Classic Daylight Coefficient File Format in Daysim

Each line in a Daysim daylight coefficient file corresponds to a complete set of daylight coefficients for a particular sensor. This Appendix describes the daylight coefficients used by Daysim, i.e. the content of an individual line in a daylight coefficient file.

The concept of daylight coefficients has been introduced in section 2.1.5. Again, the underlying idea is to theoretically divide the celestial hemisphere into disjoint sky patches. Afterwards, the contribution to the total illuminance at a point in a building is calculated for each sky patch individually. The decisive advantage of the daylight coefficient methods over other dynamic daylight simulation methods is that a set of daylight coefficients for a given point in a building merely depend on the building geometry, material characteristics and the division of the surrounding sky and ground into disjoint segments. Daylight coefficients are independent of any actual celestial sky luminance distribution. Hence, the building characteristics and the surrounding sky conditions are separated. A complete set of daylight, DC_a, coefficients can be coupled with an arbitrary sky luminance distribution, L_α, with α =1...N, by a simple linear superposition to calculate the total illuminance E(x) at x:

$$E(x) = \sum_{\alpha=1}^{N} DC_\alpha(x) L_\alpha \Delta S_\alpha$$

Daylight Coefficients in DAYSIM

The philosophy behind the daylight coefficient calculation in DAYSIM is to reduce the number of raytracing runs necessary to calculate a complete set of daylight coefficients and still correctly model all light rays which might contribute to the total illuminance at a point. To this end, DAYSIM distinguishes between contributions from the diffuse daylight, ground reflections and direct sunlight:

$$E(x) = \underbrace{\sum_{\alpha=1}^{145} DC_\alpha^{diffuse}(x) L_\alpha^{diffuse} \Delta S_\alpha^{diffuse}}_{\text{diffuse daylight}} + \underbrace{\sum_{\alpha=1}^{3} DC_\alpha^{ground}(x) L_\alpha^{ground} \Delta S_\alpha^{ground}}_{\text{ground reflection}} + \underbrace{\sum_{\alpha=1}^{65} DC_\alpha^{direct}(x) L_\alpha^{direct} \Delta S_\alpha^{direct}}_{\text{direct sunlight}}$$

The celestial hemisphere is divided into 145 disjoint sky segments, S_{d1}, ..., S_{d145}, according to the Tregenza division for the diffuse daylight coefficients. These sky segments completely cover the celestial hemisphere so that no rays that hit the hemisphere are discarded or double counted.

To include contributions to the indoor illuminance due to external ground reflections, three additional ground daylight coefficients have been introduced for negative solar altitudes. The three ground segments,S_{g1} ... S_{g3}, correspond to altitudes from 0° to -10°, -10° to -30° and -30° to -90°. Table B-1 and Figure B-1 show the partition of the celestial and ground hemispheres into diffuse and ground sky segments.

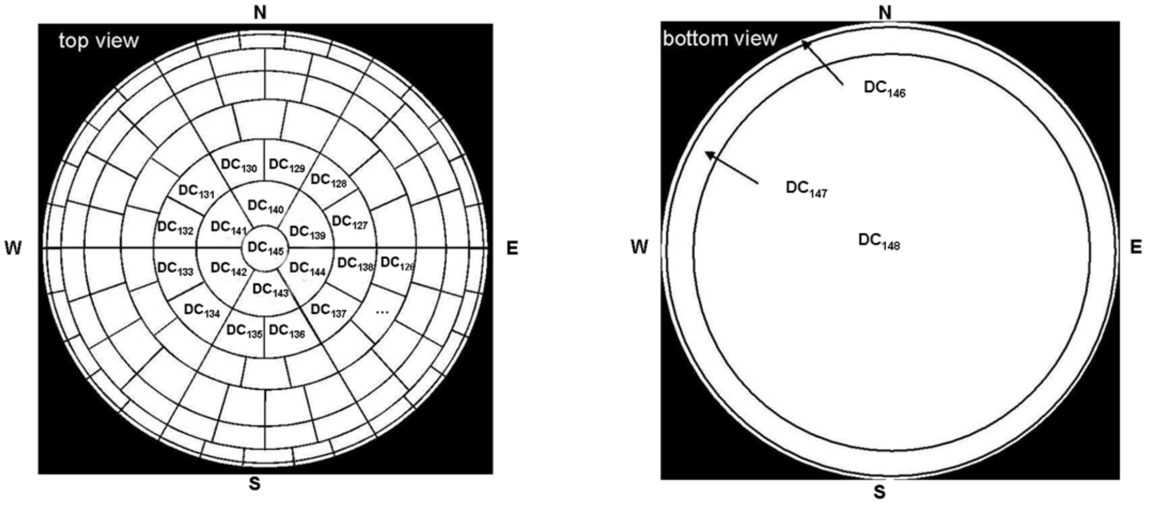

Figure B-1: Division of the celestial (top view) and ground (bottom view) hemispheres into 145 diffuse and 3 ground sky segments.

Table B-1: azimuth and altitude angles [°] of the center of the sky patches pertaining to the diffuse and ground daylight coefficients. In accordance with the Radiance coordinate system, an altitude of 90° corresponds to zenith; an azimuth of 0° is pointing South, -90° points East and +90° points West.

Type	Daylight coefficient index	altitude [°]	azimuth [°]
diffuse	1	6	-96
	2	6	-108
	…		
	30	6	-84
	31	18	-96
	32	18	-108
	…		
	60	18	-84
	61	30	-97.5
	62	30	-112.5
	…		
	84	30	-82.5
	85	42	
	86	42	
	…		
	108	42	
	109	54	
	110	54	
	…		
	126	54	
	127	66	
	128	66	
	…		
	138	66	
	139	78	
	140	78	
	…		
	144	78	

	145	90	
ground	146	altitude ∈ [0°, -10°[	azimuth ∈ [0°, 360°]
	147	altitude ∈ [-10°, -30°[	azimuth ∈ [0°, 360°]
	148	altitude ∈ [-30°, -90°]	azimuth ∈ [0°, 360°]

Contributions from direct sunlight are modeled by some 65 representative sun positions which are a subset of all possible sun positions throughout the year. Figure B-2 shows all annual hourly mean sun positions (dotted lines) for Freiburg, Germany, (47.979° N) together with the 65 representative sun positions (crosses) for which direct daylight coefficients are calculated. The representative sun positions correspond to the actual sun positions on all full hours solar time for the 21st of December, February, March, April and June at which the sun is above the horizon[1]. Accordingly, the four direct daylight coefficients surrounded by the box in Figure 2-8 correspond to the actual sun positions in Freiburg on June 21st and April/August 21st at 13.00 and 14.00 solar time. At sunrise and sunset the direct daylight coefficient correspond to the solar time with a solar altitude of 2° so that low solar altitudes can be correctly modeled. The total number of direct daylight coefficients is site dependent and varies from 61 to 65 for latitudes below 70°. Near the poles the number decreases down to 48.

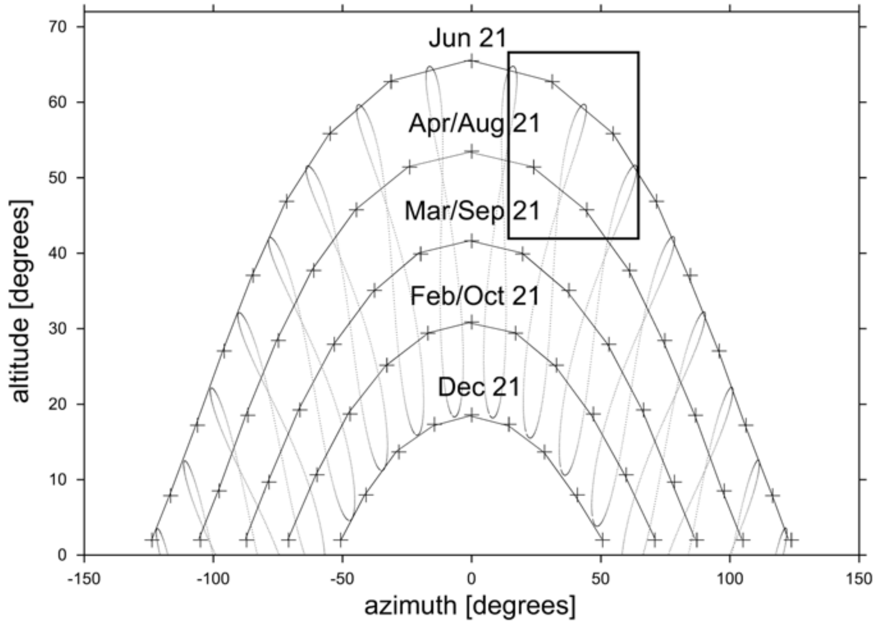

Figure B-2: The dotted lines mark all annual hourly mean sun positions for Freiburg, Germany (47.979° N); the crosses mark the 65 representative sun positions for which direct daylight coefficients are calculated. The box in the upper part of the figure surrounds four representative sun positions which correspond to actual sun positions at 13.00 and 14.00 solar time on June 21st and April/August 21st.

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[1] These sun positions have been generically chosen, as they generate an evenly spaced grid across all possible sun positions throughout the year for median latitudes. The 21st of January/November and the 21st of May/July are not calculated since these additional direct daylight coefficients would not significantly increase the simulation accuracy whereas their calculation would increase the required raytracing simulation times by roughly 40%.