GeoBIM for microclimate simulations

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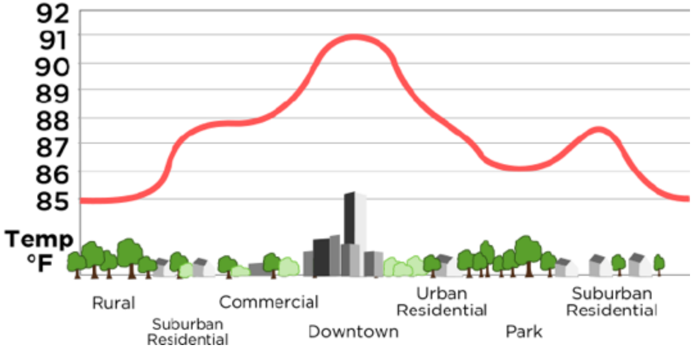
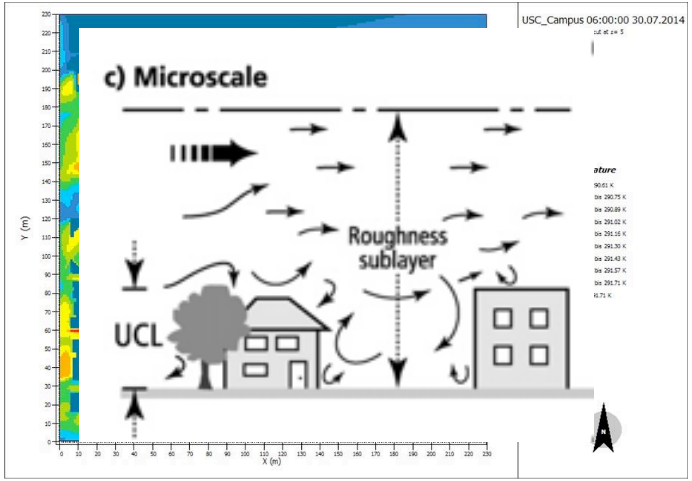
Urban microclimate

- Meso scale
  - Urban Heat Island Effect
- Micro scale
  - Influence of shadowing, vegetation, structure materials, water
- Importance
  - Providing correct data for calculations





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Microclimate Simulation tools

RayMan

CFD

UWG

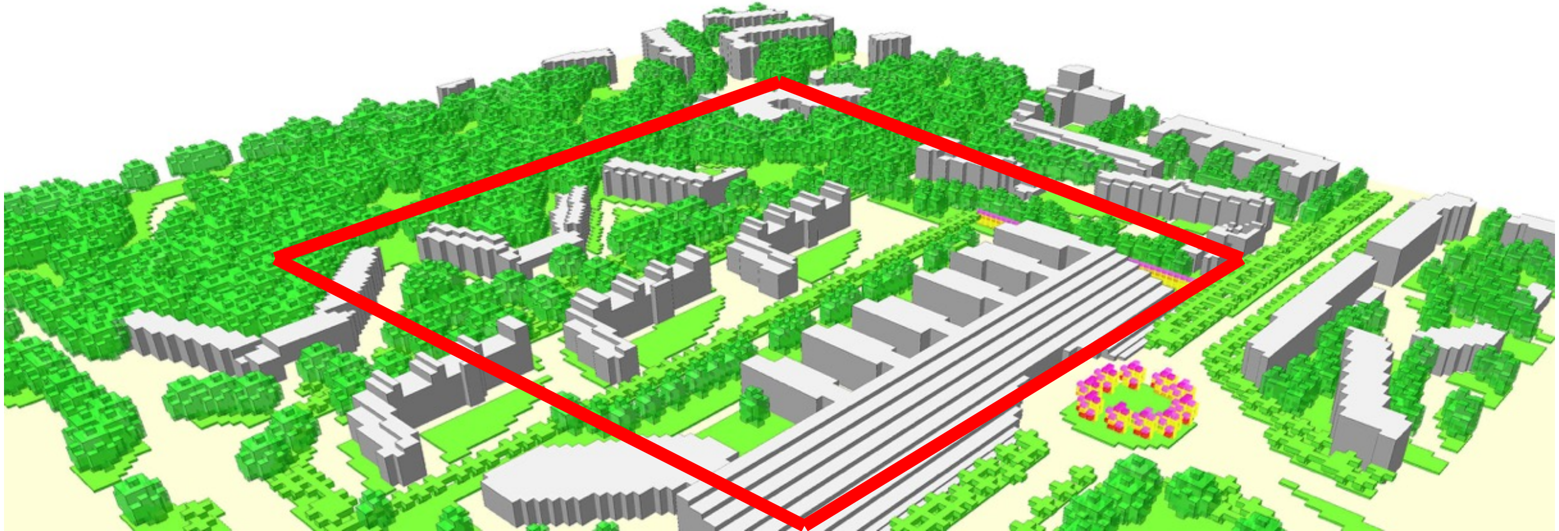
ENVI_MET

- Comparing tools:
  - Simplification of models
  - Variables
  - Ease of use
  - One main focus

- Most complete tools: CitySim Pro & ENVI-met

ENVI-met

- Computation Fluid Dynamics(CFD)
- Resolution (0.5-10m)
- Modelling of airflow, moisture and heat exchange processes between surfaces, building physics, vegetation, bioclimatology and pollution



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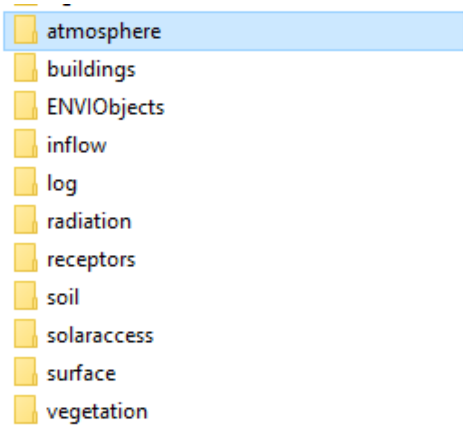
ENVI-met outputs

- Calculate a wide variety of parameters
  - Atmosphere (Air temperature, thermal comfort etc..)
  - Buildings (SVF, longwave emitted etc..)
  - Trees (Plant CO2 Flux, Stomata resistance etc..)
  - Soils (Surface temperature, Shadow % etc..)
- Voxel data (binary)
- Aggregated data (text)



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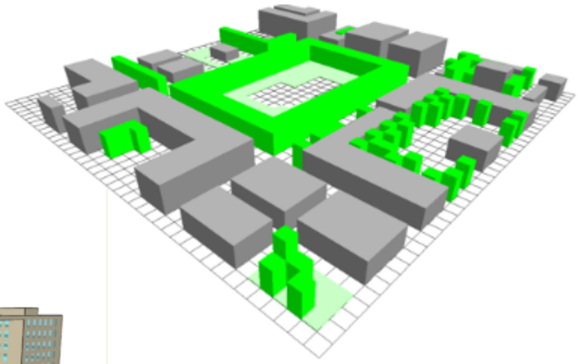
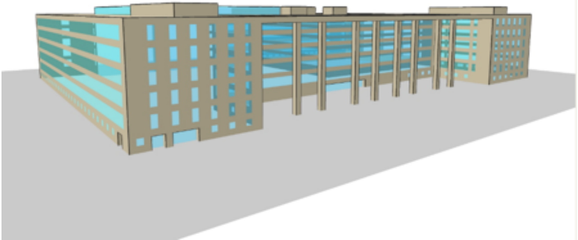
Use of digital 3D models

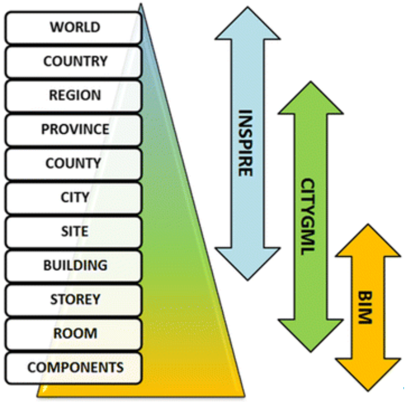
- 3D models (CAD geometries)
- Semantic 3D models
  - BIM (building scale)
    - IFC, gbXML..
  - 3D GIS (City – district scale)
    - CityGML, CityJSON..

ENVI-met scale

- Area input file
  - 2.5 D
  - 3D

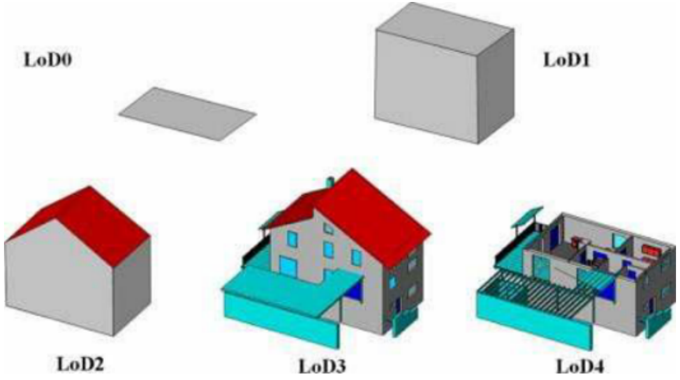


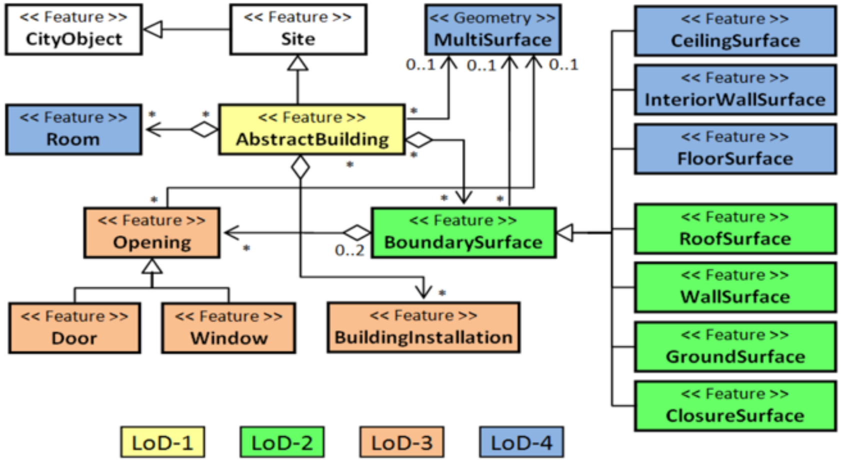




  - Incorporating geometry & urban features
  - Limited to < (~ 300*300*100)

Building information in 3D city model (CityGML + Energy ADE), BIM (if available)



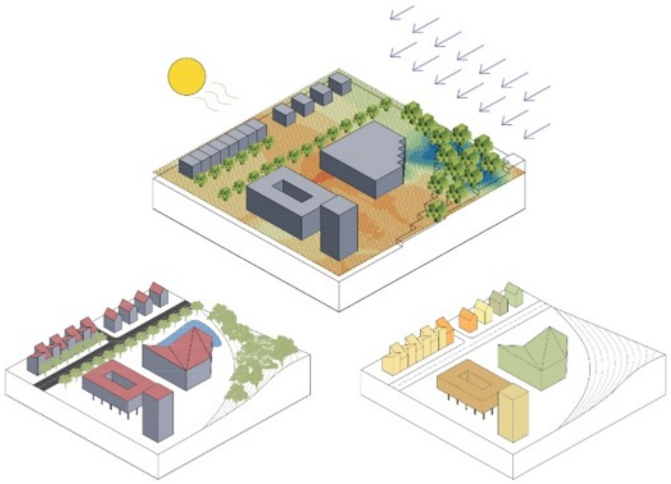


My work

- The use of 3D models in microclimatic studies – First steps to couple CityGML with ENVI-met

By Panagiotis Arapakis

Mentors : Giorgio Agugiaro, Daniela Maiullari



Aims

- Establish an automate data flow between ENVI-met & CityGML standard (Minimize human intervention)
- Store useful results back to the 3D City model to use them as input for other studies

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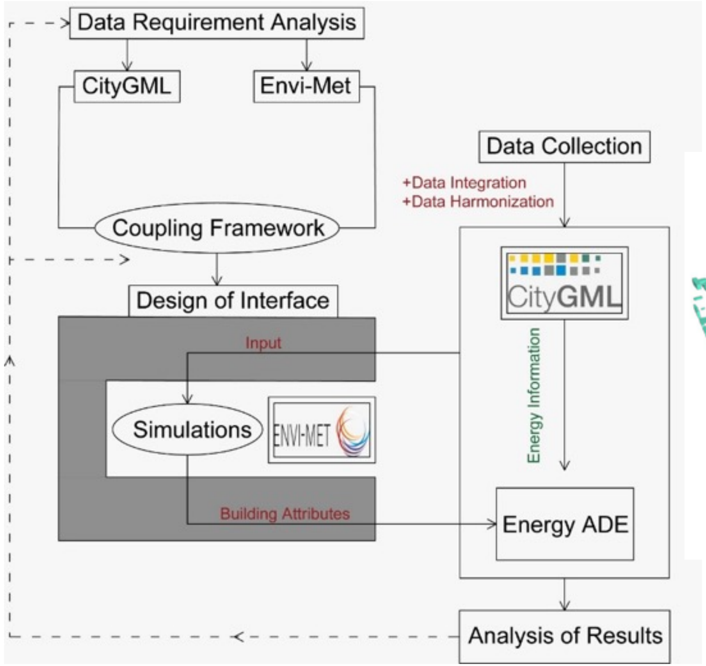
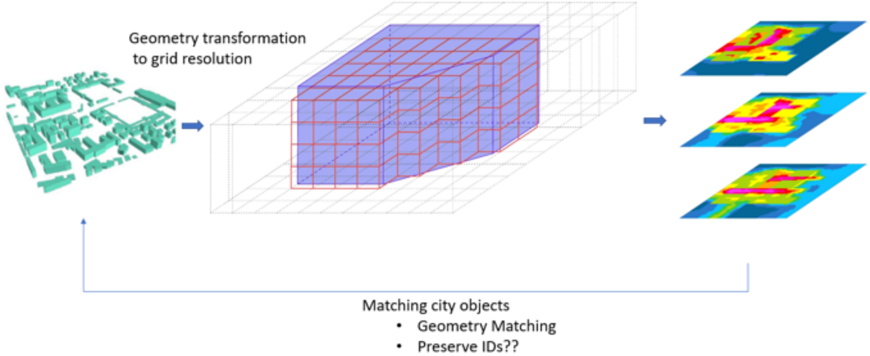
Methodology





Test case

- Almere (Floriade 2022)
  - Newly developed area with 660 building Units
  - International Horticultural Expo
  - Growing Green Cities

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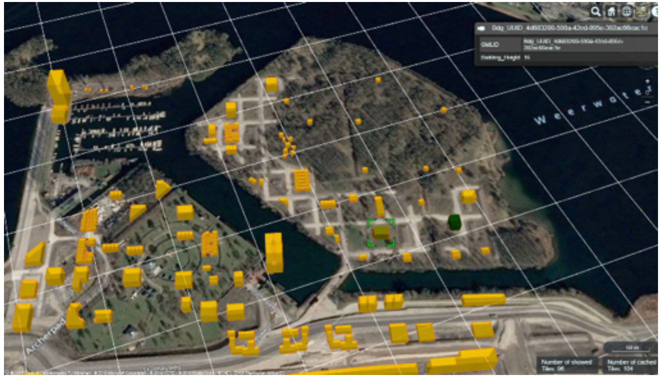
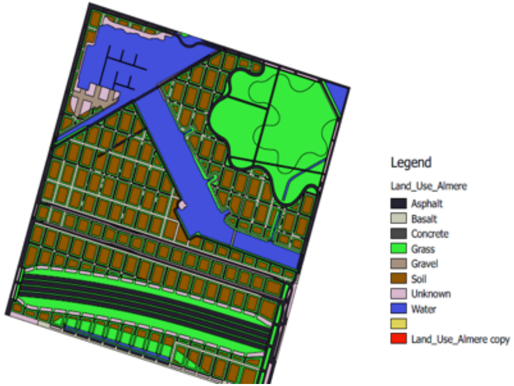
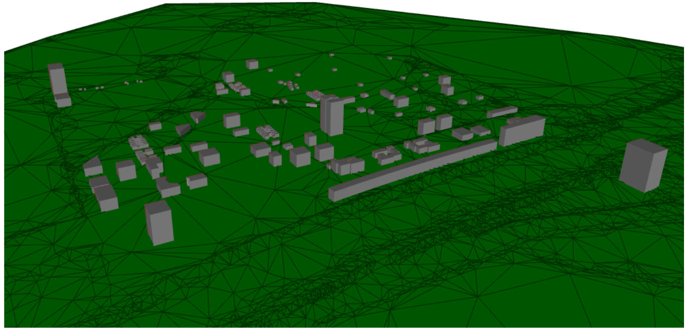
Floriade CityGML model

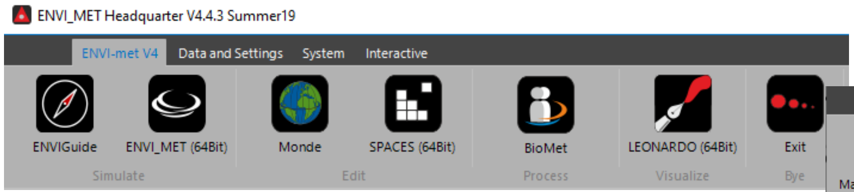


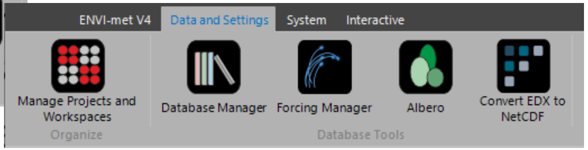




ENVI-met requirements

- Input (Configuration File)
  - Voxelized model (Area Input File) (2.5D)
  - Weather at its boundaries
  - Databases (materials and plants)
  - Simulation parameters (day, extent, roughness value etc)





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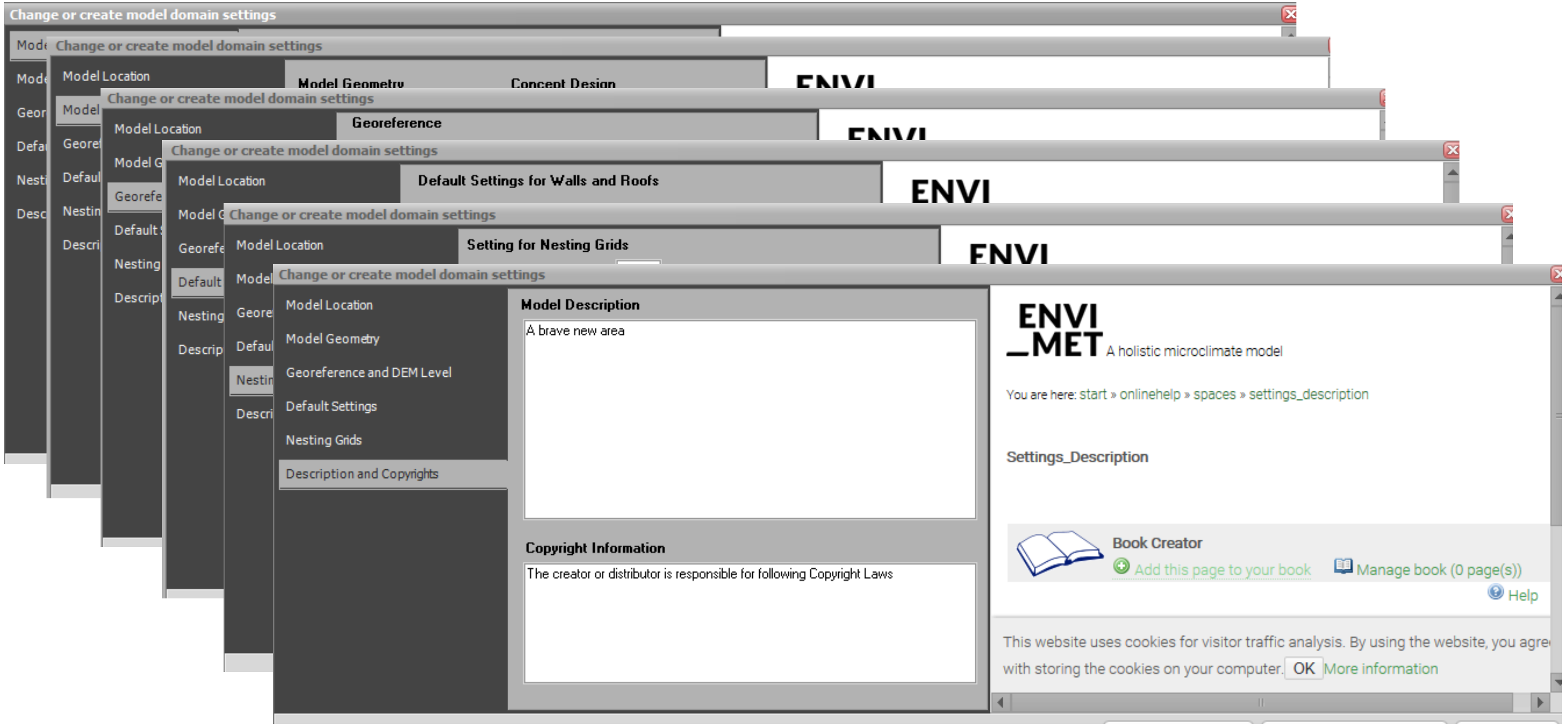
Metadata


Change or create model domain settings
Model Location
Model Geometry
Georeference and DEM Level
Default Settings
Nesting Grids
Description and Copyrights
Model Description
A brave new area
Copyright Information
The creator or distributor is responsible for following Copyright Laws
ENVI _MET A holistic microclimate model
You are here: start » onlinehelp » spaces » settings_description
Settings_Description
Book Creator
Add this page to your book
Manage book (0 page(s))
Help
This website uses cookies for visitor traffic analysis. By using the website, you agre
with storing the cookies on your computer. OK More information

Urban Data

Buildings
- Height (integer) – matrix data
- Base height (set to 0) – matrix data
- Id (integer) – matrix data

Trees
- Simple trees (Database Link) – matrix data
- 3D trees - Independent tags

Soils
- Database link – matrix data

DEM
- Reference Height (float)
- Values (Integer) – matrix data

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Mapped classes & attributes

Weather parameters	User input		
Projection System	CRS		
UTM Zone	Bounding Box		
location longitude	Bounding Box		
location latitude	Bounding Box		
building zTop	*Building, Measured_height*		
building zBottom	*Building, lod0_footprint_geometry*		
building NR	*Building lod0_footprint_geometry*		
simple plants 2D	Vegetation, Solitary Vegetation Object ,height&crown diameter)		
plants 3D	*LandUse, Usage 'Forest'*	Vegetation, Solitary Vegetation Object height&crown diameter)	
soils 2D	*Building = (* default soil)	*Land Use, gen_attribute* (Material)	*Plant_Cover Usage, 'Forest'*
dem (+z reference)	*TIN_Relief(+BoundingBox)*		

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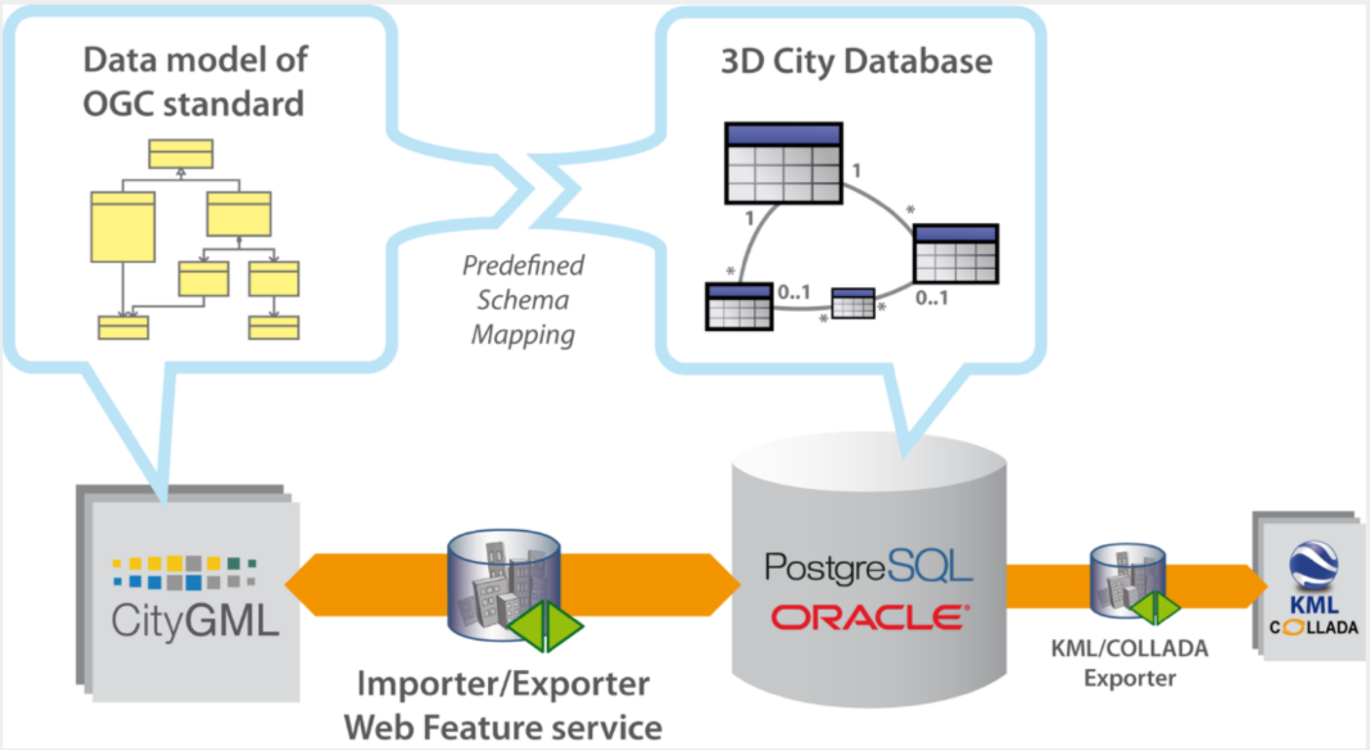
Reading and writing Data



Reading data

	id integer	obje integ	classname character varying(256)	gı ch	gı ch	na ch	na ch	de ch	eı ge	cı ti	teı tin	re ch	re ch	la ti	uı ch	re ch	linea char	class character varying(256)	cla ch	function character varying(1000)	fu ch	usage character varying(1000)	us ch	lod0_multi_surface_id integer
17	2399	4	LandUse	La				Un	01	20				20	pc			Undeveloped area		Unknown	''	Unknown	''	130846
18	2400	4	LandUse	La				Un	01	20				20	pc			Undeveloped area		Unknown	''	Unknown	''	130850
19	2402	4	LandUse	La		Gr	''	Gr	01	20				20	pc			Vegetation		Grassland	''	Grassland	''	130852
20	2404	4	LandUse	La				Un	01	20				20	pc			Undeveloped area		Unknown	''	Unknown	''	130858
21	2421	4	LandUse	La		Tr	''	In	01	20				20	pc			Vegetation		Agriculture	''	Agriculture	''	130892
22	2424	4	LandUse	La		Tr	''	In	01	20				20	pc			Vegetation		Agriculture	''	Agriculture	''	130898
23	2426	4	LandUse	La		Tr	''	In	01	20				20	pc			Vegetation		Agriculture	''	Agriculture	''	130900
24	2427	4	LandUse	La		Tr	''	In	01	20				20	pc			Vegetation		Agriculture	''	Agriculture	''	130906
25	2430	4	LandUse	La		Gr	''	Gr	01	20				20	pc			Vegetation		Agriculture	''	Agriculture	''	130908
26	2432	4	LandUse	La		Gr	''	Gr	01	20				20	pc			Vegetation		Grassland	''	Grassland	''	130912
27	2433	4	LandUse	La		St	''	Bl	01	20				20	pc			Traffic		Road	''	Road	''	130916
28	2341	4	LandUse	La				Un	01	20				20	pc			Undeveloped area		Unknown	''	Unknown	''	130732
29	2344	4	LandUse	La		Gr	''	Gr	01	20				20	pc			Vegetation		Agriculture	''	Agriculture	''	130736
30	2347	4	LandUse	La				Un	01	20				20	pc			Undeveloped area		Unknown	''	Unknown	''	130746
31	2353	4	LandUse	La		Gr	''	Gr	01	20				20	pc			Vegetation		Agriculture	''	Agriculture	''	130756
32	2359	4	LandUse	La				Un	01	20				20	pc			Undeveloped area		Unknown	''	Unknown	''	130768
33	2363	4	LandUse	La				Un	01	20				20	pc			Undeveloped area		Unknown	''	Unknown	''	130778

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Writing data

- Energy ADE *TimeSeries* & *WeatherData* classes

id integer	objecti integei	classname character varying(256)	gmlid charac	gı ch	na ch	na ch	de te	acquisition_method character varying	interpolation_type character varying	qu te	sc ch	values_array numeric[]	values_unit character varying	array_lengt integer
2	202	RegularTimeSeries	UUID_					Simulation	ConstantInSucceedingInterval			{20.720,19.780,18.145,16.85	Celsius Degrees	31
26	202	RegularTimeSeries	UUID_					Simulation	ConstantInSucceedingInterval			{20.800,19.887,18.153,16.87	Celsius Degrees	31
85	202	RegularTimeSeries	UUID_					Simulation	ConstantInSucceedingInterval			{20.884,19.946,18.235,16.89	Celsius Degrees	31
106	202	RegularTimeSeries	UUID_					Simulation	ConstantInSucceedingInterval			{20.860,19.923,18.168,16.88	Celsius Degrees	31
109	202	RegularTimeSeries	UUID_					Simulation	ConstantInSucceedingInterval			{20.842,19.873,18.154,16.86	Celsius Degrees	31
117	202	RegularTimeSeries	UUID_					Simulation	ConstantInSucceedingInterval			{20.841,19.904,18.160,16.87	Celsius Degrees	31
149	202	RegularTimeSeries	UUID_					Simulation	ConstantInSucceedingInterval			{20.811,19.881,18.150,16.86	Celsius Degrees	31
213	202	RegularTimeSeries	UUID_					Simulation	ConstantInSucceedingInterval			{20.792,19.862,18.144,16.86	Celsius Degrees	31
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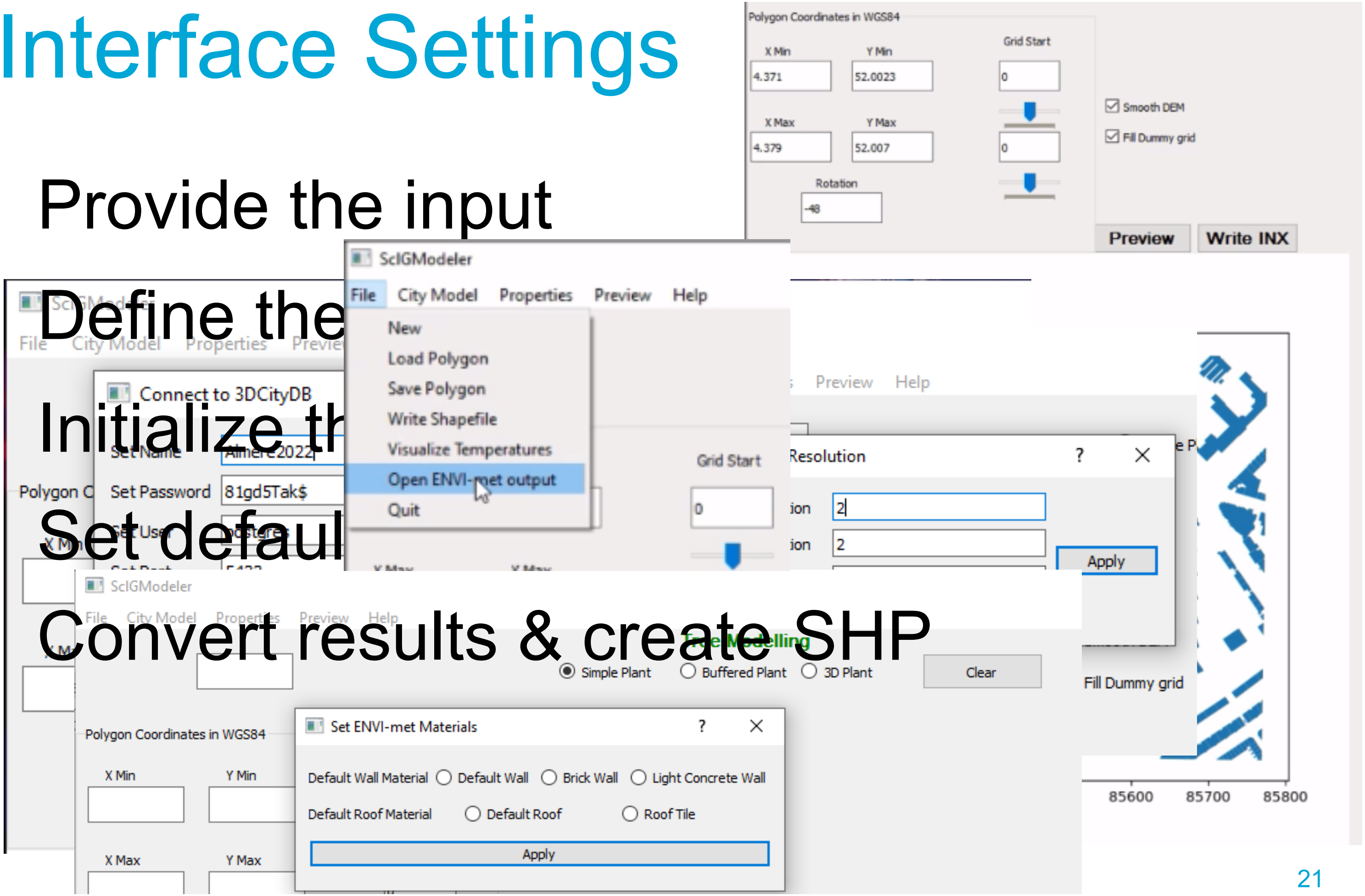
428	202	RegularTimeSeries	UUID_					Simulation	ConstantInSucceedingInterval			{20.778,19.815,18.107,16.76	Celsius Degrees	31
476	202	RegularTimeSeries	UUID_					Simulation	ConstantInSucceedingInterval			{20.847,19.941,18.203,16.92	Celsius Degrees	31

Interface Settings

- Provide the input
- Define the
- Initialize th
- Set defaul
- Convert results & create SHP



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Results

- Area Input files
  - Different resolutions
  - From different source datasets
- Results in vector format (Point Cloud)
  - Visualization
  - Easier processing
- Augmented CityGML classes
  - Buildings with average outdoor temperature
  - Many more outputs can be examined

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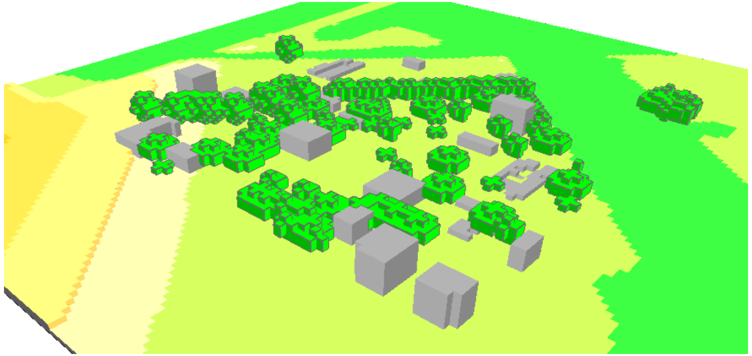
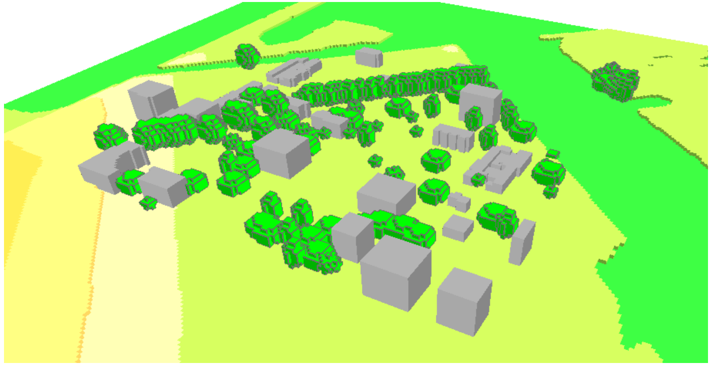
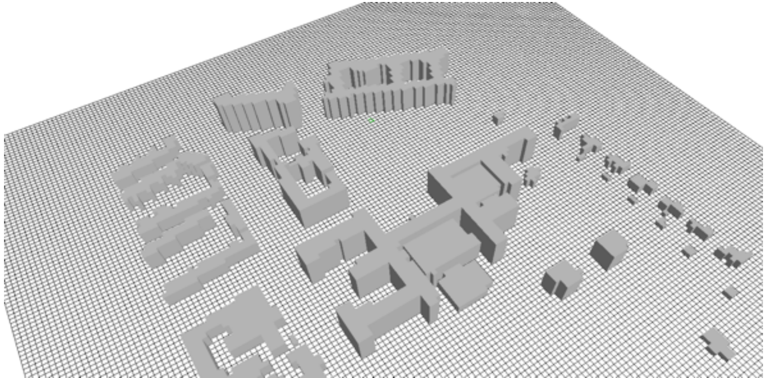
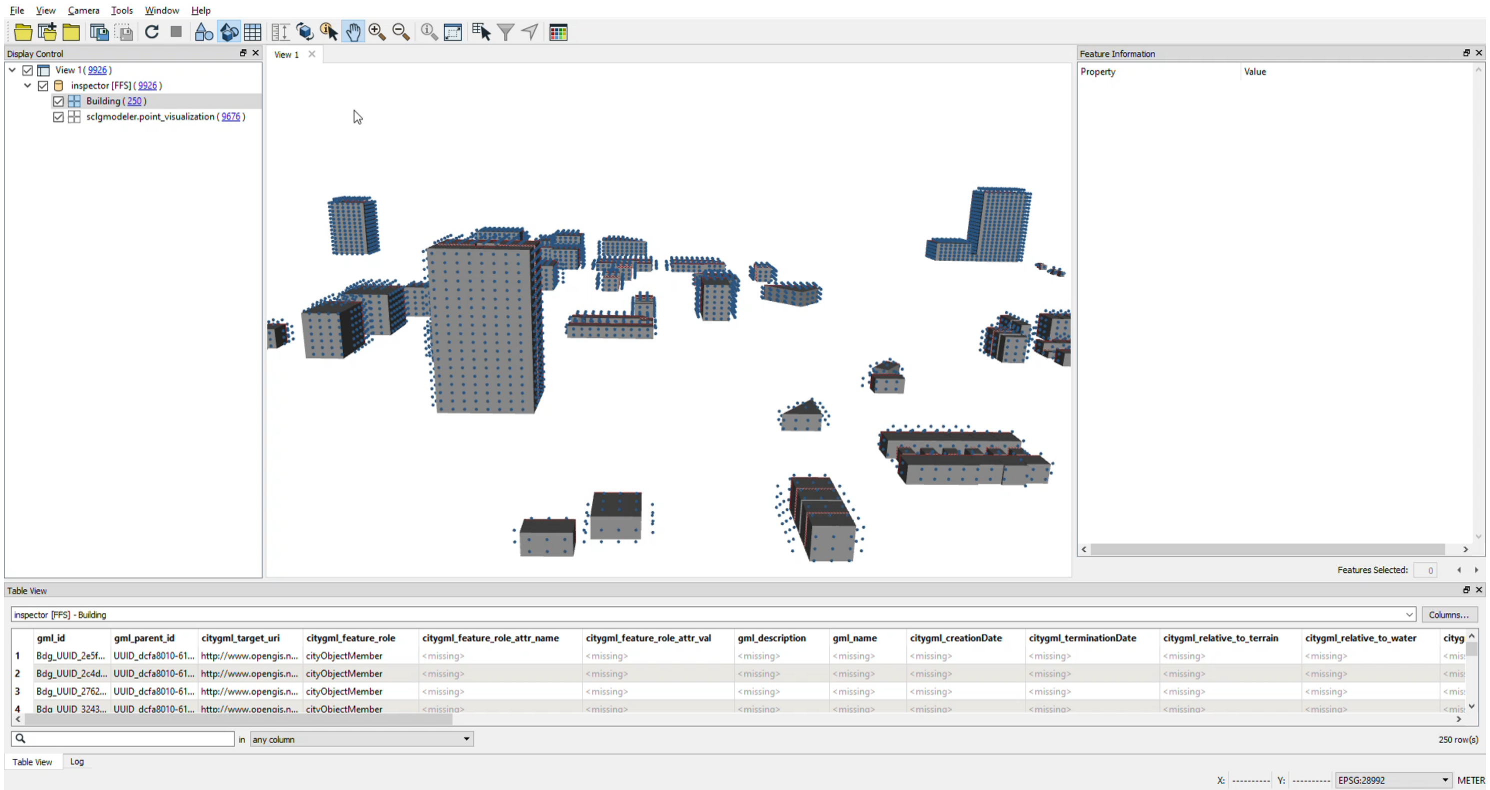
Area input files







Point cloud on same crs



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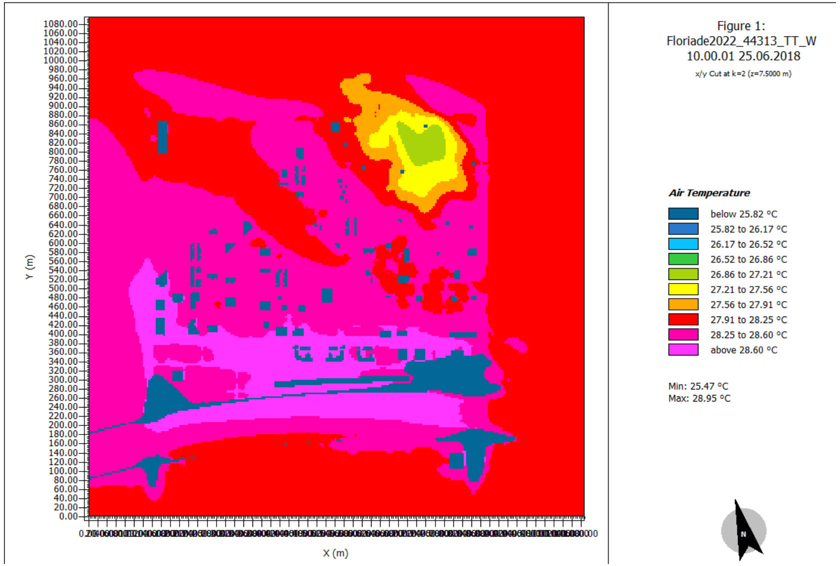
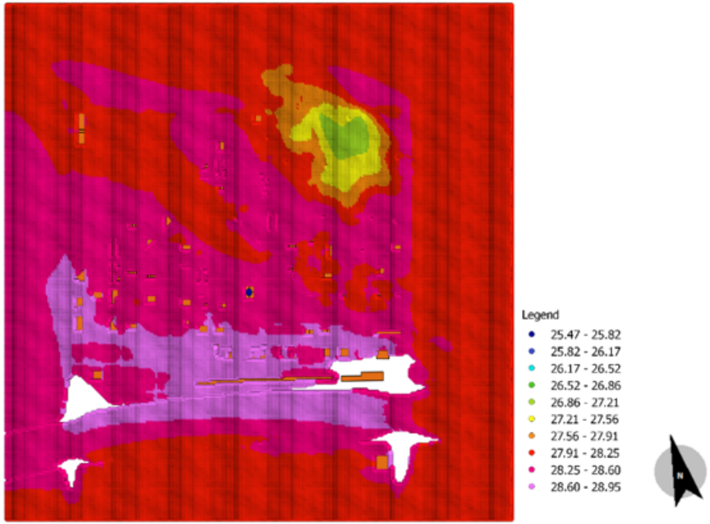
Implementation quality check of interface





2 sets of simulations

A. Three test (simulations) conducted to study the effect of different vegetation type

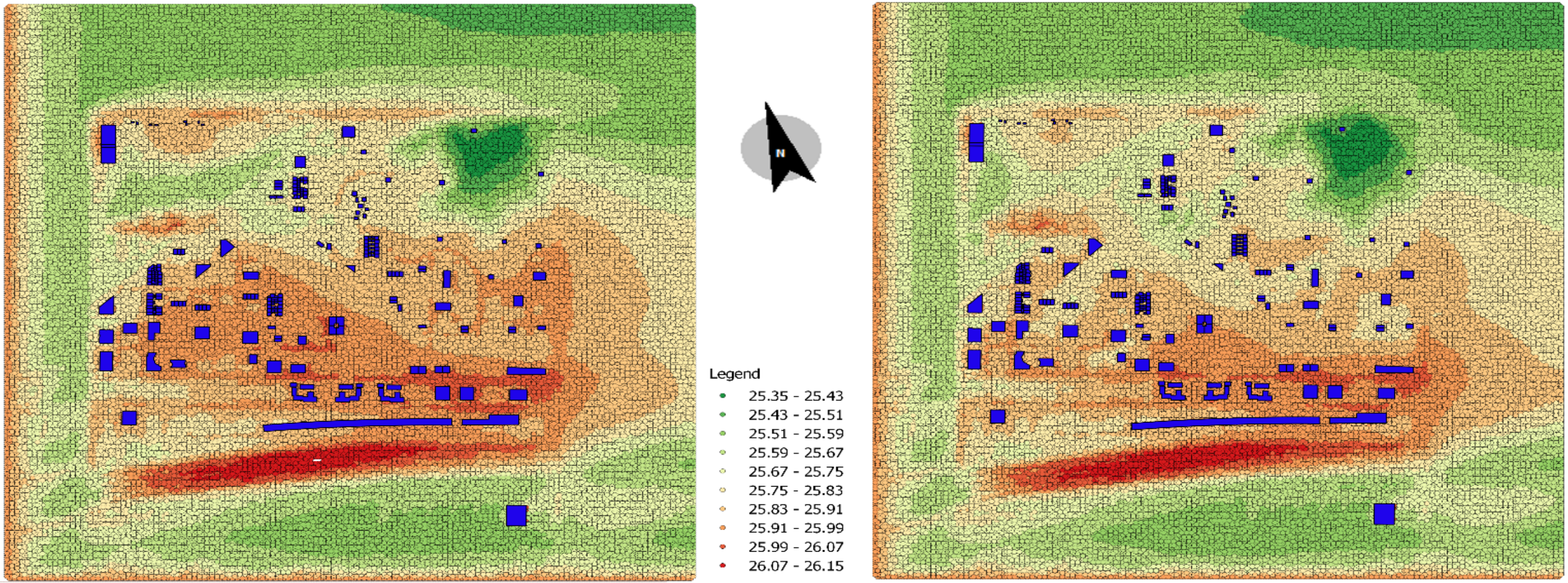
B. Simulations of two different scenario

- Full Forcing – data from Lelystand Station
- Duration 31h (17:00 – 23.59)

Vegetation Tests

		09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Building 1	Simple tree	22.441	23.259	23.753	23.750	24.274	24.351	24.105	23.837	23.538	22.706	20.168	17.019
	Buffered tree	22.414	23.261	23.740	23.742	24.267	24.353	24.124	23.855	23.533	22.702	20.120	17.009
	3D tree	22.370	23.229	23.705	23.705	24.230	24.322	24.087	23.819	23.493	22.587	19.963	16.961
Building 2	Simple tree	22.491	23.328	23.844	23.840	24.376	24.488	24.254	24.020	23.680	22.719	20.048	16.937
	Buffered tree	22.458	23.404	23.876	23.893	24.409	24.554	24.335	24.072	23.678	22.628	19.995	16.929
	3D tree	22.245	23.165	23.650	23.641	24.155	24.313	24.087	23.792	23.426	22.464	19.909	16.892
Building 3	Simple tree	22.441	23.293	23.768	23.768	24.302	24.288	24.228	24.002	23.618	22.528	19.901	16.853
	Buffered tree	22.415	23.383	23.774	23.784	24.312	24.300	24.322	24.092	23.635	22.453	19.886	16.859
	3D tree	22.294	23.206	23.637	23.638	24.170	24.166	24.152	23.908	23.503	22.393	19.849	16.826
		22.25	22.85	23.45	23.35	23.85	23.75	23.65	23.45	23.25	22.35	19.85	16.85

Scenario simulations



	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Temperature	26	27.5	28	30	31.5	32.5	33	33	33	32	30	28	26
Rel. Humidity	61	56	56	56	48	46	49	46	51	54	57	63	71
Wind Speed	2	3	3	3	3	3	5	5	4	3	3	3	3
Wind Direction	90	130	130	120	110	180	190	210	200	290	300	310	270

Conclusions

- Successfully implementation of the bi-directional interface
  - CityGML can be used to prepare automatically a voxelized model of ENVI-met
  - We can retrieve the results AND store them
- Birth of ScIGModeLer
- Methodology already applicable to other outputs
- Even more outputs can be stored back

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Limitations – Future work

- Test interface
- Evaluate mapping of more CityGML classes
- Examine and return more attributes
- Construction of 3D area input file & automatic preparation of weather files

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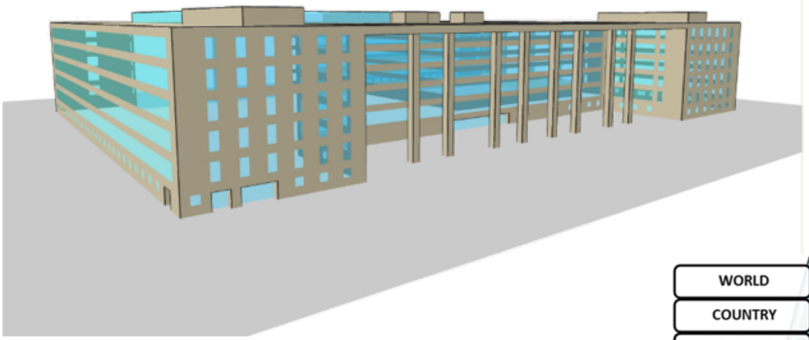
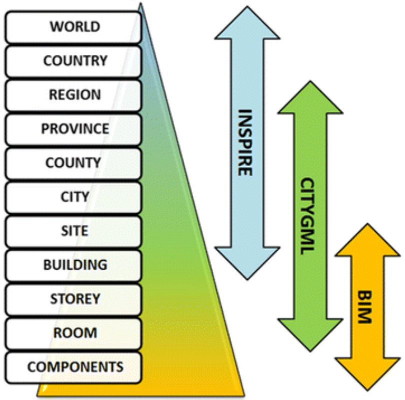
How more?

- Area input file
  - 2.5 D
  - **3D**



  - Incorporating more detailed geometry & building components information



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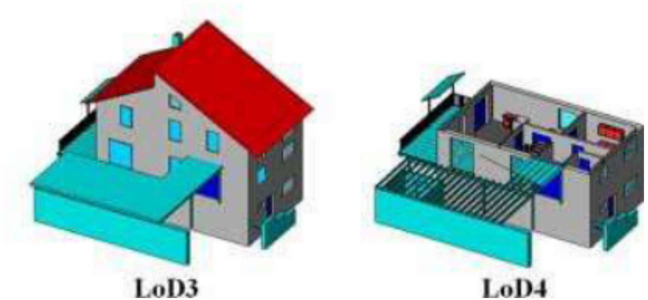
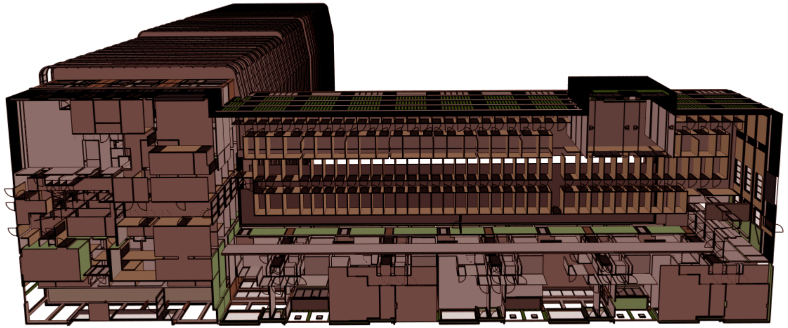
How more?





CityGML

+ Energy ADE

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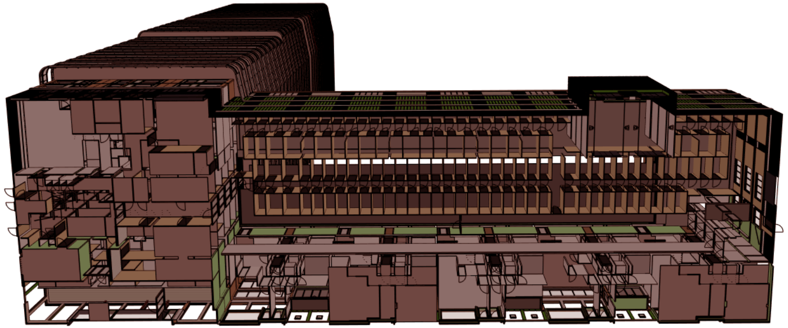
How more?



CityGML

+ Energy ADE

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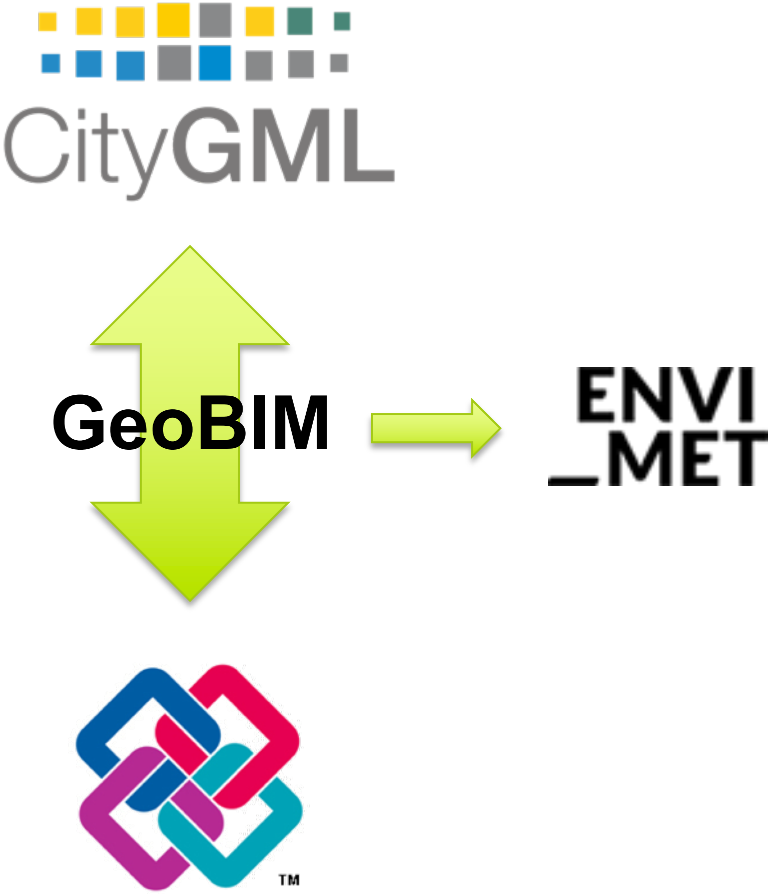
How more?



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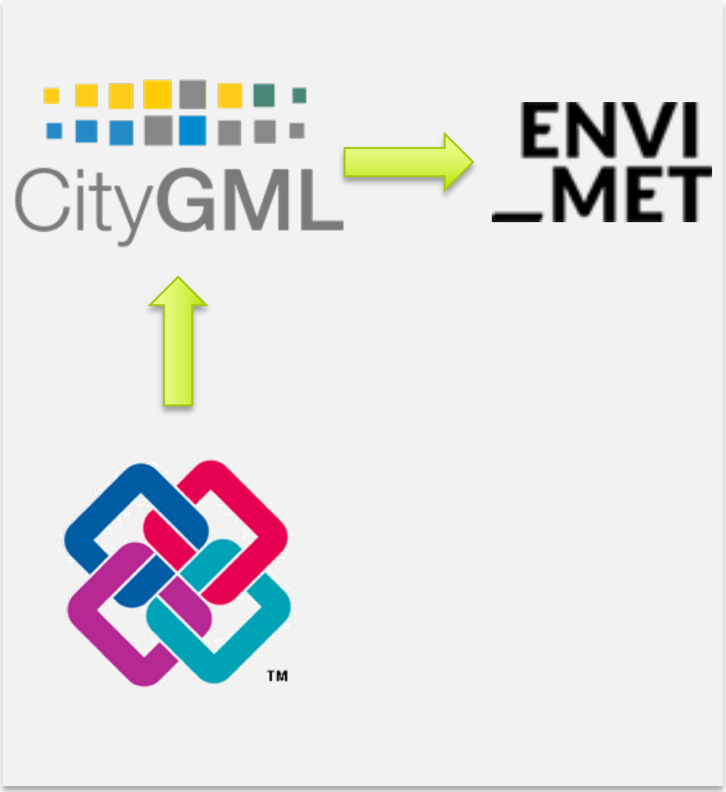
How more?



Floriade IFC model

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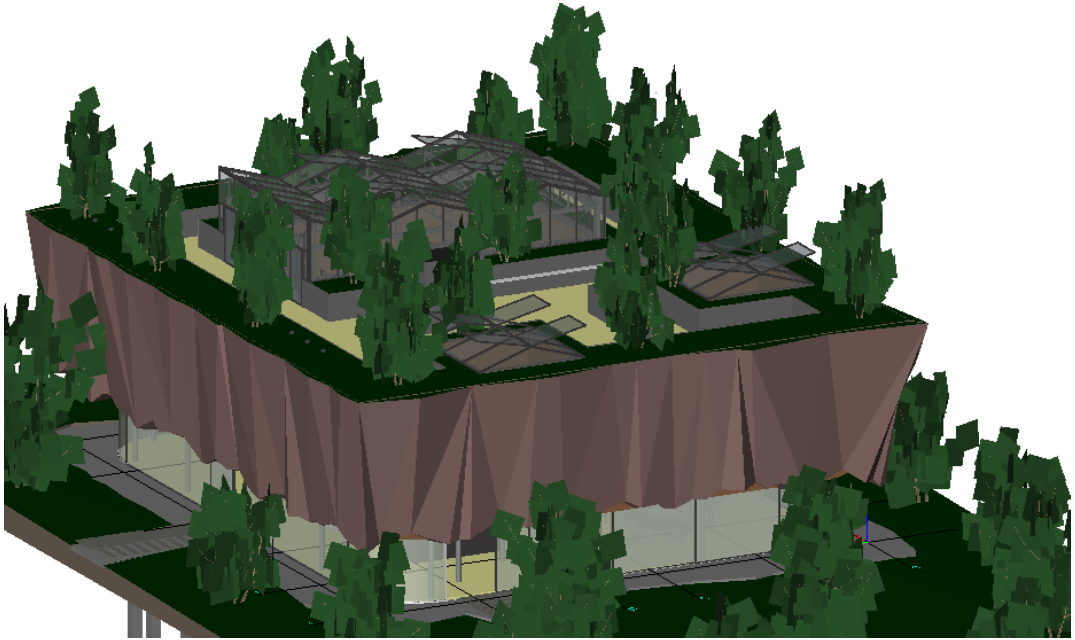

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Research Questions

*How can **BIM** information be **integrated** in a **3D city model**, in order to improve **microclimate simulations**?*

- What **data** is needed for **microclimate simulation**? Where can this information be found in IFC and CityGML schemes **and real data**?
- What **IFC entities** should be selected for a smooth conversion and simulation? What **guidelines** for designers could help the process?
- At what **level of detail** (LOD) should the CityGML be for the best result of the microclimate simulation in ENVI-met?
- How to **convert** the BIM information effectively in a 3D city model, to be usable in microclimate simulations? What **geometrical issues** do we run in to and how to deal with this?

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Initial semantic mapping and available data

Required elements	Representation in IFC schema*	Representation in existing data
Building:	✓IfcBuilding and IfcBuildingElement	✓
Geometry	✓IfcBuilding (Body Geometry)	✓
Walls/Roof	✓IfcWall, IfcRoof	✓
Material	✓IfcRelAssociatesMaterial (IfcMaterialDefinition (4), IfcMaterialUsageDefinition (4))	✓
Trees	✓IfcGeographicElement	~
Vegetation	✓IfcGeographicElement	~
Soil	✓IfcGeographicElement	~
Infrastructure	✓IfcCivilElement (4) (IfcGeographicElement (2x3))	~
Water	IfcGeographicElement	x
Location	✓IfcSite	~
Terrain height	✓IfcSite	~

IfcGeographicElement **IFC4**

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Mapping

Required elements		In IFC schema	In existing IFC data	In CityGML schema	In existing CityGML data
Model geometry					
Location data		✓	~	✓	✓
Building 2D/3D		✓	✓	✓	✓
Wall/single wall		✓	✓	~	~
Greening				✗	✗
3D Plants		✓	~	✓	~
Simple plants		✓	~	✓	~
Soils	Soils	✓ ~	~	~	✗
	Infrastructure	✓ ~	~	✓	~
	Water	~	✗	✓	~
Sources					
DEM 2D/3D		✓	~	✓	~

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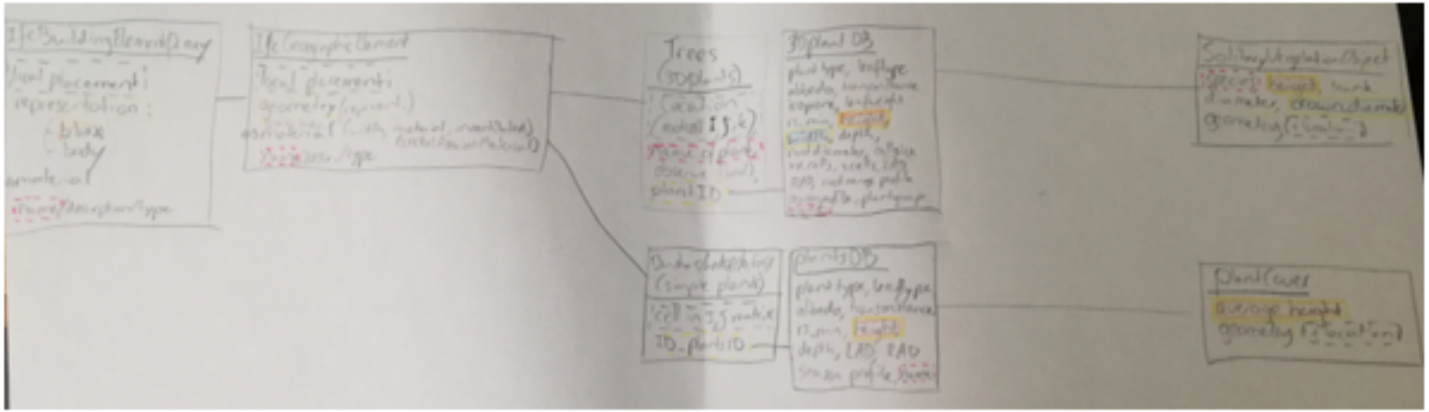
Mapping

Example [Vegetation]

- What information to define **input file**

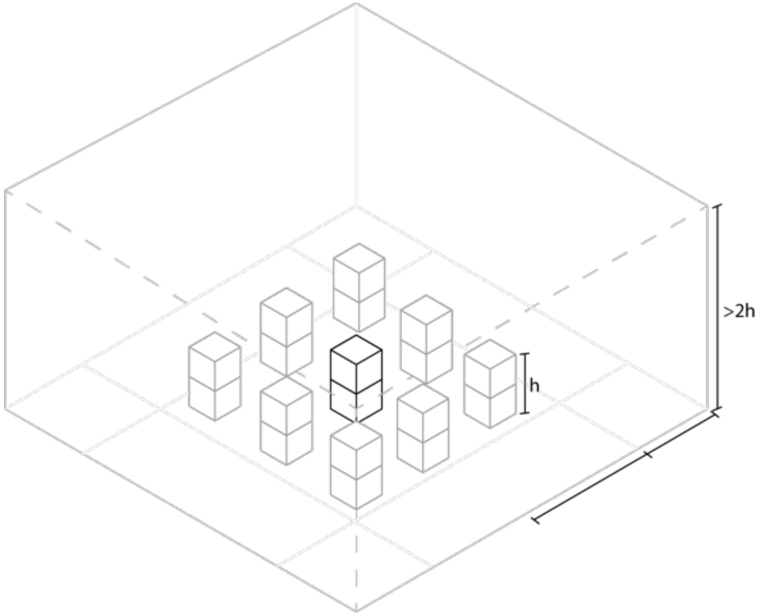
- information for **vegetation from IFC** (including exact entities, elements, characteristics)

- information for **vegetation from CityGML** (including exact classes, elements, characteristics)

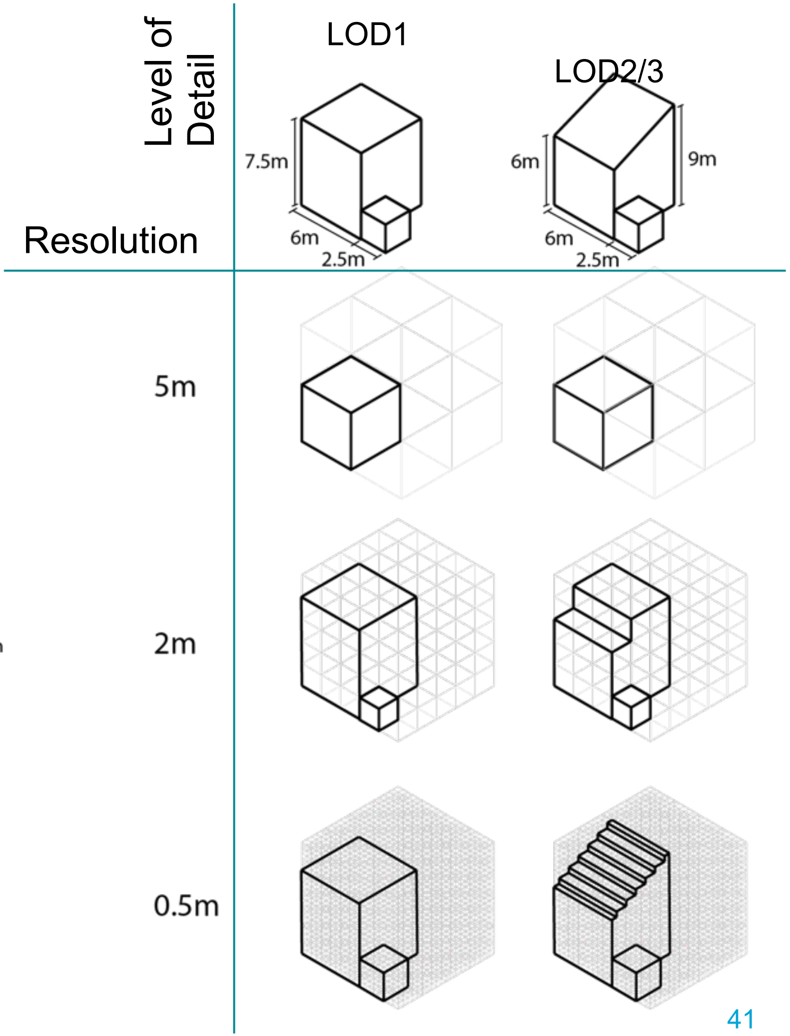


TUDelft

Geometry



>2h
h



Level of Detail
Resolution
LOD1
LOD2/3
7.5m
6m
2.5m
6m
9m
6m
2.5m
5m
2m
0.5m

A Similar case: gbXML vs IFC

Green Building XML

An industry supported standard for storing and sharing building properties between 3D Architectural and **Engineering Analysis Software**.

https://gbxml.org

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Early conclusions

- We can find the needed detailed information in BIM **but**:
  - The modelling has to follow **guidelines** and include such information in the design;
  - An **improved method** is needed to **exchange the information** between different formats (not 1:1 mapping);
  - **Manual integration** still needed in some cases.

- Once the method will be ready, it will be possible to test very efficiently the impact of the designed building on the environment, without additional effort.

Conclusions

- Effective reuse of existing information (3D city models and BIM)
- Good integration methodology is critical to achieve efficient workflow
- As long as modelling criteria and requirements

Possible next

- Integration of simulation results in 3D city model and improvement with energy information.

TU Delft