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ROMBERT STAPEL

To Map, To Ascertain

Reflections on the Practice of Mapping (Un)certain Knowledge from a Digital Humanities Perspective

▼ **SPECIAL ISSUE** in *Mapping Uncertain Knowledge*

▼ **ABSTRACT** This paper offers a reflection on the theme of this special issue, how mapmakers deal with uncertainty, from a digital humanities perspective. For modern geohumanities scholars and digital mapmakers working in the field of history, dealing with the dual uncertainties of historical data and historical societies themselves can be a difficult task. How do they deal with these challenges? Do we use similar solutions to deal with uncertainty? Can we learn from the practices of early modern cartographers? And to what extent is (un)certainty itself a fruitful research topic in the geohumanities? To answer these questions, it is important to consider the historical development of the field of geohumanities and why it has learned to adapt to dealing with uncertain or ambiguous knowledge. Practical examples from my own research demonstrate how modern geohumanities scholars are affected by the notion of uncertainty in different ways. These examples are linked to the contributions and questions raised in this special issue. The engagement with early modern cartographers shows how important it is for geohumanities scholars not only to invest in geospatial analysis tasks, but also to become cartographers themselves.

▼ **KEYWORDS** geohumanities; historical GIS; uncertainty; visualizations; cartography

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Rombert Stapel • International Institute of Social History, NL, rombert.stapel@iisg.nl

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As **Djoeke van Netten** explains in the introduction to this special issue, defining uncertainty is not a simple feat. It refers to both the state of being uncertain and the object—i.e., knowledge, as **Van Netten** points out—someone is uncertain about. Uncertainty is also a key research topic in geographic information science, to which spatial or geohumanities (a subdiscipline of digital humanities) is as indebted as to the humanities, but there it is most often addressed in the context of data quality.[1] Within that confined setting, uncertainty can be further specified in terms of imprecision, ambiguity, or vagueness.[2] The quality of the spatial data, meanwhile, is measured in six components: accuracy, precision, reliability, resolution, logical consistency, and completeness.[3] In recent years, the focus has shifted from location uncertainty (e.g., the accuracy of remote sensing data) to decision-making (how spatial uncertainty affects human actions).[4] Examples of the latter include empirical studies on visual semiotics in uncertainty visualization, discussed in more detail by **Weixuan Li**,[5] or analyses of how specific cartographic solutions that display uncertainty on maps influence decisions made by mountaineering rescue teams under pressure.[6]

Readers of the papers in this special issue will not find the early modern equivalent of such computer science approaches to uncertainty, nor a systematic overview of the visual uncertainty techniques employed by early modern cartographers (although **Chet Van Duzer** offers many examples). Elements such as imprecision (caused by measurements), ambiguity (the use of blank spaces on a map; see **Petter Hellström**), or vagueness (traces of Mercator's Antarctic coastline left on Hondius's map; see **Daniella Gravon**) appear throughout the volume, but the core theme is different. Here, uncertainty is understood as "the lens through which we can understand and analyze what was/is in between knowing and not-knowing." Uncertainty implies the existence of "known unknowns" (or "specified ignorance"), which centers the agency involved in moving from an "unknown unknowns" (ignorance) to (uncertain) knowledge (see the **introduction**). A common thread among the contributions therefore is their focus on the *practice* of making knowledge certain or uncertain. This is a facet that is sometimes overlooked or neglected in geographic information science, but to which the humanities are uniquely suited to contribute.

The contributions to this special issue question the teleological idea that maps are becoming more and more "correct" (i.e., accurate or precise in relation to geographic space), as **Djoeke van Netten** explains in the introduction

1 Shi, *Principles of Modeling Uncertainties*; Bielecka and Burek, "Spatial Data Quality."
2 Shi, *Principles of Modeling Uncertainties*, 4–5.
3 Ibid., 9–11.
4 Bielecka and Burek, "Spatial Data Quality," 291.
5 Kinkeldey, MacEachren, and Schiewe, "How to Assess"; MacEachren et al., "Visual Semiotics & Uncertainty Visualization."
6 Korporaal, Ruginski, and Fabrikant, "Effects of Uncertainty Visualization."

to this special issue and a point perhaps most clearly refuted in **Petter Hellström**'s contribution. This idea, strongly linked to Western notions of cartography, is incredibly persistent—even, or perhaps especially, in the context of twenty-first-century geoscience.[7] Rather, the contributions emphasize that (un)certainty is not a neutral property of objects, but the result of an interaction between entities, knowledge producers (who determine), and audiences (who accept, reject, or influence claims of (un)certainty). This interaction may take place within a specific framework of power (the colonial project referred to by **Petter Hellström** and very much present in **Gianamar Giovannetti Singh**'s contribution to this volume), or it may involve the adaptation of (un)certain knowledge to the interests of different audiences (addressed by **Gianamar Giovannetti Singh** and **Danielle Gravon**). **Chet Van Duzer** shows how the authority of mapmakers can be an obstacle for others to alter their maps and disturb their aura of verisimilitude.

Capturing an Uncertain World in Binary Terms

Such insights also provide a valuable mirror for modern mapmakers and digital humanities scholars. The need to integrate real-world context into the study of maps, and to address rather than downplay the role of the mapmaker, the truth claims of maps, and the supposed neutrality of visualization choices, applies to early modern cartography as much as it does to geohumanities studies. This is the case not only in subsidiary fields such as *deep mapping*, which revolves around the idea of combining a variety of sources, contexts, and viewpoints in maps (cf. **Weixuan Li**), but also in more traditional forms of historical Geographic Information Systems (GIS). Recent efforts in semantic GIS, where geospatial information is integrated into so-called knowledge graphs that represent a network of entities and their relationships in the form of a database, are particularly suited for this purpose.[8]

The scholarly shifts that have moved the disciplines of history, cartography, and knowledge away from a progress-oriented narrative (see the **introduction**) have also had a profound impact on the burgeoning field of spatial and geohumanities. As the field matured, it sought to learn how to capture in digital formats the uncertain realities of the historical societies it sought to study. To understand this development and its relevance to the issue of uncertainty in knowledge creation, it is useful to consider how and why the field developed. The use of digital mapping techniques in humanities research can be traced back decades, following the widespread adoption of GIS in the earth sciences in the 1980s. Initially, the umbrella term for the field was

7 A point that can be illustrated by looking at the scientific programs of recent geoscience conferences, such as https://sigspatial2023.sigspatial.org/ and https://giscience2023.github.io/.

8 Grossner, Janowicz, and Keßler, "Place, Period, and Setting"; Grossner and Hill, "From Linking Places"; Noordegraaf et al., "Semantic Deep Mapping"; Hübl and Scholz, "Spatial Linked Data."

"historical GIS."[9] In those early pioneering days, social science perspectives dominated the field. Numerous projects were initiated that aimed to capture boundaries of historical administrative units in national GIS projects.[10] For the first time it became possible to digitally map *and* analyze historical statistics, mostly derived from digitized census and survey material, in conjunction.

By the turn of the twenty-first century, the limitations of this static approach were becoming more widely felt.[11] Digital mapmakers wanted to communicate their uncertainty more clearly to their audiences, to advance knowledge, not obscure it by creating false representations of reality. For example, in a paper discussing the creation of the *China historical GIS*, Merrick Lex Berman pointed out that a boundary- or polygon-based historical GIS both conforms to and affirms a specific modern, Western notion of territoriality that echoes some of the points made in this special issue (e.g., **Introduction**, **Hellström**, **Giovanetti-Singh**): nation states in which every square inch is assigned to a legally defined system of administrative divisions (e.g., provinces, districts, municipalities). This notion of neatly demarcated administrative units could not be applied to all historical societies—partly because of lacking or incomplete cartographic and textual sources, partly because the idea of territory itself differs. All these issues could be applied to Ming and Qing China. Berman therefore proposed a different modeling approach, moving away from a boundary-based GIS to a network model of localities.[12] More recently, Luca Scholz made a similar point when discussing the archetypal visualization of the political geography of the early modern Holy Roman Empire [**Fig. 1**]. He argued for a programmatic move away from the contiguous polygon toward data-driven (point) maps.[13]

The critique on boundary- or polygon-based historical GIS projects, which is also a common thread in the *deep mapping* approaches mentioned by **Weixuan Li**, is relevant to our discussion of uncertainty in maps. Like the early modern maps referred to in this special issue, GIS maps are used to ascertain knowledge. Polygon maps in particular produce a false sense of certainty about boundaries, territorialization, and the relation between people or objects and the land's surface (as also clearly shown by **Hellström** and **Giovanetti-Singh**). However, in contrast to printed or drawn maps, GIS datasets store knowledge in absolute terms. In a topological sense, a point is either within a polygon or outside it; there is no imprecision, ambiguity, or vagueness at play (unless

9 Knowles, "Emerging Trends"; Gregory and Healey, "Historical GIS".

10 For an overview: "Reports on National Historical GIS Projects".

11 Lewis and Wigen, *The Myth of Continents*; Schuurman, "Introduction: Theorizing GIS"; Owens et al., "Visualizing Historical Narratives"; Gregory and Geddes, "From Historical GIS"; Bodenhamer, "Chasing Bakhtin's Ghost".

12 Berman, "Boundaries or Networks".

13 Scholz, "Deceptive Contiguity," 213.

Figure 1. A classic but problematic representation of the Holy Roman Empire and its territorial conceptualization in the thirteenth century. G. Droysens, "Mitteleuropa Zur Zeit Der Staufer." Allgemeiner Historischer Handatlas. R. Andrée, 1886. © Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Droysens-26.jpg.

that uncertainty is defined in absolute and binary terms).[14] A boundary-based topological GIS, in which every area fits neatly with its neighbors, feeds into the notion that the area being portrayed is characterized by a fully developed and contiguous notion of territoriality *and* that there is enough source material to reconstruct past administrative boundaries. Moreover, in GIS software any geometry is automatically linked to a geographical coordinate system. Even if the geometry itself is a drawn object that has no real spatial meaning, the GIS software will still treat it as such. In a certain sense therefore, defining an object in GIS is the culmination of the geometrization of space—a process that features prominently in the research by Stuart Elden.[15] And as Elden clearly argues, this geometrization of space is linked to politics and power and is not value-free.

Addressing the "Aura of Verisimilitude" of Maps

How then should modern mapmakers proceed with presenting complex, uncertain knowledge on maps? Should we cast off the yoke of the polygon, and proceed with point-, network-, and/or narrative-based representations of spatial data? Are our practices even intrinsically different from the early modern counterparts discussed in this special issue? Perhaps it is the dual practice of making maps (to convey and summarize knowledge and to inspire the creation of new knowledge with the public) *and* analyzing that cartographic data in GIS software (to produce new knowledge directly) that sets us apart from the Blaeus, Mercators, Delisles, and Anvilles. This is posed as an open question.

For such analytical purposes, polygon-based maps do still have a use in geohumanities research: for making simple calculations of densities, for instance, or to assess the composition of soil types in different village communities. Identifying incomplete data and missing geographical coverage (producing "known unknowns") typically tends to be more difficult in a cloud of point data than in polygon-based data.[16] Finally, despite their drawbacks, polygon-based maps still offer a strong visual tool in storytelling. The question is therefore how some of the negative aspects of polygon-based maps—in particular, their tendency to exaggerate levels of certainty and truthfulness—can be alleviated, and what type of (supplementary) cartographic visualizations are more suited for certain research questions.

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14 Here it is useful to refer to the scholarly fields of "fuzzy logic" and "fuzzy topology" that center on the question of how to model (spatial) data in non-binary terms.

15 Elden, "Missing the Point"; Elden, *The Birth of Territory*; Elden, "Foucault and Geometrics."

16 This process is a key objective of a replication study I am involved in: Stapel, "Conflating Historical Population Statistics."

17 Stapel, "Een rekenoefening," 393. For a similar, earlier approach: Pounds and Roome, "Population Density," 123.

18 Oostindiër and Stapel, "Demographic Shifts."

19 Produced using data from: Stapel, "Historical Atlas of the Low Countries (1350–1800)."

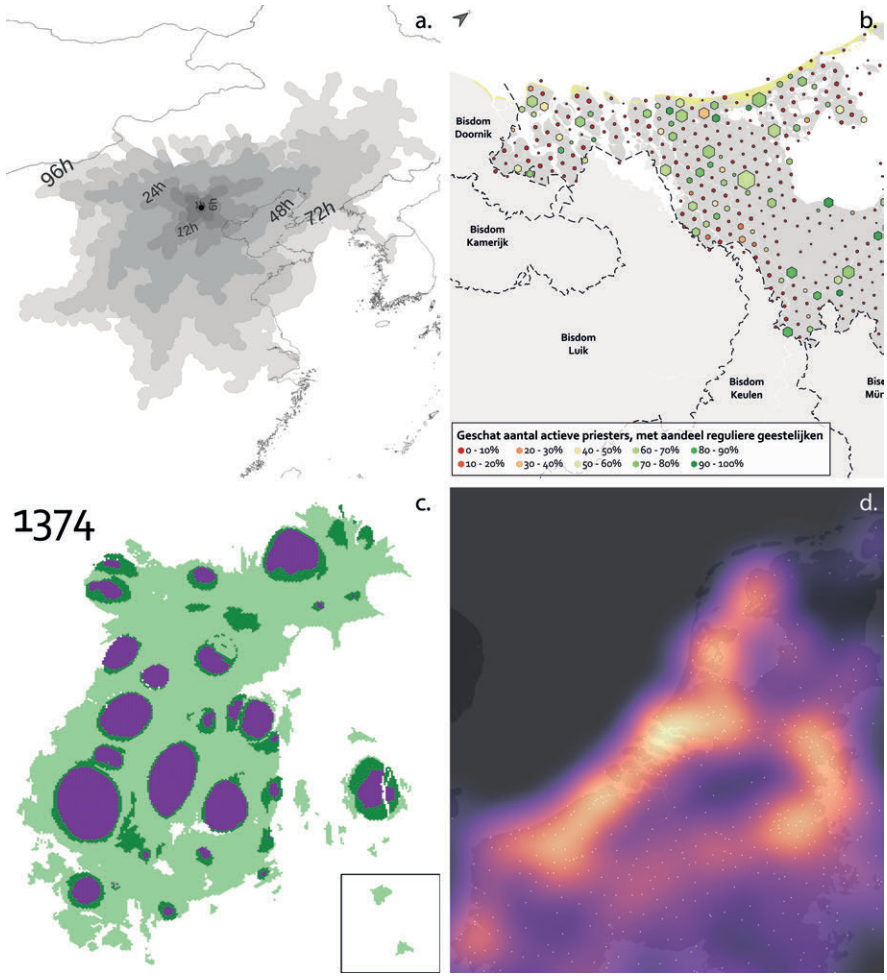

Figure 2. Cartographic visualizations that reduce the "aura of verisimilitude" of (polygon-based) maps. Clockwise from the top left corner: a) isochrone buffer zones indicating estimation of travel time from Beijing in the 1930s; b) hexagonal binning of the number of active priests (and percentage of them working as regular clergy) in the sixteenth century bishopric of Utrecht;[17] c) cartogram showing the relative population sizes in urban (purple) and rural (light green) localities in the Duchy of Brabant;[18] d) heatmap showing the density of urban centres in the medieval Low Countries.[19] © Rombert Stapel.

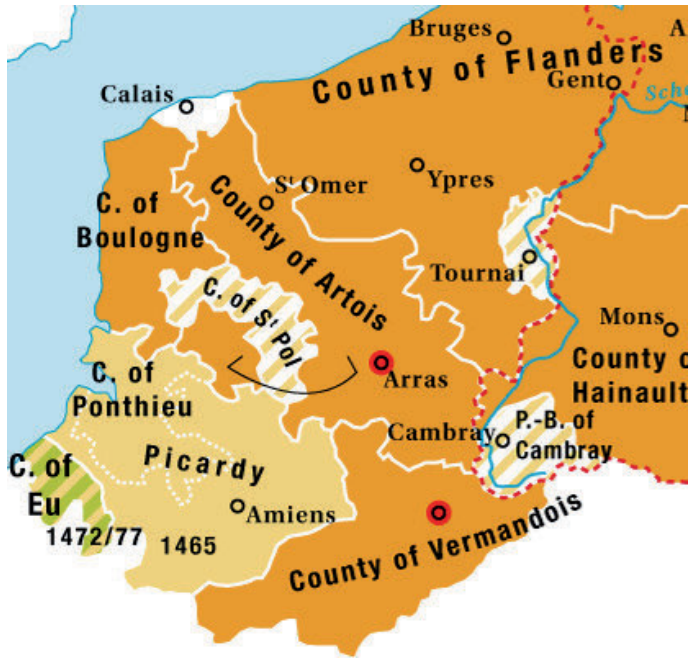

Figure 3. The County of Saint-Pol and neighboring territories in Northern France belonging to the Duke of Burgundy, mapped by Marco Zanoli, 2008. © Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Karte_Haus_Burgund_4_EN.png.

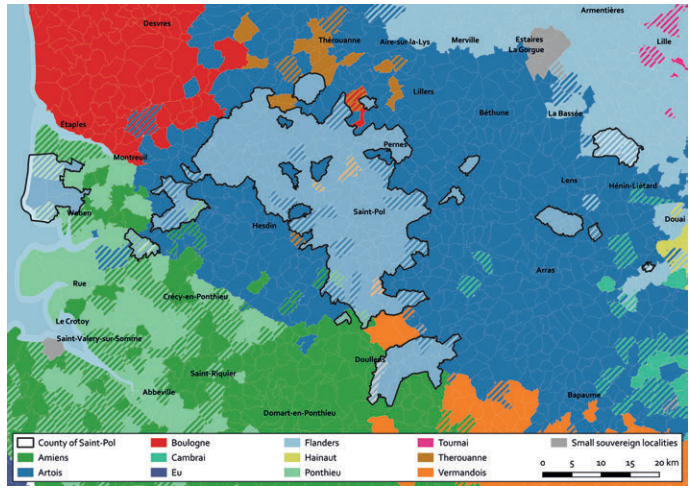

Figure 4. The same territories mapped using the HALC dataset.[20] Note the use of crosshatching to signal condominiums or disputed territorial claims. © Rombert Stapel.

20 Stapel, "Historical Atlas of the Low Countries (1350–1800)."

A key strategy among modern mapmakers is to reduce the "aura of verisimilitude" (see **Van Duzer**) of maps without losing too much of their narrating power. Figure 2 includes several examples of such visualizations, mostly drawn from my own research [**Fig. 2**]. Other approaches include applying fuzzy logic to geographical boundaries: rather than using precise, crisp boundaries, an area of transition is modeled that functions as a boundary zone.[21] Its implementation in GIS software is still a challenge though. The variable grid method, meanwhile, combines a binning approach (aggregating dispersed data points in a grid) with adjusting the size (or resolution) of the grid cells (larger sizes denote a higher level of uncertainty).[22]

Database design can also help to soften the problem of the deceptive territorial contiguity of polygon-based maps. For the "Historical Atlas of the Low Countries, 1350–1800" (HALC) project, we chose to adopt a design that consists of interacting point and polygon GIS layers.[23] The point layer offers an entry point for linking historical statistics and point-based visualizations such as heatmaps, whereas the polygons—defined as characteristics or bounding boxes of the points—can be used for density calculations, visualization, and comparisons with other data layers in GIS. This dual, data-driven approach creates more flexibility for the user to select or adapt the right visualization method for their research data and question.

The maps in the HALC project were created from the bottom up, at the locality level. From there and using the locality-level data as building blocks, a reconstruction is produced at the level of sovereign territories. This creates the additional benefit of retaining the intricate web of enclaves, exclaves, condominiums, and disputed localities that characterize the premodern world both visually and for analytical purposes [compare **Fig. 3** and **Fig. 4**].[24]

In her contribution to this volume, **Weixuan Li**, working from a similar digital humanities background, offers more detailed insight into how similar challenges may be approached. She needs to translate location-based data collected on artists in seventeenth-century Amsterdam into meaningful (art) historical insights. The spatial data she uses is both heterogeneous in terms of its accuracy, precision, and resolution, and is difficult to pinpoint on modern maps. Disambiguating places with similar names is a particular challenge, and knowing which house, street corner, or locality is referred to is not always easy or possible. Choosing one randomly or by reasoning from a range of options (e.g., the most populous locality, the most common street) is a solution that is

21 Wang and Hall, "Fuzzy Representation."

22 Bauer and Rose, "Variable Grid Method." In the discrete global grid system developed by Uber, this is referred to as compacting: Uber, "H3." For concrete examples, see: https://h3geo.org/docs/highlights/indexing.

23 Stapel, "Historical Atlas of the Low Countries."

24 For recent characterizations of this intricate web of territorial claims in premodern Europe: Scholz, *Borders and Freedom*; Hardy, "Were There 'Territories'? "; Zenobi, " Beyond the State."

often applied but creates a sense of false certainty. Rather, you want to retain the range of potential options in a cartographic visualization.

Li solved this by creating bounding box polygons that represent the outer edges of a construed space within which an artist lived or worked, based on a particular source. Within that space, a hundred random points are created that represent potential locations for a historical event. By doing so, she effectively defines the scope of the uncertainty she is dealing with in absolute terms. If the bounding box is small, these hundred points are closely clustered. If not, they are more dispersed. Taken together, the point layers can be used to capture the historical data in a visual expression that most people associate with uncertainty: heatmaps.

One can see how this solution can be developed even further. Picture a case for which you have good reason to assume that the hundred points should not be distributed evenly—for instance, because one end of a street is known to have predominantly housed other occupations. In geographical information science and population geography studies, this is a common procedure usually referred to as "dasymetric mapping."[25] Faced by a similar challenge, but on a much smaller scale, I have used the (estimated) population ratios between ambiguous (e.g., homonymous) birth places of sixteenth-century priests to adjust the sizes of the dots on the map representing the localities.[26] Instead of choosing one homonym over the other and marking it on a map, a full range of cartographic solutions is used to convey uncertainty regarding the homonyms. However, finding the right balance between presenting uncertainty and conveying a map with a clear message is often a major challenge.

Uncertainty as a Research Topic

Uncertainty is not only a burden that scholars need to overcome though. Although **Van Netten** rightfully concludes in her introduction that the question of why uncertainty should be presented on maps at all is still open ended, both the *practice* and the *state* of uncertainty (see the **introduction**) can also be a source of new knowledge itself. Several papers in this special issue (e.g., **Van Duzer**, **Gravon**) show that understanding how early modern mapmakers dealt with uncertainty—by leaving it out, by introducing it, by passing responsibility to sources—is instrumental to *our* understanding of the knowledge production process around these maps. This also applies to research inspired by digital humanities. In a publication dealing with tax reform in the medieval Duchy of Brabant, Arend Elias Oostindiër and I wanted to know to what extent knowledge, ignorance, or uncertainty about the socioeconomic geography of

25 Monteiro et al., "Spatial Disaggregation"; Pajares et al., "Population Disaggregation"; Swanwick et al., "Dasymetric Population Mapping."

26 Stapel, "Een rekenoefening', 485.

the Duchy influenced the bargaining positions of those involved in the fiscal negotiations.[27]

By mapping in detail, using GIS, how uneven demographic developments in different parts of the Duchy had led to an unbalanced distribution of fiscal burdens, and juxtaposing this information with an analysis of the negotiating process, we showed that most negotiating parties were unaware of the fiscal disbalances. A lack of knowledge or uncertainty about the Duchy's socio-geographical composition (outside their own town or village) caused them to act against their own interest. The duke and his administration were the notable exceptions. They were able to gain prior knowledge of both the fiscal capacity of Brabantine localities and the potential effects of the new fiscal system, and used that information to play off different representatives against each other.[28] It shows that knowledge of the territory, even if that spatial knowledge is stored in written rather than cartographic form, is a form of power: the knowledge used to master the space and as a tool for state formation. It also shows that this knowledge can be mapped using modern tools, expanding our own knowledge of territorialization practices.

Conclusion

Issues related to the aura of verisimilitude of polygon-based historical GIS maps have been widely reported, in particular in relation to a false notion of territoriality that they often offer. Such false notions can have political consequences, but from a modern scholar's perspective the key problem is that these notions obfuscate knowledge and could harm our understanding of historical societies—a point also stressed by **Weixuan Li**. Many geohumanities scholars have therefore tried to alleviate the "aura of verisimilitude" (see **Chet Van Duzer**) of polygon-based GIS maps, resorting to network-, point-, or agent-based maps, deep mapping, heatmaps, binning, and so forth. There is, however, not a single solution that fits every research question.

It must be stressed that reducing the "aura of verisimilitude" is also not in any way a linear process toward a higher scientific standard (a point emphasized by **Djoeke van Netten** in the **introduction**). One could argue, as others have done before, that by removing the uncertain information from maps of Africa, eighteenth-century mapmakers also addressed unjustified notions of truthfulness in earlier maps of the continent. However, **Petter Hellström** shows how limited this line of thought is, arguing that the attempts to create a blank, dehumanized space should be framed within the colonial project. In the maps of the Cape of Good Hope, what is considered useful truths depended strongly on the audience of the maps, as **Gianamar Giovannetti Singh** argues.

27 Oostindiër and Stapel, "Demographic Shifts."
28 Ibid., 159–62.

Chet Van Duzer and **Danielle Gravon**, meanwhile, show how the nature and (un)certainty of a mapmaker's sources influence the cartographic decisions. Modern mapmakers should thus be aware of the wider effects of the cartographic representations of their geospatial research data, in particular regarding the decision and practice of making knowledge certain or uncertain.

One thing the contributions in this special issue offer to geohumanities scholars is that they add to the conviction that geospatial data analysts should invest in their own cartographic skills. Geospatial data analysis is one thing. Becoming a mapmaker is another, as important (see **Marlies Vermeulen** hereafter), and sometimes undervalued in quantitative humanities research.

About the Author

Rombert Stapel is a senior researcher at the International Institute of Social History in Amsterdam. He specializes in the use of geospatial data and methods in historical research, particularly in the socio-economic history and population geography of the medieval and early modern Low Countries.

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