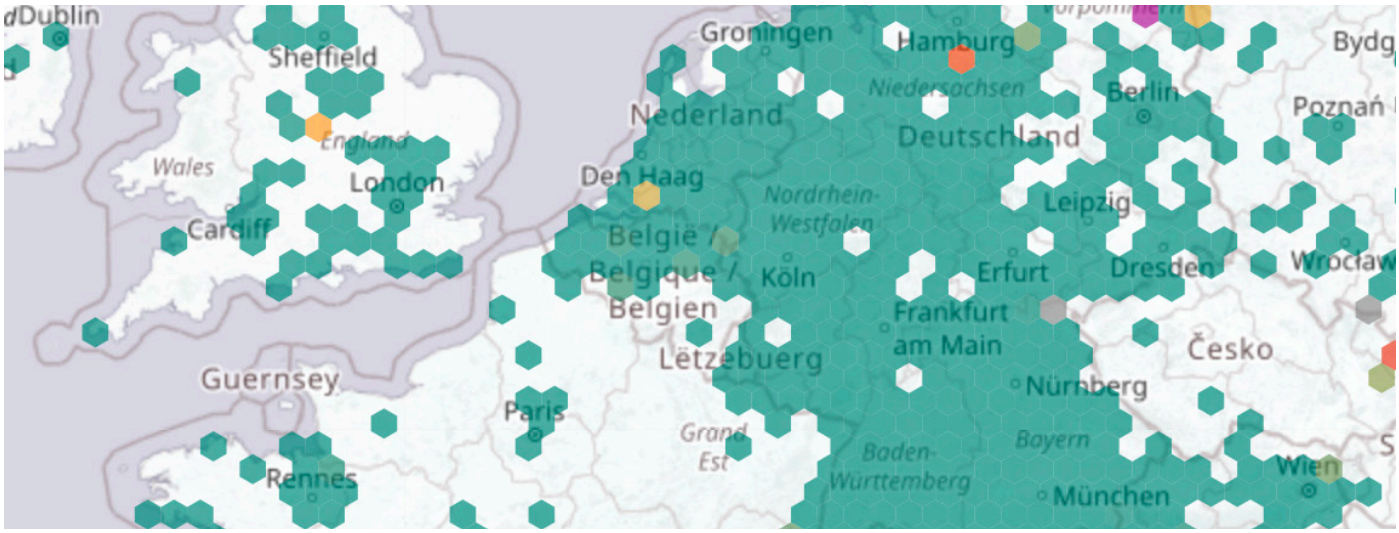

See Figure 3.

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WAYS OF SEEING URBAN DATA: CRITICAL VISUALIZATION AND THE LIMITS OF AIR QUALITY DATA

Keywords: Air quality data visualization, Visualization critique, Feminist visualization

1. RESEARCH PURPOSE

Urban air quality data visualizations are increasingly present in both scientific and public realms; for example, EU member states are obliged to report on air quality [9]; an increasing amount of grassroots-organized projects use low-tech sensors to collect air quality data and visualize them to monitor the readings [26]; and scientific research aims to understand, model and predict air quality [e.g. 14, 27].

Current challenges in air quality visualization concern design processes and usability [13], but also the overall framing, tasks and objectives of air quality data visualization. Addressing these challenges means considering the design of the interfaces available to citizens—created by citizens themselves, companies or governmental institutions and based on do-it-yourself (DIY) or official sensor data.

Air quality visualizations currently largely fail to take into account how sensor data may be contingent, incorrect, inconsistent, incomplete, political, complex, relative and situated. In other words, these limitations of the data—despite their importance—are not represented within visualizations. In fact, due to certain design choices, they may even be disguised.

This work seeks to rethink the visual language that is used to display air quality data, based on an account of the data assemblage and data settings they implicitly represent. This paper proposes starting points for re-questioning visualizations and design processes that, I argue, need to be considered when furthering our engagements with critical air quality data visualization.

Reconsidering how exactly air quality data are visualized and communicated leads to questions regarding how different visualization techniques may facilitate empowering interactions between data, citizens and the matter of air quality itself.

2. BACKGROUND

This project draws on work that engages with critical perspectives on the entanglements of data practices [e.g. 3, 5, 19, 21, 32] and work that seeks to challenge visualization practices through critical lenses [e.g. 4, 6, 7, 8, 22, 23, 31]. Situating the work amongst research areas in and around social sciences and digital humanities offers some fresh perspectives on how data—e.g. air quality data—are visualized and on the conventions that have emerged. I will specify the critical perspectives on data and data visualization that are particularly thought-provoking when applied to air quality sensor data.

D'Ignazio & Klein [4] argue that the actual bodies involved in data practices are currently obscured in data visualization. Indeed, they suggest bringing back these bodies. Two of their observations are particularly intriguing here: 'Bodies are rendered invisible' and 'Bodies go uncounted' [31]. These points raise questions regarding the perspective from which air quality data are visualized and extend to whose standpoints are (not) represented in the data set itself as well as how this representation is accounted for in the corresponding visualizations. Relatedly, Drucker pushes us to consider enunciative theory, which 'marks visualizations as situated, partial, historical, authored, observer-dependent, and rhetorical' [8].

Loukissas [21] argues that 'all data are local' and emphasizes the necessity to connect to the local conditions and contexts of data production— focusing on the data setting rather than the data set—in order to critically understand, use and make sense of data [21, 22, 23]. Air quality data, however, are usually monitored, utilized and visualized from a distance, taking into account only the quantitative data based on the sensors' readings and their geographical context, perhaps including other variables, like traffic, for analytical purposes. This approach is partly enabled by open data standards, which allow for data sets to travel far beyond the data setting, without much context or extensive meta-data, and being accessible and downloadable from anywhere.

Without considering this local and social situatedness of air quality data, we neglect opportunities that may help to make sense of the readings in a meaningful way.

3. APPROACH

While investigating the sociotechnical data assemblage [18, 19] and the local data setting [21] of air quality sensor data, one can start to understand the construction and limitations of air quality data. Applying this approach to a grassroots-driven DIY sensing project, using ethnographic methods, the following implications emerge: the sensors' workings/errors and how to make sense of the data are contingent and relative; diverse objectives and politics motivate sensing practices; sensors and the respective data deeply entangle into everyday lives and homes; the extent of social and local representation vary within the community, the data and the visualization.

The challenge however is to translate these insights into visual language—to move forward from visualization criticism, and rather philosophical ideas, towards a broader, more expressive visual language. This challenge requires reconsideration of air quality visualization techniques in order to facilitate representation of the limits and implications of data sets, bringing back bodies and local data settings.

If we are to make visible the specific issues of air quality data, a range of methodological approaches can be applied such as alternative design approaches and collaborative methods involving citizens. The conceptual and practical framework for this is currently being developed and based on social and humanistic research.

Some starting points and preliminary results follow below, focusing on what, I argue, is currently missing in air quality visualization and which implications might need to be considered.

4. ORIGINALITY

The increasing visibility of urban data visualization in many different contexts offers a testbed for a productive interplay between visualization criticism and design to rethink how exactly we visualize data—data that may be of public relevance.

Recent examples in the area of air quality visualization, coming from both academia and society, mostly focus on two approaches: a) web-based interfaces showing (average) readings with maps and graphs [e.g. 1, 10, 20, 24, 25, 28, 29, 33] or b) physical and situated ways to represent air quality data [e.g. 2, 30, 35], often located between science, art and visualization. This project considers web-based data visualization interfaces and how they can allow for a locally and socially situated experience of air quality data.

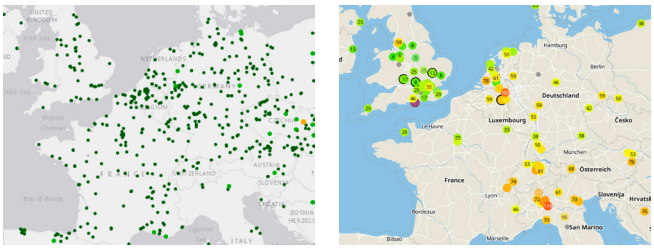

Figure 1: Maps of European Environment Agency (left) and PurpleAir (right) [10, 28].

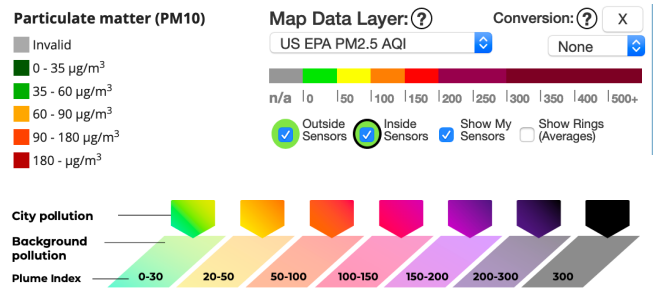

Figure 2: Scales of European Environment Agency (top left), PurpleAir (top right) and Plumelabs (bottom) [10, 28, 33].

5. PRELIMINARY RESULTS

Most air quality maps consist of base maps superimposed with color-coded visual symbols representing the sensor readings (Fig. 1). These usually represent average values of the readings covering a time span of, for example, five minutes before calling the website. The symbols are usually color-coded according to a scale from the minimum to maximum values of the possible sensor readings (Fig. 2). Some local features, like common infrastructure, land use types and names of bigger roads and districts, become more explorable by zooming in. Besides their geographical location, there is usually no additional information on the sensors or their local and social contexts.

Representing the data through homogeneous maps obscures the situatedness and contingency inherent to this data, and further suggests that the sensors generate accurate and consistent readings. However, sensor data often have gaps as there are errors or because there are no sensors available at certain locations. Many maps—through their design and analytical techniques, like interpolation—somewhat imply that there is a whole to see, an 'everything to know' ([12], cited in [23]), when there is not (Fig. 3). Although the data themselves are homogeneous (as they are digital, structured data) the social and local contexts in which these data come into existence are heterogeneous.

Moreover, readings of air quality are usually represented through a bird's eye view to be globally compared. As the data are considered to be of relative rather than absolute

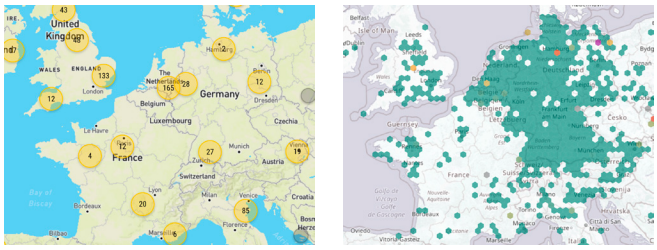

Figure 3: Visual symbols covering a bigger area than the sensors actually represent. Smartcitizen (left) and Luftdaten (right) [24, 29].

meaning, comparing them globally seems helpful. Overall, however, it is hard to interpret the data solely from this top-down view and without considering any local knowledge. The participants of sensor projects, the sensors and the deriving data represent a myriad of diverse social and local conditions, which makes it questionable as to whether the data are comparable on a global scale.

These aspects show how the limitations of air quality sensor data are currently neglected in visualizations. Visualizing air quality data through common maps and graphs omits much of the design space and, with that, the opportunities that may enable empowering interaction with the visualized data.

6. NEXT STEPS

The aim of my research project is to extend the visual language for air quality data visualization. That means exploring techniques that enable representing a range of contextual information, revisiting the choice of graphical primitives and exploring the design space. A key challenge is to enable communications on the data setting, while not leaving out the data set itself. Some of the specific design issues that will be explored are the following:

- What are useful ways, other than annotations to include contextual information?
- Which visualization types, other than maps, may be useful?
- How can we visualize (temporary) data gaps, sensor errors and uncertainties?
- How can we visually communicate whose perspectives are (not) shown and which air quality data we do (not) have?
- How can we visualize friction, heterogeneities, situatedness and partiality?
- How can high-level visual overviews be balanced or enhanced with detailed contextual information, while not hiding information at first?

To date, the design of air quality data visualizations does

not typically consider issues such as these. However, previous work on uncertainty visualization [11, 15, 16], the design of nothing [17, 34] and approaches to visualization from digital humanities [8] points towards approaches that may allow a data visualization to include interpretative and qualitative dimensions.

ACKNOWLEDGMENTS

I wish to thank Marian Dörk and Yanni Loukissas for support on the preceding research project that was foundational for developing the ideas in this paper. I also thank Greg McInerny for discussing drafts of this paper. This research was conducted with support from the Centre for Doctoral Training in Urban Science, funded by the UK Engineering and Physical Science Research Council (grant no. EP/L016400/1).

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