



# Negotiating the Data Deluge on YouTube: Practices of Knowledge Appropriation and Articulated Ambiguity Around Visual Scenarios of Sea-Level Rise Futures

Simon David Hirsbrunner\*

Human-Centered Computing Research Group, Institute for Computer Science, Freie Universität Berlin, Berlin, Germany

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### \*Correspondence:

Simon David Hirsbrunner  
simon.hirsbrunner@fu-berlin.de

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The present study aims at evaluating how YouTube users understand, negotiate and appropriate science-related knowledge on YouTube. It is informed by the qualitative analysis of post-video discussions around visual scenarios of sea-level rise (SLR) triggered by climate change. On the one hand, the SLR maps have an exemplary status as contemporary visualizations of climate change risks, beyond traditional image categories such as scientific or popular imagery. YouTube, on the other hand, is a convenient media environment to investigate the situated appropriation of such visual knowledge, considering its increasing relevance as a navigational platform to provide, search, consume and debate science-related information. The paper draws on media practice theory and operationalizes digital methods and qualitative coding informed by Grounded Theory. It characterizes a number of communicative practices of articulated knowledge appropriation regarding climate knowledge. This includes “locating impacts,” “demanding representation,” “envisioning further,” “debating future action,” “relativizing the information,” “challenging the reality of anthropogenic climate change,” “embedding popular narratives,” “attributing to politics,” and “insulting others.” The article then discusses broader questions posed by the comments and related to the appropriation and discursive negotiation of knowledge within online video-sharing platforms. Ambiguity is identified as a major feature within the practice of science-related information retrieval and knowledge appropriation on YouTube. This consideration then serves as an opportunity to reconsider the relationship between information credibility and knowledge appropriation in the age of the digital. Findings suggest that ambiguity of information can have a positive impact on problem definition, future imagination and the discursive negotiation of climate change.

**Keywords:** online media, science communication, climate change, qualitative method, visual media, YouTube, environmental communication, futures

## INTRODUCTION

“Images are made and used in all sorts of ways by different people for different reasons, and these makings and uses are crucial to the meanings an image carries”

(Gillian Rose, 2001, 14).

Images have played a crucial role in mediating scientific knowledge between various publics. They have helped to think about complex issues and negotiate meaning from abstract categories such as numbers and concepts for a long time. This is particularly true for the issue of climate change, with its perceived abstractness, invisibility, and futurity (Doyle 2009, 2011; Manzo 2009; 2010; O’Neill and Nicholson-Cole 2009; O’Neill and Smith 2014). The iconography of climate change can be described as a competition between two families of pictures—those trying to grasp the global, complex and virtual of environmental change, and those focusing on the local, concrete, vulnerable and personal. Proponents of the first type of images mainly take the form of charts and maps representing scientific results, particularly data outputs from computer simulations. Some of these data visualizations have frequently made it into the news, international policy negotiations, and other spheres of public debate. Examples, which have also been discussed from the perspectives of various academic disciplines, include the “hockey stick” (Montford 2010; Walsh 2014), the “burning worlds” (Schneider 2012; 2016; 2017) and the “burning embers” (Mahony and Hulme 2012). The second heterogeneous class of images tried for a long time to balance out the shortcomings of these diagrammatic devices, which were often perceived as distancing and failing to mobilize people to care more about the climate and its changes. As an antidote, the public was flooded with motives of polar bears, vulnerable landscapes, individuals affected, technological solutions and empowered communities. Movies such as Al Gore’s *An Inconvenient Truth* have tried to combine the benefits of different image types by featuring both techno-scientific projections of possible futures, local snapshots of past experiences and offers for an engaging present.

Another visual strategy with the similar objective—to inform, affect and engage at the same time—was to make computer-driven visualizations more concrete, tangible and germane to relevant publics (Sheppard et al., 2011; Sheppard 2012; Gurevitch 2014). This development has received a particular boost in recent years due to significant advances in visualization software and technology, as well as extensive development and access possibilities for open (climate) data. A popular example of such “affective” data visualizations are mappings of climate-related flood risks and sea-level rise (SLR), which built the cornerstone of the present study. Some of these visual devices can aptly be referred to as data visualizations, mostly representing flood risk as blue (water) or red (risk) layer on a cartographic map. Others may be characterized as dynamic animations, vividly depicting flooding often in three-dimensional, hyperrealistic landscapes. Their visual “genre” cannot be definitively set—they both incorporate characteristics of scientific, technical imagery, as well as narrative and aesthetic strategies of popular media.

In parallel to technological innovations, the social practices relating computer-generated data imagery and their publics have

also changed in recent years. Many people have acquired considerable skills to explore, analyze, understand, describe, and debate data images as representations of scientific facts and artifacts (Gray et al., 2016). Visualizations of climate-related data are at the forefront of this development—they have pedagogic devices in educational settings (Blumenthal et al., 2016), experimental devices in Climate Hackatons (Haarstad et al., 2018) and discursive devices for climate debates on social media platforms (Hopke and Hestres 2018; Wang et al., 2018). Put otherwise, data images have become crucial boundary objects (Star and Griesemer 1989) enabling the negotiation of climate change across social worlds (Hirsbrunner, in press). Social media platforms have recently become preferential places to host such visual boundary objects and discursive negotiations of scientific and environmental matters. YouTube, for example, includes thousands of videos and discussions addressing the many facets of climate-related issues. The platform now owned by Alphabet has become an important source for many people who seek information about science-related issues (Medienpädagogischer Forschungsverbund Südwest, 2015; Forum; Wissenschaftskommunikation, 2016) and particularly about climate change (Allgaier 2019).

Despite this dominant role of the platform for climate knowledge appropriation, there has not been much research on this topic yet. Existing studies on climate-related content and post-video discussions on YouTube have mainly focused on the aspects of political deliberation, controversy and the positioning of content and comments within existing discourses on climate change. For example, Shapiro and Han. (2018) have shown that post-video discussions about climate change are typically driven by few individuals actively campaigning for or against climate change-related action. According to the authors, this dominance of elite campaigners limits the deliberative opportunities for new discussants and ideas to enter the debates (Shapiro and Han, 2018, 116). Similarly, Uldam and Askanius. (2013) have analyzed YouTube user debates around COP15 climate conference in Copenhagen and evaluated the potential of the platform to provide a communicative space for citizens’ engagement in climate politics. They highlight the potential of YouTube to act as a platform enabling the mobilization of activists for the climate cause, but also show that political debates about climate change on YouTube are often characterized by a hostile ambience and tend to impede a true dialogue. These findings are confirmed by Jana Tereick’s analysis (2013) of the “climate lie” topos in German post-video debates. Tereick observes the formation of two group argumentations and identities, which mainly define themselves in opposition to the other. Members of one group are skeptical towards climate science and mass media and depict the other group as docile followers of mainstream positions. The other group is committed to the scientific consensus on anthropogenic climate change and defames members of the first group as reactionaries and conspiracy theorists. These identities are so dominant in the discussions that the respective identity-generating terminology is often assumed to be known and both groups parody each other. For Tereick, the debates represent “pseudo-dialogues” enabling users to react to mass media contributions, without the conventional mass media actually participating in the debate (Tereick 2013, 249 f).

Compared to these characterizations of discursive practices in post-video discussions, Joachim Allgaier (2019) takes a step back and asks what users find in the first place when searching for climate change-related issues on YouTube. To do so, he analyzes a sample of 200 videos triggered by different search terms. For the search terms “Climate,” “Climate Change,” “Climate Science,” and “Global Warming,” the study finds that the absolute majority of videos adhere to mainstream views based on the scientific consensus of climate change. Many of these videos are professionally produced TV news and documentaries. They accurately represent scientific views on global warming and often highlight the serious negative consequences of anthropogenic climate change. In contrast, Allgaier also shows that users searching for the terms “Geoengineering,” “Climate Manipulation,” “Climate Hacking,” “Climate Engineering,” “Climate Modification,” and “Chemtrails” are led to videos that challenge mainstream scientific positions on climate change, including material covering conspiracy theories. Conspiracy theorists have also managed to occupy space in more science-related discourses as those about geo- and climate engineering. According to Allgaier, this correlation between geoengineering and chemtrails is more than a thematic overlap, but a strategic move by conspiracy theorists to distort communication mainstream discursive spaces and to hijack and relabel new discursive concepts such as “geoengineering” with their own ideas (idem, 10 f).

All studies mentioned above look at social media discussions with an explicit climate lens. Similar to other studies evaluating the public understanding and perception of global warming, the authors analyze along a continuum between supportive (“believers”) and dismissive (“deniers”) attitudes towards climate change. This continuum is an important heuristic for the entire field of climate change communication, which can be illustrated by several seminal studies covering these issues. For example, an influential audience segmentation analysis from 2009 divided the United States-american population into six segments with different attitudes towards information on climate change: alarmed, concerned, cautious, disengaged, doubtful and dismissive (Maibach et al., 2009). The study has later been adapted to other (media) geographies such as Germany (Metag et al., 2017). In the same year as *Global Warming’s Six Americas*, media researcher Matthew Nisbet. (2009) published an article characterizing rival framings of “scientific uncertainty” and “climate crisis” in the reporting of climate change within mass media. The study highlighted the importance of media frames for public engagement, but also pointed at severe biases and misconceptions in the media coverage of global warming in the United States. Insights from these studies have helped to improve media reporting on climate change and they have informed the work of climate change communicators in the United States and elsewhere. Newer studies, however, have also criticized the believer–denier continuum. Namely, Corry and Jørgensen. (2015) argue that the continuum is focuses too heavily on climate change as a scientific object and around trust in associated scientific claims: “Critics of Kyoto-style agreements are not necessarily “deniers” of AGW [anthropogenic global warming], while on the other hand scientific evidence in itself does not legitimate one particular set of climate policies” (idem, 172). Put otherwise, the believer–denier continuum often reduces people’s complex attitudes towards global warming to two related

considerations: first, do people believe in the reality of anthropogenic climate change? Second, are they then ready to take action or at least accept climate mitigation policies? Instead, Corry and Jørgensen propose to move beyond the categories of “believers” and “deniers” in order to re-politicize the policy debate while depoliticizing the science debate. Along these lines, the present study proposes to analyze debates around visualizations of sea-level rise futures without employing an explicit “climate (change communication) lens.” It is interested in the ways people appropriate science-related knowledge on YouTube, without necessarily ordering these practices of appropriation into a believer–denial continuum about the reality of anthropogenic climate change.

After stating the main research questions of the study (**Research Questions**), the paper introduces media practice theory (**Results**), digital methods (**Ambiguity in Video Content, Comments and Media Environment**) and Grounded Theory-informed qualitative coding (**Ambiguity in Video Content, Comments and Media Environment**) as the theoretical and methodological underpinnings of the study. **Credibility and Appropriation** discusses the two SLR videos and post-video discussions as research material and presents a set of communicative practices of knowledge appropriation as a result of the analysis. Building on the characterization of these practices, **Credibility and Appropriation** then discusses *ambiguity* as a major feature in the post-video discussions and practices of knowledge appropriation. This ambiguity has different facets and is related both to the informational, narrative and esthetic qualities of the video material in question and to the ways people deal with science-related information in the “unedited public sphere” (Bimber and de Zúñiga, 2020) of social media platforms. The paper finally makes the case for ambiguity in climate change communication and highlights its role in practices of future imagination and online knowledge appropriation.

## RESEARCH QUESTIONS

The research questions of the present study are the following:

- What strategies do users operationalize to make sense of the video content, to appropriate the SLR mappings, and to negotiate aspects of the scenarios among them?
- How can these communicative patterns be formalized as distinct practices of articulated knowledge appropriation?
- What higher level issues relevant to online knowledge appropriation can be inferred through the comparison of these communicative practices?

## THEORY: UNDERSTANDING MEDIA AS PRACTICE

The study draws on media practice theory and a situated understanding of media, as elaborated by authors such as Nick Couldry. (2004), Erhard Schüttpelz. (2006), Tristan Thielmann (Thielmann and Schüttpelz, 2013) and others (Dang-Anh et al.,

2017). As Nick Couldry puts it, the approach theorizes media as practice, rather than as text or production process: “What range of practices are oriented to media and what is the role of media-oriented practices in ordering other practices?” (Couldry, 2004, 25). How then, can we characterize these situated practices among the commenting and debate of SLR scenarios on YouTube? In comparable efforts to study online communication, authors have referred to “discursive practices” (Dorne and Navarro, 2011; Wrana, 2015), “material-discursive practices” (Orlikowski and Scott, 2015), “digital practices” (Jones et al., 2015), and “media practices” (Dang-Anh et al., 2017) of online communication. While these conceptualizations have much in common, they highlight different nuances, which are informed by the specific empirical cases, research contexts or incorporation of theory.

Media linguist Jannis Androutsopoulos characterizes online communicative interactions following the broadcasting of media content as “mediatized practices of content-related communication”<sup>1</sup> (2016, 344). In his study, he specifically discusses two cases of such practices: Online discussions on Twitter following the broadcasting of the popular German TV show *Tatort*, and debates on Facebook following the most recent transmission of the major news program *Tagesschau*. Among other things, the study shows how existing dynamics of mass media reception are altered by new constellations of social media engagement across platforms. While this oscillates with our example of people discussing video content on YouTube, there are some considerable differences between Androutsopoulos’ example and our material. On the one hand, the animated SLR scenario videos have been produced specifically for YouTube, and they are also consumed and debated by users within the same platform. Accordingly, the affordances of the YouTube platform will have their share in structuring the practices of media consumption and content-discussion at hand. On the other hand, these videos are thematically and aesthetically more homogenous than the content discussed by Androutsopoulos. (2016). It is, therefore, assumed that the commenting practices can be attributed more directly to the informational, narrative and esthetic specificity of the video content—to visual scenarios of flood and SLR in particular and climate-related future imaginaries more generally.

Considering the science-related issues at hand and the strong thematic focus of the videos and user comments, we can also consider the comments as a practice of knowledge appropriation. While there are different interpretations of the term “appropriation”, the latter is commonly understood as an action aiming to bridge the distance between the appropriating subject and the object to be appropriated (Faber, 2001, 29). As a matter of fact, appropriation is not only informed by the video content, but by other factors such as psychological and social personality, the body of knowledge available and the specific circumstances of media consumption. In the context of commenting behavior on YouTube, appropriation is also influenced by the affordances of the YouTube platform: This includes the working of its search and recommendation

algorithms, and the affordances of the comments section. In addition, appropriation may also include an ordering of the past discussions and a positioning of one’s own comment within this order.

It is important to highlight here that knowledge appropriation is not to be understood as passive transfer of information, but as an active process. This is true for knowledge appropriation in general, but also specifically for the case of appropriation of media content. As Ulmer and Bergmann. (1993) highlight, media users rarely absorb media content in a passive way, but actively appropriate and process it by thematizing, reconstructing and discussing what they have experienced in conversation with others (1993, 83). This demonstrates that appropriation is more than just sense-making. While the latter is a psychological category addressing the cognitive ordering of information encountered into matters of everyday life, appropriation should be considered as a social practice. By commenting on the SLR videos on YouTube, users not only articulate their personal understanding of the videos, but they also position and negotiate meanings among themselves. They not only absorb the information and articulate their elaborated meaning of the videos, but also make their positioning digitally accountable (see Thielmann, 2012). The latter does not only have an impact on the social interactions themselves, but also allows and configures new ways of scientific investigation.

## METHODOLOGY: INVESTIGATING VISUAL MEDIA AS PRACTICE

Compared to the rhetoric of the written and spoken word, the semiotic language of visual media is often perceived as vague, ambiguous and elusive (Eppler et al., 2008). On the one hand, images carry a great deal of implicit meaning and interpretative flexibility, which is similarly true for maps (Harley, 1988; Caquard and Cartwright, 2014), digital data images (Rose, 2015), and particularly the visualization of climate data (Mahony and Hulme, 2012; Walsh, 2014; Schneider, 2017). On the other hand, the meaning of an image strongly depends on the situated use of images, its contextualization, and audience. Against this background, many different ways exist to obtain an understanding of visual media and to analyze and describe their meaning, reception and negotiation by audiences. Gillian Rose. (2016) discusses many of these approaches in her seminar book on *Visual Methodologies*, including content analysis, semiology, psychoanalysis, discourse analysis, audience interviewing, ethnography, digital and other methods (including mixed ones). Online media practices are a special case in this regard, as they also come with the promise to make themselves effectively accountable as digital traces of various kinds (Dang-Anh et al., 2017, 24 f). One should not misinterpret digital traces as virtual representations of social interaction and practice. Rather, digital research methodologies must always be vigilant to spot the distortions and situated production contexts of online social data (Marres and Gerlitz, 2015; Schäfer and van Es, 2017; Gerlitz and Rieder, 2018). Nonetheless, one can certainly make digital traces productive for practice-oriented research, as has

<sup>1</sup>German original: “Praktiken der Anschlusskommunikation”

been shown by investigative approaches such as technography (Rammert and Schubert, 2006), webnography (Strübing, 2006), and digital ethnography (Pink et al., 2015). Informed by these approaches, the present study focusses on the relationships and dynamics between visual artifacts, discursive user interactions, and YouTube as an enabling and structuring media environment. These connections are then used to carve out situated mediated practices coping with the visual future scenarios presented in the relevant videos. The characterization helps one to understand broader concerns within online debates appropriating and negotiating complex scientific problems, such as the challenge of source attribution, genre fuzziness and articulated ambiguity.

## Digital Methods and Tools

Within its techno-experimental setting, the study draws on the digital methods approach, pushed forward by proponents of the Digital Methods Initiative at the University of Amsterdam (Rogers, 2013; 2015). Rather than referring solely to the use of digital tools for analysis (instead of “analogue methods”), “digital methods” in this reading designate a specific positioning of how to *understand* such instruments and *make them productive* for critical media analysis. The guiding idea is that existing technological entities such as algorithms and APIs can be repurposed as research devices to investigate the social practices, technologies and politics of the platform economy (Rogers, 2013, 1). The aim is not to use these tools as mere instruments to extract web data representing certain social realities. The idea is rather to critically assess the ways in which digital technologies produce and reconfigure social realities, and if and how culture can be studied through digital data. Visual studies scholars like Gillian Rose have critically assessed the potential of digital methods (as research approach associated with certain tools) to be productive for the analysis and description of digital imagery (Rose, 2016). Considering that such approaches combining digital methods with image analysis are still at an early stage of development, this paper is also intended as a methodological contribution to this perspective. The following tools and applications have been operationalized for data extraction and analysis within the present study:

YouTube Data Tools (YTDT)<sup>2</sup> are a toolbox for extracting data from the YouTube platform via the YouTube API<sup>3</sup> version 3, and some scraping functionalities built on top of it. The YTDT provide a particularly convenient visual interface for social media researchers to extract data from YouTube without the need to engage directly with the API. After exploring and extracting YouTube data via YTDT, the output can then be analyzed using other software packages. The “Video Info and Comments”-module<sup>4</sup> of YTDT has been especially used here to extract user comments and associated identification and

interaction data, (e.g. numeric identifiers, channel names, likes, number of replies).

The analysis of the data has been carried out using *Gephi* and *Microsoft Excel*. *Gephi*<sup>5</sup> is an open source data visualization and exploration software for all kinds of graphs and networks, which is frequently used in the context of social network analysis. Some of the data extracted with the YTDT is optimized for analysis with *Gephi*, namely GDF-files<sup>6</sup> enabling the visualization of video, channel and user networks. However, *Gephi* also provides wide-ranging possibilities to visualize, sort, filter and manipulate all sorts of tabular data. In the present study, *Gephi* has been used to explore the datasets and to visualize networks between videos, channels and users. The spreadsheet and analysis tool *Microsoft Excel*<sup>7</sup> was used in the qualitative coding process (see next paragraph) to analyze, label and categorize the user debates linked to the two videos in question.

## Qualitative Coding and Grounded Theory

Qualitative data coding is a common way to build and analyze data in social science traditions such as sociology, anthropology and psychology. It has been operationalized in various research contexts, including social media analysis (Vieweg et al., 2010). Generally speaking, *coding* refers to the process of assigning labels or tags to research material to make it fit for analysis and scientific reasoning. Qualitative coding can equally be applied to highly unstructured and varied material, (e.g. memos, images and video in ethnographic studies) and relatively structured items, (e.g. the datasets analyzed within the present study). The data labeled are then used for theory development, which may again adhere to more formal or informal procedural rules.

A formal and common set of approaches to theory development based on qualitative coding is Grounded Theory (GT). According to sociologist Kathy Charmaz, GT methods “consist of systematic, yet flexible guidelines for collecting and analyzing qualitative data to construct theories from the data themselves.” (Charmaz, 2006, 2) GT has first been conceptualized in 1967 by Glaser and Strauss. (1999) and has been further developed and tailored to multiple fields, materials and scientific disciplines. Analytical steps in GT-informed studies are not carried out sequentially but happen rather in parallel throughout the research process. Nevertheless, advocates of GT have proposed different coding procedures, which also tend to build on each other. Firstly, research material is annotated freely with labels in a process referred to as *open* or *initial coding*, which is accompanied by constant comparison and adaptation. On the one hand, such open or initial coding should stick closely to the data and may be guided by questions such as: “What are these data a study of?“, “What do the data suggest and pronounce?“, “From whose point of view” and “What theoretical category does this specific datum indicate?”

<sup>2</sup><https://tools.digitalmethods.net/netvizz/youtube/>, last retrieved on September 1, 2020.

<sup>3</sup><https://developers.google.com/youtube/v3/>, last retrieved on September 1, 2020.

<sup>4</sup>[https://tools.digitalmethods.net/netvizz/youtube/mod\\_video\\_info.php](https://tools.digitalmethods.net/netvizz/youtube/mod_video_info.php), last retrieved on September 1, 2020.

<sup>5</sup><https://gephi.org/>, last retrieved on September 1, 2020.

<sup>6</sup><https://gephi.org/users/supported-graph-formats/gdf-format/>, last retrieved on September 1, 2020.

<sup>7</sup><https://www.microsoft.com/de-de/microsoft-365/excel>, last retrieved on September 1, 2020.

(Charmaz, 2006; Glaser, 1978; Glaser and Strauss, 1999) On the other hand, what distinguishes GT-informed coding from other labeling and categorizing activities is its focus on action. As Charmaz suggests, one should “look closely at actions and, to the degree possible, code data *as* actions” (Charmaz, 2006, 47). Categories emanating from the open coding process are then further refined in *focused coding*, synthesizing and explaining larger segments of data.<sup>8</sup> Accordingly, GT researchers engage in *theoretical sampling*, which means seeking and collecting additional data to elaborate and refine categories for the emerging theory. Theoretical sampling is expected to be carried further until no new properties emerge, a state referred to as *saturation*. Furthermore, methodological strategies such as *sorting*, *diagramming*, and *integrating* can help further in the theoretical development of the analysis. The use of working with visual, conceptual maps has proven particularly useful in this regard (Clarke, 2003; Clarke et al., 2015). It should be noted here that the coding procedures towards grounded theory are not understood as a strict formula to be followed step-by-step. Rather, GT generally leaves a lot of freedom to the analyst to decide whether and how the different modes of coding make sense within the situated researcher context. GT in the context of this study is, therefore, essentially a guiding heuristic highlighting the simultaneity of different analytical procedures and an inductive stance towards data inquiry and theory development.

## RESULTS

This section designates the selection process for the empirical material (5.1), describes the two selected videos (5.1.) and identifies a number of commenting practices within post-video discussions (5.3).

### Selection of Video Material and Post-video Discussions

At first, an exploratory study was carried out to identify what YouTube users find when they search for climate change-related issues and particularly sea-level rise. Despite the opacity of YouTube’s algorithms, we can make some statements about the way people find, consume and navigate such video content within the platform. One major entry point for people to browse videos is YouTube’s search function. The user types a certain word or phrase into the search field and receives a list of videos. By default, the content is sorted by relevance, but it can also be shown by upload date, view count or rating. The way the YouTube search algorithm ranks results by relevance is complex and opaque. It calculates relevance based on a mix of platform metrics such as semantic similarity, likes, recentness and engagement. Search results may

<sup>8</sup>Some scholars using GT approaches carry out a third kind of categorization, *axial coding*, where classes and hierarchies of codes are compared to deepen understanding and help theory-development (Corbin and Strauss 1990, 16). In other conceptualizations of GT, axial coding is only seen as a facultative step, which may or may not be useful in a concrete research situation.

also differ from interaction to interaction, depending upon a person’s search history, location, and timing of retrieval. Social media researchers have operationalized different strategies to account for such algorithmic personalization. A common approach is to create a research browser that has a clean search history and doesn’t allow for cookies or similar tracking devices. Alternatively, one can retrieve search results via YouTube’s developer API—either directly in a computer terminal or using dedicated interfaces like the YTDT. While APIs have their own issues with bias in data retrieval (Pfeffer et al., 2018), they usually provide better ways to deal with such distortions than analysis within the end-user platform interfaces. In the context of the study, the YTDT video list module<sup>9</sup> was used to retrieve YouTube search results for the queries “sea-level rise,”<sup>10</sup> while balancing out algorithmic variations using multiple iterations.

The analysis of the top ranked videos on SLR revealed a number of characteristics: first, videos with considerable debates (number of user comments) also rank highest on “relevance.” As shown elsewhere (Burgess and Green, 2018), YouTube specifically values user generated content and debate, which is also reflected in its search algorithm and related video feature. Second, a considerable share of the top ranked videos were produced by US-based popular science channels (RealLifeLore, Verge Science, The Daily Conversation, Science Insider, Business Insider). This illustrates how climate impacts have become a mainstream topic, which fits popular science formats promoted by media platforms such as YouTube. Third, animated maps showing possible flooding due to climate change triggered SLR are a prominent visual format in the top ranked results.

Considering aspects of representativeness and feasibility, two videos were selected for further analysis within the study: “The World After Sea-Level Rise” by *Climate Central/The Daily Conversation* and “How Earth Would Look If All The Ice Melted” by *The National Geographic/Science Insider*. Both videos were 1) among the top10 search results for relevant videos on SLR, 2) they triggered considerable user debates, 3) they were featured by a popular-science channel and 4) they adhered to the prominent esthetic genre, namely animated maps.

### Analysis of the Video Material

#### Video 1: The World After Sea-Level Rise (Figure 1)<sup>11</sup>

The video depicts two- and three-dimensional views of flooding cities around the world, including London, New York, Rio de Janeiro, Tokyo, Dubai and Hong Kong. The video is a showreel

<sup>9</sup>The module retrieves “related videos” from the search/list#relatedToVideoId API endpoint. Developer website on the YouTube API, available at <https://developers-dot-devsite-v2-prod.appspot.com/youtube/v3/docs/search/list#relatedToVideoId>

<sup>10</sup>The author also experimented with alternative spellings (sea level rise, sealevel rise), but these variations did not lead to different search results. In contrast, search results differ considerably when the term is translated into other languages (“Meeresspiegelanstieg” in German, ‘élévation du niveau de la mer’ in French, “subida del nivel del mar” in Spanish). The analysis in the present study has been limited to videos with English titles, narration and (most) comments.

<sup>11</sup>Link to video 1 on YouTube: <https://youtu.be/xE0KtLy5j8w> (last retrieved on 30 Sept 2020). Acknowledgments stated on YouTube: Clips courtesy of Climate Central, video edited by Robin West and produced by Bryce Plank.



**FIGURE 1** | The world after sea-level rise (© climate central/daily conversation).

of the online maps produced by the United States-based non-governmental organization *Climate Central*. Its SLR program *Surging Seas* is structured around a series of dynamic mappings of SLR and flood risks, which are presented in multiple visual formats, positioned into various discourses of public debate and disseminated throughout numerous media channels. The underlying data, elevation models, SLR projections and aesthetics of the maps have been updated several times since the start of the program in 2012, acknowledging new scientific findings, and better data and mapping technology.<sup>12</sup> Most views of the video were generated with the mapping software *Google Earth Engine*, which made it possible to render the flooding projections as overwhelming sceneries in three dimensions. The video designates two alternative scenarios of SLR, one with two degrees and one with four degrees of global warming. On the date of data retrieval (June 2, 2020), the item had had 239,715 views, 1,800 likes<sup>13</sup> and 614 comments. The video was published on January 24, 2017, by *The Daily Conversation*, a popular YouTube channel (865 M subscribers by June 2020) featuring mini-documentaries about a variety of topics. Other popular videos of the channel address topics such as *China's Future MEGAPROJECTS (2019–2050s)*, *Ebola: The Deadliest Outbreak Explained*, *10 Incredible 4K (Ultra HD) Videos*, and *Future Military Robots Explained*.

### Video 2: How Earth Would Look If All The Ice Melted Figure 2<sup>14</sup>

Similar to video 1, the item depicts cartographic views of a future with SLR. A globe is slowly turning and changing its shape—from the present face of the earth into an undesigned future, where many coastal areas are lost to the sea. The maps were produced

by the staff of the science newspaper *National Geographic*, based on multiple research insights and open data resources.<sup>15</sup> The underlying projection is different from video 1 in the sense that it shows a situation where the polar ice caps have melted completely and the water has been absorbed by the oceans. While video 1 shows two equally probable long-term scenarios of SLR, the projection from video 2 may be characterized more as a low probability high-risk scenario according to the current state of science at the time of writing (summer 2020). From its aesthetics, video 2 is more faithful to the conventions of two-dimensional satellite cartography, with color shades of blue, green, yellow and brown. In the course of the animation and the flooded future unfolding, a number of vulnerable cities are designated by white points and name tags popping up before being besieged by the blue of the rising waters. The video was published on February 18, 2015 by *Science Insider* (1.4 M subscribers by June 2020), a brand of the large news website *Business Insider*<sup>16</sup>. On the date of data retrieval (June 2, 2020), the video had had 18, 957, 824 views, 66,000 likes (averaged value) and 25,949 comments.

### Analysis of Post-Video Discussions

Open coding informed by grounded theory was carried out on user comments posted under video 1. The sample includes all comments posted between January 24, 2020 (publishing date of the video) and November 16, 2019 with 600 comments in total. The data contains original comments (N = 336) and replies to those comments (N = 264). The comments were labeled as distinctive actions, characterizing the articulated attitude of users towards the media content and SLR scenarios depicted.

<sup>12</sup>Today, the maps mostly build on open datasets provided by the United States-American government agency NOAA (North American Oceanic and Atmospheric Administration). See <https://coast.noaa.gov/digitalcoast/>, last retrieved on June 3, 2020.

<sup>13</sup>Likes are represented as rounded values within the YouTube interface.

<sup>14</sup>Link to video 2 on YouTube: [https://youtu.be/VbIRNT\\_gWUQ](https://youtu.be/VbIRNT_gWUQ) (last retrieved on 30 Sept 2020)

<sup>15</sup>Video produced by Alex Kuzoian, Science Insider. Acknowledgments for the maps stated on the National Geographic website: Philippe Huybrechts, Vrije Universiteit Brussel; Richard S. Williams, Jr, Woods Hole Research Center; James C. Zachos, University of California, Santa Cruz; USGS; NOAA; ETOPO1 Bedrock, one arc minute Global Relief Model. Copyright: September 2013 National Geographic Society.

<sup>16</sup>[www.businessinsider.com](http://www.businessinsider.com), last retrieved on June 3, 2020.

After the labeling and categorization of the user data linked to video 1, a second video and user debate was identified for theoretical sampling. Video 2 was chosen because of its high designation of relevance for the SLR issue attributed by the YouTube algorithms (top rankings for search results and recommended videos<sup>17</sup>), due to its media-specific similarities (information, narrative, aesthetics) to video 1, and its massive number of user comments (more than 25,000 by the time of data retrieval). The first 600 comments were chosen as a sample for category comparison, elaboration and refinement. The data analysis led to the identification and characterization of distinctive practices of articulated knowledge appropriation related to visual SLR scenarios. The categories include “locating impacts,” “demanding representation,” “envisioning further,” “debating future action,” “relativizing the information,” “embedding popular narratives,” “attributing to politics,” “challenging the reality of anthropogenic climate change,” and “insulting others”. Practices were included in this typology provided that a share of five to twenty percent of comments could be attributed to them. Moreover, in the case of inferred practices representing more than twenty percent, it has proven useful to split the category and use more differentiated practices.<sup>18</sup> It is important to note that comments are sometimes attributed to more than one category and practice. Comments, for example, may simultaneously imagine what will happen in the future (“envisioning further”), mobilize for climate action (“debating future action”), and play with irony (“relativizing the information”).

### Locating Impacts

The animated maps of both videos show geographic locations flooded by layers of blue water. Accordingly, an obvious practice related to the imagery is to discuss what can be seen on the map. A considerable share of the comments in both videos refer to the locations, which will be flooded according to the scenarios. Most frequently in this category, users comment on the flooding depicted of their own living environment. A frequent practice is to write “RIP” (rest in peace) or “Goodbye” and then refer to the specific city: “Goodbye to my home in Bahrain” (B016), “RIP Florida” (B026). The truthfulness, likeliness or accuracy of the scenario depicted is not challenged or debated in these comments. It is taken as it is and the articulated reception works along with the dichotomy “flooded” vs. “safe,” for example, “Australia is covered by sea, but Melbourne is totally safe” (A102).

<sup>17</sup>Relevance within search rankings was evaluated by using the “video network module” of the YTDI, which taps the YouTube data API and its search/list#relatedToVideoId API endpoint: [https://tools.digitalmethods.net/netvizz/youtube/mod\\_videos\\_net.php](https://tools.digitalmethods.net/netvizz/youtube/mod_videos_net.php). This procedure allows for relatively unbiased output and evaluation of search results and recommended videos, which are independent from cookie tracking and other personalization techniques in the web.

<sup>18</sup>This, for example, was the case with the preliminary category “localizing climate impacts”, which was subsequently split into “locating impacts” (referring to depicted locations on the map), “demanding representation” (referring to locations not represented), and partially to “attributing to popular narratives” (mentioning fictional locations such as “Atlantis”).

### Demanding Representation

A considerable number of users also complain about the places left out: “Why did you leave out the African continent? or you don’t really care whatever happens there?” (A073). As can be illustrated by this comment, cartographic representations typically evoke debates about what is put on the map and what is not, who is represented and who is not. While the reasons for showing some places and leaving out others may be attributed to specific conditions in map production, they always have both a technical and political dimension. As I have discussed elsewhere (Hirsbrunner, *in press*), the decision to show a specific location or not is connected to factors such as the availability of data, models and technology to produce the maps: The SLR maps require high-dimensional elevation data, which are expensive, technology-intensive and cumbersome to produce. Elevation models can only be developed by highly skilled experts in dedicated research institutions. Geographic information tools, such as Google Earth Engine, can only render dynamic three-dimensional landscapes (as in video 1), where the overall data resolution is particularly high, (e.g. metropolitan areas, industrialized countries). While this has not been an intention of the map producers, video 1 especially prevents people from vulnerable but less iconic places to make connections to their own living environments. The comments show that the dichotomy between the represented and unrepresented also translates to the comments section, where debates are mostly conducted by the “mapped,” with a few exceptions of users demanding representation.

### Envisioning Further

Some users take the scenarios depicted as a starting point for their own imaginations of a flooded future. They go beyond the dichotomies between flooded vs. safe and mapped vs. unmapped in their comments and add to the imaginary using their own words. Some of these personal visions are informed by science-informed models and scenarios: “(. . .) Since the people would have to move, cities would be more crowded. A lot of foreign diseases would reach other places because of all the emigration. People would starve because there would be less land for agriculture. Lots of species would die because they lost their home” (B192–01). However, many of the personal additions to the scenarios depicted are not realistic and do not try to be so. As one contributor writes: “We will have sharknado type water spouts. A lot of people will be eaten by sharks. Orcas will patrol the streets” (A001–09). However, some of these other envisioning comments discuss the potential benefits of the scenario: “Good thing egypt [sic] will have more water so more people can live in more places” (B124). Similar to “demanding representation,” “envisioning further” can be understood as a strategy of sense-making and appropriation of the scenario by commentators. Independently of the likeliness of the personalized scenarios described, “envisioning further” is cognitive and articulative work, which proves that people have processed the information depicted and linked it to their extant body of knowledge. The act of selective perception (watch the video, absorb the information) and the articulation of the reception (commenting) should not be underestimated as a



practice in a media environment such as YouTube, where abundant content cries for attention.

### Debating Future Action

Users also discuss ways to cope with a future life in the scenario depicted and solutions for the climate crisis: Planting a lot and I mean A LOT of trees is probably the cheapest, easiest way to clean up the atmosphere after reducing emissions by swapping [sic] to renewable energy, etc” (A004–02). The contributions address both, strategies to mitigate climate change (“How can we stop this from happening” A351) and adapt to it (“This is not good for me. gotta sell my house in ho chi minh city.” B194). Similar to the practices described so far, comments “debating future action” do not challenge the plausibility of the scenario(s) depicted. As a matter of fact, it is striking that comments “debating future action” do not mostly refer to the specific consequences depicted in the scenario. The scenario only serves as motivation to debate decisions, engagements and coping strategies more generally. Moreover, many comments gain an important new dimension within this practice of appropriation. They become attributable to the climate discourse, with all the mobilization strategies, unwritten rules and positionings of this debate.

### Relativising the Information

Users often use non-literal language in their comments. This includes the use of irony (“rising seas? just drink the water” A008–09), sarcasm (“Who cares! I have a kayak, that I bought from Walmart, who is part of global warming problem. But hey, it was cheap!” A275) and cynicism (“I wouldn’t mind if humans got extinct to be honest. I lost faith in humanity a while ago” A014–03). Using nonliteral language in digital media communication is a common practice, which may take the form of specific expressions, figures of speech, and the use of heavy punctuation and emojis (Whalen et al., 2009). Sarcasm especially seems to have qualities as a rhetorical strategy to fit the debate of the informational content and scenarios at stake. As Ashley Anderson and Heidi Huntington have highlighted in their study of climate debates on Twitter, the use of sarcasm allows one “to identify and appeal to like-minded others through the critique of outsiders, while maintaining an appearance of civility through plausible deniability” (Anderson and Huntington, 2017, 602). In the case of the SLR maps, the commenters maintain and verbalize a critical distance to the future scenario, without explicitly challenging or discarding it. This sometimes also leads to further discussions debating or resolving the specific tone of a comment: “I am going to ignore the cynic in me and hope that you’re joking” (A008–01).

### Challenging the Reality of Anthropogenic Climate Change

It is remarkable that the techno-scientific accuracy of the flood maps is rarely debated or challenged within the YouTube user debates surrounding the videos. The only critique about the way flooding is depicted in the maps is the missing representation discussed under above. Equally, issues such as likeliness, probability or uncertainty literally play no role in the debates.

This is, despite the fact that these categories are crucial elements of risk communication and are explicitly addressed in one of the videos: Video 1 shows two different scenarios (two degrees vs. four degrees of global warming), which are clearly labeled as such in the animation. By contrast, a considerable segment of comments challenges the climatological underpinnings of the flood scenarios: The melting of the polar ice caps, and the reality of anthropogenic climate change. Commenters claim, for instance, that “(. . .) The planet earth is getting COOLER, not warmer” (A137) and announce that “Global warming is the biggest hoax ever” (A240). Such views are voiced by mainly right-leaning, United States-based authors, who attribute the videos and depicted scenarios to “left wing propaganda” (A219). The debates around the fact- and faithfulness of the videos are especially vivid and potentially toxic (see also “insulting others”).

### Attributing to Politics

Twenty (video 1) to thirty percent (video 2) of the comments make a reference to political debates beyond SLR or climate change. The comments politicizing the imagery are distributed in fairly equal shares in liberal and conservative positionings for both videos.<sup>19</sup> This fair share also indicates that the channels are consumed by politically diverse audiences. On the one hand, conservative voices dismiss and discredit the visual scenarios as an element of unsound climate science or left-wing propaganda (as in “challenging the underlying science”). The (only) prominent figure often mentioned in these comments is former presidential candidate and Vice President Al Gore: “GIVE AL GORE MONEY TO SAVE THE EARTH AND HE WILL TURN ON HIS SPECIAL AIR CONDITIONER [sic]” (A195) On the other hand, liberal voices often refer to and criticize President Donald Trump and his administration: “This will happen if the idiot trump climate change denier dont [sic] get impeached” (A003). Interestingly, these two personifications are very stable, even if Al Gore is currently out of the political picture and current elections. It can also be debated whether making fun of President Donald Trump should be considered as a (liberal) political statement. In some comments, Trump serves more as a kind of pop figure, with all the implications this has for (the characterization of) current political debates. This tendency can be illustrated by the recurrent theme in the comments to combine the consideration of SLR futures with the debates around Trump’s plan of a United States-Mexico-border wall (“We’re going to build a wall and the ocean is going to pay for it!!!” A259).

One important specificity of the comments in the category “attributing to politics” is that most users posting right-leaning arguments are clearly of United States-descent, while critical comments evoking president Trump are much more diverse regarding user nationality.

<sup>19</sup>In the discussion section, this practice is therefore split into two categories, “attributing to politics (left-leaning)” and “attributing to politics (right-leaning).”

## Embedding Popular Narratives

“Embedding popular narratives” here means that the informational content and the aesthetics of the videos are associated with existing popular stories, cultural themes and narratives. Examples of the themes evoked are Abraham’s deluge (bible) and Atlantis and Venice as different imaginaries of flooded cities. Some media works discussed are Blade Runner (film), Inconvenient Truth (film) and Minecraft (computer game). Comments evoking cultural narratives are also among those triggering the most responses from others, including likes and replies. The comment in video 1 with most likes is “and Venice will be the next Atlantis” (A007–1) (148 likes), and in video 2, “Noooo! Where is Atlantis:’ (.” (B001) is at rank three on likes (72 likes). Other comments do not explicitly mention specific stories, but clearly play with popular narrative elements. Similar to the practice of “envisioning further,” “popularizing the imagery” can be characterized as an imaginative strategy to make sense of and appropriate technoscientifically complex scenarios and their depiction as data images.

## Insulting Others

The use of insulting language has a variety of recipients and targets in the debates accompanying the SLR scenario videos. Users offend and threaten as part of the user-user interaction (“how about you come down here to Texas and I’ll put some knuckle bumps on your IGNORANT head, BOY!!” B061–16), they insult people outside of YouTube because of their worldviews (“Send this video to all moronic climate deniers.” B256) and make openly racist statements (“I would be fine if the Earth decided to drown countries in the Middle-East and Africa” B282 and “too many indians anyway” B166–22). Tracing the posting behavior of users in this segment across multiple video discussions shows that they are either particularly active commenters on the YouTube platform, or have only posted once. In the case of active commenters, “insulting others” coincides with online practices of hate speech and trolling, which has been discussed thoroughly in academic literature (Hopkinson, 2013; Lange, 2017; 2019; Cruz et al., 2018). As Patricia Lange has highlighted, such practices of hate speech have to be differentiated from voicing criticism, considering that they do not involve any substantive occupation with the issues at hand (Lange, 2007, 6). Such comments in the context of this study mainly represent political views of the far right, and insult liberal politicians, the press, foreigners or ethnic minorities (Muslims, Jews, Indians).

## DISCUSSION

As the typology in the results section shows, users operationalize different strategies to make sense of the video content, to appropriate the SLR mappings, and to negotiate aspects of the scenarios among them. This following discussion evaluates whether and how the distinct practices of articulated knowledge appropriation are related to each other. Moreover, connections are drawn from the identified practices to higher

level issues relevant to online practices of scientific knowledge appropriation. On the one hand, this includes the discussion of ambiguity in the content, comments and media environment. On the other hand, the section discusses the relationship between information credibility and knowledge appropriation.

## Ambiguity in Video Content, Comments and Media Environment

“Ambiguity” emerged as a salient theme from the comparison and relational analysis of the practices (categories). Quoting poet William Empson, ambiguity can be understood as “an indecision as to what you mean, an intention to mean several things, a probability that one or other or both of two things has been meant, and the fact that a statement has several meanings” (Empson, 1947, 5f). Ambiguity can therefore have affinities with terms such as vagueness, uncertainty, doubtfulness or equivocality. In the context of the study, we can identify ambiguities in all aspects of the research material—the videos and their visual scenarios, YouTube as a repository for science-related information and the comments of the post-video discussions.

The fact that users have an ambiguous relationship has already been addressed explicitly for the practice “relativising the information.” Comments and their authors consider the scenario depicted, but keep it at arm’s length using rhetoric tactics such as irony and sarcasm. The use these tactics can be understood as a method of users to make their reservations towards the video content expressive and accountable to other users. As ethnomethodologist Harold Garfinkel has argued, members of communities and groups use distinct methods to make their interactions with others “visibly rational-and-reportable-for-all-practical-purposes” or “accountable” as organizations of commonplace everyday activities (Garfinkel, 1991, vii). This feature of all communicative group interaction has also been particularly acknowledged and discussed for the case of social media (Thielmann, 2012). We may therefore speak about *articulated ambiguity* with regard to the post-video discussions at hand. As a matter of fact, commenters do not only articulate ambiguity in the practice of “relativising the information.” Rather, articulated ambiguity is also a feature of various comments of other segments such as “embedding popular narratives.” By embedding popular narratives, users connect the visual facts with broader narratives of flooded cities (Atlantis) and futures (Waterworld) to make sense of the scenario depicted. They thereby signal to others that they consider the scenarios as an interesting future projection, without considering its scientific soundness.

The crucial role of articulated ambiguity in the comments and debates points to the fact that users cannot realistically evaluate the credibility of the information depicted within the situated practices of a YouTube media experience. The lack of perceived credibility can equally be attributed to characteristics of the media content and to the way the content is embedded within online media ecologies. It is obvious that the producers of the SLR videos heavily mixed formalistic conventions, storytelling and aesthetics of different visual genres. This is true for both animations, but can

here be illustrated with the case of video 1: The piece by Climate Central/The Daily Conversation can equally be read as a scientific visualization, a clip for political campaigning or a fictional story. The visualizations of flooding are informed by the insights of scientific studies, (e.g. Strauss et al., 2012; Strauss et al., 2015) and designate two alternative scenarios of global warming (two and four degrees), which evoke traditional conventions of uncertainty representation in climate research. A political reading is triggered by the depicted choice between two future pathways: A sustainable and a detrimental path. This presentation of choices is informed by scenarios of the Intergovernmental Panel on Climate Change (IPCC, 2013) and the international climate negotiations within the United Nations Framework Convention on Climate Change (UNFCCC, 2015). The caption of the video on YouTube also invites a political reading of the imagery depicted, stating that “President Donald Trump’s policies may lock us into 4 of warming.” With this comment, it becomes clear that certain policies and politics may be better suited to achieve the internationally agreed limitation of global warming to two degrees instead of a more detrimental scenario of four degrees. Finally, several esthetical design elements evoke tropes of apocalyptic fiction movies. This includes the visual focus on drowning monuments of cultural identification such as the American statue of liberty and the White House, and the pompous, heavily produced soundtrack with its menacing undertones.

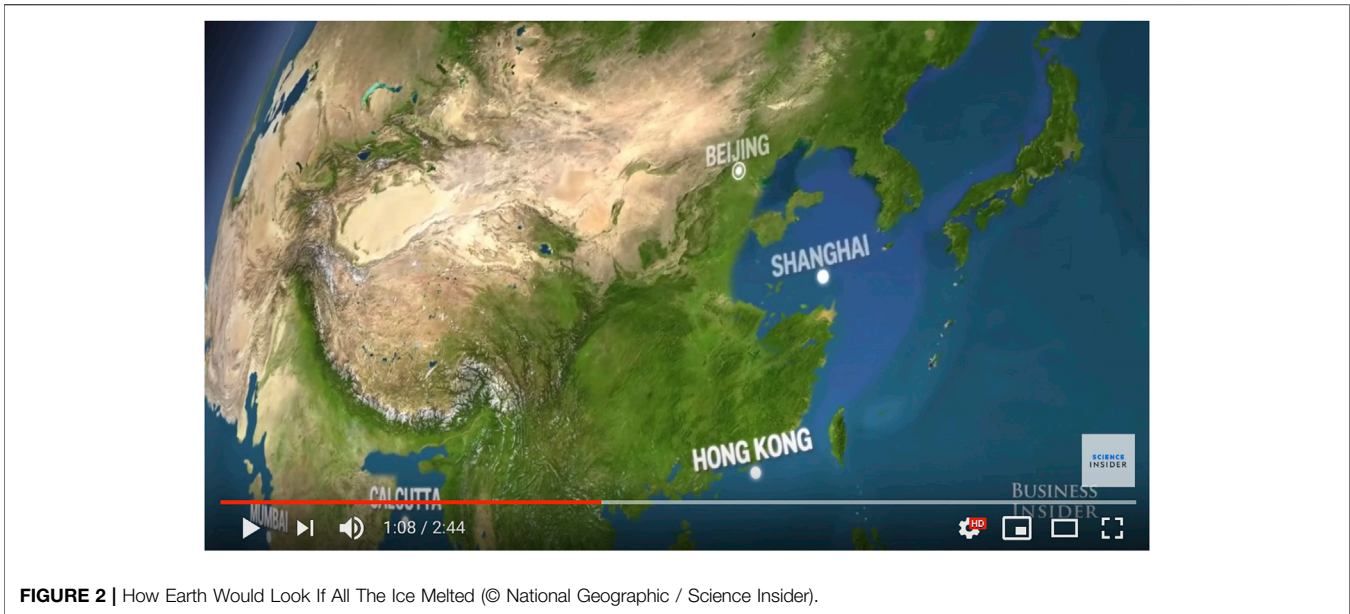
Articulated ambiguity cannot only be attributed to the characteristics of the video content, but also to YouTube as the enabling media environment. The prominence of ambiguity in the comments shows that users are aware of the challenges online media poses to information source attribution. Users make this awareness accountable to others by their use of articulated ambiguity within the comments. As S. Shyam Sundar has shown, assessments of information credibility are traditionally performed by considering the trustworthiness of the communicator. If the attributed source of a piece of information is a credible person or organization, then, according to conventional wisdom, that information is probably reliable” (Sundar, 2008, 73). Attributing information to a single actor in the digital age, however, is often difficult because of the multiple layers of sources in online information transmission (idid). Sundar specifies several cognitive heuristics that play a role in source evaluations within online media, including aspects such as the machine, bandwagon, authority, social presence, helper and identity. Several of these heuristics are likely to be triggered in the case of the SLR maps on YouTube discussed within this study. We can again examine the example of video 1 in this context. Truly assessing the credibility of the mapped flooding would include evaluating the trustworthiness of elements such as the underlying elevation models (NOAA, United StatesS LiDAR consortium, Climate Central), the future projections of CO2 emissions, the melting of polar caps and following SLR scenarios (several research institutes), their three-dimensional rendering (Google Earth Engine, Climate Central), the animation of the maps for the video (independent producers, The Daily Conversation team) and finally YouTube’s choice to recommend the video as a result of a

“sea-level rise” search query. No single actor is in sufficient control of the production and distribution chain in order to become a trustworthy actor establishing comprehensive credibility of the source, (i.e. the video). The impossibility of source attribution and evaluation is further severed by the time constrains of YouTube video consumption. YouTube users will comment and articulate their assessment while or shortly after watching the video, which then leaves a time span of about five to 6 min in our present example of video 1. Evidently, “to look up sea-level rise on YouTube” doesn’t allow for the same level of source attribution and evaluation than writing a master thesis on the subject.

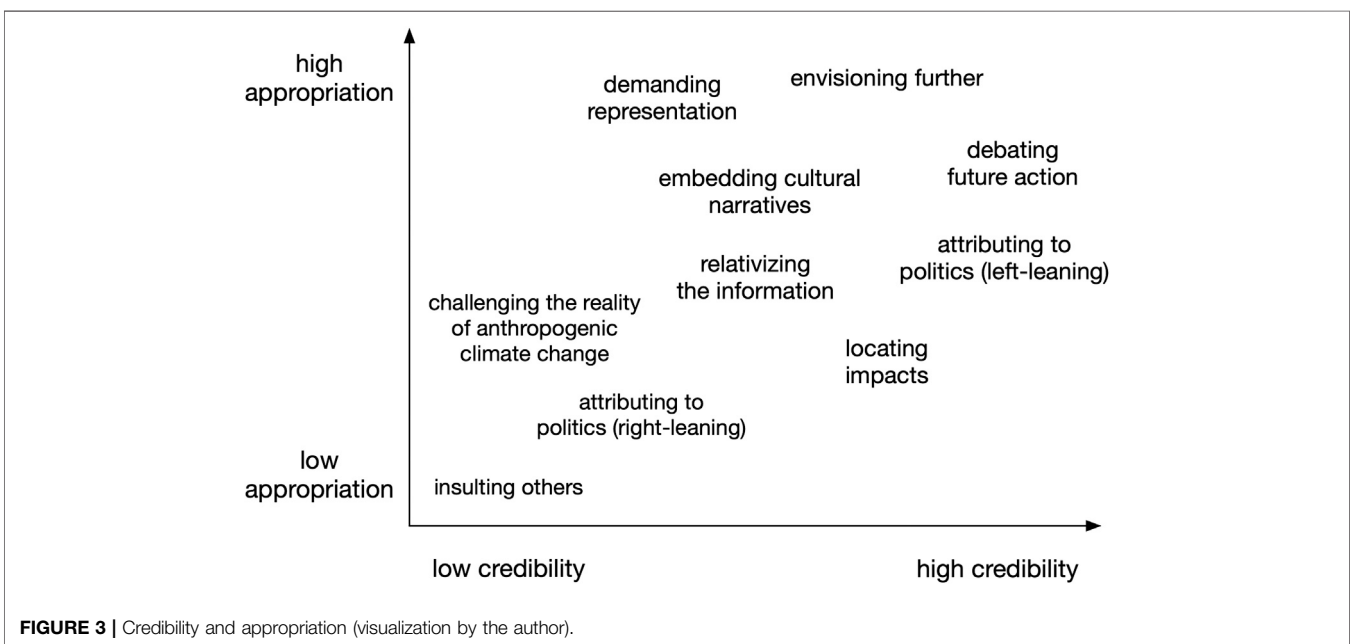
## CREDIBILITY AND APPROPRIATION

Considering the focus of the study on knowledge appropriation, it seems important to ask how credibility attribution and appropriation are related to each other. Does a high attribution of credibility in a comment signal a high knowledge appropriation by the relevant user? Does a low attribution of credibility suggest a low appropriation of the information? To evaluate these questions, the established practices were continuously compared, sorted and diagrammed as proposed by grounded theory literature. Most notably, social scientist Adele Clarke, (2003) has conceptualized such techniques of grounded theory mapping. She recommends the drawing of situational, social worlds/arenas and positional maps for the sorting of categories and the identification of further high-level issues for theory development. In the context of the present study, the continuous visual process of comparison led to the diagram shown as **Figure 3**. The visualization can be understood as a positional map, laying out “the major positions taken, and *not* taken, in the data vis-à-vis particular discursive axes of variation and difference, concern, and controversy surrounding complicated issues in the situation” (Clarke, 2003, 554, emphasis in original). **Figure 3** sorts the practices of articulated knowledge appropriation (**Limitations and Future Outlook**) within a continuum between low and high attribution of credibility on the *x*-axis and low vs. high knowledge appropriation on the *y*-axis.<sup>20</sup> On the one end of the credibility scale (left in **Figure 3**), users debate future actions based on the information provided by the scenarios depicted. They verbalize their readiness to take action to mitigate the impacts of climate change or adapt to it (‘debating future action’). They neither challenge the SLR mappings nor the underlying science (climate impact research), and are often familiar with the scientific basis of climate change. To a greater extent, they often do not even address what is seen, but use the visual scenarios as a higher-level conscription device (Henderson, 1991; Hirsbrunner, in press) to mobilize for climate action. Some users seem new to the risks at stake and verbalize a more informational absorption

<sup>20</sup>Credibility is characterized here as “believability” in information, without necessarily including elements of dependability and reliability (Fogg and Tseng 1999).



**FIGURE 2** | How Earth Would Look If All The Ice Melted (© National Geographic / Science Insider).



**FIGURE 3** | Credibility and appropriation (visualization by the author).

of the scenarios depicted (“locating impacts”). They acknowledge and absorb the depicted information, taking it as it is, and without engaging in much further interpretation and imagination. On the other end of the credibility scale (right in **Figure 3**), users explicitly challenge the plausibility of the scenarios depicted. They discard them as unscientific and misleading ways of portraying the future. They also discredit the producers of the maps, as well as climate scientists and liberal politicians at the forefront of the climate debate (“challenging the reality of anthropogenic climate change”).

In between, we find the comments and communicative practices with considerable articulated ambiguity. They neither

take the scenarios for granted, nor do they discard them. Instead, users play with the interpretative flexibility of the imagery and often exhibit great efforts to formulate their comments and engage with others. They typically refrain from using existent mainstream frames within the climate debate, but rather come up with new, situated meanings that reference the disturbing information, narrative and aesthetics. It is therefore suggested that users articulating ambiguity may actually better appropriate the media content and scenarios than those attributing a high credibility to the image (“debating future action,” “locating impacts”). Here, we can come back to definition by Marlene

Faber, characterizing appropriation as an action aiming to bridge the distance between the appropriating subject and the object to be appropriated (Faber, 2001, 29). To stick with this analogy, appropriation may therefore be higher the longer the bridge is. In our case of knowledge appropriation on YouTube, appropriation will then be highest in the case of the practice “envisioning further,” despite a relatively low degree of attributed credibility. Users “envisioning further” only take the information depicted as a starting point for their own imagination. They test the boundaries of the imaginary, add facets to it and draw relationships to everyday activities, personal value considerations and contemporary events and matters of concern. This future imagination is often a collaborative endeavor with several commenters adding imaginative elements on top of each other. They thereby bridge the large gap between the information depicted and a successful future imagination with the performative act of commenting in the post-video discussions. Against this background, it seems necessary to reevaluate the role of ambiguity in science-related communication on YouTube and other online media settings. Clarity of information may be an understandable objective for science communicators of all kinds. Teachers will strive for clarity in their pedagogic experiments with the video format to explain mathematic formula on YouTube. Epidemiologists will stick to simplicity and precision while giving instructions to protect against the spreading of a virus. Communication experts such as Edward Maibach has also made the case for clarity in climate change communication: “To effectively share what we know, we need simple clear messages, repeated often, by a variety of trusted sources” (Maibach, 2019, 337). The insights from the present study also suggest, however, that the format of online videos may not be particularly suited to convincingly communicate such clarity from trusted sources, as it simply doesn’t oscillate with the way people consume, evaluate and debate science-related information via YouTube and similar media settings. Moreover, ambiguity of information may actually be valuable and have a positive impact on problem definition, future imagination, discursive engagement and knowledge appropriation in case of “wicked problems” (Hulme, 2009) such as climate change.

## LIMITATIONS AND FUTURE OUTLOOK

This study was designed as a qualitative and explorative endeavor with particular focus on posting behavior and situated practices of knowledge appropriation on YouTube. As a result, the distinctive practices described in **Credibility and Appropriation** may not be directly and generally transferable to other scientific issues, types of visual media, or audiences. It could therefore be beneficial to

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compare the results of this study with other science-related post-video discussions. A promising comparison would involve the situated appropriation of the chart #flattenthecurve in the context of the COVID19 debates on YouTube and other social media channels. Among other things, this would allow for a more quantitative assessment of different practices and their relative importance in post-video discussions. A second limitation of the study is due to its exclusive reliance on actively commenting users. Of course, most users on YouTube only watch videos and do not comment. To obtain an understanding of the appropriation practices of silent users, it would be revealing to conduct narrative interviews or to observe audiences while they consume and engage with YouTube content and users. Finally, it would be productive to explore mixed methods approaches in order to analyze greater datasets and to evaluate representativeness of findings. A promising way forward in this regard is the combination of qualitative coding with machine learning. As explorations with such approaches have shown (Chen et al., 2018; Smith et al., 2018; Baumer, 2020), machine learning can be used to support the qualitative coding of extensive social media datasets as well as interpretative analysis and theory building.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

## AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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