METHODS OF DESIGNING OF SIMPLE AND COMPLEX ANIMATED CHOROPLETH MAPS AND CARTODIAGRAMS

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Abstract

Despite the recent state of development of cartographic animation methodology simple and complex animated choropleth maps and cartodiagrams (diagram maps) are among the less frequently published maps in the web. The process of designing them meets considerable number of methodological conditions, related to the specificity of different types and subtypes of both methods. This paper proposes the method of designing of simple and complex animated choropleth maps and cartodiagrams, employing the results of previous investigations on *entities – cartotrophic* and *entities – polystaymic* methods, and detailed classification of animated choropleth maps and cartodiagrams, results of analyses on the possibilities of its combination and combinations with other cartographic methods, as well as the results of works on new solutions, which can facilitate the reception of thematic information by users.

Introduction

One of the first geographic animation using the method of cartodiagram was probably made by Casetti & Semple in 1969. Early experiments (i.e. of Jensen (1978), Moellering (1980), Canvin and Reymond (1986)), and most recent works (i.e. of DiBiase et al. (1991), Cote et al. (1993), Peterson (1999), Andrienko & Andrienko (1999), See & Olson (2006)) resulted in considerable development of methodology of animated choropleth maps and cartodiagrams. The big step to promote it was elaboration of Descartes and GéoClip software. However, in spite of the achievements of multiyear works, simple and complex animated choropleth maps and cartodiagrams are still among the less frequently published maps in the web. In May 2009 these methods were employed only in 7 of 28 national geoportals of European countries (Dukaczewski, Bielecka 2009). The process of designing of many types of simple and complex animated choropleth maps and cartodiagrams meets a considerable number of obstacles. Big part of them aroses due to the need of comply the methodological conditions related to the specificity of different combined methods of presentation, perception of these animations, and technical problems related with its designing. Author has proposed the methods of selection of static and dynamic variables and methods of cartographic presentation for simple and complex temporal cartographic animations (Dukaczewski 2005 2007), which can be employed like a ‘general usage’ tool for designing of simple and complex animated choropleth maps and cartodiagrams.

However, in the case of both methods the considerable number of 'conditional solutions' and restrictions was noted. To clarify these cases it was necessary to propose more detailed classification of both methods of presentation, taking into the consideration its additional characteristics, related i.e. to the way they use the space. This paper proposes the method of designing of simple and complex animated choropleth maps and cartodiagrams, employing the results of previous investigations on *entities – cartotrophic* and *entities – polystaymic* methods, new research on detailed classification of animated choropleth maps and cartodiagrams, possibilities and limitations of its combination and combinations with other cartographic methods.

Objectives and methodology

The aim of this research was to propose the method of designing of simple and complex animated choropleth maps and cartodiagrams, employing the results of investigations on: possibilities of combined usage of cartographic presentation methods, methods of selection of visual variables, the methodology of designing of choropleth maps and cartodiagrams, as well as the new research on properties of different types of simple and complex choropleth maps and cartodiagrams. To achieve this goal, it was necessary to propose detailed classification of animated choropleth maps and cartodiagrams, to analyse the possibilities of its combination and combination with other cartographic methods, to verify the possibilities of usage of *entities – cartotrophic* and *entities – polystaymic* method, then to propose the modified versions of these methods dedicated to the designing of simple and complex animated choropleth maps and cartodiagrams.

Results and discussion

Classification of types and subtypes of animated choropleth maps and cartodiagrams

Classification of types of animated choropleth maps and cartodiagrams is based on typology of methods and classification of complex animations proposed by Dukaczewski (2003 2007). They include the information about the main type of method, the type of entities (α-point; β-line; γ-area entities), level of measurement (a-nominal, b-ordinary, c-quantitative scale), type of values (c–continuous, s-range). To take into the consideration the information about the way that different types of choropleth maps and cartodiagrams use the space, this classification was extended. Firstly, both in the case of choropleth maps and cartodiagrams the nature of presented information was signalized (H–homogeneous, C–comparative). In the case of cartodiagrams the information about the type and subtype was added (type: I–bars, II–diagrams, III–linear diagrams, IV–dot histograms, and subtype: 1–simple, 2–summaric, 3–structural for point and area diagrams; while type: V–vector and F–flow chart and subtype: r–range, s–stream for line cartodiagrams). In the case of choropleth maps the information about the type and subtype were included (respectively: Q–qualitative, S–selective; 1–simple, 2–summaric, 3–structural). The list of 'simple' method types and subtypes is available in *Appendix 4*. It was possible to distinguish 58 subtypes of

choropleth maps and 137 subtypes of cartodiagrams. The complex methods were noted as combinations of simple methods (i.e. Kγc1H/Kγc1H).

Evaluation of the combination of animated choropleth maps and cartodiagrams

The proposed detailed classification of types and subtypes of simple animated choropleth maps and cartodiagrams was used to evaluate the combinations of the types and subtypes of these methods, using the semiotic rules and criteria used in cartographic methodology. The result was the matrix of evaluation of the combinations of types/subtypes of choropleth maps (*App. 1*), matrix of evaluation of the combinations of types/subtypes of cartodiagrams (*App. 2*), and matrix of combination of these types/subtypes with other types of cartographic presentation methods (*App. 3*). It was possible to distinguish 318 correct (of 1711 total) combinations of types and subtypes of choropleth maps, 6589 correct (of 8128) combinations of types/subtypes of cartodiagrams and 2296 correct combinations of both with other cartographic methods. The resulting matrices can be applied like a tool for designing complex animated choropleth maps and cartodiagrams.

Additional solutions facilitating the transfer of information

To facilitate the transfer of information and to avoid the risk of their visual overload the static solutions, benchmarks and application of the sound were tested. The first solution was introduction of marginal text describing the employed method (or combination of methods) in a proximity of 'start' button. The second group were animated arrows and frames. The experiments proved, that this kind of solution is more acceptable by young users. The third group concerns the application of mimetic sound icons/'earcons' (Gaver 1986) and redundant sound variables. The earcons were used to signal the beginning of the display of animation (what is very useful in the case of animations displayed in a loop) and to highlight a time scale. The Krygier's (1994) sound variables plus *rhythm* and *frequency* were used to accentuate the visual message. The changes of *loudness* was employed to emphasize the changes of *size*, while *rhythm–form, pitch* and *register–value, timbre–colour*. The sound variables of *duration, frequency*, *order* and *rate of change* were employed to stress its visual 'namesakes'. This redundancy of variables can be helpful for reception of spatial information by considerable group of users, however it is worth to mention that effect of sound backward masking (and related need of short sound delay) as well as non fully linear perception of the animation may provoke the problems of lack of synchronization. Due to the reduced number of sound variables not all visual variables can be highlighted. This solution is possible only in case of 8 of 77 correct combined application of static variables and 25 of 127 correct applications of static and dynamic variables. Part of the users signalized problems of inversion of perception of pitch and register. There is a problem when more than 3 entities are accentuated with sound. However, these solutions can be applied to highlight individual entities or be used for presentation of the general trends. The information about the optional employment of sound variables was introduced into the

matrix of correct usage of combination of static visual variables (Dukaczewski 2005 2007), matrix of semiotic evaluation of combined application of static and dynamic variables and methods of presentation (Dukaczewski 2007), and matrix of combinations of groups of variables and related cartographic methods (ibid).

The methods of designing of simple and complex animated choropleth maps and cartodiagrams

The verification of the possibilities of employment of *entities–cartotrophic* and *entities–polystaymic* methods for designing of simple and complex animated choropleth maps and cartodiagrams has proved, that first method can be used without any changes, while the second can be easily adapted. In the case of first method the sole (optional) innovation can be choice & verification of sound variables (fig. 1 left), using new versions of matrix of correct usage of combination of static visual variables, and matrix of evaluation of combined application of static and dynamic variables, updated with information about possibility of usage of sound variables instead of its 'old' versions.

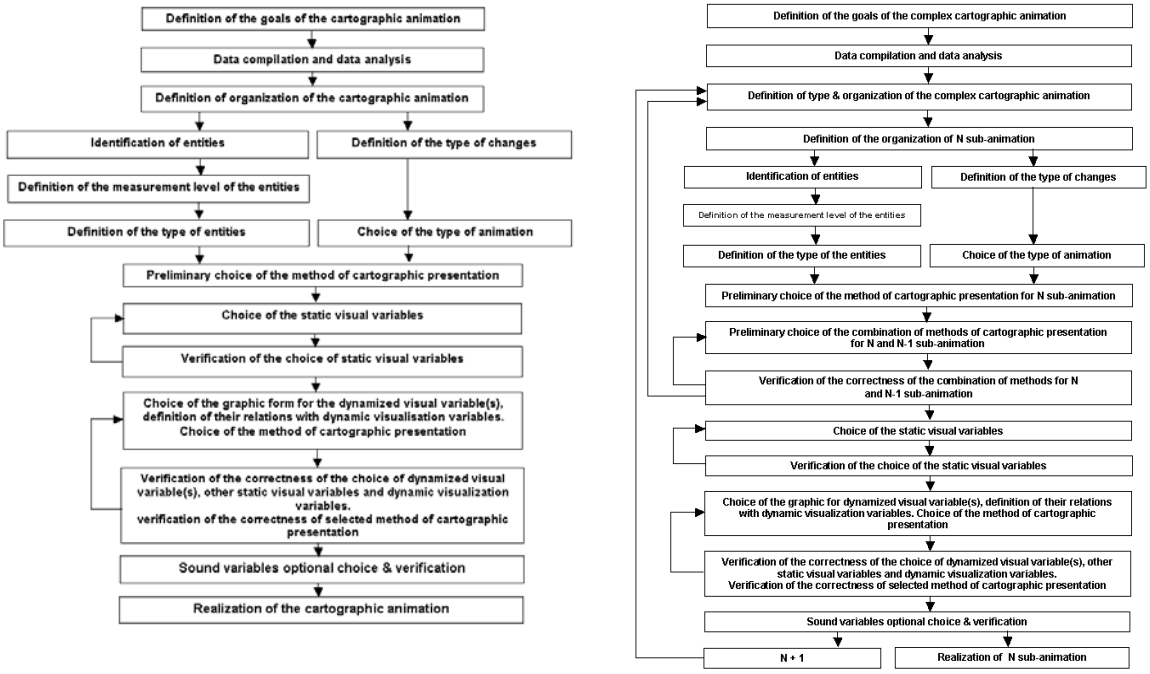

Figure 1 Modified *entities–cartotrophic* and *entities–polystaymic* methods

In the case of entities–polystaymic method (fig. 1 right) a good idea is to use the table of evaluation of the combinations of types/subtypes of choropleth maps (App. 1), or table of evaluation of the combinations of types/subtypes of cartodiagrams (App. 2), and/or table of combination of these types and subtypes with other types of cartographic presentation methods (App. 3) for the verification of the correctness of the combination of methods for N and N-1 sub-animation. This method can be also expanded by adding

the sound variables optional choice & verification, using the updated matrix of correct usage of combination of static visual variables, matrix of evaluation of combined application of static and dynamic variables, and matrix of combinations of groups of variables and related cartographic methods, however the application of these solution must be careful, and sound display should be reduced to one entity in one time. The updated methods and proposed matrices can be used like a useful tool for designing of simple and complex animated choropleth maps and cartodiagrams.

Conclusions

The carried research and tests have demonstrated, that updated *entities–cartotrophic* and *entities–polystaymic* method of selection of variables for complex temporal cartographic animations can be used for designing the different types and subtypes of simple and complex animated choropleth maps and animated cartodiagrams. The usage of elaborated additional matrices can facilitate the process of designing of these maps and theirs legends. Due to the specificity of perception of animated cartograms and cartodiagrams the employment of additional sound solutions can facilitate the reception of only one action of change of thematic information in one time. The effectiveness of such a solution can differ in the case of different age groups.

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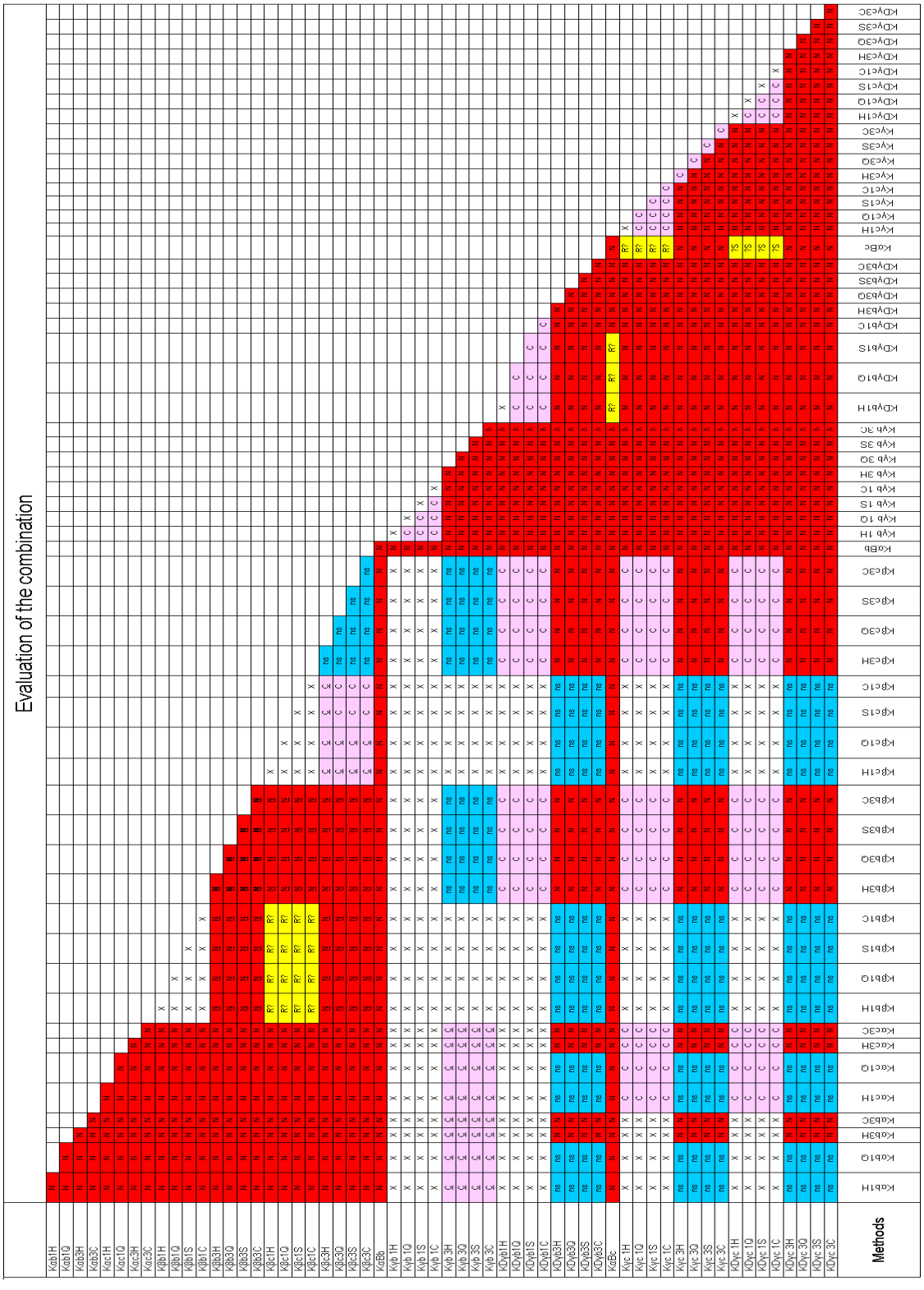
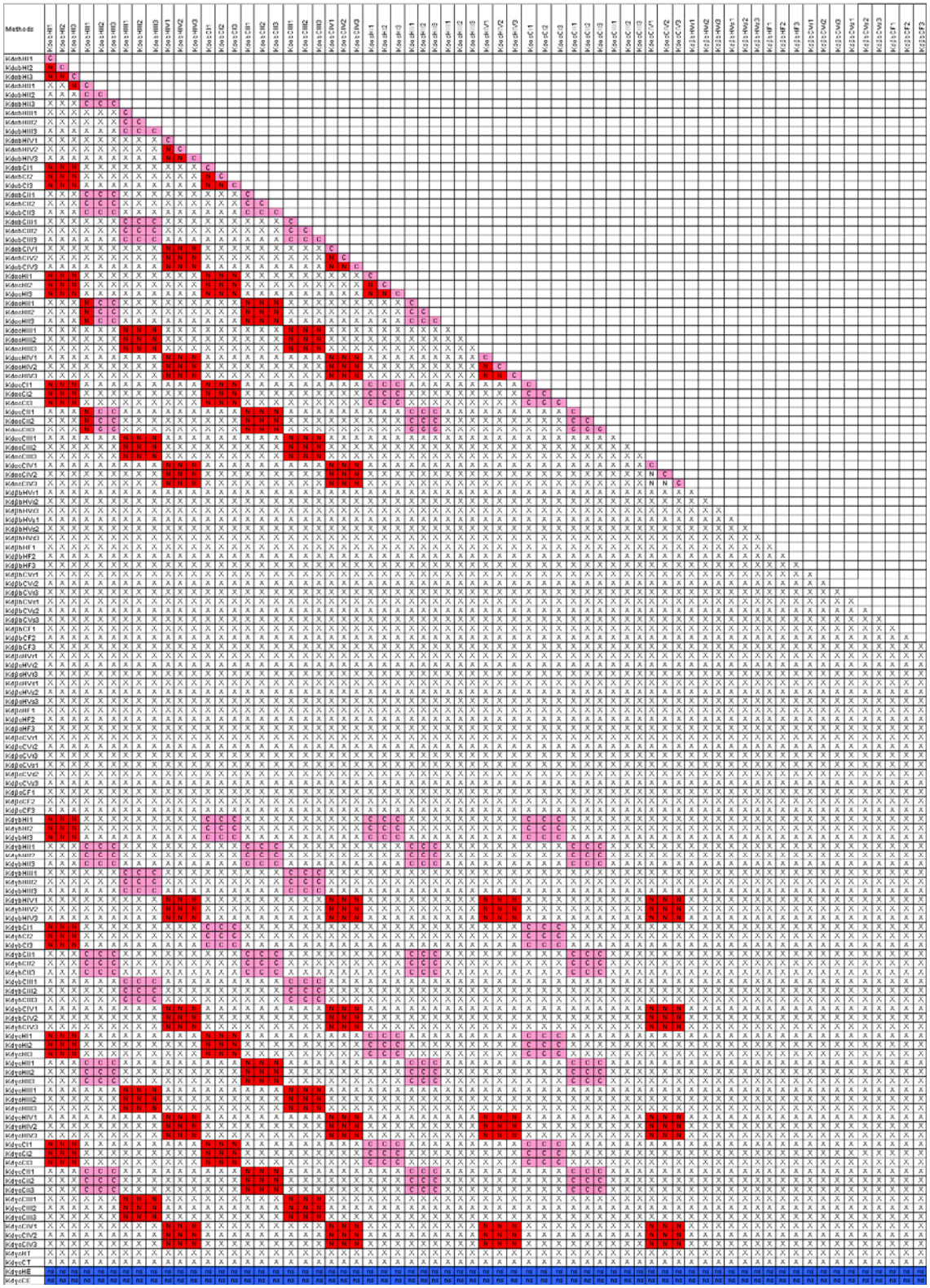
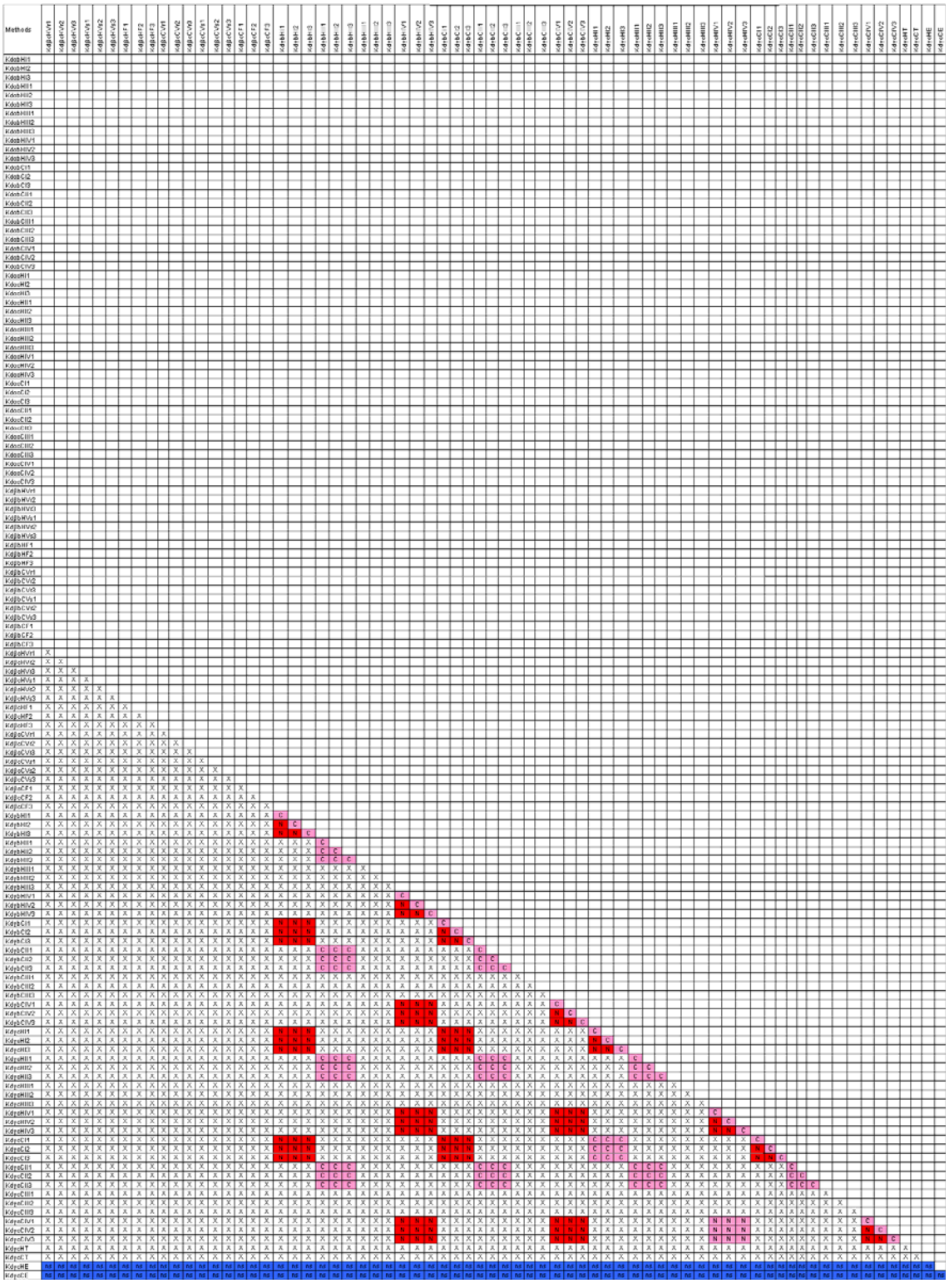
Appendix 1 Evaluation of the combinations of types and subtypes of choropleth maps



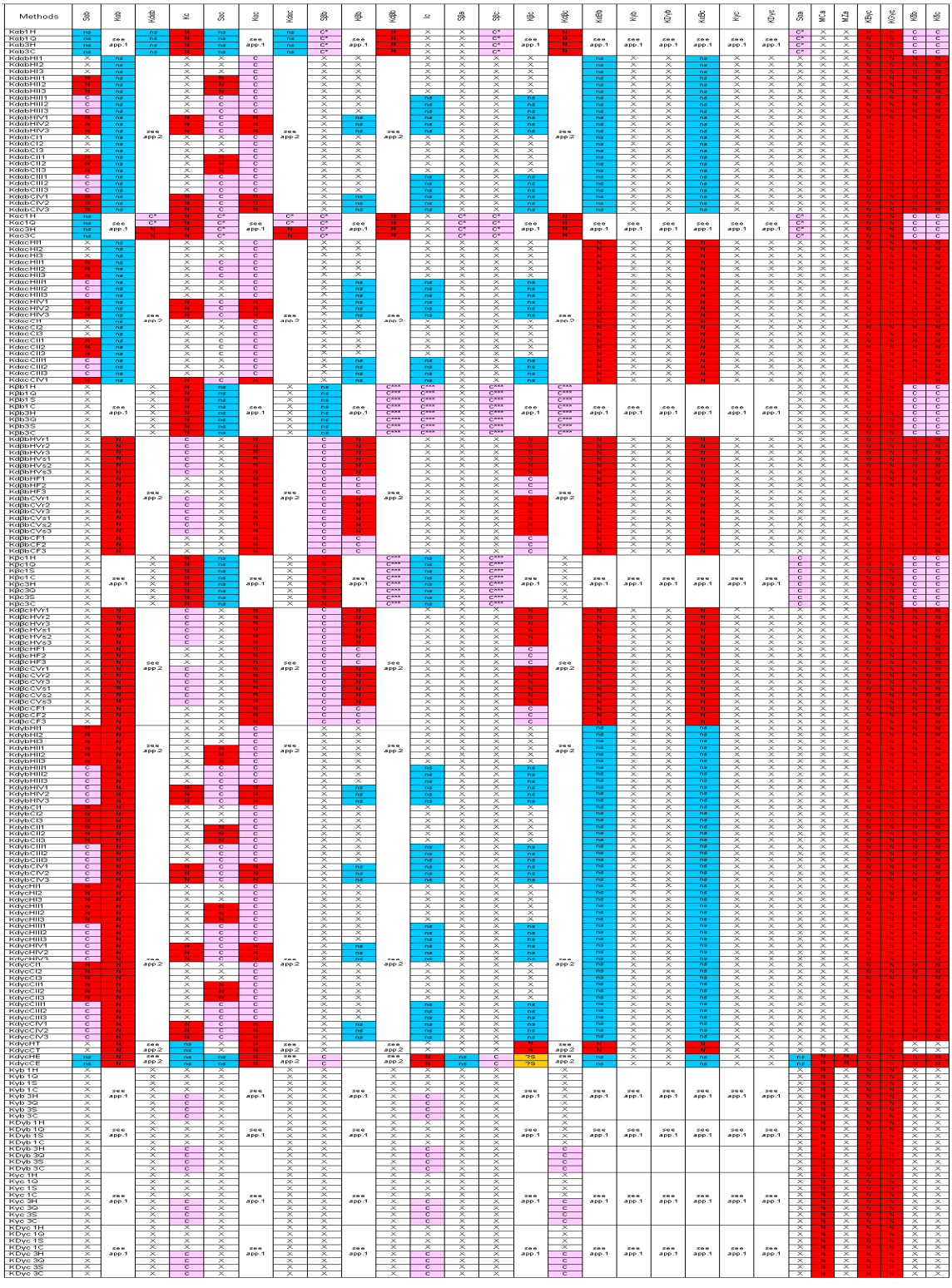
Appendix 2.1 Evaluation of the combinations of of types and subtypes cartodiagrams



Appendix 2.2 Evaluation of the combinations of types and subtypes of cartodiagrams



Appendix 3 Evaluation of combinations of choropleth map and cartodiagrams with other methods



Appendix 4 Explanations for appendices 1 - 3

Sαb – Ordinary point signatures,
Kαb – Ordinary point choropleth maps,
Kαb1H - Ordinary point simple homoneneous choropleth maps
Kαb1Q - Ordinary point simple qualitative choropleth maps
Kαb3H - Ordinary point structural homoneneous choropleth maps
Kαb3C - Ordinary point structural comparative choropleth maps
Kdαb – Ordinary point cartodiagrams
KdαbHI1 – Ordinary point homogeneous bar simple cartodiagrams
KdαbHI2 – Ordinary point homogeneous bar summaric cartodiagrams
KdαbHI3 – Ordinary point homogeneous bar structural cartodiagrams
KdαbHII1 – Ordinary point homogeneous diagram simple cartodiagrams
KdαbHII2 – Ordinary point homogeneous diagram summaric cartodiagrams
KdαbHII3 – Ordinary point homogeneous diagram structural cartodiagrams
KdαbHIII1 – Ordinary point homogeneous line diagram simple cartodiagrams
KdαbHIII2 – Ordinary point homogeneous line diagram summaric cartodiagrams
KdαbHIII3 – Ordinary point homogeneous line diagram structural cartodiagrams
KdαbHIV1 – Ordinary point homogeneous dot histogram simple cartodiagrams
KdαbHIV2 – Ordinary point homogeneous dot histogram summaric cartodiagrams
KdαbHIV3 – Ordinary point homogeneous dot histogram structural cartodiagrams
KdαbCI1 – Ordinary point comparative bar simple cartodiagrams
KdαbCI2 – Ordinary point comparative bar summaric cartodiagrams
KdαbCI3 – Ordinary point comparative bar structural cartodiagrams
KdαbCII1 – Ordinary point comparative diagram simple cartodiagrams
KdαbCII2 – Ordinary point comparative diagram summaric cartodiagrams
KdαbCII3 – Ordinary point comparative diagram structural cartodiagrams
KdαbCIII1 – Ordinary point comparative line diagram simple cartodiagrams
KdαbCIII2 – Ordinary point comparative line diagram summaric cartodiagrams
KdαbCIII3 – Ordinary point comparative line diagram structural cartodiagrams
KdαbCIV1 – Ordinary point comparative dot histogram simple cartodiagrams
KdαbCIV2 – Ordinary point comparative dot histogram summaric cartodiagrams
KdαbCIV3 – Ordinary point comparative dot histogram structural cartodiagrams
Kc – Dot method,
Sαc – Quantitative point signatures,
Kαc (cs) – Quantitative point choropleth maps,
Kαc1H - Quantitative point simple homoneneous choropleth maps
Kαc1Q - Quantitative point simple qualitative choropleth maps
Kαc3H - Quantitative point structural homoneneous choropleth maps
Kαc3C - Quantitative point structural comparative choropleth maps
Kdαc - Quantitative point cartodiagrams,
KdαcHI1 – Quantitative point homogeneous bar simple cartodiagrams
KdαcHI2 – Quantitative point homogeneous bar summaric cartodiagrams
KdαcHI3 – Quantitative point homogeneous bar structural cartodiagrams
KdαcHII1 – Quantitative point homogeneous diagram simple cartodiagrams
KdαcHII2 – Quantitative point homogeneous diagram summaric cartodiagrams
KdαcHII3 – Quantitative point homogeneous diagram structural cartodiagrams
KdαcHIII1 – Quantitative point homogeneous line diagram simple cartodiagrams
KdαcHIII2 – Quantitative point homogeneous line diagram summaric cartodiagrams
KdαcHIII3 – Quantitative point homogeneous line diagram structural cartodiagrams
KdαcHIV1 – Quantitative point homogeneous dot histogram simple cartodiagrams
KdαcHIV2 – Quantitative point homogeneous dot histogram summaric cartodiagrams
KdαcHIV3 – Quantitative point homogeneous dot histogram structural cartodiagrams
KdαcCI1 – Quantitative point comparative bar simple cartodiagrams
KdαcCI2 – Quantitative point comparative bar summaric cartodiagrams
KdαcCI3 – Quantitative point comparative bar structural cartodiagrams
KdαcCII1 – Quantitative point comparative diagram simple cartodiagrams
KdαcCII2 – Quantitative point comparative diagram summaric cartodiagrams
KdαcCII3 – Quantitative point comparative diagram structural cartodiagrams
KdαcCIII1 – Quantitative point comparative line diagram simple cartodiagrams
KdαcCIII2 – Quantitative point comparative line diagram summaric cartodiagrams
KdαcCIII3 – Quantitative point comparative line diagram structural cartodiagrams
KdαcCIV2 – Quantitative point comparative dot histogram summaric cartodiagrams
KdαcCIV3 – Quantitative point comparative dot histogram structural cartodiagrams
Sβb – Ordinary line signatures,
Kβb – Ordinary line choropleth maps,
Kβb1H – Ordinary line simple homogeneous choropleth maps
Kβb1Q – Ordinary line simple qualitative choropleth maps
Kβb1S – Ordinary line simple selective choropleth maps
Kβb1C – Ordinary line simple comparative choropleth maps
Kβb3H – Ordinary line structural homogeneous choropleth maps
Kβb3Q – Ordinary line structural qualitative choropleth maps
Kβb3S – Ordinary line structural selective choropleth maps
Kβb3C – Ordinary line structural comparative choropleth maps
Kdβb - Ordinary line cartodiagrams
KdβbHVr1 - Ordinary line homogeneous vector range simple cartodiagrams
KdβbHVr2 - Ordinary line homogeneous vector range summaric cartodiagrams
KdβbHVr3 - Ordinary line homogeneous vector range structural cartodiagrams
KdβbHVs1 - Ordinary line homogeneous vector stream simple cartodiagrams
KdβbHVs2 - Ordinary line homogeneous vector stream summaric cartodiagrams
KdβbHVs3 - Ordinary line homogeneous vector stream structural cartodiagrams
KdβbHF1 - Ordinary line homogeneous flow simple cartodiagrams
KdβbHF2 - Ordinary line homogeneous flow summaric cartodiagrams
KdβbHF3 - Ordinary line homogeneous flow range structural cartodiagrams
KdβbCVr1 - Ordinary line comparative vector range simple cartodiagrams
KdβbCVr2 - Ordinary line comparative vector range summaric cartodiagrams
KdβbCVr3 - Ordinary line comparative vector range structural cartodiagrams
KdβbCVs1 - Ordinary line comparative vector stream simple cartodiagrams
KdβbCVs2 - Ordinary line comparative vector stream summaric cartodiagrams
KdβbCVs3 - Ordinary line comparative vector stream structural cartodiagrams
KdβbCF1 - Ordinary line comparative flow simple cartodiagrams
KdβbCF2 - Ordinary line comparative flow summaric cartodiagrams
KdβbCF3 - Ordinary line comparative flow range structural cartodiagrams
Ic – isoline maps,
Sβa – Qualitative line signatures,
Sβc – Quantitative line signatures,
Kβc (cs) - Quantitative line choropleth maps
Kβc1H – Quantitative line simple homogeneous choropleth maps
Kβc1Q – Quantitative line simple qualitative choropleth maps
Kβc1S – Quantitative line simple selective choropleth maps
Kβc1C – Quantitative line simple comparative choropleth maps
Kβc3H – Quantitative line structural homogeneous choropleth maps
Kβc3Q – Quantitative line structural qualitative choropleth maps
Kβc3S – Quantitative line structural selective choropleth maps
Kβc3C – Quantitative line structural comparative choropleth maps
Sαa – Qualitative point signatures
MCa – Chorochromatic method maps,
MZa – Range maps
KByc – Bürgener preudo-choropleth map
KGyc – Geometrical variable-dense network
Kδb - Ordinary cubic choropleth maps,
Kδc - Quantitative cubic choropleth maps,

Kdβc (cs) - Quantitative line cartodiagrams
KdβcHVr1 - Quantitative line homogeneous vector range simple cartodiagrams
KdβcHVr2 - Quantitative line homogeneous vector range summaric cartodiagrams
KdβcHVr3 - Quantitative line homogeneous vector range structural cartodiagrams
KdβcHVs1 - Quantitative line homogeneous vector stream simple cartodiagrams
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KdβcHVs3 - Quantitative line homogeneous vector stream structural cartodiagrams
KdβcHF1 - Quantitative line homogeneous flow simple cartodiagrams
KdβcHF2 - Quantitative line homogeneous flow summaric cartodiagrams
KdβcHF3 - Quantitative line homogeneous flow range structural cartodiagrams
KdβcCVr1 - Quantitative line comparative vector range simple cartodiagrams
KdβcCVr2 - Quantitative line comparative vector range summaric cartodiagrams
KdβcCVr3 - Quantitative line comparative vector range structural cartodiagrams
KdβcCVs1 - Quantitative line comparative vector stream simple cartodiagrams
KdβcCVs2 - Quantitative line comparative vector stream summaric cartodiagrams
KdβcCVs3 - Quantitative line comparative vector stream structural cartodiagrams
KdβcCF1 - Quantitative line comparative flow simple cartodiagrams
KdβcCF2 - Quantitative line comparative flow summaric cartodiagrams
KdβcCF3 - Quantitative line comparative flow range structural cartodiagrams
Kdγb - Ordinary area cartodiagrams,
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KdγbHI2 – Ordinary area homogeneous bar summaric cartodiagrams
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Kdγc - Quantitative area cartodiagrams,
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KdγcCI1 – Quantitative area comparative bar simple cartodiagrams
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KdγcCIII2 – Quantitative area comparative line diagram summaric cartodiagrams
KdγcCIII3 – Quantitative area comparative line diagram structural cartodiagrams
KdγcCIV1 – Quantitative area comparative dot histogram simple cartodiagrams
KdγcCIV2 – Quantitative area comparative dot histogram summaric cartodiagrams
KdγcCIV3 – Quantitative area comparative dot histogram structural cartodiagrams
KdγcHT - Quantitative area homogeneous Uhorczak typogramme
KdγcCT - Quantitative area comparative Uhorczak typogramme
KdγcHE - Quantitative area homogeneous eumorphic cartodiagrams
KdγcCE - Quantitative area comparative eumorphic cartodiagrams
KαBb – Ordinary Bertin's choropleth map,
Kγb – Ordinary area choropleth maps,
Kγb1H – Ordinary area simple homogeneous choropleth maps
Kγb1Q – Ordinary area simple qualitative choropleth maps
Kγb1S – Ordinary area simple selective choropleth maps
Kγb1C – Ordinary area simple comparative choropleth maps
Kγb3H – Ordinary area structural homogeneous choropleth maps
Kγb3Q – Ordinary area structural qualitative choropleth maps
Kγb3S – Ordinary area structural selective choropleth maps
Kγb3C – Ordinary area structural comparative choropleth maps
KDγb – Ordinary dasimetric choropleth maps,
KDγb1H – Ordinary dasimetric simple homogeneous choropleth maps
KDγb1Q – Ordinary dasimetric simple qualitative choropleth maps
KDγb1S – Ordinary dasimetric simple selective choropleth maps
KDγb1C – Ordinary dasimetric simple comparative choropleth maps
KDγb3H – Ordinary dasimetric structural homogeneous choropleth maps
KDγb3Q – Ordinary dasimetric structural qualitative choropleth maps
KDγb3S – Ordinary dasimetric structural selective choropleth maps
KDγb3C – Ordinary dasimetric structural comparative choropleth maps
KαBc - Quantitative Bertin's choropleth map,
Kγc - Quantitative area choropleth maps,
Kγc1H – Quantitative area simple homogeneous choropleth maps
Kγc1Q – Quantitative area simple qualitative choropleth maps
Kγc1S – Quantitative area simple selective choropleth maps
Kγc1C – Quantitative area simple comparative choropleth maps
Kγc3H – Quantitative area structural homogeneous choropleth maps
Kγc3Q – Quantitative area structural qualitative choropleth maps
Kγc3S – Quantitative area structural selective choropleth maps
Kγc3C – Quantitative area structural comparative choropleth maps
KDγc(cs) - Quantitative dasimetric choropleth maps,
KDγc1H – Quantitative dasimetric simple homogeneous choropleth maps
KDγc1Q – Quantitative dasimetric simple qualitative choropleth maps
KDγc1S – Quantitative dasimetric simple selective choropleth maps
KDγc1C – Quantitative dasimetric simple comparative choropleth maps
KDγc3H – Quantitative dasimetric structural homogeneous choropleth maps
KDγc3Q – Quantitative dasimetric structural qualitative choropleth maps
KDγc3S – Quantitative dasimetric structural selective choropleth maps
KDγc3C – Quantitative dasimetric structural comparative choropleth maps

Solutions

X	correct	R?	sporadicaly practiced, but doubtful
ns	not practiced, or sporadically practiced	?S	practiced, but doubtful
C	conditional	N	incorrect

* In the case of geometric dot choropleth maps

** Only in the case of non continuus choropleth maps

*** Only when one of the method is used like a element of base map

**** Only in the case of cross choropleth maps and chorochromatic maps