



RdTools 3.0

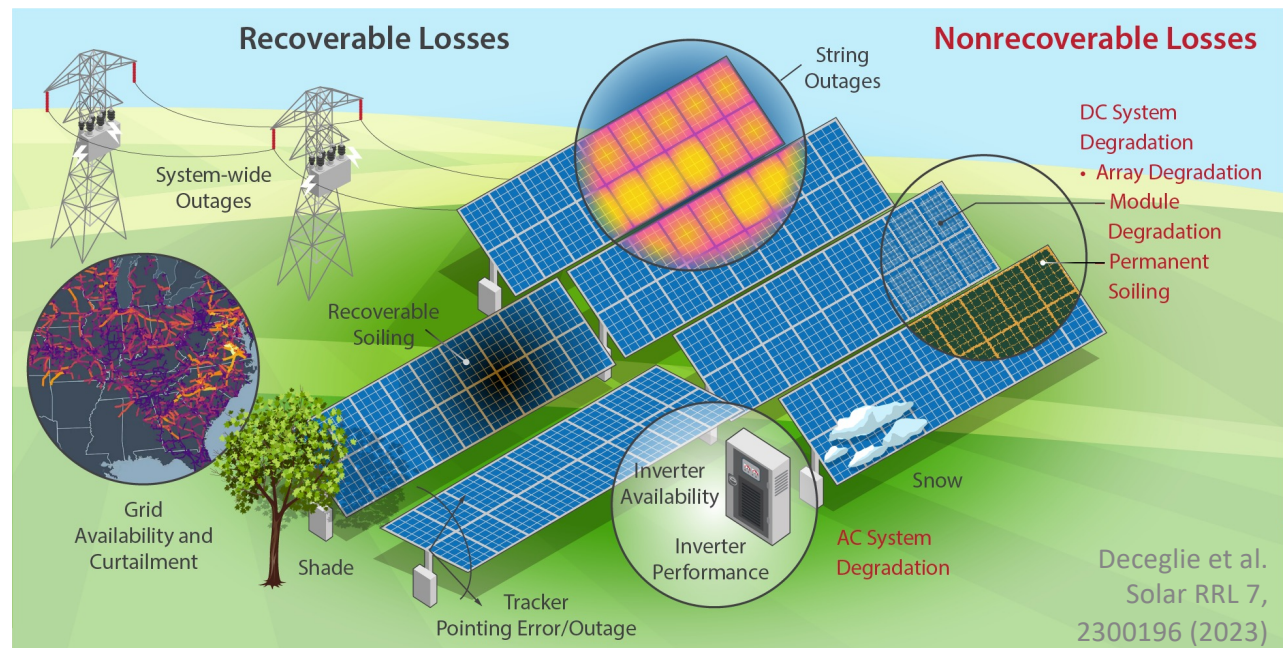
Michael G. Deceglie, Dirk C. Jordan, Matthew Muller,
Kirsten Perry, Martin Springer, Chris Deline

PVPMC

May 8, 2024

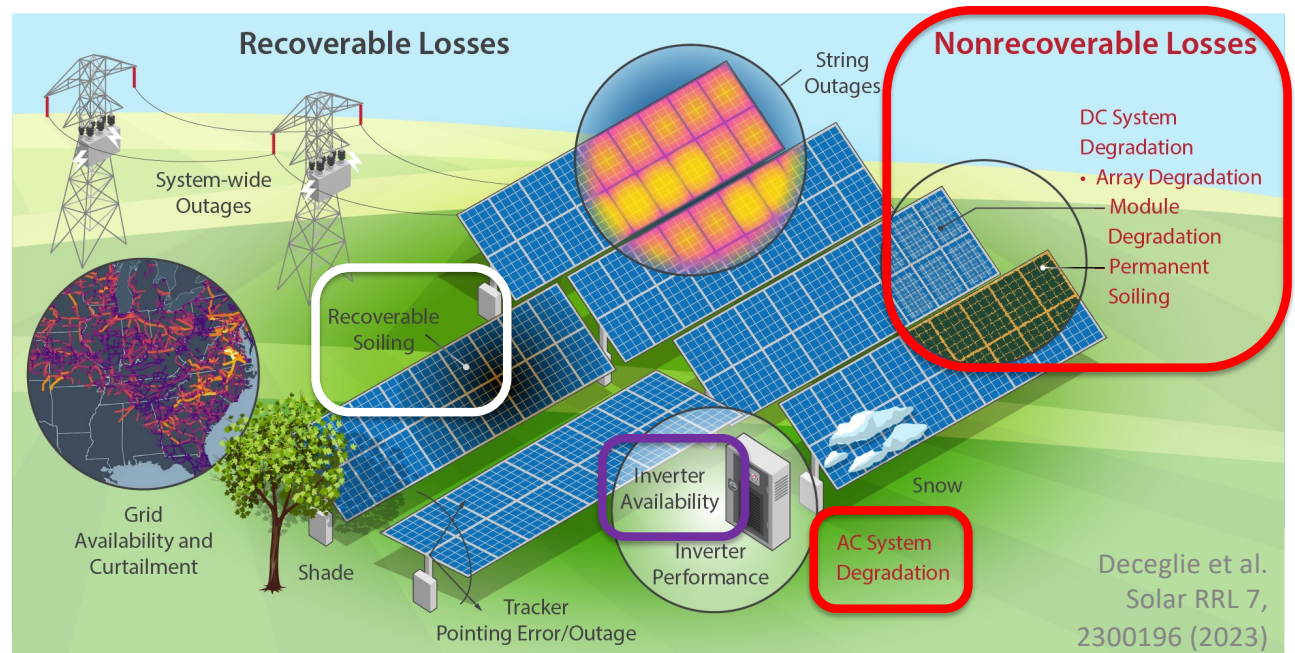
RdTools

- An open-source python library for PV time series analytics
- Why? Because models are only as good as their inputs
- Goals for today:
 - Overview of capabilities
 - Focus on what we are changing in 3.0
- A brief history:
 - 2016: 1.0 released
 - 2020: 2.0 released
 - 2021: 2.1 released with object oriented interface
 - 2024: 3.0



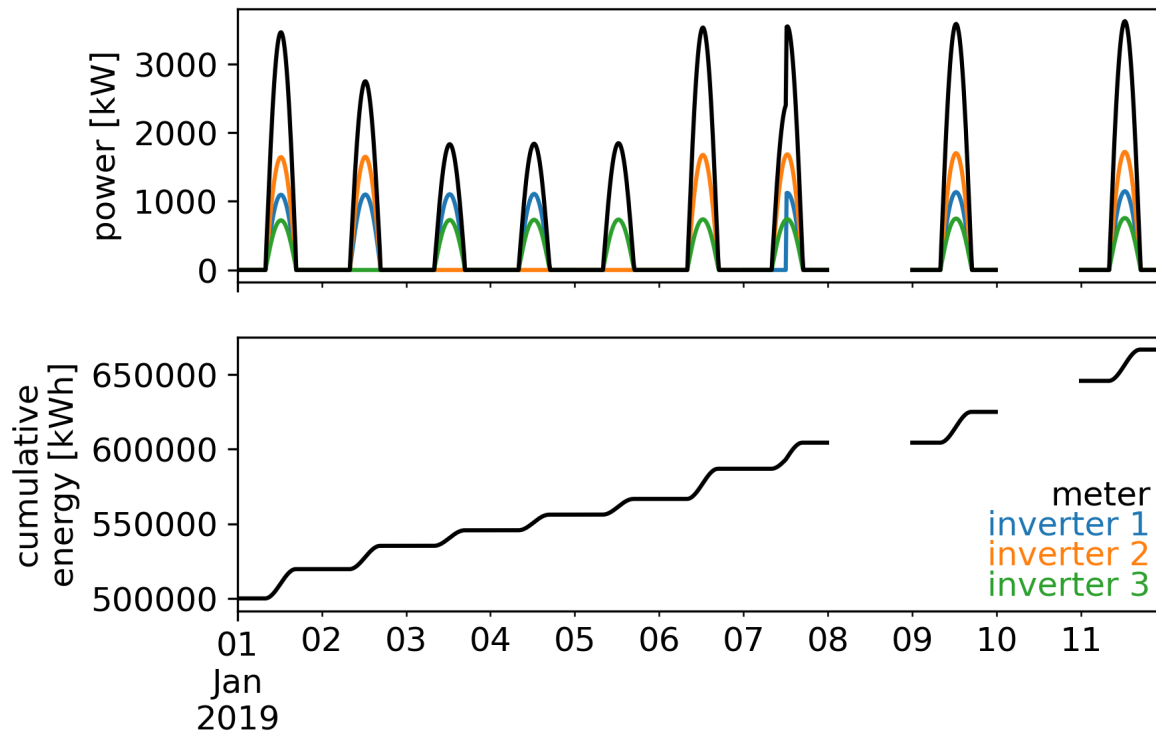
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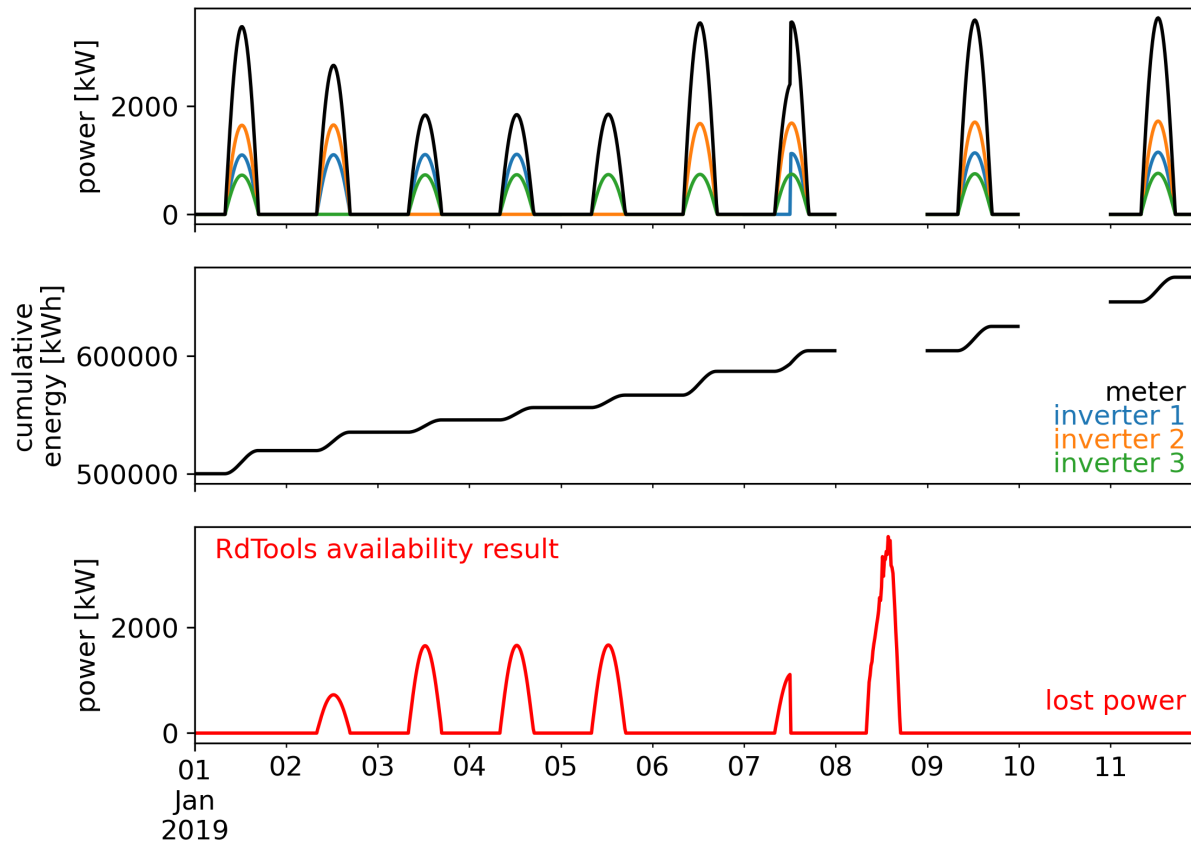
Availability

Synthetic example containing real and communication outages



Data is missing or zero:
Communication outage?
Actual outage?
Energy lost?

Availability



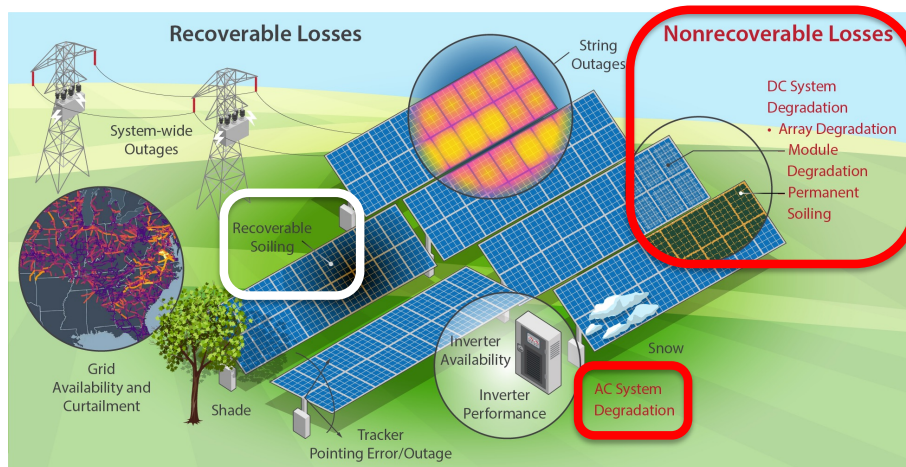
Partial outages:

- Compare meter data to expected power constructed from reporting inverters

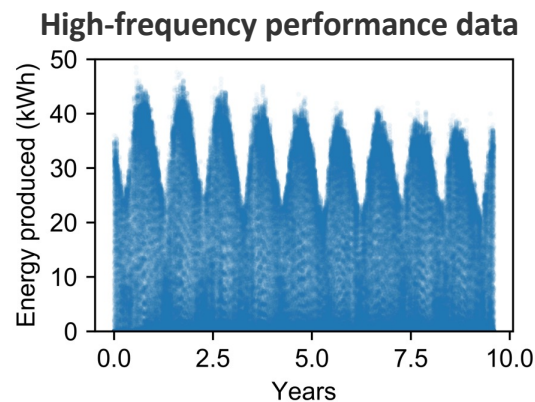
Full outages:

- Compare cumulative meter energy to expected energy based on weather/model

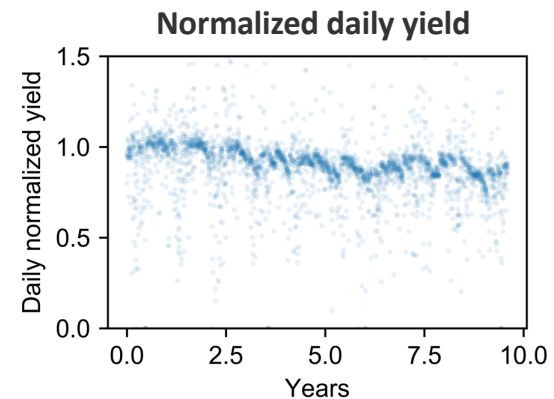
Soiling and degradation workflows



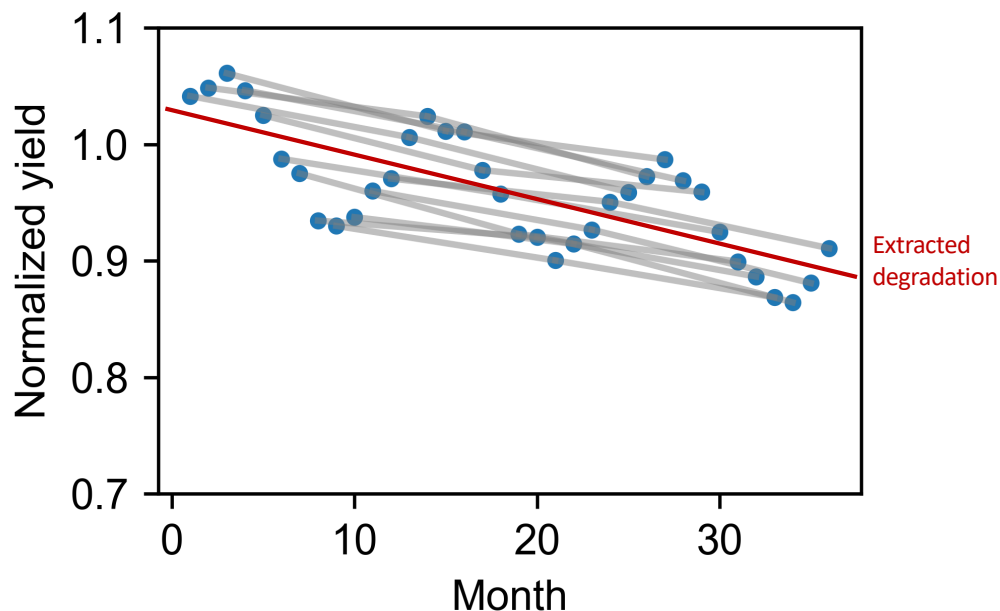
Soiling and degradation workflows operate on aggregated yield (usually daily frequency)



Filtering and normalization
Changing in 3.0



Year-on-year degradation analysis

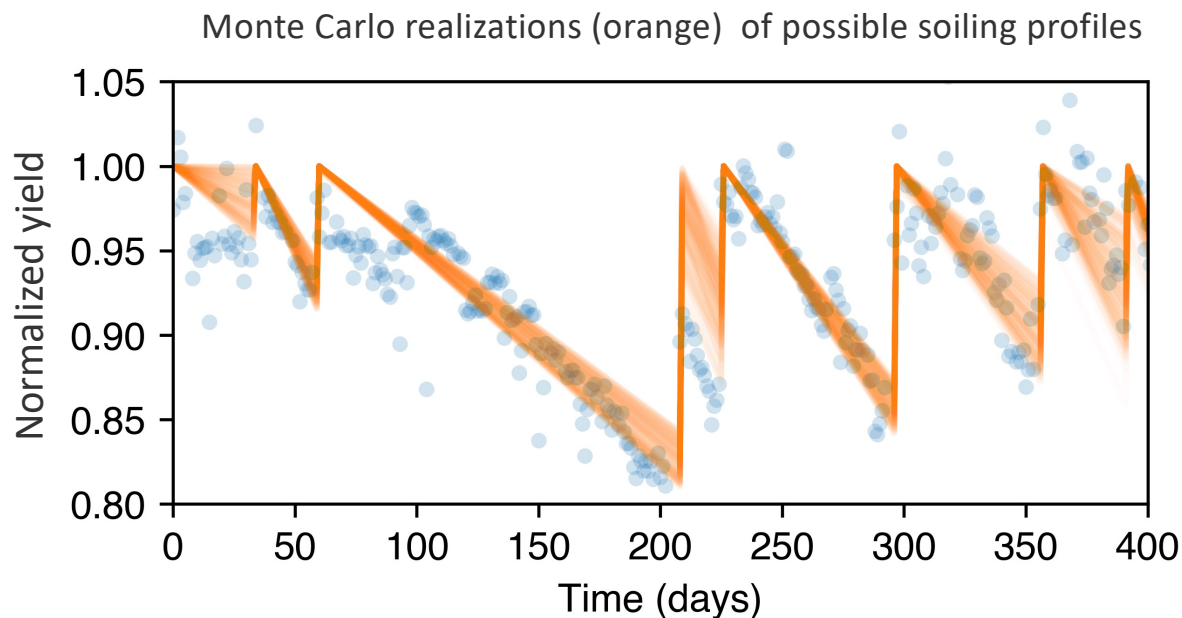


- Year-on-year is robust to seasonality and outliers
- Steps:
 - Compare each day (or week, month, etc.) to its corresponding day a year later
 - Calculate the median of all year-on-year slopes
- Pay attention to the confidence interval

E. Hasselbrink, M. Anderson, Z. Defreitas, et al., "Validation of the PVLife model using 3 million module- years of live site data," PVSC, p.0007, 2013

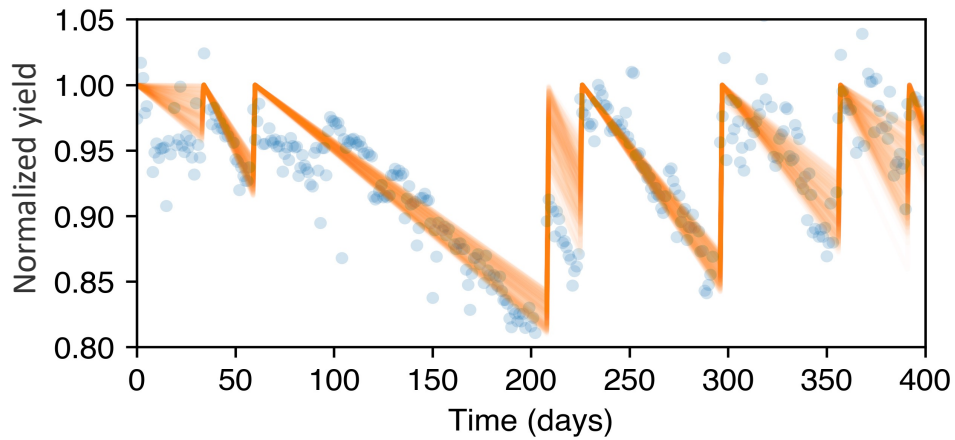
Jordan, Deceglie, & Kurtz. "PV degradation methodology comparison—A basis for a standard." PVSC, p.0273, 2016

Soiling: stochastic rate and recovery (SRR)

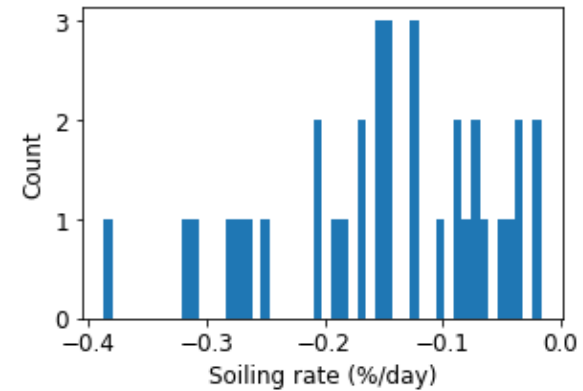


- Detect cleaning events/divide dataset into soiling intervals
- Fit the slope of each soiling interval
- Monte Carlo
 - Rate confidence intervals
 - Cleaning uncertainty

SRR output: soiling interval details

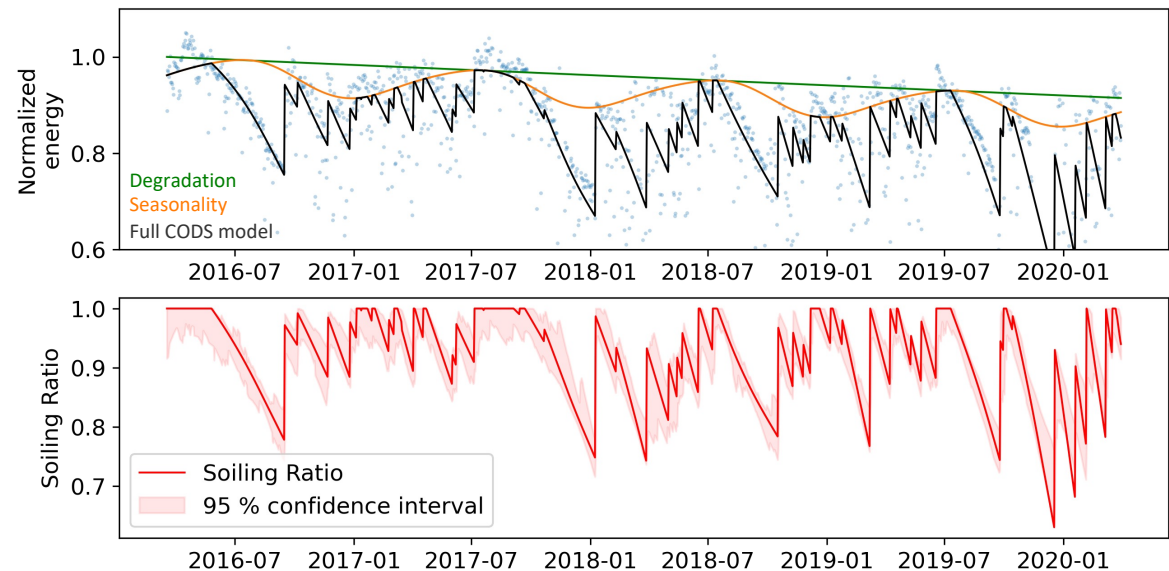
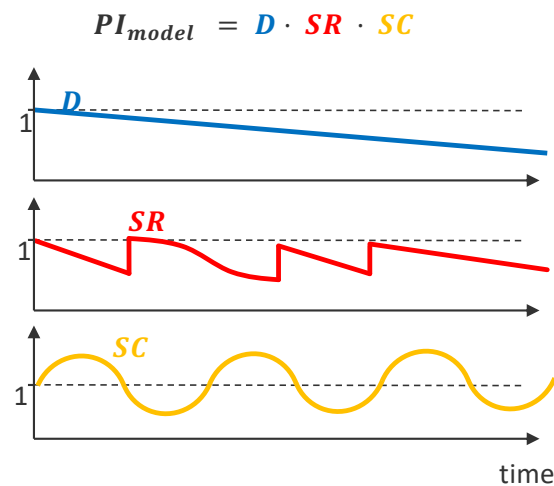


	start	end	slope	slope_low	slope_high	inferred_start_loss	inferred_end_loss	length	valid
0	2008-11-13 00:00:00+09:30	2008-12-11 00:00:00+09:30	-0.001289	-0.003674	0.000000	1.020397	0.984317	28	True
1	2008-12-12 00:00:00+09:30	2009-03-20 00:00:00+09:30	0.000000	0.000000	0.000000	0.980044	0.994708	98	False
2	2009-03-21 00:00:00+09:30	2009-03-24 00:00:00+09:30	0.000000	0.000000	0.000000	0.987630	1.023365	3	False
3	2009-03-25 00:00:00+09:30	2009-05-28 00:00:00+09:30	-0.000558	-0.000874	-0.000244	1.039202	1.003482	64	True
4	2009-05-29 00:00:00+09:30	2009-08-11 00:00:00+09:30	-0.000534	-0.000724	-0.000310	1.036823	0.997294	74	True

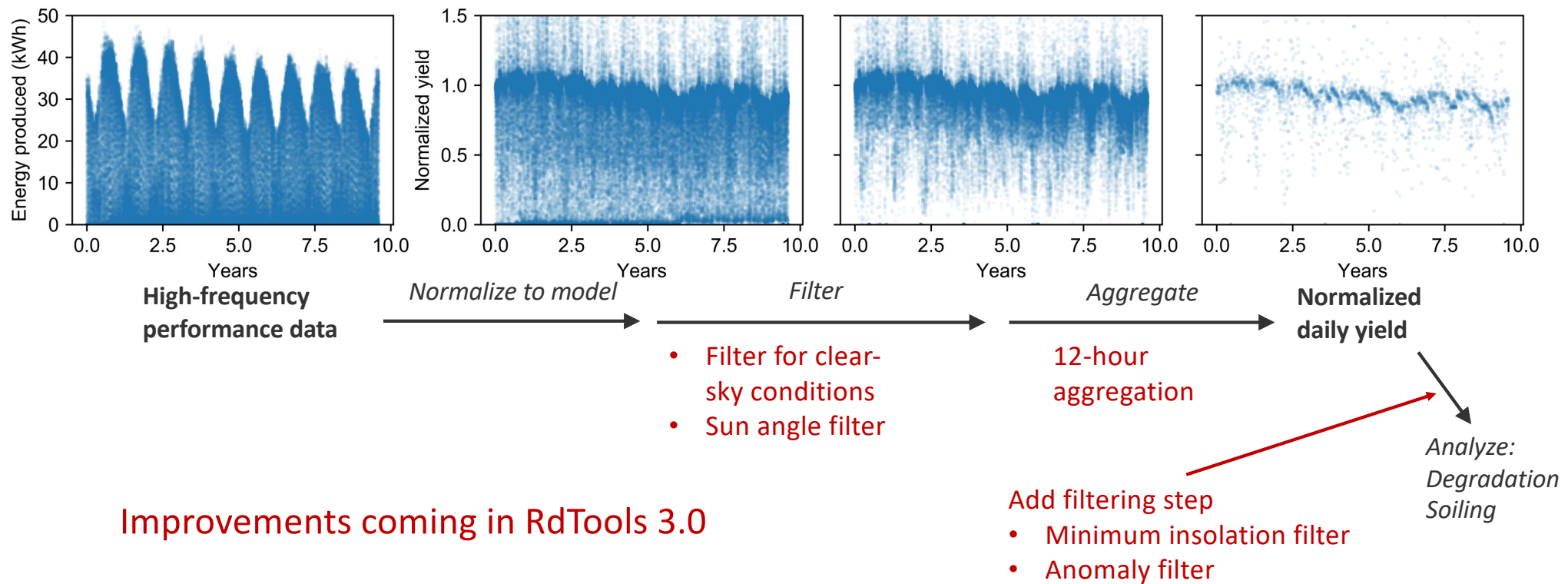


Combined estimation of degradation and soiling (CODS)

- Iteratively and self-consistently decomposes time series that include soiling
- Particularly useful when soiling frustrates a degradation analysis

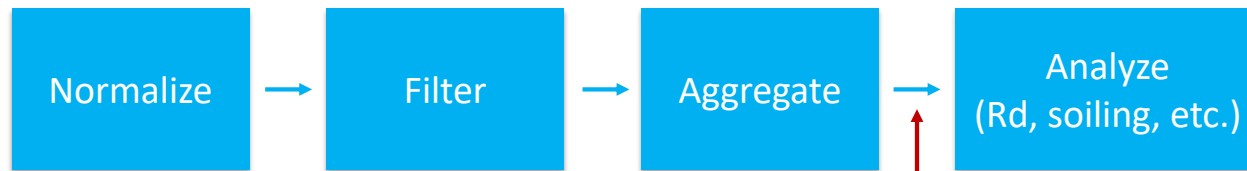


Degradation and soiling are based on daily yield



Improvements coming in RdTools 3.0

Performance on a subset of Fleets systems

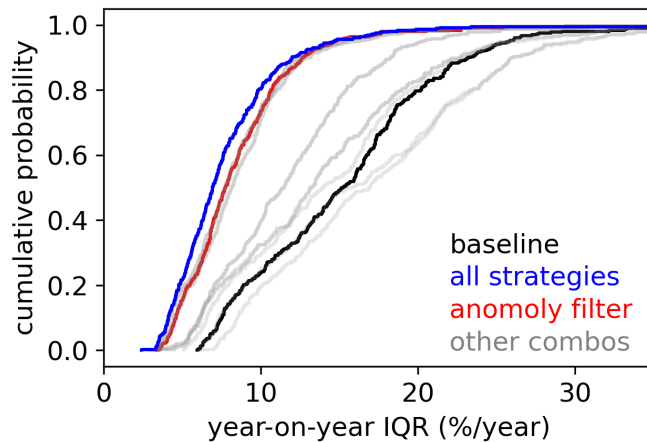


- Filter for clear-sky conditions
- Sun angle filter

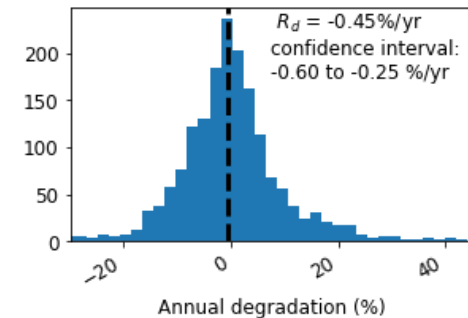
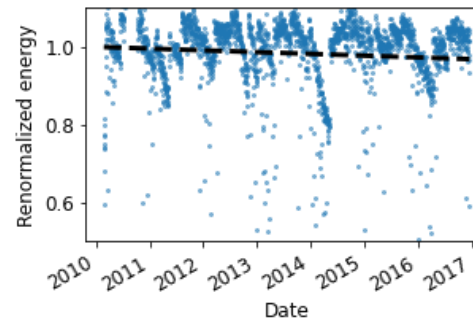
12-hour aggregation

Add filtering step

- Minimum insolation filter
- Anomaly filter

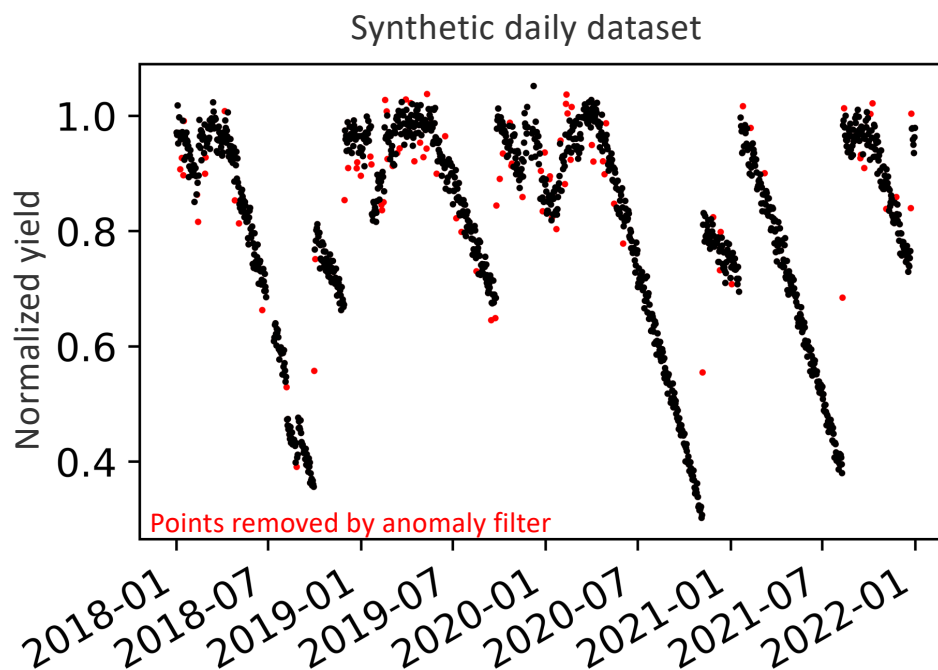


Example year-on-year results



Modifications to the baseline year-on-year (YoY) workflow improve the distribution of YoY slopes

Anomaly filter illustration

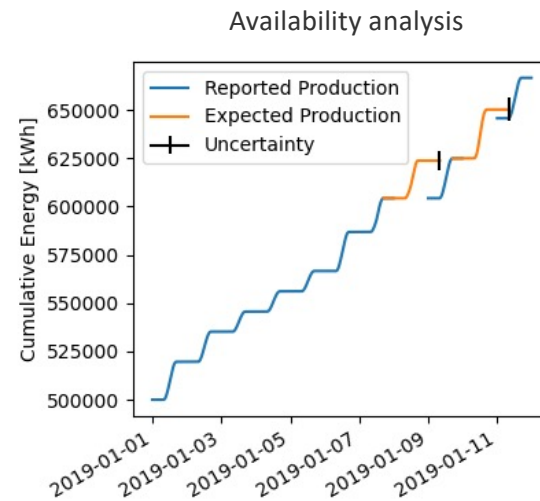
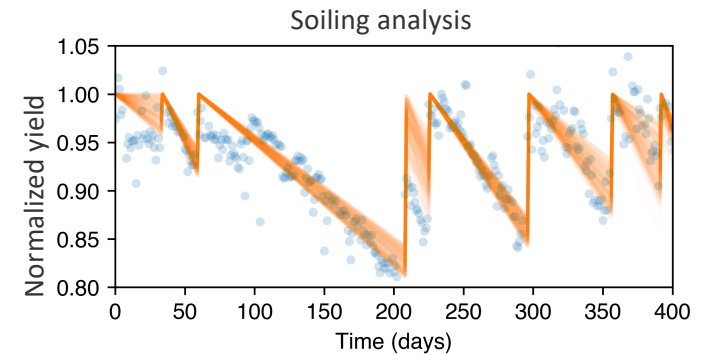
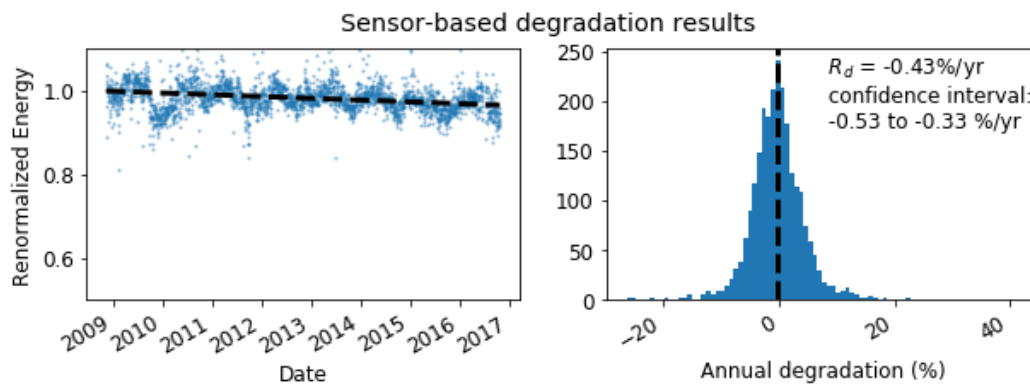


RdTools 3 will contain three options for anomaly filters:

- **Two-way window filter (default)**
 - Removes points that are beyond a threshold from both the forward- and backward-looking rolling median
- Hampel filter
- Two-way Tukey filter

RdTools

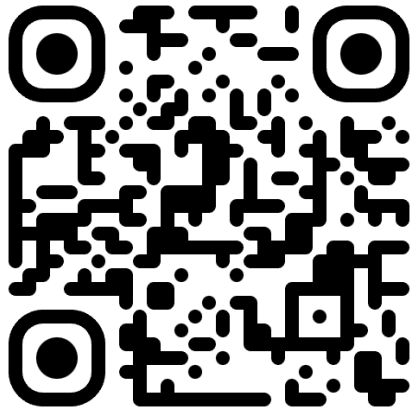
- Open-source python library for PV time series analytics
- RdTools 3: Improvements to the roll-up workflow:
 - Sun angle filter
 - Clear sky filtering (particularly useful for satellite analyses)
 - Sub-daily aggregation
 - Filtering after aggregation:
 - Insolation
 - Anomaly
 - RdTools 3-alpha available now! Full release this summer
 - `pip install rdtools==3.0.0a4`



Final words

Check out the American Made Solar Data Bounty Prize webinar

<https://pv-tutorials.github.io/>



 **Solar Data Bounty Prize**

2024_Analytics_Webinar

A tutorial for PVAnalytics, RdTools, and Solar-Data-Tools for the DOE Open-Source Tools & Open-Access Solar Data webinar series, Part 2: Analytics and Quality Tools.

[Repository](#) [Website](#) [Recording](#)

 Stars 4

Interested in scaling up what you heard today?

- At NREL, we have parallelized RdTools to take our run times from ~1 week down to hours
- Come talk to me or reach out

Acknowledgements

RdTools contributors:

Kevin Anderson
Adam Shinn
Chris Deline
Greg Kimball
Ambaraish Nag
Mark Mikofski
Martin Springer
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Where to find RdTools

- <https://pypi.org/project/rdtools>
 - pip install rdtools
 - pip install rdtools==3.0.0a4
- <https://github.com/NREL/rdtools>
- <https://rdtools.readthedocs.io>

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