

Finding Spatial Barriers by Monmonier's Algorithm

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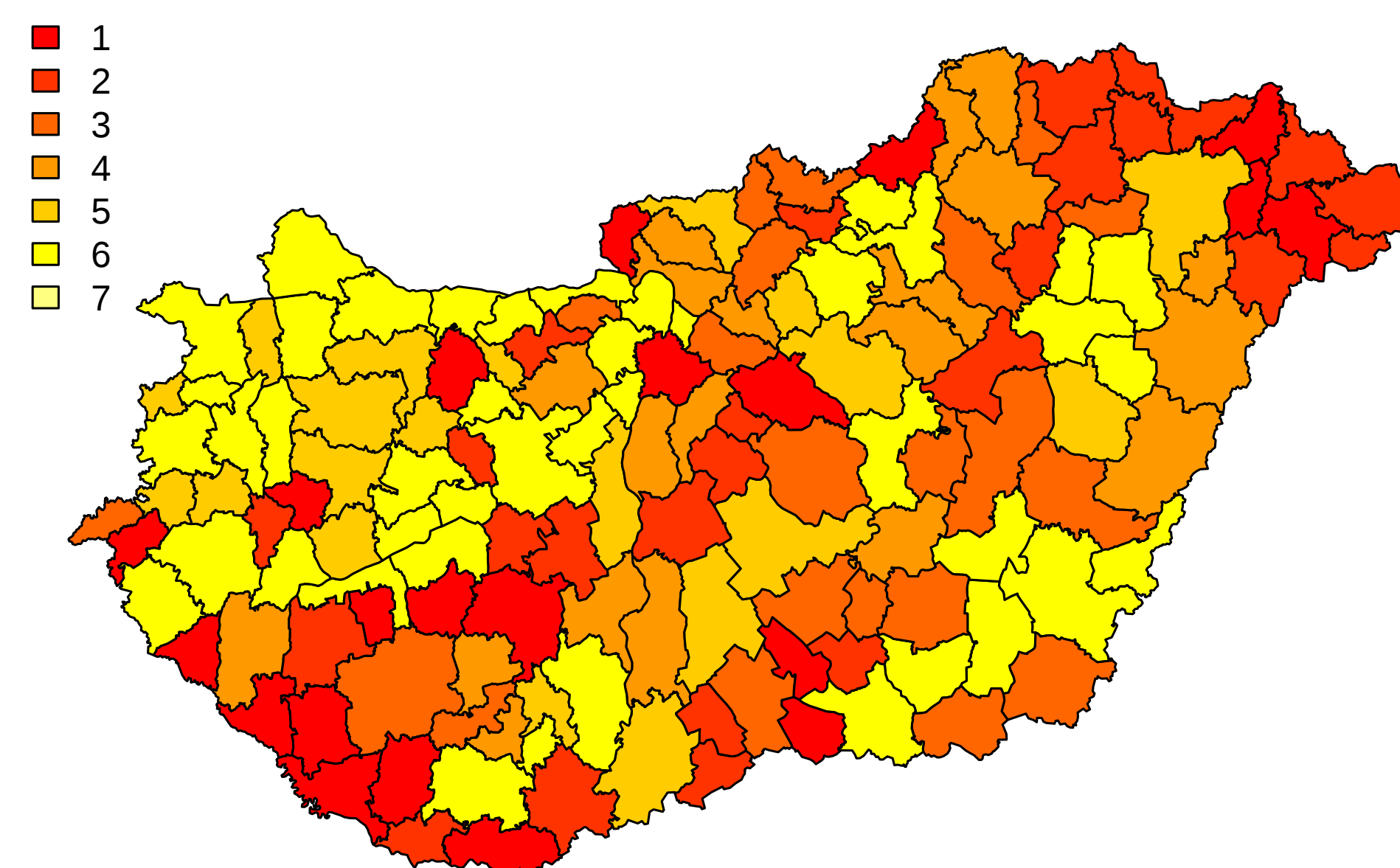
Introduction

The vast majority of explorative spatial methods is based on smoothing techniques. The underlying assumption is continuity of spatial processes and phenomena, i.e. that variables are changing continuously in space and time. In some cases in spatial epidemiology the assumption of discontinuity seems to be more realistic. E.g. the range of vector-borne disease depends on the niche of the vector that may not be continuous. Geographical features like lakes, rivers, or different types of vegetation (e.g. a forest) may also act as barriers in relation to certain diseases. Genetic differences also can build up barriers between neighboring areas (Manni, 2004). In these cases, seeking for barriers is a more adequate method to explore spatial patterns than methods assuming smooth continuous changes. Identification of barriers between neighboring areas may help to generate hypotheses on etiology of the disease and may be used in planning of disease control strategies. We propose Monmonier's maximum difference barrier seeking method (Monmonier, 1973) as a technique to determine borders between neighboring areas. To our best knowledge, no application of this method in epidemiology has been published up to now. We regard this method as a counterpart of the widely used smoothing techniques. Finding barriers can also be considered as a special approach to cluster analysis. If barriers are found, identification of the underlying phenomenon can help in eradication or prevention measures. Using the method within a longitudinal study, a further question may be whether barriers are permanent or how they change in time. As an example demonstrating the advantages of the proposed method, we present the analysis of standardized mortality ratios at micro-region level in Hungary (Klinger, 2003).

Materials and methods

Standardized Mortality Ratios (SMR)

The SMR data was classified into seven categories. The worst category is 1 and the best is 7.



Map 1. Choropleth map

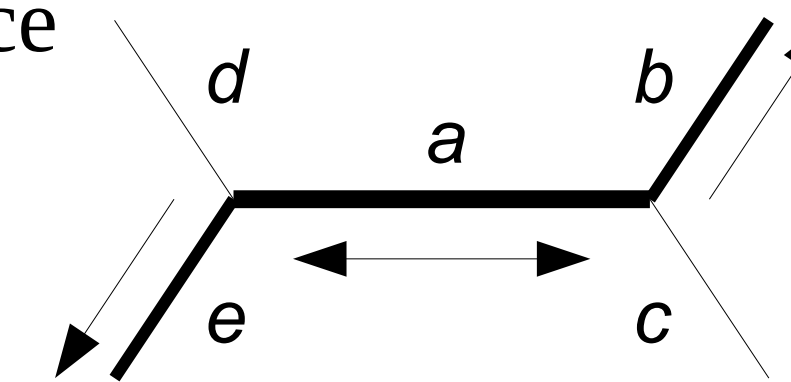
Map

We used a map containing 150 micro-region polygons as spatial representative units of the SMR data. The map was stored in a PostGIS table.

Monmonier's algorithm

Monmonier proposed a "maximal difference" method to build up barriers between adjacent areas. Computing steps:

1. calculate the differences (D_{ij}) between values belonging to areas (i and j) having a common border ($D_{ij} = |X_i - X_j|$);
2. choose the border with maximal difference D_{ij} ;
3. from both end of the border selected in step 2, follow the next (joining) border with the largest difference

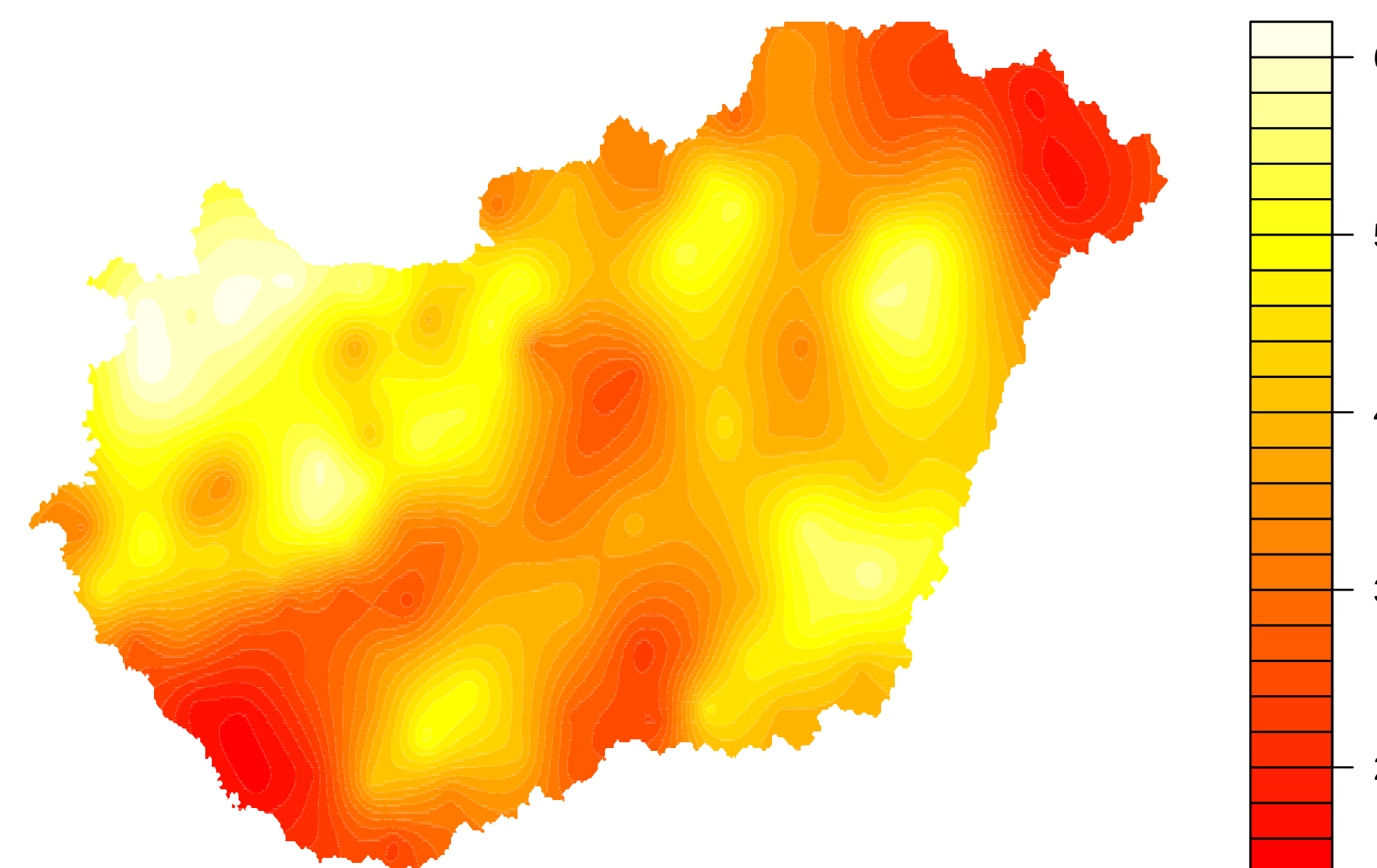


4. stop if a certain stopping criterion is satisfied (in our case, if the difference is less than the median of differences);
5. after stopping go back to step 2, choose the border with the second highest difference and repeat steps 3 and 4.

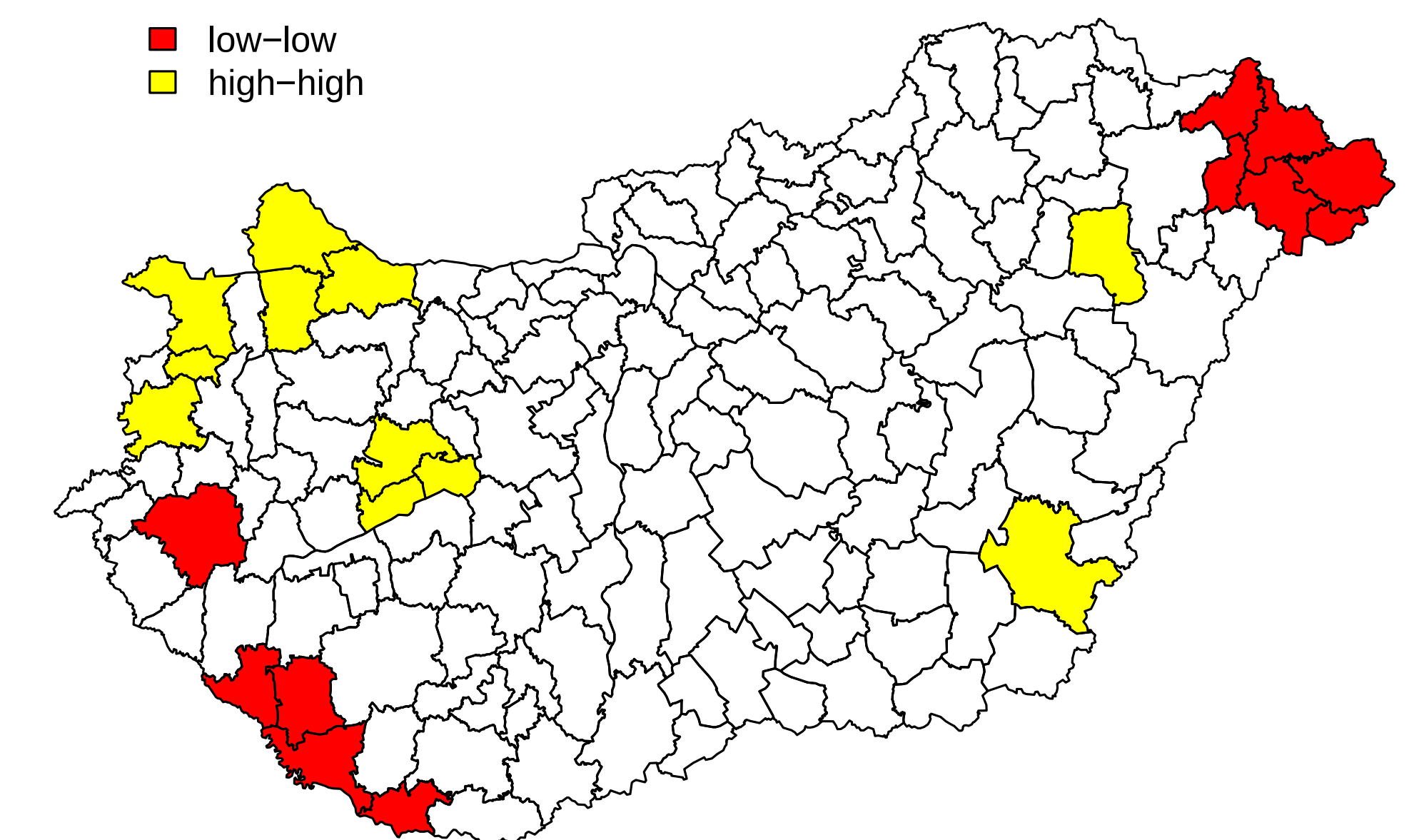
To stop the barrier building process more methods are acceptable. In Manni's *Barrier* software, the process goes up to a pre-specified number of barriers. In our case we built up barriers for every high difference ($D_{ij} \geq 6$) borders.

Software

For barrier finding we used the *R* language and environment (R Development Core Team, 2003) together with *PostgreSQL-PostGIS* spatial database server. For visualization beside *R*, the *Quantum GIS* and *MapServer* were used.

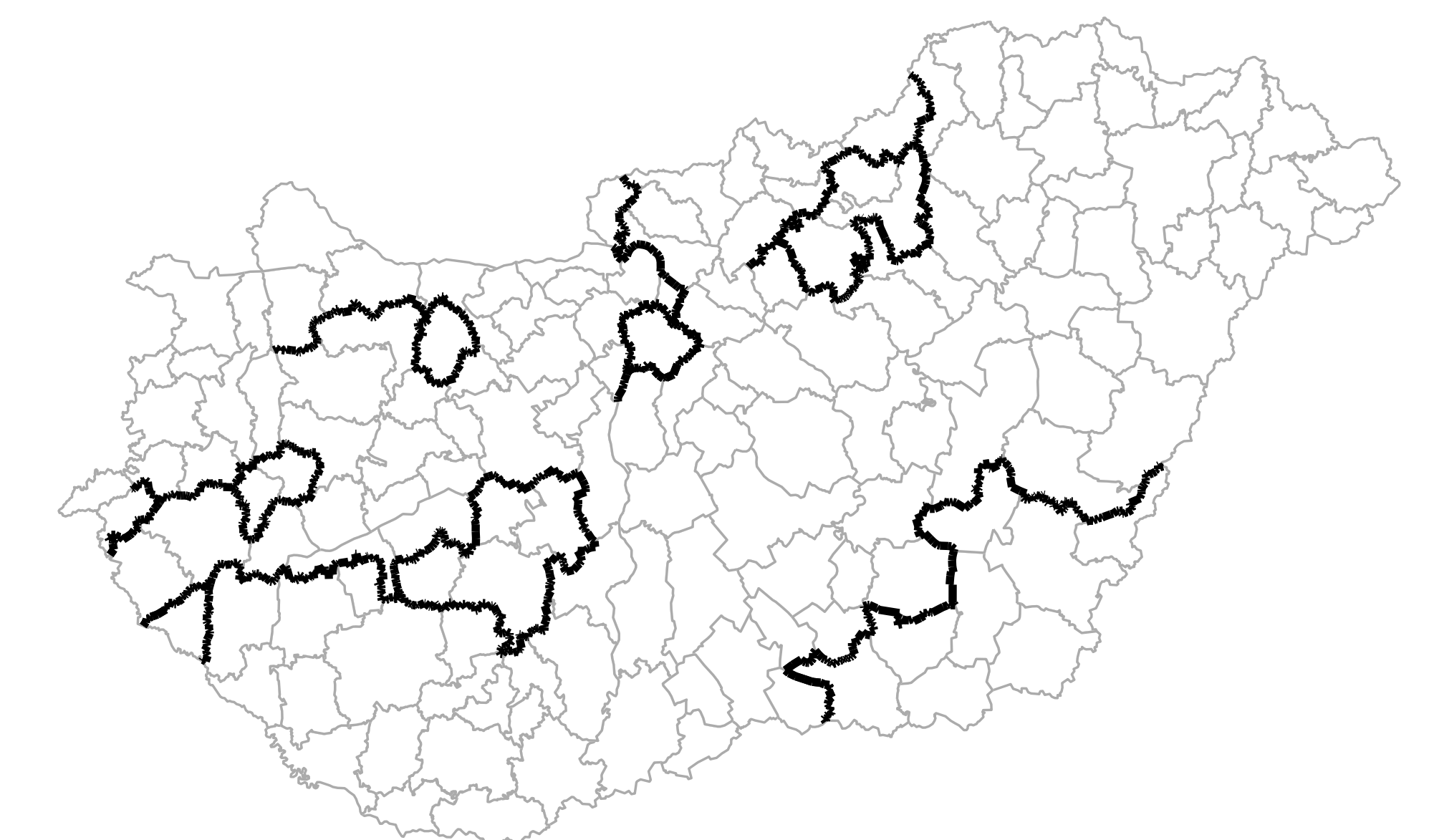


Map 2. Isopleth map



Map 3. Cluster map

Results



Map 4. Barrier map

Discussion

We think that beside the widely used spatial explorative methods like the choropleth, isopleth or cluster mapping the barrier determination may also be useful for the analysis of spatial patterns of health related data. In a further study the method should be refined with respect to the stopping rule as well as with respect to the choice of line if several distances are equal.

References

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- Monmonier Mark S. Maximum-Difference Barriers: An Alternative Numerical Regionalization method. Geographic Analysis, (3):245-261, 1973.
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