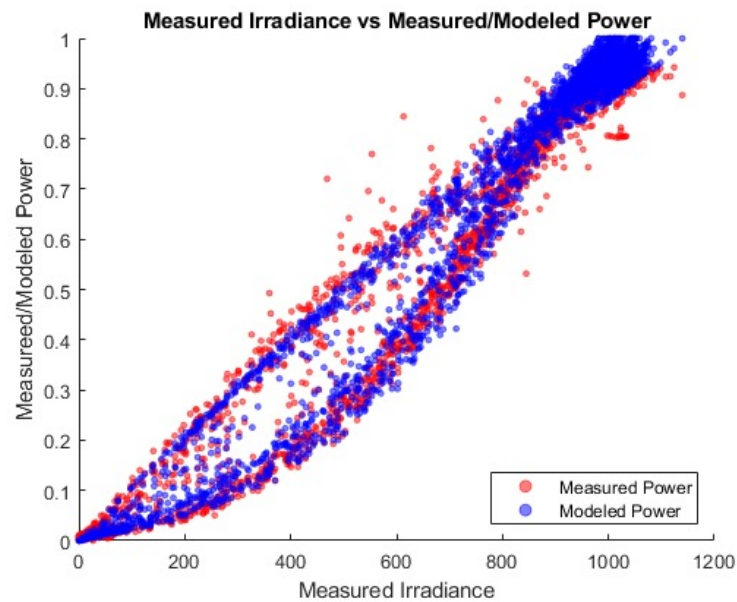
True-tracking



Azad, I., and Hobbs, W., "Improved PV expected energy modeling with a simple shading model", PVRW 2023 (Poster)

Previous Work: Simple Self-Shade Correction

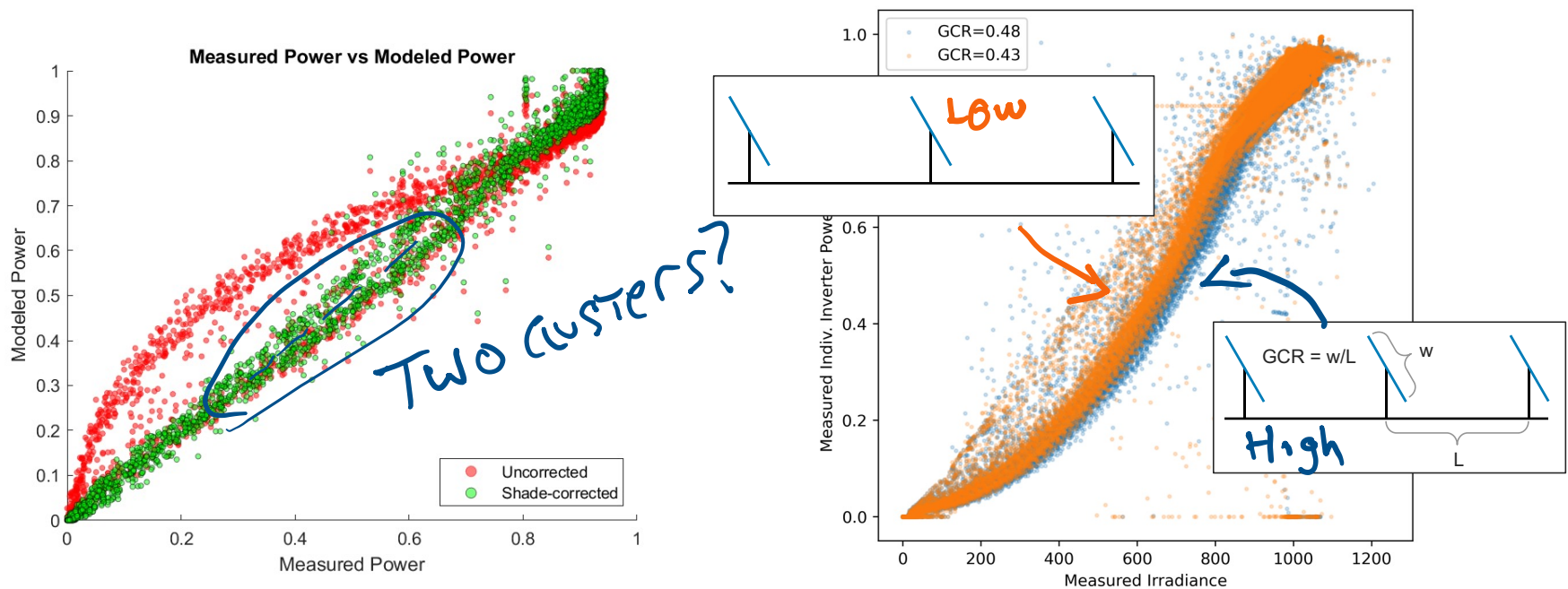
- Shaded fraction calc + 20% diffuse assumption + linear loss = better fit, 25% more usable data



Azad, I., and Hobbs, W., "Improved PV expected energy modeling with a simple self-shading model", PVRW 2023 (Poster)

Room for improvement?

- Plant has two GCR values – what if we model each inverter individually?

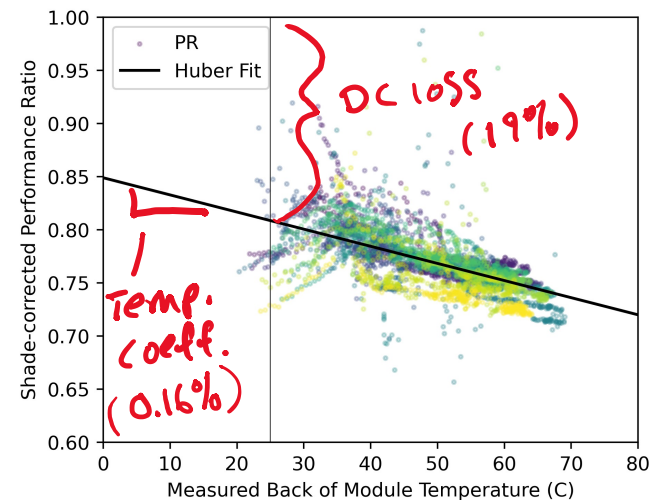


Two approaches

- **Plant-level model**
 - Weighted average of GCRs
 - Plant-level fit for loss factor, temperature coefficient
- **Inverter-level model**
 - Inverter-specific GCR
 - Inverter-level fit for loss factor, temp coeff.
 - Sum up all inverters
- **Test with one month of 2min interval data**
 - Fit with even-numbered days in the month (test w/ odd days)

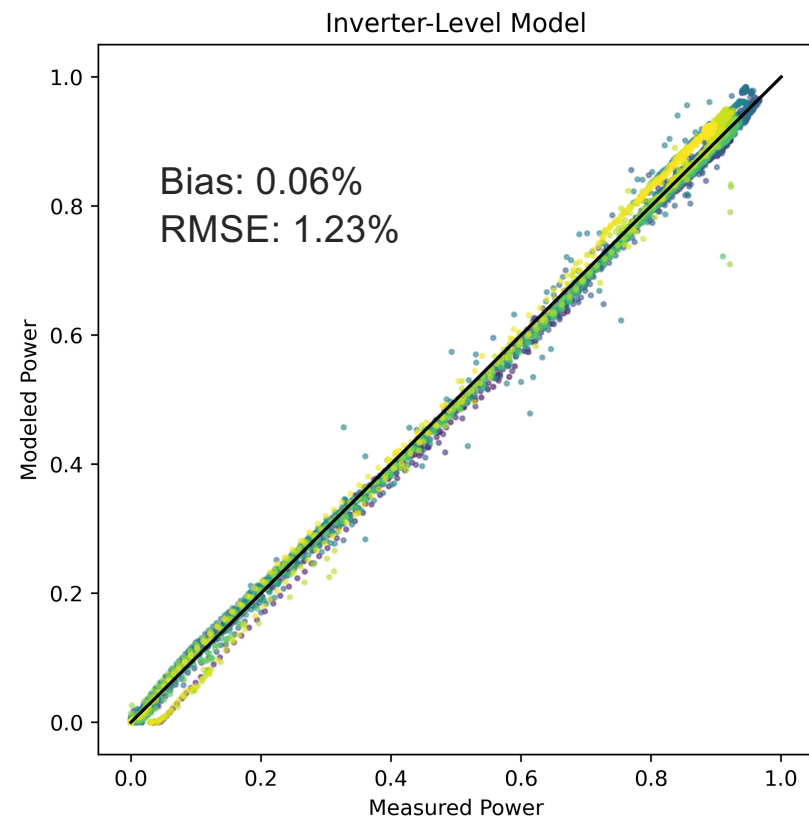
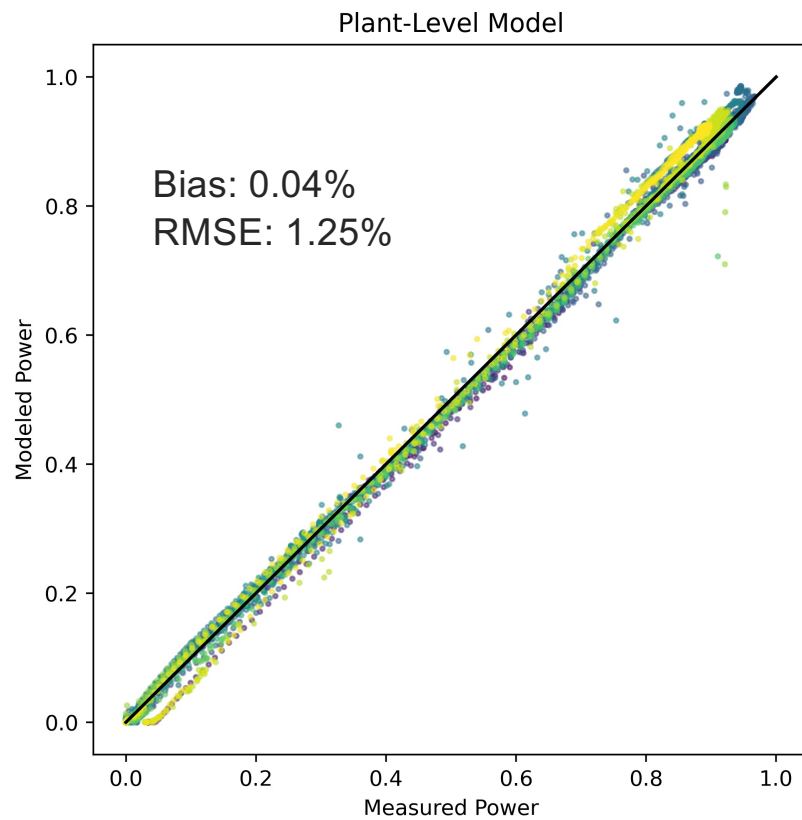
Model fitting

- Use `pvlib.pvsystem.pvwatts_dc` and `pvlib.inverter.pvwatts`
- Temp coefficient: fit of Performance Ratio (PR) vs. $T_{\text{back of module}}$
- DC loss factor: `scipy.optimize.minimize` on abs total error
- Filtering for fit:
 - POA > 200
 - No (known) curtailment
 - Sun Elev. > 10 deg

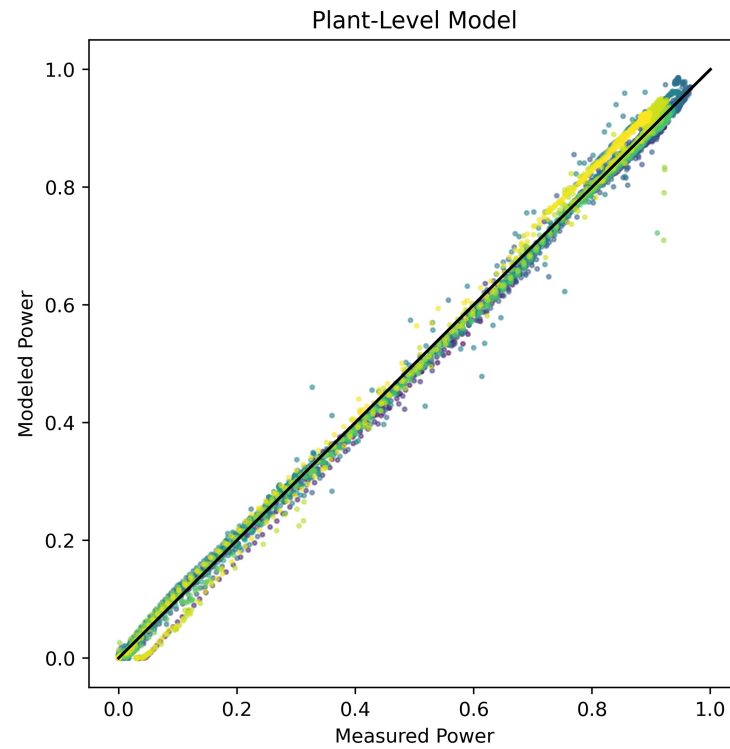


Results

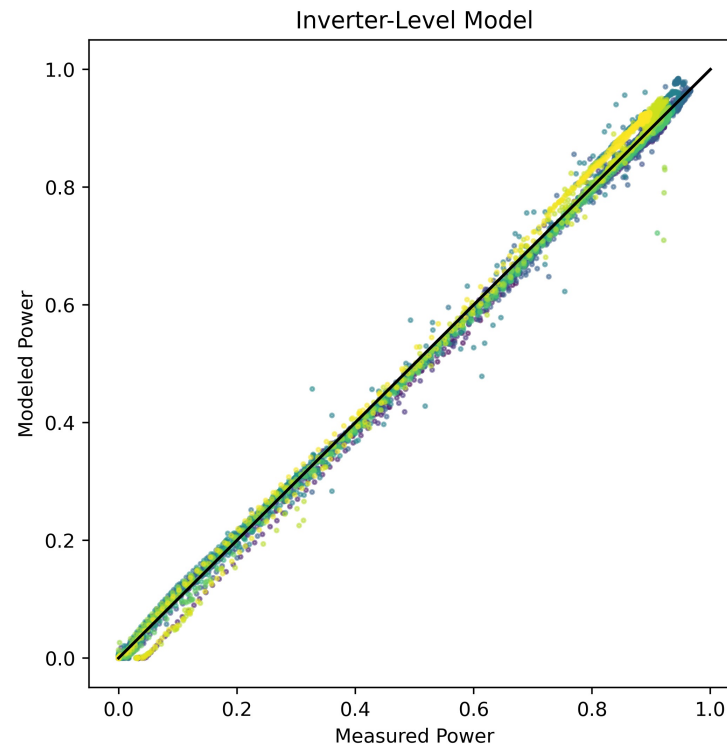
- They are *very* close:



(switch back and forth in case you missed it)



(switch back and forth in case you missed it)

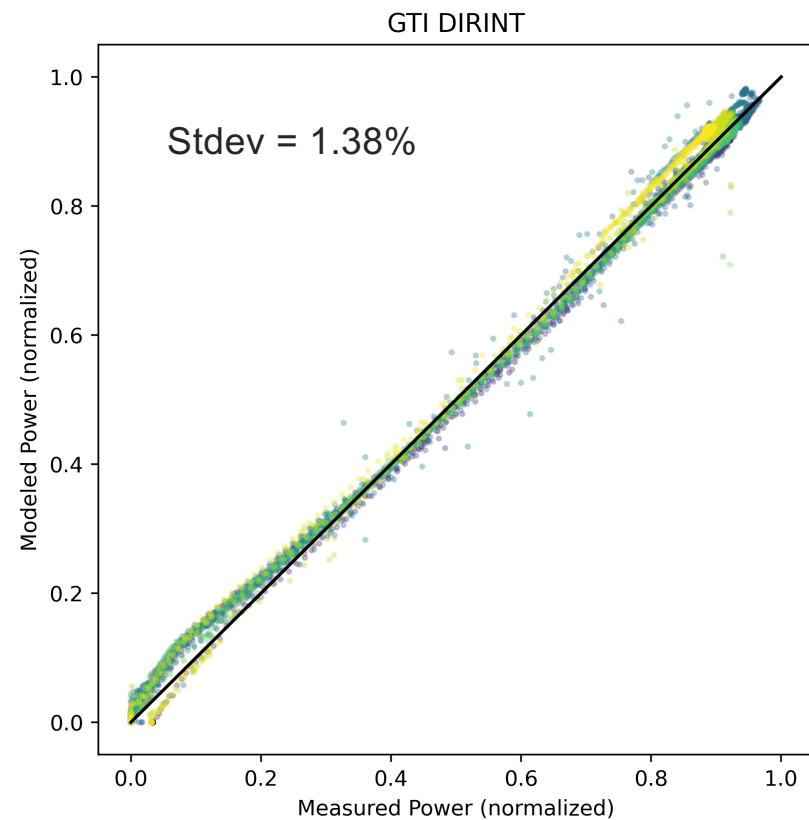
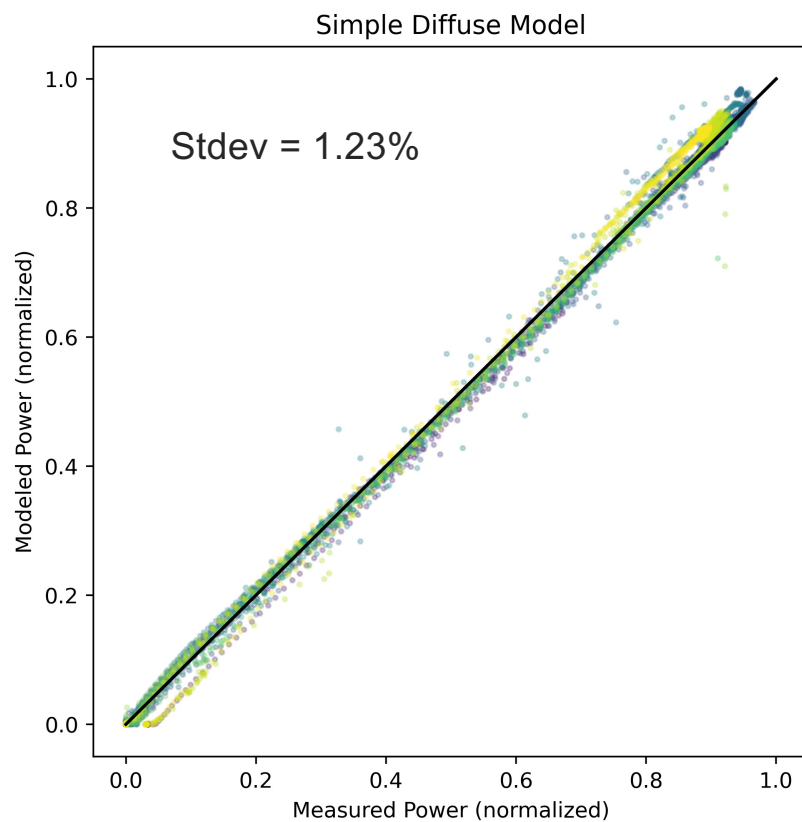


What about improved diffuse irradiance?

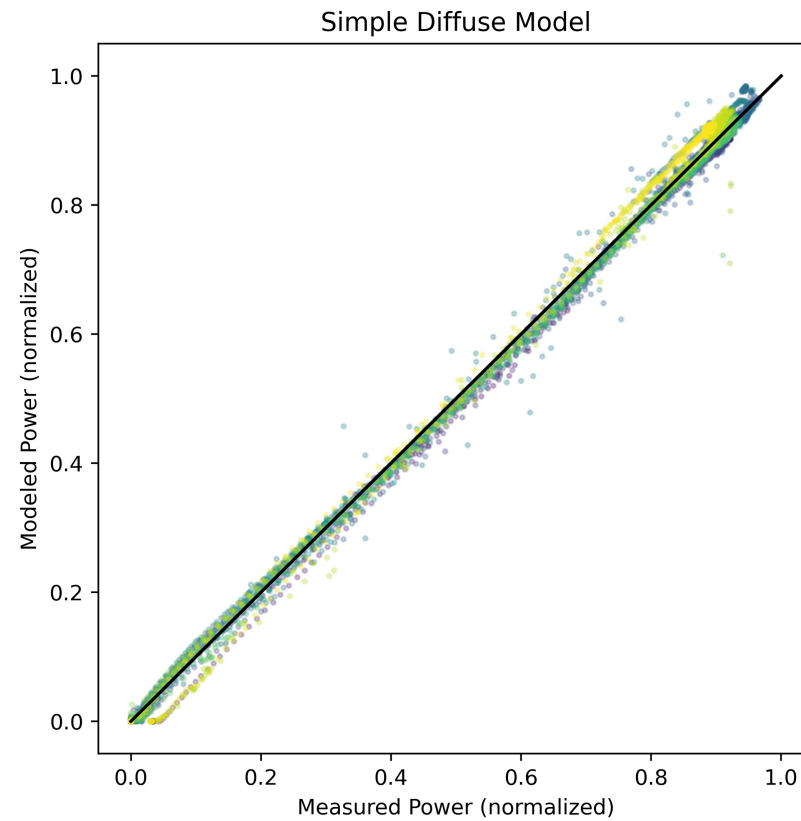
- Shade loss model needs diffuse irradiance
- “Simple” model (assume 20% diffuse fraction)
- GTI DIRINT (est. DHI/DNI from POA)
- Is a more sophisticated model better?
- (it *is* about 30x slower...)

Results

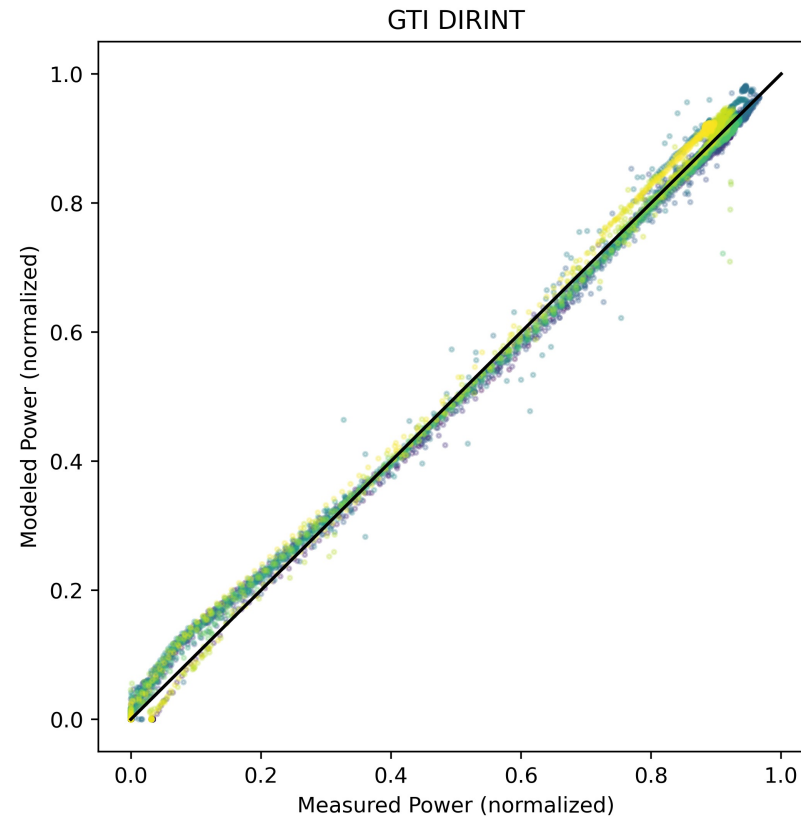
- “Simple” looks better (for this desert-like site):



(switch back and forth in case you missed it)

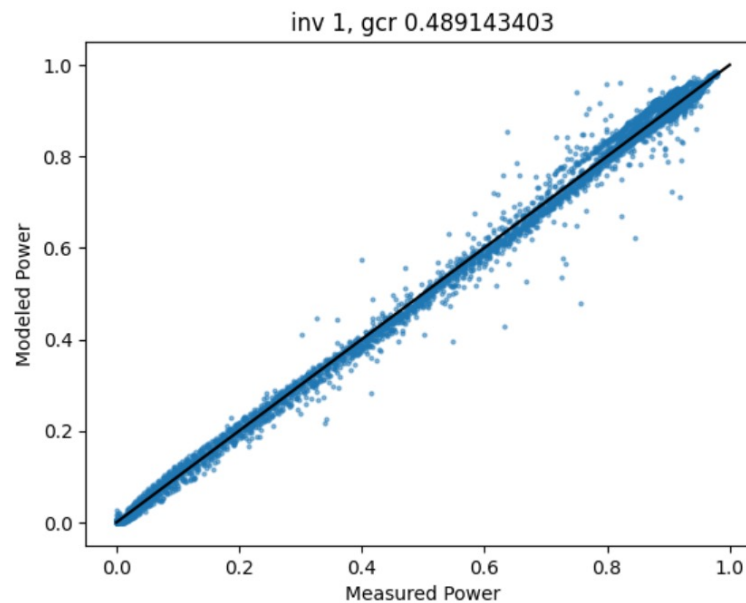


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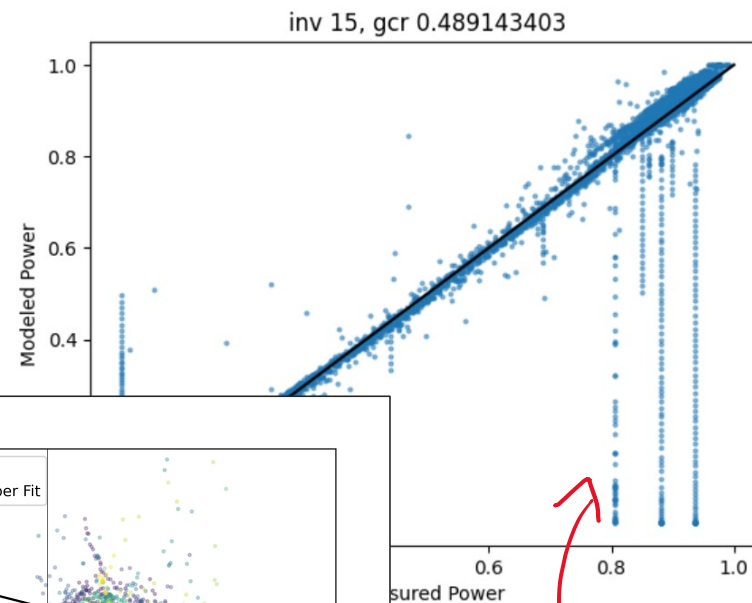


Possible Issues with this Analysis

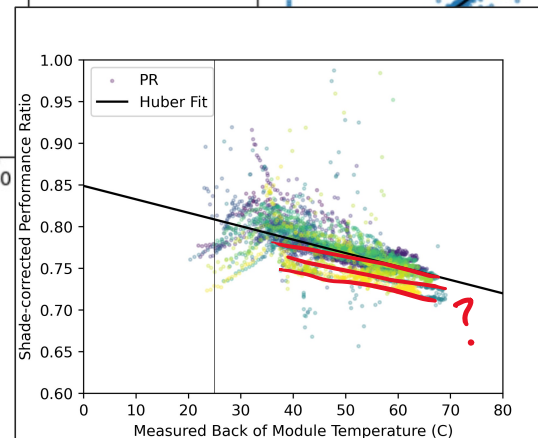
- Most inverters look like this:



- But some look like this:



- Plus general data QC issues



“STUCK” VALUES
IN SCADA/PI

Other things to explore (future work)

- Satellite-based diffuse fraction
- Spectral correction
- More data QC
- Confirm GCR values
- Additional sites with:
 - Backtracking and range of GCRs
 - Clipping and range of DC capacities (or DC loss factors)
 - Different climate (diffuse fraction)
 - Less soiling

Questions?

whobbs@southernco.com



Looking for a Job?

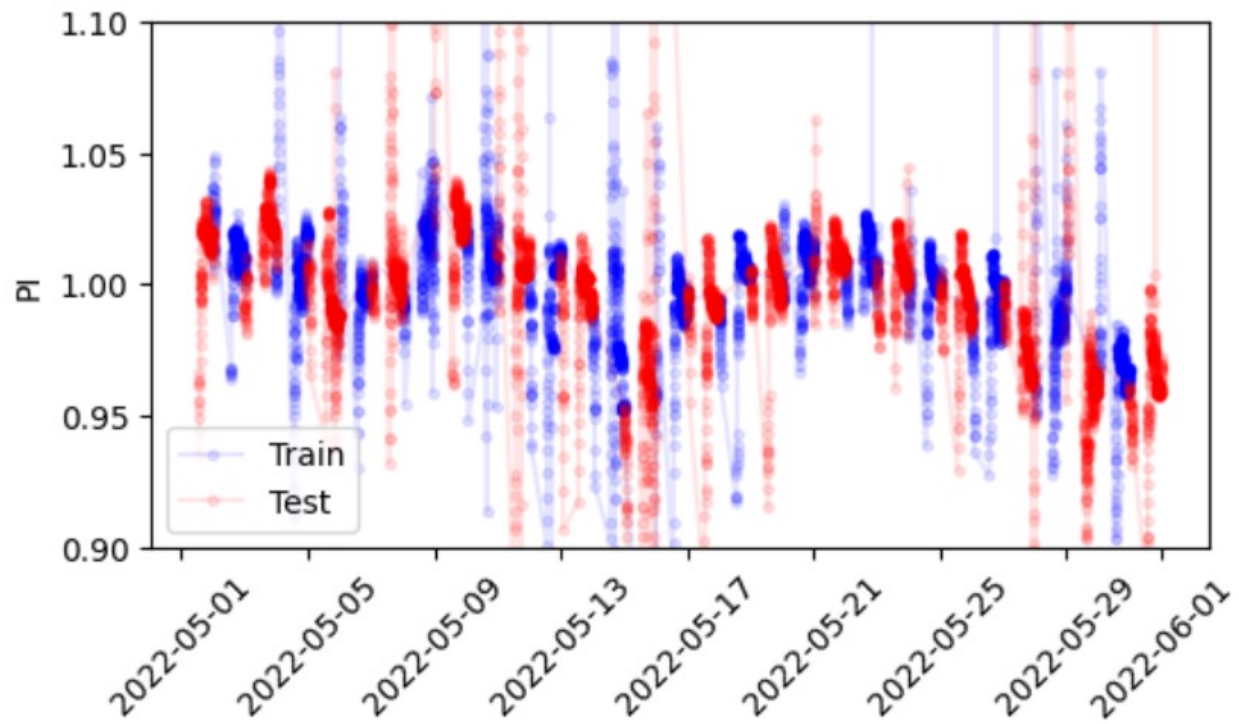
- Renewable Resource Analyst, Southern Power (wholesale IPP)
- Pre-construction solar and wind resource data analysis and energy modeling, and more
- Talk to me or Kelly!

https://southerncompany.taleo.net/careersection/cs_ep/jobdetail.ftl?job=SPC2000461



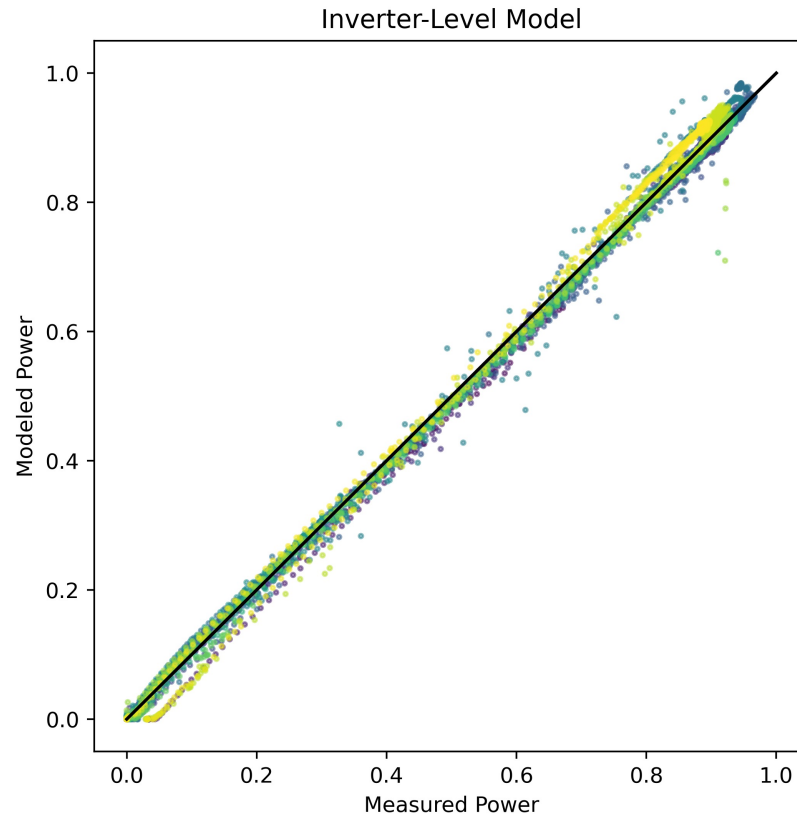
Soiling

- Performance Index over time period



Optimized GCR (0.48 \rightarrow 0.46, 0.43 \rightarrow 0.40)

- Very small improvement...



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- Very small improvement...

