GS2644 - Beyond 3D in Autodesk® InfraWorks™: Simulate What Happens in Your Real-World Models

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Class summary

This class covers the use of Autodesk InfraWorks software to create a visual representation not only of the world outside the window but also of the dynamic phenomena that evolve in it.
Starting from data related to territory many software applications can simulate the evolution of events: we'd like to bring the results of the analysis into Autodesk InfraWorks.

Key learning objectives

At the end of this class, you will be able to:

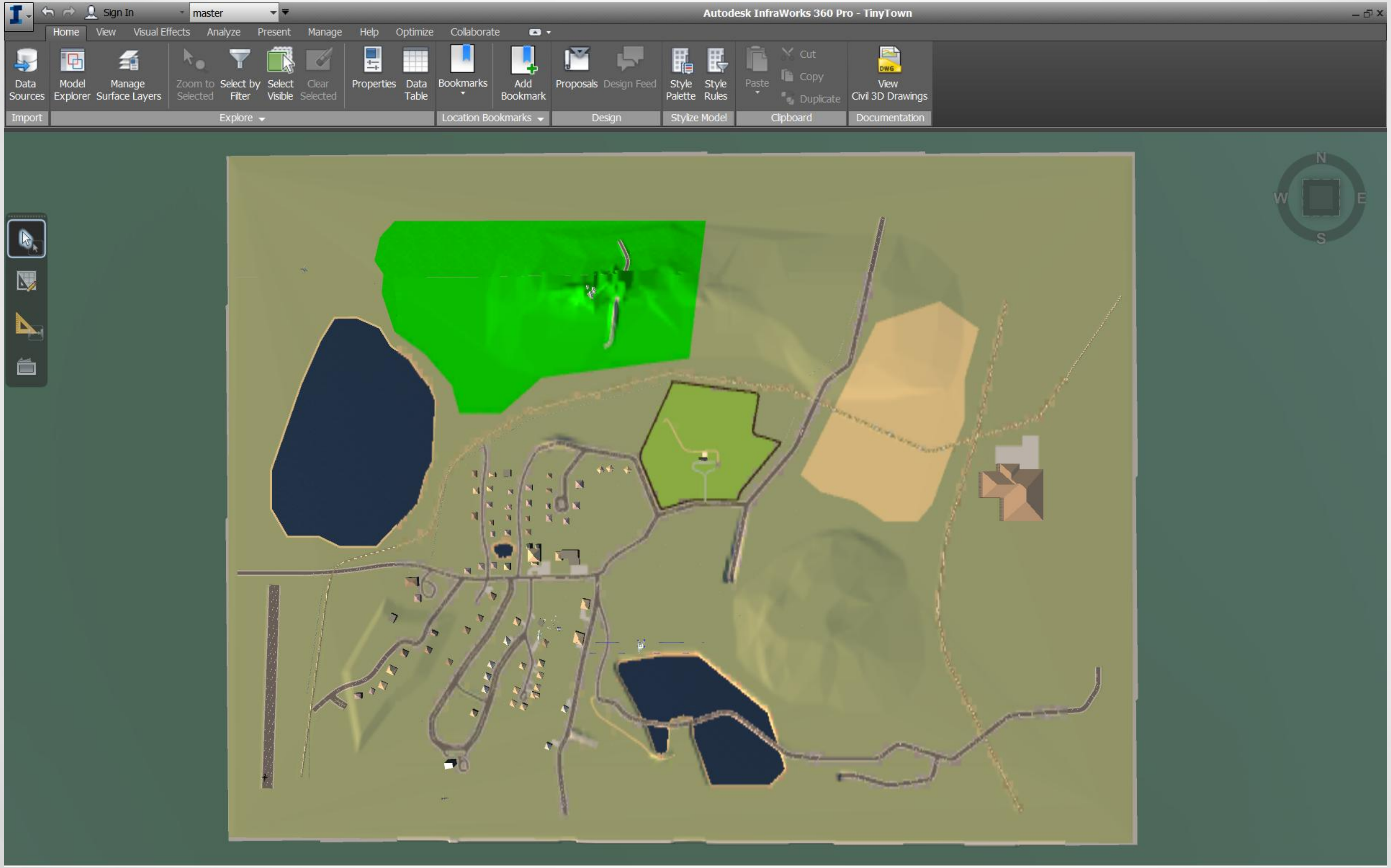
- Use Autodesk InfraWorks to display the results of complex simulations
- Interface with other software applications, such as those in Autodesk® design and creation suites or from government agencies, to simulate the real world
- Prepare data to be processed in an external simulation software
- Import complex data into an Autodesk InfraWorks model

“Boundary conditions” for this “simulation”

- No programming
  - Using just a text editor, AutoCAD Map/C3D/RD, Excel and some little utilities to prepare data
  - Cut & paste plus some scripting to avoid repetitive actions
- No time
  - As variable in formulae → systems at steady state
- No support
  - My colleagues in product(s) support will love me for this session ☺

Where do we start from?

It all started one Winter afternoon...



AIW TinyTown Model

What happens outside of our windows

How do we model these phenomena?

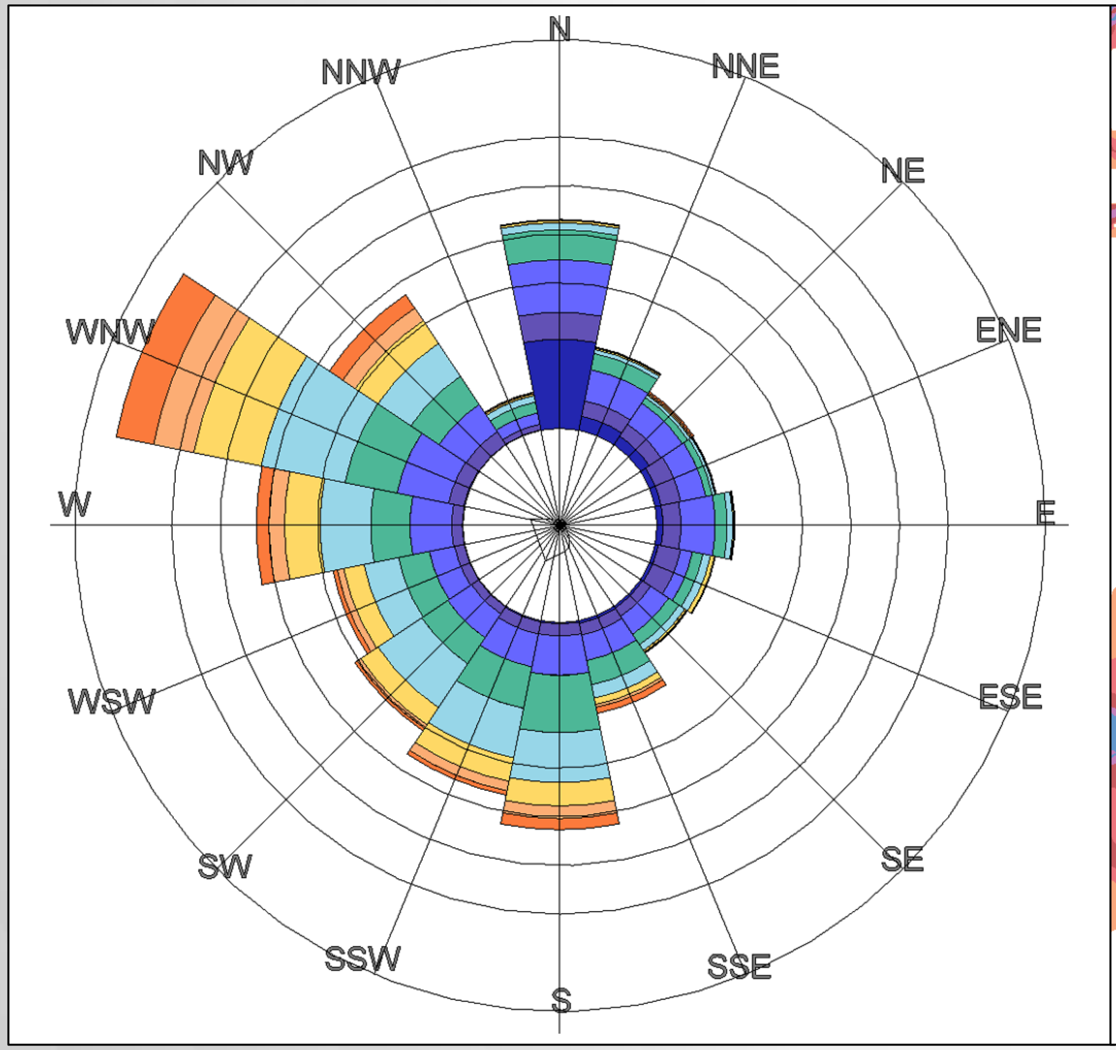
- Data tables

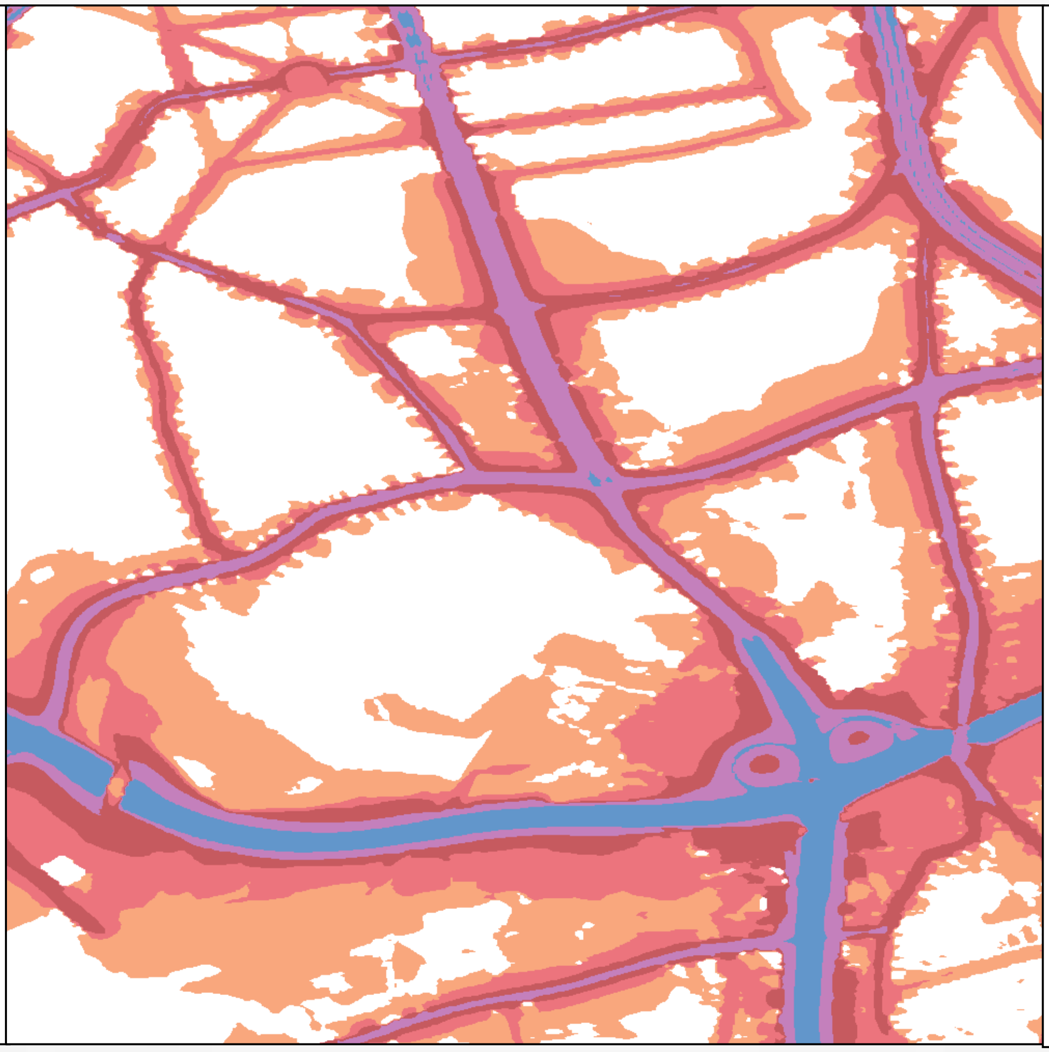
Table 4. Hourly average experimental values on August 29, 2011. VOCs were sampled from 6:45 am to 7:15 am

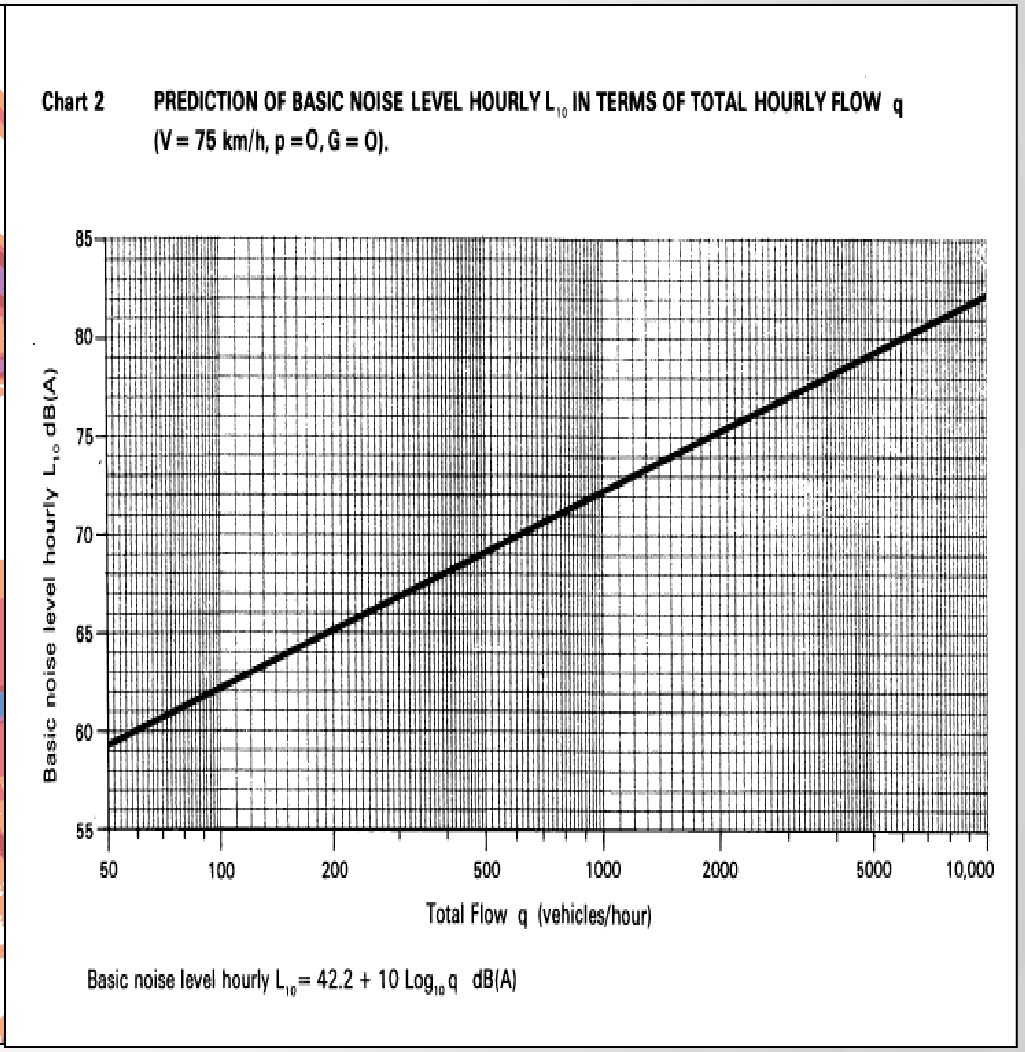
Hour	Emission			Meteorological data	
	CO / (μg m^{-3})	NOx / (μg m^{-3})	O_3 / (μg m^{-3})	Temperature / ℃	RH / %
06:30	0.09	75.08	3.99	21.34	68.06
07:30	0.42	112.76	15.17	27.02	43.05
08:30	0.06	79.10	29.17	29.80	34.34
09:30	0.14	106.78	26.86	31.43	31.78
10:30	0.10	84.71	41.71	32.28	31.28
11:30	0.08	76.15	64.97	33.44	29.15
12:30	0.09	69.88	86.40	34.66	29.11
13:30	0.13	63.45	91.07	33.74	35.09
14:30	0.08	48.83	73.49	31.63	42.34
15:30	0.10	64.8	51.31	31.55	42.45
16:30	0.22	66.62	33.89	30.58	46.87
17:30	0.53	94.13	9.07	26.89	61.04
18:30	0.67	79.11	8.65	25.23	65.30

How do we model these phenomena?

- Diagrams







How do we model these phenomena?

- Mathematics

$$L_{10}\ (\text{hourly}) = 42.2 + 10\log_{10} q \text{ , dBA}$$

$$\Delta_d = -10\log_{10}(d'/13.5)\text{, dBA}$$

$$\Delta_{GC} = 5.2I\log_{10}\frac{6H - 1.5}{d + 3.5}\text{ , dBA}$$

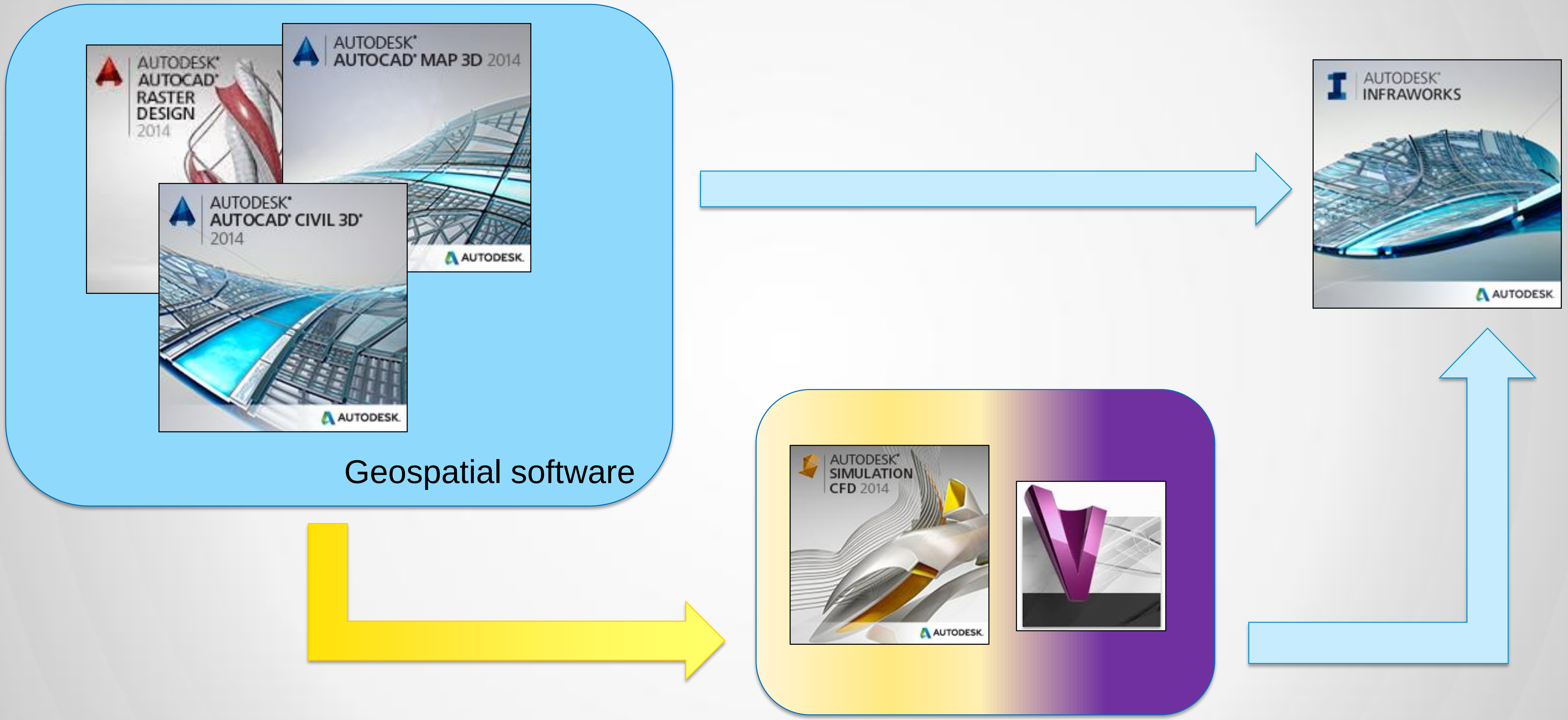
$$H = 0.5(h+1)\ , \quad 0.75 \le H < \frac{d+5}{6}$$

$$C(x,y,z) = \frac{Q}{2\pi u \sigma_y \sigma_z} \times \left[\exp - \left(\frac{y^2}{2\sigma_y^2}\right)\right]\left\{\exp\left(\frac{-(z-H)^2}{2\sigma_z^2}\right) + \exp\left(\frac{-(z+H)^2}{2\sigma_z^2}\right)\right\}$$

C = Concentration of the chemical in air. [M/L^3]
Q = Rate of chemical emission. [M/T]
u = Wind speed in x direction. [L/T]
σ_y = Standard deviation in y direction. [L]
σ_z = Standard deviation in z direction. [L]
y = Distance along a horizontal axis perpendicular to the wind. [L]
z = Distance along a vertical axis. [L]
H = Effective stack height. [L]

Workflows

Basic Workflows



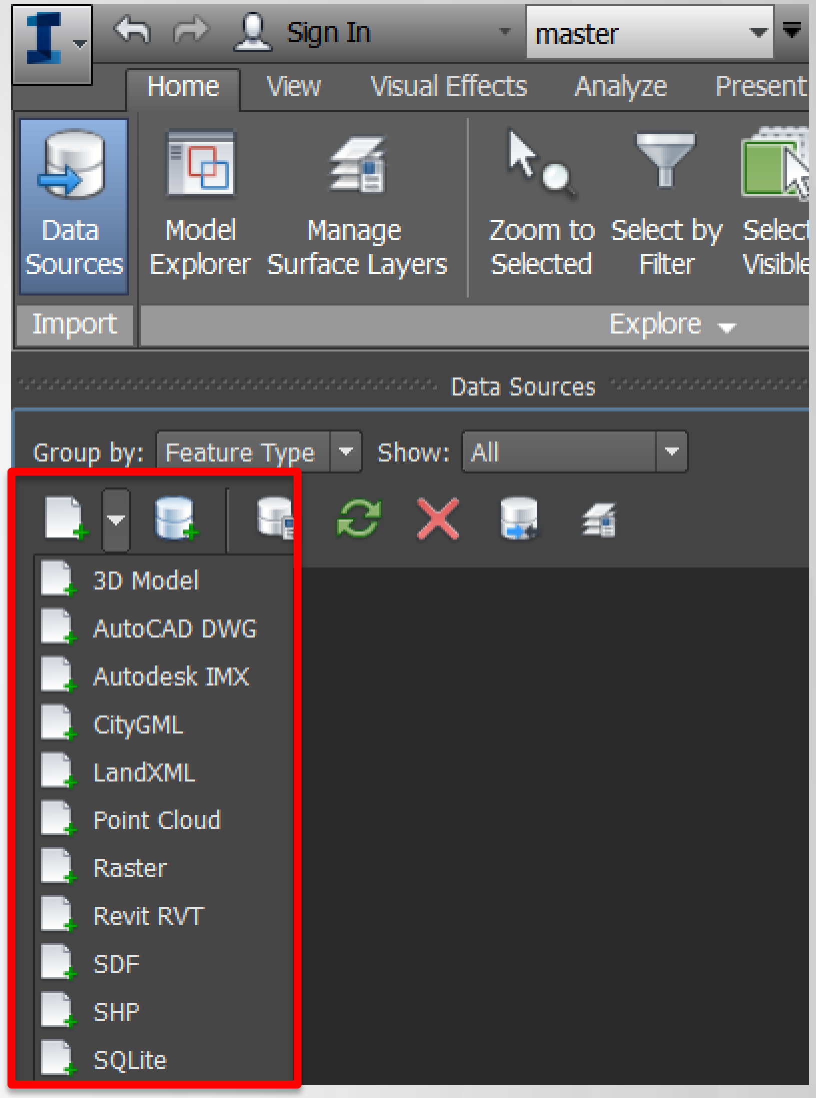
Data preparation **Simulation** **Visualization**

Data Preparation

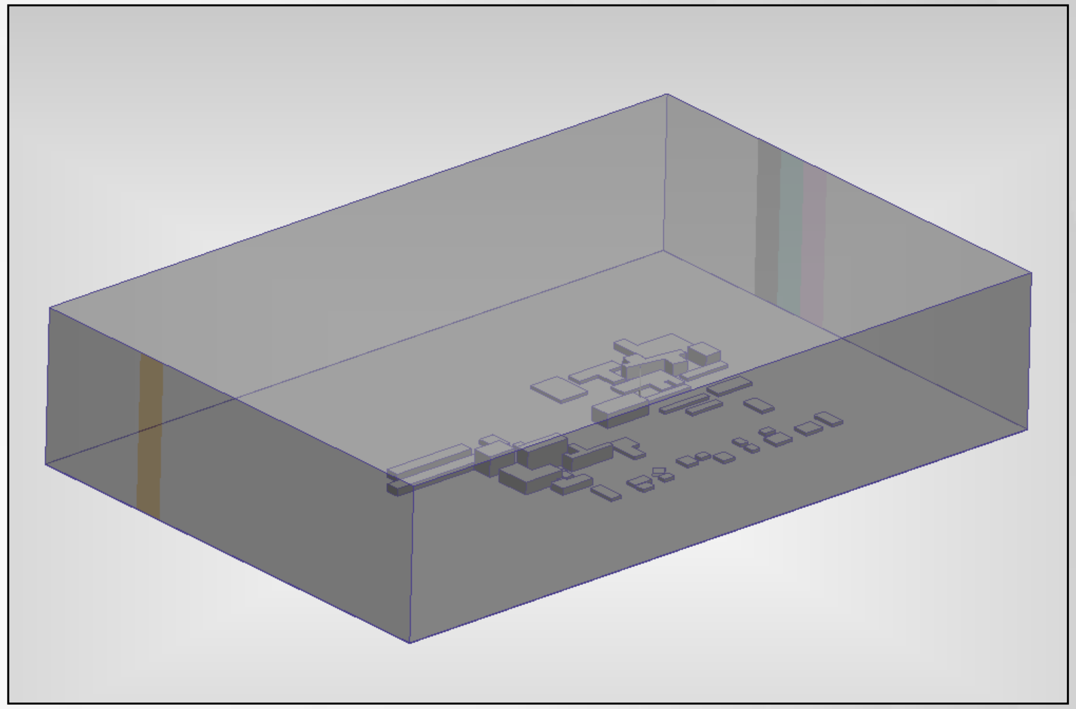
- Preparing something AIW can show or simulation software can work on

- AIW 2D/3D Supported File Formats
  - 2D: all common Geospatial data, vector and raster
  - 3D Models: FBX, 3DS, OBJ, DAE, and DWG/DXF files + direct link with Revit & Civil 3D

- Georeferencing vs De-Georeferencing
  - 2D data has to be georeferenced
  - 3D models are better managed at 0,0,0



Simulation software

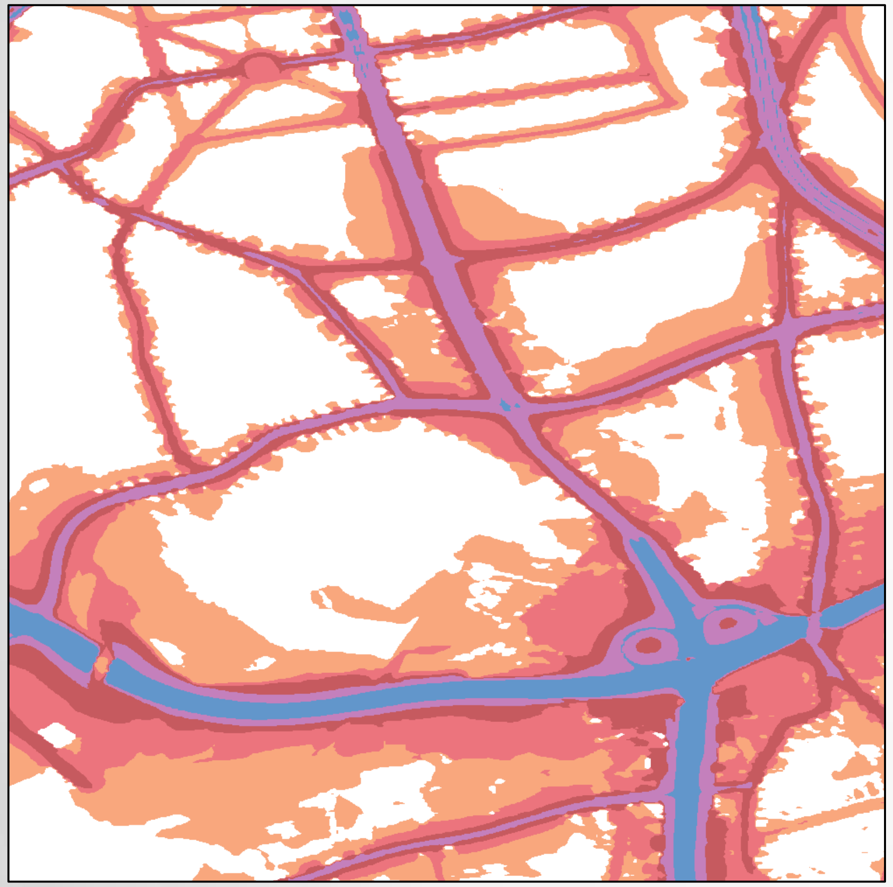


- We need to model the phenomenon
  - Boundary conditions
    - temperature, wind speed/direction, ...
  - Geometric description of the context
    - terrain, objects, ...
  - Mathematical description of the phenomena
    - Equations not depending from time → steady state
- We need to pass this data to simulation software

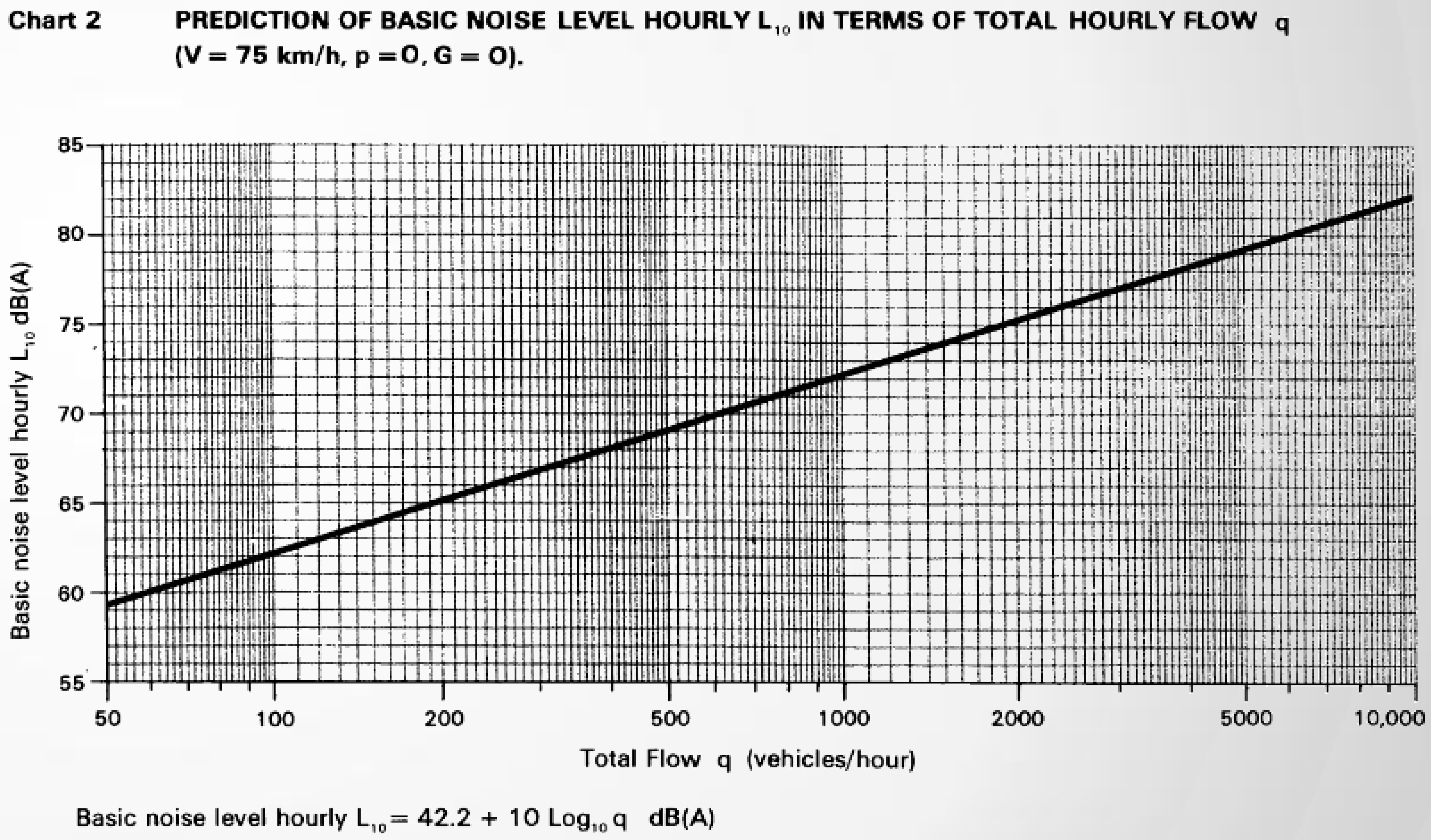
Case study 1: Noise Pollution

Noise pollution: how do we model it?

- Heat Maps



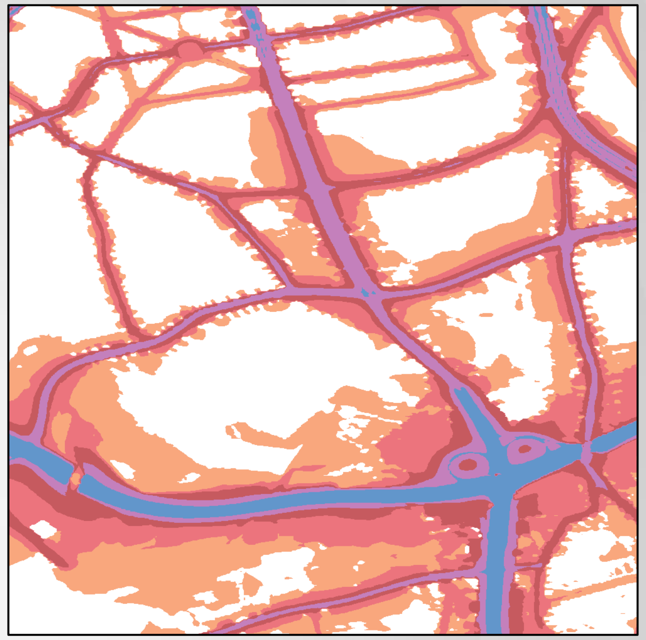
- Equations



Source: http://www.umgebungslaerm-kartierung.nrw.de/

Source: Standard UK method for the calculation of road traffic noise (CRTN)

Using Heat maps

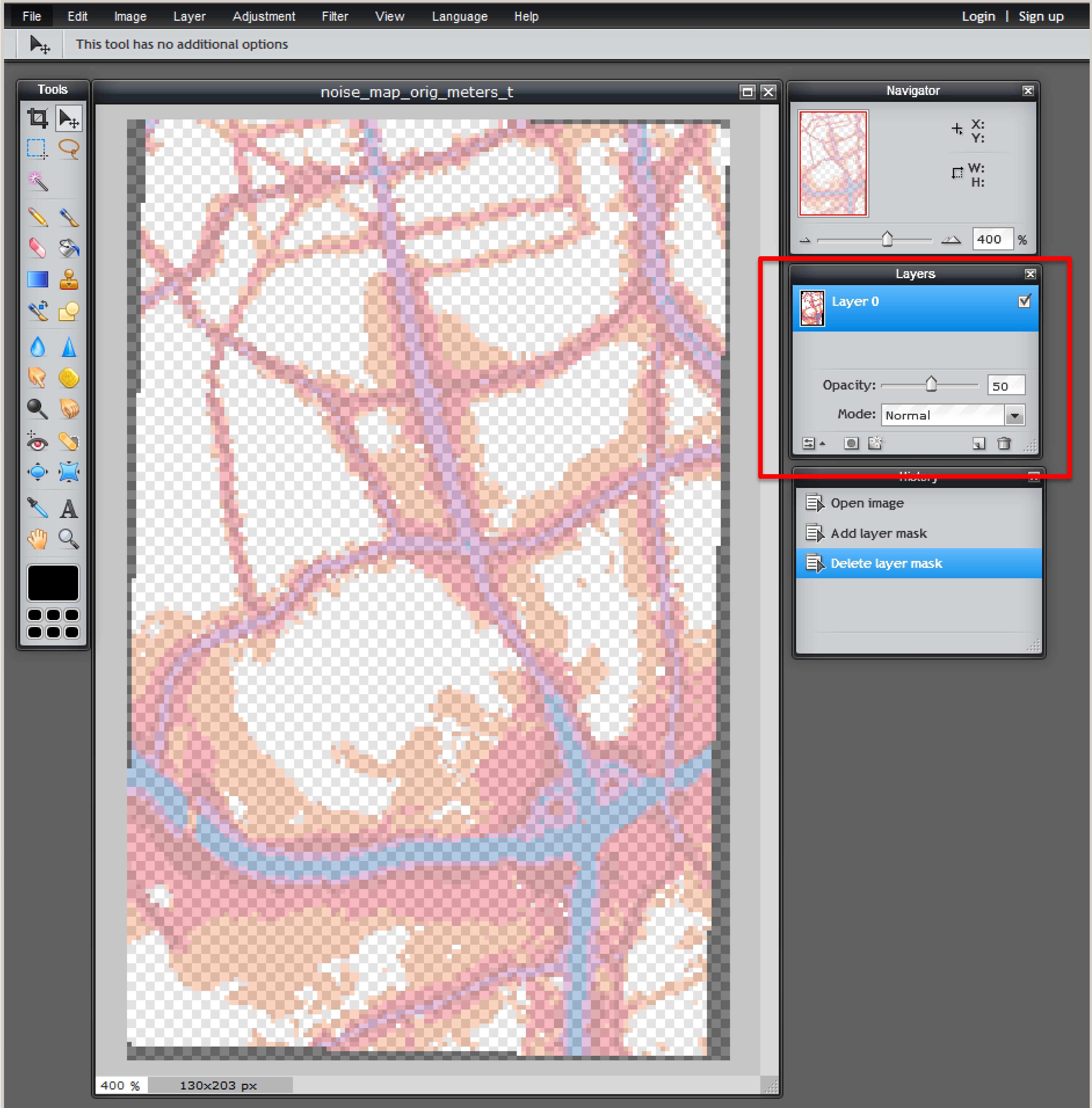


- If the image is not georeferenced
  use Raster Design to make it so
  → "World file" (i.e. .TFW, .JGW, .PGW, ...)

- If you plan to use the image as a source
  for 3D models it has to be in a projected CS
  → coordinates in meters (or what you like)
  - Use Raster Design to change CS, crop and resample

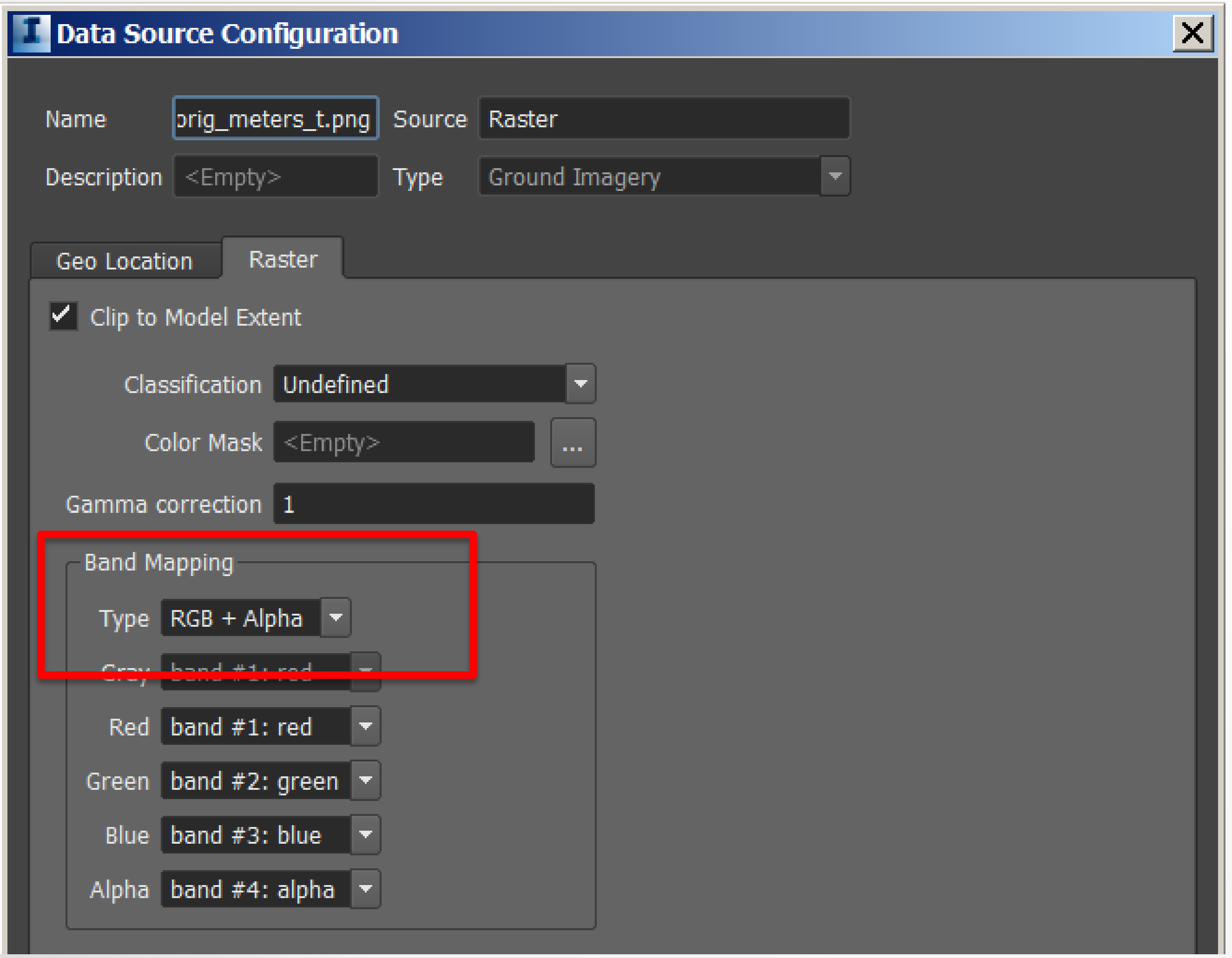
Using Heat maps

- Add “Alpha channel” → Image opacity
  - Use Pixlr Editor http://pixlr.com/editor/



Using Heat Maps

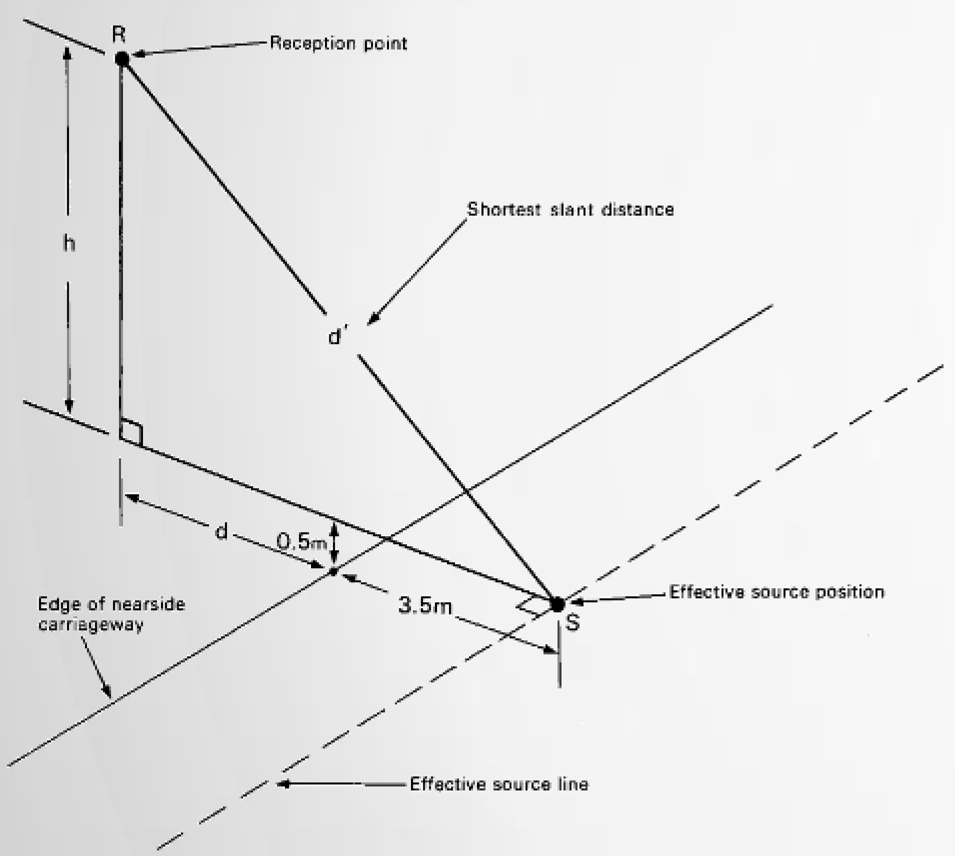
- Configure AIW to use the opacity information we configured



AIW Model Road Noise - Grid - v01

Using Formulae to design isosurfaces

Figure 1. ILLUSTRATION OF SHORTEST SLANT DISTANCE d′ FOR A RECEPTION POINT R AT A HORIZONTAL DISTANCE (d+3.5) AND A RELATIVE HEIGHT h FROM THE EFFECTIVE SOURCE POSITION S



Constant reference level at 10 meters

$$L_{10}\ (\text{hourly}) = 42.2 + 10\log_{10} q\ ,\ \text{dBA}$$

Distance correction

$$\Delta_d = -10\log_{10}(d'/13.5),\ \text{dBA}$$

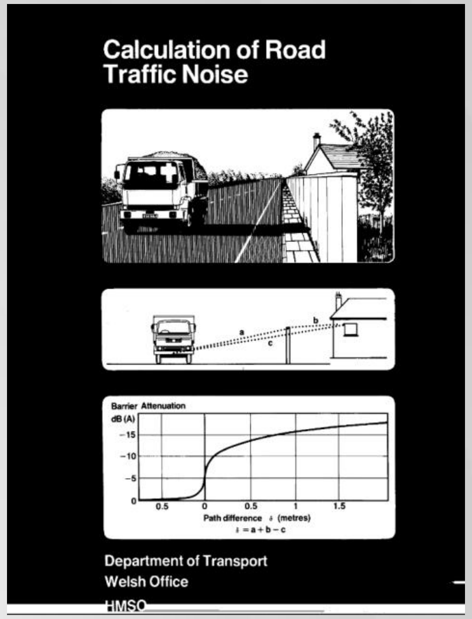
Isosurface is half a cylinder...

Ground cover correction

$$\Delta_{GC} = 5.2 I \log_{10} \frac{6H - 1.5}{d + 3.5}\ ,\ \text{dBA}$$

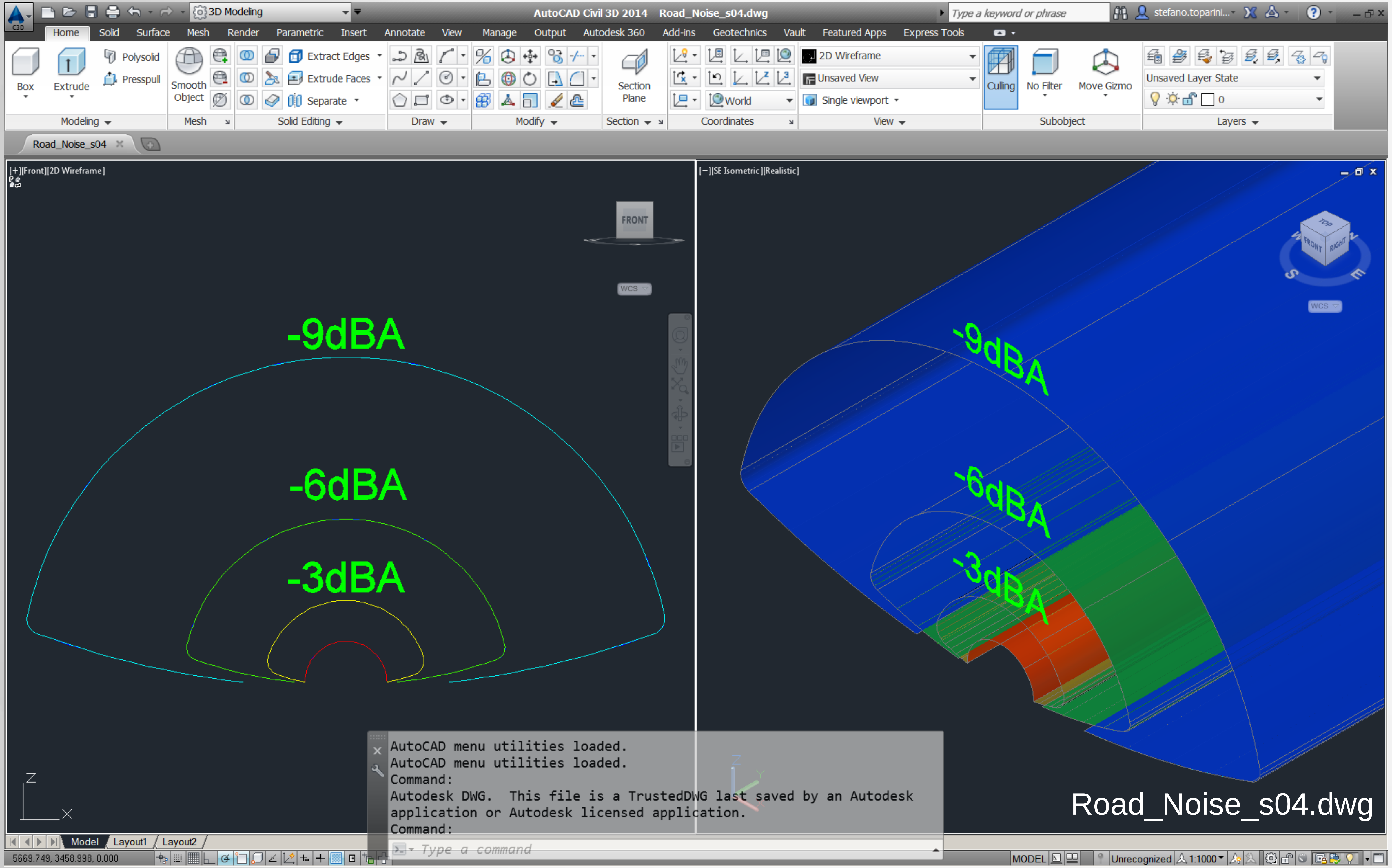
$$H = 0.5(h+1)\ ,\quad 0.75 \le H < \frac{d+5}{6}$$

...that near the ground goes closer to the road



NB: there are a gazillion more parameter to take care for a full model

Using Formulae to design isosurfaces



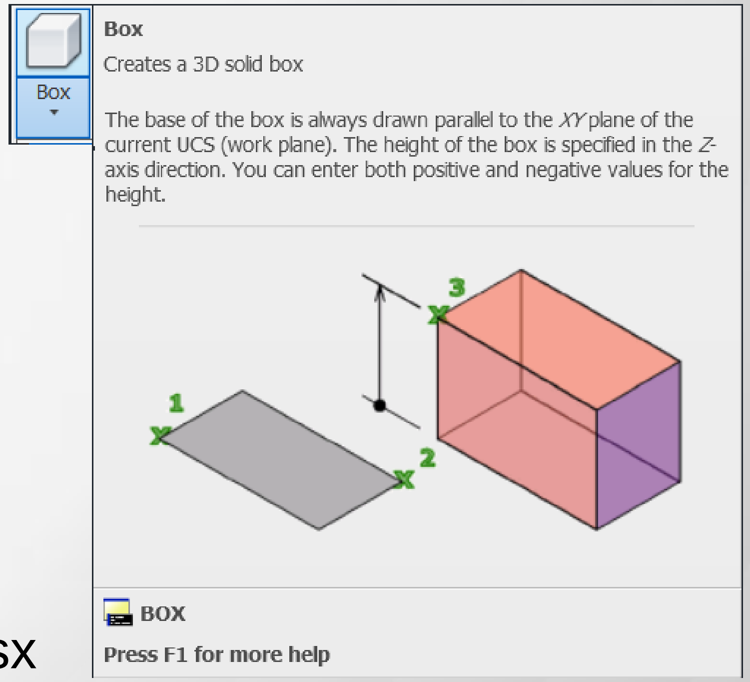
- Draw the reference curve at 10m
- Draw other curves at -3dB(A)
  Half the power
- **EXTRUDE**
- **TICKEN**
- Apply materials
- **FBXEXPORT**

Heat maps → 3D "Lego" maps

- Transform your image in a text file
  - Using ImageJ http://rsb.info.nih.gov/ij/index.html
  - Look at the hystogram for color distribution
  - Change the the image depth to 8bit in color
  - Output: matrix of pixel values + color table as text file
- Use a Text Editor & Excel to prepare a script
  - We'll produce a script to instruct AutoCAD to create a 3D "Lego" model of our noise data

Heat maps → 3D "Lego" maps

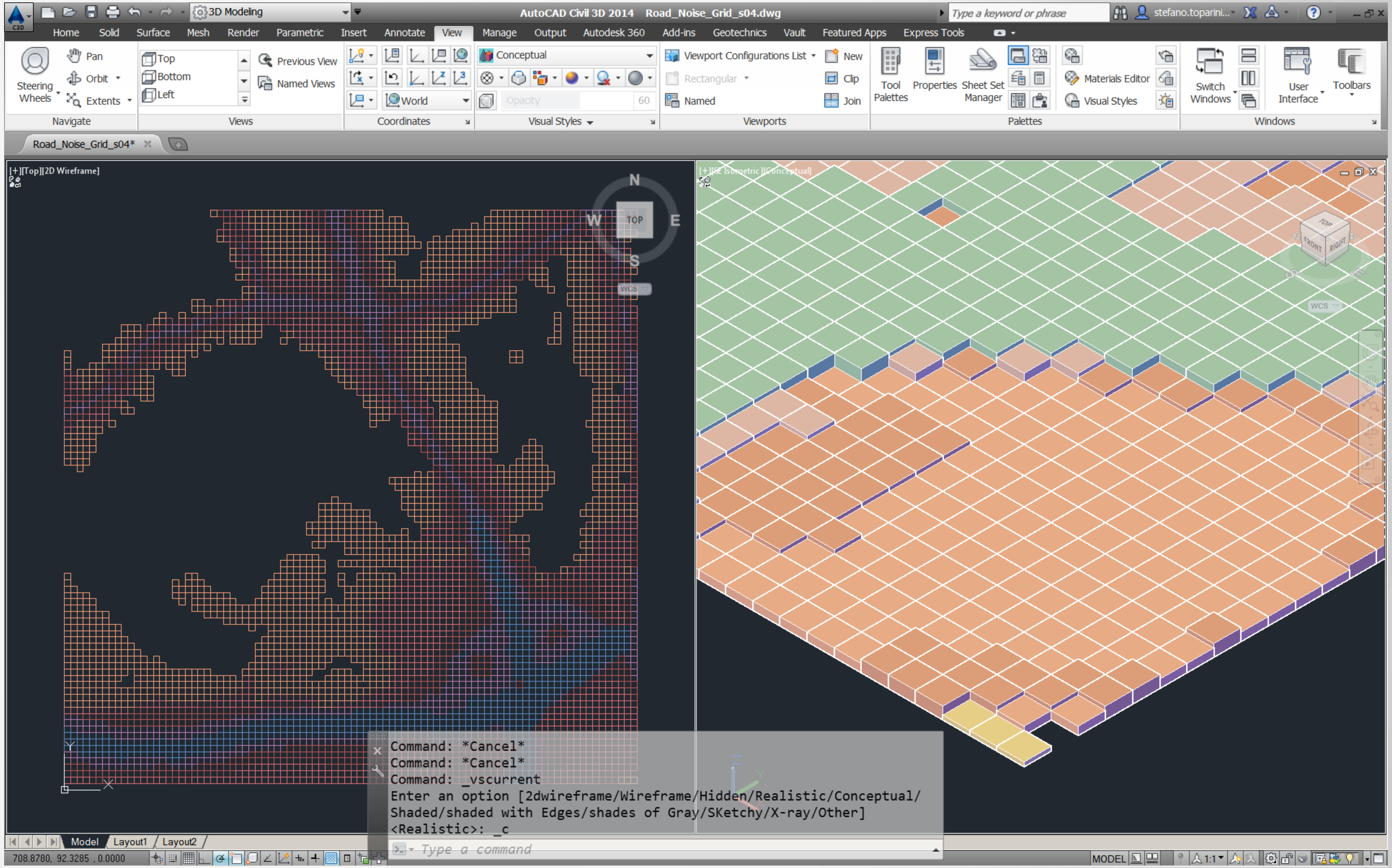
- Standard Images: "coordinates" in pixels from top left
- Georeferenced images: coordinates from bottom left
- Build a matrix of points
  - Better at 0,0,0 using CS units (i.e. meters, feets)
- Use color information to differentiate
- Build a parallelepipeds: **BOX**



noise_map_step2.xlsx

Heat maps → 3D “Lego” maps

- SCRIPT
- FBXEXPORT

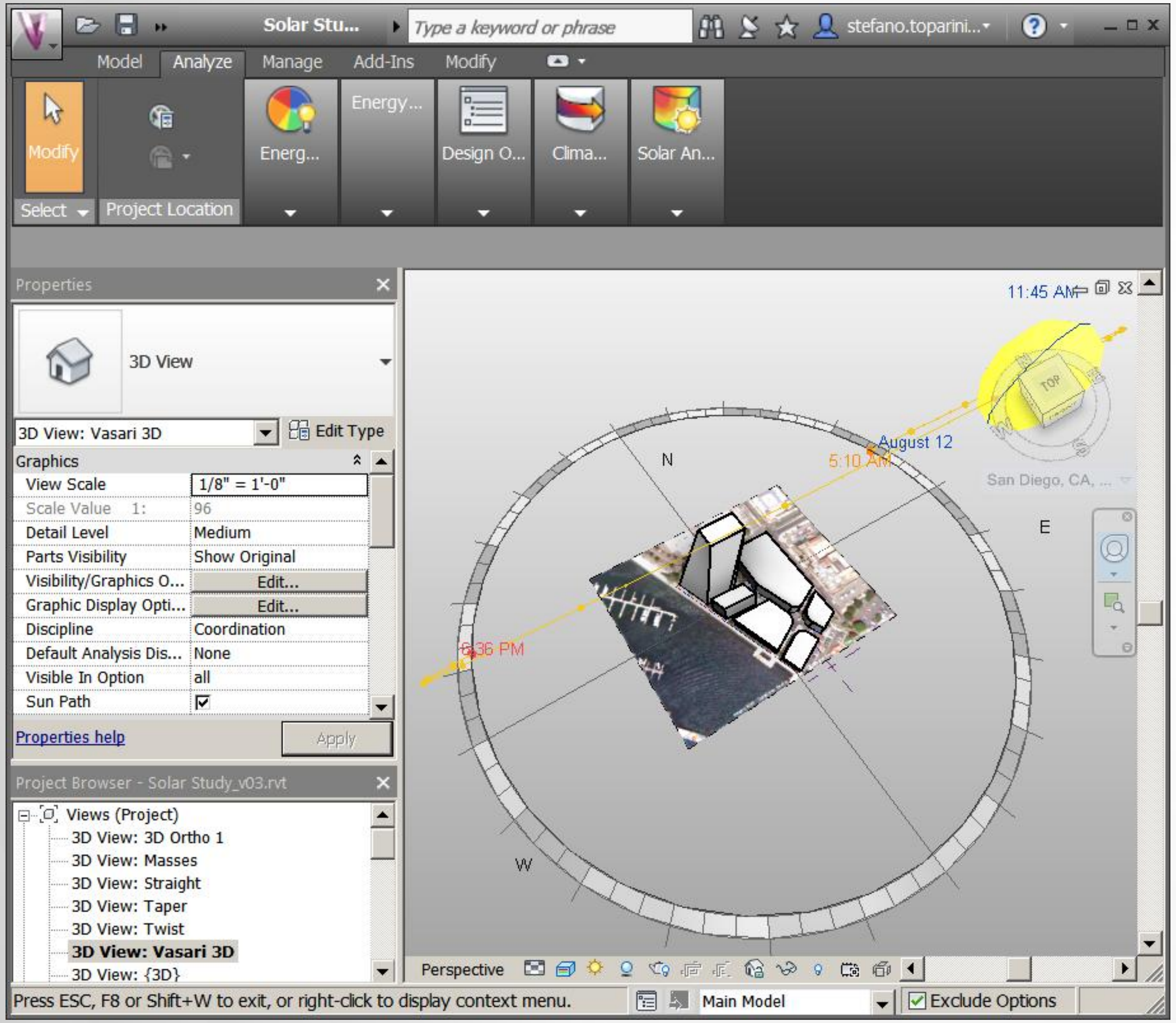


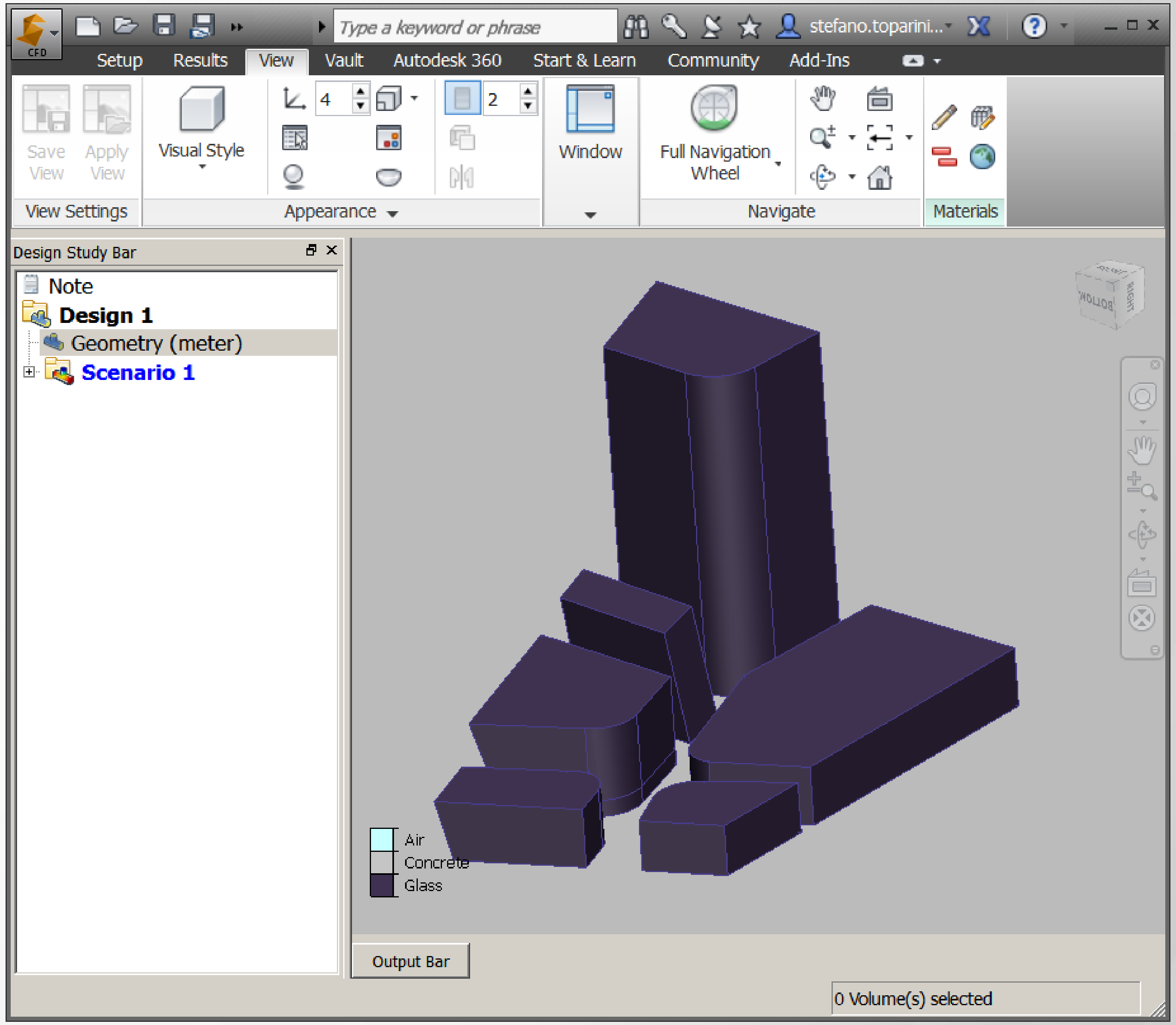
Road_Noise_Grid_s04.dwg

Case study 2: Insolation Analysis

Solar Analysis: How do we model it?

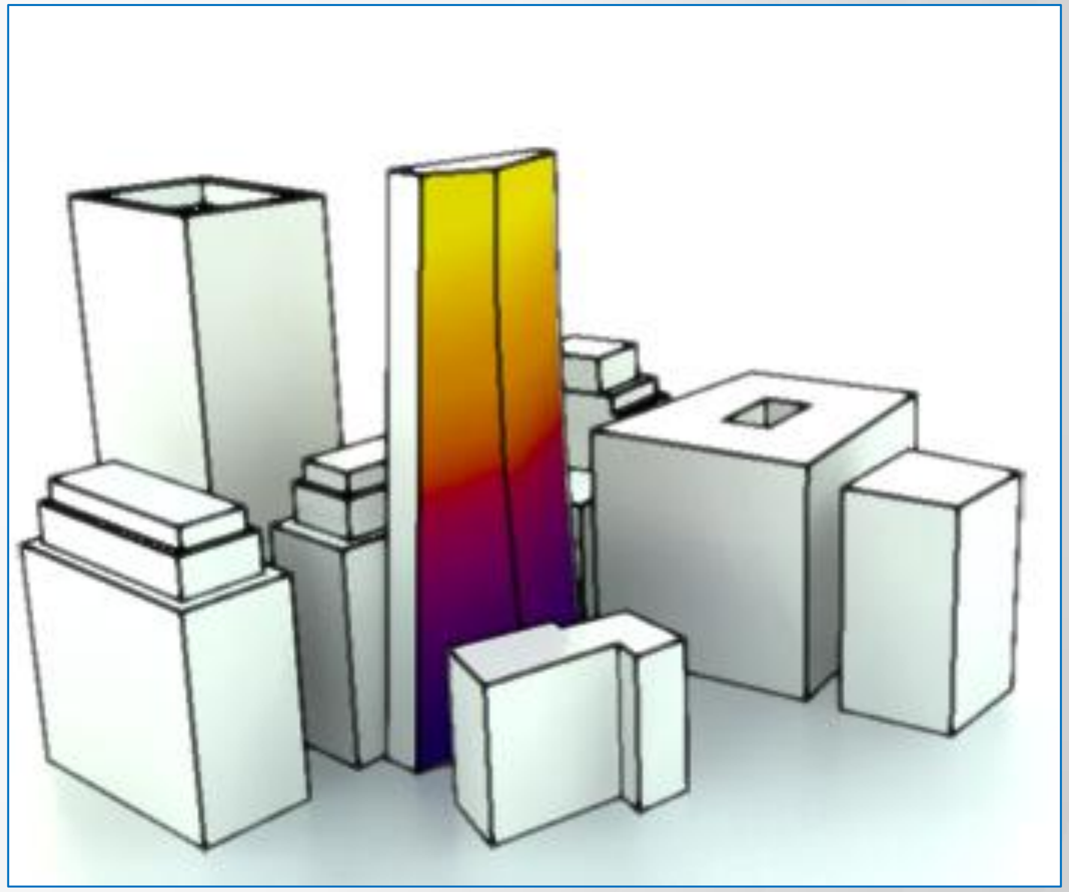
- 3D Model of Buildings + environment conditions





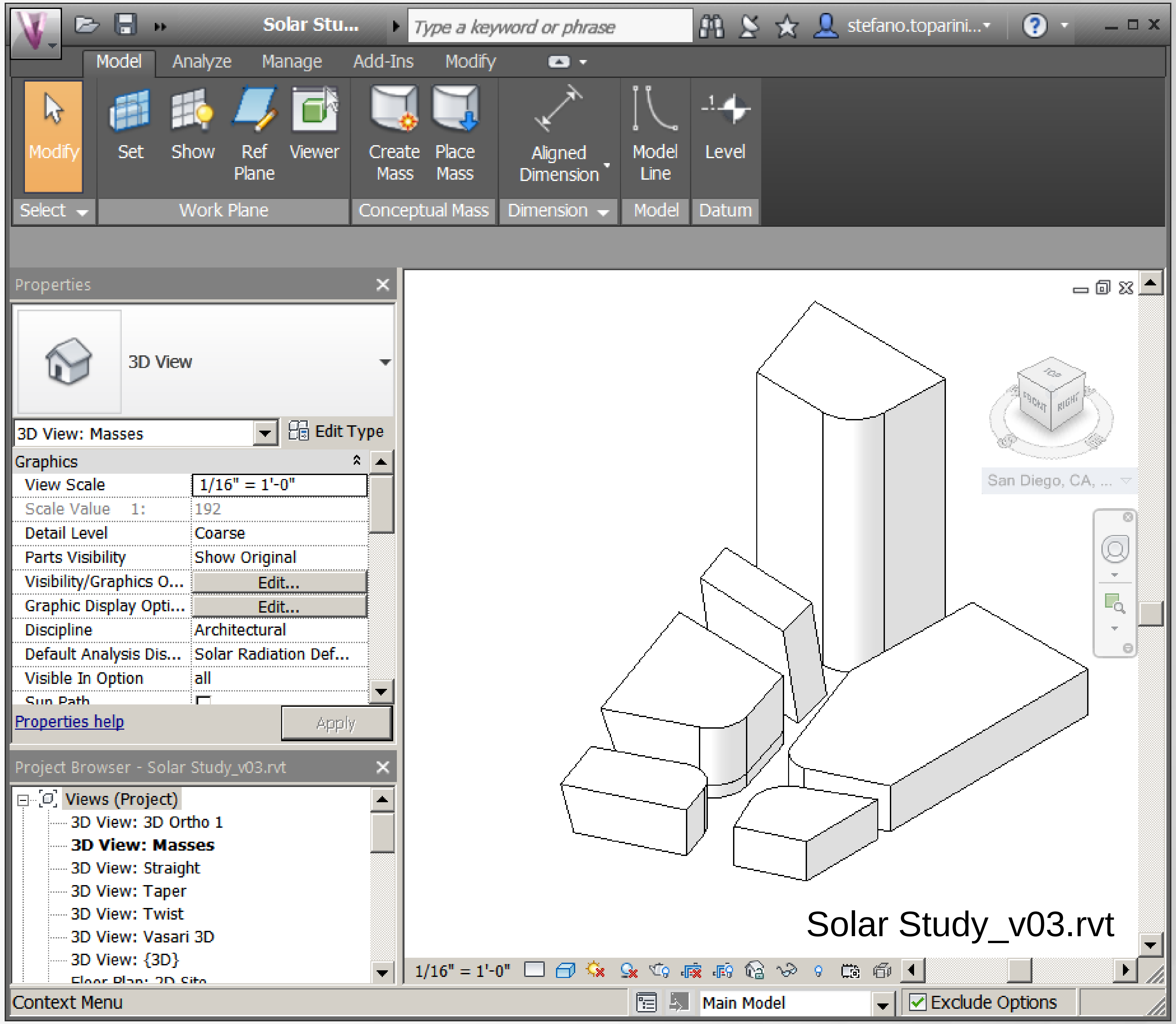
Simulating in Autodesk® Vasari

- Download at http://www.autodeskvasari.com
- Autodesk® Vasari is an easy-to-use design tool for creating building concepts
- Integrated analysis for energy and carbon emission
- Same interface & file format than Revit



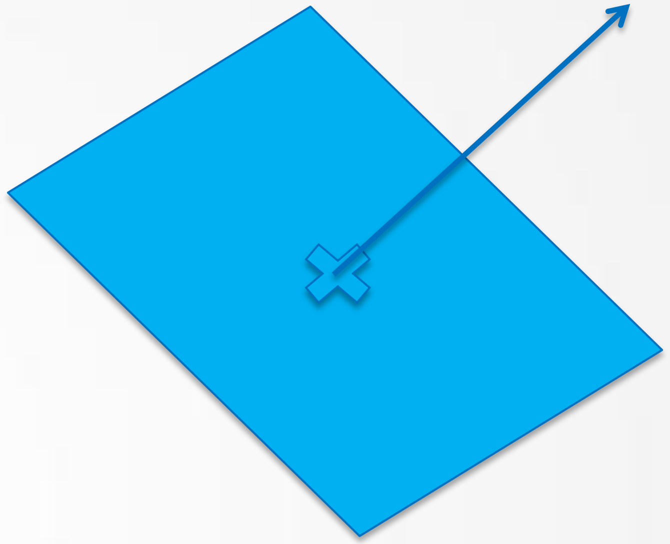
Simulating in Autodesk® Vasari

- Create building(s) model
- Select geographic location
- Launch analysis



Simulating in Autodesk® Vasari

- Exports images and tabular data
- We will use tabular data to create 3D objs
- **3DFACE**

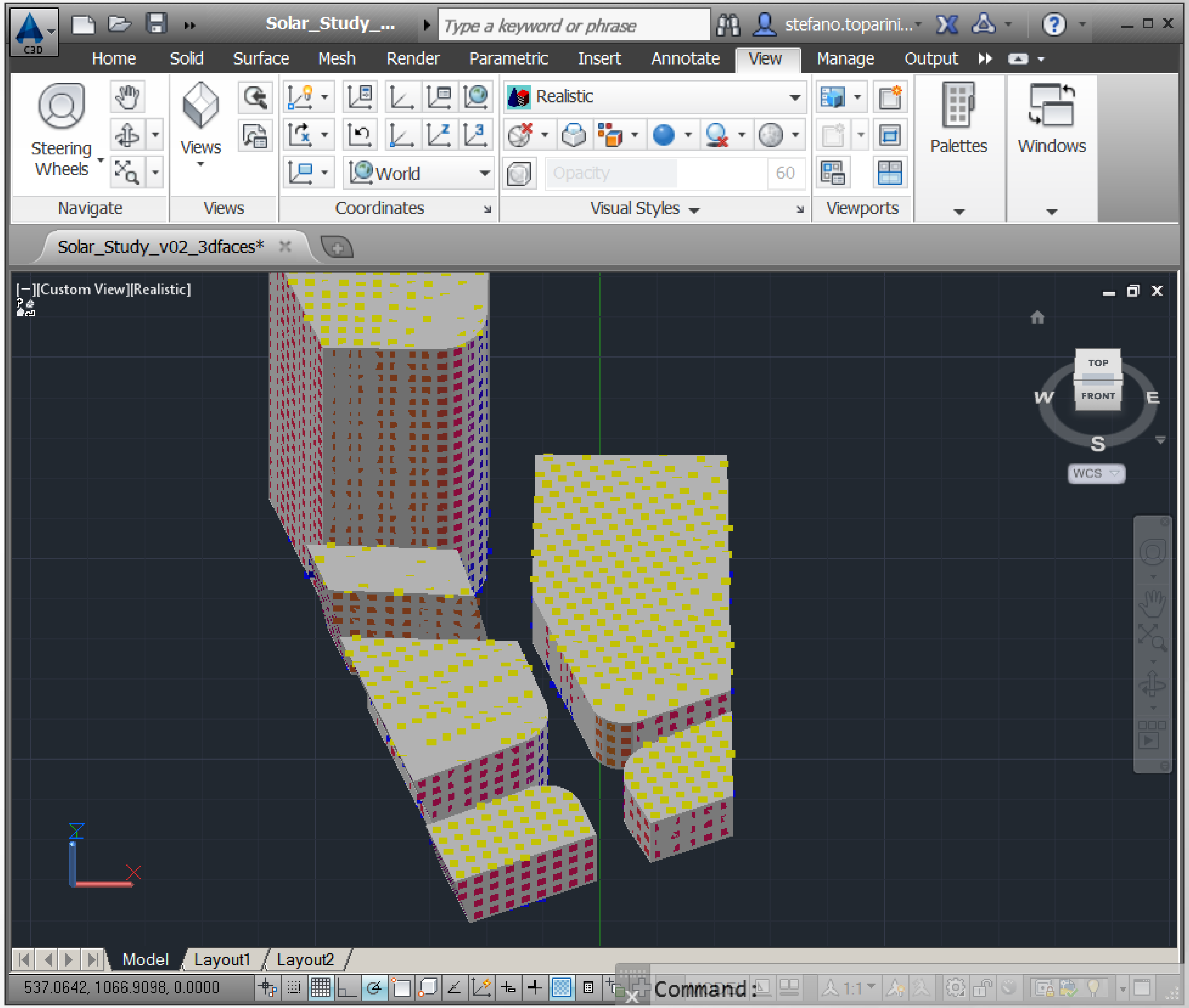


```
-LAYER S 8  UCS ZA
143.902,357.05,9.043
144.902,357.062,9.043
3DFACE -5,-5,0 @10,0,0
@0,10,0 @-10,0,0  UCS W
```

Solar_Study_v02.xlsx

Simulating in Autodesk® Vasari

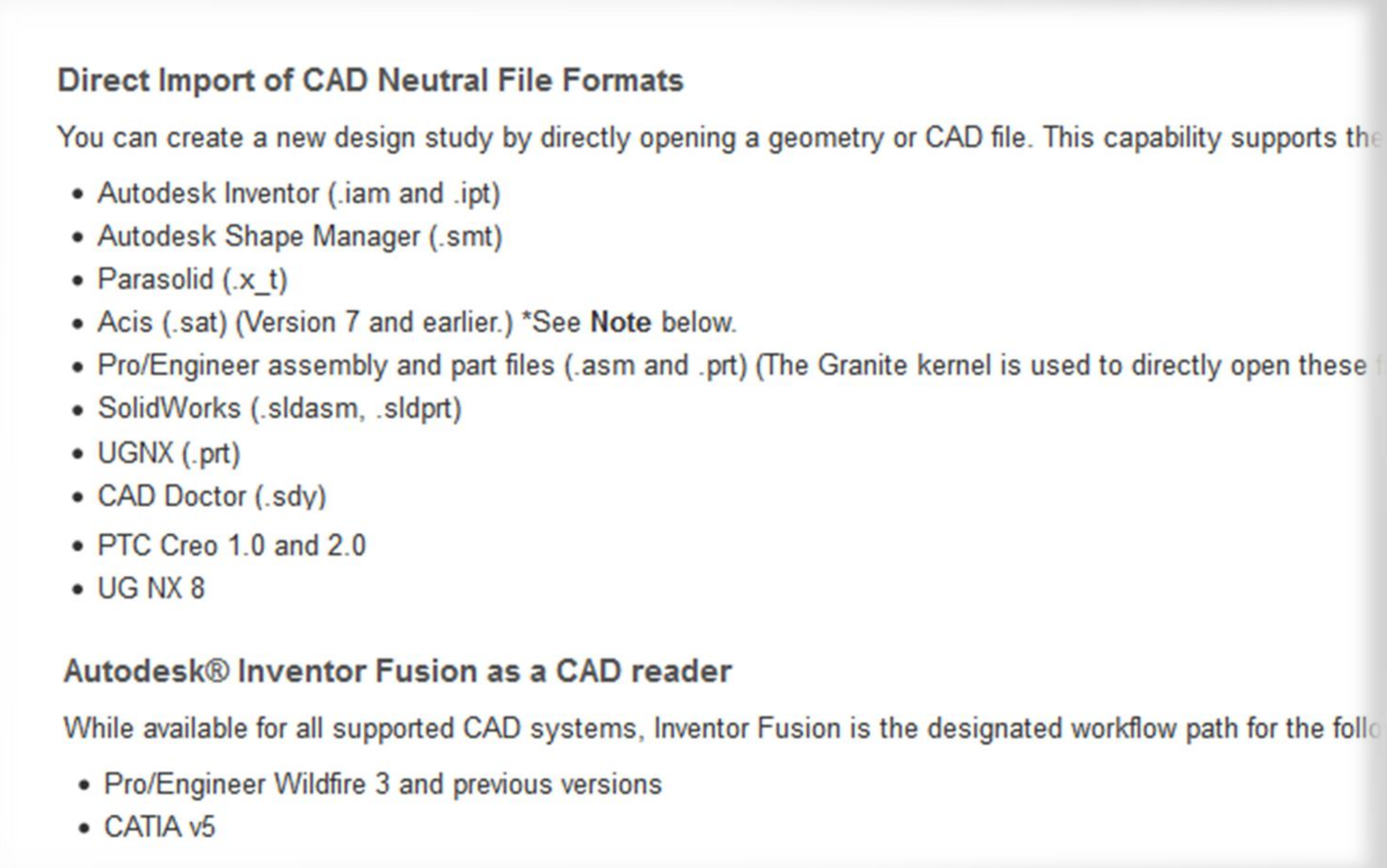
- 3D Faces with color based on the quantity of solar radiation received
- Data exported as FBX



Solar_Study_v03_3dfaces.dwg

Simulating in Autodesk® SIM CFD & SIM 360 CFD

- Supported File Formats
  - Input
    - Directly from many Autodesk products (i.e. Revit)
    - Mostly manifacturing formats
    - ACIS files .sat



Direct Import of CAD Neutral File Formats

You can create a new design study by directly opening a geometry or CAD file. This capability supports the

- Autodesk Inventor (.iam and .ipt)
- Autodesk Shape Manager (.smt)
- Parasolid (.x_t)
- Acis (.sat) (Version 7 and earlier.) *See **Note** below.
- Pro/Engineer assembly and part files (.asm and .prt) (The Granite kernel is used to directly open these
- SolidWorks (.sldasm, .sldprt)
- UGNX (.prt)
- CAD Doctor (.sdy)
- PTC Creo 1.0 and 2.0
- UG NX 8

Autodesk® Inventor Fusion as a CAD reader

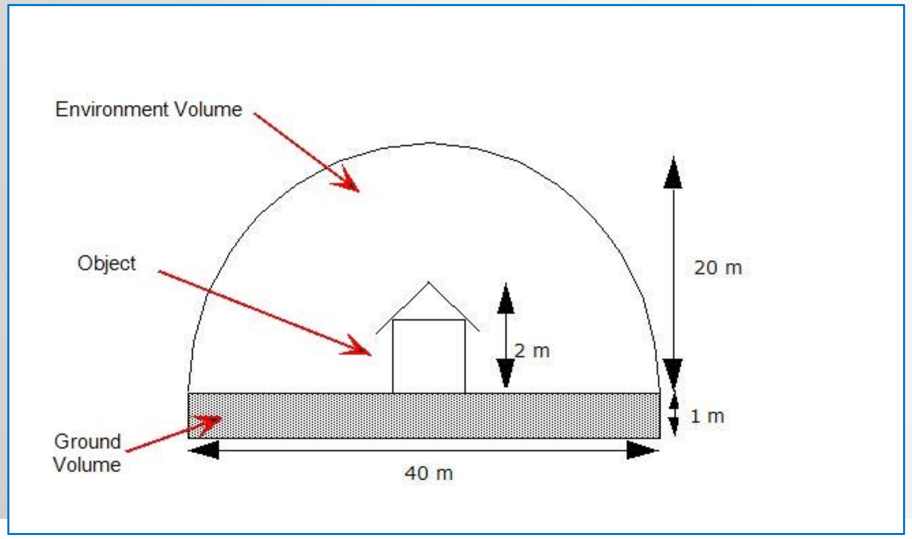
While available for all supported CAD systems, Inventor Fusion is the designated workflow path for the follo

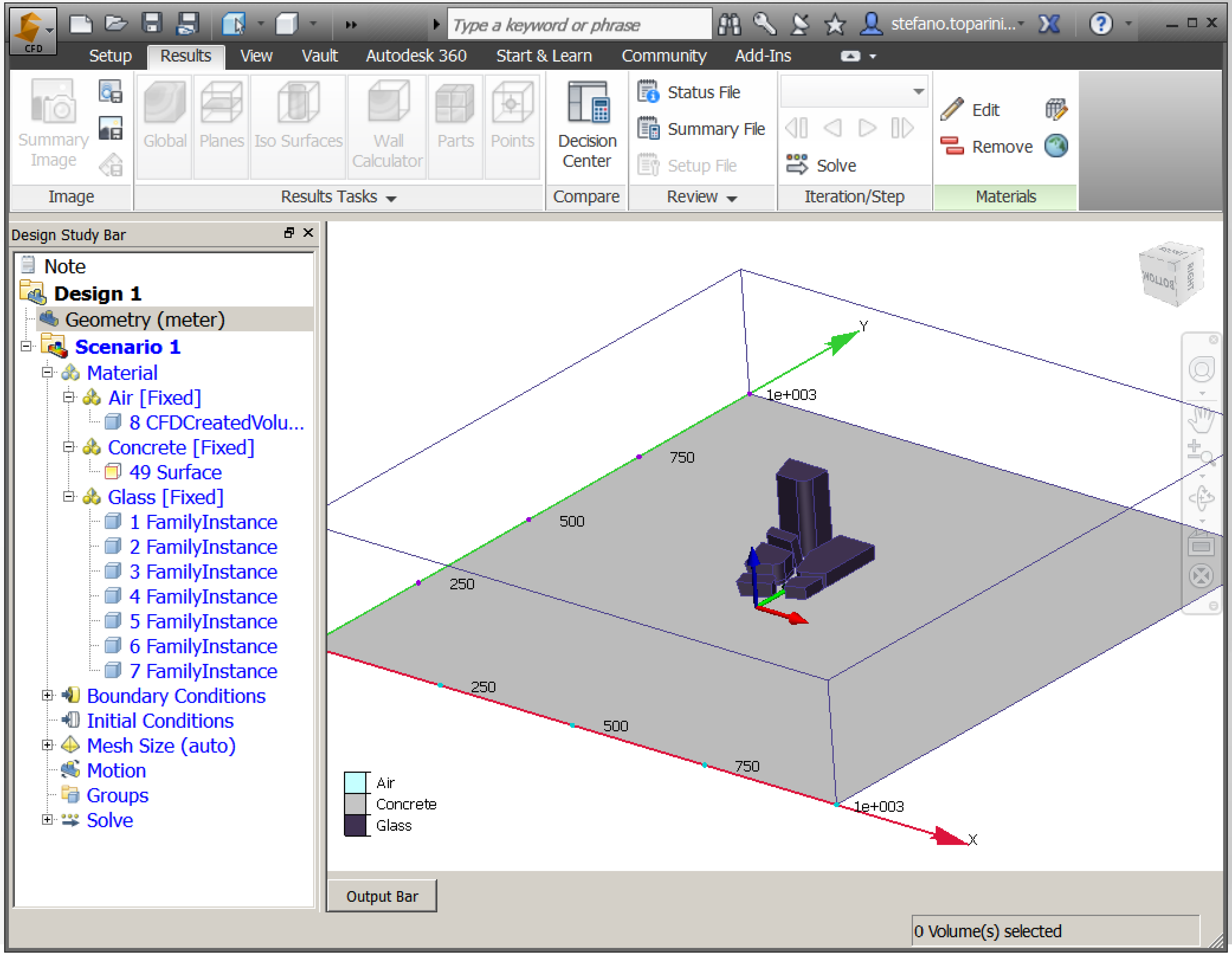
- Pro/Engineer Wildfire 3 and previous versions
- CATIA v5

  - Output
    - ACIS files .sat
    - FBX via **SimCFD Showcase Exporter** in Autodesk Exchange

Simulating in Autodesk® SIM CFD & SIM 360 CFD

- Load model
- Create a bounding box
- Assign materials to building, soil and container

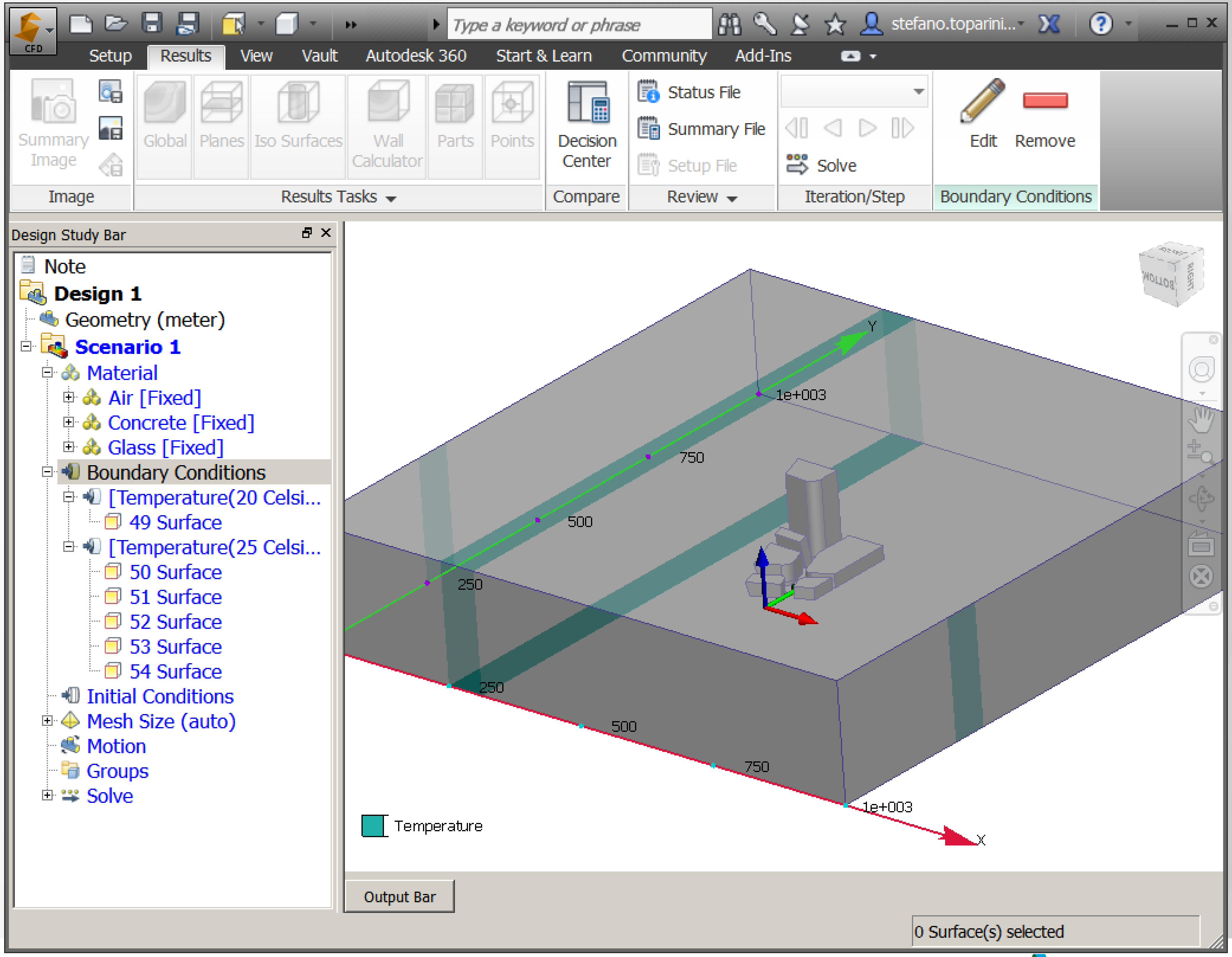




Solar Study_v02_support_support

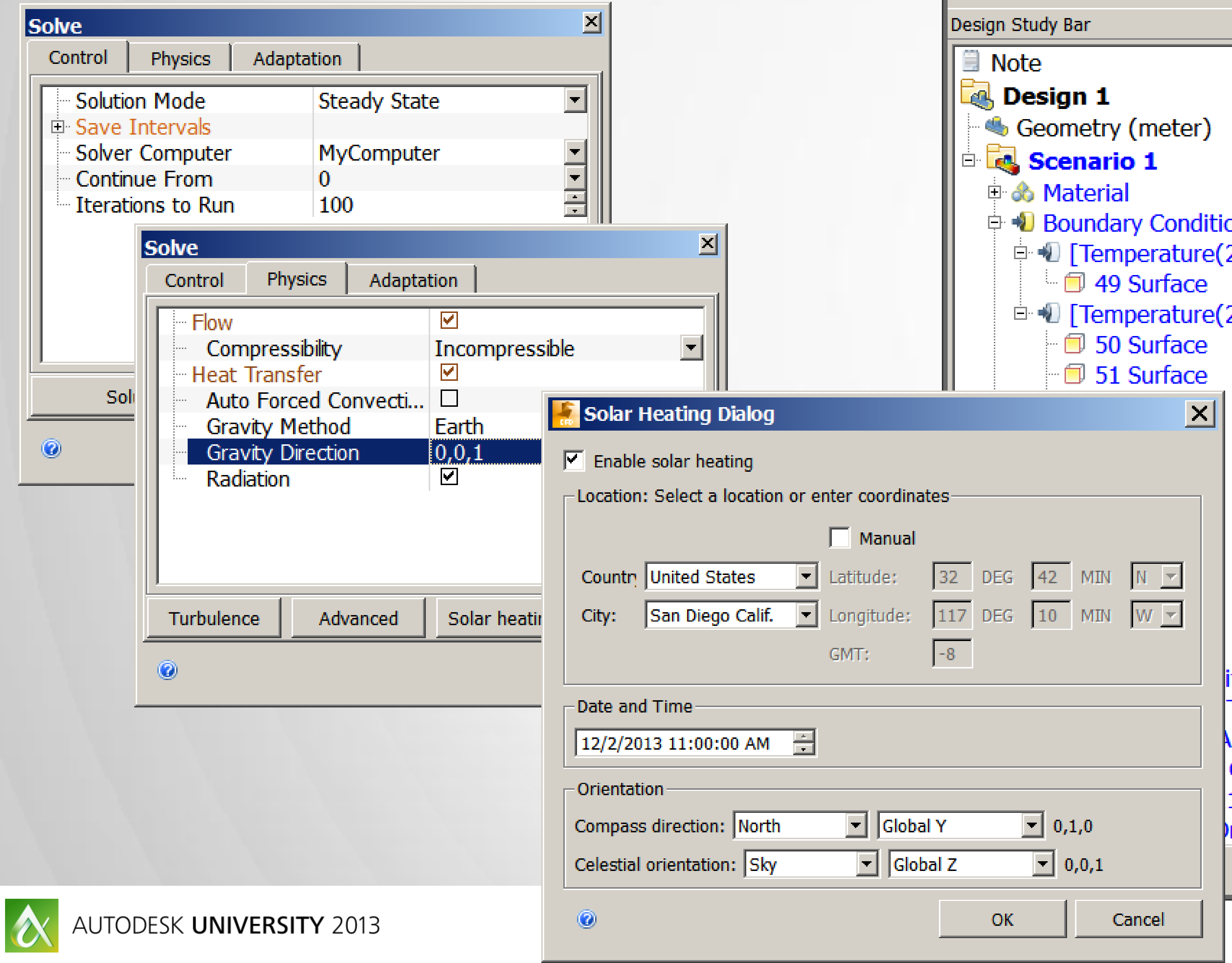
Simulating in Autodesk® SIM CFD & SIM 360 CFD

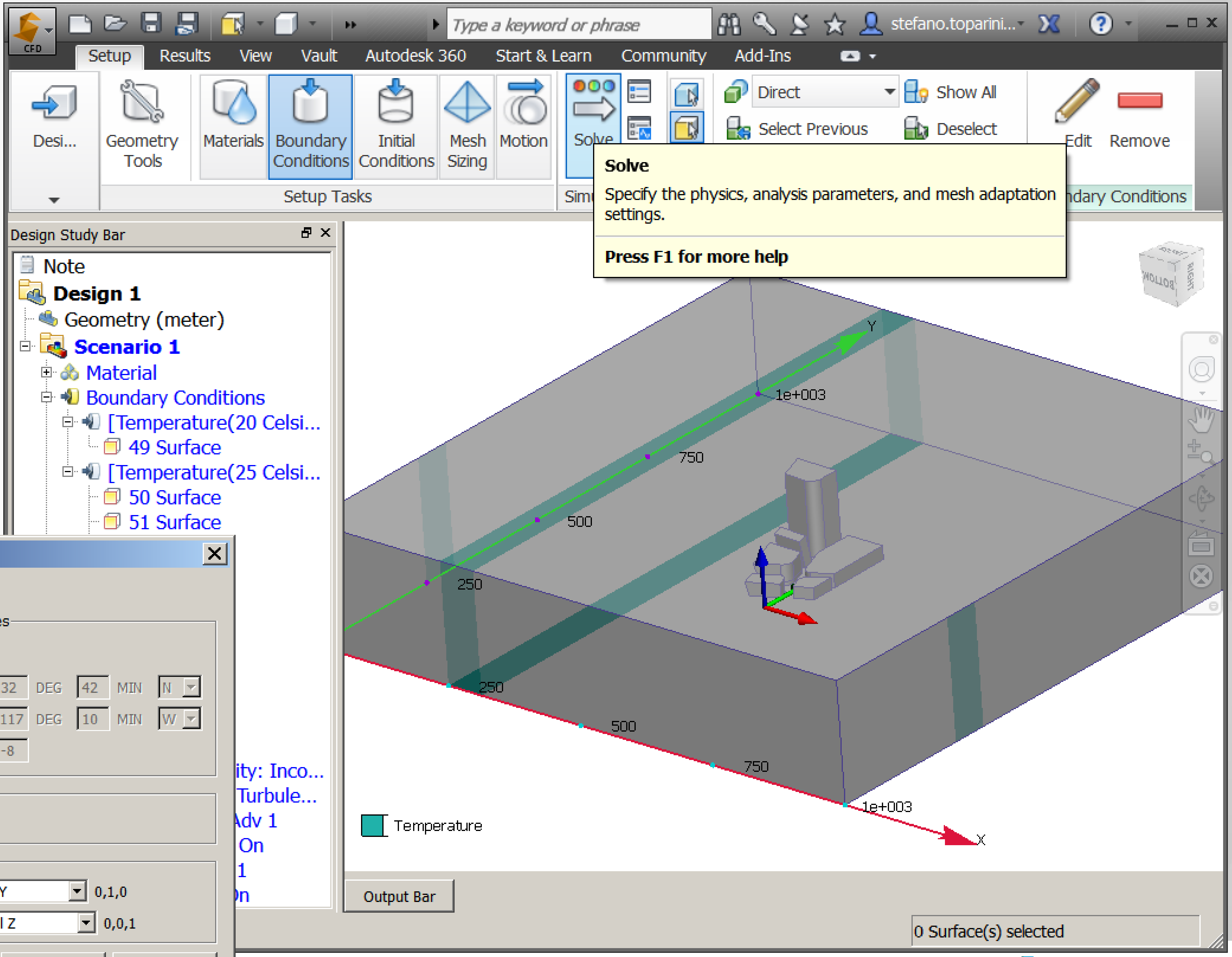
- Define boundary conditions:
  - Soil @ 20°C
  - Air @ 25°C



Simulating in Autodesk® SIM CFD & SIM 360 CFD

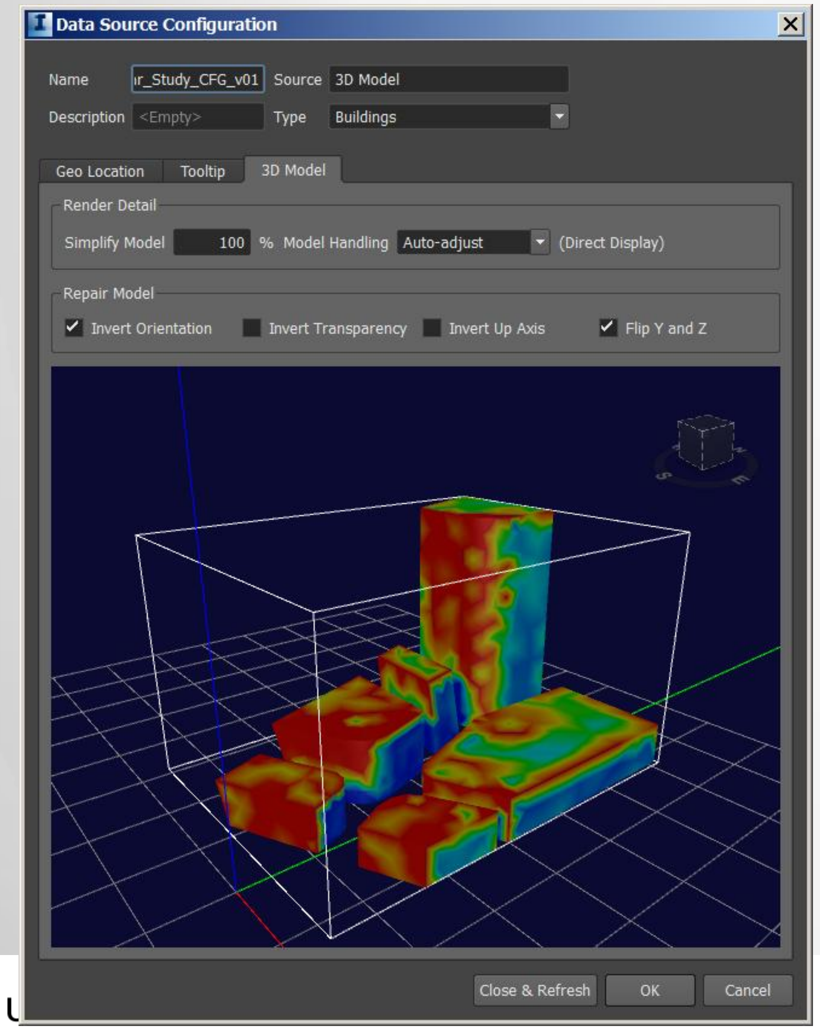
- Run simulation

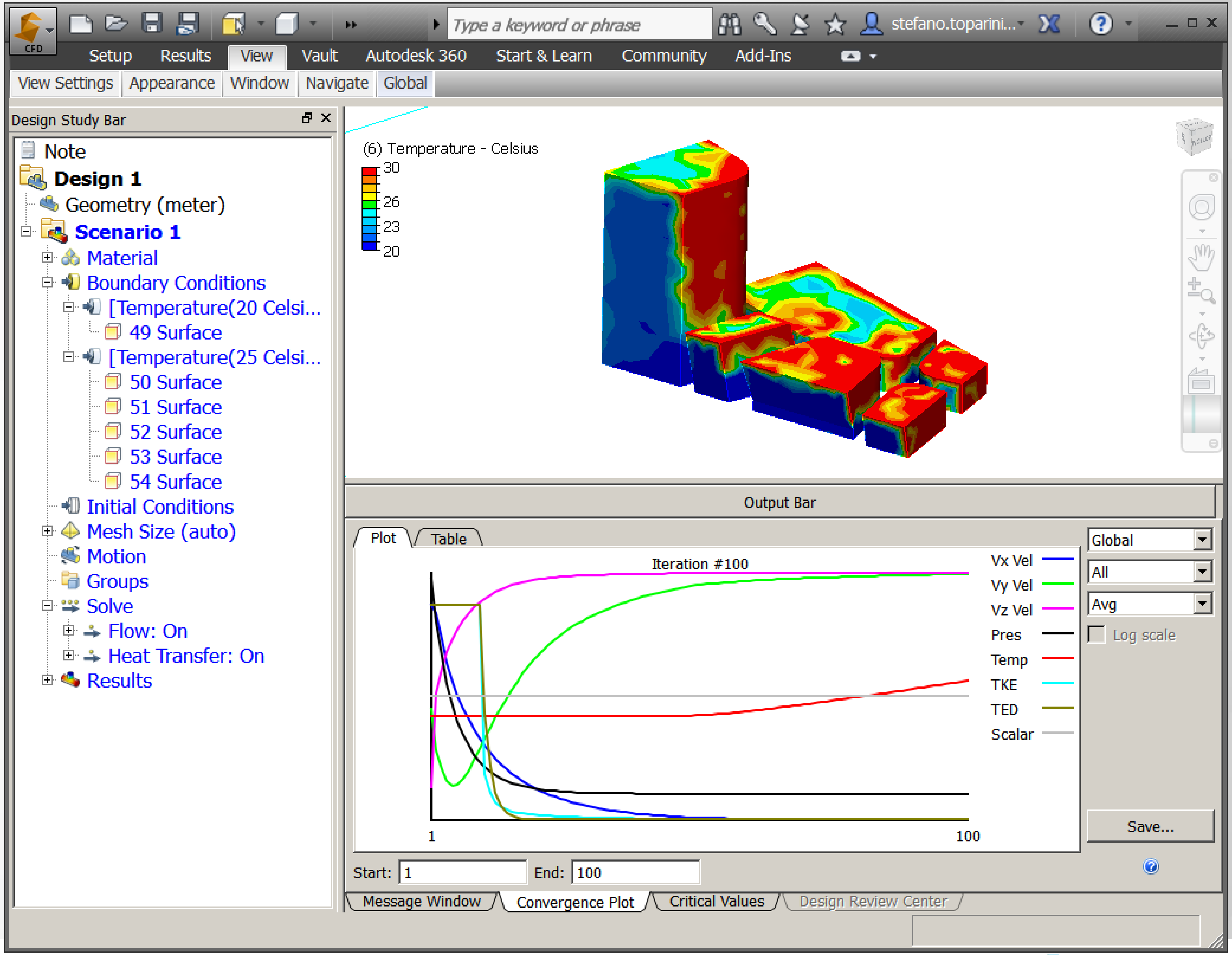




Simulating in Autodesk® SIM CFD & SIM 360 CFD

- Visualize results
- Export as FBX



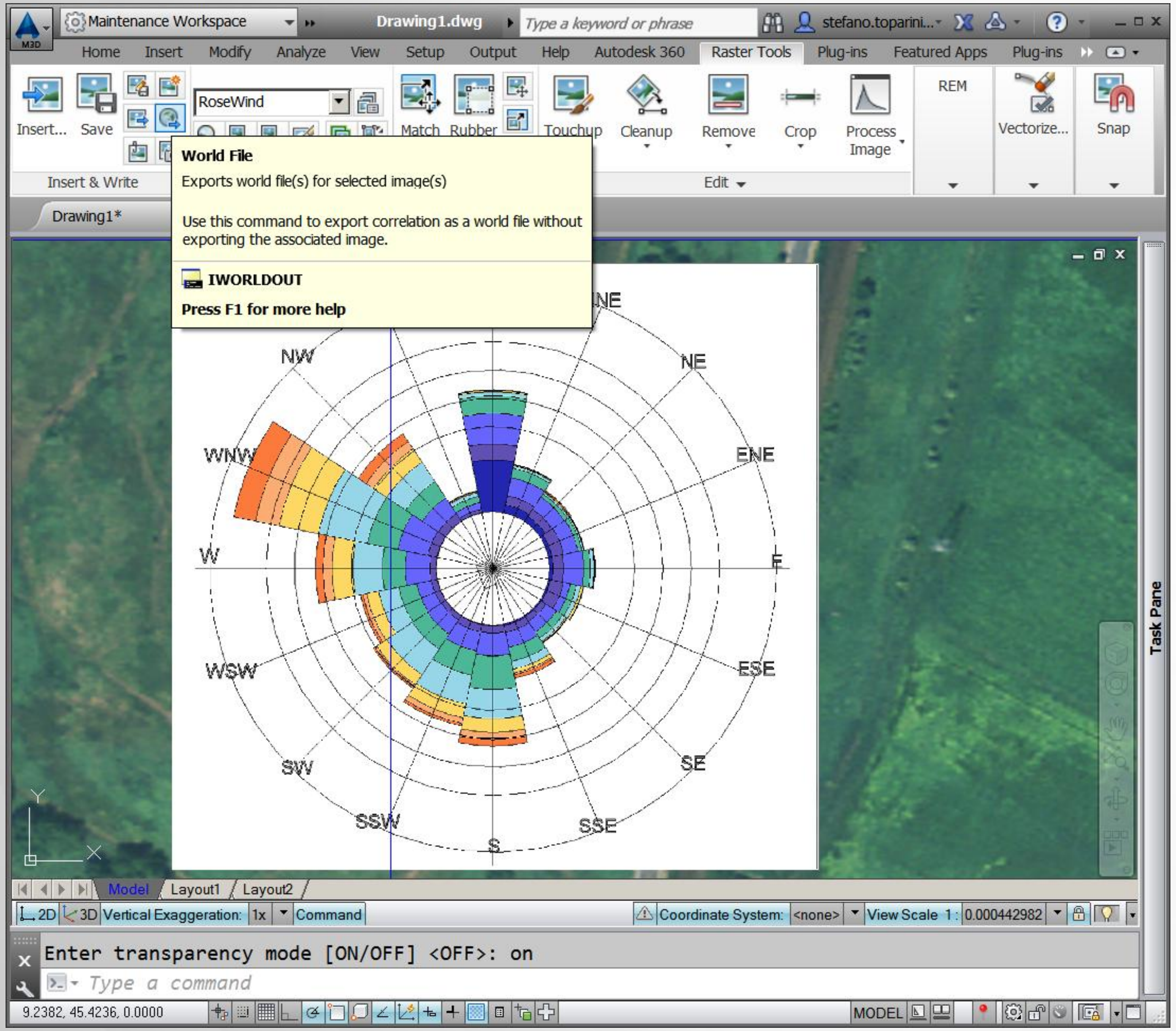


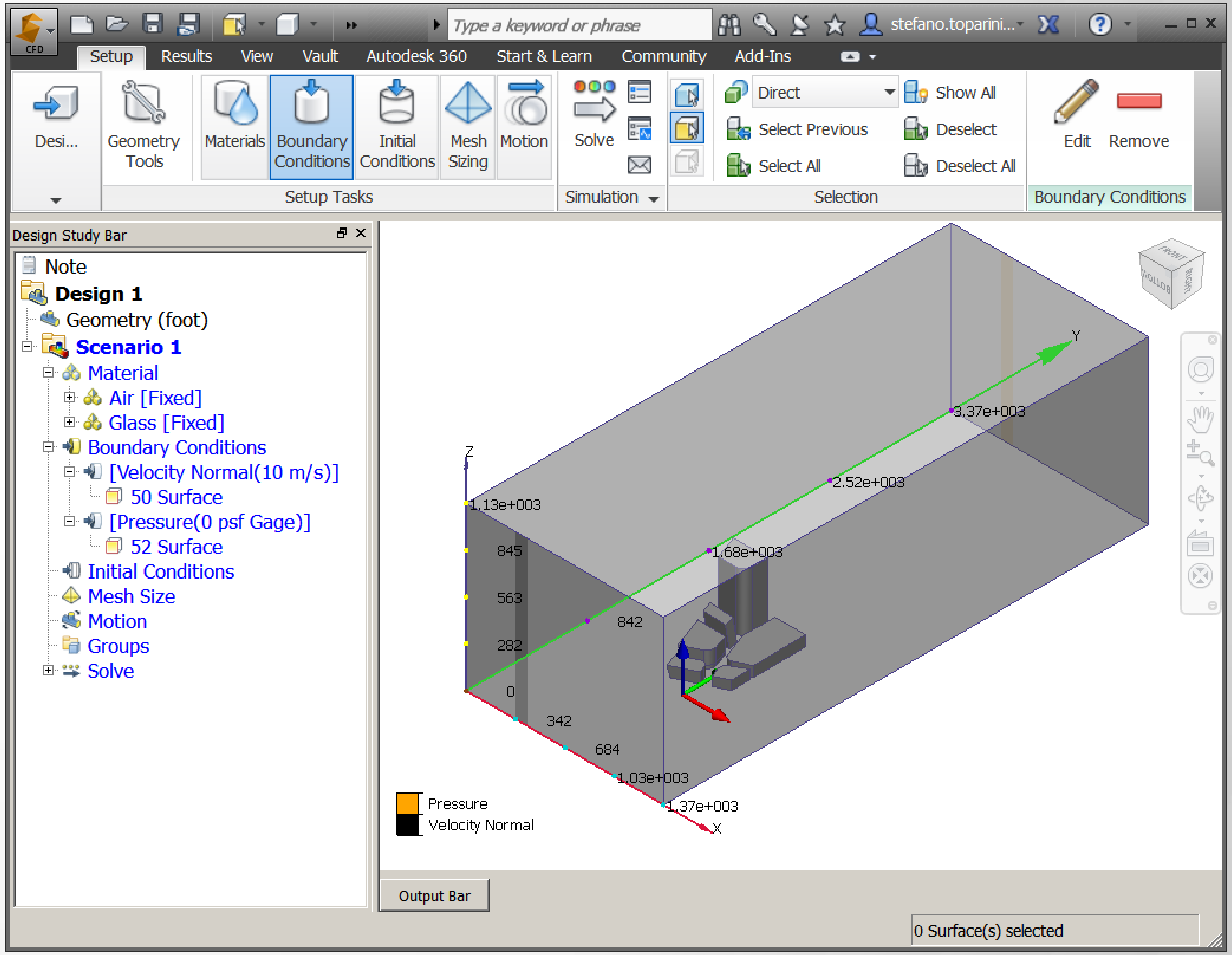
Solar Study_v02_support_support

Case study 3: Wind

Wind: How do we model it?

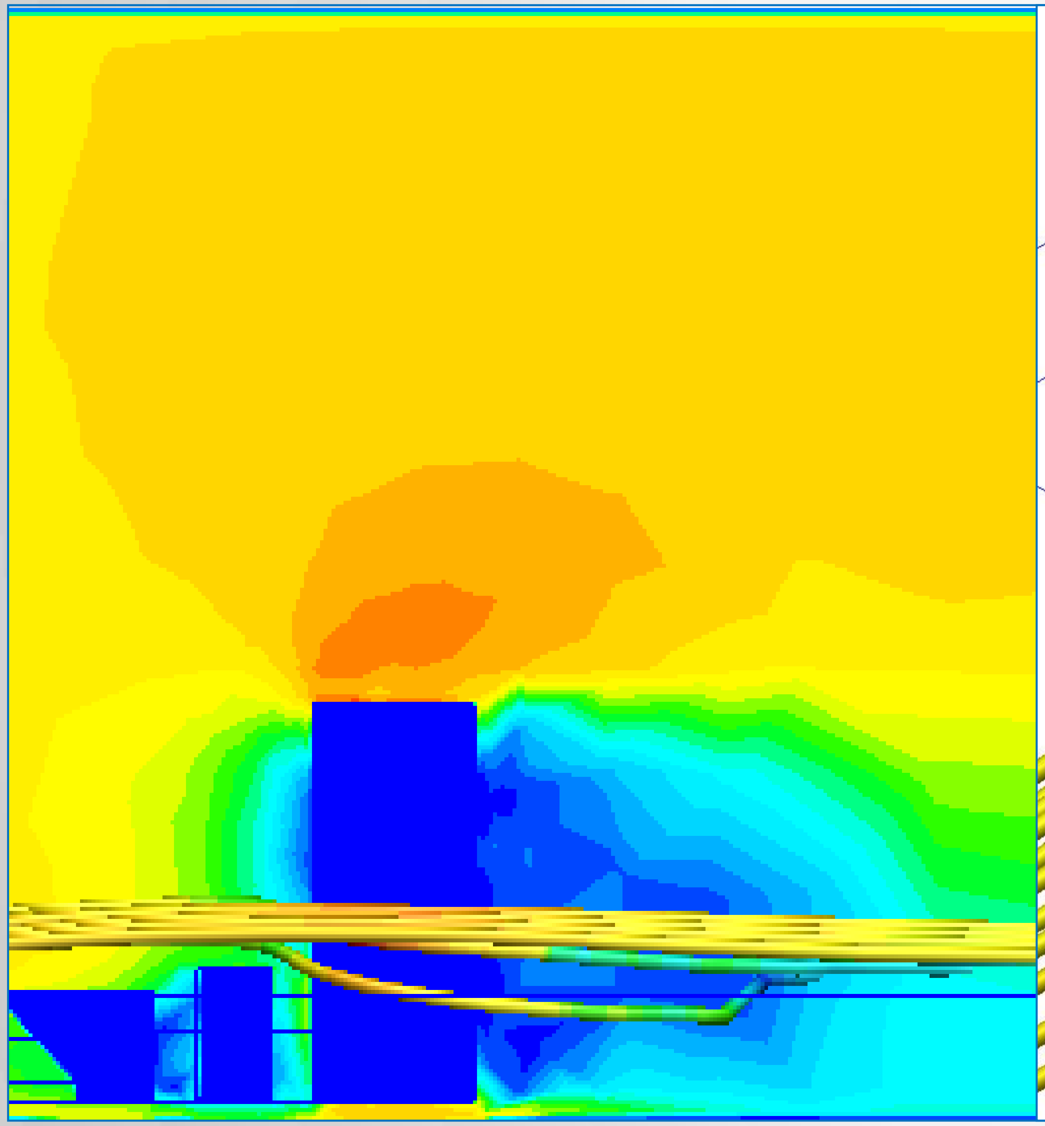
- 3D Model of Buildings + environment conditions



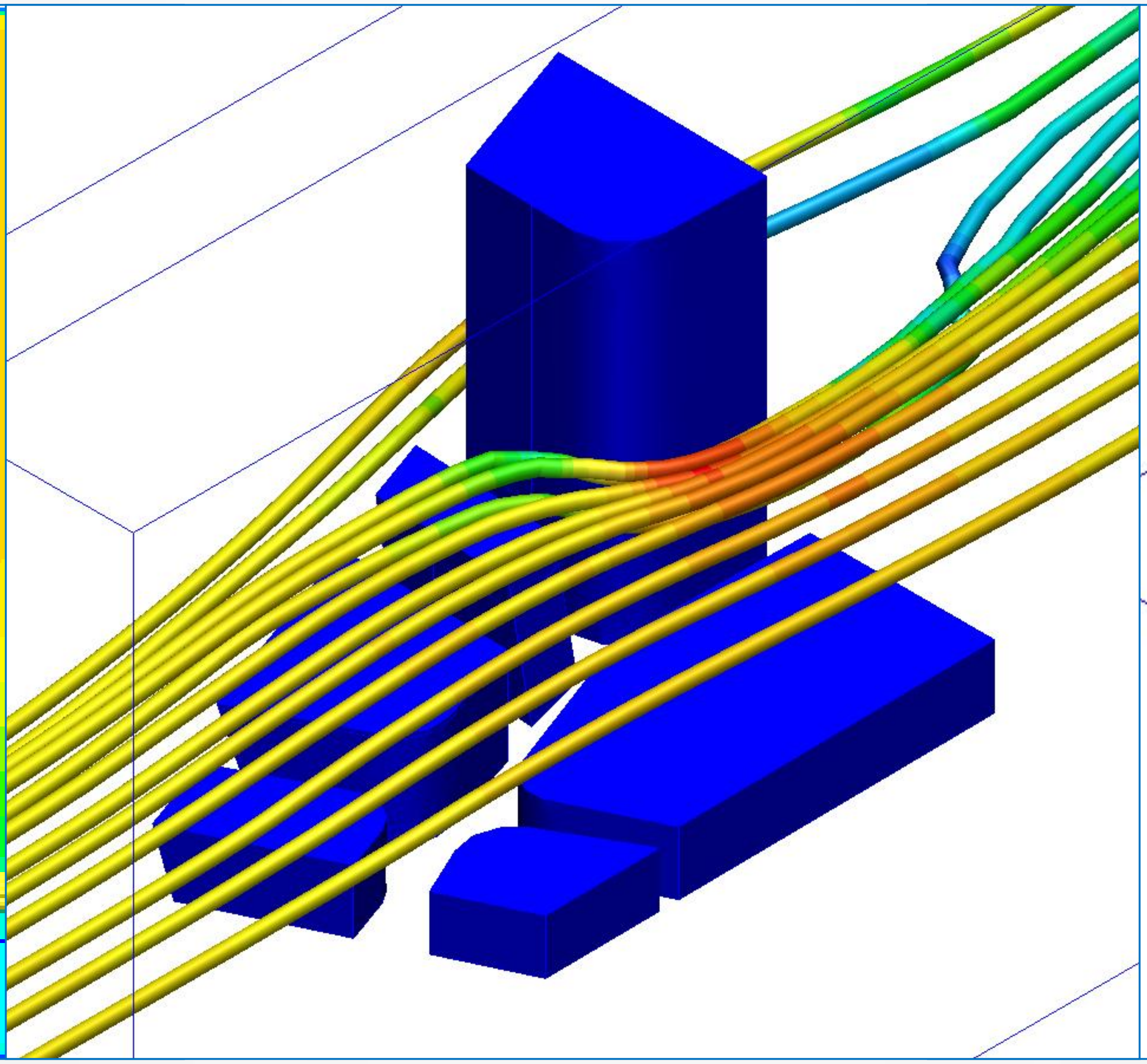


Simulating in Autodesk® SIM CFD & SIM 360 CFD

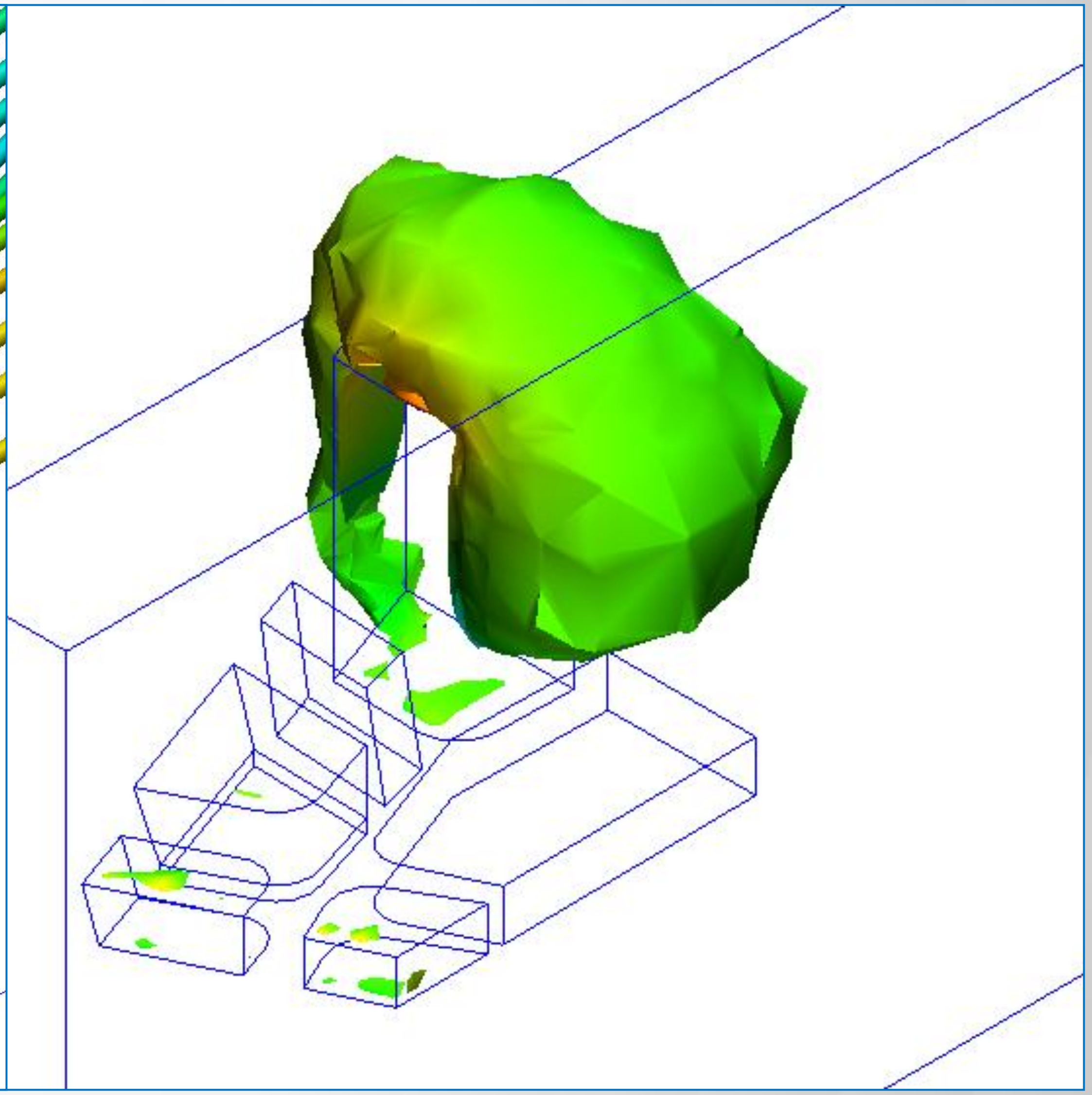
Planes



Tracks

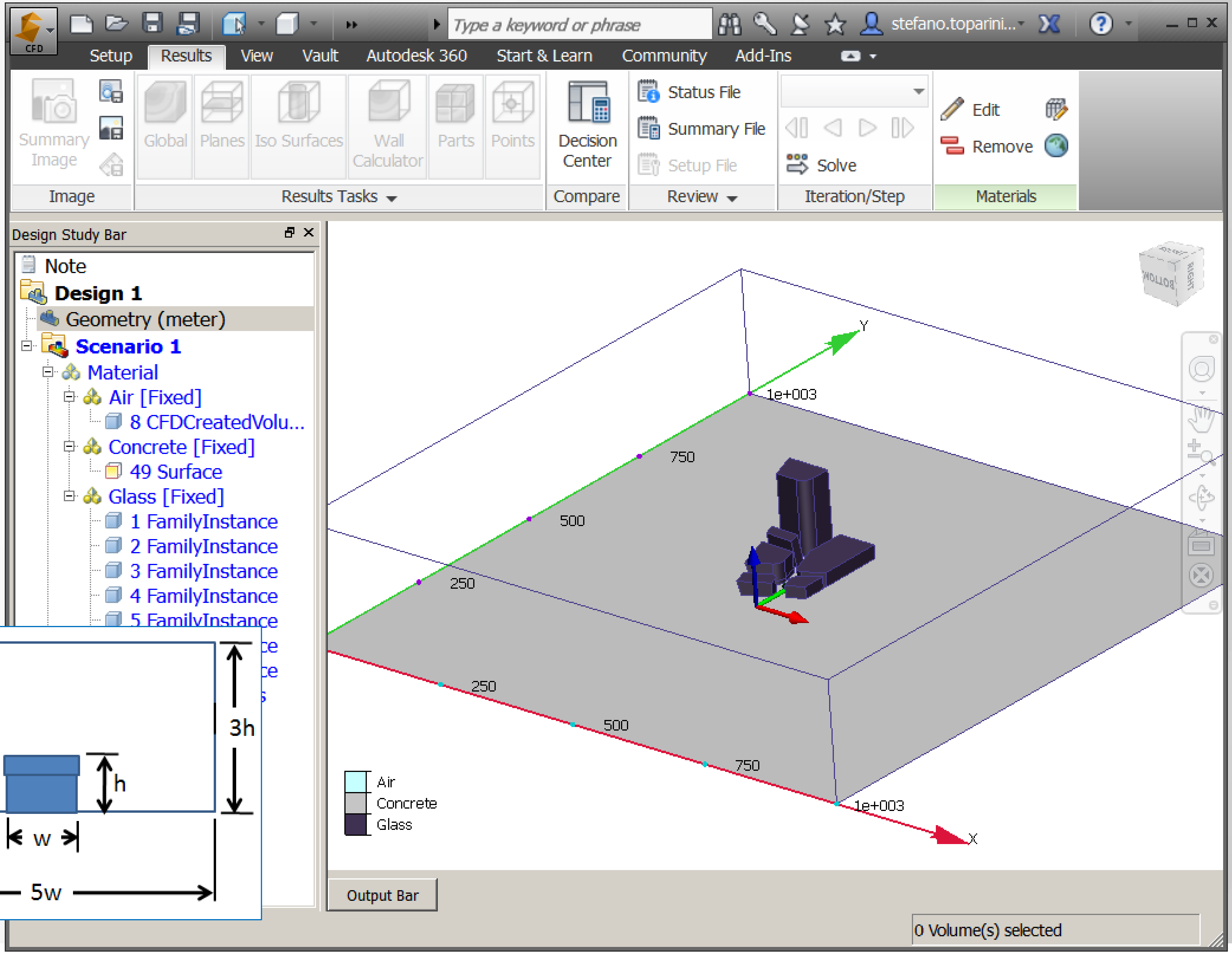


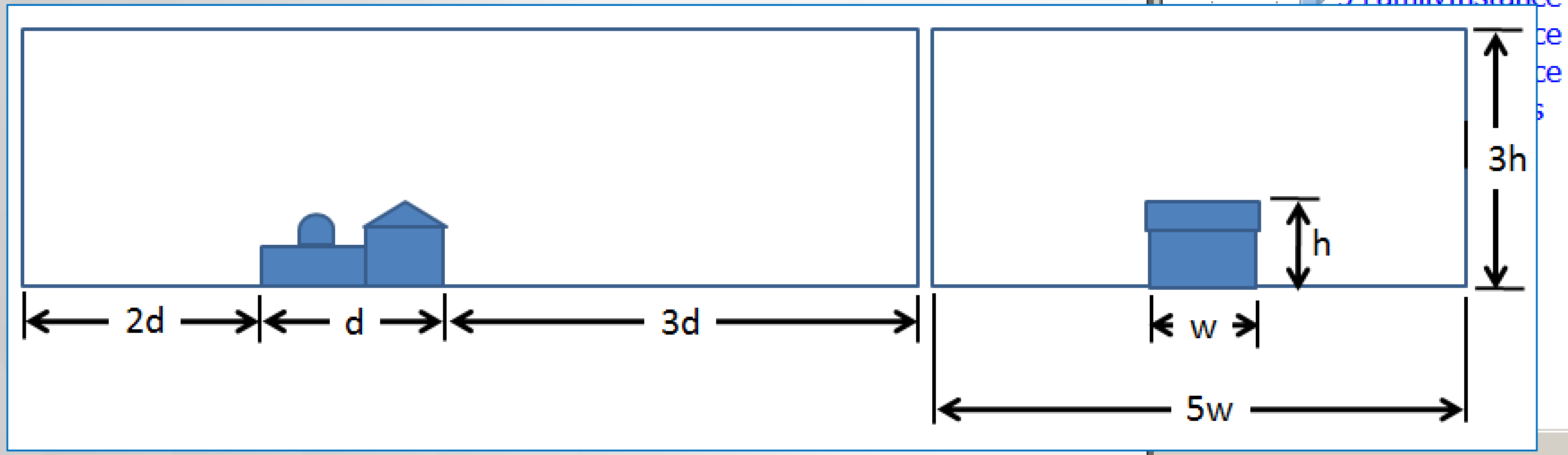
Isosurfaces



Simulating in Autodesk® SIM CFD & SIM 360 CFD

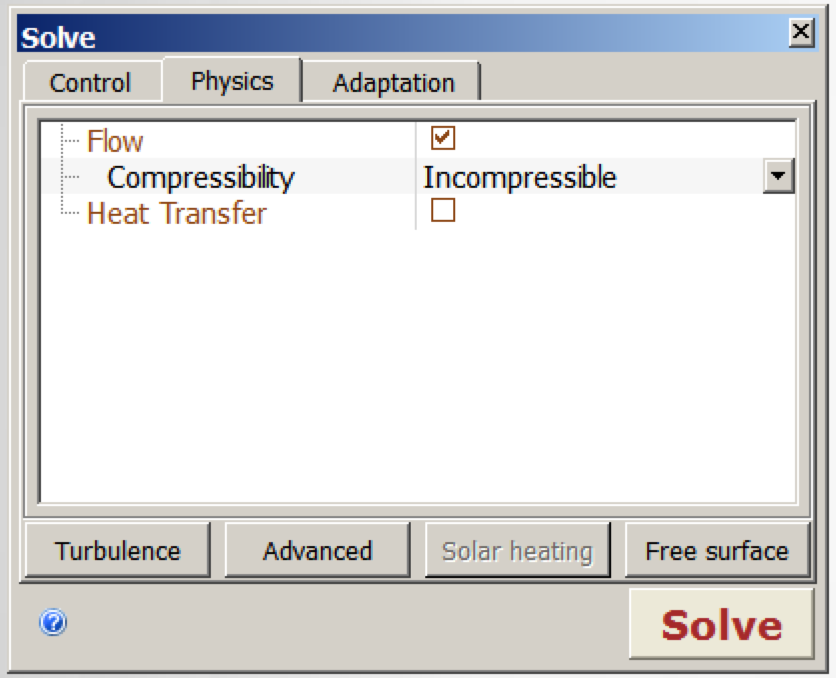
- Create a bounding box
- Assign boundary conditions

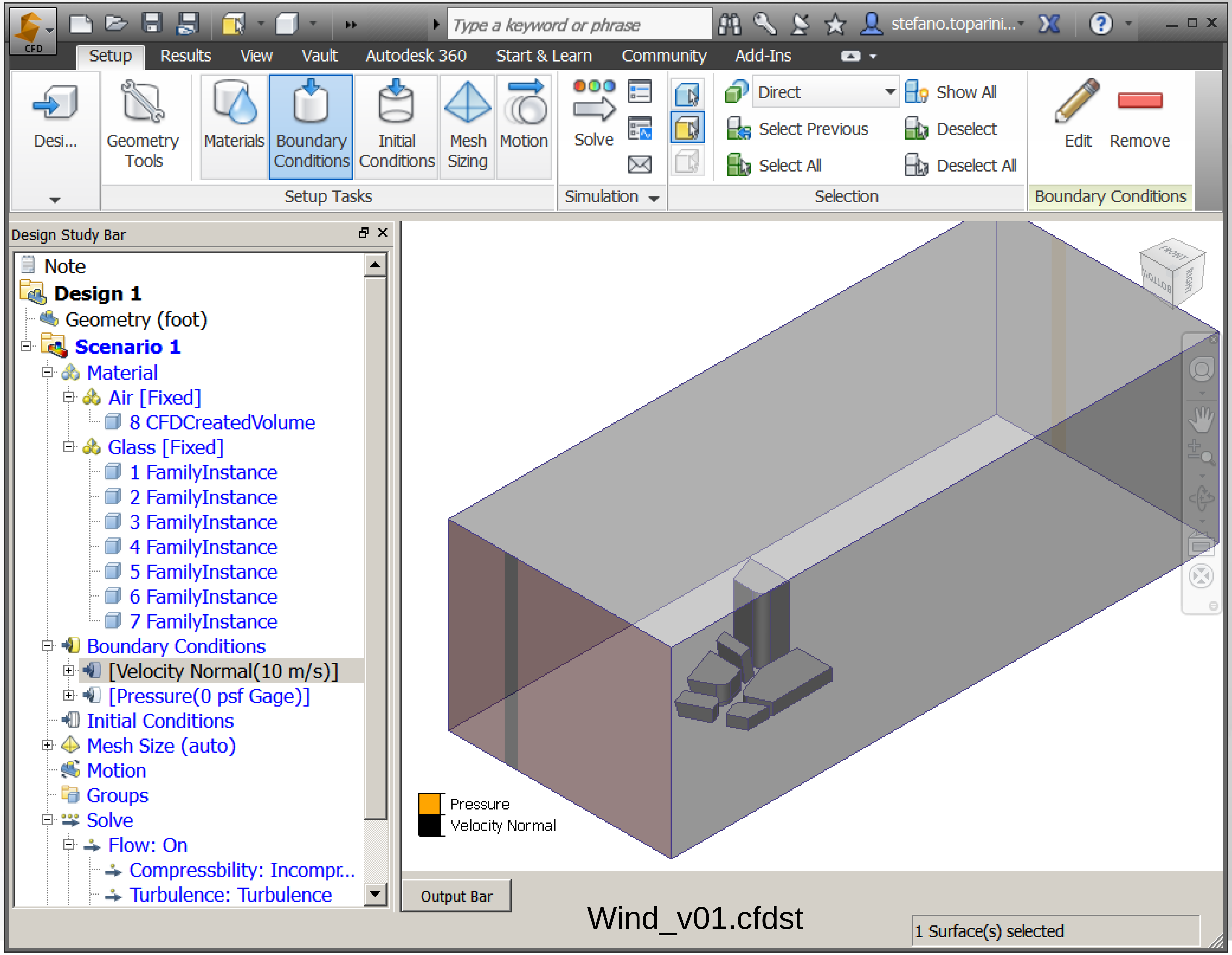




Simulating in Autodesk® SIM CFD & SIM 360 CFD

- Run simulation

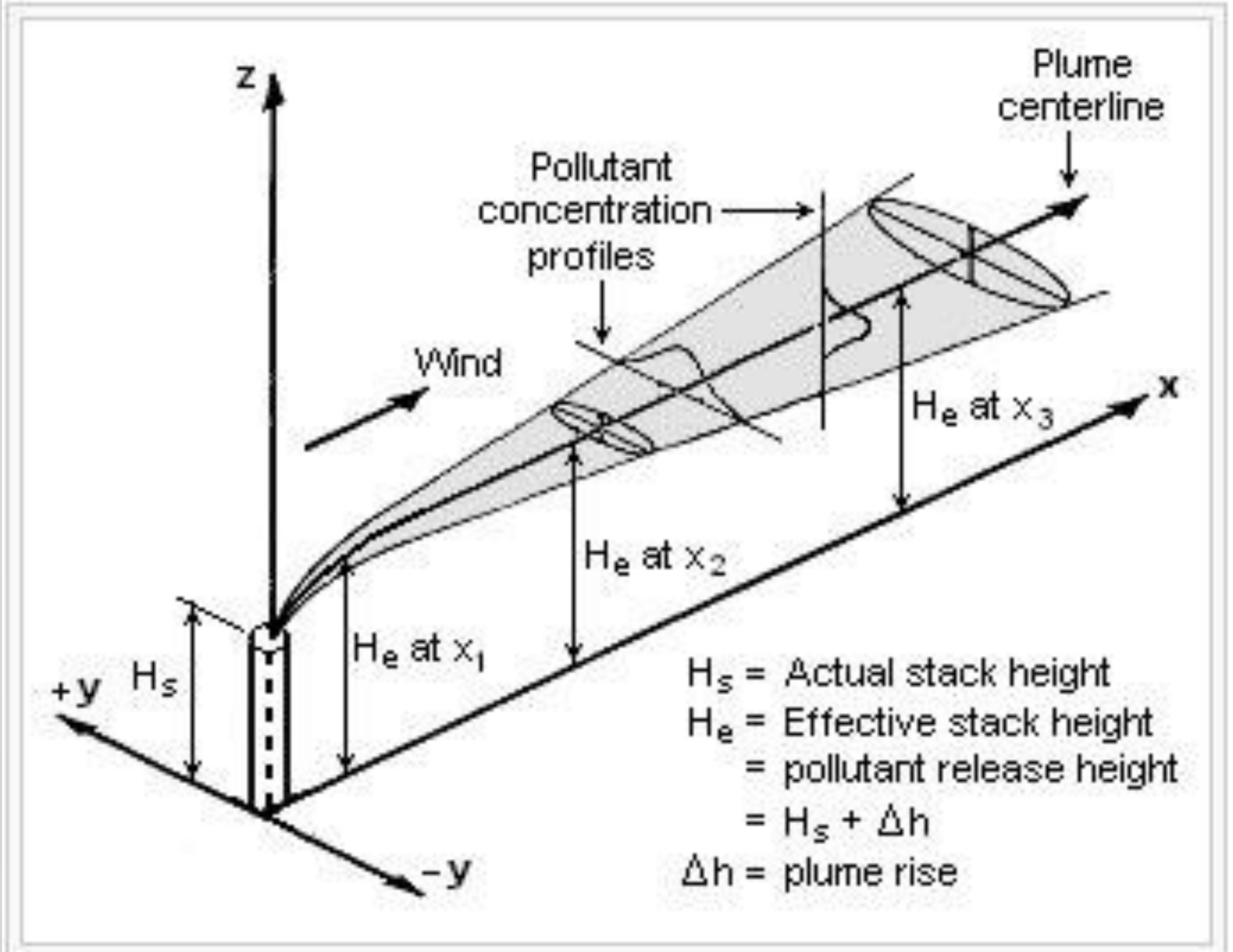




Case study 4: Stack Smoke Plume

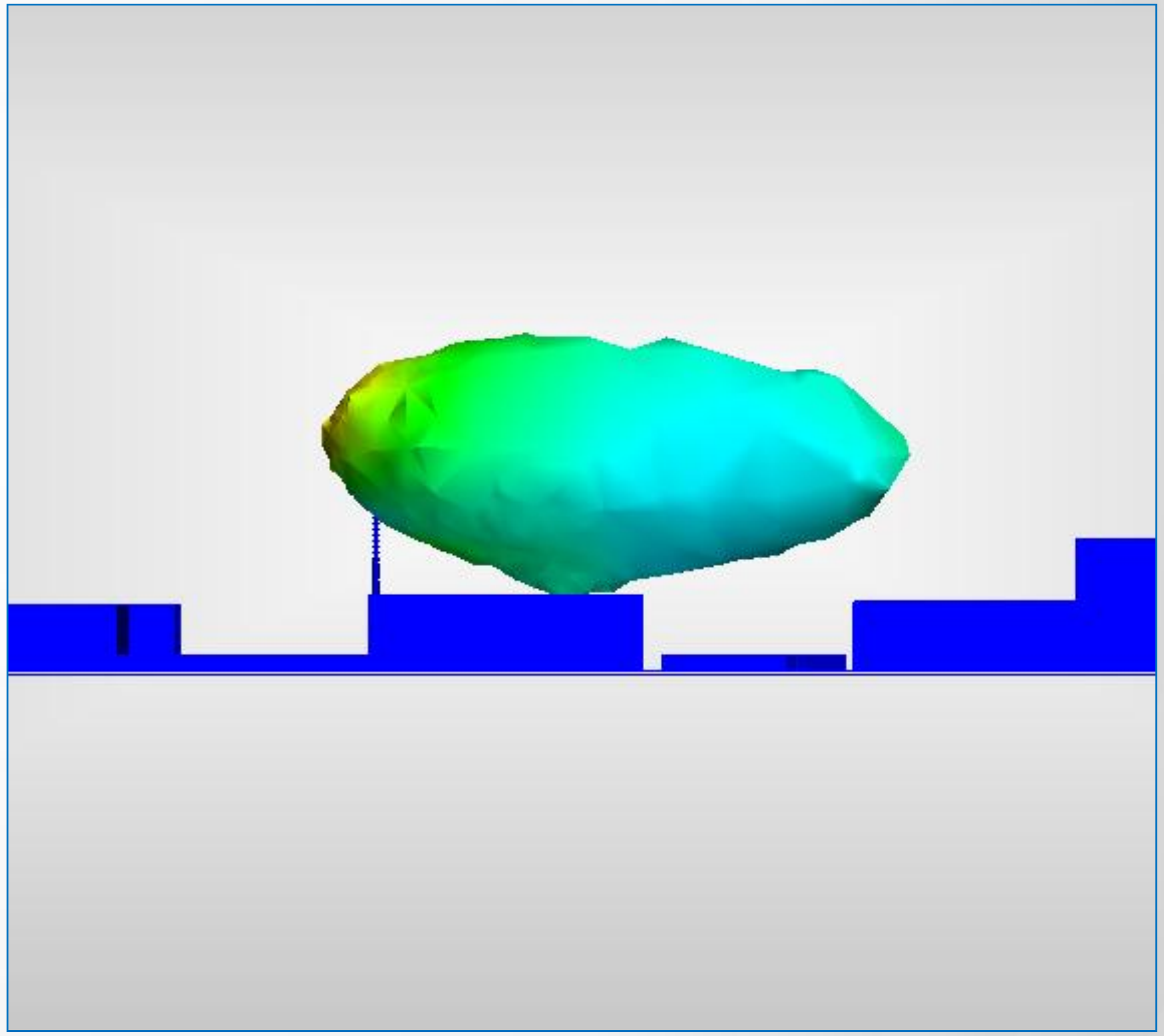
Stack Smoke Plume: how do we model it?

- Equations



Visualization of a buoyant Gaussian air pollutant dispersion plume

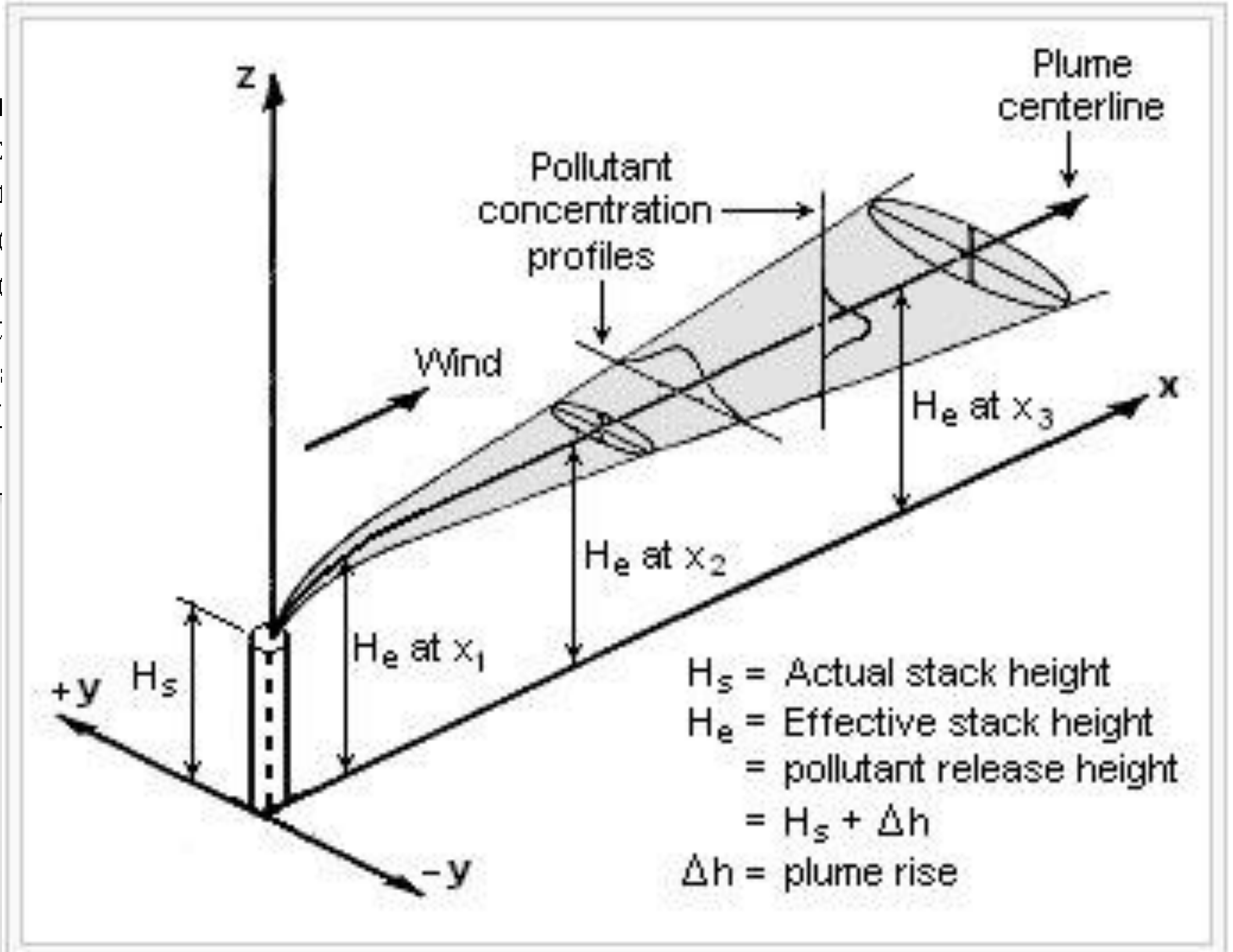
- 3D model + conditions



Simulating the plume

$$C(x,y,z) = \frac{Q}{2\pi u \sigma_y \sigma_z} \times \left[\exp -\left(\frac{y^2}{2\sigma_y^2}\right)\right]\left\{\exp\left(\frac{-(z-H)^2}{2\sigma_z^2}\right) + \exp\left(\frac{-(z+H)^2}{2\sigma_z^2}\right)\right\}$$

C = Concentration of the che
Q = Rate of chemical emissio
u = Wind speed in x directio
σ_y = Standard deviation in y
σ_z = Standard deviation in z
y = Distance along a horizont
z = Distance along a vertical
H = Effective stack height. [I



Visualization of a buoyant Gaussian air pollutant dispersion plume

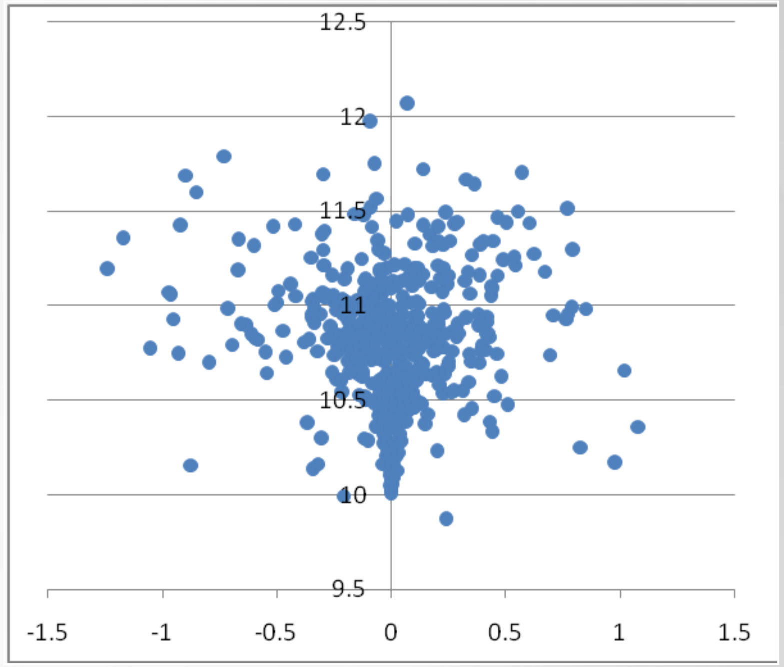
Plume shape depends on stack height and distance from stack

Smoke diffuses either horizontally or vertically according to Gaussian distributions

NB: there are a gazillion more parameter to take care for a full model

Simulating to simulate the plume

- Use Excel to generate
  a series of 3D points according
  to the Gaussian distributions

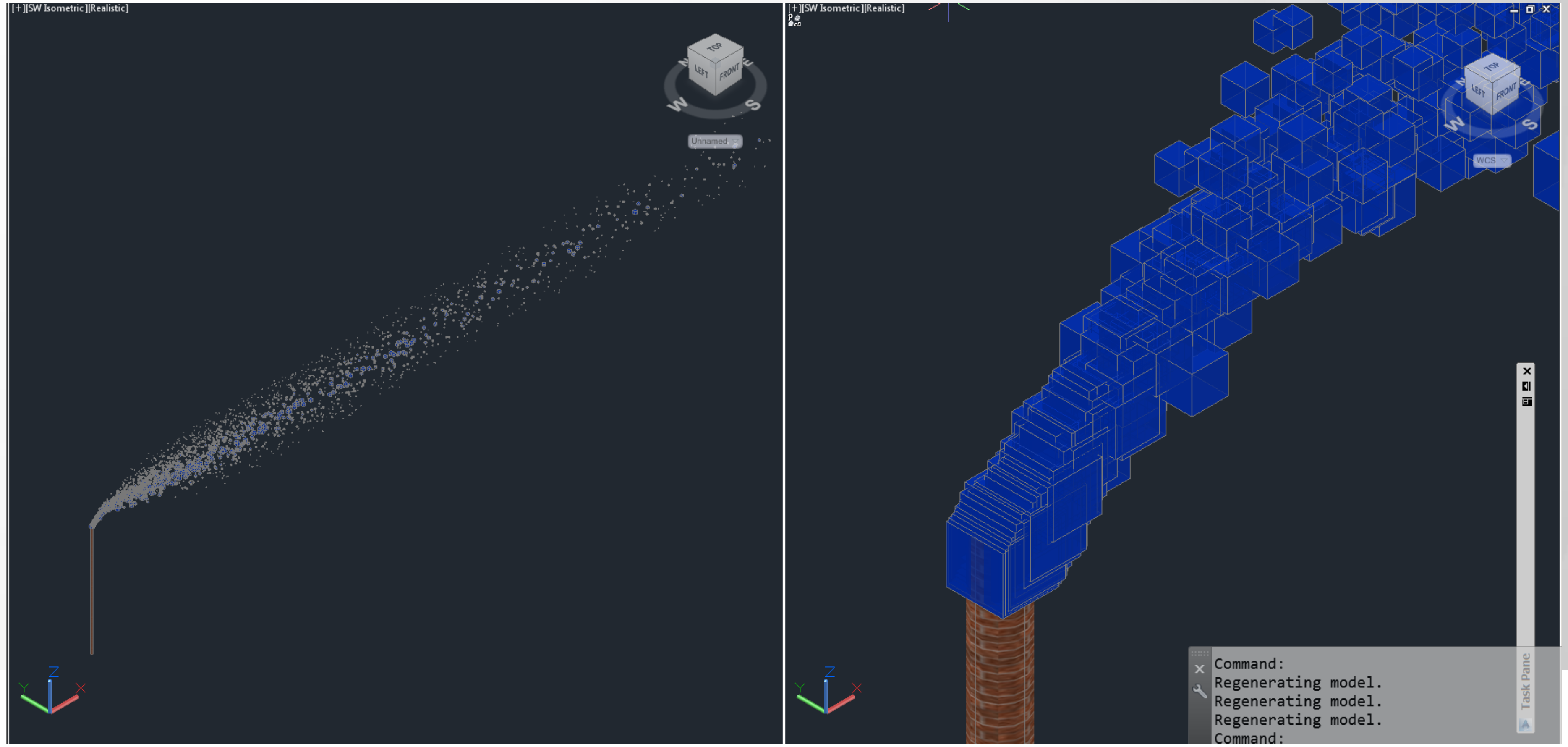


Plume Normal Distribution.xlsx

Plume_v02.dwg

- Create the plume

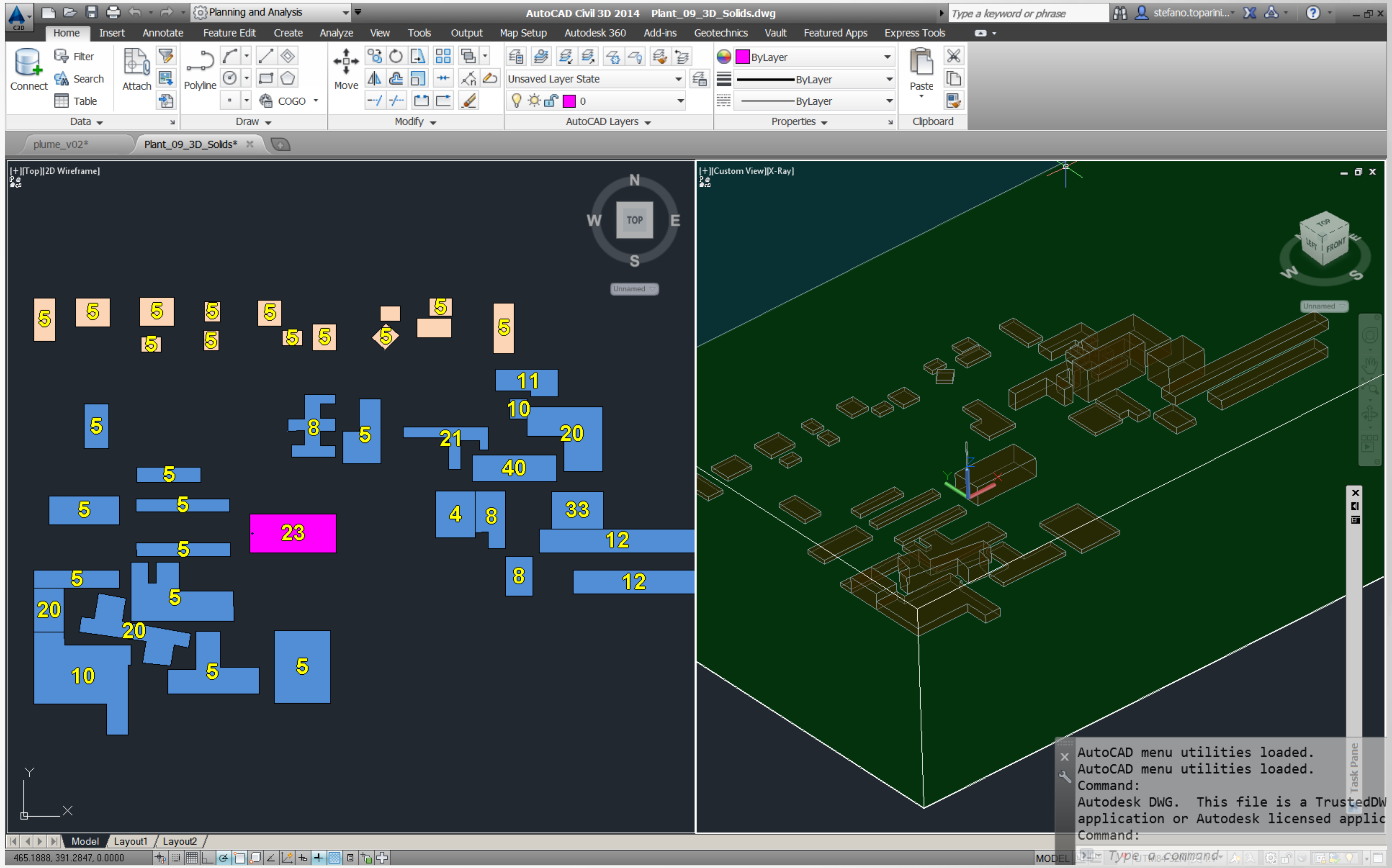
- Export to FBX



Simulating to simulate the plume

- Create 3D model from GIS data by extrusion

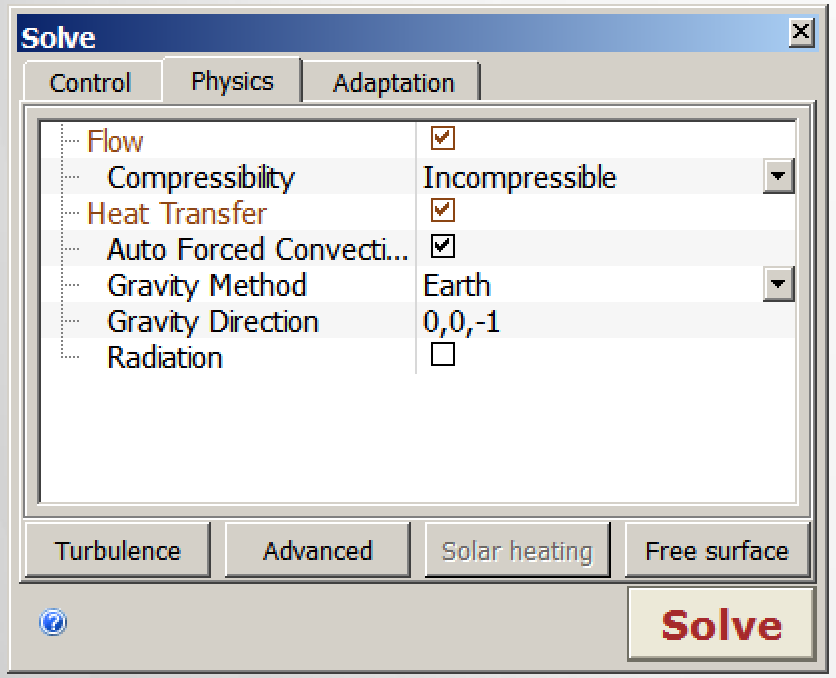
- **Export** the model as ACIS file (.sat) for SIM CFD

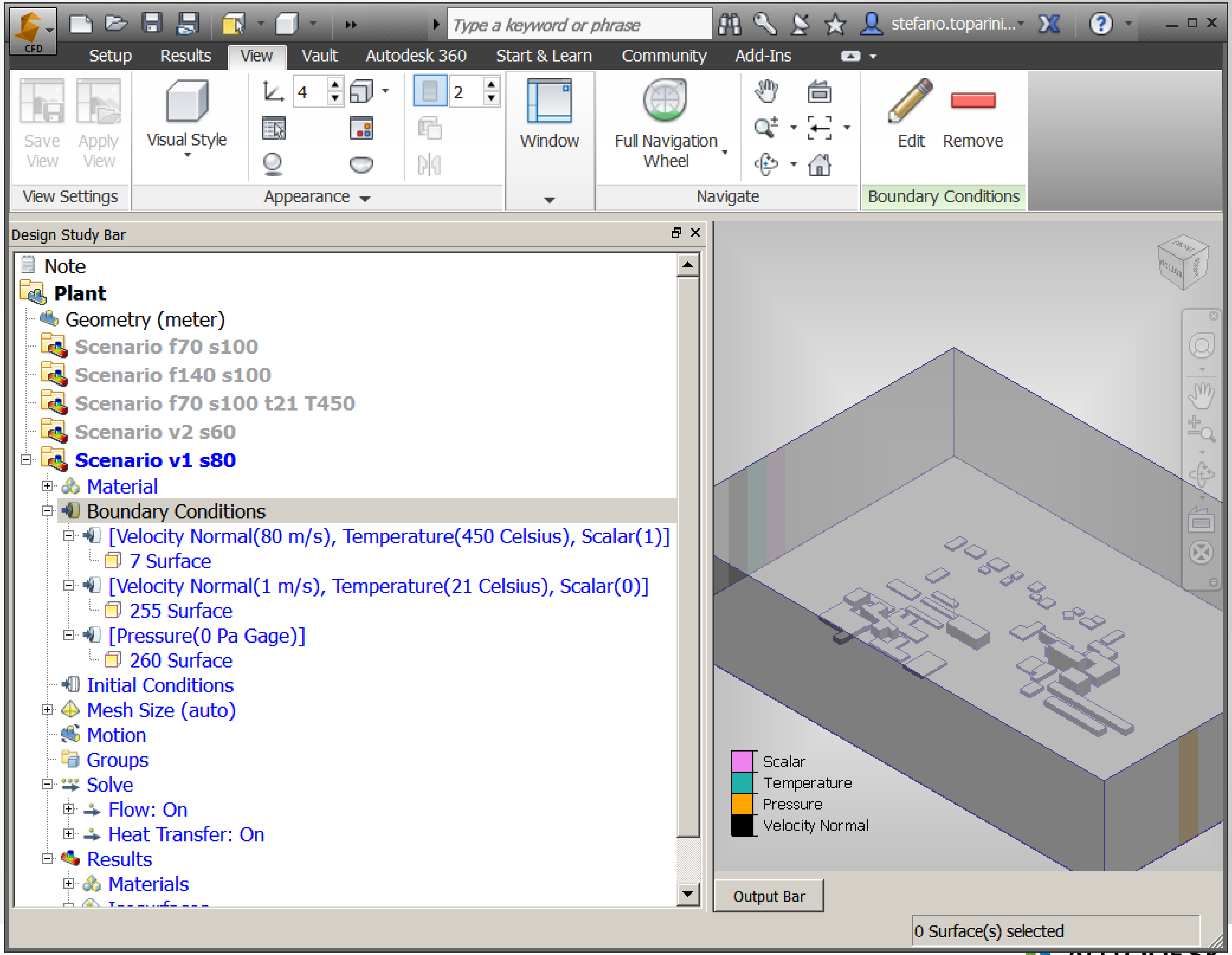


Plant_09_3D_Solids.dwg

Simulating in Autodesk® SIM CFD & SIM 360 CFD

- Create a bounding box
- Assign boundary conditions
- Run the Simulation





Questions?

THANK YOU!!!!