Detailed characterisation of daylighting under a roof, a dormer and a vertical window:

Final results of an exhaustive simulation project using Radiance

Marie-Claude Dubois (ass. professor)
François Cantin, Nicolas Roy (students)

Kjeld Johnsen, Karl Grau (senior researchers)

Radiance Workshop Montreal 2005

Image: Nicolas Roy, 2004

Question

Which design gives good daylight?

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Question

Which design gives good daylight?

What is daylight quality?

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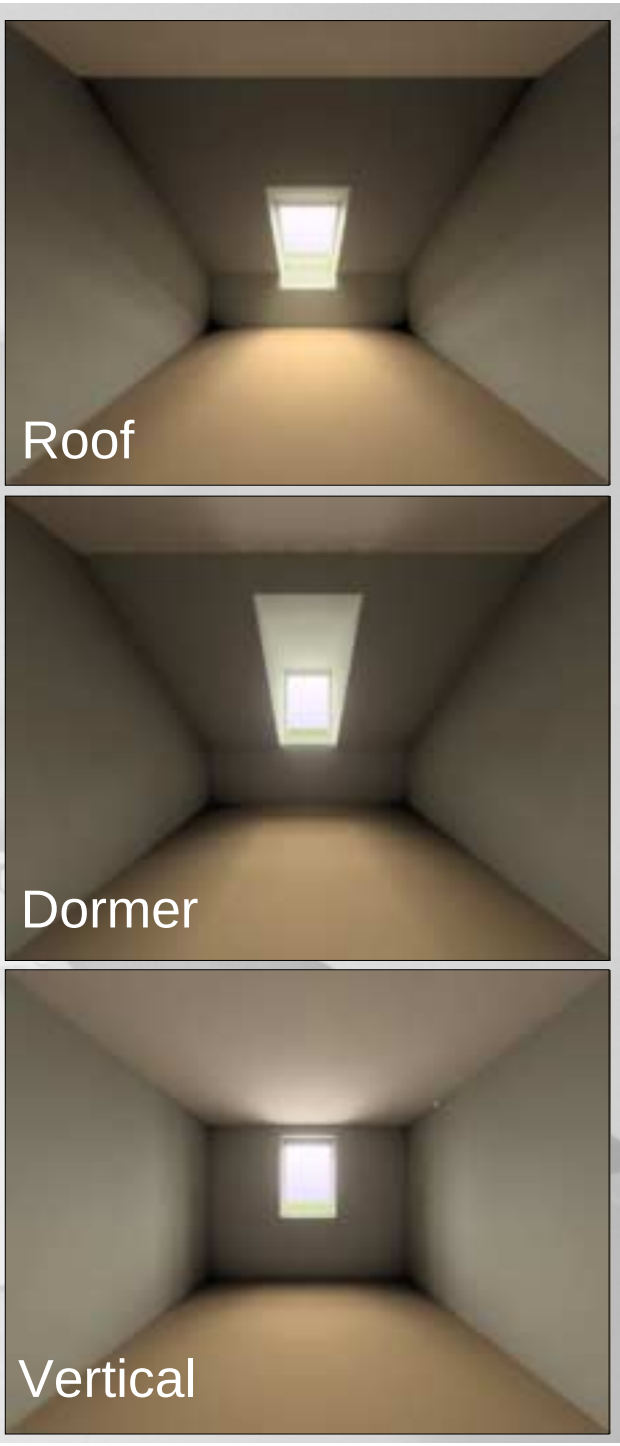
Method

Performance indicators

1. Horizontal illuminance
2. Cylindrical illuminance
3. Daylight factor (overcast)
4. Cubic illuminance
5. Vertical-to-horizontal illuminance
6. Daylight glare index
7. Sunlight patch (position, size, lum)
8. Luminance difference (LD) index
9. Luminance ratios
10. Scale of shadow
11. Average luminance 40º band



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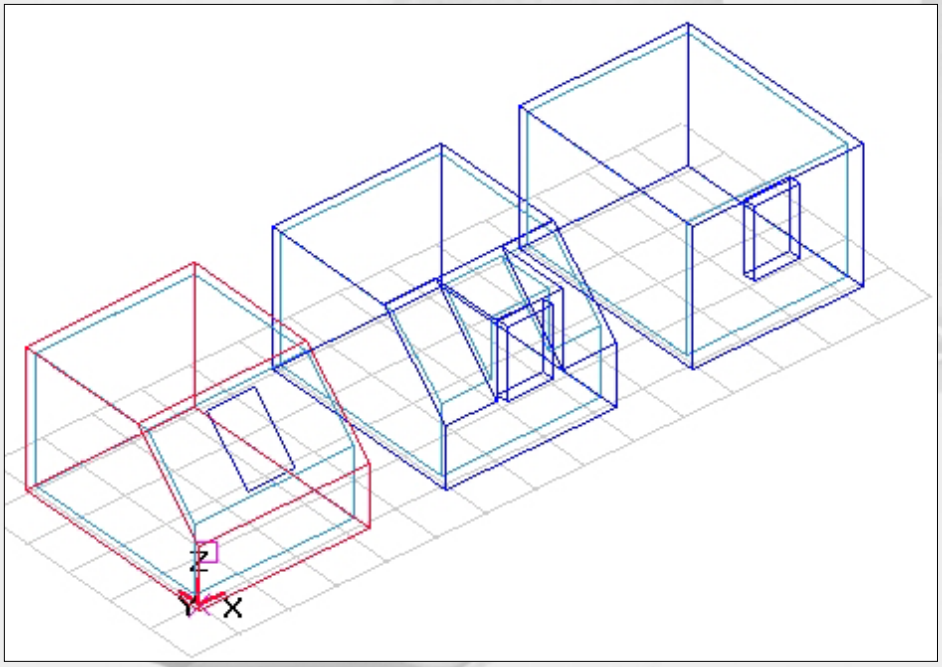
Method

Latitude, skies, orientations

Climate (DRY file) of Copenhagen (latitude 55.4ºN)



Skies:
Overcast
Intermediate
Sunny

Orientations:
South
West (East symmetrical)
North

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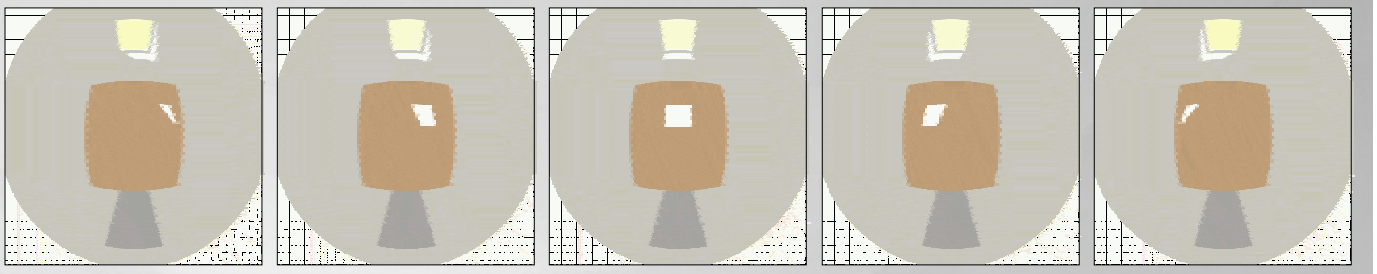
Method

Sunny skies



South

	Jan	Feb	Mar	Apr	May	Jun	Dec	Total
Vertical	10, 12	10, 12	8, 10, 12	8, 10, 12	8, 10, 12	8, 10, 12	10, 12	18
Dormer	10, 12	10, 12	8, 10, 12	8, 10, 12	8, 10, 12	8, 10, 12	10, 12	18
Roof	10, 12	10, 12	8, 10, 12	8, 10, 12	8, 10, 12	8, 10, 12	10, 12	18
								54

West (East symmetrical)

	Jan	Feb	Mar	Apr	May	Jun	Dec	Total
Vertical	14	14,16	14, 16	14, 16, 18	14, 16, 18, 20	14, 16, 18, 20	14	17
Dormer	14	14,16	14, 16	14, 16, 18	14, 16, 18, 20	14, 16, 18, 20	14	17
Roof	12, 14	12, 14, 16	12, 14, 16	10, 12, 14, 16, 18	10, 12, 14, 16, 18, 20	10, 12, 14, 16, 18, 20	12, 14	27
								61

North

	Apr	May	Jun	Total
Vertical		6, 18, 20	6, 18, 20	6
Dormer	6	6, 18, 20	6, 20	6
Roof	6, 8, 18	6, 8, 10, 12, 14, 16, 18, 20	6, 8, 10, 12, 14, 16, 18, 20	19
				31

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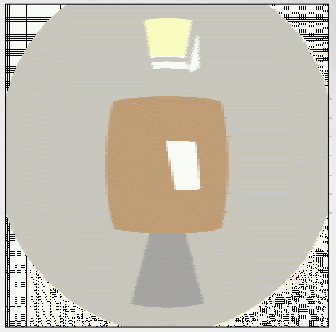
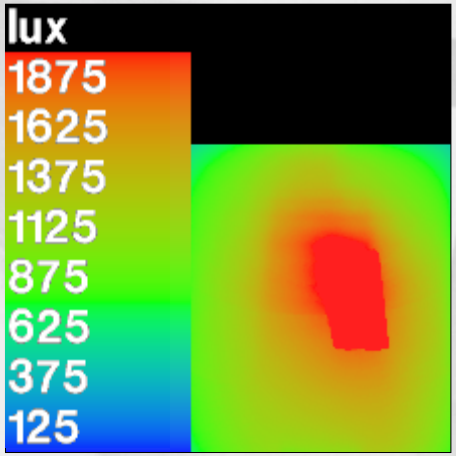
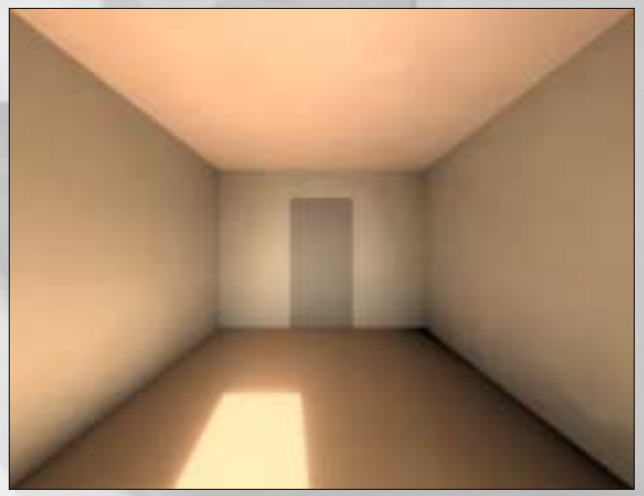
Total = 146 sunny skies

Method

Renderings, dormer, June 21, 16:00, west







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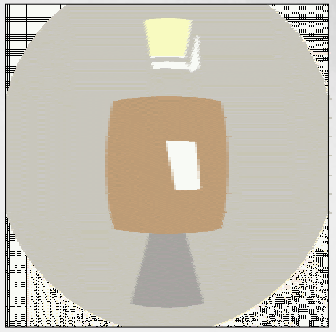
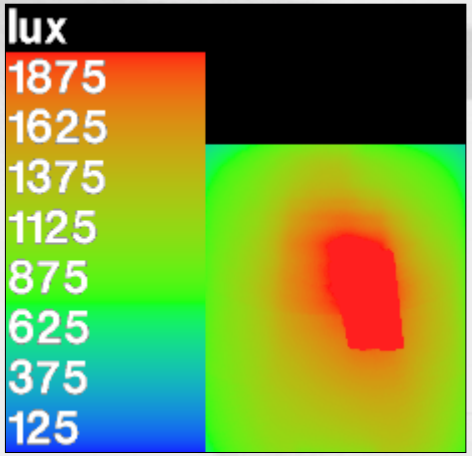
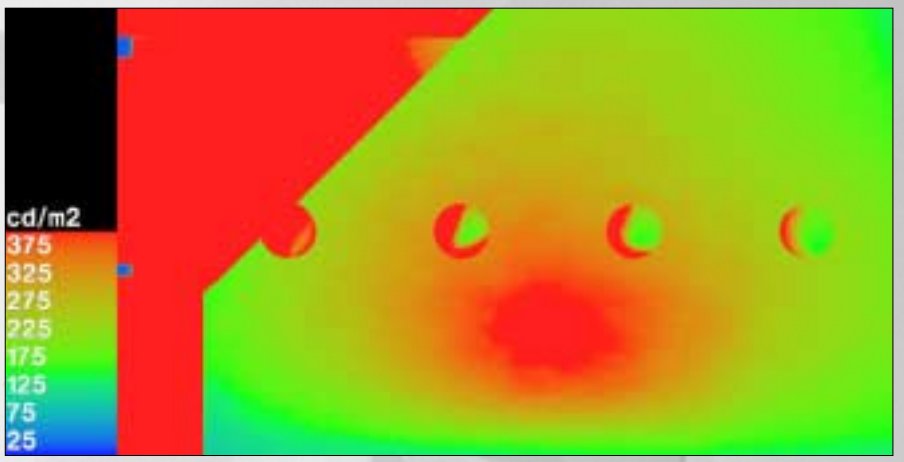
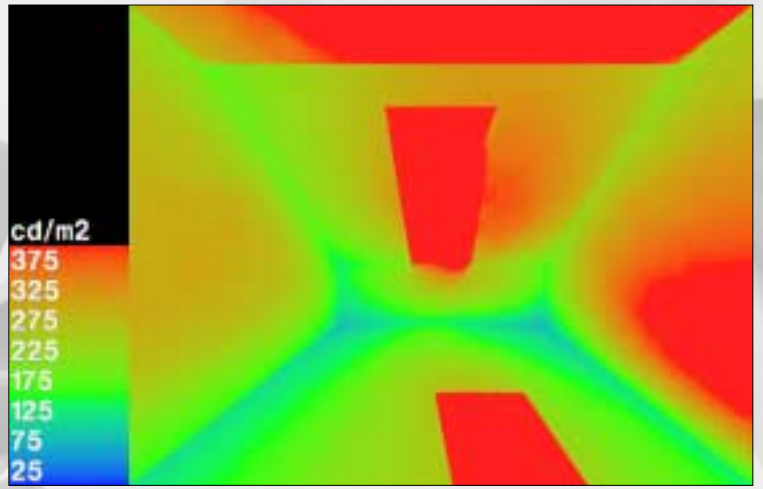
Method

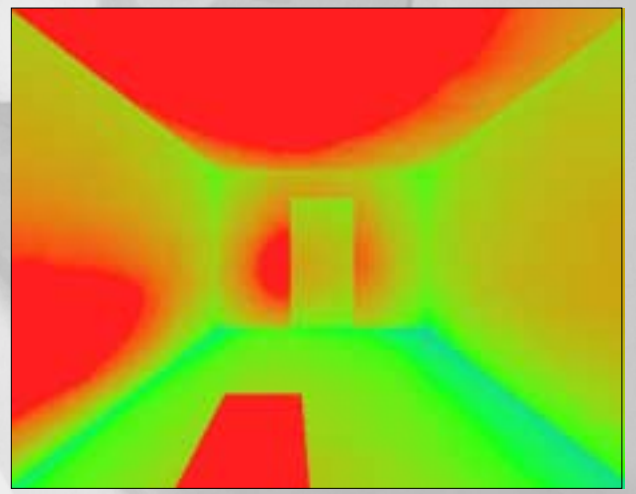
Renderings, dormer, June 21, 16:00, west











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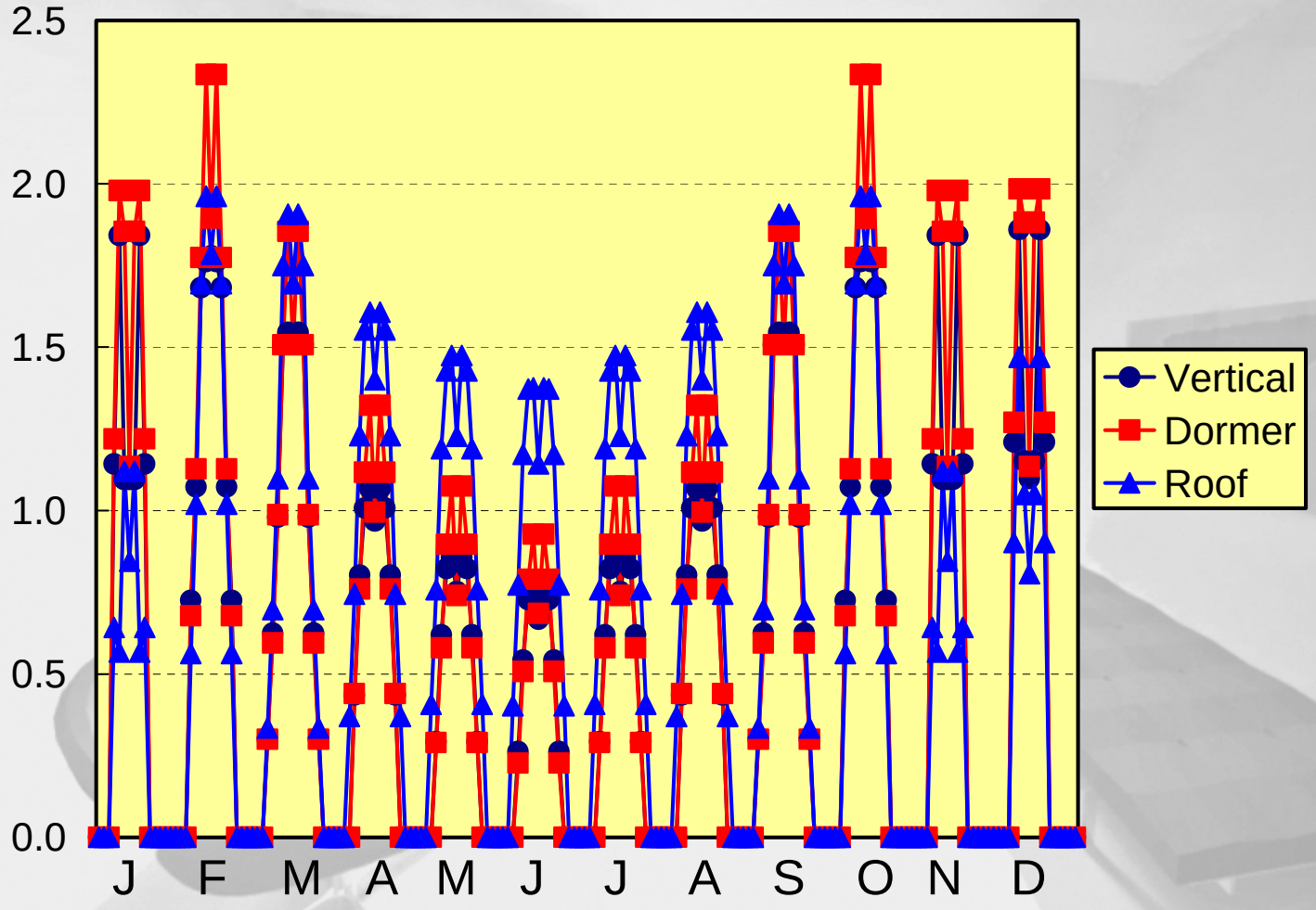
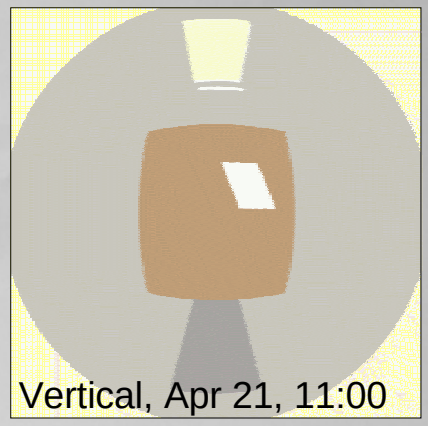
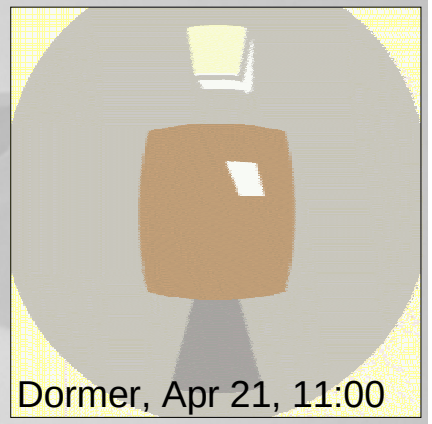
(146 + 2) skies x 3 orientations x 3 models x 4 renderings = 5328 renderings

Results

Size (m^2) of sunlight patch, south







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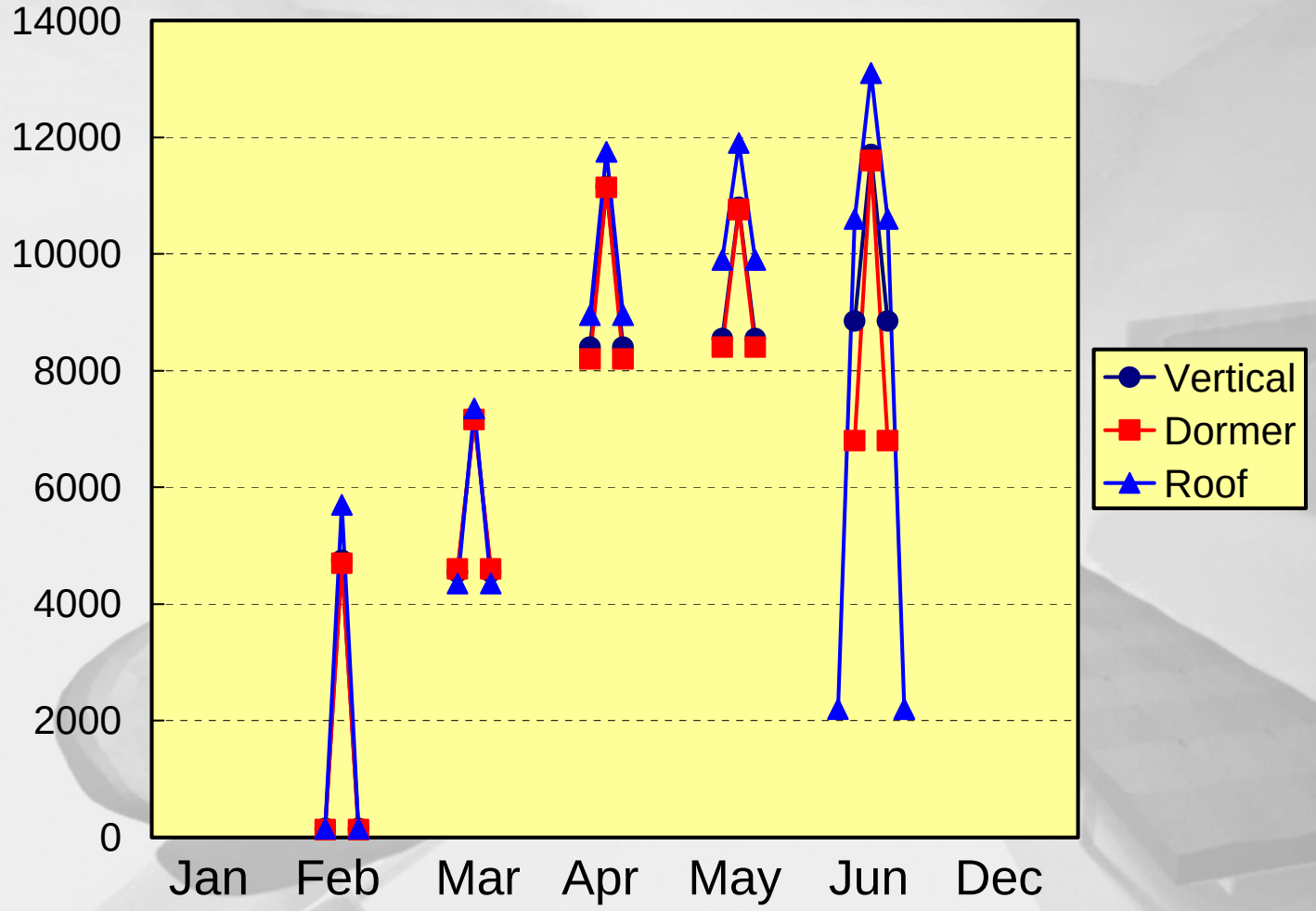
Results

Luminance (cdm^{-2}) of sunlight patch, floor, south



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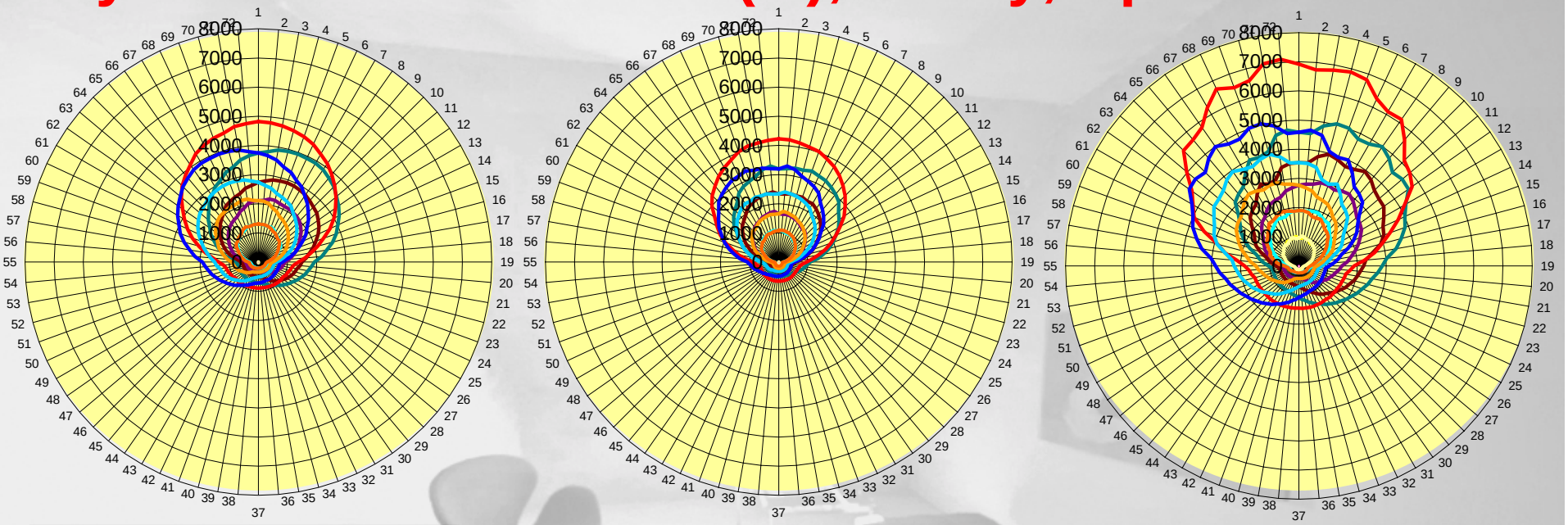
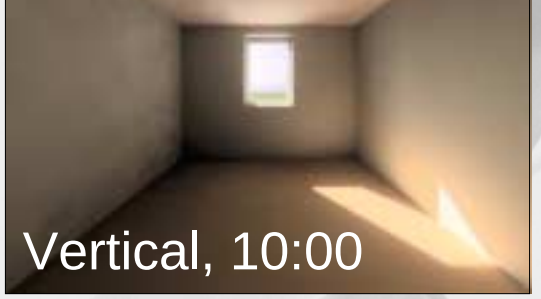
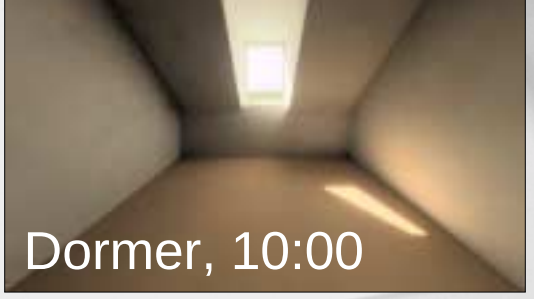
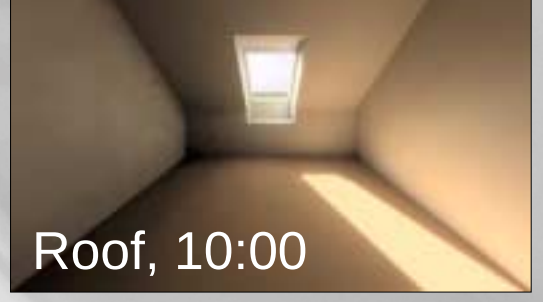
Results

Cylindrical illuminance (lx), sunny, April 21









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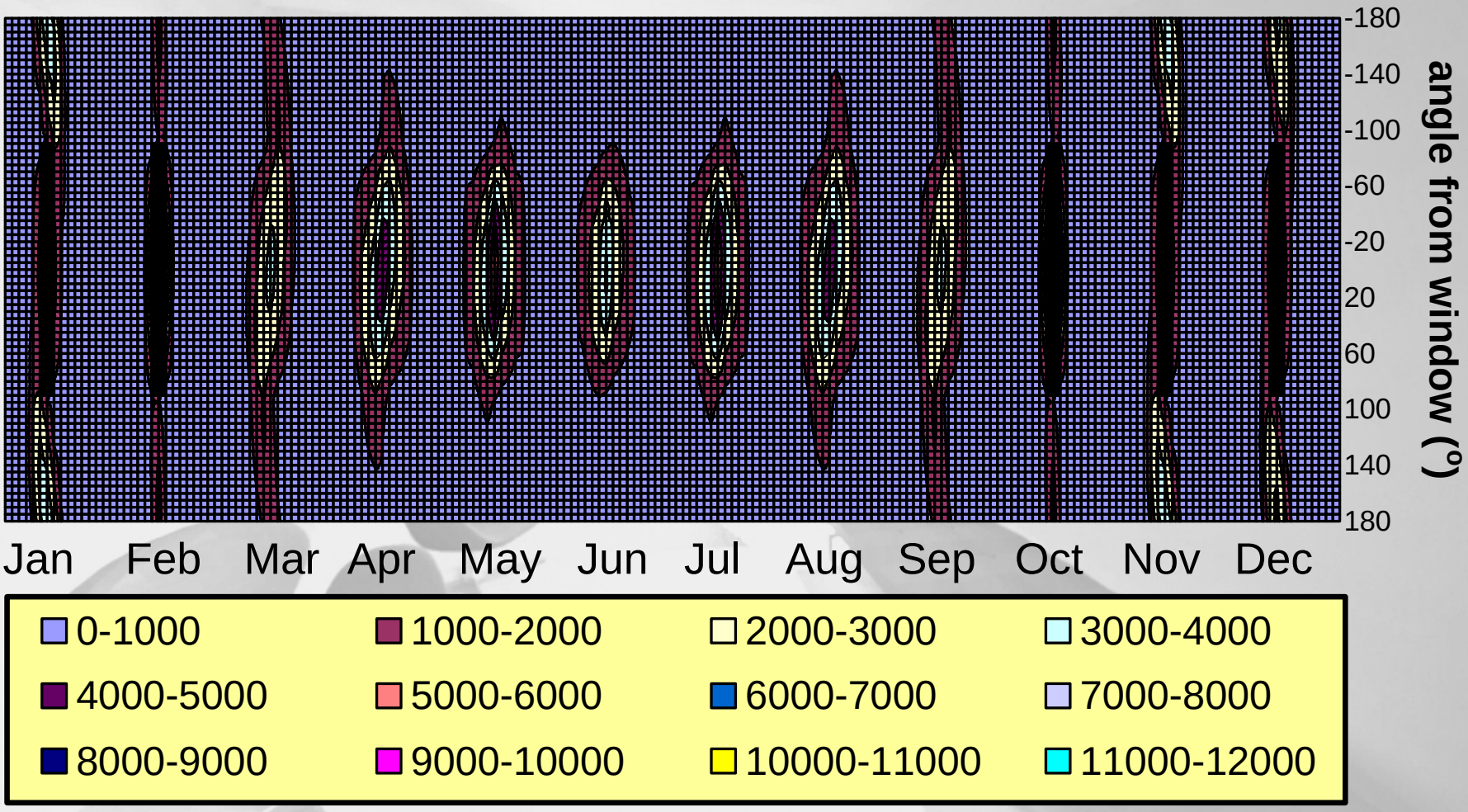
Results

Cylindrical illuminance (lx), sunny, vertical



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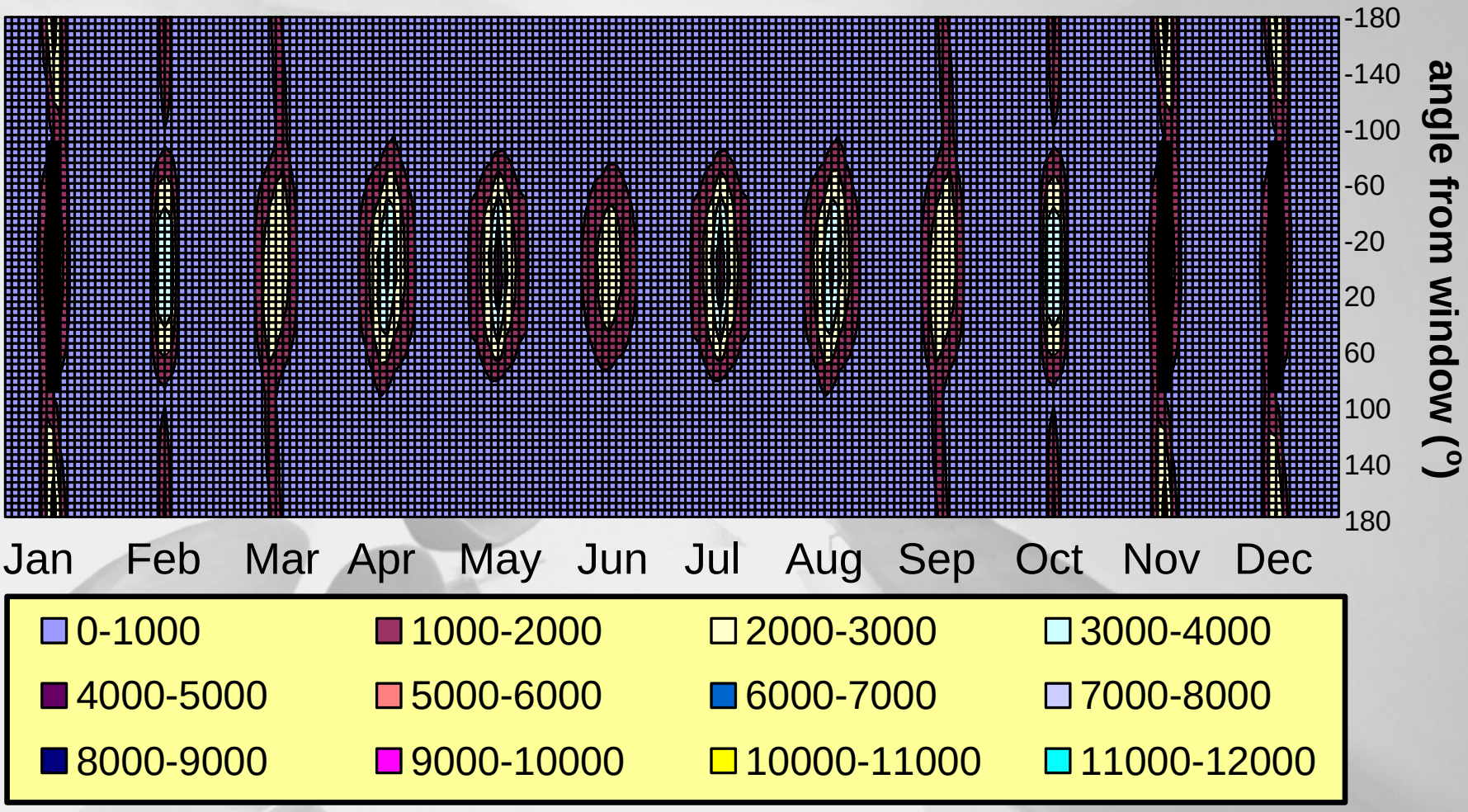
Results

Cylindrical illuminance (lx), sunny, dormer



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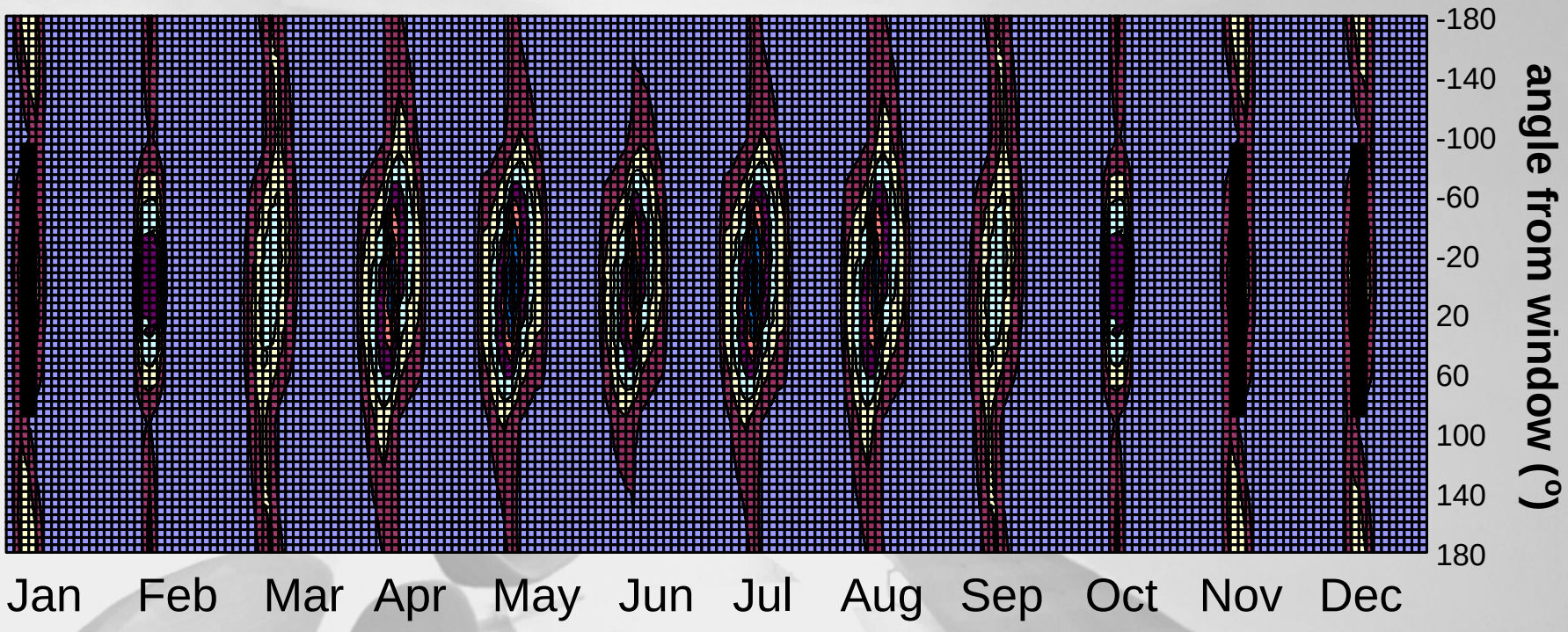
Results

Cylindrical illuminance (lx), sunny, roof



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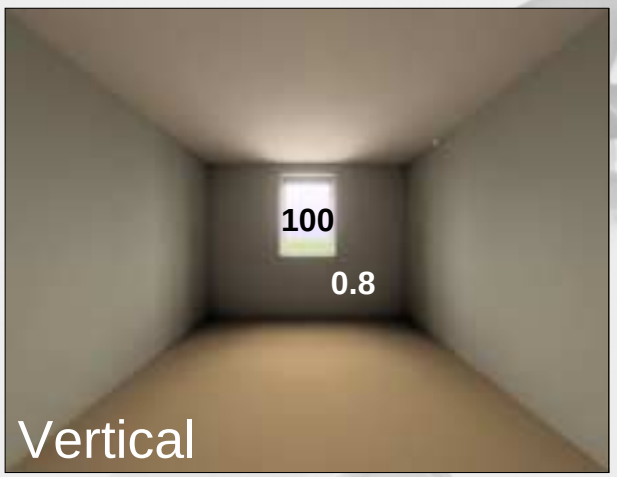
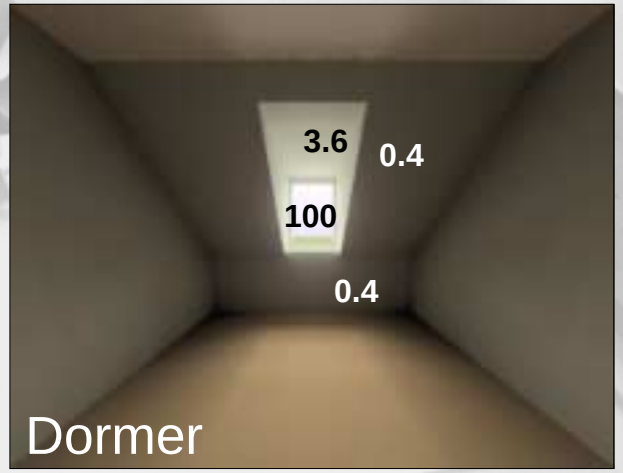
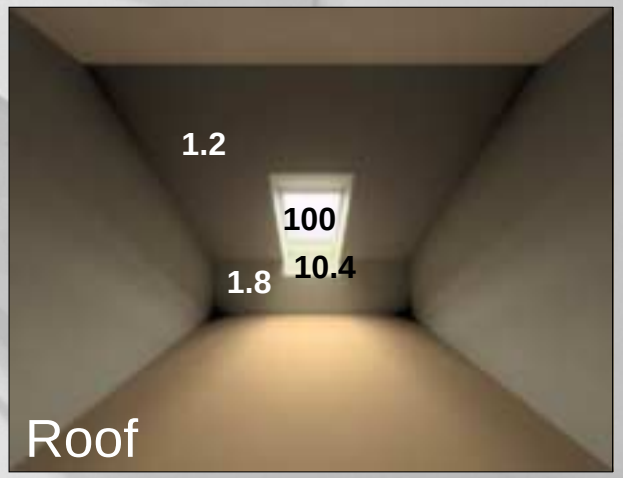
Results

Luminance ratios, overcast

	Window (sky) original data (cd/m²)	Window (sky)	Window (whole)	Window (ground)	Linings	Floor (front)	Floor (back)	Ceiling (front)	Ceiling (back)	West wall (front)	West wall (back)	East wall (front)	East wall (back)	North (back) wall	South wall	Slope south
Overcast																
Vertical	1944	100	92.3	7.3	0.8	1.9	1.3	1.7	1.3	1.6	1.4	1.6	1.4	1.3	0.8	0.8
Dormer	1891	100	90.9	7.5	0.4	1.2	0.9	0.7	0.8	0.6	0.6	0.6	0.6	0.9	0.4	0.4
Roof	1828	100	94.0	10.2	10.4	3.8	1.9	2.0	1.8	1.9	1.6	1.9	1.6	1.5	1.0	1.0







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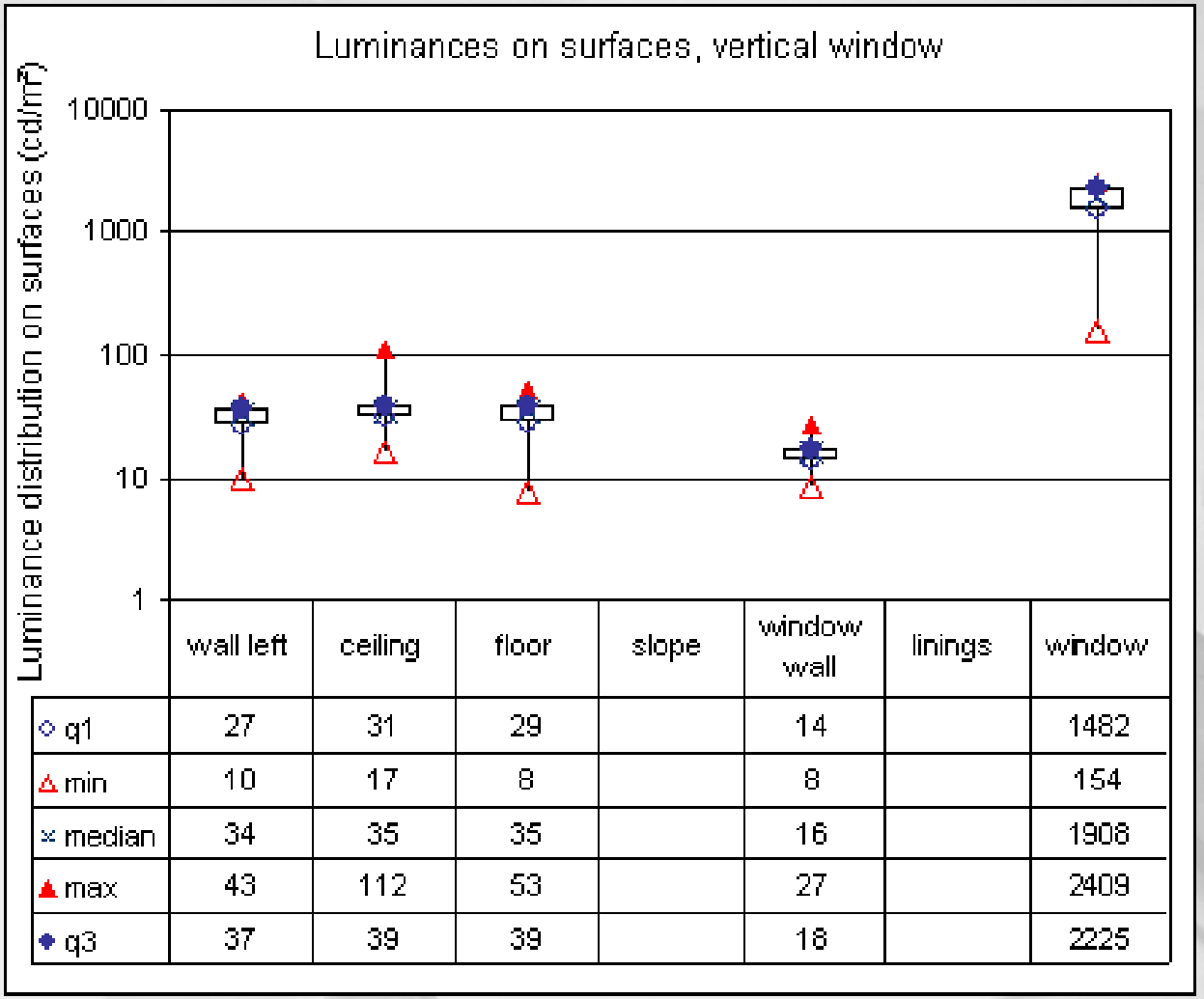
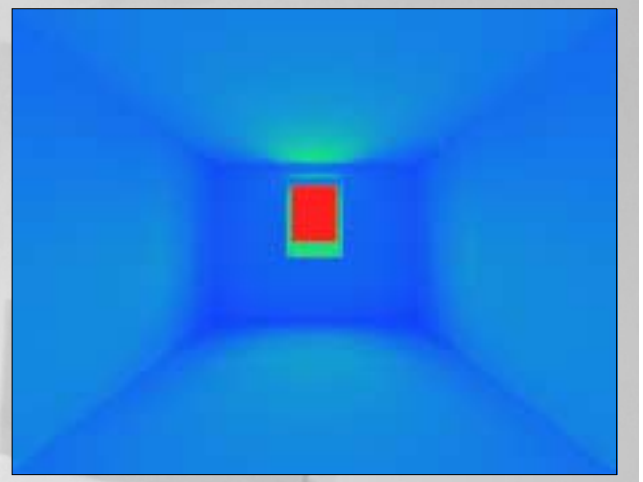
Results

Luminance ratios, overcast, vertical



	wall left	ceiling	floor	slope	window wall	linings	window
q1	27	31	29		14		1482
min	10	17	8		8		154
median	34	35	35		16		1908
max	43	112	53		27		2409
q3	37	39	39		18		2225



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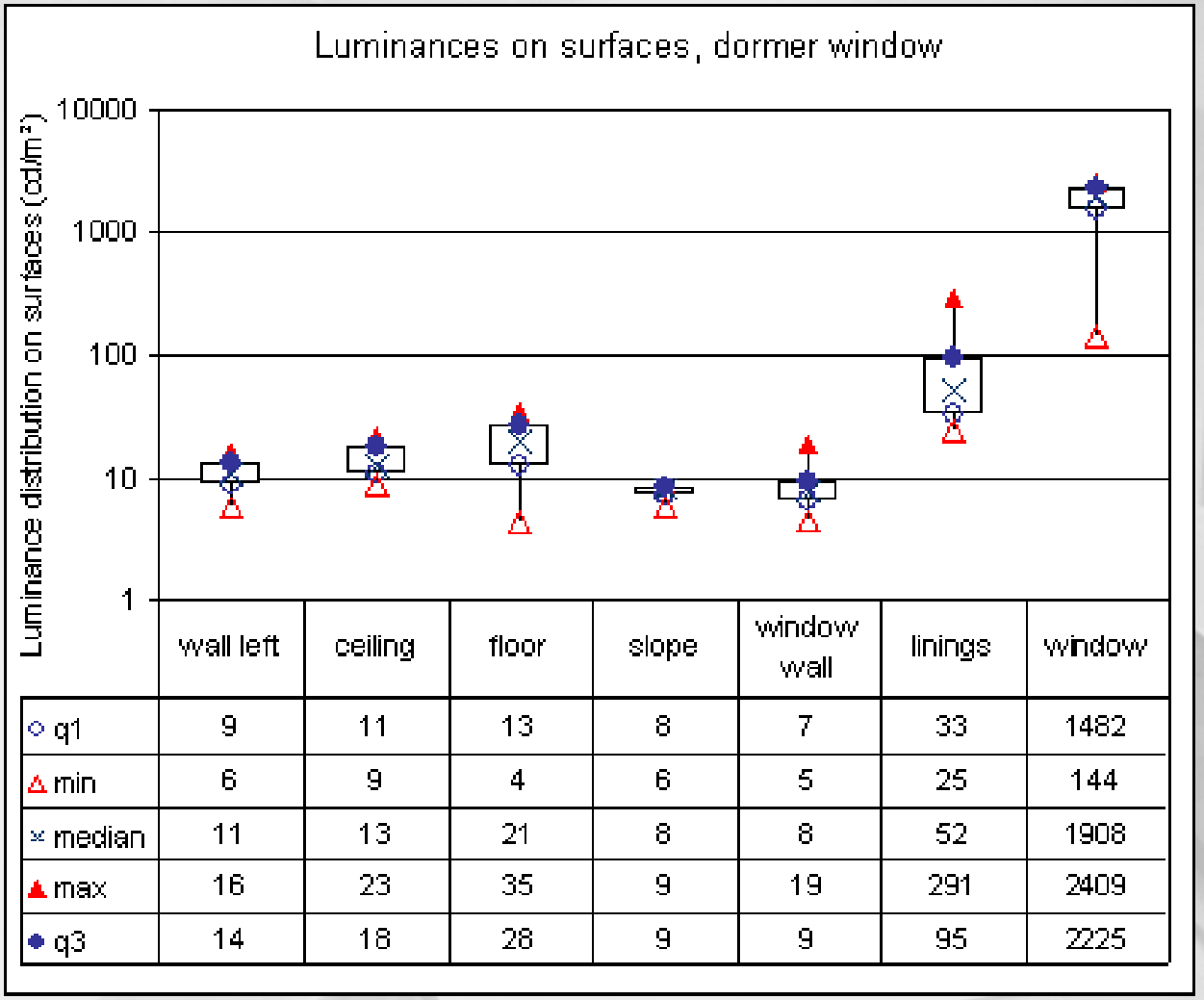
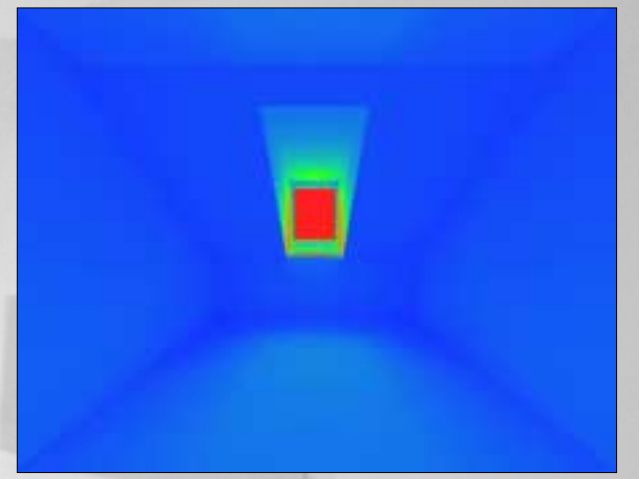
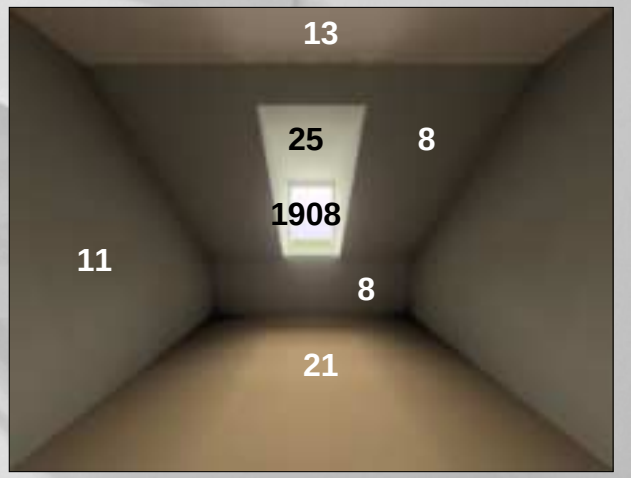
Results

Luminance ratios, overcast, dormer



	wall left	ceiling	floor	slope	window wall	linings	window
q1	9	11	13	8	7	33	1482
min	6	9	4	6	5	25	144
median	11	13	21	8	8	52	1908
max	16	23	35	9	19	291	2409
q3	14	18	28	9	9	95	2225





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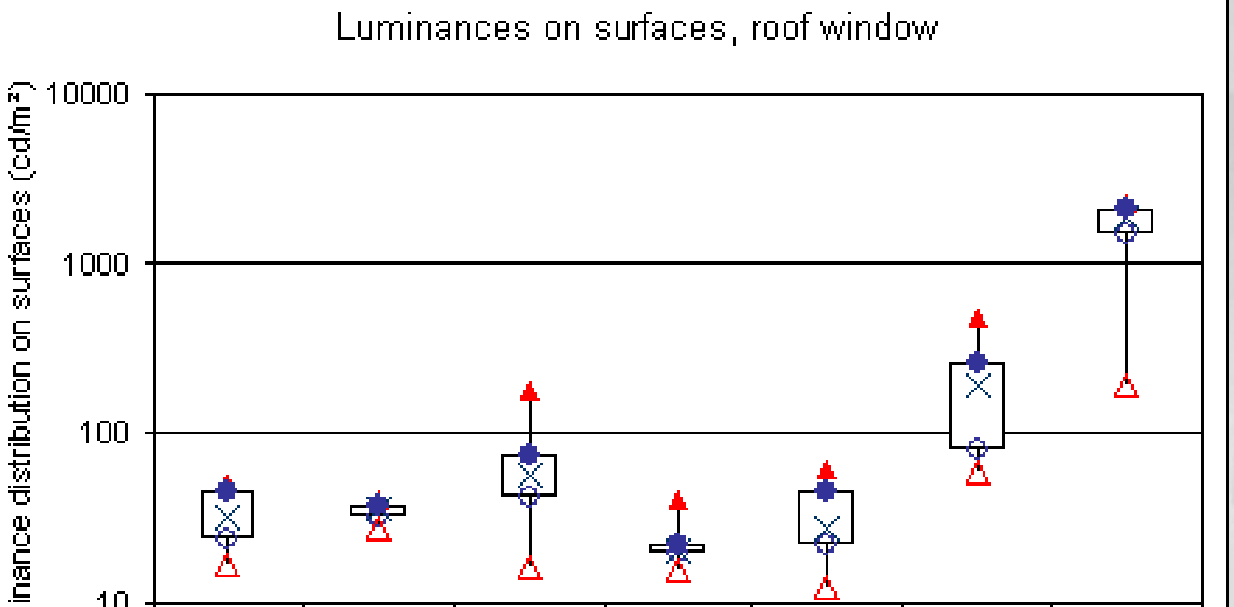
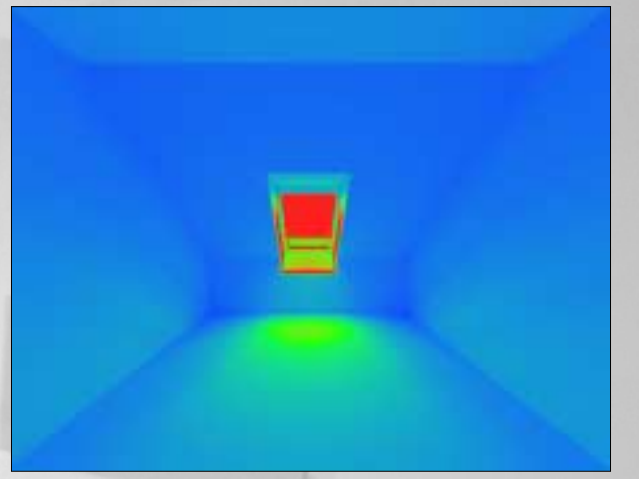
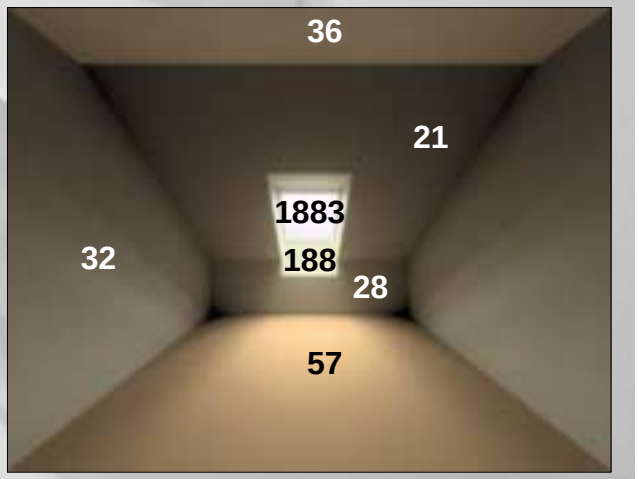
Results

Luminance ratios, overcast, roof



	wall left	ceiling	floor	slope	window wall	linings	window
q1	24	32	42	19	22	81	1513
min	17	27	16	16	12	60	190
median	32	36	57	21	28	188	1883
max	51	40	179	41	62	478	2300
q3	45	38	74	22	45	252	2114





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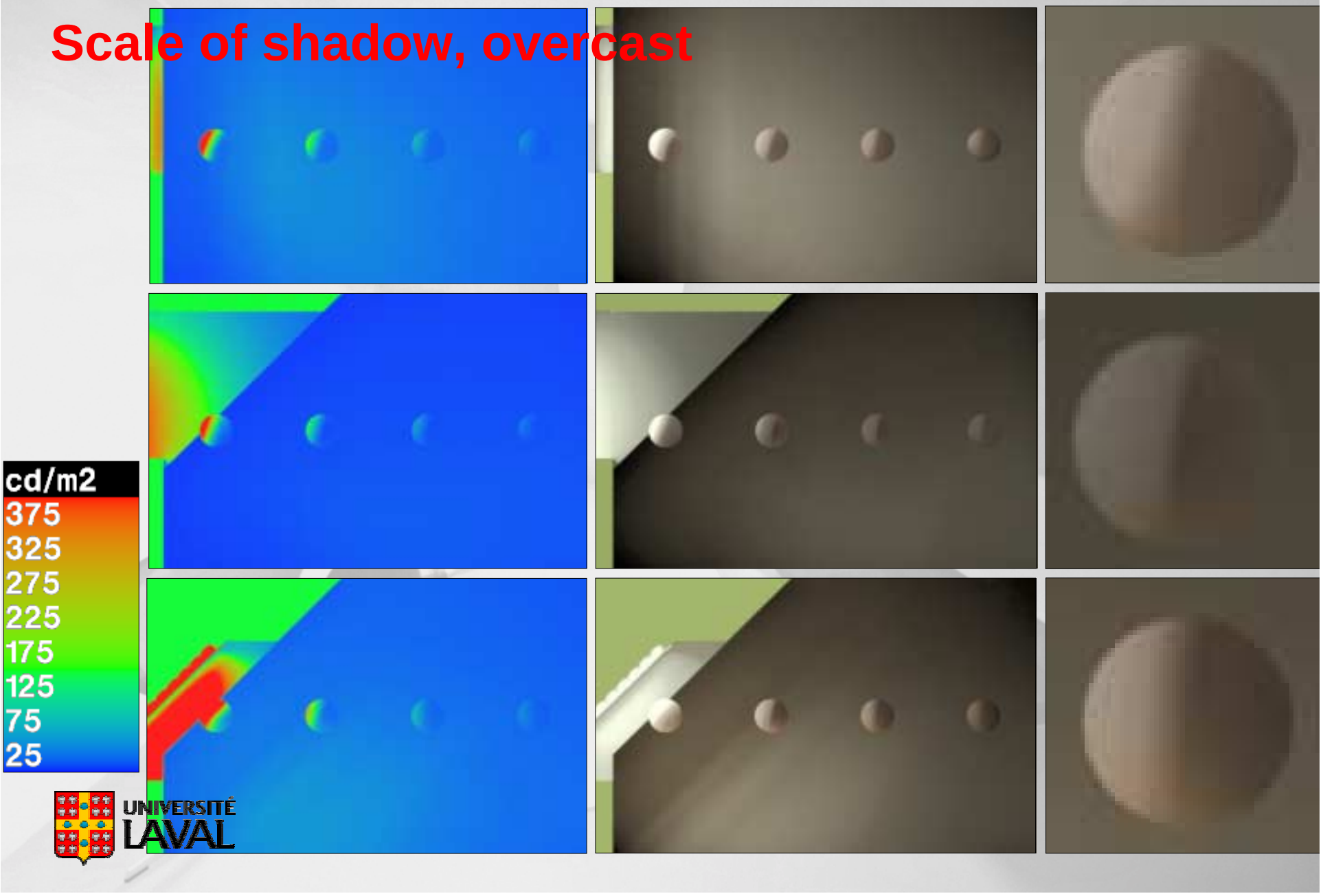
Results

Scale of shadow, overcast



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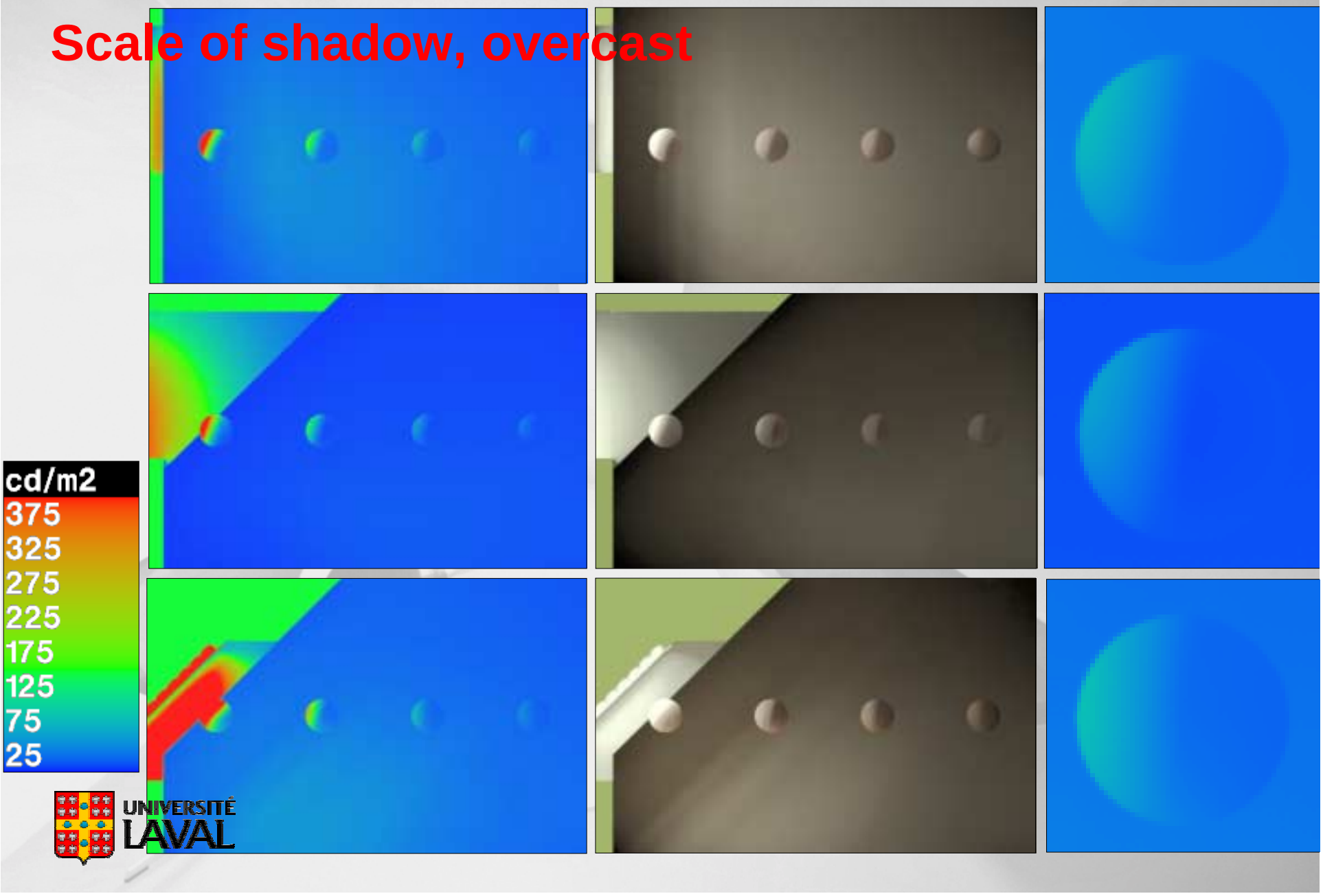
Results

Scale of shadow, overcast



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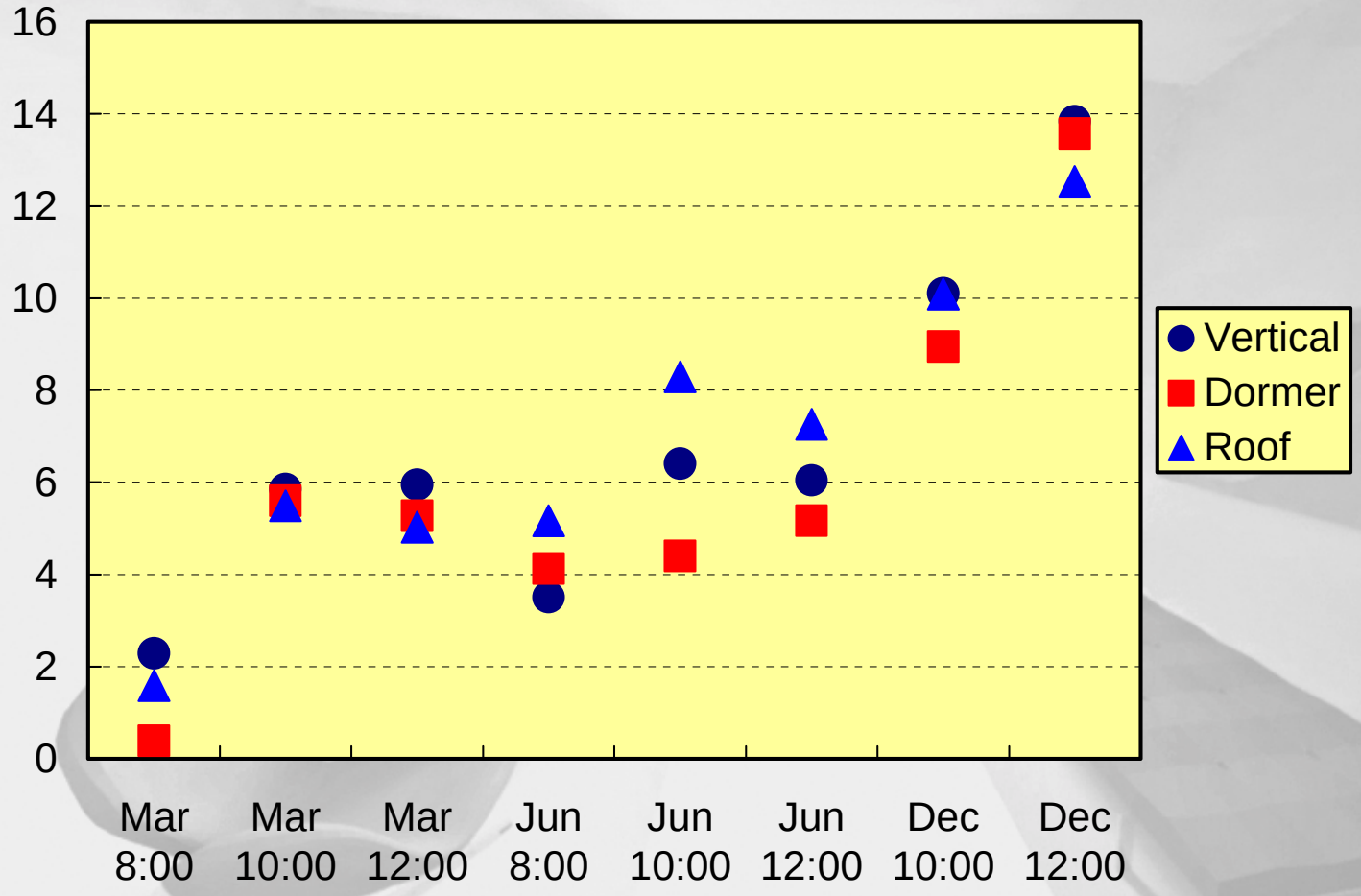
Results

Luminance difference index LD45, south



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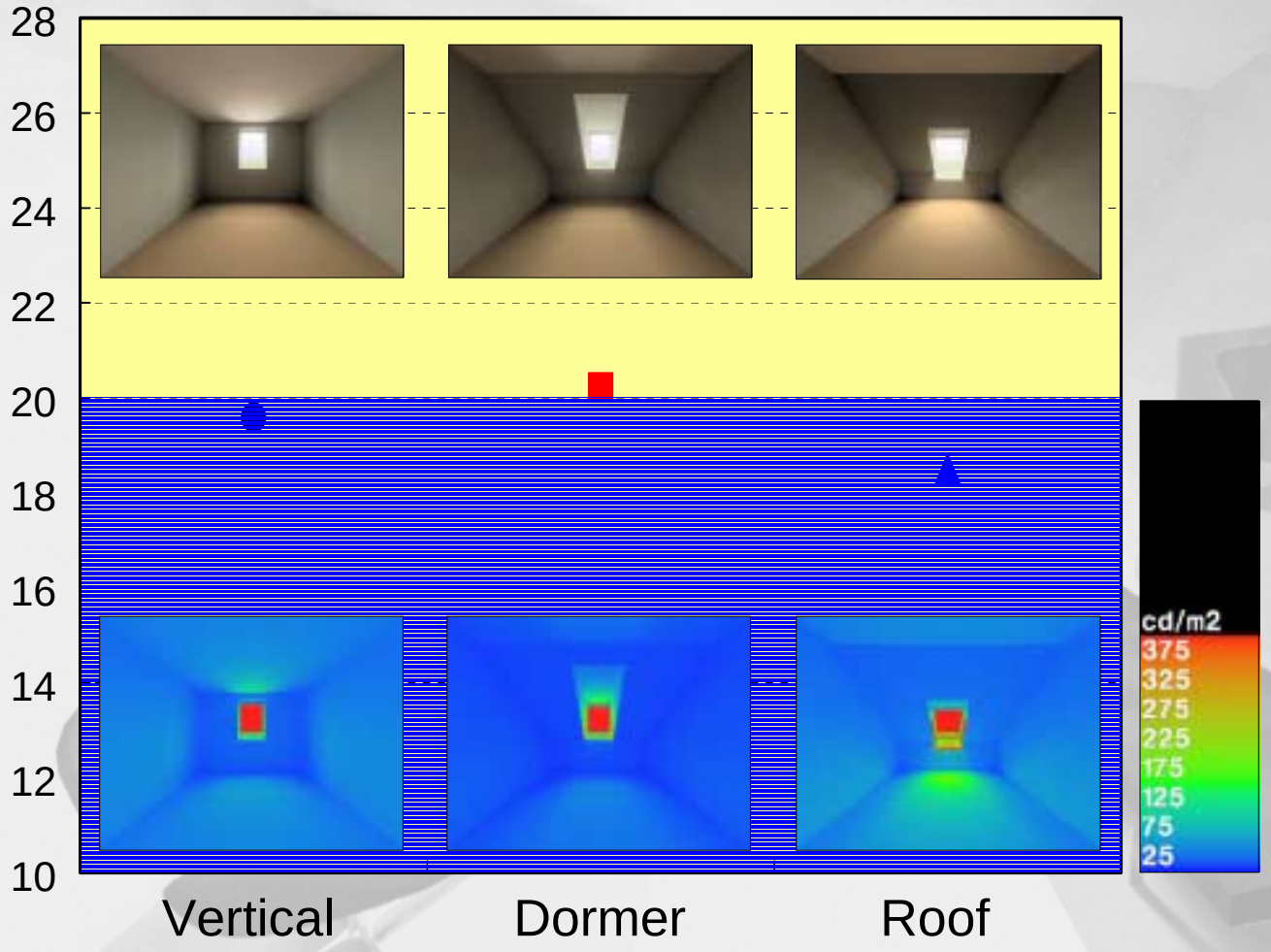
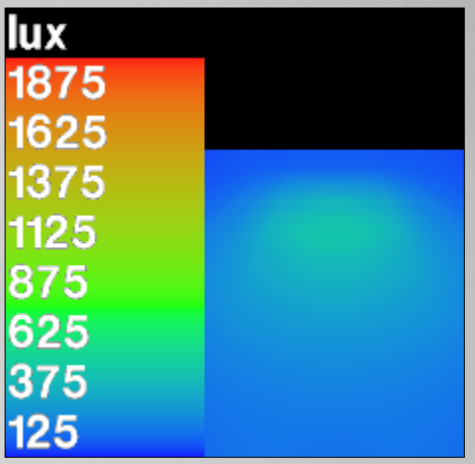
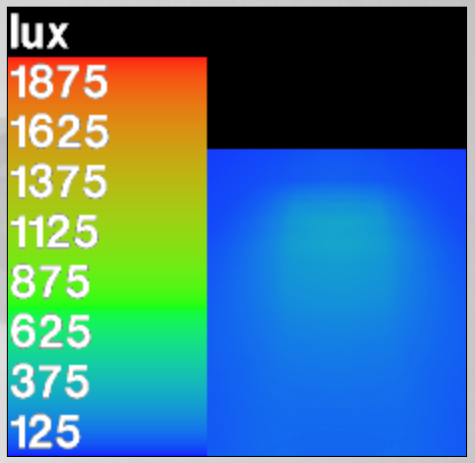
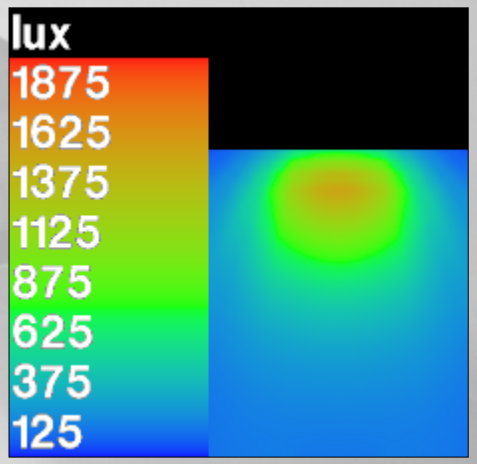
Results

Daylight glare index (DGI), overcast









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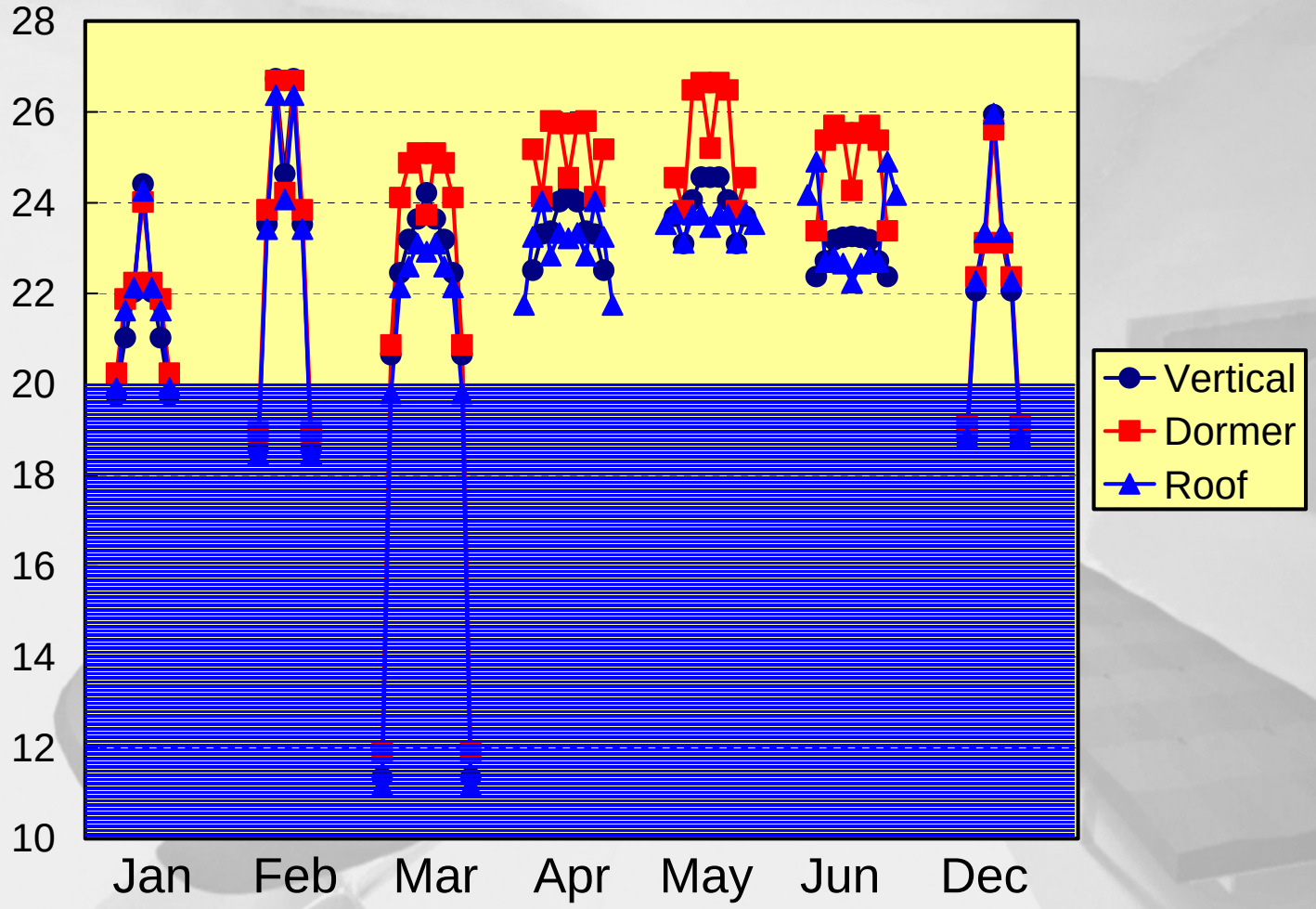
Results

Daylight glare index (DGI), sunny skies, south



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Conclusions

Please visit :

Phase 1

Dubois, M.-C., Grau, K., Traberg-Borup, S., & Johnsen, K. (2003).**Impact of three window configurations on daylight conditions: Simulations with Radiance** (By og Byg Documentation 047). Hørsholm: Statens Byggeforskningsinstitut.

Phase 2

www.sbi.dk

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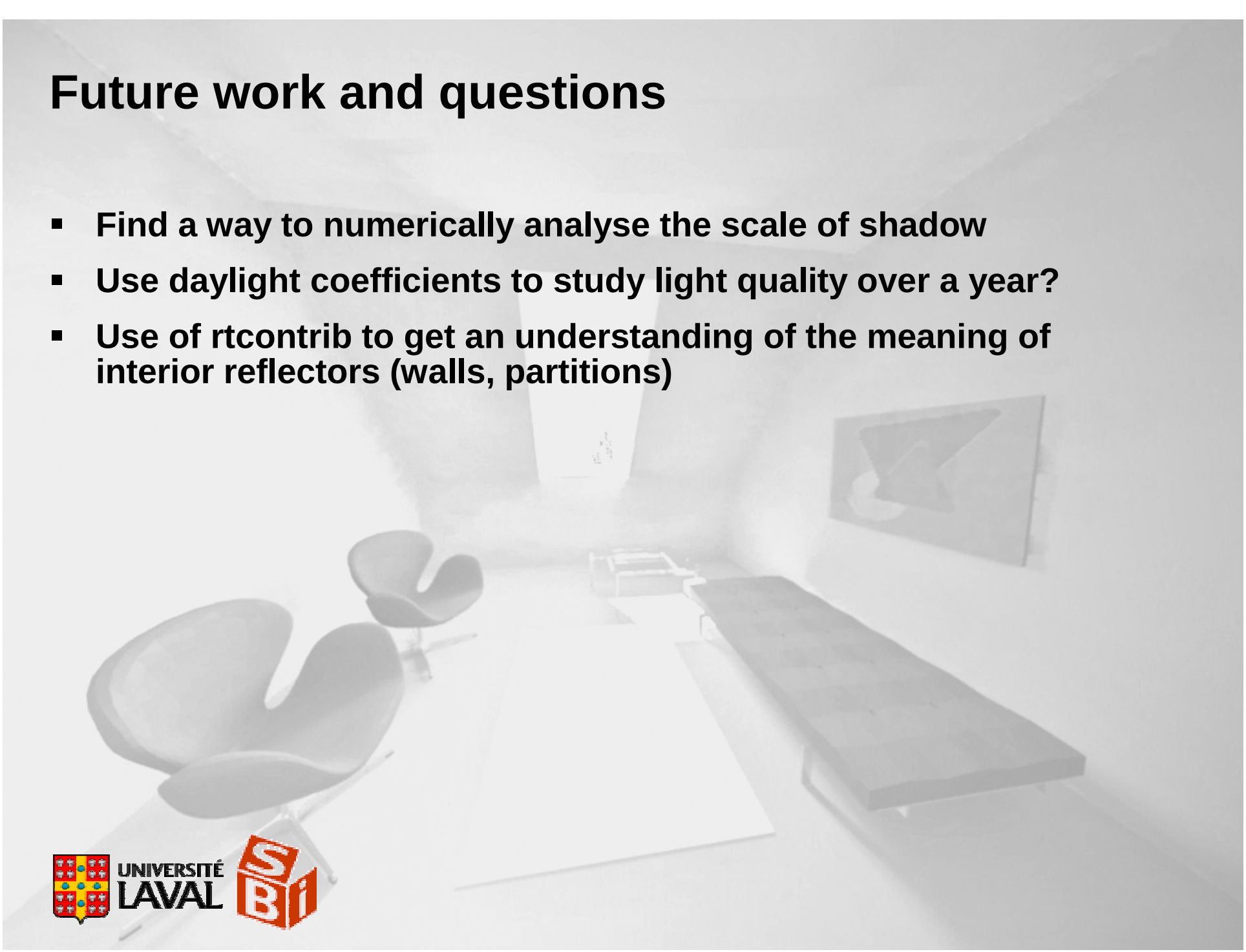
Experience gained from this study

- Real challenge : lighting quality + whole year + orientations = huge number of data : How do you general draw conclusions?

- Need for a (simple) protocole for light quality
  - depending on the action taking place
  - giving specific tips on minimum amount of times that should be looked at

Future work and questions

- Find a way to numerically analyse the scale of shadow
- Use daylight coefficients to study light quality over a year?
- Use of rtcontrib to get an understanding of the meaning of interior reflectors (walls, partitions)



Problems and challenges

- My time is limited
- No place for lighting within architecture curriculum
- Radiance not encouraged in our school (it’s not architecture…)