PPF: a tool to study solar irradiation and illuminance in urban areas

Raphaël Compagnon

(September 2002)

Ecole d'ingénieurs et d'architectes de Fribourg
Hochschule für Technik und Architektur Freiburg

Developed in the framework of the European project:

PRECis: Assessing the Potential for Renewable Energy in Cities

- A method to quantify the potential for solar (passive+active) and daylighting applications in urban areas
- Focus mainly on vertical surfaces (buildings facades)

- Goal: helping the design of "Solar Cities"

[Final Energy]

=

[Urban Solar and Daylight Availability]

⊗

[Utilisation Factors]

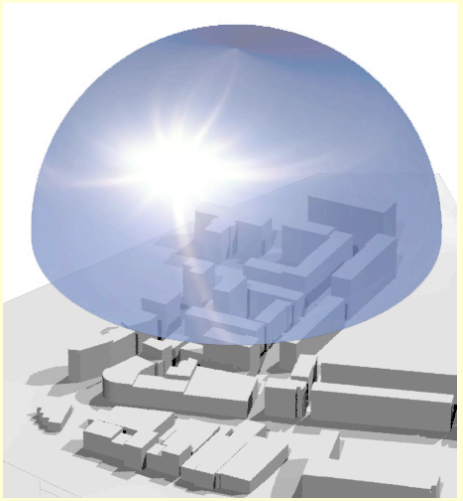
[Urban Solar and Daylight Availability]

=

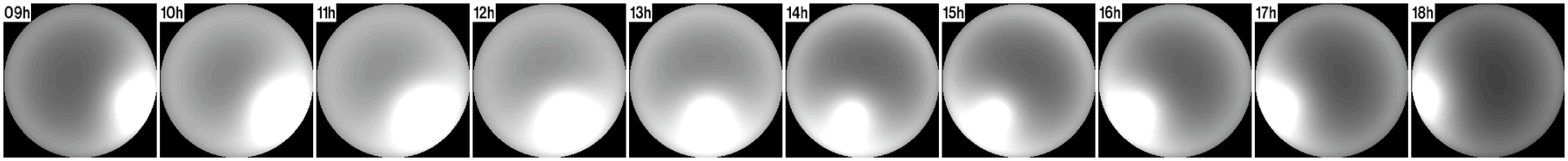
[Sky]

⊗

[Urban form]



Sky model



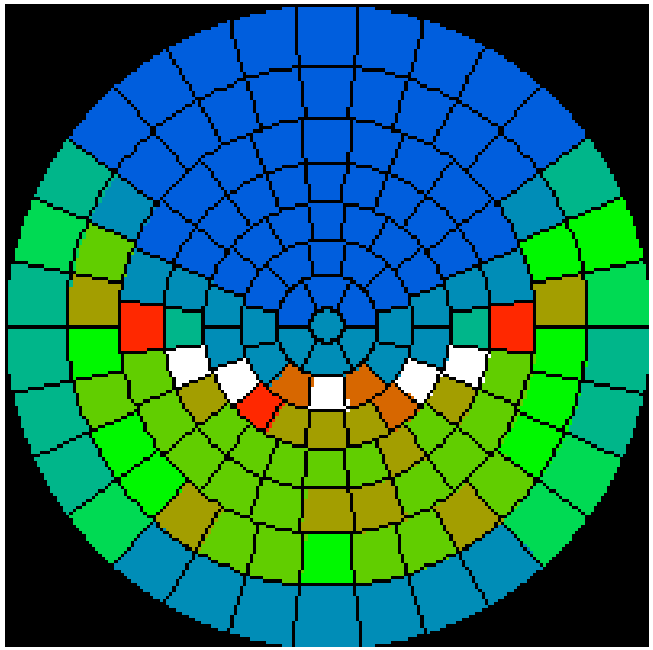
Hourly sky models generated by gendaylit using climatic data from METEONORM

Averaging process to obtain «average sky models » for specific applications

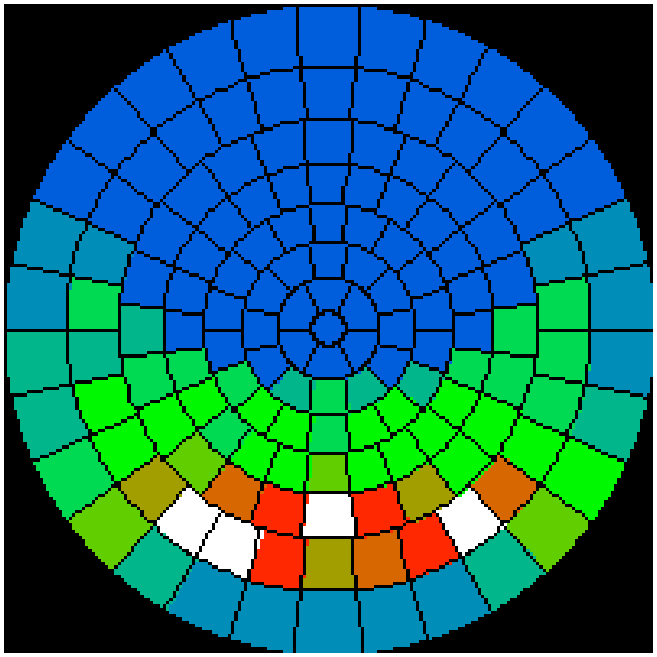
Year	Heating season	8h–18h
radiance values [$W/m^2/sr$]	radiance values [$W/m^2/sr$]	luminance values [$lm/m^2/sr$]
Active solar applications	Passive solar	Daylighting

Radiometric average skiy models (solar applications)

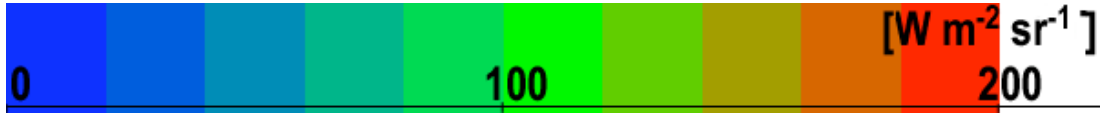
Average radiometric sky model computed over the whole year (4330 hours):



Average radiometric sky model computed over the heating season (2299 hours):

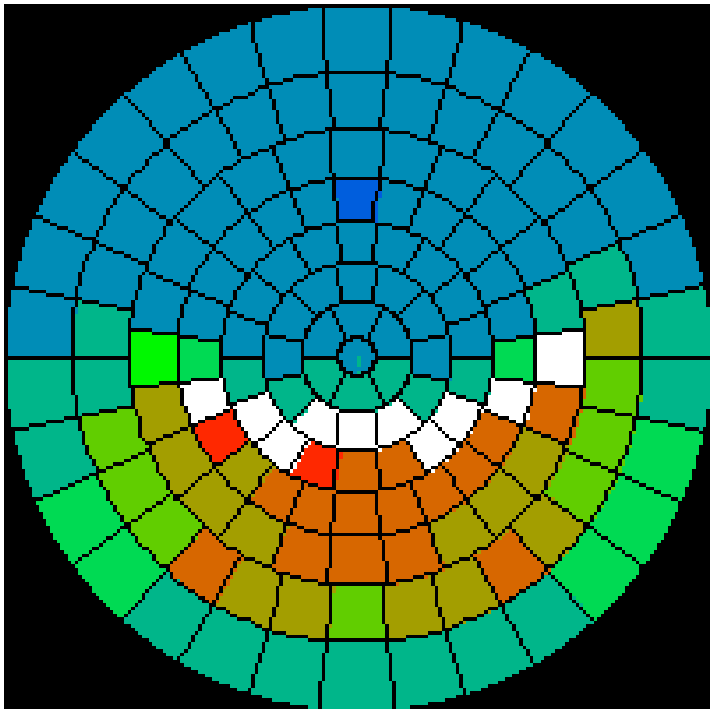


False colour radiance scale:

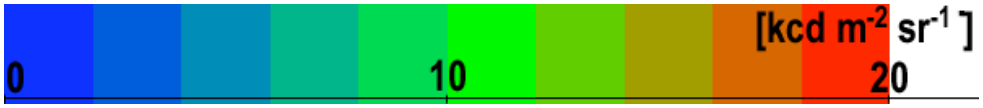


Photometric average sky model (Daylighting)

Average photometric sky model computed over the whole year (4330 hours):



False colour luminance scale:



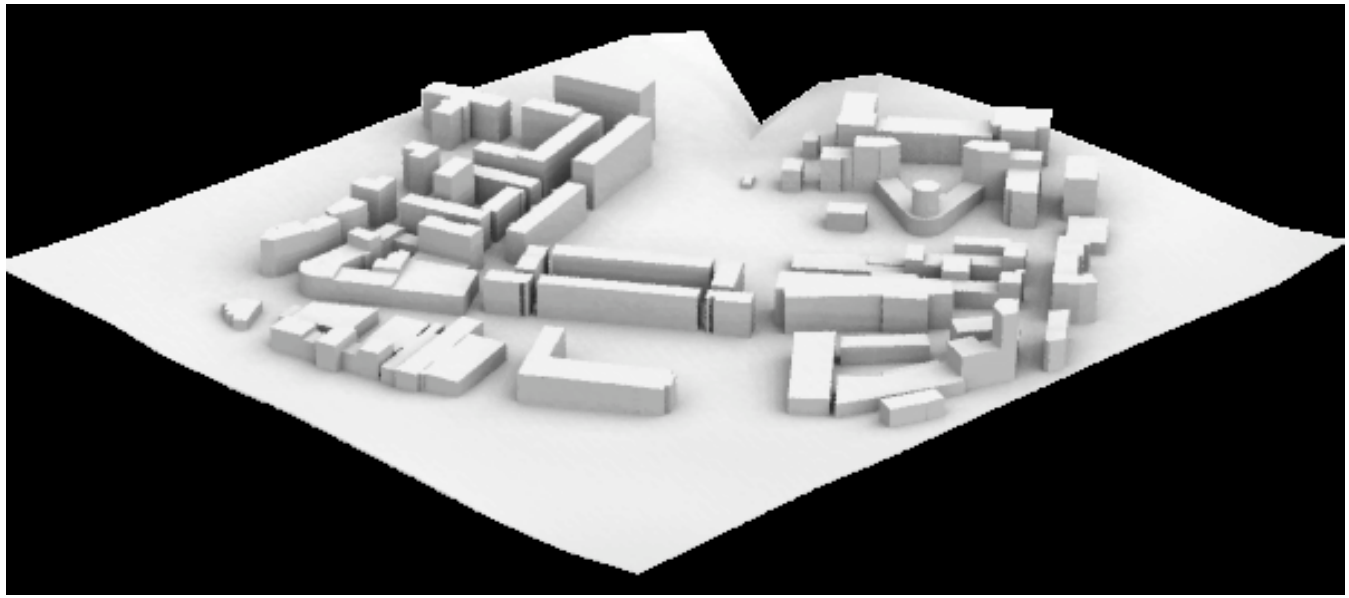
3D buildings model

Geometric data:

- Buildings footprints at ground level
- Top heights

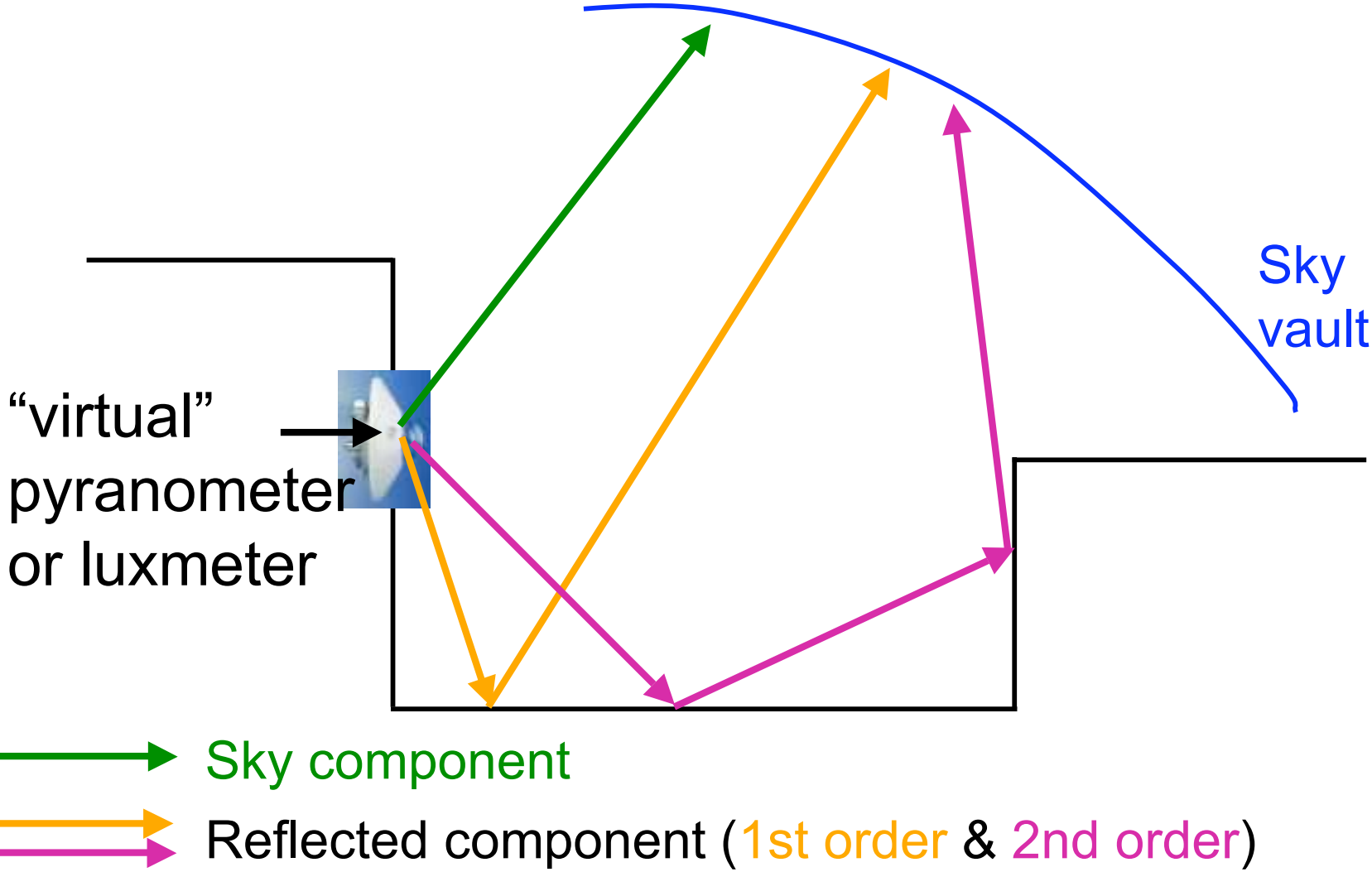
Numeric data:

- Number of storeys

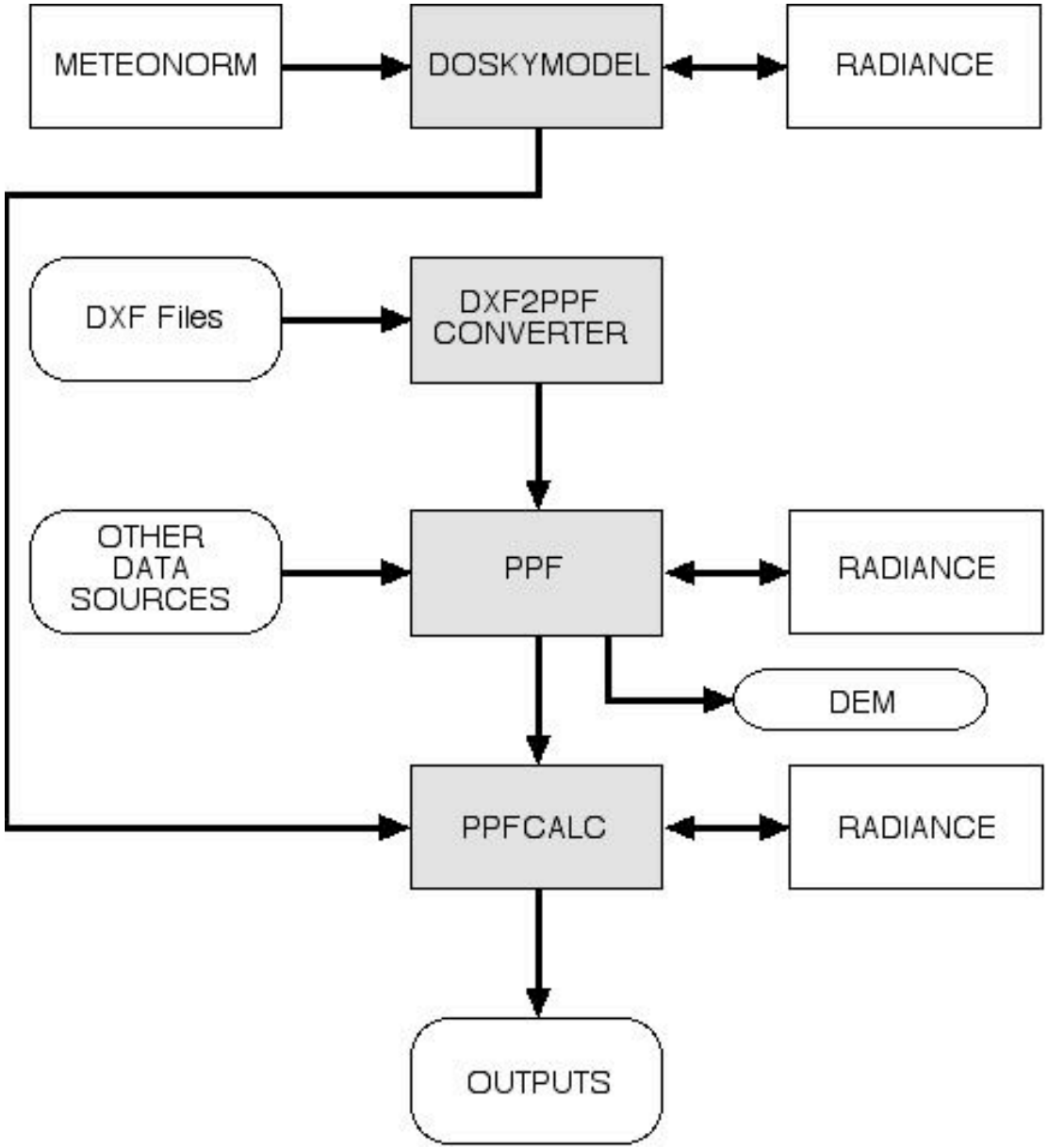


⊗ Simulations ⊗

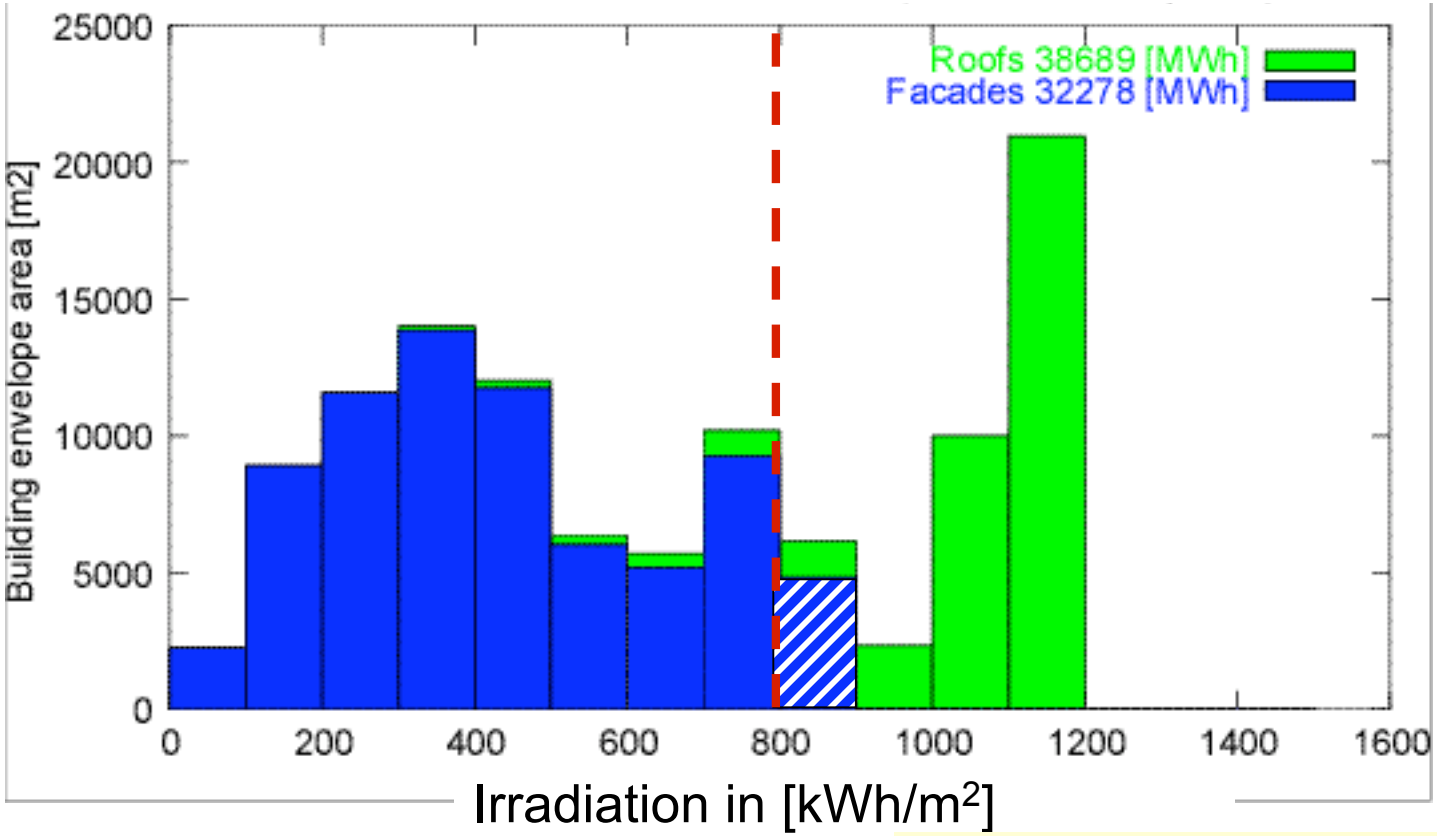
Using Radiance backward ray-tracing program



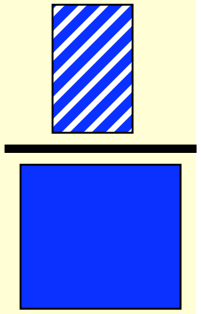
PPF structure



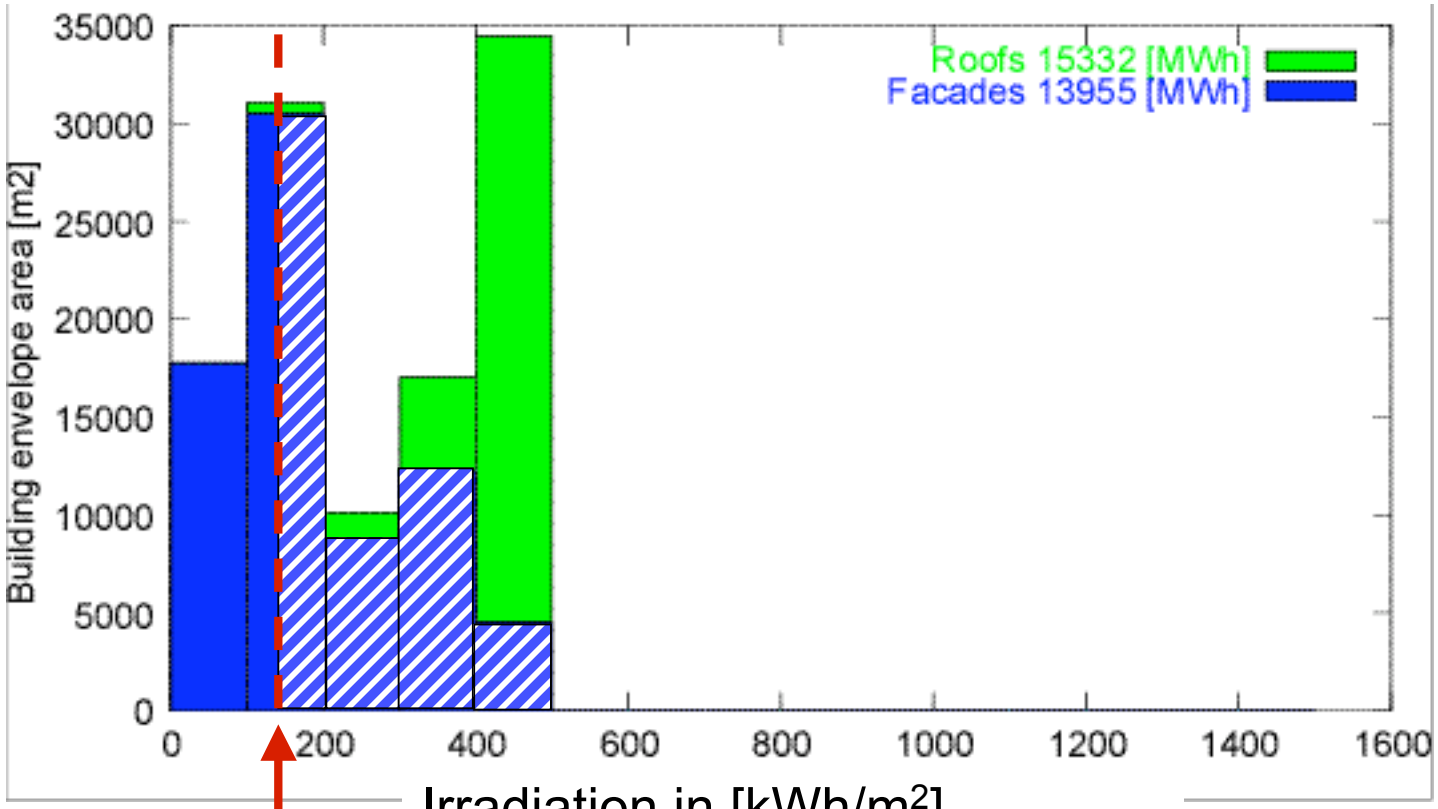
Global solar irradiation distributions



Threshold for PV facades systems

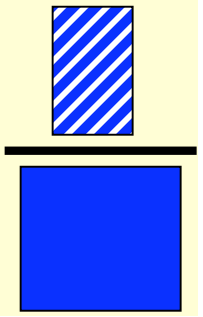
Facades % with PV potential = 

Global solar irradiation (heating season)

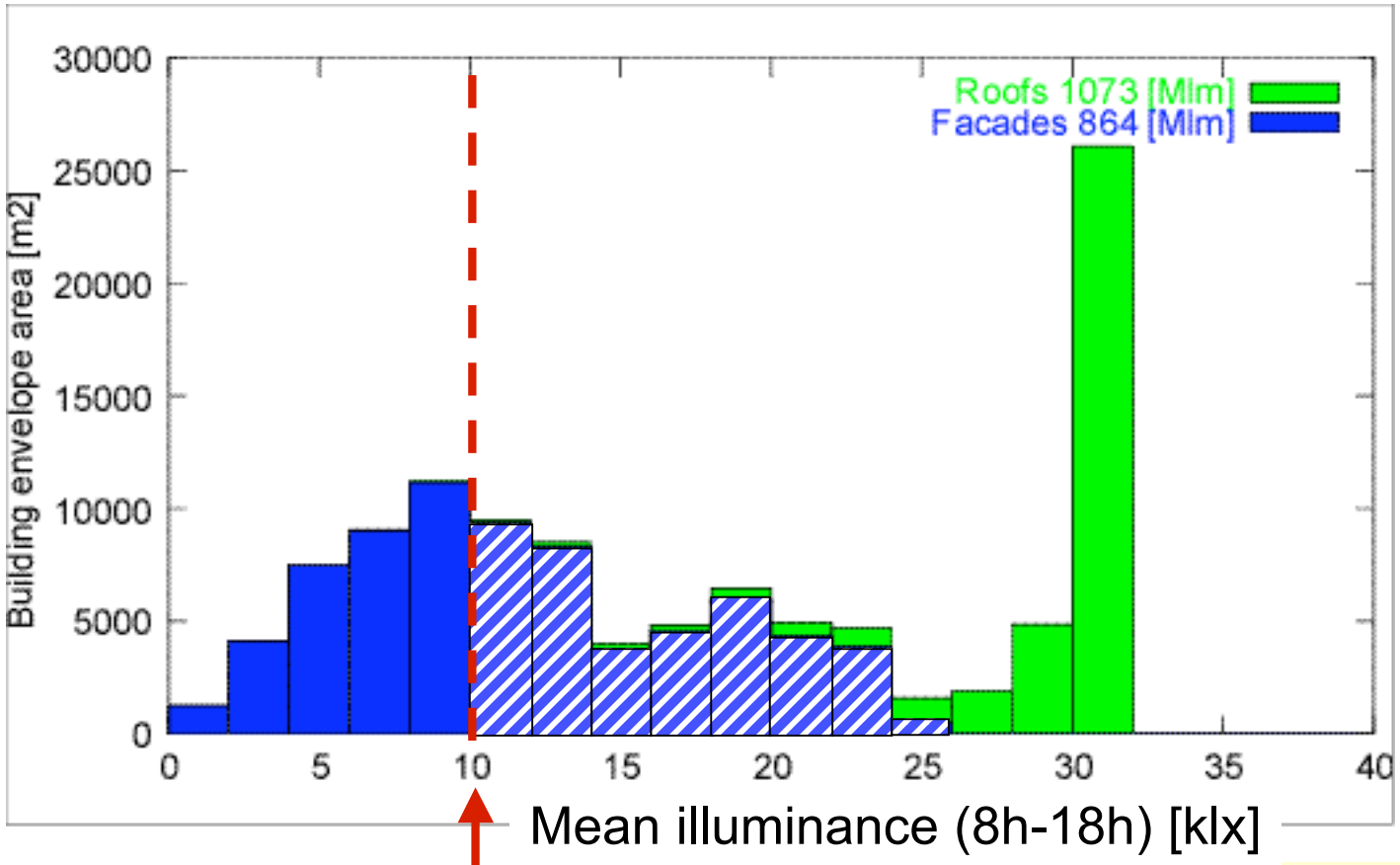


Threshold for passive solar

Facades % with passive solar potential =

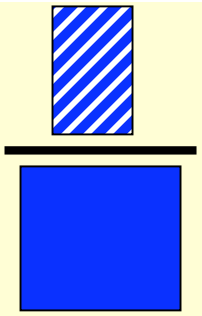


Illuminance distributions

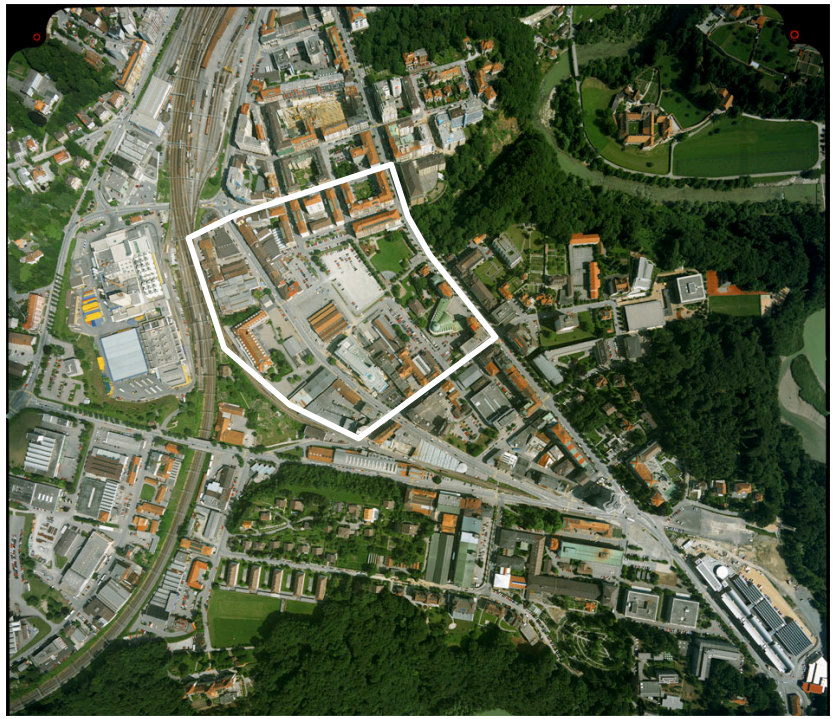


Threshold for daylighting

Facades % with daylighting potential =



Case study site in Fribourg (CH)

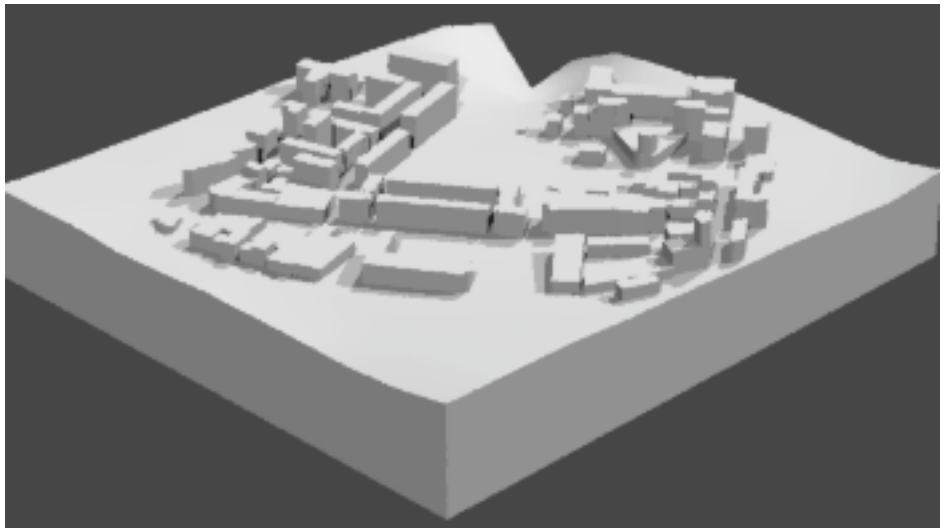


Perolles area

Plot ratio = 1.2

Facades fractions:

- for PV = 6.5 %
- for passive solar = 52 %
- for daylighting = 54 %



Hypothetical urban forms (plot ratio=2.0)

- PV = 10 %
- passive solar = 84 %
- daylighting = 83 %

Comb (6 storeys)

- PV = 15 %
- passive solar = 80 %
- daylighting = 82 %

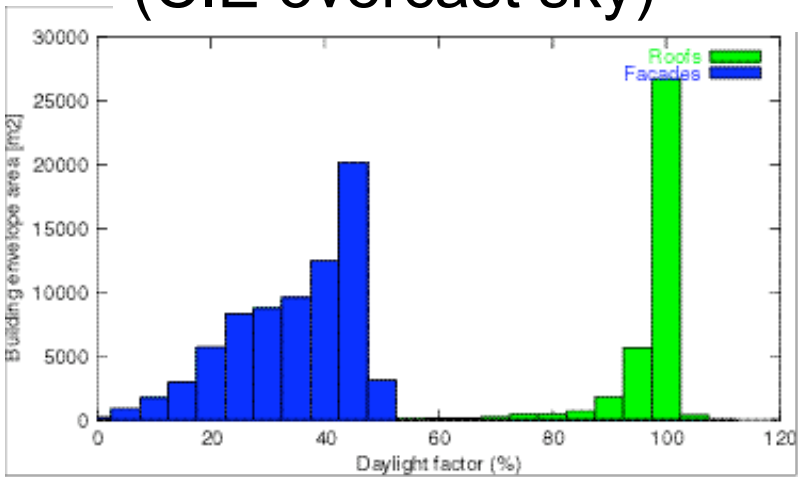
Courtyards (4 & 8 storeys)

- PV = 21 %
- passive solar = 100 %
- daylighting = 100 %

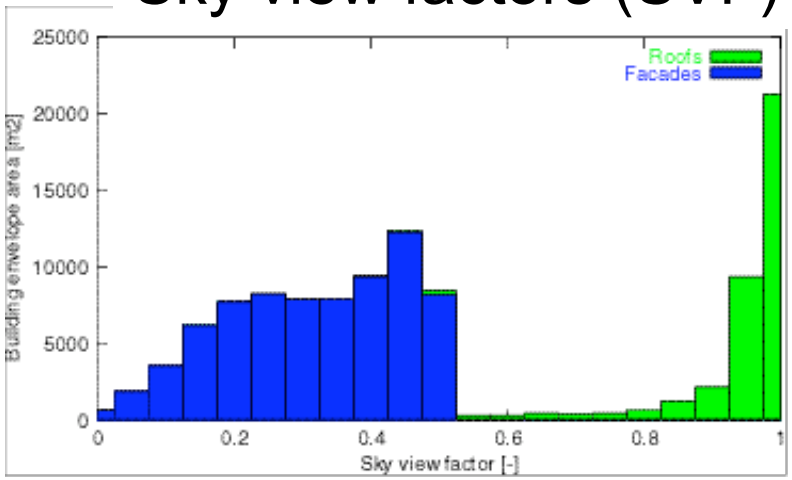
Towers (15 storeys)

Climatically independent characteristics

Outdoor daylight factors
(CIE overcast sky)



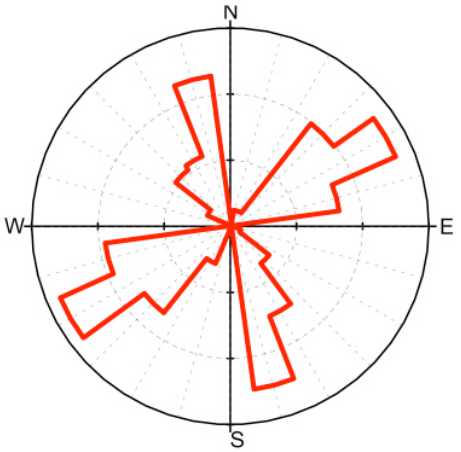
Sky view factors (SVF)



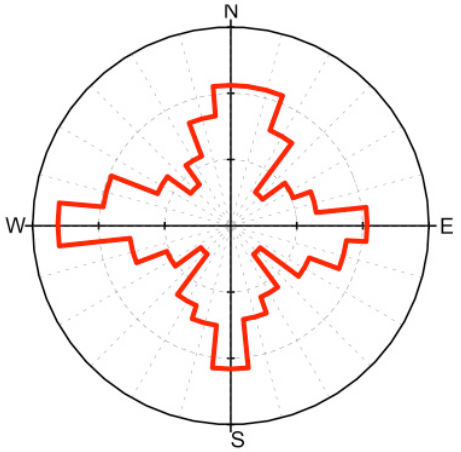
How to define the “orientation” of an urban area ?

- Count SVF-weighted facades areas facing every directions

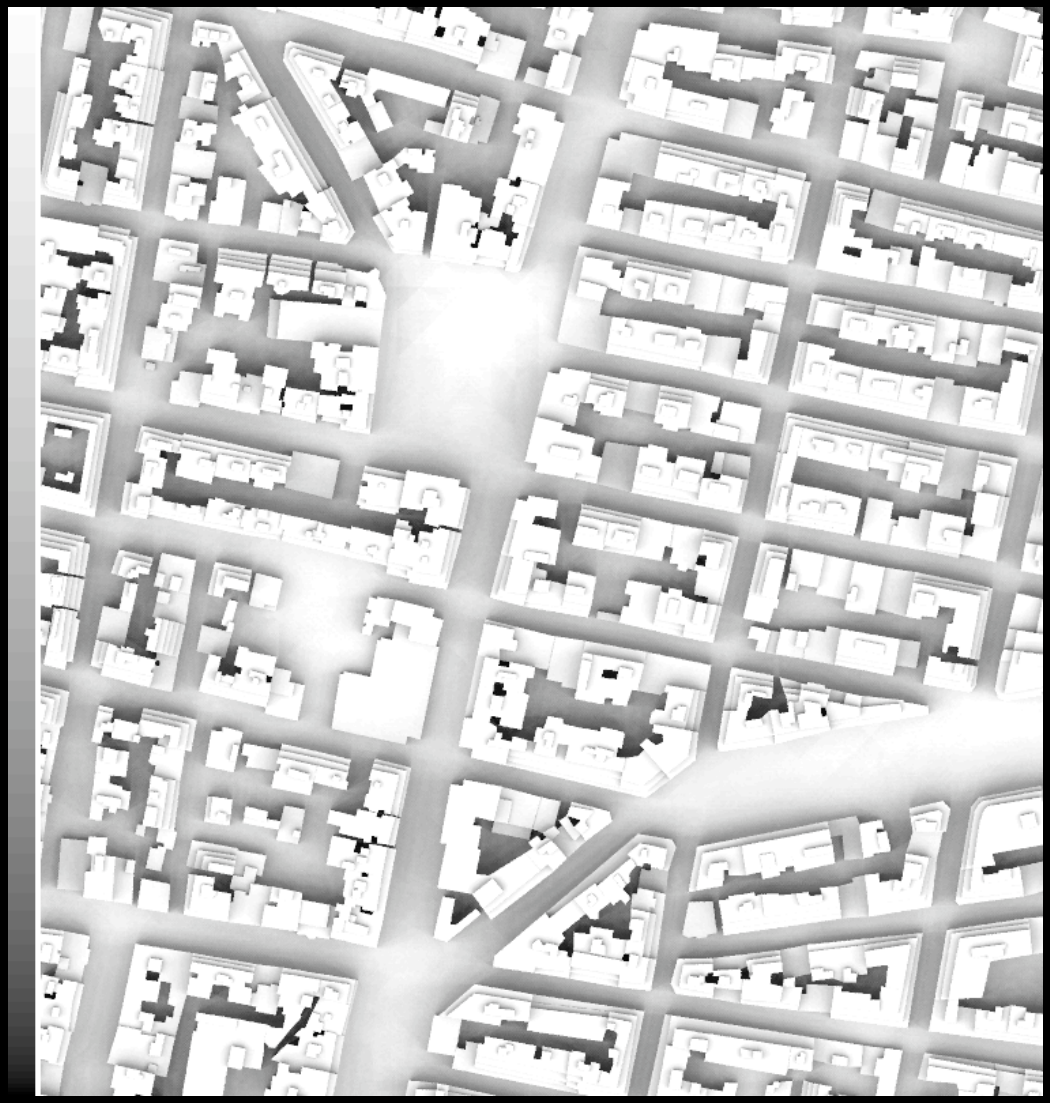
Perolles area
Fribourg (CH)



Plaka area
Athens (GR)



Visualisations



Gray level aerial view showing annual irradiation levels on a part of the PATHSIA area in Athens

Visualisations

Falsecolour aerial view showing roof areas suitable for PV modules on a part of the PATHSIA area in Athens

Conclusions

- PPF allows to compute irradiation and illuminance distributions over large urban areas
- Already used for several case studies
- PPF used as a tool for ongoing projects in collaboration with EPFL
- New extensions planned for urban open space analysis