

Instructions for making a geographical density map

Ludo Waltman and Lutz Bornmann
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In this document, we provide step-by-step instructions for making a geographical density map.¹ We use two computer programs. One program is CalcDensityRaster. This is a simple command-line tool that runs on Windows operating systems. The tool can be freely downloaded from www.ludowaltman.nl/density_map/. The other program is Quantum GIS (QGIS). This is an open source geographic information system that is available at www.qgis.org. Instead of QGIS, one may also use some other geographic information system. However, the instructions in this document apply specifically to QGIS. The instructions are based on version 1.6.0 of QGIS.

To make a geographical density map, one needs to have two files. One file is an ESRI shapefile of the area of which one wants to make a map. This file contains for instance the boundaries of countries or states.² The other file is a text file that contains geographical coordinates (i.e., latitudes and longitudes) and weights. We refer to this file as a coordinates file. A coordinates file consists of three columns, which are separated from each other by commas. The first column contains latitudes, the second column longitudes, and the third column weights. The first line of a coordinates file is a header line. An example of a coordinates file can be found at www.ludowaltman.nl/density_map/coordinates_example.txt.

Given a shapefile and a coordinates file, a geographical density map can be made by taking the following steps:

1. Store the shapefile, the coordinates file, and the CalcDensityRaster executable all in the same folder. We refer to this folder as the project folder.
2. Run the CalcDensityRaster tool.
3. Specify an input file. The coordinates file should be used for this purpose (e.g., coordinates_example.txt).
4. Specify an output file (e.g., raster.txt). The output file will be a text file in the Arc/Info ASCII Grid format. We refer to the file as a raster file.
5. Specify the borders of the area of which one wants to make a map. For instance, to make a map of the entire world, set the latitudes of the southern and the northern boundaries equal to -90 and 90, respectively, and the longitudes of the western and the eastern boundaries equal to -180 and 180, respectively. To make a map of Europe, one may set the latitudes equal to 32.5 and 65 and the longitudes equal to -15 and 40.
6. Specify the number of raster rows and columns. A larger number of raster rows and columns yields a more accurate map but also requires more computing time. In general, a raster with 500 rows and 500 columns seems a good compromise.
7. Specify the kernel type. We strongly recommend the exponential kernel.

¹ For more information on geographical density maps, we refer to our paper: Bornmann, L., & Waltman, L. (2011). The detection of “hot regions” in the geography of science: A visualization approach by using density maps. arXiv:1102.3862.

² A shapefile in fact consists of multiple separate files (see the QGIS user guide for more details). Many shapefiles can be freely downloaded from the internet, for instance from <http://geocommons.com> or www.gadm.org.

8. Specify the kernel width parameter (in kilometers). A larger value for this parameter yields a more strongly smoothed map. Choosing an appropriate value for the kernel width parameter is crucial for a satisfactory map. Some trial and error is usually needed to find an appropriate value. As a first trial, one may use a value of 100 kilometers.
9. Wait until the CalcDensityRaster tool has finished its calculations. Depending on the number of lines in the coordinates file and the number of raster rows and columns, this may take a considerable amount of time.
10. Download the file colors.txt from www.ludowaltman.nl/density_map/colors.txt and store this file in the project folder.
11. Start QGIS.
12. In the **Layer** menu, select the **Add Raster Layer** option. Select the raster file that was produced by the CalcDensityRaster tool and click on the **Open** button.
13. In the **Layer** menu, select the **Add Vector Layer** option. Select the shapefile that is stored in the project folder and click on the **Open** button.
14. In the **Layer** menu, select the **Properties** option. This brings up a dialog box. Select the **Symbology** tab. In the **Fill options** drop-down box, select the **None** option. Click on the **OK** button to close the dialog box.
15. In the map legend (in the left part of the QGIS window), change the selected layer from the vector layer (i.e., the layer obtained from the shapefile) in the raster layer (i.e., the layer obtained from the raster file).
16. In the **Layer** menu, select the **Properties** option. This brings up a dialog box. First select the **Symbology** tab. In the **Color map** drop-down box, select the **Colormap** option. Then select the **Colormap** tab. In the **Color interpolation** drop-down box, select the **Linear** option. Click on the load color map button in the upper-right part of the dialog box, select the file colors.txt that is stored in the project folder, and click on the **Open** button. (Alternatively, one may skip this step and specify one's own color map.) Click on the **OK** button to close the dialog box.

The following two steps are optional and may be skipped. In these steps, a small symbol is drawn on the map for each pair of coordinates in the coordinates file. This option should be used only if the map covers an area of limited size. Do not use this option if the map covers the entire world.

17. In the **Plugins** menu, select the **Add Delimited Text Layer** option in the **Delimited text** submenu. This brings up a dialog box. Click on the **...** button, select the coordinates file that is stored in the project folder, and click on the **Open** button. Check the other options in the dialog box and click on the **OK** button to close the dialog box.
18. In the **Layer** menu, select the **Properties** option. This brings up a dialog box. Select the **Symbology** tab. Choose an appropriate symbol and an appropriate symbol size. Click on the **OK** button to close the dialog box.

One usually needs to go through the above steps a number of times in order to obtain a completely satisfactory map. Especially the choice of an appropriate value for the kernel width parameter may require some trial and error. When a satisfactory map has been obtained, images of the map can be made using either the **Save as Image** option or the **New Print Composer** option in the **File** menu of QGIS.