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Análise clúster de datos de entrada para simulacións de sistemas fotovoltaicos con afección de sombras locais

UNIVERSIDADE DA CORUÑA

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Universidade Vigo

Adrián Blanco Aguiar



Online platform for photovoltaic system simulations

Crucial for system sizing

Open source simulation methods

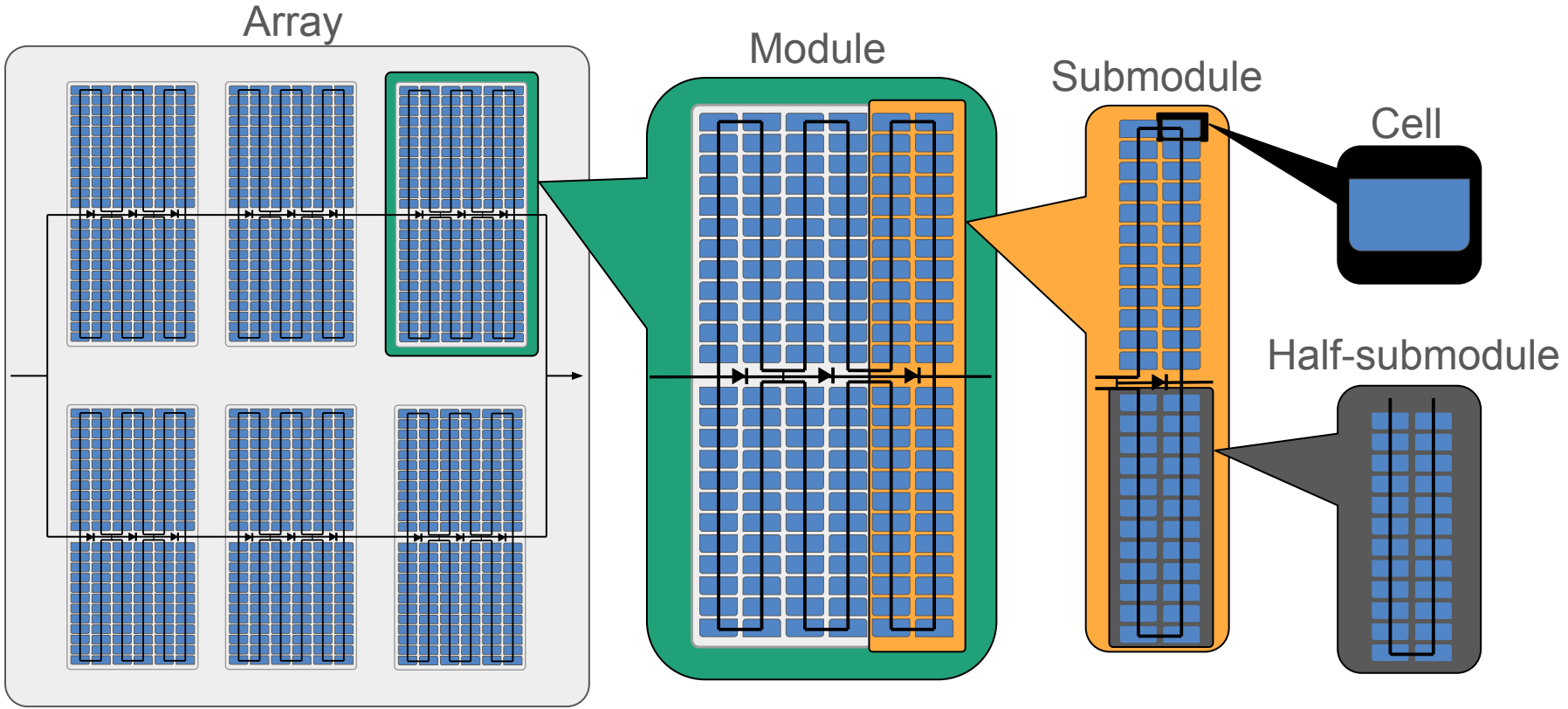
Brief photovoltaic introduction



Credits:https://unsplash.com/es/fotos/paneles-solares-en-campo-verde-513dBrMJ_5w

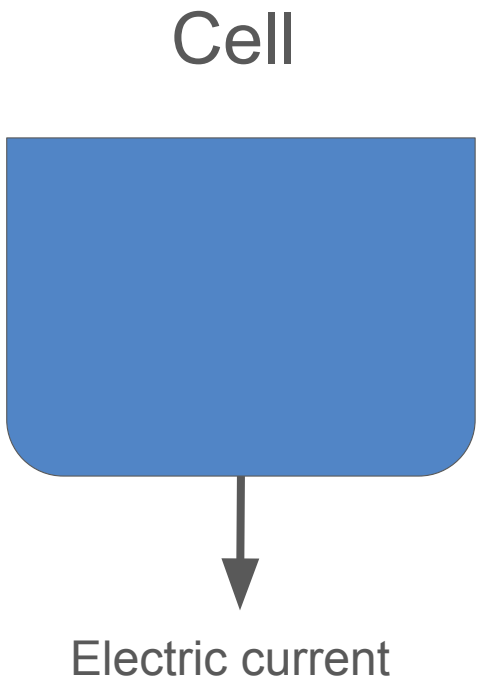
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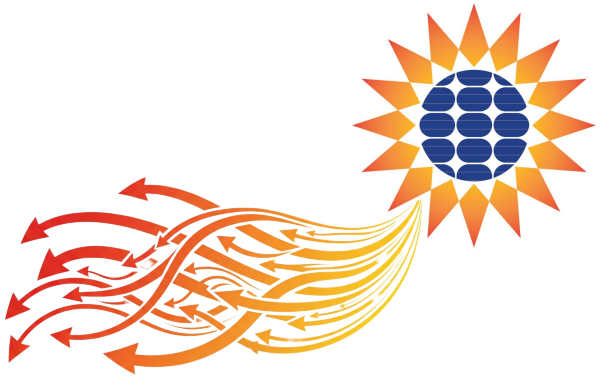
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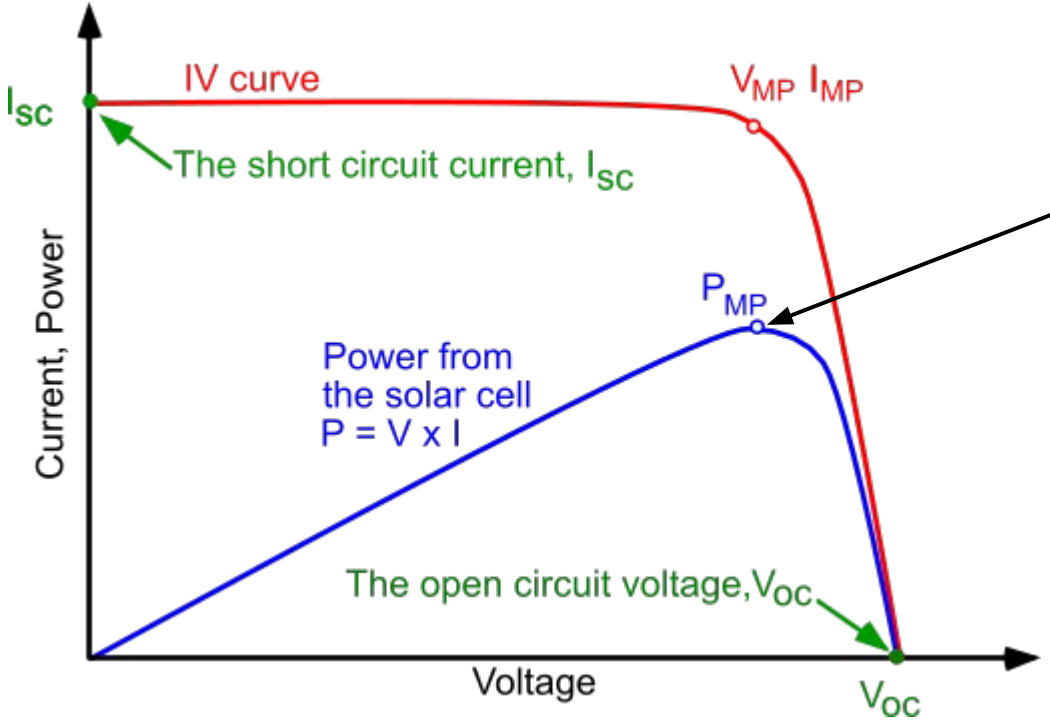
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Brief photovoltaic introduction



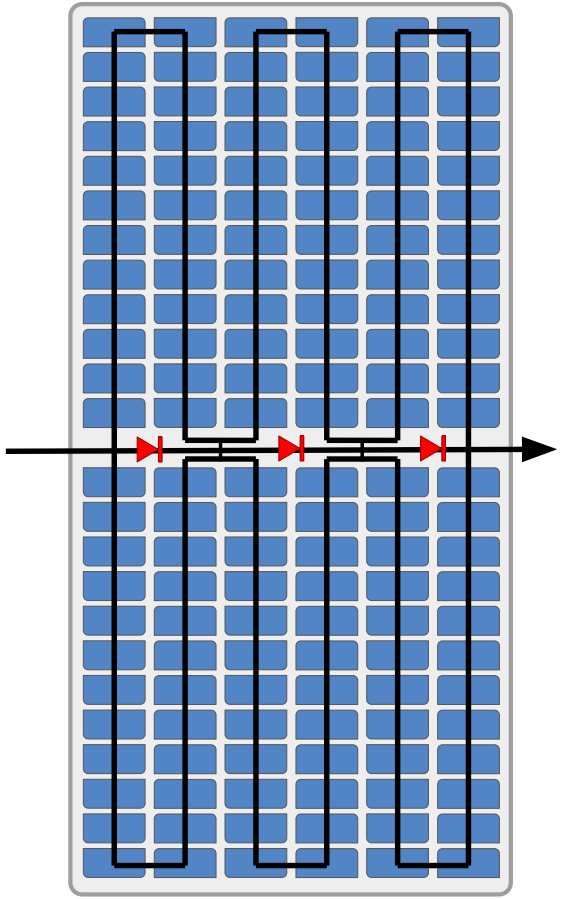


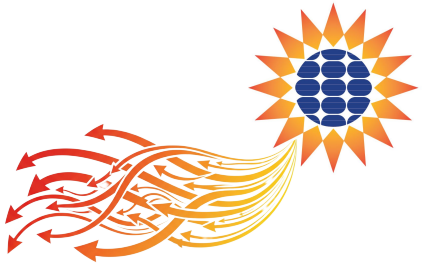
IV curve and MPP



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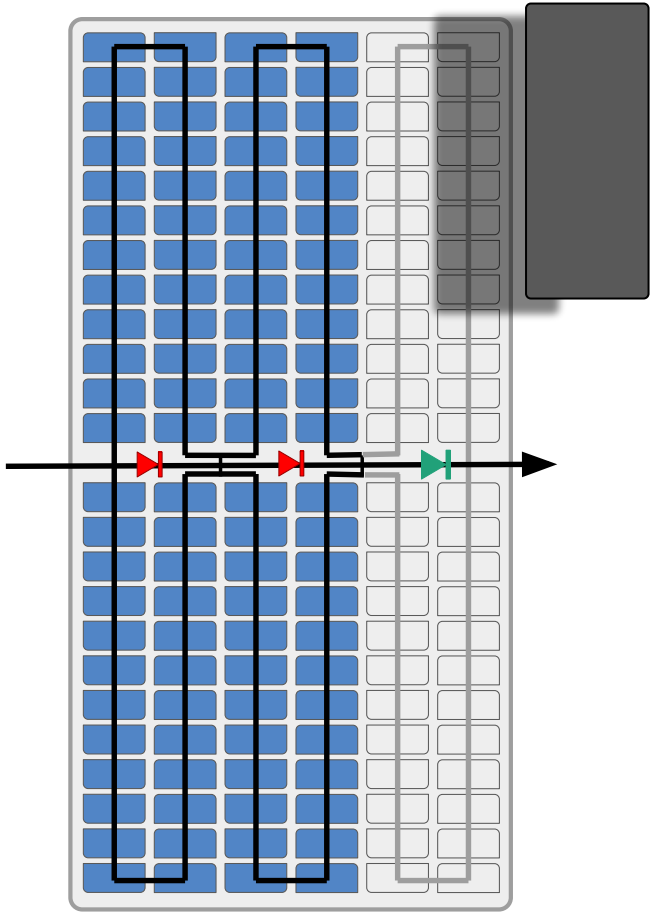
Full module

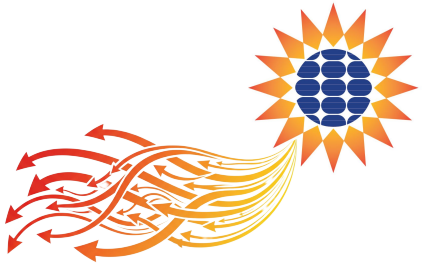




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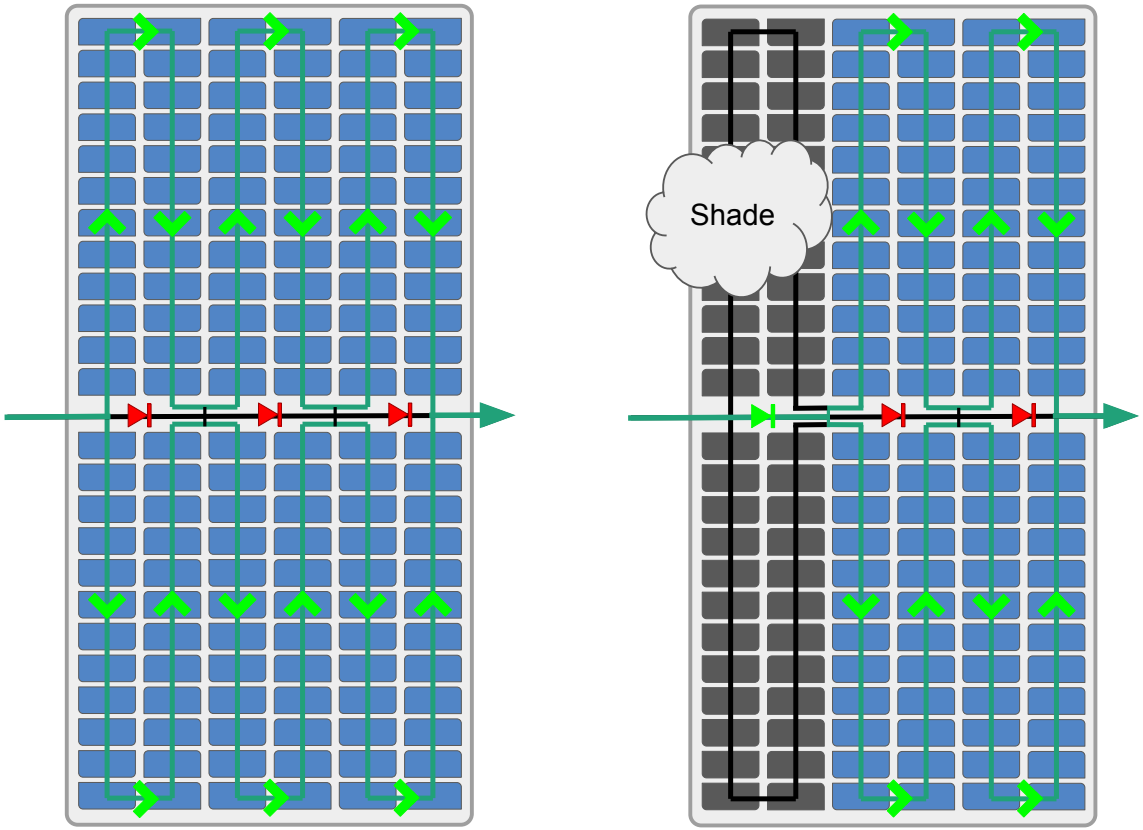
Shading mismatch





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Shading mismatch



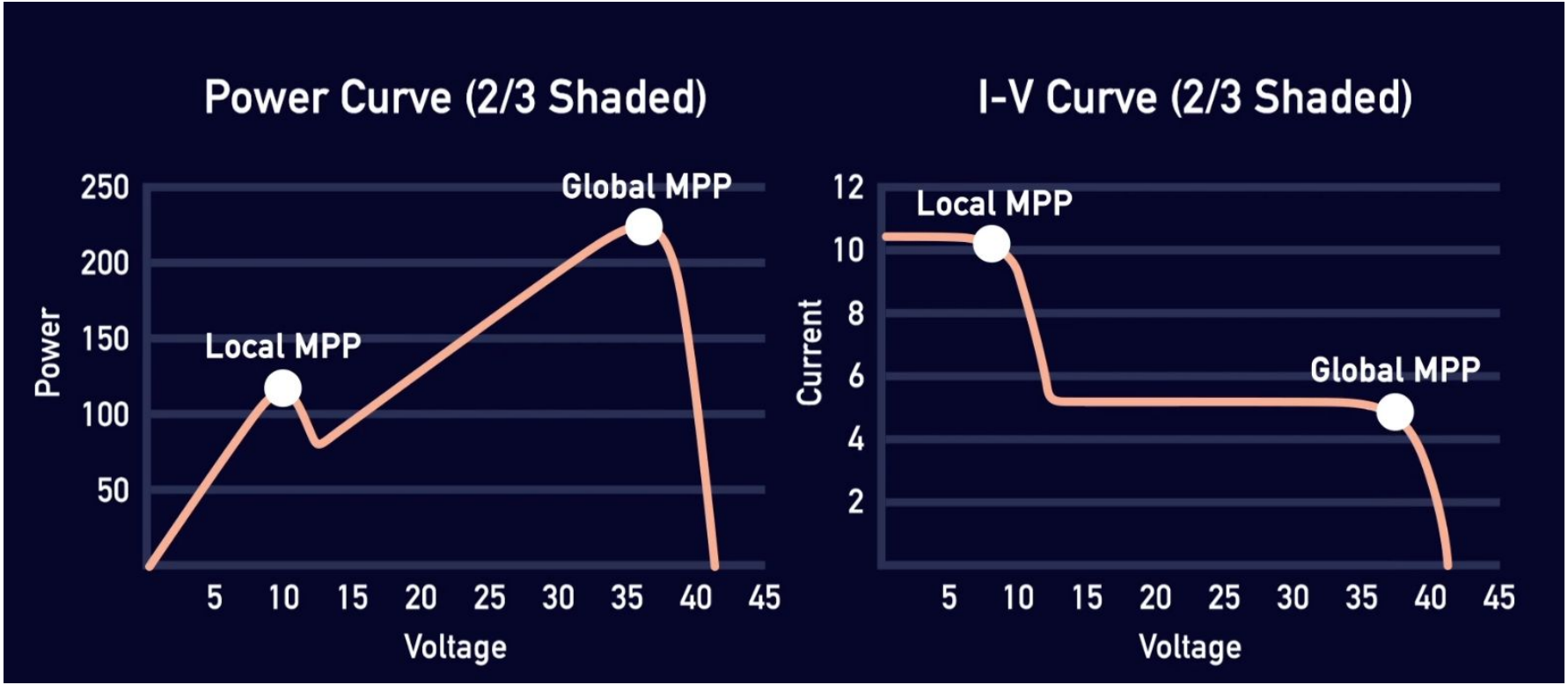
Bypass diodes

Active

Inactive

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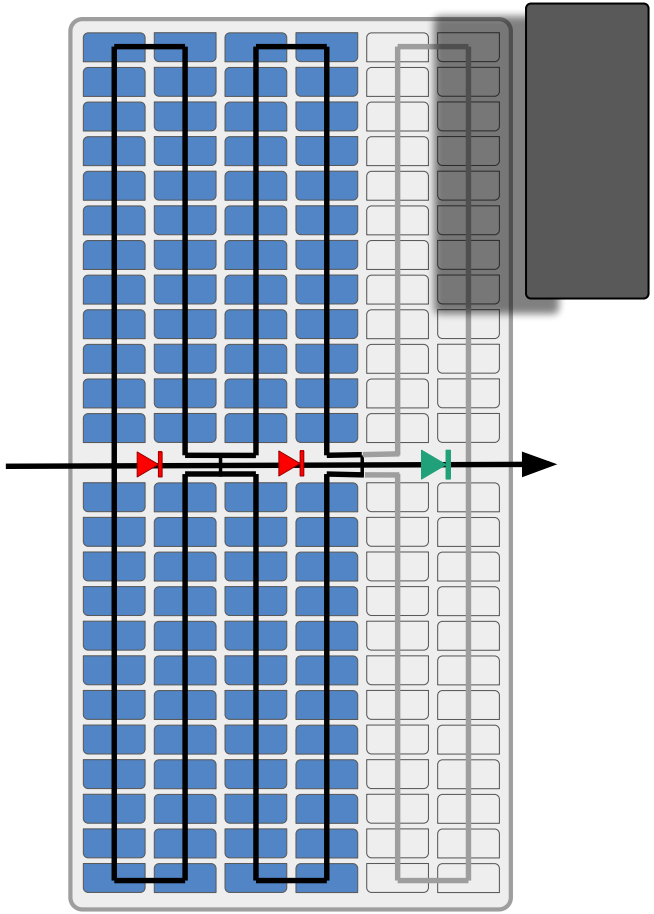
Shading mismatch

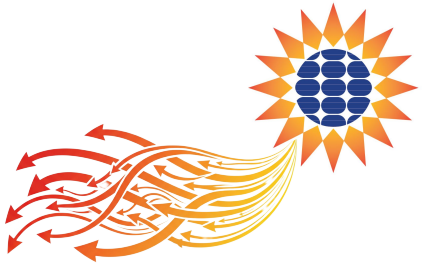


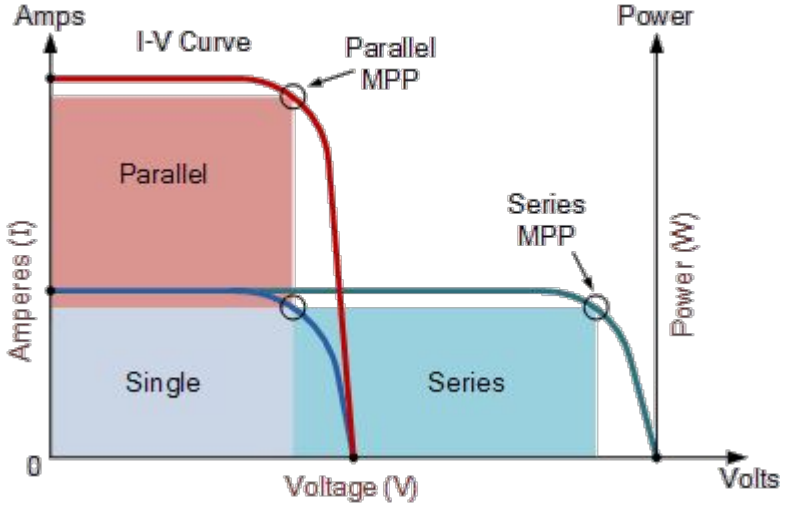
Credits: https://www.youtube.com/watch?v=AZ8VQ_zmf1M&t=209s

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Simulation process

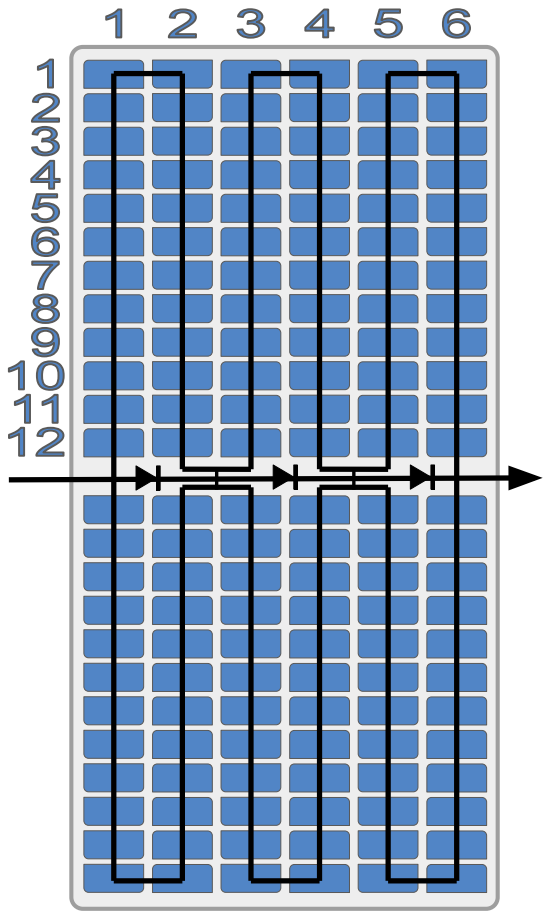






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Simulation process

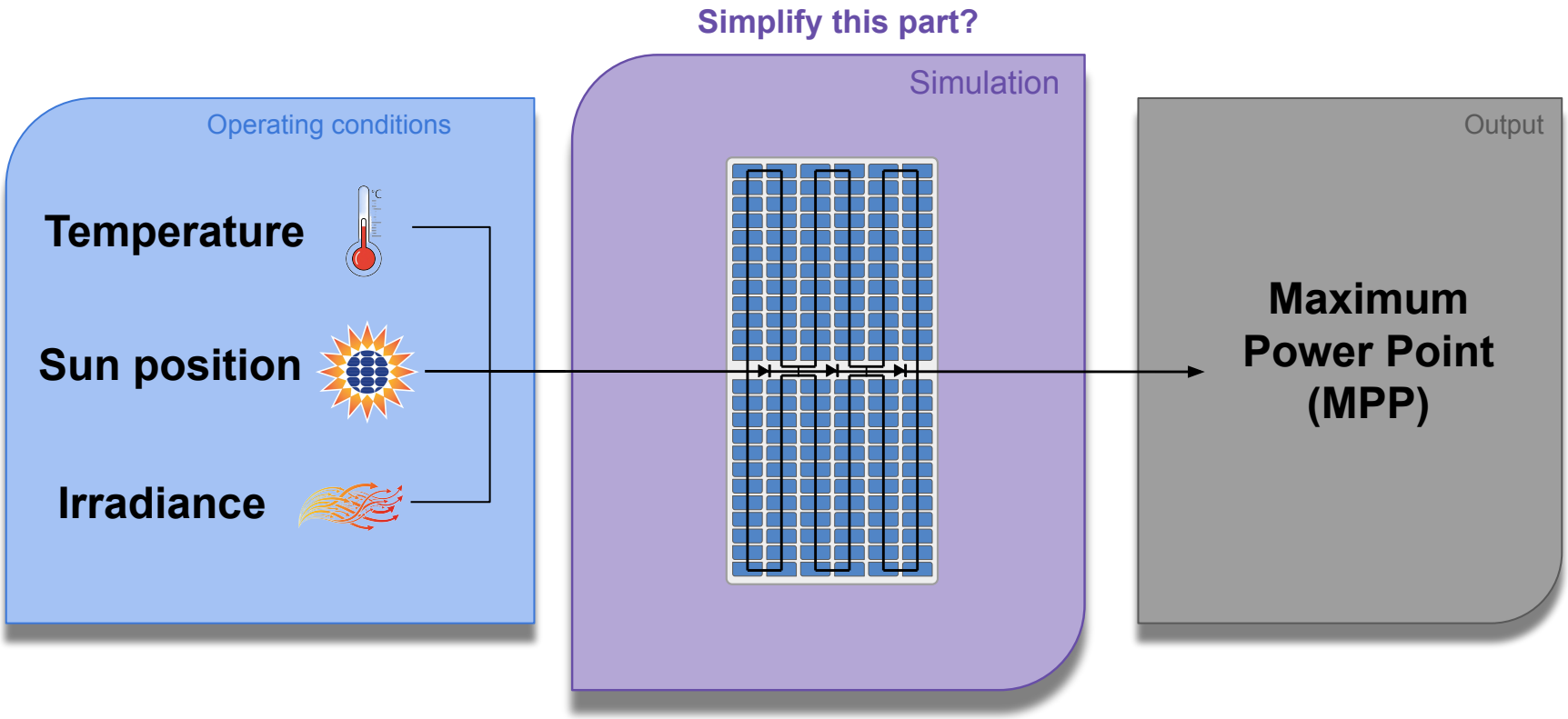


$(12 \times 6) \times 2 = 144$

cells

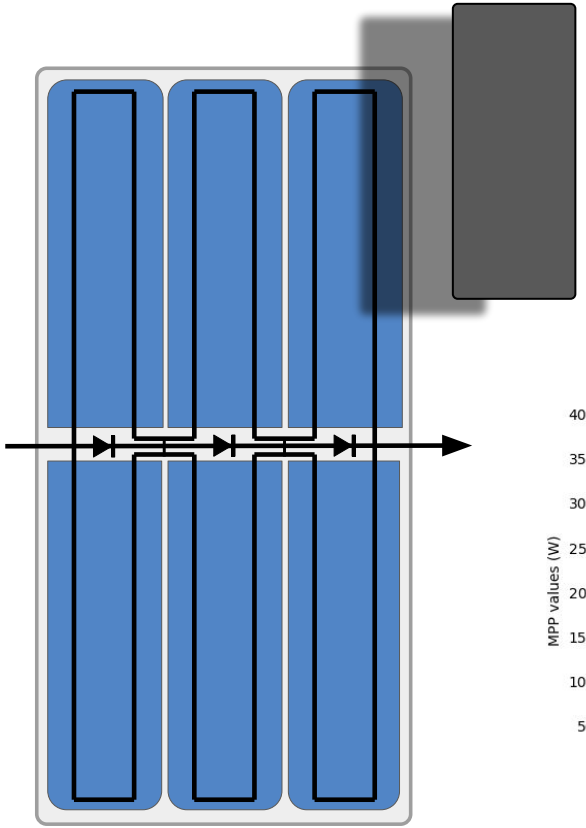
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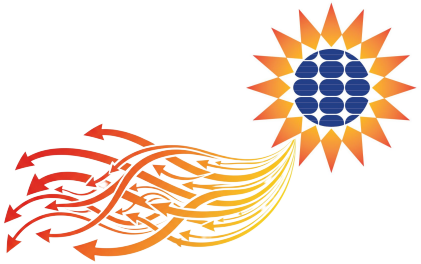
Simulation process



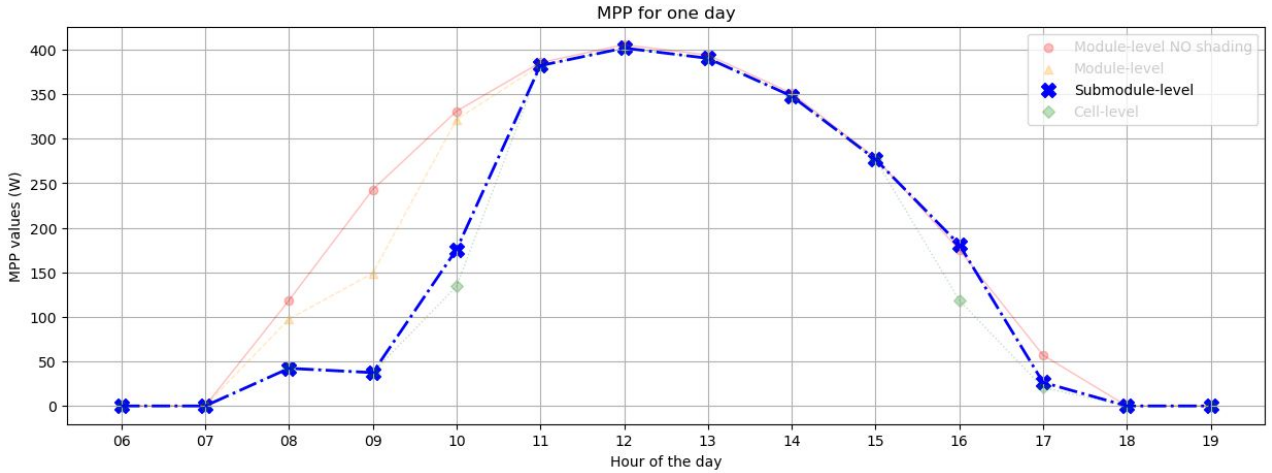
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Submodule-level simulation





This is the one we use as the accurate reference method in our work!



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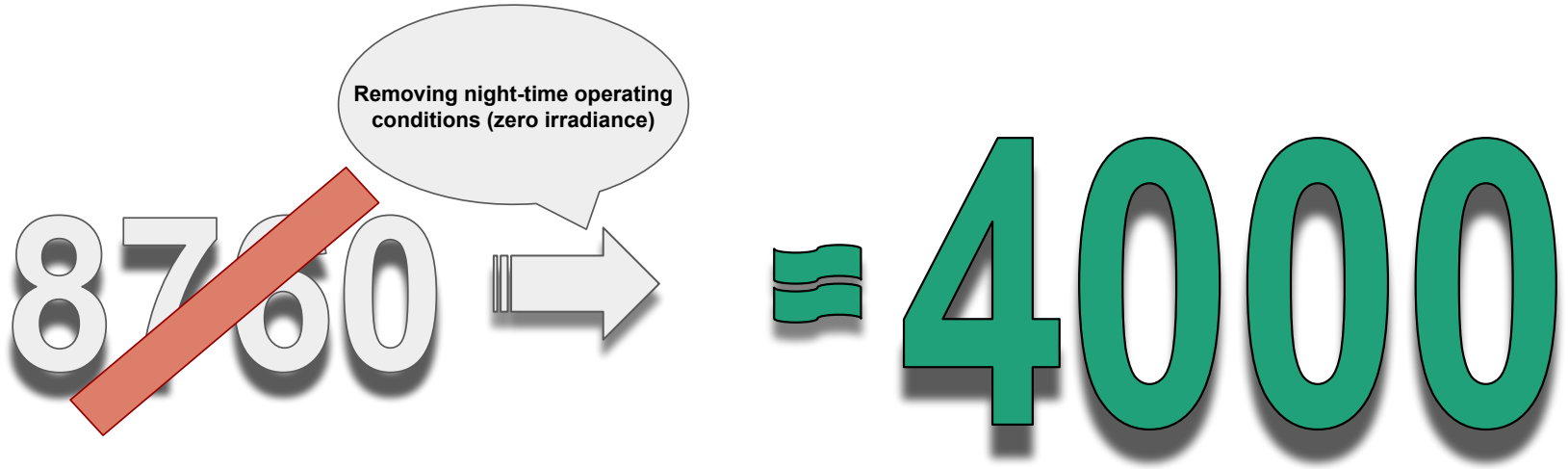
Problem

8760

hourly operating conditions in a year!

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Problem



hourly operating conditions in a year!

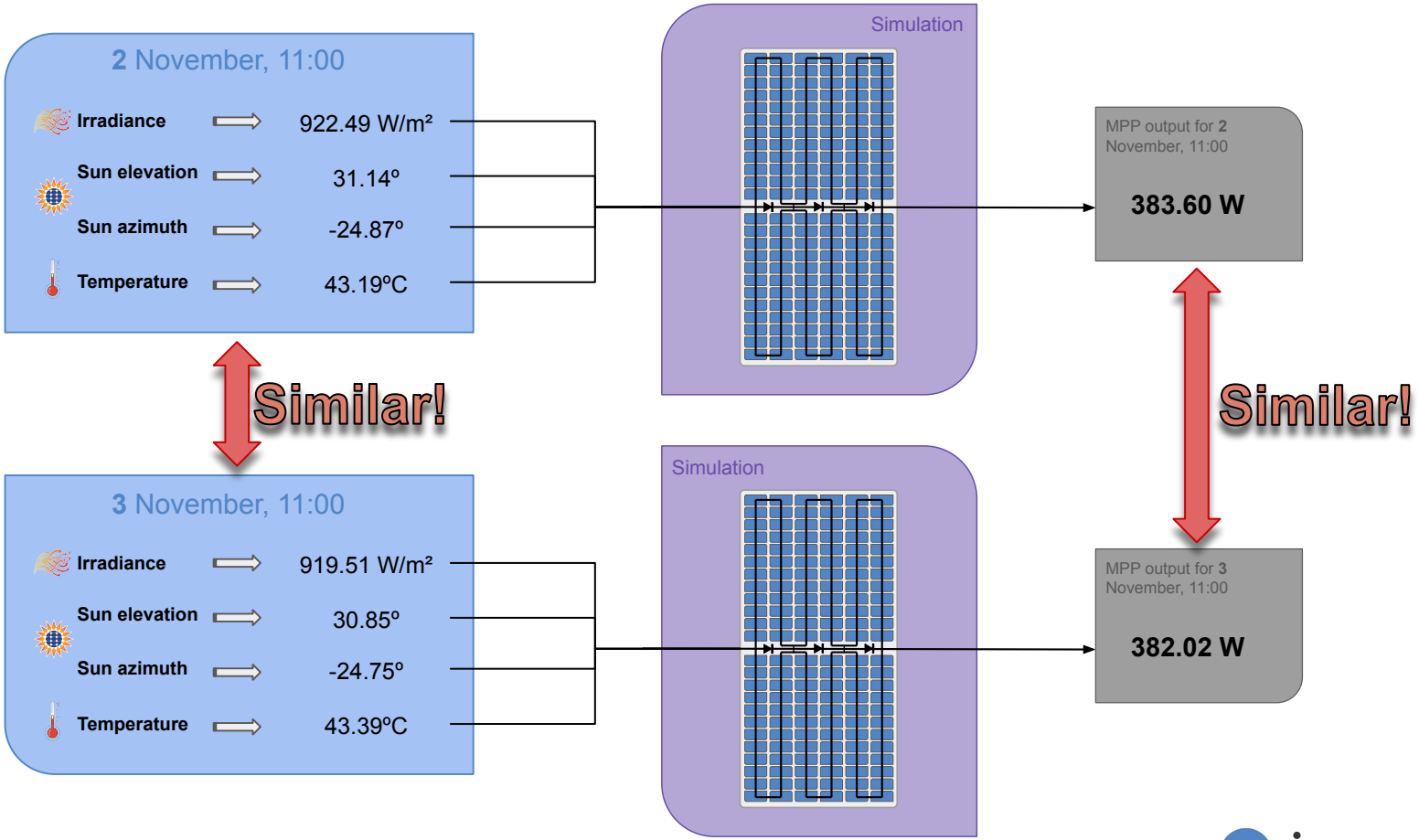
high computational cost

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4000

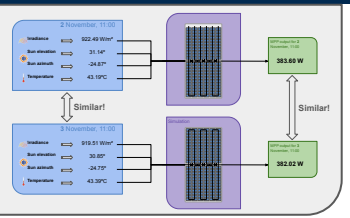
How do we reduce this number?

Similar operating conditions produce similar outputs



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Aggregation of similar operating conditions



Just one simulation!

2 November, 11:00

Irradiance	922.49 W/m²
Sun elevation	31.14°
Sun azimuth	-24.87°
Temperature	43.19°C

3 November, 11:00

Irradiance	919.51 W/m²
Sun elevation	30.85°
Sun azimuth	-24.75°
Temperature	43.39°C

Mean operating conditions

mean	921 W/m²
mean	31°
mean	-24.81°
mean	43.29°C

Simulation

MPP output

382.81 W

Real value:
383.60 W

MPP output for **2** November, 11:00

382.81 W

MPP output for **3** November, 11:00

382.81 W

Real value:
382.02 W

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Aggregation of similar operating conditions

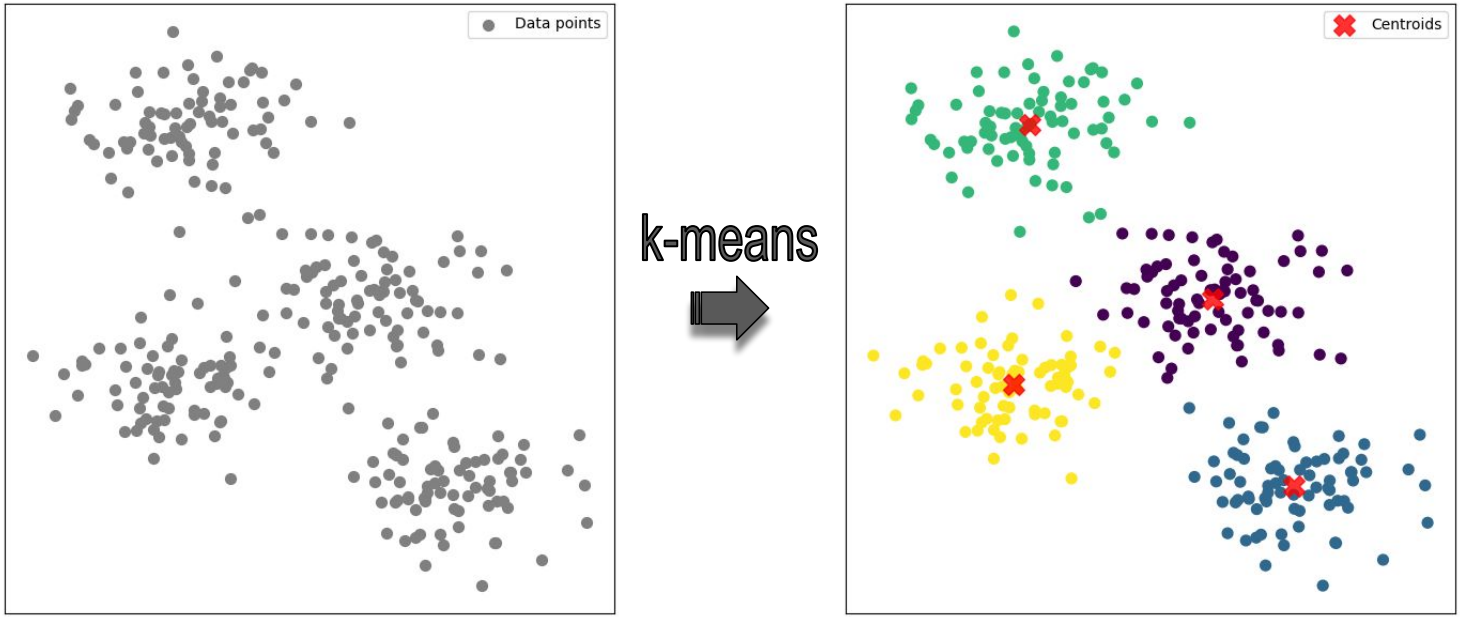
How do we automatically aggregate similar operating conditions?

k-means

Unsupervised machine learning algorithm for data segmentation (clustering)

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K-means algorithm



Centroids (✖) as new data points

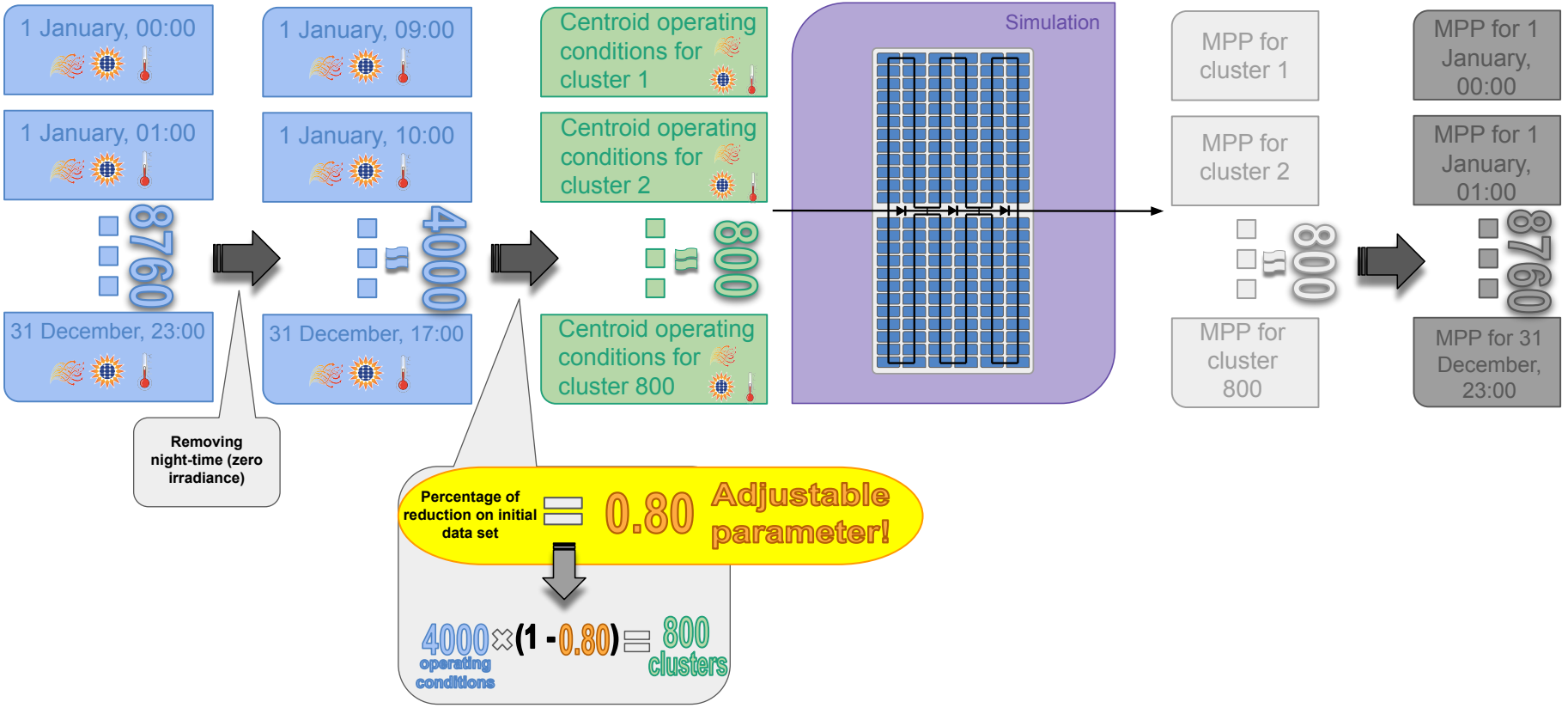
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Initial data aggregation approaches

- StraightForward Aggregation (SFA)
- Hierarchical Hourly Aggregation (HHA)

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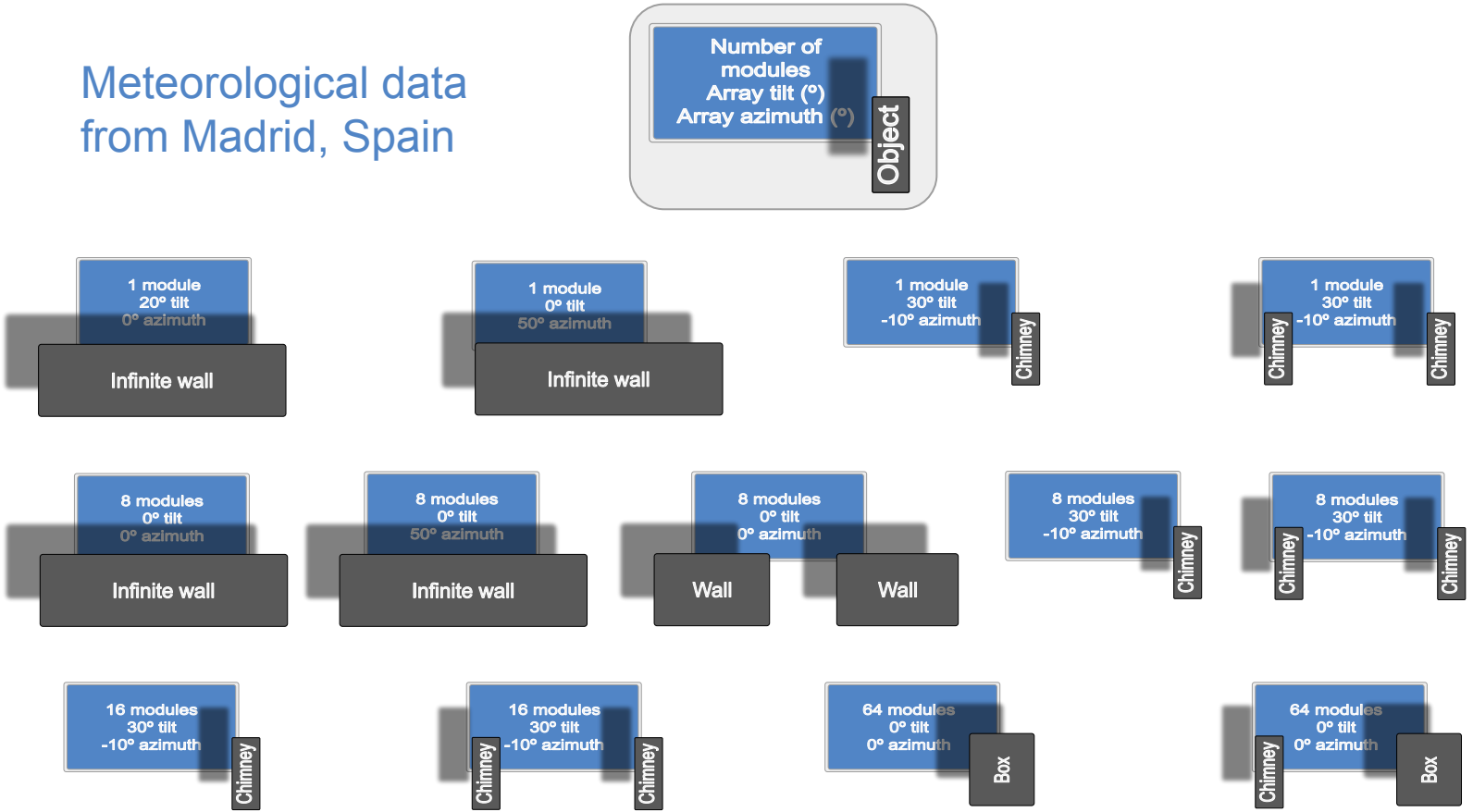
Straight-Forward Aggregation (SFA)



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Simulation scenarios for performance testing

Meteorological data
from Madrid, Spain

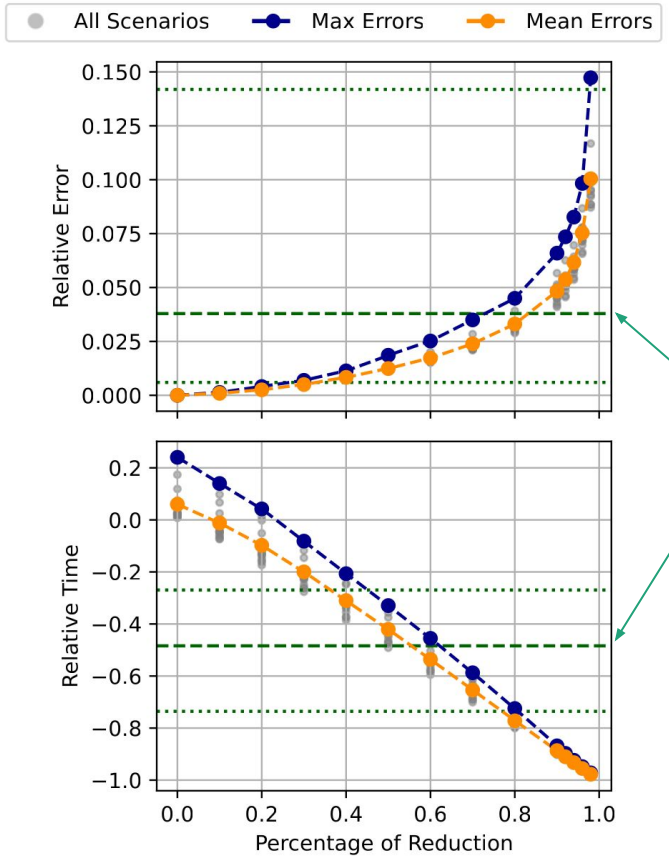


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SFA performance results

$$Relative\ Error = \frac{\sum \left| MPP_{new\ method} - MPP_{reference\ method} \right|}{\sum MPP_{reference\ method}}$$

$$Relative\ Time = \frac{time_{new\ method} - time_{reference\ method}}{time_{reference\ method}}$$



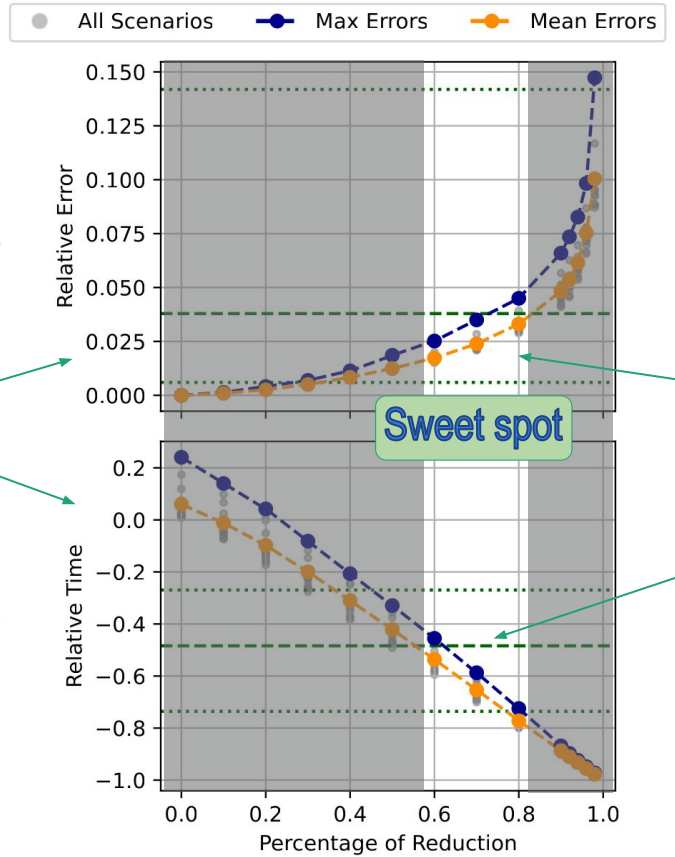
Module-level performance for comparison

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SFA performance results

$$Relative\ Error = \frac{\sum \left| MPP_{new\ method} - MPP_{reference\ method} \right|}{\sum MPP_{reference\ method}}$$

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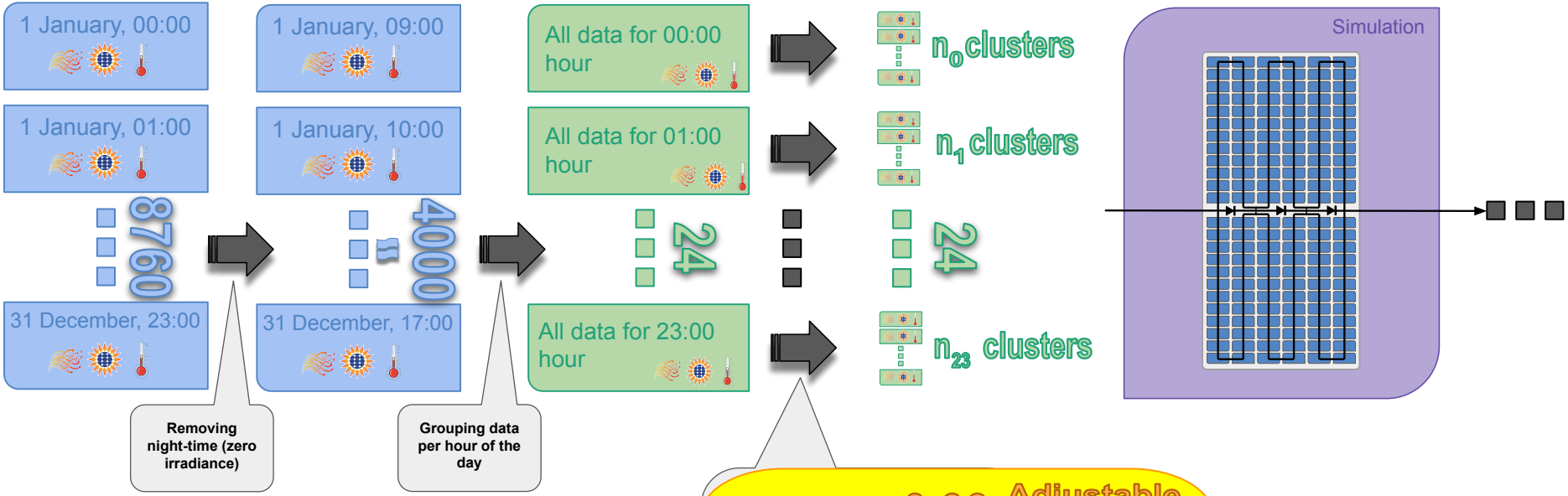
More stable results!

Less errors than module-level simulation

More reduction in computational time than module-level simulation

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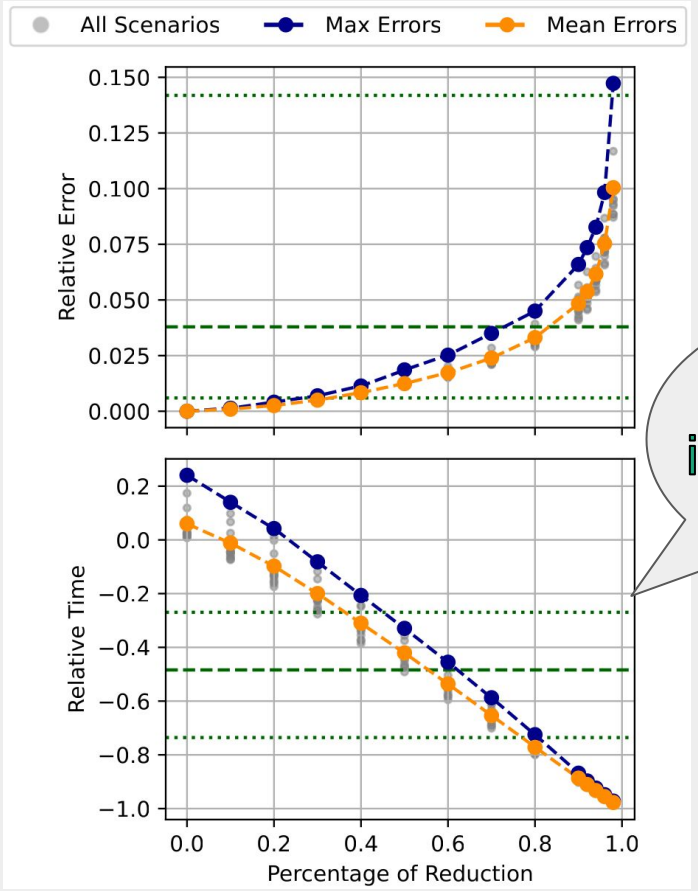
Hierarchical Hourly Aggregation (HHA)



more complex and less interpretable way of selecting the number of clusters compared with SFA

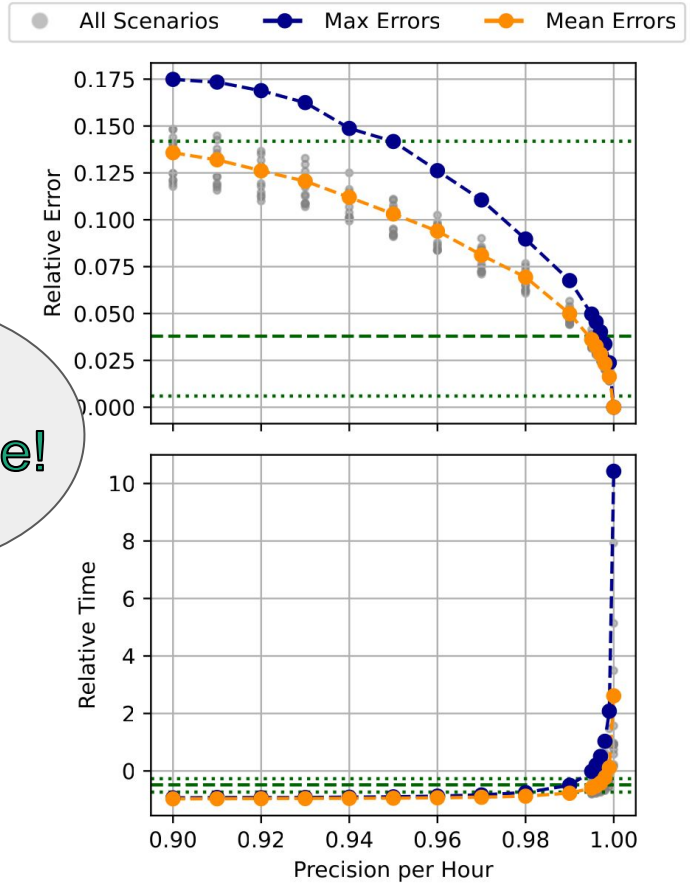
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SFA performance



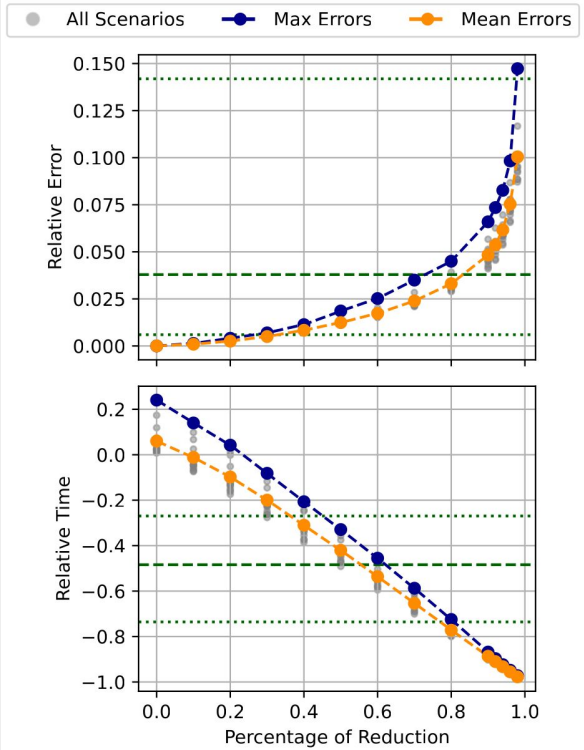
More interpretable!

HHA performance



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How do we compare both methods?



mean

$$Relative\ Error = \frac{\sum \left| MPP_{new\ method} - MPP_{reference\ method} \right|}{\sum MPP_{reference\ method}}$$

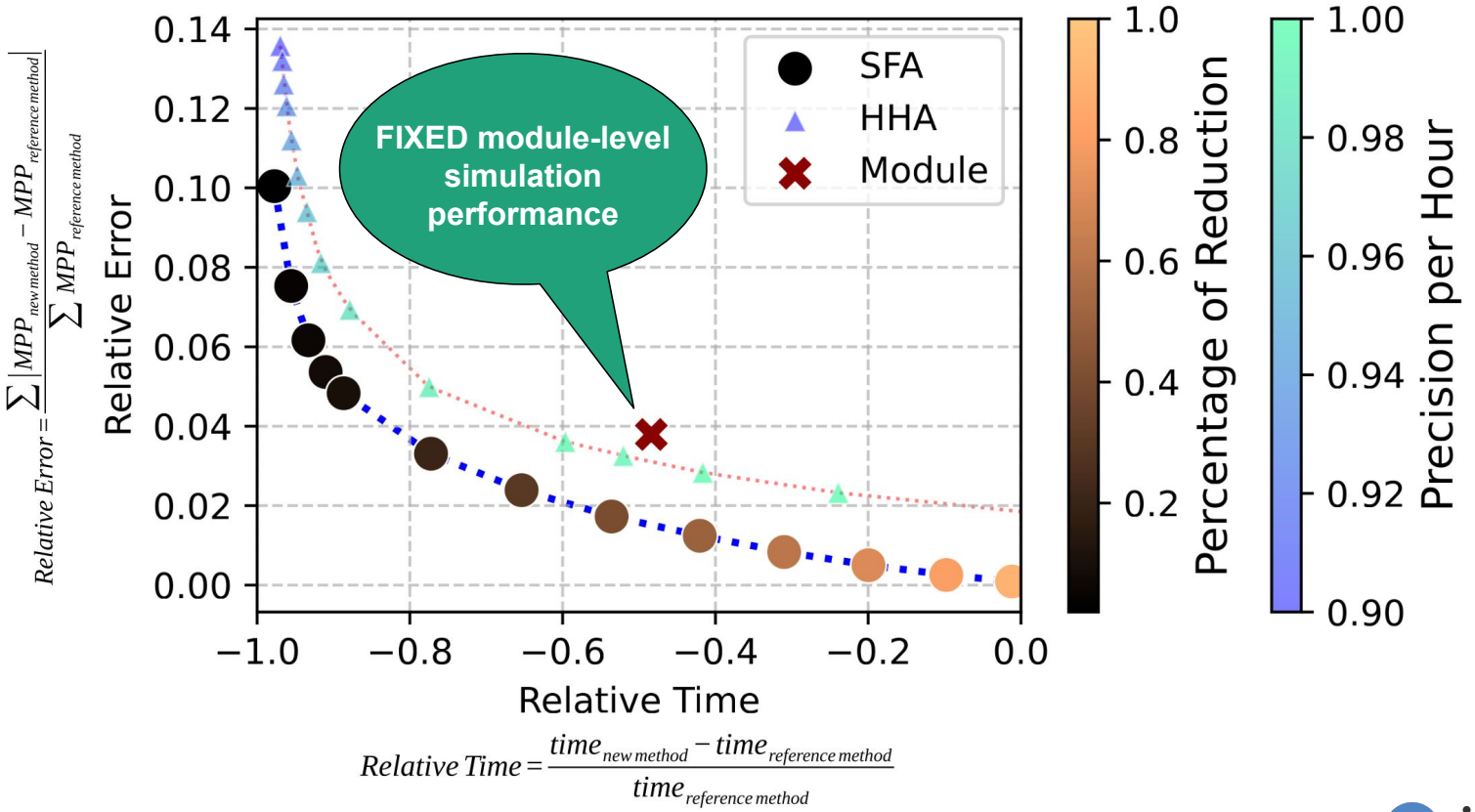
VS

mean

$$Relative\ Time = \frac{time_{new\ method} - time_{reference\ method}}{time_{reference\ method}}$$

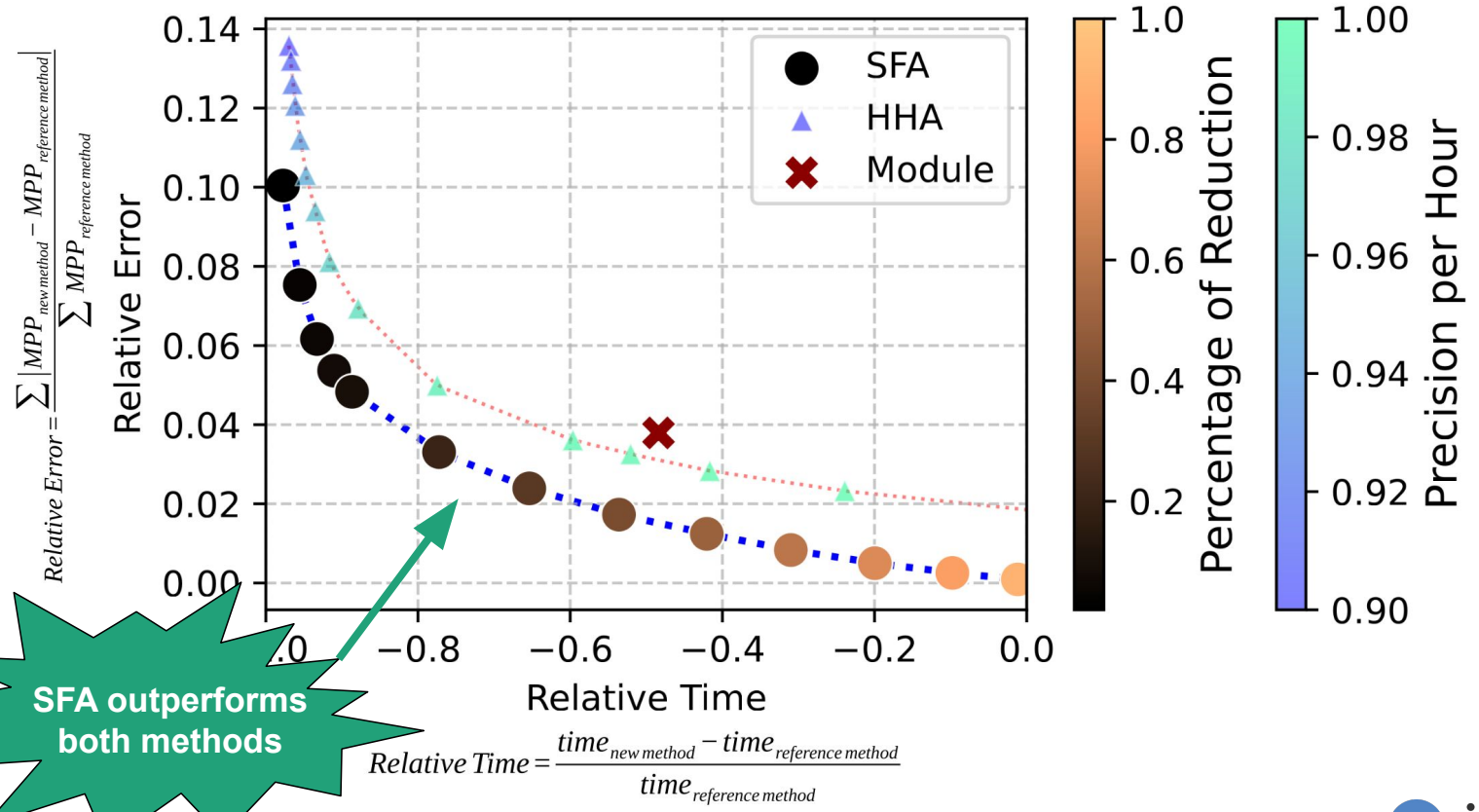
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Methods comparison (Pareto Frontier)



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Methods comparison (Pareto Frontier)



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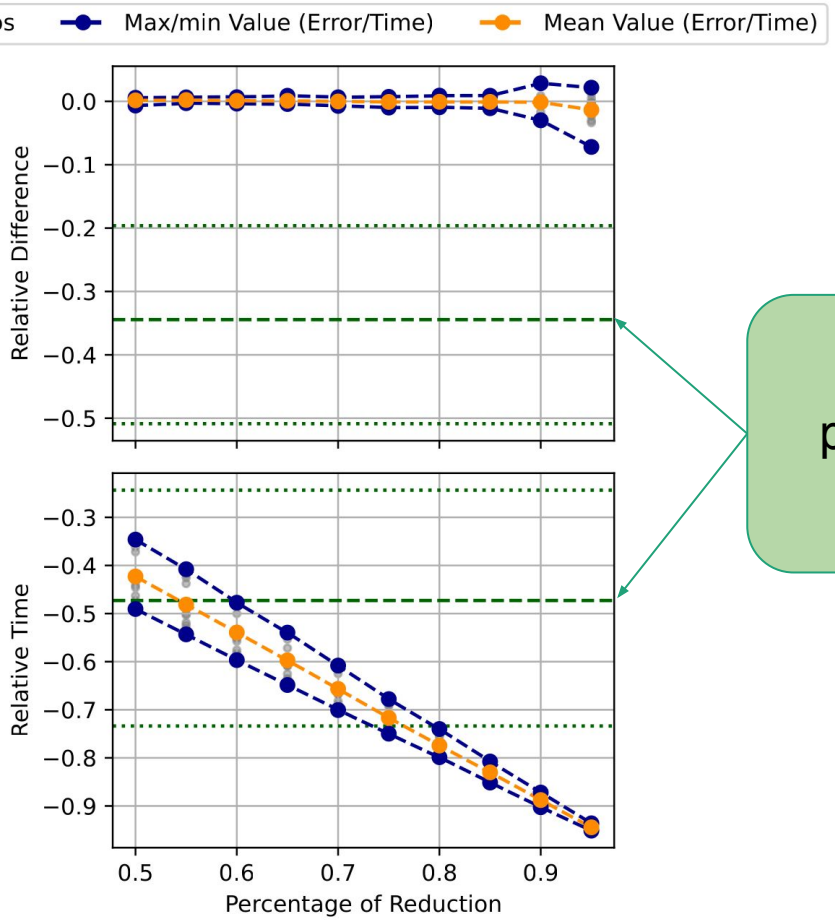
Performance in terms of total annual power loss caused by partial shading (SFA)

$$MPP_{loss} = MPP_{no\ shading} - MPP_{shading}$$

$$Relative\ Difference = \frac{\sum \left(MPP_{loss\ new\ method} - MPP_{loss\ reference\ method} \right)}{\sum MPP_{loss\ reference\ method}}$$

$$= \frac{\sum MPP_{loss\ new\ method}}{\sum MPP_{loss\ reference\ method}} - 1$$

$$Relative\ Time = \frac{time_{new\ method} - time_{reference\ method}}{time_{reference\ method}}$$



Module-level performance for comparison

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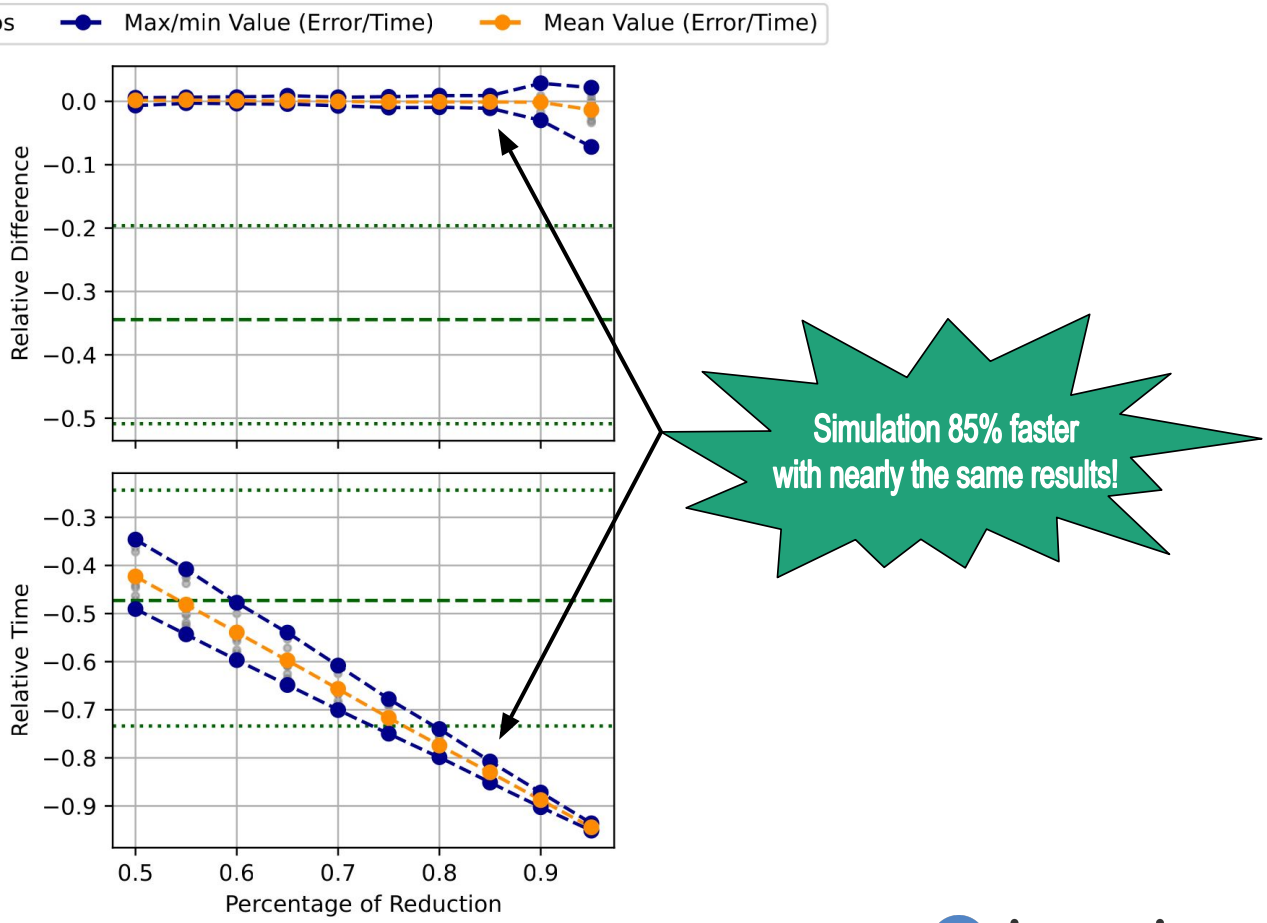
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$$= \frac{\sum MPP_{loss\ new\ method}}{\sum MPP_{loss\ reference\ method}} - 1$$

$$Relative\ Time = \frac{time_{new\ method} - time_{reference\ method}}{time_{reference\ method}}$$



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Summary

- Aggregation methods for initial data segmentation
- Better alternative in terms of accuracy/speed trade-off than module-level simulation without aggregation
- Very tunable models depending on the use case

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END

PV shading models with pvlib

Accelerating photovoltaic system simulations via statistical data aggregation