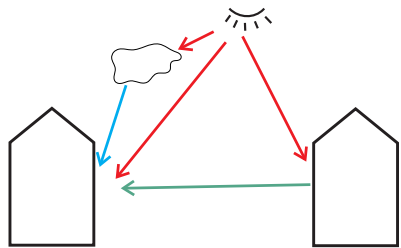
A Projection And Clipping Method To Calculate Direct, Diffuse, And Reflected Irradiation

Jacob Estevam Schmiedt, Björn Schiricke
German Aerospace Center (DLR)



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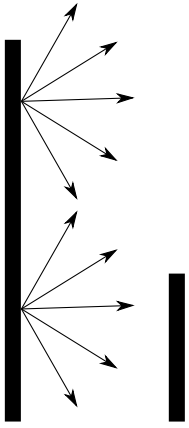
Projection & clipping does not require an initial discretization of building surfaces



ray tracing

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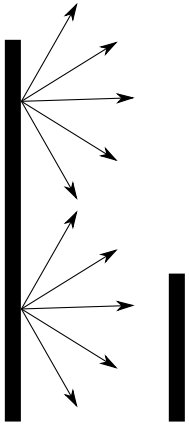
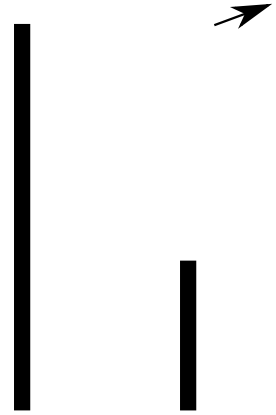


ray tracing



projection & clipping

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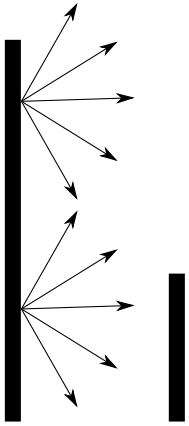
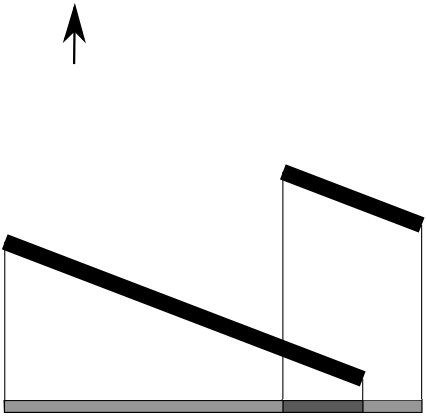


ray tracing



projection & clipping

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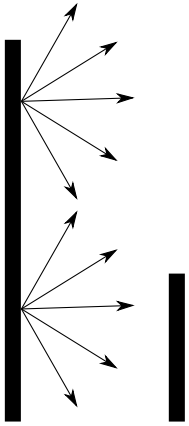
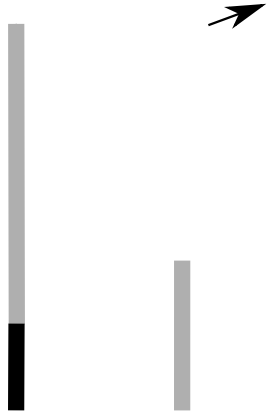


ray tracing



projection & clipping

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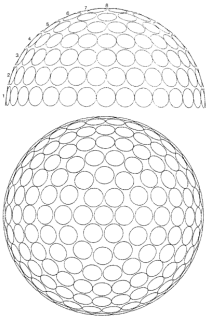
The sky radiation is modeled using standard approaches



[Tregenza 1987]

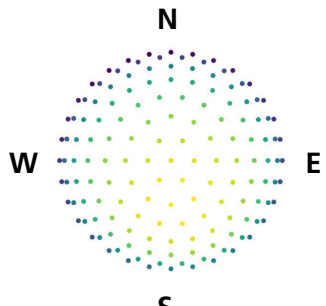
151 Sky patches

→

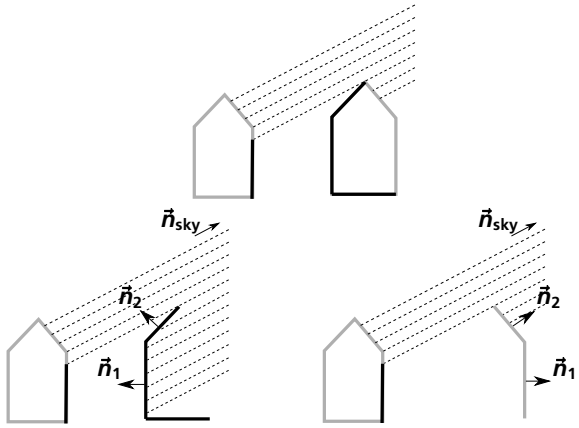
All-weather model for sky luminance distribution Perez et al., 1993

Weather file

→



Exclusion rules allow us to reduce the number of clipping operations for sky irradiance



$\vec{n}_i \cdot \vec{n}_{sky} < 0$

$\vec{n}_i \cdot \vec{n}_{sky} \geq 0$

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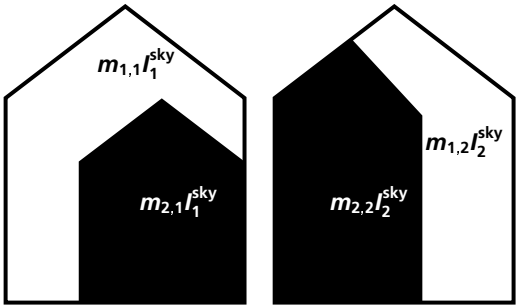
The calculation of direct and sky diffuse irradiance can be reduced to a matrix multiplication



$$m_{i,k} = \begin{cases} \vec{n}_i^{surf} \cdot \vec{n}_k^{sky} & \text{irradiated} \\ 0, & \text{else} \end{cases},$$

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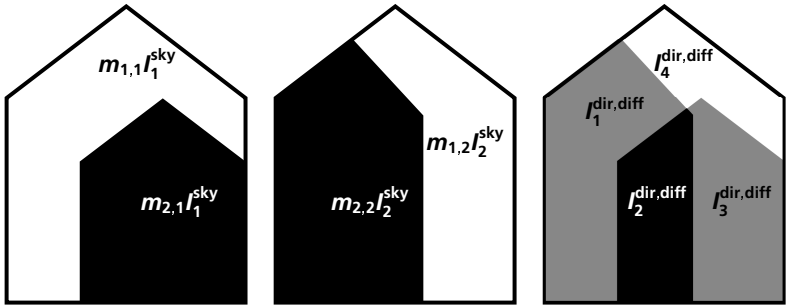

$$m_{i,k} = \begin{cases} \vec{n}_i^{surf} \cdot \vec{n}_k^{sky} & \text{irradiated} \\ 0, & \text{else} \end{cases}, \qquad \vec{I}^{dir,diff} = \boldsymbol{M} \cdot \vec{I}^{sky},$$

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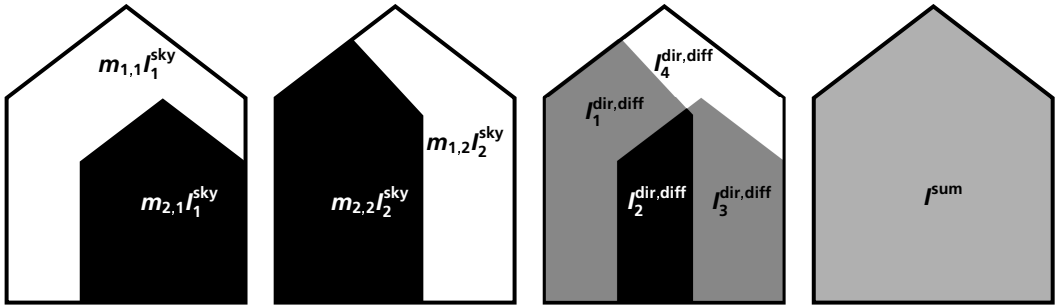

$$m_{i,k} = \begin{cases} \vec{n}_i^{surf} \cdot \vec{n}_k^{sky} & \text{irradiated} \\ 0, & \text{else} \end{cases}, \qquad \vec{I}^{dir,diff} = M \cdot \vec{I}^{sky}, \qquad I^{sum} = \vec{M}^{sum} \cdot \vec{I}^{sky}$$

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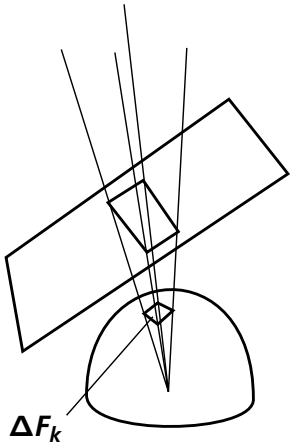
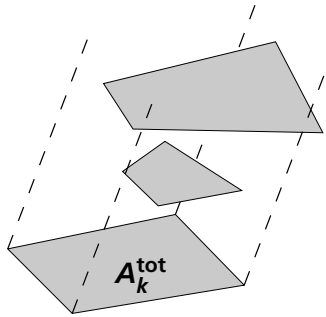
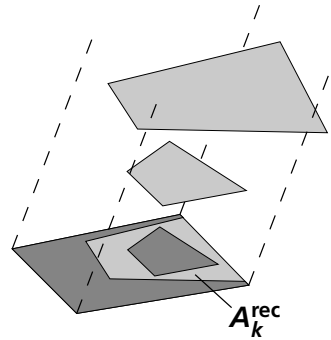
Surface–surface view factors can be obtained with another round of projection and clipping operations



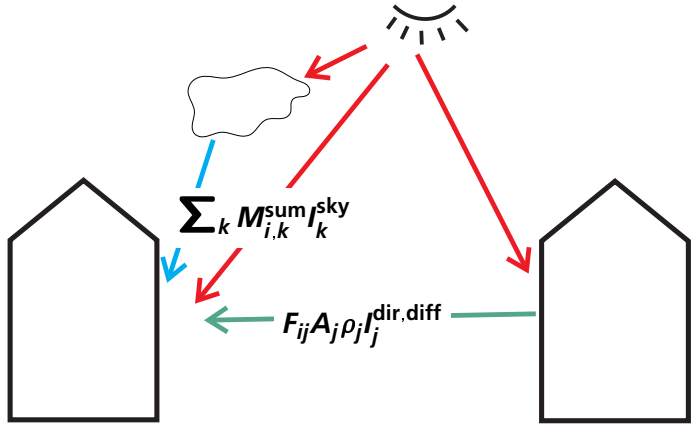
[Cohen, 1985]





$$F = \sum_k \Delta F_k \frac{A_k^{\text{rec}}}{A_k^{\text{tot}}}$$

The solar irradiance is obtained by two matrix multiplications



$$I_i^{\text{tot}} = \sum_k M_{i,k}^{\text{sum}} I_k^{\text{sky}}(t) + \sum_{k,j} F_{ij} A_j \rho_j M_{j,k}^{\text{sum}} I_k^{\text{sky}}(t)$$

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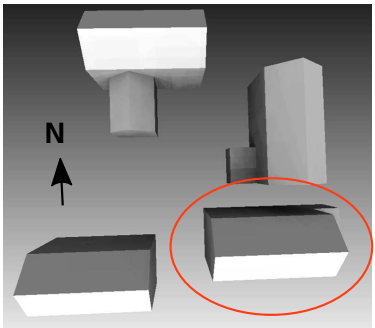
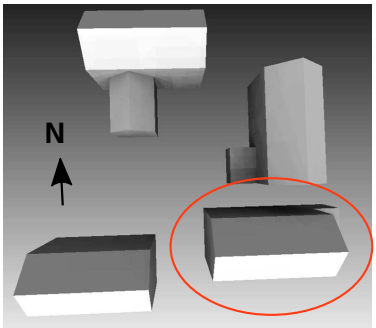
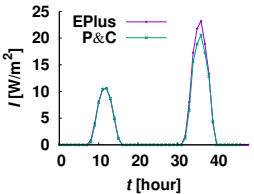
Refined projection and clipping reproduces time-dependence from EnergyPlus

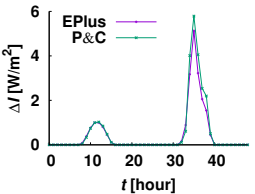


Refined projection and clipping reproduces time-dependence from EnergyPlus

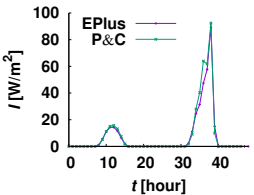


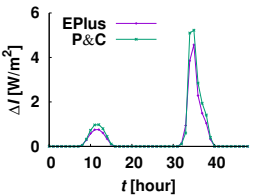
North wall





West wall





direct + diffuse

reflected

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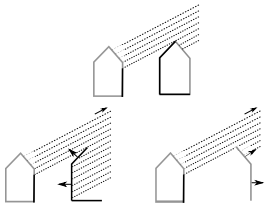
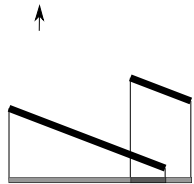
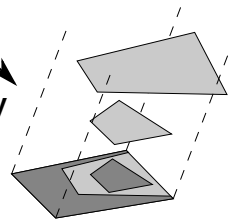
Projection & clipping can be used for direct, diffuse, and reflected irradiance



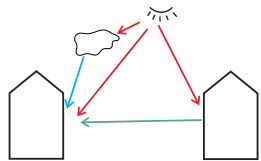
Exclusion rules



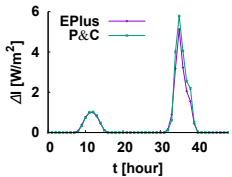
P&C for direct and sky diffuse irradiance



P&C for view factors



Total irradiance



Comparison to EnergyPlus