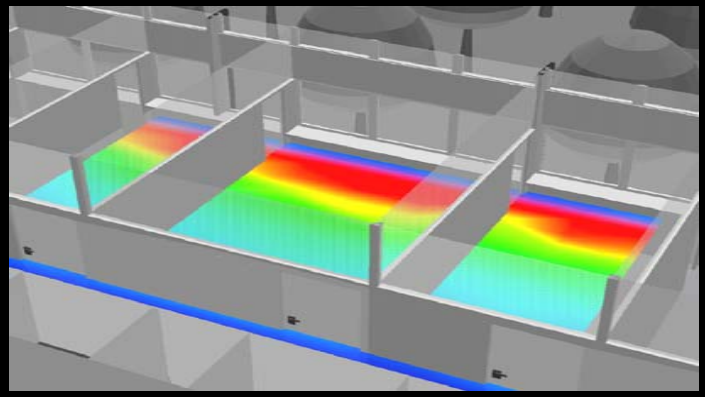
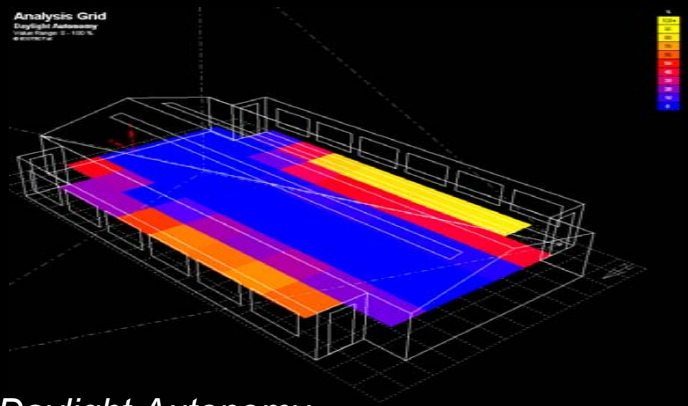
Natural Light in Design

Using simulation tools to explore realistic daylight-responsive solutions

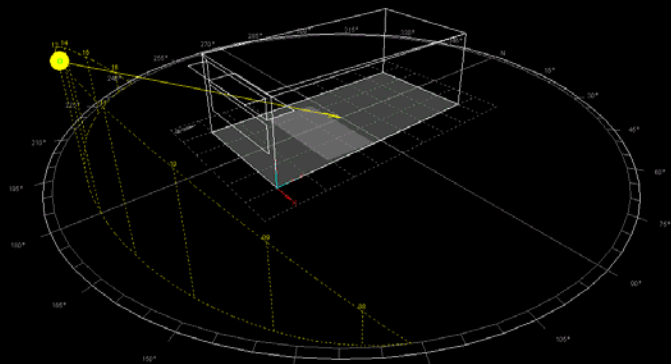


Daylight Factor

Visual Comfort



Daylight Autonomy



Avoidance of Direct Sunlight

Daylight Factor in Ecotect

Christoph Reinhart, Ph.D.

Overview - Daylight Factor & Solar Shading in Ecotect

Tuesday, Jan 24th 2006

time slot	Content	instructor
Mon 9.30	Welcome, class introduction, design project (teams formed next morning)	MA, all
Mon 10.00	- General Introduction to daylighting (benefits, history, some case studies)	MA
Mon 10.30	- Introduction to Building Simulation (why simulations for architects, tools used in this course)	CR
Mon 11.00	coffee break	
Mon 11.15	- Photometry (definition, measurement, typical values, DF definition (MA) - Static Daylighting Metrics (context of LEED, selected results from NRC survey, DF & Solar Shading) (CR) - Daylight factor calculations: protractor method, LEED spreadsheet method, sky models CIE and Perez (MA)	MA, CR, all
	- Daylight factor simulation: design sky, split flux method in Ecotect (CR) ▪ Hands-on exercise: DF calculation in Ecotect (split flux) (CR) ▪ Hands-on exercise: solar shading module in Ecotect (CR)	
	- Intro to Radiance (CR) ▪ Hands-on exercise: Radiance visualizations (CR) ▪ Hands-on exercise: DF calculation in Ecotect (Radiance) (CR)	
Mon 13.00	lunch (on your own)	
Mon 14.00	- Climate Data (kind of data and measurement, weather files, E+ weather data directory) (MA) ▪ Hands-on exercise: weather tool in Ecotect (CR) - Overview on visual comfort (glare, contrast, requirements, health) (MA) - Dynamic Metrics & related tools (CR)	MA, CR, all
Mon 15.45	coffee break	
Mon 16.00	▪ Hands-on exercise: Daysim exercise from tutorial interrupted by discussions on: - Short time steps dynamics - Daylight Coefficients - User Behavior Model - Daylight Autonomy Results	all
Mon 17.00	▪ Hands-on exercise: students to repeat at DF, Solar Shading &DA analysis on their own	all
Mon 17.30	end of first day	

Elements needed for a DL Simulation

- Performance Metrics (daylight factor, avoidance of direct sunlight)
- Building Model
- Area of Interest (analysis grid)
- Sky Model
- Simulation Model
- Material Properties

Ecotect Demo - Prepare a simple model, add a grid, start a simulation

Daylight Factor Calculation Methods

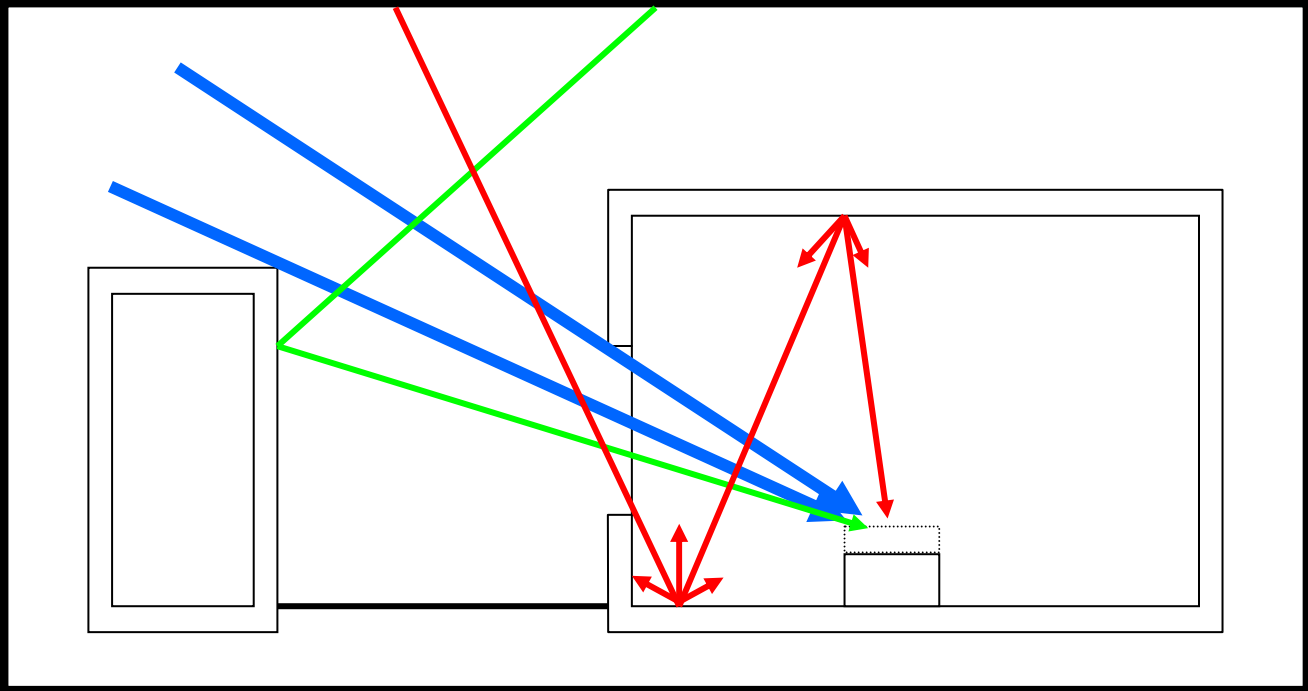
Average Daylight Factor (spread sheet method, similar to IESNA method)

Original Split Flux Method (Daylight Factor Protractors)

Split Flux Method in Ecotect

Split Flux Method

UK Building Research Establishment (BRE)



SC = direct component

ERC = externally reflected component

IRC = internally reflected component

DF= SC + ERC + IRC

Split Flux Method in Ecotect

A geometric version of the Split Flux Method (BRE)

Raytracing: each ray represents an approximately equal solid angle of sky

Split Flux Method in Ecotect

A **Sky Component (SC)** is modified by:

- relative sky illuminance of that particular sky patch
- relative angle of sky patch with a horizontal surface
- visible transmittance of each glazing material through which it travels

Split Flux Method in Ecotect

An **Externally Reflected Component (ERC)** is modified by:

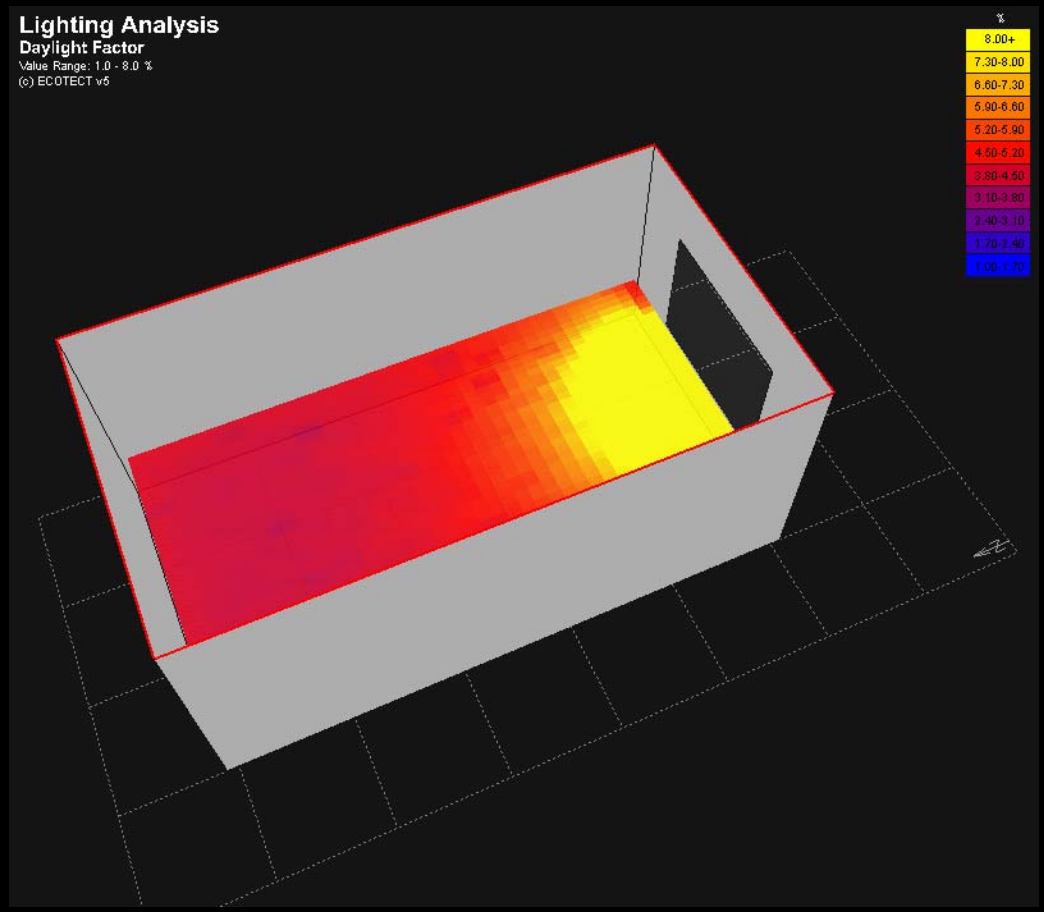
- luminance of the sky it would have hit
- reflectance of the material assigned to the external object
- relative surface angle and glazing transmittances

Split Flux Method in Ecotect

An Internally Reflected Component (IRC) is modified by:

- store internal surface reflectance of the object
- altitude angle of the ray is used to determine which parts of the IRC formula the ray contributes to.

Split Flux Method in Ecotect



Summing up over ray contribution and comparing it against the total unmodified illuminance gives the Daylight Factor.

Design Sky Values

Design Sky values are derived from a statistical analysis of outdoor illuminance levels. They represent a horizontal illuminance level that is exceeded 85% of the time between the hours of 9am and 5pm throughout the working year. Thus they also represent a worst-case scenario that you can design to and be sure your building will meet the desired light levels at least 85% of the time.

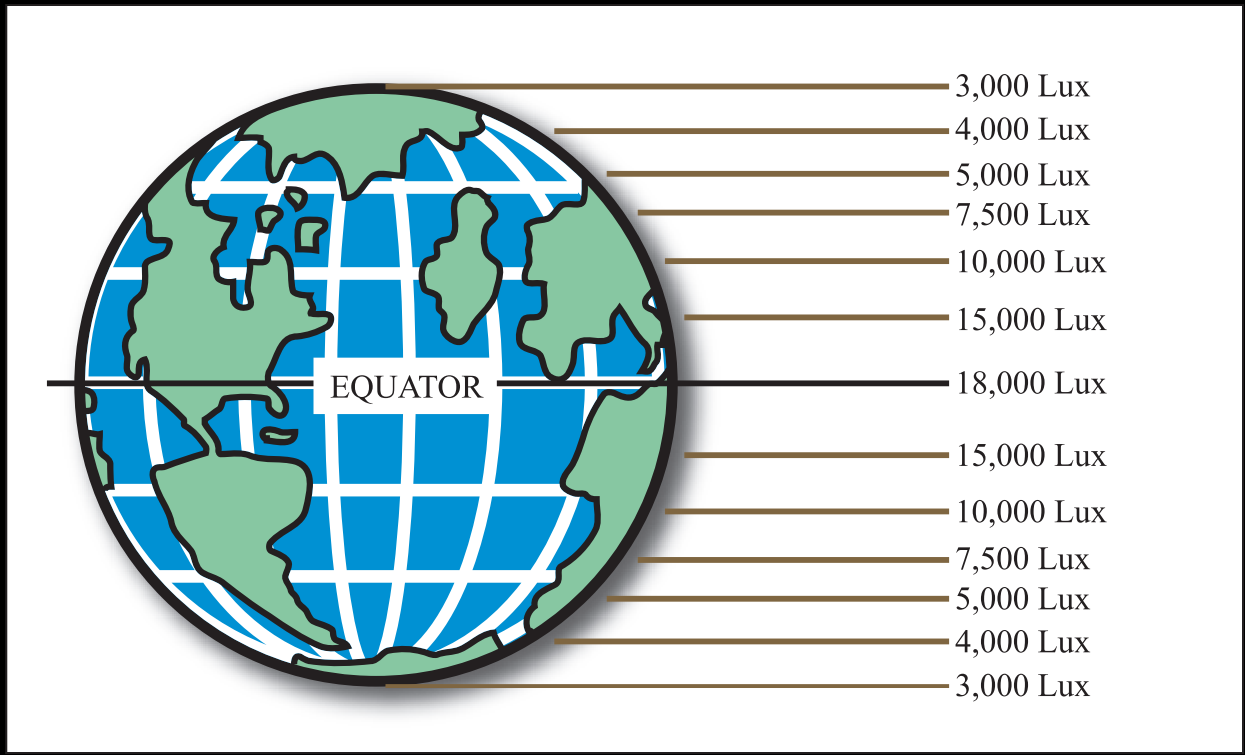
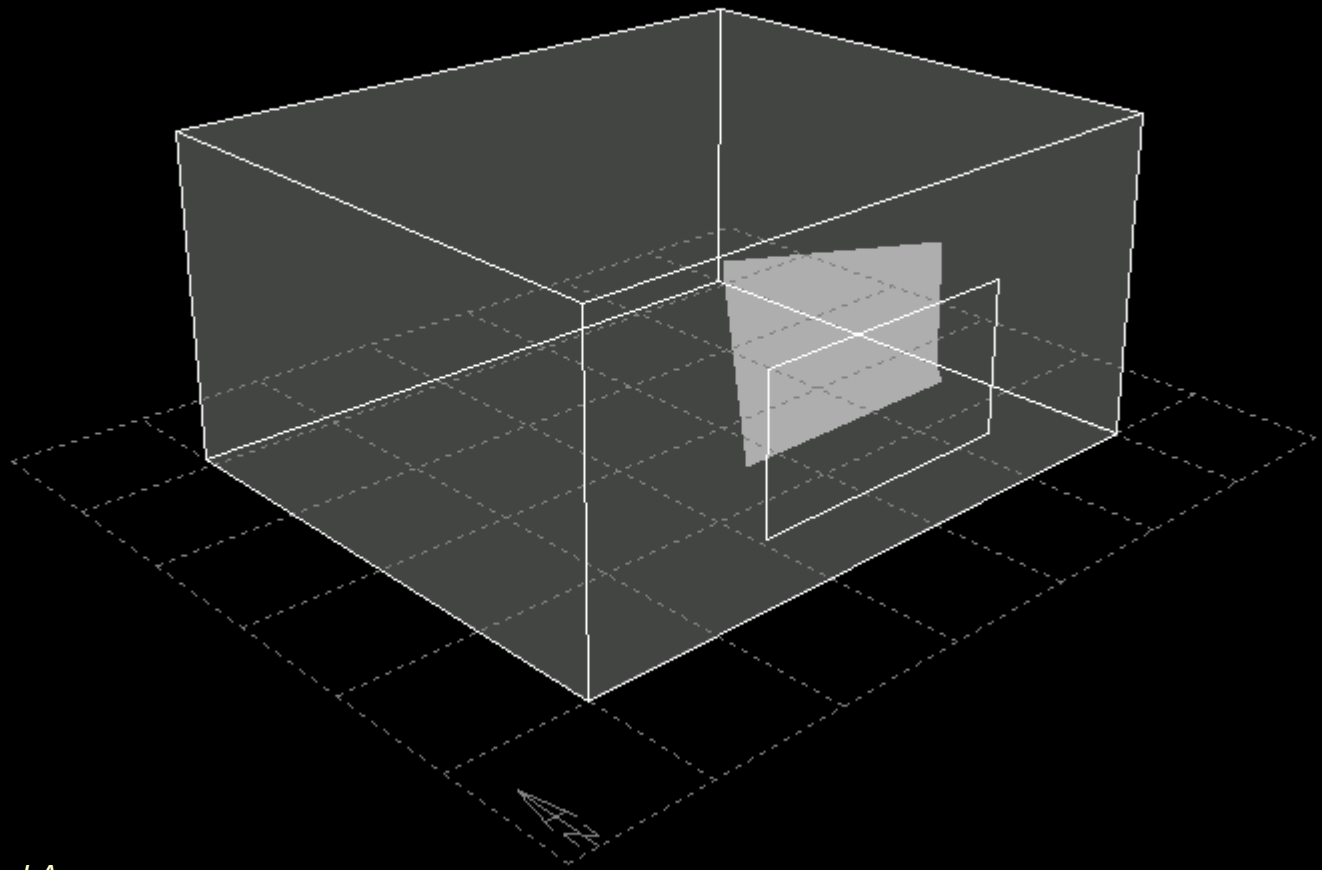


Figure by MIT OCW.

Limitation in Ecotect. Climate files are not used by lighting simulation.

Ecotect Demo – Shading Analysis & design of a simple lightshelf



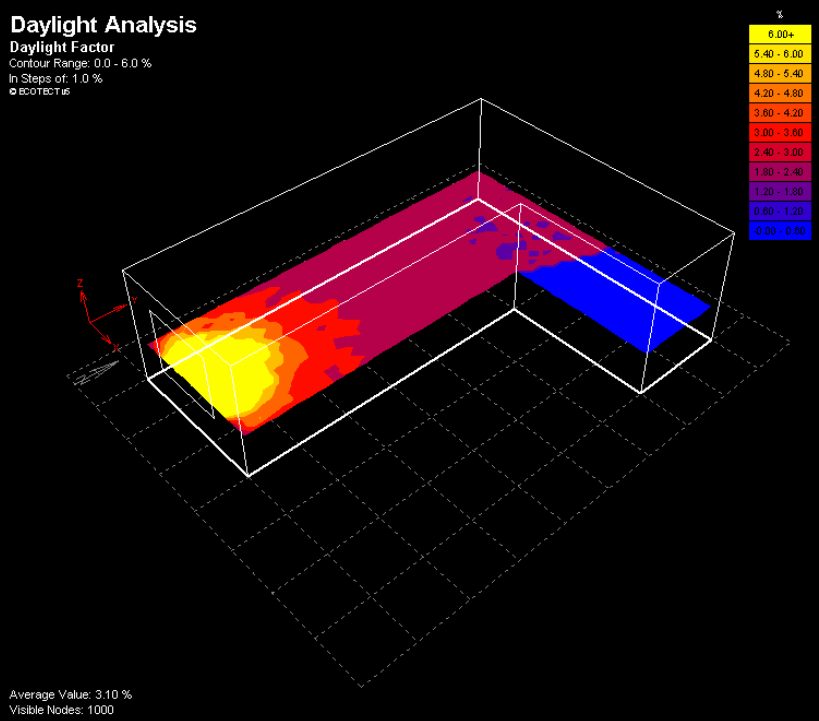
Assign Shaded As…

Save As Bitmap…

Open GL …

Ecotect Demo – Open GL

Limitations of Split Flux Method



Cannot consider multiple reflections.

Therefore, Split Flux underestimates indirect daylight solutions that rely on the reflection of light off multiple surfaces.