Digital Transformation CoLab

Experiencing the Future

Sacha T. Mould

dtx–colab.pt

About

Digital Transformation CoLab

— DTx is a **non-profit private association**;

— Carries out its activity doing applied research in different areas linked to **digital transformation**;

— Constituted by **18 associated members**:

Three universities, One international laboratory, One innovation centre, Thirteen companies

— Activities are carried out at its **three locations**: Minho (Guimarães and Braga), Matosinhos and Évora

Goals of Digital Transformation CoLab

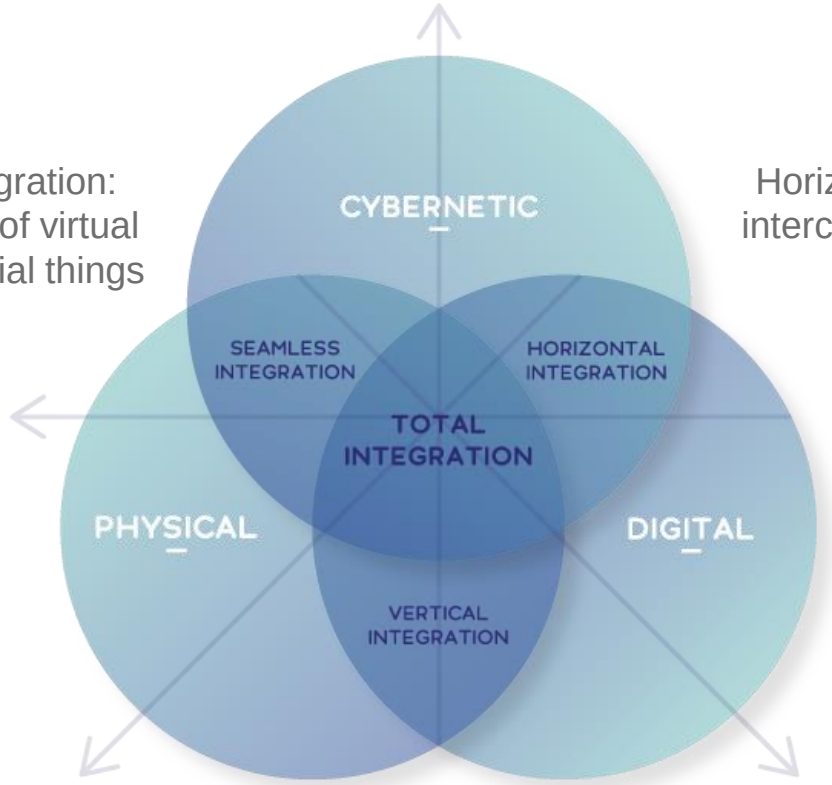
Digital Transformation CoLab

- NEW HOLISTIC APPROACHES IN THE CONCEPTION AND DEVELOPMENT OF CYBER-PHYSIC SYSTEMS (CPS)
- NEW METHODS OF ASSESSING THE CREATION OF VALUE
- TO ASSESS THE ECONOMIC, SOCIAL AND LEGAL IMPACTS
- DIGITAL ECOLOGY EFFICIENCY
- TO PROMOTE COOPERATION BETWEEN THE ACADEMY AND THE INDUSTRY

Digital Transformation CoLab

What we do...

Seamless integration: interconnection of virtual twins with material things



Horizontal integration: interconnection in value chain

Vertical integration: interconnection of material things with the internet

Digital Transformation CoLab

FOAM@IBERIA 2019

Conjugate Heat Transfer Training Session

The solarLoad Radiation Model

Sacha T. Mould

Outline

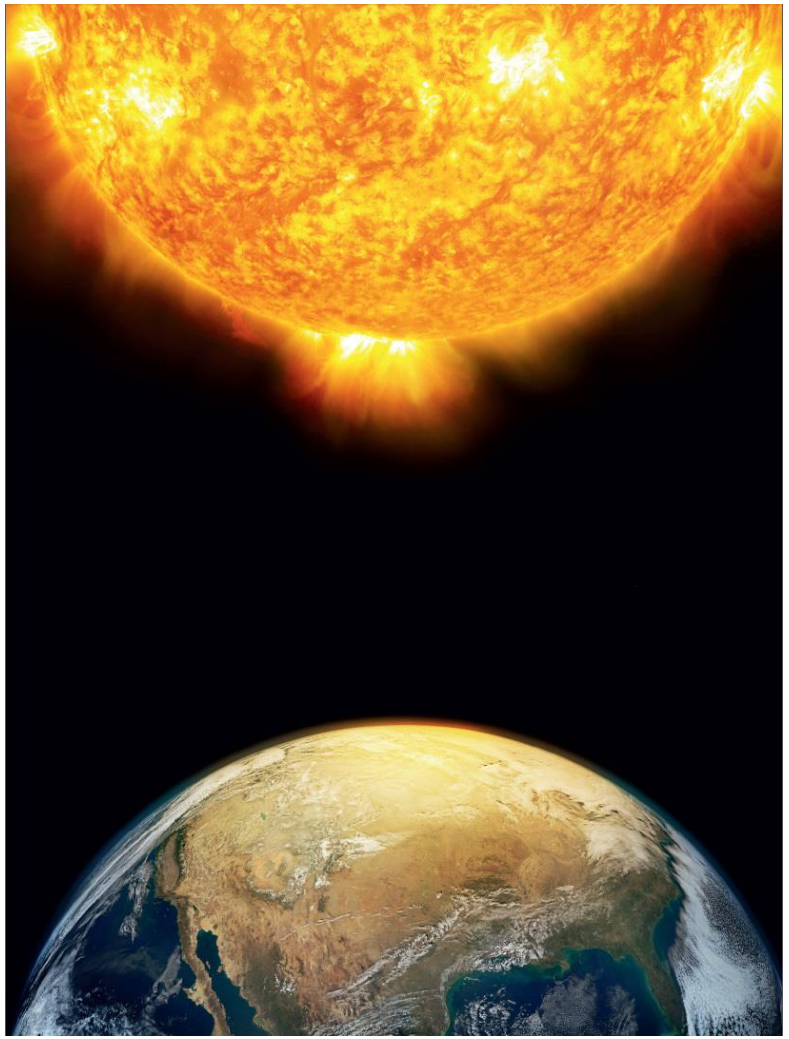
— A brief overview about Solar Radiation

— Create a Conjugate Heat Transfer case with the *solarLoad* model

Solar Radiation - *Overview*

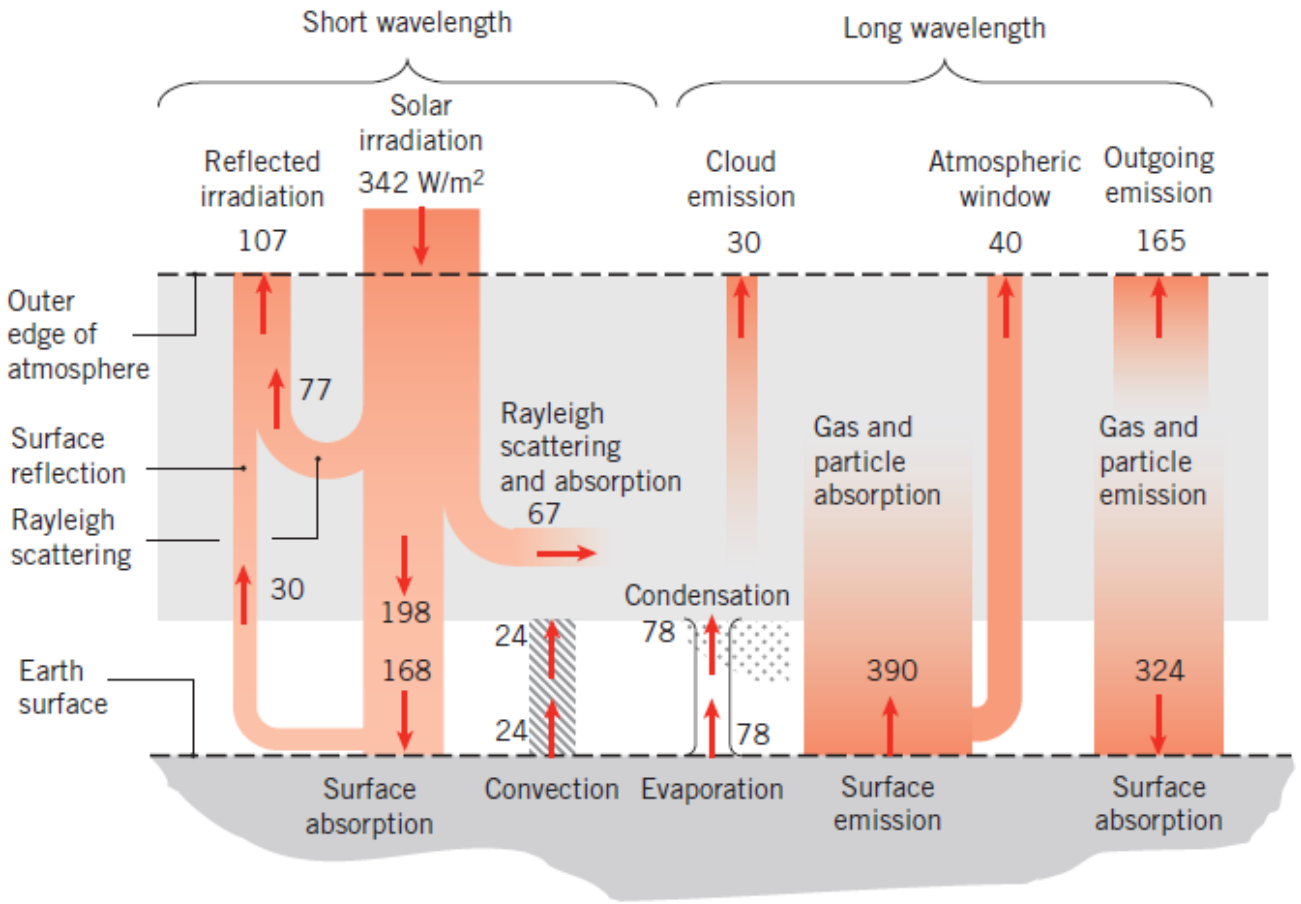
— Solar radiation is essential for life existance on earth;

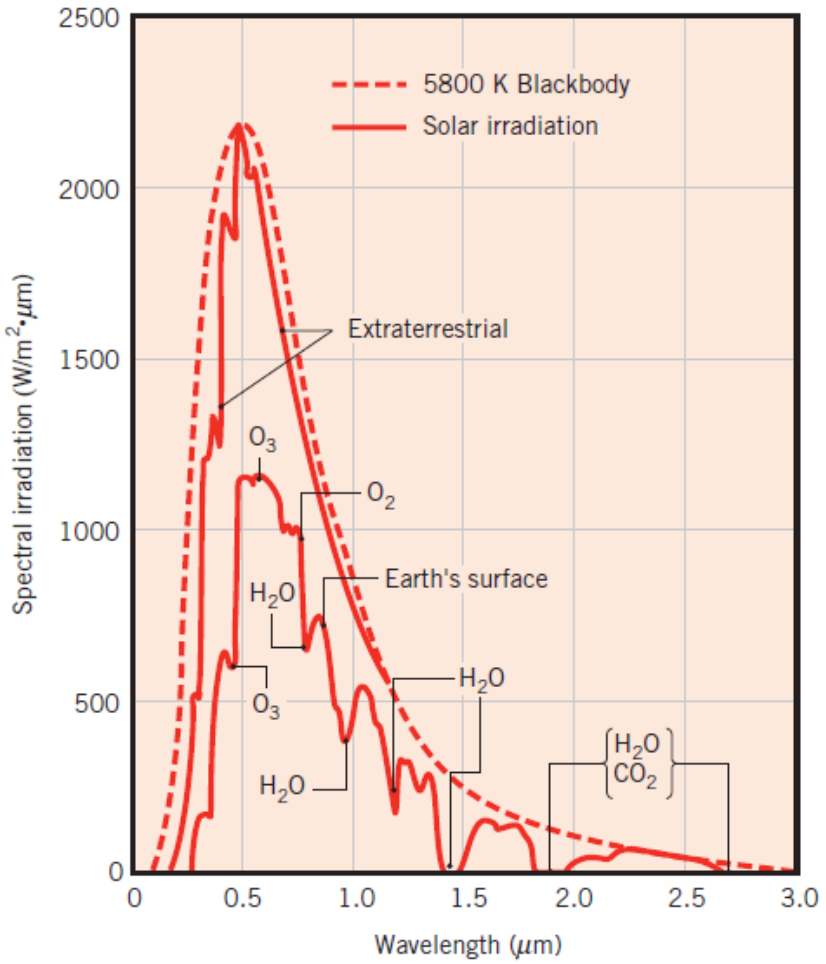
— It carries an unlimited resource of energy.



Solar Load - *Overview*

Downward-Propagating Solar Irradiation (*Short Wavelength*)

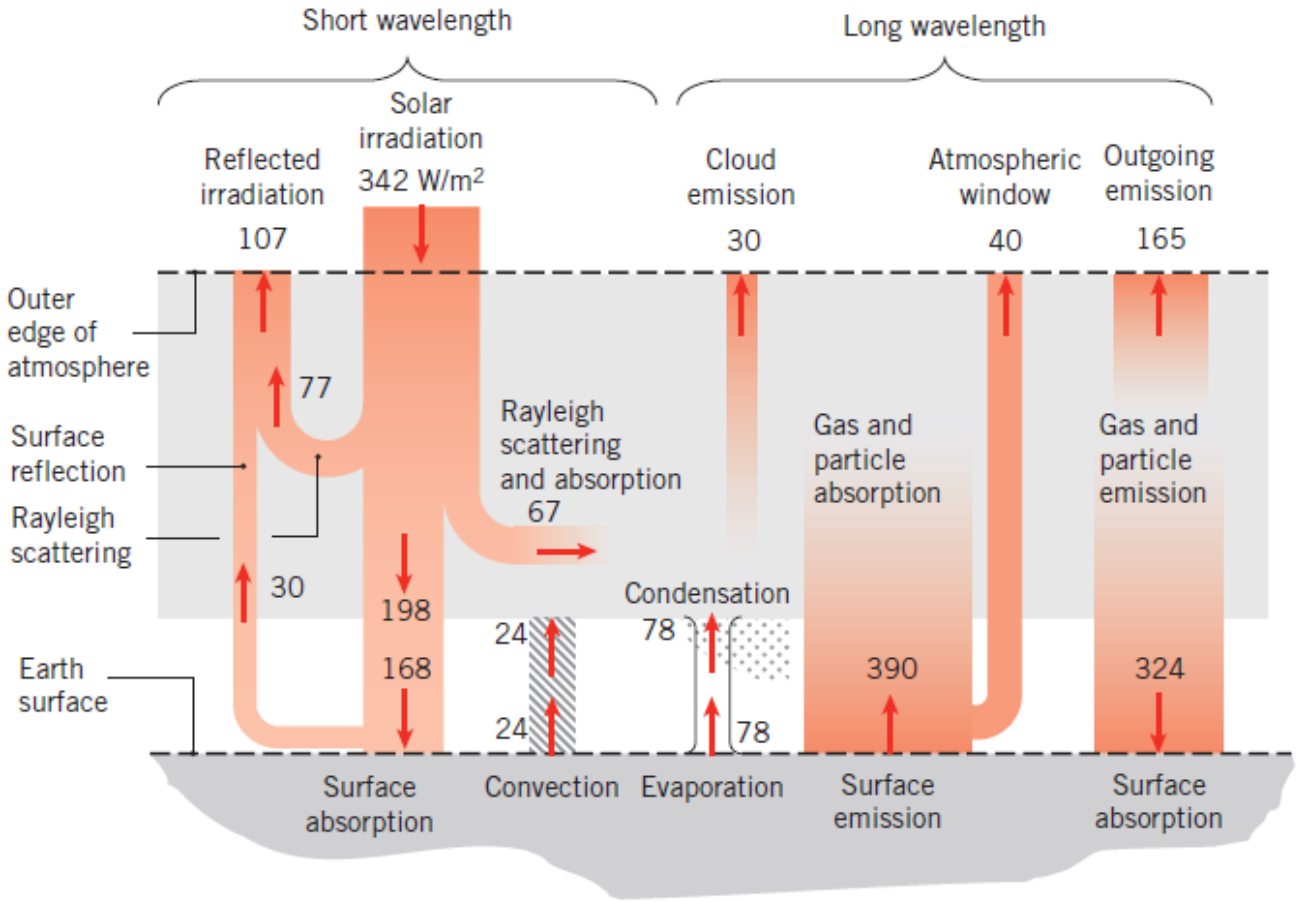


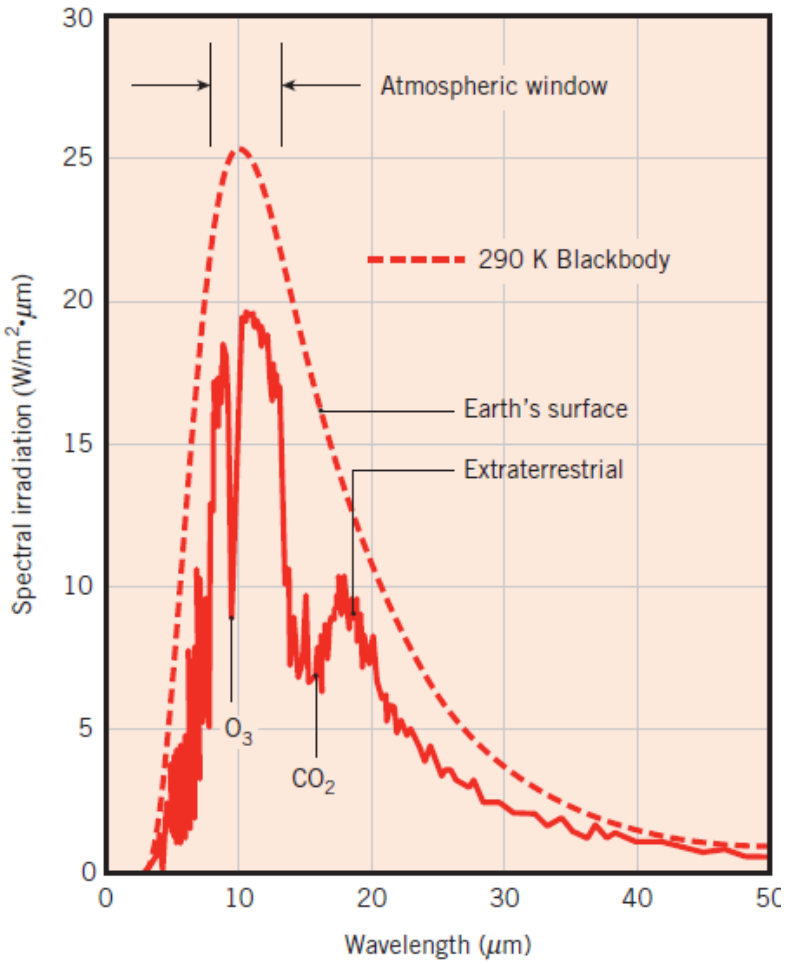


Source: T.L. Bergman, A.S. Levine, F.P. Incropera, D.P. Dewitt, Fundamentals of Heat and Mass Transfer, 7th Edition, John Wiley & Sons.

Solar Load - *Overview*

Upward-Propagating Environmental Radiation (*Long Wavelength*)

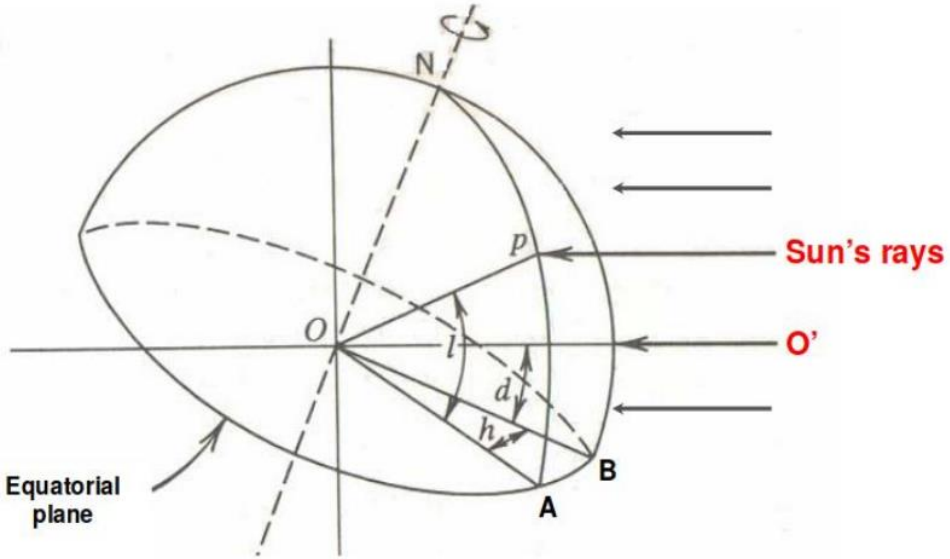




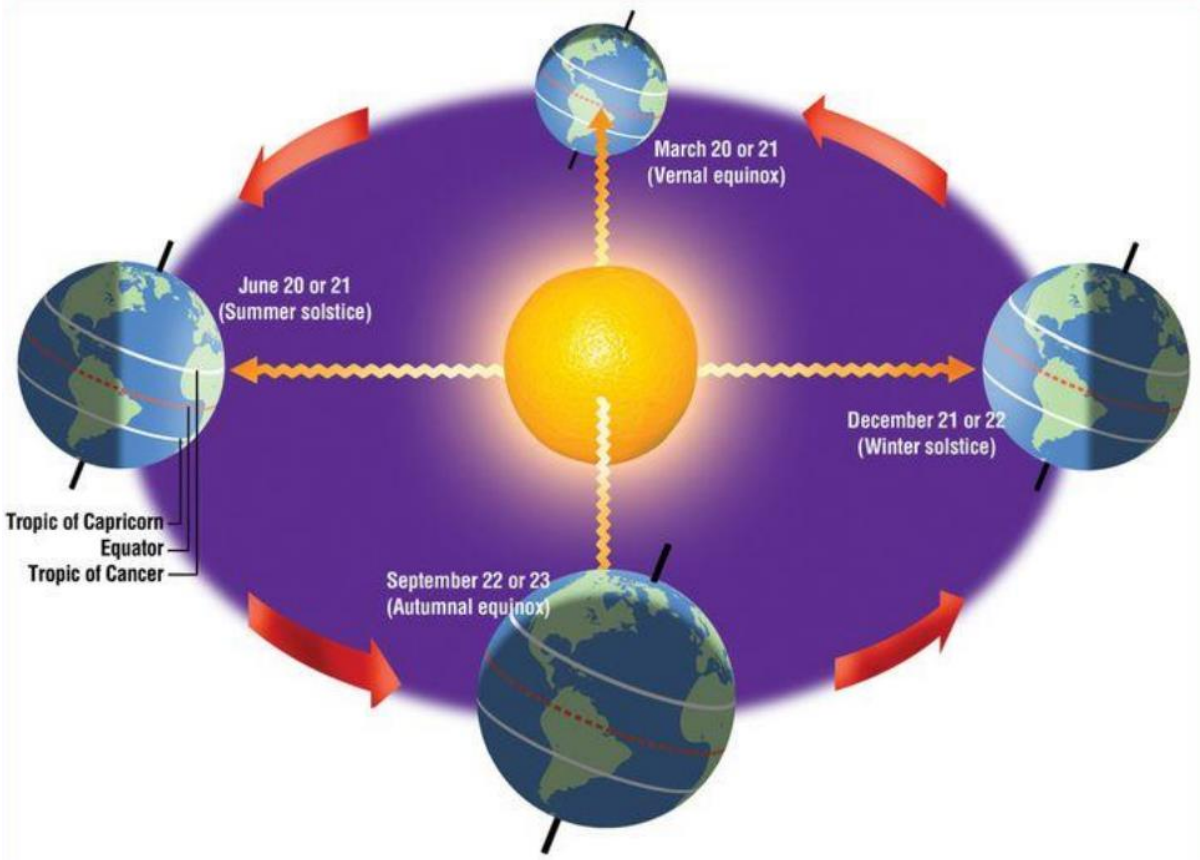
Source: T.L. Bergman, A.S. Levine, F.P. Incropera, D.P. Dewitt, Fundamentals of Heat and Mass Transfer, 7th Edition, John Wiley & Sons.

Solar Load - *Overview*

The magnitude of the solar radiation incident on the outer edge of the earth's atmosphere depends on the time (day and year) and latitude



l *– latitude,* ***d*** *– declinação,* ***h*** *– ângulo horário*

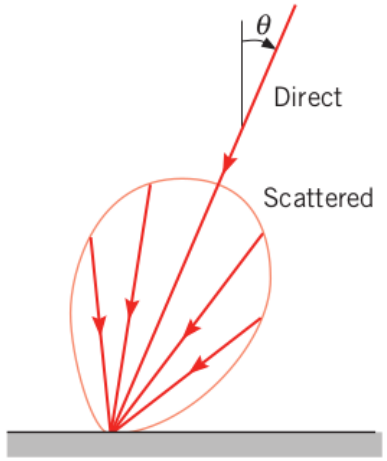


Extraterrestrial Solar Irradiation, $G_{S,o}$*:*

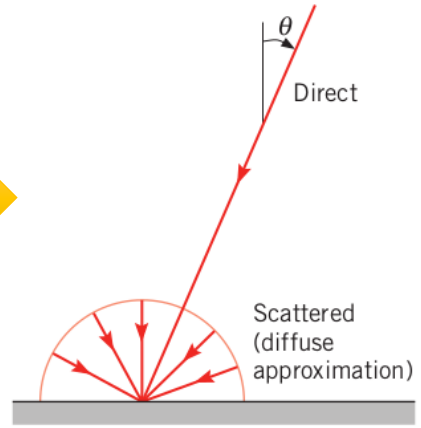
$$G_{S,o} = S_c f \cos(\theta)$$

$$G_{S,o} \approx 342 W/m^2$$

Solar Irradiation on Earth's Surface Approximation



Direct + Scattered



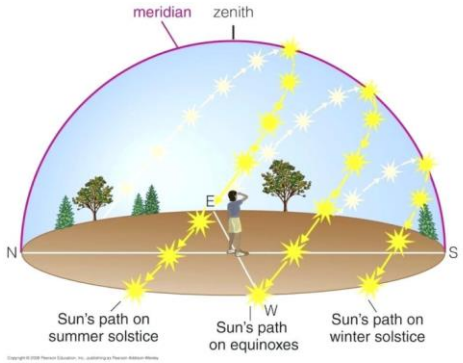
Direct + Diffuse

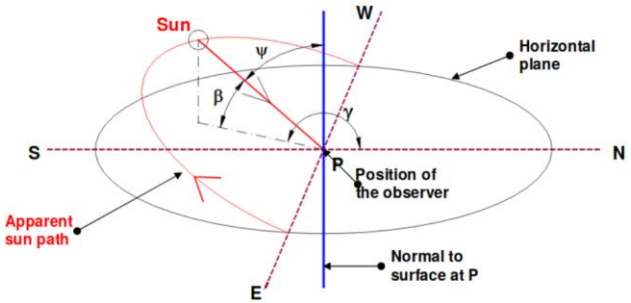
ASHRAE's Handbook Fair Weather Condition approach:

$$G_{tot,\theta} = G_{direct} \cdot \cos(\theta) + G_{diffuse,\theta} + G_{reflec,\theta}$$

$$G_{direct} = A \cdot \exp\left(-\frac{B}{\sin\beta}\right)$$

A – Apparent Solar Irradiation
B – Atmospheric Extinction Coefficient [0.14 winter, 0.21 summer]





β – altitude, Ψ – zenith, γ – azimuth

$$G_{diffuse} = C \cdot G_{direct} \cdot F_{ws}$$

C – Solar diffusivity constant [0.058 winter, 0.135 summer]
Fws – View factor

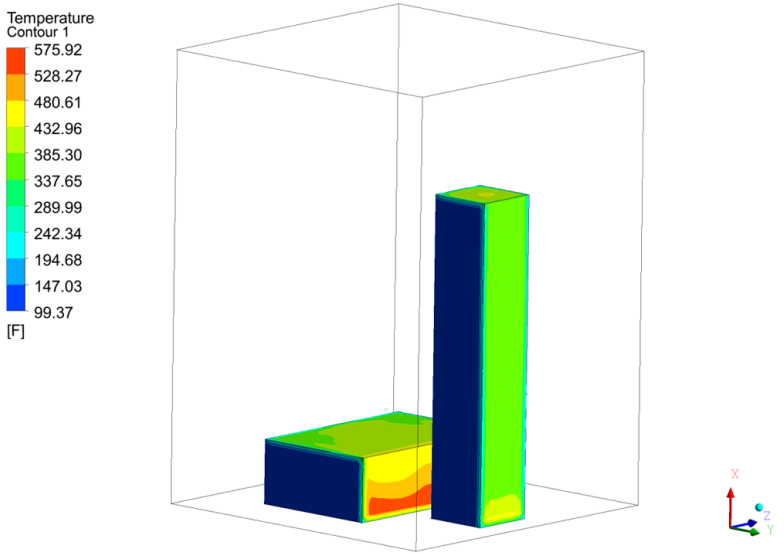
$$G_{reflect} = (G_{direct} + G_{diffuse})\rho_g F_{wg}$$

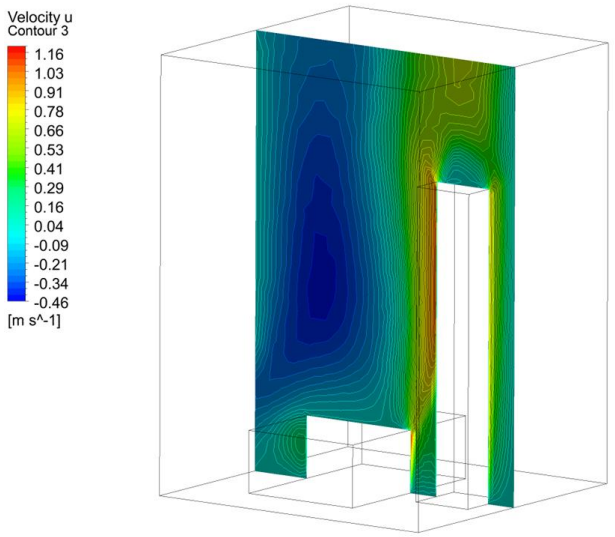
ρg – Ground Reflectivity
Fwg – View factor

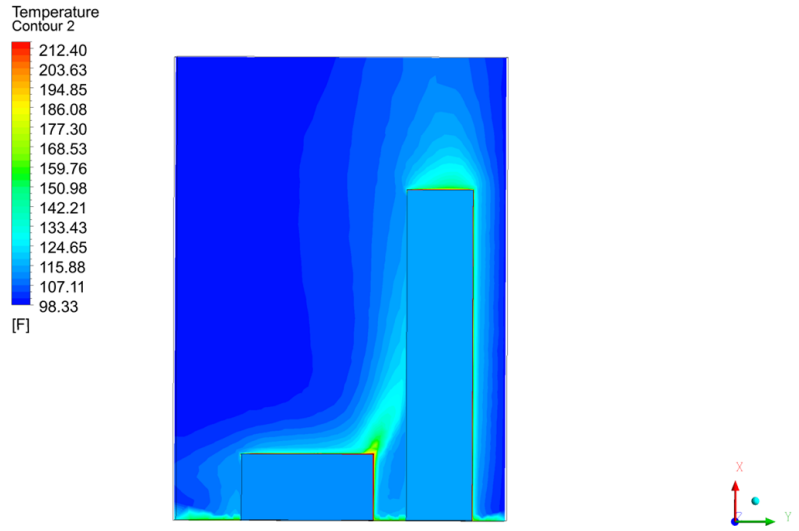
https://nptel.ac.in/courses/112105129/pdf/R&AC%20Lecture%2032.pdf

Solar Load - *Applications*

Buildings thermal balance

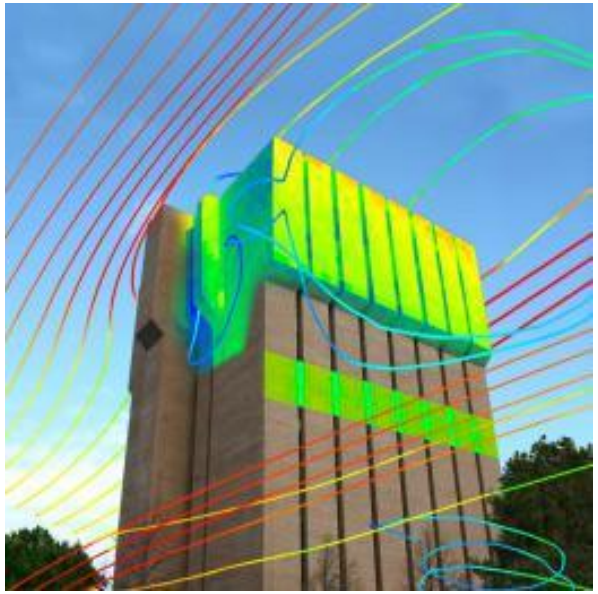


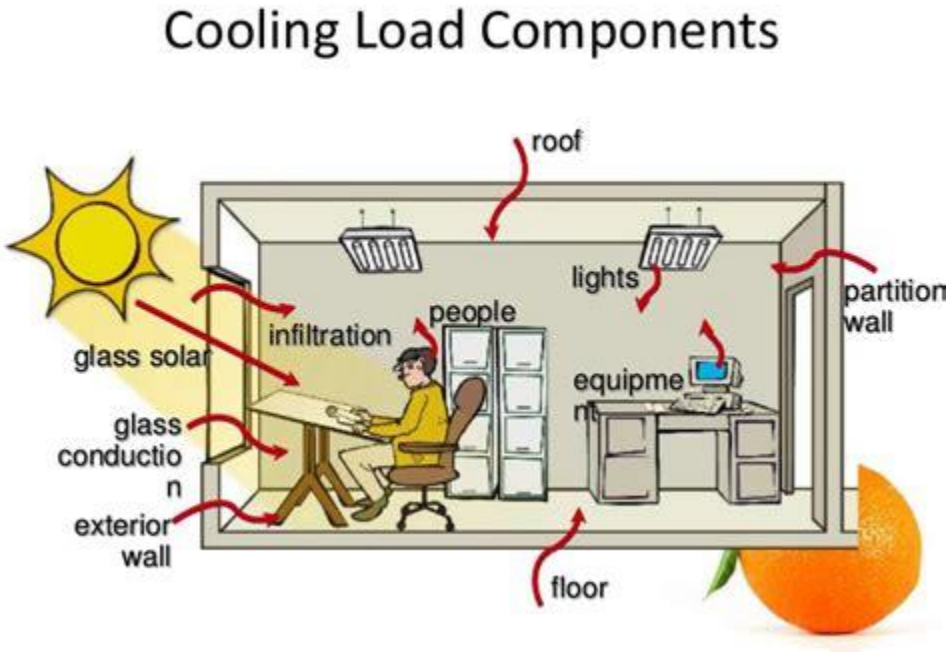


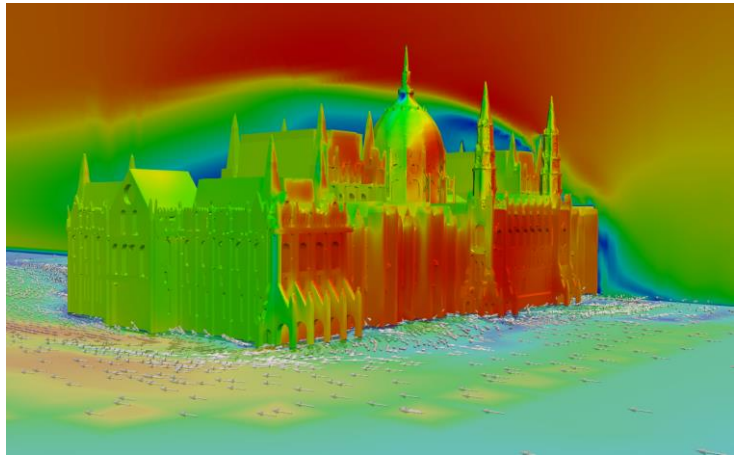


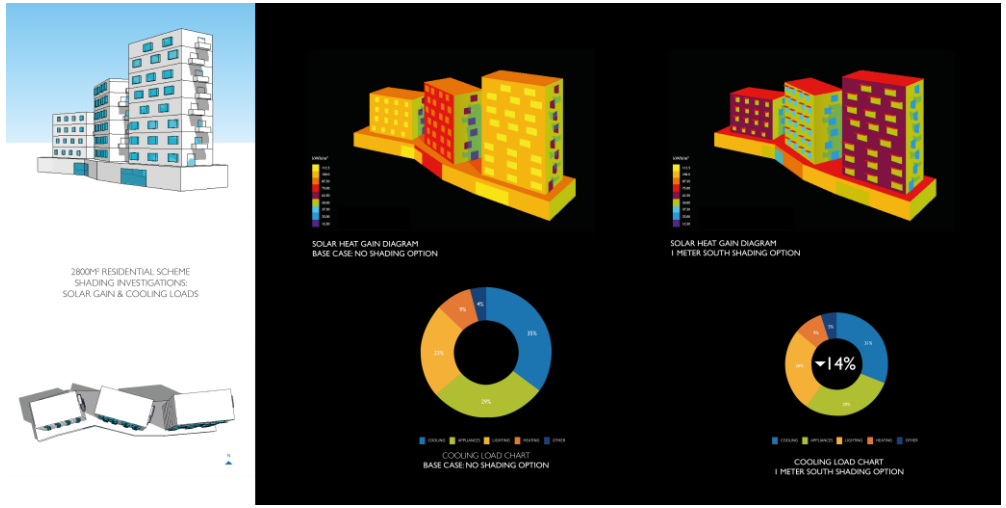
Solar Load - *Applications*

HVAC



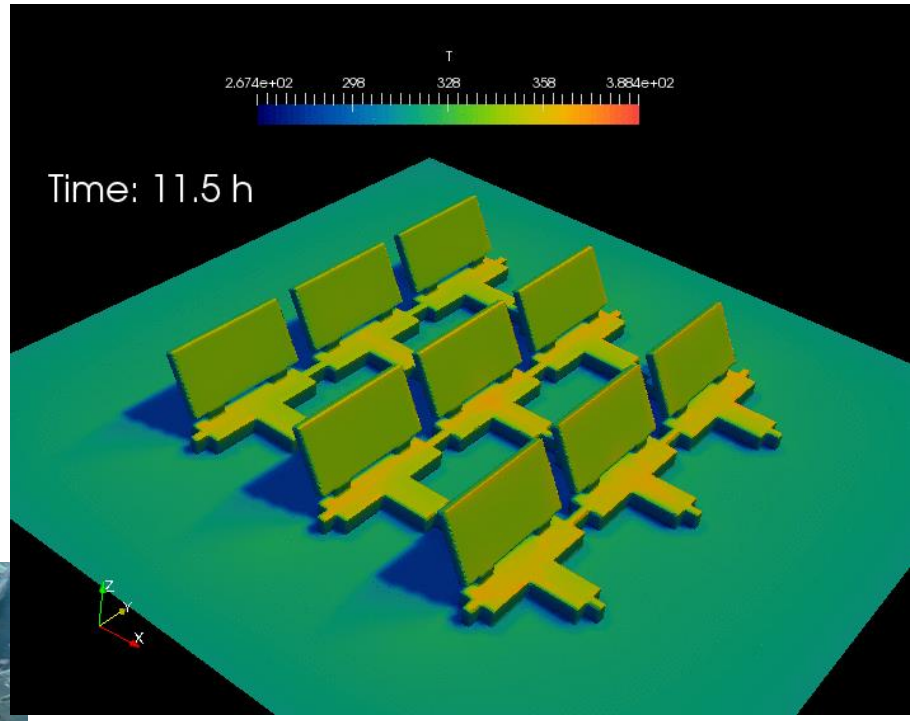






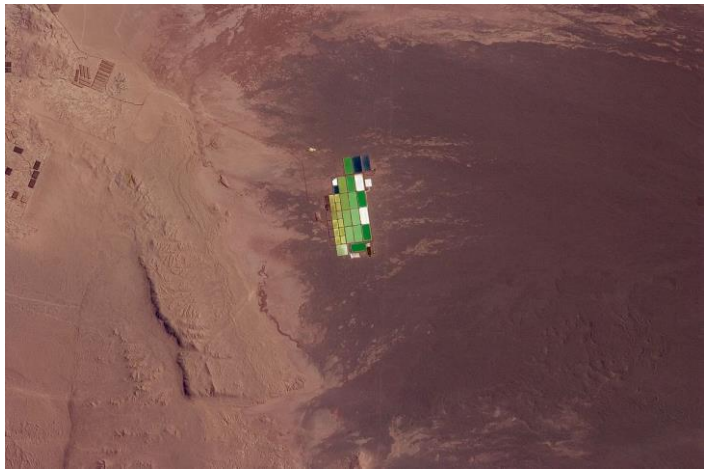
Solar Load - *Applications*

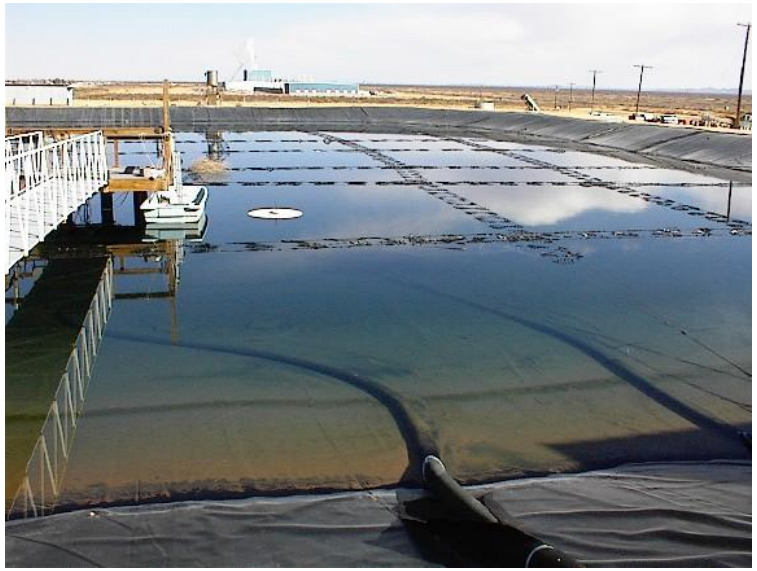
Solar Energy

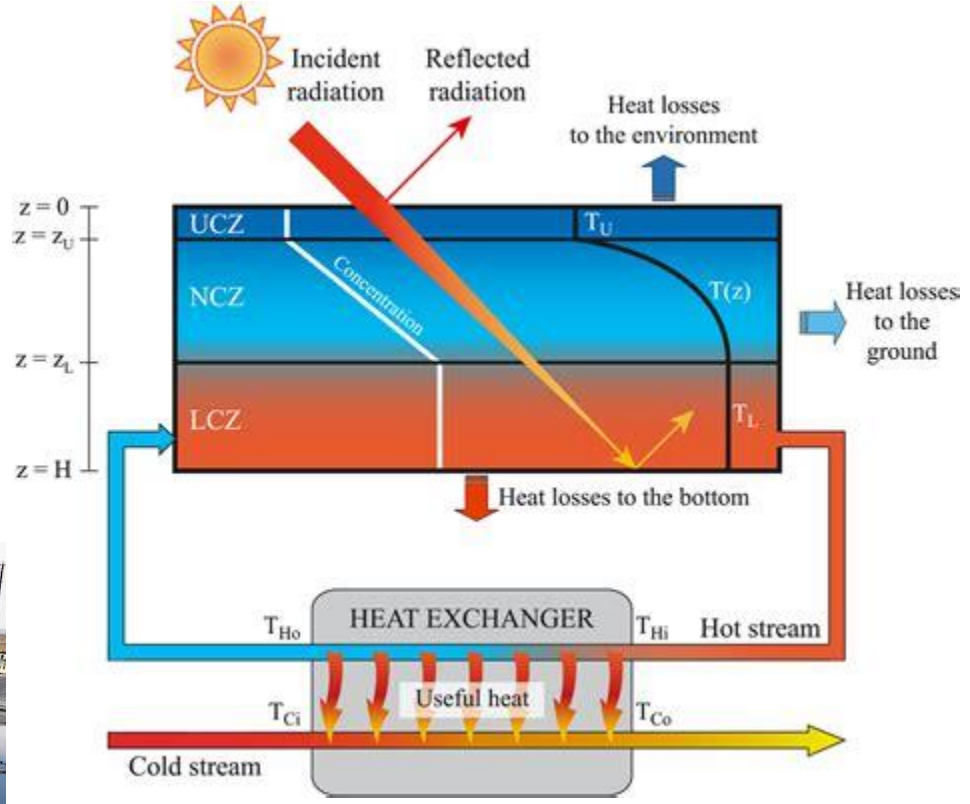


Solar Load - *Applications*

Solar Ponds

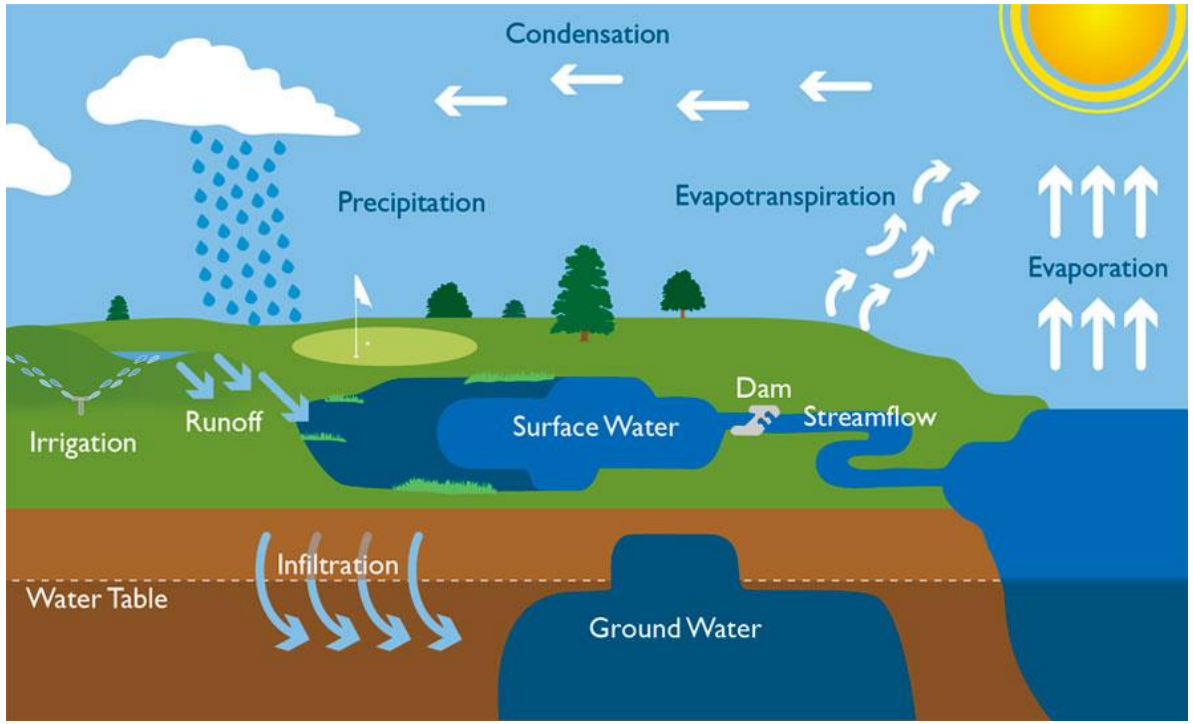






Solar Load - *Applications*

Evapotranspiration

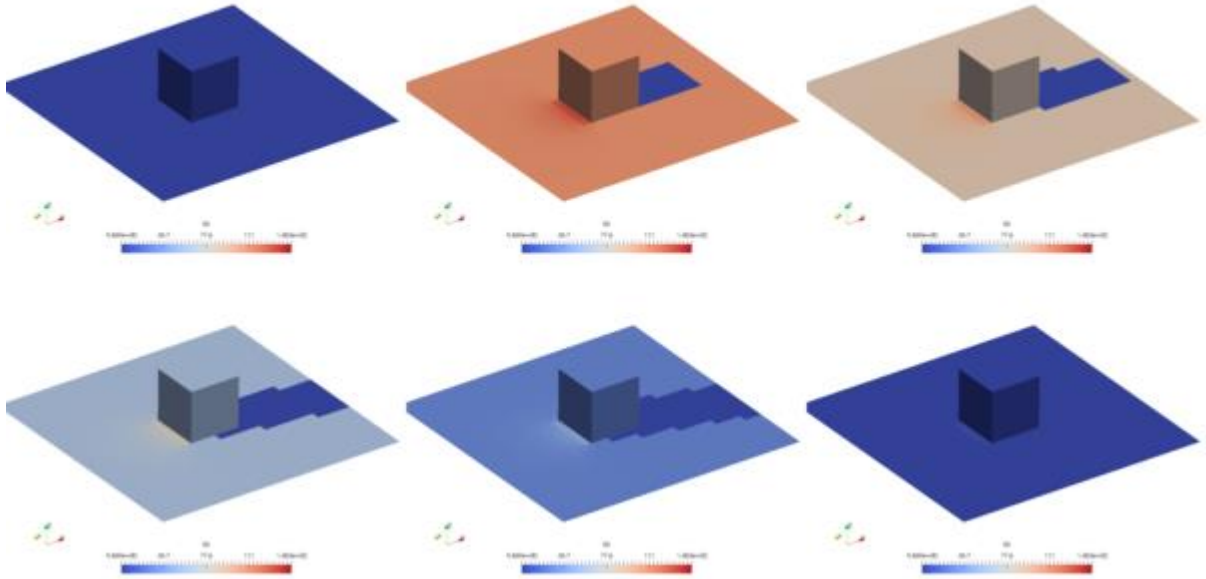


Solar Load Model in OpenFOAM®

— First announcement in January 2016 with the launch of **OpenFOAM® v3.0+**;

— Includes **sun primary hits** *(via face shading algorithm)*, **reflective fluxes** *(via view factors method)* and **diffusive sky radiative fluxes** *(via ASHRAE's Fair Weather Conditions Method)*;

— Reflected fluxes uses a grey absorption/emission model which is weighed by the spectral distribution;



— Can be used in conjuction of P1, fvDOM and View Factor radiation models;

— The model includes a solar calculator which computes the solar rays direction.

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