Inter-model comparison of five CBDM techniques

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Methods
4-component Method

DAYSIM

rtcontrib → rcontrib → 2-phase Method

3-phase Method

5-phase Method

(4-phase Method)

(6-phase Method)
A sky vector contains average sky luminance in a discretized sky patch for a specific sky luminance pattern (i.e. clear sky at 15:00 on December 21). A sky matrix is a series of sky vectors encompassing many time steps.

Sky Luminance Gradient

Discretized Sky Luminance (Tregenza)
Discretized Sky Luminance (Reinhart MF:4)

Sky luminance distribution

Tregenza
Reinhart MF:4

(a) Tregenza
(b) Reinhart MF:2
(c) Reinhart MF:3
(d) Reinhart MF:4

Andy McNeil, ‘BSDFs, Matrices and Phases’ (Radiance Workshop 2014, London)
BSDF = Bi-directional Scattering Distribution Function

Klems Angles Basis
145 patches entering + 145 patches exiting

Andy McNeil, ‘BSDFs, Matrices and Phases’ (Radiance Workshop 2014, London)
BSDF = Bi-directional Scattering Distribution Function

Generally found in .xml format

- Retrieved from a database (e.g. LBNL Window6/7)
  https://windows.lbl.gov/software/window/window.html
- Generated from a simulation run with genBSDF
- Built from measured data

Klems Angles Basis
145 patches entering + 145 patches exiting
BSDF = Bi-directional Scattering Distribution Function

Klems Angles Basis
LBNL BSDFViewer
BSDF
Tensor Tree basis
BSDF
Tensor Tree basis
Tregenza subdivision
SKY ONLY
(glow material)

Reinhart MF:6
SUN ONLY
(light material)
BSDF = Bi-directional Scattering Distribution Function

Tensor Tree Basis
LBNL BSDFViewer
<table>
<thead>
<tr>
<th>Method</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-components Method</td>
<td><code>-ab 5 -ad 2048 -ar 128 -as 256 -aa 0.2</code></td>
</tr>
<tr>
<td>DAYSIM</td>
<td><code>-ab 5 -ad 1024 -ar 1024 -as 256 -aa 0.1</code></td>
</tr>
<tr>
<td>2-phase Method</td>
<td><code>-ab 5 -ad 100000 -aa 0 -lw 1e-5</code></td>
</tr>
<tr>
<td>3-phase Method</td>
<td><code>vmx: -ab 12 -ad 50000 -aa 0 -lw 2e-5</code></td>
</tr>
<tr>
<td></td>
<td><code>dmx: -ab 2 -ad 1000 -aa 0 -lw 1e-3</code></td>
</tr>
<tr>
<td>5-phase Method</td>
<td><code>dsc: -ab 1 -ad 5000 -aa 0 -lw 2e-4</code></td>
</tr>
</tbody>
</table>

NB These values are only indicative; each geometry needs appropriate parameters setting
To know more:

A McNeil, *genBSDF Tutorial*

A McNeil, *The Three-Phase Method for Simulating Complex Fenestration with Radiance*

A McNeil, *The Five-Phase Method for Simulating Complex Fenestration with Radiance*

Models
Metrics
**UDI**
(Useful Daylight Illuminance)
Annual occurrence of illuminance binned in certain ranges

**DA**
(Daylight Autonomy)
Annual occurrence of illuminance over a certain threshold

**TAI**
(Total Annual Illuminance)
Hourly exposure cumulative for a year

**ASE**
(Annual Sunlight Exposure)
Annual occurrence of direct sunlight over a certain illuminance for more than a certain number of hrs per year
UDI
(Useful Daylight Illuminance)

DA
(Daylight Autonomy)

TAI
(Total Annual Illuminance)

ASE
(Annual Sunlight Exposure)
Requirements for LEED v4 | Daylight credit: option 1
Occupancy schedule 8:00 - 18:00 (60’ time step)
sDA > 55/75%
ASE < 10%

<table>
<thead>
<tr>
<th></th>
<th>2PM</th>
<th>3PM</th>
<th>5PM</th>
<th>4CM</th>
<th>DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>L3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>L7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>M1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>M5</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

*blinds not modelled

Requirements for Priority School Building Programme (UK)
Occupancy schedule 8:30 - 16:00 (5’ time step)

sDA > 50%
UDI_{s+a} > 80%

<table>
<thead>
<tr>
<th></th>
<th>2PM</th>
<th>3PM</th>
<th>5PM</th>
<th>4CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>L3</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>L7</td>
<td>80%</td>
<td>80%</td>
<td>82%</td>
<td>78%</td>
</tr>
<tr>
<td>M1</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>M5</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>
Total Annual Illuminance [klx hrs]
Occupancy schedule 8:00 - 18:00
Hourly time-step
### Settings for Annual Sunlight Exposure calculation

<table>
<thead>
<tr>
<th>Method</th>
<th>-ab</th>
<th>Geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-components Method</td>
<td>0</td>
<td>no modifications (computed as a matter of course)</td>
</tr>
<tr>
<td>DAYSIM</td>
<td>0</td>
<td>no modifications (computed as a matter of course)</td>
</tr>
</tbody>
</table>
| 2-phase Method          | 1 (*) | • assign black material to the model  
                          |     | • use only the direct normal column of the weather data |
| 3-phase Method          | vmx: 1  
dmx: 0 | • assign black material to the model  
                          |     | • use only the direct normal column of the weather data |
| 5-phase Method          | 1 | • assign black material to the model  
                          |     | • use only the direct normal column of the weather data |

(*) used here but not properly defined anywhere
The Sun says...

ASE [%] for the four classrooms

<table>
<thead>
<tr>
<th></th>
<th>4CM</th>
<th>DAYSIM</th>
<th>2PM</th>
<th>3PM</th>
<th>5PM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L3</strong> (NW)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>L7</strong> (NE-SE)</td>
<td>6.5</td>
<td>33.3</td>
<td>30.2</td>
<td>43.8</td>
<td>11.4</td>
</tr>
<tr>
<td><strong>M1</strong> (S)</td>
<td>8.4</td>
<td>17.9</td>
<td>17.7</td>
<td>20.5</td>
<td>12.1</td>
</tr>
<tr>
<td><strong>M5</strong> (N-S)</td>
<td>0.0</td>
<td>1.9</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Thank you!

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Twitter: @EleBrembilla