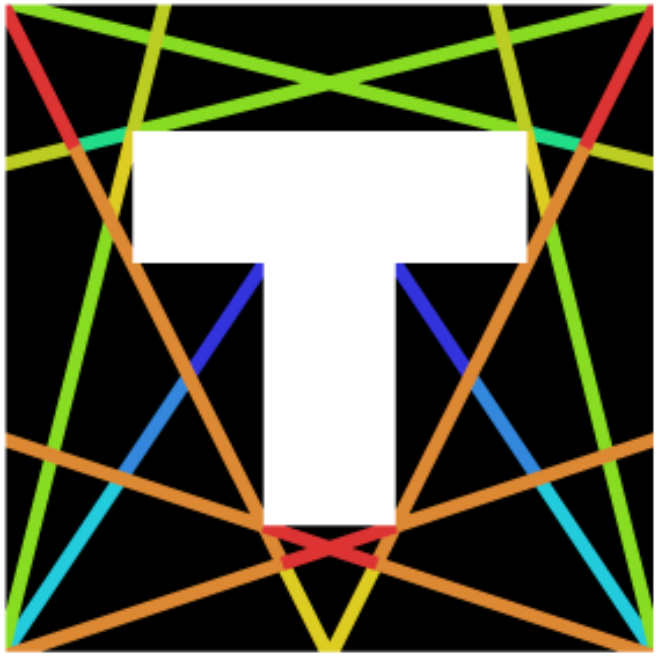
10th International Space Syntax Symposium
**Workshop 2**

# 'Space Syntax Toolkit' for QGIS

Open source GIS and network analysis for space syntax research and practice

Jorge Gil

Space Syntax Laboratory
The Bartlett, UCL



13/07/2015 – 09:00 to 16:00
Levinsky Room, Institute of Child Health, UCL

# Introduction

- Instructor
- Participants
- Objectives
- Outline

# Instructor

- Author ‘Space Syntax Toolkit’ for QGIS (2013 - )
- Author ‘Confeego’ for MapInfo (2004 - 09)
- MSc Virtual Environments, The Bartlett, UCL
- PhD Researcher, Urbanism, TU Delft (2009 - 15)
- Work on assessing the sustainability of neighbourhoods in city-regions: focus on multi-modal mobility and accessibility
- Research on City Information Modelling
- Use and development of open source GIS and statistical analysis packages

# Participants

| | Yes / Some | No |
|---|---|---|
| space syntax | 14 | 2 |
| depthmapX | 12 | 4 |
| GIS | 12 | 4 |
| QGIS | 5 | 11 |

Note: based on 16 participant's responses.

# Objectives

1. Demonstrate and learn how to use the 'Space Syntax Toolkit' (SST) for QGIS;

2. Explore ways in which QGIS (and GIS) can be used in space syntax research and practice;

3. Discuss how the SST can grow and evolve.

# Outside Objectives

- Learn about space syntax theory and methods:
  - http://www.spacesyntax.net/online-training-platform/
- Learn about space syntax applications in research:
  - http://www.spacesyntax.net/symposia/
- Learn about depthmapX:
  - https://varoudis.github.io/depthmapX/
  - https://github.com/SpaceGroupUCL/Depthmap/tree/master/docs
- Learn about QGIS:
  - http://docs.qgis.org/2.8/en/docs/index.html

'Space Syntax Toolkit' for QGIS

09:15 – **Part 1** – Overview

10:30 – Break

10:45 – **Part 2** – Demonstration and Exercise

12:30 – Lunch Break

13:30 – **Part 3** – Exploration and Discussion

16:00 – Close

# Part 1 – Overview

1. The SST project
2. Comprehensive description and explanation of the SST's features
3. Installation of the plugin
4. SST project repository

# Part 2 – Demonstration and Exercise

1. Before we begin: data formats
2. Exercise: complete SST workflow

# Part 3 – Exploration and Discussion

1. GIS stages and operations for space syntax
2. Useful QGIS plugins and tools
3. Examples of work
4. Exploration of space syntax QGIS workflows
5. Discussion on new workflows for the SST

# PART 1 – Overview

# Part 1 – Overview

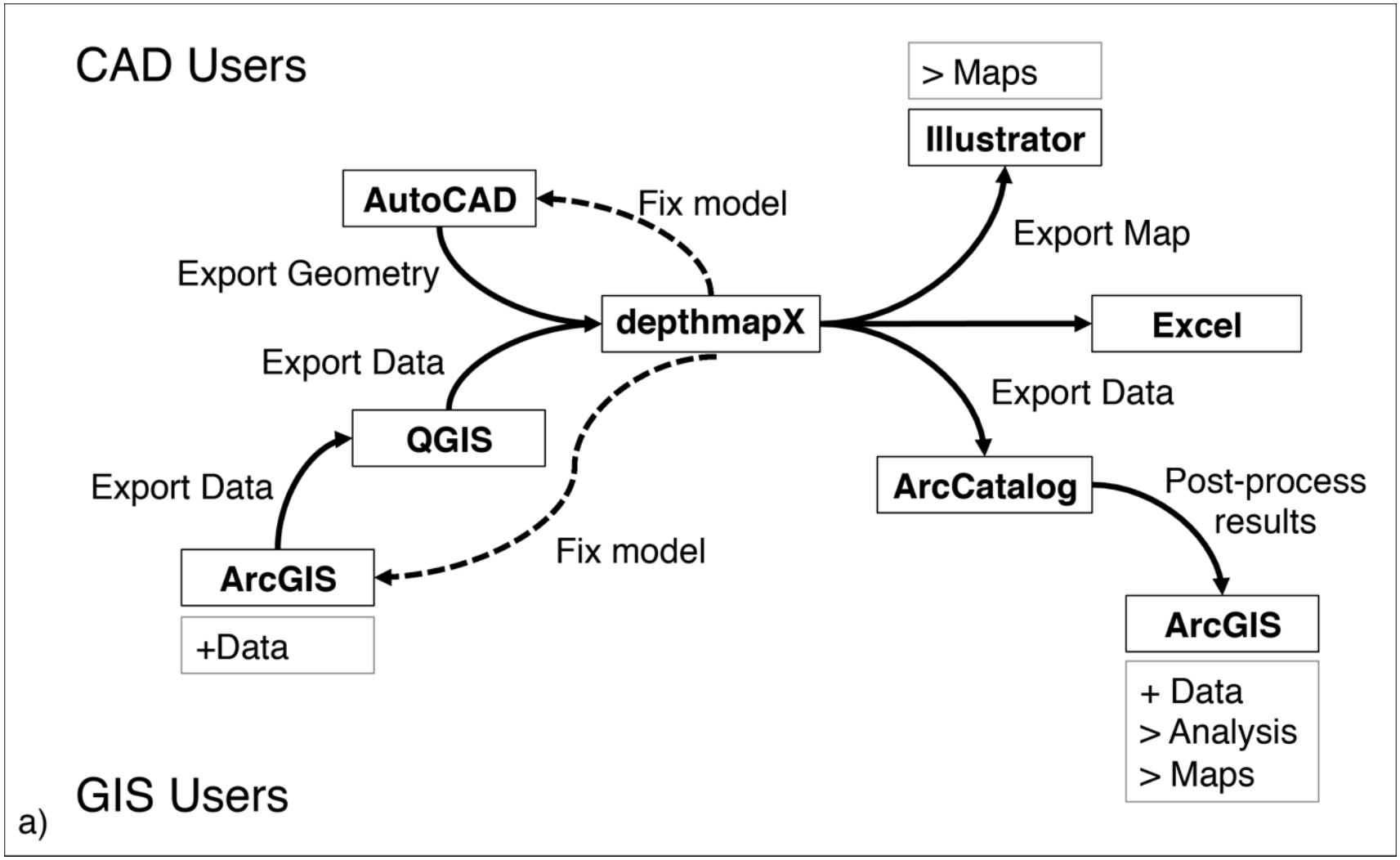
1. The SST project
2. Comprehensive description and explanation of the SST's features
3. Installation of the plugin
4. SST project repository

- An open source project for space syntax education, research and practice;
- Led by the Space Syntax Laboratory, UCL;
- Developed in connection with the depthmapX software project;
- For the space syntax community.

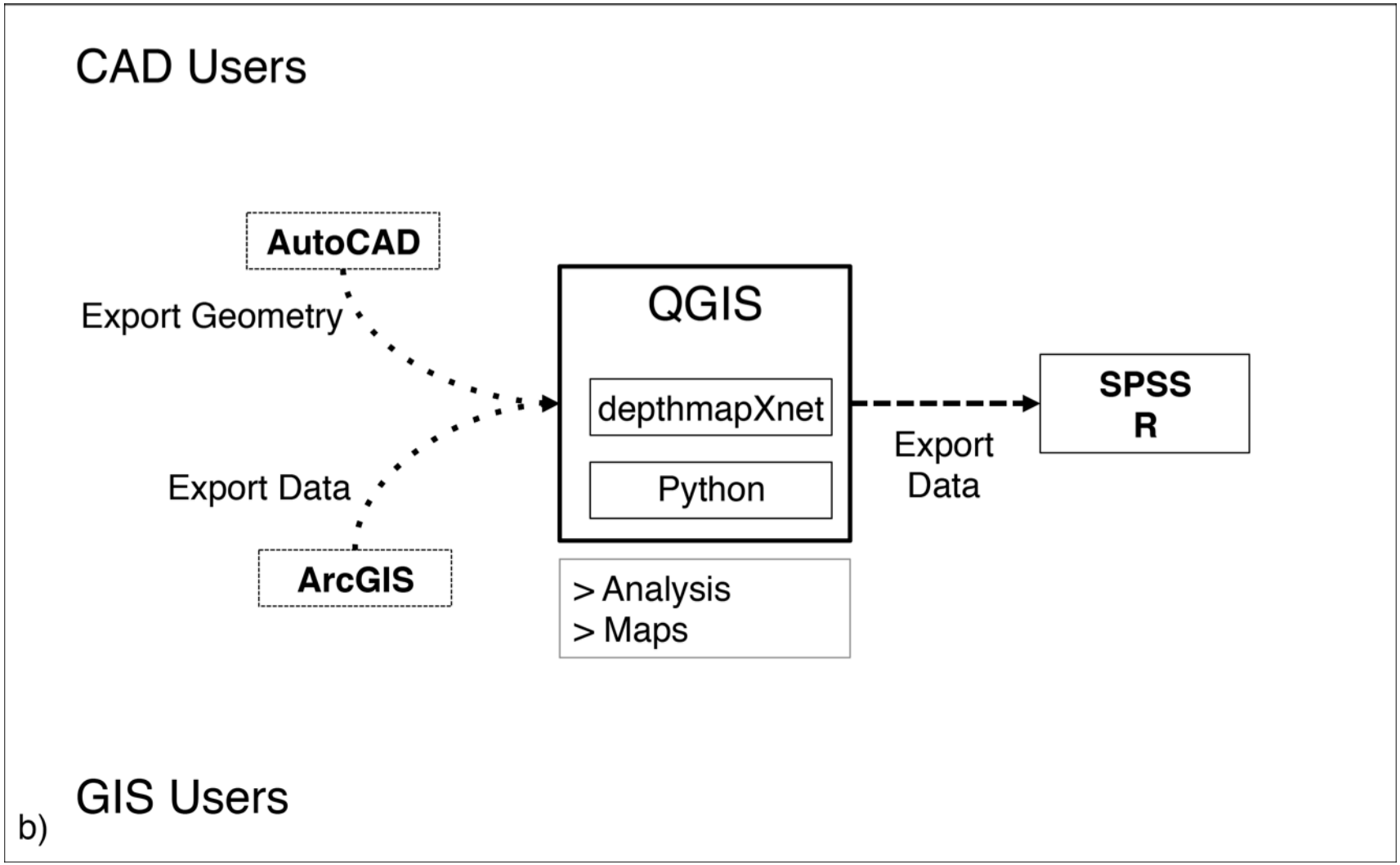
# Project aims

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

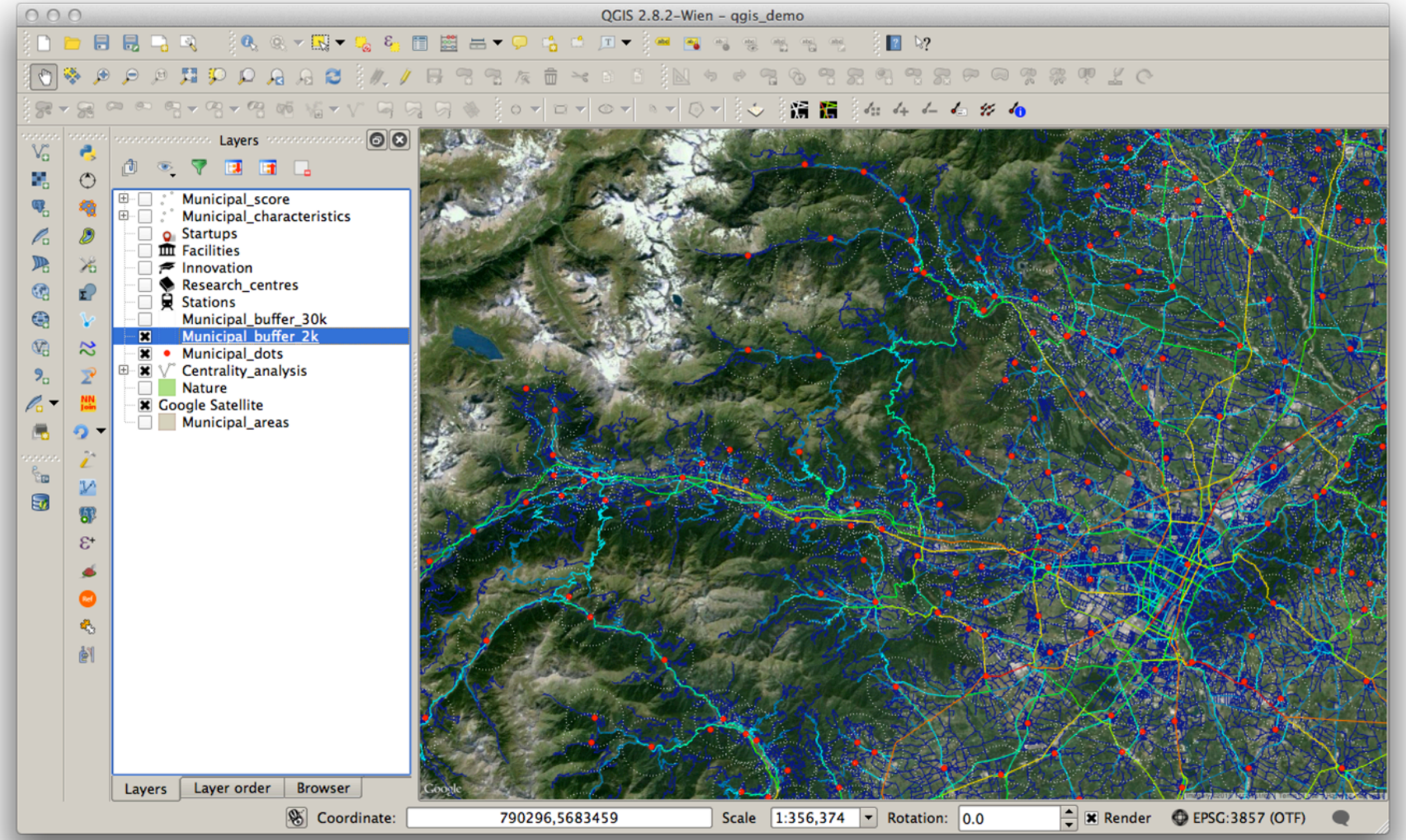
# Traditional workflow



# Desired workflow



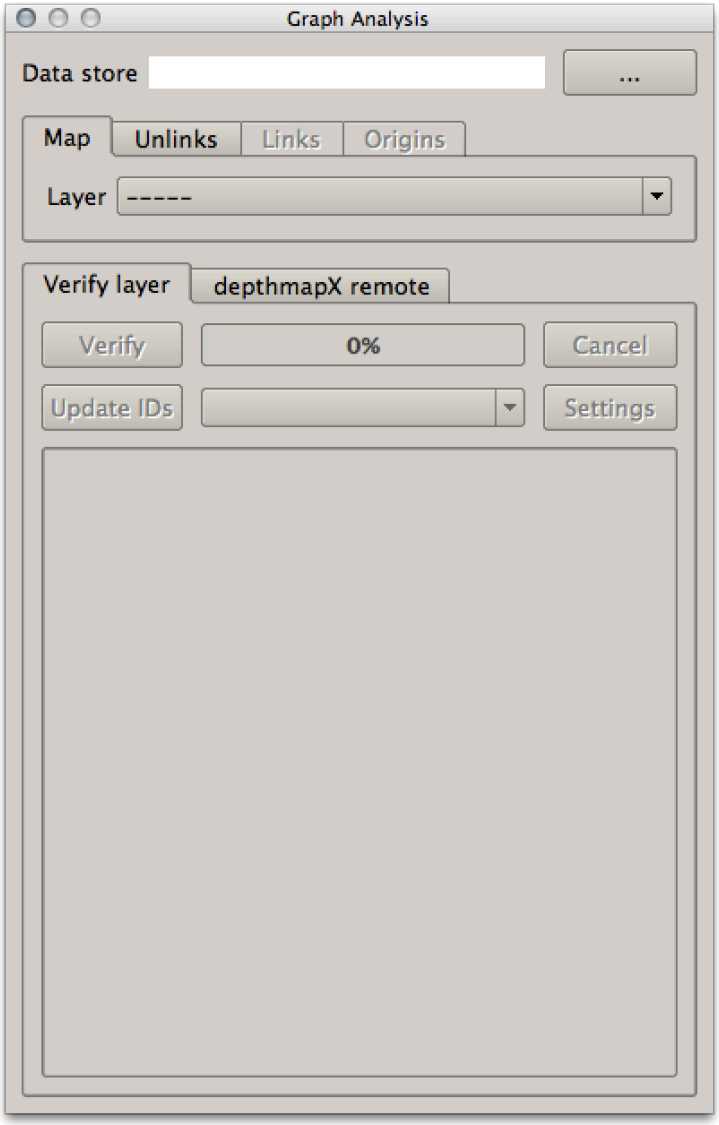
# Why choose QGIS?

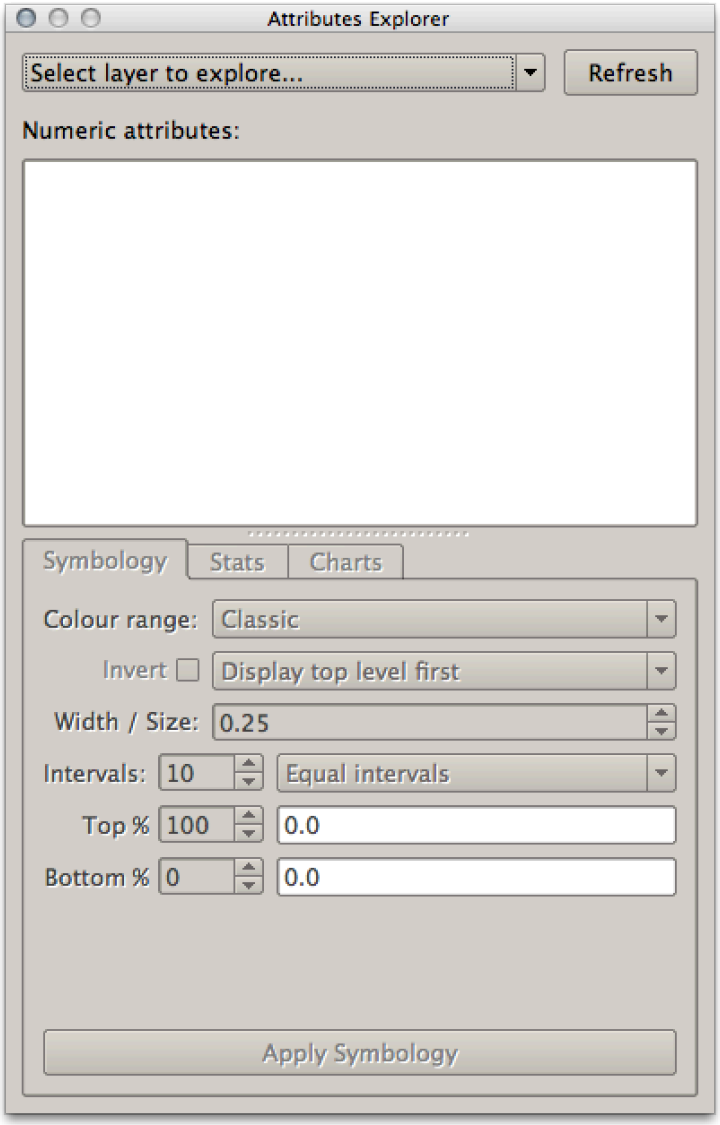


# Why choose QGIS?

- Free and open source
- Cross-platform (Windows, Linux, Mac OSX)
- User friendly interface
- Well documented (in English and other languages)
- Growing user and developer community
- Extensive input/output data formats, tools and plugins
- Managed installation and maintenance of plug-ins
- Based on open standards and packages
- Automation tools and customisation with Python

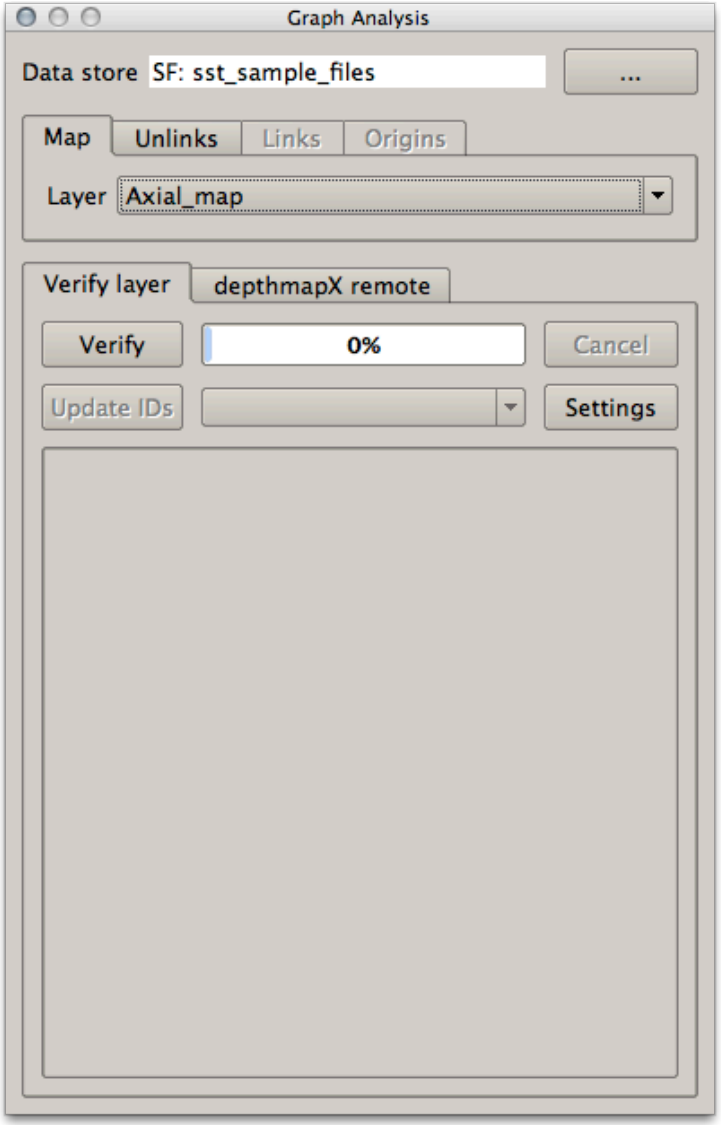
# Space Syntax Toolkit (SST)

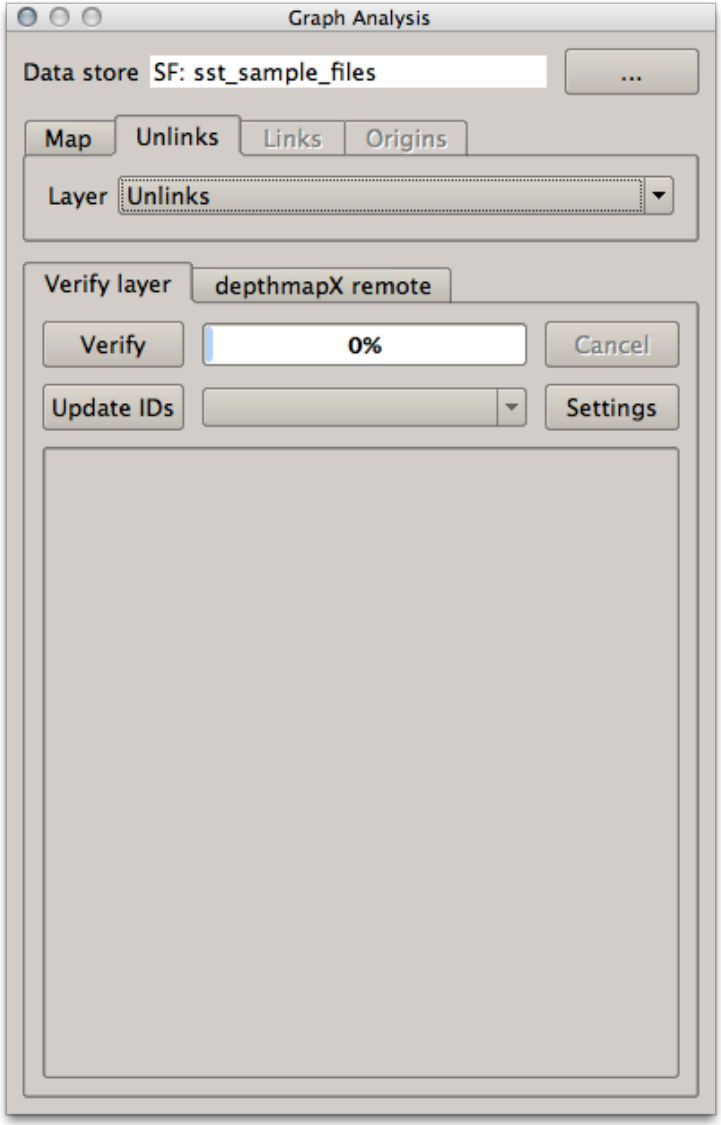


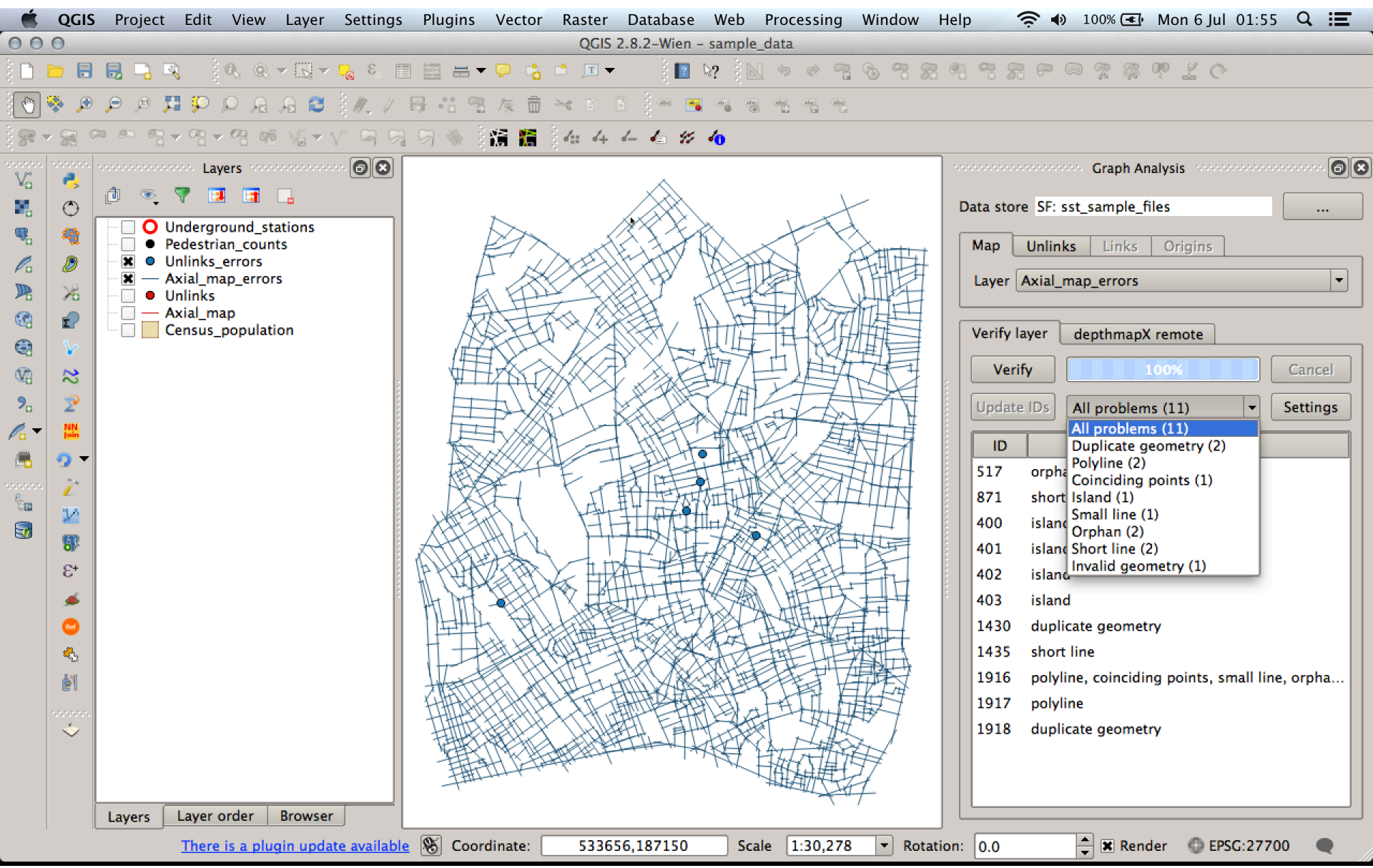
- Integrated workflows for:
  - Axial model verification and analysis
  - Results post-processing and import
- Input data format agnostic
- Output to all QGIS native formats
- Alternative algorithms optimised for geodatabases
- Standard defaults, advanced settings hidden
- Multi-threaded

# Model set-up


Graph Analysis
Data store
SF: sst_sample_files
...
Map
Unlinks
Links
Origins
Layer
Axial_map
Verify layer
depthmapX remote
Verify
0%
Cancel
Update IDs
Settings

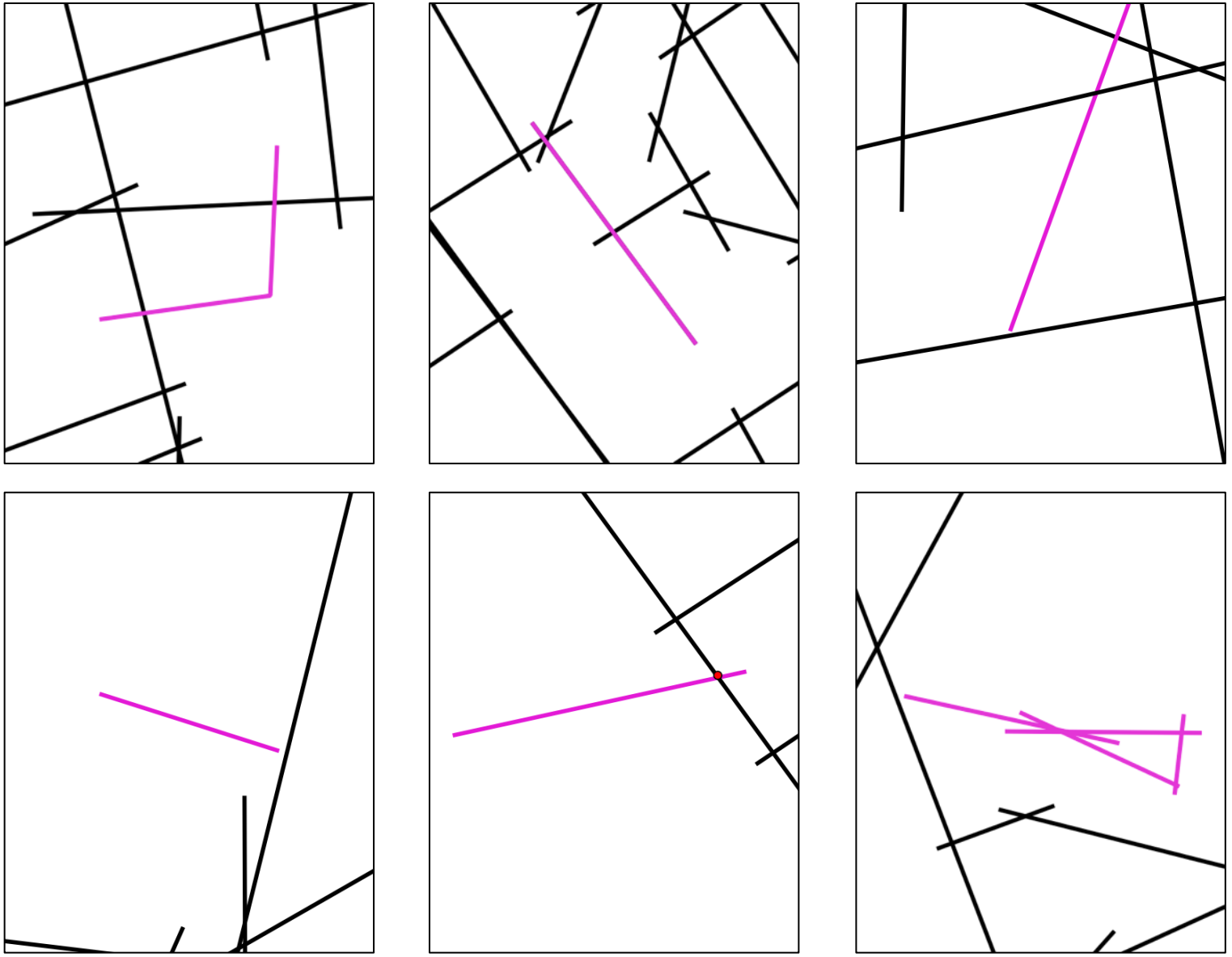

Graph Analysis
Data store
SF: sst_sample_files
...
Map
Unlinks
Links
Origins
Layer
Unlinks
Verify layer
depthmapX remote
Verify
0%
Cancel
Update IDs
Settings

# Model verification: Map

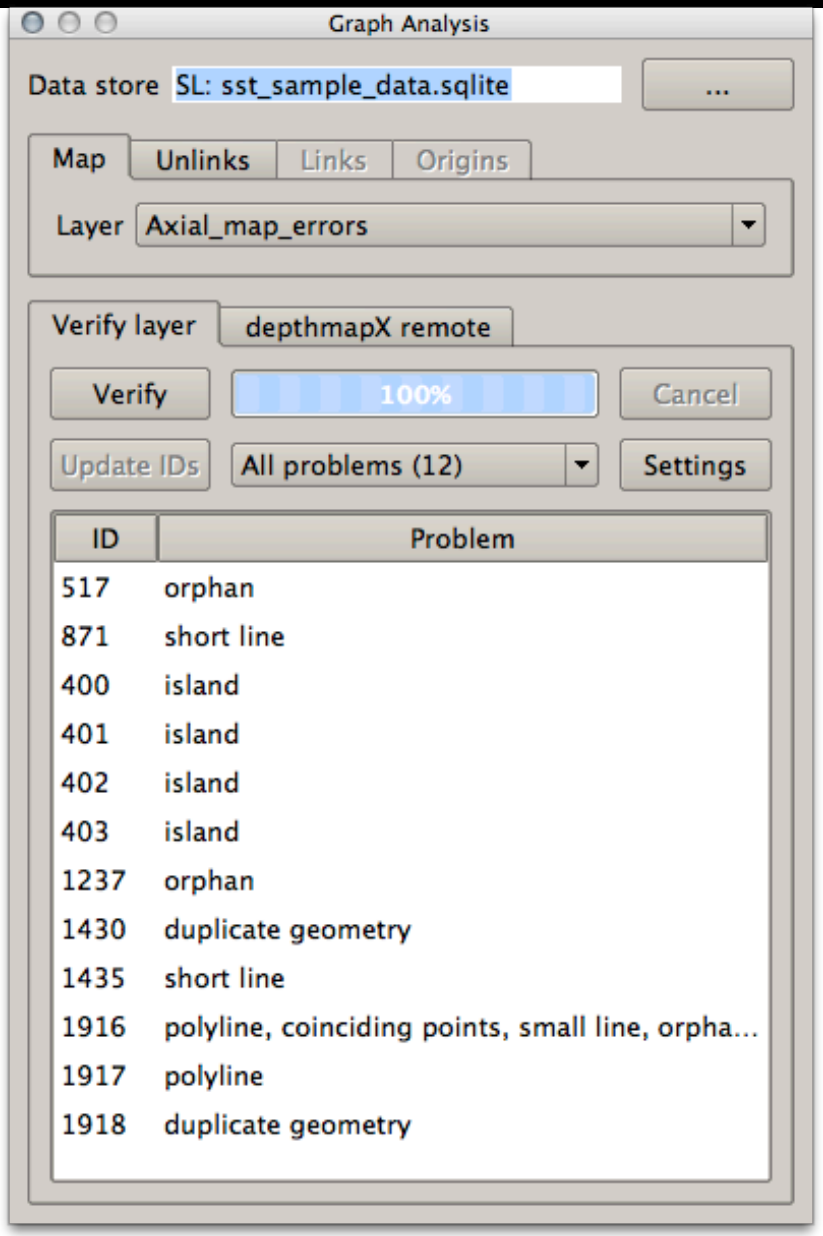


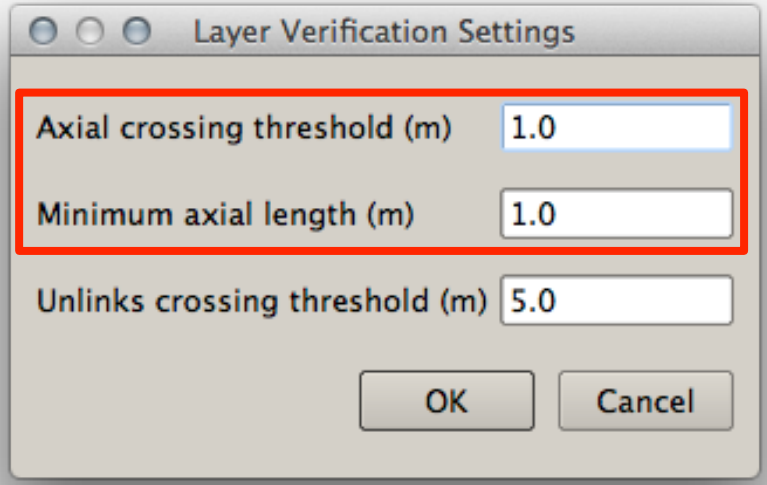
# Map error types

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

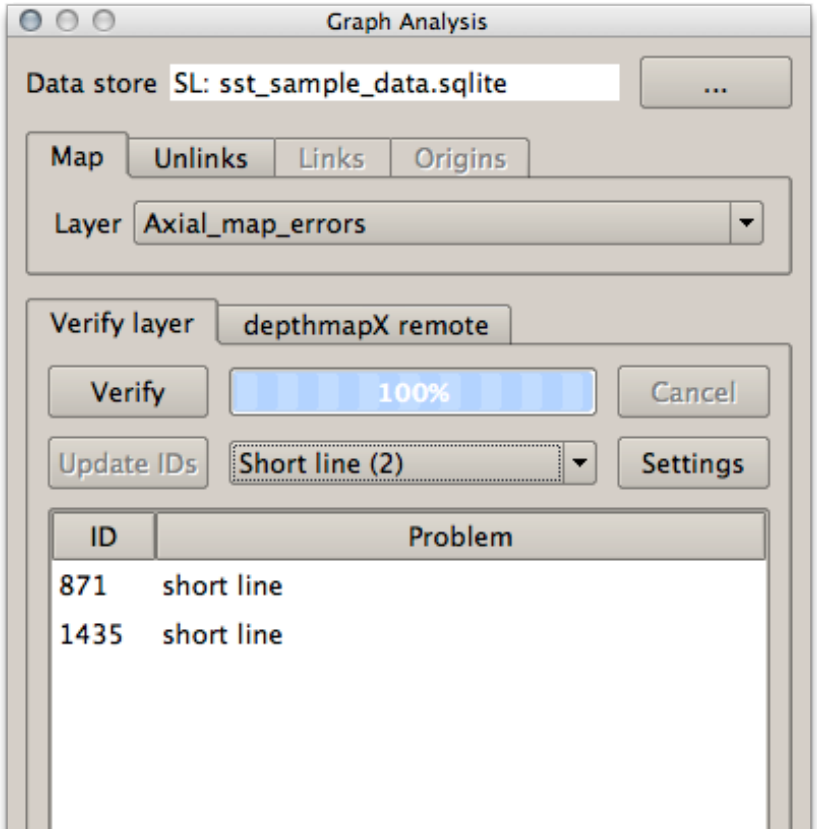


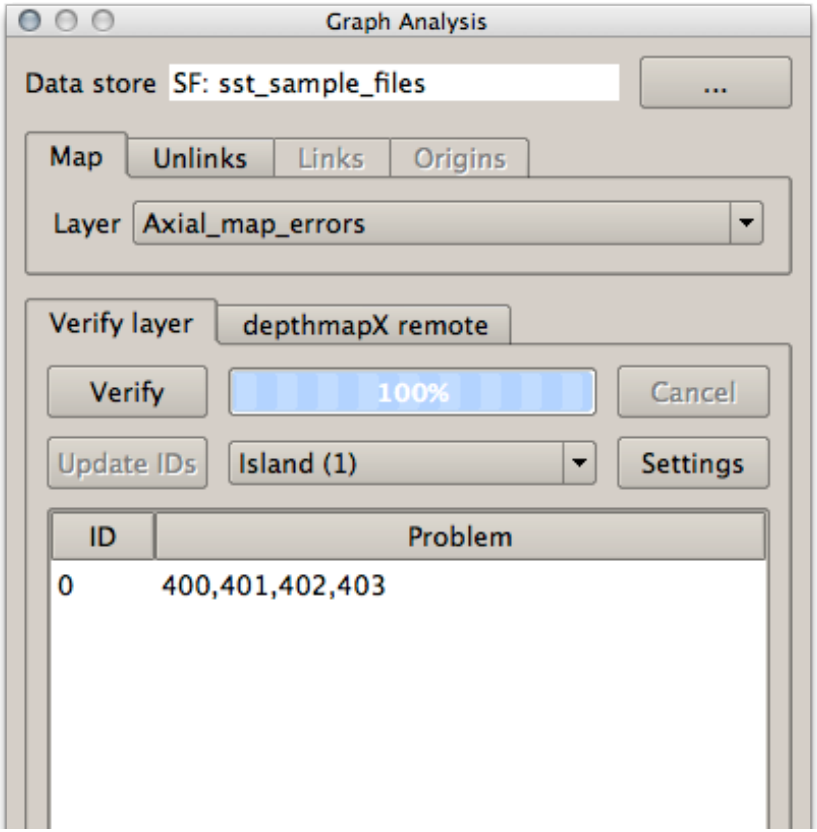
# Map verification results and settings



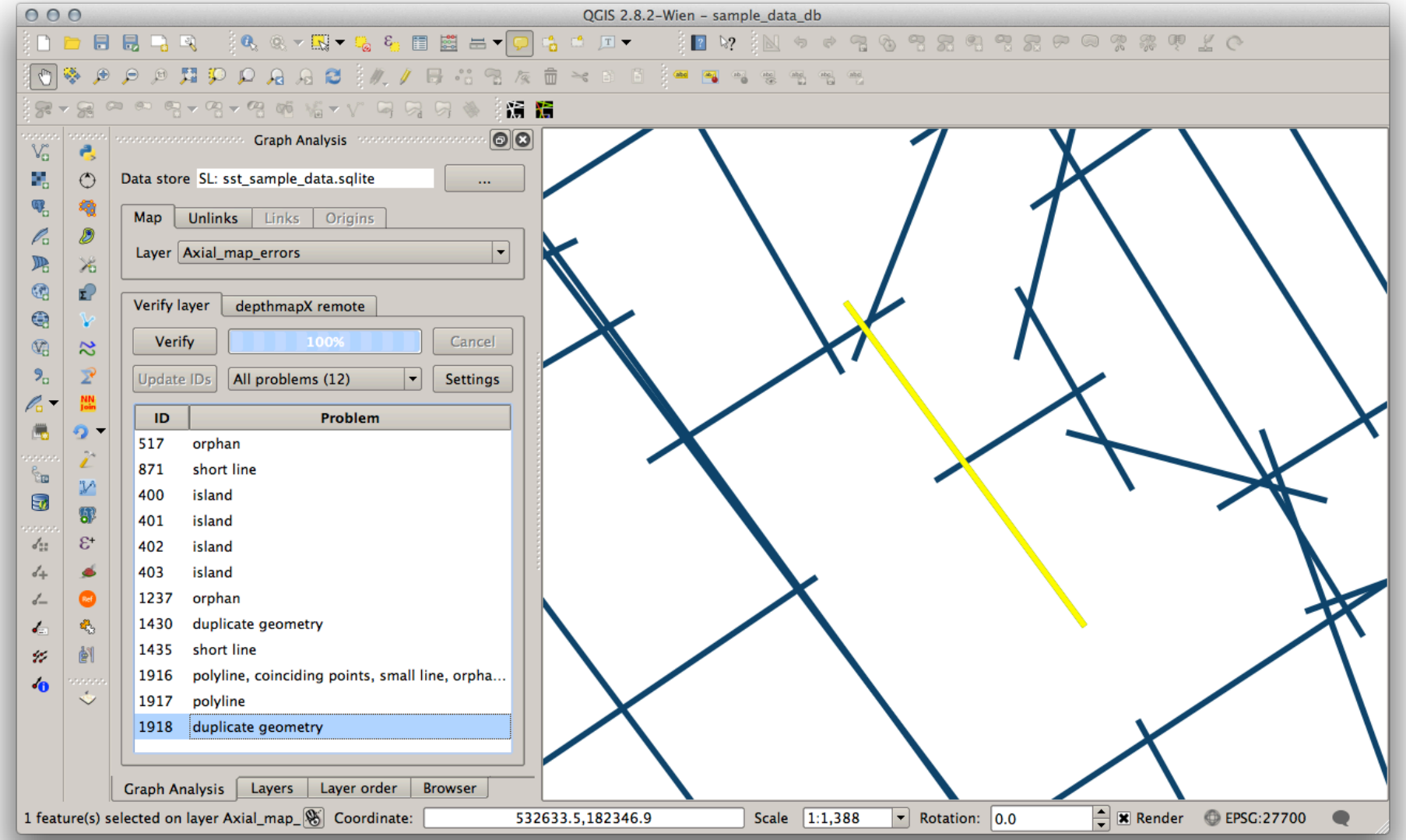



# Filter map errors

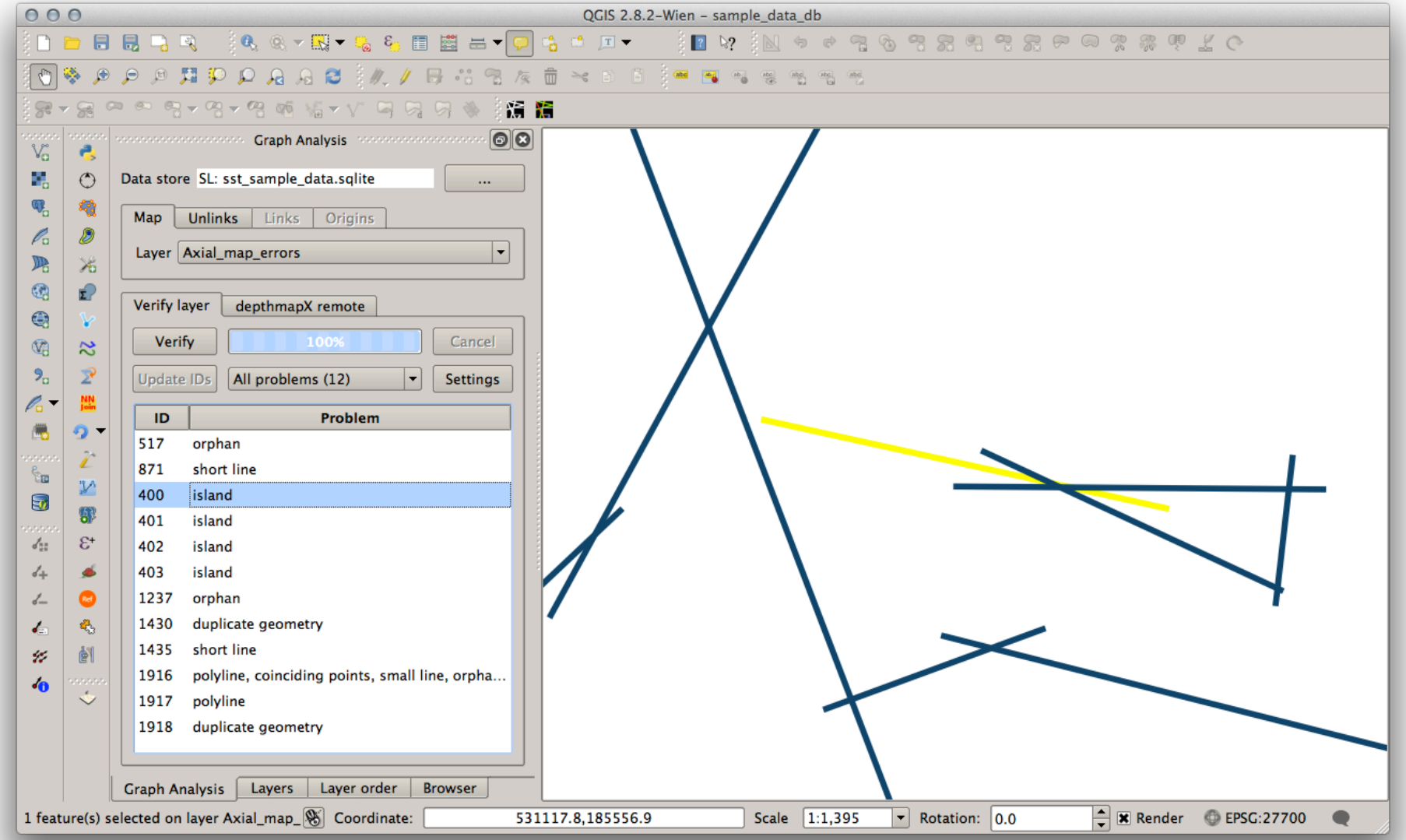


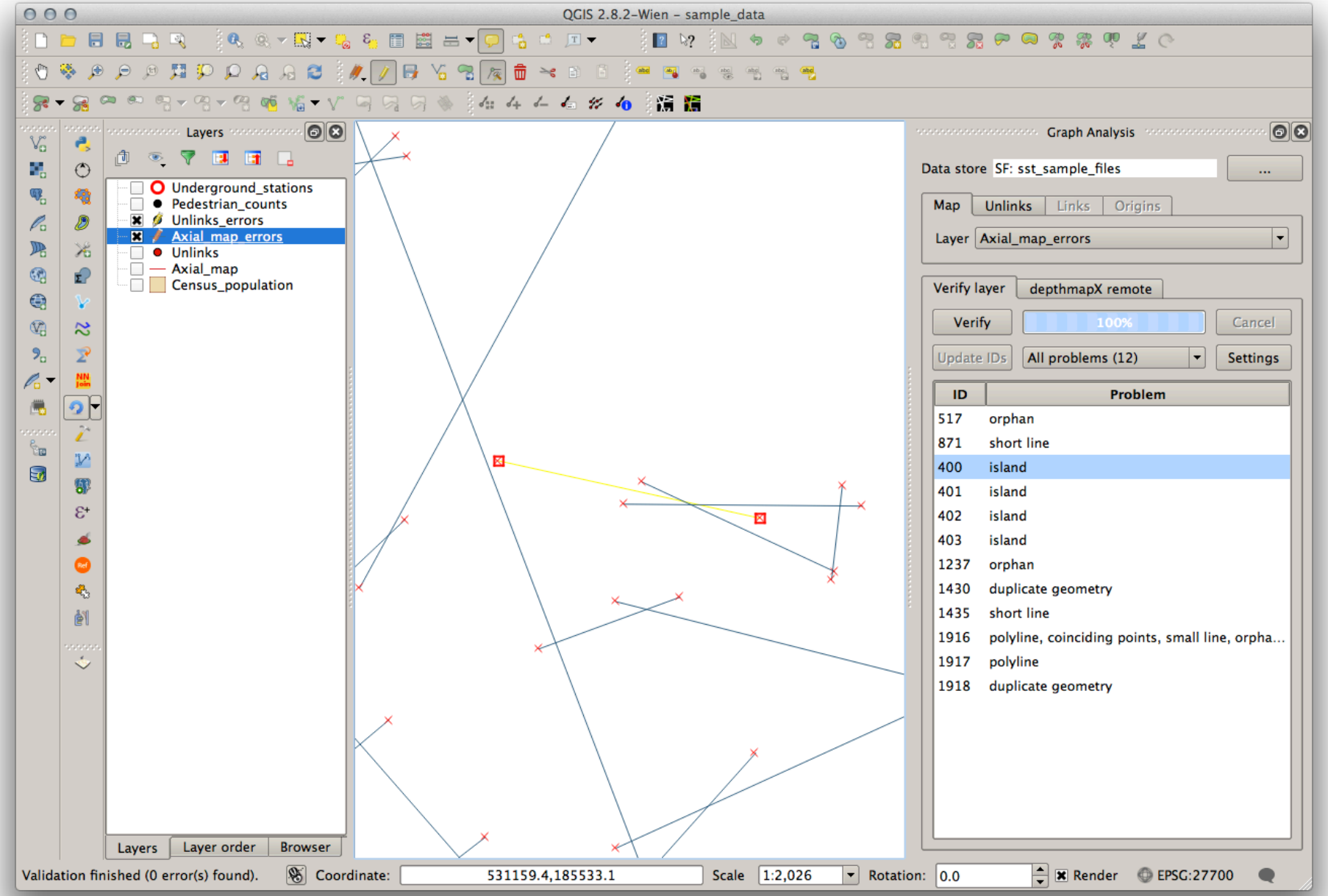
# Zoom to map errors



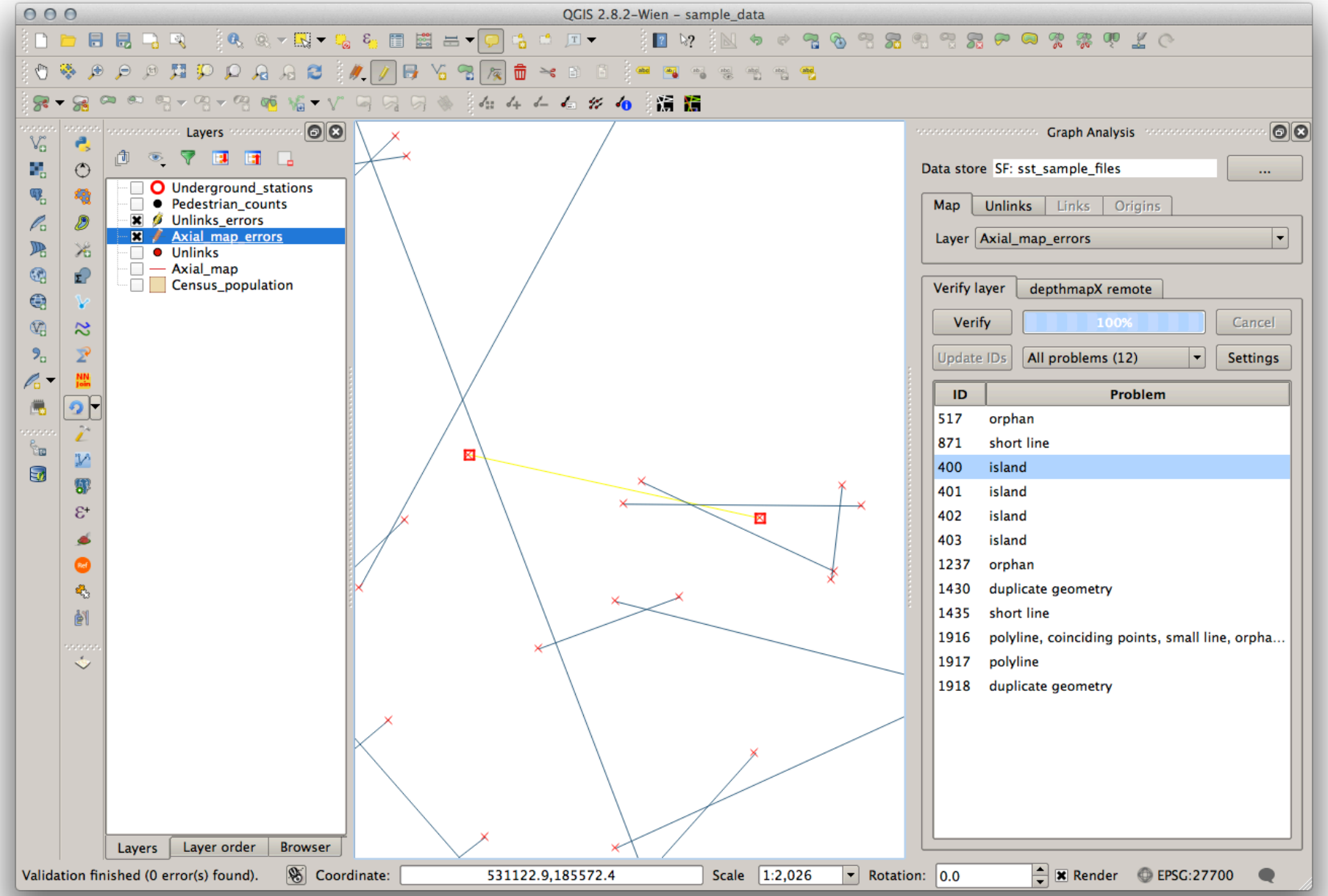
# Zoom to map errors



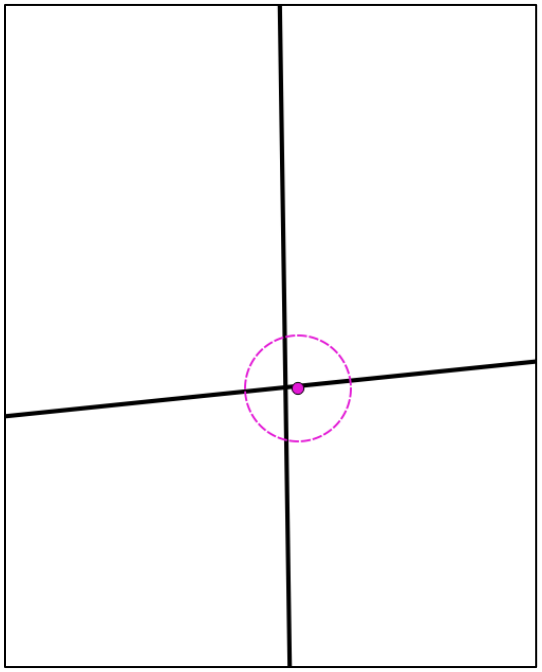
# Edit and fix map errors

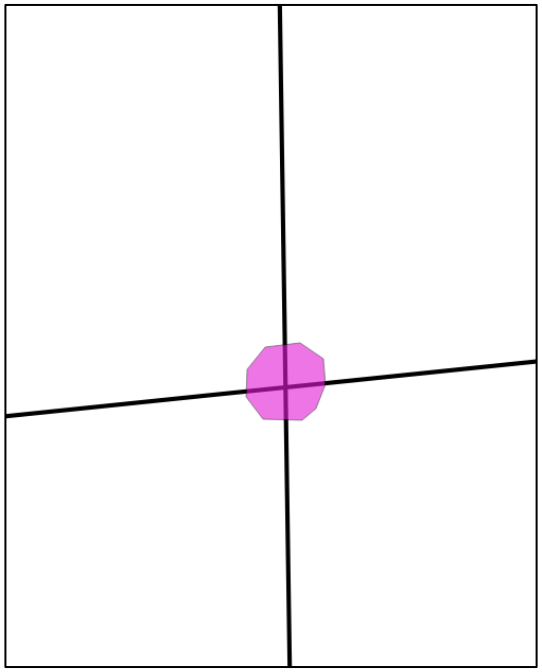


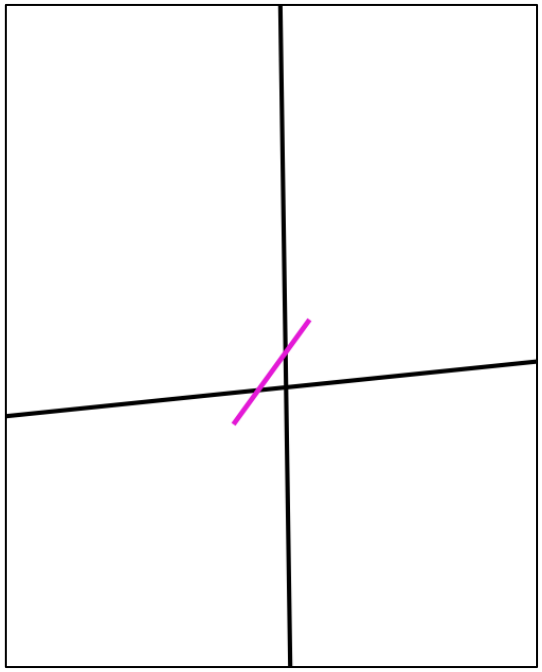
# Edit and fix map errors



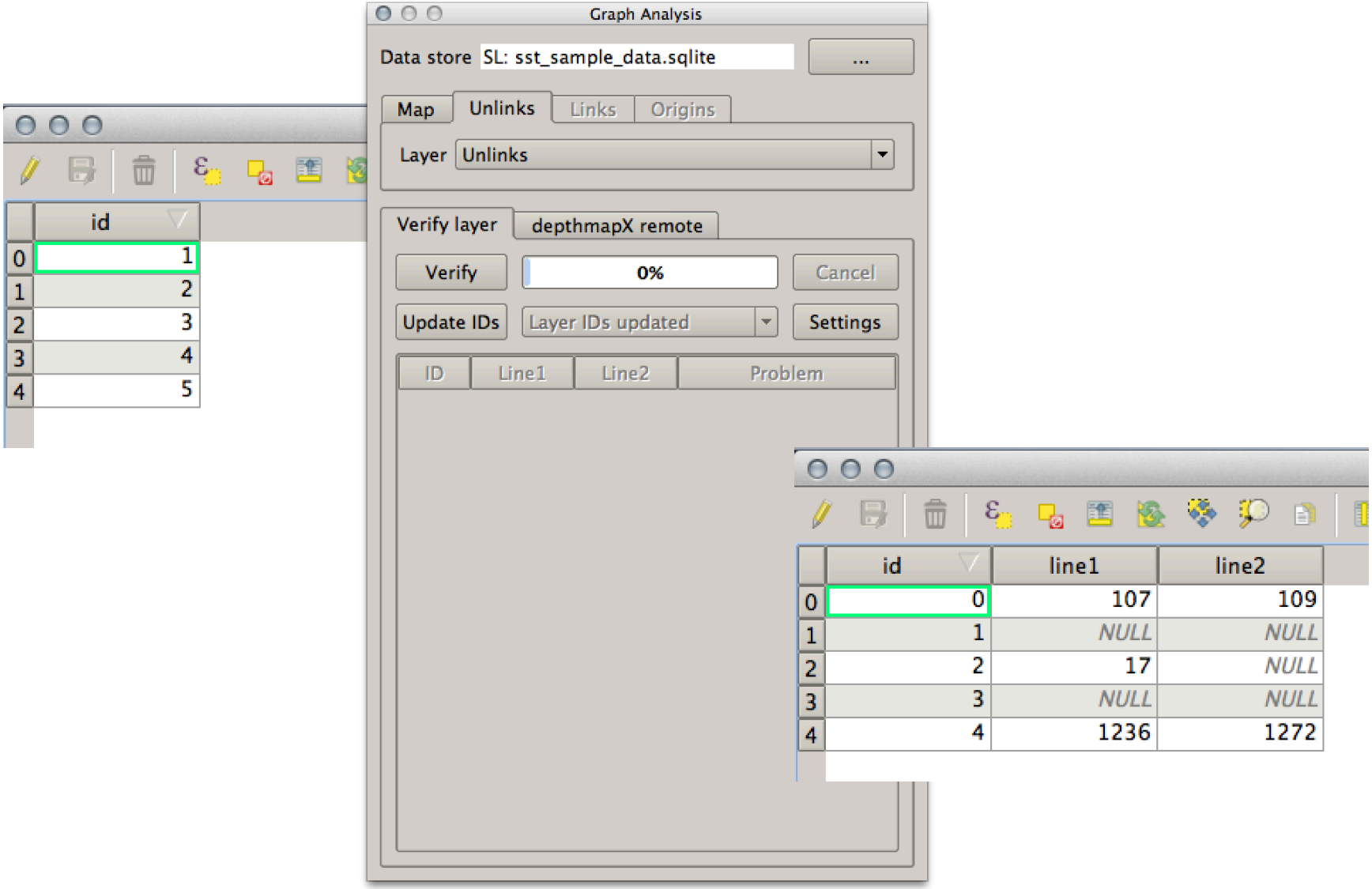
# Model verification: Unlinks





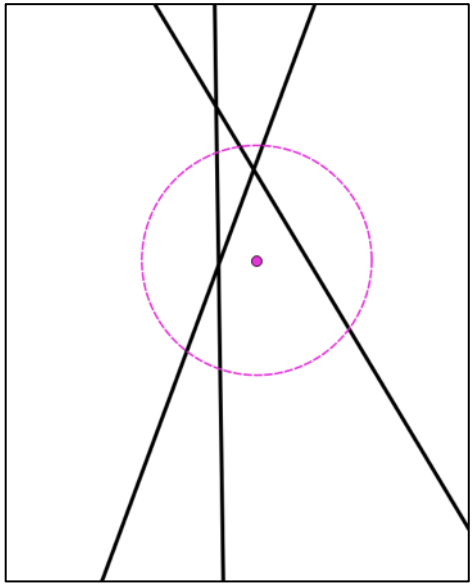


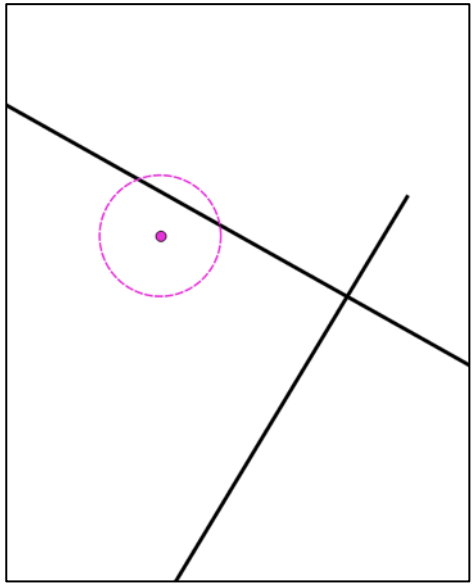
# Update line id attributes

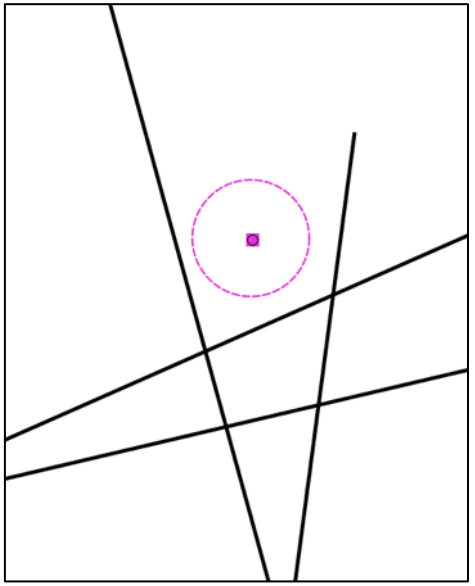


# Unlinks error types

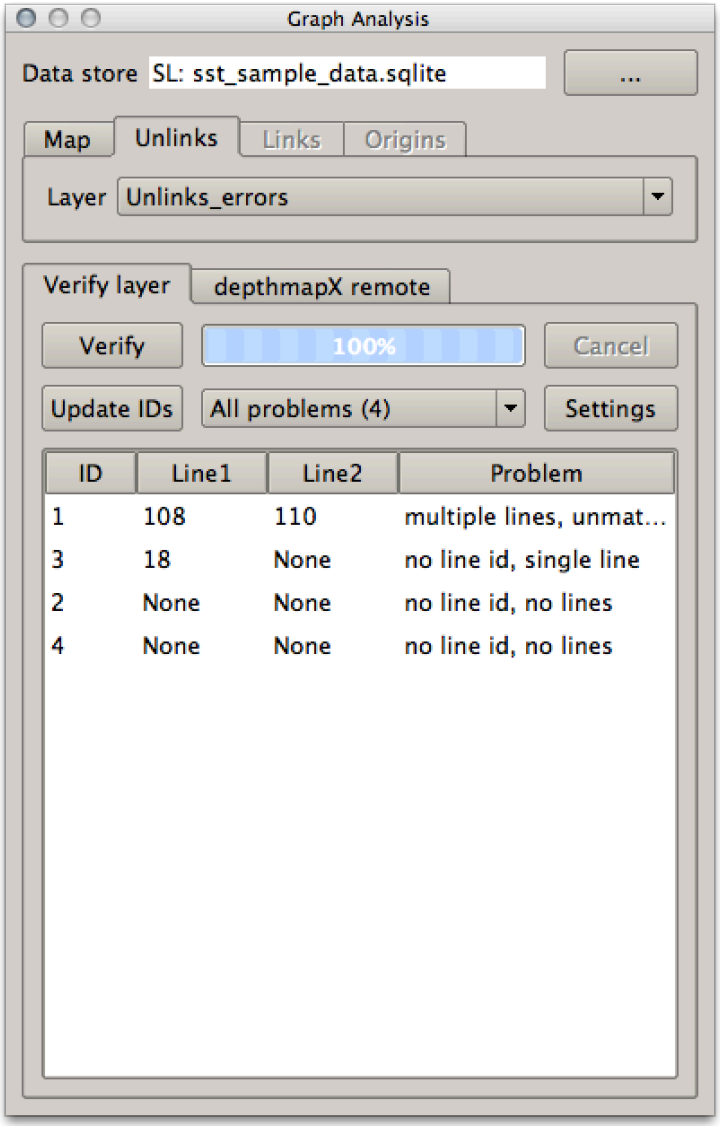
- Multiple lines
- Single line
- No lines
- No line id
- Same line id
- Unmatched line id

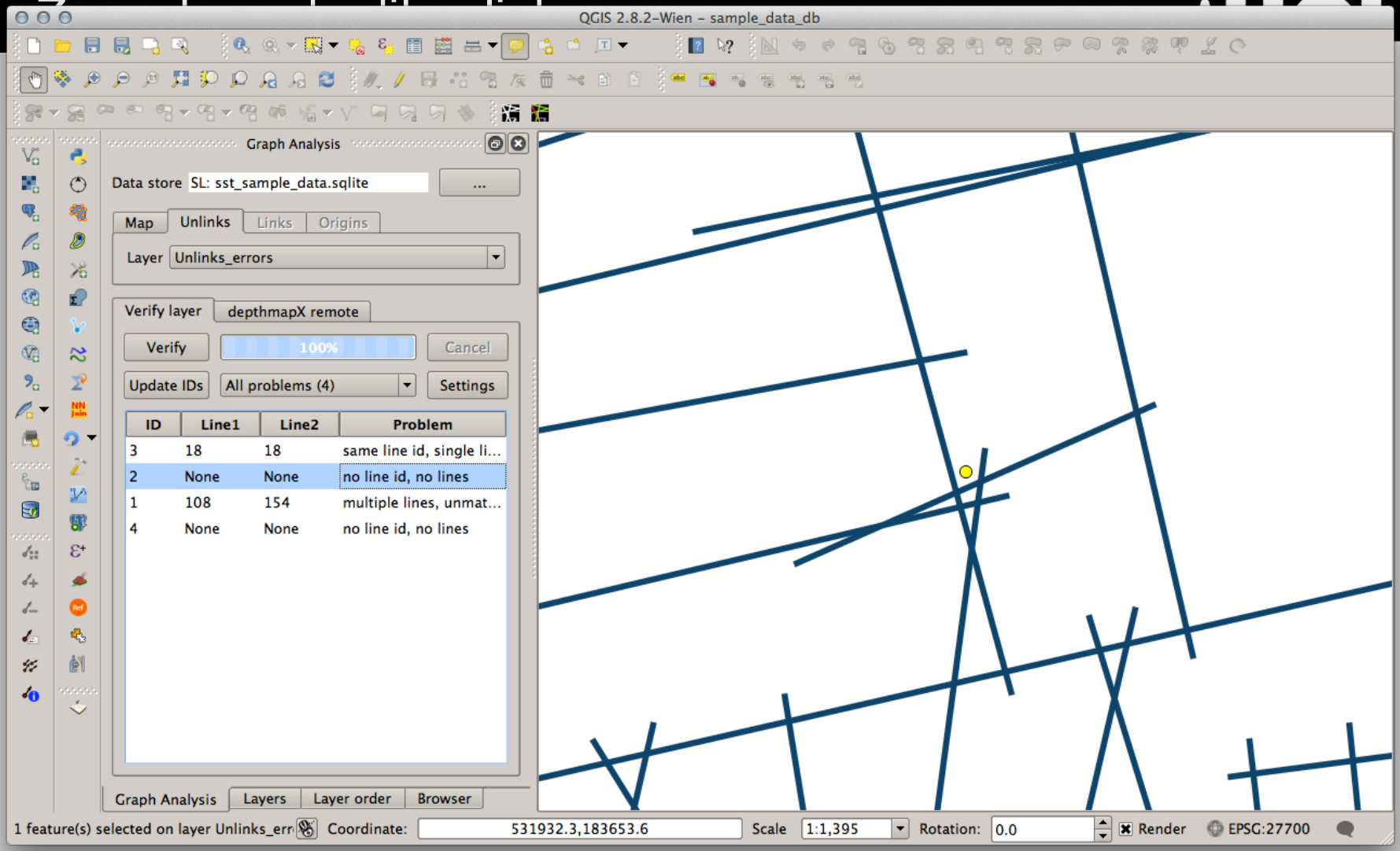






# Unlinks verification results




QGIS 2.8.2-Wien - sample_data_db
Graph Analysis
Data store
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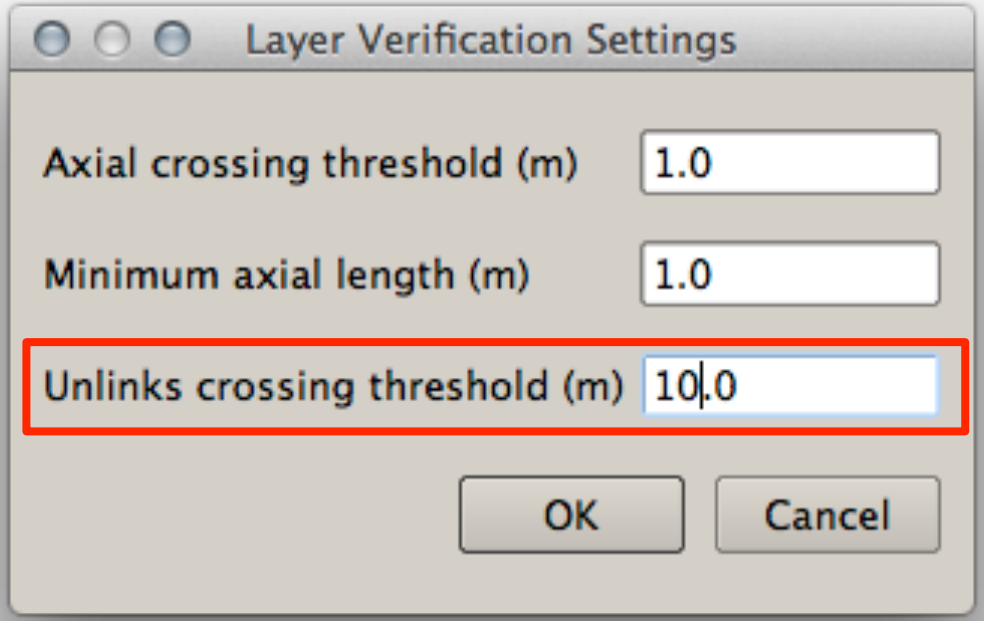
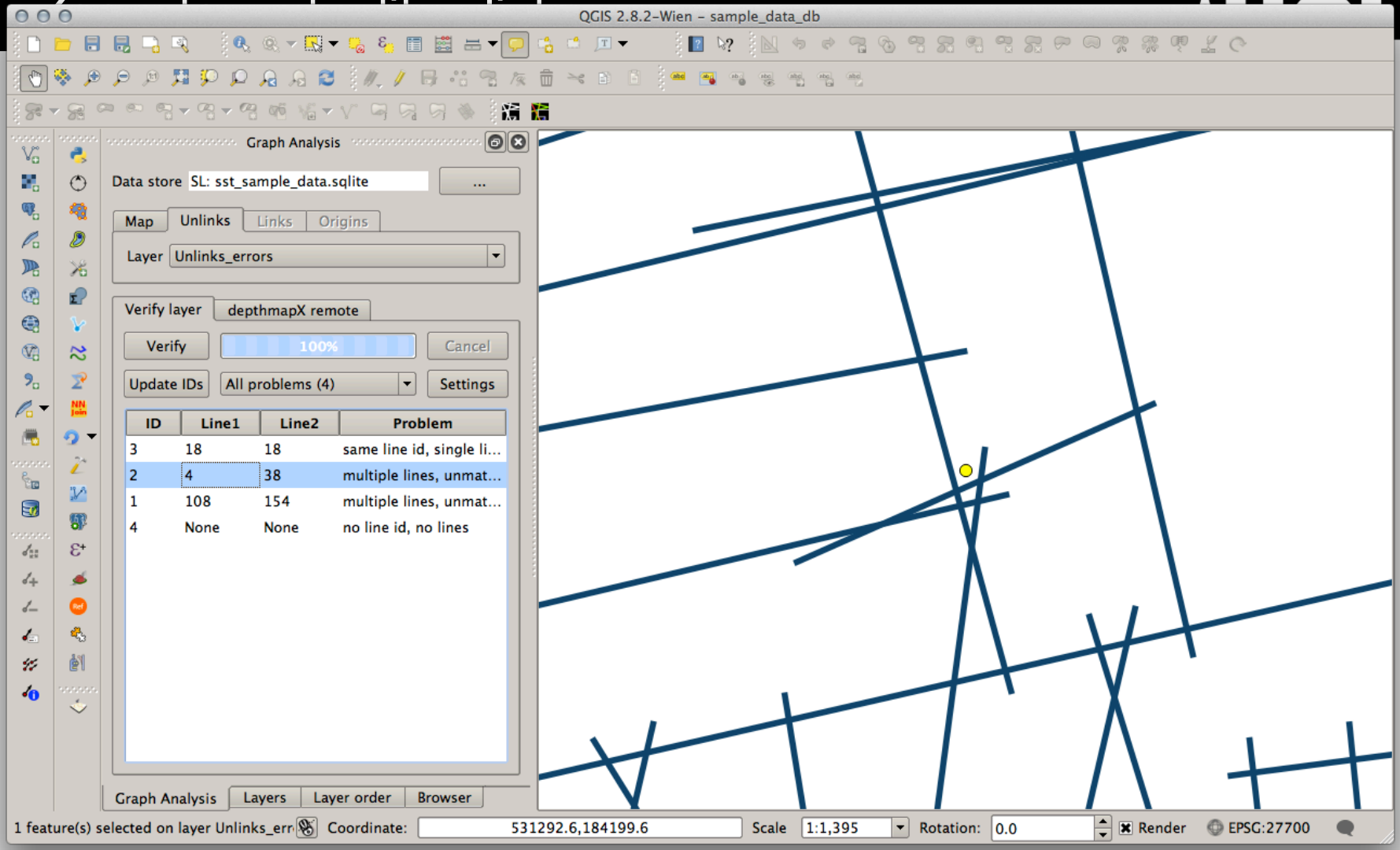
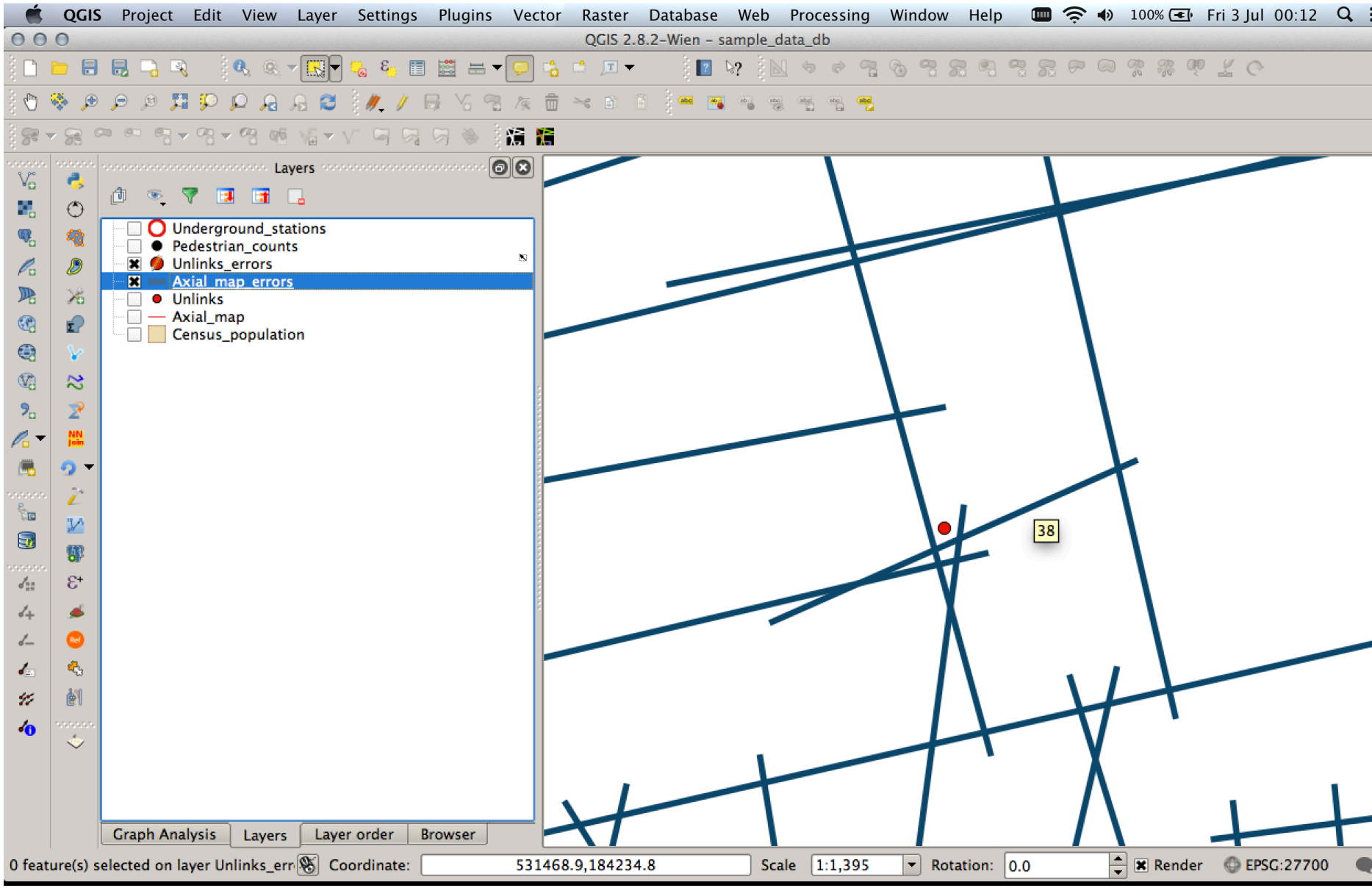
Map
Unlinks
Links
Origins
Layer
Unlinks_errors
Verify layer
depthmapX remote
Verify
100%
Cancel
Update IDs
All problems (4)
Settings
ID
Line1
Line2
Problem
3
18
18
same line id, single li...
2
None
None
no line id, no lines
1
108
154
multiple lines, unmat...
4
None
None
no line id, no lines
Graph Analysis
Layers
Layer order
Browser
1 feature(s) selected on layer Unlinks_err
Coordinate:
531932.3,183653.6
Scale
1:1,395
Rotation:
0.0
Render
EPSG:27700

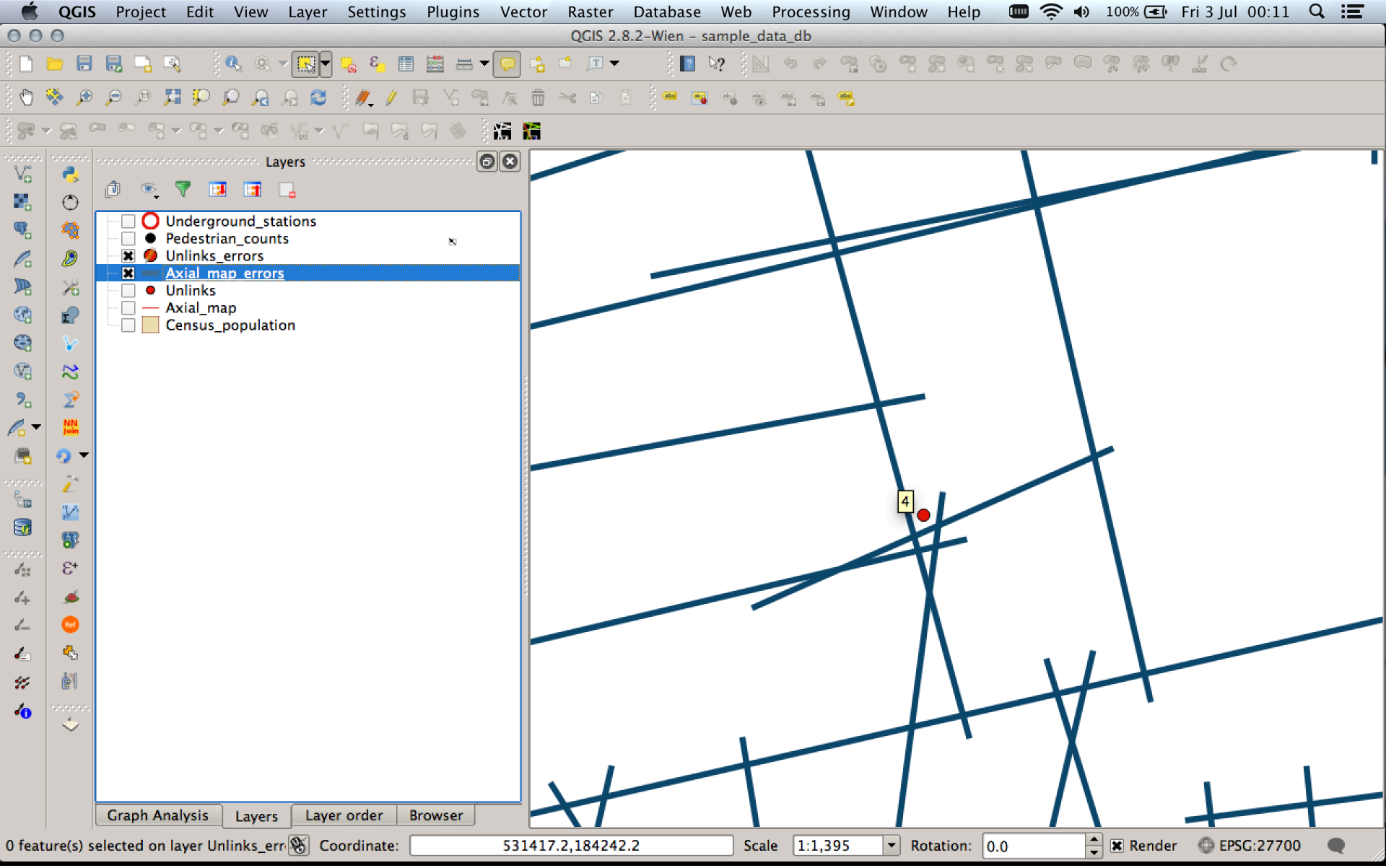
# Unlinks verification settings




QGIS 2.8.2-Wien - sample_data_db
Graph Analysis
Data store SL: sst_sample_data.sqlite
...
Map
Unlinks
Links
Origins
Layer Unlinks_errors
Verify layer
depthmapX remote
Verify
100%
Cancel
Update IDs
All problems (4)
Settings
ID
Line1
Line2
Problem
3 18 18 same line id, single li...
2 4 38 multiple lines, unmat...
1 108 154 multiple lines, unmat...
4 None None no line id, no lines
Graph Analysis
Layers
Layer order
Browser
1 feature(s) selected on layer Unlinks_err
Coordinate:
531292.6,184199.6
Scale
1:1,395
Rotation:
0.0
Render
EPSG:27700

# Zoom to and edit unlinks

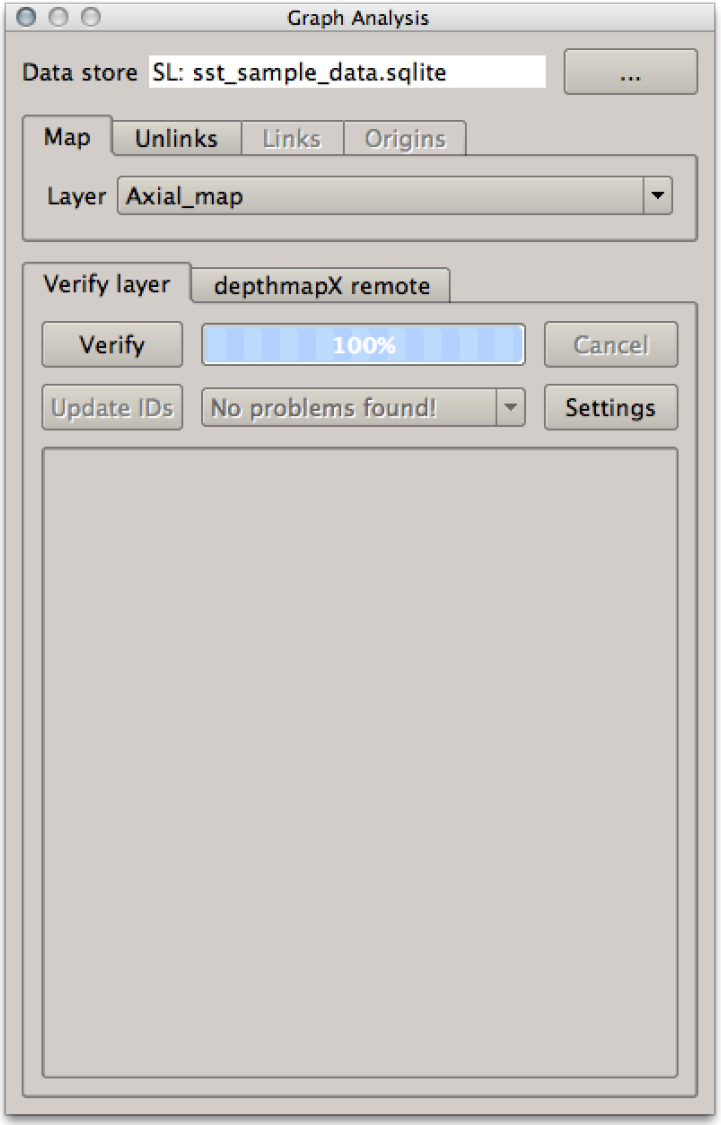


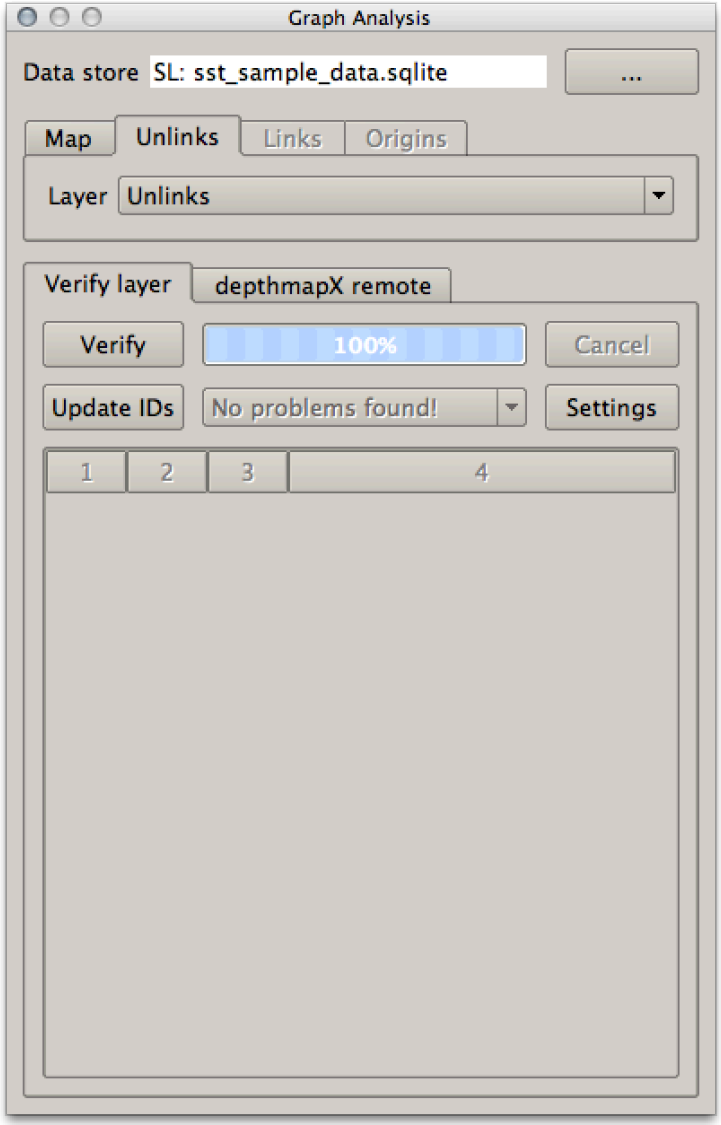

QGIS Project Edit View Layer Settings Plugins Vector Raster Database Web Processing Window Help
Fri 3 Jul 00:11
QGIS 2.8.2-Wien - sample_data_db
Layers
Underground_stations
Pedestrian_counts
Unlinks_errors
Axial_map_errors
Unlinks
Axial_map
Census_population
4
Graph Analysis
Layers
Layer order
Browser
0 feature(s) selected on layer Unlinks_err
Coordinate:
531417.2,184242.2
Scale
1:1,395
Rotation:
0.0
Render
EPSG:27700

# Model verification

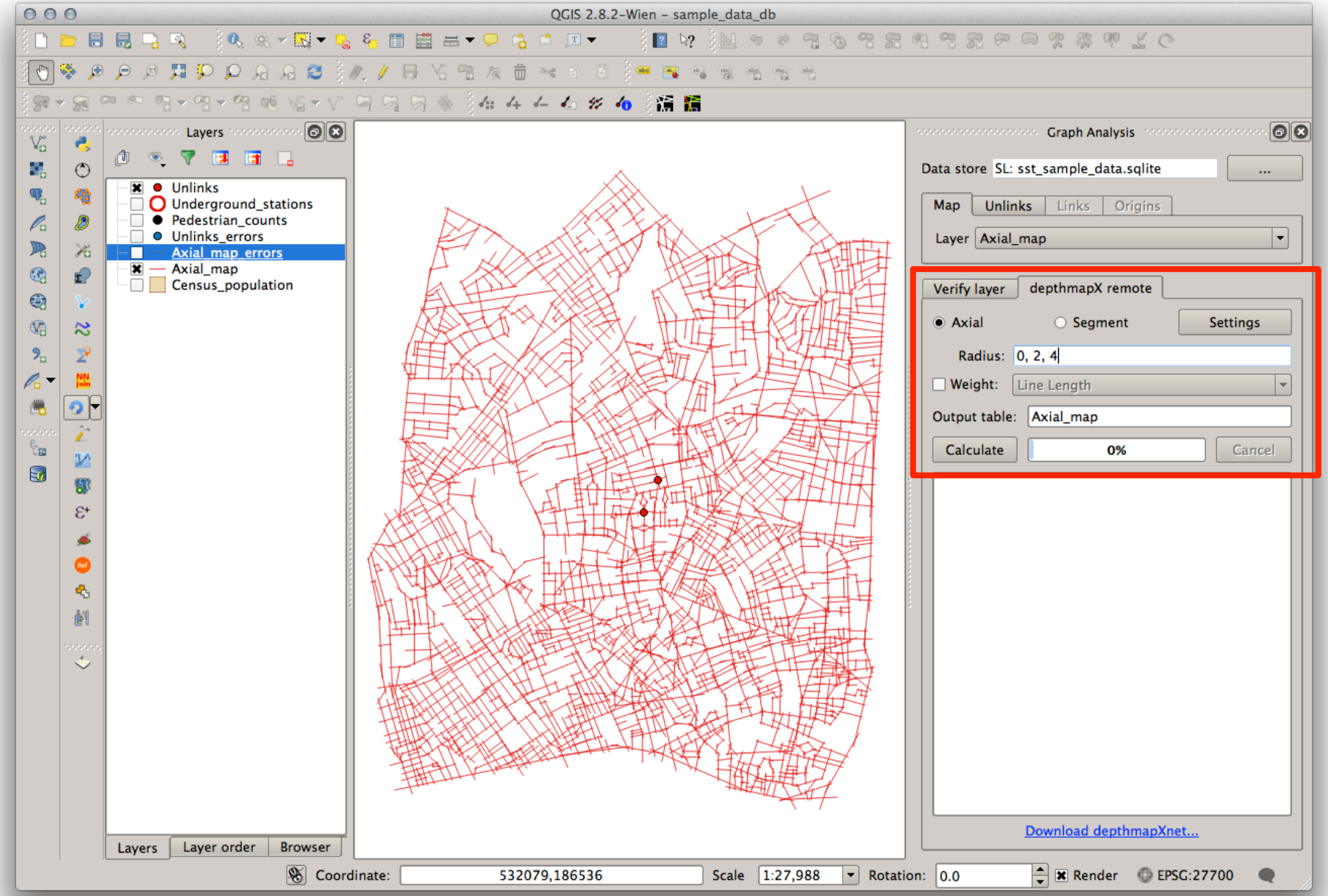
- The model verification process is iterative:
  - Verify and fix axial lines
  - Update unlinks ids
  - Verify and fix unlinks
  - Verify and fix axial lines
  - Verify and fix unlinks
  - Update unlink ids
  - Verify and fix axial lines
  - …

# Model verification concluded

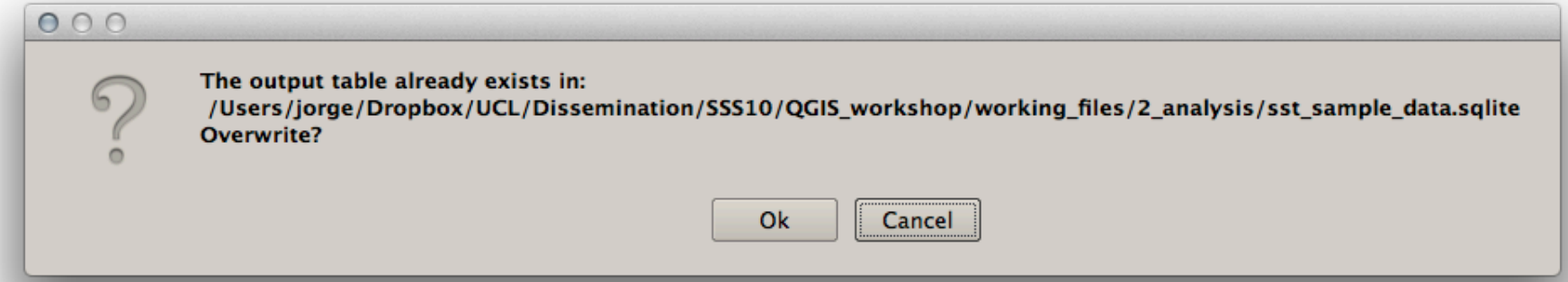


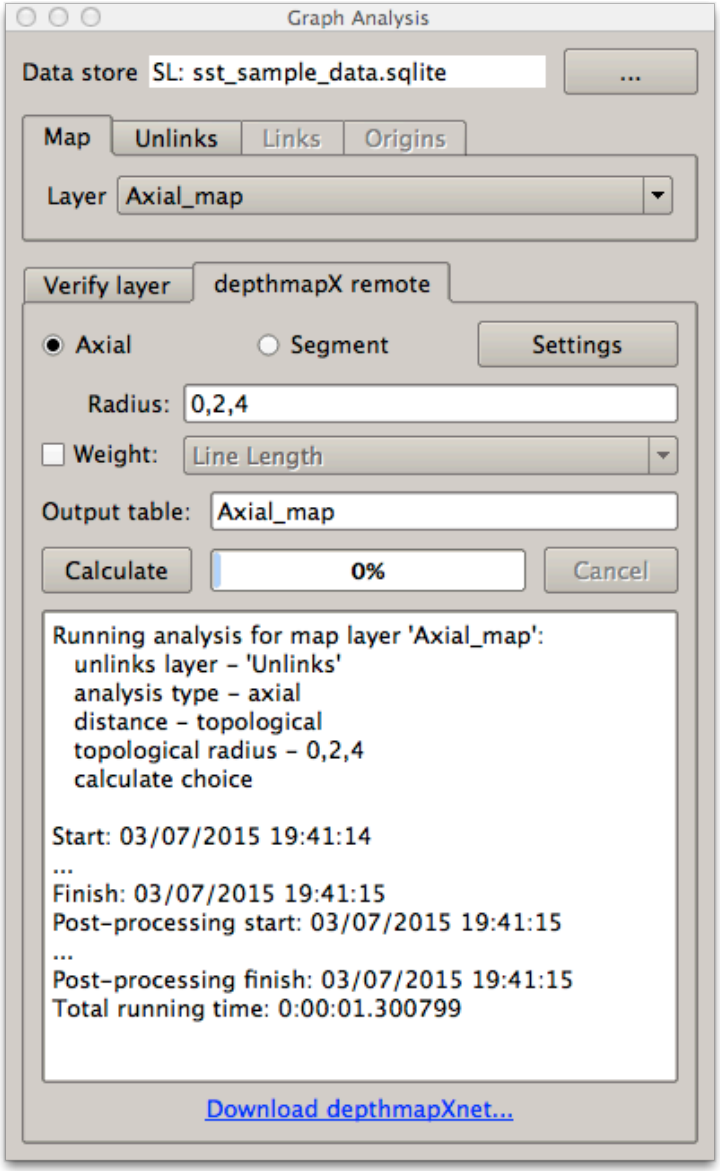
# Model analysis: Axial



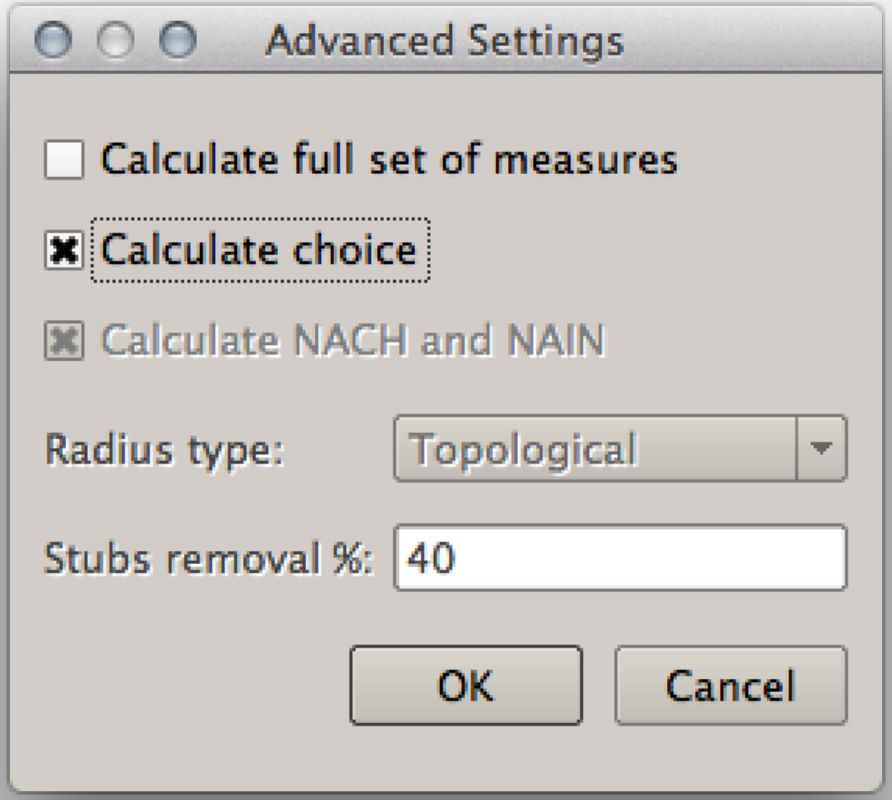
# Axial analysis report



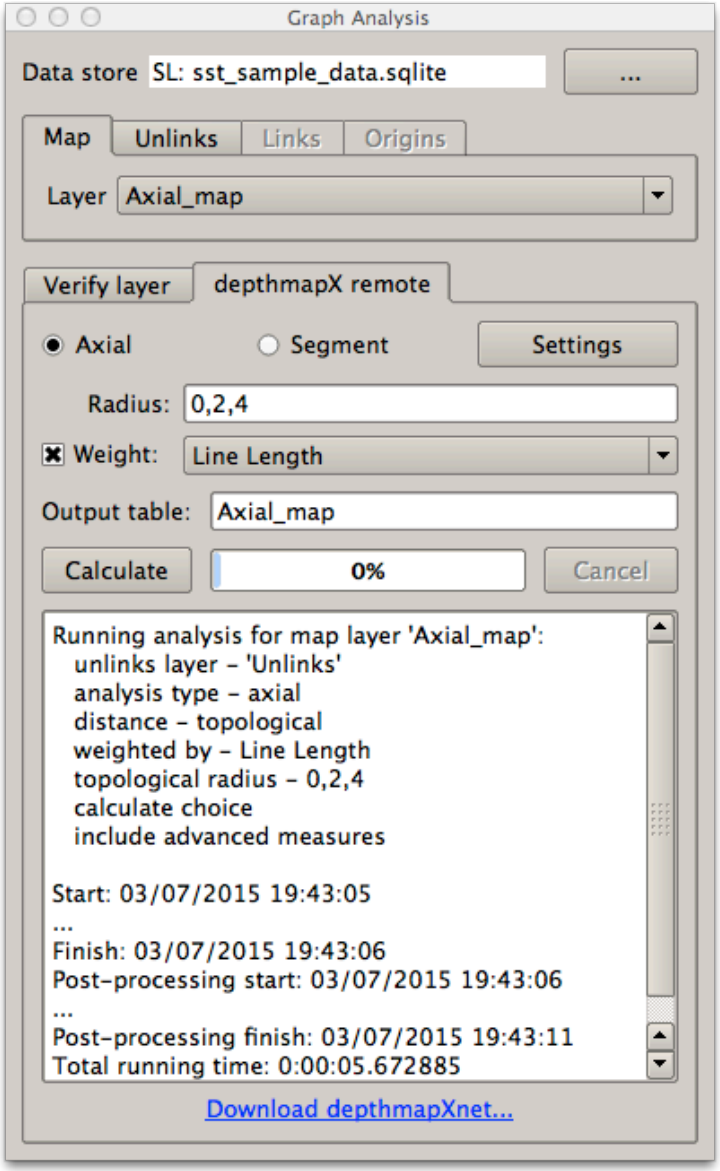
# Axial analysis report



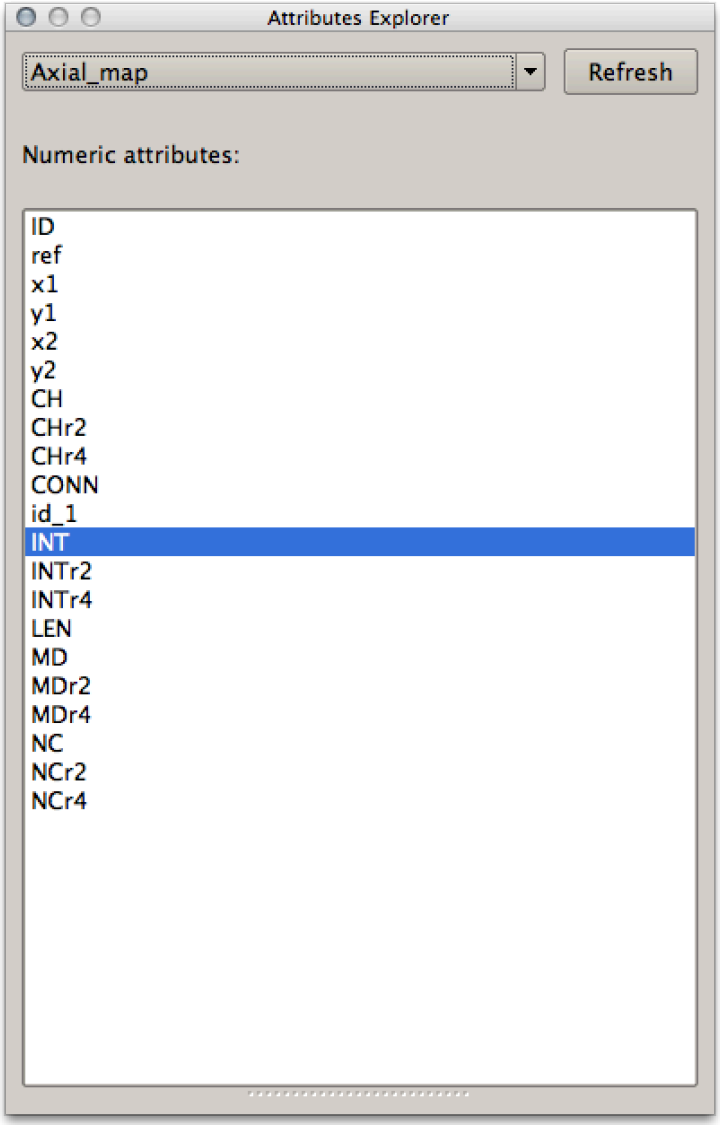
# Axial advanced settings

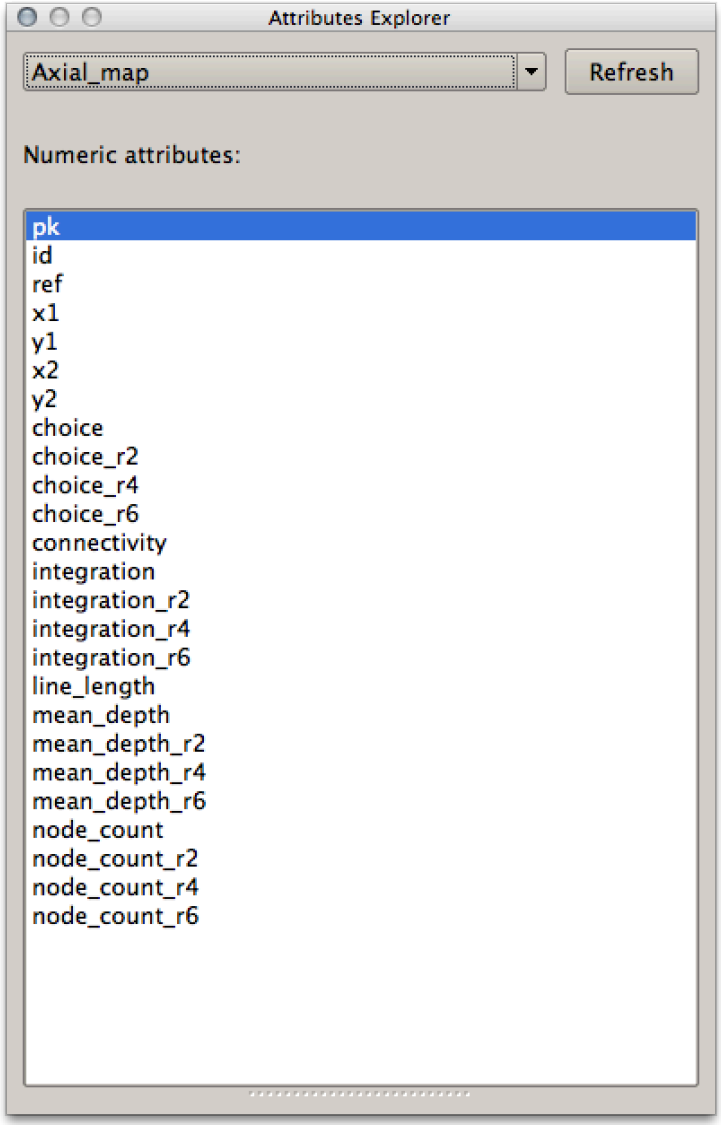


# Axial analysis report - advanced

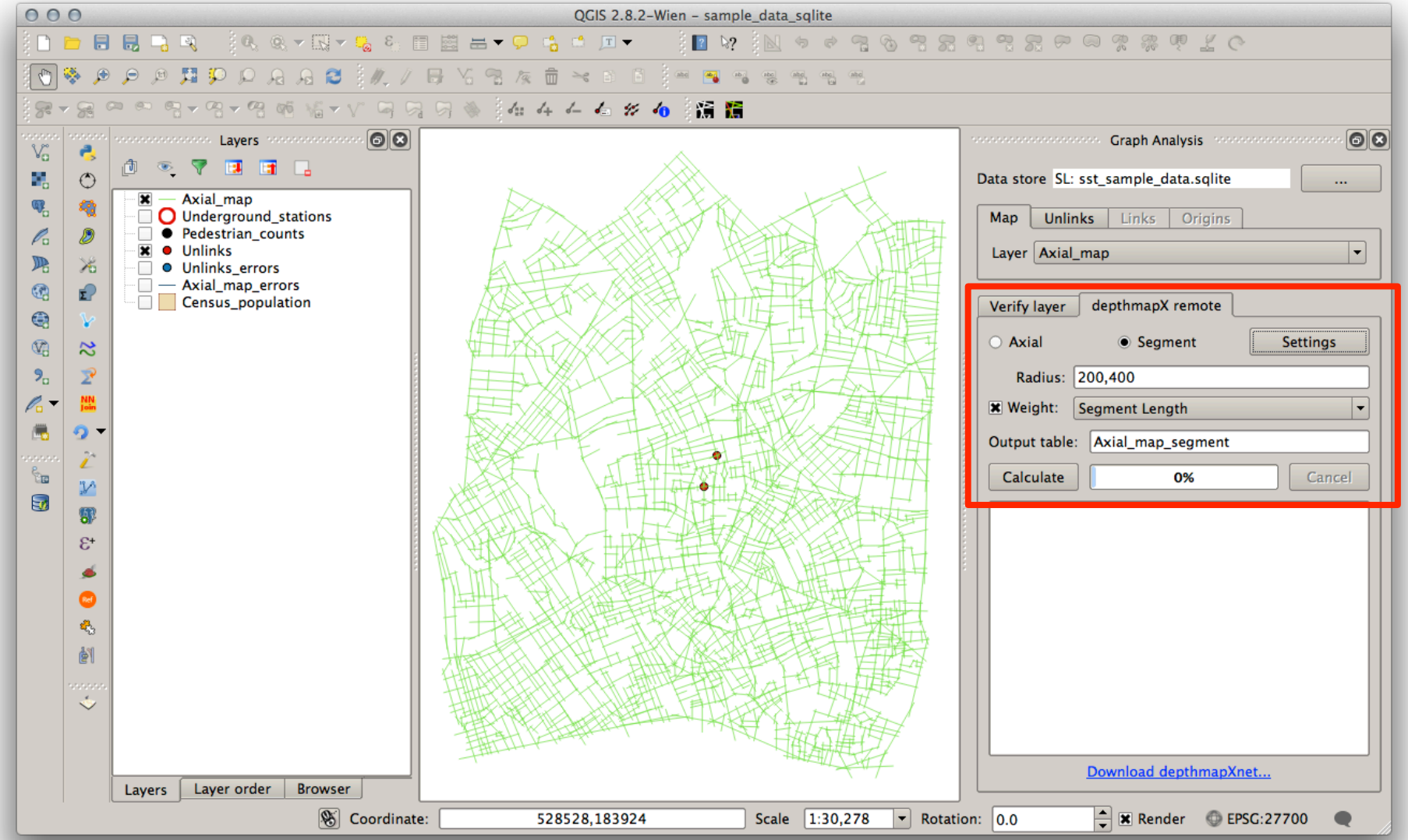


# Axial analysis: Post-processing

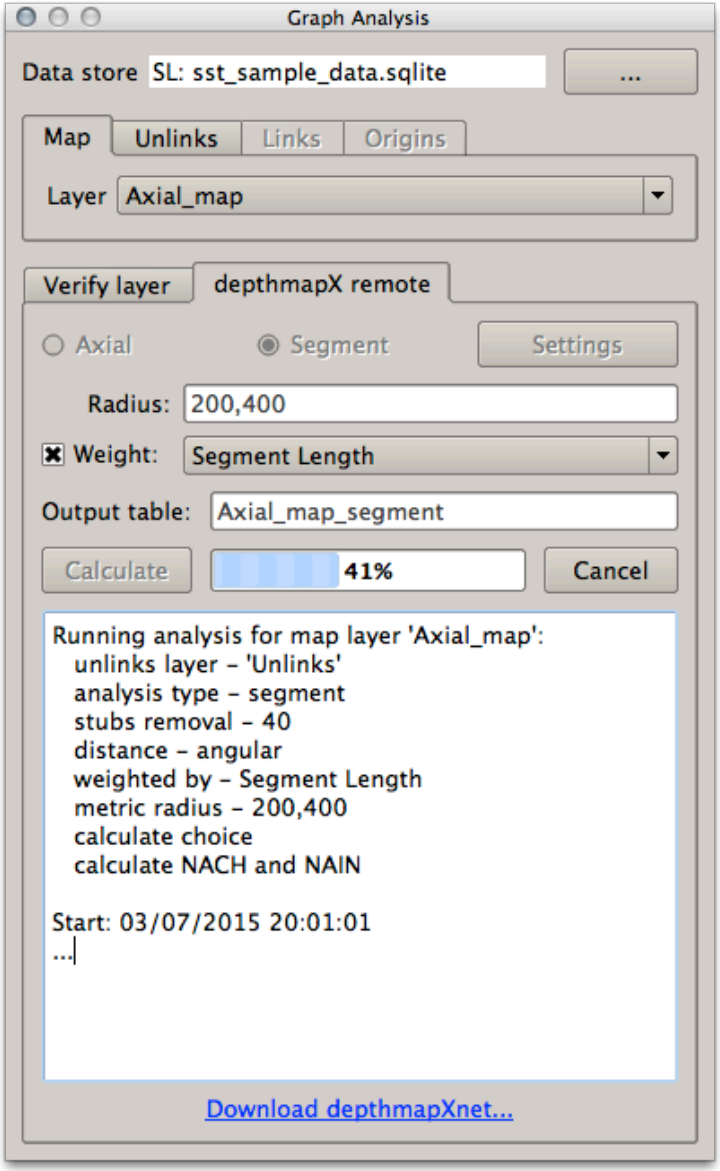


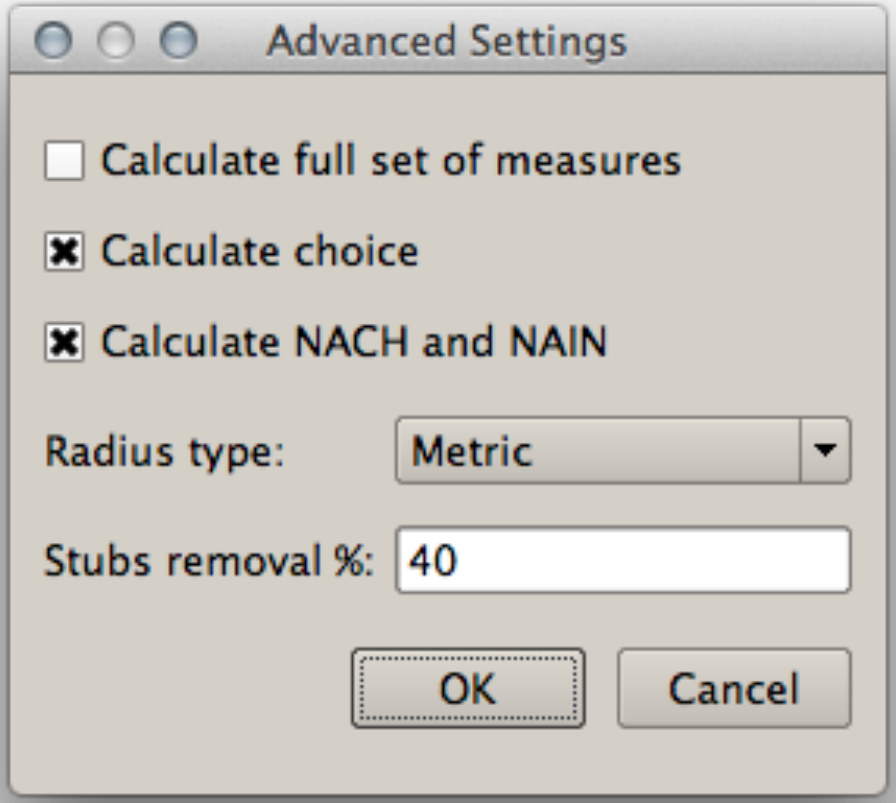
# Model analysis: segment



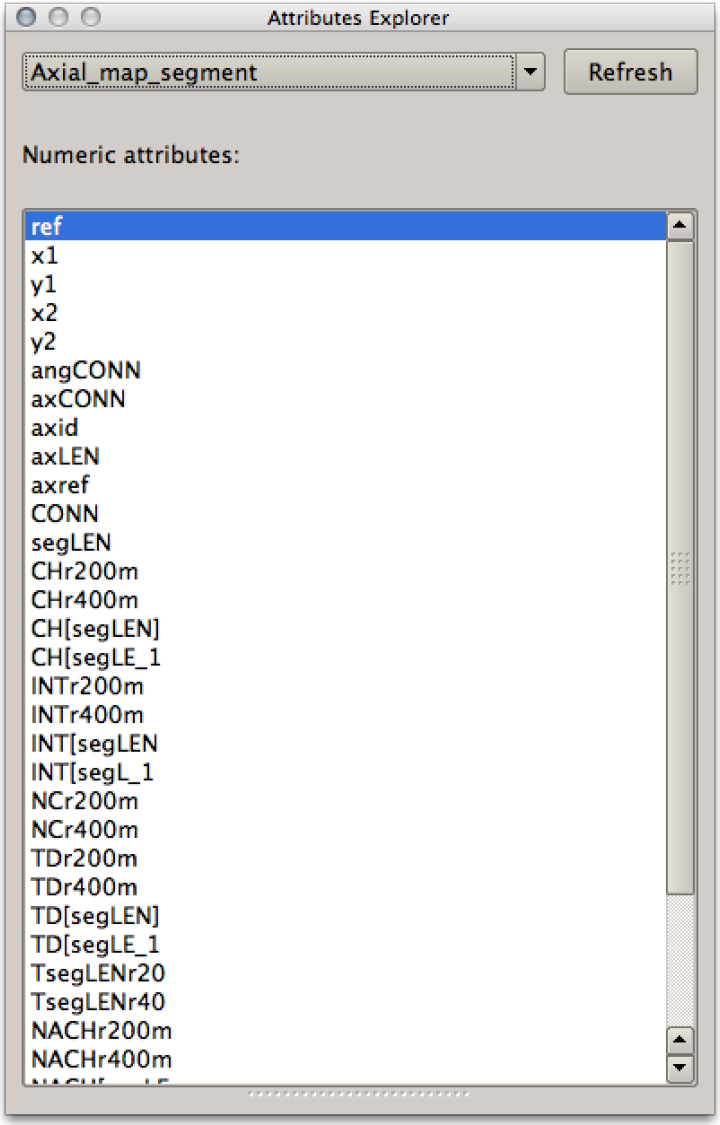
# Segment analysis report

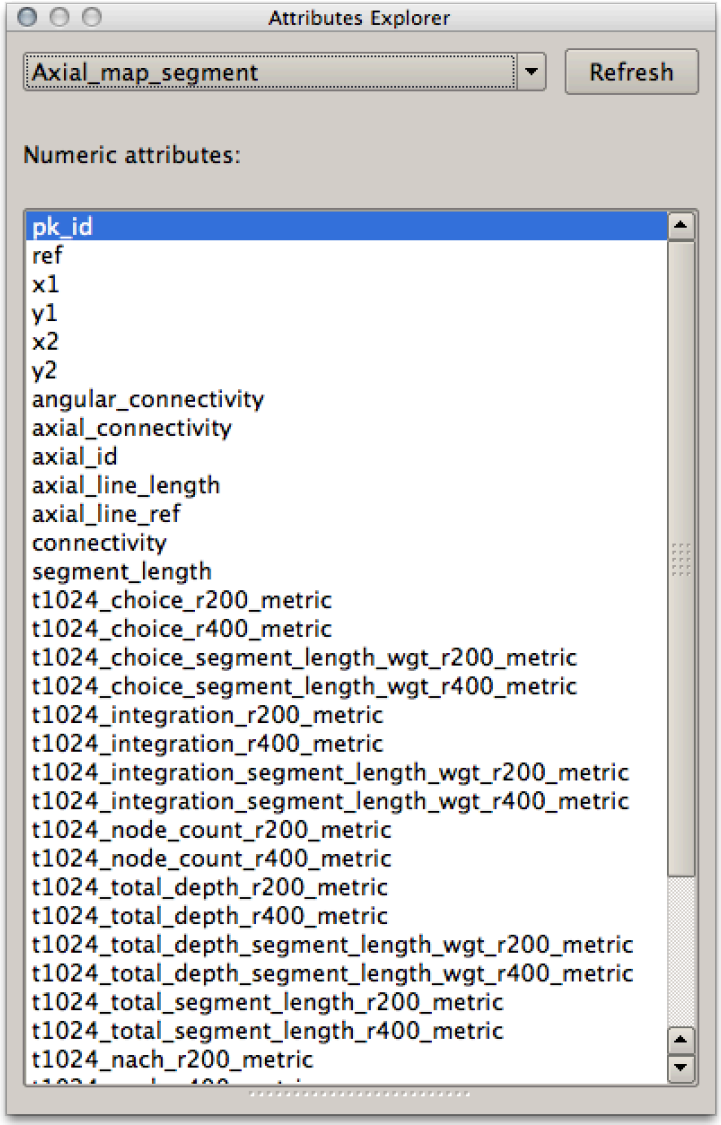


# Segment advanced settings

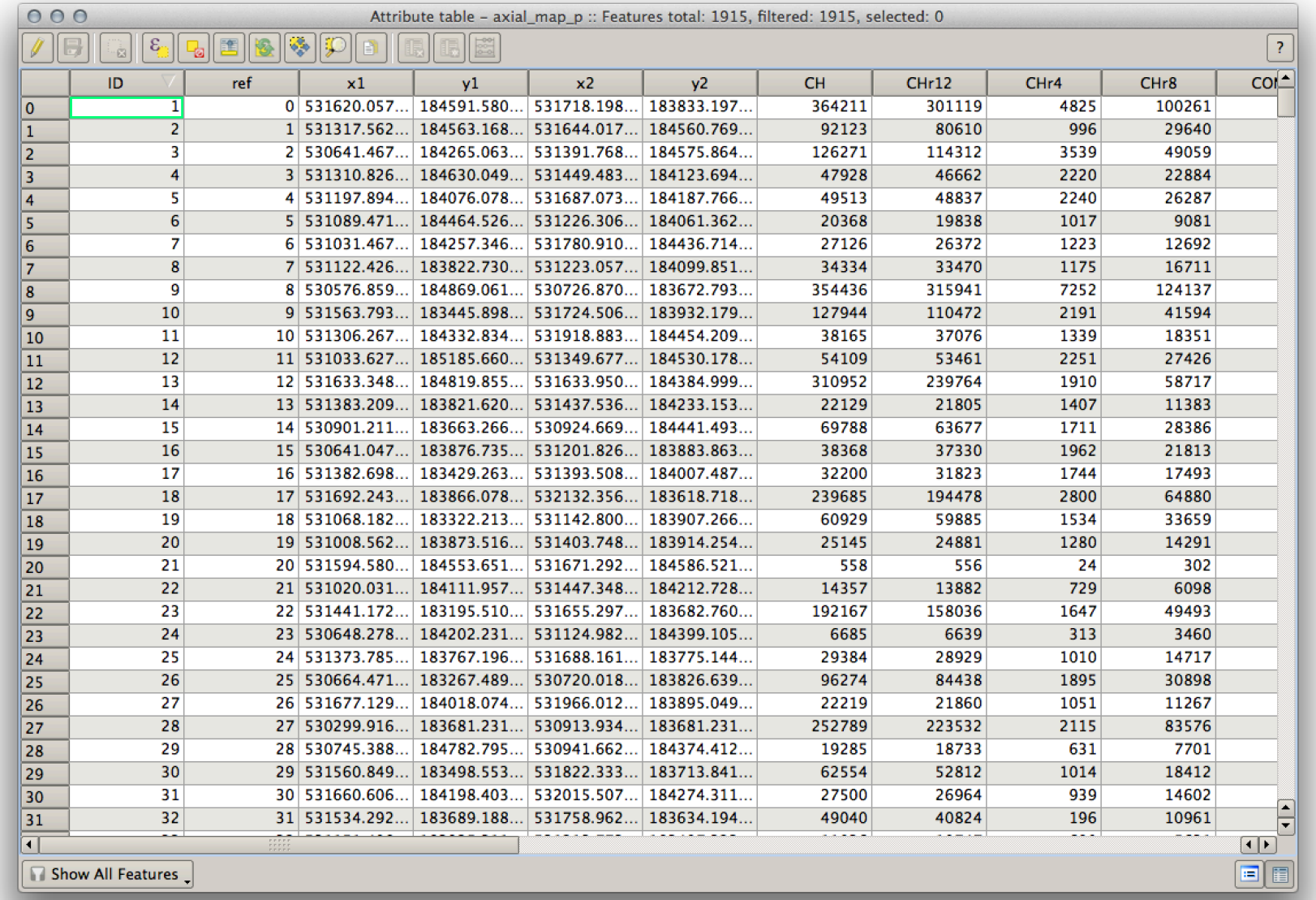


# Segment analysis: Post-processing



# Analysis results




| | ID | ref | x1 | y1 | x2 | y2 | CH | CHr12 | CHr4 | CHr8 | COI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 531620.057... | 184591.580... | 531718.198... | 183833.197... | 364211 | 301119 | 4825 | 100261 | |
| 1 | 2 | 1 | 531317.562... | 184563.168... | 531644.017... | 184560.769... | 92123 | 80610 | 996 | 29640 | |
| 2 | 3 | 2 | 530641.467... | 184265.063... | 531391.768... | 184575.864... | 126271 | 114312 | 3539 | 49059 | |
| 3 | 4 | 3 | 531310.826... | 184630.049... | 531449.483... | 184123.694... | 47928 | 46662 | 2220 | 22884 | |
| 4 | 5 | 4 | 531197.894... | 184076.078... | 531687.073... | 184187.766... | 49513 | 48837 | 2240 | 26287 | |
| 5 | 6 | 5 | 531089.471... | 184464.526... | 531226.306... | 184061.362... | 20368 | 19838 | 1017 | 9081 | |
| 6 | 7 | 6 | 531031.467... | 184257.346... | 531780.910... | 184436.714... | 27126 | 26372 | 1223 | 12692 | |
| 7 | 8 | 7 | 531122.426... | 183822.730... | 531223.057... | 184099.851... | 34334 | 33470 | 1175 | 16711 | |
| 8 | 9 | 8 | 530576.859... | 184869.061... | 530726.870... | 183672.793... | 354436 | 315941 | 7252 | 124137 | |
| 9 | 10 | 9 | 531563.793... | 183445.898... | 531724.506... | 183932.179... | 127944 | 110472 | 2191 | 41594 | |
| 10 | 11 | 10 | 531306.267... | 184332.834... | 531918.883... | 184454.209... | 38165 | 37076 | 1339 | 18351 | |
| 11 | 12 | 11 | 531033.627... | 185185.660... | 531349.677... | 184530.178... | 54109 | 53461 | 2251 | 27426 | |
| 12 | 13 | 12 | 531633.348... | 184819.855... | 531633.950... | 184384.999... | 310952 | 239764 | 1910 | 58717 | |
| 13 | 14 | 13 | 531383.209... | 183821.620... | 531437.536... | 184233.153... | 22129 | 21805 | 1407 | 11383 | |
| 14 | 15 | 14 | 530901.211... | 183663.266... | 530924.669... | 184441.493... | 69788 | 63677 | 1711 | 28386 | |
| 15 | 16 | 15 | 530641.047... | 183876.735... | 531201.826... | 183883.863... | 38368 | 37330 | 1962 | 21813 | |
| 16 | 17 | 16 | 531382.698... | 183429.263... | 531393.508... | 184007.487... | 32200 | 31823 | 1744 | 17493 | |
| 17 | 18 | 17 | 531692.243... | 183866.078... | 532132.356... | 183618.718... | 239685 | 194478 | 2800 | 64880 | |
| 18 | 19 | 18 | 531068.182... | 183322.213... | 531142.800... | 183907.266... | 60929 | 59885 | 1534 | 33659 | |
| 19 | 20 | 19 | 531008.562... | 183873.516... | 531403.748... | 183914.254... | 25145 | 24881 | 1280 | 14291 | |
| 20 | 21 | 20 | 531594.580... | 184553.651... | 531671.292... | 184586.521... | 558 | 556 | 24 | 302 | |
| 21 | 22 | 21 | 531020.031... | 184111.957... | 531447.348... | 184212.728... | 14357 | 13882 | 729 | 6098 | |
| 22 | 23 | 22 | 531441.172... | 183195.510... | 531655.297... | 183682.760... | 192167 | 158036 | 1647 | 49493 | |
| 23 | 24 | 23 | 530648.278... | 184202.231... | 531124.982... | 184399.105... | 6685 | 6639 | 313 | 3460 | |
| 24 | 25 | 24 | 531373.785... | 183767.196... | 531688.161... | 183775.144... | 29384 | 28929 | 1010 | 14717 | |
| 25 | 26 | 25 | 530664.471... | 183267.489... | 530720.018... | 183826.639... | 96274 | 84438 | 1895 | 30898 | |
| 26 | 27 | 26 | 531677.129... | 184018.074... | 531966.012... | 183895.049... | 22219 | 21860 | 1051 | 11267 | |
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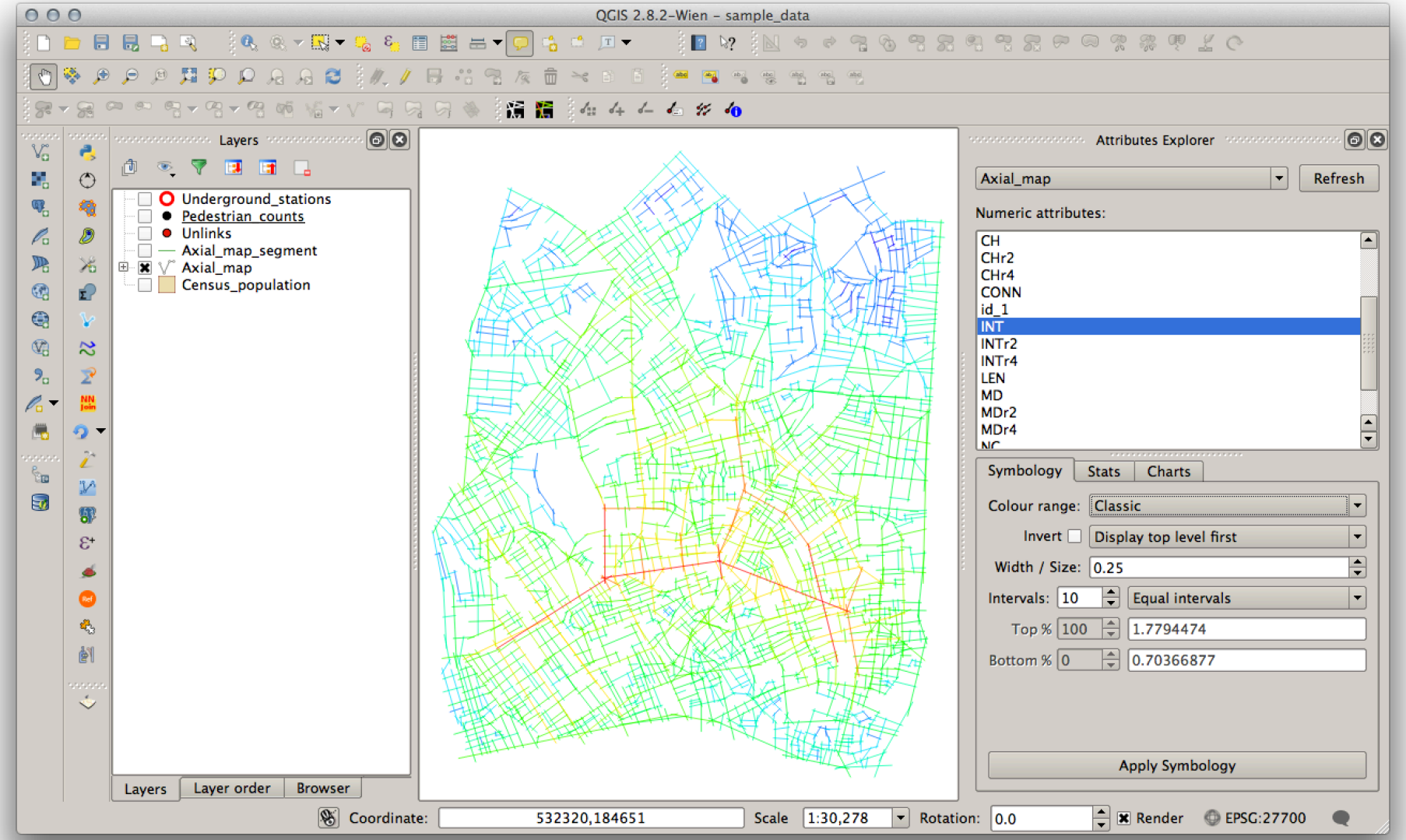
| 29 | 30 | 29 | 531560.849... | 183498.553... | 531822.333... | 183713.841... | 62554 | 52812 | 1014 | 18412 | |
| 30 | 31 | 30 | 531660.606... | 184198.403... | 532015.507... | 184274.311... | 27500 | 26964 | 939 | 14602 | |
| 31 | 32 | 31 | 531534.292... | 183689.188... | 531758.962... | 183634.194... | 49040 | 40824 | 196 | 10961 | |

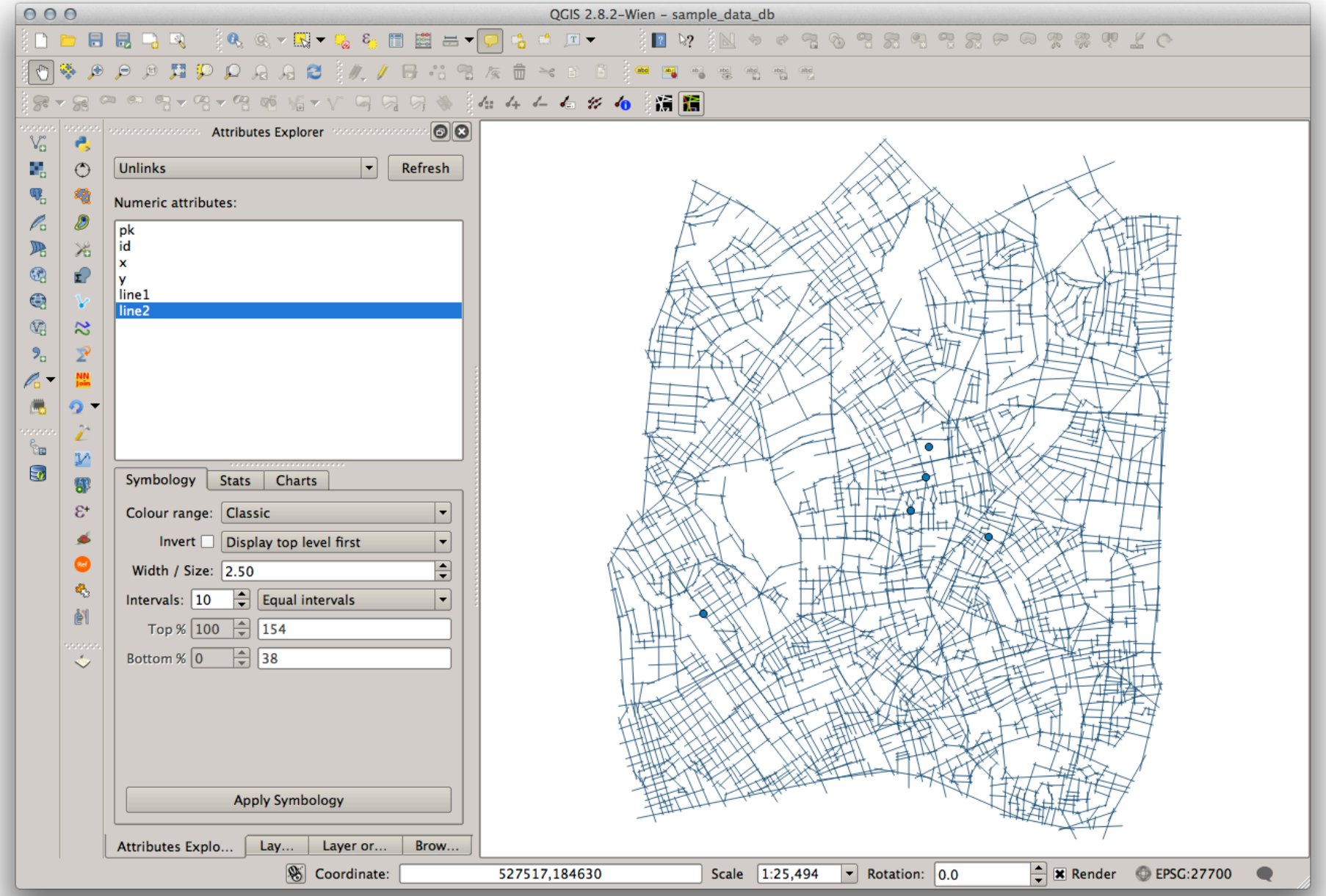
# Attributes explorer



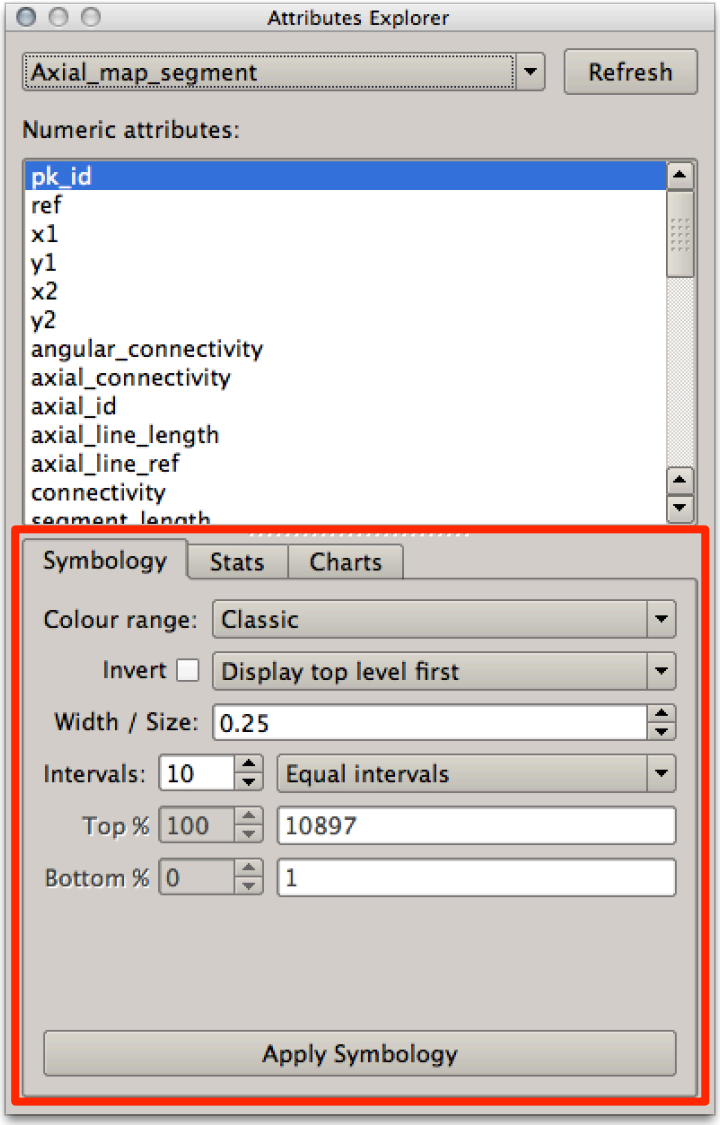
# Attributes Explorer

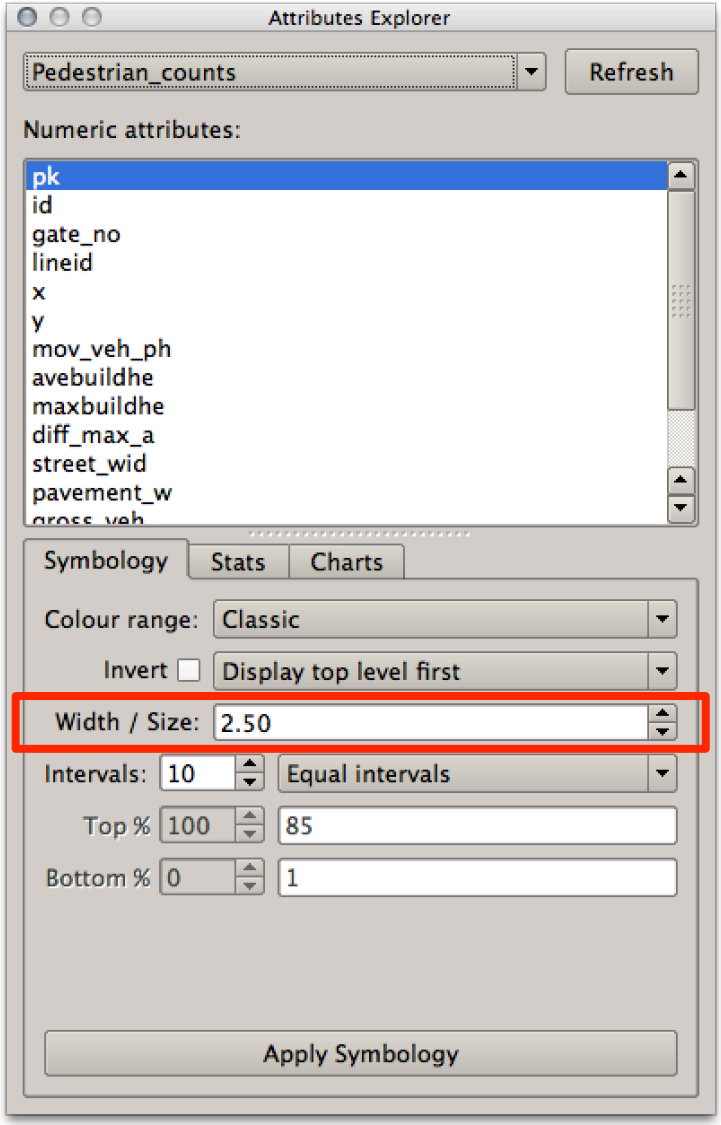
- Intuitive and interactive exploration of attributes
- Simple symbology settings
- Symbology settings for typical academic output
- Stores attributes' symbol settings with project
- Descriptive statistics and charts
- Synchronises with main window selection

# Attributes explorer docked left

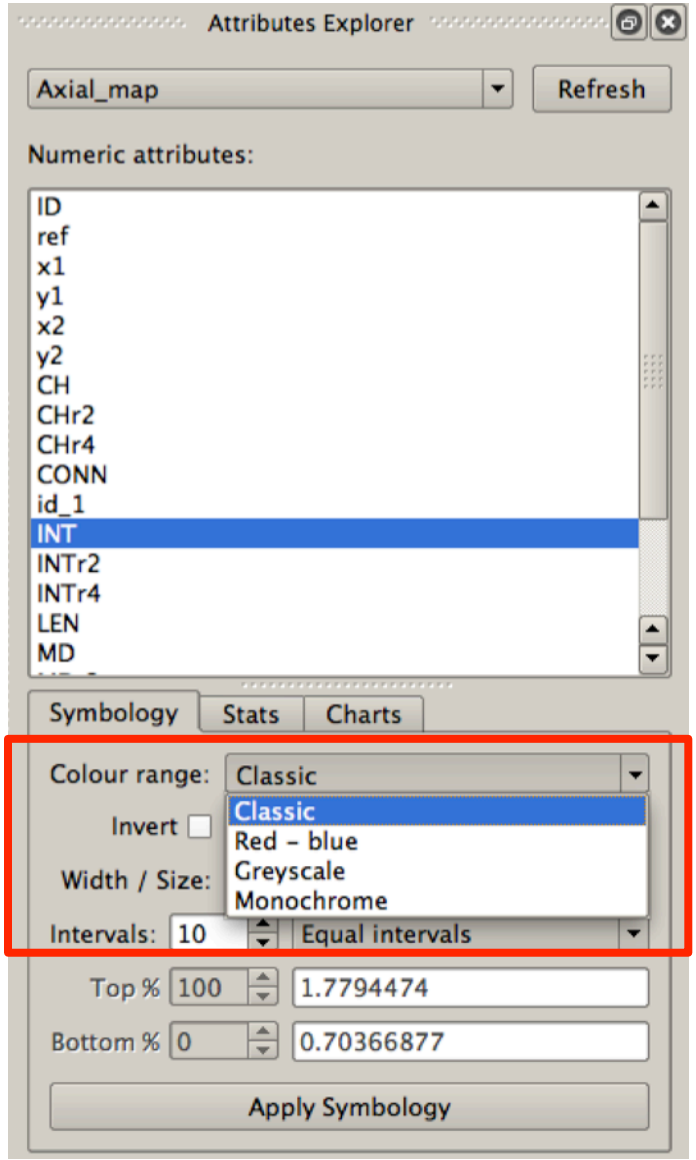


# Layer selection: attribute defaults



# Attribute symbology: colour range



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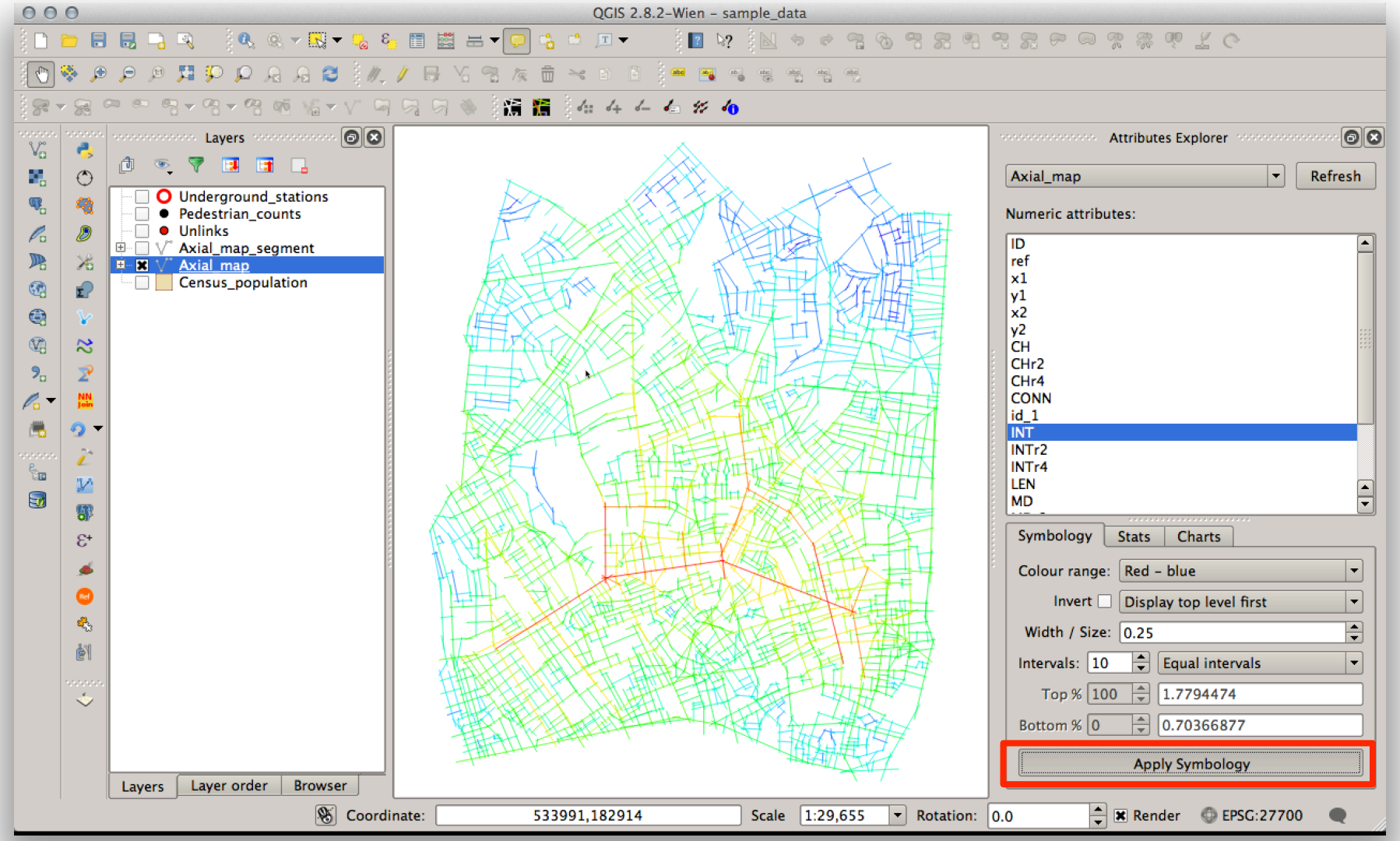

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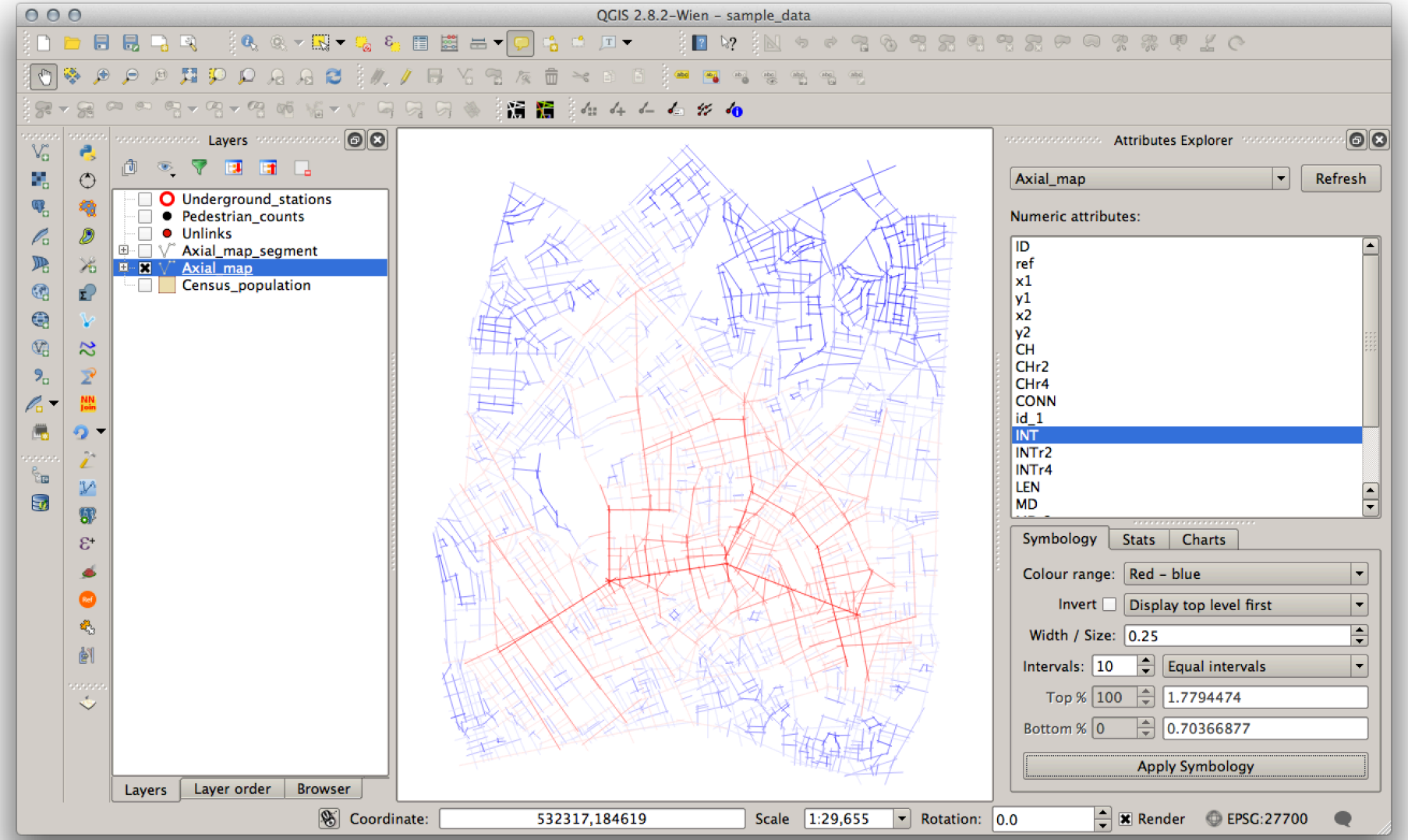
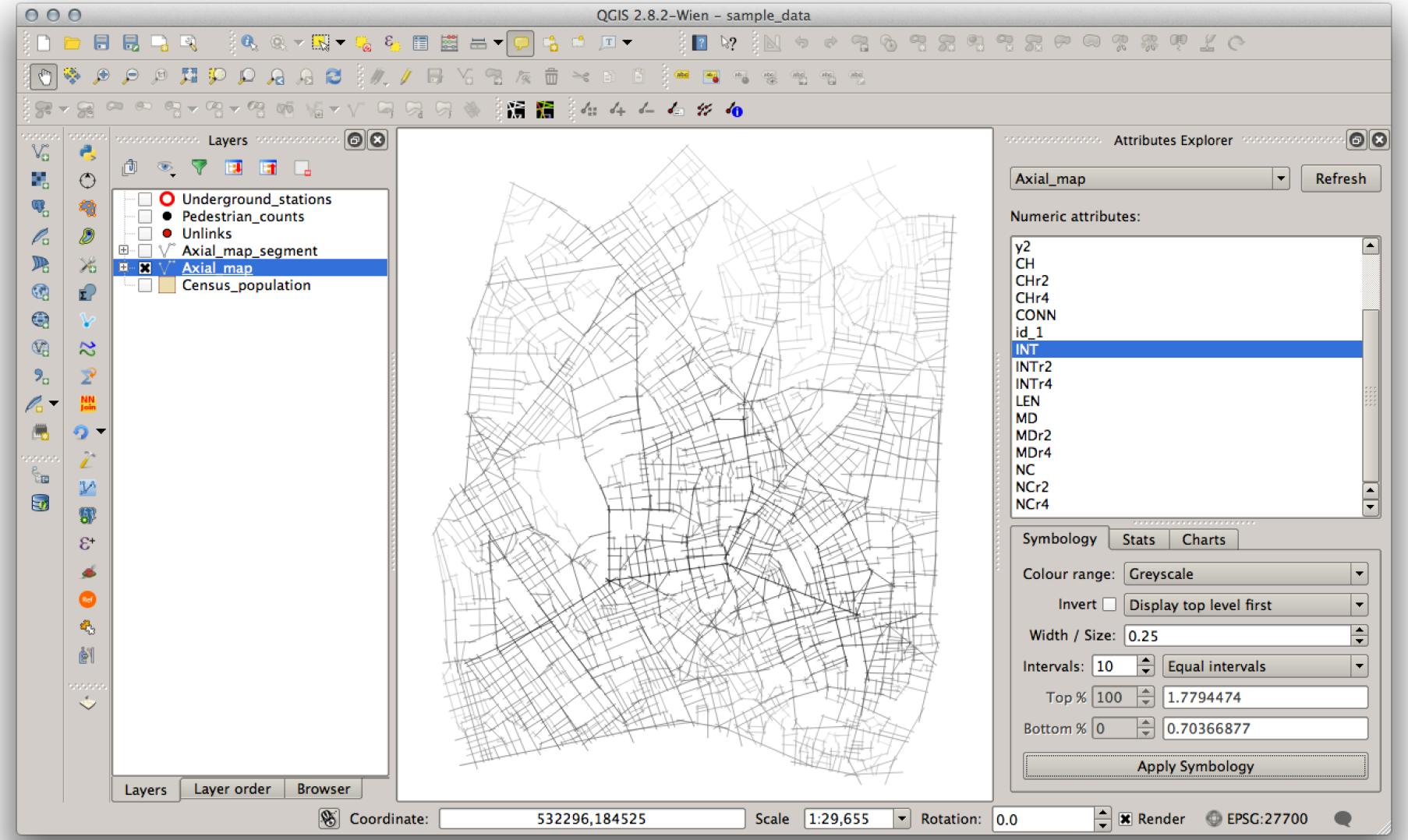
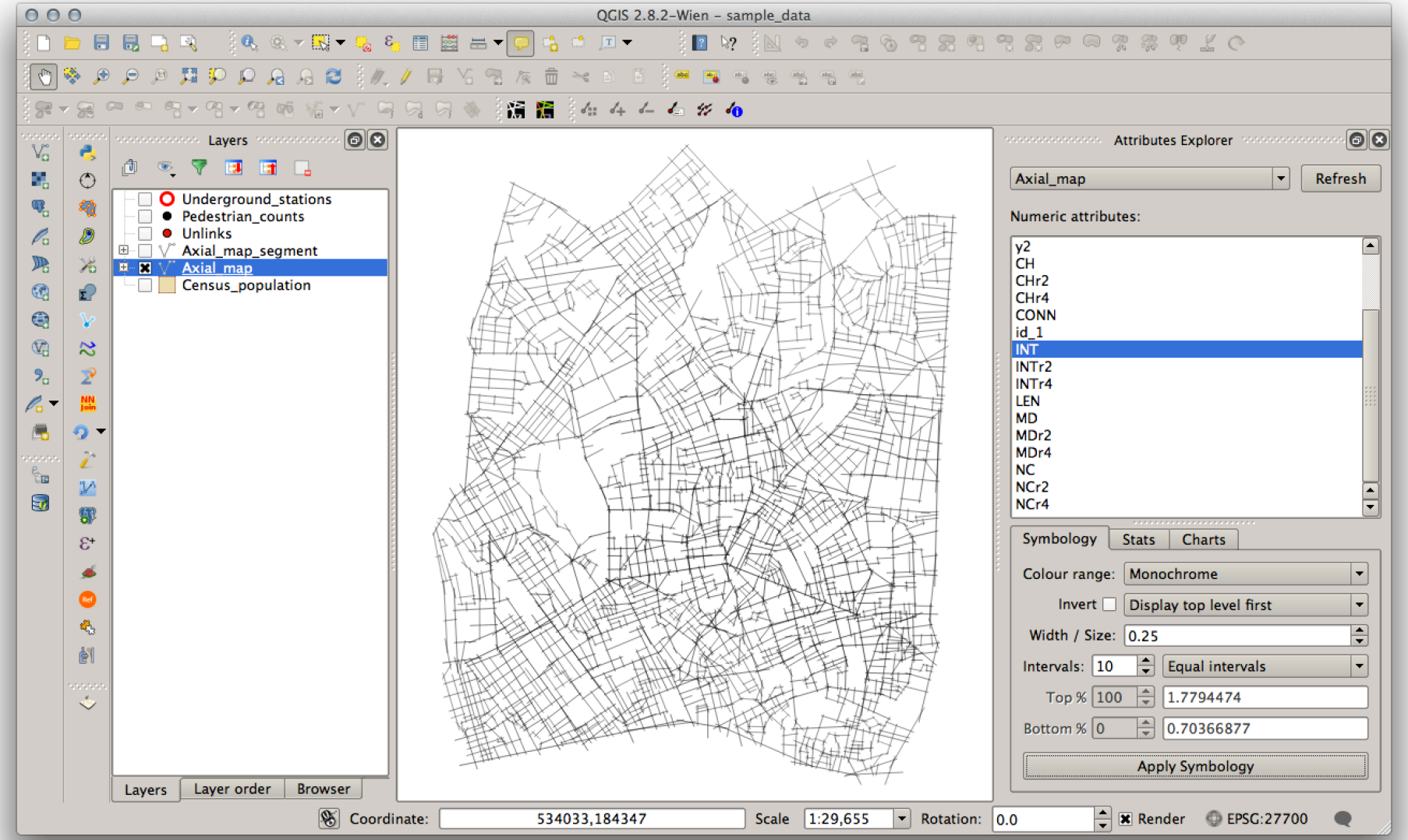


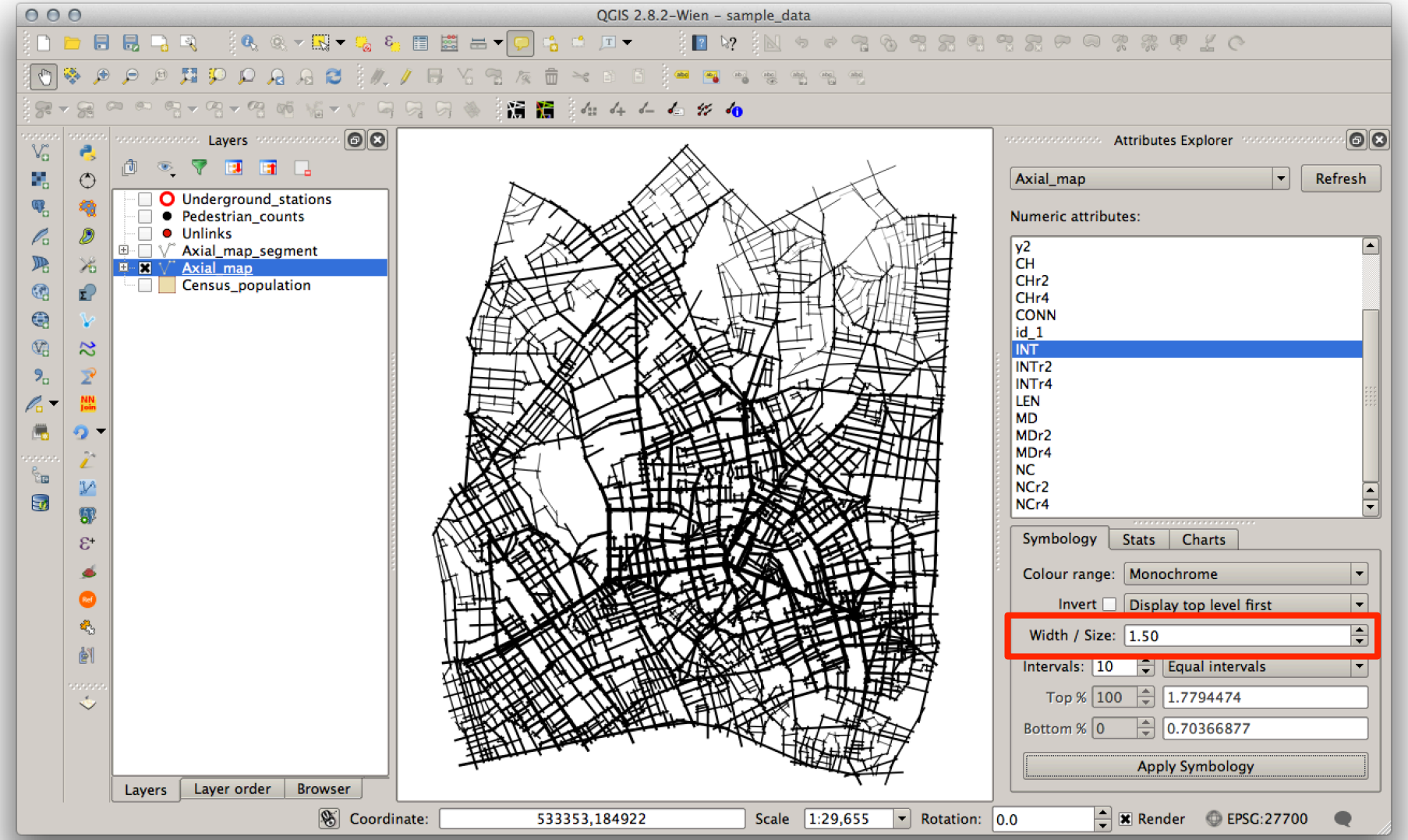
# Attribute symbology: colour ranges



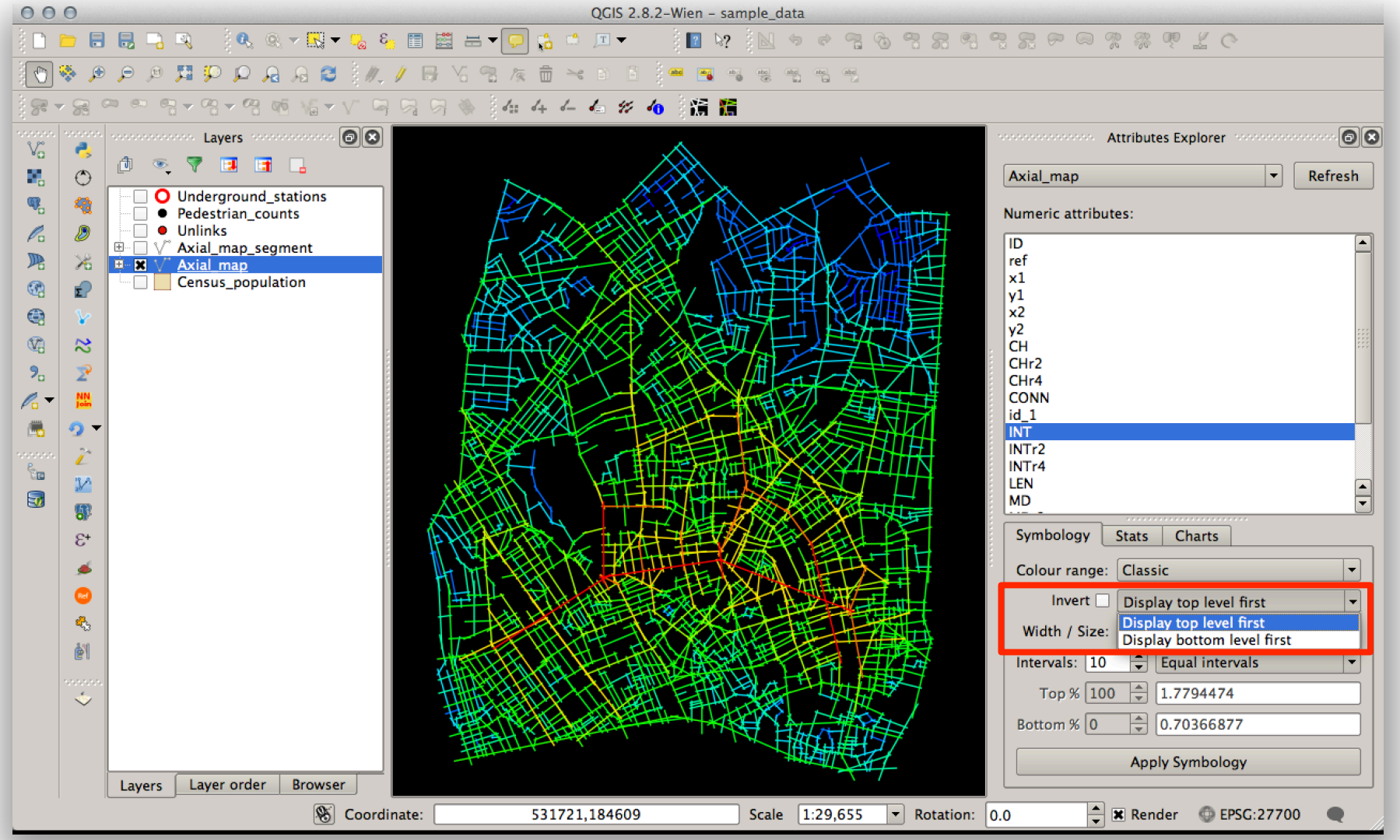
# Attribute symbology: colour ranges



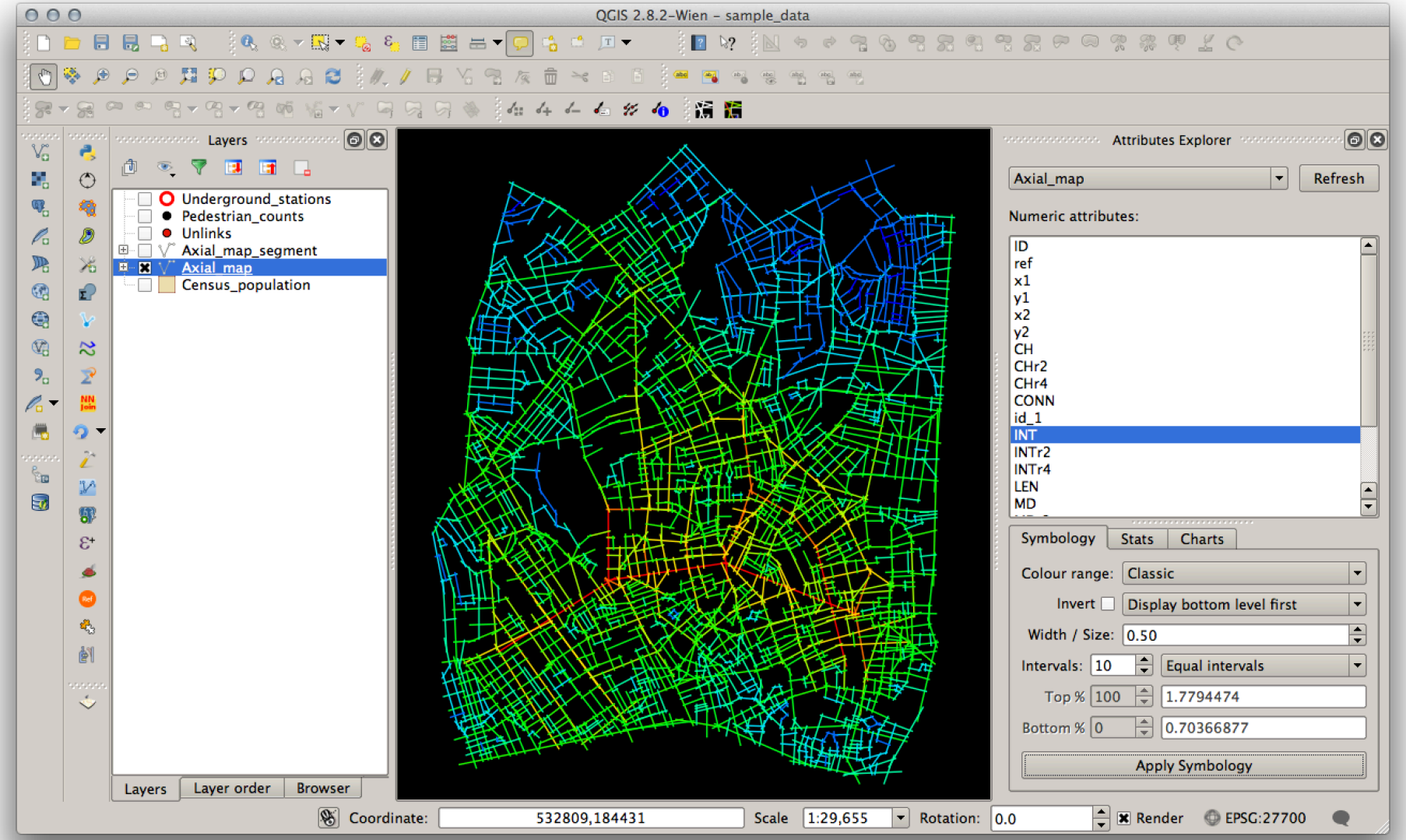
# Attribute symbology: Line width



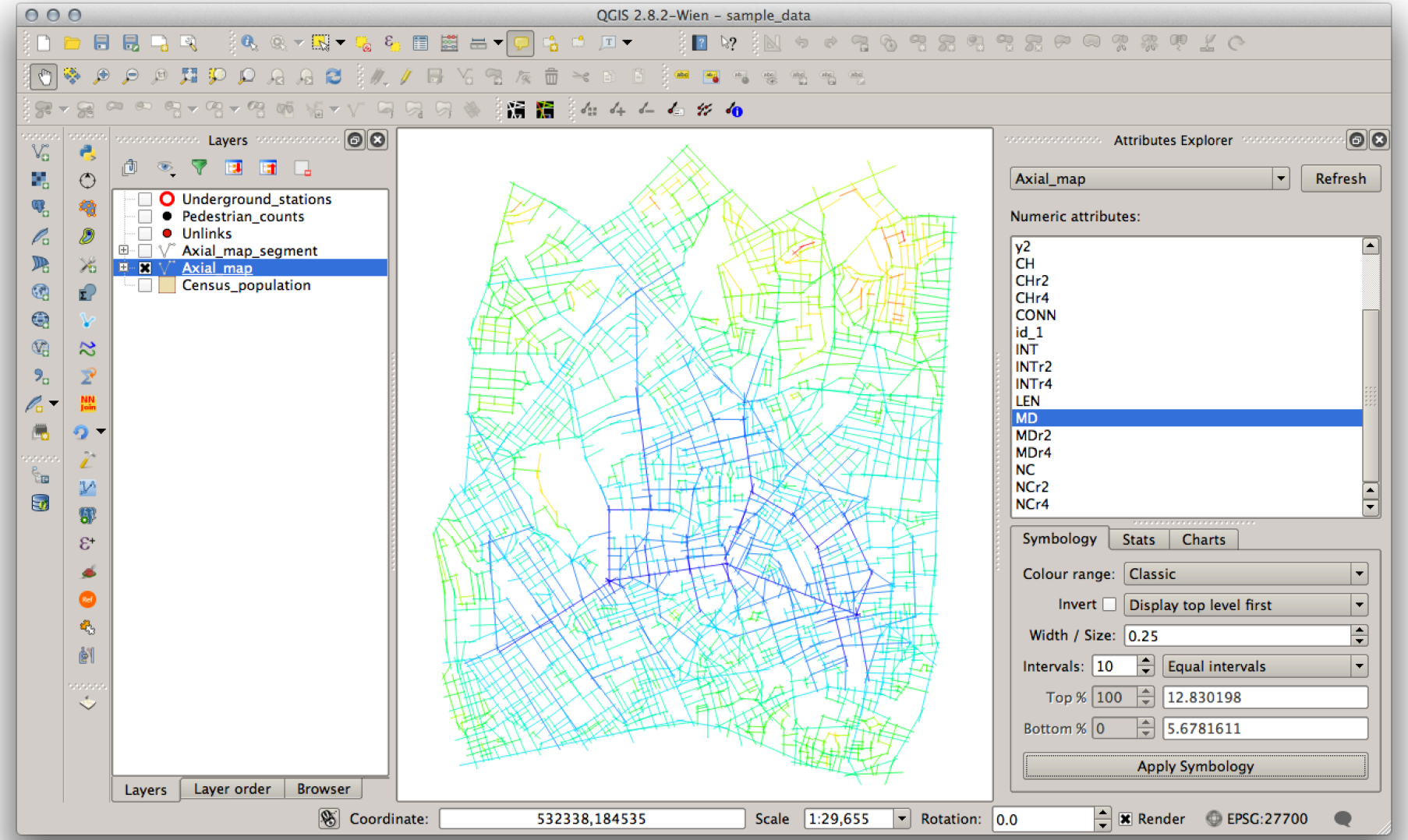
# Attribute symbology: display order



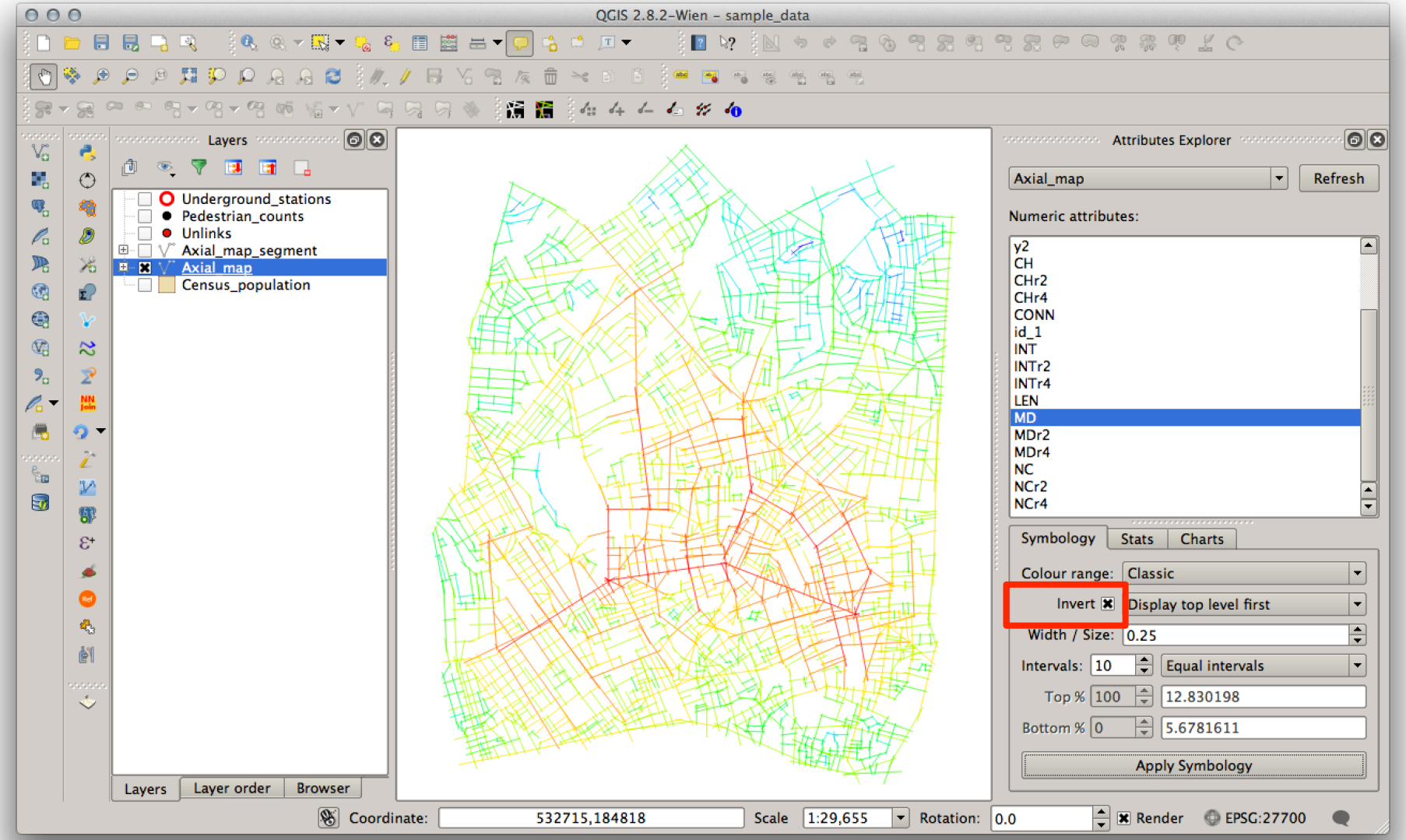
# Attribute symbology: display order



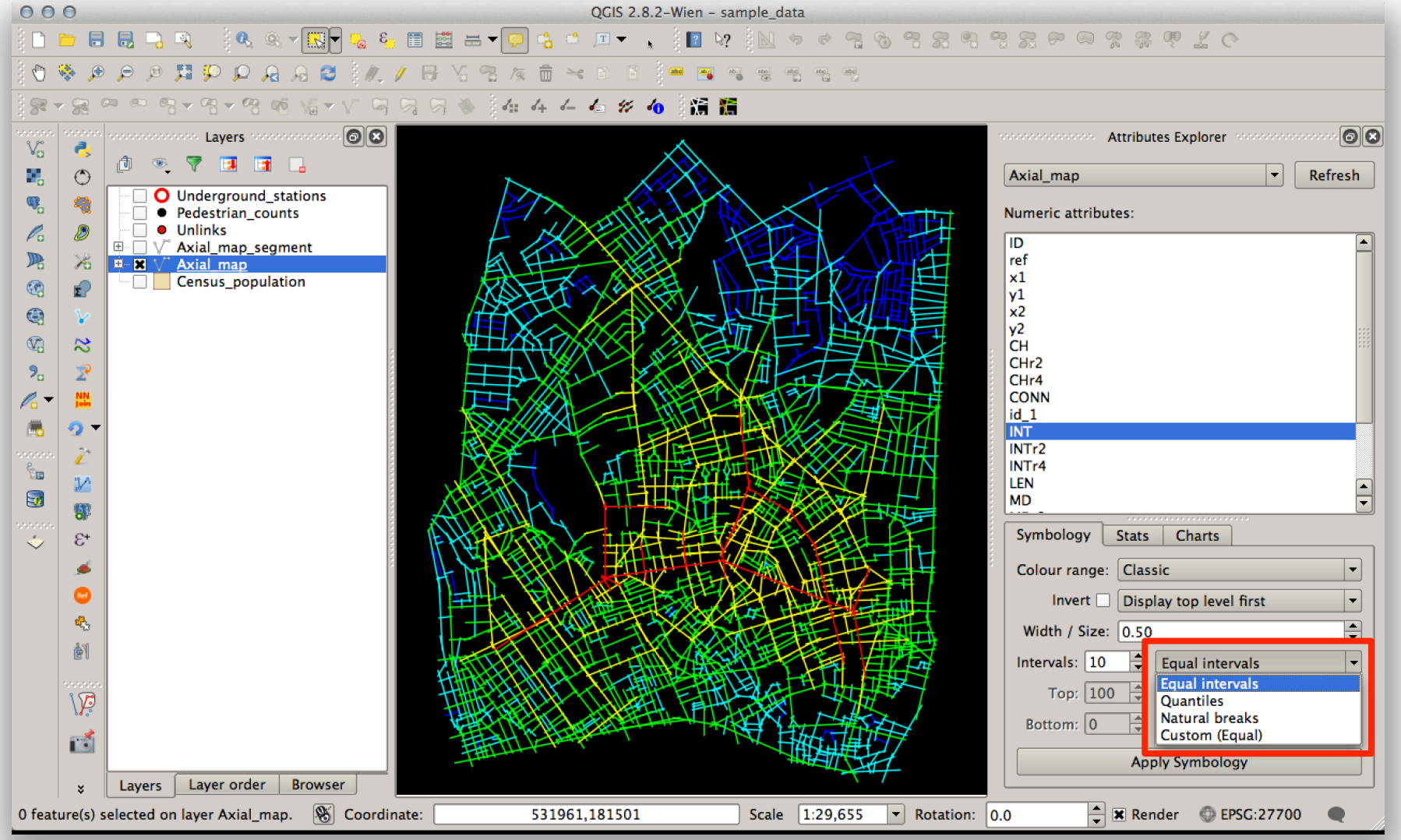
# Attribute symbology: invert range



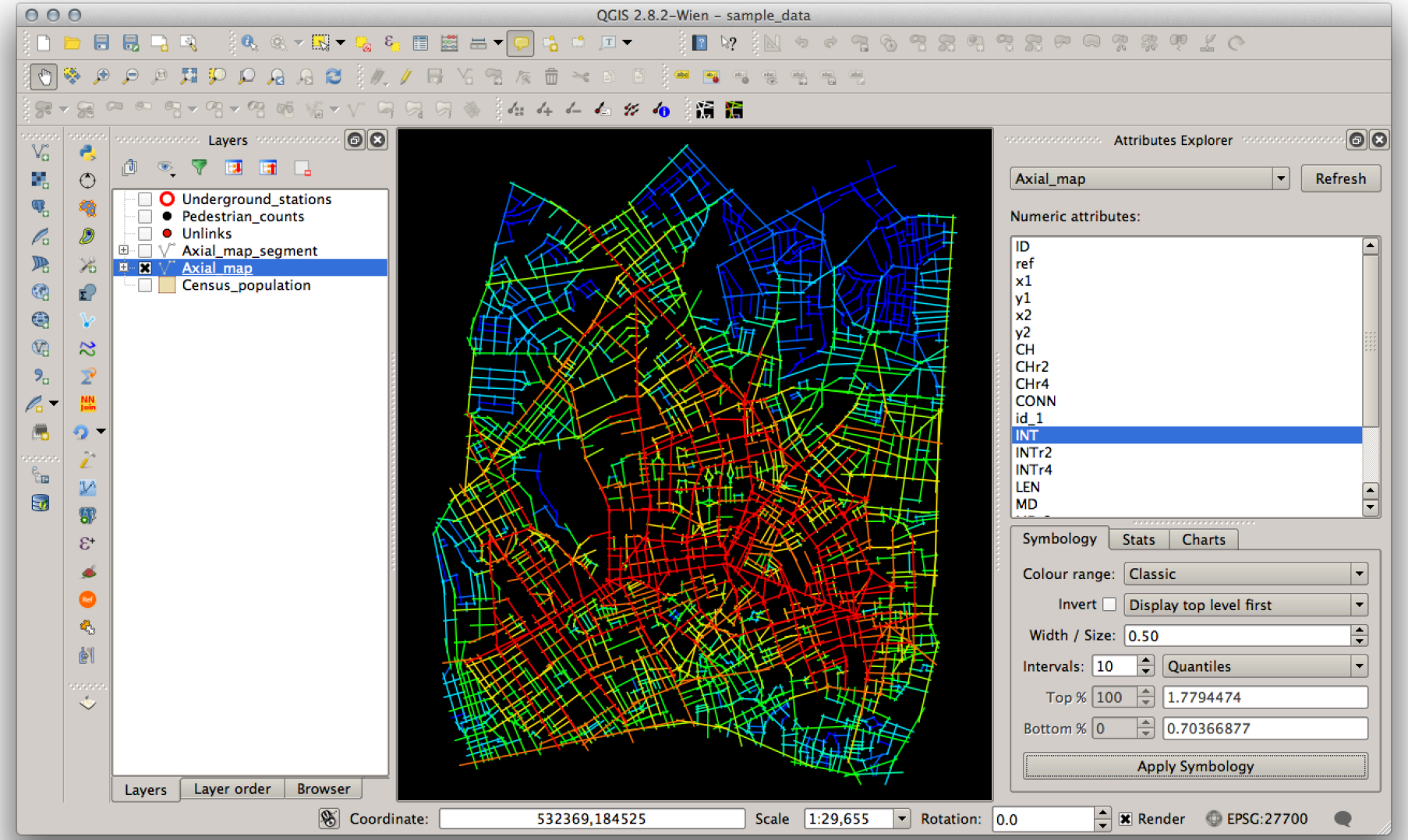
# Attribute symbology: invert range



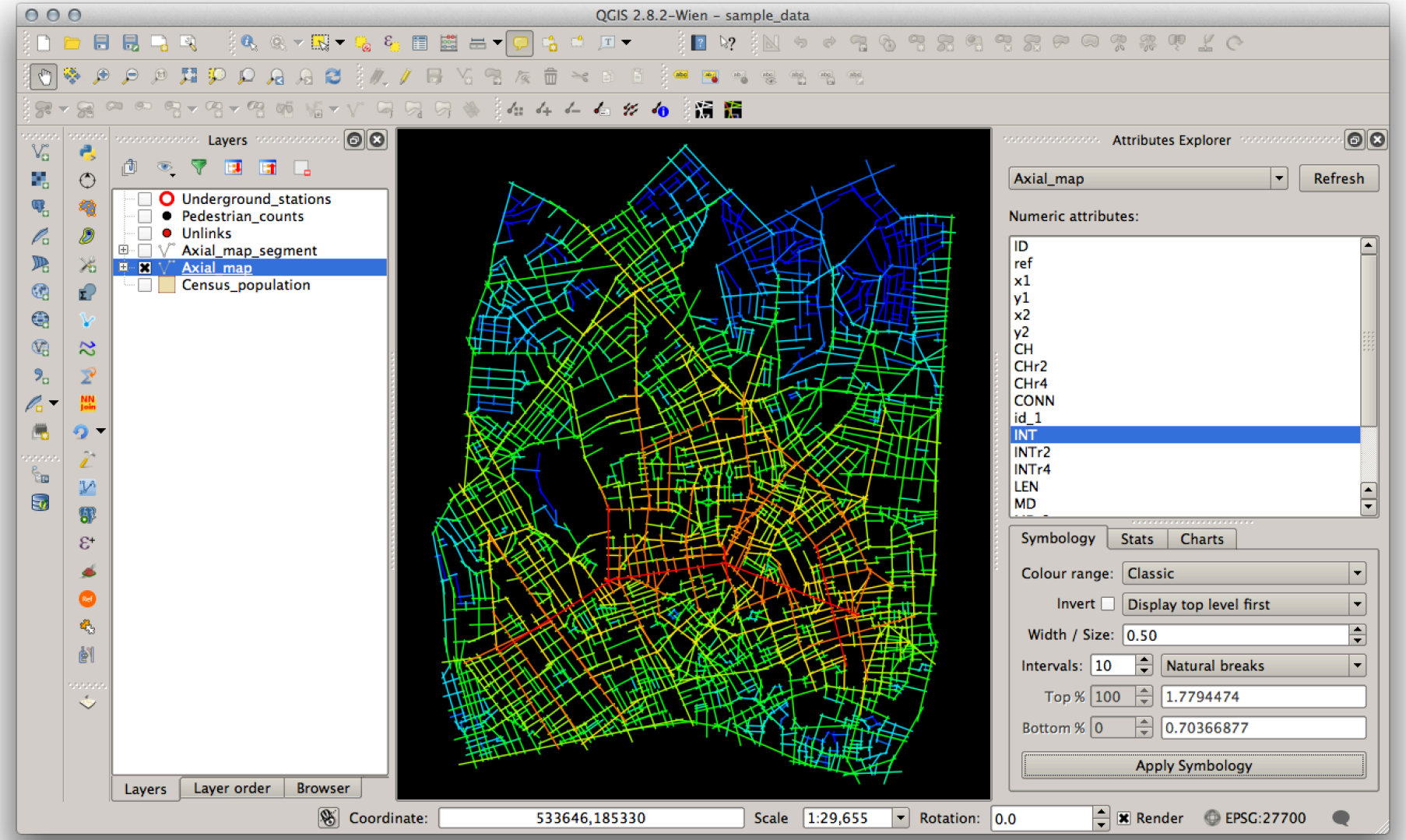
# Attribute symbology: intervals



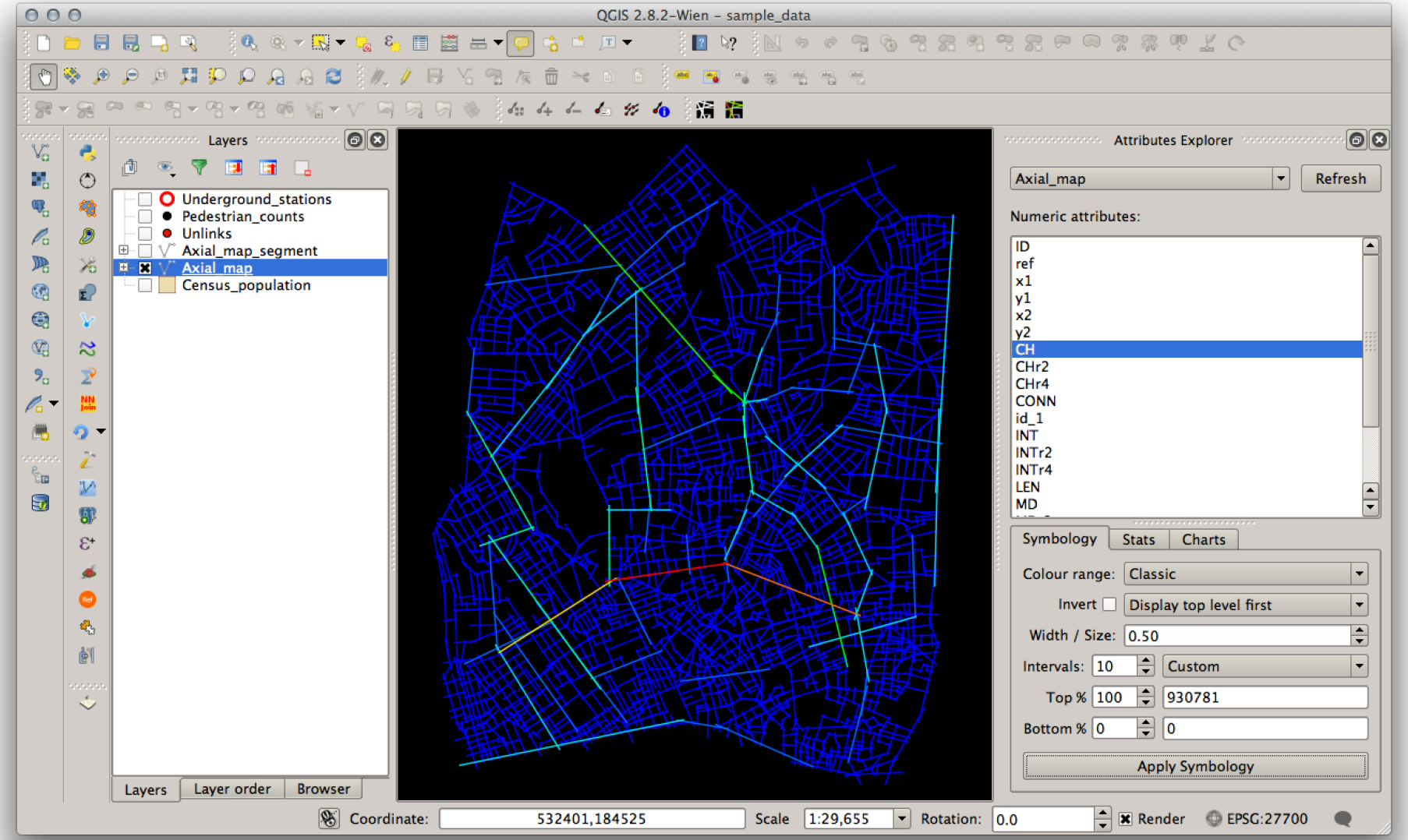
# Attribute symbology: quantiles interval



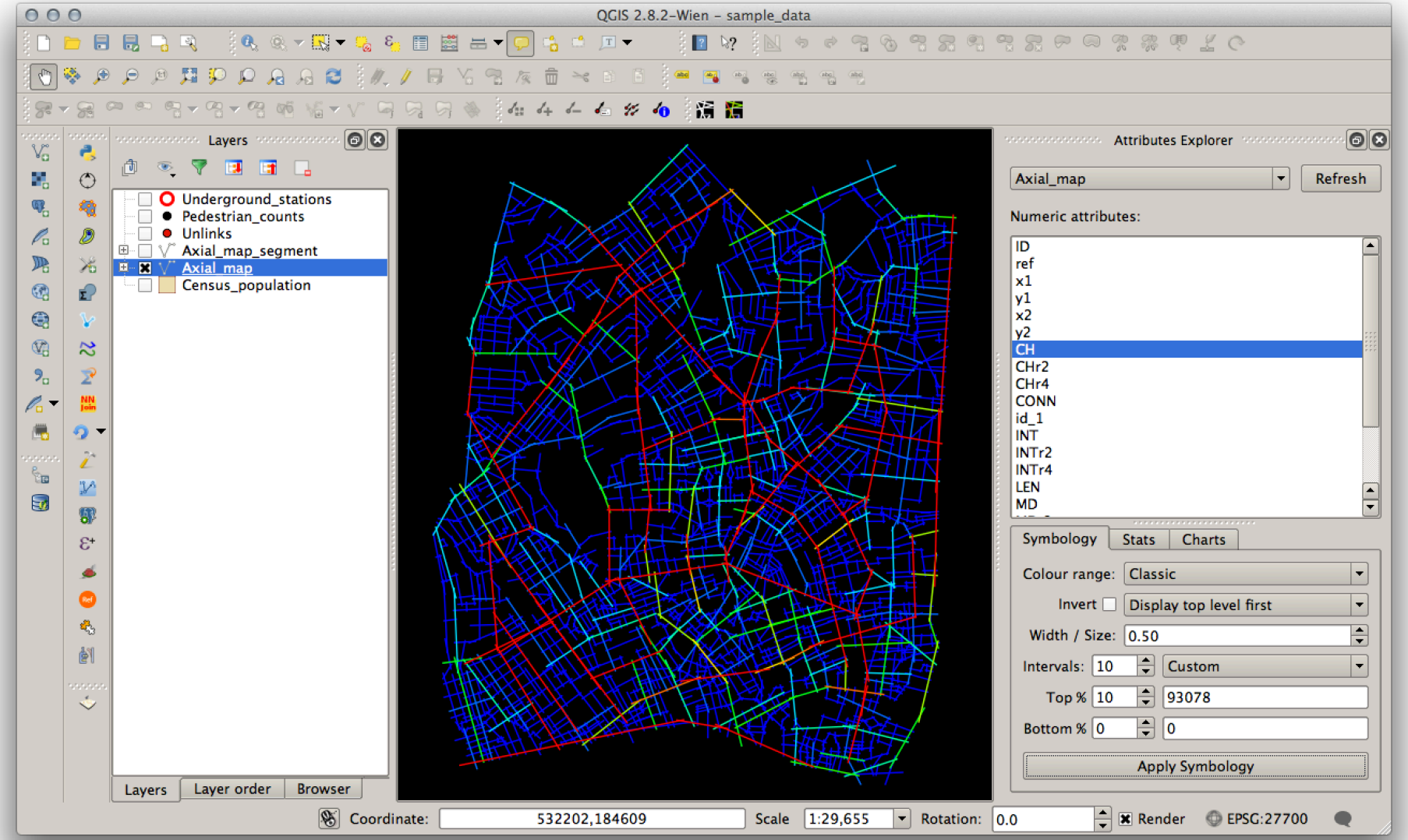
# Attribute symbology: natural breaks interval



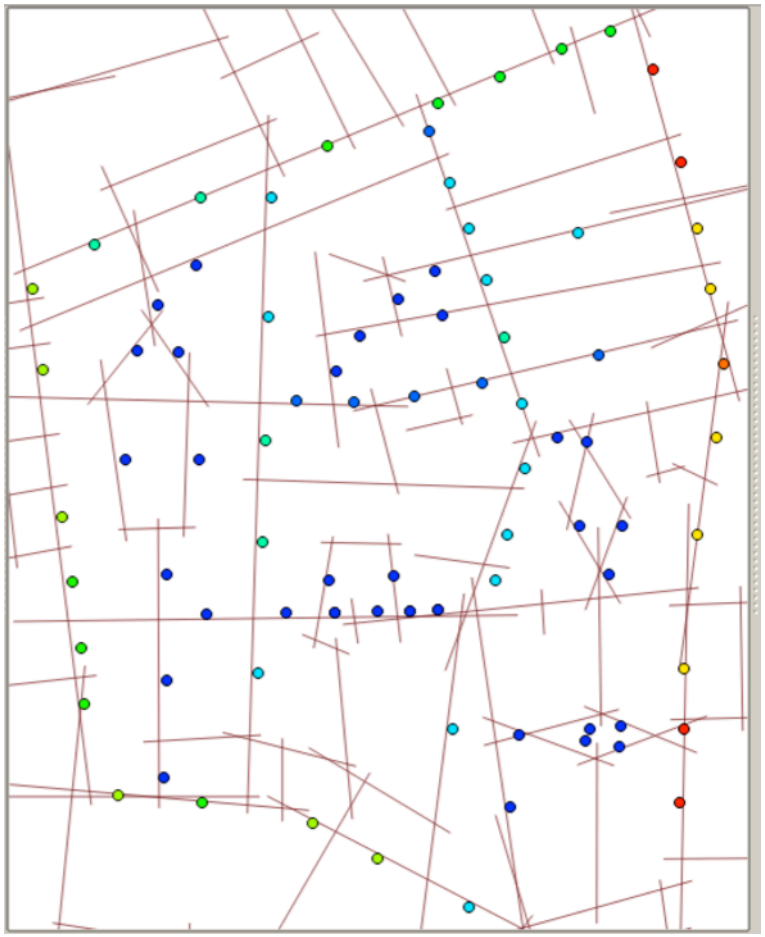
# Attribute symbology: equal intervals (Choice)

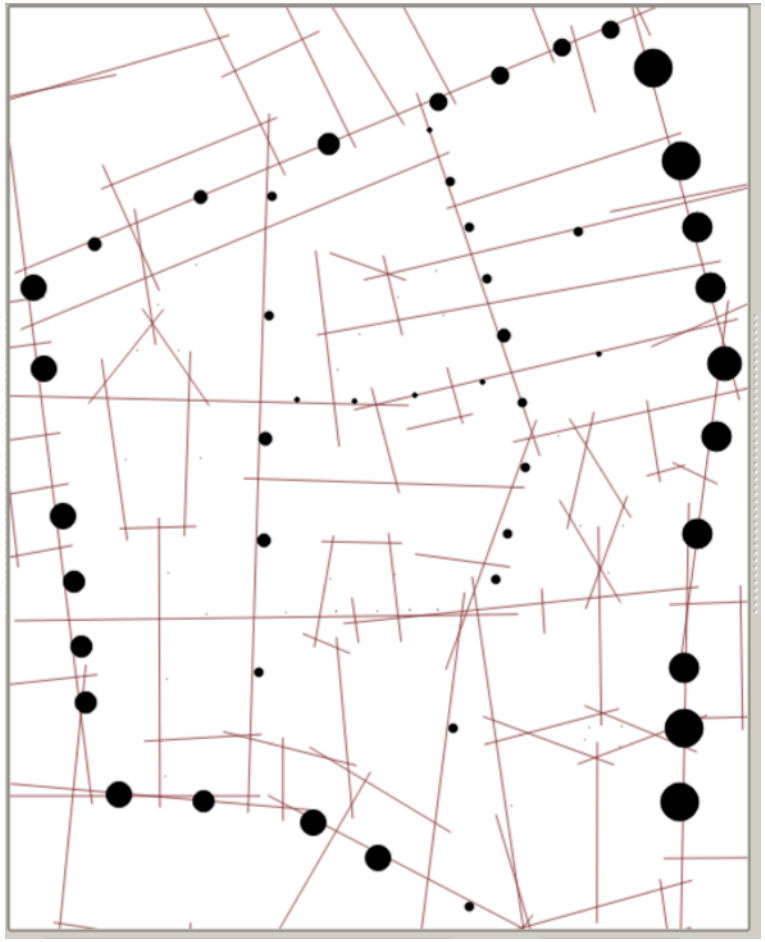


# Attribute symbology: custom interval

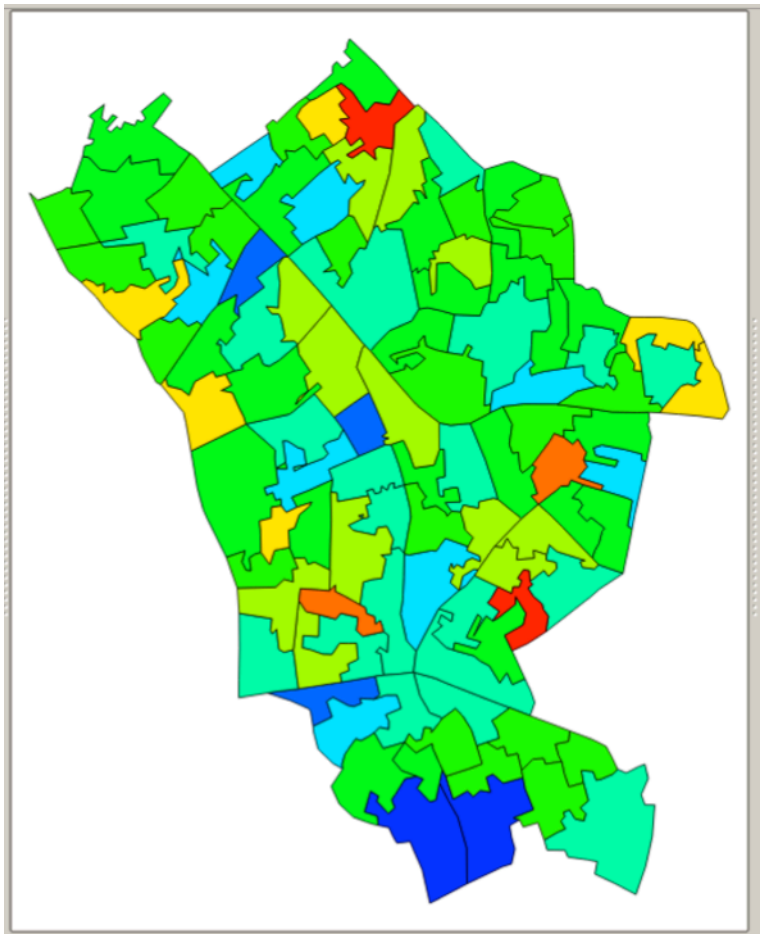


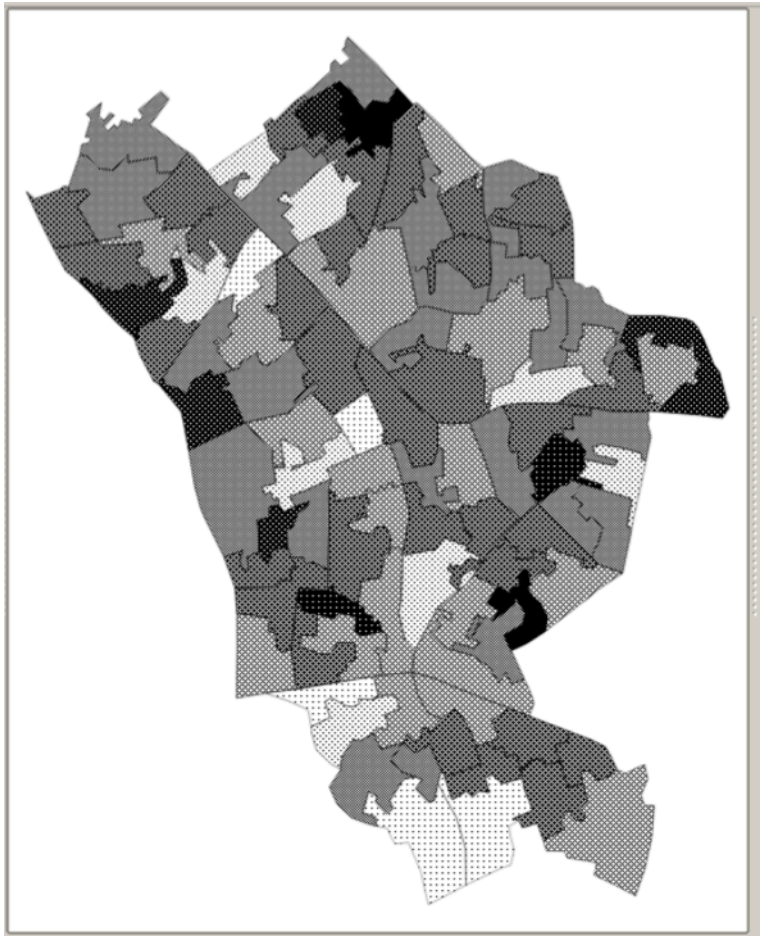
# Attribute symbology: points



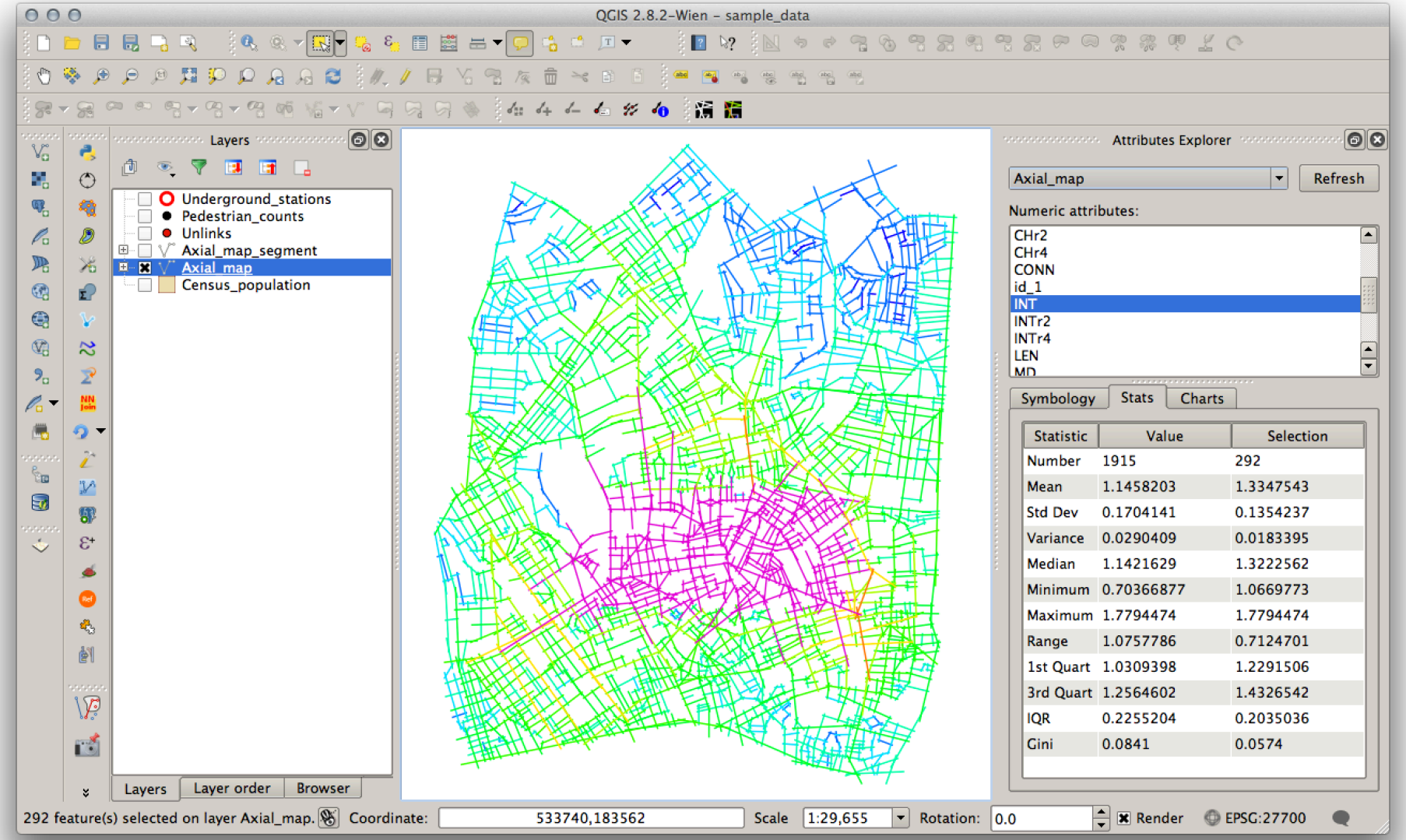


# Attribute symbology: polygons

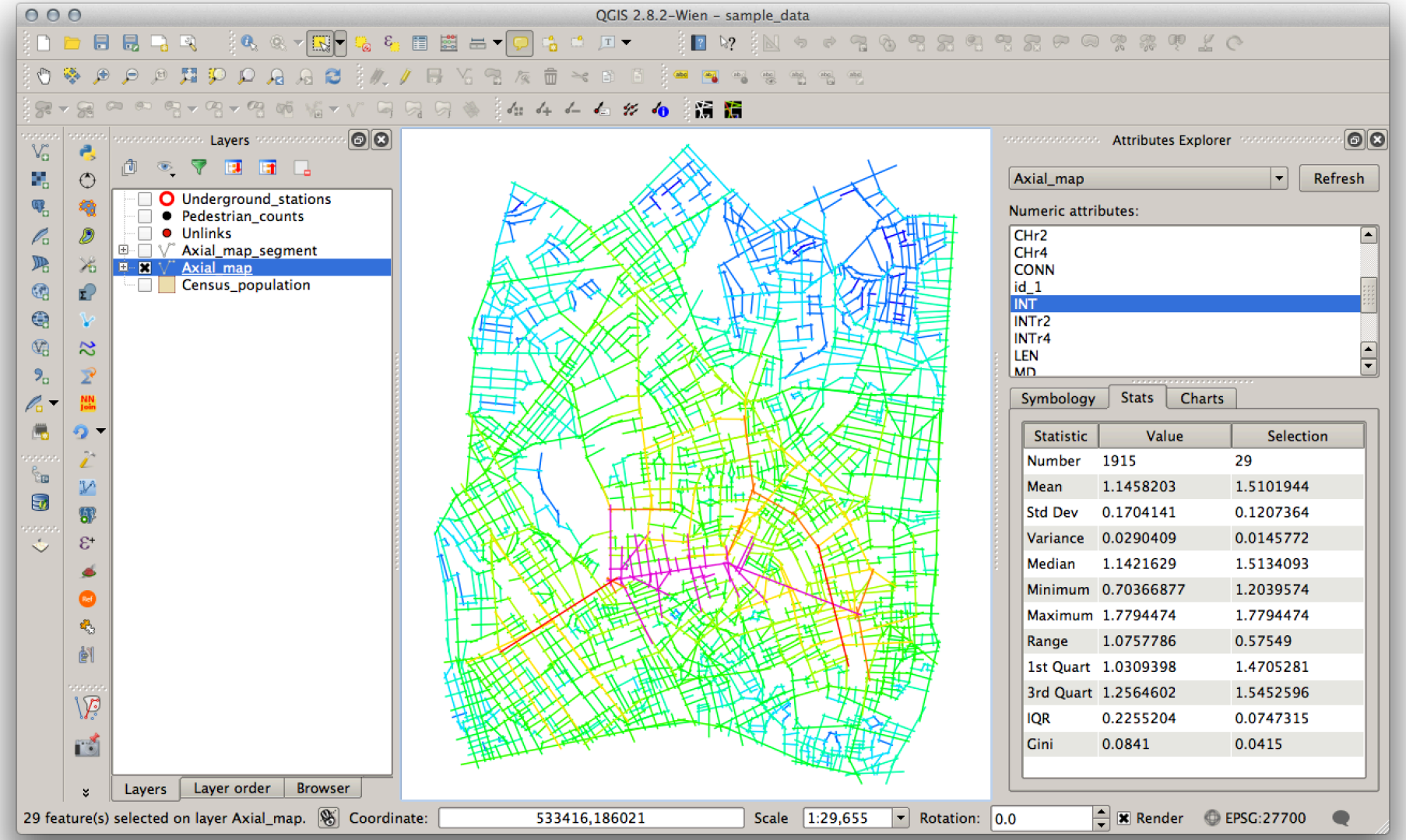




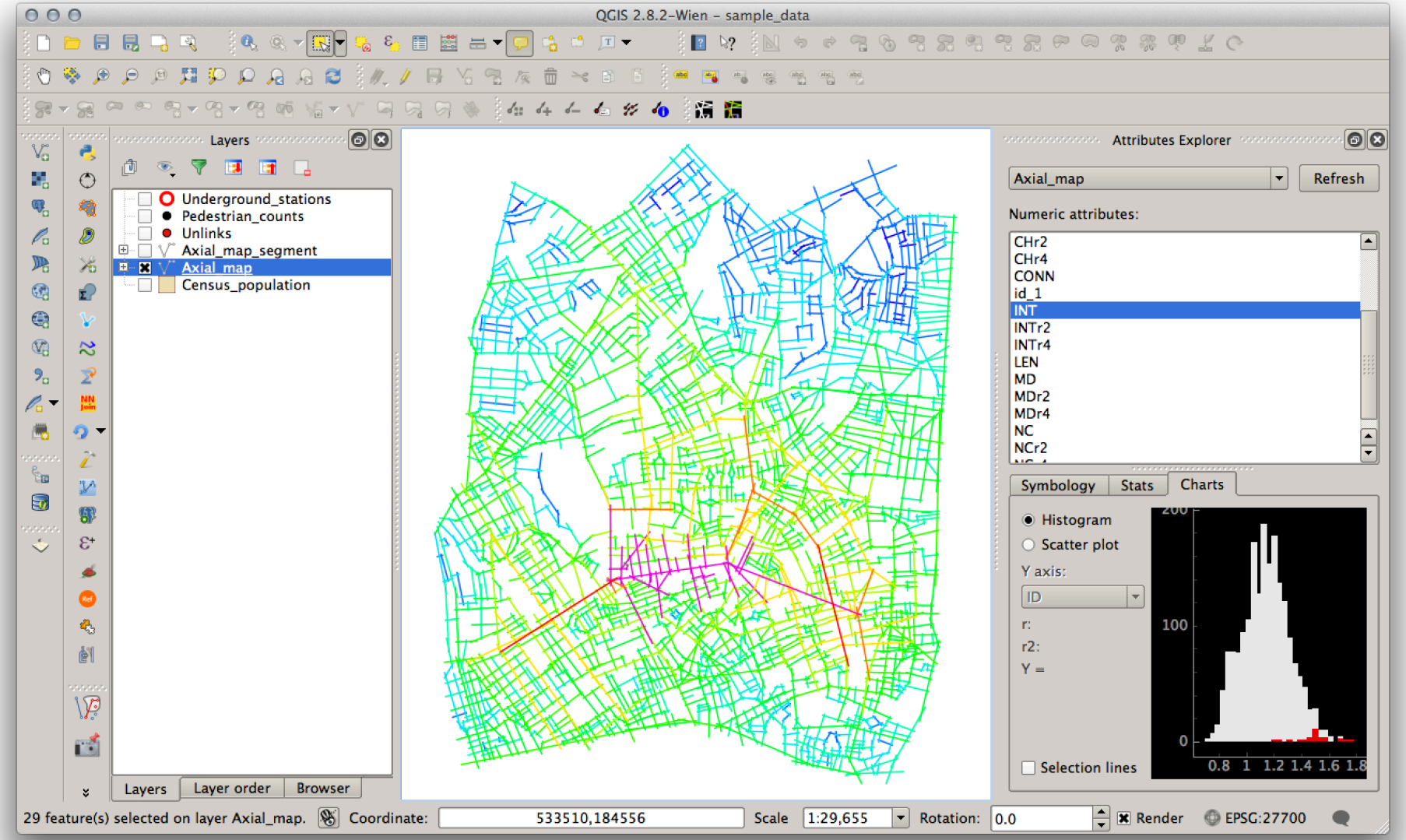
# Attribute stats



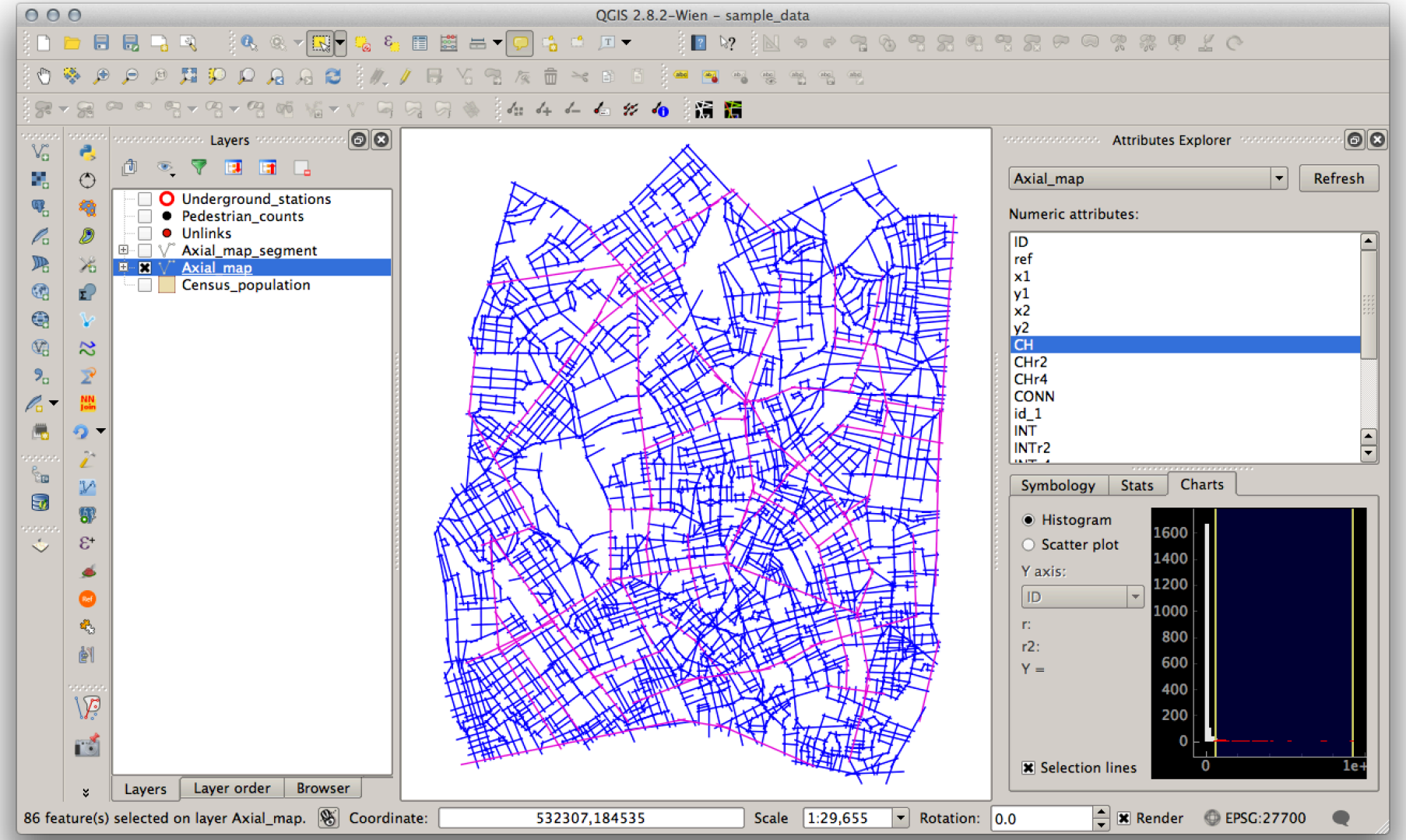
# Attribute stats



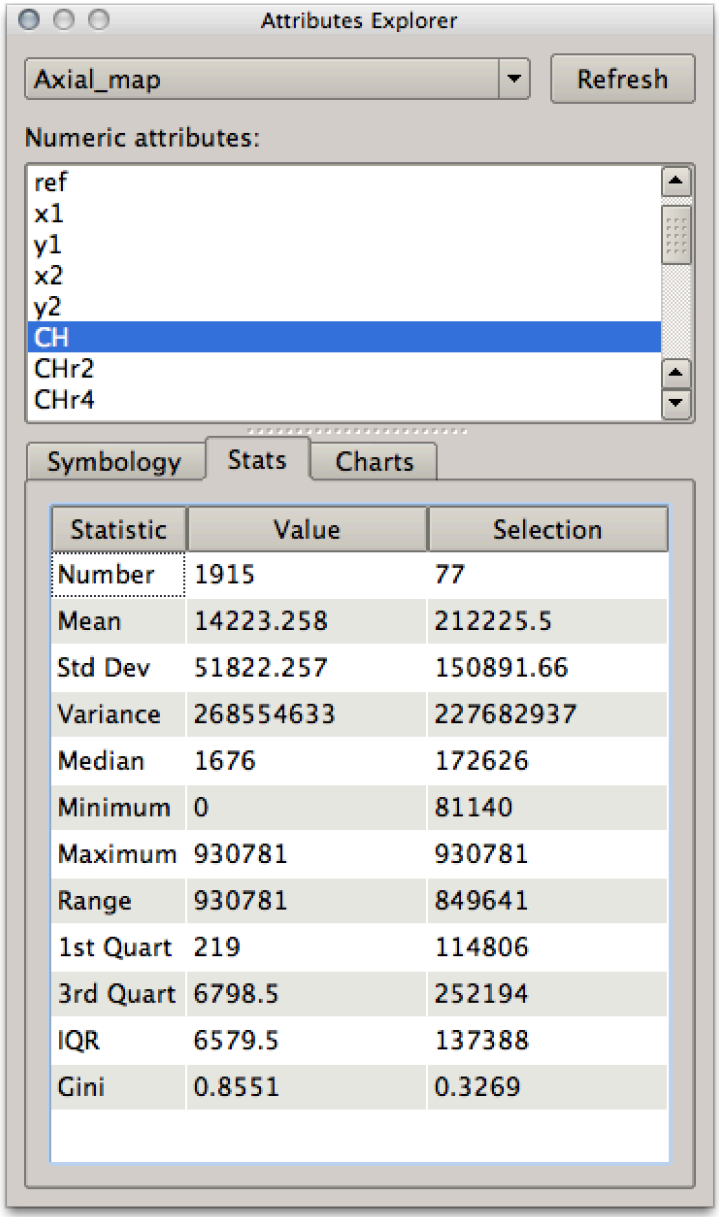
# Attribute charts: histogram



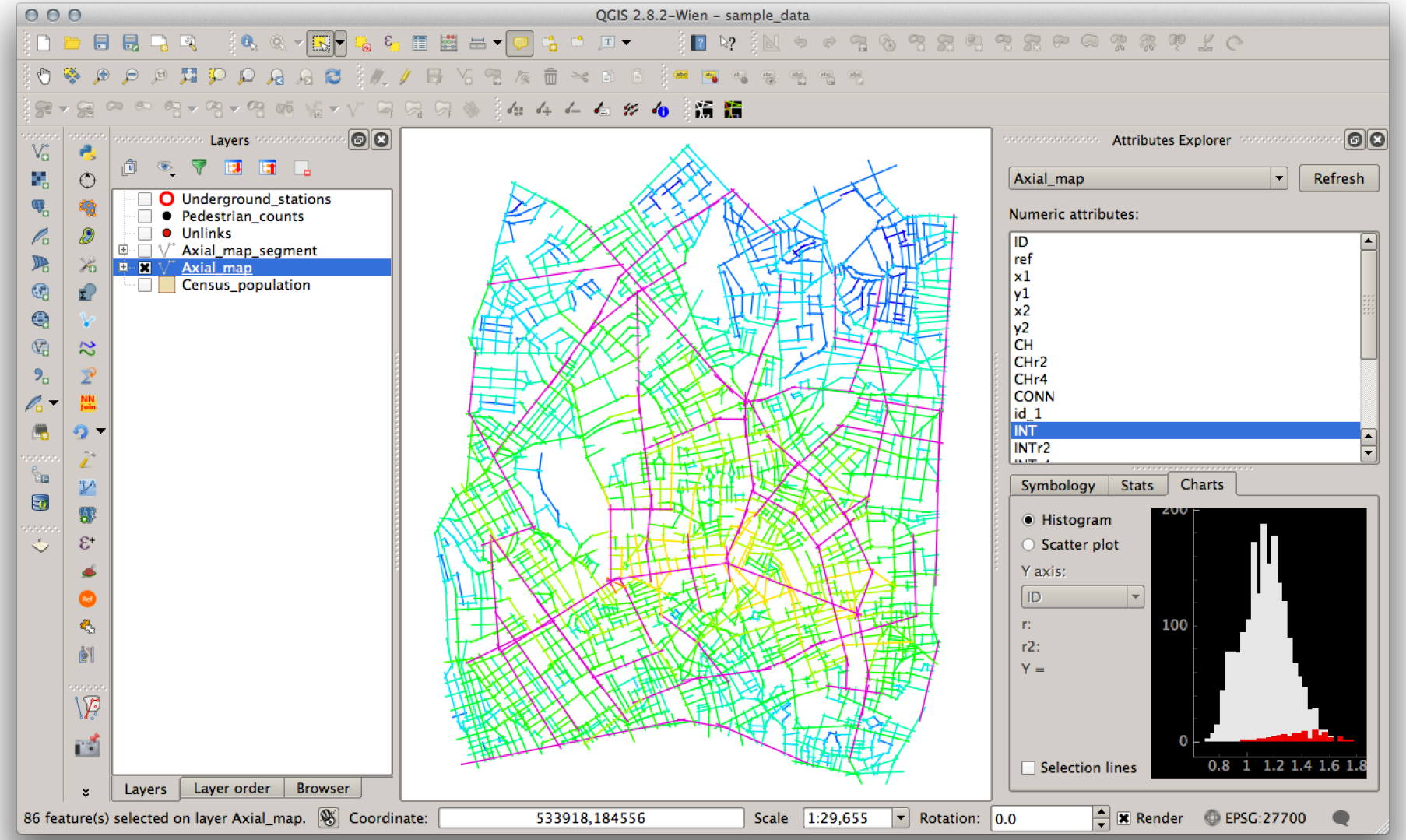
# Attribute charts: histogram selection



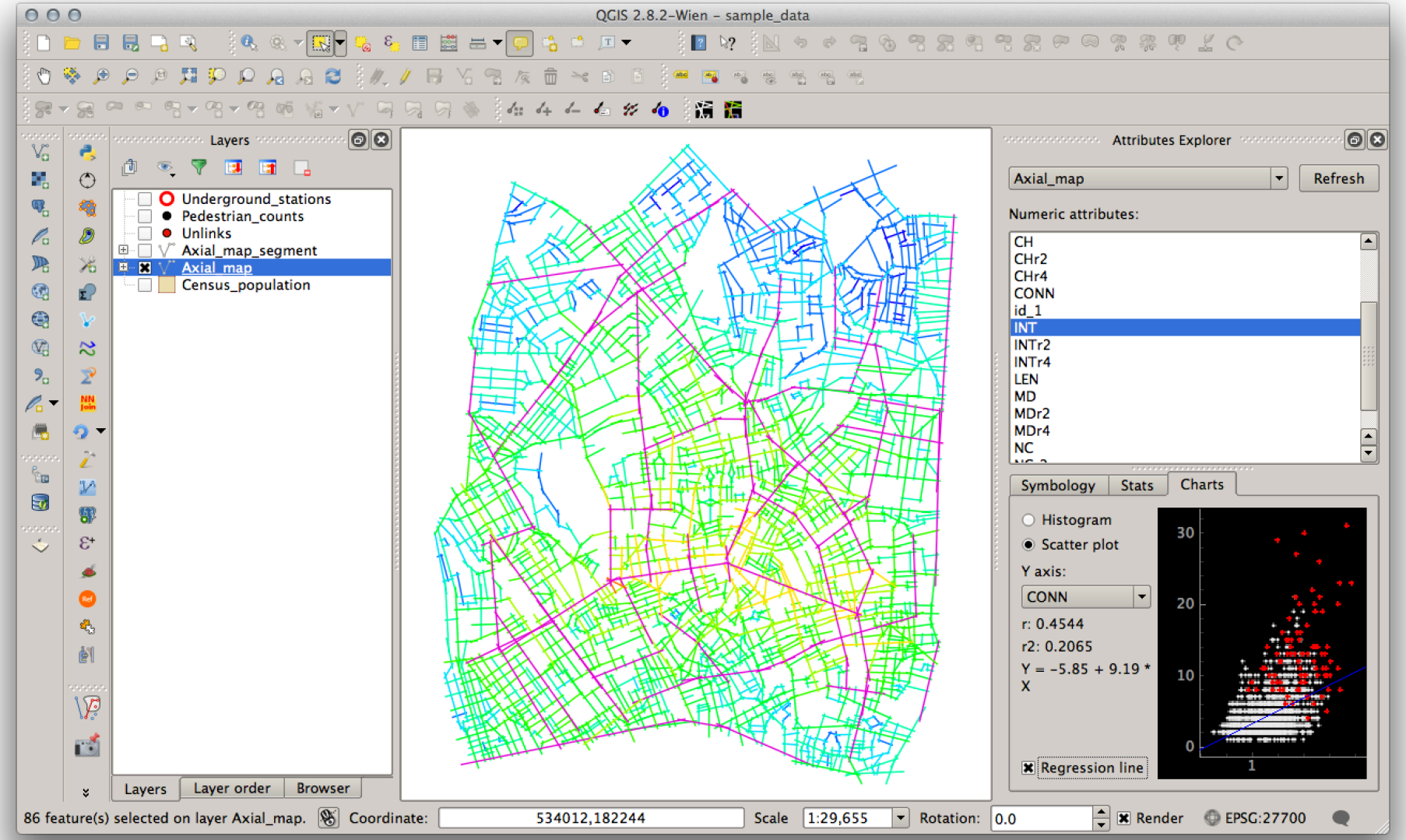
# Attribute charts: histogram selection



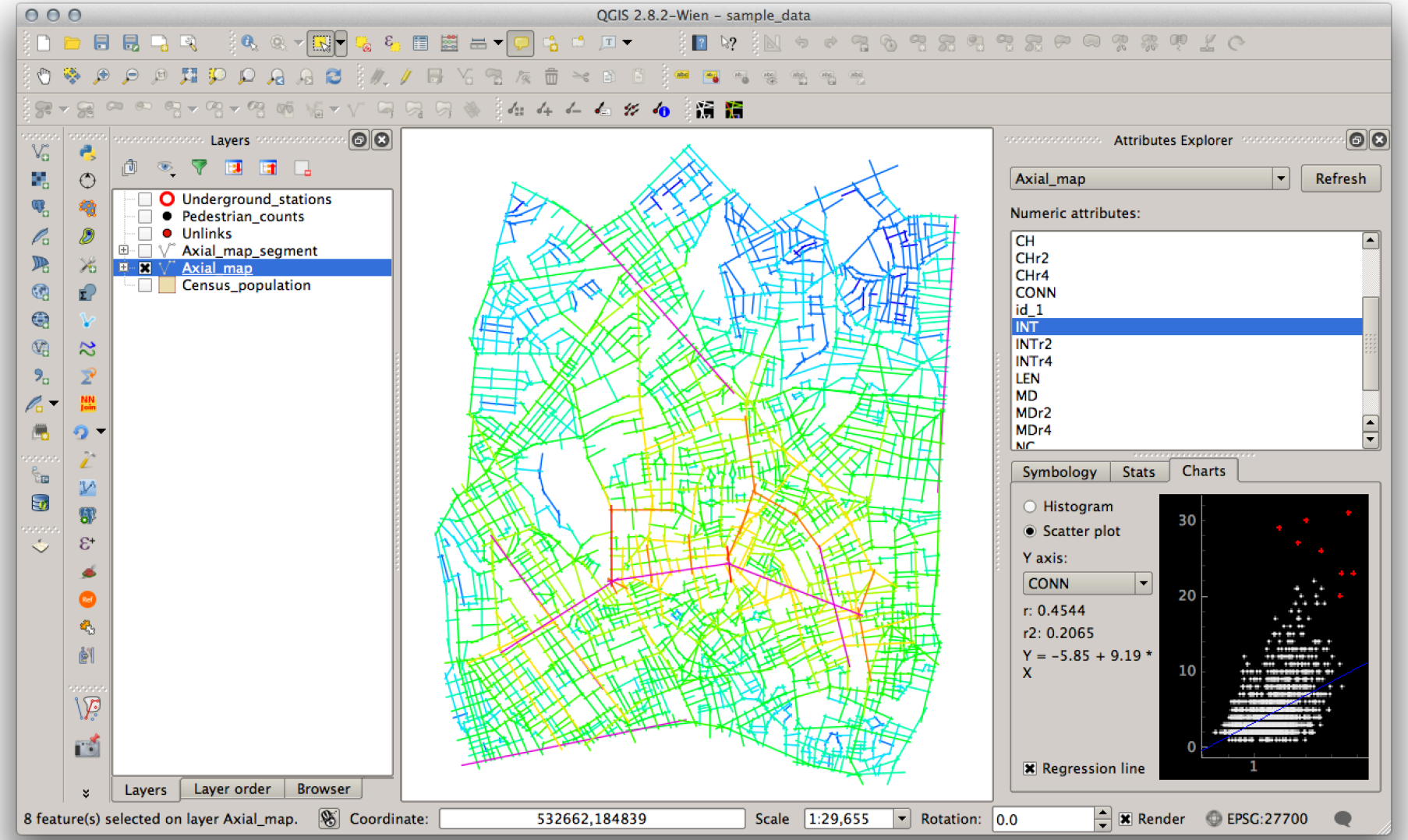
# Attribute charts: histogram



# Attribute charts: scatterplot



# Attribute charts: scatterplot selection



- QGIS: http://www.qgis.org/en/site/forusers/download.html
- DepthmapXnet:

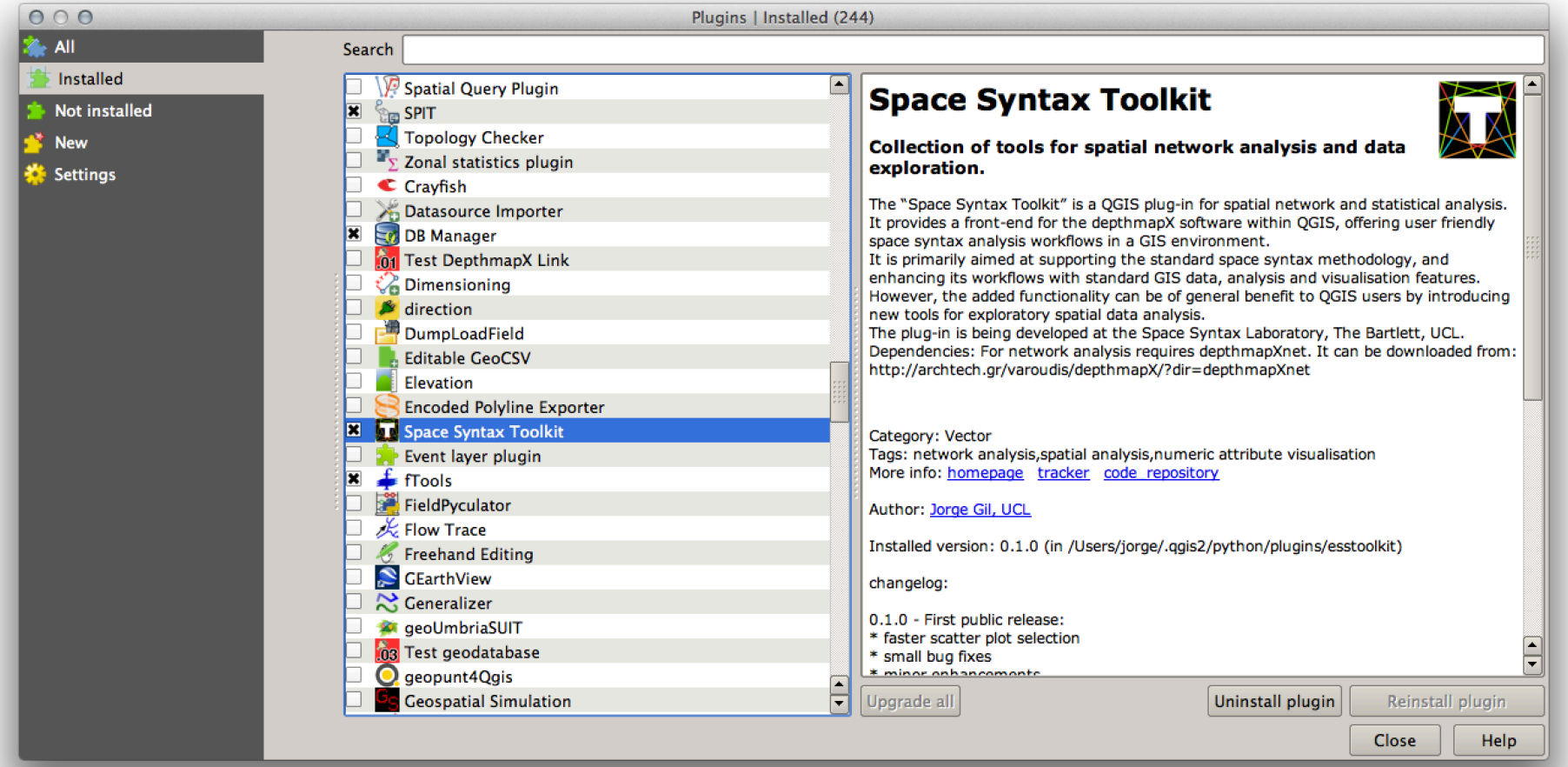
http://archtech.gr/varoudis/depthmapX/?dir=depthmapXnet

- SST:

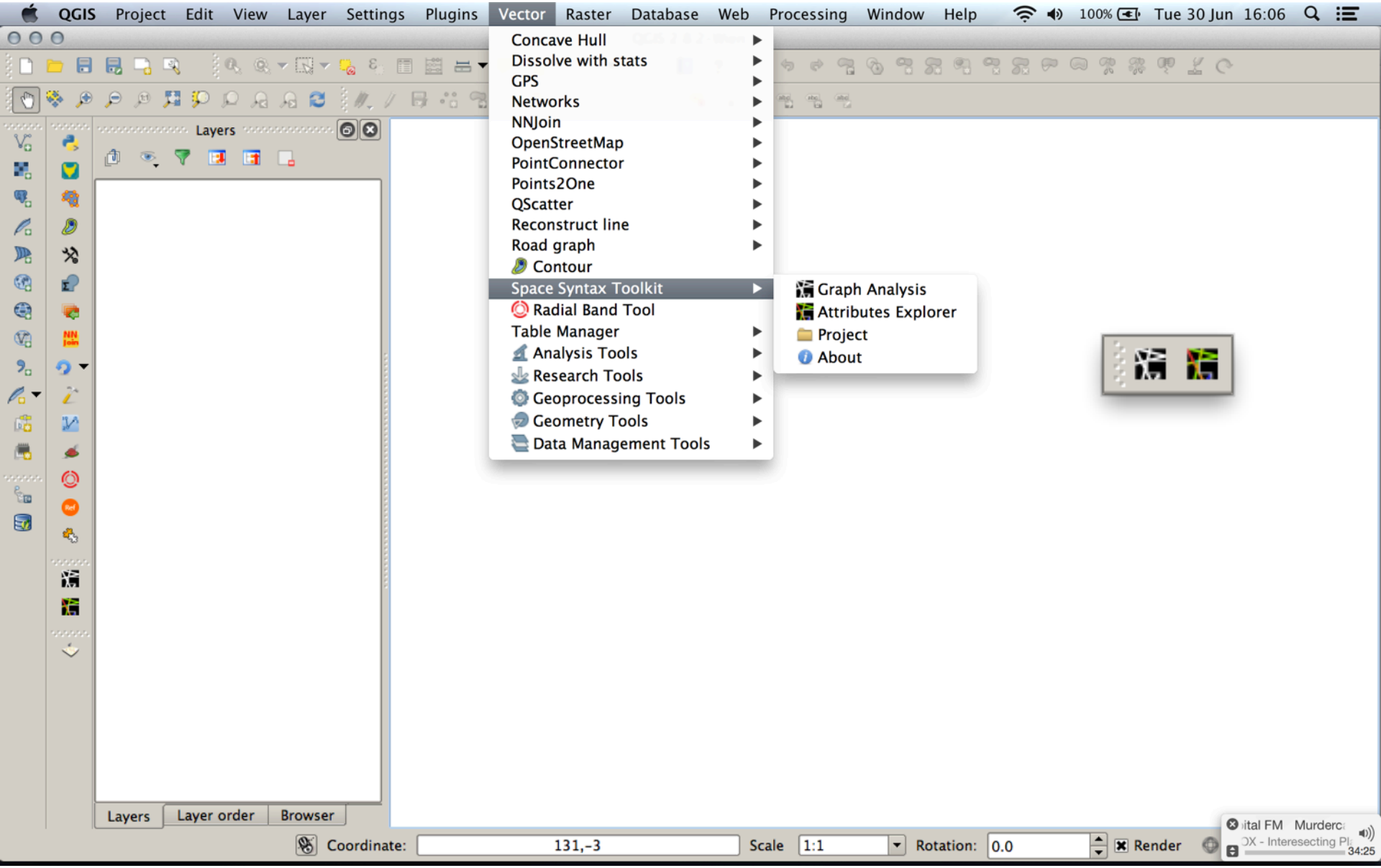
Download from QGIS plugins repository

(Also to manage updates when available)

# SST installation



# SST installation



# Other useful QGIS plug-ins

- Openlayers
- Dbmanager
- Processing

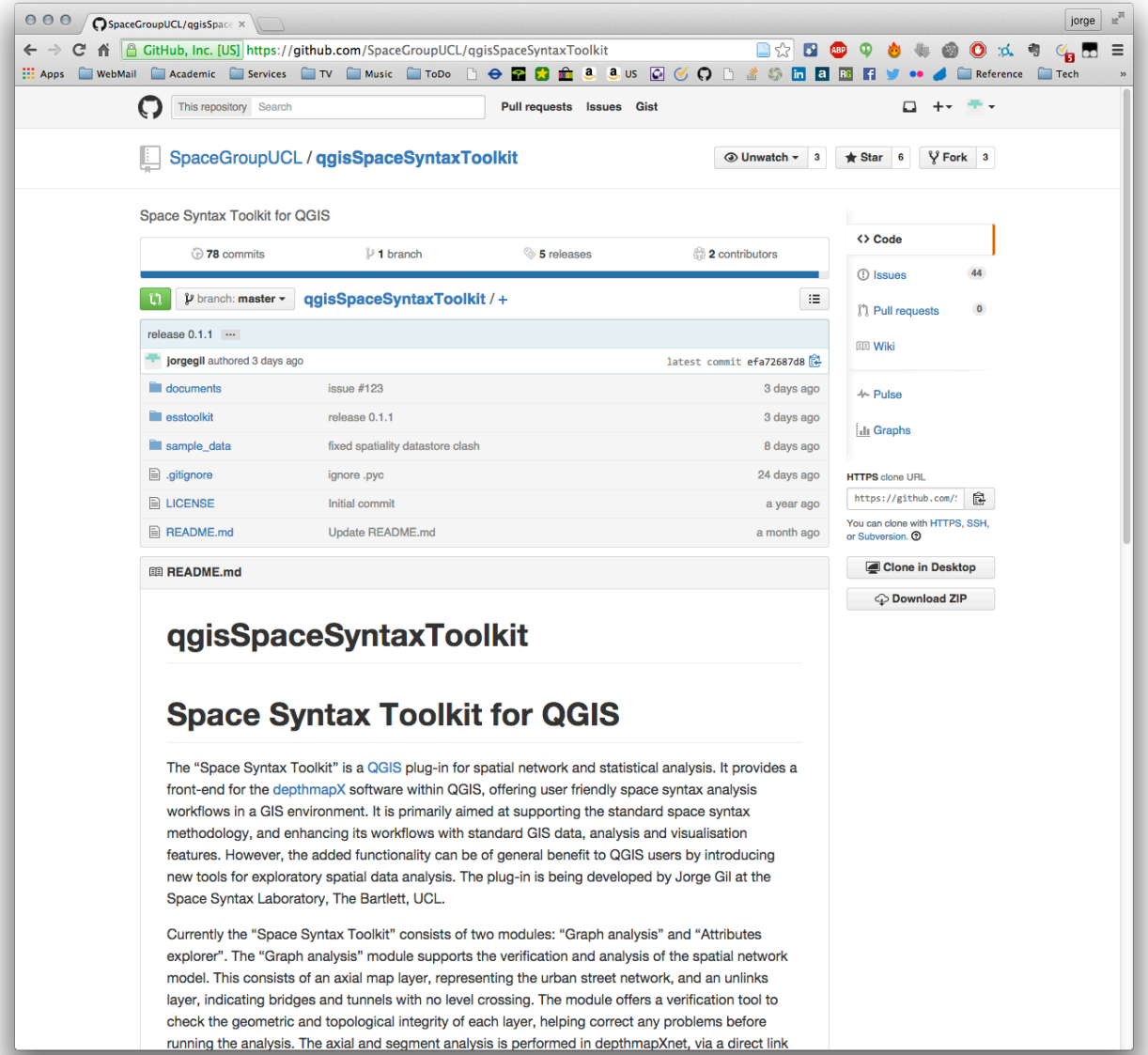
(not a comprehensive list, and there are alternatives to some of the above)

# SST project repository

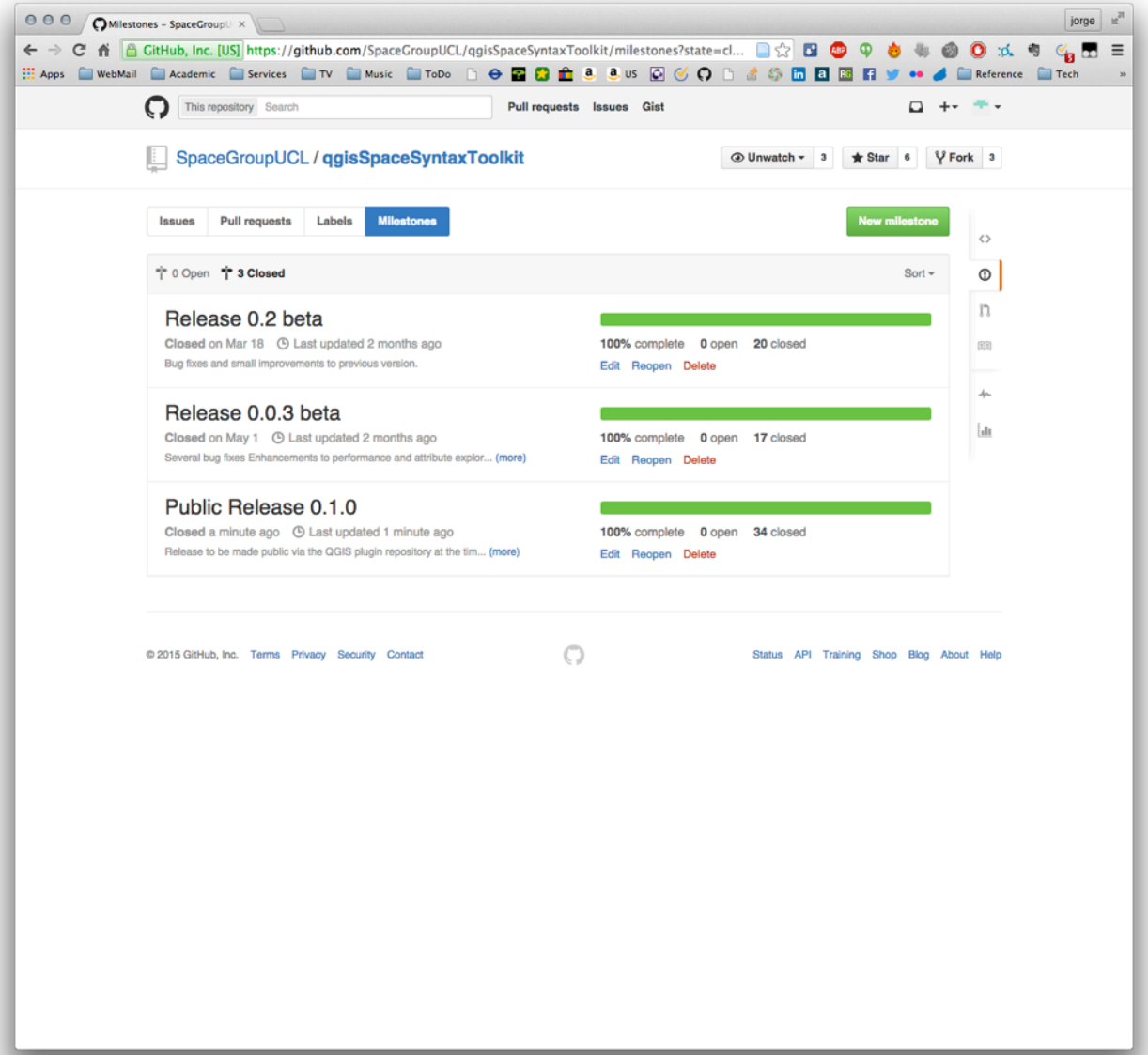
- Official Releases
- Latest source code
- Documentation
- Sample data
- Issue tracking – problems and suggestions

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

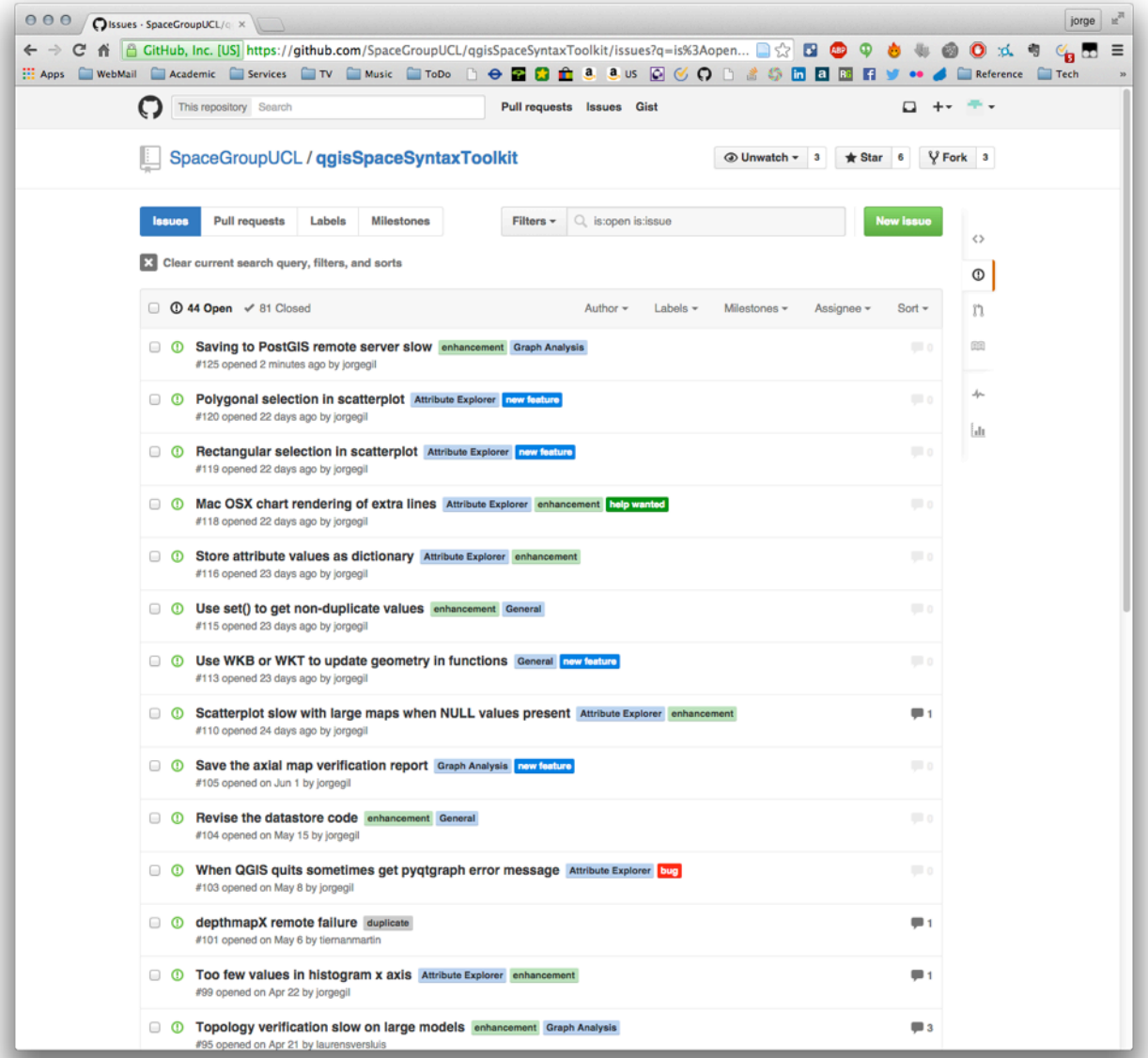
# SST Github repository



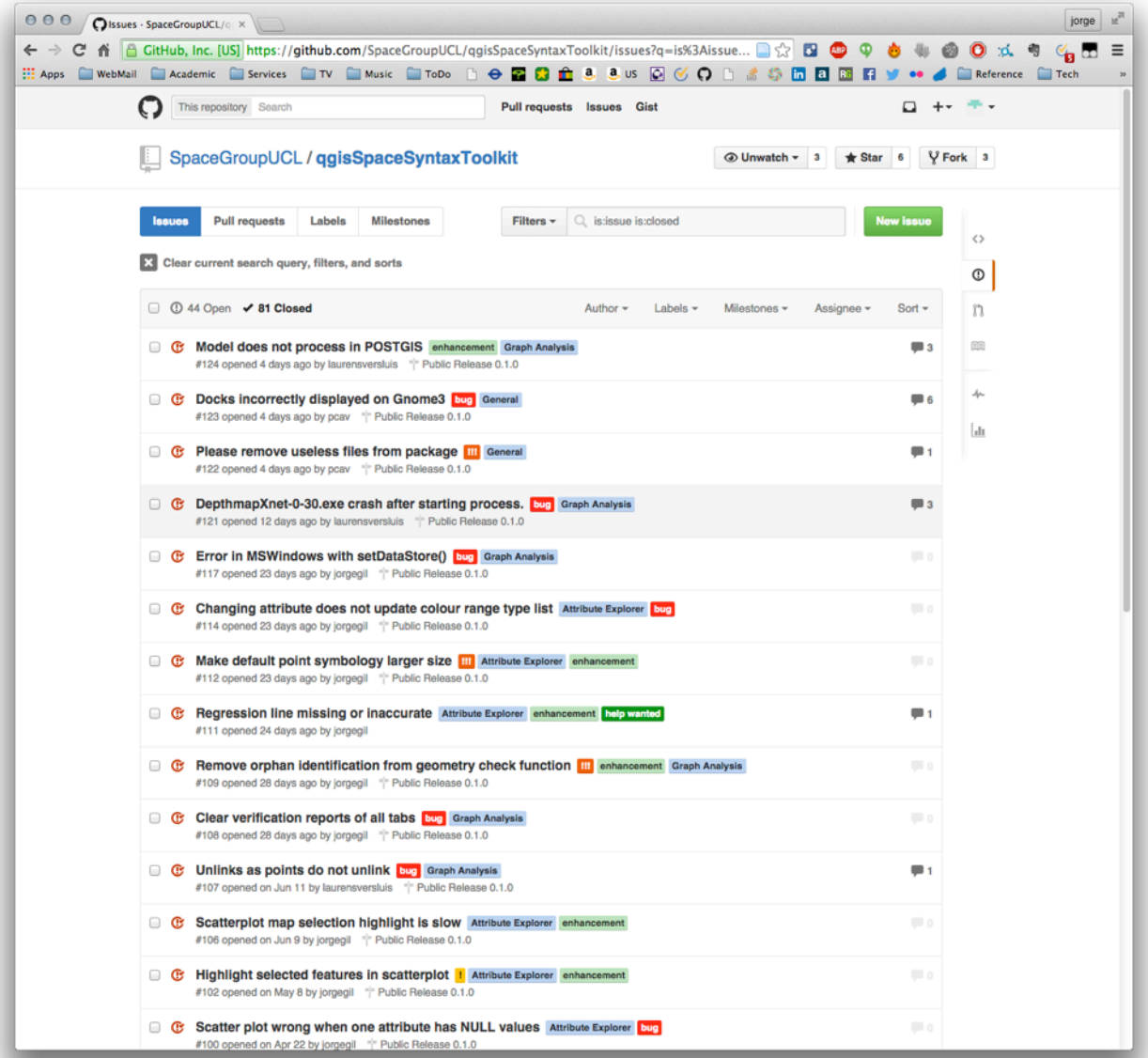
# Milestones


Milestones – SpaceGroupUCL
jorge
GitHub, Inc. [US] https://github.com/SpaceGroupUCL/qgisSpaceSyntaxToolkit/milestones?state=cl...
Apps WebMail Academic Services TV Music ToDo Reference Tech
This repository Search
Pull requests Issues Gist
SpaceGroupUCL / qgisSpaceSyntaxToolkit
Unwatch 3 Star 6 Fork 3
Issues Pull requests Labels Milestones
New milestone
0 Open 3 Closed
Sort
Release 0.2 beta
Closed on Mar 18 Last updated 2 months ago
Bug fixes and small improvements to previous version.
100% complete 0 open 20 closed
Edit Reopen Delete
Release 0.0.3 beta
Closed on May 1 Last updated 2 months ago
Several bug fixes Enhancements to performance and attribute explor... (more)
100% complete 0 open 17 closed
Edit Reopen Delete
Public Release 0.1.0
Closed a minute ago Last updated 1 minute ago
Release to be made public via the QGIS plugin repository at the tim... (more)
100% complete 0 open 34 closed
Edit Reopen Delete
© 2015 GitHub, Inc. Terms Privacy Security Contact
Status API Training Shop Blog About Help

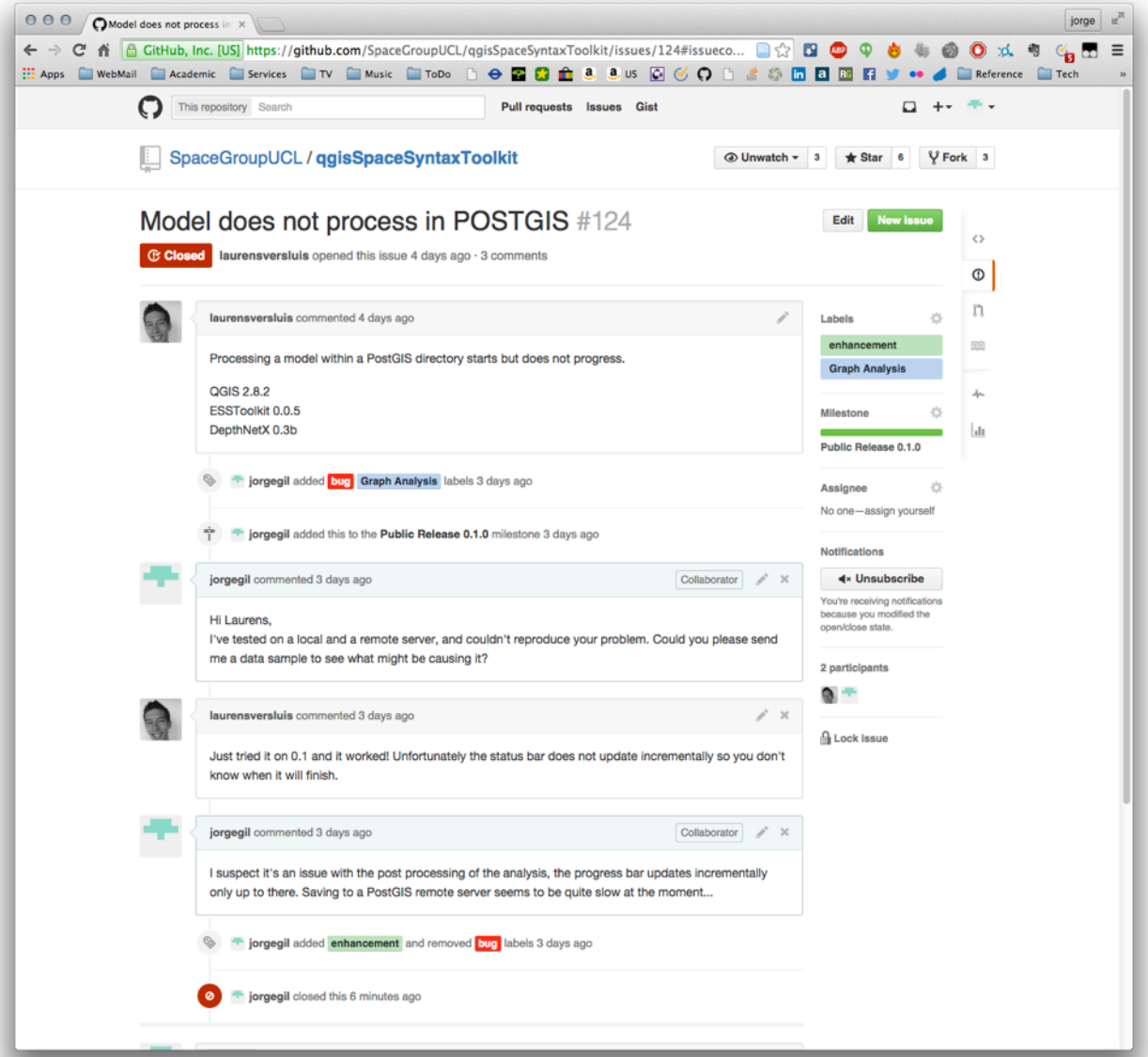
# Issue tracking



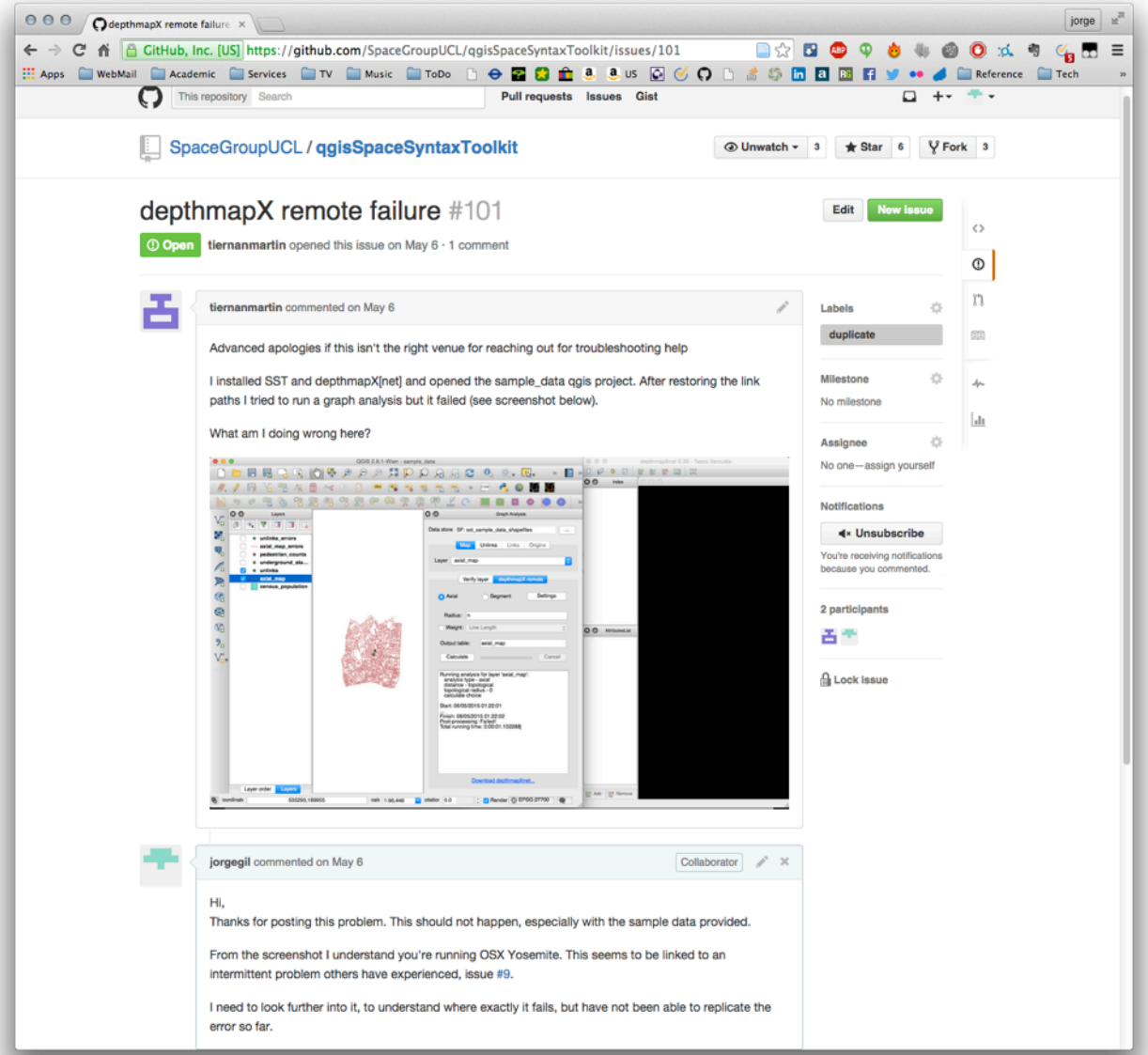
# Issue tracking



# Issue tracking



# Issue tracking



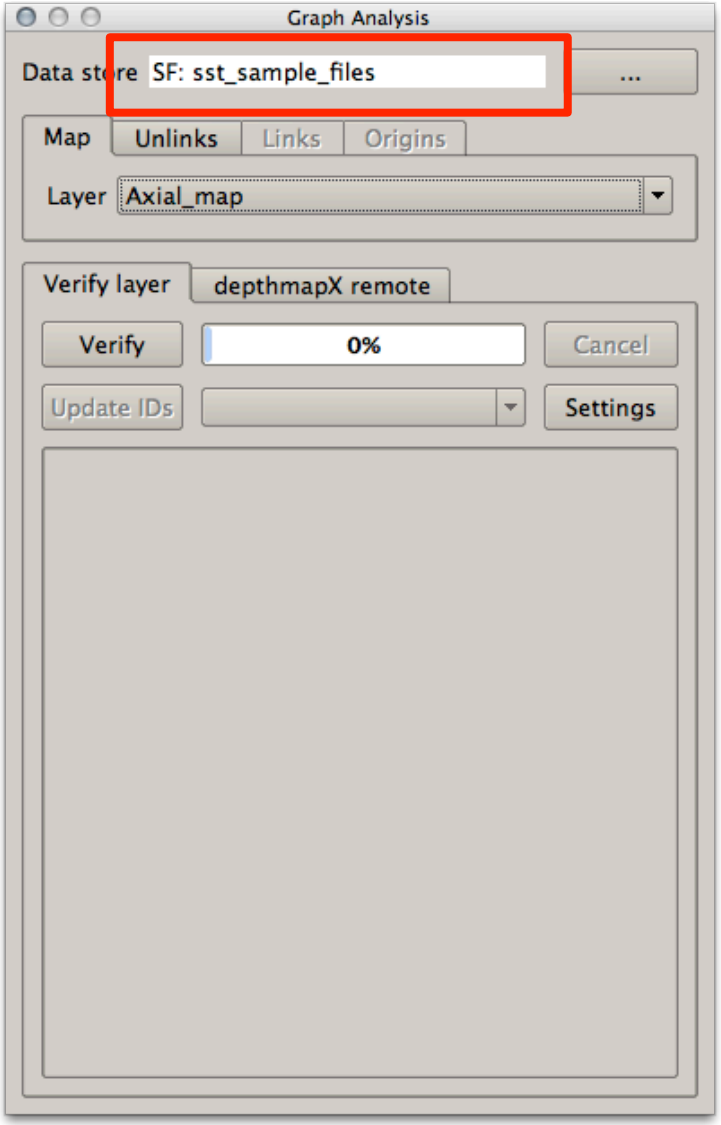
# PART 2 – Demonstration and Exercise

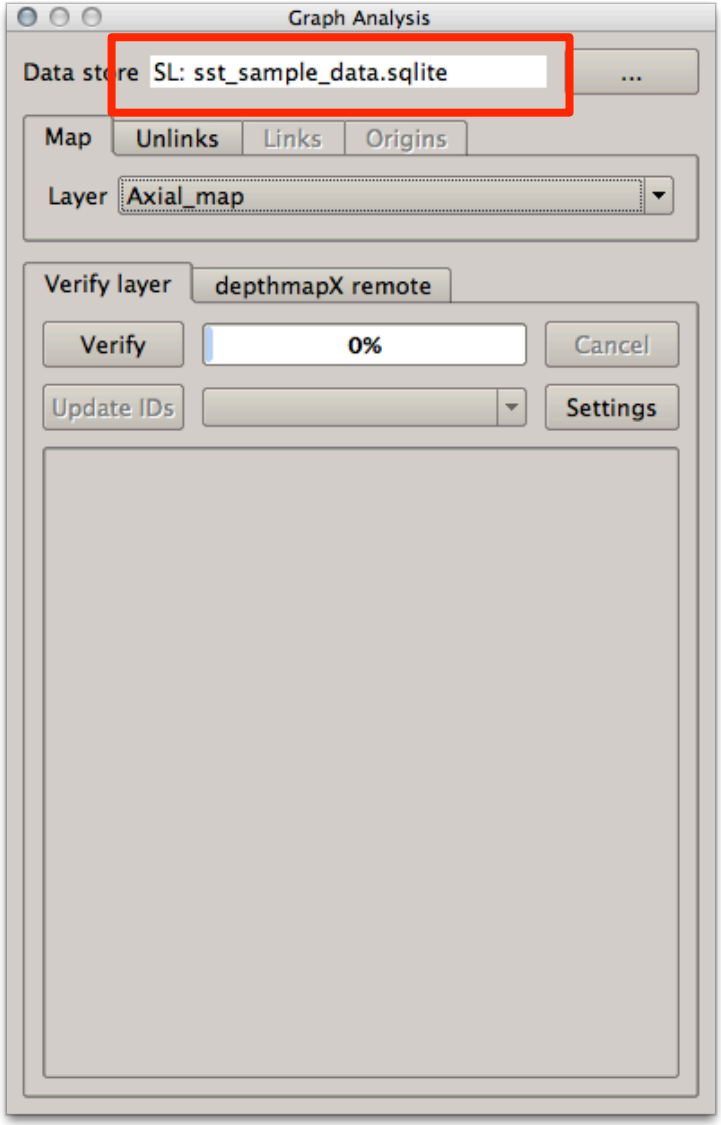
1. Before we begin: data formats
2. Exercise: complete SST workflow
    1. Creating the axial model
    2. Verifying the axial model
    3. Axial and segment analysis
    4. Creating analysis results maps

# Before we begin: data formats

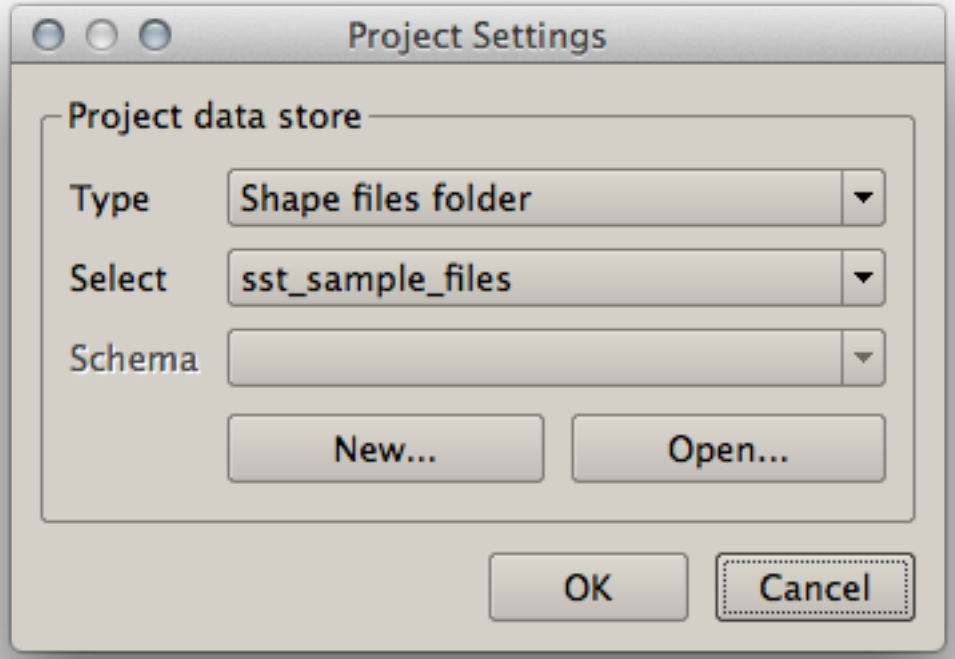
- Using sample data:
  - open a project file
  - layers are automatically added to QGIS
- Using own data source:
  - adding layers to a project
  - select file / database
- Different data formats, different features

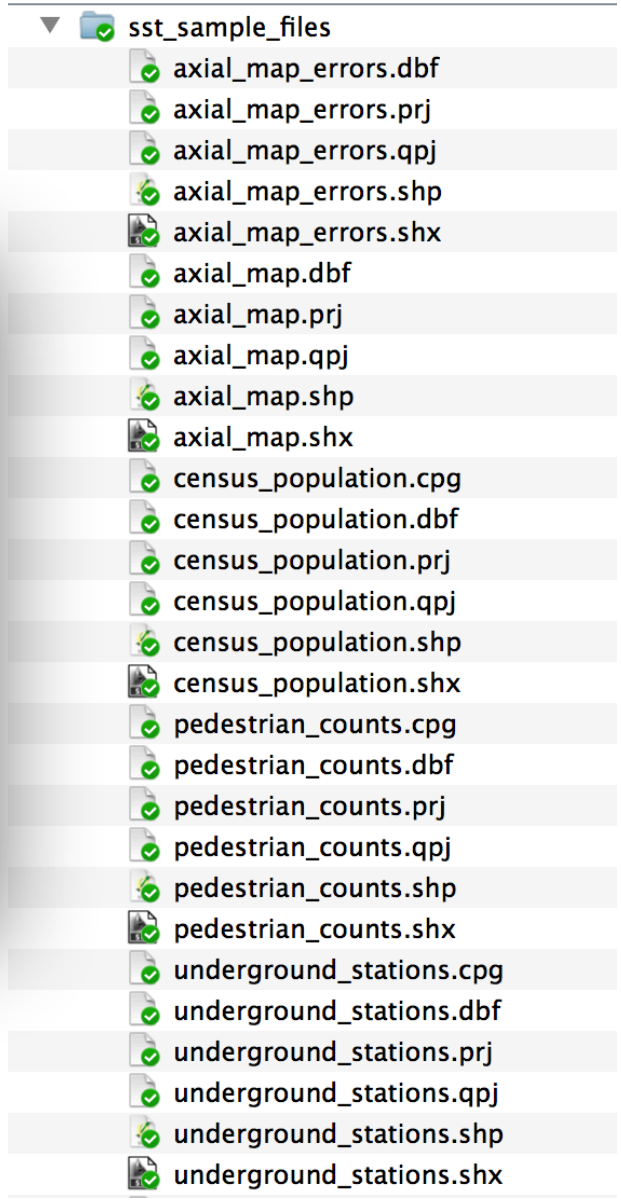
# Data store set-up



# Data store set-up: Shape Files



# Shape file format

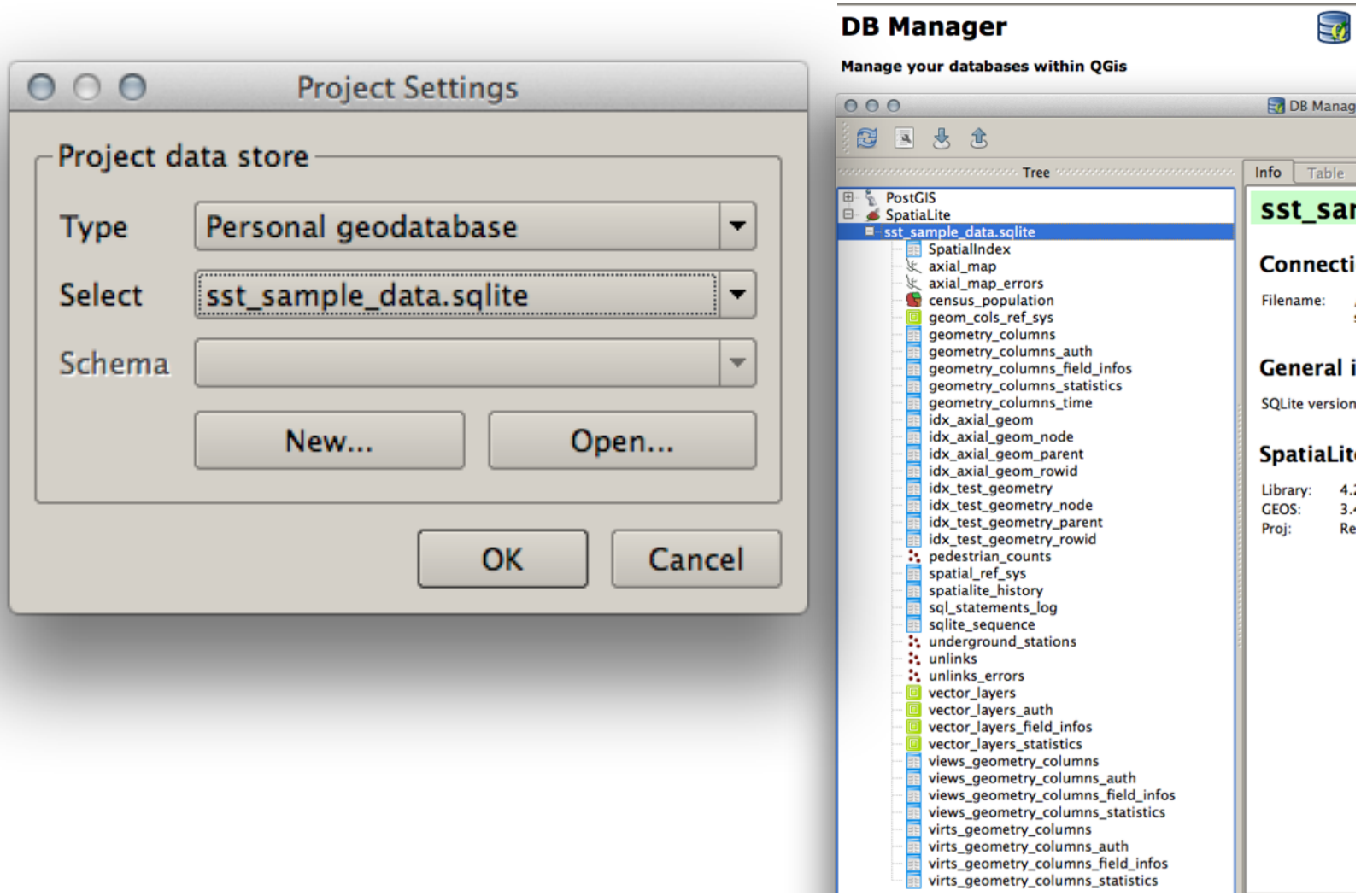
**+**

- “standard” GIS format used for distributing/sharing;
- most software reads these files;
- uses the standard file and folder approach for storage that every user is familiar with.

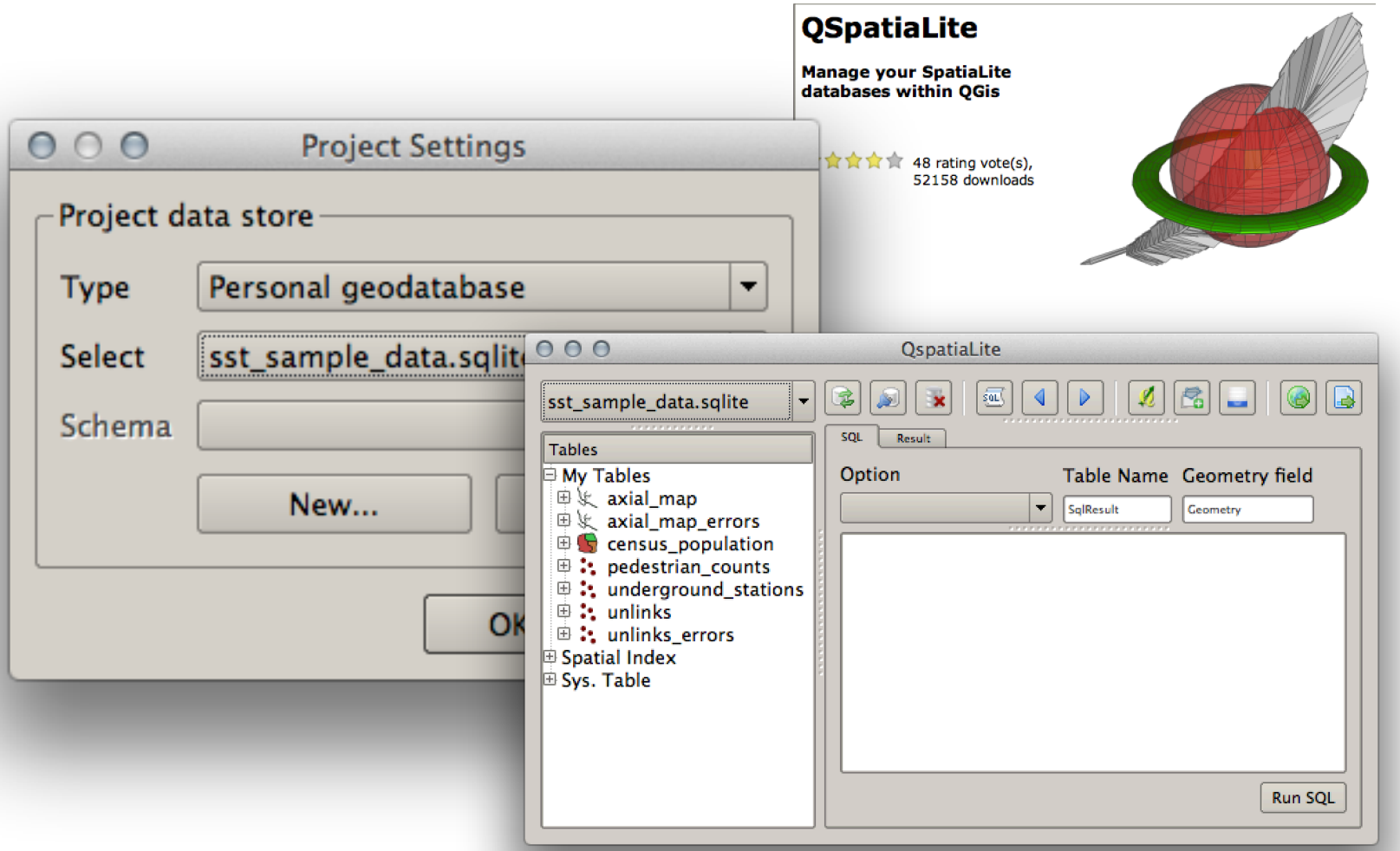
**–**

- easy to lose components when moving things around;
- limited to 10 characters in attribute names;
- limited to 2GB in the dbf (attributes) file;
- leads to huge folders with many files;
- depends solely on the QGIS API for querying and analysis.

# Data store set-up: Spatialite



# Data store set-up: Spatialite



# Spatialite format

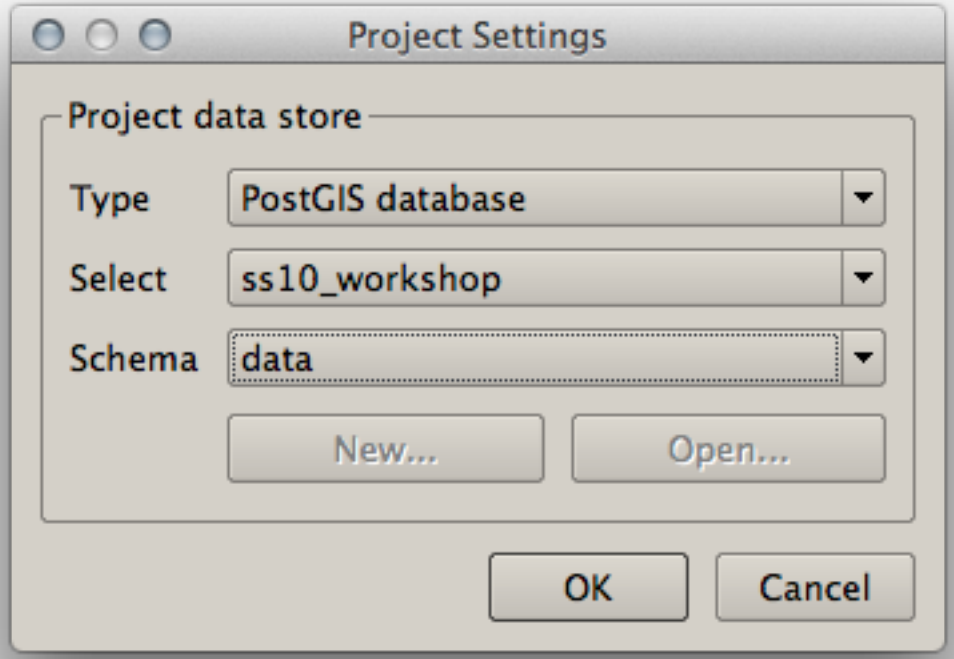
**+**

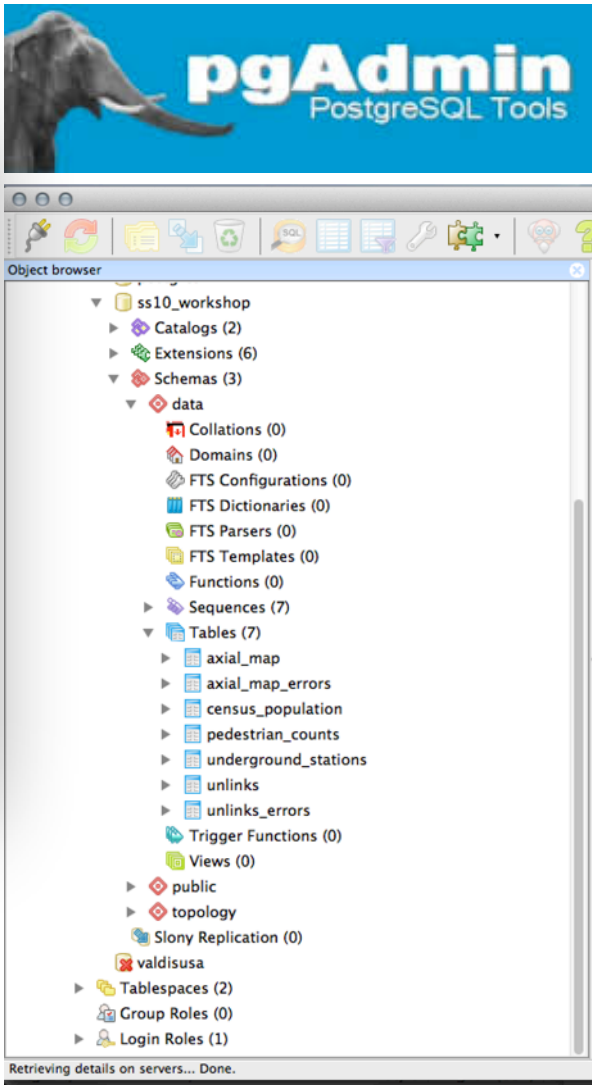
- data is stored in a single file, easy to backup and share;
- embedded SQL allows data query and analysis;
- embedded functions are many times faster than QGIS equivalents;
- no restrictions on table and attribute names;
- QGIS offers user-friendly data manager interfaces.

**–**

- requires familiarity with database principles to manage;
- database can quickly grow to have many tables;
- can be temperamental;
- the SQLite SQL standard has some limitations;
- only supports vector data.

# Data store set-up: PostGIS



# PostGIS format

+

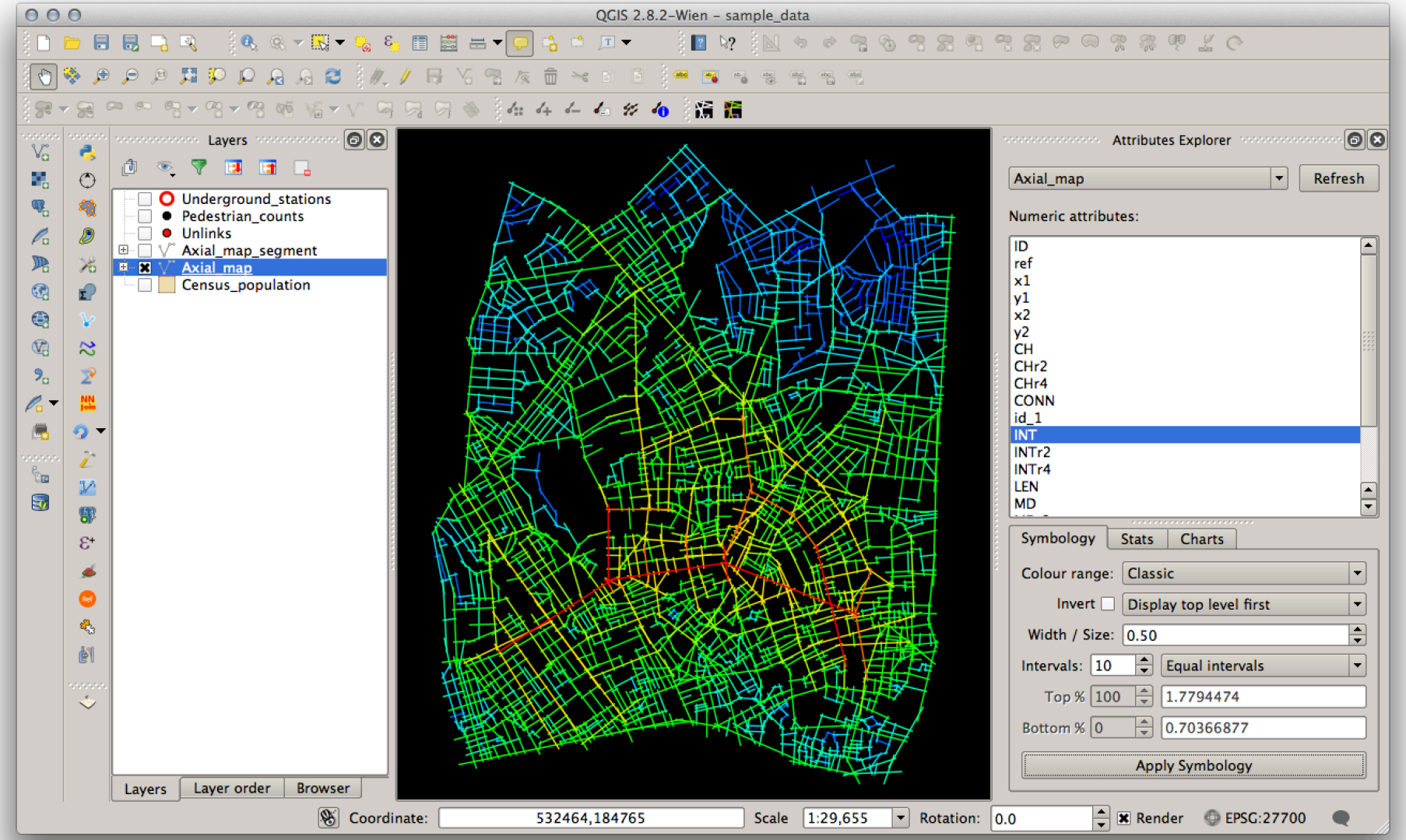
- no data size limit;
- full and enhanced SQL support;
- rich set of analysis functions;
- extremely fast operations;
- supports vector and raster data;
- has “schemes” that help keep the database organised;
- possible to have multiple users collaborating.

# PostGIS format

–

- requires installation of server and/or client platform;
- for personal use it requires knowledge of database systems and management;
- data sharing using shape files, when others don't have access to the server.

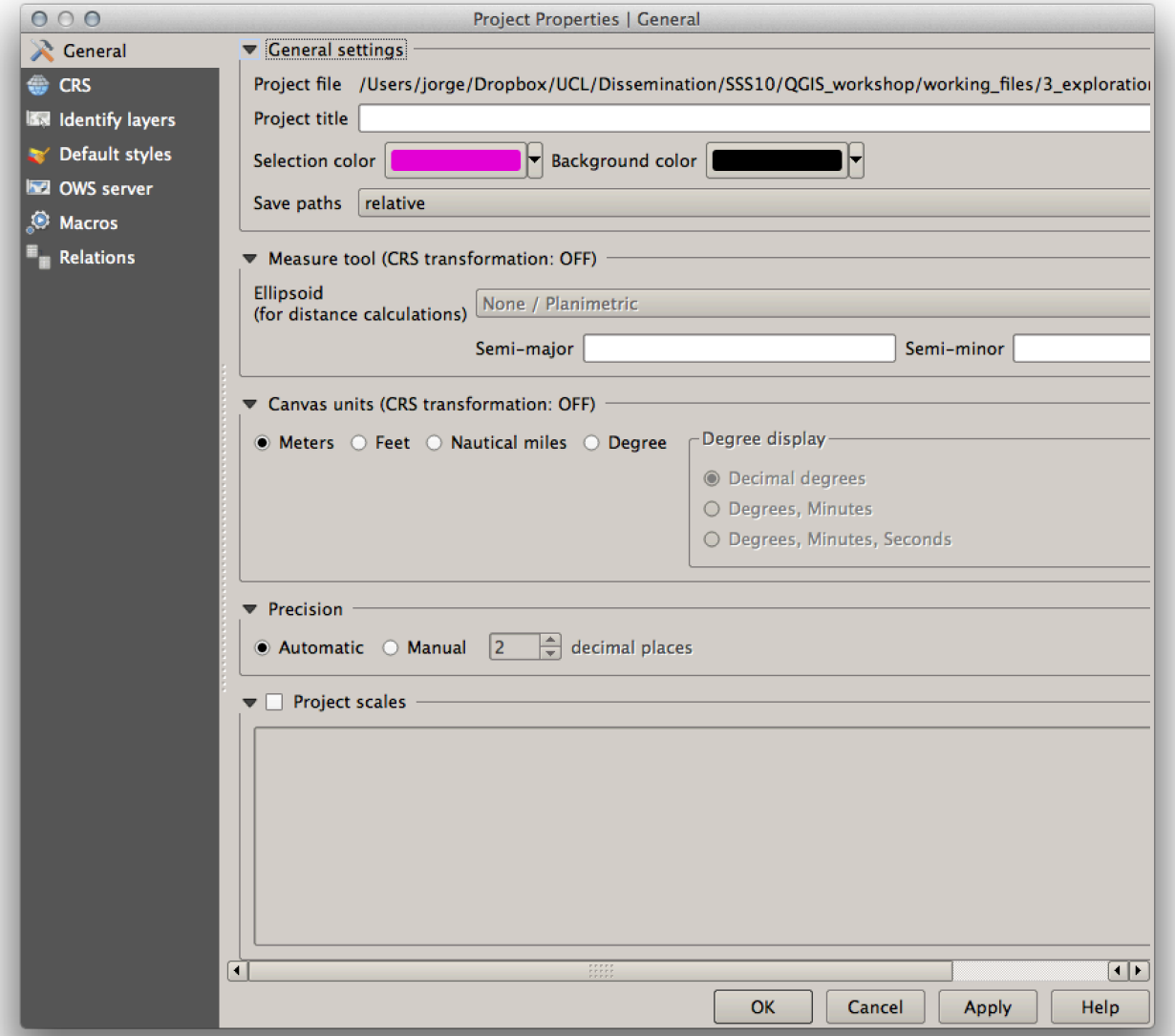
# Exercise: complete SST workflow



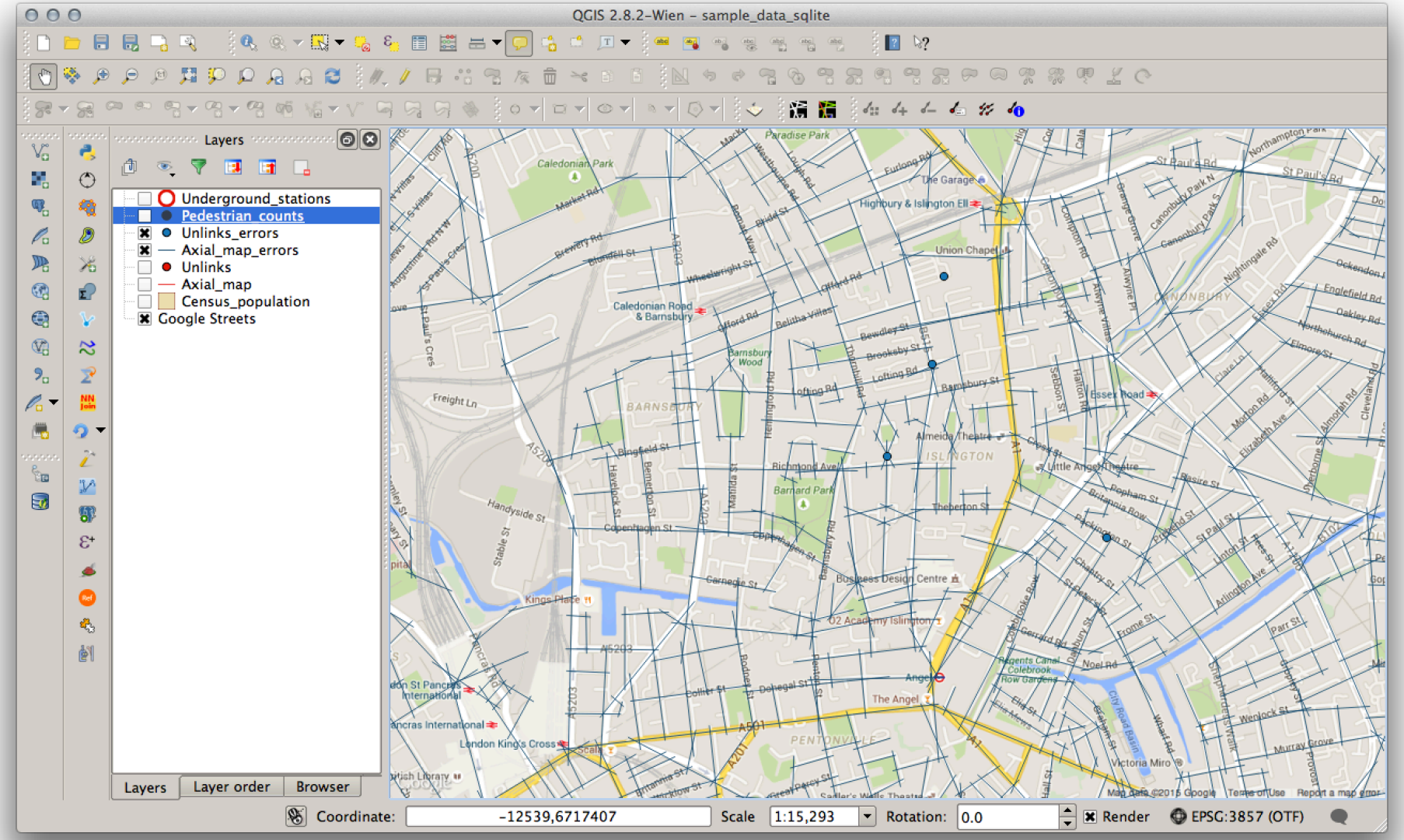
# Starting the exercise

- Using sample data:
  - open a project file
  - layers are automatically added to QGIS
- Using own data source:
  - adding layers to a project
  - select file / database

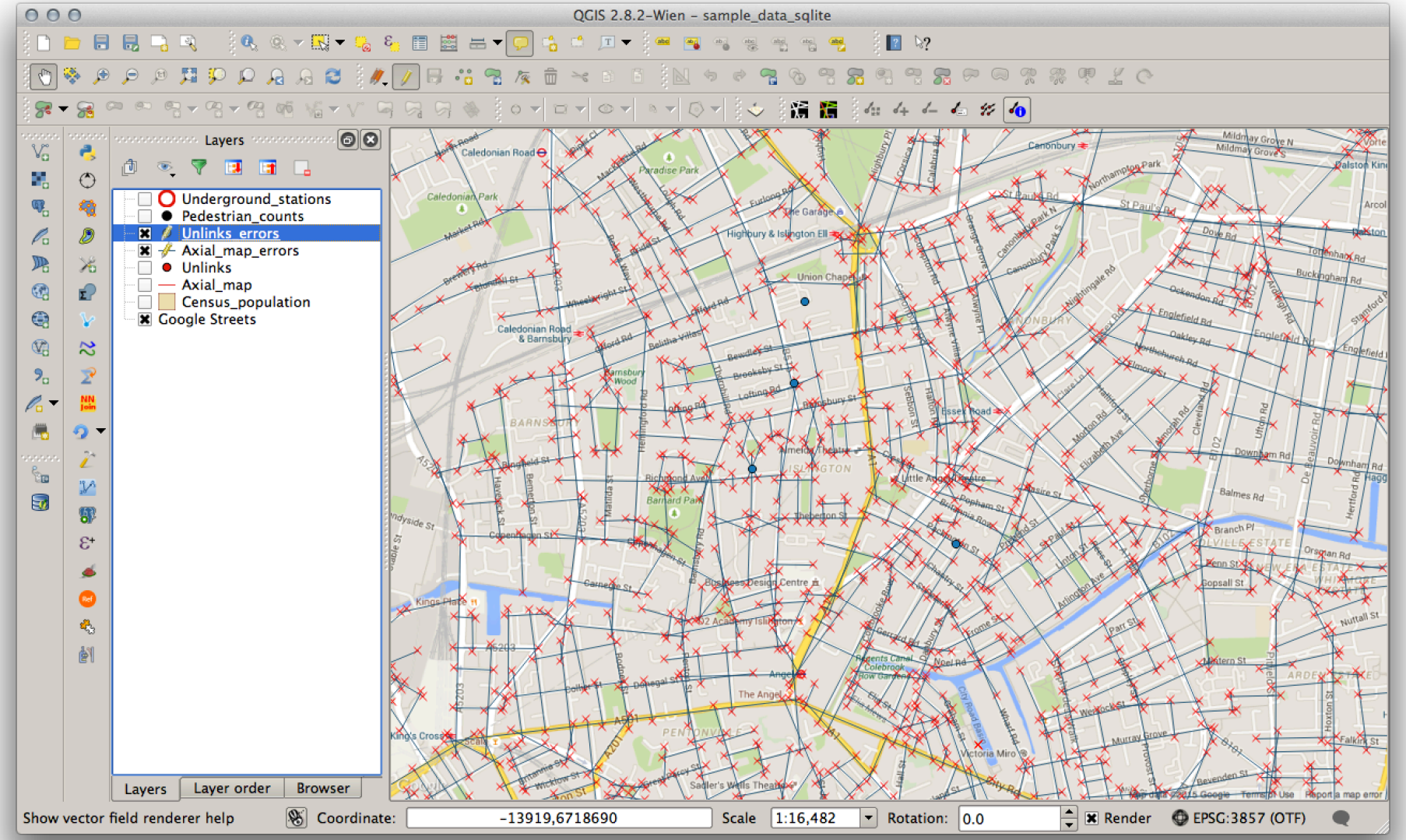
# Changing project properties



# Load background imagery



# Create axial lines and unlinks

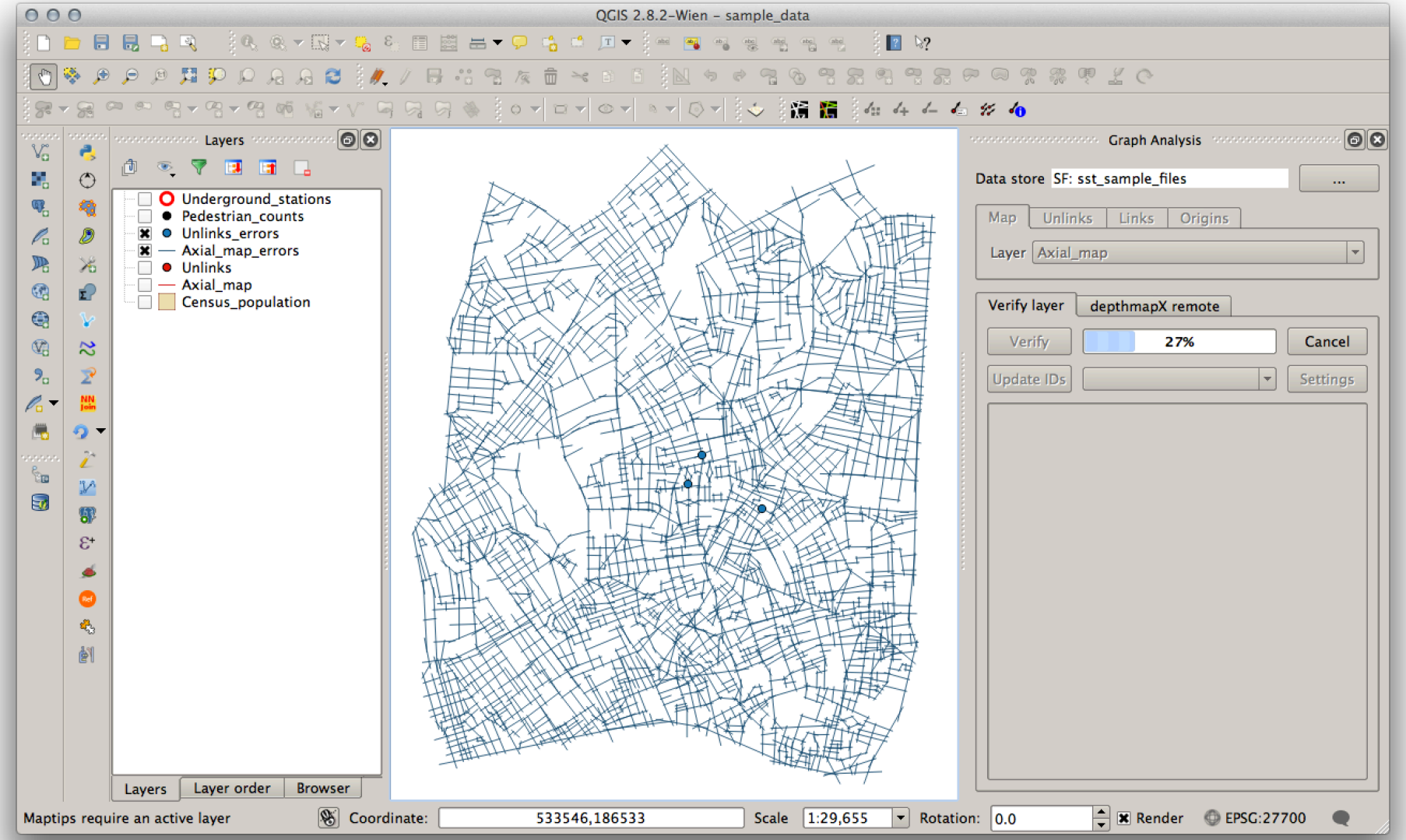


# Model verification

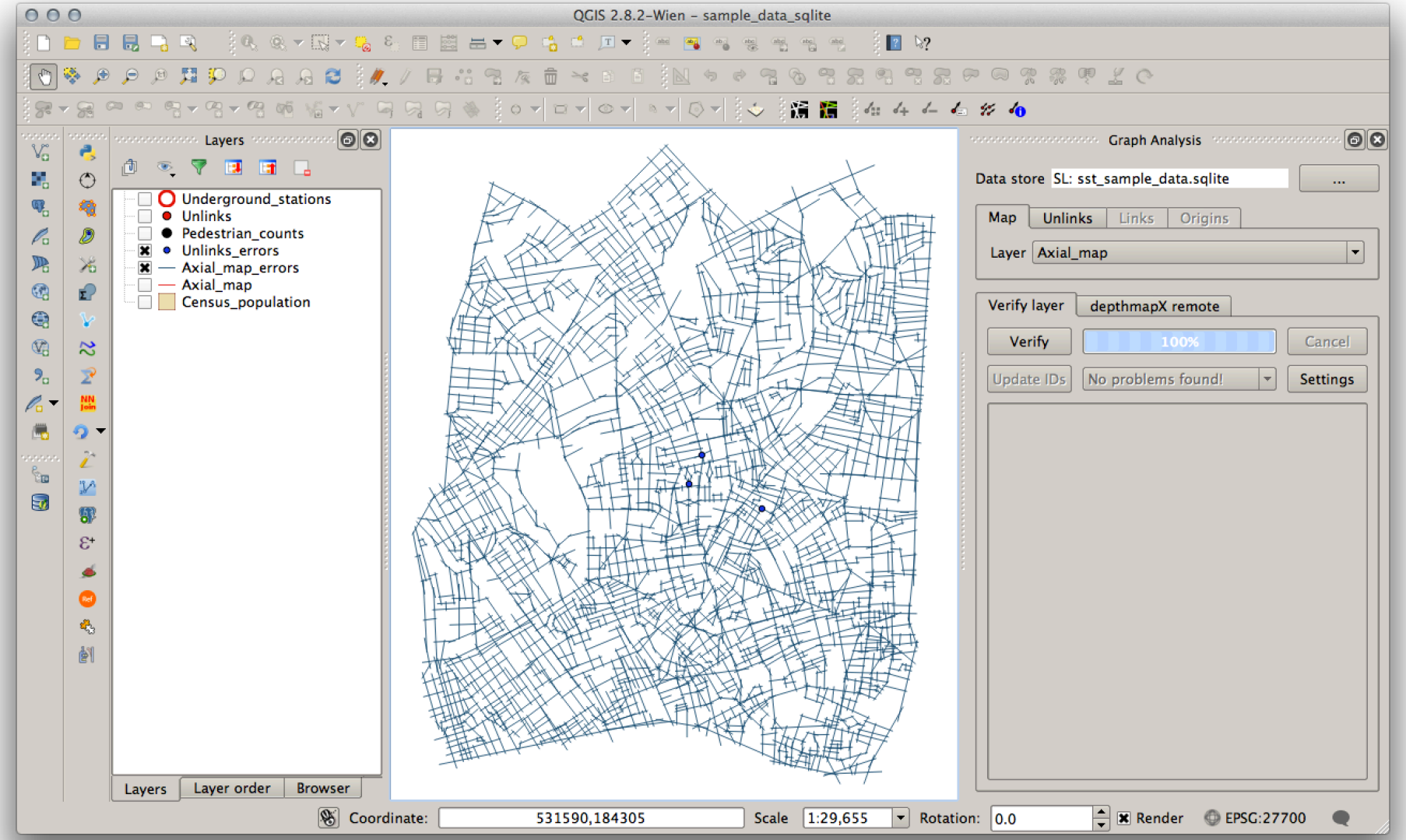
- The model verification process is iterative:
  - Verify and fix axial lines
  - Update unlinks ids
  - Verify and fix unlinks
  - Verify and fix axial lines
  - Verify and fix unlinks
  - …
- **Caution**!

Verify and fix unlinks before updating ids a second time, some unlinks might be on incorrect lines!

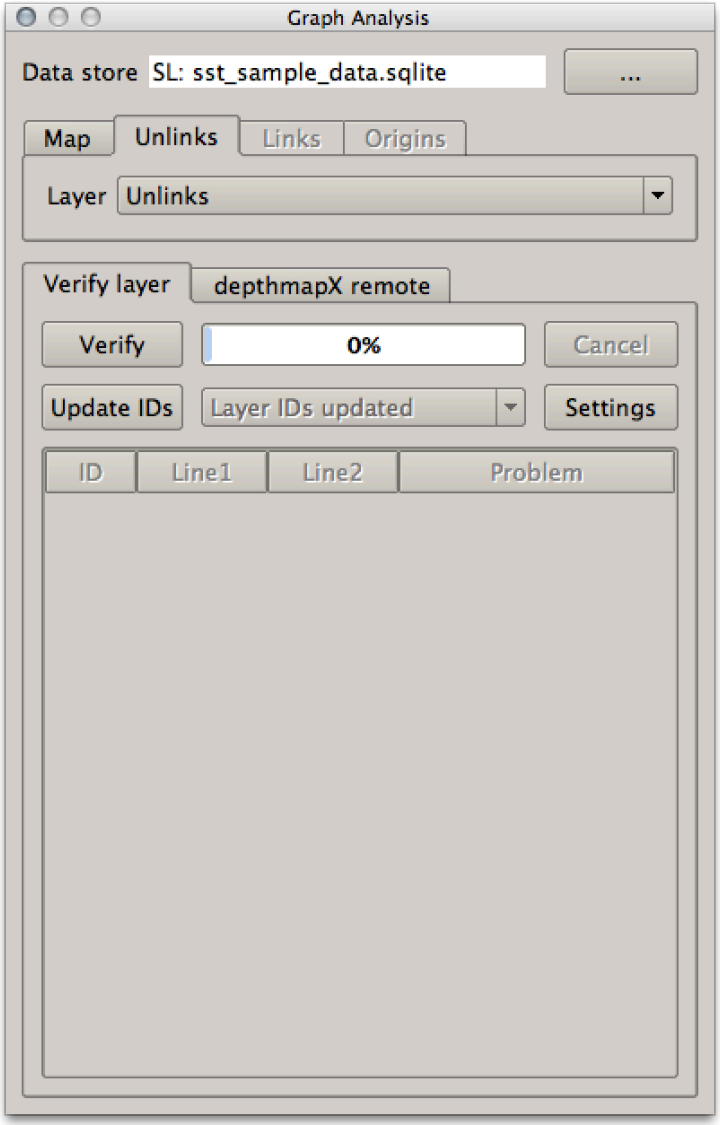
# Verifying the axial map



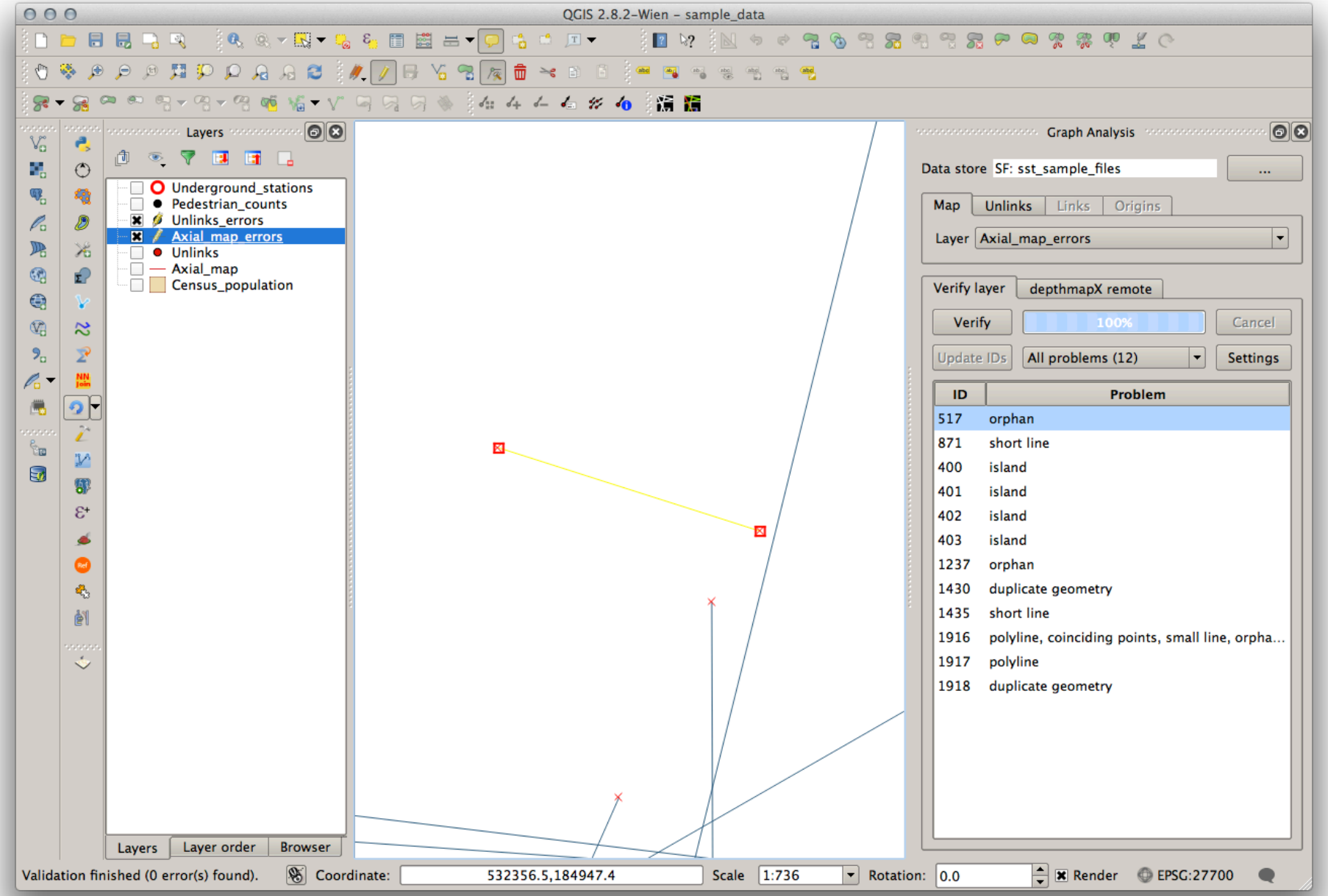
# Verifying the axial map (geodatabase)



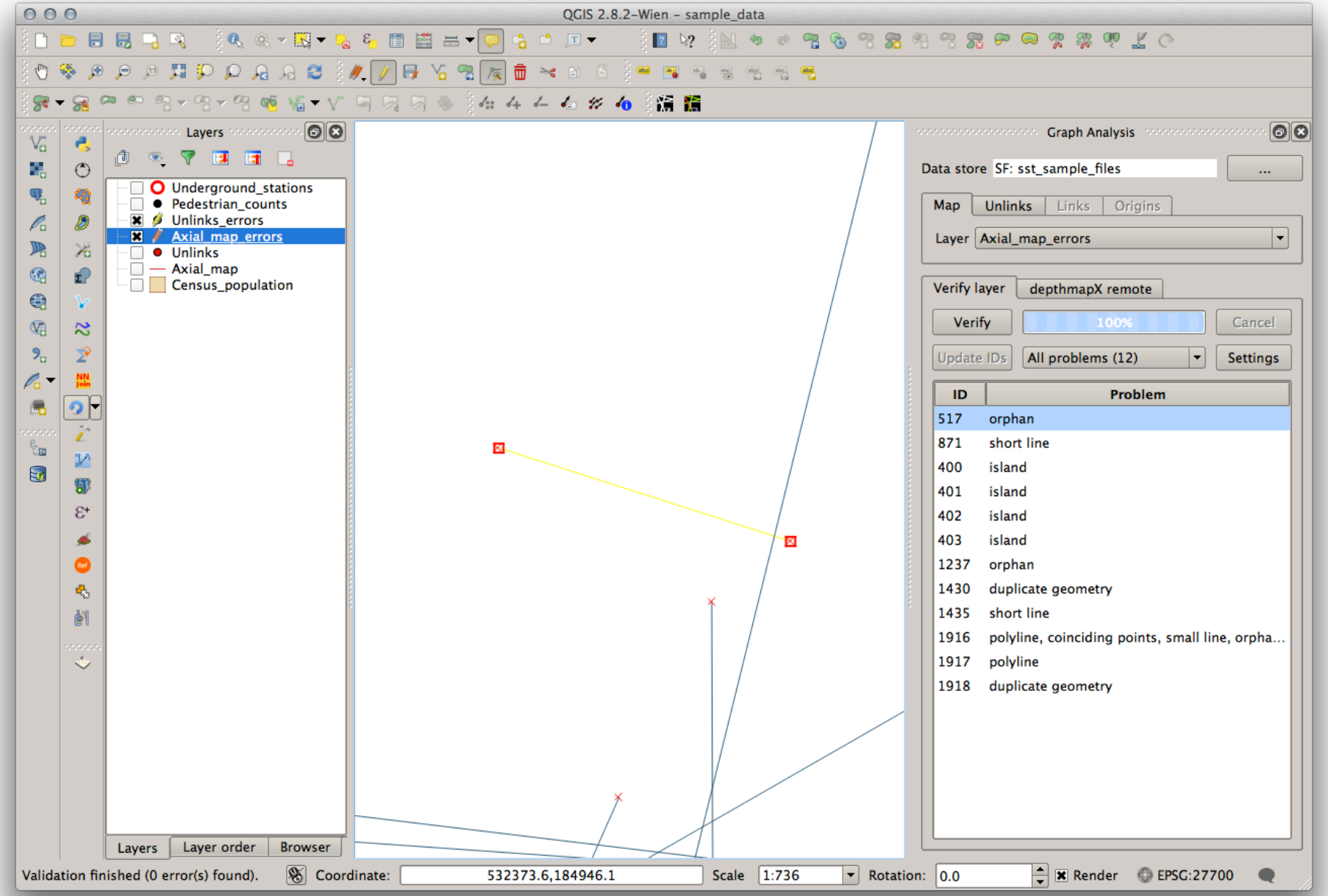
# Updating unlink ids



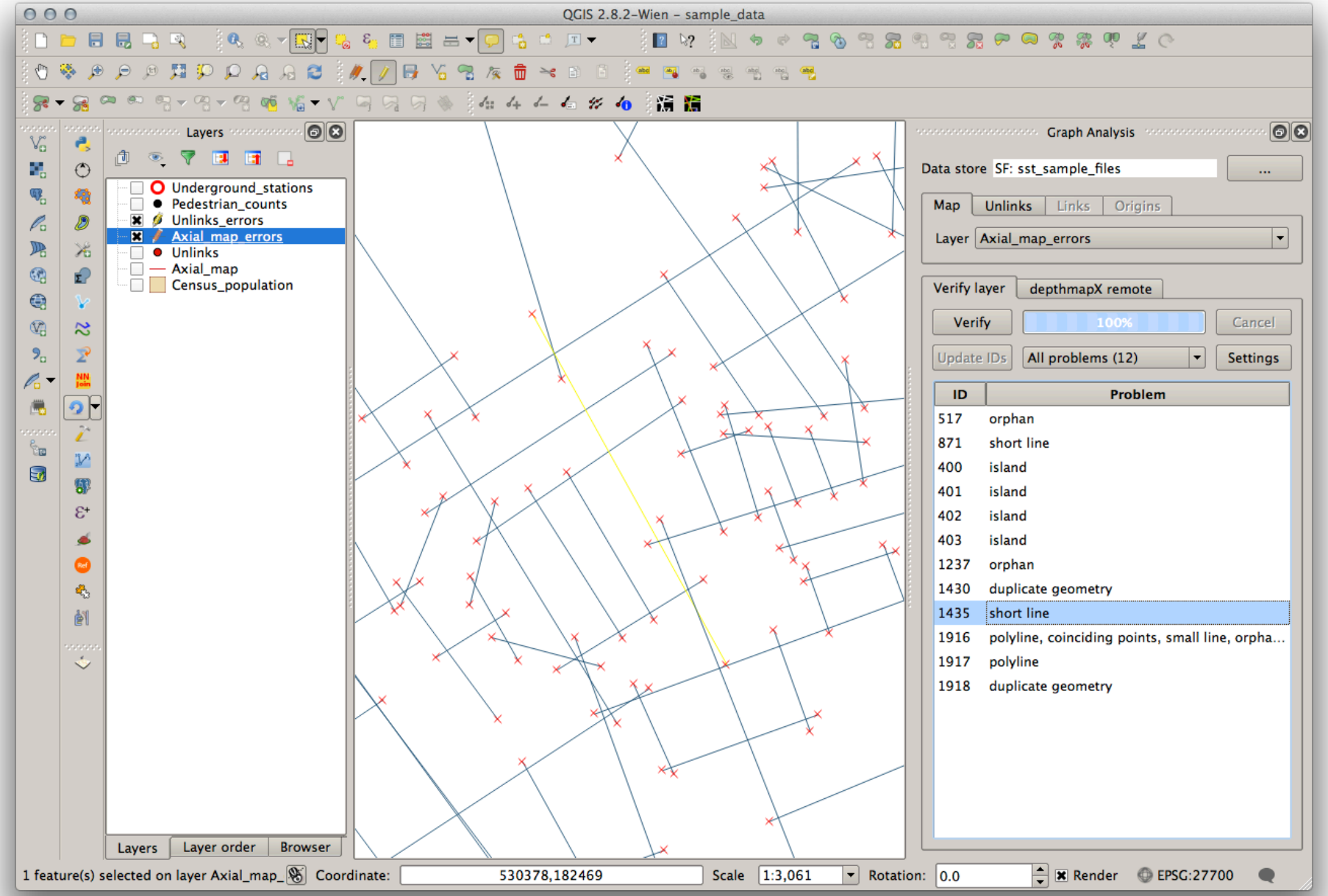
# Fixing the axial map



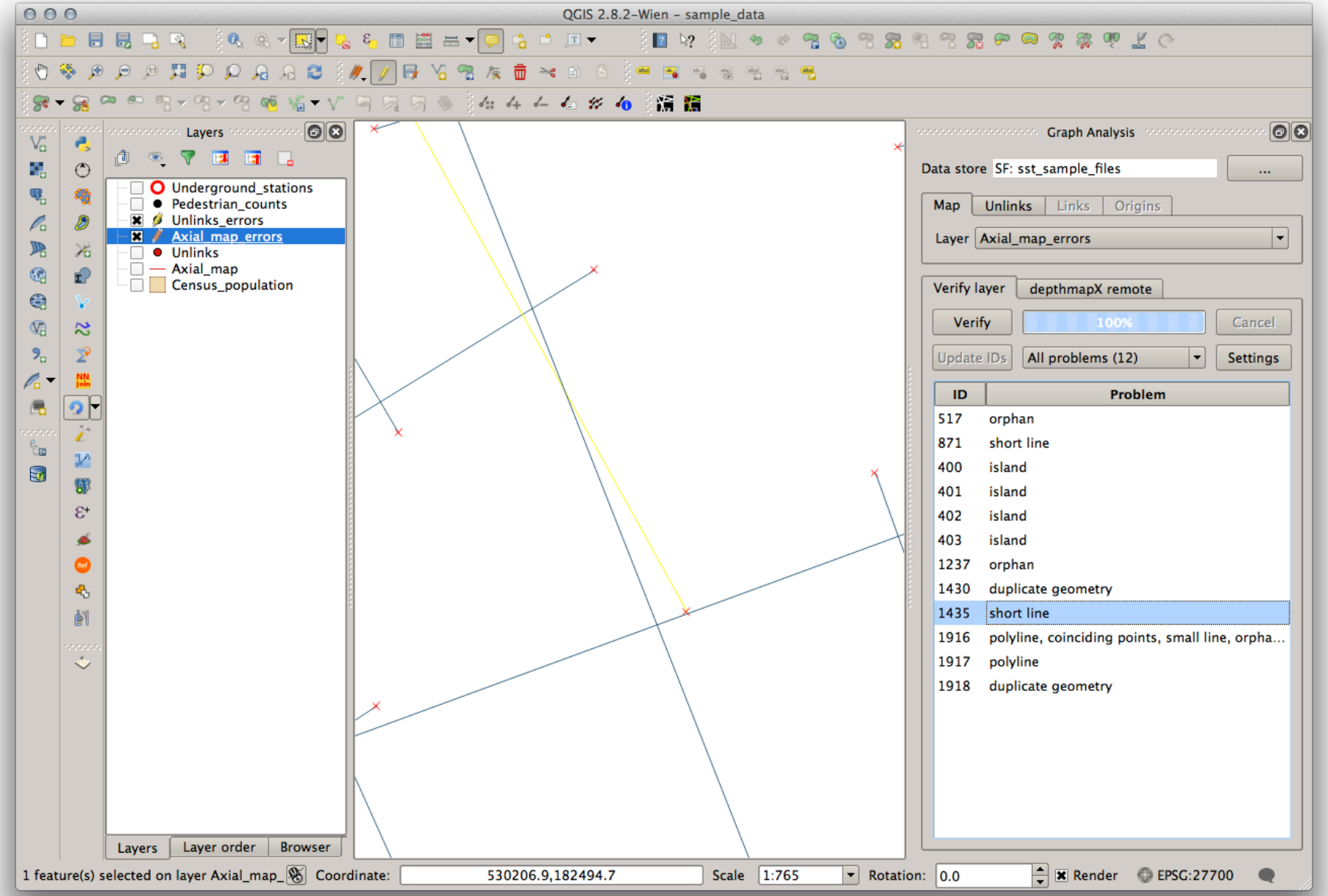
# Fixing the axial map



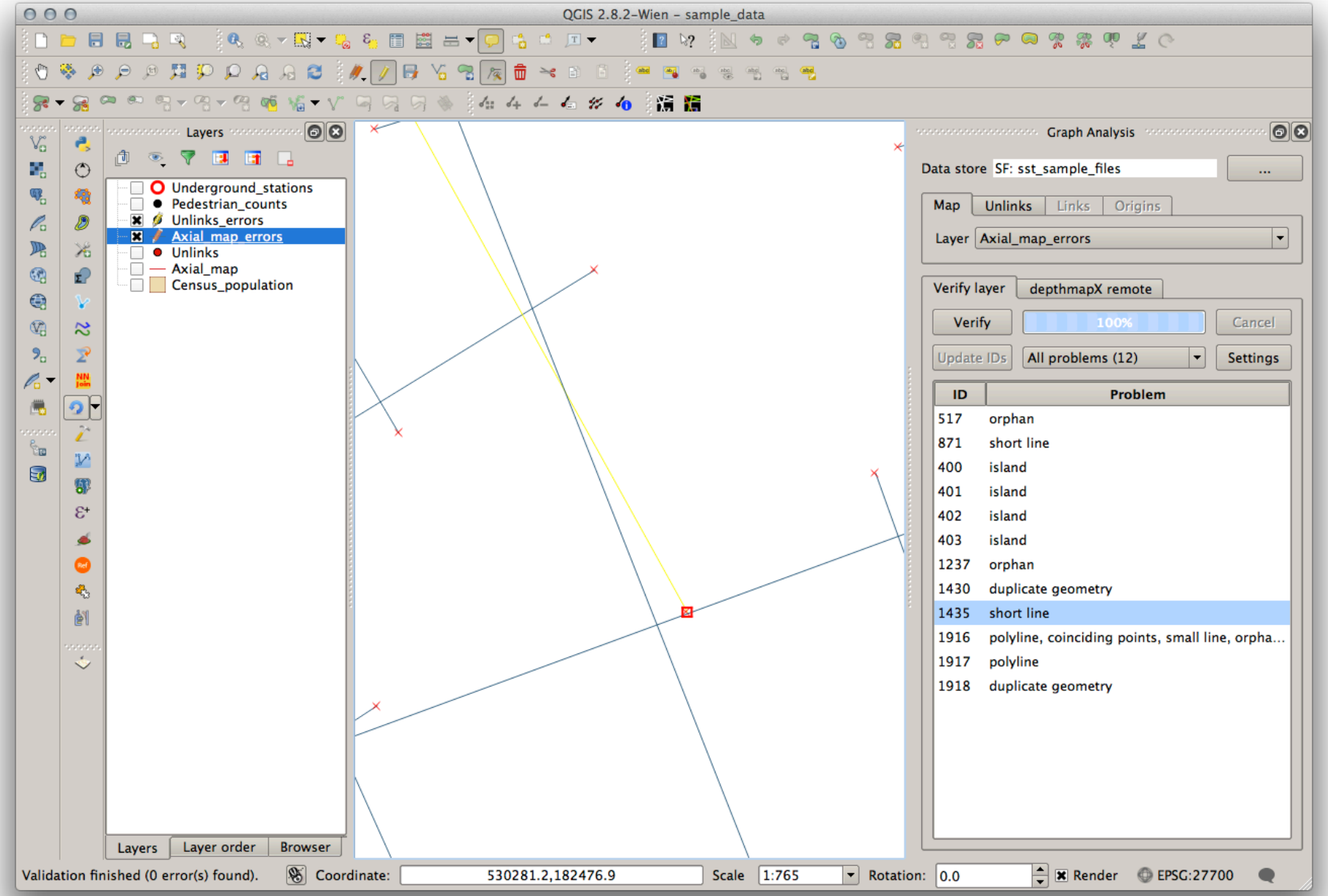
# Fixing the axial map



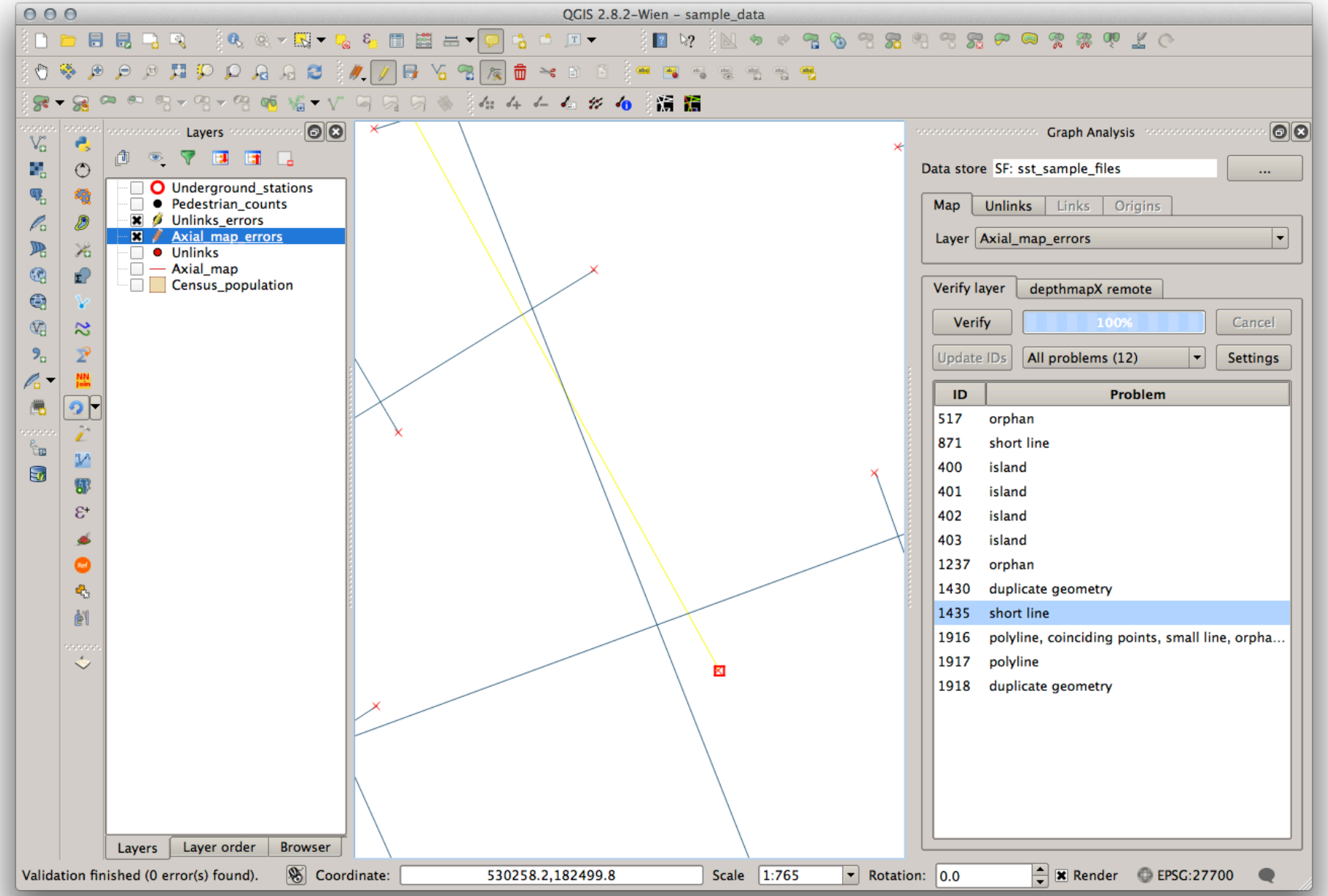
# Fixing the axial map



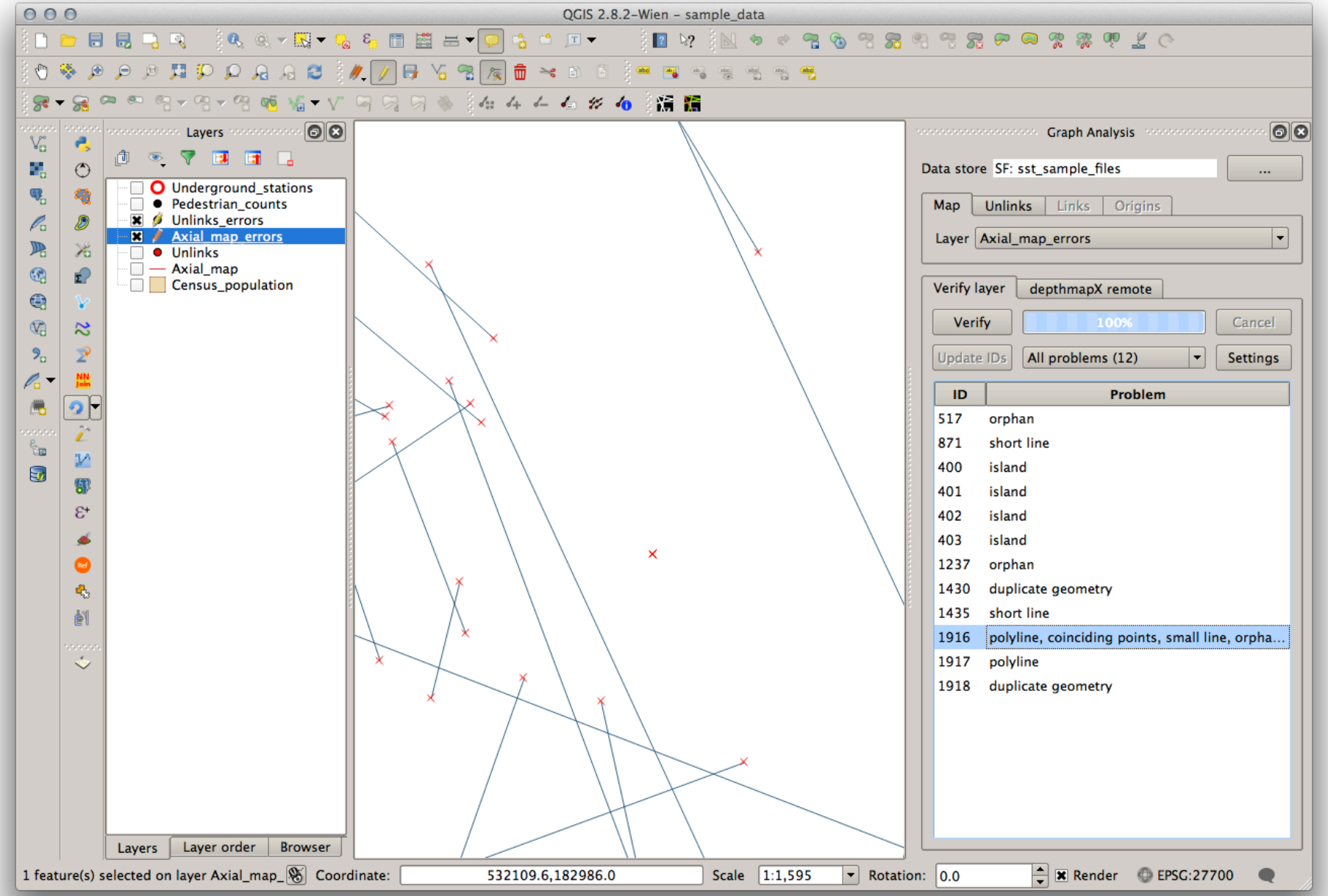
# Fixing the axial map



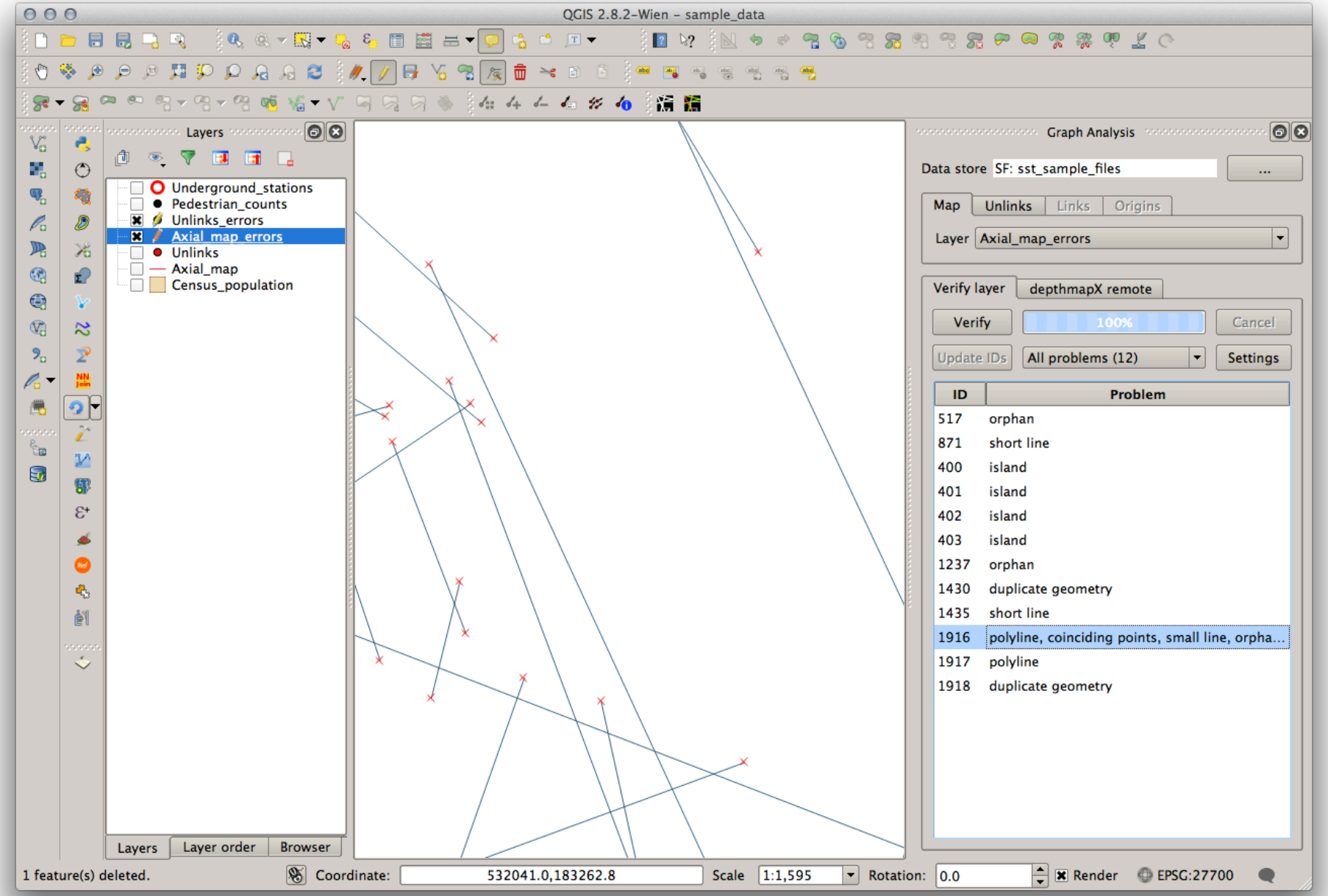
# Fixing the axial map



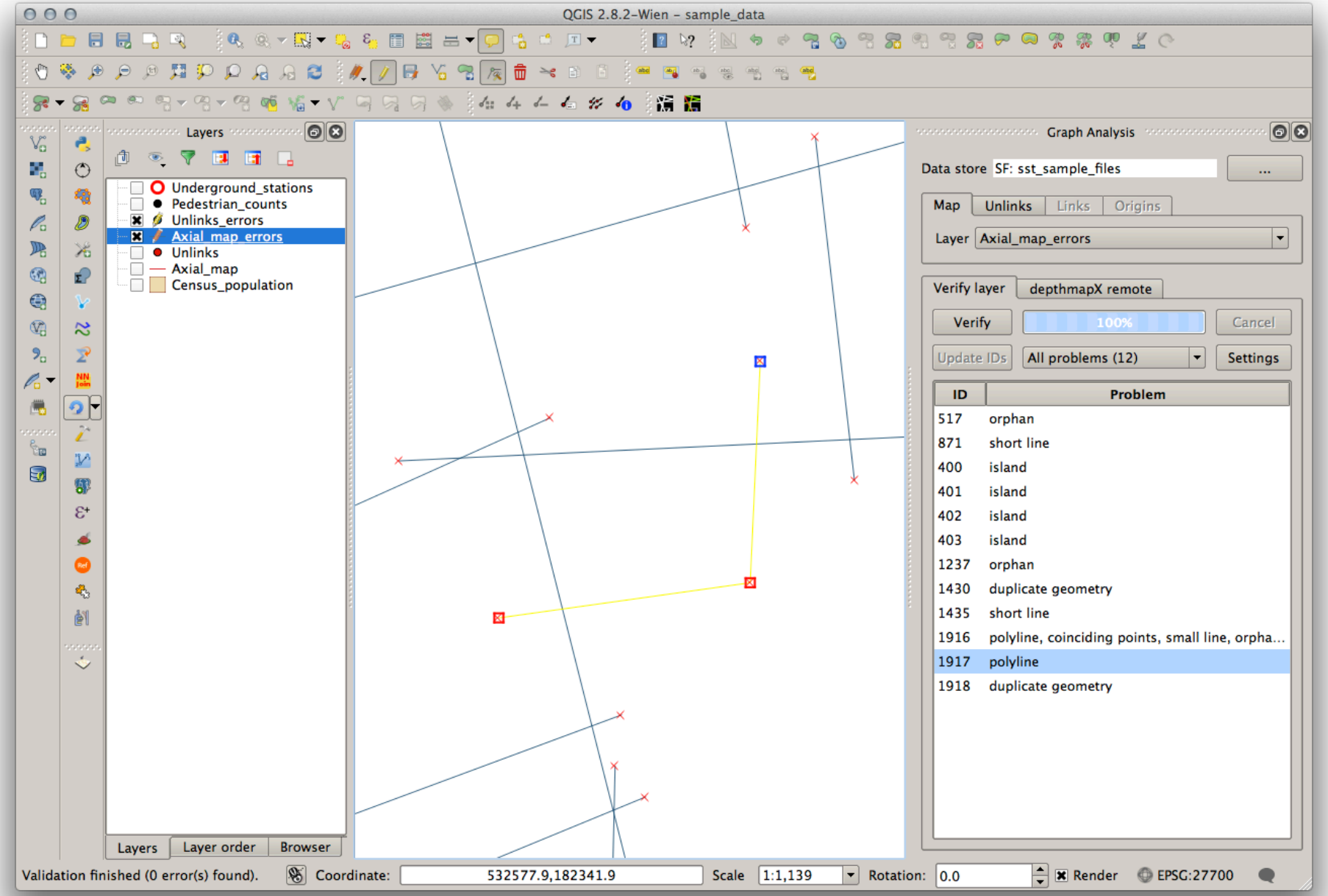
# Fixing the axial map



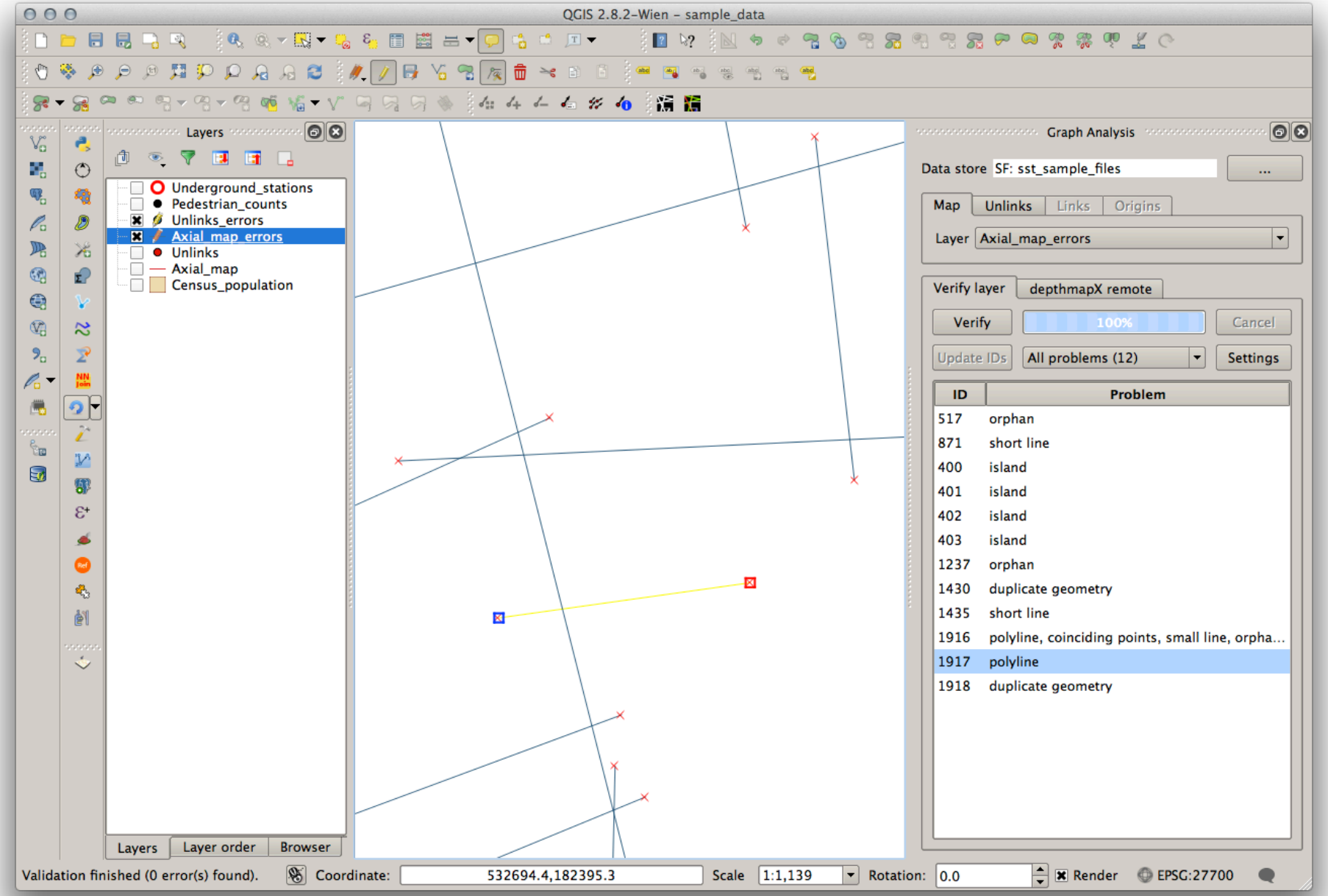
# Fixing the axial map



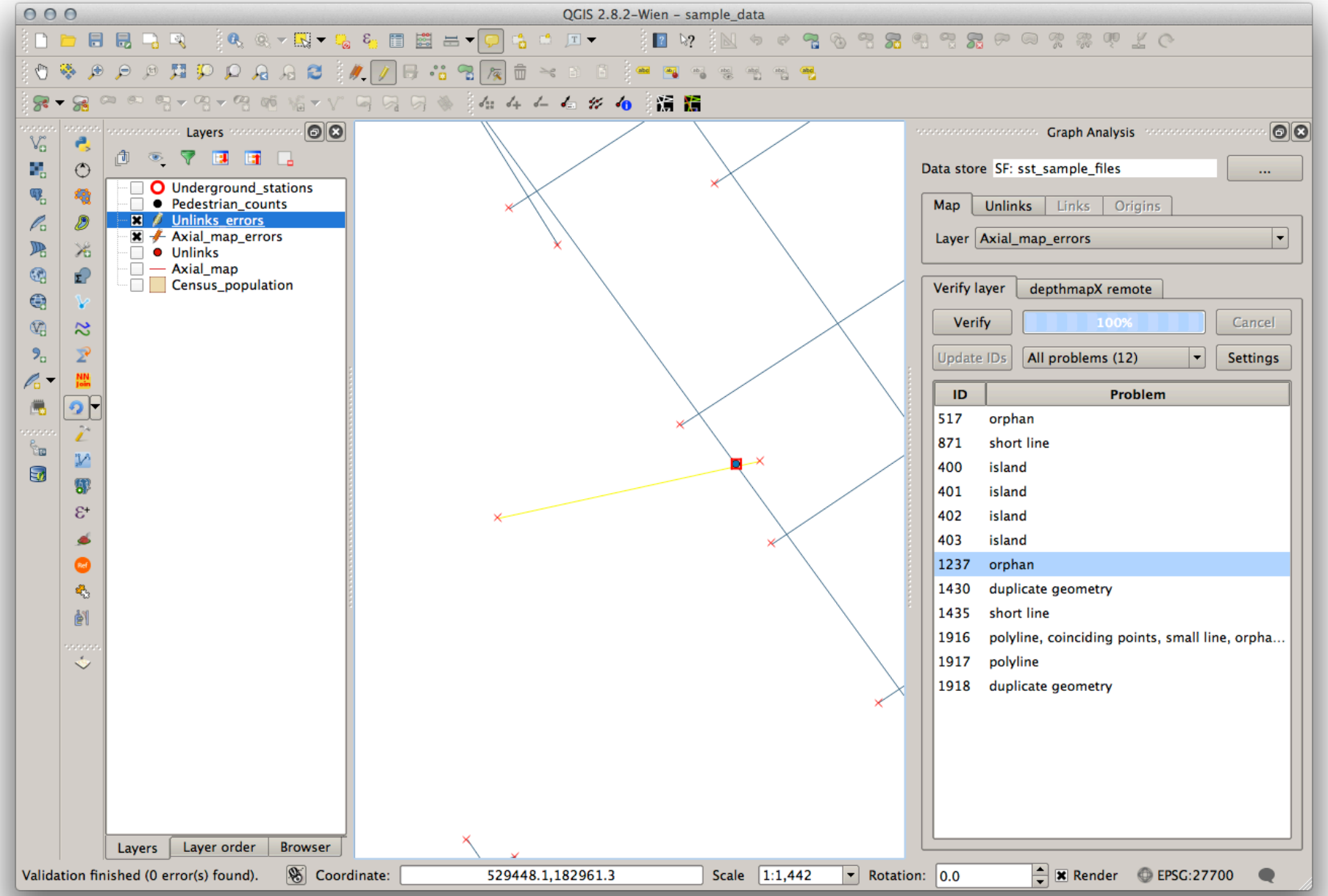
# Fixing the axial map



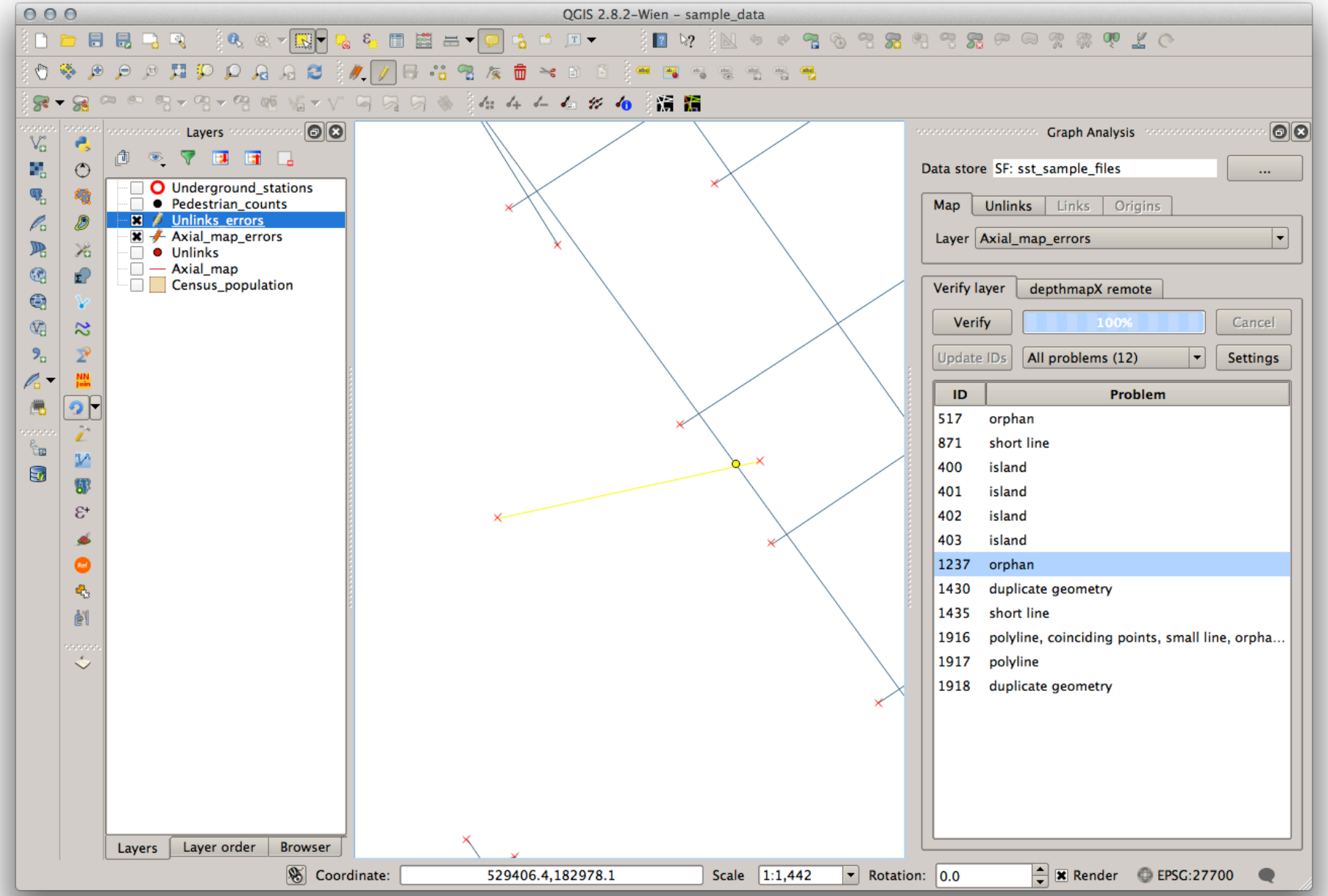
# Fixing the axial map



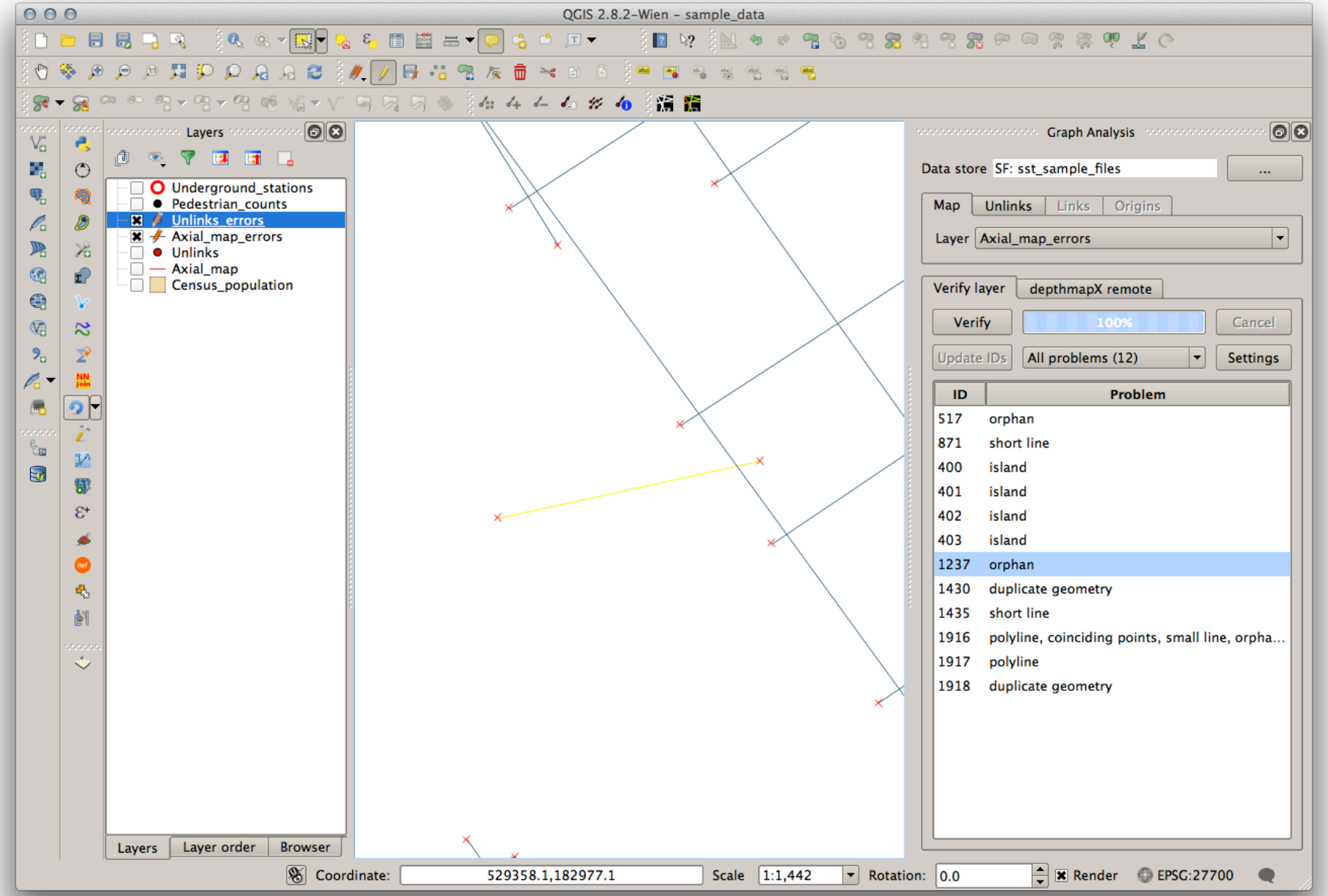
# Fixing the axial map



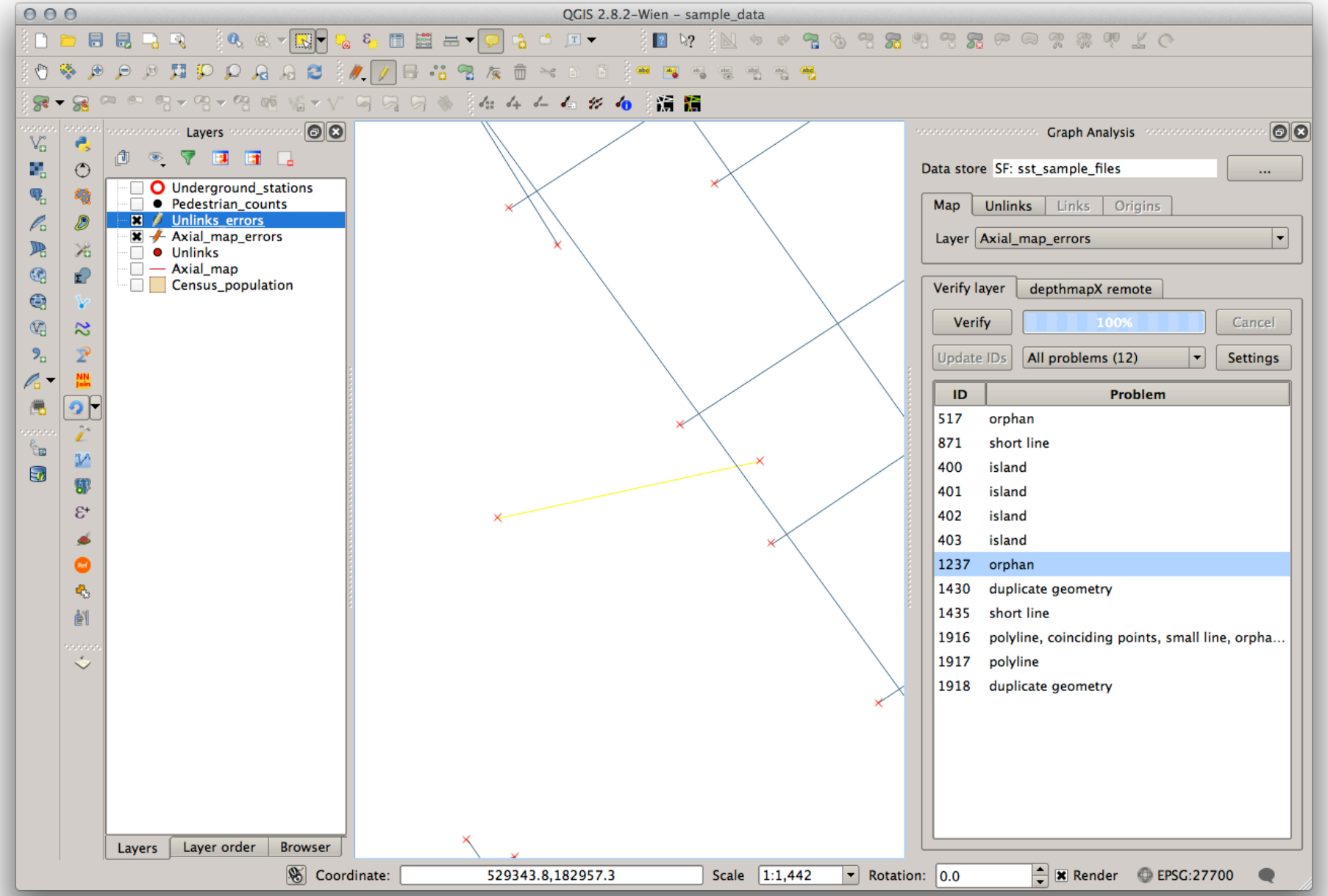
# Fixing the axial map



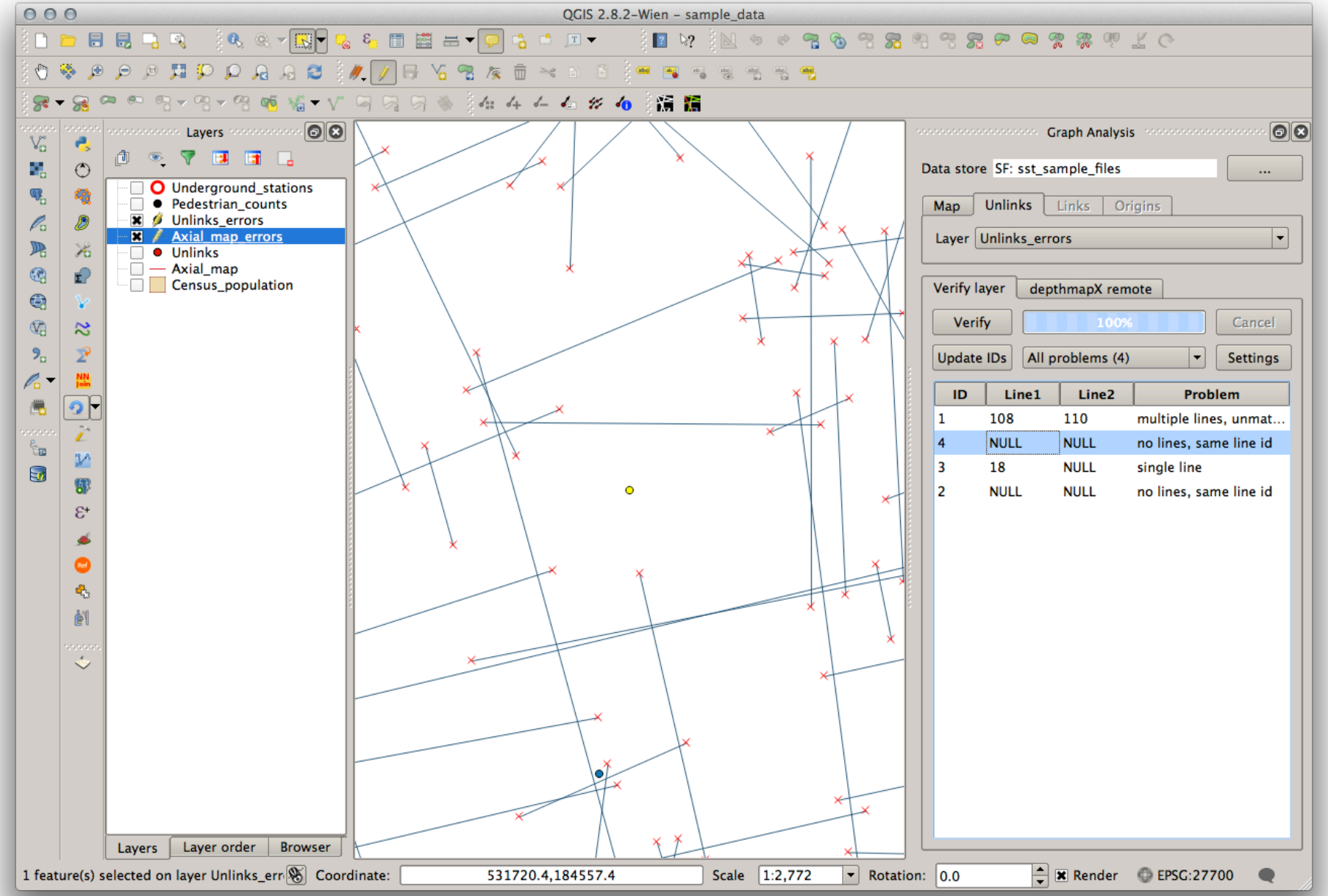
# Fixing the axial map



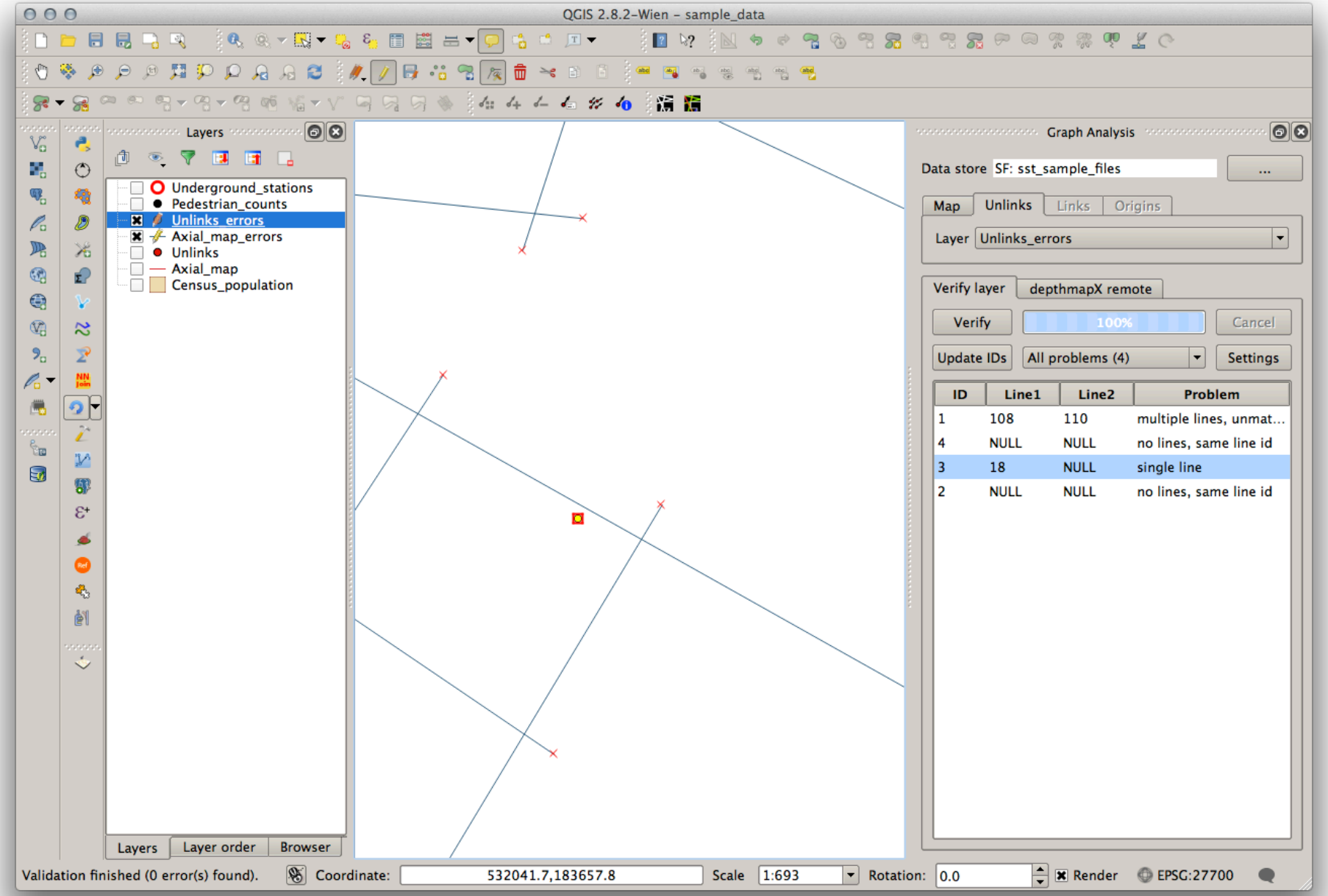
# Fixing the axial map



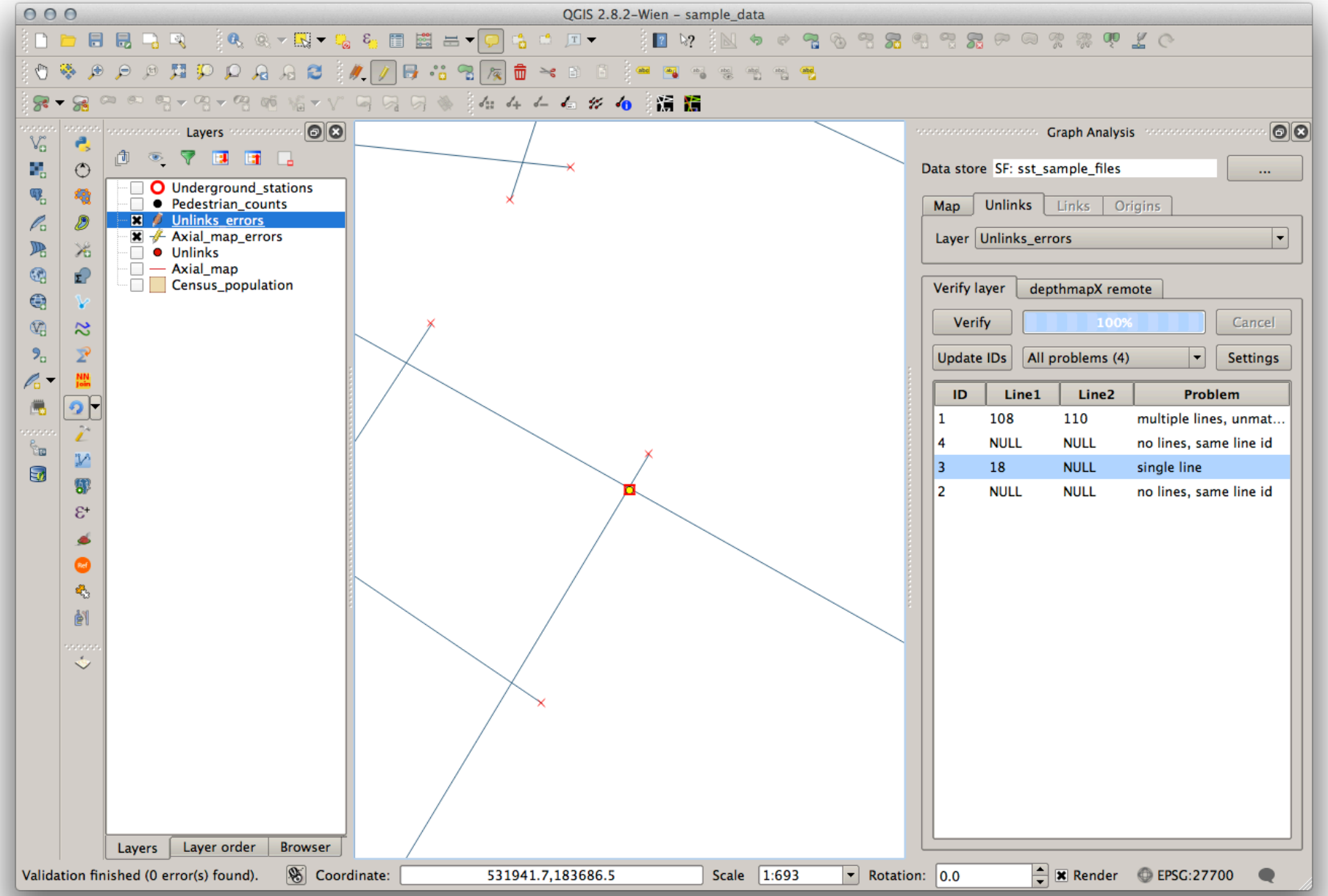
# Verifying unlinks



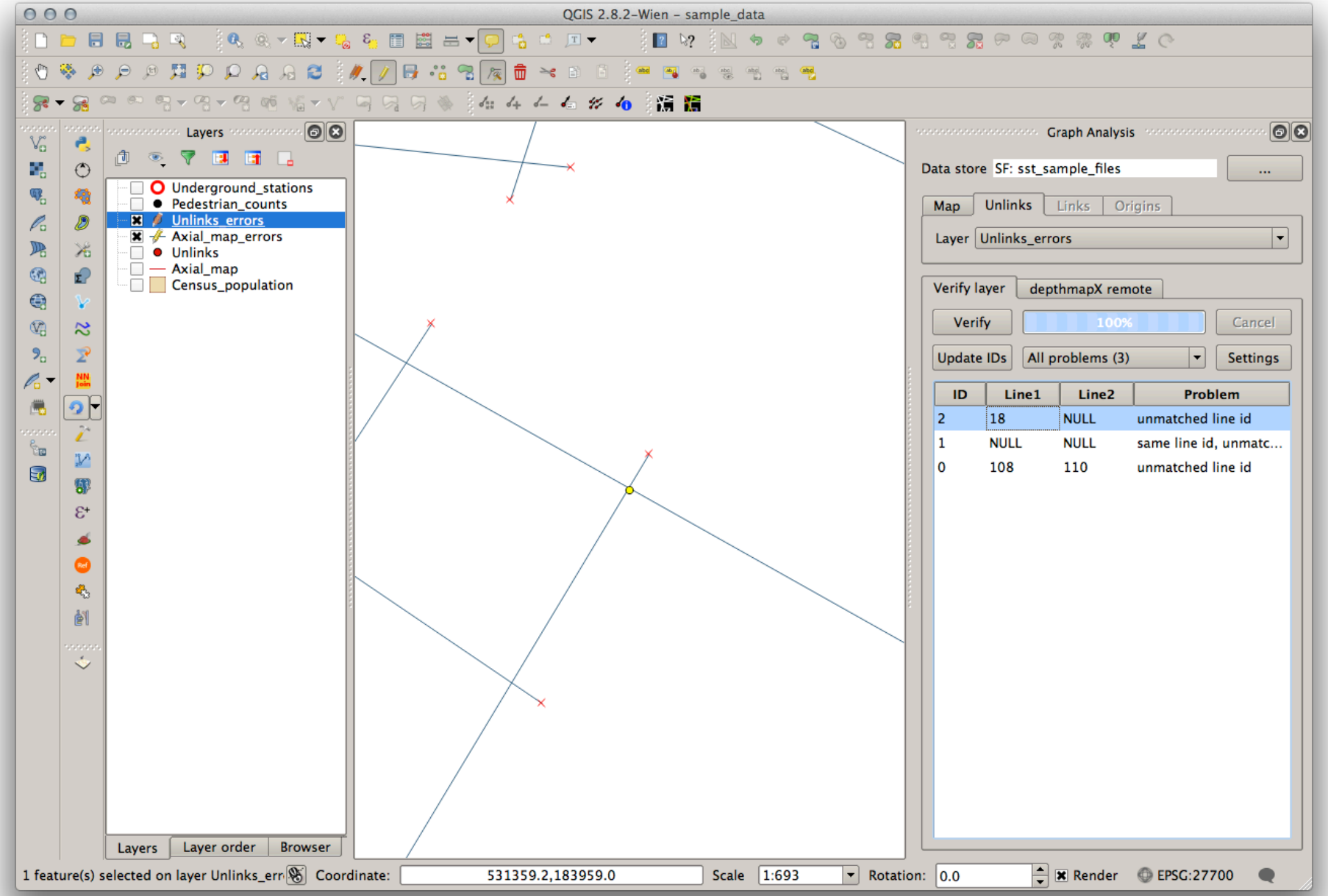
# Fixing unlinks



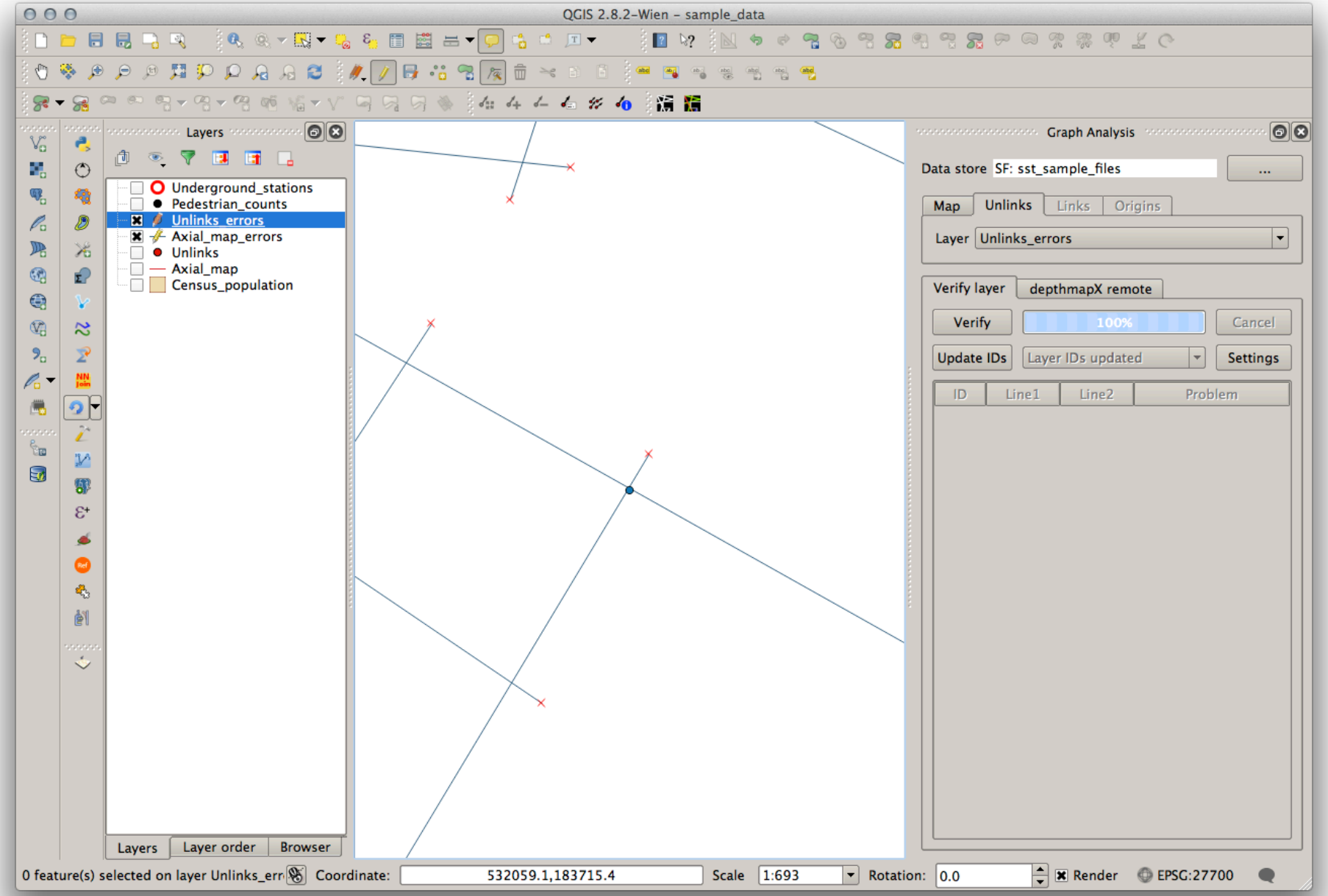
# Fixing unlinks



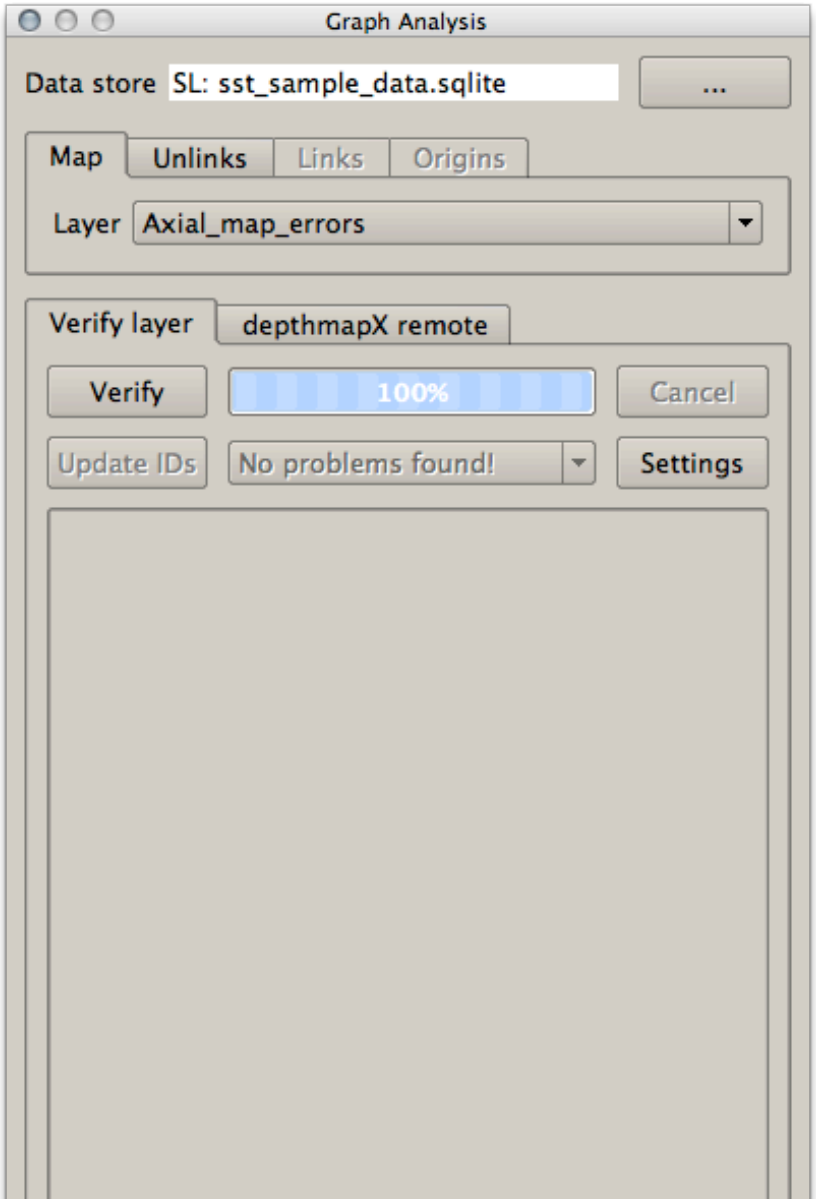
# Fixing unlinks

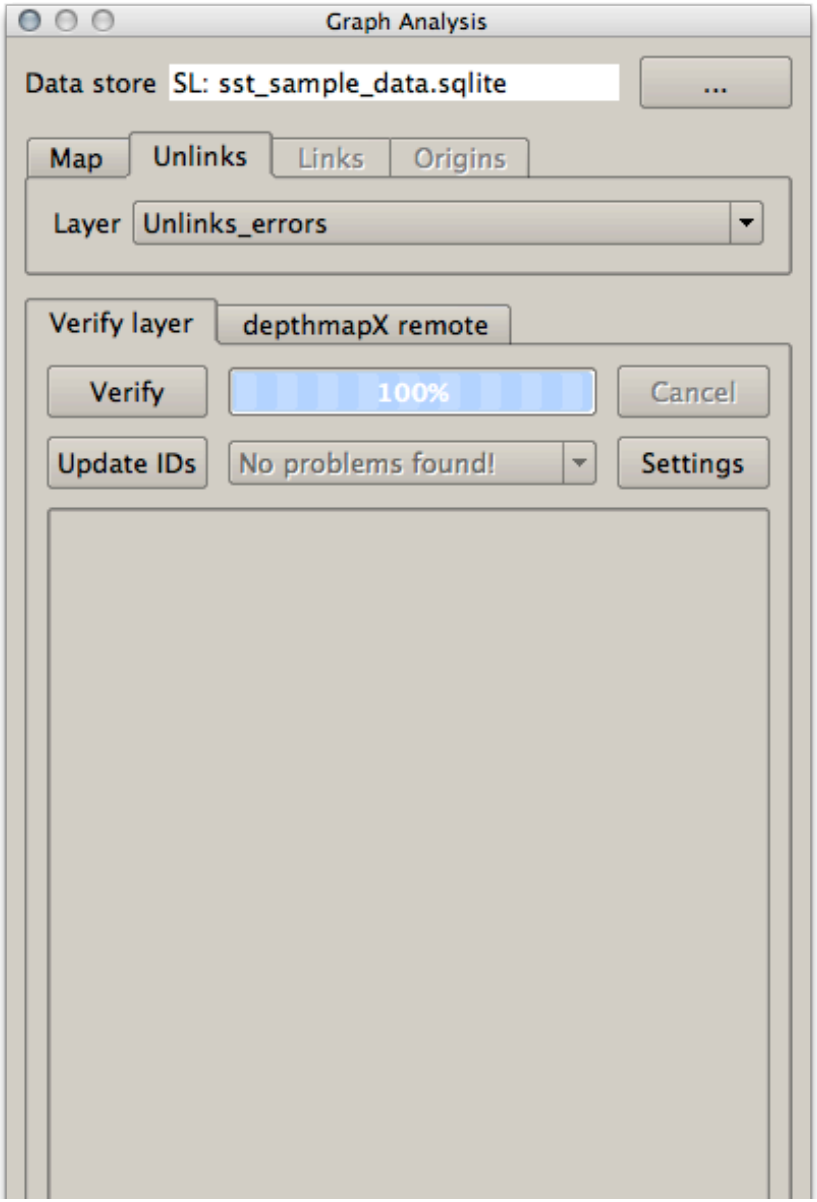


# Fixing unlinks

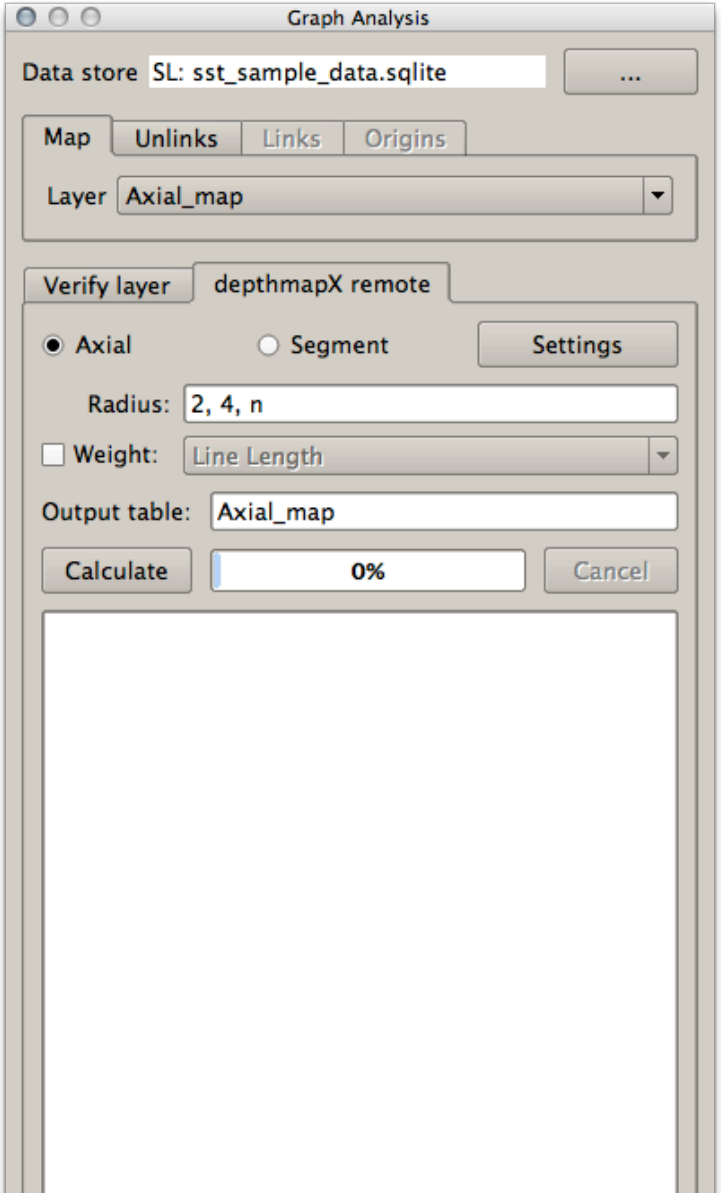


# Verification completed

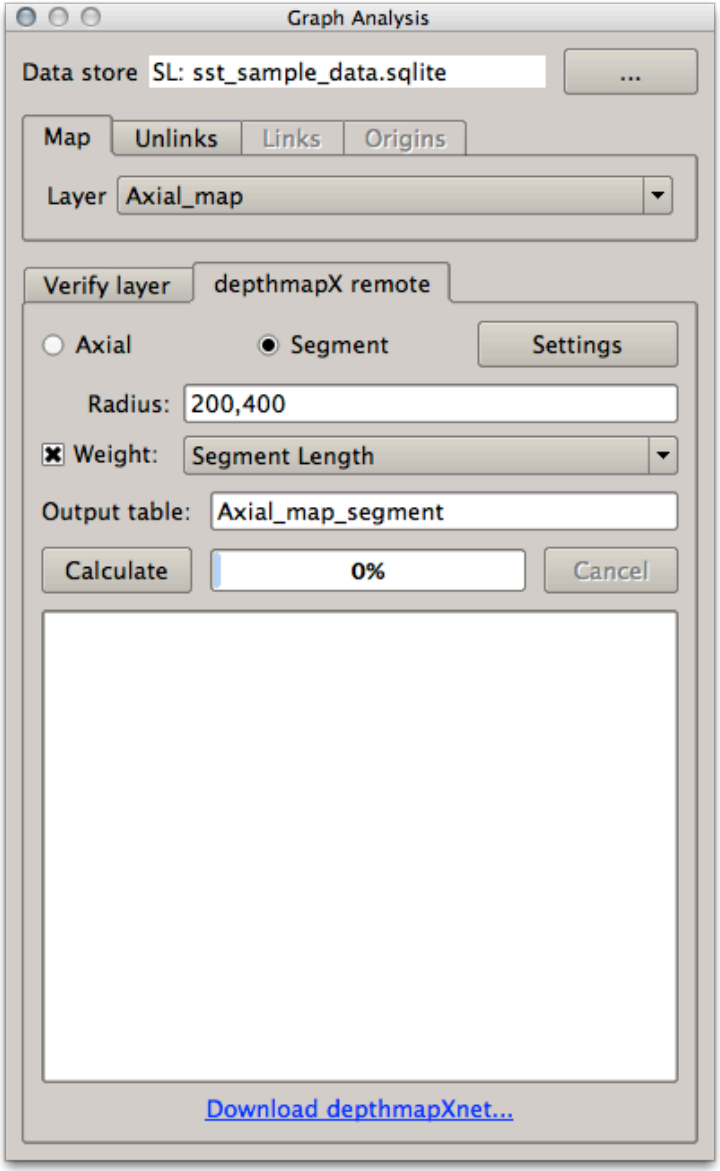


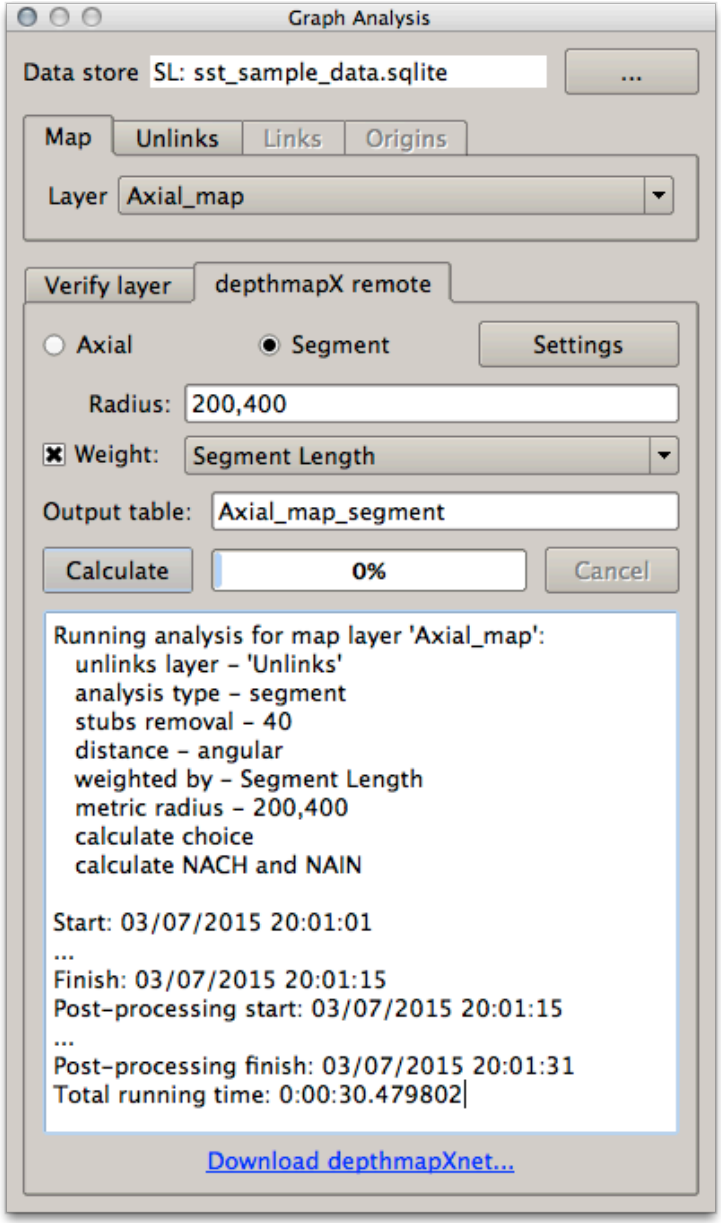



# Running axial analysis

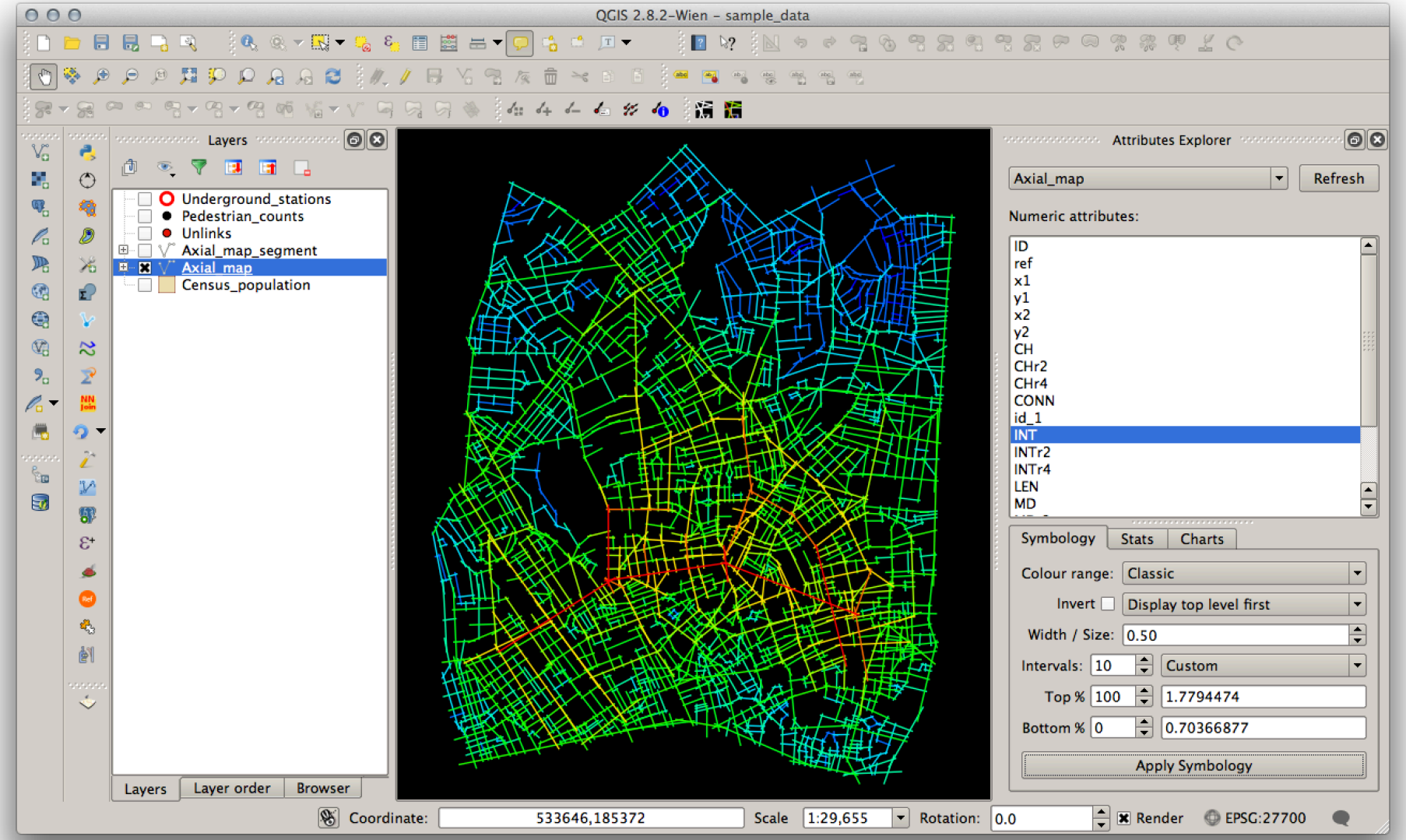


# Running segment analysis

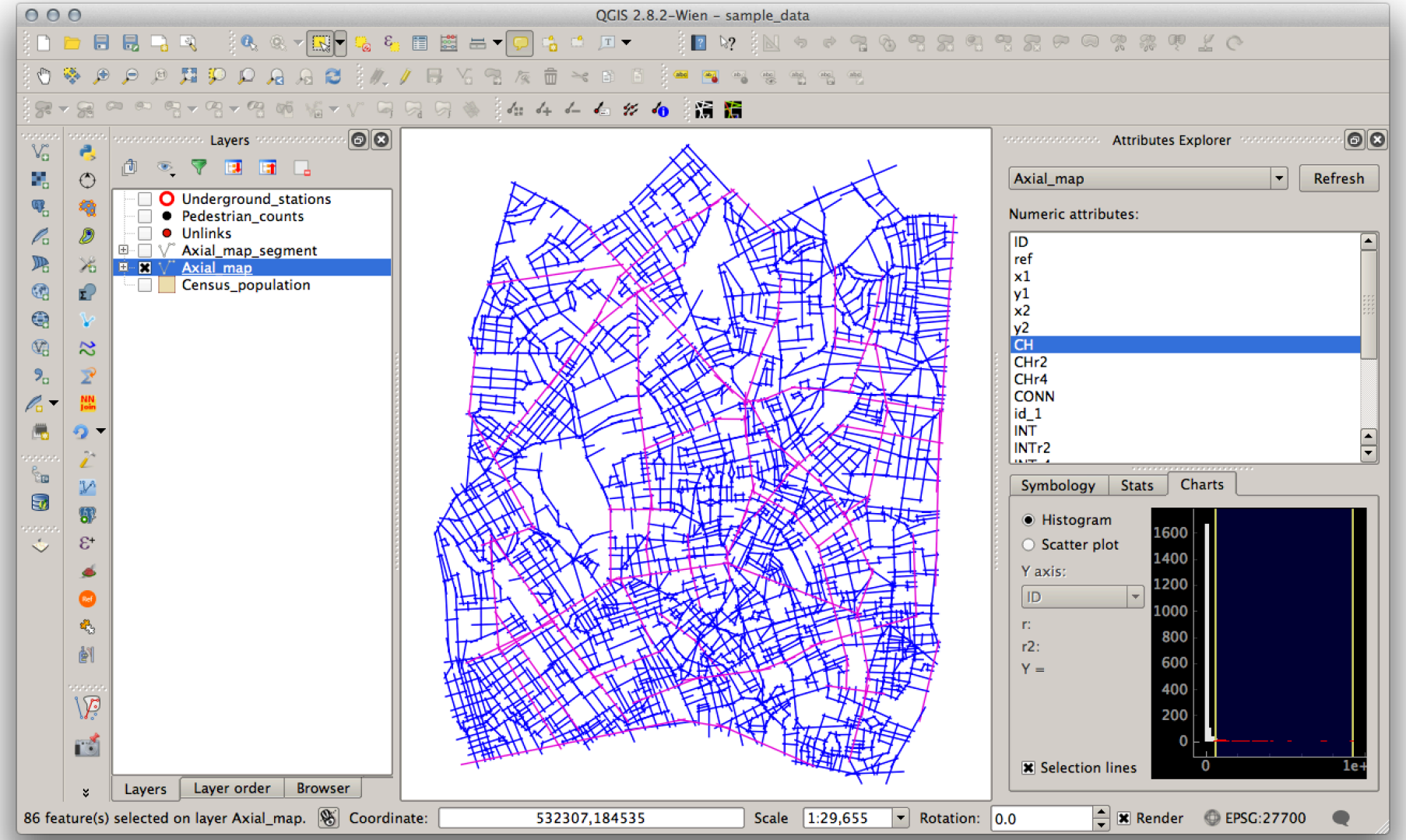


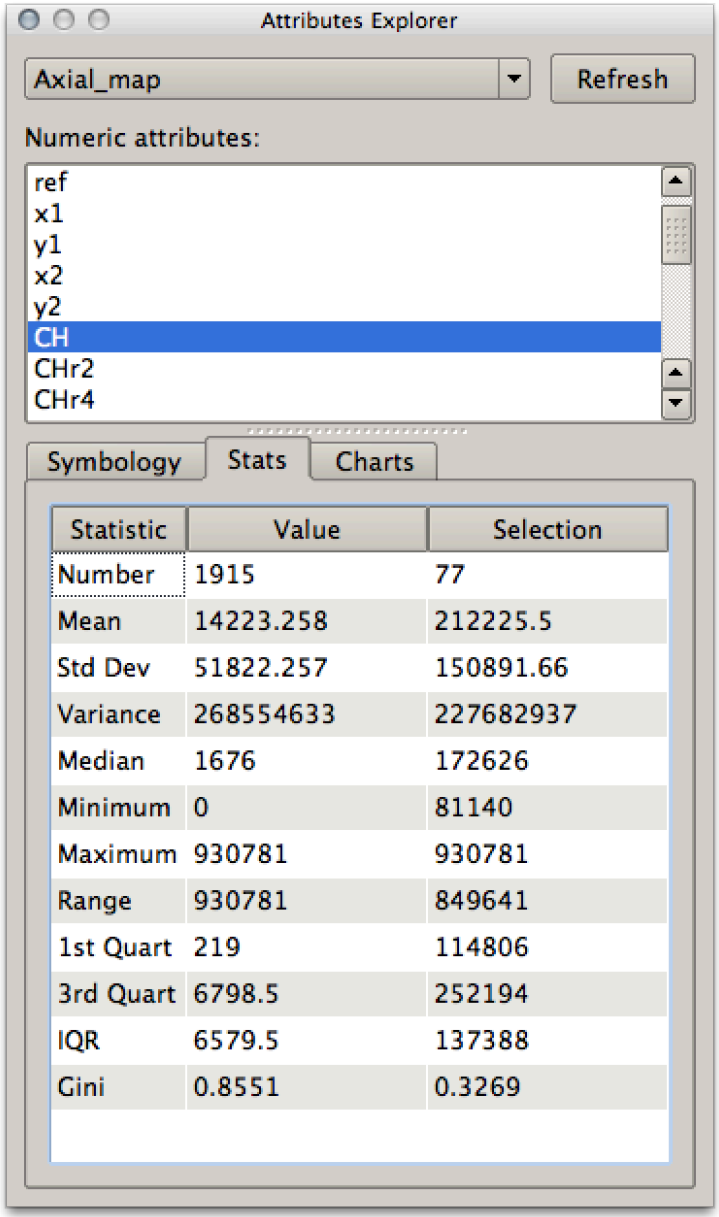
# Displaying syntax measures



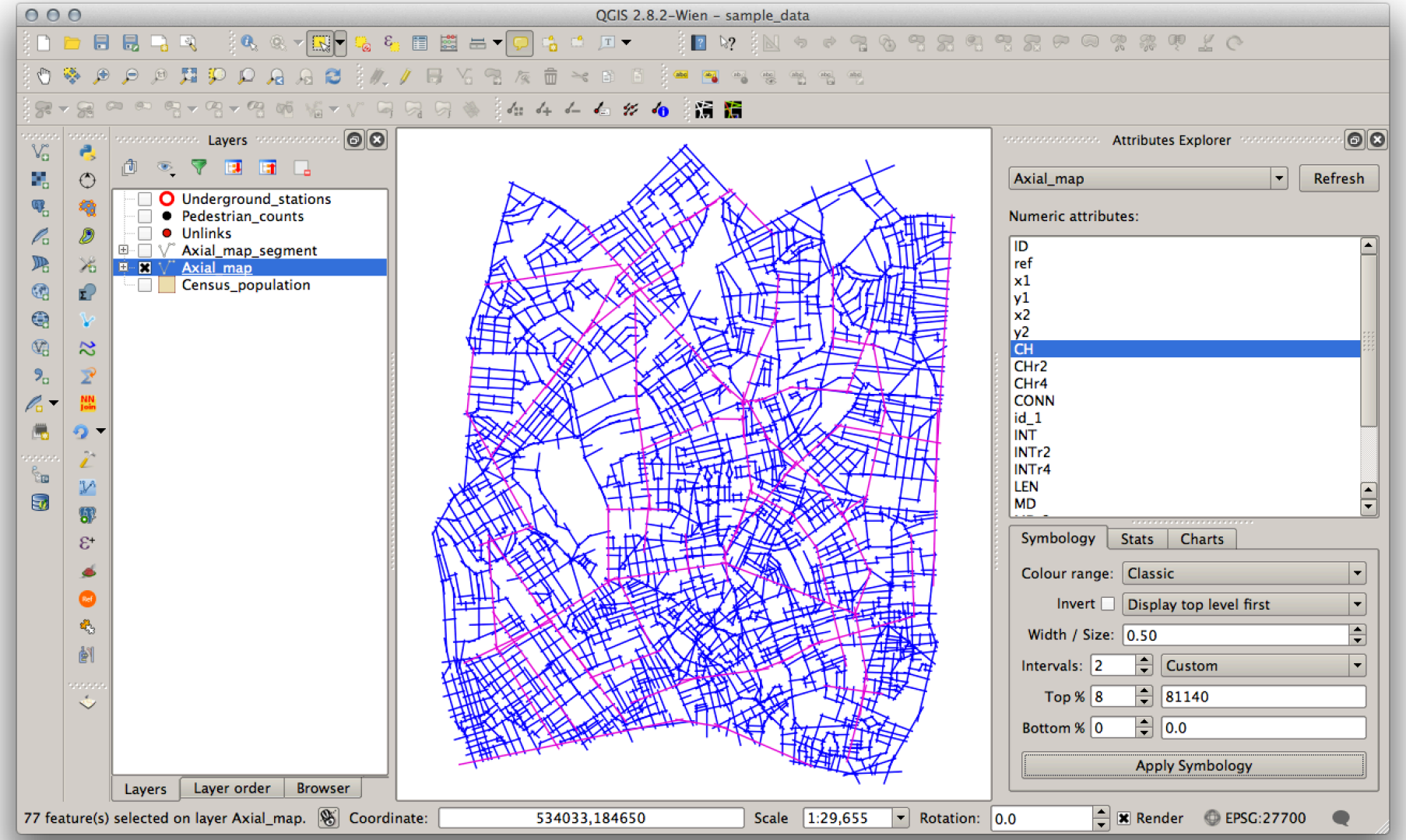
# Showing the choice structure



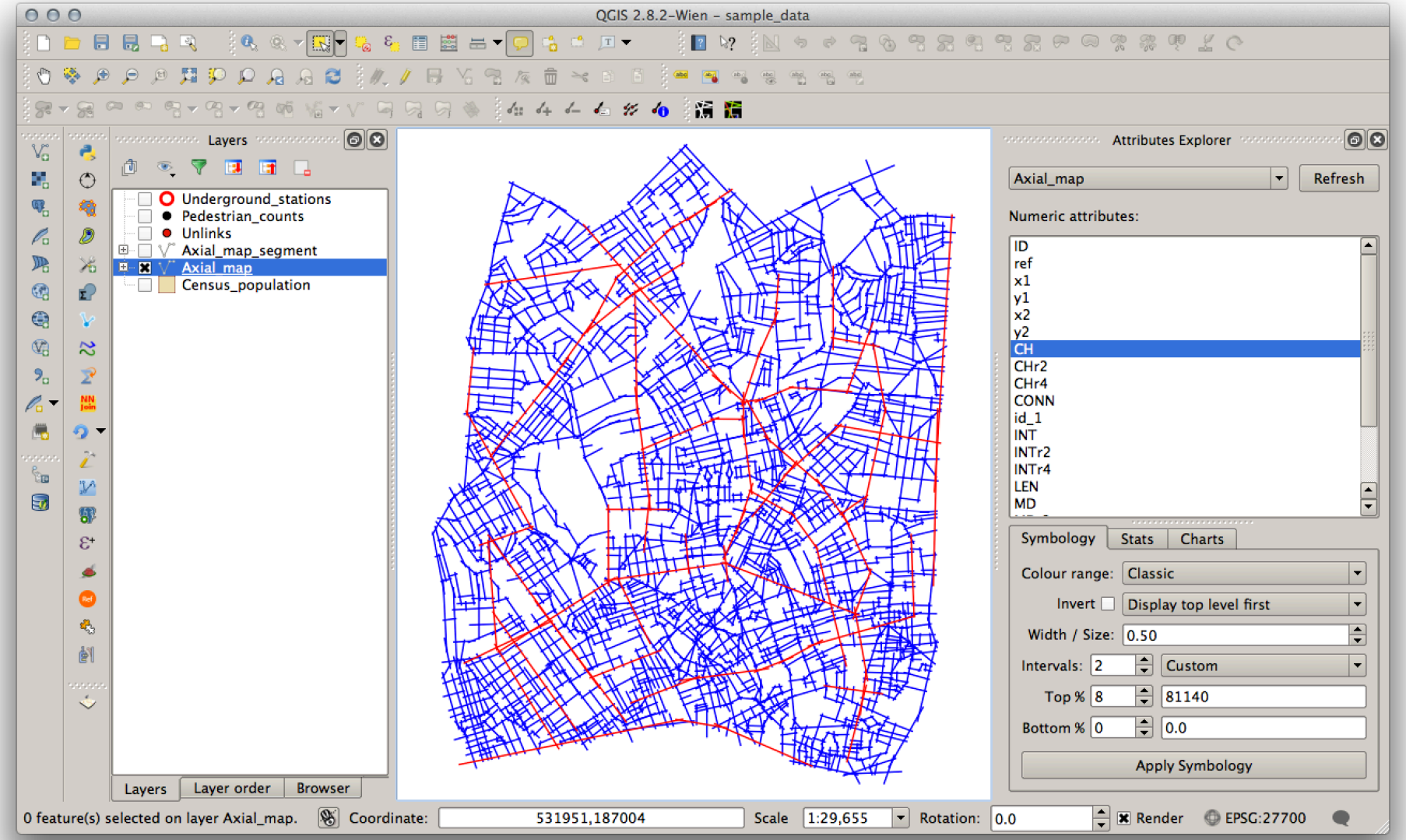
# Showing the choice structure



# Showing the choice structure



# Showing the choice structure



# PART 3 – Exploration and Discussion

1. GIS stages and operations for space syntax
2. Useful QGIS plugins and tools
3. Examples of work
4. Exploration of QGIS workflows for space syntax
    1. Continue exercise with own data, or
    2. Experiment new workflows
5. Discussion on new workflows for the SST

# GIS stages and operations for space syntax (1)

| Stage | Operations |
|---|---|
| Data acquisition | Collect base map data<br>Convert data formats<br>Georeference vector and raster data<br>User behaviour data entry<br>Location survey data entry |
| Geo-processing | Filter, aggregate and join data based on attributes and spatial relations<br>Find nearest feature<br>Transform geometries<br>Attributes update and calculation |
| Network model preparation | Draw map<br>Extract map from larger data set<br>Prepare plans<br>Generalise road network<br>Map verification<br>Manage unlinks and links |
| Network analysis | Analyse network models (space syntax)<br>Post process analysis results (attribute naming, selection, new calculations)<br>Calculate shortest route and catchment areas<br>Street and block morphology |

# GIS stages and operations for space syntax (2)

| Stage | Operations |
|---|---|
| Exploratory spatial data analysis | Interactive visual exploration of results<br>Inquiry of individual feature values<br>Identify the core of the network<br>Spatial analysis (interpolation, hotspots, clustering)<br>Terrain analysis |
| Statistical analysis | Descriptive statistics<br>Transform columns<br>Interactive charts (histogram, scatter plot)<br>Linear regression<br>Multivariate regression<br>Statistical clustering (PCA, k-means, hierarchical)<br>Export data to statistics packages |
| Reporting and visualisation | Create base map compositions for print<br>Set output format and resolution<br>Standard visualisation (colour ranges) for screen and print<br>Store named views<br>Produce map series based on attributes |

Source: Based on work by Stephen Law and colleagues at Space Syntax Ltd

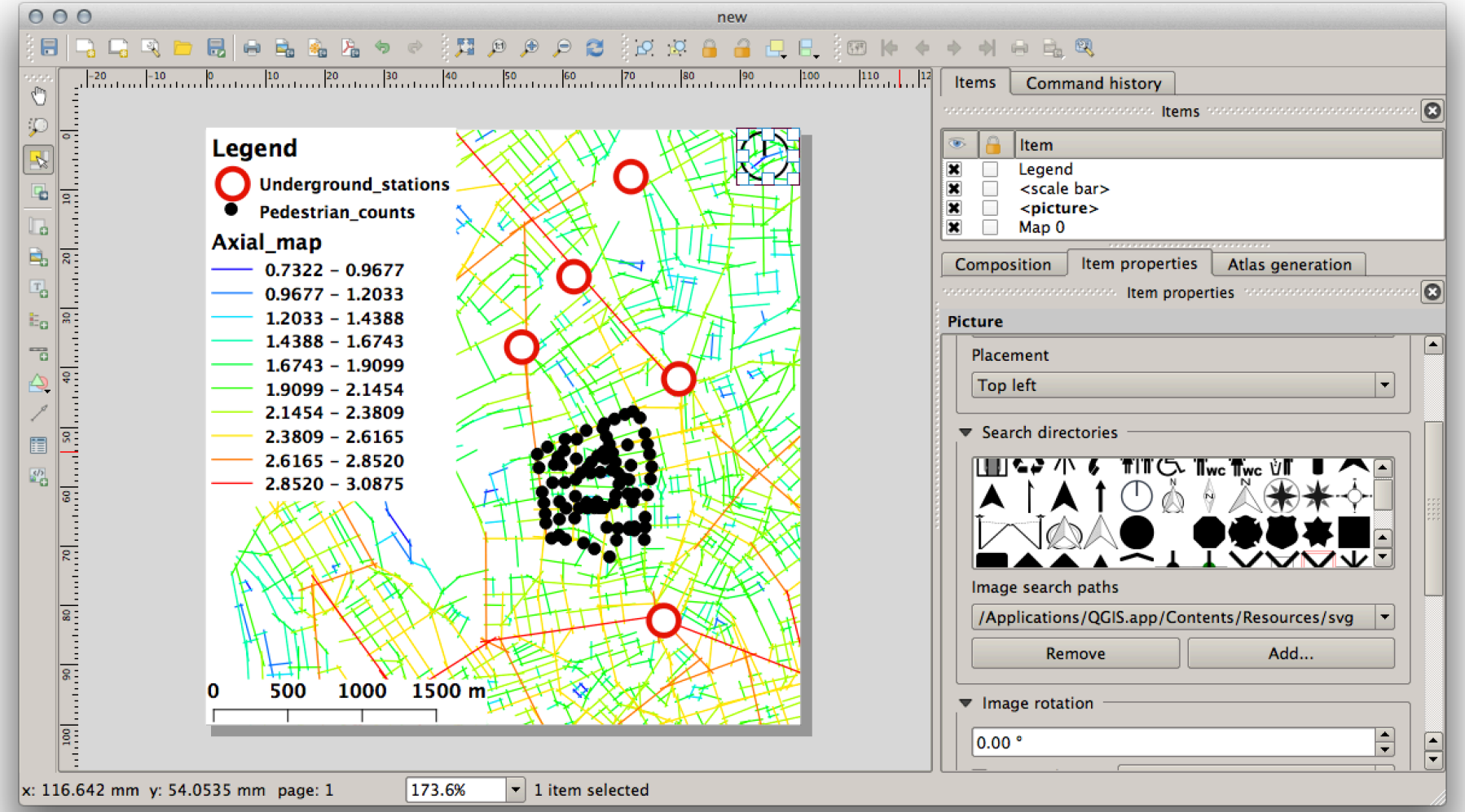
# Useful QGIS plug-ins and tools

- Openlayers
- Dbmanager
- Dissolve with stats
- CADDigitize
- Contour Plugin
- Concave Hull
- Ftools
- Generalizer
- Heatmap
- MMQGIS
- NNJoin
- Qscatter
- Spatialjoin
- Spatial Query plugin
- SPIT
- Table manager
- Affine transformations
- Composer
- Processing
- …

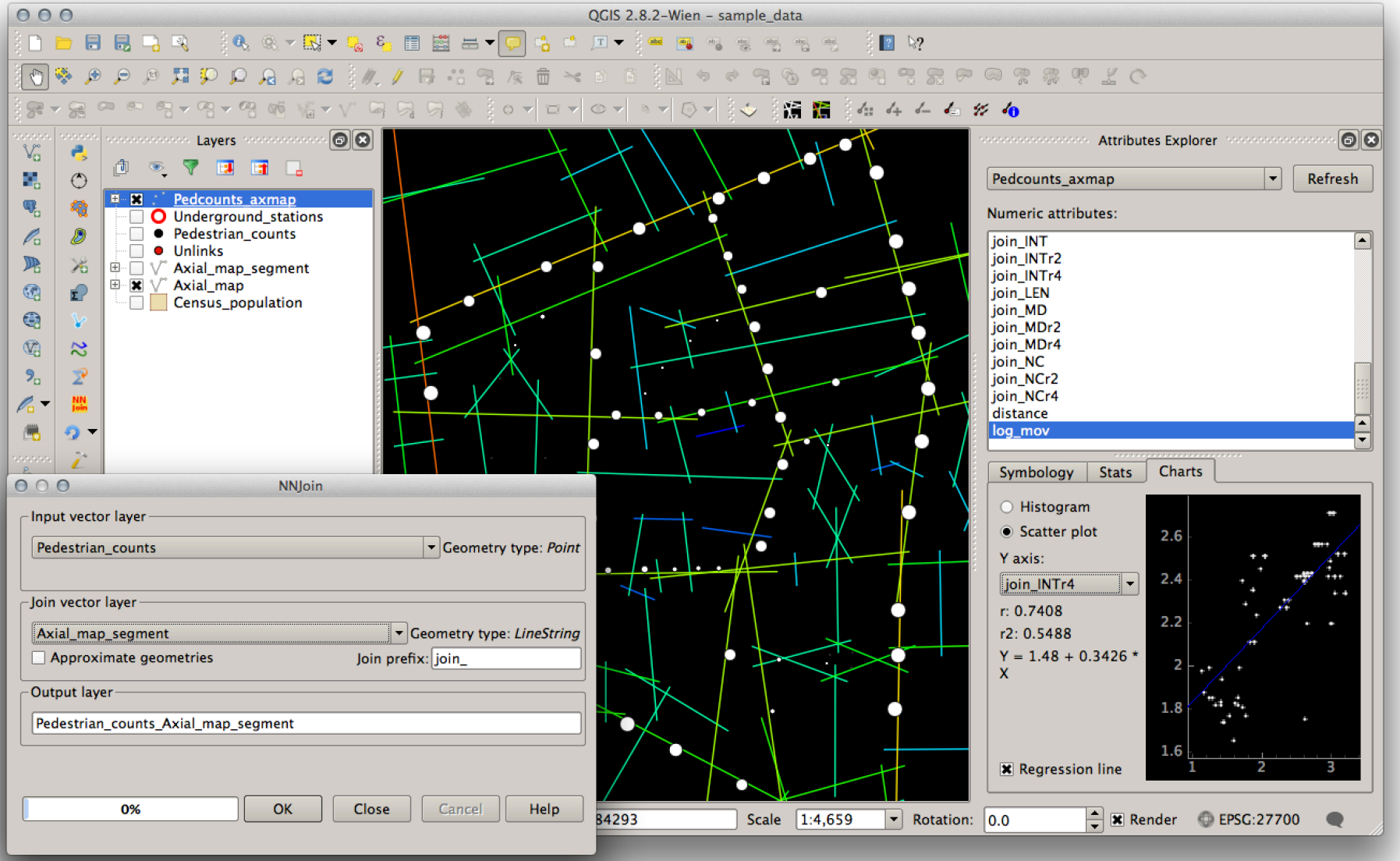
# Exploration of QGIS workflows for space syntax

- Producing a map for publication
- Movement predictive model
- Impact maps
- Aggregation of network with census
- Creating density maps

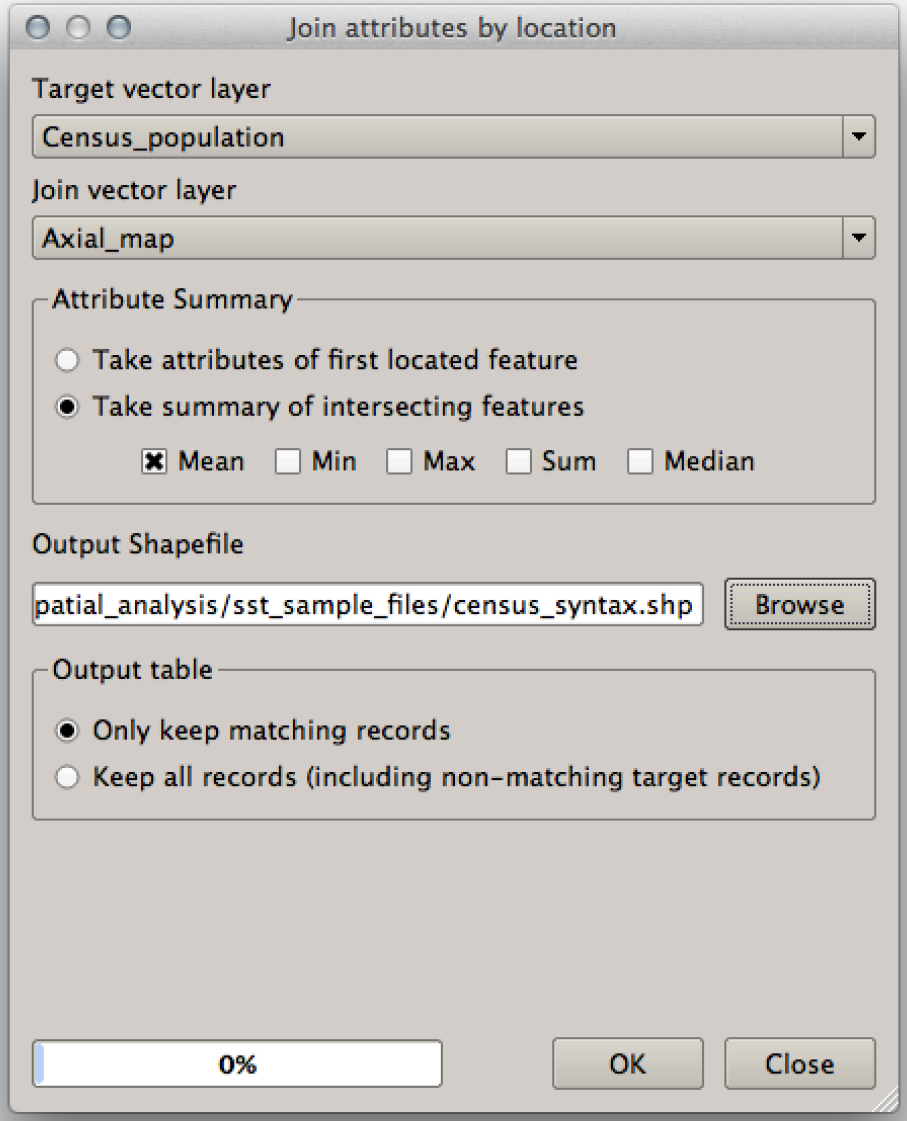
# Producing a map for publication



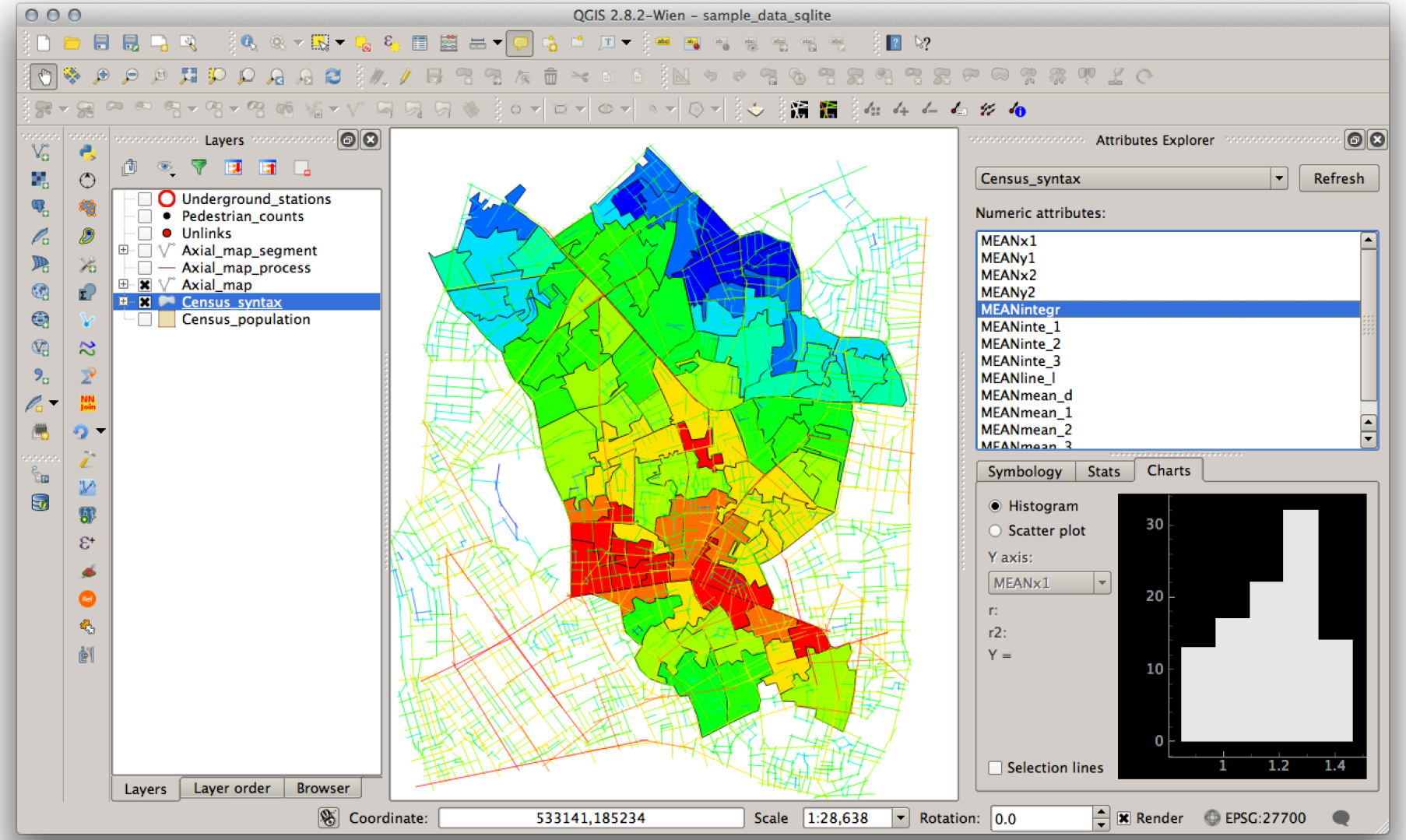
# Movement predictive model



# Aggregation of network with census



# Aggregation of network with census



# Discussion on new workflows for the SST

- Road centre line analysis
- Linking model levels
- Catchment / Service areas
- ???

# Thank you!

**jorge.gil@ucl.ac.uk**

Project part of Platform Grant Extension:
Space, Time and Interaction
EPSRC GR/S645561/01