



Parametric modelling for the quantitative study of microclimate of historical urban settings

Elena Verticchio

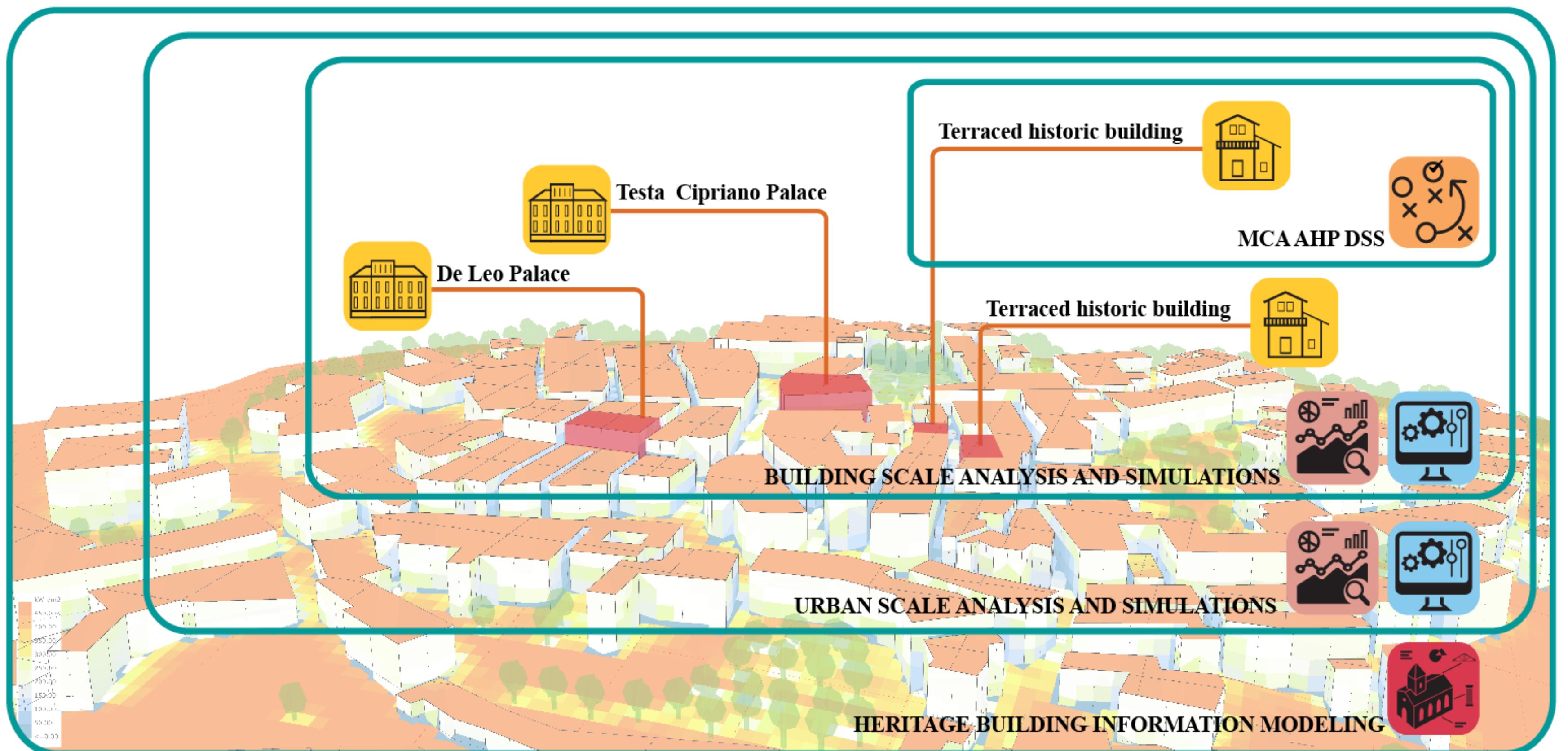
CNR Institute of Heritage Science

INTERNATIONAL WORKSHOP
DIGITAL INTEGRATED STRATEGIES TO SAFEGUARD
HERITAGE CONSTRUCTION TECHNOLOGIES
September 30 - October 5, 2024 | Poggiooreale, Trapani



Environmental analysis

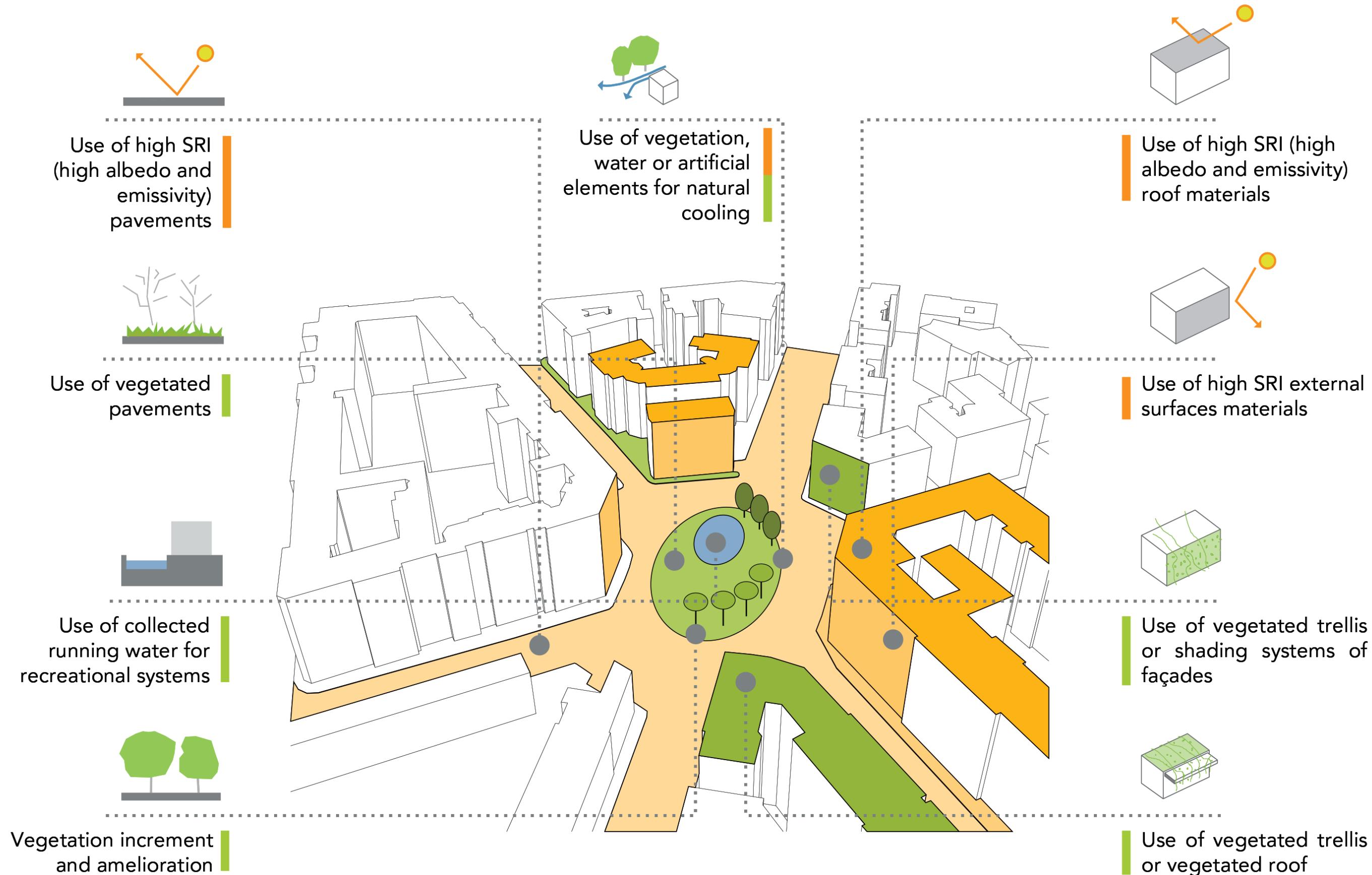
MULTI-SCALAR APPROACH



Environmental analysis

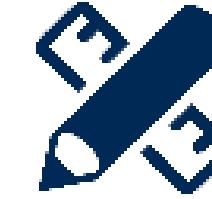
Urban design affecting the microclimate:

- urban geometry
- urban materials
- natural elements:
vegetation and water



Bioclimatic studies

Technical assessment



**GIS maps
connected
to HBIM model**

**Bioclimatic
study**



3D laser scanner



**Management strategies and
renovation solutions**



**ERA5 Copernicus
climate data**

PROSIT

Naples, ex Corradini complex

PROgettare in Sostenibilità - qualificazione e digitalizzazione in edilizia

Methodologies and procedures for assessing and quantifying sustainability in construction through the use of integrated design platforms



Unione Europea



Area ex Corradini

San Giovanni a Teduccio (NA)

19th-century industrial complex:

- great variability of typologies and construction systems
- evolution of techniques and functions

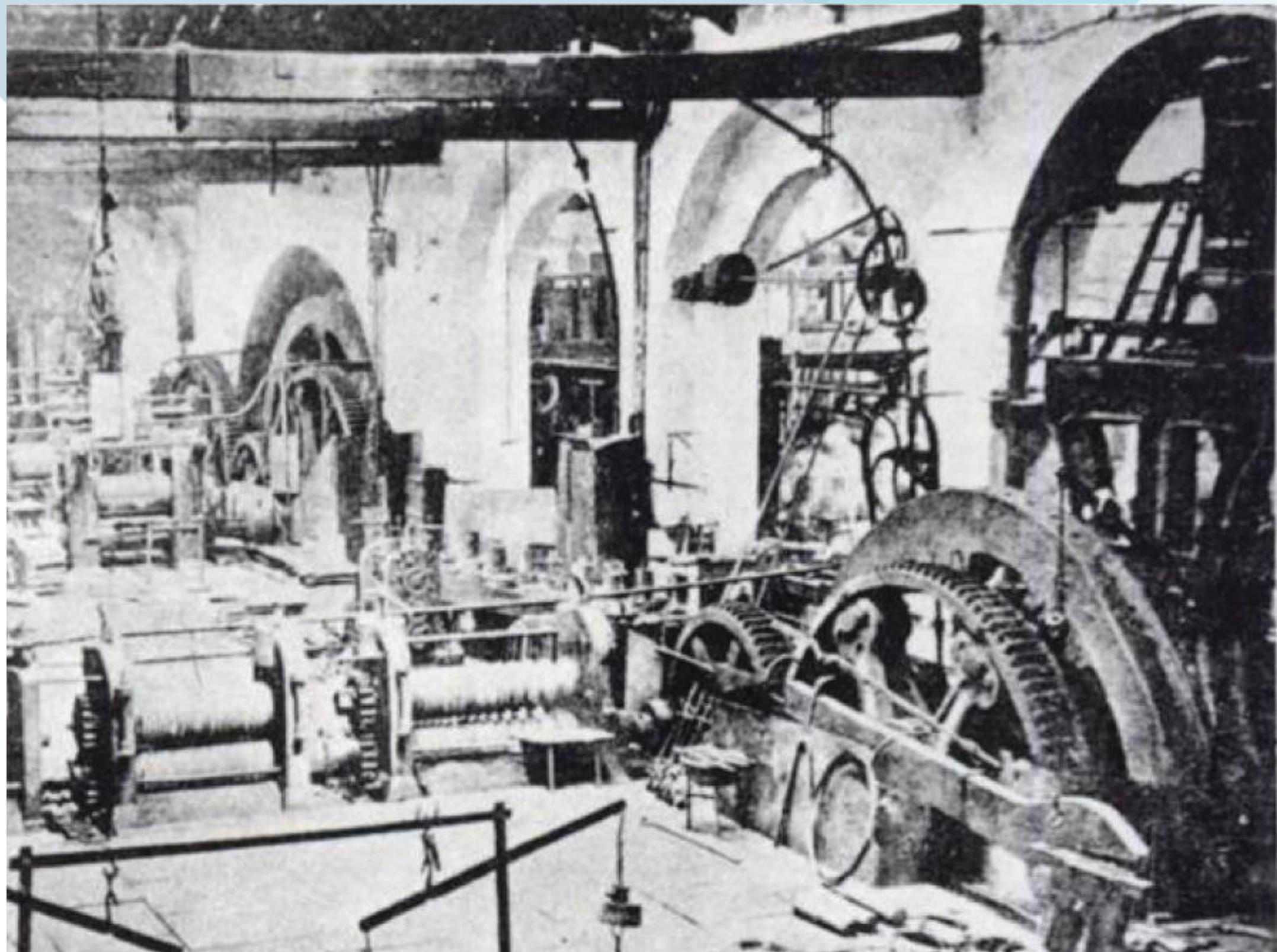


Area ex Corradini

San Giovanni a Teduccio (NA)

19th-century industrial complex:

- great variability of typologies and construction systems
- evolution of techniques and functions



Area ex Corradini

San Giovanni a Teduccio (NA)

19th-century industrial complex:

- great variability of typologies and construction systems
- evolution of techniques and functions

- Current state of neglect and disrepair
- Great potential for development



Area ex Corradini

San Giovanni a Teduccio (NA)

Relationship with the neighbourhood:

1. suburban area strongly connected to the centre
2. degraded historical context to be revitalised
3. potential for urban and local development



Area ex Corradini

San Giovanni a Teduccio (NA)

2012 regeneration project (feasibility study)

Strengths

Attention to buildings' renovation, both technological and functional

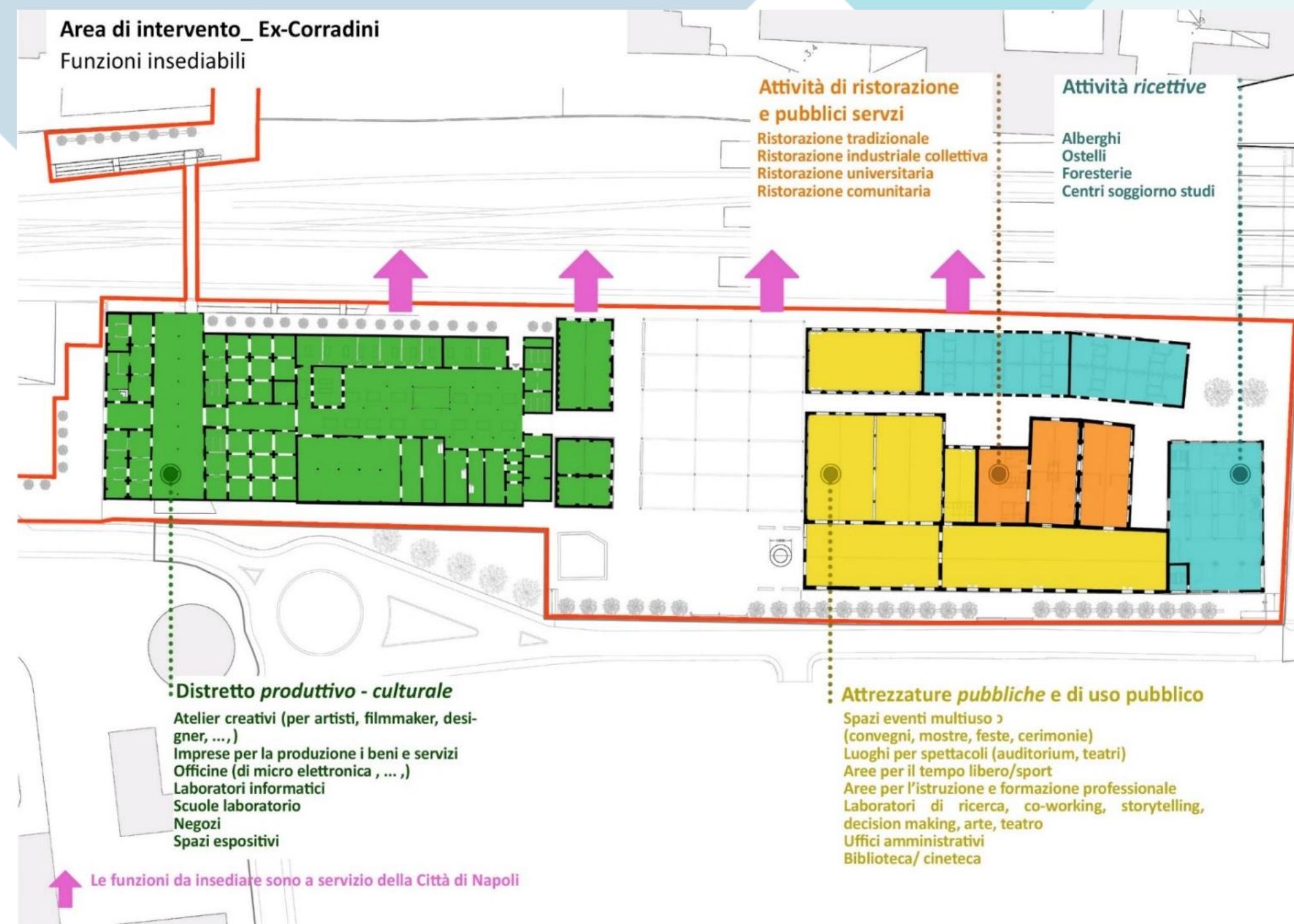
Integration of work – lodging – retail functions

Limits

Lack of participation of the local community

Poor connection with the neighbourhood

Environmental risks

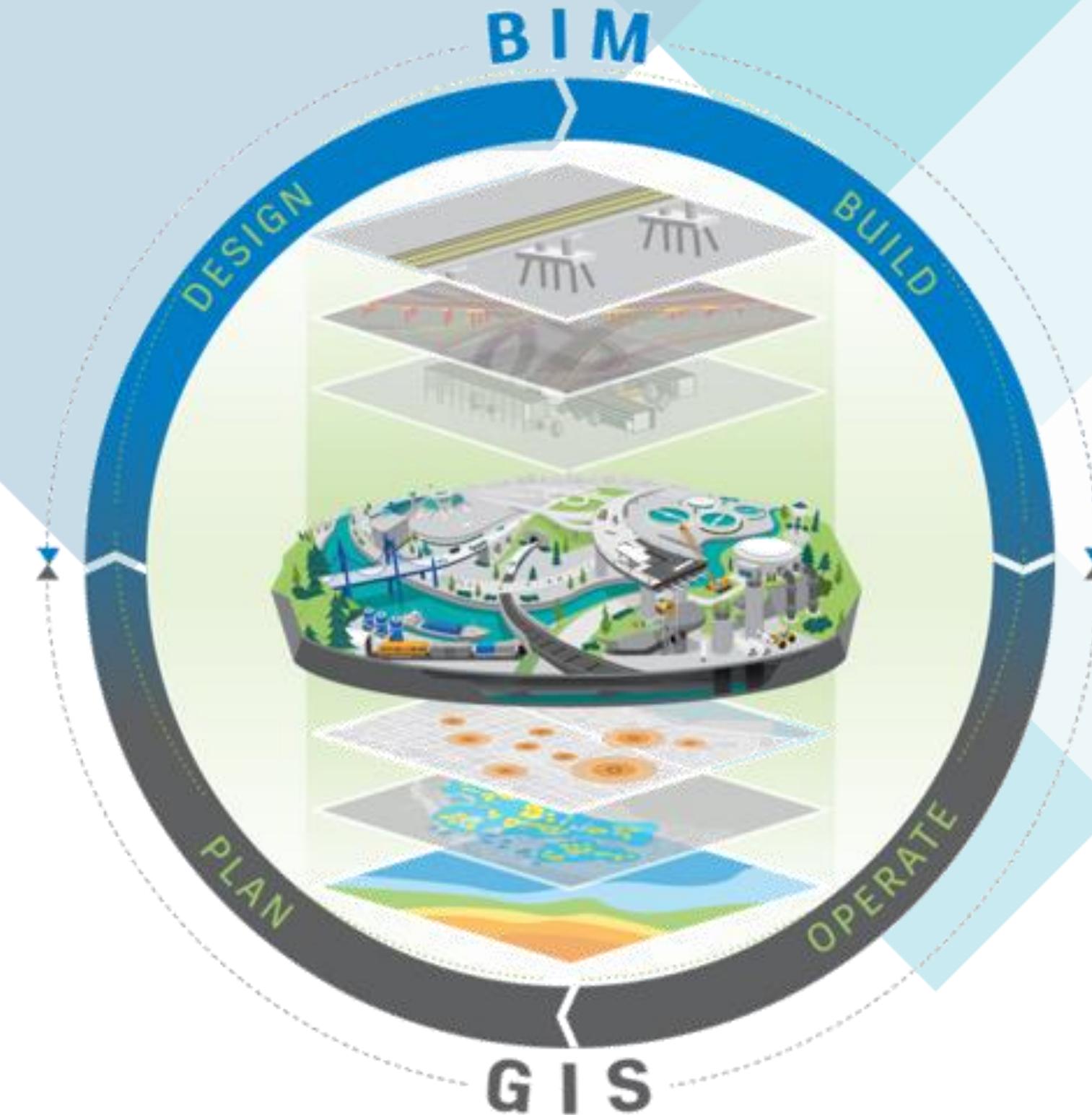


Integration of urban analysis and building design

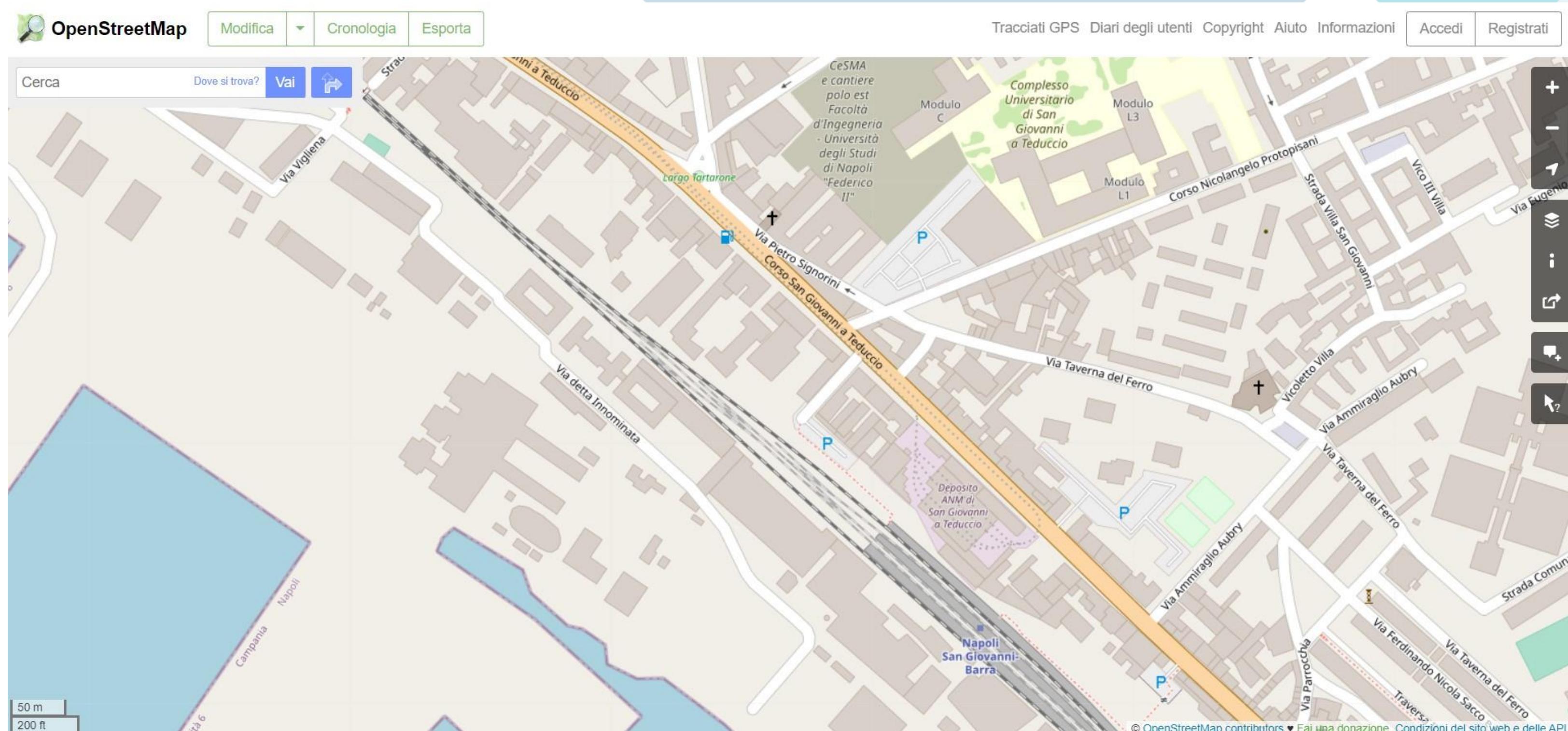
Urban analysis supports the design process at an intermediate scale closer to the building, where the GIS information database is integrated into the BIM 3D management system.

Semi-automatic process was developed to import data from an existing webGIS database.

Integration of real elements (buildings - streets - boundaries) as objects of the BIM model, defined by both geometric and informative data (from GIS database to BIM parameters).



GIS to BIM: open webGIS database integration - OpenStreetMap



GIS to BIM: open webGIS database integration - OpenStreetMap

OpenStreetMap Modifica Cronologia Esporta

Cerca Dove si trova? Vai Up

Percorso: 782717556

San Giovanni a Teduccio - building levels

Modificato 3 mesi fa da [let83](#)

Versione #2 · Gruppo di modifiche #82665309

Etichette

building	residential
building:levels	3
height	12

Nodi

- 7309465774 (parte dei percorsi)
- 782717557 e 782717557
- 7309465775
- 7309465776
- 7309465777
- 7309465778
- 7309465779
- 7309465780
- 7309465781
- 7309465782

Tracciati GPS Diari degli utenti Copyright Aiuto Informazioni Accedi Registrati

Legenda

- Autostrada
- Strada principale
- Strada forestale o agricola
- Percorso per equitazione
- Pista Ciclabile
- Percorso pedonale
- Ferrovia
- Metropolitana
- Metropolitana leggera e tram
- Funivia e Seggiovia
- Pista di decollo/atterraggio e Pista di rullaggio
- Area di parcheggio
- aeroportuale e Terminal
- Confine

© OpenStreetMap contributors [Fai una donazione](#). [Condizioni del sito web e delle API](#)

GIS to BIM: open webGIS database integration - OpenStreetMap

OpenStreetMap Modifica Cronologia Esporta Tracciati GPS Diari degli utenti Copyright Aiuto Informazioni let83

Modifica elemento Ispezione Aggiungi elemento Punto Linea Area Annulla / Ripeti Salva

Edificio residenziale Ingrandisci sulla selezione

Campi

Nome: Nome proprio (se presente)

Piani: 4

Altezza (Metri): 19

Indirizzo: Strada 123 Unità, Codice postale, Città

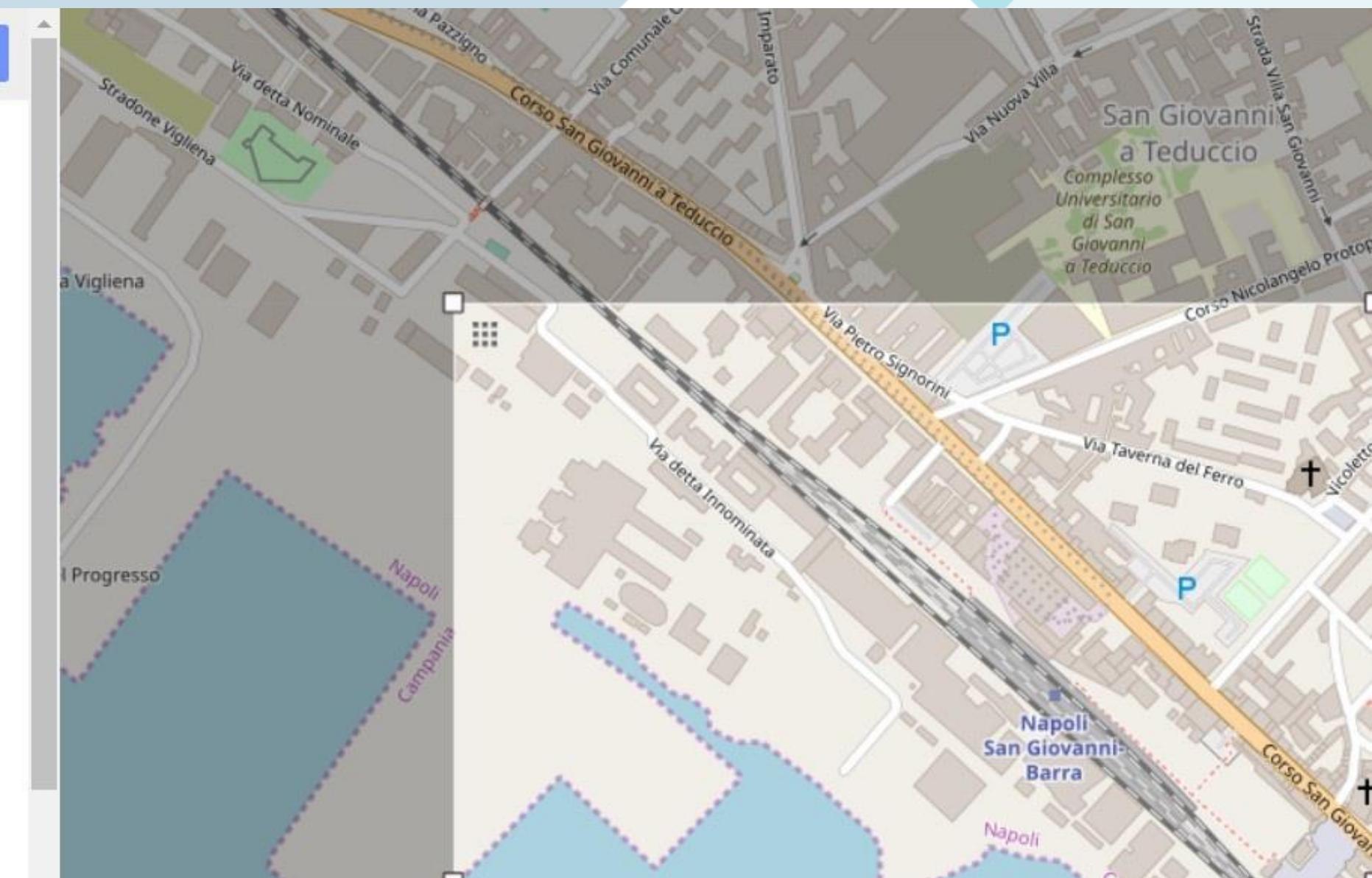
Aggiungi campo: Accesso in carrozzina, Architetto, Colo...

Etichette (3): Vedi su openstreetmap.org

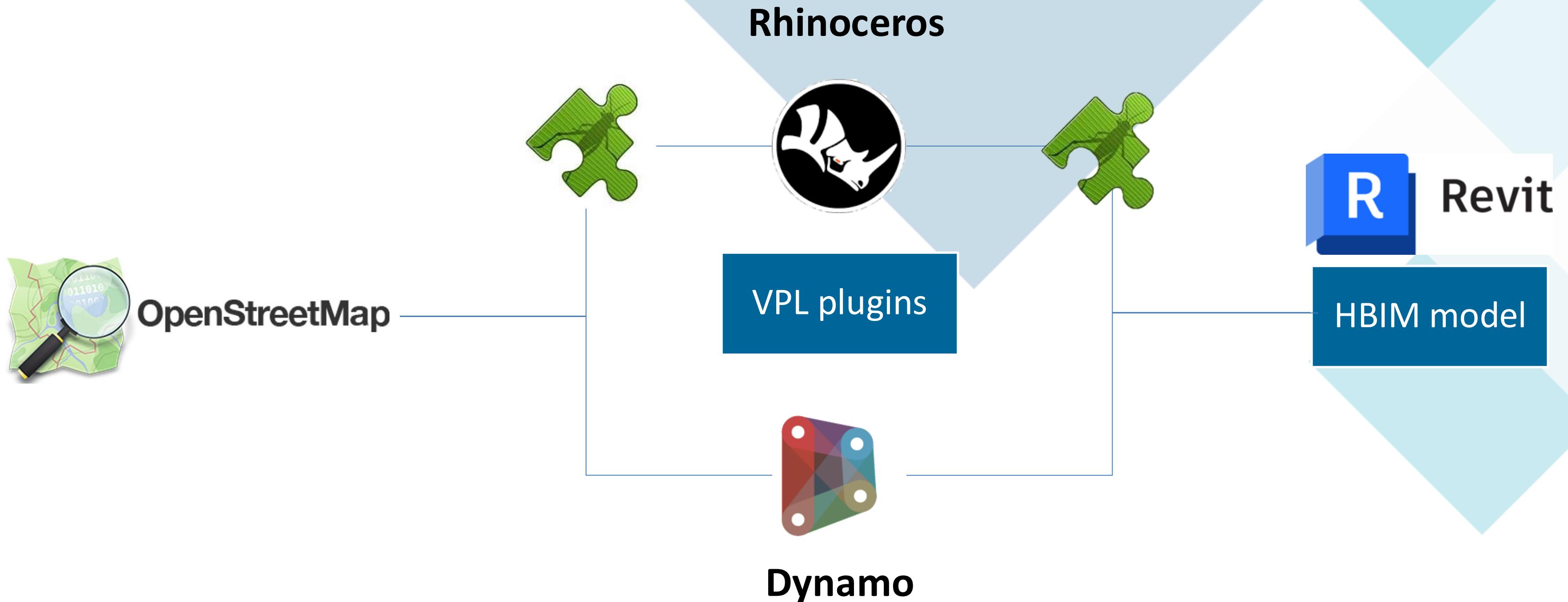
Termini & Feedback 50 metri Modifiche di let83, micha_k, robertocog, e 24 altri 2.17.3

GIS to BIM: OpenStreetMap to Revit via VPL

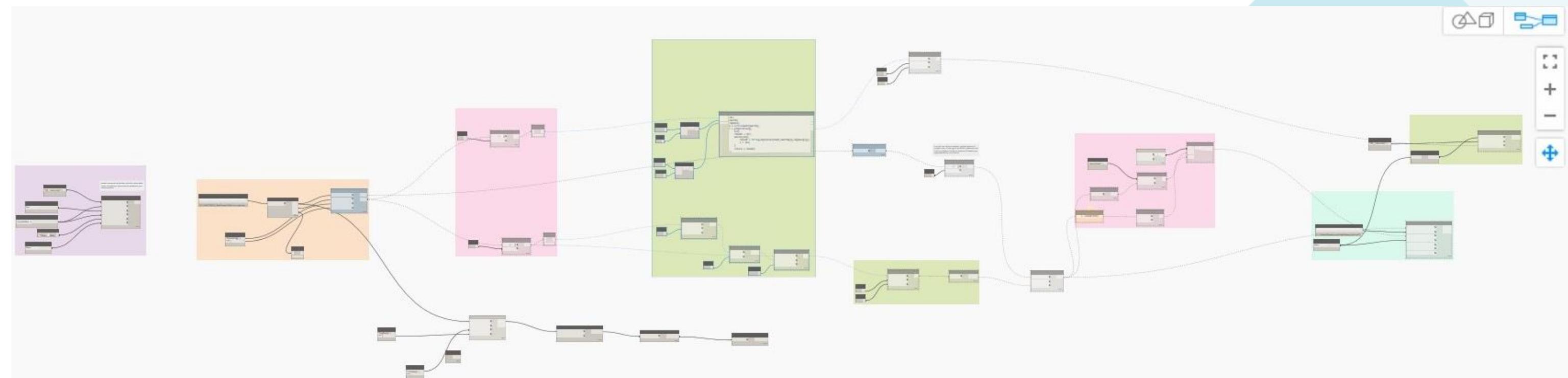
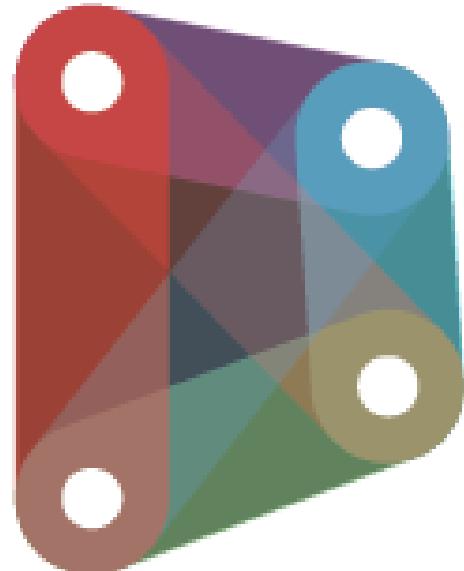
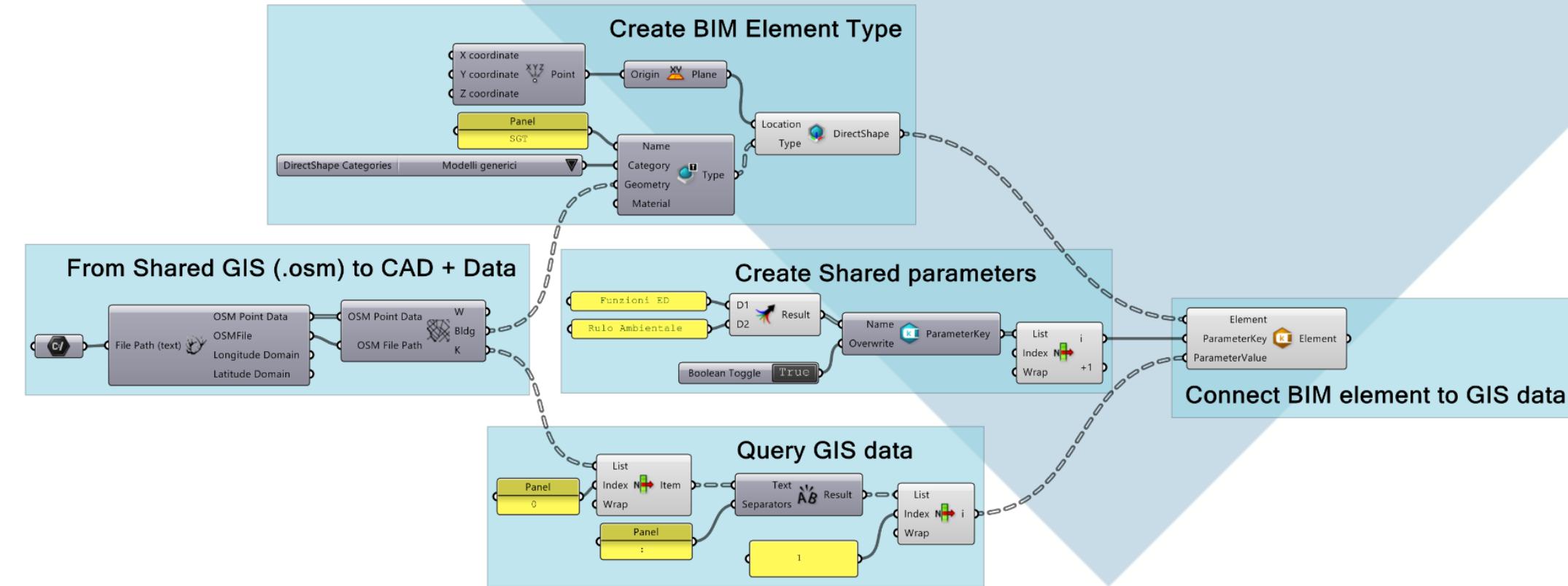
Using a script developed with Visual Programming Language (**VPL**), it is possible to automatically import **OpenStreetMap** data into Revit, transforming textual geometric information into **3D data** and transferring the GIS data into **Revit parameters**.



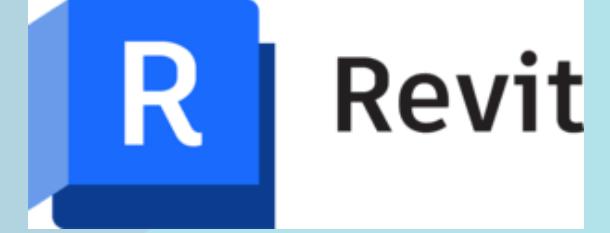
From GIS to BIM through VPL



GIS to BIM: OpenStreetMap to Revit via VPL



GIS to BIM: BIM model from GIS data



Screenshot of the Revit interface showing a 3D BIM model of a construction site. The model consists of numerous colored 3D blocks representing different building components and structures. The Revit ribbon menu is visible at the top, and the Properties palette on the left shows settings for a selected "3D View: SGT_3dView". The Project Browser on the far left lists project components like "Cantiere", "Ceiling Plans", and "3D Views". A detailed "Visibility/Graphic Overrides" dialog box is open at the bottom, showing a table where categories like "Edifici residenziali", "Chiese", "Edifici vari", "Scuole", and "Edifici industriali" are mapped to specific line styles, patterns, and transparency levels. The status bar at the bottom provides standard Revit navigation and selection information.

Properties

SGT_3dViews X prova

3D View: SGT_3dView: Edit Type

Graphics

View Scale	1 : 100
Scale Value	1:100
Detail Level	Medium
Parts Visibility	Show Original
Visibility/Graph...	Edit...
Graphic Disp...	Edit...
Discipline	Coordination
Show Hidden ...	By Discipline

Apply

Project Browser - SGT_Centrale_pla... X

- Cantiere
- Ceiling Plans (Pianta del con:
- 3D Views (Vista 3D)
- SGT_3dViews

Visibility/Graphic Overrides for SGT_3D_Funzioni

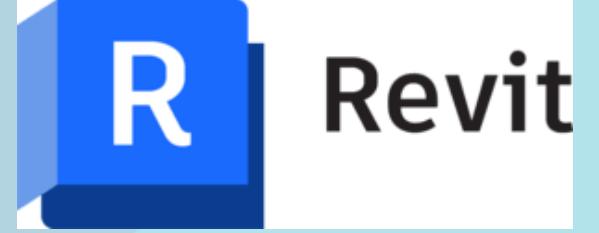
Name	Visibility	Projection/Surface			Cut		Halftone
		Lines	Patterns	Transparen...	Lines	Patterns	
Edifici residenziali	<input checked="" type="checkbox"/>					<input type="checkbox"/>	
Chiese	<input checked="" type="checkbox"/>					<input type="checkbox"/>	
Edifici vari	<input checked="" type="checkbox"/>					<input type="checkbox"/>	
Scuole	<input checked="" type="checkbox"/>					<input type="checkbox"/>	
Edifici industriali	<input checked="" type="checkbox"/>					<input type="checkbox"/>	

Model Categories Annotation Categories Analytical Model Categories Imported Categories Filters Revit Links

Click to select, TAB for alternates, CTRL adds, SHIFT unselects.

Main Model

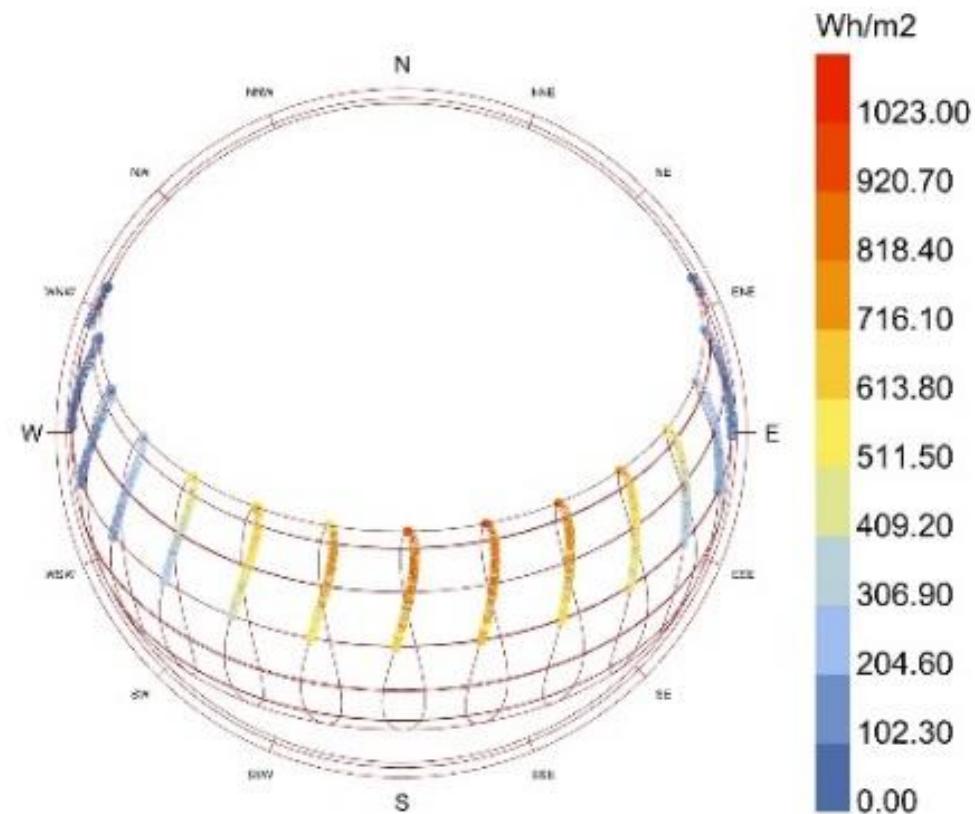
GIS to BIM: model federation



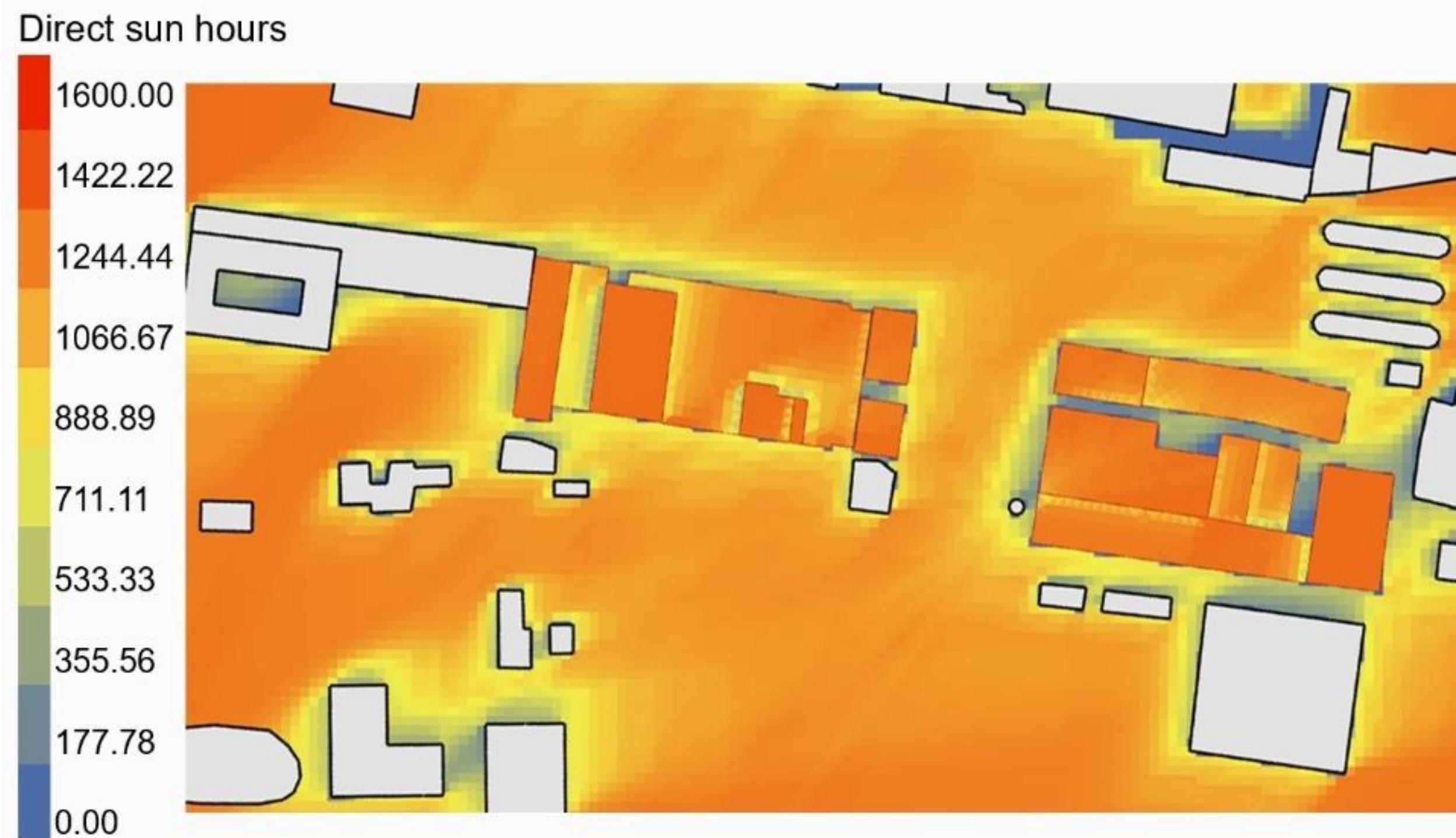
The screenshot shows the Revit application interface. The top menu bar includes File, Architecture, Structure, Steel, Systems, Insert, Annotate, Analyze, Massing & Site, Collaborate, View, Manage, Add-Ins, BIM One, and Modify. The ribbon tabs are Project Parameters, Transfer Project Standards, Shared Parameters, Purge Unused, Additional Settings, Design Options, Main Model, Design Project, Phasing, Selection, Inquiry, Macros, and Visual Programming. The left side features the Project Browser with categories like Cantiere, Ceiling Plans, 3D Views, Elevations, Sections, Renderings, Legends, Schedules/Quantities, Sheets, and Families. A Properties panel on the left displays settings for a 3D View named "SGT_3dViews" with a "Vista 3D" icon, showing View Scale (1:100), Scale Value (1:100), Detail Level (Medium), Parts Visibility (Show Original), and Discipline (Coordination). The main workspace shows a complex 3D model of a building structure composed of numerous colored 3D blocks (blue, red, orange) representing different parts or disciplines. A legend is visible in the bottom right corner of the workspace.

Microclimate analysis – interoperability via VPL

Sunshine duration: Summer

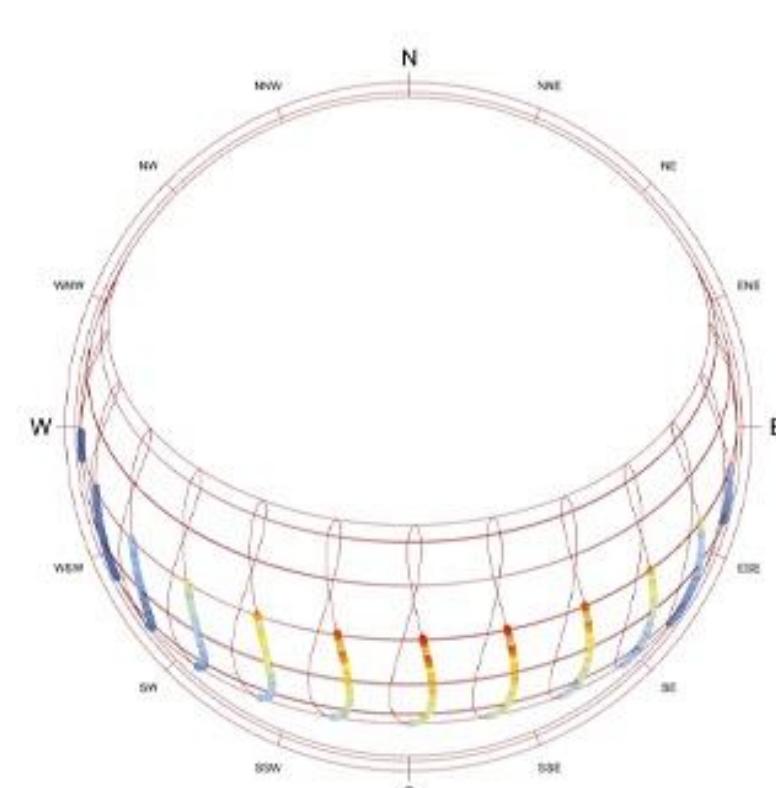


Global Horizontal Radiation (Wh/m²)
city: Napoli-Capodichino
country: ITA
source: IGDG

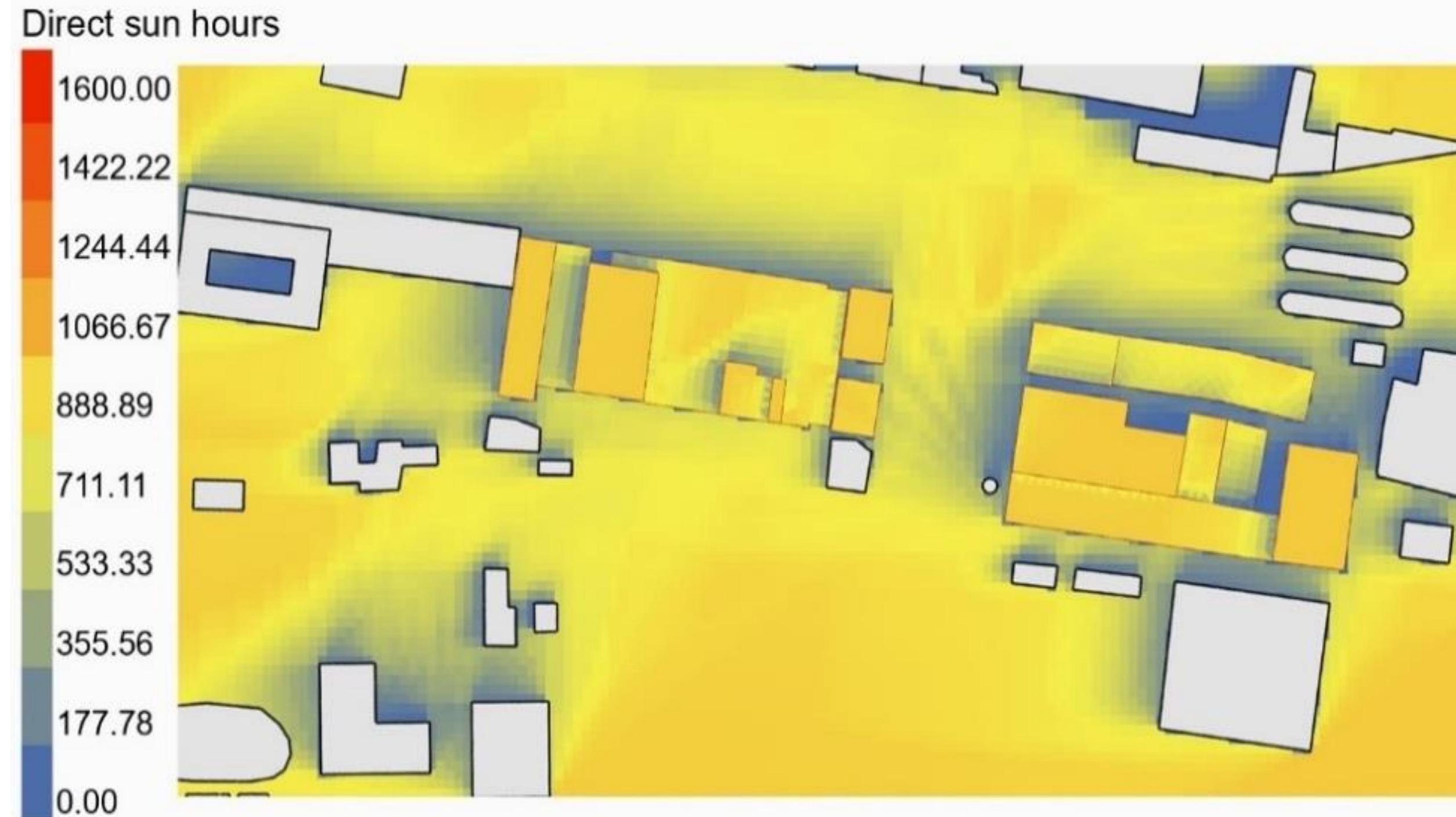


Microclimate analysis – interoperability via VPL

Sunshine duration: Summer

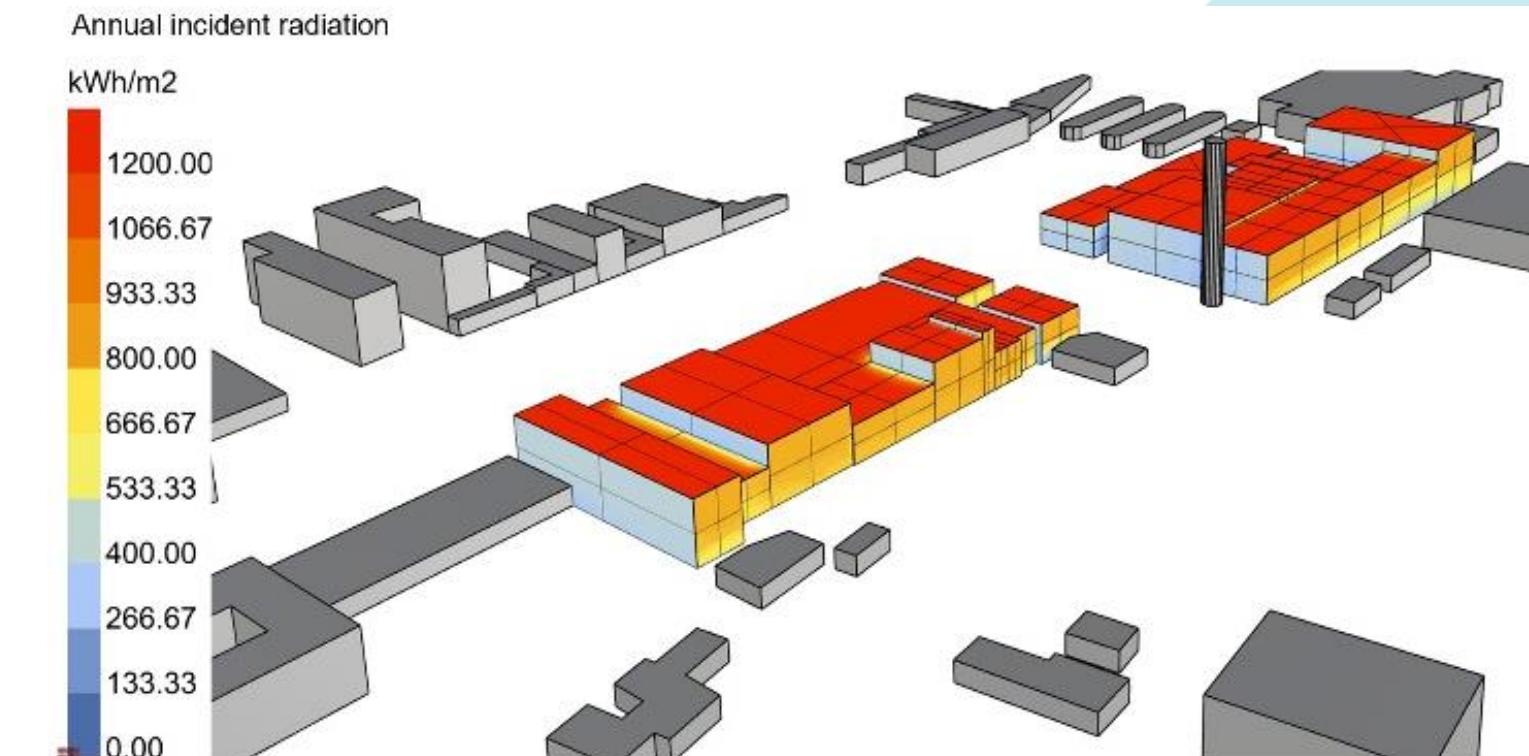
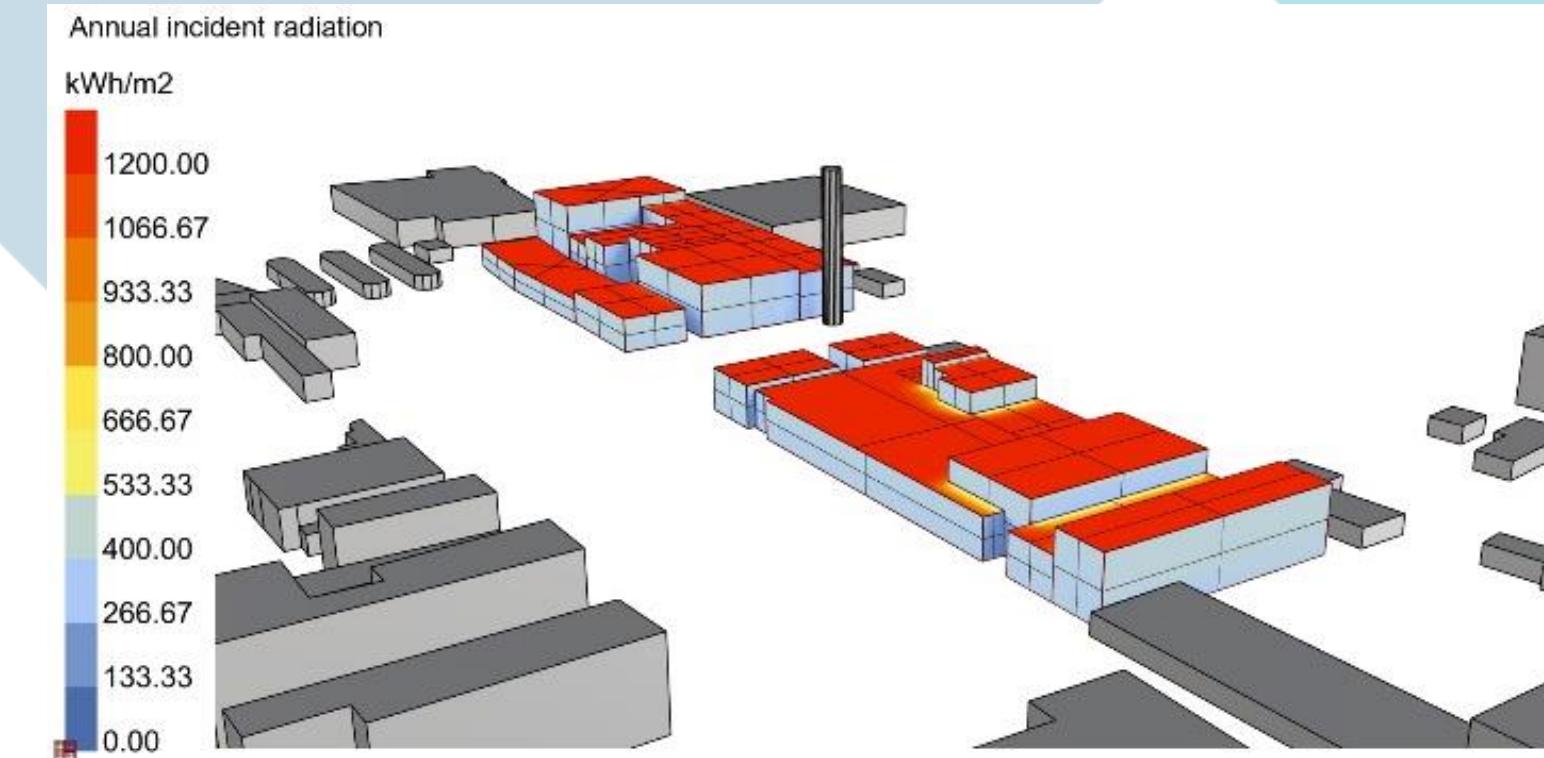
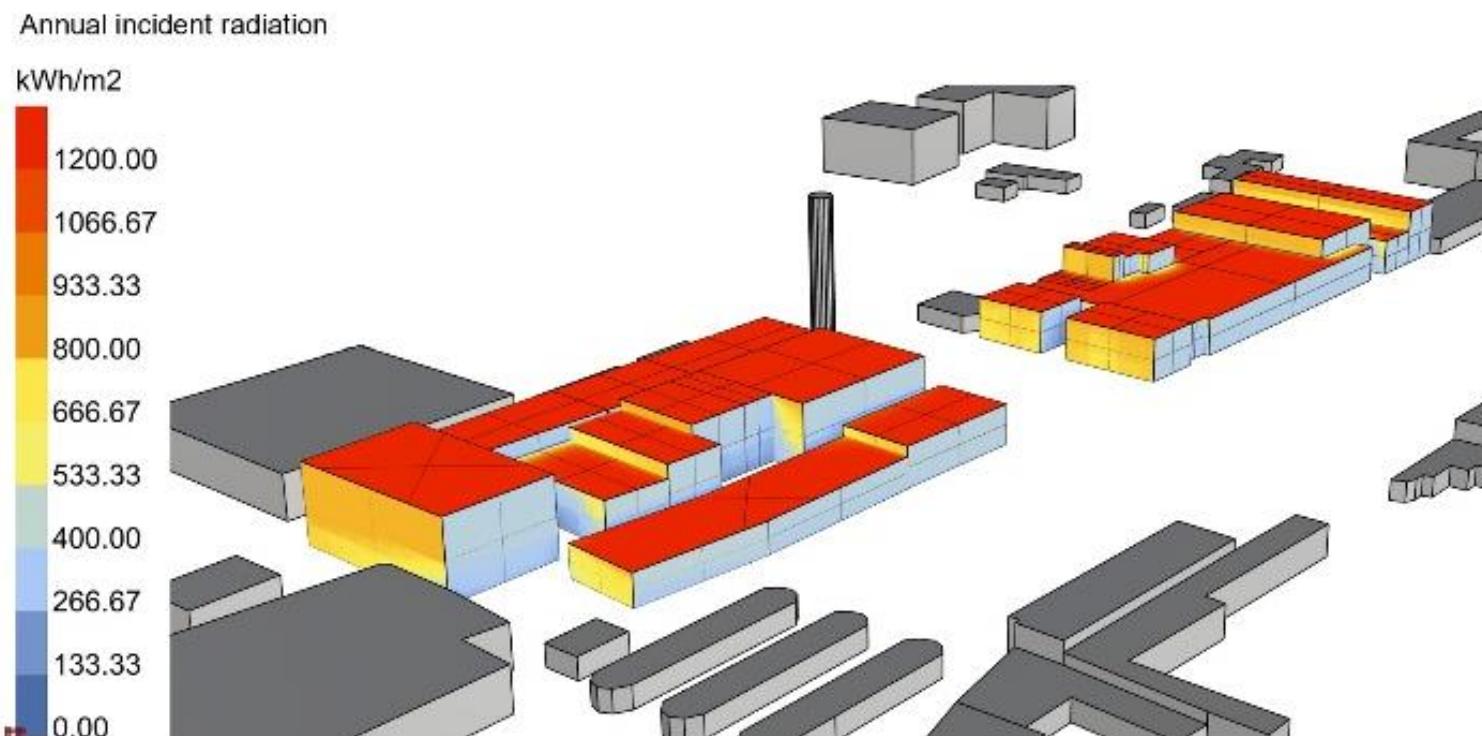
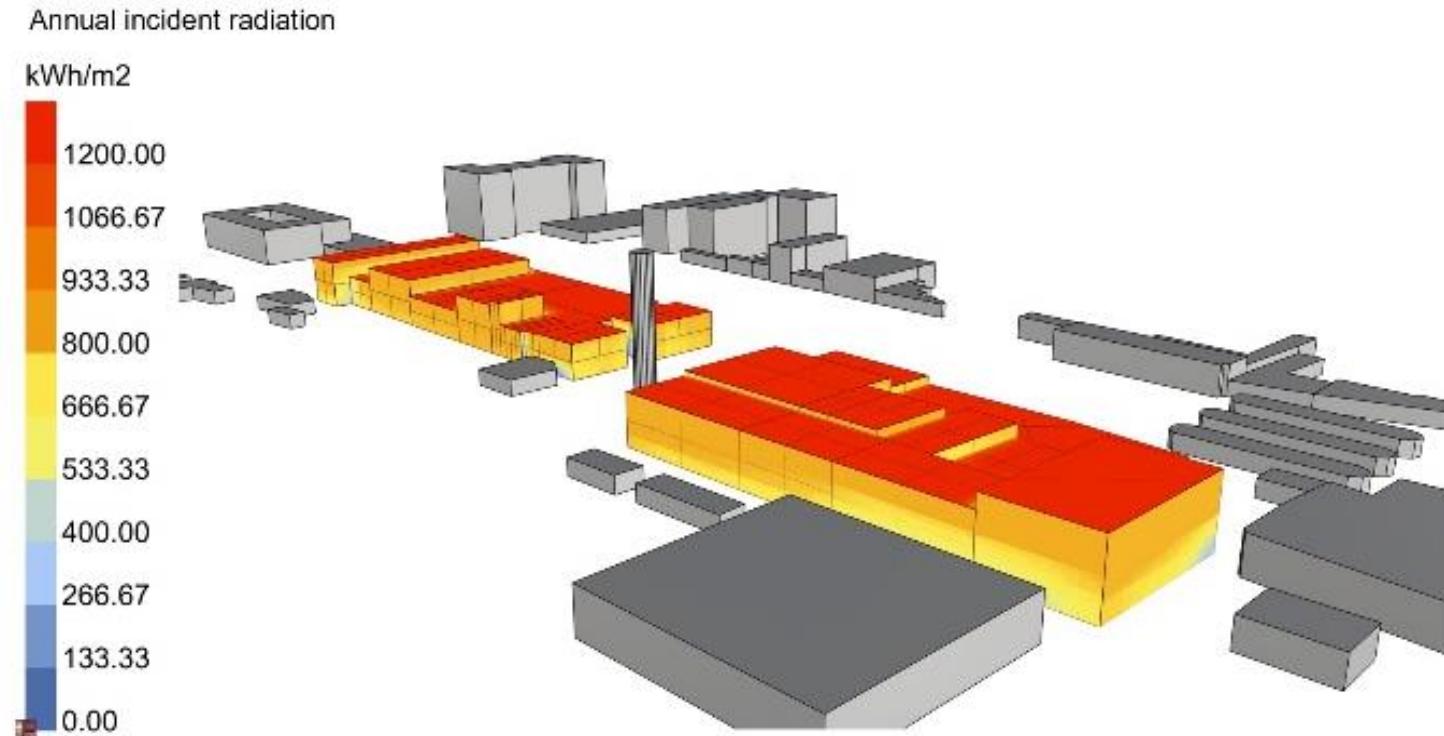


Global Horizontal Radiation (Wh/m²)
city: Napoli Capodichino
country: ITA
source: IGDG



Microclimate analysis – interoperability via VPL

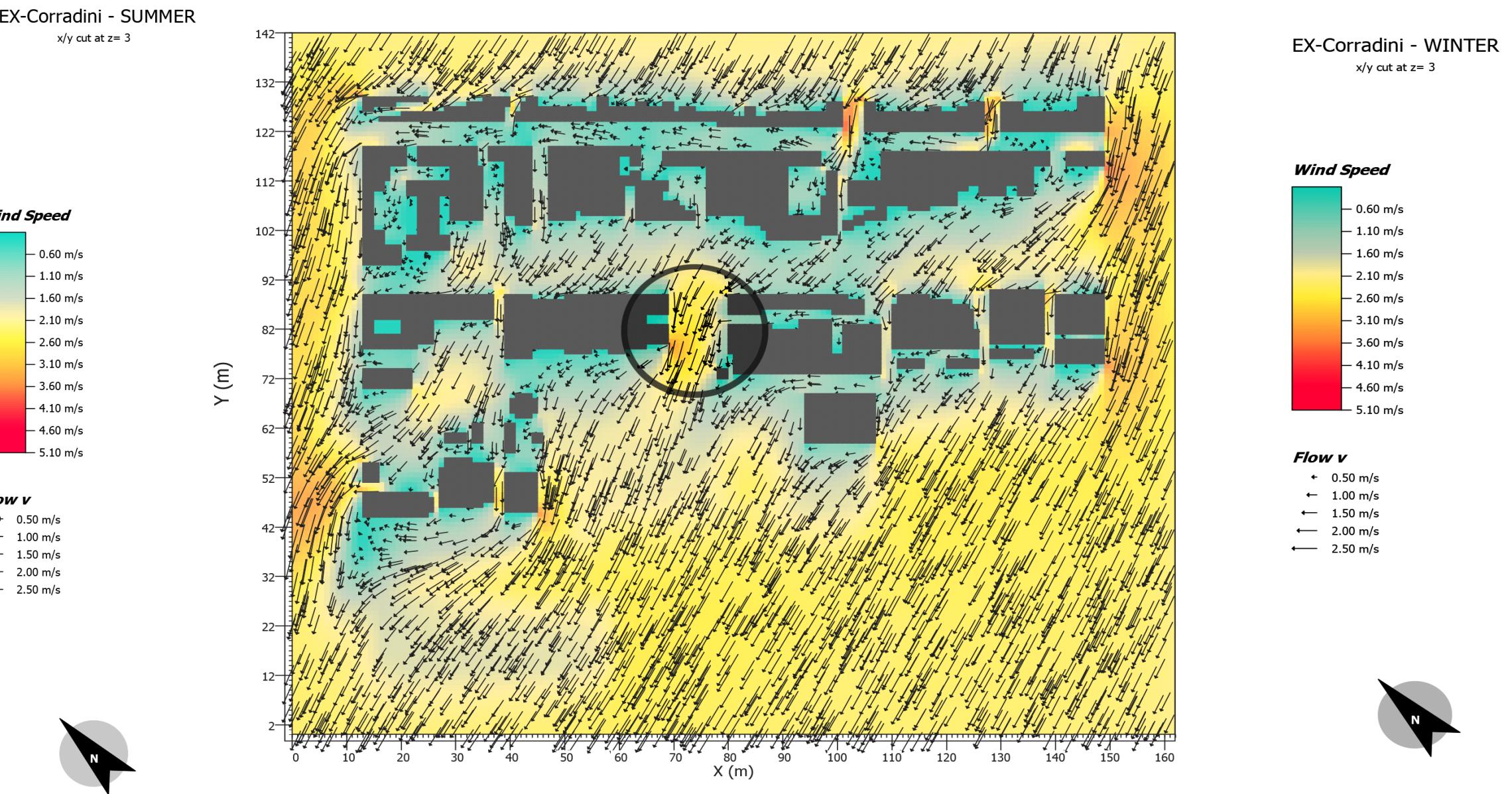
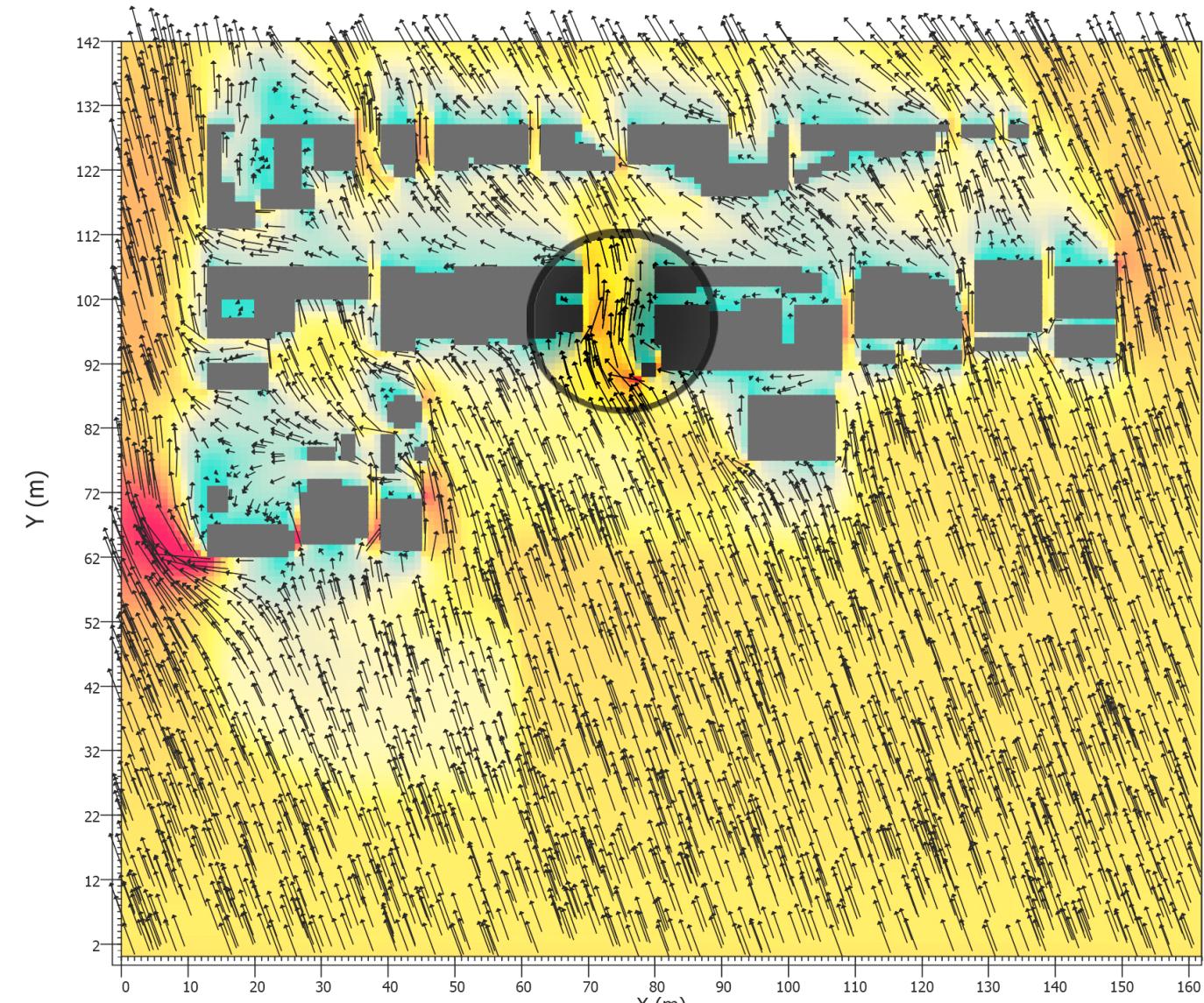
Annual incident solar radiation



Microclimate analysis – indirect integration

ENVI
MET

Ventilation analysis



Microclimate analysis – strategies

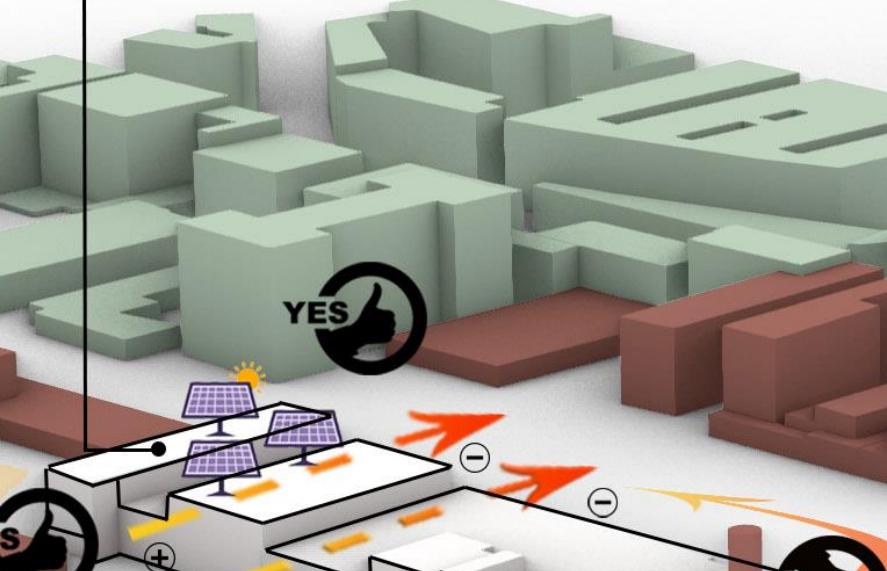
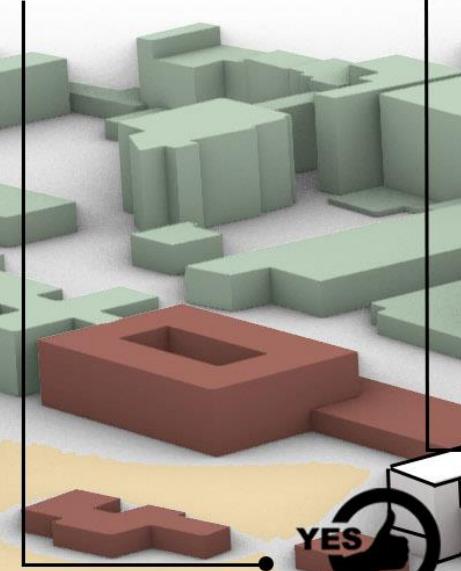
Summer and intermediate seasons: potential for cross-ventilation in the buildings

Annual: Horizontal and vertical surfaces with potential for photovoltaics

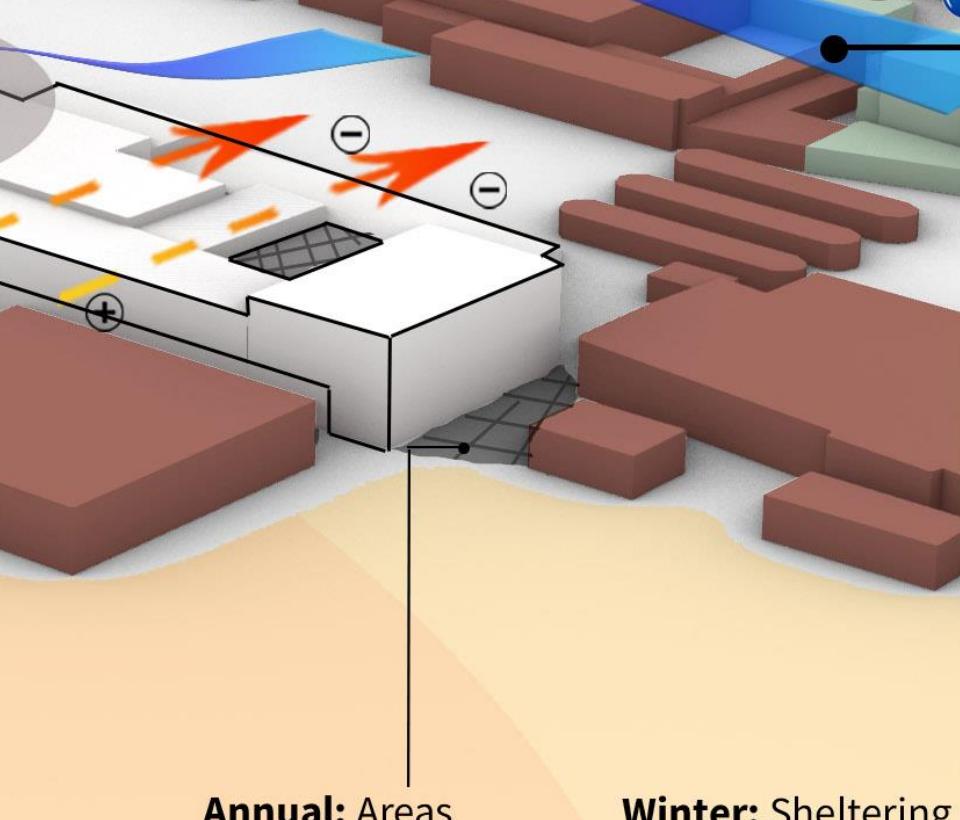
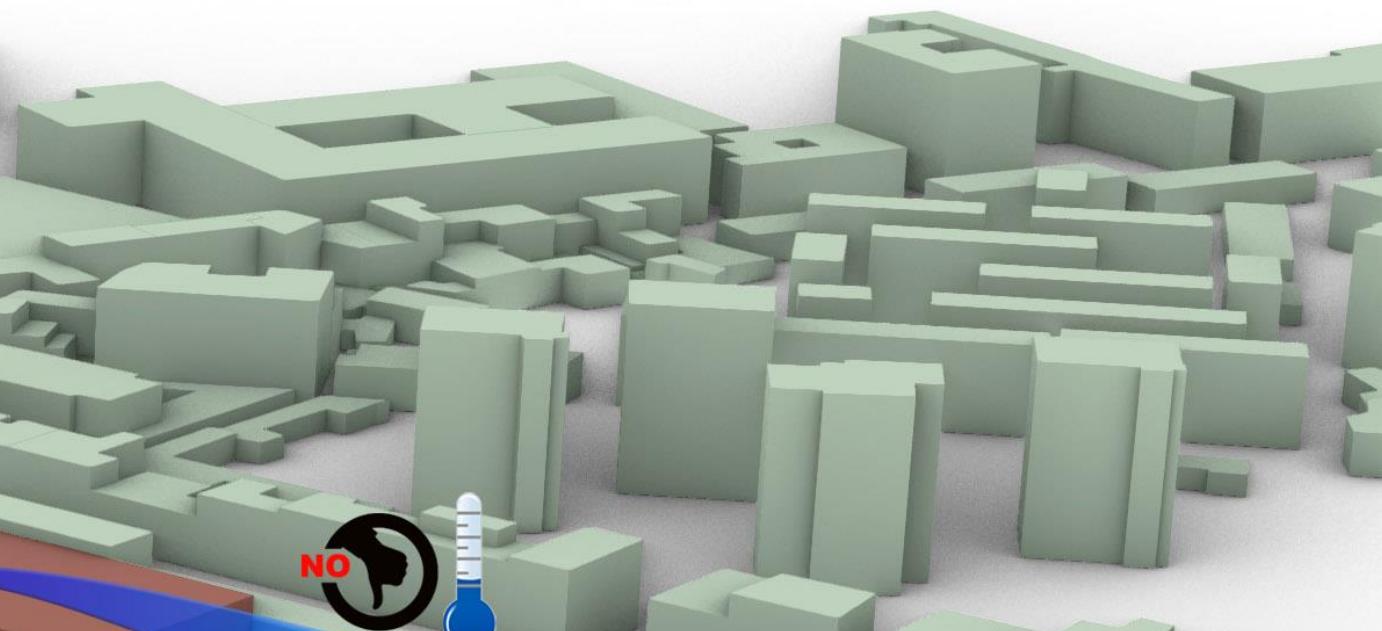
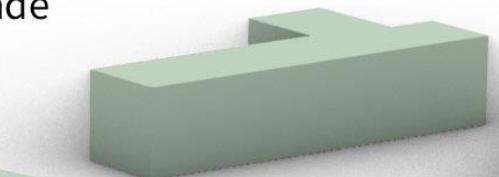
Summer: Lack of shade



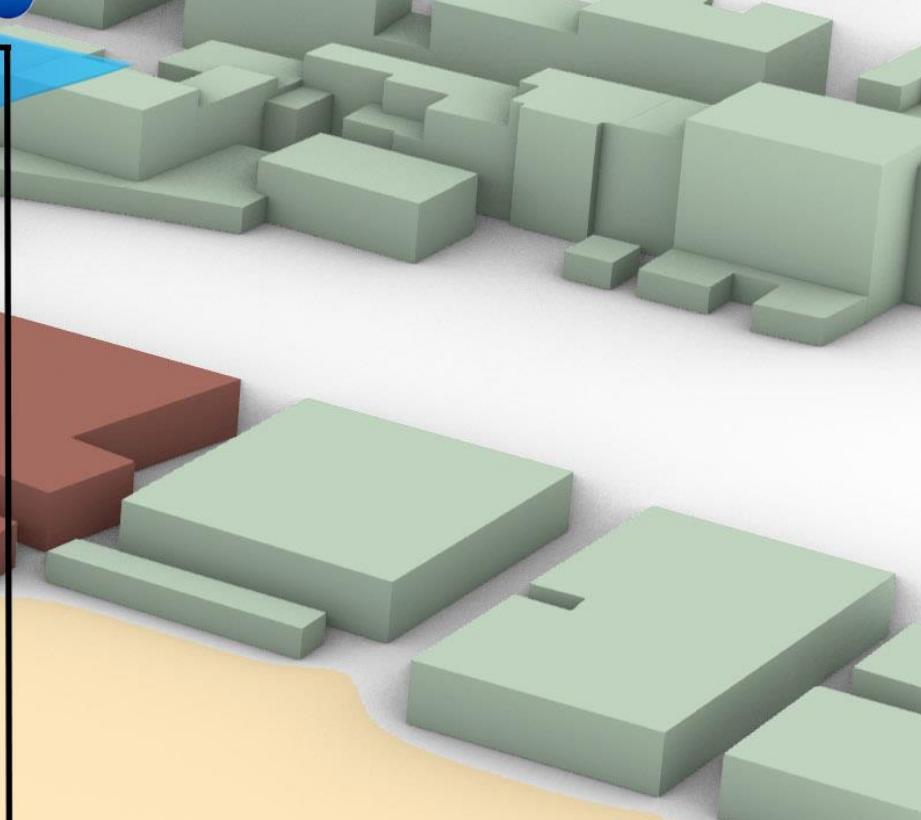
Summer: Need to control Mean Radiant temperature



Summer: summer breezes



Annual: Areas perpetually in shade

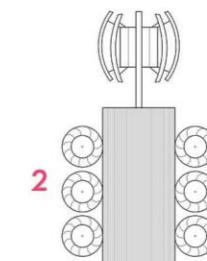


Winter: Sheltering against cold winds

Retrofit project - ground floor



Retrofit project - sections



LEGENDA

1. Pannelli fotovoltaici integrati nella copertura
2. Microelolico integrato
3. Sistema di raccolta, e riuso dell'acqua piovana
4. Giardino pensile





HBIM model - design



TECH-START

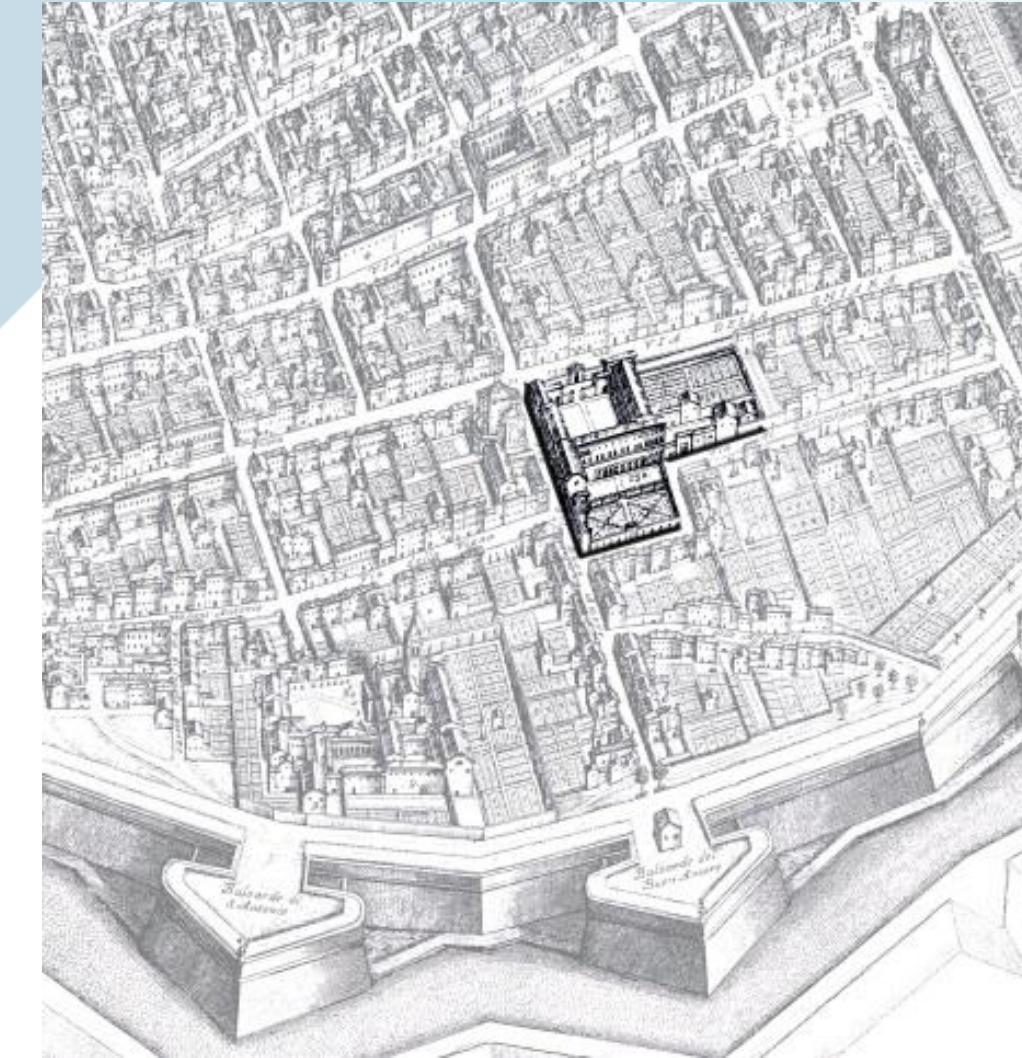
Ferrara, Palazzo Costabili

key enabling TECHnologies and Smart environment in the Age of gReen economy.
Convergent innovations in the open space/building system for climaTe mitigation

Enviromental study of the passive potential of transition spaces ("liminar spaces") of historic buildings, through knowledge management and simulation, to promote comfort and energy efficiency



Case study: Palazzo Costabili, Ferrara

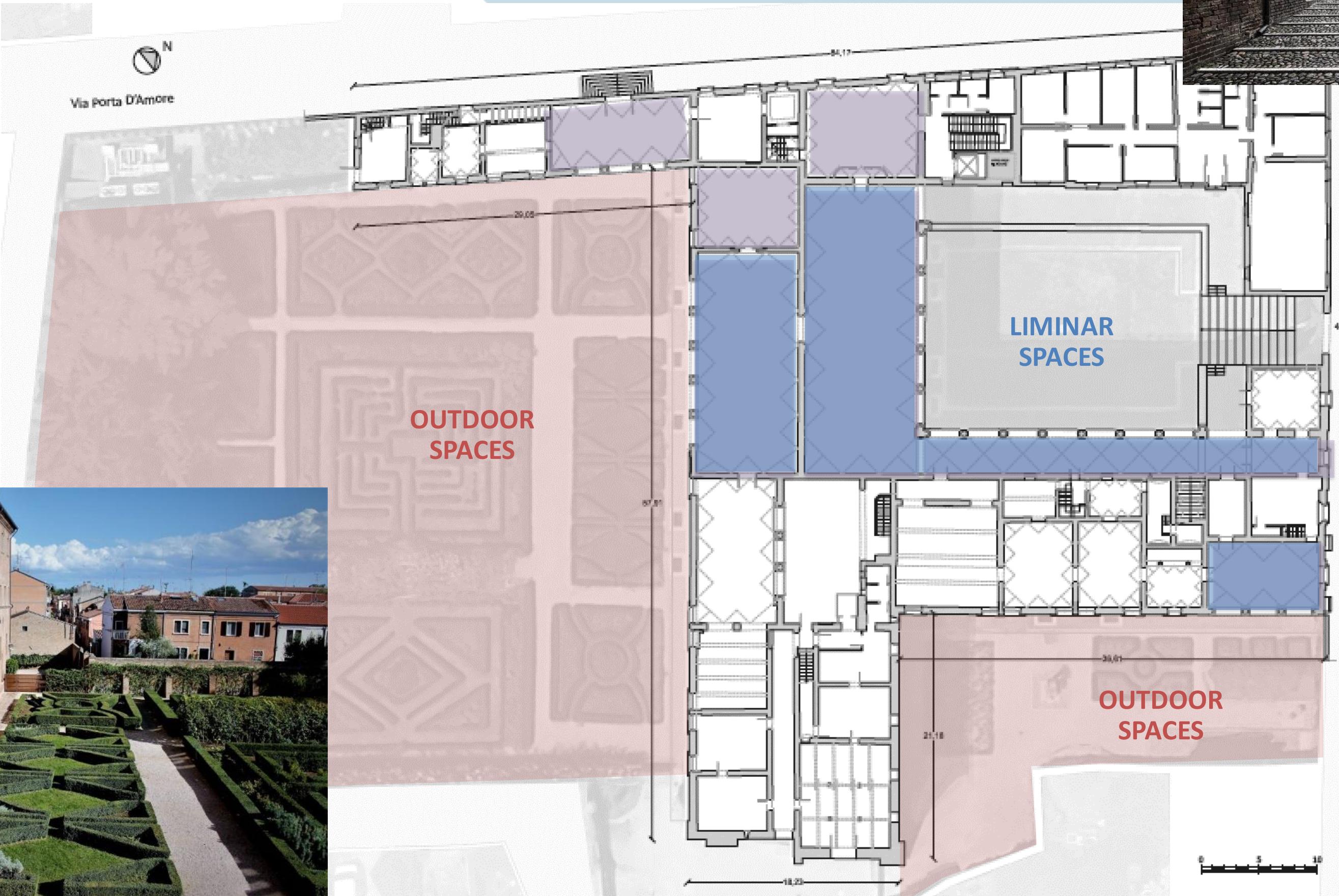


Plan and elevation of Ferrara, by
Andrea Bolzoni 1782

Case study: Palazzo Costabili, Ferrara



Case study: Palazzo Costabili, Ferrara



Field of study and research topic

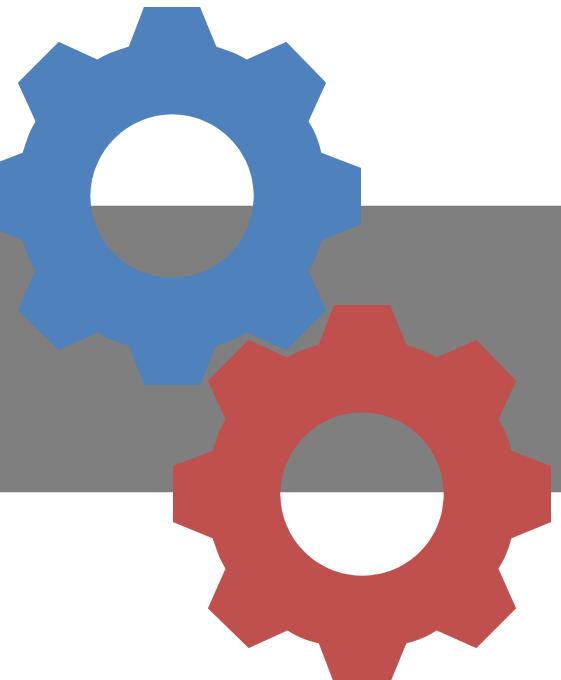


Università
degli Studi
di Ferrara

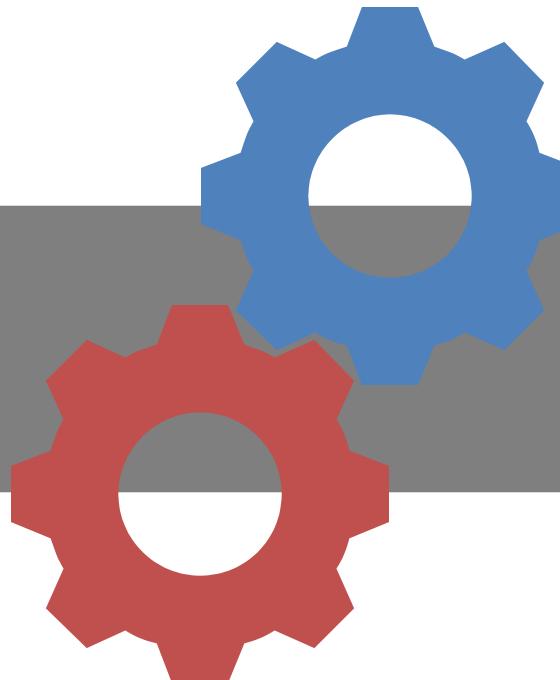
DA

Dipartimento
Architettura
Ferrara

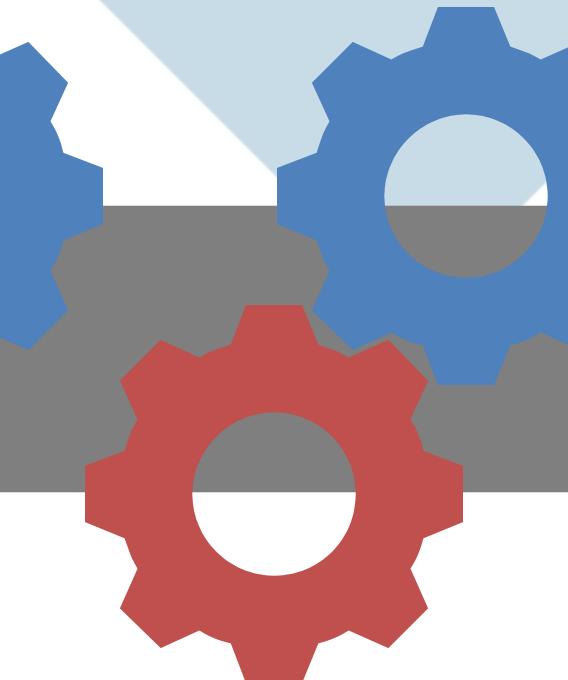
DATA
COLLECTION



ENVIRONMENTAL
MONITORING



INTERVENTION
STRATEGIES



SCALABILITY TO
THE CITY



Consiglio
Nazionale
delle Ricerche

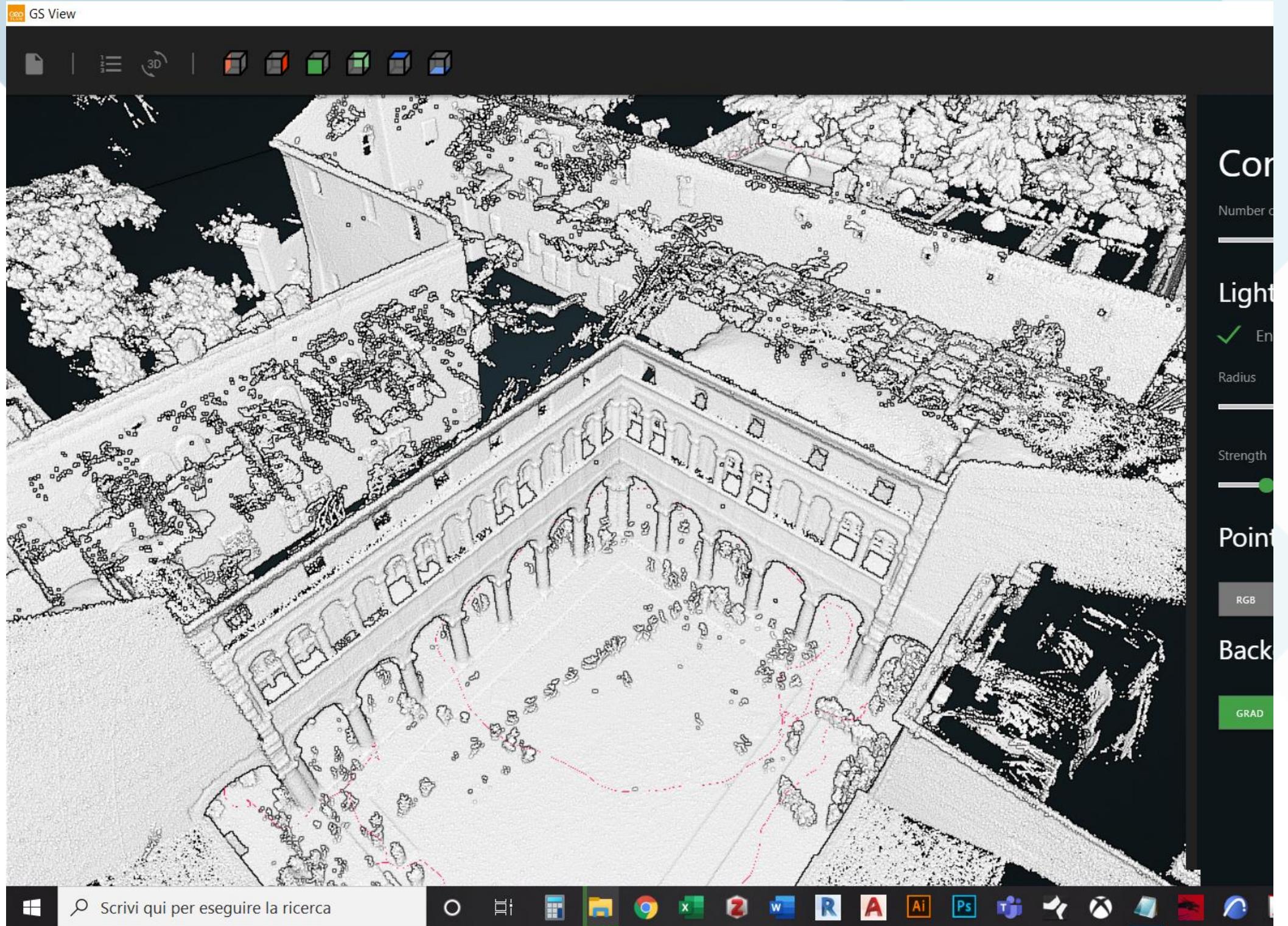


ISTITUTO DI
SCIENZE DEL
PATRIMONIO CULTURALE

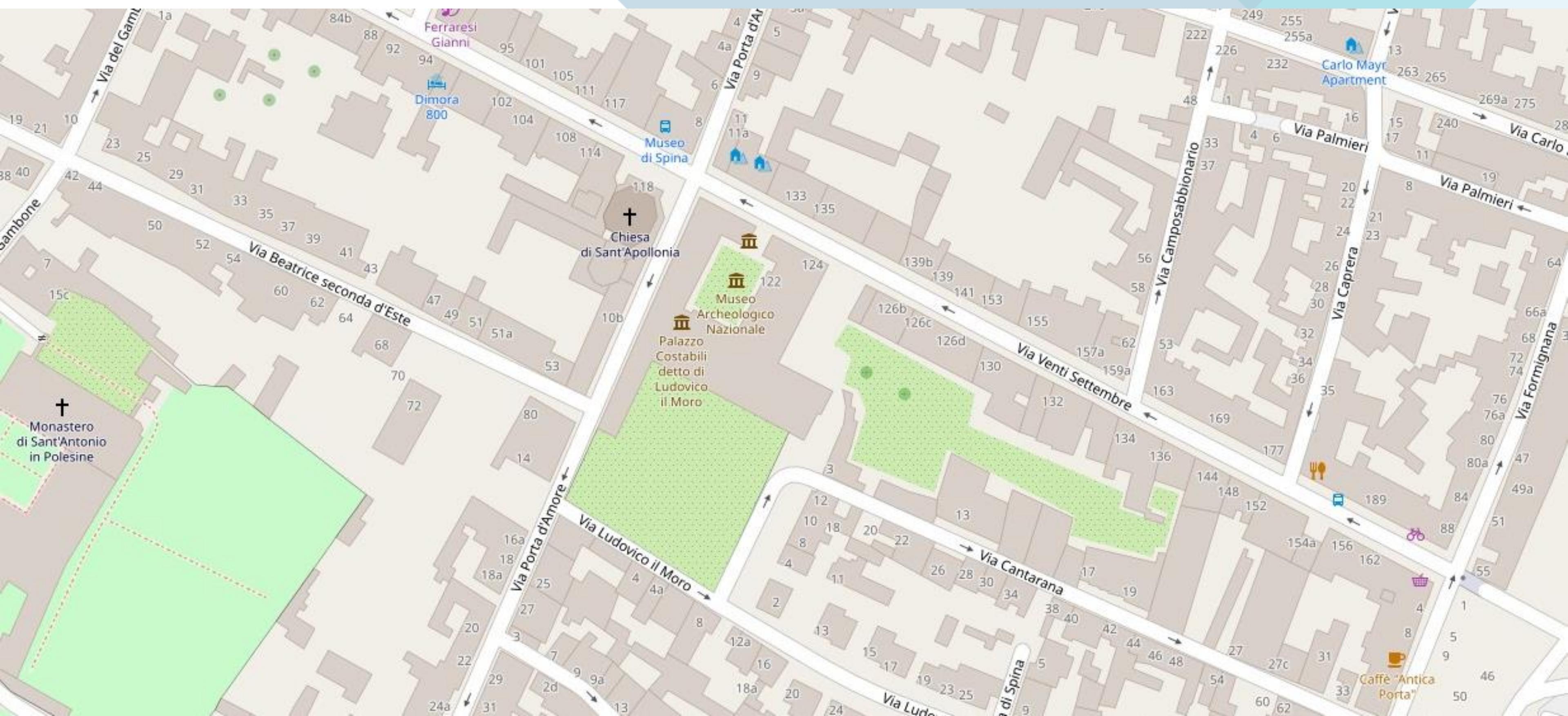
Geometric survey SLAM (Simultaneous Localization and Mapping)



Point cloud by SLAM



webGIS database preparation - OpenStreetMap



webGIS database preparation - OpenStreetMap

Edit feature

Residential Building

Point Line Area

Undo / Redo Save

Feature Type: Residential Building

Fields:

- Name: Museo Archeologico Nazionale
- Common name (if any):
- Levels: 2
- Height (Meters): 10
- Address: Street: 123, Unit: , Postcode: , City:

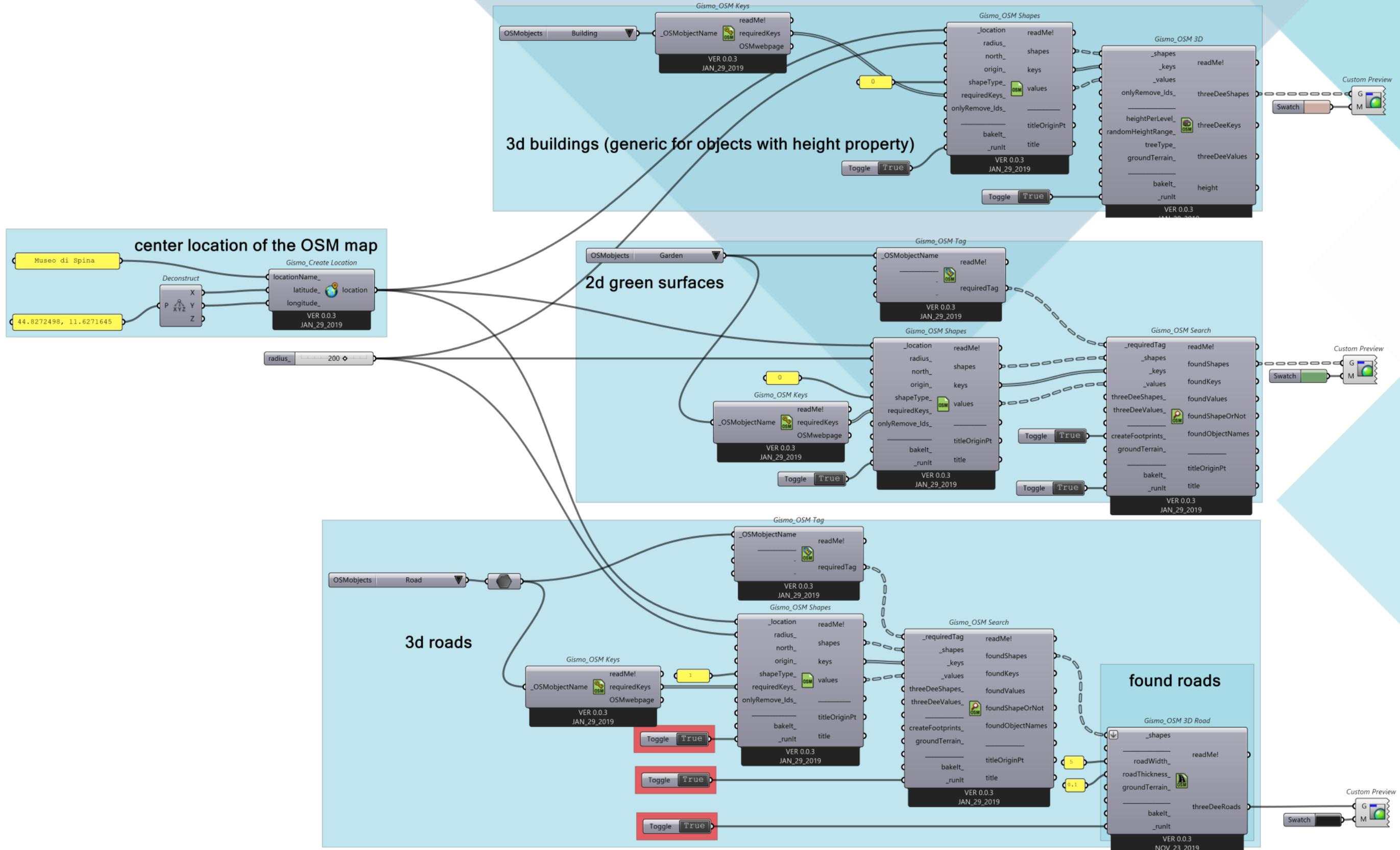
Add field: Architect, Description, Elevation...

Tags (3):

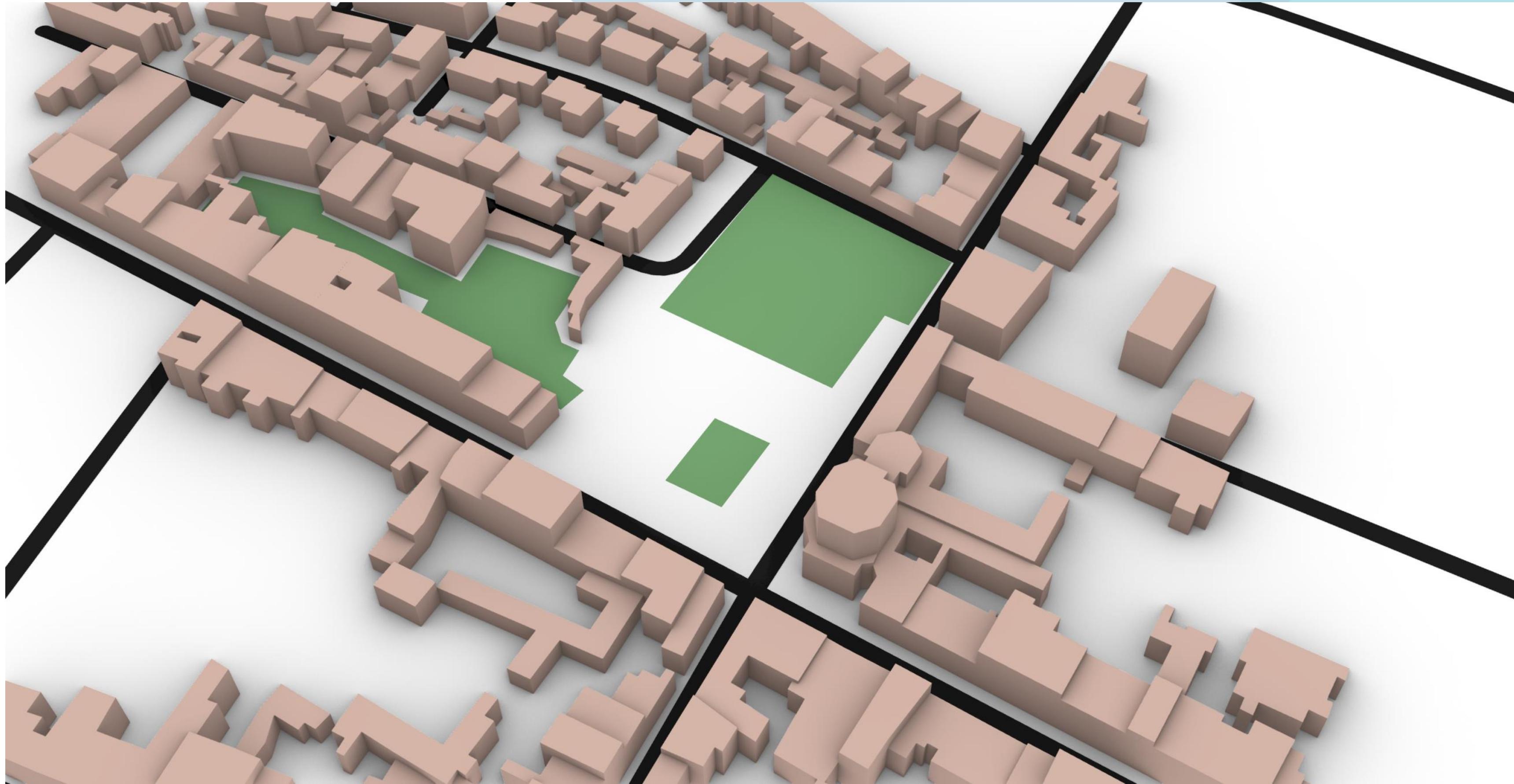
- building:residential
- building:levels:2
- height:10

Bing

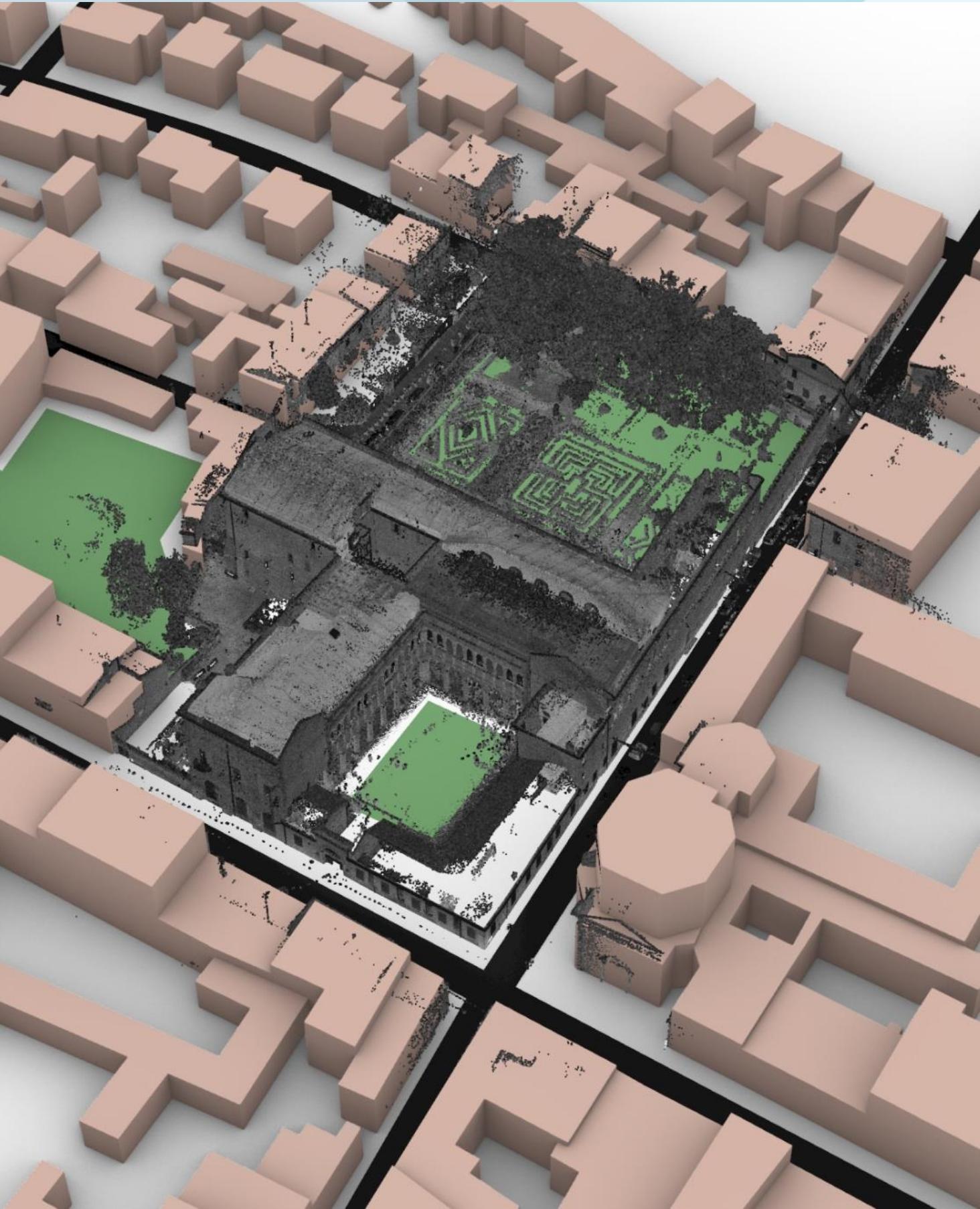
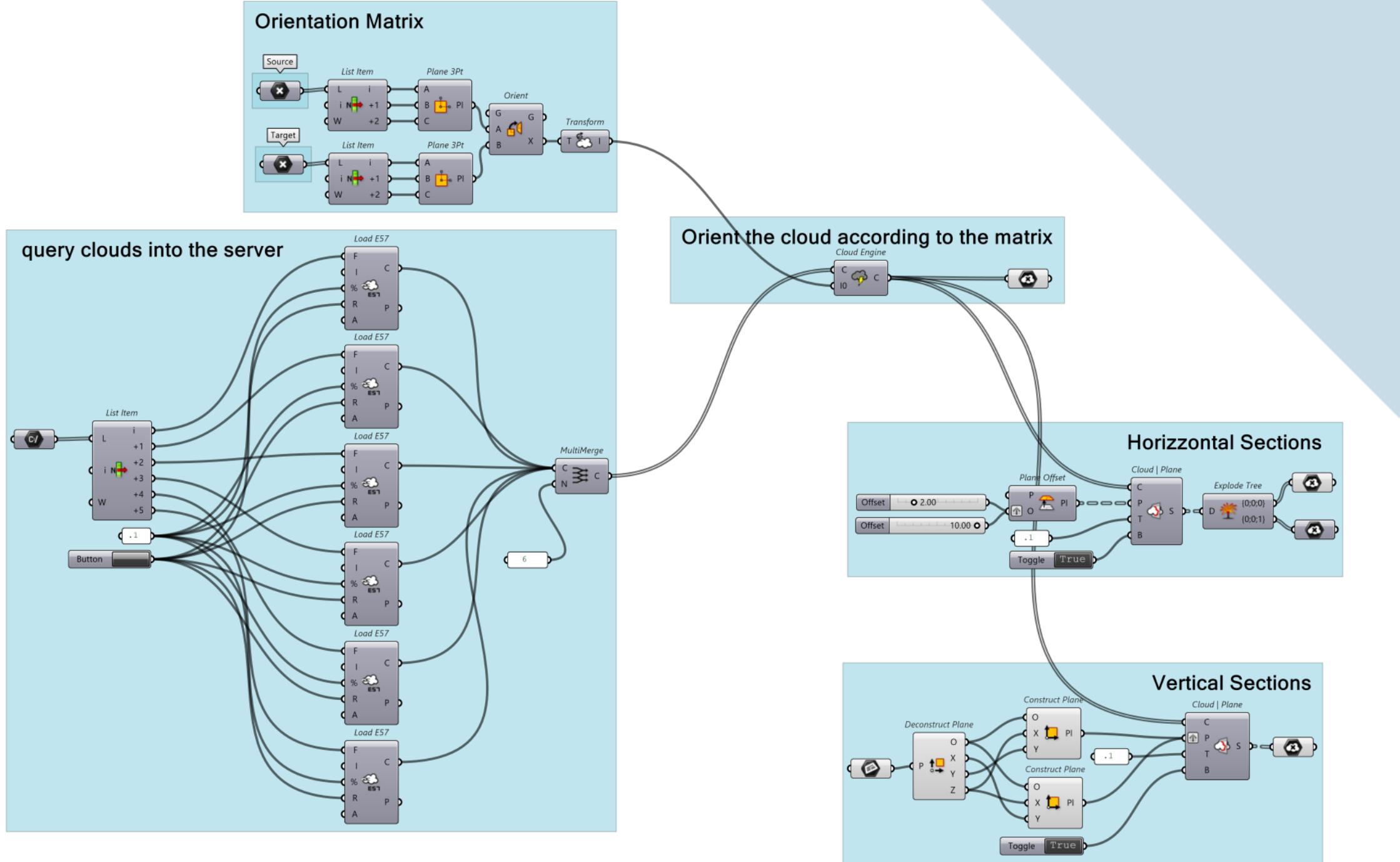
GIS to BIM: OpenStreetMap to Rhinoceros via VPL



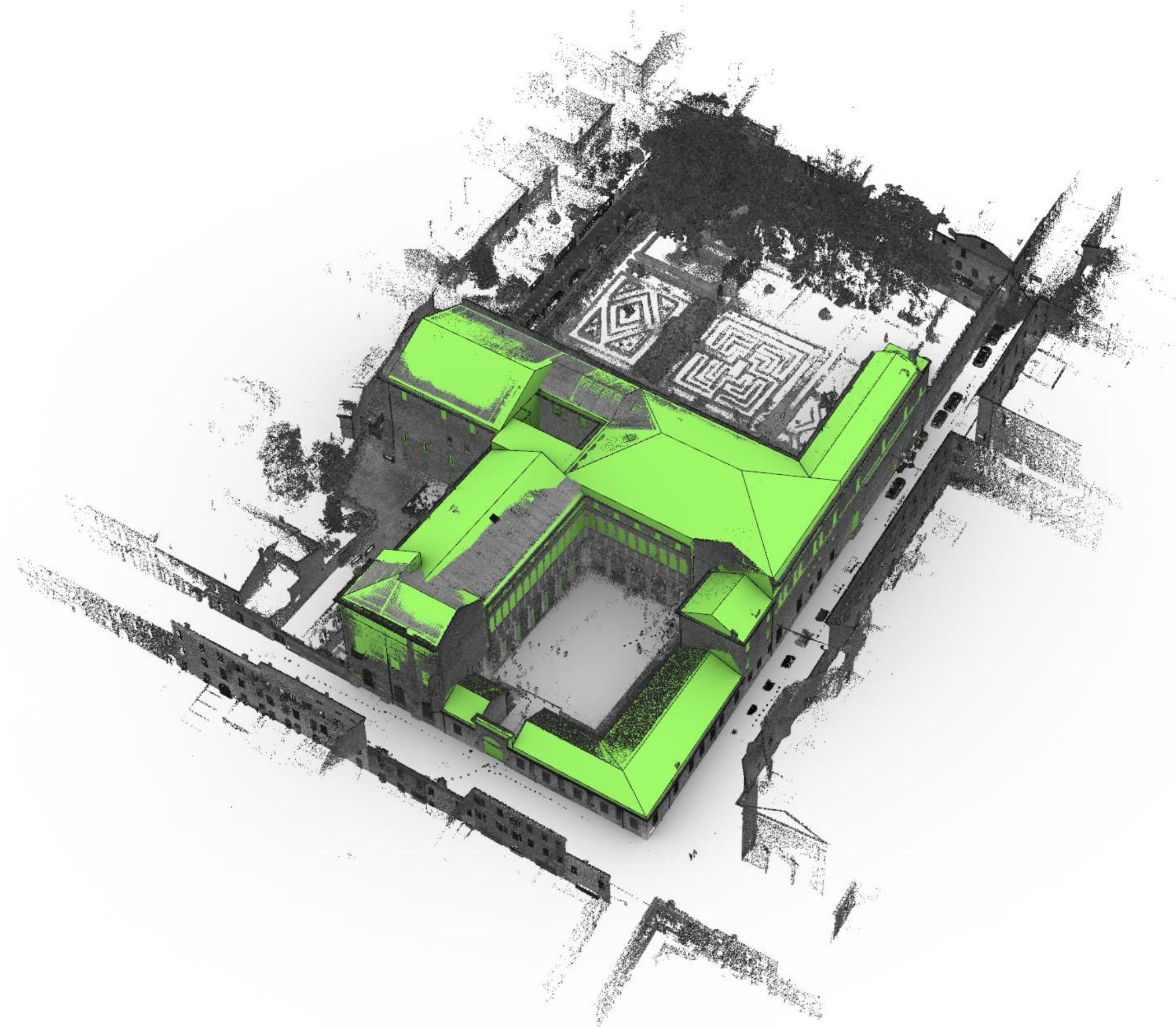
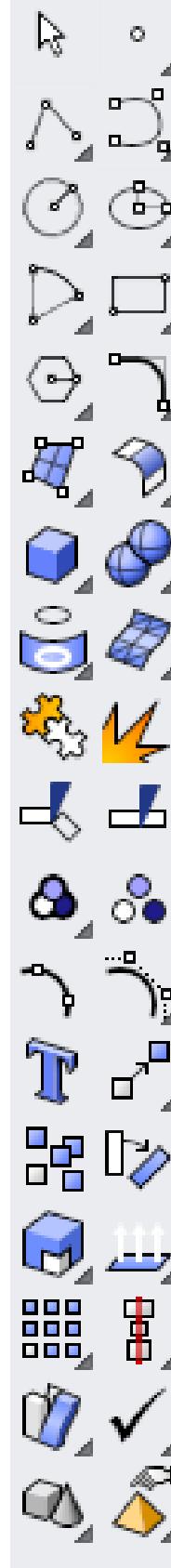
GIS to BIM: 3D model of the surroundings



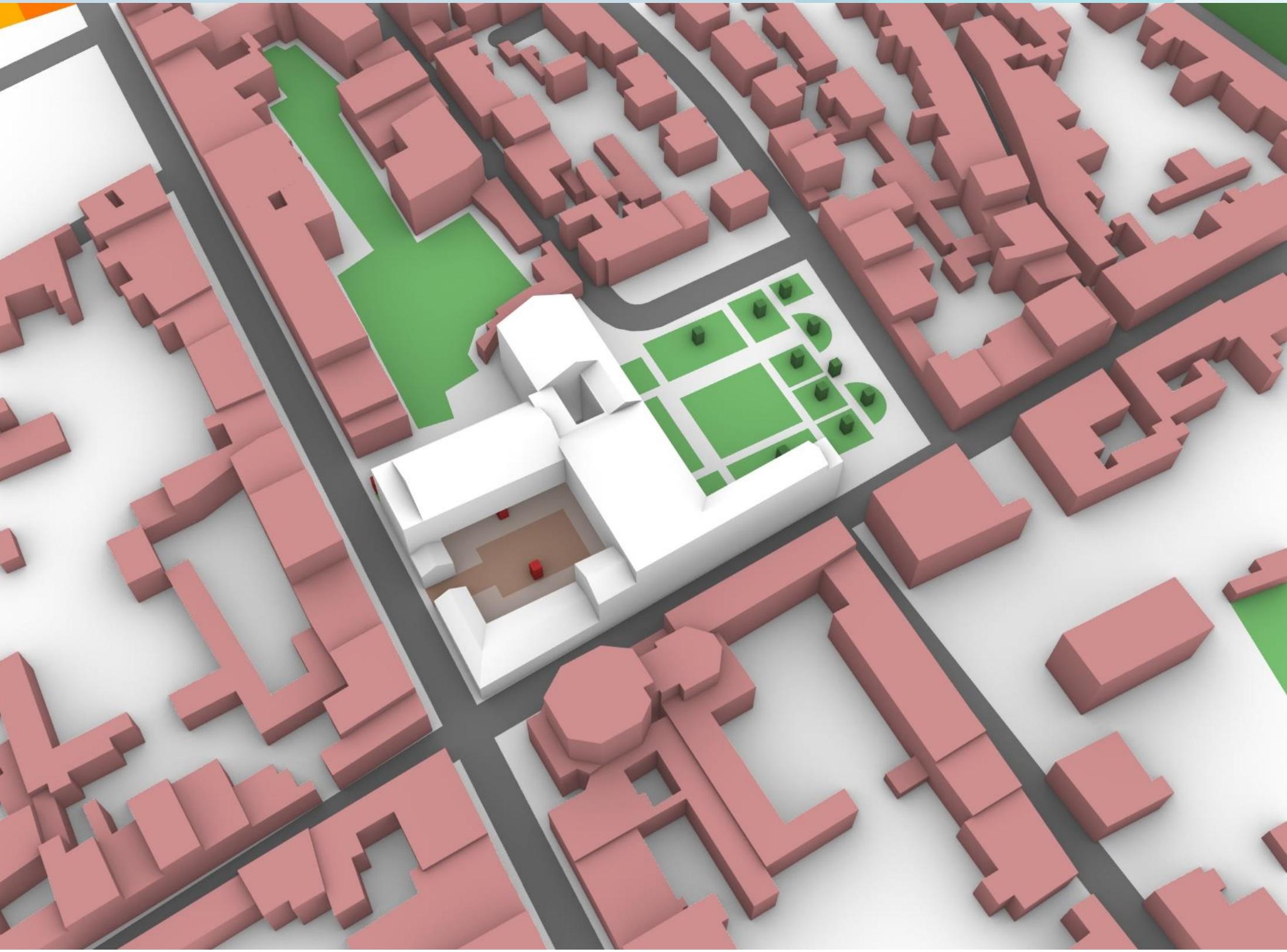
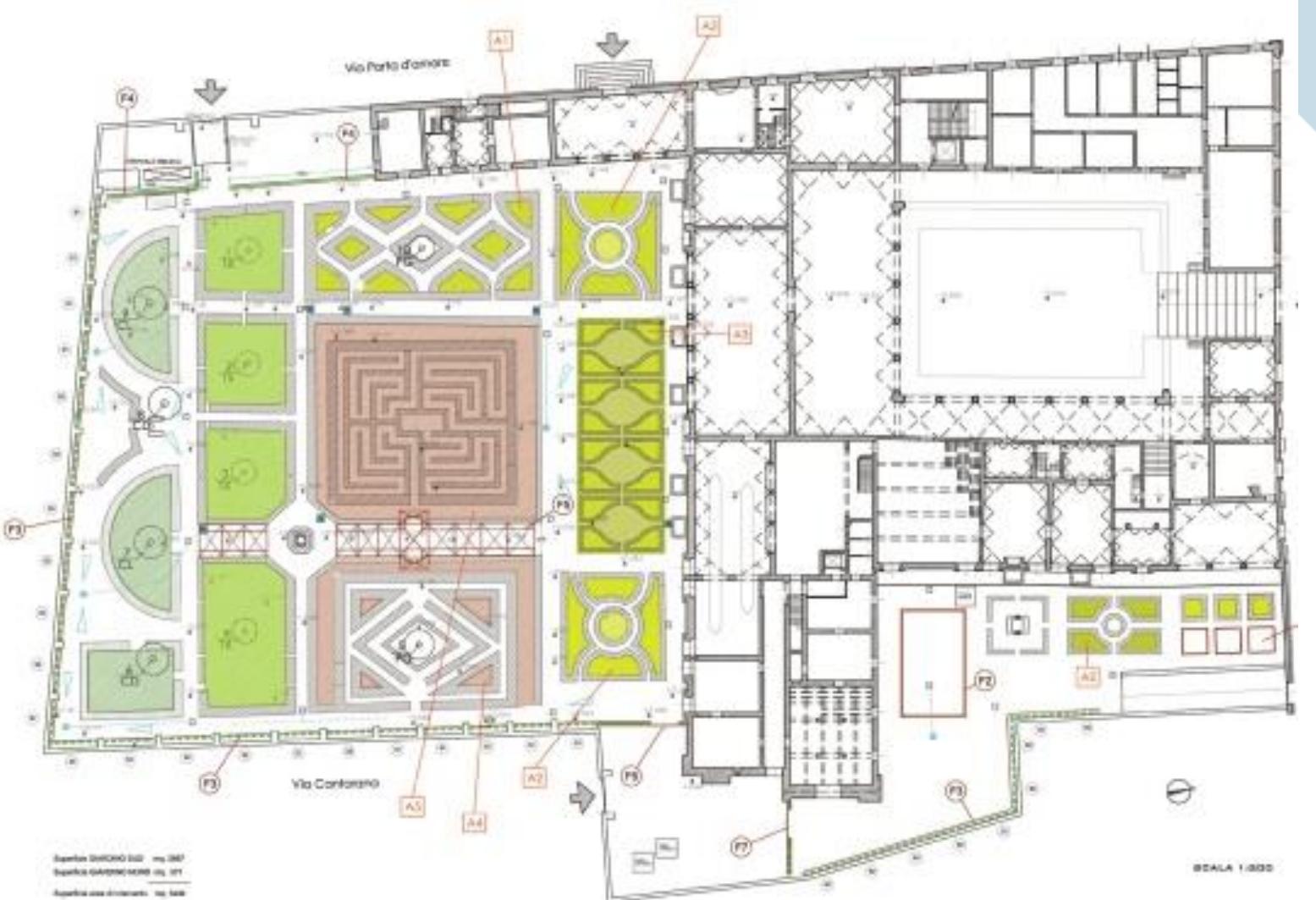
Integration of the point cloud via VPL



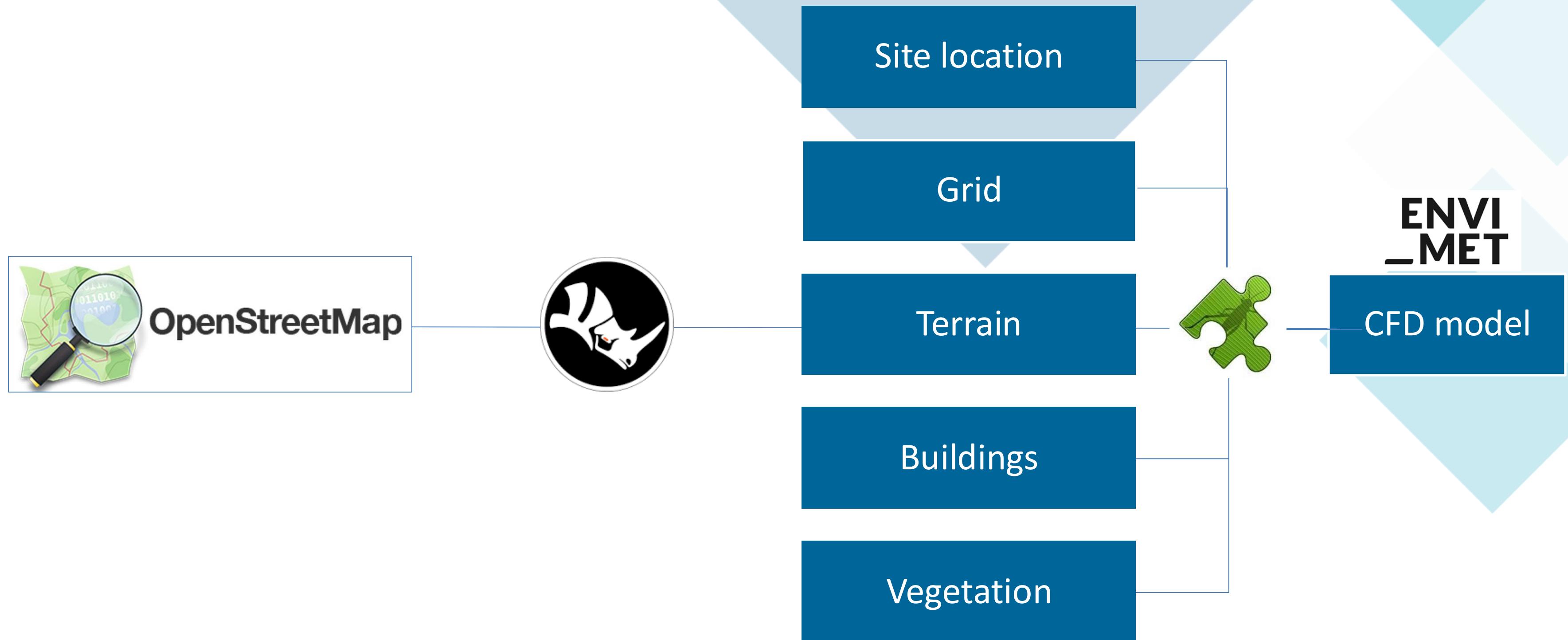
Simplified 3D modeling from the point cloud



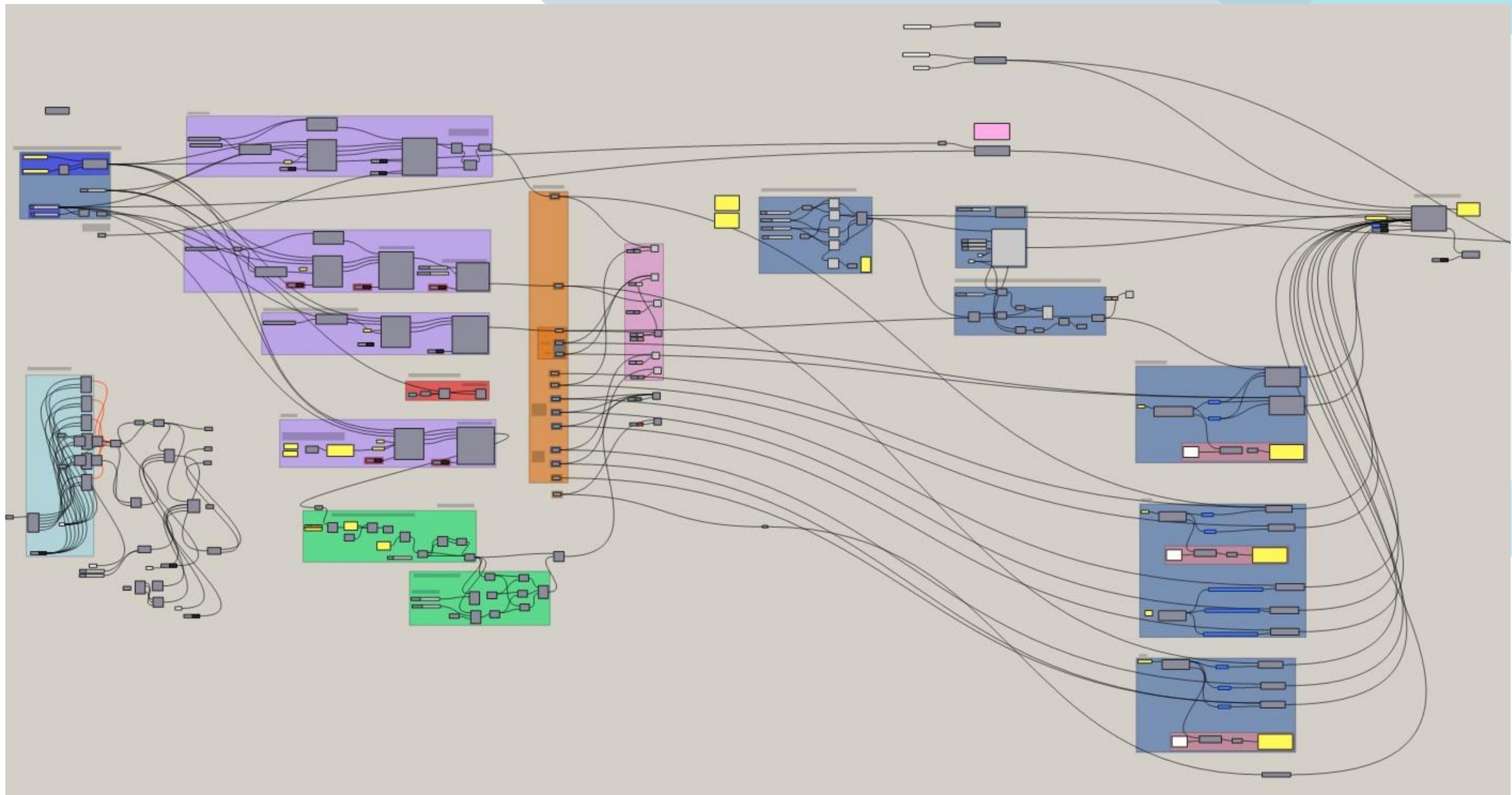
Detailed modelling of pavements and green spaces



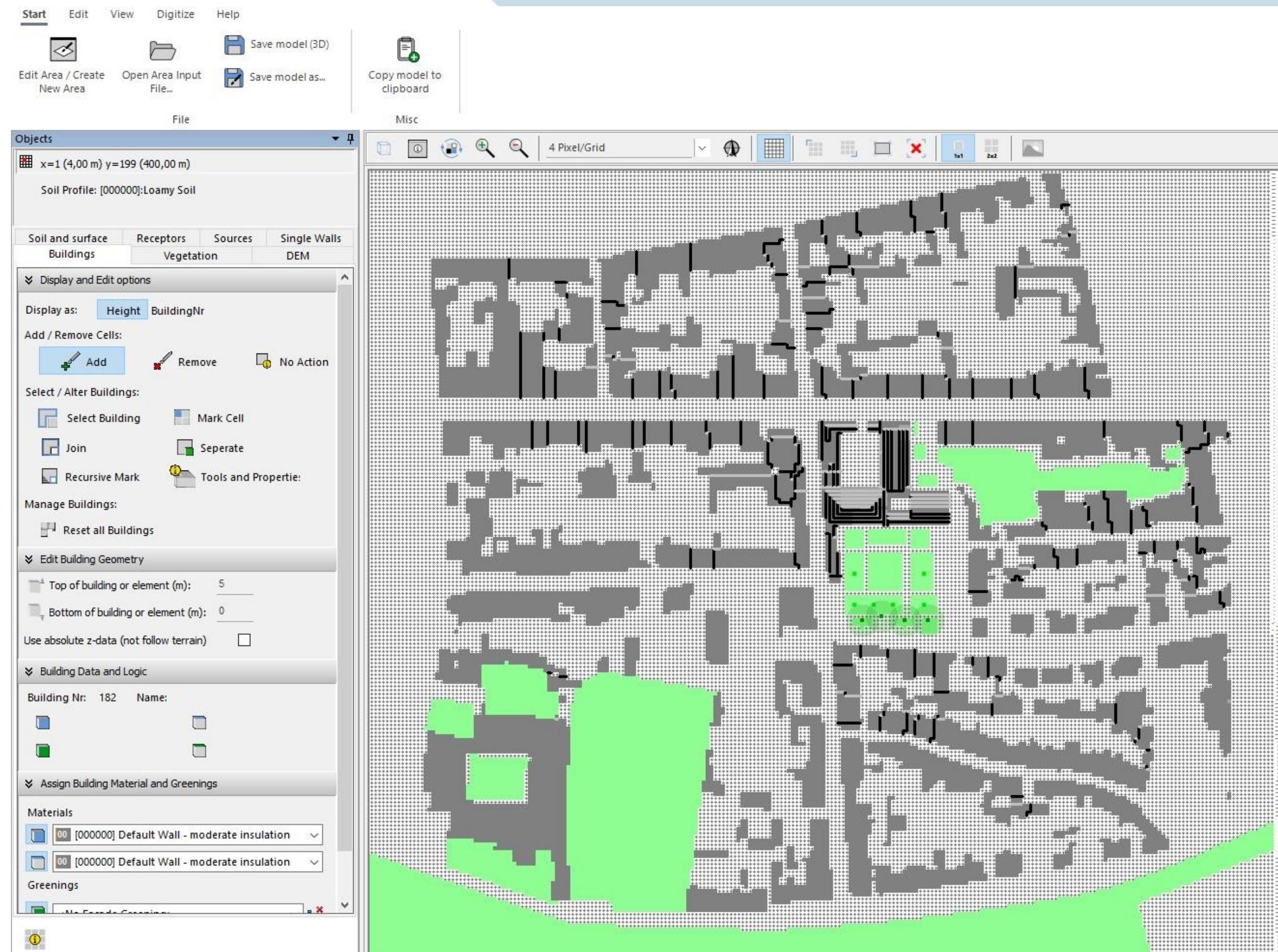
From OpenStreetMap to Rhinoceros to ENVI met through VPL



VPL code to export .INX file



VPL code to export .INX file



Meteorological data - monitoring

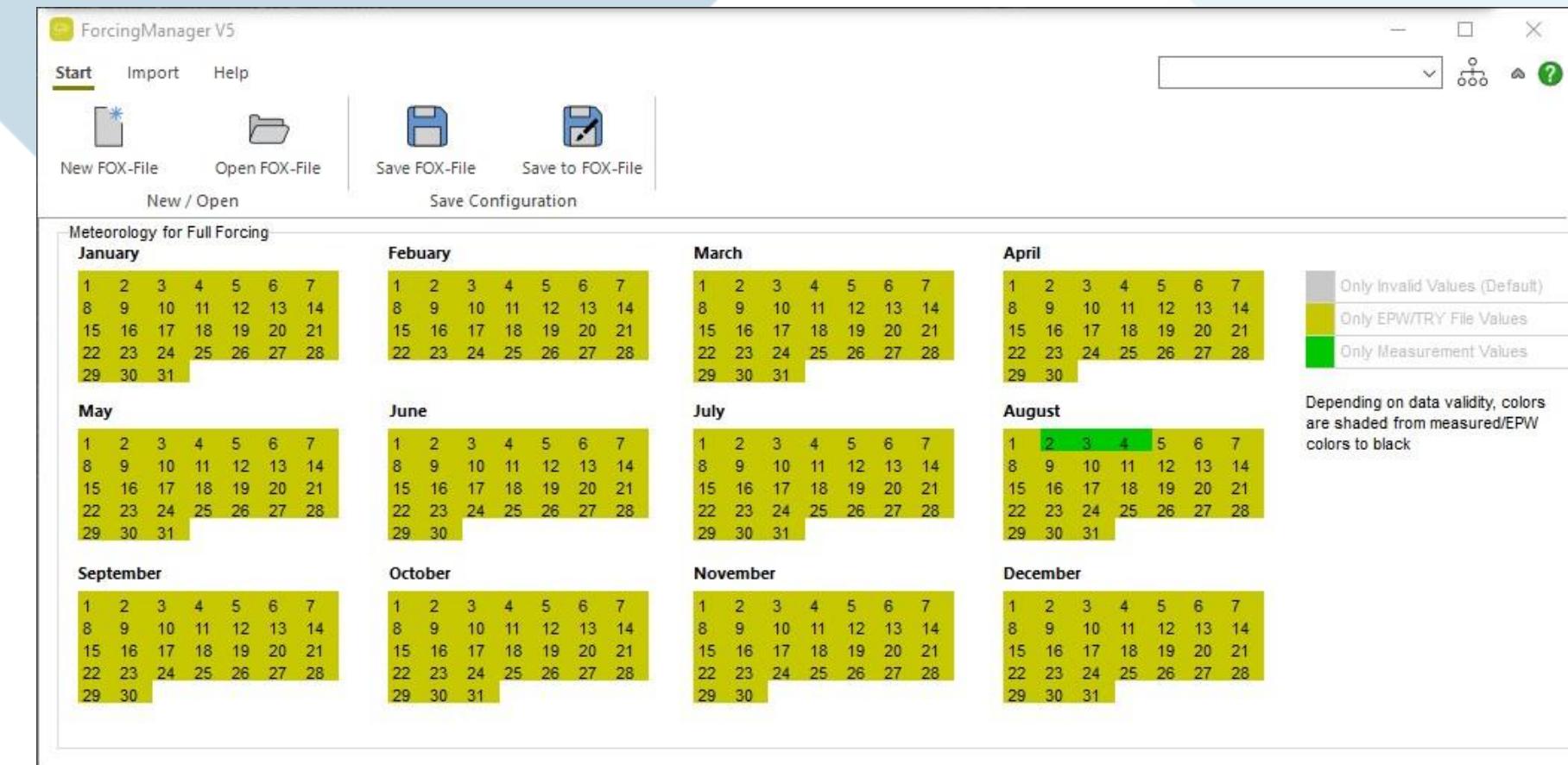


Meteorological data - data input for ENVI-met

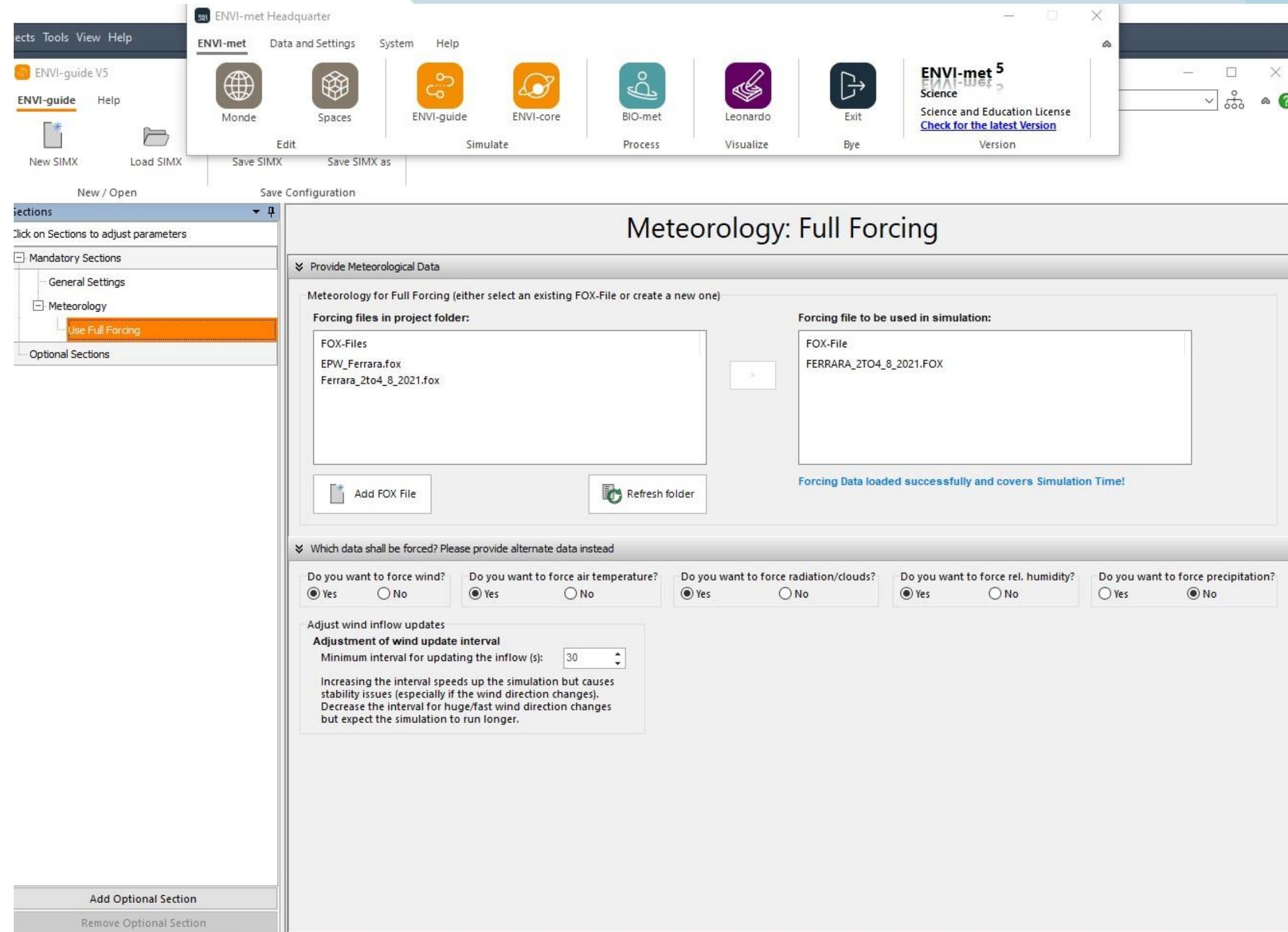
```
E:\ownCloud\BHILab\04_TECH-START\PILOTA\Costabili_CNR-UNIFe\04_Dati\Input_Envimet.py

temp.py x Output_Envimet.py x Input_Envimet.py x Output_EV_Receptors.py x TEMP_lineplot_time.py x

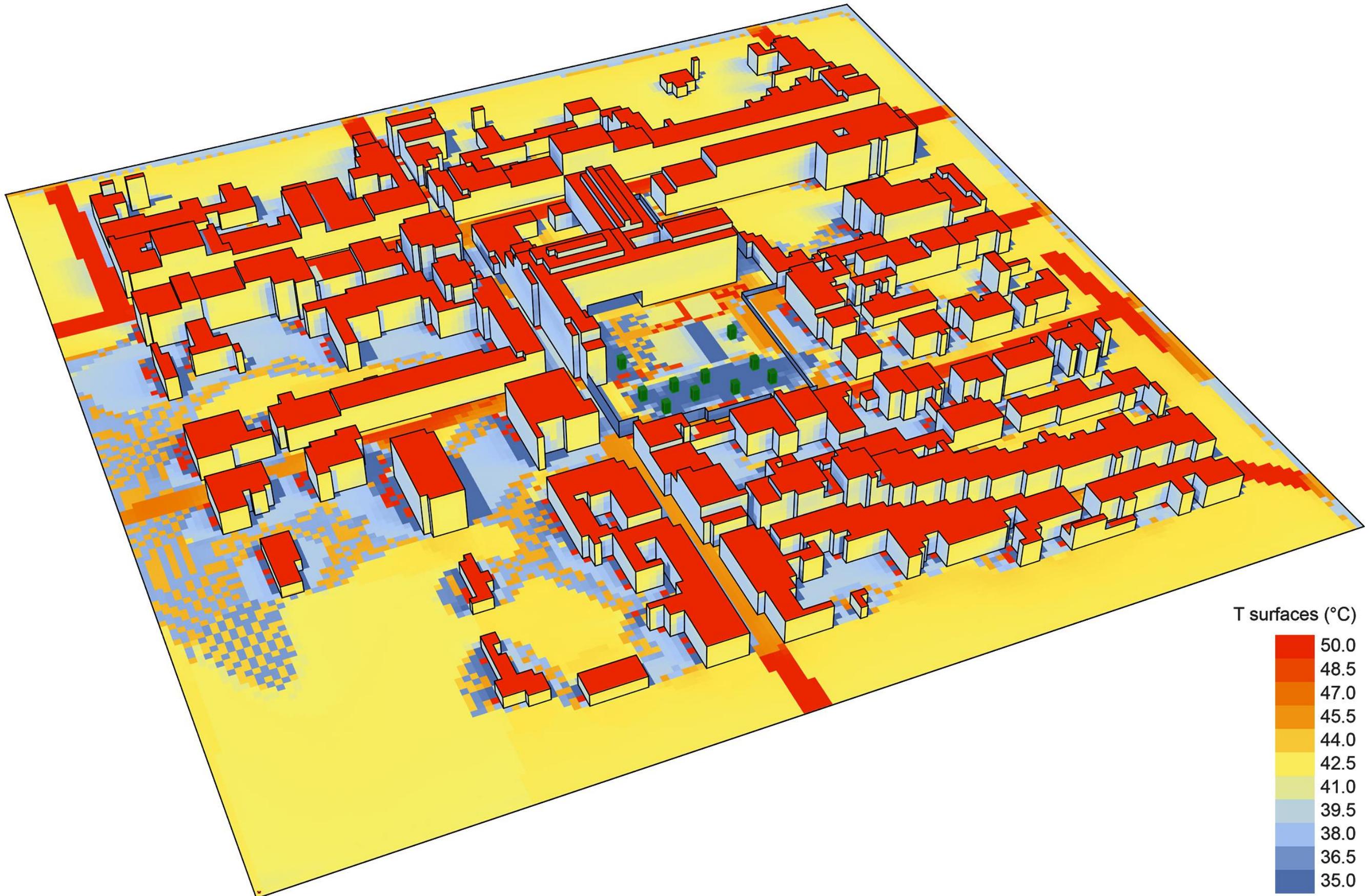
100 #make a new column with the correct python datetime (%b is the format for 3 letter months)
101 df_prin['DateTime'] = pd.to_datetime(df_prin['Date'], format='%b %d %Y %H:%M')
102
103 df_meteo['DateTime'] = pd.to_datetime(df_meteo['Data'] + df_meteo['Ora'], format='%d/%m/%Y%H:%M', errors='coerce')
104
105
106 #####ADJUST MEASURED DATA
107
108 """conversion from sensor data (x 10 to avoid comma, different units) to Envimet input
109 make a function for each conversion
110 apply the function to the selected values in 'Measured value' column
111 TO BE CONTINUED FOR ALL THE DATA!!!"""
112
113 # select Temp based on condition (# register == 9 and 13) and apply function
114 df_prin.loc[(df_prin['# register'] == 9) | (df_prin['# register']== 13), 'Measured value'] = df_prin.loc[(df_prin['# register'] == 9) | (df_prin[
115
116 # select RH based on condition (# register == 10) / 10
117 df_prin.loc[df_prin['# register'] == 10, 'Measured value'] = df_prin.loc[df_prin['# register'] == 10, 'Measured value'] / 10
118 # select radiation (irradianza) based on condition (# register == 14) / 10
119 df_prin.loc[df_prin['# register'] == 14, 'Measured value'] = df_prin.loc[df_prin['# register'] == 14, 'Measured value'] / 10
120 # select wind speed based on condition (# register == 11) / 10
121 df_prin.loc[df_prin['# register'] == 11, 'Measured value'] = df_prin.loc[df_prin['# register'] == 11, 'Measured value'] / 10
122
123 #replace all wind dir values by using a dictionary and .replace function
124 wd_replace_values = {'N' : 0, 'NNE' : 22.5, 'NE' : 45, 'ENE' : 67.5, 'E' : 90, 'ESE' : 112.5, 'SE' : 135, 'SSE' : 157.5, 'S' : 180,
125 'SSW' : 202.5, 'SW' : 225, 'WSW' : 247.5, 'W' : 270, 'WNW' : 292.5, 'NW' : 315, 'NNW' : 337.5}
126
127 df_meteo = df_meteo.replace({"Dir": wd_replace_values})
128
129 """
130 filtering data
131 & is different from and: and is boolean operator, while & is an element-wise logical-and and is used for filtering
132 parentheses are mandatory since & has a higher operator precedence than ==
133
134 element-wise AND == &
135 element-wise OR == |
136 element-wise NOT == ~"""
137
138 #####TEMP: rearrange columns
139 df_prin = df_prin.iloc[:, [-1,2,3,5,6]]
140 df_meteo = df_meteo.iloc[:, [-1,2,3,4,5,6,7]]
141
142 #####DATAFRAME FOR EACH BOARD
143
144 """TEMP: make a dataframe for each board, with each register as a column - timestep 30min - data mean
145 as the datalogger is not uniform, it's easier to extract each column with the right timestep and then combine them
146 (slow and clumsy, but effective)"""
147
148 """wind speed and dir from the monitored dataset are only for reference,
149 wind input data comes from the meteorological station Orto Botanico"""
150
151 #BOARD 11
152 #register 9 - air temperature
153 df_prin_b11_9T = df_prin[(df_prin['# register'] == 9) &(df_prin['# board'] == 11)] #retrieving data based on conditional statements
154 #register 10 - RH
155 df_prin_b11_10rh = df_prin[(df_prin['# register'] == 10) &(df_prin['# board'] == 11)]
```



Outdoor environmental simulation



Outdoor environmental simulation



OpenStreetMap X +

openstreetmap.org/#map=18/44.82717/11.62785

App LollyGame Facebook MoMA | The Collect... Sapienza - Universit... david-laserscanner CONFLUENCES war... padisuniroma1.it/b... Free Online YouTub... Shades of Grey: OU... YACHT DESIGN - P... CdA Formazione | C... Altri Preferiti Elenco di lettura

OpenStreetMap Modifica Cronologia Esporta Tracciati GPS Dati degli utenti Copyright Aiuto Informazioni michelecalvano

Cerca Dove si trova? Var jp

Livelli mappa

Standard i CyclOSM Mappa ciclabile Mappa dei trasporti ÖPNVKarte Umanitario

Abilità sovrapposizioni per la risoluzione dei problemi della mappa

Note sulla mappa

Dati della mappa

Tracciati GPS pubblici

30 m 100 ft

a | spc

The screenshot shows a detailed map of a residential area in Italy, likely Rome, with a grid of streets and buildings. A large green park, 'Parco del Montebianco', is visible on the right side. The map includes labels for 'Monte Mario', 'Monte Sacro', 'Monte Testaccio', and 'Monte Cavo'. A search bar at the top left allows users to search for locations. On the right, a 'Livelli mappa' (Map Layers) sidebar lists several options: Standard (selected), CyclOSM, Mappa ciclabile, Mappa dei trasporti, ÖPNVKarte, and Umanitario. Below these, a section titled 'Abilità sovrapposizioni' (Overlays) provides tools for resolving mapping issues. At the bottom right, there are logos for 'a' and 'spc'.

VPL for CFD: Chuandixia case study

Chuandixia

Ancient Chinese village

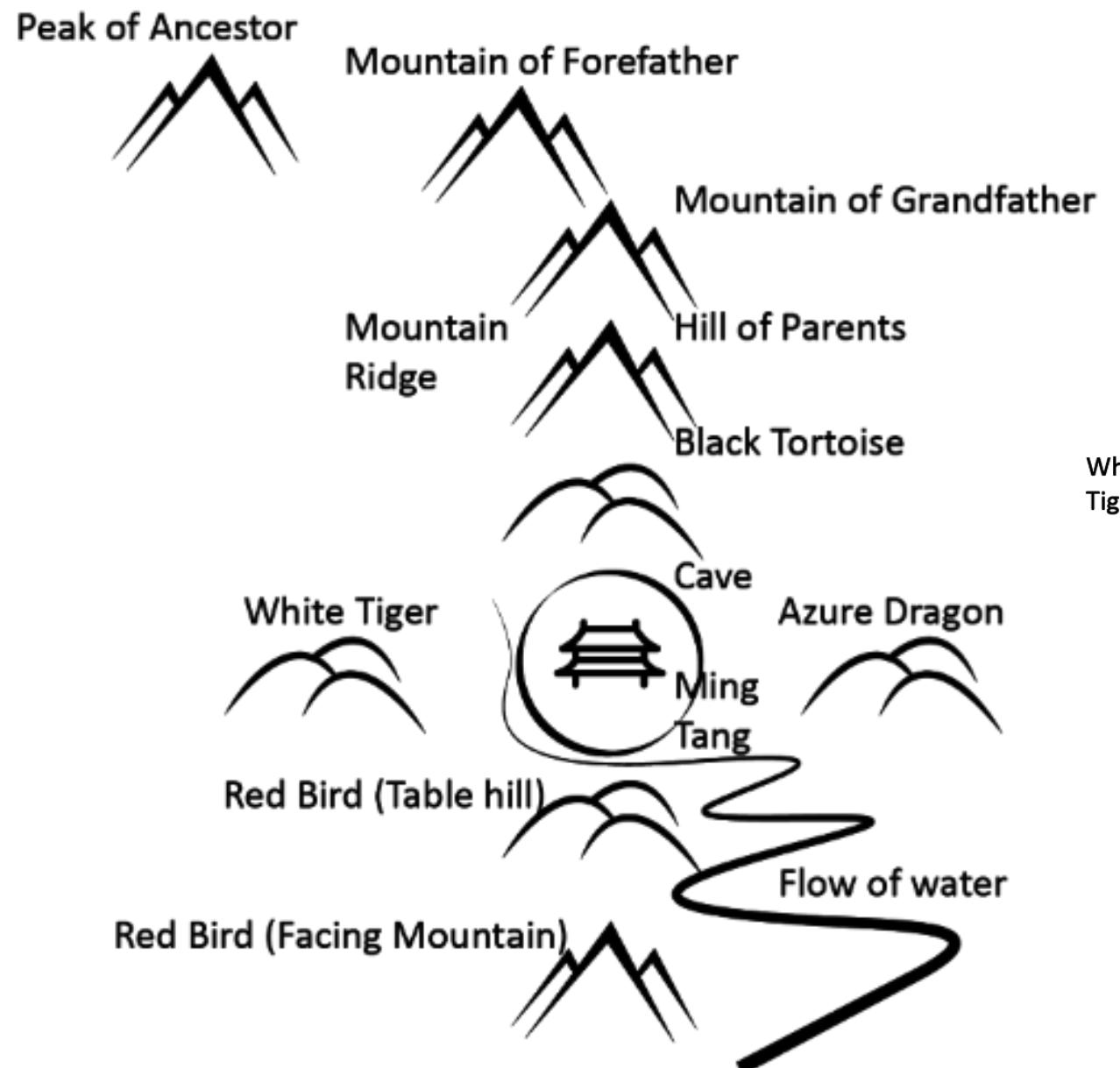
The ancient village of Chuandixia is located about 90 km NW of Beijing (China) at an altitude of about 650 m.



Chuandixia

Ancient Chinese village

Chuandixia was built during the Ming Dynasty (1368-1644) following the Feng Shui principles.



Theory of the Four Emblems

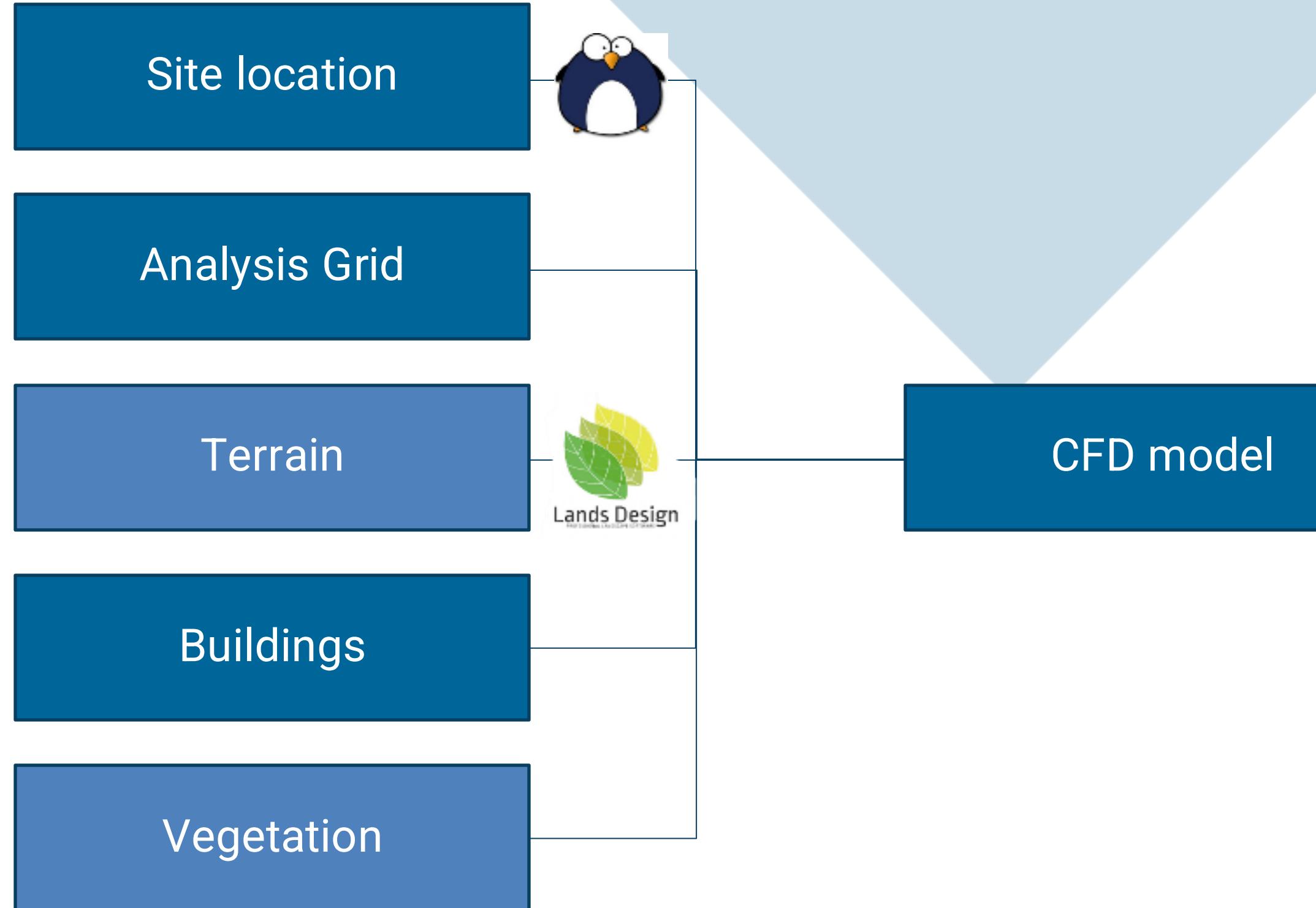


Siheyuan

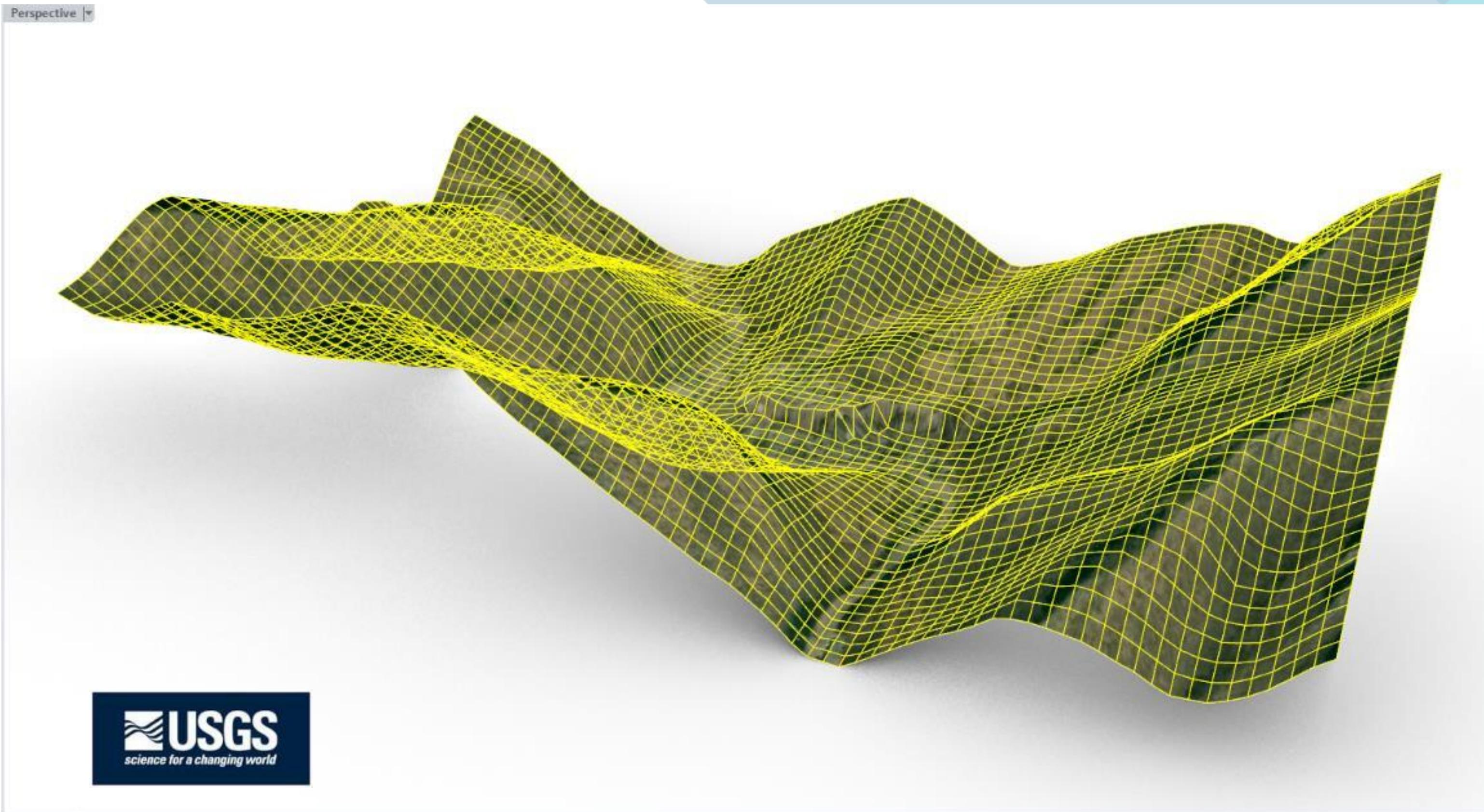


From Rhinoceros to ENVI met through VPL

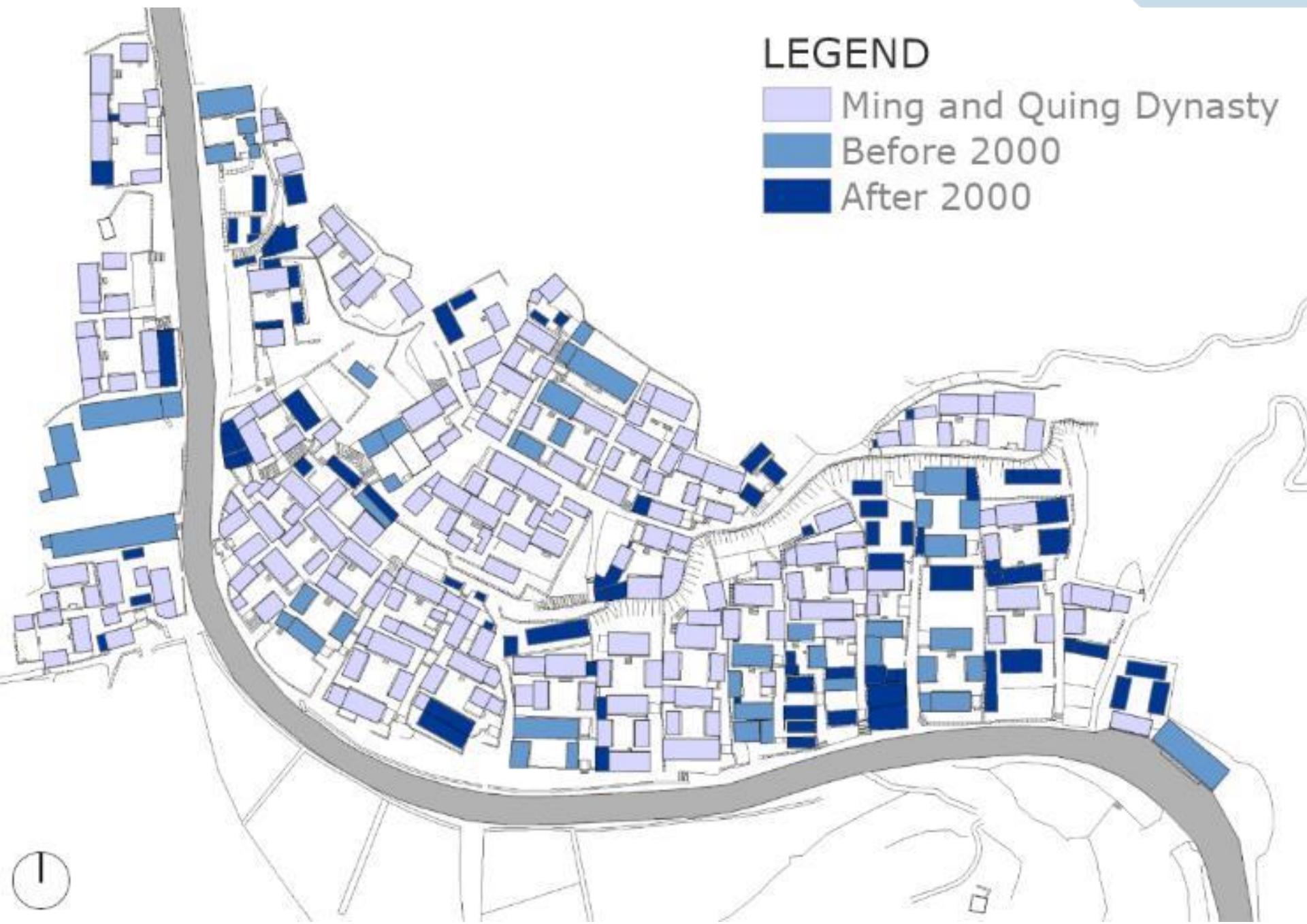
Insert your long title here



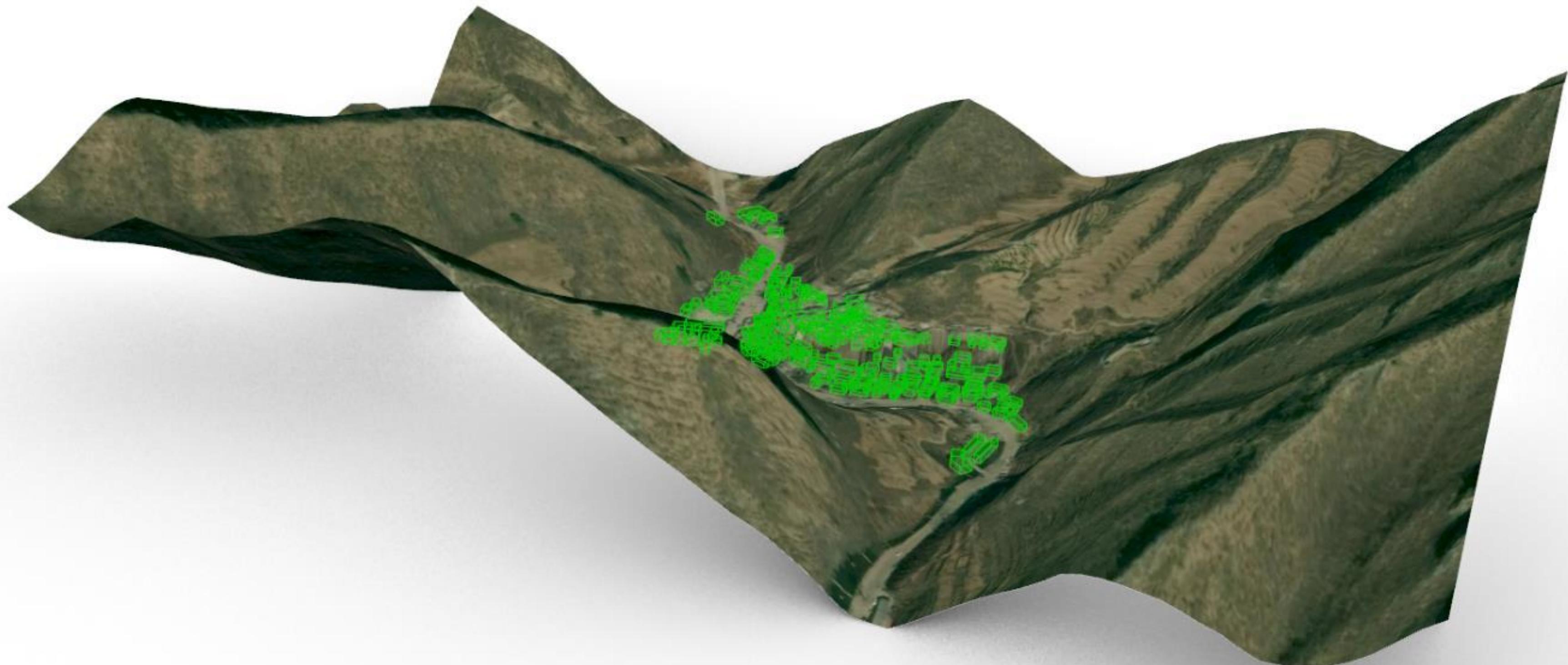
Digital Elevation Model (DEM)



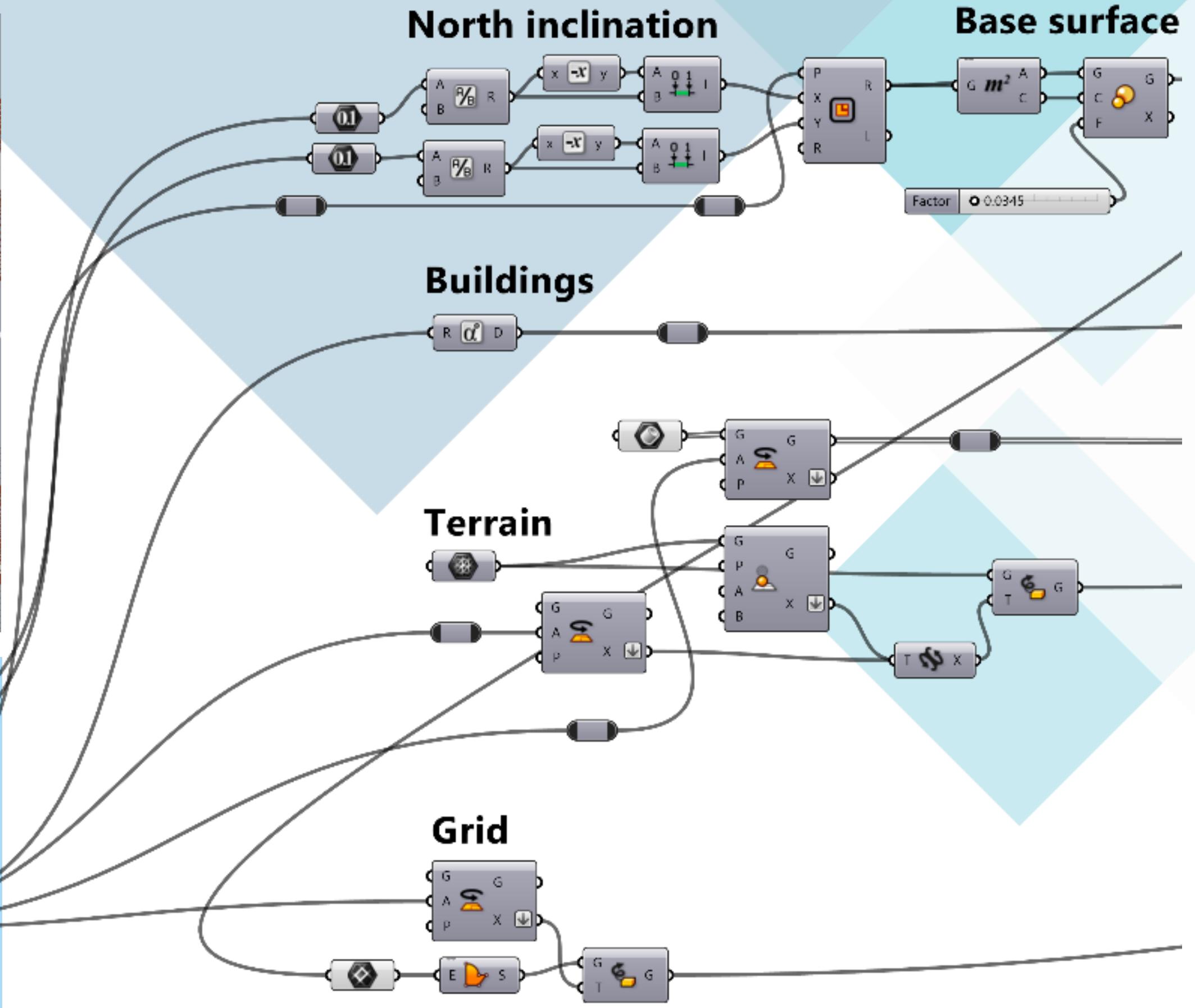
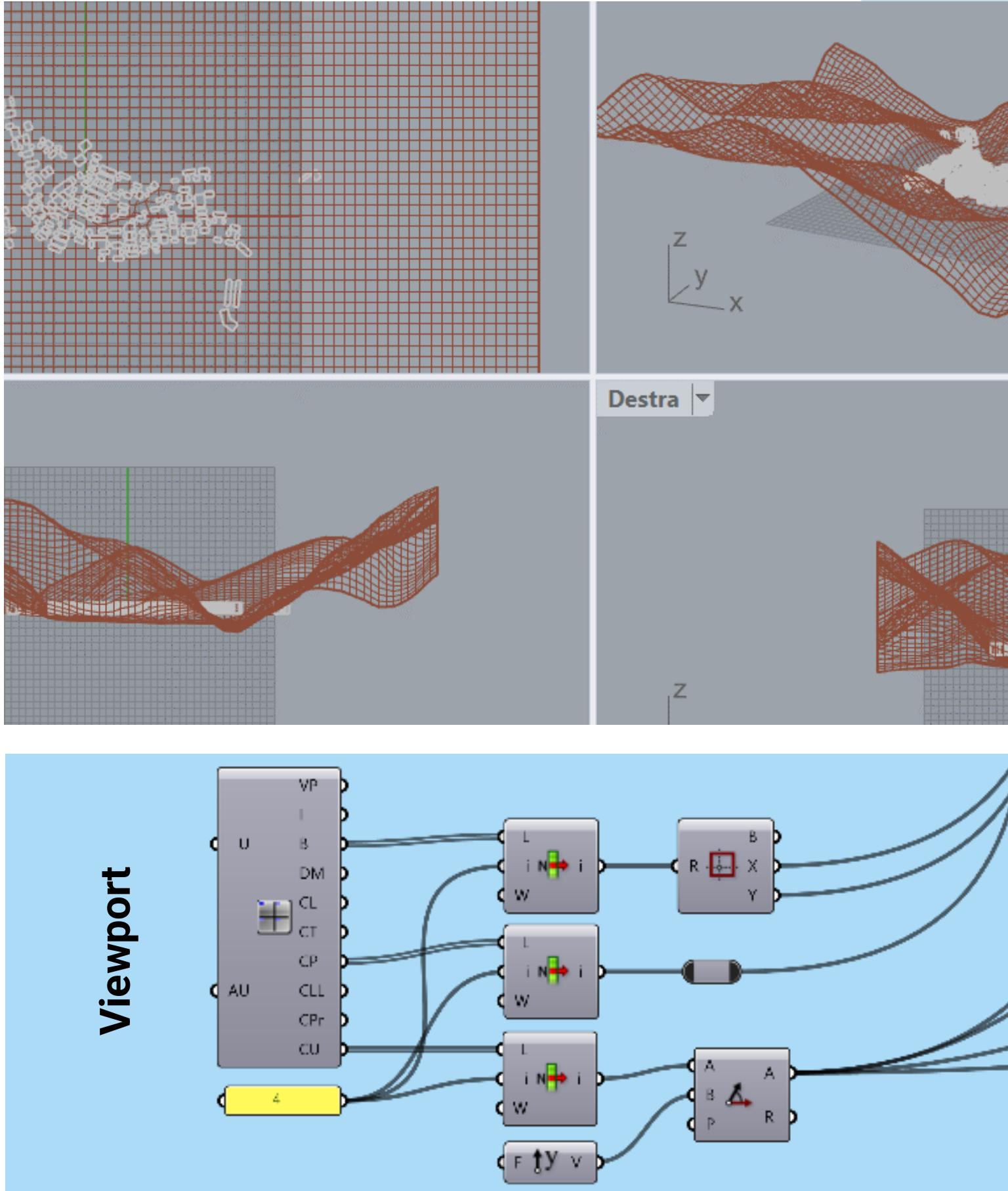
Buildings layout



Buildings layout on the DEM



Viewport interface for area selection



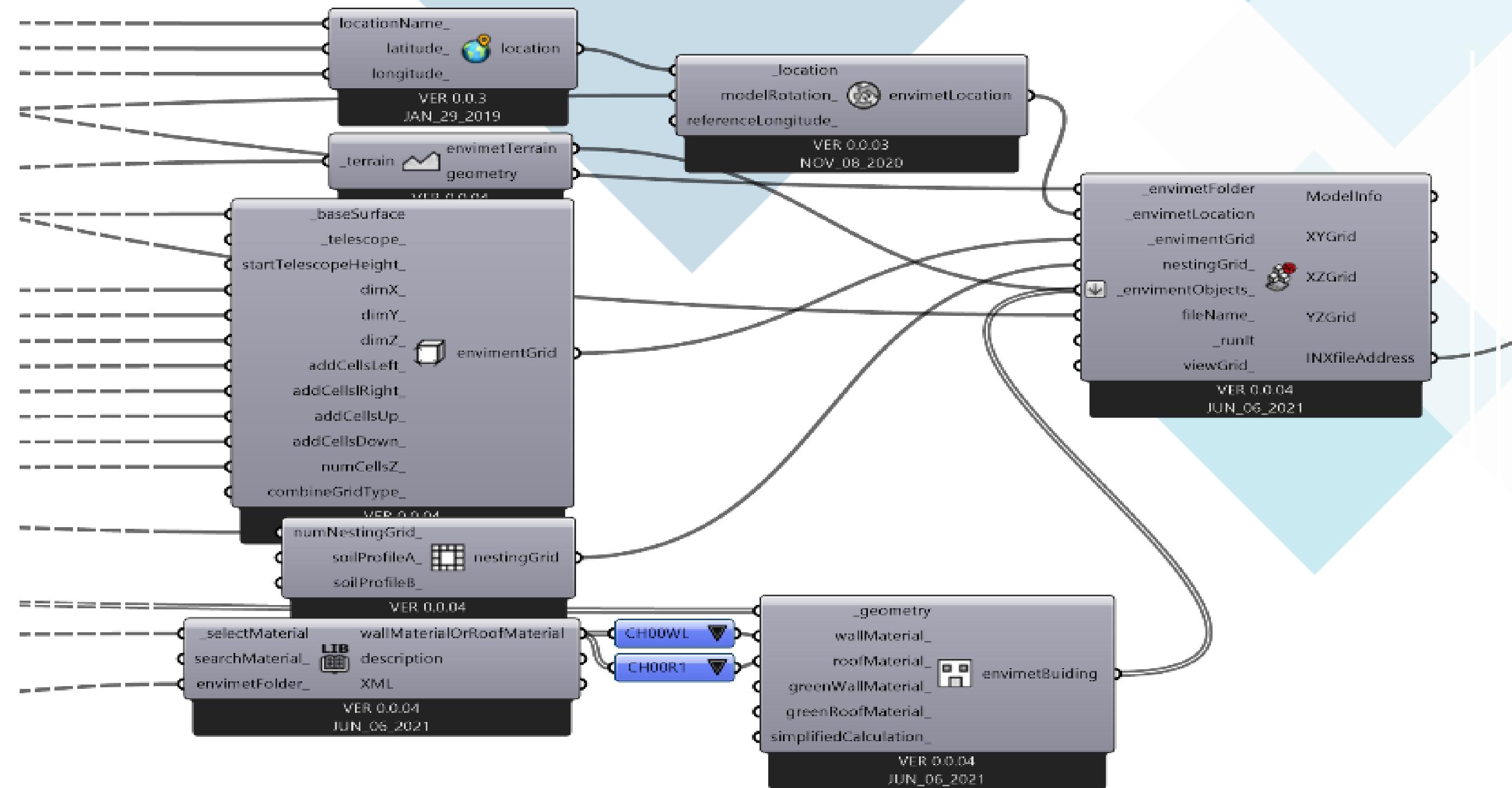
Dragonfly legacy to export .INX file



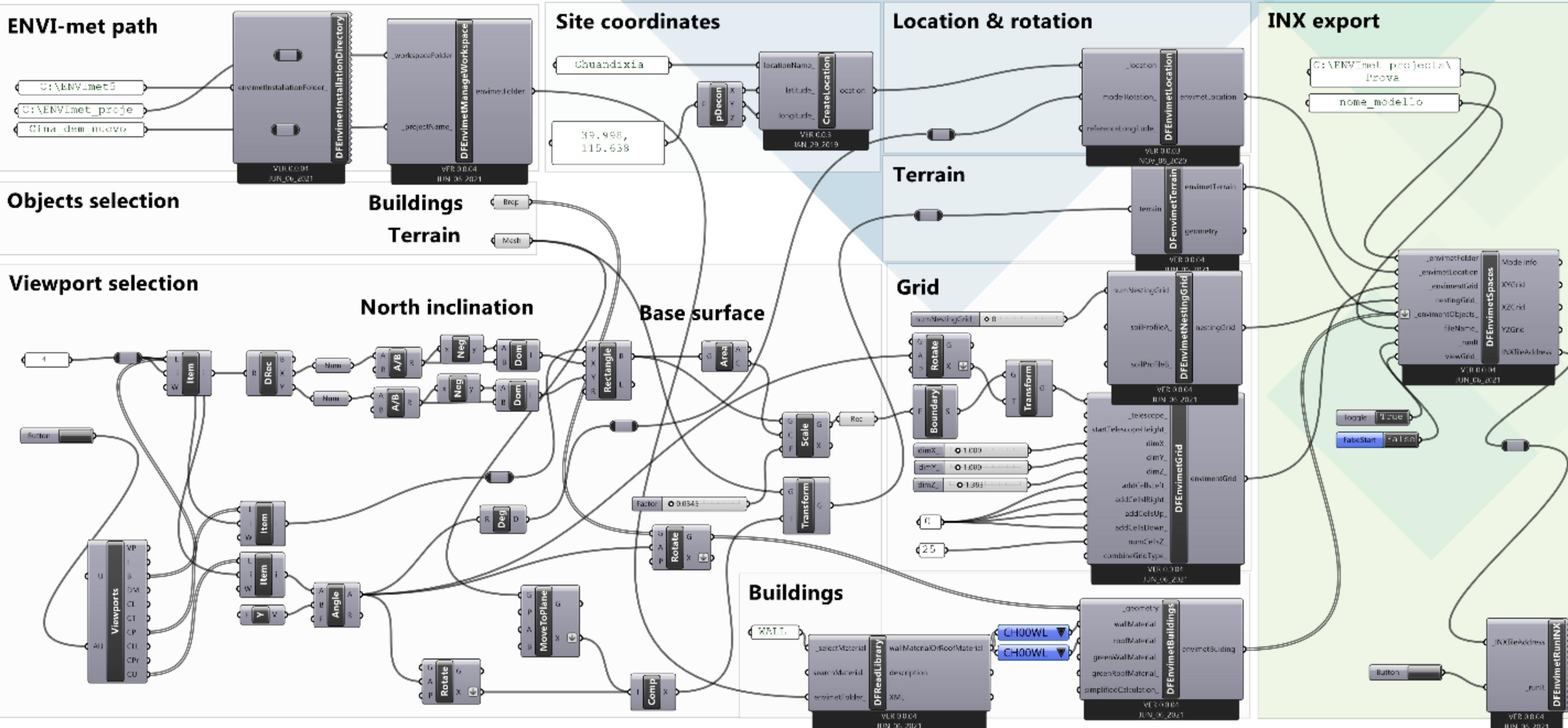
A Dragonfly Legacy code was used to connect Ladybug, Dragonfly and Gismo to Envimet for urban microclimatic analysis.

An Envimet 3D model (INX) was created, including information on:

- the model **grid**,
- site **location**
- morphology of **terrain**,
- **shapes and materials** of buildings
- ...



Final VPL code



Manual steps: DEM refinement

GRID:
338*222*100
nodes, 1.5 m
grid resolution

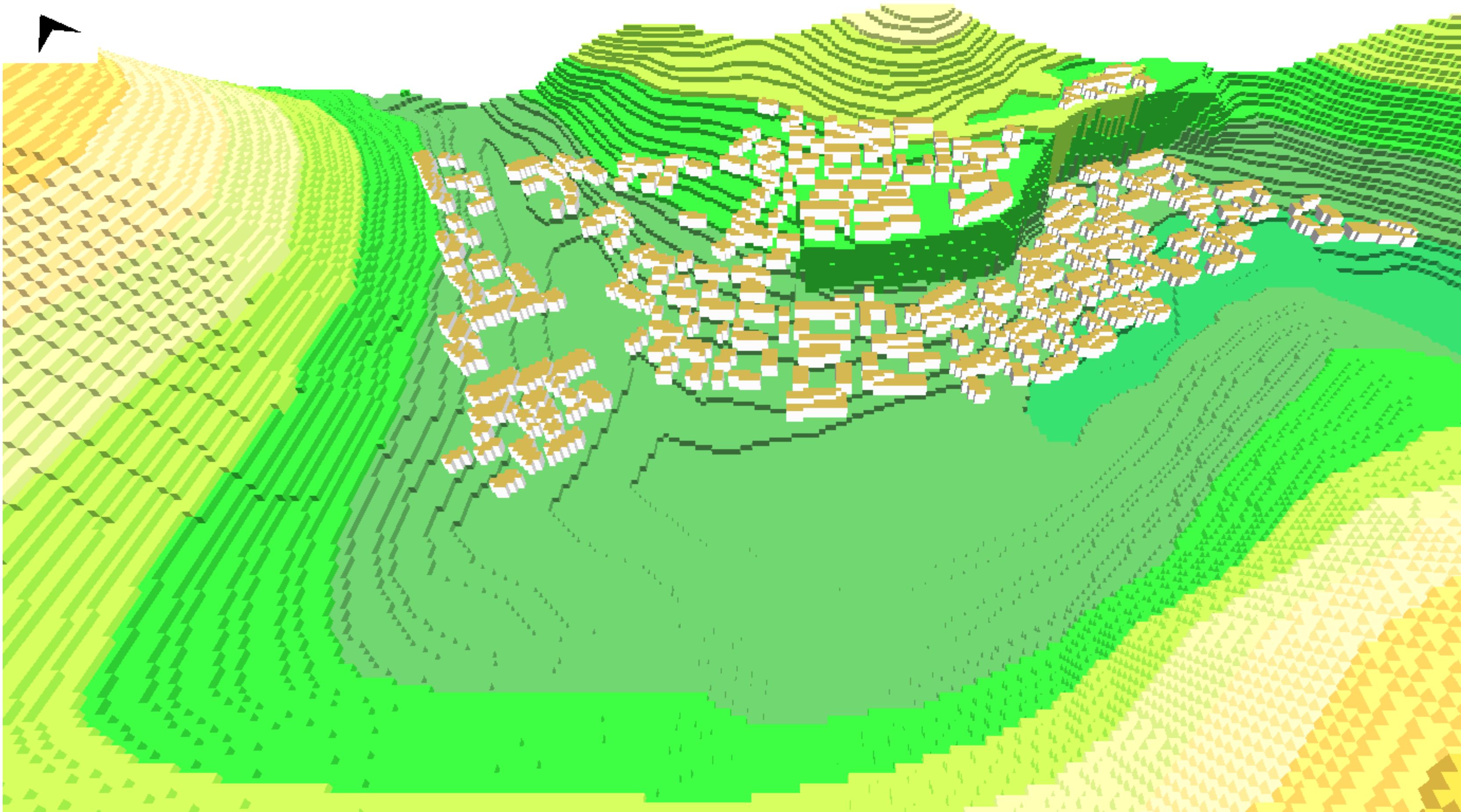
▼ Edit Elevation Model

Terrain height in m: 650

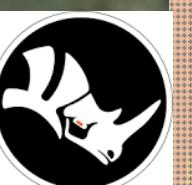
▼ DEM Legend

Terrain Height

below 12.10 m (rel)
12.10 to 24.20 m (rel)
24.20 to 36.30 m (rel)
36.30 to 48.40 m (rel)
48.40 to 60.50 m (rel)
60.50 to 72.60 m (rel)
72.60 to 84.70 m (rel)
84.70 to 96.80 m (rel)
96.80 to 108.90 m (rel)
above 108.90 m (rel)



Manual steps: Vegetation



ENVI
MET

Prevailing climate conditions

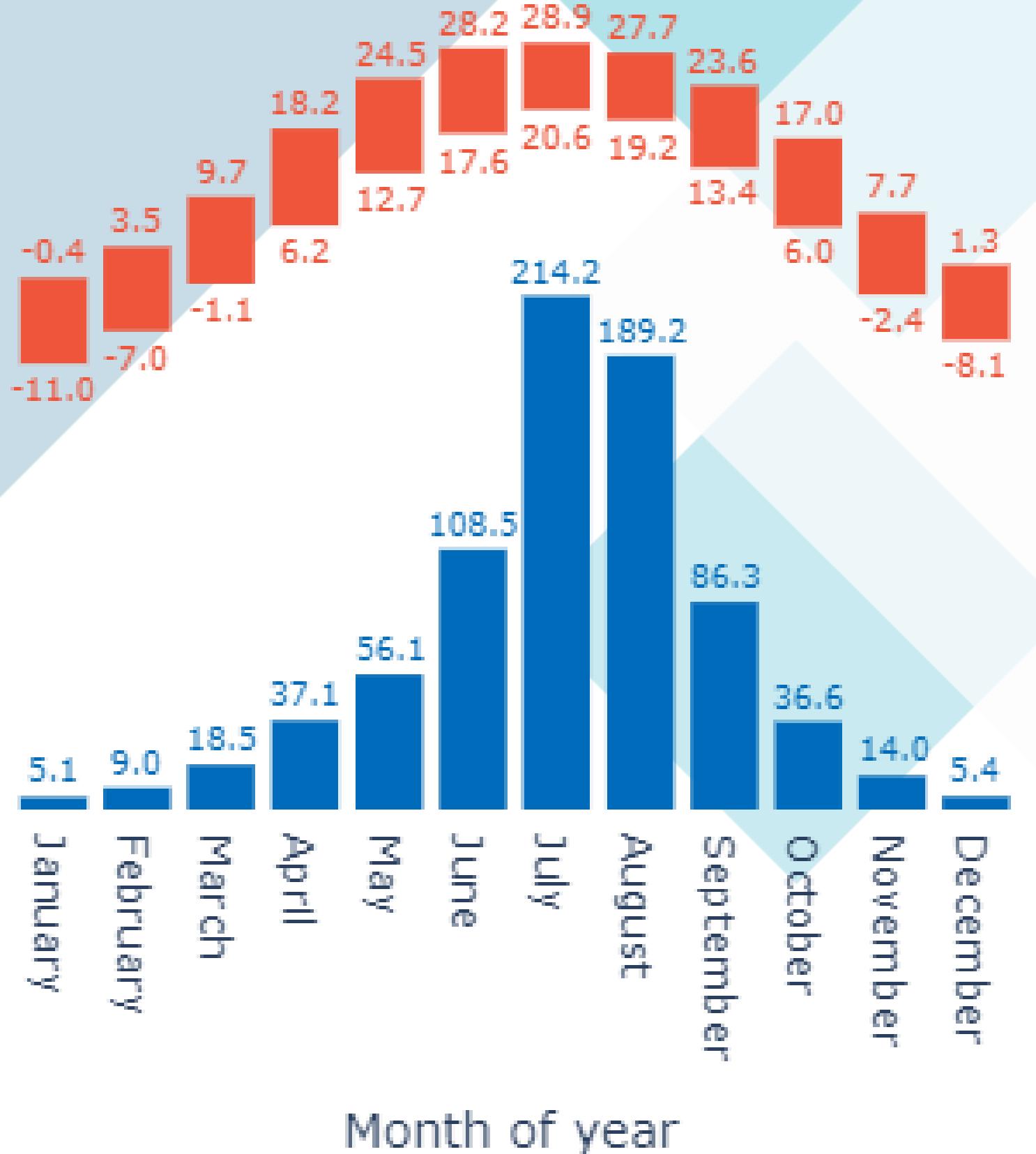
Based on ERA5 climatological data ([Copernicus Climate Data Store](#)), for the 1981-2010 reference period, the annual average temperature in the area was 10.5°C.

Typical climate of the area is **temperate monsoon**, cold in winter and cool in summer.

Monthly mean of daily max and min temperatures ranged from -11°C (January) to 28.9°C (July).

Monthly mean precipitations ranged from 5.1 mm (January) to 108.5 mm (July).

- Monthly mean precipitation (mm)
- Monthly mean of daily max and min temper



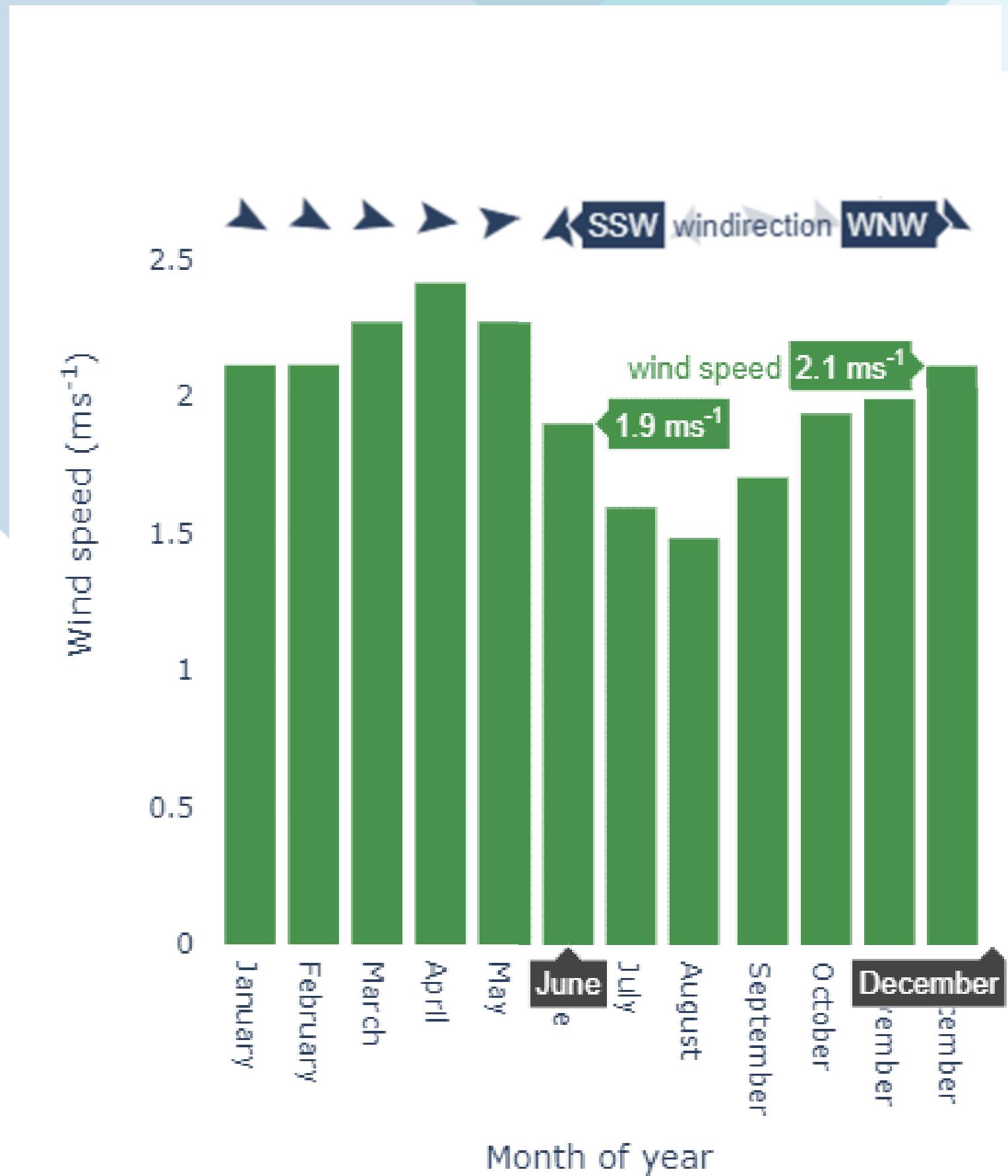
Prevaling climate conditions

Based on ERA5 climatological data ([Copernicus Climate Data Store](#)), for the 1981-2010 reference period, the annual average wind speed in the area was 2.0 ms^{-1} .

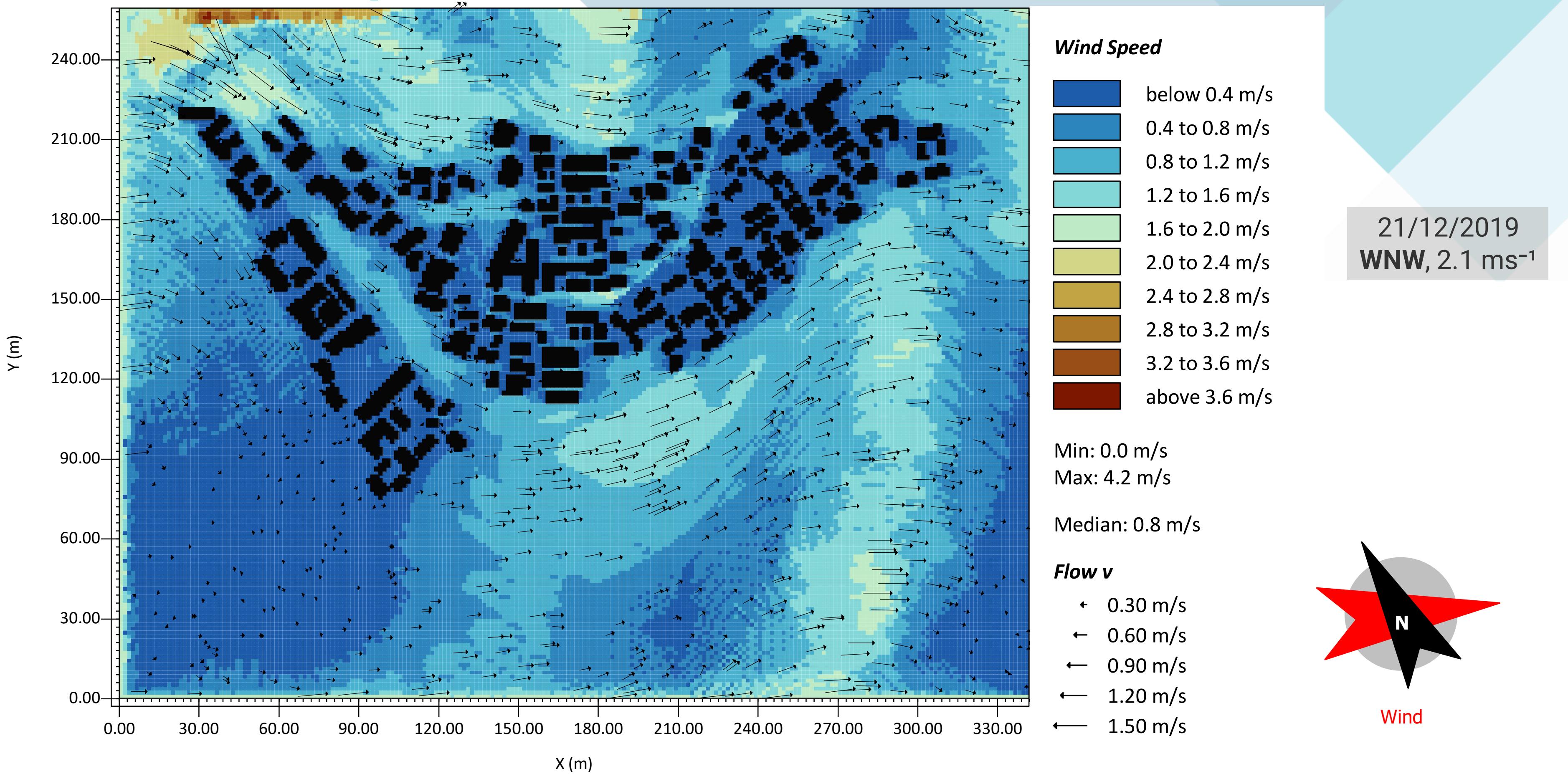
Monthly average wind speed ranged from 1.5 ms^{-1} (August) to 2.4 ms^{-1} (April).

Exploratory simulations were run on:

- **Winter** (21/12/2019) – WNW, 2.1 ms^{-1}
- **Summer** (21/06/2019) – SSW, 1.9 ms^{-1}



Wind speed



Thanks for your attention!

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