The Importance of Data Quality for Reducing the Uncertainty of Site-Adapted Solar Resource Datasets

SolarAnywhere®

Patrick Keelin | Lead Product Manager

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Clean Power Research®

Clean Power Research

20+ years advancing the energy transformation

Team

75+ employees

- HQ: Kirkland, WA
- Research: Napa, CA
- Satellites: NY & MA

20+ people with advanced degrees

- Engineering/Environment/Resources
- Meteorology/Atmospheric Science
- Business

Expertise

Secure, enterprise-grade cloud software

Focus

- Renewable energy
- DERs, EVs and beyond
- Solar data & intelligence

Patents: 44 granted, 18 pending

Partnered with Dr. Perez @ SUNY Albany

Industries Served

65+ Electric Utilities & Energy Agencies

- IOUs
- Munis
- Co-ops

200+ Solar Industry Partners

- Independent engineers
- Solar financiers, operators, installers
- Utility planners

Powering Intelligent Energy Decisions® for the Solar Industry

1,074

Equivalent solar dataset validation years

90%

Influencing 90% of U.S. solar development

>10M

Delivering >10M API data requests per month

>200

Serving the industry's leading enterprises

>1M

Operational data services provided for >1M PV systems (10+GW of solar)

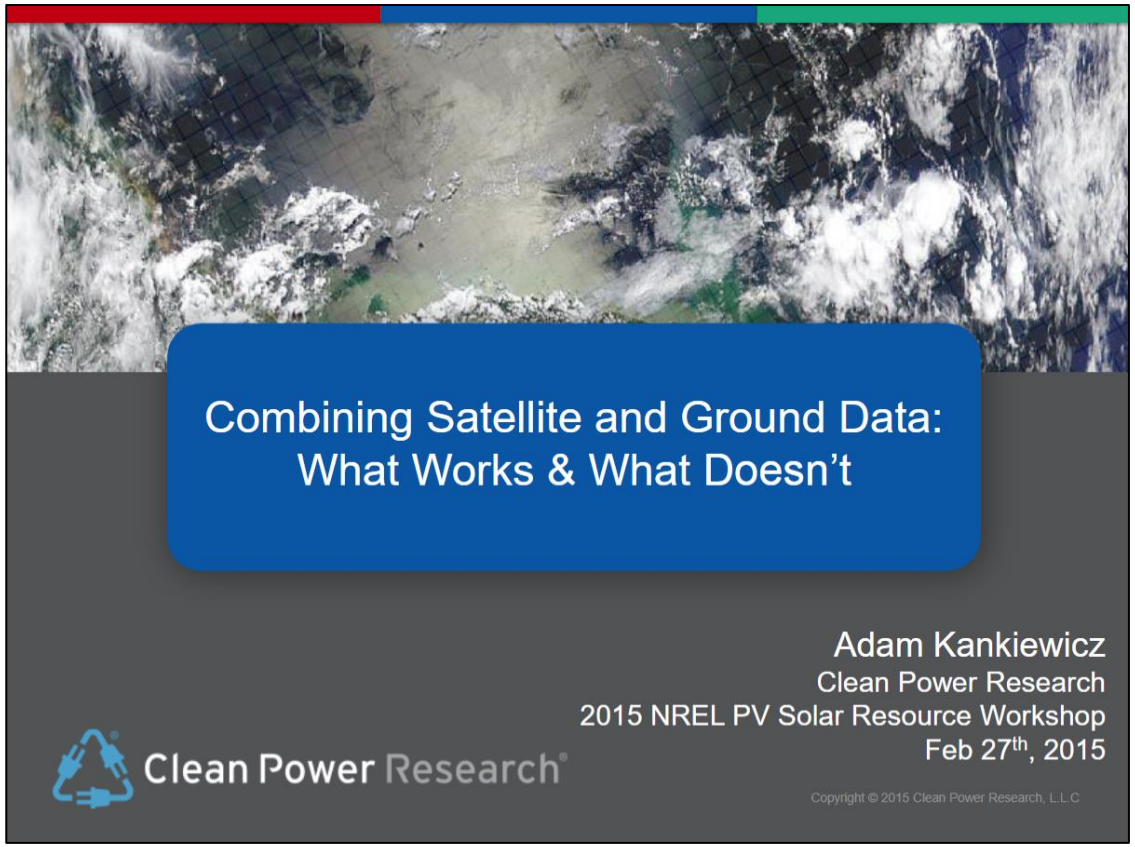
#1

Winner of double-blind EPRI forecast trial

Clean Power Research®

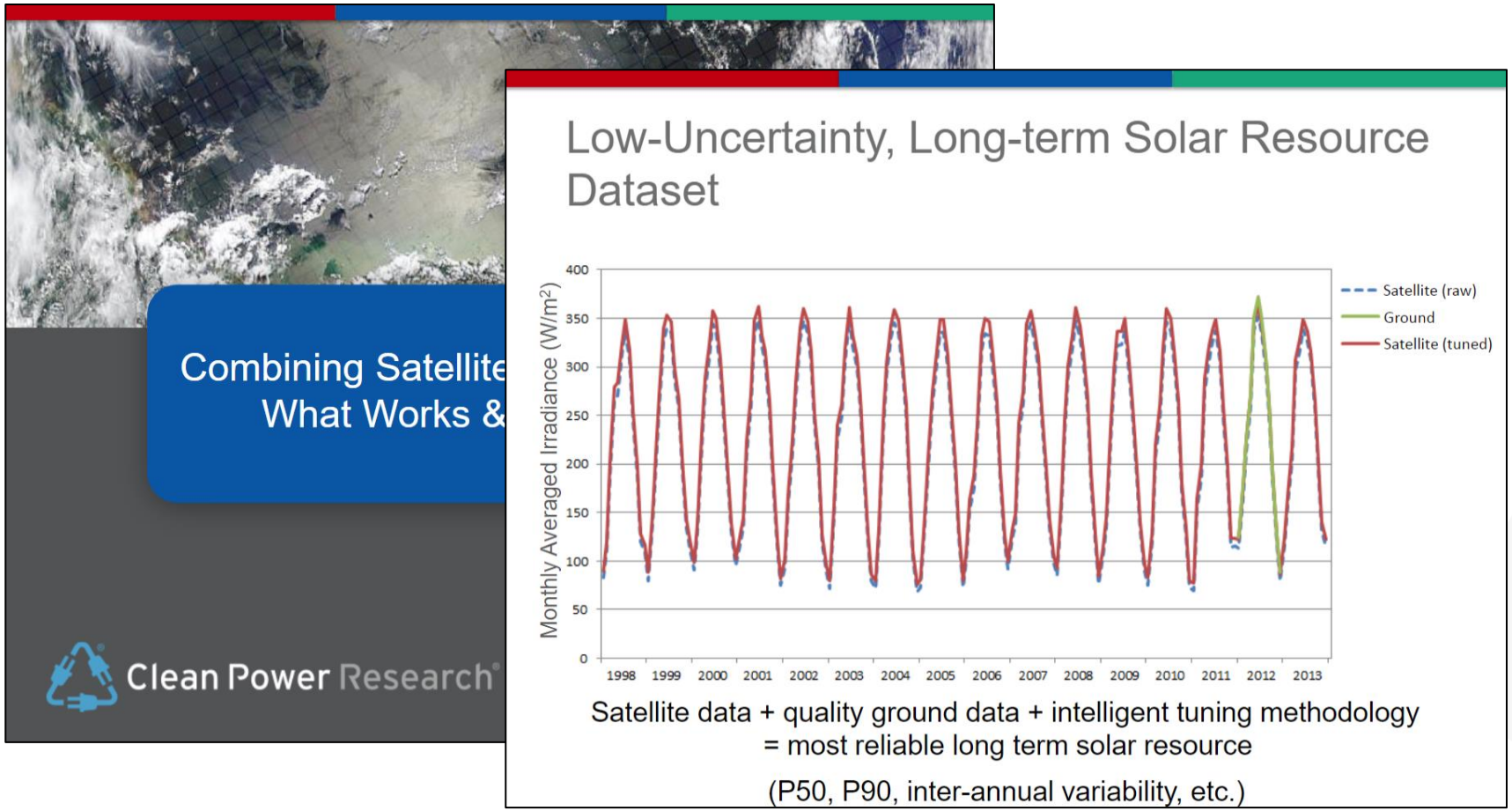
v021622

Background - What is a tuning study



Tuning methodology: Kankiewicz, A., Wu, E., Dise, J., Perez, R., (2014): Reducing Solar Project Uncertainty with an Optimized Resource Assessment Tuning Methodology. Proc., ASES Solar 2014 Conference, San Francisco, California

Background - What is a tuning study



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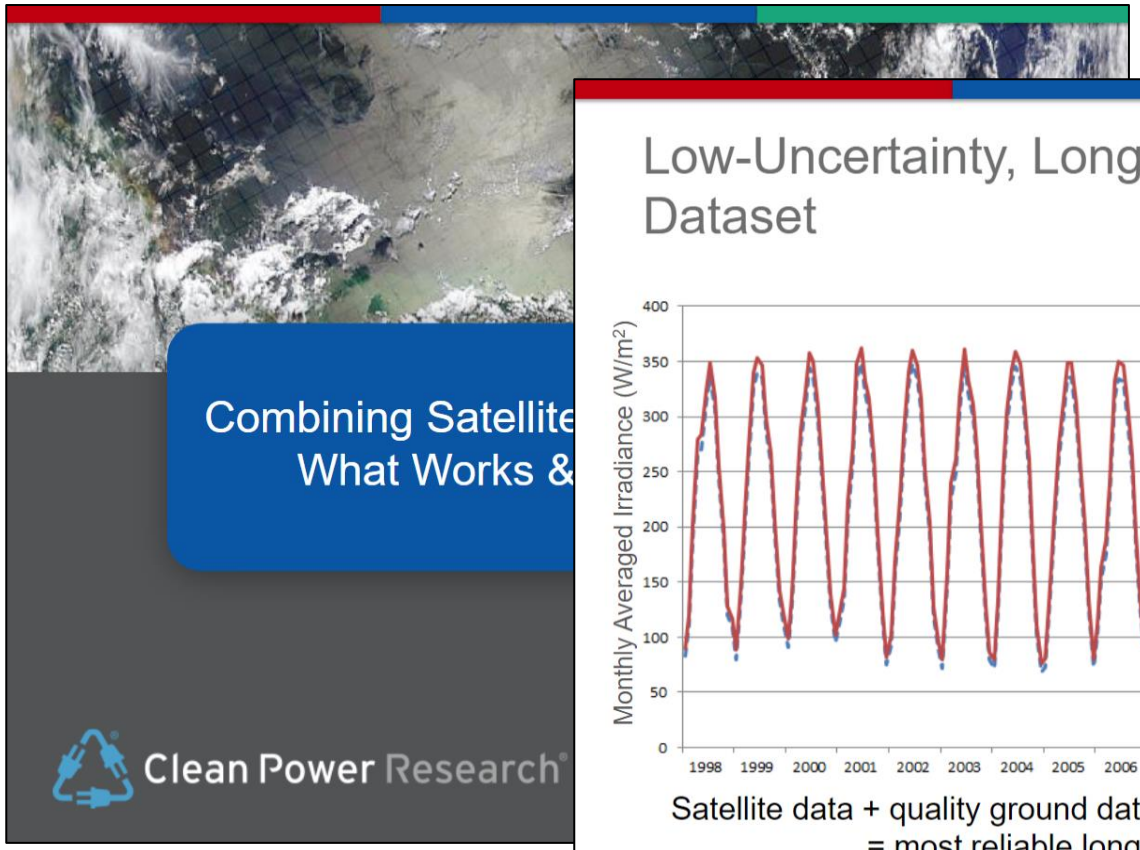


Low-Uncertainty, Long-term Solar Resource Dataset

Satellite data + quality ground data +
= most reliable long terr

(P50, P90, inter-annual

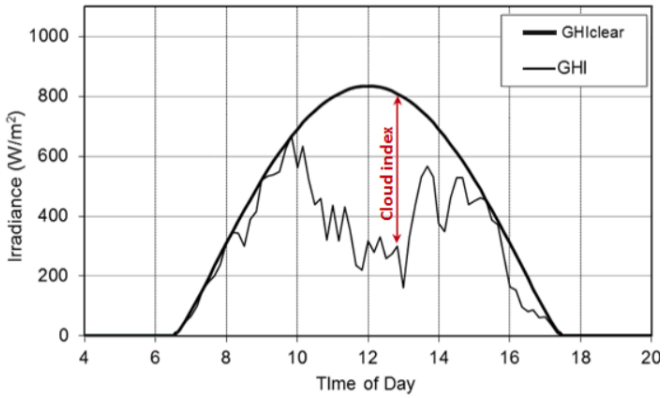
Understanding Differences: Satellite and Ground Datasets

Sources of satellite-model and ground irradiance differences:

- Clear sky bias (AOD, etc.)
- Seasonal (winter v. spring, etc.)
- Cloudy sky measurement error (satellite/ground mismatch, etc.)

Other considerations:

- Irradiance rebalancing
- Ancillary data



Differences need to be targeted individually during the tuning process

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Background - What is a tuning study

Site-Specific Solar Resource Assessment:
[Location]: ([Latitude], [Longitude]°)

SAMPLE
REPORT

GHI site tuning and DNI/DHI rebalance
Report Version 1.0 - May 13, 2020

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Method and Tuning Design
Dr. Richard Perez
Research Professor
University of Albany

GroundWork

Clean Power Research
Powering Intelligent Energy Decisions

Executive Summary

GroundWork Renewables, Inc. and Clean Power Research have conducted a site-specific resource assessment for the [project name] site in [location] on behalf of [customer]. Ground measured data was provided by GroundWork Renewables and used to tune the long-term data from SolarAnywhere® [1]. The tuning methodology developed by Dr. Richard Perez at the State University of New York (SUNY) has been shown to reduce the annual uncertainty of the solar resource data [2]. An analysis of the site-specific, tuned data quantifies the solar resource and the associated uncertainty that can be expected for this site. The results of the study are summarized in Table 1.

Table 1. Site-Specific Resource Assessment Summary

General	
Customer	[Customer]
Project	[Project Name]
Location	[Latitude, Longitude]
County, State, Country	[Location]
Ground Measurement Campaign	
Data provided by	GroundWork Renewables
Maintenance provided by	GroundWork Renewables
Maintenance frequency	Weekly
GHI sensor 1 used for tuning	Hukseflux SR30-D1 2373
GHI sensor 2 used for tuning	Hukseflux SR20-T2-UF 8640
Sensor 1 calibration date	3/20/2018
Sensor 2 calibration date	6/7/2018
Measurement Period	4/11/2019 to 4/13/2020
Percent of sensor 1 GHI data qualified	96.0%
Percent of sensor 2 GHI data qualified	95.9%
Site-Specific Resource Assessment Results	
Solar resource data	SolarAnywhere® V3.4
Overlapping data period	12 months
Native annual average GHI	1,925 kWh/ m²/year
Tuned annual average GHI	1,944 kWh/ m²/year
Native GHI rMBE for the overlapping period	-0.90%
Tuned GHI monthly rMAE	0.89%
Interannual variability	2.85%
Tuning uncertainty[1]	2.00%
Report Version	
20200423	Version 1

[1] Alfi, J., Kubiniec, A., Mani, G., Christopherson, J., He, Y., Bosch, J., (2016): Importance of Input Data and Uncertainty Associated with Tuning Satellite to Ground Solar Irradiation. Proc. IEEE PVSC 43, Portland, Oregon.

GroundWork 2 Clean Power Research

Tuning uncertainty: 2.00%

Background - Tuning uncertainty

Importance of Input Data and Uncertainty Associated with Tuning Satellite to Ground Solar Irradiation

James Alfi[1], Alex Kubiniec[2], Ganesh Mani[1], James Christopherson[1], Yiping He[1], Juan Bosch[3]

[1] EDF Renewable Energy, San Diego, CA, 92128, USA
[2] Clean Power Research, Kirkland, WA, 98003, USA
[3] Dept. Applied Physics, University of Granada, 18071, IISTA-CEAMA, Granada, Spain

***Abstract* — High quality satellite solar irradiation data is used throughout the solar industry to perform energy estimates. The uncertainty of the raw satellite data has been shown to be low. Ground data is often used to correct satellite data but determining the uncertainty of the final dataset could be challenging since the traditional statistical uncertainty and error calculation methods have proven to be unrepresentative. In this paper the limitations of traditional statistical methods are explored along with alternative approaches to calculate a more representative uncertainty value for a long term dataset resulting from ground corrected satellite data.**

the final long term dataset. For a ground-satellite correction based on least-squares regression, uncertainty is driven by residuals and the variability of the input dataset. While these methods typically produce accurate uncertainty results, they have been found to be insufficient for solar irradiation ground-satellite corrections for a number of reasons: 1) The resulting long term average of a ground-satellite correction is dependent on the time period that is being used for regression, thus simply looking at the residuals from the regression would not account for the uncertainty and error that is present from

J. Alfi, A. Kubiniec, G. Mani, J. Christopherson, Y. He and J. Bosch, "Importance of input data and uncertainty associated with tuning satellite to ground solar irradiation," 2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC), 2016, pp. 0301-0305, doi: 10.1109/PVSC.2016.7749598.

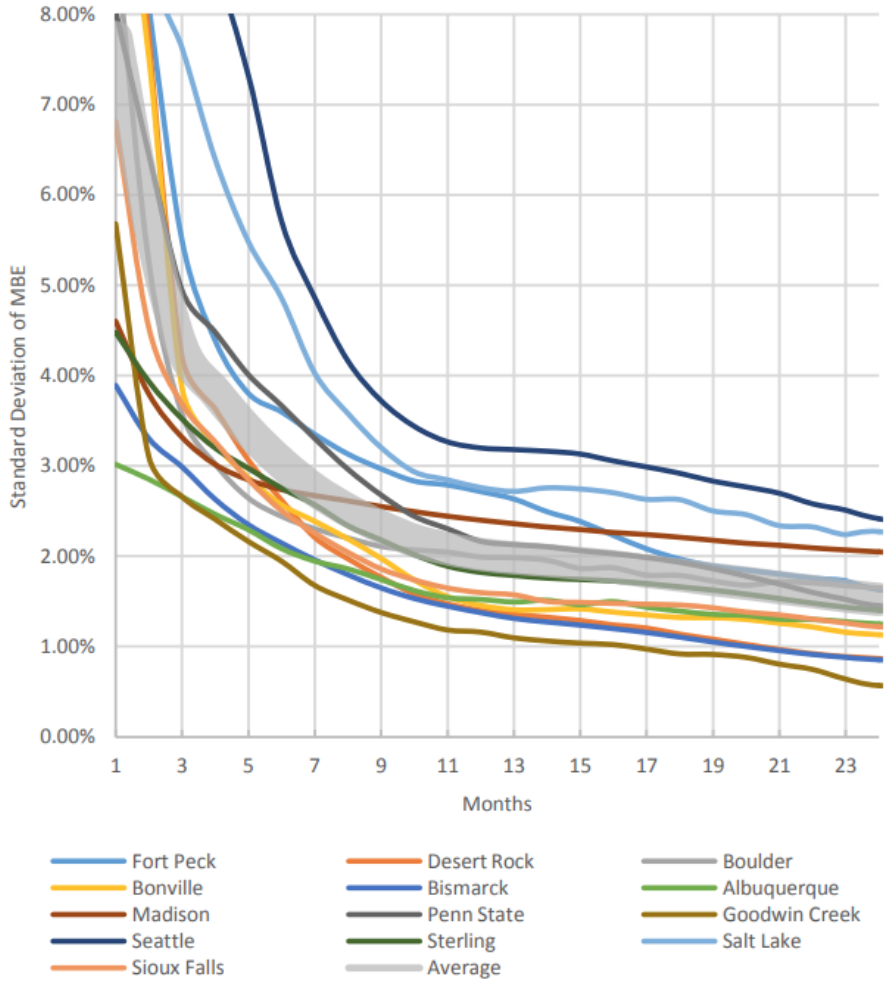
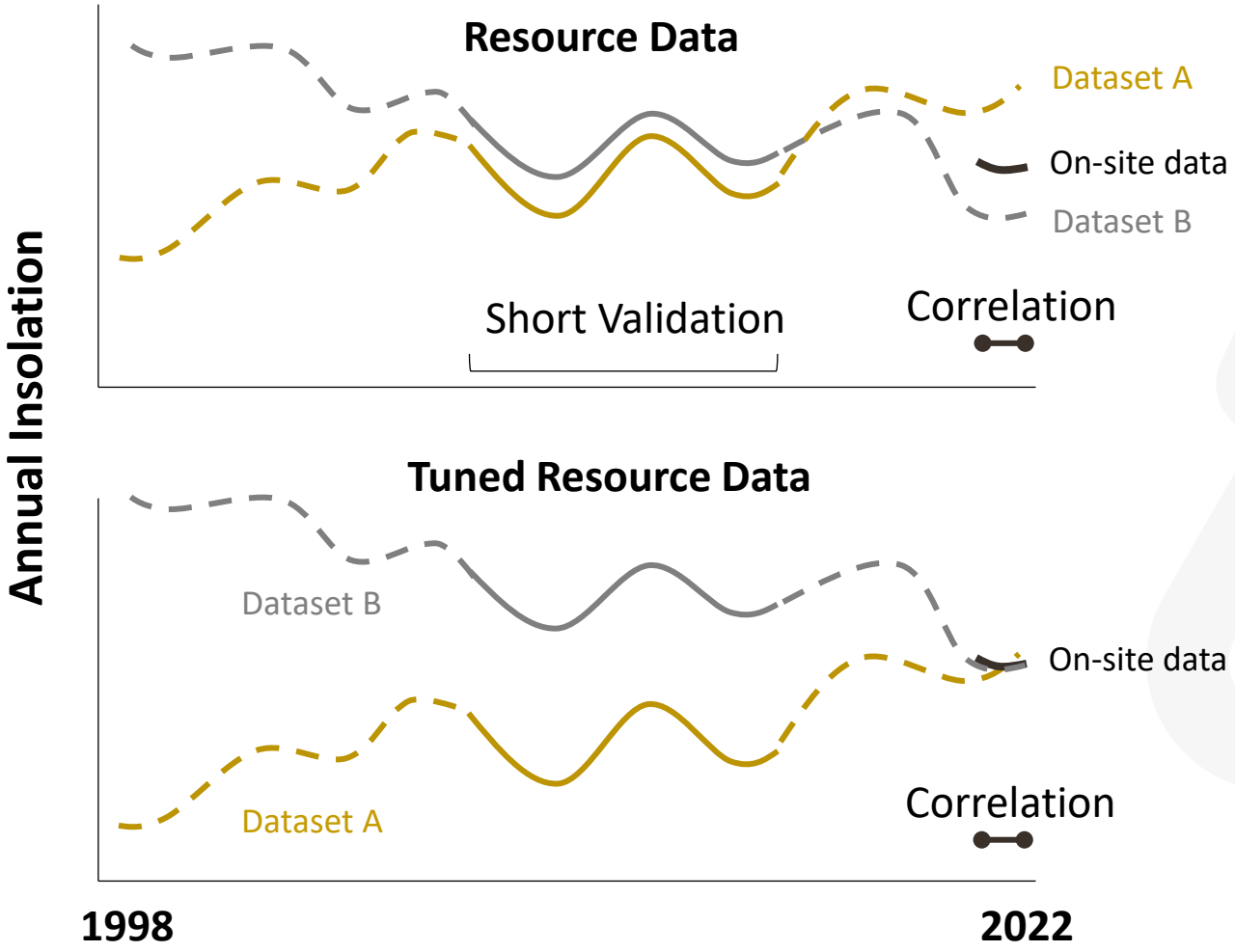


Figure 1: Standard Deviation of Tuned MBEs

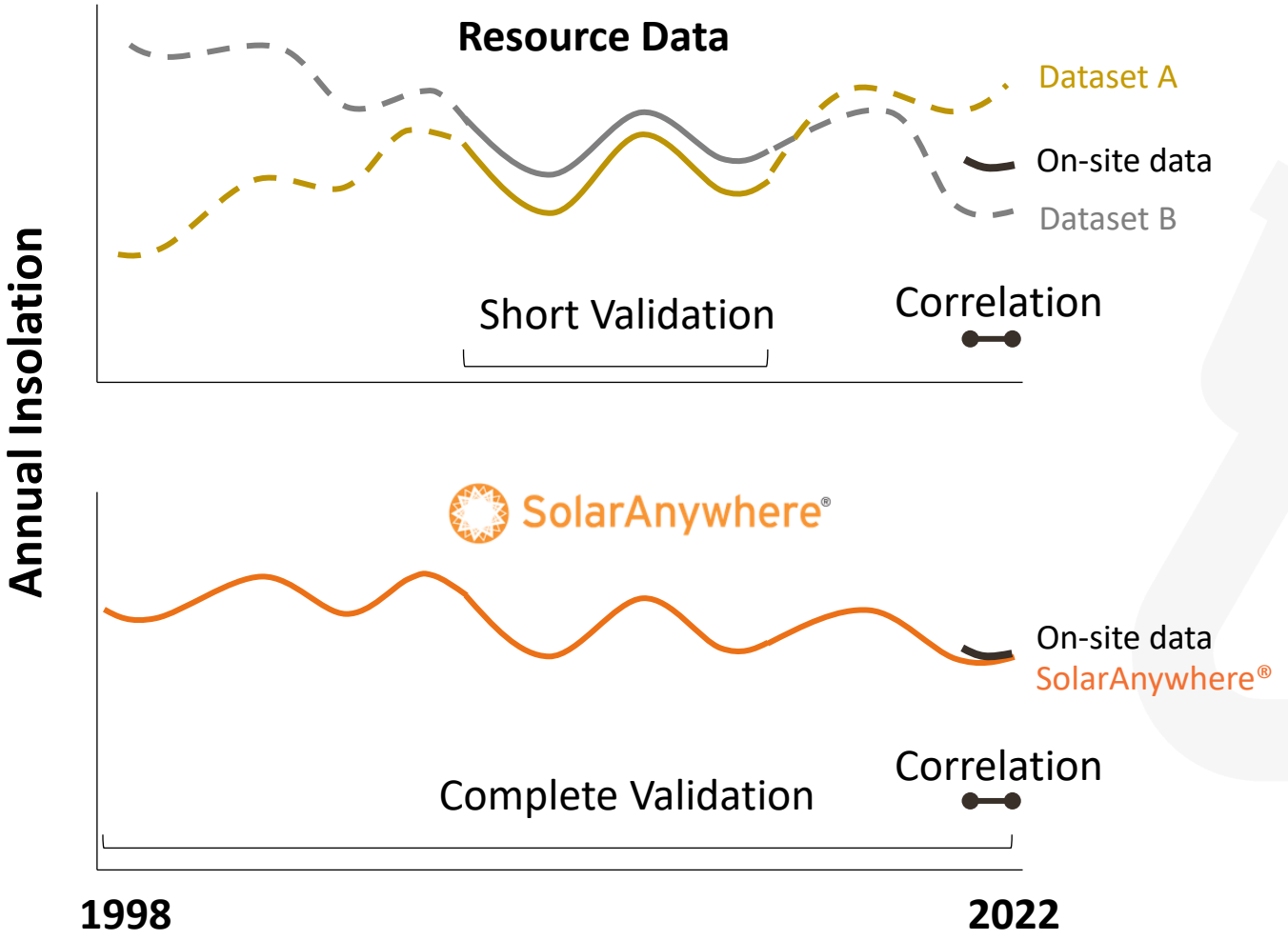
Motivation for an updated study

- What's the best achievable today?
- Improved ground-data QC methods
- SolarAnywhere model updates
- Experience with hundreds of projects

Why does solar resource data quality matter?



Why does solar resource data quality matter?



2020 PV Systems Symposium Webinar: Satellite Irradiance Model Accuracy Improvements (Clean Power Research)
See also: Eva Plaza Sanz & Peter Johnson (UL): Multiple Satellite Models for On-Site Long-Term References

Updated study design

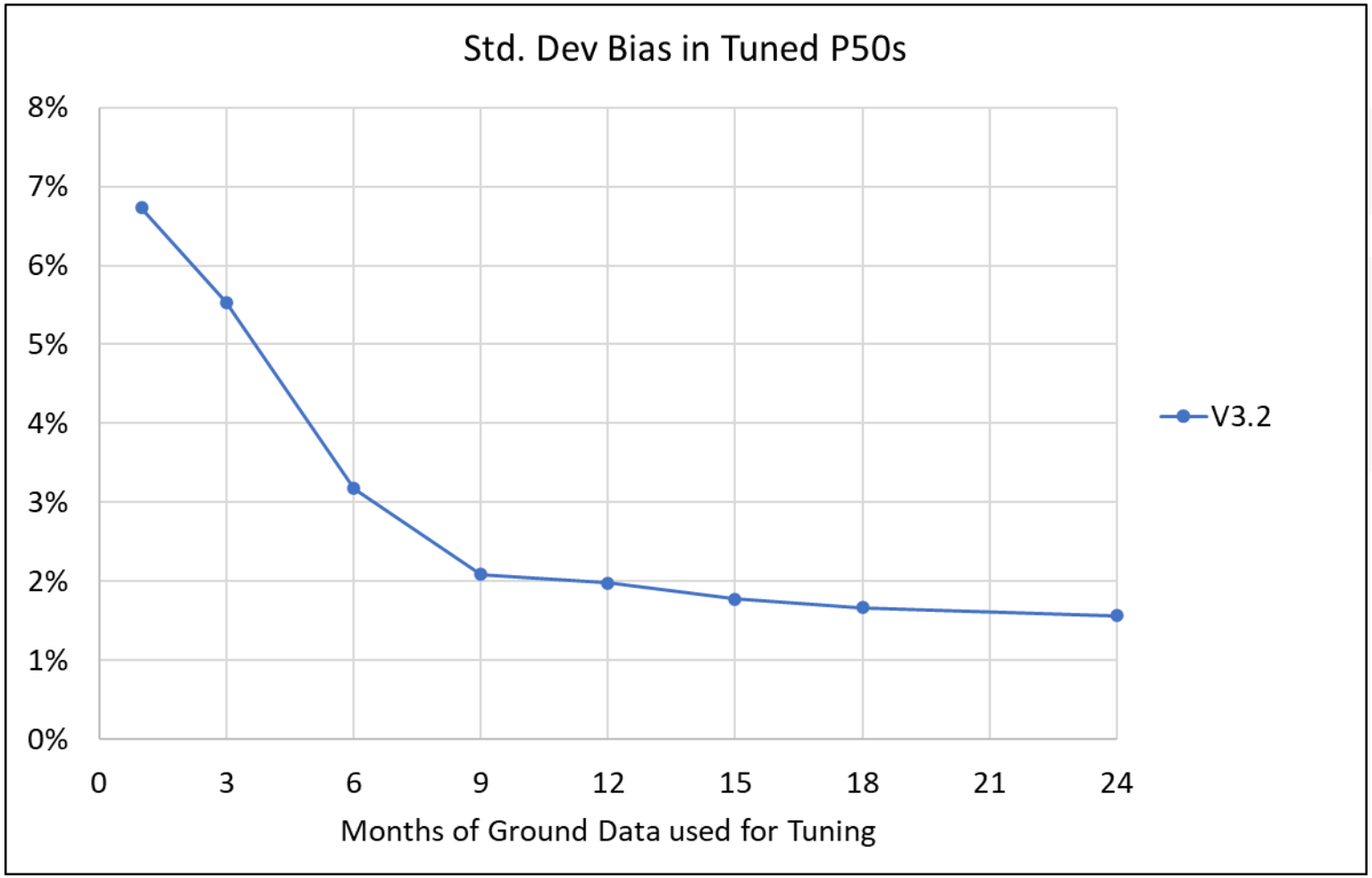
Same as original study:

- Tuning procedure
- Study methodology (but expanded period, 1998 – 2021 SURFRAD, 2011- 2021 SOLRAD)

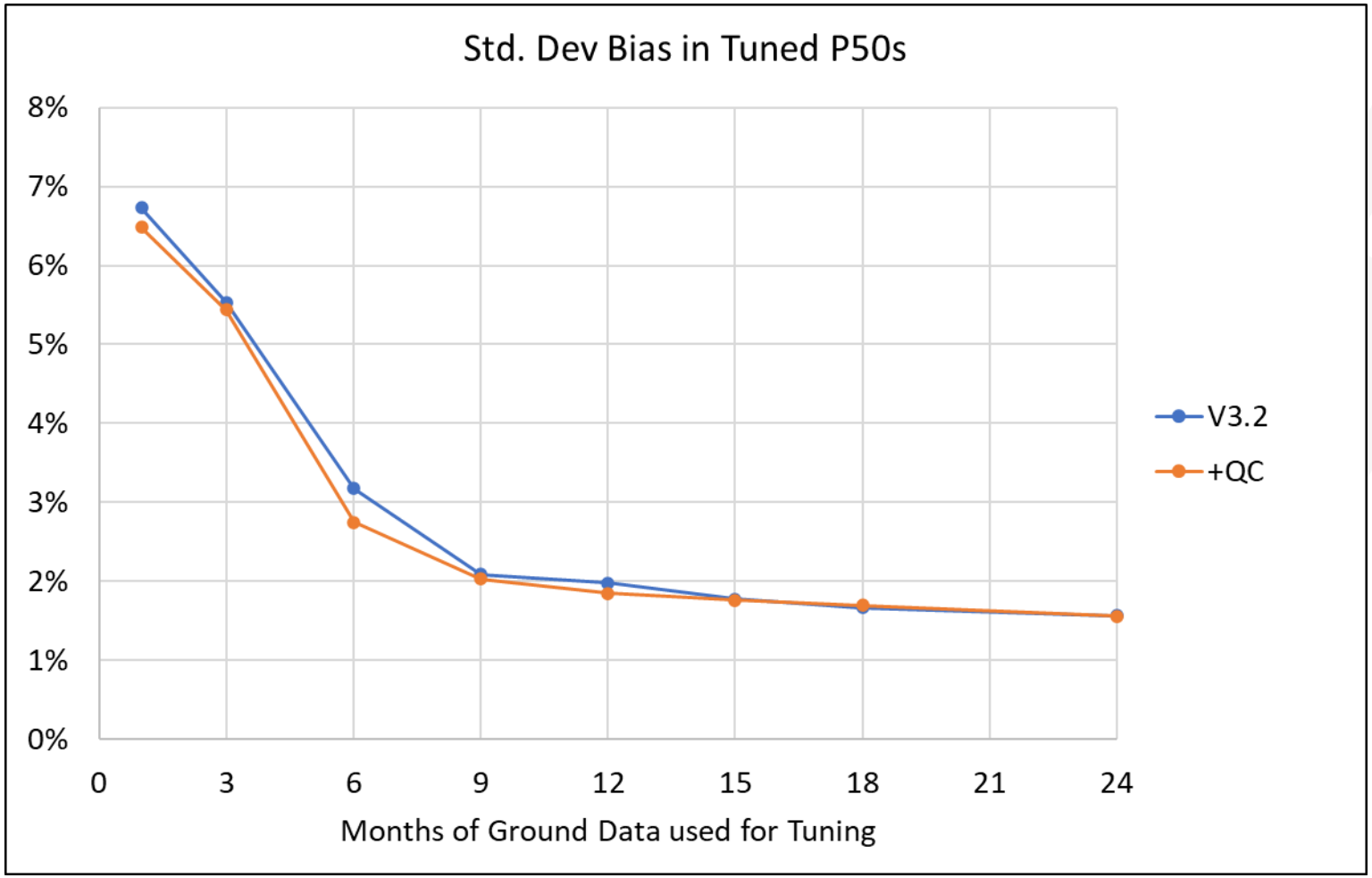
Test Datasets:

- V3.2 to approximate original study
- Improved ground-data QC
- V3.6 (latest)
- Expanded geography – Europe

Results


Std. Dev Bias in Tuned P50s
8%
7%
6%
5%
4%
3%
2%
1%
0%
0
3
6
9
12
15
18
21
24
Months of Ground Data used for Tuning
V3.2

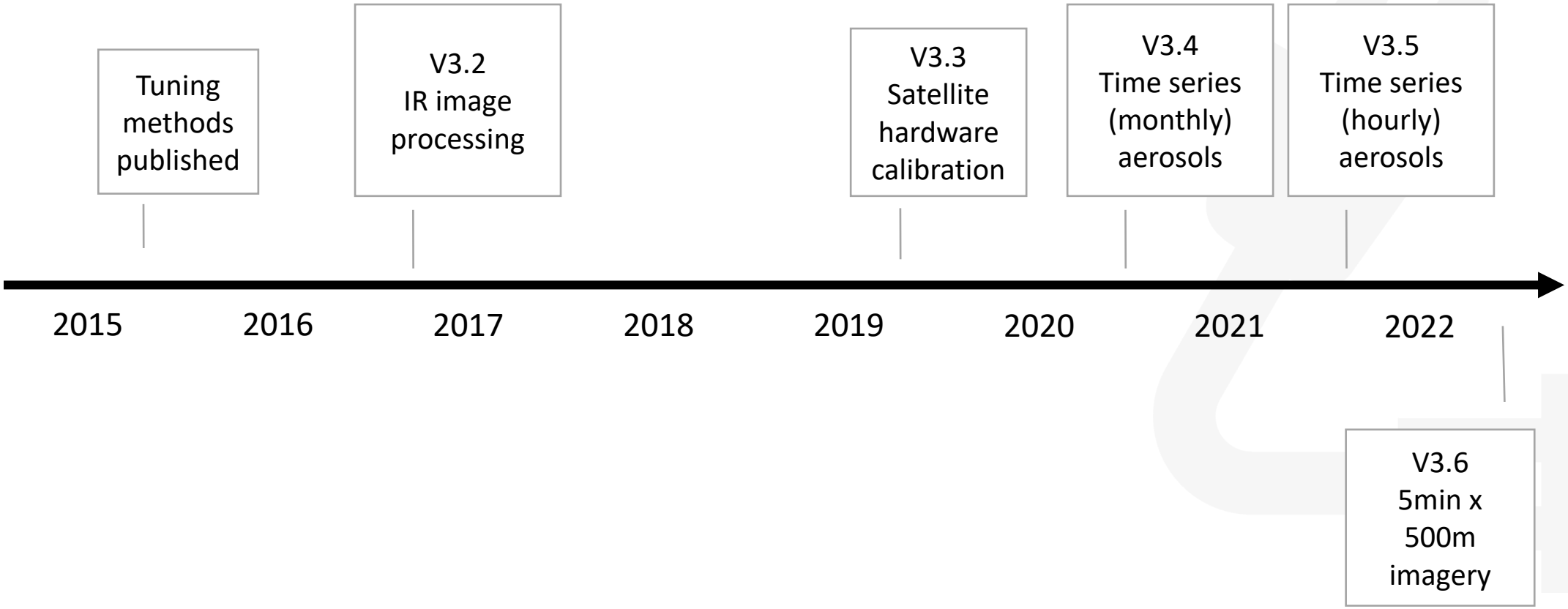
Results



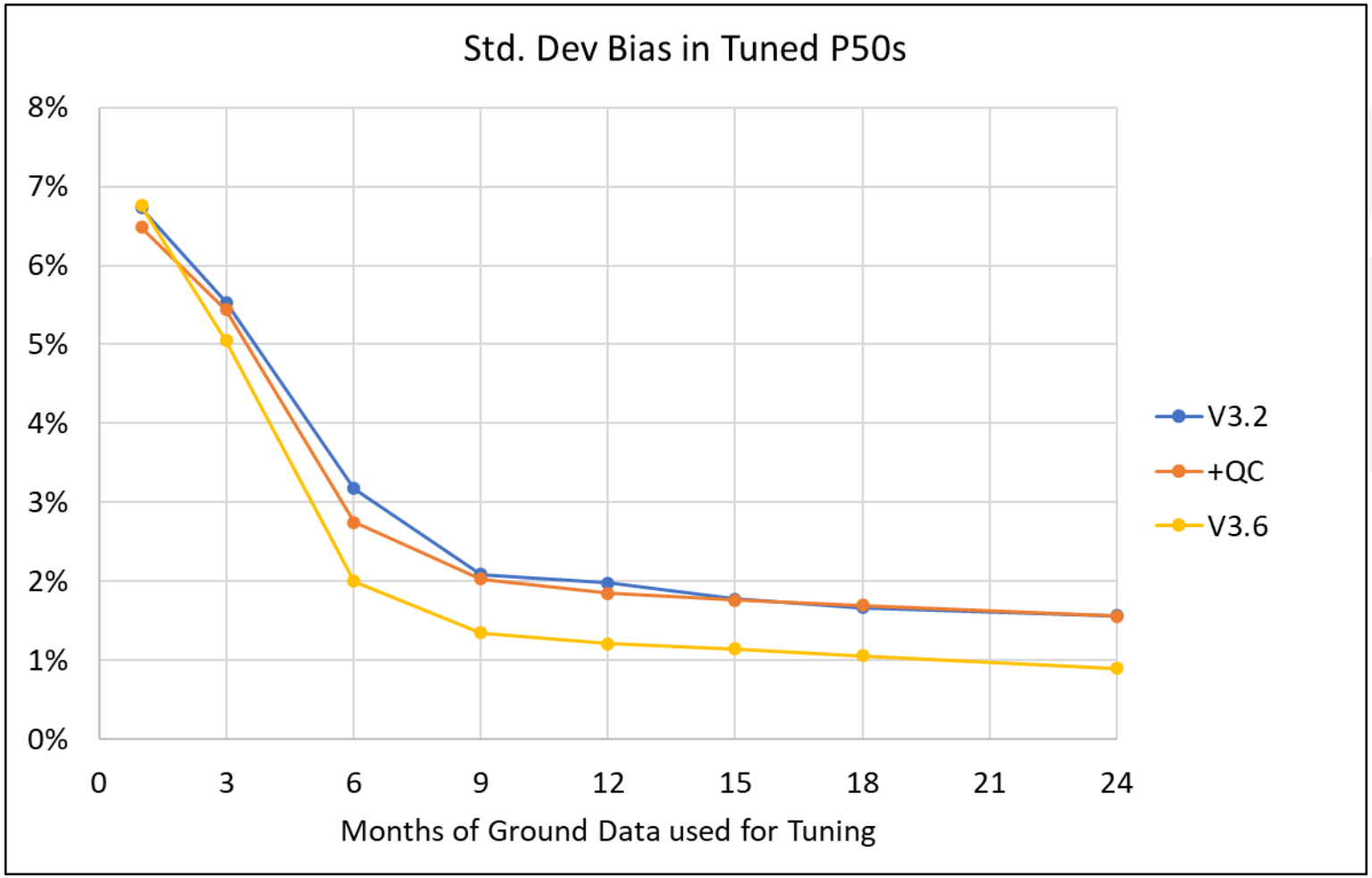
QC similar to BSRN recommended quality checks. See https://bsrn.awi.de/en/data/quality-checks

SolarAnywhere model improvements

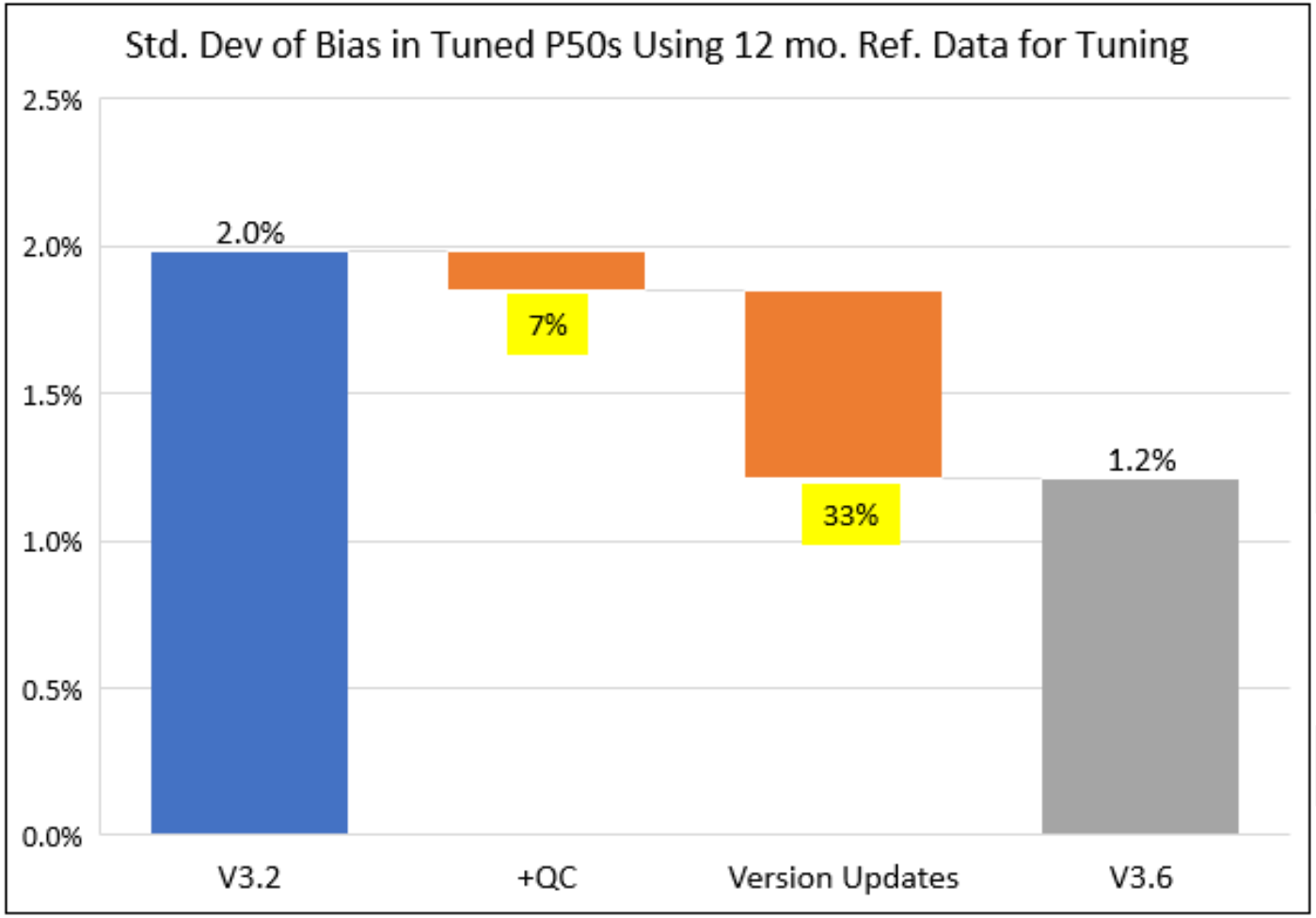
Selected features



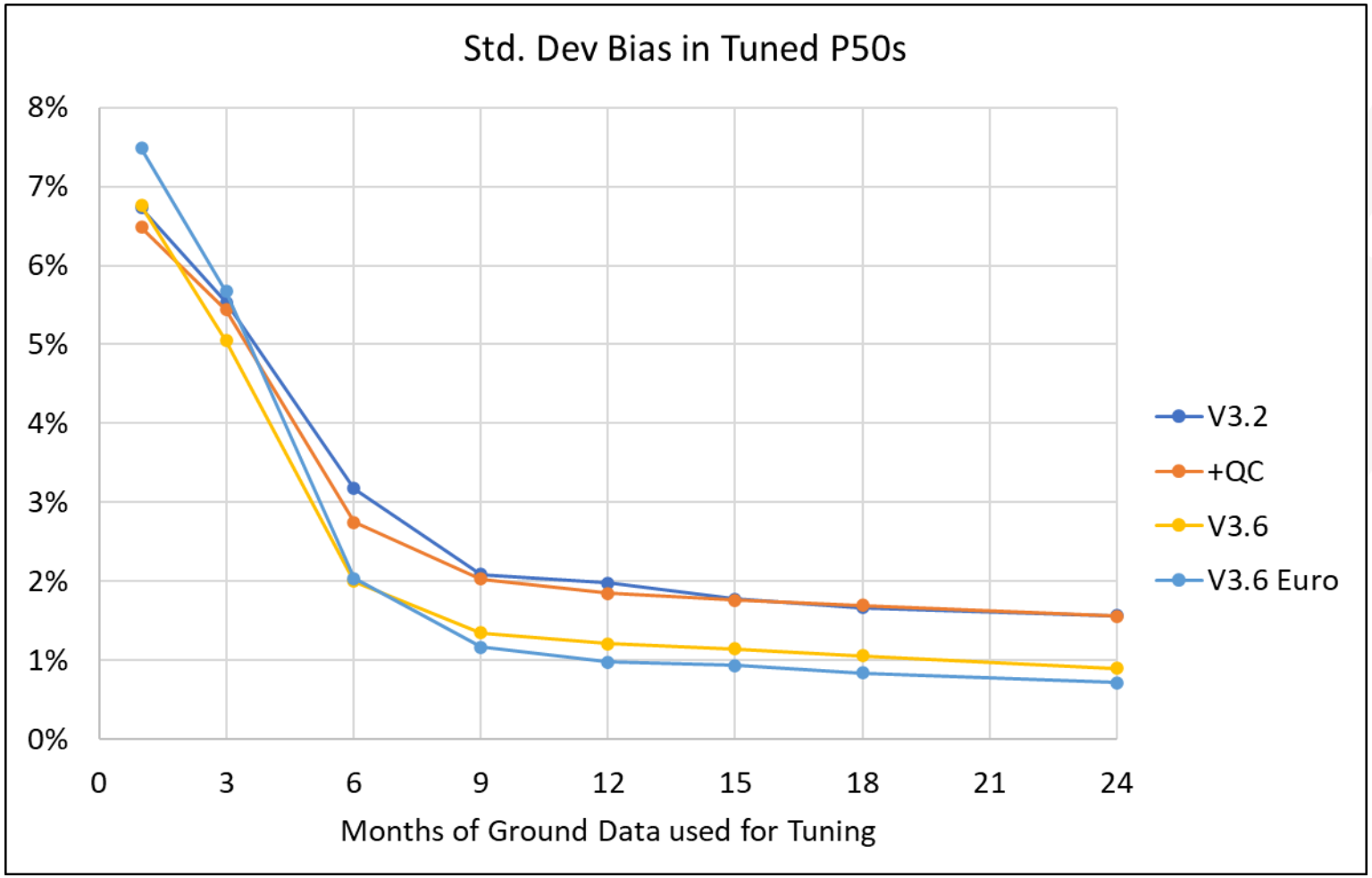
Results


Std. Dev Bias in Tuned P50s
8%
7%
6%
5%
4%
3%
2%
1%
0%
0
3
6
9
12
15
18
21
24
Months of Ground Data used for Tuning
V3.2
+QC
V3.6

Bottom line


Std. Dev of Bias in Tuned P50s Using 12 mo. Ref. Data for Tuning
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
2.0%
7%
33%
1.2%
V3.2
+QC
Version Updates
V3.6

Results


Std. Dev Bias in Tuned P50s
8%
7%
6%
5%
4%
3%
2%
1%
0%
0
3
6
9
12
15
18
21
24
Months of Ground Data used for Tuning
V3.2
+QC
V3.6
V3.6 Euro

Additional sources of solar resource uncertainty

- Reference measurement uncertainty
- Resource shift
- DNI and DHI (transposition to plane of array)
- Other environmental factors (e.g., snow, soiling, albedo, shading)
- Modeling errors (e.g., sub-hourly clipping)

Learn more

Tuning Study Resources

- https://www.solaranywhere.com/resources/webinars-whitepapers/#ground-tuning-studies
- https://pvpmc.sandia.gov/resources-and-events/events/

Follow Clean Power Research on LinkedIn!

- Upcoming webinar – High Res. Data http://ow.ly/FOcw50Kh87V

Thank You

Questions?

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