comparing annual glare simulation methods

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Radiance Workshop 2022: Toronto, Canada

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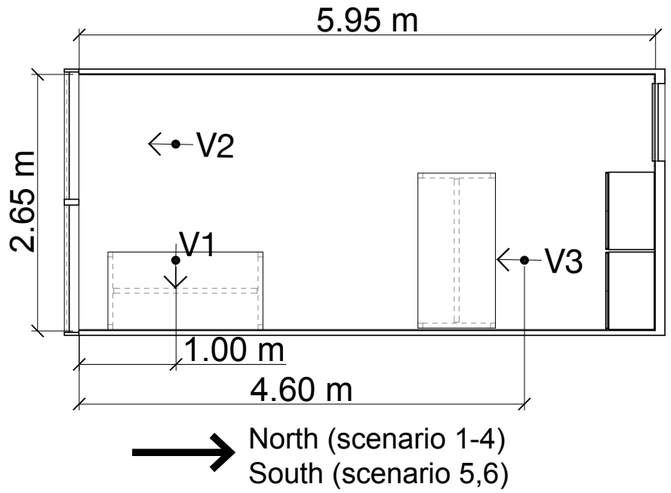
Methods Producing DGP or DGP analogues

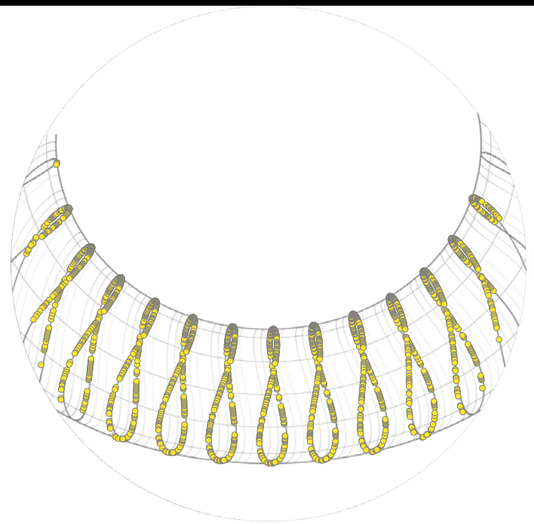
- DGPs (Wienold, 2009)
- eDGPs (Wienold, 2009)
- imageless DGP (dcglare) (Jones, 2019)
- ClimateStudio Annual Glare (www.solemma.com)
- raytraverse 1compdv (Wasilewski et. al, 2021)
- AGC (adaptive glare coefficients) (Wienold, pending)
- glare annual classes evaluation (GLANCE) (Giovannini et al., 2020)
- a heuristic zonal approach (Santos and Caldas, 2021)

- magenta colored methods use illuminance values or matrices from 2-phase DDS sensor calcs (Subramaniam, 2017)

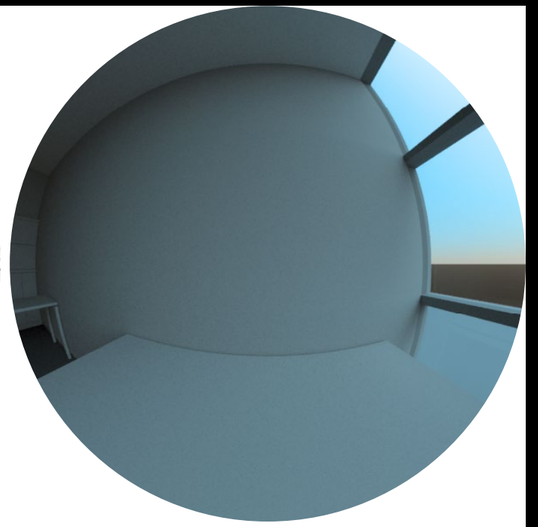
Base Model



a. Floor Plan - Viewpoints are at 1.2 meters above floor.



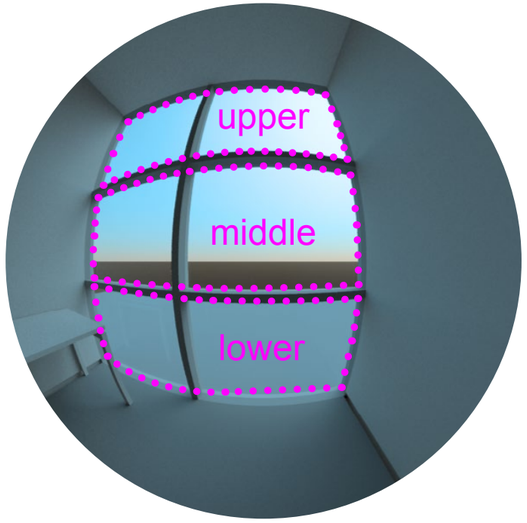
b. Sun Positions - sun-path for Geneva. yellow dots show tested sun-positions with direct normal > 50 W/m²



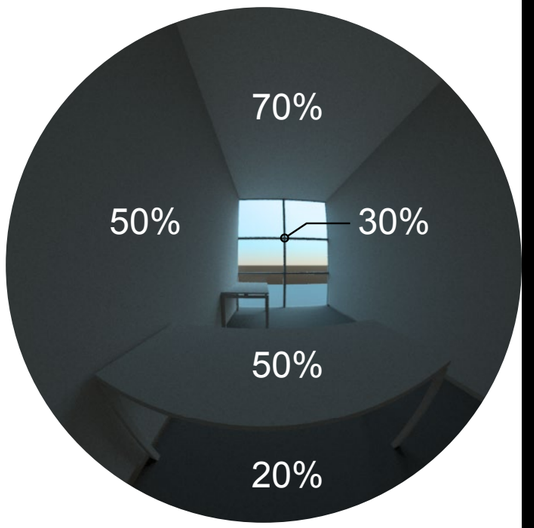
c. View 1 (V1)

Scenario	Lower	Middle	Upper
1. GLZ	70% VLT		
2. ECG	60% VLT	1% VLT	
3. SHD	70% VLT	70% VLT *w/ 3% openness, 2% VLT, 10% VLR fabric*	
4. TRN	30% VLT		30% VLT Trans
5. NGL	70% VLT *w/ South Facing Glass Reflector*		
6. NMT	70% VLT *w/ South Facing Metal Reflector*		

d. Glazing Properties by Scenario

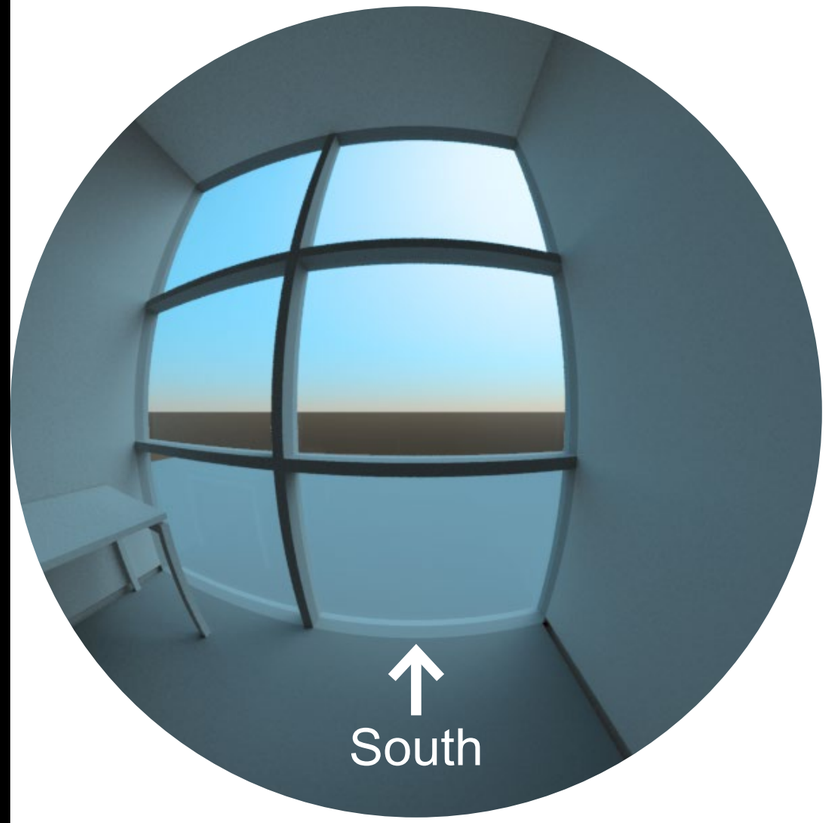


e. View 2 (V2) labelling window positions used in describing scenarios

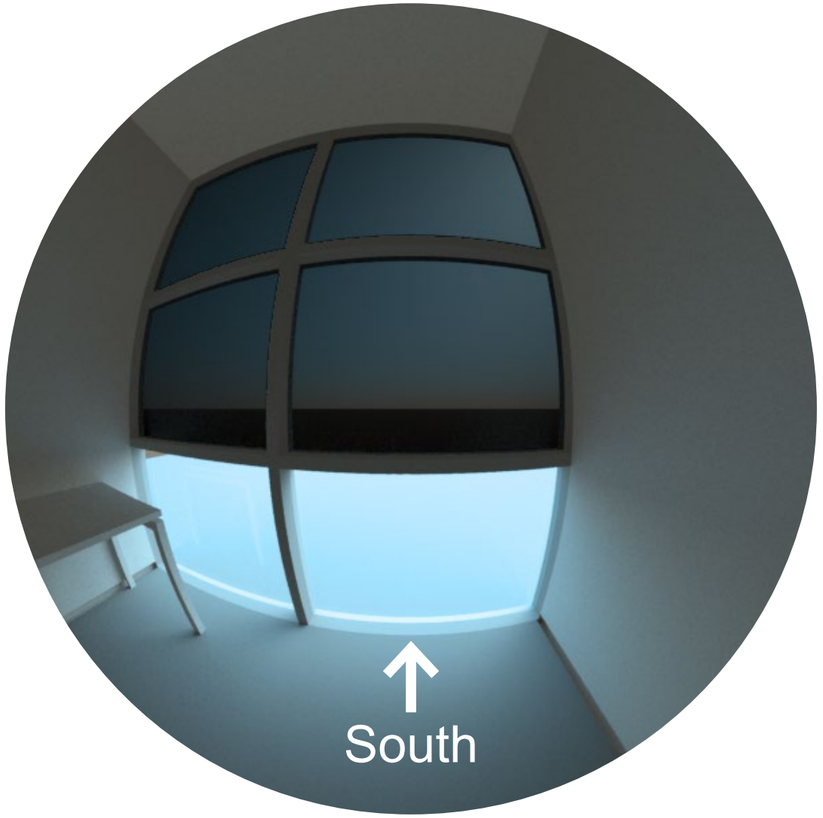


f. View 3 (V3) showing Visible light reflectance (VLR) of interior surfaces

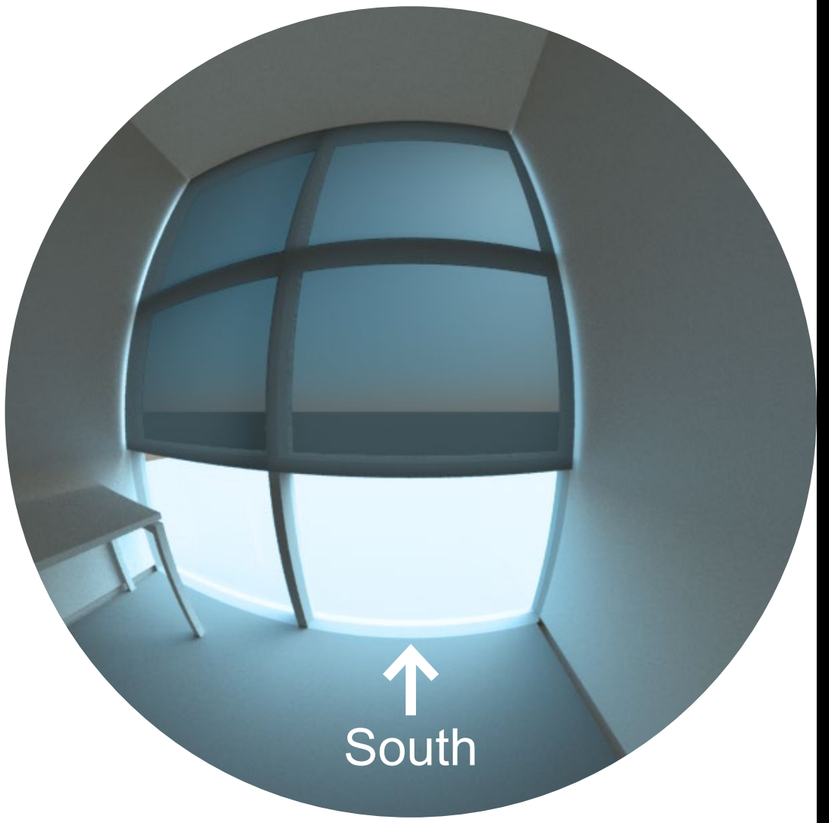
Fenestration and Reflection Scenarios



a. Scenario 1 - Clear Glazing (GLZ)

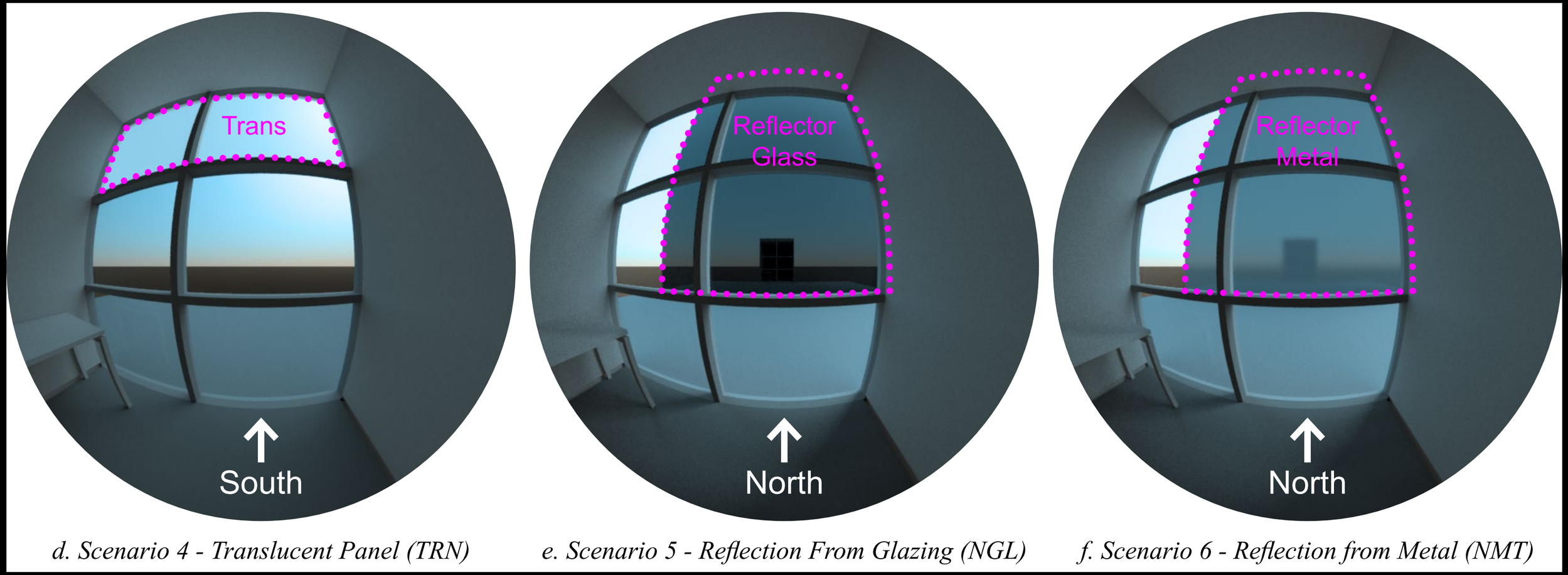


b. Scenario 2 - Low VLT Glazing (ECG)



c. Scenario 3 - Fabric Roller-shade (SHD)

Fenestration and Reflection Scenarios



d. Scenario 4 - Translucent Panel (TRN)

e. Scenario 5 - Reflection From Glazing (NGL)

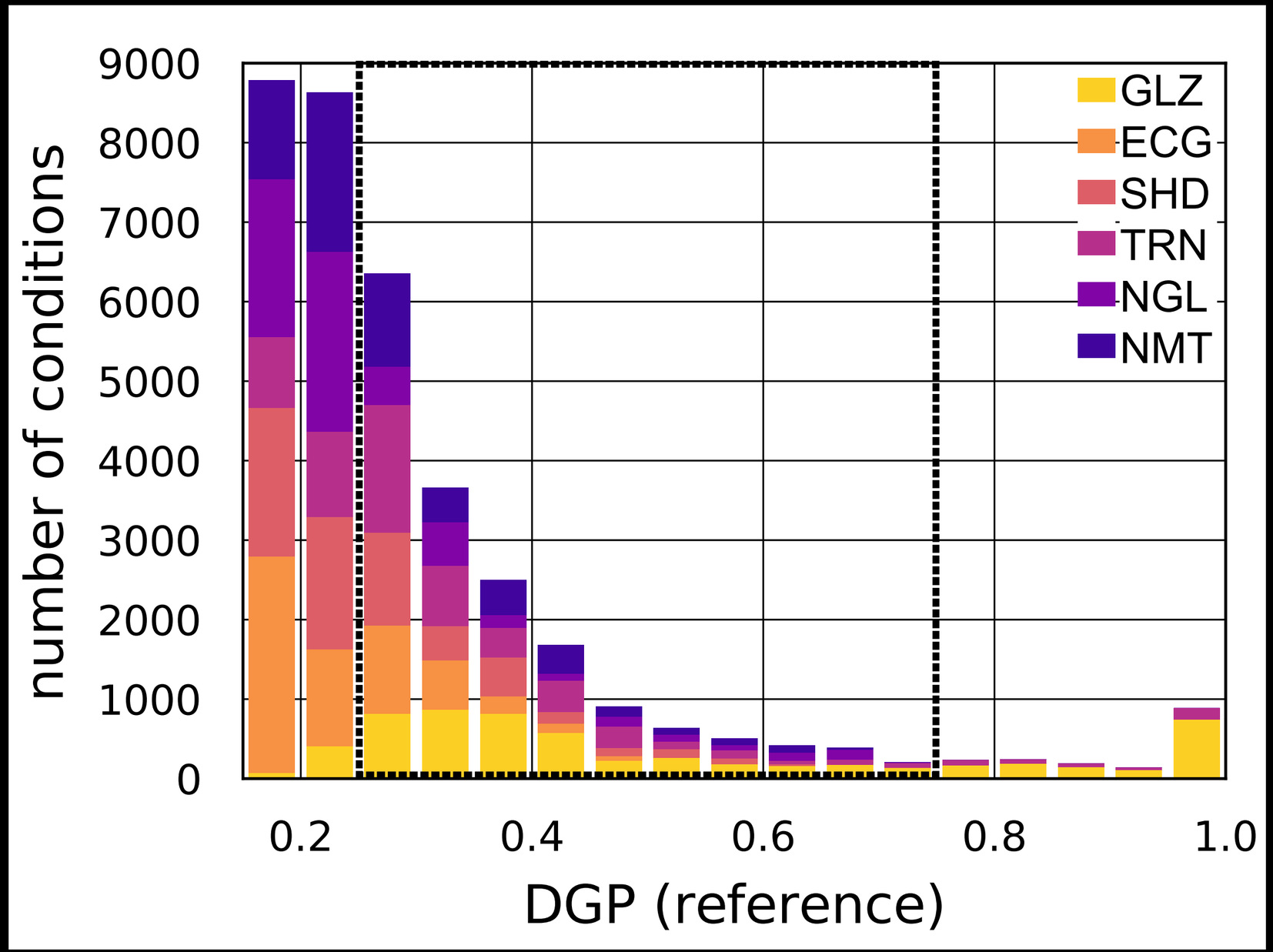
f. Scenario 6 - Reflection from Metal (NMT)

Results

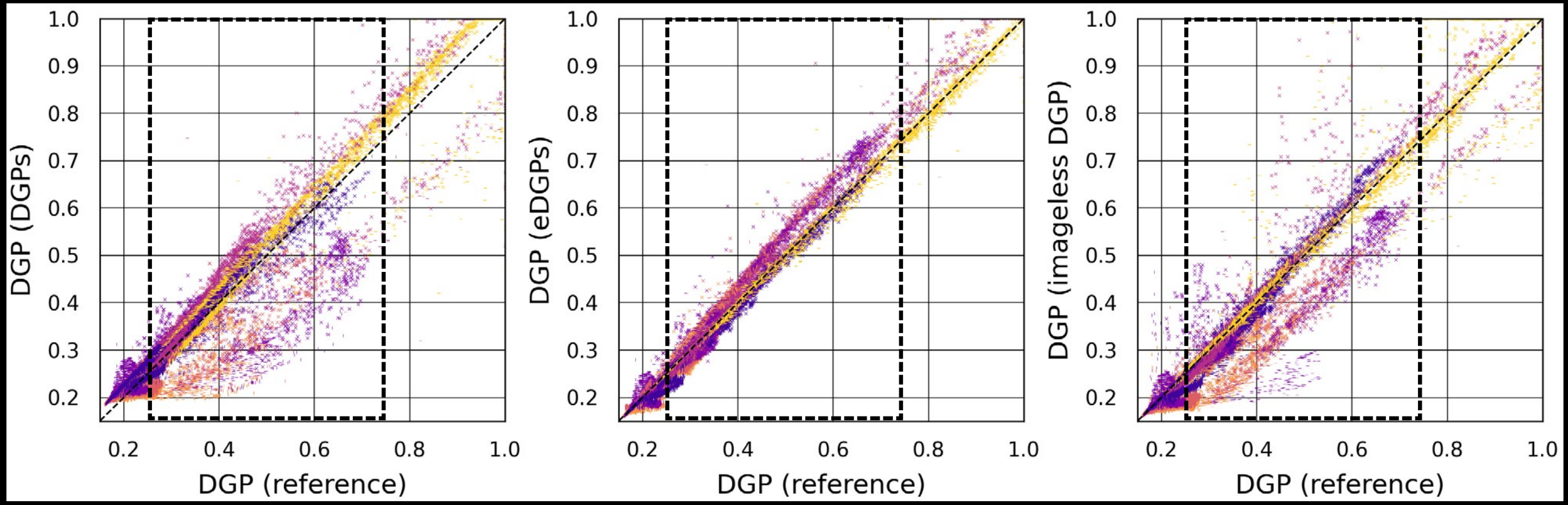
histogram plots distribution of DGP values for evaluated conditions per the reference simulation:

```
rpict -x 3000 -y 3000 -vta -vh 180 -vv 180 -dp 4096 -dt .01 -dc 1 -ds.2 -dr3 -ms 0.025 -ss 16 -st .01 -lr 12 -lw 1e-5 -af afile -av 0 0 0 -aa .075 -ar 600 -ab 6 -ad 1500 -as 750 -ps 3 -pt .04 octree > img.unf

pfilt -1 -e 1 -m .25 -x /3 -y /3 img.unf > img.hdr
```

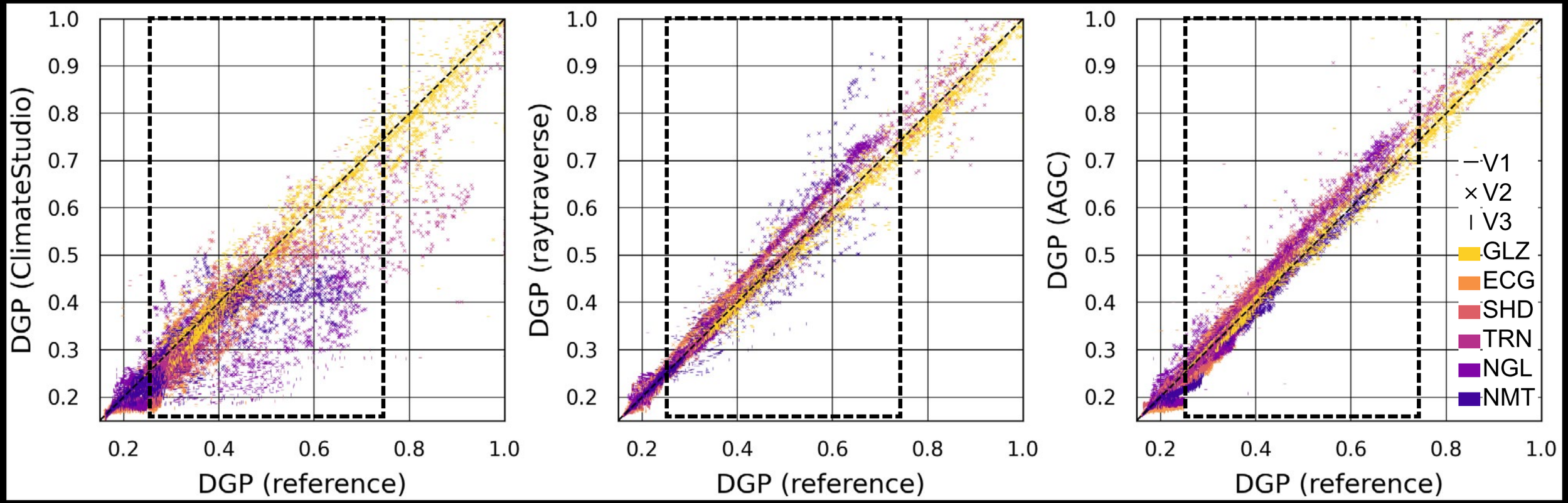


Results



scatter plots show DGP calculated by the reference vs. each timestep tested method

Results



scatter plots show DGP calculated by the reference vs. each timestep tested method

GLZ
ECG
SHD
TRN
NGL
NMT

Time

	time*(base)	time*(high)	Computer
DGPs	9.8	19.0	A
eDGPs[2]	6170	-	A, D
imageless DGP	3.8	12.5	A
ClimateStudio[1]	2.3	16.2	B
Raytraverse	15.5	-	A
AGC[2]	31.8	-	A, C

**times given are real time in average seconds per point and scene.*

A. 2018 MacBook Pro with Intel 2.9 GHz Core i9 processor, 16 GB RAM, and a solid-state hard drive. Using 12 processes.
B. Windows 10 Virtual Machine with Intel Xeon Gold 6248R CPU @ 3.00GHz, 8 GB RAM, Nvidia GRID RTX8000P-2Q GPU
C. 2022 MacBook Pro M1max. Using 3 processes.
D. Dell PowerEdge R6515 Server AMD EPYC 7413 with Ubuntu 20.04.3 LTS, using 1 process.

1. *ClimateStudio requires simulating a grid of points, so six points were simulated instead of three. Reported times are pro-rated.*
2. *Illuminance calculations done on computer A.*

Accuracy

DGP

RMSE	GLZ	ECG	SHD	TRN	NGL	NMT	AVG
reference	0.01	0.02	0.02	0.01	0.03	0.01	0.02
DGPs	0.03	0.07	0.07	0.05	0.11	0.03	0.06
eDGPs	**0.01**	**0.03**	**0.03**	0.02	**0.04**	0.02	**0.03**
imageless DGP	0.04	0.07	0.07	0.05	0.09	0.03	0.06
climatestudio	0.04	0.06	0.06	0.06	0.14	0.07	0.07
raytraverse	0.02	**0.02**	**0.02**	**0.01**	**0.04**	0.03	**0.02**
AGC	0.02	**0.03**	**0.03**	0.03	**0.04**	0.02	**0.03**
MAE							
reference	0.00	0.01	0.01	0.00	0.02	0.01	0.01
DGPs	0.03	0.05	0.05	0.04	0.08	0.02	0.04
eDGPs	**0.01**	0.02	0.02	0.01	**0.03**	0.01	**0.02**
imageless DGP	0.01	0.07	0.06	0.02	0.06	0.02	0.04
climatestudio	0.03	0.06	0.05	0.04	0.09	0.05	0.05
raytraverse	0.01	**0.01**	**0.01**	**0.01**	**0.03**	0.02	**0.01**
AGC	0.01	0.03	0.03	0.02	**0.03**	0.01	0.02
MSD							
reference	0.00	0.01	0.01	0.00	0.01	0.00	0.01
DGPs	0.01	-0.05	-0.04	0.02	-0.05	**0.01**	**-0.02**
eDGPs	**0.00**	**0.00**	**0.00**	**0.01**	**0.02**	**-0.01**	**0.00**
imageless DGP	**0.01**	-0.07	-0.06	**0.00**	-0.05	**-0.01**	-0.03
climatestudio	-0.01	-0.05	-0.04	-0.03	-0.08	-0.04	-0.04
raytraverse	**0.00**	**0.01**	**0.01**	**0.00**	**0.02**	**0.00**	**0.01**
AGC	**0.00**	**-0.01**	**0.00**	0.01	**0.02**	-0.01	**0.00**

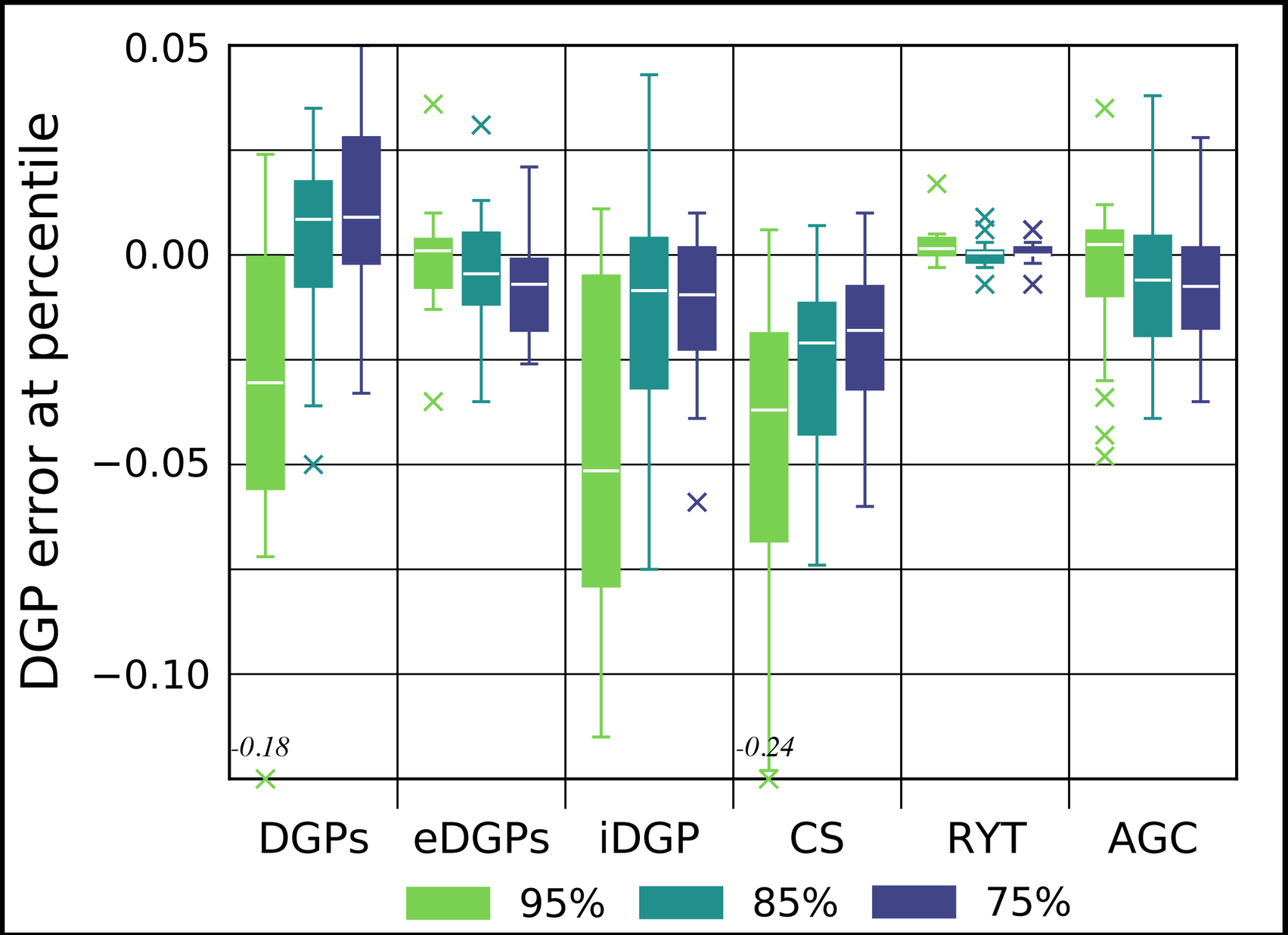
DGPs (Illuminance Error)

RMSE	GLZ	ECG	SHD	TRN	NGL	NMT	AVG
2-phase DDS	0.01	0.01	0.01	0.02	0.02	0.01	0.01
2-phase	0.03	0.01	0.01	0.03	0.02	0.01	0.02
ClimateStudio	0.04	0.02	0.02	0.04	0.04	0.05	0.03
raytraverse	0.02	0.00	0.00	0.01	0.01	0.03	0.01
MAE							
2-phase DDS	0.01	0.00	0.01	0.01	0.01	0.01	0.01
2-phase	0.01	0.00	0.01	0.01	0.01	0.01	0.01
ClimateStudio	0.03	0.01	0.01	0.02	0.02	0.03	0.02
raytraverse	0.01	0.00	0.00	0.01	0.01	0.01	0.01
MSD							
2-phase DDS	0.00	0.00	0.01	0.01	0.01	0.00	0.01
2-phase	0.01	0.00	0.00	0.01	0.01	0.00	0.00
ClimateStudio	0.02	0.00	0.00	-0.01	0.01	-0.01	0.00
raytraverse	0.00	0.00	0.00	0.00	0.01	0.00	0.00

Error in Illuminance Calculation scaled as DGPs. AGC, DGPs, eDGPS use 2-phase DDS. Image- less DGP uses 2-phase matrices.

Accuracy

Distribution of error in annual percentiles for 18 view/ scene combinations. Method abbreviations: imageless DGP (iDGP), ClimateStudio (CS), raytraverse (RYT)



Accuracy

Comparing GLANCE and Heuristic Zonal approaches requires a different quantification of error. This bar chart shows the true prediction rates for each method used as a binary classifier with a threshold of 0.35 at each view (all 6 options) as well as the average of all views (AVG)