# Long-standing research challenges in geographic visualization

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As a part of a broader effort (one of five papers by various authors) in revisiting research challenges in cartography and geovisualization during and after the last International Cartographic Conference, we present a study in identifying persistent problems in geovisualization. Specifically, over four workshops held in various professional conferences, we collected community input on what people considered as *persistent problems* in geovisualization with the participation of 72 experts from various sub-domains of geographic information science and technology. In this study, we categorize and analyze this bottom-up input, and contrast it with a top-down view, through previously published research challenges based on five research agenda papers (MacEachren & Kraak, 1997; Fairbairn et al., 2001; Andrienko et al., 2006; Laramee & Kosara, 2006; Virrantaus et al., 2009).

We observe certain overlaps between the top-down and bottom-up approaches, but also some interesting differences. A synthesis of the top-down and bottom-up approaches suggest three major issues as persistent problems: 1) a better understanding of the scope of our domain, how it interacts with other domains, and how to make this interdisciplinary interactions happen, 2) a systematic understanding of human factors 3) a 'practicable' set of guidelines that matches the visualization types to task types, and guides the practitioner to design geovisualizations that are appropriate and helpful to the user for a given task. In connection to these, but in a more fine-grained manner, we observed that both bottom-up and top-down studies suggested a large number of design issues, including topics linked to abstraction-realism, visual complexity, and relevance – all of which are broadly rooted in cartographic generalization. In terms of differences, a major difference is that the research agenda papers mention theory and concepts considerably more often and more explicitly than the workshop participants. On the other hand, there is a very clear emphasis on (the lack of) transferring knowledge from science to practice in the bottom-up view, while, albeit present, this topic is not as prominent in the research agenda papers.

To be able to identify a time frame for the top-down analysis, we studied of the evolution of the terms used for describing the domain (using Google ngrams), which revealed interesting trends. The ngram analysis (based on a sample of books) suggests that while the term cartography dates back to 1800s, the term geovisualization enters the discourse starting only in ~1990s, and its use steadily increases, seemingly at the cost of the term cartography (and other related/competing terms) after ~1997, linked to the emergence of SciVis. Despite its close links in its core research interests to SciVis and InfoVis, now after nearly 20 years, geovisualization is an established domain, and with this paper, we document what (a sample of) the geovisualization community considers persistent problems.

Distinguishing *persistent* from *important*, we will discuss why the identified problems are persistent, and draw recommendations for action based on our observations and interpretations. Note that a full paper from this study with further observations and more detailed analyses is currently under revision for the International Journal of Cartography.

Keywords: persistent problems, research challenges, cartography, geovisualization, survey

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