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# Making the political landscape visible: mapping and analyzing voting patterns in an ideological space

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**Abstract.** This paper investigates the applicability of knowledge domain mapping for analyzing political science data. Utilizing metaphorical-space models grounded on political science theory, and applying sound cartographic visualization techniques, we demonstrate the construction and analysis of knowledge domain maps for exploring voting behaviour in Switzerland. We digitally transformed the results of Swiss popular referenda of the last twenty years to generate a 3-dimensional semantic space representing the current political landscape of Switzerland. The whole country is depicted in this semantic political space at various spatial scales. Locations in this spatialization represent aggregated voting outcomes from cities, regions, and provinces. Special attention was given to the interpretation of the resulting spatial configuration. This includes the assignment of meaning to the axes of the 3D space, depicted in two dimensions. Armed with political science theory locations in the voting behaviour space can be analyzed and the resulting political pattern can be interpreted meaningfully. The spatialized views were disseminated to the public after recent Swiss elections. The initial feedback from domain specialists and decision-makers alike has been very encouraging. Measured by high number of substantive reactions and wide-spread feedback on these spatializations of voting behaviour one could deduce that these abstract views were readily accepted and understood by public administrators, political party leaders, and the politically interested public. Based on these experiences we conclude the paper with a first attempt at identifying design recommendation for spatializing multidimensional political datasets.

## Introduction—mapping politics and political maps

Communicating social phenomena visually through thematic maps or graphs is a common practice in science, public administration, and education. Typically, cartographic maps (as opposed to graphs) communicate the depicted sociodemographic information within a geographic reference system, such as the cardinal directions (N – S – E – W). Alternatively, social scientists, such as researchers in psychology, sociology, economics or political science, have long used relative reference systems, or metaphorical spaces, to visualize outcomes from multivariate analysis of nonspatial social science datasets. However, more recent developments in geovisualization (eg 3D modelling, surface interpolations, animations, etc) have not yet infiltrated knowledge domain mapping approaches in the social sciences. This paper investigates the applicability of knowledge domain mapping with advanced geovisualization tools for analyzing political science data. Utilizing metaphorical-space models grounded on political science theory, and applying sound cartographic visualization techniques, we demonstrate the construction and analysis of knowledge domain maps for exploring voting behaviour and especially the geography of political behaviour in Switzerland. Based on this work we make a first attempt at identifying recommendations for spatializing multidimensional political datasets.

### Cartography of political behaviour

Maps of political behaviour—for example, used to communicate election results and issue-voting outcomes—are very popular and broadly used by newspapers or TV news channels. Usually the goal is to provide a broad overview of the varying democratic

choices across different regions and social contexts. The most common maps of politics are univariate choropleth maps—for example, depicting party or candidate votes (in percentages) across different electoral districts as a single theme. The more elaborate multivariate thematic maps have more than one layer of data. Quite often election results are depicted in combination with a second socioeconomic data layer in order to suggest graphically potential correlations between socioeconomic variables and voting behaviour.

A pioneer work of systematic cartographic analysis of regional election behaviour was published by Siegfried (1913), who discovered the amazing persistency of spatial patterns in all elections between 1871 and 1908 in the northwest of France. Notwithstanding this long electoral mapping tradition the scientific benefit of maps is controversial in both political geography and political science disciplines. In political science the principal contentions are of a methodological nature. Some authors argue that correlations between social characteristics and voting results on a spatially aggregated level are not adequate to explain political behaviour of individuals and refer to the problem of ecological fallacy discovered by Robinson (1950). Others point out that shapes and size of the electoral districts are arbitrary and do not follow the spatial distribution of the electorate (eg Lohmöller et al, 1985). Referring to the modifiable areal unit problem, critics argue that the measurability of correlations is dependent on the aggregation level of the data. Questions about ecological inference do not bear on maps of political behaviour, but are generally related to statistical analyses of aggregated data, which is still an area of active research by political scientists, geographers, and geostatisticians alike (eg Fotheringham, 2000; King, 1997; 2000; O'Loughlin, 2000).

On a more fundamental level one might generally mention the suggestive power of images when utilizing graphical representations to communicate political phenomena. One argument is that the intuitiveness of images and maps might blur the boundary between a scientific model and the real-world phenomenon—for example, when the scientific model employed to represent the phenomenon might be taken too literally by uninformed viewers. Another argument from the mapmaker's perspective and supported by historic evidence (eg propaganda maps) alerts us to the abuse of maps as an instrument of power in politics (Monmonier, 1991; 2001; Taylor, 1992). As an important innovation, Dorling (1995) draws maps with circle cartograms, where each spatial unit is represented by a dot and its size is proportional to the population size.[1]

Political geographers tend to argue more conceptually than political scientists. Cox (1969) was one of the earliest critics of an electoral geography as a simple mapping problem. In his fundamental paper on electoral geography Cox (1969) suggests that the spatiality of political behaviour should be seen as a process of decision making in a spatial context which should lead to the study of spatial information flows, networks, neighbourhood, and relocation effects. Geographers and political scientists have since shared the same methodology to study the impact of the neighbourhood effects on a microsociological level (eg Johnston et al, 2004; Pattie and Johnston, 2000).

Agnew (1996) counters that recent political geography reduces the spatial context to microlevel locality and neighbourhood effects. He argues for a multiscale methodology and for context analysis from local neighbourhoods to states in a globalized world. This approach should bridge the gap between 'abstract, nomothetic sociological analysis', which focuses only on global factors, and the 'concrete ideographic geographical analysis', which concerns 'the particular' and 'the local'. With this argument

[1] Dorling-style cartograms are an alternative perspective to explore the spatiality of political behaviour and are indeed also applied for the visualization of referendum outcomes in Switzerland. See, for example, http://www.statistik.zh.ch/themen/mapresso/index.php?p=3.

in mind, choropleth mapping of election results is seen as a limited concept of space, ignoring the multiscale spatial dimension of political behaviour (Agnew, 1996). Moreover, if districts serve only as spatial containers for the comparison of different subsets of voters based on their social characteristics, the spatial distribution of political behaviour is explained only by nonspatial factors (Agnew, 1987; 1996).

Even though maps and graphs are still widely employed for the communication of election results, it is perhaps due to such critical voices that they have been underused as a tool for scientific analysis in the past. As we will demonstrate in the next sections, the recent renewed interest and demand for methods and tools for visual analysis seems to suggest a change of direction in social science. Perhaps this is due to the recent developments in geovisualization, exploratory visuospatial data analysis, and, more generally, information visualization, which emphasize graphical tools for thinking and decision making.

**Space metaphors in social science**

In the past three decades several approaches to thinking and modelling society, social structure, and social diversity in a multidimensional space metaphor can be observed in social science research (eg Blau, 1977; Bourdieu, 1979; McPherson, 1983; Vester et al, 2001). In this field of sociology the work of Bourdieu (1979) is a central piece. Bourdieu claims that the unidimensional characteristics of sociological discourse and thinking are due to the linearity of written language, which dominates social science research. "Une des difficultés du discours sociologique tient au fait que, comme tout discours, il se déroule de manière strictement linéaire [ ... ], il faudrait rappeler en chacun des ses points, la totalité du réseau de relations qui s'y trouve, d'une certaine manière engagé" [One of the difficulties of sociological discourse is that it proceeds strictly in a linear way ... it should be possible to refer at all points of the discourse to the whole network of relations which are connected to it] (Bourdieu, 1979, page 139). He argues that the characteristics of spatial thinking like multidimensionality and relationality exceed the possibilities of the traditional sociological discourse. He therefore postulates the modelling of social phenomena in a space metaphor and the use of graphical representation and maps of society as alternative modes of analysis and communication.

The basic idea of space metaphors in social science is that social relations are expressed through spatial relations. In Bourdieu's concept of social space the driving forces of social division and structuration, namely the unequal distribution of economic and cultural resources (capital), are considered as axes of a coordinate system and represent the dimensions of the social space. Individuals are located in this space due to their sociodemographic characteristics. Those who are similar in their characteristics are located close to each other and those who differ socially are located at a greater distance. Regions in the social space then represent status groups and different social milieus.

The benefit of the use of space metaphors in social science is that rivalry between groups, flows of power, or hierarchies, can be detected by analyzing both: the spatial relations of groups to each other and the direction of these relations in relation to the space dimensions. Bourdieu (1979) overlays the social space with other layers, like the space of lifestyles or the political space, and analyzes the correlations and interdependences between these layers. With a similar approach McPherson examines the social composition of networks and voluntary organizations. He explains the development of a system of voluntary organizations with their distinctive social niches as an evolutionary process or competition amongst members and the existence of contested, over exploited, and underexploited 'regions' in the so called Blau space (McPherson, 1983; 2004; McPherson and Ranger-Moore, 1991).

**Multidimensional space metaphors of politics**

The description of political attitudes in spatial terms is wide spread in society. 'Verbal spatialization' penetrates everyday speech, and has its origin in the need to order different opinions and their relations to each other in a conceptual network (Lakoff, 1987; Lakoff and Johnson, 1980). Terms like 'close' and 'far' have become accepted measures for similarities of values, opinions, attitudes or the degree of accordance with a political position.

The space metaphor of politics is not limited to spatial terminology. Since the first national assembly of the French Revolution, the positioning of political opinions and political actors in a one-dimensional coordinate system between left and right has been commonplace. Postindustrial societies have become more complex and pluralist (Beck, 1984) and the field topology of political opinions has also become more differentiated (see, for example, Giddens, 1994). As a consequence, political scientists employ sophisticated multidimensional models to describe social cleavages and their political mobilization in recent Western democracies (see Kitschelt, 1994; Kriesi, 1993; Lipset and Rokkan, 1967). Kitschelt (1994) employs a two-dimensional space metaphor of politics. In addition to the well-known left – right axis, he adds a second perpendicular axis encapsulating the conflicting notions between 'libertarian' attitudes on the one end, and 'authoritarian' attitudes on the other. The two axes span a Cartesian reference system of politics including two types of independent, but conflicting, political conceptualizations.

Within this political space Kitschelt analyzes the shift of major political conflicts using the left to right, left – libertarian to right – authoritarian nexus within various European countries. In this framework Kitschelt (1994) was able to demonstrate not only the ideological change of social democracy, but also the rise of new nationalist and right-wing movements within the last decade of the 20th century (Kitschelt, 1995). To explain further these political changes Kitschelt (1994, page 27) maps selected occupational groups (eg high-skilled professionals in social and communicative services, employees in commercial services) as a layer into the two-dimensional political space. Doing this for different points in time, he is able to show that the political shift of the main political conflict axes in European democracies correlates with the numerical increase of the groups located in the left – libertarian sector of the political space. Vester et al (2001) present similar findings, but with an inverse direction of explanation. Integrating political attitudes and party preferences into a space metaphor based on 'social space theory' developed by Bourdieu (1979), Vester et al (2001) devise maps of political milieus to compare the sociopolitical structure in different European countries.

There are strong commonalities in the approaches mentioned above: both use a space metaphor to represent sociodemographic differences of social groups, and another space metaphor to differentiate the political preferences of those groups. To explain the observed changes in the political space they compare the two space metaphors in an overlay. From a cartographic point of view, there is a further commonality: both resulting maps are highly abstract, and they lack graphical elaboration.

**Spatialization—a tool for mapping political space**

In the preceding two sections we presented recent discourses in political science and political geography about maps, mapping, and spatial metaphors. The preceding examples of two different disciplinary discourses (geography and political science) show a remarkable divergence in the relevance of graphical representations of spatial relations. On the one hand, traditional choropleth mapping has lost its importance in political geography. It has been substituted by other research foci, such as microlevel neighbourhood or network analyses. Mapping has been replaced with advanced statistical methods,

which are claimed to be more analytic and therefore more 'scientific'. On the other hand, recent research in sociology and political science seems to adopt more and more multidimensional space metaphors for modelling complex social phenomena. Particularly with respect to multidimensional political models, we contend that the traditionally employed univariate and bivariate statistical methods, and the written language to explain the outcomes of such analyses, might be limiting modes of communication. One can observe an increasing demand for graphical exploratory representation techniques, which might be more conducive for dealing with hard-to-conceptualize multidimensional phenomena, graduated differentiation, and complex relations. We believe that novel mapping approaches and cartographically informed spatialization techniques have a high potential to fill this gap. Recent approaches and methods emerging from the areas of knowledge domain visualization (Börner et al, 2003) and mapping (Chen, 2002; Skupin, 2002), information visualization (Card et al, 1999), and geovisualization (Skupin and Fabrikant, 2003), which have improved the visualization of spatial and nonspatial data in a space metaphor (Fabrikant and Skupin, 2005), can be adapted for the demands of social science.

In the following sections we report on our own work on mapping politics within an ideological space metaphor, as one example of how research in political science and political geography might benefit from advanced graphical spatialization methods. We first outline the creation of a multidimensional space metaphor, extracting statistically the principal components of political behaviour in Switzerland. We then discuss the modelling and the depicting of three-dimensional landscapes of this metaphoric space using geographical information systems (GIS). Thirdly, we demonstrate the integration of linguistic data as secondary information into the metaphorical political-landscape model and the depicting of a map of the political landscape.

**Modelling the political space of Switzerland**

There is no doubt about the fact that Switzerland is an excellent laboratory for research on political culture and democracy because of its geographical and cultural diversity, its institutional persistence, and its long tradition of direct democracy (Kriesi et al, 2004). The crosscutting of social and cultural cleavages finds its manifestation in a highly varied regionalized landscape of political attitudes. The country is institutionally organized into 26 spatial units called cantons on a first level, and on a second level into about 2900 municipalities.[(2)] Frequently held popular referenda (approximately nine a year) about political projects give us a spatially finely resolved picture about the geographical variety of political mentalities. Our work directly benefits from these ideal research conditions, which provide an ideal test bed for innovation in electoral geography. We propose a political-landscape model based on an (relative) ideological coordinate system. This model is utilized to investigate voting behaviour in Switzerland. The political landscape is built with the first law of geography (Tobler, 1970)—that is, cities and municipalities that have similar voting outcomes are placed closer to one another in the political space than those with different voting behaviours. We then visualize the political landscape, employing a continuous surface model, in the form of 2D relief maps. A series of such Swiss political-landscape maps were published in a thematic atlas (Hermann and Leuthold, 2003a). The next section outlines the construction details of the atlas maps.

[(2)] The number of municipalities has changed in time owing to mergers in the past decade. For our analysis we had to consort the data with respect to these changes.

**Data from popular referenda**

It is a particularity of the Swiss political system that direct democratic participation of citizens is not limited to electoral votes for parties and candidates, but is also extended to referenda about single issues from everyday politics. About 4 850 000 Swiss citizens decide on up to nine different political issues at the ballot box, about four to five times a year. These issue referenda consider a wide range of topics, such as social security and social welfare, homeland security, national defence, economy, taxes, environment protection, citizen rights, immigration, transportation politics, and gender equality.[3] Popular referenda are held on the federal level. This means that citizens all over the country vote on the same issues. The results of the ballots are counted for each individual municipality. This makes the results of the referenda amenable for regional analysis, as voting issues are brought to four million citizens at once, and voting outcomes are aggregated at a relatively high spatial resolution of about 2900 municipalities. Because of the large amounts of referenda data, including the heterogeneity of the topics, the ideological differentiation covered by these data is much higher than by using election results alone.[4]

Our referenda-based study also stands in contrast to commonly applied questionnaire-based value studies.[5] Referenda data represent real-world decisions, with a direct impact on people's futures, thus they are not derived from potentially artificially derived questionnaires. As a result, the reliability of the referenda data is considered to be very high. Potential methodological problems and artefacts of political value surveys, like the 'social-desirability bias' or the 'spiral of silence' issue (Noelle-Neumann, 1984) can be avoided with referenda data.

One needs to point out that about 75% of federal referenda in Switzerland are claimed by petition. Owing to a relatively low number of required petition signatures (ie 50 000 – 100 000) the claim of a referendum is within reach of even smaller political groups. This particularity of Swiss voting culture needs to be considered when choosing the appropriate method for spatialization. One could argue that the low threshold to claim a referendum guarantees that the referenda data capture a valid image of relevant political conflicts in Swiss society. The variables included in the referenda dataset are a product of ongoing political processes and debates. This may be contrasted with other types of sociodemographic datasets (typically based on questionnaires) where researchers, or governmental agencies, select the variables of interest. While theoretically designed datasets should normally be analyzed deductively by statistical inference, data produced by social (or political) practice are more suitable for inductive analyses.

As input data for our analysis we used results of up to 218 referenda collected in all Swiss municipalities during the period 1982 – 2005. The data are collected and validated by the Swiss Federal Chancellery and are provided by the Swiss Federal Statistical Office (SFO). The dataset contains absolute numbers of registered voters, participating voters, valuable votes, yes votes and no votes for each municipality. For our analysis

[3] For a list of all popular referenda held in Switzerland since 1848, see http://www.bk.admin.ch/themen/pore/index.html?lang=de.

[4] These observations, which are made in the Swiss context, are confirmed by findings from Hodge and Staeheli (1992), who compared issue-voting behaviour and electoral-voting behaviour in King County, Washington State, USA.

[5] Referendum data are available not only for Switzerland, where the tradition of direct democracy is very old. The number of plebiscites held is increasing all over the world for different reasons. Therefore we see a potential for comparative analysis of political landscapes in other countries too. For detailed information about the spread of popular referenda see the website of the 'centre de la démocratie directe' (C2D) at the University of Geneva (http://c2d.unige.ch).

we used the percentage of yes votes relative to the number of valuable votes. The population data and the linguistic information about the individual municipalities are from the Swiss Federal Census 1990, provided by the SFO.

**Factor analysis of referenda results**

Data reduction methods generally applied for spatialization typically include factor analysis (Thurstone, 1947), multidimensional scaling (MDS) (Kruskal and Wish, 1978), self-oganizing maps (Kohonen, 1995) or cluster analysis (Aldenderfer and Blashfield, 1987). Factor analysis was the method of choice for this study, as, specifically, the systematic identification and labelling of the political space dimensions were of highest priority. Factor analysis operates on the basis of correlations between a set of *manifest variables* and helps identify so-called *latent variables* or *factors*, which might explain most of the variance of all the manifest variables. The found latent variables represent the axes of a coordinate system into which all observations are projected. Factor scores extracted for each dimension determine the location of the observations in the projected space. As a result, one can associate meaning to a location in this space (eg top, bottom, left, or right) determined by space axes. The factor analytic approach allows the building of a semantic frame of reference that helps to read and interpret the political landscape.

A potential weakness of factor analysis is the oblique conceptualization of distance between locations in the space. If there are large differences in the variance explained by the factors, then the resulting map exaggerates distances in some directions but compresses them in others. In contrast, MDS might provide a more transparent conceptualization of distance. MDS is based on an input matrix of distances between observations. While this method is able to project the relative input distance relationships into an output space, the labelling of the spatial axes (thus the extraction of meaning) is not as straightforward. The meaning of the axes can be reconstructed from the input data by means of multivariate regressions—for example, by regressing input variables onto the location coordinates of the observations. The decision for using factor analysis or MDS is based on a trade-off between 'external' and 'internal' validity concerns. In the case of the political landscape the research question "what does the position of an observation mean politically?" outweighs the need for a geometrically precise conceptualization of distance. In fact, the output spaces generated with factor analysis or MDS turn out to be quite similar in the case of Swiss voting behaviour. Moser (2005), who scaled the referenda data with MDS, discovered an almost identical spatial distribution of municipalities, but struggled to identify the meaning of the axes.

The dataset used for the empirical analysis consists of 218 metrically scaled variables (percentage of yes votes) at 2896 municipalities (observations). The factor analysis results computed on various subsets of the database suggest that political conflicts in the Swiss direct democratic system yield a stable three-dimensional political space. In a first analysis we integrated all 218 variables. The scree plot of eigenvalues indicates that three factors explain a substantial amount of the overall variance (48%) and thereby stand out against the rest of potential factors. In a second analysis we split the database into two subsets. In one subset we included all 101 referenda from 1981 to 1993. The second subset includes all 117 referenda from 1994 to 2005. The factor analyses computed on both subsets separately produced the same three-dimensional structure as the analysis, containing all variables. The overall variance explained is 49% in the first subset (1981 – 1993) while 52% is explained in the second subset (1994 – 2005). Factor loadings in the two subsets correlate highly with the loadings on the analysis including all variables. The average Pearson correlation coefficient ($r$) is 0.97

(first subset) and 0.99 (second subset). In a third analysis we drew a random sample of 93 variables, which again produced very similar results (variance explained: 49%, correlation with superset: 0.99). The stability of the factor structure over a period of twenty-four years facilitates a longer term perspective.

The strength of the factor analytic approach is its potential to identify a semantic frame of reference by interpreting the factor loadings. To achieve this objective it is recommended to rotate the factor space (Thurstone, 1947). A factor rotation does not change the overall variance explained by the model, but maximizes the variance of the factor loadings and produces a so-called 'simple structure' (Thurstone, 1947). The idea behind this is to produce a parsimonious model with as few variables as possible that explain most of the variance, instead of spreading the variance over too many variables. Factor rotation can either be orthogonal or oblique. We applied both types of rotation: orthogonal VARIMAX as well as oblique PROMAX rotation. Generally, oblique rotation is preferred (Fabrigar et al, 1999), because important latent variables do not necessarily need to be independent. However, experts also suggest the use of orthogonal rotation, especially if the factors have close to zero correlation between one another (Fabrigar et al, 1999). This has been the case for this study. The inter-factor correlations after an oblique PROMAX rotation are $-0.01$, $-0.09$, and 0.21, respectively. The fact that the result of an orthogonal and an oblique rotation are quite similar indicates that we have found a political space with three nearly independent dimensions, which subsequently can be treated independently. After rotation the share of variance explained by each factor is almost the same ($f1$: 16.9%; $f2$: 15.8%; $f3$: 15.1%).

**Analysis of referenda issues for interpretation**

As mentioned earlier, a key feature of factor analysis is the interpretation of the factors. Typically, one compares factor-loading patterns across the input variables to identify latent variables (eg which variables load high on certain factors and low on others). In our case this procedure did not seem sufficient, owing to the large amount of variables, and the heterogeneity of the voting issues. We decided to apply a more systematic approach, which is described in detail in Hermann and Leuthold (2001). The approach can be outlined as a factor interpretation based on content analysis of meta-information on the variables. The metainformation we analyzed were official brochures of the Swiss Federal Chancellery,[6] containing the main arguments of the procommittee and the contracommittee. Based on a qualitative content analysis of the brochures, a catalogue of thirty-six categories was defined (see Mayring, 1988). Each category stands for a specific political goal. The categories (political goals) were then assigned to the analyzed text passages. By assigning political goals to the referenda, an average factor loading of each political goal could be calculated. Finally the interpretation and labelling of the factors was based not simply on the raw variables, but on a systematic content analysis of metainformation (see figure 1).

**Three dimensions of Swiss politics**

The first factor was labelled *left versus right*. It represents political conflicts concerning public redistributions, social welfare, and economic self-responsibility, but also includes conflicts about civil rights and military defence. A 'left' attitude in our understanding means a preference for social distribution and a critical position about governmental authority and control. The 'right' attitude is the opposite of left, meaning preference for competitive distribution, and the maintenance of law and order by the government.

[6] http://www.bk.admin.ch/themen/pore/index.html?lang=de.

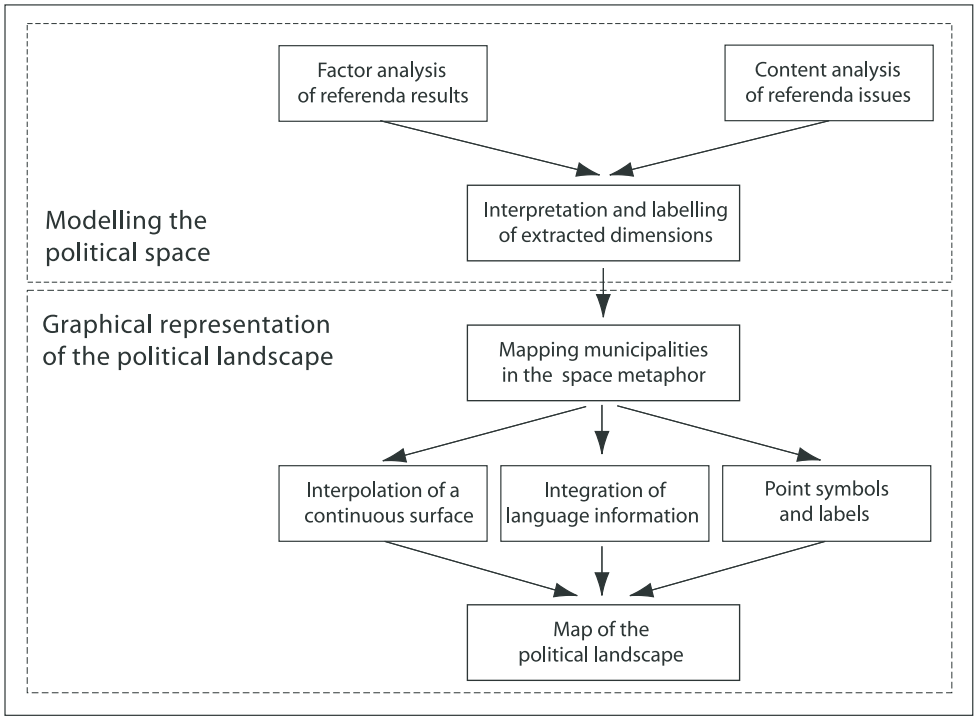


**Figure 1.** Schematic overview of the different working steps of statistical and semantic data reduction, interpolation, and graphical representation for modelling maps of metaphorical political landscapes.

The second factor was labelled *liberal versus conservative*. It represents conflicts concerning institutional reforms and internationality, including openness versus the exterior, and integration of foreigners and immigrants. In our definition a liberal attitude stands for a progressive, reformist, and international political mentality, while a conservative attitude stands for the preservation of traditions, scepticism versus reforms, and restriction for immigration. The third factor was labelled *ecological versus technocratic*. It represents the conflicts about protection of the natural environment or exploitation of natural resources.

The result of our inductive approach is a very stable three-dimensional ideological space of Swiss politics (see figure 2). The findings correspond highly with the outcome of recent deductive approaches, which postulate the multidimensional structure of political conflicts based on theoretical considerations. The first two dimensions represent the same axes as the deductive model of Kitschelt (1994) described earlier. Our empirical study confirms the theoretical assumptions made by Kitschelt about the existence of a second dimension of political differentiation.

The third dimension, including the ecological and technocratic attitudes, seems to be a particular political phenomenon in Switzerland. As discussed elsewhere, this third dimension follows the linguistic cleavage between French-speaking and German-speaking regions in Switzerland and has its origin in a culturally different conceptualization of nature (Hermann and Leuthold, 2003a; 2003b; see also Brechbühl and Rey, 1998).

**Graphical representations of the political landscape**

Owing to the statistical independence (orthogonality) and the metric scale of the factor loadings and factor scores, we can utilize the three identified dimensions as axes of a

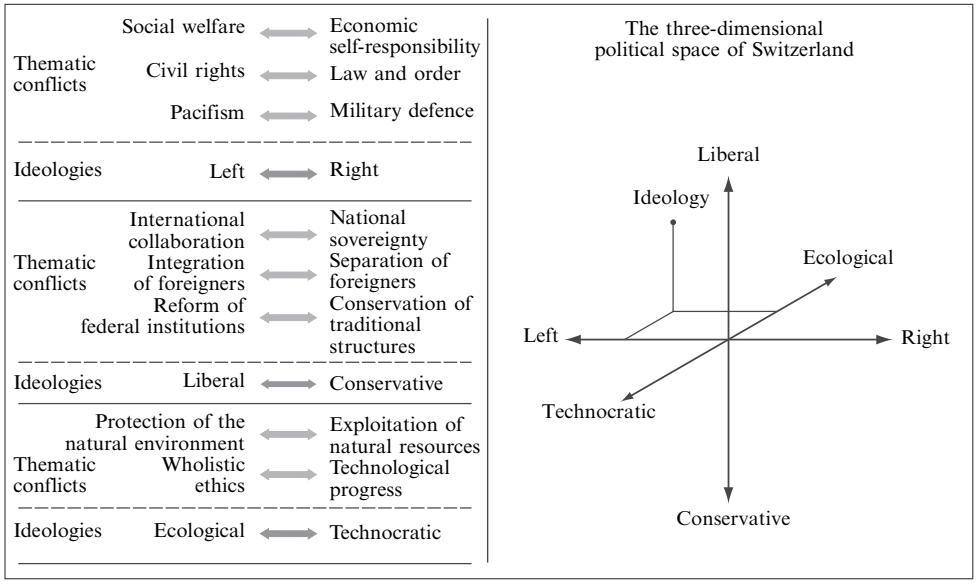


**Figure 2.** Thematic conflicts and ideological labels of the three extracted factors, which constitute the three dimensions of the political space of Switzerland.

Cartesian coordinate system to depict the political landscape of Switzerland. This semantic coordinate system allows three different types of analyses:
(1) Location of political attitudes within the ideological coordinate system and analysis of their similarities and dissimilarities. Political actors, such as parties, politicians, associations, etc, can be mapped into the space for further analysis.
(2) Prediction of voting outcomes and campaign planning. For example, political projects can be decomposed into their respective ideological factor loadings that might frame the public discussion about the project.
(3) Explanation of regional political mentalities and political culture. When calculating factor scores of the observed spatial units, these units can be mapped into the political landscape, and their position can be explained with socioeconomic variables.

The first two types of analysis are useful for political research, consulting of political actors, and for civic education. The third type is more interesting for geographical research, as it supports the identification of regional mentalities, and assists in revealing the spatial pattern of political cleavages. In the next section we concentrate on this third analysis type, and demonstrate how the topography of the political landscape can be depicted using cartographic modelling and representation techniques.

Maps typically are two-dimensional representations of phenomena of the Earth's surface. It is also common to visualize the Earth's undulating surface with so-called 2.5D representations—that is, perspective '3D-looking' views. Truly three-dimensional structures would require interactive depiction mechanisms to be able to overview the entire structure. For the reason, the generated three-dimensional political space is split up into two-dimensional pairs. Two perspectives that are particularly useful for the analysis are left versus right combined with liberal versus conservative, and left versus right combined with ecological versus technocratic. Within the scope of this paper we focus on the first perspective with the dimensions left versus right and liberal versus conservative, as it possibly yields the greatest explanatory potential. We have shown in relate publications (Hermann and Leuthold, 2003a; 2003b) that the third dimension

(ecological versus technocratic), which we will not discuss further, mainly distinguishes between the French-speaking and the German-speaking parts of Switzerland.

**Modelling the political landscape**

Cartographic modelling of the political landscape consists of three basic design steps: (1) projecting the voting units as points into a Cartesian coordinate space; (2) calculating a density map to represent a continuous ideological surface; (3) delineating ideological zones of concentration by integrating secondary information about the mapped spatial units (eg socioeconomic variables or spoken language within voting districts); and (4) inclusion of standard map elements, such as symbols, to represent geographic features (eg cities), labels, legends, and map marginalia (eg dates, data sources).

**Point maps**

We first created a traditional symbol map, which looks like a two-dimensional scatterplot, where every municipality is represented by a dot. The positions were determined from the calculated factor scores. The coordinate axes are represented by our primary two factors (left versus right and liberal versus conservative).

The scatterplot map [figure 3(a)] shows a concentration of municipalities in the right–middle sector of the ideological space, while the left–liberal corner is sparsely populated. This suggests that there are fewer municipalities dominated by a left–libertarian ideology. In figure 3(b) we scaled the points proportional to the population size of the municipality to better convey the population distribution in the political landscape. Even though the left–liberal sector has fewer municipalities than the other sectors, one can see that more people are represented in those municipalities. The respective dots represent all major cities in Switzerland. There is a noticeable gradient in population magnitude from the left–liberal towards the right–conservative sectors, along the diagonal of the ideological space.

**Interpolation of a density surface**

Graduated circle maps normally give an appropriate representation of the distribution of variable-sized objects. However this is not the case if the number of visualized objects is very high. If objects overlap strongly—as the 2896 municipalities in the political space do—the distribution is not as clear. In this case, the principal of a density surface is an alternative means of representation. Classic spatial analysis methods allow the transformation of point configurations into smooth surfaces, which visually emphasize the density distribution of objects. One of the standard methods to generate a density surface is kernel smoothing (Bailey and Catrell, 1995). Kernel smoothing creates a smooth map of density values in which the density at each location reflects the concentration of points in the surrounding area. The concept of kernel smoothing can be used to generate a density map of the objects in the political space, which visualizes in a smooth manner the discrete distribution of the municipalities.

Kernel algorithms in commonly available GIS—for example, ArcView GIS—typically work with fixed bandwidth, which means the density distribution of each object has the same range. This restriction is appropriate if each object has the same or a similar weight. In our analysis the objects (municipalities) vary largely from small villages to large cities. The bandwidth should therefore be variable. We developed a kernel algorithm with an individual bandwidth for each object. The bandwidth is proportional to the weight (in this case the number of inhabitants) of the object (see Silvermann, 1986).

The used kernel algorithm is described in figure 4. The algorithm calculates a Gaussian bell curve for each municipality proportionally scaled to a weight, in this

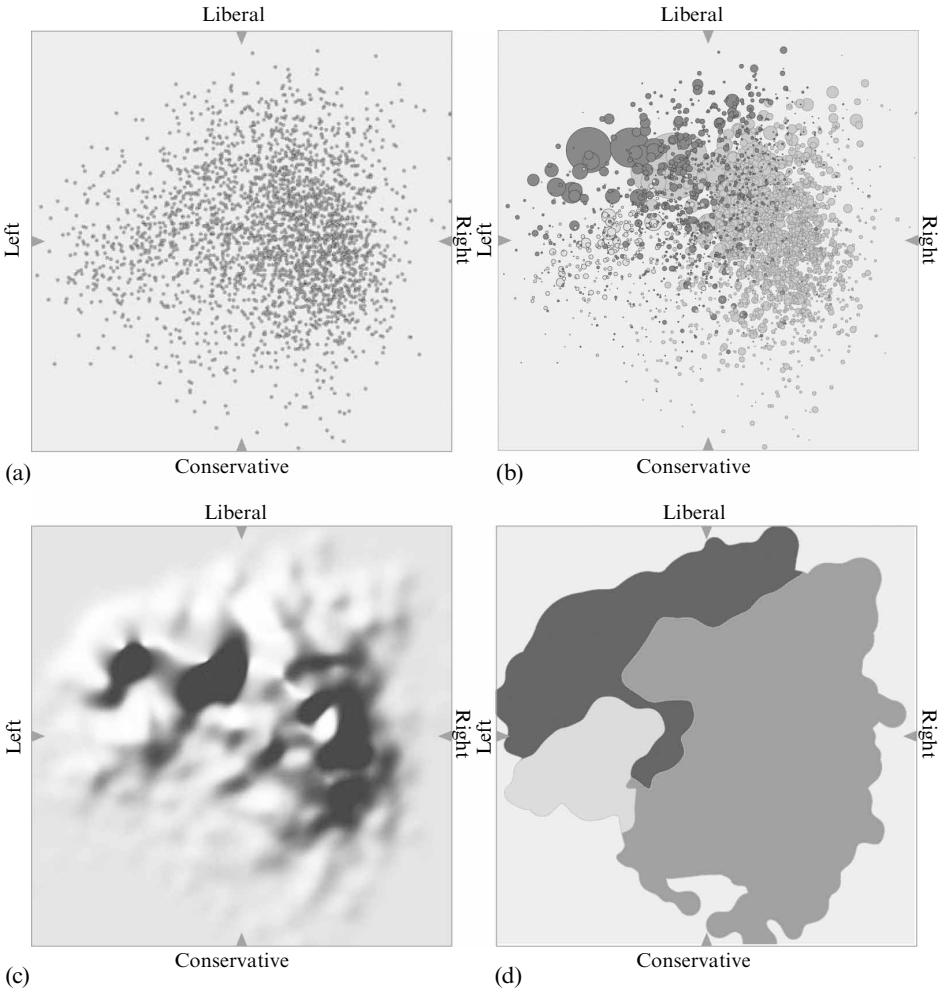


**Figure 3.** Four steps of modelling the political landscapes: (a) single scatterplot; (b) graduated symbol map of population; (c) hillshaded density surface; (d) and zones of linguistic dominance.

case the number of inhabitants per municipality. In a second step all bell curves are superimposed like sedimentary layers to create the topography of the density surface (see figure 4).

Using standard GIS functionality one can easily generate a shaded relief map of the density surface [figure 3(c)] and derive elevation contours. The resulting continuous surface shows peaks and valleys, ridges, and planes of the political landscape in Switzerland. We generalized the map further, by assuming a minimum density threshold. Locations of the landscape with a summarized population size below a threshold of fifty inhabitants are considered 'at or below sea level' and are depicted in blue in figure 5.

**The colours—linguistic diversity in the ideological space**

The most remarkable characteristic of this ideological landscape of Switzerland is the clear demarcation of the existing geographical boundaries dividing the country along the three major linguistic regions: German, French, and Italian. These linguistic regions are contiguous in geographic space, and the borders between them are almost crisp. Historically, the linguistic division of the country has always been an important factor in Swiss politics, even though in some periods in time it has been more

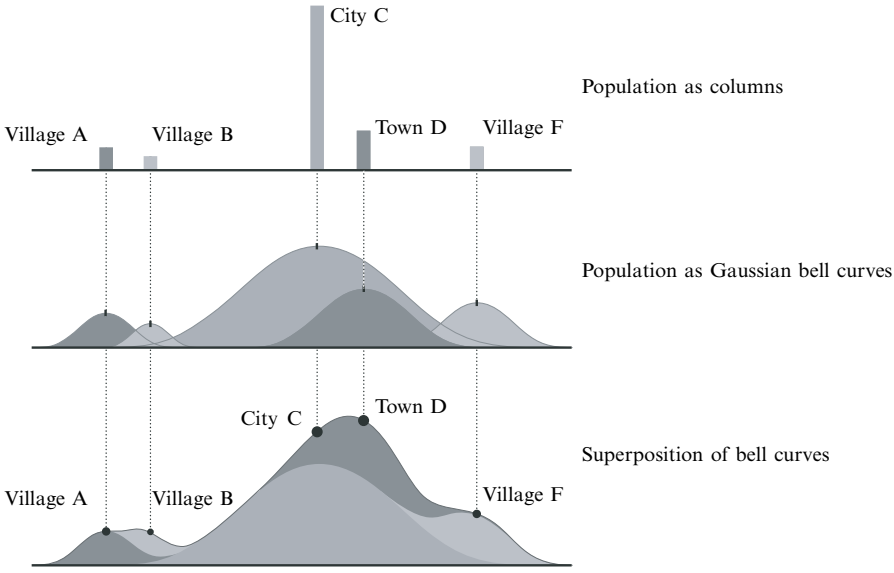


**Figure 4.** Schematic illustration of the modelling of the density surface by superposing single bell curves.

pronounced, in others less so (see Büchi, 2000; Hermann and Leuthold, 2003a; 2003b; Kriesi et al, 1996).

Owing to its importance, it seems relevant to integrate the spoken language as a secondary variable into the political landscape model. Because the linguistic regions overlap at a few locations of the ideological space, we used the concept of linguistic dominance. First, we calculated for each municipality the percentage for each language, and then we identified for each location the majority language. As a result we can identify three distinct zones of linguistic dominance in the political landscape, which are rendered with different colours.

**Labels of cities and regions**

The continuous surface serves as a base map of the political landscape. Its peaks and valleys show the structure and the quantitative distribution of political attitudes. One potential of a smoothed density surface is that its gradual shape allows the overlaying of additional graphic layers. Dot maps with a high number of objects, by contrast, have a look that is too edgy for overlaying further layers. By overlaying the density surface with vector data, specific information about municipalities and regions can be visualized. Using standard cartographic design principles we identify the location of the city with point symbols, and represent differences in population magnitude by scaling the label sizes accordingly.

The resulting ideological map of the Swiss political landscape looks like a topographic map (see figure 5). The country appears as an island with mountains, plains, peninsulas, bays and inlets. Instead of the cardinal directions (North and South) typically used for navigation, map readers orient themselves within the differentiation between liberal and conservative attitudes; instead of the traditional directions east and west, right-wing and left-wing attitudes. The correlation of the linguistic divide with political attitudes is evident in the map. The French-speaking part (red) is located farther on the left side than the German-speaking majority (green). The Italian speaking part (yellow) dominates the left – conservative sector. The highest peak of the island is located in the left – liberal sector, where the five cities with over 100 000 inhabitants

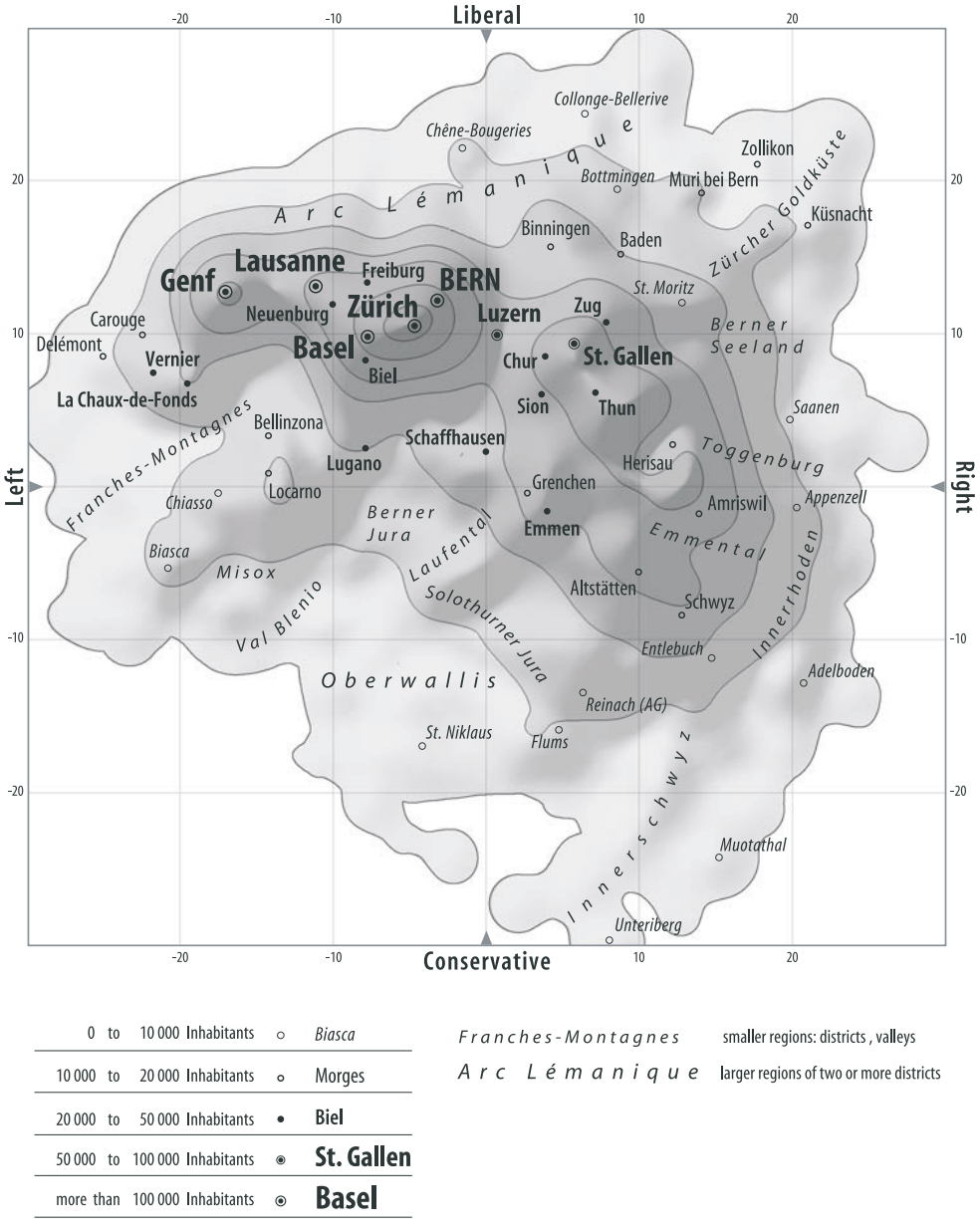


**Figure 5.** Map of the Swiss political landscape (source: Hermann and Leuthold, 2003a; page 59). A colour version of this figure is shown on the *Environment and Planning* website at http://www.envplan.com/misc/b3304t/.

are located. The urban centres Zürich, Basel, Bern, Lausanne, and Geneva are clustered together. This suggests a left–liberal ideology as the typical urban attitude. Also located in the liberal zone, but farther to the right than the largest cities, we find the affluent suburbs. Small German-speaking towns, rural areas, and alpine villages dominate the coastal plane on the other side of the space, located in the conservative half of the landscape.

## Discussion

### Advantages of a metaphoric spatial model of the Swiss political landscape

The first maps of the Swiss political landscape were published in autumn 2003 and found a broad echo in the media. They show the country in an unusual view, but within a familiar cartographic style. The presented spatializations of voting behaviour in Switzerland feature two types of innovations aimed at bridging two disciplines. First, they integrate actual knowledge about political behaviour, political change, and the diversification of political attitudes from a political sciences perspective. Additionally, the maps are based on advanced cartographic modelling techniques, using GI Systems for depiction. Perhaps this interdisciplinary approach has been key for the public acceptance of such abstract displays. In the following section we discuss firstly the scientific benefit of our spatialization model for the different disciplinary perspectives, and secondly we report on our initial experience with display acceptance and understandability through the public.

### A multidimensional view on politics

Encouragingly, the outcome of our inductive approach corresponds highly with the findings of state-of-the-art political science research, typically of a theoretic – deductive nature. In accordance with the theoretically deduced Kitschelt (1995) model, we found an additional independent dimension of political differentiation, which we call the liberal – conservative axis. This axis divides society across the traditional frontlines of the left (socialist) versus right (capitalist) political dimension. These similar results were achieved with significantly different methods. The stability of the resulting pattern, in spite of diverging methodological approach, perhaps suggests the validity of the model. The primary distinction of our exploratory approach is that the dimensions were not fixed a priori, but emerged from the data reduction analysis technique employed.

Our empirical results make a strong case for the current hypothesis of multidimensionality of politics. The existence of a second dimension of ideological differentiation is not only apparent on the level of political parties, but also in the electorate itself. As mentioned earlier, we also found a third, new, dimension of differentiation: the axis labelled ecological versus technocratic. This political frontline seems not to have been considered previously as an independent dimension of political differentiation in political science. It is usually considered as part of the 'new political dimension' between postmaterialist, left – liberal values versus traditional, and materialist, right – conservative values (Inglehart, 1971; 1977). We believe our empirical results suggest that the ecological axis exists in society as a discrete dimension, but it is not articulated, as such, as an independent conflict line in institutionalized politics.

A metaphorical political space is a useful tool with which to conceptualize the multidimensionality of political attitudes. It allows us to organize ideological diversity within a systematic framework. Particular political attitudes can be fractioned into different subcomponents and these can be compared to other relevant subcomponents. Similarities or partial relations between apparently divergent ideologies—for example, those between green parties and the liberals—can be identified, and analyzed based on their social origin. The extension towards relational and topological conceptualization of political thinking seems an important step towards the usability of the spatial model. It is not sufficient to analyze the relative positions of ideologies within a space, without having a well-understood semantic system to describe the space. We contend that, with our model, existing political differences between left-wing liberalism and a right-wing liberalism, or between right-wing conservatism and a left-wing conservatism can be meaningfully externalized for further analysis. Both the spatial model of

political attitudes, and the respective terminology, have great potential for more precise handling of the ideological complexity of advanced capitalist societies.

**Generalization and focusing**

The above-mentioned innovations for electoral studies and the analysis of political change do not essentially depend on specific graphical representation methods or knowledge-mapping tools. However, the graphic representation of the spatialization is a crucial component of our approach, specifically the integration of different levels of detail into the same model and the respective visual communication of this integration. Following Agnew's (1996) concerns of a political geography that integrates the dichotomy between the 'universal' or 'global' and the 'specific' or 'local', we consider in our approach 'context' always as an overlapping interaction of global processes and local particularities. In doing so, we depict different spatial scales and levels of detail of the mapped phenomenon as different visual layers. Particular attention is given to the cartographic generalization to visually emphasize underlying global trends. For the global structure particularities due, for example, to specific cultural or historical or other circumstances have to be considered as noise when exploring the global structure. The surface interpolation method applied can be seen as such a generalization. At the most general level, the smooth continuous surface communicates the overall distribution of the Swiss population in the political space, highlighting dominant linguistic divisions within the country. More specific information is depicted only on a more detailed level. This information refers to effects of the local context, such as specific social conditions, economic dependencies, cultural heritance, including collective consciousness, and memory. In our political landscapes local details are mapped through the positioning and labelling of regions, individual cities, towns, and villages at various cartographic scales.

The multilevel approach allows us visually to identify anomalies of political mentalities due to a particular social structure in a small town or village. 'Outlier' voting patterns can be detected below the global structure at the localized level, which can be explained, for example, by the presence of a nuclear power plant, a military base, an important railway depot, or a tourism resort whose employees have a special education and a particular collective mentality. On a higher level of analysis we can detect regionalized political cultures, which might have their origins in their specific history, in a certain constellation of religious and/or linguistic majorities and minorities. Once these cross-level effects have been visually detected in the spatialization they can be operationalized for further quantitative multilevel analyses.

**Comparative perspective**

A comparison of a regional structuration and differentiation is an inherently geographical task. There is an existing set of quantitative indices to statistically measure diversity, dissimilarity, or concentration—such as the index of segregation by Duncan and Duncan (1955), the concentration index developed by Gini (1912), or the nearest-neighbour index by Clark and Evans (1954). Such kinds of indices are useful for description and comparisons of population structures over time. Simplicity is a major advantage of such global indices. This is contrasted with a loss of information about potential underlying complex spatial relations, which might only be detectable at higher levels of detail. Comparisons of graphical representations at various levels of detail have the advantage that within-level and cross-level variations can be investigated. Once possible relationships have been detected through the maps in abductive fashion, they can be analyzed further with respective statistical tools.

To foster this comparative approach we visualize the political landscape of Switzerland as an atlas—that is, a series of separate maps, at different spatial scales.

The regions appear as 'islands' or 'archipelagos' in the 'sea' of politics, each with a unique 'morphology' and 'coastline'.

One key way in which the cartographic map metaphor is violated is that the large-scale political landscape maps are not spatially contained within the small-scale maps, as one would expect when zooming into a geographic landscape. While the same statistical parameters are used for all levels, the subspaces are calculated separately, at scale, considering only the municipalities of the focused region. However, the visual cross-comparison between the larger scale maps is facilitated by a common graticule based on the ideological coordinate system. On all larger scale maps the silhouette of the entire landscape is depicted as a backdrop in a brighter blue colour, akin to a 'continental shelf' in a cartographic map.

The spatial unit for analysis in our case study of Swiss voting behaviour is the canton, of which there are twenty-six in the country. Cantons are similar to US states in that they have traditionally had great autonomy to organize their political institutions and party structure. Inspecting the political landscape we notice that even though the institutional diversity has a great impact on the party alignments, the political attitudes themselves seem not to be affected. In other words, the spatial distribution of the political attitudes correlates more strongly with the socioeconomic structure and the urbanity of the milieu, than with the political infrastructure. Cantons containing urban zones are more alike in political attitudes than cantons dominated by rural or alpine areas, regardless of their political structure. The maps in figure 6 show the political landscapes of the cantons of Zurich and Basel, containing large urban areas. Both agglomerations have the same triangular structure, which can be considered as an ideal type. The core city in the canton (Zurich and Basel, respectively) is the municipality with the most leftist attitude, and is located in the left–liberal sector of the ideological space. Its rich suburbs are located in the right–liberal corner. While Zumikon, Zollikon, and Küsnacht are geographically adjacent to the city of Zurich, they are further apart in the ideological landscape. These municipalities are typically preferred zones of residence by those in the high-income-tax brackets, attracted by low-income-tax rates. The same pattern can be observed in the Basel region, with the rich suburbs Bettingen, Oberwil, and Bottmingen. In the right–conservative sector we find the so-called 'periurban zones'—that is, mostly smaller villages at the frontiers of the highly urban zones. In these municipalities the traditional rural structures still persist, even though most of the inhabitants commute for work to the core city.

**Ground truth: impact and acceptance by the public**

Whether developing new theoretical frameworks or presenting novel visualization methods certain key questions remain: To what extent is the approach accepted? Is it understandable also for the nonspecialist? What is the real impact of this type of method? Answers to these questions can be found by exposing scientific findings to the stakeholders of the investigated field. In such an approach of 'ground truth', the validity and plausibility of a model can be tested. For example, if those who are reordered and depicted within a space metaphor can recognize themselves within it, and explain their relative location in the space with their everyday experiences, then one could argue that the model is indeed understood by these stakeholders, and more importantly, that this model is not only a theoretical construct produced by data handling and data transformation techniques, but also depicts a reality that the stakeholder perceives to be true. In our case the stakeholders are political analysts, politicians, officials from government, and political parties, but also the general public. They all are actors in the political field and therefore involved in the production of the referendum results, which are the empirical bases for the constructed political landscape.

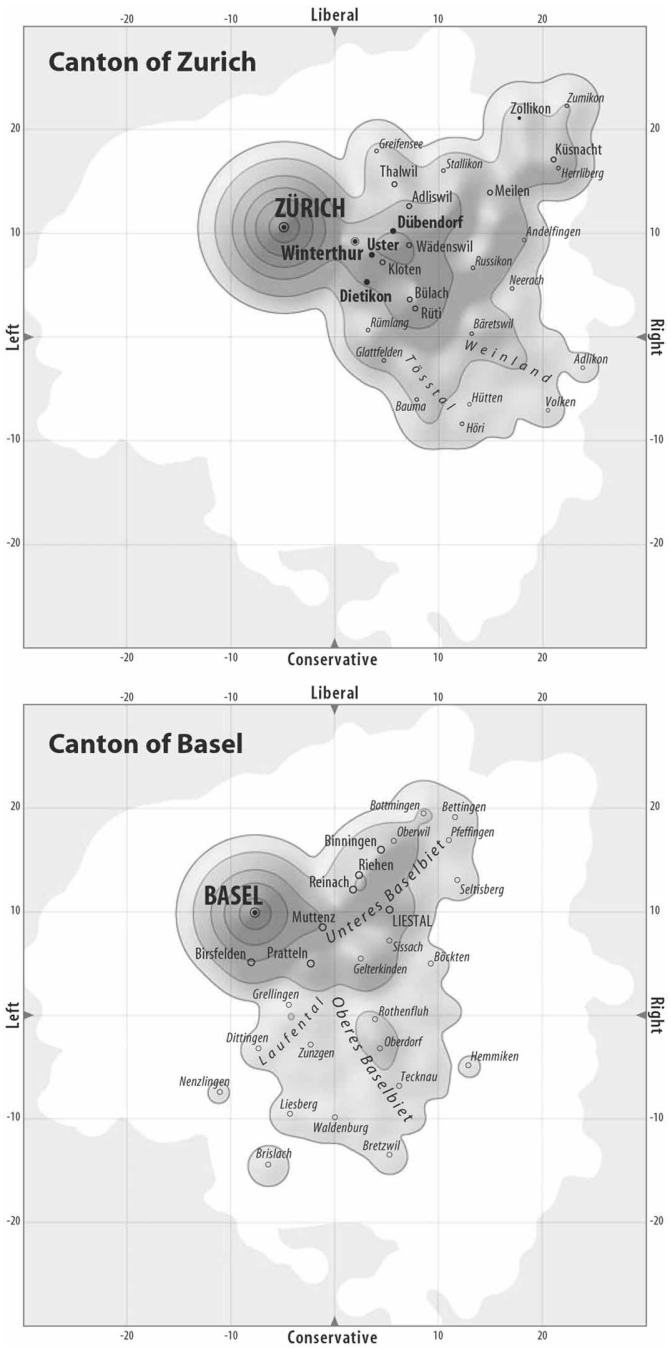


**Figure 6.** Comparison of the extension of two urban agglomerations (Basel and Zurich) in the Swiss political landscape (source: Hermann and Leuthold, 2003a, pages 61 and 71).

The publication of various spatialized views of Swiss politics in the "Atlas of political landscapes" (Hermann and Leuthold, 2003a) was well received by the media. More than forty national and regional newspapers printed one or more maps, and discussed their meaning and information content in a public discourse. This allowed additional first insights into the understandability of this work by a nonscientific audience.

The wide range of map interpretations by different authors (eg journalists) with varying backgrounds, and from different regions, was of great interest for us.

Direct interactions and confrontations with stakeholders provided a second source of feedback. We presented our findings in different regions—for example, at conventions of different political parties, or at various association meetings covering the whole political spectrum. This direct feedback in different contexts can be seen as a kind of ground truth of the proposed model and the maps. We were specially impressed by the ready acceptance of the spatial metaphor by the public. Presented with the ideological maps people began to shape their arguments within the frame of reference provided by the political space of in front of them. Regardless of education level, regional origin, political attitude, or party affiliation, people recognized themselves within the ideological space of Switzerland, and concurred with the presented topography of the Swiss political landscape. Quite often people mentioned that the mapping of their own area was congruent with their own perception of the political situation, and explained the visible structure through specific local knowledge about the region.

Additional evidence for the acceptability of our approach by the public is the transfer of the method to various educational settings. For example, some maps of the published "Atlas of political landscapes" are used by civic education teachers or by governmental institutions—for example, to explain particularities of the Swiss political systems (eg Schweizerische Bundeskanzlei, 2004). Some maps are now integrated into a new edition of a school atlas, which is commonly used for teaching geography at the secondary school level (Westermann Schweiz, 2006).

Developers of so-called 'smartvoting engines' on the Internet (Trechsel and Mendez, 2004) integrated the two-dimensional model of the political landscape in their platform for interactive candidate selection and candidate evaluation.[7] After a user has generated his political profile by answering a series of questions, a map is generated on the fly depicting the position of the candidates and the user in the political space, compiled on the political profile comparisons. This allows the user visually to identify candidates in close ideological proximity (Rouiller et al, 2004).

This broad acceptance of the spatialized maps of politics by the public, the interdisciplinary knowledge transfer, and the publicly accessible applications of the spatialization model might suggest a good starting point for systematically assessing the validity of the graphical representation of the political landscapes indicators further.

**Conclusions—the potential of spatialization for social science**

In this paper we discuss the increasing number of applications using spatial metaphors for politics, and argue for the need for such models due to the increased complexity of political cleavages in postindustrial societies. Complexity increase is not limited to political issues, but extends to most social phenomena. The popularity of multidimensional spatial models is also a result of changing conditions in empirical research. Important factors are the significant increase in available data, and the availability of new data types, including respective digital processing methods (eg automated text analysis techniques and image processing tools).

Traditionally, social scientists have used a deductive research design, led by research hypotheses, operationalized with indicators and variables, measured on adequate information levels (typically within a data-poor environment), and subsequently tested inferentially with appropriate statistical analysis methods. Under actual data-rich conditions we observe in certain domains an abundance of available, often inadequately documented, data, which need first to be sifted and tested for applicability for specific

[7] For an example see http://www.smartvote.ch/.

research questions. This situation calls for a more exploratory, abductive approach to research. A 'renaissance of exploration' has been more recently observable in the social sciences, with a trend away from the strict deductive analytical research designs towards a more inductive and interpretative research understanding. It should be noted that data exploration is not applicable to all aspects of research. Abductive methods that lead to researchable hypotheses about relationships or even causalities have to be embedded within a broader theoretical context. Therefore it is necessary that visual data exploration is performed by social scientists themselves, and that the exploration process is always guided by sound theory.

Many of the current spatialization displays and knowledge domain maps of social phenomena have been designed typically by methodological specialists—such as information scientists, computer scientists and GI-scientists—whose primary interests have been in the methodological and technical challenges of spatialization. In these research communities the meaning of the displays and the theoretical consistency of many spatialization models are of the secondary importance, and are often not sufficiently investigated.

Spatialization based on sound social theory and a longstanding cartographic depiction technique provides a systematic and fruitful methodological framework for understanding social phenomena. Its strength lies in the high adequacy for the conceptual modelling of multidimensional and relational phenomena, and for the well-understood depiction principles provided by the cartographic language. The mostly linear structure of written language can be complemented with the parallel processing of graphically presented information; an arguably cognitively more adequate form for the description and understanding of multidimensional relationships.

**Recommendations for the application of spatialization in social sciences**

In this paper we showcase the potential of spatialization for political geography based on the modelling of the Swiss political landscape. This model requires methodological considerations about statistics, GI systems, and cartography, as well as a theoretical understanding of the phenomena to be mapped (eg theories of political cleavages, including social and political change). Based on our experiences with political phenomena in Switzerland, we conclude this paper with recommendations for the successful use of spatialization in the social sciences.

*Meaning and labelling of the space dimensions*

A key feature in our spatialization approach is the meaning and labelling of the space dimensions. Contrary to exploratory database spatializations (Card et al, 1999), spatializations of social phenomena that rest on established social science theories—such as vertical and horizontal stratification (Bourdieu, 1979), differentiation of lifestyles (Vester et al, 2001), degrees of postmaterialism, or maturity of democracy (Inglehart, 2000)—require a systematic interpretation of the number and the meaning of the used dimensions. The meaning and labelling of the dimensions is not only very important for interpretation of the map, but is also relevant for the spatial terms used to explore the space, such as next to, higher, lower, far away, opposite to, and between. These terms must be embedded within a specific theoretical framework so that the phenomenon can be compared across theories. The careful interpretation and labelling of the space dimensions requires access to metadata, and more detailed information of the data production context.

*Embedding in a disciplinary discourse and theoretical tradition*

In order to gain acceptance for a new modelling, representation, and communication methodology in a scientific community, it is essential to show the interoperability of

the proposed new model with established models and theories. When developing spatialized models, special attention should be given to the relationships with and integration into the existing theoretical discourses in the specific disciplines. Even if the spatialization serves only for an initial abductive device for exploration of the phenomenon, data exploration, interpretation, and building of further hypotheses should still be theoretically guided. Spatialization seems to work particularly well as an integrating method in an interdisciplinary domain in which spatial metaphors already exist, either for the description of the phenomenon—such as comparative political analyses (eg Kitschelt, 1995), social structure, and lifestyle analyses (Bourdieu, 1979, Vester et al, 2001)—or where spatial concepts seem to exist to structure abstract thought (Lakoff, 1987; Lakoff and Johnson, 1980).

*Adequacy of the used cartographic features and graphic semiology*

The cartographic language is a very powerful instrument for communication. Besides its suitability to describe relations within multidimensional frameworks, the possibility for multiple graphic overlays, including the widespread use of maps in the general population, is a major advantage of the cartographic language. The intuitive power of maps (or other graphic displays) bears inherent dangers of misunderstanding, misinterpretation, and miscommunication. As discussed elsewhere it is imperative to pay particular attention to the graphic quality of the spatialized displays—this includes the correct application of graphic variables, the appropriate use of symbols, and the extensive use of labels and explanatory text in legends, marginalia etc (Fabrikant and Skupin, 2005; Skupin, 2002).

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