

GIS Methodology in Determining Population Centers and Distances to Nuclear Power Plants

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The methods used to determine the population centres are described below. The default approach in determining the population centre of a NUTS region is the geometric/geographic centre. The weighted centre is determined by values of an attribute (variable) that decides where the most weight is located. In our case, it is the population in the respective NUTS regions.

1. Mean centre

The mean center is the most central location of features/objects in GIS. They can be represented by points, lines or polygons/area (see Fig.1). Since the population in a NUTS region can be represented either by points or polygons, these are the two options available to us. We are interested in allocating a point that is most representative of the population in a NUTS region, therefore we are restricted to point feature which represents the population center.

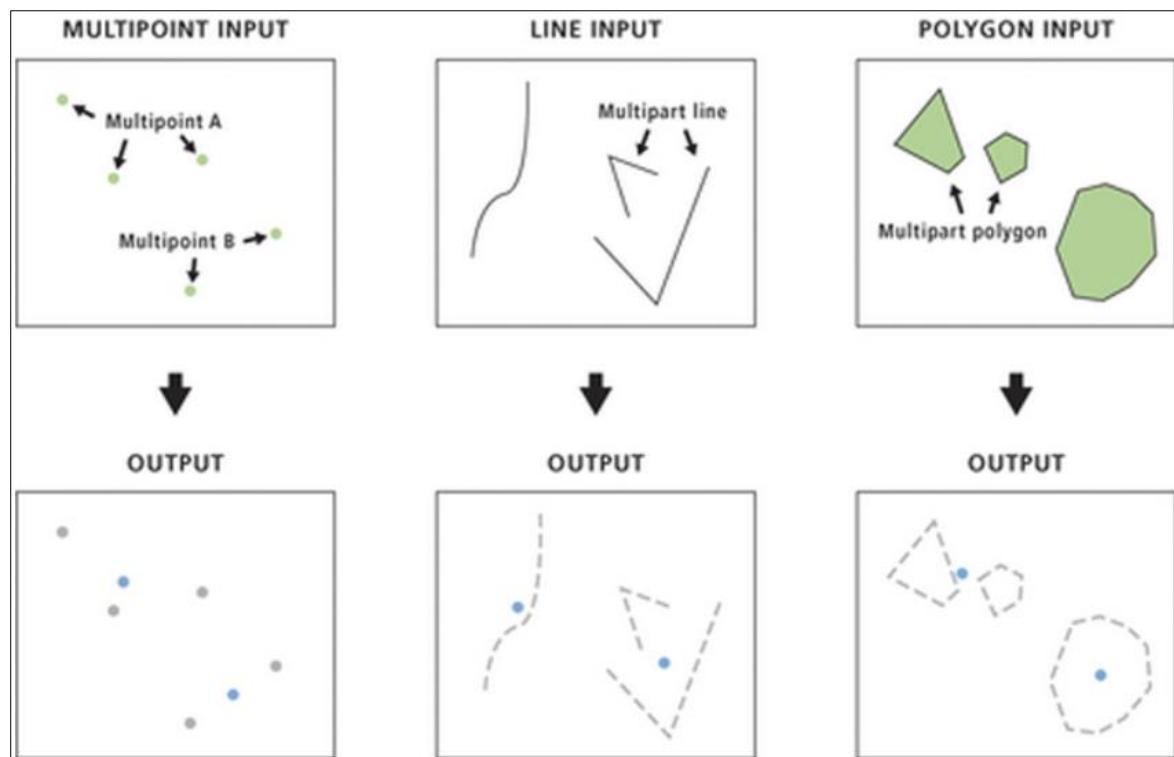


Figure 1. Geometric mean center based on spatial distributions of points, lines and polygons (ESRI)

2. Geometric populated centre

This method assumes that the population of a NUTS is equally distributed in a region and thereby places a point in the geographic centre of the NUTS region (see Fig.2). Since we have a number of points representing population in a NUTS region, the mean geographic/geometric centre is taken as the representative center. This method is based entirely on the spatial locations (x,y coordinates) and does not take into account any weights or criteria to determine the mean geometric center. In reality, this does not reflect the actual population concentration in a NUTS region and can introduce errors, although for NUTS with smaller geographic regions such as urban areas, this method can produce sufficiently accurate results.

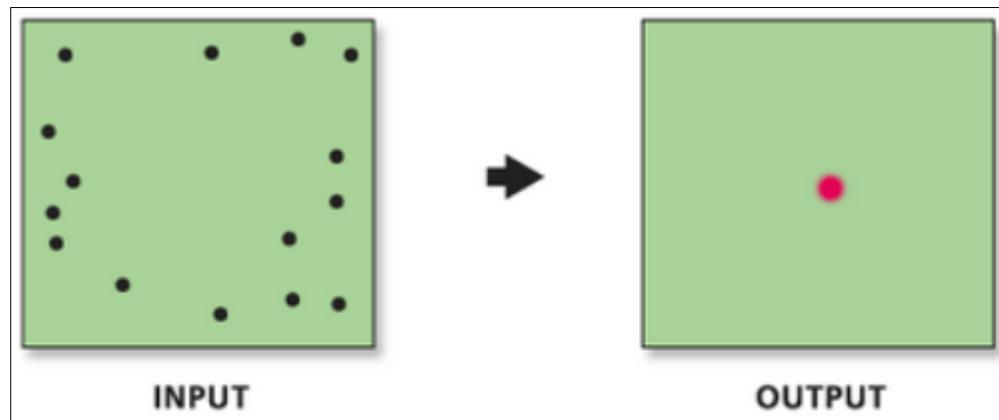


Figure 2. Geometric center based on spatial distributions of points in a region (ESRI)

3. Weighted populated centre

The weighted populated centre uses weights as a criteria from an attribute (variable) to determine the most likely population centre. For example, instead of using the geographic locations (x,y coordinates) to determine the mean location of the population in an area, a weight such as population is used to determine its likely spatial location.

4. Gridded Population of the World (GPW)

The gridded population of the world data from SEDAC/NASA (see Fig.3) was acquired which represents population by pixels. Darker areas indicate lower population while lighter areas show high population counts.

The gridded world population for Europe (Fig.4) was extracted in GIS and the pixels representing population values were converted to geometric points (see Fig.5). These points representing population were enumerated and categorized by NUTS regions (NUTS0 to NUTS3) and the weighted centre was determined by aggregating the points in the respective region. This method can place the point anywhere the weighted mean is located and may not necessarily be located inside the NUTS regions (Fig.6). This approach is more representative and confirms well when checked for their accuracies with other data such as urban areas.

5. Generating Buffer Distances from population points

After creating both geometric/geographic and weighted population centers, multiple buffer distances (25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450 and 500 kilometres) were generated for both population points (see Figs. 7 and 8). It is clear that there is variation in distances between the geometric and weighted population centers within the same NUTS

regions. This demonstrated that the distance from population centers to the nearest nuclear power plants (NPPs) does make a difference if a geometric population center or a weighted population centre is chosen.

6. Populated Centers and Distance Analysis for Switzerland

In the case for Switzerland, the geometric population centre for NUTS0 is located somewhere in the centre of the country, however, the weighted population centre is approximately 50 kilometres north-north-west of the geometric centre. When the urban populated layer is overlaid, it can be clearly seen that the weighted population centre is more or less in the centre of the populated places (see Figure on page 9).

7. Distances from both population centres to NPPs for Switzerland

The distances from the two (geometric and weighted) population centres were measured to each NPPs in Switzerland and shows the differences between the two methods. This is shown in Table 1 (page 8) at NUTS0 level for Switzerland. The pattern emerging is that there can be marked differences in distances between population centres and NPPs, depending on the method used in GIS to determine the population centers. Choosing the appropriate GIS function is crucial to achieving a truly representative result that mimics reality.

8. Buffer distances from population centres for Switzerland

Two sets of multiple ring buffers were created to portray the distances from the populated centres to the NPPS. One is the buffer generated from the weighted population centre while the other is generated from the geometric centre. Both maps are appropriately labelled (see pages 10 and 11) following the topographic map of Switzerland (page 9).

9. NUTS2 - Buffer distances from population centres for Switzerland

The same methodology used in NUTS0 was applied in NUTS2 for Switzerland using both geometric and population weighted centers. Instead of only one population center, this time there are seven points, representing seven NUTS2 regions in Switzerland. The buffer distances were computed for both geometric and weighted population points and the differences between the two methods are shown in Table 2 on page 12.

NUTS2 represents well for most of the countries in Europe because while some countries have fewer NUTS regions due to their geographical extents, other countries such as Germany and France among others have many NUTS regions. Therefore, the example using NUTS2 with Switzerland depicts most countries in Europe.

The results from the distance analysis for Switzerland by NUTS2 regions are shown in Table 2 as stated above, and the maps on pages 14 and 15 are the graphical representations. The topographic map on page 13 shows the NUTS2 regions with the geometric and weighted population centers with respect to their locations to NPPs and urban centres. This provides a clear visualization of the relative locations and distance proximities between the two methods of representing population by NUTS2 regions to NPPs.

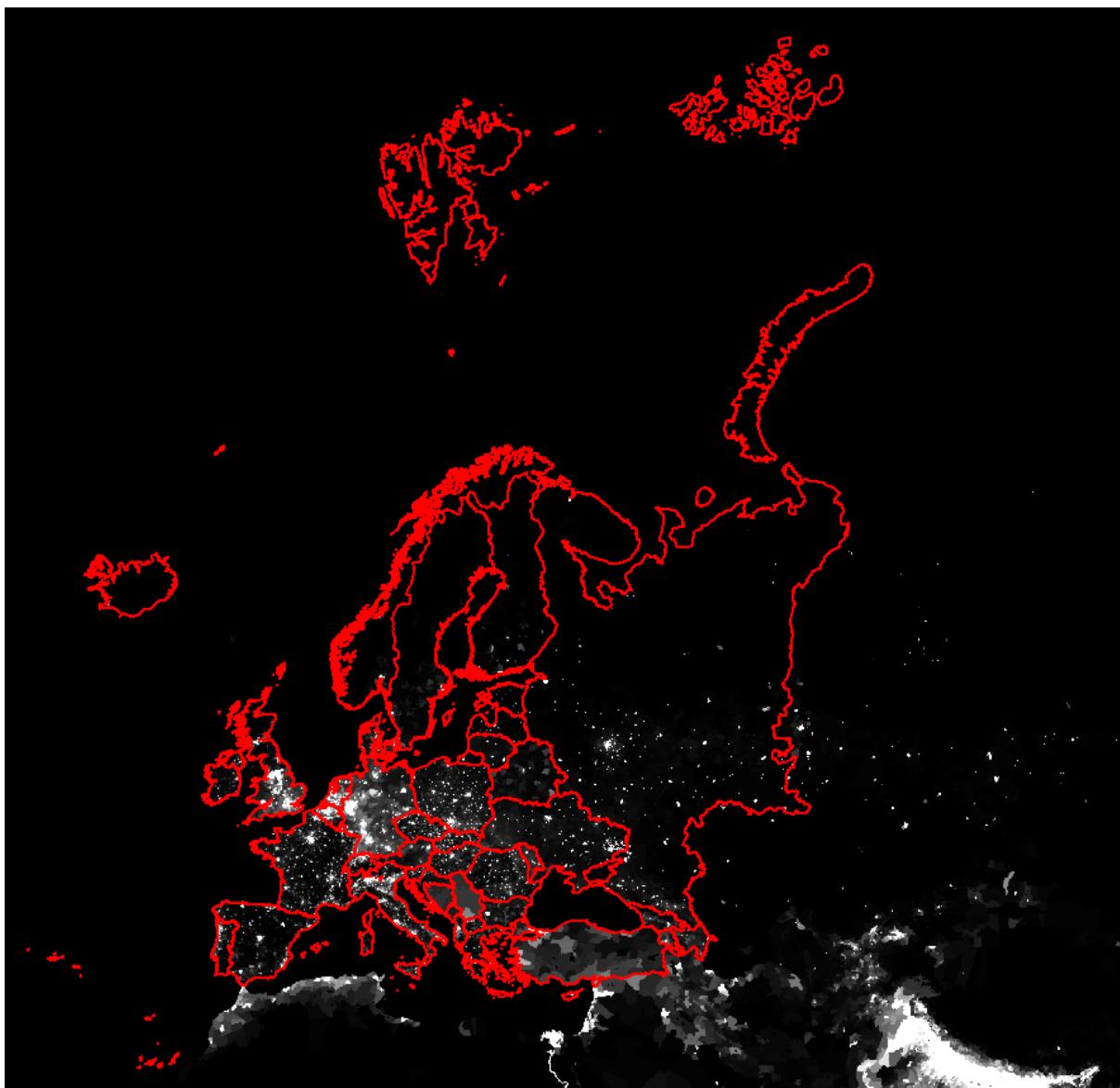


Figure 3. Gridded Population of the World (GPW) for 2010 from NASA – Socioeconomic Data and Application Centre (SEDAC - <http://sedac.ciesin.columbia.edu/>).

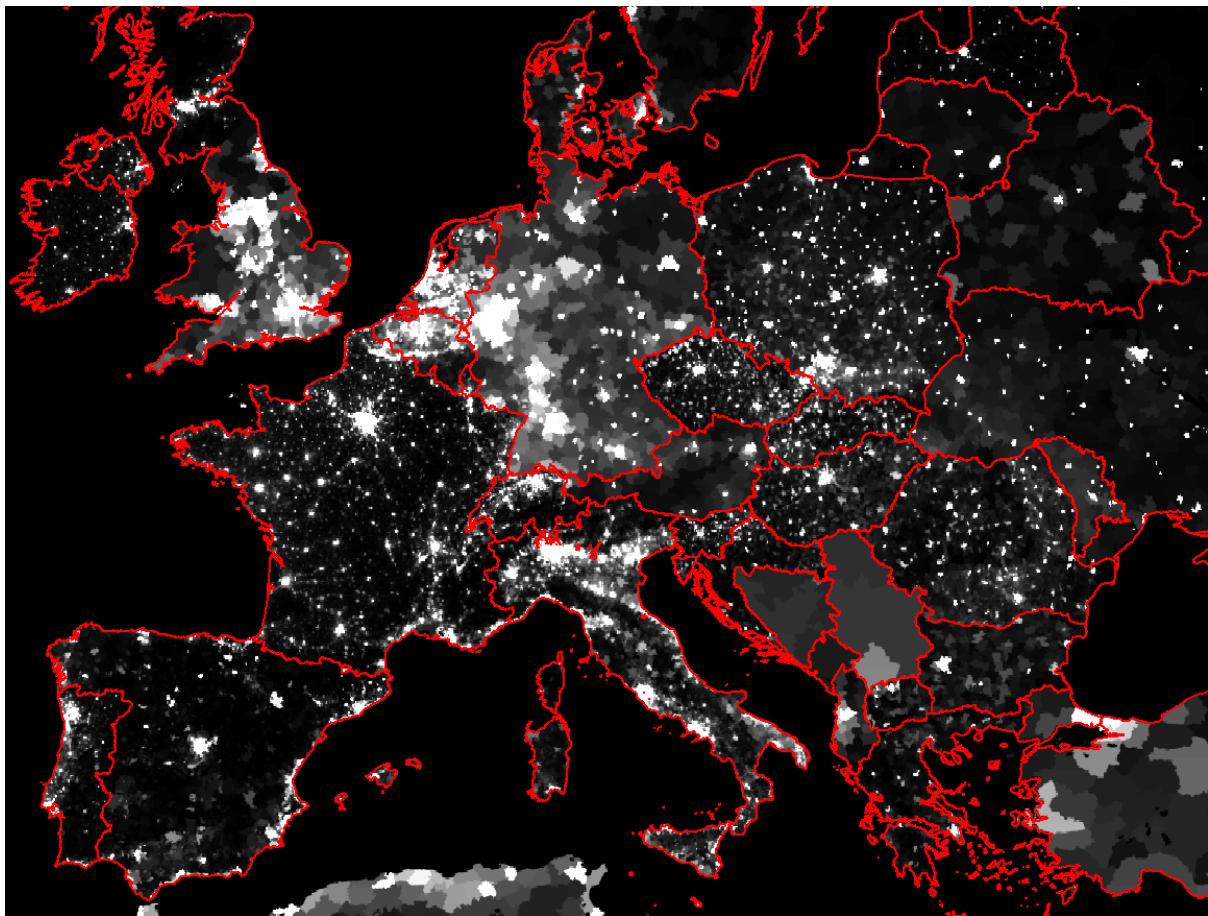


Figure 4. Enlargement of Gridded Population of the World for Europe

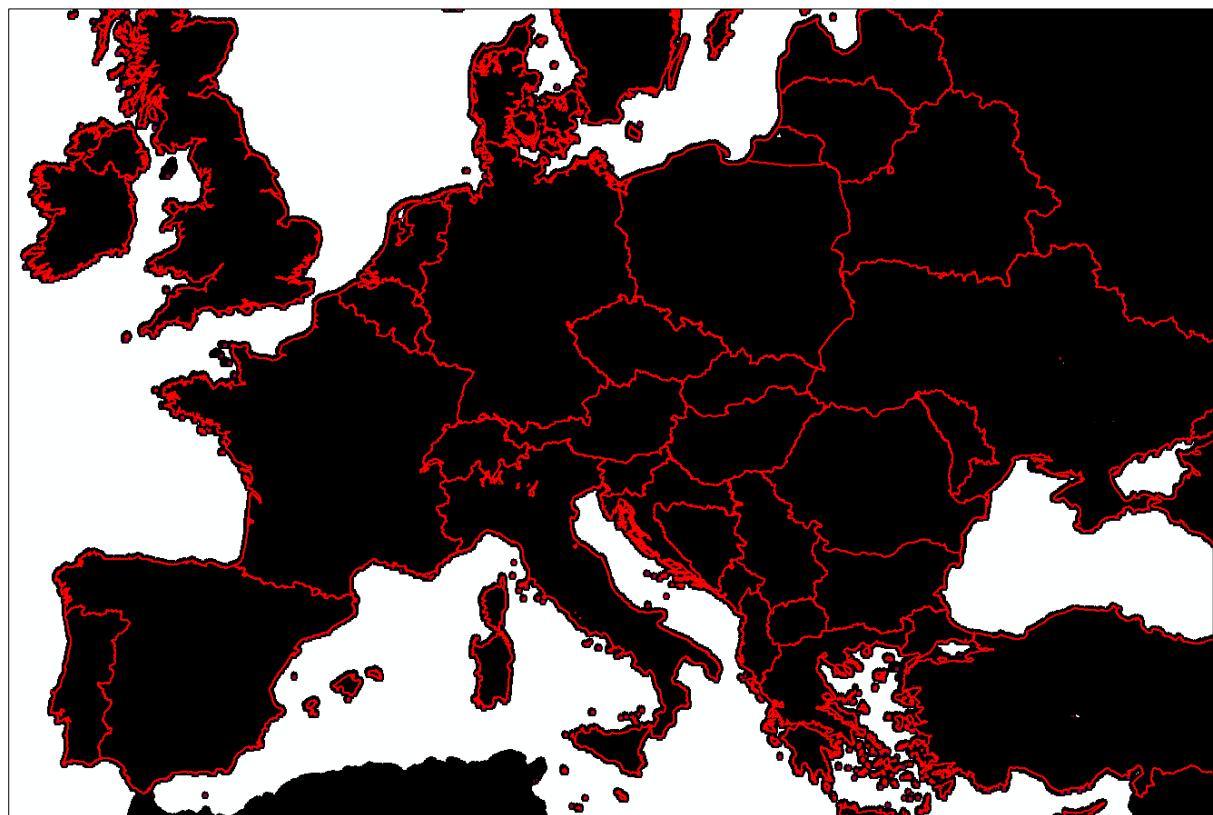


Figure 5. Gridded Population of the World for Europe converted from raster pixels to vector geometric points

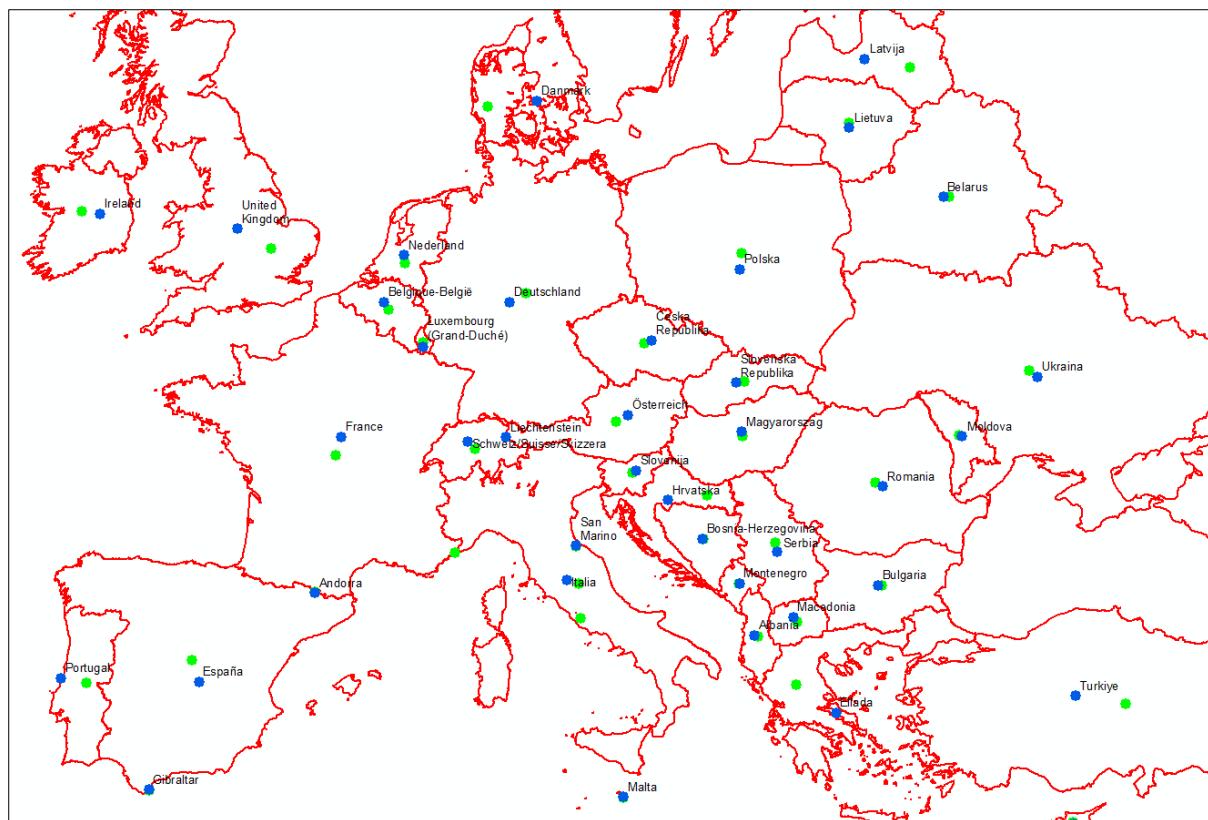


Figure 6. Geographic/geometric centroids (green) and population weighted centers (blue) for NUTS0

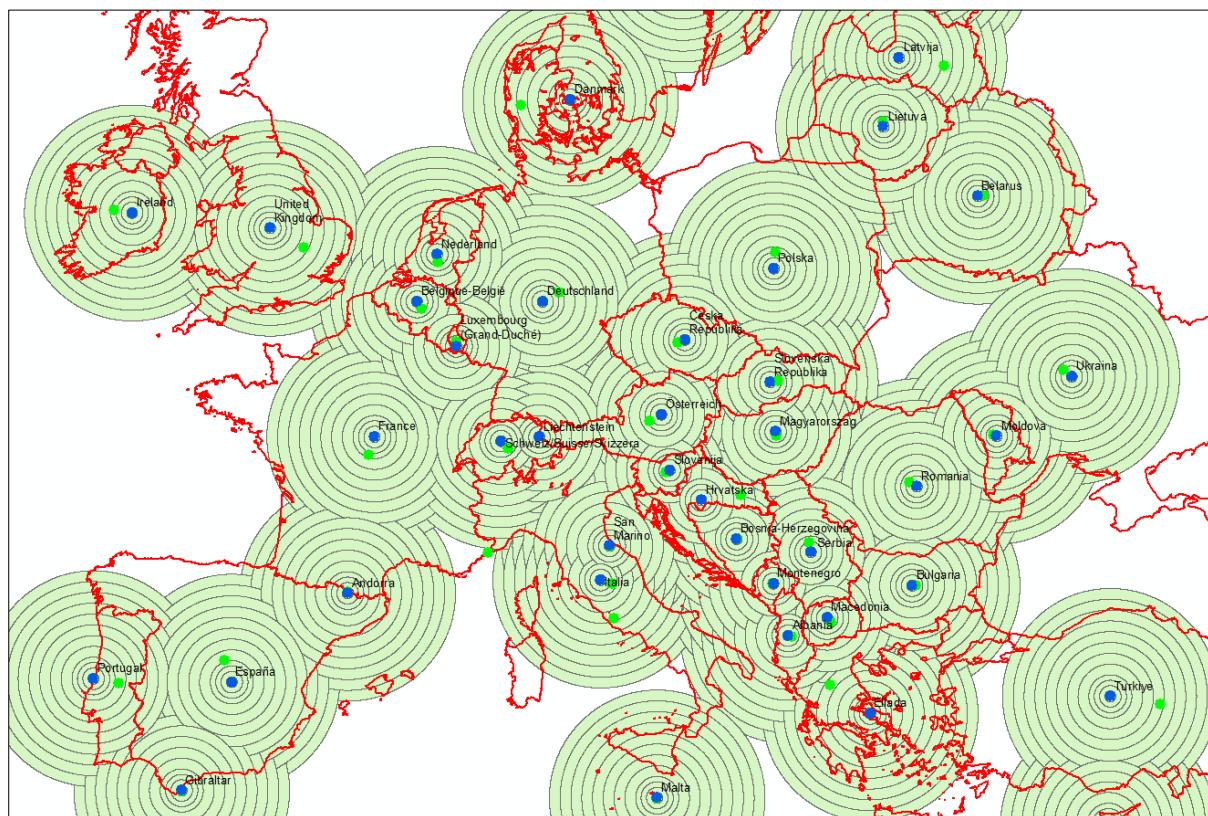


Figure 7. Multiple buffer distances from weighted population centers for NUTS0

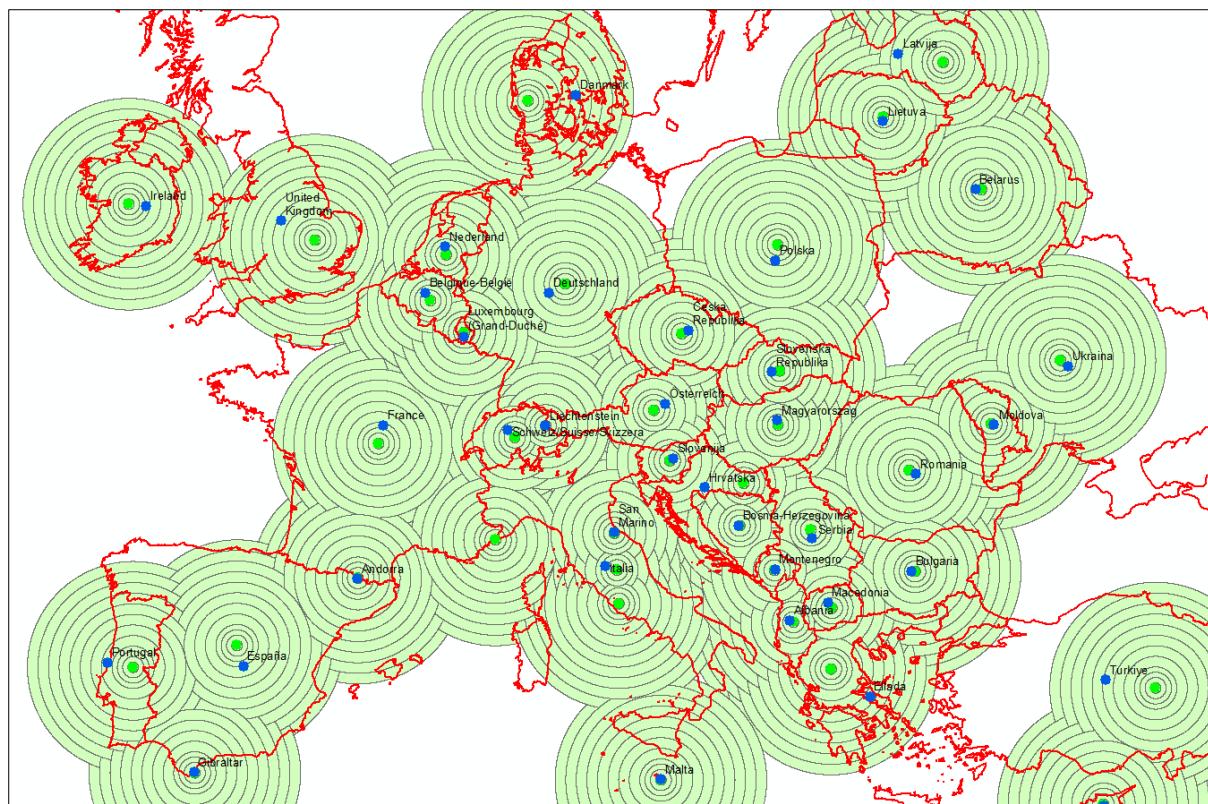


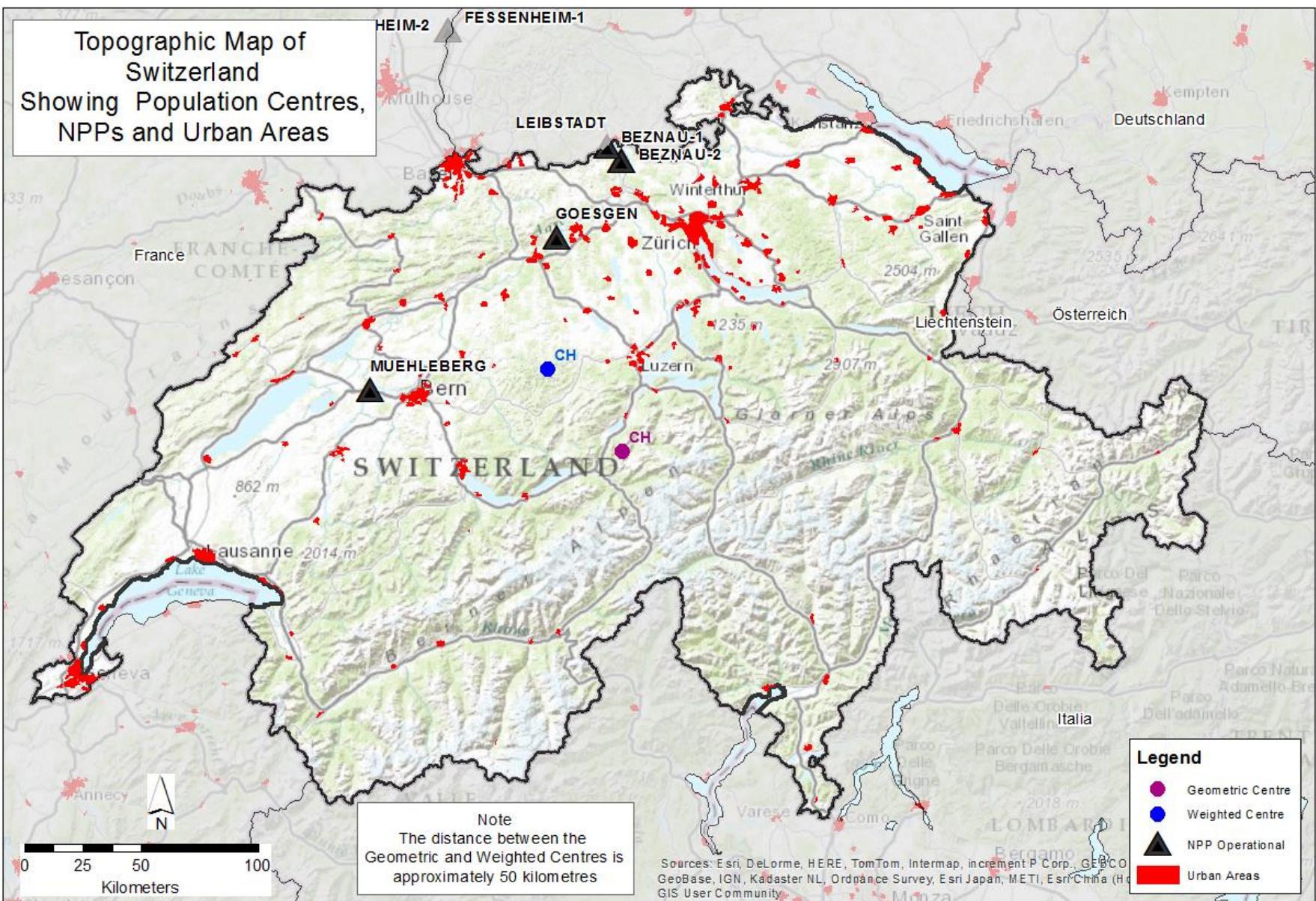
Figure 8. Multiple buffer distances from geometric/geographic population centers for NUTS0

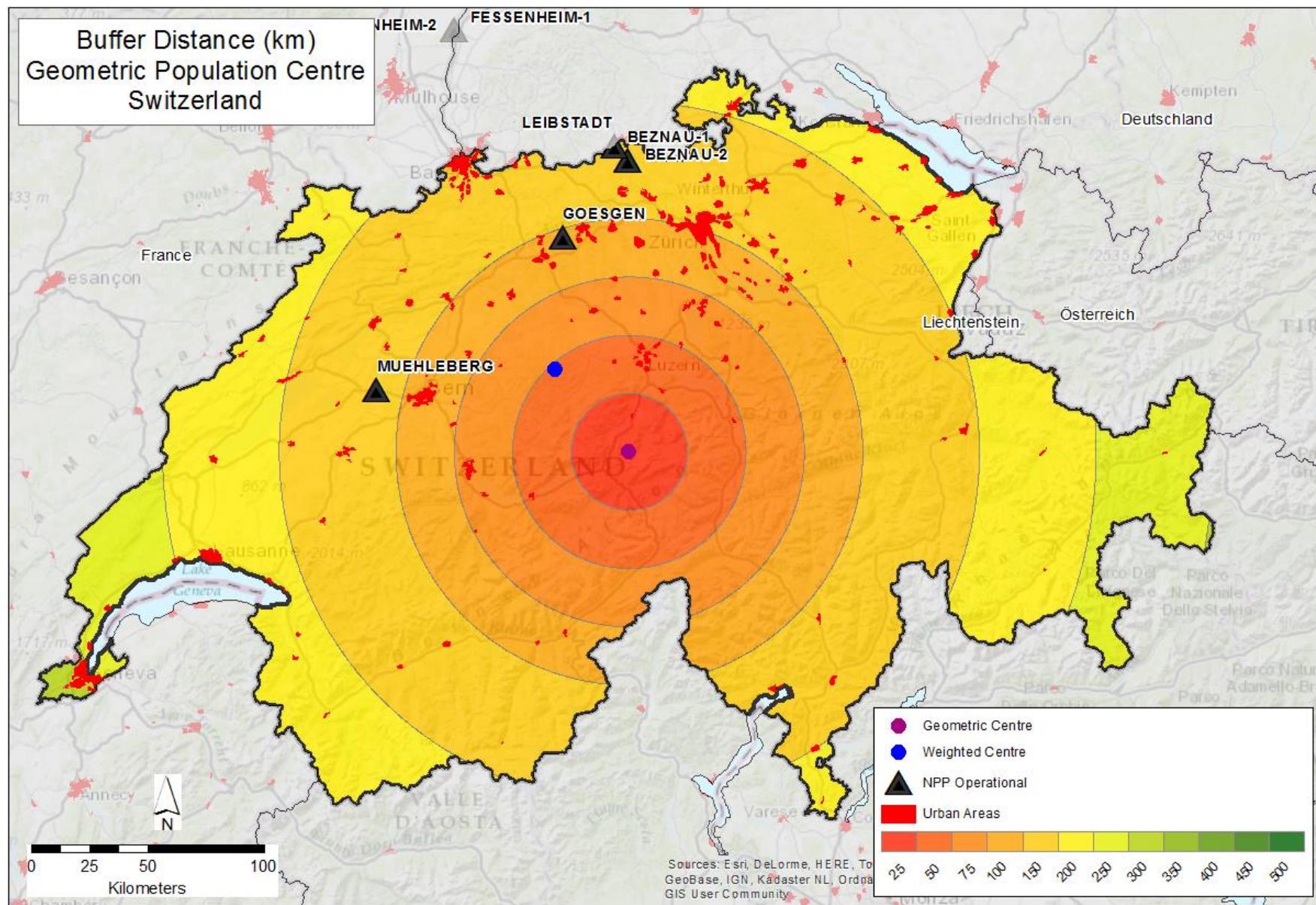
NUTSO

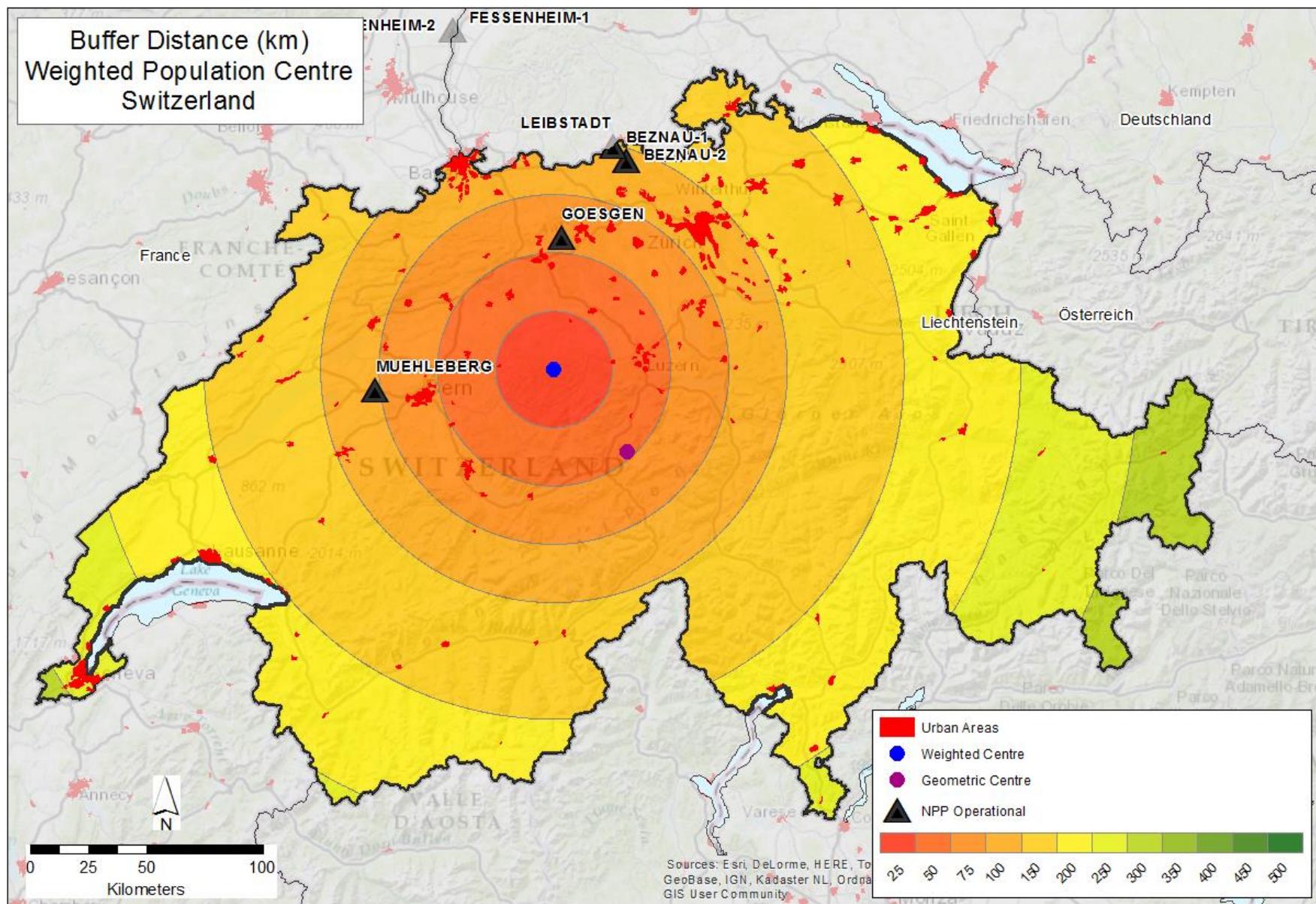
Table 1. Distances to NPPs from geometric and weighted populated centres for NUTSO

	Distances to Nuclear Power Plants (NPPs) km			
	Beznau	Leibstadt	Goesgen	Muehleberg
Populated Centres NUTSO				
Population Weighted	95	99	57	77
Geographical Centre	125	132	97	111
Difference	30	33	40	34

Distance between weighted population center and geographic center for Switzerland for NUTSO is 50 km.







NUTS2

Table 2. Distances to NPPs from both geometric and populated weighted centres for NUTS2 and the differences

Populated Centres NUTS2	Geometric Populated Centre				Weighted Population Centre				Geometric vs Weighted Distances				Distances	
	Distances to Nuclear Power Plants (NPPs) km				Distances to Nuclear Power Plants (NPPs) km				Differences between different measures (km)				Geometric and Weighted Population Centres	78
	Beznau	Leibstadt	Goesgen	Muehleberg	Beznau	Leibstadt	Goesgen	Muehleberg	Beznau	Leibstadt	Goesgen	Muehleberg		
CH01 - Région lémanique	260	258	217	133	265	262	220	120	5	4	3	13		
CH02 - Espace Mittelland	140	138	96	23	132	129	88	15	8	9	8	8		19
CH03 - Nordwestschweiz	30	20	25	128	35	35	17	110	5	15	8	18		28
CH04 - Zürich	60	52	78	174	57	50	69	165	3	2	9	9		10
CH05 - Ostschweiz	182	175	182	245	129	122	142	227	53	53	40	18		67
CH06 - Zentralschweiz	106	98	80	130	88	81	64	126	18	17	16	4		20
CH07 - Ticino	220	215	195	203	259	251	231	231	39	36	36	28		38

