Public Health GIS

Lab 4 Centrography & Clustering Analysis and Kernel Density Maps

PART 1 – Centrography & Clustering Analysis

In this exercise, we will utilize point pattern analysis to examine the distribution of cholera death cases in SoHo England. We will overlay the results with the location of water pumps and see how point pattern analysis could help us track the sources and spatial distribution of disease outbreak.

Visualizing cholera death case locations and SOHO boundary

Open QGIS.

1. Navigate to the **Lab4** folder and drag in the **cholera_death_cases.shp** and **soho.shp** boundary file into your QGIS window.
2. Drag the **soho** boundary layer beneath the points layer.
3. Customize the **cholera_death_cases** points layer in **Symbology**. Change the size to 1.5, fill color to black and stroke color to transparent. See **Lab 3 Customizing map—Points** for details.
4. Customize the **soho** layer in **Symbology**. Change the stroke style to dashed line, fill color to transparent and stroke color to red.

The **OpenStreetMap** reference layer in QGIS can serve as a base layer, but as you can see, it is quite visually busy to use to make our maps…

Instead, we will utilize the QuickMapServices plugin to add our base layers to the map.

Selecting a base layer using QuickMapServices

1. Navigate to the **Plugins** tab in the top bar and click **Manage and Install Plugins**.
2. Search *quickmapservices* in the new window and click **Install Plugin**.
3. Once the installation is complete, **Web** will pop up on the top bar of your QGIS window.

4. Navigate to the **Web** tab >> **QuickMapServices** where you can see a list of different map layers available (see drop-down menu on the right). **Note:** If these options do not appear, you can navigate to the bottom of this drop-down menu to **Settings** >> **More services** >> **Get contributed pack**.

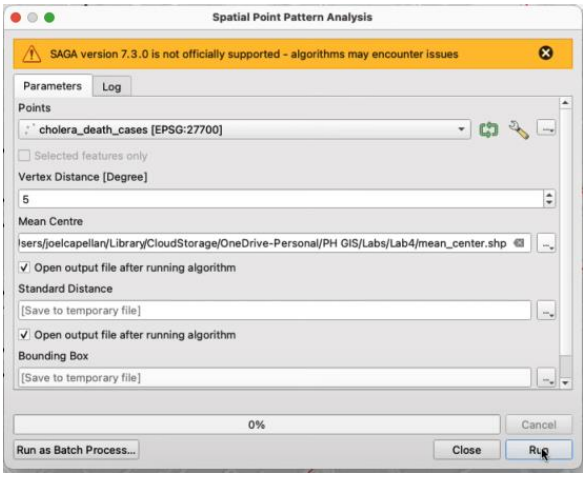
5. We will select a modern and minimalist base layer for this map. Navigate to the **Web** tab >> **QuickMapServices** >> **CartoDB** >> **Positron [no labels] (retina)**.

6. Revisit the **soho** layer in **Symbology** and increase the stroke width to 0.66.

We will now calculate from this fairly cluster distribution the mean center and standard deviational ellipse to help pinpoint the source of this outbreak.

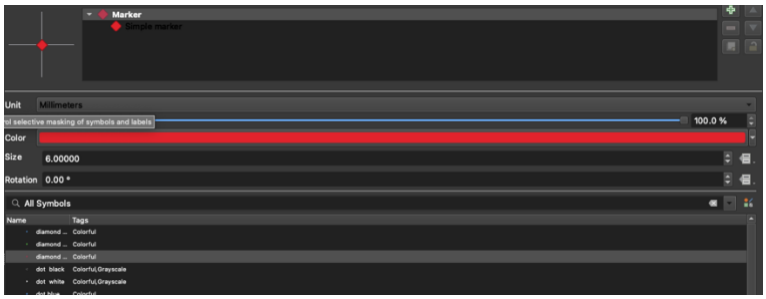
Calculate mean center

1. Navigate to the **Processing** tab in the top bar >> **Toolbox**.
2. Search for the **Spatial point pattern analysis** tool.
3. In the new window, select **cholera_death_cases** as your **Points**.
4. For **Mean Centre** click the ..., we will **Save to File**. Specify the location to our Lab4 folder and file name as **mean_center**.
5. We are not calculating the standard distance now, so leave this field as is, but know that you can also calculate this parameter using this tool.
6. Click **Run**.



You should now have three additional layers on your map—Bounding Box, Standard Distance, and mean_center.

1. Remove the **Bounding Box** and **Standard Distance** layers from your map.
2. Move the **mean_center** layer to the top of the list.
3. Customize the **mean_center** points layer in **Symbology**. Click on **Marker** and select a **diamond red** symbol.



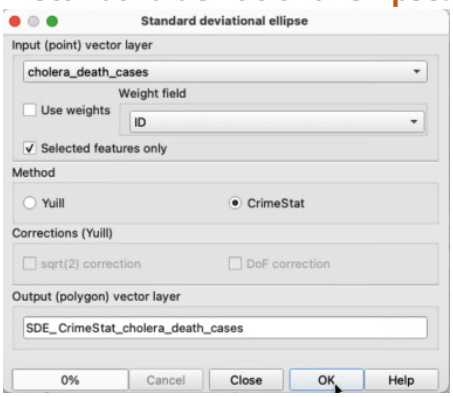
Now we have our mean center point of our spatial distribution visualized. The mean center might be at or near the source of contagion, which is important to keep in mind.

Calculate standard deviational ellipse

Most cases (~ 63%) will lie within the first standard deviational ellipse from the mean center. Unlike just the standard deviation from the mean center, this will also give us a sense of the spatial direction of the distribution.

1. Navigate to the **Plugins** tab in the top bar and click **Manage and Install Plugins**.
2. Search "*standard deviational ellipse*" in the new window and click **Install Plugin**.
3. Now, the feature  should pop up on your screen.

4. You can also navigate to it via the top bar **Vector** >> **Standard deviational ellipse.**
5. Click on the  or navigate to it via the top bar **Vector** >> **Standard deviational ellipse**.
6. In the new window, select **cholera_death_cases** as your **Input (point) vector layer**.
7. Set **Method** to be **CrimeState**.
8. Click **OK.**



Customize standard deviational ellipse area

1. Double-click the **SDE_CrimeState_cholera_death_cases** layer and navigate to **Symbology**. Change fill color to yellow. Double-click on the fill color ribbon and set opacity to 35%.
2. To better visualize the SDE layer with the points, drag the **SDE_CrimeState_cholera_death_cases** layer below **cholera_death_cases.**

Visualizing water pump locations

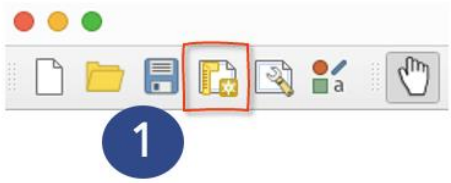
1. Navigate to the **Lab4** folder and drag in the **pumps.shp** into your QGIS window.
2. Double-click the **pumps** layer and navigate to **Symbology**. Change marker to blue triangle and change the size to 6.0

We can see that the infamous Broad Street pump is fairly close to the mean center of our cholera death cases distribution. The mean center and standard deviational ellipse can serve as powerful tools of identifying sources of disease outbreaks.

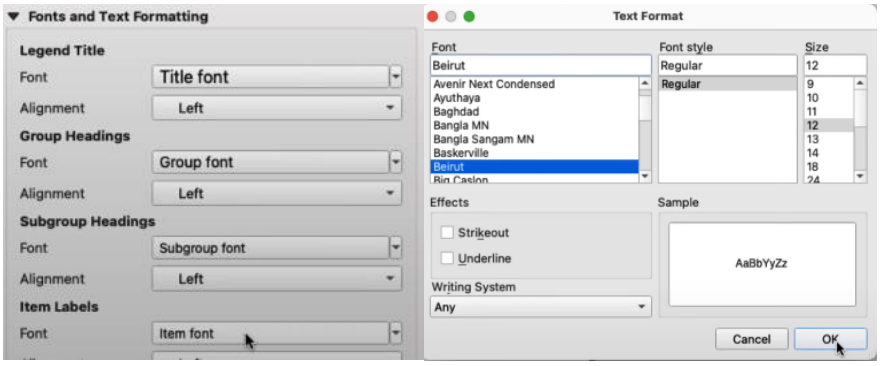
Preparing map for Print Layout

1. Ensure your ordering of the layers is as follows (top to bottom): **mean_center**, **pumps**, **cholera_death_cases**, **SDE_CrimeState_cholera_death_cases**, **soho**, and **Positron [no labels] (retina)**
2. Rename the **mean_center** layer to "**Mean center**"
3. Rename the **pump** layer to "**Water pump**"
4. Rename the **cholera_death_cases** to "**Cholera deaths**"
5. Rename **SDE_CrimeState_cholera_death_cases** to "**Standard deviational ellipse**"
6. Rename **soho** to "**Soho boundary**"

Use New Print Layout to add final elements to the map

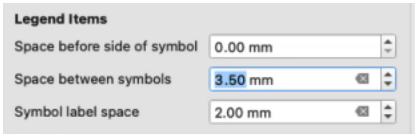


1. Click on **New Print Layout** in the upper part of the window.
2. Enter a print layout title ***cholera*** and click **OK**.
3. To paste our map on the layout, click on **Add Map** , left-click-and-hold your mouse to draw the map window in the lower-left of your print layout.
4. Click on **Move item content** to move your layer within the map window.
5. Click on **Select/move item** to move and adjust the size of your map window.
6. Click on **Add Legend** and left-click-and-hold to draw the legend window.
7. Under Legend Items, deselect **Auto update**.
8. Click on the **Positron [no labels] (retina)** layer in **Legend Items** and remove it.
9. Drag and hold the legend to reposition the legend to be in line with the top of your map window.
10. To change the font of the legend, navigate to **Item Properties** >> **Fonts and Text Formatting** >> **Item font**. Select Beirut as your **Font** and click **OK**.

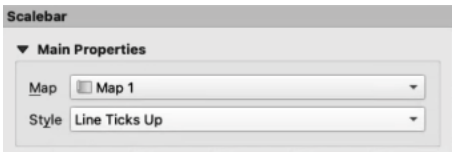


11. Now, we will adjust the spacing of the legend items. Close out of the **Fonts and Text Formatting** tab and open the **Spacing** tab.

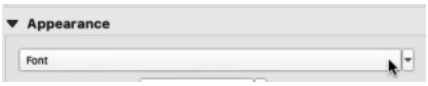
12. Navigate to **Legend Items** and increase the **Space between symbols** to 3.50 mm.



13. Click on the **Add a Scale Bar** to paste a scale bar.
14. Navigate under **Item Properties** >> **Scalebar** and select for **Style**: Line Ticks Up.



15. Adjust the scale bar on your map window. To change the units on the legend, you can adjust the **Fixed width**.
16. Click on **Add North Arrow** to paste a north arrow.
17. Click on **Add Label** to add a text box with details about **Author**, **Data Sources**, and **Date**. Set the **Horizontal alignment** to Left and **Vertical alignment** to Middle.
18. In the Main Properties text window, enter in your *Author information*, *Sources: John Snow, 1885*, and the *Date*.
19. To add a title at the top of the map, click on **Add Label** and under Main Properties window type in the title "*The Soho Cholera Outbreak of 1884*." Set **Vertical alignment** to Middle.
20. Adjust the font by double-clicking **Font**.

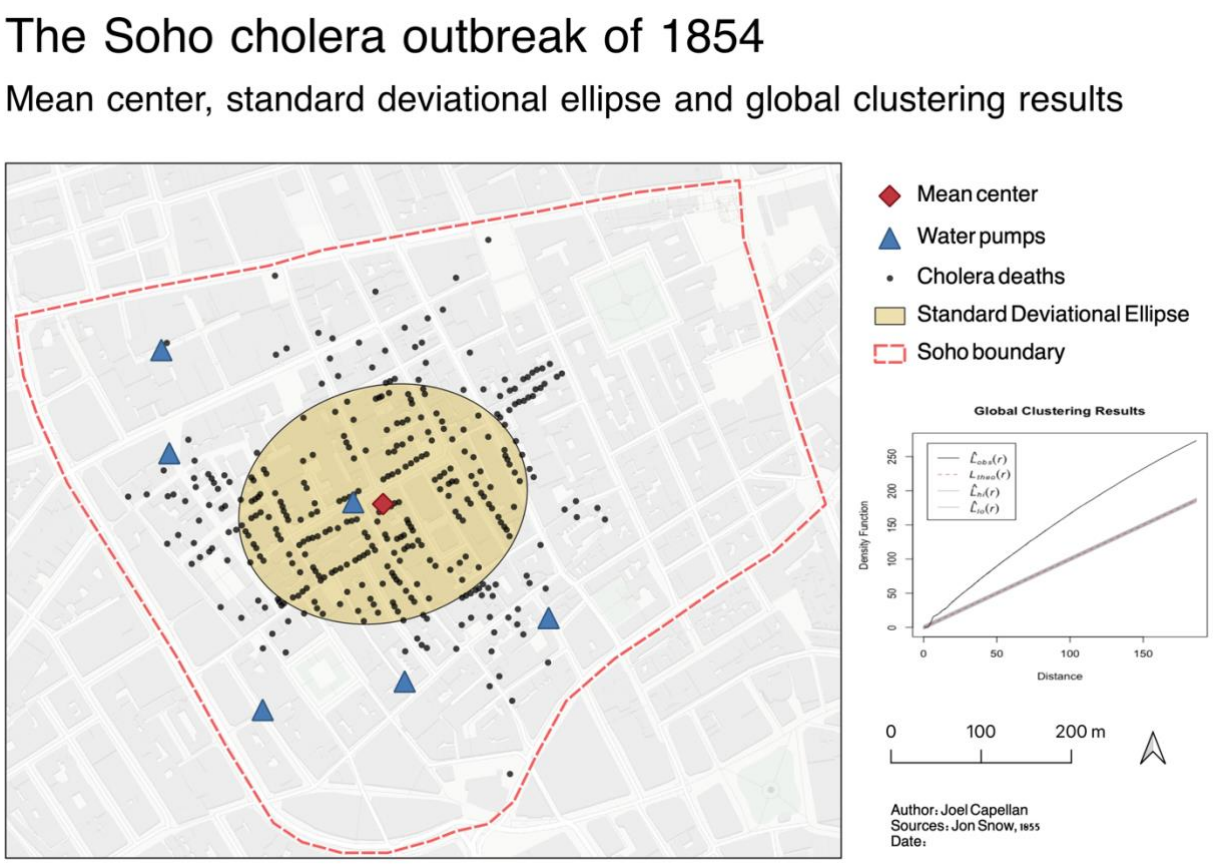


21. Set Apple Braille as your **Font** and **Size** as 24.
22. To create a subtitle, copy the title text box and paste directly below your title.
23. Change the **Font** of the subtitle box to 20 and edit the text under Main Properties to "*Mean center, standard deviational ellipse and global clustering results*".

Complete Ripley's K-function Analysis (R section of the lab) and add figure to map.

1. Click on **add image**
2. Select **Raster** and **browse** to Ripley's K-function figure and click on **Add**.

Export map as PNG or PDF.



PART 2 – Kernel Density Maps

Centrography is very helpful when the goal is to identify the source of an outbreak or identifying how the level of concentration and direction of an outbreak over time. Ripley's K function can determine the type of spatial point pattern process behind an outbreak. But as you may have noticed, neither technique is great for visualizing the spatial distribution of a point pattern process.

Although you may always plot the points, sometimes it is difficult to get a sense of the intensity of the point process by looking at the points. This problem is exacerbated when you are dealing with thousands of overlapping points. When your goal is to map the intensity of a spatial point pattern, Kernel Density maps will be the tool you want to use.

In part 2, we will use the Kernel Density map tool in QGIS to map the intensity of cholera death cases in Soho, 1854.

Visualizing cholera death case locations and SOHO boundary

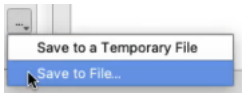
1. Open QGIS. Navigate to the **Lab4** folder and drag in the **cholera_death_cases.shp** and **soho.shp** boundary file into your QGIS window.
2. Drag the **soho** boundary layer beneath the points layer.

3. Customize the **cholera_death_cases** points layer in **Symbology**. Change the fill color to yellow.

Calculate kernel density function

1. Navigate to the **Processing** tab in the top bar >> **Toolbox**.
2. Navigate under the **Interpolation** tab and click on **Heatmap (Kernel Density Estimation).**

3. In the new window, select **cholera_death_cases** as your **Point layer**.
4. For **Radius**, select **50.00** meters.
5. Open the **Advanced Parameters** tab and set **Kernel shape** to **Quartic**.
6. For Heatmap, click the three dots and **Save to File**.

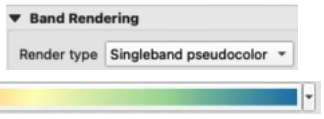


7. Navigate to the **Lab4** folder and save your file name as "**KDE**".
8. Click **Run**.
9. The layer will be saved out as a .TIF file and you should now have the additional KDE layer in your map.
10. Move the **cholera_death_cases** layer to the top of the layers list.

The highest values (lighter-colored areas) of the **KDE** layer correspond to the highest density of points. The values in the band indicate the number of cholera cases in a 50-mile radius.

Visualizing kernel density function

1. Remove the **cholera_death_cases** layer from your map.
2. Customize the **soho** layer in **Symbology**. Change fill color to white.
3. Note that **KDE** is a raster layer (you can inspect the layer by zooming in and seeing the pixels). Customize the **KDE** layer in **Symbology.**
4. Set **Render type** to **Singleband pseudocolor**.
5. Set **Color ramp** to **Spectral**.

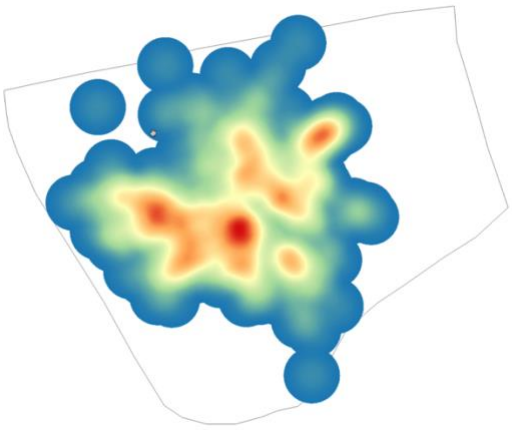


We can see that the lowest values are symbolized in red while the highest values are symbolized in blue. We want it the other way around. To do so:

6. Click on the **Color ramp** strip and select **Invert Color Ramp**.
7. Set the **Max** to **16.2**.
8. Ensure **Mode** is **Continuous** and we have **5 Classes.**
9. Click **Apply**.

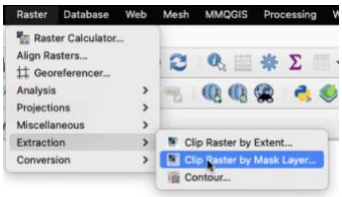
Note: We can change the visualization to a contour map by changing the **Interpolation** to **Discrete**.

Your map should now look something like this:

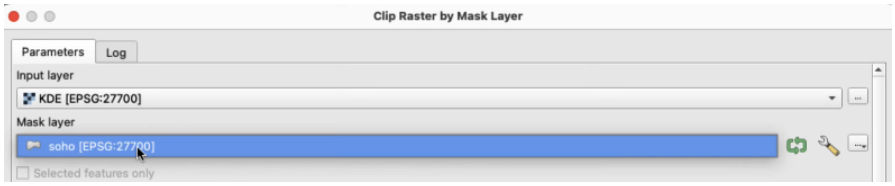


However, there are areas of the **KDE** map outside the **soho** boundary layer. To resolve this issue, we can clip our **KDE** raster layer using the **Clip Raster by Mask Layer** tool.

Clip raster by mask layer



1. Navigate to the **Raster** tab in the top bar >> **Clip Raster by Mask Layer**.
2. Set the **Input layer** as your **KDE** layer and **Mask layer** as your **soho** layer.



3. Specify that you save out your clipped raster file. Select **Save to File** the **Clipped (mask)**.

4. Navigate to your **Lab4** folder and name the file **KDE_clipped**. Click **Save**.
5. Click **Run**.

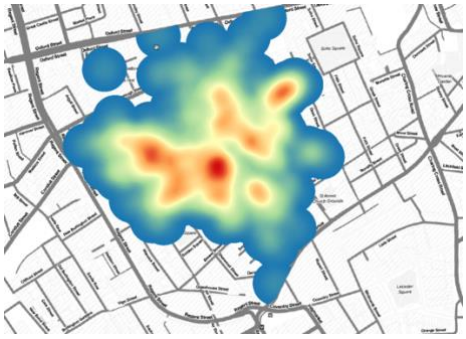
Now the **KDE clipped layer** is overlayed onto our original **KDE layer**.

6. Remove the **KDE** layer from the map.
7. Similar as the original KDE layer, we will customize the **KDE clipped** layer in **Symbology**. Set **Render type** to **Singleband pseudocolor**.
8. Set **Color ramp** to **Spectral**.
9. Click on the **Color ramp** strip and select **Invert Color Ramp**.
10. Click **Apply**.

Selecting base layer using QuickMapServices

1. Remove the **soho** layer from the map.
2. Navigate to the **Web** tab in the top bar >> **QuickMapServices** >> **Stamen** >> select **Stamen Toner Lite**.

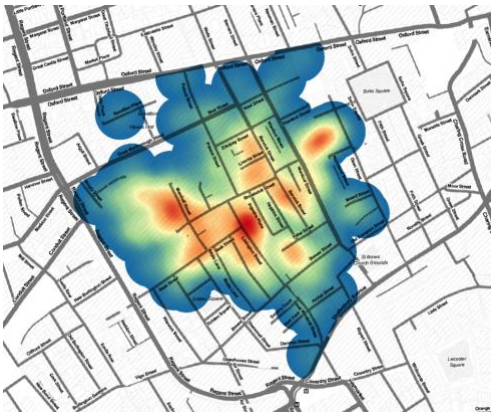
The kernel density estimates are now overlayed completely over the base map. This visualization is not ideal because the underlying geographic features are not visible.



Blending KDE and base layer

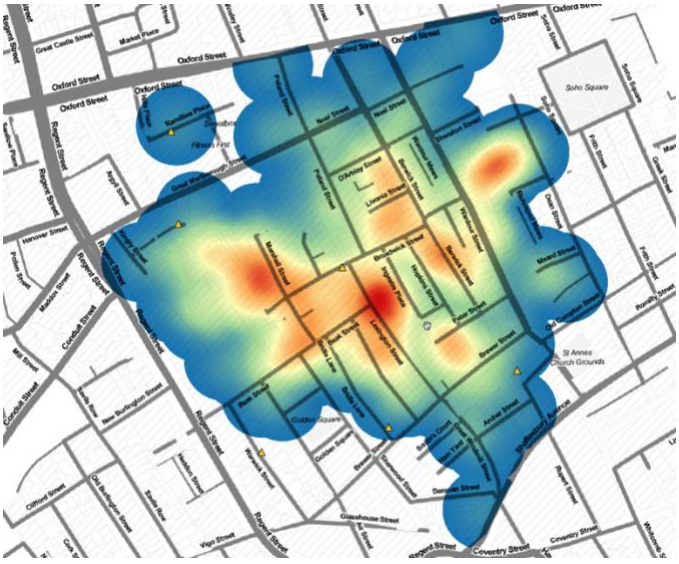
1. Double click on the **KDE_clipped** layer and navigate to **Symbology**.
2. Scroll down to the **Layer Rendering** section. For **Blending mode**, select **Multiply**.

Now, we can see the underlying base map with the kernel density estimates.



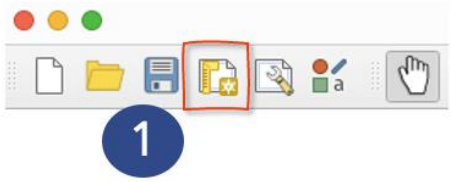
Adding water pumps layer

1. Navigate to the **Lab4** folder and drag in the **pumps.shp** into your QGIS window.
2. Double-click the **pumps** layer and navigate to **Symbology**.
3. Choose a triangle shape for your marker.
4. Change fill color to a yellow, stroke color to black.
5. Rename the **pump** layer to "**Water pump**"



As we can see, the Broad Street pump is located at the center of the outbreak while the other water pumps are located more in the outskirts, or "cold spots".

Use New Print Layout to add final elements to the map



1. Click on **New Print Layout** in the upper part of the window.
2. Enter a print layout title ***KDE*** and click **OK**.
3. To paste our map on the layout, click on **Add Map** , left-click-and-hold your mouse to draw the map window to fill the entire layout window.
4. Click on **Move item content** to move your layer within the map window and scroll to zoom in on our study area. Try to center the kernel density estimates.
5. Click on **Add Legend** and left-click-and-hold to draw the legend window.
6. Under **Item Properties** >> **Legend Items**, deselect **Auto update**.
6. Under **Legend Items**, double click on the **KDE_clipped** layer. Under **Label**, type "Density" to rename the legend item.
7. Return to your QGIS window and double-click on the **KDE_clipped** layer. Navigate to **Symbology** and round the **Max** value to the first decimal place, 16.2. Your legend should now be updated to this decimal place.
8. Return to your Print Layout window and in **Item Properties**, scroll down to the **Rotation** tab. Double-click the **Color** band and decrease the **Opacity** to 80%.

9. Click on the **Add a Scale Bar** to paste a scale bar.
10. Navigate under **Item Properties** >> **Scalebar** and select for **Style: Line Ticks Up**.
11. Adjust **Fixed width** to 50.00 units.
12. Scroll down to the **Rotation** tab. Check the **Background** option to add a white background. Double click on the **Color** band and decrease the **Opacity** to 40%.
13. Click on **Add North Arrow** to paste a north arrow.
14. Click on **Add Label** to add a text box with details about **Author**, **Data Sources**, and **Date**.
15. Check the **Background** option to set the text box on a white background.
16. In the Main Properties text window, enter in your *Author information*, *Sources: John Snow, 1885*, and the *Date*.
17. Set the **Horizontal alignment** to Left and **Vertical alignment** to Middle. Increase **Horizontal margin** to 2.00mm.
18. Check the **Frame** option to add a frame around your text box.
19. Adjust your map so there is room for a title.
20. Click on **Add Label** to add a title. Check the **Background** option to add a white background.
21. Under **Item Properties** >> **Main Properties** text box, type in the title "*Kernel Density Map of Cholera deaths in SOHO, 1884*."

22. Navigate to **Appearance** >> **Font**. Double click on the bar and set Avenir as your **Font**. Set **Size** to 38. Click **OK**.
23. Set the **Horizontal alignment** to Left.
24. Scroll down to the **Rotation** tab. Double click on the **Color** band and decrease the **Opacity** to 70%.

Once you are satisfied with the final version of the map, you can export it as a print-ready file, such as a PDF, or as an image. To export it as an image:

1. Go to the **Layout** menu at the top of the screen, select **Export as an Image**, name the image file "KDE_cholera", and click **Save**.
2. In the Image Export Options, select your **Export Resolution** (300 dpi is appropriate for most applications) and **Page width** and **Page Height**.

Click **Save** to export image.