SATELLITE RETRIEVAL OF SURFACE SOLAR IRRADIANCE DURING AN ECLIPSE

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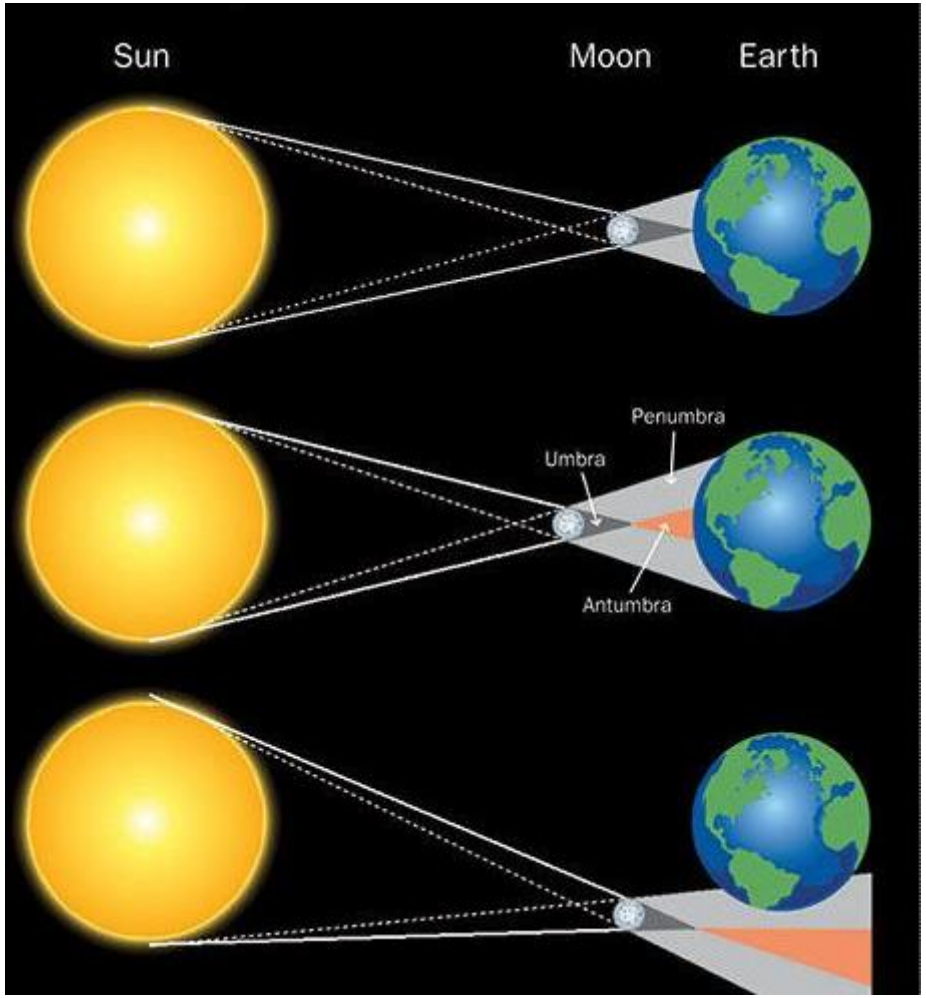
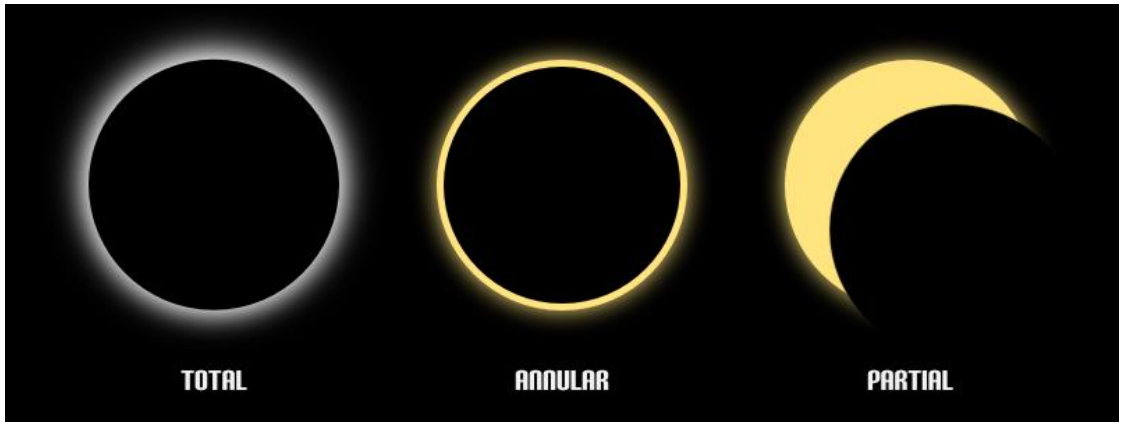
DLR

INTRODUCTION

Solar Eclipse – When does it happen ?



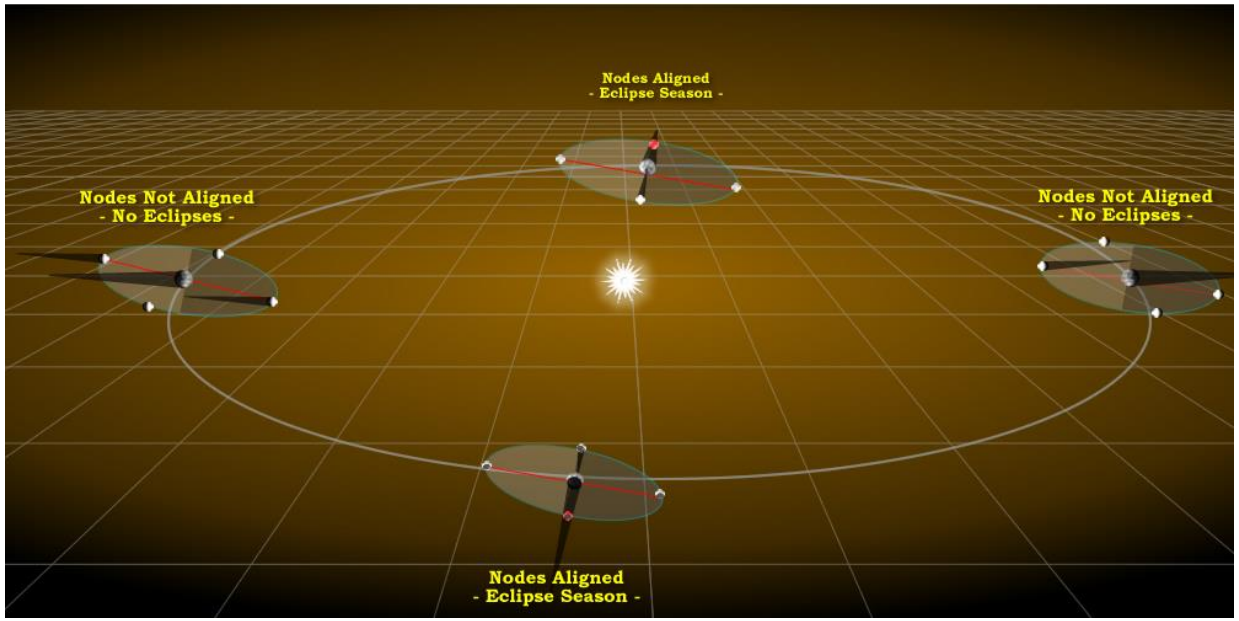
Source: https://www.timeanddate.com/eclipse/solar-eclipse.html



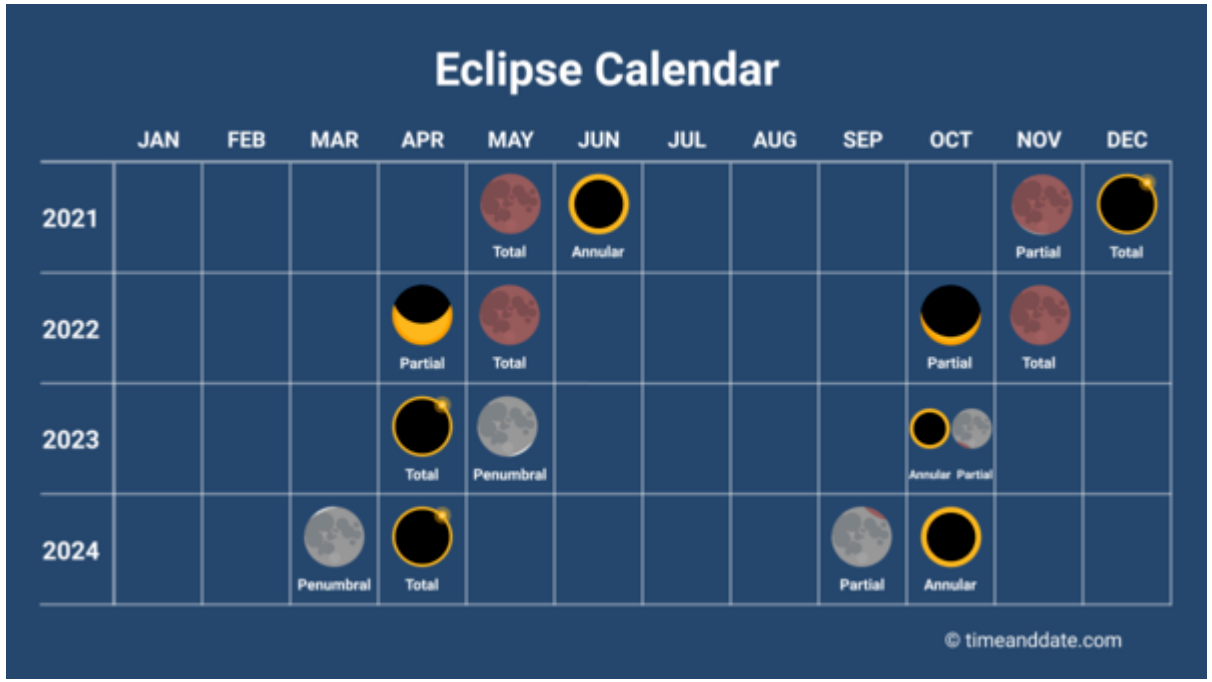
Source: https://photographylife.com/landscapes/how-to-photograph-a-solar-eclipse

- Moon between the Earth and Sun.
- Moon shadow on the Earth surface.
- Reduction in Surface Solar Irradiance (SSI)

Solar Eclipse – How frequent are they ?



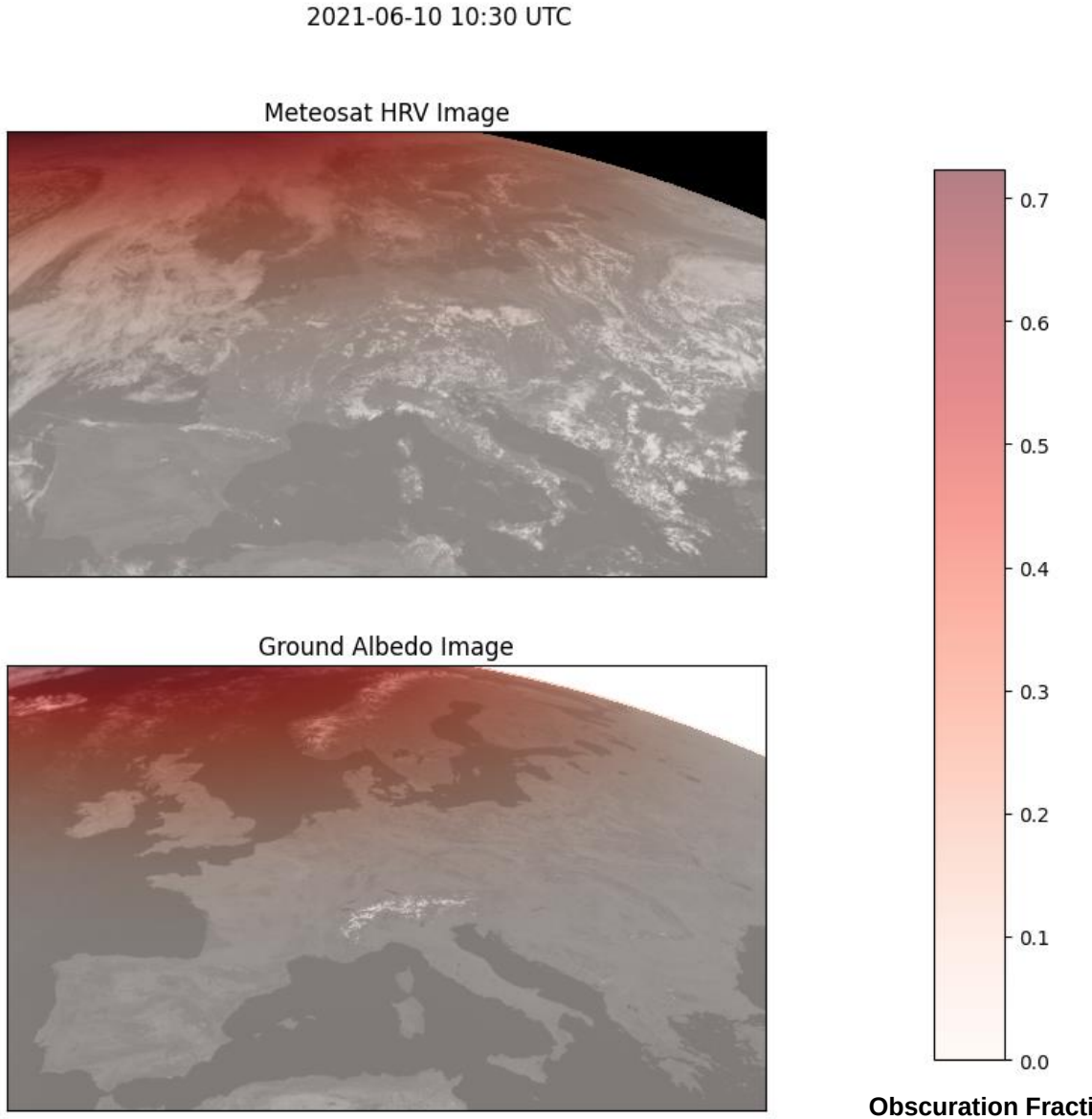
Source: http://gosciencego.com/what-is-eclipse-season



Source: https://www.timeanddate.com/eclipse/solar-eclipse.html

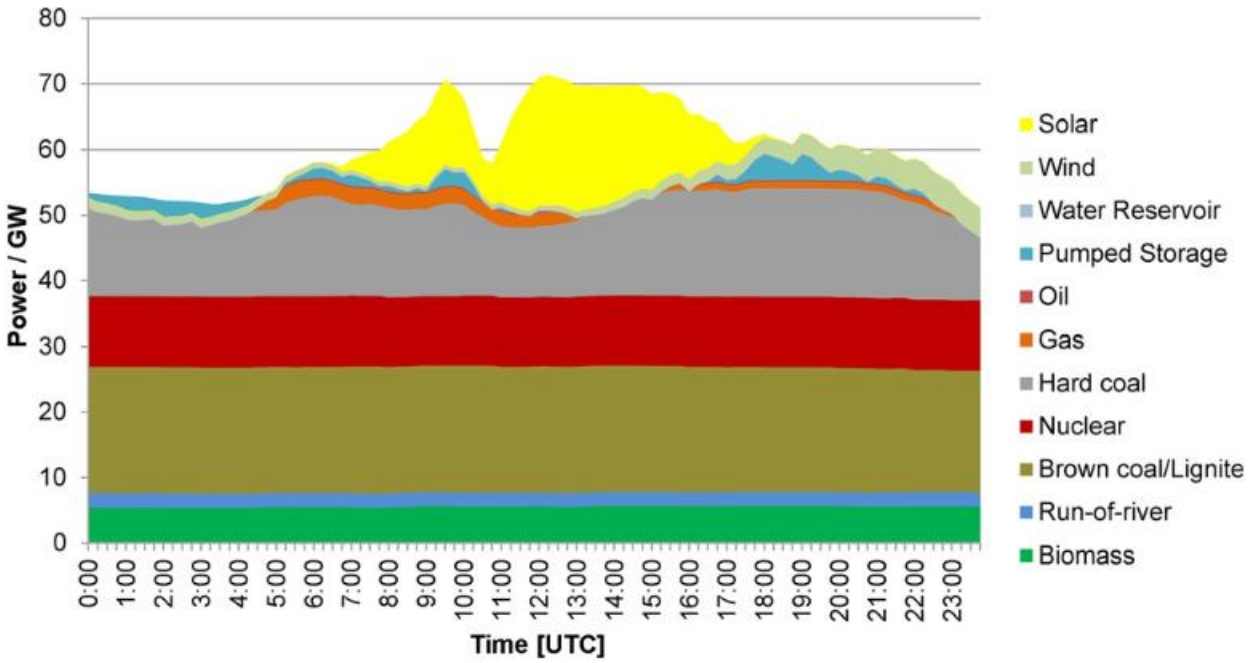
Solar Eclipse – Effect on Satellite Retrieval

- Lower pixel intensity in regions affected by eclipse → lower Bidirectional Reflectivity Factor (BRF)
  - Clouds appear darker → lower Cloud Index (CI) → Over-estimation of SSI
  - Land surface appears darker → lower (or negative) CI → Over-estimation of SSI

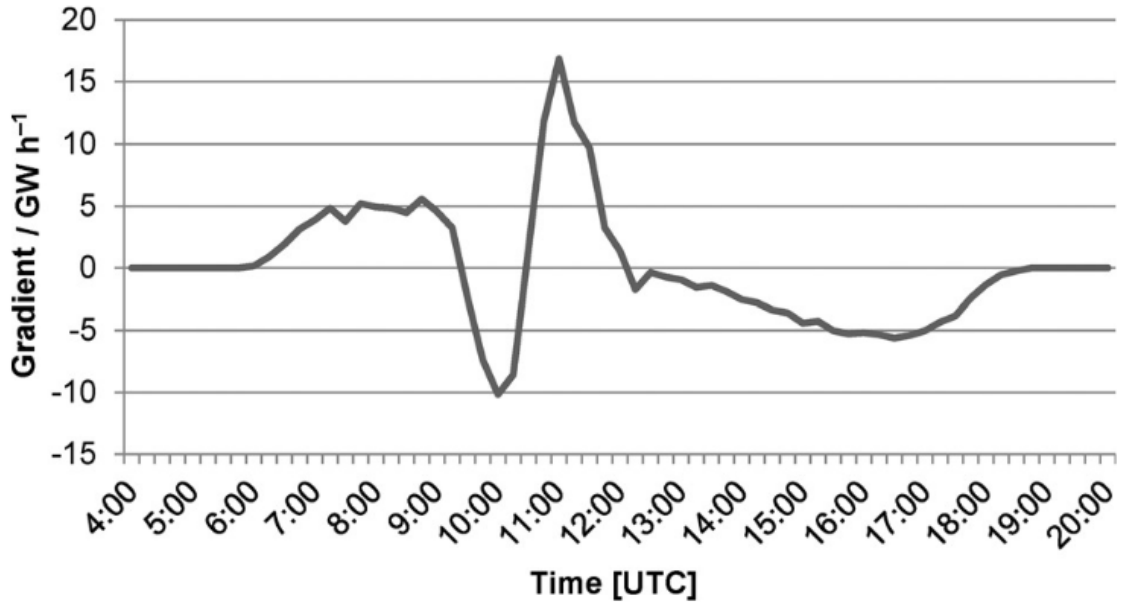


Roy et al, DLR, Institute of Networked Energy Systems

Solar Eclipse – Impact on Solar Generation



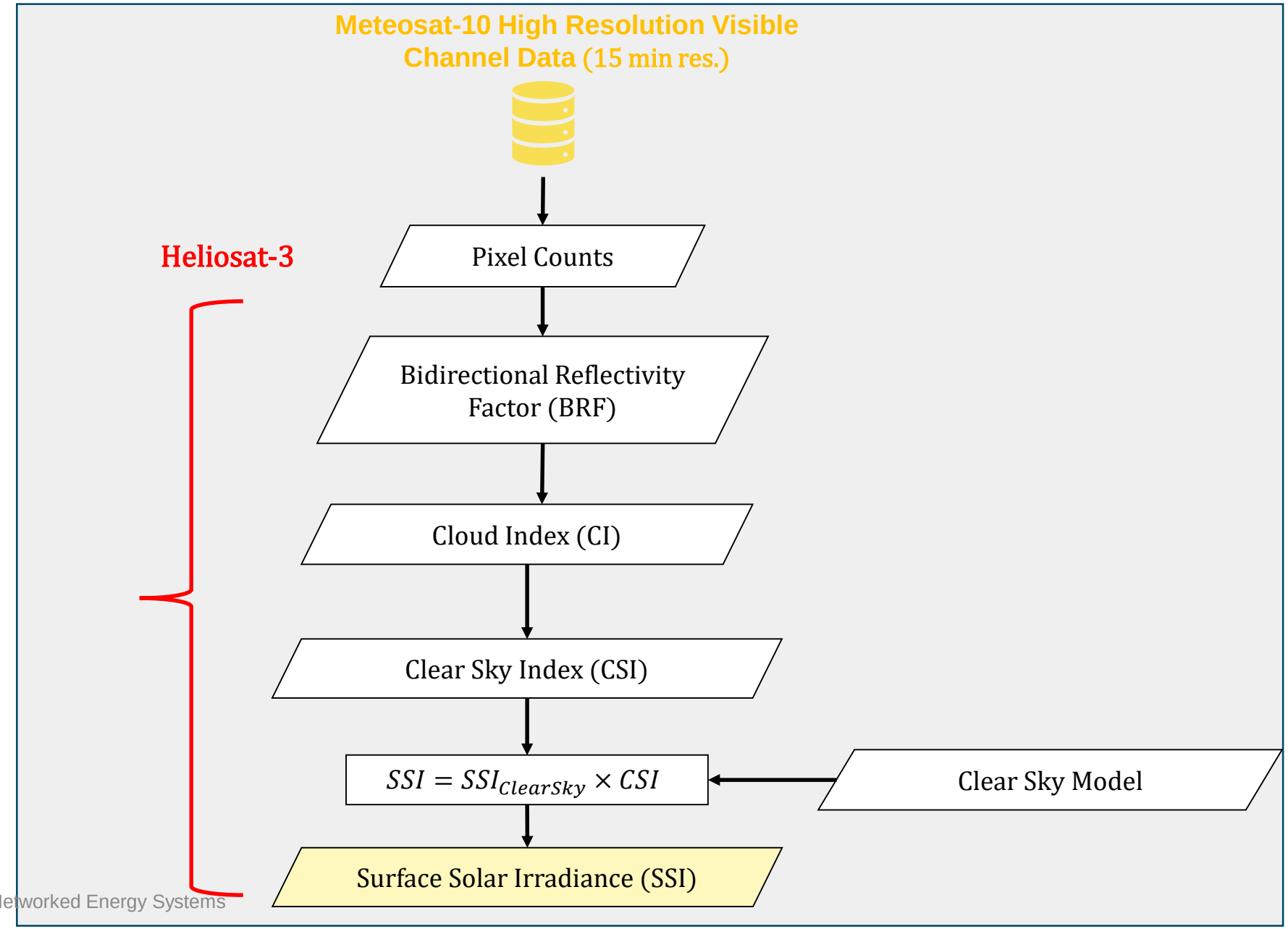
Technology based energy generation in Germany on 20.03.2015



Gradient of PV production on 20.03.2015 derived from EEX PV data

*** Source:** *Killinger et al 2015* Impact of the Solar Eclipse from 20th Match 2015 on the German Electrical Supply – Simulation and Analysis

Satellite Retrieval of SSI



Our Method

Astronomical Ephemeris

Meteosat-10 High Resolution Visible Channel Data (15 min res.)[1]

Heliosat-3

Pixel Counts

Bidirectional Reflectivity Factor (BRF)

Corrected BRF

Cloud Index (CI)

Clear Sky Index (CSI)

$BRF_{corr} = \frac{BRF_{meas}}{(1 - OF)}$

Obscuration Fraction (OF)

Clear Sky Model

$SSI = SSI_{ClearSky} \times CSI \times (1 - OF)$

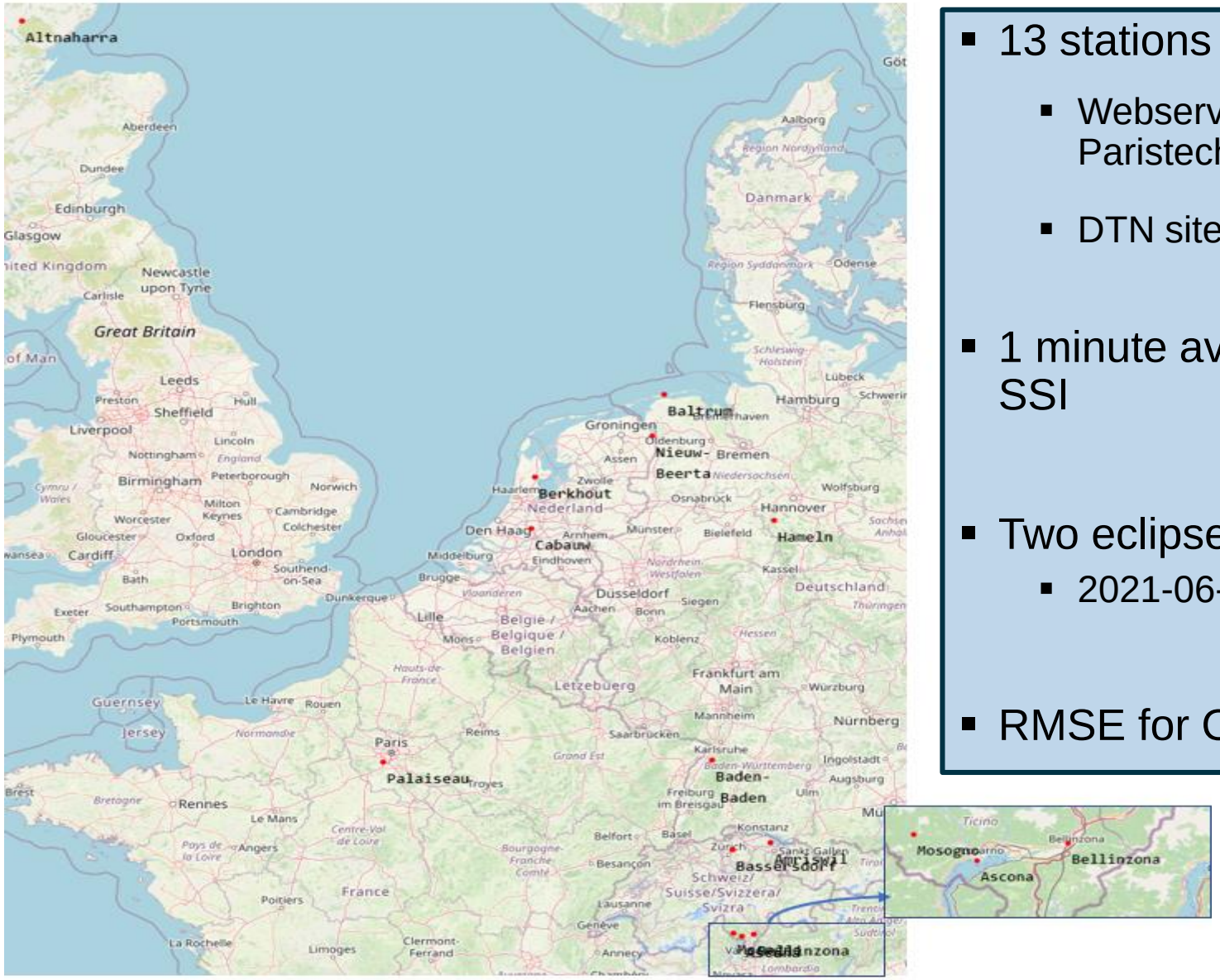
Surface Solar Irradiance (SSI)

Validation against Ground Measurements

- 13 stations
  - Webservíce energy data from MINES Paristech[1]
  - Meteomedia sites[2]
- 1 minute averaged ground measured SSI
- Two eclipse events in Europe
  - 2021-06-10; 2022-10-25
- RMSE for Obscuration Fraction > 0

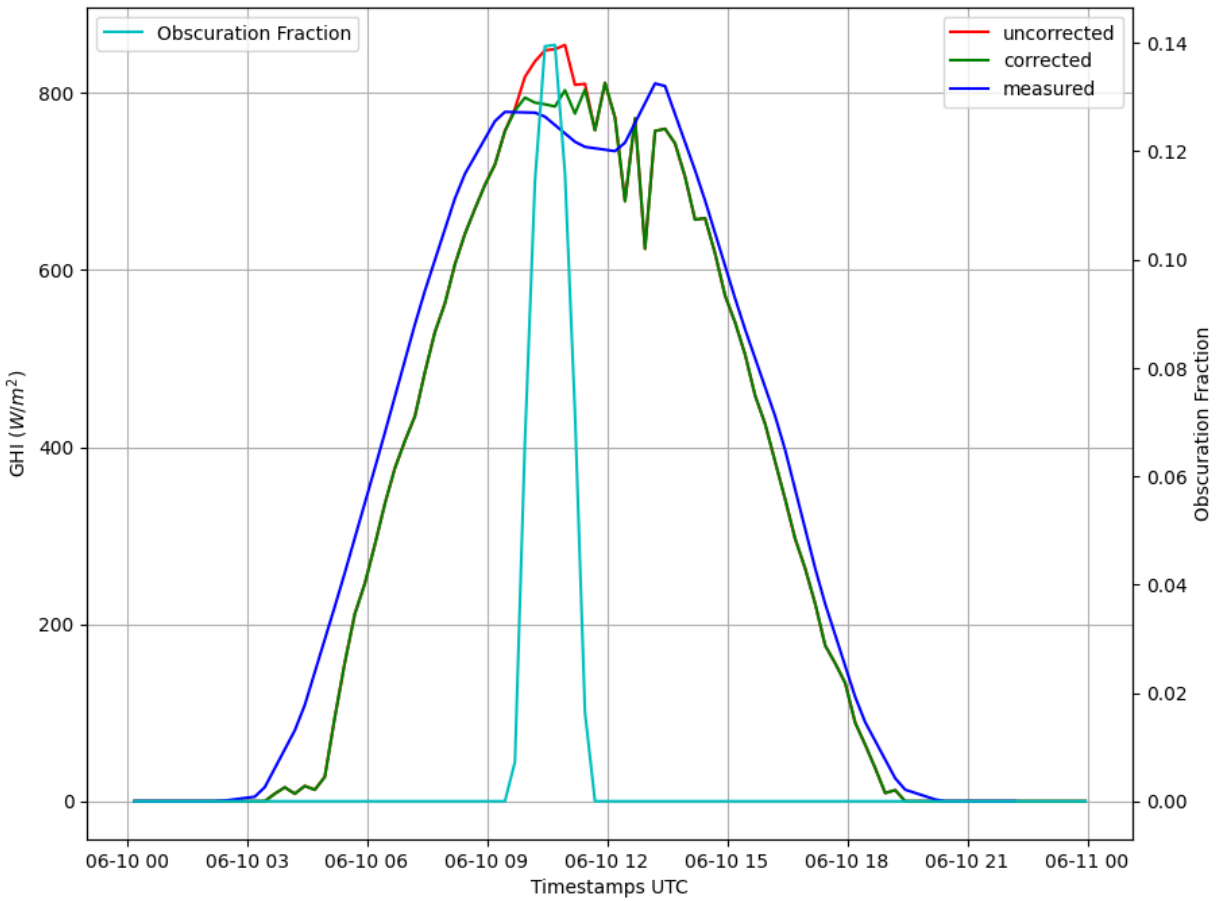
1. THREDDS data server https://viewer.webservice-energy.org/in-situ/ obtained with libinsitu (https://pypi.org/project/libinsitu/)
2. https://wetterstationen.meteomedia.de/station=092150&wahl=vorhersage

Validation against Ground Measurements

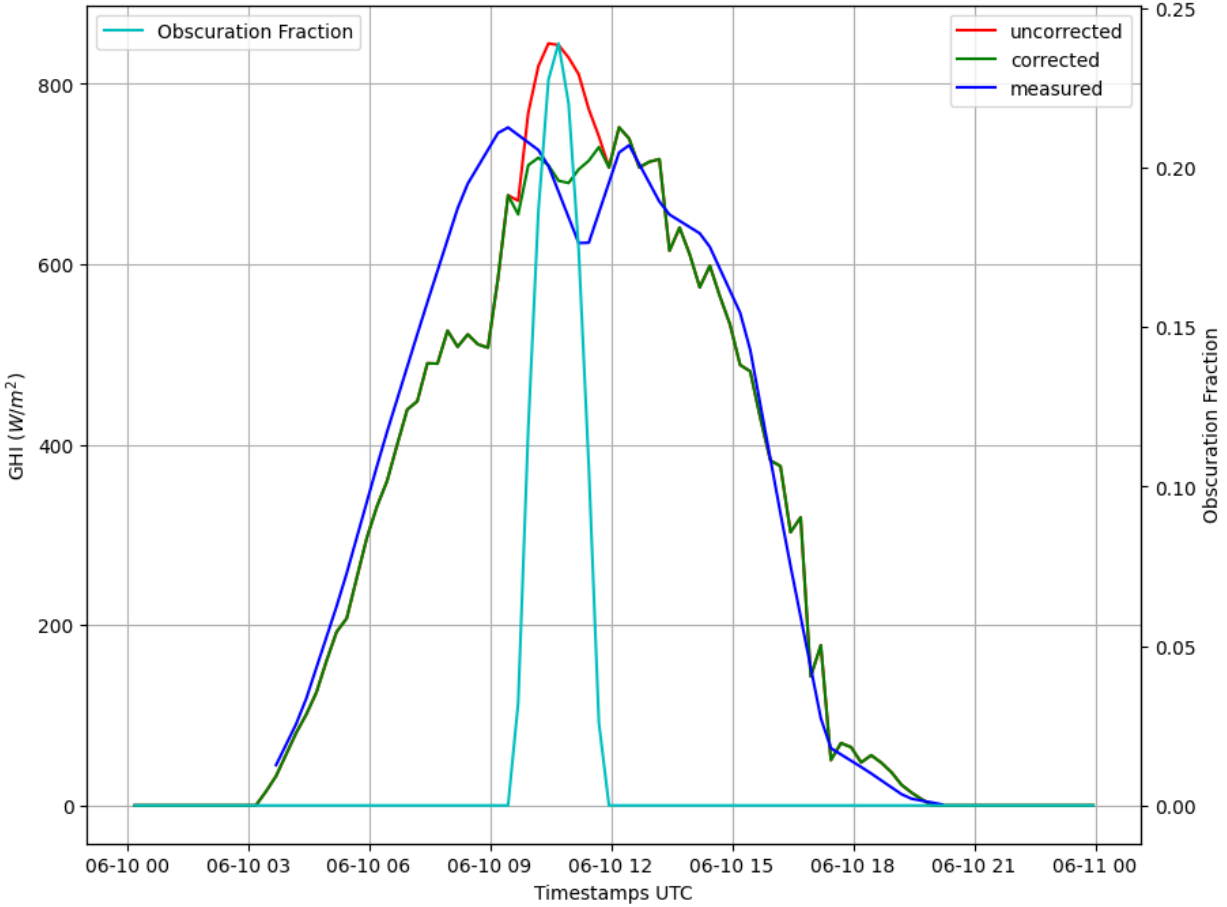


- 13 stations
  - Webservíce energy data from MINES Paristech
  - DTN sites
- 1 minute averaged ground measured SSI
- Two eclipse events in Europe
  - 2021-06-10; 2022-10-25
- RMSE for Obscuration Fraction > 0

Validation against Ground Measurements

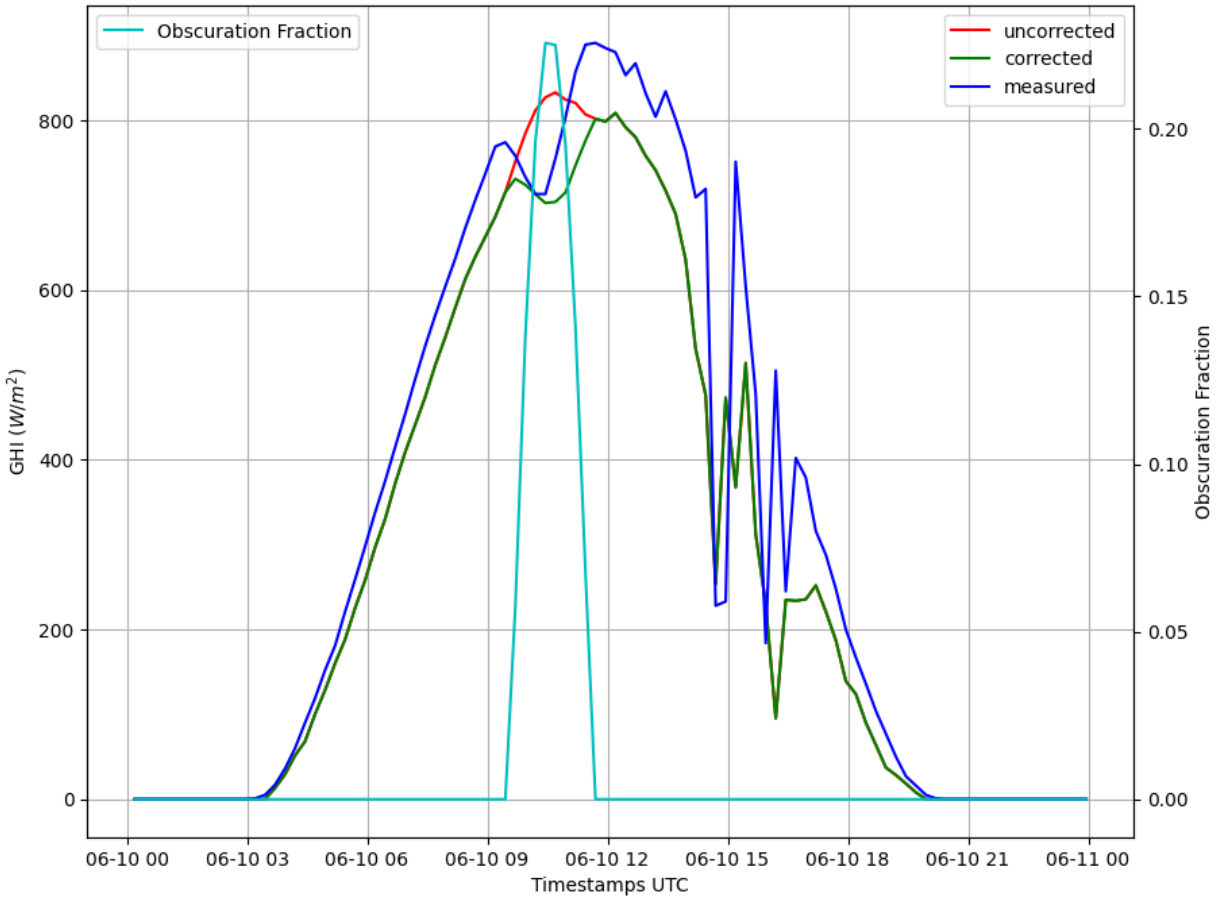


Baden-Baden

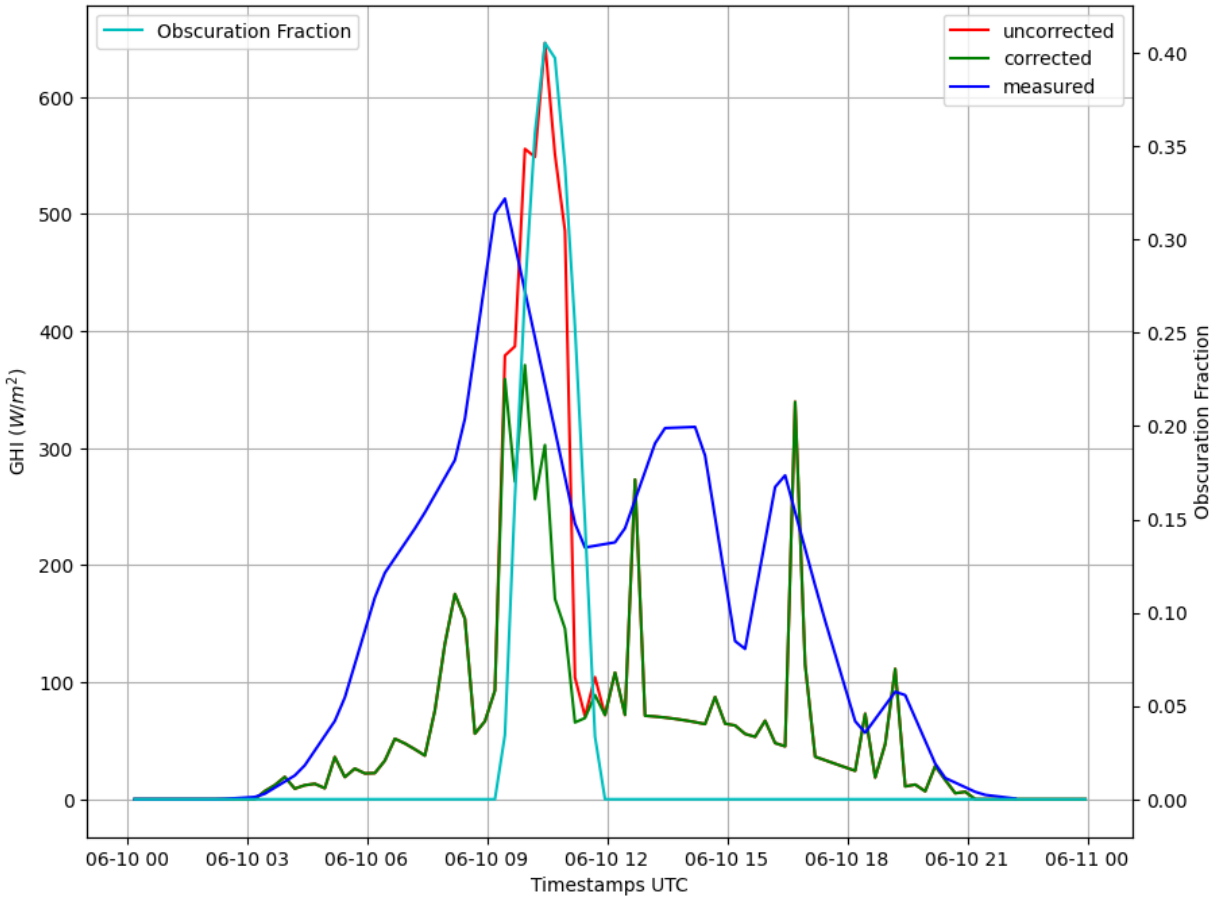


Nieuw Beerta

Validation against Ground Measurements



Cabauw



Altnaharra

Validation against Ground Measurements –

2021-06-10

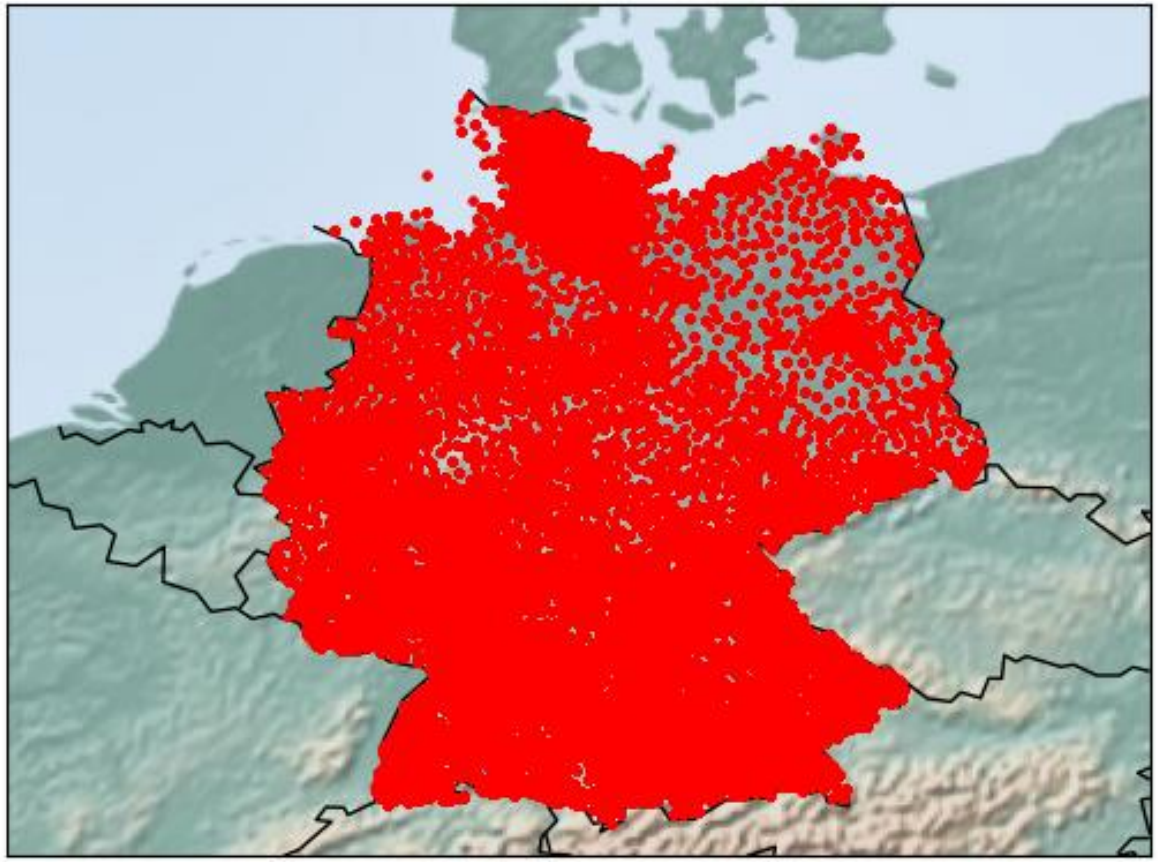
Site name	Pre-correction rel. RMSE	Post-correction rel. RMSE
Altnaharra	50.50 %	40.67 %
Amriswil	17.28 %	13.27 %
Baden-Baden	8.92 %	4.30 %
Bassersdorf	19.28 %	15.57 %
Cabauw	9.09 %	8.66 %
Hameln	79.93 %	66.51 %
Nieuw Beerta	19.23 %	8.49 %
Palaiseau	36.40 %	32.56 %

Validation against Ground Measurements –

2022-10-25

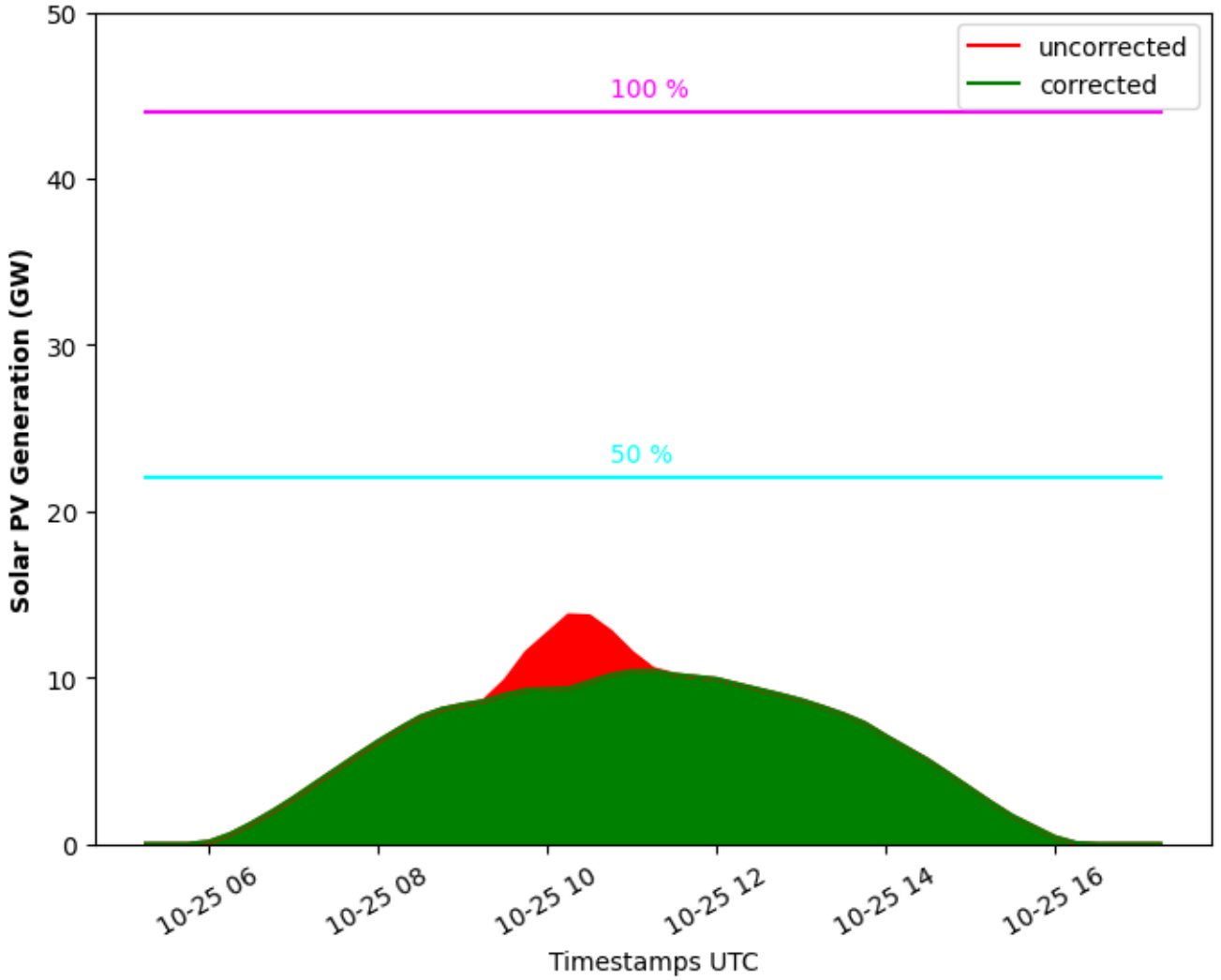
Site name	Pre-correction rel. RMSE	Post-correction rel. RMSE
Altnaharra	53.28 %	46.26 %
Baden-Baden	29.26 %	16.55 %
Baltrum	22.01 %	19.13 %
Berkhout	8.85 %	8.26 %
Berolle	24.89 %	20.99 %
Mosogno	18.33 %	15.37 %
Nieuw Beerta	51.47 %	31.90 %
Sax	14.64 %	10.65 %

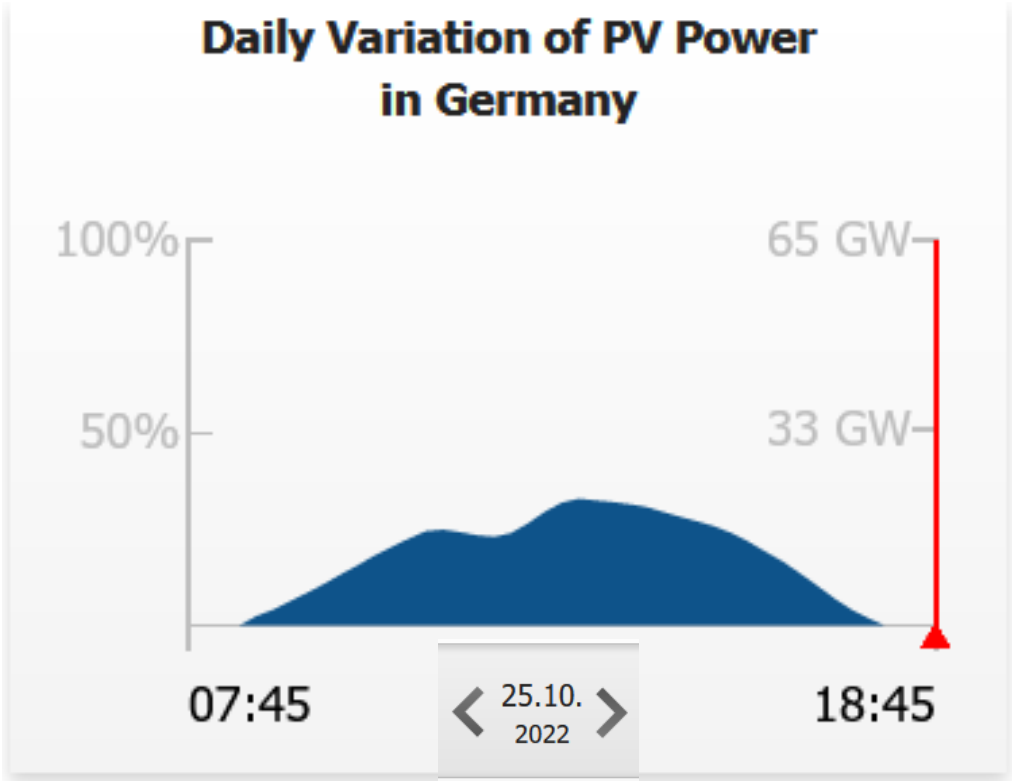
Simulation of PV Generation Shortfall during Solar Eclipse



- Location and capacity of PV plants from Open Power System Data https://open-power-system-data.org/
- Info available on 44 GW installed capacity approximately
- Effect of temperature neglected

Simulation of PV Generation Shortfall during Solar Eclipse





Source: https://www.timeanddate.com/eclipse/solar-eclipse.html

- Applying the corrections to CI forecast made in eclipse period.
- It is the direct irradiance that is obscured. How to treat the diffused ?
- How do the reductions due to eclipse compare to typical redispatch performed by grid operators ?


THANK YOU