UVNET EMRP ENV03

Traceability for surface spectral solar ultraviolet radiation

Calculations of street level spectral irradiances using the Google Street View photographic database:

Implementation and potential applications on ultraviolet light studies

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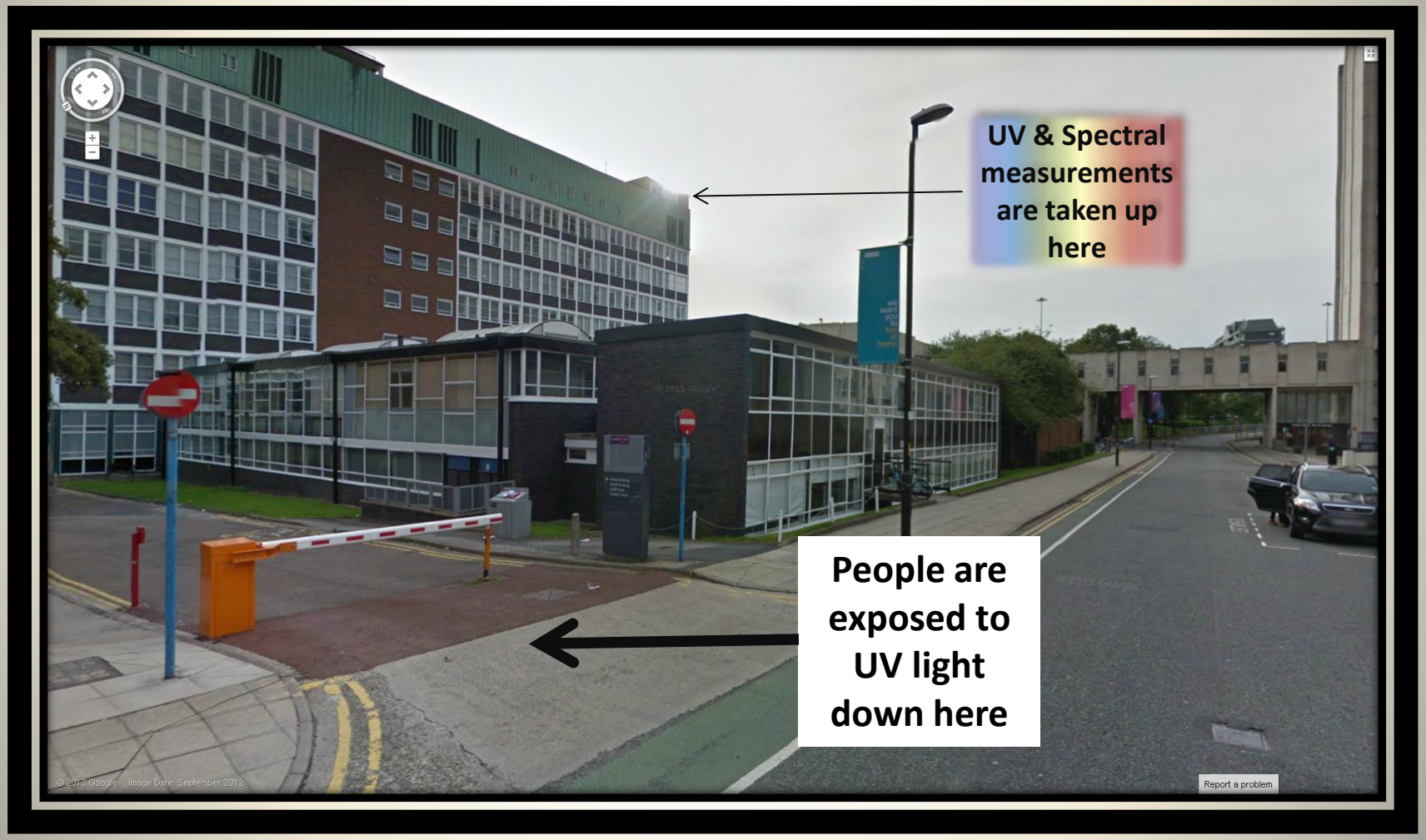
MANCHESTER 1824

The University of Manchester

CONACYT

The Problem



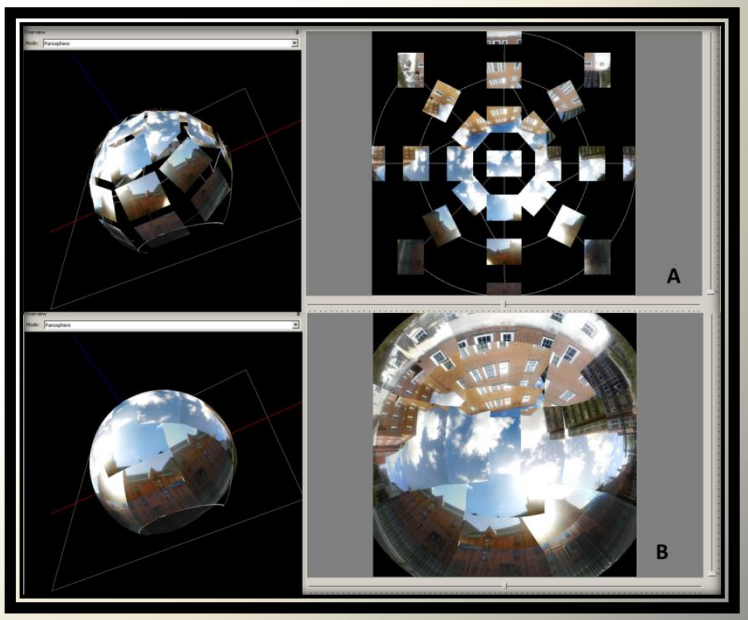
Photograph: Google Street View.com

Layout

- Important: Easy Access Modelling Tools
- Image processing approach to reconstruct urban canyon geometries from Google.
- Considerations needed for Canyon Irradiance Models (Total shortwave and spectral irradiances).
- Current state of development and future scope of the project.

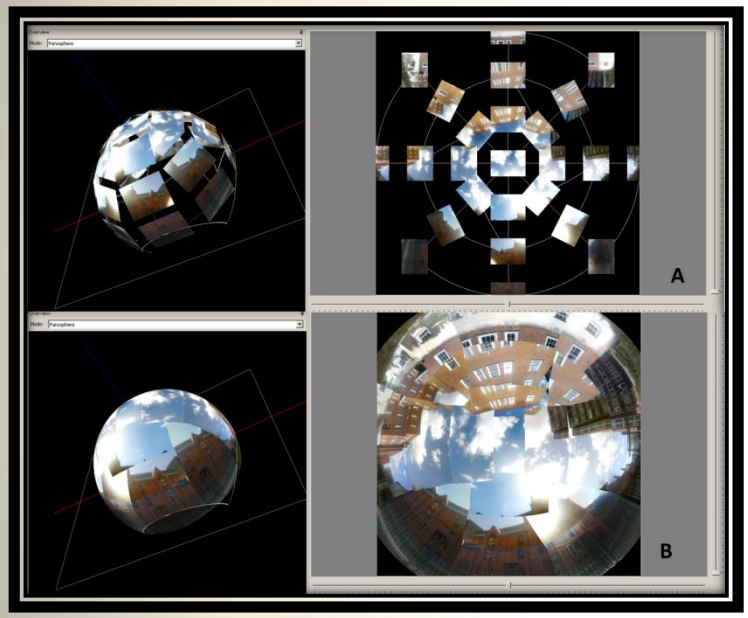
Image Digital Processing
Software tools:
Google Street View + Hugin

Set of photographs linked to one single position in the city of Manchester, taken from Street View.



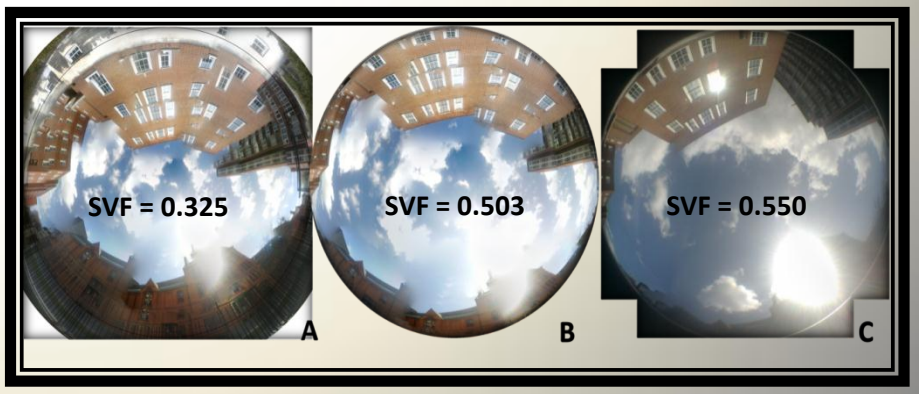
Snapshots of the Hugin interface:
A.-Independent photographs covering the full upper hemispheric view.
B.-The reconstructed hemispheric view using a fisheye projection.

Image Digital Processing Software tools: Google Street View + Hugin

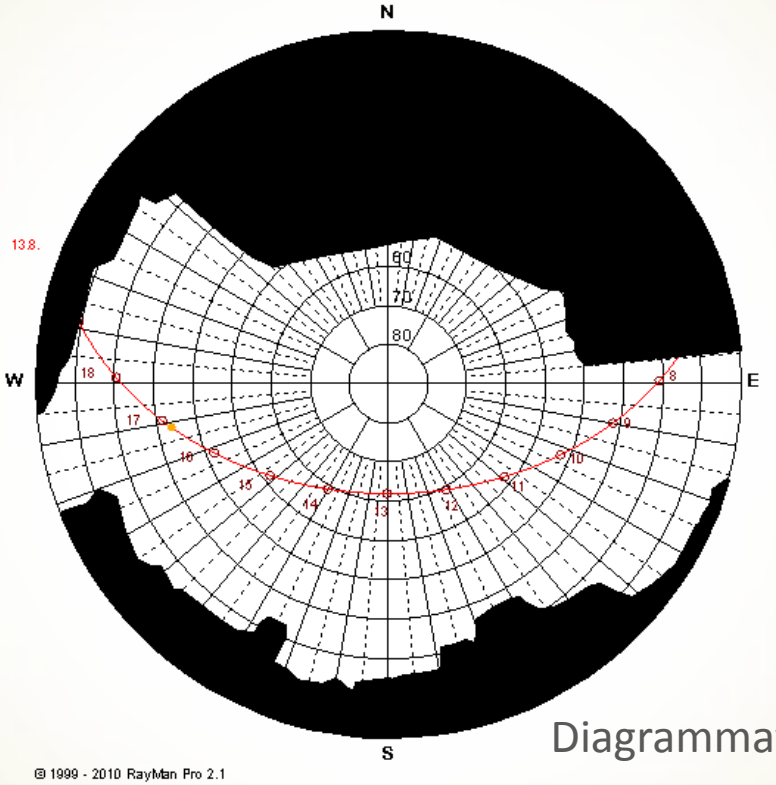


Snapshots of the Hugin interface:
A.-Independent photographs covering the full upper hemispheric view.
B.-The reconstructed hemispheric view using a fisheye projection.

A.- Orthographic reconstructed projection;
B.- Equidistant reconstructed projection;
C.- Control fisheye photograph, taken with an adaptable phone mini fisheye lens.
Pictures were taken at the Zochonis Canyon, University of Manchester.
SVF: Sky View Factor for each image.



Total Shortwave Irradiance Calculations: Rayman Software (Matzarakis et al. 2010)

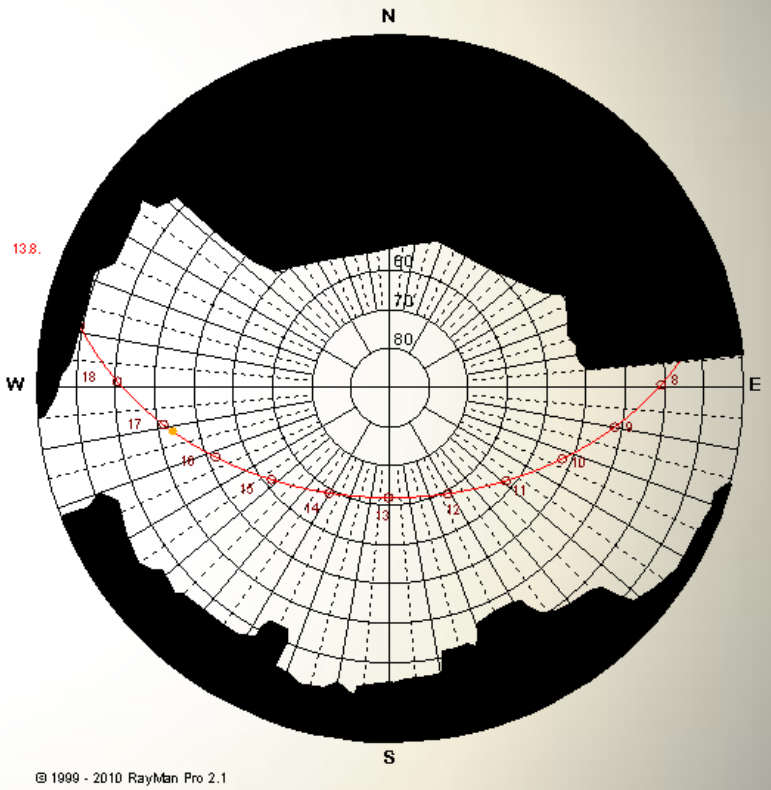


Diagrammatic output results from Rayman.
The software can calculate Sky View Factor (SVF), Global, Direct and Diffuse Irradiances.------We tested it

Assumptions and Limitations of the Rayman Model.

- NO Spectral Irradiances
- “Black” Obstructions
- Isotropic Diffuse Irradiance

(NO Circumsolar Irradiance)



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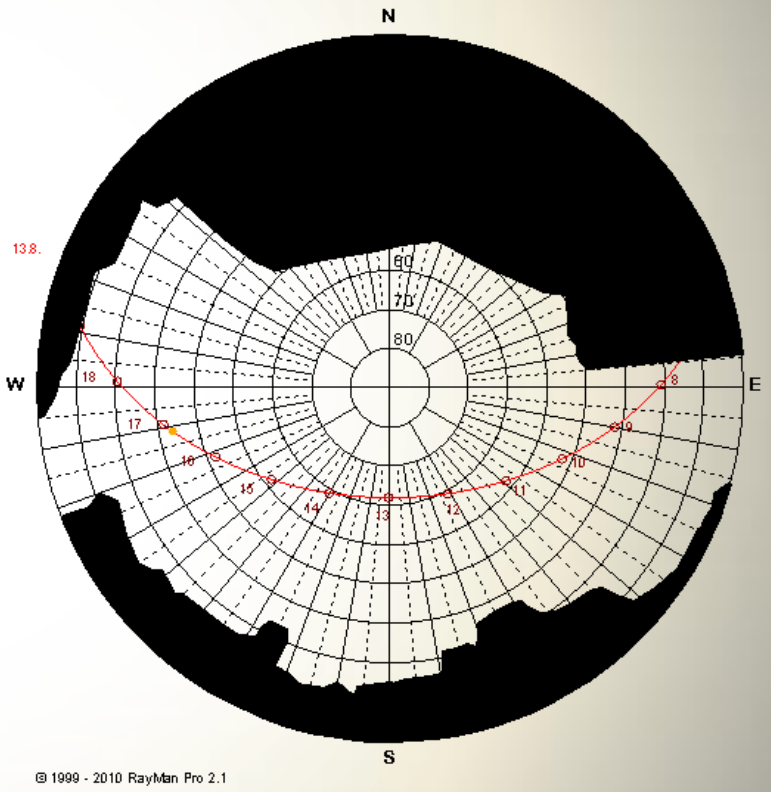
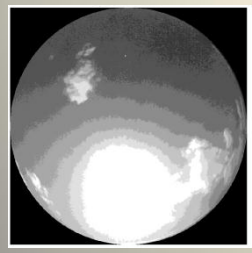
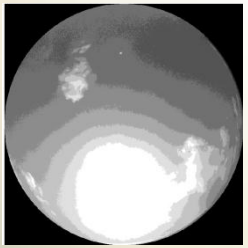
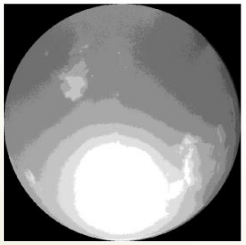




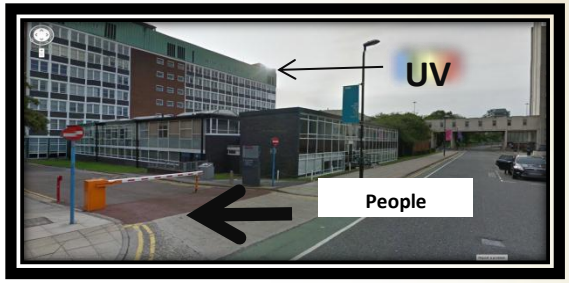


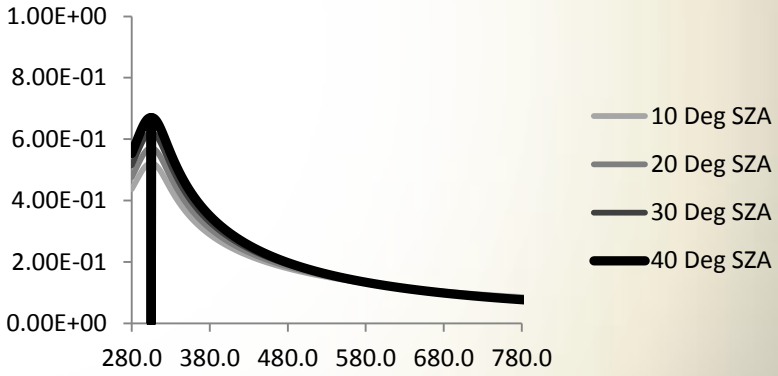


This anisotropic distribution is not considered by these models

First approach to calculate Spectral Irradiances in Urban Canyons

- Assumption 1: Canyon Spectral Irradiance -at any wavelength- is a fraction of Rooftop Spectral Irradiance, at the same wavelength. And it is a function of the SVF.
- Assumption 2: The ratio of Diffuse/Global irradiance is explained by Rayleigh scattering, and is dependent on wavelength, Ozone, turbidity and SZA.
- Assumption 3: Diffuse light is isotropic.





First approach to calculate Spectral Irradiances in Urban Canyons

Model:

$$G_{u,\boldsymbol{\lambda}} = \left[\left(G_{f,\boldsymbol{\lambda}}\right) * \left(1 - Diffuse/Global_{\boldsymbol{\lambda}}\right) * S_{bin}\right] + \left[\left(G_{f,\boldsymbol{\lambda}}\right) * Diffuse/Global_{\boldsymbol{\lambda}} * svf_u\right]$$

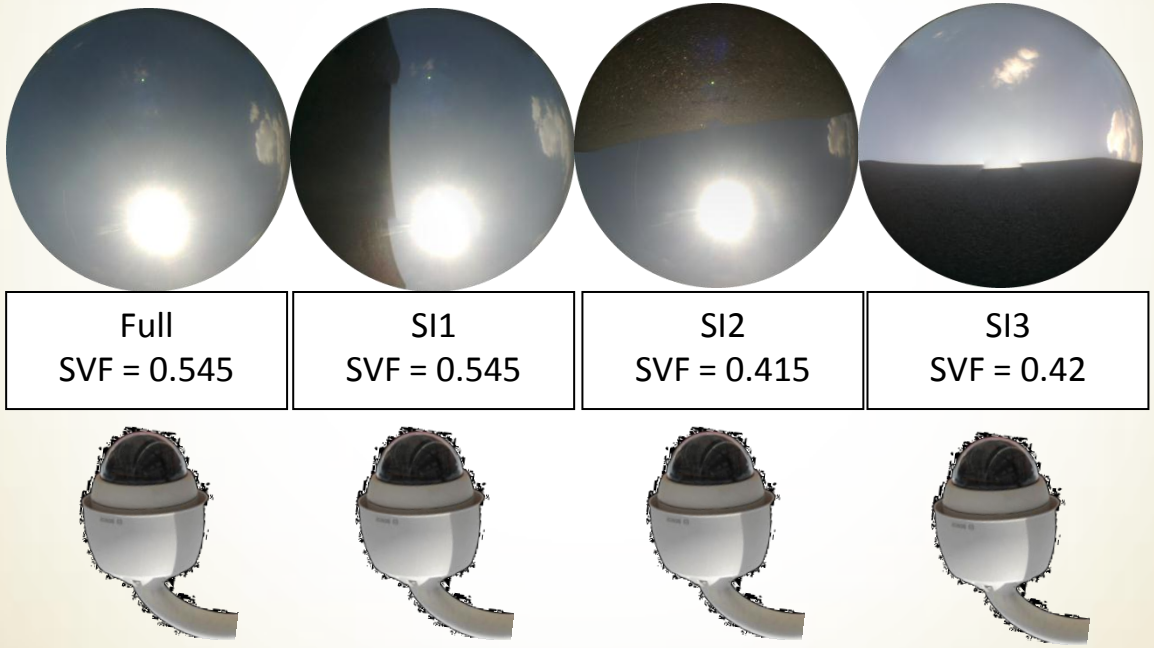
- $G_{u,\boldsymbol{\lambda}}$: Global "Canyon" Irradiance in canyon"u", canyon and at wavelength"$\boldsymbol{\lambda}$"
- $G_{f,\boldsymbol{\lambda}}$: Global "Rooftop" Irradiance -also "full viewirradiance"- at wavelength"$\boldsymbol{\lambda}$"
- $Diffuse/Global_{\boldsymbol{\lambda}}$: Ratio of diffuseto global irradiances at wavelength"$\boldsymbol{\lambda}$", accordingto the equation:

$$\frac{Diffuse}{Global} = \frac{log_{305nm}\left\{1+AOD+\left|\left(\frac{305nm}{(305nm-\boldsymbol{\lambda})}\right)^{\left(\frac{SZA}{100}\right)+0.9}\right|\right\}}{1+log_{305nm}\left\{1+\left|\frac{305nm}{(305nm-\boldsymbol{\lambda})^{2}}\right|\right\}}$$

- svf_u: Sky View Factor at canyon"u"

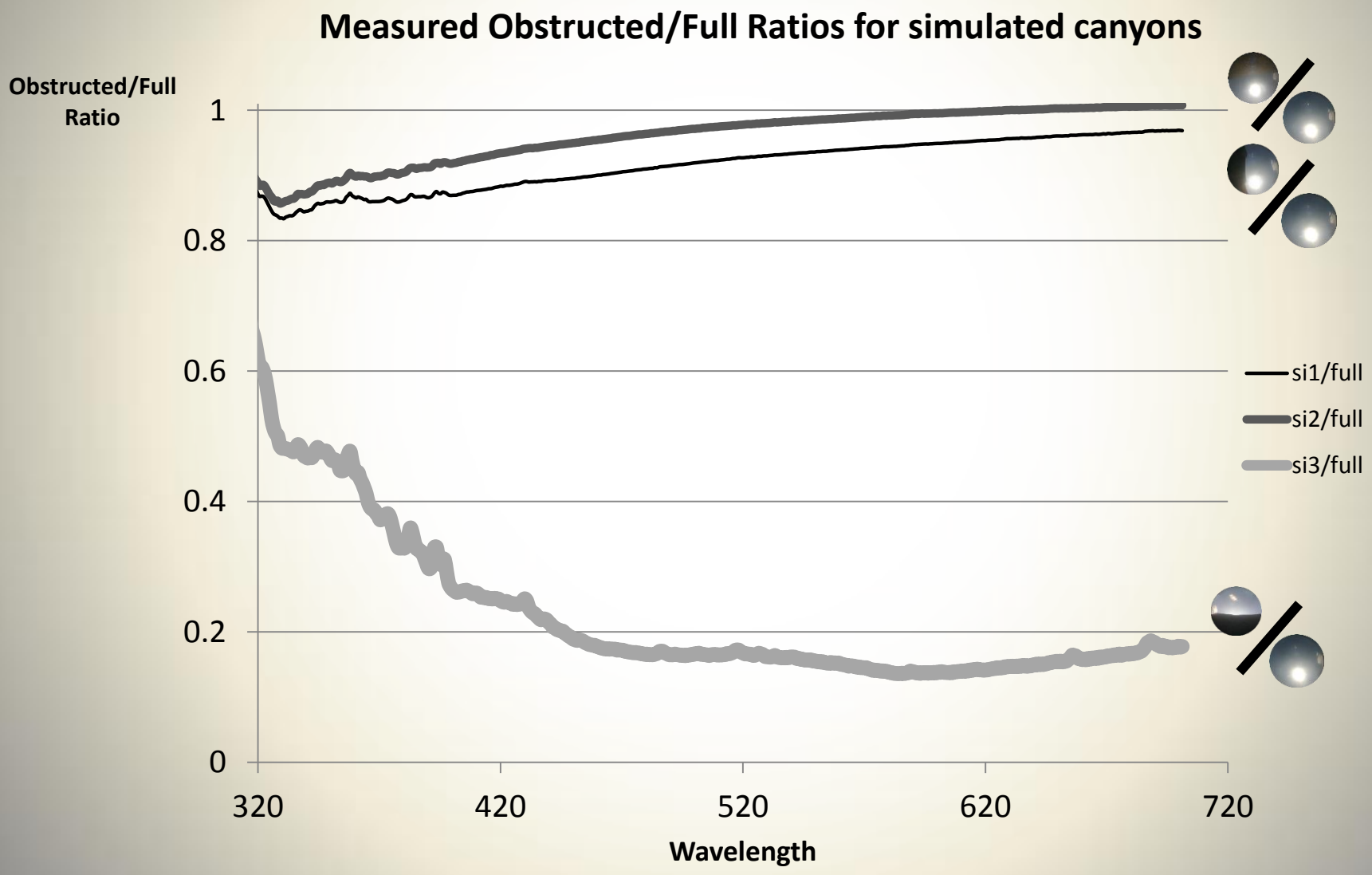
Model Validations

- Simulated Canyons

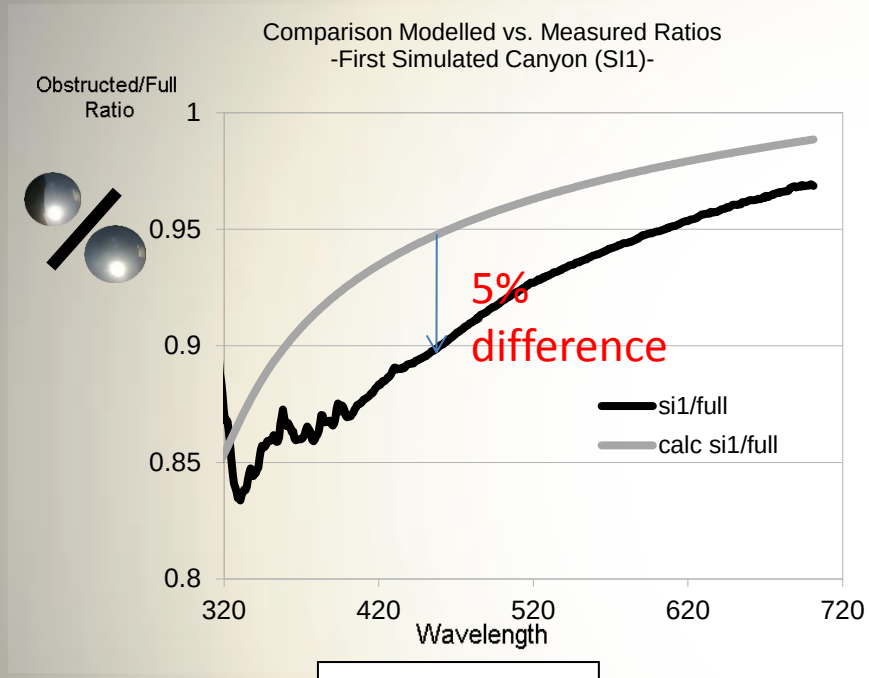


Diode Array Spectroradiometer

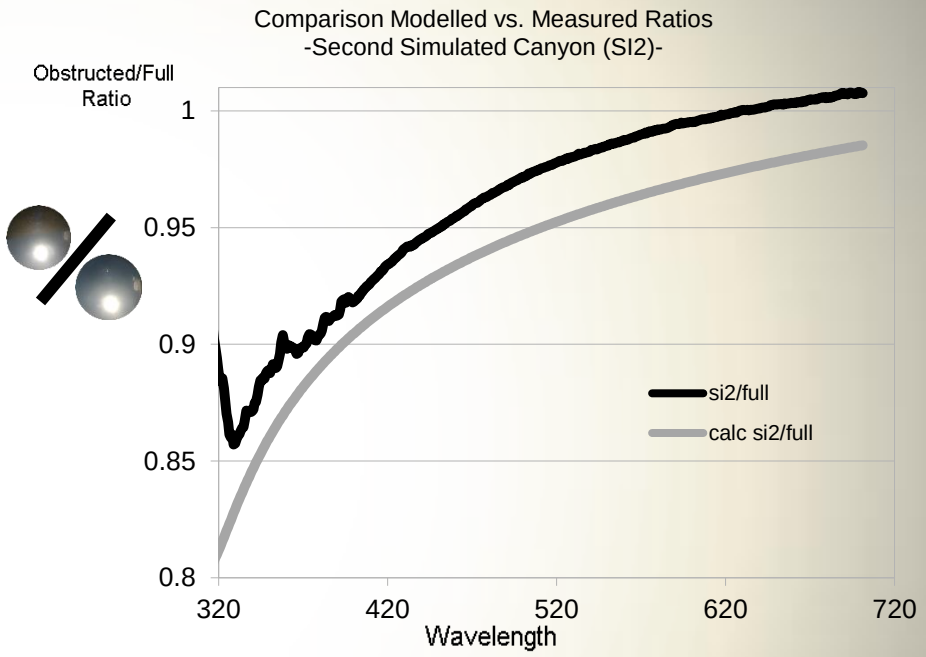
- Results: Ratios of obstructed global spectral irradiance to full sky view.



Comparisons Modelled vs. Measured Ratios

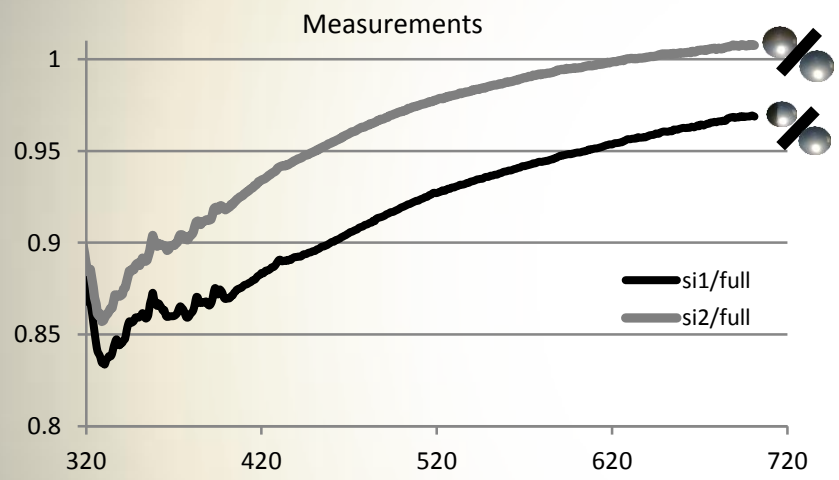


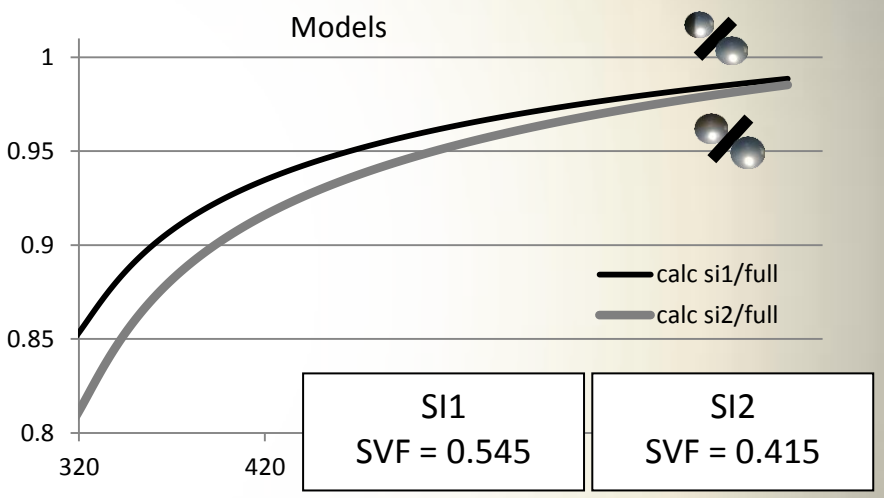
SI1
SVF = 0.545



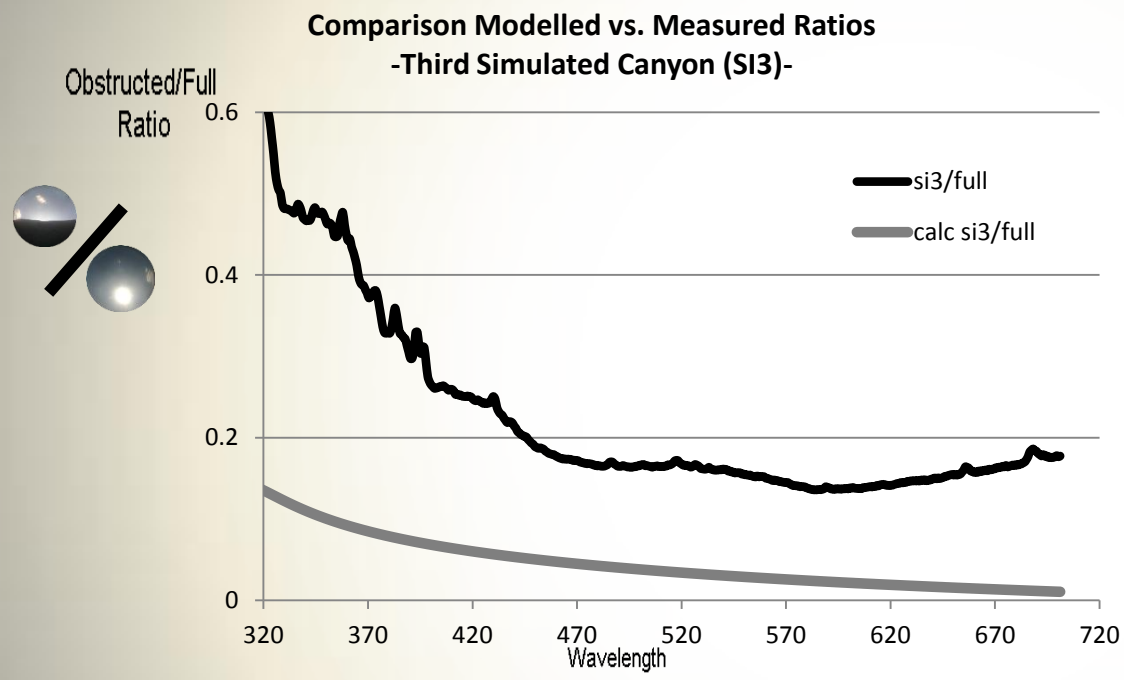
SI2
SVF = 0.415

• Results: Comparisons Modelled vs. Measured Ratios





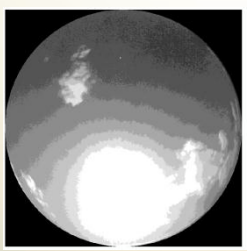
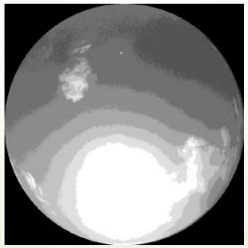
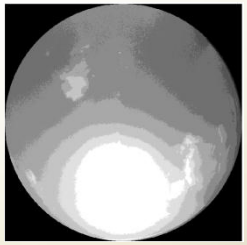
• Results: Comparisons Modelled vs. Measured Ratios



It is necessary to consider the anisotropic distribution of diffuse light, as well as the potential effect of reflective surfaces in the canyons.

Conclusions

- The reconstruction and “fisheye” projection of urban geometries is possible from Google Street View. This has the potential to become a useful tool in solar radiation studies at street level.

- The Rayman software allows the calculation of total-shortwave irradiances in urban canyons from the reconstructed “fisheye” images, but there is a need for spectral irradiance models.

- The spectral model proposed here represented an acceptable approximation, however, -in order to improve the performance of the models at canyons with different orientations- methods that account for diffuse light anisotropy and reflectivity of horizon obstructions are yet to be developed.