

API-231 / GIS-PubPol

Meeting 07 (Lab Exercise + Problem Set 4)

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February 20, 2024

Georeference and vectorize a historical map



Figure 1: Specifically, this map

Overview of lab exercise and problem set

1. Lab exercise
 - a) Georeference WWI map
 - b) Create new vector layer for front line
2. Problem set
 - a) Map of WWI Western Front, relative to contemporary borders

We will use image tracing to vectorize battle lines on a historical map

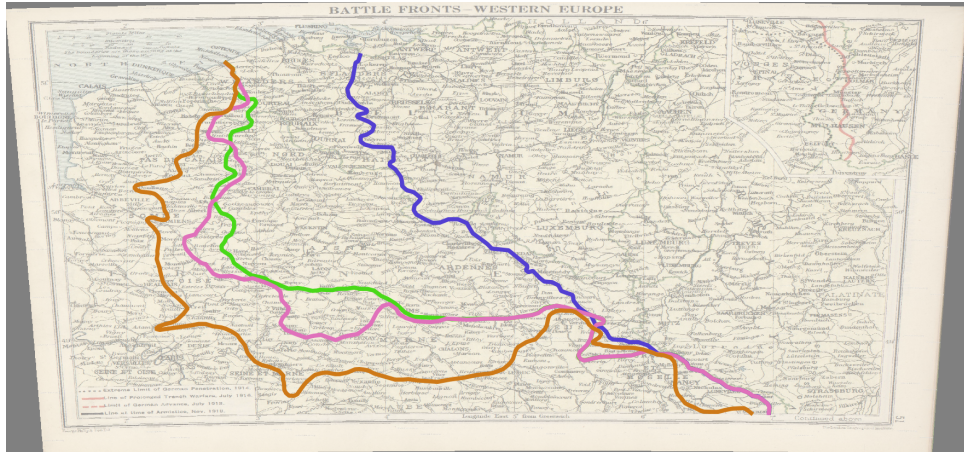


Figure 2: Vectorized front line

... which, in turn, requires georeferencing this map

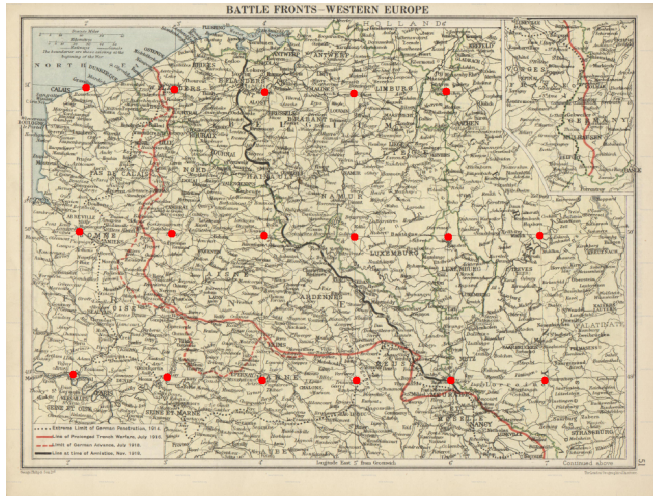


Figure 3: Western Front of WWI

... by creating a set of ground control points

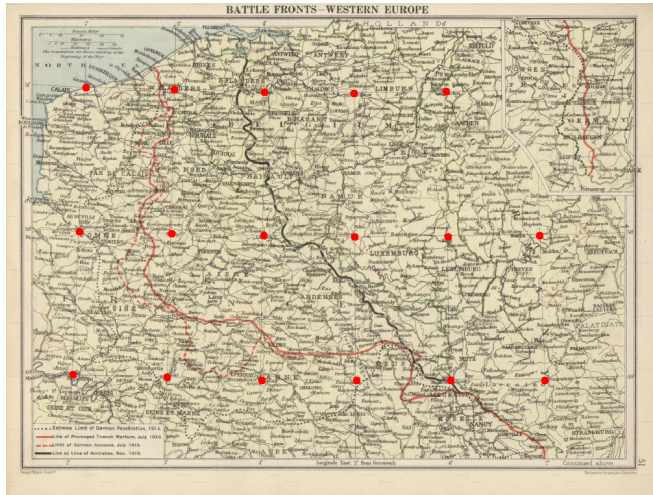


Figure 4: Red dots = ground control points

... and applying a polynomial transformation to align it with border data

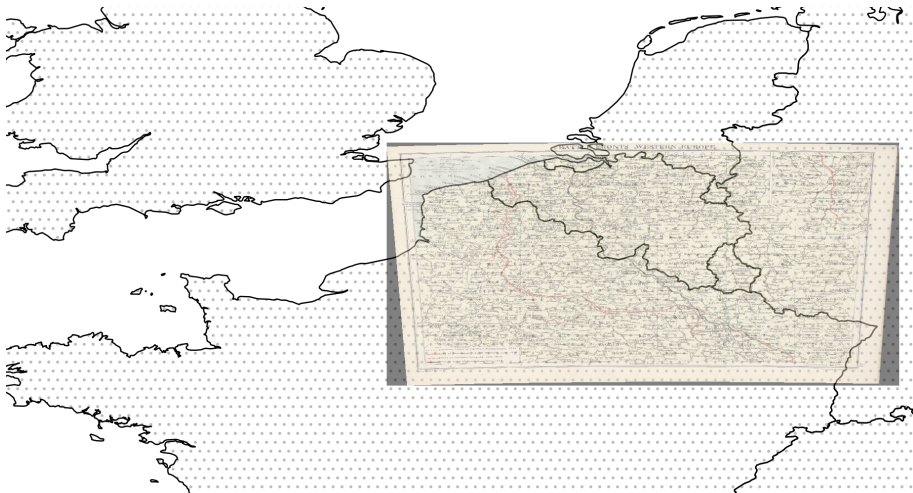


Figure 5: Transformation result

You will make this map for your **problem set**

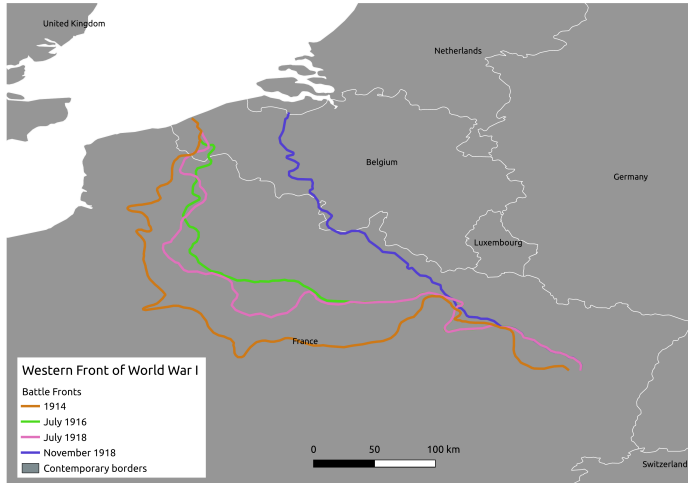


Figure 6: Save as `wwi_battle_fronts.png`

We have two **sources of data**:

Category	Type	Format	Data source
WWI map	Raster (non-spatial)	.jpg	tinyurl.com/mvh999tm
Country borders	Vector (polygons)	.geojson	naturalearthdata.com

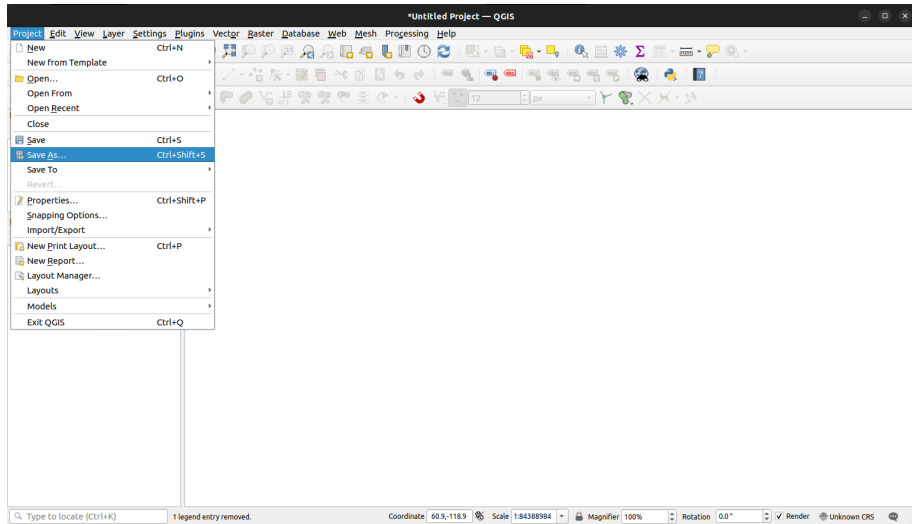
These are all in the PS04.zip file posted on Canvas.

Let's open QGIS...

QGIS

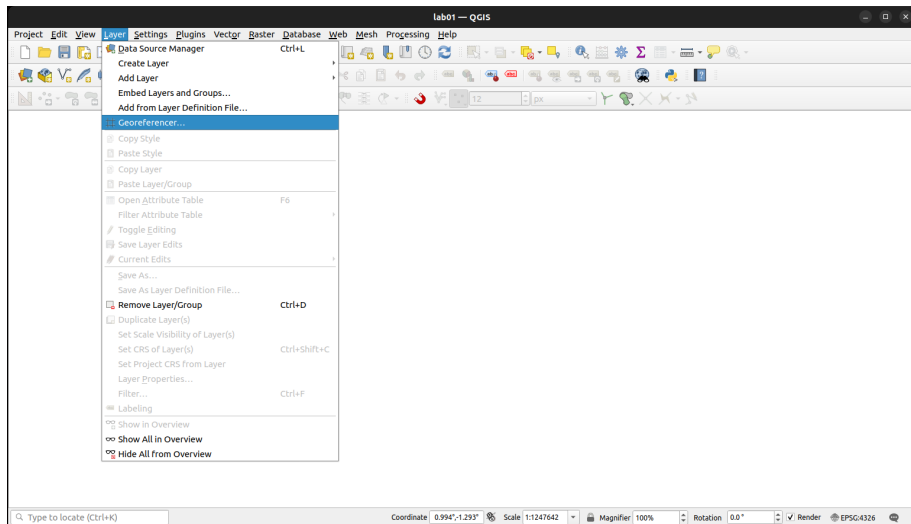
Always save your progress!

Go to Project → Save As...



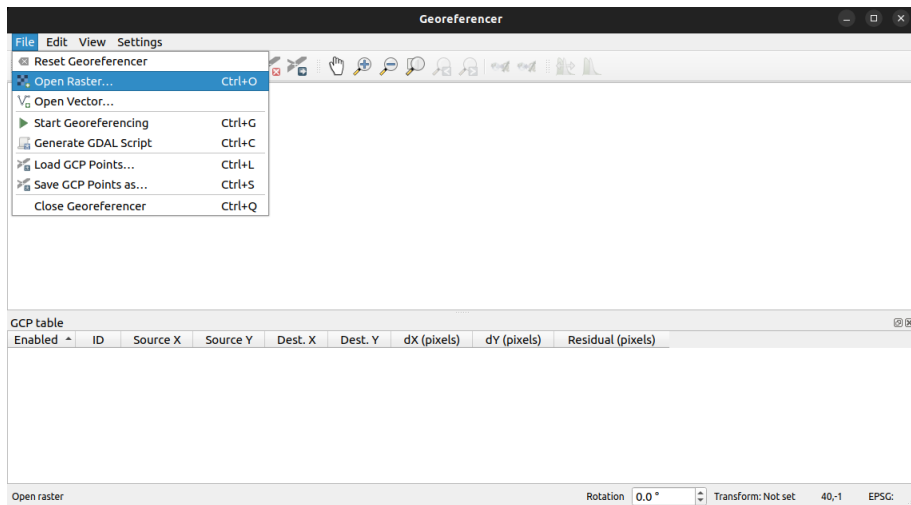
Georeferencing

To open the georeferencer, click on Layer → Georeferencer

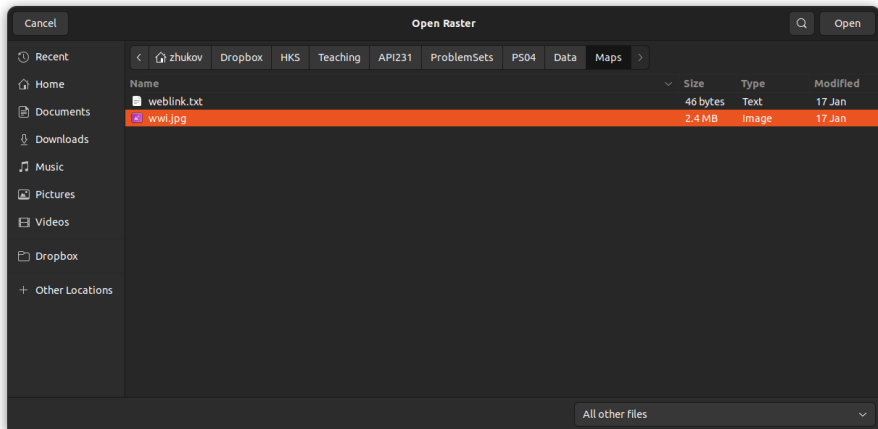


This will open an empty Georeferencer window.

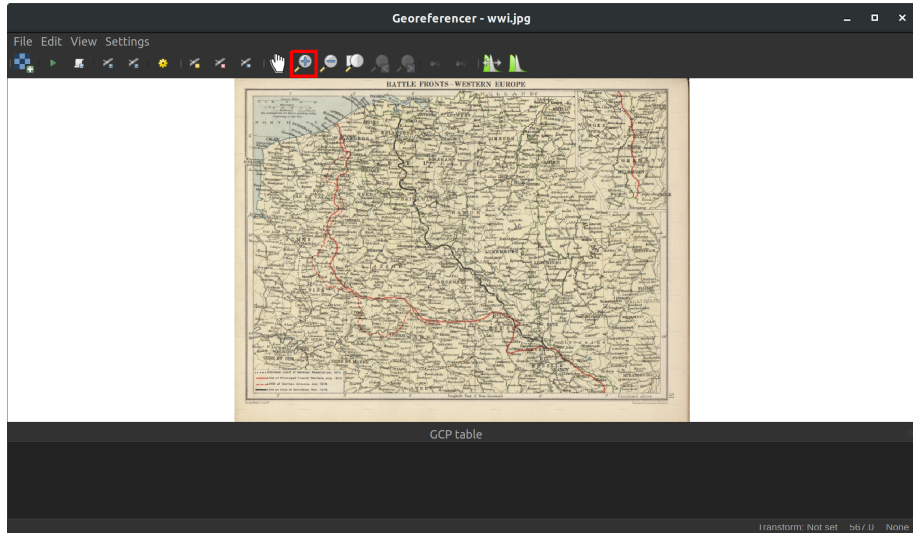
To open our JPG image, go to File → Open Raster



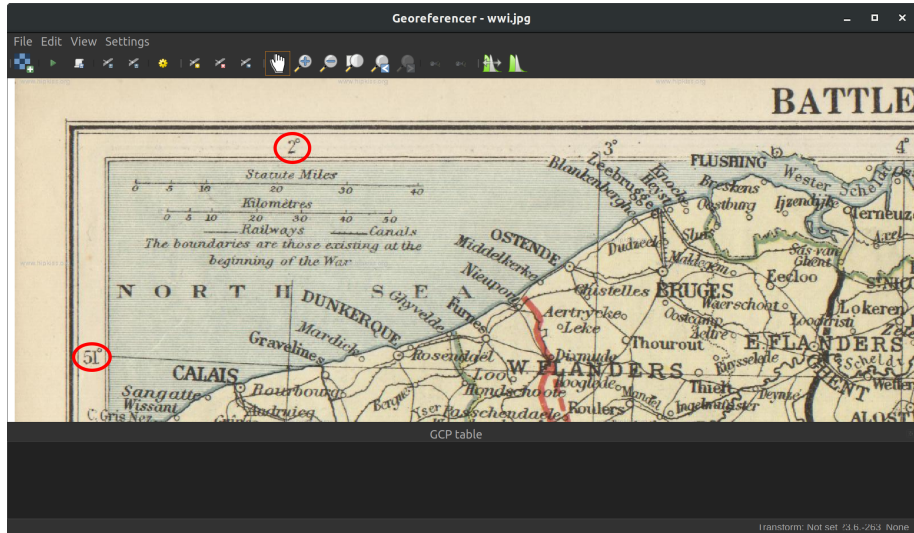
Navigate to the `wwi.jpg` image in Data/Maps. Click Open



The image will appear in the Georeferencer's top pane.
Zoom in on its top-left corner.

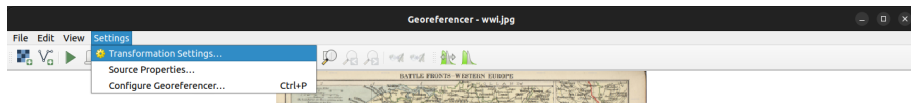


This map has markings for Latitude and Longitude, and 1-degree graticule lines. This will make it easier to assign coordinates to points on this map.



Let's define the *Transformation Settings*

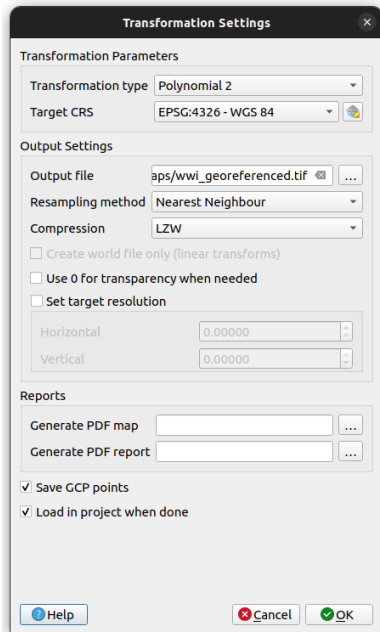
Go to Settings menu → Transformation settings in Georeferencer



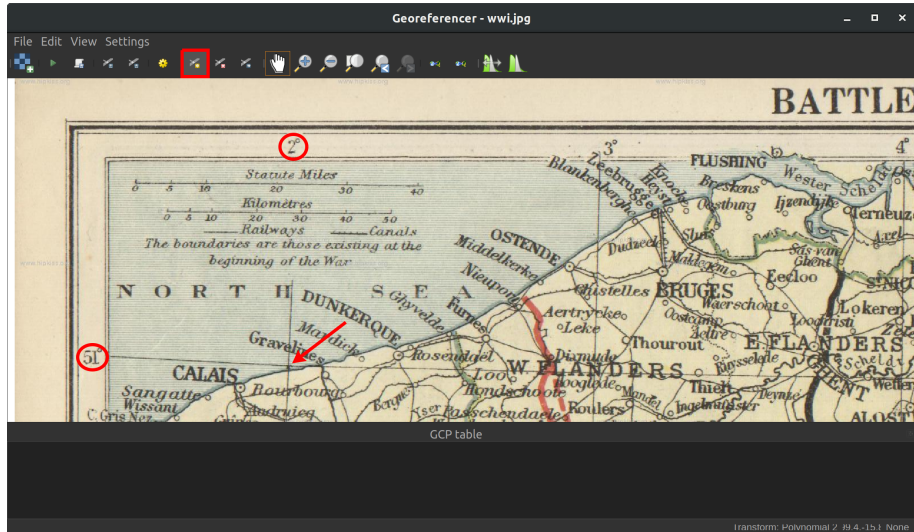
Set

- Transformation type = Polynomial 2
- Target CRS = EPSG:4326 - WGS 84
- Output file = select a folder, name the output file wwi_georeferenced.tif
- Resampling method = Nearest neighbor
- Compression = LZW
- ✓ Save GCP points
- ✓ Load in QGIS when done

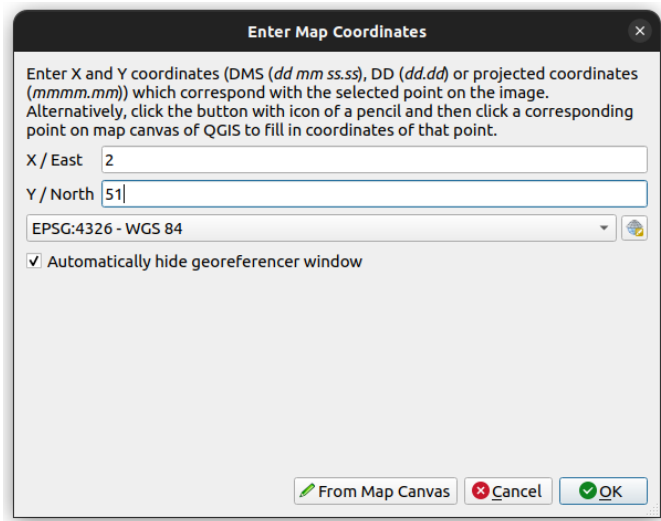
Click OK



Let's add GCPs. We will use *intersections of graticule lines* as locations of control points. Click Add Point icon, then click on the intersection of 2nd and 51st



In the pop-up window, enter the longitude ($x = 2$) and latitude ($y = 51$) of the intersection as the coordinates. Click OK



Enter Map Coordinates

Enter X and Y coordinates (DMS (*dd mm ss.ss*), DD (*dd.dd*) or projected coordinates (*mmmm.mm*)) which correspond with the selected point on the image. Alternatively, click the button with icon of a pencil and then click a corresponding point on map canvas of QGIS to fill in coordinates of that point.

X / East

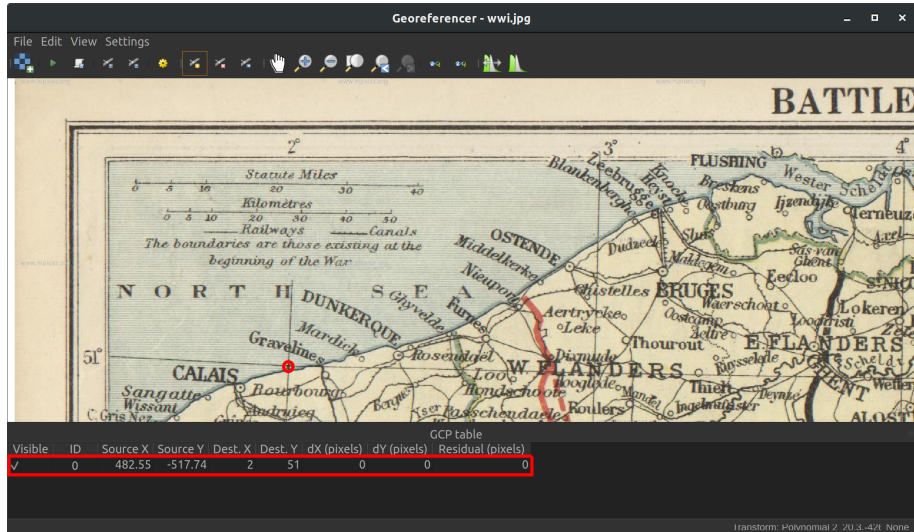
Y / North

EPSG:4326 - WGS 84

☒ Automatically hide georeferencer window

 From Map Canvas  Cancel  OK

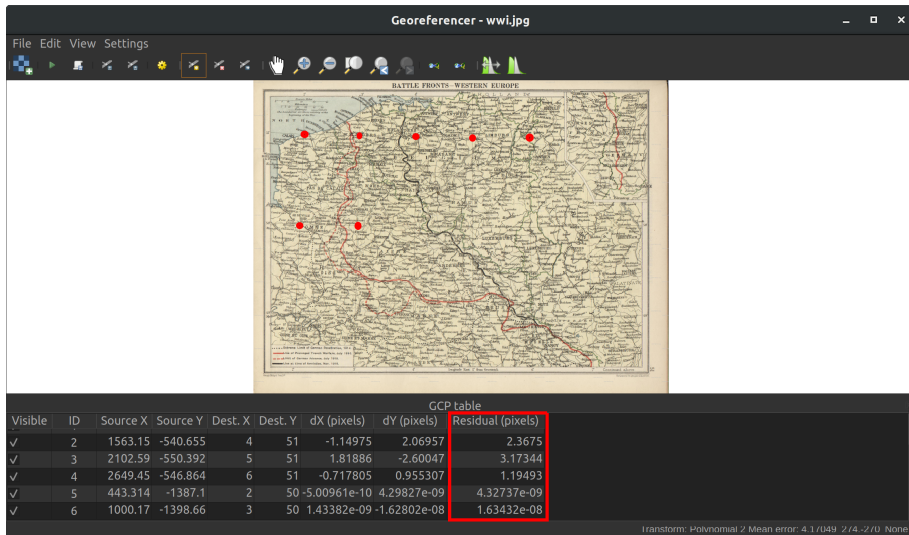
The table should now have a row with information on your first GCP. The more GCPs you add, over the whole map, the more accurate the georeferencing will be



After you add at least 6 GCPs (minimum required for Polynomial 2), you will see non-zero residual values in the table. You want these to be as low as possible.

Georeferencer - ww1.jpg

File Edit View Settings



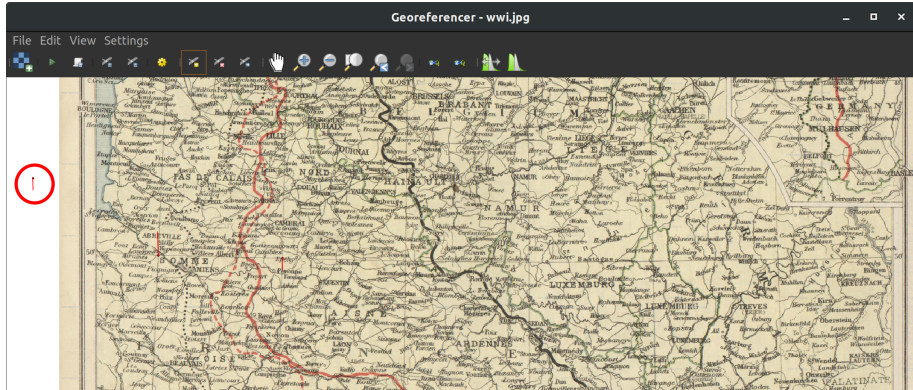
Visible	ID	Source X	Source Y	Dest. X	Dest. Y	dX (pixels)	dY (pixels)	Residual (pixels)
✓	2	1563.15	-540.655	4	51	-1.14975	2.06957	2.3675
✓	3	2102.59	-550.392	5	51	1.81886	-2.60047	3.17344
✓	4	2649.45	-546.864	6	51	-0.717805	0.955307	1.19493
✓	5	443.314	-1387.1	2	50	-5.00961e-10	4.29827e-09	4.32737e-09
✓	6	1000.17	-1398.66	3	50	1.43382e-09	-1.62802e-08	1.63432e-08

Transform: Polynomial 2 Mean error: 4.1/049 2/4 -2/0 None

Suppose you *made a mistake*, and put a GCP in the wrong place (or mis-specified its coordinates). You can fix this. . .

Georeferencer - wwi.jpg

File Edit View Settings



GCP table

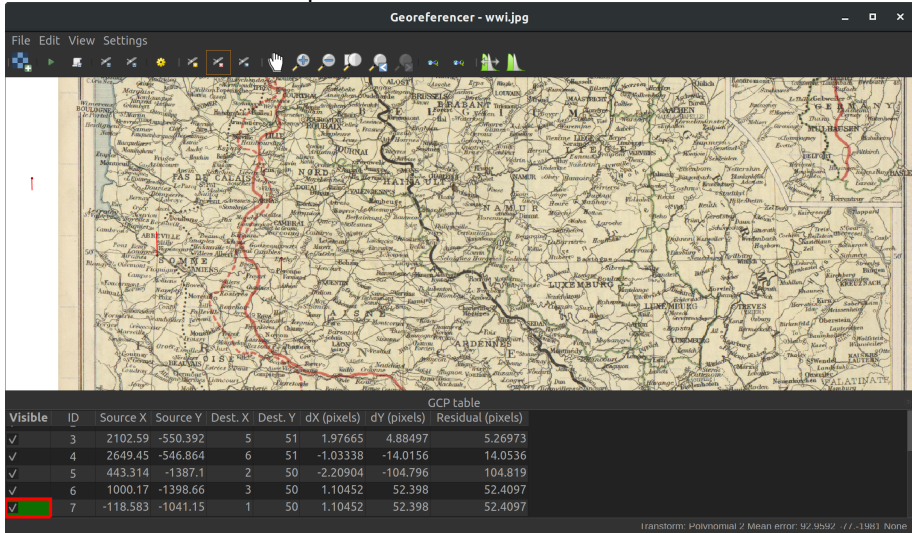
Visible	ID	Source X	Source Y	Dest. X	Dest. Y	dX (pixels)	dY (pixels)	Residual (pixels)
✓	3	2102.59	-550.392	5	51	1.97665	4.88497	5.26973
✓	4	2649.45	-546.864	6	51	-1.03338	-14.0156	14.0536
✓	5	443.314	-1387.1	2	50	-2.20904	-104.796	104.819
✓	6	1000.17	-1398.66	3	50	1.10452	52.398	52.4097
✓	7	-118.583	-1041.15	1	50	1.10452	52.398	52.4097

Transform: Polynomial 2 Mean error: 92.9592 -37.693 None

Right-click on the erroneous point's row on the GCP table and click Remove

Georeferencer - wwi.jpg

File Edit View Settings



Visible ID Source X Source Y Dest. X Dest. Y dX (pixels) dY (pixels) Residual (pixels)

✓	3	2102.59	-550.392	5	51	1.97665	4.88497	5.26973
✓	4	2649.45	-546.864	6	51	-1.03338	-14.0156	14.0536
✓	5	443.314	-1387.1	2	50	-2.20904	-104.796	104.819
✓	6	1000.17	-1398.66	3	50	1.10452	52.398	52.4097
✓	7	-118.583	-1041.15	1	50	1.10452	52.398	52.4097

Transform: Polynomial 2 Mean error: 92.9592 / -1.1981 None

There are 17 intersections overall. Once you add all these GCPs, we'll be ready to create the georeferenced raster.

Georeferencer - ww1.jpg

File Edit View Settings

Visible	ID	Source X	Source Y	Dest. X	Dest. Y	dX (pixels)	dY (pixels)	Residual (pixels)
✓	12	978.041	-2263.36	3	49	-4.10316	3.77261	5.57391
✓	13	1541.4	-2279.18	4	49	0.01999	-1.41955	1.41969
✓	14	2109.65	-2283.76	5	49	0.335914	-1.42818	1.46715
✓	15	2678.6	-2279.33	6	49	1.05548	1.54469	1.87085
✓	16	3250.16	-2274.94	7	49	0.270336	-1.58138	1.60432
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When you're satisfied with the GCPs, click on Start georeferencing (▶) button

Georeferencer - wwj.jpg

File Edit View Settings

Visible ID Source X Source Y Dest. X Dest. Y dX (pixels) dY (pixels) Residual (pixels)

✓	12	978.041	-2263.36	3	49	-4.10316	3.77261	5.57391
✓	13	1541.4	-2279.18	4	49	0.01999	-1.41955	1.41969
✓	14	2109.65	-2283.76	5	49	0.335914	-1.42818	1.46715
✓	15	2678.6	-2279.33	6	49	1.05548	1.54469	1.87085
✓	16	3250.16	-2274.94	7	49	0.270336	-1.58138	1.60432

Transform: Polynomial 2 Mean error: 3.15065 -19/8 -12 None

If the process is successful, you will see a notification at the top

Georeferencer - ww1.jpg

File Edit View Settings

Georeference Successful: Raster was successfully georeferenced.

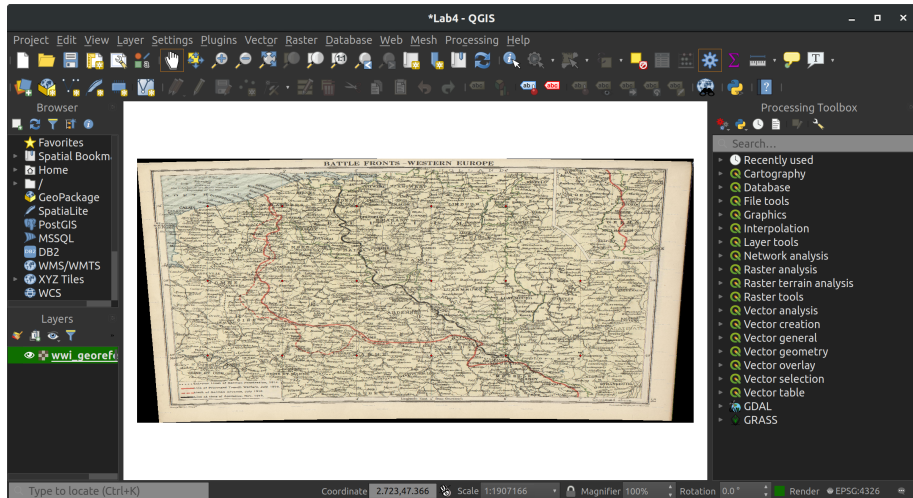


GCP table

Visible	ID	Source X	Source Y	Dest. X	Dest. Y	dX (pixels)	dY (pixels)	Residual (pixels)
✓	12	978.041	-2263.36	3	49	-4.10316	3.77261	5.57391
✓	13	1541.4	-2279.18	4	49	0.01999	-1.41955	1.41969
✓	14	2109.65	-2283.76	5	49	0.335914	-1.42818	1.46715
✓	15	2678.6	-2279.33	6	49	1.05548	1.54469	1.87085
✓	16	3250.16	-2274.94	7	49	0.270336	-1.58138	1.60432

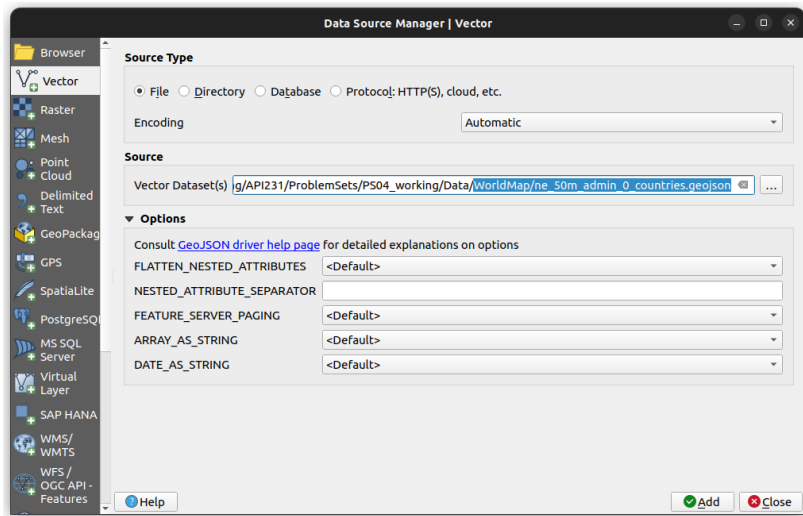
Transform: Polynomial 2 Mean error: 3.15065 -19/4 -12 None

The (slightly warped) georeferenced raster should appear as a layer in the main QGIS project window. Let's compare it against country boundaries

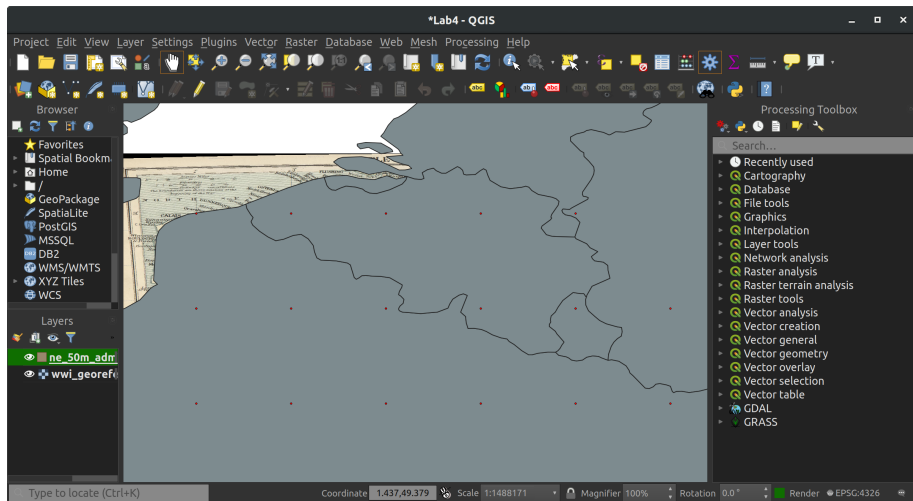


Go to Layer → Add Layer → Add Vector Layer....

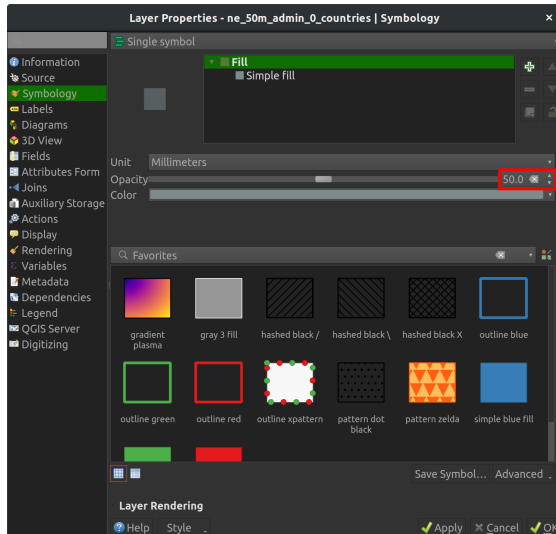
Navigate to ne_50m_admin_0_countries.geojson in Data/WorldMap



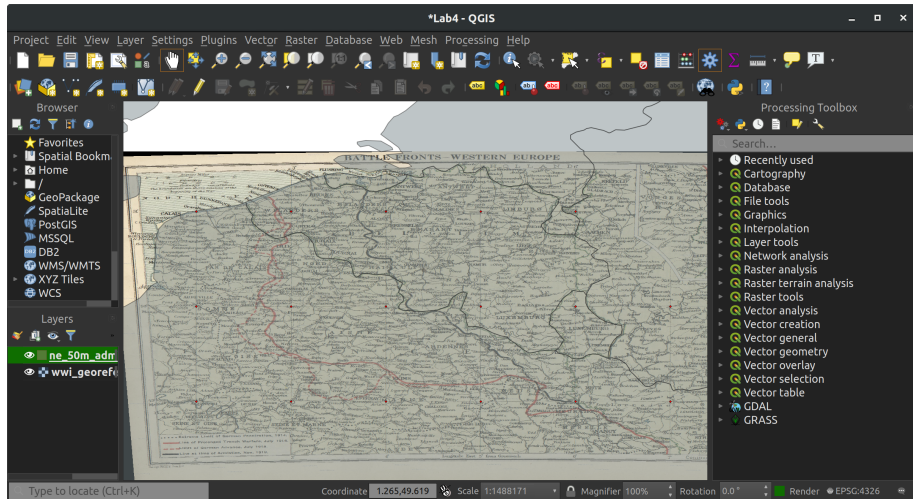
Let's make the countries layer semi-transparent.



Double-click on the layer, go to Properties → Symbology. Set Opacity = 50.

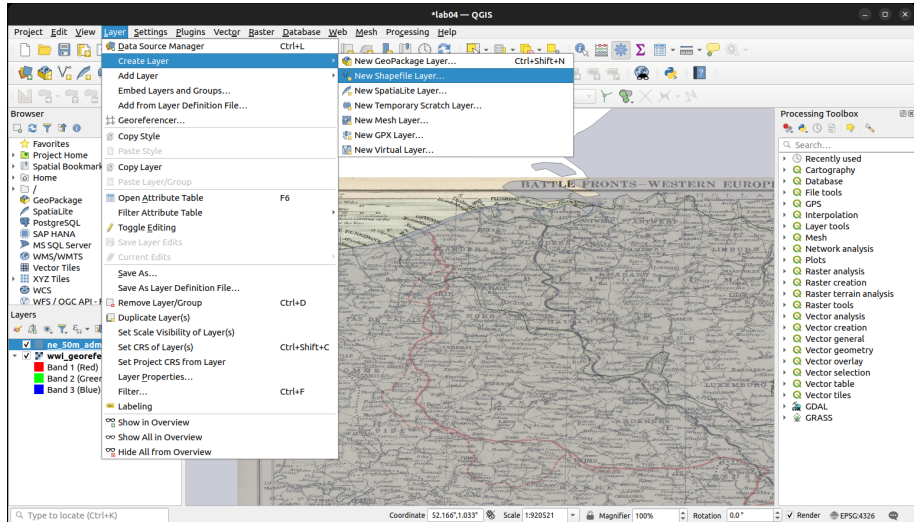


The fit isn't perfect, but acceptable (keep in mind these are simplified polygons).
Now let's vectorize the raster (create polyline layer of battle fronts)



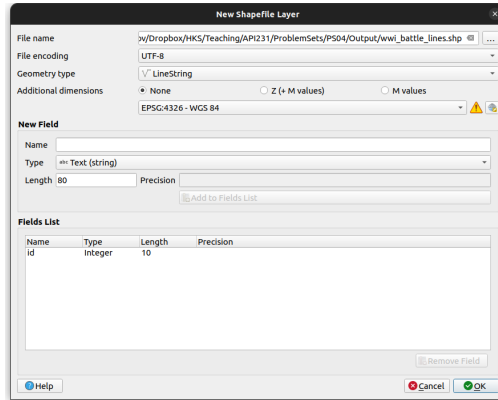
Vectorization

Go to Layer → Create Layer → Create New Shapefile Layer...



Set

- File name = wwi_battle_lines.shp in Output folder
- Geography type = LineString
- select EPSG:4326 - WGS 84 for the CRS



Let's add a couple fields to the attribute table.

1. Name = Date, Type = Text. Click Add to Fields List

New Shapefile Layer

File name: yv/Dropbox/HKS/Teaching/API231/ProblemSets/PS04/Output/wwi_battle_lines.shp

File encoding: UTF-8

Geometry type: LineString

Additional dimensions: ☒ None ☐ Z (+ M values) ☐ M values

EPSG:4326 - WGS 84

New Field

Name: Date

Type: Text (string)

Length: 80 Precision:

Add to Fields List

Fields List

Name	Type	Length	Precision
id	Integer	10	

Remove Field

Help Cancel OK

2. Name = Comment, Type = Text.
Click Add to Fields List

New Shapefile Layer

File name: ...

File encoding:

Geometry type: ☒ LineString

Additional dimensions: ☒ None ☐ Z (+ M values) ☐ M values

⚠

New Field

Name:

Type:

Length: Precision:

Fields List

Name	Type	Length	Precision
id	Integer	10	
Date	String	80	

Click OK

New Shapefile Layer

File name:

File encoding:

Geometry type: ☒ LineString

Additional dimensions: ☒ None ☐ Z (+ M values) ☐ M values

New Field

Name:

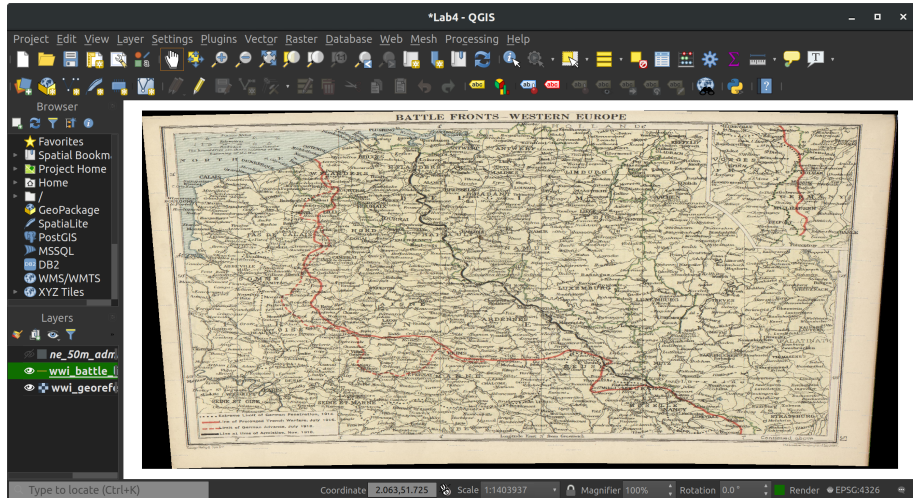
Type:

Length: Precision:

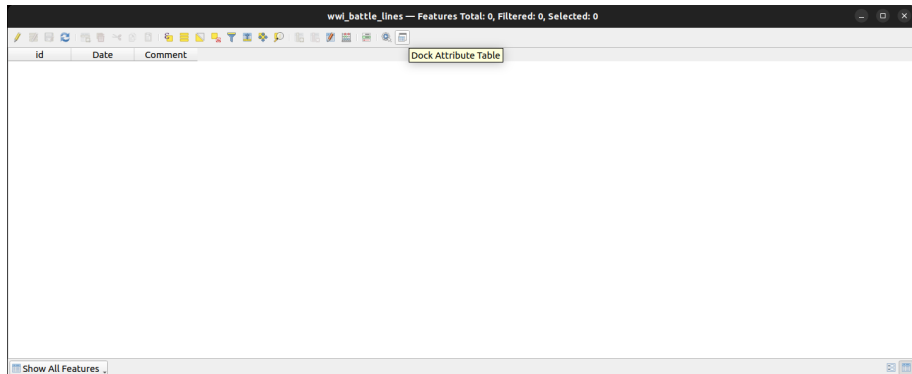
Fields List

Name	Type	Length	Precision
id	Integer	10	
Date	String	80	
Comment	String	80	

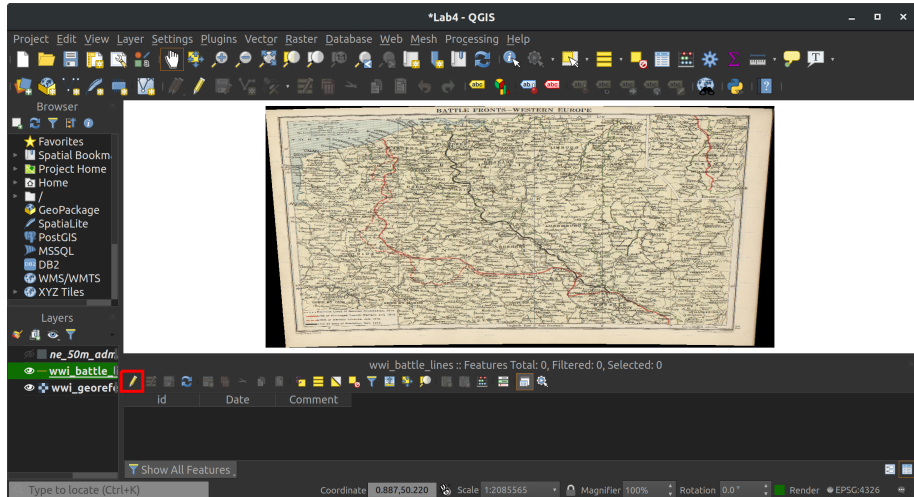
The new layer is visible in the menu.



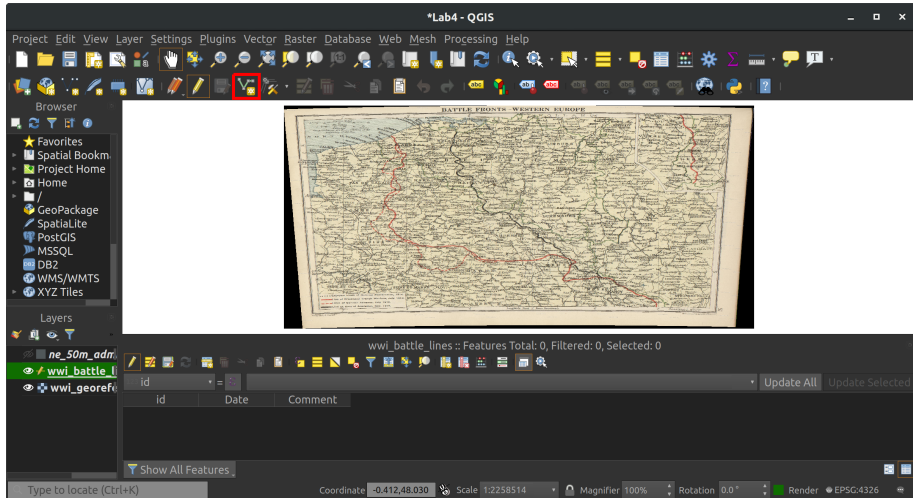
Open the new layer's Attribute Table. Three columns, but no features yet.
Click on the Dock Attribute Table



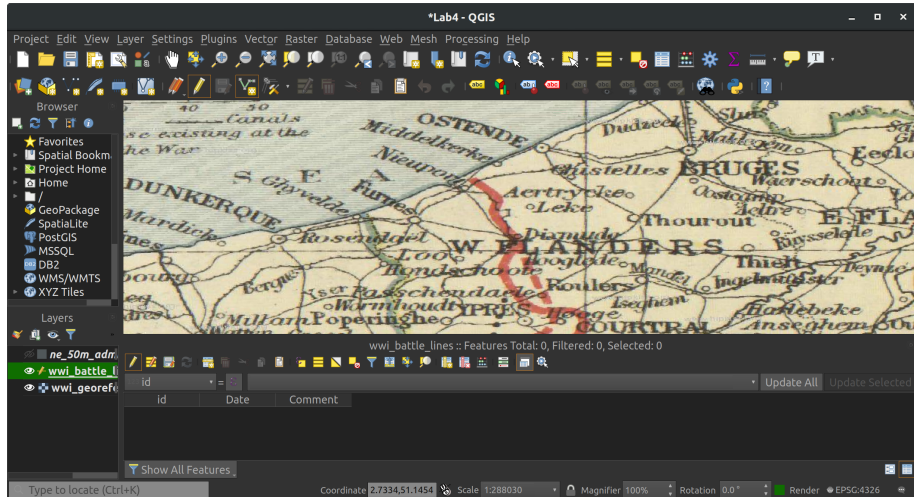
The attribute table should appear at bottom of main QGIS window.
Click on Toggle Editing button (pencil)



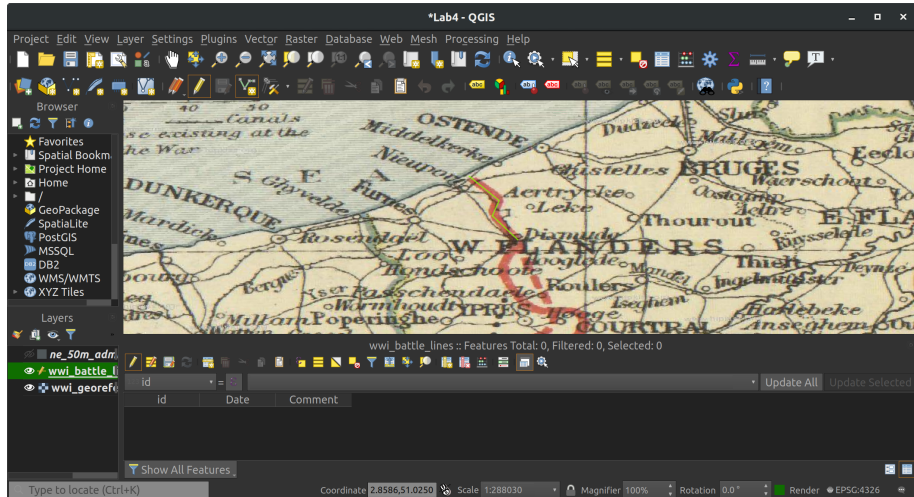
Click on the Add Line Feature tool



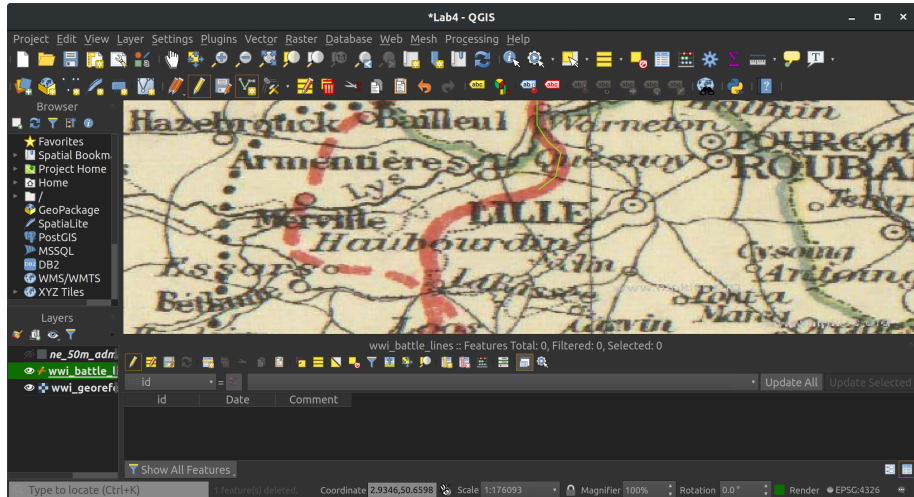
Let's create a line feature along the **solid red line** (July 1916 front line).
Zoom in to see this line more closely



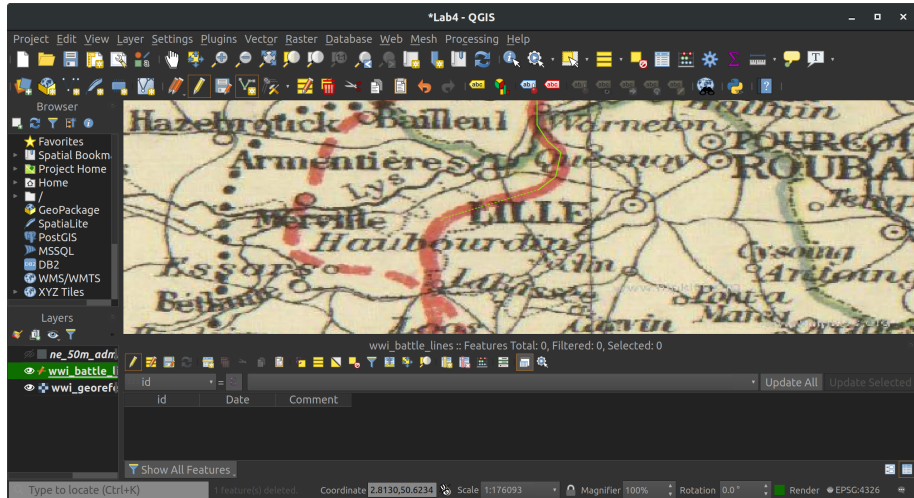
Click a set of points along the line. (You can change the appearance of the line in Settings menu → Options → Digitizing → Line width/color)



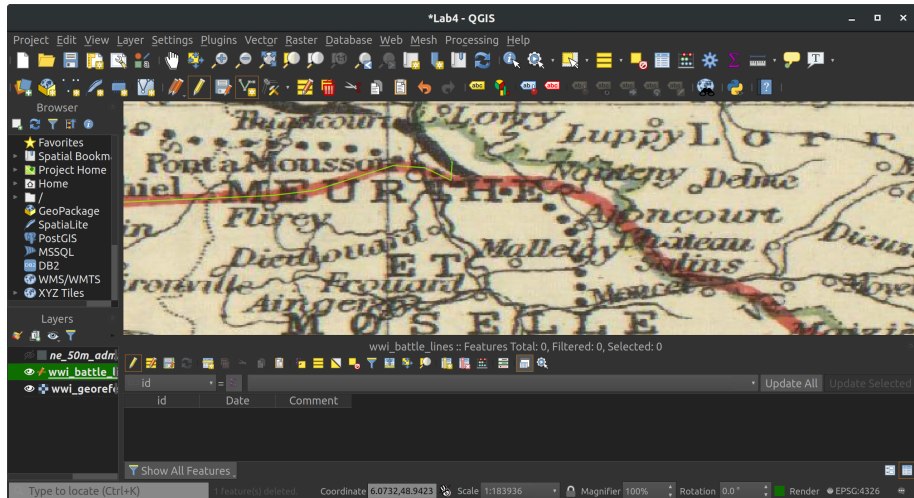
Continue along the entire length of the line, using up/down/left/right arrow buttons on your keyboard to pan/move around the map



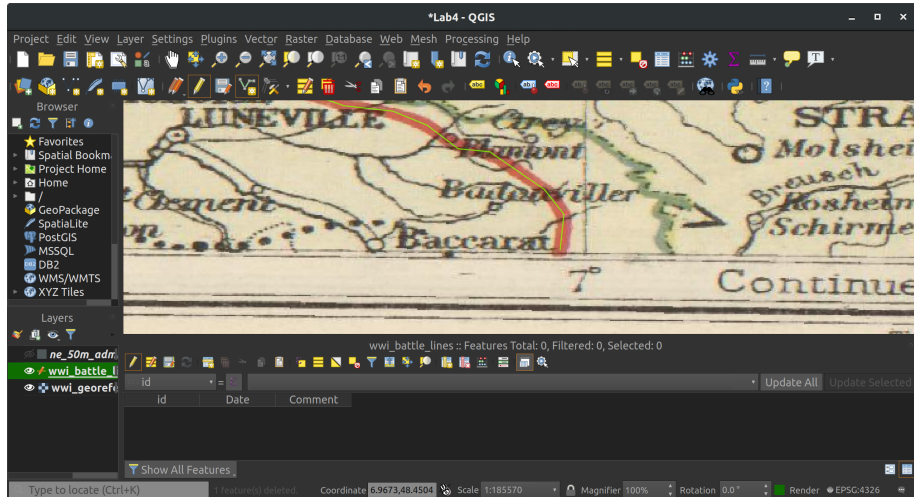
Keep going until you reach the end of the line...



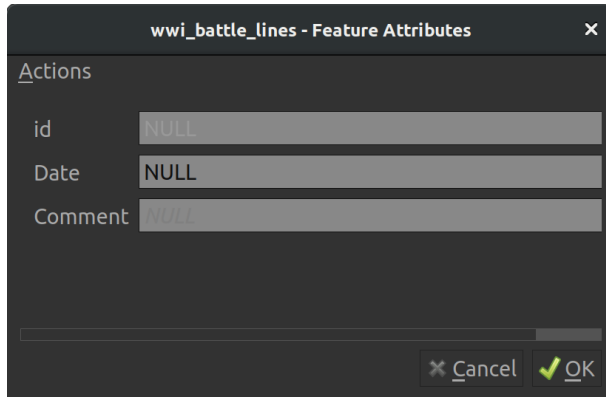
If you *make a mistake* along the way, press Delete or Backspace to remove the last node you added



When you have finished adding points, *right-click* anywhere on the map area to complete the geometry of the feature



An attribute window will appear, prompting you to enter the information for the new feature (Date, Comment)



wwi_battle_lines - Feature Attributes

Actions

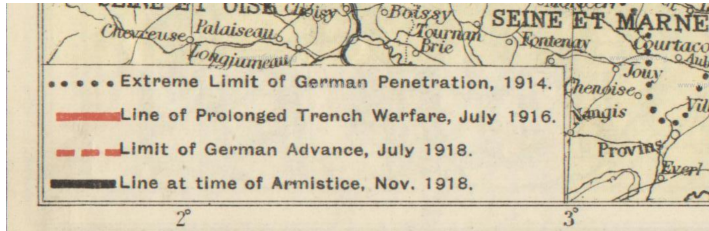
id NULL

Date NULL

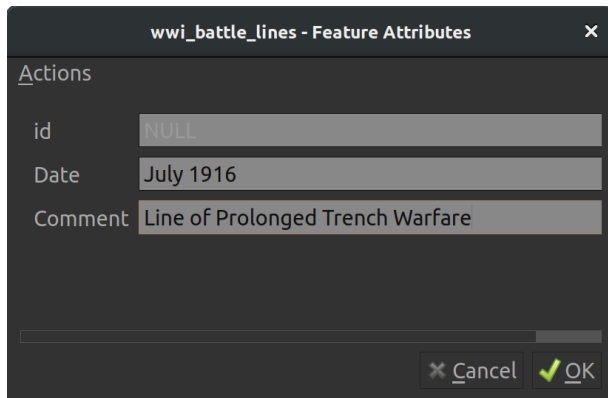
Comment NULL

Cancel OK

Refer to the original map's legend for information what on each line represents



Set Date = July 1916 and Comment = Line of Prolonged Trench Warfare
(from original map's legend)



wwi_battle_lines - Feature Attributes [X]

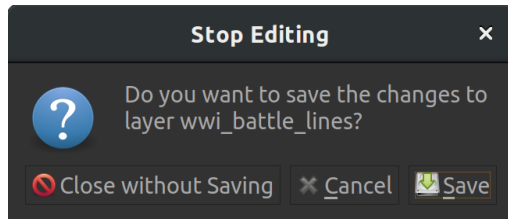
Actions

id	NULL
Date	July 1916
Comment	Line of Prolonged Trench Warfare

[Progress Bar]

[X] Cancel [✓] OK

Click on Toggle Editing button again to commit the changes. Save the layer



Problem Set 4

Your assignment:

- create a map of all 4 battle fronts and contemporary borders
- export the map as an image, showing:
 - all four battle fronts as line vector features
 - contemporary borders of northern France, Belgium, Germany, etc.
 - legend
 - scale bar
- name the file
`wwi_battle_fronts.png`
- upload map to Canvas
(by next Monday)

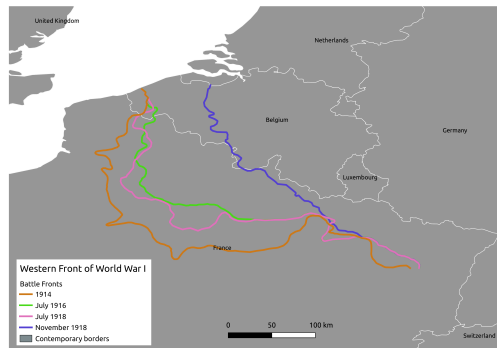
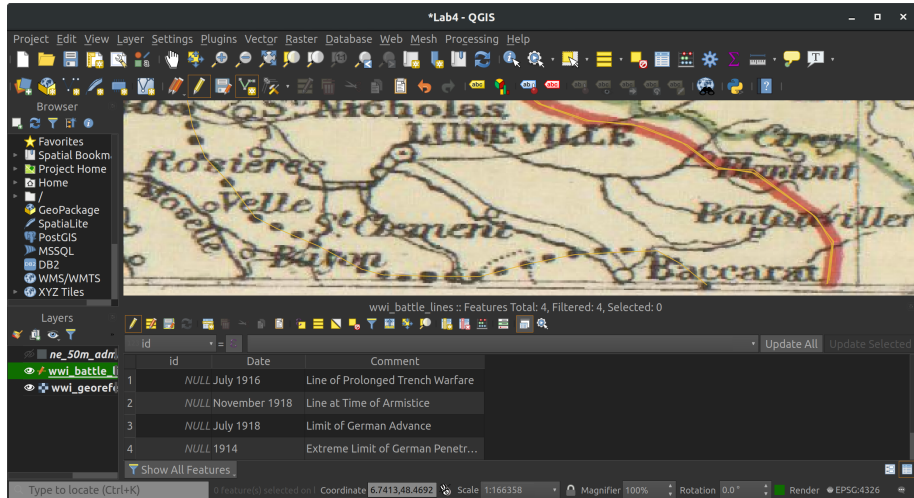
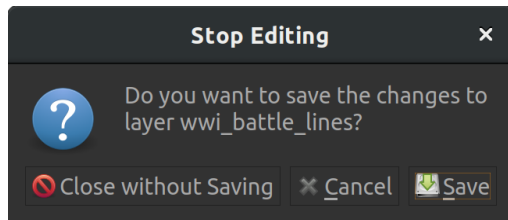


Figure 7: Can you make this map?

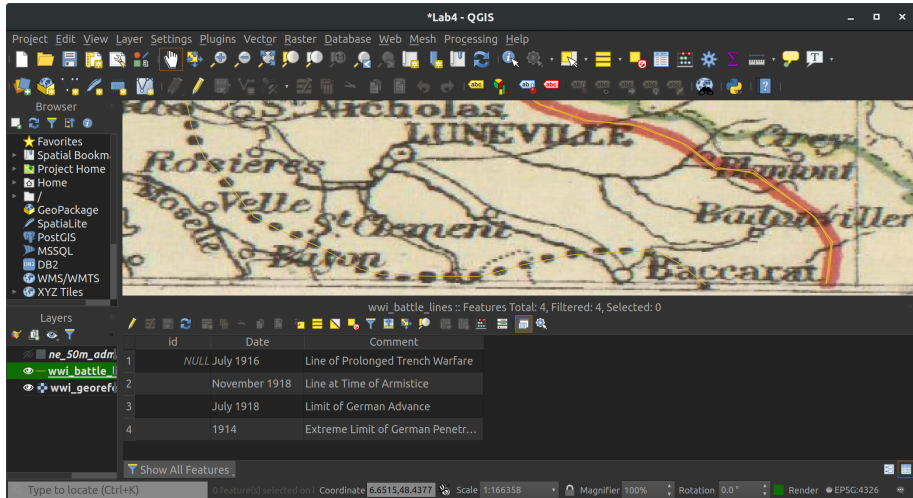
Repeat the same Add Line Feature process for the other 3 lines.



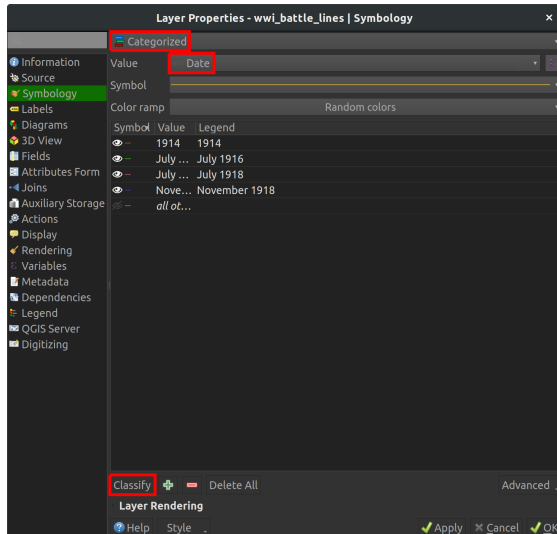
Save your edits!



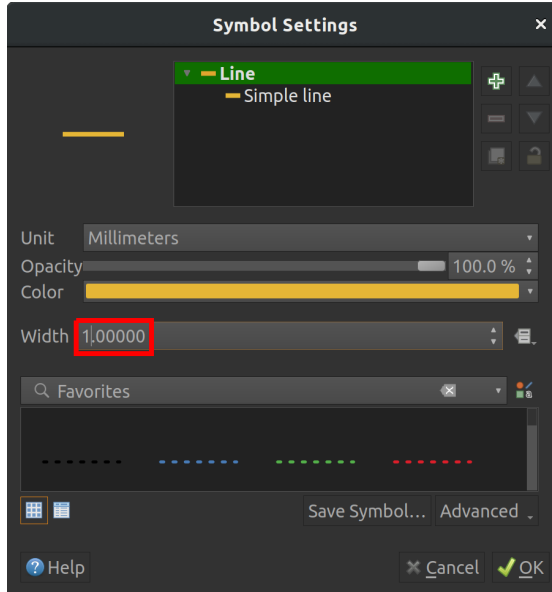
Put each line in a different color. Go to the new layer's Properties



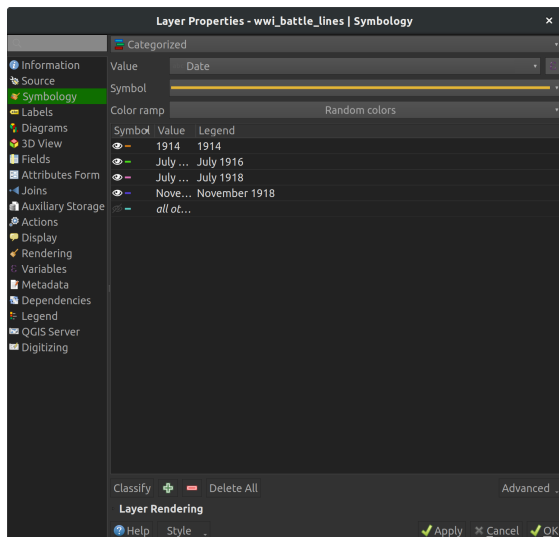
Set Categorized as symbology type. Set Value = Date. Click Classify



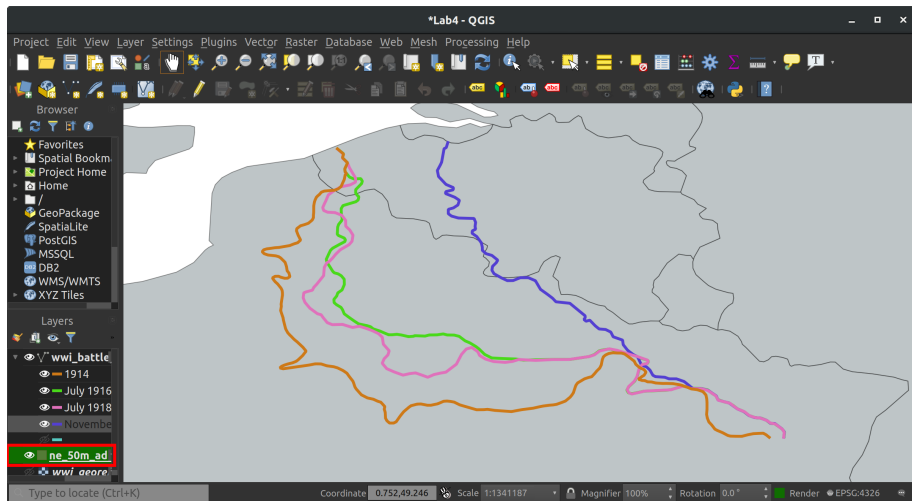
You can make the lines thicker by clicking on Symbol → Width



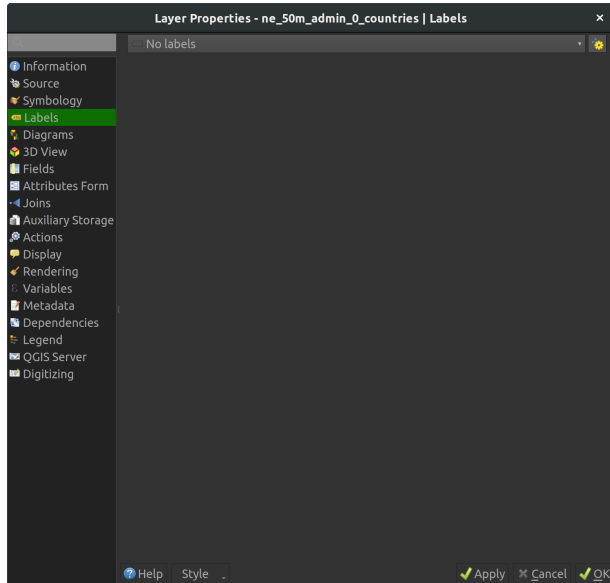
Click OK



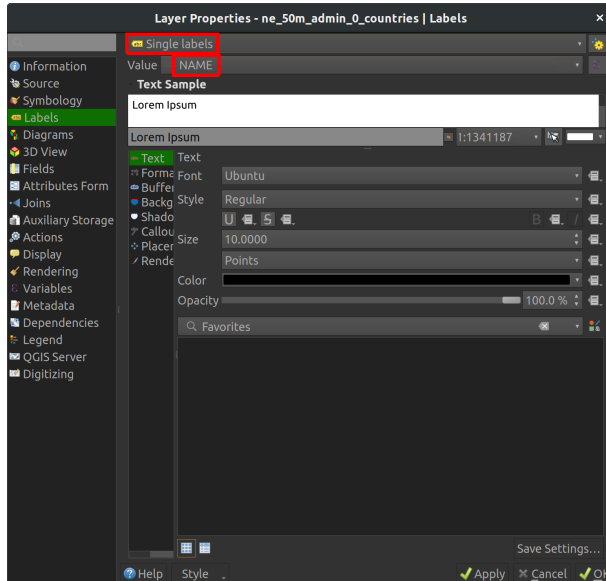
Add labels for country names. Double-click on `ne_50m_admin_0_countries`



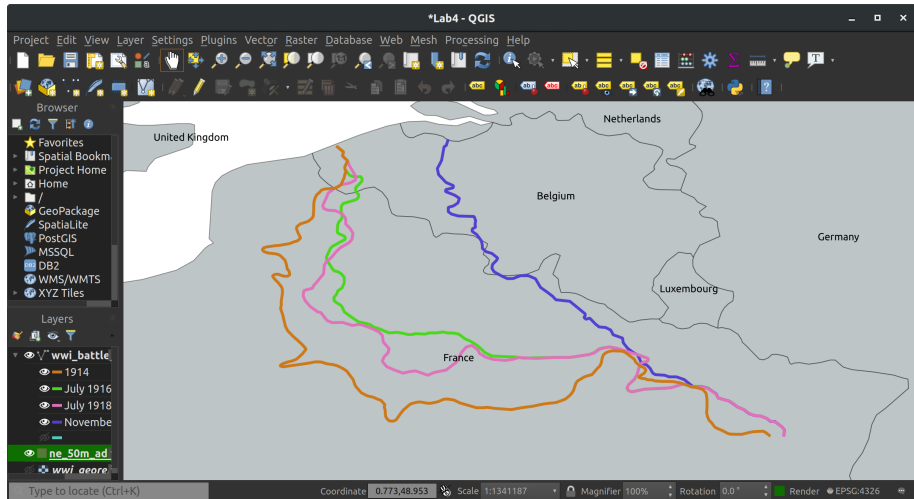
Go to the layer's Properties → Labels tab



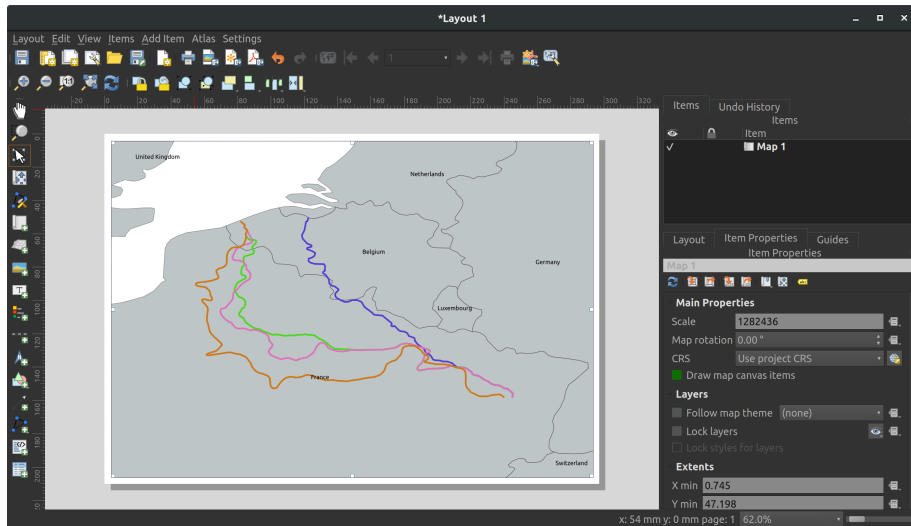
Set label type to Single labels, and Value = NAME. Click OK



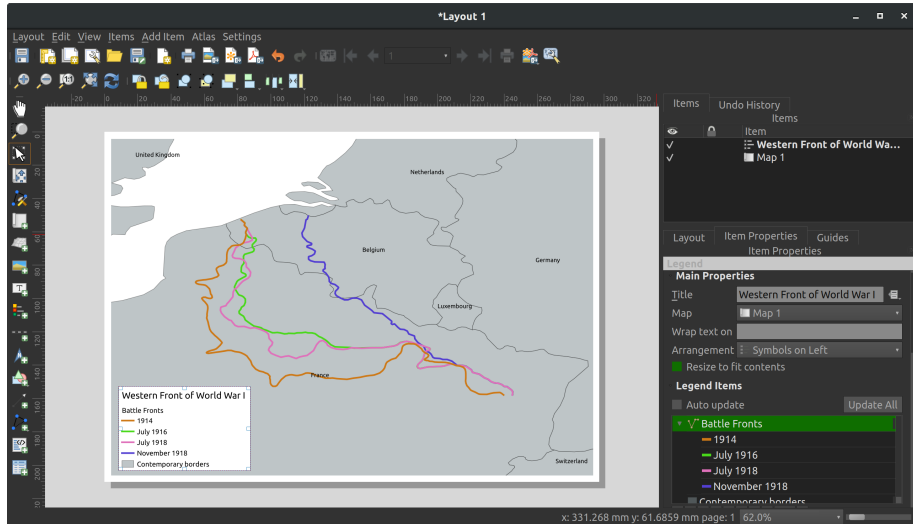
Country labels should appear on the layer



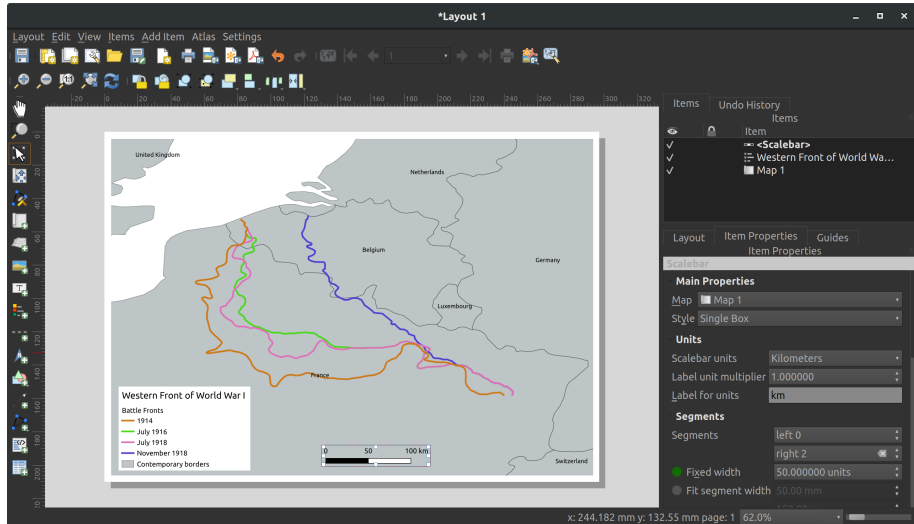
Create a new map layout



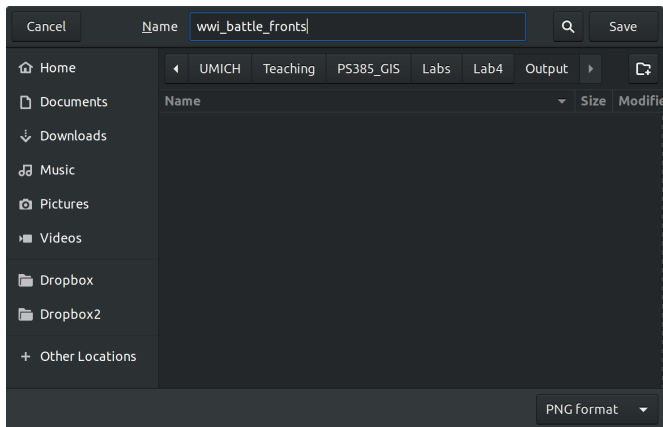
As always, you'll need to clean up the legend



You can keep the scale units in kilometers (if you want)



Save the file as `wwi_battle_fronts.png`



The saved image should look something like this

