Space Syntax Toolkit for QGIS
Introduction and recent developments

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Stephen Law
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Space Syntax Limited - Open Digital Works

11th International Space Syntax Symposium
Fundação Calouste Gulbenkian, Lisbon
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Introduction

Who we are

Jorge Gil MSc, PhD

Researcher UCL, Chalmers, TU Delft

Open Source GIS consultant and developer

Author 'Space Syntax Toolkit' for QGIS (2013 -)

Author 'Confeego' for MapInfo (2004 - 09)

Stephen Law MSc, PhD

Researcher Turing Institute, UCL

Associate, Space Syntax Limited

Ioanna Kolovou MRes

Consultant, Space Syntax Limited

Abhimanyu Acharya MSc

Associate, Space Syntax Limited

Introduction

SpaceGroupUCL / **qgisSpaceSyntaxToolkit**

Unwatch 11 | Star 24 | Fork 11

Code | Issues 51 | Pull requests 0 | Projects 0 | Wiki | Insights

Space Syntax Toolkit for QGIS

162 commits | **6** branches | **13** releases | **2** contributors | GPL-3.0

This organization | Search | Pull requests | Issues | Marketplace | Gist

Space Syntax Limited

Original technology that forecasts the impacts of planning, transport, economic and design decisions on people and property for all scales of development

London | http://www.spacesyntax.... | london@spacesyntax.com

Repositories | People 1

Pinned repositories

Rcl-simplification-
QGIS plug-in to simplify a road centre line for angular segment analysis
Python

UrbanDataInputTool
Urban Data Input Tool for QGIS
Python

GateTransformer
Gate Transformer QGIS plugin
Python

SSS11-workshop
Material for the 11th Space Syntax Symposium workshop

MetricCatchmentAnalyser
Network based metric catchment analysis
Python

Rcl-topology-cleaner
Python

Ioanna
Anafi

booboo
booboo18

\\W//A\\
double-u-a

Jorge Gil
jorgegil

Laurens Versluis
laurensversluis

Abhimanyu Acharya
Morri1234

Introduction

Who are you?

Name and affiliation

Who are you?

	Yes / Some	No
space syntax	5	1
depthmapX	4	2
QGIS	1	5
GIS	3	2

Note: based on 6 participant's responses.

Introduction

Objectives

Learn how to use the 'Space Syntax Toolkit' (SST) for QGIS

Learn about its latest features and tools

Explore various space syntax analysis workflows in QGIS

Main objective is not to...

Learn about space syntax theory and methods

Learn about the depthmapX software

Learn about specific space syntax applications in research

Requirements

Participants must bring their own laptops in order to carry out the practical exercises, with the necessary software pre-installed:

QGIS 2.14 LTR (or higher):
http://qgis.org/en/site/forusers/download.html

depthmapXnet 0.35:
http://archtech.gr/varoudis/depthmapX/?dir=depthmapXnet

Space Syntax Toolkit:
https://github.com/SpaceGroupUCL/qgisSpaceSyntaxToolkit/wiki/Installation

Introduction

Programme

09:30	Introduction to the workshop
09:45	Overview of space syntax and the SST project
10:00	Task 1: Preparing and analysing axial models
11:00	**Break**
11:45	Task 2: Preparing and analysing road centre line models
12:30	Visualisation and discussion of the results
13:00	**Lunch Break**
14:00	Task 3: Preparing other urban data layers
15:00	Task 4: Connecting and analysing the various results
16:00	Discussion on QGIS methods for space syntax research
16:30	**Close**

Overview

Space syntax theory and the SST project

- Overview of relevant space syntax concepts
- Overview of the SST project
- SST installation in QGIS and downloading the sample data set

Space syntax theory

Relevant space syntax concepts

- Representing space: axial maps and unlinks
- Topology of space: graphs and centrality analysis
- Segment maps and angular centrality analysis
- Radius and distances

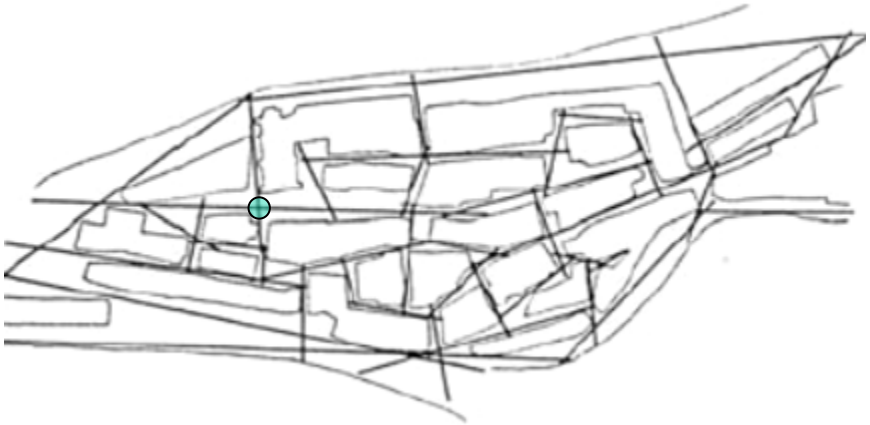
Representing space: axial maps and unlinks

The axial map is a linear representation of space, with the fewest longest set of straight lines that covers all spaces.

Source: Hillier, B., Hanson, J., 1984. The Social Logic of Space. Cambridge University Press, Cambridge, UK

Representing space: axial maps and unlinks

The axial map is a linear representation of space, with the fewest longest set of straight lines that covers all spaces.



Unlinks are features that mark a location where the intersection between two axial lines does not allow a change of direction.

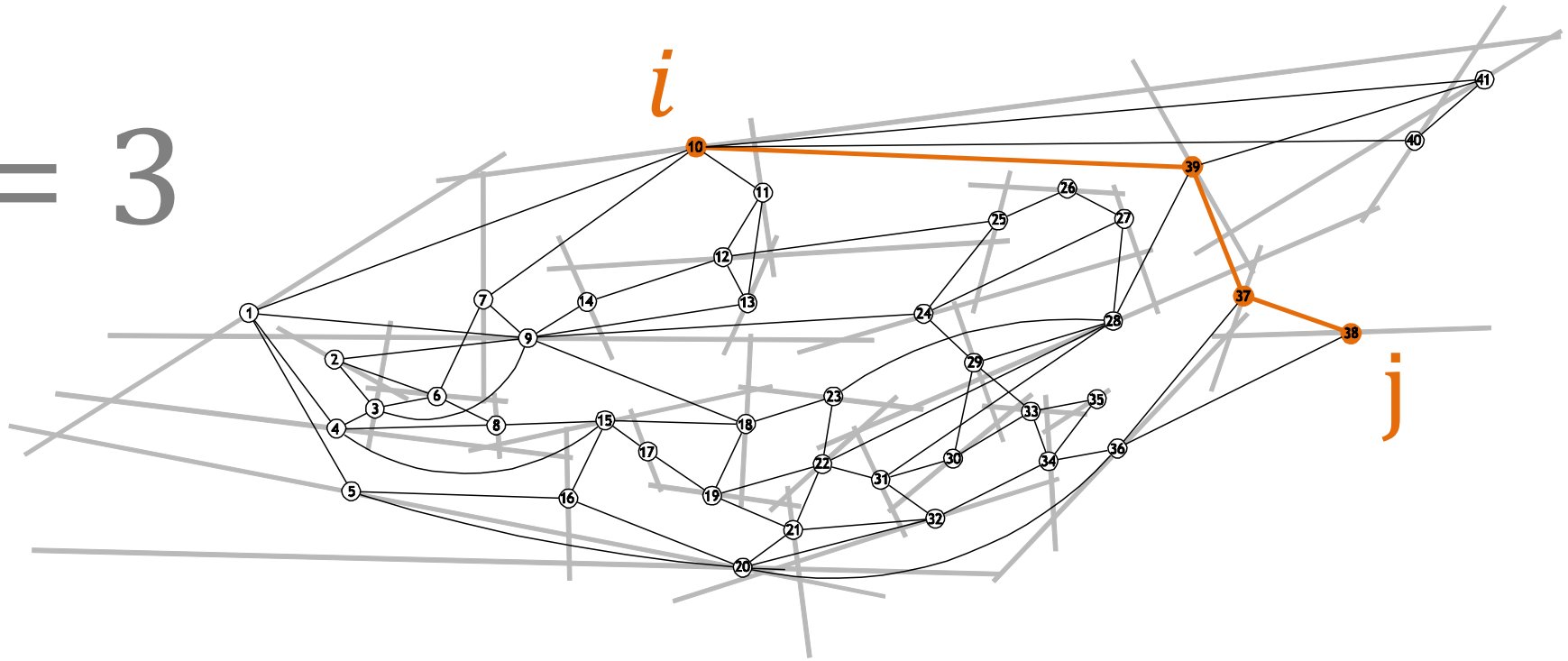
Source: Hillier, B., Hanson, J., 1984. The Social Logic of Space. Cambridge University Press, Cambridge, UK

Topology of space: graphs and centrality analysis

Axial maps are translated into mathematical graphs where every line represents a node, and every intersection between lines represents an edge, or link.

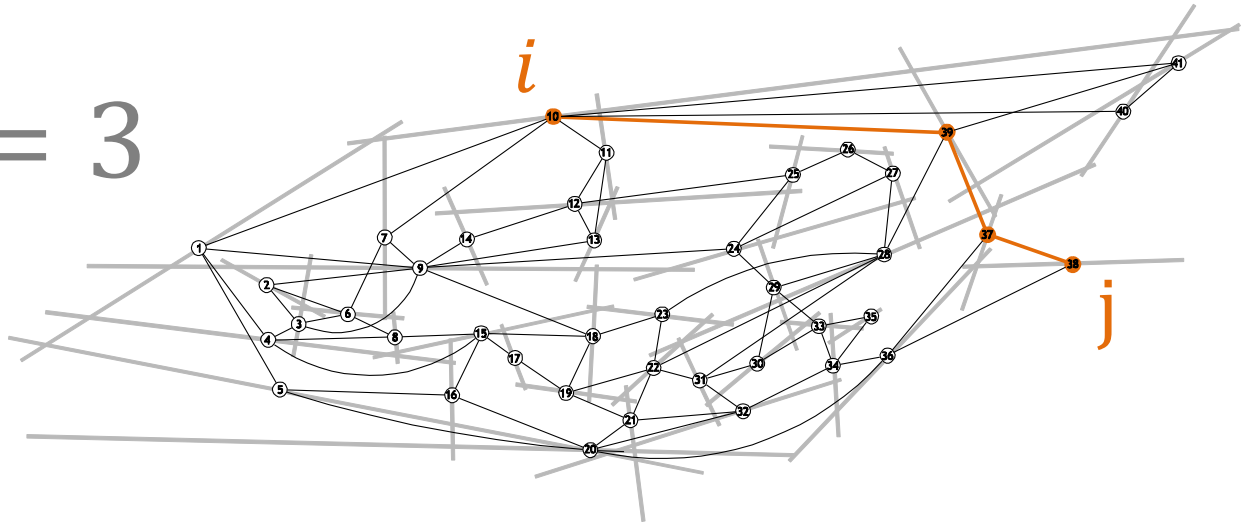
Where there is an unlink, no edge is created, because there is no intersection.

$$d_{ij} = 3$$



Topology of space: graphs and centrality analysis

$$d_{ij} = 3$$



Connectivity
(Degree centrality)

Number of connected nodes

$$CON_i = \sum_{i \sim j} d_{ij}$$

Mean Depth → Integration
(Closeness centrality)

Average distance to all other nodes

$$MD_i = \frac{1}{N-1} \sum d_{ij}$$

Choice
(Betweenness centrality)

Number of times on the shortest path
Between pairs of nodes

$$C_i = \frac{n_{jk}(i)}{n_{jk}}$$

Topology of space: graphs and centrality analysis

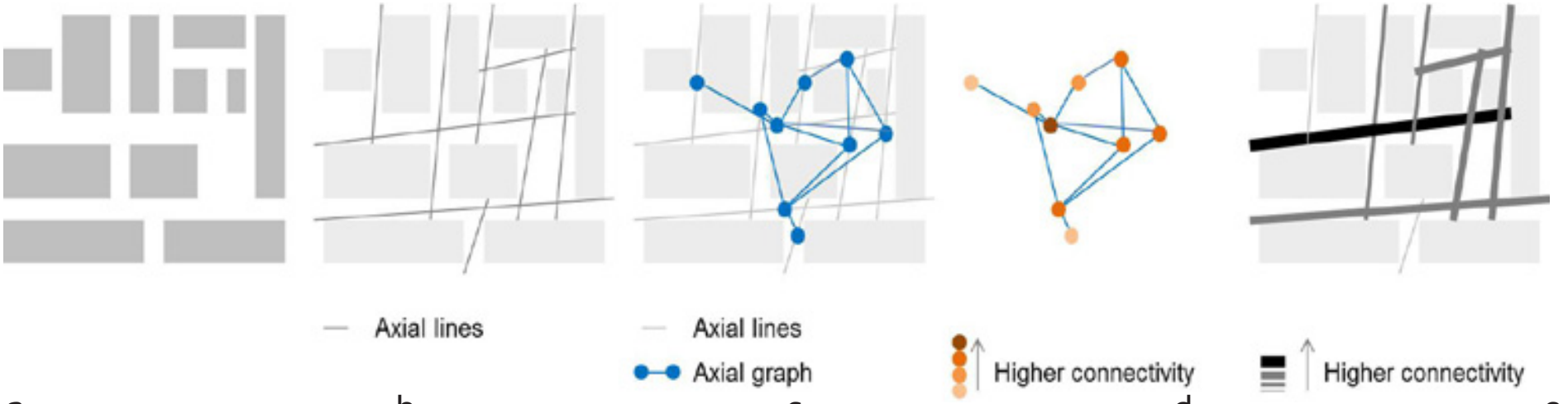


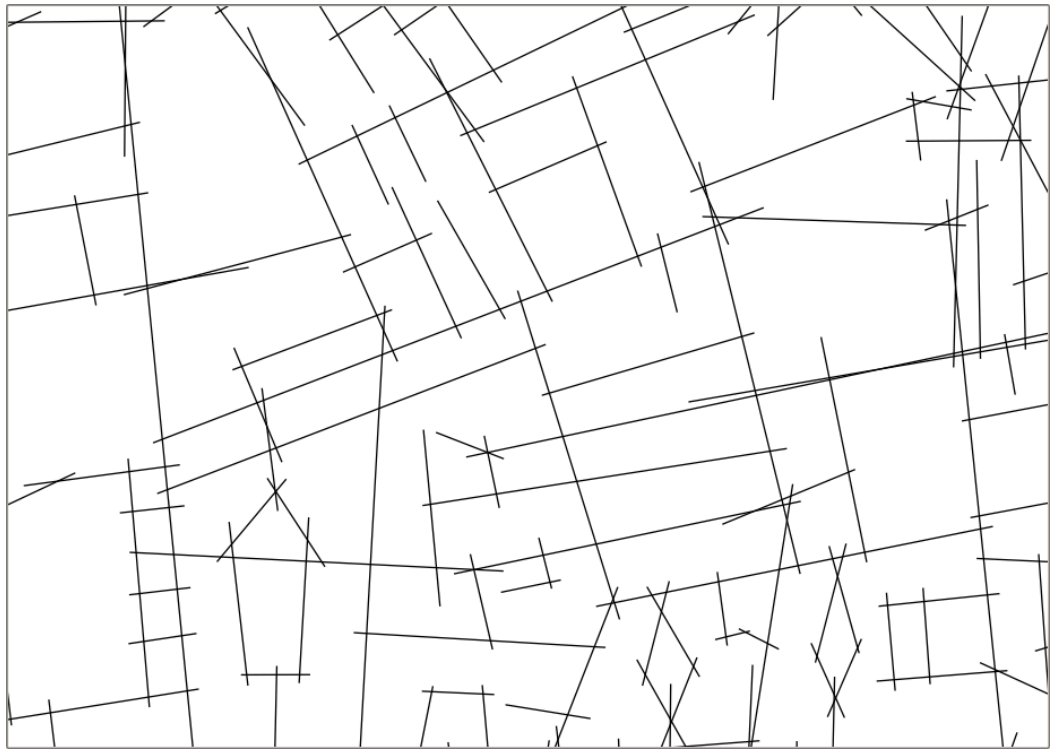
Figure 2.2 The axial representation of Space Syntax. An urban space represented by the fewest and longest axial lines (b), axial lines are represented by a graph (c), the graph Connectivity is by highlighted in (d & e).

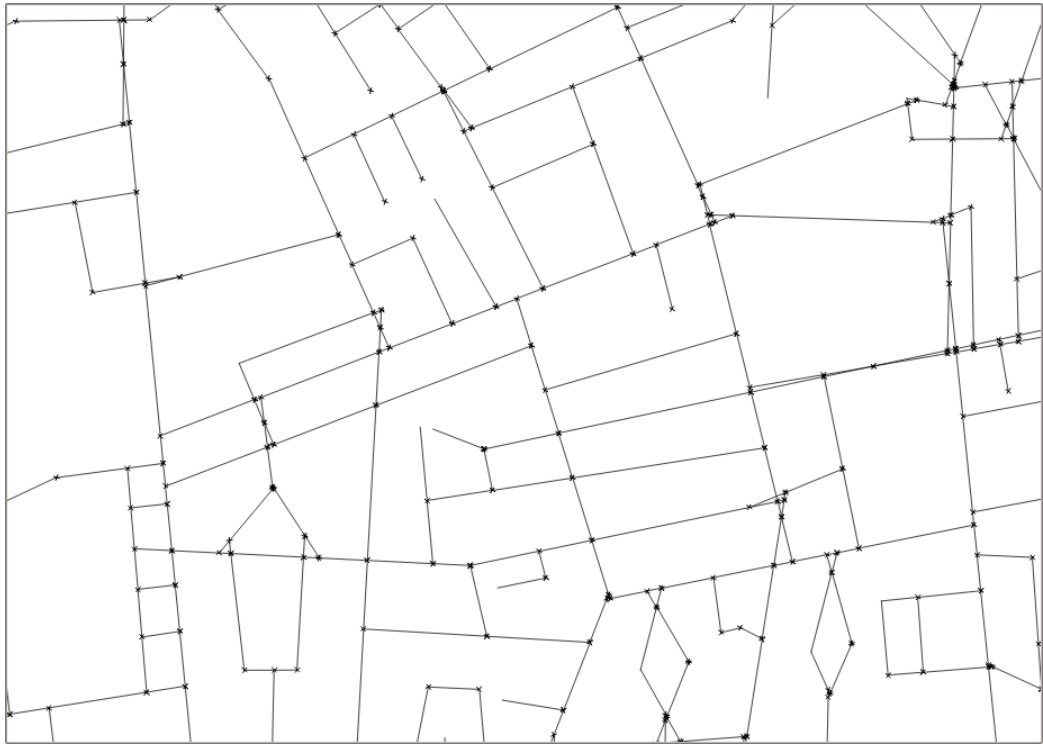
Source: Al-Sayed, K., Turner, A., Hillier, B., Iida, S., Penn, A., 2015. Space Syntax methodology. Bartlett School of Architecture, UCL, London.

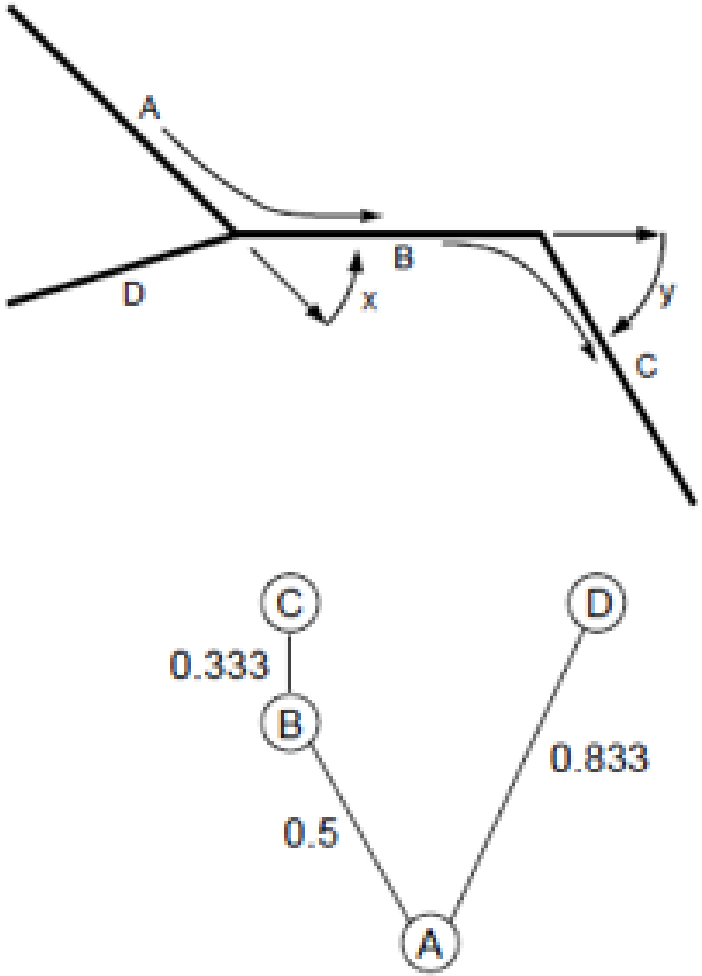
Segment maps and angular analysis

The segment map is the result of a transformation of the axial map, where the lines are broken at every intersection:

- to obtain a more fin-grained result along axial lines;







Segment maps and angular analysis

The segment map is the result of a transformation of the axial map, where the lines are broken at every intersection:

- to obtain a more fin-grained result along axial lines;
- to allow the measurement of the different angles of intersection along a route.

[18] Diagram source: Turner, A. (2005) Could A Road-centre Line Be An Axial Line In Disguise?

Radius and distances

The graph analysis can be carried out for distances to all nodes in the graph, or just to nodes within a certain distance. This cut-off point is called the RADIUS of analysis.

To all nodes the radius is called 'Radius N'

The distance used to calculate the shortest paths or determine the radius can vary, depending on the model being analysed:

Axial analysis: distance is always *Topological*, for paths and radius.

e.g. Axial Integration R3, or Axial Choice RN

Segment analysis: distance can be topological, metric or angular. BUT the standard in space syntax research is, *Angular* path distance, with *Metric* radius distance.

e.g. Segment Angular Choice R800m

The SST Project

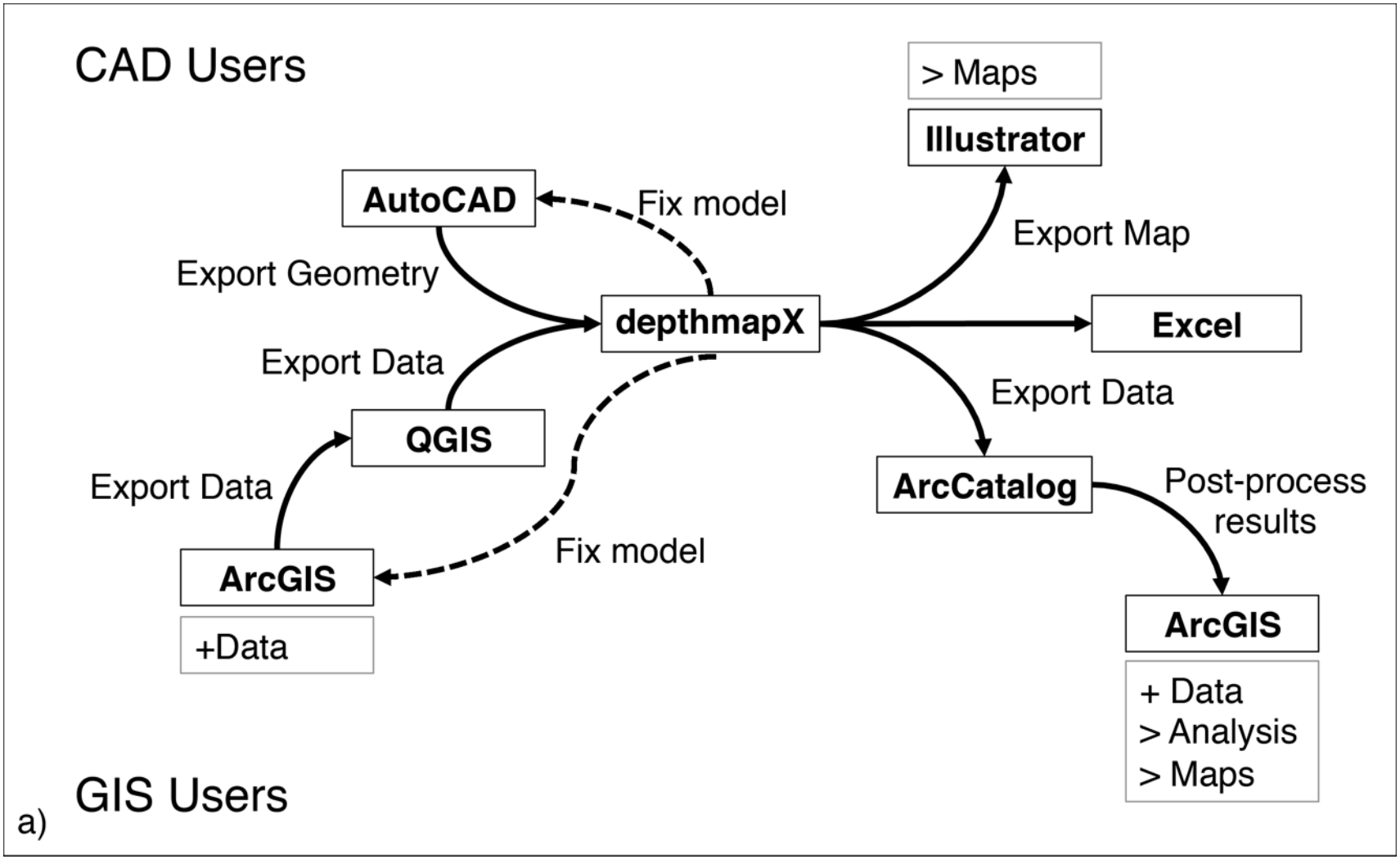
Overview of the project

- An open source project for space syntax education, research and practice
- Initiated by the Space Syntax Laboratory, UCL
- For the space syntax community
- *WITH* contributions from the space syntax community

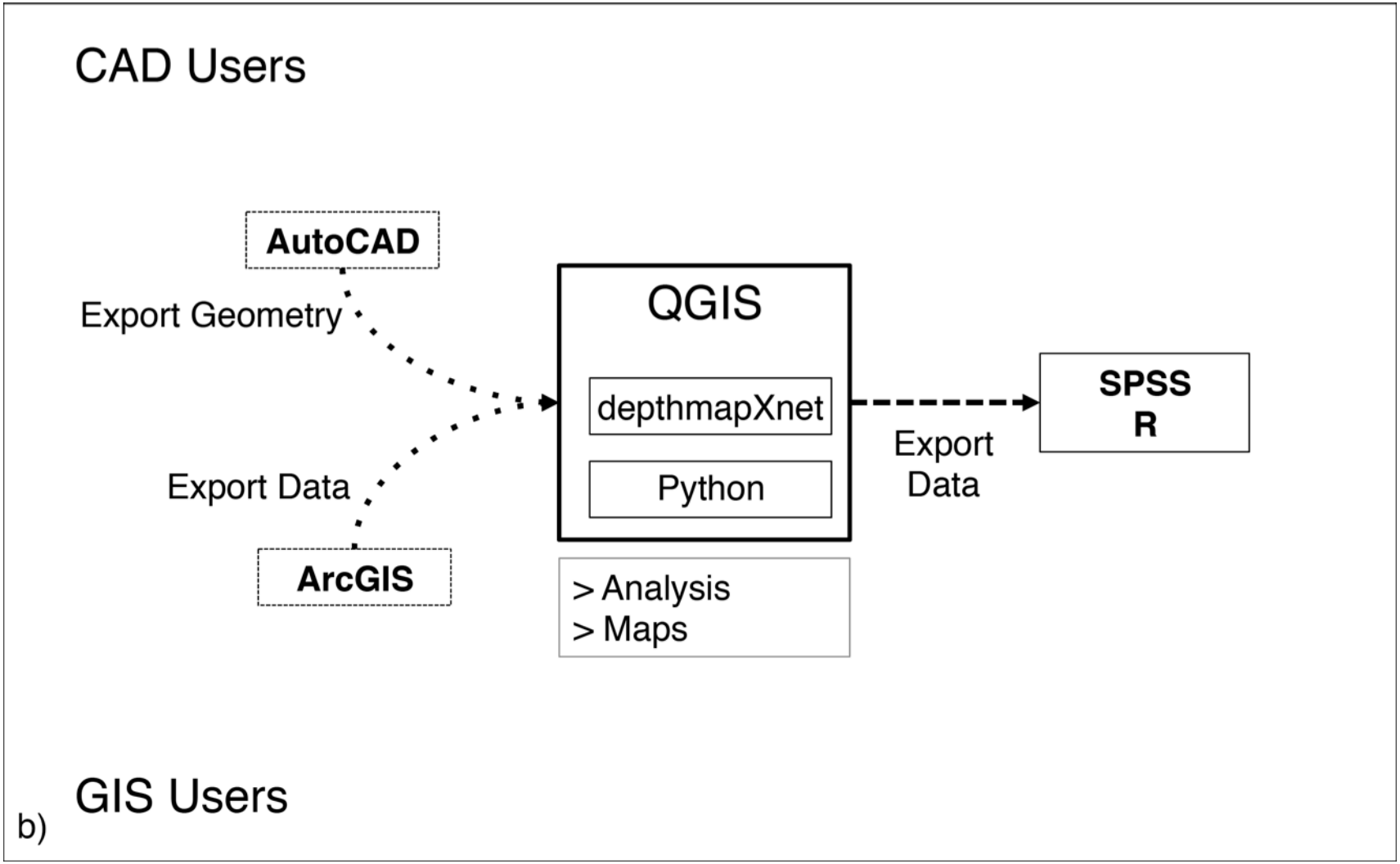
Aims of the project

- *Integrate* space syntax spatial analysis (depthmapX) with QGIS
- *User friendly* for students: clear and linear workflows
- *Flexible* for researchers: analytic options and exploratory depth
- *Operational* for practice: robust, fast and optimised workflows

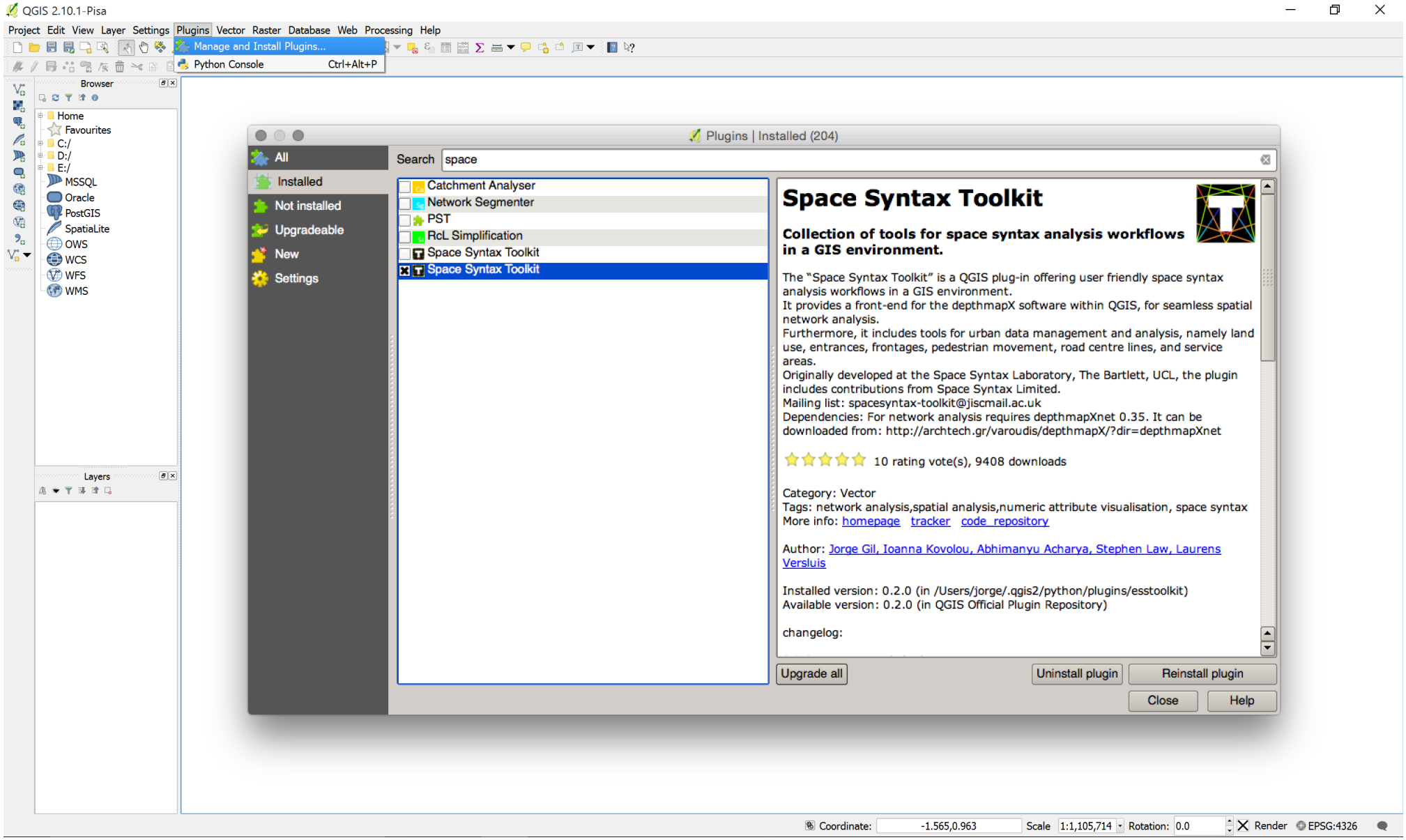
The SST Project



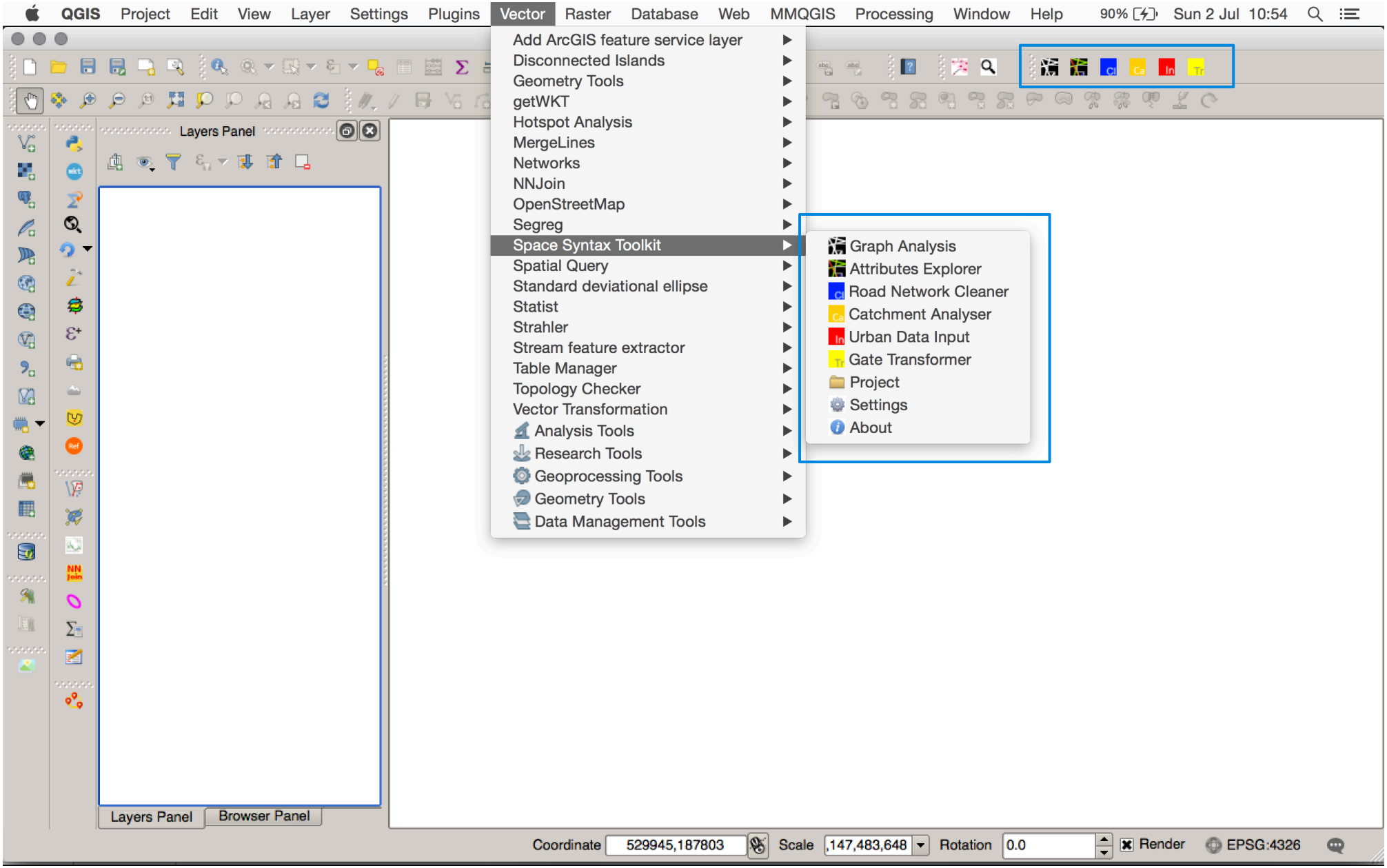
The SST Project



SST Installation

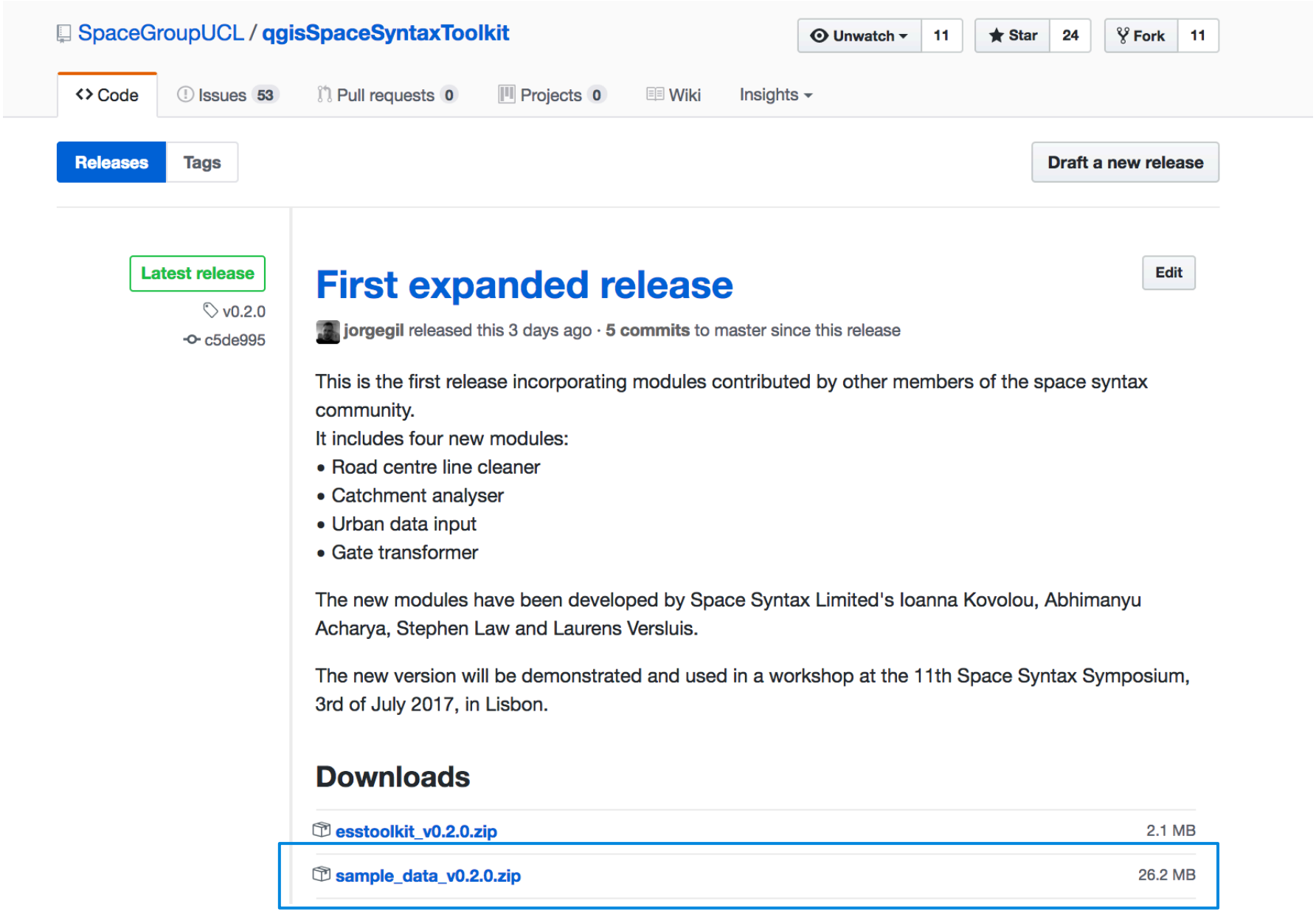


SST Installation

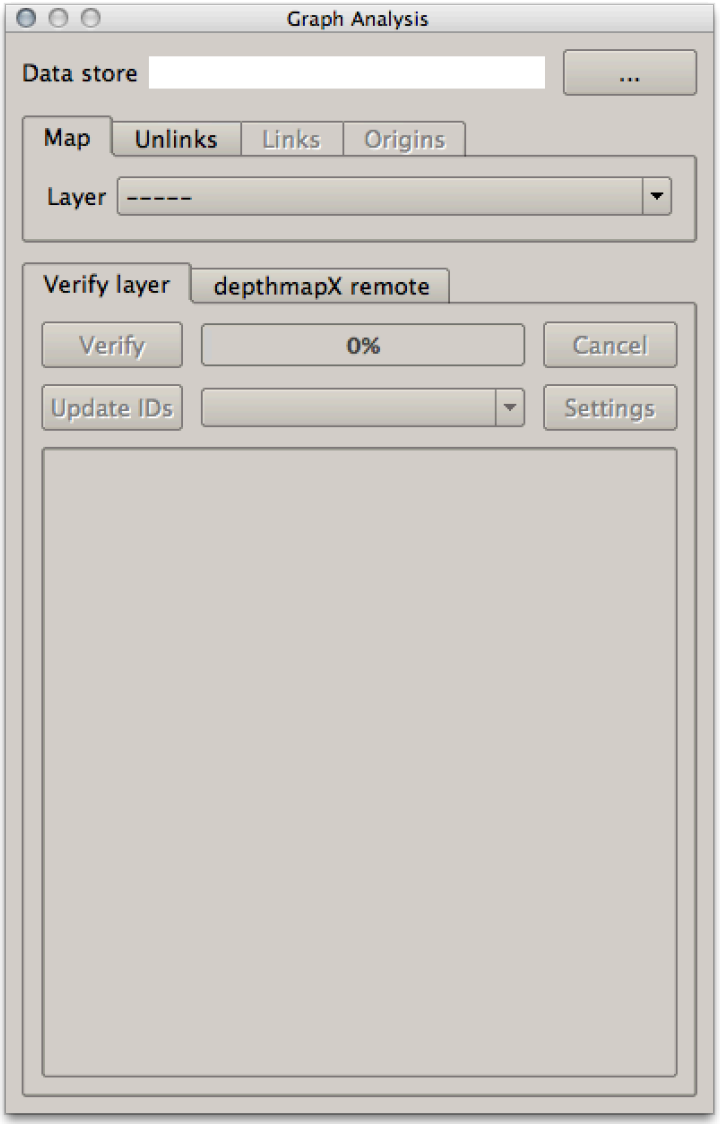


SST sample data

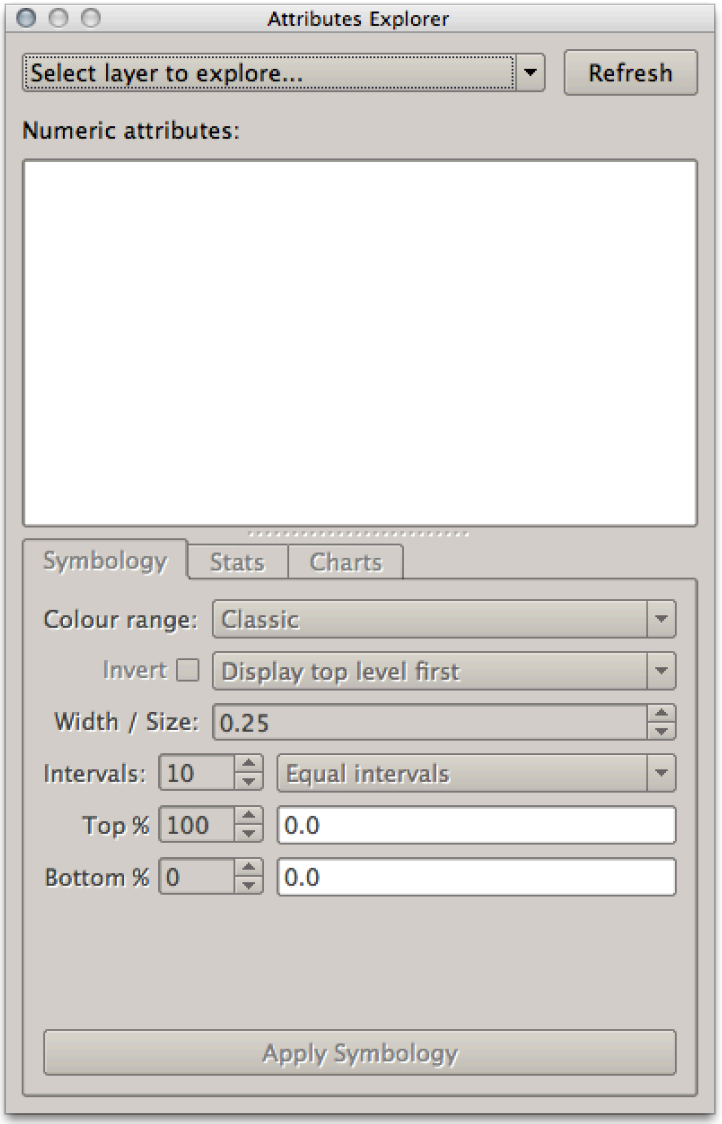
https://github.com/SpaceGroupUCL/qgisSpaceSyntaxToolkit/releases



Original tools: SST version 0.1.x

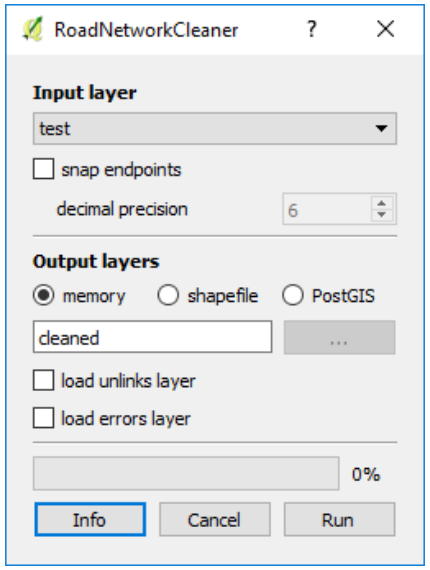


Graph Analysis

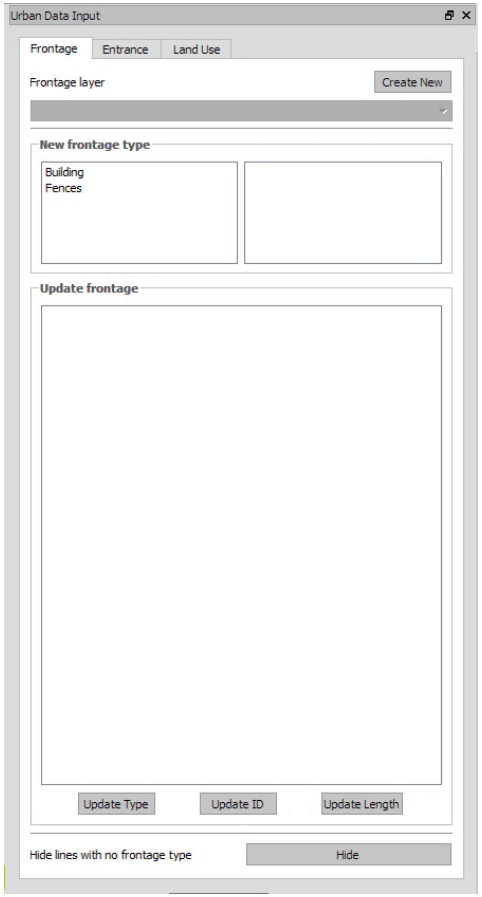


Attribute Explorer

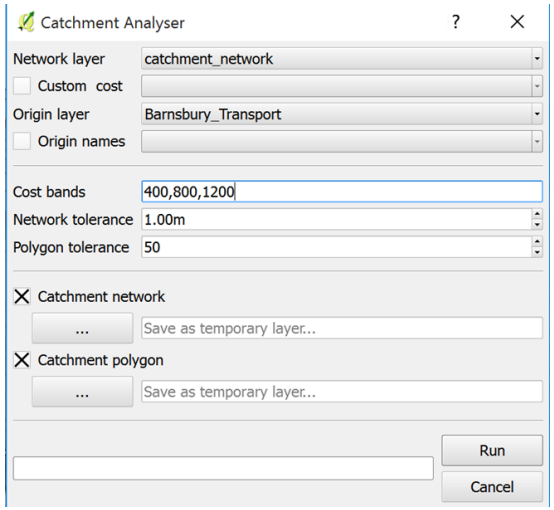
New Set of tools: SST version 0.2.0



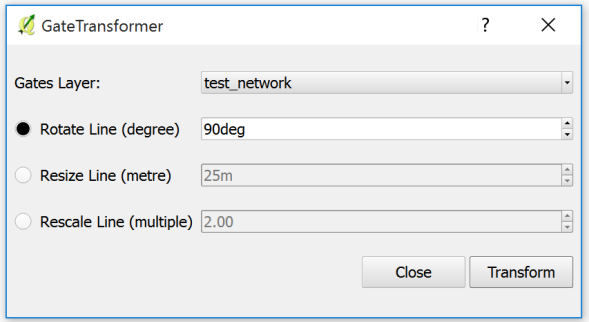
Road network cleaner



Urban Data Input Tool

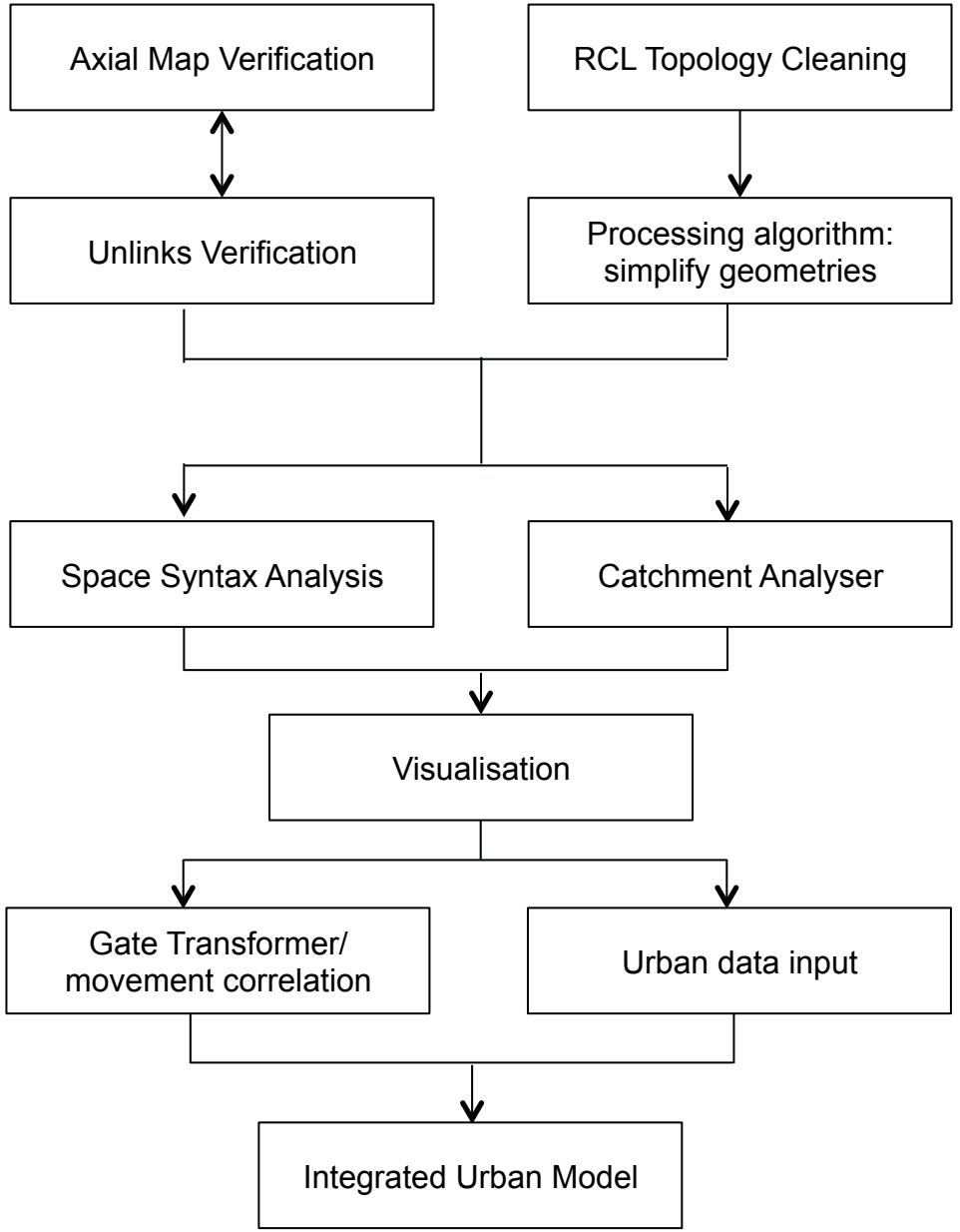


Catchment Analyser



Gate Transformer

Demo Workflow



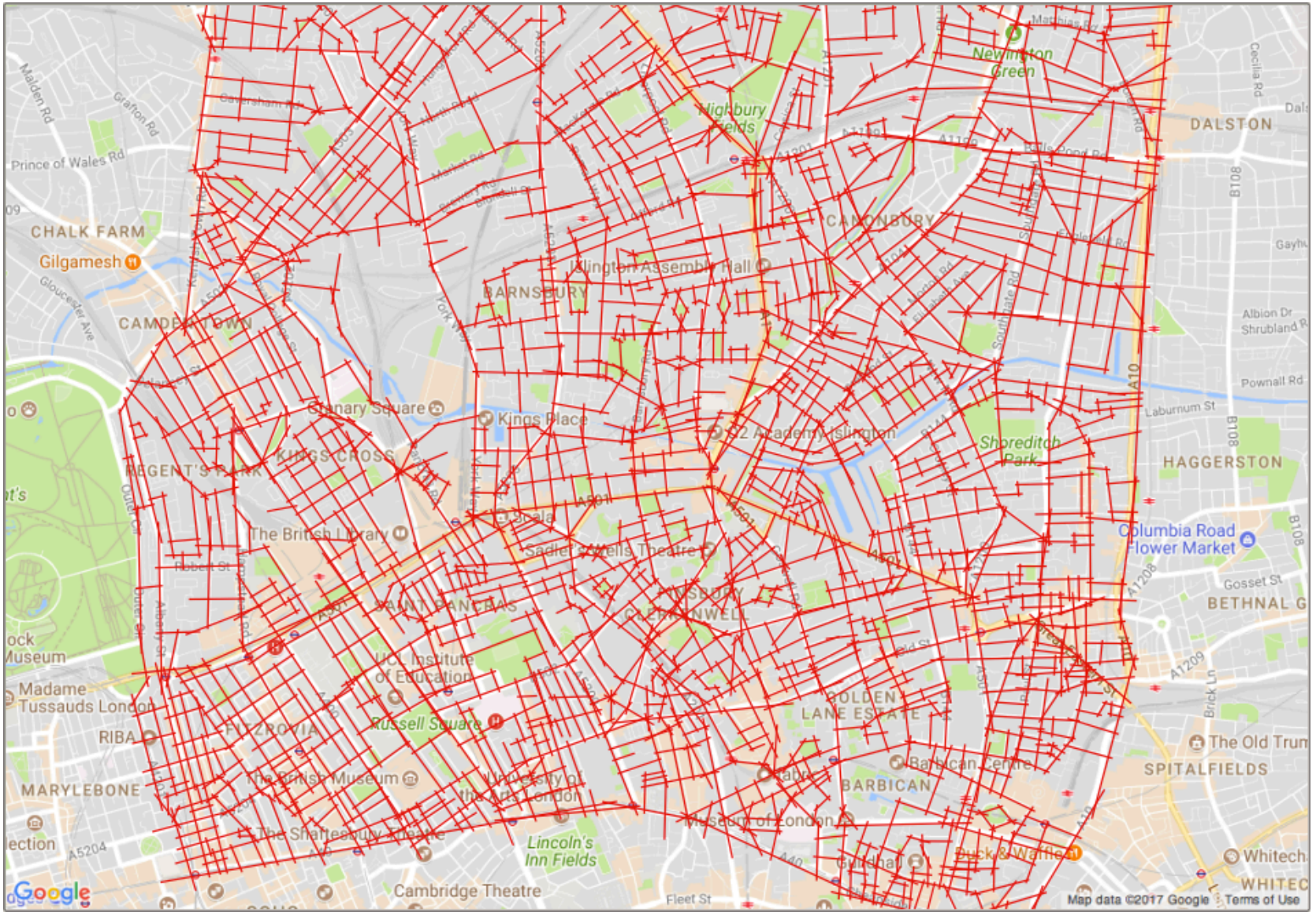
Task 1

Preparing and analysing axial models

- Model preparation: making axial and unlinks maps
- Model verification: verifying the axial and unlinks maps
- Model analysis: Axial and segment analysis of the axial model
- Visualising the results

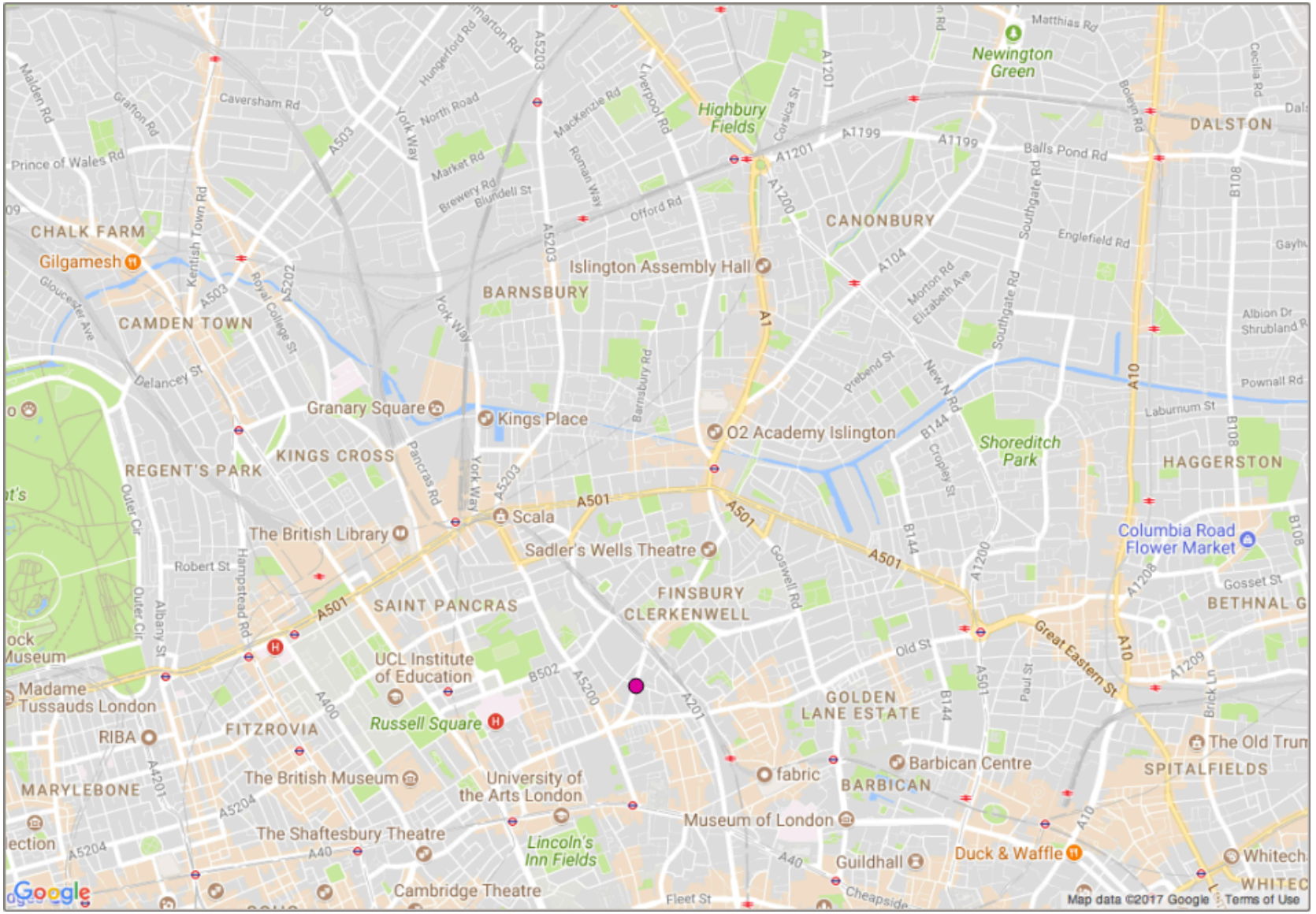
Model preparation: making axial and unlinks maps

Drawing an axial map (use a projected CRS!)



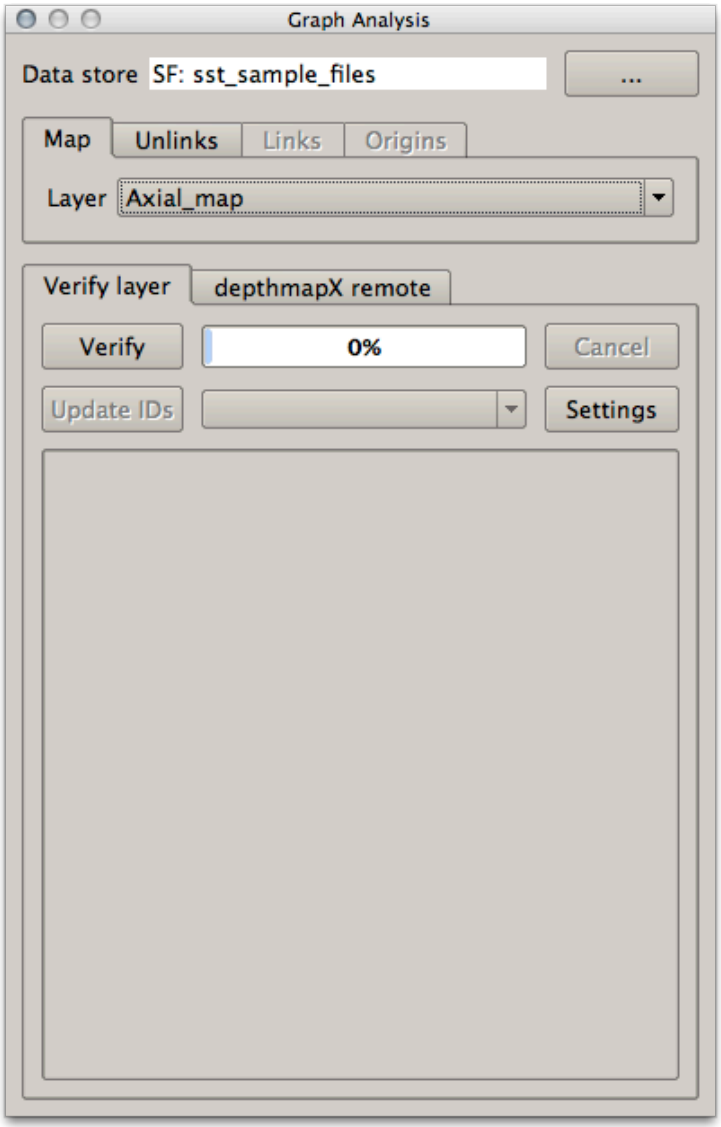
Model preparation: making axial and unlinks maps

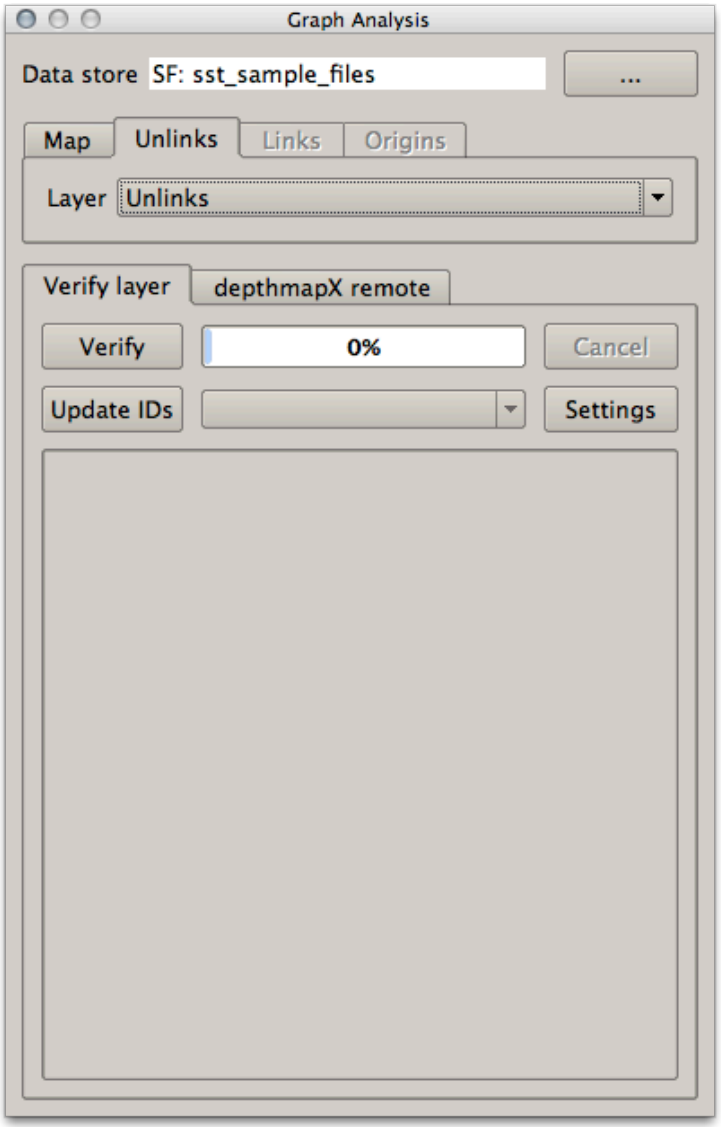
Drawing an unlinks map



Model verification: verifying the axial and unlinks maps

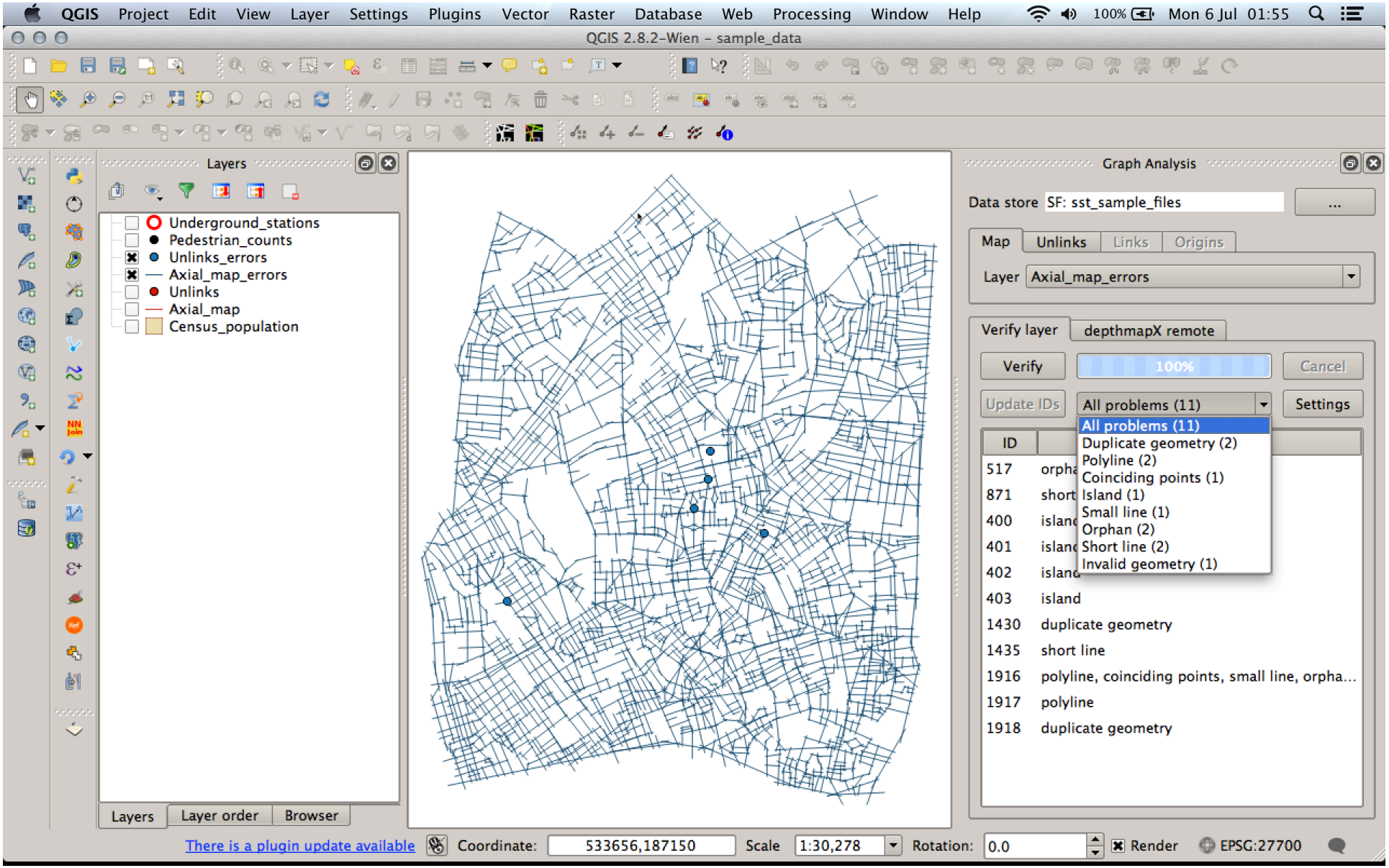
Load map layers in Graph Analysis Tool





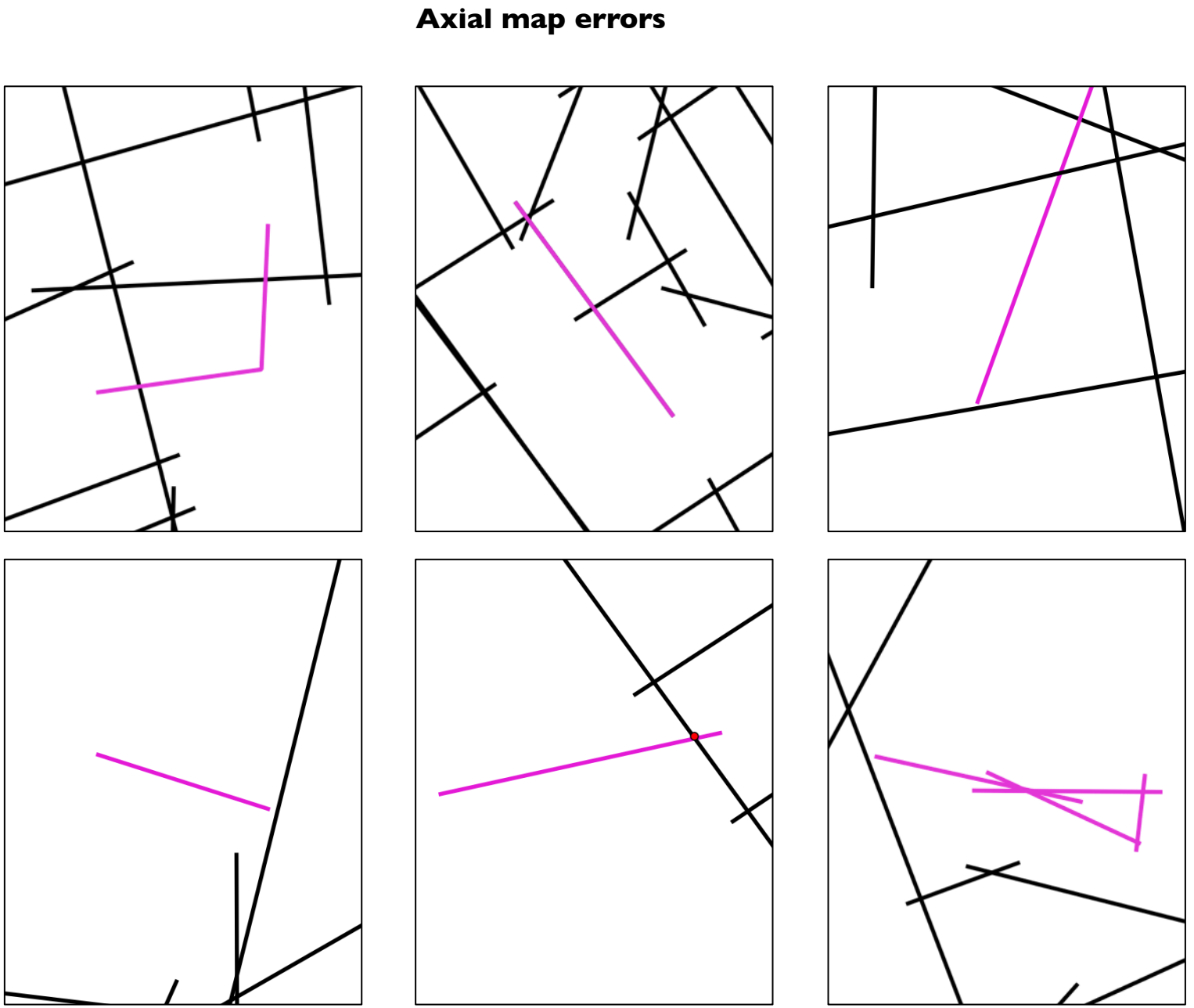
Model verification: verifying the axial and unlinks maps

Verification is done on the two layers combined



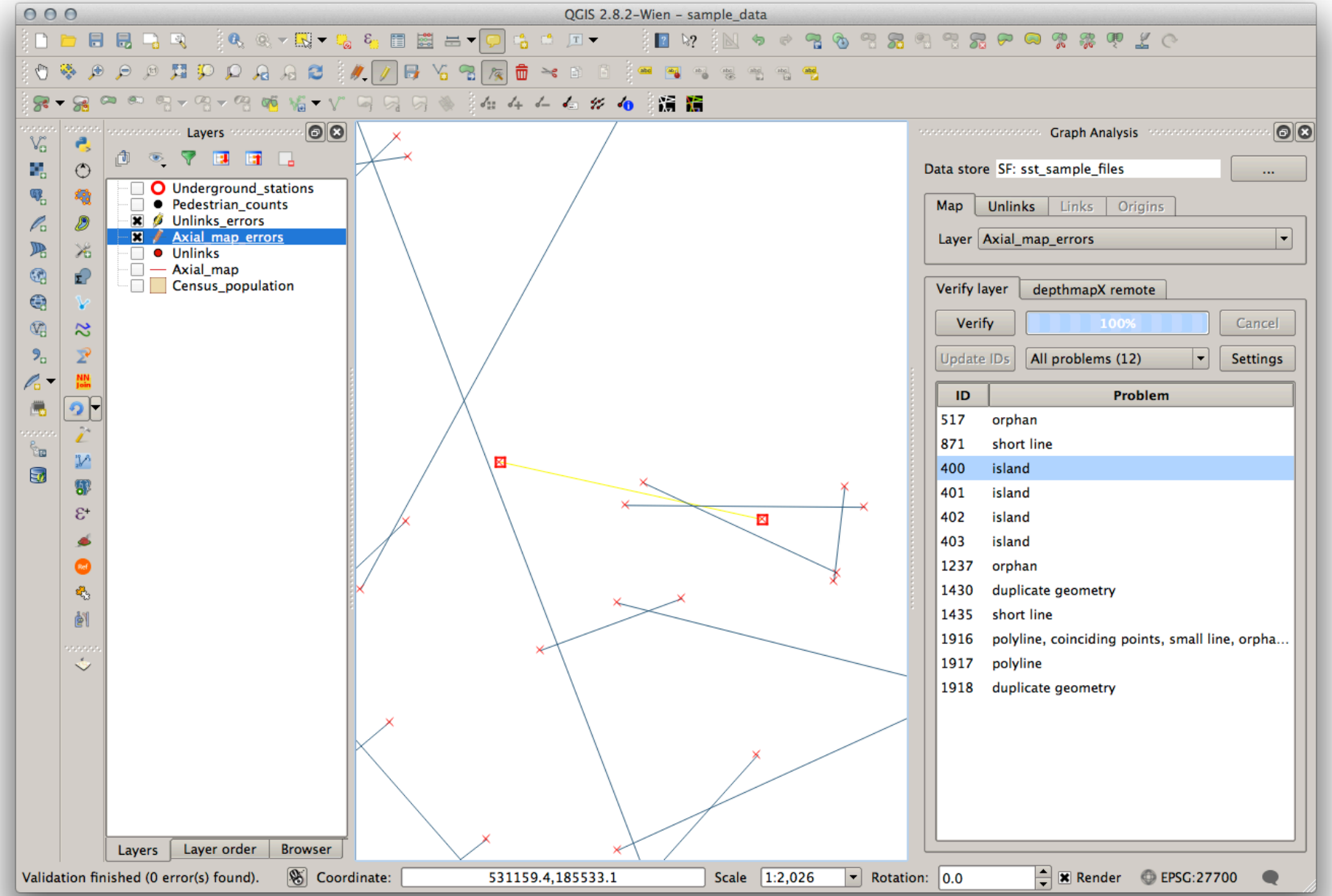
Model verification: verifying the axial and unlinks maps

- Polyline
- Duplicate
- Short
- Orphan
- Unlinked orphan
- Island
- Small
- Coinciding points



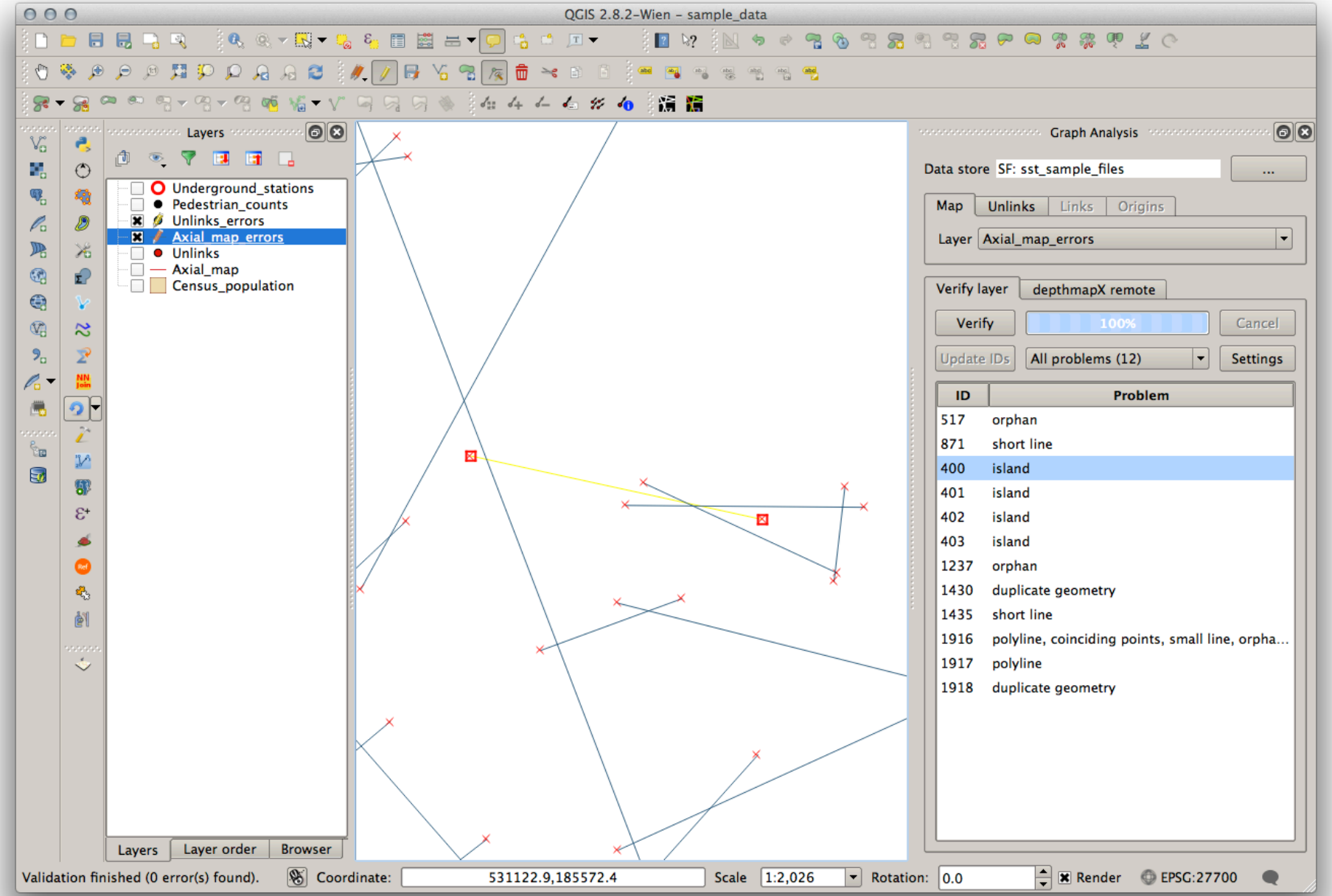
Model verification: verifying the axial and unlinks maps

Correcting the axial map



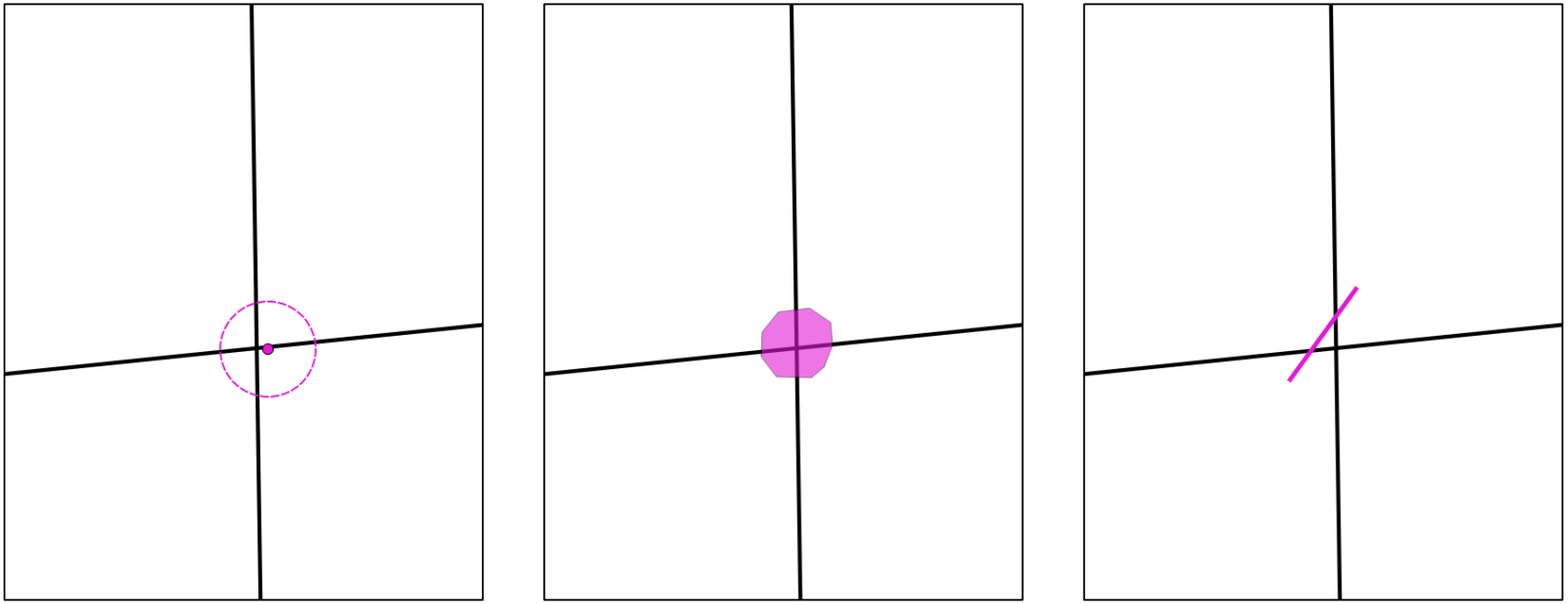
Model verification: verifying the axial and unlinks maps

Correcting the axial map



Model verification: verifying the axial and unlinks maps

Representing unlinks



Model verification: verifying the axial and unlinks maps

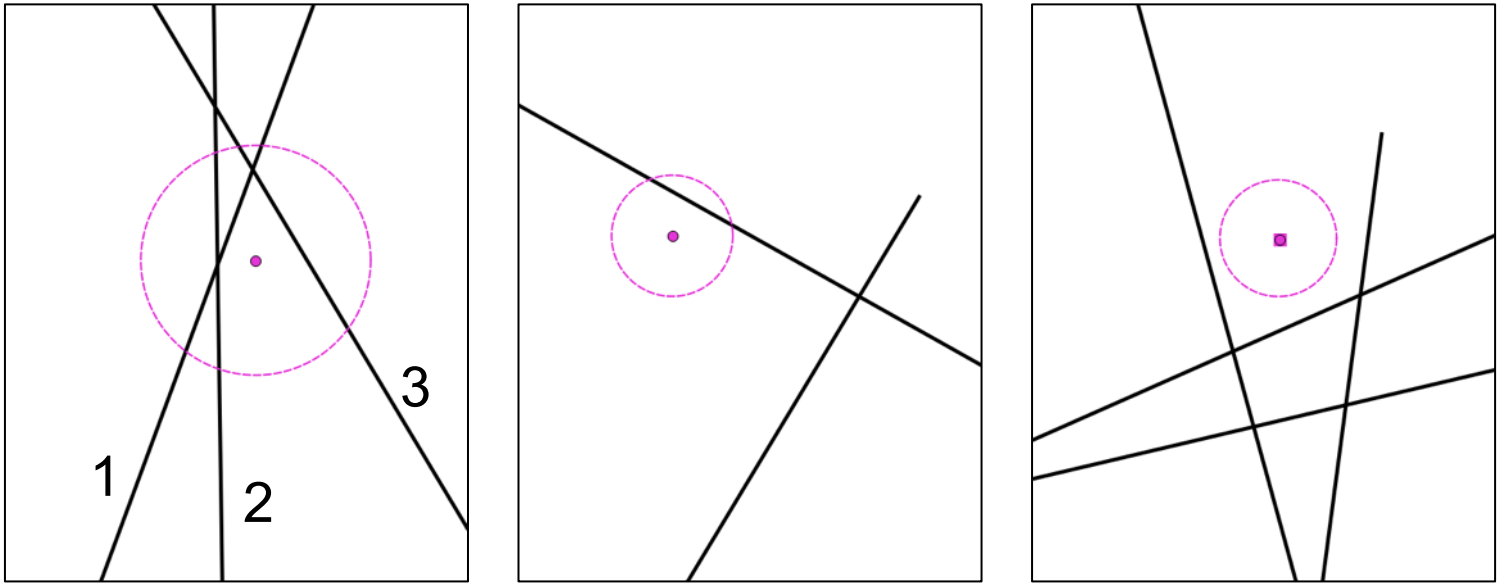
Unlink errors

Feature errors:

- More than 2 lines
- Single line
- No lines

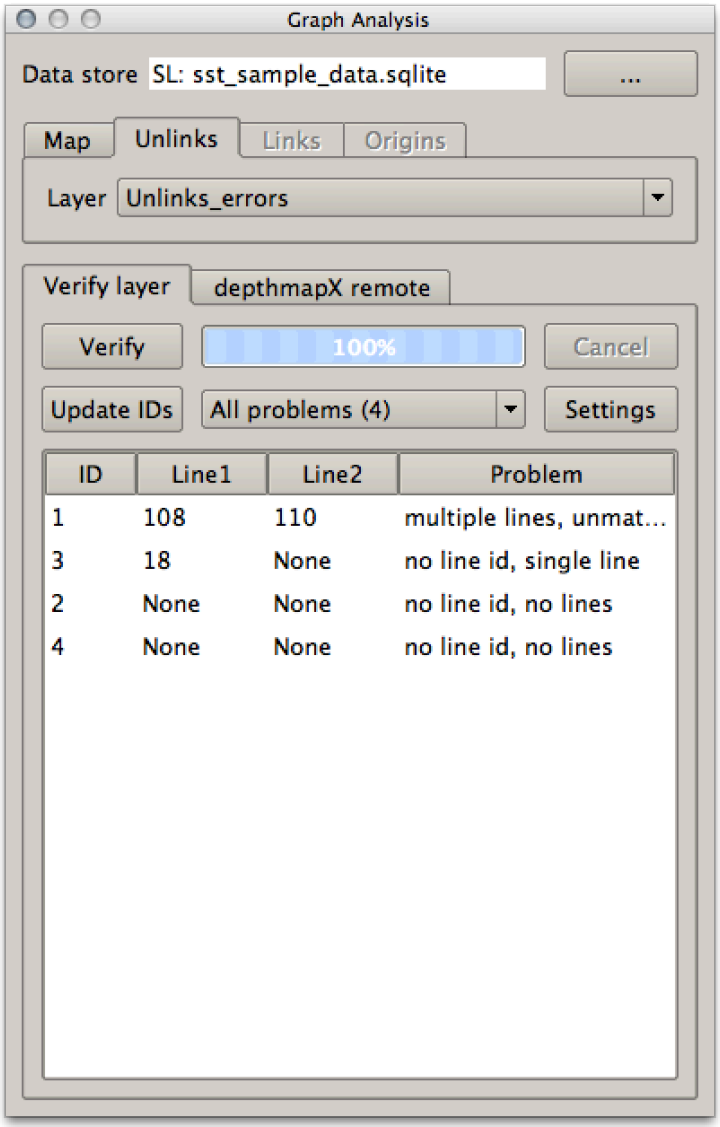
Attribute error:

- No line id
- Same line id
- Unmatched line id

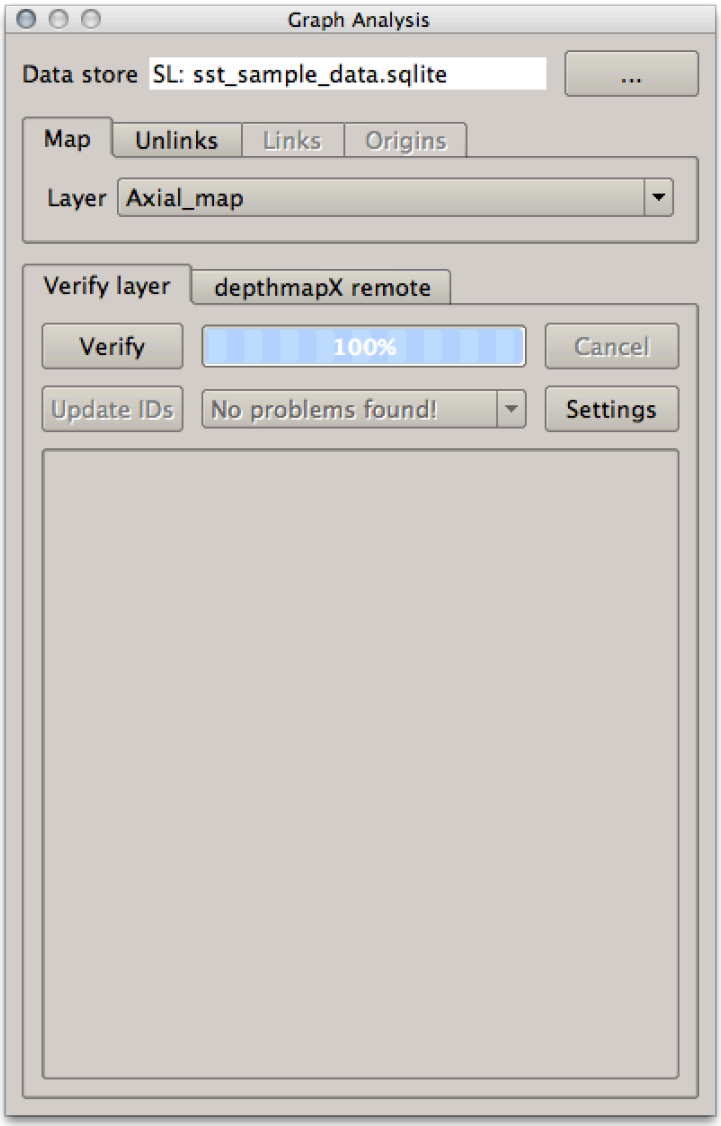


Model verification: verifying the axial and unlinks maps

Correcting the unlinks map



Model verification: verifying the axial and unlinks maps



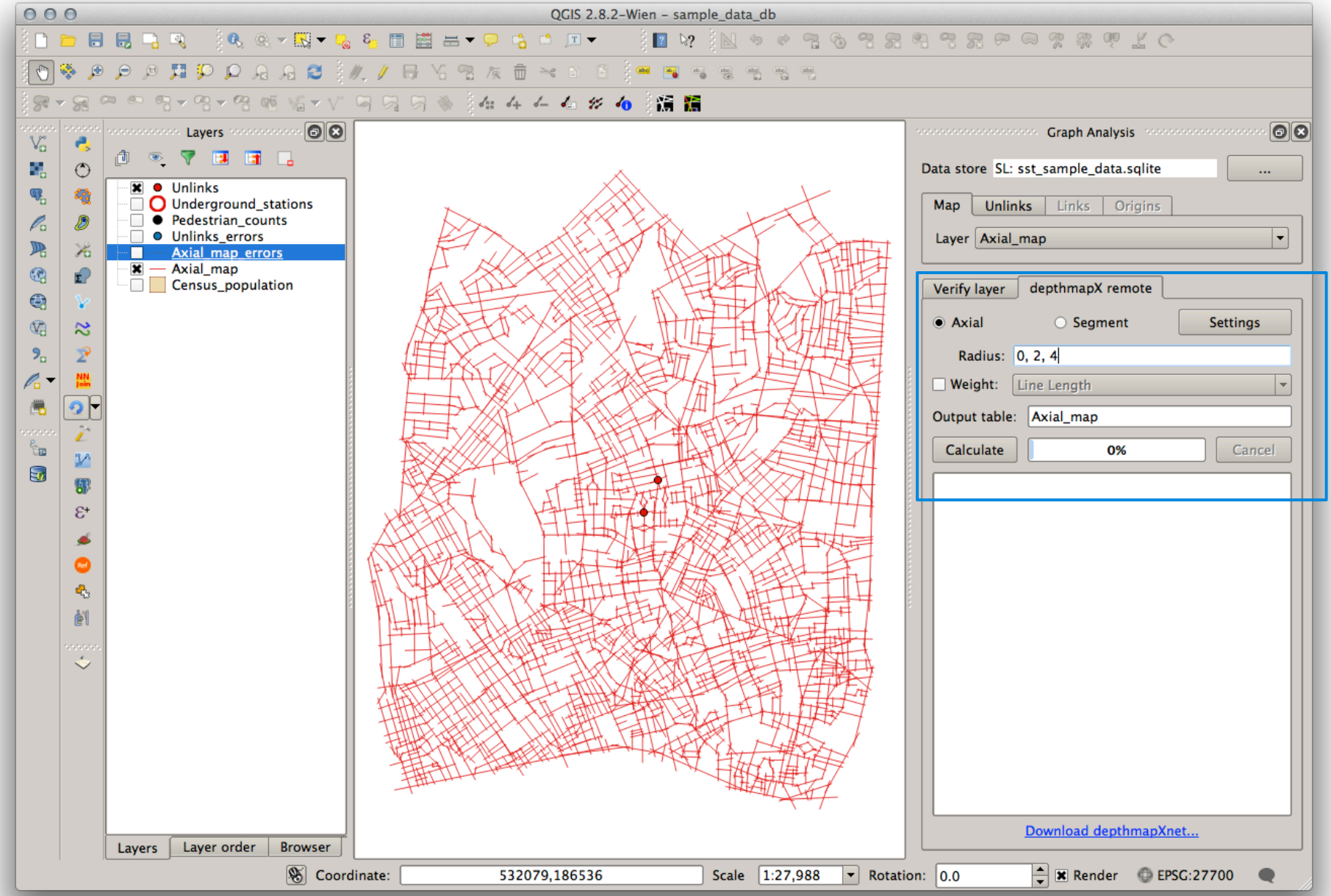
Axial model verification workflow

It's an *iterative* process that stops when the verification of axial map and unlinks returns no errors.

1. Verify and fix axial lines
2. Update unlinks ids
3. Verify and fix unlinks
4. Verify and fix axial lines
5. Verify and fix unlinks
6. Update unlink ids
7. Verify and fix axial lines
8. …

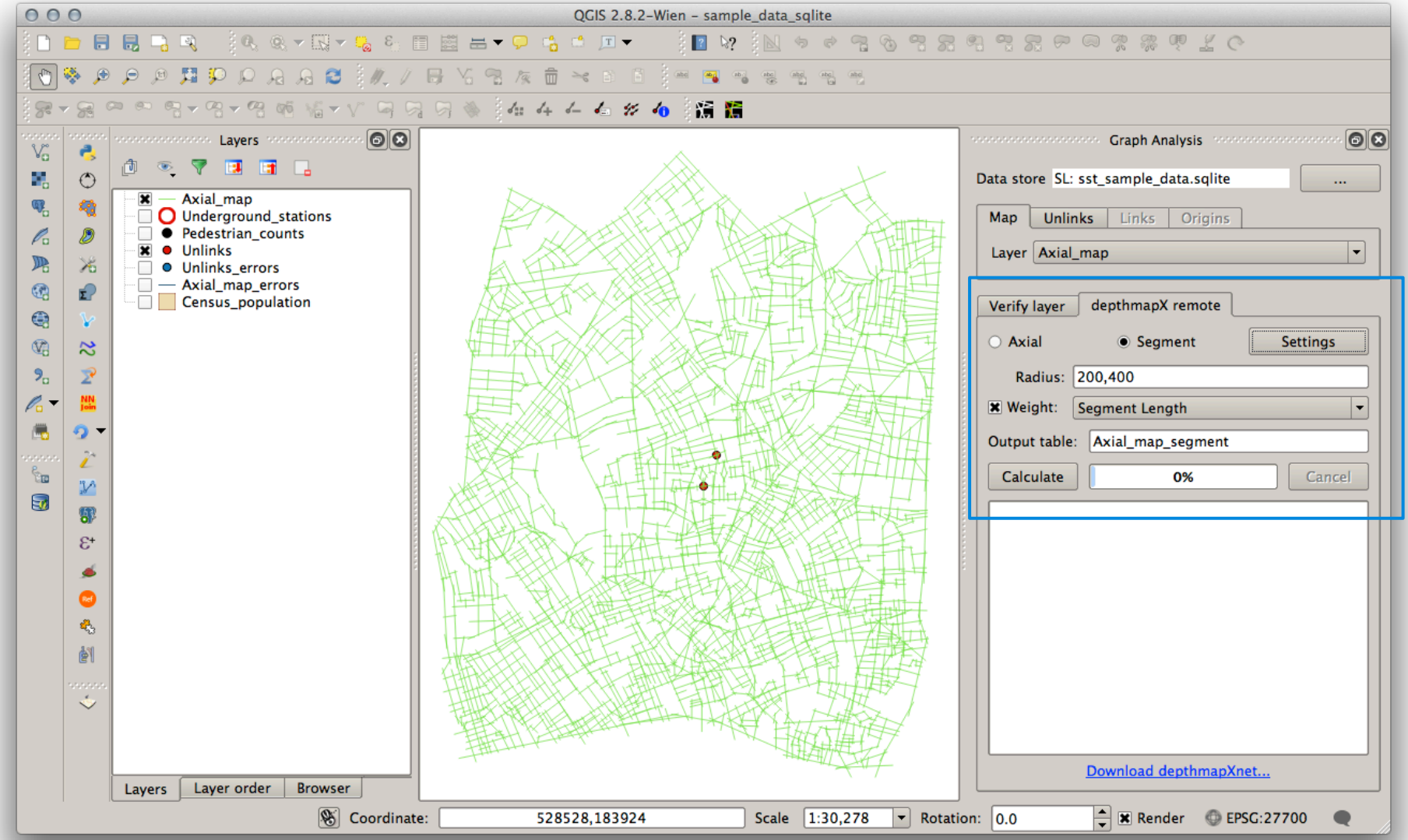
Model analysis: Axial analysis of the axial model

DepthmapX remote axial analysis settings

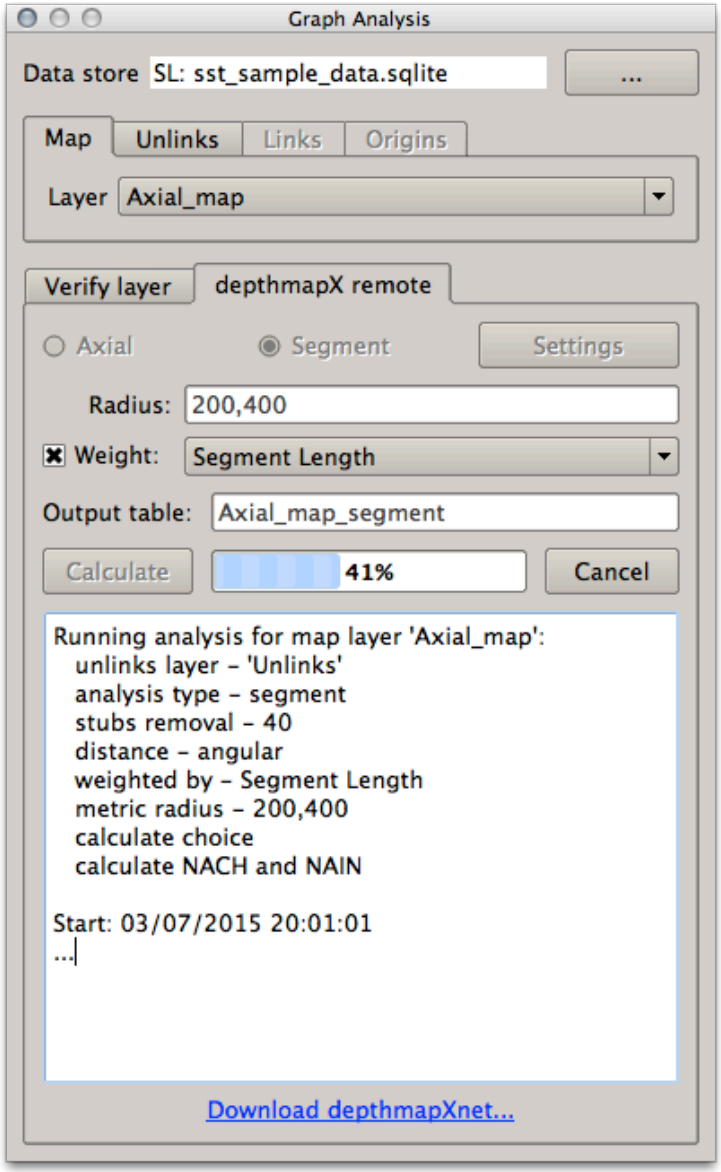


Model analysis: Segment analysis of the axial model

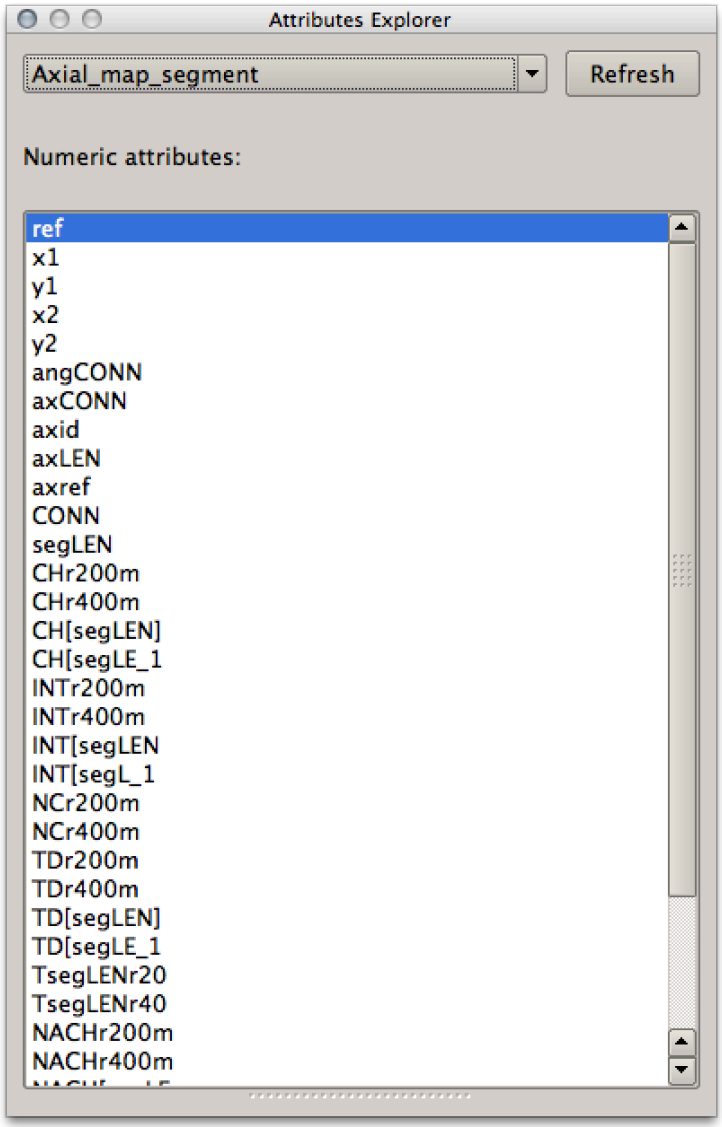
DepthmapX remote segment analysis settings



Model analysis

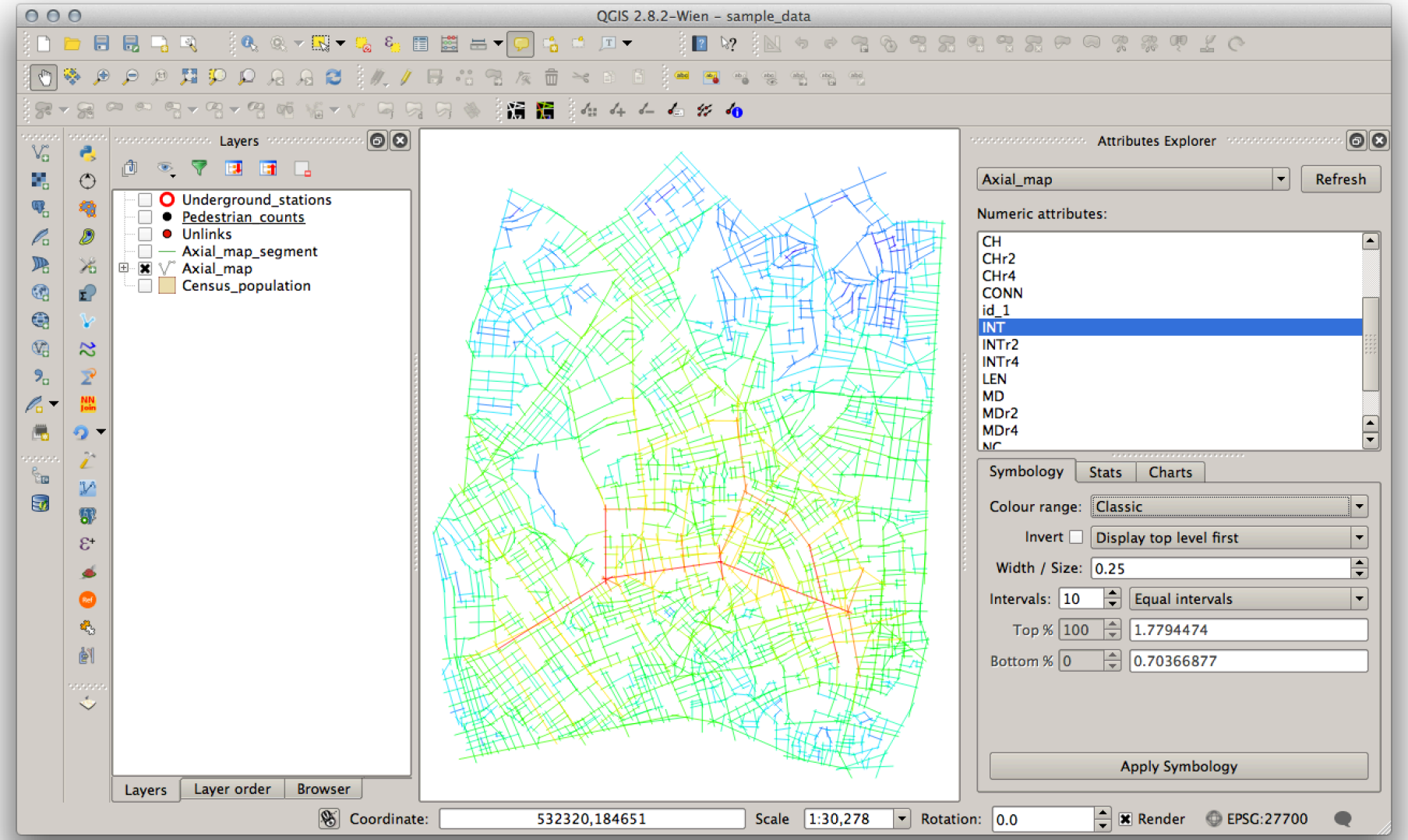


Results report and postprocessing the results



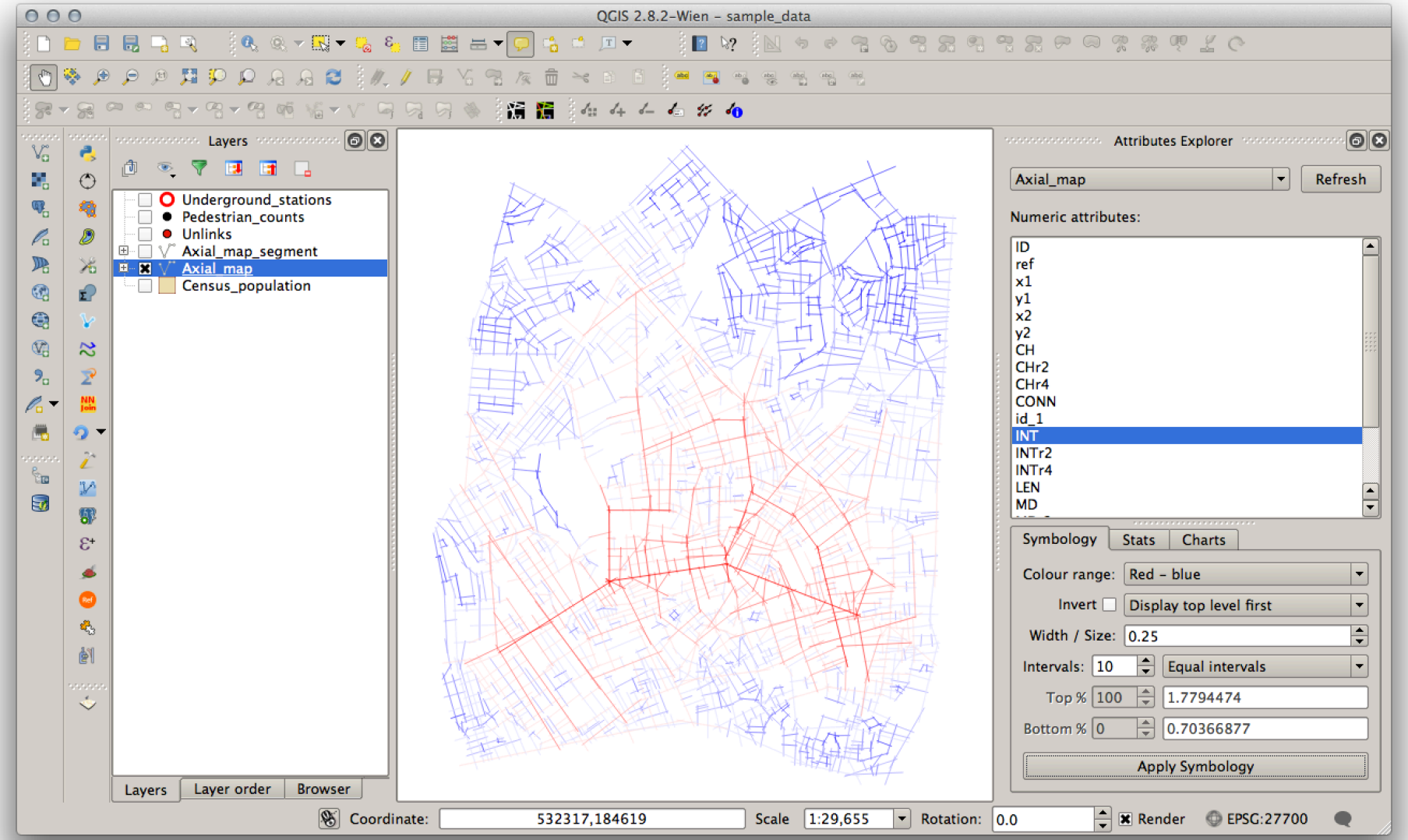
Visualising the results

Loading analysis results in Attributes Explorer Tool



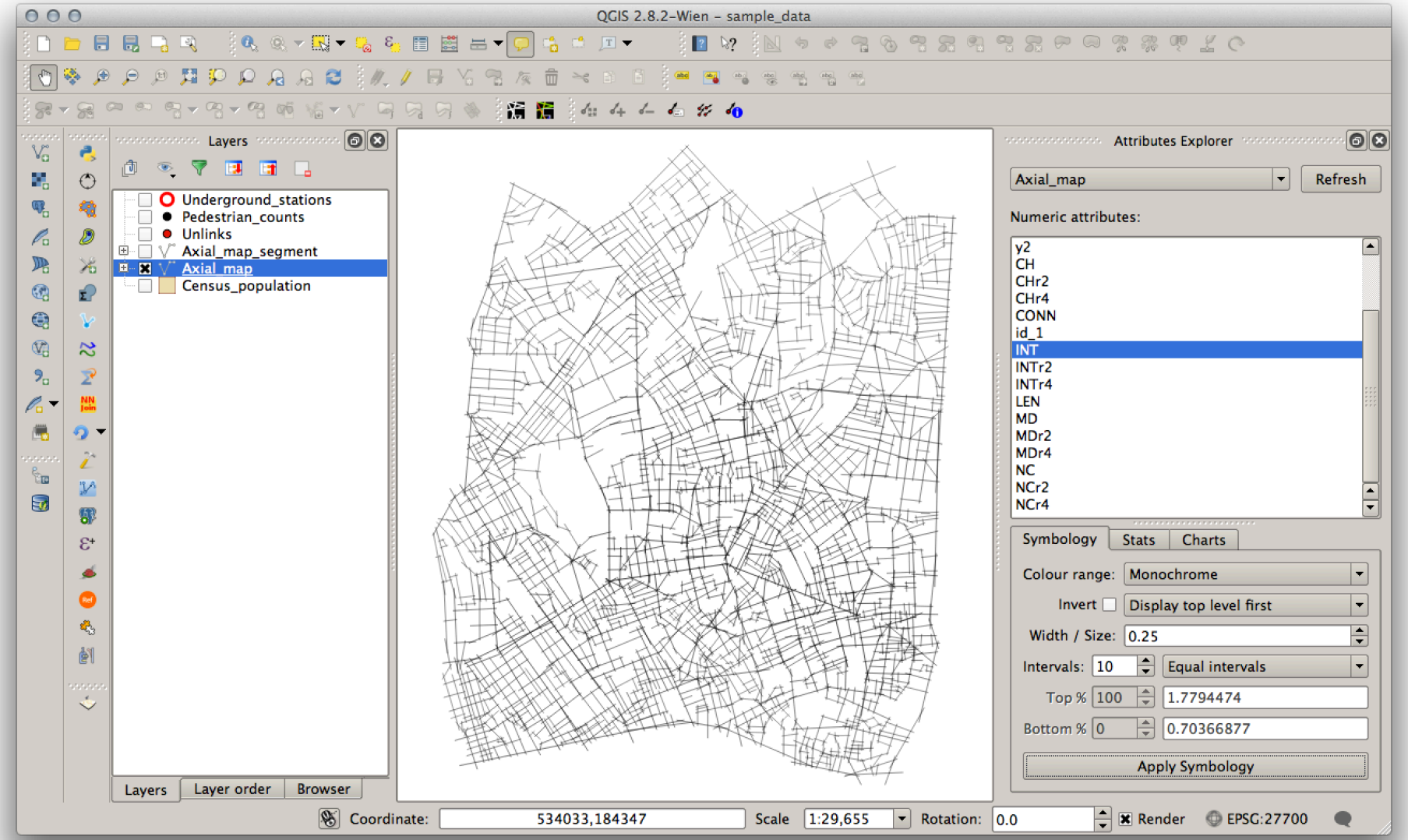
Visualising the results

Changing symbology: colour range



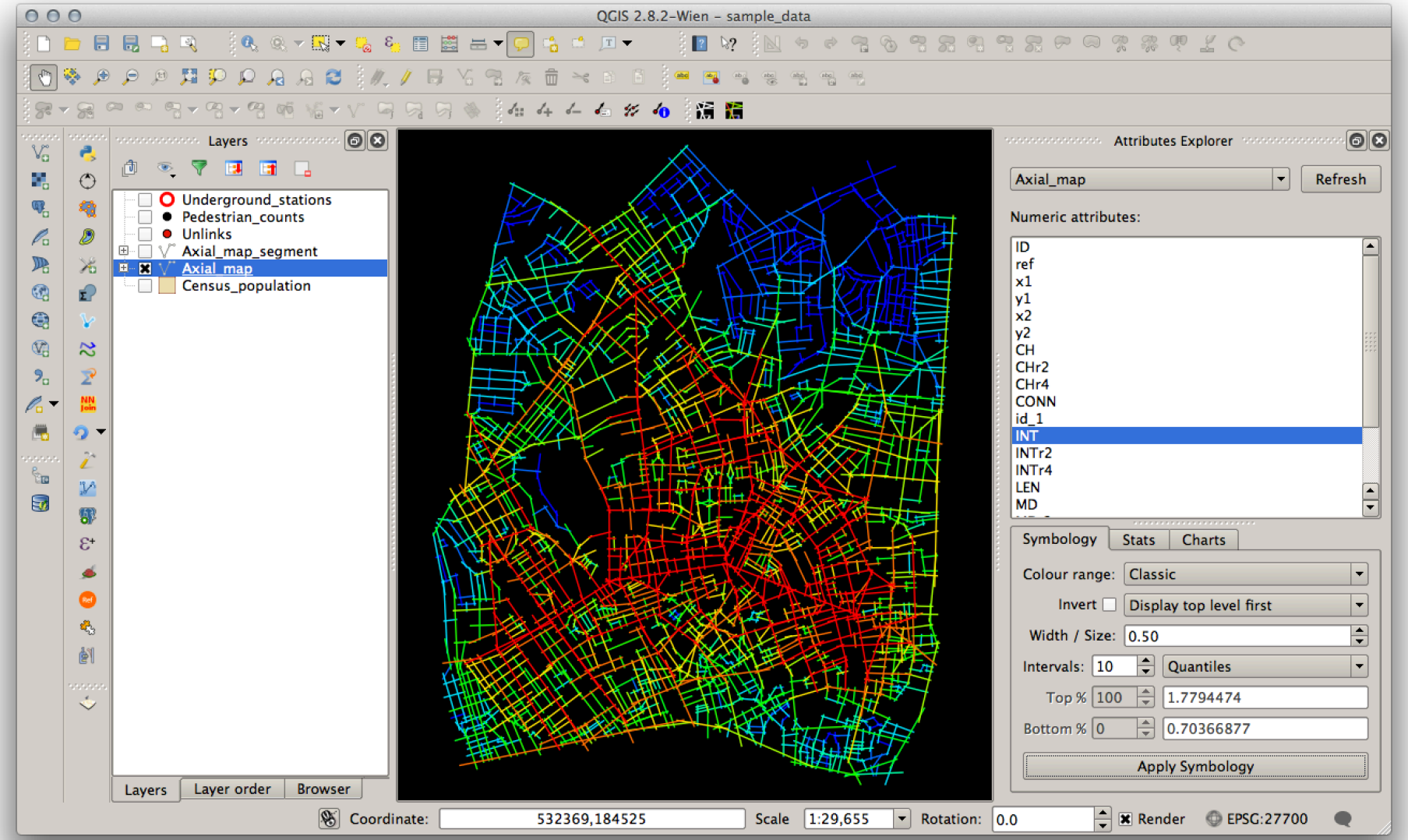
Visualising the results

Changing symbology: colour range



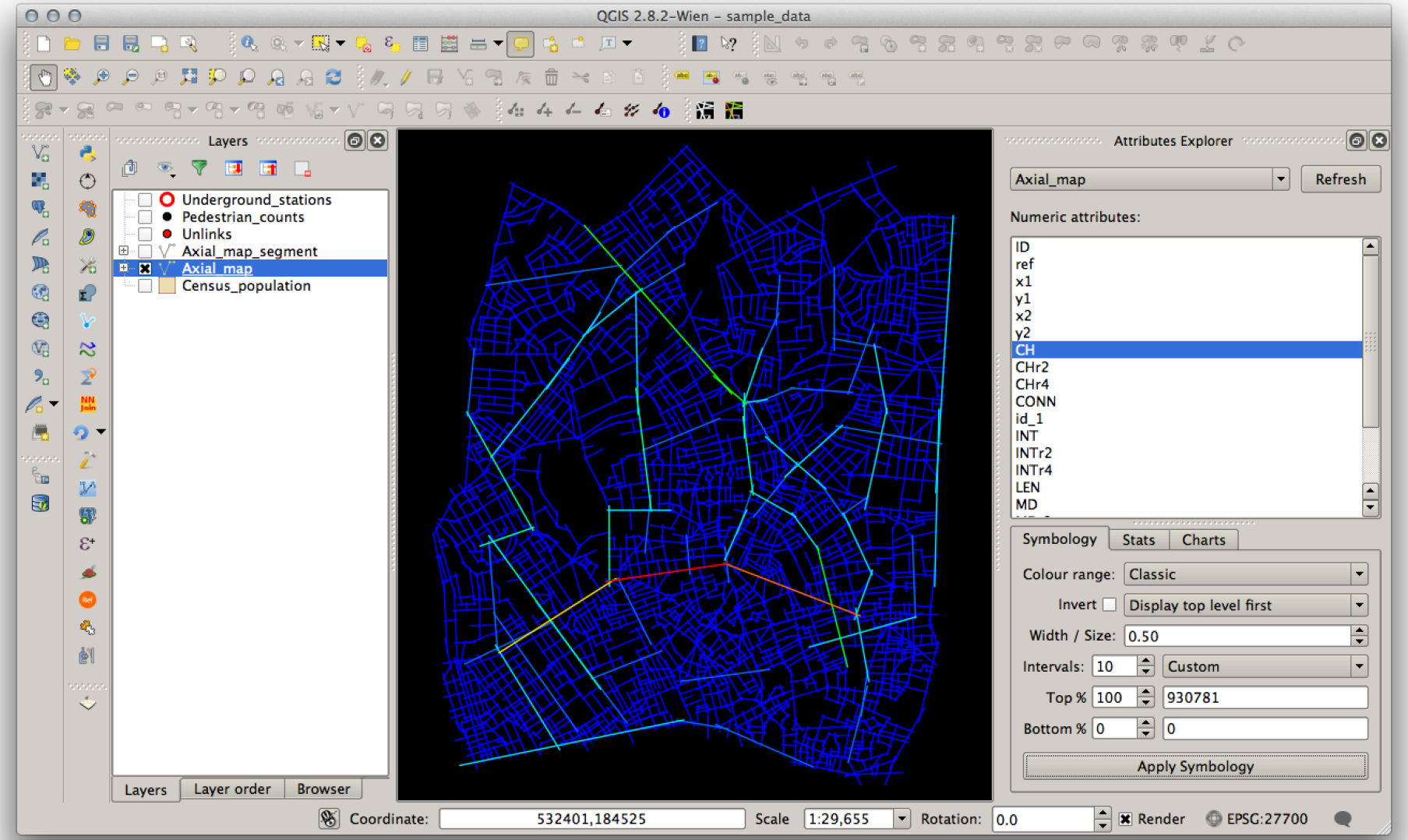
Visualising the results

Changing symbology: intervals quantiles



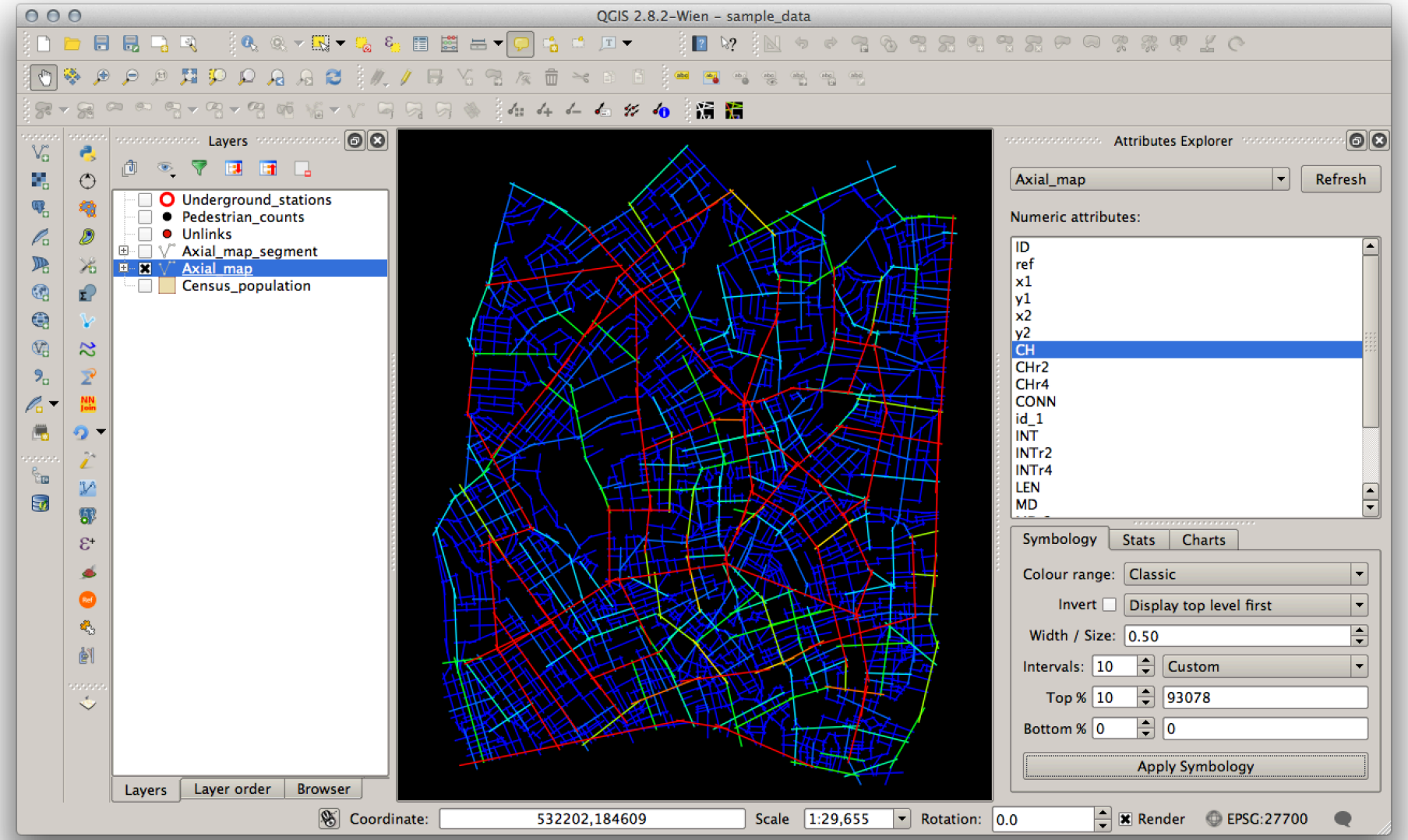
Visualising the results

Changing symbology: equal intervals with Choice



Visualising the results

Changing symbology: custom intervals with Choice



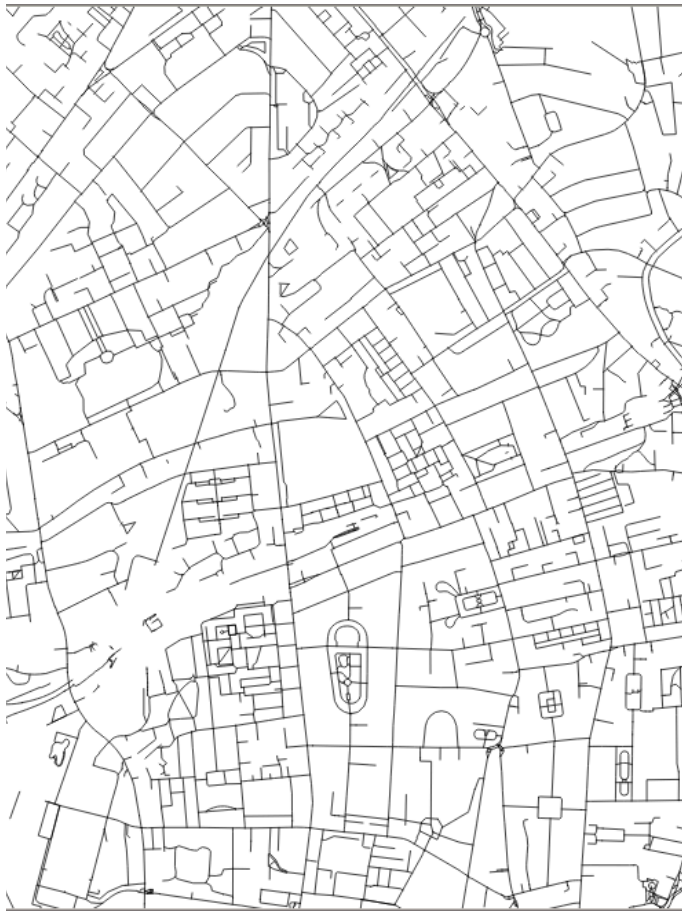
Task 2

Preparing and analysing road centre line (RCL) models

- Comparing RCL maps
- Cleaning RCL maps
- Simplifying RCL maps
- Verifying RCL maps
- Analysing RCL maps

Comparing Road Centre Line maps

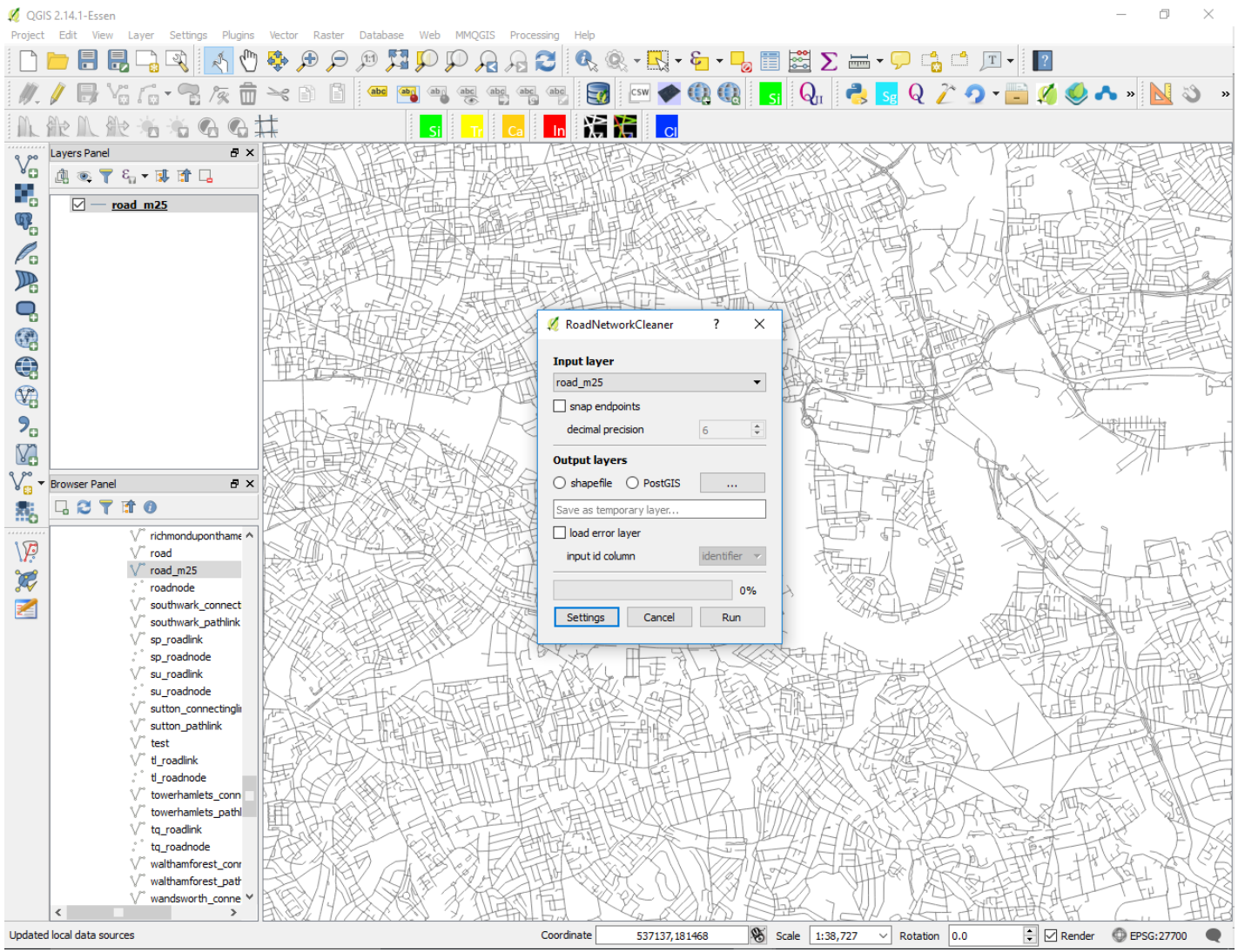
OpenStreetMap



OS Open Roads

OS Meridian 2

Cleaning RCL maps: Road network cleaner tool

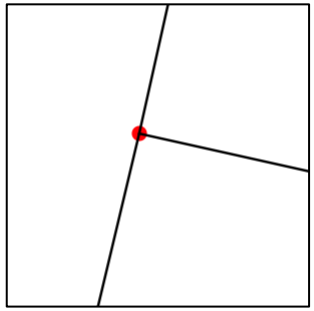


This plugin corrects topological errors of Road-centre-line (RCL) maps. This is a necessary step before performing space syntax analysis to any network.

Road network cleaner

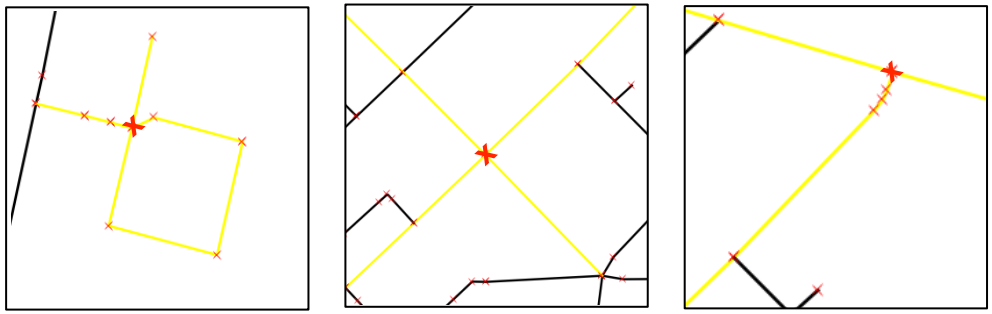
Geometry

- Removes invalid geometries
- Breaks multi-part geometries
- Removes point geometries

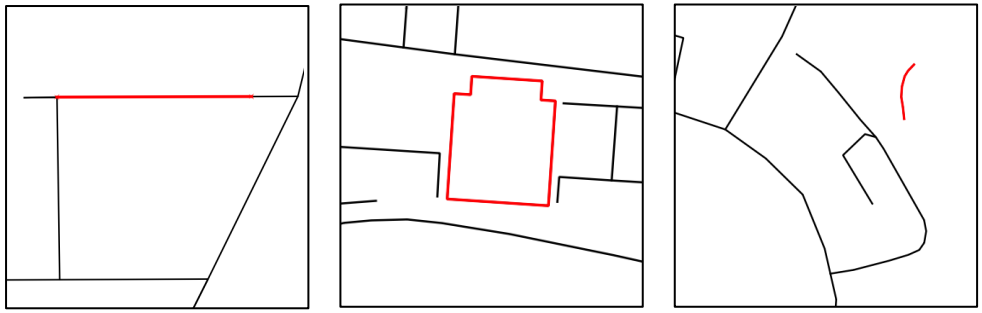


Topology

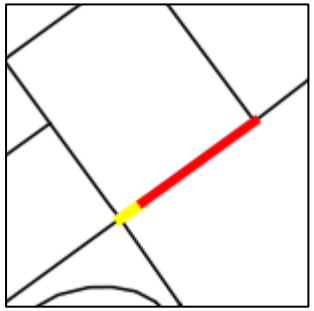
- Breaks geometries at self intersection (1), at shared vertices (2) and where they touch endpoints of other lines (3).



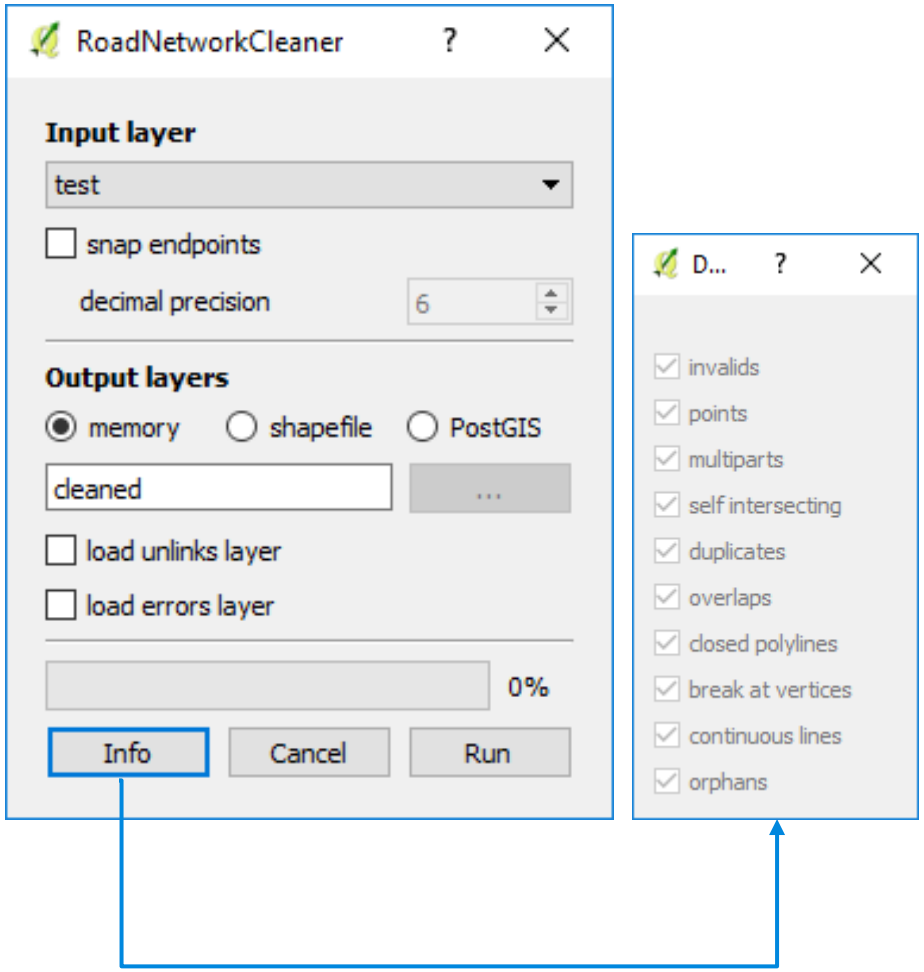
- Removes duplicate and overlapping (1) geometries, closed polylines that do not connect to any other line (2) and isolated lines (3).



- Merges lines between intersections



Road network cleaner



Input layer Choose RCL map to clean. The input can be any QGIS layer.

- **Snap endpoints** The user can specify a decimal precision of the coordinates

Output layers The user can choose between a memory QGIS layer a shapefile or a PostGIS database layer.

- **Load error layer** The errors that have been corrected by the plugin can be loaded as a memory layer.

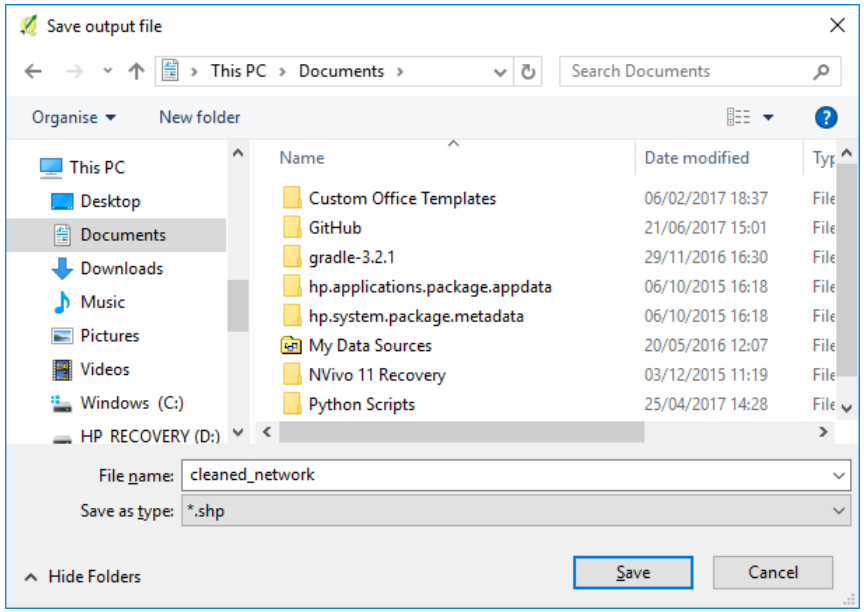
- **Load unlinks layer** There is an option to create a memory unlinks layer where the lines of the input layer cross. However, unlinks should be verified by the user as RCL may represent differently unlinked lines.

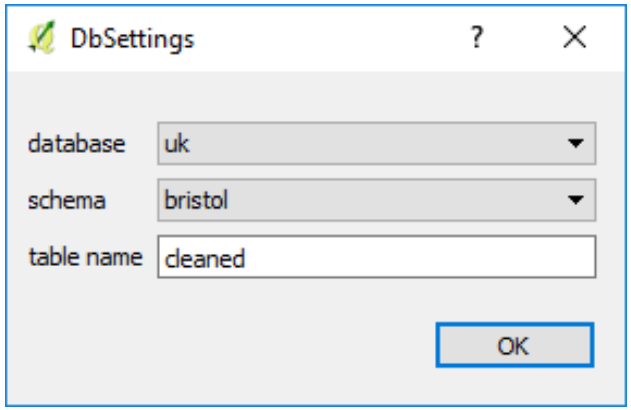
Info See which topological errors are corrected.

Run Pressing run will perform the cleaning of the selected map

Cancel Pressing close will close and terminate the Road network cleaner

Road network cleaner





Shapefile

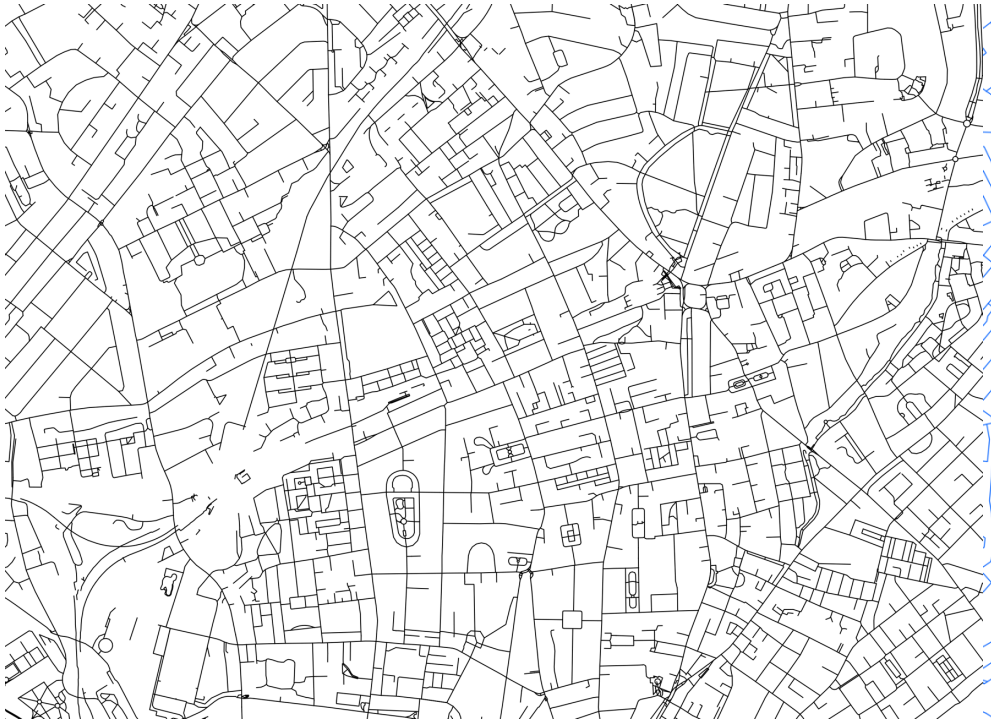
- **Save output file:** Select the location you wish to save the cleaned shapefile.

PostGIS layer

- **Database** Select the database where to save the cleaned layer
- **Schema** Select the schema where to save the cleaned layer
- **Table name** Specify the table name of the cleaned layer or leave it as default (‘cleaned’)

Cleaning RCL maps

OpenStreetMap



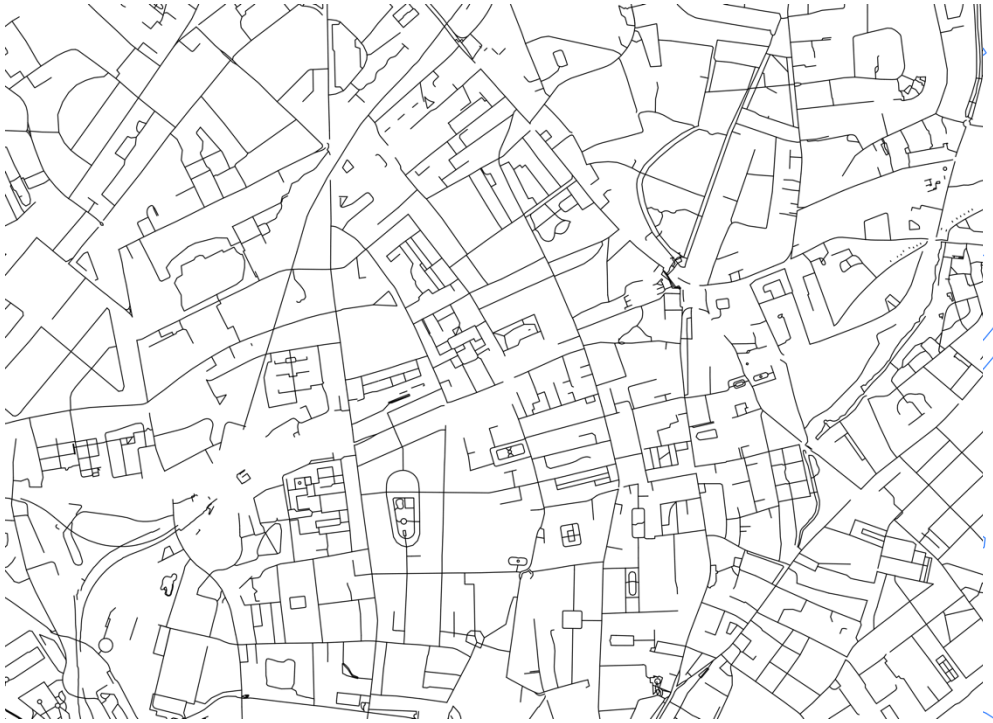
input

OS Open Roads

input

Cleaning RCL maps

OpenStreetMap



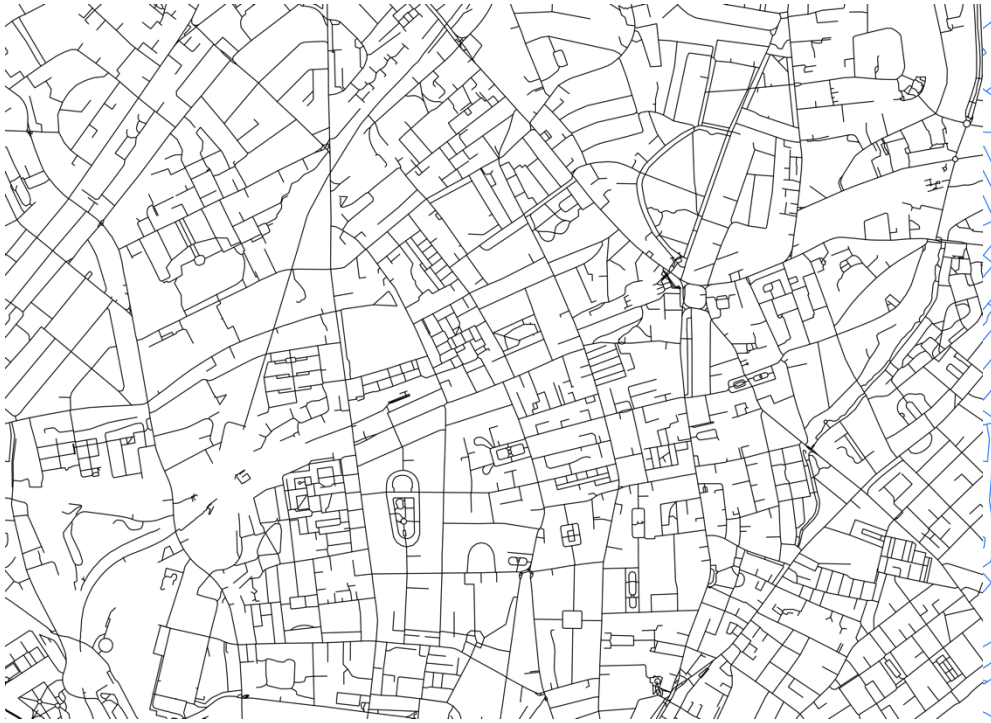
errors

OS Open Roads

errors

Cleaning RCL maps

OpenStreetMap



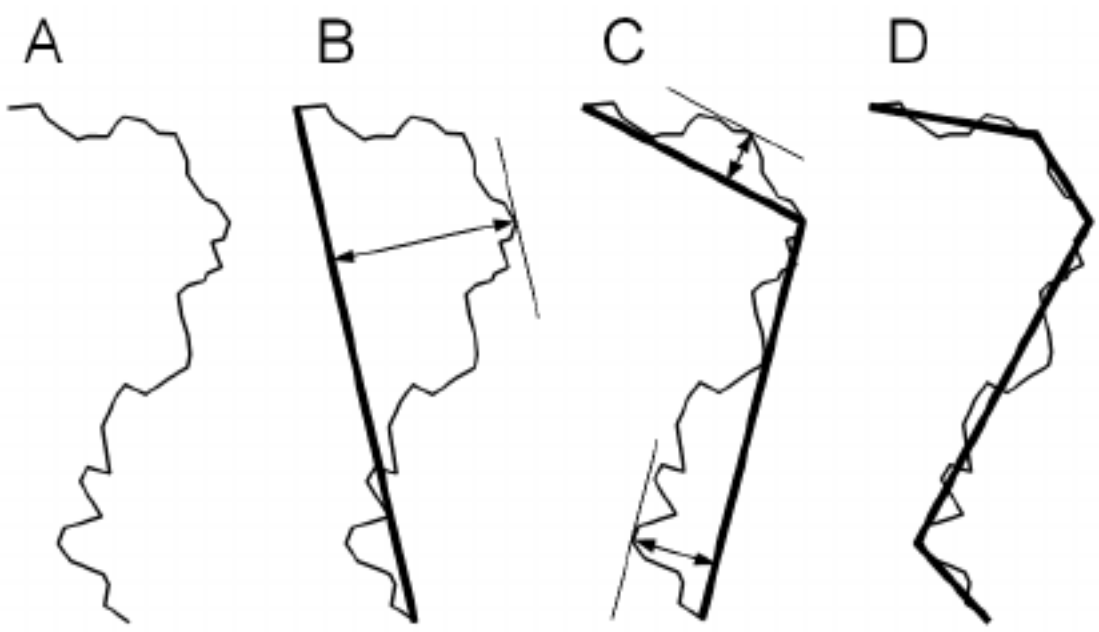
output

OS Open Roads

output

Simplifying RCL maps

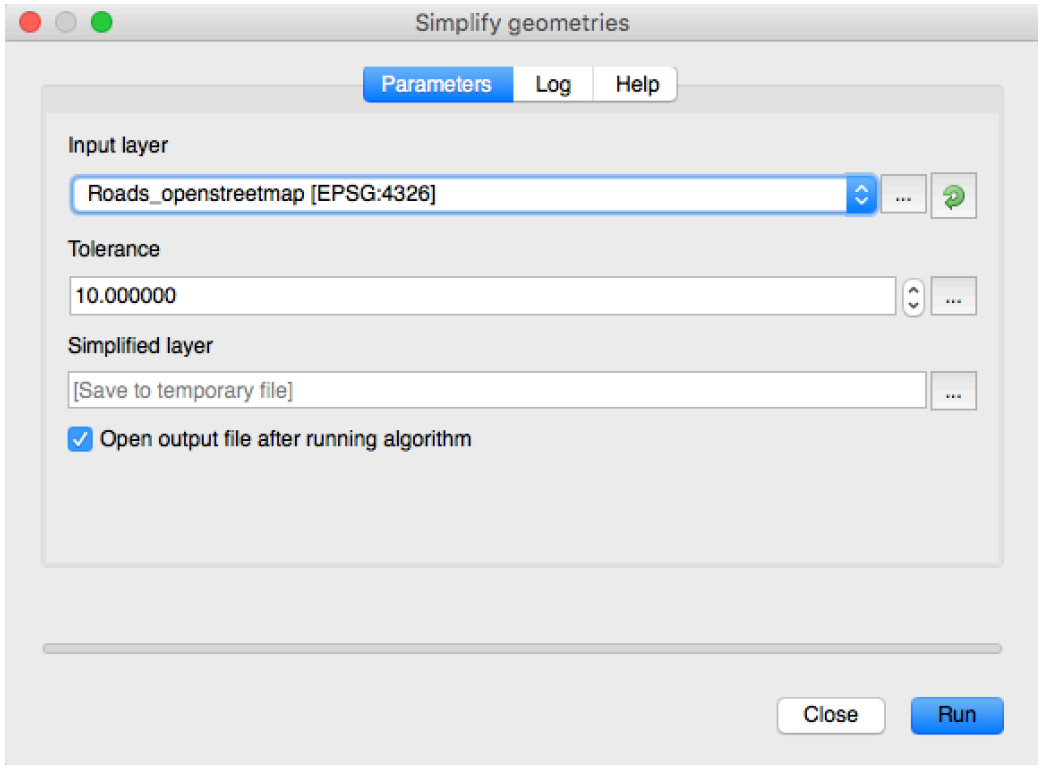
Douglas-Peucker generalisation algorithm



Source: https://www.researchgate.net/figure/260758647_fig6_Figure-6-Simplification-of-a-polygonal-curve-with-the-Douglas-Peucker-algorithm-A

Simplifying RCL maps

QGIS – Simplify geometries



Simplifying RCL maps

OpenStreetMap

OS Open Roads

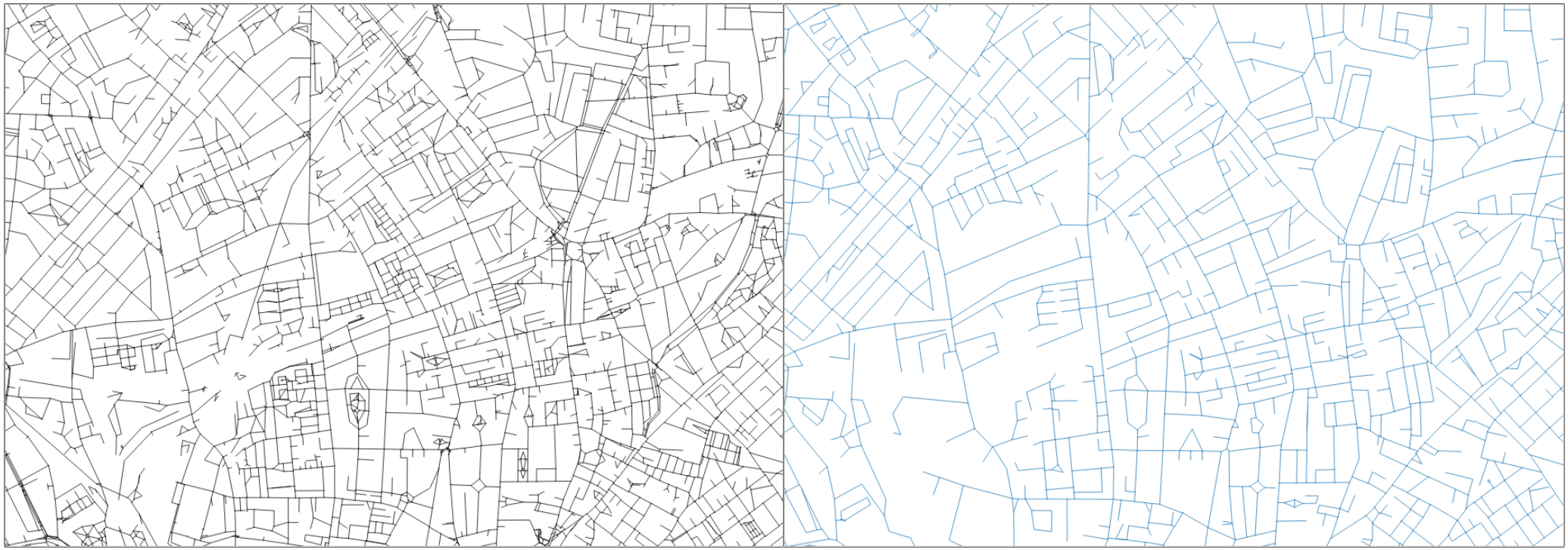
Simplification threshold 10

Simplification threshold 10

Simplifying RCL maps

OpenStreetMap

OS Open Roads



Simplification threshold 20

Simplification threshold 20

Simplifying RCL maps

OS Meridian 2

OS Open Roads

No simplification

Simplification threshold 20

Simplifying RCL maps

OpenStreetMap – threshold 20

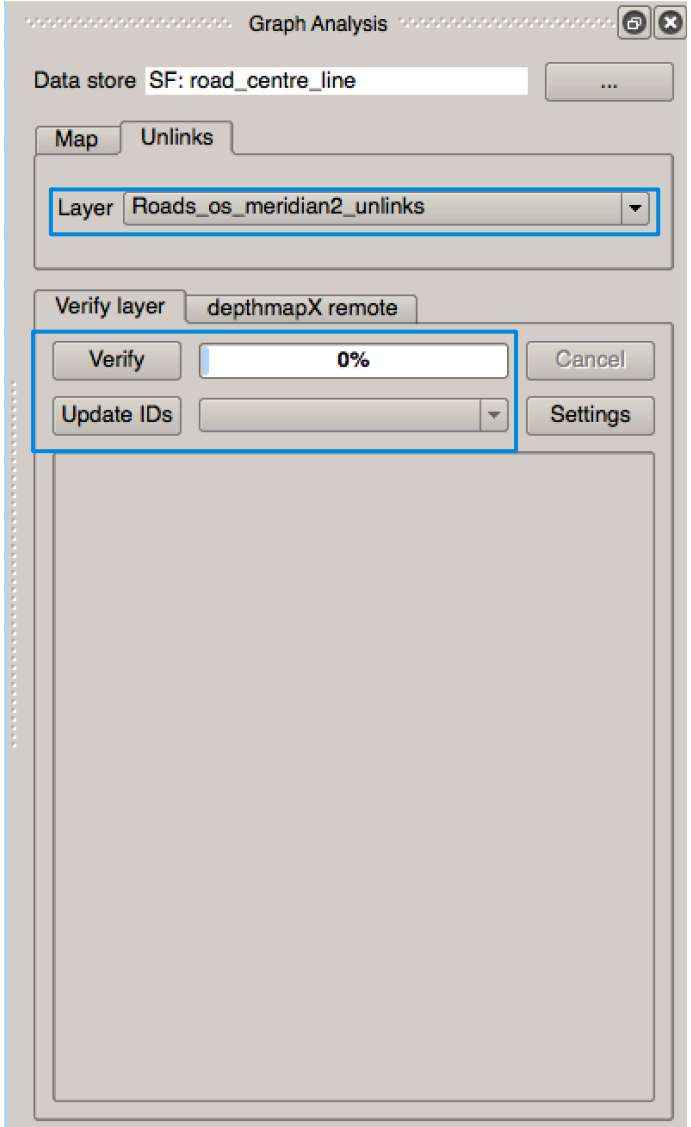
OpenStreetMap

Simplification threshold 20

No simplification

Verifying RCL maps

Graph Analysis tool

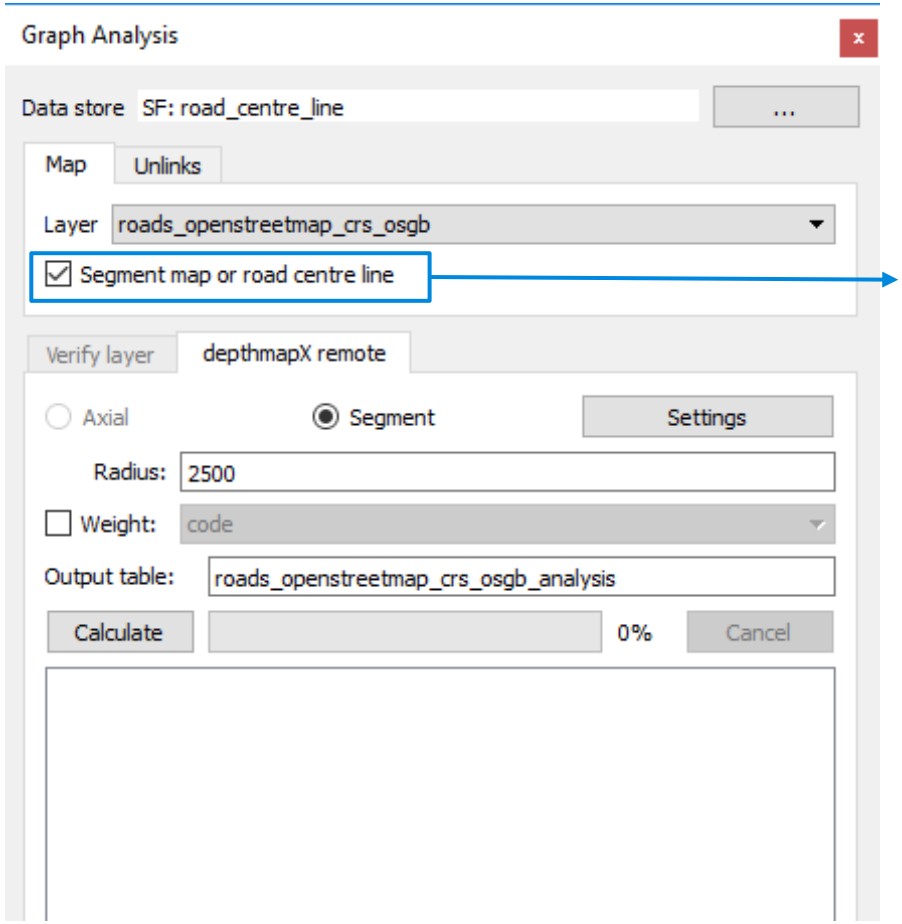


Unlinks

- **Verify the unlinks:** This is required in the cases where the cleaning tool produces a meaningful unlinks result file, e.g. OS OpenRoads and OS Meridian2.

Analysing RCL maps

Graph Analysis tool



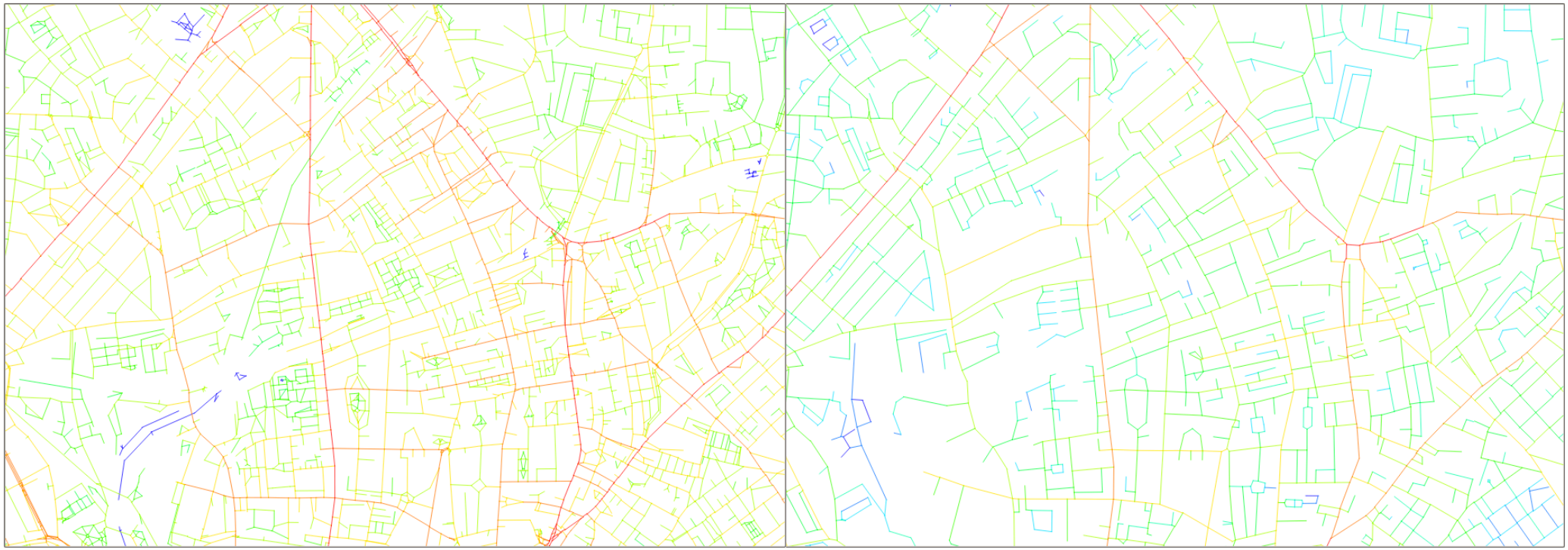
Map

- **Segment map or road centre line:** Tick this option when you are analysing road centre line maps or axial maps already segmented.

Analysing RCL maps

OpenStreetMap

OS Open Roads



Integration RN, 10 equal ranges

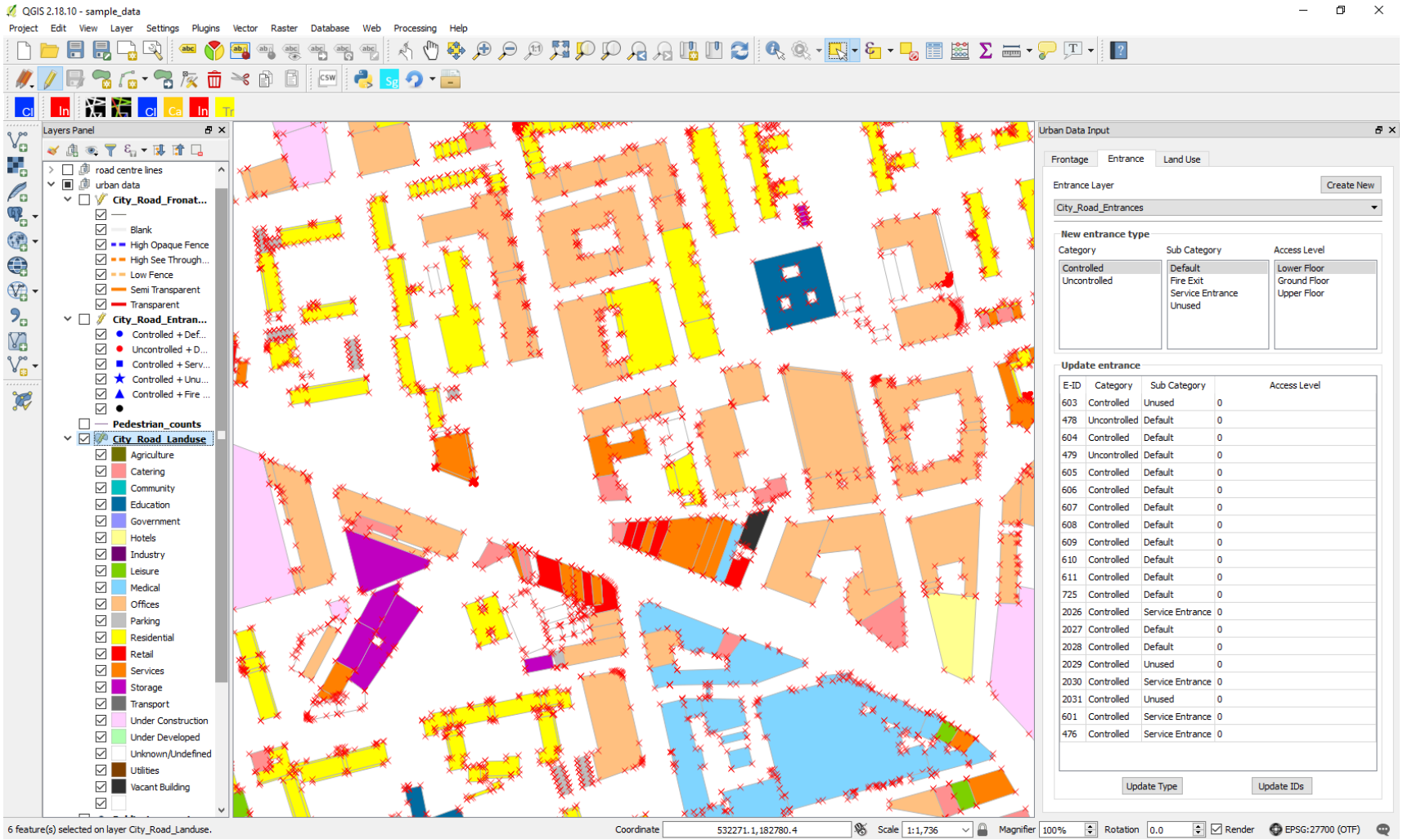
Integration RN, 10 equal ranges

Preparing other urban data layers

Urban Data Input Tool: recoding frontages, entrances and land use surveys

- Creating the data layer
- Drawing new features
- Updating features
- Viewing the attributes

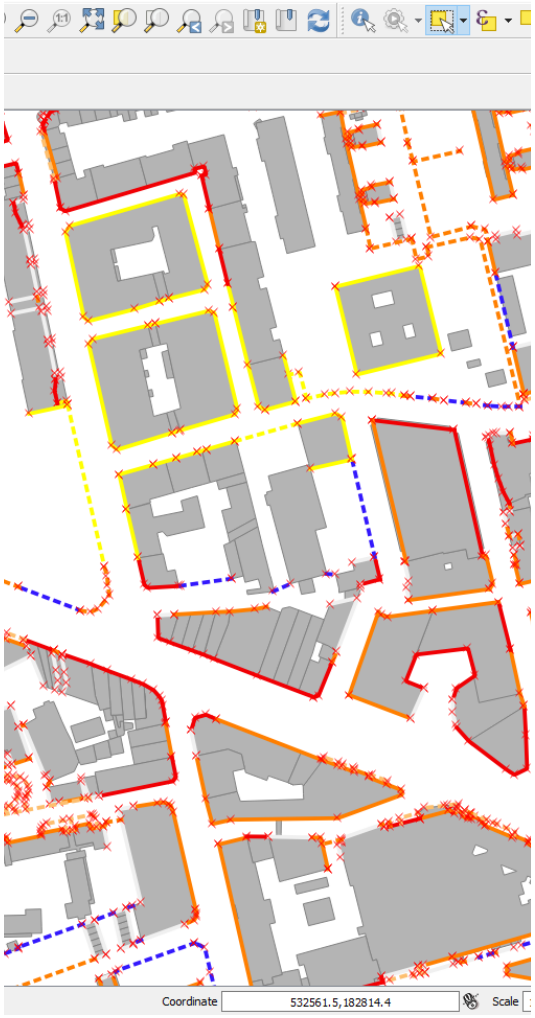
Urban Data Input Tool



Urban Data Input Tool is a plugin to ease aid the input of urban data like frontage type, entrance type and land use type as per Space Syntax Limited standards. The Space Syntax community is the key users for the plugin. The display styles and categories included are as per Space Syntax Limited Standards.

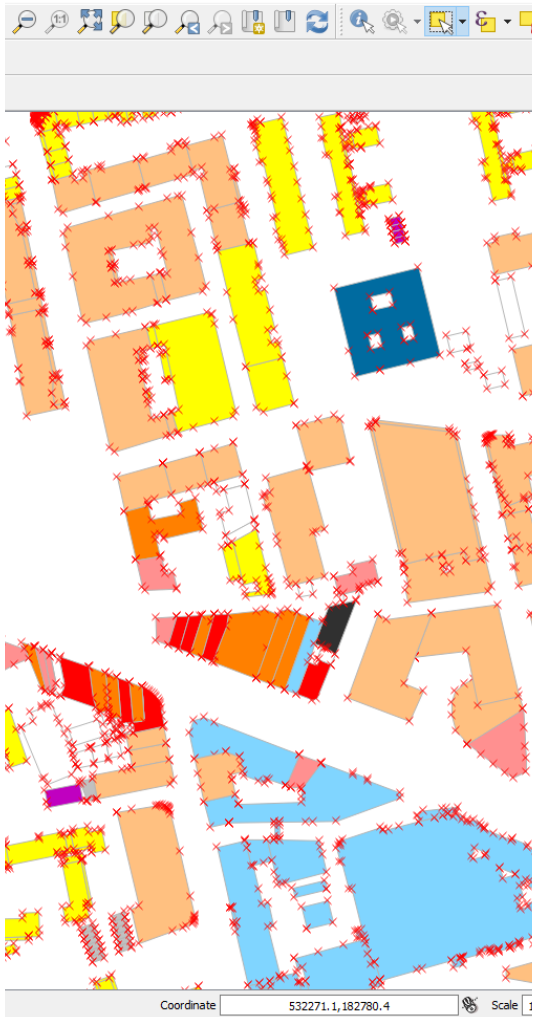
Urban Data Input Tool

Frontage survey



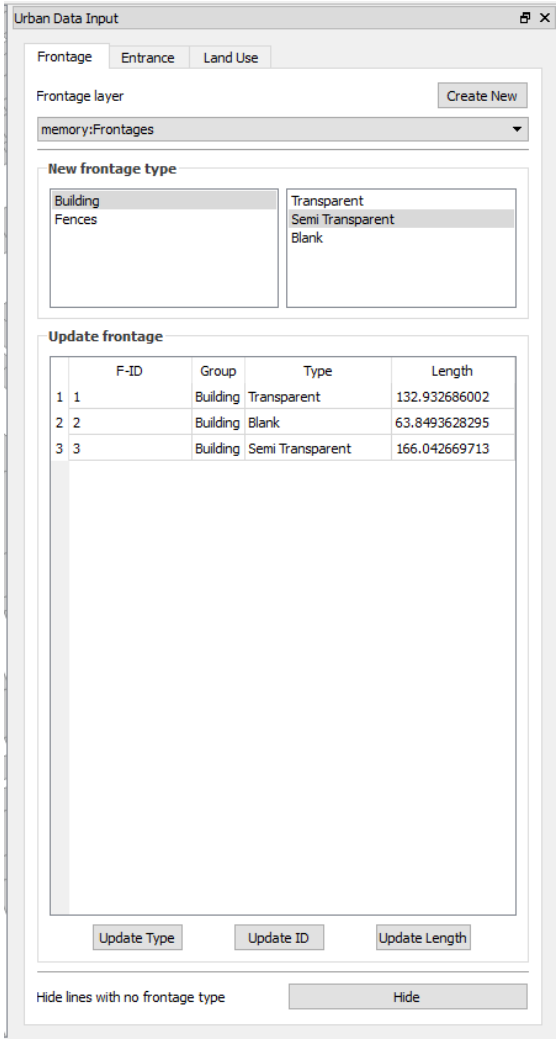
Entrance survey

Land use survey

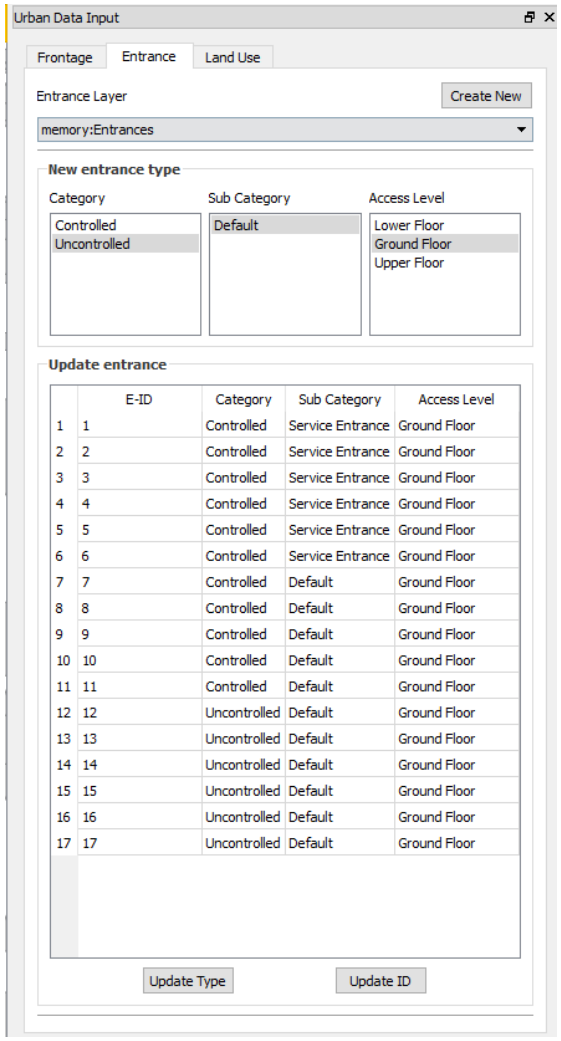


Urban Data Input Tool

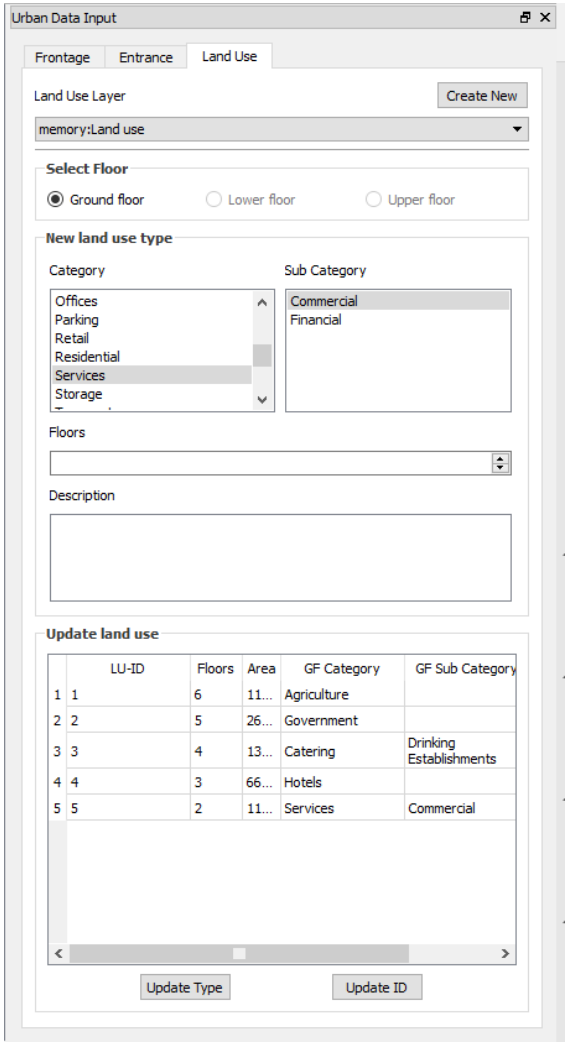
Frontage tool



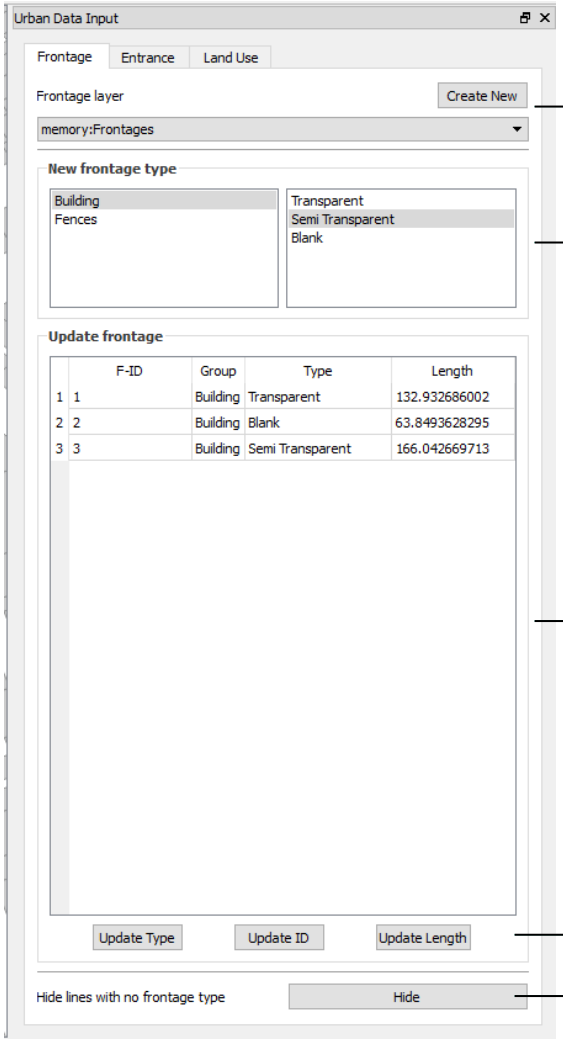
Entrance tool



Land use tool



Urban Data Input Tool Frontage tool



Create New Frontage layer
- Using buildings/block dataset
- Without using building/block dataset

Frontage Category

Selected feature data

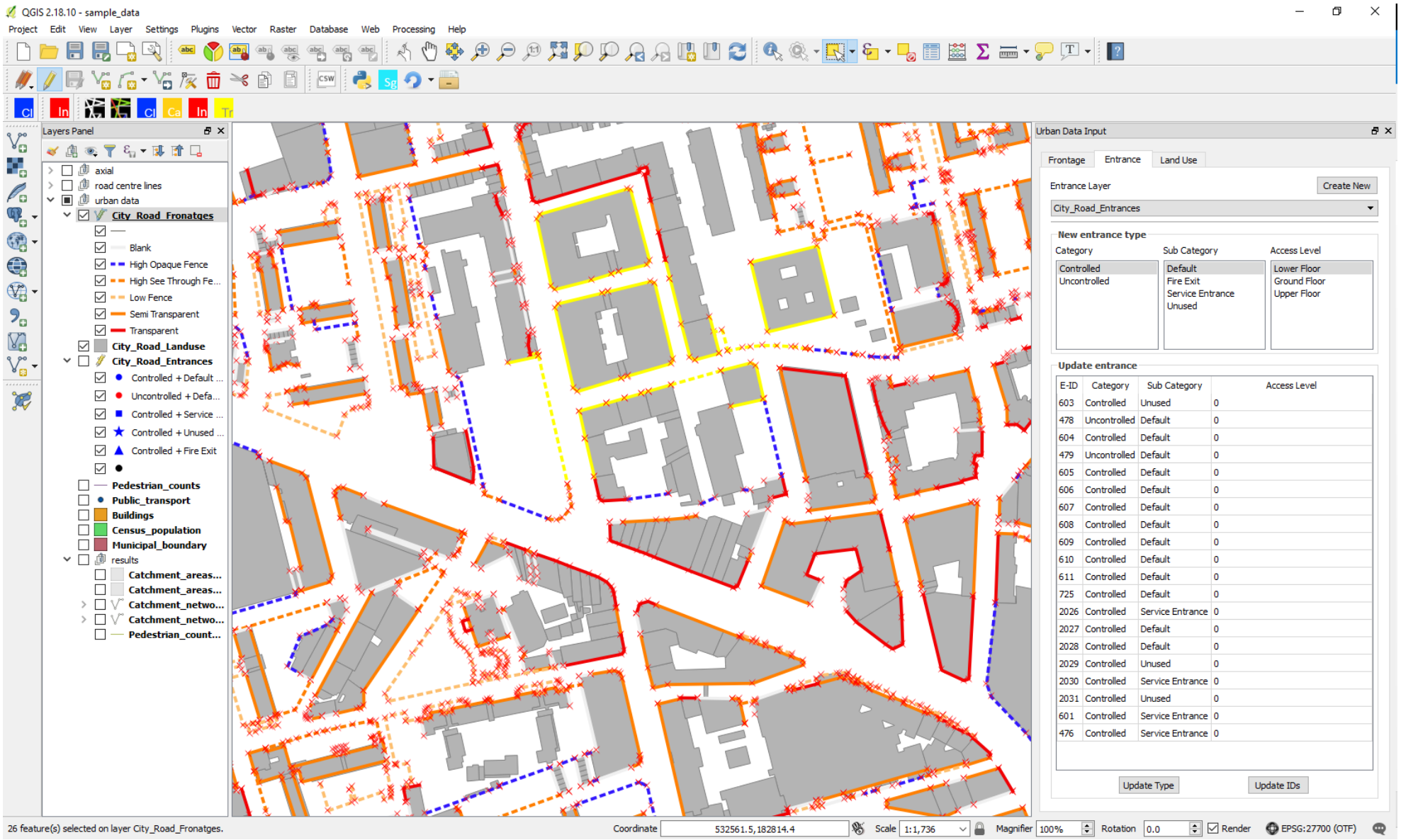
Update buttons

Hide lines with no data

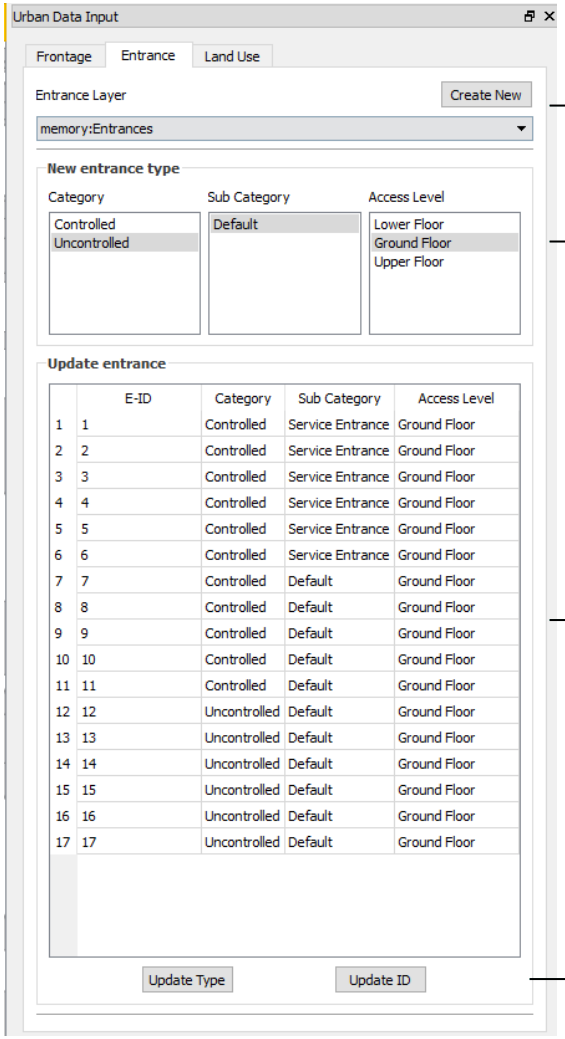
Data categories

- Blank
- High Opaque Fence
- High See Through Fence
- Low Fence
- Semi Transparent
- Transparent

Urban Data Input Tool Frontage tool



Urban Data Input Tool Entrance tool



Create New Entrance layer

Entrance Category

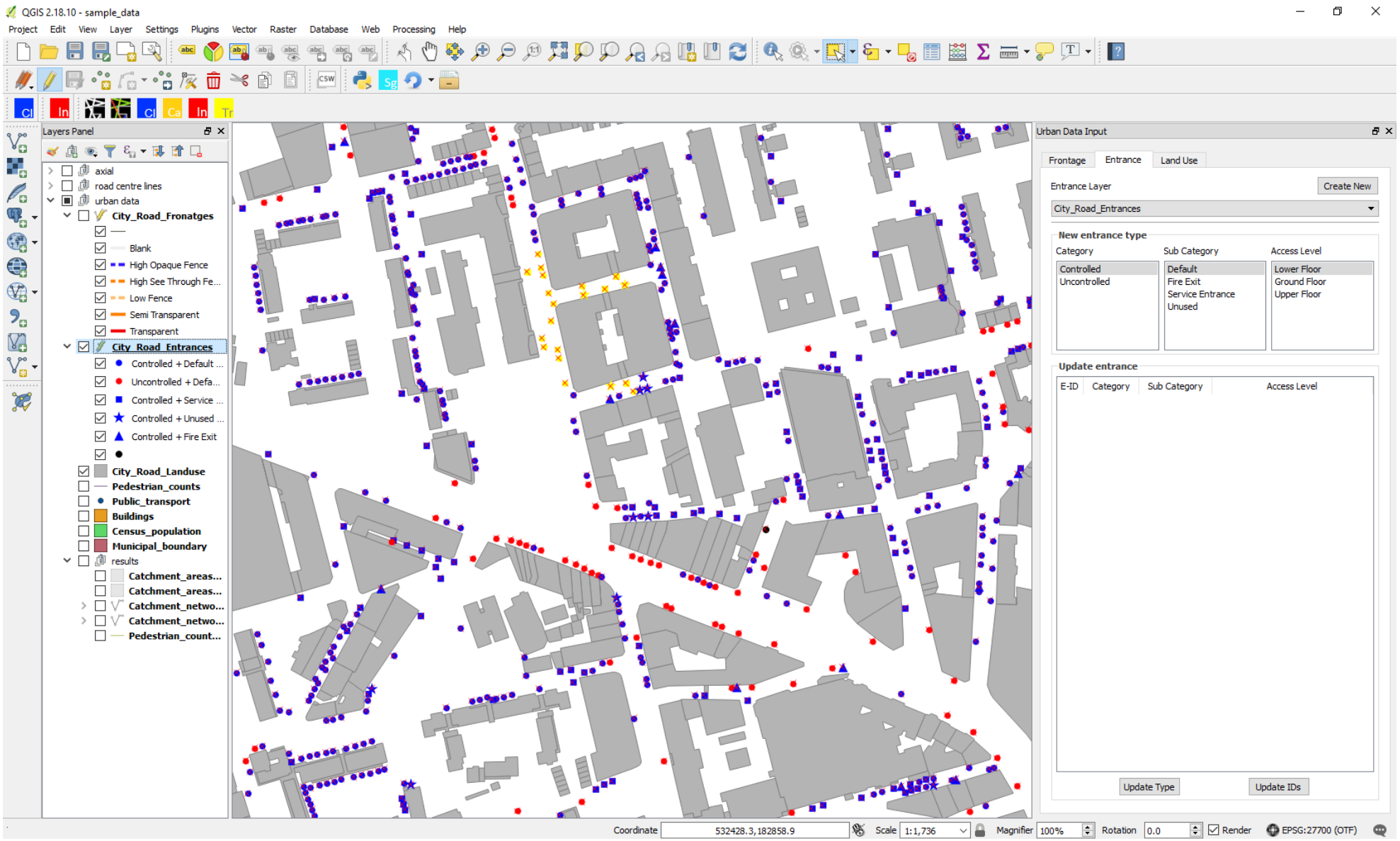
Selected feature data

Update buttons

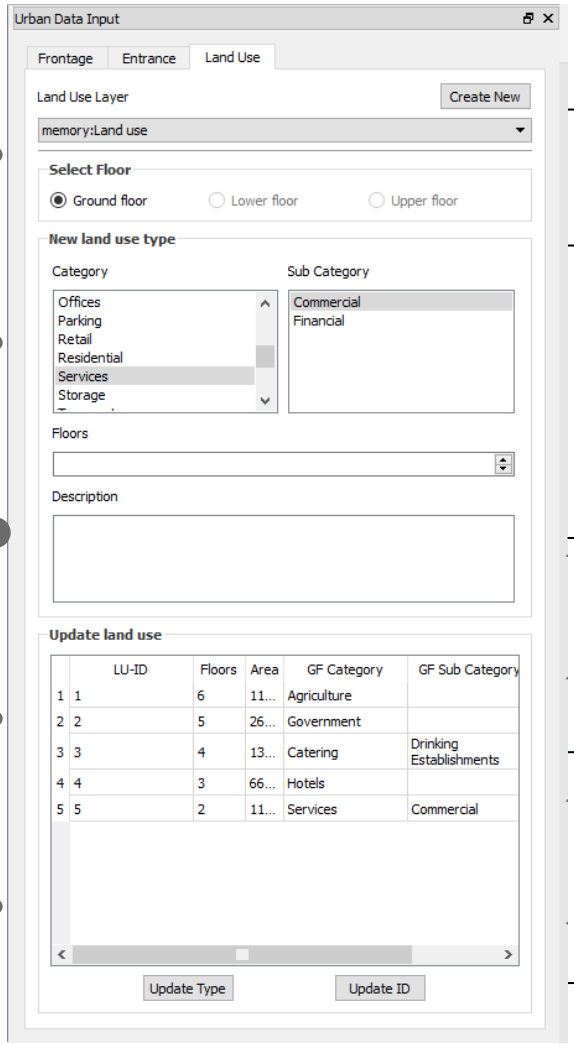
Data categories

- Controlled + Default Entrance
- Uncontrolled + Default Entrance
- Controlled + Service Entrance
- Controlled + Unused Entrance
- Controlled + Fire Exit

Urban Data Input Tool Entrance tool



Urban Data Input Tool Land use tool



Create New Land use layer

Land use Category

Building data/ description

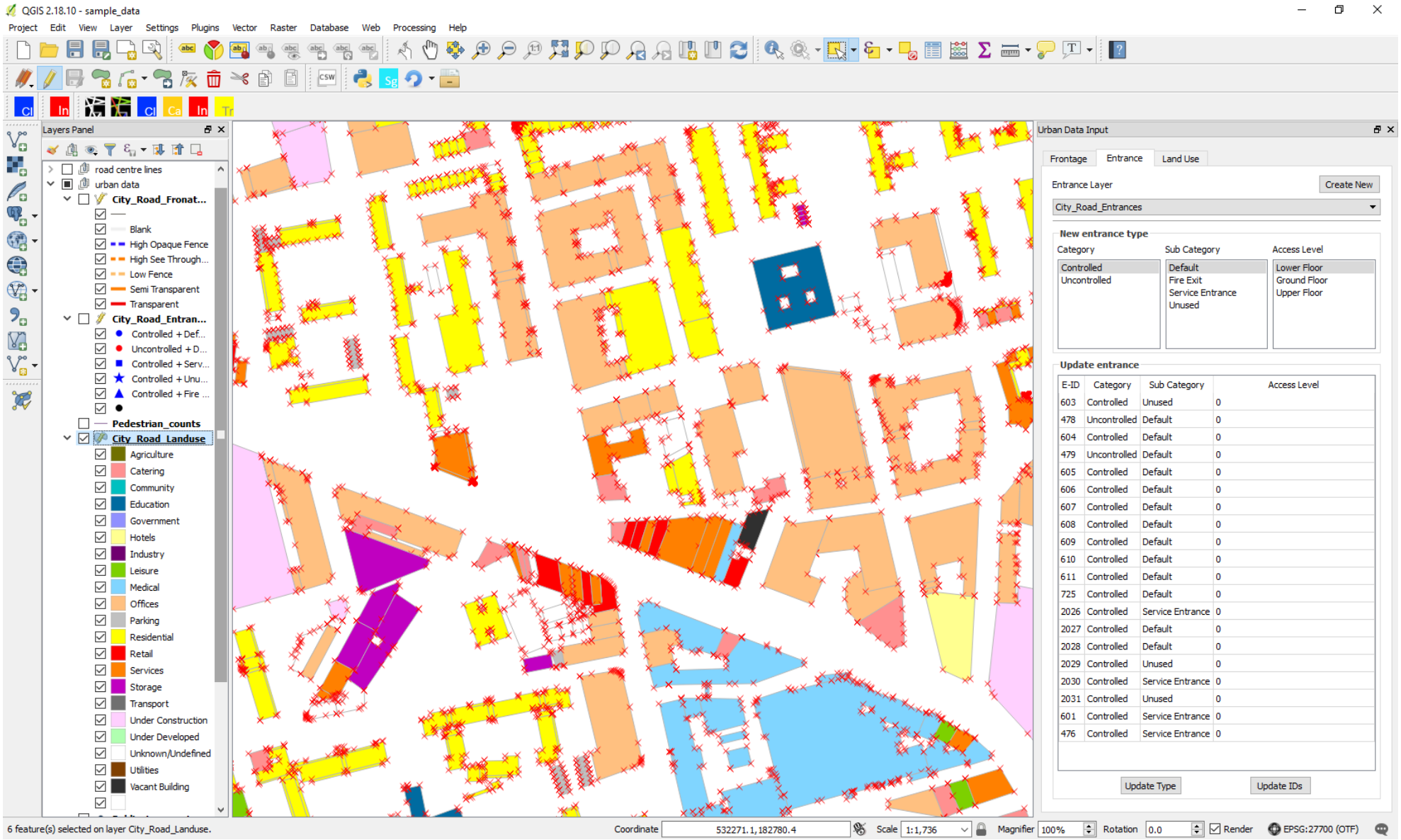
Selected feature data

Update buttons

Data categories

- Agriculture
- Catering
- Community
- Education
- Government
- Hotels
- Industry
- Leisure
- Medical
- Offices
- Parking
- Residential
- Retail
- Services
- Storage
- Transport
- Under Construction
- Under Developed
- Unknown/Undefined
- Utilities
- Vacant Building

Urban Data Input Tool Land use tool

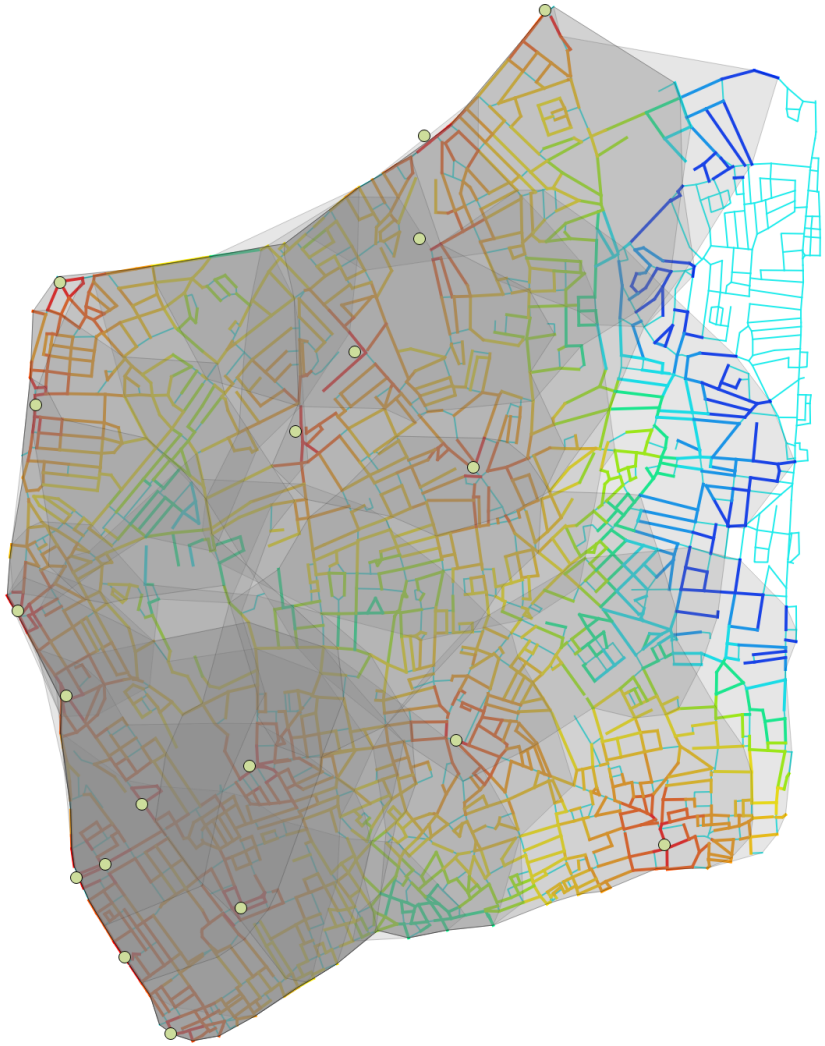


Task 4

Connecting and analysing the various results

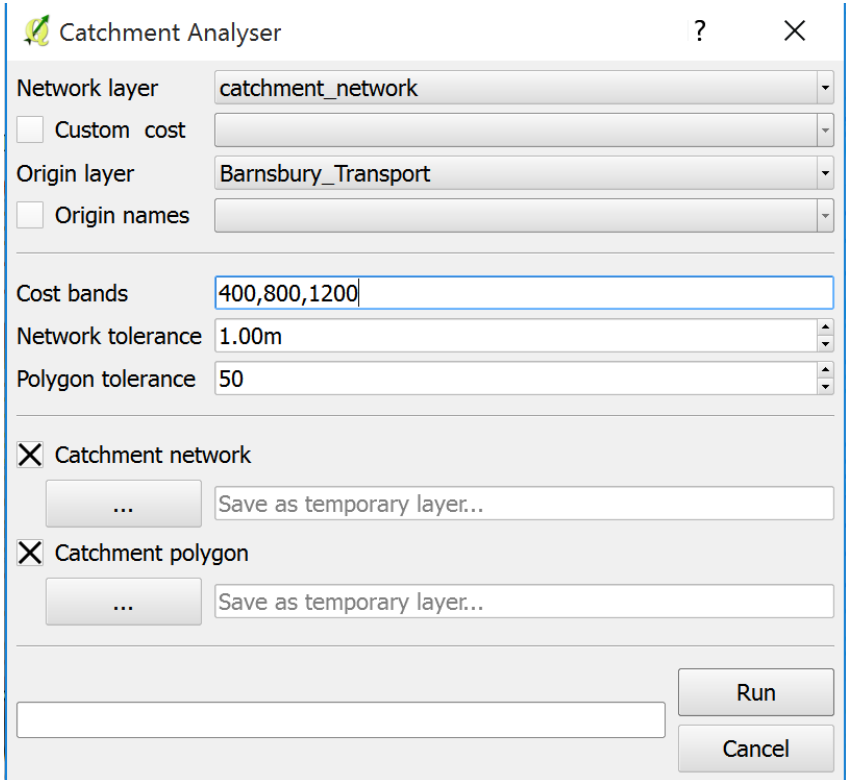
Catchment Analyser: calculating service/catchment areas from different locations (e.g. public transport nodes) along the road centreline network.

Catchment Analyser



This plugin takes a line-based network and point-based origin layer and calculated the distance from each segment within a given distance or list of distances to each of the origins. The tool outputs the catchment as lines and as a concave hull polygon layer. Credit for the concave hull functionality goes to the algorithm described by Adriano Moreira and Maribel Yasmina Santos.

Catchment Analyser



Network layer Choose the line-based vector layer that comprises a topological network you want to analyse. (projected CRS only!!)

Custom cost By default the tool will generate catchments based on the length of the network segments. If checked the tool will apply a weight based on the column selected.

Origin layer Choose the point-based vector layer containing the origins from which catchment will be calculated.

Origin Names By default the origin names will be based on the feature ids. If checked the tool will run the catchment analysis based on the column selected.

Cost Bands This sets the radius for the catchment analysis. For example, 400,800,1200,2000.

Network tolerance This is a tolerance for disconnected network. For example, it will connect lines that are within 1m by default.

Polygon tolerance The Catchment Analyser tool creates concave hull polygons from a specific origin. The polygon tolerance defines the level of 'concaveness' of the catchment. The lower the value, the more concave and the higher the value the more convex.

Catchment network The tool provides a catchment network output based on the original network layer with cost information on every origin. If checked the tool will generate the network as a temporary layer or as a shapefile using the browse button.

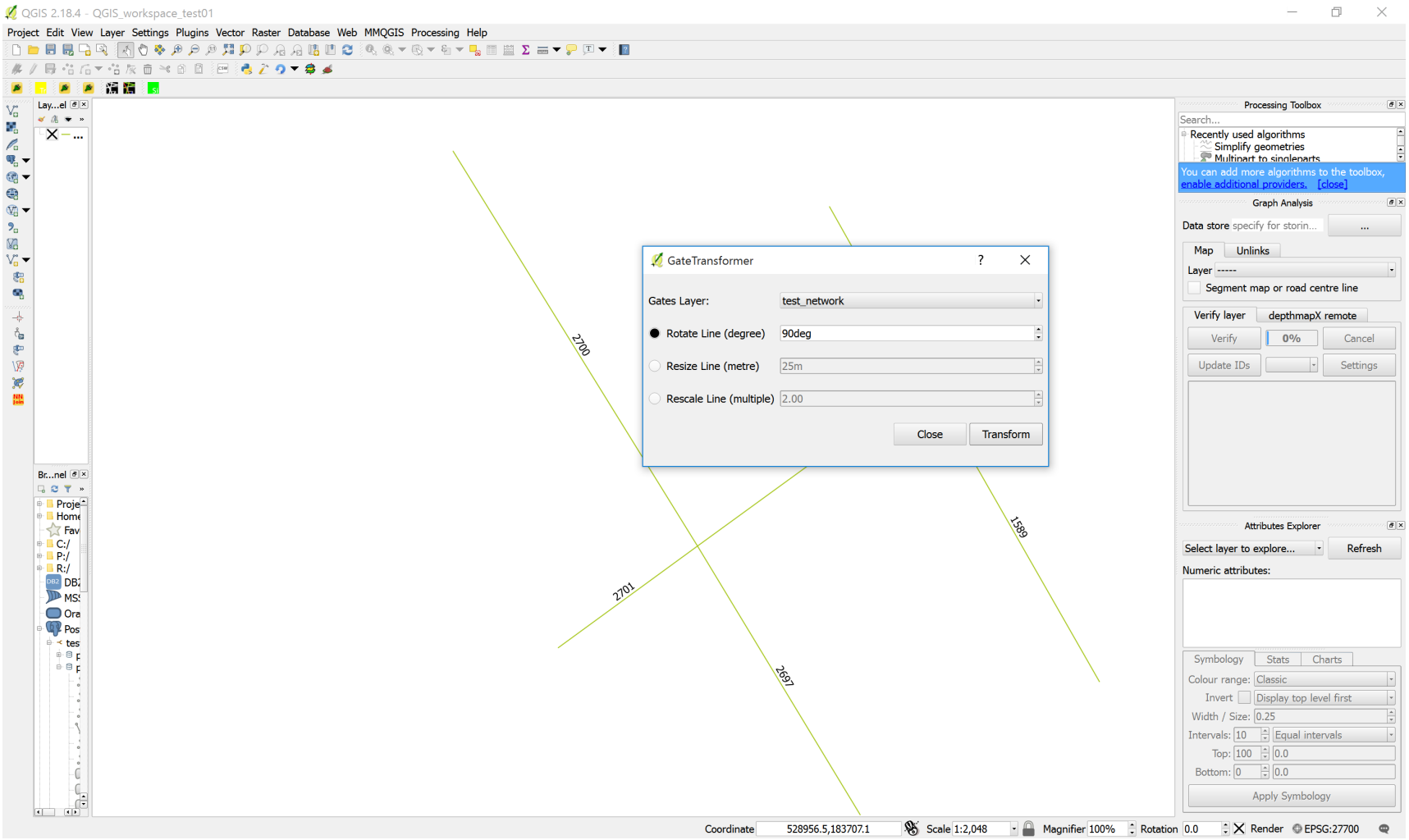
Catchment polygon The tool provides a catchment polygon output for each origin and each specified cost. If checked the tool will generate the polygons as a temporary layer or as a shapefile using the browse button.

Task 4

Connecting and analysing the various results

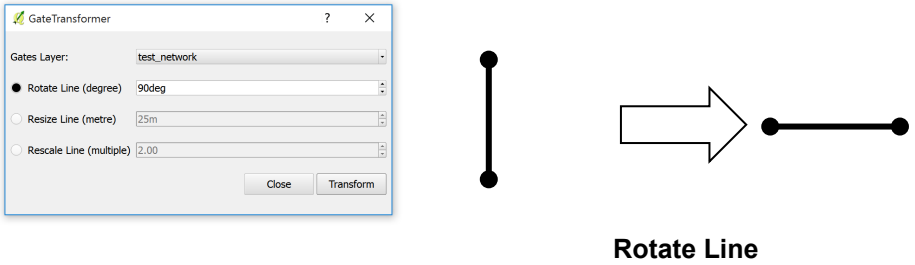
- Gate Transformer: preparing pedestrian counts
- Connecting the centrality measures with pedestrian counts
- Connecting the catchment results with pedestrian counts
- Statistical analysis of two variables

Gate Transformer

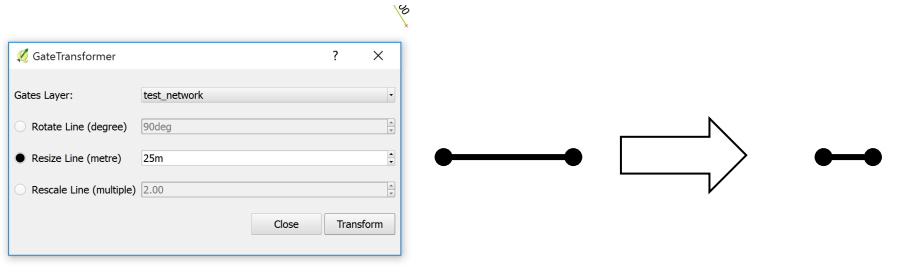


Gate Transformer is a plugin to modify the geometry of gates used in space syntax movement observations. Gates are usually drawn perpendicular to the axial line, with varying lengths. For presentation of movement observations the typical output is a map showing lines along the axial lines to indicate the movement direction. The gates should all be rotated 90degrees and have the same length.

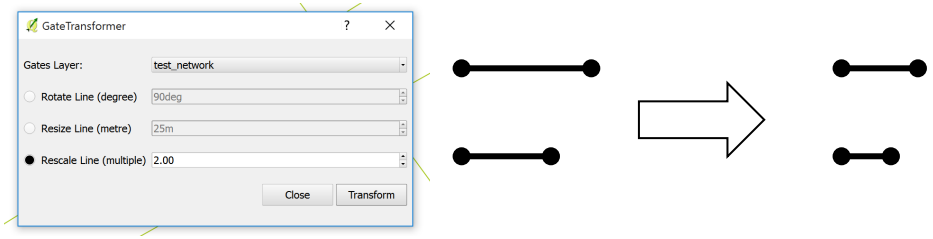
Gate Transformer



Rotate Line



Resize Line



Rescale Line

Gates layer Choose the line-based gate layer from the drop-down menu that you want to transform

Rotate Line (degree) Define the angle in degrees for rotating the selected gates

Resize Line (metre) Define the length in metres for resizing the selected gates

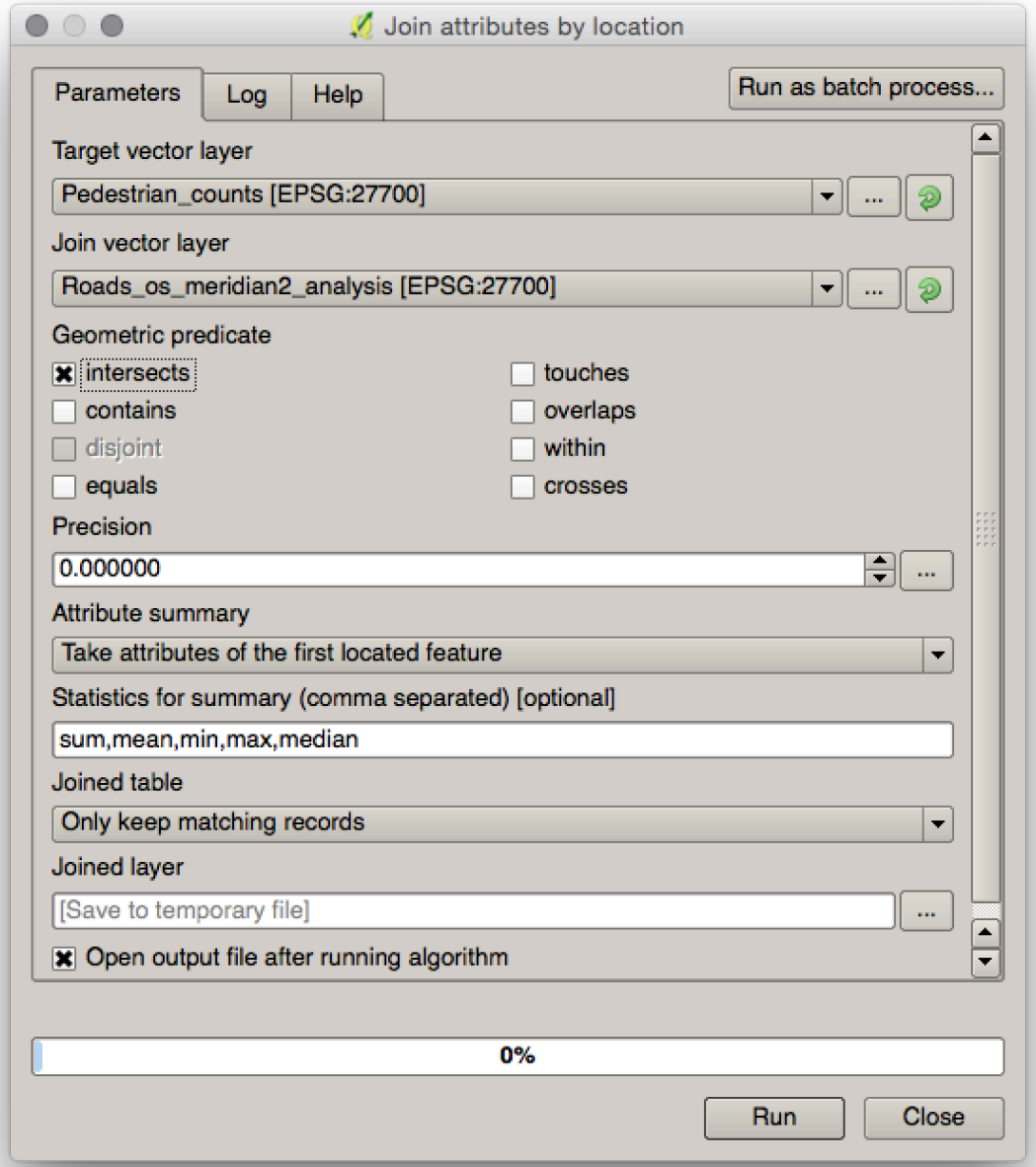
Rescale Line (multiple) Define the multiple in ratio for rescaling the selected gates

Transform Pressing the transform button will activate the analysis for the selected transformation

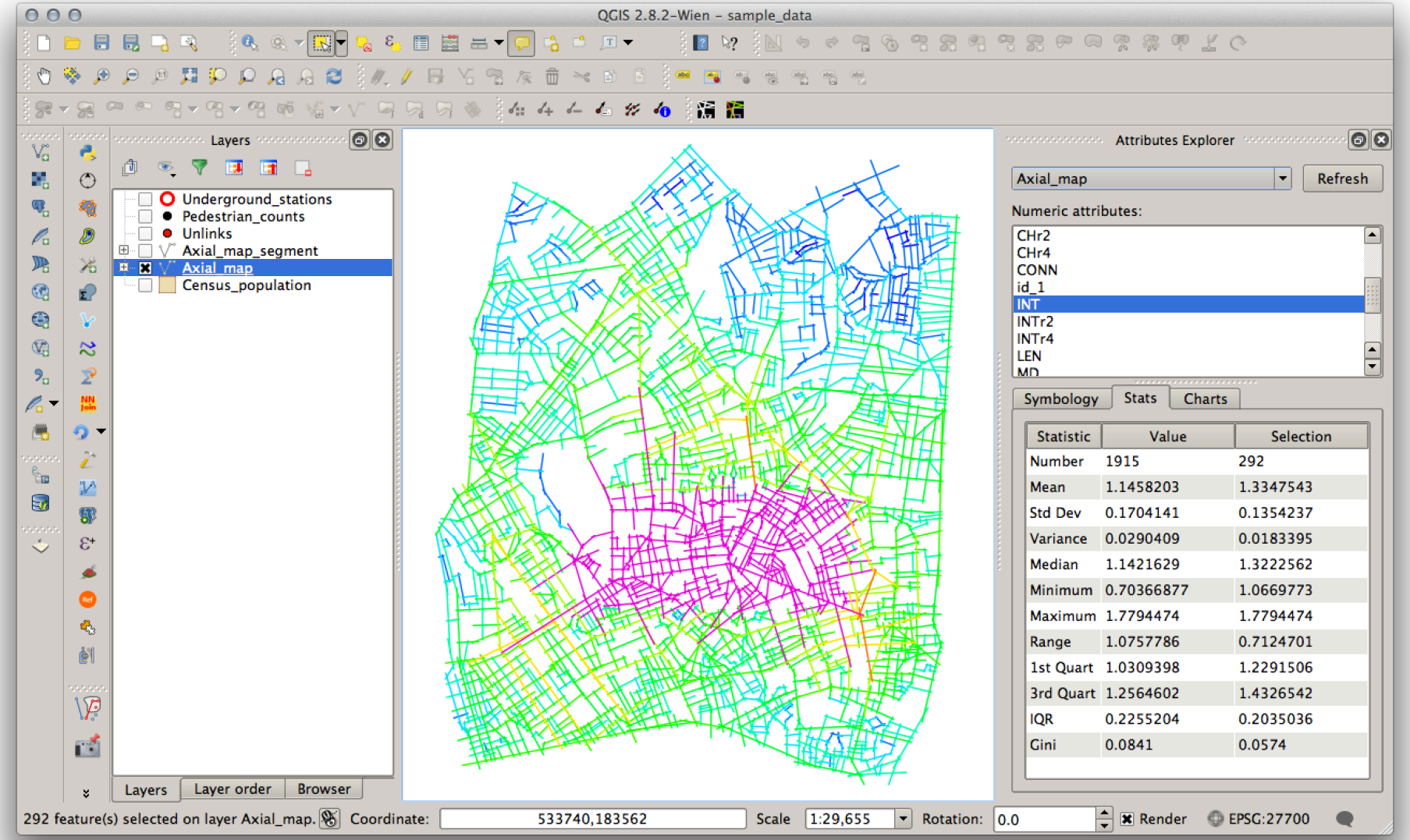
Close Pressing close will close and terminate the Gate Transformer

Connecting layers by spatial join

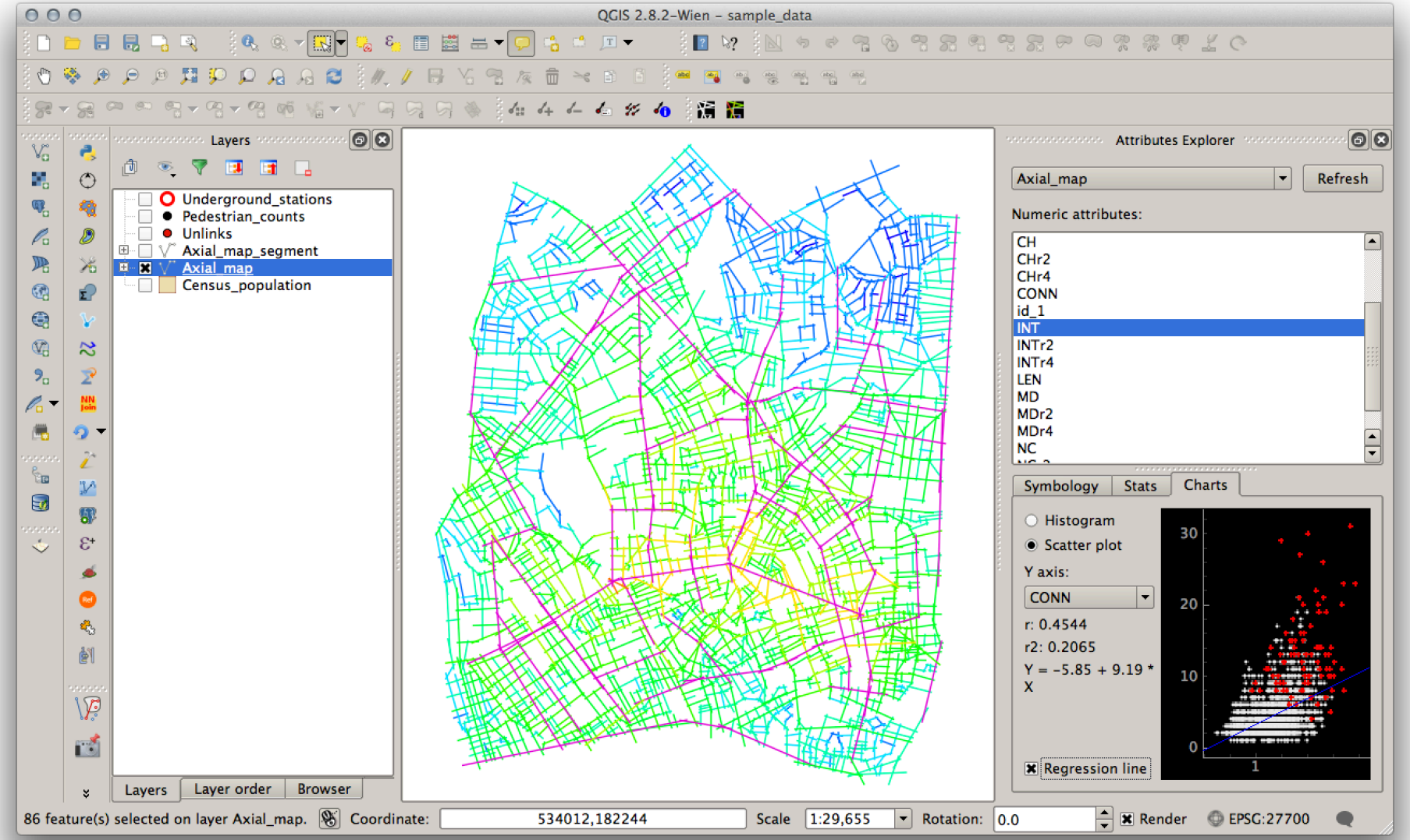
Use the 'Join attributes by location' from the processing toolbox



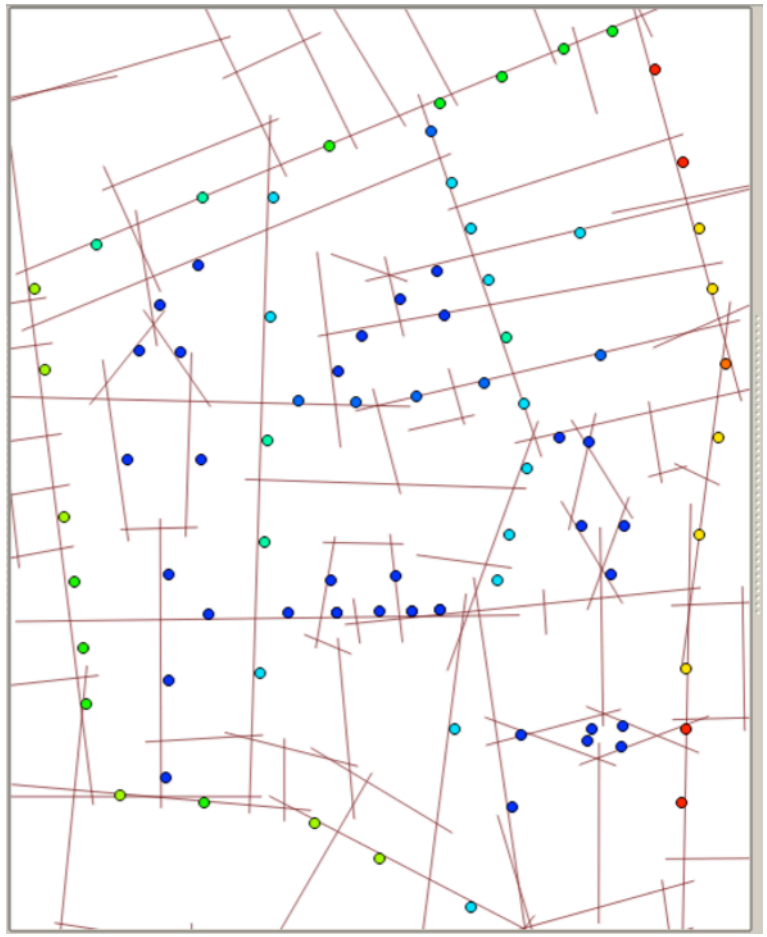
Statistical analysis of a single variable

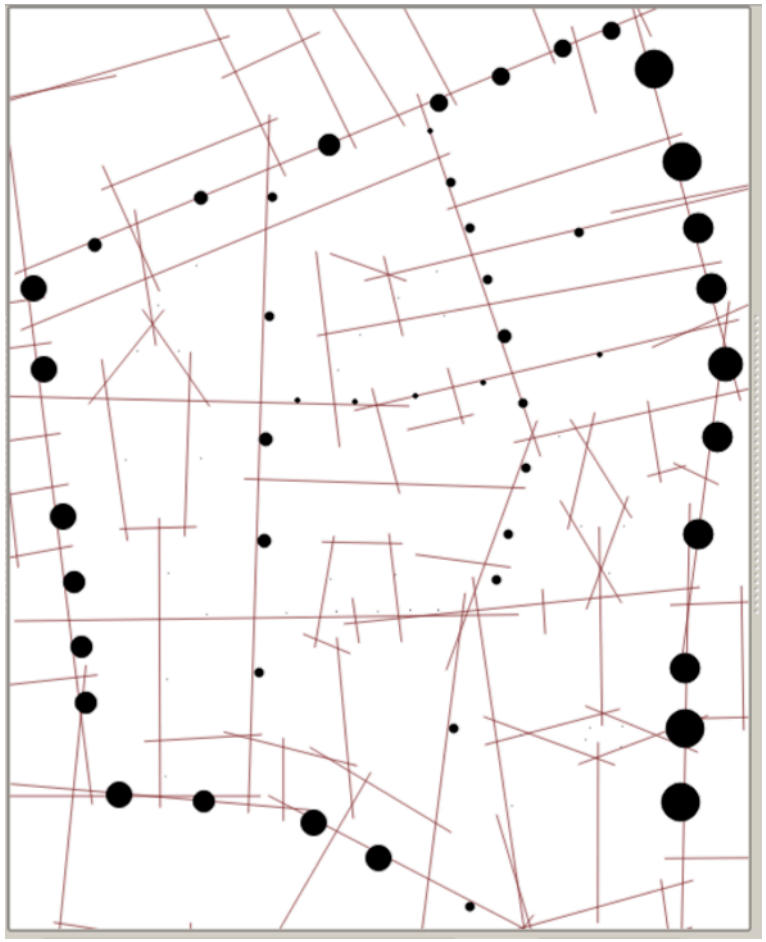


Statistical analysis of two variables

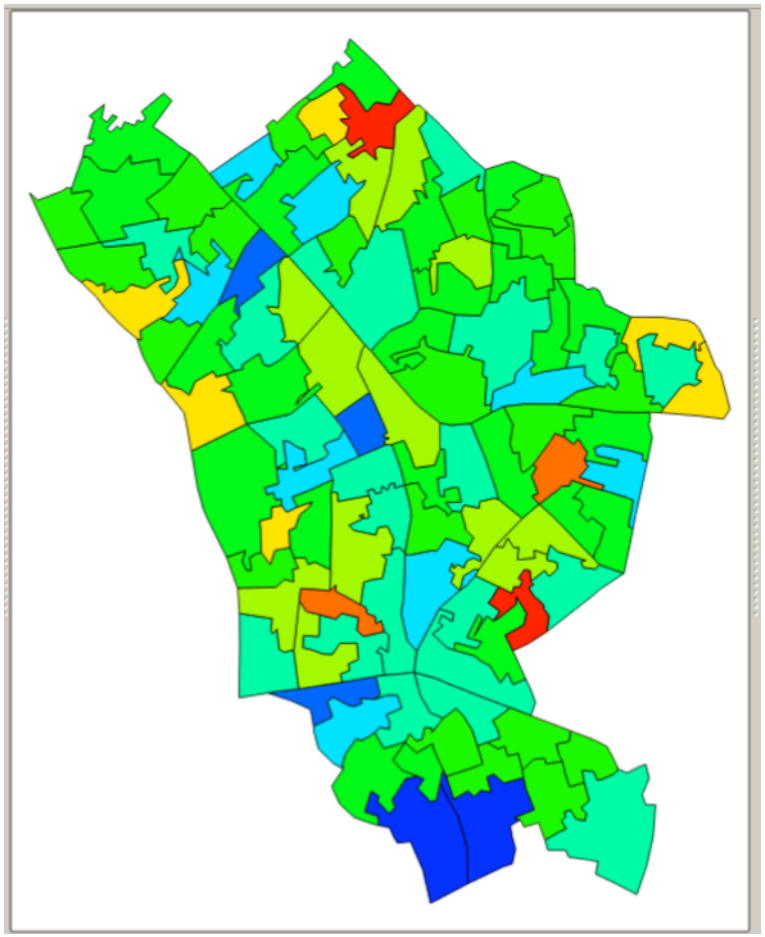


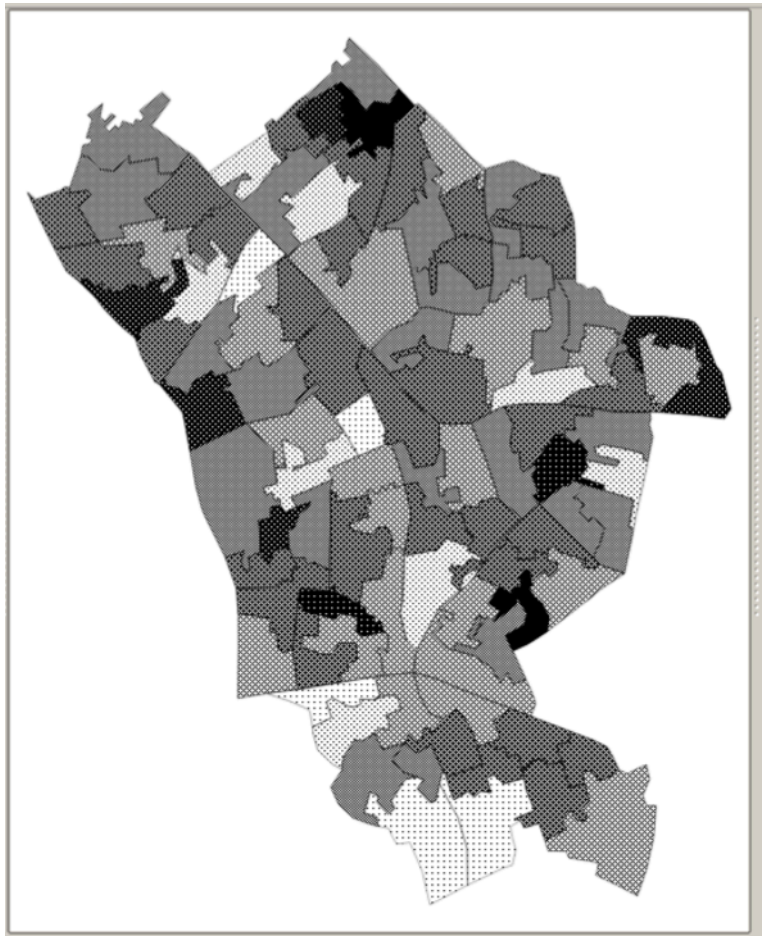
Visualising other layers with Attributes Explorer





Visualising other layers with Attributes Explorer





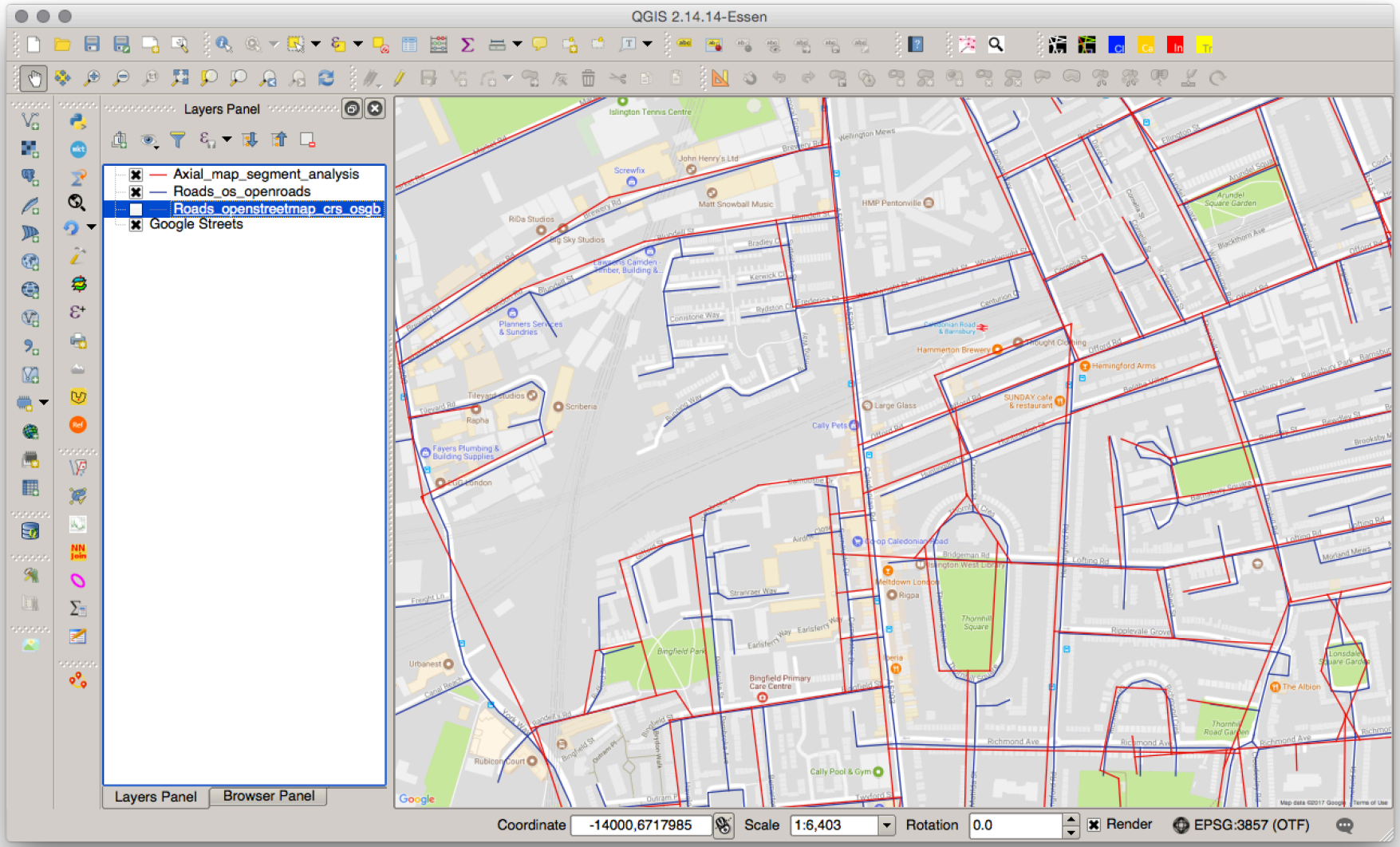
Questions and Discussion

QGIS methods for space syntax research

- Road centre lines: an approximation of segment maps?
- Road centre lines: which model is more appropriate?
- Connecting and analysing other data layers
- Analysis with R and other statistics packages
- Open to questions from the participants

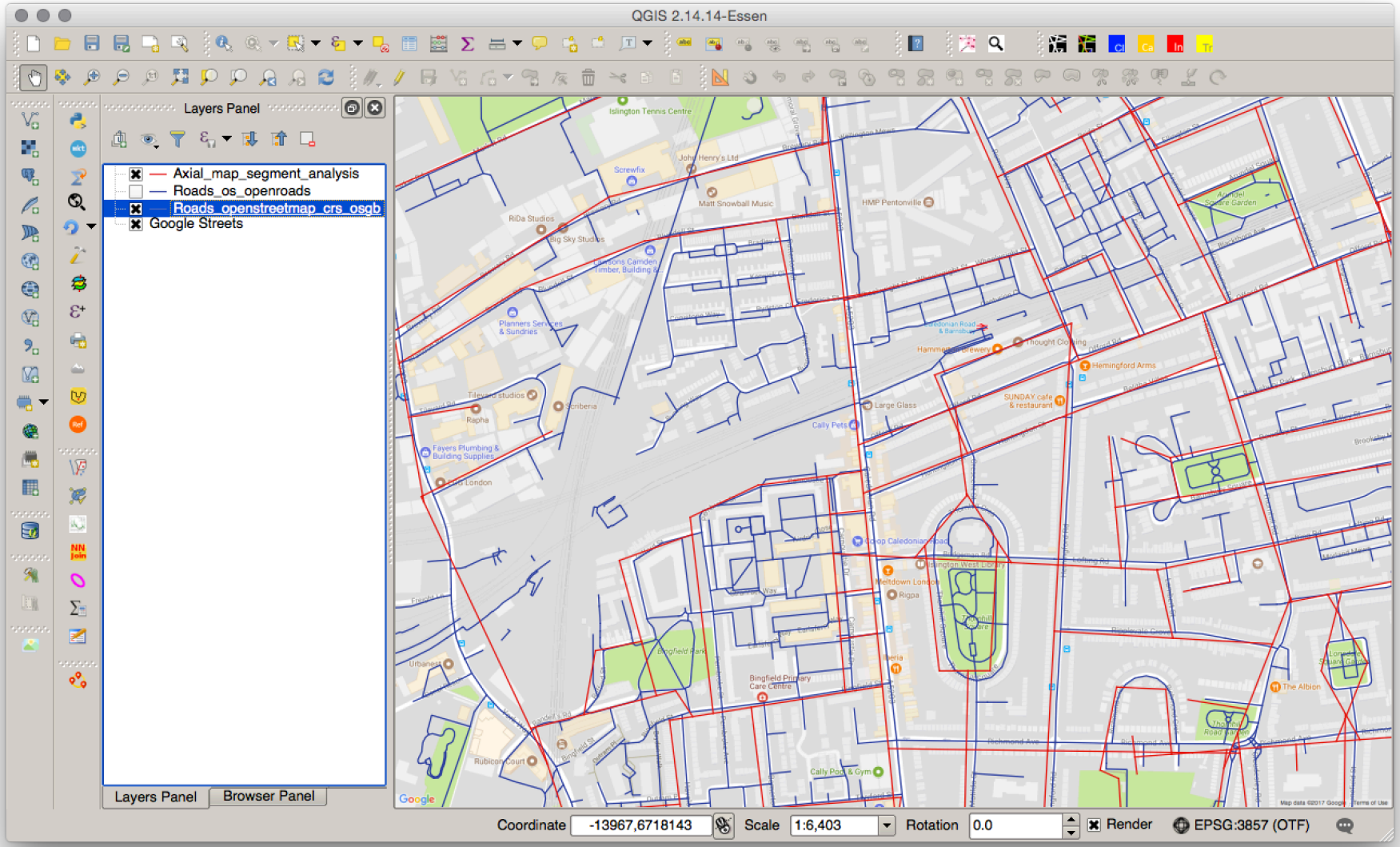
Questions and Discussion

Road centre lines: an approximation of segment maps?



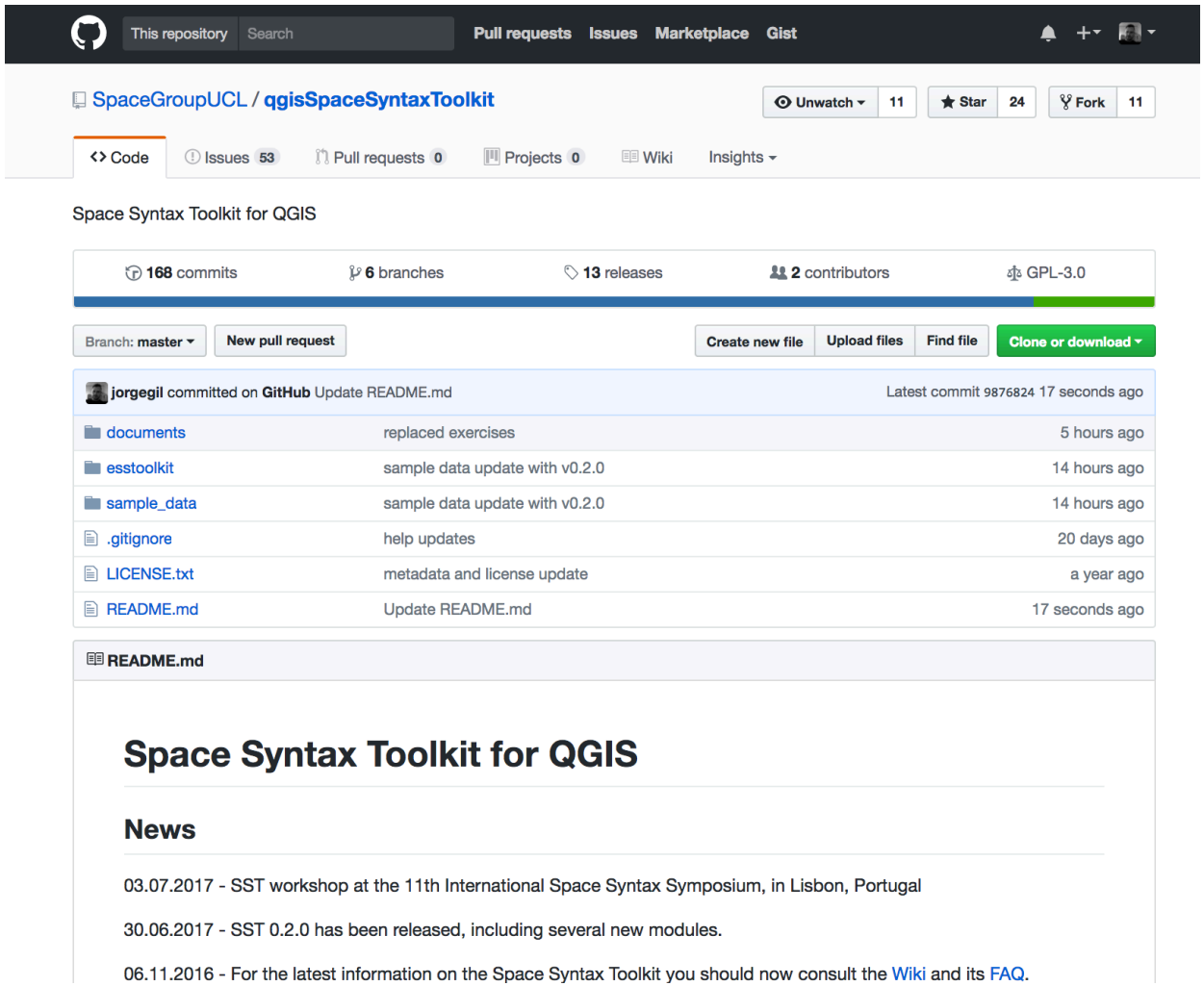
Questions and Discussion

Road centre lines: which model is more appropriate?



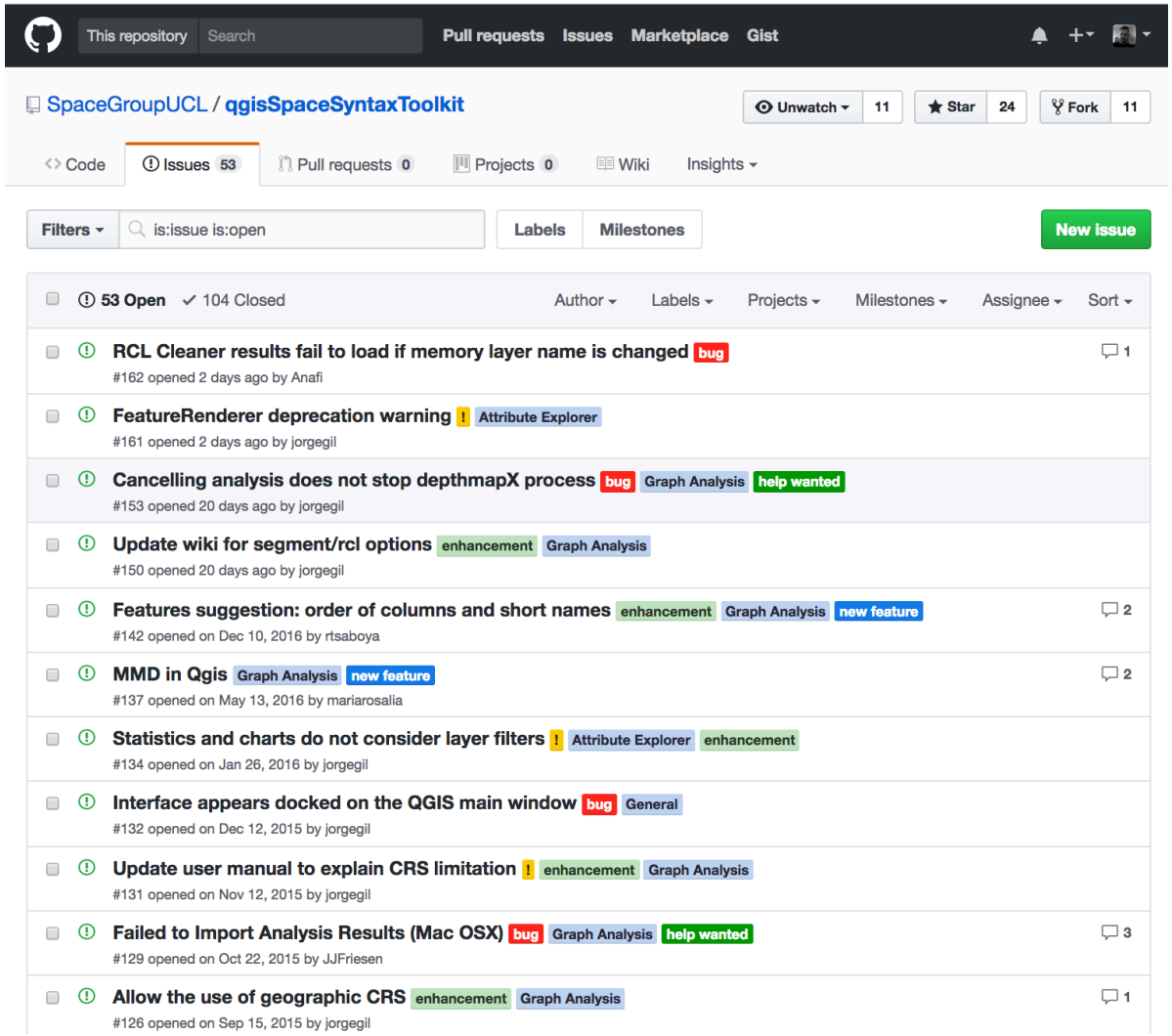
SST Github repository

https://github.com/SpaceGroupUCL/qgisSpaceSyntaxToolkit



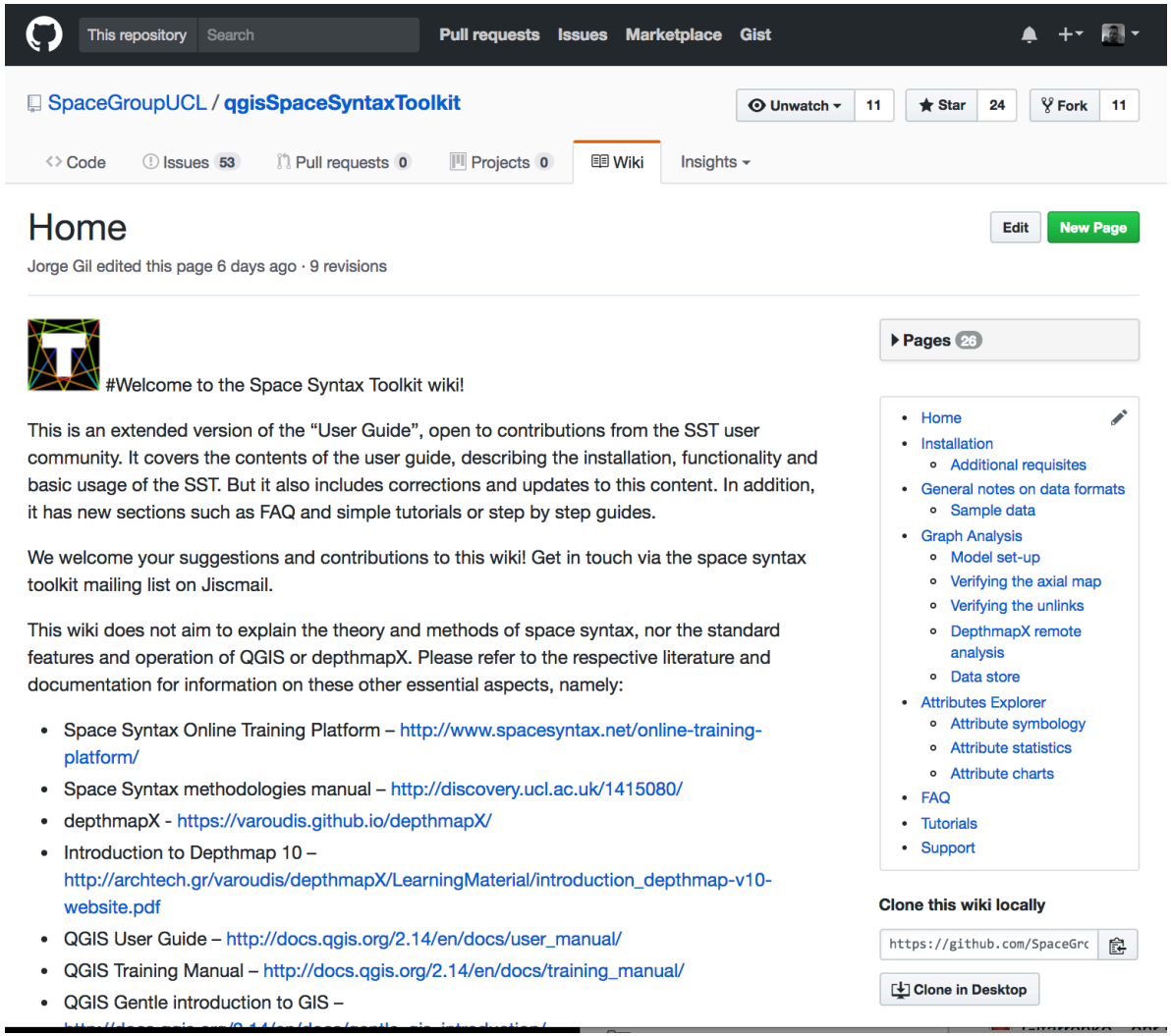
SST Issues

https://github.com/SpaceGroupUCL/qgisSpaceSyntaxToolkit/issues



SST Wiki

https://github.com/SpaceGroupUCL/qgisSpaceSyntaxToolkit/wiki



Thank you!

SST mailing list:

https://www.jiscmail.ac.uk/cgi-bin/webadmin?A0=SPACESYNTAX-TOOLKIT

Space syntax mailing list:

https://www.jiscmail.ac.uk/cgi-bin/webadmin?A0=SPACESYNTAX