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The new denial: climate *solution* misinformation on social media

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Research Article

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Abstract

Non-technical summary. A remarkable shift in climate change misinformation has taken over social media streams. The conversation is no longer totally absorbed with denying that climate change exists. Instead, the 'New Denial' is bent on condemning solutions to climate change and their supporters. Our study meticulously analyzed this shift, using extensive methods to untangle the content of over 200,000 Tweets from 2021 to 2023. We found that the New Denial is a heated political debate that often calls up common far-right arguments, falsely accuses climate solutions as ineffective and risky, and attacks climate solution supporters.

Technical summary. Over the past five years, a 'New Denial' has emerged in regards to climate change misinformation on social media. This shift marks a transition of the dominance of rhetoric centered around denial of climate change science to attacks that seek to undermine and cast doubt on proposed climate solutions and those who support them. While much of the academic literature to date has explored misinformation about climate science, there is a great need to explore this shift and seek out increased understanding of misinformation around climate change solutions specifically. In this paper, we employ a mixed-methods analysis, drawing on data from Twitter from 2021 to 2023, to analyze the content of climate solution misinformation. We find that the New Denial is frequently centered on politically-laden debates nestled in common narratives on the right, often attacking supporters of climate solutions as harbingering ulterior motives for climate solutions that are fundamentally flawed. We use these insights to reflect on targeted interventions for climate solution misinformation on social media.

Social media summary. A New Denial is sweeping social media, no longer bent on denying climate science. It's new target: climate solutions and the people pushing for them.

1. Introduction

Social media is playing an increasingly important role in the communication of science to the public (Adams & Gynnild, 2013). In fact, The Pew Research Center found that Facebook was a regular news source for one third of Americans in 2021, with half of Americans getting their news from social media at least sometimes (Liedke & Wang, 2023). At the same time, climate change disinformation (the spreading of falsehoods with the intent to mislead, often for a strategic goal) on social media has ballooned in recent years (Dornan, 2020; Falkenberg et al, 2022). Climate disinformation refers to content that obfuscates the existence of, human contribution to, and/or need for mitigation of and adaptation to climate change, by misrepresenting data to erode trust in climate science and its institutions (adapted from Climate Action Against Disinformation). 'Misinformation' also refers to the spread of false information but without the intent to mislead, while 'malinformation' centers on true information that is, for example, taken out of context, to negative intentions (Wardle & Derakhshan, 2017). In this paper, we follow previous researchers by using the term 'misinformation' to encompass all three because of the difficulty in discerning intent (Chen et al, 2023).

In the case of climate change, the intentional effort to portray environmental science as 'junk science' began in the early 1990s and developed into a concerted campaign funded by coal and oil corporations and others with economic interests in fossil fuel consumption, often using the cover of associations (Dunlap & McCright, 2011). Today, these misinformation campaigns are thriving in the 'perfect environment' of social media (Stöcker, 2020). Climate misinformation has serious negative consequences for society, including public polarization, decreasing climate literacy, invalidating accurate information, amplifying silence around climate change,

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and inadvertent seepage into the scientific community (Ranney & Clark, 2016; Cook et al, 2017; McCright et al, 2016; Geiger & Swim, 2016; Lewandowsky et al., 2015).

From an academic perspective, there is a large research gap in understanding climate solution misinformation specifically, Moreover, in the literature, there is much focus on the issue of acceptance of or 'belief in' climate science, with the problem identified as a simple (and over-simplified) information deficit (Suldovsky, 2017). However, climate change actions do not necessarily follow from attitudes about climate change (Shove, 2010). Following this logic, we posit that the acceptance of climate solutions might actually be more important than the acceptance of climate science. For example, one can drive an electric car and put solar panels on their roof without believing in climate change. Indeed, there are many other reasons to take such climate action (e.g., improvement in health and well-being), as are there conservative solutions to climate change (Shultz & Baker, 2017). Thus, we argue that focus on delivery and acceptance of climate information needs to shift toward climate solutions.

In addition, the shift to 'New Denial' underscores the need to move academic attention to climate solution misinformation. Researchers from the Center for Countering Digital Hate (CCDH) utilized a dataset of climate-related YouTube videos spanning nearly six years and conducted a nationally representative survey, uncovering the prevalence of climate skepticism among teenagers, particularly heavy users of social media. The study highlights a shift in climate denial narratives, A notable shift from denying the occurrence or human causation of climate change to questioning the efficacy of proposed climate solutions.

> In this report, for the first time, researchers at the Center for Countering Digital Hate have quantified the startling and important rise over the past five years in what we call 'New Denial' — the departure from rejection of anthropogenic climate change, to attacks on climate science and scientists, and rhetoric seeking to undermine confidence in solutions to climate change. 'New Denial' claims now constitute 70% of all climate denial claims made on YouTube, up from 35% six years ago. (Center for Countering Digital Hate, 2024, p. 4)

This shift underscores the importance of focusing on climate solution misinformation specifically, as it seeks to undermine public confidence in effective climate action and scientific consensus (Center for Countering Digital Hate, 2024).

2. Literature review

2.1. Climate change misinformation

Previous research has examined the spread of misinformation in general online, and in relation to recent phenomena such as domestic extremism (e.g., Allain et al, 2024) and COVID-19 (e.g., Boberg et al, 2020; Geeng et al, 2020). In an important meta-analysis, Chen et al (2023) reviewed 423 papers on the subject of misinformation on social media between 2010 and 2021. Treen et al (2020) reviewed the literature on climate change misinformation online specifically. We review climate change misinformation research in general rather than research on climate solution misinformation because of the lack of studies in regard to the latter.

Previous researchers have found that climate change misinformation is born from a concerted effort on the part of specific groups. Naomi Oreskes's 2010 book and 2014 documentary (Kenner, 2014) *Merchants of Doubt* famously drew connections between the tactics developed by the tobacco industry to sow doubt on the dangers of smoking with those developed by the fossil fuel lobby. Dunlap (2013, p. 692) wrote of an organized disinformation campaign 'waged by a loose coalition of industrial (especially fossil fuel) interests and conservative foundations and think tanks'. Brulle (2014) echos the 'overwhelming majority' of funding for the counter climate change movement in the US comes from conservative foundations, where Goldberg et al (2020) analyzed 14 consecutive election cycles, finding that oil and gas companies support 'anti-environmental' politicians.

The climate change misinformation created by these actors then undergoes a process of amplification. In a review of climate misinformation online, Treen (Treen et al, 2020) outlines a positive feedback loop that begins with the aforementioned corporate and philanthropic actors (conservative foundations, industry and corporations), who fund the producers of climate change misinformation (political and religious organizations, astroturf, grassroots organization, and contrarian scientists). This misinformation is then reinforced in 'the influencers echo chamber', where media, skeptical bloggers, and politicians amplify the misinformation. For example, Elsasser and Dunlap (2013) analyzed 203 op-eds written by conservative newspaper columnists and found that the conservative echo chamber fuels the climate change denial machine. Misinformation is then disseminated and amplified within the public echo chamber, particularly by white males who vote Republican (Bjornberg et al, 2017).

With a general framework for the production of misinformation in mind, and the actors involved, more specific questions about the diffusion of misinformation are of interest. Researchers have attempted to approach this question using theoretical models such as contagion models used to investigate the spread of disease (e.g., Amoruso et al, 2017; H. Webb et al, 2016). In these models, individuals are 'infected' with misinformation, which they can then spread and perhaps reach significant proportions (an 'epidemic' or 'pandemic'), in conversation with social, historical, and cultural contexts (Karlova et al, 2012).

Other research has considered empirical data in the study of the diffusion of information. Researchers have traced the spread of misinformation on Facebook and Twitter particularly in the wake of events: political events such as elections (e.g., Badawy et al, 2018), natural disasters (Gupta et al, 2013a), or other crises (Gupta et al, 2013b).

A subset of research has focused on the contrast between misleading and accurate information, in the context of rumors, news stories, fake news websites, and fact checking efforts (Friggeri et al, 2014; Bovet & Makse, 2019; Shao et al, 2016). Researchers have identified malevolent purveyors of disinformation as bots, spammers, and astroturfers (Lee et al, 2013; Shao, Hui, et al, 2018; S. Webb et al, 2008).

2.2. Misinformation diffusion

The characteristics of networks that diffuse misinformation also play a crucial role in its spread. Homophily describes the tendency toward similarity in individuals within social networks (McPherson et al, 2001), which has a large influence on the type of information presented to users (Bessi et al. 2015). 'Echo chambers' tend to form in homophilous groups, contributing to polarization around particular issues (Sunstein, 2007). Increased polarization of viewpoints (Vicario et al, 2016) and engaging (over truthful)

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content (Sirbu et al, 2019) in online social networks further exacerbate polarization.

Innate human behaviors also can contribute to the amplification of misinformation online. Humans tend to prefer information that confirms what they already believe ('confirmation bias'), and that comes from those within their own social networks (e.g., Bessi et al, 2014). Regarding climate misinformation specifically, social networks among both climate advocates and denialists Williams et al (2015) found social networks to be highly homophilous (Williams et al, 2015). Social media users who believe climate change is false, or who are a part of networks that circulate these beliefs, will have a greater likelihood of receiving and 'echo-ing' climate misinformation.

2.3. Combating misinformation

A large subsection of climate misinformation research has turned to the problem of how to combat this misinformation. Interventions explored include those made before exposure to misinformation, such as education about climate change and critical thinking techniques, and inoculation (exposure warnings, proactive supply of correct information) (e.g., Lutzke et al, 2019; Cook et al, 2017; van der Linden et al., 2017). Post-exposure to misinformation, researchers have explored corrective and collaborative approaches (Lawrence & Estow, 2017), and regulatory methods such as fines and imprisonment (Funke, 2019). Technological solutions on either end of exposure include proactive identification of malicious accounts (Shao, Ciampaglia, et al, 2018, and algorithmic ranking and selection (Safieddine et al, 2016).

While many assume that the acceptance of climate science is crucial to engagement mitigation, others have argued that changes in behavior do not necessarily follow from changes in attitude (Shove, 2010). Increasing public awareness and acceptance of climate science is not enough to surmount the obstacles to the execution of climate change mitigation policy (Pearce et al, 2017a, 2017b). At the same time, climate change denial is political and likely has contributed to political inaction on climate change (Treen et al, 2020).

While much of the literature has explored misinformation about climate science, there remains a great need for a better understanding of misinformation around climate change solutions specifically. It is important to focus on understanding climate solution misinformation specifically rather than climate misinformation generally because addressing climate change requires not only understanding the scientific consensus but also promoting effective solutions. Existing research has primarily focused on climate science misinformation, leaving a gap in understanding misinformation surrounding climate solutions. Focusing on climate solution misinformation is crucial for fostering informed decision-making, promoting public engagement, and advancing effective climate action initiatives (Nyhan et al., 2010; Cook et al, 2017). In addition, the shift to the New Denial underscores the need to better understand climate solution misinformation. As researchers at the CCDH write, It is vital that those advocating for action to avert climate disaster take note of this substantial shift from denial of anthropogenic climate change to undermining trust in both solutions and science itself, and shift our focus, our resources, and our counternarratives accordingly (Center for Countering Digital Hate, 2024, p. 4). By addressing misinformation about climate solutions specifically, researchers can help bridge the gap between scientific consensus and public understanding, facilitating more meaningful conversations and actions toward addressing climate change. In this way, we hope to address not only a large literature gap but also a great societal need.

3. Methodology

The overarching objective of this research is to examine misinformation on climate solutions propagated on Twitter and to leverage these insights to inform future academic research, and interventions to counter misinformation for the public. This research aims to identify the narrative trends and proponents of climate misinformation. We examine two types of climate solution misinformation: (1) claims that climate solutions are ineffective (e.g. policies are harmful, or ineffective), and (2) claims that efforts that in fact contribute to climate change support climate change mitigation (i.e., greenwashing) or have oversized benefits. Our main research questions for this project are: What types of climate solution misinformation are being propagated on Twitter? Which are the most prevalent? What narratives/themes are they focused on? In reflection of these questions, we consider how the insights (from the above) might inform solutions to this problem in the Discussion.

3.1. Database construction

The initial step was the selection of categories pertaining to Climate Solution Misinformation (CSM) on social media (Table 1). We used an inductive approach to create categories before data collection and analysis, as these categories were necessary to proceed with those processes (Mittal et al, 2021; Perry & Jensen, 2001). In this process, the first author observed and explored CSM circulating on Twitter and Facebook as a 'lurker'. This involved following accounts promoting CSM, searching exhaustively for terms related to climate solutions with a misinformation bent (e.g. 'solar power' + 'scam'), reading comments on CSM posts, and following links and hashtags on CSM posts found. The first author took exhaustive notes during this process, which were organized thematically into the following categories for use in data collection and analysis.

The second step in our database construction was to find the most frequently used search terms for each category. For this step, we used Google's Artificial Intelligence system (Bard) and ChatGPT which at the time had access to the Twitter database in order to more thoroughly and quickly search the Twitter database than was possible manually. The researchers prompted both Bard and ChatGPT to return the most frequently used search terms for each category, using prompts such as 'Return search terms used on Twitter to spread misinformation on climate change solutions, for example regarding climate policies' one by one, using several variations of wording and phrasing of the definitions listed above (see e.g. Alharbi et al, 2024). The researchers contunied until we acquired 10 search terms each category.

Following Inel et al (2023), we thoroughly scrutinized the data that was collected by the AI tools to ensure responsible use. The last step in our database construction was verifying the search terms returned by Bard and ChatGPT. We analyzed 50 random tweets from each of the search terms to ensure the posts were faithful to the climate solution topic at hand, resulting in the removal of several search terms from the dataset. In total, our database included 73 search terms and a total of 236,108 original Tweets from 2021 to 2023.

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Table 1. Search terms used in this study

Category No	Category Type	Definition	Search Terms
1.1	'Scam'	Claims that efforts to mitigate climate change are deceptive, fraudulent, dishonest acts, schemes, or operations	Green Energy Scam, EcoFraud, Clean Energy Scam, Carbon Tax Scam, Green Scam, Green Lies
1.2	Power/government	Claims that climate solutions endeavor to gain political power in general or specifically in relation to authoritarian, communist governmental forms.	Climate Tyranny, Climate Control, Climate Totalitarianism, Climate Fascism, Climate Communism, Climate Socialism, Climate Authoritarianism, Climate Stalinism, Climate Dictatorship
1.3	Policy	Claims that policy-based climate solutions are ineffective or have disproportionately negative impacts	Green New Deal Disaster, Green New Deal Is Bad, Climate Policy Ineffective, Climate Policies Are A Tax, Climate Policies Kill Jobs, Climate Policies Are Unfair, Climate Policies Are Unworkable, Climate Policies Are A Power Grab
1.4	Climate solution supporters	Claims that attempt to denigrate and/or de-legitimize climate activists and advocates	Greta Thunberg Is A Shill, Climate Alarmists, Climate Extremists, Climate Cult, Climate Grifters, climategate
1.5.1	Renewable energy: general	Claims that renewable energy in general does not work or has disproportionately negative impacts	Green Energy Fail, Renewable Energy Is Bad, Renewable Energy Fail, Renewable Energy Is A Waste Of Money, Renewable Energy Is Unreliable, Renewable Energy Is Dangerous
1.5.2	Renewable energy: solar power	Claims that solar power in general does not work or has disproportionately negative impacts	Solar Panels Are Bad, Solar Panels Are Useless, Solar Panels Are Not Green, Solar Panels Are Dangerous, Solar Scam, Solar Pollution, Solar Fails, Solar Fraud
1.5.3	Renewable energy: EV	Claims that Electric Vehicles (EVs) specifically does not work or has negative impacts.	Electric Vehicles Are Unsafe, Electric Vehicles Are Not Green, Not Ready for EVs, Electric Vehicles Are A Luxury, EV fail, EV scam, EV fraud
1.5.4	Renewable energy: wind	Claims that wind energy specifically does not work or has negative impacts.	Wind Turbines Are Ugly, wind turbines are bad, Wind Turbines Kill Birds, Wind Turbines Are A Waste Of Money, Wind Turbines Are Not Green, Wind Turbines Are Dangerous, Bird Blender, Wind Scam, Wind Turbines Are A Public Nuisance
2.1	Greenwashing	Claims that fossil fuels are green or clean energy, or generally promote fossil fuels as disproportionately positive without mention of negative impacts.	Natural Gas Is Green, Fossil Fuels Are Green, Fossil Fuels Are Clean, Green Fossil Fuels, Fossil Fuels Are Good, Fossil Fuels are Clean, Fossil Fuels Are Necessary, Fossil Fuels Are Reliable, Fossil Fuels Are Safe, Fossil Fuels Are The Future
2.2	Fossil fuel glorification	Claims that praise and glorify fossil fuels.	Fossil Fuels Forever, Drill Baby Drill, Fracking Works, Fossil Fuels Are Jobs

3.2. Analysis

Our methods included an exploratory quantitative analysis and an in-depth qualitative analysis. For the quantitative analysis, we used the open-source program R to analyze top tweets by search terms, category, and content, 1. frequency of search terms, 2. frequency of categories, and 3. by creation of a word cloud to illustrate the most common words (R Core Team, 2024).

We then performed a thematic content analysis for each of the top 10 search terms, using the top 50 most retweeted Tweets for each search term. We used an inductive approach to qualitative content analysis, as described in Cho and Lee (2014). This includes an open coding approach by four researchers who separately and carefully read the data for themes: ideas and arguments that were consistently repeated by multiple authors and that were relevant to each research question (Schreier, 2012). In a spreadsheet, each researcher made notes of themes to which the data corresponded. Next, the four researchers cross-compared the themes that each found, discussing the comments from which each emerged and ultimately converging on and agreeing upon each theme.

4. Results

4.1. Prevalence of search terms

The quantitative analysis of Twitter data revealed significant insights into the discourse surrounding climate-related search terms. In Figures 1 and 2, notably, the most tweeted search term was 'climate control', indicating a prevalent focus on narratives related to exerting political control over climate issues. Other prominent search terms included 'green fossil fuels', 'drill baby drill', and 'climate cult' reflecting an emphasis on discussion around

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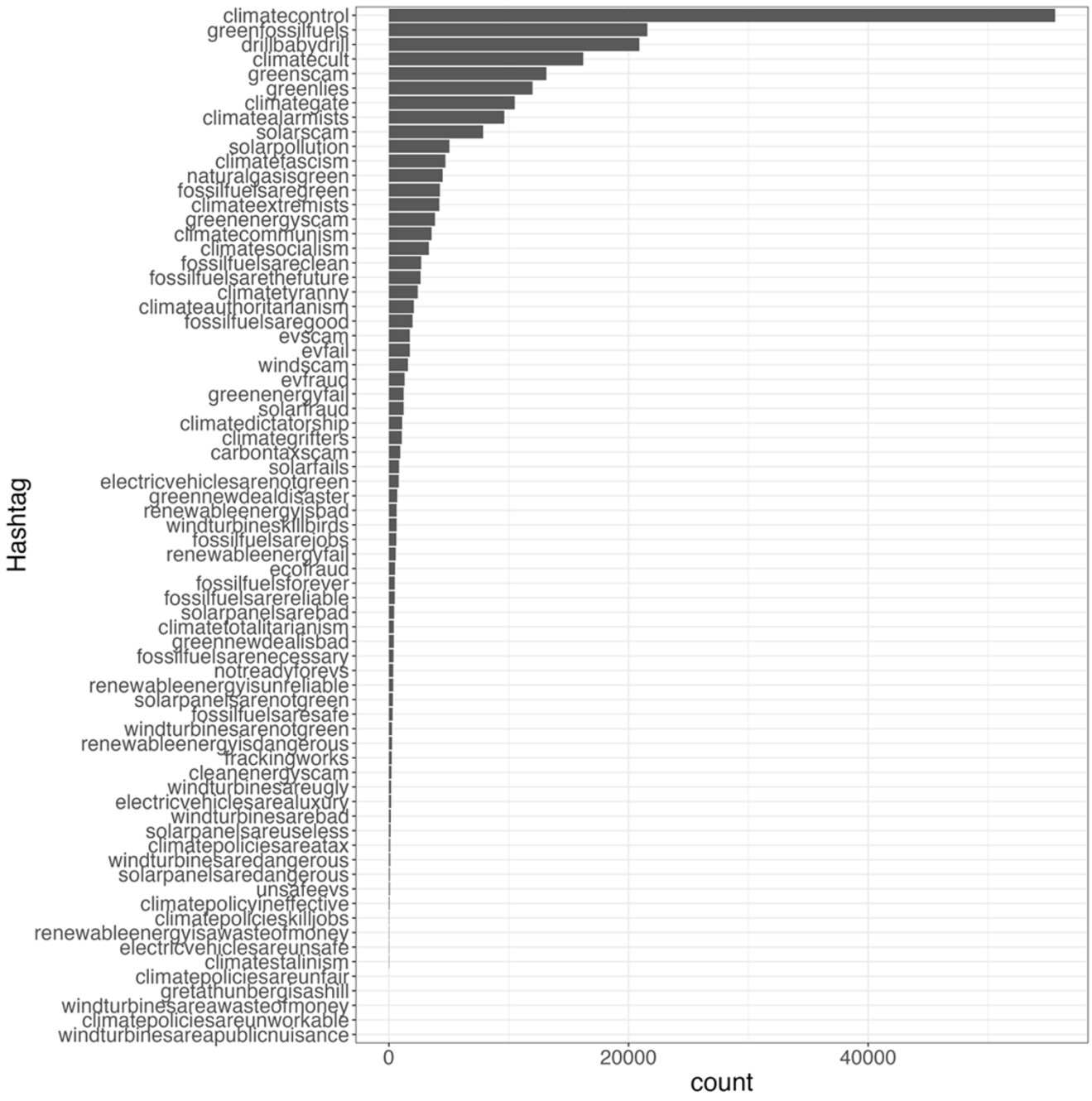


Figure 1. Frequency of all search terms.

activists and activist strategies, and the glorification of fossil fuel combustion.

Below, we present the qualitative analysis of the top ten search terms. The order in which the content categories appear is by frequency, for a summary see Table 2.

Climate Control. In the 'climate control' search term, the dominant theme centered on anxieties surrounding control and power. Conspiratorial narratives frequently framed climate initiatives as an 'agenda', a pretext for totalitarian governance and personal restriction, ranging from broad societal concerns to specific policy anxieties. Many Tweeters asserted, as one wrote, 'They are using climate change as an excuse to implement a total control society'. This narrative variously attributed such totalitarianagendas to 'elites', Democrats, communist sympathizers, those motivated by financial gain, or proponents of a 'New World Order'. The discourse often intertwined with other concerns, notably the COVID-19 pandemic, reinforcing perceptions of a broader plan to manipulate public fear and curtail individual liberties. Many Twitter users expressed apprehension that such control measures would precipitate widespread collapse, impacting social, economic, and political spheres. Climate activists, particularly high-profile figures, frequently faced accusations of hypocrisy for behaviors perceived as incompatible with their advocacy, such as frequent air travel. The most retweeted accounts in the 'climate control' were

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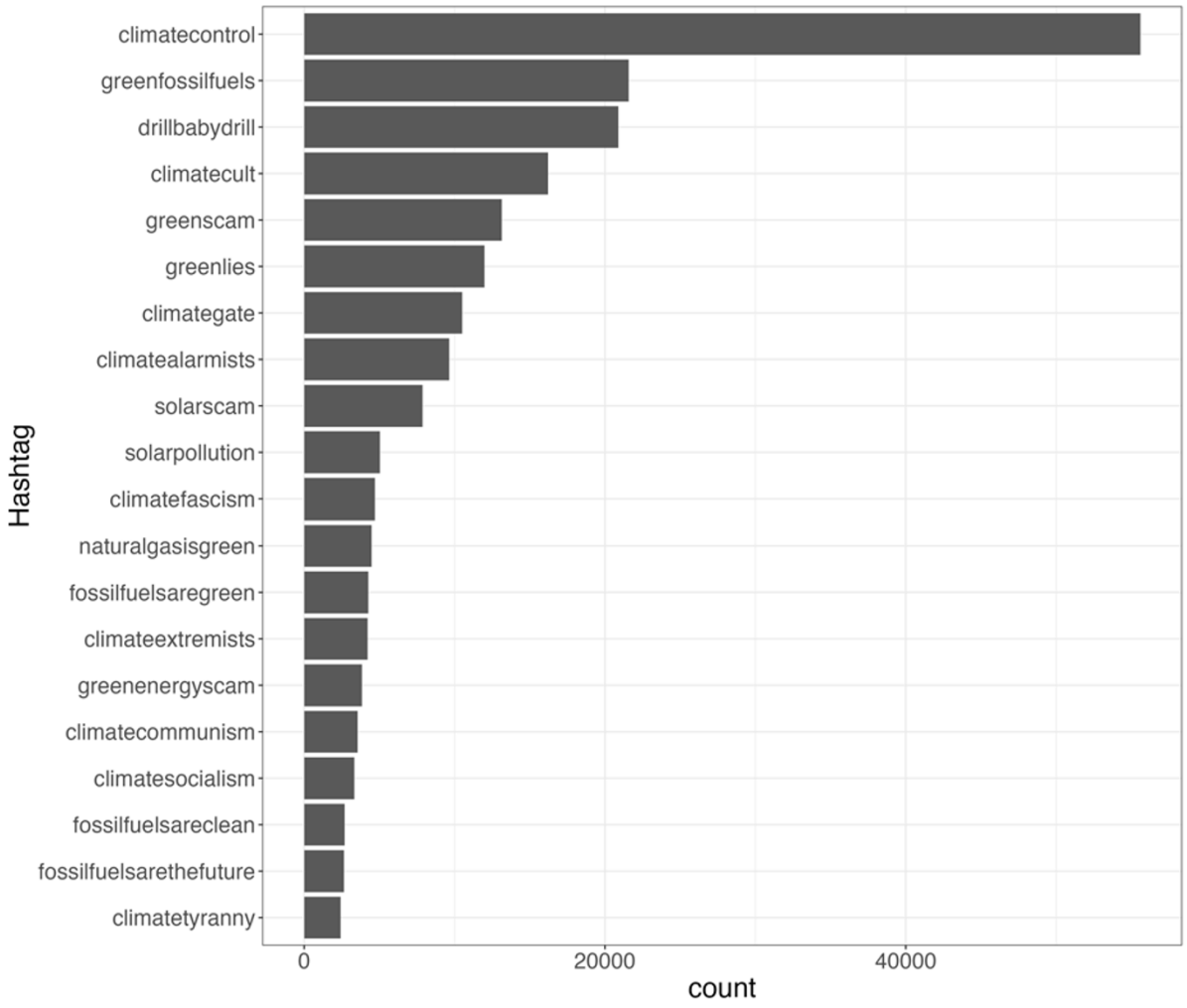


Figure 2. Frequency of top 20 search terms.

American conservative news bloggers and talk show hosts and smaller accounts of non-professional far-right individuals.

Green Fossil Fuels. The most prevalent theme in this search term centered on the perceived hypocrisy of green energy, with arguments asserting that its production and implementation rely heavily on fossil fuels, mining, harmful chemicals, and environmentally damaging practices. Economic skepticism emphasized a perception of a high cost and potential infeasibility of green energy, with concerns about rising gas prices and overall economic viability. Some individuals expressed anxieties about national security, fearing increased foreign dependency for fuels and potential negative impacts on global power dynamics. Allegations regarding the reliability, scalability, and safety of green energy technologies, raised alarms around susceptibility to natural disasters and resource limitations. Fears of inflation, energy shortages, and compromised national security abounded, often framed within a narrative of government overreach and corruption. Some critiques extended to attacks on President Biden and accusations of government control and corruption, with some characterizing climate solutions as a 'green agenda' with authoritarian undertones. The most retweeted accounts in the 'green fossil fuels' search term were American conservative news bloggers, political commentators and authors, and US House Representatives.

Drill Baby Drill. The most prominent discourse in this category centered around attacks and criticism of US President Biden. A nationalistic discourse emphasized the conflation of patriotism with support for US oil production over foreign oil dependence, positioning energy independence as essential for national prosperity, global well-being, and reduced gas prices. An exemplative user declared, 'Drill baby, drill! Frack baby, frack! That's the lesson in all of this: ENERGY INDEPENDENCE!' Many tweets propagated the notion that climate solutions would precipitate disastrous consequences such as blackouts and economic downturns. These tweets advocated against such solutions, contending that their absence would lead to improved economic conditions, including increased employment opportunities, reduced gas prices, and lower inflation. References to US politics in general were ubiquitous, with many in particular citing and retweeting Lauren Boebert, a far-right politician who often promotes the phrase, 'drill baby drill'.

Climate Cult. The most prominent theme in this search term was climate denial, or the false claim that climate science is unscientific, incorrect, or a hoax. Users presented manipulated or outright false data to support this claim. A prominent theme focused on the conspiratorial belief that climate change science and solutions are like COVID-19 measures, in that both are part of a broader scheme to control people's lives. Framed in a negative

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Table 2. Summary of qualitative analysis by frequency of search term

Climate control	Exhibitions of anxieties around control and power
	Accusations of aim for totalitarian control by Democrats and 'elites'
	Criticism of hypocritical advocates
	Warnings of consequent collapse
Green fossil fuels	Allegations of hypocrisy of green energy (e.g. relies on fossil fuels)
	Skepticism around economics
	Concerns around national security, practicality, and corruption
Drill baby drill	Criticism of Democratic leaders
	Assertion of patriotic and economically beneficial energy independence/danger of alternatives
	References to US politics and politicians
Climate cult	Climate science denial (e.g. presentations of false data)
	Allegations of climate science as a scheme for control
	Criticism of advocates as hypocritical
Green scam	Accusation of green energy is a scam (e.g. corrupt scheme)
	Criticism of advocates
	Proclamations of green energy causing environmental and economic disaster, as ineffective and impractical.
Green lies	Charges of fraudulent climate science
	Criticism of US government and Democratic leaders
	Warnings of potential economic loss and holistic damage from climate solutions
Climategate	References to 'climategate' conspiracy theory
	Climate scene denial
	Criticism of climate scientists and green technology
Climate alarmists	Allegations of 'climate alarmists' as extreme, corrupt, hypocritical
	Climate scince denial
	Repetition of far-right/anti-left arguments
Solar scam	Charges of solar power as a scam (e.g. causes environmental damage, not economically viable or practical)
	Criticism of Democratic leaders
	Anti-China sentiments
Solar Pollution	Claims that solar power causes pollution (e.g. environmental damage, socially unjust resource extraction) that outweighs benefits

light, climate solutions were frequently linked with other progressive advocacy issues, including = reproductive rights, free college tuition, addressing systemic racism, education reform, combating homophobia and transphobia, gender equality, immigration reform, affirmative action, and stricter federal regulations. Many voices expressed the accusation that climate advocates were frauds, basing their claims on two main arguments: (1) the perceived lack of response from climate activists to other disasters, such as the 2023 train derailment in Palestine, Ohio, suggesting their concern was not genuine; and (2) the belief that their advocacy was primarily motivated by personal gain, seeking money, power, and/or cult memembership rather than truly caring about the environment. Warnings were prevalent that pursuing climate solutions would result in a disastrous outcome, encompassing various consequences such as increased debt, heightened energy dependence, the potential for World War III, insufficient heating during winter months, and widespread poverty. There was a notable presence of retweets of an account of an American far-right internet troll.

Green Scam. The most prominent theme in this category was the argument that green energy is a scam. The prevalent assertion that climate change solutions are not genuinely about protecting the environment but rather a deceptive and corrupt scheme driven by financial motives sometimes specified to enrich specific individuals or entities, often singling out Democrats, wealthy elites or green energy companies. An exemplative user wrote, 'Green energy doesn't exist. Climate change is a scam. It's all a lie to try and scare you into submission'. People who support climate solutions faced widespread criticism, ranging from skepticism to mockery, with some even being likened to criminals or Nazis, labeled as 'woke' or 'brainwashed', further undermining their credibility. Tweeters spread misinformation that climate solutions, rather than helping the environment, cause biological harm and contribute to environmental damage. Some went as far as to project that climate solutions would result in disasters, especially negative economic impacts like increased wealth disparity. Many promoted the misinformation that fossil fuels are indispensable, claiming green energy solutions are ineffective or nonexistent. Retweets of American conservative news bloggers and political commentators, and US House Representatives were common in this search term.

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Green Lies. This category contained less text than others in the top ten, with the most prominent theme centered around promoting the misinformation that climate change science and solutions (using the term 'green') were lies or false information. These claims often targeted President Biden and the US government. Commentators often criticized climate solutions on economic bases, including accusations of price hikes, taxpayer loss, and the promotion of American poverty. Some Tweets referenced climate solutions causing environmental damage, social impacts, and some others criticized proponents of climate solutions, for example as communist ploys. Several retweets of US Representatives, especially Marjorie Taylor Greene and Ronny Jackson were present in this search term.

Climategate. The term 'climategate' usually refers to a controversy that emerged in 2009 when an unknown actor leaked when emails from the University of East Anglia's Climatic Research Unit. Climate skeptics falsely claimed these emails revealed scientific misconduct and a conspiracy to fabricate evidence of human-caused global warming. A common thread of misinformation falsely asserted that climate science is not legitimate and is being debunked by 'real science'. This narrative often accused the IPCC or climate scientists of deliberately manipulating or cherry-picking data to support a predetermined agenda. It painted climate change reporting as a trick, scandal, hoax or a conspiracy, with some suggesting that media outlets orchestrated it to deceive the public. To this end, many users criticized climate scientists to discredit their claims, accused of being 'extremists', 'alarmists', 'liars', and 'dogmatic'. Misinformation in this category also frequently painted green technology as toxic, dangerous, and prone to failure. Many of the Tweets in this category came from a Dutch account, perhaps because this account was extremely active in promoting the term 'climategate'.

Climate alarmists. The most prominent theme in this category was promoting the label 'climate alarmists', which suggests that climate change is not an urgent problem, and those claiming it is so are wrong, willfully ignorant, extreme, unreasonable, or have ulterior motives. Generally many promoted climate change denial here, including a denial of climate impacts, with an underlying suggestion of a willful and purposeful campaign of misinformation on the part of climate scientists. For example, as one user asserts, 'I bet most people have no idea how climate alarmists manipulate data'. Several users accused 'climate alarmists' of having other motivations or purposes than environmental protection, and of being hypocritical in not responding to other disasters (e.g., the East Palestine train derailment). Commentators wielded common far-right arguments, linking climate alarmism with other anti-left issues, criticizing left political figures and climate solutions supporters aselitistand privileged. The most retweeted accounts here were a far-right British journalist and author, British politicians, US right wing political commentators, and US House and Senate representatives.

Solar scam. The most prominent thread in this category was the claim that solar power was a scam. Numerous tweets falsely portrayed solar energy as extremely toxic and dangerous, claiming that it causes pollution, requires extensive mining, and ultimately leads to environmental destruction that far outweighs its benefits. A significant number of arguments centered on the economic aspects of solar energy, alleging that it is a scheme for profiteering, exorbitantly expensive, or unfairly subsidized by taxpayers. Political discourse frequently criticized President Biden and other congressional leaders for their support of solar energy. Additionally, arguments emerged that solar development disproportionately benefits China, protraying this as a significant negative consequence. Climate solutions were also criticized for being unreliable and ineffective, with fossil fuels being portrayed as a more dependable energy source. The most retweeted accounts included American and British far-right authors and political commentators, and far-right individuals.

Solar pollution. This category centered around claims that solar power causes an unreasonable amount of pollution compared with the benefits that it creates. This misinformation often claimed that solar and other renewable energy lead to increased waste and pollution due to mining and environmental destruction. This narrative falsely asserted that these renewable energy sources are detrimental to the environment, despite their potential to reduce reliance on fossil fuels and decrease greenhouse gas emissions. These claims also often exaggerated the resource intensity and environmental impact of solar energy. Notably, there were a few alarming references to child slavery in the production of batteries, the US Department of Labor (n.d..) has noted that Child Labor is at times used in the mining of cobalt, a key ingredient in lithium ion batteries (Department of Labor, n.d.). The most retweeted accounts included far-right American podcasters and authors, with some retweets of Canadian politicians and Australian political commentators.

4.2. Cross-cutting themes

With an understanding of the prevalence of climate-related search terms and the conversations emergent in those terms, we move to discussion of cross-cutting themes throughout the dataset. First, within the quantitative analysis, the most highly represented category in the top 20 search terms (see Figure 3) was the 'Power/Government' (n = 5), Greenwashing category (n = 4), 'Climate Solution Supporters' (4), Scam (3), Solar Power Criticism (2), and Fossil Fuel Glorification (1), highlighting the dominance of narratives around activists/advocacy attempting political control or deception or criticizing supporters of climate solutions, over narratives critiquing renewables or climate policy.

In analyzing the prevailing categories of climate solution misinformation (Figure 3), several noteworthy patterns emerge. 'Power/government' and 'Climate Solution Supporters' were overwhelmingly the most prevalent categories, suggesting that climate solution misinformation may be associated with political ideas or to discredit climate action advocates. Interestingly, greenwashing and scam claims were the next most popular categories. This may indicate that while misleading environmental claims and fraudulent schemes exist in climate solution misinformation, they are not as popular as Tweets surrounding advocates or political ideas. The remaining categories, including fossil fuel glorification, renewable energy criticism, and policy criticism, comprised a relatively small proportion of the overall misinformation landscape. This could imply that these tactics, while employed, are less effective or less strategically advantageous than the top four.

The word cloud (Figure 4) shows the frequency of words in the dataset, where the size of the word correlates to the frequency. The most prominent words allow for an impression of the most popular terminology used in the dataset. The words 'green, 'energy', 'fossil', and 'fuel' are descriptors logically associated with this content; however, the promenade of words, 'control', 'scam', 'power', and 'lie' point to the often heated and political debate that characterized many of the Tweets. It is important to note that the term 'drill baby drill' remains politically relevant and

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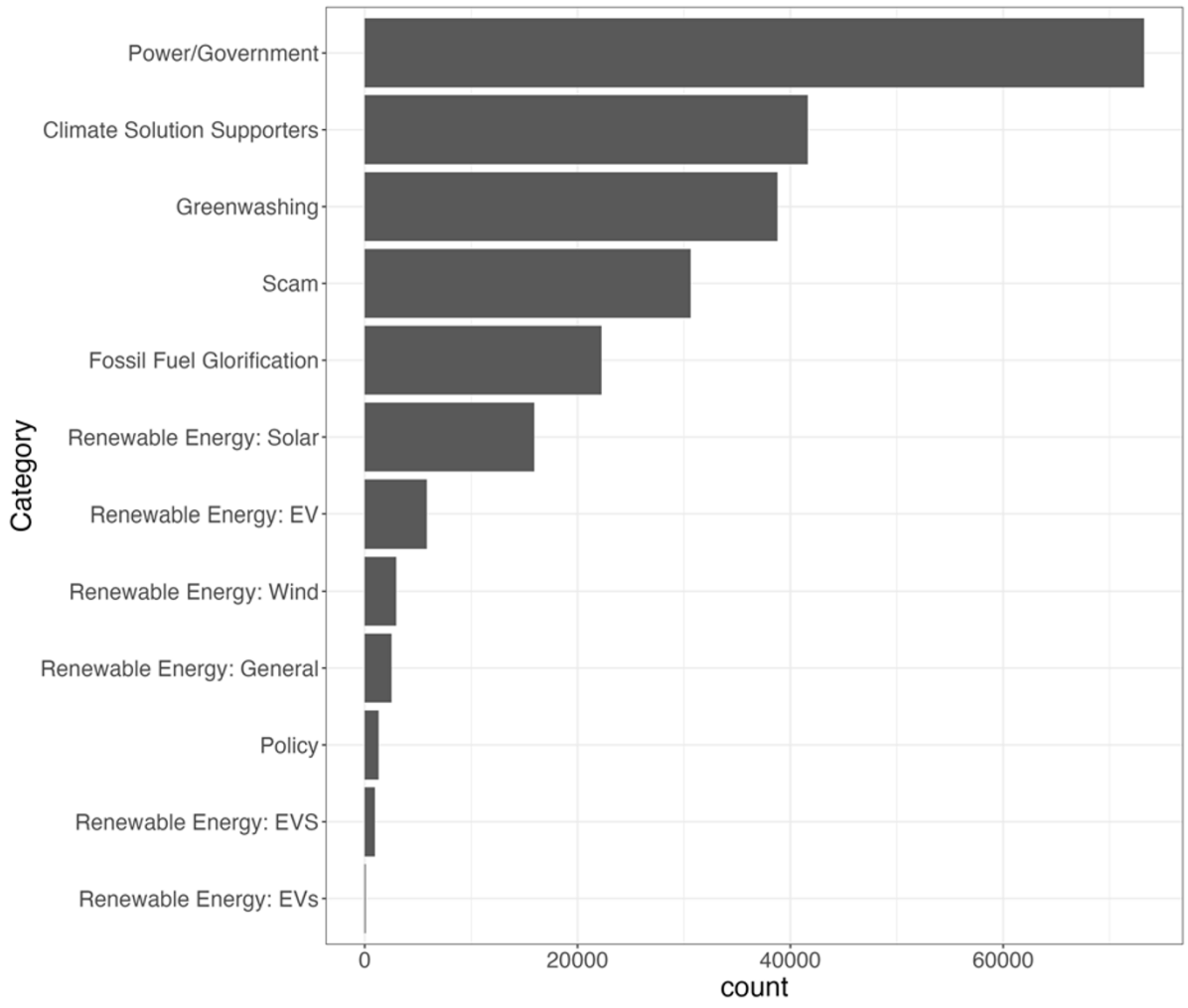


Figure 3. Frequency of categories of search terms.

greatly contested, as Donald Trump frequently references the term (Khadka, 2025).

In the qualitative analysis, several general trends of note emerged. The most common types of climate solutions criticized were (1) solar, (2) wind, (3) policy, and (4) Electric Vehicles (EVs). Several comments mentioned nuclear power a controversial topic. The most commonly referenced political figure was Joe Biden, left political figures and the White House were also commonly mentioned, references to the left were more common than references to the right, reflecting a proclivity to attack the left. The most commonly referenced issue links were COVID, and pro-oil sentiments.

Several recurring themes emerged across the top ten search terms, suggesting a pattern of discussion and interest surrounding specific viewpoints.

Right wing discourses: Several lines of argument aligned with typical discourse and narratives prevalent on the right, mirroring the anti-climate solution viewpoints often expressed within that political perspective. This suggests a potential overlap in ideologies and talking points between those who oppose climate solutions and the right political movement, mirroring previous research on homophilous networks and echo chambers. These common right arguments, often promulgated by media influencers like Julie Kelly and Jack Posobiec (Folkenflik & Dreisbach, 2025) invoke fears of communism (Hanson & O'Dwyer, 2019), attacks on perceived 'elites' (Bonikowski & Zhang, 2023), Democrats (Hanson & O'Dwyer, 2019), and left-leaning issues (such as gender (Corrales & Kiryk, 2022) and affirmative action), as well as concerns over tax and price increases, anti-China sentiment (Holt et al, 2022), and a push for US energy independence (Schneider & Peeples, 2021), were strategically employed to discredit and cast doubt on the viability and legitimacy of climate solutions. This approach tapped into existing political narratives (see papers cited in this paragraph) to undermine support for climate action.

Ulterior motives. A recurring theme in the tweets was the accusation that hidden agendas drive climate solution supporters of agendas beyond a genuine desire for environmental protection. This implies that their self-interest motivates their advocacy, political gain, financial gain, or other ulterior motives rather than a sincere concern for the planet. A prominent theme was the accusation that supporters of climate solutions are primarily driven by a desire for control and power, rather than genuine environmental concern. This narrative often casted climate solutions as a conspiracy orchestrated by 'elites' or Democrats. Those who support climate solutions were also discredited in myriad ways, especially by claiming climate solution supporters faced widespread discrediting through various tactics, primarily by labeling them as alarmists, cultists, hypocrites, or individuals with ulterior motives.

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Figure 4. Word cloud.

These accusations aimed to undermine their credibility and cast doubt on the sincerity of their support for climate action.

Fundamentally flawed. A dominant narrative across discussions was the assertion that climate solutions are fundamentally flawed and will lead to detrimental outcomes. This encompasses several key claims. Many argued that climate solutions rely on technologies that either do not work as advertised or fail to deliver genuine environmental benefits. Some even contended that these solutions create more pollution in the long run than they prevent. There was widespread concern that implementing climate solutions will result in severe economic consequences, such as tax increases, or even trigger broader social and political upheaval. A significant portion of the discourse dismissed climate solutions as a 'scam', implying that they are a deceptive scheme designed to exploit the public or serve ulterior motives rather than genuinely addressing environmental concerns. Together, these claims form a pervasive narrative that casts doubt on the effectiveness, feasibility, and legitimacy of climate solutions, portraying them as a threat to economic stability and social well-being.

Shift from climate denial to climate solution attacks. In addition to the dominant themes, a smaller but notable thread of climate change denial cut accross the top ten search terms. Interestingly, this denial primarily focused on attacking climate solutions rather than directly discrediting the science behind climate change itself. This observation aligns with other research findings that suggest a shift in the strategies of those who oppose climate action. Perhaps due to the overwhelming scientific consensus on climate change, directly challenging the science has become less effective. Instead, opponents may be redirecting their efforts towards undermining proposed solutions, potentially as a way to delay or derail meaningful action. This shift in focus highlights the evolving nature of climate change denial and the need to adapt communication and advocacy strategies accordingly. It is important to note that this observation's basis is inthe specific data analyzed in this study. The broader trends and implications of this shift in climate denial tactics is a crucial area for further research. However, it does raise interesting questions about the most effective ways to counter misinformation and build public support for climate action in the face of evolving opposition.

4.3. Suggestions for countering climate solution misinformation

The authors note some ideas on countering the most prevalent forms of climate solution misinformation based on our findings.

Connecting with conservative audiences. It may be difficult to counter the wave of far-right ideologies as those are deeply held beliefs. However, in regard to attacks against 'elites', we suggest showcasing down-to-earth stories of individuals and communities that support and benefit from climate solutions. Emphasizing how climate solutions support energy independence and local job creation could help support the narrative of American energy independence and economic. Highlighting Republicans or conservative ideologies (see e.g. the American Conservative coalitions, whose mission it is 'to build the conservative environmental movement' who champion these solutions could help demonstrate how climate solutions might align with conservative values (American Conservative Coalition, n.d.; Bustillo, 2024).

Motivations of climate solution supporters. To help clear out the motivations for promoting climate solutions, we suggest a few different tactics. We suggest comparing profits and subsidies of climate solutions to those of the fossil fuel industry to dispel misinformation around unfair tax benefits for renewable adopters. To counter misinformation about the motives of climate solution supporters and the efficacy of the solutions themselves, we suggest humanizing the issue and showcasing real-world impact. By sharing stories of (1) Climate scientists, highlighting their dedication

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to research and the everyday challenges they face in understanding and addressing climate change. (2) Business owners in the climate solutions sector, showing their passion for innovation and the positive economic impact their companies are creating. (3) Everyday people using renewable energy, showing how these solutions improve their lives through lower bills. (4) Small American businesses benefiting from climate solutions, demonstrating how these businesses are thriving by adopting sustainable practices, creating jobs, and contributing to their local economies.

Climate solutions work. To dispel doubts about the effectiveness of climate solutions, we suggest providing accessible and transparent information. Comparing the pollution generated during production and operation to the significant reduction in carbon emissions achieved throughout their lifespan could help demonstrate the net positive impact of climate solutions. Explanations of how renewable energy sources function could counter misinformation, for instance, clearly illustrate how batteries store and release energy to power homes and businesses. To address concerns about the effectiveness and reliability of climate solutions, provide concrete evidence of successful renewable energy projects and innovative storage technologies, highlighting the growing reliability and affordability of renewable energy sources.We also suggest directly addressing and refuting common false claims, such as the myth that wind turbines harm whales, with evidence-based information.

Shift toward climate solution messaging. Recognizing the evolving landscape, we recommend prioritizing efforts to counter misinformation on climate solutions rather than engaging in debates about the existence of climate change. This shift aligns with the current narrative and promises to be more impactful in achieving our ultimate goal of addressing climate change.

Who is delivering the messages: We note that many of the most commonly retweeted accounts were far-right political commentators, authors, bloggers, and politicians. In addition, climate solution misinformation aimed at discrediting climate solutions often targeted scientists, 'elites', and Democrats. As such, we recommend showcasing stories that relate to everyday people of different economic backgrounds, and Republicans or well-known individuals with conservative ideologies.

Message content: On X (previously Twitter) and other social media platforms, messages are short and often contain simple memes or short videos to capture quick attention spans. We recommend promoting quick, impactful facts that folks can easily understand and quickly repost. Also, creating simple memes with impactful photographs or cartoons would align well with current messaging practices. Finally, short videos with simple and impactful messaging could prove to be popular. In all of these recommendations, the content of the most popular messaging noted is simple, direct, impactful, and occasionally contains humor.

How to address the spread of climate solution misinformation on social media. Due to the unreliability of current practices regarding flagging misinformation on social media, it is not certain if efforts to promote flagging programs would be successful. A grassroots approach involving developing counter-narratives with messaging that appeals to misinformation audiences is a direct way to counter climate solution misinformation that does not rely on the decision-making of inaccessible actors.

5. Conclusion

This study acknowledges several limitations. First, the data collection period occurred before Elon Musk's acquisition of Twitter, potentially impacting the prevalence and nature of climate solution misinformation due to subsequent changes in content moderation policies. Second, our analysis represents a snapshot in time, and the narratives surrounding climate solutions may have evolved since data collection concluded. We were limited to the data we obtained for this study, scraped just before free academic access was shut down following Musk's acquisition. Third, while our research employed a rigorous methodology, the time- and resource-intensive nature limited the exploration of all possible search terms related to climate solution misinformation. Consequently, there may be additional terms and narratives not captured in our analysis. These limitations highlight the need for ongoing research to monitor the dynamic landscape of online misinformation and its potential impact on climate action.

While this study provides valuable insights into climate solution misinformation (CSM) on Twitter (now X), it also highlights several avenues for further exploration. The evolving landscape of X's data accessibility under Elon Musk's ownership may necessitate expanding research to other platforms like Facebook, Reddit, and TikTok to gain a more comprehensive understanding of CSM dissemination. Examining the specific sources of CSM, whether from individuals, organized groups, or bots, could reveal the underlying motivations and networks involved (see Nicolosi et al, Forthcoming). Additionally, a longitudinal analysis of CSM could reveal how narratives and tactics have shifted over time, potentially in response to political events or technological changes. Finally, investigating how CSM varies across different generations or age groups could shed light on the differential impact of misinformation and inform targeted interventions. These research directions collectively offer a promising path toward a deeper understanding of climate solution misinformation and its potential countermeasures.

The world's leading authority on climate change, the Intergovernmental Panel on Climate Change (IPCC), is urging that the next few years are critical to limit warming (Kikstra et al., 2022). To accomplish this, there is an overwhelming need at this moment to push forward climate solutions and to remove any barriers that stand in their way. This paper answers this call by furthering our understanding of and enriching the potential response to efforts to diminish uptake of climate solutions vis-a-vis misinformation. We suggest that everyday social media users, policymakers, and advocates might use the insights gained in this study to provide a direct intervention in the countering of climate science misinformation and promotion of climate solution information, especially its benefits.

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