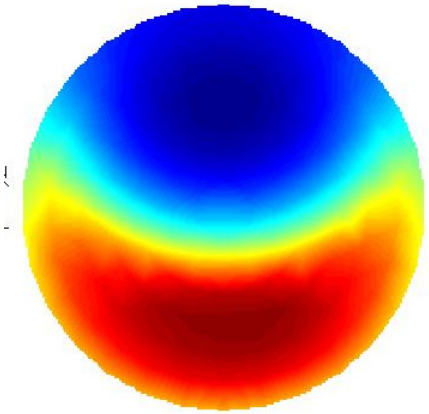


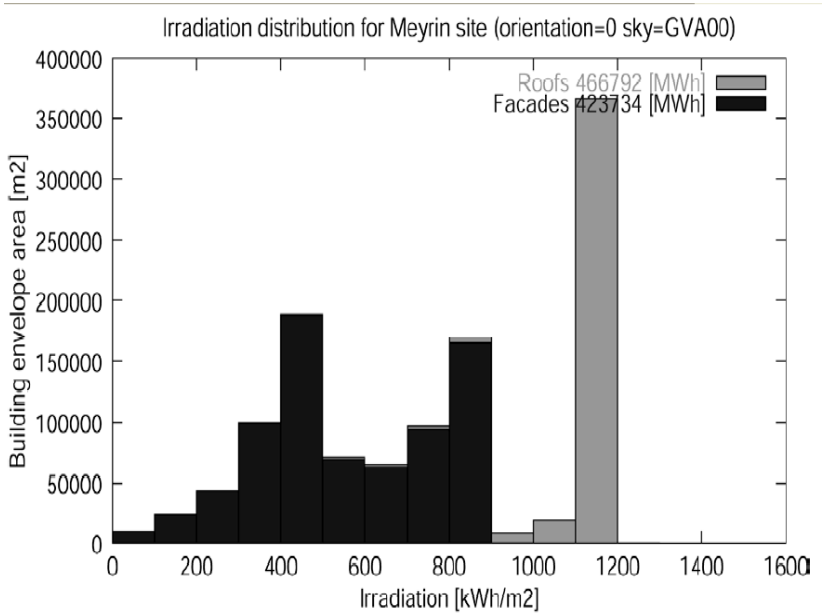
Irradiation modelling with cumulative skies

Darren Robinson[1,2] & Andy Stone[1]

[1] BDSP Partnership, UK

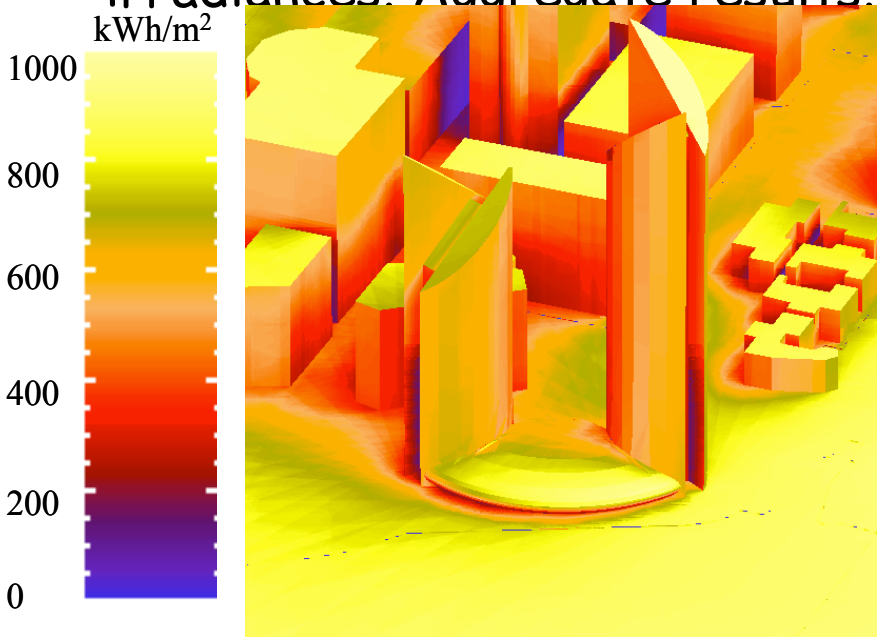
[2] LESO-PB / EPFL

Irradiation modelling is not new…

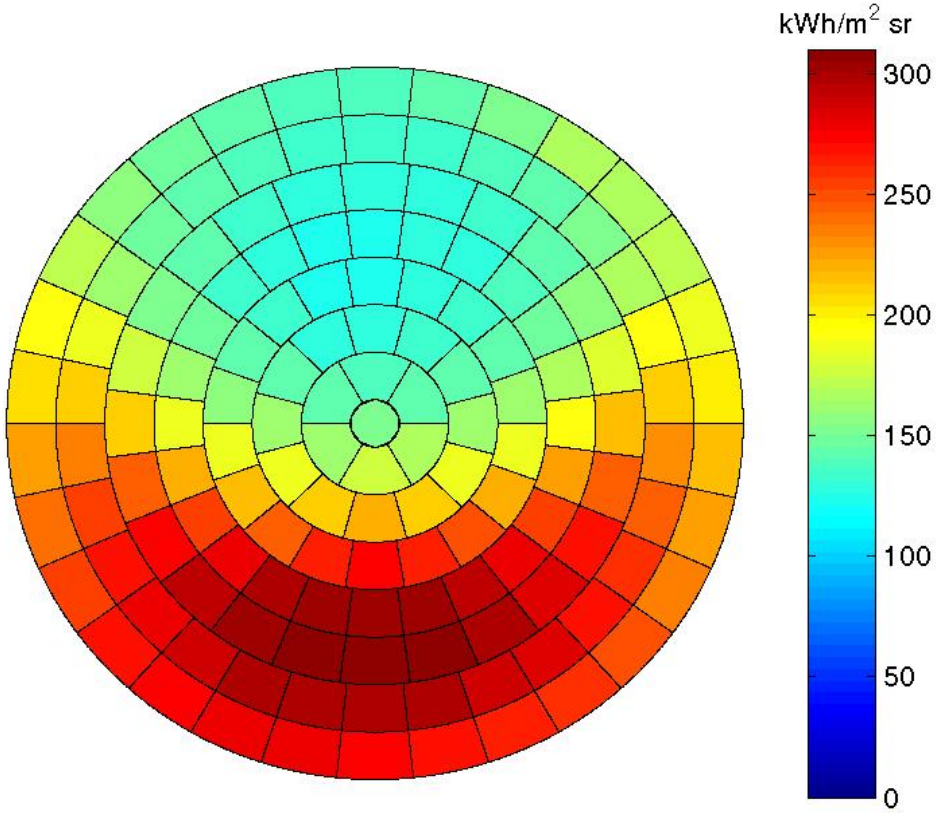


Compagnon: aggregate results from simulations at discrete points [rtrace].

Mardaljevic: simulate entire scenes [rpict] for a statistical sample of sun positions and clear skies. Extrapolate by blending overcast / clear sky results and scaling sky/solar irradiances. Aggregate results.



Cumulative sky modelling



$$\ell_i = f(Z, \theta)$$

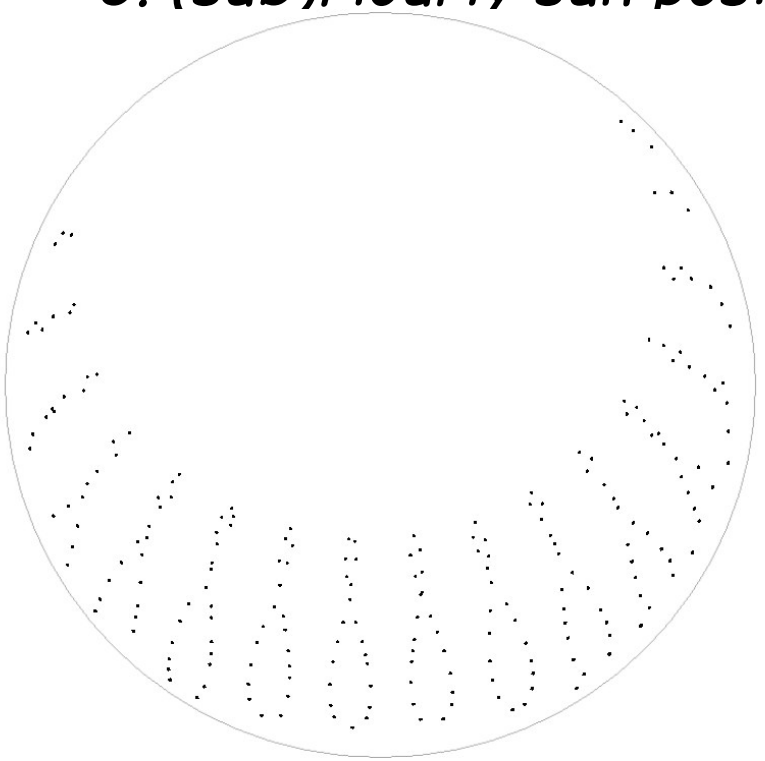
$$\chi = I_{dh} \Big/ \sum_{i=1}^{p} \ell_i \Phi_i \sin \bar{\gamma}_i$$

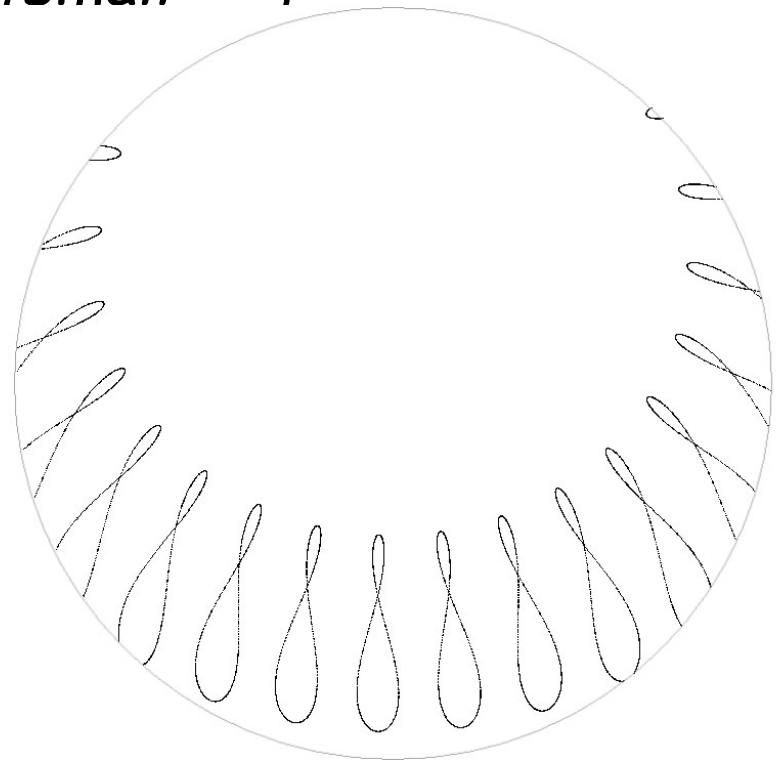
$$R_i = \ell_i \chi$$

$$R_i^T = \sum_{j=1}^{n} R_{i,j}$$

Solar radiance

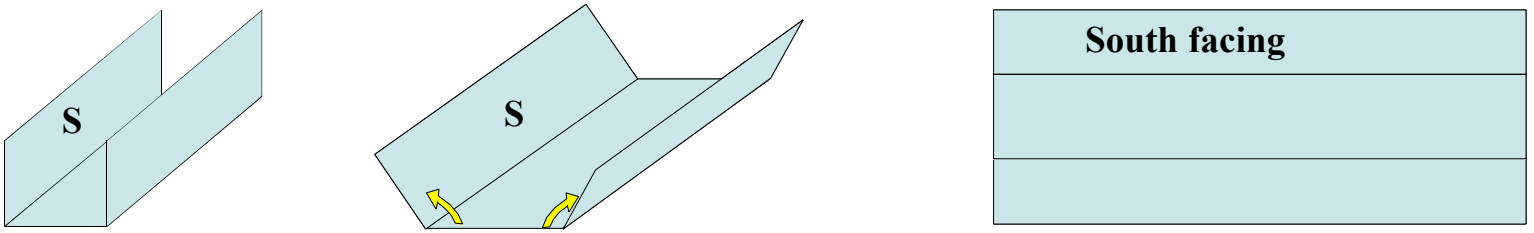
1. Global sky radiance distribution $R_i = R_{di} + I_{bi}/\Phi_i$
2. Binned sun positions and scaled radiance [-dt=0]
3. *(sub)Hourly sun positions [small Φ_s]*

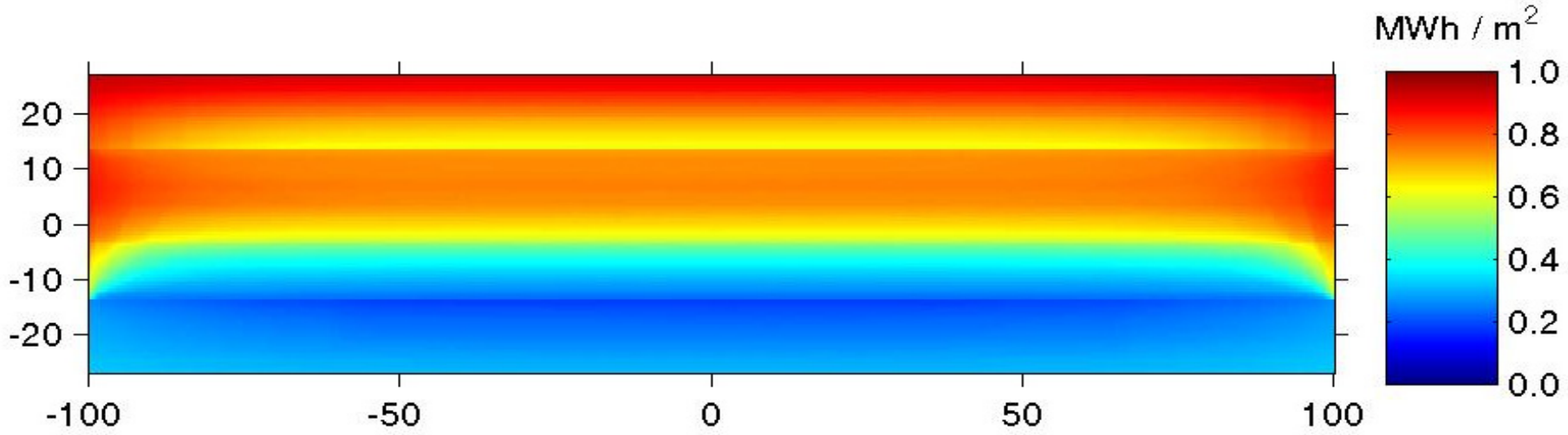




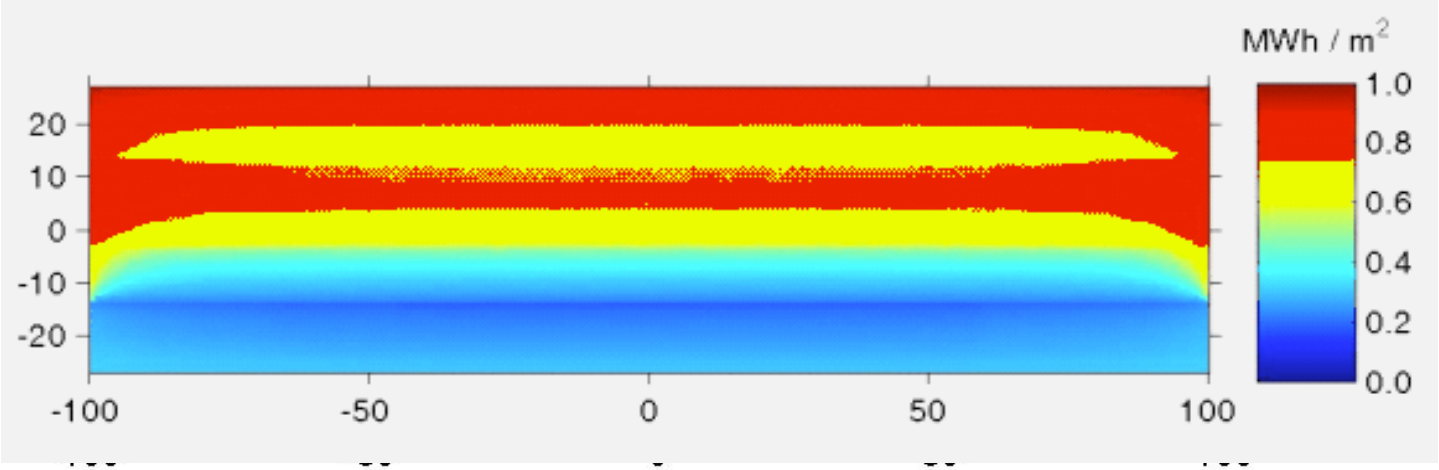
Comparisons

A street canyon in Oslo…

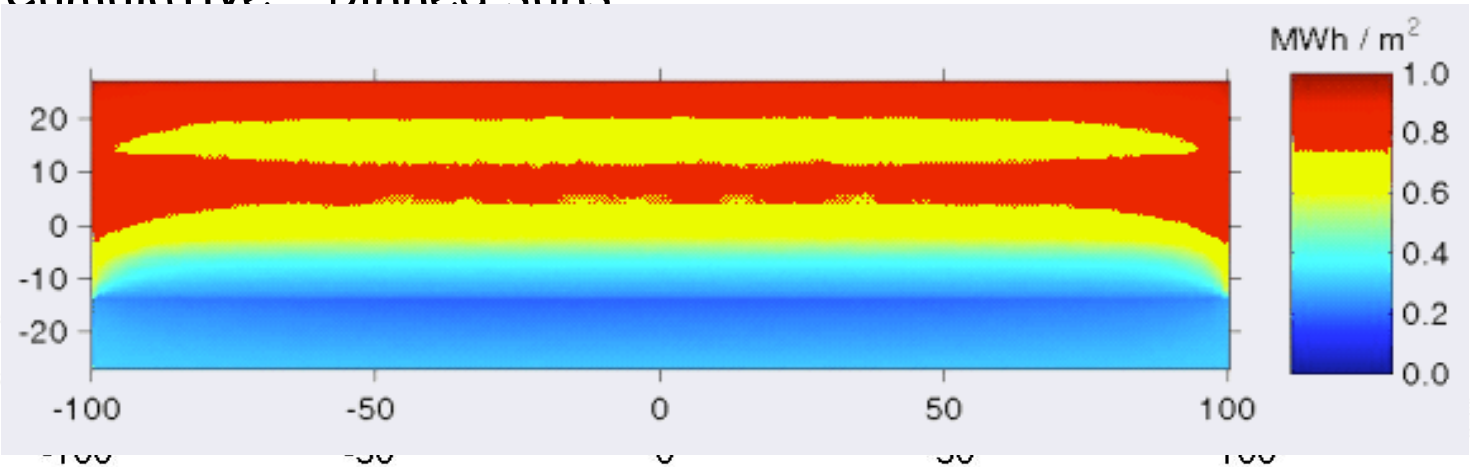




Hourly simulation



Cumulative – binned suns



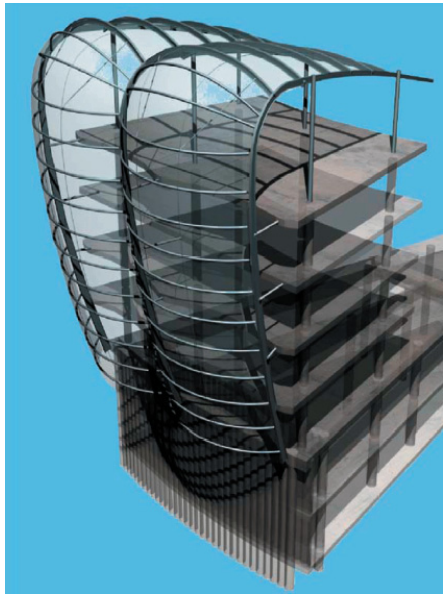
Cumulative – global radiance distribution (577 patches)

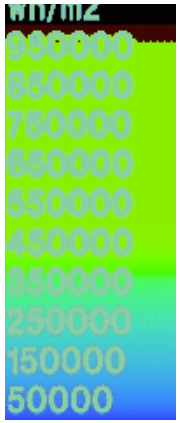
Method	RMS error, %	Relative run time
Hourly simulations	0	1
Diffuse discretised sky, binned suns	1.2	1/180
Global discretised sky	2.2	1/1130

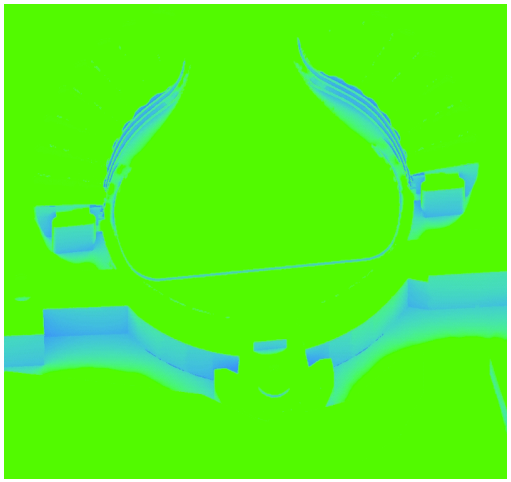
Applications

Pelham place – Hastings [F+P]

external irradiation

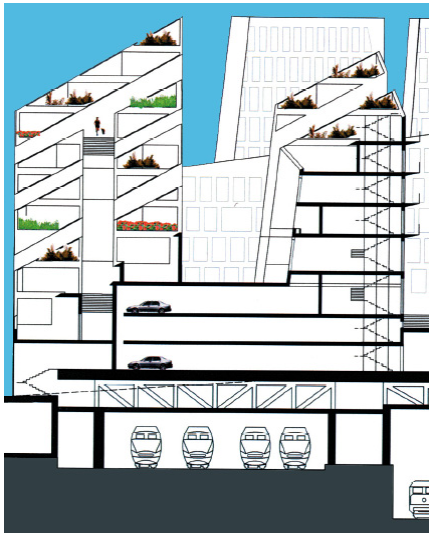




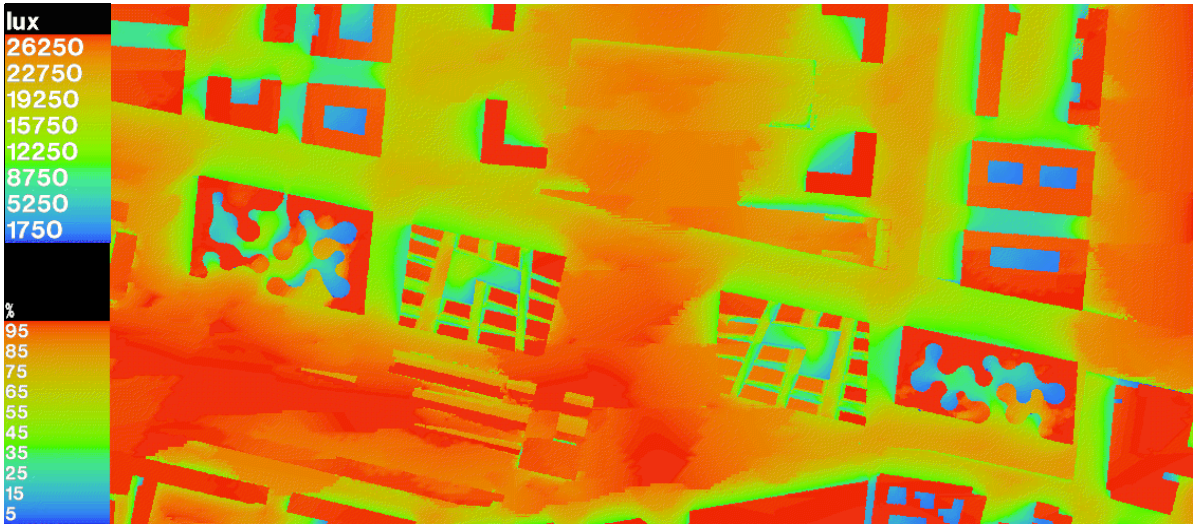


Rive Gauche – Paris [1A]

temporal mean external illumination



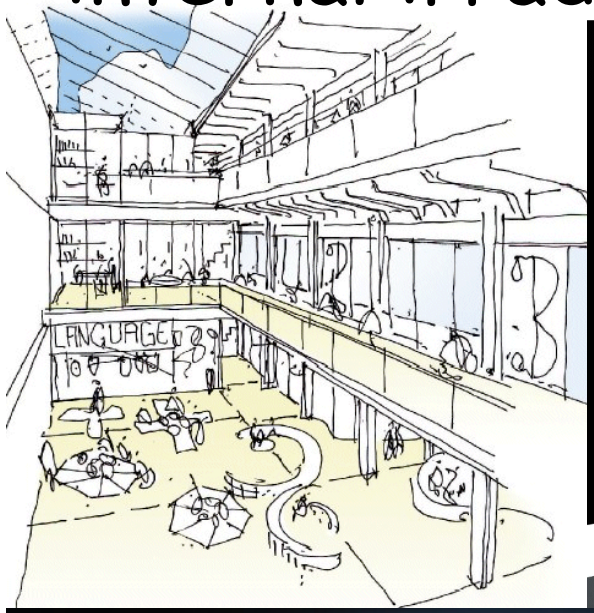
$$L_i = R_i \eta_d$$

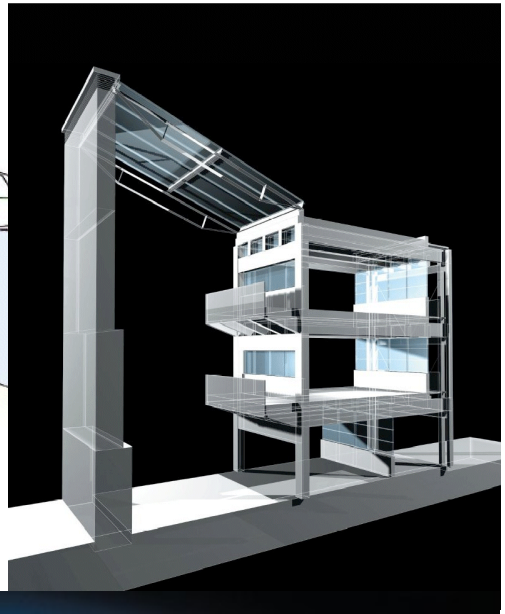


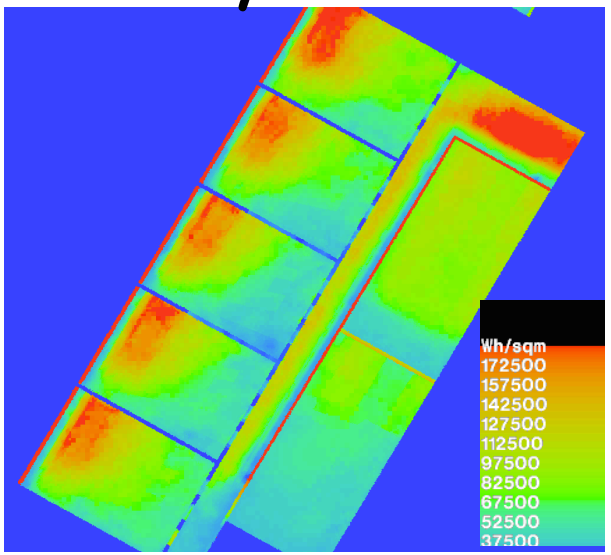
Or lux-hours

Hackney city academy [RRP]

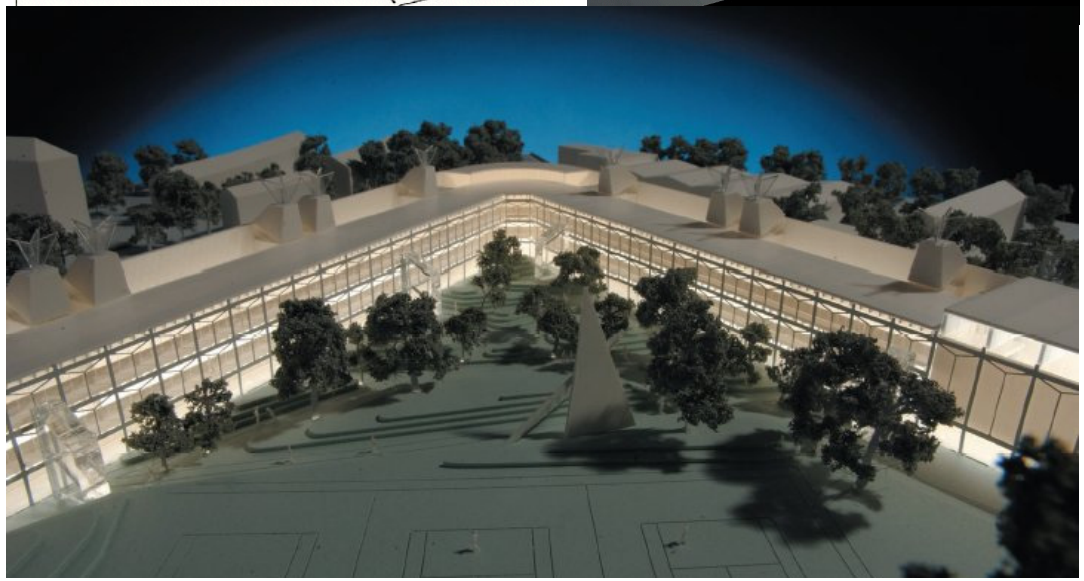
internal irradiation / solar visibility hours

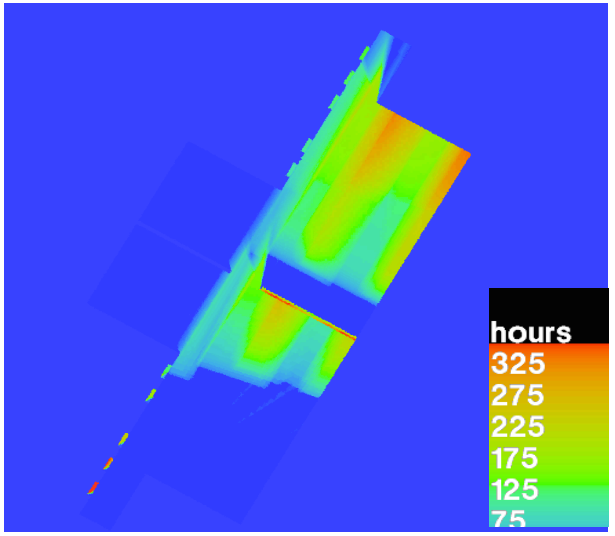






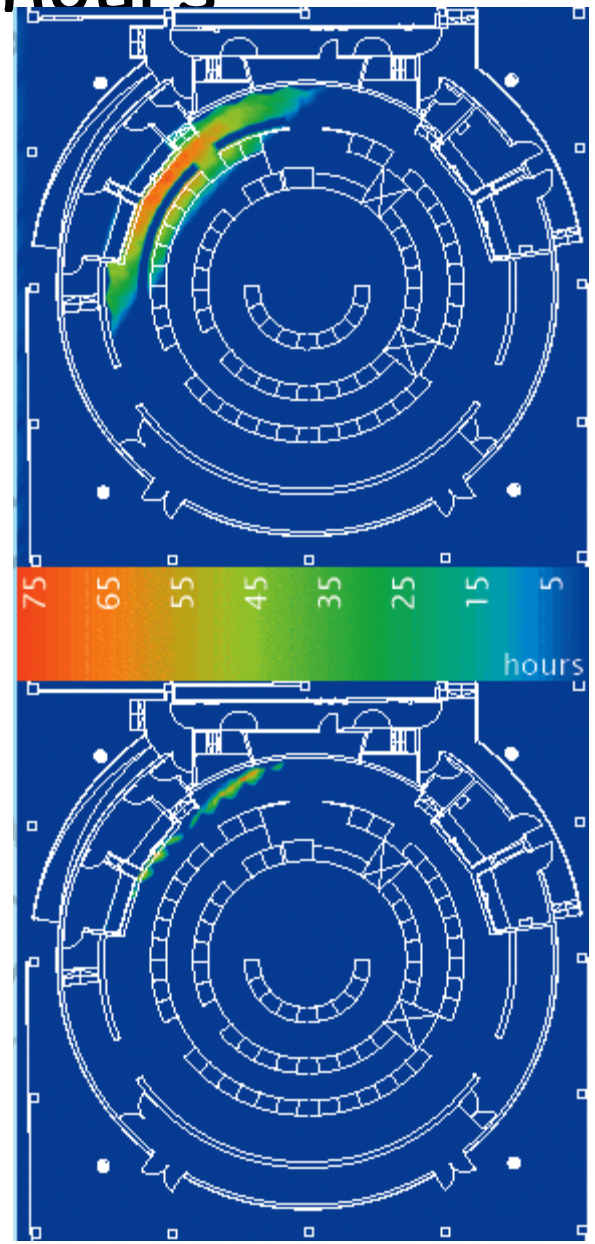
$$R = \left(\Phi \sin \gamma\right)^{-1}$$

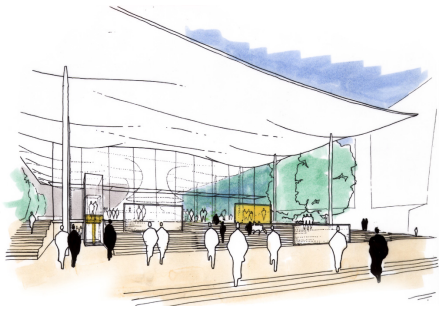




National Assembly for Wales [RRP]

internal solar visibility hours

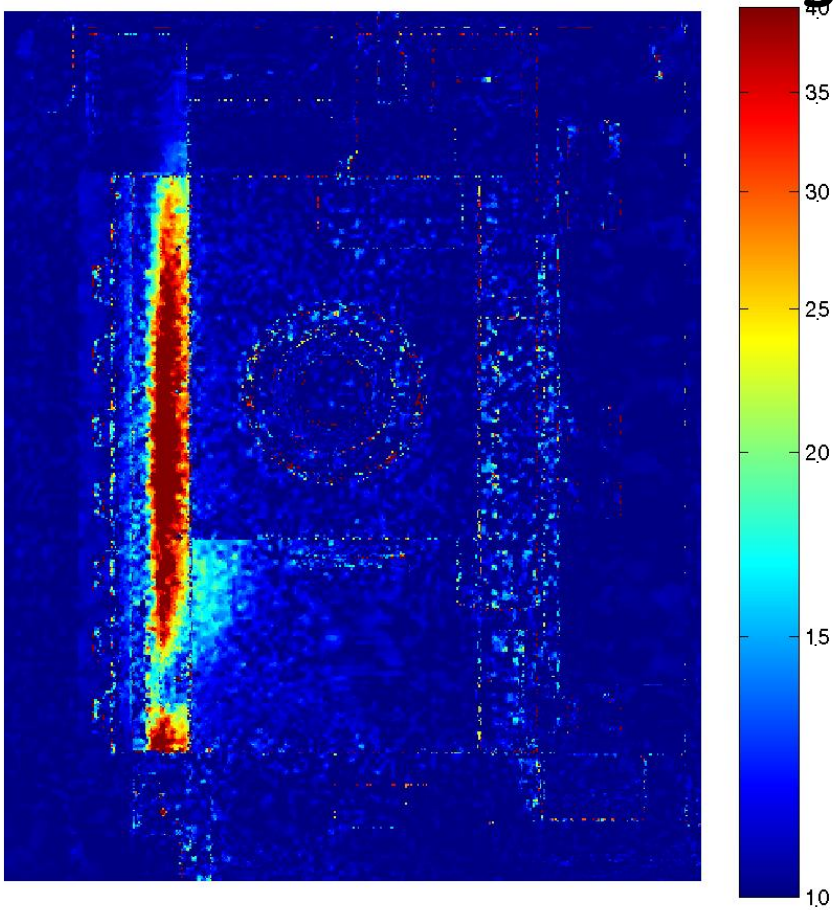




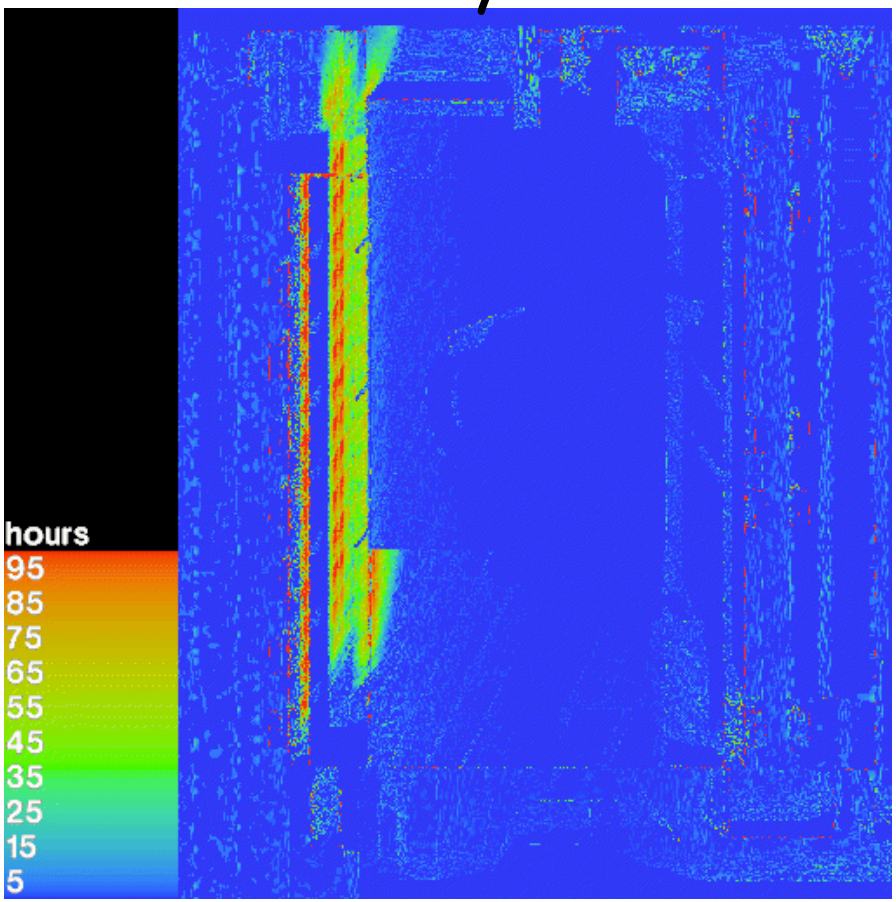
National Assembly for Wales

internal irradiation & image processing

Louvres reduce energy transmitted by ~26%



Change in irradiation by omitting louvres (quotient image)



Number of hours of direct insolation

Conclusions

- Pre-processing cumulative skies is:
  - Computationally efficient
  - Reasonably accurate
- The principal has been applied to predict:
  - Solar irradiation
  - Solar visibility hours
  - Temporal mean illuminance
- It *could* be applied to study daylight availability
- But there is no substitute to multiple simulations if temporal information is required

Thank you!