APPENDIX B
RESULTS FOR SOUTHEAST-FACING PV ARRAYS

Glare Analysis Results

Summary of Results

Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
PV array 6	10.0	103.0	59,069	984.5	0	0.0	-	6,323
PV array 7	10.0	103.0	68,797	1,146.6	0	0.0	-	95,217

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1000Ft-GA_5L23R_05L-L_23R-R	7,260	121.0	0	0.0
1000Ft-GA_5L23R_05L-R_23R-L	23,073	384.6	0	0.0
1000Ft-GA_5R23L_05R-L_23L-R	0	0.0	0	0.0
1000Ft-GA_5R23L_05R-R_23L-L	13,107	218.4	0	0.0
1500Ft-CA_5L23R_05L-L_23R-R	11,351	189.2	0	0.0
1500Ft-CA_5L23R_05L-R_23R-L	23,446	390.8	0	0.0
Approach_05L	0	0.0	0	0.0
Approach_05R	0	0.0	0	0.0
Approach_23L	12,210	203.5	0	0.0
Approach_23R	13,137	218.9	0	0.0
1-ATCT	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	2,771	46.2	0	0.0
OP 6	1,176	19.6	0	0.0
OP 7	940	15.7	0	0.0
OP 8	0	0.0	0	0.0
OP 9	2,109	35.1	0	0.0
OP 10	1,943	32.4	0	0.0

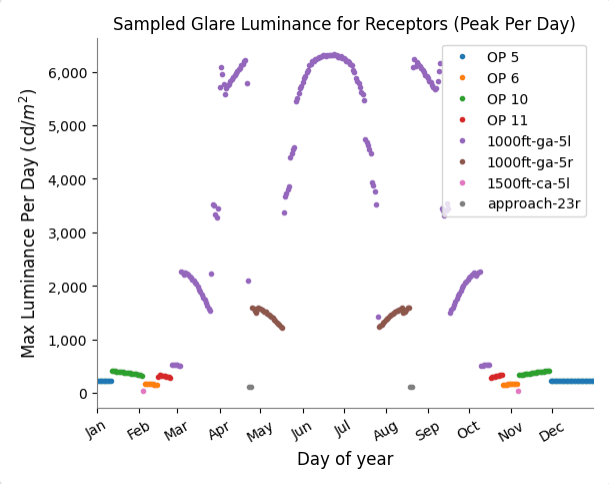
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 11	1,154	19.2	0	0.0
OP 12	958	16.0	0	0.0
OP 13	913	15.2	0	0.0
OP 14	0	0.0	0	0.0
OP 15	968	16.1	0	0.0
OP 16	1,166	19.4	0	0.0
OP 17	3,329	55.5	0	0.0
OP 18	2,991	49.9	0	0.0
OP 19	1,784	29.7	0	0.0
OP 20	0	0.0	0	0.0
OP 21	1,323	22.1	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	448	7.5	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0
OP 32	309	5.2	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

PV: PV array 6 low potential for temporary after-image

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
1000Ft-GA_5L23R_05L-L_23R-R	3,574	59.6	0	0.0	231
1000Ft-GA_5L23R_05L-R_23R-L	9,538	159.0	0	0.0	6,323
1000Ft-GA_5R23L_05R-R_23L-L	5,719	95.3	0	0.0	1,597
1500Ft-CA_5L23R_05L-L_23R-R	5,645	94.1	0	0.0	230
1500Ft-CA_5L23R_05L-R_23R-L	11,628	193.8	0	0.0	230
Approach_23L	6,060	101.0	0	0.0	146
Approach_23R	6,524	108.7	0	0.0	230
1000Ft-GA_5R23L_05R-L_23L-R	0	0.0	0	0.0	0
Approach_05L	0	0.0	0	0.0	0
Approach_05R	0	0.0	0	0.0	0
OP 5	1,317	21.9	0	0.0	235
OP 6	523	8.7	0	0.0	168
OP 7	426	7.1	0	0.0	111
OP 9	1,024	17.1	0	0.0	208
OP 10	804	13.4	0	0.0	411
OP 11	475	7.9	0	0.0	335
OP 12	410	6.8	0	0.0	207
OP 13	406	6.8	0	0.0	130
OP 15	419	7.0	0	0.0	299
OP 16	439	7.3	0	0.0	577
OP 17	1,204	20.1	0	0.0	968
OP 18	1,261	21.0	0	0.0	244
OP 19	792	13.2	0	0.0	131
OP 21	563	9.4	0	0.0	291
OP 26	215	3.6	0	0.0	101
OP 32	103	1.7	0	0.0	64

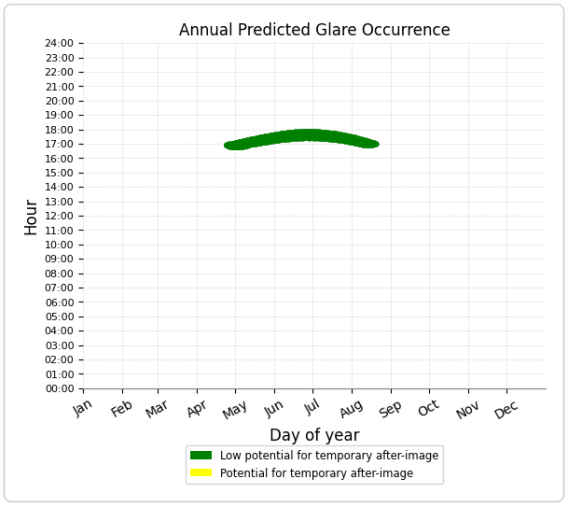
Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
1-ATCT	0	0.0	0	0.0	0
OP 2	0	0.0	0	0.0	0
OP 3	0	0.0	0	0.0	0
OP 4	0	0.0	0	0.0	0
OP 8	0	0.0	0	0.0	0
OP 14	0	0.0	0	0.0	0
OP 20	0	0.0	0	0.0	0
OP 22	0	0.0	0	0.0	0
OP 23	0	0.0	0	0.0	0
OP 24	0	0.0	0	0.0	0
OP 25	0	0.0	0	0.0	0
OP 27	0	0.0	0	0.0	0
OP 28	0	0.0	0	0.0	0
OP 29	0	0.0	0	0.0	0
OP 30	0	0.0	0	0.0	0
OP 31	0	0.0	0	0.0	0
OP 33	0	0.0	0	0.0	0
OP 34	0	0.0	0	0.0	0
OP 35	0	0.0	0	0.0	0
OP 36	0	0.0	0	0.0	0
OP 37	0	0.0	0	0.0	0
OP 38	0	0.0	0	0.0	0
OP 39	0	0.0	0	0.0	0
OP 40	0	0.0	0	0.0	0

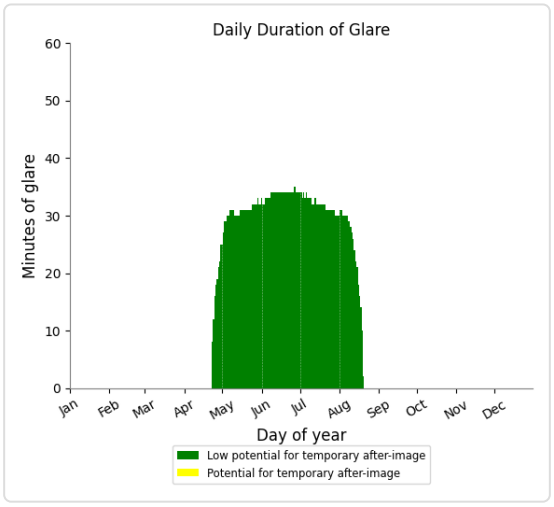


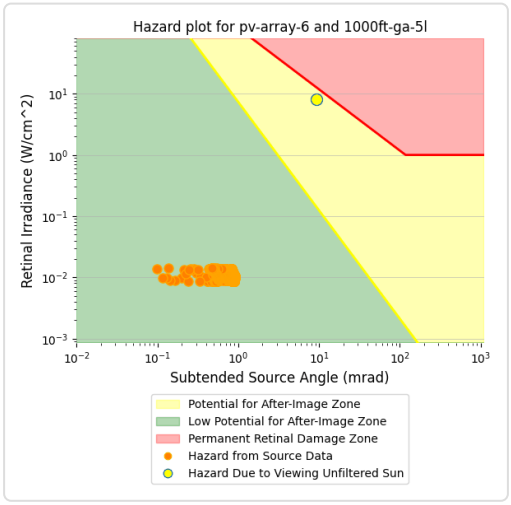
PV array 6 and Route: 1000Ft-GA_5L23R_05L-L_23R-R

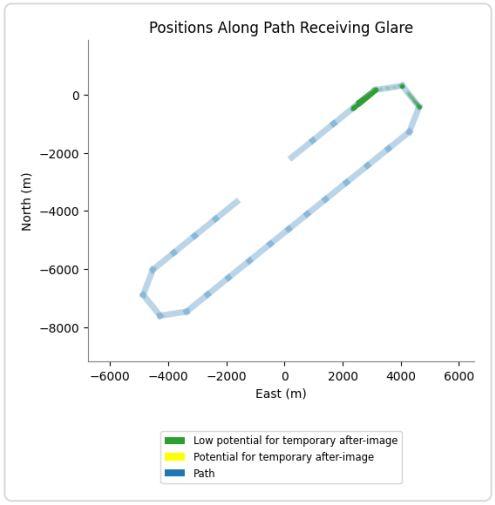
Yellow glare: none

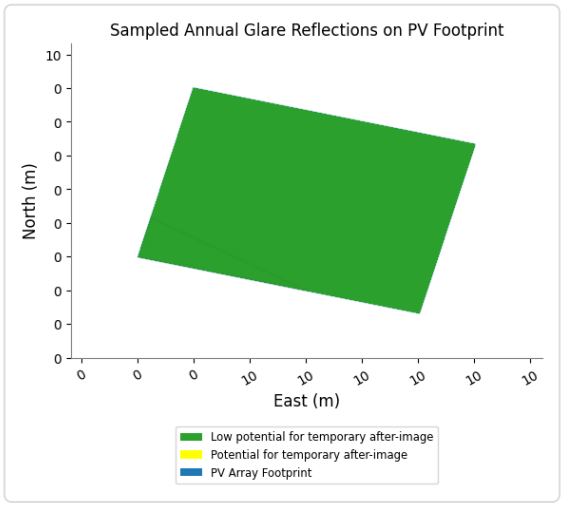
Green glare: 3,574 min.

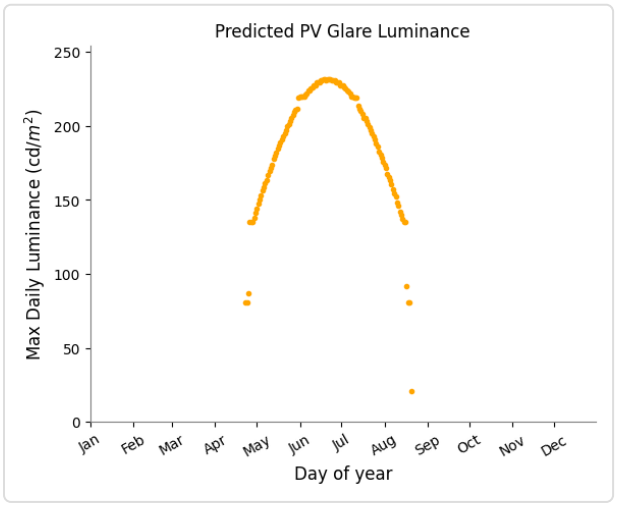








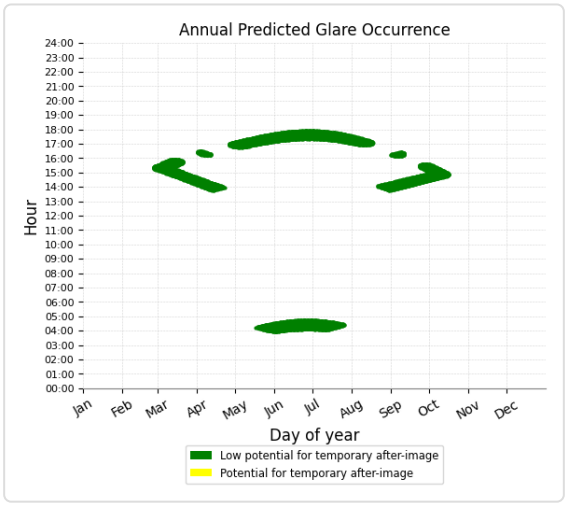


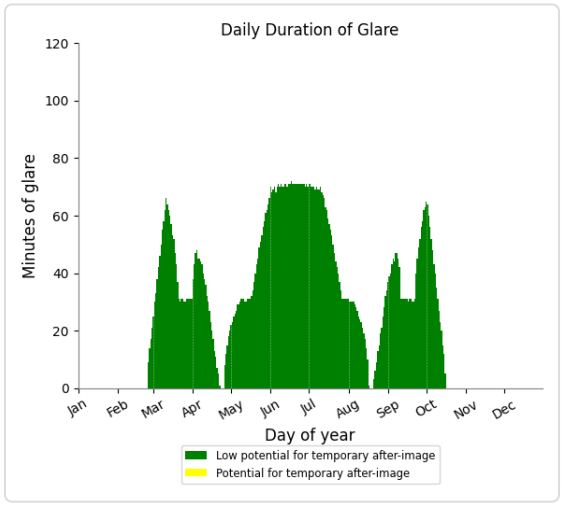


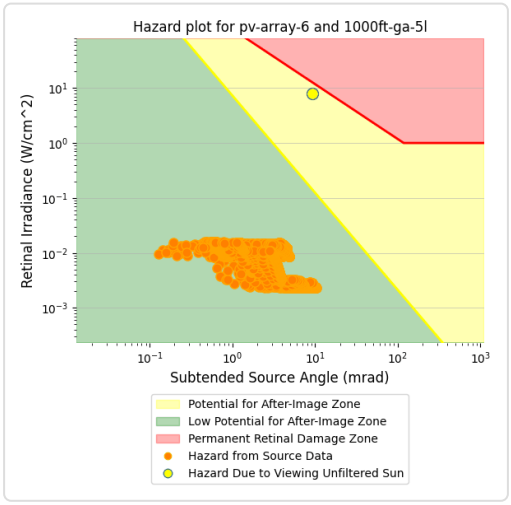
PV array 6 and Route: 1000Ft-GA_5L23R_05L-R_23R-L

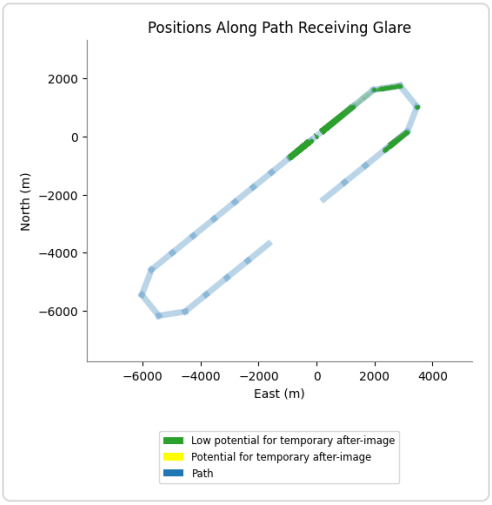
Yellow glare: none

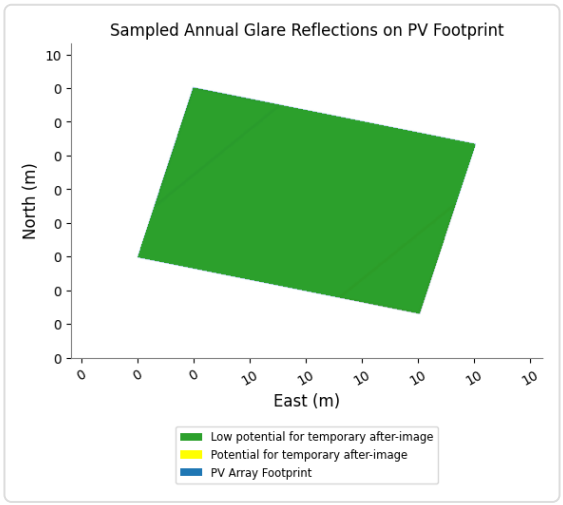
Green glare: 9,538 min.

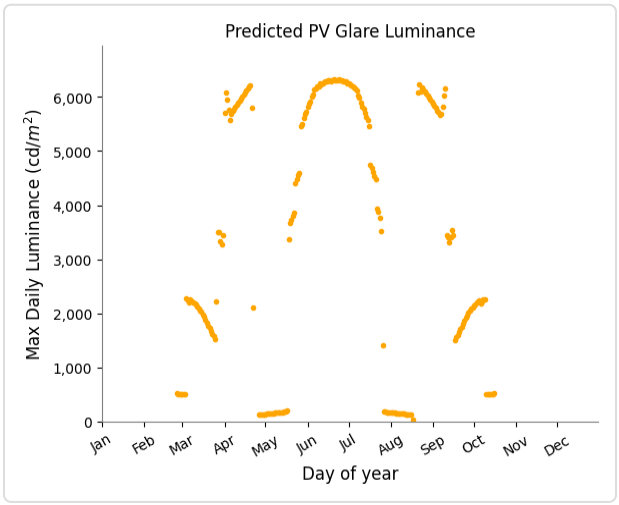








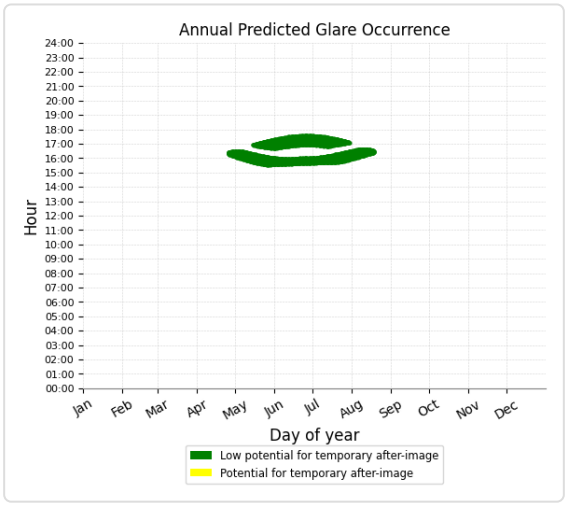


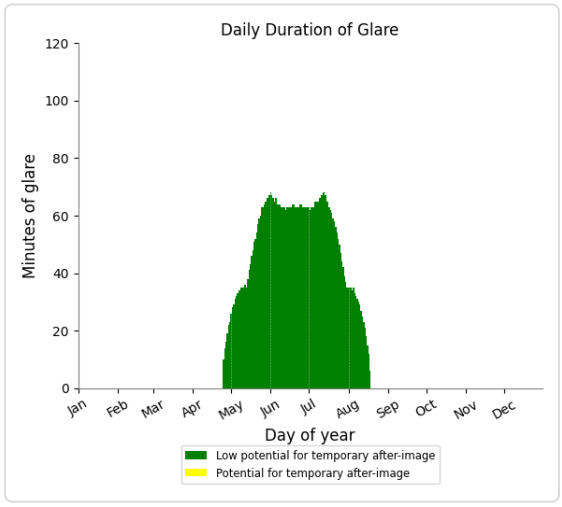


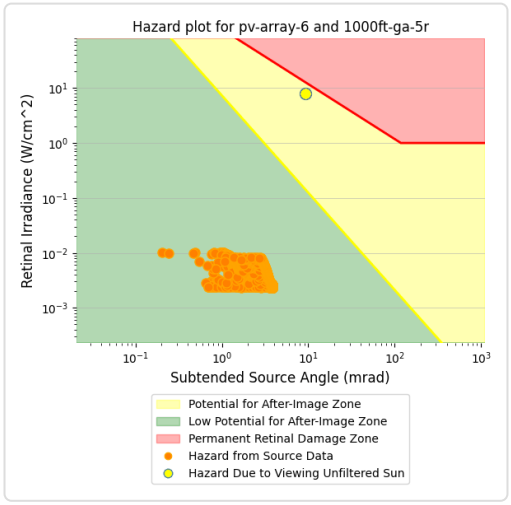
PV array 6 and Route: 1000Ft-GA_5R23L_05R-R_23L-L

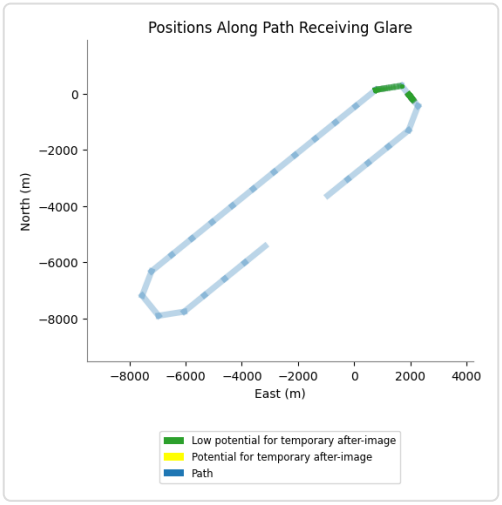
Yellow glare: none

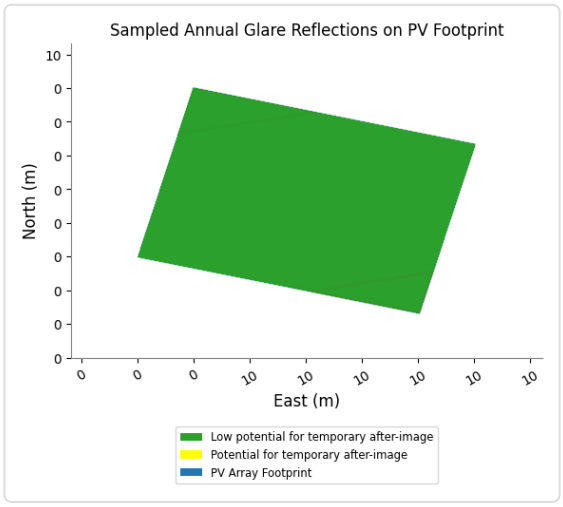
Green glare: 5,719 min.

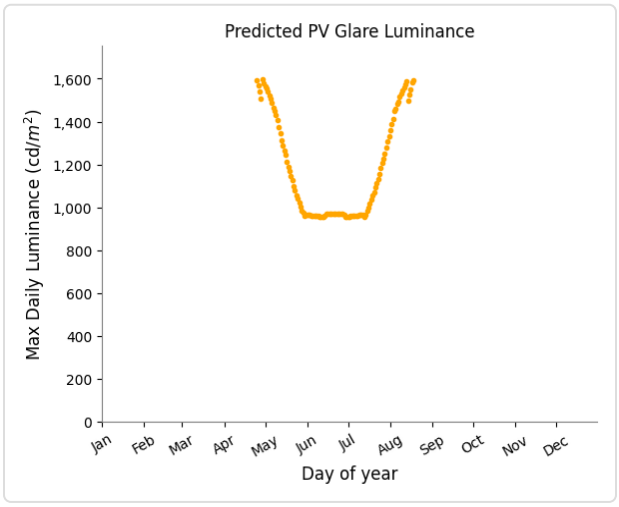








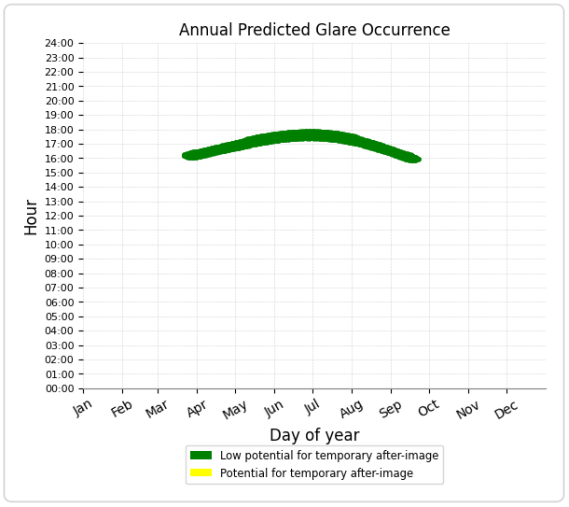


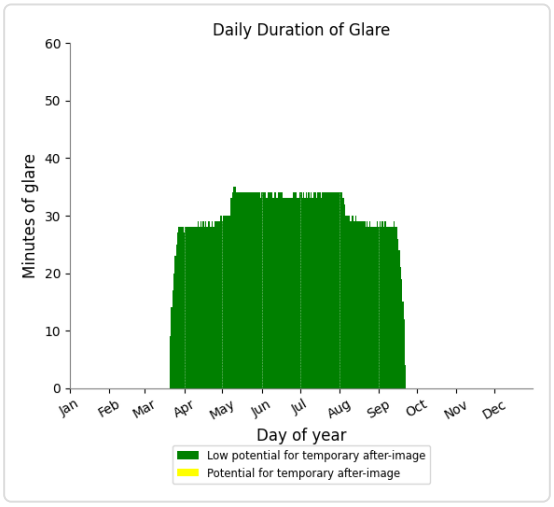


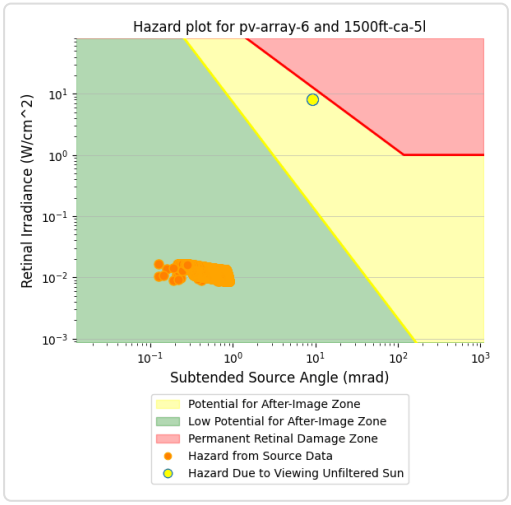
PV array 6 and Route: 1500Ft-CA_5L23R_05L-L_23R-R

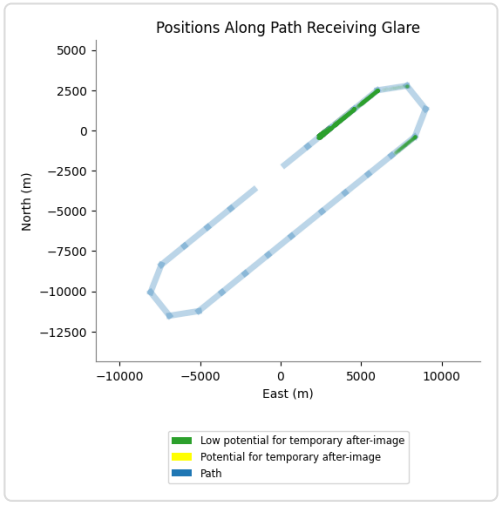
Yellow glare: none

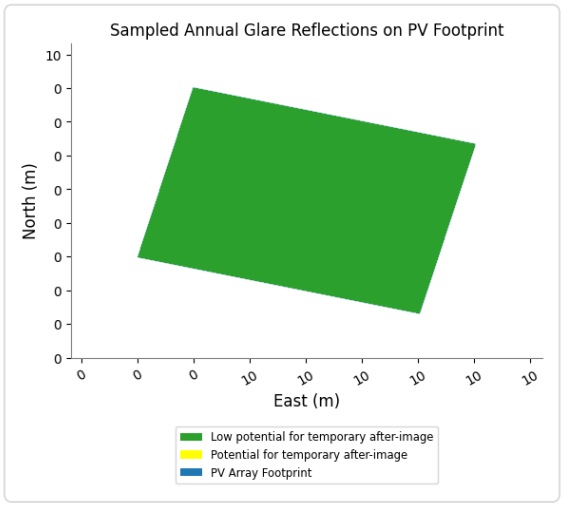
Green glare: 5,645 min.

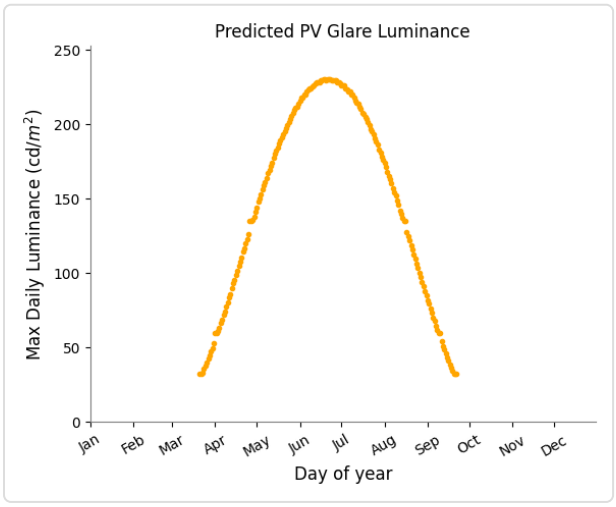








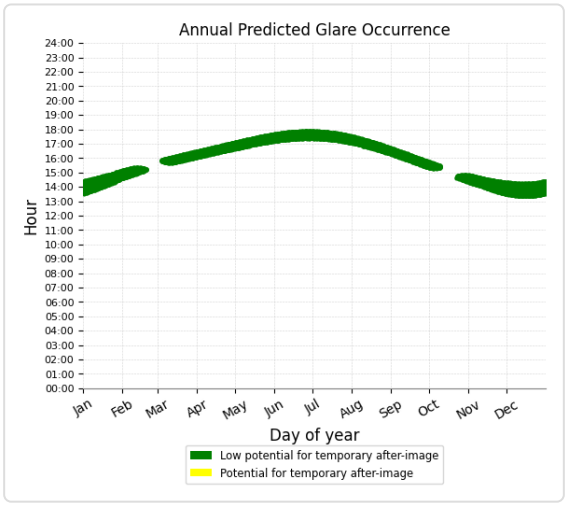


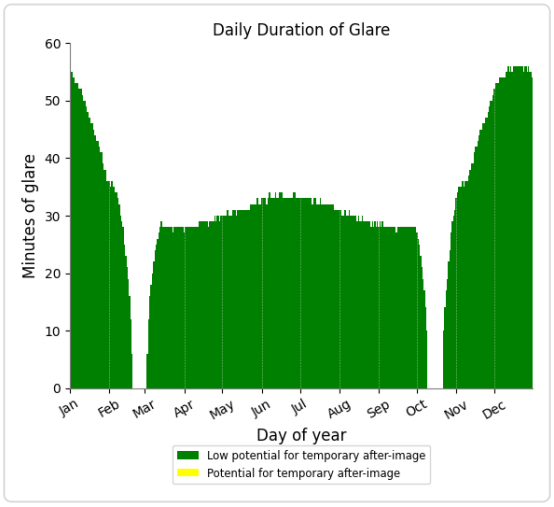


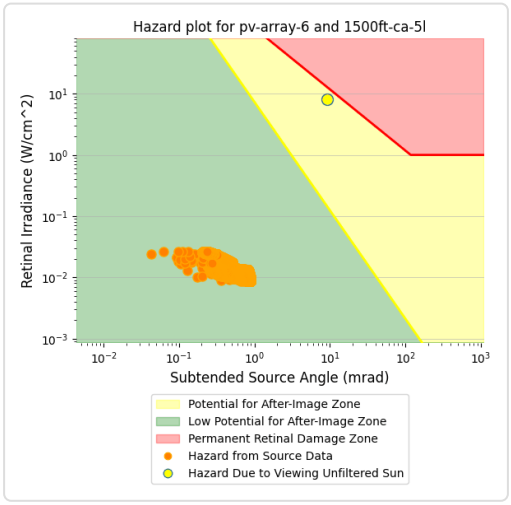
PV array 6 and Route: 1500Ft-CA_5L23R_05L-R_23R-L

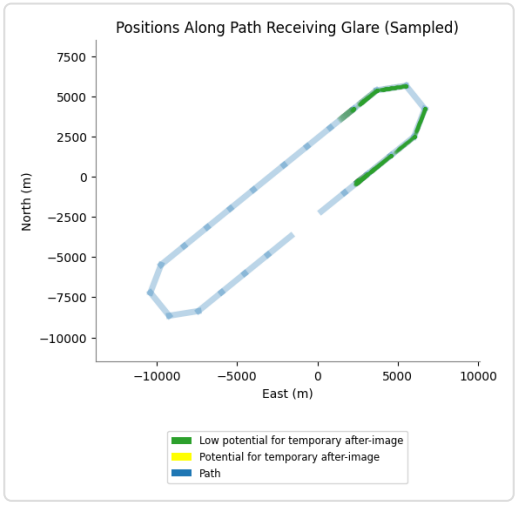
Yellow glare: none

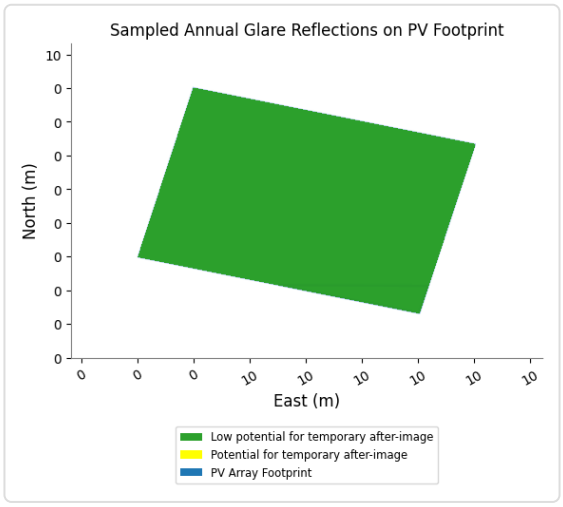
Green glare: 11,628 min.

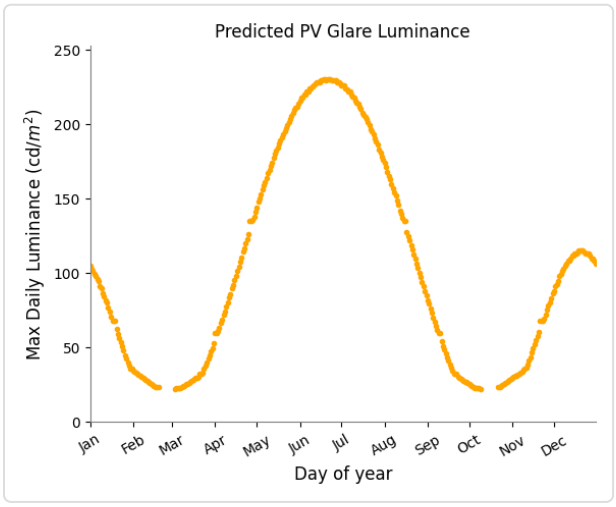








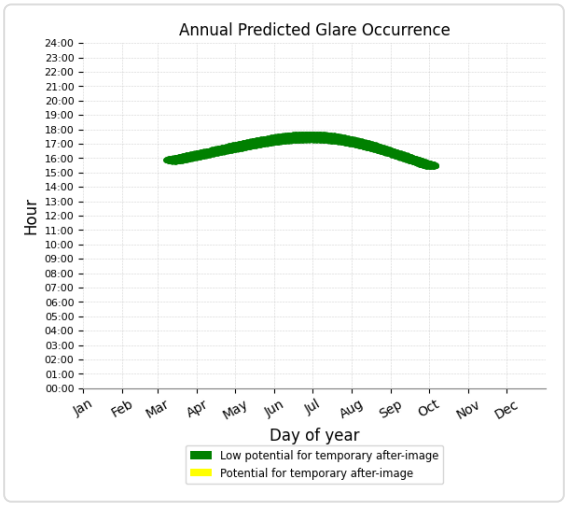


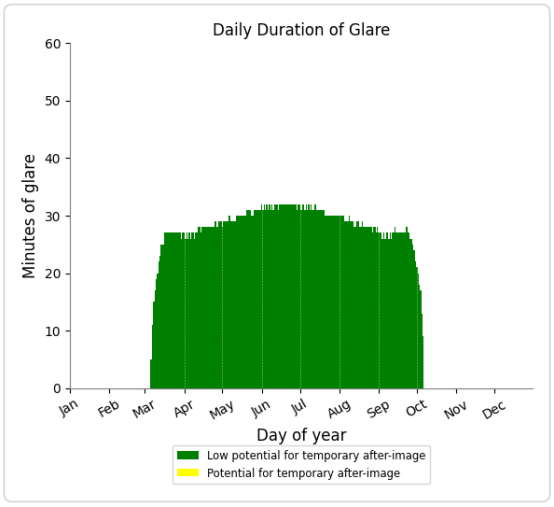


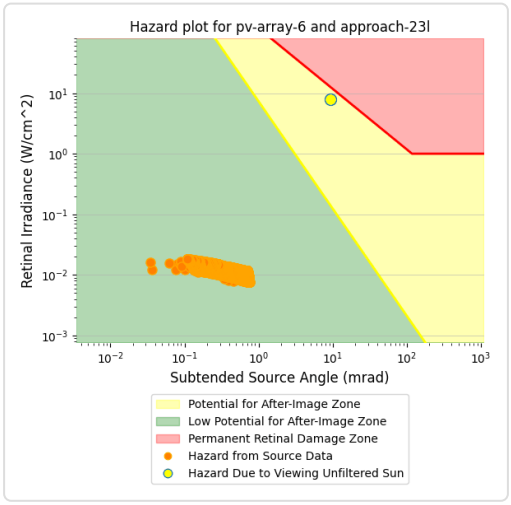
PV array 6 and Route: Approach_23L

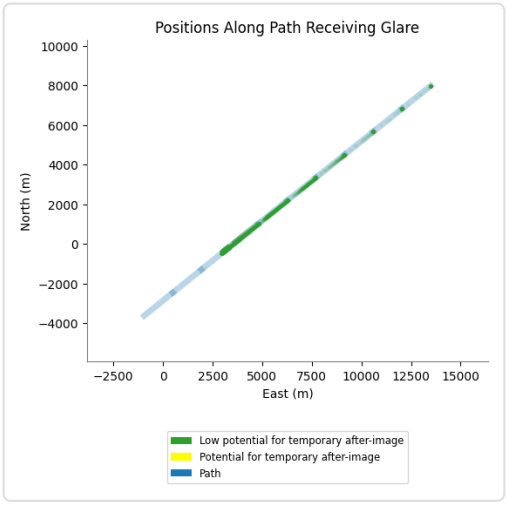
Yellow glare: none

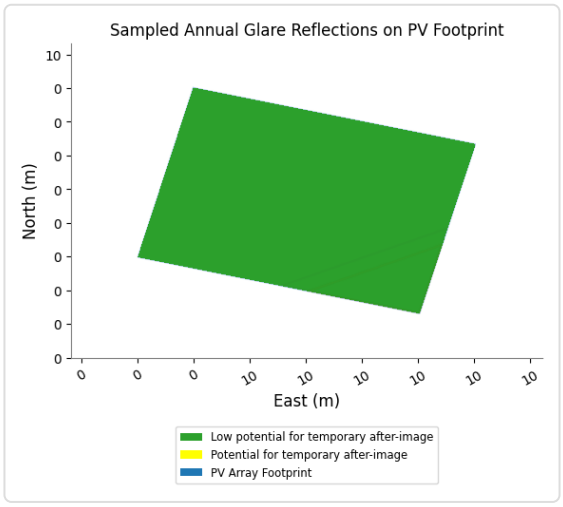
Green glare: 6,060 min.

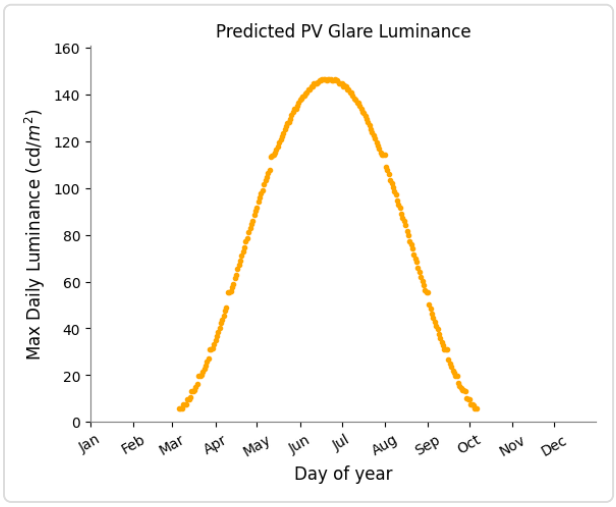








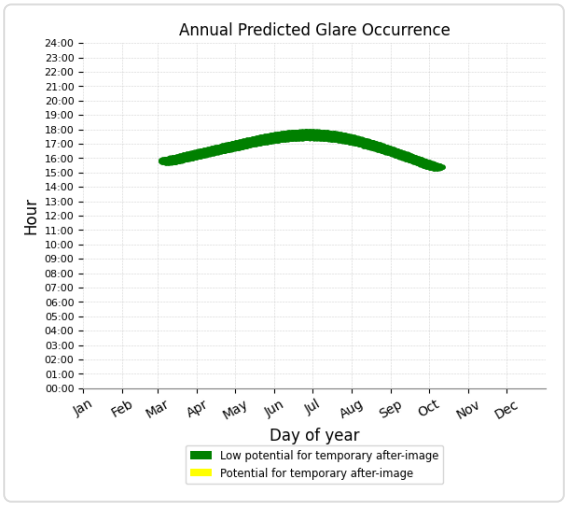


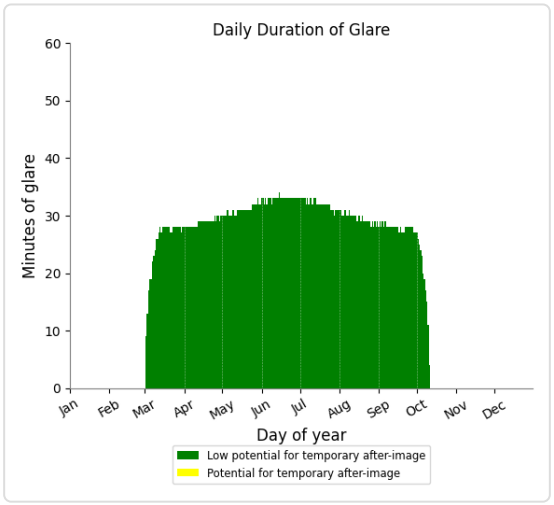


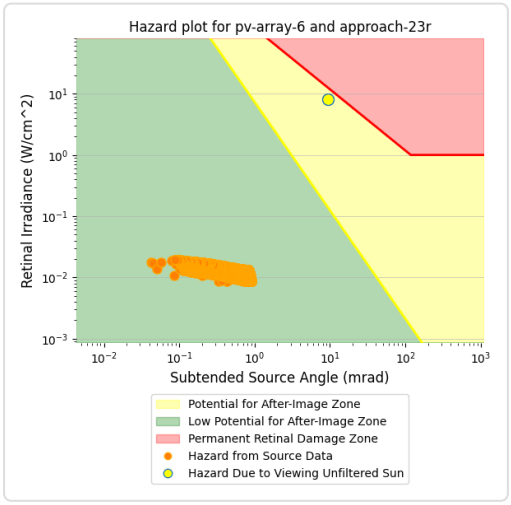
PV array 6 and Route: Approach_23R

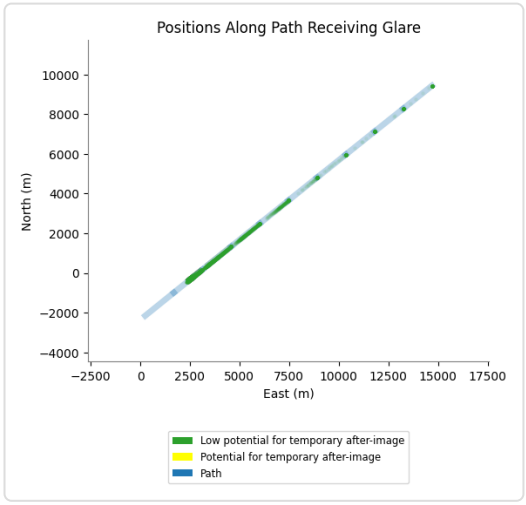
Yellow glare: none

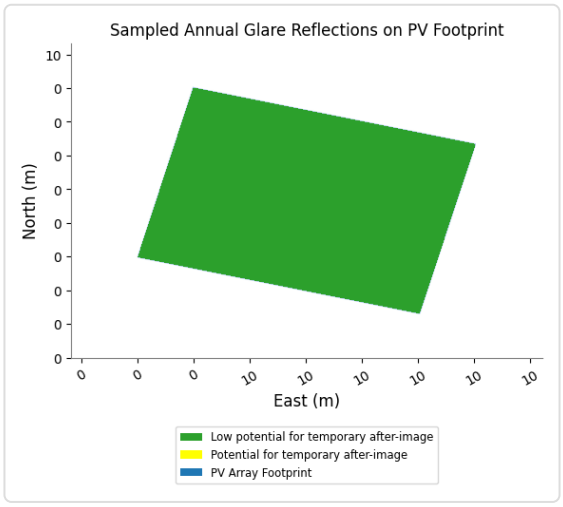
Green glare: 6,524 min.

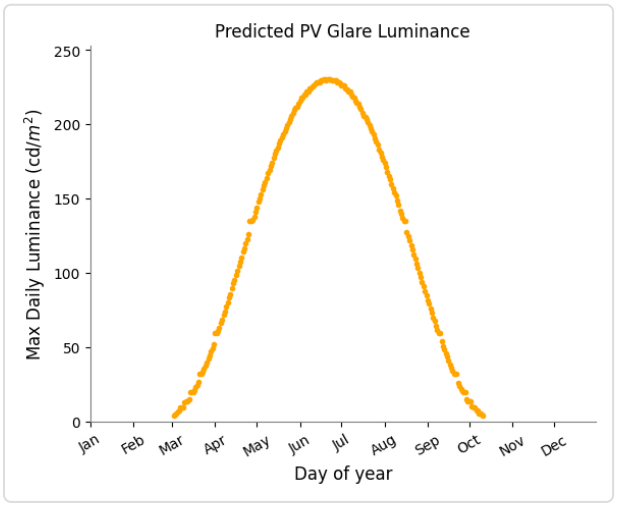












PV array 6 and Route: 1000Ft-GA_5R23L_05R-L_23L-R

No glare found

PV array 6 and Route: Approach_05L

No glare found

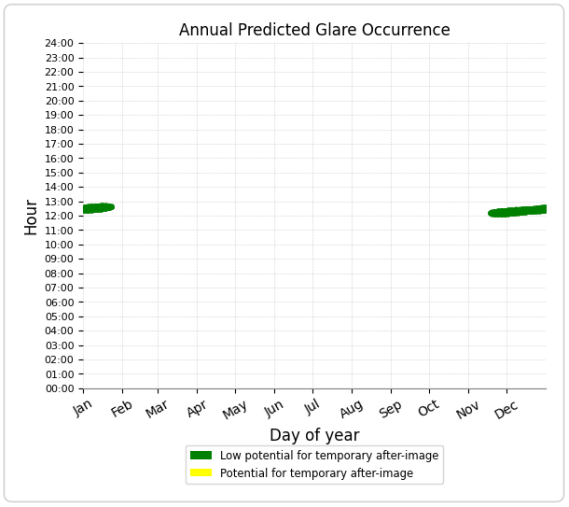
PV array 6 and Route: Approach_05R

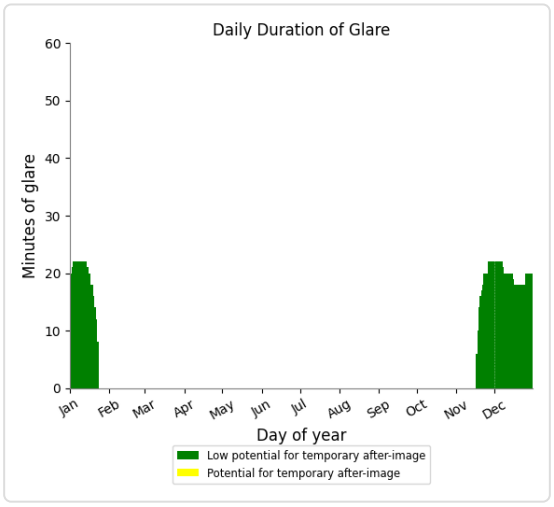
No glare found

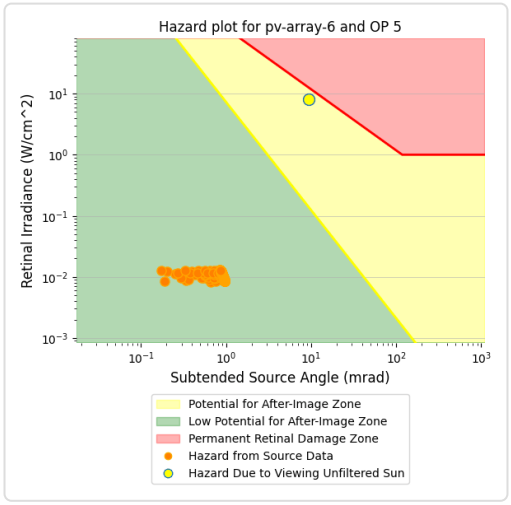
PV array 6 and OP 5

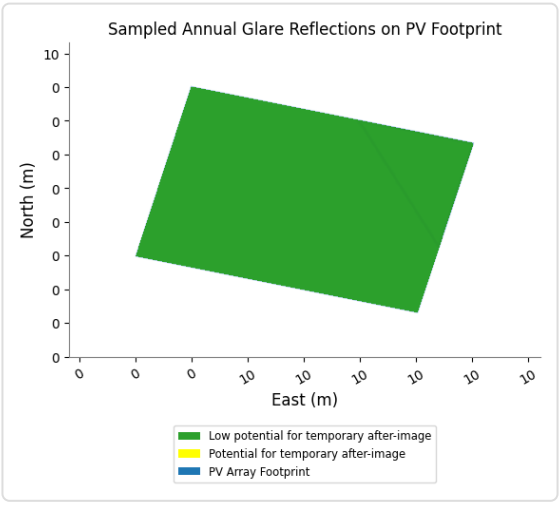
Yellow glare: none

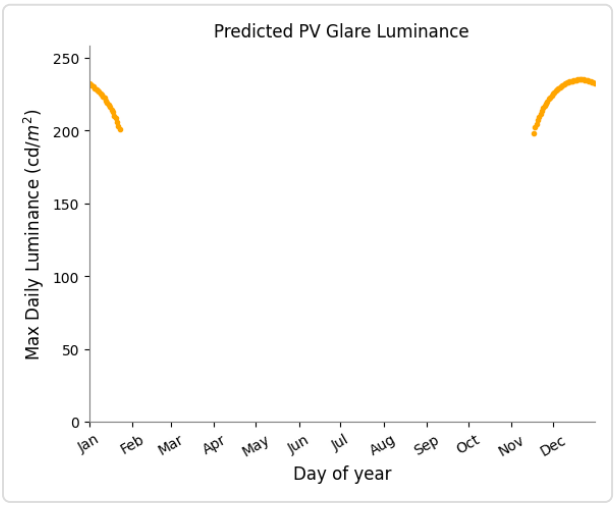
Green glare: 1,317 min.







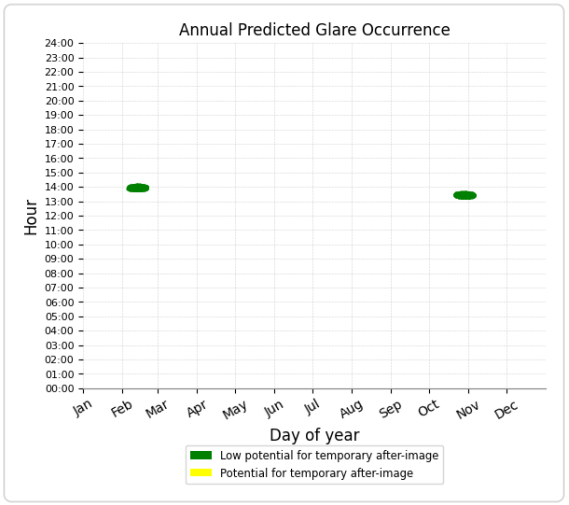


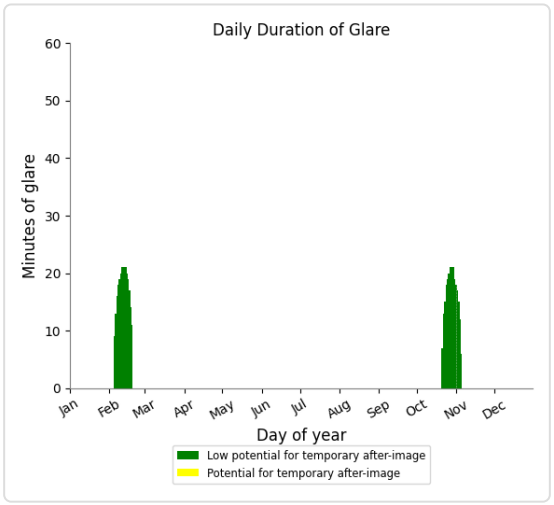


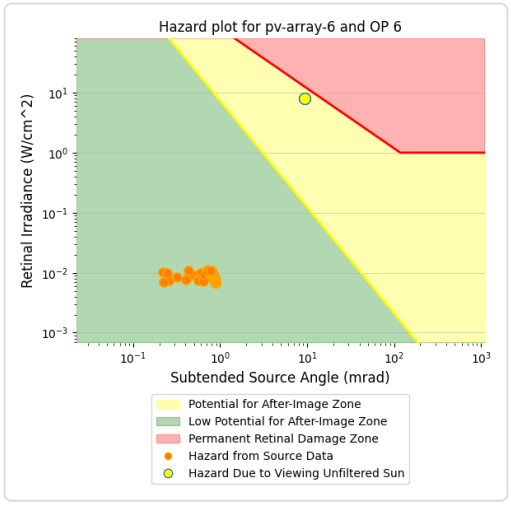
PV array 6 and OP 6

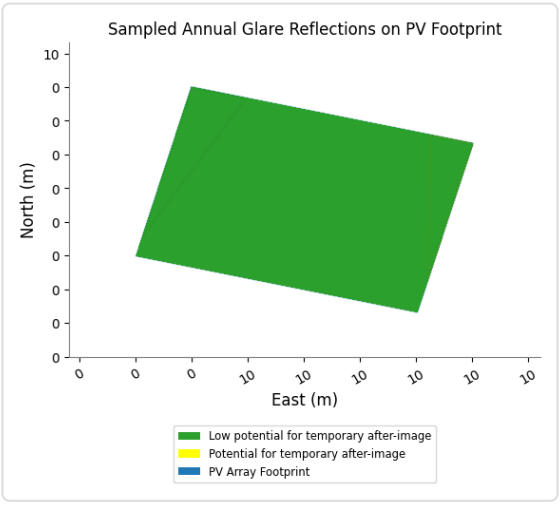
Yellow glare: none

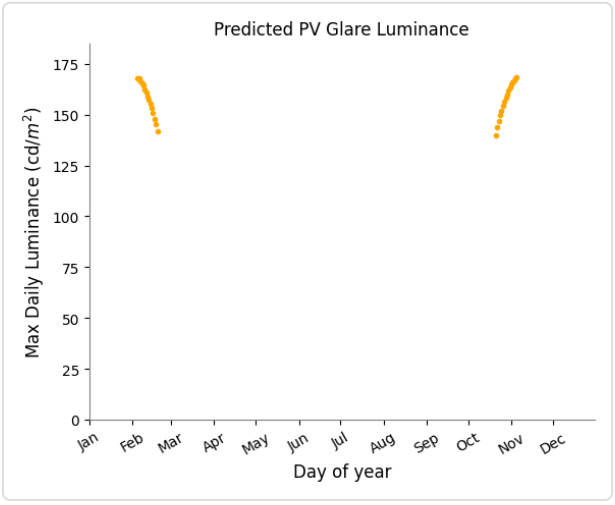
Green glare: 523 min.







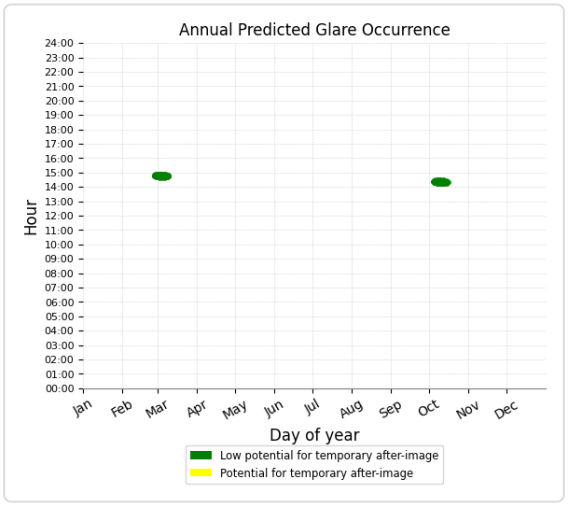


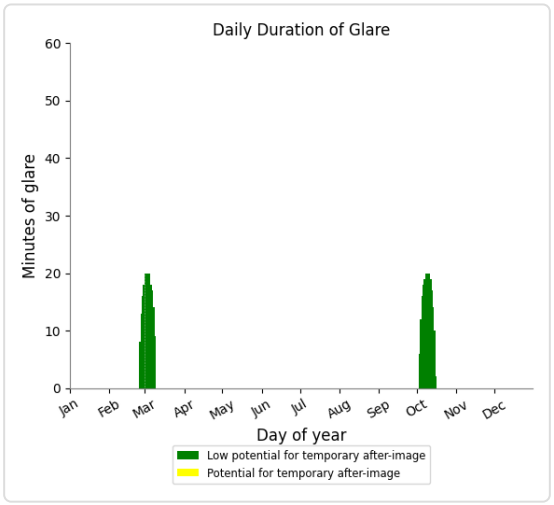


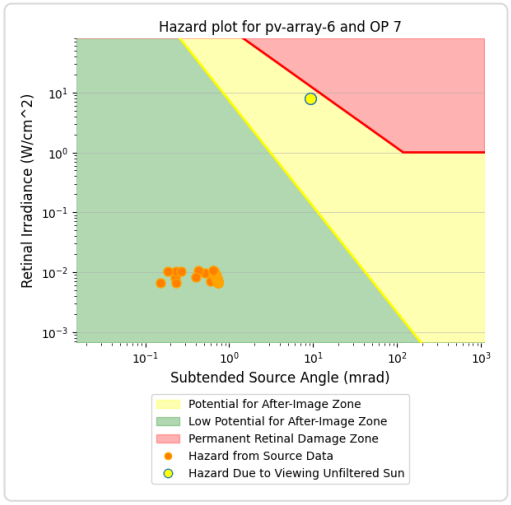
PV array 6 and OP 7

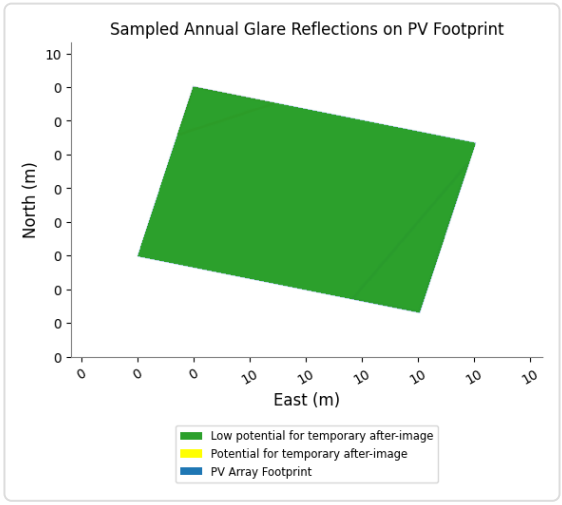
Yellow glare: none

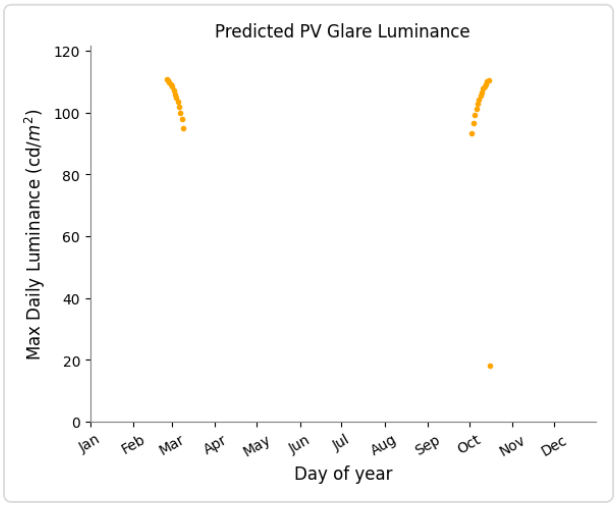
Green glare: 426 min.







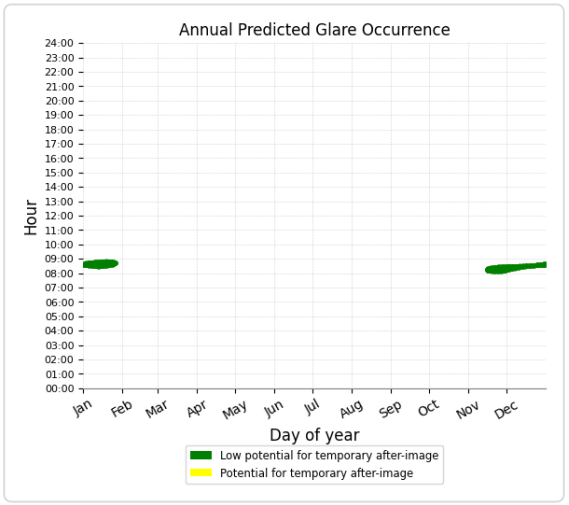


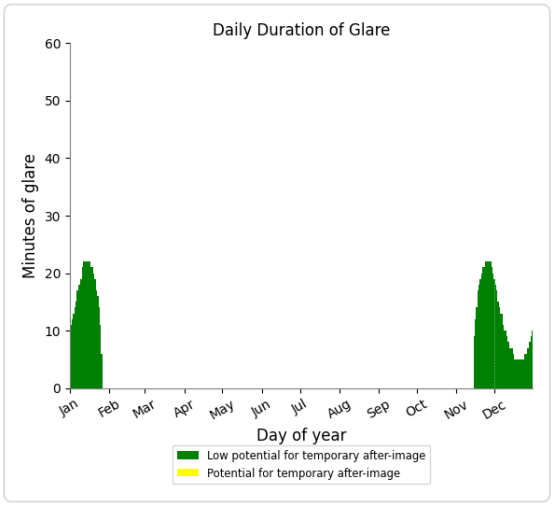


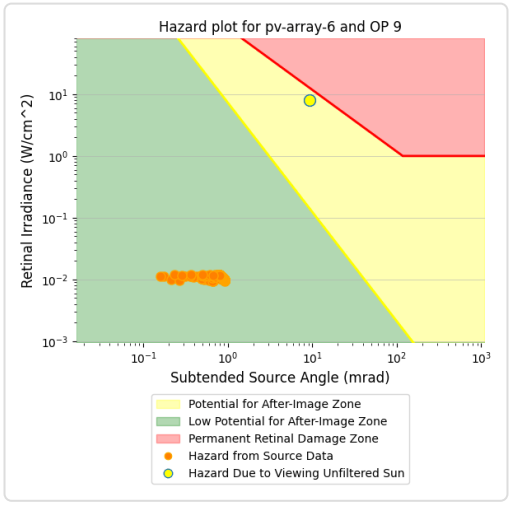
PV array 6 and OP 9

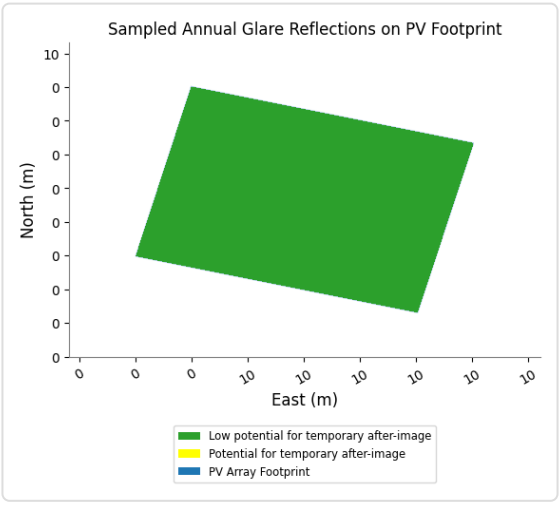
Yellow glare: none

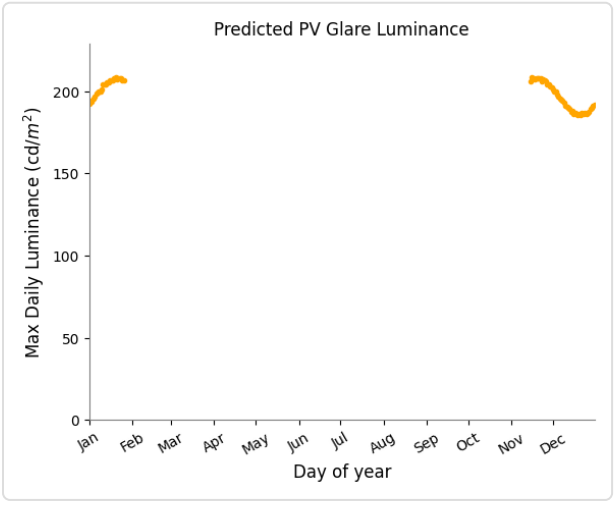
Green glare: 1,024 min.







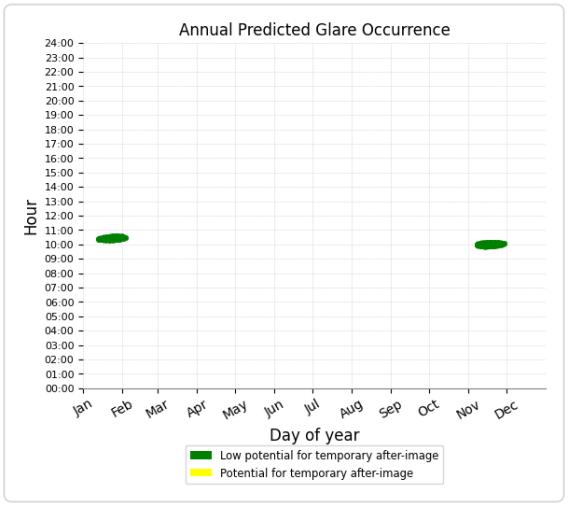


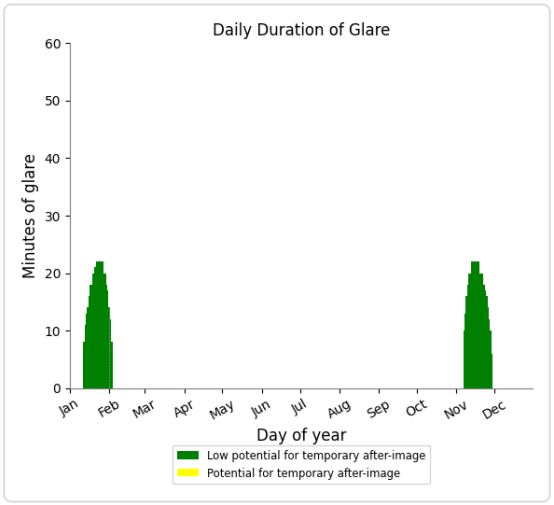


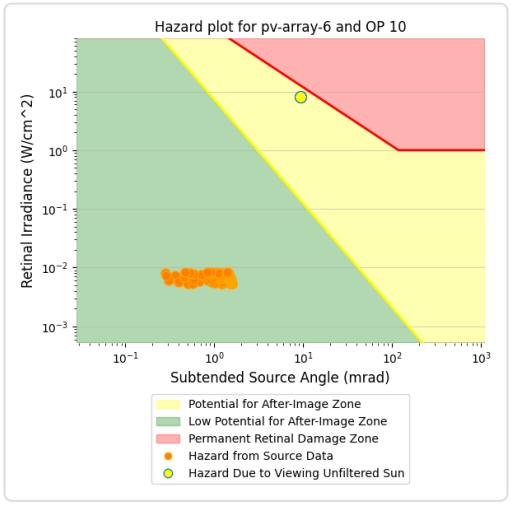
PV array 6 and OP 10

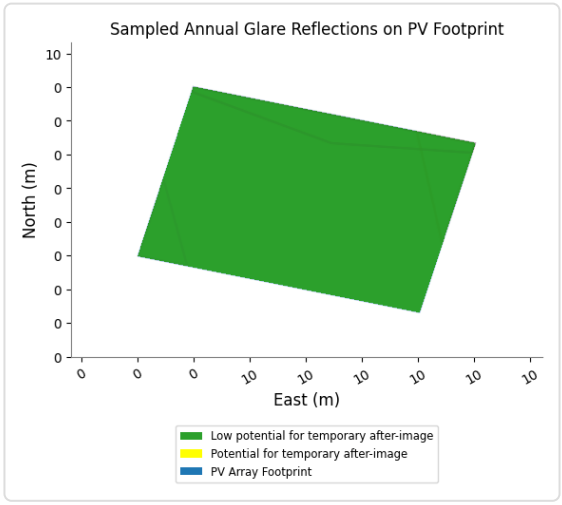
Yellow glare: none

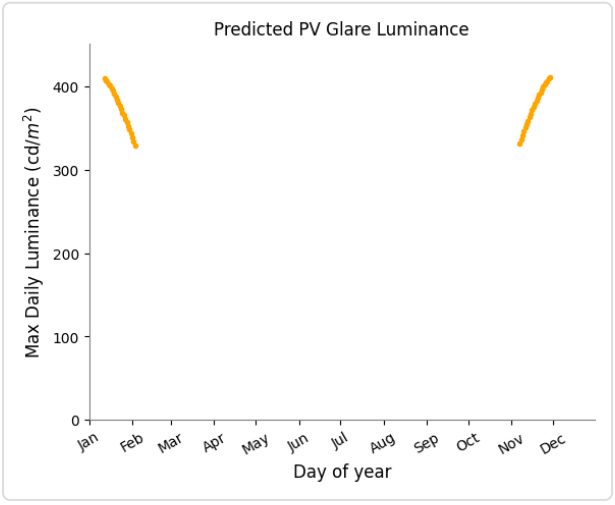
Green glare: 804 min.







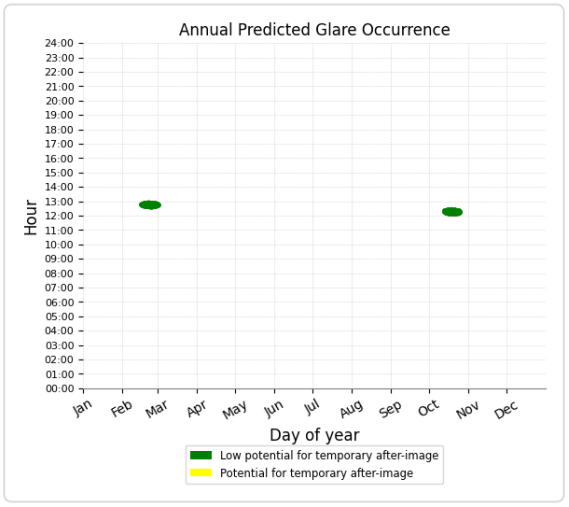


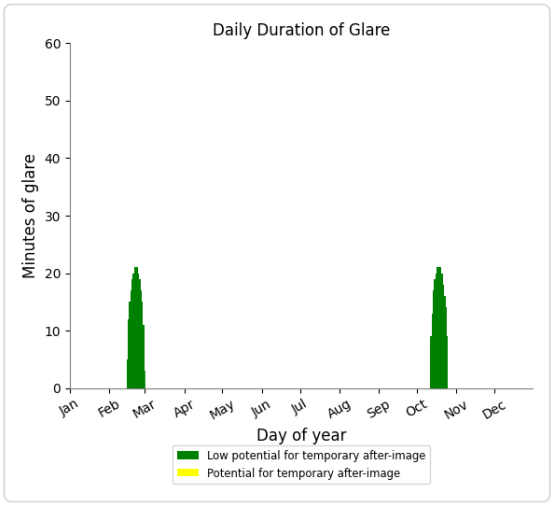


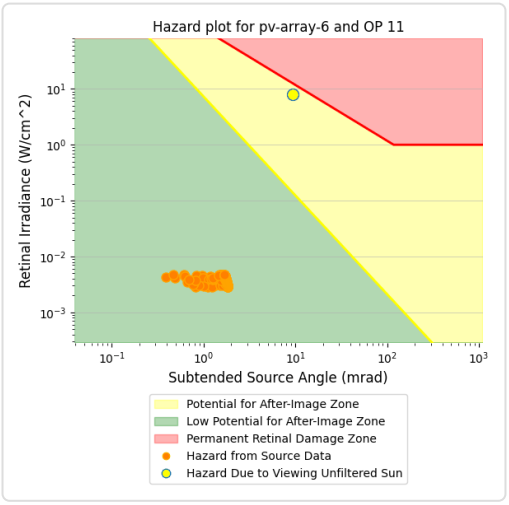
PV array 6 and OP 11

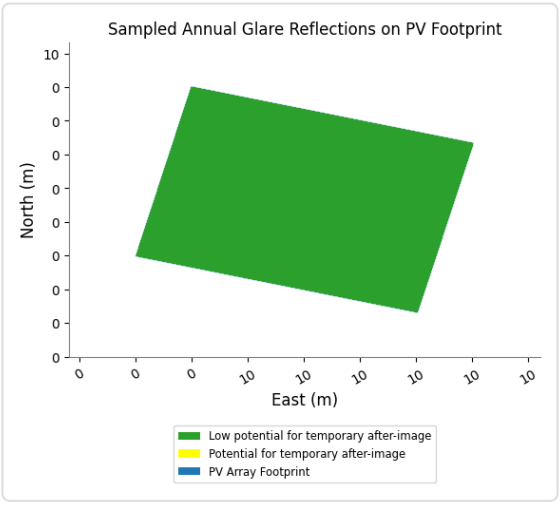
Yellow glare: none

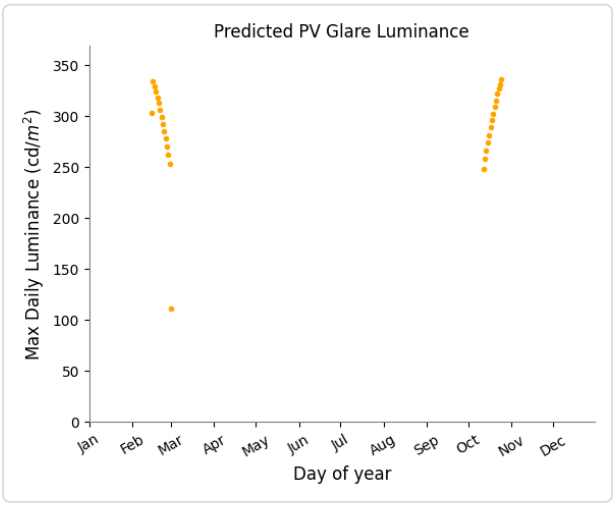
Green glare: 475 min.







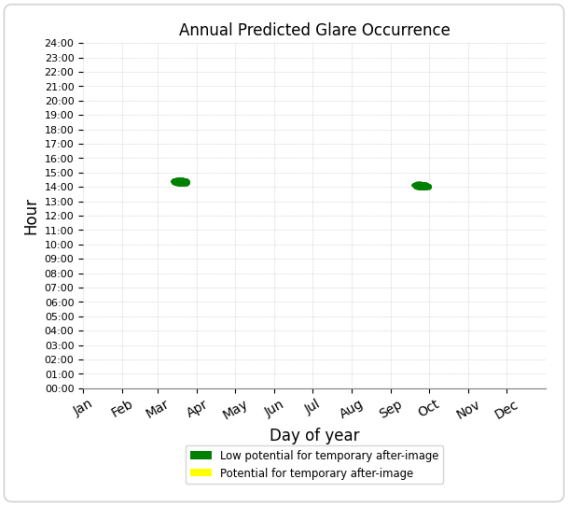


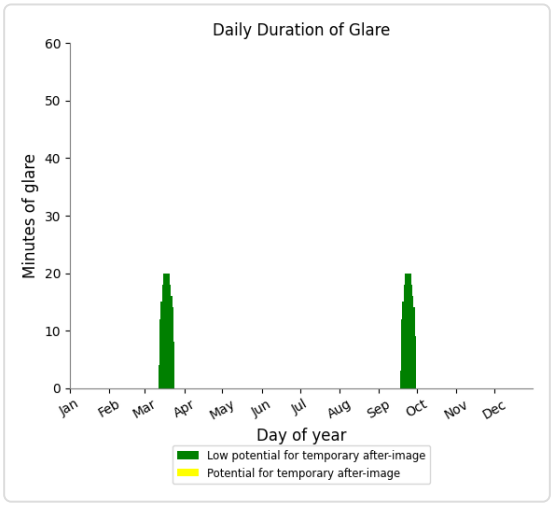


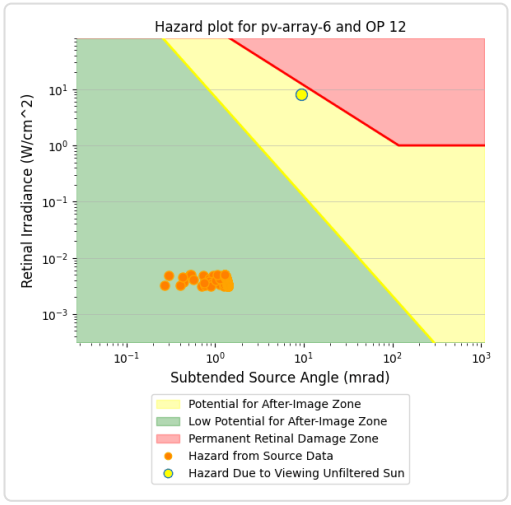
PV array 6 and OP 12

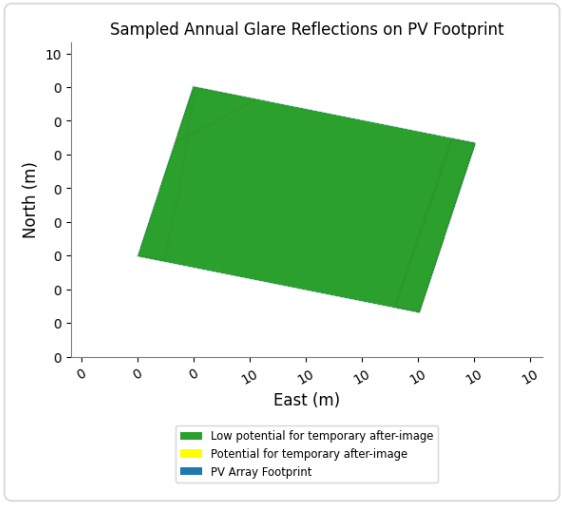
Yellow glare: none

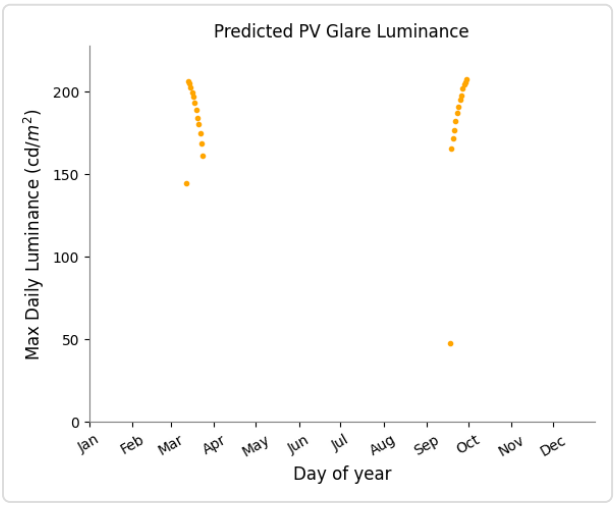
Green glare: 410 min.







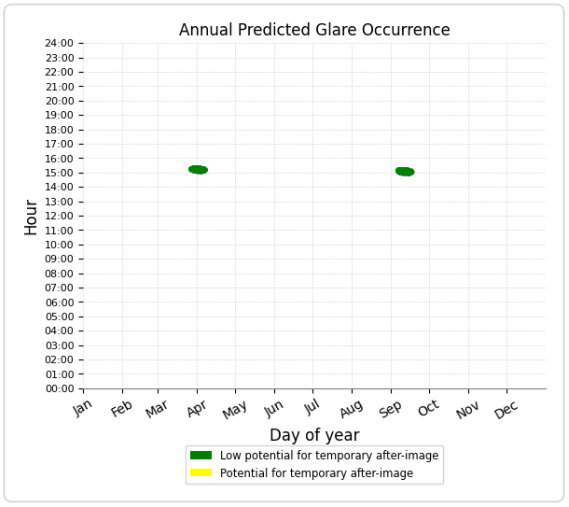


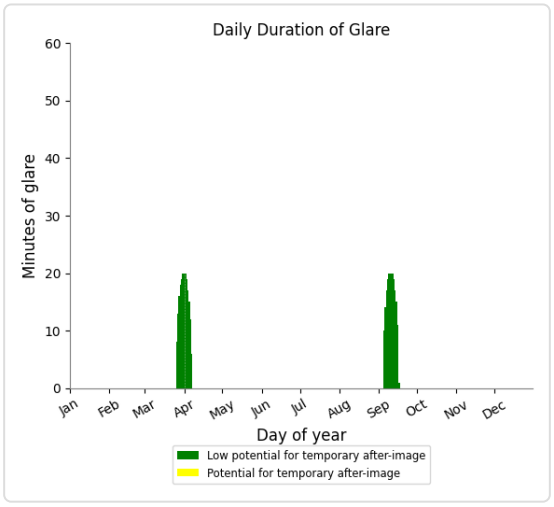


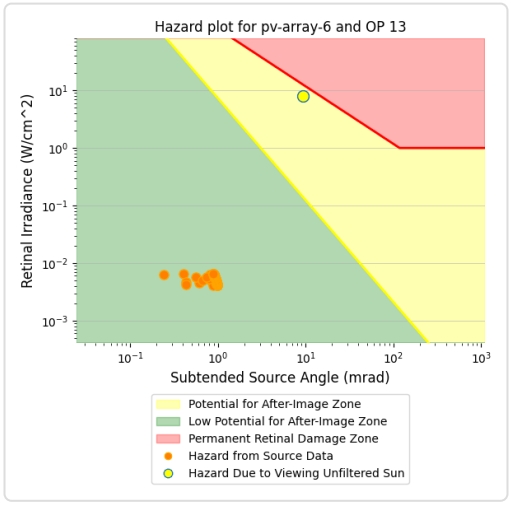
PV array 6 and OP 13

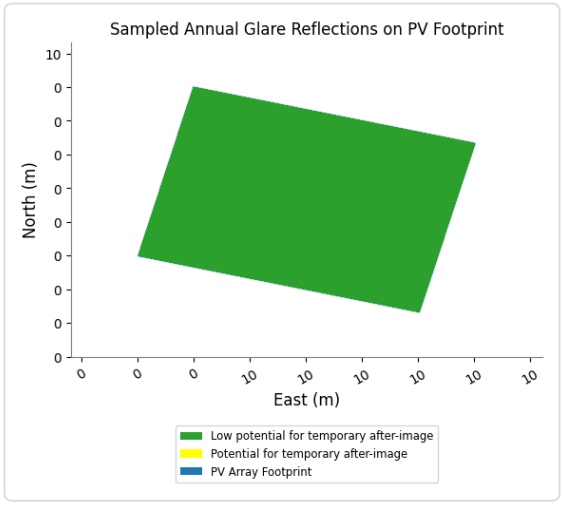
Yellow glare: none

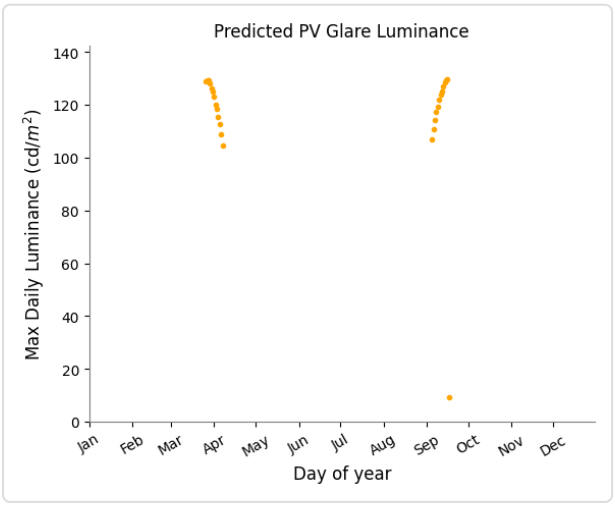
Green glare: 406 min.







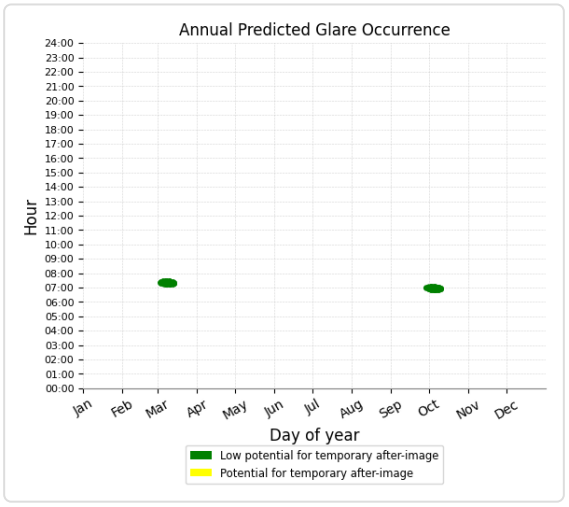


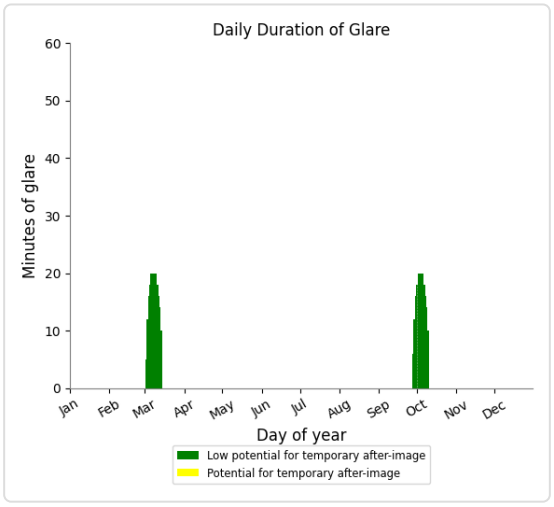


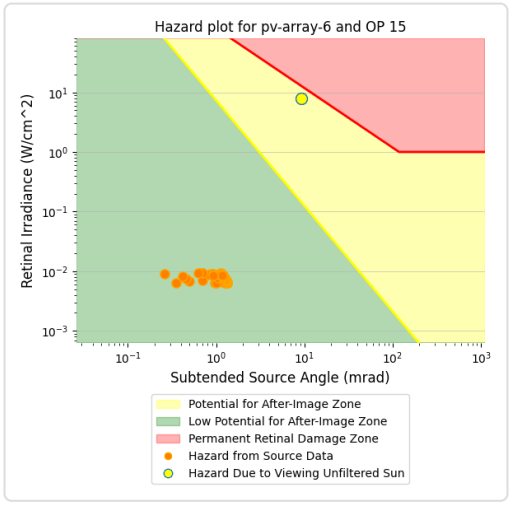
PV array 6 and OP 15

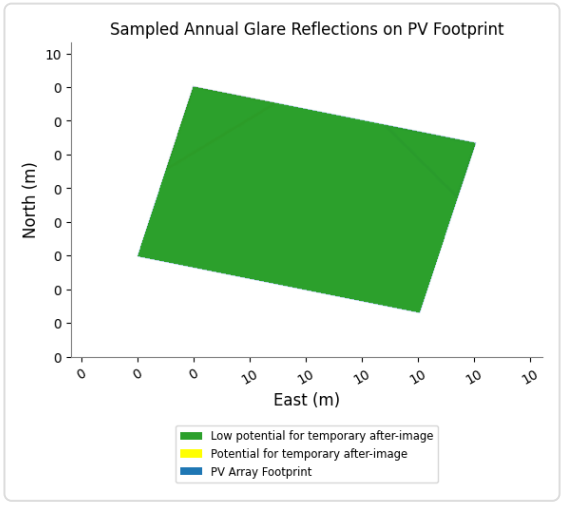
Yellow glare: none

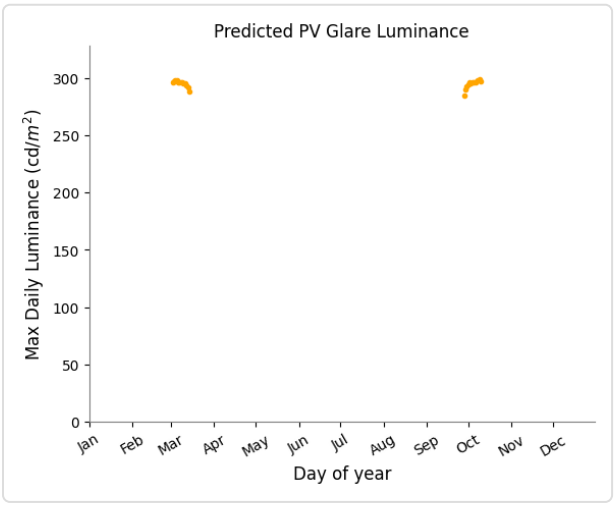
Green glare: 419 min.







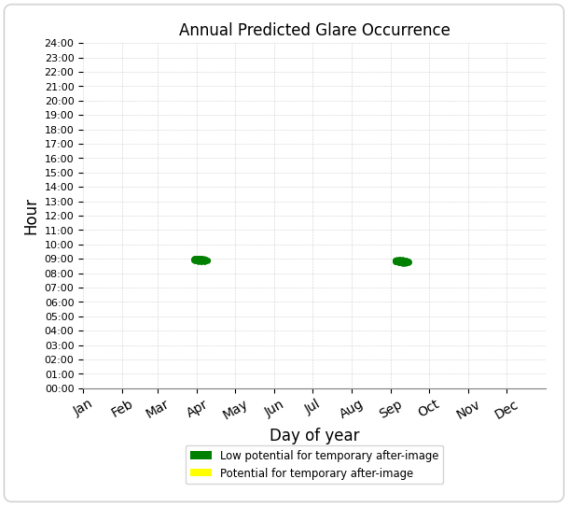


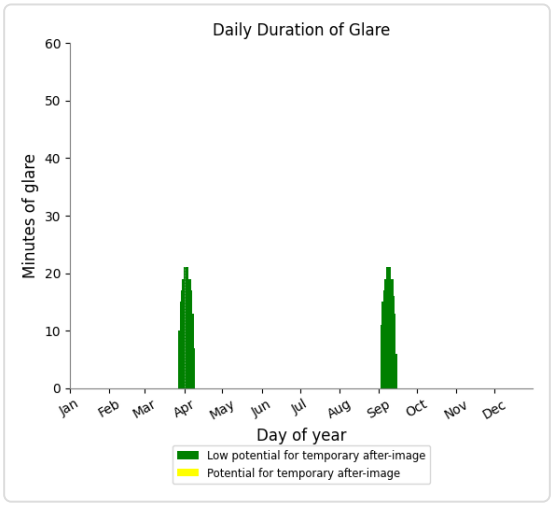


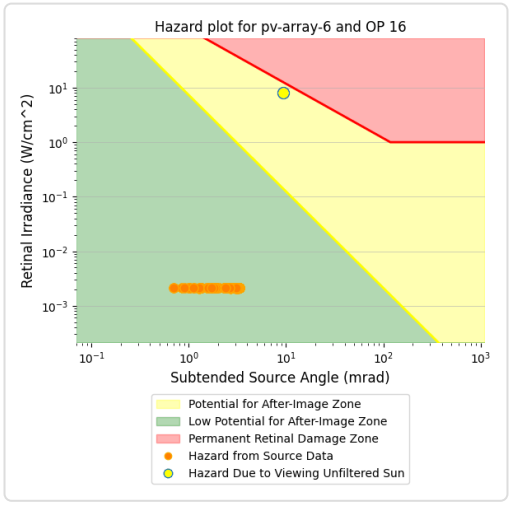
PV array 6 and OP 16

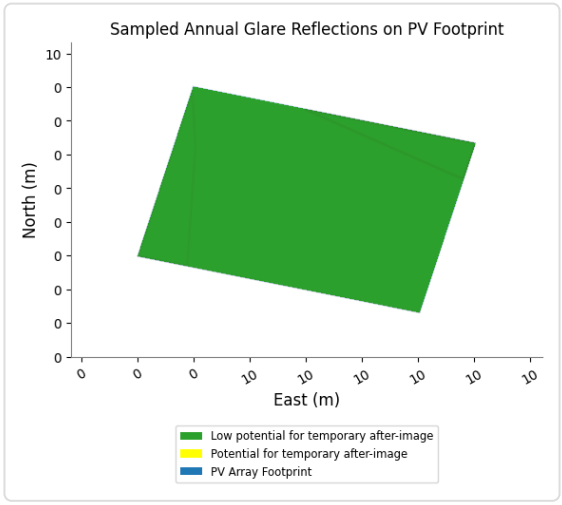
Yellow glare: none

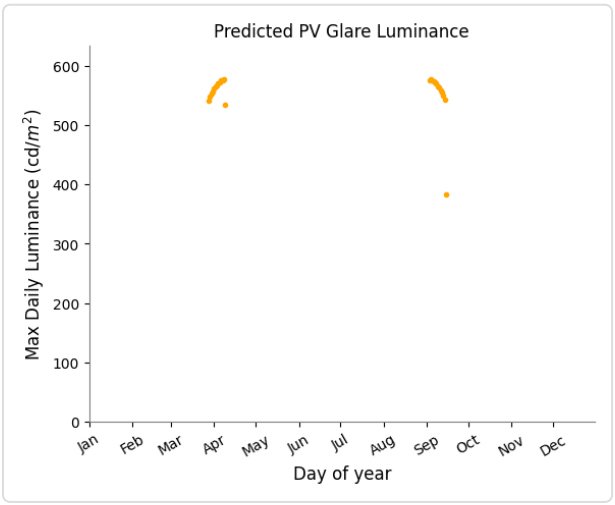
Green glare: 439 min.







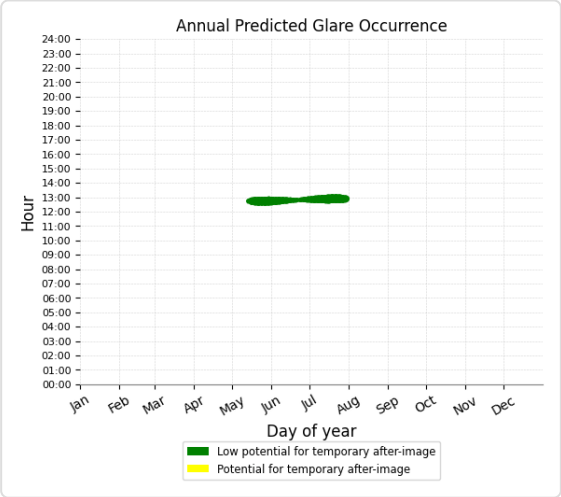


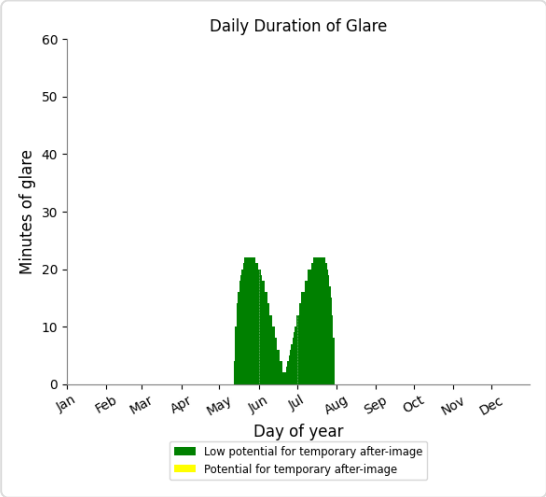


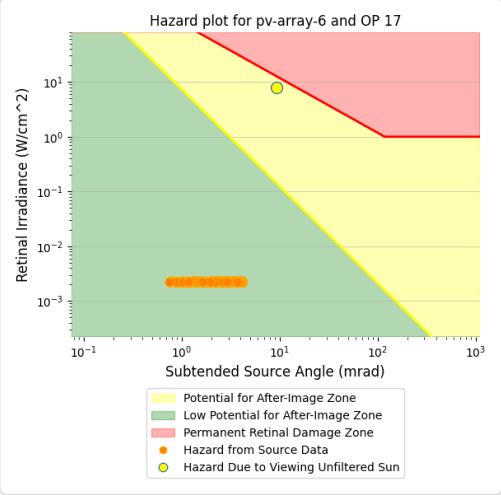
PV array 6 and OP 17

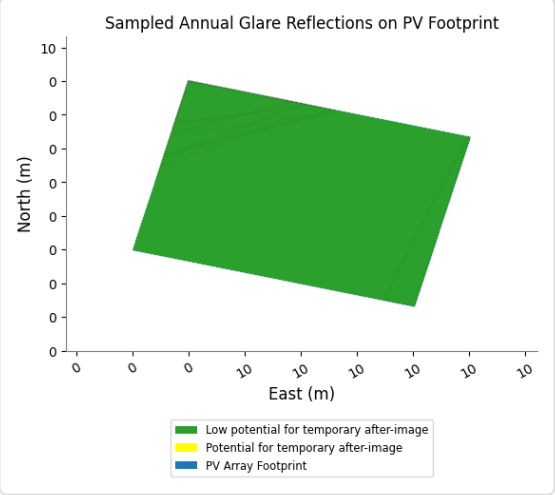
Yellow glare: none

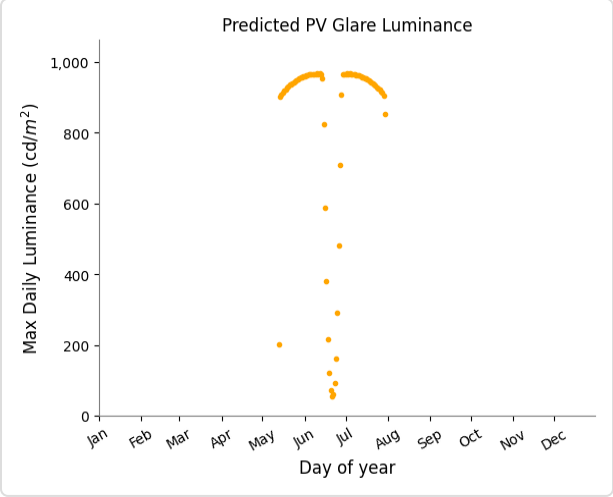
Green glare: 1,204 min.







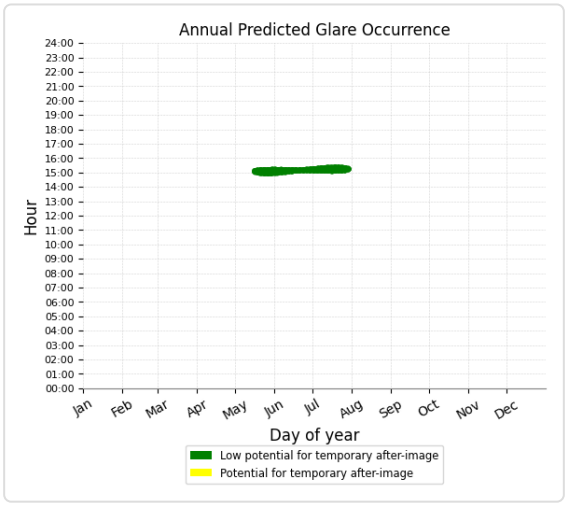


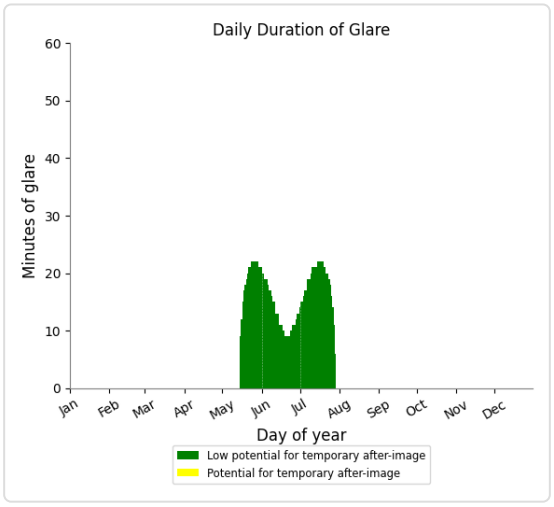


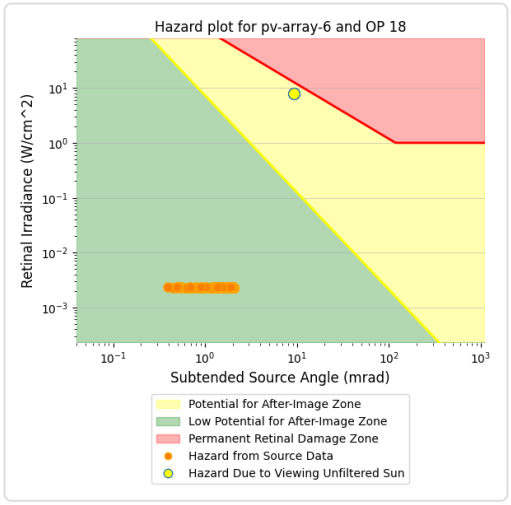
PV array 6 and OP 18

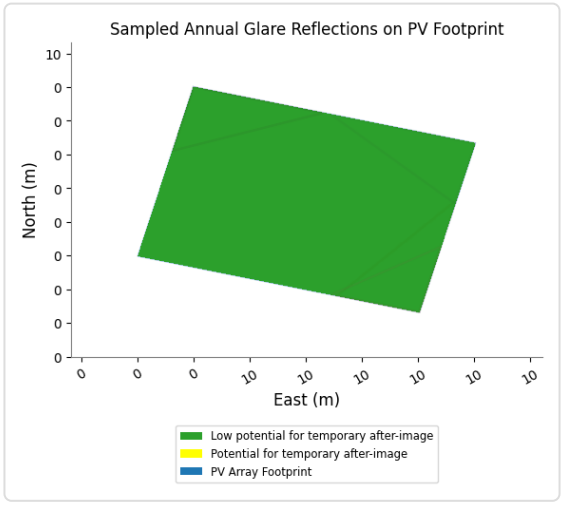
Yellow glare: none

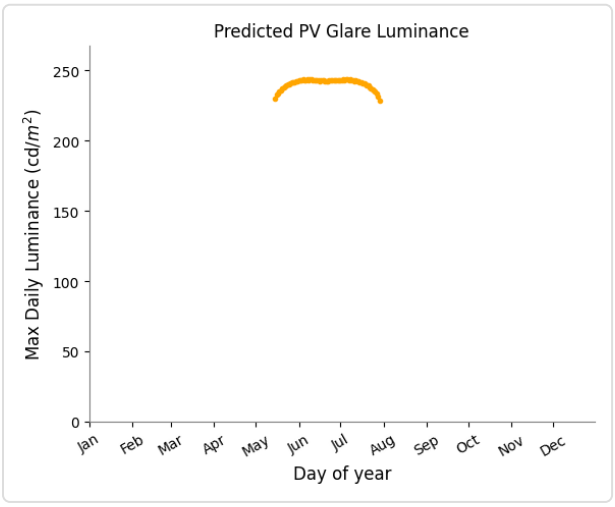
Green glare: 1,261 min.







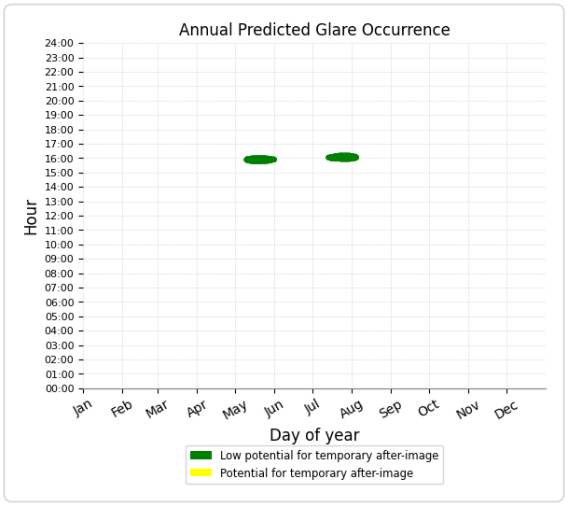


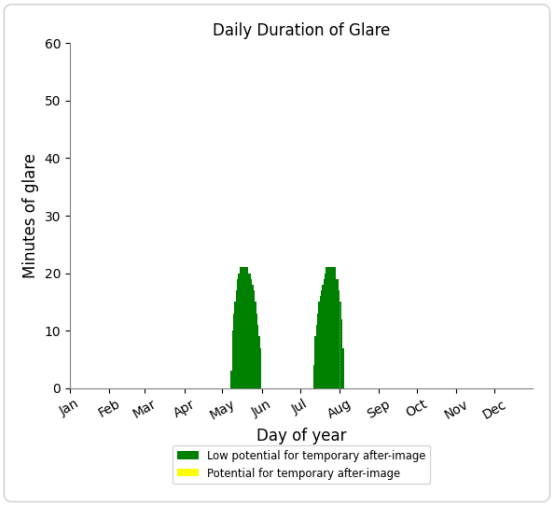


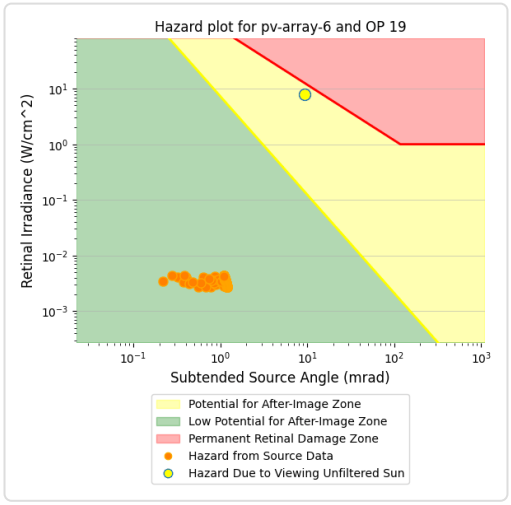
PV array 6 and OP 19

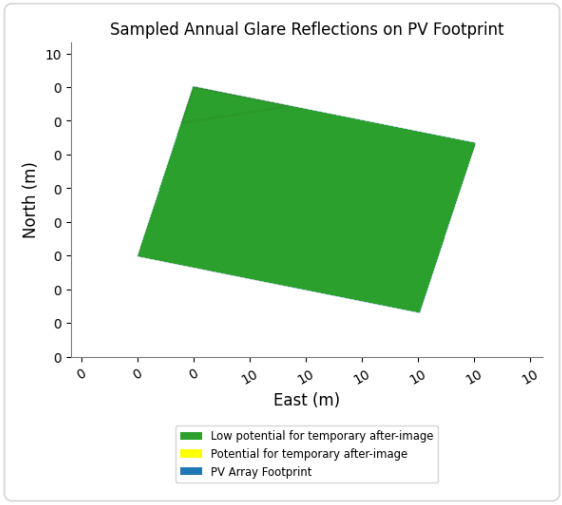
Yellow glare: none

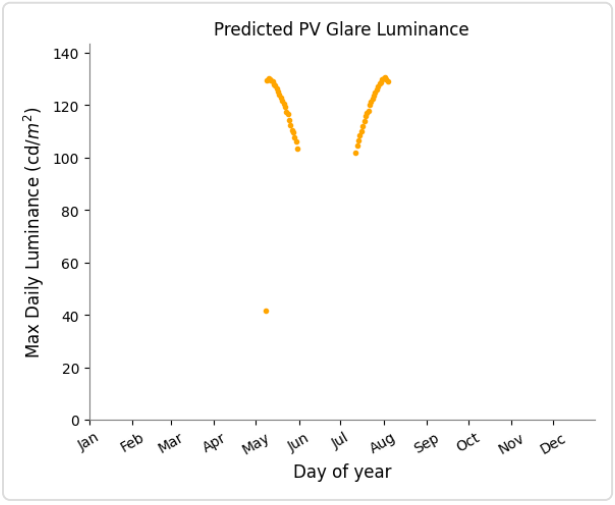
Green glare: 792 min.







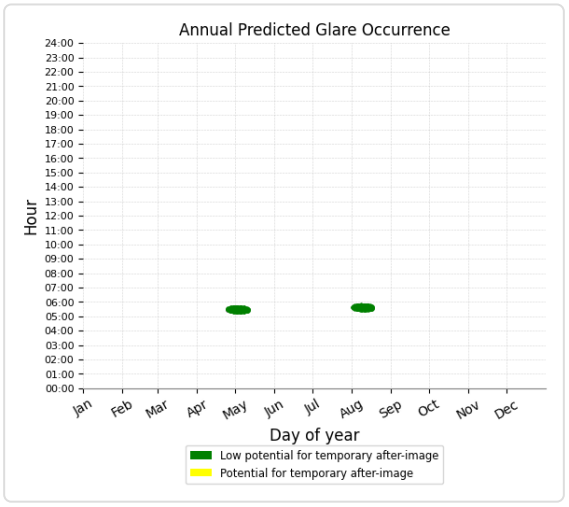


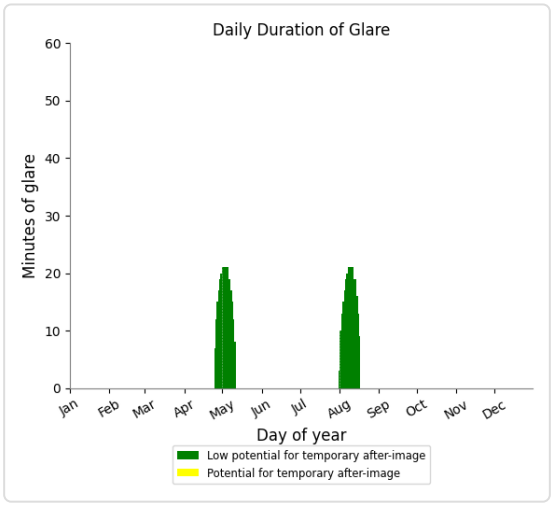


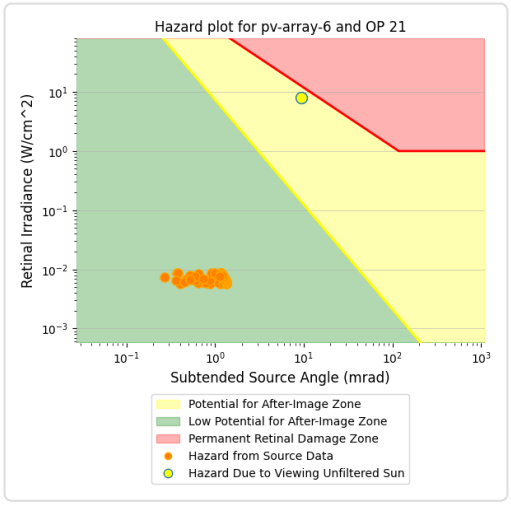
PV array 6 and OP 21

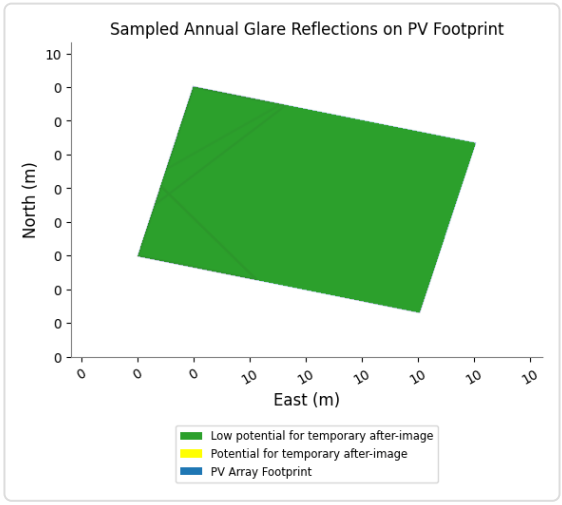
Yellow glare: none

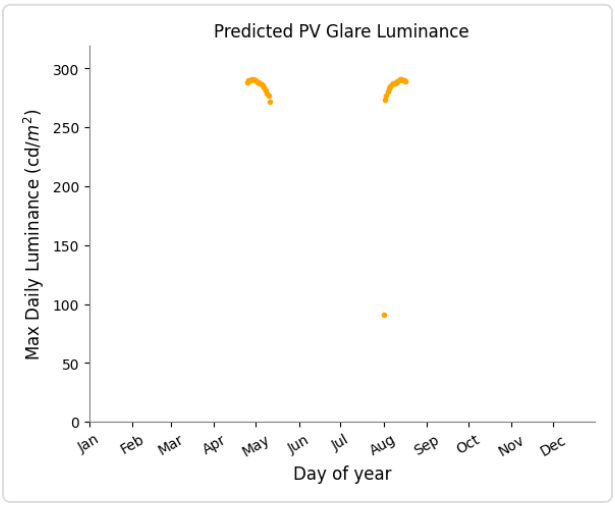
Green glare: 563 min.







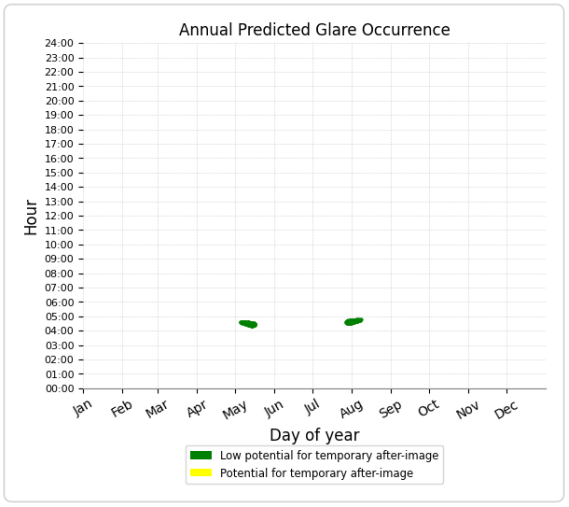


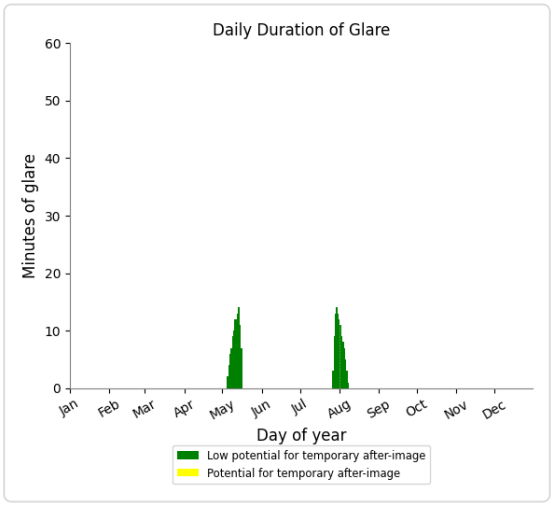


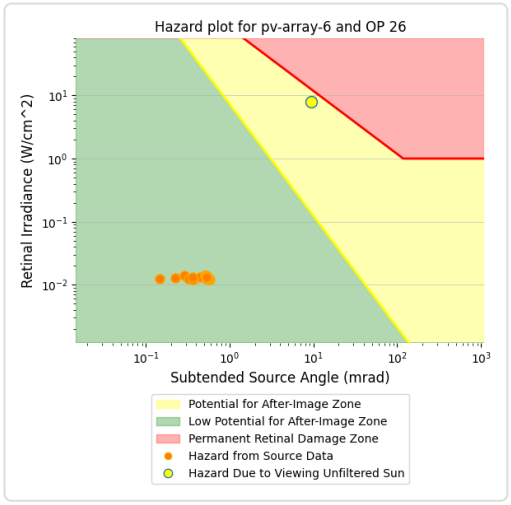
PV array 6 and OP 26

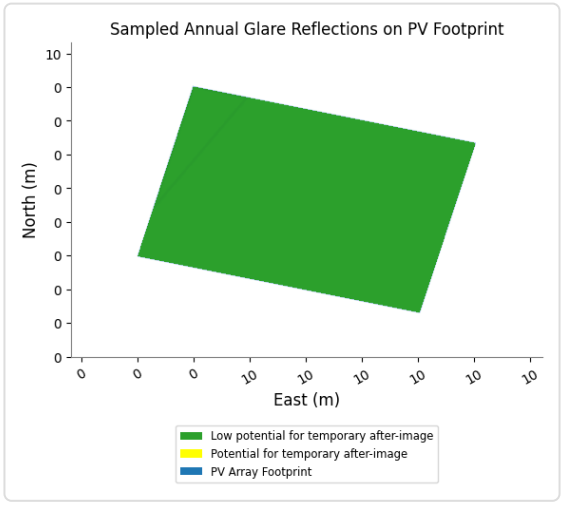
Yellow glare: none

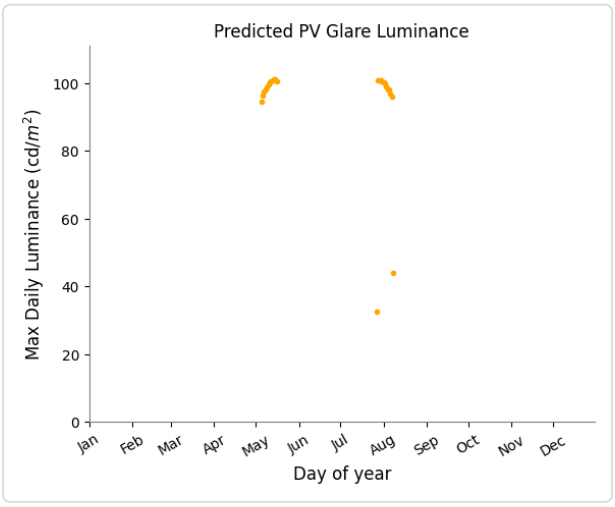
Green glare: 215 min.







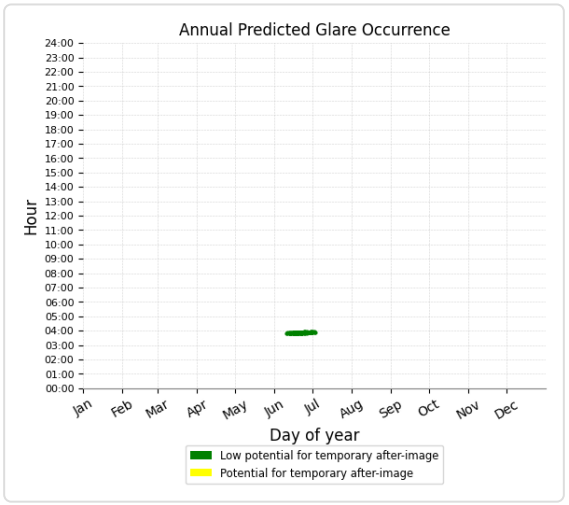


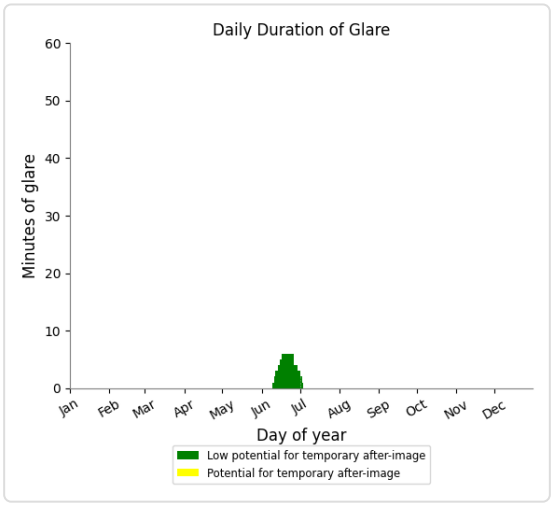


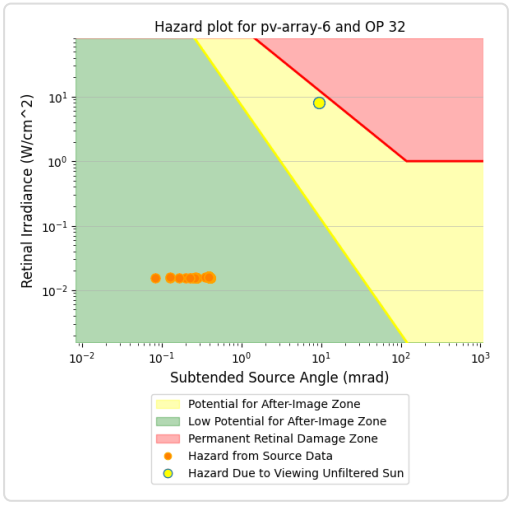
PV array 6 and OP 32

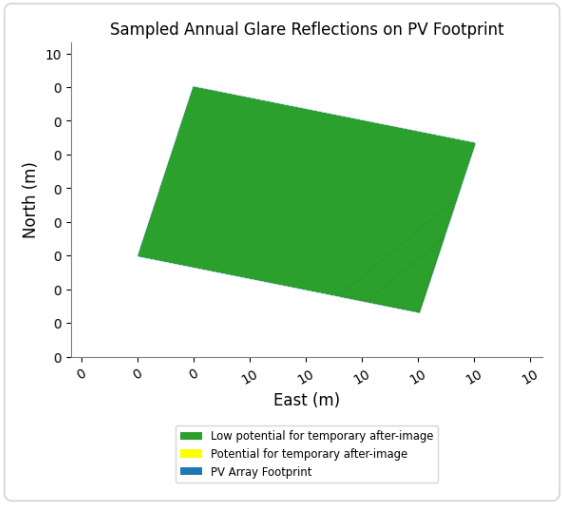
Yellow glare: none

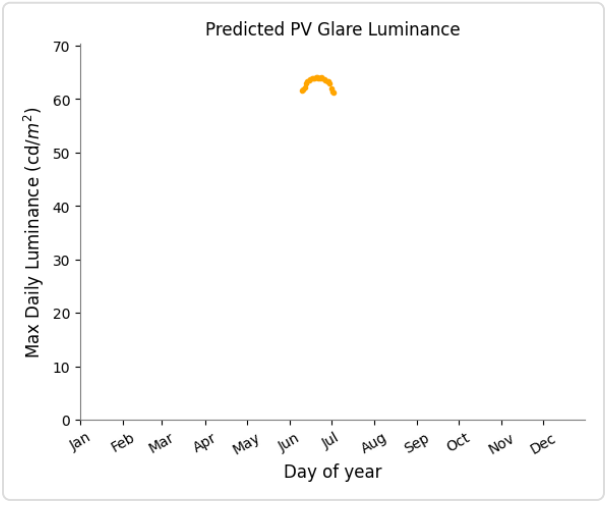
Green glare: 103 min.











PV array 6 and 1-ATCT

No glare found

PV array 6 and OP 2

No glare found

PV array 6 and OP 3

No glare found

PV array 6 and OP 4

No glare found

PV array 6 and OP 8

No glare found

PV array 6 and OP 14

No glare found

PV array 6 and OP 20

No glare found

PV array 6 and OP 22

No glare found

PV array 6 and OP 23

No glare found

PV array 6 and OP 24

No glare found

PV array 6 and OP 25

No glare found

PV array 6 and OP 27

No glare found

PV array 6 and OP 28

No glare found

PV array 6 and OP 29

No glare found

PV array 6 and OP 30

No glare found

PV array 6 and OP 31

No glare found

PV array 6 and OP 33

No glare found

PV array 6 and OP 34

No glare found

PV array 6 and OP 35

No glare found

PV array 6 and OP 36

No glare found

PV array 6 and OP 37

No glare found

PV array 6 and OP 38

No glare found

PV array 6 and OP 39

No glare found

PV array 6 and OP 40

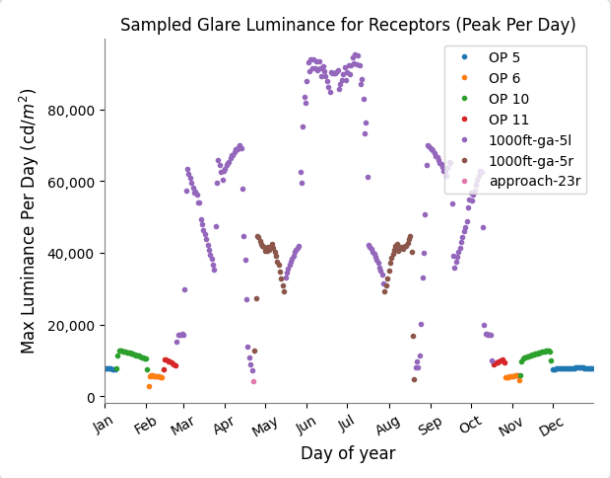
No glare found

PV: PV array 7 low potential for temporary after-image

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
1000Ft-GA_5L23R_05L-L_23R-R	3,686	61.4	0	0.0	8,073
1000Ft-GA_5L23R_05L-R_23R-L	13,535	225.6	0	0.0	95,217
1000Ft-GA_5R23L_05R-R_23L-L	7,388	123.1	0	0.0	44,679
1500Ft-CA_5L23R_05L-L_23R-R	5,706	95.1	0	0.0	7,822
1500Ft-CA_5L23R_05L-R_23R-L	11,818	197.0	0	0.0	7,822
Approach_23L	6,150	102.5	0	0.0	5,051
Approach_23R	6,613	110.2	0	0.0	7,832
1000Ft-GA_5R23L_05R-L_23L-R	0	0.0	0	0.0	0
Approach_05L	0	0.0	0	0.0	0
Approach_05R	0	0.0	0	0.0	0
OP 5	1,454	24.2	0	0.0	7,930
OP 6	653	10.9	0	0.0	5,784
OP 7	514	8.6	0	0.0	3,868
OP 9	1,085	18.1	0	0.0	6,793
OP 10	1,139	19.0	0	0.0	12,836
OP 11	679	11.3	0	0.0	10,288
OP 12	548	9.1	0	0.0	6,721
OP 13	507	8.4	0	0.0	4,413
OP 15	549	9.2	0	0.0	9,484
OP 16	727	12.1	0	0.0	14,289
OP 17	2,125	35.4	0	0.0	23,706
OP 18	1,730	28.8	0	0.0	7,456
OP 19	992	16.5	0	0.0	4,335
OP 21	760	12.7	0	0.0	9,295
OP 26	233	3.9	0	0.0	3,457
OP 32	206	3.4	0	0.0	2,266
1-ATCT	0	0.0	0	0.0	0
OP 2	0	0.0	0	0.0	0

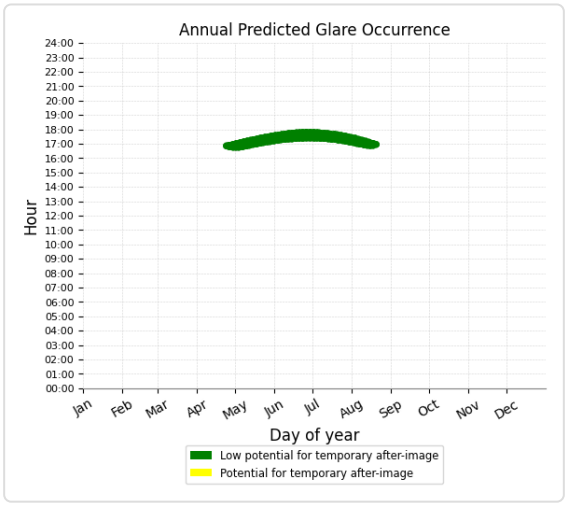
Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
OP 3	0	0.0	0	0.0	0
OP 4	0	0.0	0	0.0	0
OP 8	0	0.0	0	0.0	0
OP 14	0	0.0	0	0.0	0
OP 20	0	0.0	0	0.0	0
OP 22	0	0.0	0	0.0	0
OP 23	0	0.0	0	0.0	0
OP 24	0	0.0	0	0.0	0
OP 25	0	0.0	0	0.0	0
OP 27	0	0.0	0	0.0	0
OP 28	0	0.0	0	0.0	0
OP 29	0	0.0	0	0.0	0
OP 30	0	0.0	0	0.0	0
OP 31	0	0.0	0	0.0	0
OP 33	0	0.0	0	0.0	0
OP 34	0	0.0	0	0.0	0
OP 35	0	0.0	0	0.0	0
OP 36	0	0.0	0	0.0	0
OP 37	0	0.0	0	0.0	0
OP 38	0	0.0	0	0.0	0
OP 39	0	0.0	0	0.0	0
OP 40	0	0.0	0	0.0	0

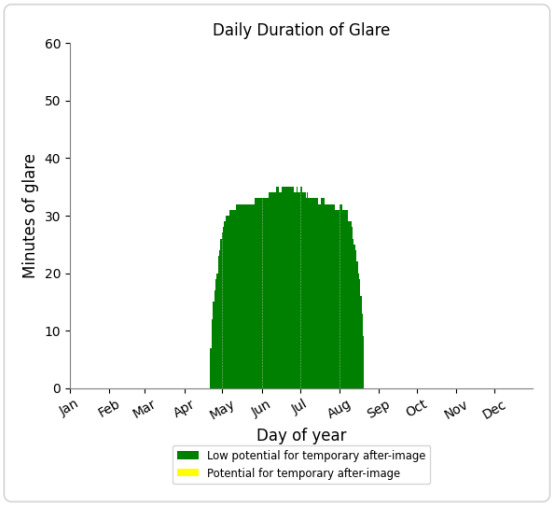


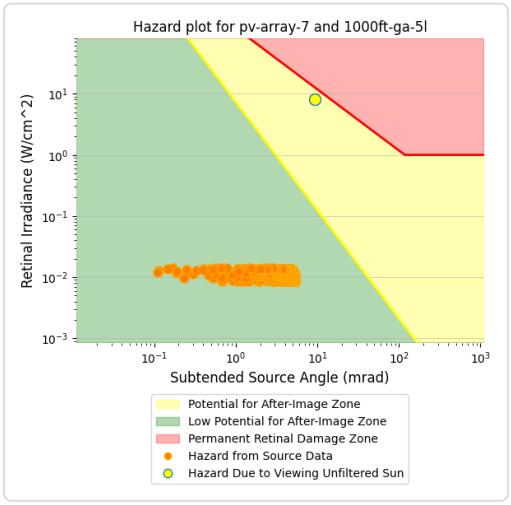
PV array 7 and Route: 1000Ft-GA_5L23R_05L-L_23R-R

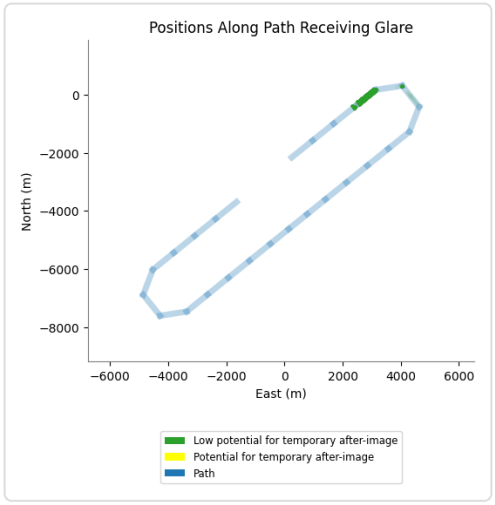
Yellow glare: none

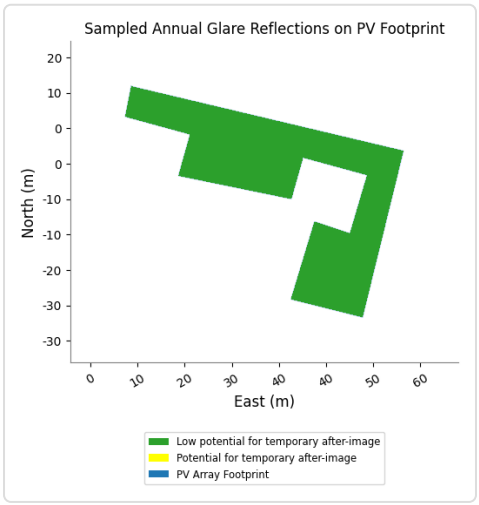
Green glare: 3,686 min.

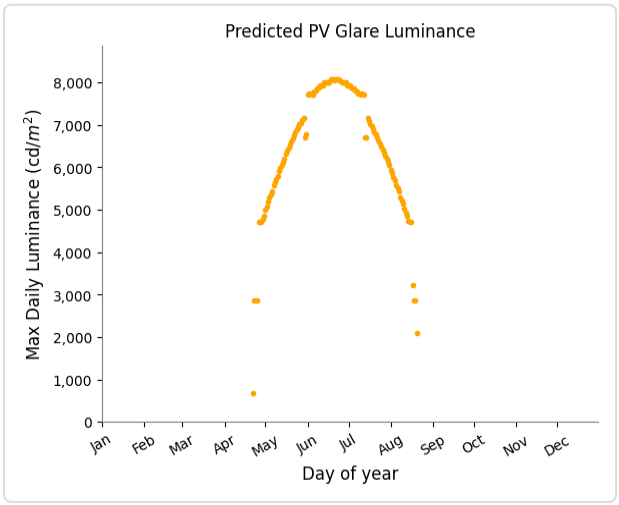








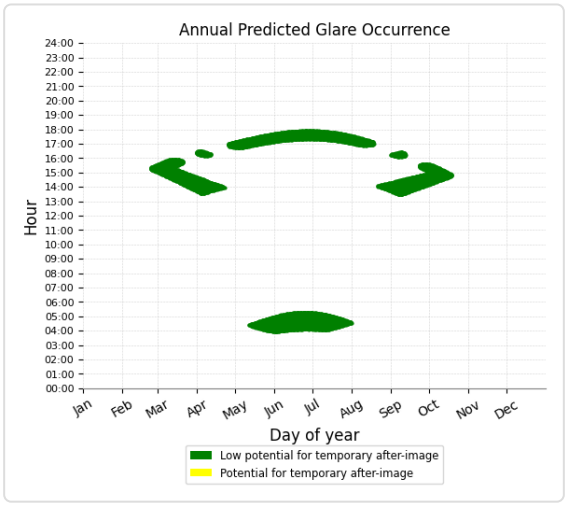


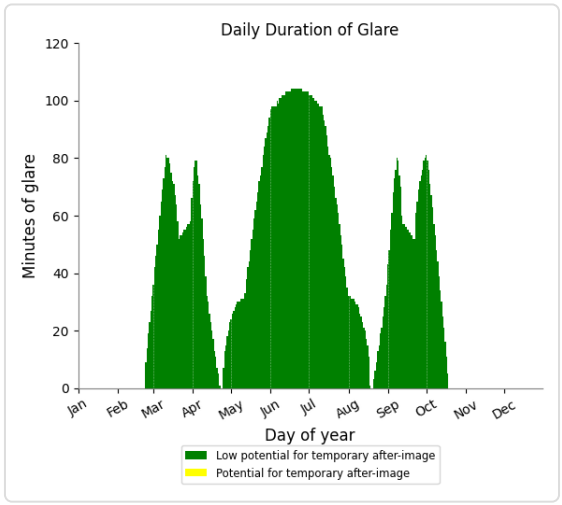


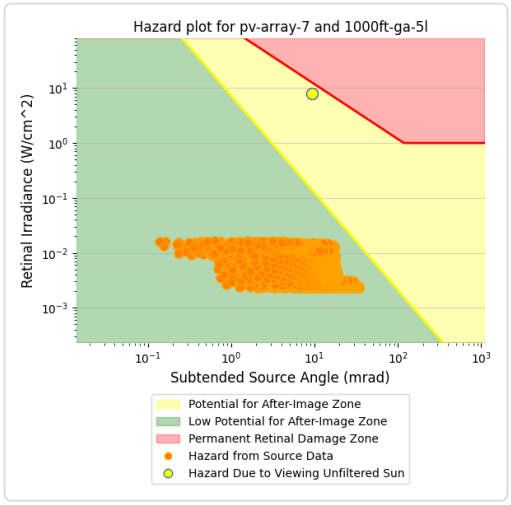
PV array 7 and Route: 1000Ft-GA_5L23R_05L-R_23R-L

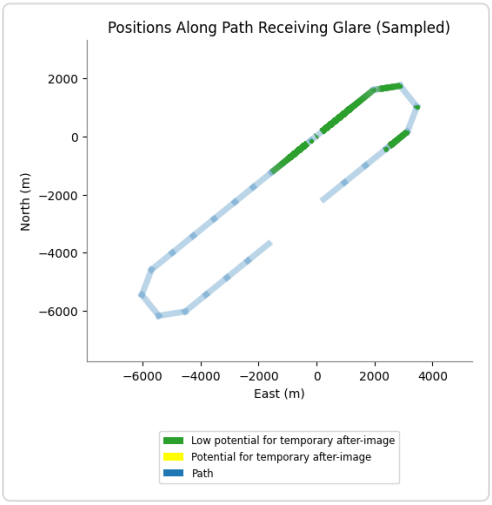
Yellow glare: none

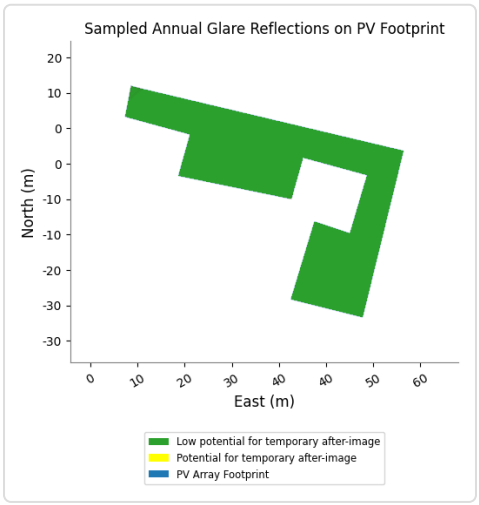
Green glare: 13,535 min.

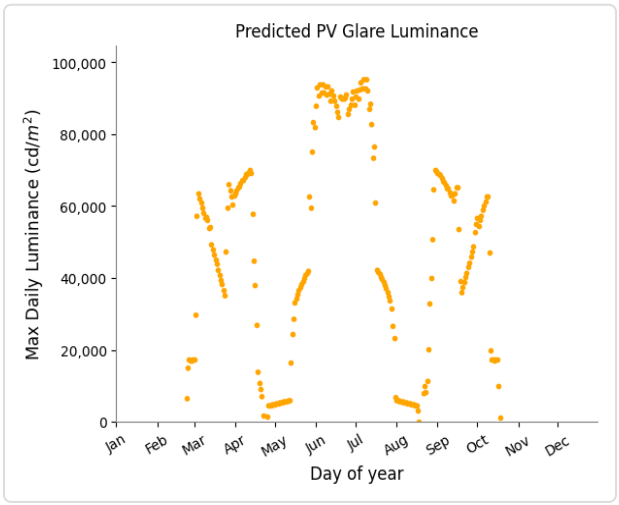








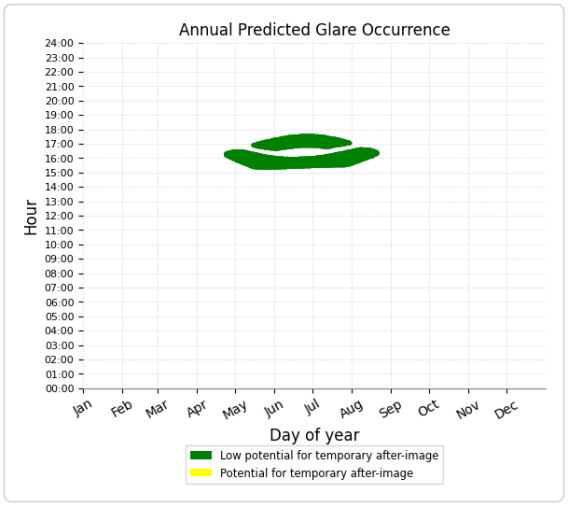


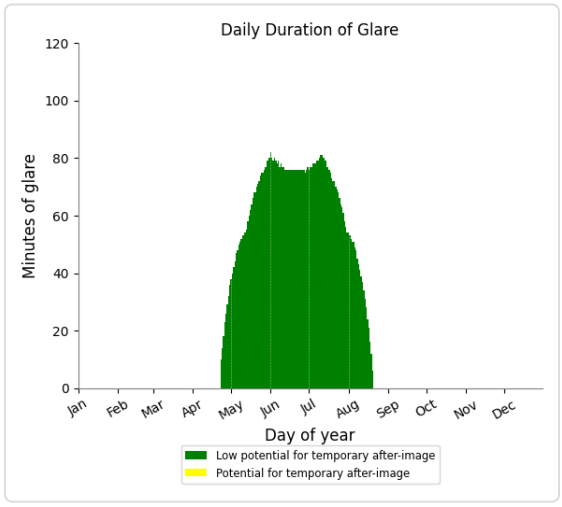


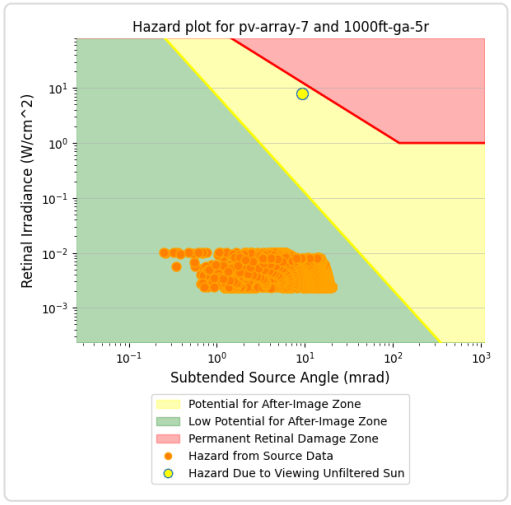
PV array 7 and Route: 1000Ft-GA_5R23L_05R-R_23L-L

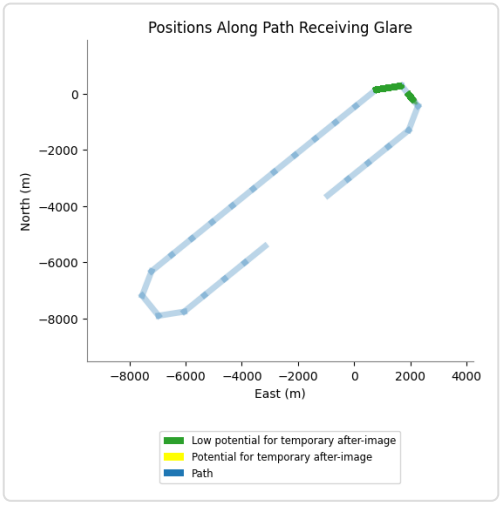
Yellow glare: none

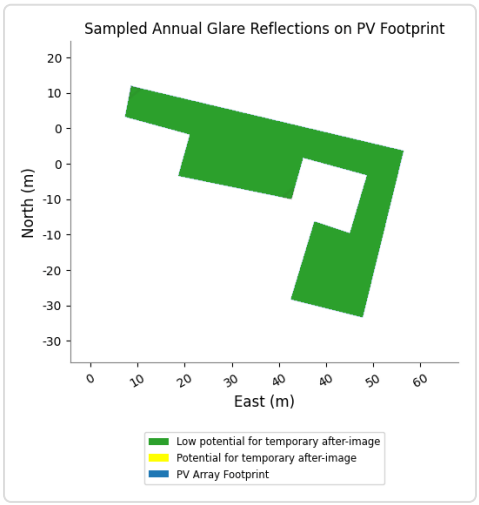
Green glare: 7,388 min.

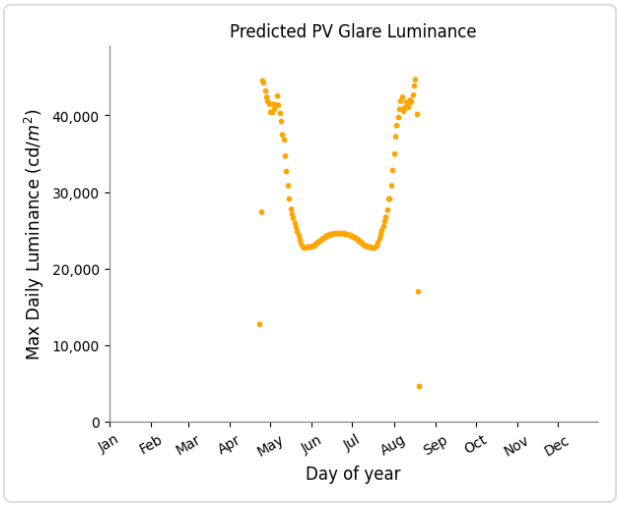








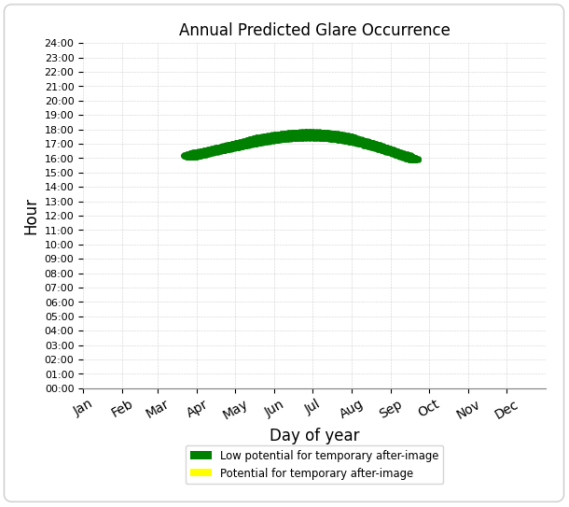


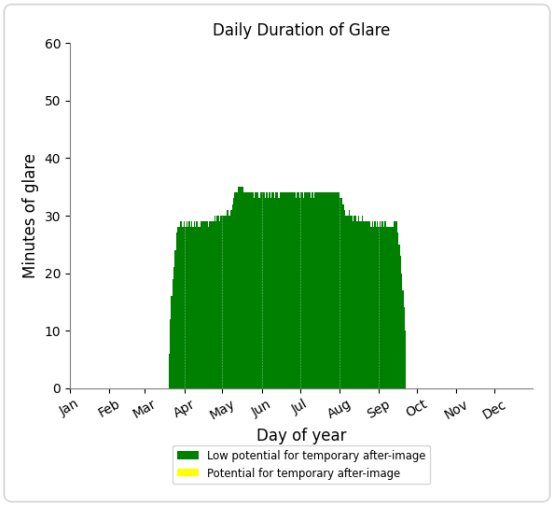


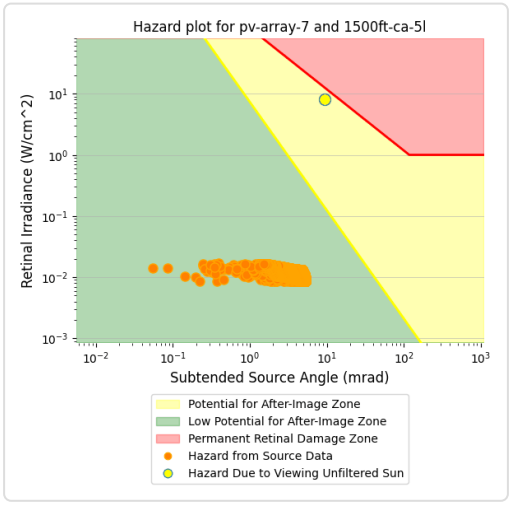
PV array 7 and Route: 1500Ft-CA_5L23R_05L-L_23R-R

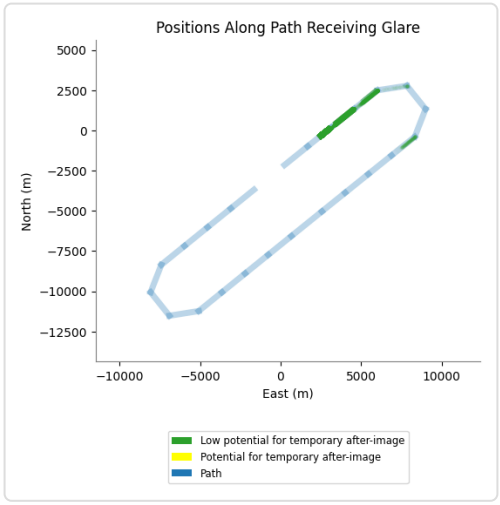
Yellow glare: none

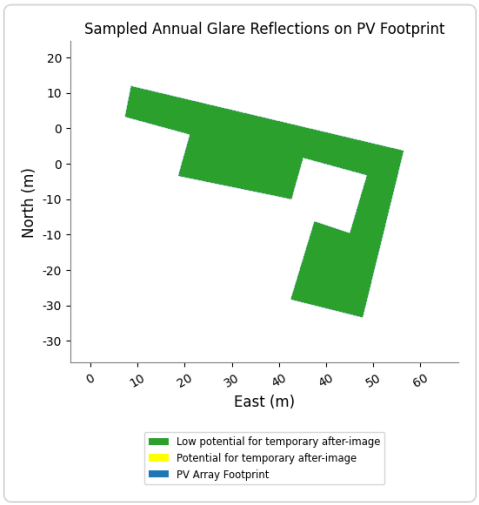
Green glare: 5,706 min.

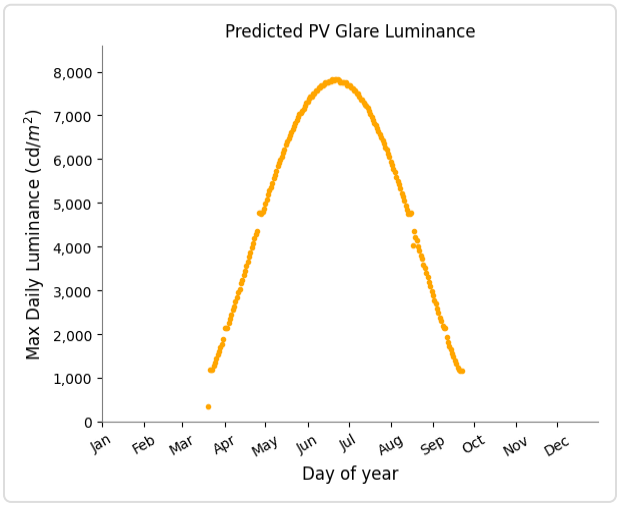








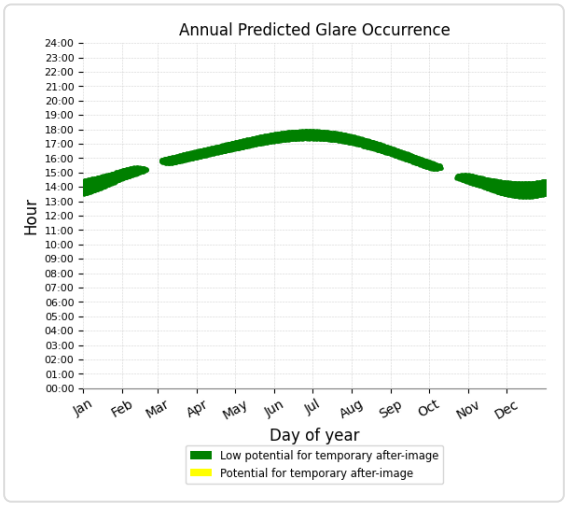


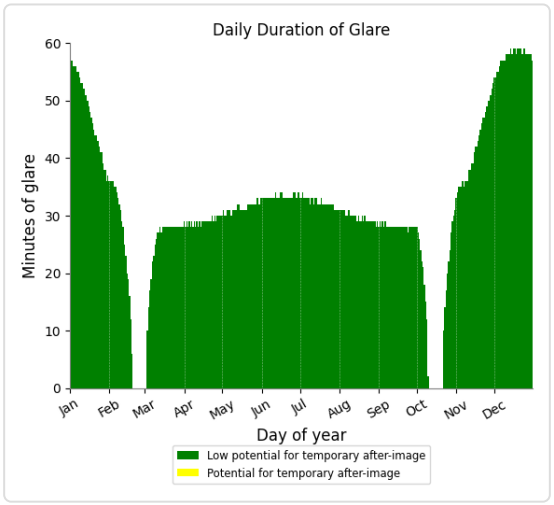


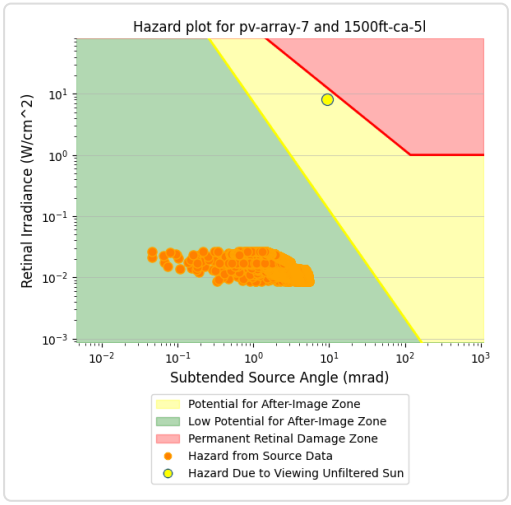
PV array 7 and Route: 1500Ft-CA_5L23R_05L-R_23R-L

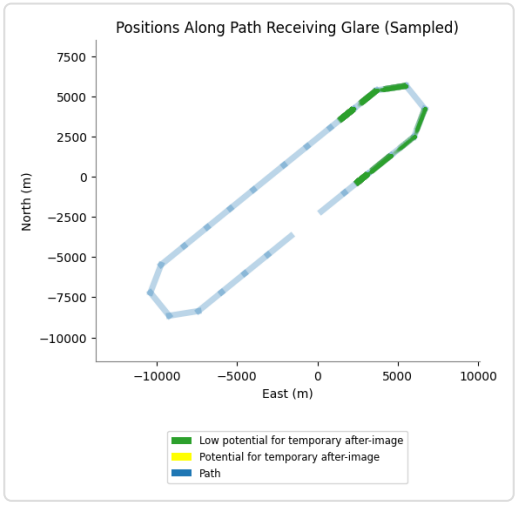
Yellow glare: none

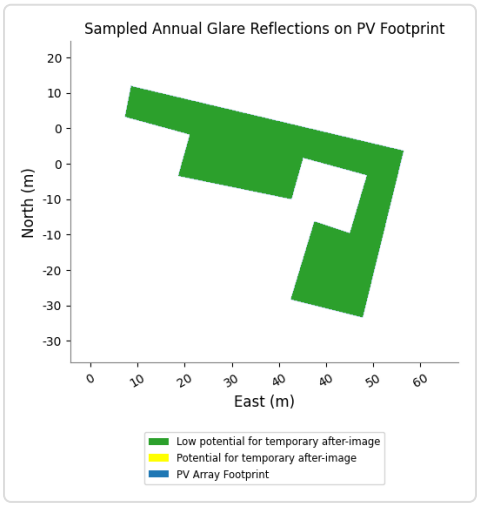
Green glare: 11,818 min.

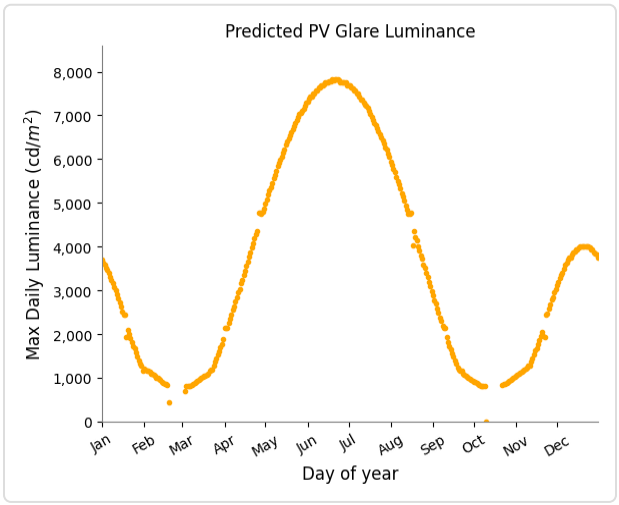








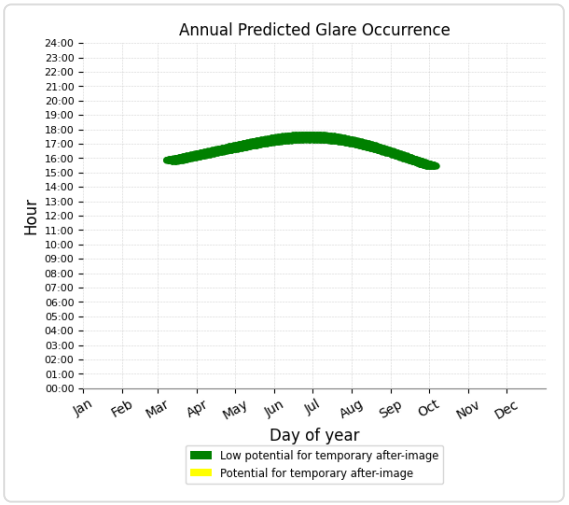


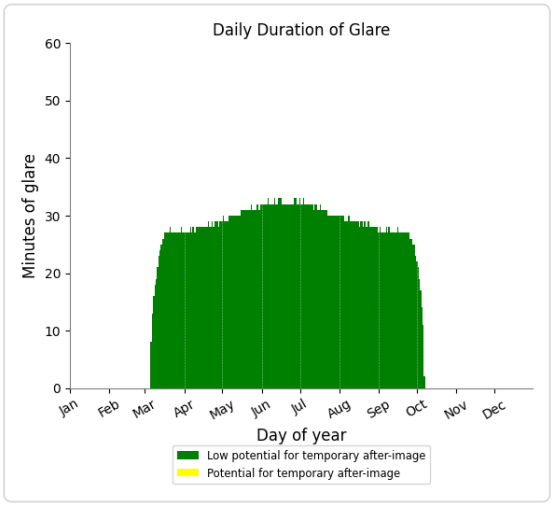


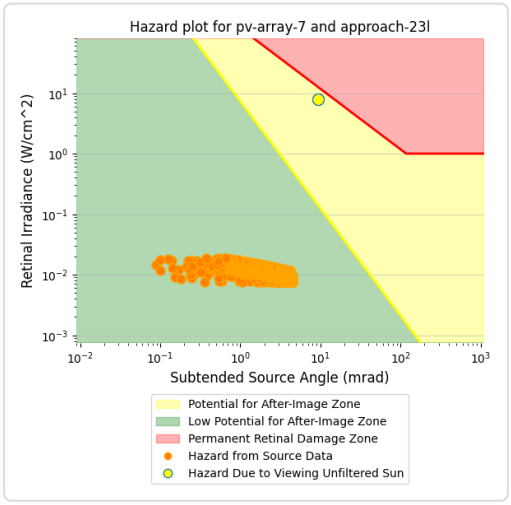
PV array 7 and Route: Approach_23L

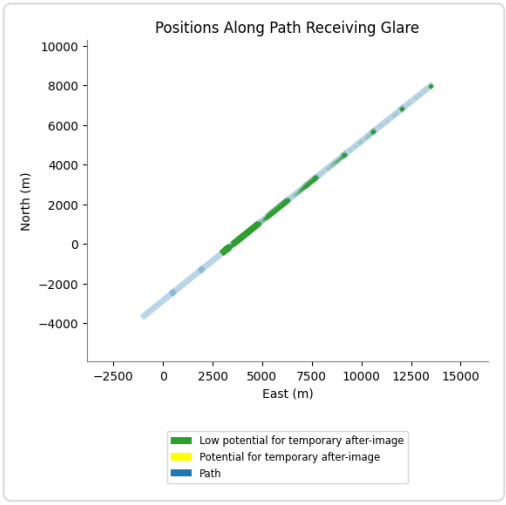
Yellow glare: none

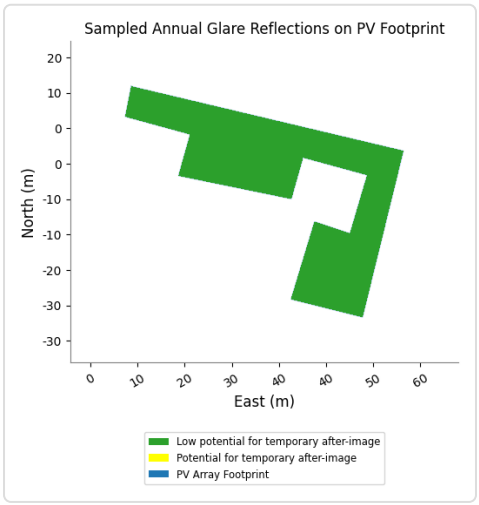
Green glare: 6,150 min.

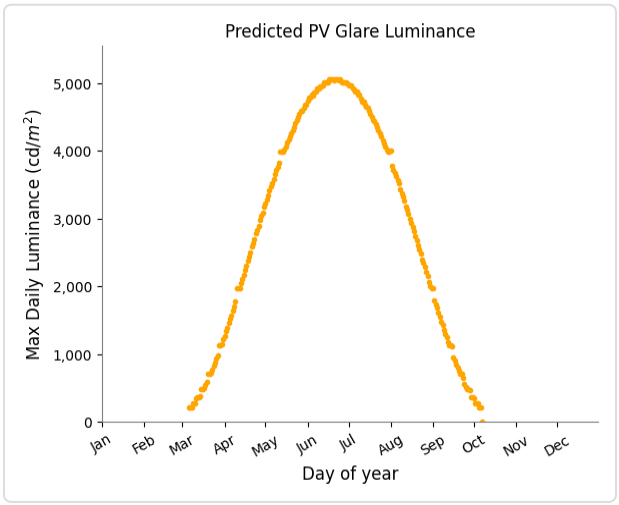








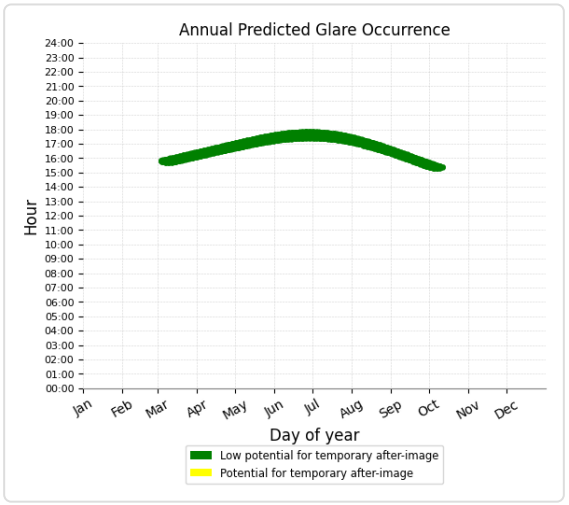


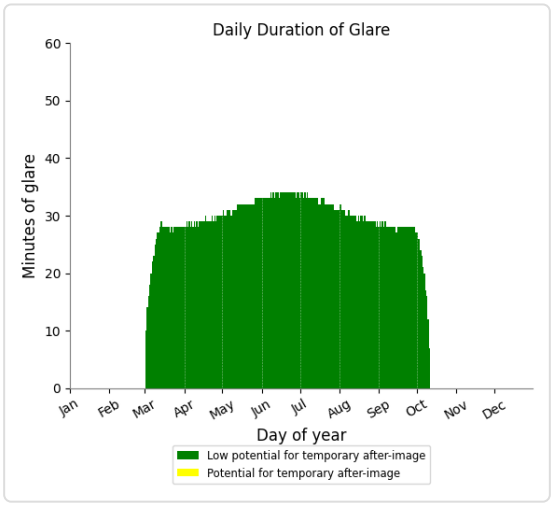


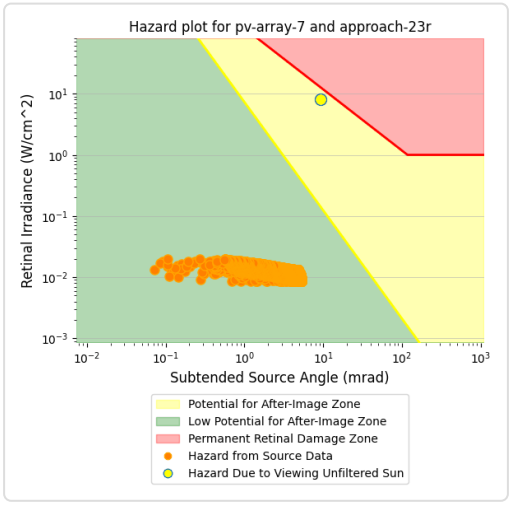
PV array 7 and Route: Approach_23R

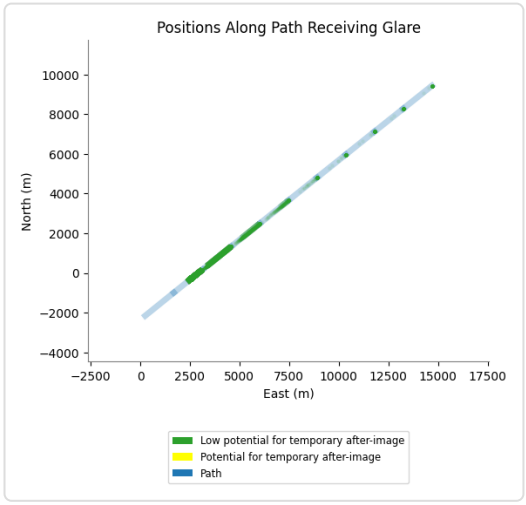
Yellow glare: none

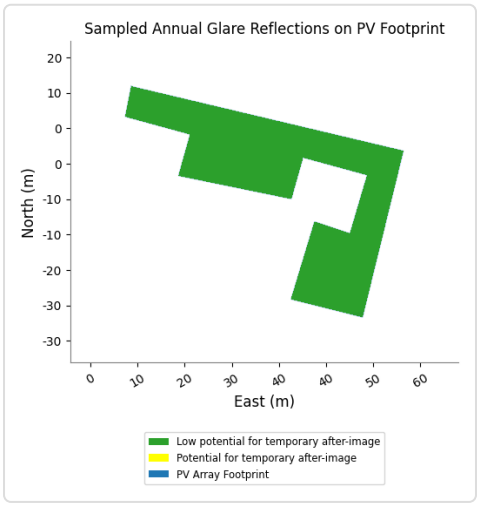
Green glare: 6,613 min.

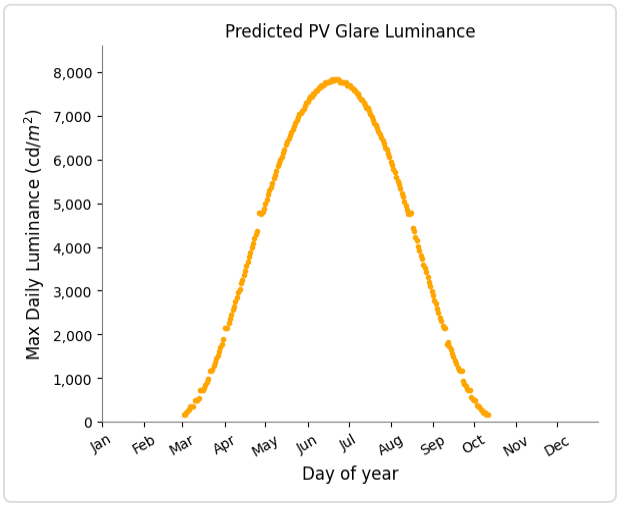












PV array 7 and Route: 1000Ft-GA_5R23L_05R-L_23L-R

No glare found

PV array 7 and Route: Approach_05L

No glare found

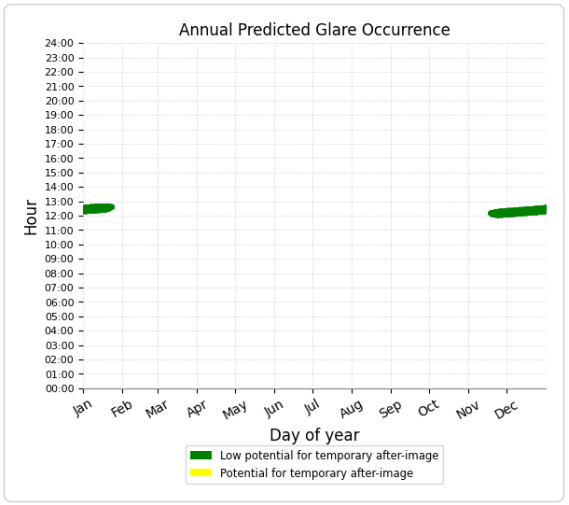
PV array 7 and Route: Approach_05R

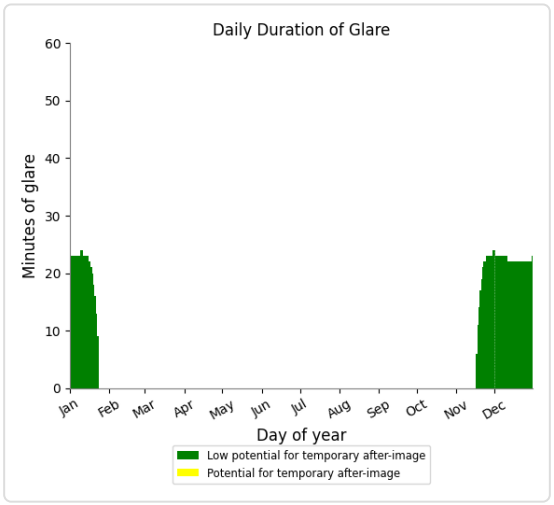
No glare found

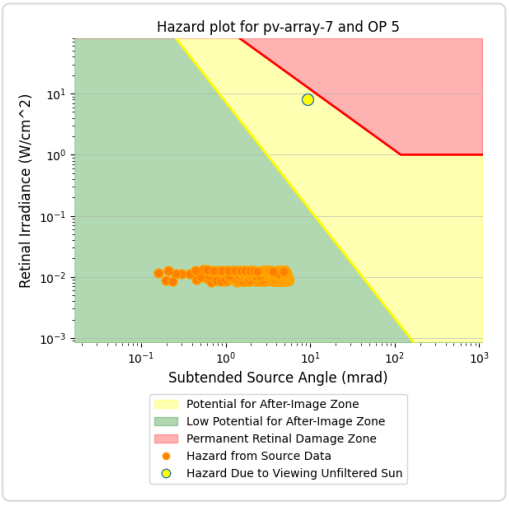
PV array 7 and OP 5

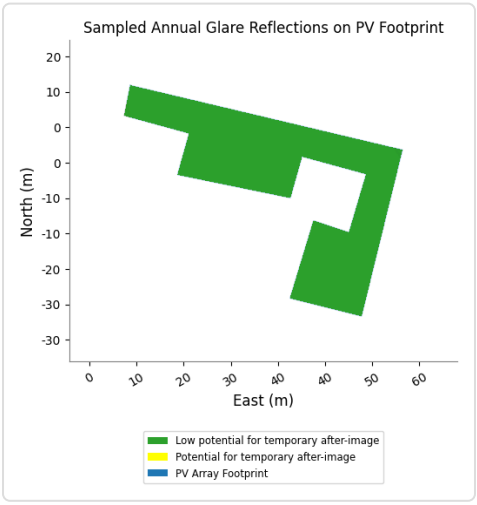
Yellow glare: none

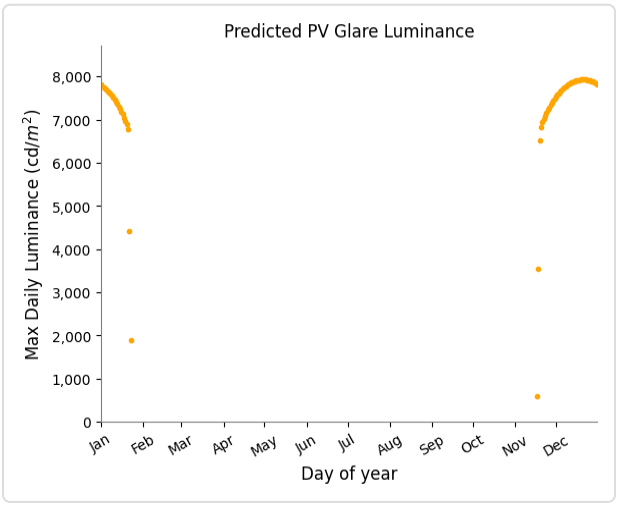
Green glare: 1,454 min.







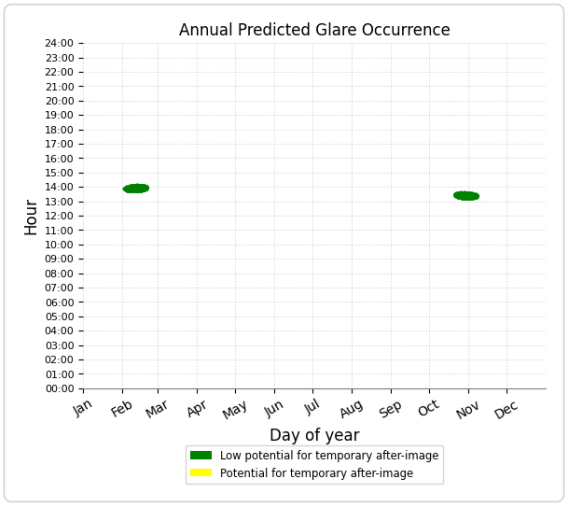


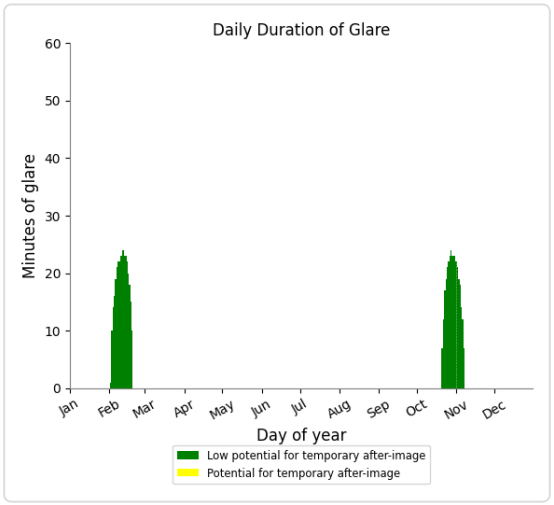


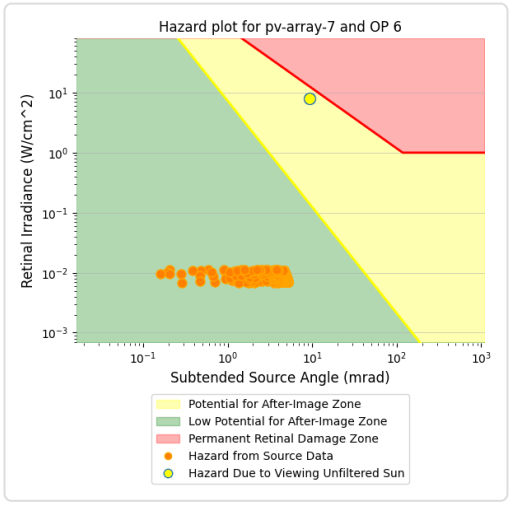
PV array 7 and OP 6

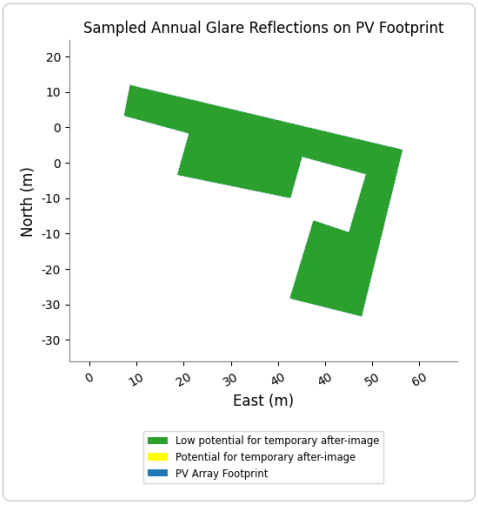
Yellow glare: none

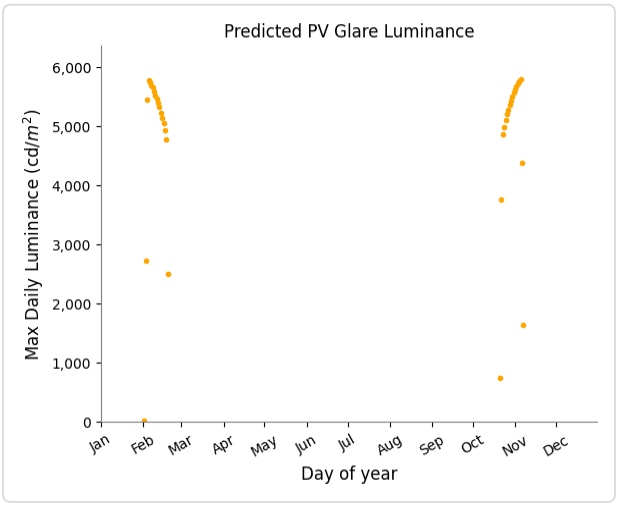
Green glare: 653 min.







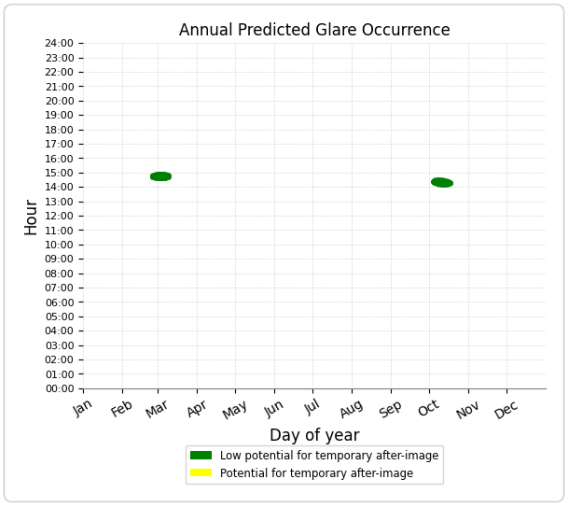


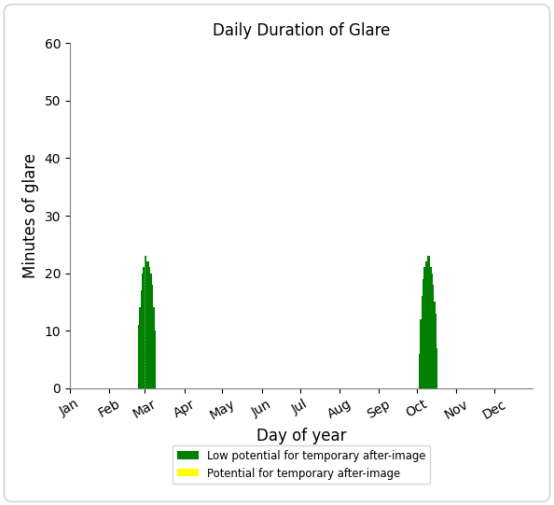


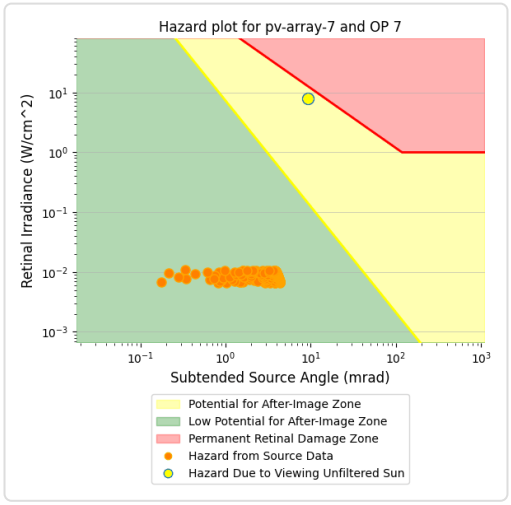
PV array 7 and OP 7

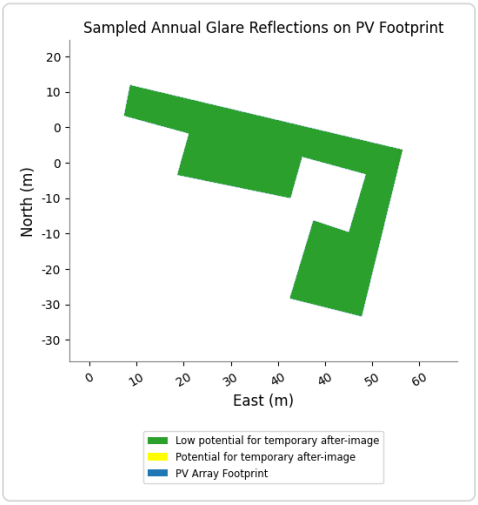
Yellow glare: none

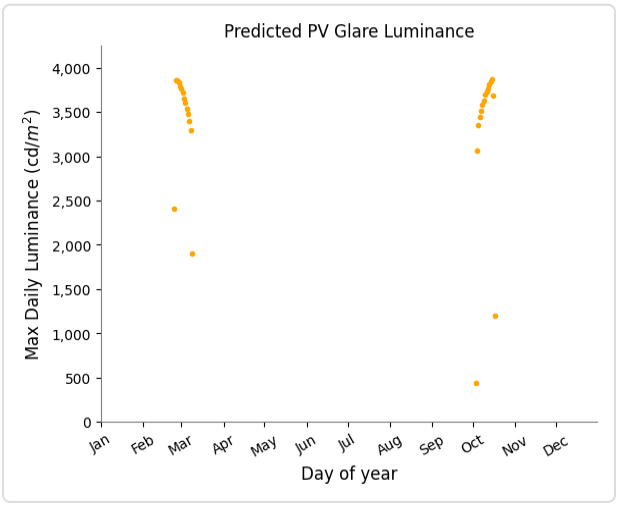
Green glare: 514 min.







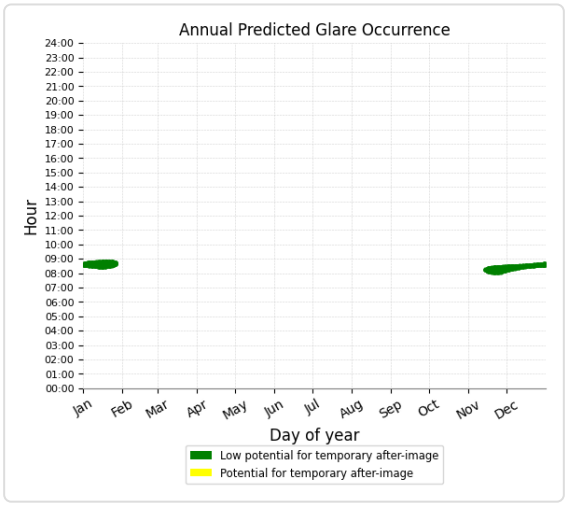


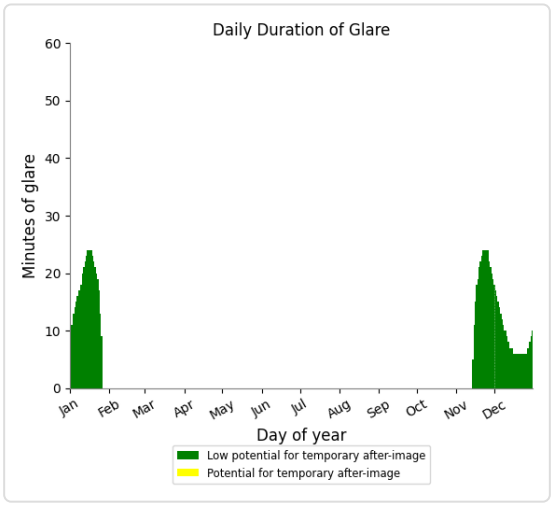


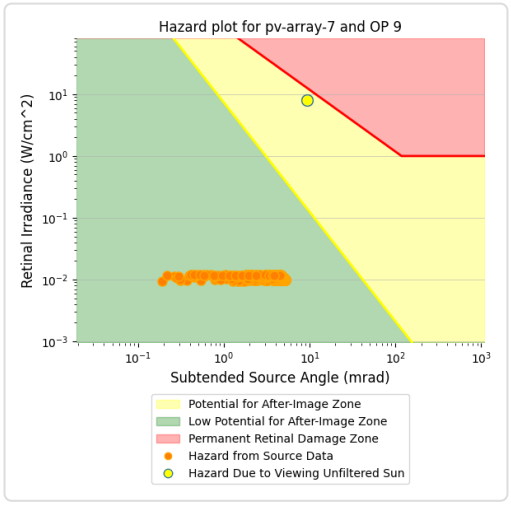
PV array 7 and OP 9

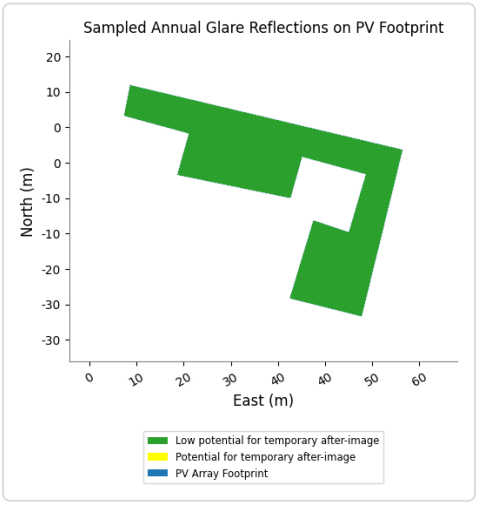
Yellow glare: none

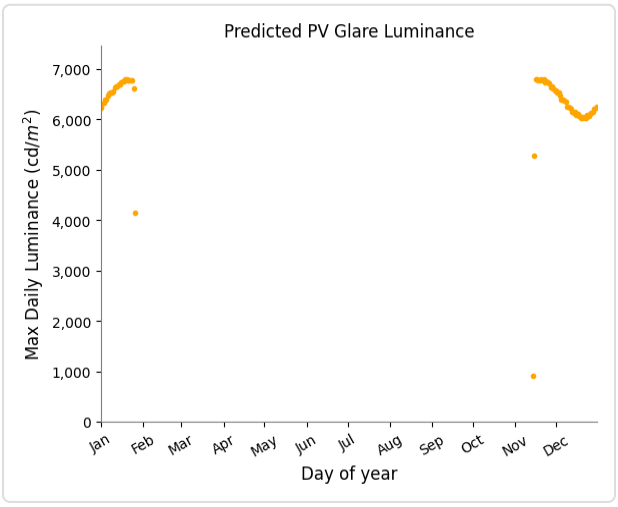
Green glare: 1,085 min.







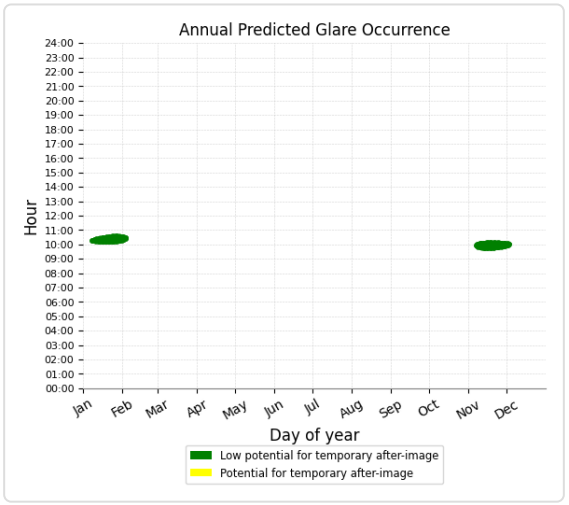


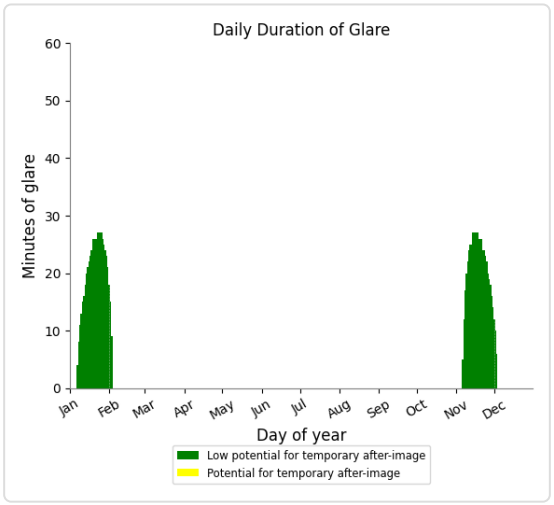


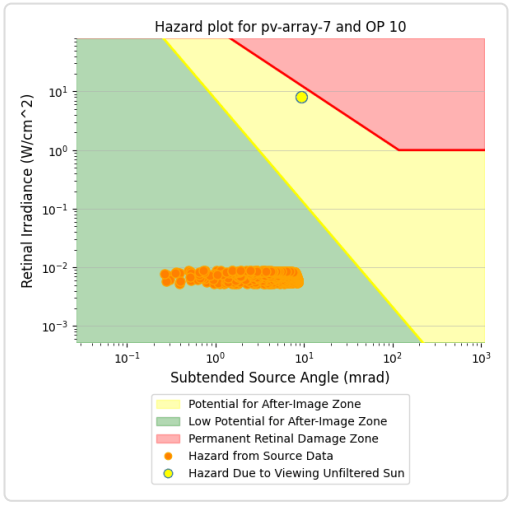
PV array 7 and OP 10

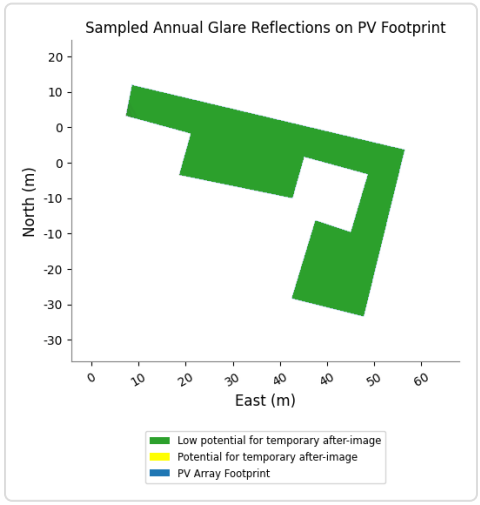
Yellow glare: none

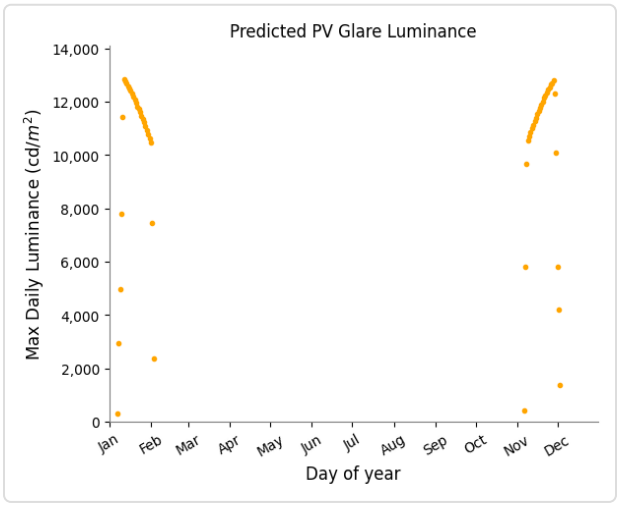
Green glare: 1,139 min.







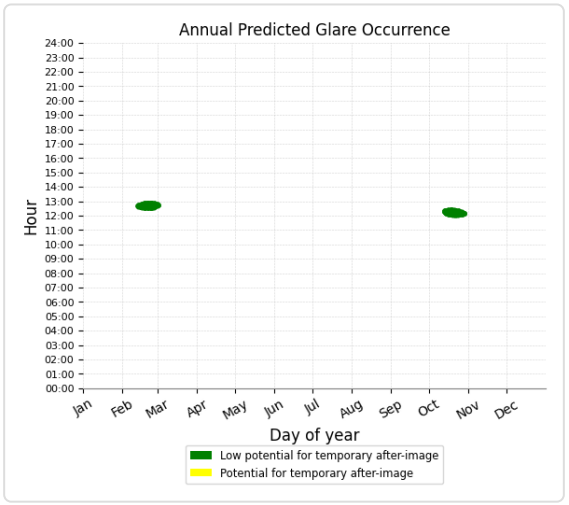


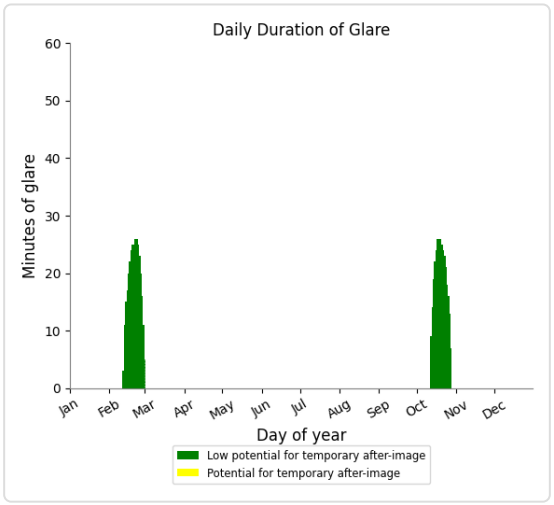


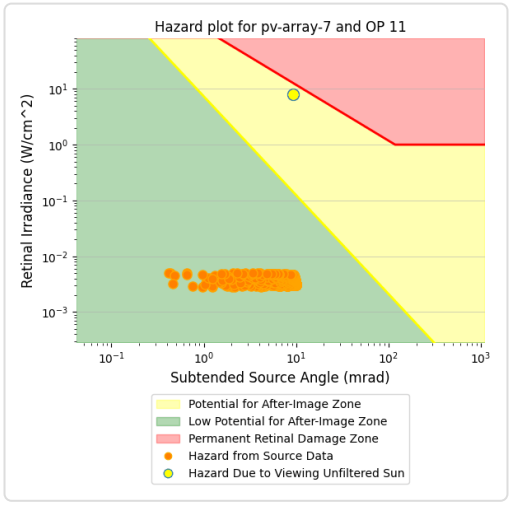
PV array 7 and OP 11

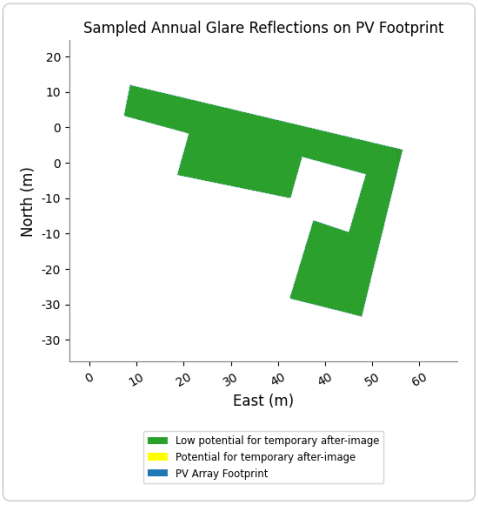
Yellow glare: none

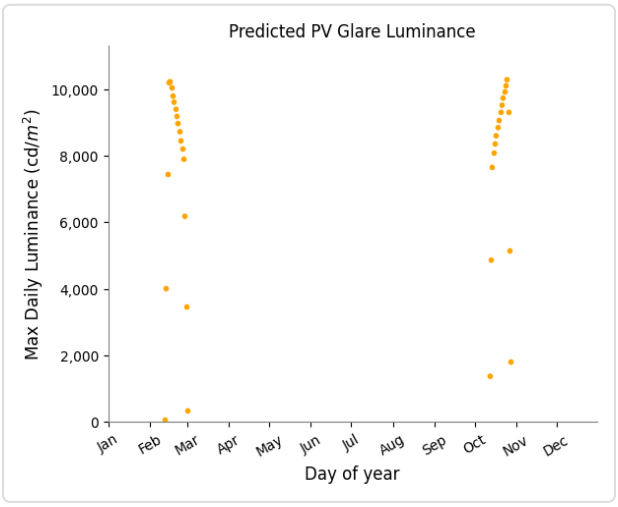
Green glare: 679 min.







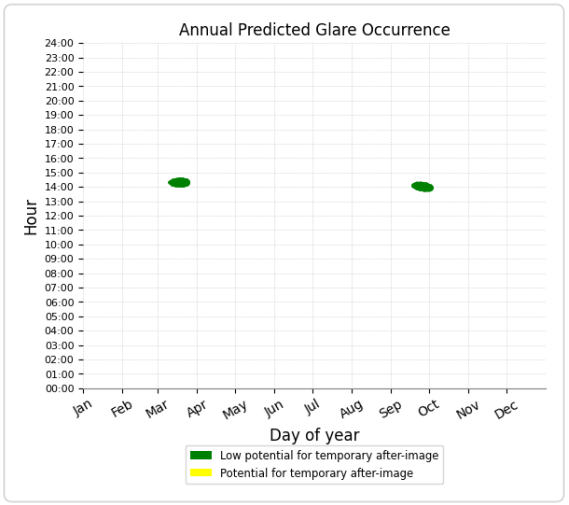


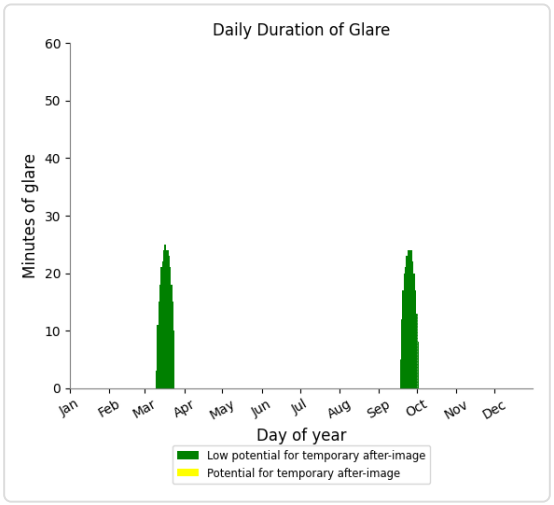


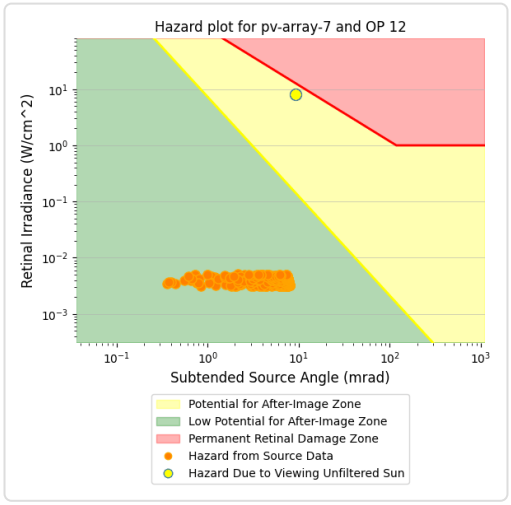
PV array 7 and OP 12

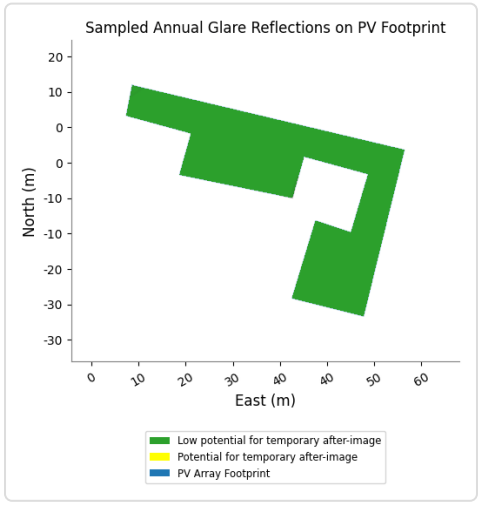
Yellow glare: none

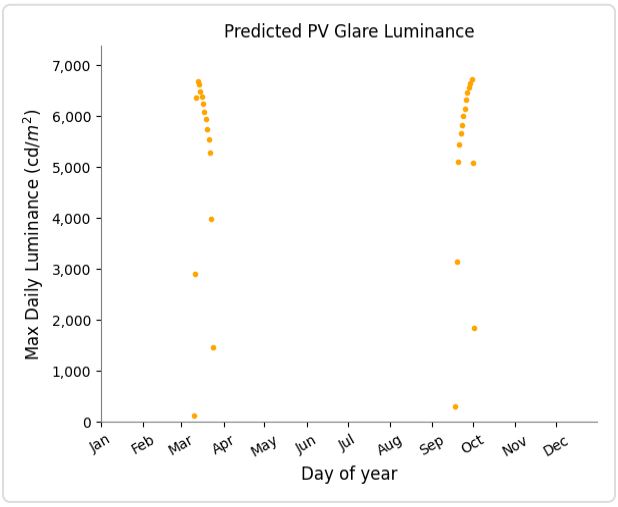
Green glare: 548 min.







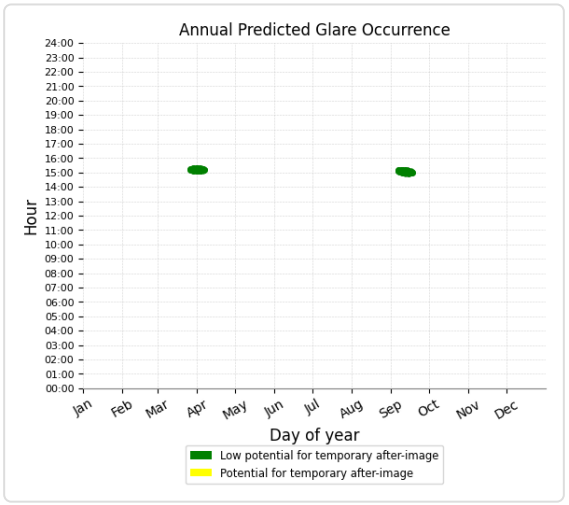


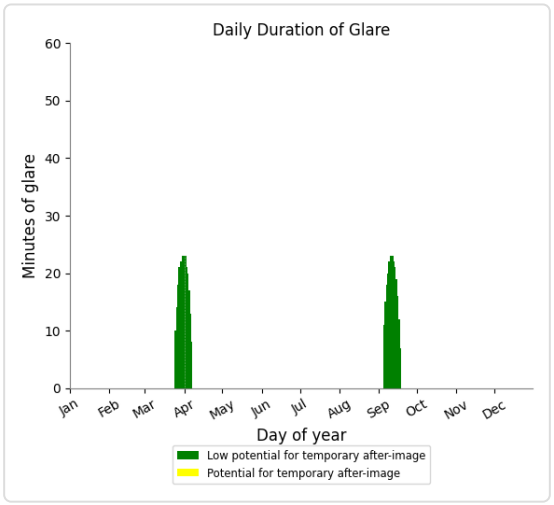


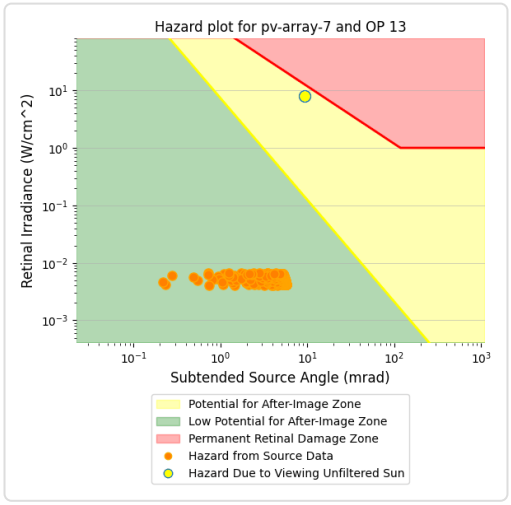
PV array 7 and OP 13

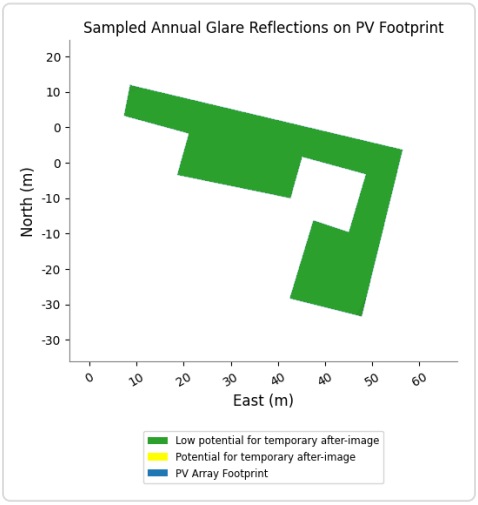
Yellow glare: none

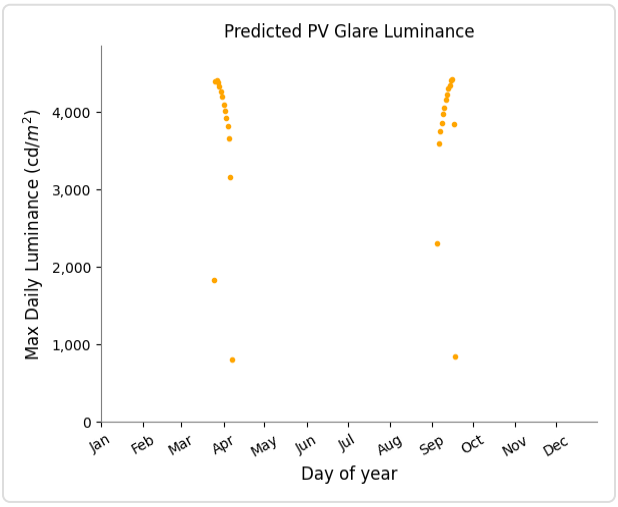
Green glare: 507 min.







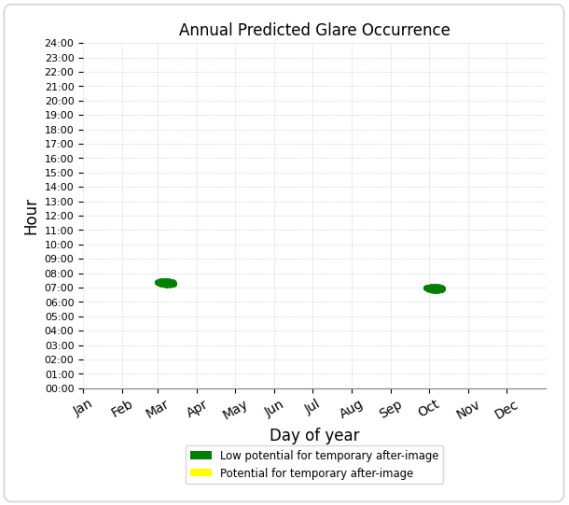


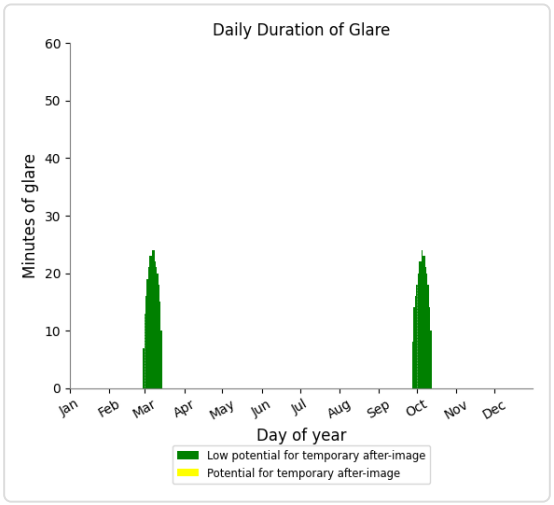


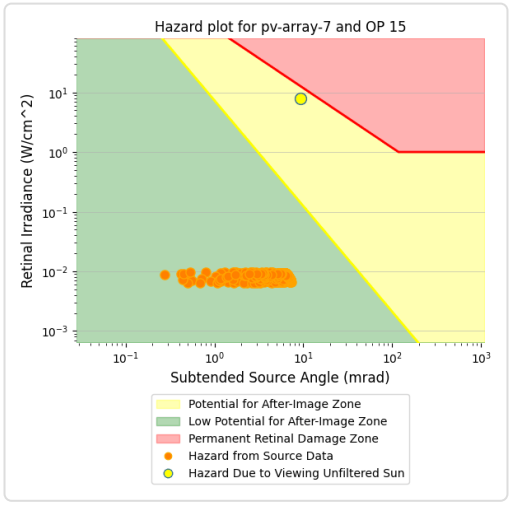
PV array 7 and OP 15

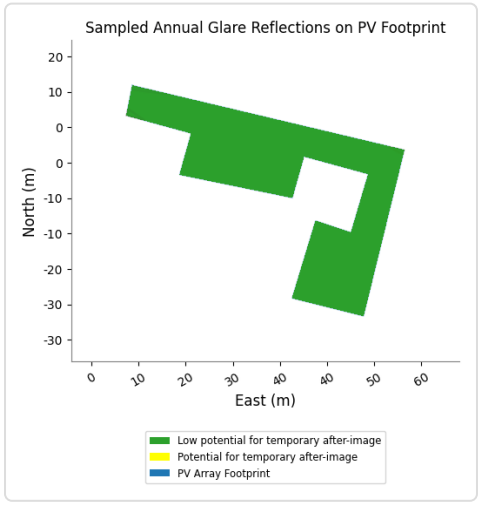
Yellow glare: none

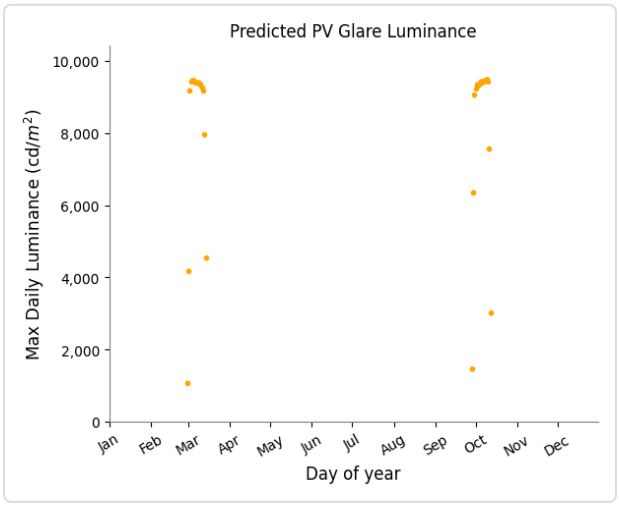
Green glare: 549 min.







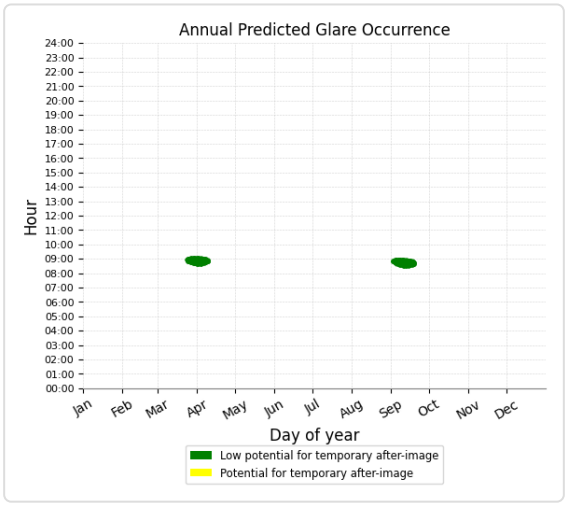


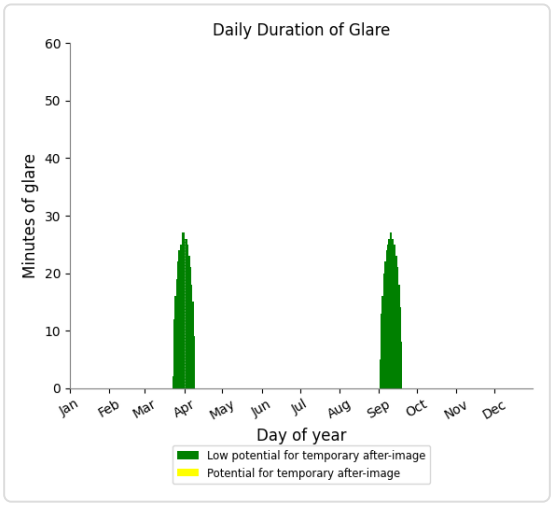


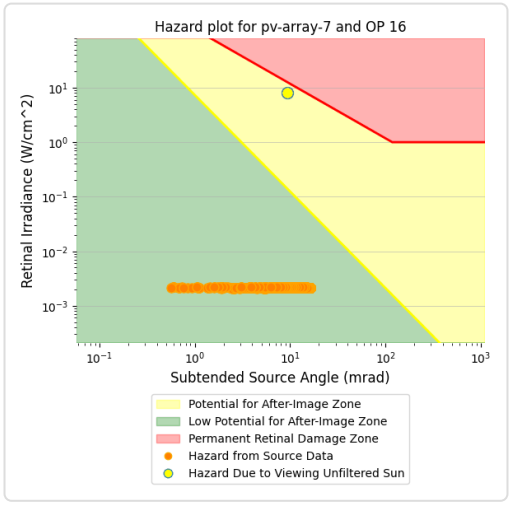
PV array 7 and OP 16

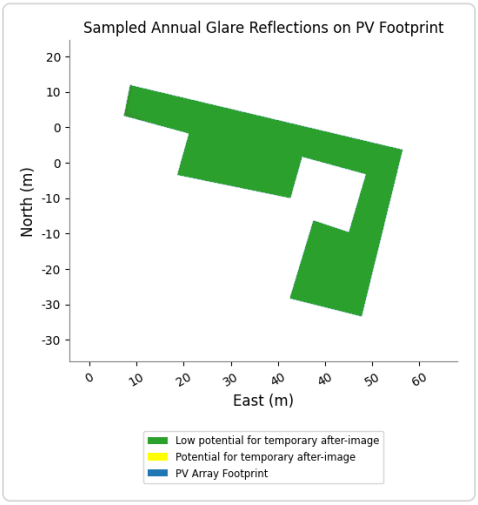
Yellow glare: none

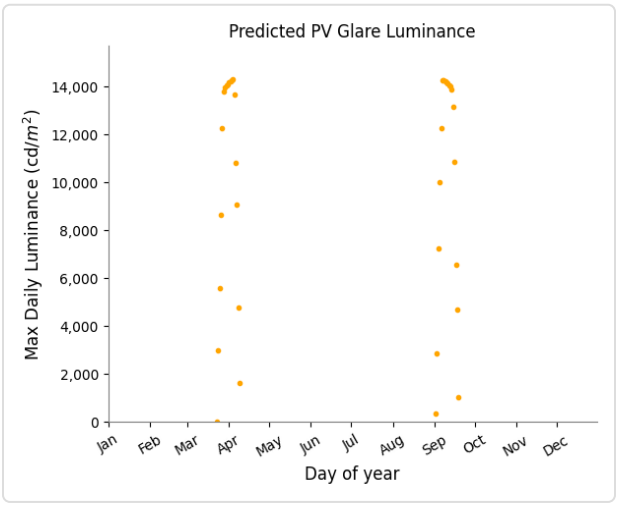
Green glare: 727 min.







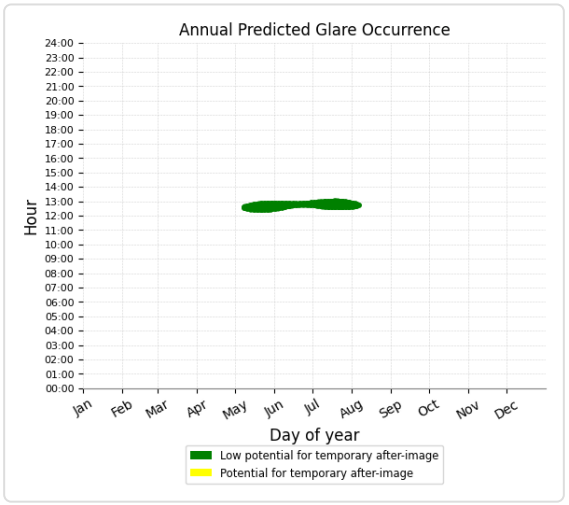


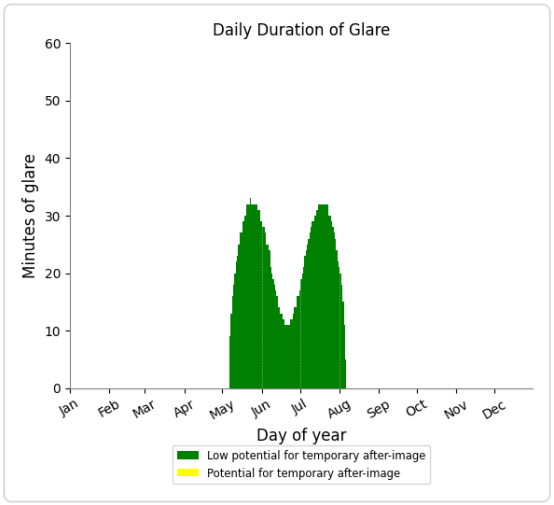


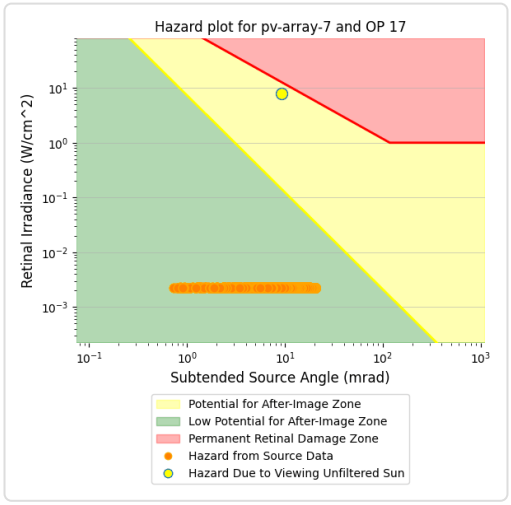
PV array 7 and OP 17

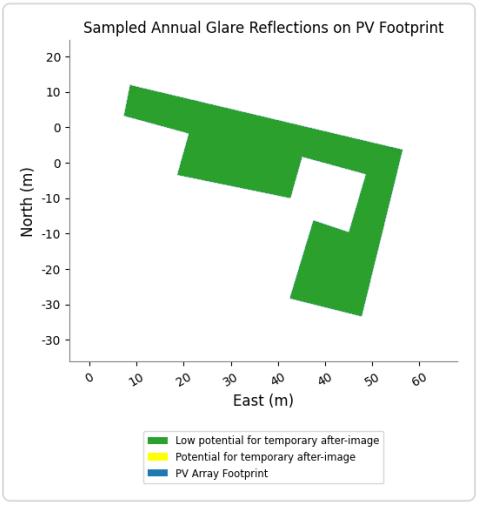
Yellow glare: none

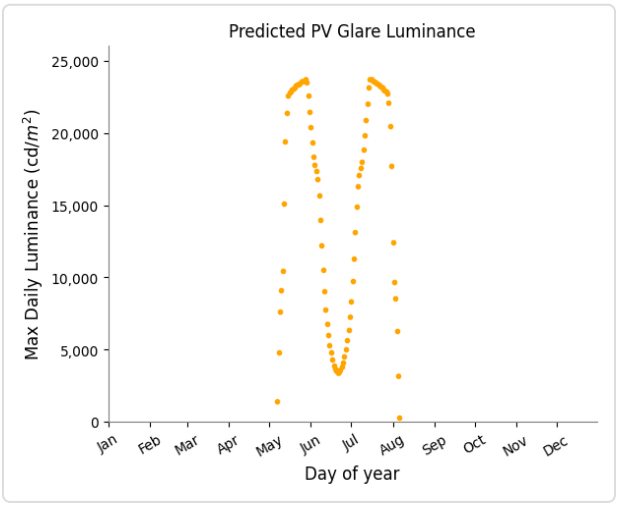
Green glare: 2,125 min.







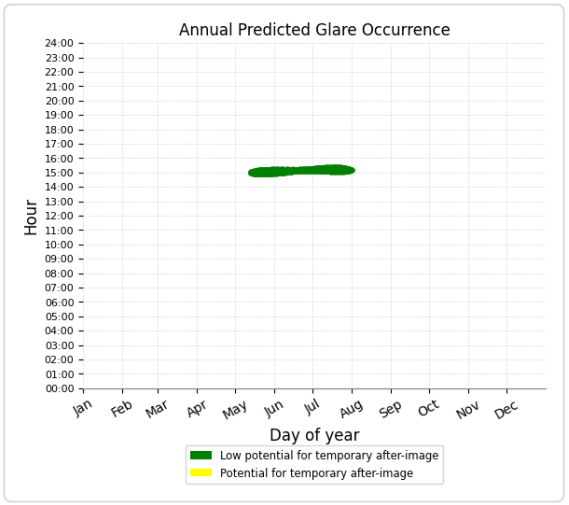


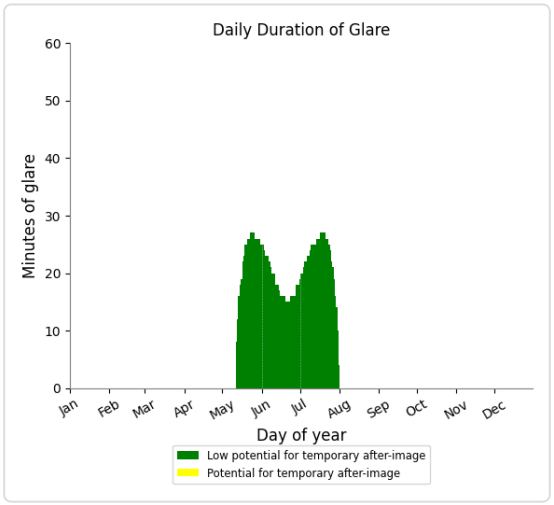


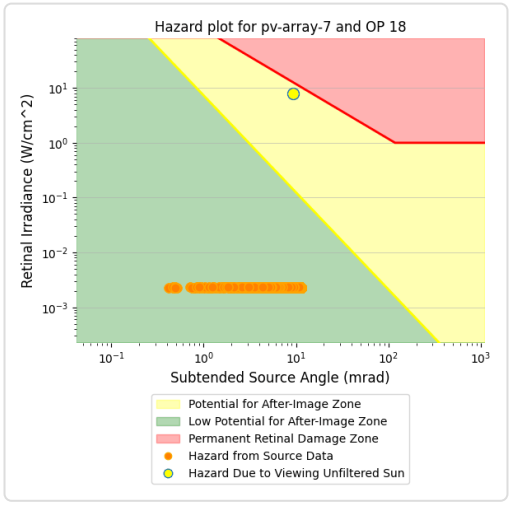
PV array 7 and OP 18

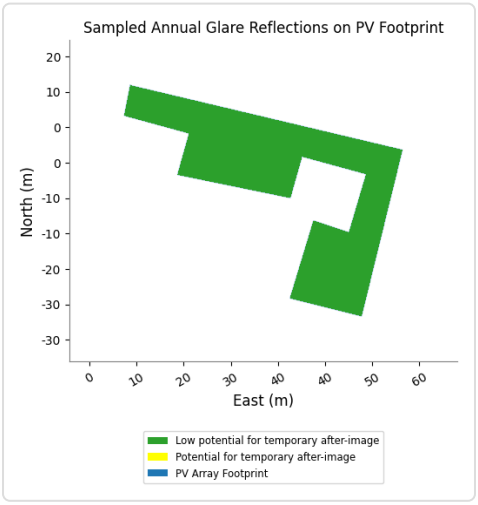
Yellow glare: none

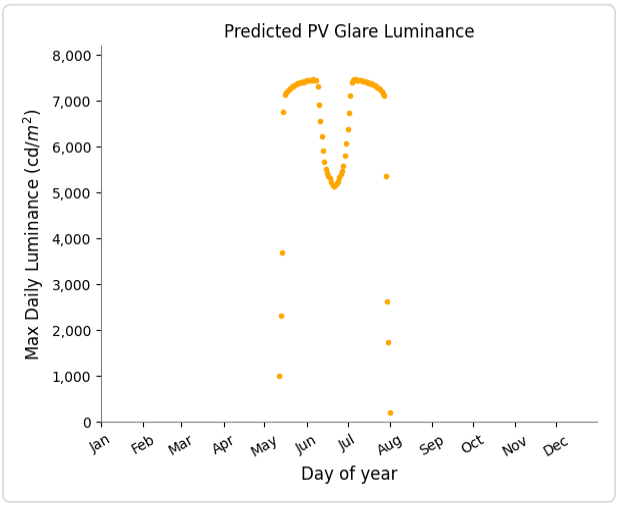
Green glare: 1,730 min.







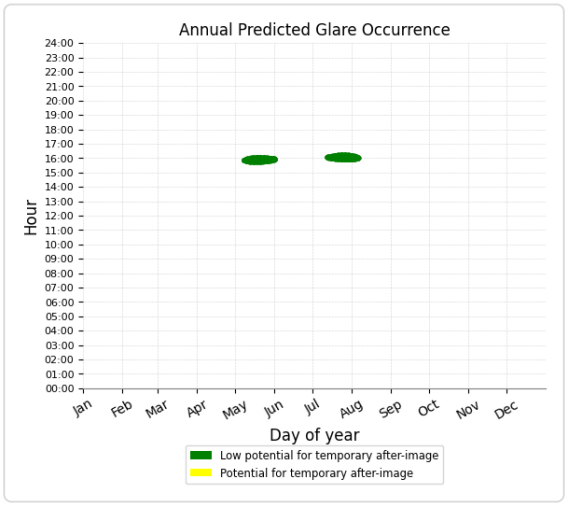


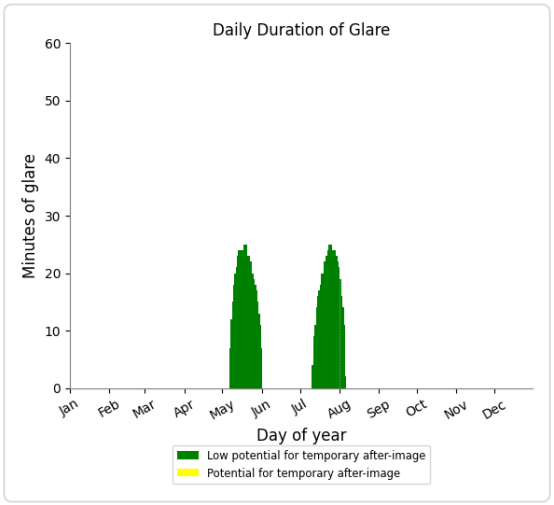


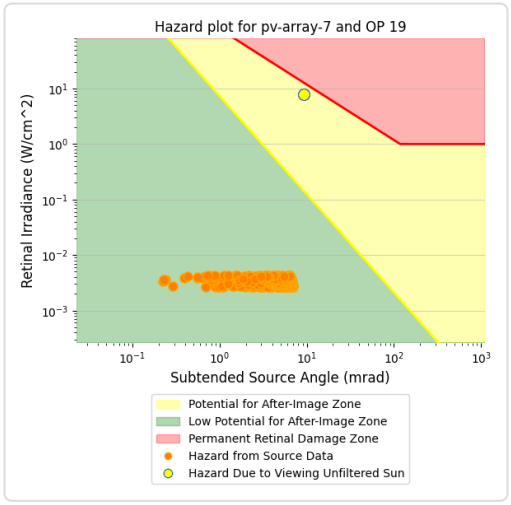
PV array 7 and OP 19

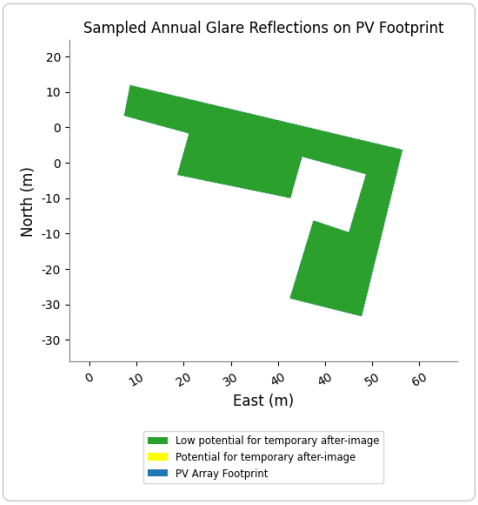
Yellow glare: none

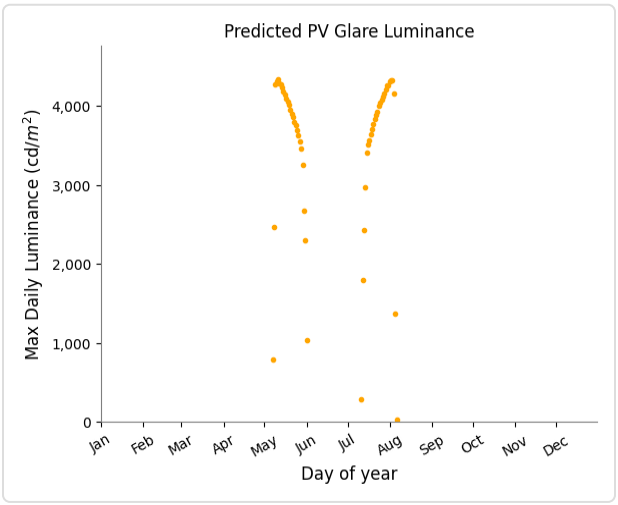
Green glare: 992 min.







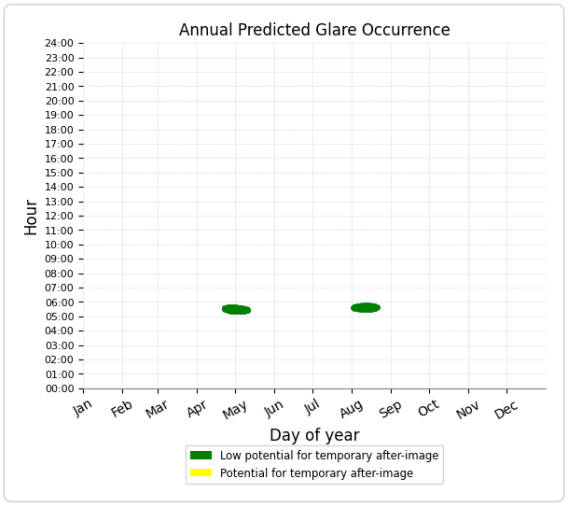


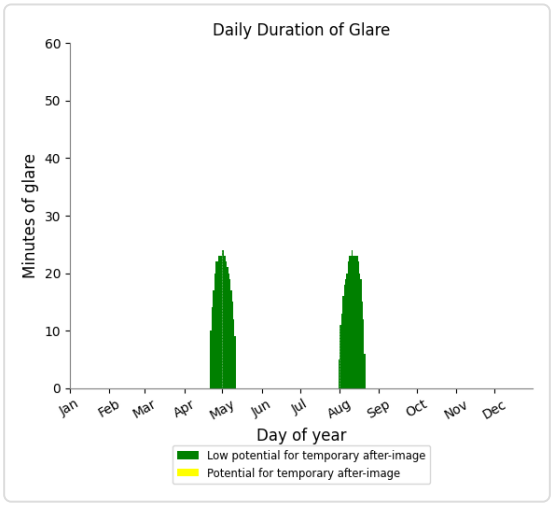


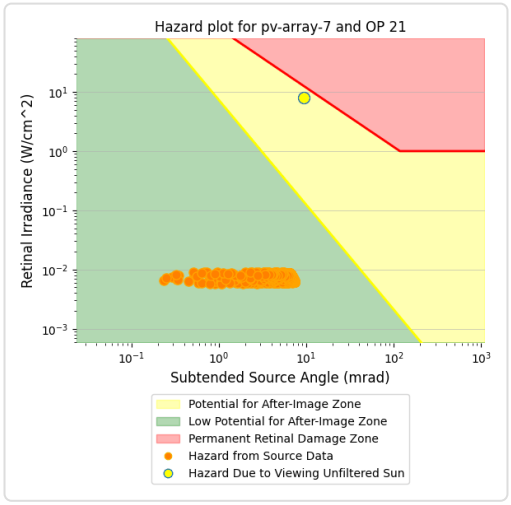
PV array 7 and OP 21

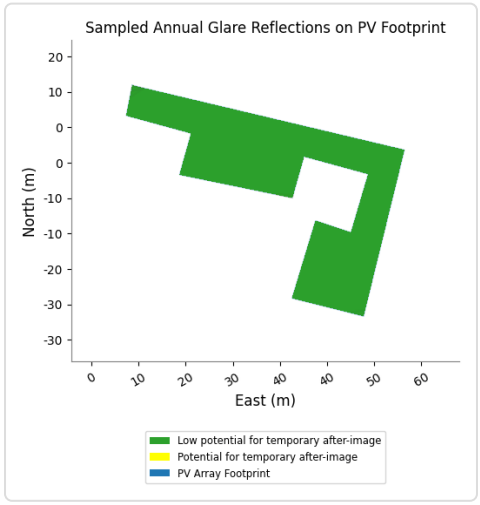
Yellow glare: none

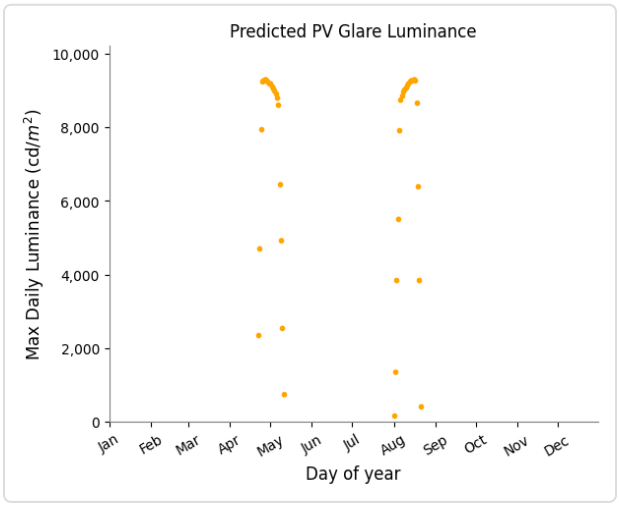
Green glare: 760 min.







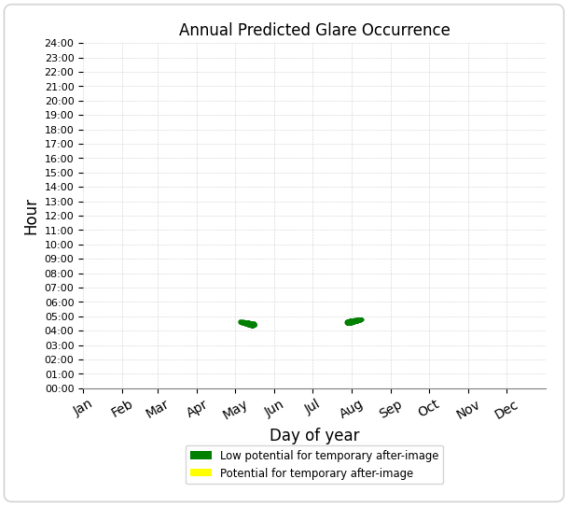


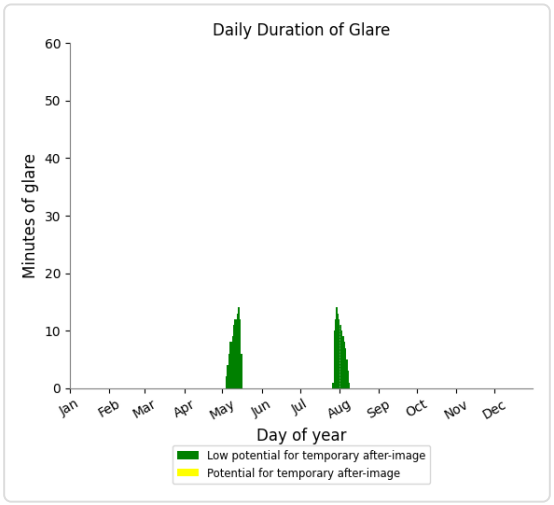


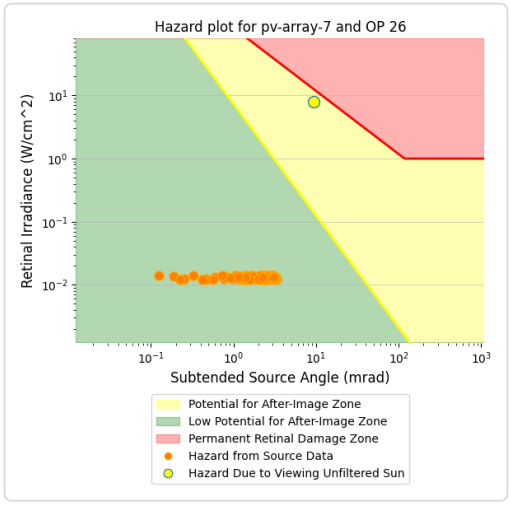
PV array 7 and OP 26

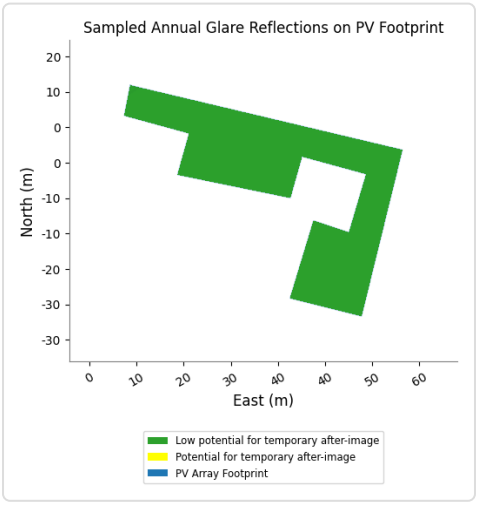
Yellow glare: none

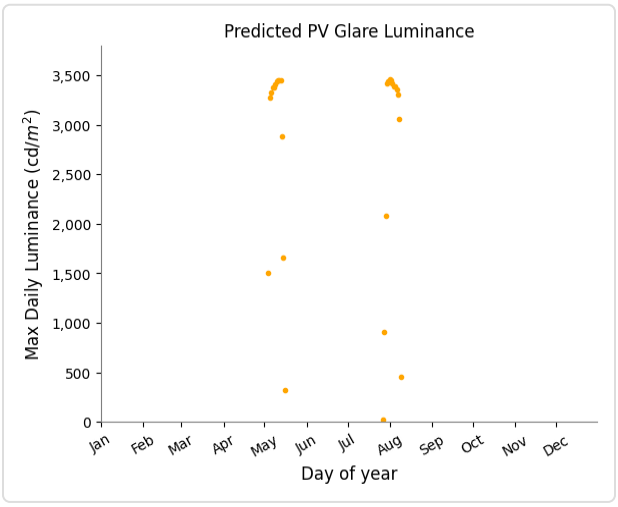
Green glare: 233 min.







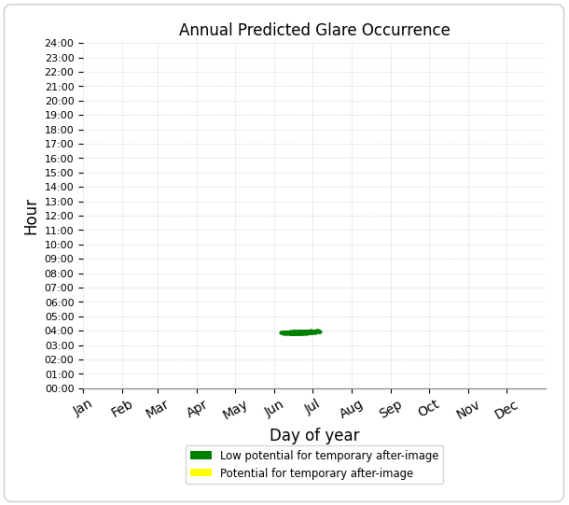


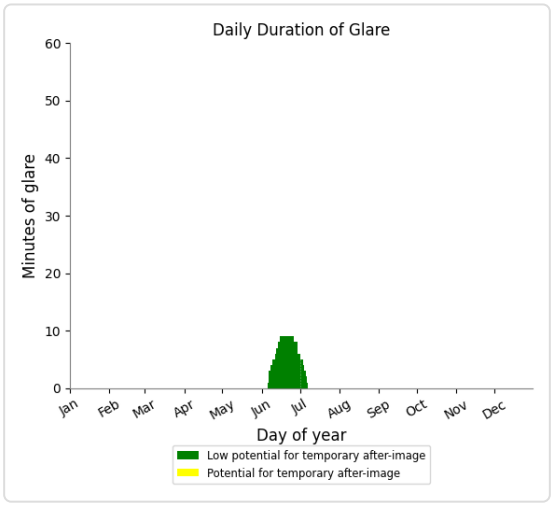


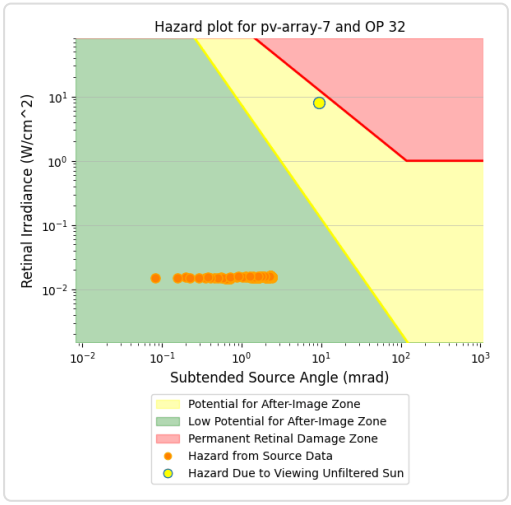
PV array 7 and OP 32

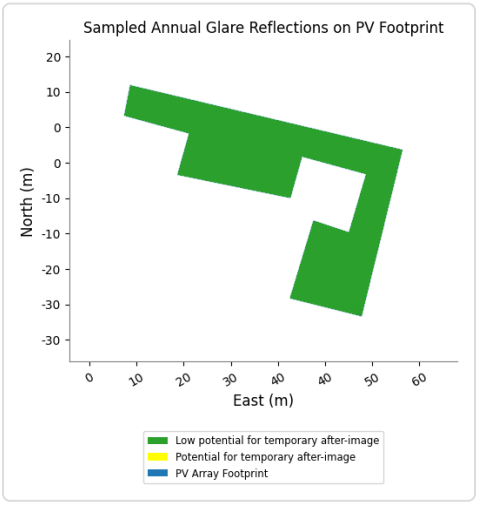
Yellow glare: none

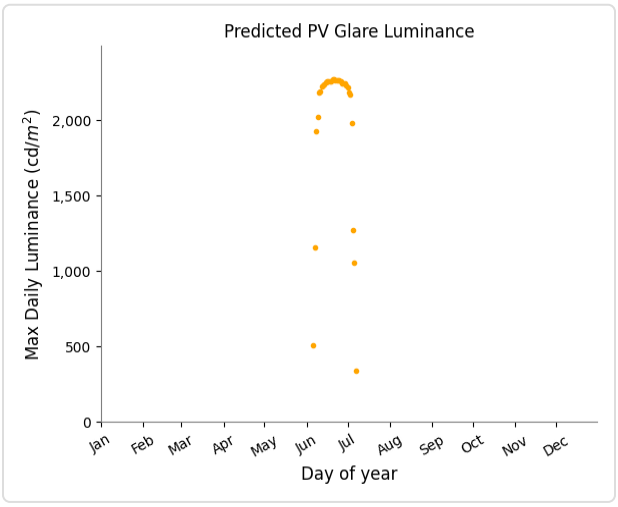
Green glare: 206 min.











PV array 7 and 1-ATCT

No glare found

PV array 7 and OP 2

No glare found

PV array 7 and OP 3

No glare found

PV array 7 and OP 4

No glare found

PV array 7 and OP 8

No glare found

PV array 7 and OP 14

No glare found

PV array 7 and OP 20

No glare found

PV array 7 and OP 22

No glare found

PV array 7 and OP 23

No glare found

PV array 7 and OP 24

No glare found

PV array 7 and OP 25

No glare found

PV array 7 and OP 27

No glare found

PV array 7 and OP 28

No glare found

PV array 7 and OP 29

No glare found

PV array 7 and OP 30

No glare found

PV array 7 and OP 31

No glare found

PV array 7 and OP 33

No glare found

PV array 7 and OP 34

No glare found

PV array 7 and OP 35

No glare found

PV array 7 and OP 36

No glare found

PV array 7 and OP 37

No glare found

PV array 7 and OP 38

No glare found

PV array 7 and OP 39

No glare found

PV array 7 and OP 40

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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