WHAT'S NEW IN CLIMATESTUDIO

Solemma team: Violeta Lialios-Bouwman, Demi Chang, Timur Dogan, Alstan Jakubiec, Jeff Niemasz, Brandon Pachuca, Christoph Reinhart, Jon Sargent

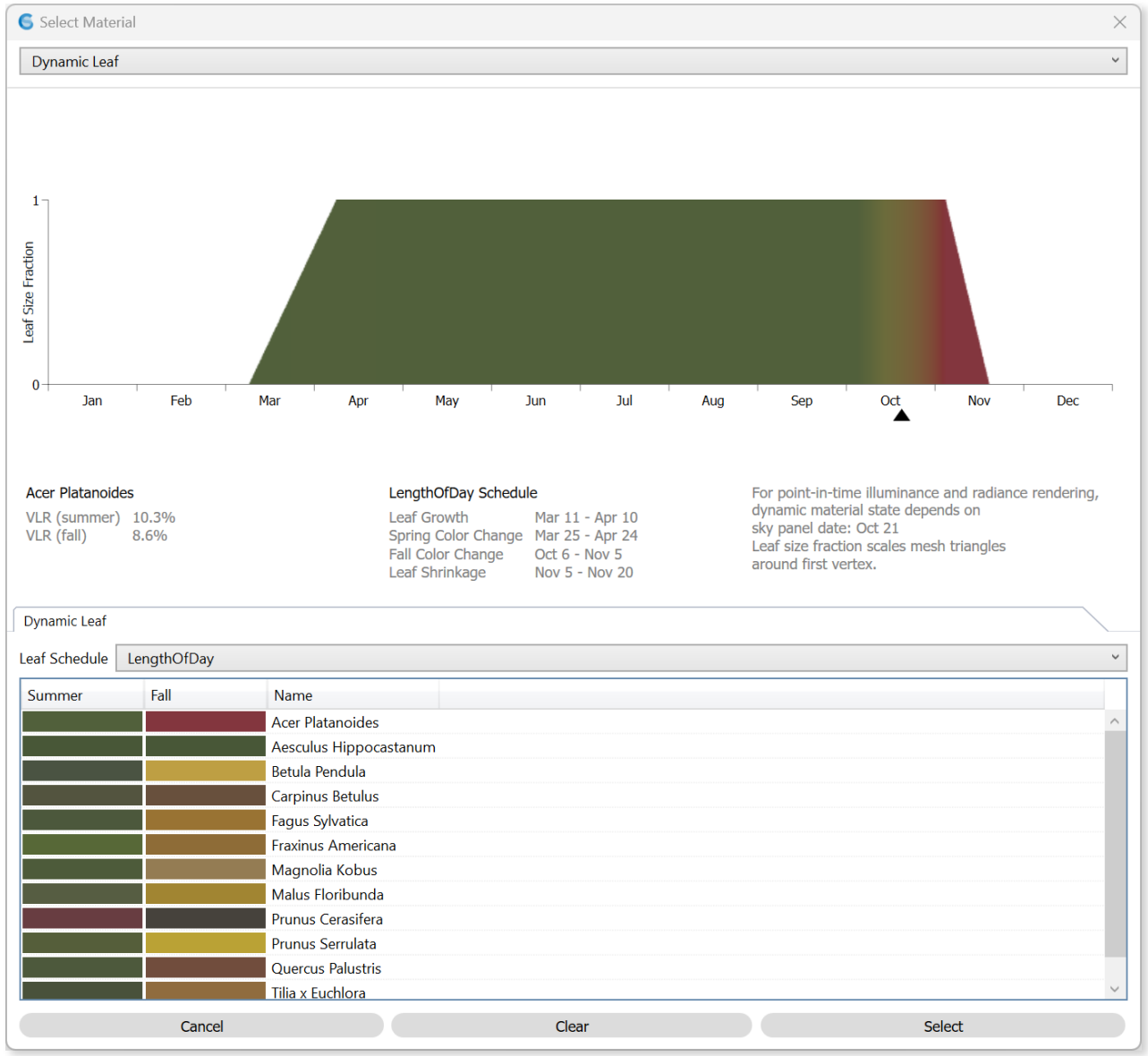
Slides: Jon Sargent

Narrator: Alstan Jakubiec

SOLEMMA

MULTIVERSE

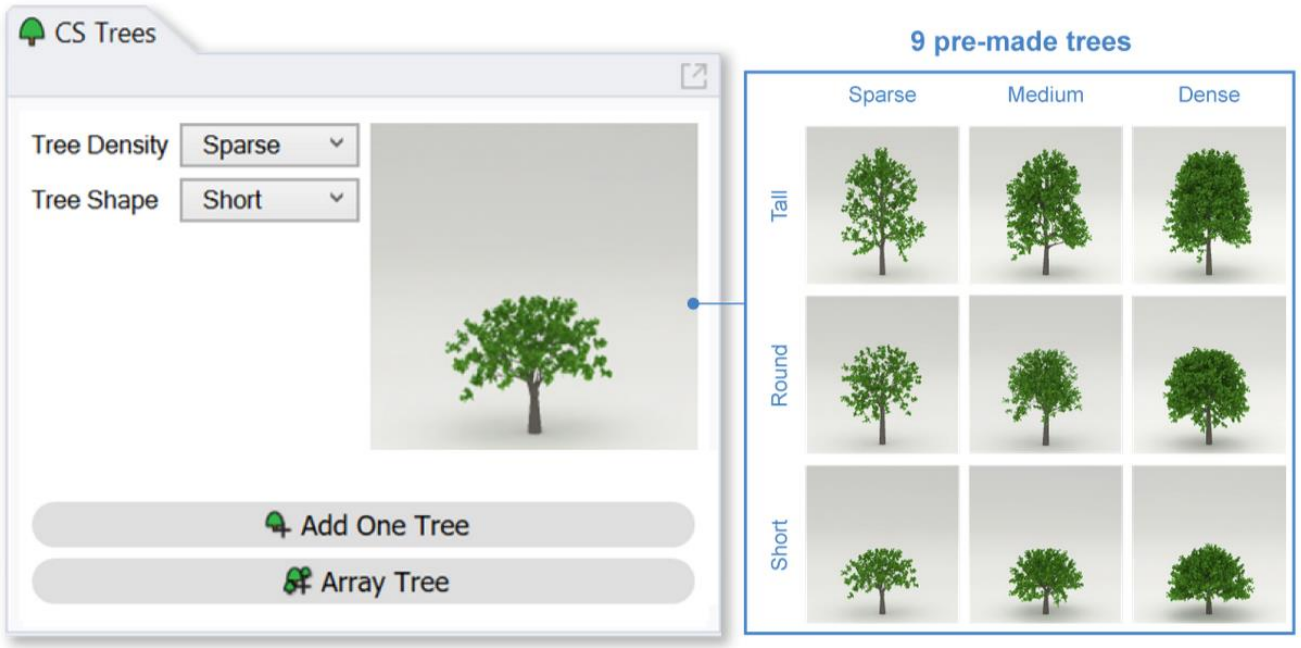
(one) ray trace



Dynamic Leaf

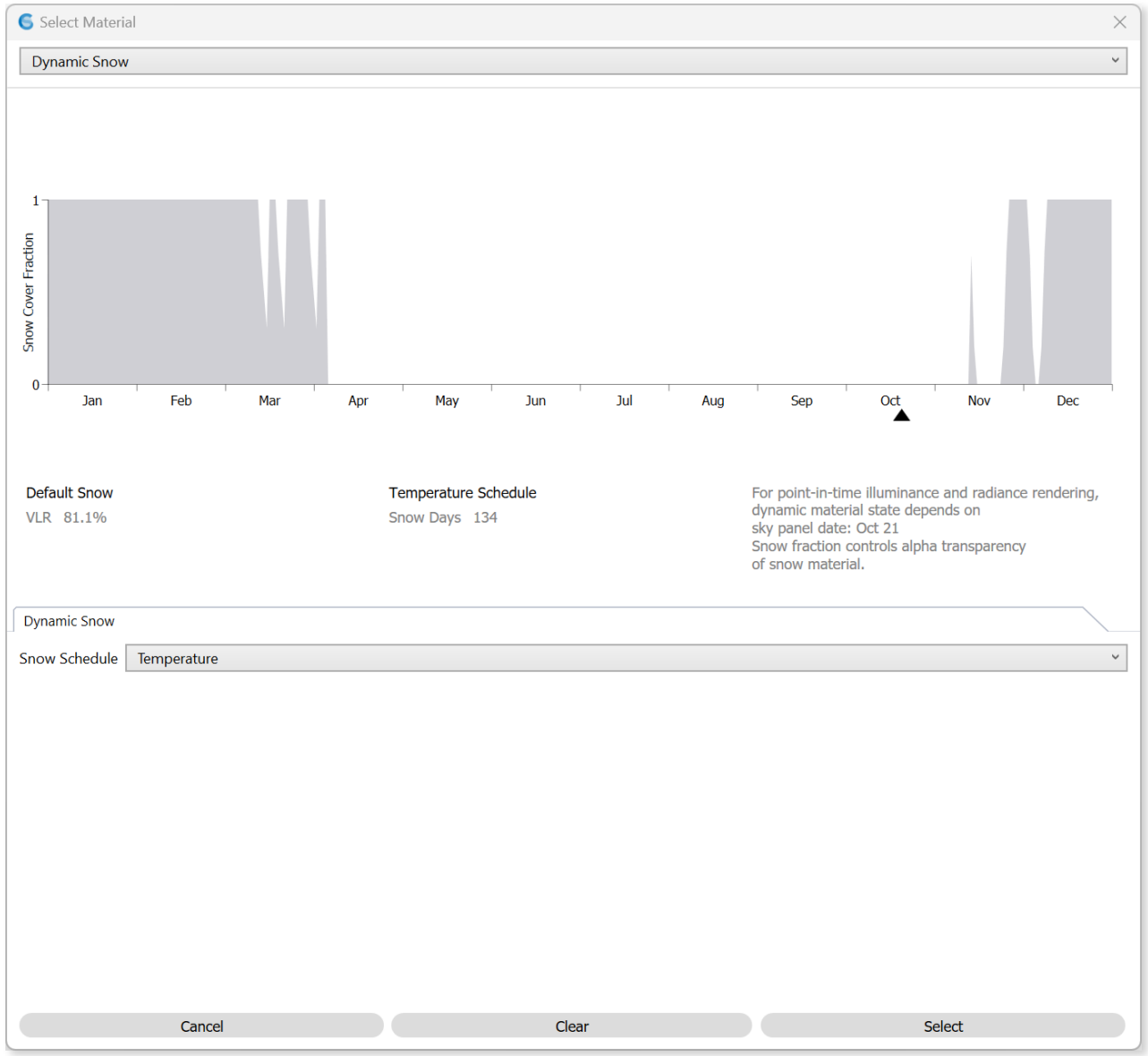
- Species-specific summer/fall color measurements[1]
- Size / color schedule based on length of day
- Transition colors by interpolation

[1] "Simulating the Impact of Deciduous Trees on Energy, Daylight, and Visual Comfort," Pan and Jakubiec (2022)



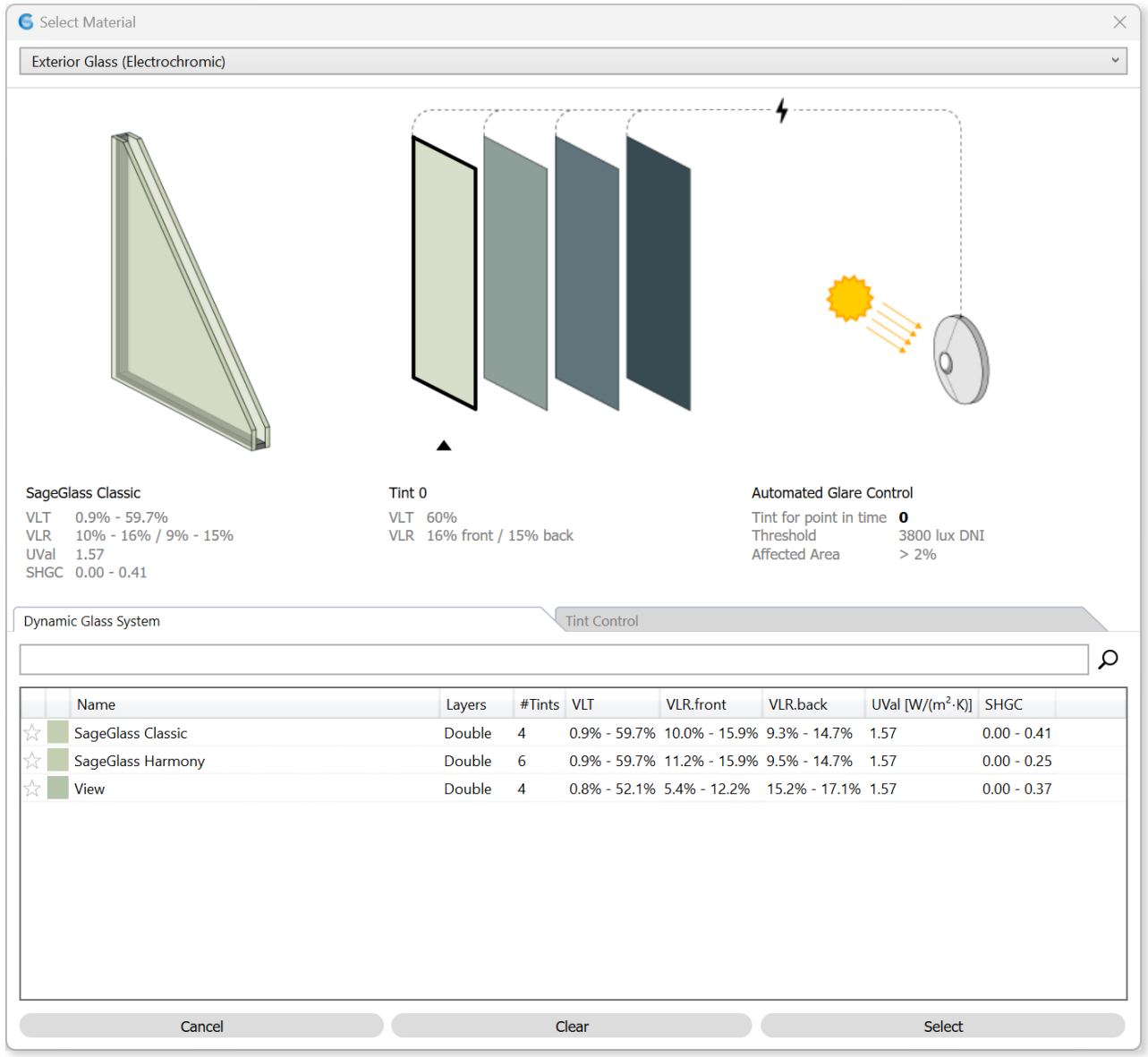
Dynamic Leaf

- Species-specific summer/fall color measurements[1]
- Size / color schedule based on length of day
- Transition colors by interpolation
- Small lib of tree assets (.rtm) or build your own



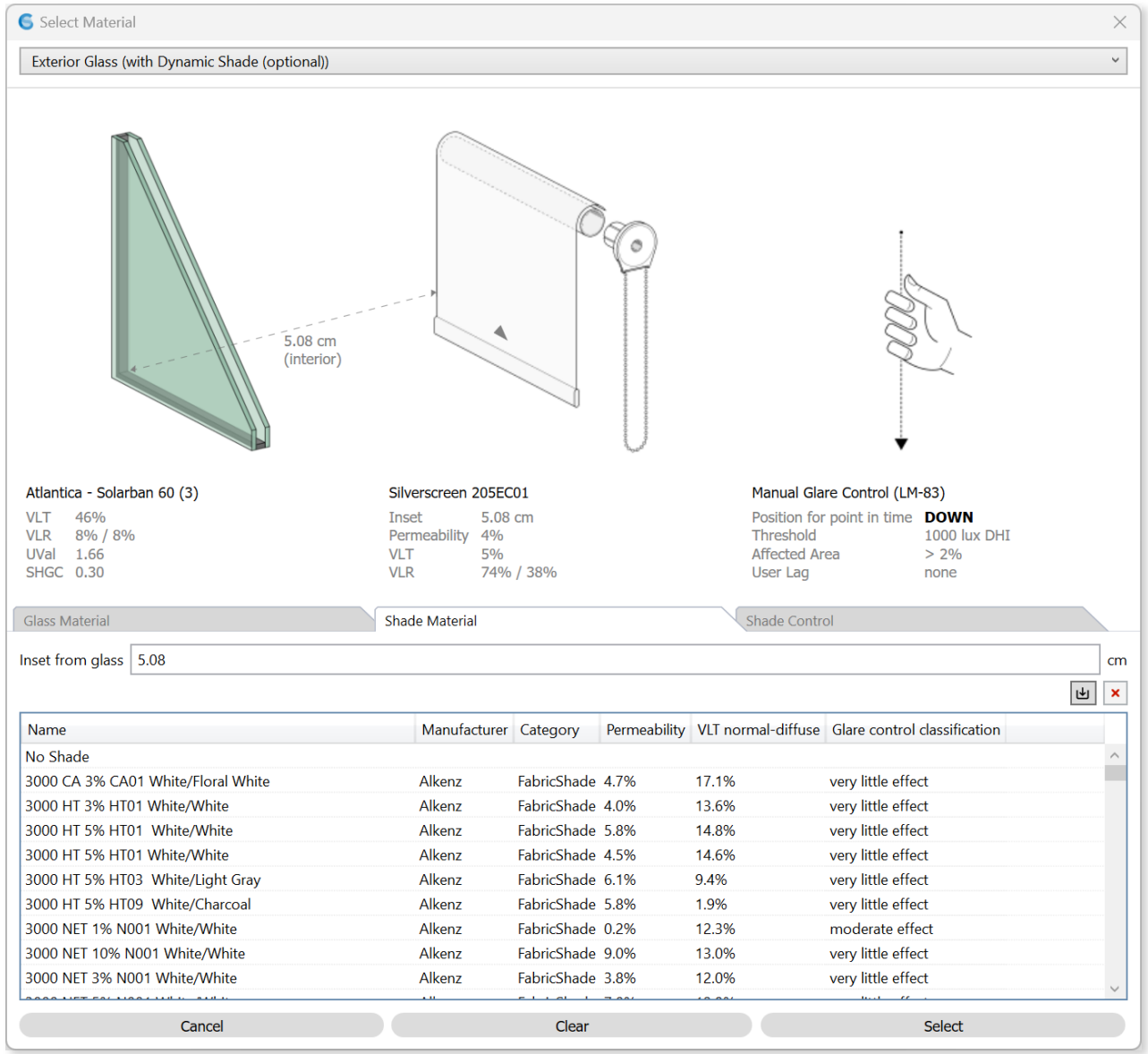
Dynamic Snow

- Fixed white color (81% VLR)
- Transparency schedule based on temperature
- Precipitation not considered



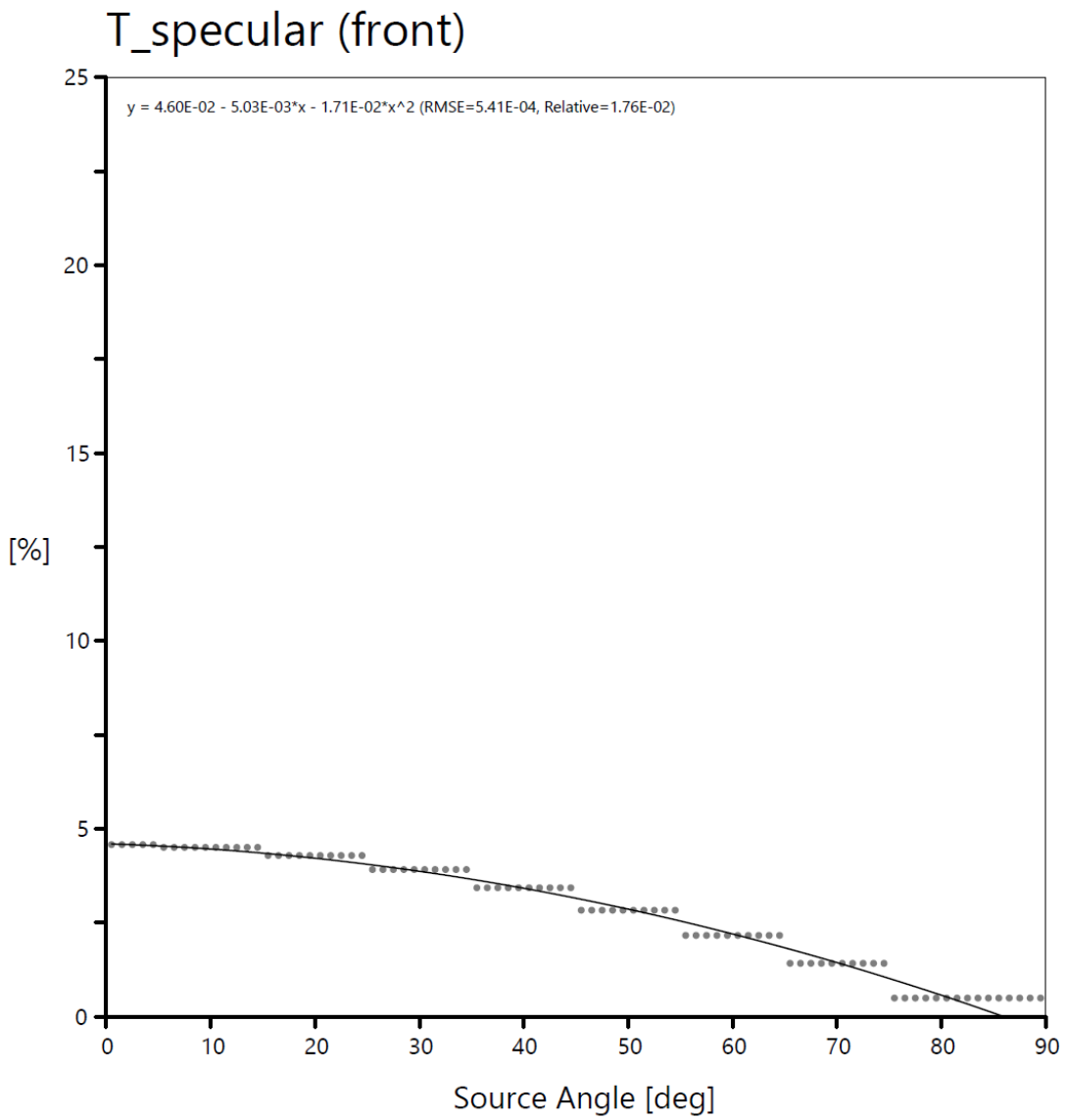
Dynamic Glazing (EC)

- Manufacturer (IGDB) data
- Auto control based on sun penetration depth (5’ default, customizable)



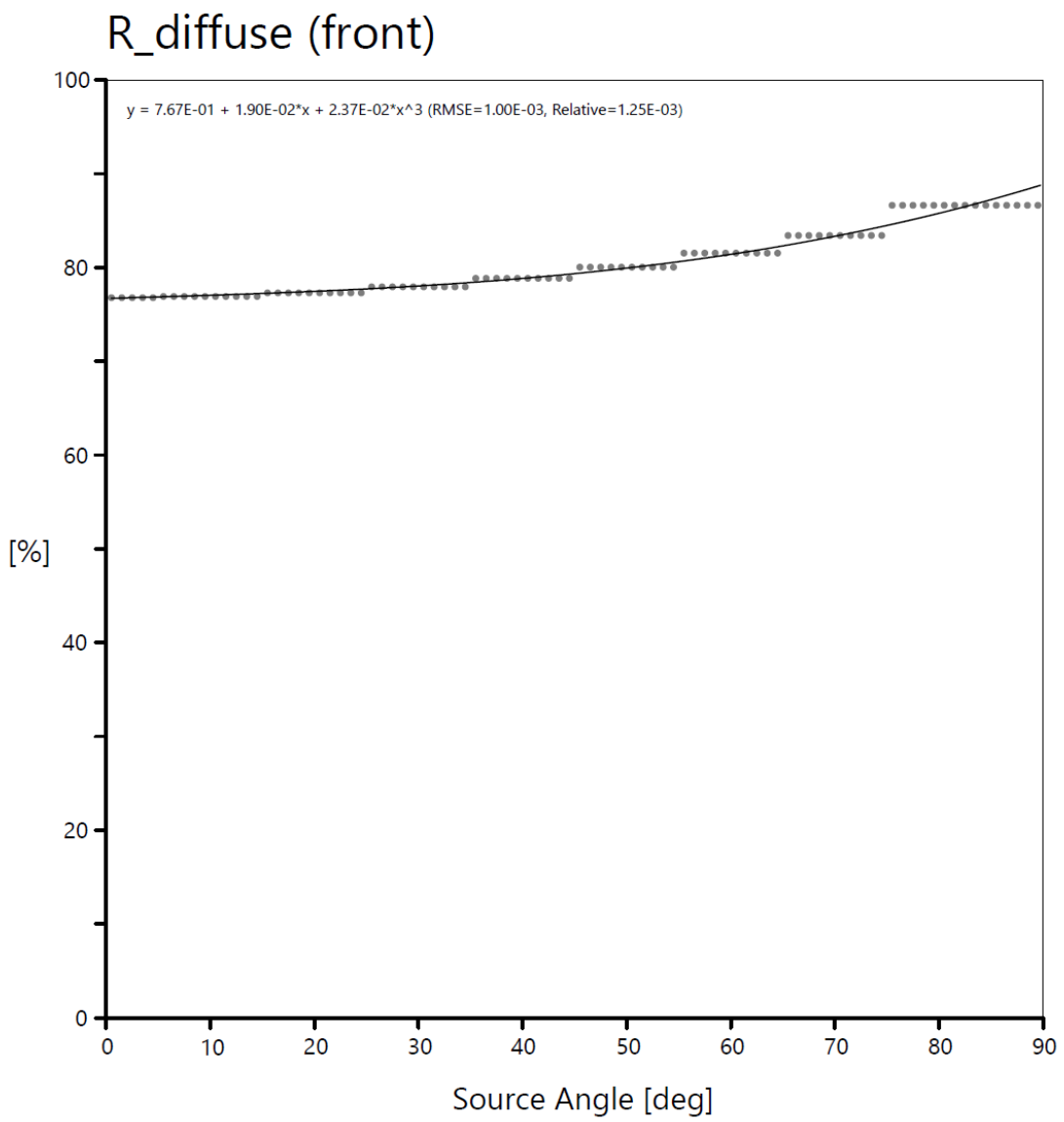
Dynamic Shade

- CGDB fabric shade data
- EN 14501 glare control classification
- LM-83 control, or manual / auto based on sun penetration depth
- Semi-active user option (custom lag time)



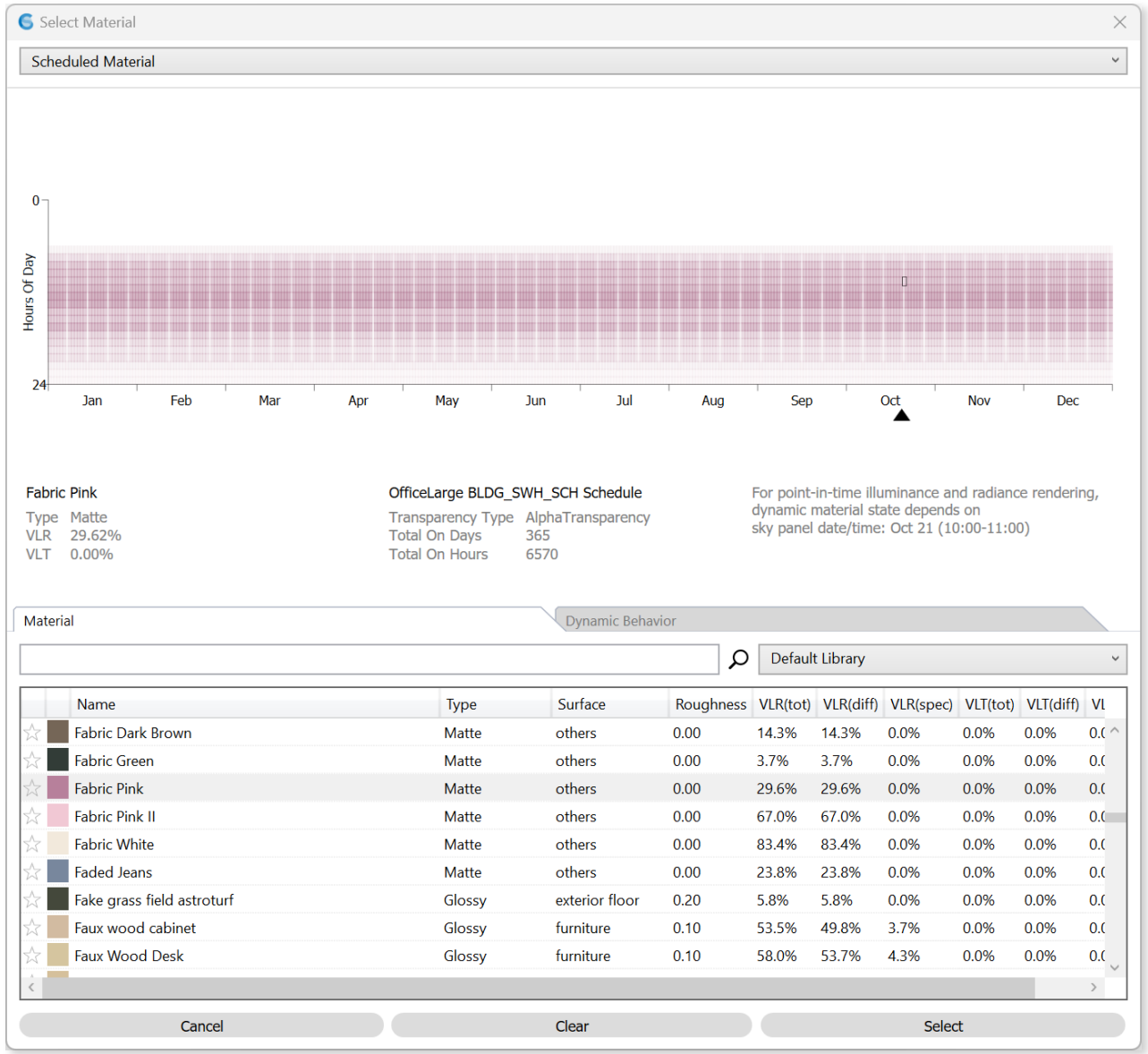
Dynamic Shade

- CGDB fabric shade data
- EN 14501 glare control classification
- LM-83 control, or manual / auto based on sun penetration depth
- Semi-active user option (custom lag time)
- Two material modes:
  - aBSDF
  - BRTDfunc(2)
    - Polynomial fit to CGDB Klems data
    - Evaluates faster than aBSDF



Dynamic Shade

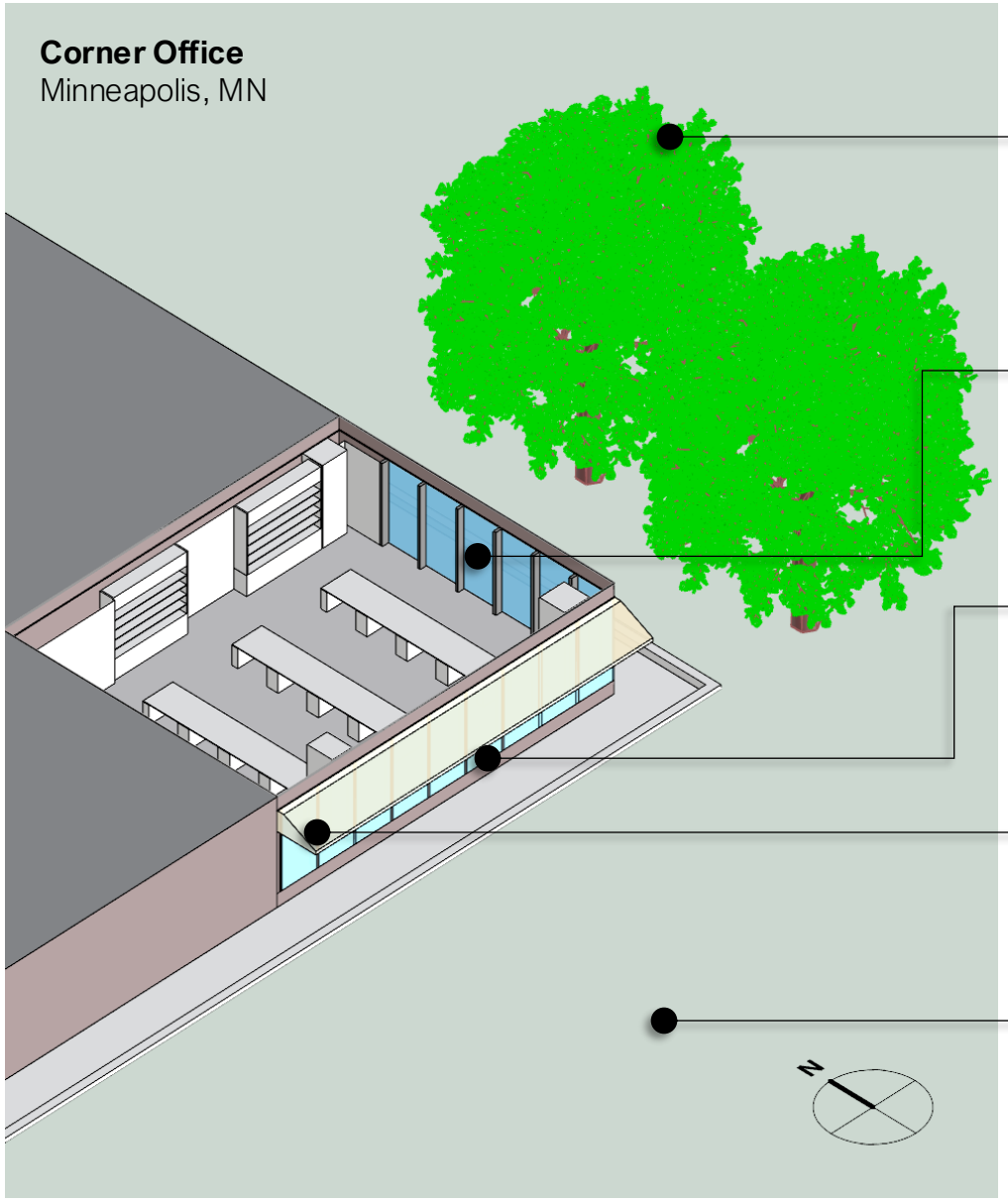
- CGDB fabric shade data
- EN 14501 glare control classification
- LM-83 control, or manual / auto based on sun penetration depth
- Semi-active user option (custom lag time)
- Two material modes:
  - aBSDF
  - BRTDfunc(2)
    - Polynomial fit to CGDB Klems data
    - Evaluates faster than aBSDF
    - Modified BRTDfunc implements incident-angle-dependent T and R in ambient calc
    - Appropriate for fitting BSDFs generated from integrating sphere data (perhaps not much else)



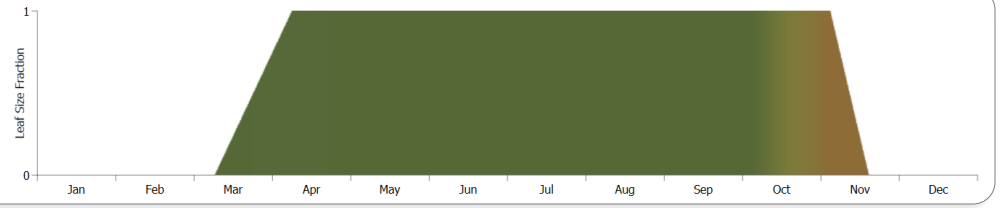
Scheduled Material

- Any material you want
- Any schedule you want
- Partial-state modes:
  - Transparency
  - Mesh-face scaling

MULTIVERSAL SCENE

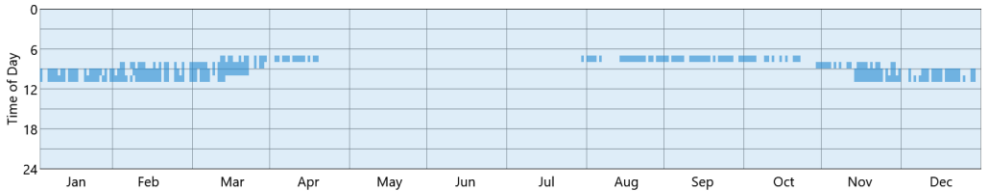


Fraxinus Americana
Mar 11 – Nov 20



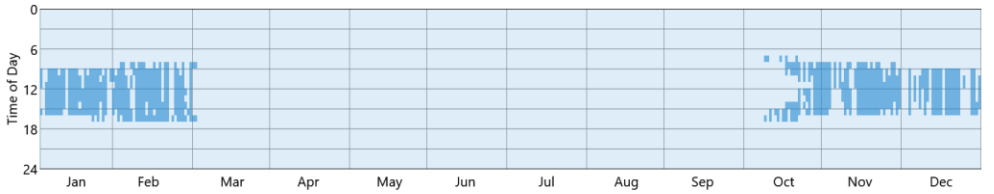
East Shade
LM-83
Time Open: **91%**

closed open



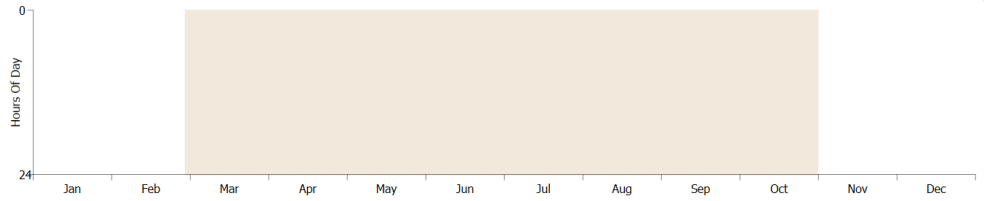
South Shade
LM-83
Time Open: **79%**

closed open



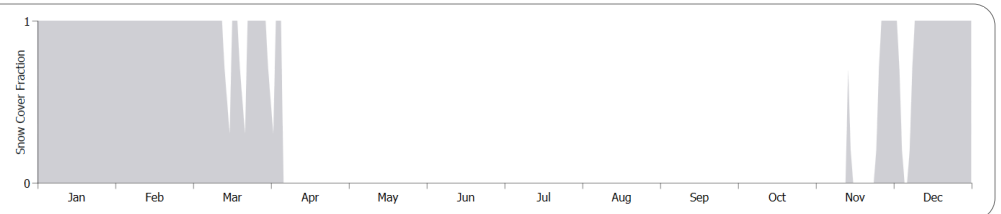
South Awning
Mar - Oct

material present



Snow
(on top of grass)
Snow Days: 134

snow opacity

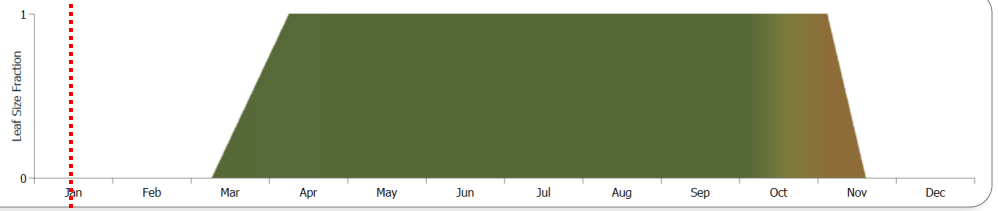


SOLEMMA

MULTIVERSAL SCENE

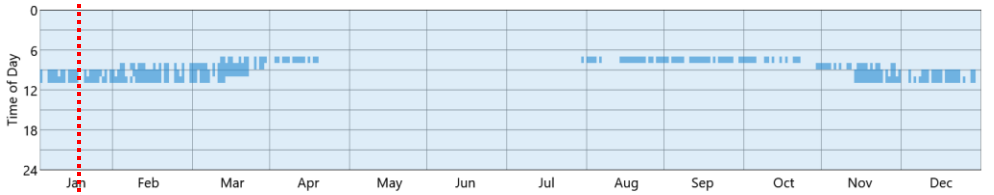
JAN 15

Fraxinus Americana
Mar 11 – Nov 20



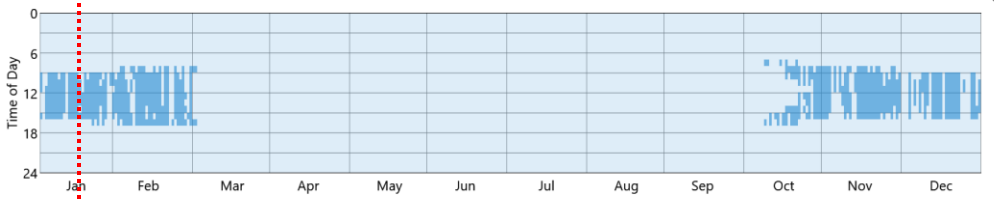
East Shade
LM-83
Time Open: **91%**

closed open



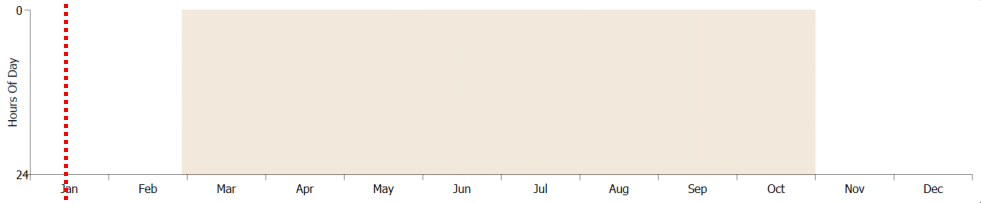
South Shade
LM-83
Time Open: **79%**

closed open



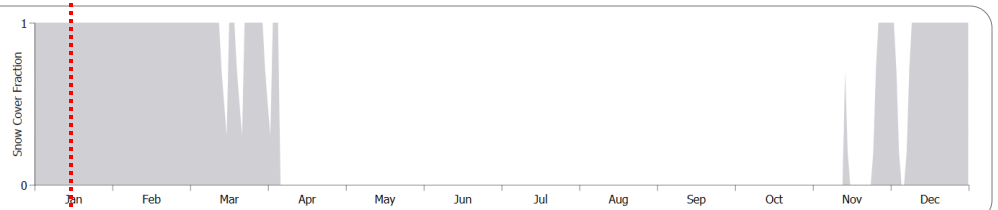
South Awning
Mar - Oct

material present



Snow
(on top of grass)
Snow Days: 134

snow opacity

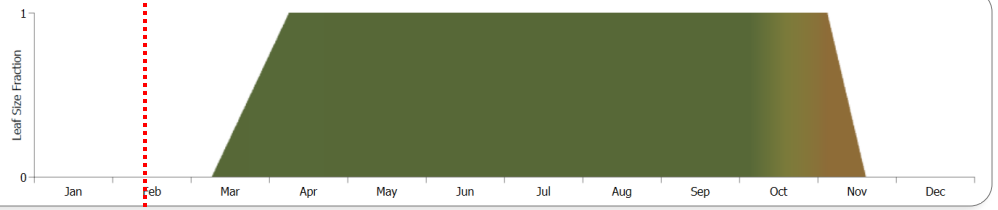


SOLEMMA

MULTIVERSAL SCENE

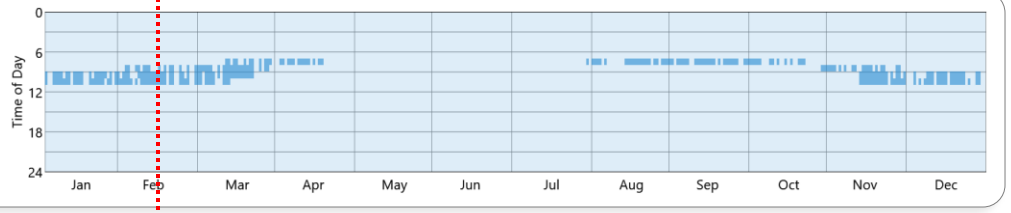
FEB 15

Fraxinus Americana
Mar 11 – Nov 20



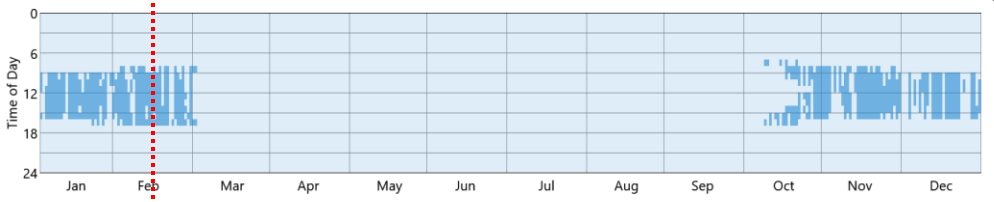
East Shade
LM-83
Time Open: **91%**

closed open



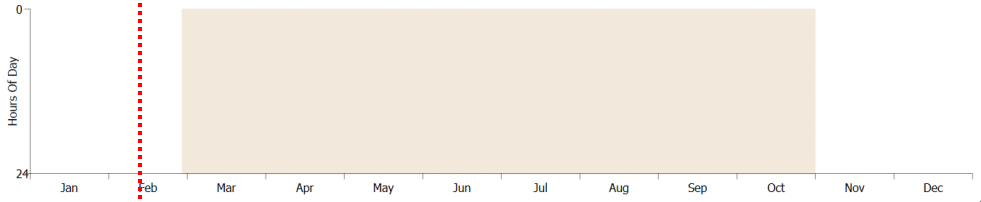
South Shade
LM-83
Time Open: **79%**

closed open



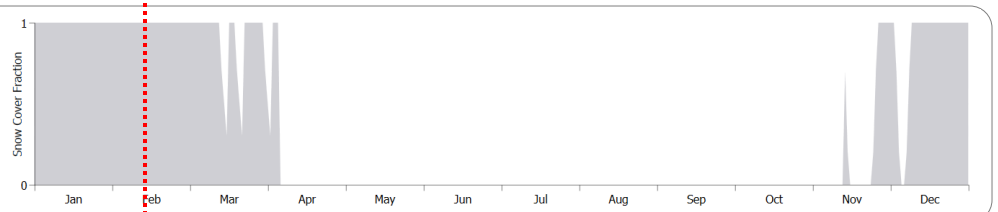
South Awning
Mar - Oct

material present



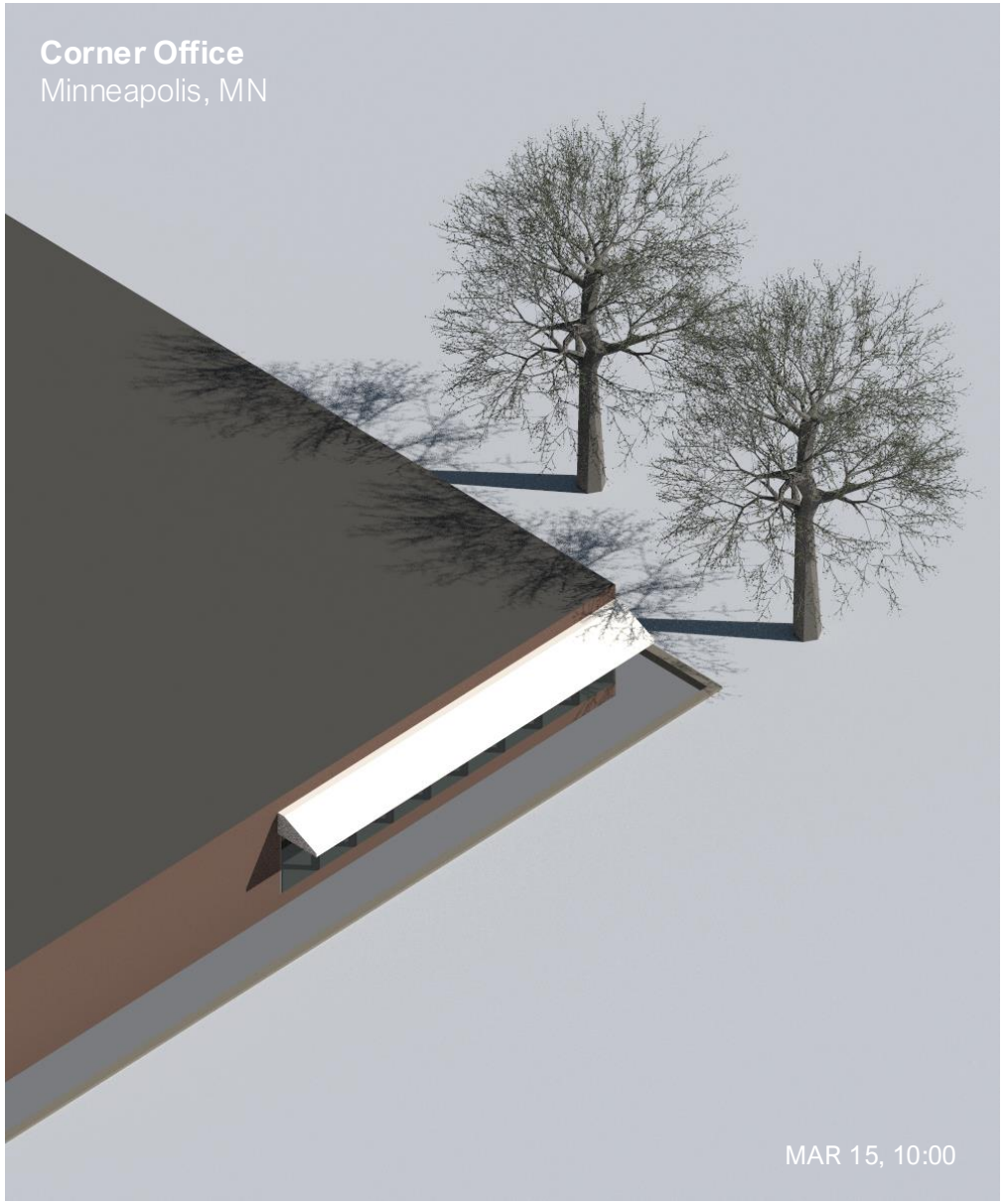
Snow
(on top of grass)
Snow Days: 134

snow opacity



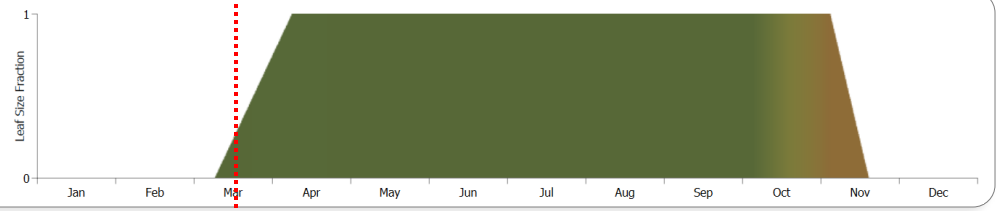
SOLEMMA

MULTIVERSAL SCENE



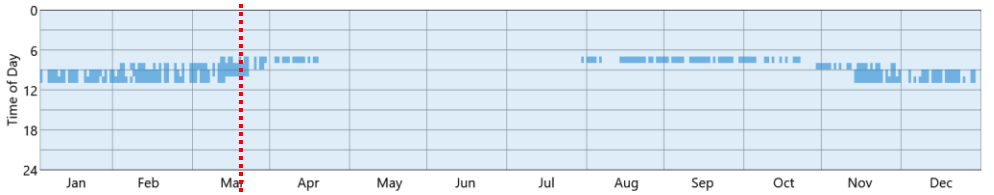
MAR 15

Fraxinus Americana
Mar 11 – Nov 20



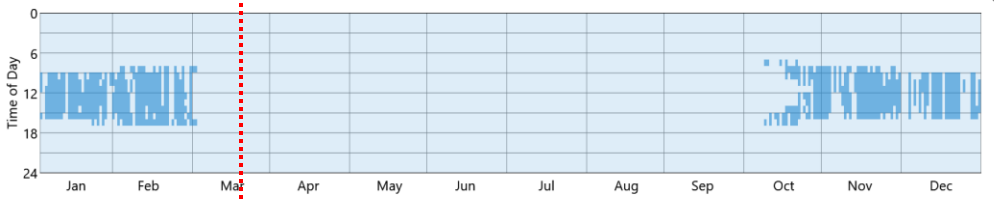
East Shade
LM-83
Time Open: **91%**

closed open



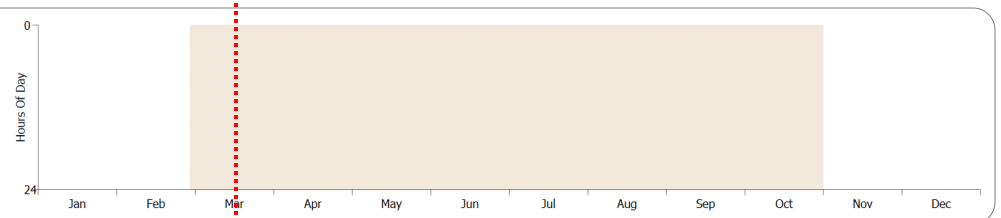
South Shade
LM-83
Time Open: **79%**

closed open



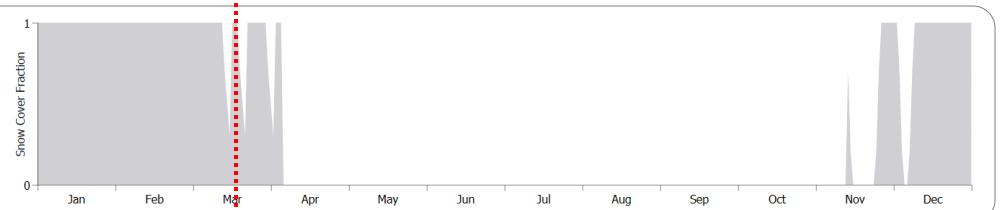
South Awning
Mar - Oct

material present



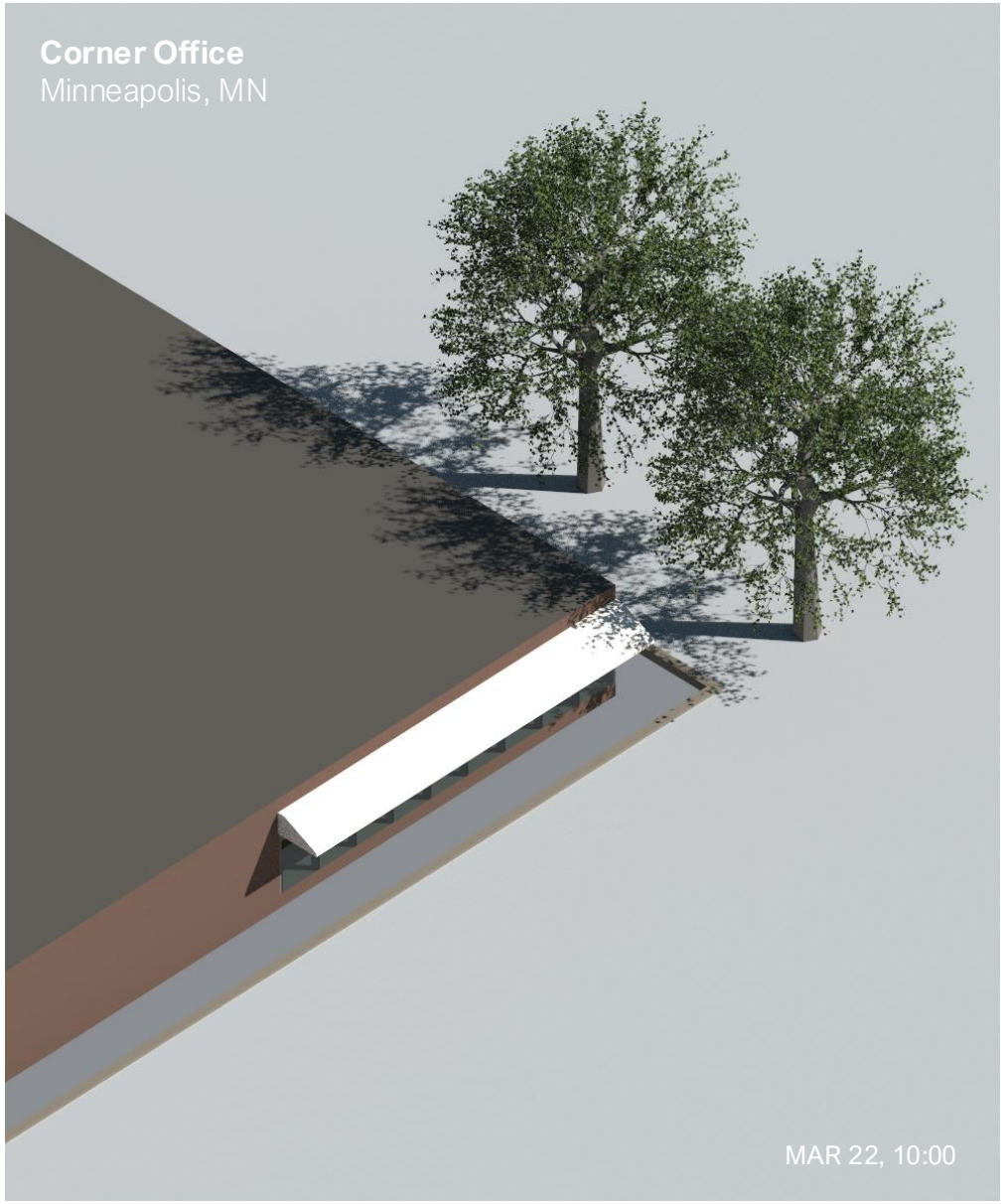
Snow
(on top of grass)
Snow Days: 134

snow opacity



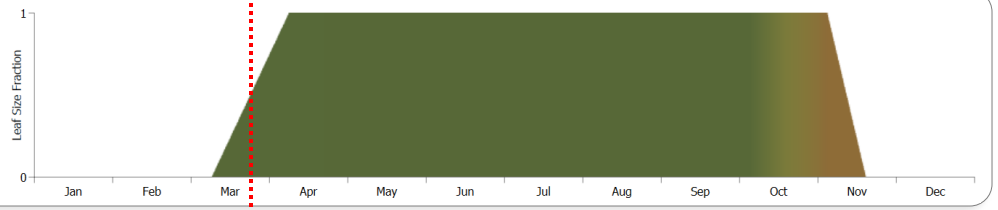
SOLEMMA

MULTIVERSAL SCENE



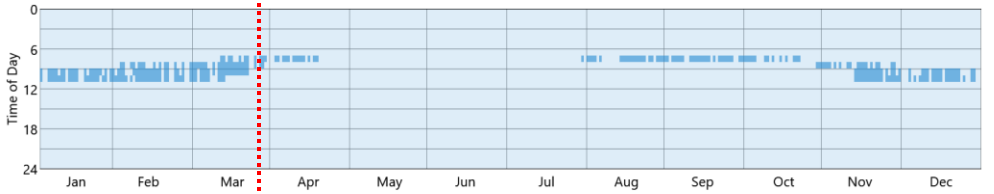
MAR 22

Fraxinus Americana
Mar 11 – Nov 20



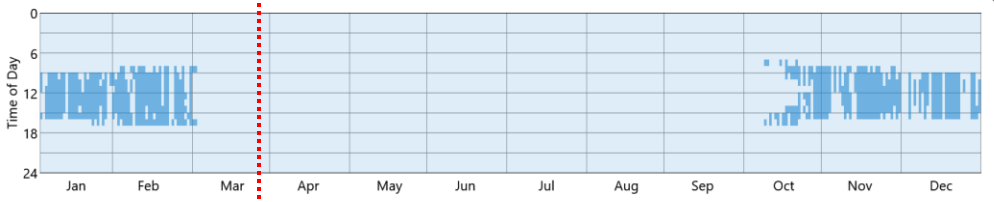
East Shade
LM-83
Time Open: **91%**

closed open



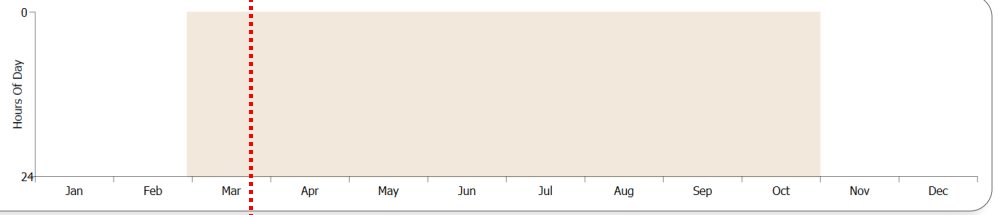
South Shade
LM-83
Time Open: **79%**

closed open



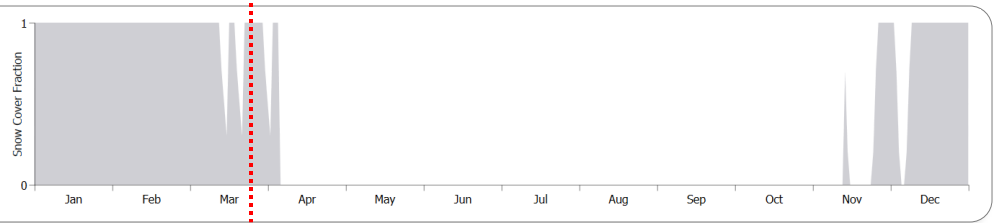
South Awning
Mar - Oct

material present



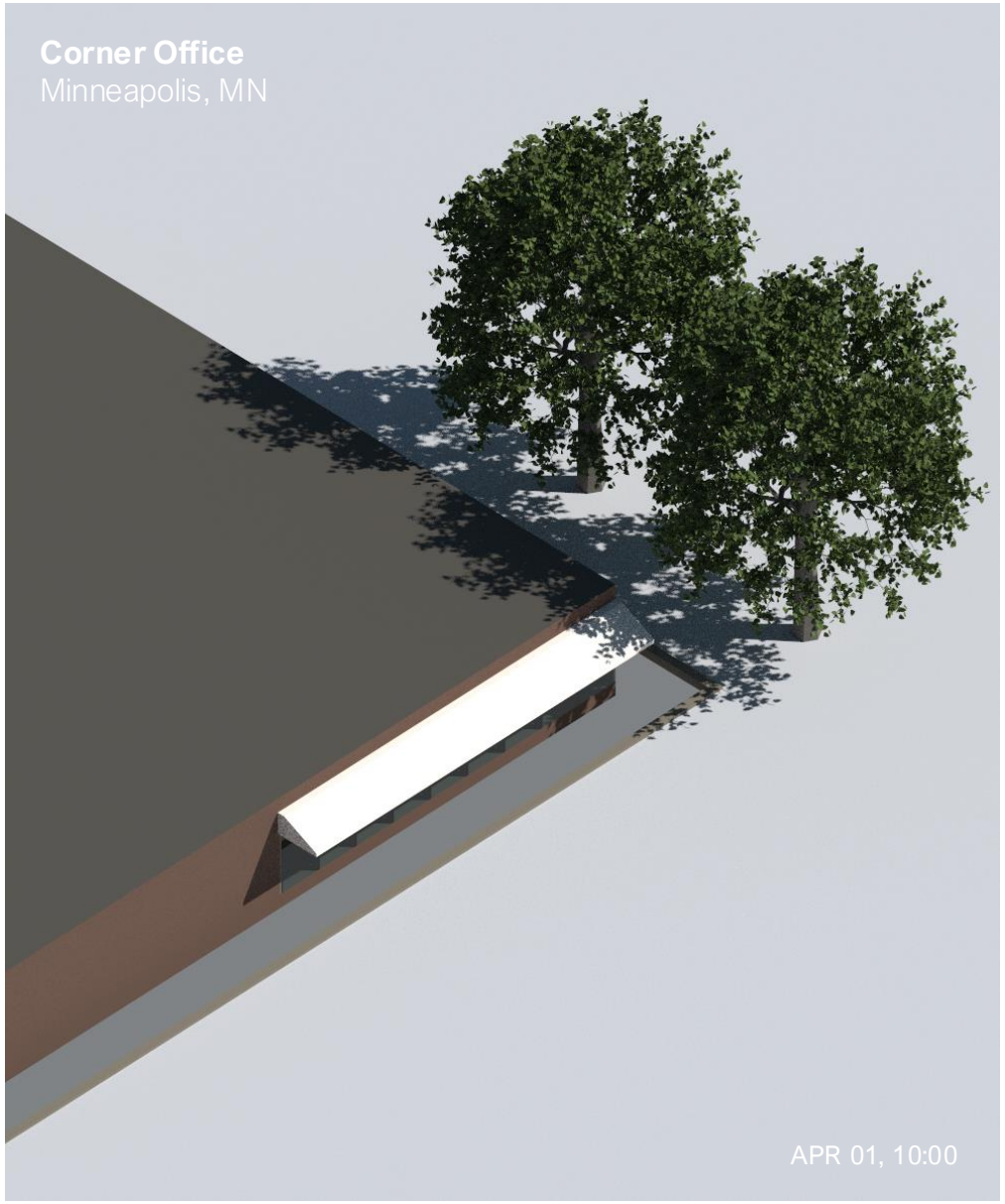
Snow
(on top of grass)
Snow Days: 134

snow opacity



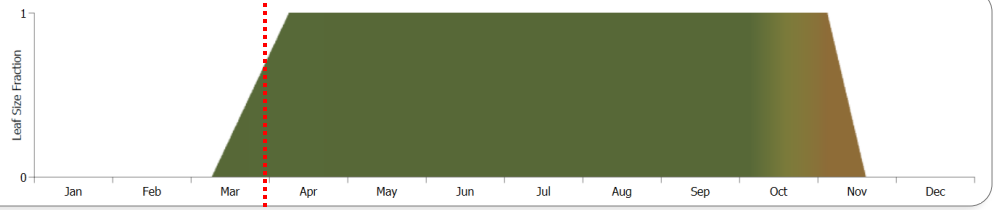
SOLEMMA

MULTIVERSAL SCENE



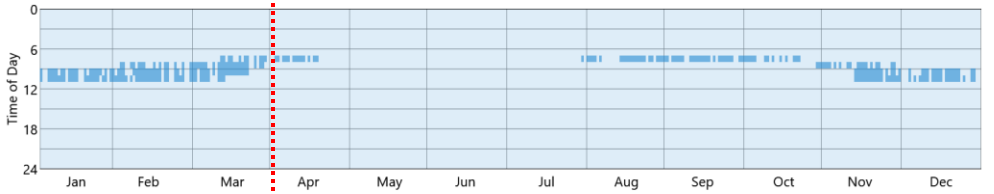
APR 01

Fraxinus Americana
Mar 11 – Nov 20



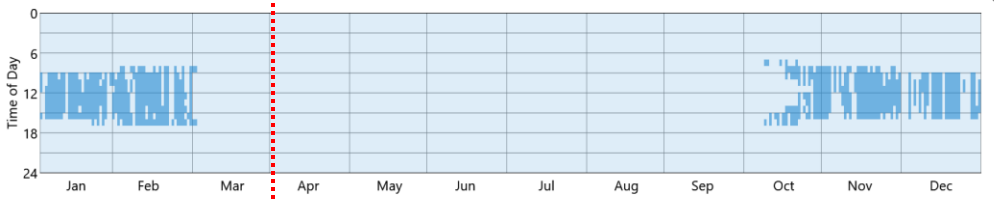
East Shade
LM-83
Time Open: **91%**

closed open



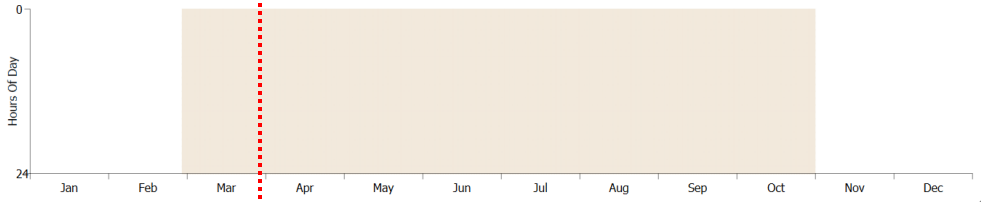
South Shade
LM-83
Time Open: **79%**

closed open



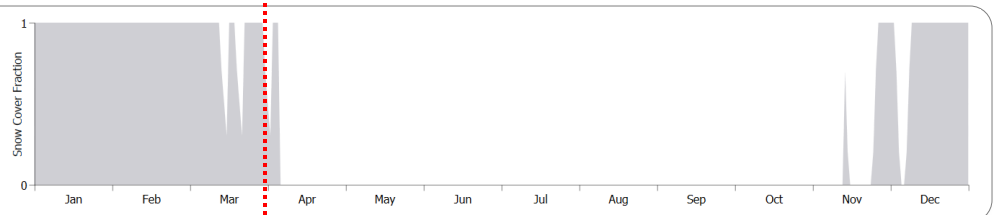
South Awning
Mar - Oct

material present



Snow
(on top of grass)
Snow Days: 134

snow opacity

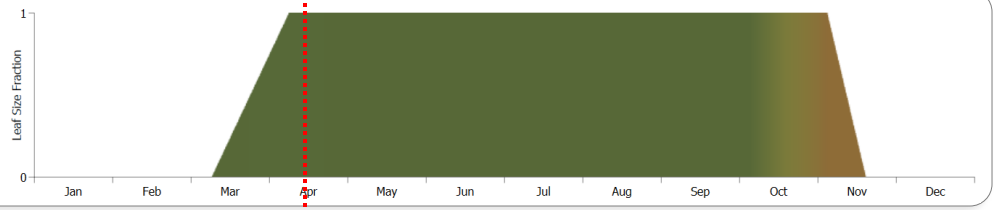


SOLEMMA

MULTIVERSAL SCENE

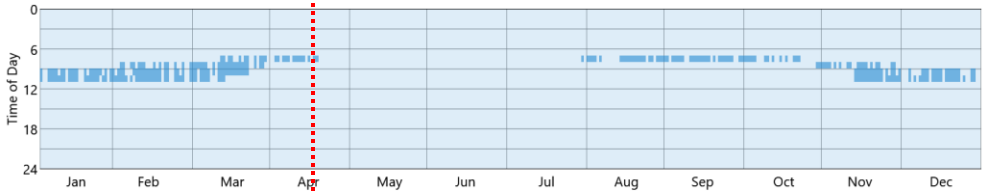
APR 15

Fraxinus Americana
Mar 11 – Nov 20



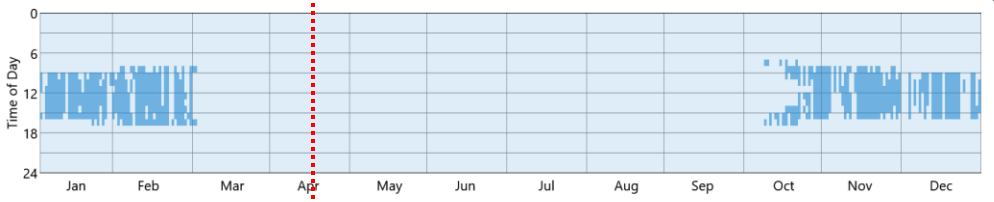
East Shade
LM-83
Time Open: **91%**

closed open



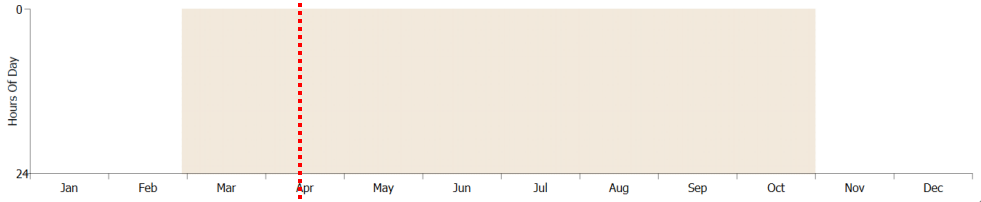
South Shade
LM-83
Time Open: **79%**

closed open



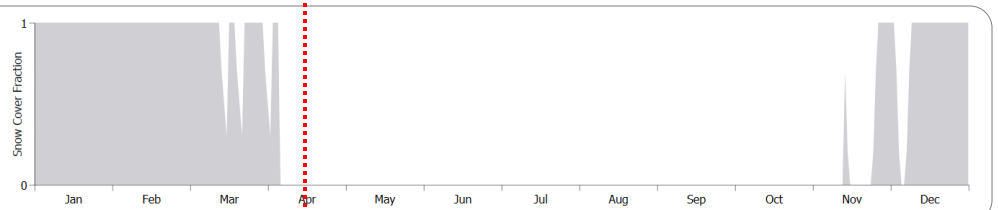
South Awning
Mar - Oct

material present



Snow
(on top of grass)
Snow Days: 134

snow opacity

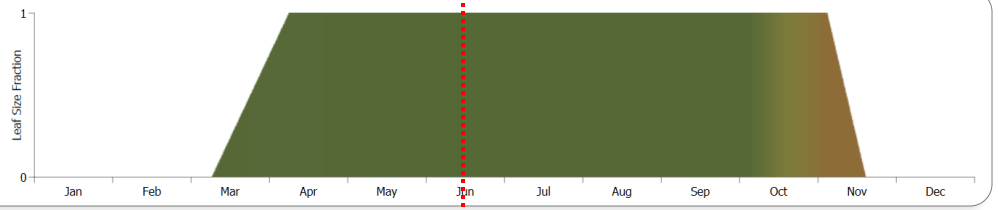


SOLEMMA

MULTIVERSAL SCENE

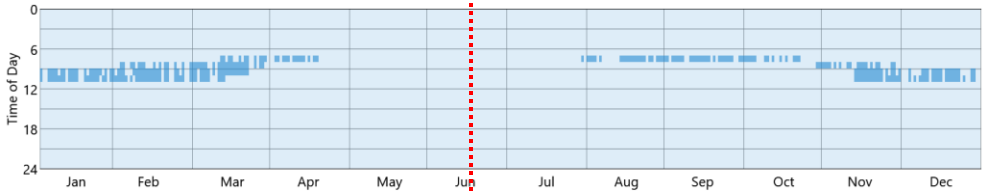
JUN 15

Fraxinus Americana
Mar 11 – Nov 20



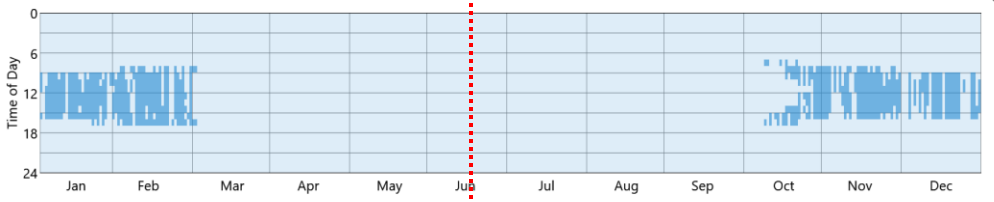
East Shade
LM-83
Time Open: **91%**

closed open



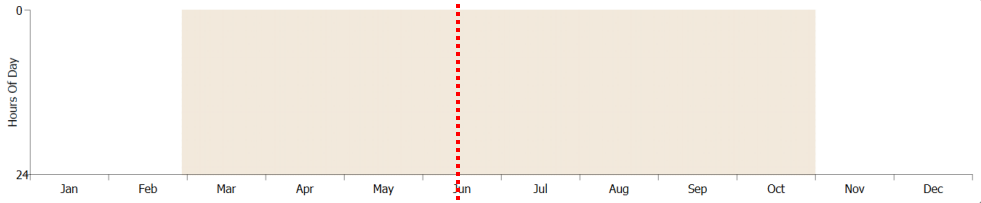
South Shade
LM-83
Time Open: **79%**

closed open



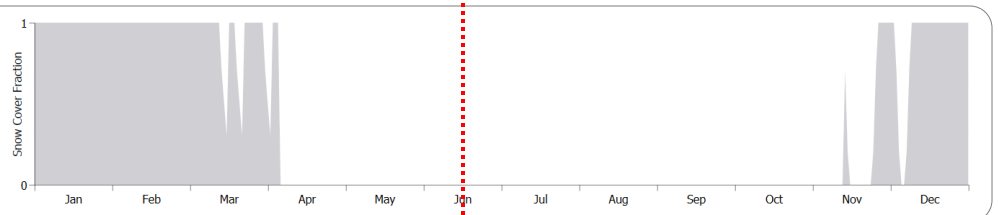
South Awning
Mar - Oct

material present



Snow
(on top of grass)
Snow Days: 134

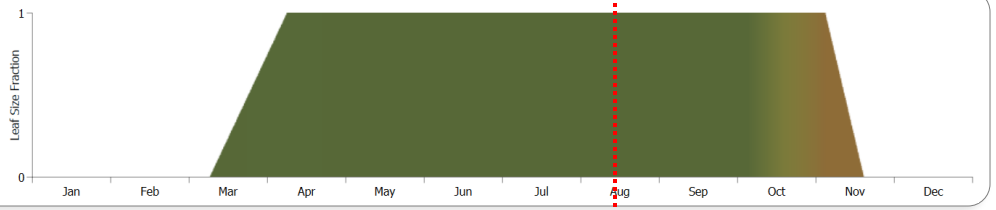
snow opacity



SOLEMMA

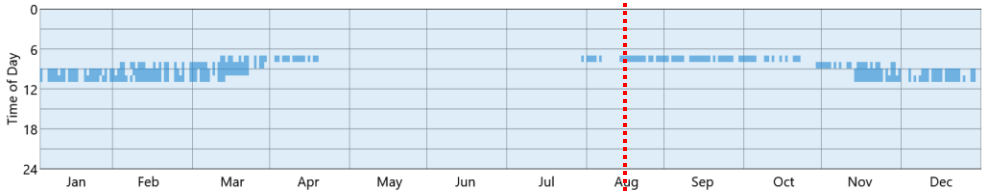
AUG 15

Fraxinus Americana
Mar 11 – Nov 20



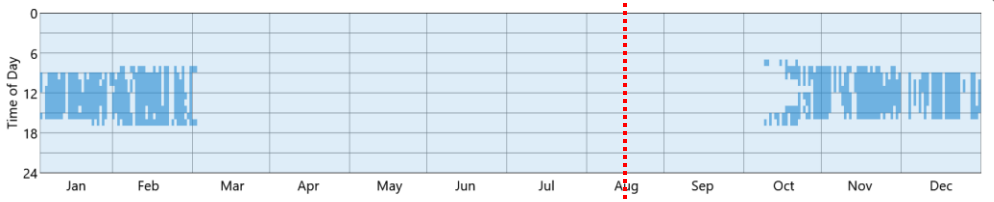
East Shade
LM-83
Time Open: **91%**

closed open



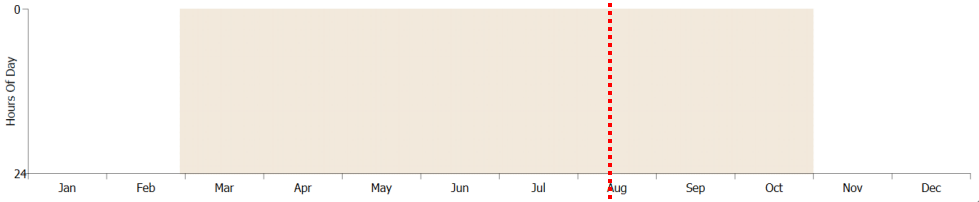
South Shade
LM-83
Time Open: **79%**

closed open



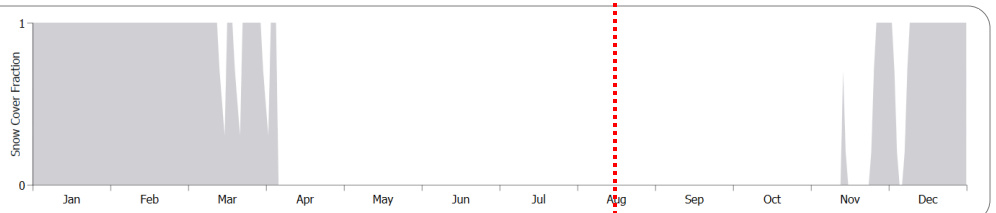
South Awning
Mar - Oct

material present



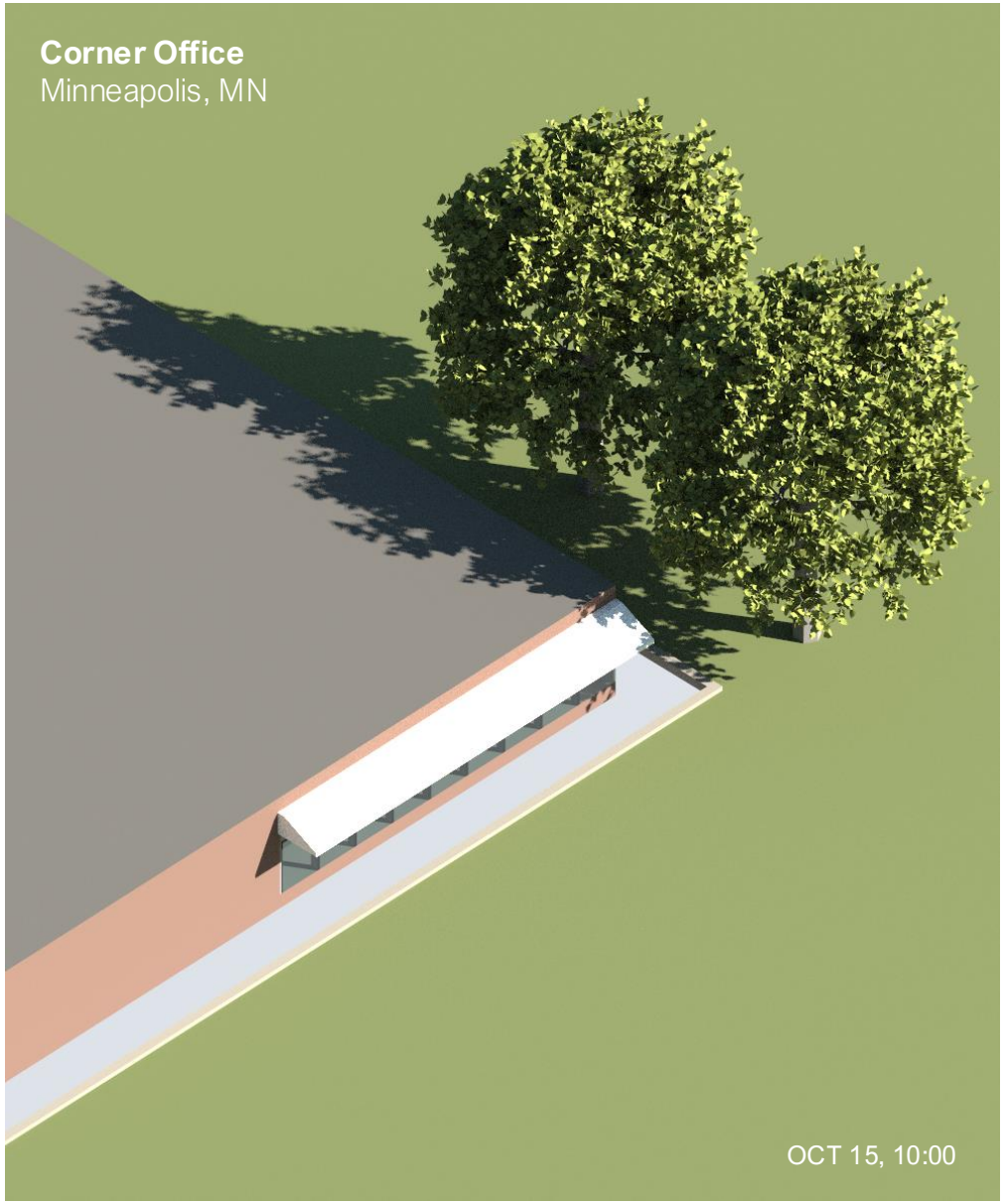
Snow
(on top of grass)
Snow Days: 134

snow opacity



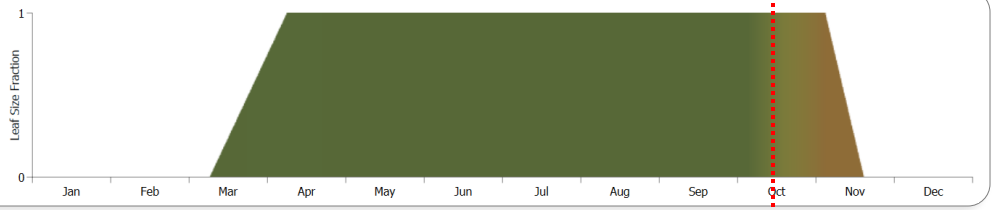
SOLEMMA

MULTIVERSAL SCENE



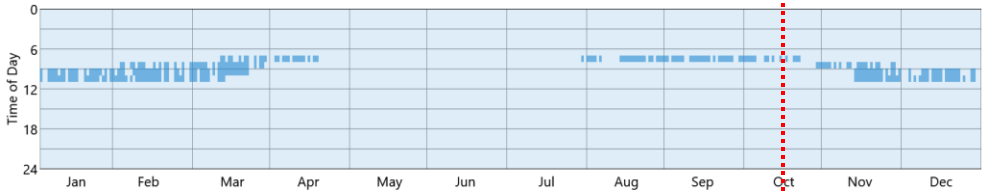
OCT 15

Fraxinus Americana
Mar 11 – Nov 20



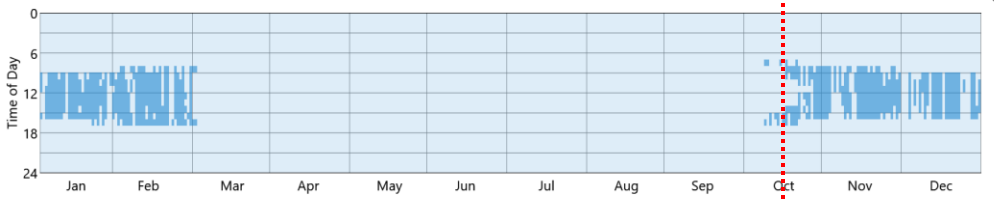
East Shade
LM-83
Time Open: **91%**

closed open



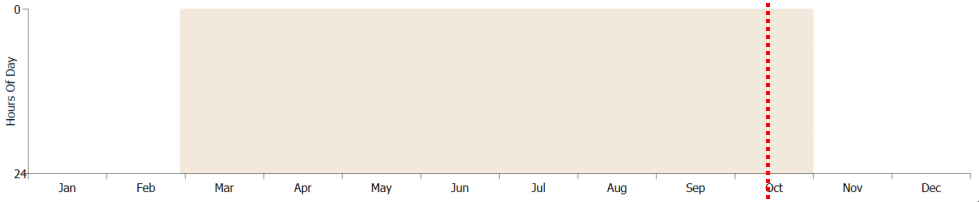
South Shade
LM-83
Time Open: **79%**

closed open



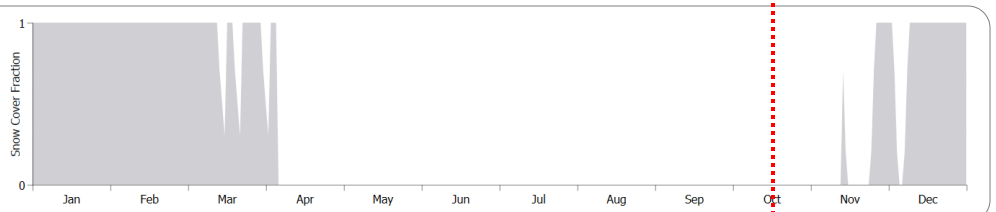
South Awning
Mar - Oct

material present



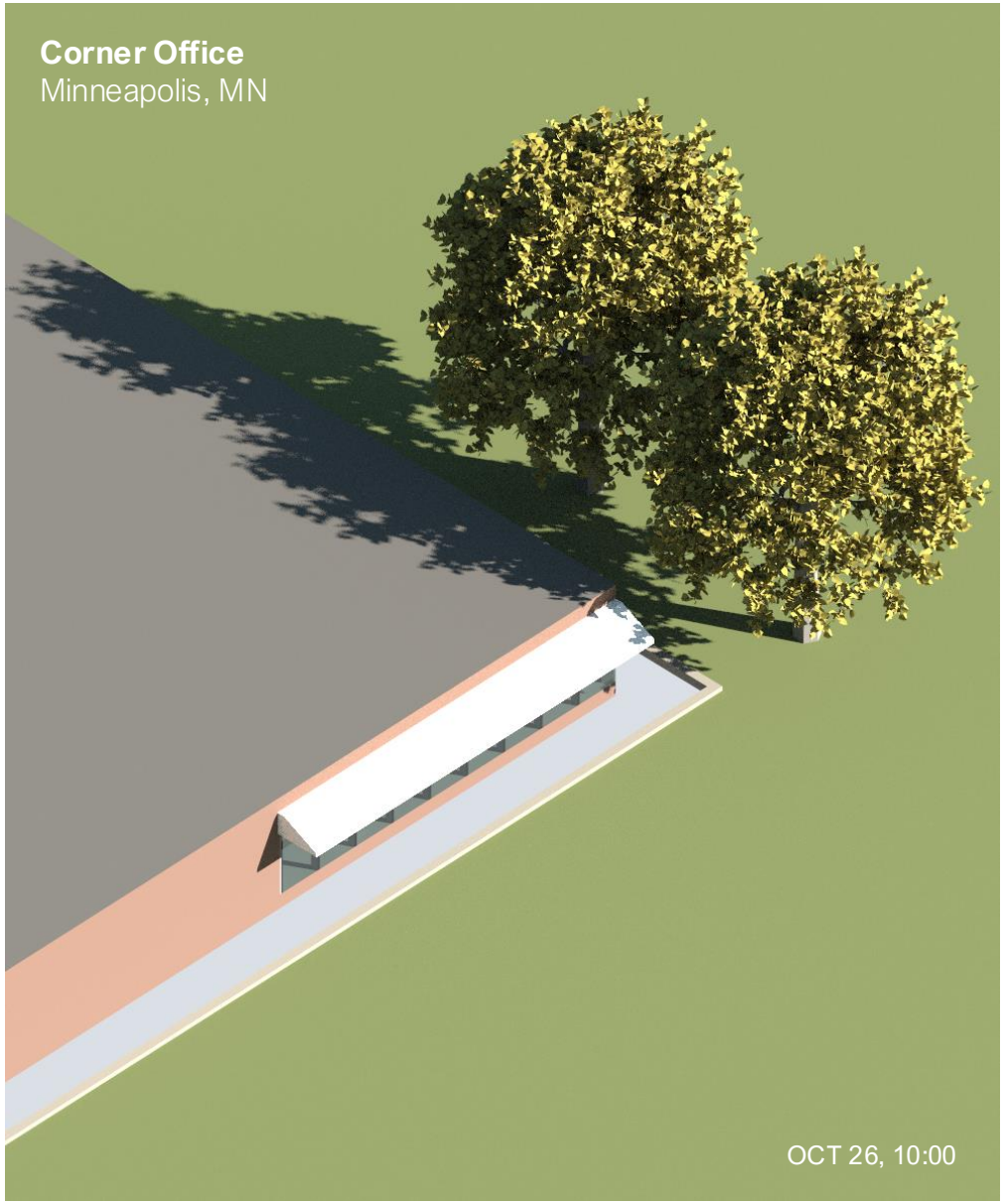
Snow
(on top of grass)
Snow Days: 134

snow opacity



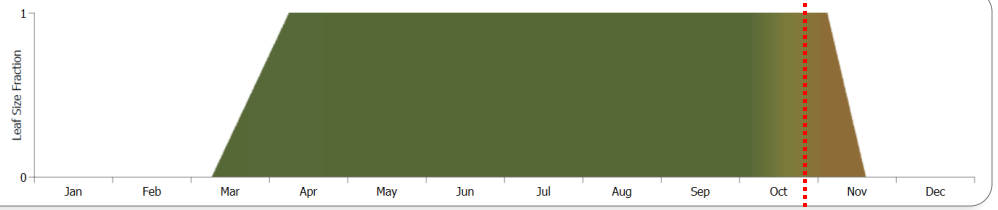
SOLEMMA

MULTIVERSAL SCENE



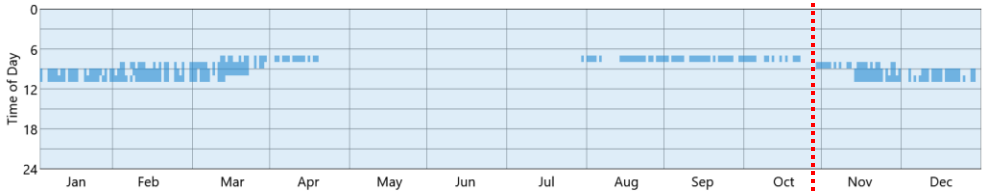
OCT 26

Fraxinus Americana
Mar 11 – Nov 20



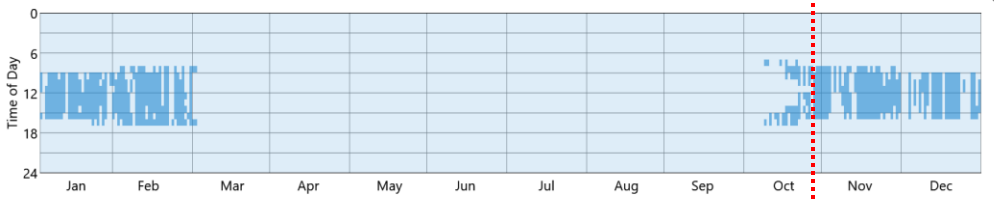
East Shade
LM-83
Time Open: **91%**

closed open



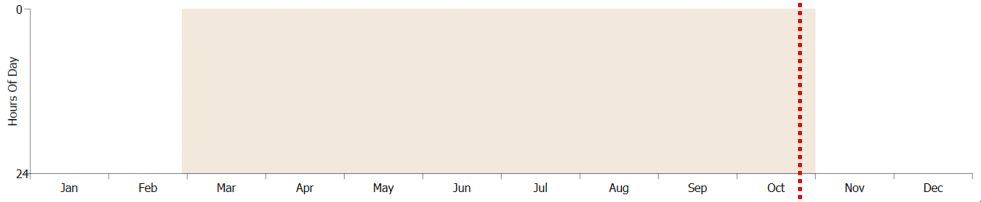
South Shade
LM-83
Time Open: **79%**

closed open



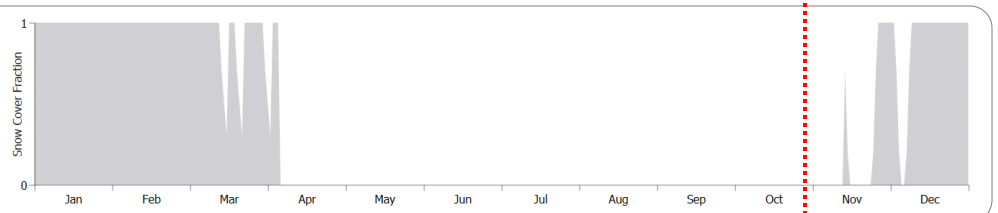
South Awning
Mar - Oct

material present



Snow
(on top of grass)
Snow Days: 134

snow opacity

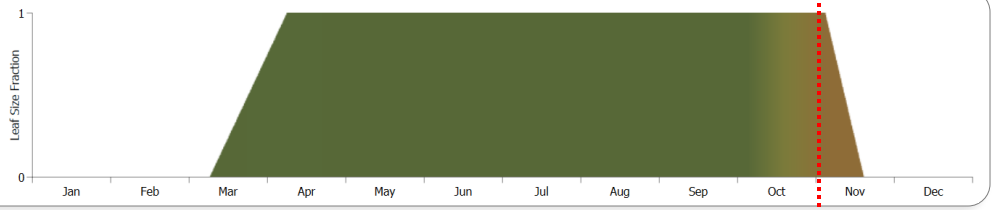


SOLEMMA

MULTIVERSAL SCENE

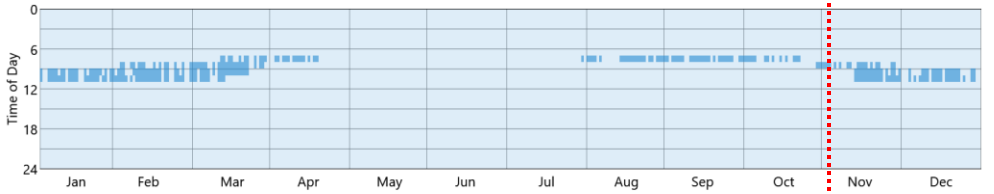
NOV 03

Fraxinus Americana
Mar 11 – Nov 20



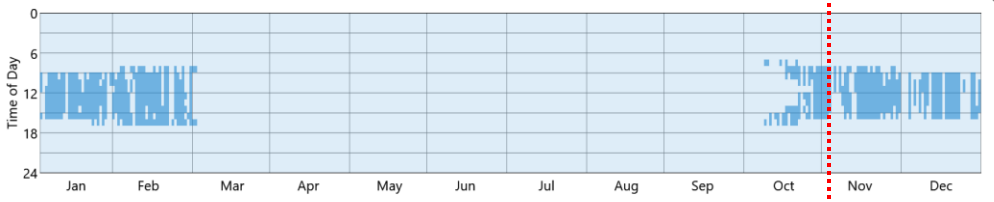
East Shade
LM-83
Time Open: **91%**

closed open



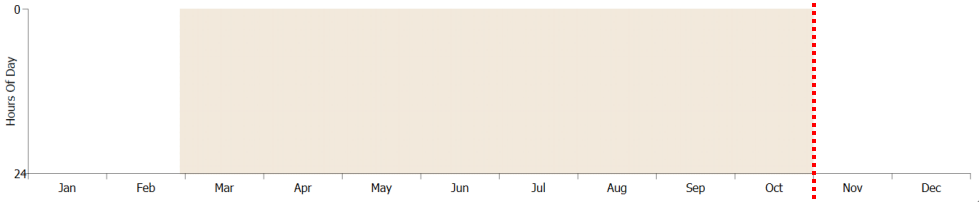
South Shade
LM-83
Time Open: **79%**

closed open



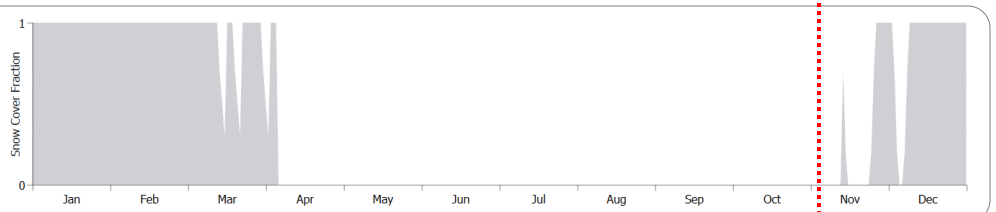
South Awning
Mar - Oct

material present



Snow
(on top of grass)
Snow Days: 134

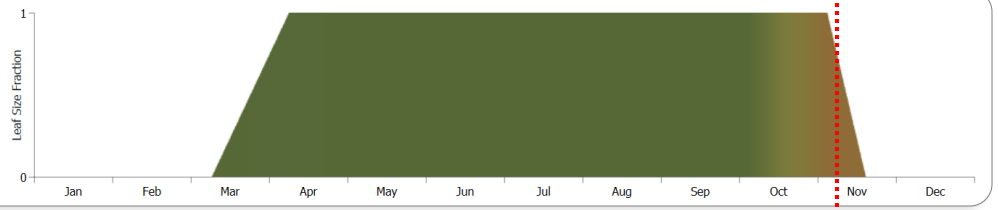
snow opacity



SOLEMMA

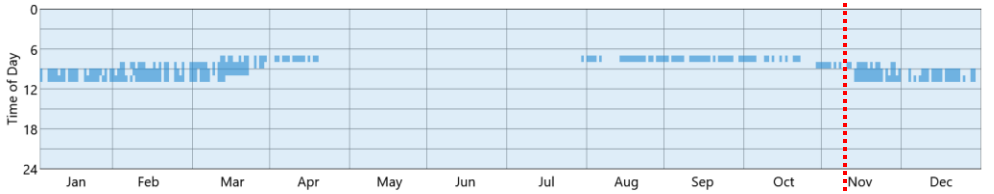
NOV 09

Fraxinus Americana
Mar 11 – Nov 20



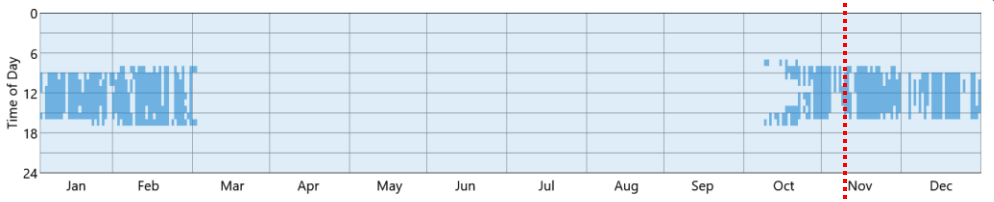
East Shade
LM-83
Time Open: **91%**

closed open



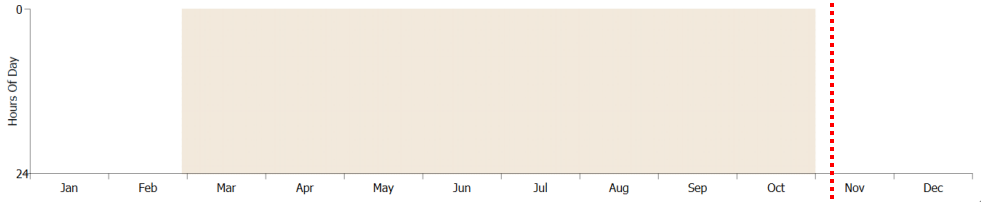
South Shade
LM-83
Time Open: **79%**

closed open



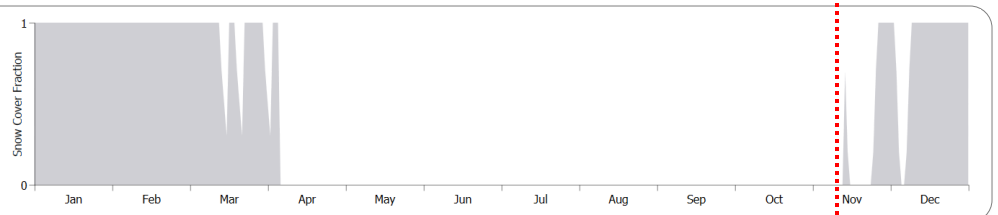
South Awning
Mar - Oct

material present

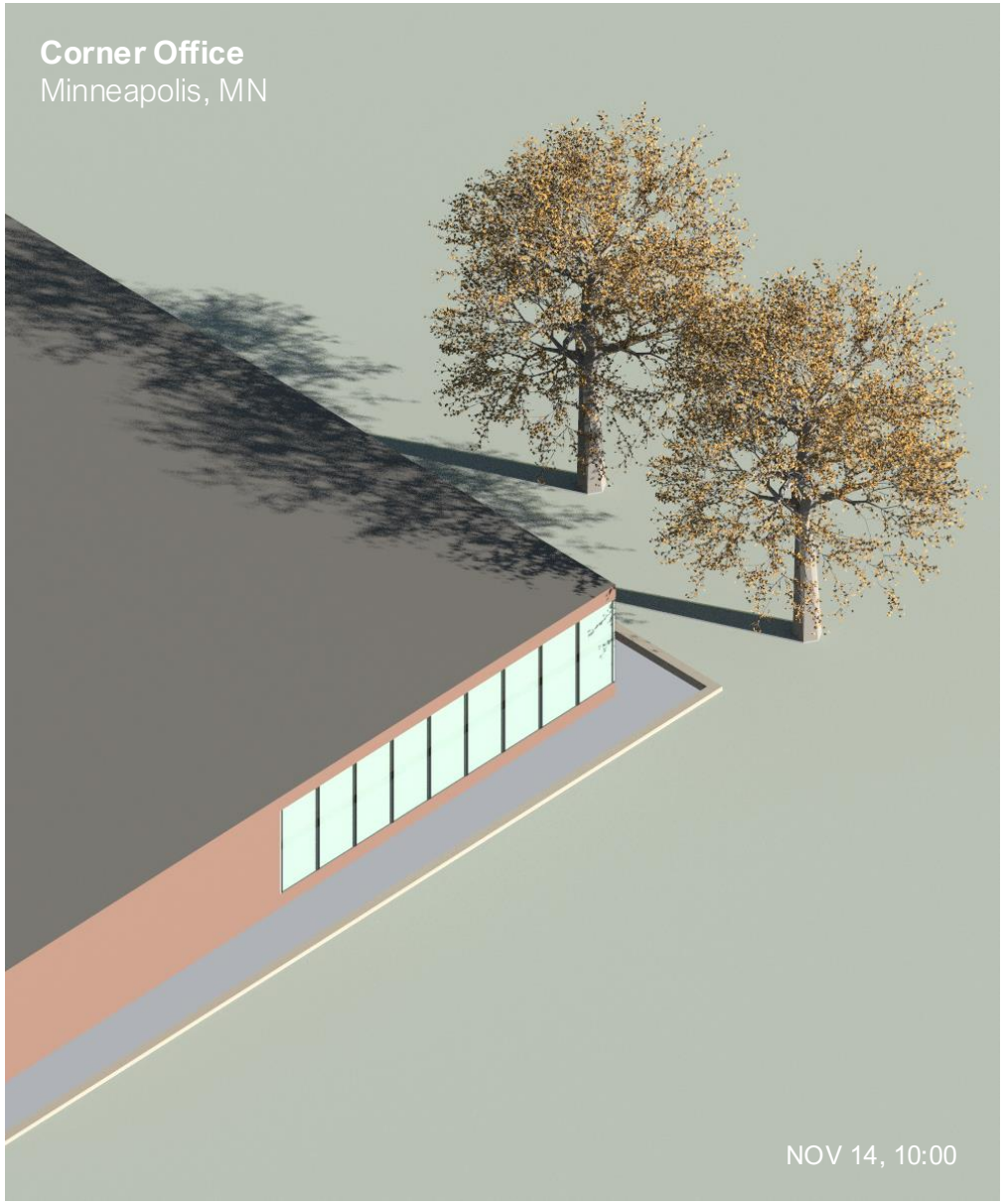


Snow
(on top of grass)
Snow Days: 134

snow opacity

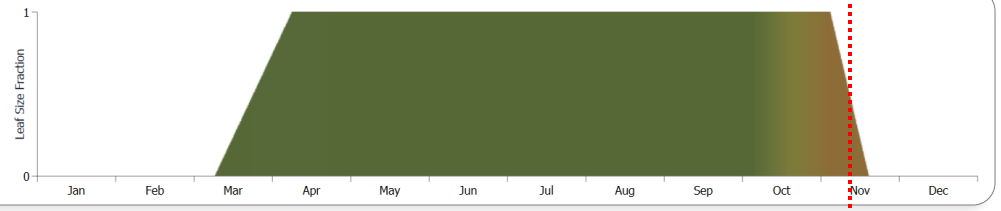


SOLEMMA



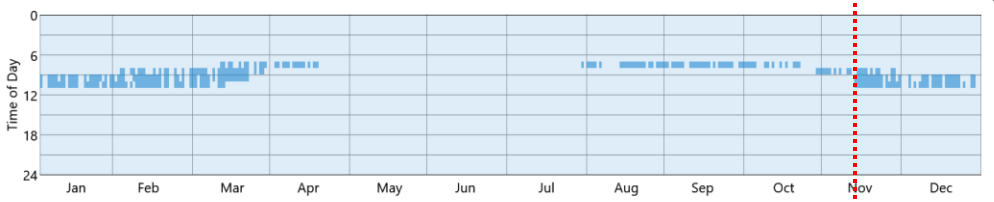
NOV 14

Fraxinus Americana
Mar 11 – Nov 20



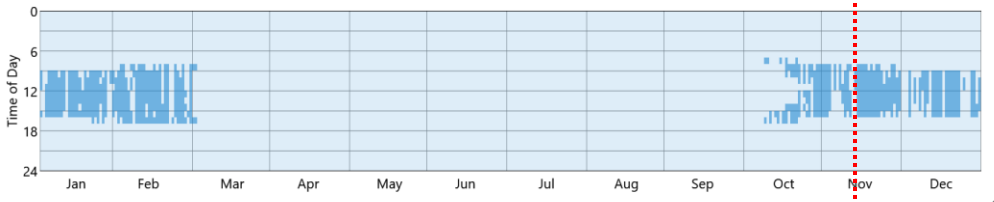
East Shade
LM-83
Time Open: **91%**

closed open



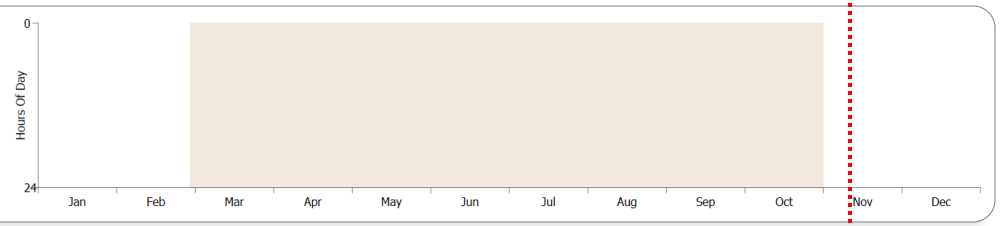
South Shade
LM-83
Time Open: **79%**

closed open



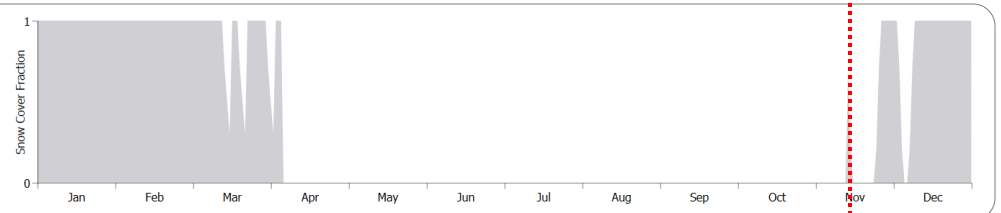
South Awning
Mar - Oct

material present

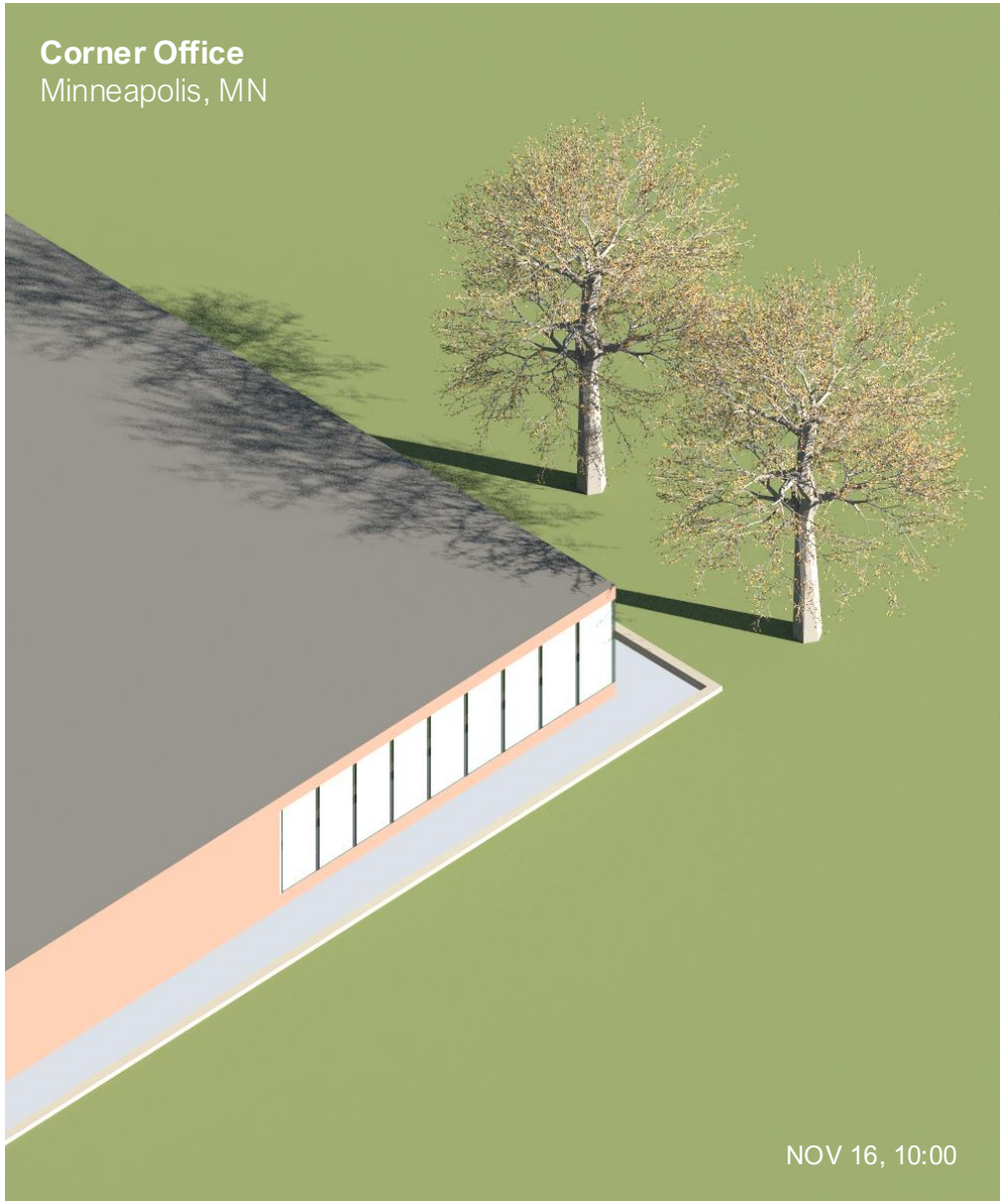


Snow
(on top of grass)
Snow Days: 134

snow opacity

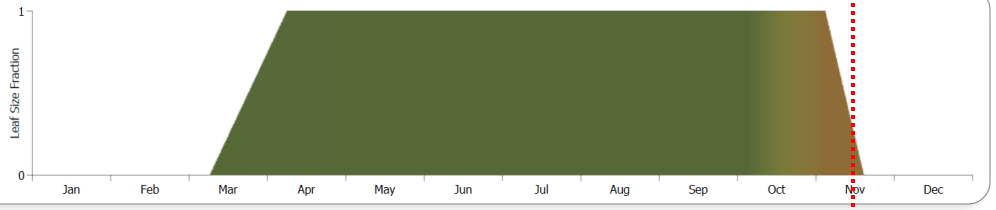


SOLEMMA



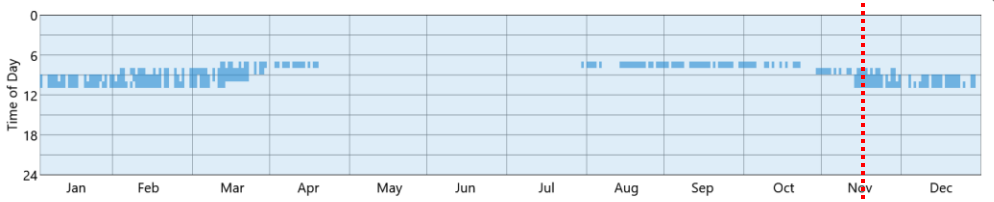
NOV 16

Fraxinus Americana
Mar 11 – Nov 20



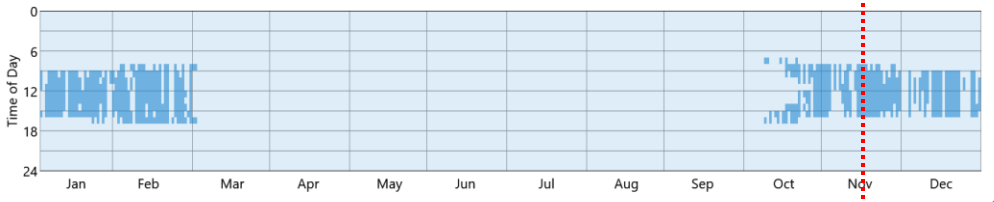
East Shade
LM-83
Time Open: **91%**

closed open



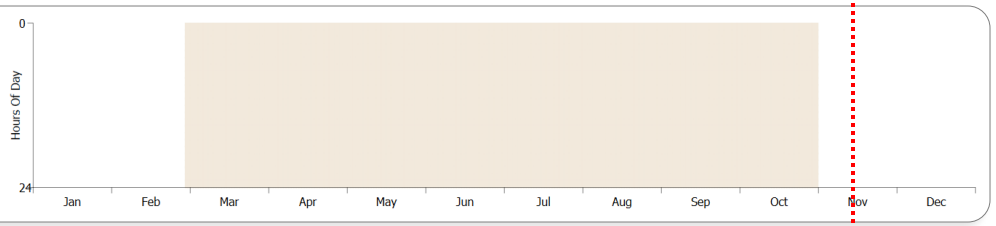
South Shade
LM-83
Time Open: **79%**

closed open



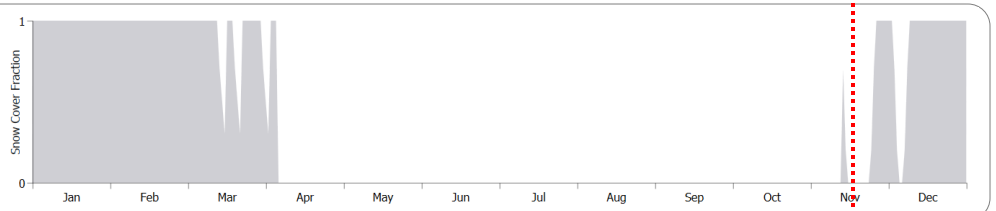
South Awning
Mar - Oct

material present



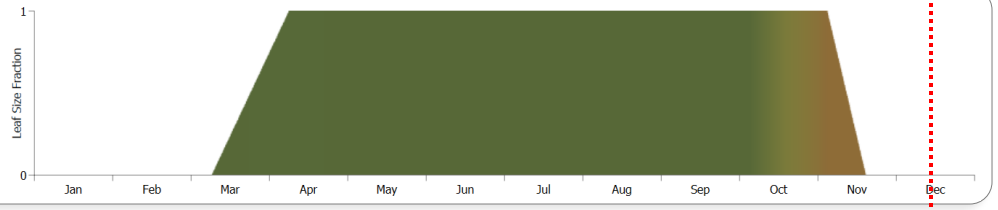
Snow
(on top of grass)
Snow Days: 134

snow opacity



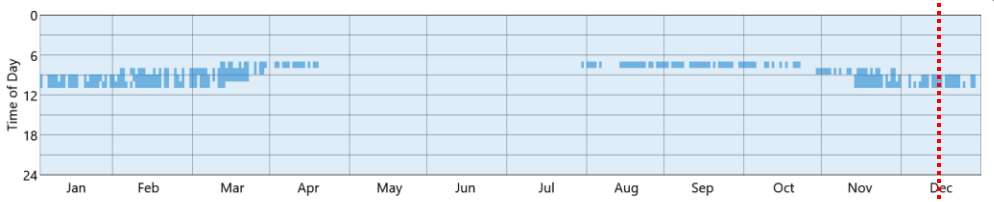
SOLEMMA

Fraxinus Americana
Mar 11 – Nov 20



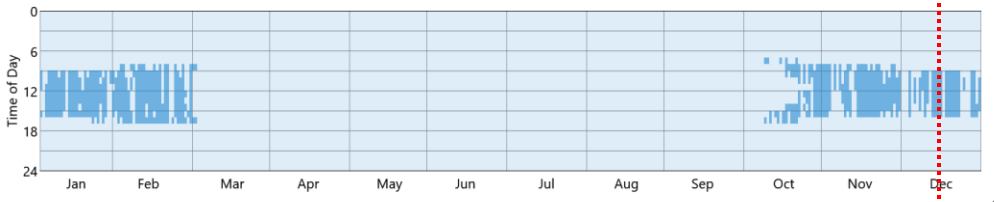
East Shade
LM-83
Time Open: **91%**

closed open



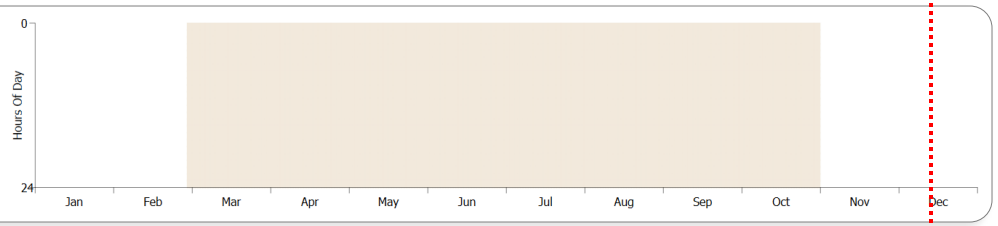
South Shade
LM-83
Time Open: **79%**

closed open



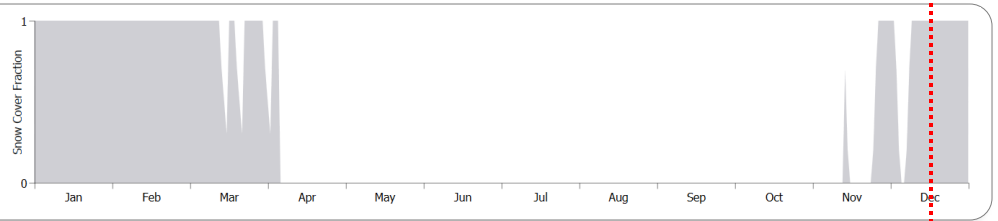
South Awning
Mar - Oct

material present



Snow
(on top of grass)
Snow Days: 134

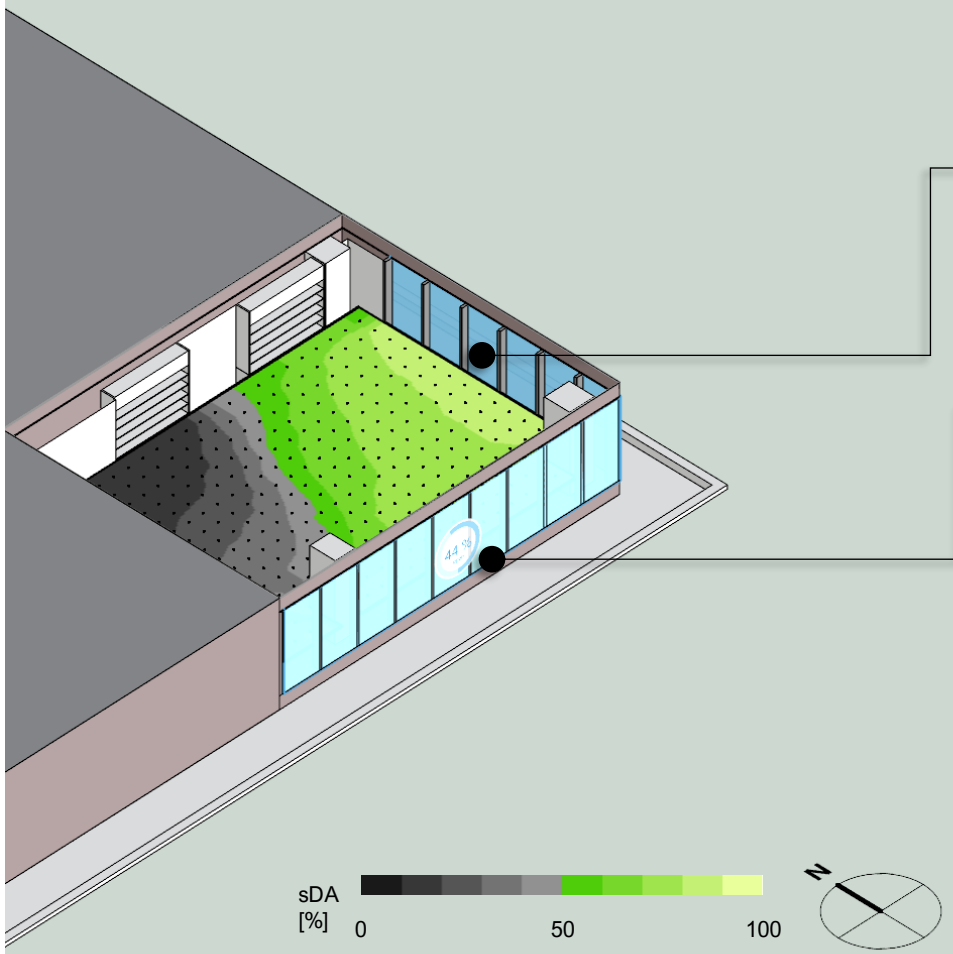
snow opacity



DEC 15

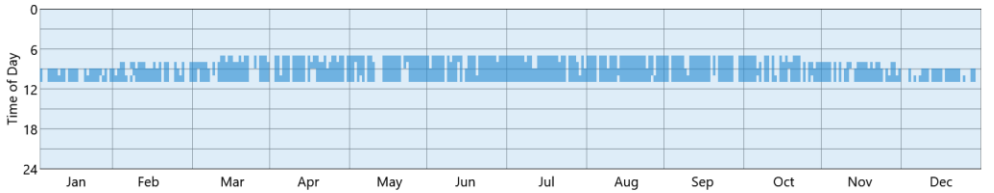
SOLEMMA

Corner Office: Shades Only
Minneapolis, MN



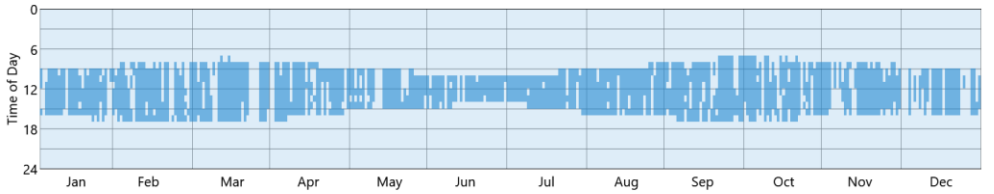
East Shade
LM-83
Time Open: **74%**

closed open



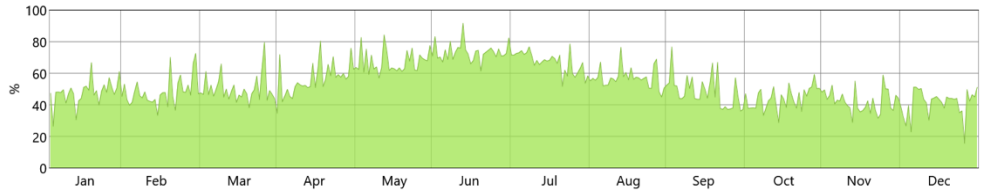
South Shade
LM-83
Time Open: **44%**

closed open



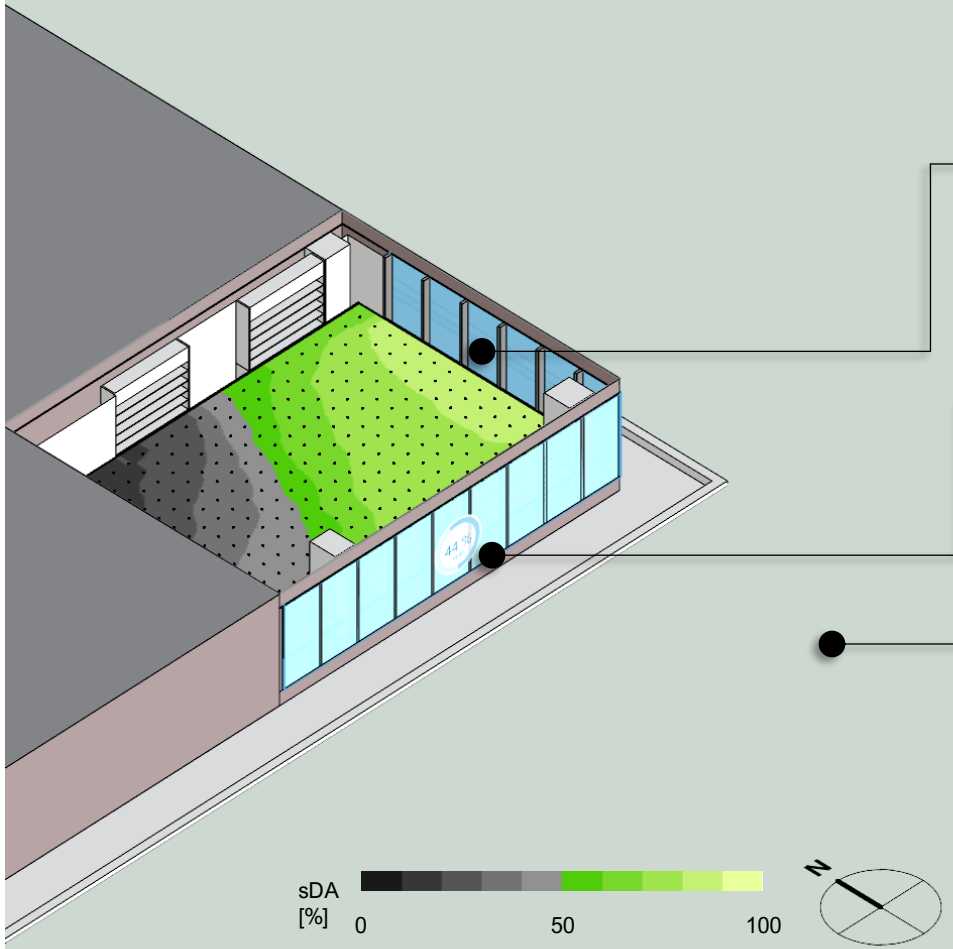
sDA **58.8%**

mean daylit area



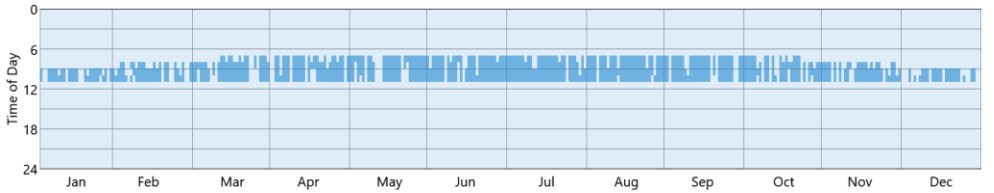
SOLEMMA

Corner Office: + Snow
Minneapolis, MN



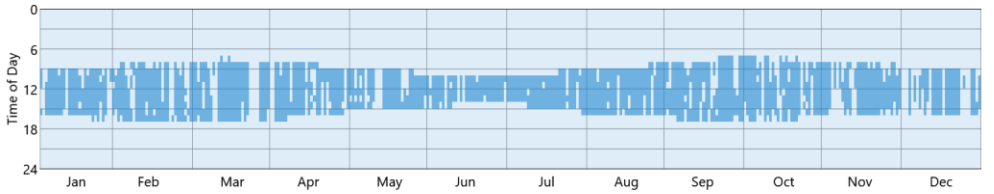
East Shade
LM-83
Time Open: **74%**

closed open



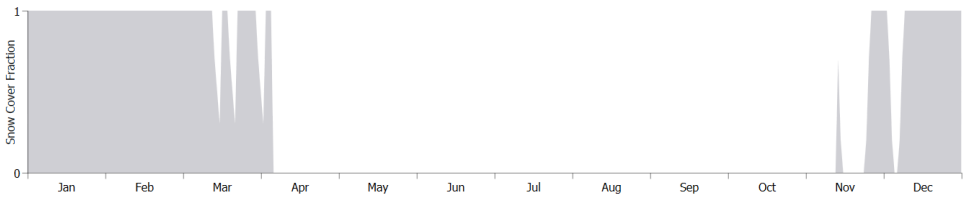
South Shade
LM-83
Time Open: **44%**

closed open



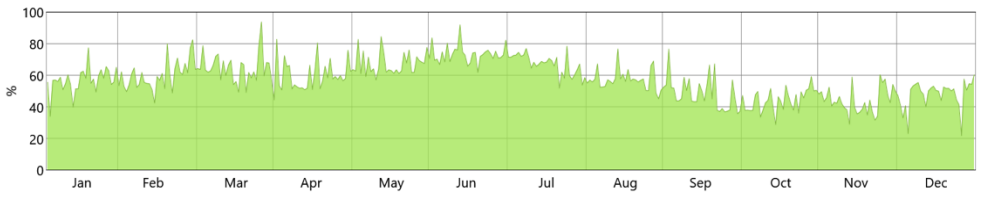
Snow
Snow Days: 134

snow opacity



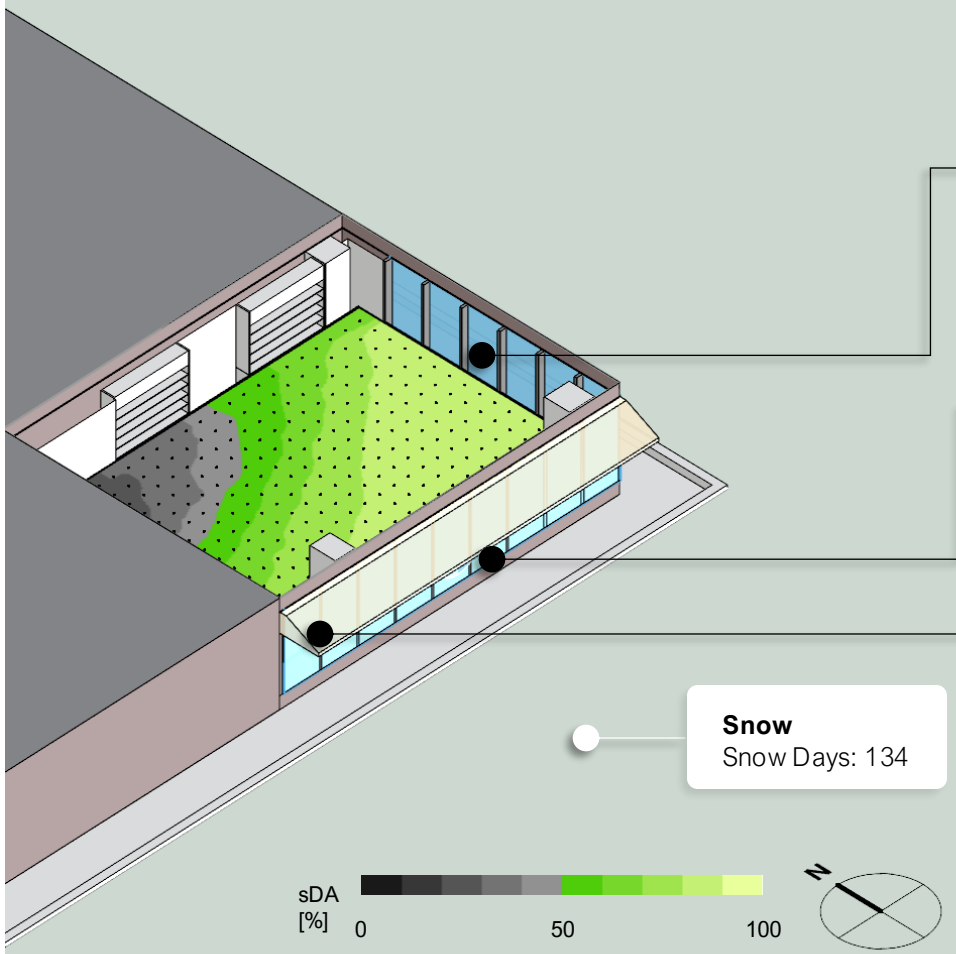
sDA **62.3%**

mean daylit area



SOLEMMA

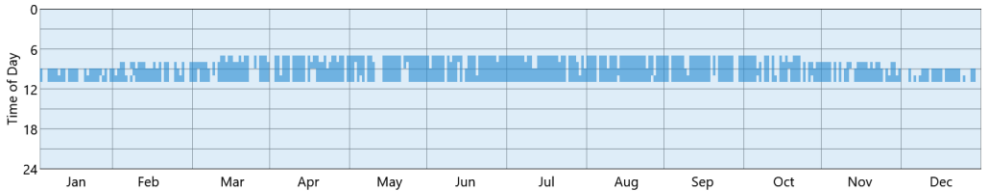
Corner Office: + South Awning
Minneapolis, MN



Snow
Snow Days: 134

East Shade
LM-83
Time Open: **74%**

closed open

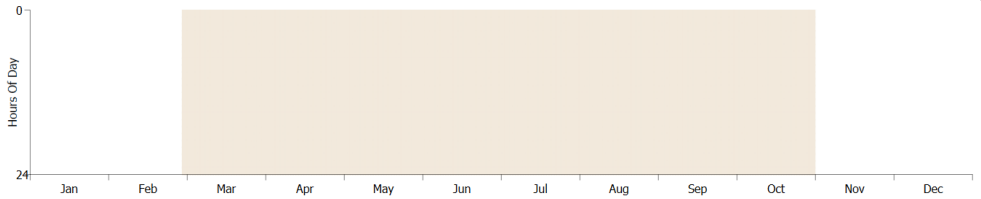


South Shade
LM-83
Time Open: **79%**

closed open

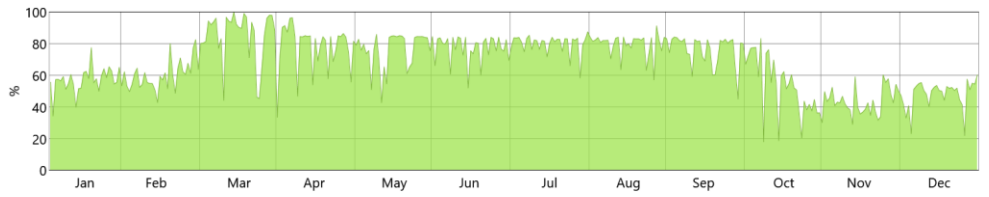
South Awning
Mar - Oct

material present



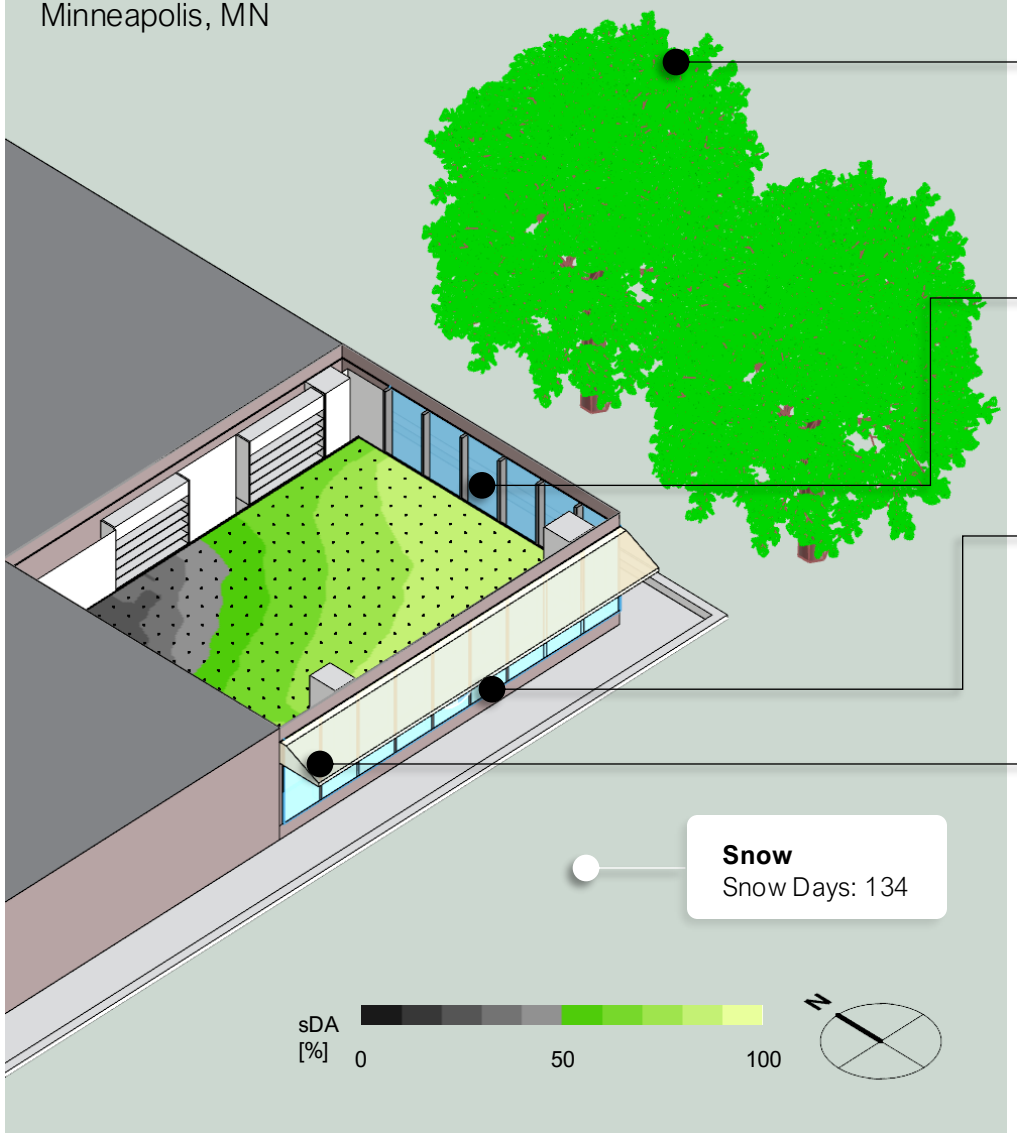
sDA **79.8%**

mean daylit area

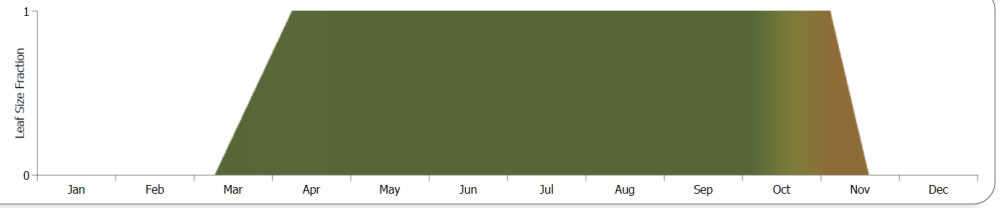


SOLEMMA

Corner Office: + Deciduous Trees
Minneapolis, MN

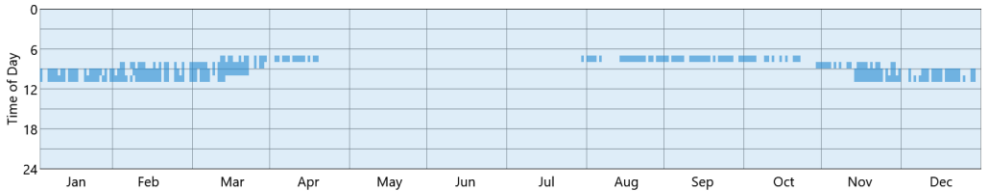


Fraxinus Americana
Mar 11 – Nov 20



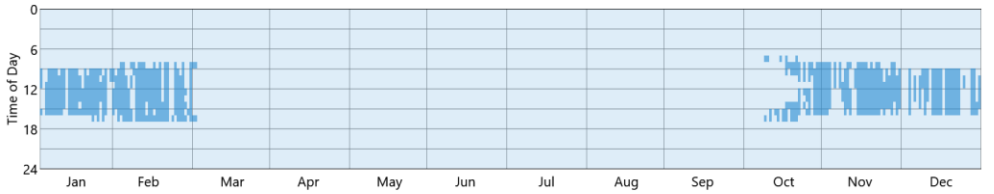
East Shade
LM-83
Time Open: **91%**

closed open



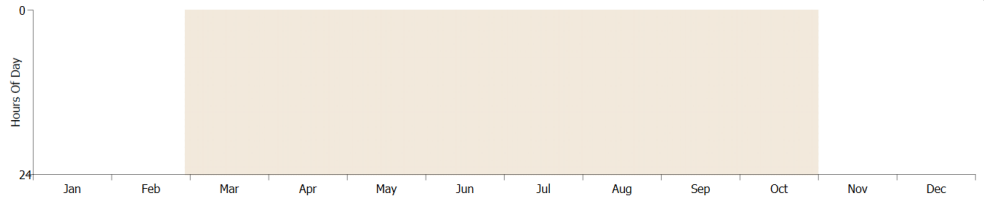
South Shade
LM-83
Time Open: **79%**

closed open



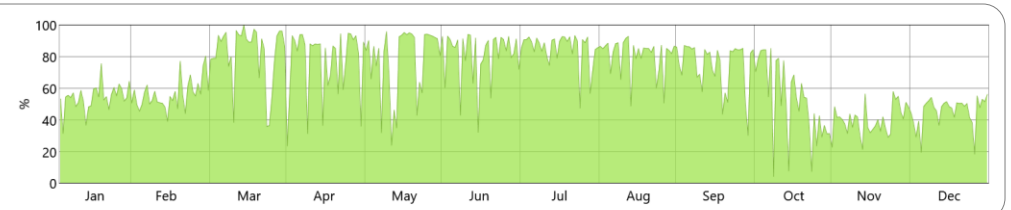
South Awning
Mar - Oct

material present

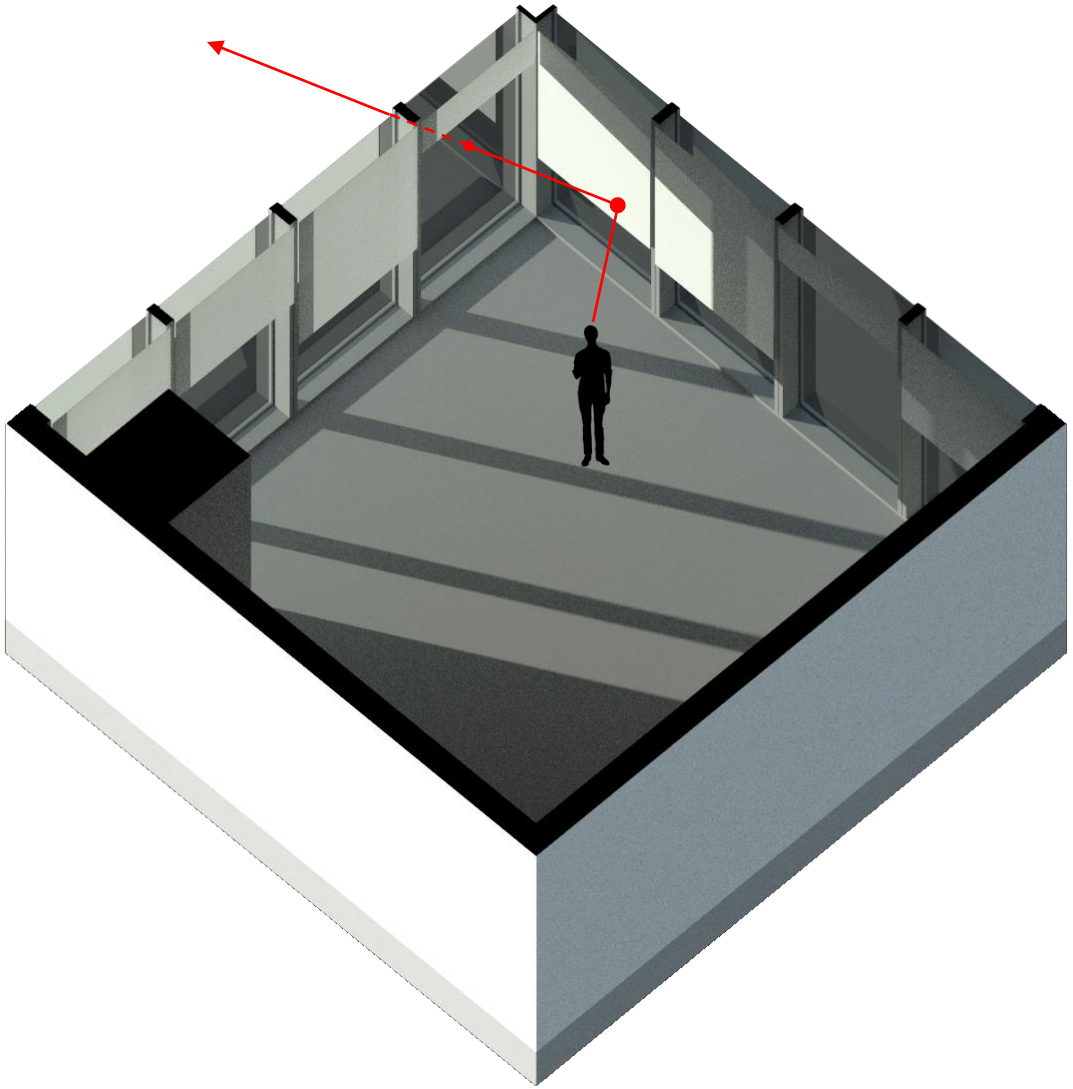


sDA **81.3%**

mean daylit area



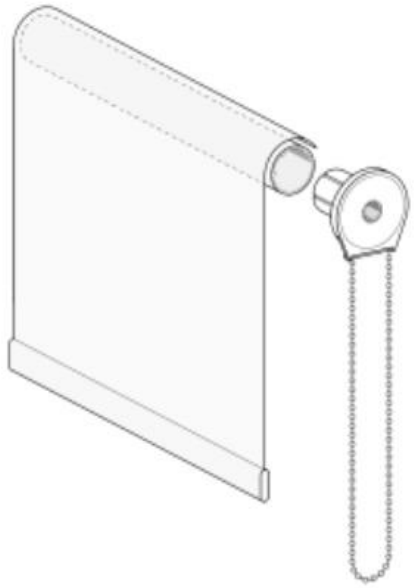
SOLEMMA

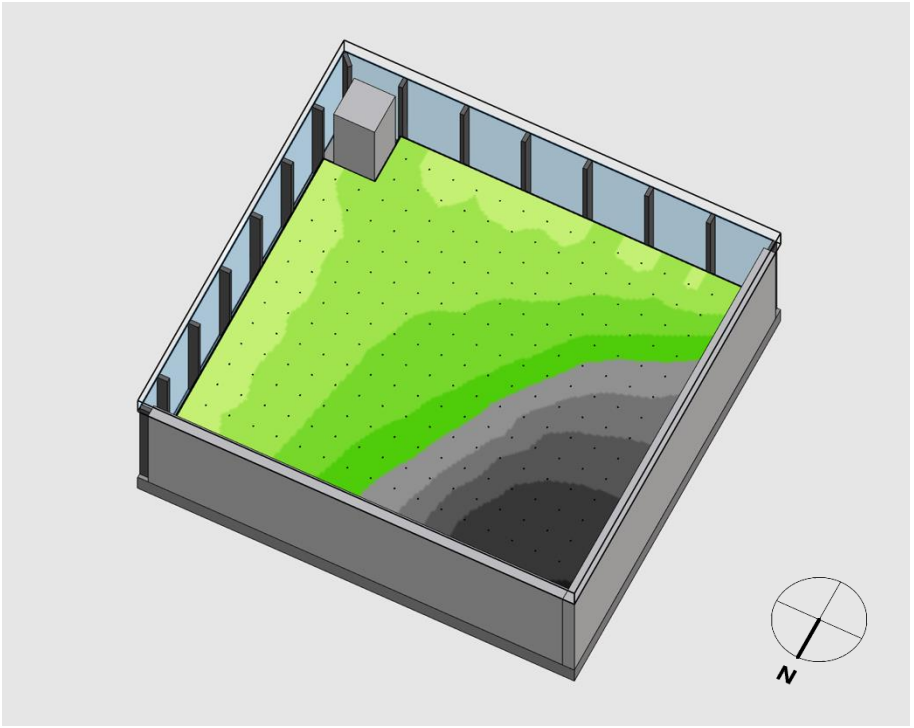


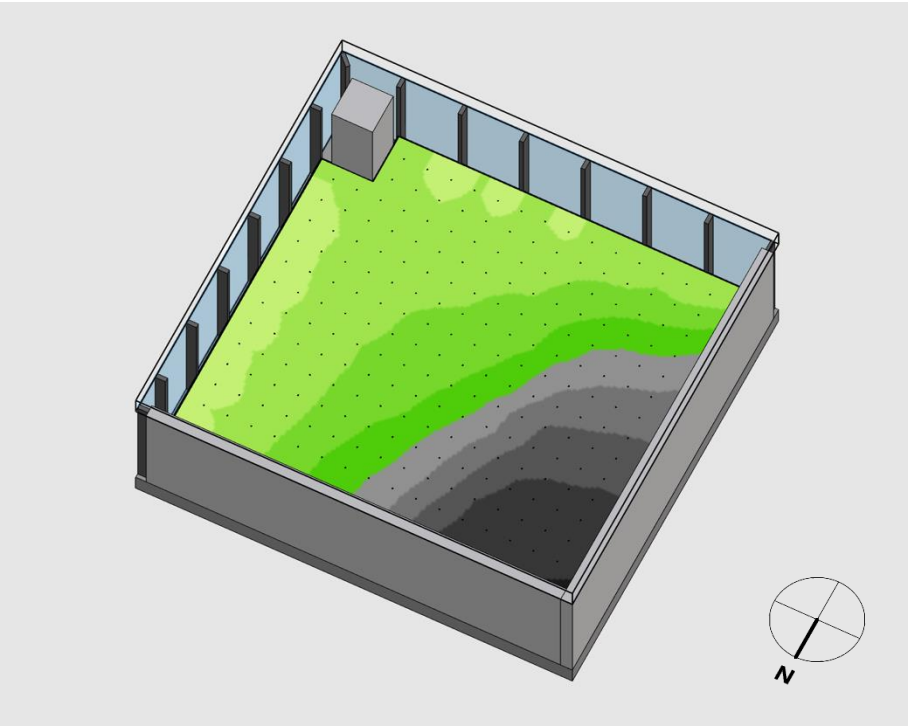
Multiverse finds more reflected light than 3/5-phase methods.

Is this significant?

Low VLR Scenario







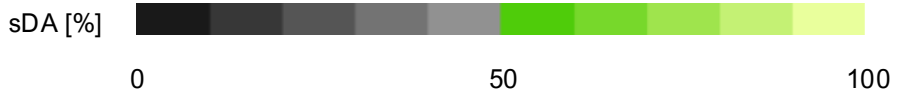
Shade
SheerWeave 2410 Performance
V24 CCL/Chestnut
VLR (back) **6%**

Glazing
Pacifica – Solarban 60 (3)
VLT 30%
VLR (back) **7%**

CFS Reflections On	
sDA	67.2%
Mean Lux	552

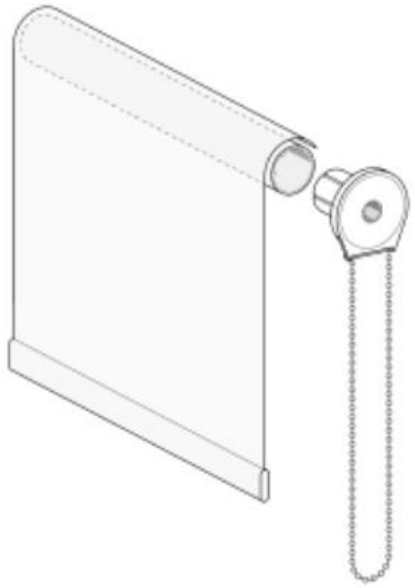
CFS Reflections Off		**Rel. Error**
sDA	64.9%	**-3.2%**
Mean Lux	541	**-2.0%**

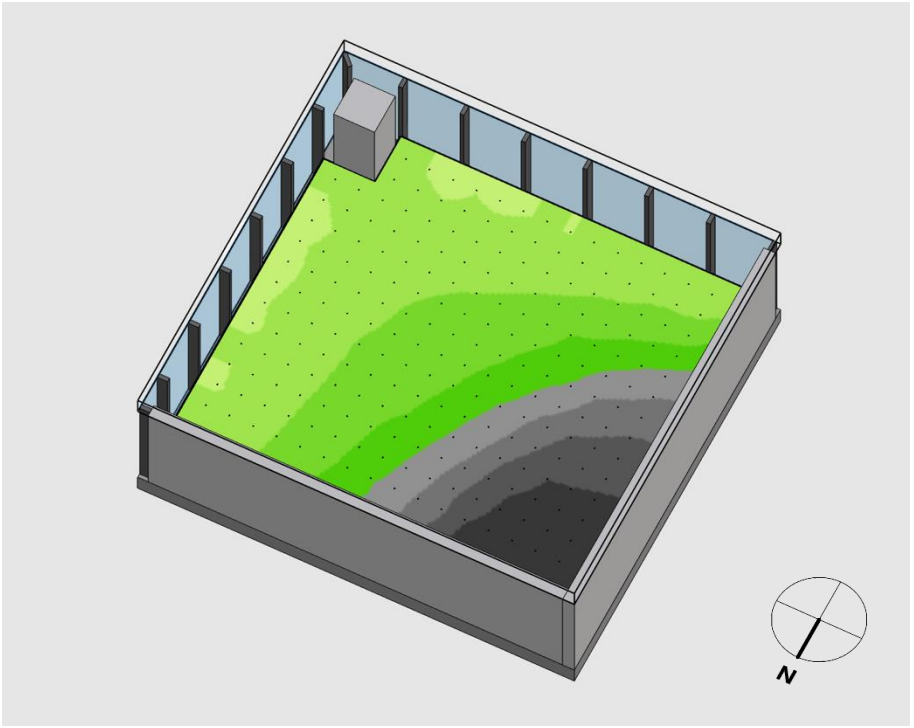
Params
USA_MA_Boston-Logan.Intl.AP.725090_TMYx.2004-2018.epw
65536 samples/sensor, -ab 10 -ad* 1 -lw* 0.001 *per sample
LM-83 shading control

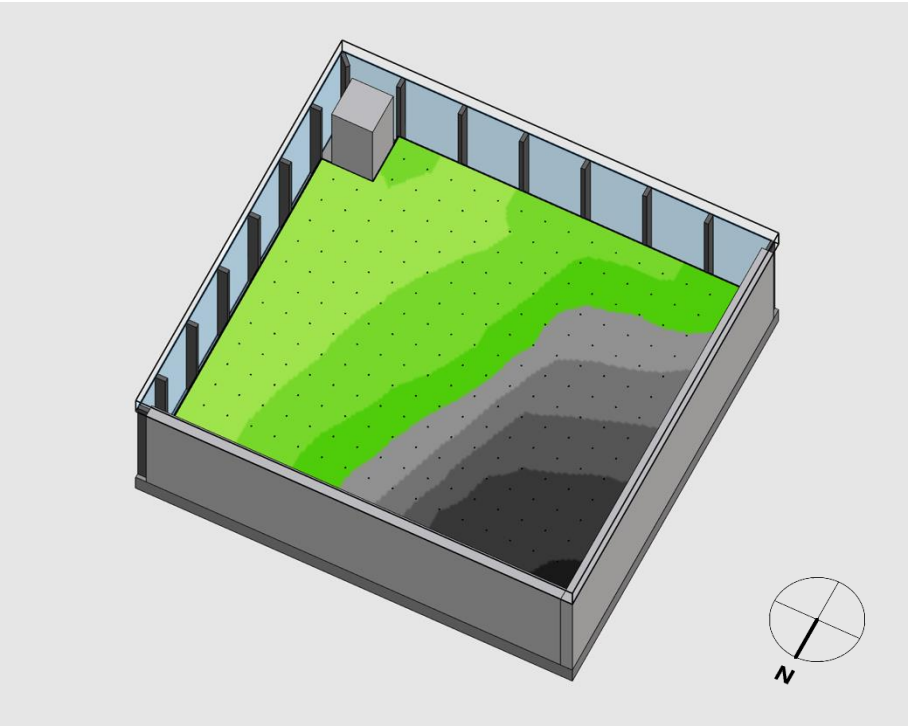


SOLEMMA

High VLR Scenario







Shade
SheerWeave 2410 Performance
P12 Oyster
VLR (back) **78%**

Glazing
Vistacool on Pacifica – Clear
VLT 29%
VLR (back) **31%**

CFS Reflections On

sDA	68.7%
Mean Lux	536

CFS Reflections Off

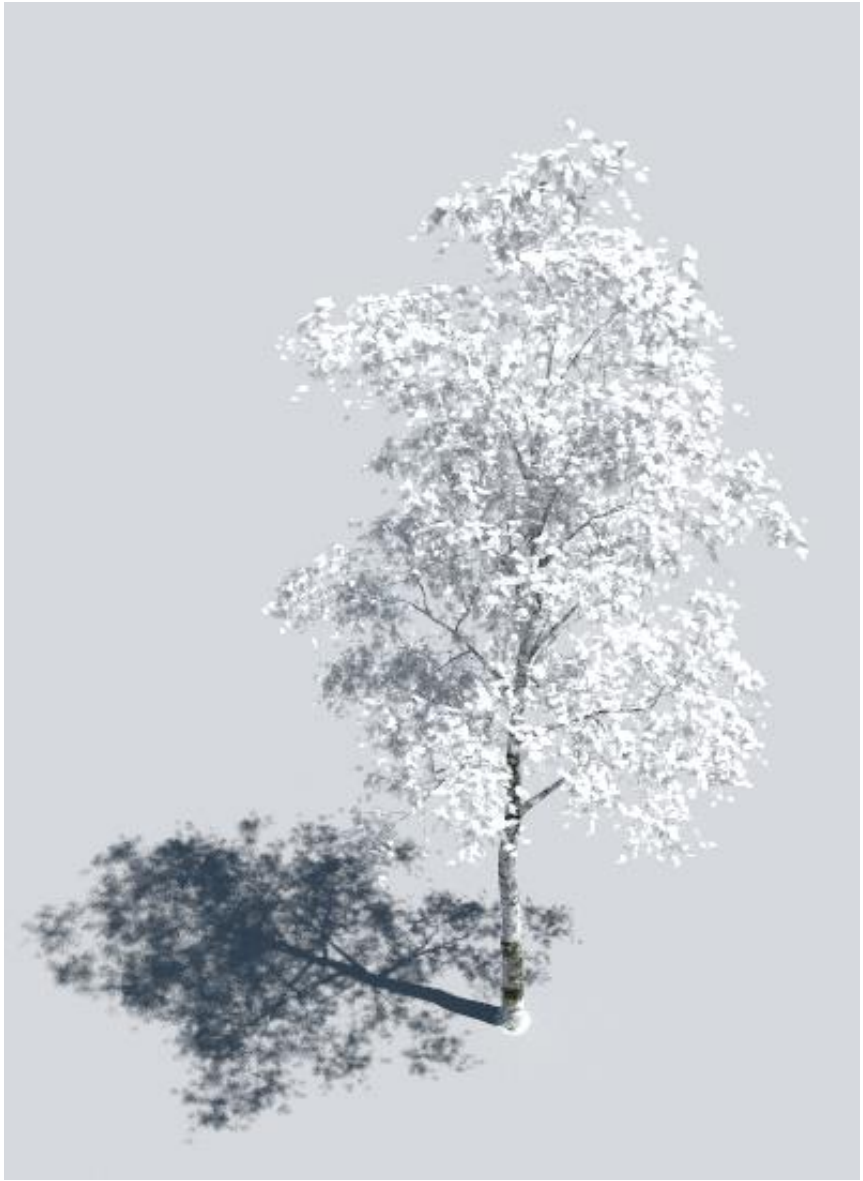
		Rel. Error
sDA	58.2%	**-15.5%**
Mean Lux	489	**-8.8%**

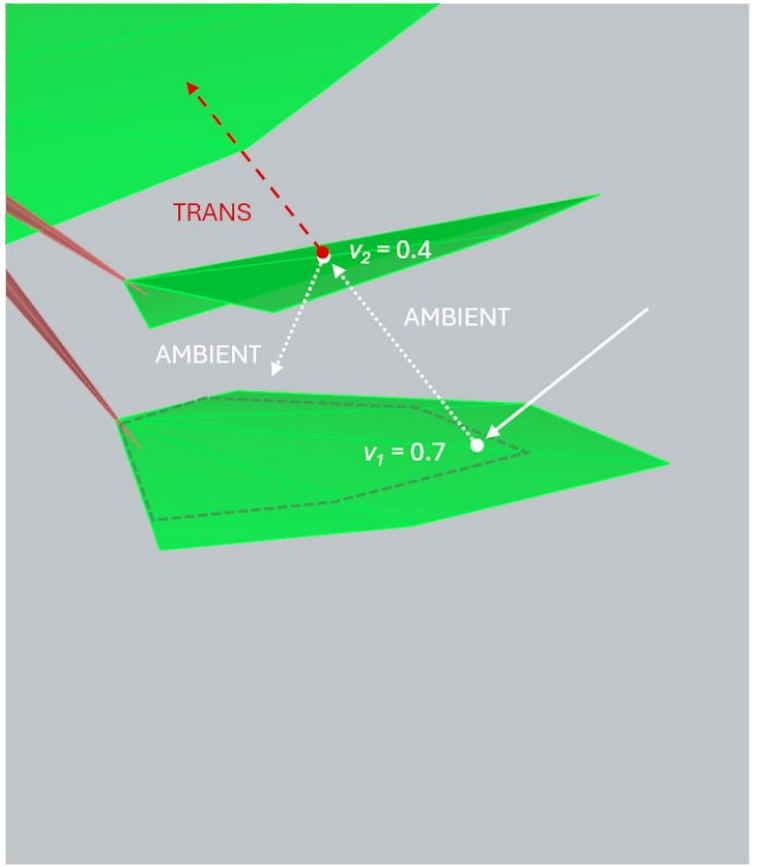
Params
USA_MA_Boston-Logan.Intl.AP.725090_TMYx.2004-2018.epw
65536 samples/sensor, -ab 10 -ad* 1 -lw* 0.001 *per sample
LM-83 shading control

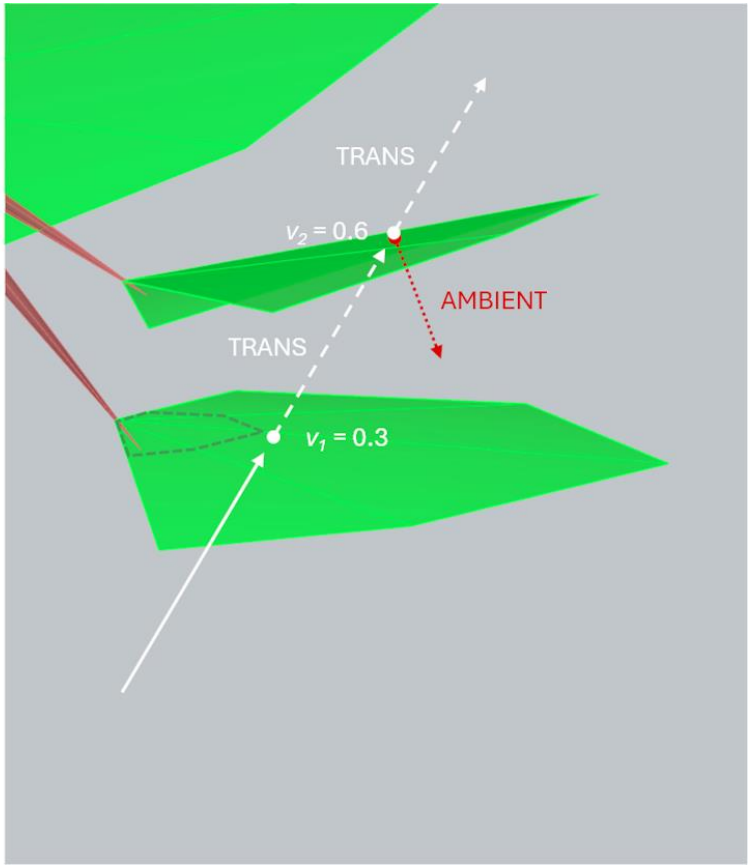
sDA [%]
0 50 100

SOLEMMA

MULTIVERSE PATH TERMINATION



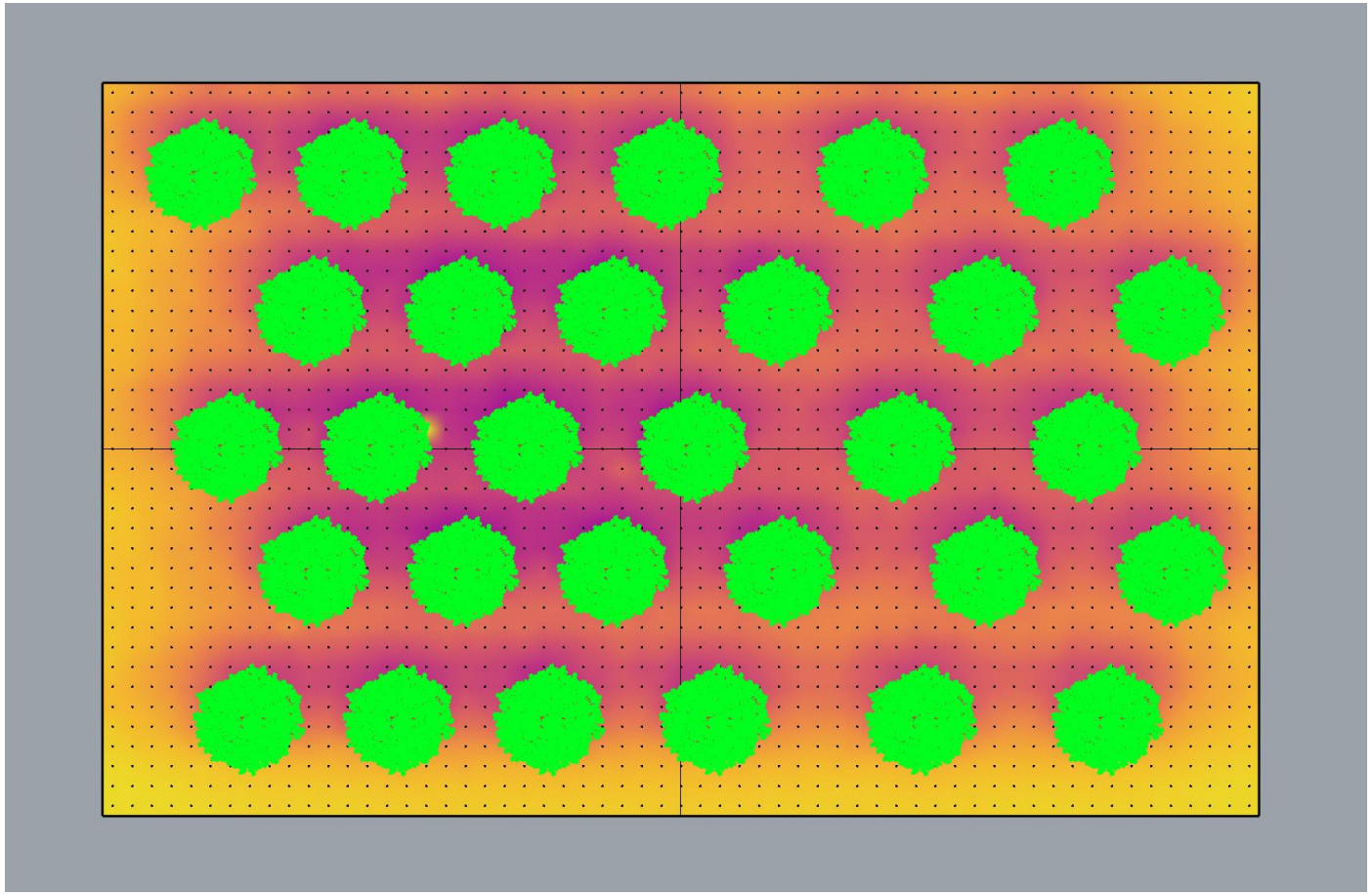




Some paths aren't used by any scene state (red rays can't happen if leaves are same size)

SOLEMMA

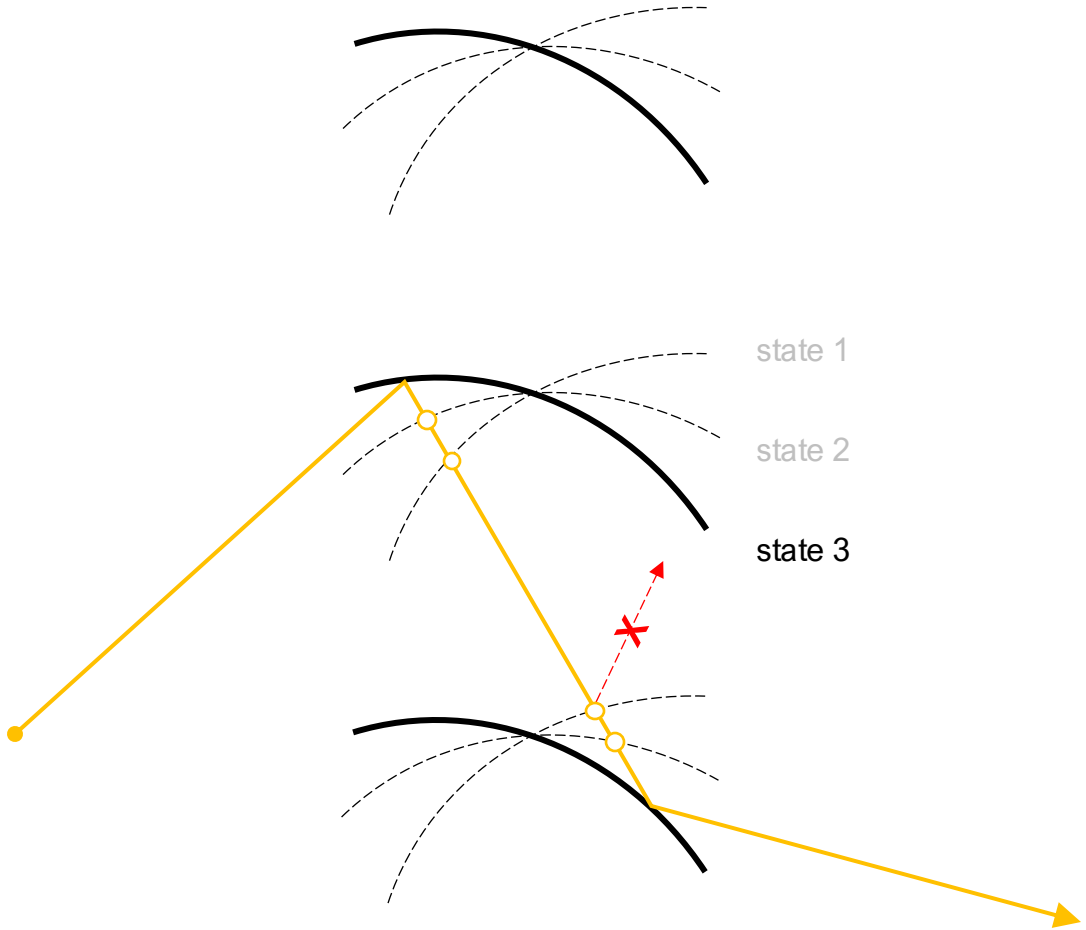
MULTIVERSE PATH TERMINATION



- Custom mixfunc(2) **terminates useless paths**
- 2x speedup for radiation map with dense tall trees

	paths	useless paths	interactions	useless interactions	**time [sec]**
path termination OFF	13216976	3721244	58882503	35561237	**148**
path termination ON	9493947	0	23297516	0	**71**

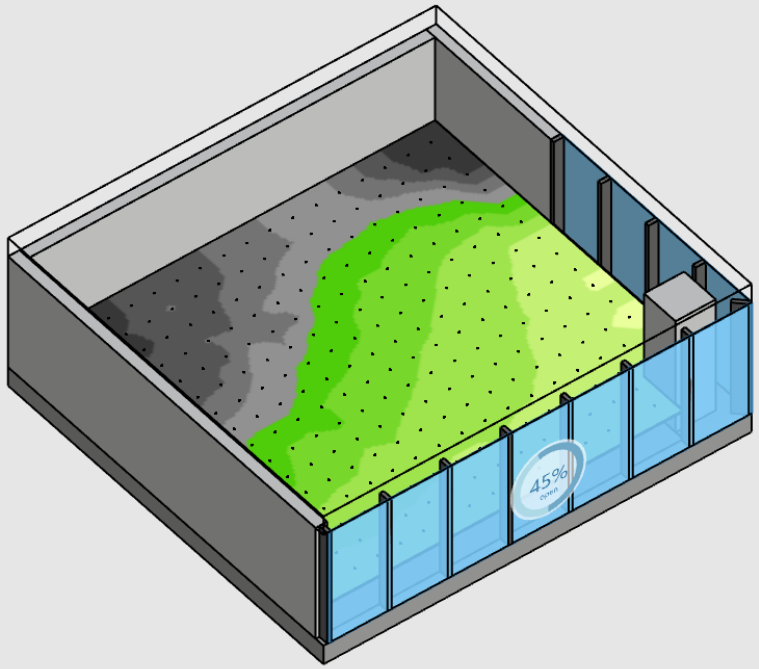
MULTIVERSE PATH TERMINATION



rotating blinds

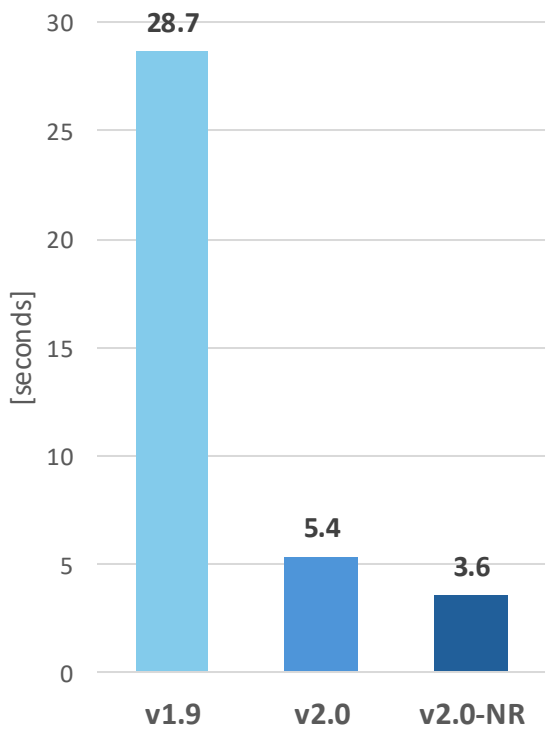
- Custom mixfunc **terminates useless paths**
- 2x speedup for radiation map with dense tall trees
- Potentially useful for rotating blinds, design options

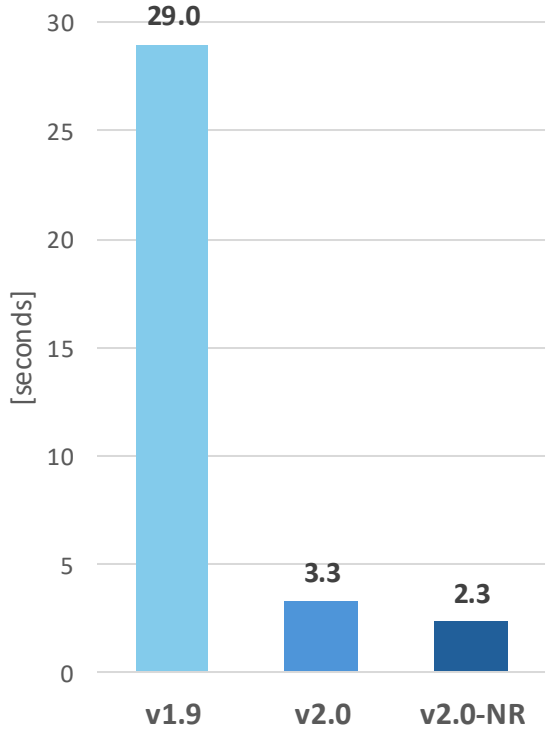
Stay tuned…



Small Model · CBDM Run Time

Single-room corner office
1,013 ft^2 | 268 sensors | 2 shading groups



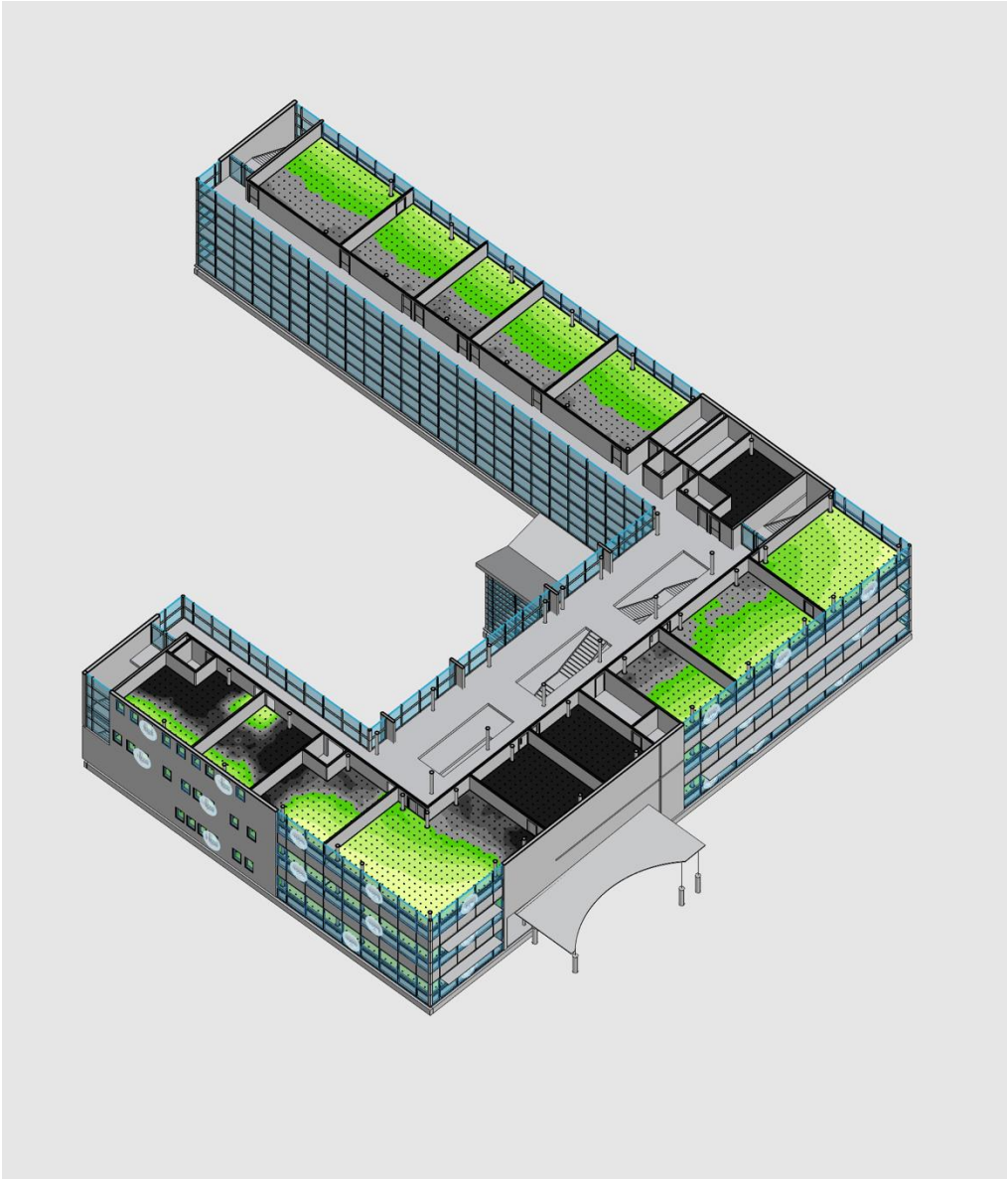


8-Core Laptop
AMD Ryzen 9 7940HS 8-Core CPU (4.00 GHz)
16 GB RAM
NVIDIA GeForce RTX 4060 Laptop GPU

16-Core Desktop
AMD Ryzen Threadripper 2950X 16-Core CPU (3.50 GHz)
64 GB RAM
NVIDIA GeForce RTX 2080Ti GPU

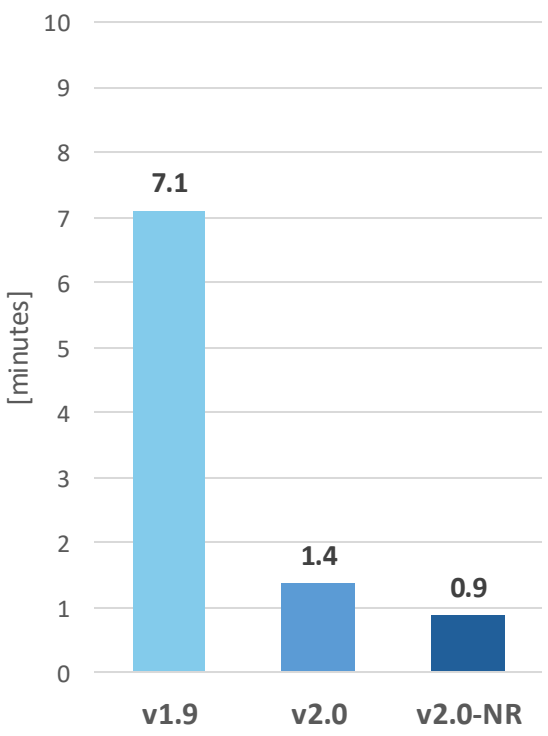
NR: No interior reflections from fenestration
Params: -ab 6, 4096 samples/sensor

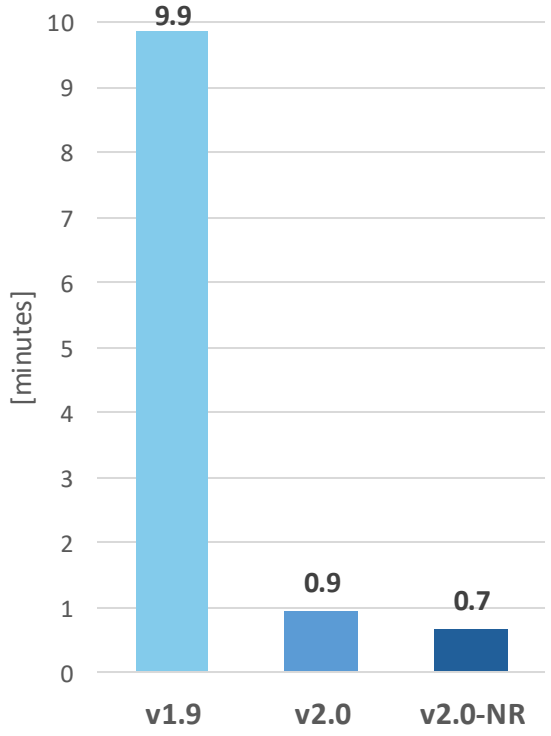
SOLEMMA



Medium Model · CBDM Run Time

Three-story classroom building
29,020 ft^2 | 6,912 sensors | 46 shading groups



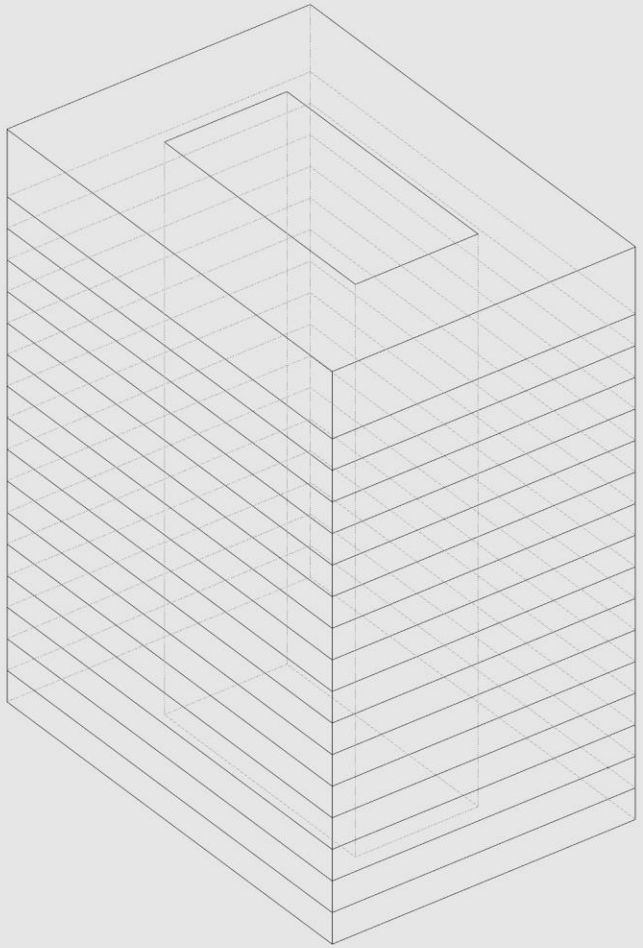


8-Core Laptop
AMD Ryzen 9 7940HS 8-Core CPU (4.00 GHz)
16 GB RAM
NVIDIA GeForce RTX 4060 Laptop GPU

16-Core Desktop
AMD Ryzen Threadripper 2950X 16-Core CPU (3.50 GHz)
64 GB RAM
NVIDIA GeForce RTX 2080Ti GPU

NR: No interior reflections from fenestration
Params: -ab 6, 4096 samples/sensor

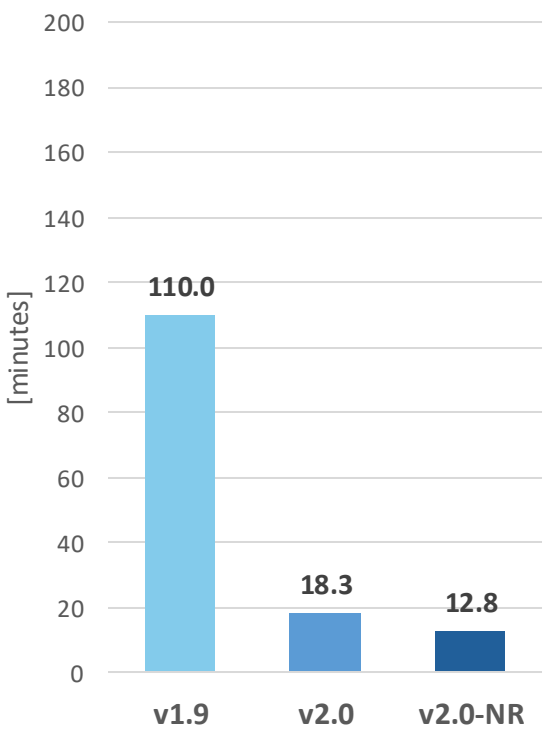
SOLEMMA

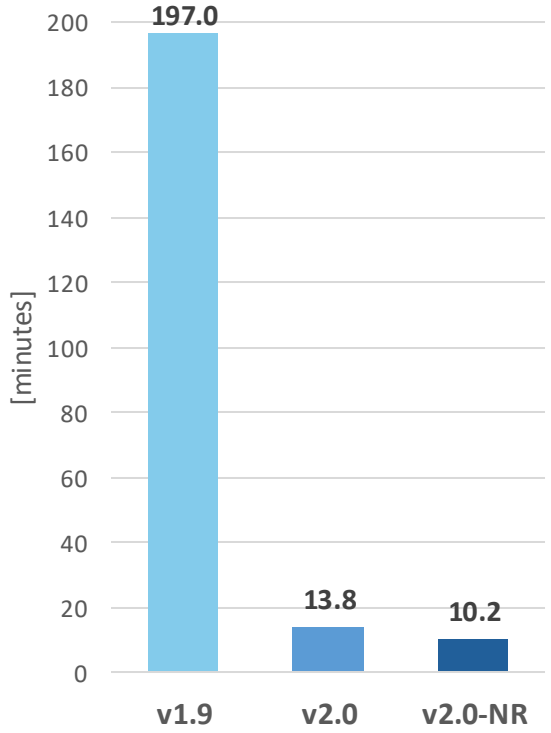


(proprietary)

Large Model · CBDM Run Time

Seventeen-story office tower
399,764 ft^2 | 97,353 sensors | 174 shading groups



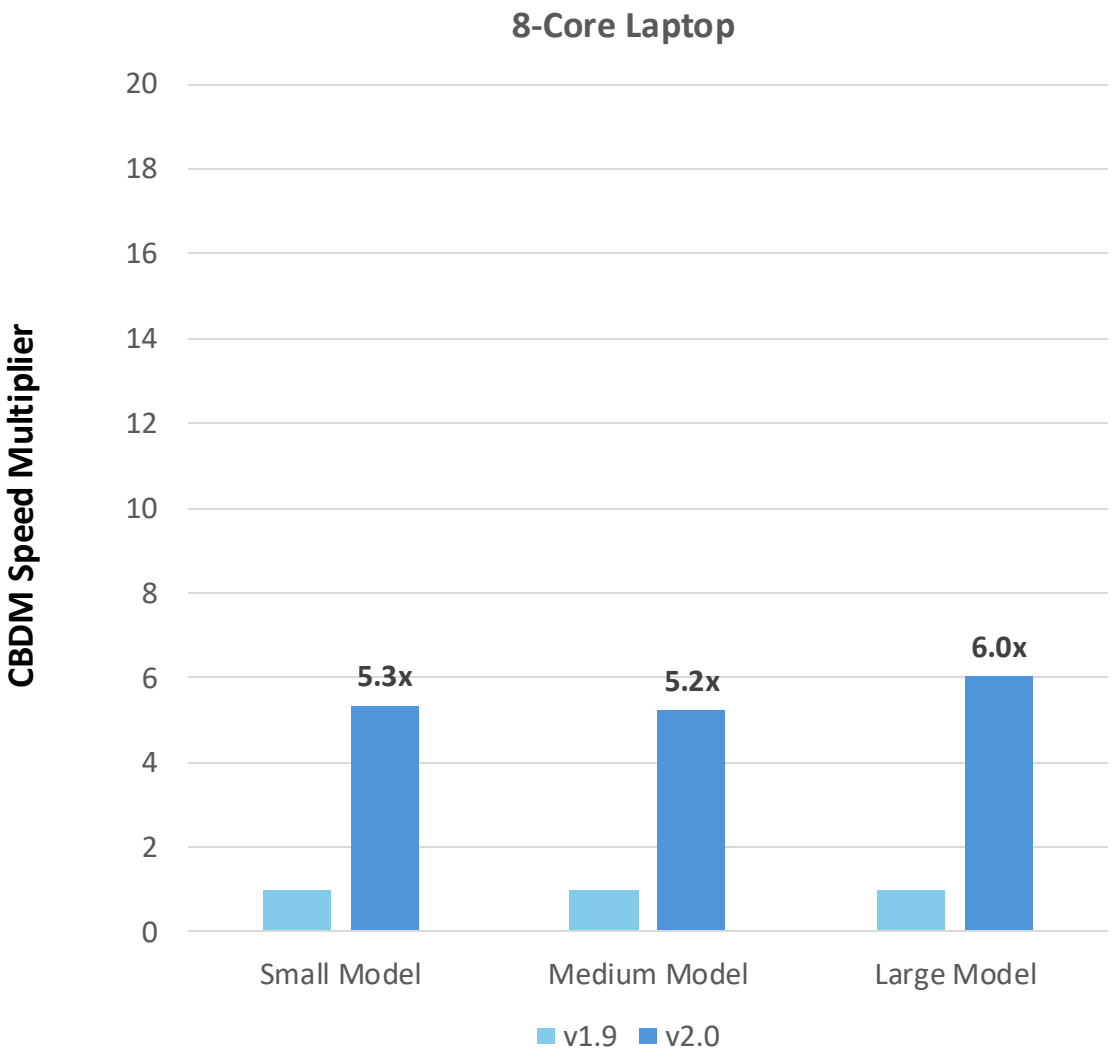


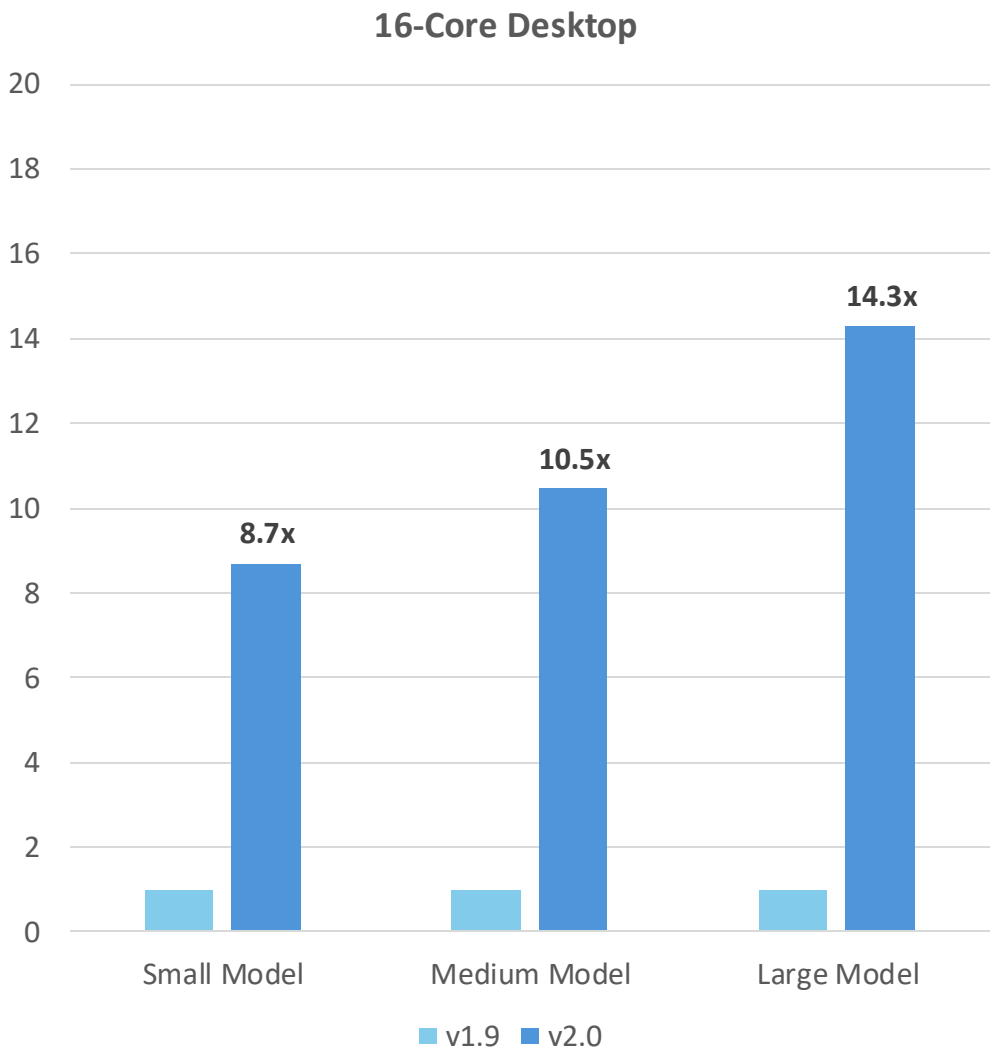
8-Core Laptop
AMD Ryzen 9 7940HS 8-Core CPU (4.00 GHz)
16 GB RAM
NVIDIA GeForce RTX 4060 Laptop GPU

16-Core Desktop
AMD Ryzen Threadripper 2950X 16-Core CPU (3.50 GHz)
64 GB RAM
NVIDIA GeForce RTX 2080Ti GPU

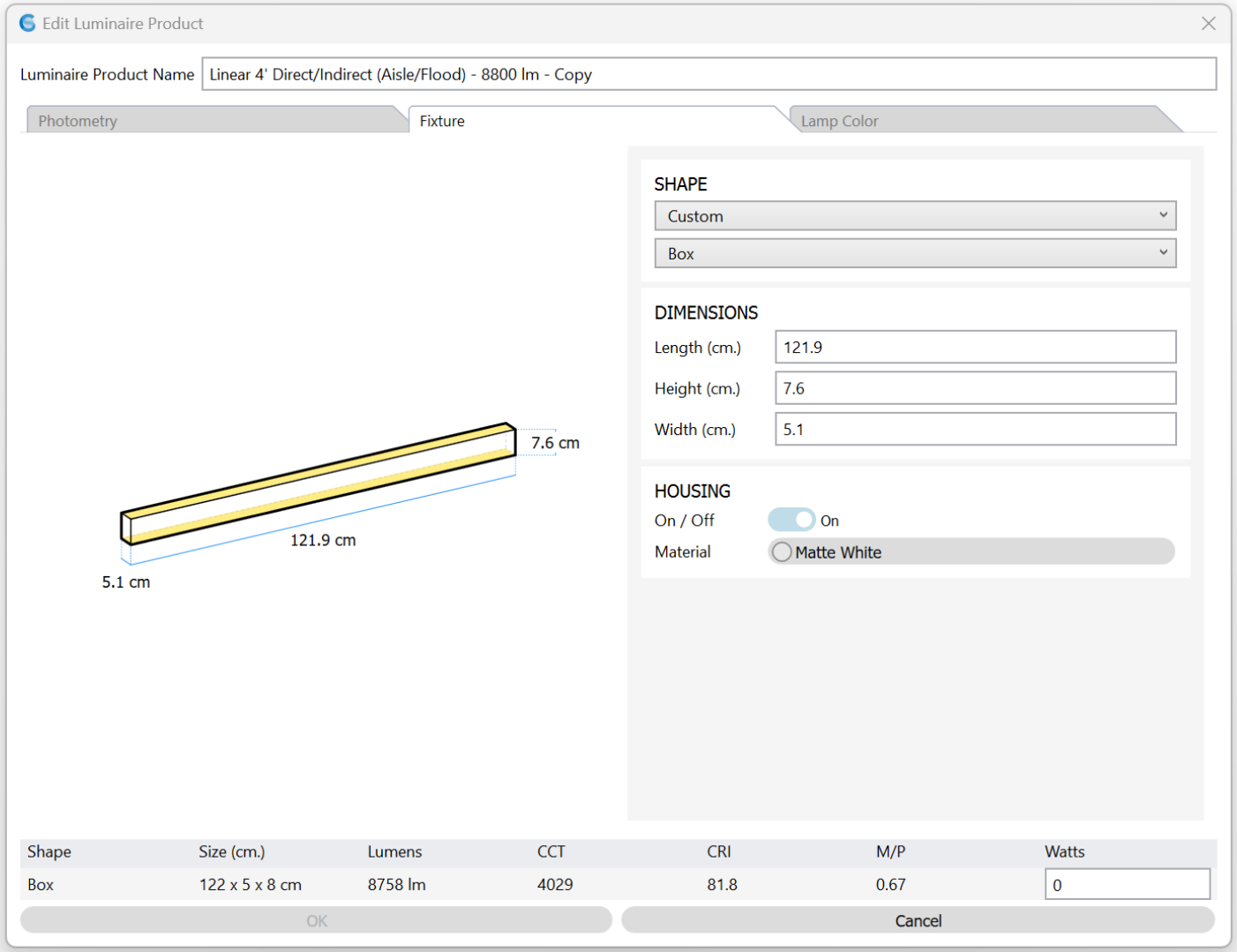
NR: No interior reflections from fenestration
Params: -ab 6, 4096 samples/sensor

CBDM SPEED

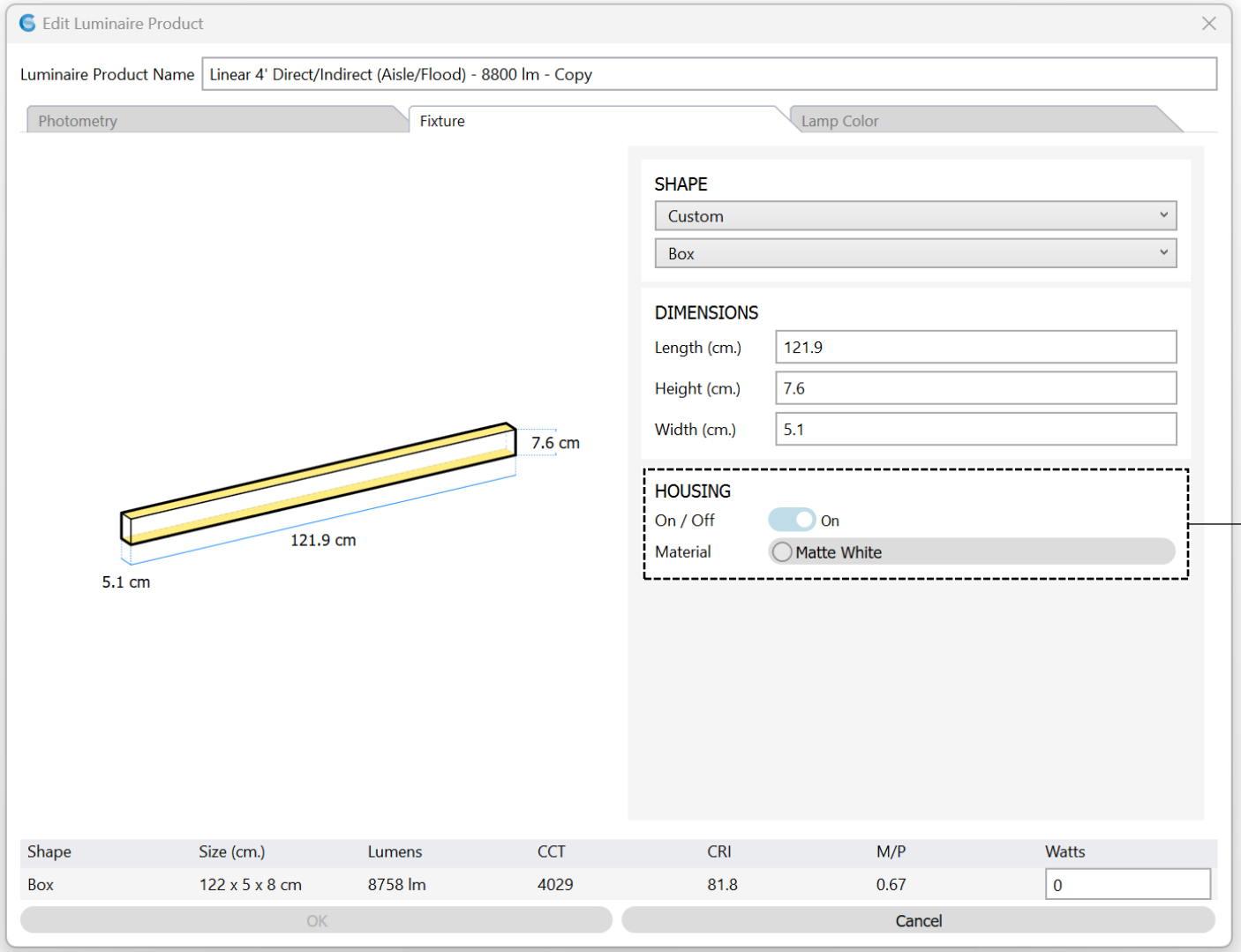




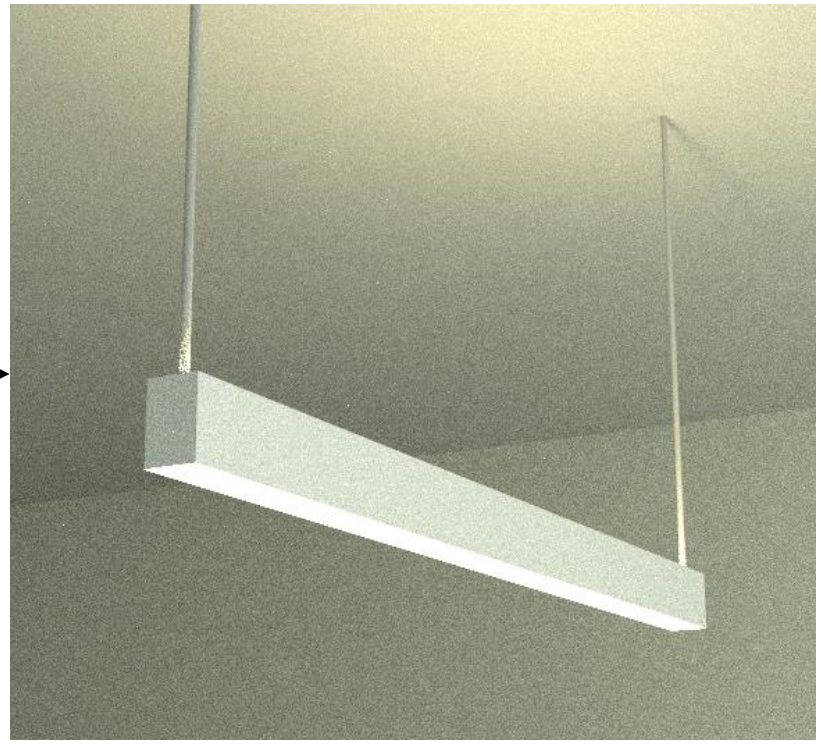
SOLEMMA



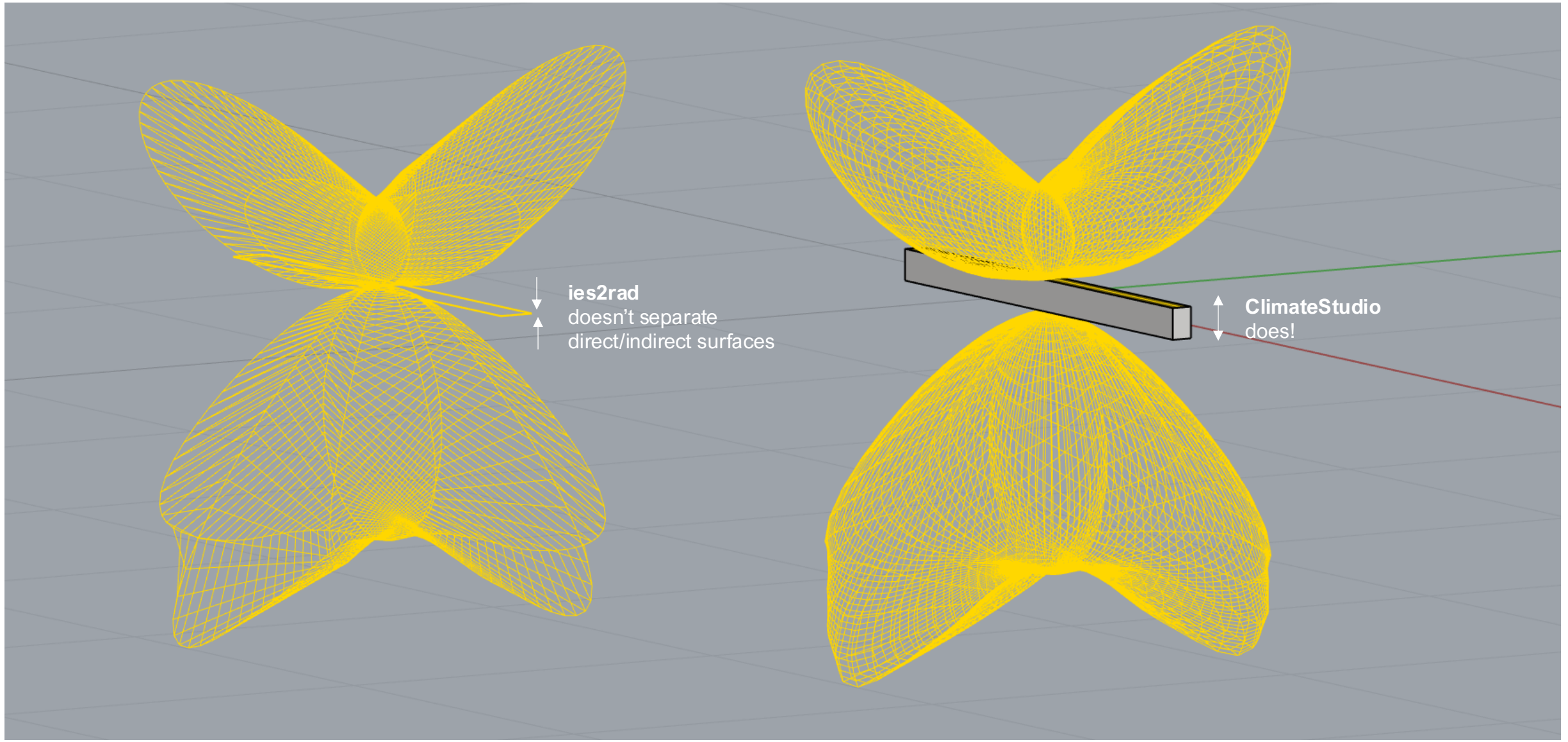
- Editable fixture shapes!

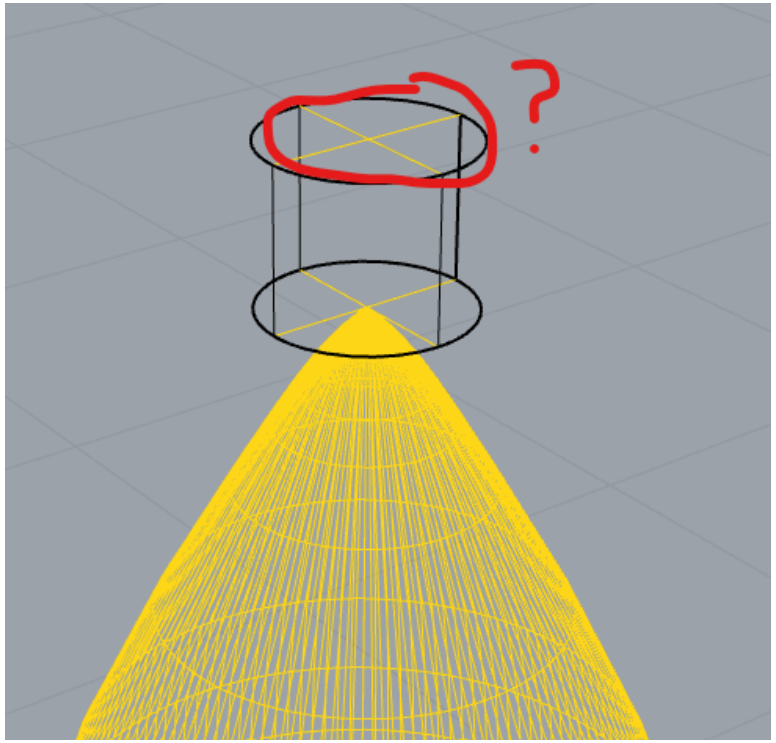


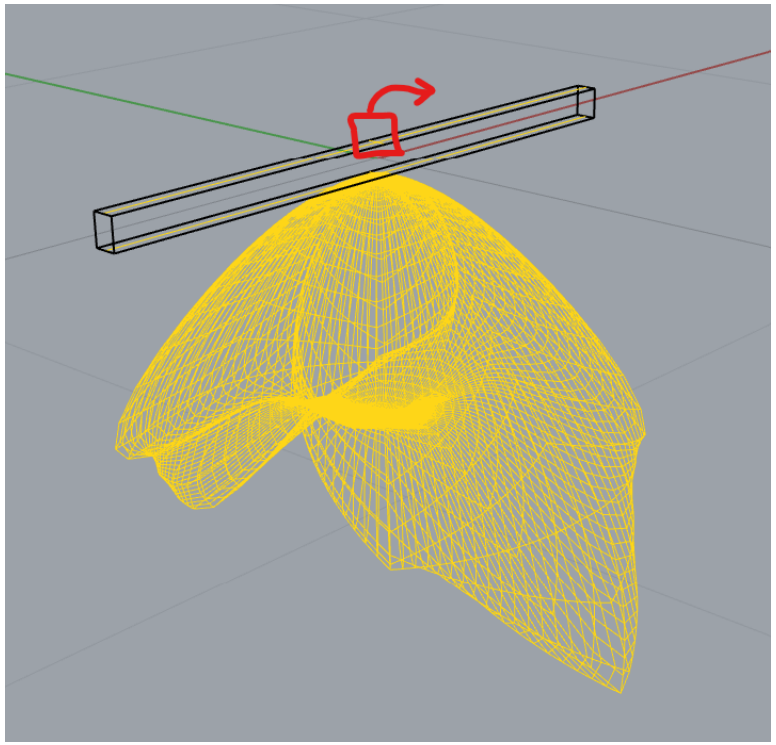
- Editable fixture shapes!
- Auto-generated housing

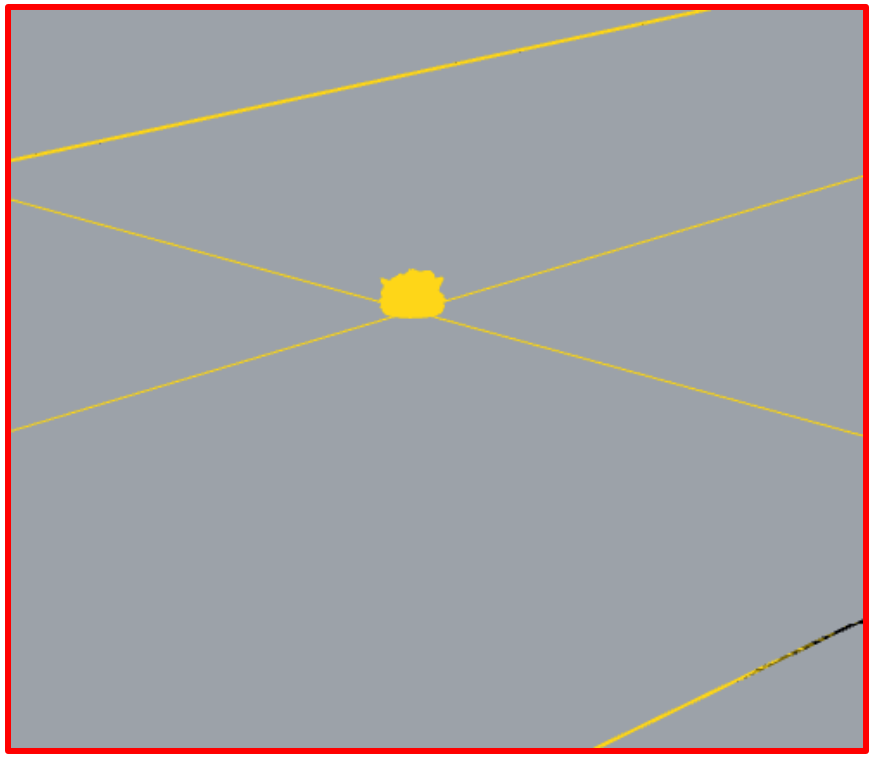


SOLEMMA

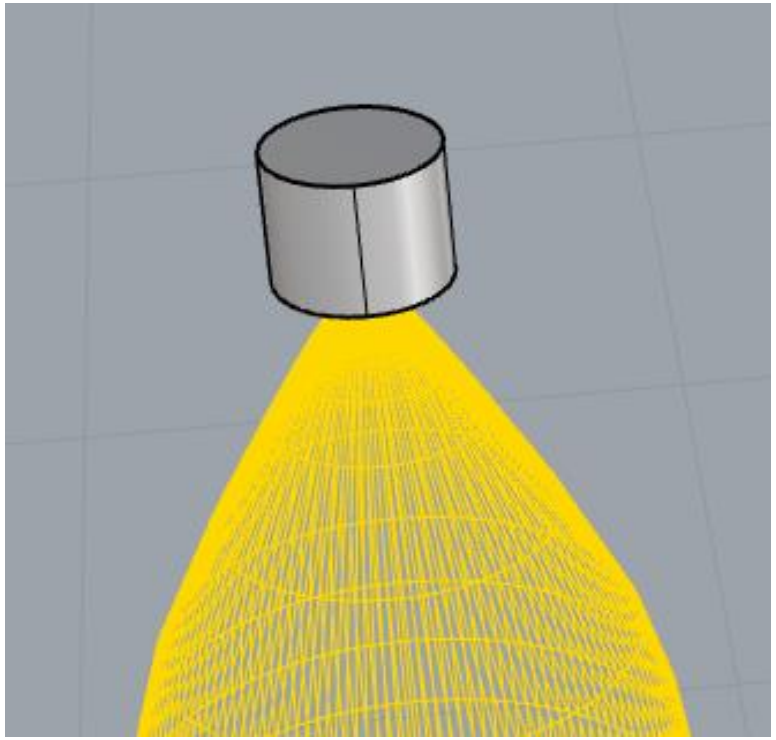

ies2rad
doesn't separate
direct/indirect surfaces
ClimateStudio
does!

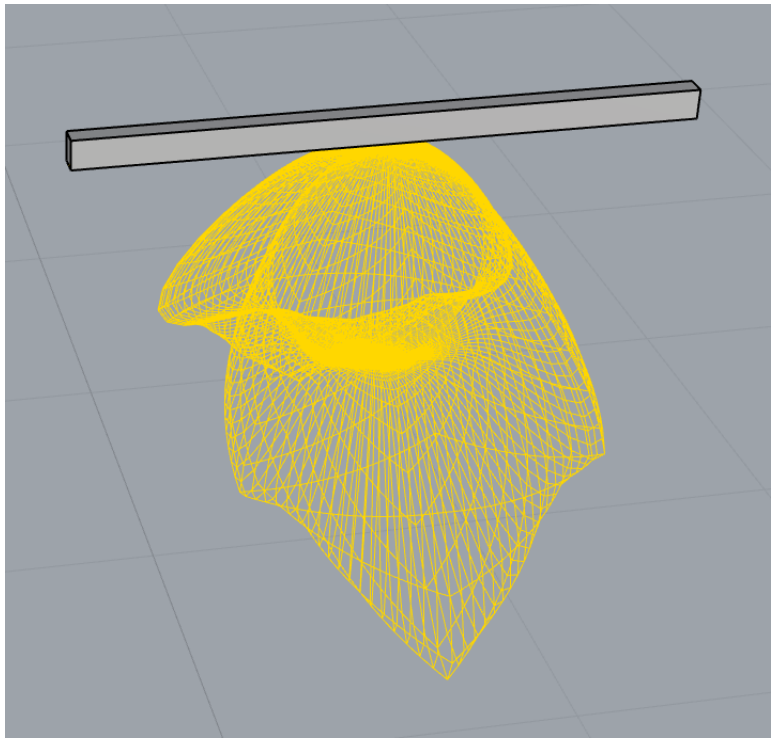




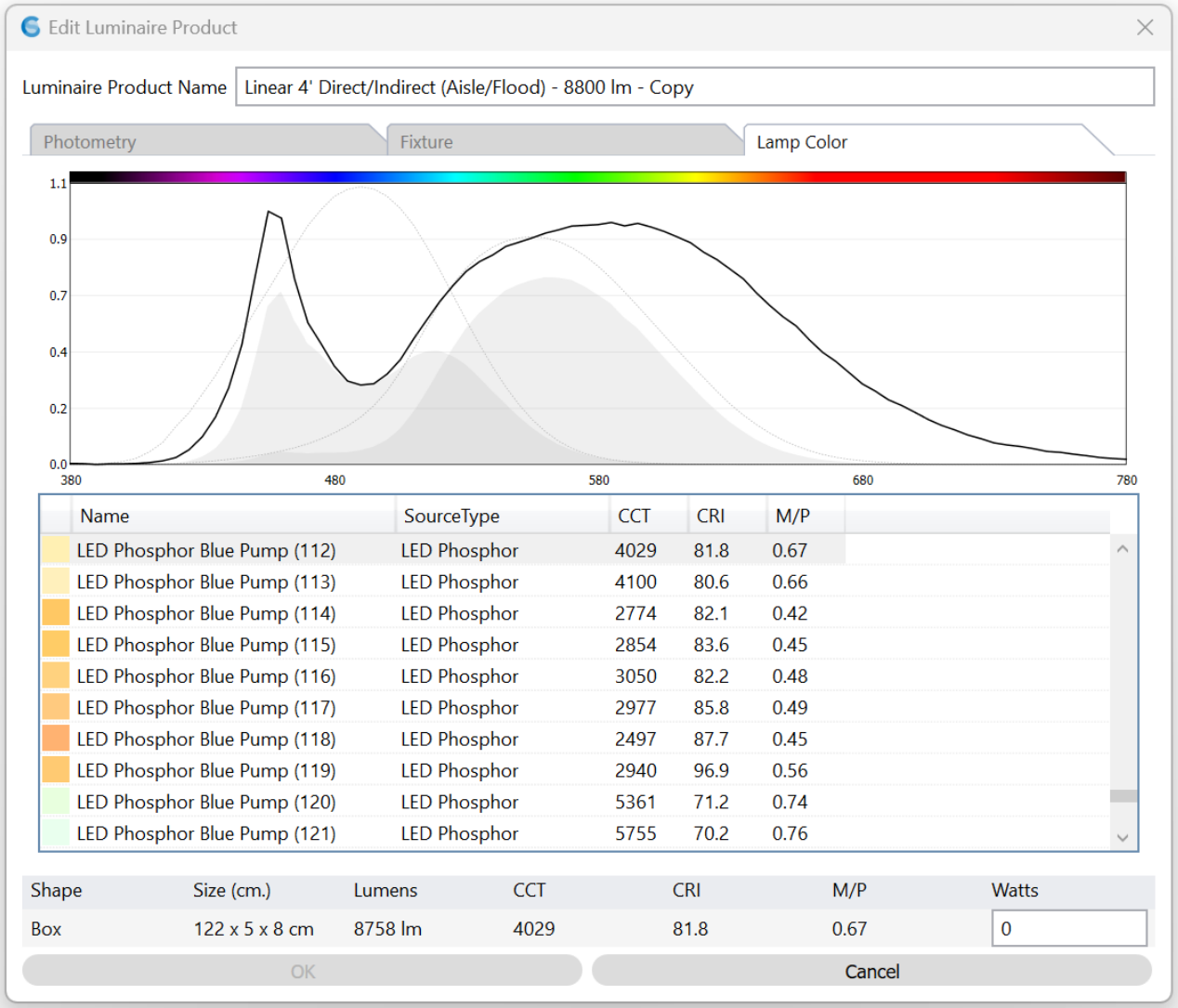


- *ies2rad* sometimes produces luminous faces with insignificant flux



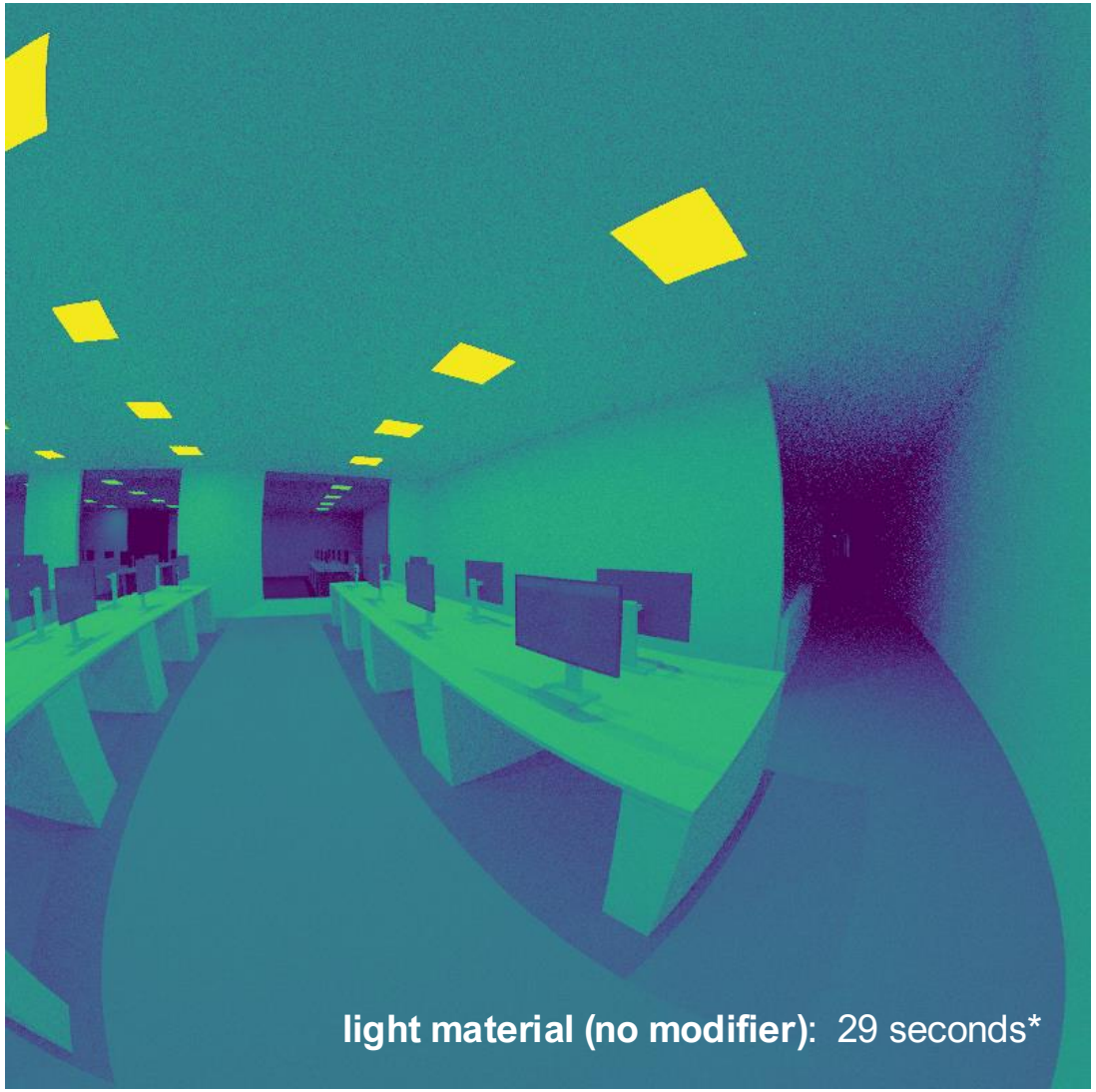


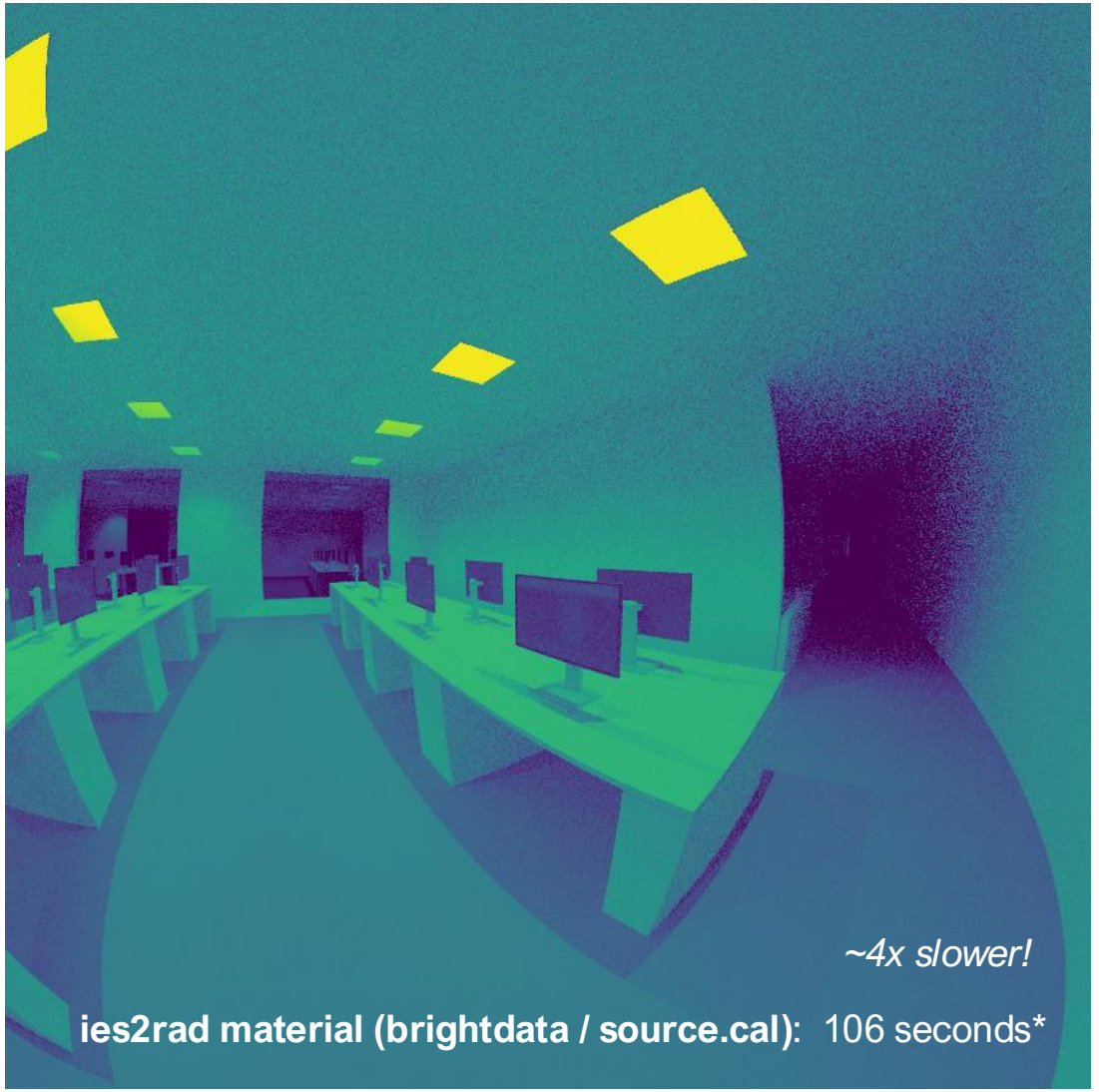
- *ies2rad* sometimes produces luminous faces with insignificant flux
- ClimateStudio now removes them (if <1% actinic flux through hemisphere)



- Measured SPDs provided by Pacific Northwest National Laboratory (**PNNL**)
- Spectrum > RGB for 3-channel simulation
- Hyperspectral output using Radiance 6 coming soon (thank you Greg!)

IES BRIGHTDATA

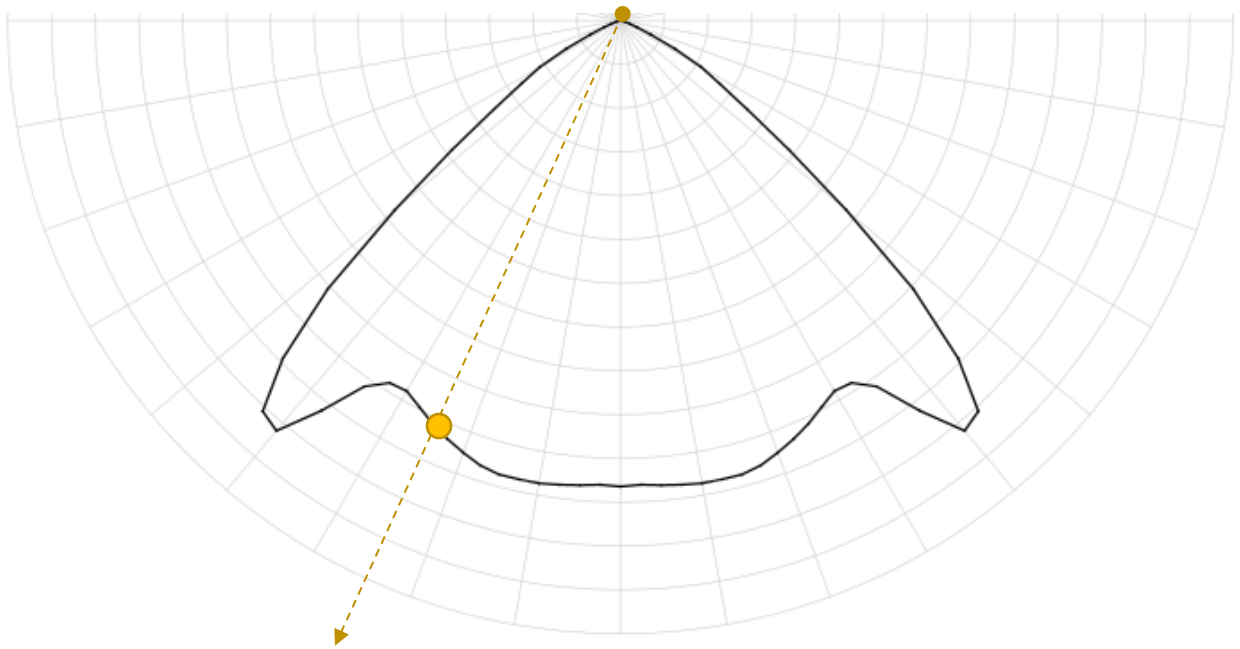




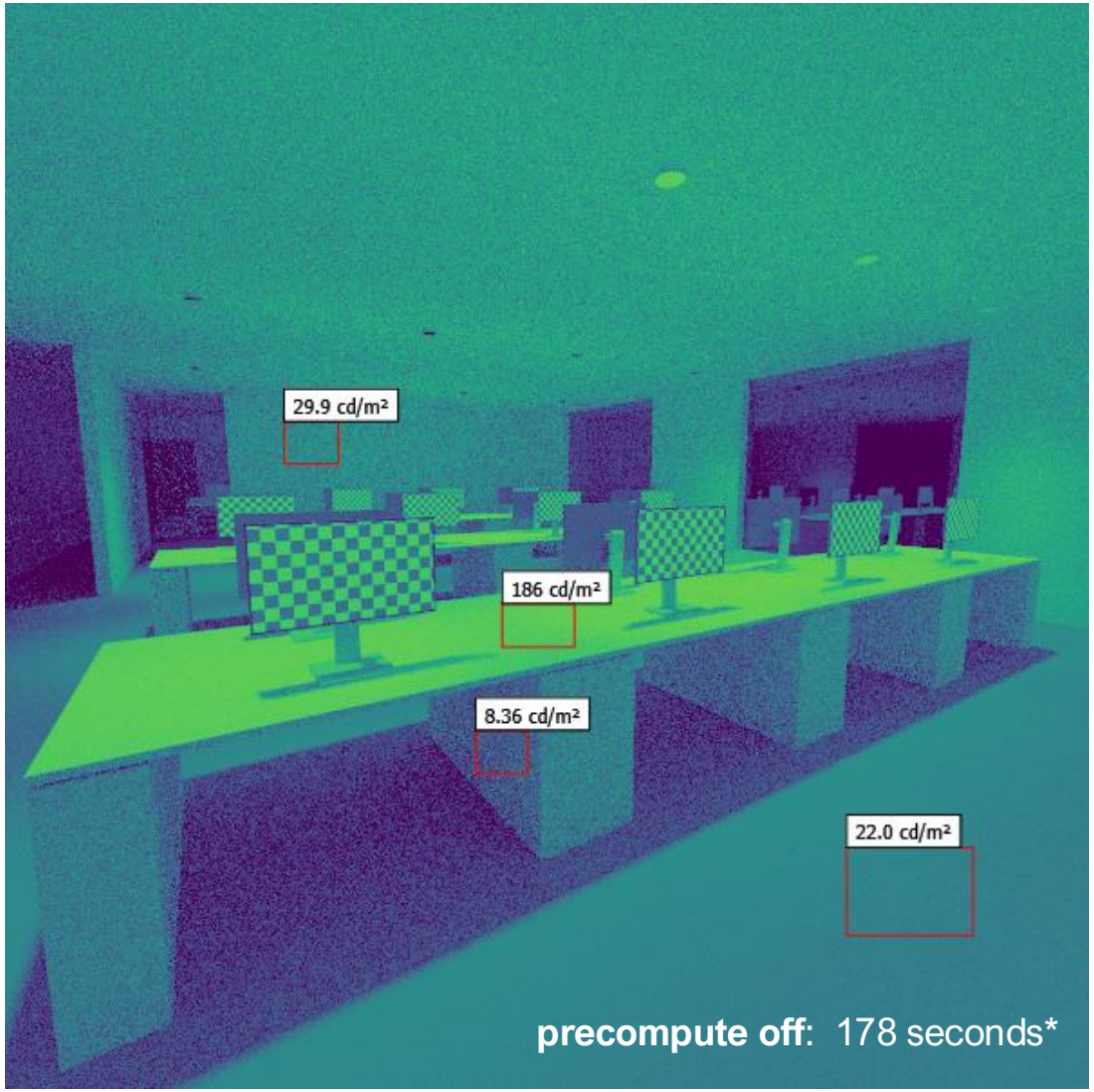
*rtrace –ds 0 –dj 0 (16 lights, 10 spp, 16 CPU cores)

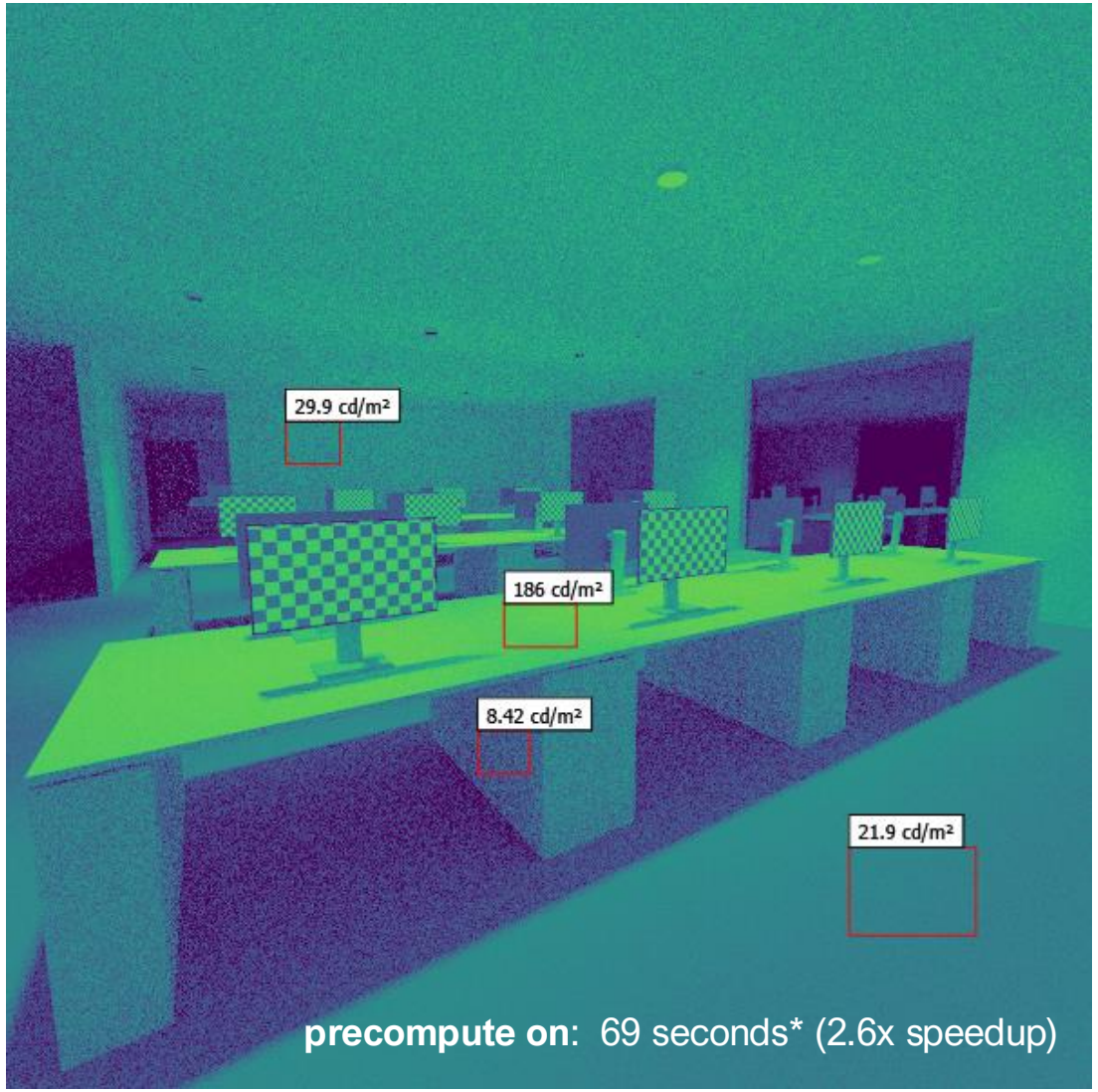
SOLEMMA

IES BRIGHTDATA



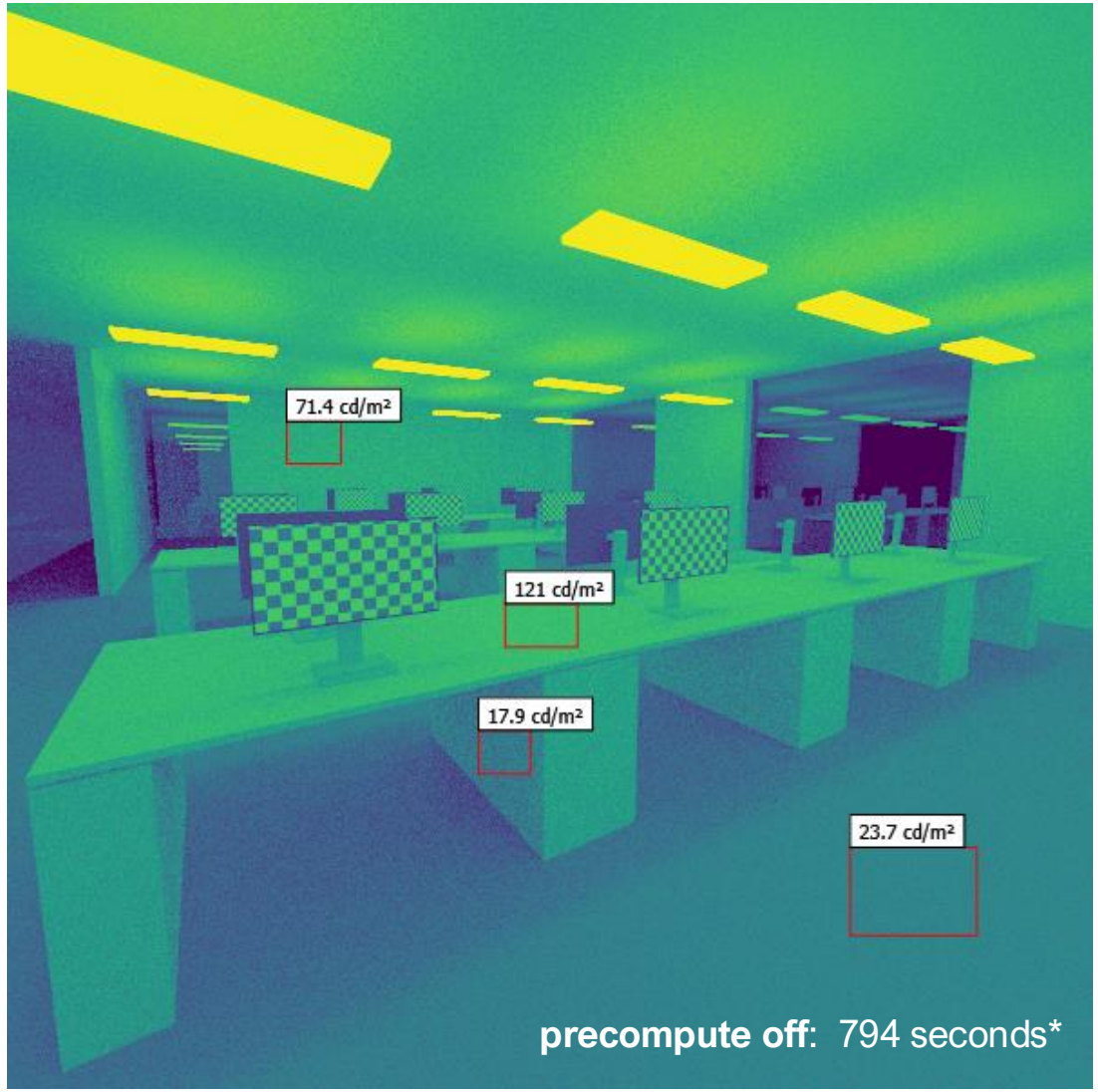
- brightdata / source.cal overhead is significant
- Lookup can be accelerated by precomputing ***L(θ,φ)*** for each luminaire on a high-resolution grid (0.5˚)
- Speedup depends on scene and IES-file(s), typically 2-4x

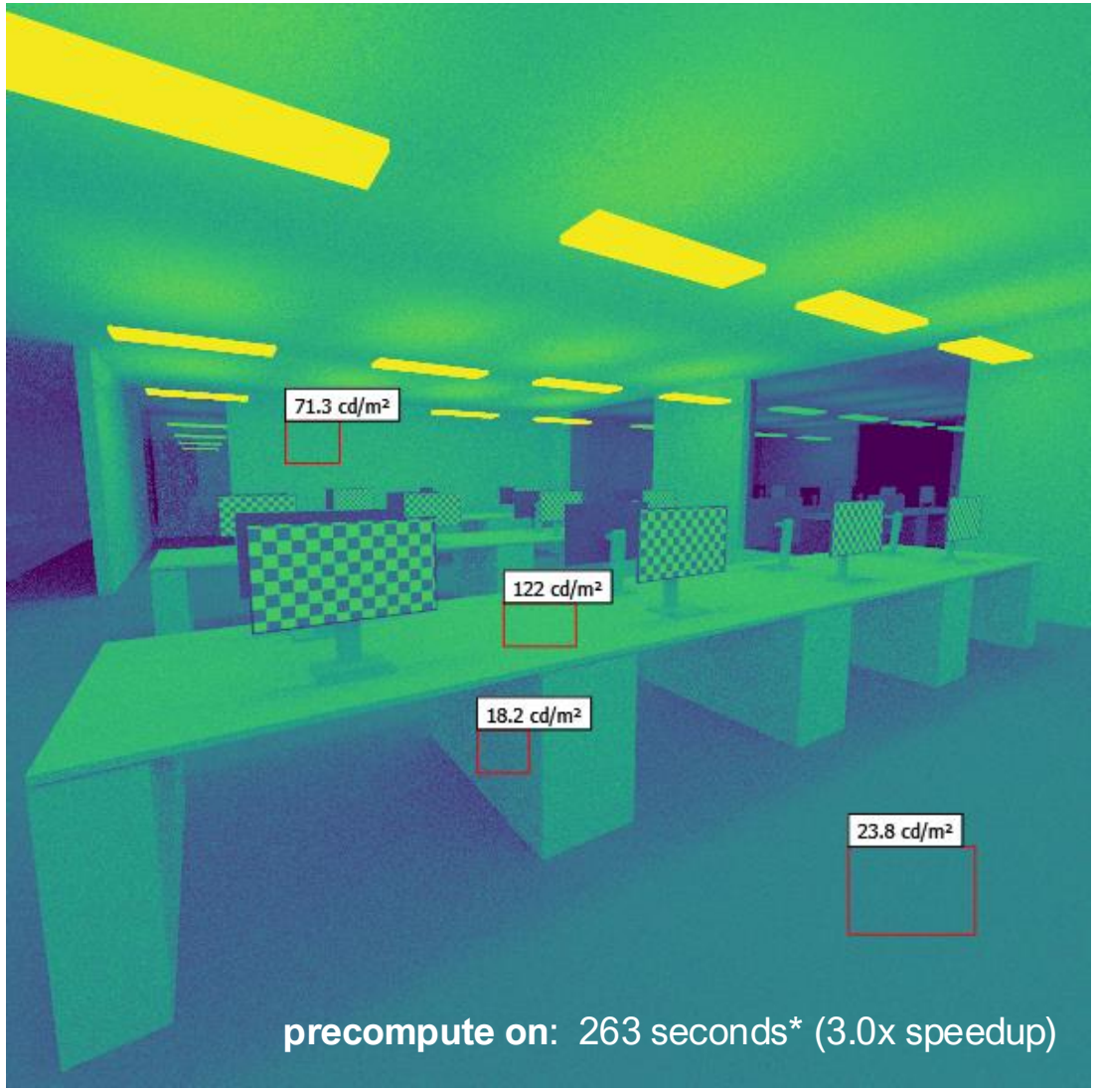




**16 down lights, 16 spp, 6 CPU cores*

SOLEMMA





*16 box lights, 16 spp, 6 CPU cores

SOLEMMA