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The Colors of a #climatescam: An Exploration of Anti-Climate Change Graphs on Twitter

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Abstract: *Climate change is a looming and present threat. Although reported and explored in traditional media, there is still a general ignorance regarding its acceleration and its real-world consequences. Specifically, in recent years, a number of natural disasters including tsunamis, derechos and hurricanes have shown a very prescient threat. Unfortunately, misinformation regarding climate change's severity is rampant. One such channel of misinformation is social media. Both verbal evidence and images can be shared when presenting an argument. When discussing climate change, one such argument style is showing evidence; graphs are one such way to demonstrate empirical evidence. I obtained graphs from Twitter and analyzed how they were utilized in furthering climate denial. While understanding the spread of misinformation regarding climate change is no doubt important, this paper seeks to evaluate one potential solution: identifying the graphs used, and the methodology they employ. Information literacy and specifically, media literacy, is one step in understanding climate change. The results show that the most popular graphs reused were line graphs, and the most prominent arguments against climate change were that the science was incorrect, or that climate change was instead natural temperature fluctuation. The most popular colors used were blue and green.*

Keywords: Climate change; hashtag exploration; social media; information visualization; visual misinformation

Introduction

Climate change denial is widely viewed as science denial. In recent years, natural disasters such as derechos, tornados and hurricanes have become widely regarded proof of climate change. Similarly, scientists have projected that unless specific preventative actions are taken, such as ending reliance on fossil fuels, the damage done to the Earth will be irreversible. Pew Research found that most people believe in climate change and want certain steps such as planting trees to reduce the carbon footprint and taxing corporations based on their carbon emissions (Funk, 2021). However, many still doubt climate change's existence or severity. Some of this misinformation can be found on social media: The New York Times

stated that when malicious users issued polls arguing that wind turbines or President Biden caused a Texas February power blackout on Twitter, Twitter chose not to correct this information (Bensinger, 2021). Although Twitter and other social media sites are sources of correct information, misinformation is still prevalent on these sites. One major source of misinformation is repurposing an image, ignoring its original context. I chose to explore climate change misinformation visualizations on Twitter. Specifically, I chose to explore the graphs shown as evidence against climate change. I also chose to explore factors of visualization such as color and graph type, as these are used to implicitly lend credibility to a graph's legitimacy. I found that the major theme of these graphs is that the science and evidence presented was incorrect. I also found that the majority of the graphs were bar charts that used a specific four colors: blue, green, red and yellow. Media literacy is one major solution when combatting misinformation. While it is important to understand how visualizations are reproduced, understanding an image's original context is only one step in detecting and combatting online misinformation visualizations.

Literature review

I chose to examine current literature on climate change discourse in traditional media, climate change discourse on social media, media literacy and the use of scientific images in social media.

Climate change discourse in traditional media is an oft-explored topic. Feldmen et al (2012) evaluated news outlet coverage of global warming, finding that even Republicans may be less skeptical and more open minded when viewing global warming evidence. Krosnick and MacInnis (2010) found that those who consume Fox News still trusted scientists and science regarding climate change. Finally, Painter et al. (2018) discussed new media outlets such as Huffington Post and Buzzfeed, explaining that these outlets focused on protests when covering the Paris climate summit rather than only discussing the summit itself. They also determined that Vox utilized graphical representations of climate change.

Researchers have also focused on information visualizations in climate change stories released by news outlets, though this has less coverage. Schafer explains that "pictures of climate change impacts (for example floods) attract attention and trigger emotions - but also invoke feelings of power- and helplessness…pictures of concrete options for action (for example renewable energy sources, low-emission mobility) create a feeling of self-efficacy and have a strongly motivating effect - but draw little attention and are therefore rarely used by the media" (p. 143). O' Neill (2020) conducted a longitudinal analysis of images that accompanied articles about climate change, finding that newspapers with different ideologies presented very different images. Specifically, conservative news outlets preferred cliched images rather than nuanced ones when discussing climate change (O' Neill, 2020).

Perez-Montoro and Viera-Gonzalez (2018) found that charts depicting climate change often accompanied stories discussing climate change. Oftentimes, these images used a linear narrative. Wang et al. (2018) discussed climate change imagery and explained that the

constant barrage of photos and information literacy regarding climate change is a priority in climate change communication research. Bounegru et al. (2020) evaluated Youtube videos about climate change.

Researchers have previously explored climate change advocacy and denial on social media. Cody et al. (2015) argued that Twitter users who discuss climate change and share climate change news are typically climate change activists rather than climate change deniers. Marlow et al. (2020) found that celebrities and journalists tweet the majority of tweets about climate change. Specifically, they found that "While the amount of messages related to climate change is staggering, the flow of information is highly centralized, with few media outlets, celebrities, and prominent bloggers leading the debate" (p. 181).

Foderaro and Lorentzen (2022) found that argumentative practices are used when debating climate change on Twitter and that counter-arguments are used more than disagreements. Chen et al. (2019) found that 88% of users who tweeted about climate change were climate change believers. They also found that extreme weather events such as droughts and rain in the Seine River were cited as evidence regarding climate change. Al-Saqaf and Berglez (2019) found that flooding, droughts and heat waves were the most cited results of climate change on Twitter. Treen et al. (2020) discussed misinformation regarding climate change on twitter, explaining that "skepticism, contrarianism, and denial are concepts often associated with climate change misinformation" (p. 4).

Marlow et al. (2020) explored bots on Twitter, finding that bot tweets were more likely to support then-President Trump's withdrawal of the United States from the Paris Agreement or simply deny the existence of climate change. When using the phrase climate change, Al-Rawi (2021) found that 82.2% of users believed that climate change was man-made. Tyagi found that Twitter climate change deniers often stated that concerns about climate change were exaggerated.

Information literacy is essential when evaluating social media. The Association of College and Research Libraries defines information literacy as "the set of integrated abilities encompassing the reflective discovery of information, the understanding of how information is produced and valued, and the use of information in creating new knowledge and participating ethically in communities of learning" (Dmueller, 2022). One subset of information literacy is media literacy. Specifically, media literacy is "the ability to access, analyse, evaluate and create messages across a variety of contexts" (Livingstone, 2004). Messaris (1998) solidly positions the ability to identify and evaluate the factual quality of images, including graphs, as an essential component of media literacy.

Most researchers have explored the importance of learning about media literacy as well as general information literacy skills. Khan and Idris (2019) found that often people with less internet experience and skills verify information they find online before sharing it. They also argue that individual users should be able to flag potentially misinformative content. Vraga et al. (2012) discussed media literacy in the case of global warming, stating that media literacy

contributed to people's trust of a source: media literacy could result in further trust of the media to cover the issue properly. Nagle (2018) argued that while teachers have successfully used Twitter in education, Twitter is a source of racism and misogyny, and that people must use it with caution, understanding that not everything they read is factual. Vraga and Tully (2021) found that those who are more news literate are typically skeptical about what they read on social media. They are unlikely to share content unless they are convinced it is true. Durodolu and Ibenne (2020) argued that information literacy is one of the best ways to combat fake news. By identifying user ignorance as one of the major contributors to the re-sharing of incorrect information, they presented information exploration and evaluation as a potential solution.

Furthermore, they state that the public must learn about information literacy and how to use information literacy skills when confronted with information. This would not only lead to user empowerment, but to the curtailing of the spread of fake news. Vraga et al. (2020) also explored news literacy in misinformation on Twitter, finding that news literate tweets were often lost in a social media feed when trying to correct information. Another important literacy when evaluating media is that of statistical literacy. Repurposing of graphs is a means of spreading visual misinformation. Cairo (2012) explained that graphs often misrepresent reality when malicious users utilize tactics such as displaying too much data and distorting data through graphic forms. Gould (2017) also stated that statistical literacy is important to properly translate graphs. While media literacy and graph literacy are both important, they are relatively underexplored.

Education in information literacy is necessary, but there is no uniform methodology. Prakoso et al (2017) expressed concern regarding the suitability of information on social media, explaining that media literate individuals might actively participate in removing incorrect information. Mason et al. (2018) explained that media literacy should not only be incorporated into lesson plans regarding information literacy but should be a major part of school curriculum at all levels. Bridges (2012) developed and implemented a course meant to educate undergraduate freshmen at Oregon State University, finding that although students are social media users, many of them have not learned how to use information literacy on social media. Bista (2015) discussed using Twitter as a teaching tool, focusing on information literacy. Briandana et al. (2019) conducted research on Indonesian adolescents' media literacy rate, finding that their rate was middle. This media literacy rate focused on use skill, critical understanding and communicative abilities. Manca et al (2021) focused on the multifaceted nature of social media, arguing that social media literacy must use a combination approach: identifying social media as a tool, process, collaboration and participation. Finally, Jones-Jang (2021) found that although information literacy is important when presented with fake news, media literacy is the only literacy that significantly increased a user's likelihood to correctly identify a fake news story. Studying media literacy and learning how to implement literacy techniques can help stop misinformation from spreading; however, there is no consensus on how and when to begin teaching it. Researchers have also explored rhetoric use on Twitter and social media regarding information literacy in a number of disciplines. When exploring fourth wave feminism online, Zimmerman (2017) found that

this rhetoric included commanding readers to educate themselves regarding intersectional struggles. Bouvier (2020) also found that Twitter users scolded ignorant users regarding racist tweets and images, using Twitter for social justice. Hoffman et al. (2021) argued that specific hashtags should be used when educating anti-vaccine Twitter users about the benefits of vaccines.

Image reproduction is still relatively underexplored. The reproduction of images may often lend a basic credibility to a piece of information. Zhang (2018) found that images reproduced in memes were often humorous and meant to spread messages of socialism in a safe manner. Oftentimes, these images were paired with humorous text. Andreu-Sanchez and Martin-Pascuel (2022) discussed misuse of images to spread disinformation during the Covid-19 pandemic. They argued that not only should accurate images of Covid-19 be used, but that scientists should also provide usable images that present a clear picture of Covid-19 when disseminating information. Hakokõngäs et al. (2020) found that pre-existing images were used in memes to spread nostalgia for nationalism, focusing on a supposedly ideal past. This reproduction of images used nostalgia to remind people of previous times. Baptista and Gradim (2020) found that when reproduced, malicious users often manipulated the images or used them out of context. This supports the idea of image reproduction being used to spread both accurate and fake information. Twitter users may use images to spread information. However, these images often originate elsewhere. Boothby et al. (2021) found when analyzing tweets that tweets with a visual such as a chart or photo were often rated as more credible than a tweet without an image. Specifically, tweets with a chart were considered the most credible. Hutchinson (2016) found that tweets that contain images are more likely to be tweeted, and often images tweeted were not created by the Twitter user. Balli et al. (2020) stated that due to the availability of photo-editing software, "the wider reach for images than plain text makes it more susceptible kind of media for the spread of fake news" (p. 8).

Schlitzer (2018) found that Twitter bots often used a repurposed photo for their Twitter profiles. Researchers have begun to explore repurposing of images with algorithms. Krishnan and Chen (2018) designed an algorithm that used Google reverse image search to determine if an image is credible. Jaiswal et al (2019) explained that examples of visual misinformation are when images are used without context, or to provide evidence for a malicious user's incorrect context. They stated that these images, even without image manipulation, are still dangerous, and designed an algorithm meant to identify repurposing of images. Luo et al (2021) explored reused out of context news photos on social media, explaining that when images are used out of context, they may spread misinformation. To detect these images, they designed a dataset and filtering technique. This technique, although impressive, is still underused.

Based on the current research, I chose to explore scientific depictions of climate change on social media. My research questions are the following: How is scientific evidence meant to spread climate change misinformation represented on Twitter? What arguments are used to argue against the existence of climate change? What types of graphs are used as evidence against global warming?

Methodology

I chose to use Twitter to build my dataset, specifically because of its opportunity for real-time dialogue and image sharing. Because Twitter is a site used for many purposes, Twitter users typically do not have a handle for one specific subject. Rather, they use hashtags to discuss their topic. Twitter users may also use photos, videos and other media that they did not create. As a result, many users repurpose a graph or an image from its original source, rather than designing their own. I decided to explore graphs due to their empirical nature: a graph can show empirical evidence of a phenomena in a way that memes and photographs cannot. Similarly, graphs are often used to convey new information and support current information in both journal articles and news articles. Therefore, since graphs are still underexplored especially when shared by a layperson, I chose to explore graphs on Twitter.

One major form of misinformation is the reuse of images without context (Andreu-Sanchez, 2022; Baptista, 2020; Zhang, 2018). When presented without context, climate change images are often sources of misinformation (Lomeli, 2021; Oswald, 2021). Although news outlets have reported on obsolete graphs as a source of climate change misinformation, these graphs are still relatively underexplored in research (Bump, 2021; McCrary, 2023). After identifying major hashtags meant to deny the existence of climate change, I searched the hashtags "#climatescam", "#climatehoax" and #climatecult" on Twitter. If a tweet contained a graph, I used the graph from the tweet. I chose not to analyze the tweets proper, as I wanted to focus on the image itself. I chose a two-month time frame from January 1, 2022, to March 5, 2022. In total, I collected 35 graphs. I then analyzed the following aspects of the graphs: which hashtag was used, the user who tweeted the tweet, the title of the graph, what information the graph used as evidence against global warming, and the colors used by the graphs. For the sake of anonymity, each user was assigned a number rather than identified by their handle. Not all of the graphs that were presented had a title, therefore I was unable to analyze the titles used.

Tables 1 evidence table:

Subject/Evidence Against Climate Change	# of Times
incorrect science	11
natural temperature fluctuation	7
resource use	5
CO2 is lower	3
Ice	2
no change	1
solar decline	1
decrease in deaths and global catastrophes	1
covid-19	1
lowest burn	1

money invested	1
electricity prices	1

Tables 2 Types of graph used:

Type of Graph	Count
line graph	22
Map	5
bar chart	4
violin plot	1
Diagram	1
diagram with percentages	1
solar system map	1

Tables 3 All colors used more than once:

Colors Used	COUNT
blue	24
green	14
yellow	13
red	12
orange	9
black	8
red	6
grey	6
yellow	5
pink	5
turquoise	5
green	4
black	3
purple	3
blue	3
purple	3
orange	2
white	2
lilac	2

Results

I chose to focus on the colors, graphs used, information used as evidence, users, and most popular hashtags used. Overall, I found that while a range of colors were used, most graphs chose to implement traditional, primary colors. Meanwhile, the most popular type of graph was a line graph.

I found that blue was the most popular color, appearing in 24 out of 35 of the graphs. Green, yellow and red were also prominent, found in 14, 13 and 12 of the graphs respectively. 95% of the graphs contained more than one color. The most popular type of graph used was a line graph, used 22 times. The second most popular type of graph used was a map used 5 times, followed by a bar chart used 4 times.

The most popular information that the graph used as evidence was that the science behind global warming was incorrect. The second most popular evidence against climate change was that temperature fluctuations are natural, and therefore global warming does not exist. Resource use and CO2 levels were also used as evidence against global warming. Finally, ice and a supposed lack of Arctic frost were used as evidence.

I found that 18 Twitter users spread the 35 graphs. The average number of climate change denial tweets tweeted by a user was 1.7, with a standard deviation of 1.97. 27.7% of users tweeted more than one graph. The user who tweeted the most graphs tweeted 28.57% of the tweets. 75% of users only tweeted one climate change graph.

I found that the most popular hashtag used was #climatescam (48.57%). The second most popular hashtag used was #climatehoax (45.71%), and the third most popular hashtag used was #climatecult (34.29%). I also found that many of the tweets used more than one hashtag: 28.57% of tweets used both #climatehoax and #climatecult. Meanwhile, 58.9% of tweets that used the hashtag #climatehoax also used the hashtag #climatecult, and 83.3% of tweets that used the hashtag #climatecult also used the hashtag #climatehoax.

Other prominent hashtags used were “climatecrisis” which appeared 13 times, “climateemergency”, which appeared 11 times, and “#climatebrawl” and “#climatechange” which appeared 10 times each. These are all hashtags associated with climate change activists.

Analysis and Discussion

Discussion of numbers

The most common hashtag, #climatescam was also used independently. Because #climatecult and #climatehoax were used together, we can see that these two hashtags may have been used to appeal to more audiences. It is also interesting to see the phrase “scam”, “cult” and “hoax” used to refer to the same phenomenon.

The most common chart shown was a line graph. This may be for a number of reasons: line graphs are fairly common graphs and are also the one of the most well-known graphical types. It is also important to note that all of these graphs were labelled properly and showed a relationship between two related concepts. This is important, as some misinformative graphs use improper labelling, scale, title or even relationships between two different elements.

The average number of climate change denial tweets tweeted by a user was 1.7, which shows that most users tweeted more than once. None of these tweets contained anything regarding climate change denial in their user's handle. Therefore, none of these handles were only meant to argue against the existence of climate change. This shows that users who do not believe in climate change often have more than one example of evidence against climate change. For example, one user tweeted a graph on January 6 and then a different graph on January 8. It is also telling that almost all of these images were shared without any specific websites or links to their sources. This may show that although the images exist, they may have been recontextualized to show evidence for climate change denial.

Discussion of themes

The major theme, stating that current climate change science was incorrect, shows that many people are in denial regarding climate change. Rather than citing any specific events, climate change deniers simply argued that the science explained was incorrect. This explanation took many forms: explaining that climate change did not exist, stating that current climate change graphs were incorrect, and arguing that climate change scientists faked evidence. Users also argued that temperature fluctuations were normal and natural. Most users who discussed temperature fluctuations stated that it is normal for some temperature increases at different points of history. They also said that the earth is in the middle of a cooling period, and that temperatures are actually lower than they have been. Resource use was another subject presented as evidence against climate change: one graph argued that the US was focusing on steel to increase dependence on China, rather than its recyclability. Another major argument cited was that C02 levels were also lower than they have been in the past. Physical evidence and arguments mainly explored the amount of ice in the Arctic, stating that there was a sufficient amount of ice in the Arctic. This shows that rather than pointing to specific examples of proof, climate change deniers choose to simply deny the science and state that it is incorrect. This shows a concerning trend: physical evidence can be discussed and examined.

Each of these examples of misinformation are easily disproved. For example, while some users argue that global warming may be explained by natural temperature fluctuation, average temperature of land and ocean has been increasing at a higher-than-normal rate (Hatfield, 2015). Meanwhile, simply arguing that the science that supports climate change is incorrect and scientists behind NASA and scientists at the United Nations are lying to people is harder to disprove. Furthermore, any alternative explanation could be countered with "that's what they want you to think" or another similarly dismissive comment. Another major

difficulty when arguing against climate change denial is that acknowledging global climate change may result in changing someone's lifestyle.

The inclusion of hashtags such as "#climatechange" and "#climateemergency" also shows that these tweets are meant for people who may also believe in climate change. Someone searching with the hashtag "#climatechange" would come across these tweets that deny its existence. This could result in people potentially determining that climate change is not concerning, or that the science behind its existence is flawed. Seeing these hashtags shows that the science behind climate change is majorly disputed. There are a number of reasons for the emphasis on climate change denial. Using science to dispute scientific evidence may provide climate change denial with a false sense of credibility and legitimacy.

Color symbolism

Blue appeared in 25 graphs, green appeared in 15 graphs, yellow appeared in 13 graphs and red appeared in 12. The most popular graph was a line graph, appearing 22 times, while a map appeared 5 times and bar chart appeared 4 times. These colors are typically found in scientific graphs; therefore, this is unsurprising (Muth, 2021). Blue is also often recommended for scientific graphs, as it can evoke a sense of trust or stability (Widrich, 2013). Other colors such as red and yellow are complementary to blue; ergo, they may also be used in conjunction with blue (Muth, 2021, Custer, 2021). Therefore, the colors in the visualizations, while seemingly trite, contain subtle meanings.

Another major reason these colors may be used is because they evoke natural imagery. Green's prominence may be due to its symbolism of nature and abundance. Meanwhile, blue may evoke other natural phenomena such as lakes. Conversely, blue may also represent honesty (Fleck, 2017). Therefore, someone examining a graph with blue in it may implicitly trust it. Yellow symbolizes the sun, and red symbolizes warmth (Pan, 2018). Tweeting graphs that use these colors would allow malicious users to use color to spread misinformation convincingly. Blue, yellow and red are all primary colors, and distinct from one another. Therefore, it is easier to identify the colors used. This may have been another major factor in their selection for the graphs.

Repurposing Graphs

It is important to note that because these graphs were reused, they were therefore effective in conveying their message to a user. The repurposing of these graphs supports Hutchinson's 2016 findings: images not created by the user are repurposed in tweets. The graphs' use in spreading misinformation is also supported by Jaiswal et al's 2019 findings: the images themselves were not altered from their original format. These images were initially effective. If they had been ineffective, they would not have been selected and reproduced for Twitter users. However, their original meaning is irrelevant when reused to spread misinformation. Twitter users discard the initial meanings of these graphs and assign them a new identity: anti-climate change. When analyzing the reproduction of these images, it is important to note

that not all of them are current: some were from textbooks used in the 2000s, and others were graphs that originally said that climate change would result in a higher yearly temperature. In many cases, these images may be incorrect due to new findings about climate change and more accurate technology. A lack of media literacy and statistical literacy may result in sharing and belief in outdated and repurposed visual misinformation.

The Importance of Media Literacy

Media literacy is a partial solution in combatting misinformation. Specifically, media literacy regarding both text and imagery is essential when evaluating a tweet. Examining the other tweets that the user has tweeted from their account is one step in understanding the motives of a source. Similarly, reading someone's bio and identifying if they have any qualifications that might make them an expert in the field is helpful. When analyzing images, information users must be careful. Other important facets of media literacy that must be addressed are the image reproduction: finding where an image originated could help someone determine whether it is pertinent to the topic. Researchers currently agree that media literacy is essential when determining if a source is trustworthy or not. Vraga's 2020 findings: that quick corrections to incorrect tweets are insufficient, further support media literacy as the main solution to this problem. The user must use autonomy in determining what to trust. Furthermore, the user must use their skills to help others. Khan and Idris's research (2019) focused on the user as the flagger of potential misinformation supports these ideas, as someone who is media literate may be able to help others who are less informationally literate. Vraga and Tully's 2021 exploration of news literacy also demonstrates that another literacy, news literacy, may potentially help someone in identifying fake news. My findings support this idea: someone who is news literate would understand the science and authority behind current global warming discussions and identify the potential issues with misinformation. These findings support both allowing users to educate others while still investing in media literacy training and tools so that everyone can become more media literate.

Understanding the tools used in visualization can further help information seekers identify misinformation. Furthermore, this media literacy can allow consumers of information to fact-check the information they encounter. Evaluating information with a skeptical eye can help information consumers identify misinformation.

Limitations

A sample size of 35 is comparatively small, though still large enough to run analysis on. Using memes, photographs or other images may have presented a more complete picture of climate change denial opposition. Since climate change denial uses a variety of media, more research exploring this media is necessary. The hashtags I used, although the most confident and definitive against climate change, also present a definite opposition to climate change; I could have searched for a more seemingly benign term, such as climate skeptic. Future research could expand this study to Reddit or Facebook, as Twitter is only one platform, and

climate change denial is on many different social media sites. Examining the number of people who rebutted this misinformation and instead, tried to prove that climate change is a current threat would be interesting. Similarly, cross-referencing the images with their original sources, and examining whether they were taken out of context would also be an excellent idea. More research discussing climate change denial over social media is necessary.

Conclusion

Climate change is a current and escalating danger. Although there are many real-world examples of climate change's devastation, many people are still willfully ignorant. One of the means by which people justify their denial is by examining and sharing flawed evidence to the contrary. Graphs are one such example: they may be used as scientific evidence that findings about the severity climate change are incorrect. Furthermore, their reproduction in tweets may mislead viewers. Media literacy is one step toward understanding how to identify climate change denial. However, more information is necessary when evaluating climate change misinformation. While global warming denial is very popular online, global warming is a very real and present danger. Denying the science and facts behind global warming will not only cause people to underestimate the issue, but avoid taking the very real precautions against its escalation.

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