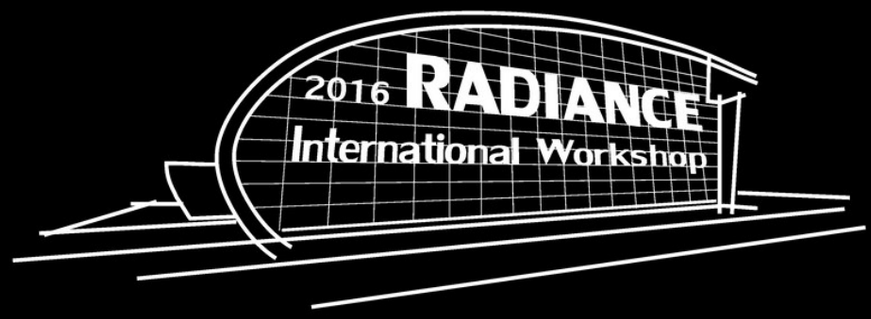
2016 IRW
15th International Radiance Workshop



The Sunlight Beam Index:
A Simple Method to Rate Windows and Shading Systems

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Loughborough University

VELUX®


3 ITA
10:48
Padua (Pádova)
Current 10:00
10:15
26°C
0.0 mm/h
Satellite
08:00
14:00
20:00
02:00
0.0mm 30°C
0.0mm 27°C
0.0mm 20°C
Sat 27/08
19°C 32°C
12.4h
1%
0.0mm
7 km/h
Sun 28/08
18°C 33°C
12.3h
2%
0.0mm
6 km/h
Mon 29/08
19°C 33°C
11.6h
5%
0.0mm
4 km/h
Weather
Favourites
Maps
Rad/Sat
More

How much sunlight can enter a room?

“The centre of at least one window to a main living room can receive 25% of annual probable sunlight hours, including at least 5% of annual probable sunlight hours in the winter months between 21 September and 21 March”

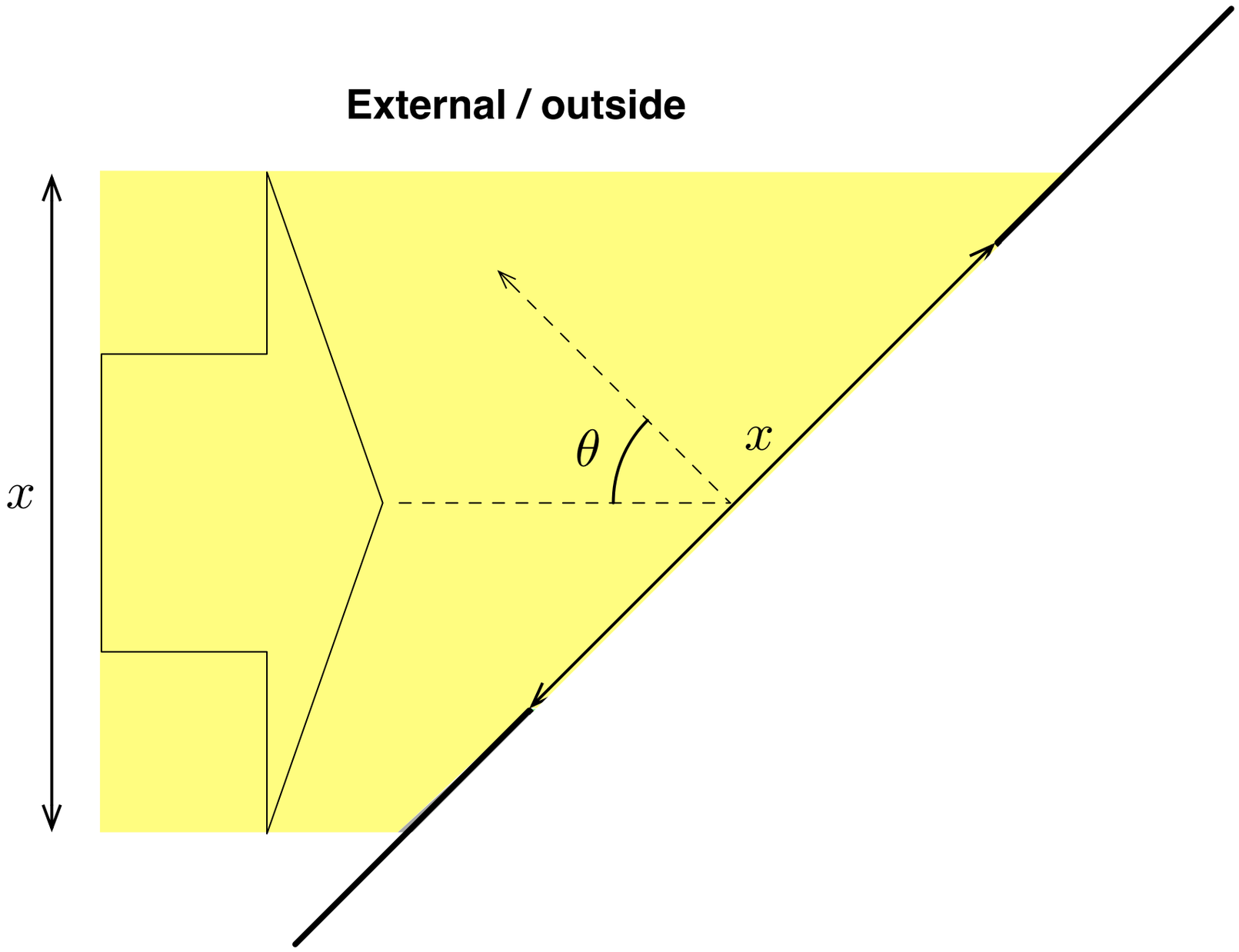
P. Littlefair. Site Layout Planning For Daylight And Sunlight: A Guide To Good Practice 2nd Edition. Building Research Establishment, 2011

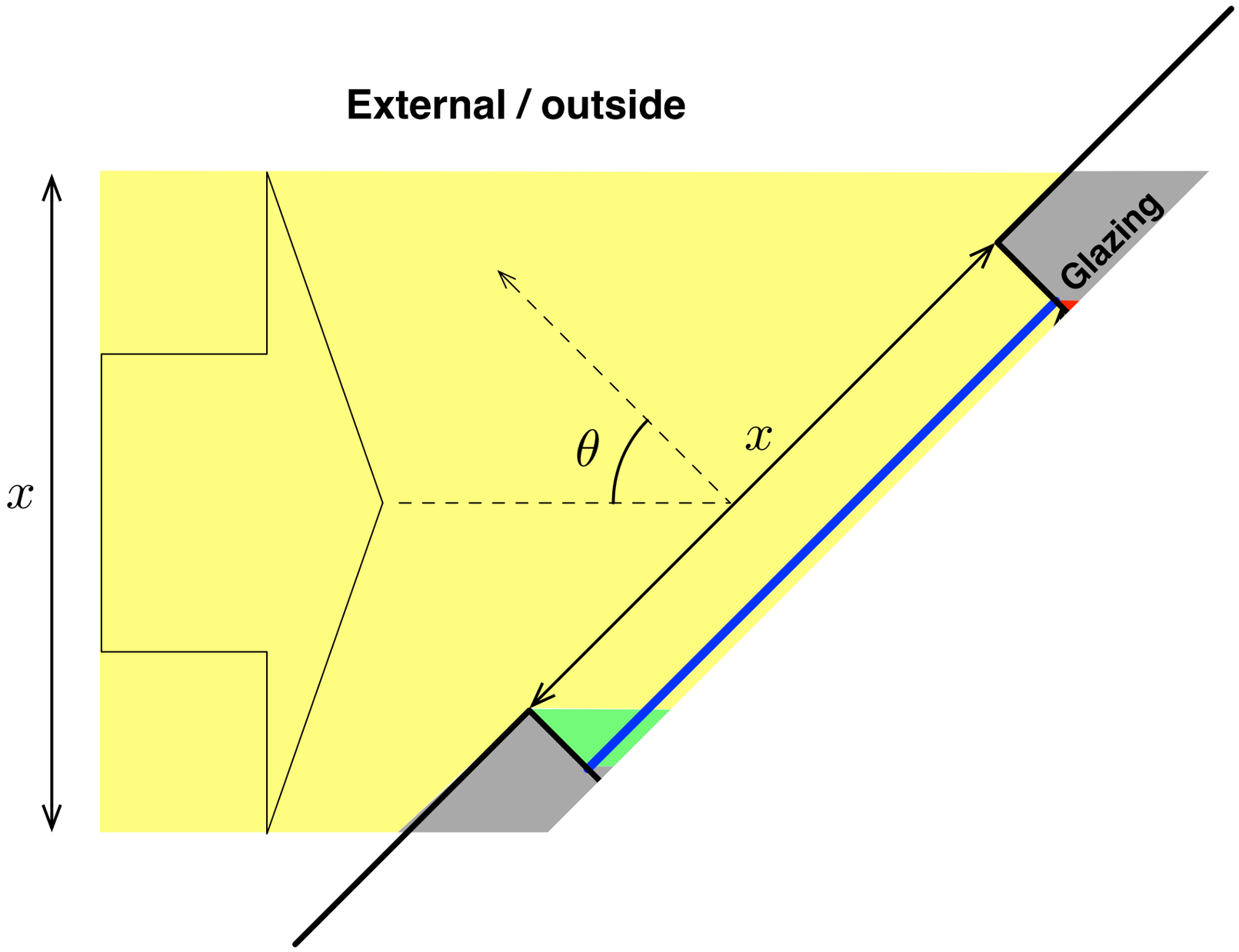
Country	Sunlight duration requirements
Czech Republic	At least 1.5 hrs on March 1st or balance of sunlight duration in the period from February 10th to March 21st is at least 1.5 hrs; solar altitude is at least 5°
Italy	At least 2 hrs of sun per day in the period February 19th to October 21st
Sweden	At least one room or separable part of a room shall have access to direct sunlight; at least 5 hrs sunlight between 9 am and 5 pm at spring and autumn equinox

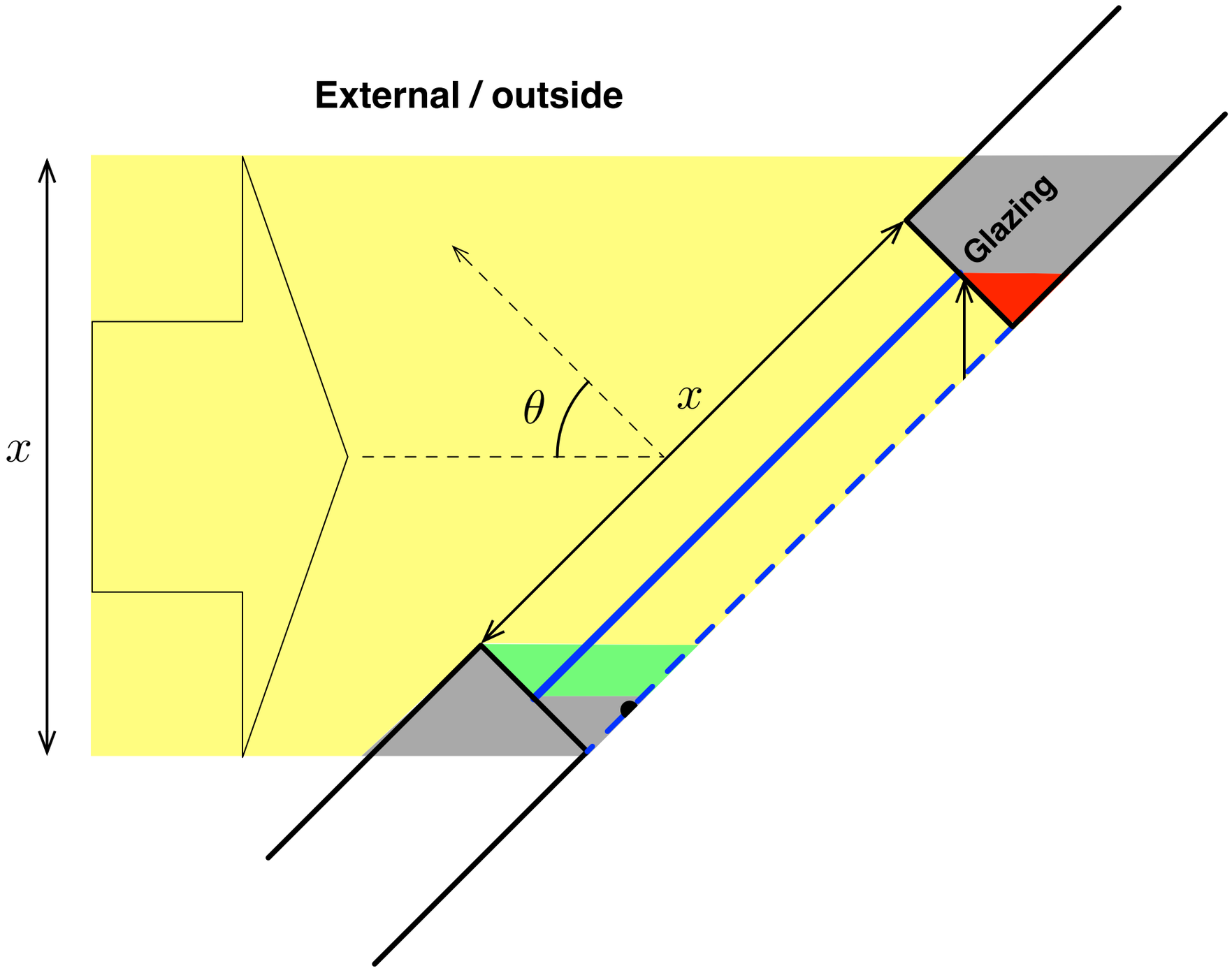
Problems, issues, limitations of the various schema:

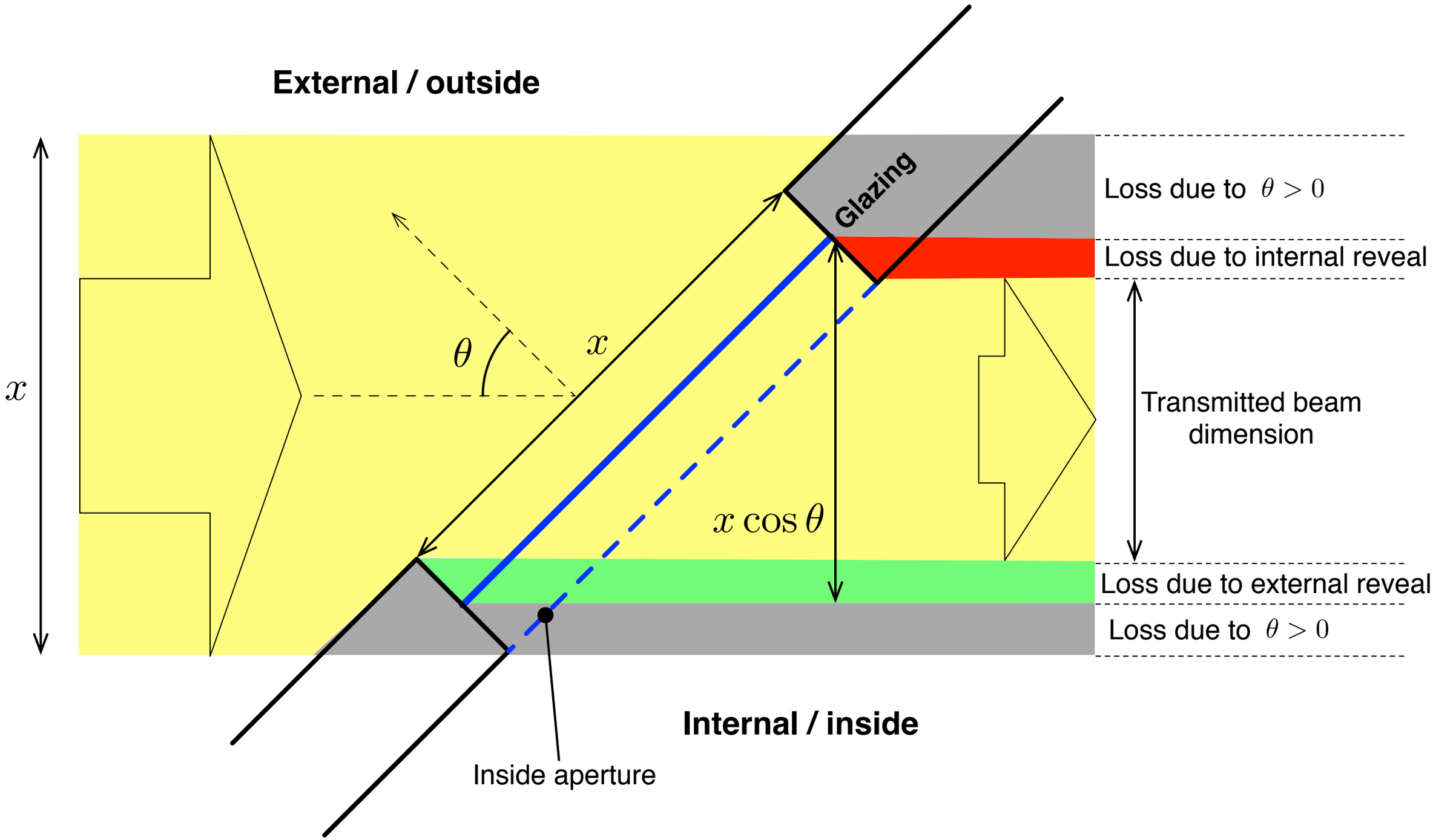
- They consider only certain times of the day and/or year, e.g. one of the equinox conditions.
- They either ignore the direction at which the sun is incident on the window, or employ crude switch mechanisms such as the ‘dead angle’.
- They ignore the size of the window.
- They ignore or cannot adequately account for the shadowing effects of frame bars or window reveals.
- They ignore or cannot adequately account for shadowing caused by surrounding structures or buildings.
- The method employed is restricted to idealised geometry or built forms.
- The evaluation cannot produce a meaningful, aggregate measure for multiple windows and/or an entire dwelling.
- The evaluation provides no information on the temporal dynamics of possible sun exposure.

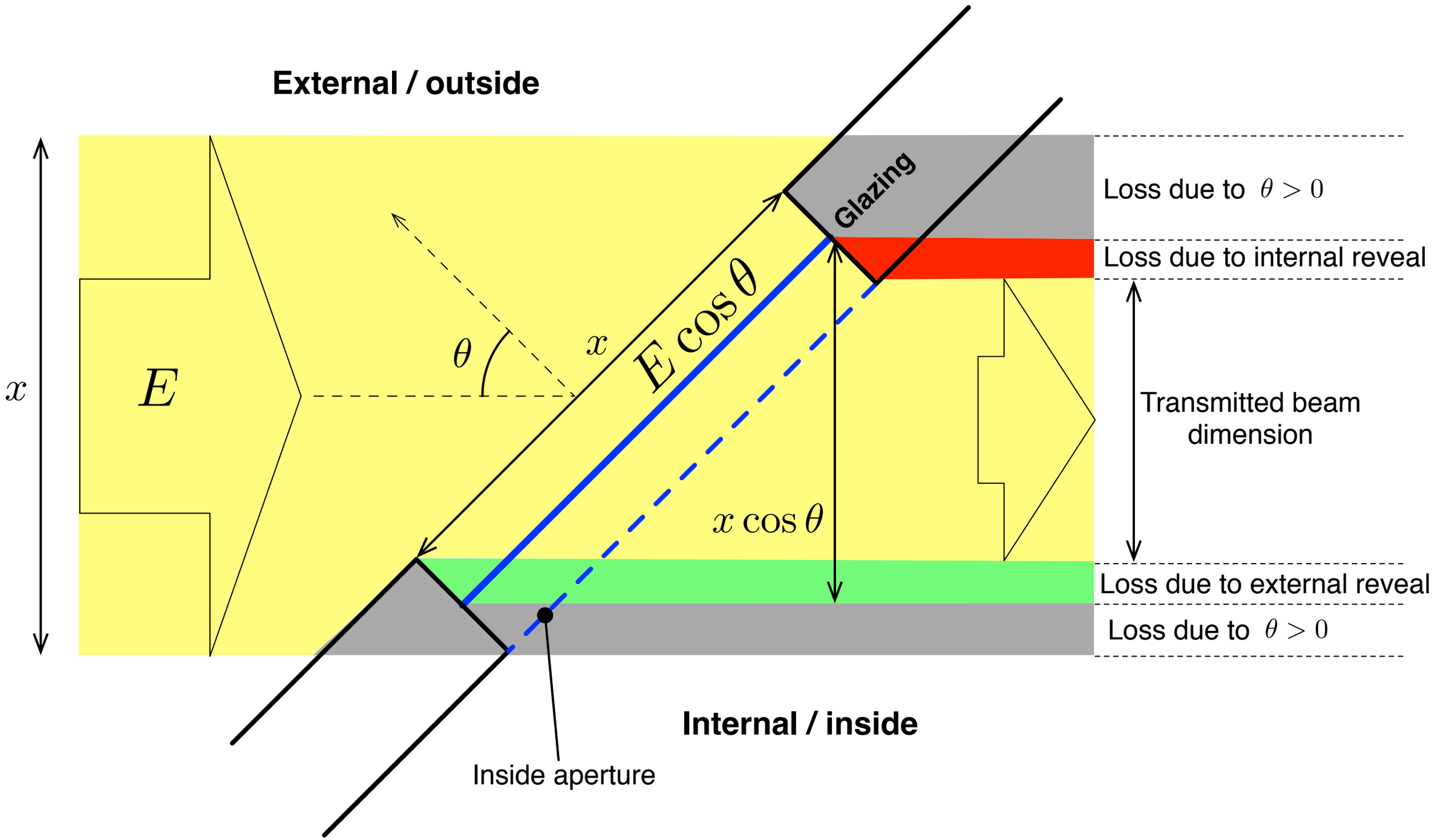
Back to basics...


External / outside
x
θ
x


External / outside
Glazing
θ
x
x


External / outside
Glazing
θ
x
x

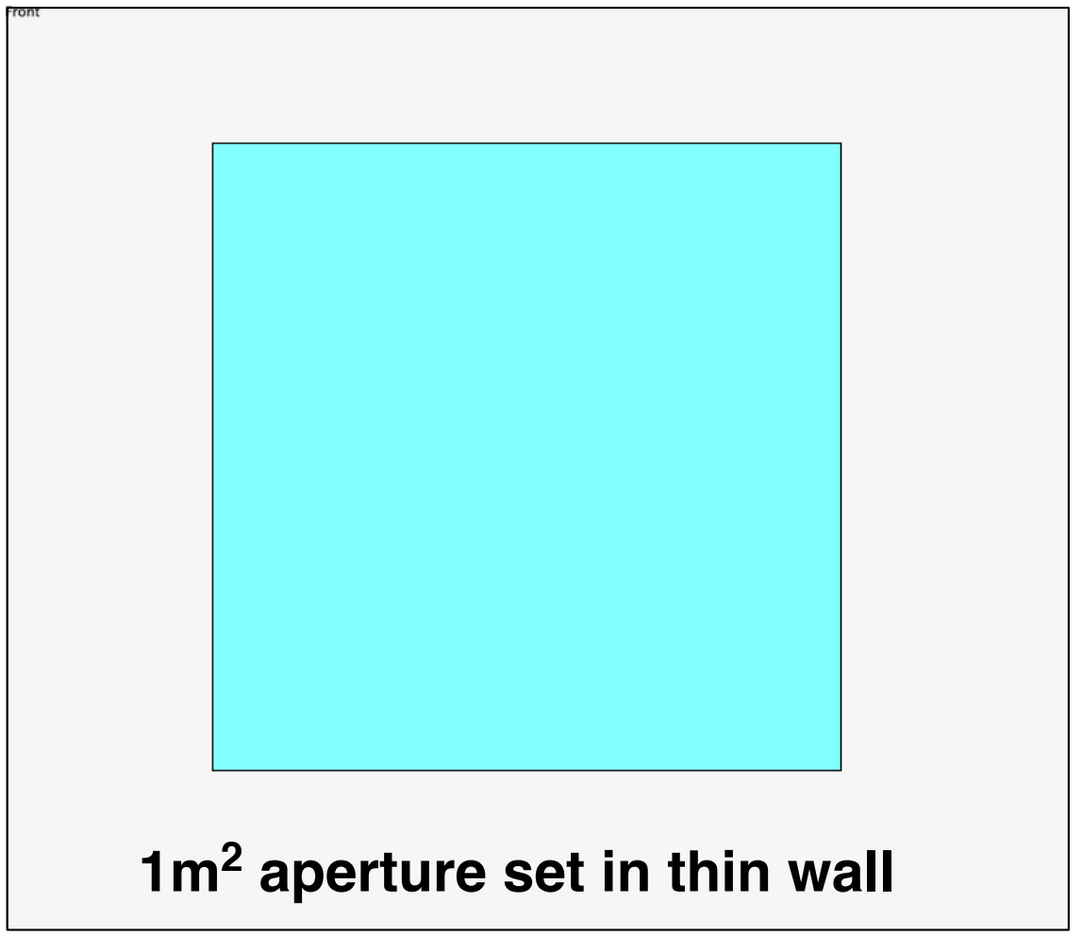

External / outside
Glazing
Loss due to $\theta > 0$
Loss due to internal reveal
x
θ
x
Transmitted beam dimension
$x \cos\theta$
Loss due to external reveal
Loss due to $\theta > 0$
Internal / inside
Inside aperture


External / outside
Glazing
Loss due to $\theta > 0$
Loss due to internal reveal
x
E
θ
x
$E \cos\theta$
Transmitted beam dimension
$x \cos\theta$
Loss due to external reveal
Loss due to $\theta > 0$
Internal / inside
Inside aperture

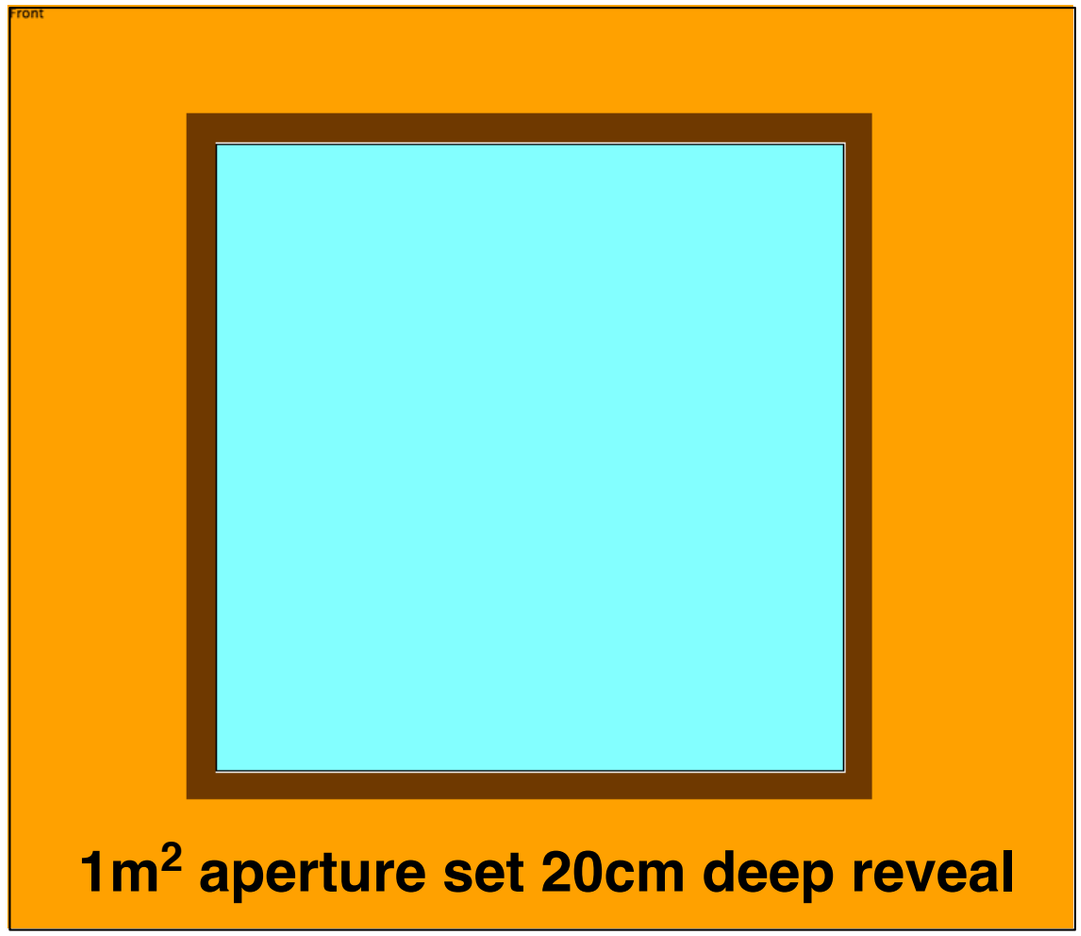
Basic unit of SBI:

$$1 \times 1 = 1\,\mathrm{m}^2\,\mathrm{hrs}$$

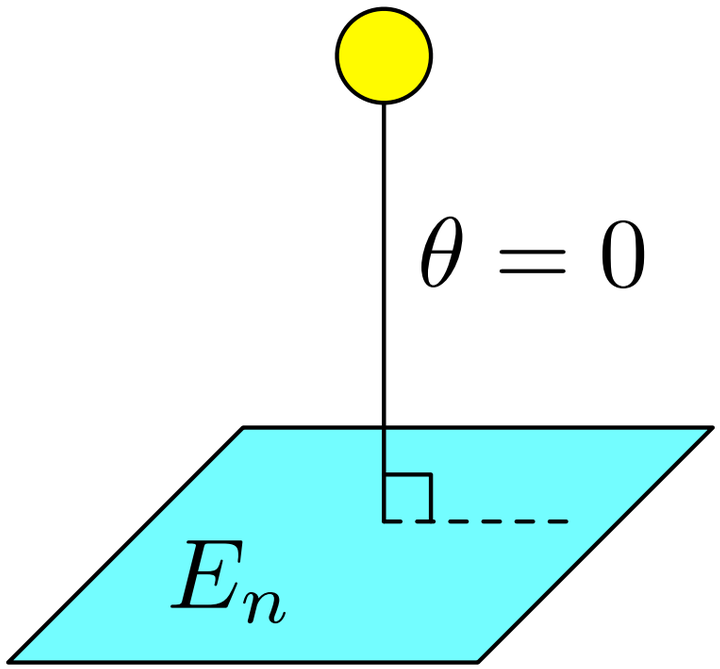
1m² window with external reveal

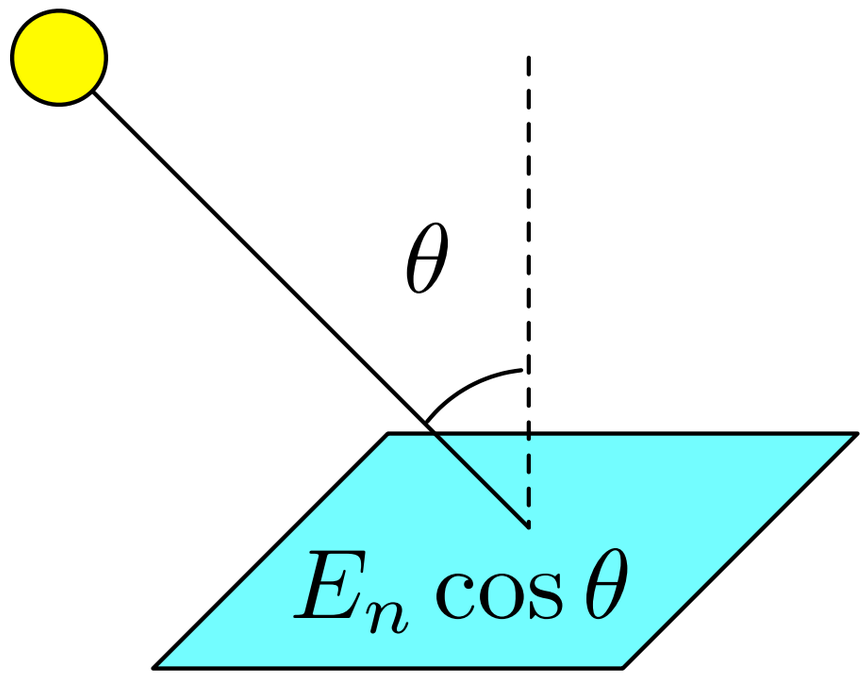


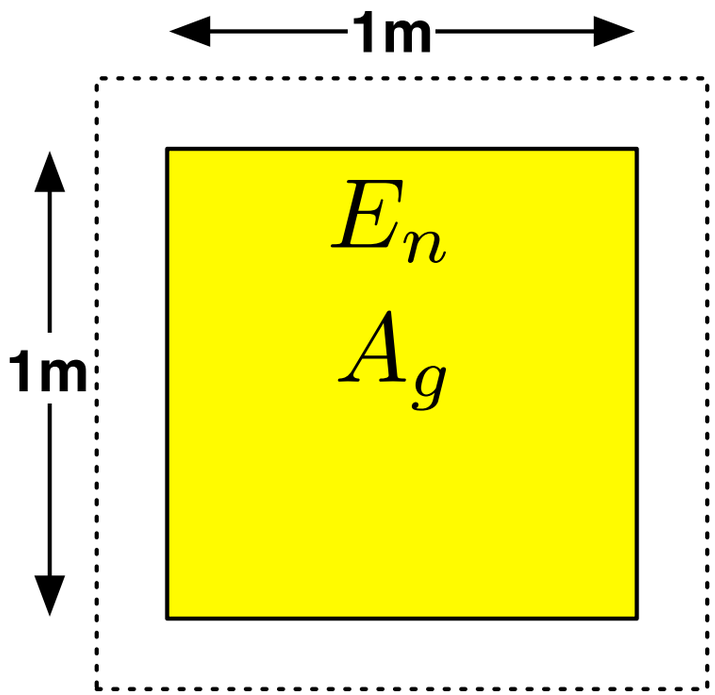
1m^2 aperture set in thin wall



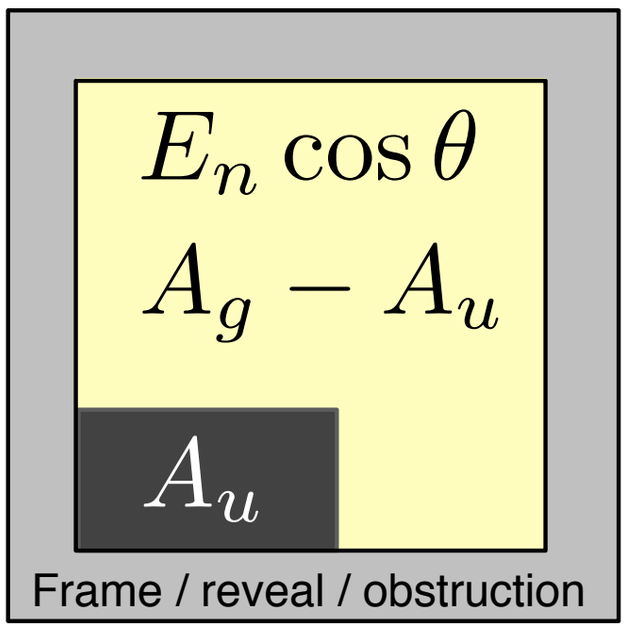
1m^2 aperture set 20cm deep reveal







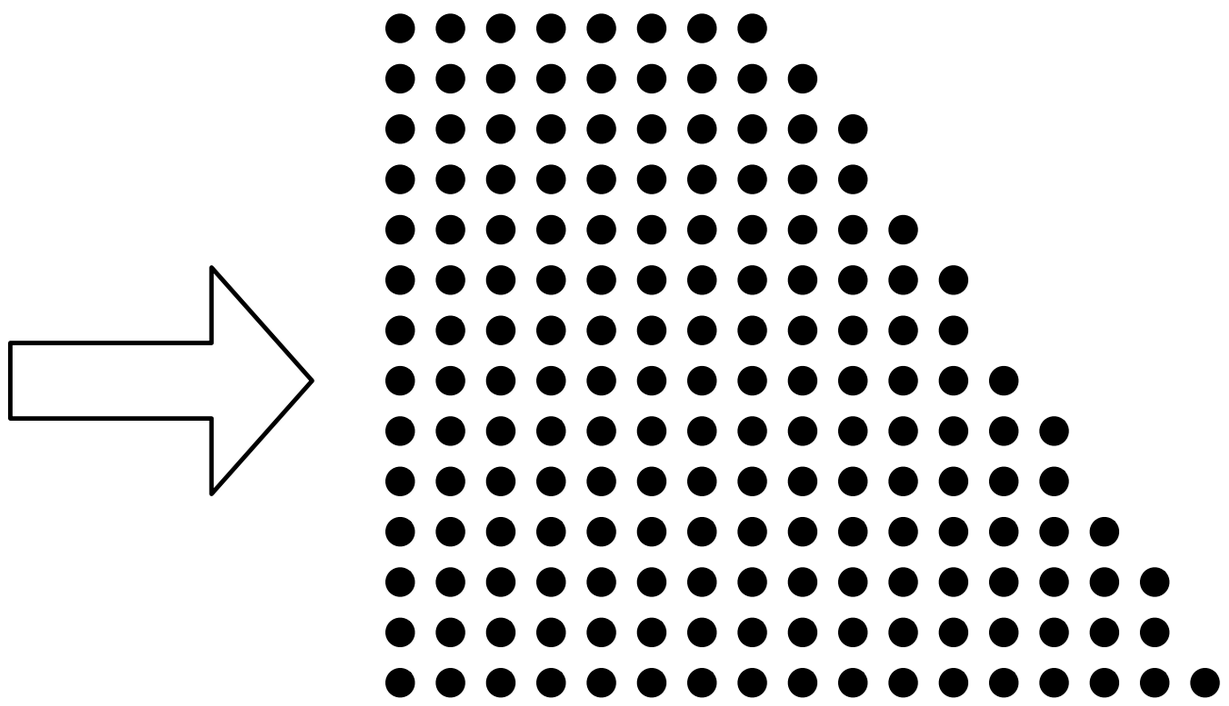
Normal incidence



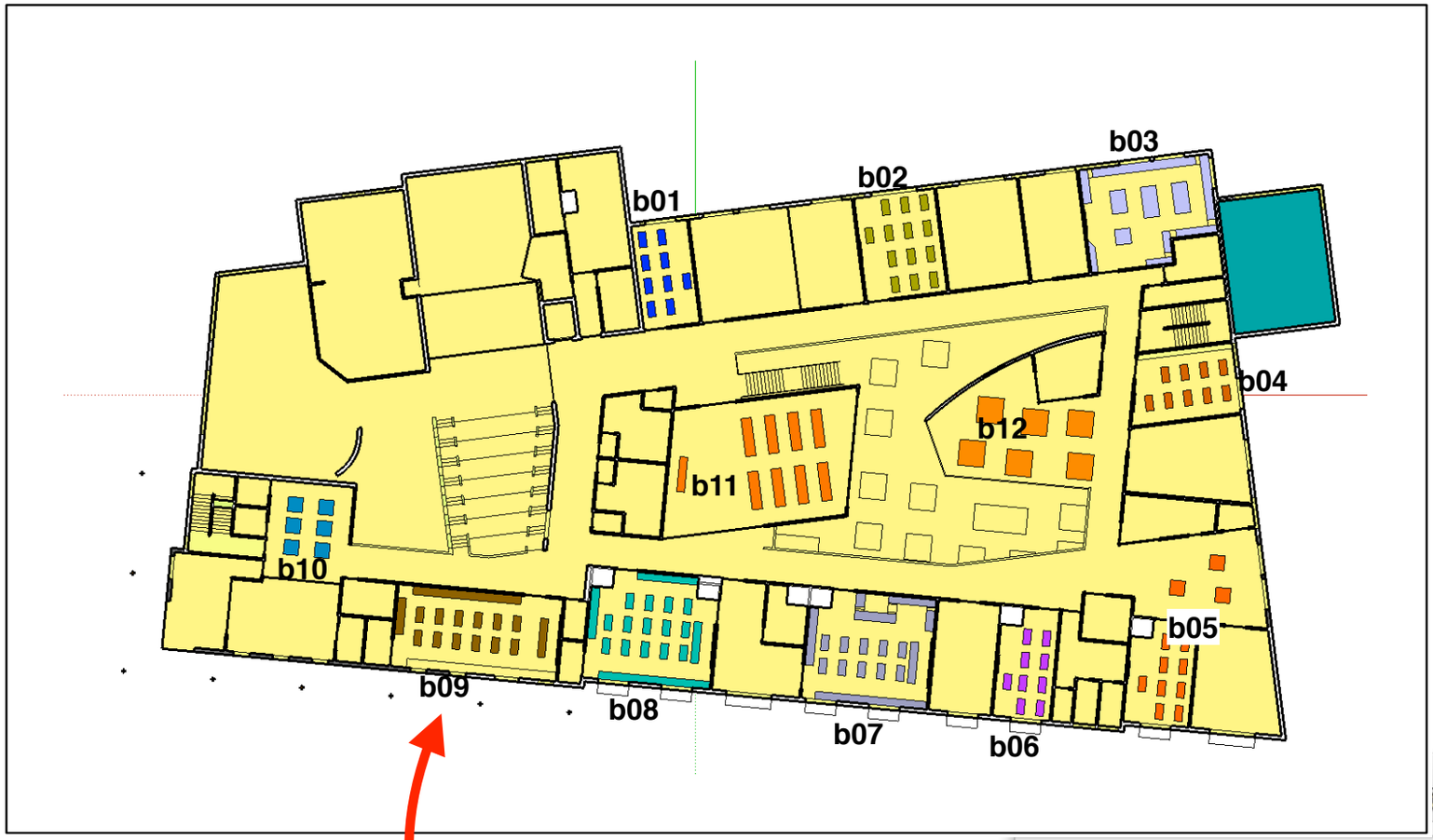
$\theta > 0$

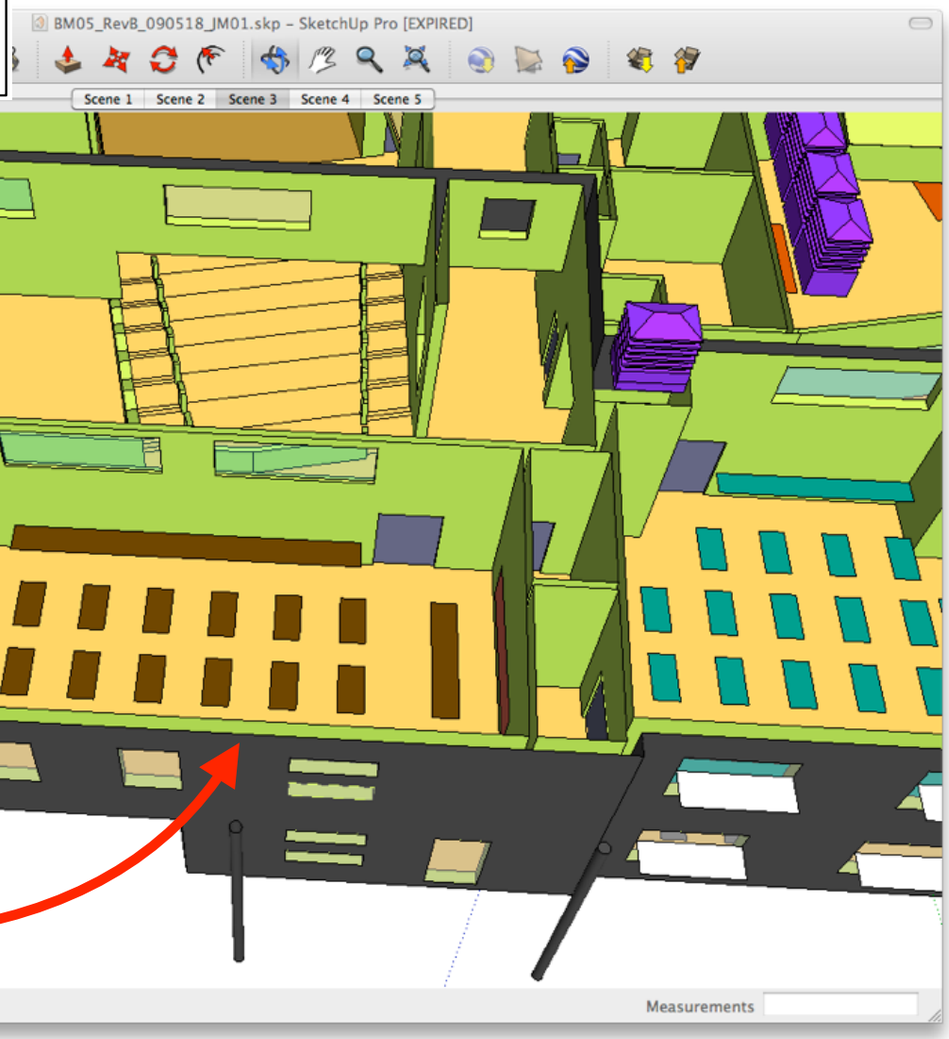
Sensor grid: stencil method

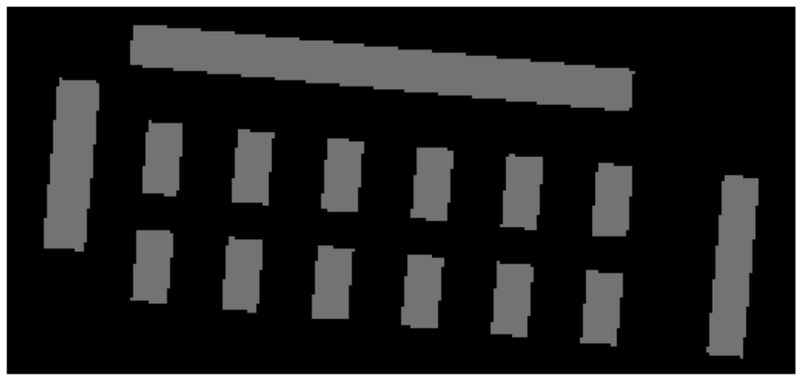
Radiance image of sensor plane

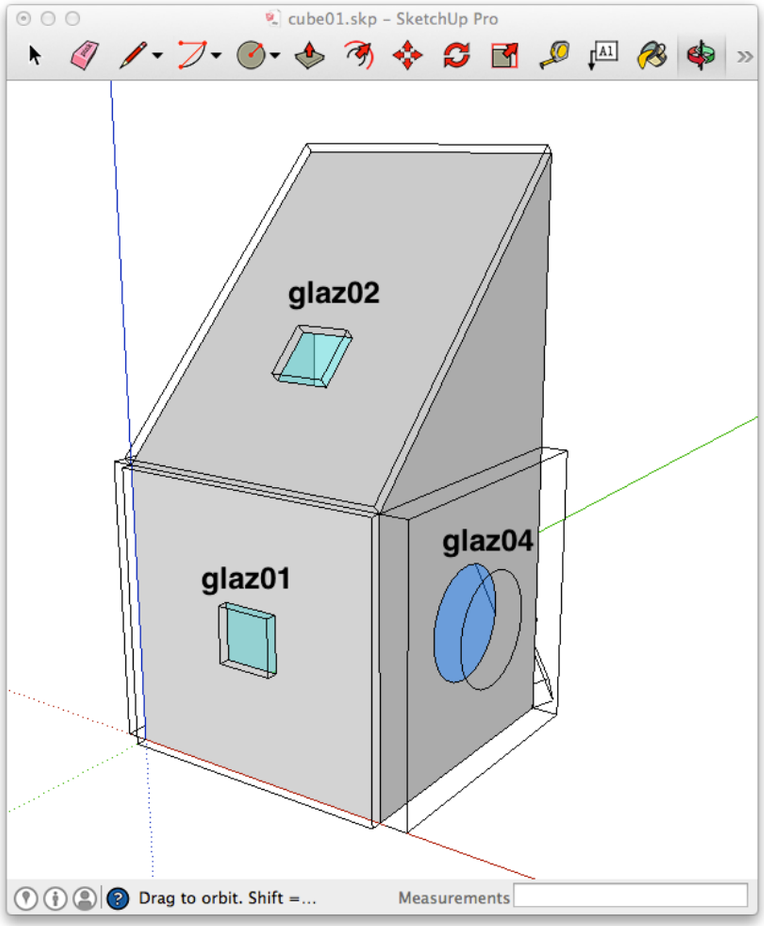


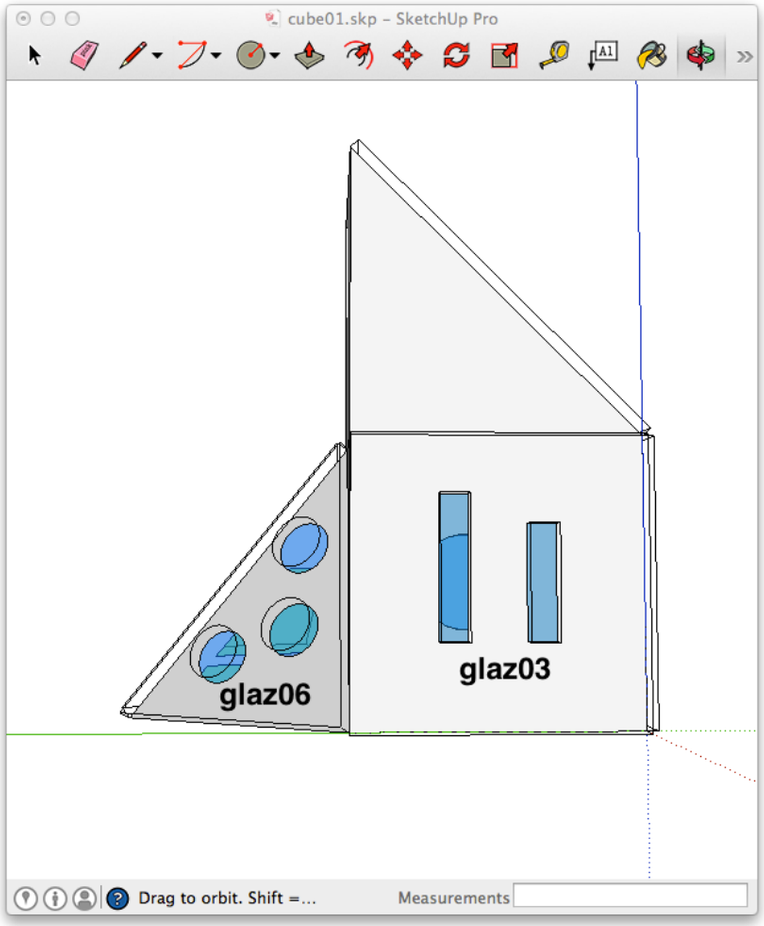
Sensor grid points

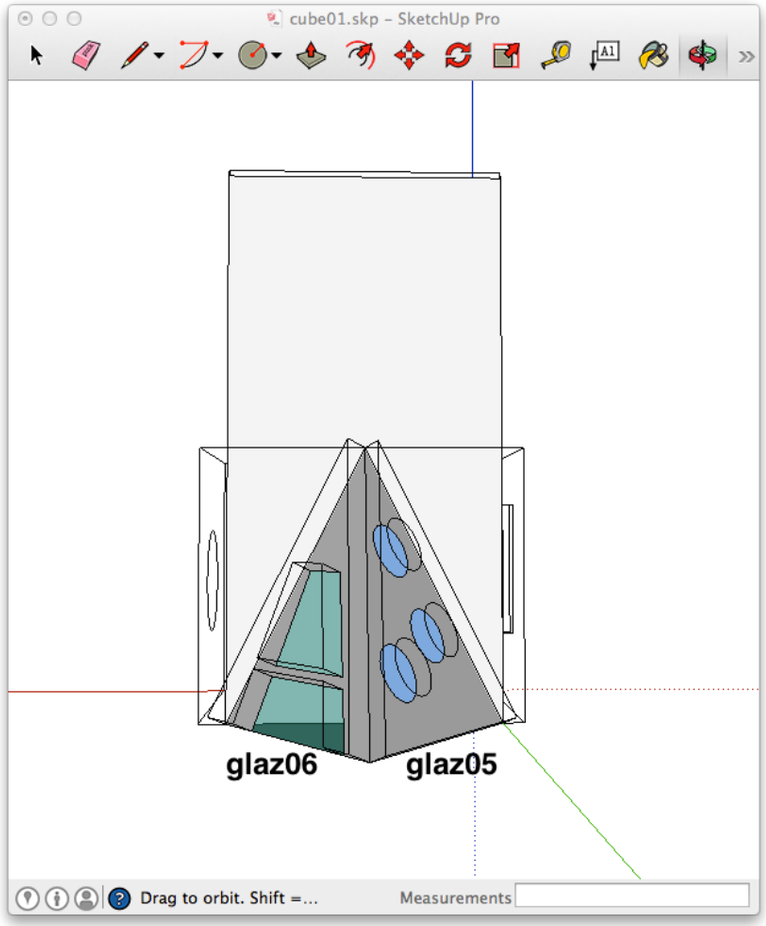

b01
b02
b03
b04
b05
b06
b07
b08
b09
b10
b11
b12

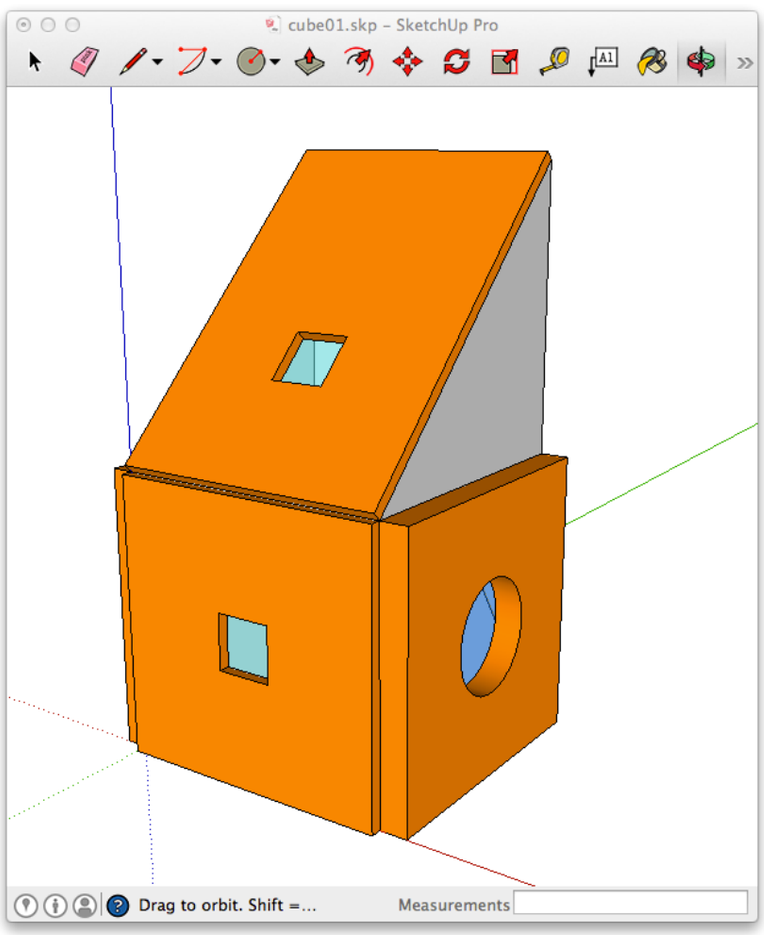

BM05_RevB_090518_JM01.skp – SketchUp Pro [EXPIRED]
Scene 1
Scene 2
Scene 3
Scene 4
Scene 5
Drag to orbit. Shift = Pan
Measurements




cube01.skp – SketchUp Pro
glaz02
glaz01
glaz04
Drag to orbit. Shift =...
Measurements


cube01.skp – SketchUp Pro
glaz06
glaz03
Drag to orbit. Shift =...
Measurements


cube01.skp – SketchUp Pro
glaz06
glaz05
Drag to orbit. Shift =...
Measurements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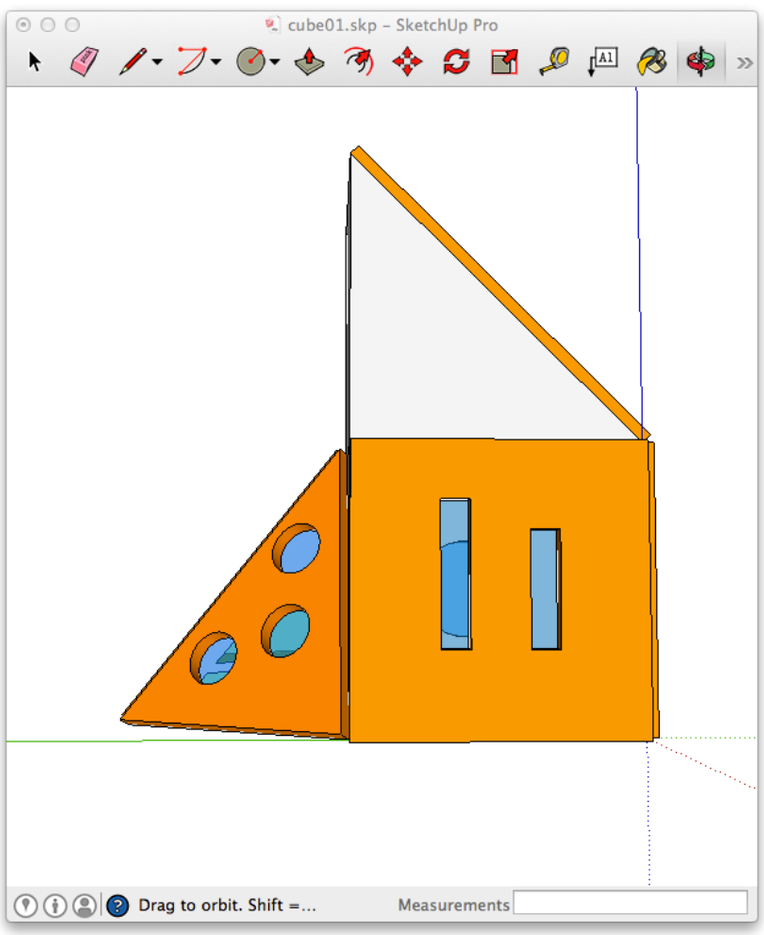
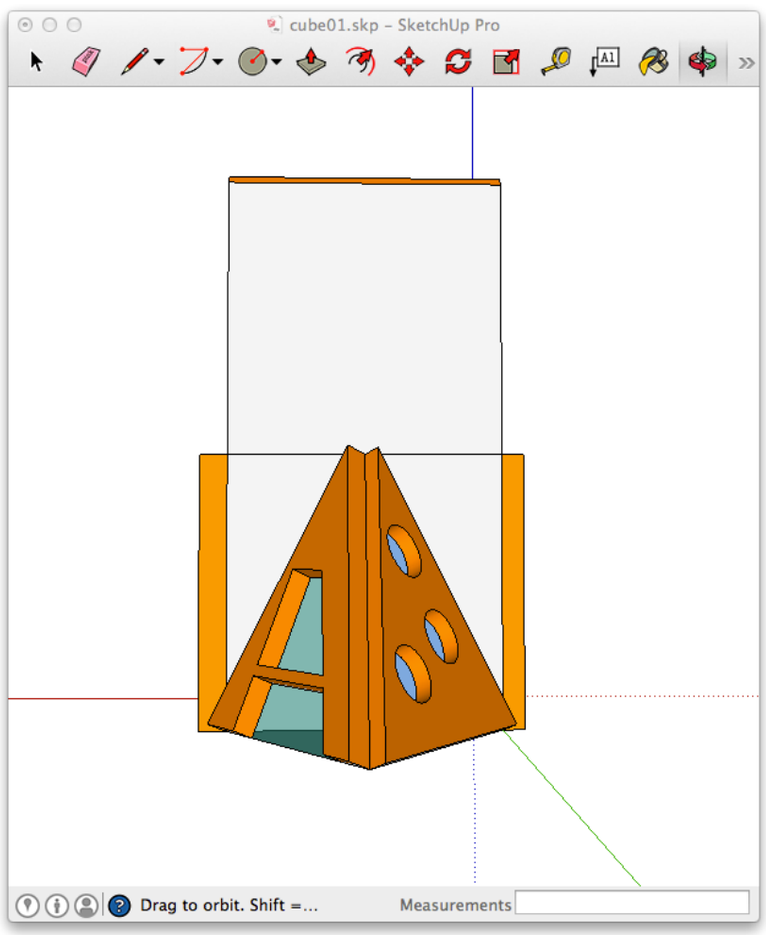
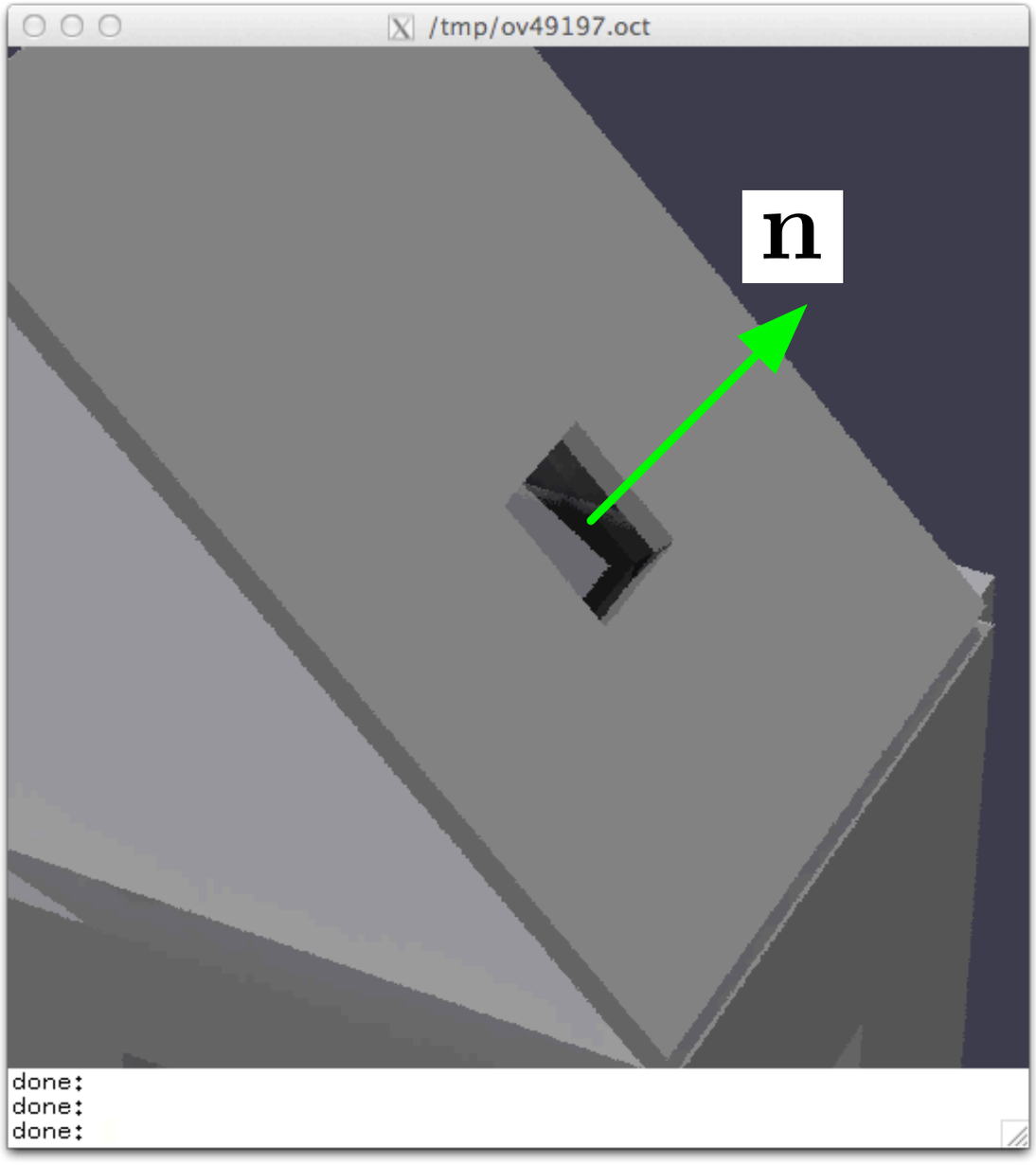
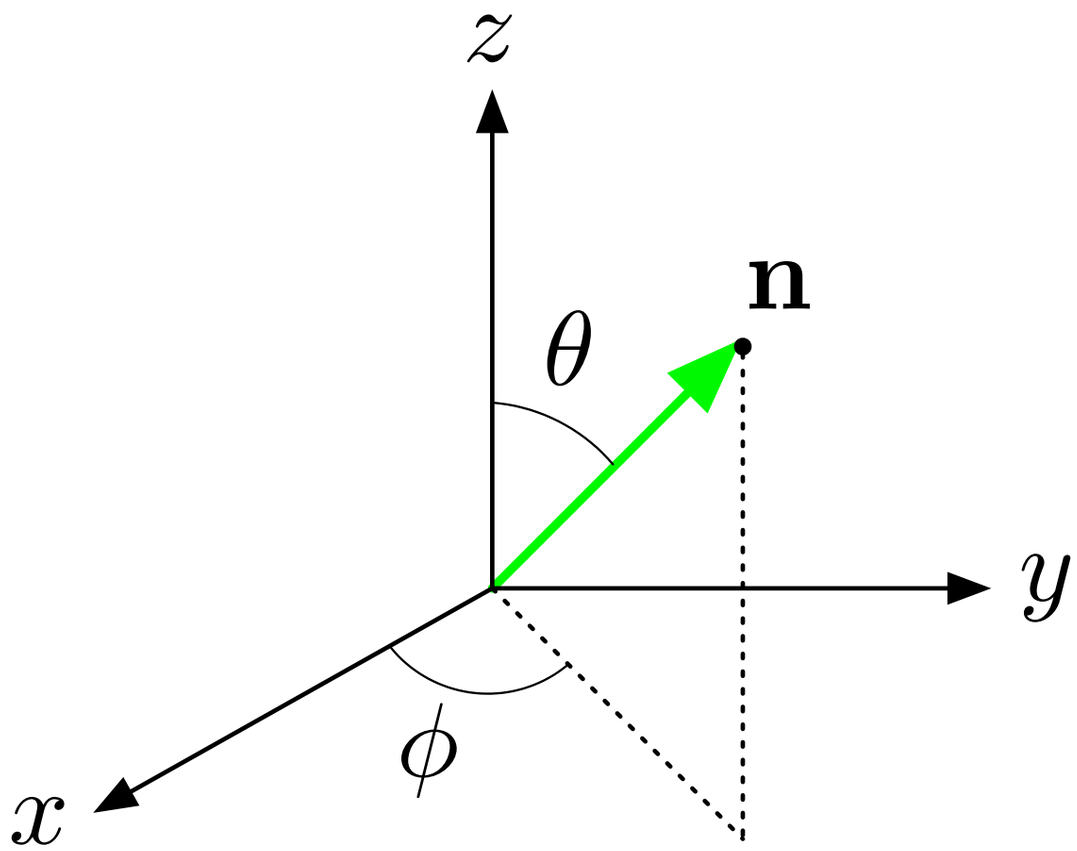
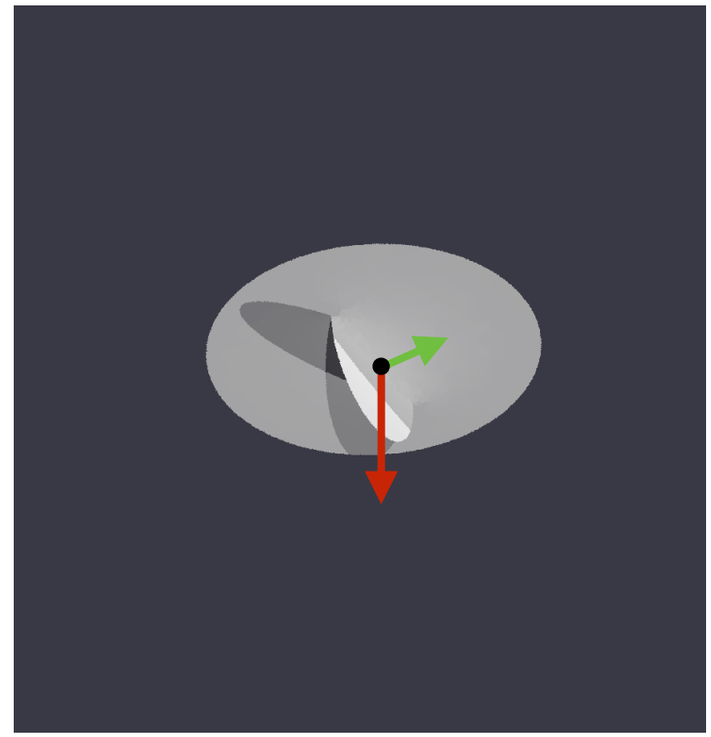
Drag to orbit. Shift =...
Measurements

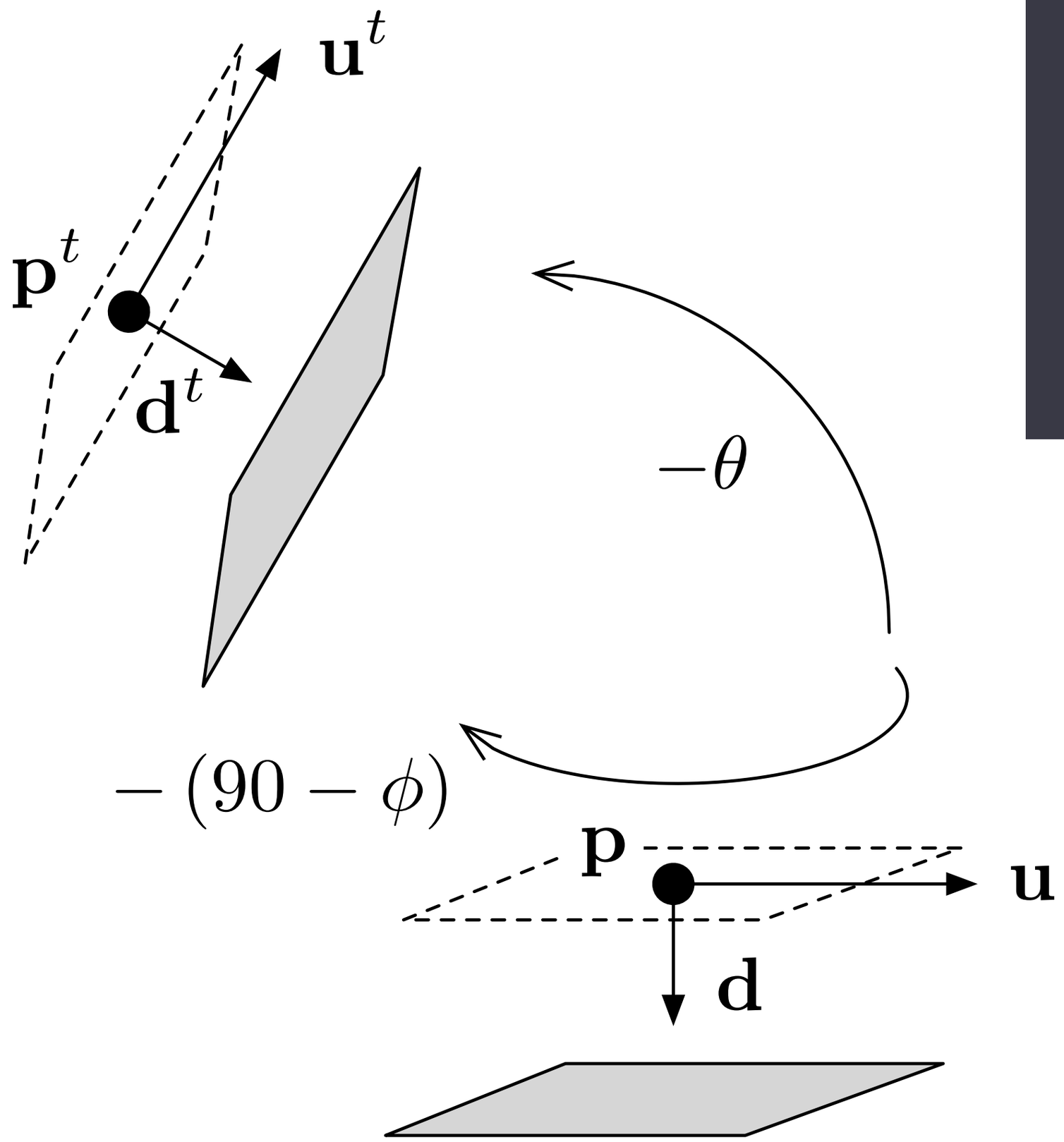

cube01.skp – SketchUp Pro
Drag to orbit. Shift =...
Measurements


cube01.skp – SketchUp Pro
Drag to orbit. Shift =...
Measurements

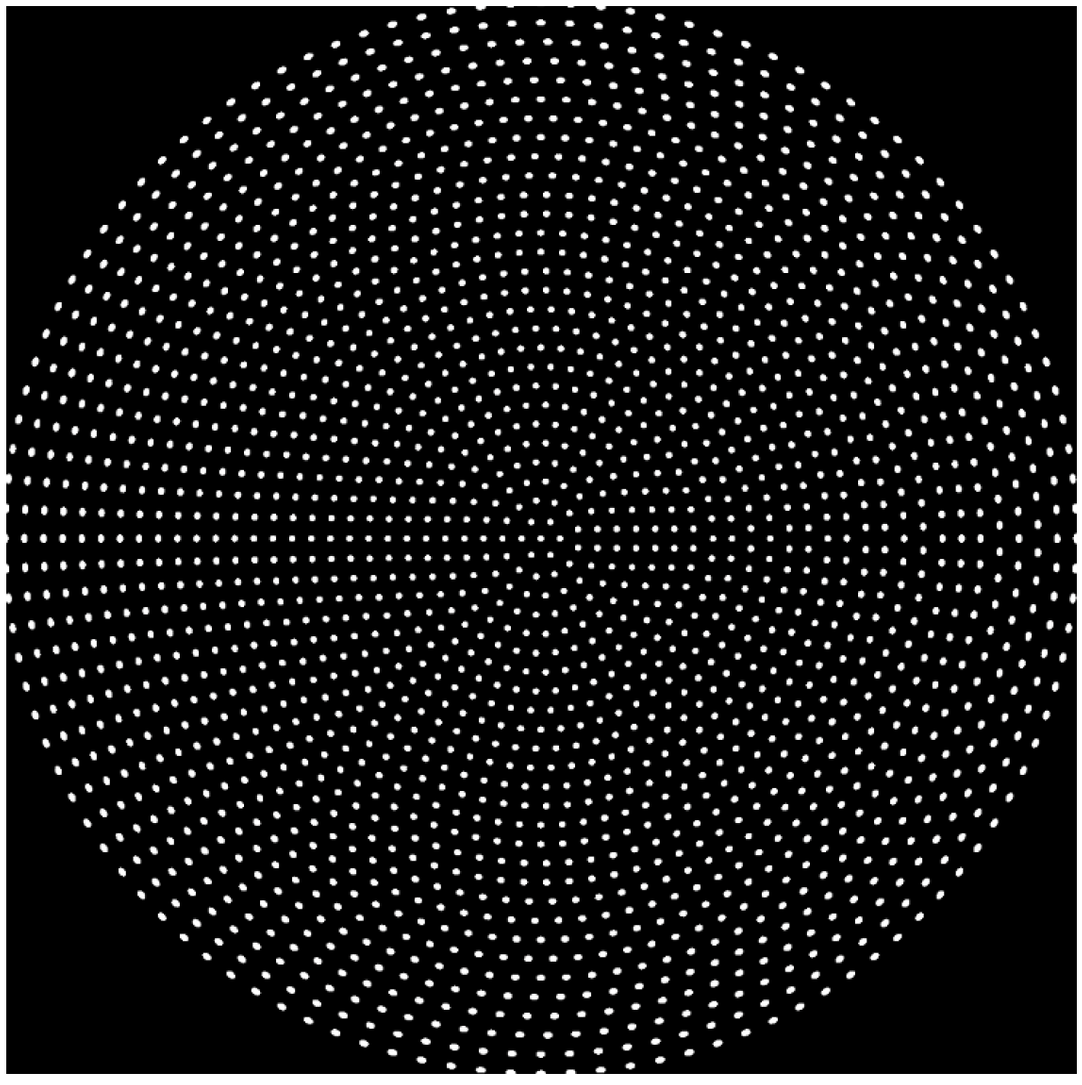

/tmp/ov49197.oct
n
done:
done:
done:

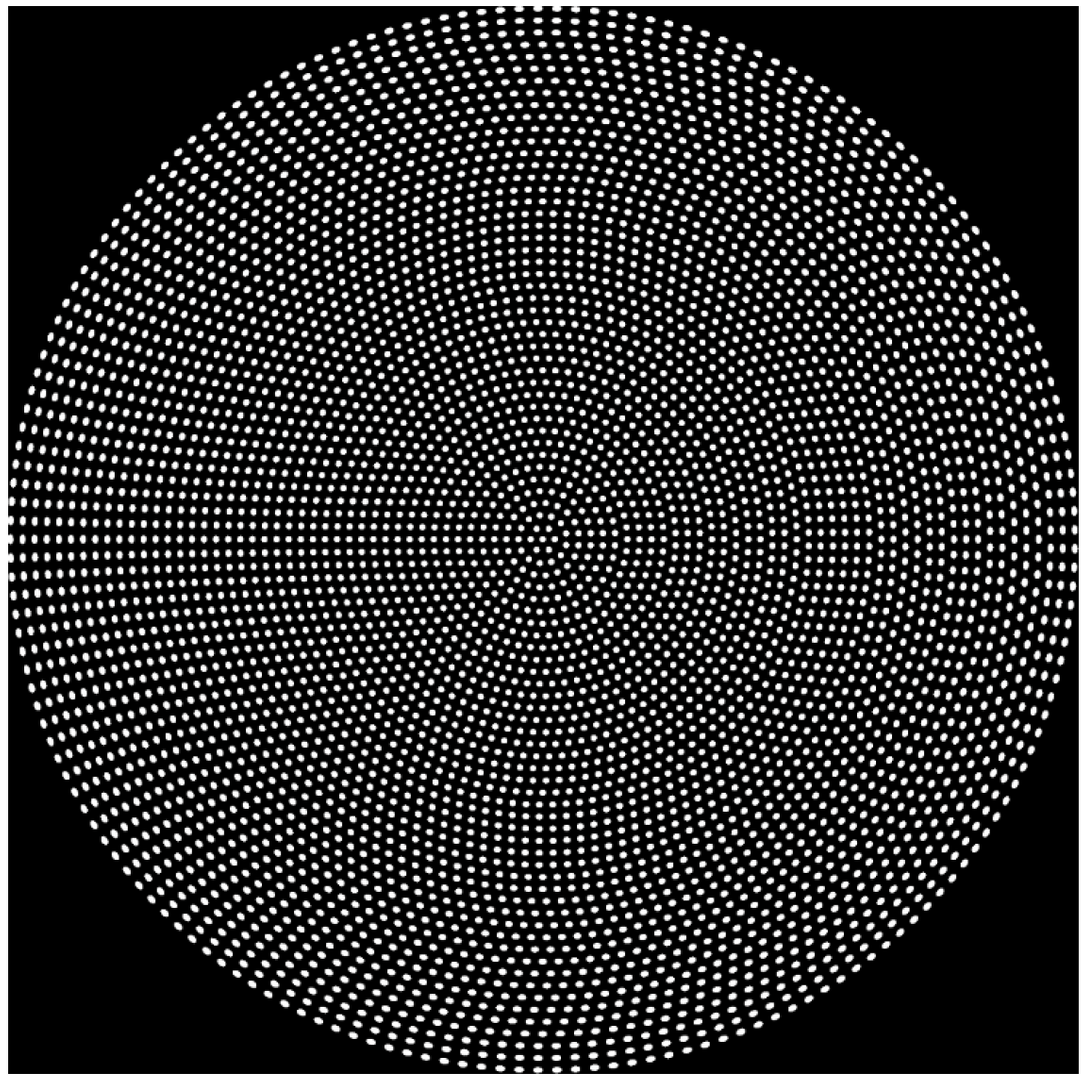

z
n
θ
y
x
ϕ




$\mathbf{u}^t$
$\mathbf{p}^t$
$\mathbf{d}^t$
$-\theta$
$-(90-\phi)$
$\mathbf{p}$
$\mathbf{u}$
$\mathbf{d}$

Direct sun component





2,056 or 5,035

evenly distributed ‘suns’

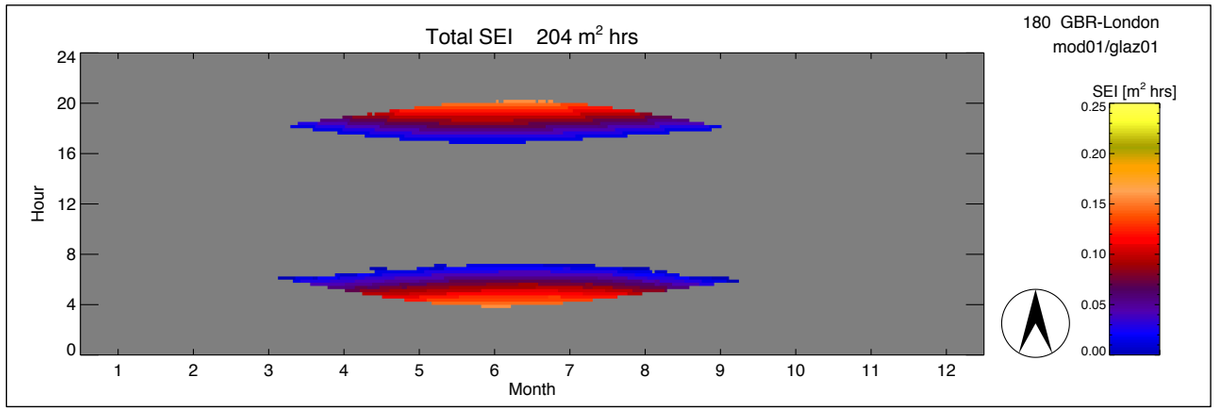
SBI results for 1m^2 aperture

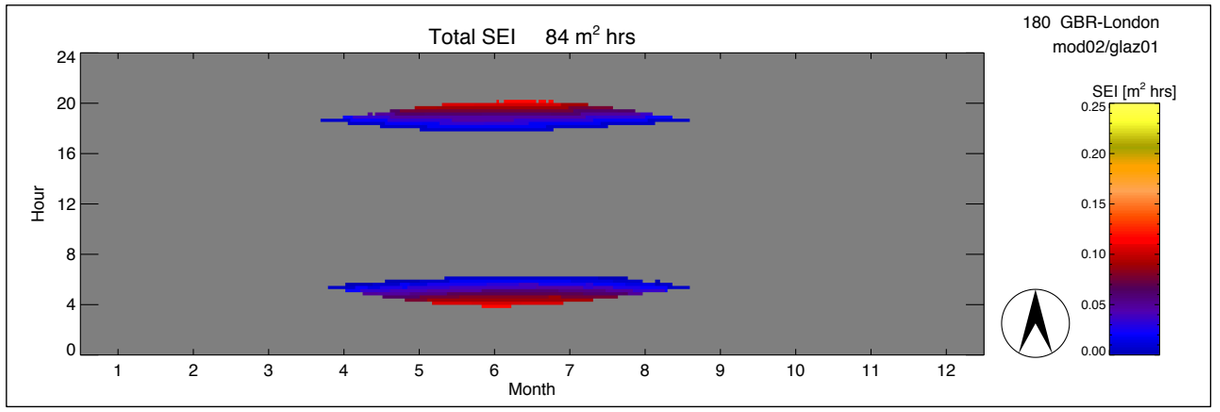
Cumulative annual sunlight beam index

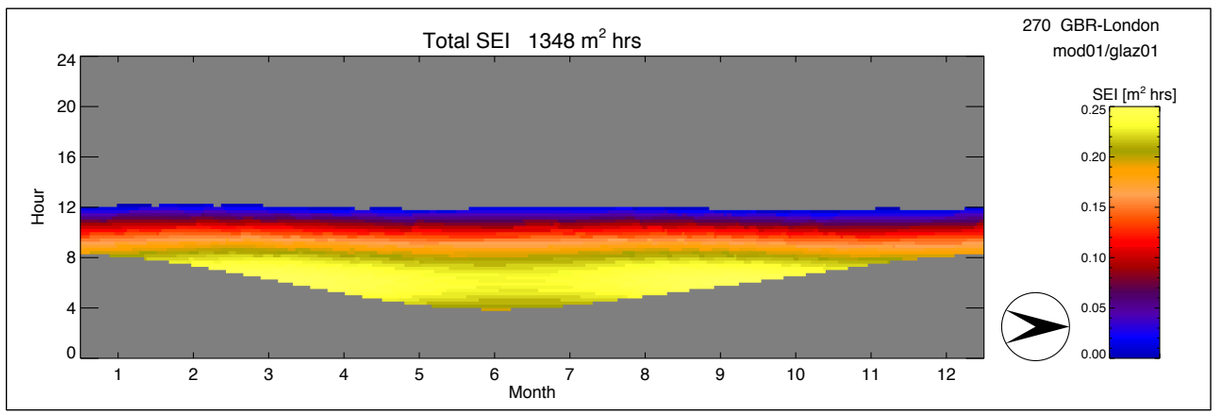
Aperture orientation	Without reveal SBI [m^2 hrs]	With reveal (20 cm) SBI [m^2 hrs]
North	204	84
NE	608	414
East	1,348	1,037
SE	1,826	1,343
South	1,927	1,340
SW	1,822	1,342
West	1,345	1,033
NW	604	411

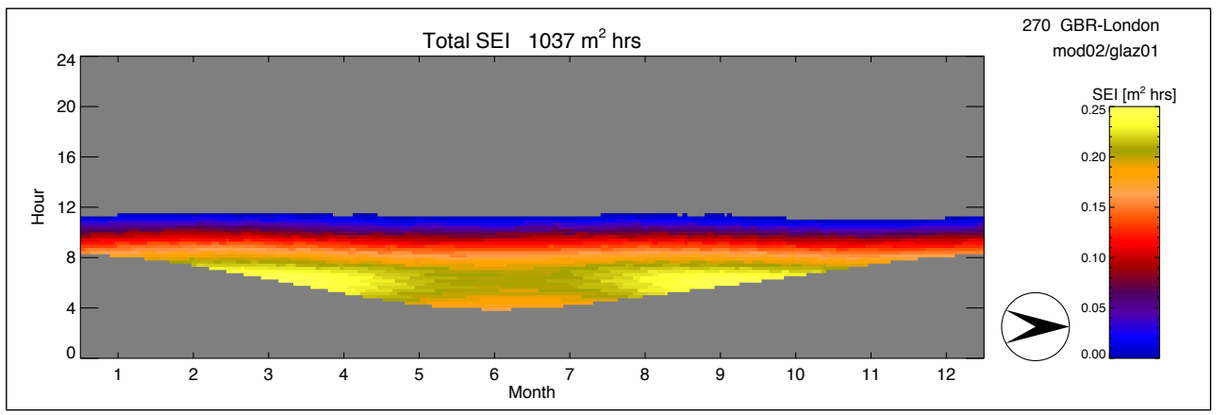
London, UK

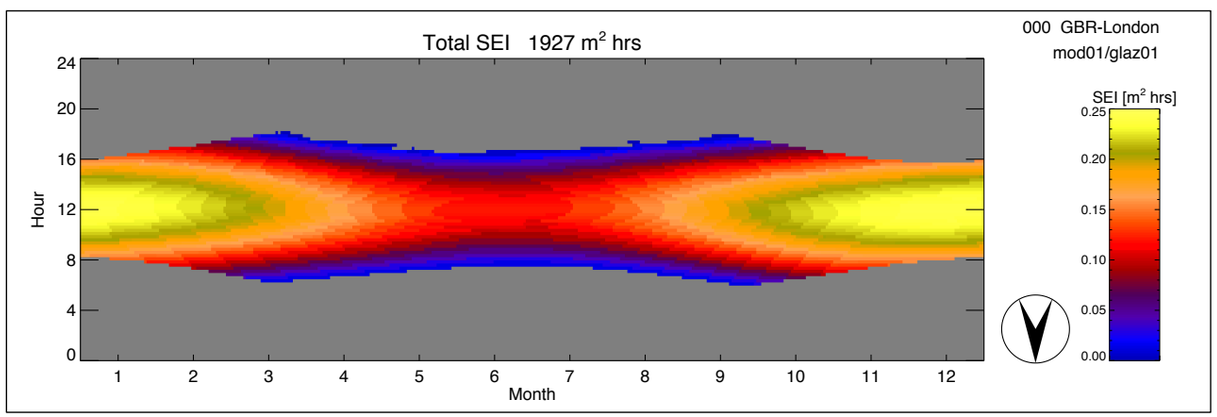
Temporal SBI Map


Total SEI 204 m² hrs
180 GBR-London
mod01/glaz01
SEI [m² hrs]
Hour
Month


Total SEI 84 m² hrs
180 GBR-London
mod02/glaz01
SEI [m² hrs]
Hour
Month


Total SEI 1348 m² hrs
270 GBR-London
mod01/glaz01
SEI [m² hrs]
Hour
Month


Total SEI 1037 m² hrs
270 GBR-London
mod02/glaz01
SEI [m² hrs]
Hour
Month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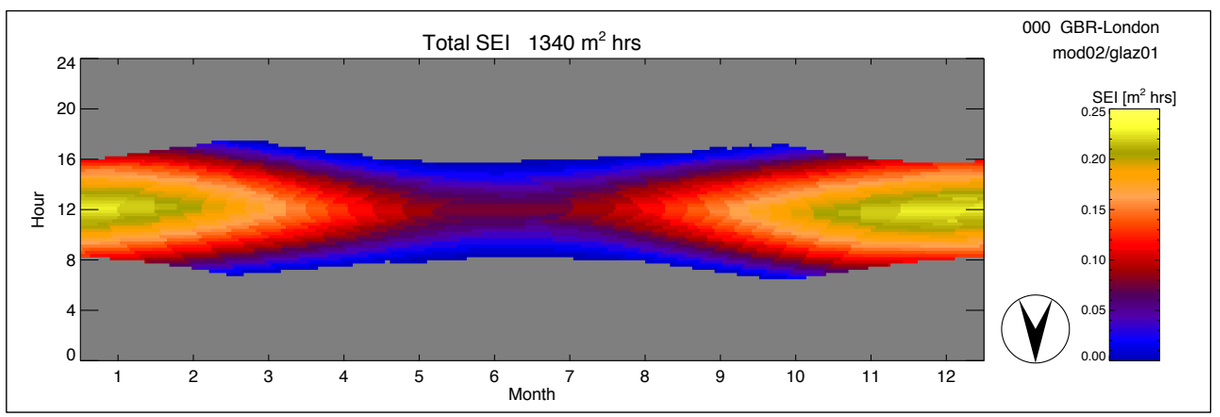
000 GBR-London
mod01/glaz01
SEI [m² hrs]
Hour
Month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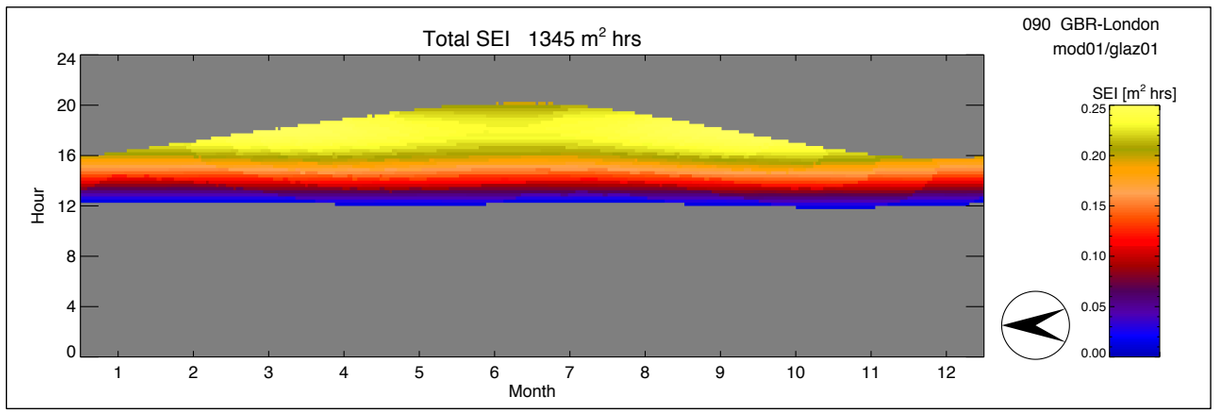
000 GBR-London
mod02/glaz01
SEI [m² hrs]
Hour
Month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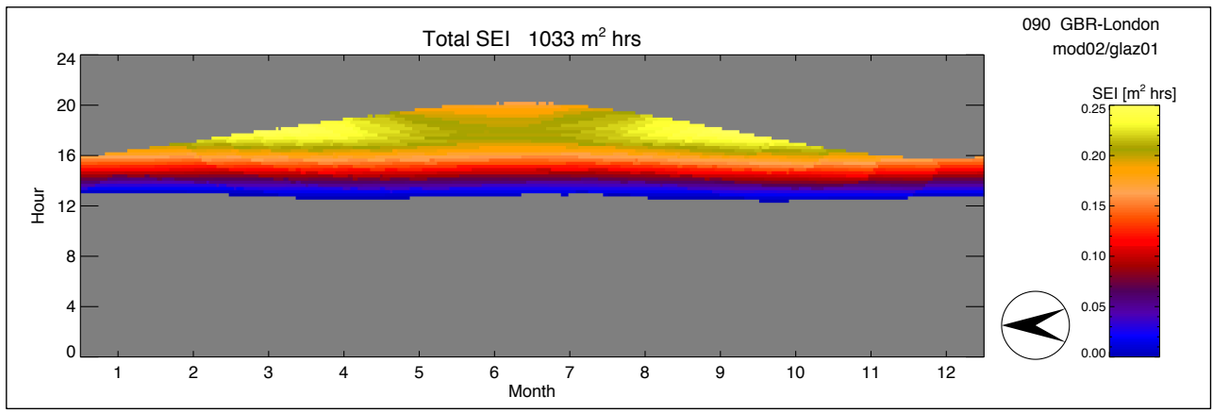
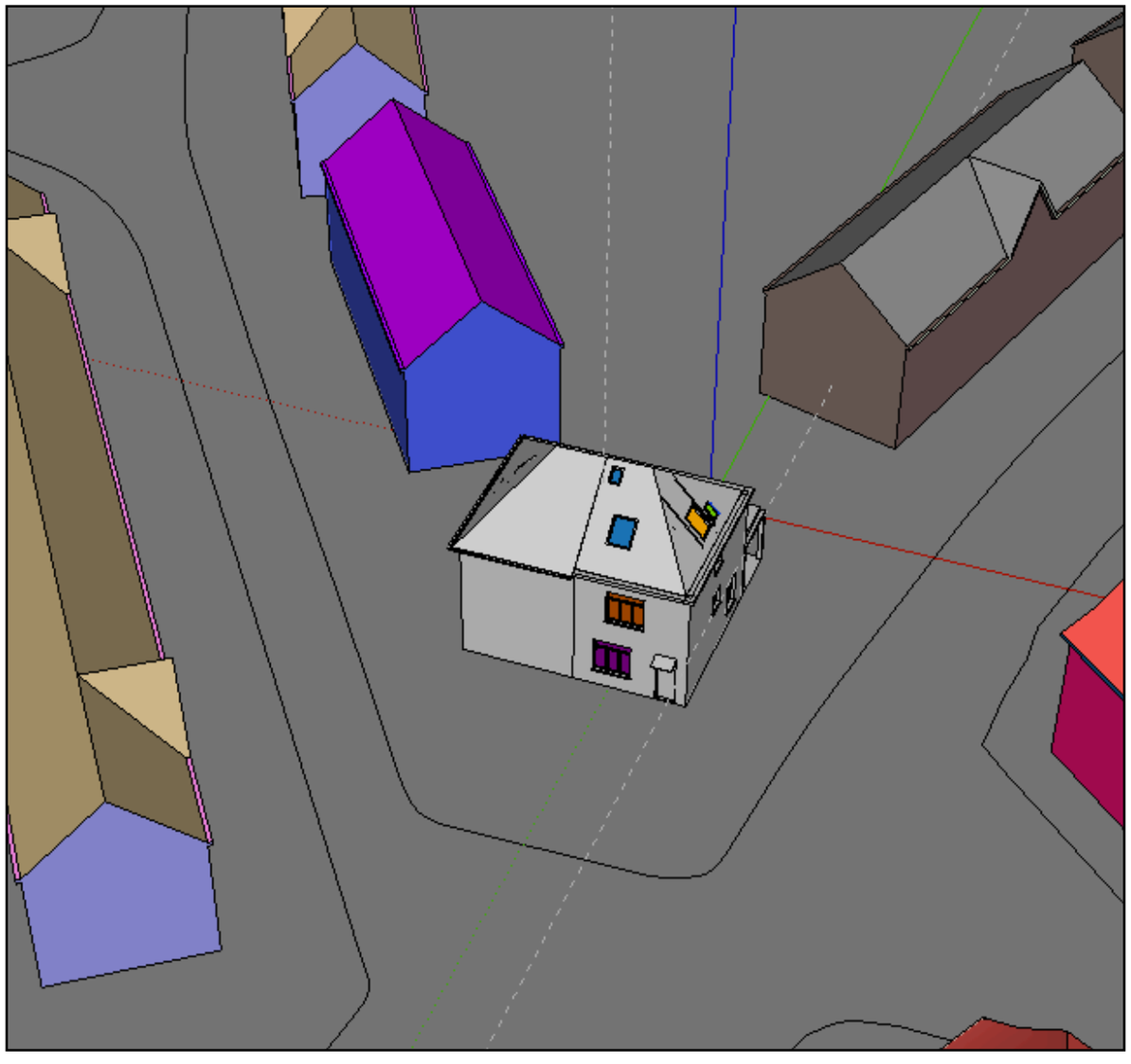
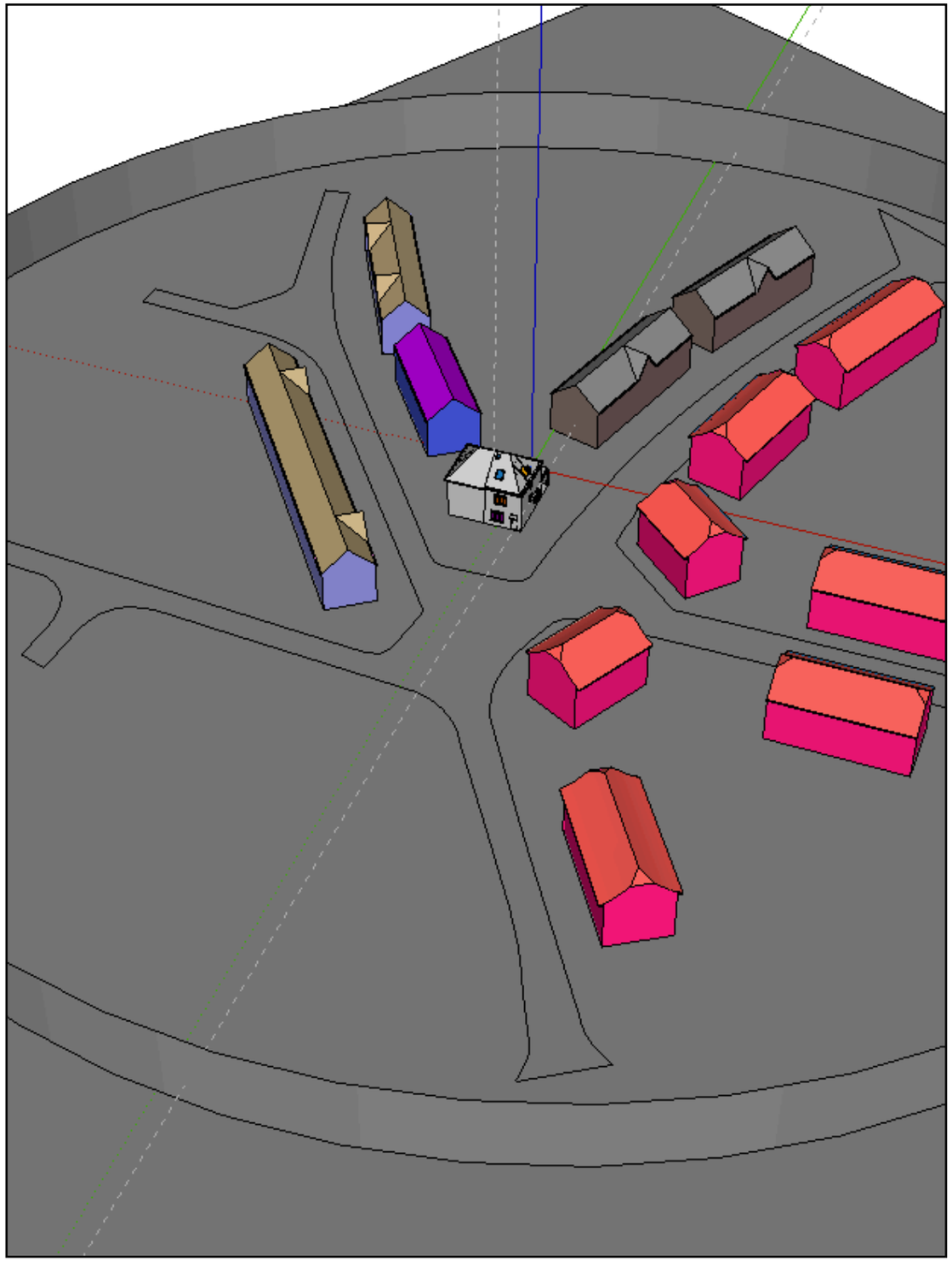
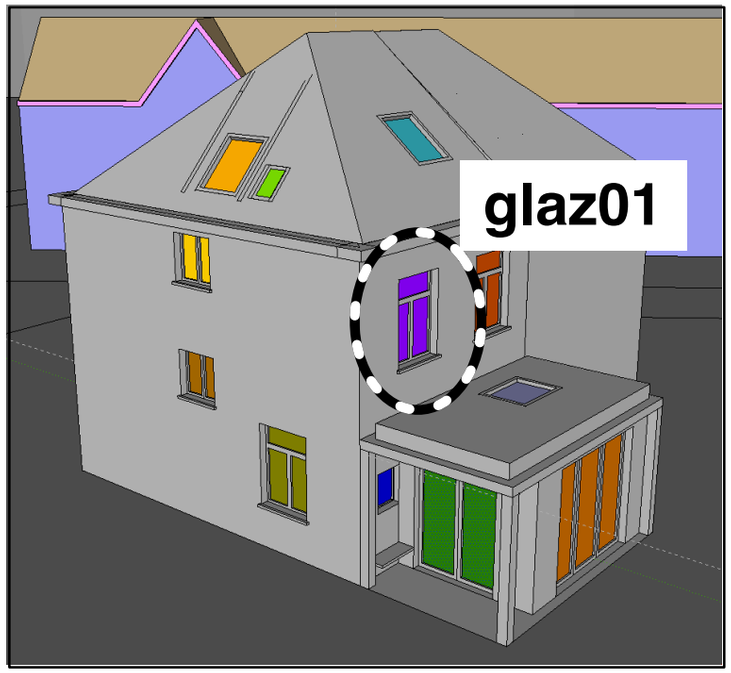
090 GBR-London
mod01/glaz01
SEI [m² hrs]
Hour
Month

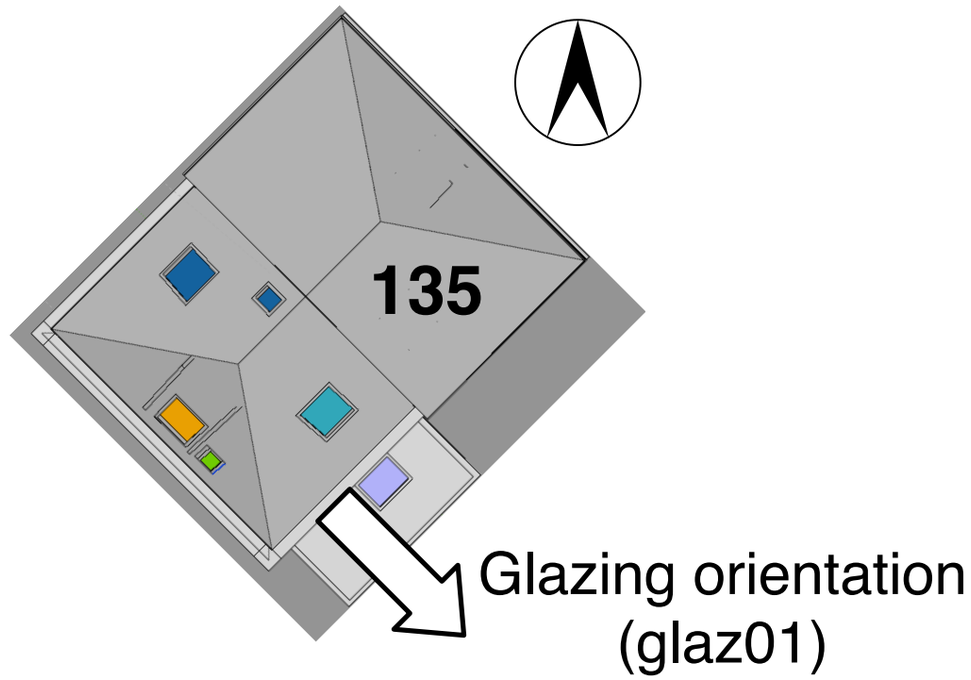

Total SEI 1033 m² hrs
090 GBR-London
mod02/glaz01
SEI [m² hrs]
Hour
Month

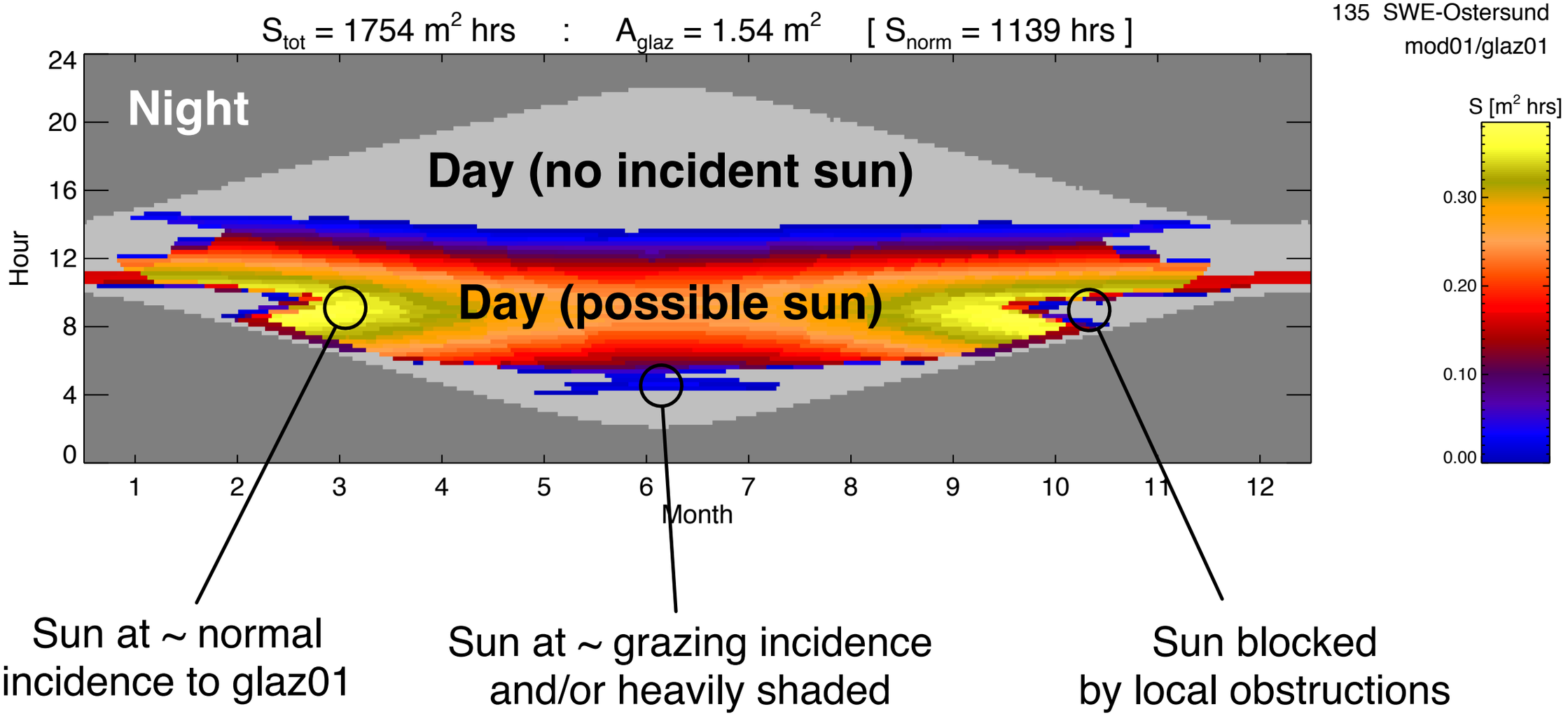
House

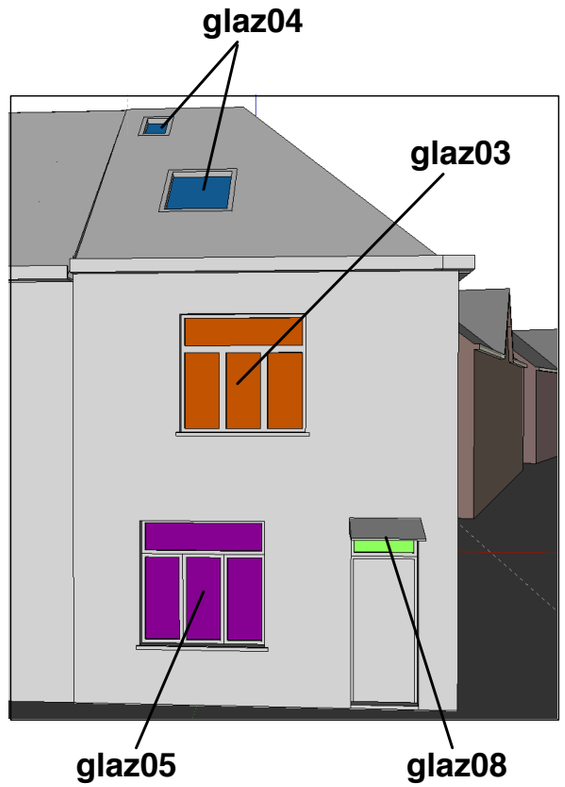


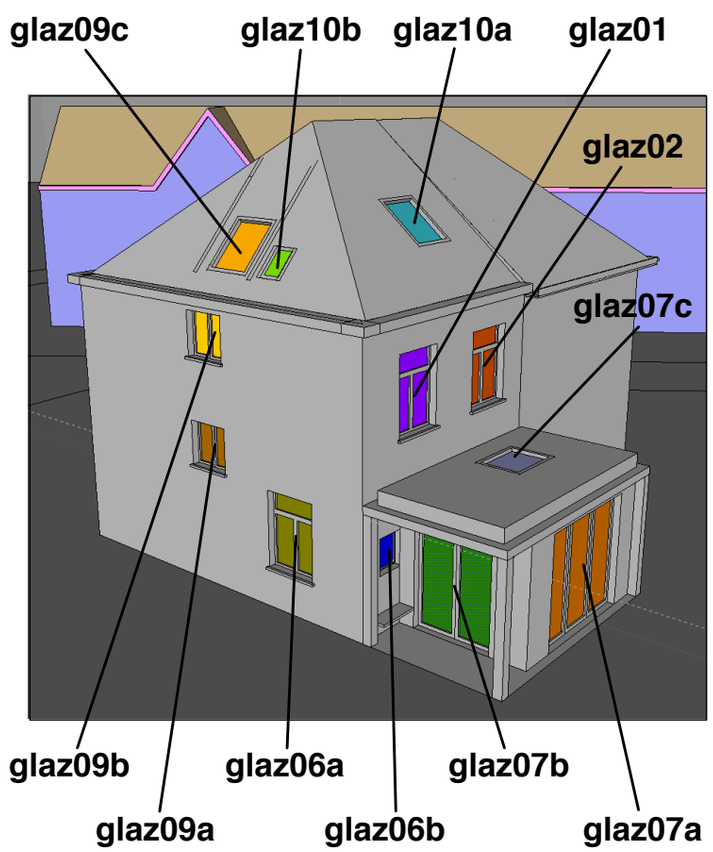



glaz01


135
Glazing orientation
(glaz01)

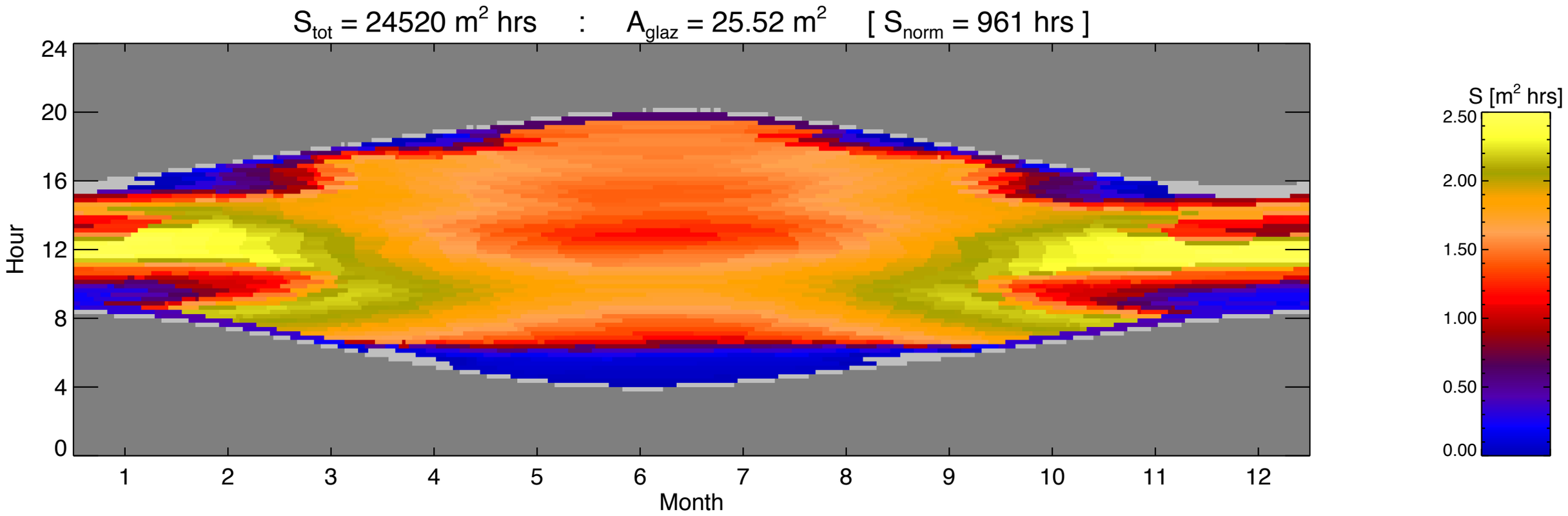

S_{tot} = 1754 m^2 hrs : A_{glaz} = 1.54 m^2 [S_{norm} = 1139 hrs]
135 SWE-Ostersund
mod01/glaz01
S [m^2 hrs]
0.30
0.20
0.10
0.00
Night
Day (no incident sun)
Day (possible sun)
Hour
Month
24
20
16
12
8
4
0
1
2
3
4
5
6
7
8
9
10
11
12
Sun at ~ normal incidence to glaz01
Sun at ~ grazing incidence and/or heavily shaded
Sun blocked by local obstructions

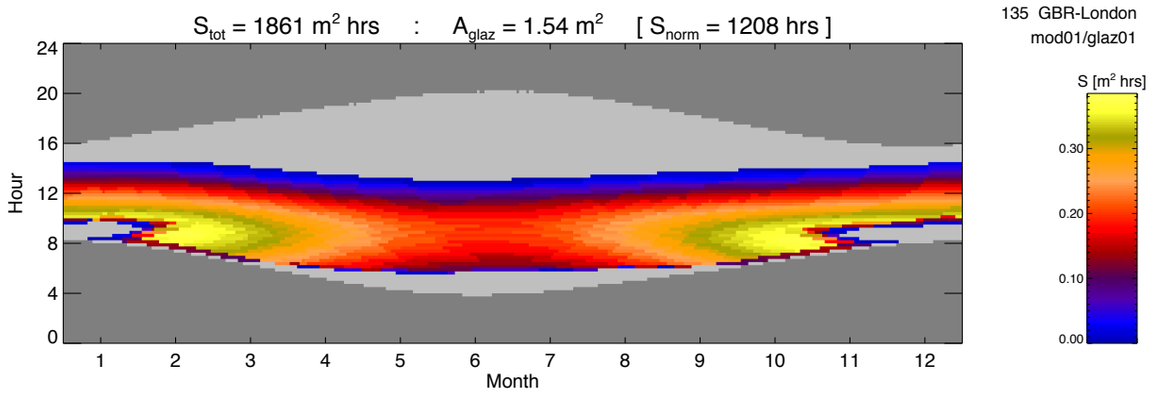


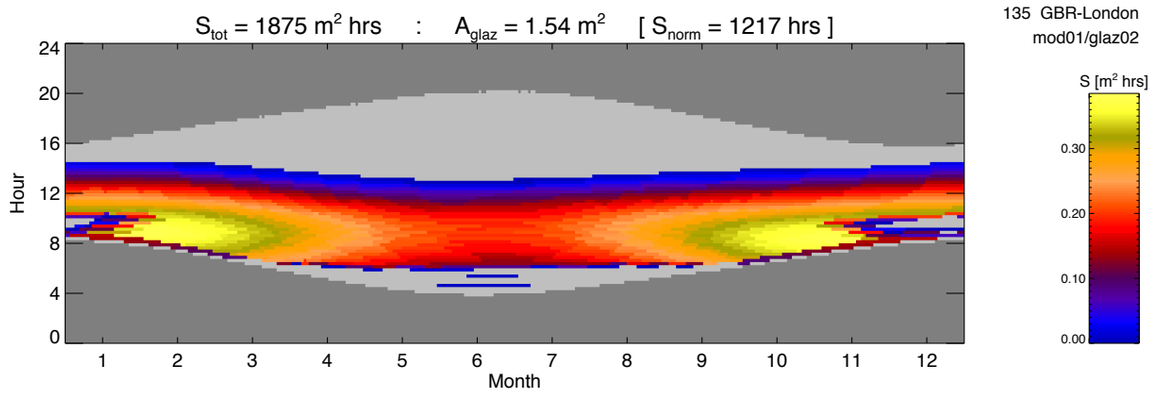


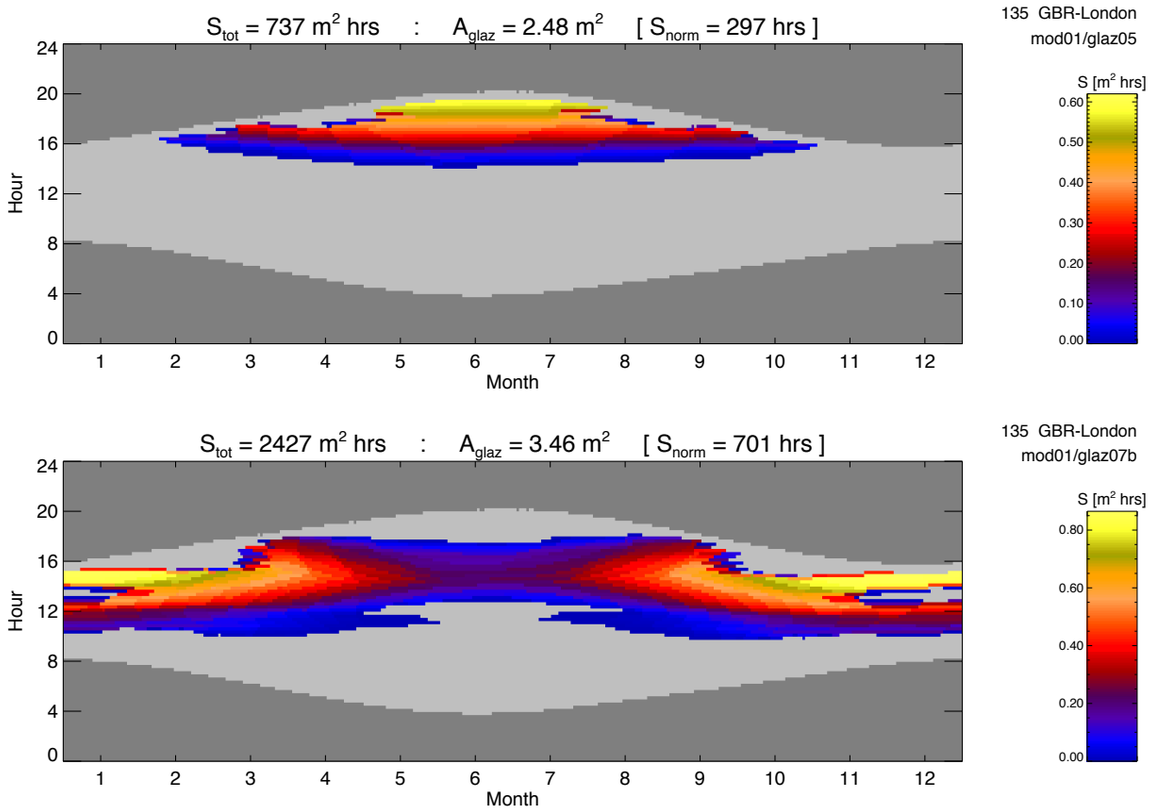
01-02-03-04-05-06a-06b-07a-07b-07c-08-09a-09b-09c-10a-10b

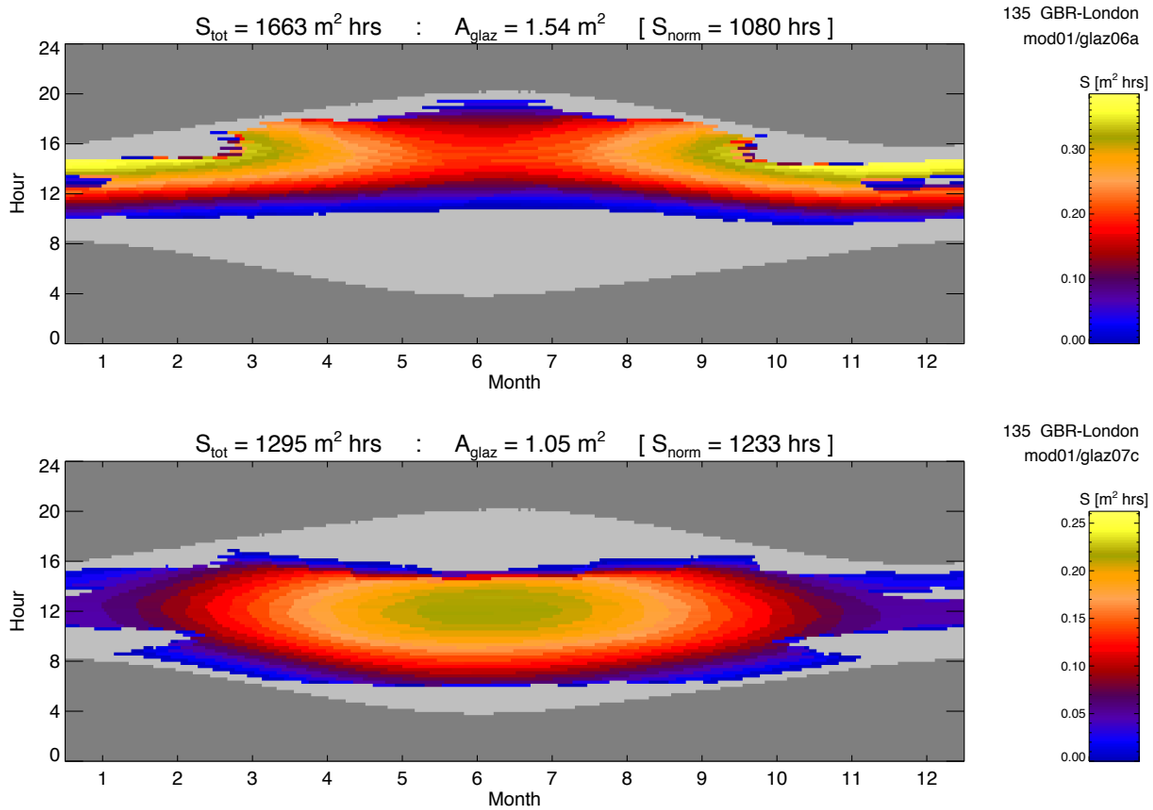
mod01-GBR-London-135




S_{tot} = 1861 m² hrs : A_{glaz} = 1.54 m² [S_{norm} = 1208 hrs]
Hour
Month
135 GBR-London
mod01/glaz01
S [m² hrs]
0.00
0.10
0.20
0.30

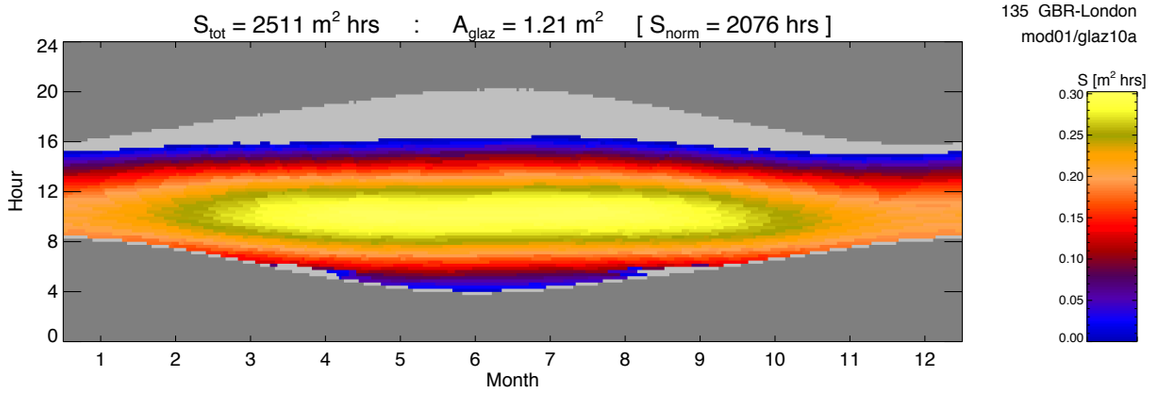

S_{tot} = 1875 m² hrs : A_{glaz} = 1.54 m² [S_{norm} = 1217 hrs]
Hour
Month
135 GBR-London
mod01/glaz02
S [m² hrs]
0.00
0.10
0.20
0.30

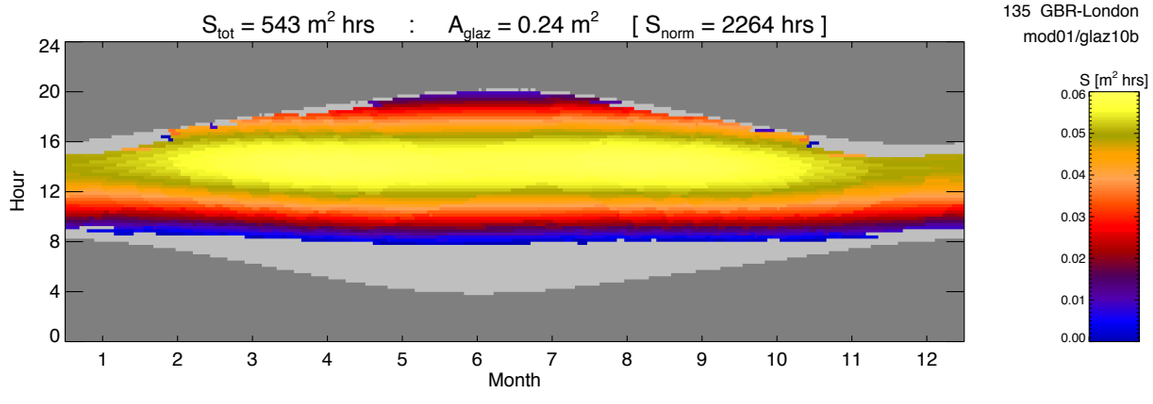

S_{tot} = 737 m² hrs : A_{glaz} = 2.48 m² [S_{norm} = 297 hrs]
Hour
Month
135 GBR-London
mod01/glaz05
S [m² hrs]
0.00
0.10
0.20
0.30
0.40
0.50
0.60

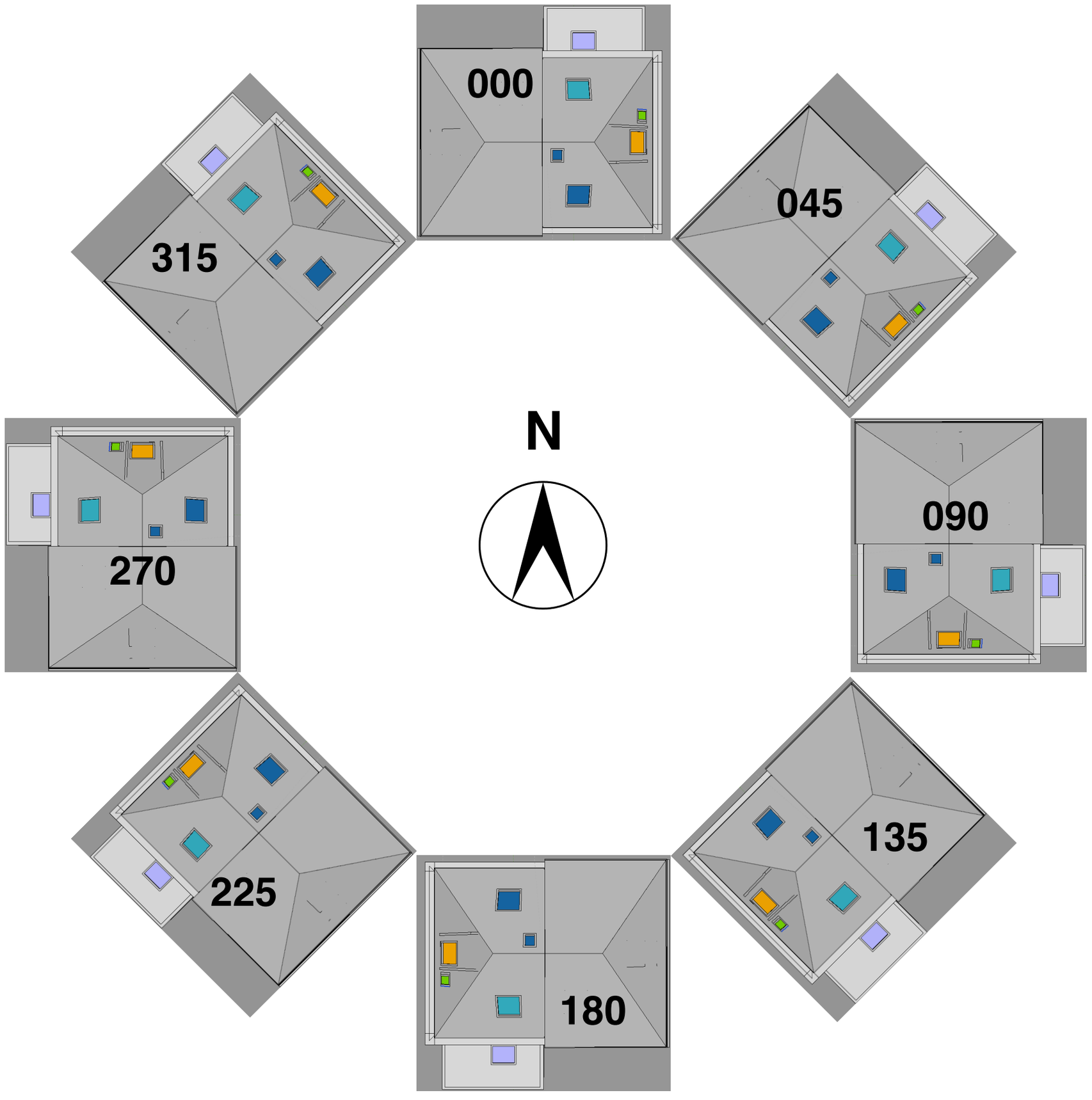

S_{tot} = 1663 m² hrs : A_{glaz} = 1.54 m² [S_{norm} = 1080 hrs]
Hour
Month
135 GBR-London
mod01/glaz06a
S [m² hrs]
0.00
0.10
0.20
0.30

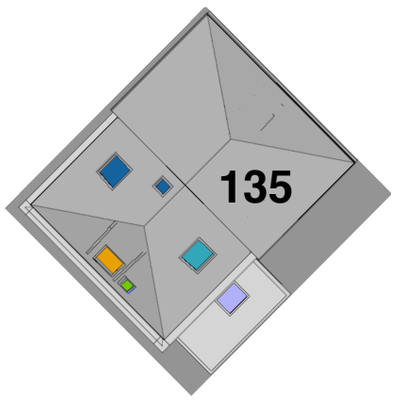
S_{tot} = 2427 m² hrs : A_{glaz} = 3.46 m² [S_{norm} = 701 hrs]
Hour
Month
135 GBR-London
mod01/glaz07b
S [m² hrs]
0.00
0.20
0.40
0.60
0.80

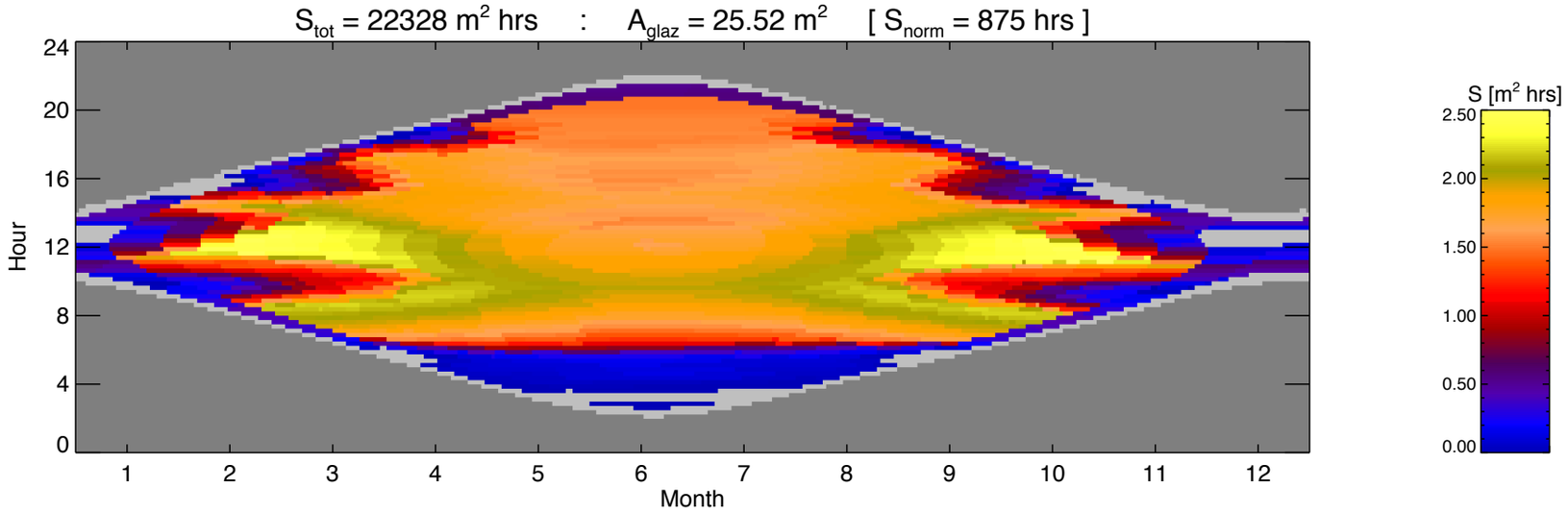
S_{tot} = 1295 m² hrs : A_{glaz} = 1.05 m² [S_{norm} = 1233 hrs]
Hour
Month
135 GBR-London
mod01/glaz07c
S [m² hrs]
0.00
0.05
0.10
0.15
0.20
0.25


S_{tot} = 2511 m² hrs : A_{glaz} = 1.21 m² [S_{norm} = 2076 hrs]
Hour
Month
135 GBR-London
mod01/glaz10a
S [m² hrs]
0.00
0.05
0.10
0.15
0.20
0.25
0.30

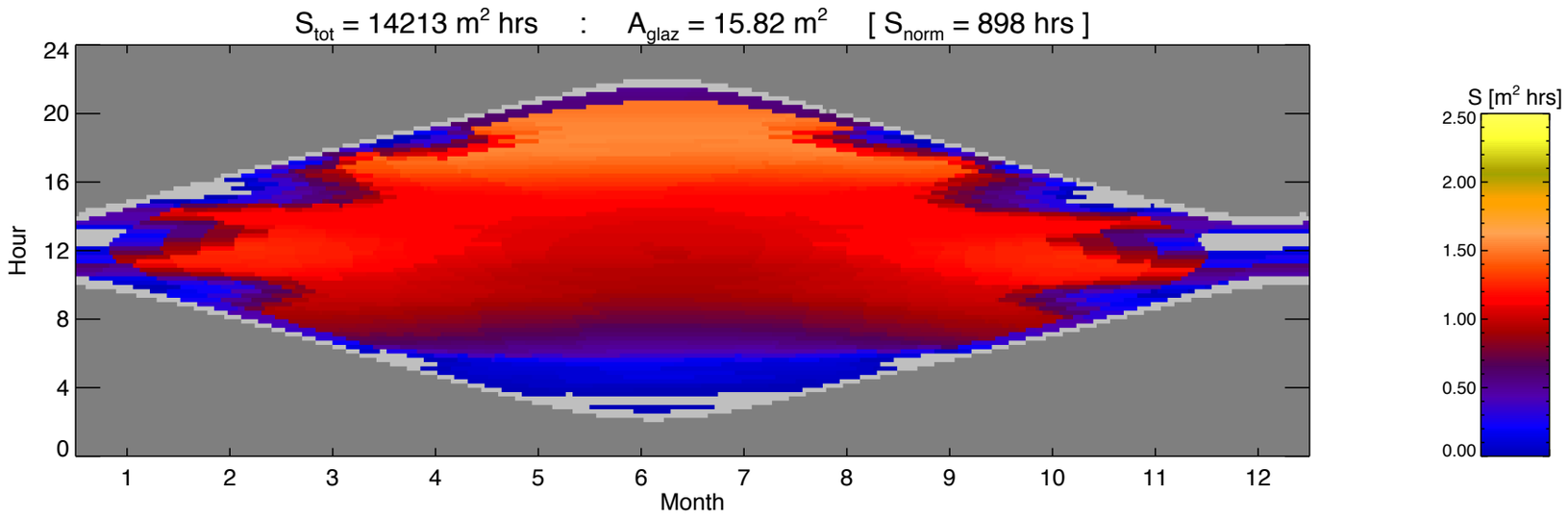

S_{tot} = 543 m² hrs : A_{glaz} = 0.24 m² [S_{norm} = 2264 hrs]
Hour
Month
135 GBR-London
mod01/glaz10b
S [m² hrs]
0.00
0.01
0.02
0.03
0.04
0.05
0.06


000
045
315
N
270
090
135
225
180

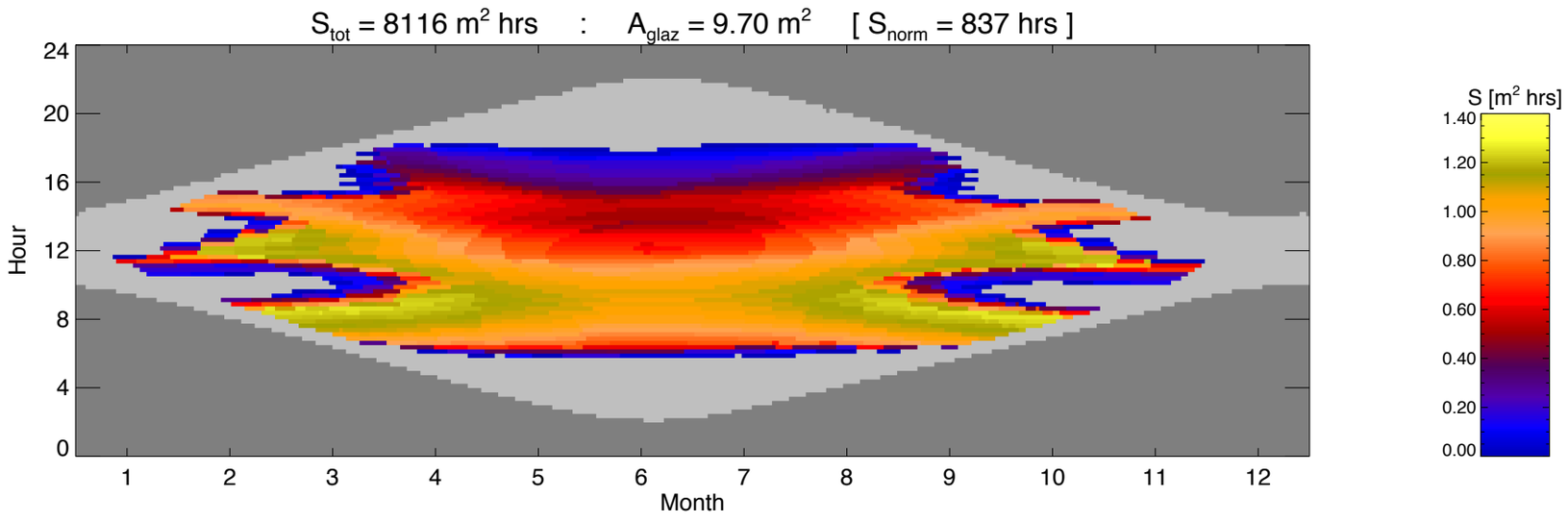




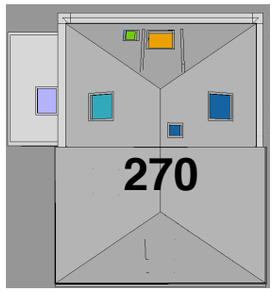
With sunroom

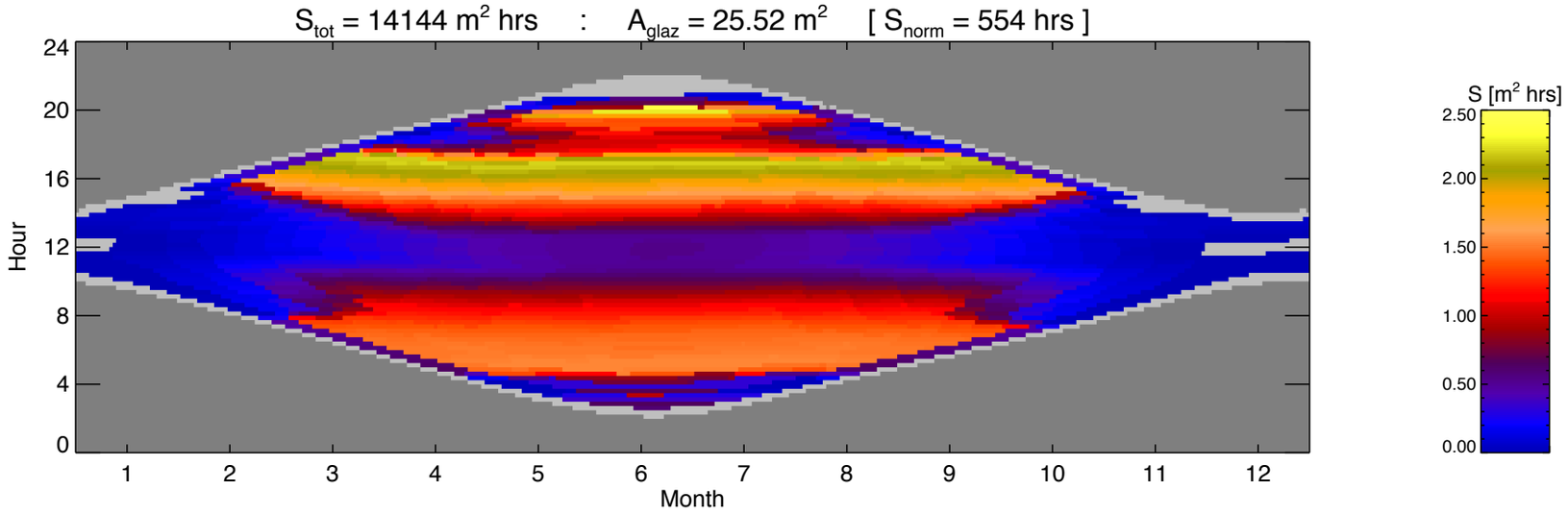


Without sunroom

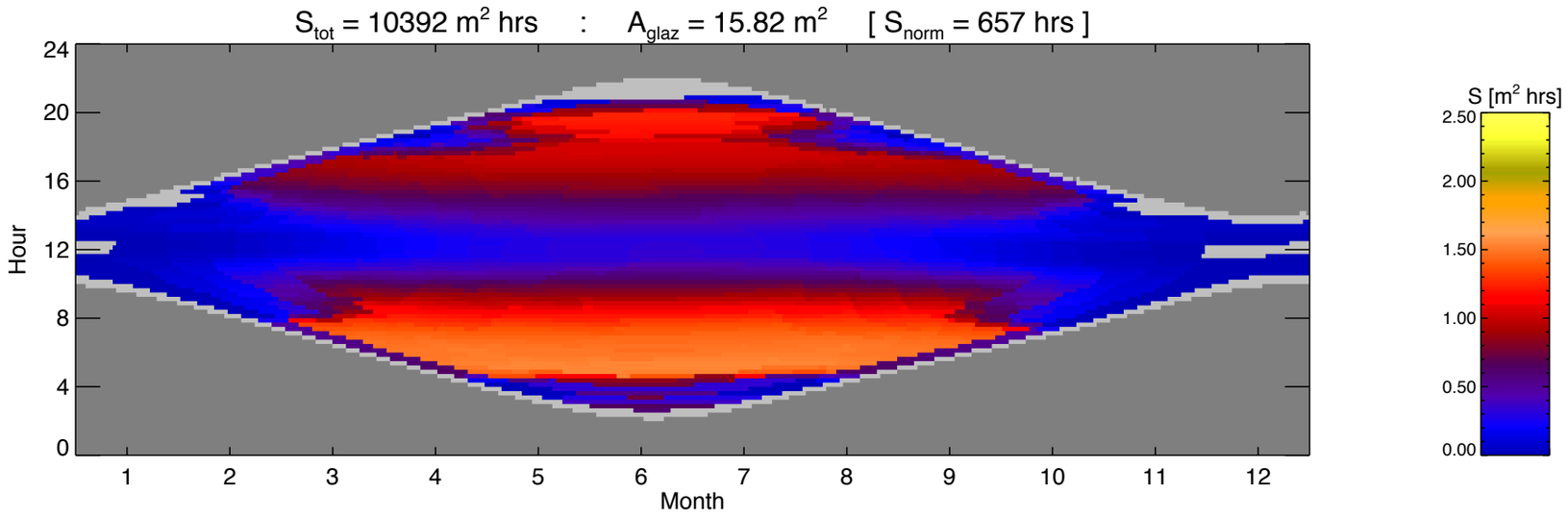


Sunroom only

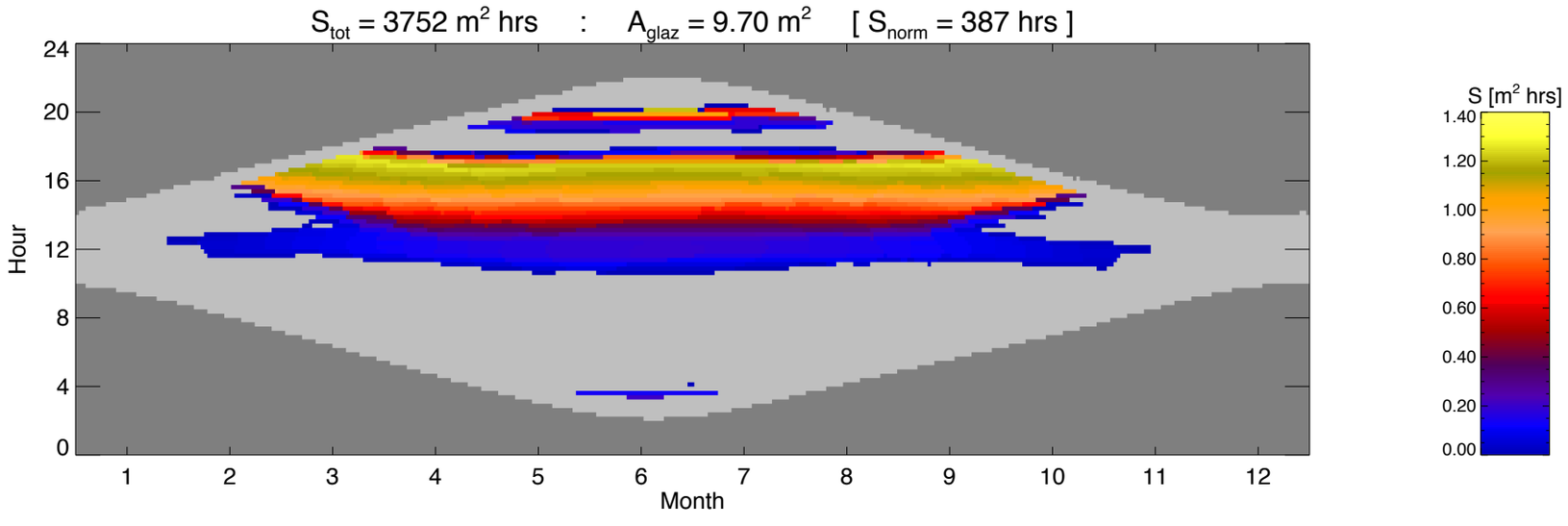




With sunroom

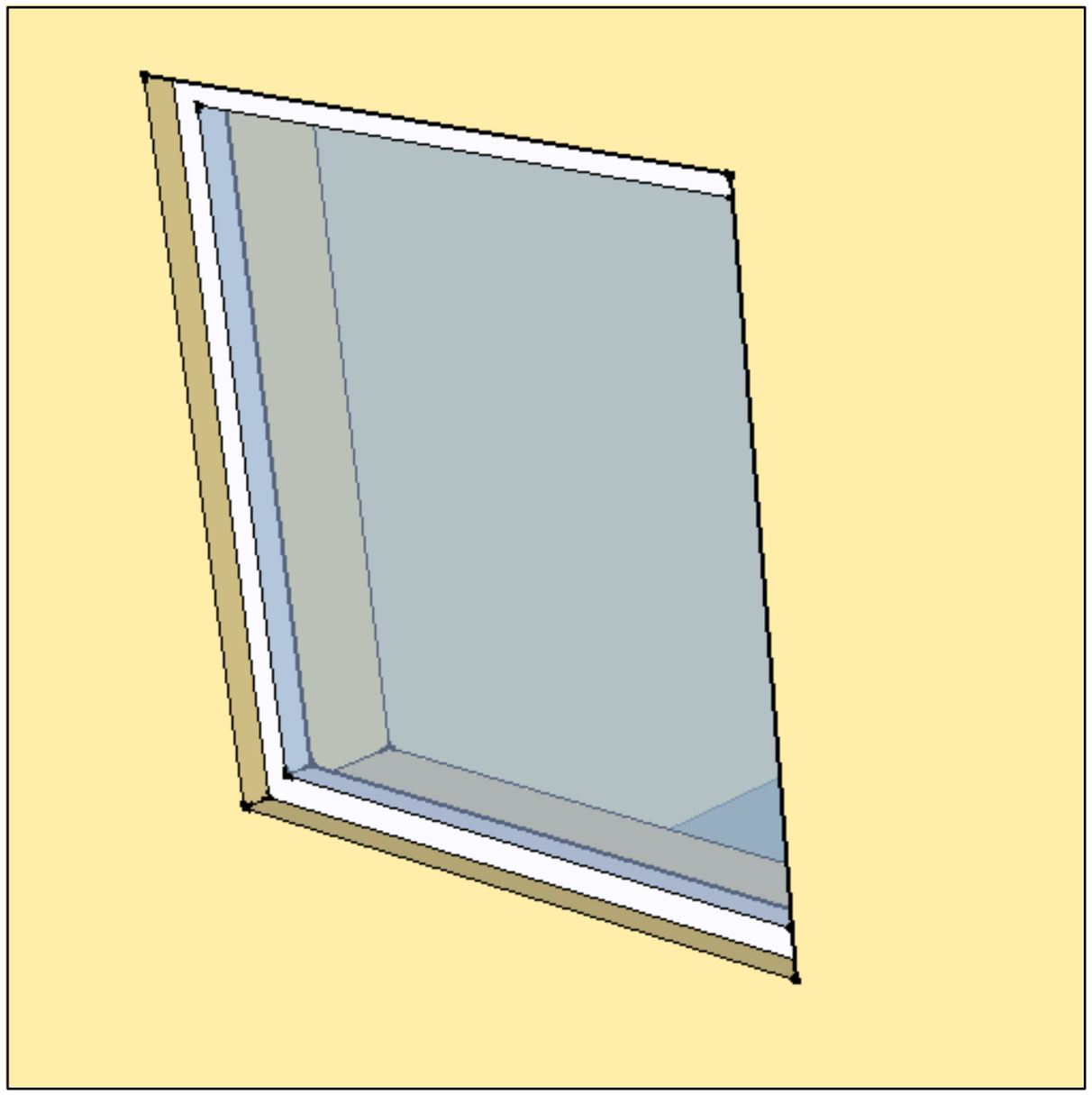


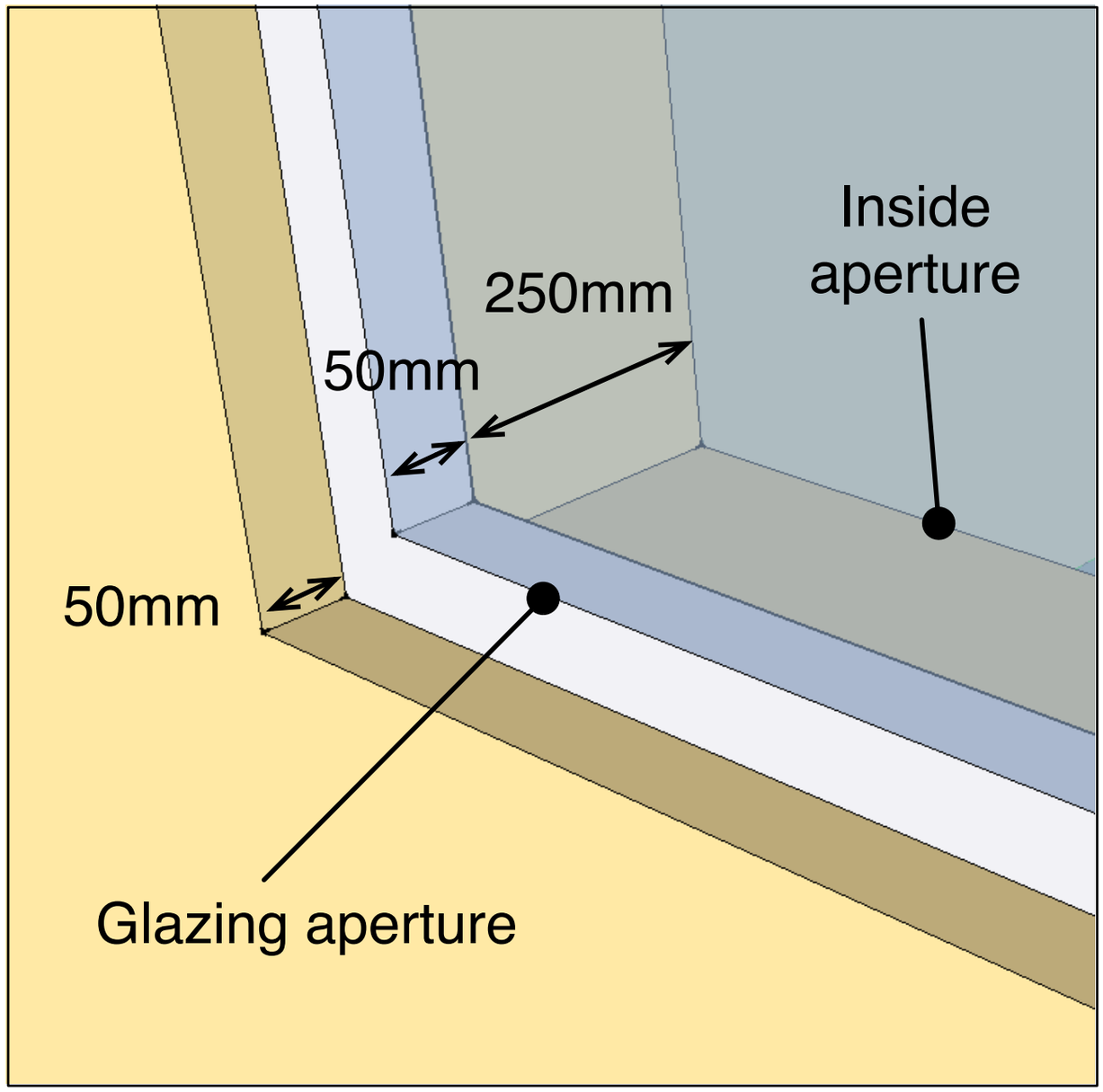
Without sunroom



Sunroom only

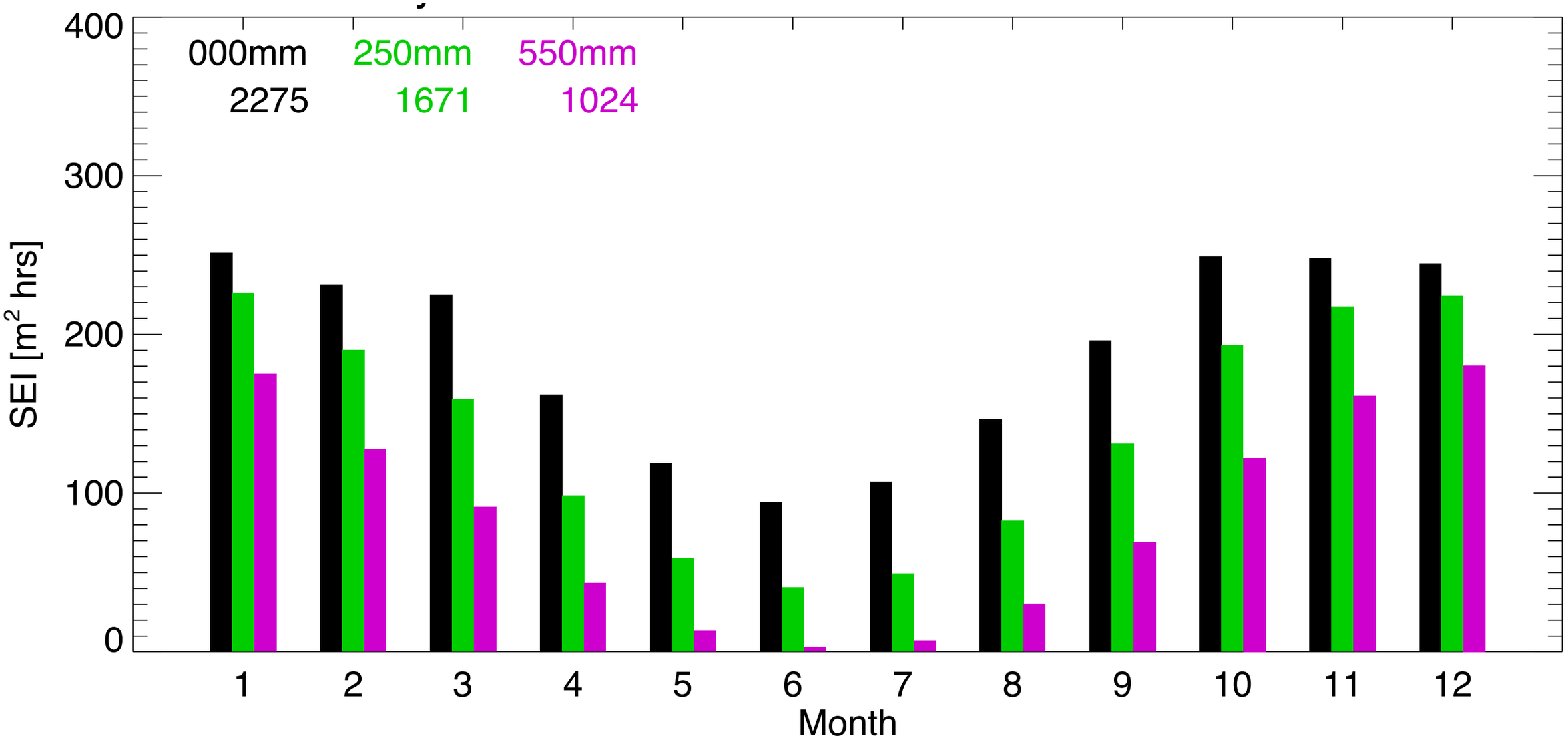
Effect of internal reveals

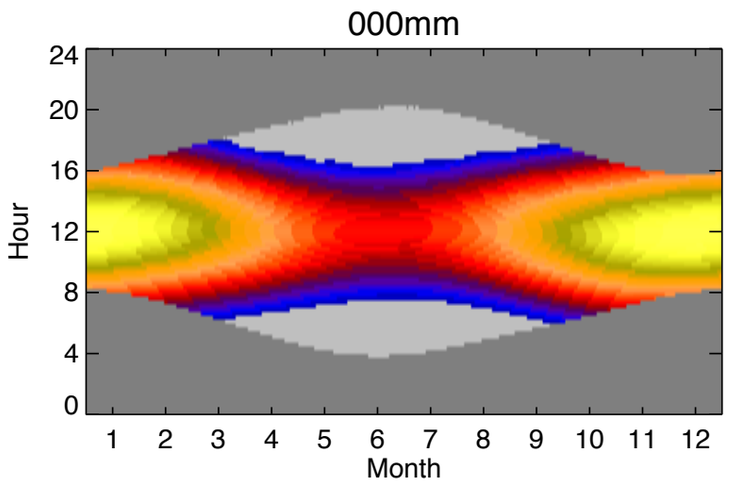


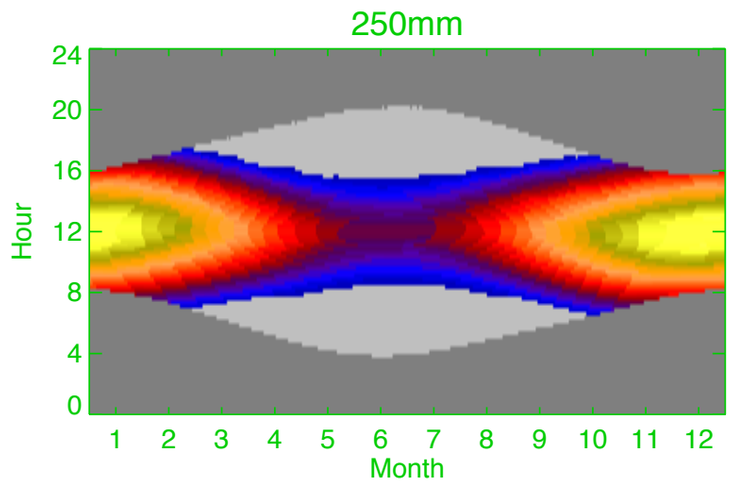


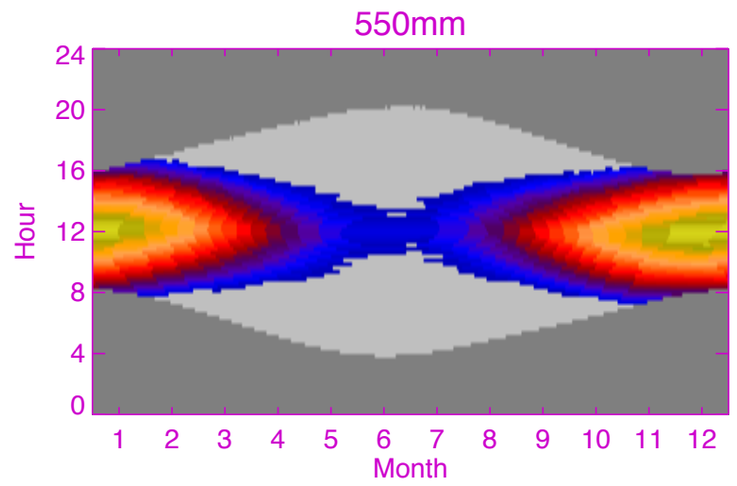
250mm and 550mm reveal depths

Monthly SBI: London (UK), south facing glazing



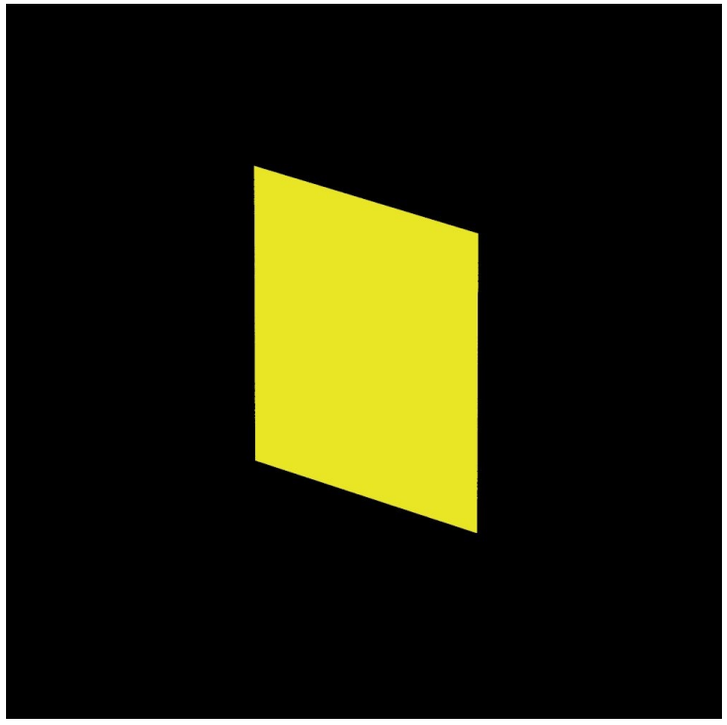




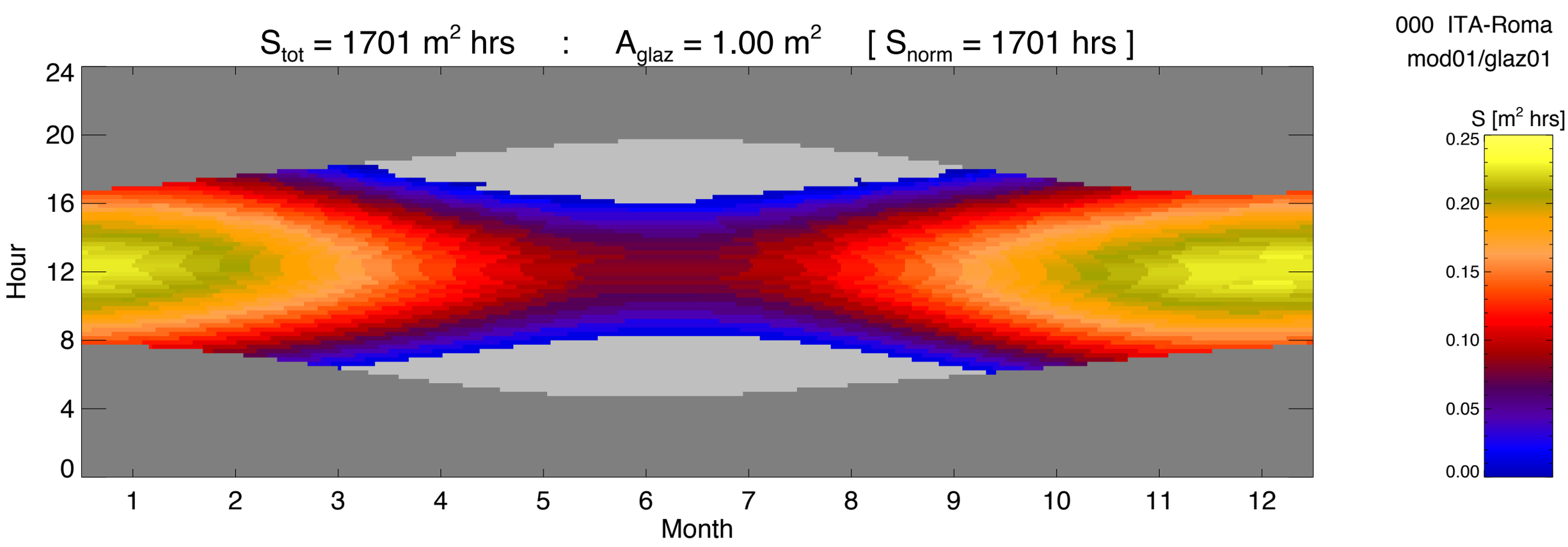


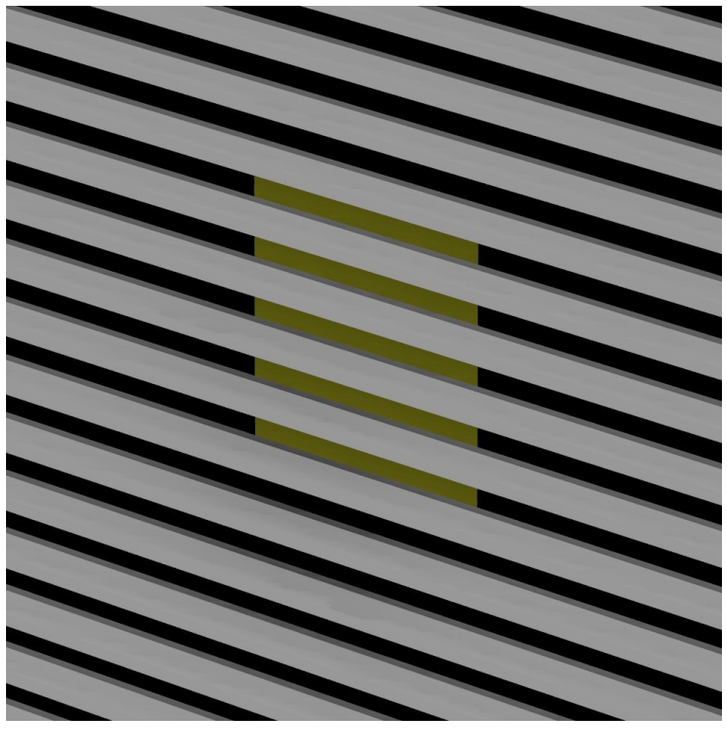
External shading devices

1m² aperture

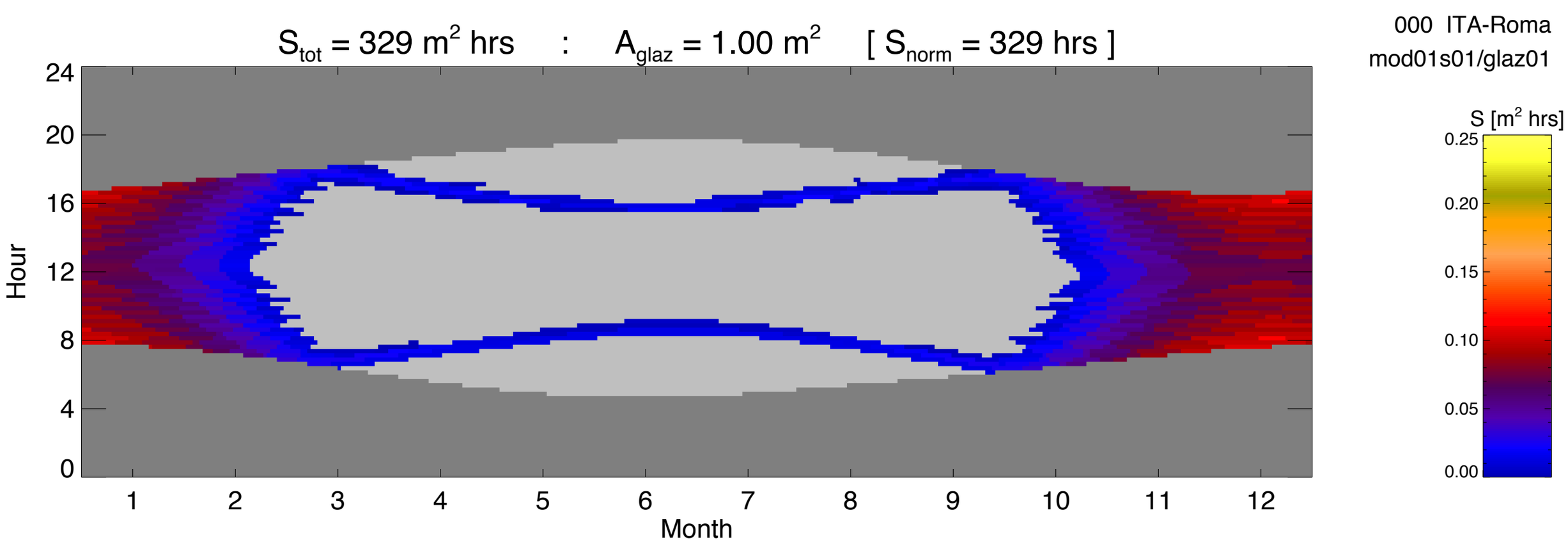


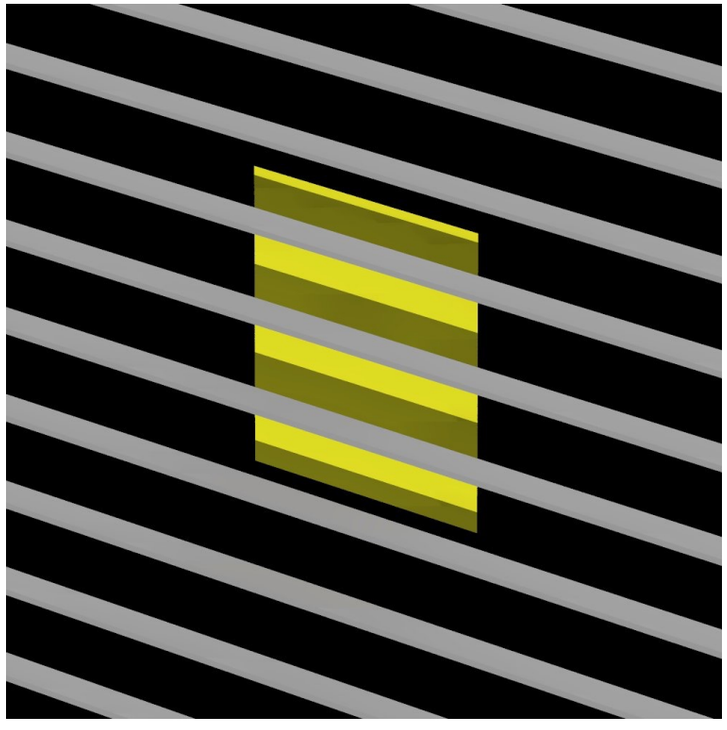
Shading: None



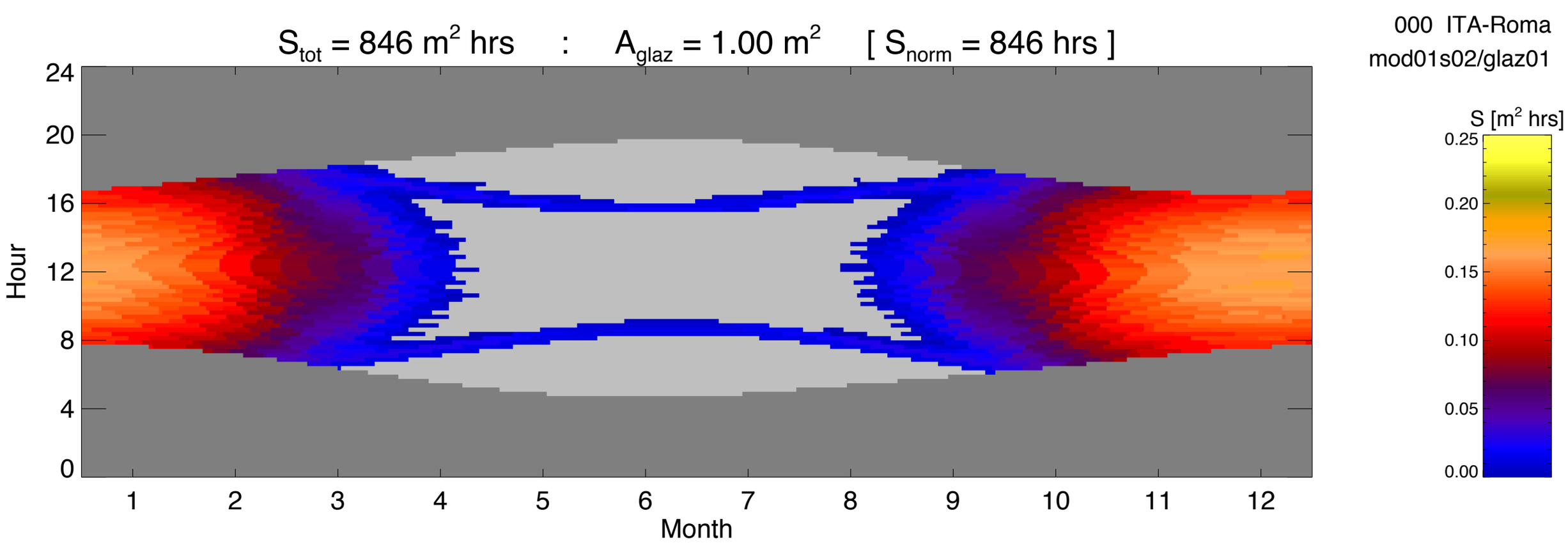


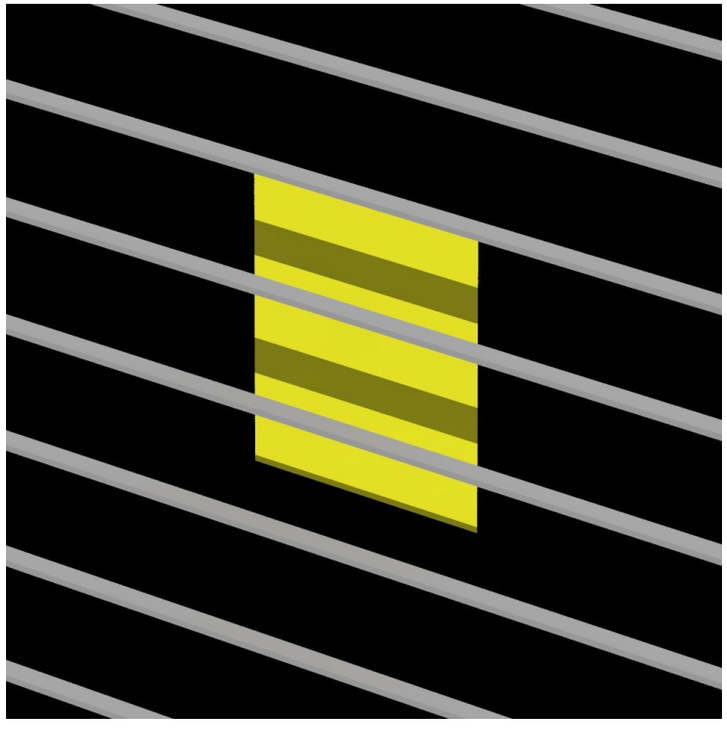
20x4cm
20cm pitch



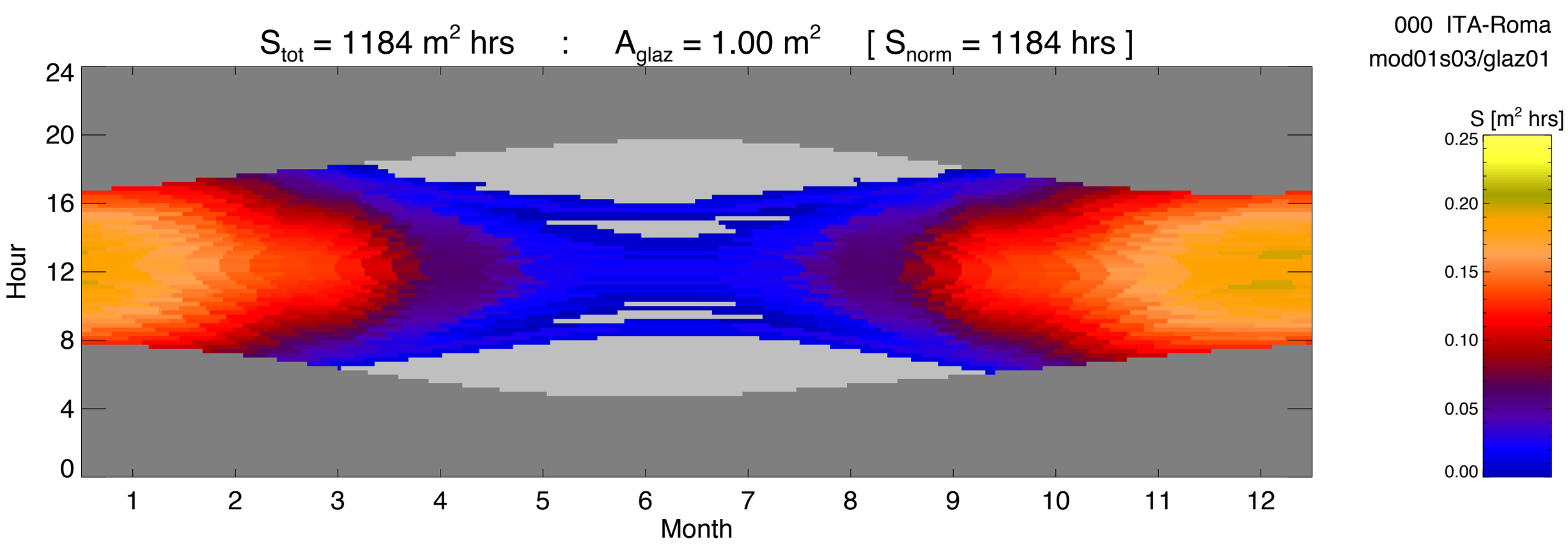


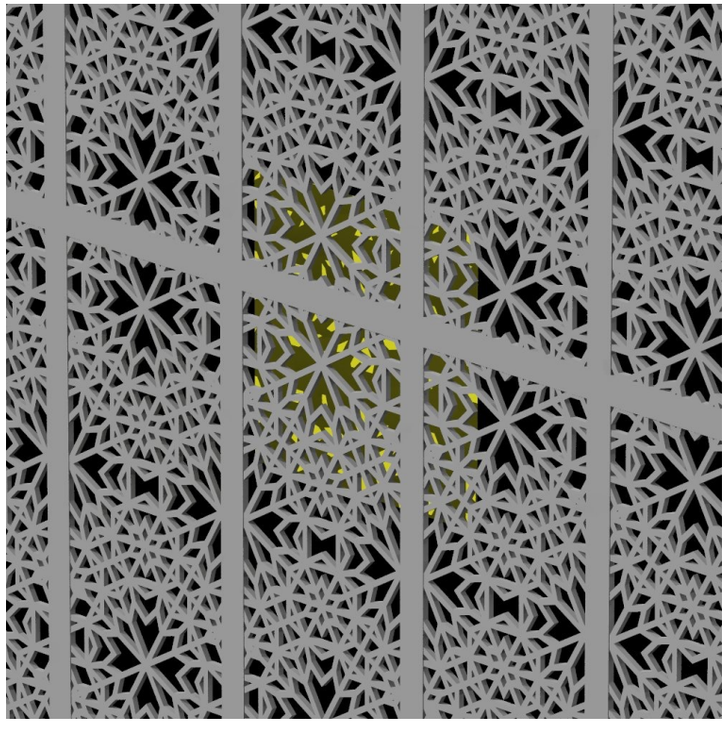
15x2cm
30cm pitch



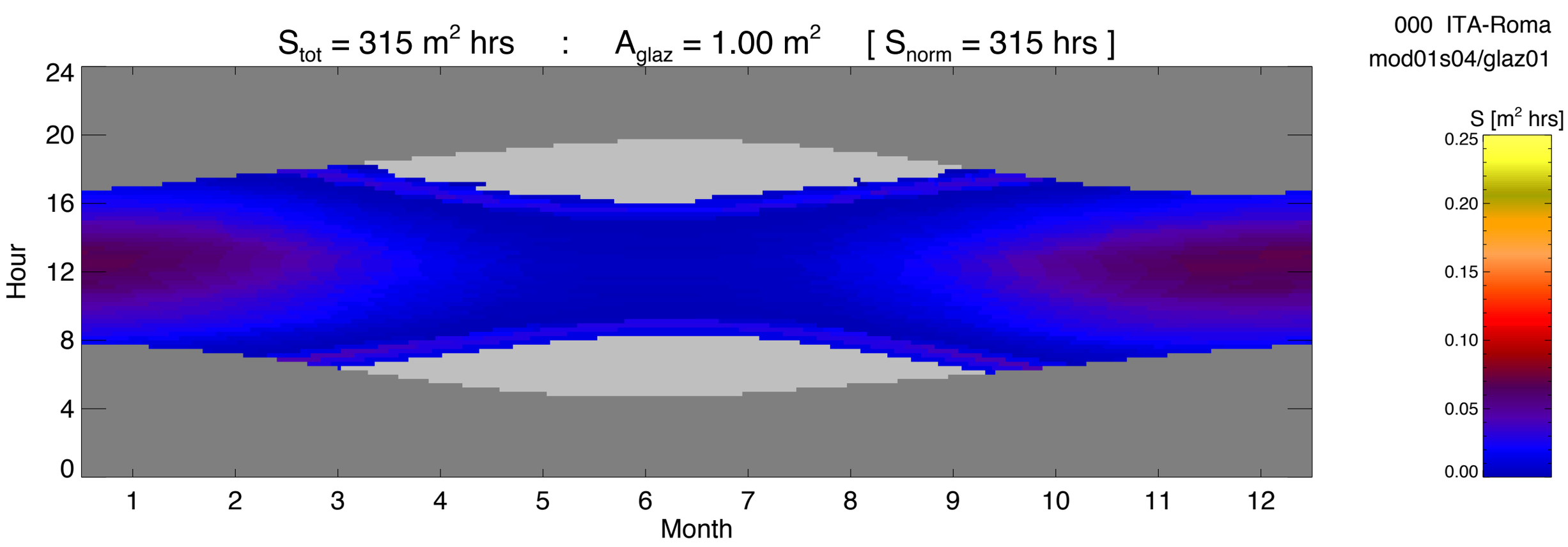


10x2cm
40cm pitch

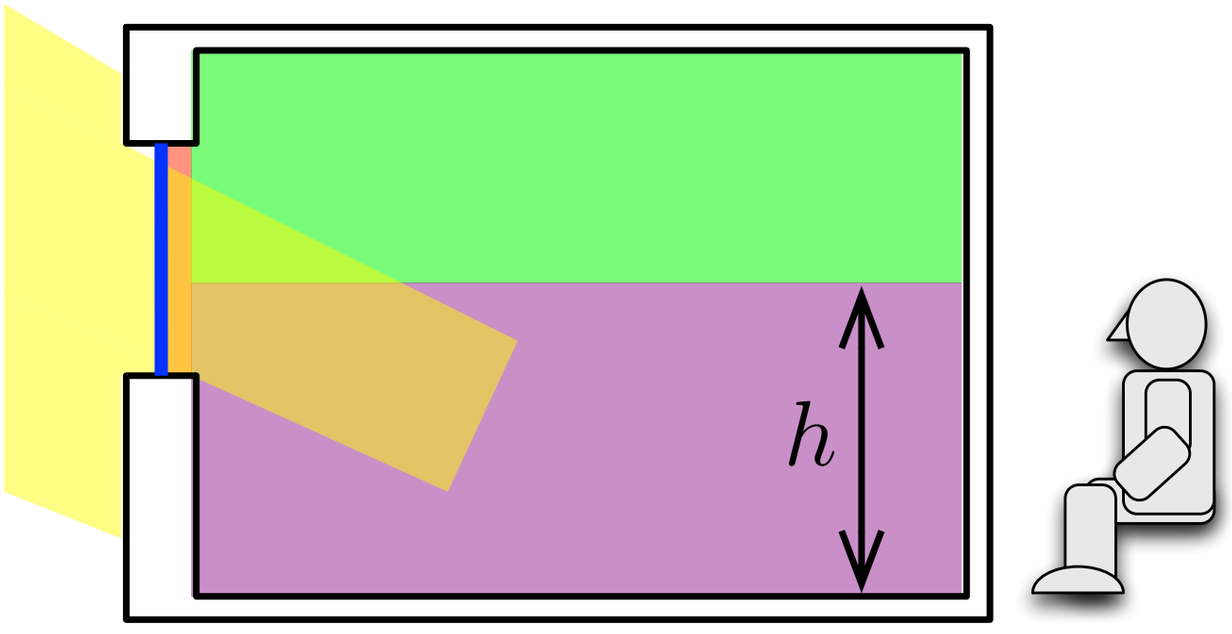


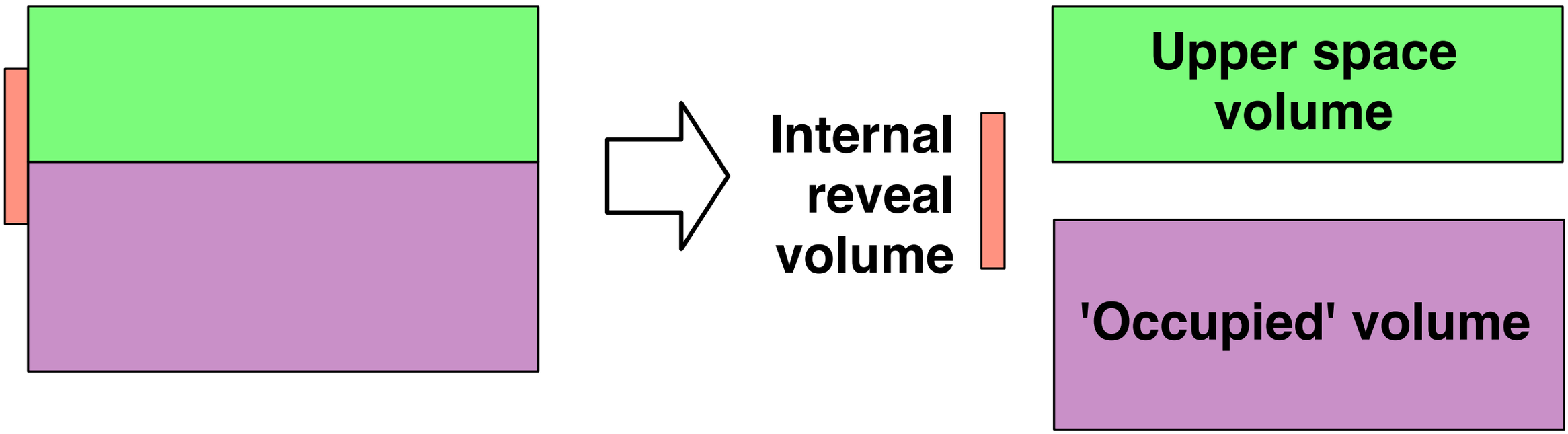


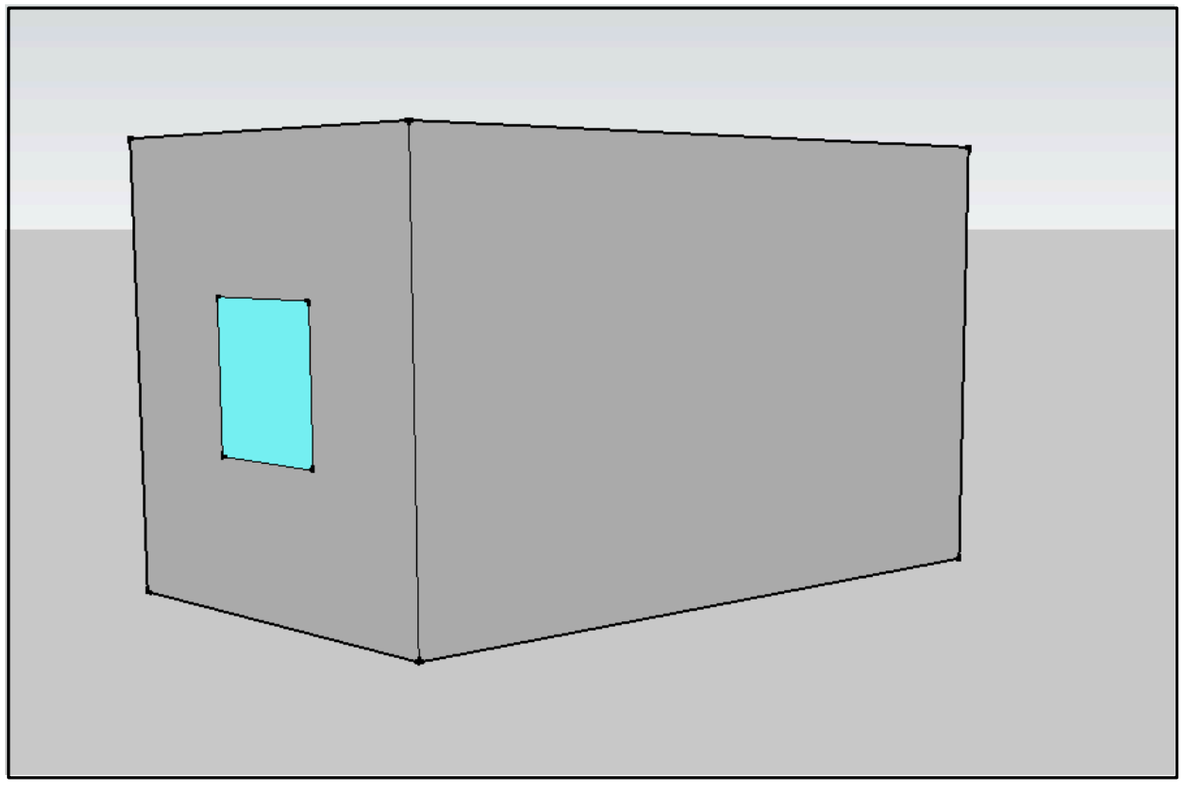
Mashrabiya

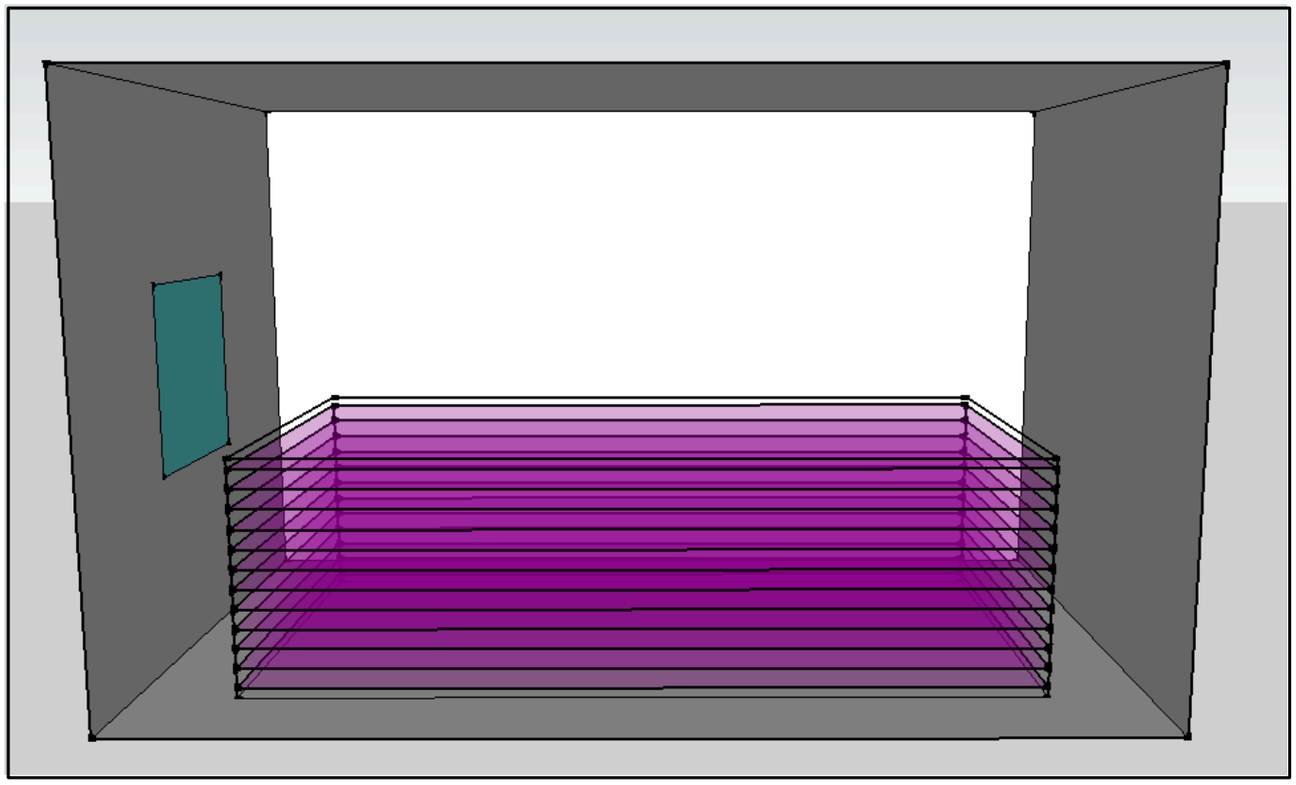

S_{tot} = 315 m^2 hrs : A_{glaz} = 1.00 m^2 [S_{norm} = 315 hrs]
000 ITA-Roma
mod01s04/glaz01
S [m^2 hrs]
0.25
0.20
0.15
0.10
0.05
0.00
Hour
24
20
16
12
8
4
0
1
2
3
4
5
6
7
8
9
10
11
12
Month

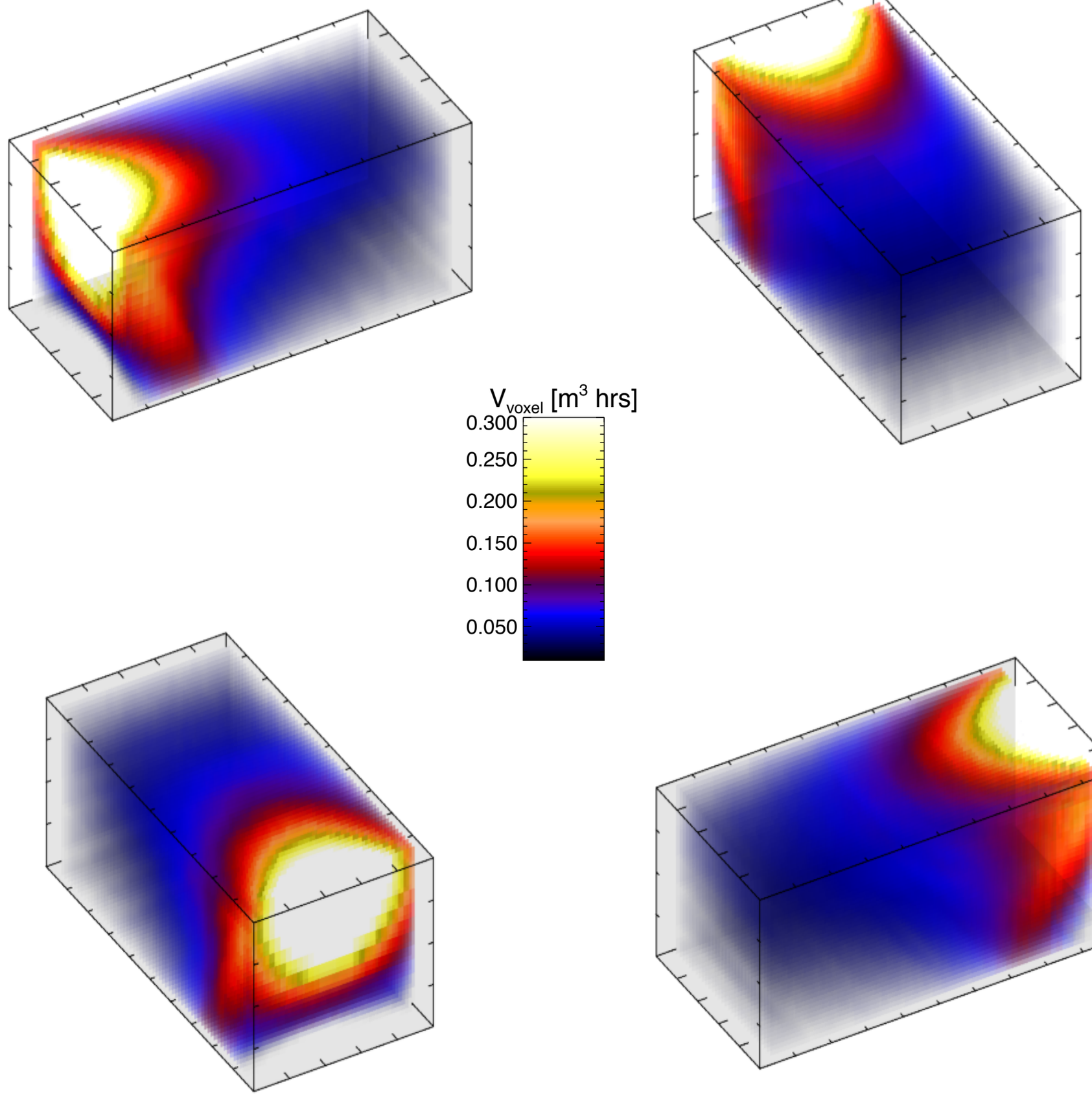
Volumetric evaluation


h

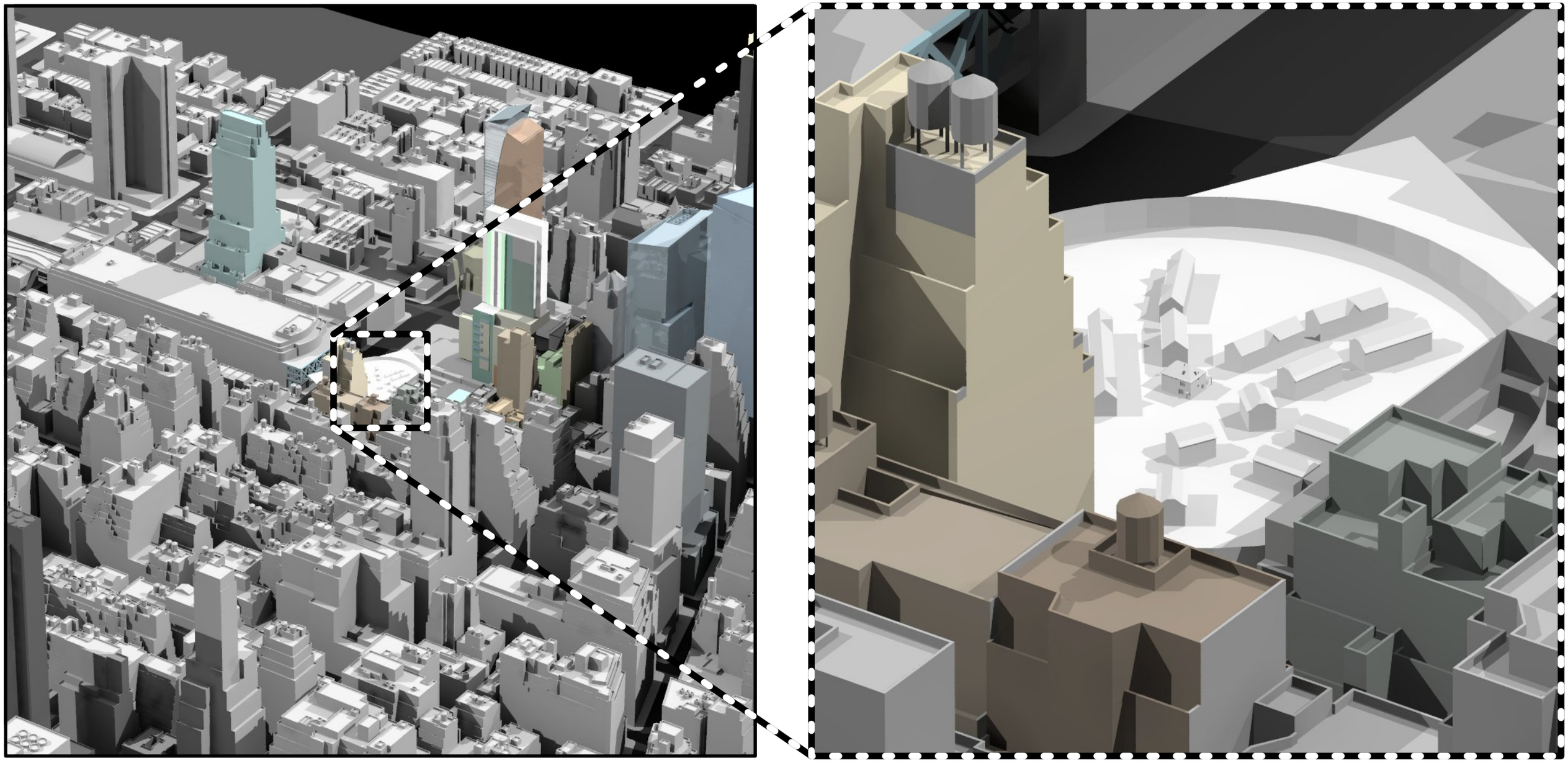

Internal reveal volume
Upper space volume
'Occupied' volume






V_{voxel} [m^3 hrs]
0.300
0.250
0.200
0.150
0.100
0.050

Scaleability



European Committee for Standardization

CEN COMMUNITY | TECHNICAL BODIES | STANDARDS EVOLUTION AND FORECAST | SEARCH STANDARDS

CEN/TC 169/WG 11 - Daylight

General | Work programme | Published Standards

CEN/TC 169/WG 11 Scope

This working group specifies the methods to assess the daylight available in buildings together with methods to assess view, sunlight availability and glare. The working group makes recommendations for the necessary conditions to ensure a minimum level of daylight.

Officers

Convenor	Mr Marc Fontoynont

Further information

CEN Technical Secretariat(s)	DS

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‘Climate connectivity’ in the daylight factor basis of building standards

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J. Mardaljevic and N. Roy. **The sunlight beam index.** *Lighting Research and Technology*, 48(1):55–69, 2016.
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