

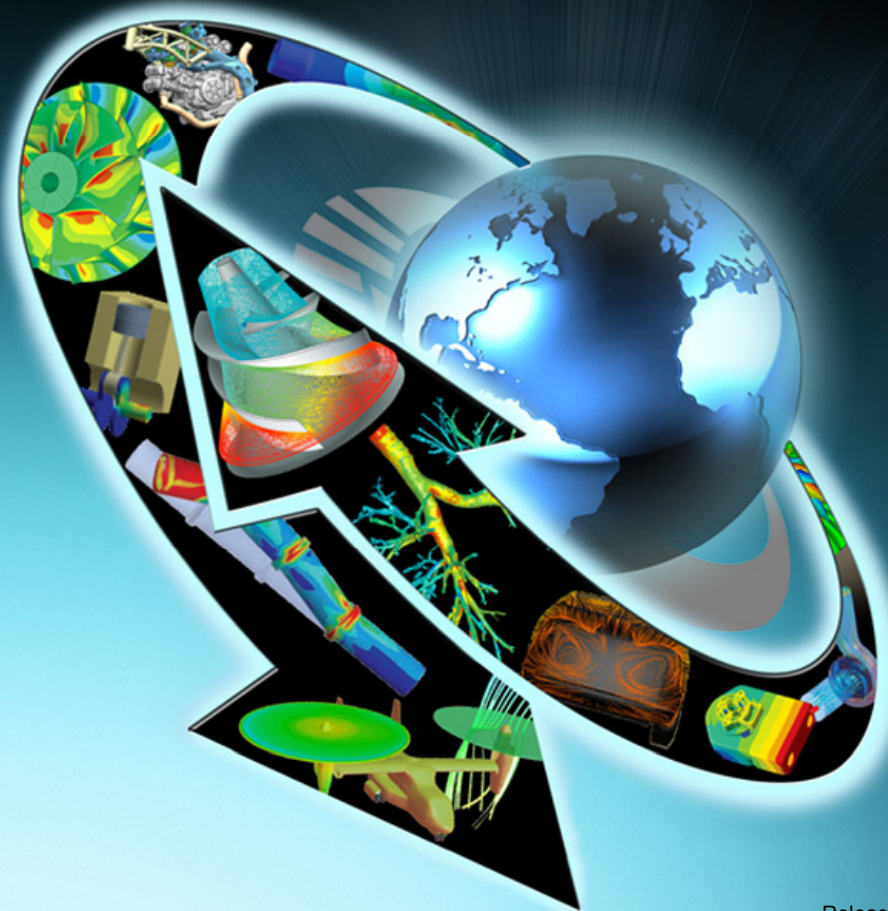


Customer Training Material

Lecture 6

Solar Load Model

Heat Transfer Modeling using ANSYS FLUENT

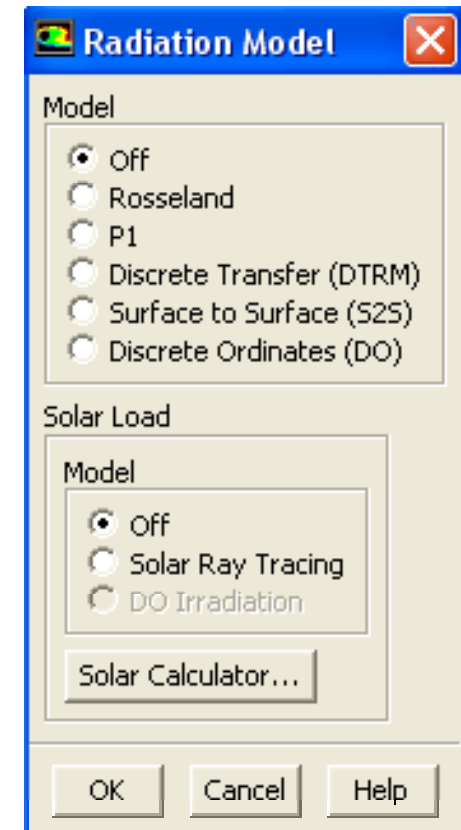


Outline

- **Introduction**
- **Setting Up Cases Using the Solar Load Model**
- **Practical examples**
 - Automotive cabin
 - Indoor ventilation of FLUENT Europe's office
- **Advantages and limitations**

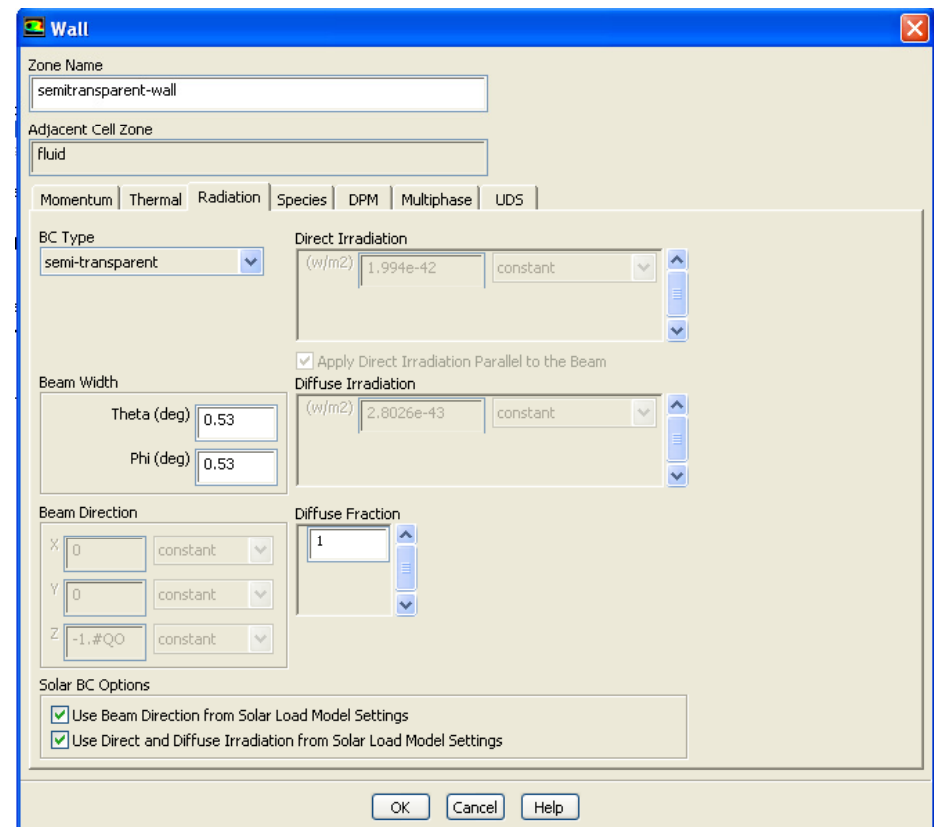
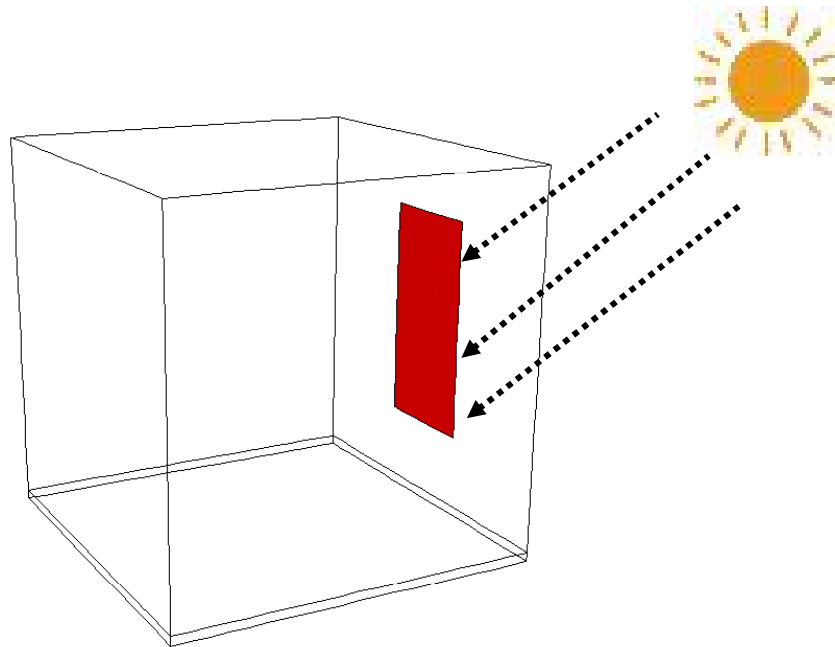
Introduction

- The Solar Load Model is **not** a stand-alone radiation model.
- Calculates radiation effects from the Sun's rays entering the computational domain.
- Only available for 3D cases.
- Available for both steady and unsteady cases.
- Typical applications :
 - Automotive climate control.
 - Human comfort modeling in buildings.
- Two options are available
 - Solar ray tracing using a tracing algorithm
 - Discrete ordinates (DO) irradiation, providing a means to apply solar loads directly into the DO model.



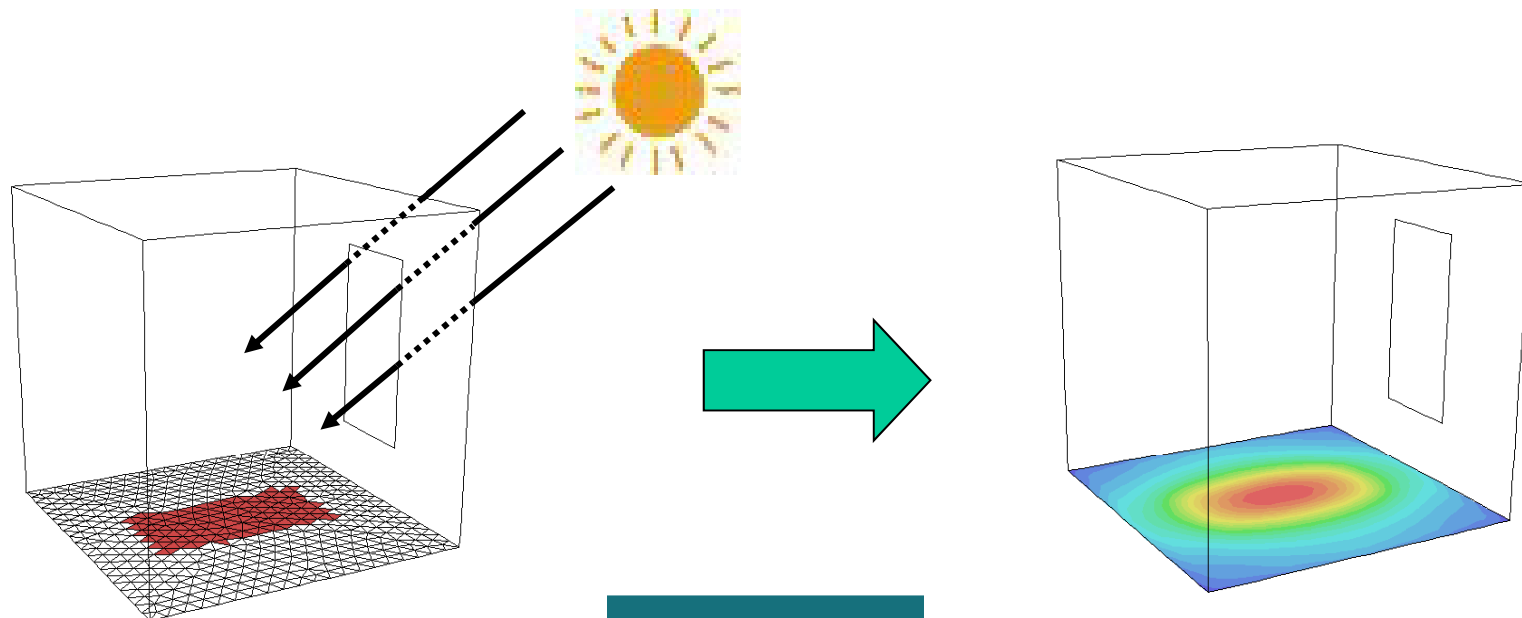
DO Irradiation Option

- Available only in combination with the Discrete Ordinates (DO) radiation model.
- Provides a means of applying radiation flux to semi-transparent walls.
- The radiation heat transfer is derived from the solution of the DO radiation transfer equation



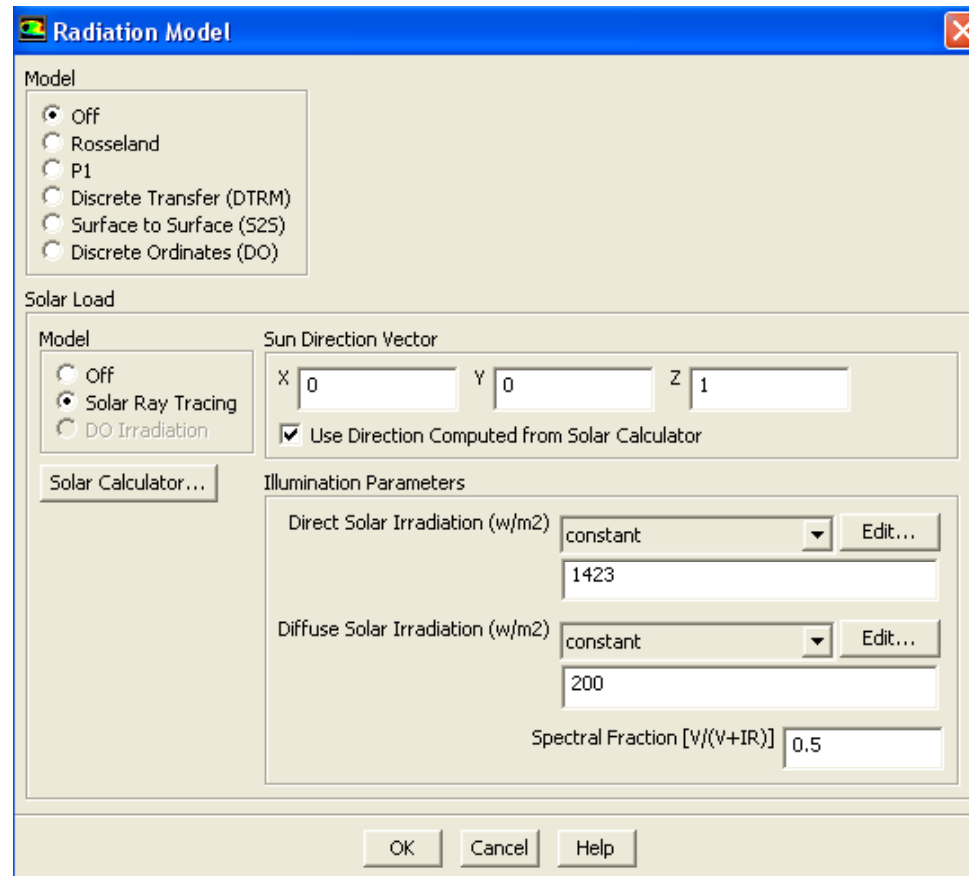
Solar Ray Tracing

- Only adds the effects of an external radiation source to the thermal energy equation.
- Models collimated beams of radiation entering in a particular direction through selected semi-transparent walls.
- Uses a ray-tracing type algorithm to find where the beams pass.
- Where the beams hit opaque walls, they dump their energy into those wall faces.



Activating the Solar Load Model

- Select the Solar Load Model in the Radiation Model panel
- Solar load parameters panel allows the user to set :
 - The position of the sun. (Not beam direction as in DO-Model)
 - The Direct and Diffuse Solar Irradiation values



Solar Calculator

- The Solar Calculator panel allows the user to set the position of the sun by prescribing
 - The global location and orientation of the object
 - The date and time of day.

Solar Calculator

Global Position

Longitude (deg) -84.62999

Latitude (deg) 13.65

Timezone (+-GMT) -5

Mesh Orientation

North East

X 0 X 1

Y 1 Y 0

Z 0 Z 0

Date and Time

Day of Year

Day 21

Month 6

Time of Day

Hour 13

Minute 0

Solar Irradiation Method

☐ Theoretical Maximum

☒ Fair Weather Conditions

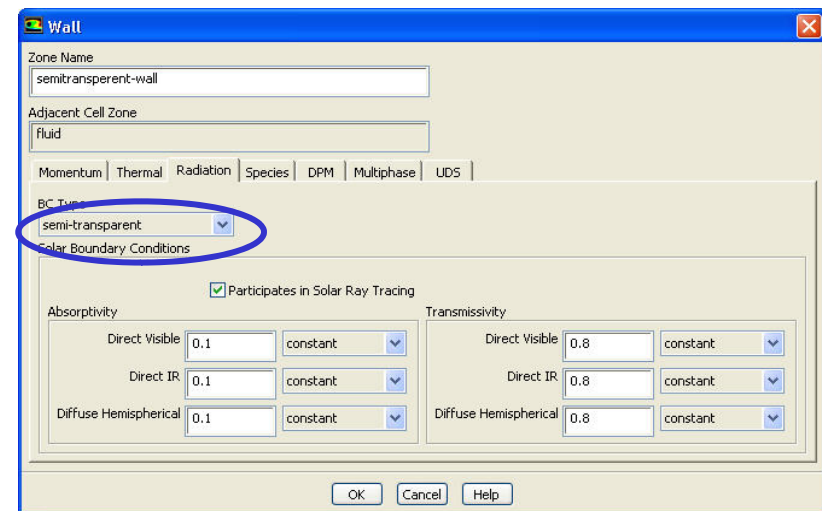
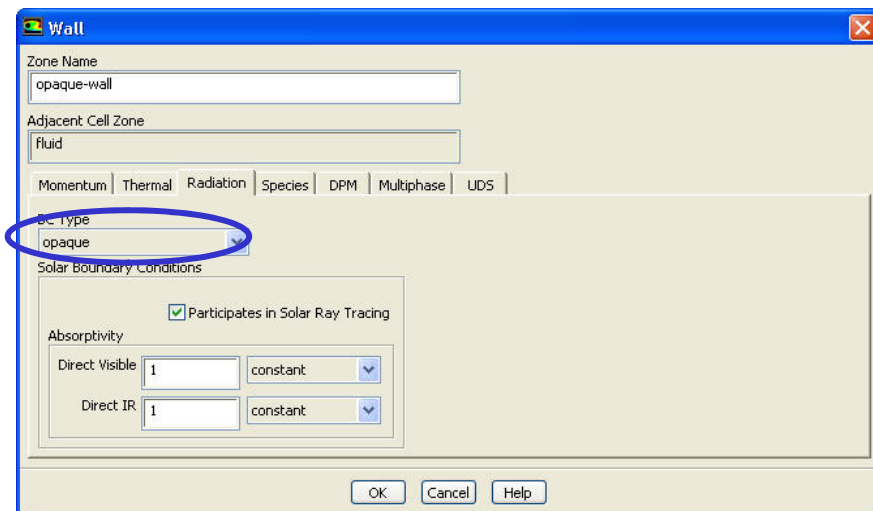
Options

Sunshine Factor 1

Apply Close Help

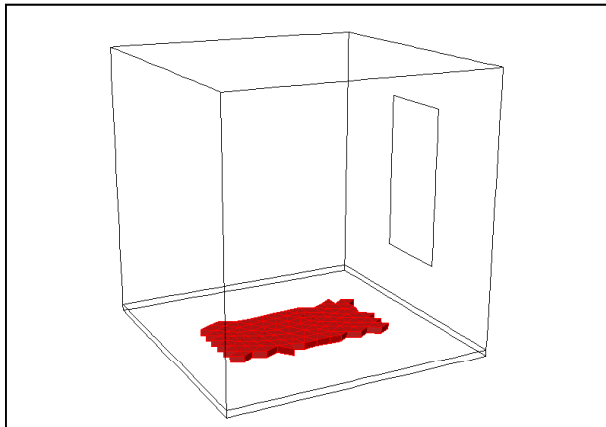
Boundary Conditions

- Once the Solar Load Model is selected and set up, the user must specify:
 - Any semi-transparent walls
 - Opaque walls
 - Optical properties of each zone

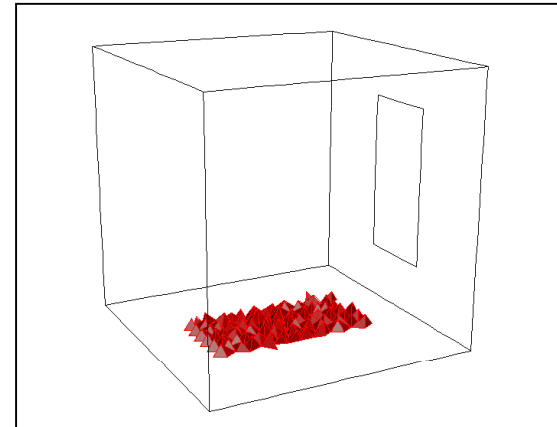


Source Term Position

- The solar load model calculates energy sources for every face subjected to solar load.
- By default this energy will be sourced into the adjacent cells in the following order:
 - Shell conduction cells
 - Solid cells
 - Fluid cells



Heat Source Positioned in Solid Cells



Heat Source Positioned in Fluid Cells

Other Parameters

- **Other parameters are available in the TUI.**

`define/models/radiation/solar-parameters/...`

`ground-reflectivity`

- **Set the amount of radiation reflected from the ground and add in the total diffuse background radiation.**

`Scattering fraction`

- **Set the amount of direct radiation that has been reflected from opaque surfaces (after entering through the transparent surfaces) that will be considered to remain inside the domain.**

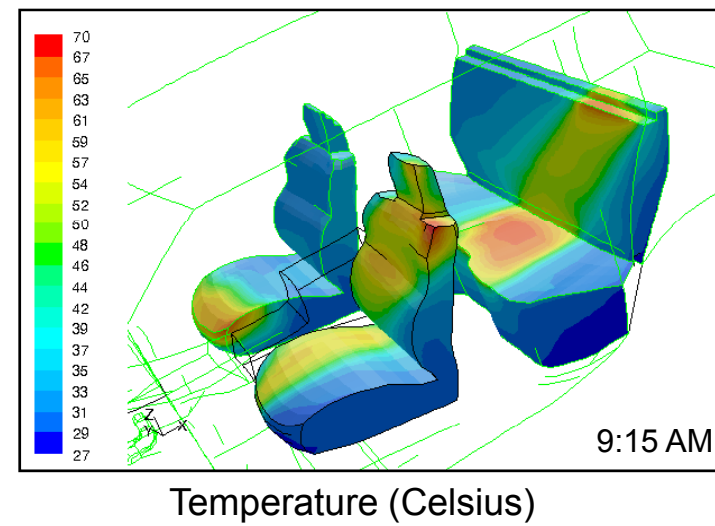
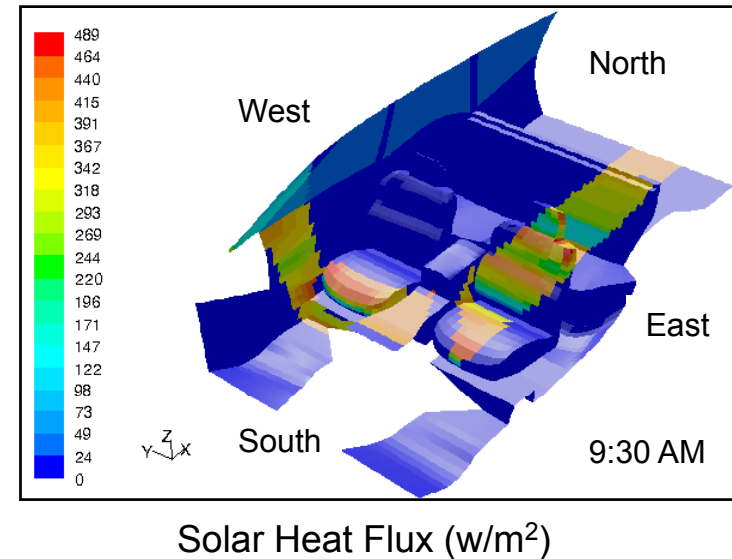
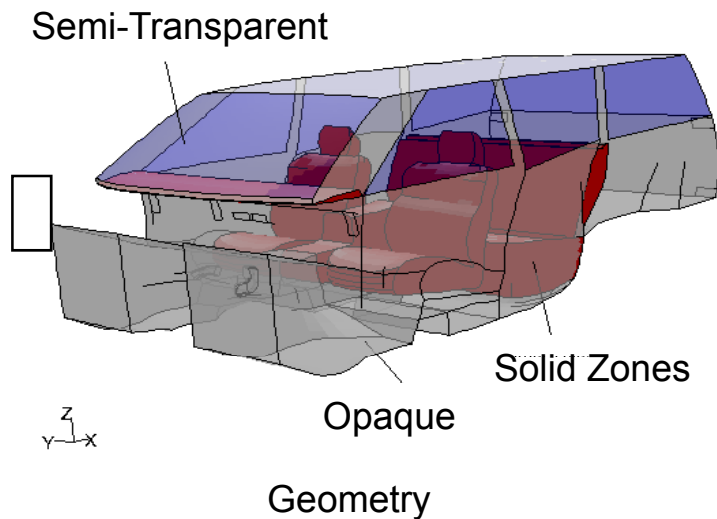
`sol-adjacent-fluidcells`

- **Apply solar loads to adjacent fluid cells only, even if solid or shell conduction zones are present**

Advantages and Disadvantages

- **Solar load modeling is a useful approach for many climate control applications.**
- **Advantages**
 - Once the solar loads are calculated, exhibits low cost per iteration.
 - Simple and quick to implement.
 - Low memory and data file storage requirements
 - Accurate prediction of “hot spots.”
 - Can be used in conjunction with other radiation models.
- **Disadvantages**
 - Often too simple as there is no internal radiation calculated.
 - Reflection, absorption, and scattering effects are not considered.
 - Only one beam direction is permitted.

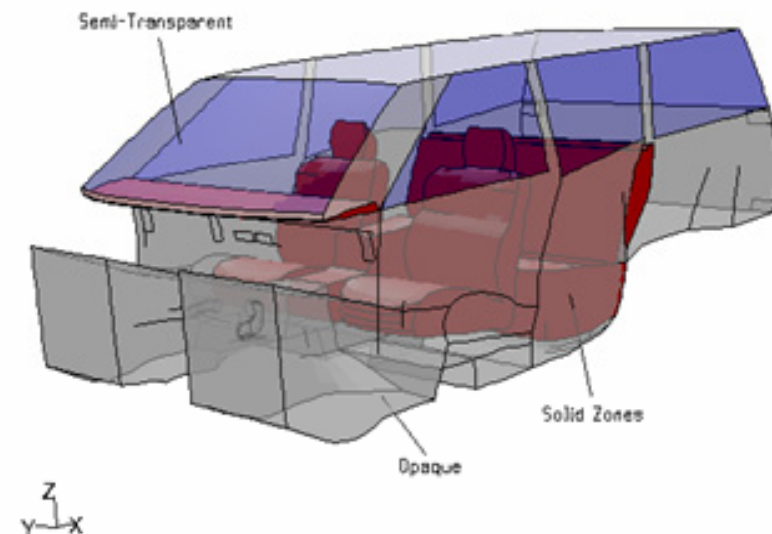
Case Study – Automotive Passenger Cabin



Courtesy National Renewable Energy Laboratory

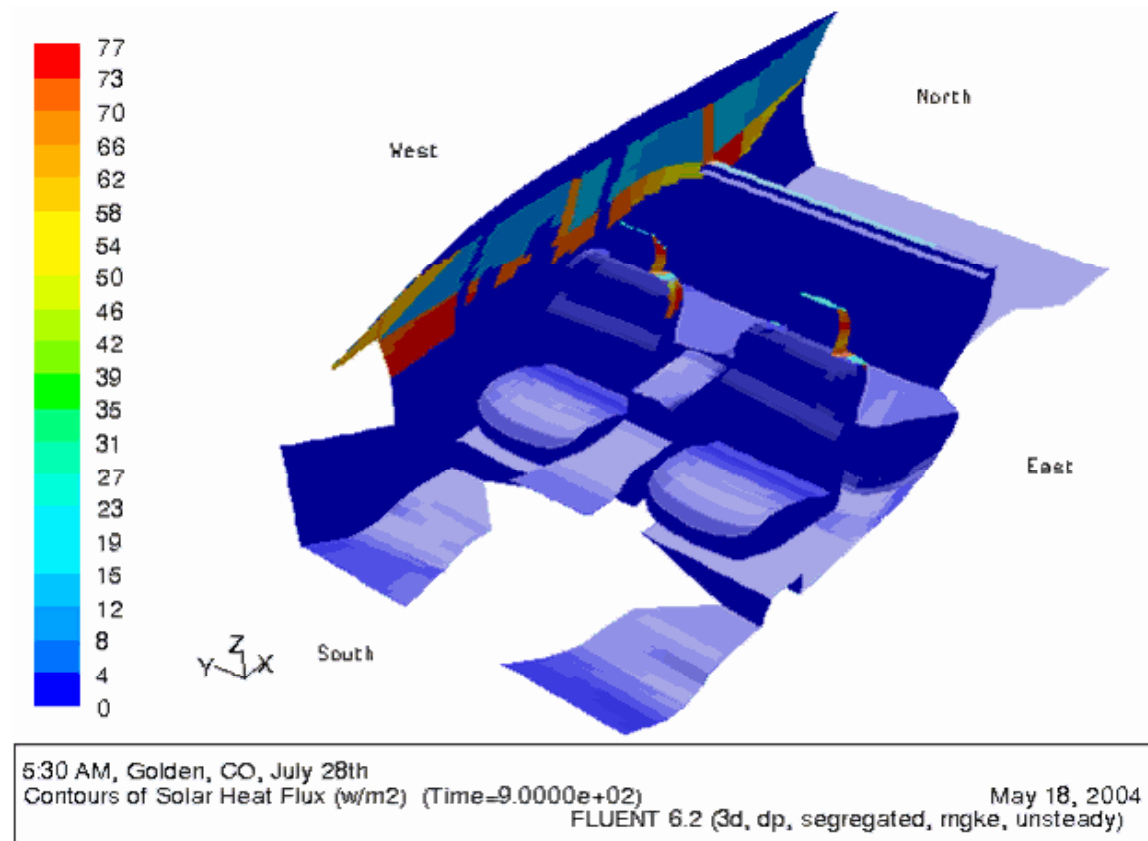
Case Study – Automotive Passenger Cabin

- **Modeled the interior of an automobile using 160,000 hexahedral cells**
 - Experimental data for 11 hours of soaking from NREL experiment is available.
 - Ran a CFD simulation of the first 4 hours.
 - Calculated natural convection flow and heat transfer
- **Solar Load Model to compute the heat fluxes due to solar radiation**
 - Sun position updated every 5 minutes and heat fluxes are recalculated
 - Serial solver has been run ahead only to compute the partial data files with solar flux
- **DO Radiation model used for internal re-radiation of the energy**
- **Parallel solver used to solve flow, turbulence, and DO equations, while reading intermediate data files automatically.**



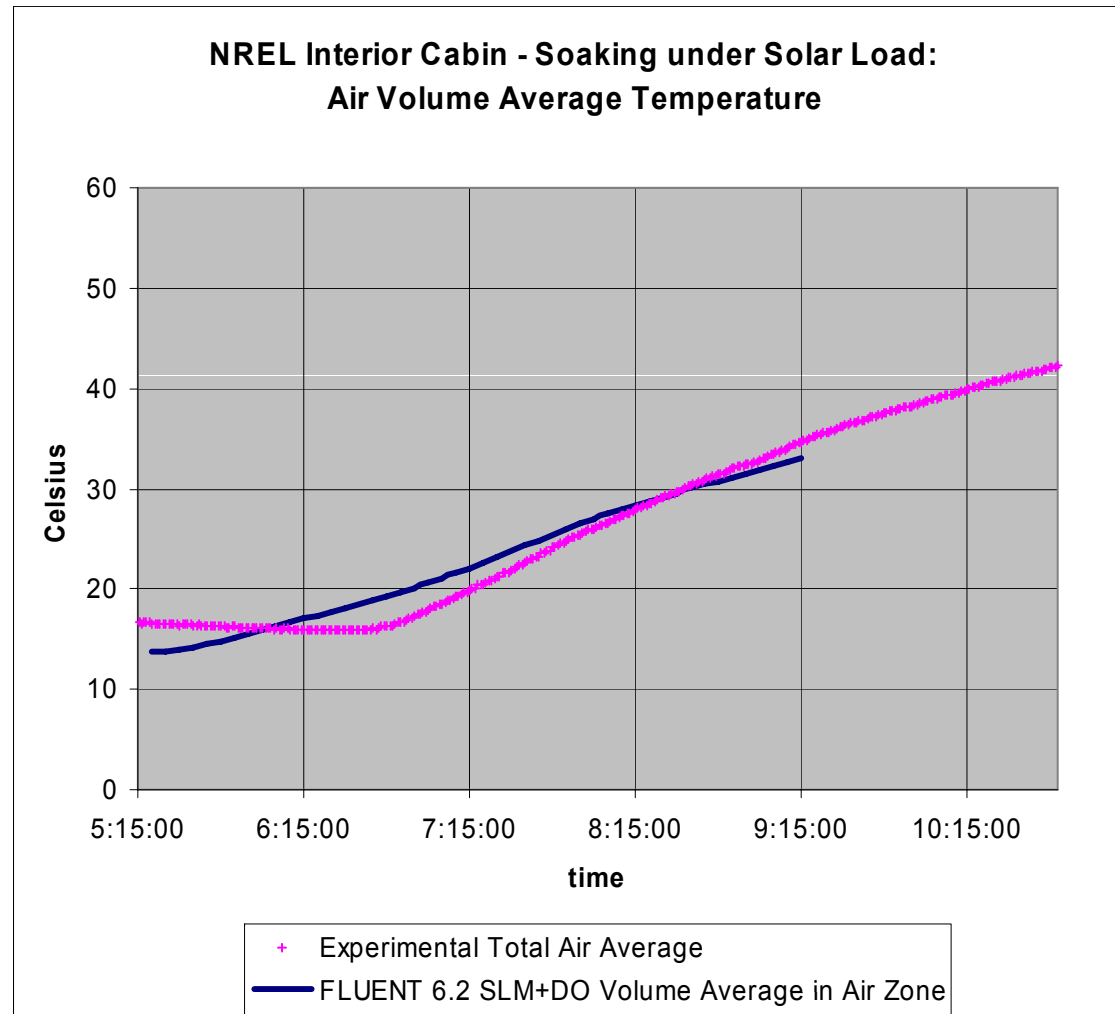
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Case Study – Automotive Passenger Cabin



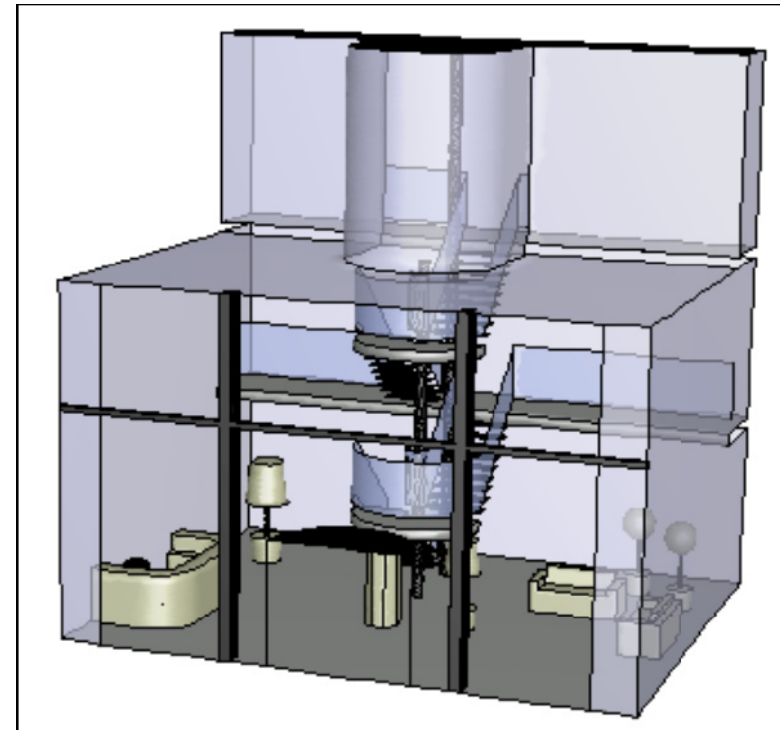
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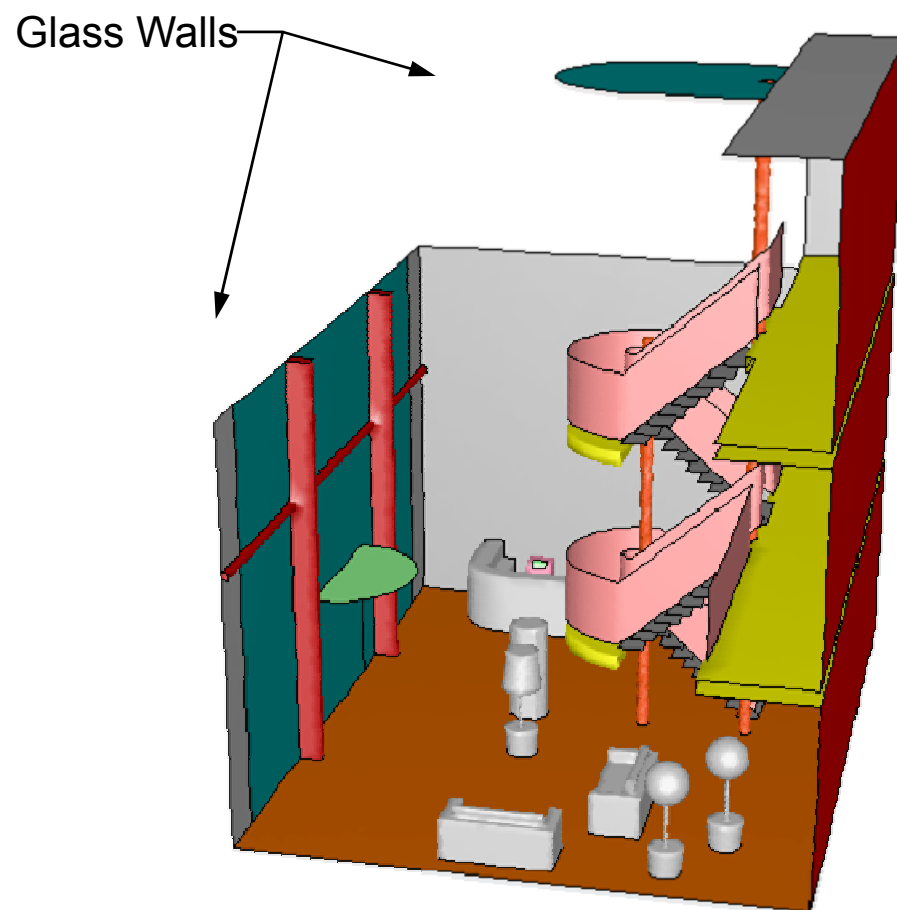
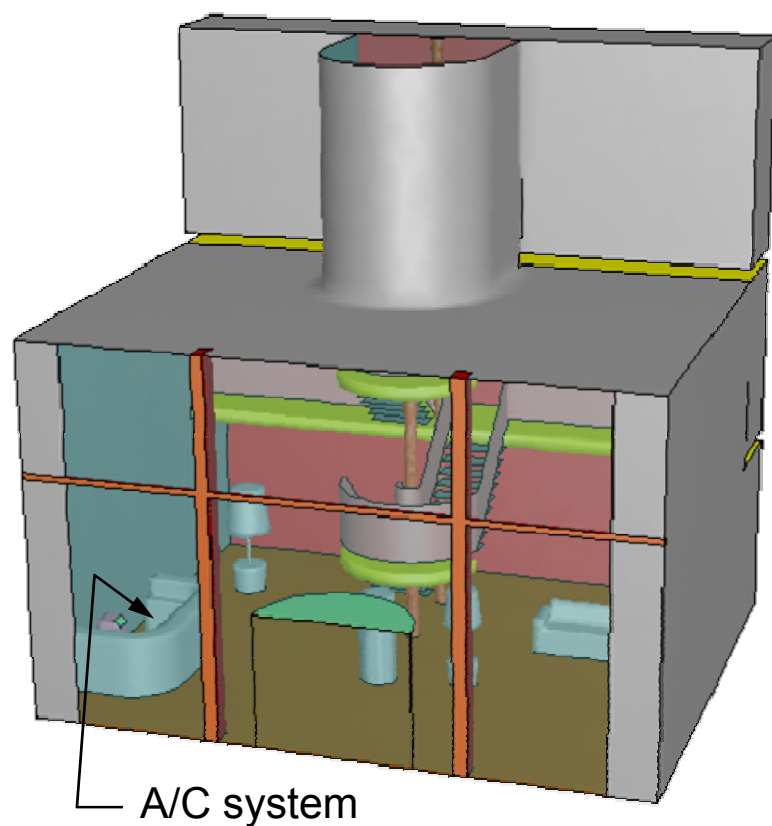
Case Study – Automotive Passenger Cabin



Case Study: FLUENT Europe's Office HVAC Analysis

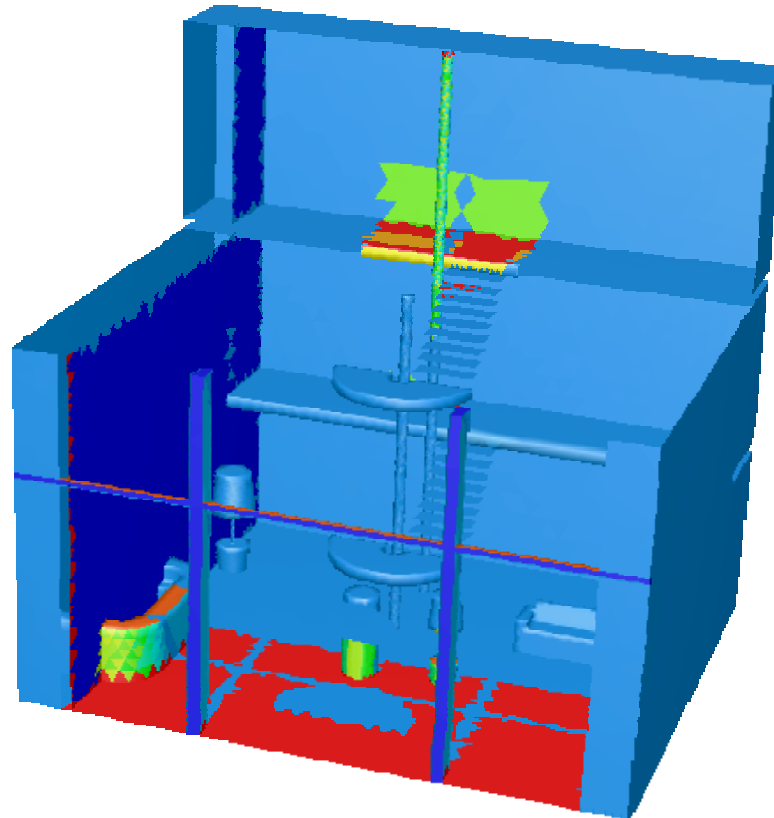
- **Goal is to analyze the HVAC requirements in the reception area of FLUENT Europe's office in Sheffield, UK.**
 - Fully glazed front wall
 - Small glazed area on roof.
 - A/C system behind the reception desk.
- **270,000 tetrahedral cell mesh without boundary layer mesh.**
 - Natural/forced convection flow
 - Radiative heat transfer calculation (DO or S2S model)
 - Solar load model used to calculate solar heat fluxes on a normal day in the middle of summer.



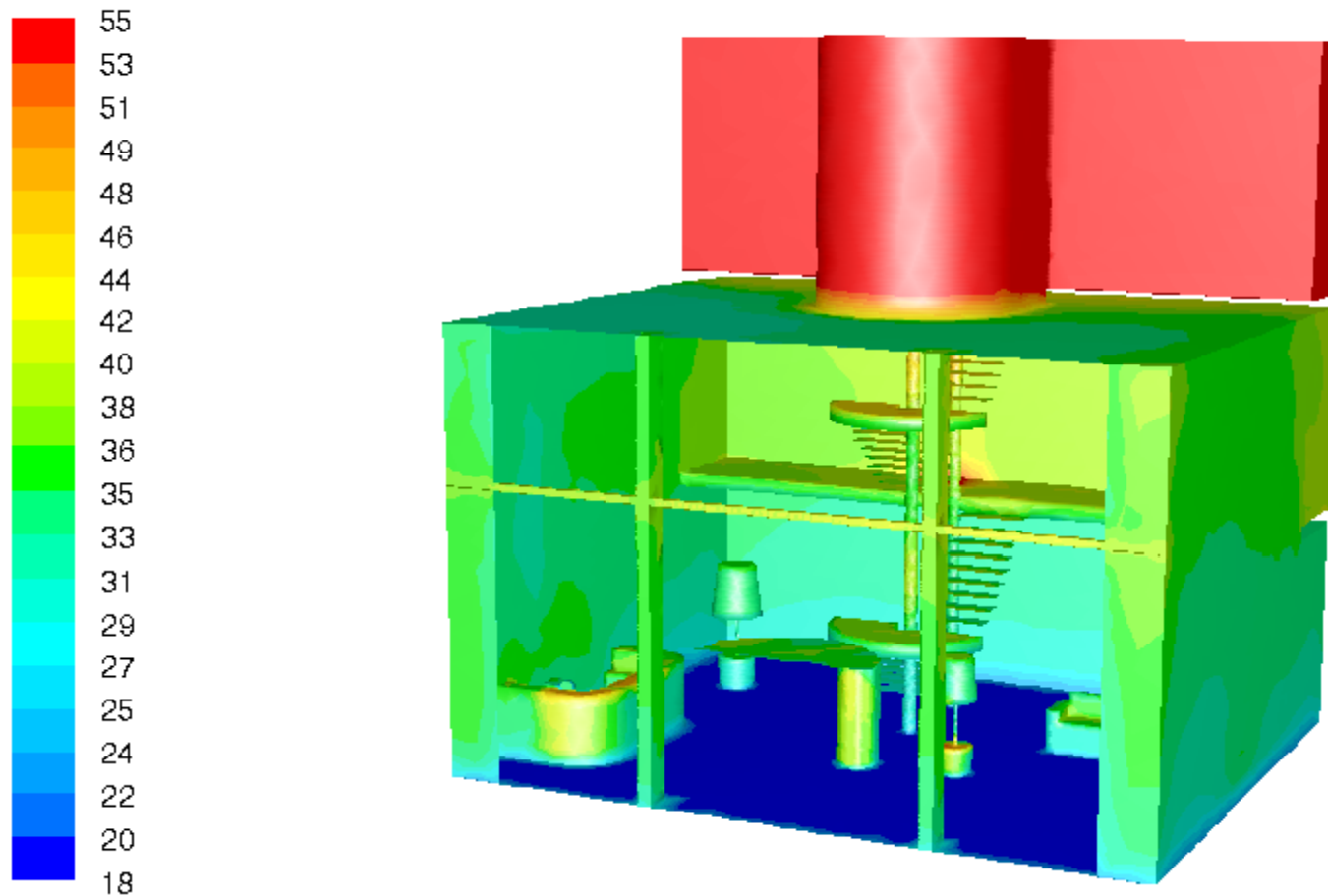


Case Study: FLUENT Europe's Office HVAC Analysis

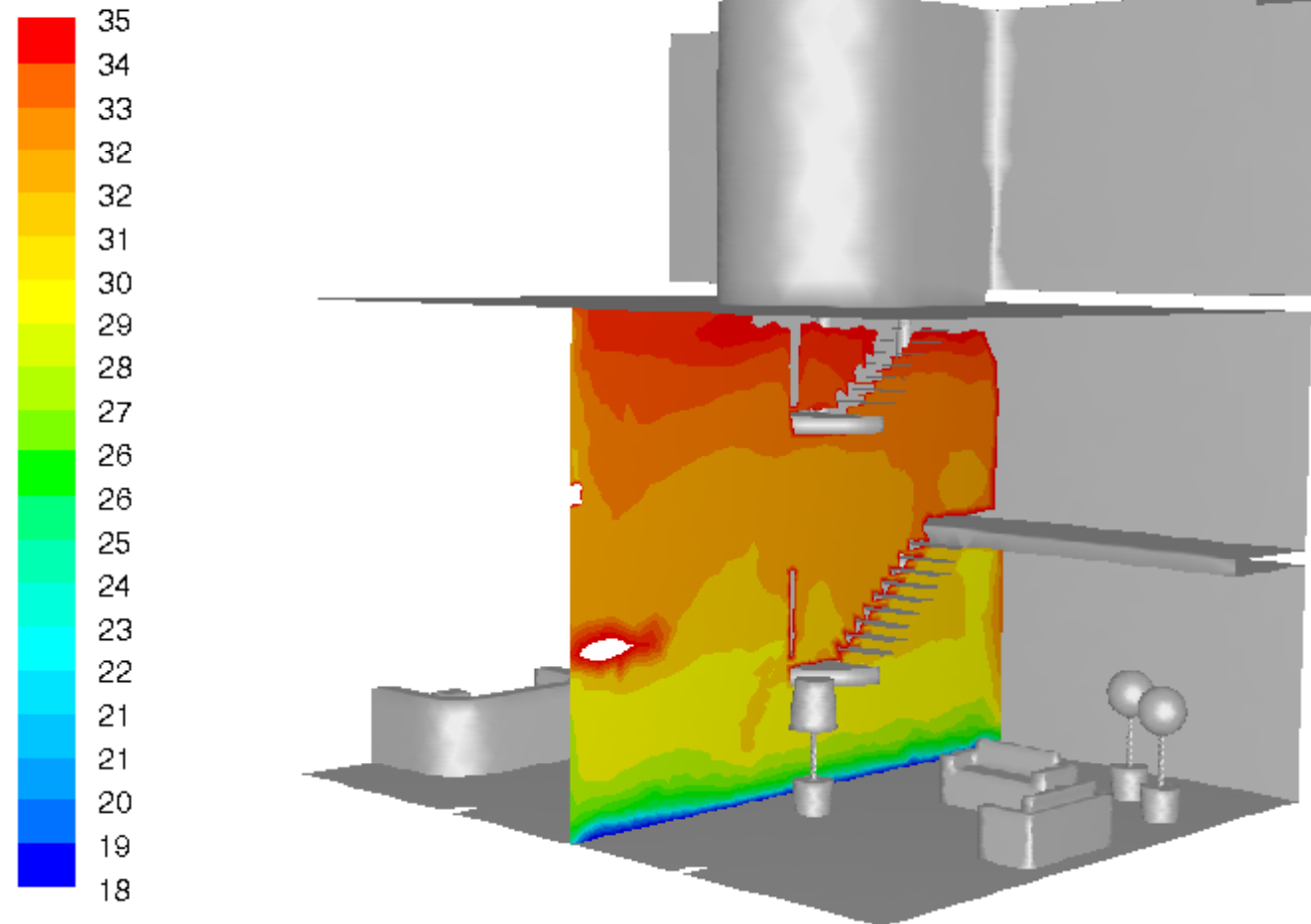
- **Solar heat sources on June 21 at 1:00 pm of a typical year.**
- **Source terms positioned in adjacent fluid cells**



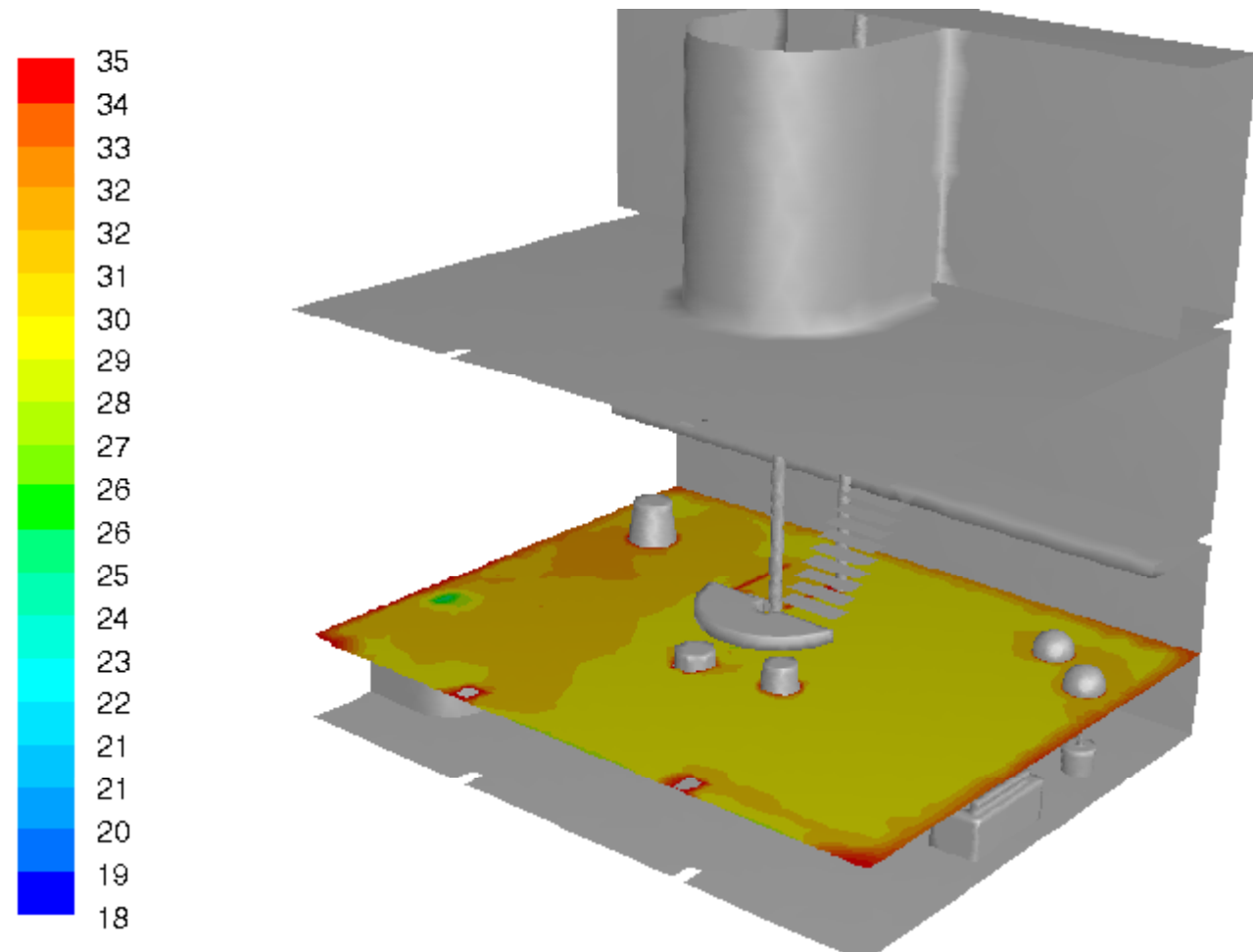
Case Study: FLUENT Europe's Office HVAC Analysis



Temperature Contours on Opaque Walls
(Temperatures in Degrees C)



Temperature Contours on Interior Surfaces
(Temperatures in Degrees C)



Temperature Contours on Interior Surfaces
(Temperatures in Degrees C)

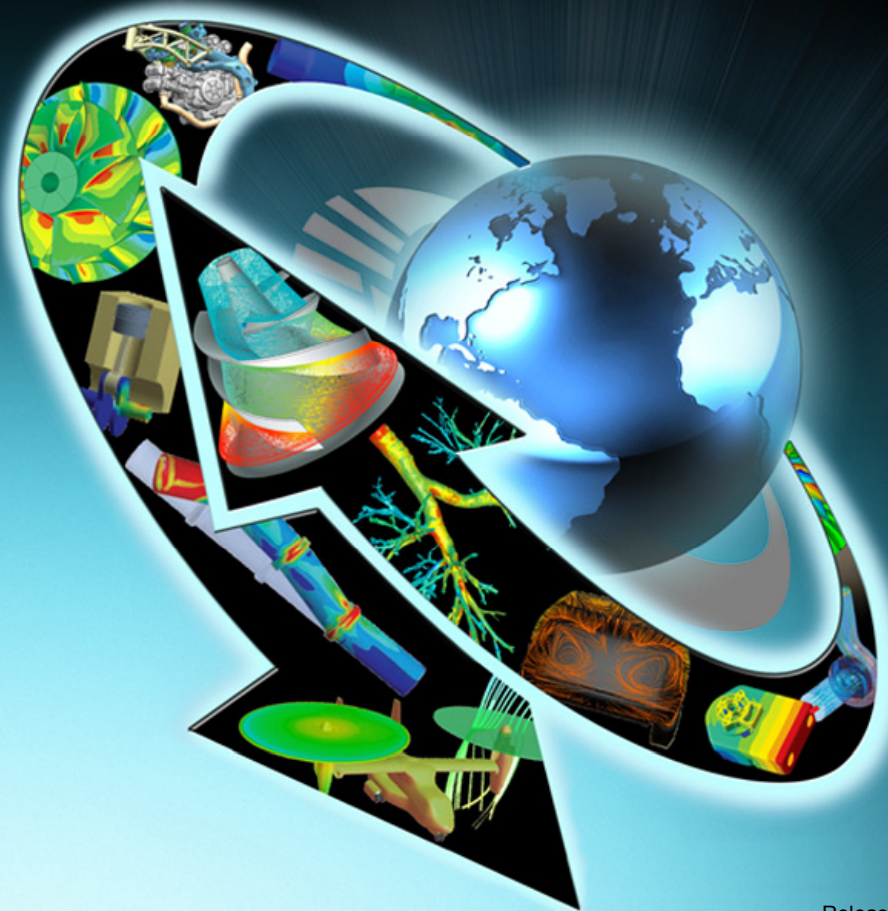


Customer Training Material

References

Lecture 6

Solar Load Model



References

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5. R. Hendes, F. van der Flugt, and C. Hoogendorn (1991), “Natural Convection Flow in a Square Cavity Calculated with Low Reynolds Number Turbulence Models,” Int. J. Heat and Mass Transfer, Vol. 34, pp. 1543-1557.