Lucerne University of
Applied Sciences and Arts

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EvalDRC: a new, versatile frontend for climate-based daylight assessment with Contribution Photon Mapping

CC Envelopes and Solar Energy
Lucerne University of Applied Sciences and Arts

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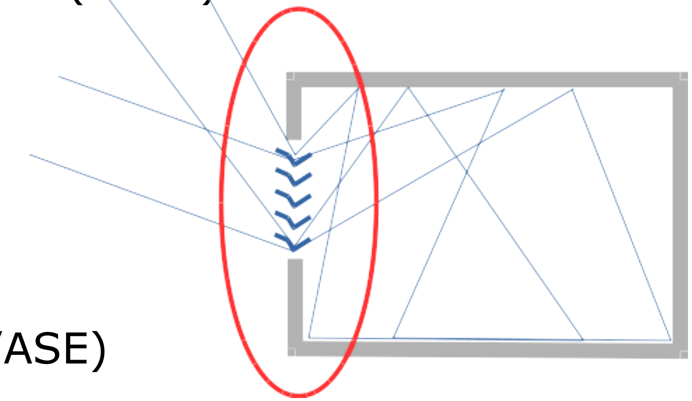
Overview

EvalDRC is a scripted frontend for simulating and assessing the annual performance of Daylight Redirecting Components (DRCs)



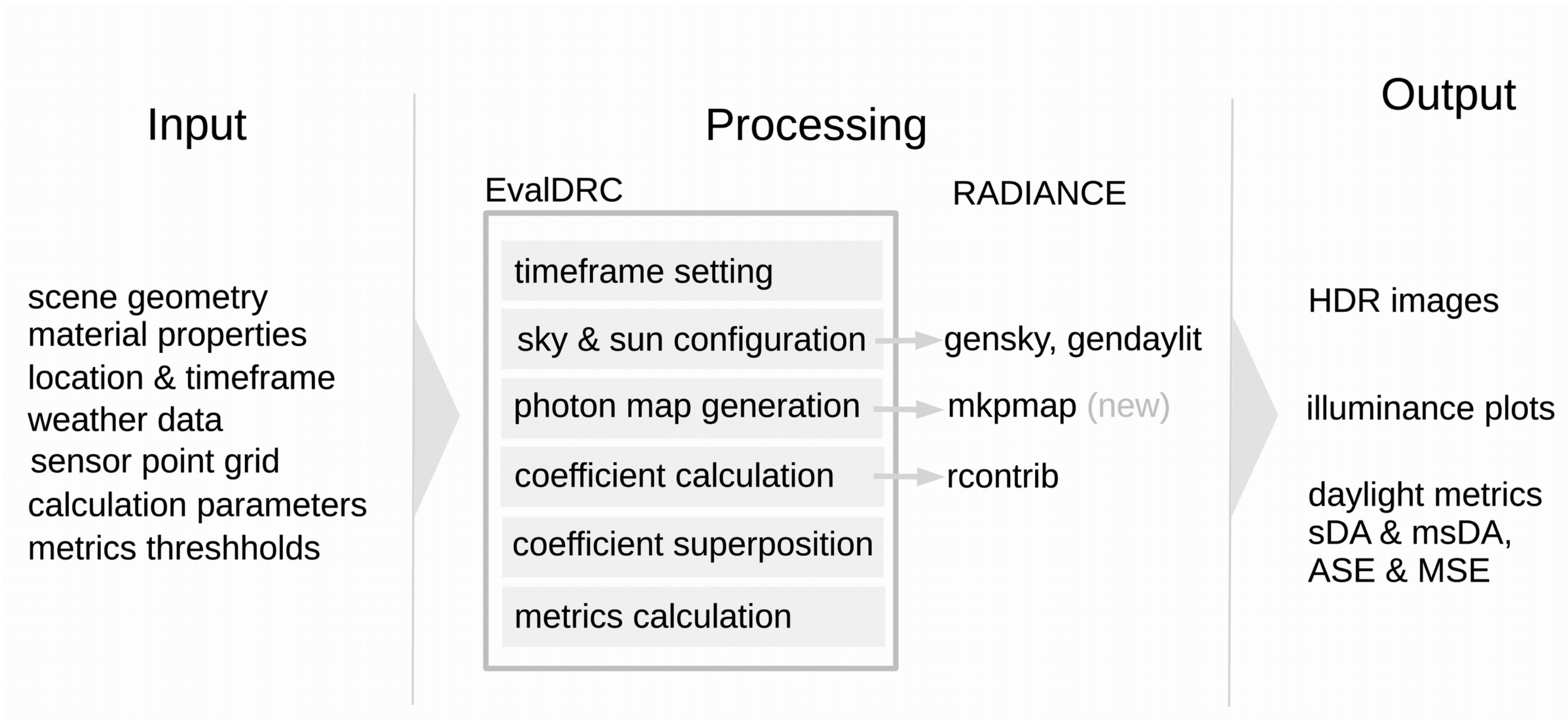
General Features

- Visual evaluation as HDR rendering
- Numerical evaluation as illuminance plots
- Postprocessing with Daylight Metrics (sDA/ASE)
- Supports analytical and climate based sky models

Special Features

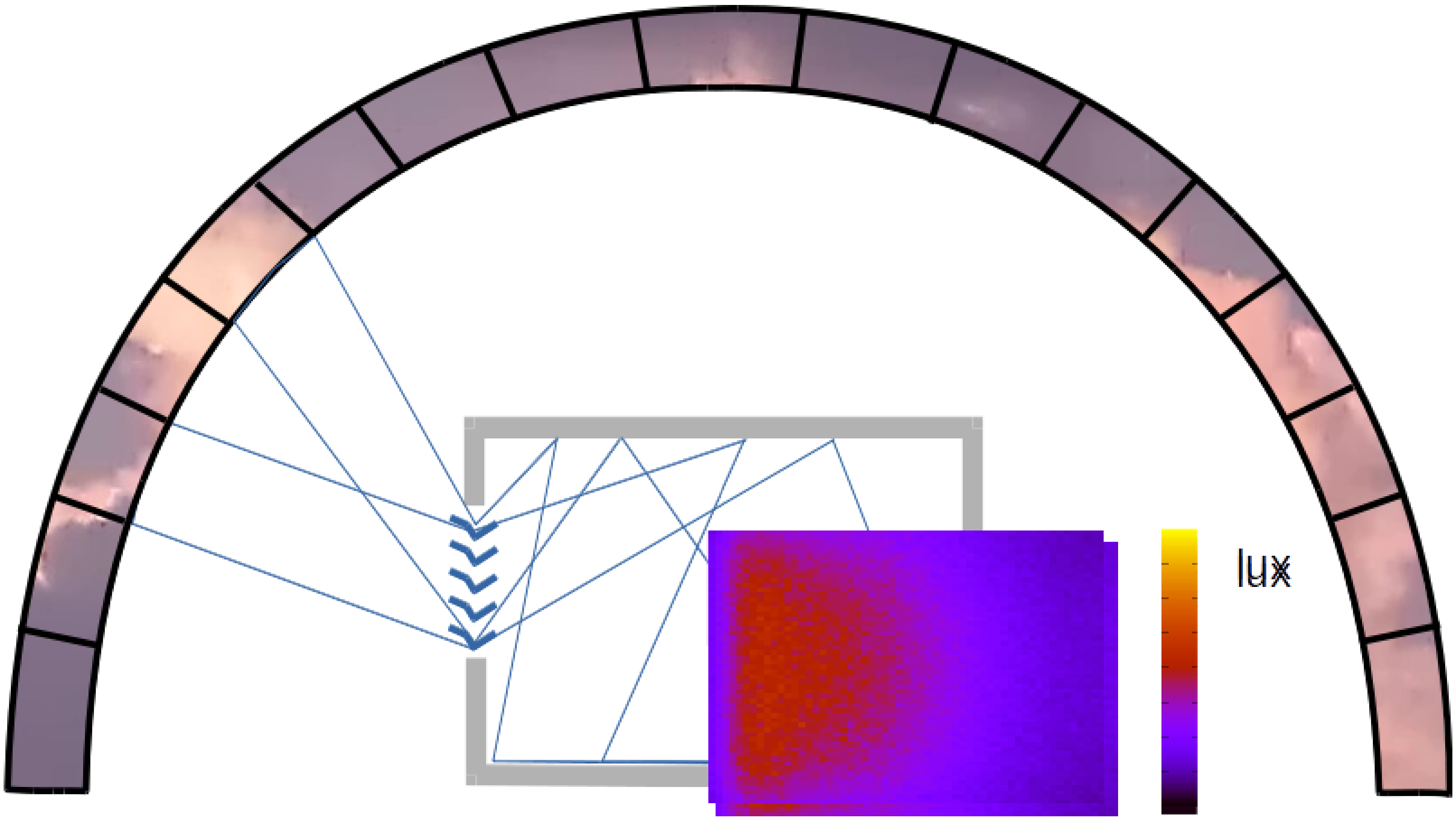
- Supports Contribution Photon Map a./o. classic BSDF data models
- TrueSun coefficients for accurate solar contribution
- Enhanced monthly Daylight Metrics (msDA / MSE)

Process Flow



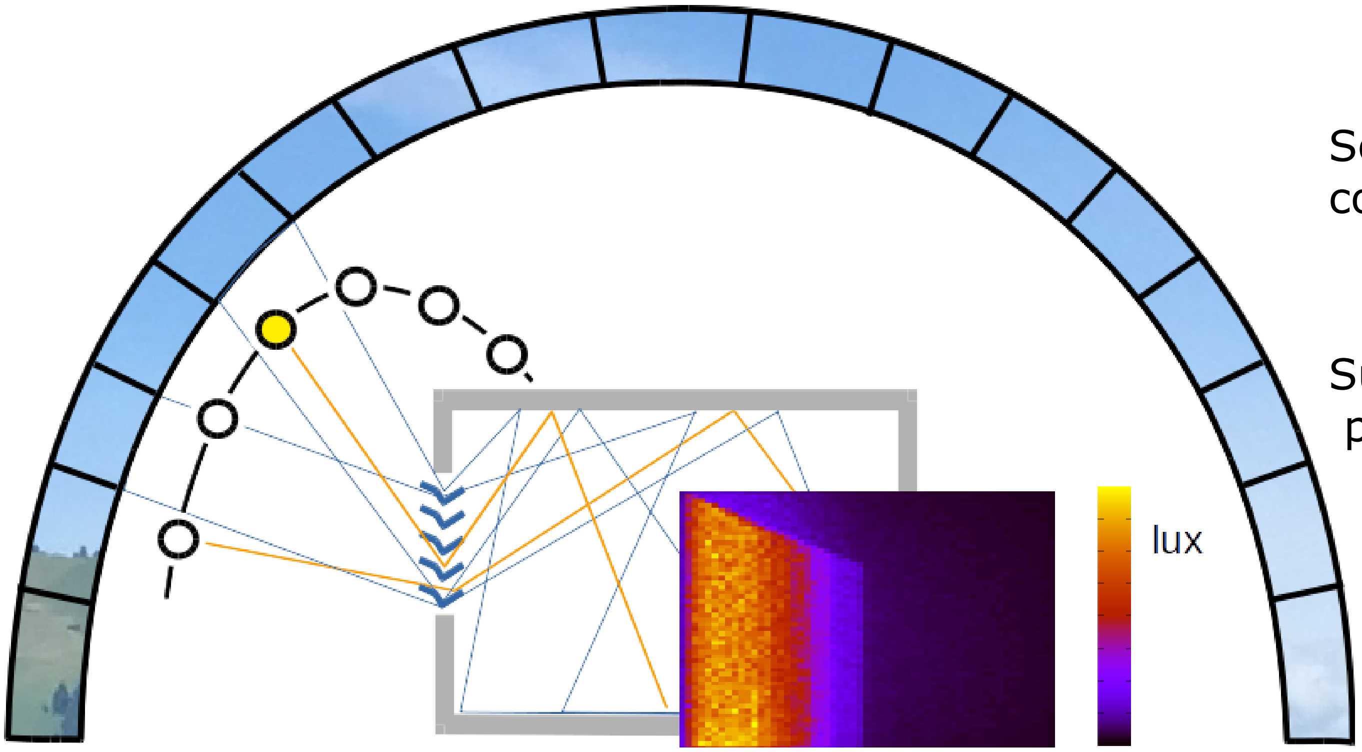
Coefficient Generation

Sky: Standard Sky Discretization with Patches (Tregenza)



Coefficient Generation

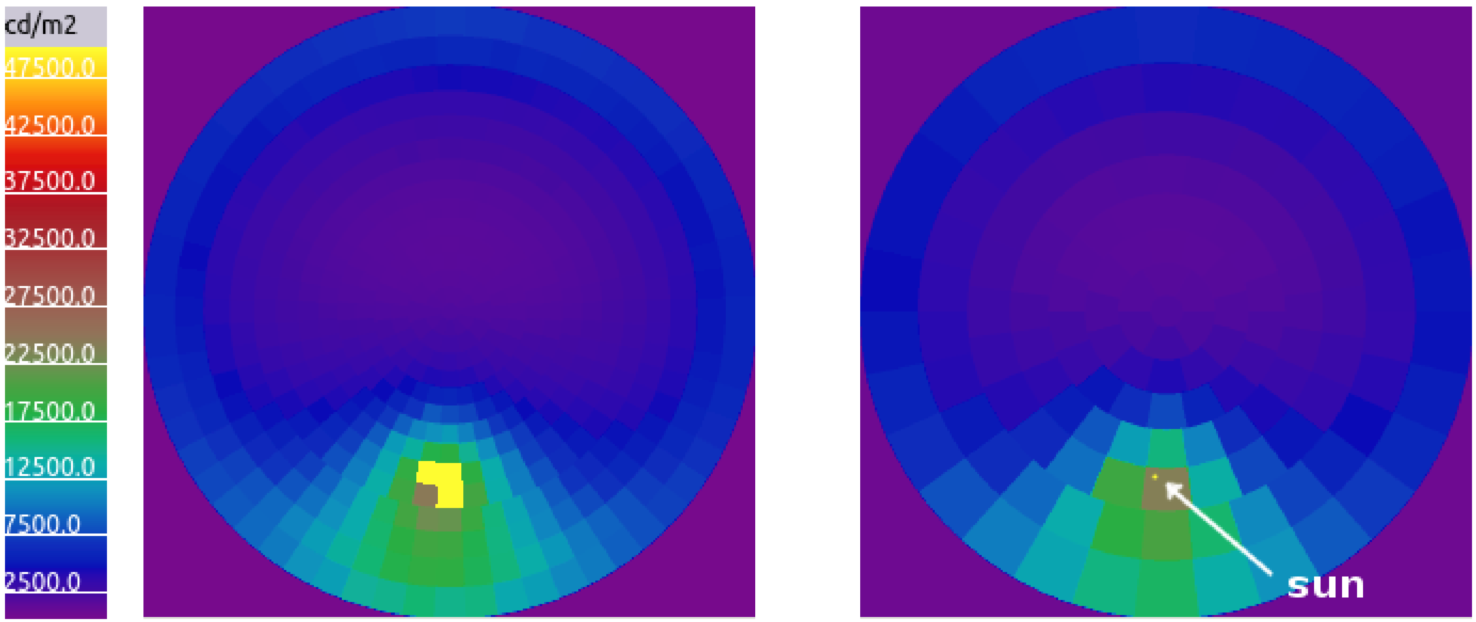
Sun: separate solar coefficients calculated with 0.5° sun sources



Solar contribution coefficients

Superposition of sky patch coefficients plus one solar coefficient

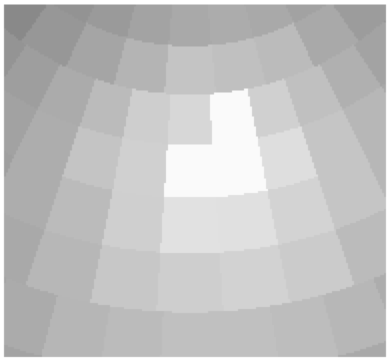
Sky/Sun Model Comparison



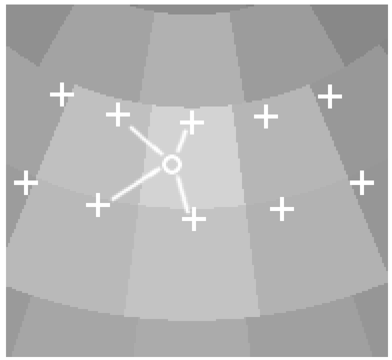
Standard:
sun luminance distributed among neighbouring sky patches

EvalDRC:
sky patches + separate accurate 0.5° sun sources

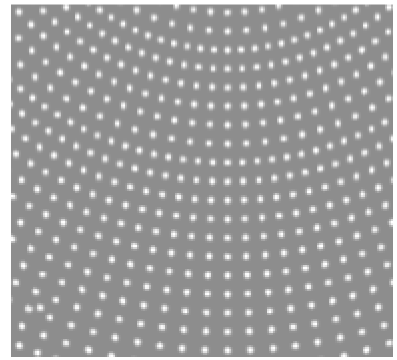
Various Strategies for the Solar Contribution



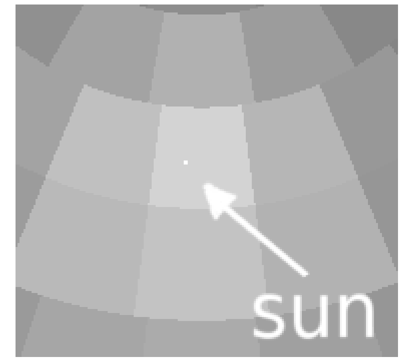
3 Phase Method / Reinhart subdiv. of Tregenza patches



DAYSIM (64 pos.)

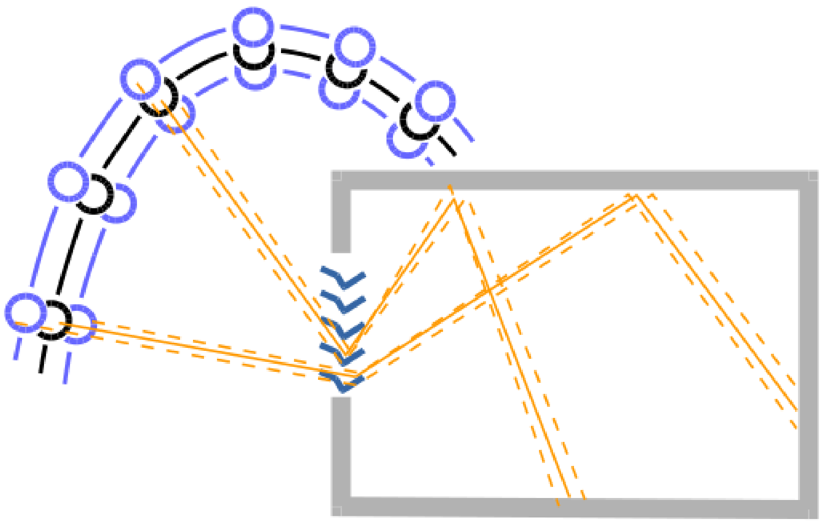


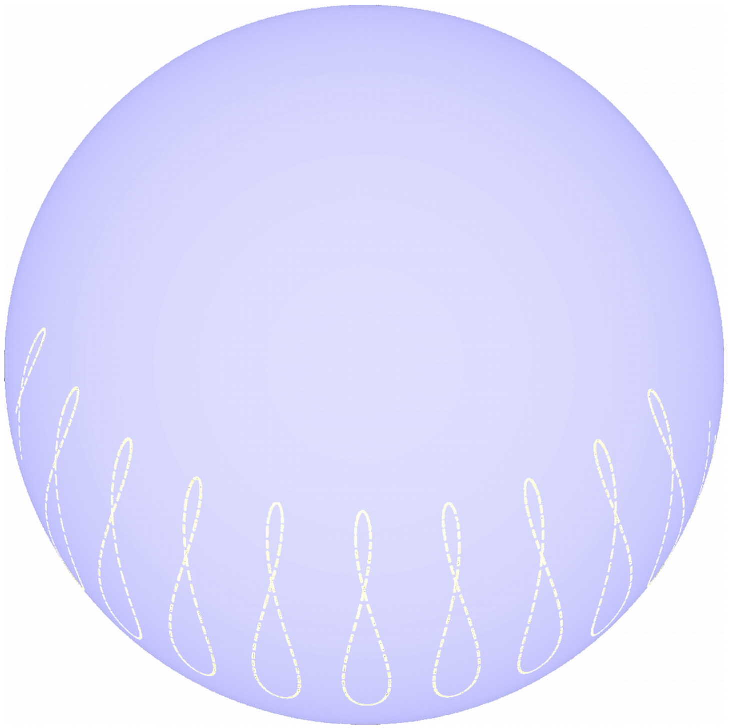
5 Phase Method (Solar Vector)



EvalDRC

TrueSun Compromise: Shared Sunpaths

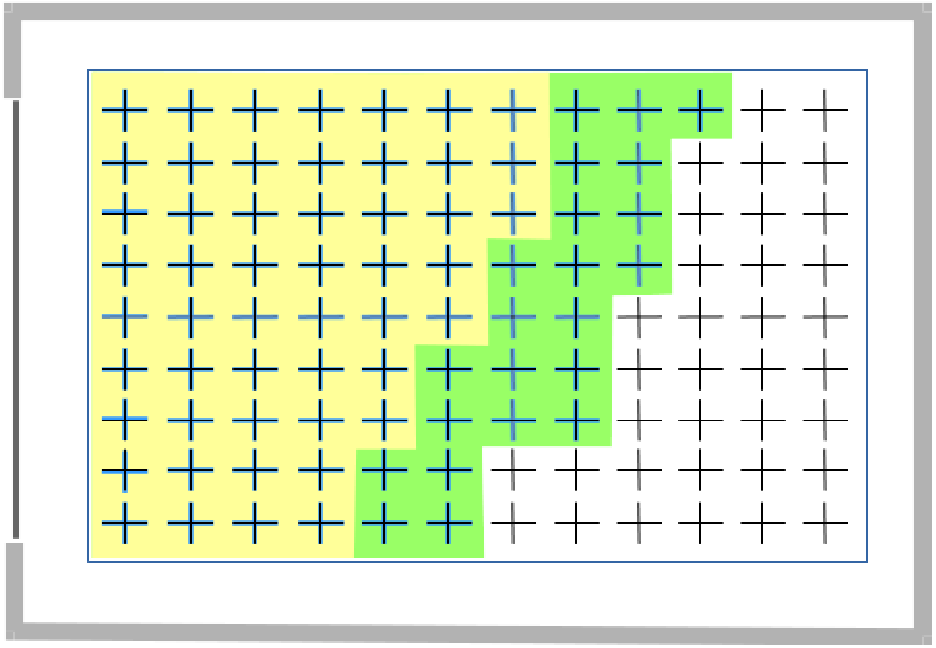




Deviation between sun positions on consecutive days is much less than between the hourly timestamps of the usual metrics time schedule (5d working week, 10h per day). Sunpath for one day can be utilized for 1 or 2 days befor and after it with negligible accuracy loss for the final metrics results. (Max. deviation from the true sun positions is approx. 1 °)

sDA / ASE Daylight Metrics

spatial Daylight Autonomy: sDA $_{300,50}$



1: Time
I >300 lx for T>50%
of office hours

2: Space
A > 55 %: acceptable

A > 75 %: preferred

Monthly Daylight Metrics

The monthly metrics are calculated analogously to the annual counterparts.

E.g., for a grid with N points, the msDA for month m is:

$$msDA_m = \frac{\sum_{j=1}^{N} S(j,m)}{N} \quad \text{with} \quad S(j,m) = \begin{Bmatrix} 1 : s_{j,m} \geq \tau t_m \\ 0 : s_{j,m} < \tau t_m \end{Bmatrix},$$

$s_{j,m}$ = occurence count of exceeding the sDA illuminance threshold at point j for month m

t_m = timestamp count for month m

There is no simple relationship between monthly and annual metrics. Especially, the annual value is *not* the average of the monthly values. (Cf. [1])

Generic Dynamic Sunshade Model

The sDA definition demands the consideration of sun shading for timestamps with sunlight exposure on the workplane. (Default definition: more than 2% of grid points receive more than 1000 lux direct sunlight).

Current implementation in EvalDRC:

1) perform 2 annual simulation runs, one for a scene with, and one for the scene without sun shade gemoetry

2) EvalDRC then performs a dynamic combination of the 2 result sets acc. to the specified thresholds

DRC Evaluation methods

Contribution Photon Map

Provide accurate geometry and material model of DRC system

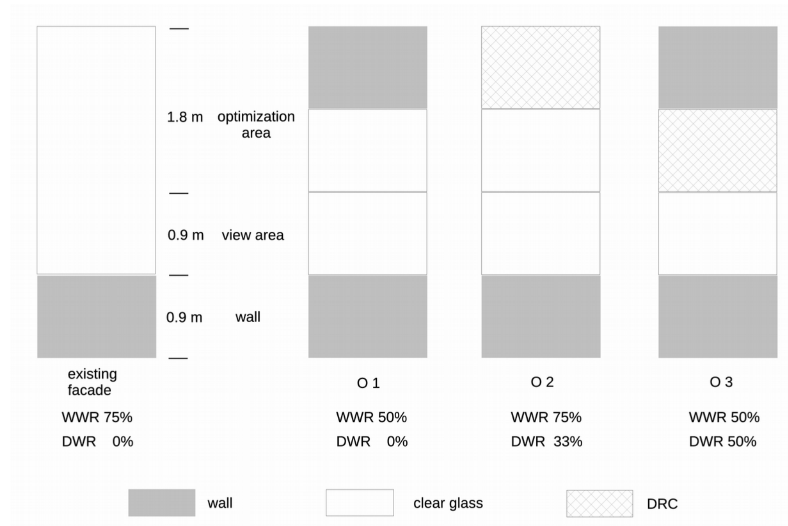
BSDF Data Representations

Provide (more or less) abstract 'representative' models of DRC systems with attached BSDF data sets

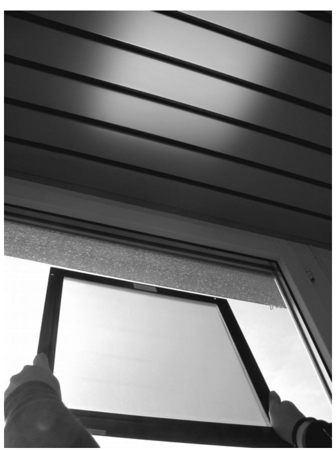
Application Example: Daylight Optimization Study

Classroom (Studio) at the Dept. of Architecture, Lucerne University

View towards south facing facade



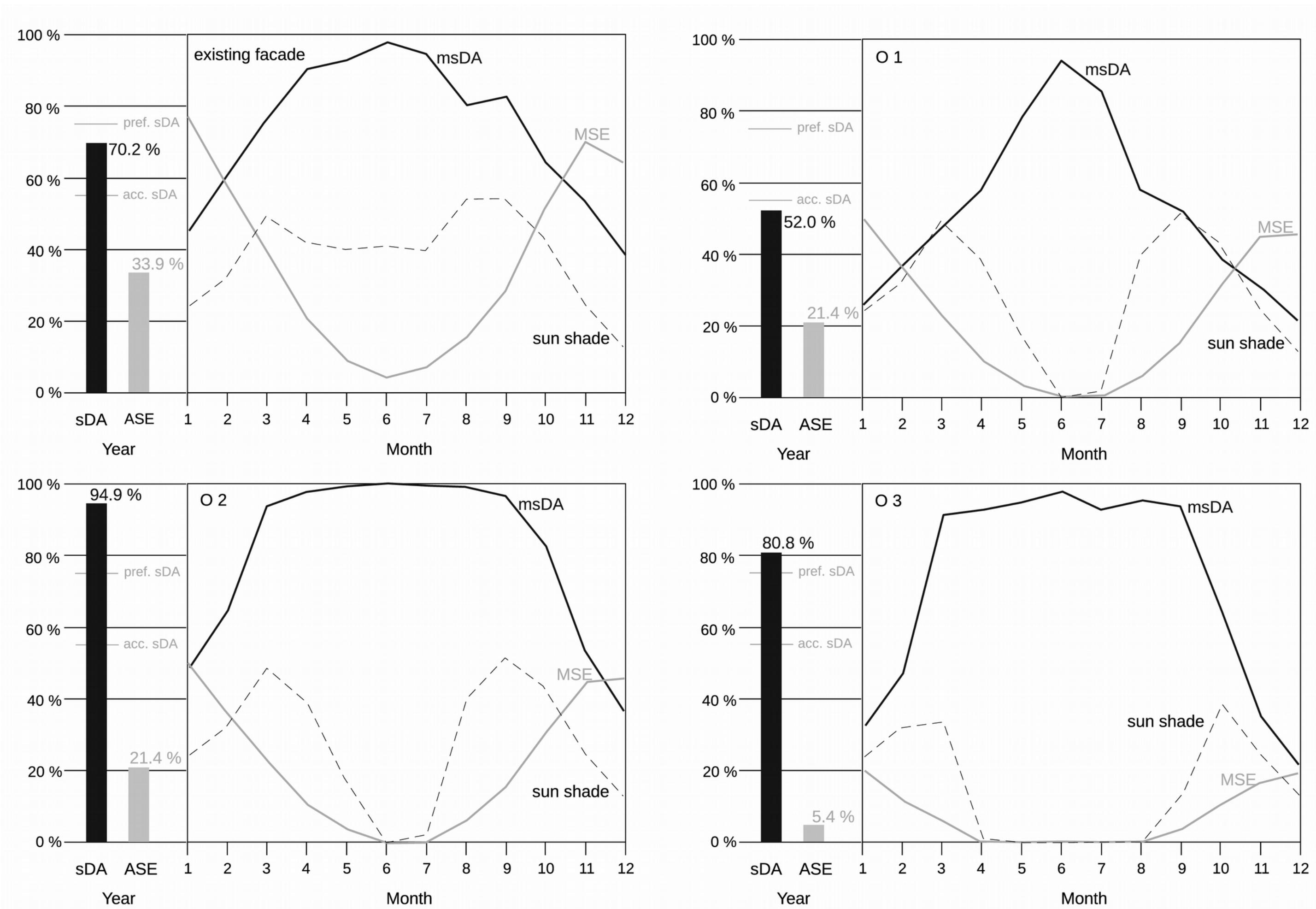
Abstract facade model



Strategy: Reduce WWR to reduce solar gain, compensate with DRC (microstructured film). Cf. [2]

Sample of holographic film, BSDF measured at CC EASE goniophotometer lab

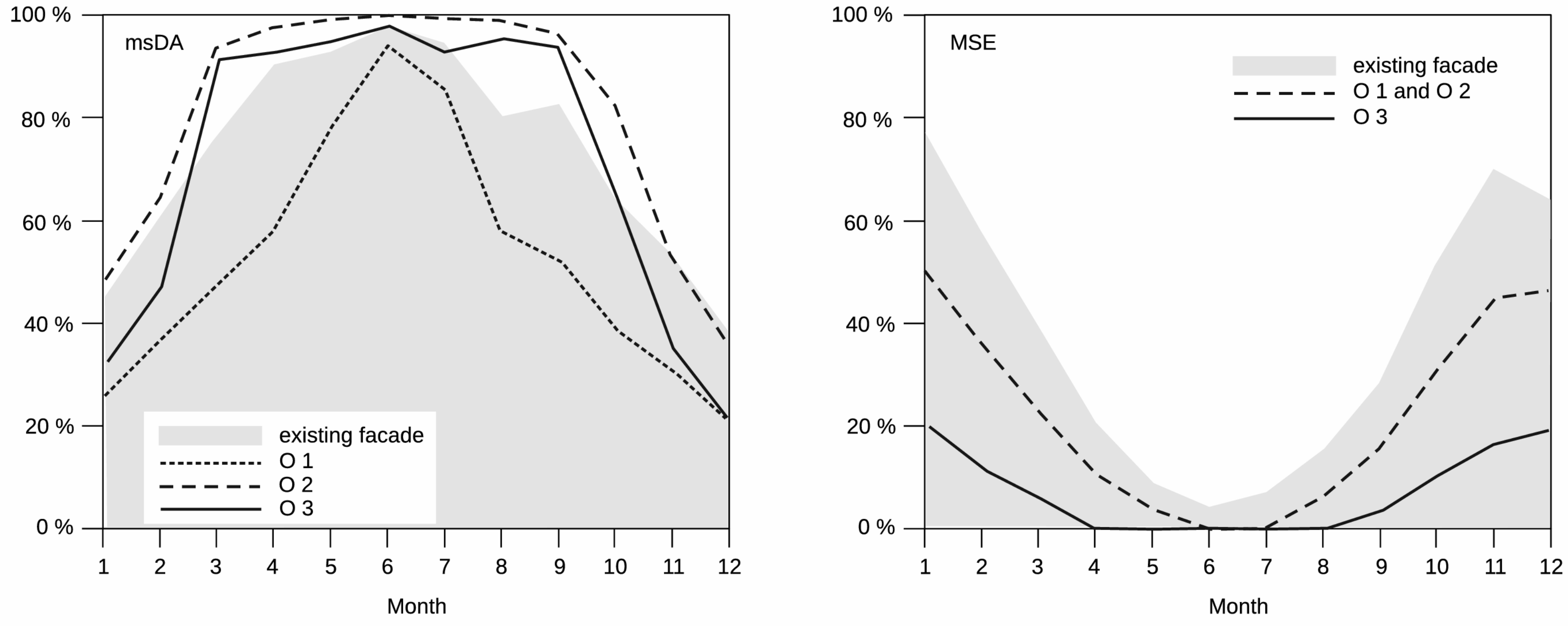
Daylight Metrics Results



bar diagrams (left): annual sDA/ASE, graphs (right): monthly msDA / MSE

Daylight Metrics Results

Comparison of monthly msDA and MSE



Application Example: Daylight Course at IYTE (İzmir)

Learning goals

- Daylight redirection stategies / DRC types
- Geometry model aspects (level of detail, etc.)
- Material models (diffuse, diffuse+specular, full BSDF, ...)
- Software based simulation techniques and limitations (Radiosity, Raytracing, Photon Mapping, …)
- Daylight assessment (metrics, visualizations for confirmation/cross-checking

Study Project

Development of a daylight strategy with self-modeled DRC elements for a classroom with south facing facade.
3D Models built in Relux
Final evaluation with EvalDRC
Discussion and analysis of simulation results

Conclusion & Outlook

Conclusion

- EvalDRC is a powerful, flexible and convenient framework for the performance assessment of DRCs
- Support for both Contribution Photon Mapping and/or BSDF data makes it applicable for a wide variety of DRC systems
- Monthly daylight metrics provide a better means for understanding DRC system performance compared to the coarser annual avarages

Tentative Outlook

- Going public ? (Funding ... ?)
- Using EvalDRC together with field-of view based glare evaluation tools
- Connection to thermal simulation tools
- Enhanced calculation methods for dynamic sunshade models

Thank you for your attention!

Our website: http://www.hslu.ch/ccease

References / Suggested further reading:

[1] C. Bauer, S. Wittkopf, Annual daylight simulations with EvalDRC – Assessing the performance of daylight redirection components, Journal of Facade Design and Engineering 3 (2016) 253–272, DOI: 10.3233/FDE-160044

[2] T. Kazanasmaz, L. O. Grobe, C. Bauer, M. Krehel, S. Wittkopf, Three approaches to optimize optical properties and size of a South-facing window for spatial Daylight Autonomy, Building and Environment 102 (2016) 243–256. DOI: 10.1016/j.buildenv.2016.03.018

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