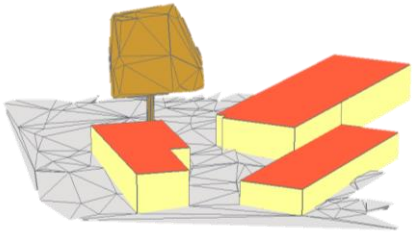
CitySim crash course

Camilo León-Sánchez, Denis Giannelli, Giorgio Agugiaro



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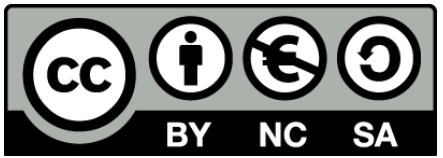

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Overview

- CitySim in a nutshell
- Quick installation guide
- CitySim fundamentals
  - GUI & main functionalities
  - Input data requirements
    - XML-encoded CitySim file or xml-encoded CityGML file
    - Climate data (.cli)
    - Horizon data (.hor)
  - Typical operations
    - Solar analysis
  - Output data
    - CityGML 2.0 + Energy ADE
    - TSV files
- References
- Appendix

CitySim in a nutshell

- **CitySim**
  - Is a set of software tools to provide a decision support for urban energy planners and stakeholders to minimize the net use of non-renewable energy sources as well as the associated emissions of greenhouse gases (EPFL)
  - It is fast (compared to other dynamic simulation engines), reliable (successfully tested against energy monitoring) and needs few input data (available at early design stages) (KAEMCO)
  - Currently, it consists of two main modules:

a) CitySim (Solver)

- Originally developed at the Solar Energy and Building Physics Laboratory of EPFL, it is a **command-line Integrated solver** for simulating the energy demand and supply of buildings for space conditioning, together with the specification of the input buildings' characteristics and the climate files

b) CitySim Pro

- It is a **Graphical User Interface (GUI)** built on top of the CitySim Solver and originally developed at KAEMCO

CitySim in a nutshell

- **Several applications**
  - Short-wave irradiation (Wh/m²) at surface resolution
  - Long-wave net irradiation (Wh/m²) at surface resolution, except for shading surfaces
  - Surface temperature (°C) at surface resolution, except for shading surfaces
  - Photovoltaic production (Wh) at building resolution
  - Solar thermal production (Wh) at building resolution
  - Sky view factor [0,1] at surface resolution
  - Heating demand (Wh/m³) at thermal zone resolution
  - Cooling demand (Wh/m³) at thermal zone resolution
  - Indoor temperature (°C) at thermal zone resolution

- **Different temporal resolutions of results visualised in the GUI**
  - Hourly values
  - Daily values (average or summation, depending on the application)
  - Monthly values (average or summation, depending on the application)
  - Yearly values (average or summation, depending on the application)

  However: exported values are always at hourly resolution!

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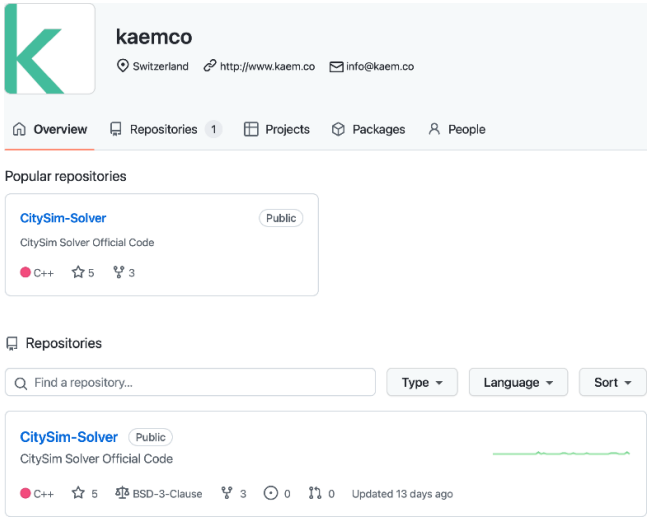
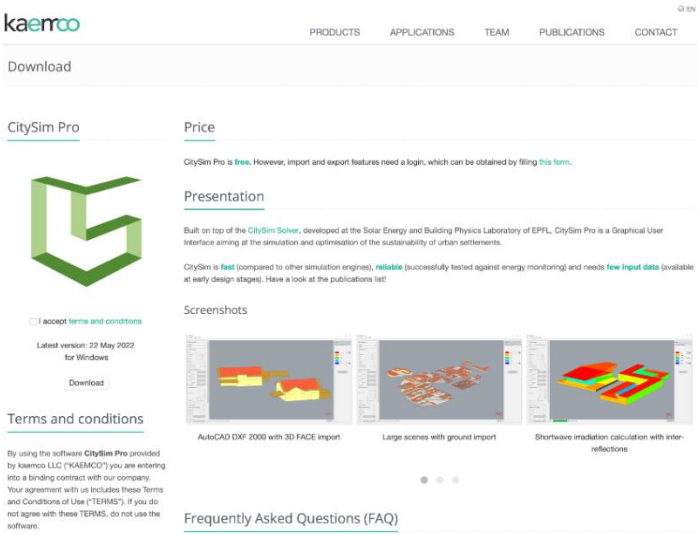
  However: exported values are always at hourly resolution!

Quick installation guide

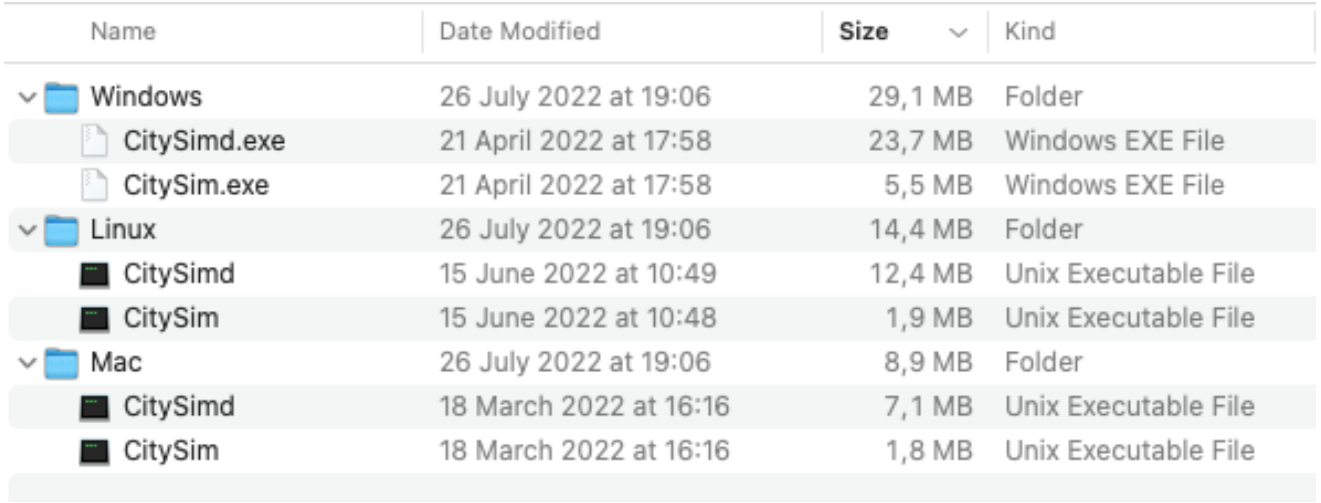
- There are two possibilities to use CitySim:
  - CitySim Solver "only". Available in GitHub. It is the actual engine performing the simulations
    - https://www.epfl.ch/labs/leso/transfer/software/citysim/
    - https://github.com/kaemco/CitySim-Solver
  - CitySim Pro. A GUI that allows the visualisation of data and ease its use. CitySim Pro is free to use, but it requires a license that can be requested online
    - http://www.kaemco.ch/download.php





CitySim Solver fundamentals

- **How to install CitySim Solver?**
  - Clone or download the Github CitySim-solver repository
  - Build the binaries for the corresponding OS: Windows, macOS, Linux (Ubuntu), Docker



Name	Date Modified	Size	Kind
Windows	26 July 2022 at 19:06	29,1 MB	Folder
CitySimd.exe	21 April 2022 at 17:58	23,7 MB	Windows EXE File
CitySim.exe	21 April 2022 at 17:58	5,5 MB	Windows EXE File
Linux	26 July 2022 at 19:06	14,4 MB	Folder
CitySimd	15 June 2022 at 10:49	12,4 MB	Unix Executable File
CitySim	15 June 2022 at 10:48	1,9 MB	Unix Executable File
Mac	26 July 2022 at 19:06	8,9 MB	Folder
CitySimd	18 March 2022 at 16:16	7,1 MB	Unix Executable File
CitySim	18 March 2022 at 16:16	1,8 MB	Unix Executable File

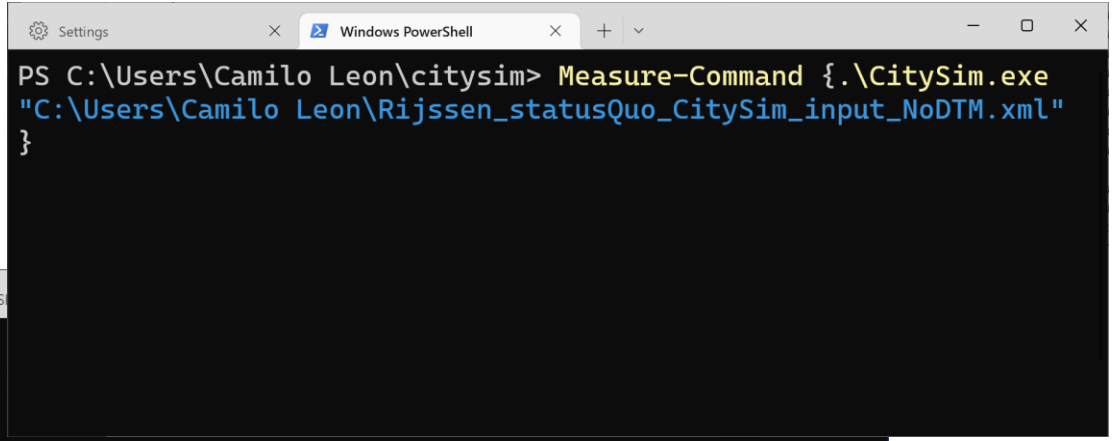
CitySim Solver fundamentals

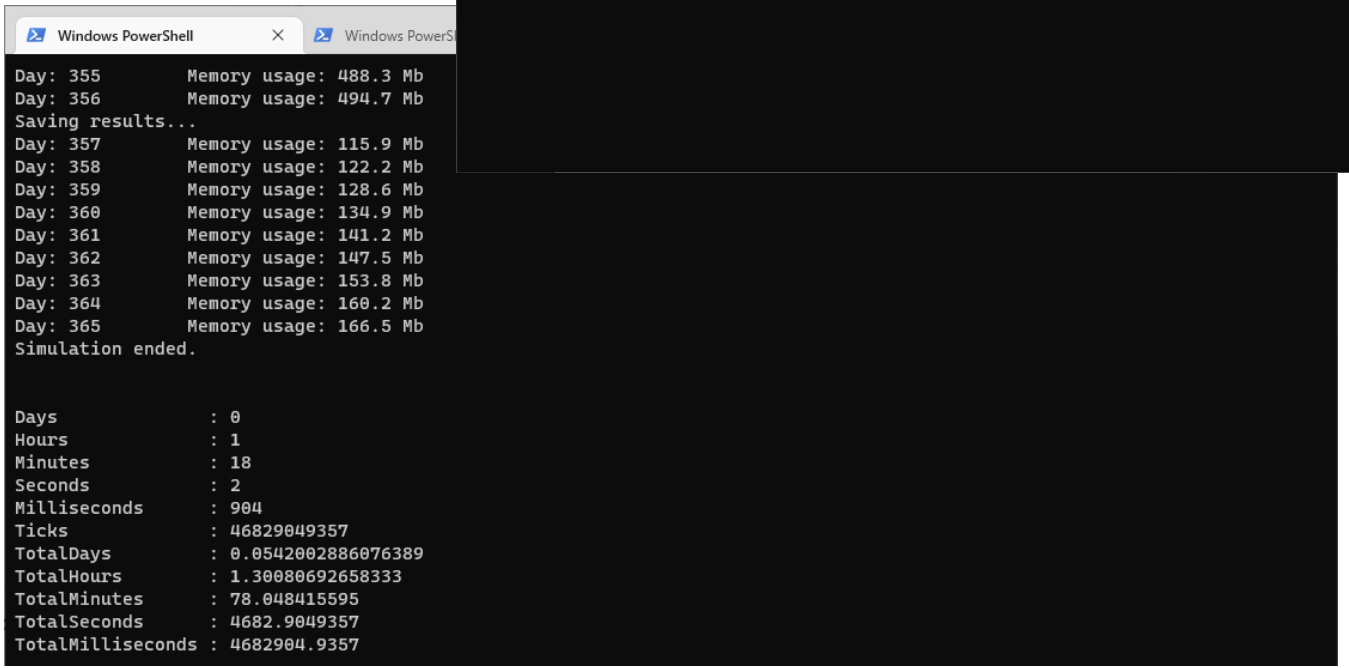
Overview of data workflows

- CitySim runs all applications at a time
- It is wise to **first** run simulations with small datasets, and **then** with the complete dataset
- Data pipeline consists of the following steps:

Path_to_executable_files **path_to_XML_file**

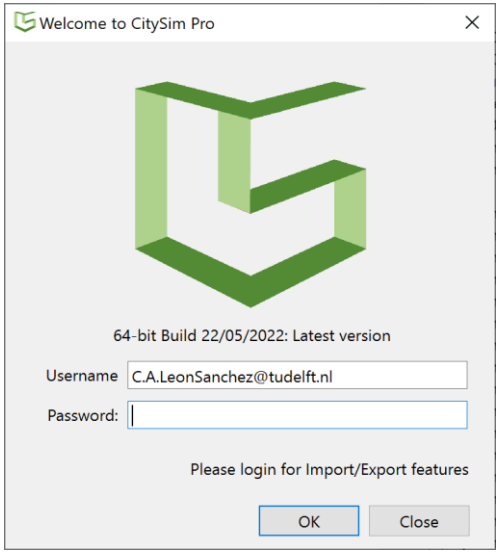
CitySim Solver fundamentals





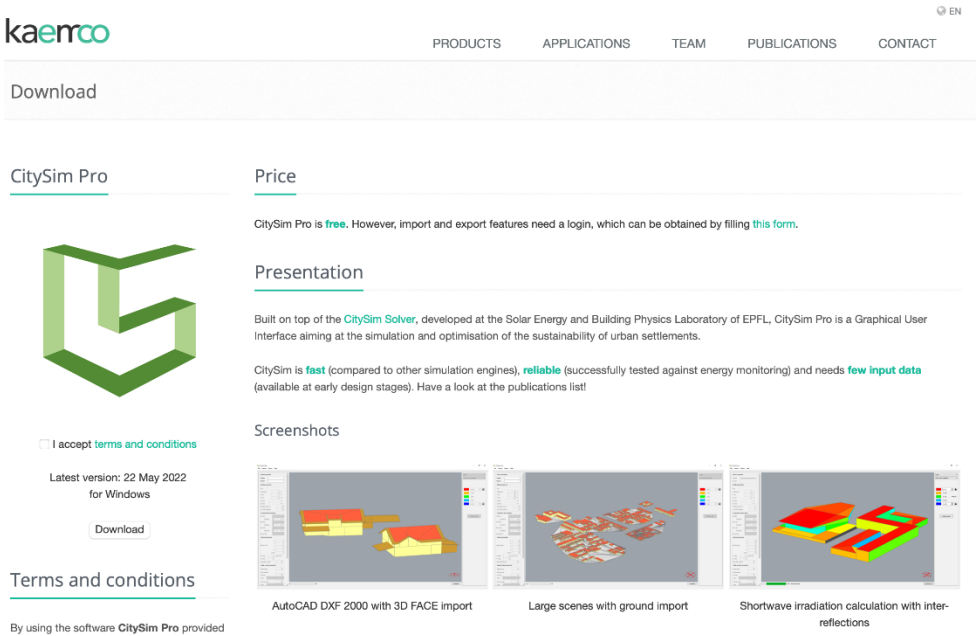
CitySim Pro fundamentals

- **How to install CitySim Pro?**
  - Extract the CitySimPro.zip file and place it on a directory of your preference
    - E.g. C:\Program Files
  - Double-click on CitySimPro.exe
  - Upon first run, you will be asked to insert your license credentials



Quick installation guide

- **How to install CitySim Pro?**
  - Access the developer's website here;
  - Fill and sign this form, and send it to the developer at info@kaemco.ch ;
  - You will receive a login and password to activate the license
  - Attention: CitySim Pro is available only for Windows 32/64bit!



CitySim Pro fundamentals

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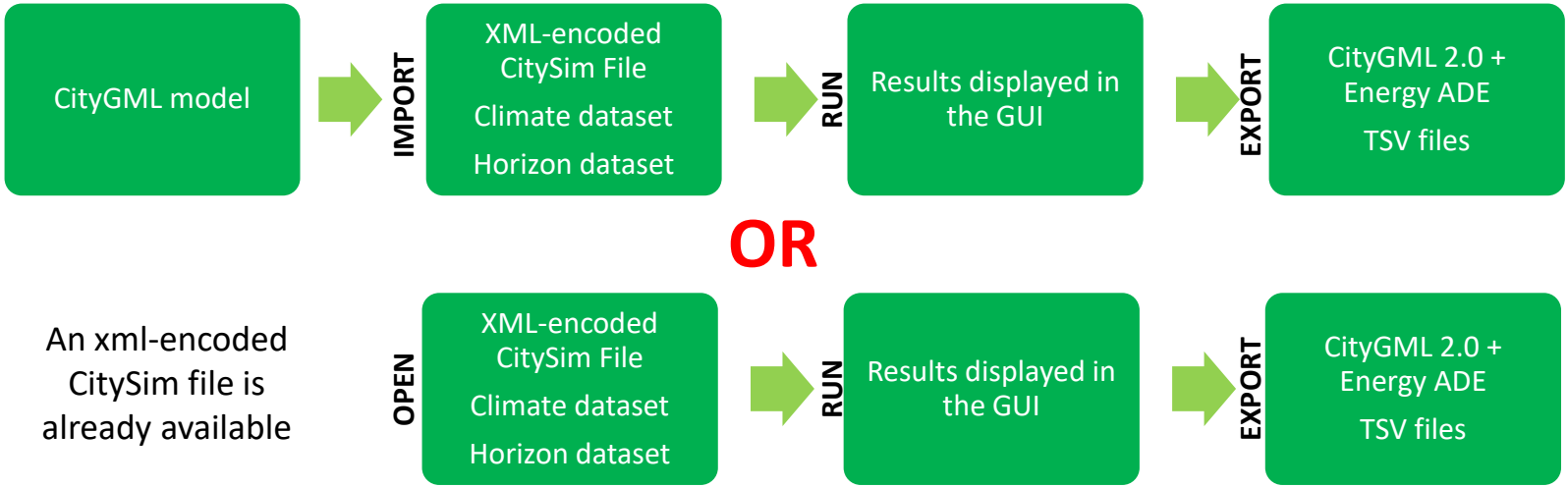


CitySim fundamentals

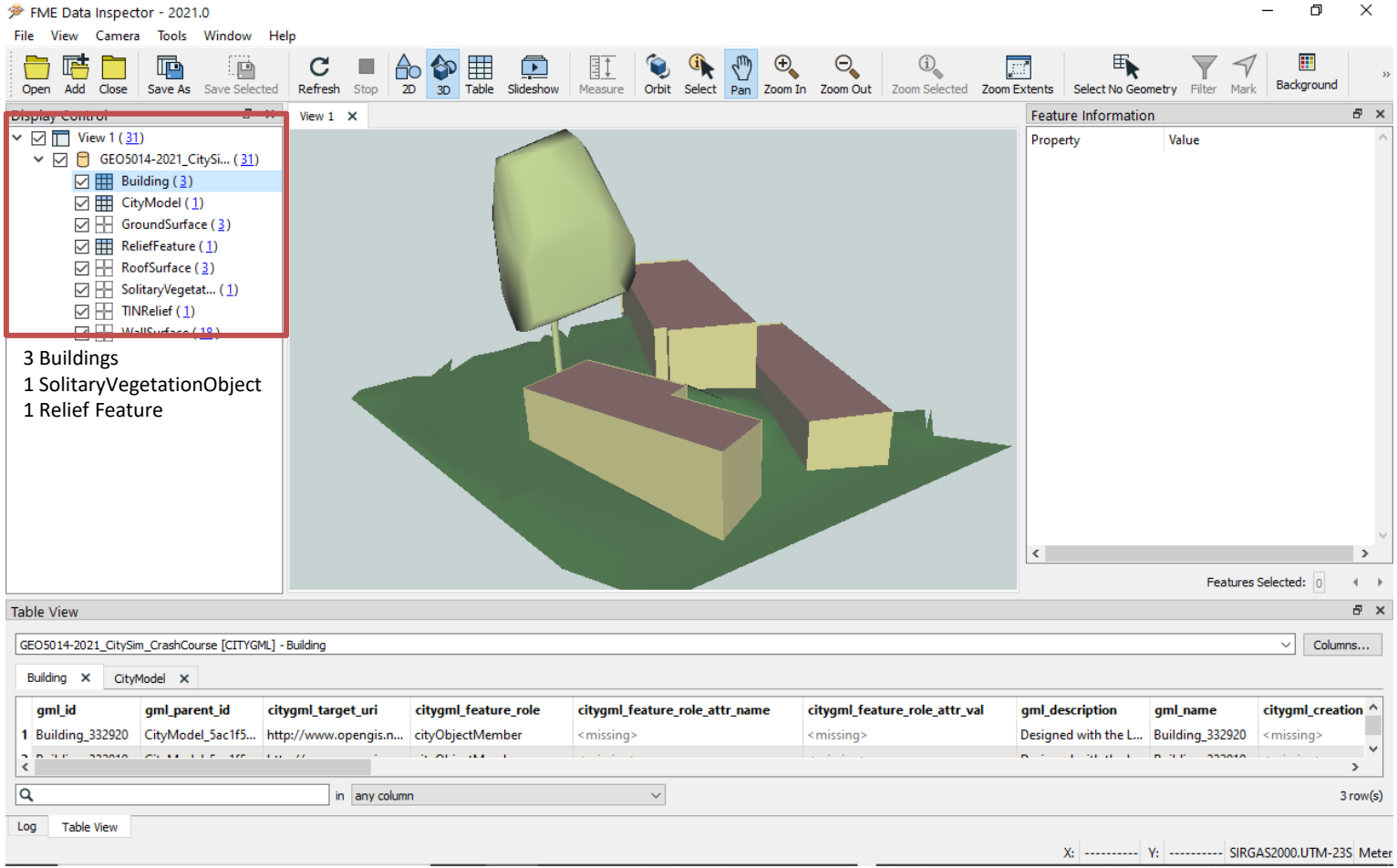
Foreword

The following slides are based on a very simple CityGML model just to demonstrate the potentialities of CitySim

- This CityGML model contains objects from three modules of the CityGML schema:
  - 3 Buildings
  - 1 SolitatyVegetationObjects
  - 1 Relief
- The focus is on converting an (xml-encoded) CityGML file to a CitySim file
- For more details about the **xml encoding of CitySim files**, please refer to the examples at (…)\CitySimPro\64-bit\Resources\exampleXmlFiles

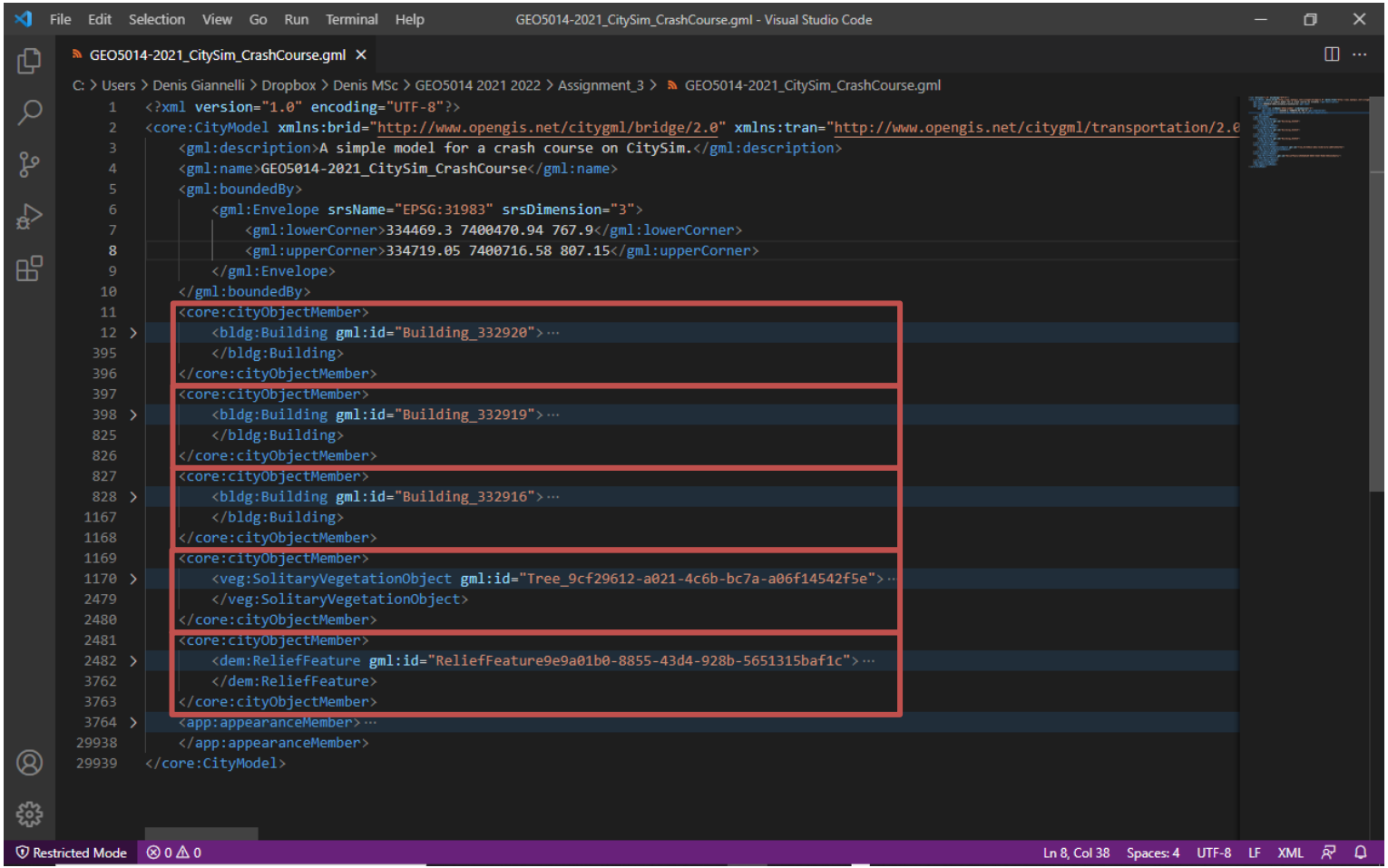
CitySim fundamentals

CitySim_CrashCourse.gml

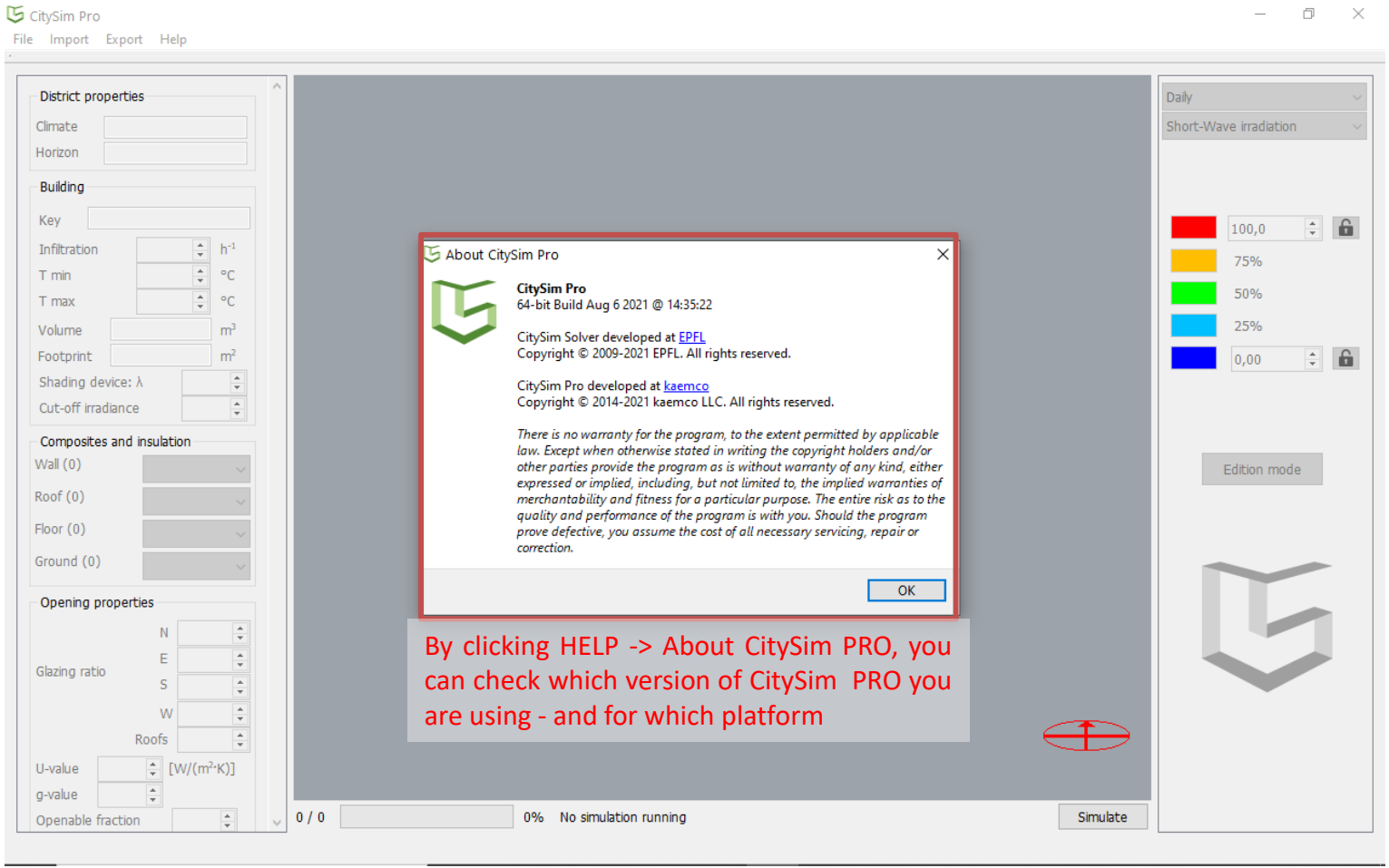


CitySim fundamentals

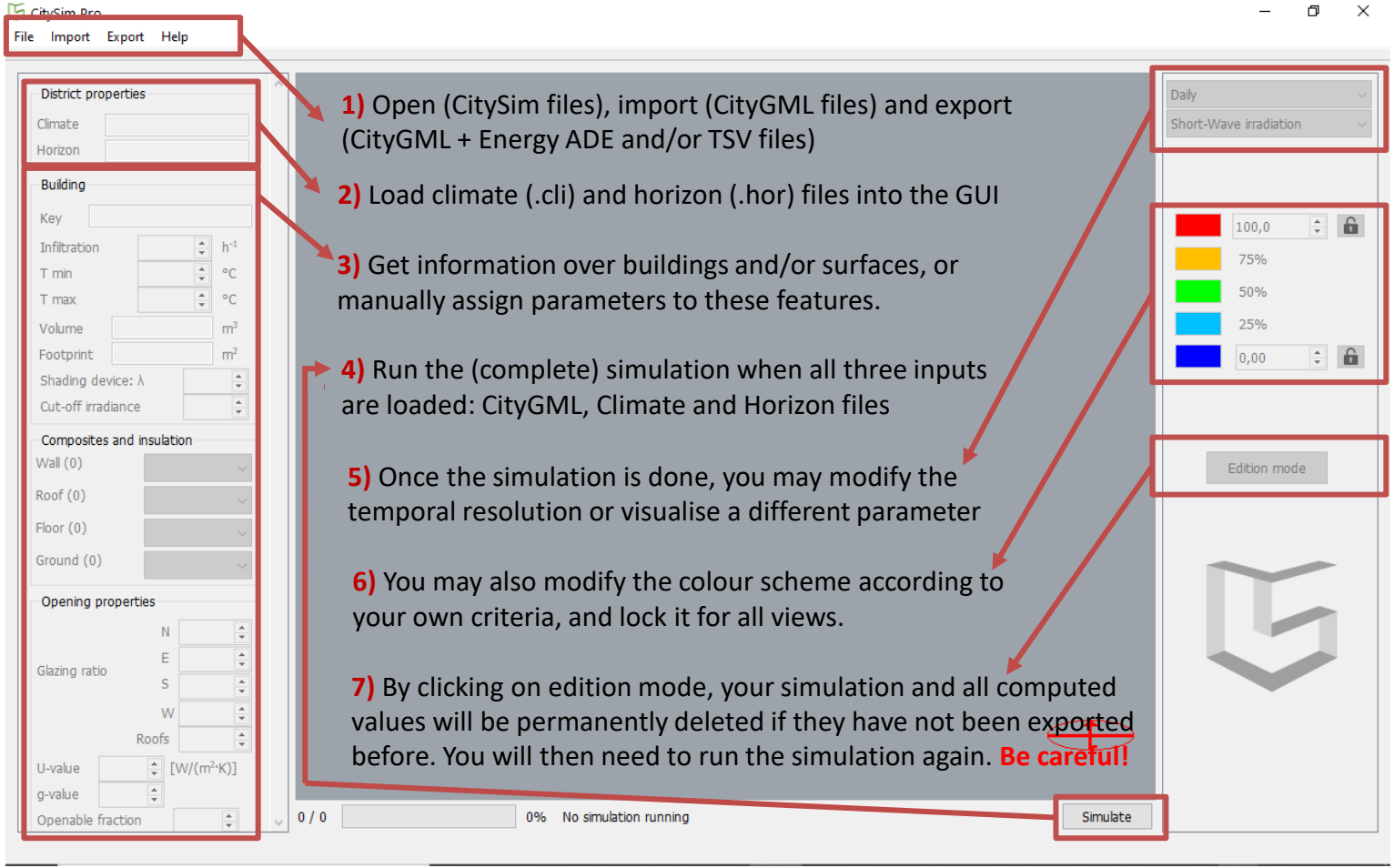
CitySim_CrashCourse.gml



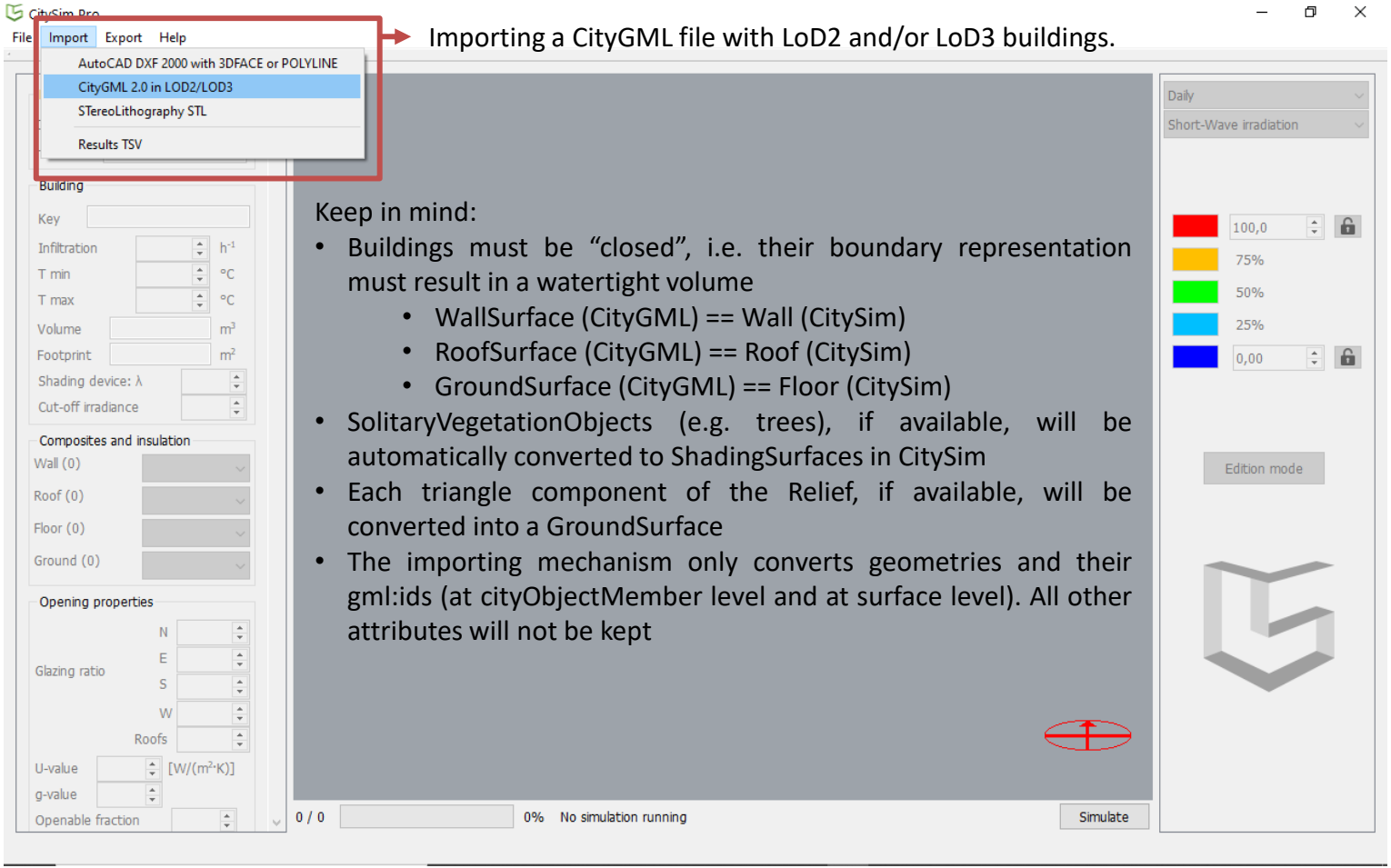
CitySim fundamentals



CitySim fundamentals



CitySim fundamentals

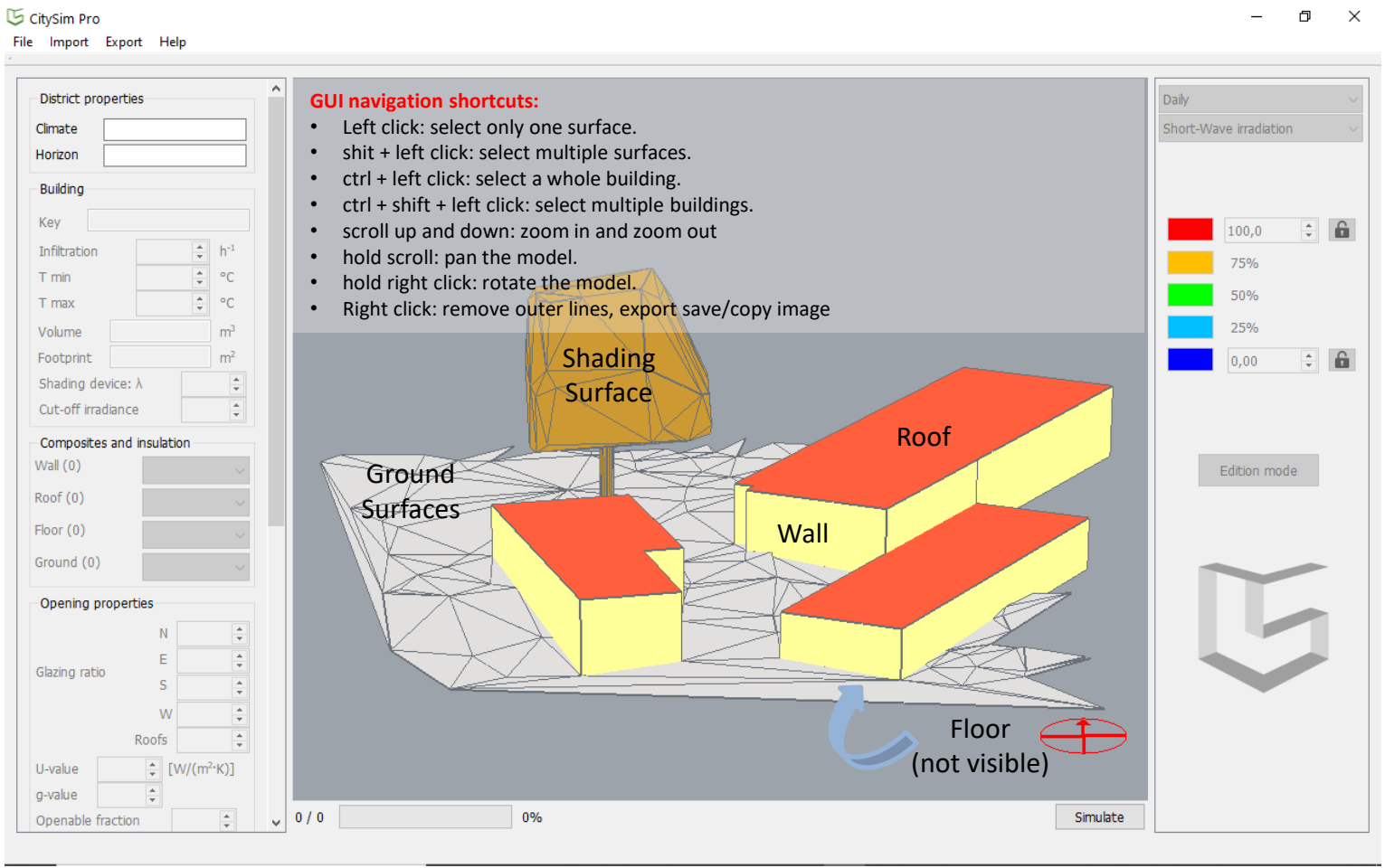


Importing a CityGML file with LoD2 and/or LoD3 buildings.

Keep in mind:

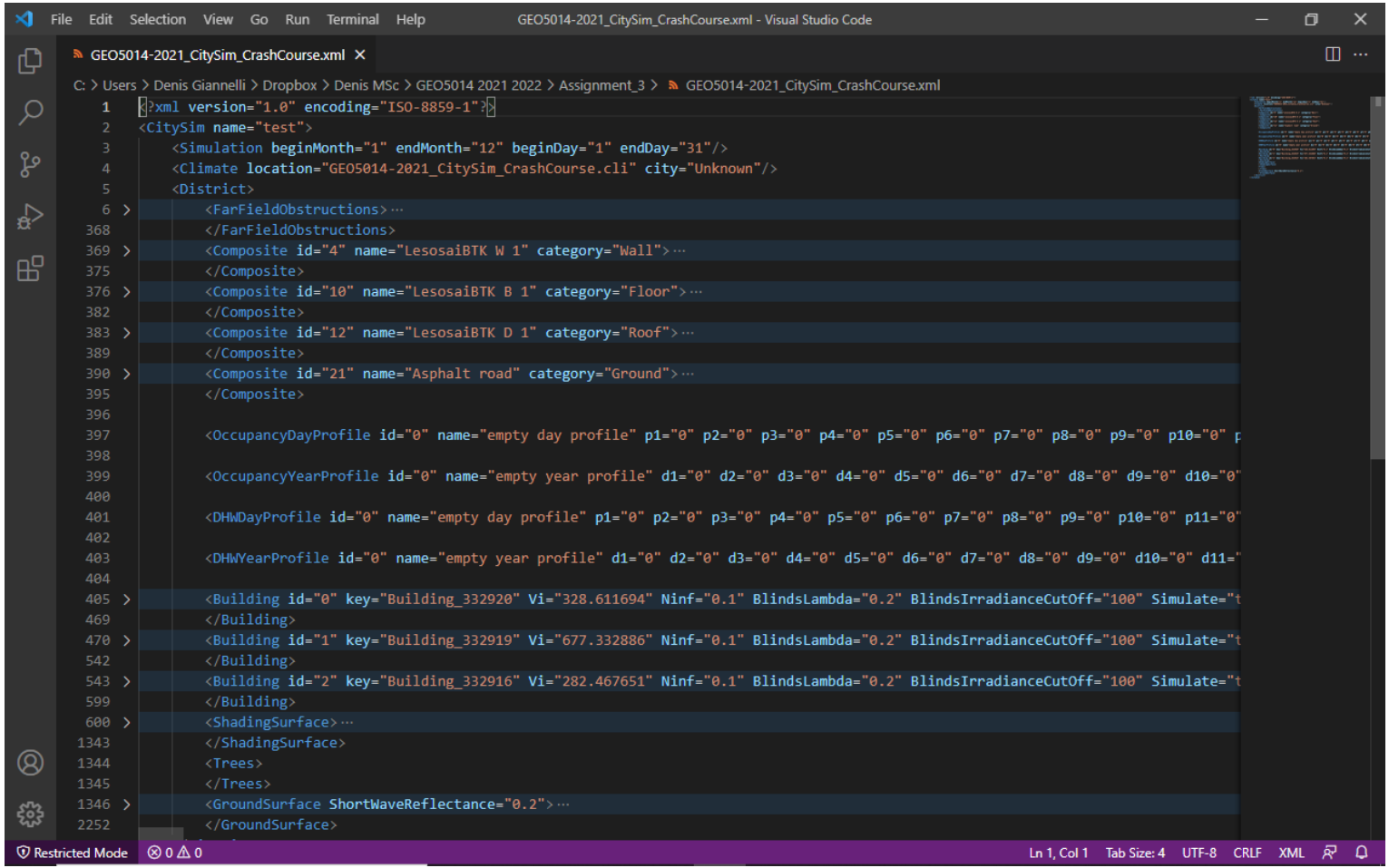
- Buildings must be "closed", i.e. their boundary representation must result in a watertight volume
  - WallSurface (CityGML) == Wall (CitySim)
  - RoofSurface (CityGML) == Roof (CitySim)
  - GroundSurface (CityGML) == Floor (CitySim)
- SolitaryVegetationObjects (e.g. trees), if available, will be automatically converted to ShadingSurfaces in CitySim
- Each triangle component of the Relief, if available, will be converted into a GroundSurface
- The importing mechanism only converts geometries and their gml:ids (at cityObjectMember level and at surface level). All other attributes will not be kept

CitySim fundamentals

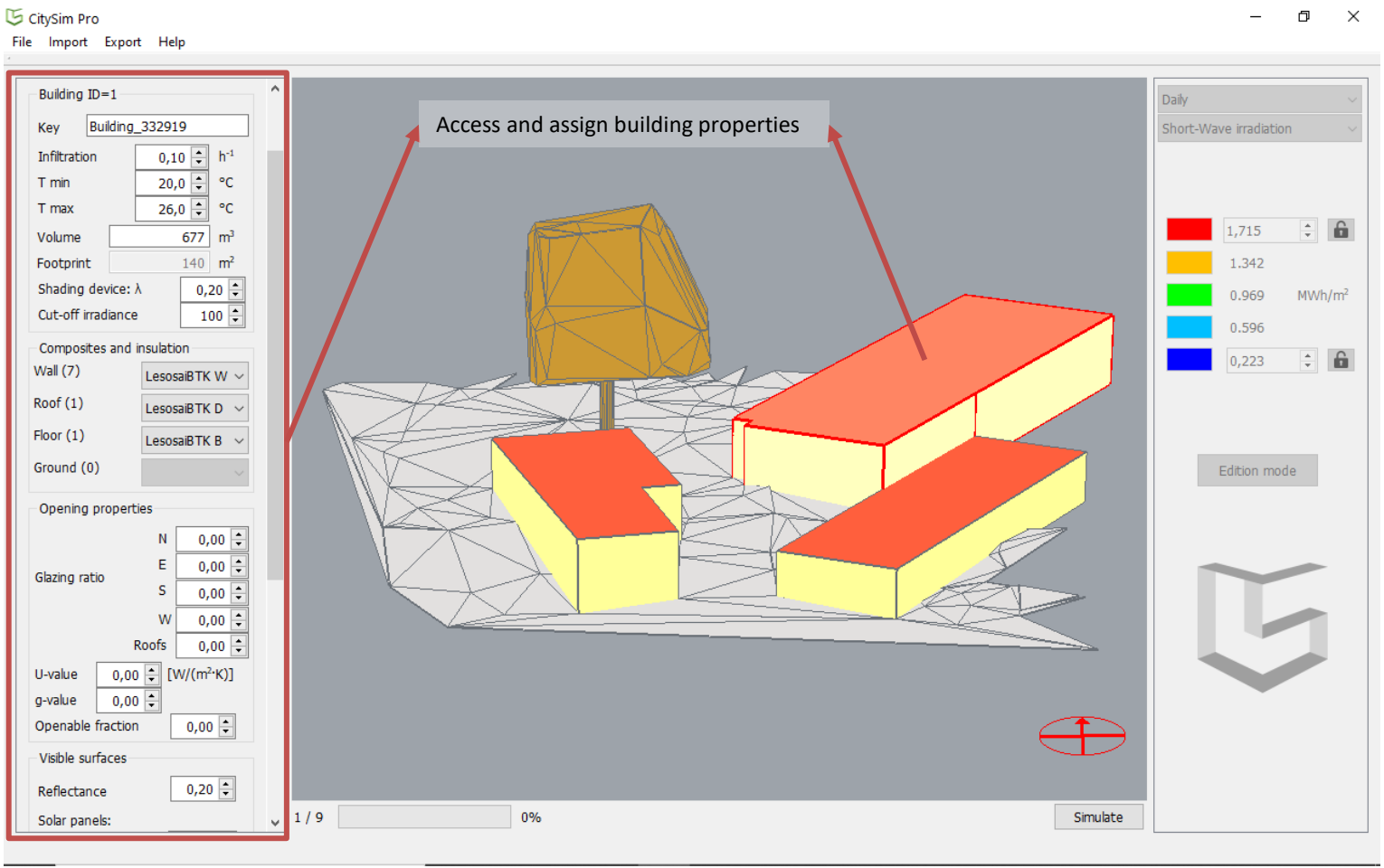


CitySim fundamentals

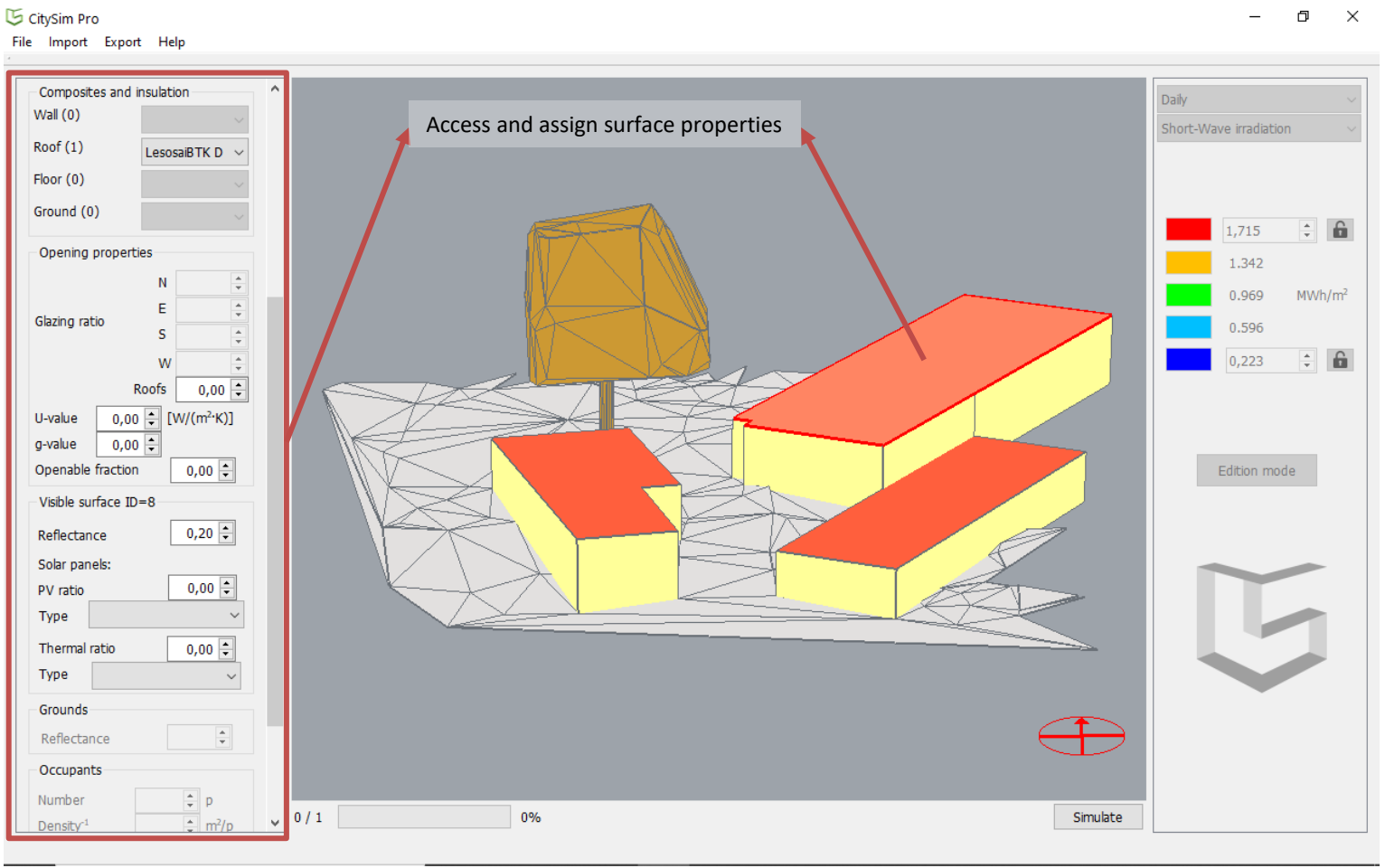
Take a moment to analyse an xml-encoded CitySim file



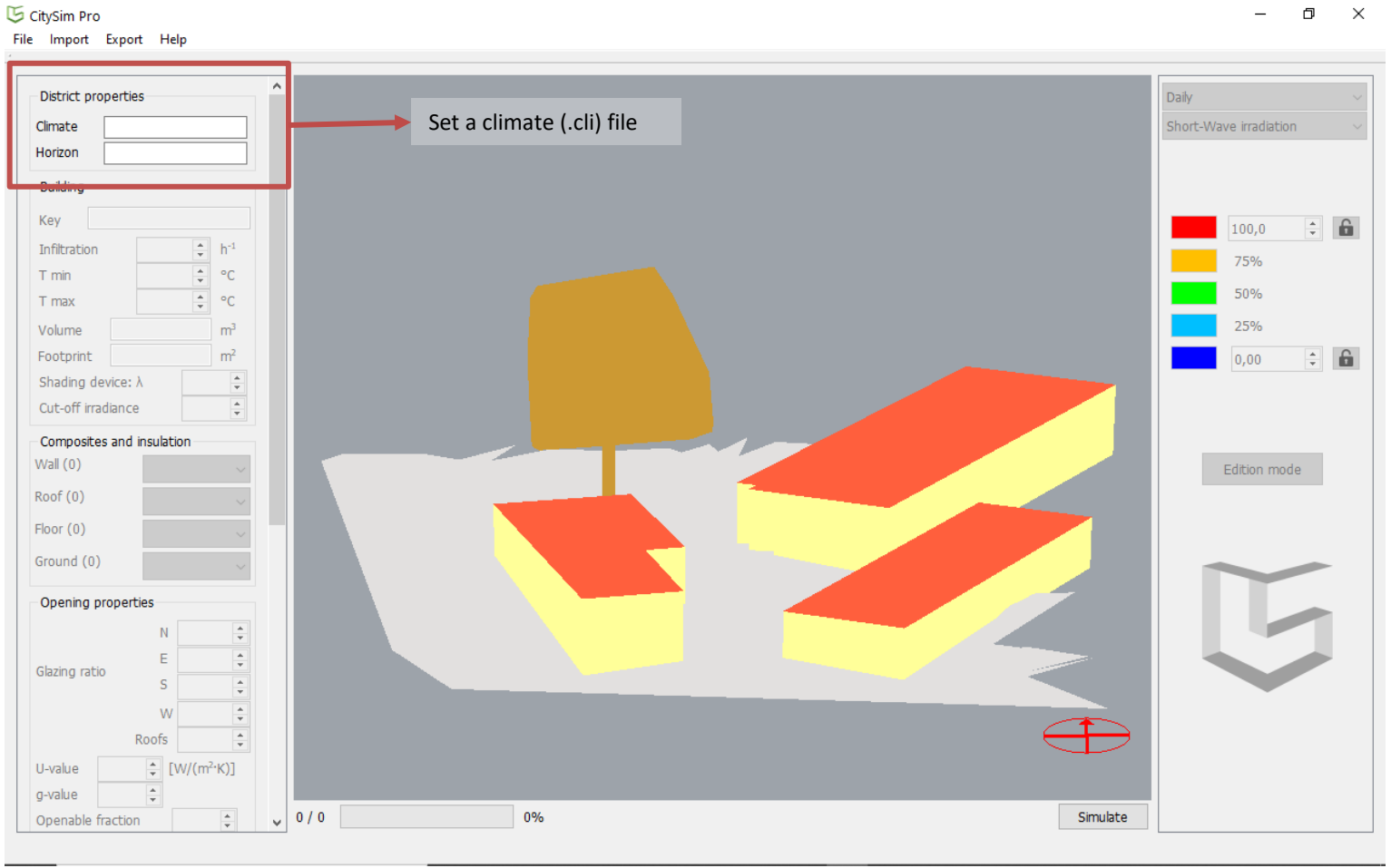
CitySim fundamentals



CitySim fundamentals

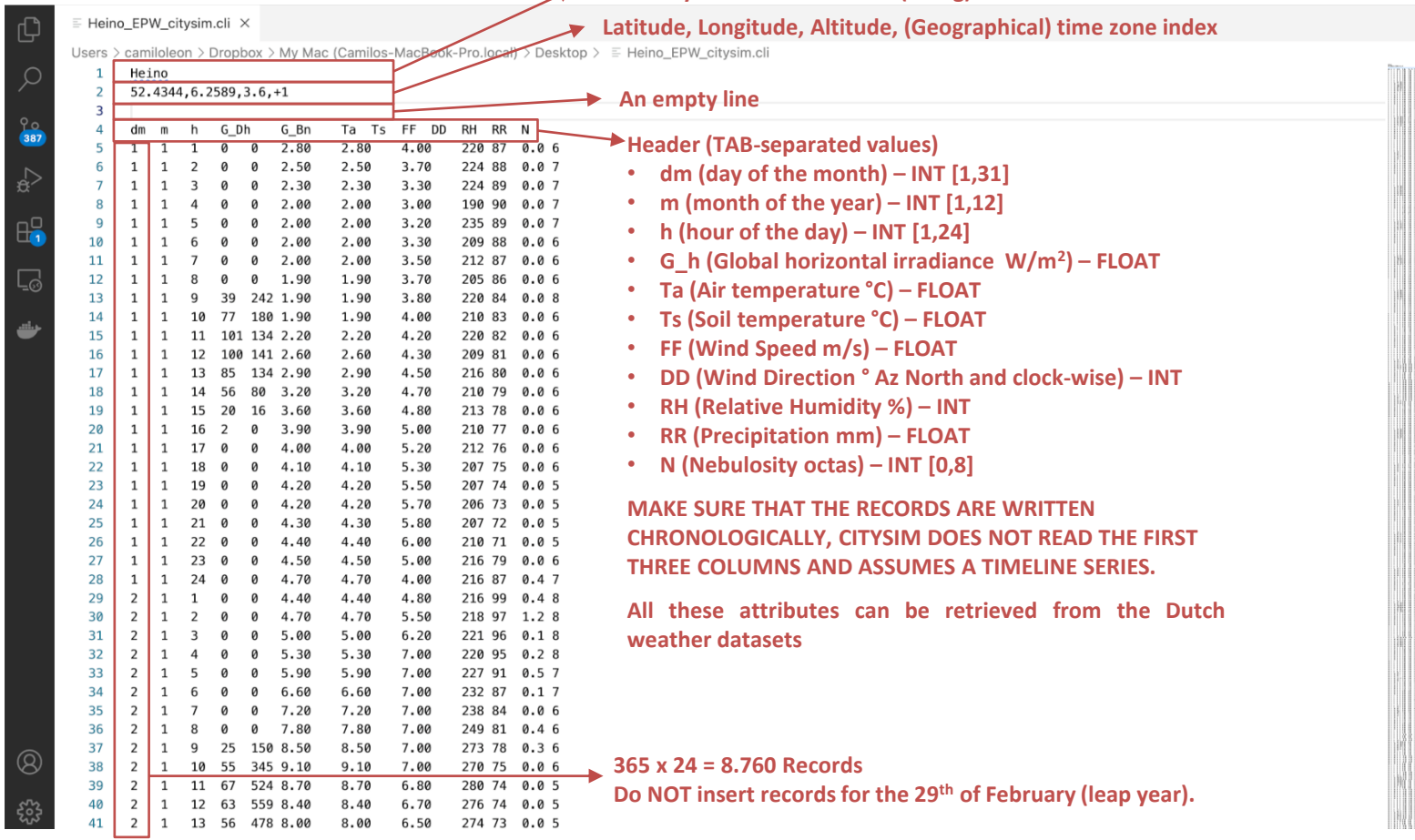


CitySim fundamentals



CitySim fundamentals

Structure of a climate file (.cli)



Name of your weather station (string)

Latitude, Longitude, Altitude, (Geographical) time zone index

An empty line

Header (TAB-separated values)

- dm (day of the month) – INT [1,31]
- m (month of the year) – INT [1,12]
- h (hour of the day) – INT [1,24]
- G_h (Global horizontal irradiance W/m^2) – FLOAT
- Ta (Air temperature °C) – FLOAT
- Ts (Soil temperature °C) – FLOAT
- FF (Wind Speed m/s) – FLOAT
- DD (Wind Direction ° Az North and clock-wise) – INT
- RH (Relative Humidity %) – INT
- RR (Precipitation mm) – FLOAT
- N (Nebulosity octas) – INT [0,8]

MAKE SURE THAT THE RECORDS ARE WRITTEN CHRONOLOGICALLY, CITYSIM DOES NOT READ THE FIRST THREE COLUMNS AND ASSUMES A TIMELINE SERIES.

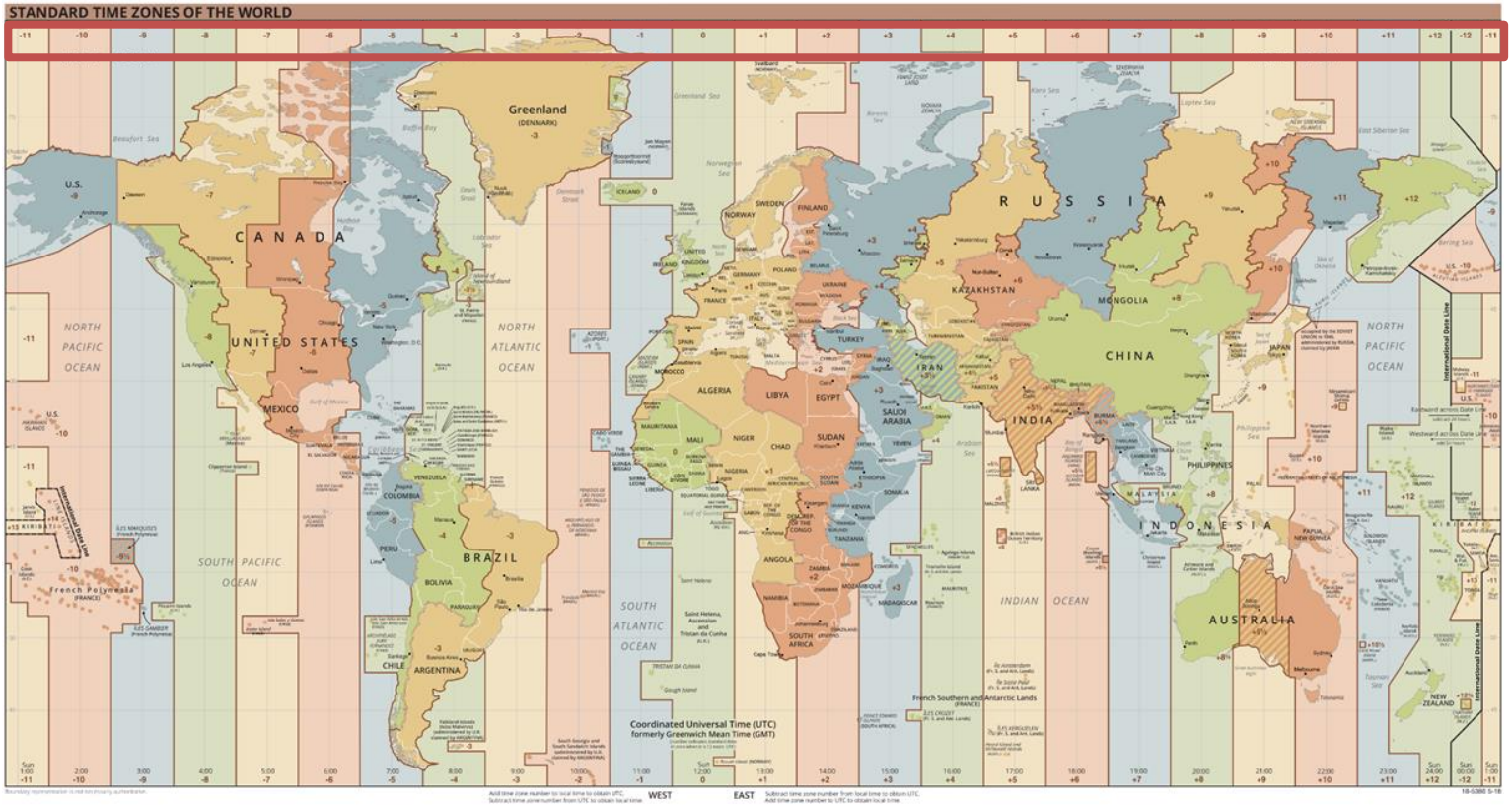
All these attributes can be retrieved from the Dutch weather datasets

365 x 24 = 8.760 Records

Do NOT insert records for the 29th of February (leap year).

CitySim fundamentals

Latitude, Longitude, Altitude, time zone index



Watch out! Some countries have a time zone that does not correspond to the actual geographical time zone (e.g. Argentina, Spain, etc.)

CitySim fundamentals

Weather data (according to Meteonorm)

If
- Beam (solar) normal irradiance (G_Bn)

AND
- Diffuse horizontal irradiance (G_Dh)

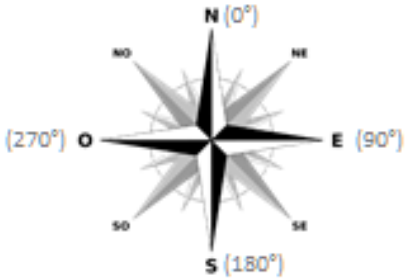
are known, then you may substitute
- Global horizontal irradiance (G_h)

with these two for a more accurate algorithm

Payerne
46.8116 6.9424 490 1

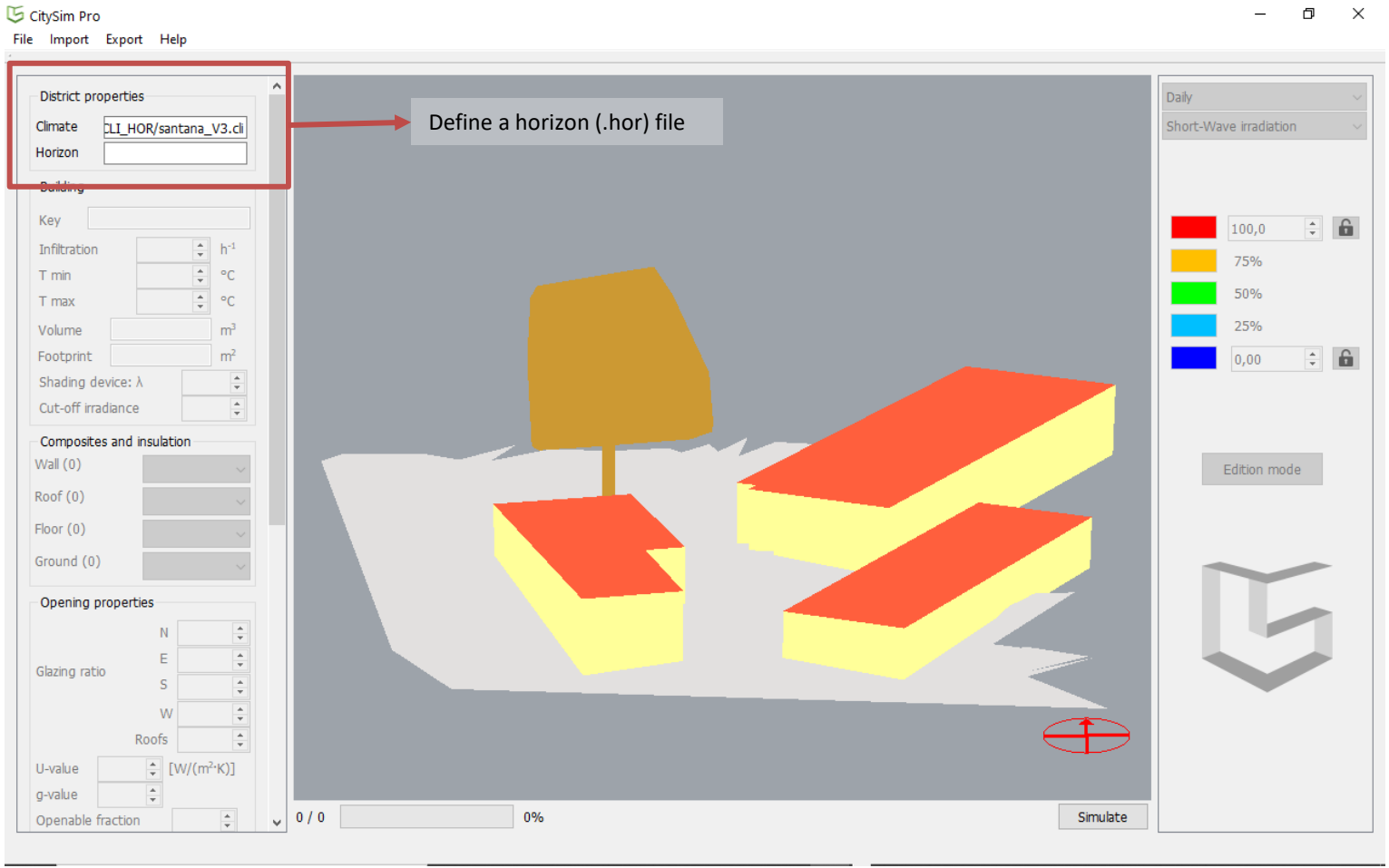
m	dm	h	ST	Az	hs	G_Bn	G_Dh	Ta	FF	DD	RH
1	1	1	23.91	-177	0	0	0	8.6	0.8	173	74
1	1	2	0.91	-150.2	0	0	0	8.3	0.4	252	76
1	1	3	1.91	-125.6	0	0	0	8	0.3	249	74

- m: month [1..12]
- dm: day of the month [1..31]
- h: hour [1..24]
- Ta: air temperature (°C)
- FF: wind speed (m/s)
- DD: wind direction (**azimuth from North, clockwise**)

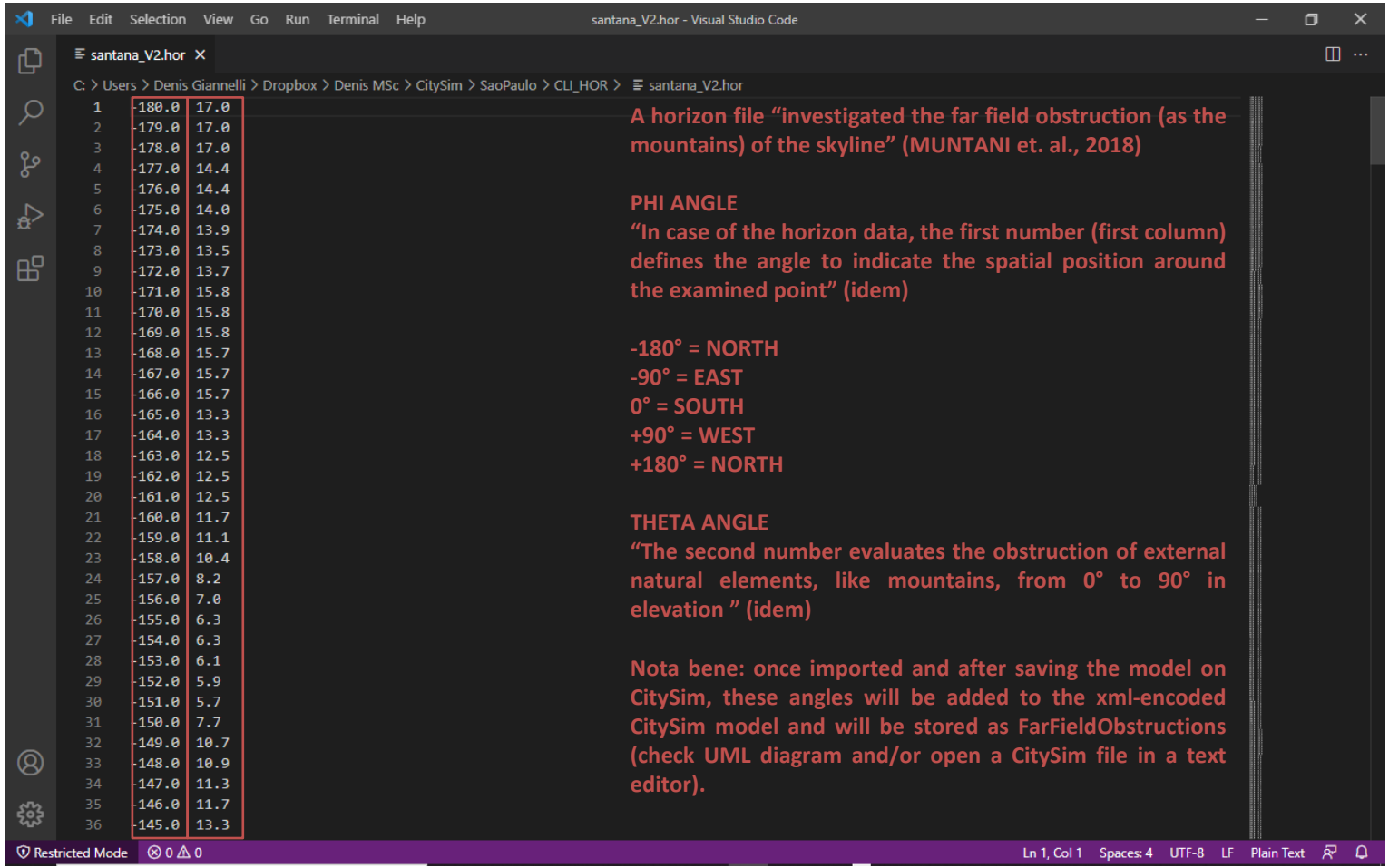


For more information:
https://docs.google.com/document/d/1NyWL9Oe6eQ0XPYGqRrzgT3p0sgg4zbCXirxFsQ-sdGk/edit

CitySim fundamentals



CitySim fundamentals



CitySim fundamentals

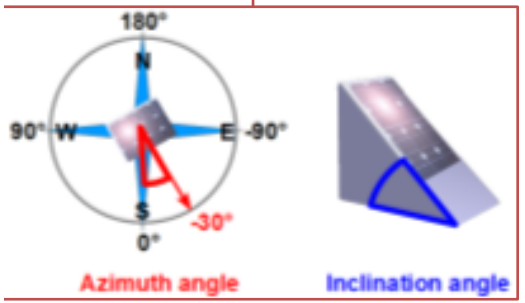
Solar irradiance on a surface (according to Meteonorm)

WATCH OUT! Look here how to encode phi and theta values in a .HOR file

Payerne
46.8116 6.9424 490 1

m	dm	h	ST	Az	hs	G_Bn	G_Dh	Ta	FF	DD	RH
1	1	1	23.91	-177	0	0	0	8.6	0.8	173	74
1	1	2	0.91	-150.2	0	0	0	8.3	0.4	252	76
1	1	3	1.91	-125.6	0	0	0	8	0.3	249	74

- Az: azimuth of the sun position (**from South, clockwise**)
- hs: height (vertical angle) of the sun (from the horizontal plane)
- G_Bn: Direct (Beam) solar normal irradiance (W/m^2)
- G_Dn: Diffuse (i.e. Sky without sun) solar irradiance on the horizontal plane (W/m^2)



For more information:
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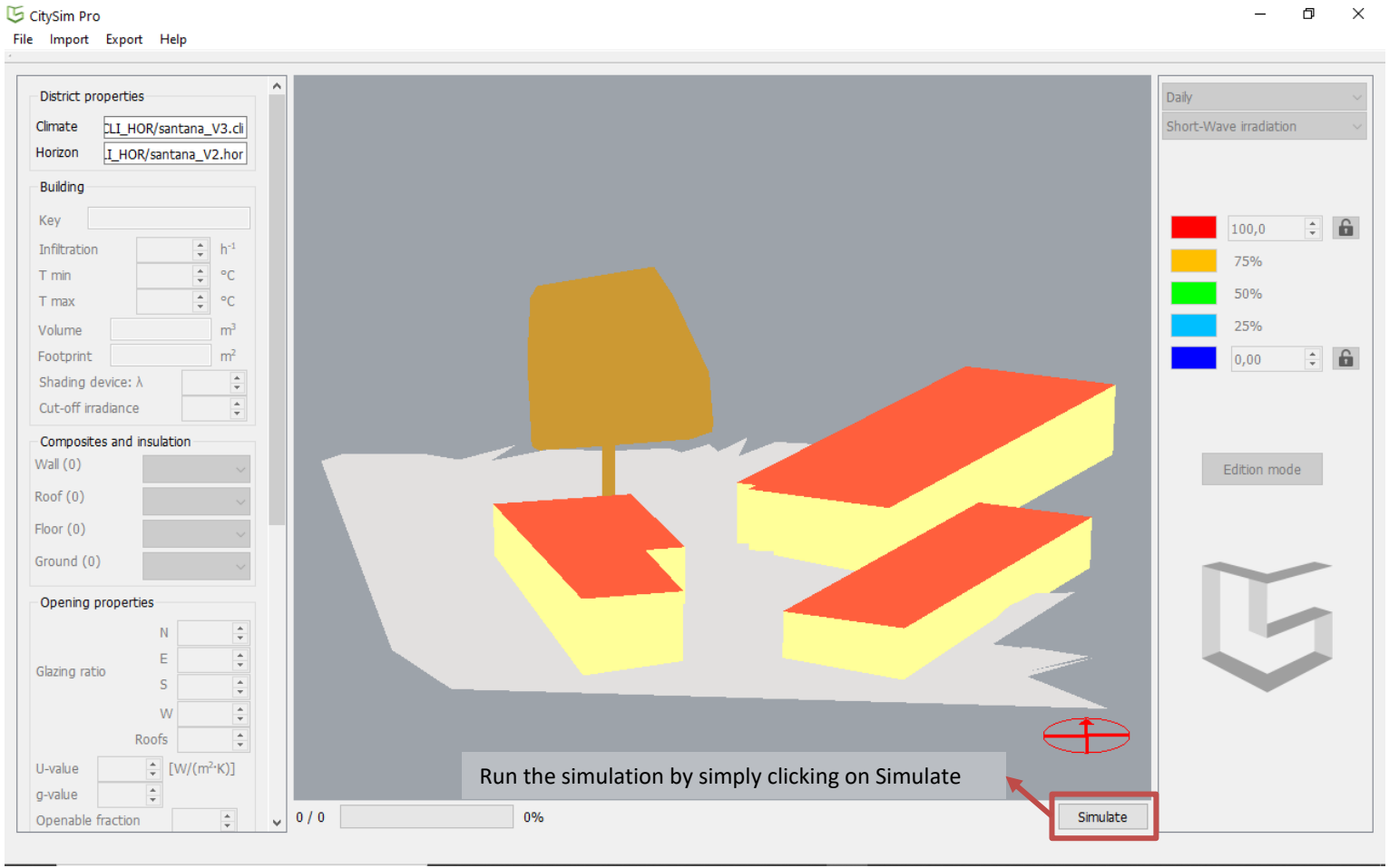
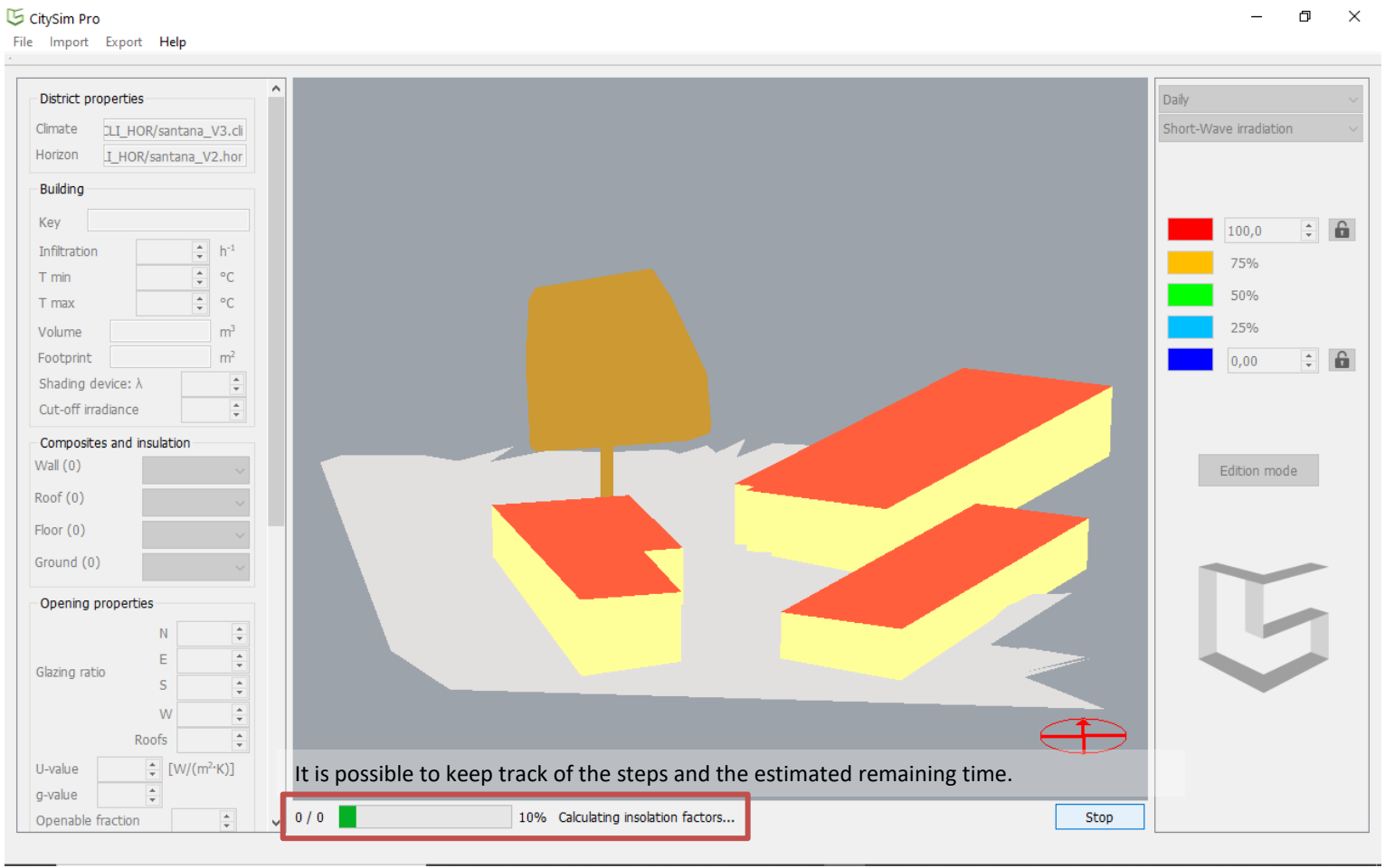
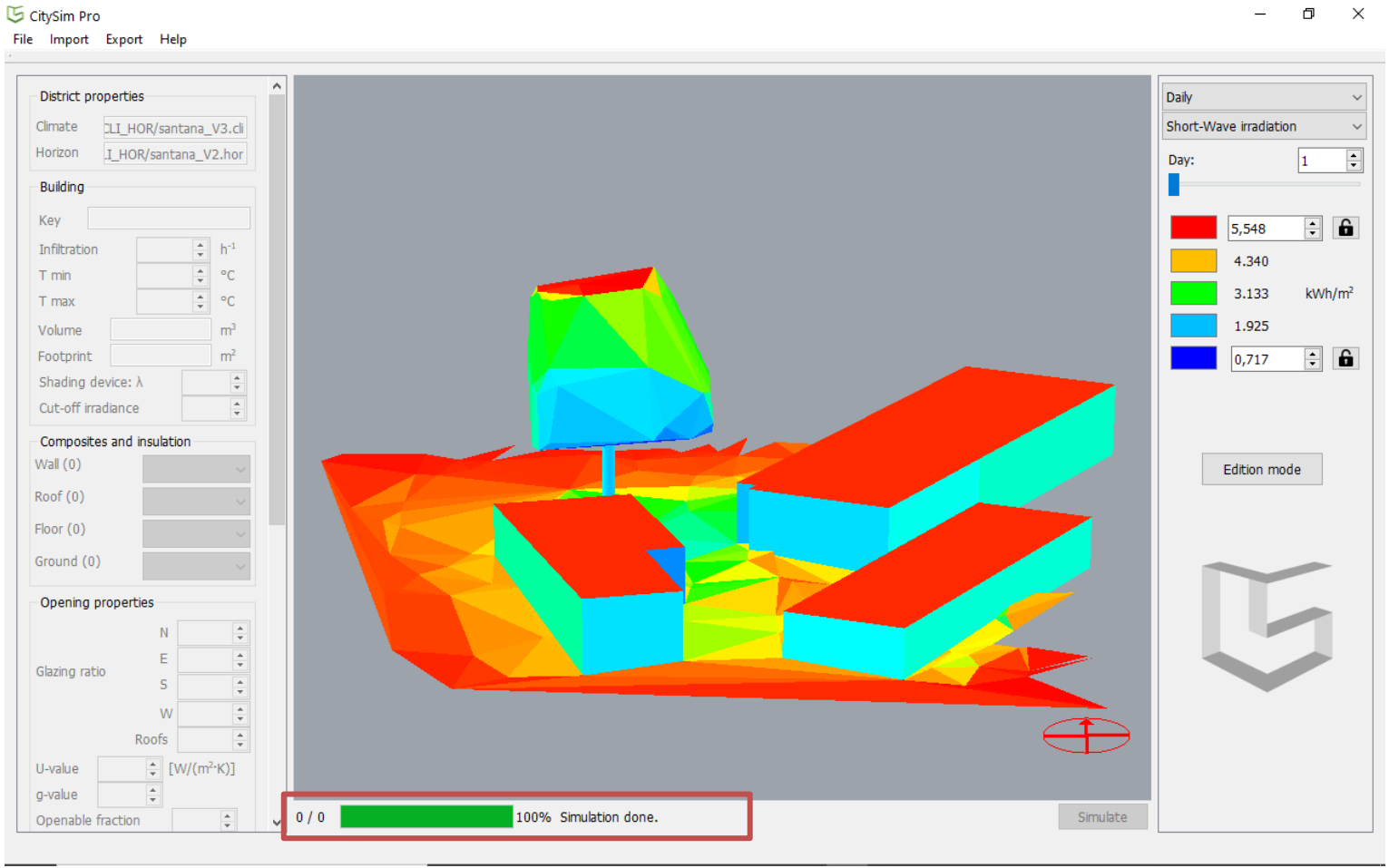
CitySim fundamentals



CitySim fundamentals



CitySim fundamentals



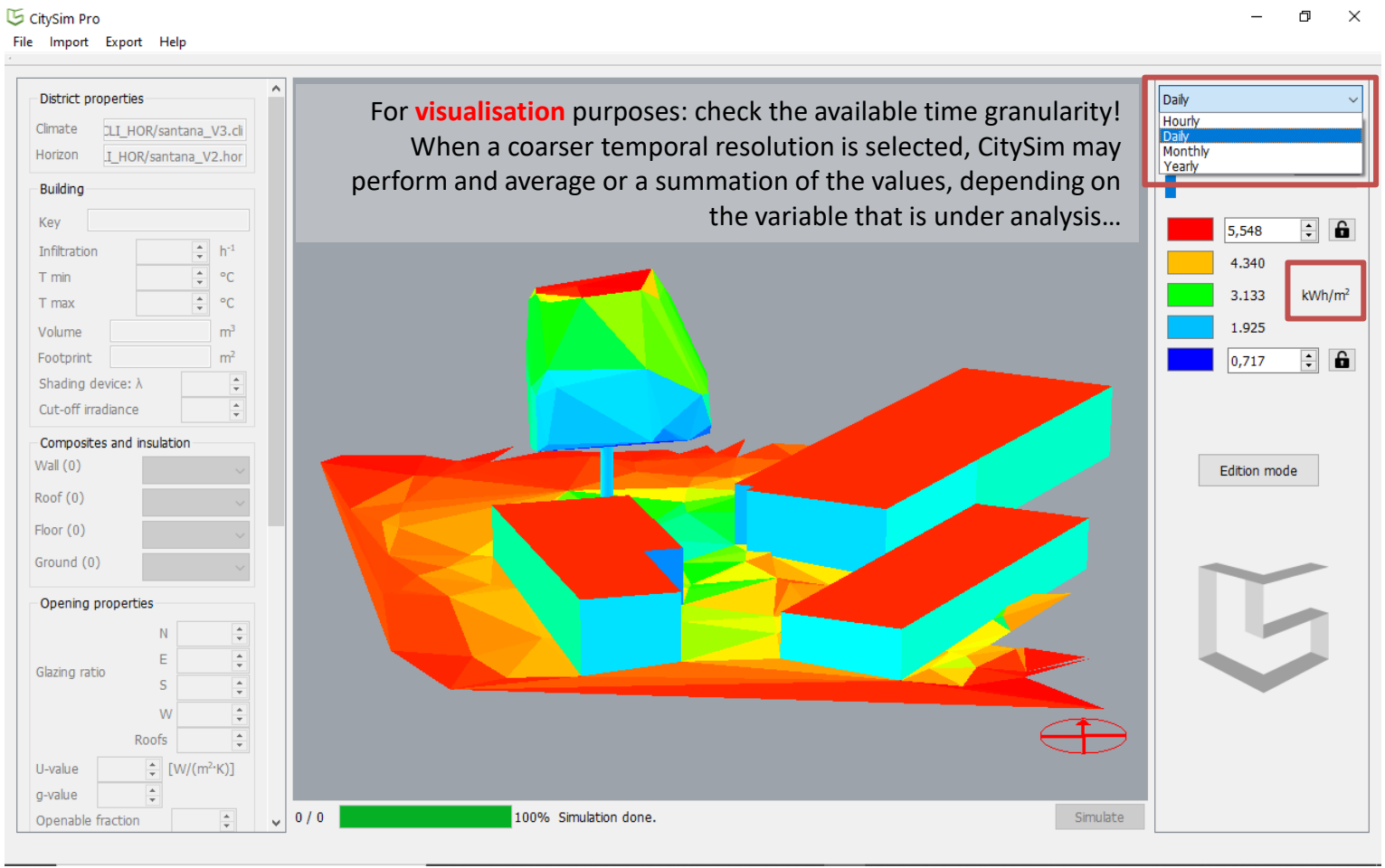
CitySim fundamentals

IMPORTANT!

1) As soon as the simulation is successfully completed, **save immediately** the results as TSV files and – optionally – as CityGML (+ Energy ADE)

2) Once the results are stored, you do not need to run the simulation again to explore the results in the GUI. If CitySim crashes, you can simply re-open it and load the stored results!

CitySim fundamentals



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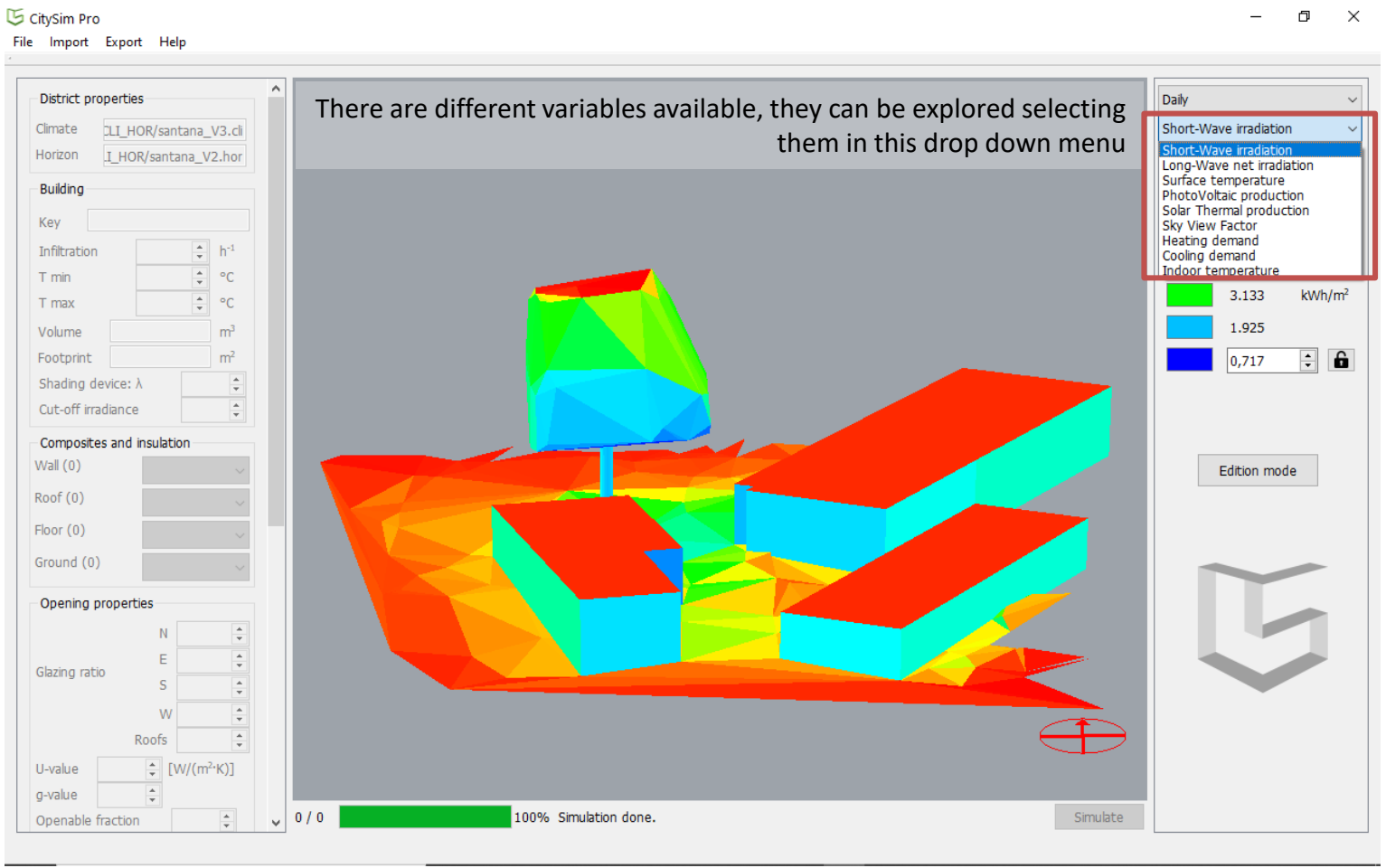
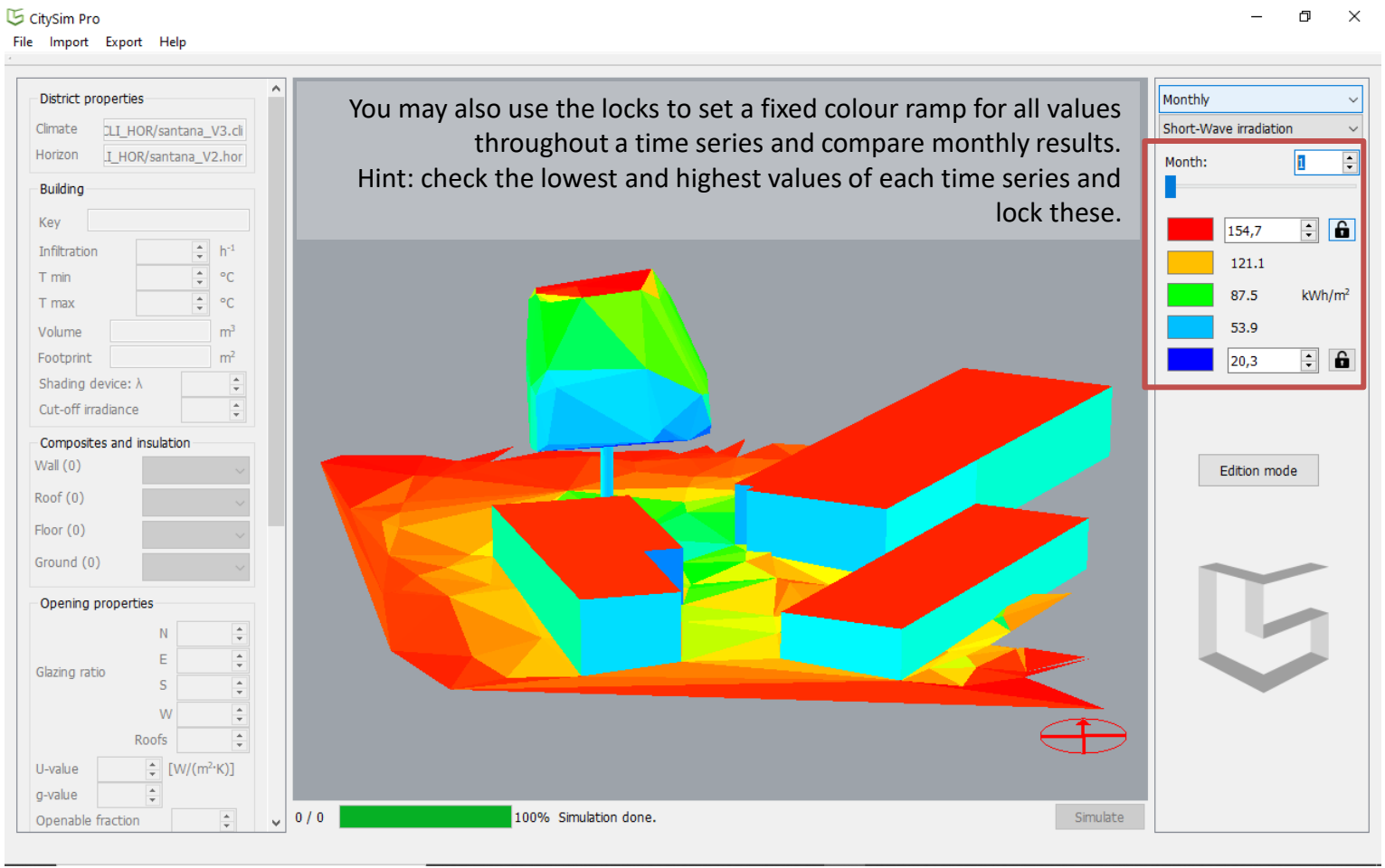
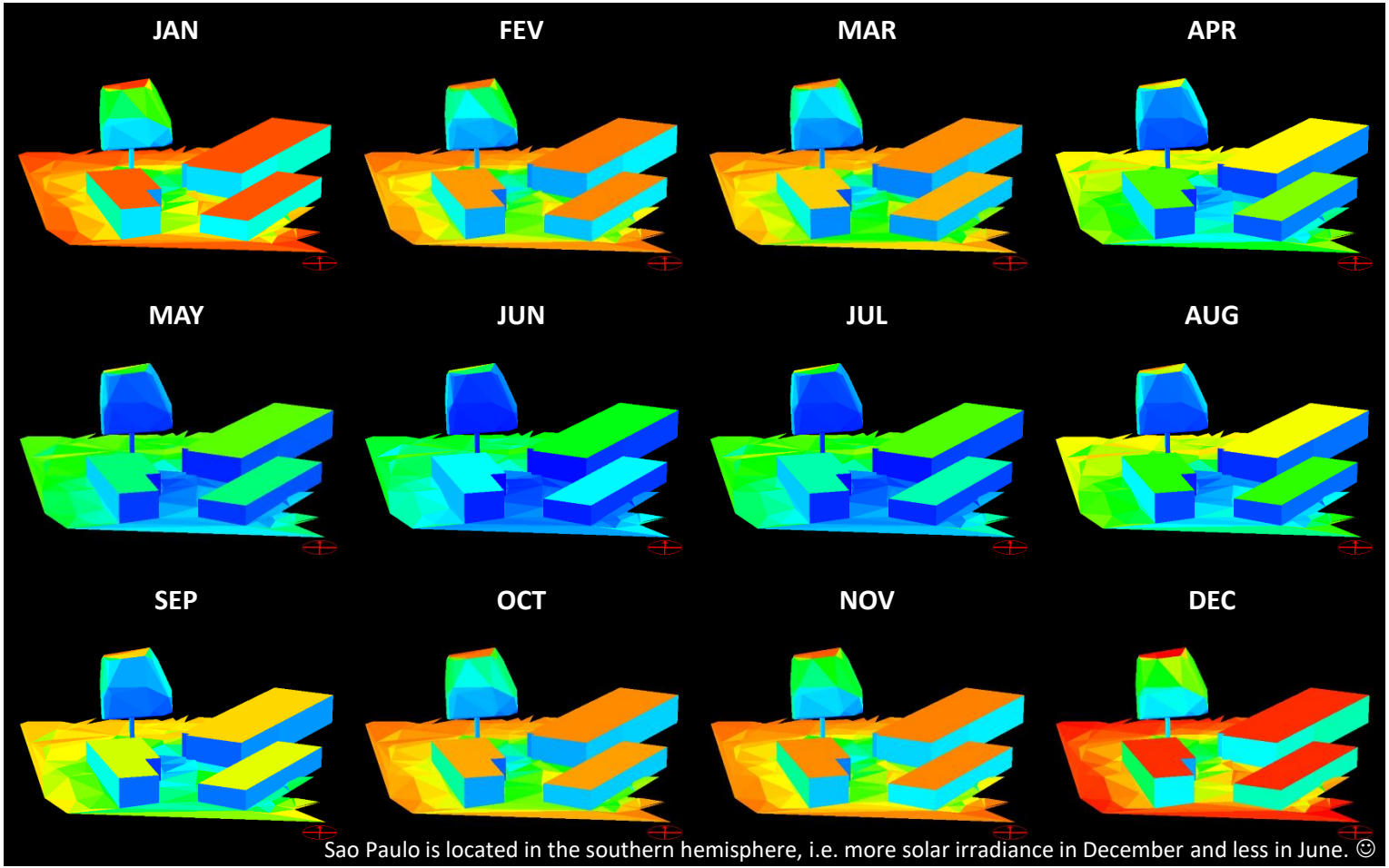


CitySim fundamentals

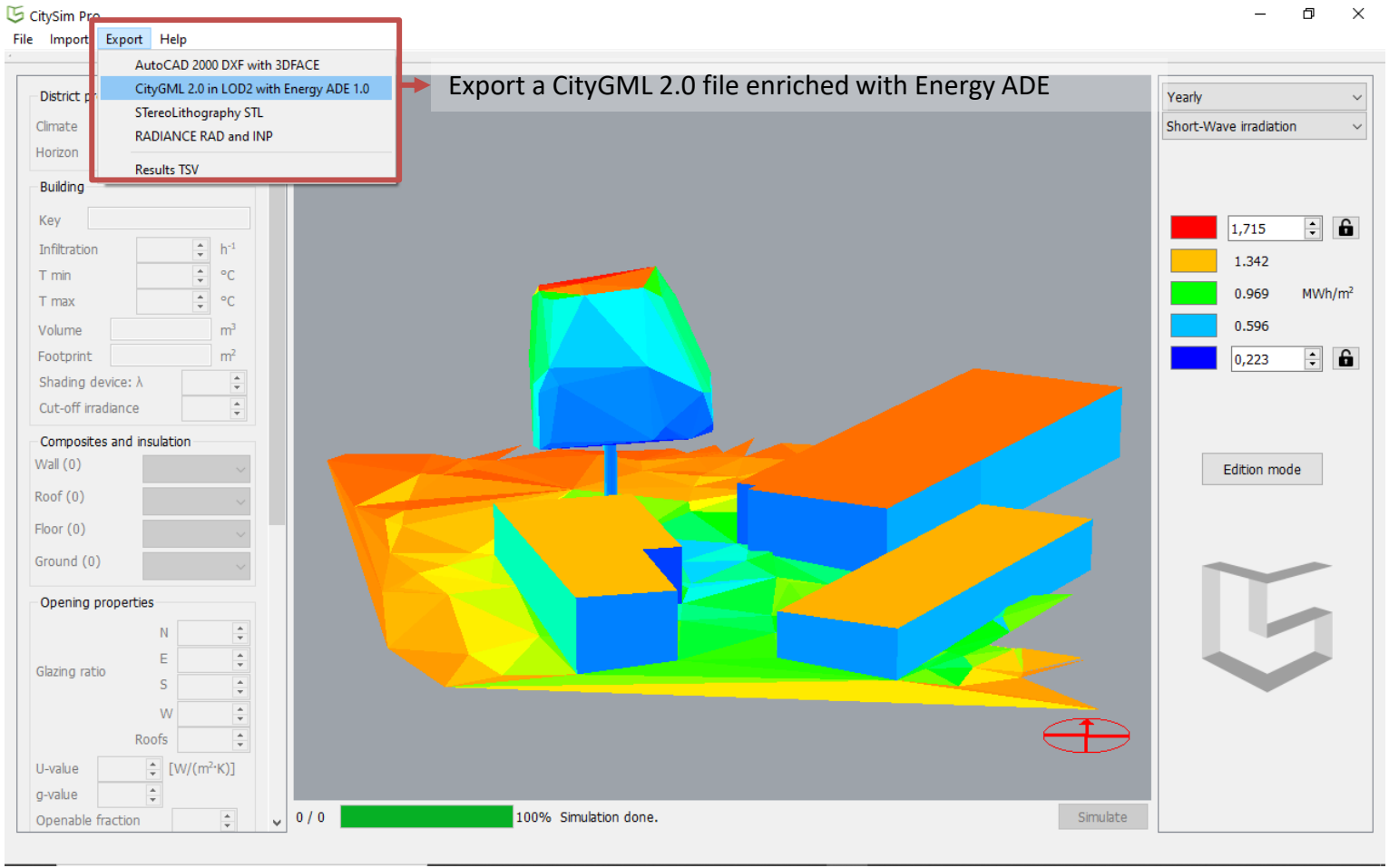


CitySim fundamentals

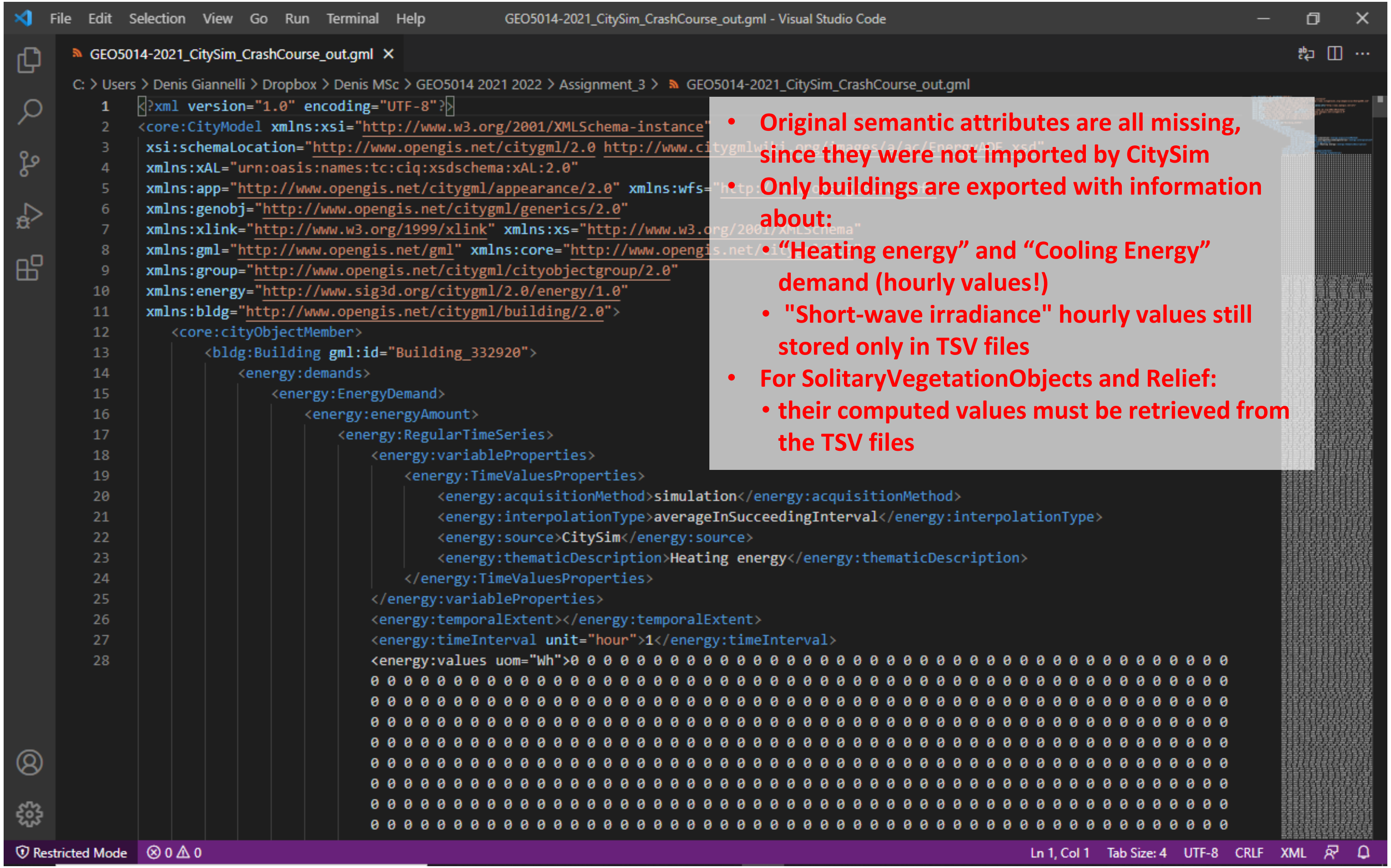


Sao Paulo is located in the southern hemisphere, i.e. more solar irradiance in December and less in June. ☺

CitySim fundamentals

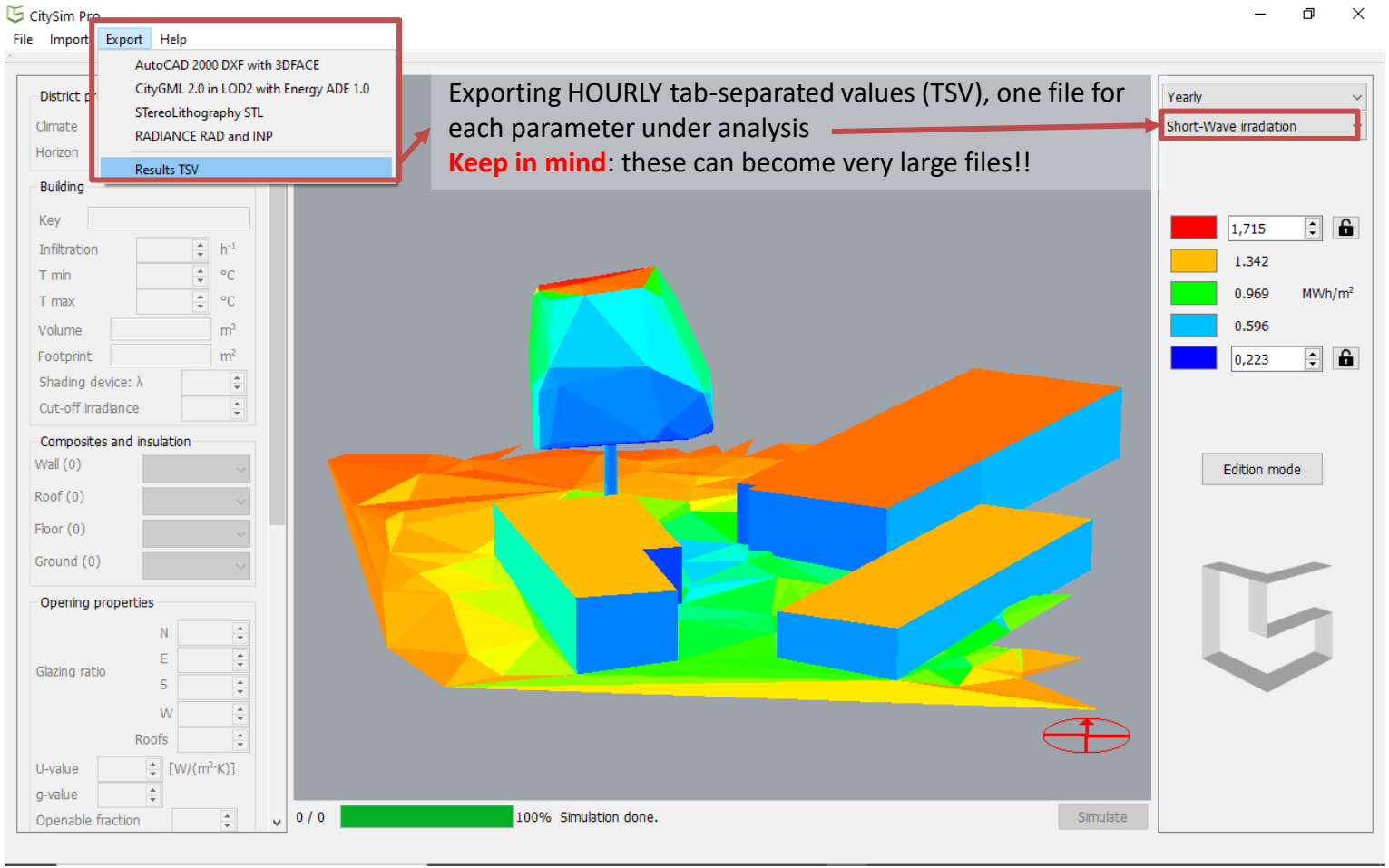


CitySim fundamentals



- Original semantic attributes are all missing, since they were not imported by CitySim
- Only buildings are exported with information about:
  - "Heating energy" and "Cooling Energy" demand (hourly values!)
  - "Short-wave irradiance" hourly values still stored only in TSV files
- For SolitaryVegetationObjects and Relief:
  - their computed values must be retrieved from the TSV files

CitySim fundamentals



CitySim fundamentals

The chosen directory will contain several TSV files, one of which stores short-wave (SW) irradiation values

Name	Date Modified	Size	Kind
Rijssen_statusQuo_CitySim_input_NoDTM.gml	2 September 2022 at 15:14	8,5 MB	GML document
Rijssen_statusQuo_CitySim_input_NoDTM_YearlyResultsPerBuilding.out	2 September 2022 at 15:14	2 KB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_YearlyResults.out	2 September 2022 at 15:14	387 bytes	Document
Rijssen_statusQuo_CitySim_input_NoDTM_Inertia.out	2 September 2022 at 15:14	3 KB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_Area.out	2 September 2022 at 15:14	3 KB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_ClimaticData.out	2 September 2022 at 15:14	420 KB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_CM.out	2 September 2022 at 15:14	9 KB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_ET.out	2 September 2022 at 15:14	9 KB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_HC.out	2 September 2022 at 15:14	53,9 MB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_TS.out	2 September 2022 at 15:14	58,7 MB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_TH.out	2 September 2022 at 15:13	16,7 MB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_LW.out	2 September 2022 at 15:13	69,4 MB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_DL.out	2 September 2022 at 15:13	86,9 MB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_SWv.out	2 September 2022 at 15:12	34,9 MB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_SW.out	2 September 2022 at 15:11	42,8 MB	Document
Rijssen_statusQuo_CitySim_input_NoDTM_VF.out	2 September 2022 at 15:10	79 KB	Document
Rijssen_statusQuo_CitySim_input_NoDTM.stl	2 September 2022 at 15:09	278 KB	Surface...esh File
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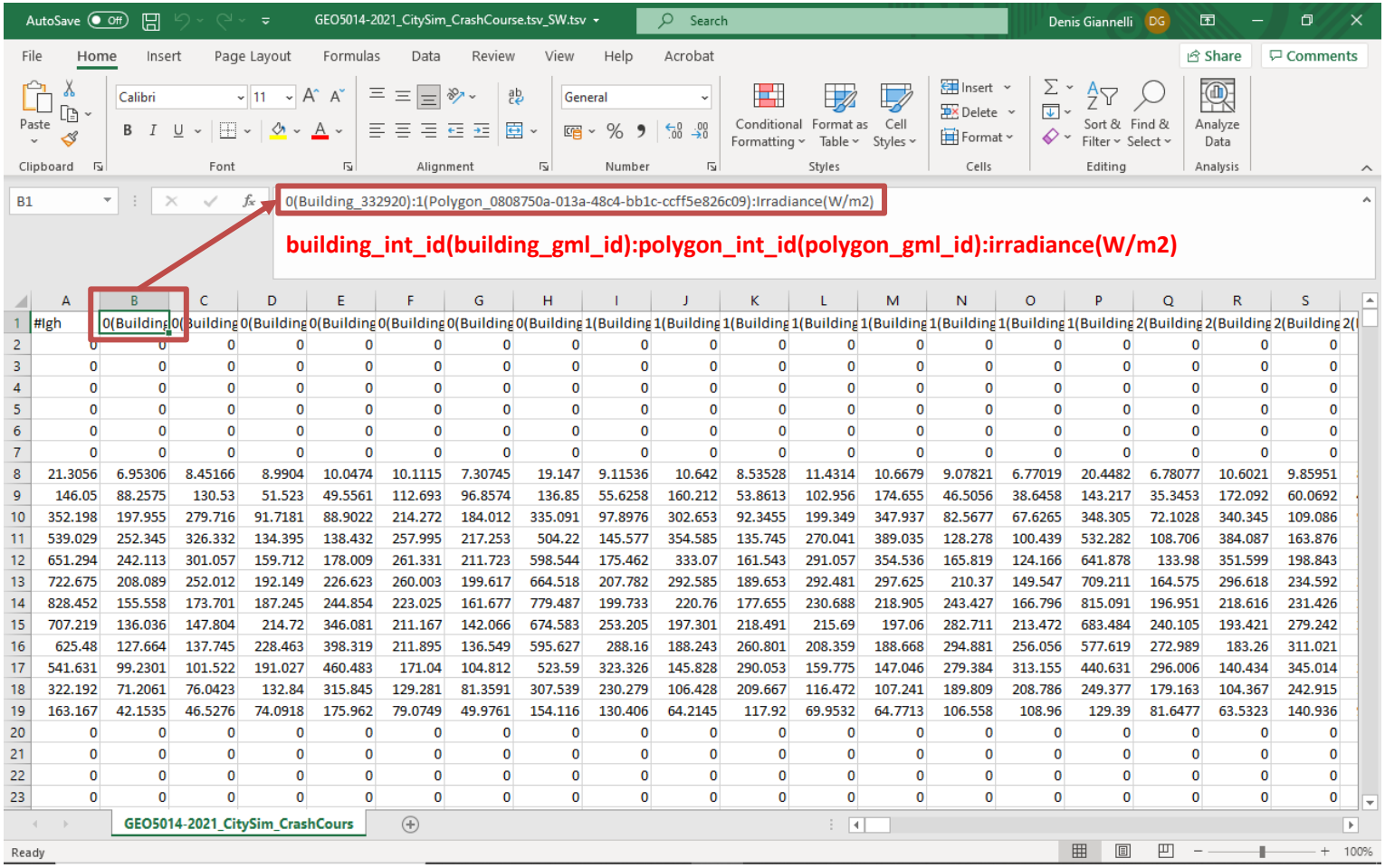
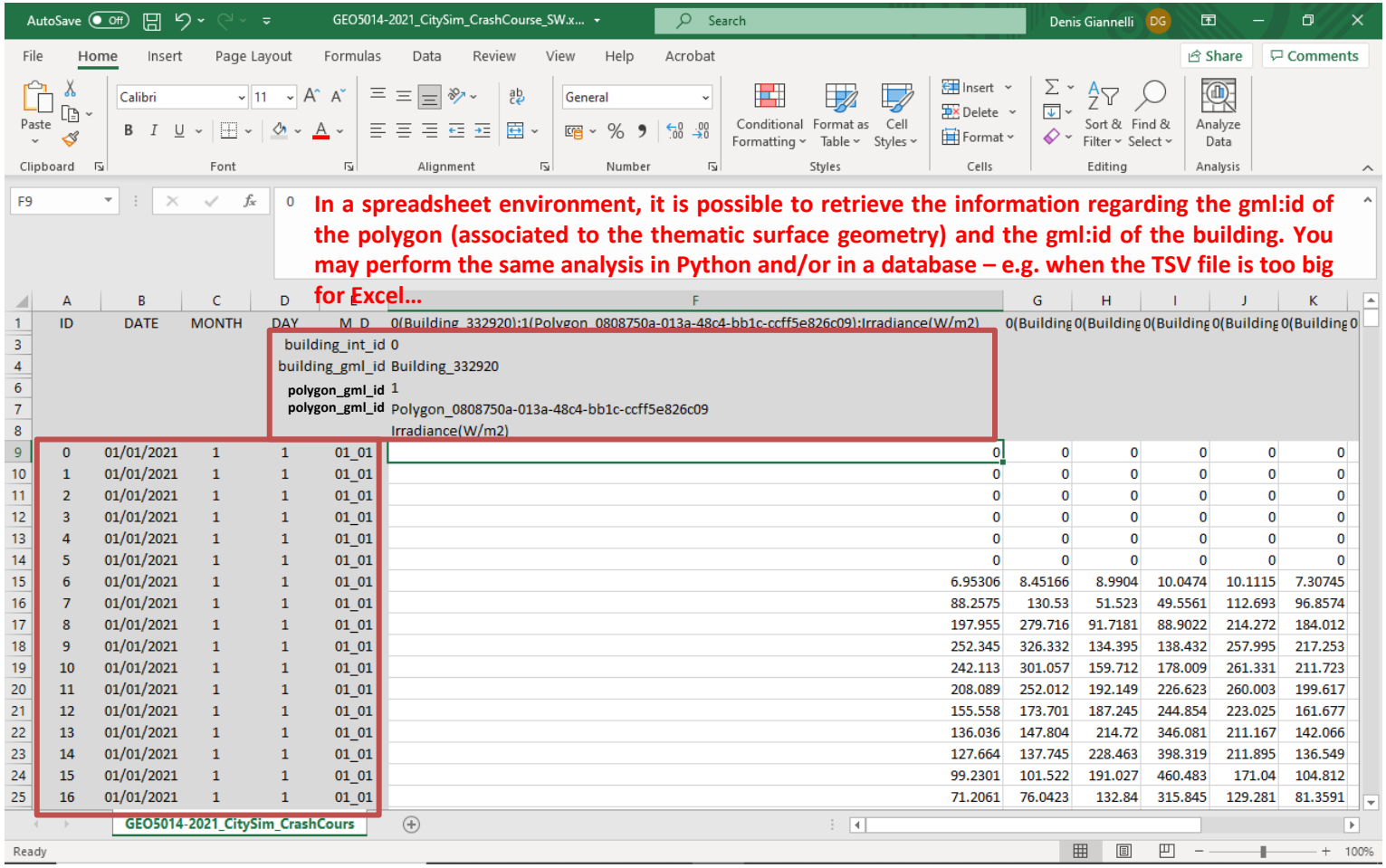
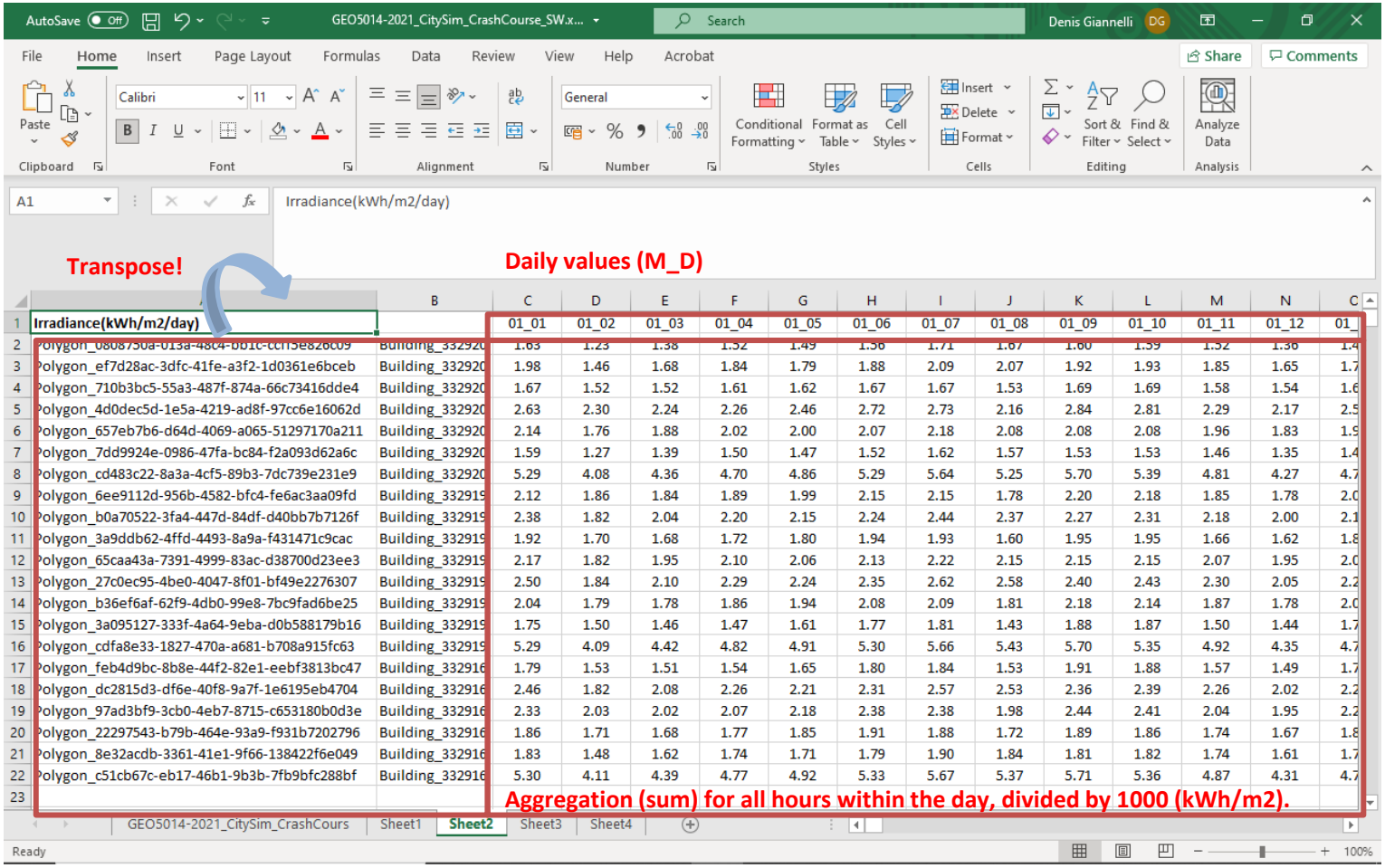
CitySim fundamentals



CitySim fundamentals

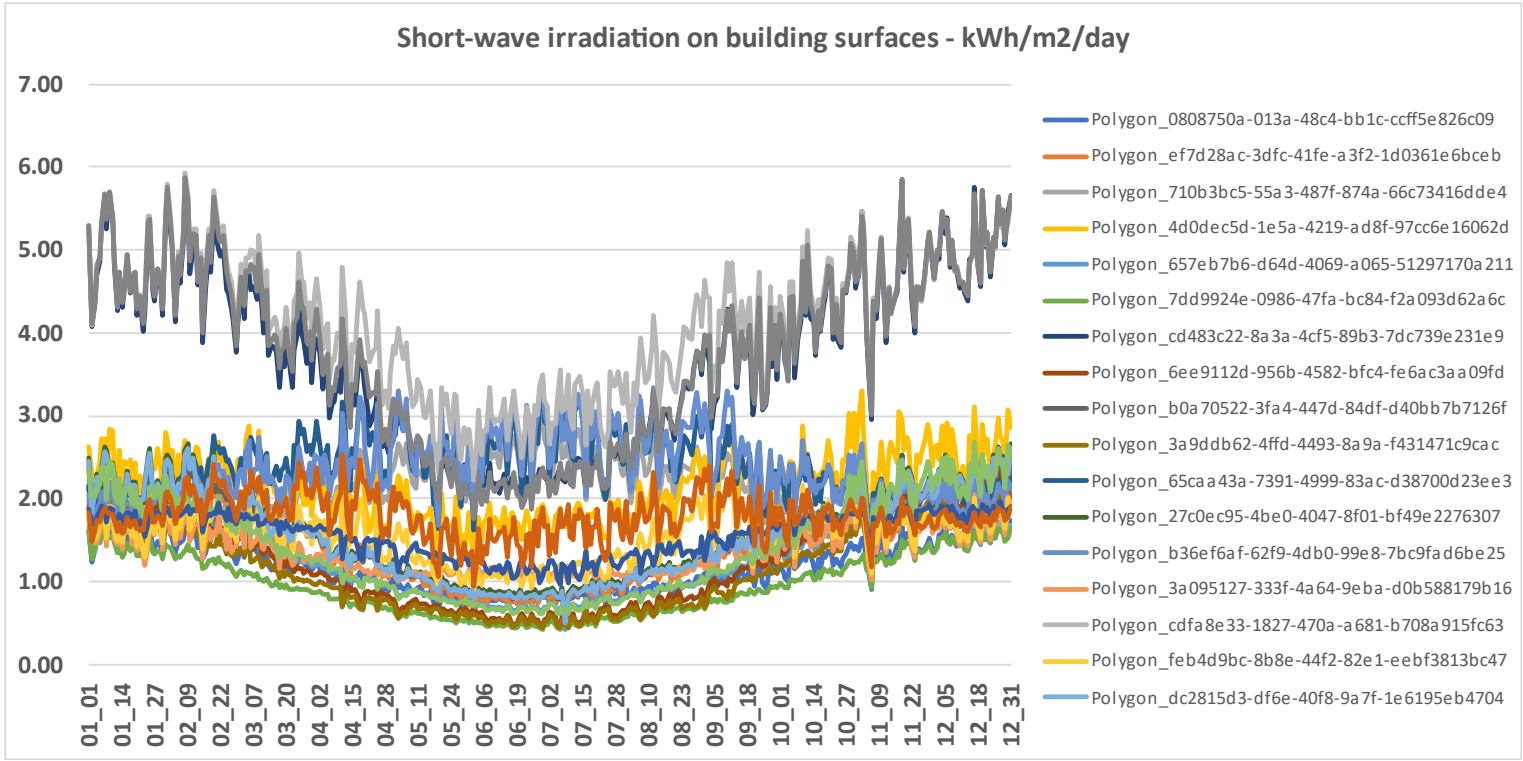


CitySim fundamentals

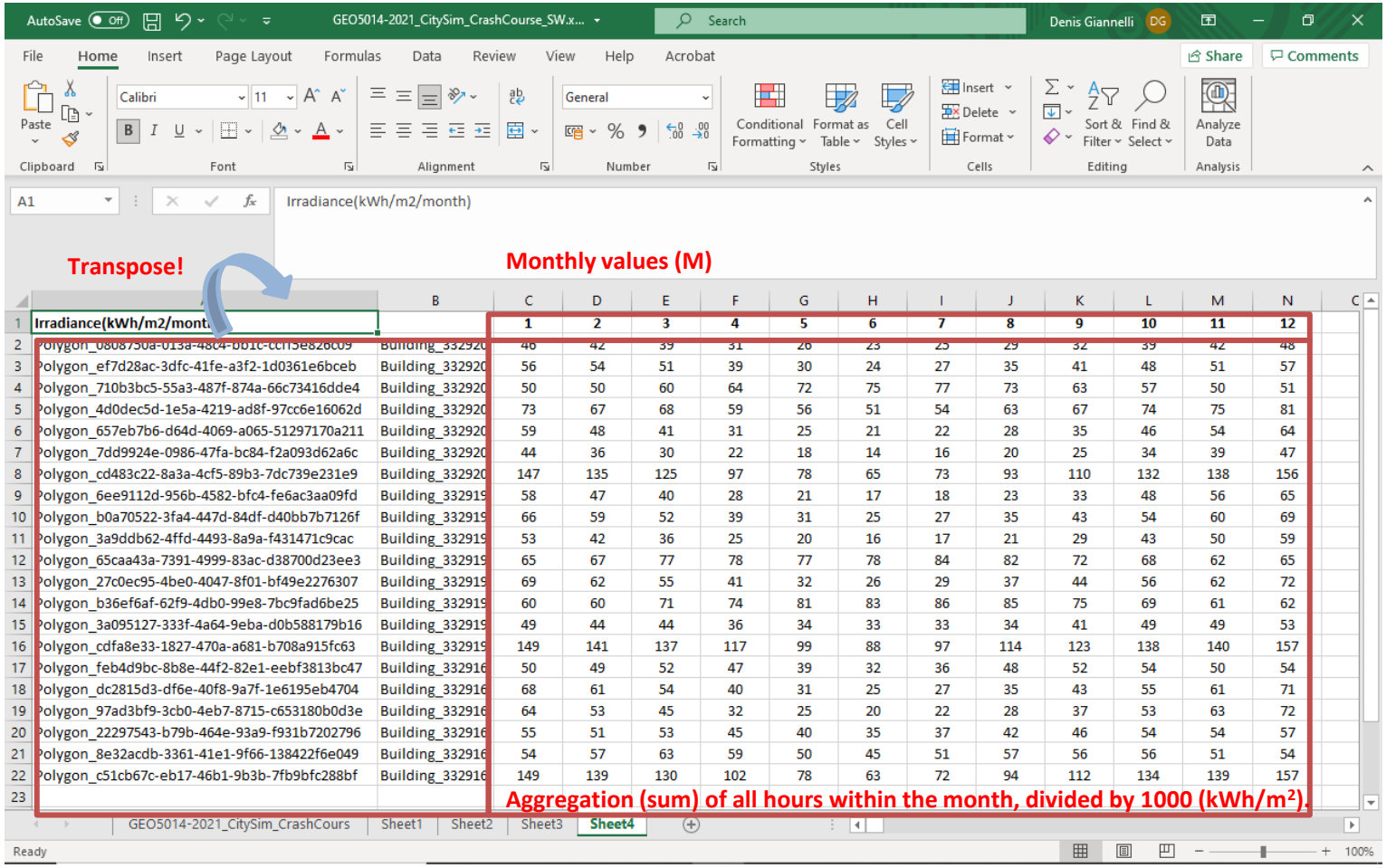


Irradiance(kWh/m2/day)		01_01	01_02	01_03	01_04	01_05	01_06	01_07	01_08	01_09	01_10	01_11	01_12
Polygon_0808750a-013a-4864-bb1c-ccf5e826c09	Building_332920	1.63	1.23	1.38	1.52	1.49	1.56	1.71	1.67	1.60	1.59	1.52	1.36
Polygon_ef7d28ac-3dfc-41fe-a3f2-1d0361e6bceb	Building_332920	1.98	1.46	1.68	1.84	1.79	1.88	2.09	2.07	1.92	1.93	1.85	1.65
Polygon_710b3bc5-55a3-487f-874a-66c73416dde4	Building_332920	1.67	1.52	1.52	1.61	1.62	1.67	1.67	1.53	1.69	1.69	1.58	1.54
Polygon_4d0dec5d-1e5a-4219-ad8f-97cc6e16062d	Building_332920	2.63	2.30	2.24	2.26	2.46	2.72	2.73	2.16	2.84	2.81	2.29	2.17
Polygon_657eb7b6-d64d-4069-a065-51297170a211	Building_332920	2.14	1.76	1.88	2.02	2.00	2.07	2.18	2.08	2.08	2.08	1.96	1.83
Polygon_7dd9924e-0986-47fa-bc84-f2a093d62a6c	Building_332920	1.59	1.27	1.39	1.50	1.47	1.52	1.62	1.57	1.53	1.53	1.46	1.35
Polygon_cd483c22-8a3a-4cf5-89b3-7dc739e231e9	Building_332920	5.29	4.08	4.36	4.70	4.86	5.29	5.64	5.25	5.70	5.39	4.81	4.27
Polygon_6ee9112d-956b-4582-bfc4-fe6ac3aa09fd	Building_332919	2.12	1.86	1.84	1.89	1.99	2.15	2.15	1.78	2.20	2.18	1.85	1.78
Polygon_b0a70522-3fa4-447d-84df-d40bb7b7126f	Building_332919	2.38	1.82	2.04	2.20	2.15	2.24	2.44	2.37	2.27	2.31	2.18	2.00
Polygon_3a9ddb62-4ffd-4493-8a9a-f431471c9cac	Building_332919	1.92	1.70	1.68	1.72	1.80	1.94	1.93	1.60	1.95	1.95	1.66	1.62
Polygon_65caa43a-7391-4999-83ac-d38700d23ee3	Building_332919	2.17	1.82	1.95	2.10	2.06	2.13	2.22	2.15	2.15	2.15	2.07	1.95
Polygon_27c0ec95-4be0-4047-8f01-bf49e2276307	Building_332919	2.50	1.84	2.10	2.29	2.24	2.35	2.62	2.58	2.40	2.43	2.30	2.05
Polygon_b36ef6af-62f9-4db0-99e8-7bc9fad6be25	Building_332919	2.04	1.79	1.78	1.86	1.94	2.08	2.09	1.81	2.18	2.14	1.87	1.78
Polygon_3a095127-333f-4a64-9eba-d0b588179b16	Building_332919	1.75	1.50	1.46	1.47	1.61	1.77	1.81	1.43	1.88	1.87	1.50	1.44
Polygon_cdfa8e33-1827-470a-a681-b708a915fc63	Building_332919	5.29	4.09	4.42	4.82	4.91	5.30	5.66	5.43	5.70	5.35	4.92	4.35
Polygon_feb4d9bc-8b8e-44f2-82e1-eebf3813bc47	Building_332916	1.79	1.53	1.51	1.54	1.65	1.80	1.84	1.53	1.91	1.88	1.57	1.49
Polygon_dc2815d3-df6e-40f8-9a7f-1e6195eb4704	Building_332916	2.46	1.82	2.08	2.26	2.21	2.31	2.57	2.53	2.36	2.39	2.26	2.02
Polygon_97ad3bf9-3cb0-4eb7-8715-c653180b0d3e	Building_332916	2.33	2.03	2.02	2.07	2.18	2.38	2.38	1.98	2.44	2.41	2.04	1.95
Polygon_22297543-b79b-464e-93a9-f931b7202796	Building_332916	1.86	1.71	1.68	1.77	1.85	1.91	1.88	1.72	1.89	1.86	1.74	1.67
Polygon_8e32acdb-3361-41e1-9f66-138422f6e049	Building_332916	1.83	1.48	1.62	1.74	1.71	1.79	1.90	1.84	1.81	1.82	1.74	1.61
Polygon_c51cb67c-eb17-46b1-9b3b-7fb9bfc288bf	Building_332916	5.30	4.11	4.39	4.77	4.92	5.33	5.67	5.37	5.71	5.36	4.87	4.31

CitySim fundamentals

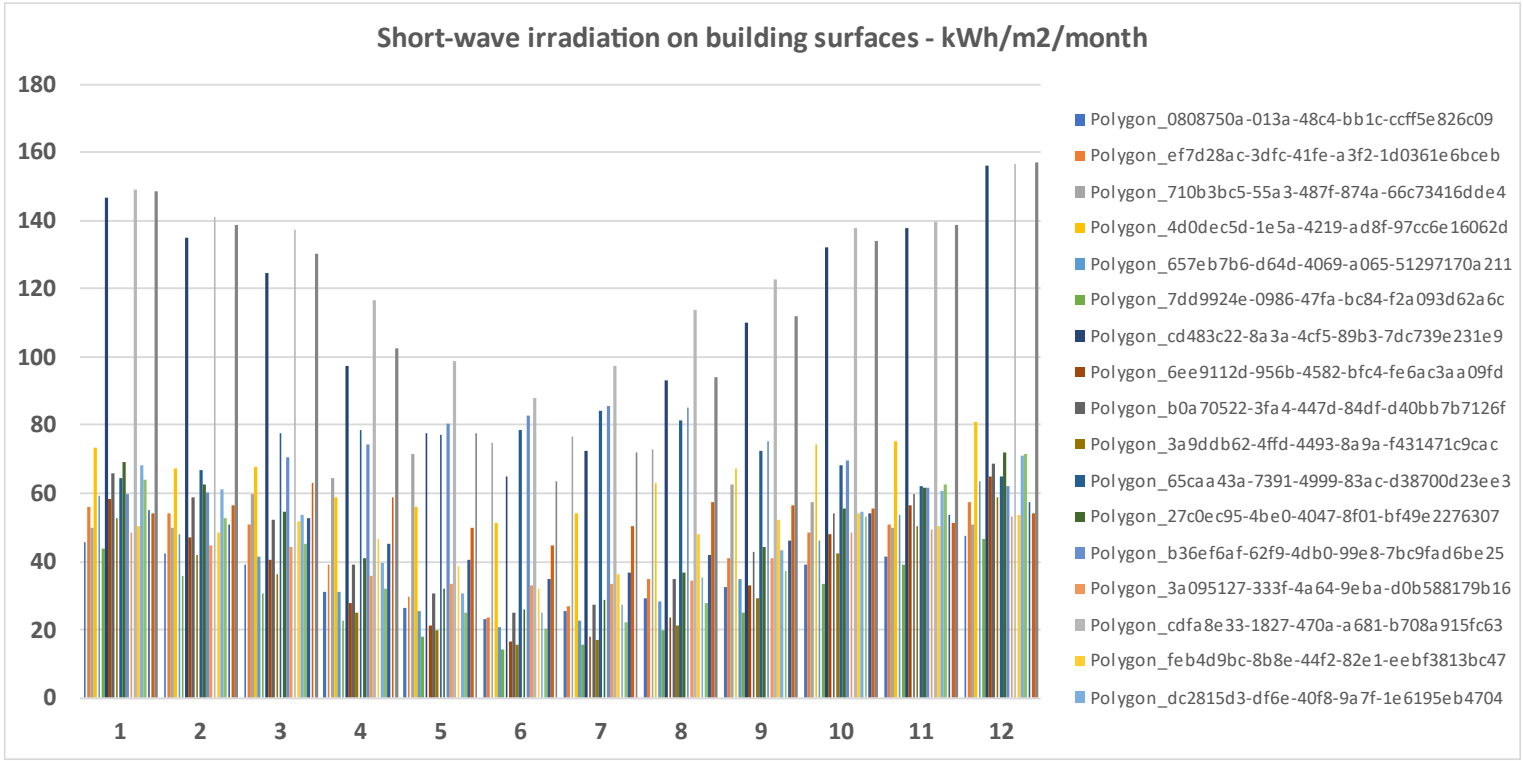


CitySim fundamentals



Irradiance(kWh/m2/mont		1	2	3	4	5	6	7	8	9	10	11	12
Polygon_0808750a-013a-4804-bb1c-ccf5e826c09	Building_332920	46	42	39	31	26	23	25	29	32	39	42	48
Polygon_ef7d28ac-3dfc-41fe-a3f2-1d0361e6bceb	Building_332920	56	54	51	39	30	24	27	35	41	48	51	57
Polygon_710b3bc5-55a3-487f-874a-66c73416dde4	Building_332920	50	50	60	64	72	75	77	73	63	57	50	51
Polygon_4d0dec5d-1e5a-4219-ad8f-97cc6e16062d	Building_332920	73	67	68	59	56	51	54	63	67	74	75	81
Polygon_657eb7b6-d64d-4069-a065-51297170a211	Building_332920	59	48	41	31	25	21	22	28	35	46	54	64
Polygon_7dd9924e-0986-47fa-bc84-f2a093d62a6c	Building_332920	44	36	30	22	18	14	16	20	25	34	39	47
Polygon_cd483c22-8a3a-4cf5-89b3-7dc739e231e9	Building_332920	147	135	125	97	78	65	73	93	110	132	138	156
Polygon_6ee9112d-956b-4582-bfc4-fe6ac3aa09fd	Building_332919	58	47	40	28	21	17	18	23	33	48	56	65
Polygon_b0a70522-3fa4-447d-84df-d40bb7b7126f	Building_332919	66	59	52	39	31	25	27	35	43	54	60	69
Polygon_3a9ddb62-4ffd-4493-8a9a-f431471c9cac	Building_332919	53	42	36	25	20	16	17	21	29	43	50	59
Polygon_65caa43a-7391-4999-83ac-d38700d23ee3	Building_332919	65	67	77	78	77	78	84	82	72	68	62	65
Polygon_27c0ec95-4be0-4047-8f01-bf49e2276307	Building_332919	69	62	55	41	32	26	29	37	44	56	62	72
Polygon_b36ef6af-62f9-4db0-99e8-7bc9fad6be25	Building_332919	60	60	71	74	81	83	86	85	75	69	61	62
Polygon_3a095127-333f-4a64-9eba-d0b588179b16	Building_332919	49	44	44	36	34	33	33	34	41	49	49	53
Polygon_cdfa8e33-1827-470a-a681-b708a915fc63	Building_332919	149	141	137	117	99	88	97	114	123	138	140	157
Polygon_feb4d9bc-8b8e-44f2-82e1-eebf3813bc47	Building_332916	50	49	52	47	39	32	36	48	52	54	50	54
Polygon_dc2815d3-df6e-40f8-9a7f-1e6195eb4704	Building_332916	68	61	54	40	31	25	27	35	43	55	61	71
Polygon_97ad3bf9-3cb0-4eb7-8715-c653180b0d3e	Building_332916	64	53	45	32	25	20	22	28	37	53	63	72
Polygon_22297543-b79b-464e-93a9-f931b7202796	Building_332916	55	51	53	45	40	35	37	42	46	54	54	57
Polygon_8e32acdb-3361-41e1-9f66-138422f6e049	Building_332916	54	57	63	59	50	45	51	57	56	56	51	54
Polygon_c51cb67c-eb17-46b1-9b3b-7fb9bfc288bf	Building_332916	149	139	130	102	78	63	72	94	112	134	139	157

CitySim fundamentals



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