EnRHEd

Enhancement of Rwandan Higher Education in strategic fields for sustainable growth

CityJSON at the Geomatics Unit
Research & Teaching

Liège
06/07/2022

Erasmus+
With the support of the Erasmus+ Programme of the European Union

CAPACITY BUILDING IN HIGHER EDUCATION
ERASMUS+ KA2: COOPERATION FOR INNOVATION AND THE EXCHANGE OF GOOD PRACTICE

Introduction

- Gilles-Antoine Nys - *Land surveyor engineer*
  - **Research engineer:** semantic web, NoSQL, IoT, etc.
  - **PhD student :** GIS 3.0 - Towards a new generation of GIS
  - **Teaching Assistant:**

Pr. R. Billen	**Pr. F. Jonard**
STER	Spatial analysis
IntroSIG (vector)	IntroGIS (raster)
Advanced GIS	Advanced Remote Sensing
UrbanGIS	Introduction to Remote Sensing
WebGIS	
GIS Project	
Spatial Data Infrastructures	

Outline

- Three parts
  - CityGML, a data model
  - CityJSON in research
  - 3D City Modelling for Education

  - **What do we do and how do we do it?**

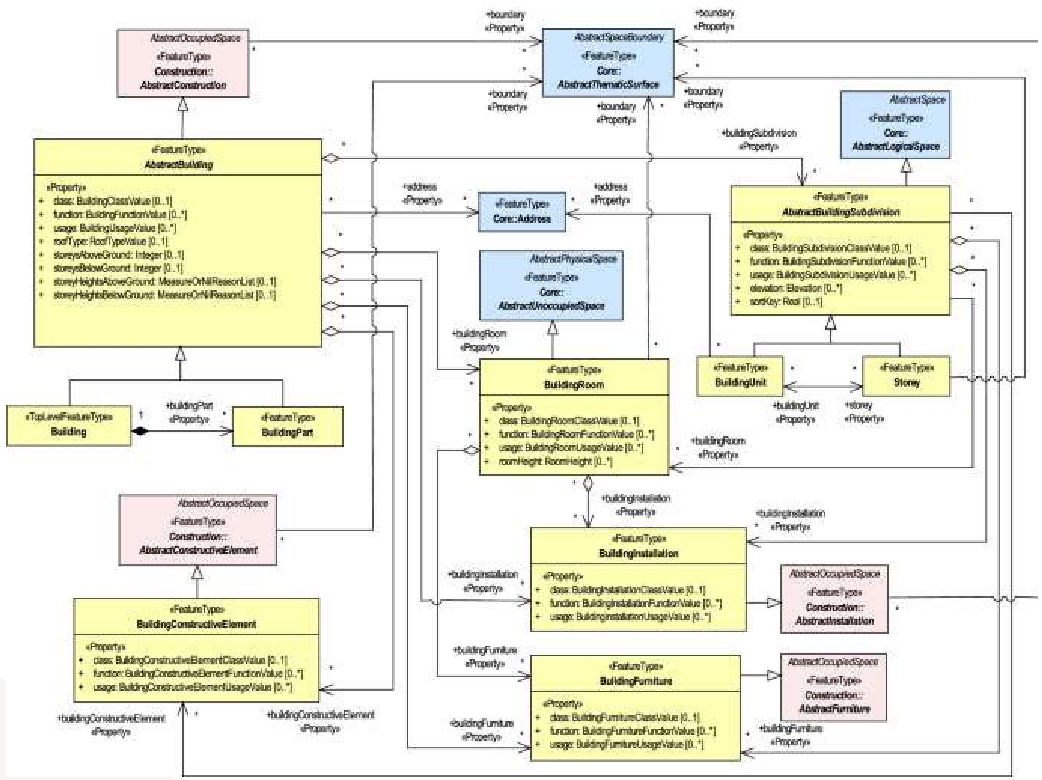
CityGML

A data model

CityGML

CityGML is an open standardised data model and exchange format to store digital 3D models of cities and landscapes. It defines ways to describe most of the common 3D features and objects found in cities and the relationships between them.

September 2022 - v3.0



CityGML

- There are 3 usages of the CityGML data model:
  - Its XML-encoding: **CityGML**
  - Its relational database schema: **3DCityDB**
  - Its JSON-encoding: **CityJSON**

We will also discover its FOURTH usage:

Measur3D
light & compact

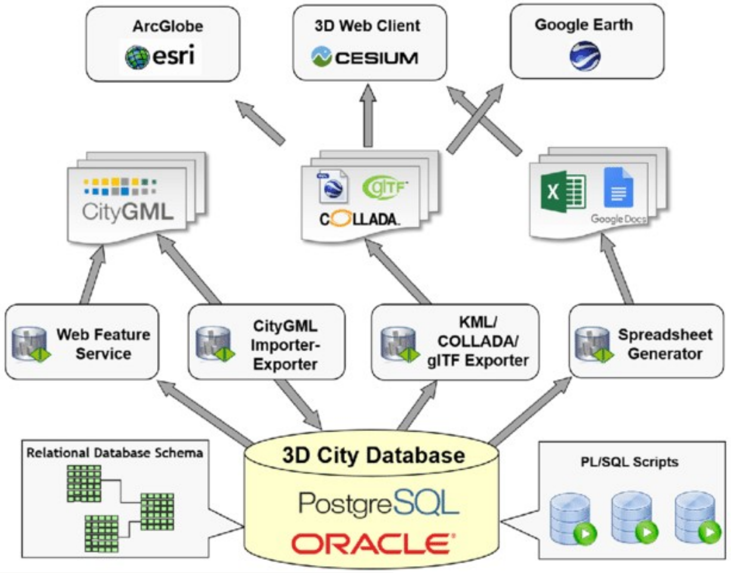
Introduction

CityGML

CityJSON

CityGML - 3DCityDB

- A software that hands CityGML 3D city models

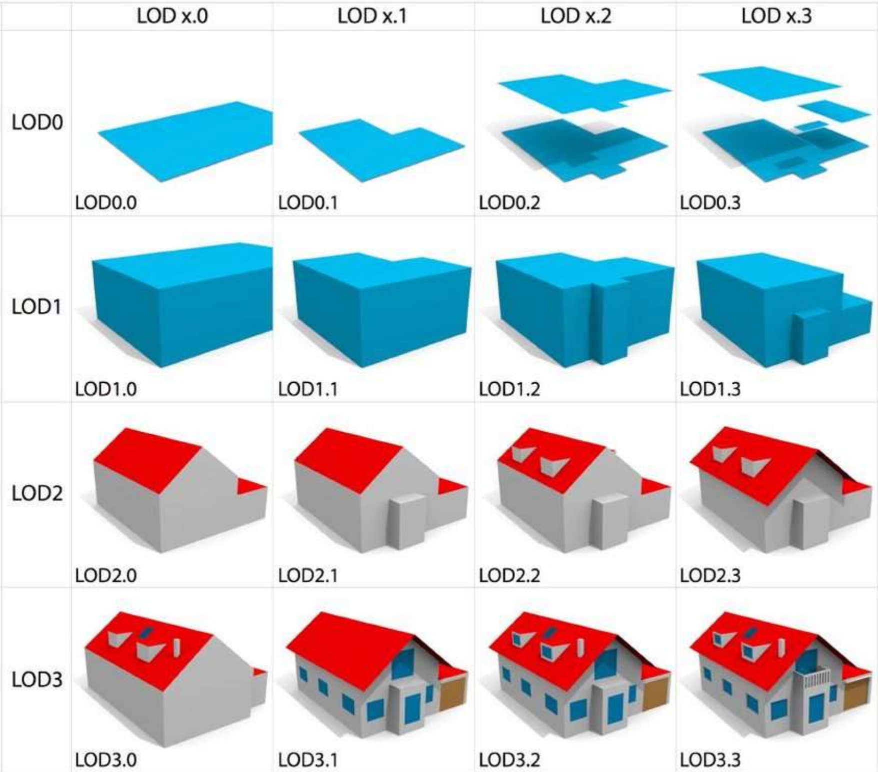


CityGML

- Refined levels-of-detail

LoDs indicate how closely the model mirrors its real-world counterpart.

The higher the LoD, the more difficult it is to generate it and the more you need information !



CityJSON

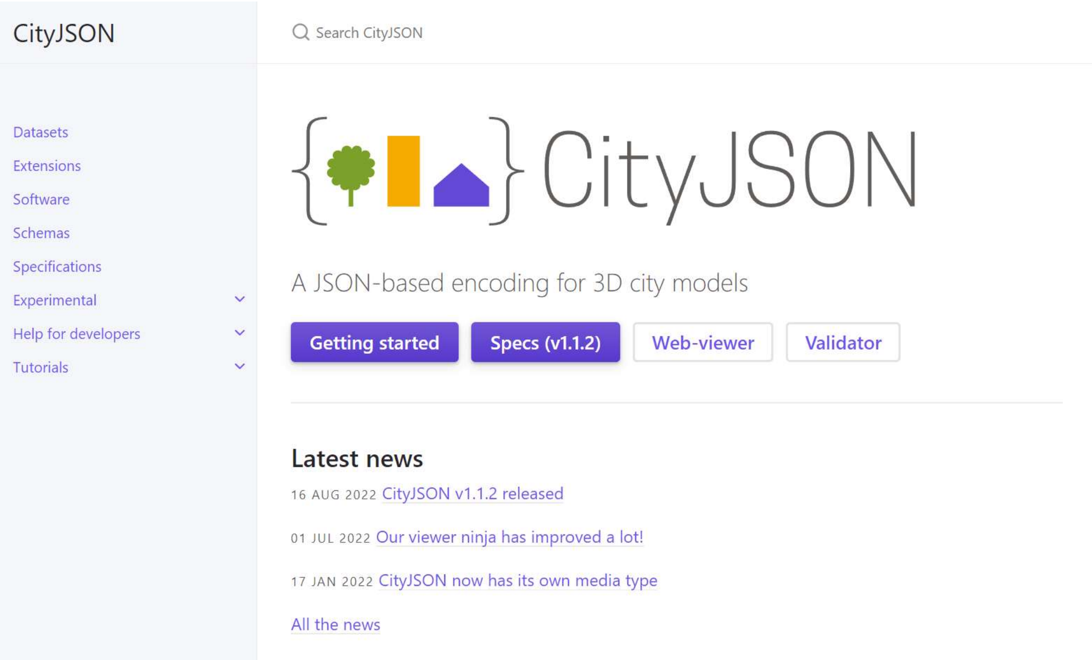
A new trend in 3D City Modelling

Lab PCs

- Connexion logs are the following:
  - **Identifier:** student
  - **Password:** st0000
- Computers are connected to the internet by default

CityJSON

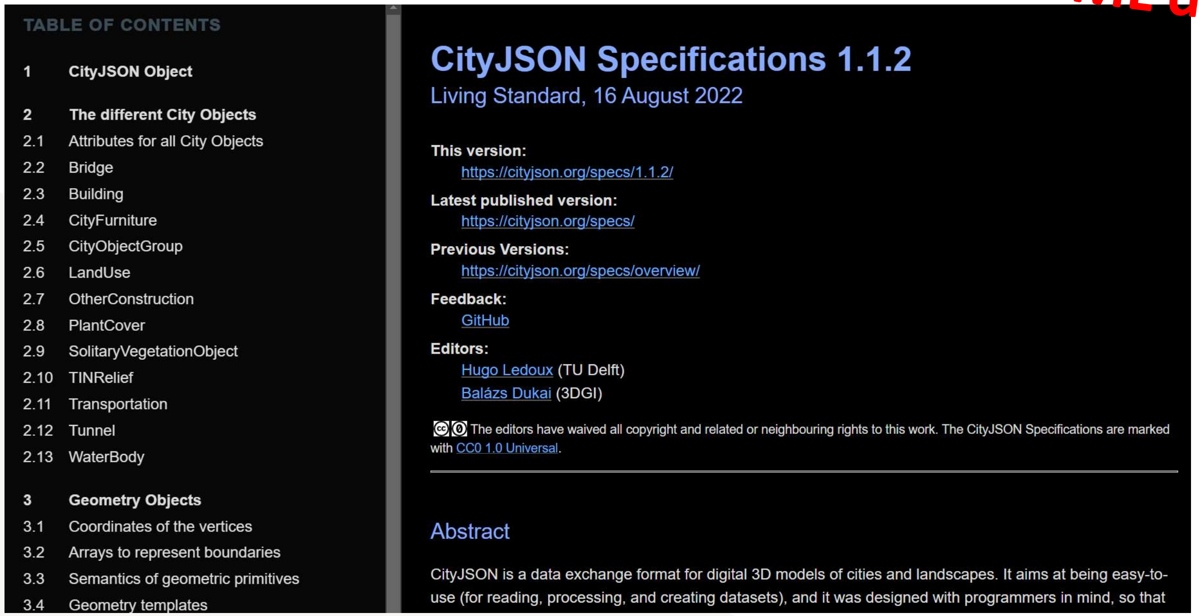
- Official Website : *https://www.cityjson.org/*



CityJSON

- Specifications are widely documented:
  https://www.cityjson.org/specs/1.1.2/

There is no need to dig in complex UML diagrams !



CityJSON Specifications 1.1.2

Living Standard, 16 August 2022

This version:
https://cityjson.org/specs/1.1.2/

Latest published version:
https://cityjson.org/specs/

Previous Versions:
https://cityjson.org/specs/overview/

Feedback:
GitHub

Editors:
Hugo Ledoux (TU Delft)
Balázs Dukai (3DGI)

Abstract

CityJSON is a data exchange format for digital 3D models of cities and landscapes. It aims at being easy-to-use (for reading, processing, and creating datasets), and it was designed with programmers in mind, so that

CityJSON - Minimal valid model

```
{
    "type": "CityJSON",
    "version": "1.1",
    "transform": {
        "scale": [1.0, 1.0, 1.0],
        "translate": [0.0, 0.0, 0.0]
    },
    "CityObjects": {},
    "vertices": []
}
```

CityJSON - Small geometry

```
{
        "type": "MultiSurface",
        "lod": "2",
        "boundaries": [ [[0, 3, 2, 1]], [[4, 5, 6, 7]], [[0, 1, 5, 4]] ]
}

"vertices": [
        [102, 103, 1],
        [25, 744, 22],
        ...
        [23, 88, 5]
]
```

Vertices identifiers in boundaries refer to vertices array

-> Wavefront OBJ system

CityJSON - Why ?

- CityJSON has many advantages:
  - **Lightweight:** exchangeable and usable everywhere (small devices, etc.)
  - **Easy to read:** great format to support education
  - **Easy to develop:** great support of JSON

CityJSON - The same but lighter

- CityJSON supports the *exact same* data model
- CityJSON files are 6-7x times lighter than the same information stored in a CityGML file !
  - No markup repetition
  - Geometries are handle in a smarter way
  - Geometry templates allow reproducing objects

CityJSON - Extensions

- Extensions
  https://www.cityjson.org/extensions/

- Current extensions are (September 2022):
  - Data quality
  - Energy
  - Generic
  - Linear Complex Cell
  - Noise
  - Point Clouds (from Geomatics Unit, ULiège)

CityJSON - Extensions

```
{
    "type": "CityJSON",
    "version": "1.1",
    "extensions": {
        “EnRHEd": {
            "url" : "https://someurl.org/enrhed.ext.json",
            "version": "2.0"
        }
    },
    "CityObjects": {},
    "vertices": []
}
```

CityJSON - Extensions

```
{
    "type": "CityJSONExtension",
    "name": “EnRHEd",
    "description": “A great extension to model something even greater",
    "uri": "https://someurl.org/enrhed.ext.json",
    "version": “2.0",
    "versionCityJSON": "1.1",
    "extraRootProperties": {},   New model metadata
    "extraAttributes": {},       New attributes for an existing CityObject
    "extraCityObjects": {}       New CityObject
}
```

CityJSON - point clouds

- Point clouds are not natively supported in CityJSON
- Point clouds are GREAT source of information

- How to support them? AN EXTENSION !

- Expend the allowed geometries for every CityObjects

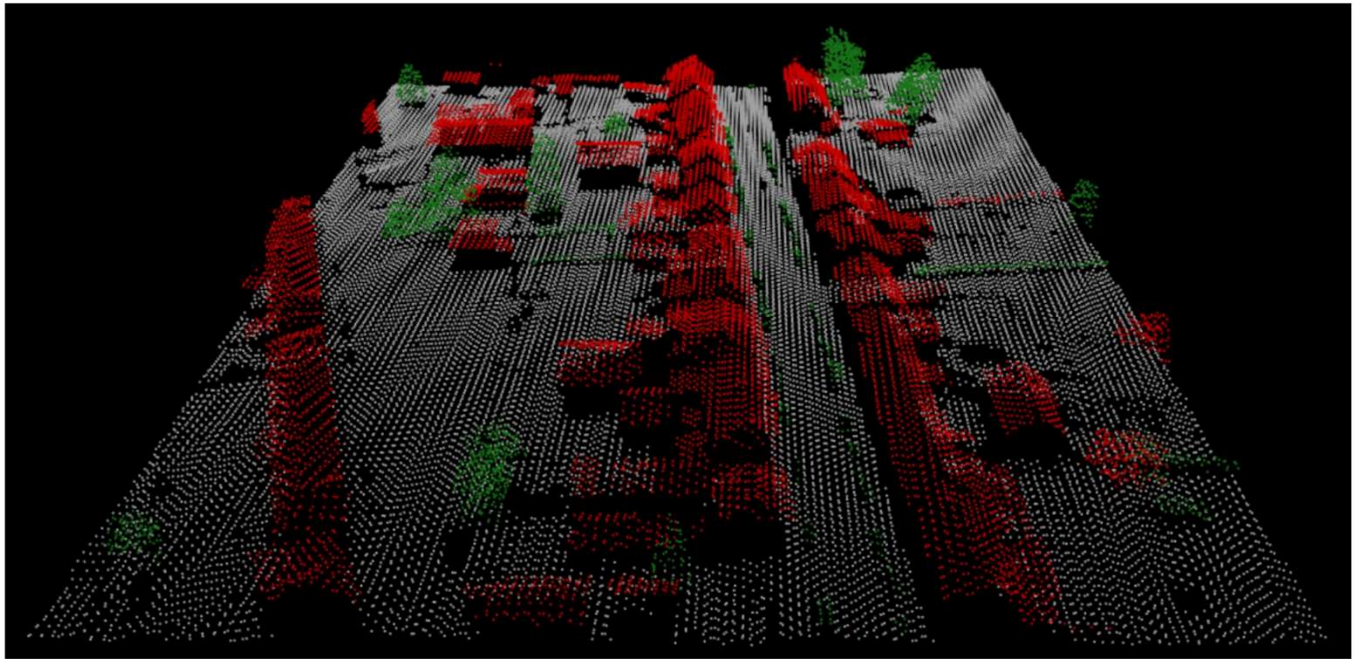
Useful link:
https://github.com/GANys/cityjson-pointcloud/blob/dev/schemas/cityjson-pointcloud.ext.json

Nys, G.-A., Kharroubi, A., Poux, F., and Billen, R.: AN EXTENSION OF CITYJSON TO SUPPORT POINT CLOUDS, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLIII-B4-2021, 301–306, https://doi.org/10.5194/isprs-archives-XLIII-B4-2021-301-2021, 2021.

CityJSON

- Real point cloud from Public Service of Wallonia, Belgium

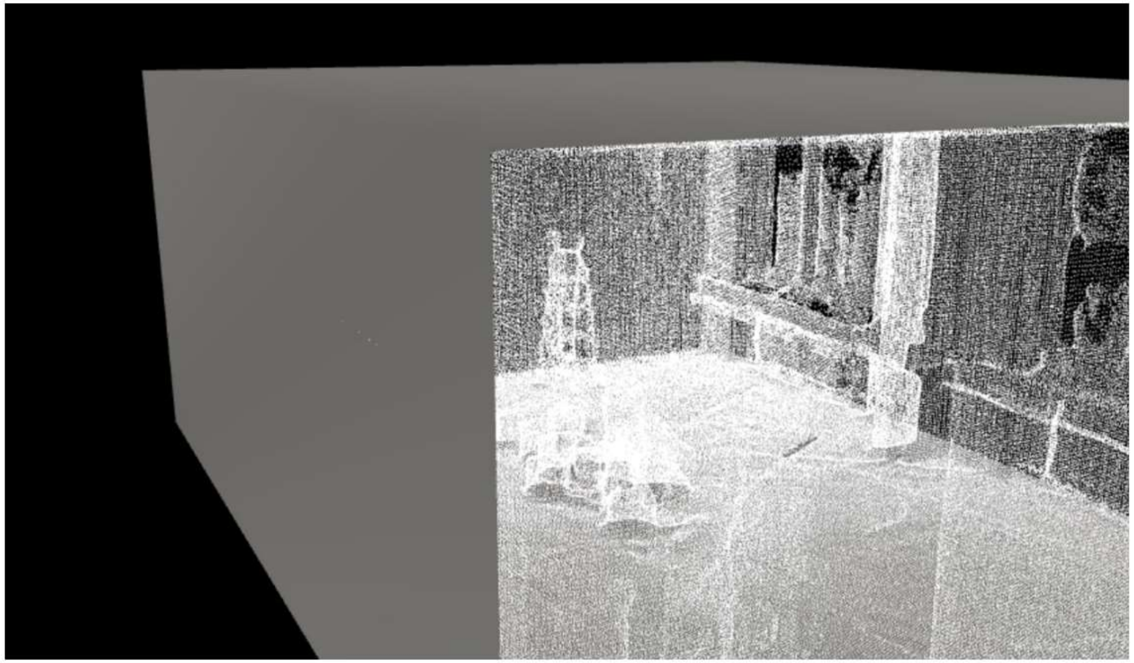
The whole model is a cloud !



CityJSON

- Real point cloud from an indoor LaserScan

Bring details to City Models



CityJSON

- Software - Creation, edition, storage, etc.
  https://www.cityjson.org/software/

Ctrl + Click on "ninja"

Software			View	Generate	Edit	Convert	Parse/API	Validate	Store
3D City DB									●
3dfier	>_	</>		●					
Autoconverter			●			●			
azul			●						
citygml-tools	>_					●			
citygml4j	>_	</>					●		
cjio	>_					●	●	●	
cjval								●	
FME			●	●		●			
IFCCityJSON	>_					●			
Measur3D			●						●

CityJSON

- Open datasets
  https://www.cityjson.org/datasets/

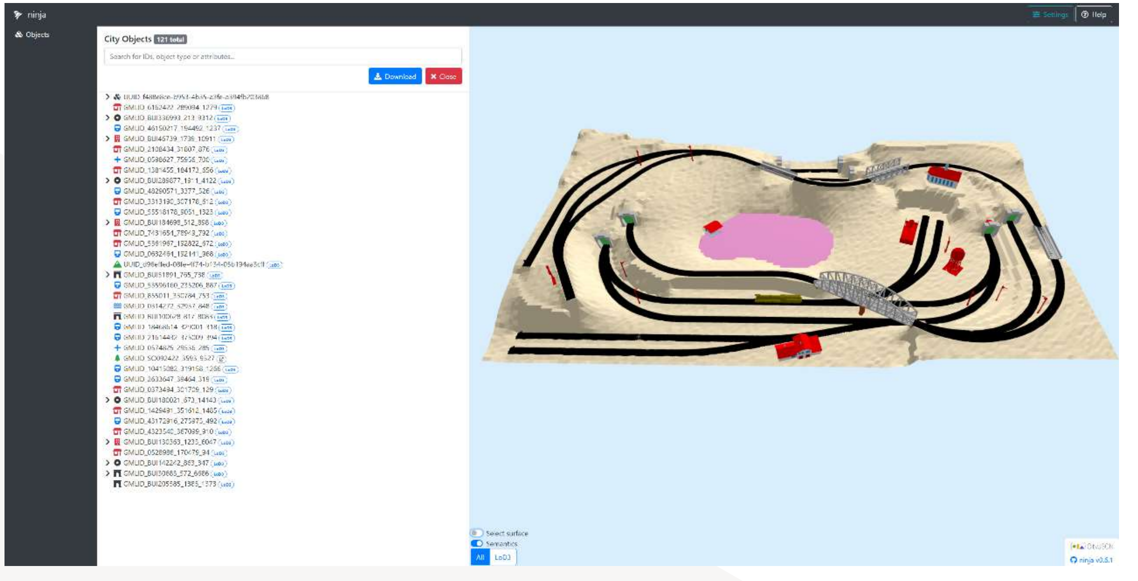
- Open extract of big international cities
  New-York, Montréal, Vienna, etc.

- Download the *railway.city.json* [ZIP file]

CityJSON

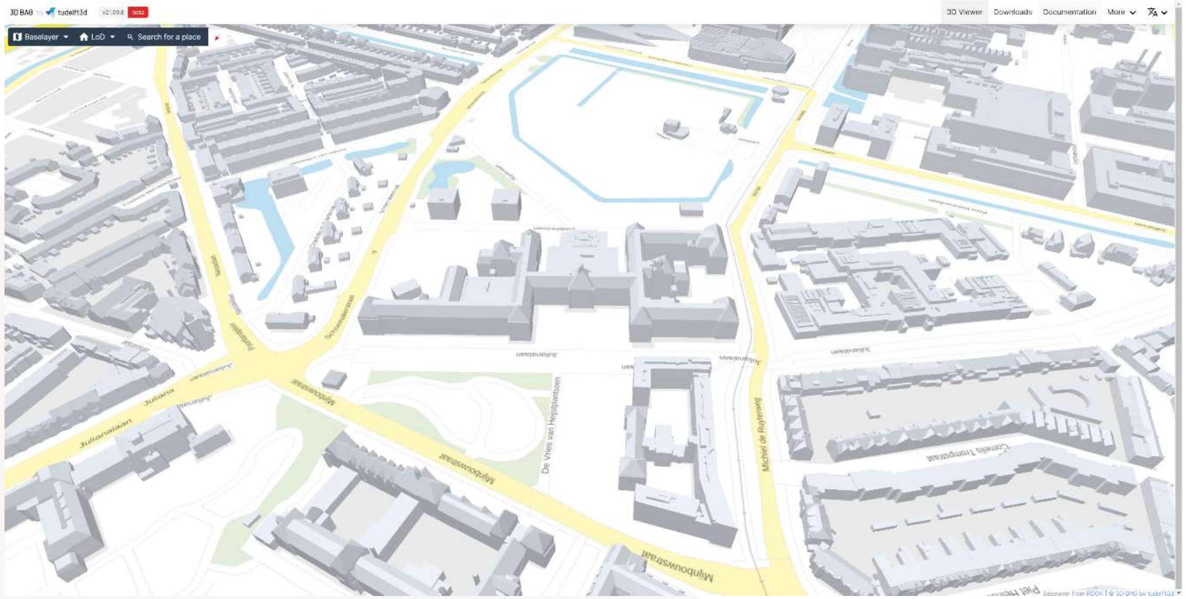
- Go to the NINJA tab

- Load the *railway.city.json* file



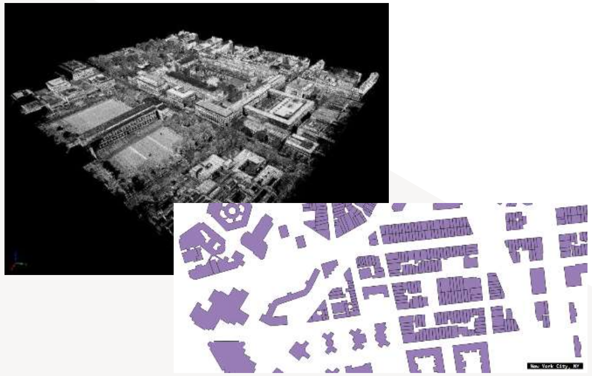
CityJSON – 3DBag

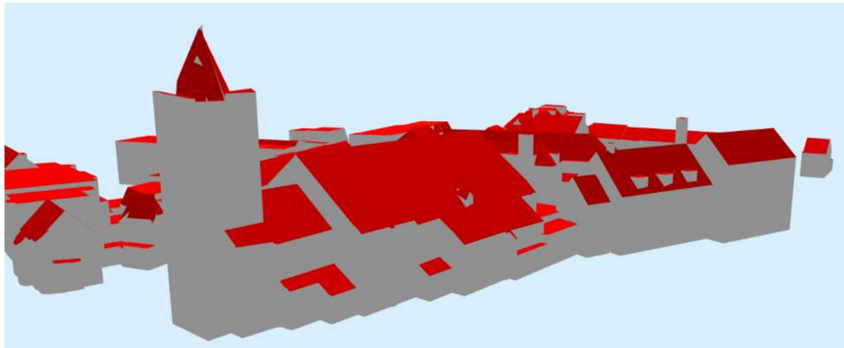
- Open datasets for the whole Netherlands
  https://3dbag.nl/



CityJSON - GeoFlow

- Cutting-edge solution to generate CityJSON models from footprint shapefiles and point clouds
  https://github.com/geoflow3d





CityJSON - Measur3D

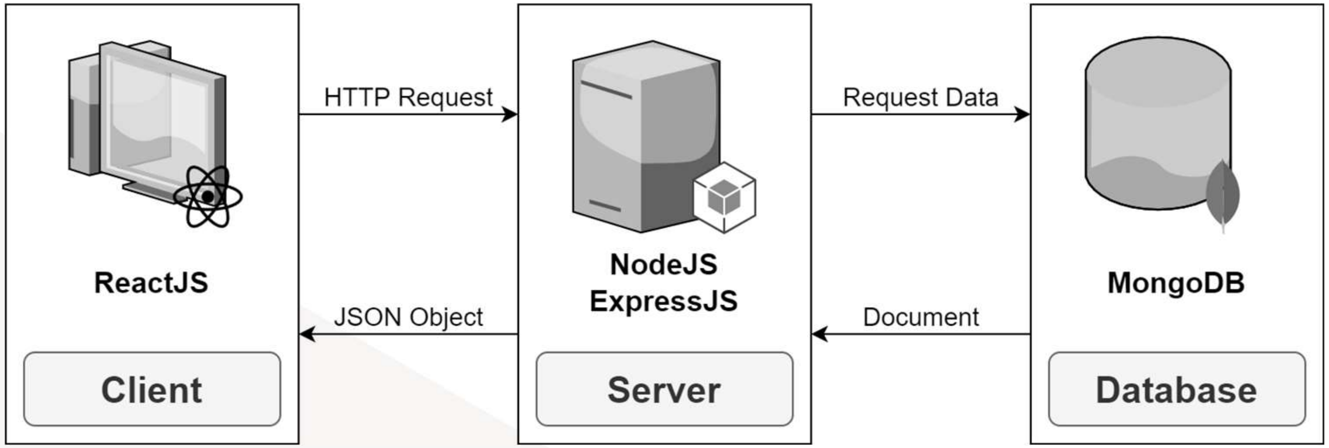
- Measur3D, a light and compact CityJSON platform
  https://ganys.github.io/Measur3D/

Measur3D
light & compact

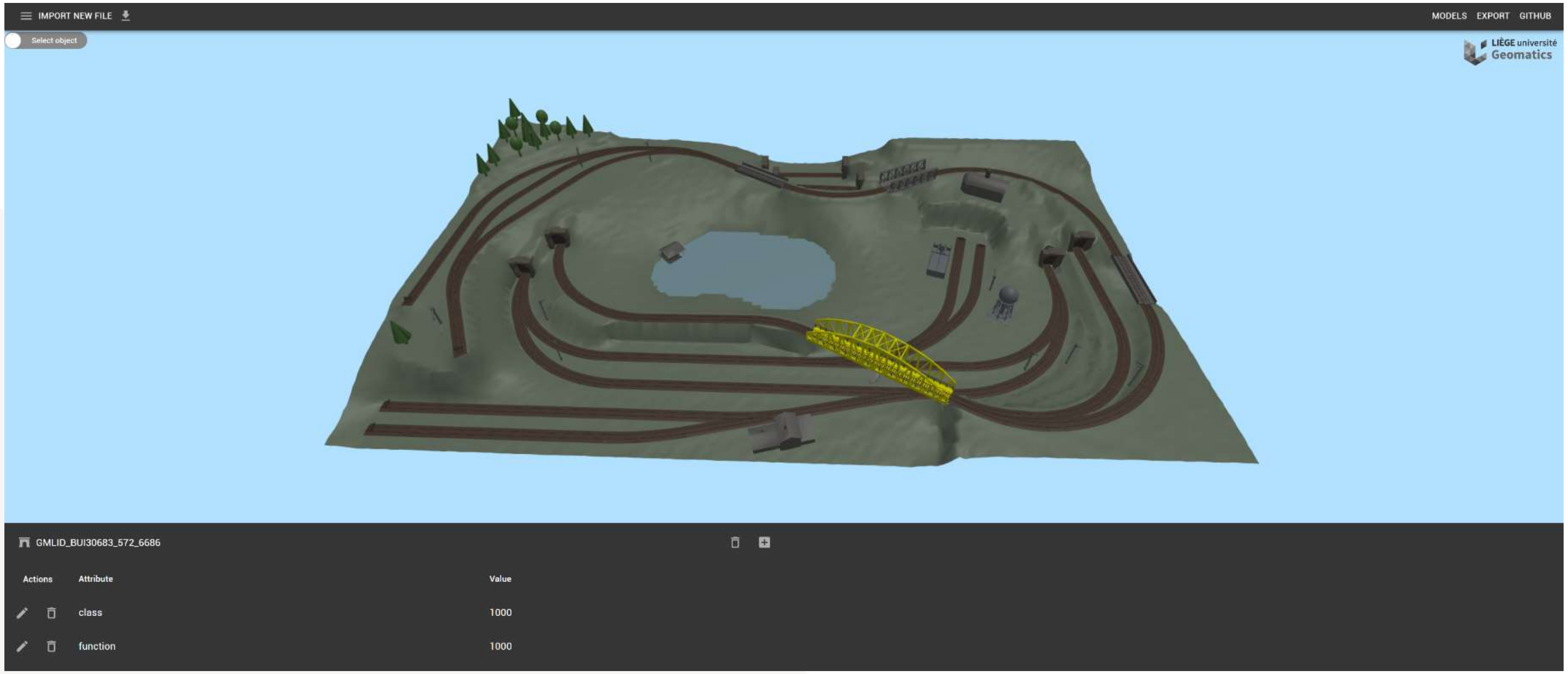
Nys G.-A. and Billen R. (2021). From consistency to flexibility: A simplified database schema for the management of CityJSON 3D city models. Transactions in GIS.

CityJSON - Measur3D

- A MERN (MongoDB, Express, ReactJS and NodeJS) application that allows handling CityJSON files

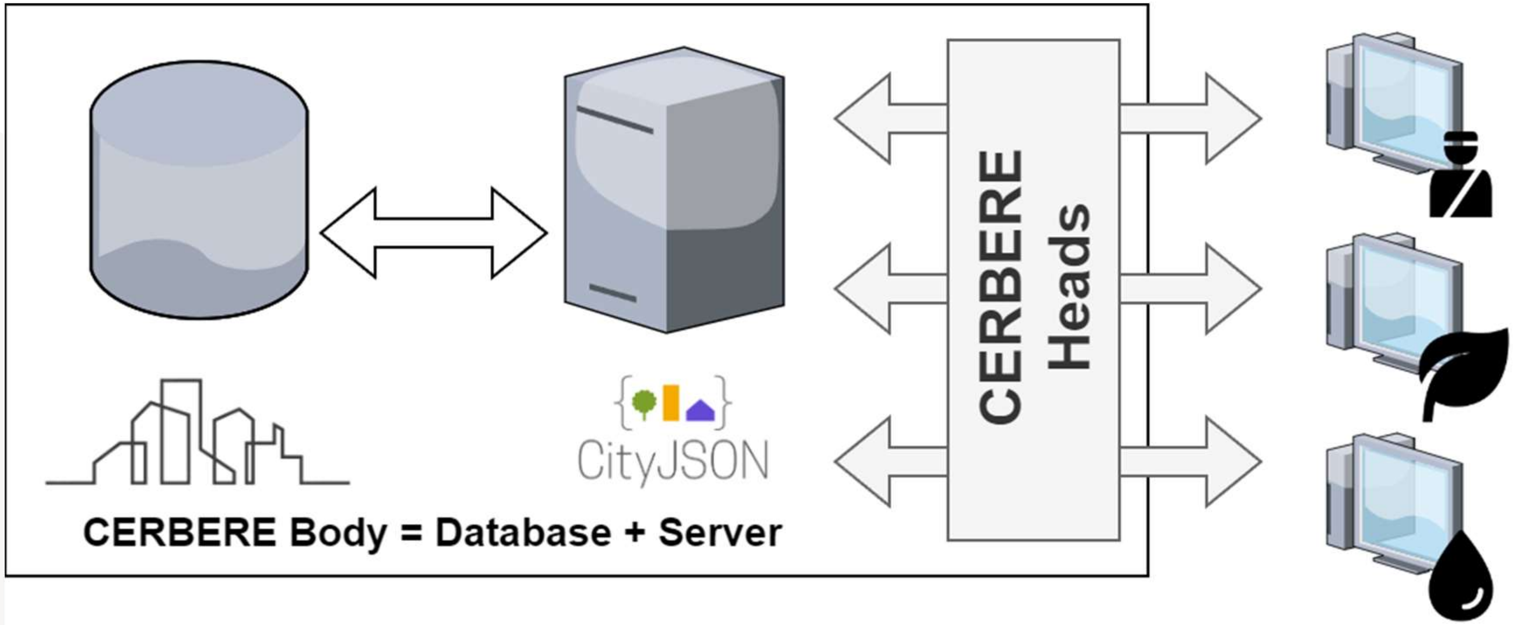


CityJSON - Measur3D



CityJSON - CERBERE

- A middleware that handles concurrent CityJSON schemas



References - 3D City Modelling

- El Yamani, S., Hajji, R., Nys, G.-A., Ettarid, M., & Billen, R. (2021). 3D Variables Requirements for Property Valuation Modeling Based on the Integration of BIM and CIM. Sustainability, 13(5), 2814. https://doi.org/10.3390/su13052814
- Joshi, M. Y., Selmi, W., Binard, M., Nys, G.-A., & Teller, J. (2020). POTENTIAL FOR URBAN GREENING WITHGREEN ROOFS: A WAY TOWARDS SMART CITIES. ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, VI-4/W2-2020, 87–94. https://doi.org/10.5194/isprs-annals-VI-4-W2-2020-87-2020
- Nys, G., & Billen, R. (2021). From consistency to flexibility: A simplified database schema for the management of CityJSON 3D city models. Transactions in GIS, tgis.12807. https://doi.org/10.1111/tgis.12807
- Nys, G.-A., Billen, R., & Poux, F. (2020). AUTOMATIC 3D BUILDINGS COMPACT RECONSTRUCTION FROMLIDAR POINT CLOUDS. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLIII-B2-2020, 473–478. https://doi.org/10.5194/isprs-archives-XLIII-B2-2020-473-2020
- Nys, G.-A., Kharroubi, A., Poux, F., & Billen, R. (2021). AN EXTENSION OF CITYJSON TO SUPPORT POINTCLOUDS. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLIII-B4-2021, 301–306. https://doi.org/10.5194/isprs-archives-XLIII-B4-2021-301-2021
- Nys, G.-A., Poux, F., & Billen, R. (2020). CityJSON Building Generation from Airborne LiDAR 3D Point Clouds. ISPRS International Journal of Geo-Information, 9(9), 521. https://doi.org/10.3390/ijgi9090521

3D City Modelling & CityJSON

Great assets for Education

Lessons at the UGeom - Masters

- Introduction to UrbanGIS (Engineer-Architects) : GEOG2053-1
  - https://www.programmes.uliege.be/cocoon/20222023/cours/GEOG2053-1.html
- Spatial data infrastructures (Geomaticians) : GEOG0059-1
  - https://www.programmes.uliege.be/cocoon/20222023/cours/GEOG0059-1.html
- GIS Project (Geomaticians) : GEOG0070-1
  - https://www.programmes.uliege.be/cocoon/20222023/cours/GEOG0070-1.html

UrbanGIS

- Introduction to Geographic Information Systems and more specifically to processing useful for urban applications.

- **Spatial information:** format, storage, accessibility, etc.
- **GIS processing:** vector/raster
- **Urban applications:** urbanism projects & 3D processing, etc.

- 12h Theory & 20h practical sessions

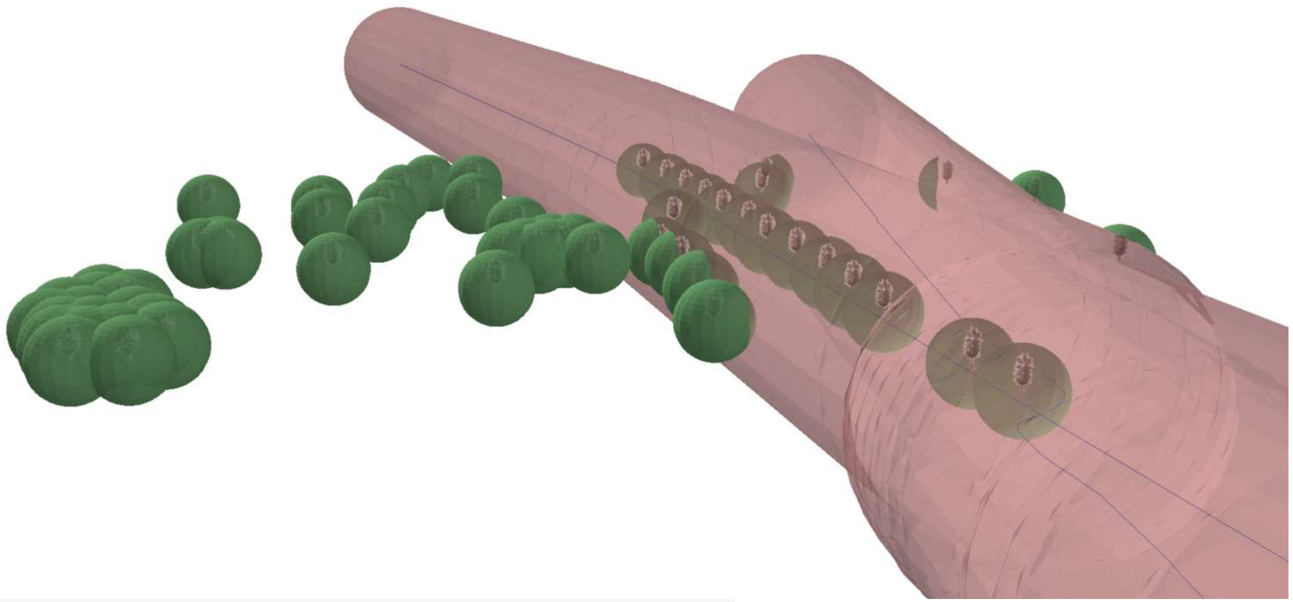
- 3 credits

UrbanGIS - 3D applications

- Contextualization of an urbanistic project

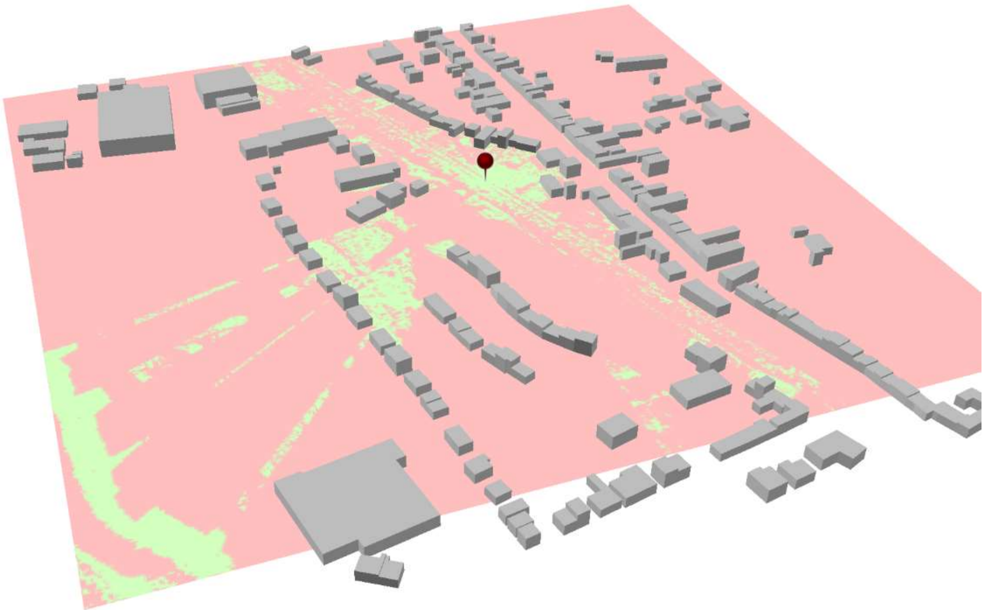
UrbanGIS - 3D applications

- Pollutant dispersion applications



UrbanGIS - 3D applications

- Viewshed analysis



UrbanGIS

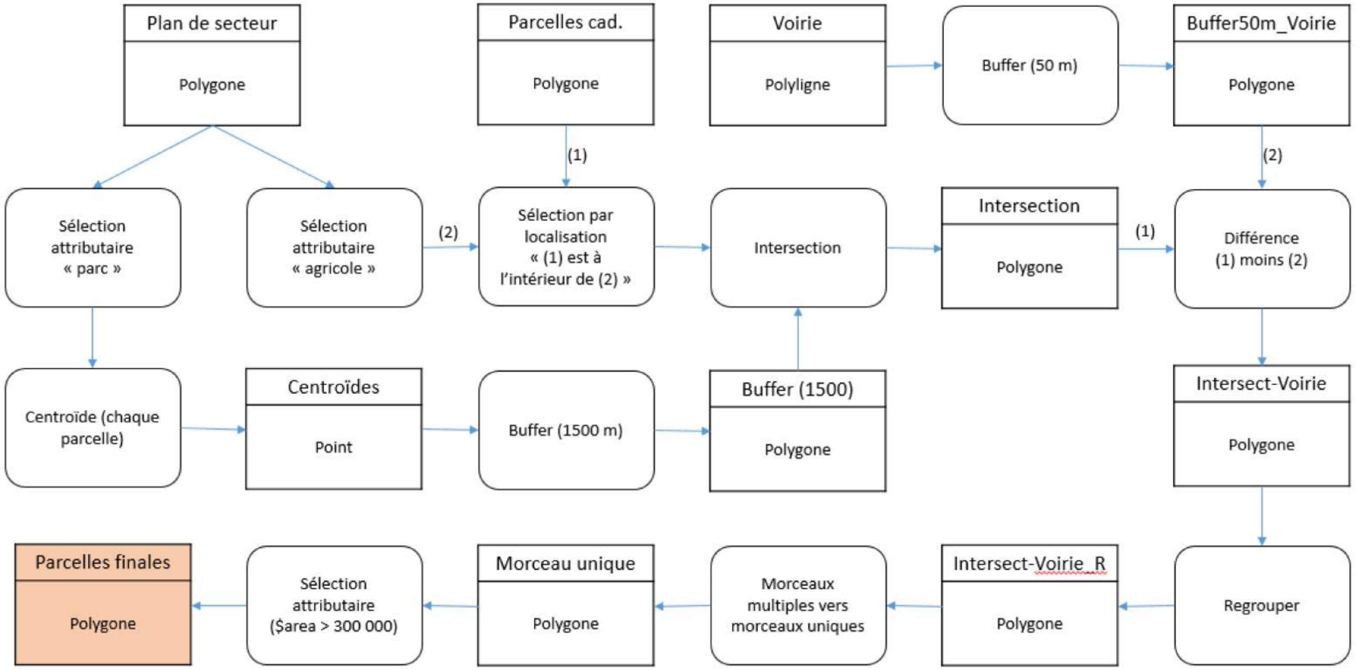
- 3D processing is not part of the examination

- Examination consist of a “traditional” GIS question with both vector/raster parts.
  - What are the cadastral parcels that are more than 50m away from the parks, that are close to a highway and that have a slope greater than 5% totaling 50 hectares?

- Three parts:
  - Final result
  - Processing chain
  - Cartographic rules

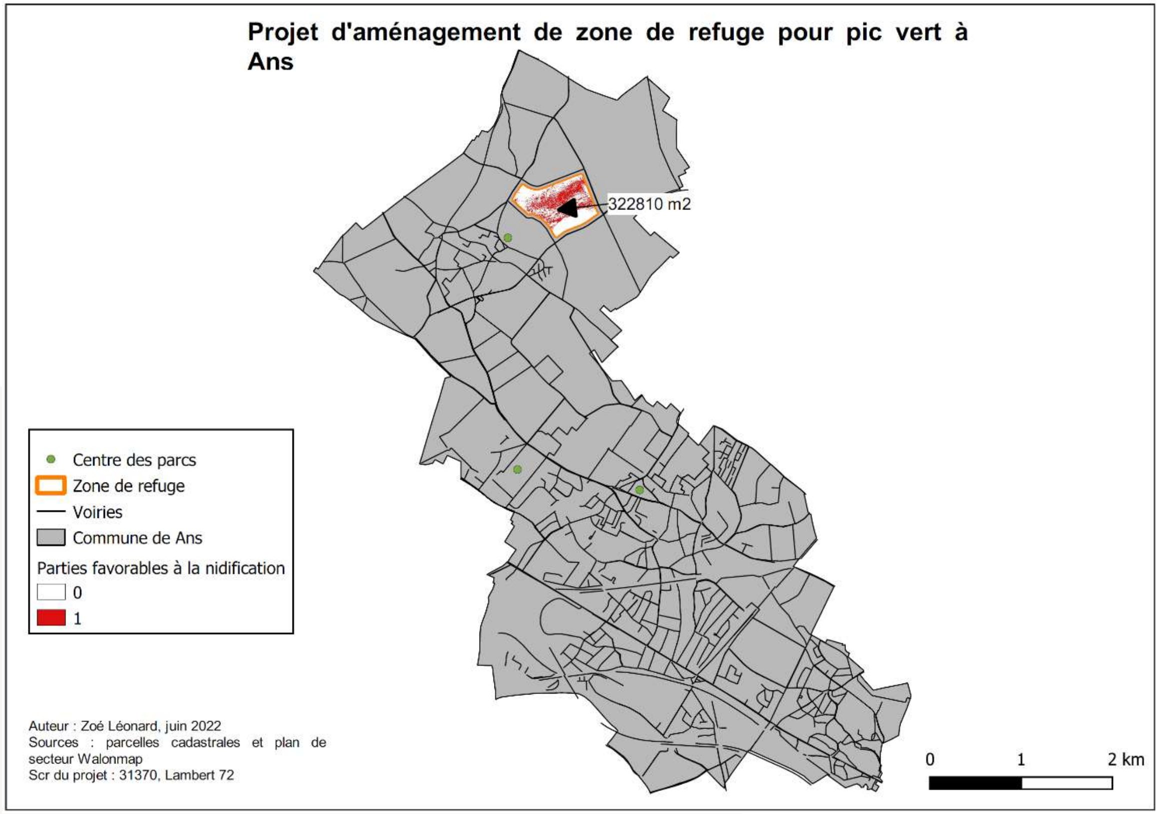
UrbanGIS

Useful if the student did not reach the final answer



Rémi Dobbelstein, 2022

UrbanGIS



Projet d'aménagement de zone de refuge pour pic vert à Ans
322810 m2
Centre des parcs
Zone de refuge
Voiries
Commune de Ans
Parties favorables à la nidification
0
1
Auteur : Zoé Léonard, juin 2022
Sources : parcelles cadastrales et plan de secteur Walonmap
Scr du projet : 31370, Lambert 72
0 1 2 km

Spatial data infrastructures

- Definition, functions and components of a geographic information system in an organization.

- **Spatial database:** storage, accessibility, standards, etc.
- **Process modelling:** UML diagrams, development strategies, ETL tools, etc.
- **WebGIS project:** conceptualisation and production of a routing application.

- 30h Theory & 30h practical sessions

- 5 credits

Spatial data infrastructures

- Relational databases
  - SQL language
  - PostgreSQL + PostGIS + pgRouting
- Spatial OGC standards
  - Web services

- WebGIS project
  - **Client :** Leaflet
  - **Server :** NodeJS
  - **Database :** PostgreSQL + PostGIS + pgRouting

Spatial data infrastructures

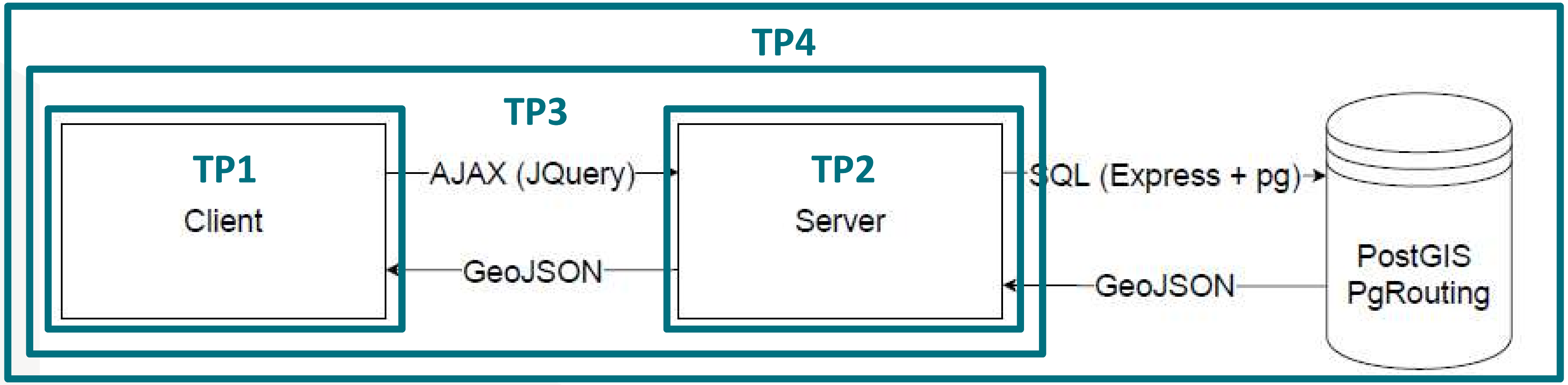
- Teacher is a PM. He guides the students building a three-tier architecture:
  - **TP1 - Client:** map interface that allows users to define position and targets
  - **TP2 - Server:** retrieve and serve information in a standardized way
  - **TP3 - Database:** store roads network and compute shortest paths

  - **TP4 - Final product (1h in class, then homework):** setting the 3 stacks to music

  - **Rating**:
    - Final report: functional analysis of the application

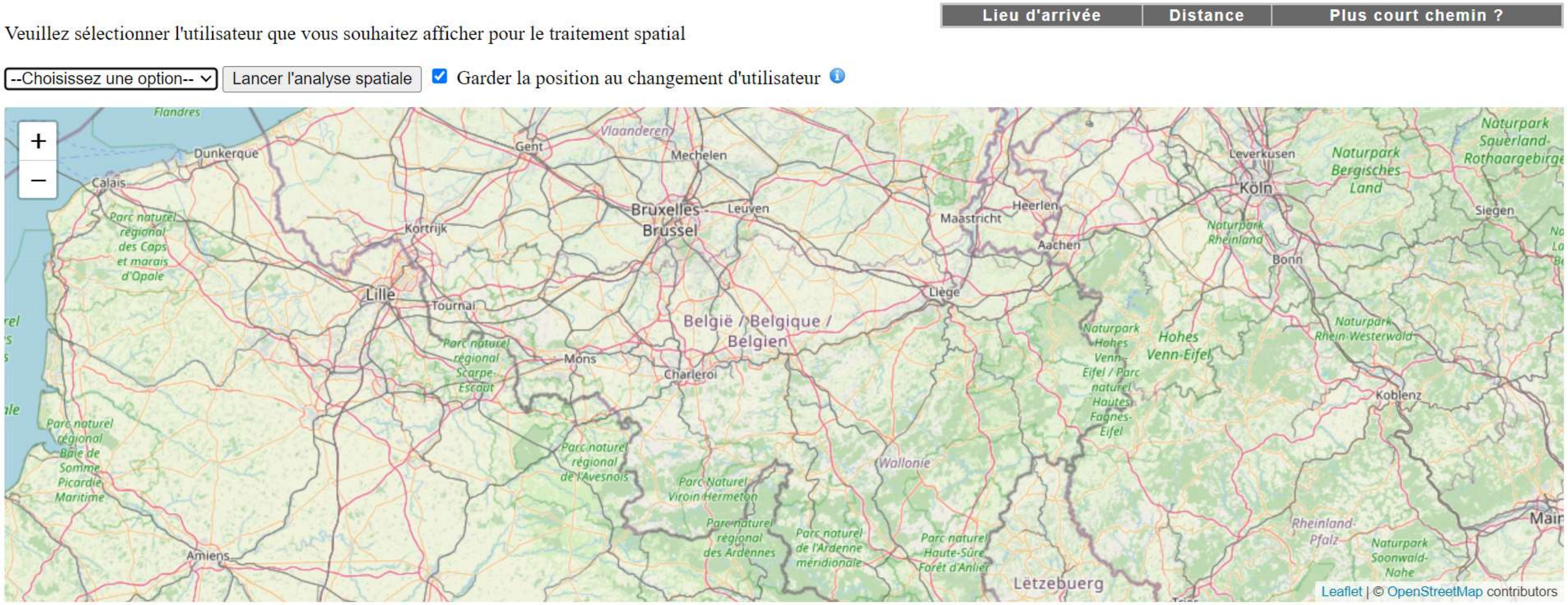
    - **A very good project goes beyond the functional demand**

Spatial data infrastructures



Database has been created during theoretical sessions

Spatial data infrastructures



Quentin Van Den Spiegel, 2022

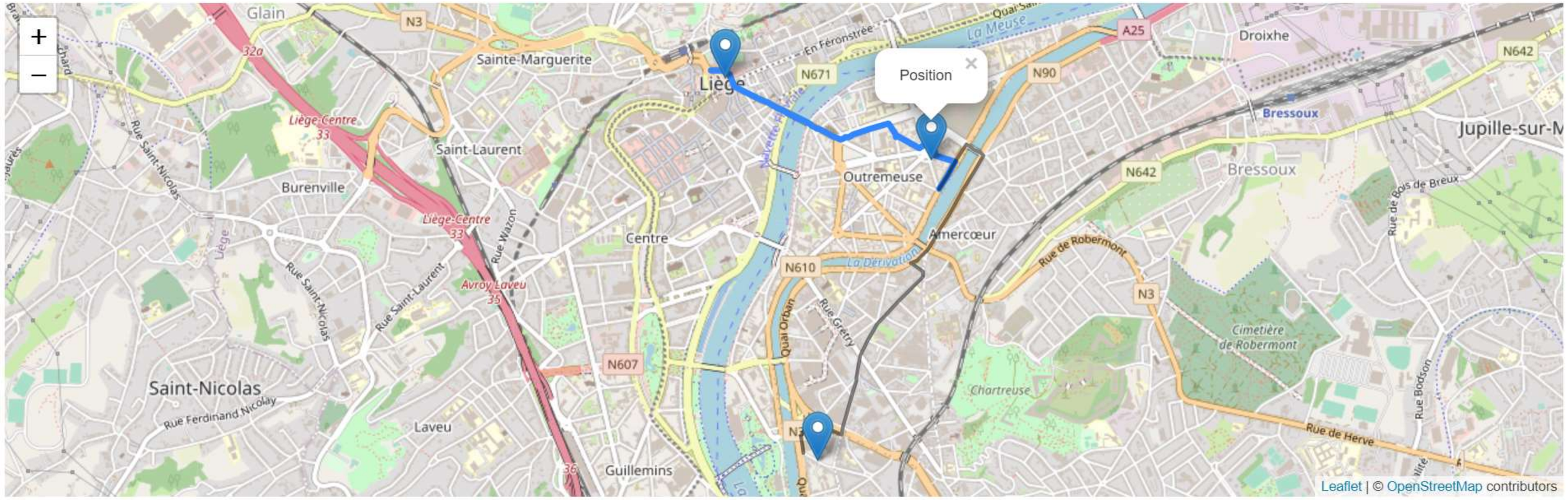
Spatial data infrastructures

Allez à votre company qui est à 1,596 km de votre localisation

Traitement fini, vous pouvez relancer un nouveau traitement.

Florence | Lancer l'analyse spatiale | Garder la position au changement d'utilisateur

Lieu d'arrivée	Distance	Plus court chemin ?
company	1,596 km	Oui
residence	2,319 km	Non



Quentin Van Den Spiegel, 2022

GIS Project

- Realization of a GIS on a remote server answering a precise schedule of conditions .
- As a Team, students are asked to model a city neighbourhood in three dimensions.
  - Data search
  - Modelling (each student has its own CityObject type to create)
  - Storage and accessibility
- 80h project
- 5 credits

GIS Project

- Students are divided into teams (min. 2 students).
  - Each student is responsible of a CityObject type (Building, Vegetation, Roads, etc.)
  - All outputs are then merged in a single CityModel
  - Each student should provide example of a specific application
- The greater the team, the more detailed the city.
  - Communication and Organization are Kiss-cool effects

- Two groups are created:
  - Setting up the database
  - Merging of CityObjects types

GIS Project - Stand Up Meeting

- A *StandUp meeting* is organized every week:
  - Summary of last SUM.
  - What we have done this week.
  - Problems/Solutions
  - What we intend to do next week.

  - 30 minutes.

  - **The meeting is maintained under all circumstances.**

  - **Teacher is present but students should be the driving force !**

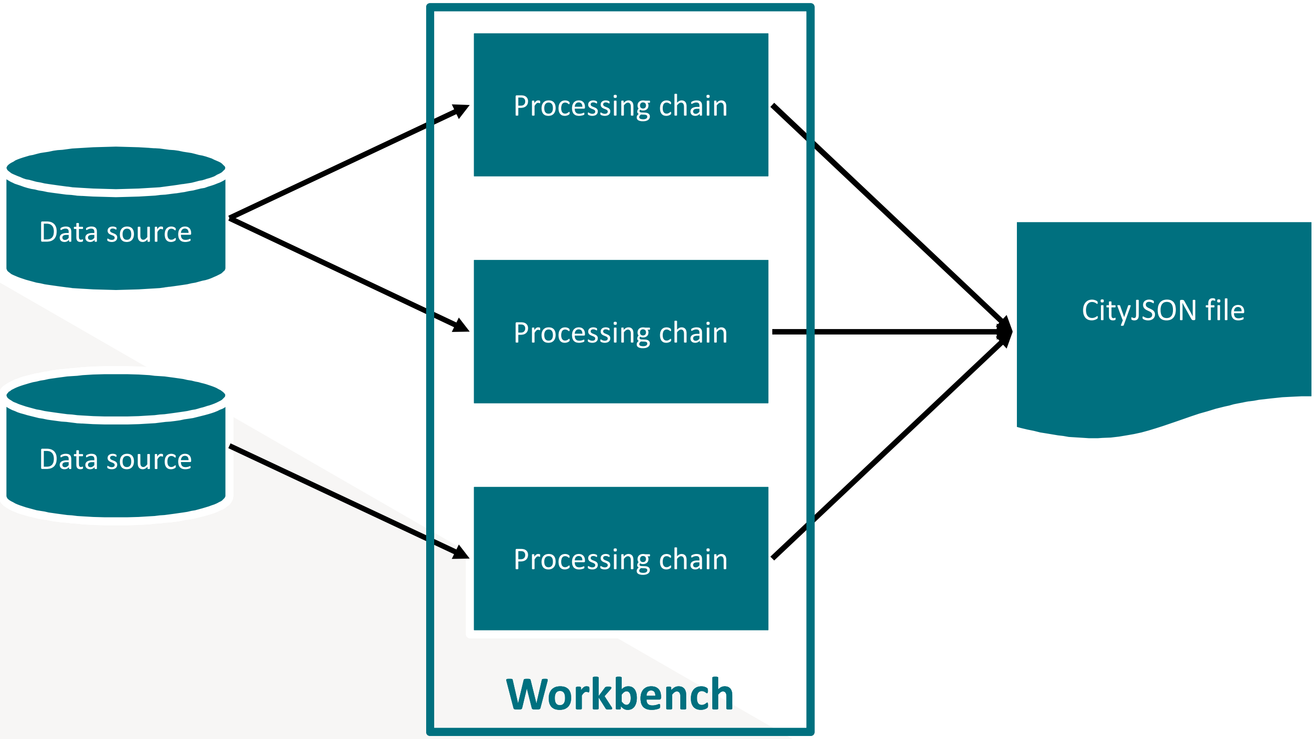
GIS Project - Product

- Depending on the CityObject type, elements are kept simple:
  - **Buildings:** LoD1 - flat roofs
  - **Roads:** LoD1 – platforms
  - **SolitaryVegetationObject:** Tree templates on point locations
  - **TINRelief:** No holes

GIS Project - Modelling

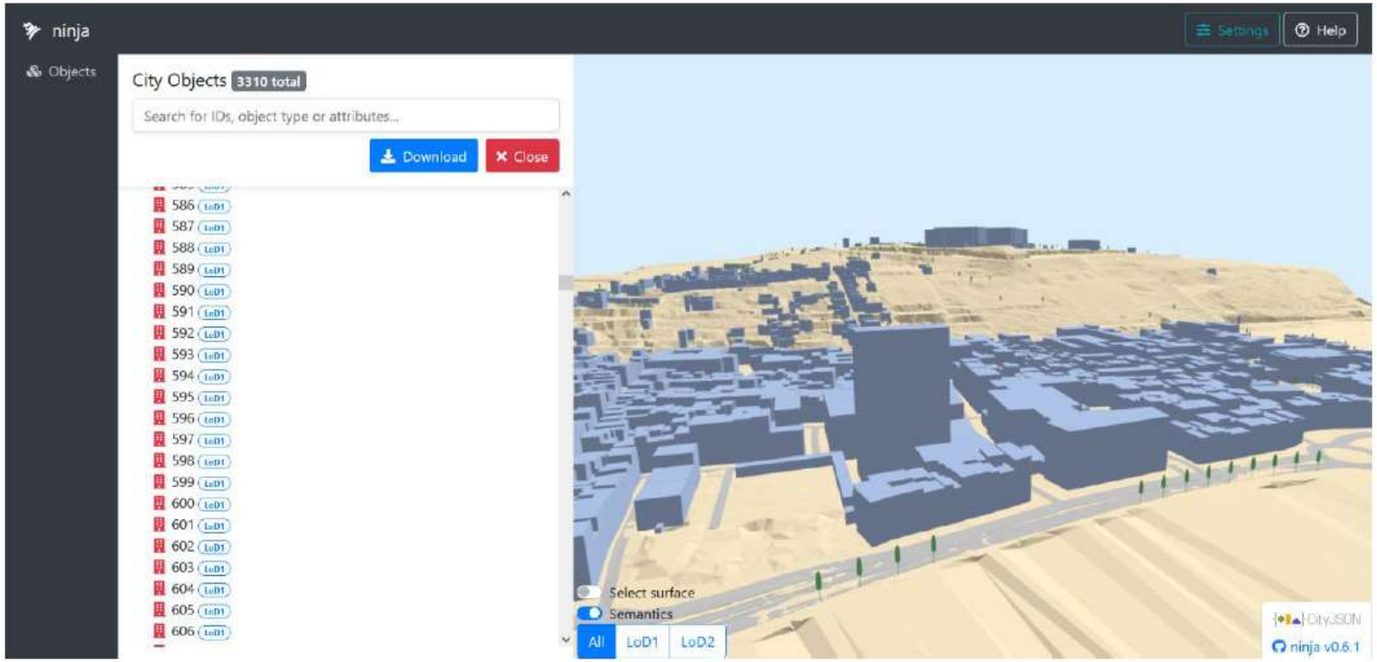
- Data sources are provided to students
  - They need to select the relevant information from it.
  - FME Workbenches are used to model CityObjects and generate the CityJSON file

GIS Project - Merging



GIS Project - Google Earth

GIS Project - Product



GIS Project - Database

- Once the model has been imported to the database (3DCityDB):
  - Student should propose, exemplify and document an application specific to their CityObject type.

  - **The application MUST use 3D processing functions !!!**

GIS Project - Report

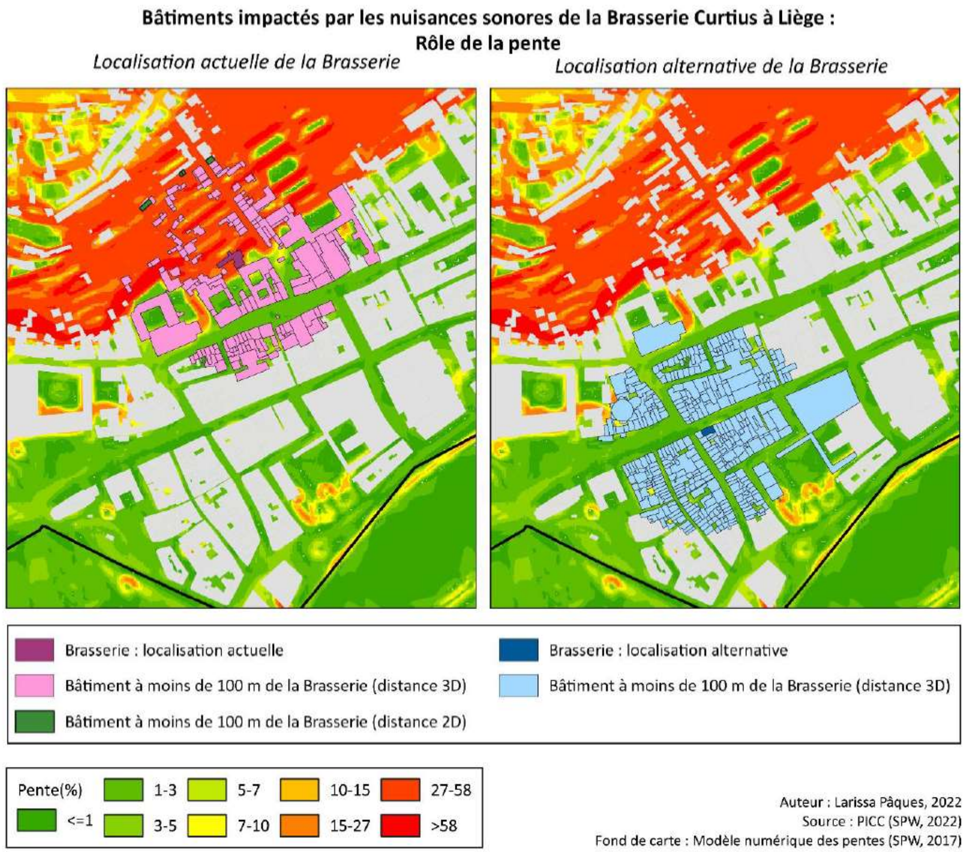
- Students need to provide their own report:
  - Modelling of their CityObject type
  - Explanations on their Group work + summary of the other Group work
  - Analysis of their specific application

- Reports are then presented before teachers
  - Students should be able to discuss all the steps, even if it was not part of its group

GIS Project

- Buildings class:
  - Study the noise pollution around a brewery and its bar
  - Setting up an alternative position

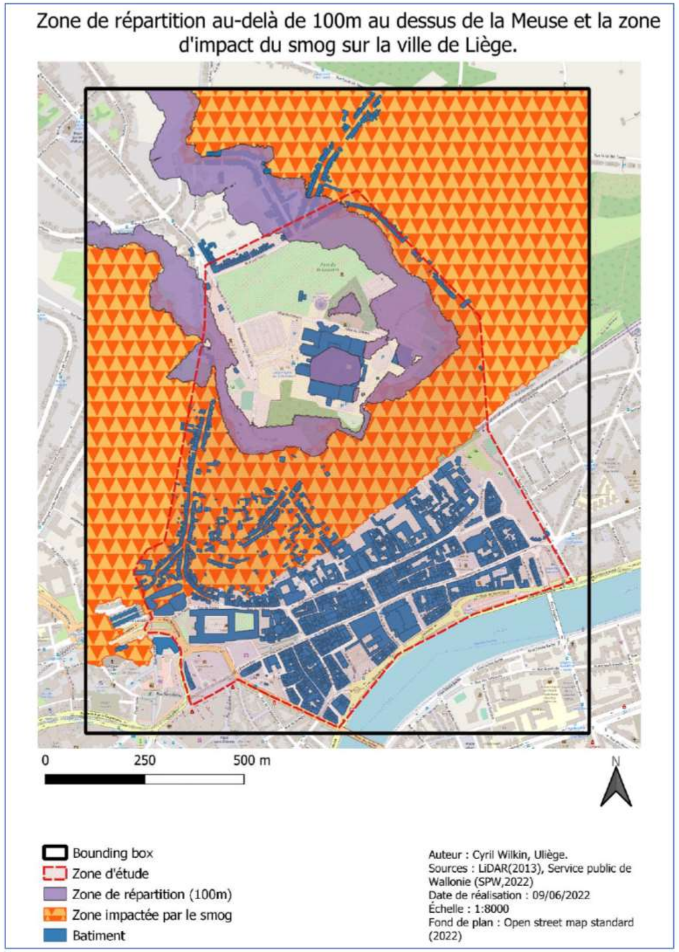
  Impact of Relief and Building 3D geometries



GIS Project

- TINrelief class:
  - Study the pollutant dispersion (SMOG)

Impact of Relief and Building 3D geometries



Thank you for listening

My email : ganys@uliege.be

Looking forward to exchanging ideas

EnRHEd

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Geomatics

LIÈGE université
Urban & Environmental Engineering

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