VI. Future fluidity

At the beginning of the research for this study, I traveled to San Francisco to hold a presentation at the annual meeting of the American Association of Geographers. Being there also provided an occasion to conduct many interviews with American climate and water risk modelers. These researchers were at the forefront of the transformations of scientific practice, which have been discussed within this study. Accordingly, the journey to the United States provided me with a taste for developments that would materialize on Telegrafenberg a few years later. As a matter of fact, the Telegrafenberg institutes are just now raising similar infrastructures as those discovered in my journey to California in 2016. Similar to the time-spaces of our fields, our own research entails complex nested temporalities, including those of the past, present and future.

Engaging in data amplification

This chapter aims at operationalizing some of the arguments and investigative devices developed so far. It does so discussing the case of *Surging Seas,* a comprehensive digital mapping of flood and SLR enabled through common efforts by a multitude of actors. I would argue that these activities can provide a glimpse of what predictive work driven by open data and digital platforms could look like in the future. While Surging Seas is not a scientific project in its own right, the example also shows how permeable the worlds of science, politics, the private sector and 'the public' have become within the sphere of the digital. The artifacts populating such digital constellations are fluid. Consequently, substantial characterizations of such objects will be ephemeral and of limited value. It is the relationality and its evolvement that matters in these constellations.

As Rob Kitchin has shown, a variety of actors are putting considerable effort into the establishment of relationships between different sets and kinds of data. Drawing on a note by Jeremy Crampton, Kitchin refers to this process as *data amplification:*

> […] that is, data when combined enables far greater insights by revealing associations, relationships and patterns which remain hidden if the data remain isolated. As a consequence, the secondary and tertiary data market is a multi-billion dollar industry […]. (2014b: 8)[105]

What does such data amplification look like in practice? And how can we make sense of the way actors are making sense of data? How can we represent relationships of 'amplified data'? This may well bow down to a question of diagrammatics. What is the form of our own mental representations of knowledge? What is the diagrammatic form we are comfortable to work with? Is it a chain of references, as in Latour's cascade of inscriptions? Or a rhizomatic network of relationships, consisting of nodes and edges? Or a triangle, representing the layers of a knowledge pyramid? The scientists in my field are confronted by the same challenges when they structure and visualize their digital datasets. The way they deal with it could be described as *kneading.* Within this practice, data is repeatedly arranged in various forms using algorithmic inscription techniques. The aim is not to find the best way to 'represent phenomena as realistically as possible,' but to experiment with the materiality of the data – its texture, robustness and resisting power. The Jupyter Notebook entangled with the Python visualization package Matplotlib (see chapter IV) is a good example of an

105 For the term data amplification, Kitchin refers to Crampton et al. (2013). However, the term actually does not appear in that publication.

environment enabling efficient and effective kneading. Here, data can be knitted (i.e. plotted) into various visual forms in seconds, and the resulting inscriptions may even be compared in parallel. In contrast to more comprehensive proprietary tools for data visualization (e.g. tableau.com), the fairly simple diagrams in Matplotlib do not give away much control over the plotting method.

I found this technique valuable for my own organization of data, kneading it repeatedly into different geometric forms. Kneading qualitative data is much more time-consuming than plotting structured datasets with Matplotlib, but it helped to gain different perspectives on the data captured from my field(s). One possible geometric representation of data and relationships is the knowledge pyramid, as represented by Rob Kitchin (2014b: 10).

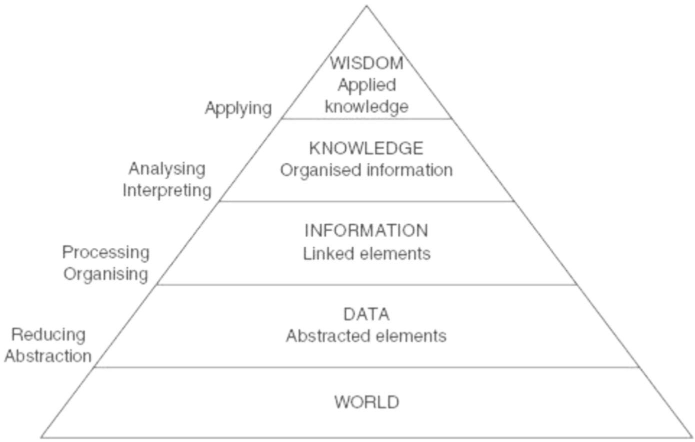

Figure 46: Knowledge pyramid. Source: Kitchin (2014b: 10)

Kitchin thinks of data as forming the base of a knowledge pyramid (see Fig. 46): "[D]ata precedes information, which precedes knowledge, which precedes understanding and wisdom" (ibid.: 9). The layers of the pyramid are distinguished by a process of distillation that "adds organization, meaning and value by revealing relationships and truths about the world" (ibid.). Stepping up the layers of the pyramid is enabled by practices of "reducing, abstracting, processing, organizing, analyzing, interpreting, applying" (ibid.). Kitchin's pyramid builds on similar visual representations of knowledge by Russel Ackoff (1989), Mortimer Adler (1986) and David Weinberger (2014). The analytical consistency of the pyramid has been critically evaluated and partially contested by various authors (Frické 2009; Rowley 2007). Whether the layering of the pyramid appears meaningful depends on the way we understand its constituting elements[106] However, as mentioned earlier, such diagrams may be understood more as tools for kneading our understanding of captured data rather than as representations of the world. Specific geometric forms might also fit particular fields and be estranged from others. For me, it represents well how the actors in my field generally understand the status of their data, their work with information and their creation of climate knowledge, hopefully enabling better ways of handling the present and the future ('wisdom'). However, the knowledge pyramid does not tell us much about the way data, information, knowledge and wisdom may actually be assembled in practice.

During the research and my interviews in California, I discovered two interrelated constellations which are formative for the way climate change-related SLR is imagined and debated in the United States: NOAA's Digital Coast, and Climate Central's Surging Seas. As I learned later, both initiatives are also connected to the PIK's work on global and local SLR. The two interconnected projects (Digital Coast and Surging Seas) provide an opportunity to investigate how actors engage in data amplification.

106 This depends greatly on one's school of thought, as can be illustrated by the multiple understandings of 'information' (Floridi 2010; Kitchin 2014b).

A Digital Coast

The NOAA is an American scientific agency within the United States Department of Commerce that focuses on the conditions of the oceans, major waterways and the atmosphere.[107] The NOAA and a consortium of partners initiated an immense project in 2010 aiming at the production, gathering and provision of high-resolution elevation data for the entirety of the US coastline. Concretely, this required numerous flights over the coastlines with airplanes carrying Light Detection and Ranging equipment (LiDAR): LIDAR, which stands for *Light Detection and Ranging,* is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses – combined with other data recorded by the airborne system – generate precise, three-dimensional information about the shape of the Earth and its surface characteristics.

As the NOAA states on its website, "LIDAR systems allow scientists and mapping professionals to examine both natural and manmade environments with accuracy, precision, and flexibility."[108] The technology has been used for a variety of purposes and application fields, including archeology, cartography, policing and, recently, as a key technology enabling self-driving cars.

As illustrated by a NOAA report, LiDAR data has permitted massive improvements of the National Elevation Dataset and enabled applications in the field of coastal management:

> Lidar data represent several important improvements over previous and commonly used vertical data sets generated for U.S. Geological Survey (USGS) topographic quad maps. The data available through the National Elevation Dataset (NED) have largely been created using photogrammetric

107 See https://www.noaa.gov/ and https://en.wikipedia.org/wiki/National_Oceanic_and_Atmospheric_Administration, retrieved on April 2, 2019.

108 Summarized from oceanservice.noaa.gov/facts/lidar.html, retrieved on April 2, 2019.

> techniques. The resulting accuracy of the NED is on the order of 3 meters or 10 feet [...] with 10- to 30-meter resolution. [...] much of the NED are fairly old, have vertical accuracies that limit coastal applications, and have horizontal resolutions that preclude the definition of coastal features. Lidar, while similar in cost to photogrammetry, is a more rapid technique that relies largely on new technology to produce results. Note that the NED is being updated with lidar data as they become available, particularly for the newer 1/9th arc-second (about 3 meters) resolution NED, [...]. (NOAA 2012: 13)

It is important to highlight that LiDAR data for individual locations may be much more precise than the three meters resolution stated above, but the data has to be averaged into a homogenous national dataset, requiring a downgrade resolution at the local level. One has to differentiate between the accuracy of LiDAR as a sensing technology and the resolution of final elevation models, resulting from cumbersome interpolation, integration and homogenization work. The outcome of this harmonization work is cast into the *Digital Coast,* a comprehensive open data infrastructure accessible through a web platform.[109] The example of the Digital Coast shows impressively that open data is about much more than just 'putting data online.' Drawing on Rob Kitchin and Tracey Lauriault's work, we can characterize the Digital Coast as a *data assemblage*:

> A data assemblage consists of more than the data system/infrastructure itself, such as a big data system, an open data repository, or a data archive, to include all of the technological, political, social and economic apparatuses that frames their nature, operation and work. (2014: 6)

The Digital Coast is about bringing countless primary datasets into a standardized format, making them identifiable and portable through a relational structure of additional information, providing visual tools for the analysis and further manipulation of the data, and offering 'open

109 coast.noaa.gov/digitalcoast/, retrieved on April 2, 2019.

data services,' such as training, and workshops for a variety of stakeholders. As such, Digital Coast has been style-building and an inspiration for many other elaborations of open data infrastructures, including the one on Telegrafenberg (see Chapter V). One has to be conscious of the fact that the Digital Coast is a multimillion dollar enterprise, which is only possible through and depending on comprehensive governmental and legislative support. This can be illustrated by the *Digital Coast Act S.110* of 2017, as reported on the website of the US Congressional Budget Office (CBO):

> S. 110 would authorize the appropriation of $4 million a year over the 2018-2022 period to continue the National Oceanic and Atmospheric Administration's (NOAA) Digital Coast program. Under that program, NOAA makes geospatial data, decision-support tools, and best practices regarding the management of coastal areas available on a public website. (In 2016, NOAA used $4 million of appropriated funds to carry out the Digital Coast program.) CBO estimates that implementing the bill would cost $20 million over the 2018-2022 period, assuming appropriation of the authorized amounts.[110]

The data assemblage of the Digital Coast has been an enabler for many other ground-breaking initiatives, including comprehensive imaginations of the future with climate change. At the same time, it also prestructures the way such imaginaries look and behave, as becomes clear with the example of the SLR mappings by Climate Central. While the NOAA is providing datasets, tools and services to expert communities and stakeholders, the mission of the NGO Climate Central is to cast these data into different visualities and to mobilize and situate them within various public debates. As NOAA employees highlighted in an interview carried out in California:

110 https://www.cbo.gov/publication/52496, retrieved on April 7, 2019.

> So, we are working with these folks who are using this to make decisions about permitting and planning, but also to reach to local folks on the ground; stakeholders that are in cities and communities, to help them see the impacts to their infrastructure and communities. In contrast to Climate Centrals Surging Seas. So, that's for a much broader audience. That is to tell stories for journalists, for the general public. So it's very different.
> (Interview with two NOAA functionaries in San Francisco)

Surging Seas

Surging Seas is a thematic program on SLR and flood risks developed by the non-governmental organization Climate Central. According to its mission statement,

> Climate Central surveys and conducts scientific research on climate change and informs the public of key findings. Our scientists publish and our journalists report on climate science, energy, sea level rise, wildfires, drought, and related topics.[111]

The organization is headquartered at Princeton University and well connected to research facilities in the US and abroad. Collaborators include climate scientist Anders Levermann, who heads the PIK's research department on complexity science[112] and is Professor of Physics at Potsdam University. The scientific intersections between Climate Central and the PIK particularly include the issue of SLR and its projection into the future. In this context, Levermann and Climate Central's Benjamin Strauss and Scott Kulp have developed a study together calculating the number of people in the US threatened by long-term SLR:

111 https://www.climatecentral.org/what-we-do#wwd, retrieved on May 3, 2019.

112 Formerly 'transdisciplinary concepts and methods,' the host department for my field research.

> Based on detailed topographic and population data, local high tide lines, and regional long-term sea-level commitment for different carbon emissions and ice sheet stability scenarios, we compute the current population living on endangered land at municipal, state, and national levels within the United States. (Strauss et al. 2015: 1)

The scientific article includes a political message urging for severe climate protection measures:

> Although past anthropogenic emissions already have caused sea-level commitment that will force coastal cities to adapt, future emissions will determine which areas we can continue to occupy or may have to abandon. (ibid.)

While Climate Central has published a number of such academic articles, their focus lies clearly on the interface between science and non-scientific publics. The most prominent example is Surging Seas, a program arranged around the production of interactive flood maps and their embedding into various platforms of public debate.

Fluid maps

The work of Climate Central and its Surging Seas program crystallizes in compelling digital mappings of floods and SLR. If the NOAA's Digital Coast is to be characterized as data assemblage, we might want to employ the term 'mapping assemblage' for the case of Surging Seas. However, as certainly as they qualify as maps, they are far from a common understanding of maps as truth documents, representing the real world with a certain degree of precision (Dodge et al. 2011: 4). Critical cartographers have always challenged this view of maps as representations of the world, and their arguments oscillate significantly with the way maps work in Surging Seas. As we have seen previously, the cartographies in question are subject to considerable interpretative flexibility. This flexibility within the maps is wanted by its developers, and it is a major source of their power.

Mapping choices

Figure 47 depicts a snapshot of one of these cartographic enterprises. 'Mapping Choices' provides a visual comparison of two SLR scenarios for the same geographic area, here focusing on New York City. Areas at risk of SLR are tainted in blue, representing the surging seas. The story of the mapping is straightforward: Carrying on with business as usual, we have to account for many more risks and expect more damages than if we limit global warming to two degrees, the threshold agreed at the Paris climate summit in 2015. On a rhetorical level, it mediates a choice: While some of the impacts of climate change are preventable, we can lessen the most severe consequences by acting now. Politically, it situates the flood data within the context of the international climate negotiations around the United Nations Framework Convention on Climate Change, which again is heavily structured by probabilistic simulation modeling and its data outputs discussed in former chapters.

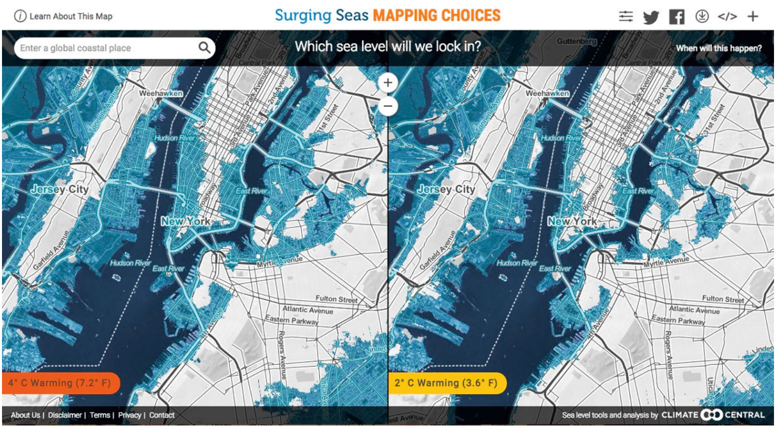

Figure 47: Mapping Choices between a 'due nothing' (4 degrees warming) and a 'transformation' (2 degrees warming) scenario in the area of New York City, USA.[113] Source: Climate Central Website

113 https://choices.climatecentral.org, retrieved on August 9, 2018.

Risk Zone Map

Mapping choices is only one of many manifestations of the Surging Seas imaginary. A second variation is the Risk Zone Map shown in Figure 48. Here, users are not confronted by an explicit visual argument as in Mapping Choices but (literally) build their own image of the future by exploring different scenarios and thematic perspectives.

Figure 48: Climate Centrals Risk Zone Map, here depicting a sea level rise (SLR) scenario of 2 m within the area of New York City, US.[114]
Source: Climate Central Website

The most prominent control element in the dashboard of the map is a symbolic water meter representing different levels of flooding. One can use the water meter as a slider, moving the water meter up and down, hereby flooding the coastal areas with the blue water layer. The spectrum of possible scenarios represented by the scale of the meter

114 https://ss2.climatecentral.org, retrieved on August 9, 2018.

stretches from zero to thirty meters of flooding.[115] The scenarios are subject to considerable interpretative flexibility. One might read the flooded map as a scenario of a distant future with SLR triggered by climate change. It can equally represent a scenario in the near future of inundation caused by extreme weather events, such a hurricane or tsunami.

> Water level means feet or meters above the local high tide line ("Mean Higher High Water") instead of standard elevation. Methods described above explain how each map is generated based on a selected water level. Water can reach different levels in different time frames through combinations of sea level rise, tide and storm surge. Tide gauges shown on the map show related projections (see just below).
> The highest water levels on this map (10, 20 and 30 meters) provide reference points for possible flood risk from tsunamis, in regions prone to them.[116]

Such a 'multi-designation' of scale would not necessarily qualify under the rules of scientific data visualization. Here, however, it allows for an amplification of the argument, while, at the same time, reducing the complexity of navigation.

Driven by open elevation data

We can trace the becoming and further development of the Surging Seas program and its mapping artefacts by making use of the stored historical website snapshots of the Internet Archive and its Wayback

115 The water meter exemplifies the ambiguities of the representation strategies used in Surging Seas: The representation does not adhere to scientific norms in visual representation, in the sense that it packages two different kinds of stories into one Y axis. Zero to 3 m represents scenarios for mean SLR, while 3 to 30 m represents flood risks due to tsunamis triggered by climate change.

116 https://ss2.climatecentral.org/#waterlevel, retrieved on May 3, 2019.

Machine.[117] The analysis shows how the Climate Central's maps are interwoven with the making of high-resolution elevation data produced by numerous actors but coordinated and make available by the NOAA. The highly detailed flood maps of Climate Central would not have been possible without this comprehensive vertical mapping effort within the United States. A description (2015 historical snapshot retrieved from the Wayback Machine) of the initial elevation data available for the maps reads as follows:

> For the elevation data behind our maps, we used the National Elevation Dataset (NED), a product of the U.S. Geological Survey. The NED divides the contiguous United States into a grid of tiny, roughly square cells covering its full area. For each of the millions of trillions of cells, NED provides coordinates and an estimate of average elevation. We used the highest-resolution edition of NED that has full coverage of the coastal contiguous U.S. Cells are approximately thirty feet (ten meters) on a side; this is the finest resolution data publicly available with such extensive coverage.[118]

One does not need extensive expertise in remote sensing technology to consider that such a resolution is barely sufficient for the creation of a robust and detailed three-dimensional picture of the Earth. Even more so, the practices and technologies used to develop the NED dataset

117 Wikipedia entry of the Wayback Machine: "The Wayback Machine is a digital archive of the World Wide Web and other information on the Internet. It was launched in 2001 by the Internet Archive, a nonprofit organization based in San Francisco, California, United States." Last retrieved on July 15, 2019, via https://en.wikipedia.org/wiki/Wayback_Machine. Official website and background information: https://archive.org/about/.

118 Historical snapshot of the Climate Central website captured on January 26, 2015. and retrieved by the Wayback Machine on July 15, 2019 via: https://web.archive.org/web/20150126135901/http://sealevel.climatecentral.org/research/methods/mapping-low-coastal-areas.

varied considerably, as the scientists of Climate Central point out in one of their scientific papers:

> Data sources of varying quality underlie the NED in a complex spatial patchwork, with varying consequences for vertical error from place to place [...]. (Strauss et al. 2012: 4)

Nevertheless, the researchers had done their best to deal with the limited data quality using various interpolation techniques. However, Climate Central also knew that the problem of poor vertical data quality would soon be a matter of the past, due to ongoing vertical mapping efforts by the NOAA. These LiDAR datasets constructed and made available by the NOAAs Digital Coast team enabled Climate Central to improve its elevation models and SLR mappings to amplify their Surging Seas program and produce a number of cartographic artifacts of persuasive detail and quality, such as the Risk Zone Map discussed earlier. Climate Central acknowledges the relevance of this improvement in data quality on a background information page describing mapping methods:

> Improved elevation data: Our 2012 analysis used the best available national coverage elevation dataset at the time. This analysis uses far more accurate laser-based (LiDAR) elevation data.[119]

This text passage triggers a crucial limitation of the Surging Seas assemblage: Its future imaginary, being essentially driven by data, strongly reflects the data divide (Gurstein 2011: 5f) discussed in Chapter V. The million dollar program Digital Coast only produces and makes available data for the coastal areas of the United States, while many of the most vulnerable places threatened by SLR are located

119 http://sealevel.climatecentral.org/maps/science-behind-the-tool, last retrieved on May 3, 2019.

within developing countries. This problem of insufficient data quality outside the US is also mentioned on Climate Central's website:

> Outside of the U.S., very little lidar data is available. Instead, we use radar satellite-based data collected from NASA's Shuttle Radar Topography Mission (SRTM). This elevation data covers nearly the entire populated world, but is less accurate than lidar. SRTM's pixel resolution is lower, and in areas of dense urban development and vegetation, SRTM tends to overestimate elevation. Recent work also suggests that SRTM usually underpredicts exposure from sea level rise and coastal flooding. Outside the U.S., our flood maps should therefore be seen as likely lower bounds on the extent of potential inundation for each water level.[120]

Figure 49: Scenario of 1 m SLR in St. Louis, Senegal (left), and Lower Manhattan, US (right). Source: Climate Central

120 http://sealevel.climatecentral.org/maps/risk-zone, last retrieved on May 3, 2019.

The comparison of the risk zone mapping for the vulnerable city of St. Louis in Senegal and Lower Manhattan in the US (Fig. 49), illustrates the data divide within the imaginary of Surging Seas convincingly. As a matter of fact, the data divide is even stronger than the maps suggest. The resolution of the elevation model available was higher than that shown in Surging Seas but had to be lowered *ex post* for data privacy reasons (similar to the agricultural maps discussed in Chapter III). The data divide is even more amplified through the mobilization of the Surging Seas mappings within digital media platforms, which is discussed in the following.

Googlelization of the future

A variation of the mapping imaginary is a series of YouTube videos. Climate Central developed a so-called 'extreme scenario 2100' within its Surging Seas program implemented through a content layer in Google's geocoding language Keyhole Markup Language (KML)[121]. This content layer can be rendered as a compelling three-dimensional landscape in Google Earth, showing a potential worst-case scenario of a future with SLR triggered by climate change. The animation does not only give users the possibility of discovering the flooded world on Google Earth (Web), the altered framework has also been operationalized as a video maker for Climate Central itself, namely, to develop tailor-made video animations of the extreme scenario for major cities. The videos are created with the built-in fly-through function of Google Earth, simulating a perspective from a low flying airplane shooting video footage.

121 Description on Google website: "KML is a file format used to display geographic data in an Earth browser such as Google Earth. You can create KML files to pinpoint locations, add image overlays, and expose rich data in new ways. KML is an international standard maintained by the Open Geospatial Consortium, Inc. (OGC)." Retrieved on June 4, 2019, via https://developers.google.com/kml/.

Climate Central produced many (about 30) of these flythrough videos to show potential SLR in New York, London, Osaka, Buenos Aires and other major cities worldwide. Above, you see the animation of London with a simulated SLR according to a 4 °C global warming scenario. Similar to *Mapping Choices,* the caption "4 °C" puts the imagery into perspective and attributes the visible flood to the invisible phenomenon of climate change. The 'worst-case' (4 °C) and 'best-case' (2 °C) scenarios are shown here one after the other to give an impression of the difference between the two possible futures.

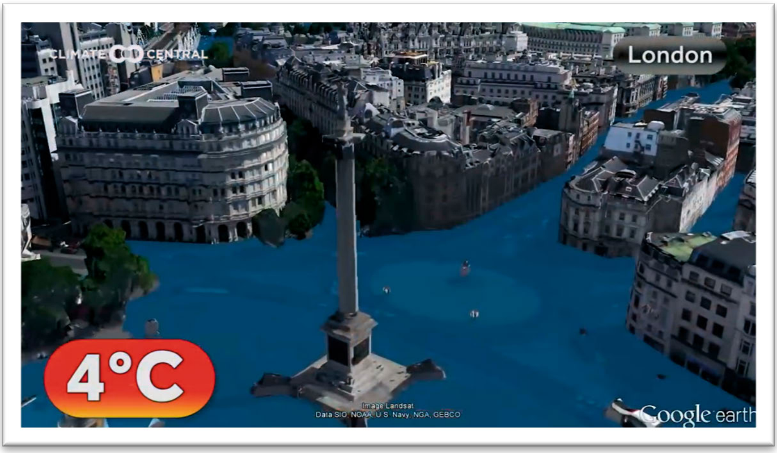

Figure 50: YouTube video by Climate Central: Mapping Choices Global Tour[122]
Source: Climate Central/YouTube

Browsing through the whole set of Climate Central's flythrough videos on YouTube, it is remarkable that these only show particularly popular places, major cities. It almost feels like a tourism advertisement, were it not for the areas tainted in dark blue. The videos fly through the main attractions of the city, showing many of them flooded. The message is

122 https://www.youtube.com/watch?v=VeXwN0ju888, retrieved on May 3, 2019.

clear: We will potentially lose a lot of the places we love to travel to. These places could vanish forever. While the Risk Zone Map struggles with a data divide between the US and the world, the Google Earth extreme scenario amplifies but also alters the composition of the divide. The Google Earth scenarios have been enabled through the decision of the NOAA to provide their datasets formatted as KMZ files. This choice of the KMZ format can be understood as an element of a wider strategy of the NOAA (and other US-American agencies) to mobilize the power of Silicon Valley to address matters of social concern. In a presentation I witnessed at Telegrafenberg in 2016, the NOAA's chief scientist Rick Spinrad called these companies the 'AMIGOS' of the NOAA, loosely referring to companies such as Amazon, IBM, Google and Oracle.[123] Thanks to the provision of LiDAR data as KMZ files, it was possible to depict the SLR scenarios of Surging Seas within three-dimensional landscapes powered by Google Earth. In this version of the mapping assemblage, Surging Seas leaves its focus on the United States and represents itself as an international initiative, visualizing SLR within multiple major cities around the world. However, the choice to 'go Google' also introduces a new data divide, namely between major cities and rural areas. As for the Risk Zone Map, the possibilities and limits of visualization are driven by the data available. Accordingly, the Google Earth scenario deals quite well with the rendering of a few major cities in emerging economies, thereby, lowering the bias towards Western cultures in the future imaginary. This includes visualizations of Buenos Aires, Rio de Janeiro, Osaka, Hong Kong, Dubai and Tokyo. However, similar to case of the Risk Zone Map, it is impossible to depict SLR at a reasonable resolution in especially vulnerable cities of the Global South, such as Dhaka (Bangladesh) and St. Louis (Senegal).

Aspects of GeoGooglization have been highlighted by Tristan Thielmann and others in the article *Dwelling in the Web: Towards a*

123 Presentation by Rick Spinrad at the GFZ on September 16, 2016.

Googlization of Space (Thielmann et al. 2012). On the one hand, Google technologies and services influence the way we ('users') depict, perceive and navigate spaces, what Thielmann and colleagues characterize as 'frontend GeoGooglization' (ibid.: 27ff). On the other hand, Google's localization technologies have enabled wide-ranging profiling and commodification of users, countries, cultures and communities, thereby inducing a 'backend GeoGooglization' (ibid.: 34ff). The example of Surging Seas suggests that (Geo-)Googlization has actually intensified since the publishing of the article (2012). Not only are geomedia user practices, visual aesthetics, and software dominated by Google, but so are the most common data standards (KML). Moreover, the Google Earth imaginaries are then embedded as flyover video animations on YouTube, which is again part of the Alphabet family. We have seen in other chapters of this study that Googlelization might also include other aspects, such as dominant programming languages (Python) and valuation in science (Google Scholar).

Mobilizing allies

Moreover, the Risk Zone Map mashes up the inundation data with other socioeconomic data and indicators, such as social vulnerability, income, population density, ethnicity, property values and cultural landmarks. By choosing 'property values,' for example, one can identify real estate at risk of flooding and SLR. Red areas in New York City in the snapshot shown in figure 50 designate the highest values of over 100 million USD per acre. On the one hand, this constitutes information to be considered for those owning or renting properties in these areas. This is especially relevant in a country which is run by a person owning vast numbers of such properties (i.e. President Donald Trump). On the other hand, for those personally affected, it has entertaining value to browse through the expensive beach houses of the rich which might be drowning in a foreseeable future. The maps generally show that SLR and flooding often harm those communities who are already vulnerable for other reasons (ethnic minorities, the poor). Equally, it shows that wealth does not necessarily protect from climate change. Bruno Latour showed in his characterization of maps as immutable mobiles that these artifacts are so powerful because they enable the effective mobilization and assembly of allies in one place (1988: 23). Surging Seas is a good example of this power of mobilization, in this case, drawing together

various agents behind the causes of Climate Central. These agents involve collective human actors, such as representatives of ethnical minorities, the poor, the socially vulnerable, disaster prevention, real estate agencies, federal and municipal authorities, and politicians. They also include nonhuman elements, such as datasets (elevation data, socioeconomic indicators) and superior project funding.

Figure 50: Risk zone mapping of vulnerable real estate.
Source: Climate Central Website

(Re)Purposing maps

The technical mutability of the maps (e.g. Mapping Choices vs. Risk Zone Map) and the interpretative flexibility of meaning (SLR vs. flood) enable Climate Central to position its imaginary effectively in various kinds of discourses and debates. While Climate Central has initially been a well-established actor within the liberal community of the climate debate, Surging Seas enabled the NGO organization to escape from there and to reposition itself as an actor beyond the climate bubble.

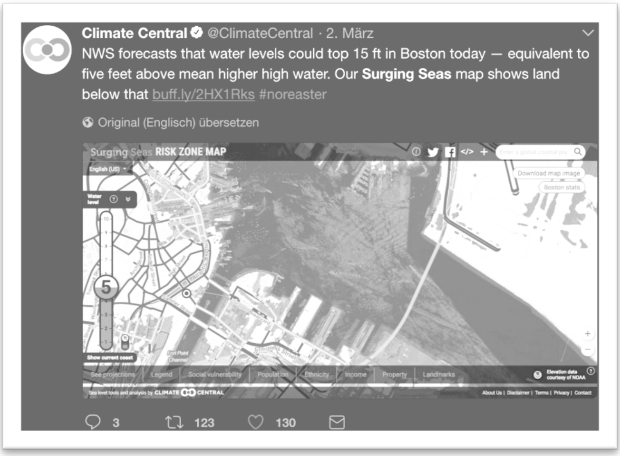

Figure 51: Tweet by Climate Central on March 2, 2018: "NWS forecasts that water levels could top 15 ft in Boston today – equivalent to five feet above mean higher high water. Our Surging Seas map shows land below that buff.ly/2HX1Rks #noreaster"[124]

The best example of this strategy is the repurposing of the Risk Zone Map to comment on ongoing events of public concern. Severe bomb cyclones hit the Eastern coast of the United States in March 2018 and caused severe flooding and damage in Boston and other major cities.[125] Before the event, Climate Central used its maps to produce a short-term (severe) weather forecast per Twitter, as shown in Figure 51. The risk zone mapping stack available was used to simulate flooding expected

124 March 2, 2018.

125 https://www.businessinsider.de/noreaster-bomb-cyclone-boston-floods-2018-1?r=US&IR=T, retrieved on May 3, 2019.

to take place during the next very day of the posting. In so doing, the spatialities available were temporally situated and attributed to events experienced in the present and reported in national and international media.

Co-creating digital publics

As we can see from the preceding examples, the mappings of Surging Seas are not only presented on their own website but effectively embedded and positioned within digital (social) media platforms. In so doing, Climate Central manages to create digital publics that are vividly discussing aspects of the cartographic imaginaries presented. An example are the post-video discussions triggered by the movie *Mapping Choices: Global Tour*[126] on YouTube. The clip shows a fly-through animation depicting popular sites of major cities flooded with water, caused by climate related SLR. The video is called Global Tour, as it is basically a 'best of' of other Climate Central videos, each focusing on one major city. The video is featured in *The Daily Conversation*,[127] a popular channel featuring mini-documentaries about a variety of topics. Glimpses of the comments show that most interactions do not expressively relate to the content of the map (flooding scenario X at location Y). Instead, the cartographic artifact is used as a container and discursive device for discussions of ongoing events and statements of political and ethical views (similar to the *anchoring device* discussed in Chapter III). At the same time, the comments can serve as digitally accountable proof for public interest in the Surging Seas maps and the work of Climate Central more generally. For Noortje Marres, participation in digital societies becomes a resource and valuable good:

126 https://www.youtube.com/watch?v=ekhLHzxc92U&t=8s, retrieved on April 4, 2019.

127 https://www.youtube.com/user/TheDailyConversation, retrieved on April 4, 2019.

> This valuation of participation takes specific forms in digital arrangements, and includes the production of data – with X users signed up, we gain access to X number of profiles – and metrics about participation – so many unique visitors, so many comments – and the development of communicative strategies for market-, audience- and brand-making – the website as community; the identification of targetable influencers. (2017: 151)

The valuation of participation is *per se* not a new phenomenon – more traditional participative arrangements, such as focus groups and stakeholder consultations, have always generated a significant amount of data and inhibited opportunities for publicity. However, as Marres argues, the deployability of participation is particularly notable in digital societies, where "participation data and metrics are not only taken up by experts, but are rather made available to a variety of third-parties and users themselves, thus identifying their deployability" (ibid.: 152)

Such deployment of participation has been explicitly operationalized by Climate Central as an excerpt from the Surging Seas website shows:

> Our Outreach is What Inspires Us.
> Press coverage of the sea level program's work so far totals more than 5,000 stories. […] More than 60 federal agencies and offices, and more than 100 state agencies, county offices, and city offices each have accessed our tools, plus numerous businesses, nonprofit organizations, and educational institutions. […] Our sea level content has received more than 10 million page views.[128]

Accordingly, the extraordinary power of the Surging Seas imaginary is not only caused by its ability to provide visual proof of future flood risks but also effectively valuate the digital publics mobilized through the imaginary. These representations of publics' participation typically

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128 http://www.climatecentral.org/news/coverage-of-surging-seas-inundates-the-nation, retrieved on April 2, 2019.

come in the form of numbers. According to Marres, such metricization constitutes a further feature of participation within digital societies:

> Digital media technologies specifically enable the monitoring, measurement and analysis of participation, and these practices are critical to their transformative effects on society. (2017: 156)

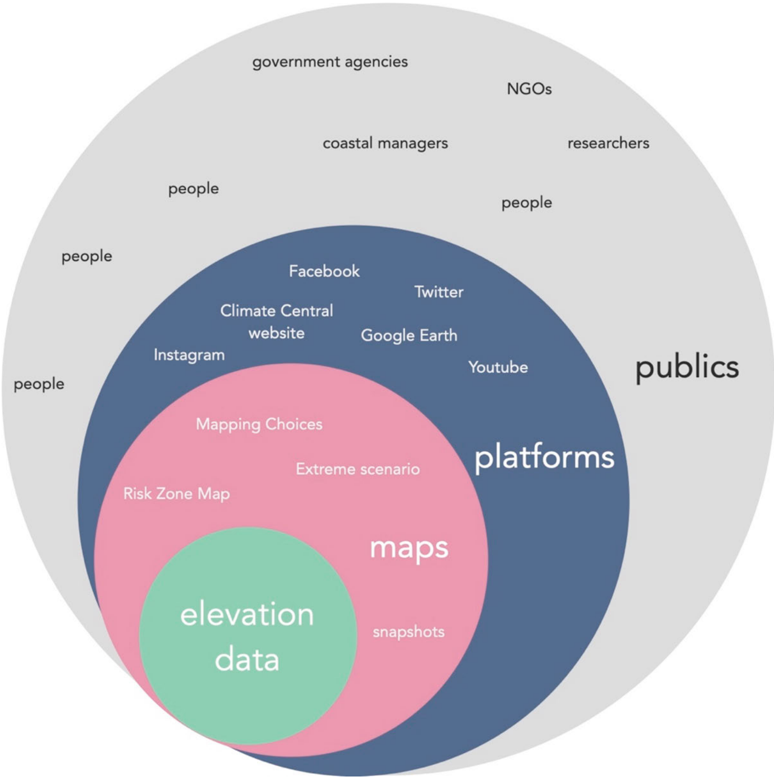

Figure 52: The socio-technical imaginary of Surging Seas, as constructed by Climate Central and captured by my own (digital) research devices. Source: My own visualization

Digital engagements of publics always leave traces, which are captured and transformed into numeric form (e.g. number of likes, mentions, views, comments). In so doing, these traces of participation can be attributed to an actor (e.g. Climate Central), to an assemblage of artifacts (e.g. Surging Seas) or to the relevance of a matter of concern (e.g. SLR). Marres shows that such a valuation of participation within digital societies can be further associated with two characteristics: It is increasingly enabled and mediated through digital technologies and it operates along politics of metricization: "[...] as digital media technologies proliferate across social, political and public life, they have become ever more visible and notable elements in the doing and staging of participation." (ibid.: 153)

Fluidity and viscosity of digital technology

During the analysis of Surging Seas, I was again confronted with the issue of fluidity that has been addressed in earlier chapters. How to account for fluidity in shape and meaning? How to identify and organize fluid elements to make them graspable for analysis? What is changing and what stays the same? And what are the decisive elements, moments, constellations, deciding whether something changes or not? Marianne de Laet and Annemarie Mol (2000) have addressed some of these questions in their case study of the Zimbabwe Bush Pump, a common water pump used in rural neighborhoods. Challenging the idea of immutability in technology, they introduce the concept of *fluid technology* in order to account for aspects of instability, flexibility, temporality and fluidity:

> The Zimbabwe Bush Pump has existed for more than half a century, but it has not remained the same. It is not an immutable but a changeable object, that has altered over time and is under constant review. (ibid.: 228)

As a matter of fact, the *fluid technology* concept has often been evoked along the description of digital phenomena, including online communities (Faraj et al. 2011), the use of mobile phones (Herold et al. 2013), laptops in developing countries (McArthur 2009) and education 2.0

settings (Selwyn 2012). The *Fluidity* of technology is also an aspect discussed on various occasions in *Time for Mapping*, an anthology addressing temporal perspectives on digital mapping endeavors (Lammes et al. 2017). Moreover, fluidity is explicitly mentioned in the context of sustainable energy and climate modeling by anthropologist Kirsten Hastrup. Referring to de Laet and Mol's article, she argues that

> […] technologies of weather and wind, whether designed to harness, to measure, or to mitigate their potential, are fluid objects in the sense described here. They will not work if too rigid, because the weather-worlds in which we live are not rock-solid, but the opposite. The fluidity of the objects is remarkable also when we consider the computer technologies, now capturing the fluidity and complexity of the climate system. (Hastrup 2013: 18f)

The issues discussed by these authors show some similarities to our case of Surging Seas and, more generally, to the phenomena discussed within the book. Against this background, the following paragraphs will elaborate on the arguments of de Laet and Annemarie Mol and consider some aspects more in detail. The hypothesis is that the Bush Pump can help us to understand and describe particularities of digital technological phenomena, using the assemblage of Surging Seas as an example.

De Laet and Mol begin by describing the solid mechanical elements of the pump, including a water discharge unit, a steel pump stand and a lever: "Of course, all this is held together by nuts and bolts" (2000: 228f). For illustrative purposes, they also provide a schematic image of the pump taken from an available instruction manual. However, as de Laet and Mol highlight, this particular shape does not make a pump yet. The pump is also defined by its hydraulic principles that make it *work:* "The hydraulic forces draw water from deep wells to the surface" (ibid.: 230) And the particular way in which the hydraulic principles work make the Zimbabwe Bush Pump part of certain family of pumps, those with a "lever activated lift pump mechanism" (ibid.). Within this family, it is the Bush Pump's capacity that makes it specific and different from all other pumps of this family: "The Bush Pump's strokes are more efficient and powerful than those of most other lift pumps […]." So, the Bush Pump is specific, but the characteristics that distinguish it from each of these also tend to be shared with one or more of the others. "For the Bush Pump, *'being itself' means that it is continuous with a number of others*" (ibid.: 230f, emphasis in original).

Does the characterization of the pump end here? De Laet and Mol would object: "[…] there is a problem, for when it's unloaded from the truck the Bush Pump yields no water. None whatsoever. It is not a pump" (ibid.: 231). For the pump to yield water, it has to be assembled and installed properly into concrete headworks and equipped with a casing. In this way, "it becomes a source of pure, fresh, *clean* water. And so the Bush Pump turns out to be a technology that provides not just water but also health" (ibid.).

Moreover, no technology operates in the void. The bush pump has to collaborate with others to be functional and successful: A tube well drilling device (ibid.: 233) and a community of villagers:

> The pump is nothing without the community that it will serve. In order to be a pump that (pre)serves a community, it not only needs to look attractive, have properly fixed levers and well-made concrete aprons, it must also be capable of gathering people together and of inducing them to follow well-drafted instructions. (ibid.: 234 f)

More than that, the pump does not only serve communities. It helps to hold them together. "As it helps to distribute clean water, it also builds the nation" (ibid.: 235).

To summarize this, we can identify two characteristics of technology that determine its *fluidity:* Firstly, it can be many things at the same time and its boundaries are not solid and sharp. It is equally a mechanical object, a hydraulic system, a provider of water and health, a community servant and a nation-building apparatus. Secondly, its components may change over time but its essence remains stable. The ability to handle temporary break-down and deploy alternative components is a source of strength in fluid technology (ibid.: 253).

The fluidity of Surging Seas

As we can see, the concept is itself fluid and subject to interpretative flexibility. This fluidity may also have been a source for its wide applicability in STS and beyond, with heterogeneous studies all referring to the peculiar technology of the Bush Pump. In the following, we can consider the different aspects of fluidity in dialogue with the empirical case of Surging Seas.

Many things at the same time

Similar to the pump, Surging Seas can be characterized as multidimensional, with these dimensions being interrelated and dependent on each other. If the pump is a mechanical object, a hydraulic system, a provider of water and health, a community servant and a nation-building apparatus, which are the different layers of entities working in Surging Seas? First of all, it is a mapping stack, an entanglement of software elements and aesthetic conventions enabling the depiction of the data on visually appealing digital maps. Secondly, Surging Seas is an informational node, drawing together data and information about probable future SLR and flood risks. Thirdly, it is an sociotechnical imaginary (Jasanoff/Kim 2015), mediating a specific perspective on the future – a future framed essentially as risky territory. Fourthly and building on that, Surging Seas also proposes certain ways of handling this risky future, which are again framed by the propositions that maps tend to make (Wood/Fels 2008). Fifthly, Surging Seas is a conscription device (Henderson 1991), capturing and interrelating a variety of publics for the cause of Climate Central (i.e. reducing GHG emissions and building more climate-resilient communities and environments). Sixthly, it is an anchoring device (see Chapter III) for debates regarding the propositions of the map. Finally, similar to the pump in Zimbabwe, Surging

Seas is increasingly engaging in nation-building. It aims at uniting different parties with potentially conflicting views behind a common challenge and vision to deal with risky futures.

Many things at different times

From time to time, the Zimbabwe bush pump will fail to deliver some of the services it usually promises – water, clean water or health for a specific community. Bolts may fall out of the bucket, the community may be too small (maintenance) or too big (capacity) for the pump, or the water quality is insufficient to meet standards for drinking water. However, this does not make the pump essentially fail. It can be repaired quite easily, spare elements are manufactured and available at multiple locations, and communities may well find temporary ways of handling poor water quality. The pump as a technology is fluid because it has incorporated the possibility of its own breakdown and the flexibility to deploy alternative components. It continues to work to some extent "even if some bolt falls out or the user community changes" (De Laet/Mol 2000: 253).

Nevertheless, we may ask: What are the elements of the bush pump as a technology that are the most difficult to exchange? Which are the elements whose dysfunction or absence is the most prone to breakdown or perceived as a 'failure' of the technology as a whole? At one point, de Laet and Mol address this question in their article:

> Spokespeople in Zimbabwe pointed out to us that the continuation of its manufacture has been a fragile element in the working of the Zimbabwe Bush Pump 'B' type. For a long time it seemed as if it might be its most fragile element – and if this was the case, then it was precisely because it is the least fluid. (ibid.: 247)

In this reading, a technology consists of 'fluid' and 'less fluid' elements, where 'least fluid' elements are considered as 'fragile' (e.g. the manufacturing system). In the following, I would like to propose a reinterpretation and shift of focus in the consideration of fluidity in technology.

Is digital technology essentially fluid?

I would argue that the concept of fluidity in technology is often used not to describe the relationship of fluid and less fluid elements but to circumscribe characteristics such as 'complexity,' 'invisibility,' 'intangibility' or 'lacking ascertainability' of contemporary technology as a challenge for human cognition. Thomas Sutherland investigates the history and meaning of 'flow' and 'fluidity' metaphors for cartography in his article in the anthology *Time for Mapping* and comes to a similar verdict:

> So why, we must ask, has this trope become so popular? Why is the term so frequently, uncritically and off-handedly deployed in the social sciences, and especially within the practices of mapping that have grown in dominance within these disciplines? The simple answer is probably to a large degree the correct one: the image of fluidity is an effective metaphor for the way in which network-driven distribution channels are able to transmit goods, information and even people at *rates and speeds* that make them effectively unthinkable by the human intellect alone, particularly when attempting to represent these movements in a visual manner. (2018: 191, emphasis in original)

In my opinion, it was also this synonymization of fluidity with 'ungraspability for the human eye' that has triggered the popularity of the fluid technology concept for the description of digital and spatiotemporally distributed phenomena, for example, not only algorithms, databases and computer models but also large infrastructures, such as Astrid Hastrup's wind farms. The term *fluid technology* may, therefore, seduce researchers to be content with the determination of fluidity and the identification of fluidity elements[129] which can be illustrated with an example from Surging Seas. In the latter, many elements show characteristics of fluidity in the sense described by De Laet and Mol, one of them being datasets describing socioeconomic indicators:

> Our 2012 research assessed land, population and housing vulnerable to sea level rise and coastal flooding. This research assesses over 100 additional variables, including socially vulnerable population, populations by racial and ethnic group, property value, roads, rail, airports, power plants, sewage plants, hazardous waste sites, schools, churches, and hospitals.[130]

As a matter of fact, the integration of socioeconomic indicators differentiates Surging Seas from other mappings of SLR which became popular around the years 2007–2010. All these cartographies entailed mainly three categories of information: Climate scenarios, inundation and infrastructure. The master narrative (Star 1999) of these flood maps is simple accordingly: Climate change will cause severe inundation in coastal areas and damage to buildings, roads and other infrastructures. Early SLR maps sometimes explicitly indicated 'infrastructure at risk,' such as healthcare facilities, schools, police and fire stations, waste-water treatment plants and nature conservation areas (see Fig. 53). These mappings (consciously or unconsciously) mediated a blunt narrative of risk. And as Ulrich Beck once declared: "Risk is a modern concept. It presumes decision-making. As soon as we speak in

129 The same critique can be made for the prolific use of the terms 'heterogeneous' and 'mobile' in STS, which is equally problematic in my opinion.

130 http://sealevel.climatecentral.org/maps/science-behind-the-tool, retrieved on December 11, 2020.

terms of 'risk', we are talking about calculating the incalculable, colonizing the future"[131] (Beck 2002: 40).

Figure 53: Early SLR mapping by the Pacific institute, detail enlargement of 'infrastructure at risk.' Snapshot taken March 2016 (Heberger et al. 2009 for publication, map no longer available)

On the one hand, 'infrastructure at risk' calls for levees and other territorial protection measures. On the other hand, it makes people check on the map whether they are affected by climate change impacts or not. If not, they may discard climate change as a relevant issue in their life. Surging Seas' association of inundation data, climate change scenarios and socioeconomic indicators shift the master narrative of SLR

131 It should be noted that Beck made this comment in the context of his assessment of counterterrorism measures after 09/11. Despite the very different context, this evaluation oscillates with the narrative of these mappings.

mappings. It mediates SLR and flood risks as issues of national concern, and pretext for solidarity. Similar to the bush pump in Zimbabwe, the SLR mappings engage in community- and nation-building. They put the issues of climate change and flooding into perspective with local and national matters of concern, such as racial discrimination and poverty. In so doing, they call for solidarity between regions, communities and citizens. While socioeconomic indicators alter the narratives of the mappings and amplify their significance and agency, they are not conditional for the whole program. They are fluid elements in the assemblage which can be added or removed rather easily without causing a breakdown or a perception of failure. If they are present, they flow through the assemblage without strongly changing its elementary structure. They are no essential dependencies of the assemblage. By contrast, there are elements that are central for the functionality, performance and success of Surging Seas. I would argue that we can characterize these phenomena as *viscous elements*. They are fluid but less fluid than other elements in an assemblage. They are *viscous* in the sense of *sticky* and *persistent* in an ever-changing network space.

Viscosity in technology

Viscosity in fluid mechanics is a measure of the internal resistance of a liquid to flow:

> The term viscosity is commonly used in the description of fluid flow to characterize the degree of internal friction in the fluid. This internal friction, or viscous force, is associated with the resistance that two adjacent layers of fluid have to moving relative to each other. Viscosity causes part of the fluid's kinetic energy to be transformed to internal energy. (Serway 1996: 427)

I would argue that we can characterize the behavior of digital technologies as a flow of different liquids. Everything may flow together but the different liquids are flowing with varying intensity – they are more or less fluid (and viscous vice versa). Accordingly, the behavior of some elements in digital technologies may be characterized as highly fluid (data flowing through a machine learning process), and others clearly are not (e.g. hardware, server rooms, cables, screens). Elements that are viscous are in between. They are persistent and tend to affect the flowing behavior (velocity, direction) of other elements.

I would argue that the reading of mapping as practice overplays the aspect of mutability in digital maps by black boxing their underlying material base, which is rather stable. We may gain the impression of a constant unfolding of a mapping by observing people's use of a navigator app: The map changes as the app is used and so does its interpretation by the user. However, the material elements in this situation remain rather immutable the whole way through: The smartphone, the app, the operation system, the geodataset, the design classes and attributes, and the servers of the app provider. The approach of this study gives more weight to the material elements and assemblages underlying the map. It abandons not only a focus on the visual surface of lines, points and areas, but also on practice (making and using mappings), and digs deeper into codes, data flows and entangled infrastructures.

Web software development provides multiple devices that can be repurposed for inventive methodologies. We can use the developer tools available in web browsers, for example, to uncover the source code of a map (or website) and identify key dependencies, such as libraries and datasets. Toggling over the Risk Zone Map, the inspector tool reveals the *Leaflet* software library as a main structural component of the mapping stack (see Fig. 54). Leaflet is an open-source JavaScript library used to build web-mapping applications. Along with OpenLayers[132] and the Google Maps API, it is one of the most popular JavaScript mapping libraries and runs in the background of websites and platforms

132 https://openlayers.org/, retrieved on May 3, 2019.

such as FourSquare, Pinterest, Flickr, Meetup, Craigslist, the Wikipedia mobiles applications and various online media providers.

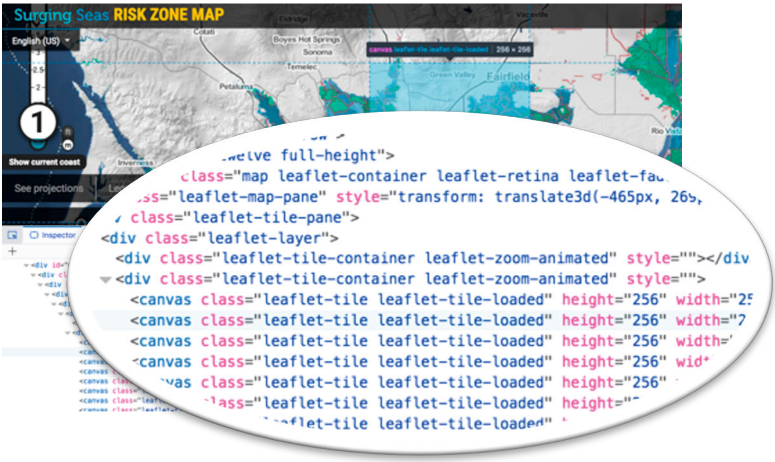

Figure 54: Source code inspector in the web browser Firefox.
Source: Own screenshots

While Leaflet enables the integration of various data sources, it is mostly used in combination with Open Street Map data. It is a free alternative to proprietary services, such as the Google Maps API[133] and ArcGIS online. First released in 2011, it supports most mobile and desktop platforms.[134]

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133 Wikipedia entry: "In computer programming, an application programming interface (API) is a set of subroutine definitions, communication protocols, and tools for building software." Retrieved on May 3, 2019, via https://en.wikipedia.org/wiki/Application_programming_interface.

134 Wikipedia entry: "Cascading Style Sheets (CSS) is a style sheet language used for describing the presentation of a document written in a markup language like HTML. CSS is a cornerstone technology of the World Wide Web, alongside HTML and JavaScript." Retrieved on May 3, 2019, via https://en.wikipedia.org/wiki/Cascading_Style_Sheets.

Leaflet allows web developers without comprehensive skills in geoinformatics to display interactive web maps hosted on a public server, with optional tiled overlays. It can load feature data from GeoJSON files (e.g. from the Open Street Map API), style it and create interactive layers, such as markers with popups when clicked.[135] It is extremely lightweight and has no external dependencies. Leaflet was developed by Ukrainian software engineer Vladimir Agafonkin, together with a strong developer community that is spread worldwide. To date (July 5, 2019), 618 developers had contributed 6,754 times ('commits') to the code of Leaflet on Github,[136] updating, debugging, improving, complementing and documenting it with continuous persistency.

How may we conceptualize the role of Leaflet for Surging Seas? It is an essential element in the assemblage because it enables the mobilization of the elevation models and their depiction as flood maps within the ecology of the web. In fact, there would be other solutions to achieve this outcome but they have several downsides. Proprietary services, such as Google Earth Engine and ArcGIS Online, provide similar functionalities as Leaflet, but their use would be associated with considerable financial costs. This financial aspect is the reason why Leaflet is so popular among NGOs, online journalists and start-up companies. Moreover, using proprietary services would make Climate Central dependent on the functionalities of their services. By contrast, Leaflet, as an open Javascript library, is endlessly modifiable and combinable with other elements. This characterization evokes a comparison with the trope of the *immutable mobile* by Bruno Latour. Referring to maps in particular, Latour lists a number of characteristics that constitute the power of immutable mobiles: They are mobile, they are immutable when they move, they are made flat, their scale may be modified

135 https://wiki.openstreetmap.org/wiki/Frameworks, retrieved on May 3, 2019.

136 https://github.com/Leaflet/Leaflet, retrieved on May 3, 2019.

at will, without any change to their internal proportions, they can be reproduced and spread at little cost, so that all the instants of time and all the places in space can be gathered in another time and place, they can be reshuffled and recombined, it is possible to superimpose several images of totally different origins and scales, they can easily become part of a written text and their two-dimensional character allows them to merge with geometry (Latour 1988: 19f). Several authors (Abend 2018; Lammes 2017; Perkins 2014) have investigated aspects of (im-)mutability in contemporary digital geomedia. Sybille Lammes, for example, has argued that cartographic images in digital mapping enterprises might have become mutable, but the "digital map as a network of control" remains stable:

> Although the image itself may have become mutable since the advent of digital mapping, the digital map as a network of control is still immutable for the map source is stored in a database (e.g. Google Maps) that is not easily transformable and operates according to set rules. (Lammes 2017: 1030)

I generally agree with this interpretation. The GIS powering CIO, discussed in Chapter III, is a good example of such stability of the map-underlying "network of control." Nevertheless, the case of Surging Seas and the operationalization of Leaflet suggests a slight alteration of this characterization. Leaflet seems to be the element which *affords* many of the characteristics described by Latour: It enables maps to be mobilized within the web, three-dimensional elevations to be flattened on a two-dimensional space, to be scaled and modified without any change in their internal proportions, to be reproduced and spread at virtually no cost, to be reshuffled and recombined with multiple information layers, and to be supplemented by written text and positioned within (social media) fora of debate. Is Leaflet the immutable mobile then, enabling the mobility of the Surging Seas maps? I would argue that this is not the case. Libraries such as Leaflet are updated frequently by their large community of contributors in order to run smoothly with the pace of the web. Similar to the Zimbabwe bush pump, their relative fluidity is the key to their internal stability. Nevertheless, one might miss the point to characterize Leaflet as a 'fluid technology.' Instead, it can be portrayed as a sticky, persistent, *viscous object* within a fluid assemblage of technological elements.