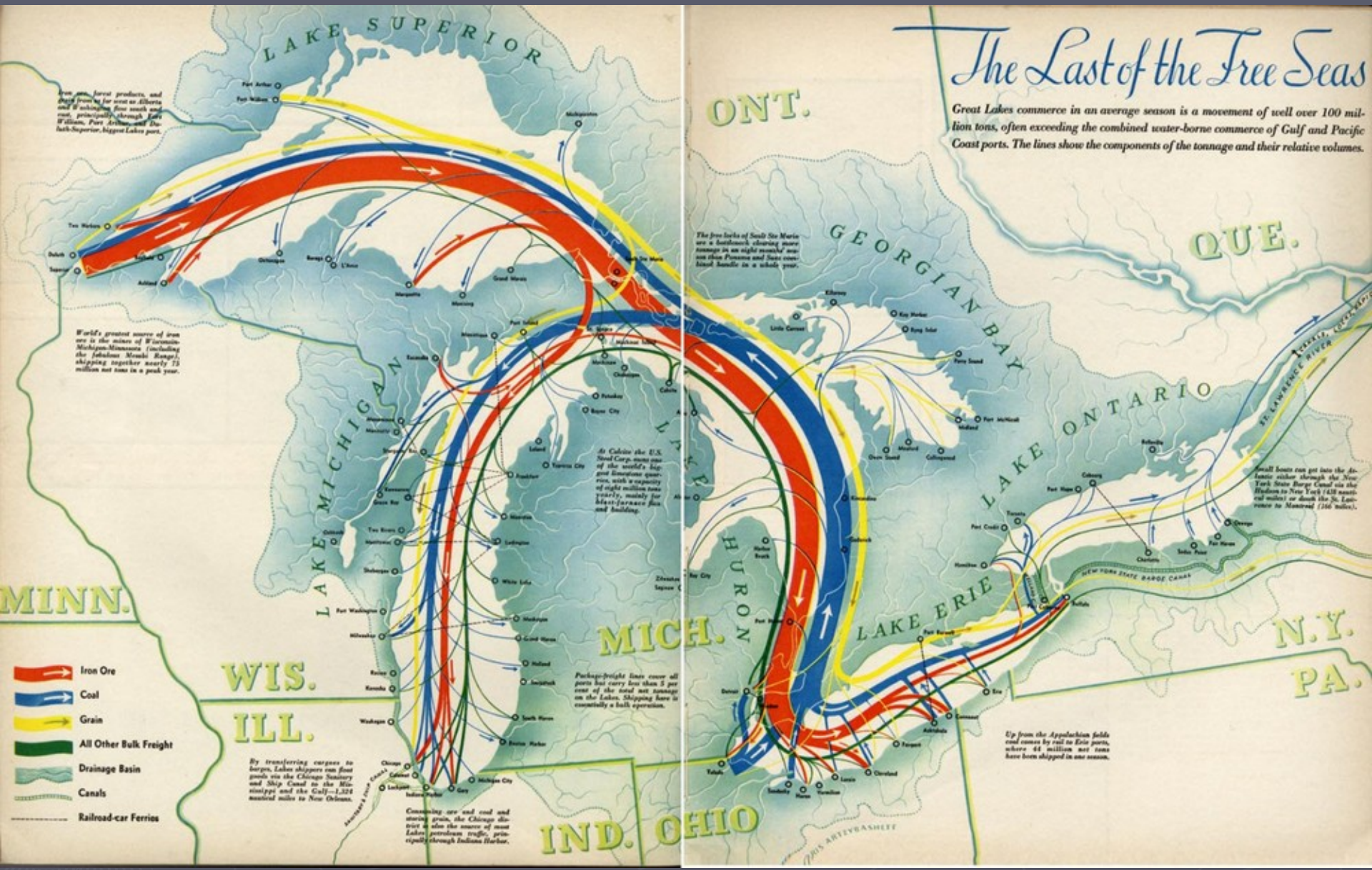
Open-Source Flow Maps with Cubic Splines

Paulo Raposo

GIP Department, Faculty ITC, University of Twente

ITC Mini Symposium On Sustainable Research Software Development For Geo-Information Science And Earth Observation

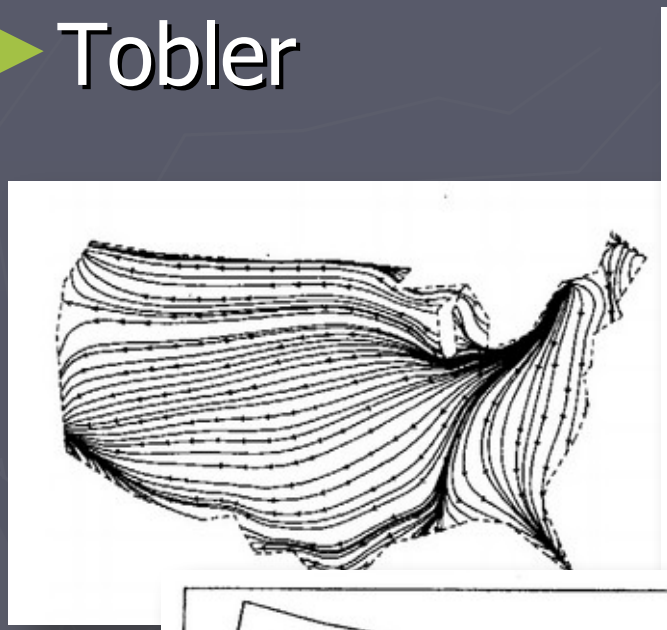
2022-11-17

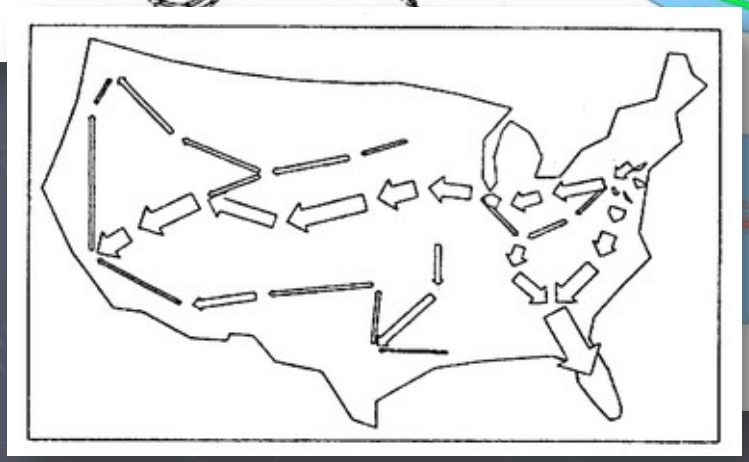


"The Last of the Free Seas," Boris Artzbasheff, Fortune Magazine in July 1940

Flow Maps

- Tobler





Flow Map Layout

Doantam Phan[1], Ling Xiao[1], Ron Yeh[1], Pat Hanrahan[2], and Terry Winograd[2]

Stanford University

Figure 1. Flow Maps. (a) Minard's 1864 flow map of wine exports from France [20] (b) Tobler's computer generated flow map of migration from California from 1995 - 2000. [18; 19] (c) A flow map produced by our system that shows the same migration data.

ABSTRACT

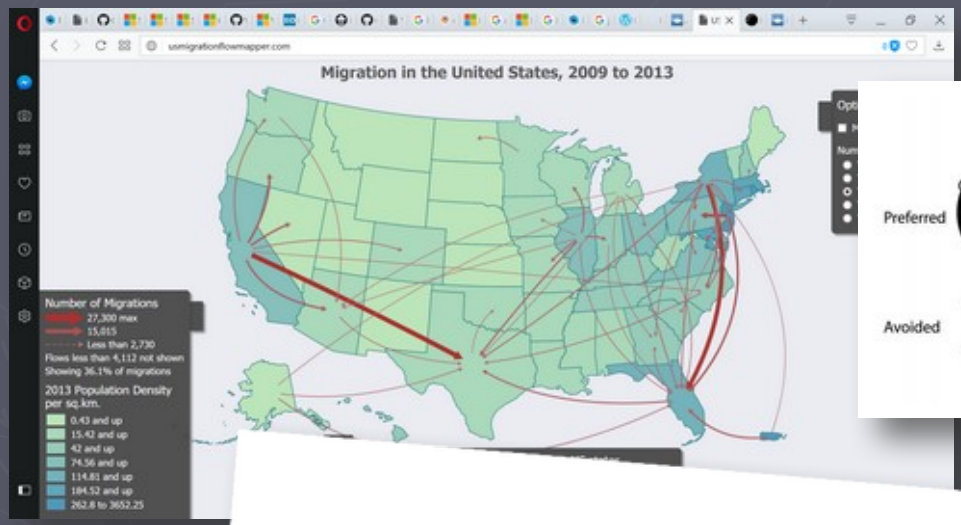
Cartographers have long used flow maps to show the movement of objects from one location to another, such as the number of people in a migration, the amount of goods being traded, or the number of packets in a network. The advantage of flow maps is that they reduce visual clutter by merging edges. Most flow maps are drawn by hand and there are few computer algorithms available. We present a method for generating flow maps using hierarchical clustering given a set of nodes, positions, and flow data between the nodes. Our techniques are inspired by graph

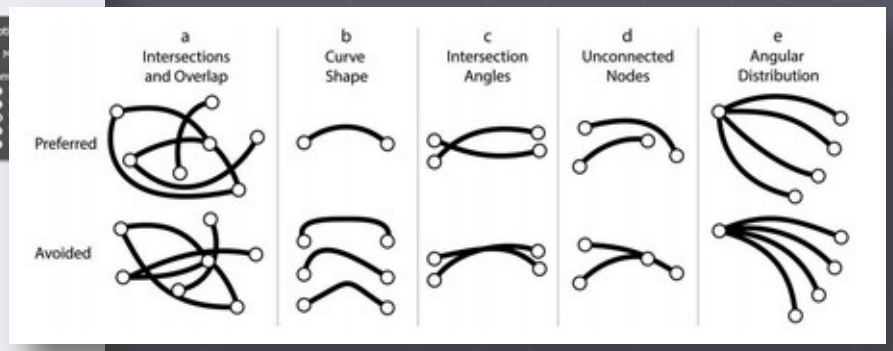
shows the spatial distribution of univariate geographic phenomena [17]. Lines of varying width which represent the number of objects being transferred are overlaid on the map. Visual clutter is reduced by merging edges that share destinations. The first flow maps illustrated rail ridership in Ireland and since then, cartographers have used flow maps to depict migrations, trade, and any data set with a from-to relationship [6].

Our goal is to produce flow maps to visualize networks and other kinds of flow data. A well-drawn flow map allows a user to see the differences in magnitude among the flows with a minimum of clutter. Figure 1a is a hand drawn map by Minard

Flow Maps

- Jenny, Marston, et al.





CARTOGRAPHY AND GEOGRAPHIC INFORMATION SCIENCE, 2016
http://dx.doi.org/10.1080/15230406.2016.1262280

Taylor & Francis
Taylor & Francis Group

Design principles for origin-destination flow maps

Bernhard Jenny[a,b], Daniel M. Stephen[b], Ian Muehlenhaus[c], Brooke E. Marston[b], Ritesh Sharma[d], Eugene Zhang[d] and Helen Jenny[b]

[a]School of Science, Geospatial Science, RMIT University, Melbourne, Australia; [b]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, USA; [c]Department of Geography, University of Wisconsin Madison, USA; [d]School of Electrical Engineering and Computer Science, Oregon State University, Corvallis, USA

ABSTRACT

Origin-destination flow

anitagraser.com/2016/12/18/details-of-good-flow-maps/

Advertisements

— Free and Open Source GIS Ramblings

written by Anita Graser aka Underdark

Home Projects Publications About

Details of good flow maps

By underdark
2016-12-18
—
QGIS
—
38 Comments

In my previous post, I shared a flow map style that was inspired by a hand drawn map. Today's post is inspired by a recent academic paper recommended to me by Radoslaw Panczak @RPanczak and Thomas Gratier @ThomasG77:

Jenny, B., Stephen, D. M., Muehlenhaus, I., Marston, B. E., Sharma, R., Zhang, E., & Jenny, H. (2016). Design principles for origin-destination flow maps. Cartography and Geographic Information Science, 1-15.

Jenny et al. (2016) performed a study on how to best design flow maps. The resulting design principles are:

— number of flow overlaps should b
— sharp bends and excessively as
— acute intersection angles should
— flows must not pass under unrc
— flows should be radially arrang
— quantity is best represented b
— flow direction is best indicate

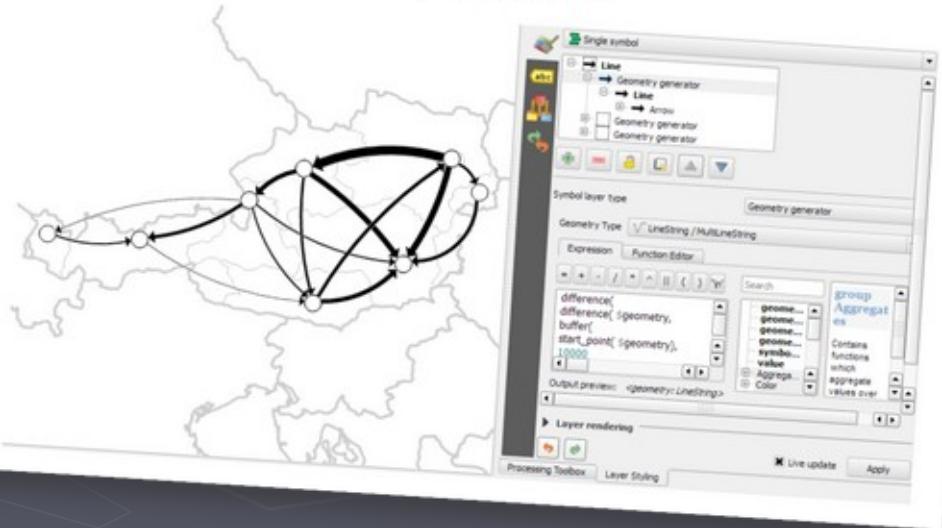
Search

Advertisements

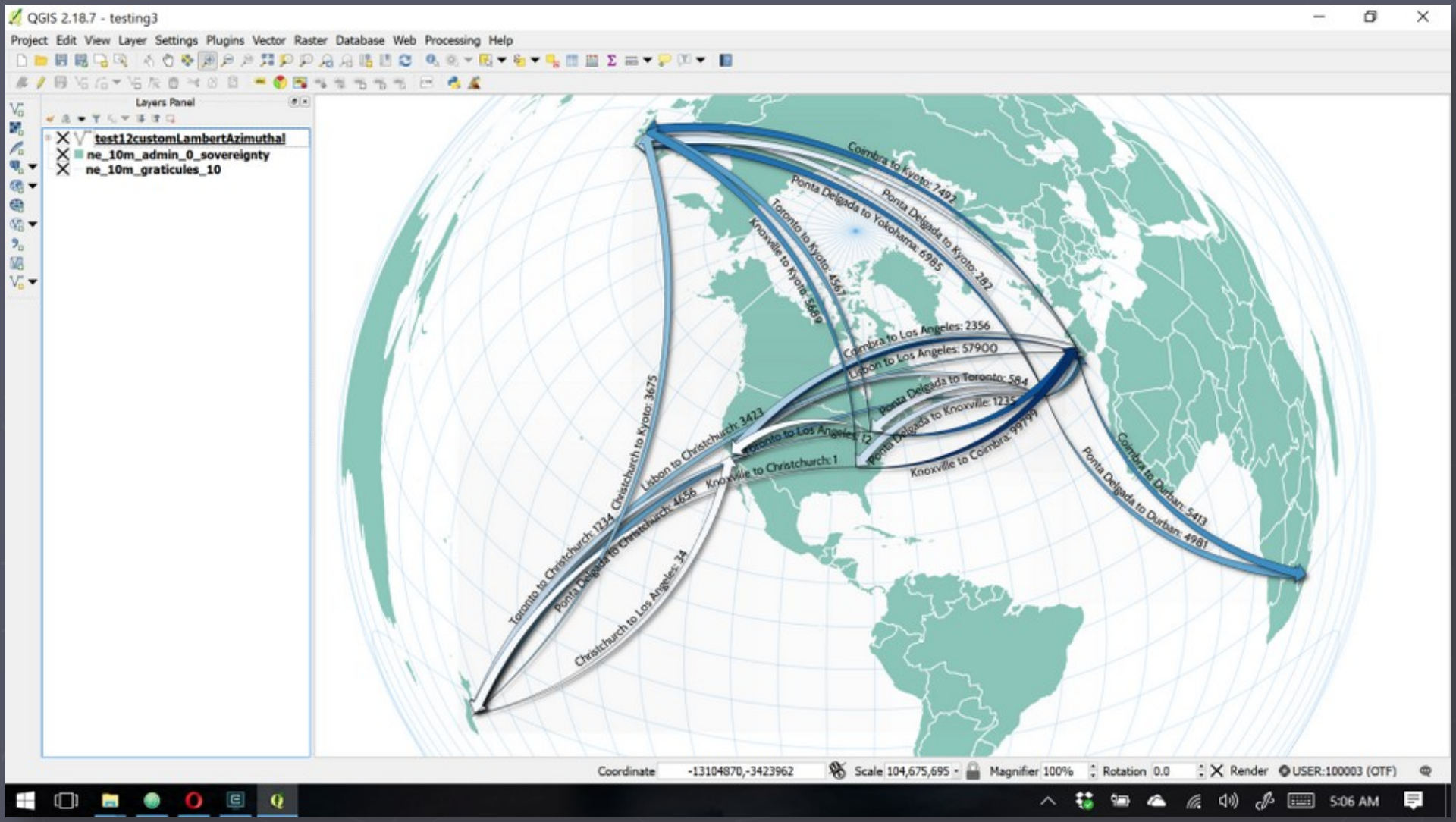
NEW for QGIS 2.14!

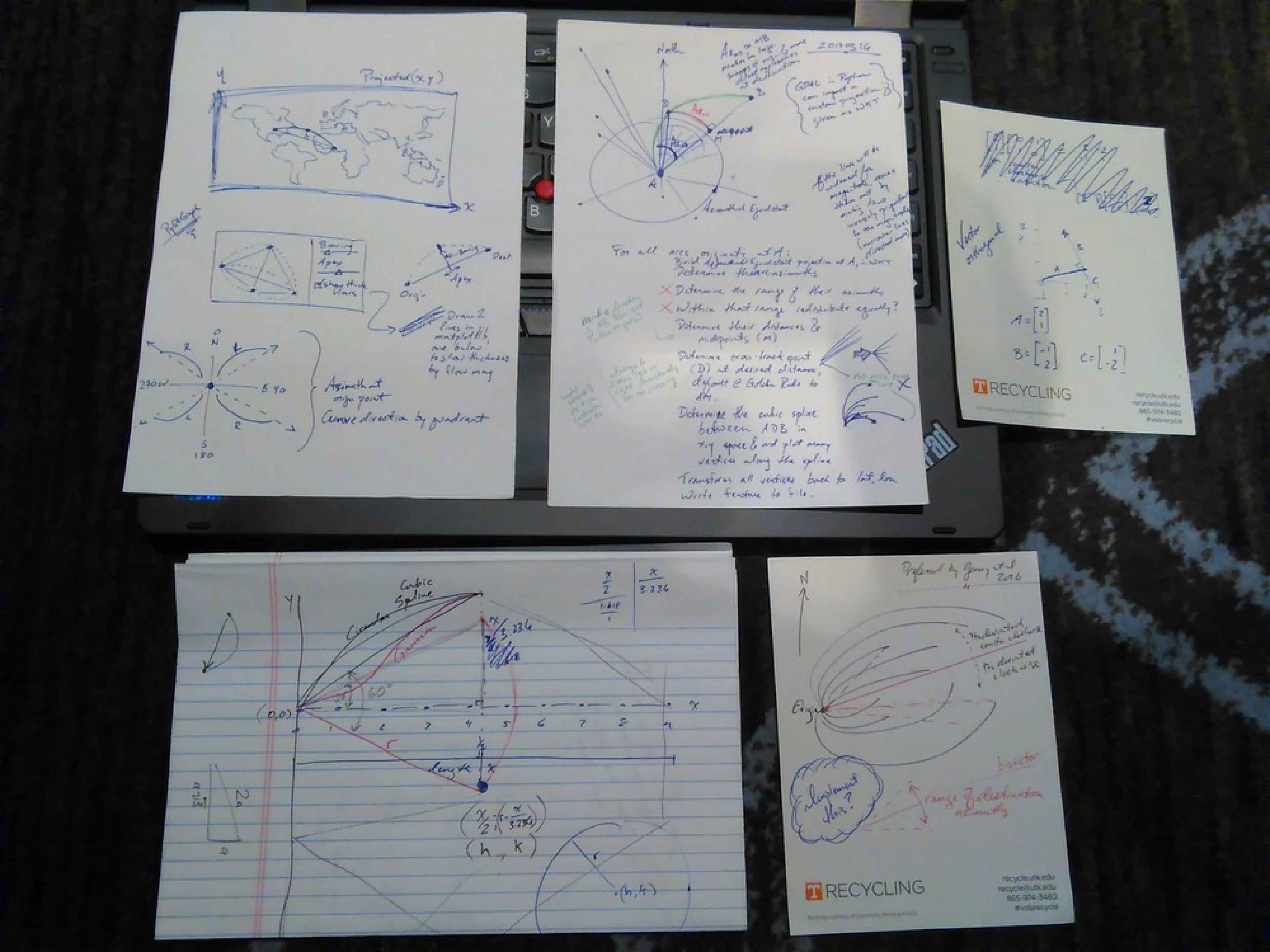

```
difference(
  difference(
    $geometry,
    buffer( start_point($geometry), 10000 )
  ),
  buffer( end_point( $geometry), 10000 )
)
```

Note that the buffer values in this expression only produce appropriate results for line datasets which use a **CRS in meters** and will have to be adjusted for other units.



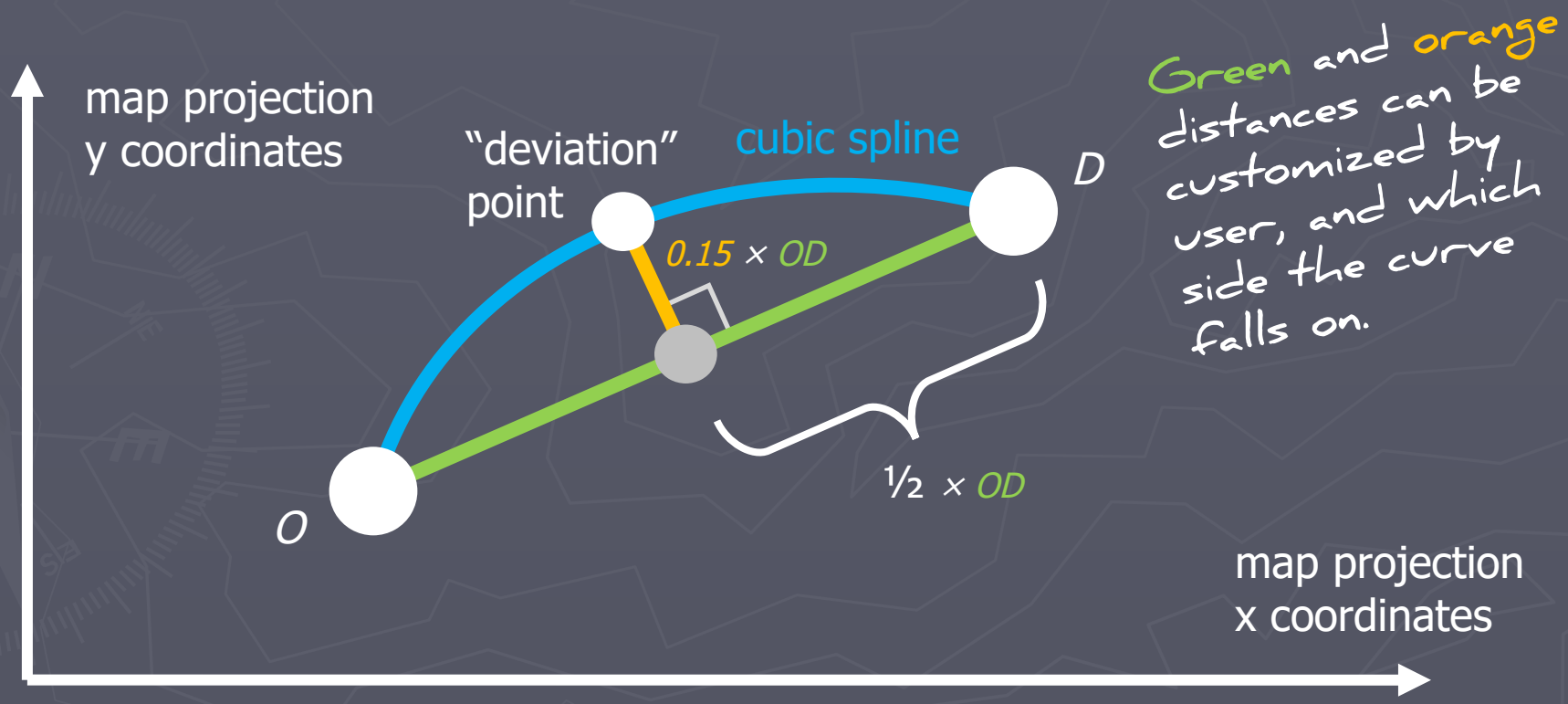
Cubic Spline Flows, Any Projection




Projected (x,y)
Y
X
Bearing
Apex
Orig
Dest
Draw 2 lines in matplotlib, one below to show thickness by flow mag
N
E 90
S
180
270 W
Azimuth at origin point
Curve direction by quadrant
2017/3/16
North
GDAL + Python can import a custom projection given as WKT
Azimuthal Equidistant
For all arcs originating at A:
Build Azimuthal Equidistant projection at A, WKT
Determine their azimuths
Determine the range of their azimuths
Within that range redistribute equally?
Determine their distances & midpoints (M)
Determine cross-track point (D) at desired distance, default @ Golden Ratio to AM.
Determine the cubic spline between ADB in xy space & and plot many vertices along the spline
Transform all vertices back to lat, lon
Write feature to file.
Vector orthogonal
A = [2 1]
B = [-1 2]
C = [1 -2]
RECYCLING
recycle.utk.edu
recycle@utk.edu
865-974-3480
#volsrecycle
Cubic Spline
Circular
(0,0)
60°
x/2
1.618
x/3.236
length x
(h, k)
Preferred by Jenny et al 2016
N
Origin
bisector
range of destination azimuths
implement this?
RECYCLING
recycle.utk.edu
recycle@utk.edu
865-974-3480
#volsrecycle

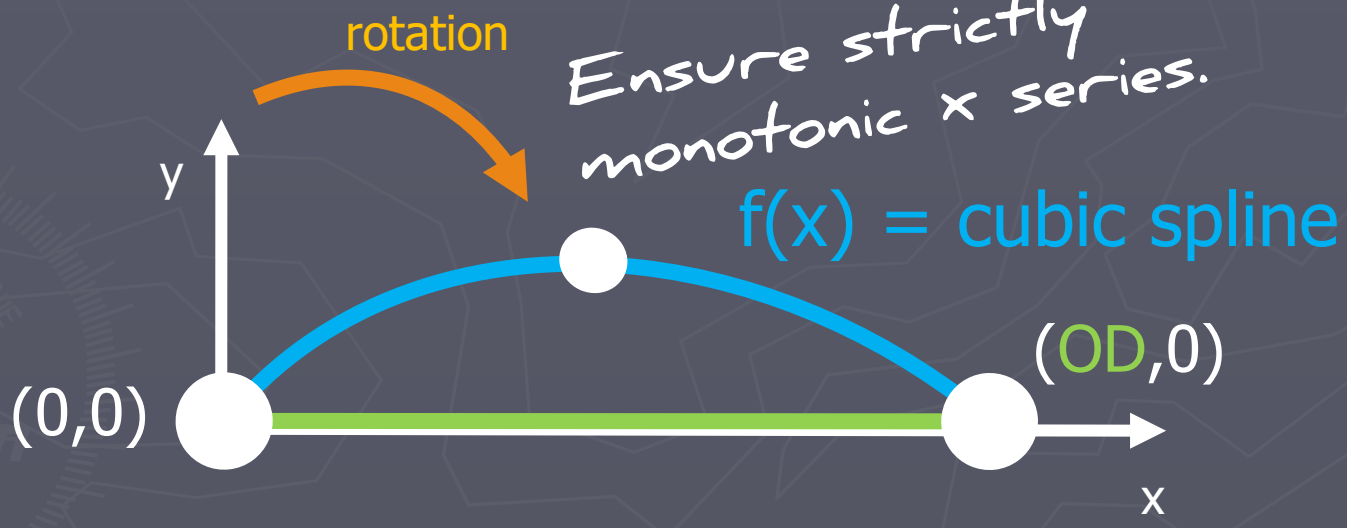
Cubic Splines Construction

- Origin, destination & "deviated" point to define spline



Cubic Splines Construction

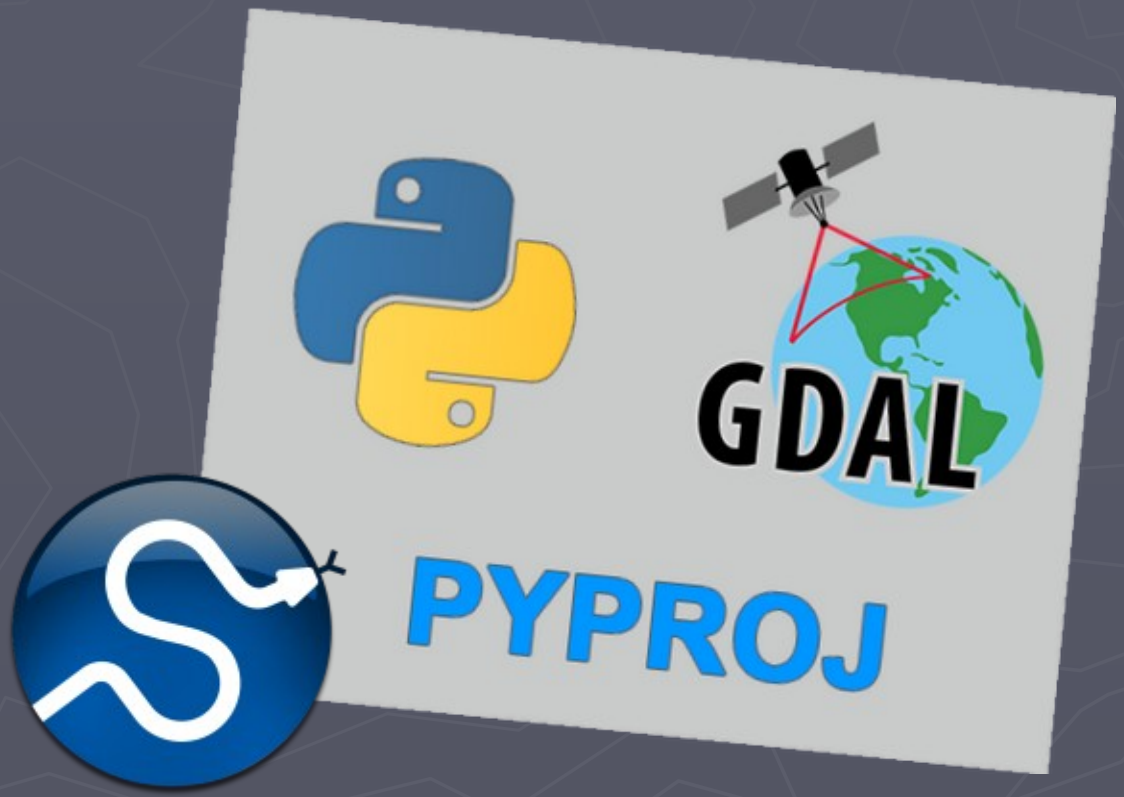
Rotate/translate for spline calculation.
Rotate/translate each (x,y) back when done.

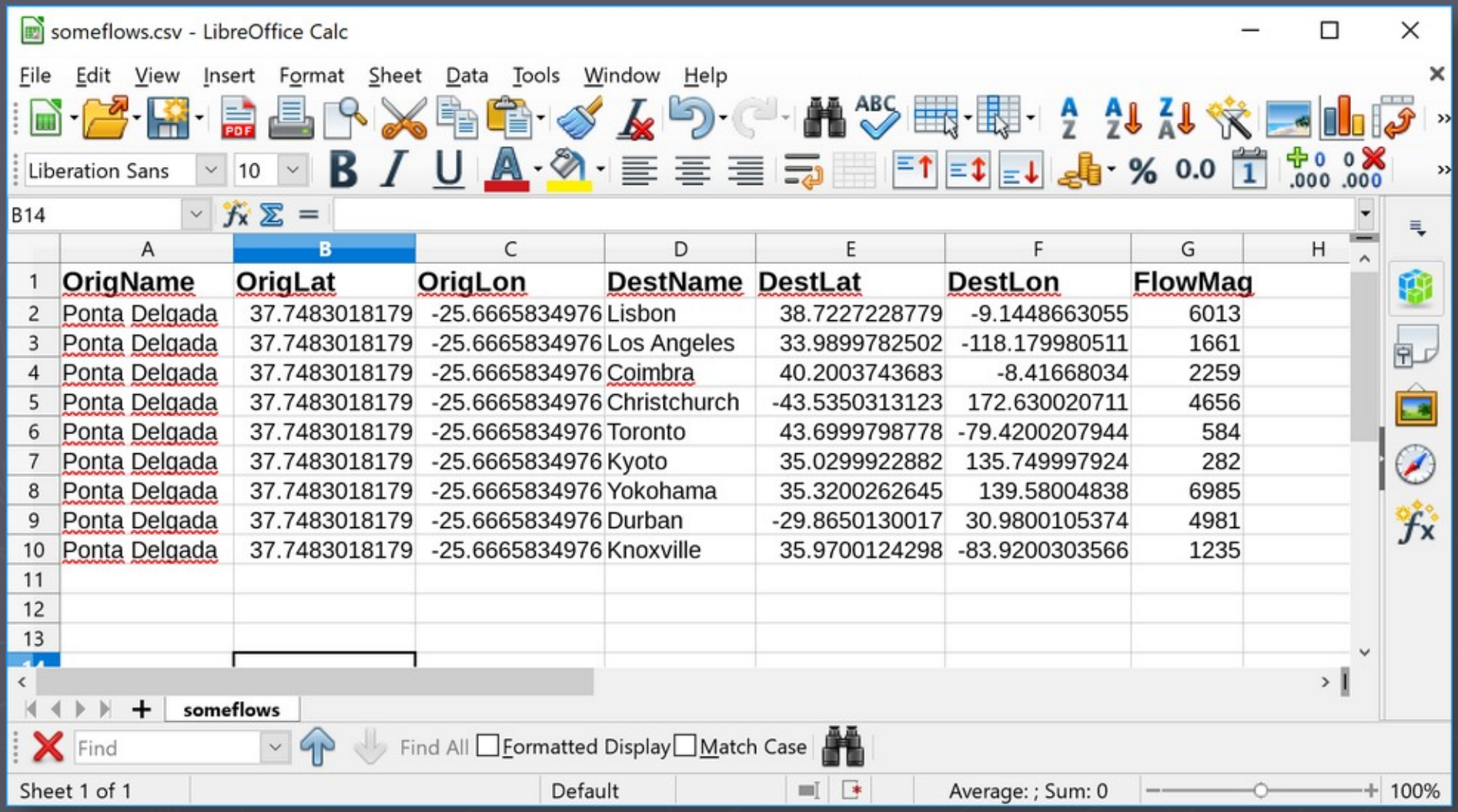


Calculate f(x) for 200 evenly-spaced x values to get x,y coordinate pairs along the arc – vertices for the flow arcs.

Open Source

- https://github.com/paulojraposo/FlowMaps
- Uses:
  - GDAL/OGR
  - Scipy
  - Shapely
  - CSV inputs



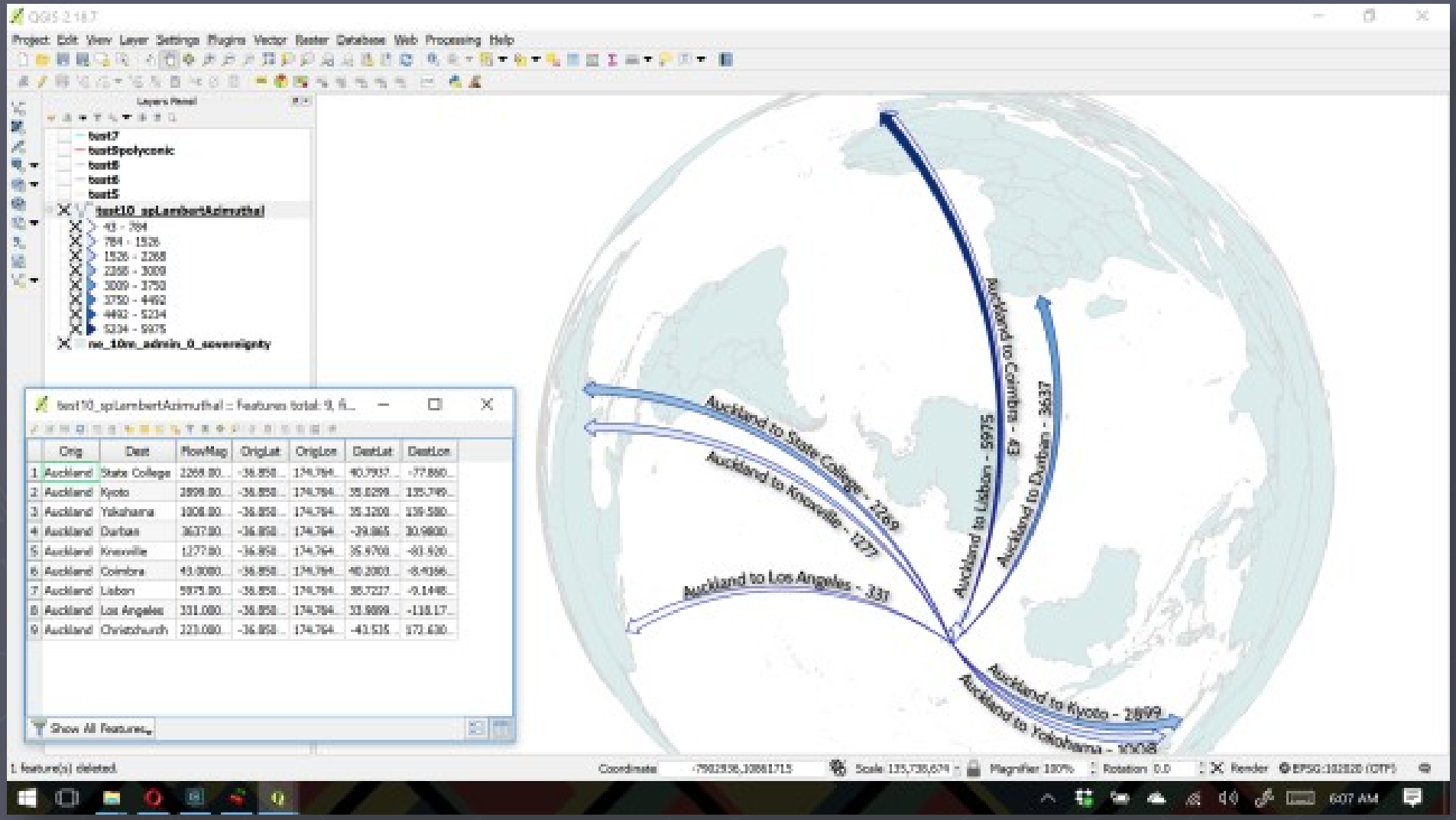

someflows.csv - LibreOffice Calc
File Edit View Insert Format Sheet Data Tools Window Help
Liberation Sans 10
B14
OrigName OrigLat OrigLon DestName DestLat DestLon FlowMag
Ponta Delgada 37.7483018179 -25.6665834976 Lisbon 38.7227228779 -9.1448663055 6013
Ponta Delgada 37.7483018179 -25.6665834976 Los Angeles 33.9899782502 -118.179980511 1661
Ponta Delgada 37.7483018179 -25.6665834976 Coimbra 40.2003743683 -8.41668034 2259
Ponta Delgada 37.7483018179 -25.6665834976 Christchurch -43.5350313123 172.630020711 4656
Ponta Delgada 37.7483018179 -25.6665834976 Toronto 43.6999798778 -79.4200207944 584
Ponta Delgada 37.7483018179 -25.6665834976 Kyoto 35.0299922882 135.749997924 282
Ponta Delgada 37.7483018179 -25.6665834976 Yokohama 35.3200262645 139.58004838 6985
Ponta Delgada 37.7483018179 -25.6665834976 Durban -29.8650130017 30.9800105374 4981
Ponta Delgada 37.7483018179 -25.6665834976 Knoxville 35.9700124298 -83.9200303566 1235
someflows
Find Find All Formatted Display Match Case
Sheet 1 of 1 Default Average: ; Sum: 0 100%

Example usage:

```
python InterpolatedFlowMaps.py routes.csv out.shp –-outproj4
 http://spatialreference.org/ref/epsg/32631/proj4/
```

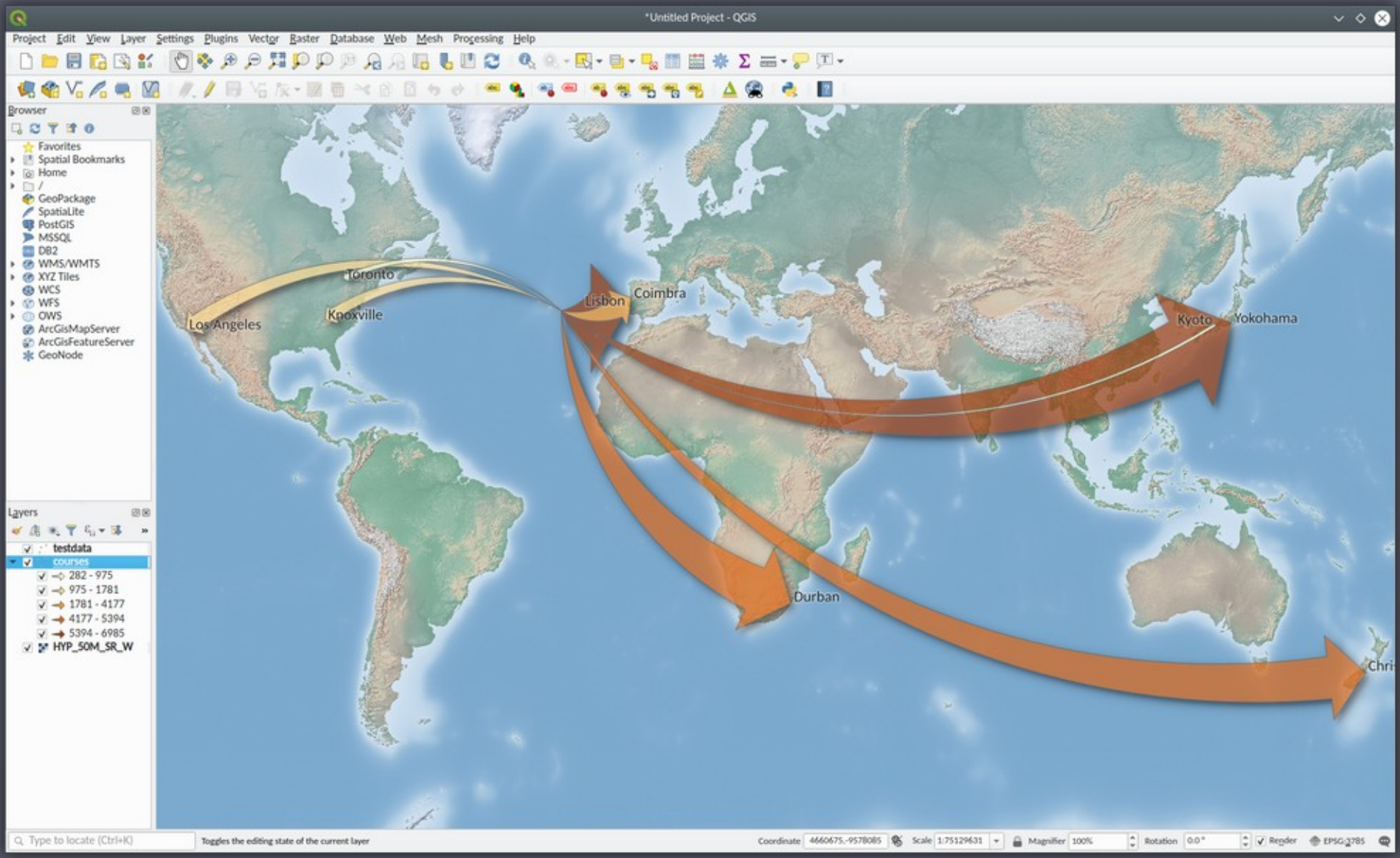
Select Windows PowerShell

```
PS C:\Users\paulo\Anaconda3\envs\geodetic> .\python.exe C:\users\paulo\code\FlowMaps\FlowMapsCubicSplines.py -h
usage: Cubic Spline Flow Maps [-h] [--outproj4 OUTPROJ4] [--dev DEV]
                              [--vpa VPA] [--rh] [-v] [-l]
                              ROUTES OUTSHPFILE

Cubic Spline Flow Maps -- A script for making flow maps in GIS, using cubic splines, by Paulo Raposo (pauloj.raposo@outlook.com).
Under MIT license.
Written for Python 3 - may not work on 2. Dependencies include: Python 3, scipy, gdal, shapely, pyproj (Proj.4)

positional arguments:
  ROUTES                CSV file specifying routes and magnitudes. Coordinates
                        must be lat and lon in WGS84. Please see the README
                        file for required formatting.
  OUTSHPFILE            File path and name for output shapefile, with extension
                        '.shp'. The directory must already exist.

optional arguments:
  -h, --help            show this help message and exit
  --outproj4 OUTPROJ4   Output projected coordinate system to draw flow arcs
                        in, given as a Proj.4 string. Often available at
                        spatialreference.org. Three input formats are
                        acceptable: a Proj.4 string, a URL starting with
                        'http://' to the Proj.4 string for a coodinate system
                        on spatialreference.org (e.g.,
                        http://spatialreference.org/ref/esri/53012/proj4/), or
                        a full path to a plain text file containing (only) a
                        Proj.4 string. Default output projection is Web
                        Mercator (http://spatialreference.org/ref/epsg/3785/).
  --dev DEV             The fraction of the projected straight-line distance
                        between start and end points of each arc at which a
                        third, across-track deviated point should be
                        established for cubic splines. Values must be between
                        0.0 and 1.0. Larger values make arcs more curved.
                        Default is 0.15.
  --vpa VPA             The number of vertices the mapped arcs should each
                        have. Must be greater than 3, but should be at least
                        several dozen to a couple hundred or so. Default is
                        200.
  --rh                  Sets the across-track deviation point on the right-hand
                        side instead of left. Changes the directions that arcs
                        curve in.
```


QGIS 2.18.7
Project Edit View Layer Settings Plugins Vector Raster Database Web Processing Help
Layers Panel
test7
test5polyconic
test8
test6
test5
test10_spLambertAzimuthal
43 - 784
784 - 1526
1526 - 2268
2268 - 3009
3009 - 3750
3750 - 4492
4492 - 5234
5234 - 5975
ne_10m_admin_0_sovereignty
test10_spLambertAzimuthal :: Features total: 9, fi...
Orig
Dest
FlowMag
OrigLat
OrigLon
DestLat
DestLon
1 Auckland State College 2268.80... -36.858... 174.764... 40.7937... -77.860...
2 Auckland Kyoto 2898.80... -36.858... 174.764... 35.0299... 135.749...
3 Auckland Yokohama 1808.80... -36.858... 174.764... 35.3200... 139.580...
4 Auckland Durban 3637.80... -36.858... 174.764... -29.865... 30.9800...
5 Auckland Knoxville 1277.80... -36.858... 174.764... 35.9700... -83.920...
6 Auckland Coimbra 43.0080... -36.858... 174.764... 40.2003... -8.4196...
7 Auckland Lisbon 5975.80... -36.858... 174.764... 38.7227... -9.1448...
8 Auckland Los Angeles 331.080... -36.858... 174.764... 33.9899... -118.17...
9 Auckland Christchurch 223.080... -36.858... 174.764... -43.535... 172.630...
Show All Features
Auckland to State College - 2269
Auckland to Knoxville - 1277
Auckland to Los Angeles - 331
Auckland to Lisbon - 5975
Auckland to Coimbra - 43
Auckland to Durban - 3637
Auckland to Kyoto - 2899
Auckland to Yokohama - 1808
1 feature(s) deleted.
Coordinate
Scale
Magnifier 100%
Rotation 0.0
Render
EPSG:102020 (OTF)
6:07 AM

C:\WINDOWS\system32\cmd.exe

```
C:\Users\paulo\Anaconda3\envs\geodetic>python C:\Users\paulo\Code\FlowMaps\FlowMapsCubicSplines.py C:\Users\paulo\flowma
psampledata\someflows.csv C:\Users\paulo\flowmapsampledata\someflowsEPSG54024.shp --outproj4 http://spatialreference.org
/ref/esri/54024/proj4/
String returned: +proj=bonne +lon_0=0 +lat_1=60 +x_0=0 +y_0=0 +datum=WGS84 +no_defs
```


*Untitled Project - QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Browser
Favorites
Spatial Bookmarks
Home
/
GeoPackage
SpatiaLite
PostGIS
MSSQL
DB2
WMS/WMTS
XYZ Tiles
WCS
WFS
OWS
ArcGisMapServer
ArcGisFeatureServer
GeoNode
Layers
testdata
courses
282 - 975
975 - 1781
1781 - 4177
4177 - 5394
5394 - 6985
HYP_50M_SR_W
Toronto
Los Angeles
Knoxville
Lisbon
Coimbra
Kyoto
Yokohama
Durban
Type to locate (Ctrl+K)
Toggles the editing state of the current layer
Coordinate
Scale
Magnifier
Rotation
Render
EPSG:3785

Thanks!

Paulo Raposo | p.raposo@utwente.nl