



Feedback on the PVPMC blind modeling exercise of 2021

**PVPMC Workshop
8,9 November 2023
Mendrisio, Switzerland**

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PVsyst SA, Switzerland

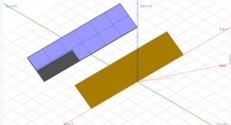
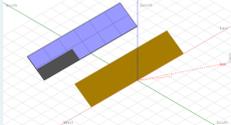
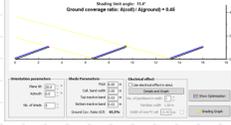
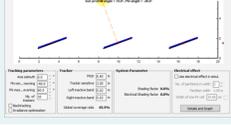
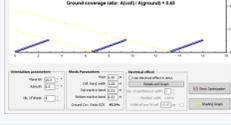
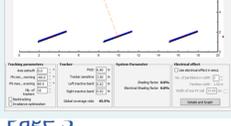
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Overview

- Introduction
 - Scenarios and simulation models
 - Metrics used for comparison
 - Compared variables
- Analysis results
 - Issues with model parameters
 - Issues with measured data
 - Improvement of models
- Conclusion



Scenarios and Simulation Models

Scenario	Location	Description	PVSyst implementation			
			Shadings	Sketch	PV Modules	Thermal coeff.
S1	Albuquerque	Fixed tilt HIT	3D model electrical shadings		Provided PAN file (modified IAM)	$U_c = 29 \text{ W/m}^2\text{K}$
S2	Albuquerque	Fixed Tilt PERC	3D model electrical shadings		Provided PAN file (modified IAM)	$U_c = 29 \text{ W/m}^2\text{K}$
S3	Roskilde	Tracker monofacial	'Unlimited trackers'		PVSyst Database	$U_c = 29 \text{ W/m}^2\text{K}$
S4	Roskilde	Tracker bifacial	'Unlimited trackers'		PVSyst Database	$U_c = 29 \text{ W/m}^2\text{K}$
S5	Roskilde	Fixed tilt monofacial	'Unlimited sheds' electrical shadings		PVSyst Database	$U_c = 29 \text{ W/m}^2\text{K}$
S6	Roskilde	Fixed tilt bifacial	'Unlimited sheds' electrical shadings		PVSyst Database	$U_c = 29 \text{ W/m}^2\text{K}$



Comparison Simulation vs. Measured Data

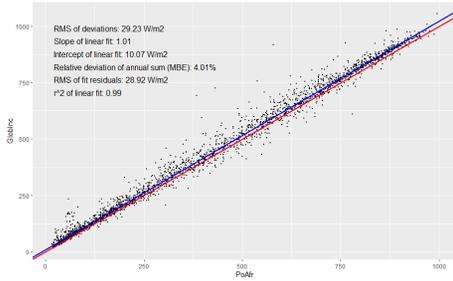
Available measurements for comparison

Quantity	Measured Variable	PVsyst variable
PoA irradiance front	PoAfr	GlobInc
DC power	DCPow	EArray
Module temperature	Tmod	TArray
Rear side irradiance	PoAre	GlobBak

Three kind of issues when comparing simulation to measurement:

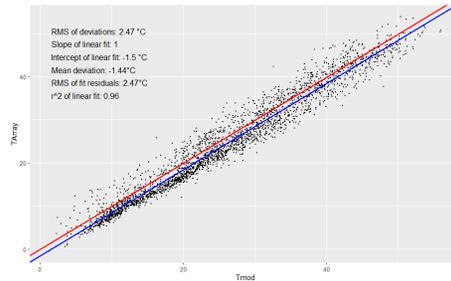
- Incorrect or approximate model parameters
- Data quality
- Non-perfect models

Front side irradiance



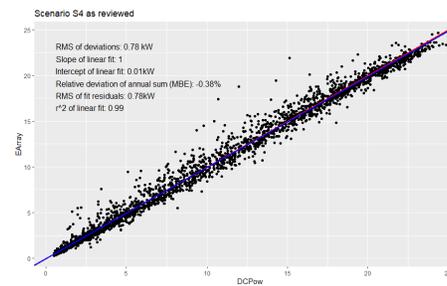
Assumed to have no shadings
 Test of transposition model
 Issues with data quality (S4-S6)

Module temperature



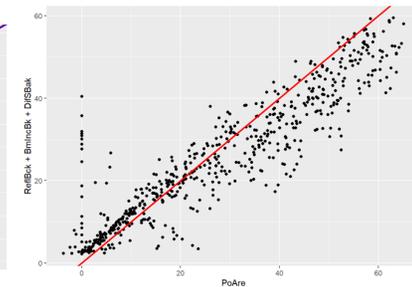
Test of temperature modeling
 Should be cell temperature
 (hard to measure)

DC power



Main comparator for modeling quality

Rear side irradiance



Measured at one point,
 representative for simulated value?



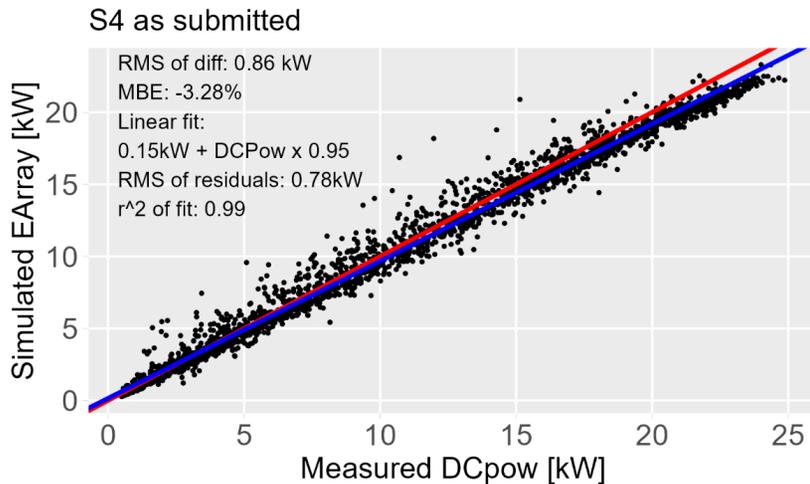
Comparison Simulation vs. Measured Data

We always apply the PVPMC filter:

- Data flagged as good

No other filtering applied unless stated otherwise

Example: comparison of DC power for scenario S4
(bifacial tracker in Roskilde, Denmark)



Metrics:

Mean bias error MBE

RMS of deviations

Linear fit (intercept, slope, RMS of residuals)

Originally submitted results

Scenario	EArray. Interc	Earray slope	GlobInc. Interc	GlobInc slope	GlobInc MBE [%]	EArray. MBE [%]	GlobInc. RMS	EArray. RMS
S1	-0.11	1.03	-6.48	1.02	0.72	-1.55	14.17	0.07
S2	-0.08	1.04	-6.72	1.02	0.71	0.64	14.05	0.08
S3	-0.12	1.04	10.44	1.01	4.08	2.46	29.55	0.86
S4	0.15	0.95	9.39	1.01	3.95	-3.28	28.77	0.86
S5	-0.08	0.99	8.84	1.01	3.77	-1.72	37.59	0.72
S6	0.10	0.97	9.57	1.01	3.97	-2.14	38.68	0.95



Model Parameters: Thermal Coefficient U_c

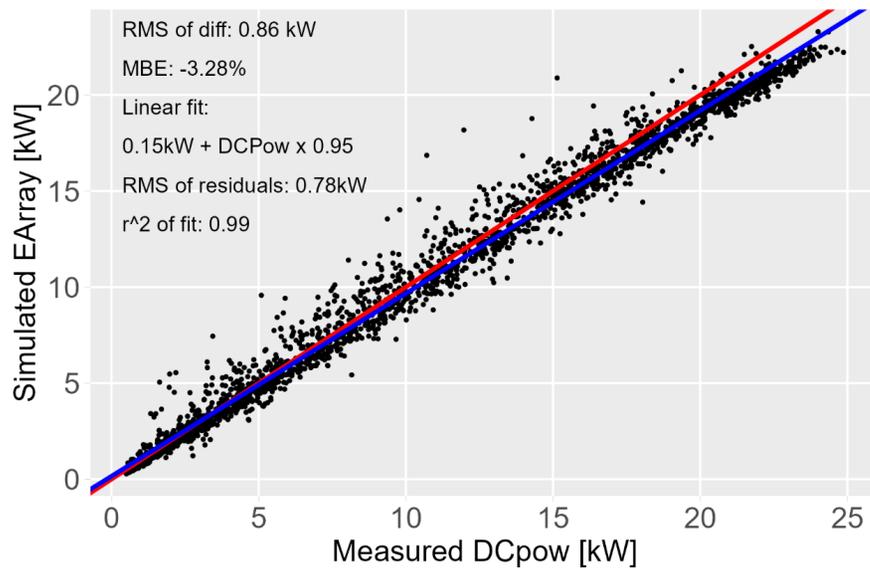
One issue found in the exercise were inaccurate modeling parameters:

- Wrong value for scenarios S4, S5, S6 (20 W/m²K instead of 29 W/m²K)
- Neglected electrical shading losses for scenarios S5 and S6
- Assumed Modules of S6 in first row instead of center row

1. Badly chosen U_c -parameter for S4, S5 and S6

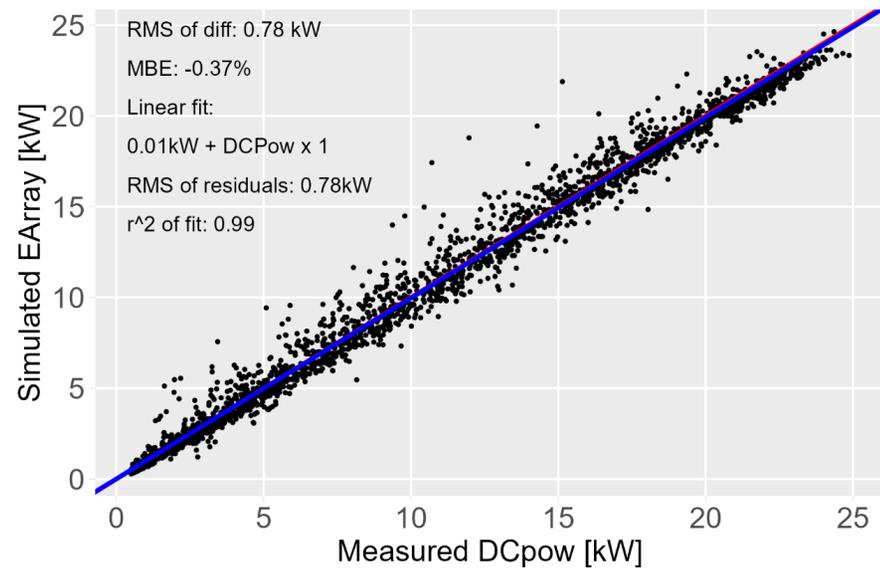
$$U_c = 20 \text{ W/m}^2\text{K}$$

S4 as submitted



$$U_c = 29 \text{ W/m}^2\text{K}$$

S4 reviewed



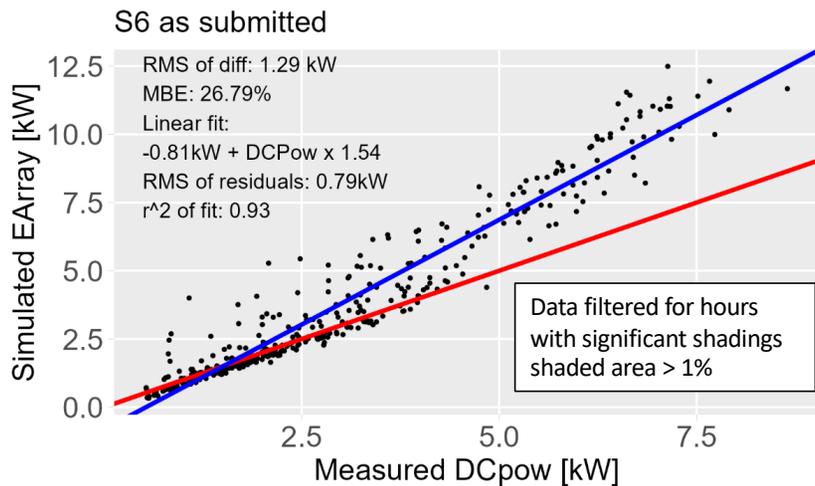
Shadings in Scenario S6

Number of rows was not well set for S6

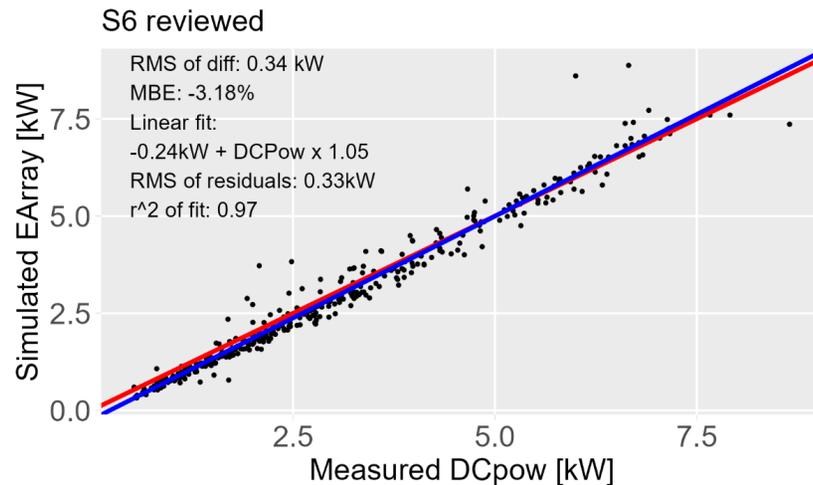
The number of rows determines how much weight the first unshaded row gets

Scenario S6 is a row in the middle of the system => A large number of rows should have been selected

Submitted (2 rows)



Reviewed (200 rows)



Wrong Uc value has almost no impact on these points

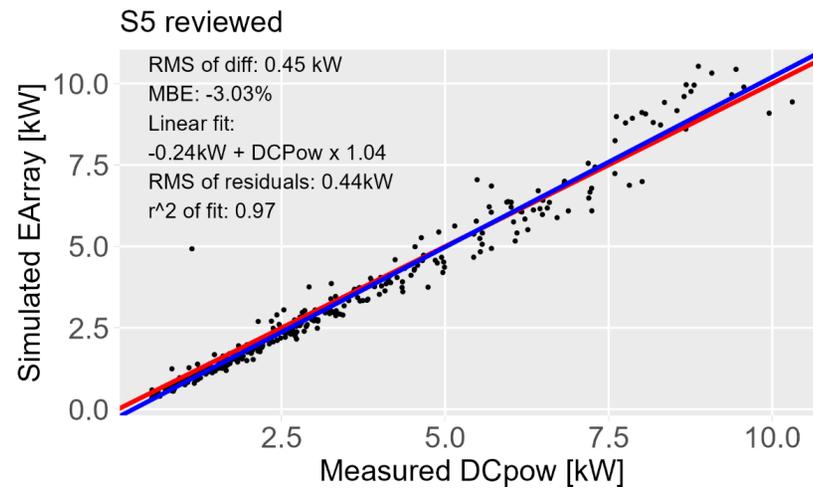
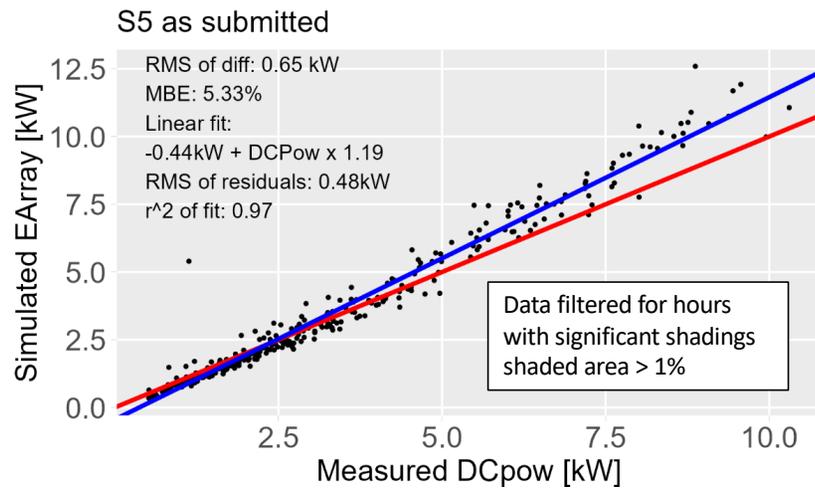


Issues with Model Parameters

Electrical shadings were not considered for scenarios S5 and S6

Electrical shadings consider the mismatch within partially shaded strings

Scenario S5 had a large number of rows already for the submitted results



Improvements of Models (electrical shadings)

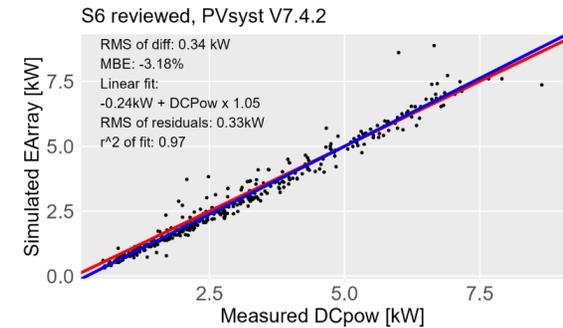
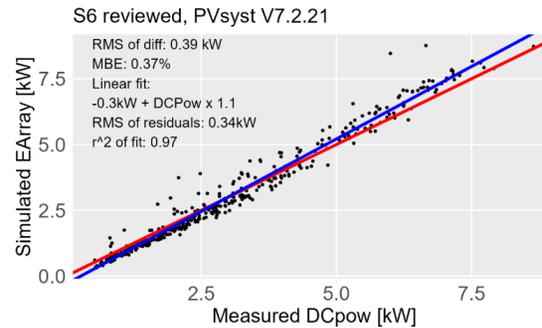
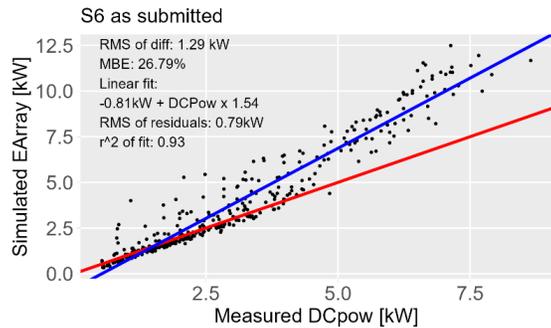
Example: The linear and electrical shading losses models were improved since the original exercise

Scenario S6, bifacial fixed tilt

Submitted simulation
simulated with PVsyst V7.2

Corrected model parameters:
Uc value fixed
Electrical shading losses included
Number of rows corrected
Simulated with PVsyst V7.2

Corrected model parameters
Change in models:
Electrical shading model for 'unlimited sheds' was improved
Simulated with PVsyst V7.4



The main discrepancies were due to wrong model parameter choice
Still the model improvements are visible when looking only at hours with shadings
In the total annual results this improvement is not significant for this scenario

Data filtered for hours
with significant shadings
shaded area > 1%



Improvement due to fixes in modeling

Originally submitted results (Pvsyst V7.2)

Scenario	EArray. Interc	Earray slope	EArray. MBE [%]	EArray. RMS
S1	-0.11	1.03	-1.55	0.07
S2	-0.08	1.04	0.64	0.08
S3	-0.12	1.04	2.46	0.86
S4	0.15	0.95	-3.28	0.86
S5	-0.08	0.99	-1.72	0.72
S6	0.10	0.97	-2.14	0.95

Reviewed results (Pvsyst V7.4)

Scenario	EArray. Interc	Earray slope	EArray. MBE [%]	EArray. RMS
S1	-0.12	1.03	-1.57	0.07
S2	-0.08	1.04	0.63	0.08
S3	-0.13	1.04	2.38	0.85
S4	0.01	1.00	-0.37	0.78
S5	-0.24	1.04	0.60	0.77
S6	-0.21	1.01	-1.25	0.80

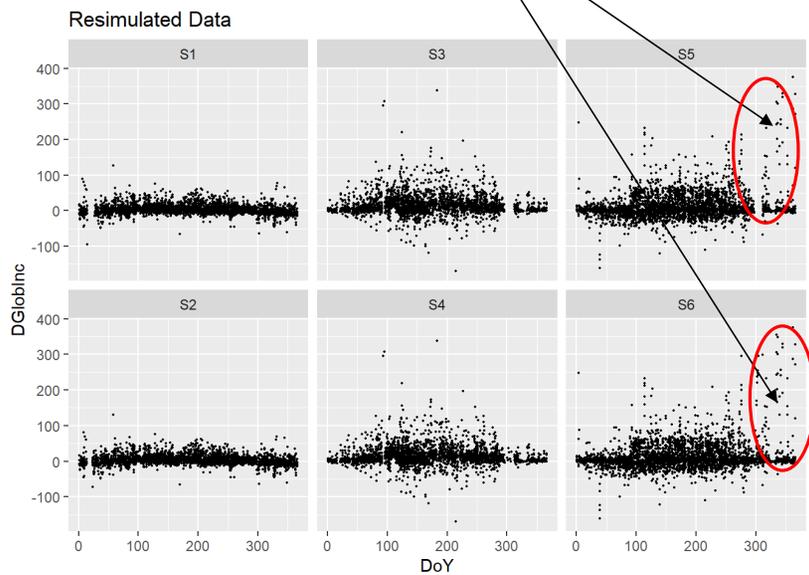
By applying the fixes in the model parameters the simulation results match better to the measurements except for S5
Improvement in linear fit and RMS do not forcedly correlated with MBE
We will continue the analysis to understand the remaining discrepancies



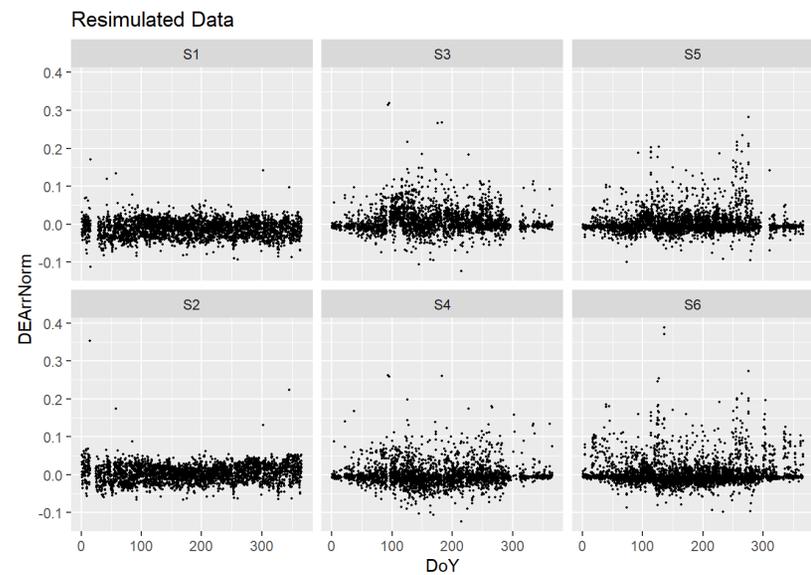
Issues with Measured Data Quality

These discrepancies in PoA do not propagate to DC power
There seem to be issues with the irradiance measurement

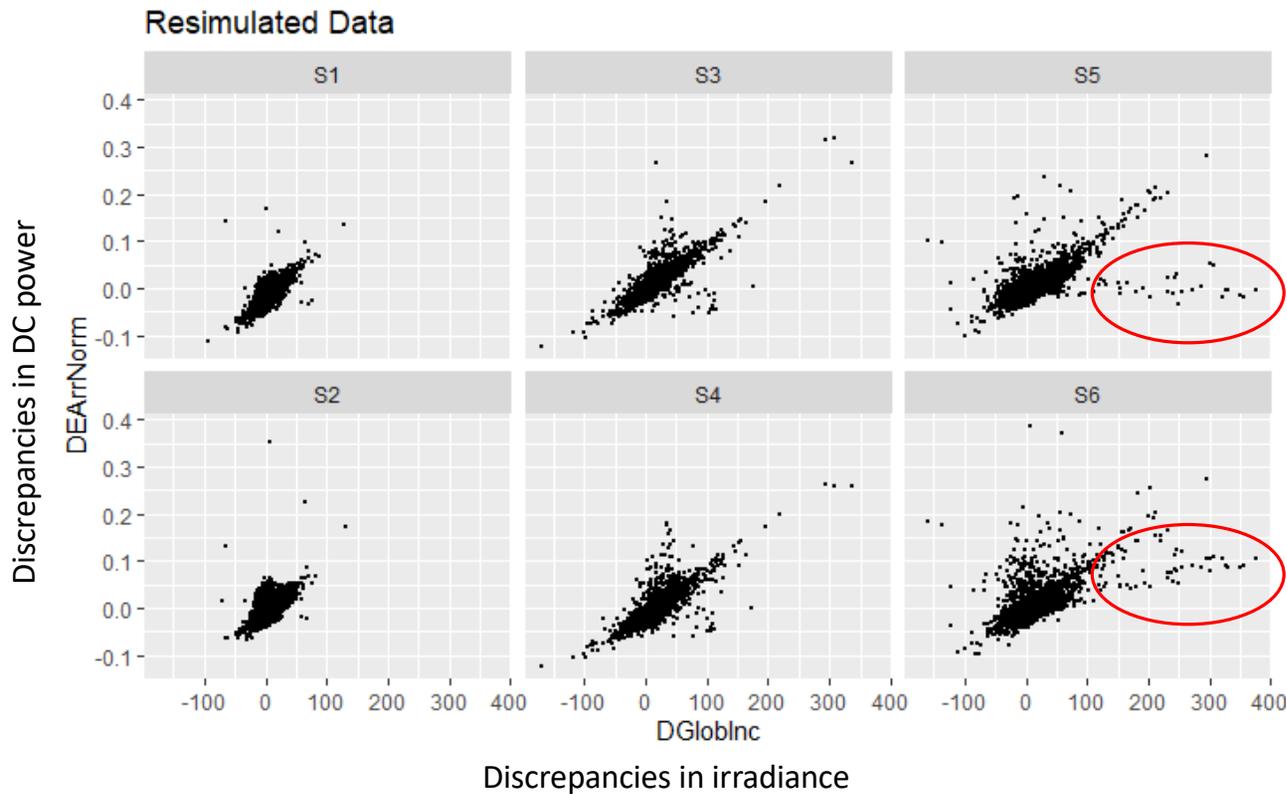
Discrepancies in irradiance



Discrepancies in DC power normalized to P_{nom}



Issues with Measured Data Quality



These discrepancies do not propagate to DC power
There seem to be issues with the irradiance measurement

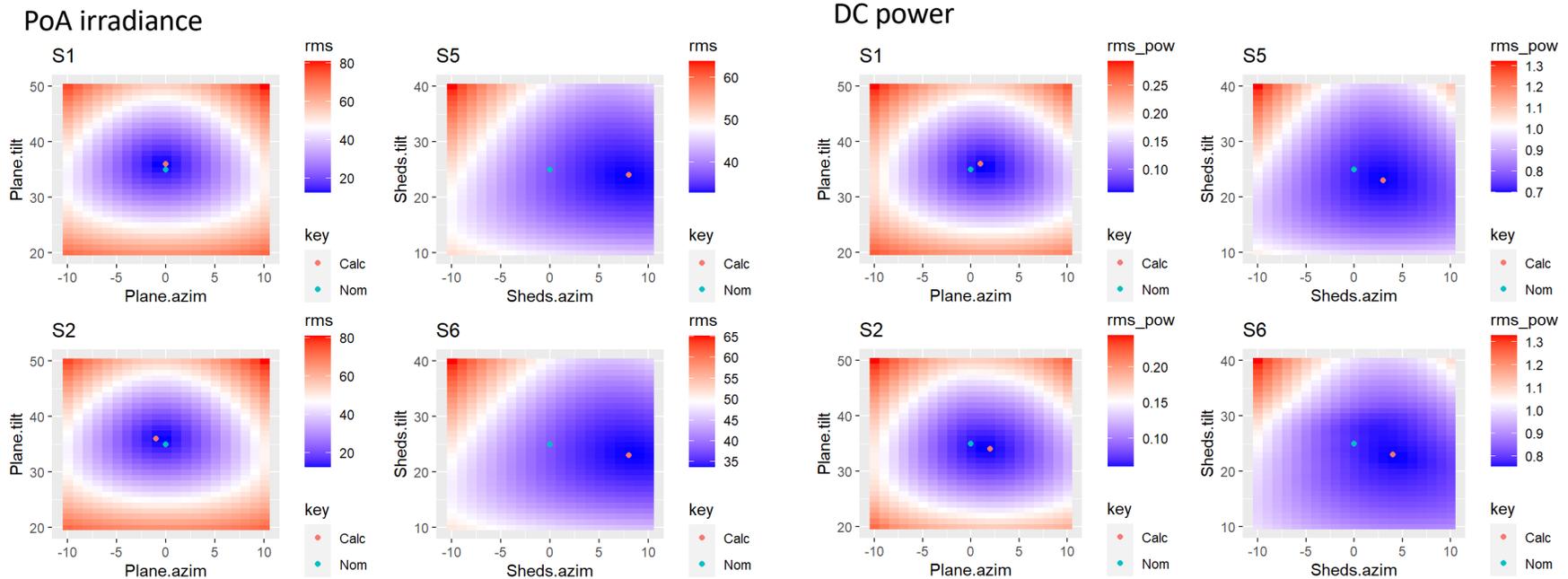


Unsolved Issues

For scenarios S5 and S6, the best match between simulation and measurement is obtained for orientations quite different from the nominal orientation.

This is different for PoA irradiance and DC power

Timestamp issue? Accuracy of orientation? Shading issue? Data quality?



Conclusions

- The measure for the modeling quality should be the RMS of hourly discrepancies, the MBE can become artificially small
- The slope and intercept of a linear fit to hourly values help to find reasons for discrepancies
- Making the comparison as function of different parameters helps in identifying the issues.
- The modeling quality of the originally submitted results was already rather good
- Several wrong choices of model parameters were identified. Correcting for this improved the modeling quality
- There are issues with the measured data:
 - PoAfr is not fully cleaned up
 - There seems to be a discrepancy in nominal and real plane orientations and/or an issue with time stamps or shading issues (scenarios S5 and S6)
- Improvements in modeling are visible in the data.
- Some discrepancies between simulation and measurements still need to be understood.

The blind modeling exercise gave us good insights on how to check the modeling quality, detect issues with data quality and identify points that could be improved in the models.

Thank you very much to the organizers and contributors of this exercise!

It would be very welcome if the monitoring data of the 2023 exercise could also be made available once that exercise is finished.

