Modelling And Impact Of Solar Eclipses On PV Energy Production

5DO.4.6 Modelling and Impact of Solar Eclipses on PV Energy Production

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About Envision Digital and Ensight Solar

Who is Envision?

Envision Energy

World champion wind turbine manufacturer and #1 order taker in 2019

Envision Digital

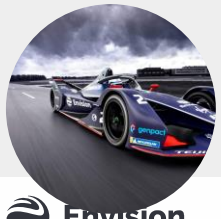
A global leader in AIoT operating system EnOS™

Envision AESC

A global leader in AIoT-defined batteries

Envision Ventures

Building a global AIoT, CleanTech eco-system

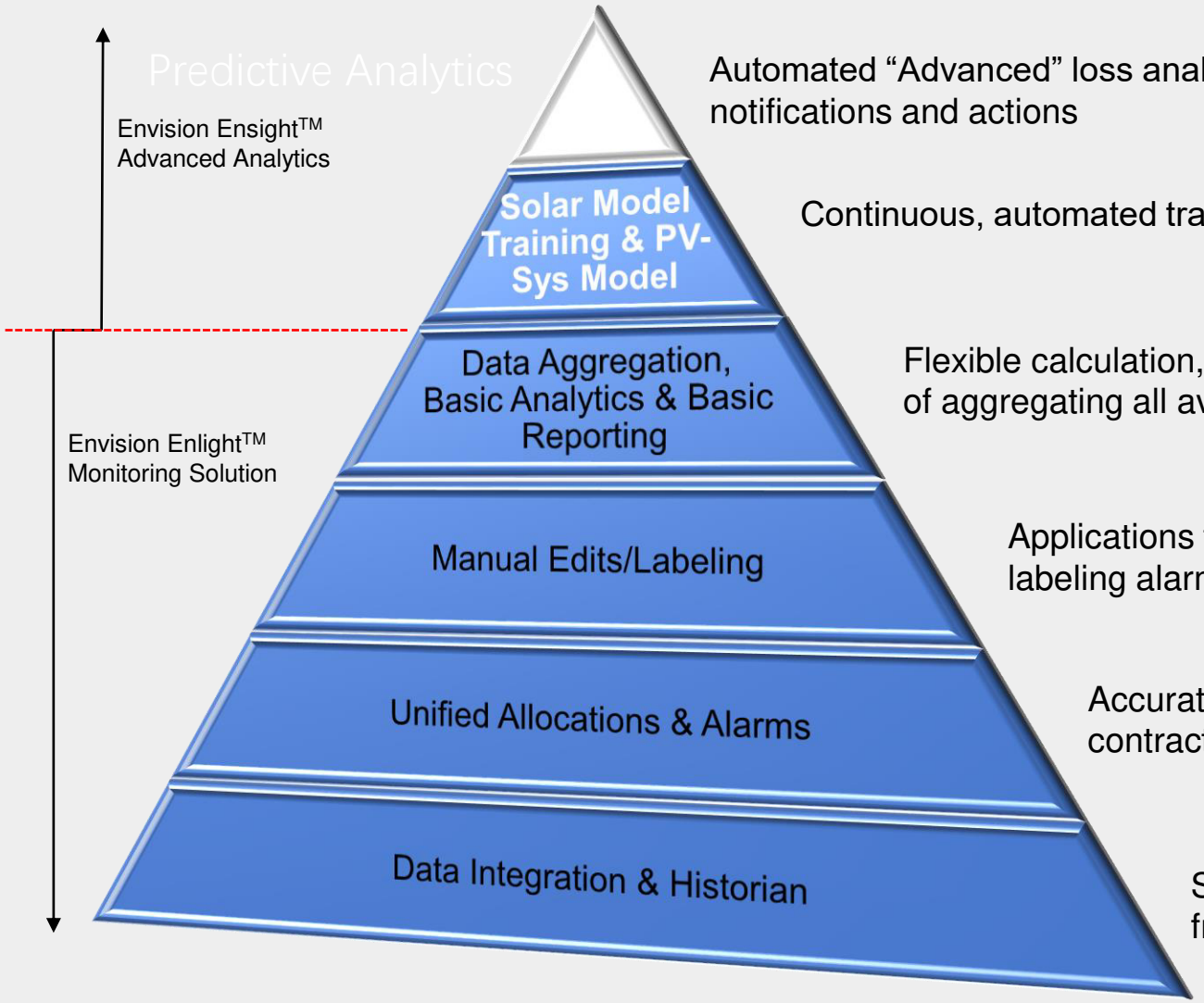


Envision Virgin Racing

eMobility powered by AIoT
#RaceAgainstClimateChange

- **A 13-year old Digital Energy Pioneer and RE100 Member**
- **Global #1 wind turbine manufacturer (by order volume)**
  - *Leading software-defined smart wind turbine; Superconducting generator pioneer; Smart Wind Farm developer; Global projects portfolio.*
- **#1 Energy AIoT Platform:**
  - *200GW of energy assets managed, across more than 30,000 sites*
  - *100M IoT sensors connected, processing over 44B energy transactions daily*
- **Global top 5 EV battery supplier**
  - *2000+ patents; powering 500,000+ EVs; 1M+ operating ESS hours with Zero incidents – making us the worlds safest battery solutions supplier*
- **Leading International CleanTech Investor:**
  - *AESC, Sonnen, Chargepoint, AutoGrid, Bazefield, ClimaCell, Baffle, PreNav, Orbital Insights, PubNub, Vidder, Onion Id, ProtectWise, ZingBox, etc.*
- **10 Research & Development Centers Globally**
- **7000+ Staff operating in more than 20 Countries**

Advanced Analytics…Where Does it Fit?



Automated “Advanced” loss analytics and asset-driven notifications

Continuous, automated training of “digital twins”

Flexible calculation, aggregation, and reporting engine capable of aggregating all availability and process data for all sites

Applications for event management, editing, and labeling alarms and allocations

Accurate event generation for all OEMs, for any contract or convention

Scalable, real time historian capable of storing all data from all sites, in sub-10-min resolution since inception

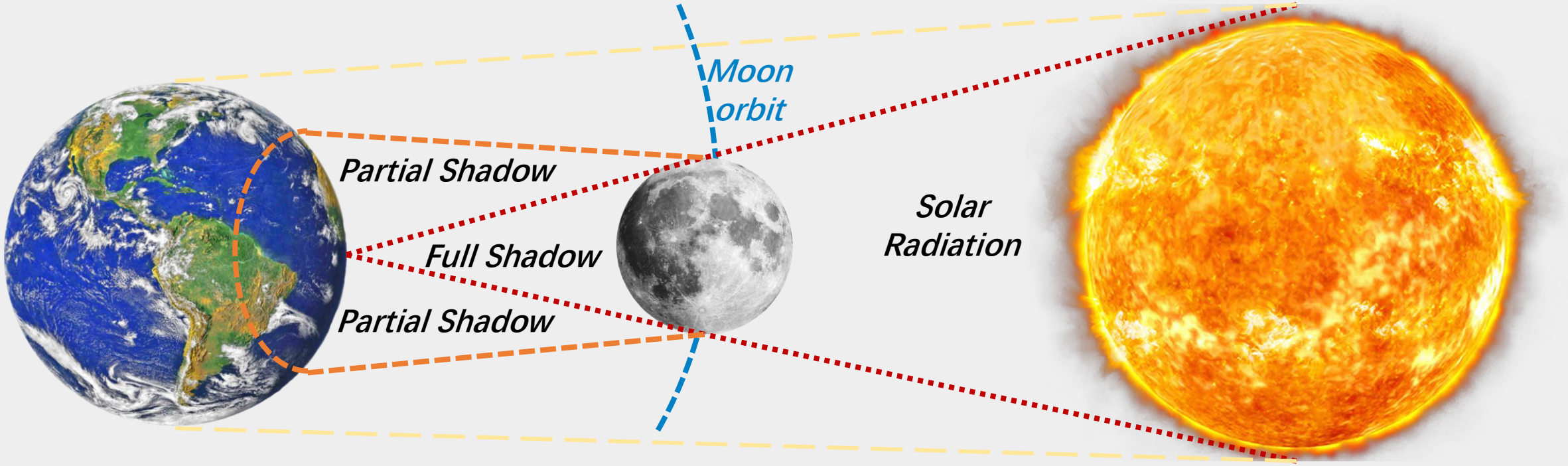
Modelling And Impact Of Solar Eclipses On PV Energy Production

Content

1. Introduction and motivation
2. Data Availability and Research Methodology
3. Results
4. Conclusions

Introduction

What a Solar Eclipse is?

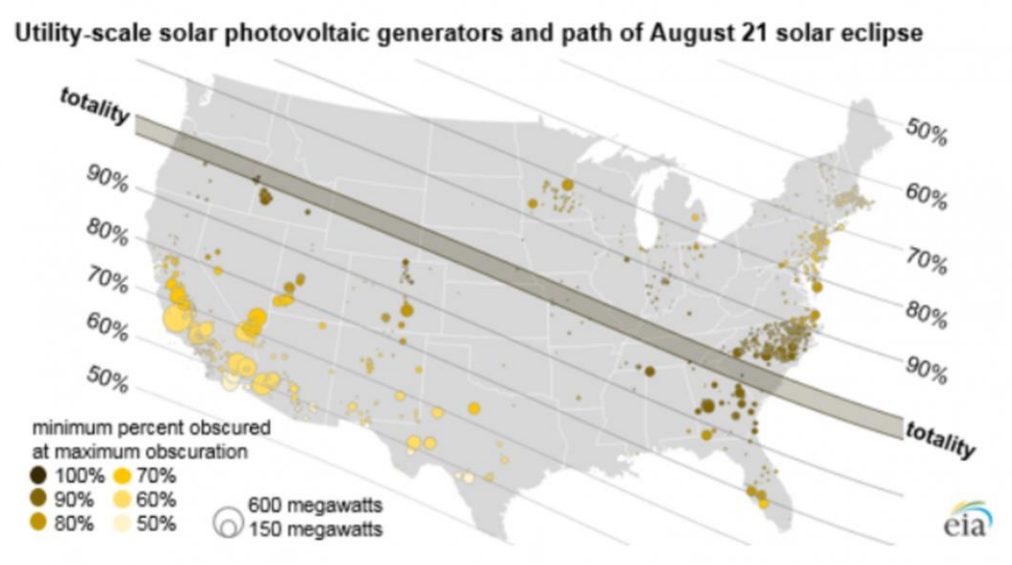


Some examples of Solar Eclipses

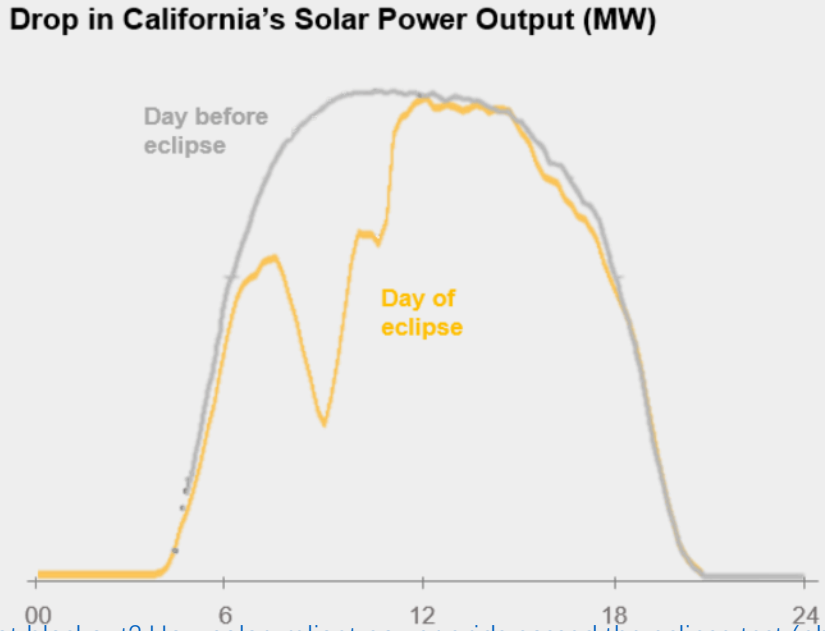
- M1.045 10am 20/03/2015 Europe
- M1.031 6pm 26/02/2017 North America
- M1.046 7pm 02/07/2019 South America
- M1.025 4pm 14/12/2020 South America

What a Solar Eclipse is?

1. Rare event that can highly impact the operation of electrical grids.
2. Grids with high PV penetration suffer the most due to the large production ramps.
3. Forecasting is important for TSO and DSO to enable an optimum grid planning.



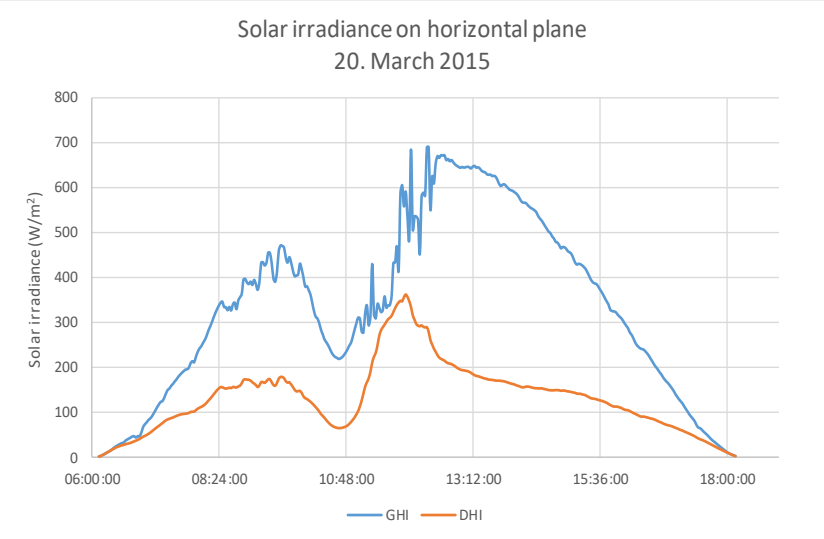
[What blackout? How solar-reliant power grids passed the eclipse test (phys.org)]

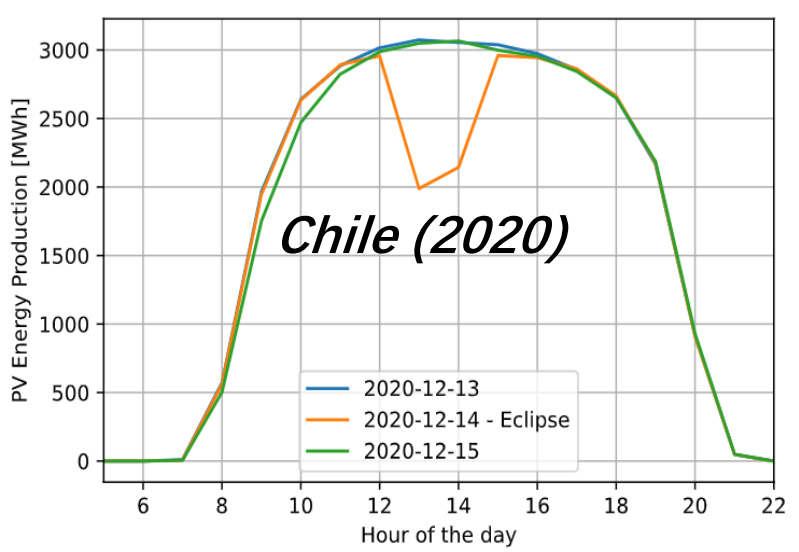


[What blackout? How solar-reliant power grids passed the eclipse test (phys.org)]

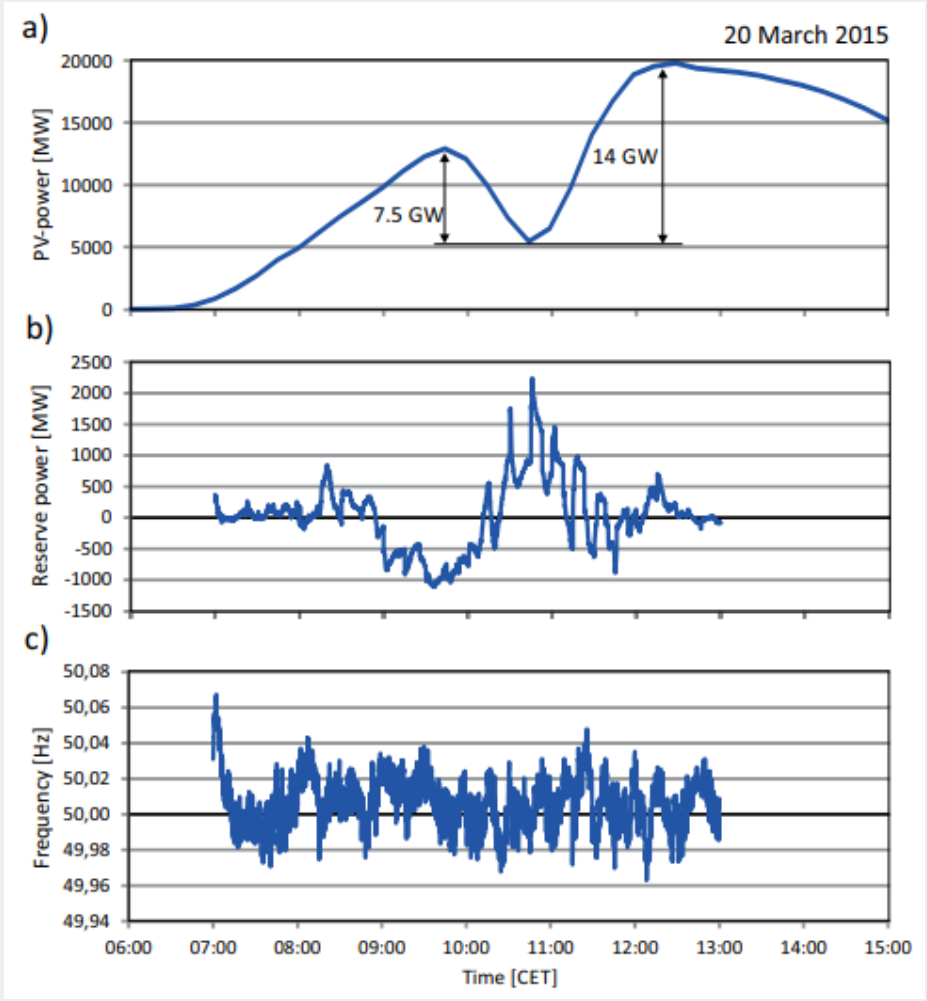
What a Solar Eclipse is?

Slovenia (2015)





Germany (2015)

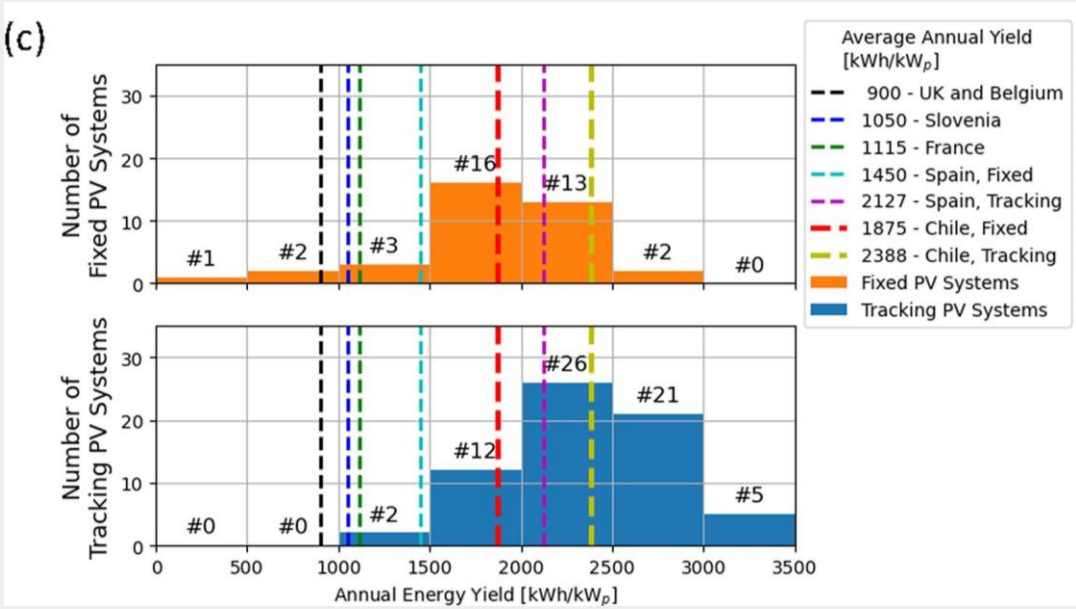


C. Köhler et al., Meteorologische Zeitschrift Vol. 25 No. 1 (2016),

Data Availability and Research Methodology

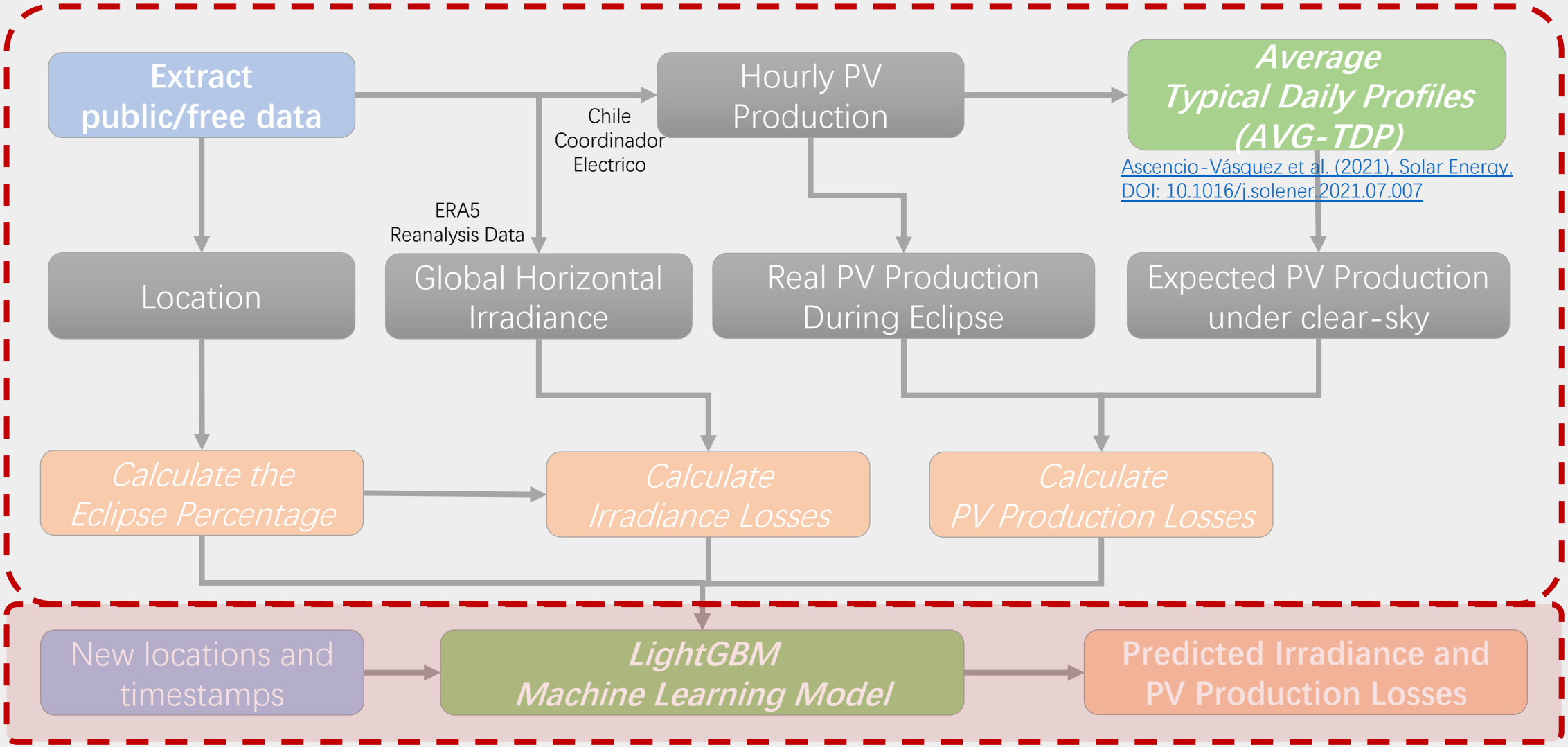
Data: *Chilean PV fleet*

- Highest irradiation levels worldwide
- Very high PV Yields
- Over 3 GW under operation
- Mounting
  - Half tracking
  - Half fixed
- Dataset description in



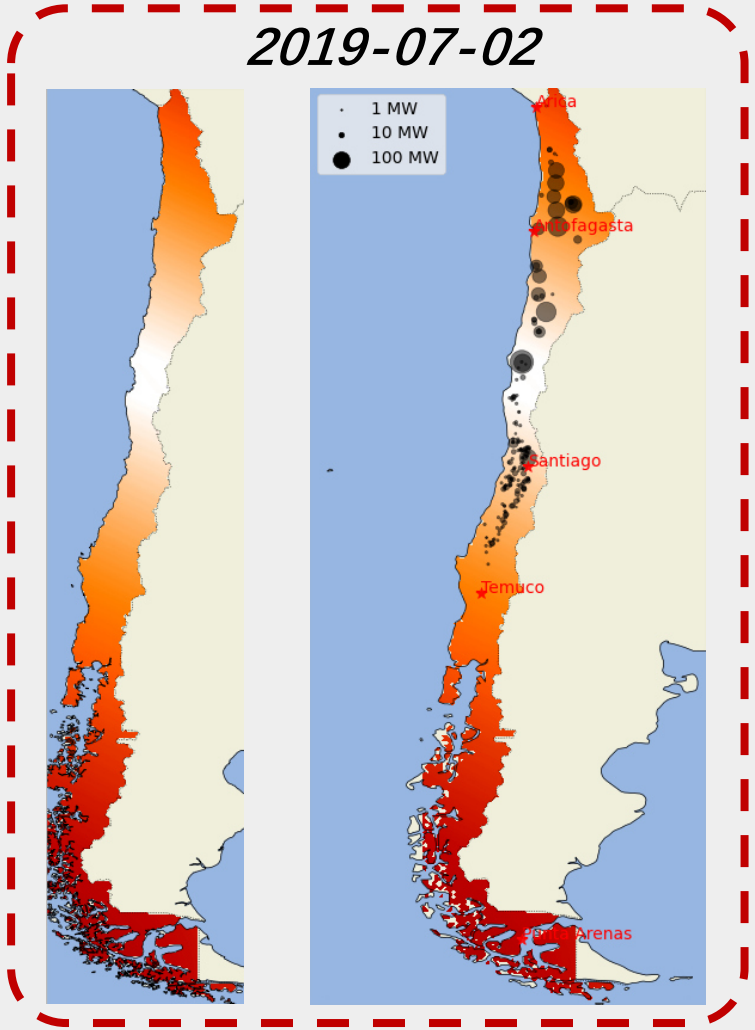
Ascencio-Vásquez et al. (2021), Solar Energy, DOI: 10.1016/j.solener.2021.07.007

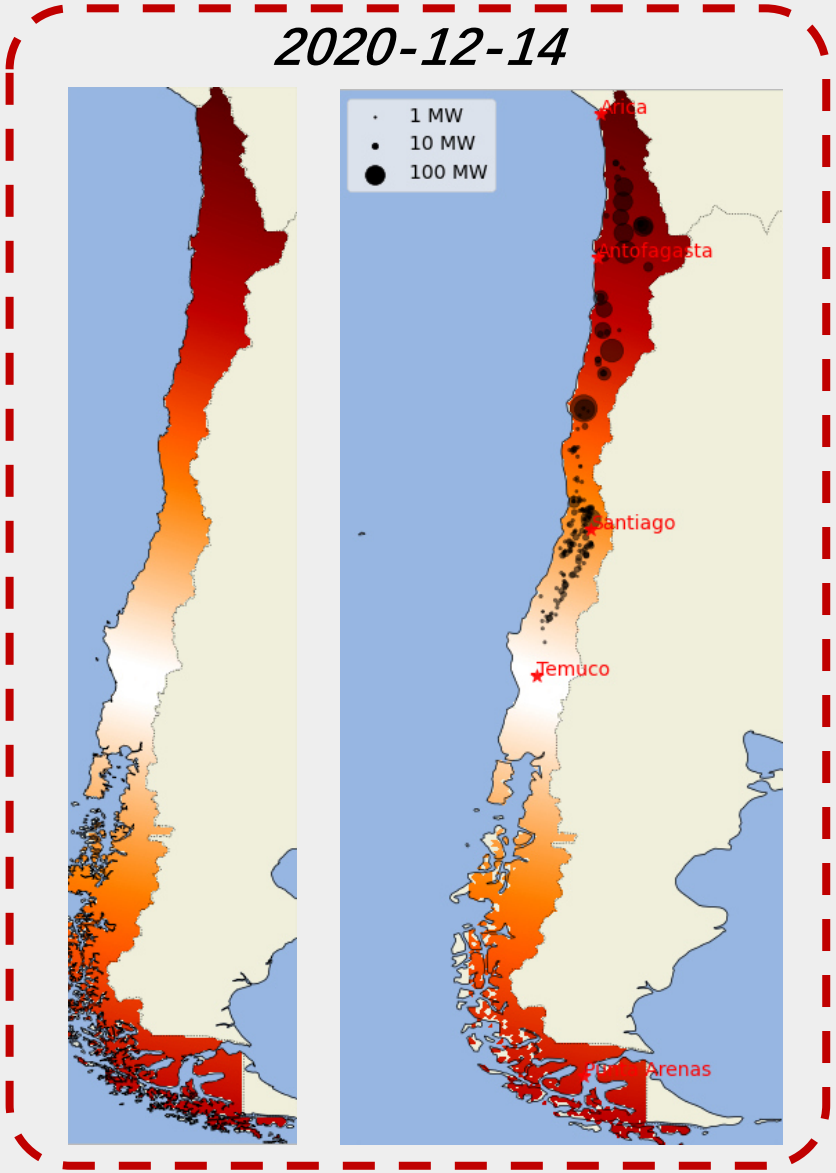
Numerical Pipeline for estimation of PV losses during eclipses

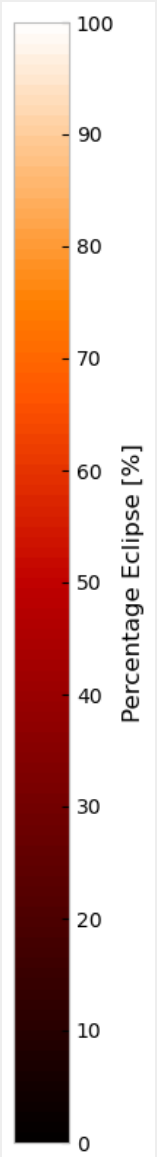


Results

Calculate the Eclipse Percentage





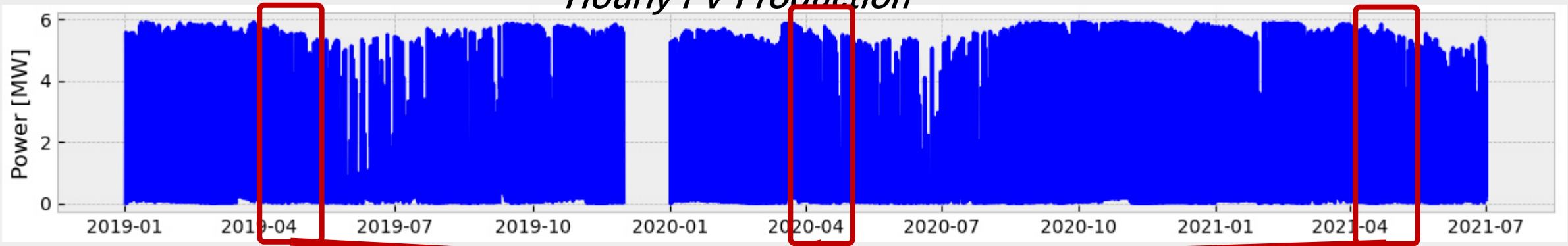


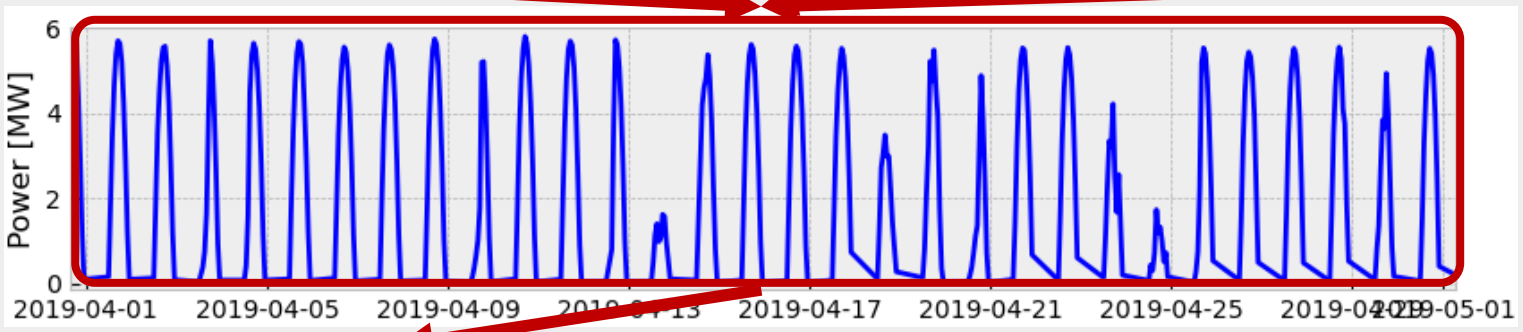
Castillejo-Cuberos et al. (2021), Energies MDPI, DOI: 10.3390/en14175352

Calculation of Typical Daily Profiles (TDP)

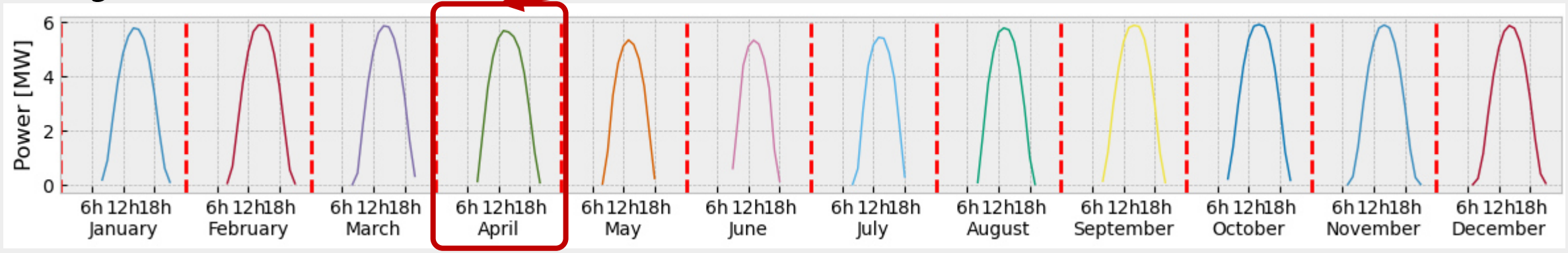
PV System 1

Hourly PV Production





Average TDP



Calculation of Typical Daily Profiles (TDP)

PV System 2

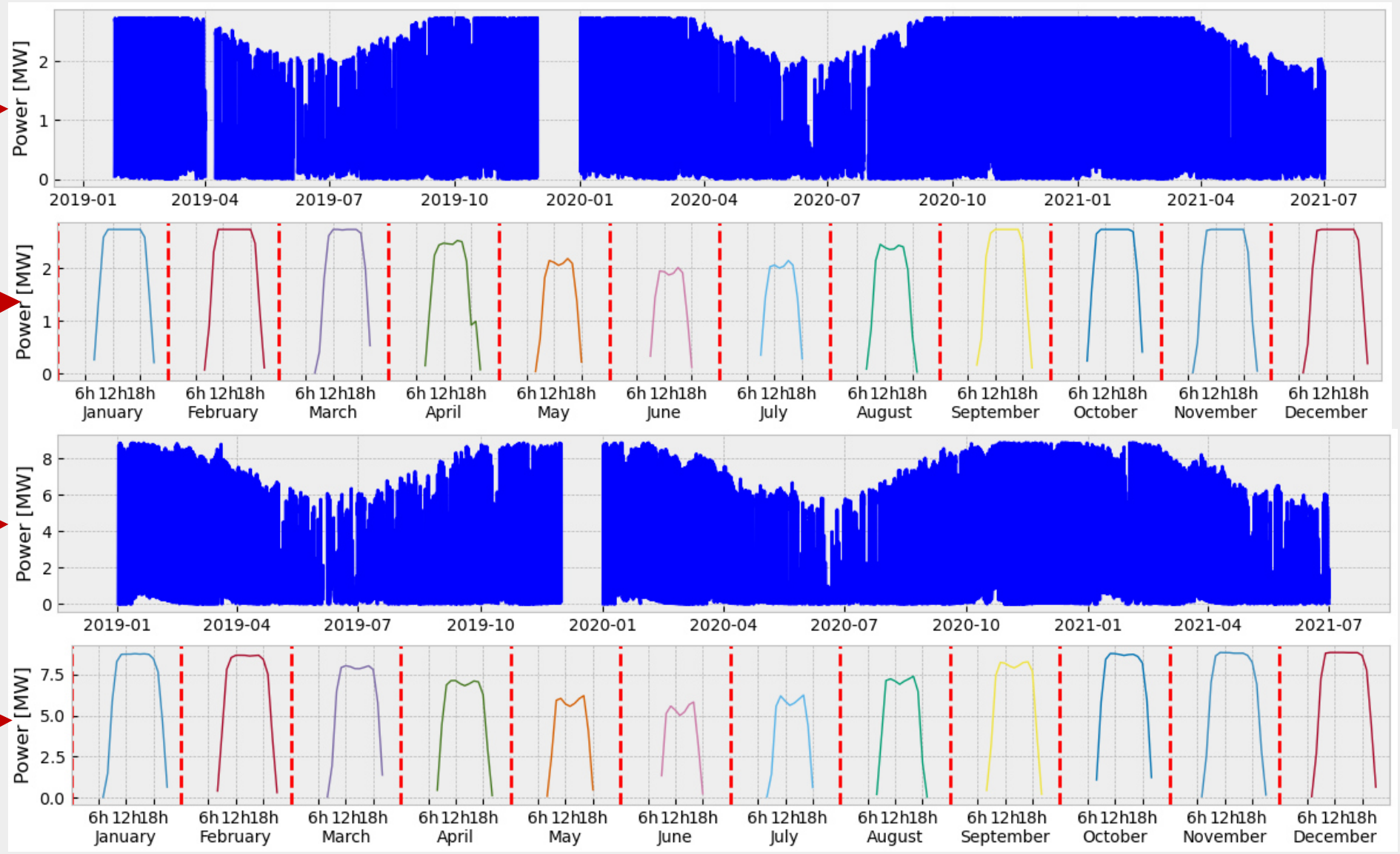
Hourly PV Production

Average TDP

PV System 3

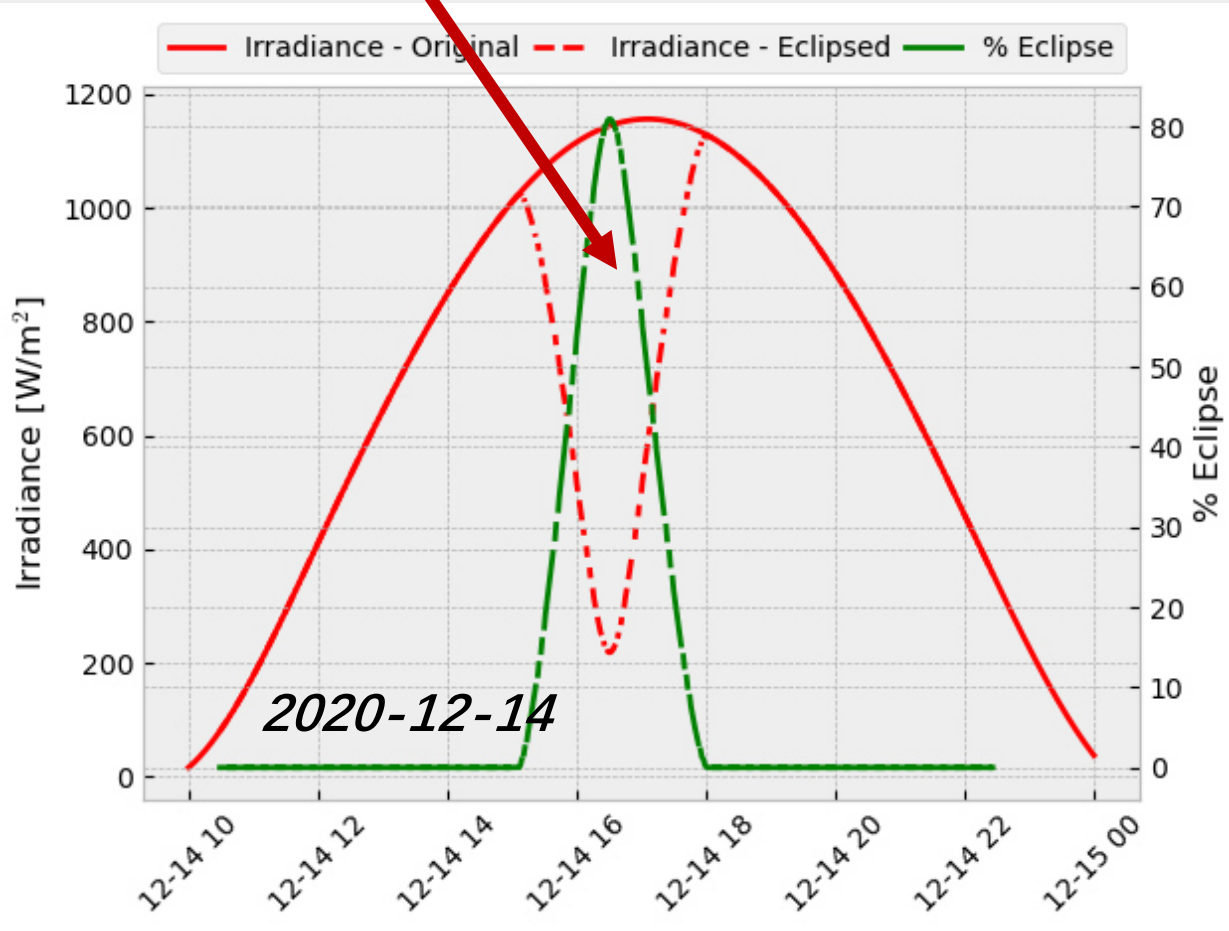
Hourly PV Production

Average TDP

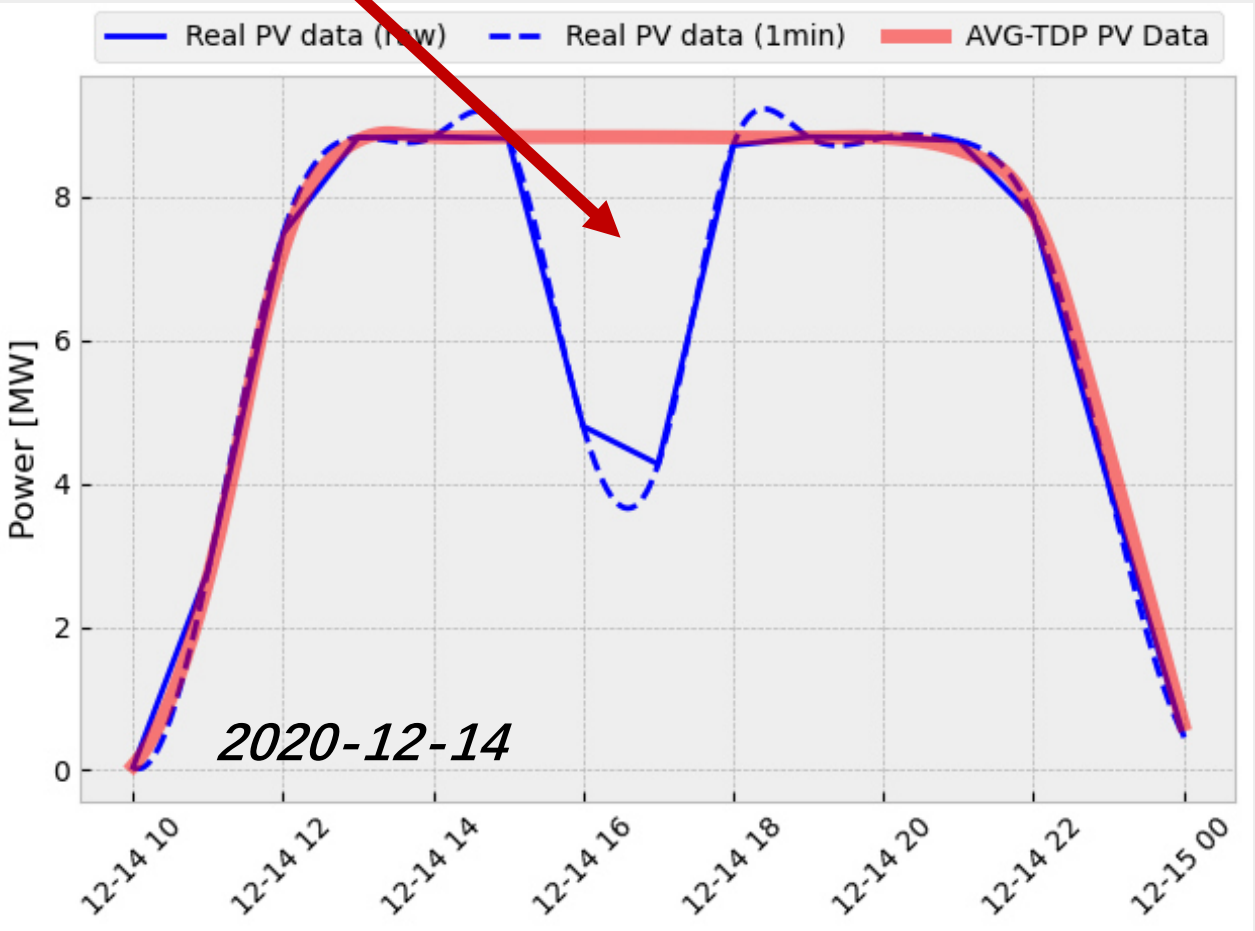


Calculation of irradiance and PV production losses

Irradiance losses



PV Production losses



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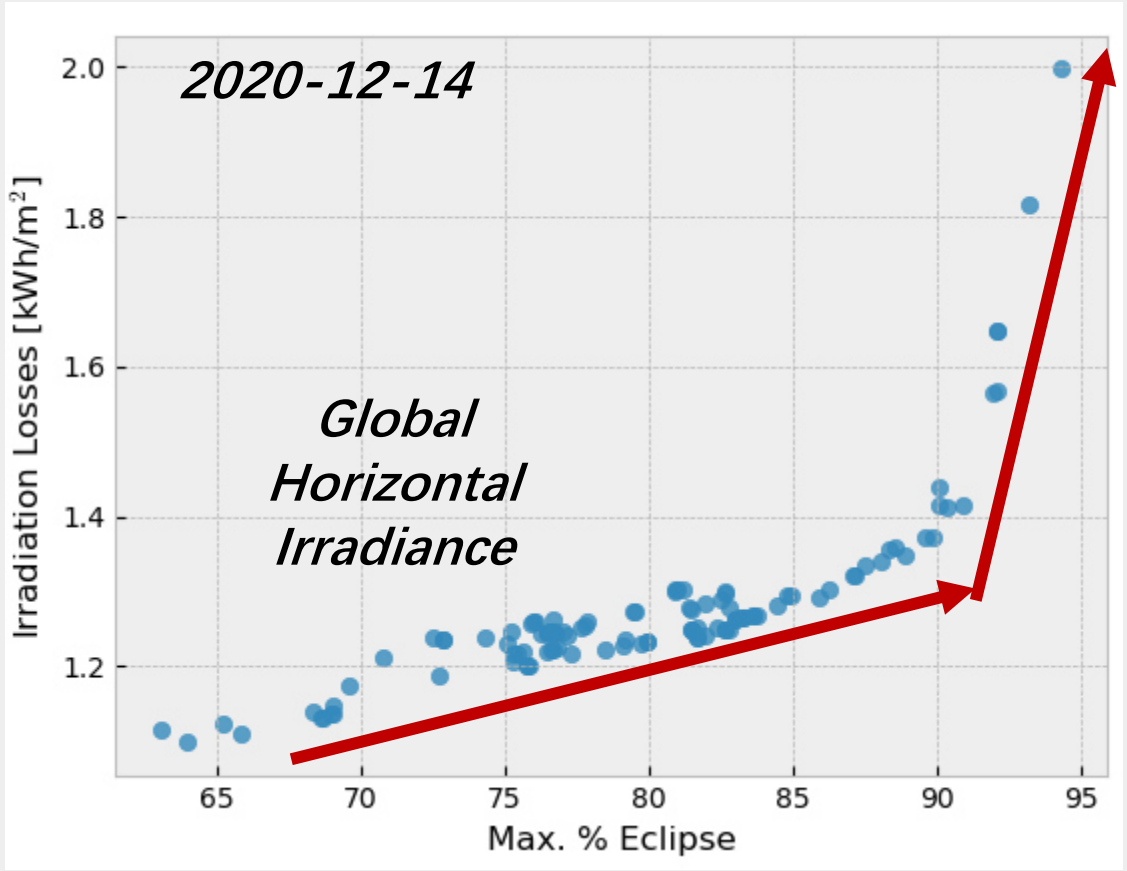

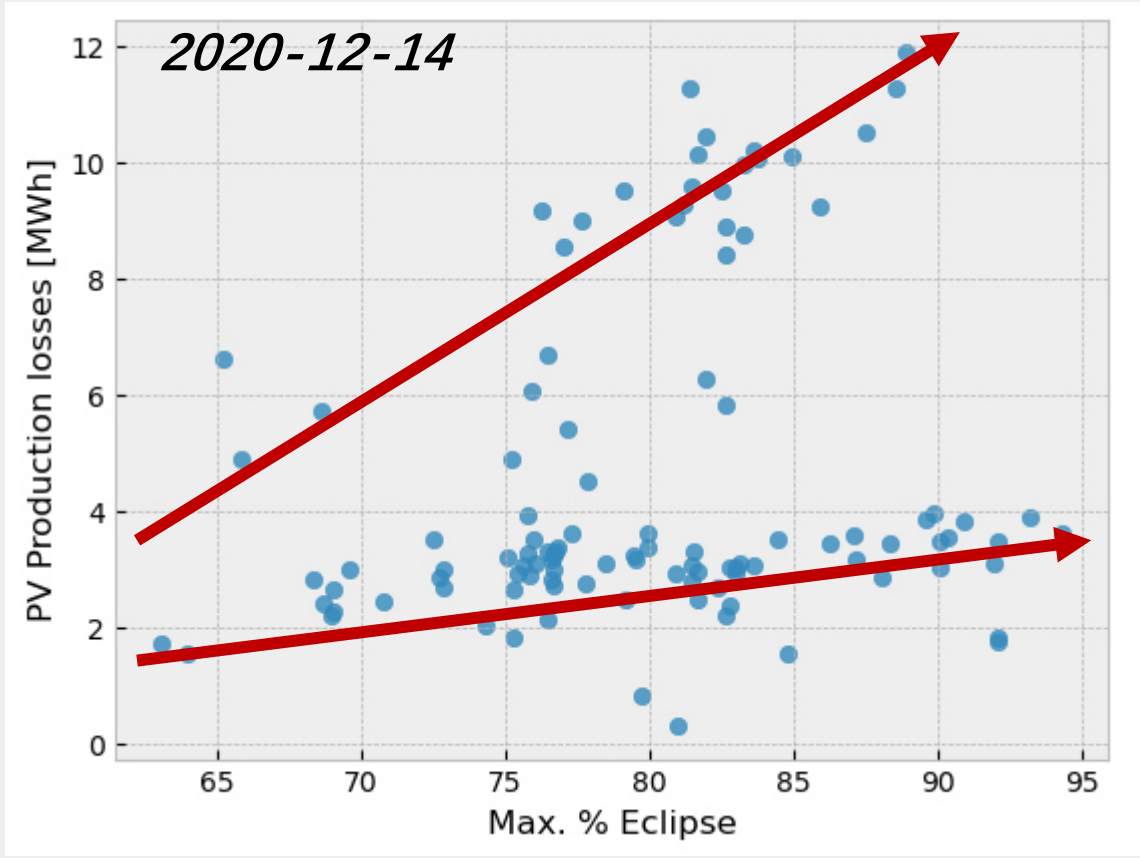

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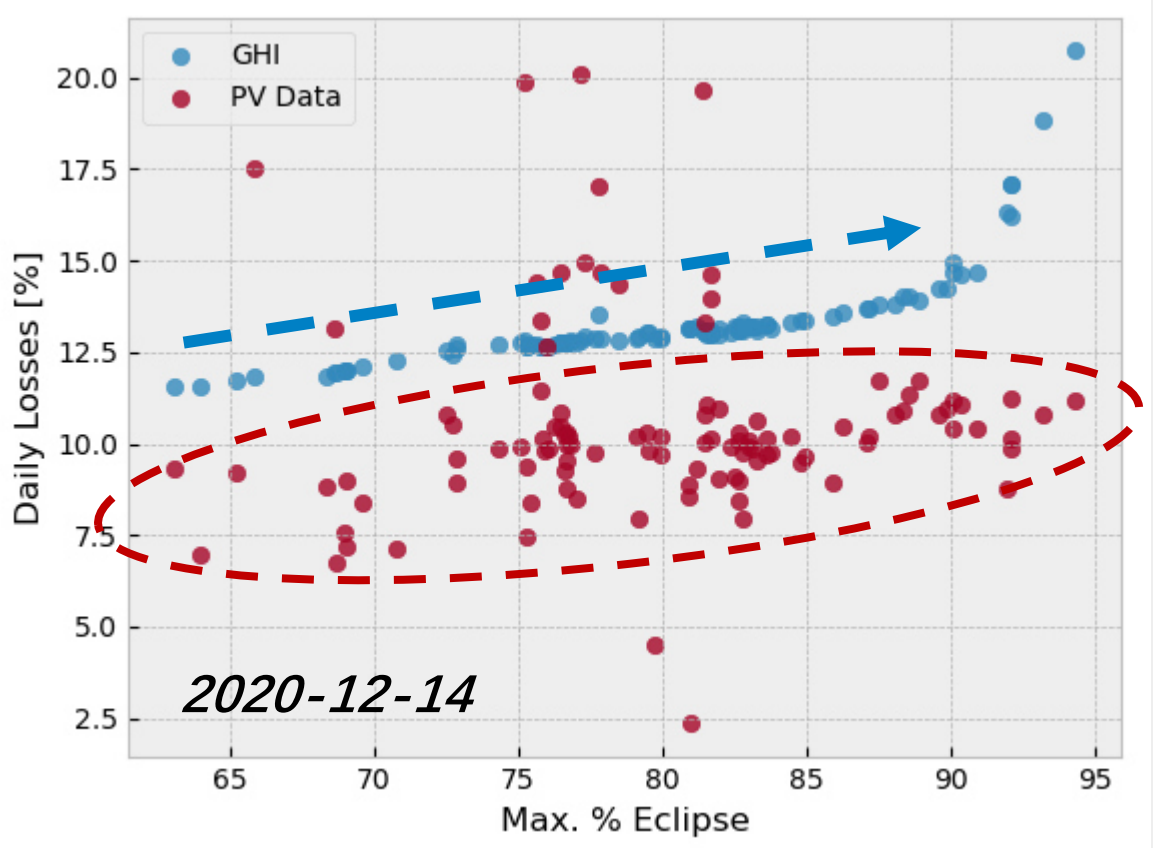

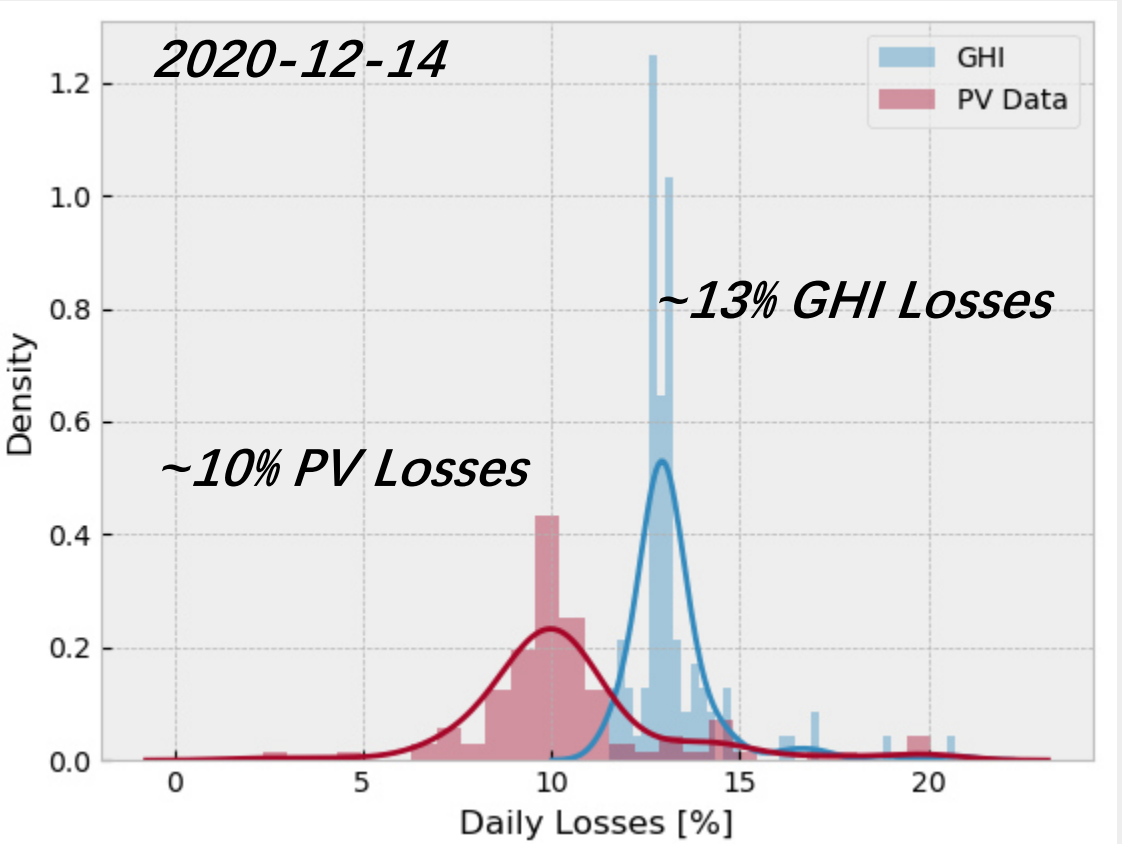

Conclusions

Conclusions

- **Quantification of irradiance changes and PV losses** during Solar Eclipses can help TSOs and DSOs to anticipate transient behavior and introduce mitigating measures.

- **TDP** proves to be a useful tool for modelling of any PV system
  - Python algorithms ready to be shared (contact me if interested)

- Approach can be applied to any ***known*** **temporal performance losses** (e.g., grid curtailment)

- Extend the study to other regions where **eclipses** are expected
  - M1.057 6pm 08/04/2024 Mexico/USA/Canada
  - M1.039 5pm 12/08/2026 South Europe
  - M1.079 10am 02/08/2027 North Africa Middle East
  - M1.046 10am 20/03/2034 North Africa Middle East
  - M1.077 5pm 12/08/2045 North/Central America

Thank You

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