Beyond Daylight Factors: Daylight Coefficients

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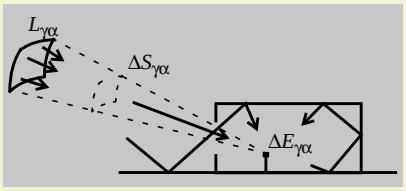
Daylight prediction has traditionally been based on the convention of a Standard Overcast Sky. The assumption of a Standard Overcast Sky transforms what is in reality a time-varying scenario - a succession of unique sky and sun conditions - into one that is static. The penalty of simplicity however is a considerable loss in realism. With the daylight factor approach it is impossible to reproduce the naturally occurring variation in the quantity, character and distribution of internal daylight levels. A true measure of the long-term daylighting performance of a building must account for the illumination that results from a wide range of sky and sun conditions. This poster summarises how **daylight coefficients** can be used to predict hourly values of internal illuminance accurately and efficiently for a period of a full year.

Daylight coefficients

Basics

The daylight coefficient approach requires that the sky be broken into many patches. The internal illuminance at a point that results from a patch of known luminance sky is computed and cached. It is then possible to determine the internal illuminance for arbitrary sky/sun conditions using relatively simple arithmetic operations on matrices.

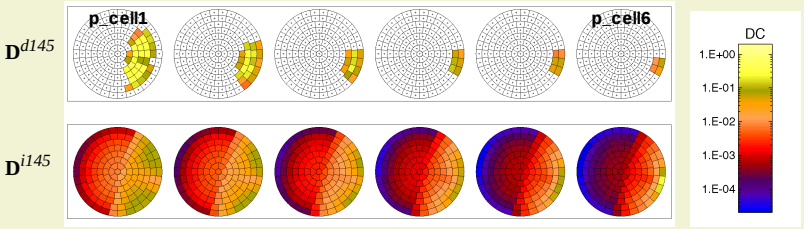


Radiance formulation

Daylight coefficients were predicted using the (UNIX) ***Radiance*** lighting simulation system. The vector for the internal illuminance is computed as the sum of the vectors for the four illuminance components - direct sky, indirect sky, direct sun and indirect sun:

$$\mathbf{E} = (\mathbf{D}^{d145} \times \mathbf{c}^{145}) + (\mathbf{D}^{i145} \times \mathbf{c}^{145}) + (\mathbf{D}_{\beta}^{d5010} S^{sun} L^{sun}) + (\mathbf{D}_{\beta}^{i145} S^{sun} L^{sun})$$

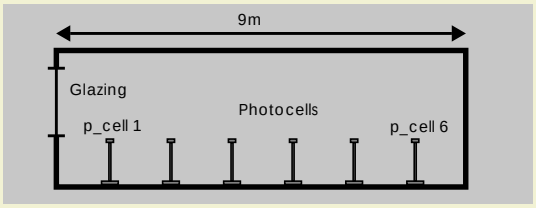
The 145 patch scheme matched the scanner pattern of the validation measurements. A fine-scale discretisation with 5010 patches was used for the direct sun component. The 145 patch DCMs are shown below.



Validation

Office model

Illuminance measured at six photocell locations in full size office space under real sky conditions.



Sky conditions

Sky luminance patterns and direct sun illuminance measured for 754 skies covering a wide range of naturally occurring conditions - simultaneous with measurements of internal illuminance.

Accuracy

Illuminances derived from daylight coefficients proved to be highly accurate.

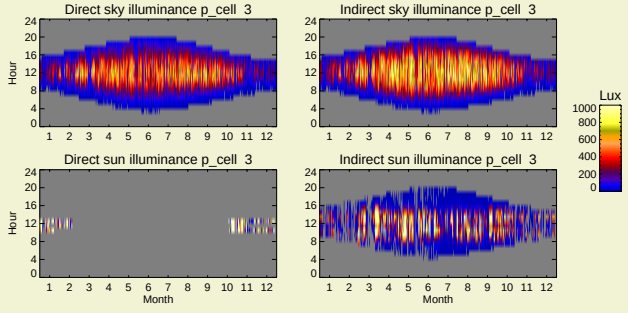
p_cell	1	2	3	4	5	6
MBE%	-2.8	-2.8	11.3	1.5	9.6	12.4
RMSE%	15.2	11.1	16.0	12.1	15.6	18.1

(Validation data provided by the BRE)

Annual daylighting profiles

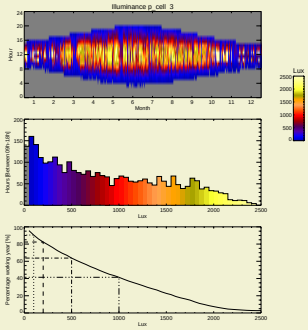
Component illuminances

Hourly internal illuminances for a full year were derived from TRY data using the *Radiance* DC formulation. The hourly illuminances for p_cell3 are shown below.



Data reduction

Component illuminances are summed and processed. The cumulative plot gives the percentage of the working year for which a target illuminance was exceeded. It is possible to analyse both the relative proportions and the magnitude of the illuminance components, e.g. for the ability of a light shelf to redirect sunlight compared to ordinary glazing.



Applications

(a) Detailed analysis of daylighting performance.
(b) Basis for design guides (DCMs are invariant to rotation/location, any building orientation and/or locale can be quickly analysed).
(c) Investigations of luminous efficacy and sky models based on predictions of internal illuminance.
(d) Evaluation of daylight-responsive lighting controls.