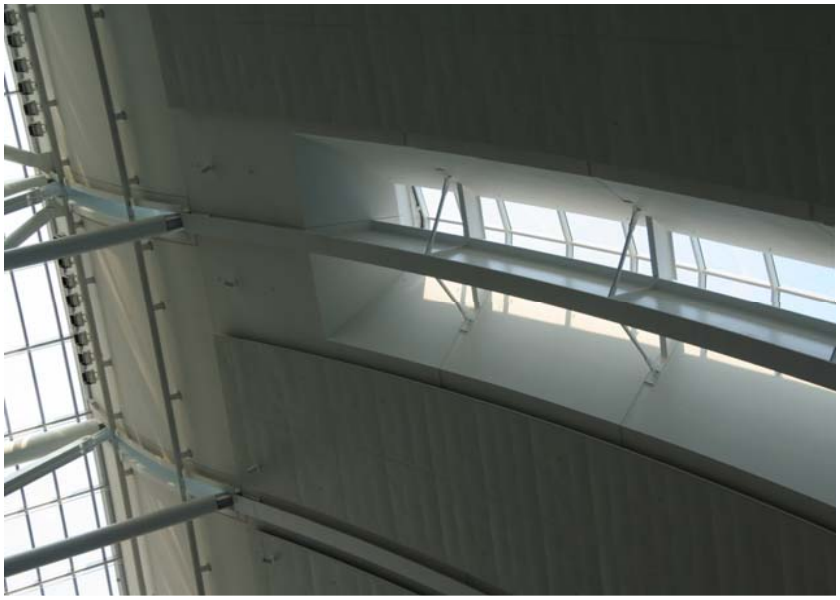


Daylight and sustainability:
Benefits and Limitations of Voluntary Certification Systems
(Environmental Rating Systems)

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LUND UNIVERSITY


Sustainability provides a drive for making daylighting the primary light source in buildings

The Distinctive benefits of Glazing

The social & economic contribution of glazed areas to sustainability in the built environment

- Over 80 research papers and books reviewed
- Objective evidence supported by empirical data included in study
- Evidence synthesised & collated into building type/function:
  - Healthcare
  - Education
  - Workplace (offices and industrial)
  - Retail
  - Residential

Available for download from Glass for Europe website:
http://www.glassforeurope.com/images/cont/225_12633_file.pdf

David Strong Consulting

Key research findings -Healthcare

- a reduction in the average length of hospital stay
- quicker post-operative recovery
- reduced requirements for pain relief
- quicker recovery from depressive illness
  - Impacts on obesity & heart disease
- Sunlight also has disinfectant qualities

Legislative requirements ensuring adequate daylight provision in new buildings

- Building Code/regulation requirements in:
  - New Zealand (habitable spaces only), Portugal, Germany, Sweden, Australia (for ventilation), France, China, Singapore, Belgium (dwellings only)
    - Requirements generally based on average Daylight Factor and/or minimum window sizes as a % of floor area (and/or wall area).
- No minimum legal requirement in:
  - Switzerland, Denmark, Ireland, UK, USA, South Africa
  - Most countries have (as a minimum) informative codes and standards requiring "sufficient" daylight or illumination
    - Mandatory levels are not defined

Environmental Rating systems for buildings

- UK BREEAM (Building Research Establishment Environmental Assessment Method)
  - BREEAM "Excellent" now mandatory for all new public buildings in UK
- USA LEED (Leadership in Energy and Environmental Design)
- Equivalent schemes in many countries (e.g. Greenmark Singapore, Green Star Australia etc
- Increasingly being adopted as de-facto standards
- All schemes award credits for daylight
  - Often based on DF and/or window/floor area %
  - **BUT can result in highly perverse outcomes**

greenstar

breeam

Main limitations of Daylight Factor approach:

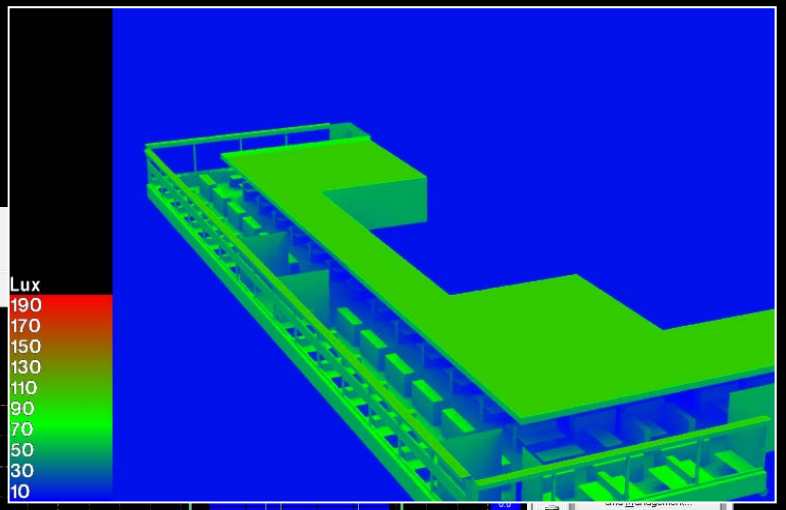
1. No maximum value for DF
2. DF is non-orientation and non-climate specific
3. DF says nothing about daylight quality

No maximum value for the Daylight Factor

Example of a simple calculation for a BREEAM-certification

Office building KOGGEN 2

Malmö, Sweden, NCC Teknik



Daylight Factor

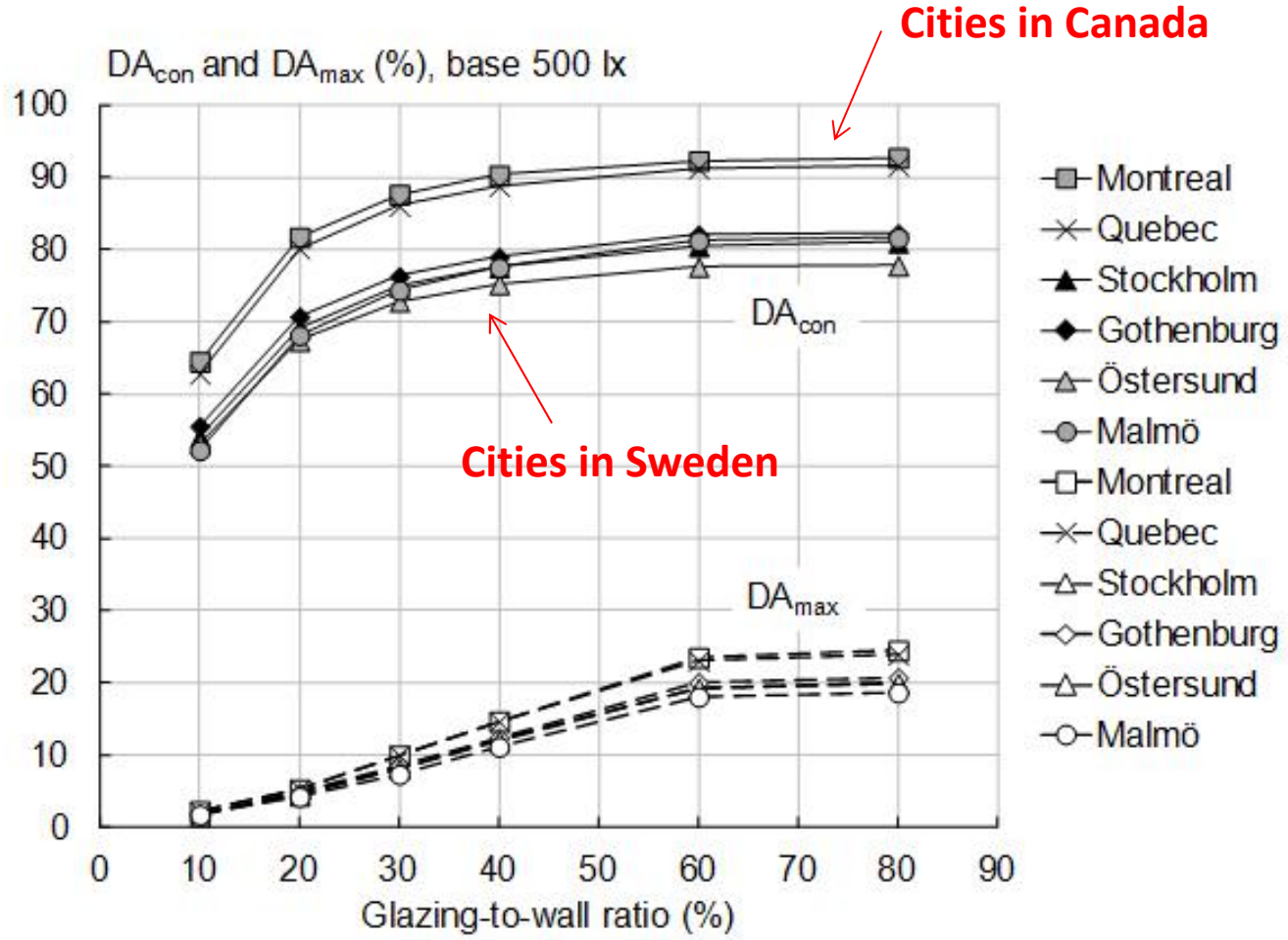
In books (and research reports) there is a maximum suggested for the Daylight Factor!

below 1%	dull gloomy appearance electric lighting masks daylight variation
1 - 2%	usually optimum balance of electric lighting and daylight
4 – 5%	totally daylit room
above 5%	**probable thermal discomfort, noise & other problems**

[source: Peter Trezenga, Sheffield University, UK]

DF is non-orientation and non-climate specific

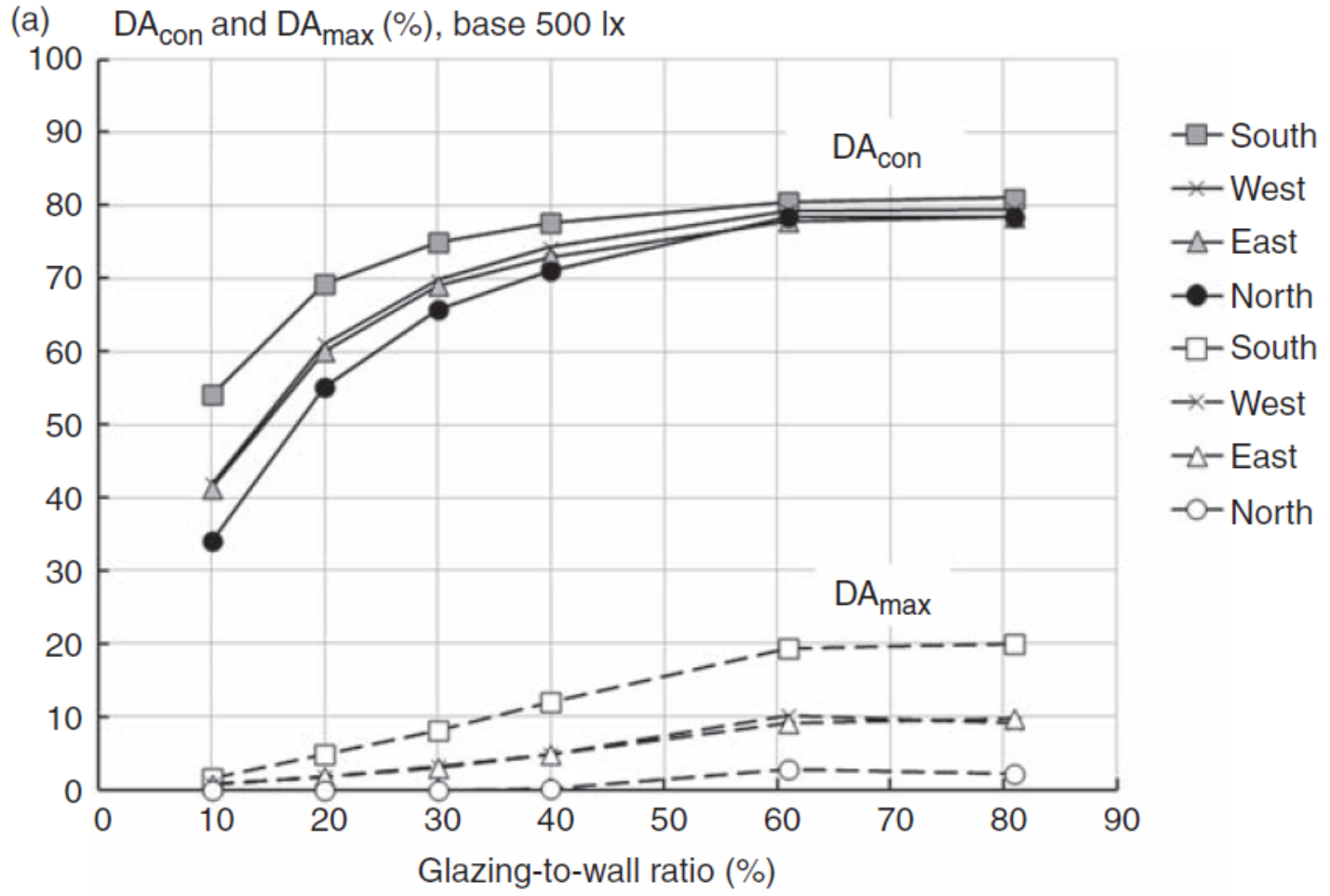
Example - effect of subtle climatic differences



[Source: Dubois M-C & Flodberg K (2012). Daylight utilization in perimeter office rooms at high latitudes: Investigation of key design features by computer simulations. Lighting Res. Technol. 2013; 45: 52–75.]

DF is non-orientation and non-climate specific

Example - effect of orientation



[Source: Dubois M-C & Flodberg K (2012). Daylight utilization in perimeter office rooms at high latitudes: Investigation of key design features by computer simulations. Lighting Res. Technol. 2013; 45: 52–75.]

Daylight autonomy, DA (%)

Percentage of the occupied times of the year when the minimum illuminance requirement (e.g. 500 lx) at the sensor is met by daylight alone.

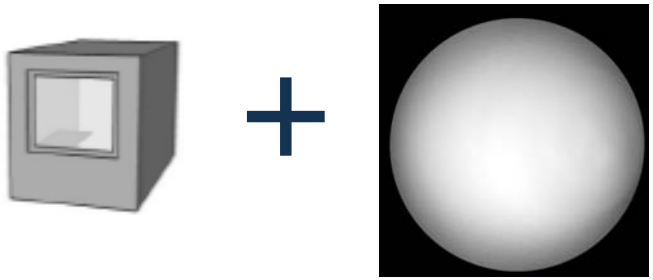
Continuous Daylight Autonomy, DA_{con} (%)

Partial credit is attributed to time steps when the daylight illuminance lies below the minimum illuminance level.

For example, in the case where 500 lx are required and 400 lx are provided by daylight at a given time step, a partial credit of 400lx/500lx=0.8 is given for that time step.

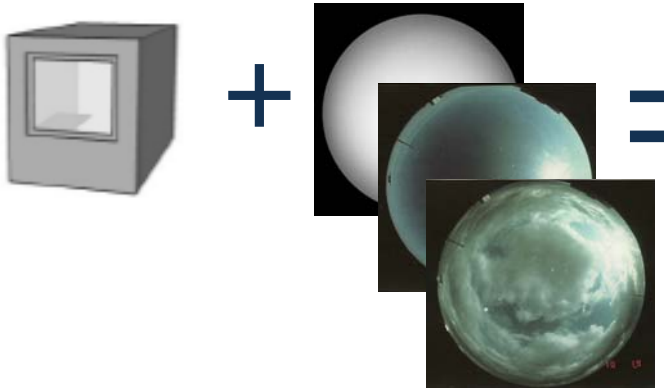
[Source: Reinhart CF, Walkenhost O. Dynamic RADIANCE-based Daylight simulations for a full-scale test office with outer venetian blinds. Energy and Buildings 2001; 33(7): 683-697]

Daylight Factor (DF) versus Daylight Autonomy (DA)



Daylight factor (%)

n= max 8760 skies



> 500 lux => off (1)

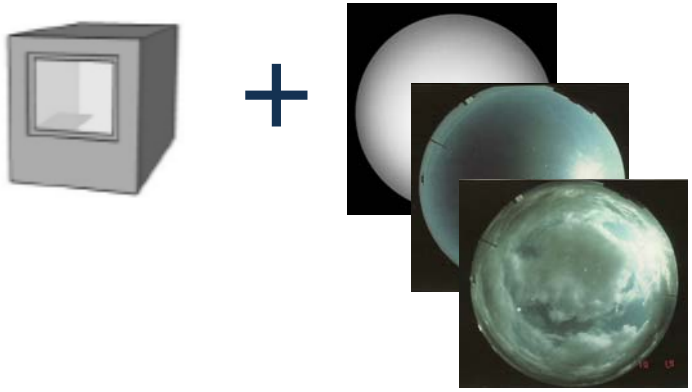
< 500 lux => on (0)

Daylight autonomy (%)

$$\frac{\Sigma\ (n=1)}{n\ \text{skies}}$$

Continuous Daylight Autonomy (DA_{con})

n= max 8760 skies



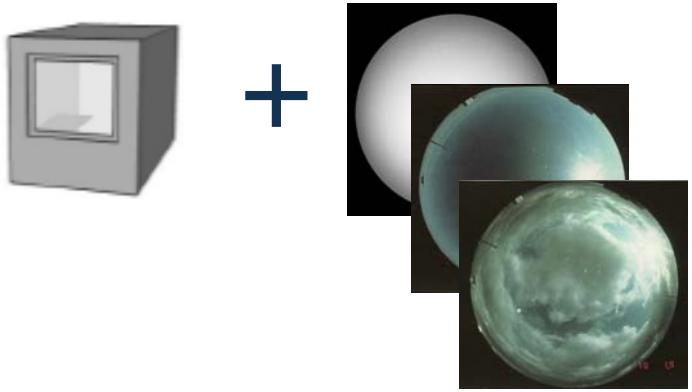
> 500 lux => off (1)

< 500 lux => on (0)

Daylight autonomy (%)

$$\frac{\Sigma\ (n=1)}{n\ \text{skies}}$$

n= max 8760 skies



> 500 lux => off (1)

< 500 lux => on (0.6)

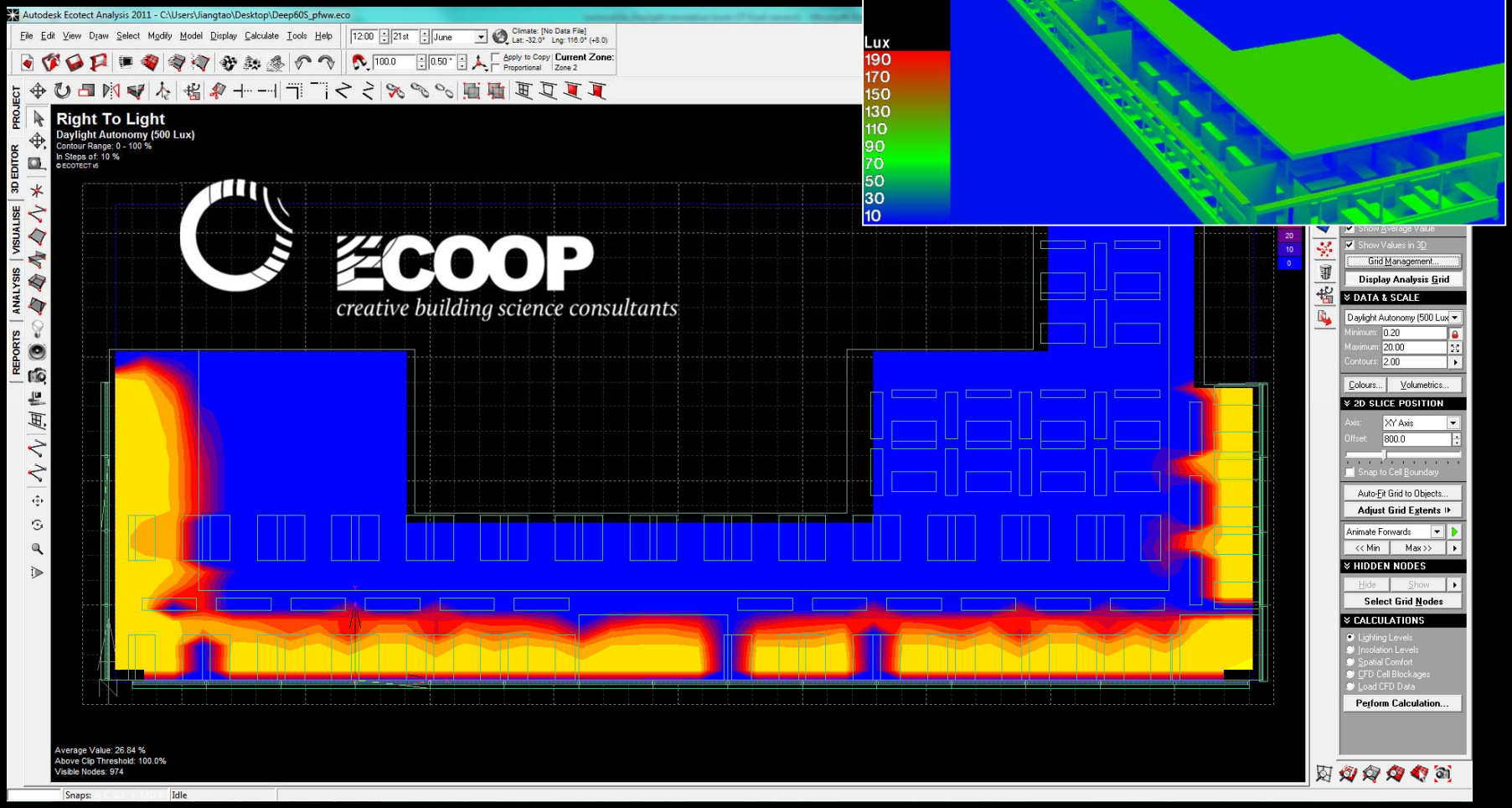
Partial daylight contribution

$$\frac{\Sigma\ (n>0)}{n\ \text{skies}}$$

Continuous DA (%)

Example of simulation of Daylight Autonomy

Kontorslandskap, KOGGEN 2
Malmö, Sverige, NCC Teknik

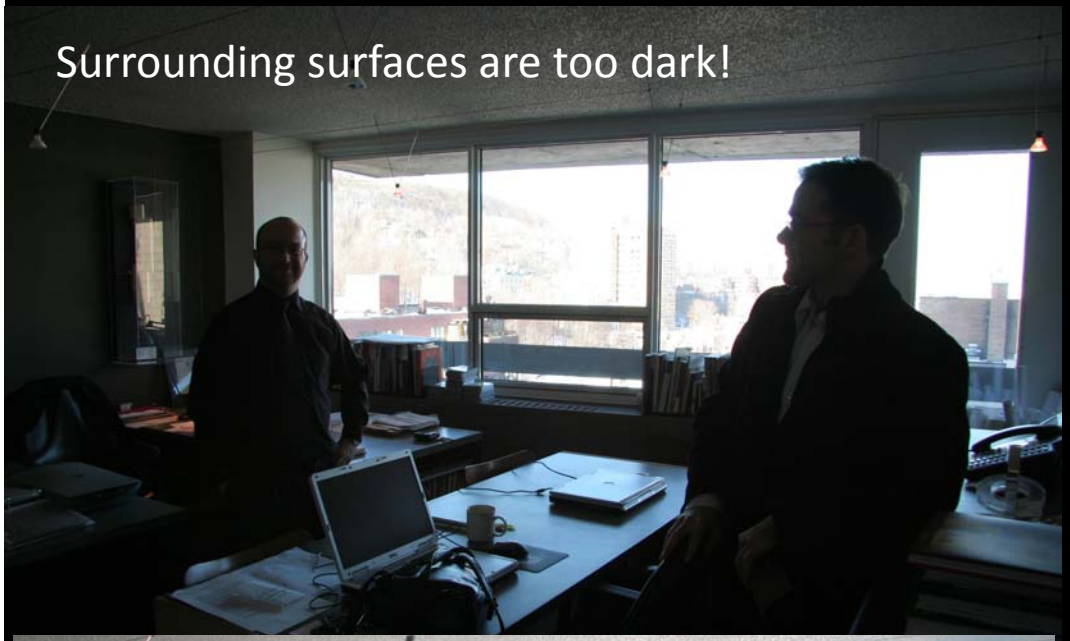


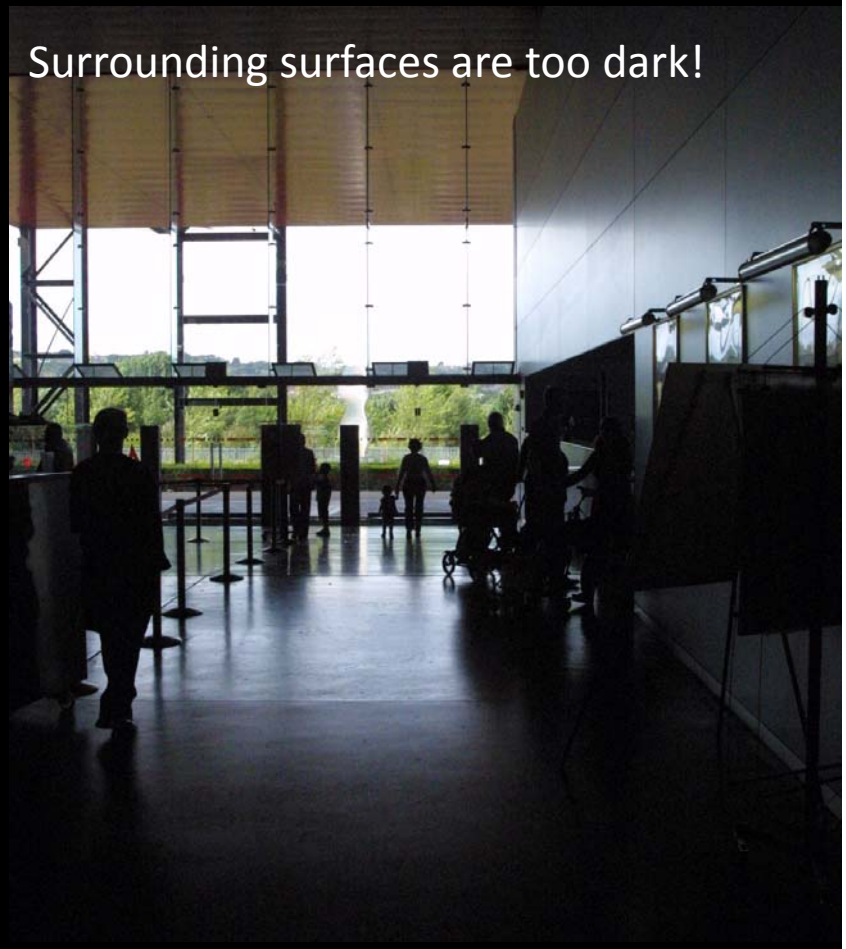
DF and DA say nothing about daylight quality!

Both measure light on a horizontal surface!
This is not the light that we see!

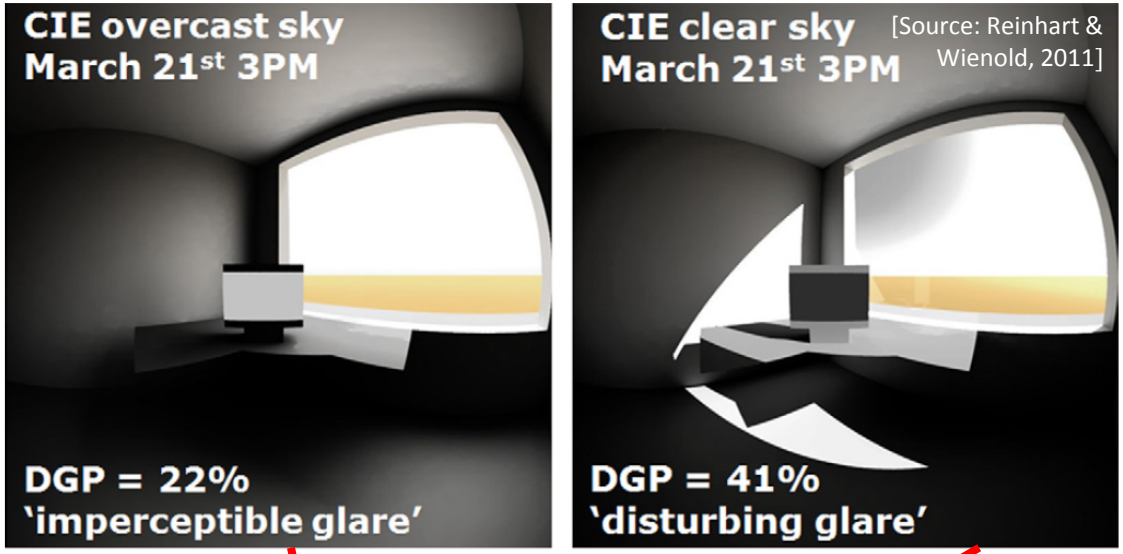
[Source: Desiré Sjöberg , Josephine Stockman]

DF and DA say nothing about daylight quality!





Climate-based dynamic glare evaluation



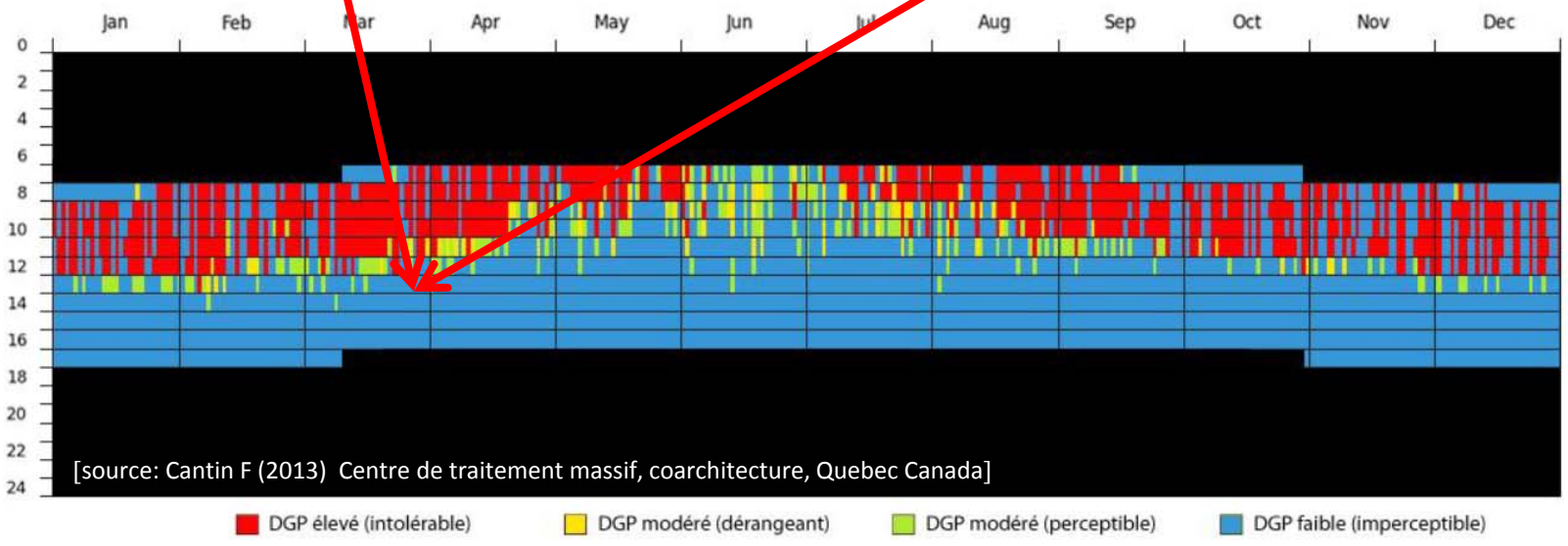
Weather data

Climate-based daylight modelling

Daylight Glare Probability

↓

Annual DGP profile



What's the way forward?

- Climate Based Daylight modelling
  - Provides a basis for considering daylight holistically based on building location & façade orientation
  - Can be integrated with thermal modelling
  - A standardised methodology requires **URGENT** international agreement regarding conventions to be adopted by software providers
    - e.g. UK National Energy Calculation Method based on CEN conventions for EU EPBD compliance
    - NB CEN conventions developed & agreed in 3 years!
      - Implemented by software providers within 3 months!!

Three major initiatives identified

- CEN / TC 169 WG11 Daylight

- CIE 4 D3/D6 Joint Technical Committee

- IES LM- 83 Daylight Metrics Committee

IES LM -83 Daylight Metrics Committee

- Mission to develop a "suite" of daylight metrics
  - Using annual, climate-based simulation
    - To meet visual needs of occupants (not energy performance) initially for 3 types of workplace building
- IES formally adopted/published two metrics
  - Spatial Daylight Autonomy
  - Annual Sunlight Exposure
- Extra LEED credits if LM-83 metrics/modelling is used (NB provides a stimulus/incentive for building designers & software providers)

Conclusions

1. Daylight to become the primary light source in buildings (health, productivity, sustainability)
2. DF is the standard metric used in most systems and countries
3. DF method too simplistic and limited:
   - no maximum
   - non-climate and non-orientation specific
   - says nothing about daylight quality

1. Defining spatial sDA and DGP is a step forward but it demands computing skills (CBDM)
2. CEN, IES and CIE work to arrive at international standard, which should be implemented in software rapidly

Thank you for your attention!